Three Tributaries Floodplain Risk Management Study & Plan

Final Report

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FINAL REPORT

for

Fairfield City Council

by

Molino Stewart Pty Ltd

ACN 067 774 332

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FOREWORD

In New South Wales the prime responsibility for local planning and the management of flood liable land rests with local government. To assist local government with floodplain management, the NSW Government has adopted a Flood Prone Land Policy in conjunction with the *Floodplain Development Manual*.

The Policy is directed at providing solutions to existing flood problems and to ensure that new development is compatible with the flood hazard and does not create additional flood problems.

The Policy sets out five sequential stages in the process of floodplain management:

Stage	**Summary**
1. Data Collection	Input to enable preparation of properly informed studies.
2. Flood Study	Technical assessment to define the nature and extent of flooding.
3. Floodplain Risk Management Study	Comprehensive evaluation of management options with respect to existing and proposed development.
4. Floodplain Risk Management Plan	Formal adoption by Council of a management plan for floodplain risks.
5. Implementation of the Plan	Measures undertaken to reduce the impact of flooding on existing development, and implementing controls to ensure that new development is compatible with the flood hazard.

This *Floodplain Risk Management Study and Plan* (FRMS&P) constitutes the third and fourth stage of the management process for the Three Tributaries catchment. In broad terms, the *Floodplain Risk Management Study* has investigated what can be done to minimise the effects of flooding and has recommended a strategy in the form of the *Floodplain Risk Management Plan*.

Fairfield City Council commissioned Molino Stewart in October 2010 to prepare this report, with WMAwater as a sub-consultant to undertake flood modelling aspects of the study and Douglas Partners as a sub-consultant to undertake geotechnical investigations at detention basins. Water Modelling Solutions was subsequently engaged to develop WaterRIDE projects and J. Wyndham Prince was subsequently engaged to provide cost estimates.

Council has prepared this document with financial assistance from the NSW Government through the Office of Environment and Heritage (OEH). This document does not necessarily represent the opinions of the NSW Government or OEH.

The assistance of Council's Floodplain Management Committee and officers from Fairfield City Council and OEH in preparing this document is gratefully acknowledged.

EXECUTIVE SUMMARY

Molino Stewart is a specialist Natural Hazard, Ecological and Environmental Consulting company which was commissioned by Fairfield City Council (FCC), with financial assistance from the NSW State Government, to prepare a Floodplain Risk Management Study and Plan for the Three Tributaries floodplain. The study area includes Orphan School Creek upstream of the Canley Vale-Fairfield Railway, Clear Paddock Creek and Green Valley Creek.

FCC has been managing flood risks within the Fairfield LGA for many decades. Many structural measures have previously been implemented in the Three Tributaries catchment, most notably the construction of 14 detention basins. Drawing upon state-of-the-art flood modelling techniques, the current study sought to assess the effectiveness of these previous measures and to evaluate the whole suite of available floodplain management measures to reduce the risk posed by flooding to lives and property.

The study was overseen by Council's Floodplain Management Committee, which comprises councillors and staff from Council, officers from the Office of Environment and Heritage, the NSW State Emergency Service, other local councils and several community representatives. There has also been opportunity for residents within the study area to provide input to the investigation through the engagement process (see Chapter 5).

Principal Outcomes

The principal outcomes of this study include:

- A revision of the Flood Study (Chapter 6), with improved estimates of flood extents, levels, depths and velocities for the 20 year, 50 year and 100 year average recurrence interval (ARI) floods and probable maximum flood (PMF) (Chapters 7);
- Mapping of the High, Medium, Low and Very Low flood risk precincts used for planning and development control (Section 7.1.3c));
- Definition of the flood problem by construction of a property database and assessment of building inundation, road inundation, evacuation 'hot spots' and flood damages; about 48 houses and 16 commercial/industrial premises would be flooded above floor in the 100 year ARI event; the average annual damages is $1.9 million and the net present damage is $26.2 million (Chapter 8);
- A detailed evaluation of potential floodplain management measures (Chapter 9), including flood modification measures (Chapter 10), property modification measures (Chapter 11) and response modification measures (Chapter 12);
- A recommended Floodplain Risk Management Plan (FRMP) for the Three Tributaries floodplain (Chapter 13)

Floodplain Risk Management Plan

The draft Three Tributaries FRMP is presented in Table 25 and Figure 51. The recommended measures have been selected from a range of available measures, after an assessment of the impacts on flooding, as well as economic, environmental and social considerations.

The recommended measures are summarised below:

Flood modification measures

- Raise embankment at Mimosa Road Basin to contain 100 year ARI flood;
- Assess merits of increasing capacity of Prairiewood Basin;
- Raise embankment at Fairfield Golf Course Basin to contain 100 year ARI flood;
- Bunding between Basin W3 and Basin C to reduce flooding entering Kalang Road/ Attilio Place and Smithfield Road;
- Implement structural, functional and safety measures for all 14 basins, on a priority basis and to improve flood mitigation and basin safety;
- Include all 14 basins in Council's Asset Management Policy/Strategy;
- Assess need and practicality of removing trees from basin embankments;
- Update Urban Area On-Site Detention Code and apply to 'knock down and rebuild' developments;
- Assess merits of realignment of Orphan School Creek channel north of Freeman Avenue;
- Install flap gate on the outlet to the northern Sackville Street 1200mm diameter pipe at Orphan School Creek;

- Manage vegetation upstream of culvert at Moonlight Road on Orphan School Creek;
- Maintain clear grates across culvert entrances at Elizabeth Drive on Henty Creek;
- Install debris control structure upstream of culvert at Cabramatta Road West on Green Valley Creek;
- Flood barrier to protect six properties at southern end of Gregorace Place from Henty Creek flooding;
- Sealing of soundwall, bunding and speed hump to protect two properties near corner of Katinka Street and Lisa Crescent from Green Valley Creek flooding;

Property modification measures

- Seek to VP serious flood risk exposures when implementing FCC's Open Space Strategy;
- Adopt a scheme to raise, redevelop or flood-proof 16 houses flooded above floor in the 20 year, 50 year or 100 year ARI events;
- Revise planning policies:
  - Consider amending Clause 6.3 of Fairfield LEP 2013 to clarify that it does not apply beyond the PMF extent;
  - Backzone Freeman Ave to Low Density Residential, to be more compatible with its High flood risk;
  - Amend Chapter 11 of Fairfield City Wide DCP, including incorporation of a Very Low flood risk precinct;
  - Amend Section 149 planning certificates, including incorporation of a Very Low flood risk precinct;

Response modification measures

- Improve flood warning system:
  - Install three real-time rain gauges in the catchment;
  - Alarm the existing water level recorder for Orphan School Creek at Sackville Street;
  - Install basin water level recorders for the Mimosa Road and Fairfield Golf Course Basins;
- Improve emergency response capability:
  - Construct an elevated emergency evacuation route from Freeman Avenue to Canley Vale Road;
  - Update Fairfield Local Flood Plan and Sackville Street gauge Flood Intelligence Card;
  - Support preparation and updating of private flood plans for key floodplain exposures;
- Improve community flood awareness and readiness:
  - Continue to implement the Fairfield City community flood education action plan 2012-15;
  - Regularly issue flood information to all flood-affected residents;
  - Conduct meet-the-street events for key risk sites (highest priority Freeman Avenue);
  - Conduct a Business FloodSafe breakfast for Smithfield Road;
  - Prepare NSW SES FloodSafe guides for three creeks;
  - Install flood depth indicators and evacuation route signage for five locations.

Funding

The total capital cost of implementing the Plan is about $3.5M, comprised mainly of the Mimosa Road Basin upgrade ($1.1M), the Fairfield Golf Course Basin upgrade (~$0.6M), the Voluntary House Raising/Redevelopment/ Flood-Proofing Scheme (~$0.7M) and the elevated emergency evacuation route from Freeman Avenue (~$0.6M). This would yield damage savings of at least $2.5M, resulting in an overall benefit-cost ratio of about 0.7. It would reduce the number of houses flooded above floor level in the 100 year ARI flood by 42. There are also significant intangible benefits associated with the recommended basin upgrades and improvements to flood warning systems, emergency response planning and community flood awareness and readiness.

PART A: CONTEXT

1 INTRODUCTION

1.1 BACKGROUND

The Three Tributaries study area is comprised of three highly urbanised sub-catchments of Prospect Creek, including Orphan School Creek (upstream of the Canley Vale-Fairfield Railway) and its tributaries, Green Valley Creek and Clear Paddock Creek. These creeks comprise a drainage system running generally through the middle of Fairfield City (see Figure 1).

The three creeks have a history of flooding, which is often associated with flooding on Prospect Creek. Fairfield City Council has been actively addressing flooding issues since the 1960s and has a proactive, ongoing program of preparing and implementing Floodplain Risk Management Plans throughout the Fairfield Local Government Area (LGA). This report presents the Three Tributaries Floodplain Risk Management Study & Plan (FRMS&P).

1.1.1 History of Flooding

Creeks in Fairfield City have a history of flooding. For instance, flood heights for Prospect Creek at Lansdowne Bridge have been kept since the 1850s (see Appendix B) and floods higher than the 100 year ARI flood were observed in 1860, 1873 and 1889. Other floods exceeding 5.0m AHD at Lansdowne Bridge have been observed in 1898, 1950, 1956, 1986 and 1988. The 1986 and 1988 floods caused serious financial loss and hardship to a large number of families and businesses in Lower Prospect Creek (Willing & Partners, 1990).

It is likely that the tributaries of Prospect Creek were flooded, to a greater or lesser extent, at the same time as the floods reported above.

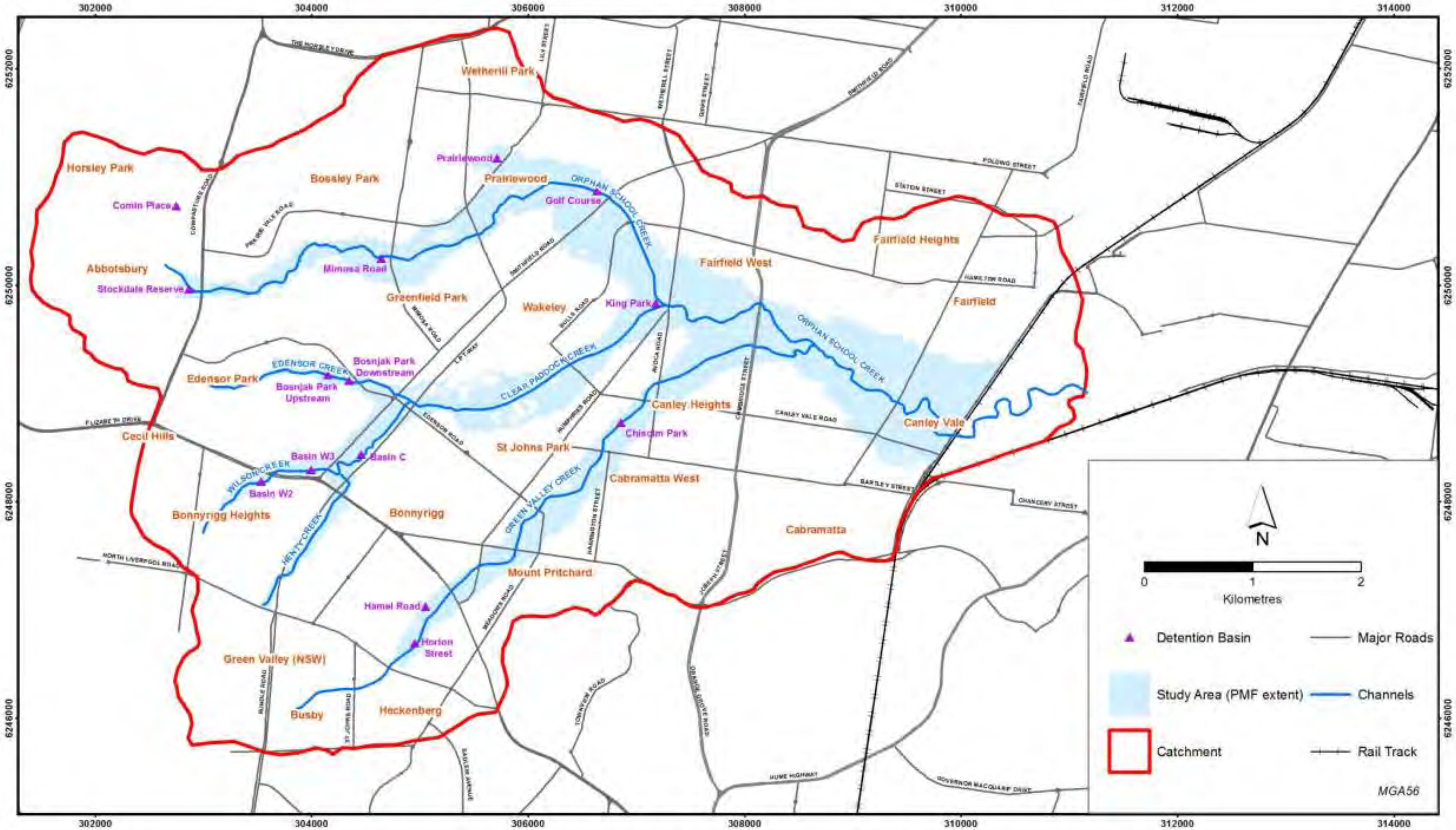
A NSW Office of Water level recorder has been operating on Orphan School Creek at Sackville Street since 1988. Appendix B plots available maximum monthly water levels and shows that flood heights exceeded 5.0m in April 1988, July 1988, June 1991, January 2001 and April 2012.

The following effects of the 1988 flood were reported in *The Sydney Morning Herald* (2 May 1988):

- *Canley Heights: St Johns Road closed due to flooding.*
- *Canley Vale: Residents of Togil Street refuse to evacuate despite serious flooding. Bad flooding on Sackville Street and Freeman Avenue.*
- *Fairfield: virtually all roads flooded to varying degrees. Flash floods, hundreds evacuated to a welfare centre as creeks break banks.*

In 2001, some inundation of garages was reported for Orphan School Creek, as well as external flooding in Clear Paddock Creek and inundation of grounds in Green Valley Creek (FCC, 2001).

In 2012, high flows were observed in Orphan School Creek but no overbank flooding was reported (see Figure 2). The Delamere Street/Railway Parade intersection at Canley Vale was closed due to backwater effects from Orphan School Creek. An erosion control project at Mimosa Road was damaged (FCC, 2012). WMAwater (2013a) found that the average catchment rainfall for the critical duration corresponded to about a 5 year ARI event.



Three Tributaries Floodplain Risk Management Study: Study Area				
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Figure 1 – Study area

Figure 2 – 2012 flood photos

a. Clear Paddock Creek, Kalang Road

b. Orphan School Creek, King Park basin inlet

c. Orphan School Creek, King Park basin outlet

d. Orphan School Creek, Sackville Street bridge and flooded Sackville Street access lane; looking south

e. Orphan School Creek, Railway Parade bridge (left) and heritage-listed Fairfield–Canley Vale Railway bridge (right); looking north

1.1.2 Previous Floodplain Risk Management in Three Tributaries

Fairfield Council has been managing flood risks within the Fairfield LGA for many decades. Many structural measures have previously been implemented in the Three Tributaries catchment. Channel 'improvement' works involving enlarging, straightening and clearing channels, and channelization involving the conversion of natural creeks into open concrete drains, were used to increase the ability of a creek channel to discharge floodwater (e.g. see Figure 3). Unfortunately, while this may locally reduce flood levels, it tends to make flooding worse downstream. It is also associated with adverse geomorphic and ecological impacts, including accelerated stream bank erosion for unprotected areas, the loss of in-stream habitat, and the reduced frequency of floodplain deposition known to be important for many species. In recent times, efforts to restore natural channels, without exacerbating local flood problems, have been successfully implemented, notably the 'Restoring the Waters' project along a reach of Clear Paddock Creek (Figure 3). The most prominent measure to manage flood risk in the Three Tributaries catchment has been the construction of 14 detention basins to offset the adverse hydrological impacts of urbanisation (e.g. see Figure 3).

In addition to these flood mitigation measures, land use planning has to a degree been successful in keeping residential development away from the highest flood risk areas (see Section 11.3.2).

Voluntary House Purchase, Voluntary House Raising and Flood Proofing schemes have been implemented elsewhere in the LGA, but not yet in the Three Tributaries catchment.

Figure 3 – Previous floodplain risk management measures

a. Clear Paddock Creek below Brisbane Road

b. 'Restoring the Waters', Clear Paddock Creek

Source: FCC, 2006

c. King Park detention basin

Council has commissioned a number of technical studies for the purposes of designing channels and detention basins within the Three Tributaries catchment. Recently Council prepared a *Flood Study for Orphan School Creek, Green Valley Creek and Clear Paddock Creek* (SKM & FCS, 2008), which was subsequently reviewed and updated (WMAwater, 2013b). The Flood Study provides the technical basis for the next stage of investigations in the Three Tributaries catchment. This report assesses flood problems, evaluates potential options and develops a strategic plan for managing the risk.

1.2 FLOODPLAIN RISK MANAGEMENT PROCESS

The NSW Government's Flood Prone Land Policy and a *Floodplain Development Manual* (NSW Government, 2005) form the basis of floodplain management in NSW. The main responsibility for managing flood prone lands in NSW rests with local government councils. The NSW Government's Floodplain Management Program is administered by the Office of Environment and Heritage (OEH) and provides councils with technical and financial assistance to undertake flood and floodplain risk management studies, and for the implementation of works identified in those studies.

The primary objective of the NSW Government's Flood Prone Land Policy is to reduce the impact of flooding and flood liability on individual owners and occupiers of flood prone property, and to reduce private and public losses resulting from floods.

The implementation of the Flood Prone Land Policy generally culminates in the preparation and implementation of a Floodplain Risk Management Plan (FRMP) by Council, which is the ultimate objective of the current study. Community engagement is an important part of the process and this has been undertaken via Council's Floodplain Management Committee and public displays and questionnaires with the local community.

The steps in the floodplain management process are summarised in Figure 4. This report presents the Floodplain Risk Management Study and Plan (FRMS&P) for the Three Tributaries catchment.

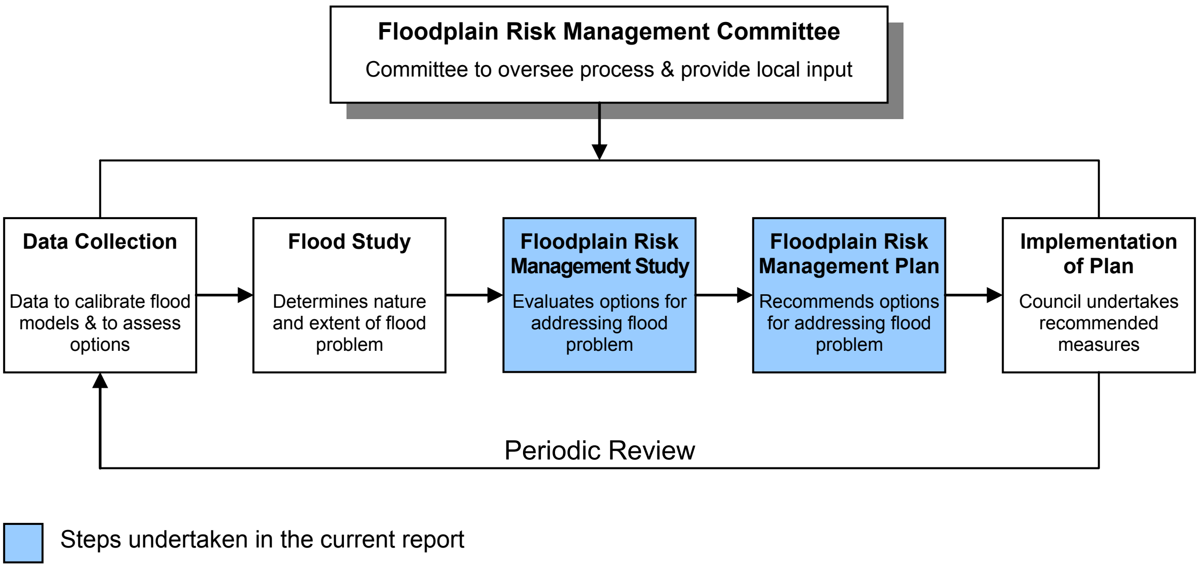

Figure 4 – Floodplain risk management process in NSW

1.3 STUDY AREA

The Fairfield LGA is divided by a major ridgeline located approximately along Cowpasture Road and through the Western Sydney Regional Park. The two thirds of the LGA east of the ridgeline lies within the Georges River catchment while the western third forms parts of the Hawkesbury-Nepean catchment.

A large part of the eastern section of Fairfield City is within the Prospect Creek catchment. Prospect Creek is a major tributary of the Georges River and its 98km^2 catchment is the largest in the Fairfield LGA. The waterways in the Prospect Creek catchment are a mix of natural creeks, concrete-lined channels and enclosed pipe drainage systems.

This study addresses mainstream flooding risks from three tributaries of Prospect Creek (see Figure 1):

- Orphan School Creek (upstream of the Canley Vale-Fairfield Railway)
- Clear Paddock Creek
- Green Valley Creek

Orphan School Creek is the largest tributary of Prospect Creek and passes through the LGA in an easterly direction. Green Valley Creek and Clear Paddock Creek are two main tributaries of Orphan School Creek.

Orphan School Creek is approximately 12km long and has a total catchment area of 34.3km^2, including Clear Paddock Creek and Green Valley Creek sub-catchments. The creek passes under a road bridge and railway viaduct at Canley Vale and joins Prospect Creek approximately 500m upstream of the railway bridge at Carramar Station. The upper and lower reaches of Orphan School Creek are natural waterways, while a section of the middle reach, between Smithfield Road and King Road, is a concrete-lined channel.

Clear Paddock Creek is approximately 5km long and has a catchment area of 8.8km^2. At the upstream end of Clear Paddock Creek are three smaller, predominantly natural waterways known as Edensor, Wilson and Henty Creeks. Wilson and Henty Creeks join to form the main channel of Clear Paddock Creek at Basin C (also known as Bonnyrigg Town Centre Park, Dungabi Badu Wadi). Edensor Creek joins the main channel at a naturalised section of the creek, named 'Restoring the Waters'. The creek is then concrete lined from Brisbane Road to the confluence with Orphan School Creek.

Green Valley Creek is piped upstream of North Liverpool Road (in Liverpool LGA), whilst downstream it flows in a vegetated waterway for approximately 7km to its confluence with Orphan School Creek. It has a catchment area of 7.4km^2.

For the purposes of this investigation, the study area is limited to the area upstream of the Canley Vale-Fairfield Railway line. The area downstream is covered in the *Prospect Creek Floodplain Management Plan: Flood Study Review* (Bewsher Consulting, 2006).

Part of the study area overlaps with the Canley Corridor overland flow floodplain, which is the subject of a separate FRMS&P being prepared for Fairfield City Council by Molino Stewart. Typically in the overlapping areas, the greater flood depths and velocities will arise from flooding of Orphan School Creek (modelled as part of the Three Tributaries Flood Study), though the overland flows from Canley Corridor may be (slightly) faster rising.

1.4 STUDY OBJECTIVES

Fairfield City Council is responsible for local planning and land management in the Three Tributaries catchment incorporating Orphan School Creek, Green Valley Creek and Clear Paddock Creek.

The overall purpose of this study is to find practical, affordable and acceptable means to manage the impacts of flooding on people, property and the environment.

The Three Tributaries FRMS&P has the following major objectives:

- To summarise flood behaviour in the catchment, drawing upon the *Flood Study for Orphan School Creek, Green Valley Creek and Clear Paddock Creek (2008)* and a review and update of flood modelling reported in WMAwater (2013b);
- To identify problem areas and to assess potential flood damages in the study area;
- To identify and evaluate potential works, measures and restrictions aimed at reducing the social, environmental and economic impacts of flooding, addressing existing, future and continuing flood risk, over the full range of potential flood events and taking into account the potential impacts of climate change;
- To develop a strategic plan to manage existing, future and continuing flood risk, ensuring that the draft FRMP is fully integrated with Council's existing corporate, business and strategic plans, existing and proposed planning proposals, meets Council's obligations under the Local Government Act, 1993, and has the support of the local community.

In parallel to the Three Tributaries FRMS&P is the preparation of two reports, the first assessing the safety of Council's flood detention basins and the second documenting basin safety management procedures.

1.5 OUTLINE

The report includes the sections shown in Table 1.

Table 1 – Outline of report

Chapter	**Outline of Content of Section**
Part A: Context	
1. Introduction	Describes brief history of flooding and floodplain risk management in the Three Tributaries catchment
2. Catchment Characteristics	Describes the natural, built and social characteristics of the Three Tributaries floodplain
3. Land Use Planning Context	Describes existing State and local legislation and policies relevant to land use planning in the Three Tributaries floodplain
4. Emergency Management Context	Describes role of NSW SES and positions relating to evacuation compared to shelter-in-place
5. Community and Stakeholder Engagement	Describes findings from the community and stakeholder engagement process
Part B: Flood Behaviour and Impacts	
6. Flood Studies	Describes the Flood Study and review of the Flood Study
7. Flood Behaviour Summary	Summarises flood behaviour within the study area both for existing conditions and for climate change scenarios
8. Defining the Flood Problem	Assesses the impacts of flooding in terms of building inundation, road inundation, evacuation hotspots and tangible damages
Part C: Floodplain Risk Management Measures	
9. Options Overview	Provides an overview and summary of options considered
10.Flood Modification Measures	Evaluates flood modification options including detention basin upgrades, OSD policy, channel modifications, riparian vegetation management, drainage upgrades, debris control and levees
11. Property Modification Measures	Evaluates property modification measures including voluntary house purchase, voluntary house raising/redevelopment/flood-proofing and revisions to planning policies
12. Response Modification Measures	Evaluates response modification options including improvements to flood warning, emergency response planning and community education
Part D. Draft Floodplain Risk Management Plan	
13. Draft Floodplain Risk Management Plan	Describes the recommended floodplain risk management measures

2 CATCHMENT CHARACTERISTICS

This chapter describes the natural and developed features of the catchment as well as a socio-economic profile of those who live in the catchment to provide some context for the FRMS&P. The location of extent of these features is, where possible, related to the current floodplain of the Three Tributaries as extracted from the most recent flood modelling (Section 6.3).

2.1 TOPOGRAPHY

The Three Tributaries catchment is located on the Cumberland Plain, which has a predominantly flat topography and Wianamatta shale derived clay soils. The catchment drains from the south west to the north east towards Prospect Creek, which is a tributary of the Georges River (see Figure 5). The highest elevation in the catchment is about 140m above sea level along its western ridgeline. The lower parts of the floodplain along Orphan School Creek are about 10m above sea level and the creek itself is three or four metres deep from the top of the bank to the bed of the creek.

2.2 ENVIRONMENT

It is important to understand the environmental assets within a catchment because they may:

- be adversely impacted by flooding;
- affect flood behaviour by impeding flood flows;
- be a constraint to implementing some flood mitigation options; or
- be able to be enhanced when implementing some flood mitigation options.

Comprehensive clearing of the catchment for residential, commercial and industrial development has resulted in a dramatic reduction in natural areas. Figure 6 shows the areas of remnant vegetation within the Three Tributaries Catchment as identified by Sydney Metropolitan Catchment Management Authority (SMCMA). Figure 7 shows locations of threatened fauna and flora species.

Much of the remnant vegetation within the Three Tributaries floodplain is identified as the endangered Cumberland Riverflat Forest (this is the same as River-Flat Eucalypt Forest Endangered Ecological Community under the *Threatened Species Conservation Act*).

Threatened species within the Three Tributaries floodplain include *Acacia pubescens* (Downy wattle), *Marsdenia viridiflora subsp. Viridiflora* (Native pear) and the *Miniopterus schreibersii oceanensis* (Eastern Bent-wing Bat).

The NSW Department of Fisheries has mapped Orphan School Creek as far upstream as the junction with Green Valley Creek as ‘key fish habitat’.

Opportunities to enhance the environment include consolidating habitat links (especially desirable along Orphan School Creek, which represents an important east-west corridor within Fairfield City), managing vegetation in areas of high conservation significance, revegetation and regeneration, facilitating fish passage and naturalising channels. These positive environmental outcomes, however, are not in and of themselves eligible for funding under the NSW Floodplain Management Program, unless a benefit in terms of flood risk management can be demonstrated.

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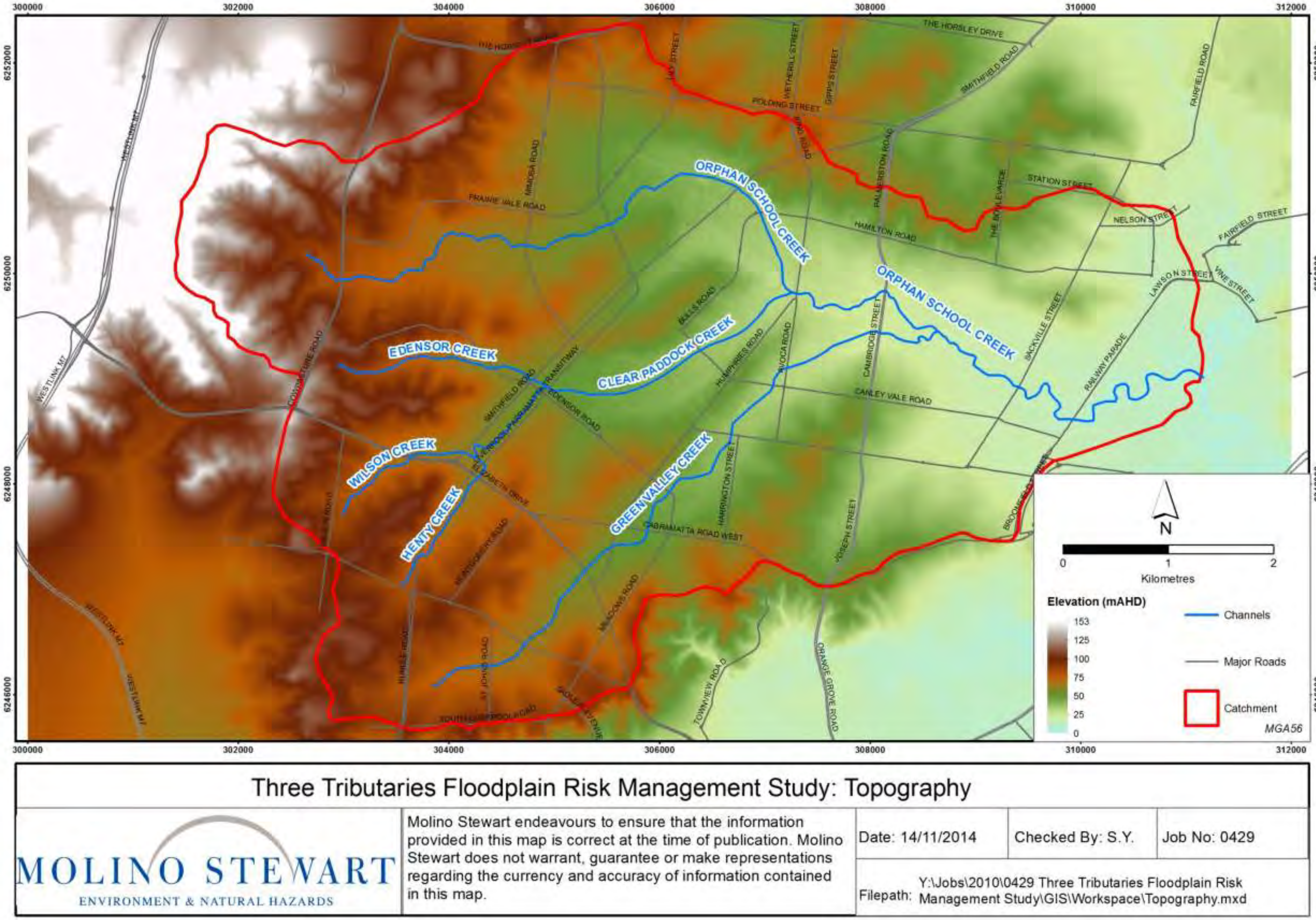


Figure 5 – Topography

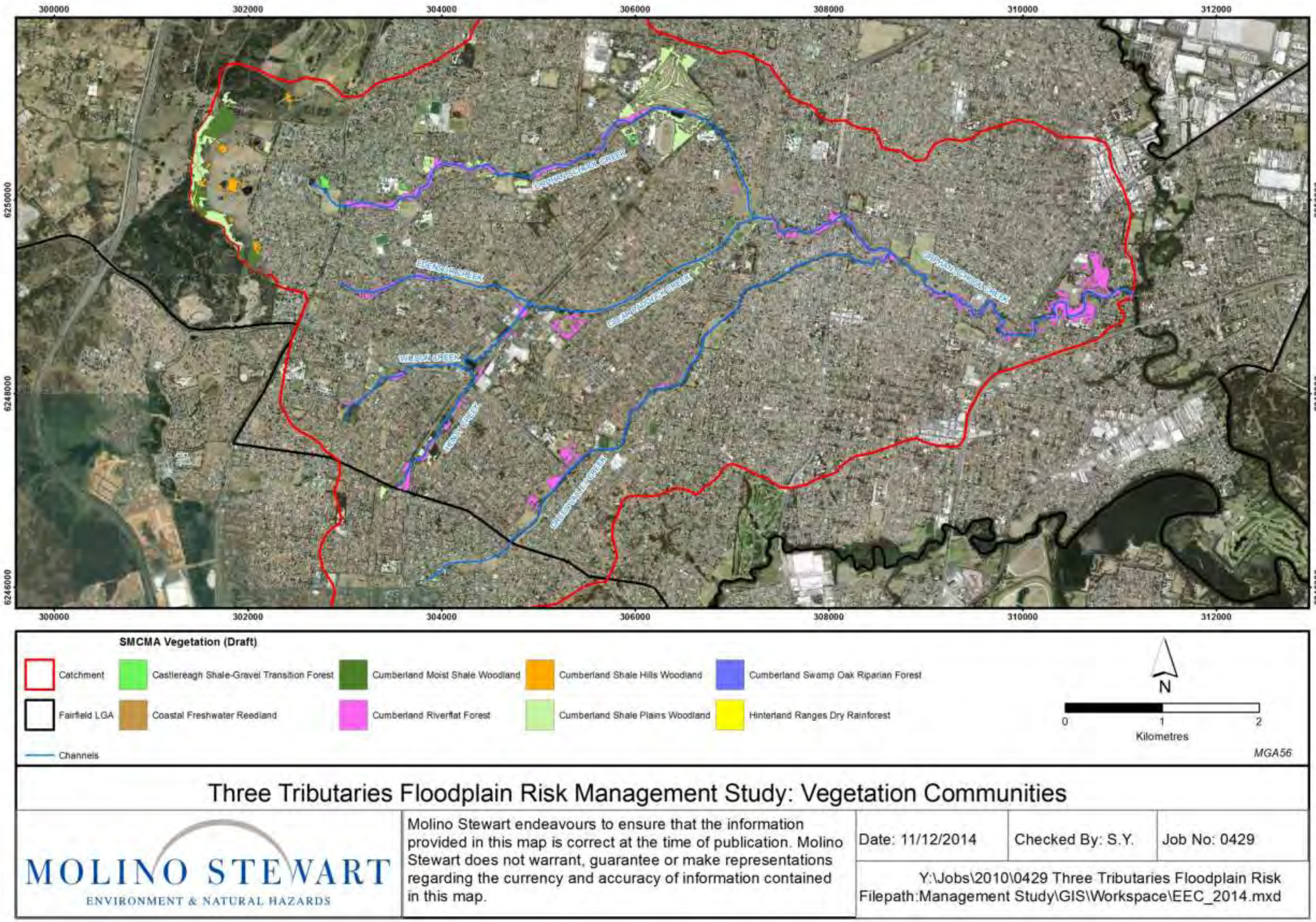


Figure 6 – Vegetation communities

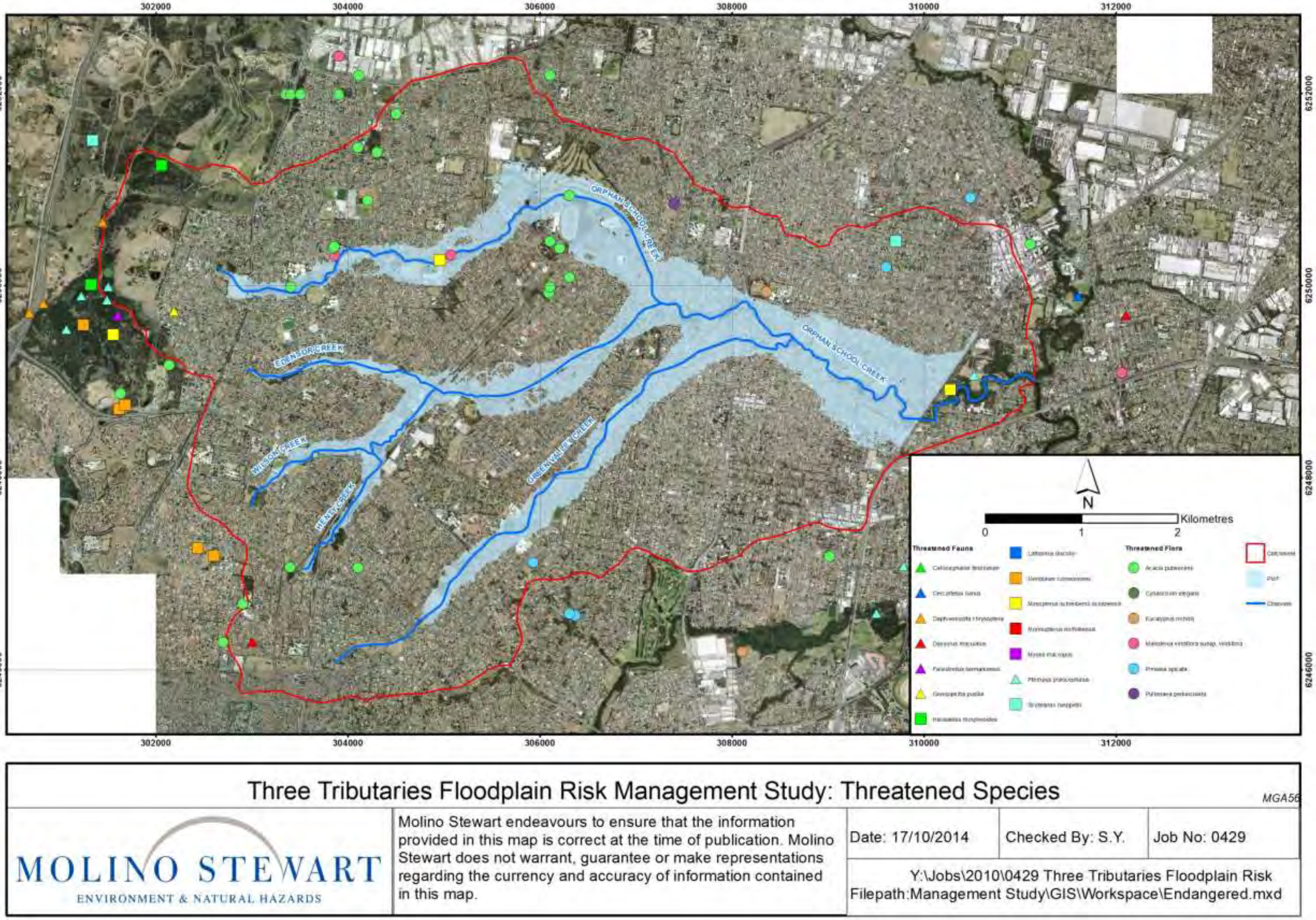


Figure 7 – Threatened species

2.3 URBAN DEVELOPMENT

Woodlands would have originally covered the whole of the Three Tributaries Catchment which was part of the traditional lands of the Cabrogal tribe for thousands of years (Eco Logical Australia, 2009).

A 1943 aerial photo shows that a road network was by then established in Canley Vale and Canley Heights (Figure 8), ready for anticipated urban development. The area west of Cambridge Street (now the Cumberland Highway) was evidently given over to farming. After the Second World War, urban development advanced at pace in the eastern part of the Three Tributaries catchment. Progressively urbanisation expanded westwards such that now the catchment is more or less fully urbanised (Figure 8).

A closer view of the changes that have occurred in one area in Canley Vale is presented in Figure 9. The 1943 image shows that Orphan School Creek had been depleted of much of its riparian vegetation, which probably contributed to an unstable river channel. A much better coverage of riparian vegetation is evident in the contemporary photo. Less positive is the residential subdivision in modern times of Freeman Avenue, which the 1943 image clearly shows to be located on what during a flood becomes an 'island' between Orphan School Creek and the flood runner to the south. As a one road in and out subdivision, this area presents serious evacuation risks.

Current land use zonings are shown in Figure 10. The creek corridors can be detected by following the Environmental Conservation Zone, and to a lesser extent the adjacent Public Recreation Zones. Much of the catchment is dominated by Low Density Residential use. There is an area of land currently zoned Medium Density Residential at Canley Vale which is within the floodplain, including the Freeman Avenue area, much of which would be inundated over ground in a 20 year ARI flood, and which also has serious evacuation constraints. Field inspections also suggest that a degree of intensification is occurring in areas zoned for Low Density Residential use west of Sackville Street, with duplexes replacing older fibro dwellings. This urban renewal may result in more flood-compatible building structures but is also likely to result in more people living within the floodplain, potentially needing to be evacuated during floods.

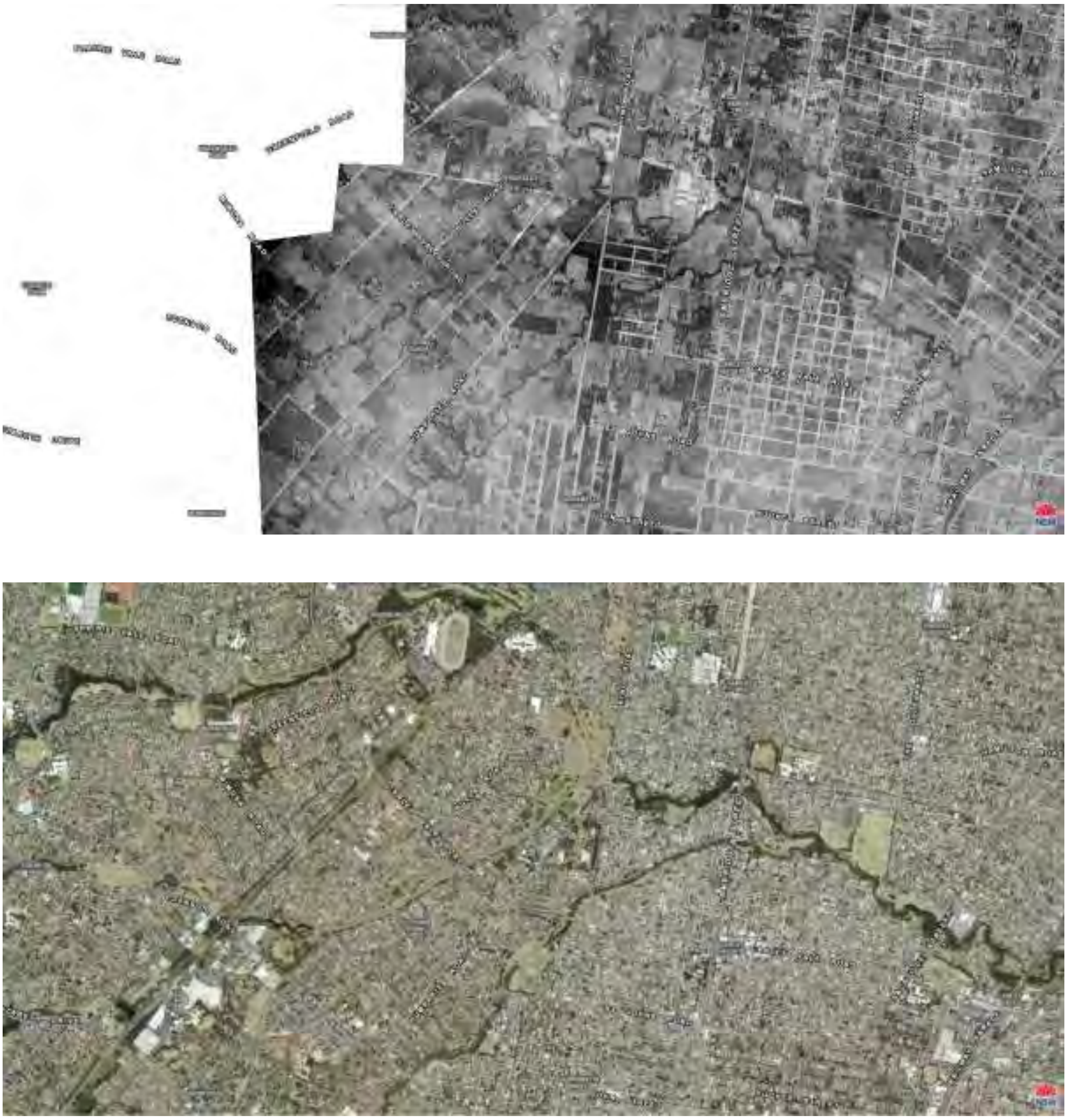
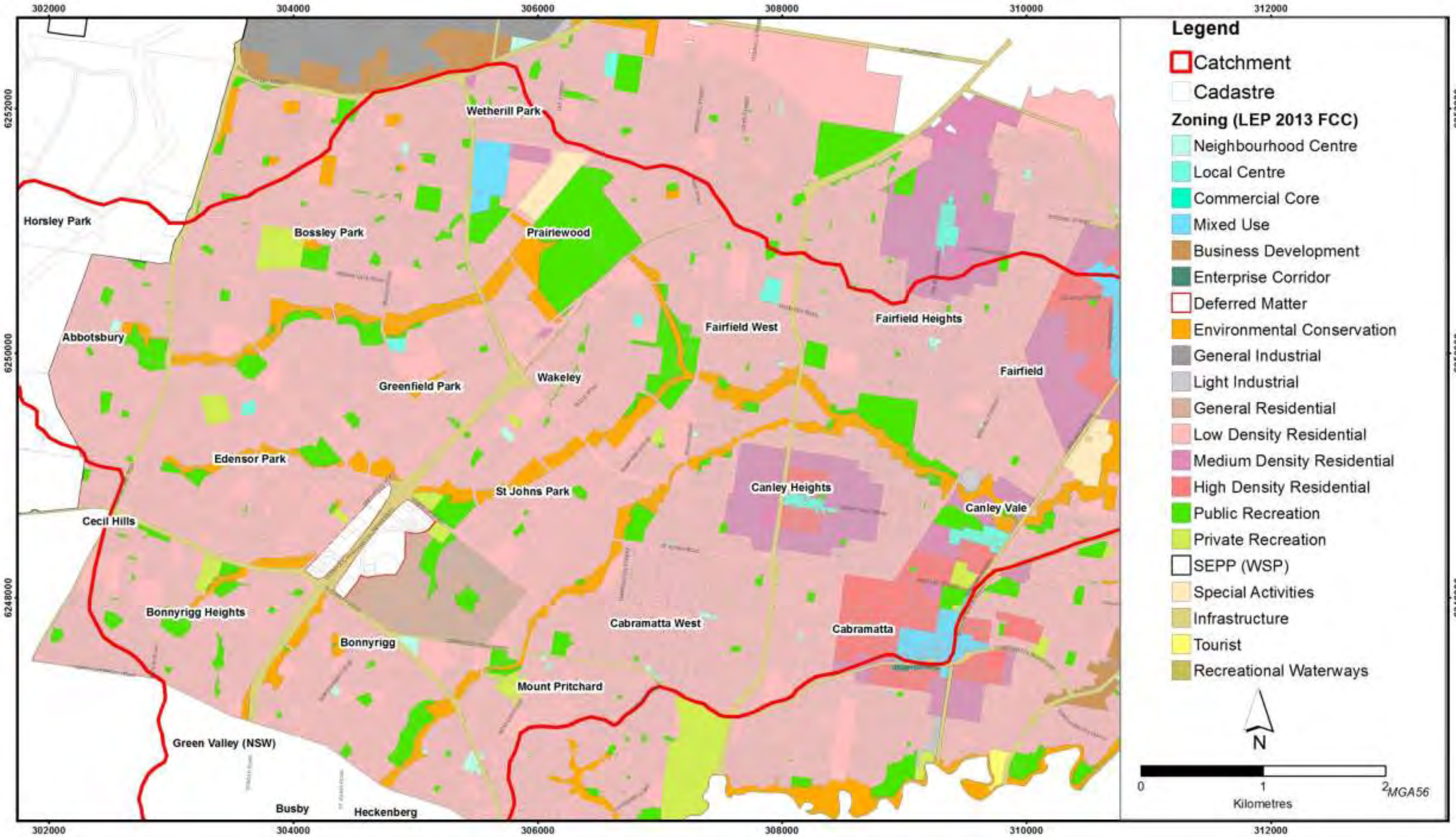


Figure 8 – Aerial photography of the lower catchment area, 1943 and present-day

Source: Spatial Information Exchange, Land & Property Information, NSW Government

Figure 9 – Aerial photography of the Freeman Avenue area, 1943 and present-day

Source: Spatial Information Exchange, Land & Property Information, NSW Government



Three Tributaries Floodplain Risk Management Study: Land Zoning

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Figure 10 – Current (2014) land use zoning

2.4 HERITAGE VALUES

A number of items of heritage significance are located in the Three Tributaries floodplain, as shown in Figure 11. Opportunities to protect these items from the adverse effects of flooding are considered in this FRMS. Any proposed floodplain risk management measures need to be sympathetic to the heritage values. Clause 5.10 of Fairfield LEP 2013 stipulates that development consent is required for a range of proposed activities including demolishing, removing or altering the exterior of a heritage item, Aboriginal object or item within a heritage conservation area.

Table 2 lists indigenous heritage items and Table 3 lists non-indigenous heritage items located within the Three Tributaries 100 year ARI floodplain.

Table 2 – Indigenous heritage items within the 100 year floodplain

Source: Aboriginal Heritage Information Management System (AHIMS) search, Nov 2014

Site ID	**Location**	**Site type**
45-5-2022	Orphan School Creek at Cowpasture Road	Open camp site
45-5-2819	Orphan School Creek d/s Stockdale basin	Artefact not defined
45-5-0729	Orphan School Creek near Clarence Street	Open camp site, scarred tree
45-5-0731	Orphan School Creek near The Boulevarde	Open camp site
45-5-0732	Orphan School Creek u/s Sackville Street	Scarred tree

Table 3 – Non-indigenous heritage items within the 100 year floodplain

Source: Fairfield LEP 2013 Schedule 5 and Fairfield LEP 1994 Schedule 4

Item no.	**Item Name**	**Address**	**Suburb**
I28	Railway Viaduct	Railway Parade ((between Stuart Street & Canley Vale Road)	Canley Vale
I32	Victorian House	1 Stuart Street	Canley Vale
I75	Church (Cathedral of St Hormisdas)	7 Greenfield Road	Greenfield Park
I85	Indigenous flora park	Corner Moonlight Road and Christie Street	Prairiewood
I86	Fairfield Showground, original grand stand and trees	Smithfield Road	Prairiewood
n/a	Temple (Wat Phrayortkeo Dhammayanaram Lao Buddhist Temple)	711 Smithfield Road	Edensor Park

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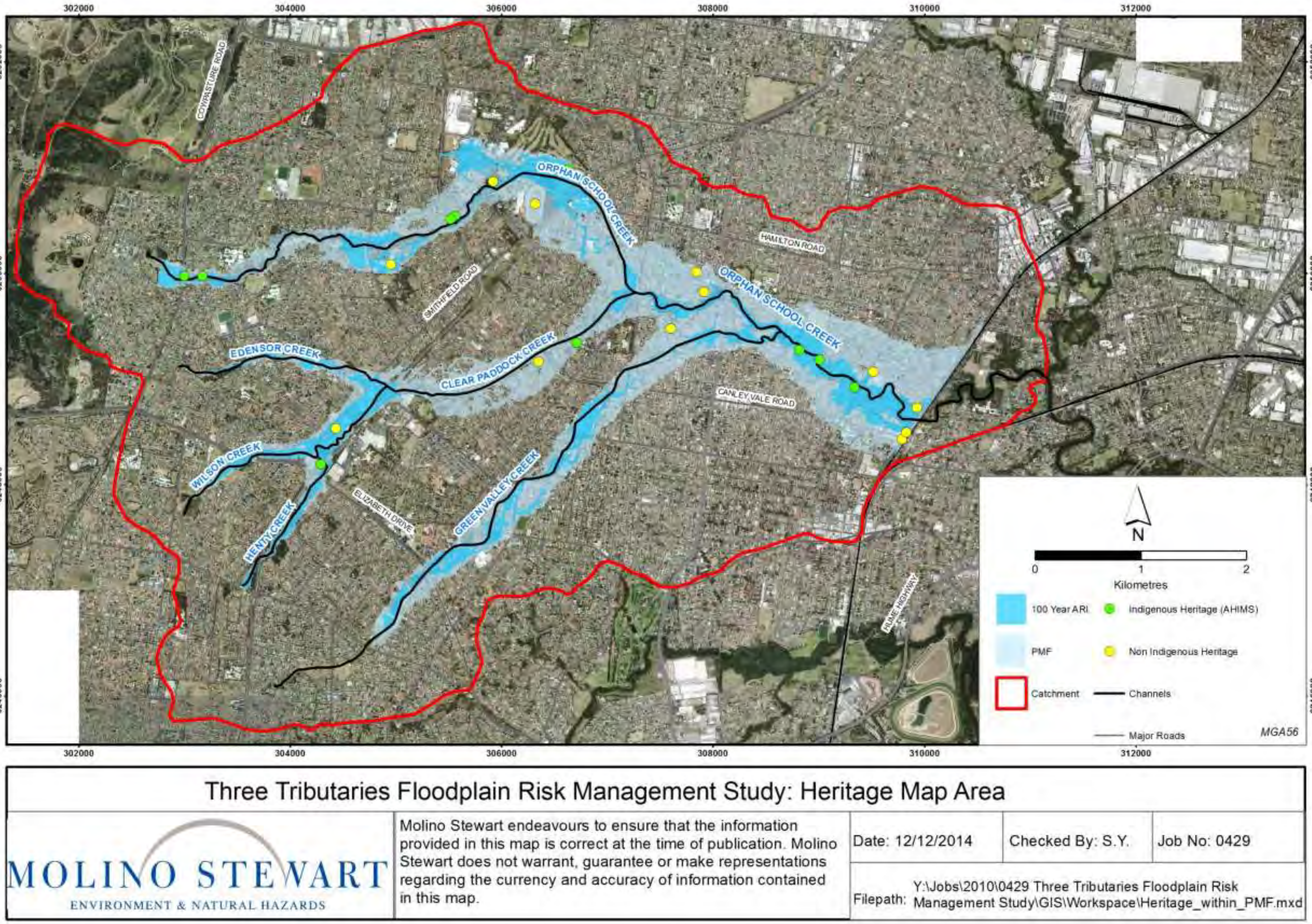


Figure 11 – Heritage items within the PMF floodplain

2.5 SOCIAL PROFILE

2.5.1 Background

A general understanding of the makeup of the community potentially affected by flooding is an essential factor in the development of floodplain management measures. For example, if the community features a number of languages or has little formal education then methods of communication and education in relation to flooding must reflect that. If the internet is not widely used, then a 'social media' campaign to raise awareness may not be as effective as planned. Age and income can be indicators of vulnerability during response and recovery.

Accordingly, a limited social profile of the community in the Three Tributaries catchment was developed from the 2011 Census data and is detailed in Table 4.

Census data is not defined by the floodplain; it utilises statistical areas that extend beyond the study area boundary (see Figure 12). Whilst data is collected in smaller areas, referred to as Mesh Blocks, the Australian Bureau of Statistics does not report this information at a Mesh Block level, other than dwelling and population counts, for privacy reasons. Here we report relevant data for five suburbs having significant overlap with the Three Tributaries floodplain. The same statistic for NSW as a whole is shown for comparison (see Table 4).

2.5.2 Statistics of Interest

The following is a brief discussion of a selection of statistics which may have relevance to:

- Vulnerability to flood impacts;
- Ability to receive information before, during or after a flood;
- Ability to comprehend communications in relation to flooding including planning controls, resilience education, flood warnings, emergency response orders and recovery actions;
- Ability to recover from flooding.

a) Age and Household Structure

Compared to the NSW average, suburbs overlapping the study area have slightly higher proportions of children aged less than 14 and youth aged 15 to 24 and slightly lower proportions of senior citizens aged 65 or over. Children may require assistance during a flood. Youth may need to be targeted with education messages to discourage unsafe behaviours during flooding, such as 'surfing' in stormwater channels. The 11-14% of the population that is 65 or over may be particularly vulnerable to the impacts of flooding, have communication challenges and find it difficult to recover after a flood. This will be particularly the case if they live alone as 20% of residents in Canley Vale do (lower elsewhere in the study area).

b) Cultural and Linguistic Diversity

Compared to the NSW average, suburbs overlapping the study area exhibit very high cultural and linguistic diversity. About 60% of the population was born outside of Australia. Only 16% of persons in Canley Vale speak English alone (rising to 29% at Fairfield West).

The languages other than English with the greatest usages are Vietnamese, Cantonese, Assyrian, Arabic and Khmer. Any communications with these communities will need to not only recognise this linguistic diversity but also any potential cultural barriers to communication.

c) Education

Compared to the NSW average, a much higher proportion of the population within the study area did not attend school. For those who did, the level of schooling attained is lower.

This means that a significant proportion of the population might not be literate, even in their first language let alone in English. It will be important that the means of communication and the terminology used to describe technical concepts is appropriate to the ability of the community to comprehend the information.

d) Employment and Income

Compared to the NSW average, a lower proportion of the population participates in the labour force and a higher proportion (13% at Canley Vale) is unemployed. Median household incomes at Canley Vale are $824 per week which puts them about $21,000 per annum below the NSW State median, though incomes at Wakeley are on a par with the State. Factoring in either monthly mortgage repayments or weekly rental, people within the study area – particularly at Canley Vale – have considerably less disposable income (compared to the NSW average) to meet other routine expenditure. This suggests that it is unlikely they will have the financial capacity by themselves to invest in measures to reduce their flood risk exposure through property modification or preparedness actions, or to recover following a flood.

e) Motor Vehicle Ownership

A relatively high proportion of dwellings in Canley Vale do not have a motor vehicle. This could limit options for evacuation prior to or during a flood.

f) Home Ownership

About one third of the dwellings in Canley Heights and Canley Vale are rented with the remainder owner occupied with about half of these owned outright by the owners and the others mortgaged. It is not possible from the Census data to determine how this varies by dwelling type (house, townhouse, flat). Home ownership could be relevant to willingness to participate in property modification options.

g) Internet Access

Compared to the NSW average, a high proportion of dwellings lack an internet connection. Thus, while there is a significant movement to provide flood education and warning messages by internet, there remains a sizable proportion of the community for whom more conventional methods of engagement will continue to be required.

The Census results are emphasised by the results published in the *Community Flood Education and Awareness in Fairfield City* report (Molino Stewart, 2012) in which 60% of respondents to a Council survey indicated that they had no internet access. This does indicate that emphasis should be placed on communication methods for flood education and flood warning on methods other than websites, especially in areas where there are significant older populations where 'traditional' communication means such as newspapers and radio should be used in flood education.

h) Population Continuity

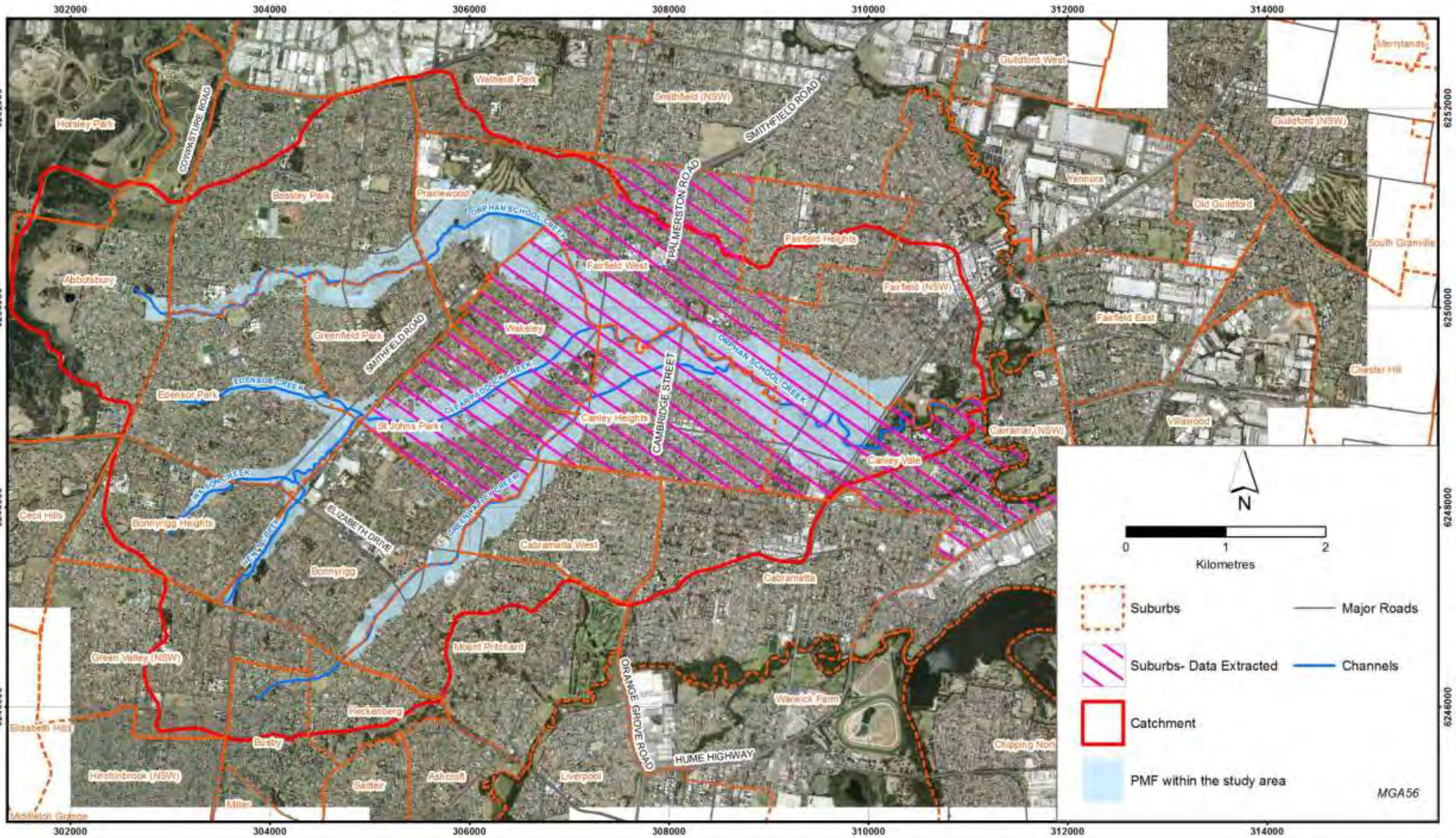
Compared to the NSW average, a high proportion of people lived at the same address both 1 year prior to the Census and 5 years prior to the Census. This suggests that people in the study area may be expected to have more opportunity to familiarise themselves with local hazards and support mechanisms. However, the turnover of population means that a majority would not have experienced the significant floods of 1986 and 1988, and that flood awareness and readiness would naturally be expected to be low.

Table 4 – Census data for selected suburbs in study area

Source: 2011 Census Basic Community Profiles, www.censusdata.abs.gov.au/

Topic	Canley Heights	Canley Vale	Fairfield West	St Johns Park	Wakeley	NSW
SELECTED PERSON CHARACTERISTICS [B01]: % of persons						
Total persons	10,455	9,296	10,759	5,961	4,671	6,917,658
Aged 14 years and under	21%	21%	22%	17%	19%	19%
Aged 15-24 years	15%	14%	14%	14%	15%	13%
Aged 65 years and over	12%	12%	13%	14%	11%	15%
Aboriginal/Torres Strait Islander	1%	1%	1%	0%	0%	2%
Australian born	40%	36%	44%	40%	41%	69%
Born overseas	55%	59%	51%	56%	56%	26%
Speaks English only at home	21%	16%	29%	19%	22%	72%
Speaks other language at home	75%	79%	67%	78%	76%	22%
Completed year 12	34%	38%	35%	39%	41%	41%
Completed year 10	14%	12%	15%	15%	15%	21%
Did not attend school	7%	7%	6%	6%	5%	1%
SELECTED MEDIANS AND AVERAGES [B02]						
Median age	35	35	36	39	36	38
Median total household income ($/week)	$1,018	$824	$1,083	$1,172	$1,236	$1,237
Median mortgage repayment ($/month)	$1,733	$1,430	$1,879	$2,000	$1,990	$1,993
Median rent ($/week)	$270	$250	$335	$340	$350	$300
Average household size	3.4	3.1	3.3	3.4	3.4	2.6
LANGUAGE SPOKEN AT HOME [B13a,b]						
Other language speakers as % of all persons (results shown >5.0%)	Cantonese 7% Khmer 6% Vietnamese 36%	Cantonese 11% Khmer 5% Mandarin 5% Vietnamese 33%	Arabic 7% Assyrian 11% Spanish 5% Vietnamese 19%	Assyrian 5% Cantonese 7% Croatian 6% Italian 5% Khmer 5% Vietnamese 21%	Arabic 6% Assyrian 18% Cantonese 5% Spanish 5% Vietnamese 16%	All languages other than English are <5%
NUMBER OF MOTOR VEHICLES BY DWELLINGS [B29]: % of occupied private dwellings						
Dwellings with 0 motor vehicles	11%	17%	7%	6%	6%	10%
Dwellings with 1 motor vehicle	36%	41%	34%	27%	29%	38%
Dwellings with 2 motor vehicles	35%	27%	35%	40%	38%	34%
Dwellings with 3+ motor vehicles	15%	11%	20%	24%	25%	15%

Topic	**Canley Heights**	**Canley Vale**	**Fairfield West**	**St Johns Park**	**Wakeley**	**NSW**
HOUSEHOLD COMPOSITION BY NUMBER OF PERSONS USUALLY PRESENT [B30]: % of occupied private dwellings						
One person usually resident	12%	20%	12%	10%	9%	24%
DWELLING STRUCTURE [B31]: % of total private dwellings						
Separate house	68%	52%	92%	93%	81%	63%
Semi-detached, row or terrace house, townhouse etc	28%	18%	4%	2%	14%	10%
Flat, unit or apartment	0%	24%	0%	1%	1%	17%
Other dwelling	0%	0%	1%	0%	0%	1%
TENURE TYPE BY DWELLING STRUCTURE [B32]: % of occupied private dwellings						
Fully owned	32%	30%	38%	48%	41%	33%
Being purchased	33%	30%	37%	32%	39%	33%
Rented	30%	36%	21%	16%	17%	30%
TYPE OF INTERNET CONNECTION [B35]: % of occupied private dwellings						
No internet connection	26%	29%	24%	22%	18%	20%
SELECTED LABOUR FORCE AND EDUCATION [B37]: % of total labour force or % of persons aged 15 years and over						
Unemployment	11%	13%	9%	8%	8%	6%
Labour force participation	50%	48%	51%	53%	57%	60%
POPULATION CONTINUITY [B38,B39]: % of persons aged 1 and over or % of persons aged 5 years and over						
Same usual address 1 year ago	87%	85%	87%	92%	90%	81%
Same usual address 5 years ago	67%	63%	68%	78%	75%	57%
OCCUPATION [B44]: % of employed persons aged 15 years and over						
Managers	6%	5%	7%	8%	8%	13%
Professionals	12%	13%	12%	14%	14%	23%
Technicians and trades workers	13%	14%	17%	17%	16%	13%
Community and personal service workers	9%	9%	8%	9%	8%	9%
Clerical and administrative workers	13%	12%	16%	15%	16%	15%
Sales workers	9%	9%	9%	10%	10%	9%
Machinery operators and drivers	15%	15%	13%	12%	12%	6%
Labourers	19%	17%	15%	14%	12%	9%



Three Tributaries Floodplain Risk Management Study: Census Areas

MOLINO STEWART
ENVIRONMENT & NATURAL HAZARDS

Molino Stewart endeavours to ensure that the information provided in this map is correct at the time of publication. Molino Stewart does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

Date: 17/10/2014	Checked By: S.Y.	Job No: 0429
Filepath	Y:\Jobs\2010\0429 Three Tributaries Floodplain Risk Management Study\GIS\Workspace\Census_Areas.mxd	

Figure 12 – Location of suburbs used for social profile

3 URBAN PLANNING CONTEXT

Appropriate land use planning is one of the most effective measures available to floodplain managers, both to reduce existing flood risks as redevelopment occurs, and to control future risk. The management and development of flood prone land must be undertaken within the current NSW legislative, policy and planning framework. This chapter summarises relevant legislation and policy as well as recent reforms by the NSW Government relating to the flood development controls. This provides a basis for the review of land use planning in the Three Tributaries floodplain in Section 11.3.

3.1 NSW ENVIRONMENTAL PLANNING AND ASSESSMENT ACT 1979

3.1.1 Background

The *Environmental Planning and Assessment Act 1979* (EP&A Act) creates the mechanism for development assessment and determination by providing a legislative framework for development and protection of the environment from adverse impacts arising from development. The EP&A Act outlines the level of assessment required under State, regional and local planning legislation and identifies the responsible assessing authority.

Prior to development taking place in New South Wales a formal assessment and determination must be made of the proposed activity to ensure it complies with relevant planning controls and, according to its nature and scale, conforms with the principles of environmentally sustainable development.

3.1.2 Section 117 Directions of the Environmental Planning and Assessment Act 1979 – Direction No. 4.3 (Flood Prone Land)

Pursuant to the EP&A Act, Section 117 Direction No 4.3 (Flood Prone Land) was reissued on the 19 July 2007 by the Minister for Planning replacing all existing directions previously in operation. This applies to councils that contain flood prone land within their Local Government Area and any draft LEP that creates, removes or alters a zone or provision that affects flood prone land.

Key objectives of Direction 4.3 are:

- To ensure that development of flood prone land is consistent with the NSW Government's Flood Prone Land Policy and the principles of the *Floodplain Development Manual* 2005 (including the Guidelines or Development Controls on Low Flood Risk Areas); and
- To ensure that the provisions of an LEP on flood prone land are consistent with flood hazard and includes consideration of the potential flood impacts both on and off the subject land.

Under Direction 4.3, when preparing draft LEPs, Councils must not include provisions that apply to the flood planning areas which:

- permit development in floodway areas;
- permit development that will result in significant flood impacts to other properties;
- permit a significant increase in the development of that land;
- are likely to result in a substantially increased requirement for government spending on flood mitigation measures, infrastructure or services; or
- permit development to be carried out without development consent except for the purposes of agriculture (not including dams, drainage canals, levees, building or structures in flood ways or high hazard areas), roads or exempt development.

The Direction also requires that Councils must not impose flood related development controls above the residential flood planning level for residential development on land, unless a relevant planning authority provides adequate justification for those controls to the satisfaction of the Director-General. In the case of Fairfield City Council, this justification was accepted in Council's successful application for 'exceptional circumstances', so that it has the opportunity to apply controls out to the PMF (NSW Department of Planning and Infrastructure, 2013).

3.1.3 Environmental Planning and Assessment Amendment (Flood Related Development Controls Information) Regulation 2007

Schedule 4, clause 7A of the *Environmental Planning and Assessment Regulation 2000* (EP&A Act Regulations) was amended in 2007 to include references to flood related development and is referred to as the *Environmental Planning and Assessment Amendment (Flood Related Development Controls Information) Regulation 2007*. This amendment requires councils to distinguish where flood related development controls are for nominated types of residential development and all other development. Nominated residential development includes dwelling houses, dual occupancies, multi dwelling housing and residential flat buildings, but does not include group homes or seniors living.

3.2 STATE ENVIRONMENTAL PLANNING POLICIES (SEPP)

3.2.1 SEPP (Exempt and Complying Development Codes) 2008

SEPPs are the highest level of planning instrument and generally will prevail over LEPs. *State Environmental Planning Policy (Exempt and Complying Development Codes) 2008* defines development which is exempt from obtaining development consent and other development which does not require development consent if it complies with certain criteria.

The SEPP defines 'Flood Control Lots' as property where 'flood-related development controls apply' i.e. this would have a notation on its Section 149 Certificate. These development controls may apply through an LEP or DCP. Exempt development is not permitted on Flood Control Lots but some complying development is allowed on Flood Control Lots.

Complying development is permitted on Flood Control Lots where a Council or professional engineer can certify that the part of the lot proposed for development is not a:

- flood storage area;
- floodway area;
- flow path;
- high hazard area; or
- high risk area (see Clause 3.36C).

The SEPP specifies various controls in relation to floor levels, flood compatible materials, structural stability, flood affectation, safe evacuation, car parking and driveways (see Clause 3.36C).

Flood control lots have not been specifically defined as part of the FRMS&P. However there is sufficient information to define flood control lots based on hazard and risk categories.

3.2.2 SEPP (Infrastructure) 2007

State Environmental Planning Policy (Infrastructure) 2007 aims to facilitate the effective delivery of infrastructure across the State by identifying development permissible without consent.

Clause 15 governs public authorities' consultation with councils for development with impacts on flood liable land (as defined by the PMF).

Part 3 Division 7 specifies that development for the purpose of flood mitigation work may be carried out by a public authority without consent.

Part 3 Division 20 specifies that development for the purpose of stormwater management systems may be carried out by a public authority without consent.

SEPP (Infrastructure) 2007 overrules Fairfield LEP 2013. It allows Council to undertake stormwater and flood mitigation work without development consent.

3.3 NSW FLOOD RELATED POLICIES & PLANNING CONTROLS

3.3.1 Floodplain Development Manual, 2005

The *Floodplain Development Manual* 2005 (the Manual) was gazetted on 6 May 2005 and relates to the development of flood liable land. It incorporates the NSW Flood Prone Land Policy, which aims to reduce the impacts of flooding and flood liability on individual owners and occupiers of flood prone property and to reduce private and public losses resulting from floods. To implement this policy and achieve these objectives, the Manual develops a merit based framework to assist with floodplain risk management. The Manual indicates that responsibility for management of flood risk remains with local government. It assists councils in their management of the use and development of flood prone land by providing guidance in the development and implementation of local floodplain risk management plans.

The Manual builds upon and replaces the 2001 Floodplain Management Manual. Key changes include outlining altered agency roles in floodplain risk management and clarifying the State Government's position on development standards.

3.3.2 Guidelines on Development Controls in Low Flood Risk Areas, 2007

The Guidelines on Development Controls on Low Flood Risk Areas – Floodplain Development Manual (the Guidelines) were issued on 31 January 2007 as part of Planning Circular PS 07-003 at the same time as the S117 Directive described in Section 3.1.2. The Guidelines are intended to be read as part of the *Floodplain Development Manual*. They have been created to supply additional guidance on matters within the Manual, including determining the appropriate flood planning level (FPL) for councils and appropriate flood related development controls on residential development in low flood risk areas. Strategic consideration of a number of key issues which must be addressed include safety to existing and future occupants of flood prone land, management of the potential damage to property and infrastructure and the cumulative impacts of development.

The Guidelines do not strictly conform with the Manual's merit based approach to selection of appropriate flood planning levels (FPLs) however they recognise the need to consider the full range of flood sizes, up to and including the probable maximum flood (PMF) and the corresponding risks associated with each flood.

The Guidelines have caused significant consternation amongst Councils and floodplain managers generally because they state:

- *unless there are exceptional circumstances, councils should adopt the 100-year flood as the FPL for residential development; and*
- *unless there are exceptional circumstances, councils should not impose flood related development controls on residential development on land above the residential FPL (low flood risk areas).*

Fairfield Council made an application for 'exceptional circumstances' in April 2011 (FCC, 2011). This was based on a number of reasons including:

- Fairfield's documented flood history;
- plans for future residential development;
- risk of detention basin overflow or failure;
- predicted increased flood levels and velocities due to climate change;
- evidence of floods larger than the 100 year ARI event;
- typically rapid rates of rise within local catchments meaning little time to respond to flood warnings;
- large numbers of non-English speaking residents meaning difficulty in responding to flood advice; and
- the relative risks of evacuating or shelter-in-place suggesting that in some circumstances the latter is safer.

In May 2013, the Director-General of the NSW Department of Planning and Infrastructure advised FCC that the exceptional circumstance application had been approved.

3.3.3 NSW State Flood Plan, 2008

The NSW State Flood Plan (NSW SES, 2008) is a sub-plan of the State Disaster Plan (DISPLAN). The Plan sets out the emergency management aspects of prevention, preparation, response and initial recovery arrangements for flooding and the responsibilities of agencies and organisations with regards to these functions.

A sub-plan of the NSW State Flood Plan, the Fairfield City Local Flood Plan 2005/2013, is relevant to the Three Tributaries catchment and is discussed in Section 4.1.

3.4 REGIONAL ENVIRONMENTAL PLANS (REP'S)

As of 1 July 2009, Regional Environmental Plans (REPs) are no longer part of the hierarchy of environmental planning instruments in NSW. Accordingly, all existing REPs are now deemed to be State Environmental Planning Policies (SEPPs).

Greater Metropolitan Regional Environmental Plan No 2 – Georges River Catchment applies to the Catchment, which is part of the region declared under the Act and known as the Greater Metropolitan Region. The Catchment consists of parts of Bankstown City, Blacktown City, Campbelltown City, Camden, Canterbury City, Fairfield City, Holroyd City, Hurstville City, Kogarah, Liverpool City, Rockdale City, Sutherland, Wollondilly and Wollongong City local government areas that are within the Georges River Catchment. The catchment map indicates the boundary of the Catchment.

Greater Metropolitan Regional Environmental Plan No 2 – Georges River Catchment aims to protect the water quality of the Georges River and its tributaries and the environmental quality of the whole catchment. The objectives of the plan are to be achieved through coordinated land use planning and development control. The plan establishes the framework within which local, State and Federal agencies will consult so that there is a consistent approach to planning and development within the catchment.

The following considerations are included in the assessment for land which is subject to flooding:

- the benefits of periodic flooding to wetland and other riverine ecosystems;
- the pollution hazard posed by development on flood liable land in the event of a flood; and
- the cumulative environmental effect of development on the behaviour of flood water and the importance of not filling flood prone land.

3.5 LOCAL ENVIRONMENTAL PLANNING INSTRUMENTS (LEP'S)

In accordance with *Standard Instrument (Local Environmental Plans) Order 2006*, a Fairfield Local Environmental Plan (LEP) was prepared by Council and approved on 17 May 2013.

Land use planning decisions within the Fairfield LEP 2013 are based on a 'best fit' transfer from the Fairfield LEP 1994. Some areas have been rezoned to accommodate higher density housing.

Part 6 of the LEP allows Council to include clauses that address local circumstances within the City. It details specific local provisions for the following issues:

- Earthworks
- Flood planning
- Floodplain risk management
- Terrestrial biodiversity
- Riparian land and watercourses
- Landslide risk
- Infrastructure development—Council
- Essential services

Flood Planning and Floodplain Risk Management are addressed amongst a range of specific local provisions in clauses 6.3 and 6.4 respectively and reproduced below.

6.3 Flood planning [local]

(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 land's flood hazard, taking into account projected changes as a result of climate change,

(c) to avoid significant adverse impacts on flood behaviour and the environment.

(2) This clause applies to land at or below the flood planning level.

(3) Development consent must not be granted to development on land to which this clause applies unless the consent authority is satisfied that the development:

(a) is compatible with the flood hazard of the land; and

(b) is not likely to significantly adversely affect flood behaviour resulting in detrimental increases in the potential flood affectation of other development or properties, and

(c) incorporates appropriate measures to manage risk to life from flood, and

(d) is not likely to significantly adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses, and

(e) is not likely to result in unsustainable social and economic costs to the community as a consequence of flooding.

(4) A word or expression used in this clause has the same meaning as it has in the NSW Government's Floodplain Development Manual [ISBN 0 7347 54756 0] published in 2005, by the NSW Government, unless it is otherwise defined in this clause.

(5) In this clause:

flood planning level means the level of a 1:100 ARI (average recurrent interval) flood event plus 0.5 metre freeboard.

6.4 Floodplain risk management [local]

(1) The objectives of this clause are as follows:

(a) in relation to development with particular evacuation or emergency response issues, to enable evacuation of land subject to flooding in events exceeding the flood planning level,

(b) to protect the operational capacity of emergency response facilities and critical infrastructure during extreme flood events.

(2) This clause applies to land between the flood planning level and the level of a probable maximum flood, but does not apply to land subject to the discharge of a 1:100 ARI (average recurrent interval) flood event plus 0.5 metre freeboard.

(3) Development consent must not be granted to development for the following purposes on land to which this clause applies unless the consent authority is satisfied that the development will not, in flood events exceeding the flood planning level, affect the safe occupation of, and evacuation from, the land:

(a) caravan parks,

(b) commercial premises,

(c) correctional centres,

(d) emergency services facilities,

(e) group homes,

(f) hospitals,

(g) industries,

(h) residential accommodation,

(i) residential care facilities,

(j) tourist and visitor accommodation.

(4) In this clause:

flood planning level means the level of a 1:100 ARI (average recurrent interval) flood event plus 0.5 metre freeboard.

probable maximum flood has the same meaning as it has in the Floodplain Development Manual (ISBN 0 7347 5476 0), published in 2005 by the NSW Government.

Note.

The **probable maximum flood** is the largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation.

The inclusion of Clause 6.4 in the LEP was based on the Department of Planning and Infrastructure's acceptance of Council's case for exceptional circumstances lodged in April 2011. It is a significant moment for floodplain risk management in Fairfield as it allows Council to manage the risks associated with flooding up to the PMF, not just to an arbitrarily chosen Flood Planning Level. It recognises that there are a very large number of residential, commercial and other property uses potentially affected by flooding above that arbitrary line and up to the PMF event.

3.6 LOCAL DEVELOPMENT CONTROLS

3.6.1 Fairfield City Wide Development Control Plan 2013

Chapter 11 of Fairfield City Wide DCP 2013 entitled 'Flood Risk Management' outlines the context, background and controls necessary for addressing existing flood risk and future flood risk through land use planning.

The criteria for determining applications for proposed development that is potentially affected by flooding recognise that different controls are applicable to different types of land uses and levels of flood risk.

The method used to determine which controls apply to proposed development involves:

- firstly, identifying the land use category of the development (from Schedule 2 at the end of Chapter 11);
- secondly, determine which flood risk precinct the land is located within (refer to Clause 11.7 and relevant flood risk mapping); and
- then apply the controls outlined under Clause 11.8.

Clause 11.8 states:

> *The development controls apply to all land within a Flood Risk Precinct described above. The type and stringency of controls have been graded relative to the severity and frequency of potential floods, having regard to categories determined by the relevant Floodplain Risk Management Study and Plan or, if no such study or plan exists, council's interim considerations. The categories applicable to each floodplain are depicted on the planning matrices contained in the following schedules at the rear of Chapter 11:*
>
> • *Schedule 4 –Georges River (south of the Hume Highway) Floodplain;*
>
> • *Schedule 5 – Cabramatta Creek Floodplain; and*
>
> • *Schedule 6 – All Other Floodplains including areas affected by local overland flow.*
>
> *Note: The controls applying to 'all other floodplains' are interim only until catchment specific Flood Risk Management Plans are prepared as required by the FDM.*

Developers can choose to either meet the prescriptive controls (refer Section 11.8.3) or the performance criteria (refer Section 11.8.2). Usually the former approach is taken.

Clause 11.9 provides specific requirements for fencing in the floodplain, while Clause 11.10 identifies special considerations which will apply only to some development in specific circumstances.

The Three Tributaries Floodplain Risk Management Study relates to a floodplain that is neither Georges River (south of the Hume Highway) floodplain nor Cabramatta Creek. This means that 'Schedule 6 - All Other Floodplains' applies with the specific rider that the controls are interim until catchment specific Floodplain Risk Management Plans are prepared as required by the *Floodplain Development Manual*. Accordingly, an evaluation of the viability of the controls for the Three Tributaries floodplain is undertaken in Section 11.3.3 of this report.

It is noted that the area covered by the Three Tributaries FRMS&P overlaps with the area that covered in the Canley Corridor Overland Flooding FRMS&P. Where development is proposed for areas included in both study areas, a developer would presumably need to satisfy the requirements of both relevant schedules, though in most cases it is expected that flood conditions in the Three Tributaries floodplain will be more hazardous (greater depths and velocities) and so compliance with the Three Tributaries schedule is likely to be more onerous.

3.6.2 Bonnyrigg Town Centre DCP

Bonnyrigg Town Centre Development Control Plan (prepared by Civitas Partnership and Guppy & Associates for Council, November 2010) guides development in the Bonnyrigg Town Centre. One of the design objectives it to ensure that the design of the Town Centre takes into constraint environmental constraints including flooding. All land covered by the DCP is subject to the provisions of Chapter 11 (Flood Risk Management) of the Fairfield City Wide DCP. The flood modelling of Clear Paddock Creek undertaken for this study will help guide planning for the area.

3.6.3 Section 149 Planning Certificates

Council has a detailed process for responding to requests for planning certificates made under both Section 149(2) and 149(5) of the *Environmental Planning and Assessment Act 1979*. This process has been in force for a significant period and there has generally been minimal complaint about if from either the community or real estate professionals (see also Bewsher and Maddocks, 2003). This is not to say the type of information which the certificates include and the way it is communicated cannot be improved.

Section 149 (2)

The information provided in response to requests under Section 149(2) comprises the issue of a general flooding statement (numbered 50015), then a range of mainstream flood risk categories and then, if applicable, a range of overland flood risk categories. The wording and information issued in response to requests under this section is attached at Appendix C.

Section 149 (5)

If further flooding information is required under Section 149(5), this information is provided in a Flood Information Sheet that provides information on flood levels for a range of flood events, under either mainstream flooding or local overland flooding, or both, depending on circumstances. The Section 149(5) certificate must be purchased from Council and the relevant S149(5) certificate would include the Flood Information Sheet. A copy of the type of information conveyed in response to requests under this section is attached at Appendix D.

3.6.4 Section 94 Development Contributions

Section 94 of the *Environmental Planning and Assessment Act 1979* enables councils to collect contributions from developers for the provision of infrastructure which will be necessary as a consequence of development. This can include roads, drainage, open space and community facilities. Each Council must develop a Section 94 Contributions Plan which demonstrates a quantifiable link between the development intensification and the need for the additional infrastructure as well as a detailed costing of such infrastructure and formulae to be used to determine contributions from each type of development.

Fairfield City Council's current Section 94 contributions plan includes provision for the acquisition of land for public open space but now does not include provisions for stormwater management works.

3.6.5 Stormwater Drainage Policy

The objectives of this policy are to:

- Provide clear guidelines to Council's customers of requirements for stormwater drainage and civil works;

- Ensure that developments meet all relevant standards for the disposal of stormwater and that developments do not increase the hazard to persons or property;
- Cater for minor and major stormwater systems;
- Provide latitude for merit based assessment of stormwater issues; and
- Expedite the assessment of development applications with respect to stormwater drainage.

It is not intended that this policy will cover all situations and it does not absolve the designer of the necessity to plan for specific site requirements. It is also not the intention of this policy to encompass the growing field of Water Sensitive Urban Design. It is envisaged that the principles of Water Sensitive Urban Design will be included in a separate policy in the future.

This policy should be read in conjunction with relevant standards, instruments and policies, including:

- Australian Standard AS 3500.3.2;
- Australian Rainfall & Runoff;
- Building Code of Australia Housing Provisions 1996;
- Fairfield City Council's On-Site Detention Handbooks;
- Fairfield City Council's Local Environmental Plans;
- Fairfield City Council's Road and Drainage Specification Associated With Subdivision or Other Development;
- Fairfield City Council's Flood Plain Management Policy; and
- Fairfield City Council's Development Control Plans, Policies and Guidelines relevant to the proposed development.

3.6.6 Urban Area On-Site Detention (OSD) Code

The On-Site Detention (OSD) Code was originally prepared in 1994 and has been updated, in part, in the most recent Handbook dated 1997. The objectives of the Code are:

- To minimise increases in the frequency and/or severity of surcharging of the local drainage system resulting in downstream flooding problems;
- To minimise increases in flood levels on the major trunk drainage networks and on the creek systems;
- To emphasise that OSD drainage requirements within Fairfield City's urban area need to be integrated with the architectural design and layout of the development in order that adequate storage areas can be located in the very early stages of the building design process; and
- To provide developers with information relating to the location of overland flow paths for stormwater flows in excess of the capacity of the in-ground system for storm events up to the 100 year Average Recurrence Interval (ARI) storm.

OSD is to be applied to the following developments ultimately draining to the Georges River:

- All multi-unit residential development;
- All industrial developments where the impervious area is increased (not required in Wetherill Park Industrial Area); and
- All commercial developments where the impervious area is increased.

OSD may also be required for single dwelling development, including dual occupancies, and the redevelopment of multiple parcels of land which Council considers likely to produce excessive stormwater runoff. However, if a significant portion of the site is affected by a major overland flowpath, the emphasis shifts from OSD to safely conveying flows through the site and applying other controls to minimise flood damage, e.g. elevating flood levels.

The Code also provides data on 'Permitted Site Discharge', Ponding Depths, Freeboard and the application of the Code within the overall Development Approval Process.

The Code as it currently stands does not control the cumulative impacts of runoff created by small residential building extensions or increased paved areas on properties.

Given the passage of time since this Code was developed, its upgrading and updating will form a specific recommendation within the Floodplain Risk Management Plan.

3.7 STRATEGIC PLANNING

There are some strategic planning documents which are of relevance to Canley Corridor and options which may be available for managing overland flows. Of specific relevance are the following.

3.7.1 Draft Fairfield Residential Strategy

The population of Sydney is projected to increase by 1.3 million people by 2031, meaning an additional 545,000 homes are needed. The State Government has set a target of 24,000 additional dwellings in Fairfield City by 2031 to help accommodate Sydney's growth. Council has a long-term plan that will allow more people to live around town centres and areas that have good public transport and are close to railway stations.

A draft residential strategy report was prepared in 2009 for areas east of the Cumberland Highway and included draft planning visions for Canley Vale and Canley Heights (Hassell, 2009). Investigations identified local road and traffic issues which would need to be resolved before further urban consolidation would be possible in these areas. The urban consolidation vision for Canley Heights is reflected in the rezoning of land as part of the LEP 2013.

Other areas which were part of the 2009 study were included in the public exhibition of the Draft Residential Strategy East which came off public exhibition in October 2014. It does not apply to any areas within the Three Tributaries catchment.

3.7.2 Open Space Strategy

The Fairfield Open Space Strategy (Clouston Associates, 2007) identifies the open space needs within Fairfield LGA. Figure 2 of the report maps possible land acquisition zones as identified by Council. These include areas within the Three Tributaries floodplain where there is currently a significant flood risk, including Green Valley Creek between Elizabeth Drive and Cabramatta Road West and the area near the junction of Green Valley Creek and Orphan School Creek at about Pitt Street. Related to this is the recommendation to extend the connected system of open spaces through the ongoing acquisition of land along the major creek lines (p.40).

4 EMERGENCY MANAGEMENT CONTEXT

Emergency management represents one the three pillars of floodplain risk management. It is generally not affordable to treat all flood risk up to and including the PMF through flood modification and property modification measures, especially where there is a large legacy of existing risk but also for future risk. Emergency management measures such as flood warning systems, evacuation planning and community flood education are aimed at increasing resilience to reduce risk to life and property, both for frequent flood events and for very rare but extreme flood events.

This chapter sets out some context for the detailed evaluation of emergency management measures in Section 12.2.

4.1 NSW STATE EMERGENCY SERVICE ROLE

As stipulated in the *State Emergency Service Act 1989*, the NSW State Emergency Service (SES) acts as the combat agency for dealing with floods (including the establishment of flood warning systems) and to co-ordinate the evacuation and welfare of affected communities. NSW SES is tasked to protect persons from dangers to their safety and health, and to protect property from destruction or damage, arising from floods.

Details of the roles and responsibilities of NSW SES (and other emergency services and affected parties) can be found in the *State Flood Sub Plan*, a Sub Plan of the New South Wales Disaster Plan (NSW SES, 2008). This role covers:

- **Prevention:** includes providing emergency management advice to councils.
- **Preparedness:** includes preparing and maintaining Flood Sub Plans and developing and maintaining flood intelligence systems. It also involves community education and preparing communication messages and systems for the delivery of flood information during flooding.
- **Response:** includes controlling and coordinating flood operations, communicating flood advice to at-risk communities and coordinating evacuation and rescue operations.
- **Recovery:** includes debriefs following flood operations.

The *Fairfield City Local Flood Plan* (NSW SES, 2005) covers preparedness measures, the conduct of response operations and the coordination of immediate recovery measures from flooding within Fairfield City. This Local Flood Plan (LFP) is currently being updated to align it with the new NSW SES LFP template.

Volume 1 of the revised Fairfield LFP has been submitted to the Local Emergency Management Committee (LEMC) for review and as of January 2015 was still in draft (NSW SES, pers. comm.). Volume 2, which will include Annexes A and B of the current LFP, is in the process of being prepared.

According to the LFP, the NSW SES Fairfield City Local Controller is invested with the responsibility of dealing with floods as detailed in the *State Flood Sub Plan*, within the Fairfield LGA. This includes training NSW SES members, coordinating the development and operation of a flood warning service, coordinating a public education program, and appointing an incident controller to undertake response roles.

Among the many responsibilities set out in the LFP, the Australian Government Bureau of Meteorology has an important role in flood warning including providing Flood Watches for the Georges River Basin and Severe Weather Warnings when flash flooding is likely to occur (see Section 12.1).

The LFP recognises that Fairfield City Council is a significant player in preparedness, response and recovery. This includes maintaining a Dam Failure Warning System, maintaining Dam Safety Emergency Plans, contributing to the development and implementation of a public education program, closing and opening Council roads, providing information on the status of roads, and removing debris and waste after flooding.

The Local Flood Plan is reviewed in Section 12.2.2a).

NSW SES also maintains one flood intelligence card within the study area, for the NSW Office of Water stream gauge located on Orphan School Creek at Sackville Street. This is reviewed and updated in Section 12.2.2b).

4.2 PLANNED RESPONSE IN THREE TRIBUTARIES FLOODPLAIN

A major point of contention in contemporary emergency management policy and practice relates to the advantages and disadvantages of evacuation compared to sheltering-in-place, particularly for flash flood catchments such as Three Tributaries. The NSW SES has prepared or contributed to a number of publications, which are summarised below:

4.2.1 NSW SES Position

a) Opper and Toniato (2008)

- NSW SES holds the position that if development is to occur on floodplains, it must be possible to evacuate people out of the floodplain in advance of floods.
- NSW SES has recognised that in an existing flash flood context, and only in that context, causing residents to attempt to evacuate at the time of flash flooding is occurring, could be a serious risk to life. Only in areas where urban redevelopment cannot be prevented under existing planning policy, it has therefore been proposed that the DCP for any new or redeveloped dwelling will require an internal refuge area above the level of the PMF. (Note, the Fairfield DCP is one that allows this in parts of some floodplains).
- This concession has been seized upon to wrongly apply it to all flood contexts and to justify any new development.
- In response, NSW SES may have no choice but to adopt a harder line and to not support any redevelopment or development in flash flood areas.
- Two elements of flood isolation risk are particularly significant: structural fire and medical emergency.
- An example of the problems that can arise due to isolation and the vagaries of human behaviour occurred during flooding in June 2007, when a nursing home at Wyong needed to be urgently evacuated due to its rapid isolation by floodwater and the threat of further inundation. This required six ambulance crews and other emergency services to deal with just this one facility. The management and residents had ignored early advice to evacuate before they were isolated and then had a change of mind once they were surrounded by floodwater.

b) Opper et al. (2011); AFAC (2013)

- The safest place to be in a flash flood is well away from the affected area. Evacuation is the most effective strategy, provided that evacuation can be safely implemented. Properly planned and executed evacuation is demonstrably the most effective strategy in terms of a reliable public safety outcome.
- Late evacuation may be worse than not evacuating at all because of the dangers inherent in moving through floodwaters, particularly fast-moving flash flood waters. If evacuation has not occurred prior to the arrival of floodwater, taking refuge inside a building may generally be safer than trying to escape by entering the floodwater.
- Remaining in buildings likely to be affected by flash flooding is not low risk and should never be a default strategy for pre-incident planning. It is not equivalent to evacuation.

- The risks of 'shelter-in-place' include:
  - Floodwater reaching the place of shelter (unless the shelter is above the PMF level);
  - Structural collapse of the building that is providing the place of shelter (unless the building is designed to withstand the forces of floodwater, buoyancy and debris in a PMF);
  - Isolation, with no known basis for determining a tolerable duration of isolation;
  - People's behaviour (drowning if they change their mind and attempt to leave after entrapment);
  - People's mobility (not being able to reach the highest part of the building);
  - People's personal safety (fire and accident); and
  - People's health (pre-existing condition or sudden onset e.g. heart attack).
- For evacuation to be a defensible strategy, the risk associated with the evacuation must be lower than the risk people may be exposed to if they were left to take refuge within a building which could either be directly exposed to or isolated by floodwater.
- Pre-incident planning needs to include a realistic assessment of the time required to evacuate a given location via safe evacuation routes. This requires consideration of barriers to evacuation posed by available warning time, availability of safe routes and resources available.
- Successful evacuation strategies require a warning system that delivers enough lead time to accommodate the operational decisions, the mobilisation of the necessary resources, the warning and the movement of people at risk.
- Effective evacuation typically requires lead times of longer than just a couple of hours and this creates a dilemma for flash flood emergency managers. Due to the nature of flash flood catchments, flash flood warning systems based on detection of rainfall or water level generally yield short lead times (often as short as 30 minutes) and as a result provide limited prospects for using such systems to trigger planned and effective evacuation.
- Initiating evacuation of large numbers of people from areas prone to flash flooding based only on forecasts may be theoretically defensible in a purely risk-avoidance context but it is likely to be viewed as socially and economically unsustainable. Frequent evacuations in which no flooding occurs, which statistically will be the outcome of forecast-based warning and evacuation, could also lead to a situation where warnings are eventually ignored by the community.

c) NSW SES (2014)

- In the context of future development, self-evacuation of the community should be achievable in a manner which is consistent with the NSW SES's principles for evacuation.
- Development must not conflict with the NSW SES's flood response and evacuation strategy for the existing community.
- Evacuation must not require people to drive or walk through flood water.
- Development strategies relying on deliberate isolation or sheltering in buildings surrounded by flood water are not equivalent, in risk management terms, to evacuation.
- Development strategies relying on an assumption that mass rescue may be possible where evacuation either fails or is not implemented are not acceptable to the NSW SES.
- The NSW SES is opposed to the imposition of development consent conditions requiring private flood evacuation plans rather than the application of sound land use planning and flood risk management.

d) Summary

Clearly, the NSW SES holds that evacuation is the preferred emergency response for floodplain communities, where this can safely be achieved. Late evacuation, through floodwater, may be a recipe for disaster and in that situation it might be safer to remain inside the building, though sheltering-in-place has a number of direct and indirect risks associated with it. Evacuating prior to flooding is therefore much preferred. Where current hydro-meteorological monitoring systems, communications systems, road infrastructure and expected community behaviours do not allow this, the SES advocates improvements to these so that evacuation can proceed safely. However, the AFAC (2013) guide makes clear that even with improvements in monitoring, insufficient time may be available to inform evacuation decisions with any confidence. If evacuations are ordered based only on predicted rainfall, the community may eventually come to ignore warnings.

4.2.2 FCC Position

Chapter 11 of Fairfield's City Wide DCP contains a number of provisions relating to response to flooding, which in effect sets out Council's current position.

One objective of the DCP is '*to minimise the risk to life by ensuring the provision of appropriate access from areas affected by flooding up to extreme events*'. Several performance criteria have bearing:

> *a) The proposed development should not result in any increased risk to human life.*
>
> *c) The proposal should only be permitted where effective warning time and reliable access is available for evacuation from an area potentially affected by floods to an area free of risk from flooding. Evacuation should be consistent with any relevant flood evacuation strategy.*
>
> *f) Procedures would be in place, if necessary, (such as warning systems, signage or evacuation drills) so that people are aware of the need to evacuate and relocate motor vehicles during a flood and are capable of identifying an appropriate evacuation route.*

Prescriptive evacuation controls vary from catchment to catchment. For residential uses in the Medium flood risk precinct in the Georges River floodplain, proponents need to demonstrate that:

> *Adequate flood warning is available to allow safe and orderly evacuation without increased reliance upon the SES or other authorised emergency services personnel*
>
> and that:
>
> *The development is to be consistent with any relevant flood evacuation strategy or similar plan.*

For the Cabramatta Creek floodplain and other floodplains in the LGA, proponents need to demonstrate *either* an ability to evacuate *or* a safe refuge above the PMF:

> *Reliable access for pedestrians or vehicles is required from the building, commencing at a minimum level equal to the lowest habitable floor level to an area of refuge above the PMF level, or a minimum of 20% of the gross floor area of the dwelling to be above the PMF level.*
>
> and that:
>
> *The development is to be consistent with any relevant flood evacuation strategy or similar plan.*

If the proponent chooses to provide a PMF refuge, there is a condition that the building structure can withstand PMF inundation:

> *Applicant to demonstrate that the structure can withstand the forces of floodwater, debris and buoyancy up to and including a 100 year flood plus freeboard, or a PMF if required to satisfy evacuation criteria (see below). An engineer's report may be required.*

The *Prospect Creek Floodplain Management Plan Review* (Bewsher Consulting, 2010, p.80) recommended that the area of the Prospect Creek floodplain downstream of the Granville Railway

Line should not have a shelter-in-place provision. This is because that area is largely influenced by flood behaviour within the Georges River, where the PMF can be many metres higher than the 100 year ARI event, limiting the practicality of providing a PMF refuge area within a building. Also, the duration of flooding typically exceeds 24 hours or longer, suggesting that the isolation risks are too great since power, water and sanitary services would likely be lost. Early evacuation is the preferred response strategy for all homes and businesses in that area. A specific matrix was prepared for the Prospect Creek floodplain including a revised evacuation control incorporating this spatial distinction in evacuation/isolation risks:

> *Reliable access for pedestrians or vehicles is required from the building, commencing at a minimum level equal to the lowest habitable floor level to an area of refuge above the PMF level. In the case of property upstream of the Granville Railway Line, this refuge can be on site provided a minimum of 20% of the gross floor area of the dwelling is above the PMF level.*

However, the current version of the DCP has not included the Prospect Creek matrix, so developments there would be assessed under the 'other floodplains' schedule.

4.2.3 Review

Flood behaviour in the Three Tributaries catchment is such that flooding can rise and peak within a few hours of the onset of rainfall. The critical duration – the duration of the storm that produces the highest peak runoff, and therefore flooding – is about 2 hours – and typical warning times are considerably less, in the order of about 30 minutes. Although there is scope for improvements to rainfall and water level monitoring (see Section 12.1), the inescapably 'flashy' nature of flooding suggests that it will always be difficult to ensure everyone in the floodplain evacuates prior to flooding of evacuation routes. And while there is scope for strategically upgrading evacuation routes (see Section 12.2.1) and for community education to promote appropriate behaviours such as early evacuation (see Section 12.3), floodplain managers need to recognise that perhaps a majority of floodplain occupants will not respond in an optimal fashion and may be isolated in their houses.

In the Consultant's opinion, it is appropriate that both the Fairfield City Local Flood Plan and the Fairfield City Wide DCP recognise this for already developed areas and seek to minimise the risk to life in these circumstances. The 2005 edition of the LFP is appropriately pragmatic in including these clauses:

> *Evacuations should be completed before inundation occurs or evacuation routes are closed. However, this may not always be possible due to the short warning time generally available (3.12.2)*
>
> *Where evacuation is considered too dangerous due to flooding of access routes, shelter in place should be recommended until flooding eases or rescue occurs (3.12.3)*

However, similar caveats are evidently not located in Volume 1 of the 2013 edition of the LFP. It appears that NSW SES has adopted a harder line and no longer explicitly recognises that it may not be possible (indeed, that it is more than likely that it is not possible) to evacuate everyone within the affected area prior to flooding. Although wholesale evacuation is an understandable aspiration, the absence of an alternative – admittedly, not an equivalent risk-reducing option – means that the revised LFP is not practical for the Three Tributaries floodplain. By excluding any concession for the likely situation wherein many people have not evacuated prior to flooding, the draft 2013 version is also arguably inconsistent with AFAC (2013, p.3), which states, 'if evacuation has not occurred prior to the arrival of floodwater, taking refuge inside a building may generally be safer than trying to escape by entering the floodwater'. Recommended amendments to the LFP are discussed in Section 12.2.2a).

In the Consultant's opinion, and consistent with the Prospect Creek FMP Review, the provision of a shelter-in-place option for the Three Tributaries floodplain – which is upstream of the Canley Vale-Fairfield Railway – is appropriate in Council's DCP. This also recognises the typically short duration of floods in this area, which suggests that isolation is likely to be limited to about a few hours in most events. As a way of reducing existing risks to life, shelter-in-place should at least be made available for the concessional development category. It is also defensible for existing residential areas where urban renewal is occurring. If the NSW SES adopts the current version of Volume 1 of the 2013 edition of the LFP, which does not include explicit recognition that shelter-in-place may be a safer option in some circumstances, developers could also struggle to comply with the control requiring that '*The development is to be consistent with any relevant flood evacuation strategy or similar plan*'. Recommended amendments to the DCP are discussed in Section 11.3.3.

5 COMMUNITY AND STAKEHOLDER ENGAGEMENT

5.1 GENERAL

The success of any floodplain management plan hinges on its acceptance by the local community and other stakeholders. This can only be achieved by engaging the community at all stages of the decision-making process. It includes collecting the community members' knowledge about flood behaviour in the study area, consulting about management options, and discussing the issues and outcomes of the study with them.

Community engagement has been an essential component of the Three Tributaries FRMS&P. This has aimed to inform the community about the development of the floodplain management study and its likely outcomes. It has also aided learning about community flood awareness and preparedness. The engagement process has also provided an opportunity for the community to participate in the study by submitting ideas about potential floodplain management measures.

The key elements of the consultation process have been as follows:

- Gleaning the key points from earlier consultation activities;
- Meetings of the Floodplain Management Committee;
- Engagement with Government agencies and key stakeholders;
- Community questionnaire and 'script';
- Public exhibition of the draft FRMP.

5.2 PRIOR CONSULTATION

5.2.1 Flood Study Consultation (2008)

Council distributed questionnaires during exhibition of the 2008 Three Tributaries Flood Study. Some 395 responses were received. A few salient findings are reported below:

- Of those who responded, 92% had not previously observed flooding at their property; some people recalled flooding in June 1991, April 1988 and August 1986; only 8 respondents reported that their dwellings had previously been flooded above floor; those who had observed flooding typically received no prior warning;
- People's preferred method of being informed about flood risk was for Council to provide a certificate to all residents (60%); some 30% of respondents supported the installation of flood markers on telegraph poles as reminders of the heights of previous floods; relatively low levels of support (18%) were indicated for providing information on Council's website;
- In answer to an open question about the most favoured flood risk management measures, the highest response was for dredging and widening of the creeks so they could convey more flow. The second highest received response was for 'cleaning' or 'clearing' the creeks, again to convey more flow. Levees and detention basin upgrades also received more than 20 mentions. Several respondents requested raising of roads to facilitate evacuation. Flood proofing, development control and voluntary house raising enjoyed some support (see Figure 13).
- It is difficult to interpret the results of an open question about the least favoured flood risk management measures, since several respondents apparently used this to describe measures they supported. Nevertheless, is appears that more people oppose voluntary house raising than support it. (Perhaps the communication has failed to clearly convey that it is *voluntary*).
- The key conclusion from this is that people prefer structural measures that are built, visible and that someone else (i.e. Council) takes responsibility for. Property modification and response

modification are less well understood, imply taking greater personal responsibility, and therefore are not as well supported.

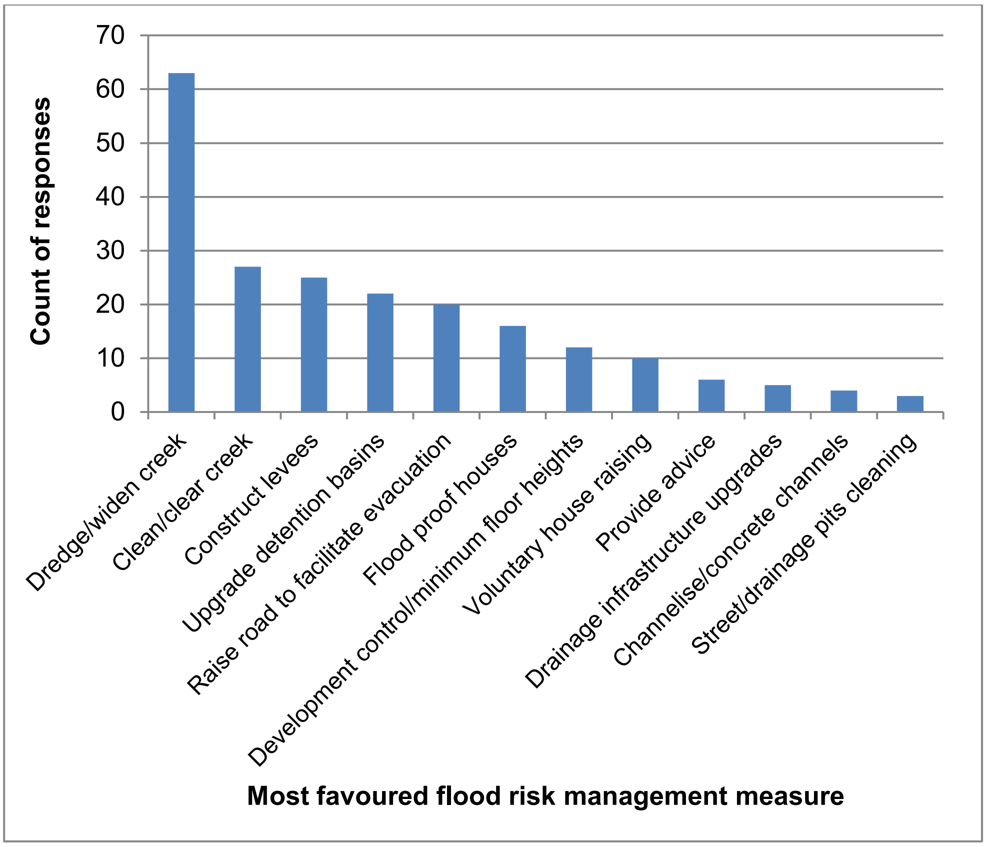


Figure 13 – Questionnaire results: most favoured flood risk management measure

5.2.2 Community Flood Education and Awareness in Fairfield City (2012)

Molino Stewart (2012) was engaged to prepare a community flood education plan for the city. This involved assessing the current level of flood awareness and preparedness via community surveys and a forum on flooding. Generally low levels of awareness and preparedness were detected, probably due to the absence of significant flooding since 1988. One finding of interest is the poor conversion rate from being *aware* of flood potential to being *prepared* for flooding, measured by having an effective emergency plan.

Closer inspection shows that 17 responses were received from the Freeman Avenue and Sackville Street areas near Orphan School Creek. It should be observed that these responses over-represent a female, older and stable demographic, with 13 women replying, 13 aged over 55, and 14 having lived there for more than 10 years. Salient findings include:

- 18% of the Freeman Avenue/Sackville Street respondents believed that their property could not flood, and 29% believed that their house could not flood; whilst flood affectation varies in this area, there is somewhat of a mismatch between people's perceptions and modelled flood behaviour, because many properties would be flooded in a 20 year ARI flood, and all properties (and houses) would be flooded in the probable maximum flood; this points to a need to increase knowledge of true risk;
- 47% of respondents rated the risk of flooding to their property as 'none' or 'low'; 53% rated the risk of flooding to their safety as 'none' or 'low'; these perceptions also discount the true risk, with much of the area identified as medium flood risk and evacuation constraints arguably rendering the same area as high flood risk;

- 29% of respondents indicated that they had an emergency plan for their home (but whether these plans address flood risks, or address them adequately, or are even written, is not known);
- Over 70% of respondents indicated that they would help others in a flood; over 70% also indicated that they would require help in a flood; this indicates some level of community self-reliance.
- Nearly 80% of respondents anticipate finding out about a flood in the street by watching local creeks; 64% anticipate learning from neighbours; 57% anticipate learning from television; in reality it is unlikely that television coverage would provide any warning of specific floods in Orphan School Creek;
- More respondents than not indicated that they would *not* evacuate their house if there was a chance of flooding in the street;
- 76% of respondents indicated that they would evacuate their house if told to do so by the Police or NSW SES;
- 71% of respondents indicated that if floodwaters entered their home, they could not repair damages to their house well; 76% indicated they would need help from others to repair damages;
- To learn more about what to do before, during and after a flood, respondents anticipate learning from family and friends, from neighbours and by speaking with NSW SES in person; this result highlights the role of learning *within* families and communities; it also shows that meet-the-street scale gatherings with NSW SES representation might be well received forums for education.

5.2.3 Henty Creek Flood Mitigation (2013)

As part of the Henty Creek Flood Mitigation study (WMAwater, 2013c), residents of Brown Road and Gregorace Place attended a public consultation session in April 2013. This consultation identified significant local overland flow issues in Gregorace Place, which Council would need to consider if the proposal to construct a flood wall or levee at the back of the properties (to address Henty Creek flood risks) is pursued. Residents in Gregorace Place also expressed concern about loss of access to the reserve at the rear (though currently this access appears to be cut off by fencing) and concern about possible adverse effects of a levee. This suggests that additional consultation with residents and education about the function of the wall will be required if this option is to be constructed.

Residents in Brown Road had experienced flooding and were eager for flood mitigation measures to be implemented.

5.3 FLOODPLAIN MANAGEMENT COMMITTEE

The study has been overseen by Fairfield City Council's Floodplain Management Committee. This committee comprises representatives from:

- Fairfield City Council;
- Office of Environment and Heritage (OEH);
- Fairfield State Emergency Service (SES);
- Floodplain managers from neighbouring councils; and
- Local residents.

The Committee has met regularly to hear progress reports by the consultant, and to provide direction as the study progressed. The Committee has provided a valuable mechanism for the views of many interested parties to be represented. The main agenda items at each meeting are summarised in Table 5.

Table 5 – Meetings of the Floodplain Management Committee

Date of meeting	Main agenda items
12 Apr 2012	Debrief of March 2012 flood; general update
26 Jul 2012	Flood education and awareness project; community consultation
13 Mar 2013	Basin safety review and basin failure assessment
28 Aug 2013	Preliminary draft FRMS&P
9 Oct 2013	Options assessment
7 May 2014	General update
26 Nov 2014	Review of recommended options

5.4 AGENCY CONSULTATION

The consultant has engaged with a number of relevant agencies with assets in the area or an interest in the study. These agencies were issued with a letter. A number of these are represented on the Floodplain Management Committee and several were also contacted by telephone. Responses are summarised in Table 6.

Table 6 – Input from agencies

Agency	Response
Aquatic Habitat Protection Unit, Dept of Primary Industries	Orphan School Creek downstream of its junction with Green Valley Creek is designated key fish habitat,[1] which is to be conserved under the *Fisheries Management Act 1994*. It is important that flood mitigation structures are constructed outside of these waterways and seek to not impact upon any significant areas of riparian vegetation.
NSW Office of Water, Dept of Primary Industries	Any proposed mitigation works resulting from the study that impact on the creeks and its environment need to follow the guidelines available on the Office of Water website.[2] The water level recorder at Orphan School Creek at Sackville Street (213014) could be alarmed to provide early notice of a rising flood.

[1] http://www.dpi.nsw.gov.au/fisheries/habitat/publications/protection/key-fish-habitat-maps
[2] http://www.water.nsw.gov.au/Water-Licensing/Approvals/Controlled-activities/default.aspx

Agency	**Response**
Bureau of Meteorology	A number of warning services are available for weather systems likely to result in flash flooding, including Detailed Severe Thunderstorm Warnings, Severe Weather Warnings and Flood Watches for the Georges River. Local real-time rain gauges could provide NSW SES and the public with information about flood potential within local catchments. This would need to be accompanied by some public education.
NSW State Emergency Service (SES)	The NSW SES provided comments on a draft chapter and also attended a meeting with Council and the consultant. The SES's input is described and incorporated into relevant chapters of this report.
NSW Office of Environment and Heritage (OEH)	The Waters, Wetlands and Coast Division provided input during the meetings of the Fairfield Floodplain Risk Management Committee. No input was received from the Ecosystems & Threatened Species and Planning Groups of the Metropolitan Branch of OEH.
Asset Management Division, Roads and Maritime Services (RMS)	RMS supplied road traffic count data for major roads, to better understand risks of road inundation.
Engineering and Projects Division, Railcorp	No issues identified by Sydney Trains or Transport NSW.
Government Property NSW	No issues identified.
Greater Sydney Local Land Services	No input.
Sydney West Region, Department of Planning and Infrastructure	No input.
Emergency Information Coordination Unit, Land & Property Information	No input.
Housing NSW, within the Department of Finance & Services	No input.
SummitCare (owner of Canley Vale nursing home in Freeman Avenue)	SummitCare considers that the greater risk to patients is presented by the evacuation process rather than by inundation of the residential care centre.

5.5 COMMUNITY QUESTIONNAIRES AND INTERVIEWS

A round of community consultation was held in November and December 2013. The consultation process involved issuing letters and questionnaires to 1,726 owners and occupiers in High and Medium flood risk precincts (i.e. within the 100 year ARI flood extent). A media release and Mayor's column were also issued. Completed questionnaires were received from 69 residents in the Three Tributaries floodplain. A display of potential options was set up in the Council foyer; Council officers were available to discuss flooding issues with residents; and there was an opportunity for interested residents to complete a more detailed interview known as 'the script', which 14 persons agreed to participate in.

A copy of the consultation materials is attached at Appendix E. The following results draw upon both the submitted questionnaires and the interviews conducted at the Council office.

a) General

95% of respondents were from residential dwellings and 4% were from commercial buildings.

Most of the respondents owned the building they were in (91%), and 5% rented.

b) Flood experience

Only 20% of respondents had experienced a flood previously, and fewer had any records of flooding (10%). Close to half of the respondents had seen or heard information about flooding (42%).

c) Flood knowledge and preparedness

67% of respondents stated that they did not know how to protect themselves or their properties.

Only 2% of respondents reported having a written plan for flood emergencies.

When asked who they thought they should contact in a flood, the most common answer given by respondents was NSW SES (Figure 14). The next most common response was Emergency 000, 'not sure', and the FCC. In this question 19% of respondents gave multiple answers, which suggests either that the respondents did not know precisely who to contact and so would try at least two different sources to obtain information, or that they thought it would be appropriate to contact any of the organisations which they selected.

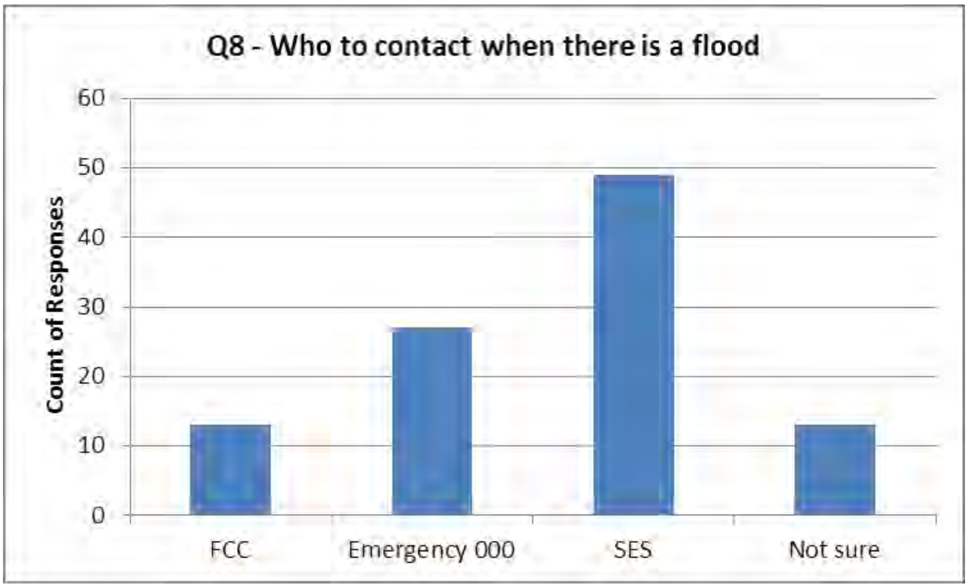


Figure 14 – Questionnaire and interview results: point of contact during a flood

The respondents to the questionnaire were split fairly evenly regarding their preference of staying in their homes or evacuating in the event of a flood occurring: 32% indicated that they would prefer to evacuate, 28% that they would prefer to stay in their house and, significantly, 38% were not sure, confirming that many people have not considered the best approach to surviving a flood.

This question was explored in greater detail with the interview 'script' (note, the sample size was only 14). For a flood reaching a depth of 0.5m in the street, 43% of respondents would prefer to stay in their houses, 36% would self-evacuate, 14% would protect and mitigate, and 7% were not sure what they would prefer (Figure 15). In a 1m flood, the respondents who would prefer to stay in their homes dropped to only 21%, the respondents who would self-evacuate increased to 72%, and those who were not sure what they would prefer remained at 7% (Figure 15). A difficulty with the preferred responses described here – exemplified by a comment 'once the water got into the house, I would leave' – is that it could very well be more risky to evacuate a house if evacuation is delayed! Reasons given for staying in houses were that the floor was raised, that the house was two-storey, or that it is considered safer to remain rather than attempt to navigate lower-lying roads.

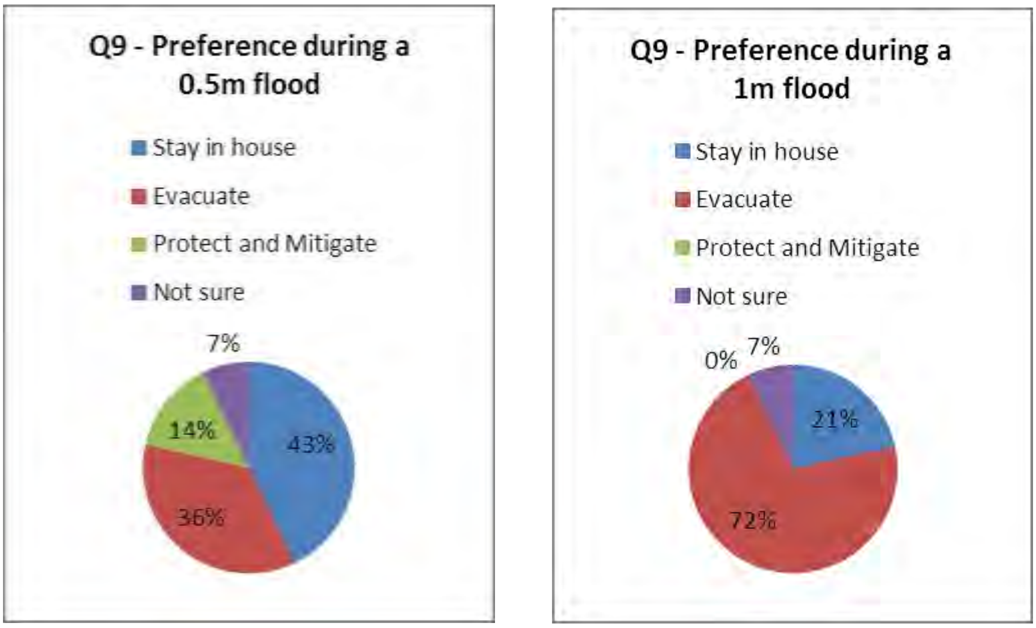


Figure 15 – Interview results: preferred response during floods

When asked what kind of assistance they would want Council to provide to help them prepare for floods, the most common answer was a flood preparedness pack (71%), followed by online information (29%), workshop (20%), 'not sure' (12%), and then 'other' (10%) (Figure 16). Of the respondents who answered 'other', three did not specify what other assistance they would like, two responded with a request for improving the functionality and cleanliness of local creeks and water systems, another responded that they would like Council to provide flood maps, another responded that they would like more hardcopy information delivered by mail to flood affected properties, and another said that what was already being done was good and they could see no room for improvement. Multiple answers were provided for this question by 28% of the respondents. The most common combination given was for all three of the options (workshop, online information and flood preparedness pack); the next most common response was for online information and a flood preparedness pack.

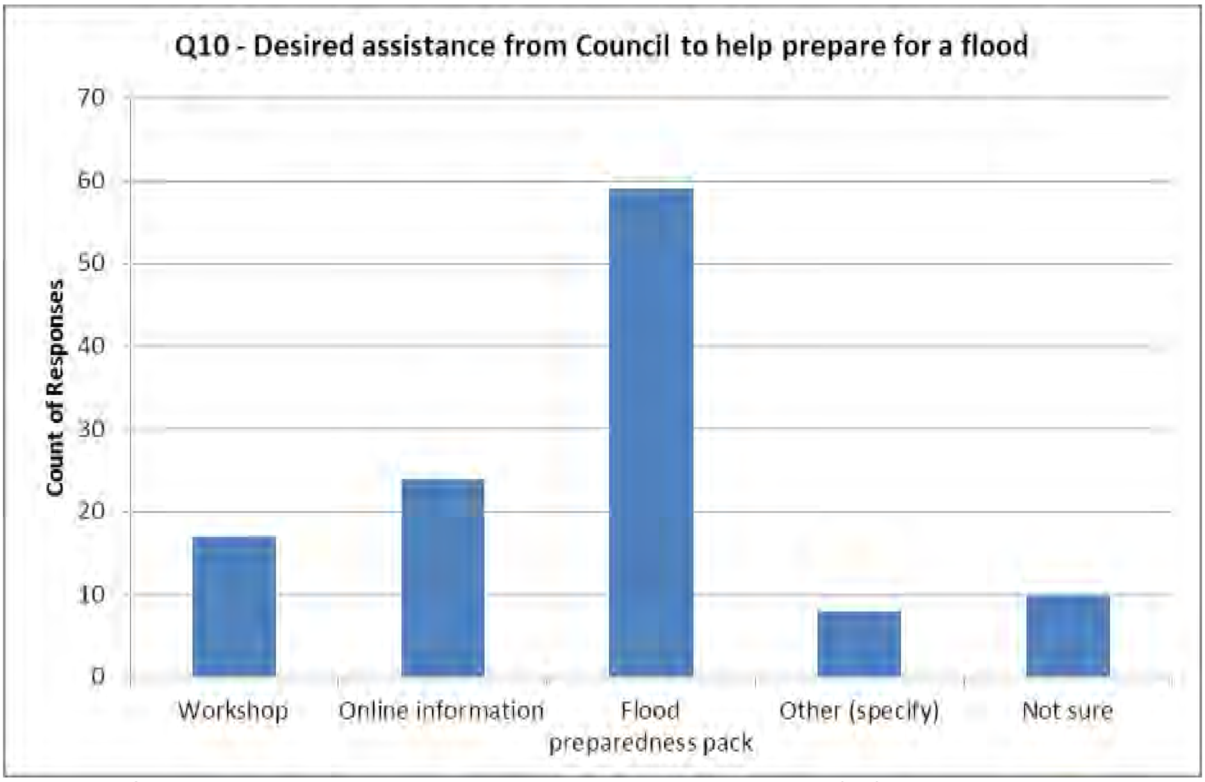


Figure 16 –Questionnaire and interview results: desired assistance to prepare for flood

d) Flood risk management responsibility and expenditure

Over half of the respondents provided multiple answers when asked who they thought should be responsible for reducing flood risk (Figure 17). The most common answer was FCC (86%), followed by the NSW Government, NSW SES, the landowner/resident and by 'someone else'. For 'someone else', respondents indicated the 'Federal Government', 'developers' and 'real estate agent before the property is purchased'. Where multiple answers were provided, the most common combination was that of FCC and the NSW Government.

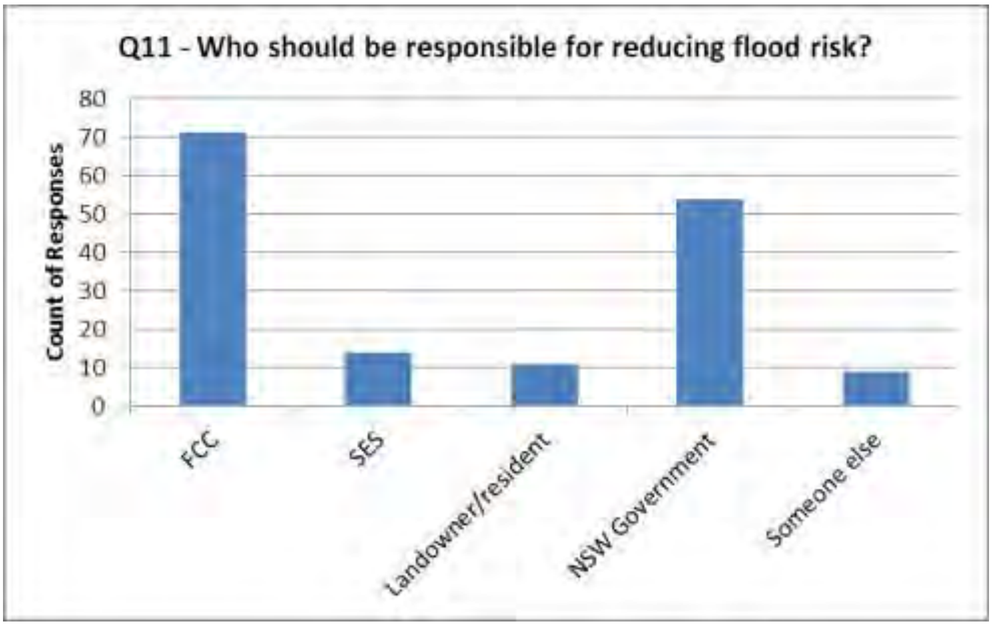


Figure 17 – Questionnaire and interview results: flood risk management responsibility

Most of the respondents indicated that they think Council should spend more on floodplain management such as structural works and flood awareness activities (78%) (Figure 18).

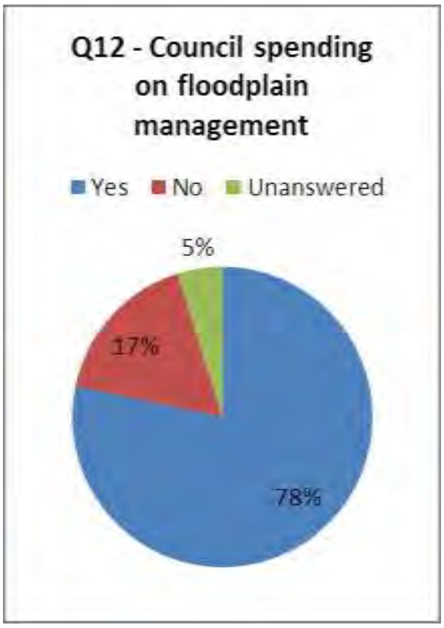


Figure 18 – Questionnaire and interview results: future Council floodplain management spending

e) Floodplain management options

Potential floodplain management options were prioritised based on the sum of the priority values which it was assigned (where 1 is least preferred and 10 is most preferred) as shown in Table 7.

The most preferred option was upgrading existing detention basins, followed by 'clearing' creeks of obstructions, new detention basins, development controls, levees and creek restoration. The least preferred options were voluntary house purchase, on site detention, voluntary house raising and flood proofing (the latter possibly less popular due to the direct reference to '*your*' home).

Again, the questionnaire results point to the community's focus on structural works by Council, though planning controls also rate highly.

f) Additional Comments

Twenty of the survey respondents made additional comments, with three common themes. Consistent with its prominence in the consultation conducted at the conclusion of the 2008 Flood Study, several respondents urge clearing of creeks to improve conveyance. The second most frequent theme is that Council should ensure that development is only built in locations and to standards which make it invulnerable to flooding. Another common theme is that drainage from the streets needs to be better maintained.

Table 7 – Questionnaire and interview results: preferred floodplain management options

Option	Sum of all Responses	Rank	Average Response
Upgrade existing basins	633	1st	8.6
Channel enhancement by removing flow restrictions in creeks	623	2nd	8.5
New detention basins	617	3rd	8.5
Development controls/constraints	609	4th	8.2
Levees	582	5th	8.1
Creek restoration by removing concrete channels	578	6th	7.9
Education	574	7th	7.7
Local Flood Plan	539	8th	8.0
Floor-level controls for new developments	502	9th	7.8
Flood proofing of your home with water resistant material	482	10th	6.7
Voluntary House Raising	465	11th	6.5
On Site Detention	340	12th	4.7
Voluntary Purchase	318	13th	5.0

5.6 PUBLIC EXHIBITION

The final stage of the community consultation for this study was the public exhibition of the draft Three Tributaries FRMS&P. The document was placed on exhibition from 16 February to 20 March 2015. Over 6,400 letters were issued to inform every resident and owner within the PMF extent of the exhibition, and to invite comments. Council received 49 responses. Some residents expressed scepticism about the flood risk affectation on their properties, and some expressed concern about the possible effect on insurance premiums or property values. Council explained that recent flood history is not a sound indicator of the risk of large floods outside people’s experience and that the evidence for any discounting effect on property values following the release of flood information was weak (see Yeo et al., 2015). Several residents described the presence of rubbish in watercourses that needs to be cleared. Two recommendations were added in response to the feedback from public exhibition: (1) to investigate enlarging Prairiewood detention basin, and (2) to install a flap gate on a pipe where Sackville Street meets Orphan School Creek.

PART B: FLOOD BEHAVIOUR AND IMPACTS

6 FLOOD STUDIES

An essential foundation for the Three Tributaries Floodplain Risk Management Study and Plan (FRMS&P) is a Flood Study that describes flood behaviour for a range of events including the probable maximum flood (PMF). Flood modelling for the Three Tributaries floodplain has been undertaken in various stages. A *Flood Study for Orphan School Creek, Green Valley Creek and Clear Paddock Creek* was prepared by Sinclair Knight Merz and Fairfield Consulting Services in 2008 (SKM & FCS, 2008). The modelling used for that Flood Study was reviewed to assess its suitability for the requirements of this FRMS&P. As a result of this review process, detailed below, the models were updated. The updates were undertaken in stages by multiple parties, including the original model developers (SKM), then by Fairfield City Council, and finally by WMAwater, who were responsible for hydraulic modelling components of the FRMS.

The various stages of the model development, review and revision process are summarised in the following sections.

6.1 FLOOD STUDY FOR ORPHAN SCHOOL CREEK, GREEN VALLEY CREEK AND CLEAR PADDOCK CREEK

Sinclair Knight Merz (SKM) and Fairfield Consulting Services (FCS) jointly undertook a Flood Study for Orphan School Creek, Green Valley Creek and Clear Paddock Creek (the Three Tributaries of Prospect Creek) for Fairfield City Council in October 2008 (SKM & FCS, 2008).

This study employed XP-RAFTS (hydrologic model) and TUFLOW (hydraulic model) computer modelling packages, using the (then) latest available topographic data, survey data and design data on existing hydraulic structures, including bridges, culverts and detention basins. The models were calibrated using stream gauging data from the NSW Office of Water gauge on Orphan School Creek at Sackville Street and using high water marks from the 31 January 2001 flood event. Catchment flows and flood levels were subsequently estimated using the calibrated models for the 20, 50 and 100 year ARI and PMF events for a range of storm durations.

The Three Tributaries XP-RAFTS hydrologic model (2008) included the thirteen detention basins that existed within the catchment at the time, ten of which were also modelled in the TUFLOW hydraulic model (Prairiewood, Stockdale and Comin Place excluded). Detention basins in the TUFLOW model were represented as 2D objects in the floodplain. Local hydrographs from RAFTS were used as flow inputs into the TUFLOW model, which was used to estimate details of the flood behaviour (such as flood level and velocity) throughout the study area, including at detention basins. Following the development of the models, additional basins were constructed (Basin W2) or amplified (Basin W3), and the outlet from Basin C was strengthened to withstand higher loading from flood flows (to a PMF design standard).

The 100 year ARI flood levels and discharges were compared to those from a number of previous studies undertaken in the catchment. Flood levels and flows were found to be typically lower than those estimated from previous studies. SKM attributed the differences to changes to the creek conditions, such as upgraded hydraulic structures and implemented channel works, in addition to differences in modelling assumptions.

Modelling for events up to and including the 100 year ARI event indicated that flooding in the middle to upper reaches of the system would be generally confined to the channel and a relatively narrow strip of the floodplain on either side of the creek. This flooding was estimated to affect a number of properties adjacent to the creek. In the lower reaches of Orphan School Creek, between the Green Valley Creek confluence and Railway Parade, the modelling indicated flooding would break out onto the floodplain to a greater extent than the upper catchment, in events greater than and including the

20 year ARI event. For the PMF, a corridor up to 1.4km wide was estimated to be inundated by floodwaters just upstream of Railway Parade (which was the downstream extent of the study area).

Several sensitivity tests were undertaken, including to assess: the effect of blockage at culverts; varied catchment roughness; varied rainfall losses; and varied initial water levels in the detention basins.

Interim flood risk precinct mapping was produced as part of the Flood Study, using the flood risk precinct definitions then adopted by Fairfield City Council.

6.2 REVIEW OF THREE TRIBUTARIES FLOOD STUDY

A review of the SKM & FCS (2008) Flood Study was conducted at the outset of this FRMS&P to verify that the models were fit for purpose. This review was undertaken by WMAwater (2011), which identified some technical issues with the modelling, described below:

- Specific parameter settings used in modelling work resulted in the flow capacity of several model elements (most notably basin outlets and concrete lined channels) being higher than could be reasonably expected. The miscalculated conveyance of these structures was to some degree offset by other aspects of the modelling approach. However, adjustment of the model indicated that the flood levels estimated in the Flood Study were likely to be underestimated;
- It was observed that the SKM Flood Study peak flood levels for the 100yr ARI event were up to 2.0m lower than the flood levels determined by earlier studies (SMEC, 1985, and Bewsher Consulting, 1997), for locations upstream of King Road. Downstream of King Road the differences were less significant between SKM and the earlier studies; and
- The difference in peak flood levels between the 20 year and 100 year ARI events reported in SKM & FCS (2008) was understated when compared to the study area's indicative flood range as indicated by observations of flood behaviour from the 1986, 1988 and 2001 events.

In summary, it was considered that the modelling approach used in the Flood Study was likely to misrepresent the capacity of some of the open channels and detention basin outlets, with a result that flood levels and the extent of overbank flooding were likely to be underestimated, particularly in the vicinity of detention basins. As there are several detention basins in the study area, and these basins were a key focus for the FRMS (due to their ongoing role in flood risk mitigation for the study area as well as the risk of basin failure), it was recommended that the identified modelling issues be resolved before the models were adopted for use as part of this FRMS&P.

The review included recommendations to:

- Update the modelling with a series of revisions to various aspects of the Flood Study modelling methodology. The recommended updates included:
  - Changes to the method of conveyance calculation for open channels and hydraulic structures (such as detention basin outlets);
  - Correction of the schematisation of survey cross-sections along overflow points at detention basins;
  - Revision of links between 1-dimensional and 2-dimensional components of the model, which were resulting in some 'leakage' of flow through detention basin embankments, thereby affecting the assessment of overtopping risk for these embankments; and
  - Minor changes to the delineation of sub-catchments and the approach to design storm temporal patterns and antecedent conditions;
- Review the adopted method for design storm temporal patterns and consider the use of an embedded design storm approach;
- Undertake a full re-calibration and validation of the revised model, including consideration of all available historic data;

- Undertake sensitivity testing of the revised model (as per previous sensitivity tests), with additional investigation into the sensitivity to changes in 1D roughness values and changes to inflow magnitudes;
- Revise outcomes of the Flood Study that change as a result of revised models, such as maps of flood behaviour, hazard categorisation, property tagging of flood affected properties (including updates to Section 149 certificates if appropriate) and other documentation of design flood levels; and
- Document the above actions in a revised Flood Study report.

6.3 TUFLOW MODEL REVIEW AND UPDATE

To address the issues raised during the review process, SKM undertook a subsequent update of the Flood Study's hydraulic model (SKM, 2011). This model revision work implemented the majority of recommendations from the WMAwater (2011) review. In particular:

- The conveyance calculation method was rectified for the detention basin outlets and for concrete-lined open channels;
- The energy loss parameters at key hydraulic structures were revised.

Fairfield City Council continued the refinement of the model by undertaking the remainder of the model updates recommended by WMAwater (2011). This additional work included recalibration of the model against historical floods, and was undertaken primarily by Fairfield City Council staff, with a supervisory and review role from WMAwater.

Finally, WMAwater also completed additional revisions to the model to reflect construction of waterway infrastructure in the study area that occurred after the Flood Study (2008). These additional modifications were identified as part of the FRMS scope of work, and included:

- The inclusion of additional basins in the model (Basin W2, Basin W3 and Basin C), which had either been constructed or modified since 2008; and
- The extension of the hydraulic model area to include the Stockdale and Prairiewood Basins, to allow for a more comprehensive analysis of detention basin failure risk as part of the FRMS. These basins were included in the geotechnical investigation undertaken by Douglas Partners, and for completeness it was considered reasonable to include them in the basin failure assessment.

The selection of storm durations for the modelling is complicated by the need to model both runoff potential and basin storage. Based on consideration of the modelled catchment response for a range of peak burst durations, for the revised modelling a 2-hour peak burst was embedded into 9-hour peak burst to form an Embedded Design Storm (EDS). This is described further in Appendix F.

WMAwater prepared revised risk precinct mapping and maps of design flood depths and velocities estimated using the revised models.

The revised hydraulic model developed through the process outlined above formed the basis of computational model assessments undertaken as part of the FRMS, including:

- Assessment of potential impacts of climate change on rainfall and consequently on flood behaviour;
- Assessment of potential mitigation measures to manage the existing risk e.g. detention basin upgrades; and
- Assessment of potential failure of detention basins within the study area.

6.4 FUTURE WORK

Modelling of flood behaviour in the Three Tributaries catchment is technically demanding due to the large number detention basins and the particular characteristics of each basin, as well as the potential for culvert blockage which can cause flow diversions. The *Flood Study for Orphan School Creek, Green Valley Creek and Clear Paddock Creek* (SKM & FSC, 2008) and particularly the revised flood modelling documented in WMAwater (2013b) provide an up-to-date prediction of design flood behaviour for a catchment scale using the best modelling techniques available at the time.

Nevertheless, all flood studies are subject to periodic revision for reasons that include:

- The availability of new design rainfall or ground topography information;
- The occurrence of new floods which provide additional data to improve models;
- The availability of better computer models as the science of flood modelling improves and computer capabilities increase; or
- The implementation of flood mitigation works, or development within the catchment that was not previously simulated in the models.

A list of known issues to be addressed at the next review of the *Three Tributaries Flood Study* is provided below:

- Ensure the best possible topographic information is included. Some significant differences between the various topographic datasets provided for the current study have been observed including in the vicinity of the embankment for the Fairfield Golf Course Basin.
- Model an intermediate design flood between the 100 year ARI and the PMF such as a 200 year ARI event. Whilst three climate change scenarios were modelled, these cannot readily be used for flood damages assessment.
- Ensure that the culvert under the Canley Vale-Fairfield Railway in the vicinity of Cathcart Street is included in the model. Whilst this is not relevant for mainstream floods up to and including the 100 year ARI event, its inclusion could moderate PMF depths upstream of the railway. It might also be advisable to model the possibility of erosion of the railway embankment, which could reduce flood depths upstream but increase flood depths and velocities downstream.
- Include selected ‘micro’ features in the hydraulic model. Whilst a catchment-scale model cannot include every fence, WMAwater’s (2013c) refinement to the model in the vicinity of Brown Road showed that there can be significant changes when smaller scale features are included. A solid brick wall separates the Mounties Club from Kewin Avenue and could act as a barrier to conveyance during flooding of Green Valley Creek. This could be modelled.

7 FLOOD BEHAVIOUR SUMMARY

7.1 EXISTING FLOOD BEHAVIOUR

7.1.1 General description

Design flood extents for the four events modelled in the Three Tributaries catchment (i.e. the 20, 50 and 100 year ARI and PMF) are presented in Figure 19.

a) 20 year ARI event

For each of the three tributaries, floods up to the 20 year ARI magnitude are primarily contained within the channel banks (for both naturalised and concrete-lined sections) and within the detention basins. Downstream (east) of King Road, much of Orphan School Creek is naturalised, and the channel is more sinuous than the upstream areas. Model results indicate that the 20 year ARI flood is above the top of channel bank, with floodwater encroaching into private properties in Duke, Queen, Earl and Sackville Streets as well as Freeman Avenue.

b) 100 year ARI event

Figure 20 shows the flood extent and depths for the 100 year ARI event. In this event, there are several locations throughout the study area where flows exceed the capacity of the channel, in some locations forming alternative flow paths along road reserves, with relatively low velocities typically less than 1.0 m/s.

Along the upstream reaches of Orphan School Creek, areas of overbank flow in the 100 year ARI event include:

- Adjacent to and downstream of the Mimosa Road Basin, with an overland flow path forming through the commercial precinct south of the creek, and also to the north in the vicinity of Aberdeen Street. Properties on Comanche Road, Yuma Place, Mohave Place, Powhatan Street, Mimosa Road, Aberdeen Street, Brahma Close, Greenfield Road, Devenish Street, Ripple Close, and Falcon Close may be affected by flooding in the 100 year ARI event. Modelling indicates that overland flow may occur through properties at the cul-de-sac in Ripple Close.
- Downstream (south) of the Golf Course Basin, to the west of the channel. In the 100 year ARI event a flow path forms through Mary MacKillop College, and along Mallacoota Street, Brockham Street, Bulls Road, Lomond Street, Shoalhaven Street and Esperance Crescent, potentially affecting properties in these roadways.
- Downstream of Prairiewood basin, potentially affecting properties along Prairie Vale Road, Christie Street and Donahue Close.

Through Esperance Reserve and King Park, and downstream of King Road, 100 year ARI flows are primarily confined to the riparian reserve with a flow width of up to approximately 100 m. Some roadways along the edge of the riparian reserve are affected by shallow flooding. Downstream of Salisbury Street / Baragoola Street, the 100 year ARI flow breaks out into a wider flow path up to 350 m wide at some locations and potentially affecting several properties, particularly in the vicinity of Freeman Avenue, and upstream of Sackville Street on the southern side of the creek. Velocities in these overbank flow areas are typically less than 1.0 m/s outside the riparian corridor for the 100 year ARI event.

In Clear Paddock Creek, there are several detention basins in the upstream reaches (including W2, W3, C, Bosnjak Park U/S and D/S basins) that attenuate flood flows. There are some properties affected by flooding in the 100 year ARI event in the vicinity of the Henty Creek crossings of Brown Road and Elizabeth Drive, and along Smithfield Road adjacent to Basin C.

Downstream of the Basin C outlet, the 100 year ARI flow is confined within the banks of the relatively high-capacity concrete channel through Hampshire Reserve, which joins Orphan School Creek at the King Road Basin outlet.

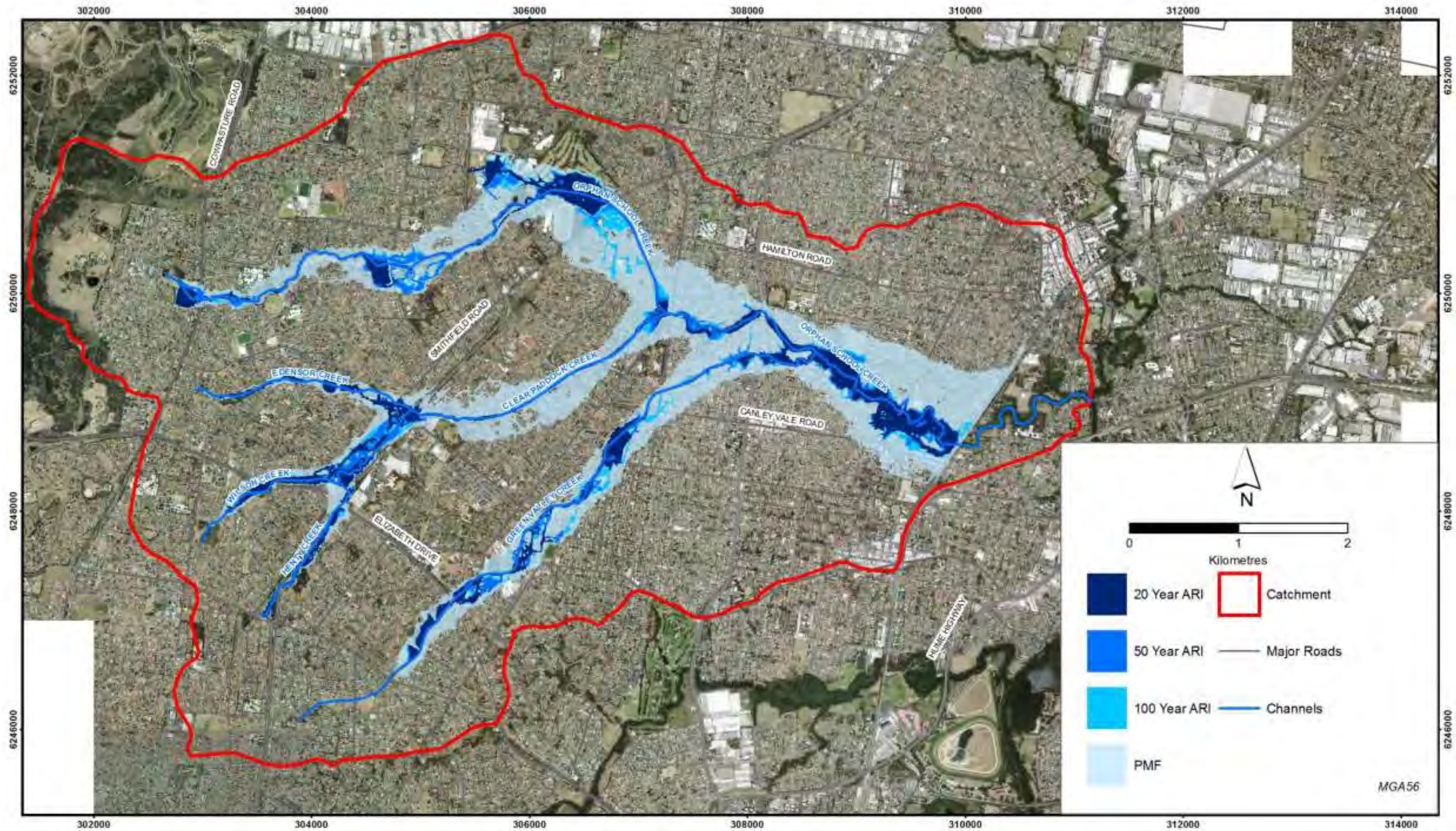
Along Green Valley Creek, overbank flow in the 100 year ARI event occurs at the following locations:

- Along Humphries Road, Barook Place, Fig Place and Kewin Avenue;
- At the Cabramatta Road West crossing, with surcharging across the road, and potentially affecting downstream properties on Cayley Place, Meadows Road, Moonshine Avenue and Edensor Road. Velocities up to 2.0 m/s are modelled in these areas;
- Clare Street and Katrina Crescent;
- St Johns Road crossing upstream of Chisholm Park Basin;
- The cul-de-sac at the northern end of Ruth Street;
- In the vicinity of the Cumberland Highway crossing, potentially affecting properties on Fernlea Place, Craigslea Place, Chelsea Drive, Parklea Parade, Glenlea Street, Carre Avenue, Avonlea Street, and Kingslea Place.

c) PMF event

The PMF event has significantly greater consequences in terms of flood extent and potential damages to property. Modelling indicates the PMF would produce a flow path up to 250 m wide for areas upstream of Sweethaven Road (for Orphan School Creek) and Edensor Road (for Clear Paddock Creek). The flowpath width increases to be generally between 350 m and 500 m as far downstream as King Road. There is a significant increase in the PMF flood extents relative to the 100 year ARI along the concrete-lined channel reaches through Esperance and Hampshire Reserve, with hundreds of additional properties affected in these areas. Downstream of King Road the PMF flood extent is approximately 600 m wide, reducing to approximately 400 m at the Green Valley Creek confluence, then increasing to approximately 1,000 m at Railway Parade. There are several hundred properties within the PMF extent between King Road and Railway Parade. Overbank velocities in the PMF are also significantly higher than for the 100 year ARI event, with velocities generally up to 2 m/s in road reserves, and isolated patches greater than 3 m/s.

The PMF produces a flow path approximately 300 m wide along the majority of Green Valley Creek, with overbank velocities exceeding 3 m/s in areas from Cabramatta Road West to Canley Vale Road.



Three Tributaries Floodplain Risk Management Study: Existing Design Flood Extents			
MOLINO STEWART ENVIRONMENT & NATURAL HAZARDS	Molino Stewart endeavours to ensure that the information provided in this map is correct at the time of publication. Molino Stewart does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.	Date: 14/11/2014	Checked By: S.Y.	Job No: 0429
		Filepath: Y:\Jobs\2010\0429 Three Tributaries Floodplain Risk Management Study\GIS\Workspace\Design flood extents.mxd		

Figure 19 – Design flood extents

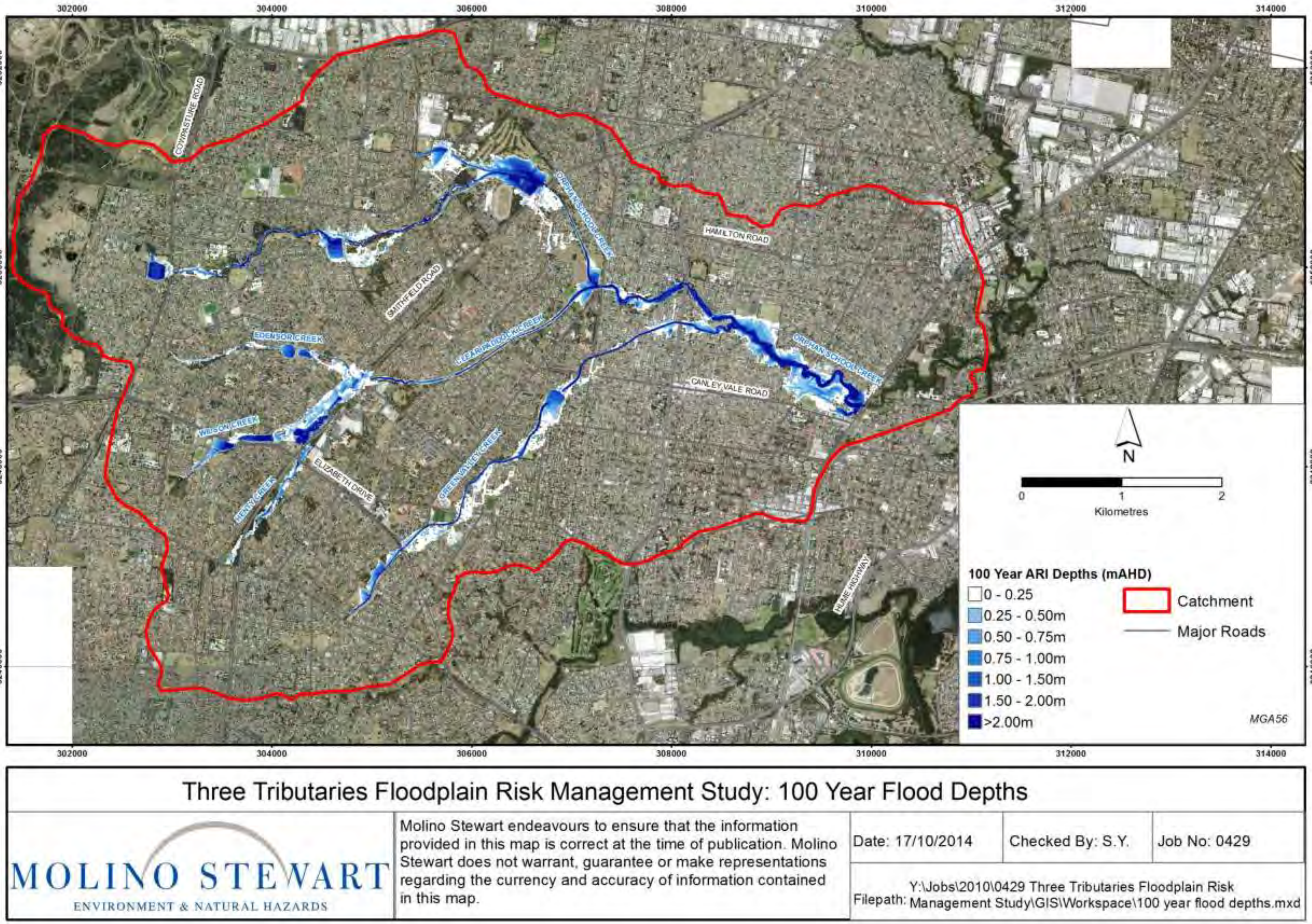


Figure 20 – 100 year ARI flood depths

7.1.2 Detention basin performance

A key component of Council's approach towards managing flood risk in the Three Tributaries catchment is its 14 detention basins (see Figure 1 for basin locations). WMAwater (2013b) assessed the capacity of each detention basin according to the design event at which its embankment would be overtopped (assuming no failure). Table 8 presents the results. Seven basins would be overtopped in the 20 year ARI event, though the consequences of this overtopping vary from site to site, and very few houses are flooded above floor level in such an event (see Section 8.2).

Table 8 – Overtopping details for detention basins within the Three Tributaries catchment

Source: WMAwater (2013b)

Basin	Spilling Level (mAHD)	Smallest Overtopping Design Event			PMF Event		
		Event	Water Level (mAHD)	Depth of overtopping (m)	Event	Water Level (mAHD)	Peak depth of overtopping (m)
Stockdale	55.4	20 year ARI	55.9	0.5	PMF	56.5	1.1
Mimosa Road	39.9	20 year ARI	40.0	0.1	PMF	40.8	0.9
Prairiewood	31.4	20 year ARI	31.5	0.1	PMF	32.2	0.8
Golf Course	27.1	50 year ARI	27.2	0.1	PMF	27.9	0.8
Bosnjak Park Upstream	43.0	100yr +20%	43.2	0.2	PMF	43.8	0.8
Bosnjak Park Downstream	39.8	20 year ARI	40.0	0.2	PMF	41.0	1.2
King Park	20.5	100yr +10%	20.6	0.1	PMF	21.9	1.4
Horton Street	40.7	100yr +10%	40.7	0.0	PMF	41.7	1.0
Hamel Road	39.1	PMF	39.6	0.5	PMF	39.6	0.5
Chisholm Park	23.6	20 year ARI	23.8	0.2	PMF	24.5	0.9
Basin W2	46.8	20 year ARI	47.0	0.2	PMF	48.2	1.4
Basin W3	43.2	20 year ARI	43.4	0.2	PMF	44.1	0.9
Basin C	41.7	Not Overtopped	N/A	N/A	PMF	40.0	N/A

7.1.3 Flood Risk Mapping

While mapping flood extents, depths and velocities is useful, some form of classification of flood behaviour is required for determining what risks flooding poses and what are appropriate land uses in the floodplain. Two such ways of doing this is by means of hydraulic classification and hazard classification.

a) Hydraulic categories

Hydraulic classification divides the floodplain according to its hydraulic function. The NSW *Floodplain Development Manual* (2005) recommends three hydraulic categories: floodway, flood storage and flood fringe.

It is not feasible to provide explicitly quantitative criteria for defining floodways, flood storage areas and flood fringe areas, as the significance of such areas is site specific. Often, the following criteria are applied:

- Floodways – areas conveying a significant proportion of the flood flow and where even partial blocking would cause a significant redistribution of flood flow or a significant increase in flood levels.
- Flood storage areas – those areas outside floodways which, if completely filled with solid material, would cause peak flood levels to increase anywhere by more than 0.1 m and/or would cause the peak discharge anywhere downstream to increase by more than 10%.
- Flood fringe areas – the remaining area of land affected by flooding, after floodway and flood storage areas have been defined. Development in flood fringe areas would not have any significant effect on the pattern of flood flows and/or flood levels.

Hydraulic categorisation has not been undertaken for the Three Tributaries floodplain. Presumably this was because these categories are not explicitly required for application of Council's City Wide DCP. It is noted that the DCP does have controls to ensure that development will not increase flood levels elsewhere, requiring consideration of the loss of flood storage and alterations to flood conveyance.

b) Provisional Hazard Categories

Both the SKM & FCS (2008) Flood Study and the revised TUFLOW modelling by WMAwater (2013b) generated provisional hydraulic hazard categories for the Three Tributaries floodplain for the 100 year ARI event. This mapping is based on Figure L2 of NSW *Floodplain Development Manual* (2005), which distinguishes high hazard, low hazard and a 'transitional' hazard using peak flood depths, velocities and depth-velocity product. This mapping is then used as a starting point for mapping flood risk precincts.

For the purposes of the Three Tributaries FRMS&P consideration has also been given to a more a finely divided classification, drawing upon recently published research associated with the revision of Australian Rainfall and Runoff (AR&R). This work has been driven by a desire to identify areas and land uses that may not require planning controls (see Section 11.3.3).

Figure 21 shows the depths, velocities and depth-velocity product at which it becomes unsafe for people. There are five categories from 'low hazard to children' to 'extreme hazard to adults'. It is noted that the 'low hazard for children category' may not be a low hazard for infants, frail or older people or people with physical or mental disabilities and AR&R recommends against locating facilities for such people (aged care facilities, retirement villages, preschools, child care centres etc.) in areas which can be subject to any flooding.

Figure 22 shows a similar diagram for vehicle stability. Research suggests that flood depths greater than 300mm are sufficient for small vehicles to become unstable but where velocities exceed 1 m/s this reduces to 100mm. Any cars, even four wheel drives, can become unstable when velocities exceed 3 m/s.

Figure 23 shows a similar diagram for building stability. Structures are exposed to a moderate-high hazard where depths exceed 2.0 m, where velocities exceed 2 m/s or where the depth-velocity product exceeds 1 m^2/s. An analysis of building damage following the 2011 Lockyer Valley floods suggests that buildings constructed for Australian conditions are vulnerable to damage and collapse under flood hazard conditions at the lower end of the scale, toward the green curve in Figure 23 (McCluckie et al., 2014).

Figure 24 presents a consolidated hazard diagram taking into consideration stability of people, vehicles and buildings.

Provisional flood hazard categorisation based around depth and velocity combinations does not consider a range of other factors that influence flood hazard. Therefore provisional hazard categorisation should be used with the following factors to determine true hazard categories:

- Extent of flood;
- Effective warning time;
- Flood preparedness;
- Rate of rise of floodwaters;
- Duration of flooding;
- Evacuation problems;
- Effective flood access; and
- Type of development.

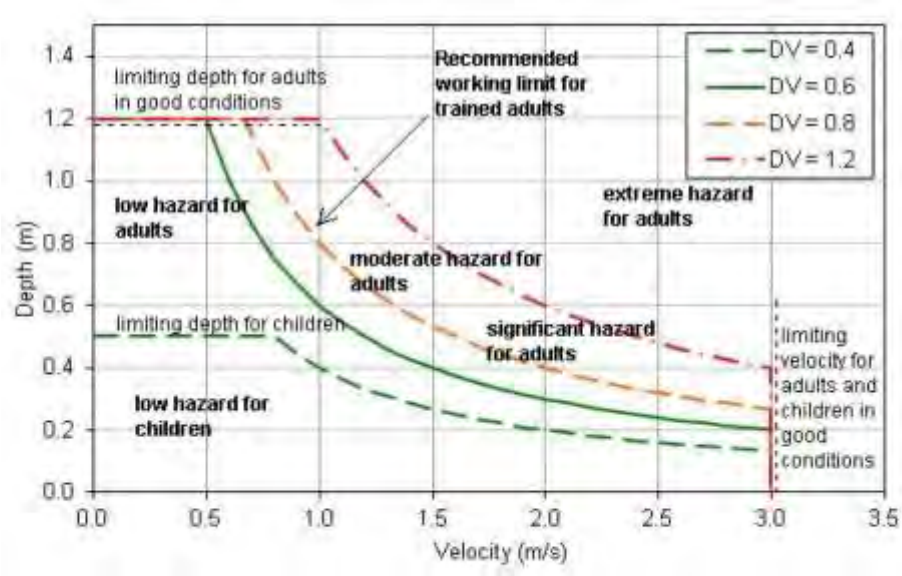


Figure 21 – Safety criteria for people in variable flow conditions

Source: Smith and Cox (2009)

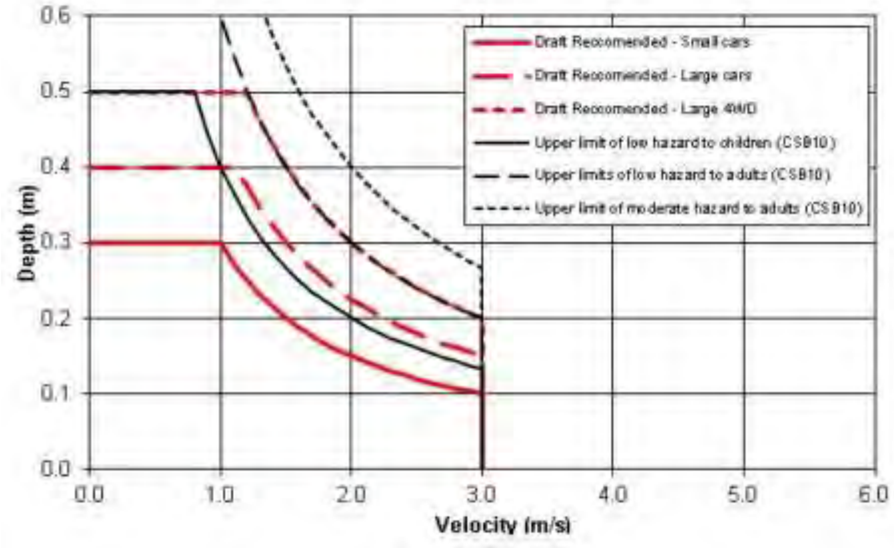


Figure 22 – Interim safety criteria for vehicles in variable flow conditions

Source: Smith and Cox (2009)

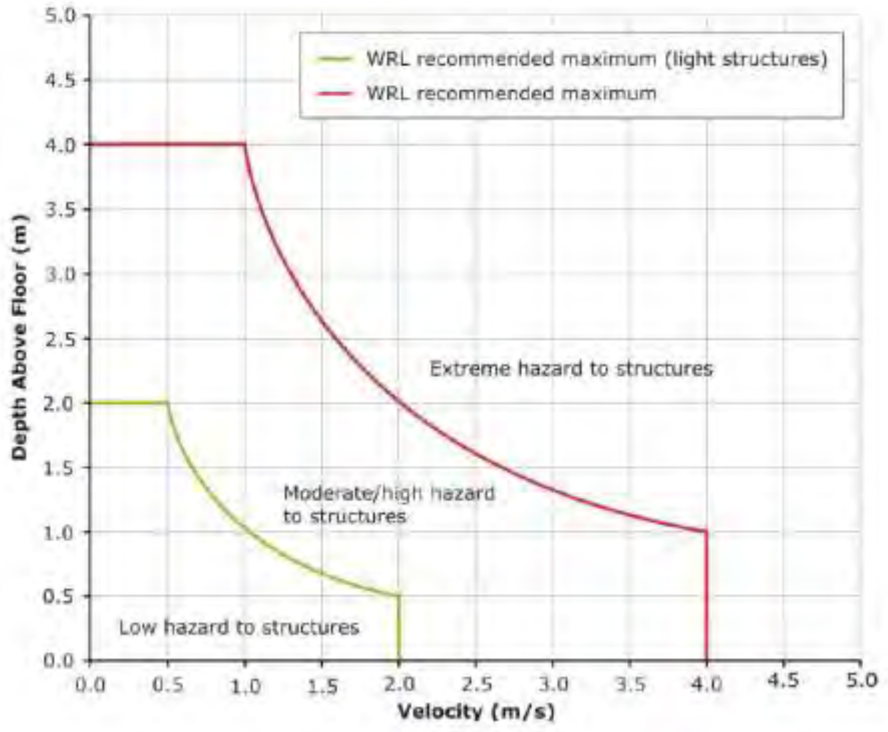


Figure 23 – Proposed thresholds for building stability in floods

Source: McCluckie et al. (2014)

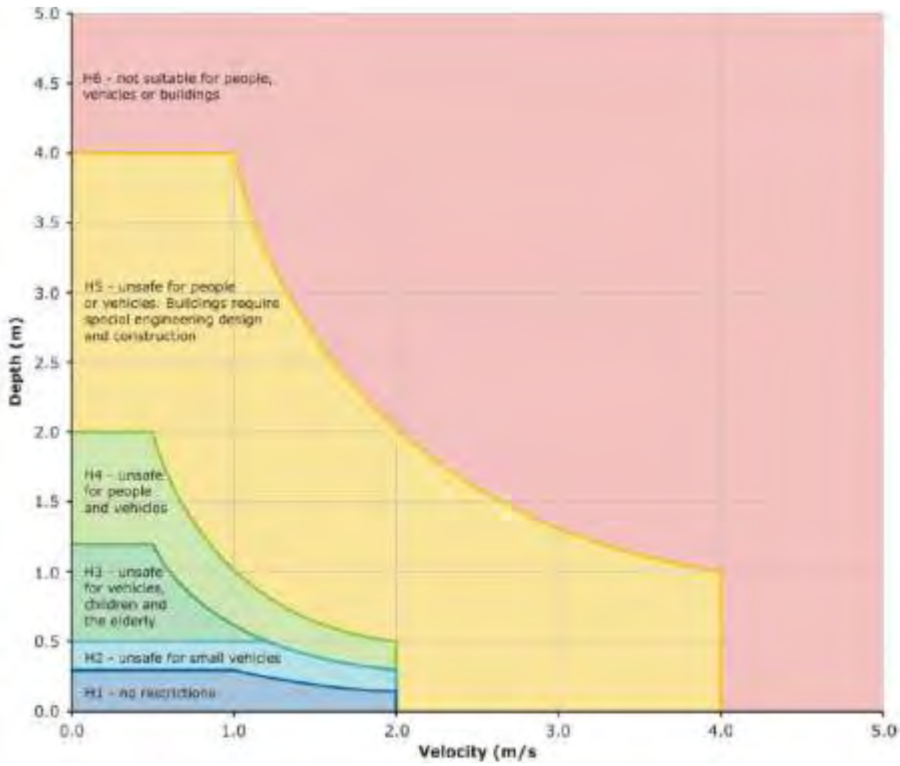


Figure 24 – Combined flood hazard curves

Source: McCluckie et al. (2014)

c) Flood Risk Precincts

Mapping of flood risk precincts (FRPs) is a critical outcome of the FRMS&P since this is a primary determinant of planning and development controls in Chapter 11 of the Fairfield City Wide DCP.

High and Medium FRPs

For the Three Tributaries floodplain, the High and Medium FRPs have been mapped consistent with the approach adopted for other floodplains within Fairfield LGA (Table 9). Land within High and Medium FRPs is modelled to be inundated in the existing 100 year ARI flood. Areas in a High FRP are subject to a high provisional hydraulic hazard as defined by Figure L2 of the *Floodplain Development Manual*. Areas in a Medium FRP are not subject to a high provisional hydraulic hazard. Based on this initial assessment, areas of High FRPs are essentially within or close to main creek channels, the adjoining parklands and in the detention basins where storage depth can be significant. There are areas of High risk in some streets including the Fernlea Place cul-de-sac, Pitt Street and Freeman Avenue.

However, evacuation constraints also need to be factored in. The most pressing case is the houses in Freeman Avenue. Although no residence is subject to a high hydraulic hazard in the 100 year ARI event, consideration of the 'true hazard' suggests that with the possible exception of a few parcels not inundated in the 100 year flood, properties in this area would be more appropriately marked as High FRP. The flood risk in Freeman Avenue is given significant attention in various sections of this report and is summarised below:

- Houses in Freeman Avenue are serviced by only one low-set road that is subject to a high hydraulic hazard (maximum depth of 1.1m in the 100 year event) over a distance of about 160 metres; other sections of the road are also subject to high hydraulic hazard;
- Access is lost *early* in an Orphan School Creek flood when the low-point is flooded, prior to inundation of the properties; it is possible that access could be lost earlier due to overland flows from the Canley Corridor catchment inundating the low-set road;
- Access is lost relatively *frequently* – the low-point is flooded to a depth of 0.8m in the 20 year ARI Orphan School Creek flood and to a depth of 0.6m in the 5 year ARI Canley Corridor overland flow event;
- Available warning times are generally very short, accentuating the constraints to evacuation;
- Rescuers' lives would be put at risk attempting to evacuate this area;
- The hydraulic hazard in the PMF would present an extreme risk to the existing dwellings.

In the Consultant's opinion, the above flood risk considerations require that most of Freeman Avenue be upgraded to a High FRP. This decision was previously made in preparation of the *Canley Corridor Overland Flood Study* (SKM & FCS, 2009), since properties in the Freeman Avenue subdivision are *all* shown as High FRP even though high hydraulic hazard in the 100 year ARI event was largely confined to the street. A High FRP would serve to indicate to Council and the community that any intensification of the use in this area should be restricted, since this would place more people in harm's way during flooding. Also, a High FRP would signal that a significant investment to improve evacuation capability is required (possibly allowing a later downgrading to Medium FRP). A High FRP does not necessarily stop improvements to properties, since owners are still able to redevelop their properties if they qualify for concessional development.

Low and Very Low FRPs

Council successfully petitioned the Department of Planning and Infrastructure for 'exceptional circumstances', enabling it to apply controls relating to emergency response, evacuation and structural soundness of buildings to ensure the safety of occupiers in the event of severe flooding, rarer than the 100 year ARI event. However, Council is not obliged to apply these controls everywhere in the floodplain, and recently has indicated a desire to consider whether flood risk considerations demand the application of planning and development controls to residential developments as far as the PMF extent, or whether there are some areas within the PMF extent where the flood hazard is such that controls on emergency response are not warranted.

In consultation with Council, this has resulted in the development of an additional FRP, the Very Low FRP. The intention is that planning and development controls would not need to be applied to residential developments in the Very Low FRP. Accordingly, Council requires confidence that residents could survive an extreme, low-probability flood by either evacuating to higher ground or by remaining in their house, even if that house – designed without necessarily meeting the planning and development controls applied to higher-level flood risk precincts – is flooded above floor. The hydraulic hazard criteria presented previously provide a robust basis for mapping areas where Council can have such confidence.

Adopted criteria are presented in Table 10. These are based on both the 'low hazard to children' threshold in Figure 21 and the 'low hazard to structures' threshold in Figure 23. A house may be inundated and yet pose minimal risk of drowning even for children and negligible risk of building failure where flood depths, velocities and depth-velocity product do not exceed low hazard conditions. The adopted velocity threshold of 2 m/s is based on building stability rather than people stability. It is also worth noting that to meet Building Code of Australia (BCA) standards, most houses would be raised at least a little above the ground, which means that actual over-floor flood hazards would be lower.

Consideration was given to applying the lower stability thresholds determined for small cars from Figure 22 (depth 0.3m and depth-velocity product 0.3 m^2/s). When applied to evacuation routes from houses, this would enable mapping of routes where vehicular evacuation could be safely achieved even in a PMF. However, it is considered unduly complex to assess evacuation risks from each dwelling in a PMF and unduly conservative to require safe evacuation from each dwelling in a PMF, especially for replacement dwellings. What the Very Low FRP does signify are areas where the risk to life from flooding within dwellings to which planning controls have *not* been applied is very low even in the PMF. In these areas, sheltering in place is expected to be safer than attempting to cross flooded roads.

As Table 10 indicates, areas above the 100 year ARI flood level but below the 100 year ARI plus 0.5m freeboard level are incorporated into the Low FRP even if low hazard conditions are experienced there in the PMF. The line delineating the Low / Very Low boundary is determined by the greater of the 100 year + 0.5m level or PMF hazard thresholds.

If this approach to differentiating Low from Very Low FRPs is accepted, the current definition of the Low FRP will need to be amended (since it may not necessarily extend to the limit of the PMF) and a definition of the Very Low FRP will need to be added to Council's DCP and Section 149 Certificates (see Section 11.3). Table 9 includes provisional definitions.

Summary

Mapped flood risk precincts for the Three Tributaries floodplain are shown in Figure 25. This includes the upgraded FRP for Freeman Avenue.

Council has assessed the number of cadastral lots that intersect each FRP. This is shown in Table 11. Less than 7% of lots within the PMF floodplain are located within High FRPs. The intersection of different land use zones with the four FRPs is considered later in Section 11.3.2. It shows that the High FRP is largely given over to environmental and recreational uses.

Table 9 – Proposed flood risk precincts for the Three Tributaries floodplain

FRP	Description
High	Land below the 100 year flood that is either subject to high hydraulic hazard or where there are significant evacuation difficulties
Medium	Land below the 100 year flood level that is not subject to high hydraulic hazard and where there are no significant evacuation difficulties
Low	Land above the 100 year flood level but below the Probable Maximum Flood (PMF) level *and* where in the PMF there is a significant hazard to children or a moderate-high hazard to buildings; *or* where the elevation is within 0.5m height of the adjacent 100 year flood level
Very Low	Land above the 100 year flood level but below the Probable Maximum Flood (PMF) level; *and* where in the PMF there is a low hazard to children and a low hazard to buildings; *and* where the elevation is not within 0.5m height of the adjacent 100 year flood level

Table 10 – Hydraulic criteria used to help distinguish Low and Very Low flood risk precincts

FRP	PMF depth		PMF velocity		PMF depth-velocity product		Within 100y + 0.5m region
Low	>0.5 m	or	>2 m/s	or	>0.4 m^2/s	or	Yes or No*
Very Low	<0.5 m	and	<2 m/s	and	<0.4 m^2/s	and	No

* Provided the area formed by the addition of 0.5m to the 100 year flood level remains within the PMF floodplain. If the site is not within the PMF floodplain, the land is marked as no flood risk

Table 11 – Number of cadastral parcels for each flood risk precinct

FRP	Number of lots*
High or partly High	519
Medium or partly Medium	906
Low or partly Low	4114
Very Low or partly Very Low	1493
TOTAL	7032

* Only the higher level FRP is counted for each parcel

7.2 CLIMATE CHANGE ASSESSMENT

There is increasing evidence that the earth's atmospheric and ocean temperatures have increased over the last century and that accumulation of greenhouse gases in the earth's environment may accelerate this process. Future climate change can potentially affect flood behaviour through:

- Increased sea levels; and
- Increased severity of storms and other weather systems.

The NSW Government previously advocated sea level rise planning benchmarks for consideration in all coastal and flood hazard assessments. The NSW sea level rise planning benchmarks are an increase above 1990 mean sea levels of 40cm by 2050 and 90cm by 2100. Although the NSW Government has since ceased to advocate these sea level rise planning benchmarks, they remain the best available estimates for accounting for sea level rise due to climate change. However, FloodMit (2011) found that sea level rise alone would have negligible impacts along Prospect Creek. It is inferred then that sea level rise would not affect flooding in the Three Tributaries study area. The effect of sea level rise has therefore not been assessed in this study.

The impact of climate change on rainfall is less certain. The 2014 *State of the Climate* report (CSIRO/BoM, 2014) states that the frequency and intensity of extreme daily rainfall is projected to increase for most regions of Australia. A previous report (CSIRO, 2007) found that extreme rainfall (measured as 1 in 40 year 1 day rainfall) in the Sydney Metropolitan catchments could change from -3% to +12% by 2030, and by -7% to +10% by 2070, though a footnote indicated that these regional results may not be applicable to Sydney.

An assessment of the potential impact of climate change on flooding in the Three Tributaries was undertaken by increasing rainfall intensities by 10%, 20% and 30% for the 100 year ARI event. These tests are recommended in the *Practical Consideration of Climate Change* Floodplain Risk Management Guideline prepared by DECC (2007a). Rainfalls were increased in the RAFTS hydrologic model then the flows were used in the TUFLOW hydraulic model. The sensitivity was modelled for a single storm: the 2-hr in 9-hr embedded storm (using the method of Phillips et al., 1994).

Figure 26 compares the flood extents for each climate change scenario with the existing 100 year ARI event. For the upper Orphan School Creek floodplain, a 10% increase in rainfall intensity would see significantly more extensive inundation of private properties downstream of the Fairfield Golf Course Basin in the vicinity of Mallacoota Street and Bulls Road. In Clear Paddock Creek, there would be more extensive inundation of private properties along the northern side of Basin W3 (Wilson Creek) and more extensive inundation of Gregorace Place (Henty Creek). In Green Valley Creek, a new flood runner would develop from Canley Vale Road to Sappho Street and Craigslea Place. For the lower Orphan School Creek floodplain, a new flood runner would develop from The Boulevarde to Sackville Street and water would also back up upstream of Railway Parade in the vicinity of Stuart Street, Delamere Street and The Avenue.

For the scenario with an increased rainfall intensity of 20%, flooding would reach Prairie Vale Road, downstream of the Mimosa Road Basin. The Fairfield Showground would be extensively flooded. Downstream of the Golf Course Basin, Hay Place would be newly flooded. Flooding of Henty Creek would overtop Elizabeth Drive. For Green Valley Creek floodplain, Homebush Street would be flooded and the flow path from Canley Vale Road to Craigslea Place would be larger. Flooding immediately below the King Park Basin would be significantly more extensive, including in the vicinity of Avoca Road, Amelia Crescent and Goodacre Avenue. The flow path between The Boulevarde and Railway Parade would be substantially wider. Floodwater would reach Canley Vale Road near Sackville Street.

For the scenario with an increased rainfall intensity of 30%, floodwaters would be more extensive in all of the areas mentioned above but especially along the Green Valley Creek floodplain downstream of Chisholm Park Basin and along the Orphan School Creek floodplain downstream of King Park Basin, including Hawkesbury Street, Parklea Parade and Baragoola Street. There would be an extensive flow path between The Boulevarde and Sackville Street, with the flooding continuing down to Railway Parade via The Avenue.

The model results were interrogated to assess changes in flood depths. These would increase by less than 0.1m for the +10% scenario, with the exception of Craigslea Place (Green Valley Creek) and Orphan School Creek immediately downstream of the Golf Course Basin (+0.18m at Bulls Road) and at Railway Parade (+0.28m). For the +20% scenario, flood depths are expected to increase by 0.1-0.2m over the existing 100 year ARI depth for many sites throughout the study area, and by 0.2-0.3m immediately downstream of the Golf Course Basin, and by 0.4m at Railway Parade. For the +30% scenario, flood depths would increase by 0.2-0.3m for many sites, but would increase by almost 0.6m at a low-point in Railway Parade.

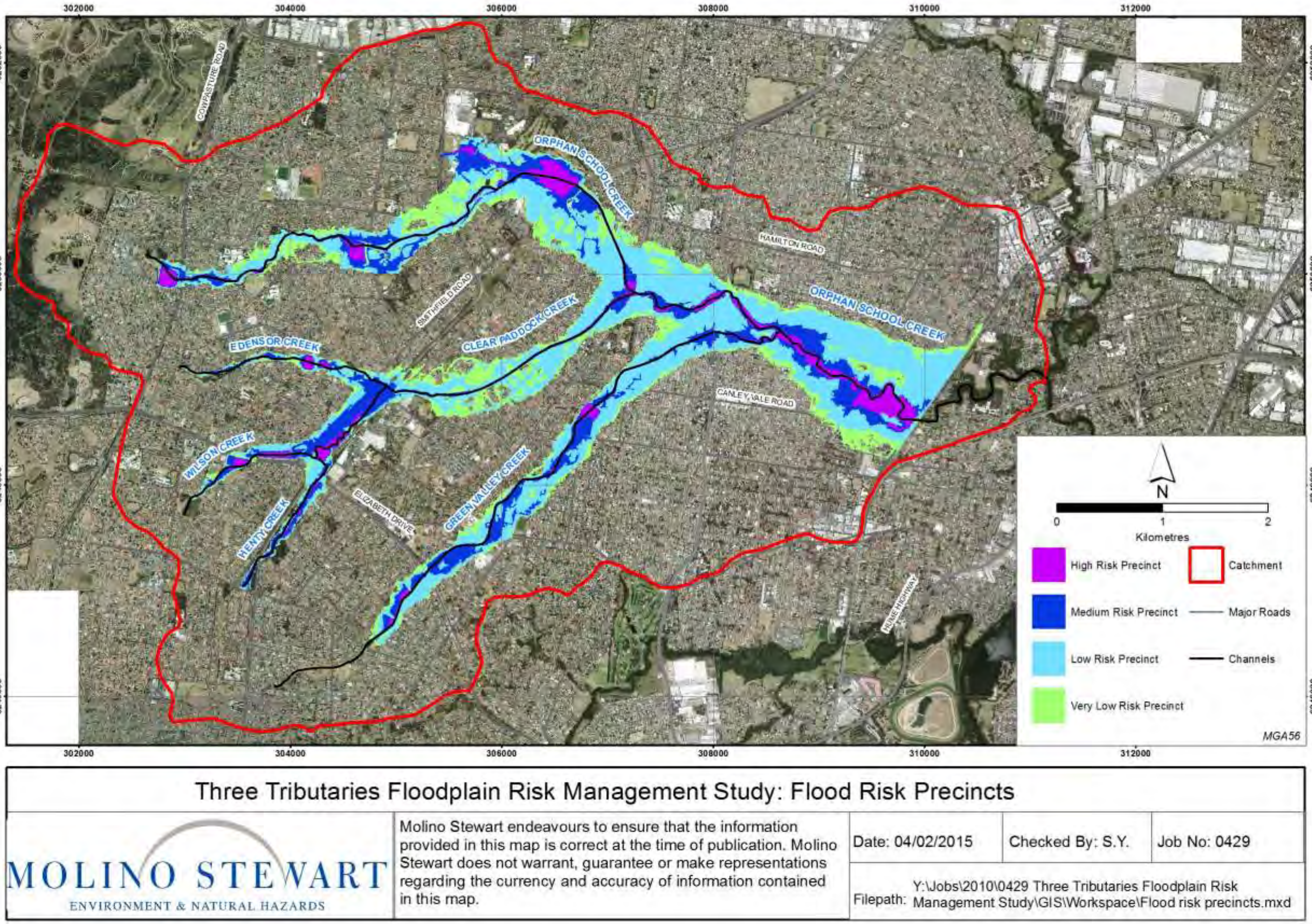


Figure 25 – Flood risk precincts

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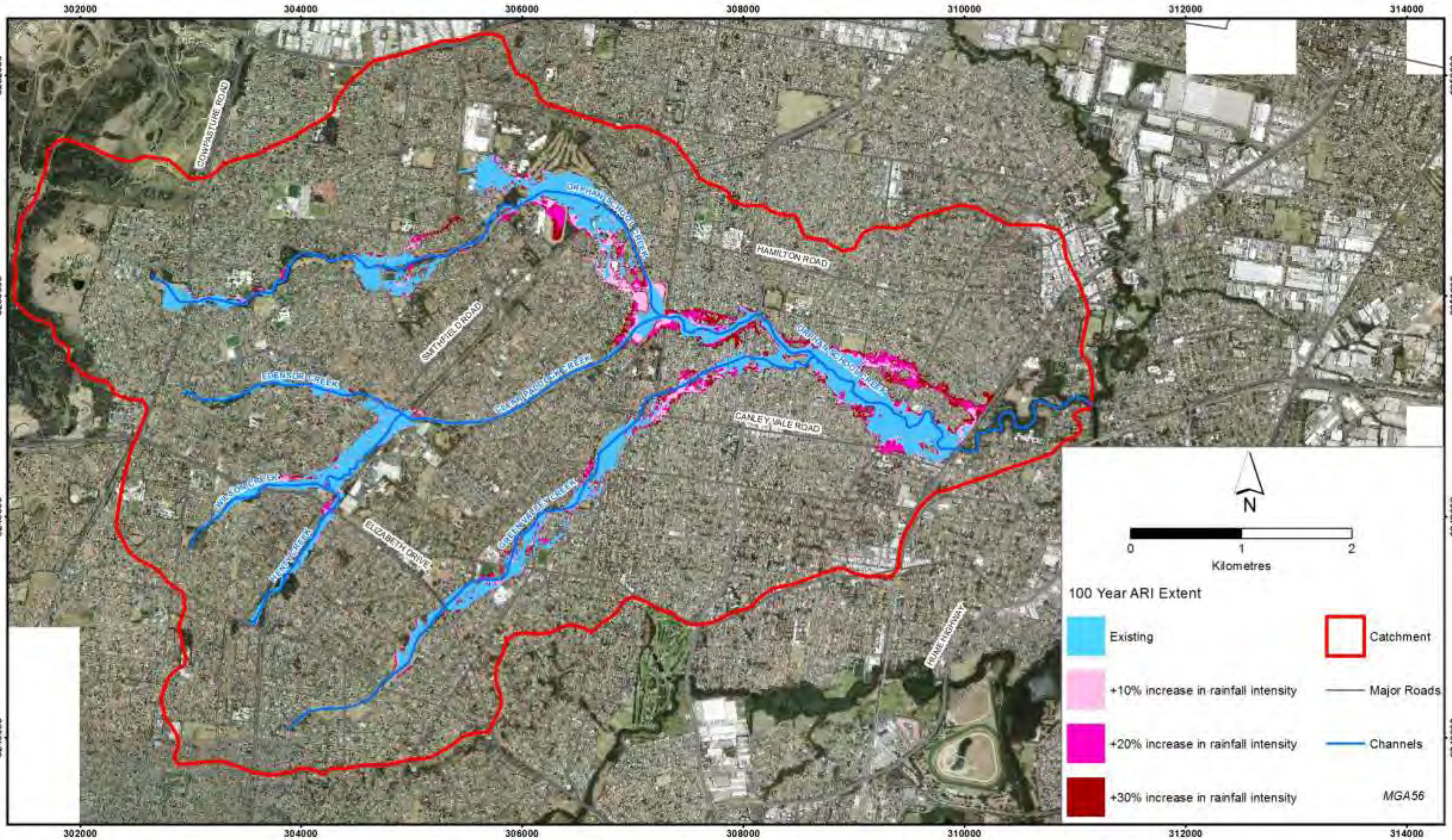

Three Tributaries Floodplain Risk Management Study: Climate Change Scenarios Flood Extents				
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Figure 26 – Flood extents for climate change scenarios

8 DEFINING THE FLOOD PROBLEM

8.1 PROPERTY DATABASE

A property database was prepared to better understand the spatial distribution of building inundation, and to quantify the impacts of flooding in the Three Tributaries study area. This also allows an economic appraisal of floodplain management options.

Based on high resolution 2014 aerial photography and the modelled probable maximum flood (PMF) extent, the database lists details of 4,755 properties with yards potentially affected by flooding up to the PMF.

A list of attributes recorded for each property, together with an explanation of the derivation or source of those attributes, is provided in Table 12.

Ground levels were extracted from the 5m Digital Elevation Model (DEM) used for the TUFLOW flood modelling, in order that the flood levels derived from the model could be directly compared to the ground levels and estimated floor levels. (The existence of higher resolution and more recent terrain data is noted).

Floor levels were surveyed by Council surveyors for buildings located within an early estimate of the 100 year ARI flood extent. However, some surveyed floor levels were spurious – recorded as several 100mm and even more than 1000mm below the flood model ground surface. Consequently a check of the sense of floor heights was made using Google Street View. Some 40% of houses located within the latest modelled 100 year ARI flood extent have surveyed floor levels. Floor levels for another 10% of houses were estimated by applying an adjacent surveyed floor level, such as from the other 'half' of a duplex. Floor levels for the remaining 50% of houses were estimated by adding a floor height to the DEM ground level extracted near the building. The floor heights were estimated using Street View.

For the purpose of deriving floor levels for all remaining buildings out to the PMF extent, it was considered too coarse to apply a global floor height estimate given the significant variation that was observed across the catchment, with higher pier and beam construction for older properties around Canley Vale but lower slab-on-ground construction for newer subdivisions towards the western part of the study area. No obvious 'line' between the older and newer styles was identified, and urban renewal is now seeing slab-on-ground construction anywhere within the catchment on a property by property basis. For this reason, the floor heights for buildings out to the PMF extent were estimated by using Google Street View to sample a few properties within each street, estimating the height between the observed floor level and ground level, and applying the average floor height to all dwellings in each street.

An important input for the assessment of residential flood damages using the OEH Guideline and spreadsheet is the number of stories. This was inspected for all properties within the 100 year ARI flood extent using Google Street View. For properties out to the PMF extent, this was estimated using the shadow profile from recent aerial photography.

OEH's method for assessing residential flood damages requires houses be split into three categories for the application of three different stage-damage curves:

- Single story high set (applied where floor level > 1.5m higher than ground level) (coded '1' in the property database)
- Single storey low set/slab-on-ground (coded '2')
- Two storey (coded '3')

In addition to these, three more categories were derived for smaller floor areas where lower potential damages are expected:

- *Small* single storey high set (applied to units where the garage is at ground level but the unit is on the first storey) (coded ‘4’)
- *Small* single storey low set/slab-on-ground (applied to villas) (coded ‘5’)
- *Small* two storey (applied to townhouses) (coded ‘6’).

For commercial/industrial land uses, the type of activity was split into one of six codes provided by Council for the application of six different stage-damage curves:

- Commercial low (CL)
- Commercial medium (CM)
- Commercial high (CH)
- Industrial low (IL)
- Industrial medium (IM)
- Industrial high (IH)

Floor areas for each business were estimated by a combination of aerial photography and inspection of Street View.

Flood surfaces for the 20 year, 50 year and 100 year ARI floods and the PMF were used to extract flood levels at the tag point of each building in the database.

8.2 BUILDING INUNDATION

Based on the flood depth recorded at the tag point for each property, the numbers of residential and commercial/industrial properties flooded above ground and above floor in each design event are listed in Table 13. Only three dwellings and two commercial/industrial buildings are expected to flood above floor in the 20 year ARI event. For the 100 year ARI event, this increases to 48 dwellings and 16 commercial/industrial premises. There is a very substantial increase in the numbers flooded above floor in the PMF, which is emphasised by Figure 27. A 10% increase in rainfall intensities would be expected to more than double the number of houses flooded above floor level in the 100 year ARI event.

Table 12 – Attributes recorded in property database

Attribute	Source/Comment
Easting/Northing	• Derived from GIS, with digitised points for each main building on a lot based on 2014 aerial photography
Address	• Council • Note: some street numbers are spurious
Zoning	• Council
Land use (residential or commercial/industrial)	• Some from FCC survey • Some from Council's Zoning and Street View
Residential value (small, typical, raised)	• Some from FCC survey • Some from Street View (note: townhouses, villas, duplexes etc were allocated a 'small' value rating)
Commercial value (high, medium, low)	• Some from FCC survey • Some from Street View • Note: based on codes provided by FCC and used for the Georges River FRMS&P
Commercial floor area (m^2)	• Building flood areas estimated using aerial photography and GIS • Street View used to estimate number of premises within building
Construction type (brick, fibro or cladding)	• Some from FCC survey
Number of stories	• Buildings within 100 year ARI extent individually inspected via Street View • Buildings between 100 year ARI and PMF extents estimated from aerial photography
Ground level (m AHD)	• Extracted from 5m DEM used for TUFLOW modelling (provided by WMAwater)
Floor height (m)	• Estimated where surveyed floor levels not provided by FCC survey • Buildings within 100 year ARI extent individually inspected via Street View • Buildings between 100 year ARI and PMF extents estimated by inspection of a few properties within the street or precinct
Floor level (m AHD)	• Some surveyed levels from FCC survey • Many estimated levels based on the addition of a floor height to the ground level
Design flood levels (20 year ARI, 50 year ARI, 100 year ARI, PMF)	• Flood surface grids provided by WMAwater all for the "no fail" scenario

Table 13 – Number of flood affected properties

Event	Residential Properties with Above Ground Flooding	Residential Properties with Above Floor Flooding*	Commercial and Industrial Properties with Above Ground Flooding	Commercial and Industrial Properties with Above Floor Flooding*
20 Year ARI	150	3	10	2
50 Year ARI	267	17	24	10
100 Year ARI	392	48	35	16
100 Year ARI + 10% increase in rainfall intensity#	529	103	53	20
PMF	4,330	3,295	203	189

* These are a subset of those properties with above ground flooding
\# WMAwater (2013b) estimated that this scenario corresponds to a 100 year to 300 year ARI event.

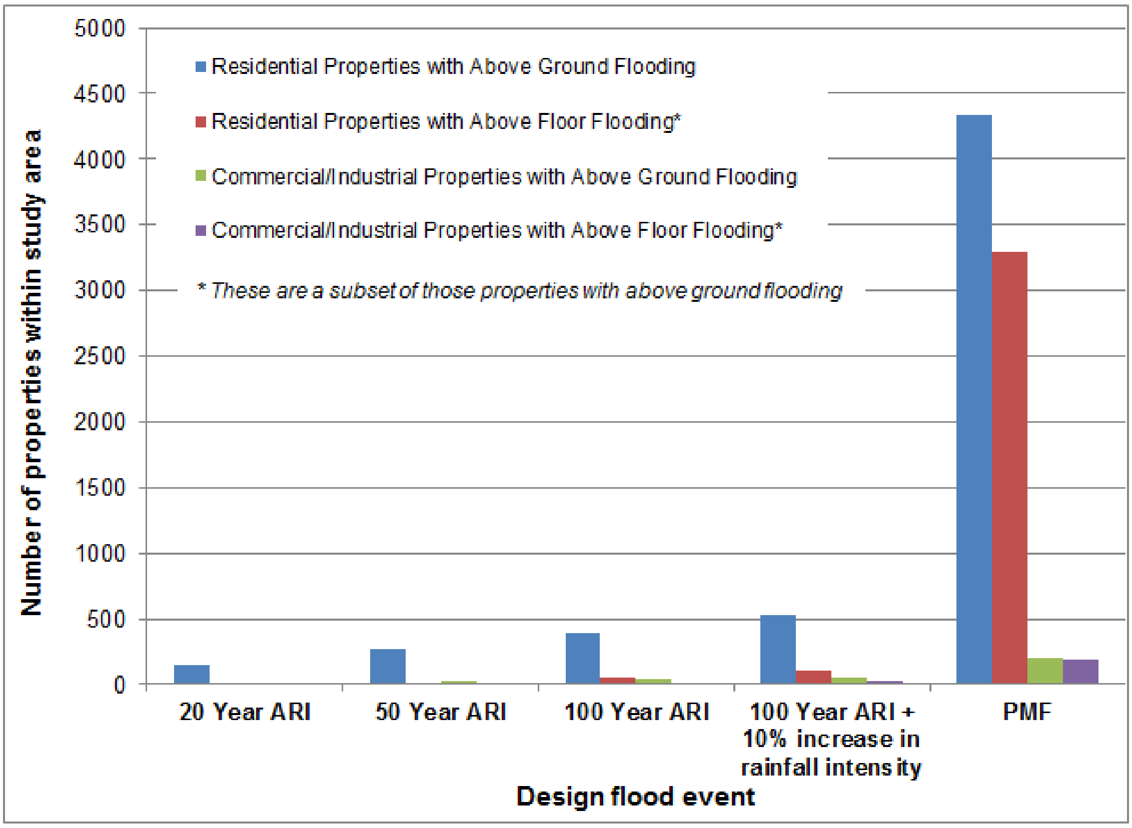


Figure 27 – Flood affectation of properties by design event

The distribution of buildings flooded above floor level is shown in Figure 28. Two out of the three dwellings expected to be inundated in the 20 year ARI event are located immediately upstream of the Brown Street culvert on Henty Creek (a tributary of Clear Paddock Creek).[1] One is located just downstream of Elizabeth Drive adjacent to Green Valley Creek. The 'commercial' buildings flooded in a 20 year event are in fact a shed in Chisholm Park and a scout hall (or similar) at the corner of Prince and Chandos Streets.

About 15 of the dwellings flooded above floor in the 100 year ARI event are located a short distance downstream of the Mimosa Road detention basin, including several townhouses below the Greenfield Shopping Centre and houses in Ripple Close and Falcon Close affected by the same flowpath. Two dwellings in Prairie Vale Road and Donahue Place are expected to be inundated when Prairie Vale basin overtops. Three dwellings in Mallacoota Street would be inundated by water escaping from the Golf Course basin. Two dwellings in Gregorace Place are expected to be flooded from Henty Creek.[2] An additional dwelling would be flooded from Green Valley Creek downstream of Elizabeth Drive. One dwelling in each of Cabramatta Road West and St Johns Road and two dwellings in Fernlea Place are expected to be flooded above floor from Green Valley Creek. Nine dwellings along the Orphan School Creek floodplain between Gladstone and Burdett Streets would be flooded. Some eight dwellings would be flooded above floor in Freeman Avenue. The greatest above floor depth of flooding in the 100 year event is about 0.3m at the Brown Street residence.[3]

Buildings classified as 'commercial' flooded above floor in the 100 year ARI event include the Greenfield Tavern below the Mimosa Road basin, Mary MacKillop College below the Golf Course basin and several businesses along Smithfield Road between Elizabeth Drive and Edensor Road. Council's Sackville Street depot would also be flooded.

About 52 houses are expected to be flooded to severe depths (reaching or exceeding 2m) in the PMF event. Most of these are located a short distance west (upstream) of the Canley Vale-Fairfield Railway, which in the PMF acts as an obstruction to flows travelling across the floodplain. Houses in Cathcart Street, Malabar Street, The Avenue and Railway Parade would be particularly affected by deep floodwater in this extreme event. One house in Hawkesbury Street, Fairfield West, would also be inundated to a depth exceeding 2m, as floodwater backs up from the Cumberland Highway crossing over Orphan School Creek. Houses in Avoca Road near the junction of Orphan School Creek and Green Valley Creek, in Fernlea Place and Cambridge Street upstream of the Cumberland Highway crossing over Green Valley Creek, and in Clarence Street, Duke Street and Freeman Avenue would be flooded above floor to depths exceeding 1.5m.

[1] A detailed investigation by WMAwater (2013b) subsequent to the conclusion of the catchment-wide flood modelling resulted in fine-tuning of the model in this area such that only one of these houses is suspected to be flooded in the 20 year ARI event (but by only 0.02m above floor rather than the 0.17m derived from the catchment model). But the refined local area model – particularly the lowering of the modelled road crest at Brown Road – results in two additional houses being flooded in the 20 year event downstream towards the southern end of Gregorace Place. The surveyed floor level for 12-19 Gregorace Place listed in the WMAwater (2013b) report is believed to be in error. Based on an estimated floor height of 0.4m, added to the DEM used for the flood modelling, yields a floor level there of 42.51m AHD, above the 100 year ARI event.

[2] See previous footnote. The refined modelling shows that six houses in Gregorace Place would be flooded above floor.

[3] See previous footnote. The refined modelling shows that the Brown Road residence is expected to be flooded to a lesser depth of 0.09m above floor whilst above floor depths are expected to reach 0.50m, 0.35m and 0.30m in three Gregorace Place residences.

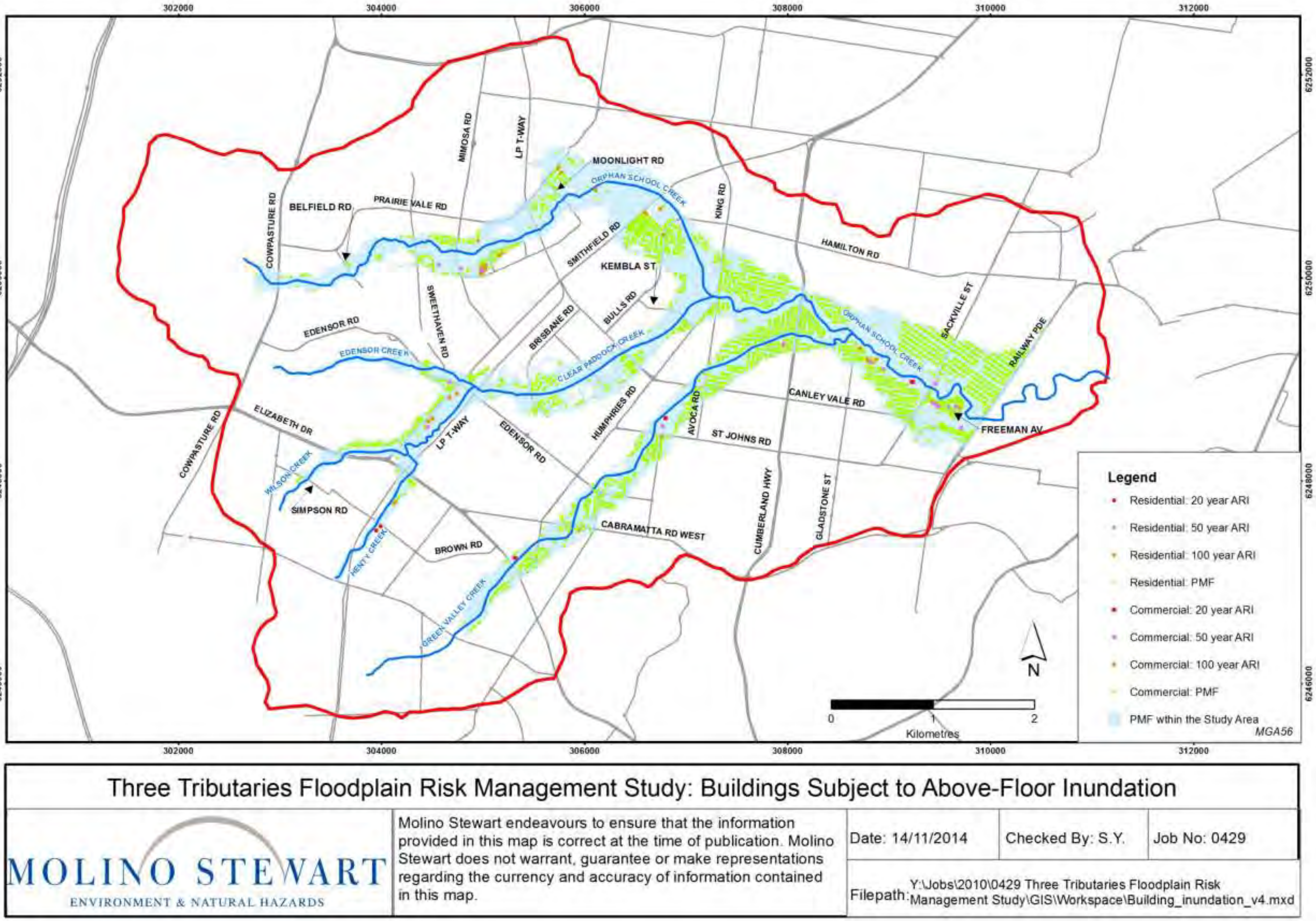


Figure 28 – Distribution of buildings flooded above floor level

8.3 ROAD INUNDATION

An assessment of the frequency and depths of road inundation is important for understanding the risk of vehicles becoming unstable, posing a risk to life for their drivers and passengers, and for understanding evacuation risks, which also informs the classification of communities according to flood emergency response planning considerations.

Figure 29 shows the frequency of road inundation at several major road crossings, as well as at local roads where people could be isolated. Using a WaterRIDE project[1] based on the flood model's 15 minute increments, Table 14 records the time and depth at which each road point is first inundated, as well as the maximum depth of inundation. (Care was taken to ensure the depths over the road surface are real and not reflective of the lower elevations in the DEM from creek channels). Road traffic count data was procured from RMS and FCC, and provides an indication of the importance of each road.

Cumberland Highway would not be flooded in events up to and including the 100 year ARI event. Northbound lanes south of Orphan School Creek would be expected to flood to a depth of about 0.2m in the 100 year plus 10% increase in rainfall intensity climate change scenario, and to a depth of about 1.5m in the PMF. Alarmingly, in the PMF the road would be flooded to a depth of about 0.7m just 45 minutes after the commencement of rain and within 15 minutes of there being no inundation of the road at all (see site 'OS6').

Elizabeth Drive would be flooded to shallow depths from Wilson Creek even in the 20 year ARI event (see site 'CP11'). Given the maximum depth of inundation there is modelled to be 0.17m in the 100 year ARI event, and 0.20m in the 100 year plus 10% increase in rainfall intensity climate change scenario, it might still be trafficable in these events, since velocities are modelled to be 1.1m/s and 1.3m/s respectively, which places the depth-velocity combination below the recommended threshold for instability of small cars (Smith and Cox, 2011).

Cowpasture Road at Orphan School Creek below the Stockdale basin would likely be cut by floodwater in the 50 year ARI event (see site 'OS19').

Edensor Road at Clear Paddock Creek would be inundated in frequent events but would probably still be trafficable in the 100 year ARI event (see site 'CP7').

Carrying about 25,000 vehicles a day, Smithfield Road would be cut between Elizabeth Drive and Edensor Road ('CP9') by floodwaters from Wilson Creek in the 20 year flood.

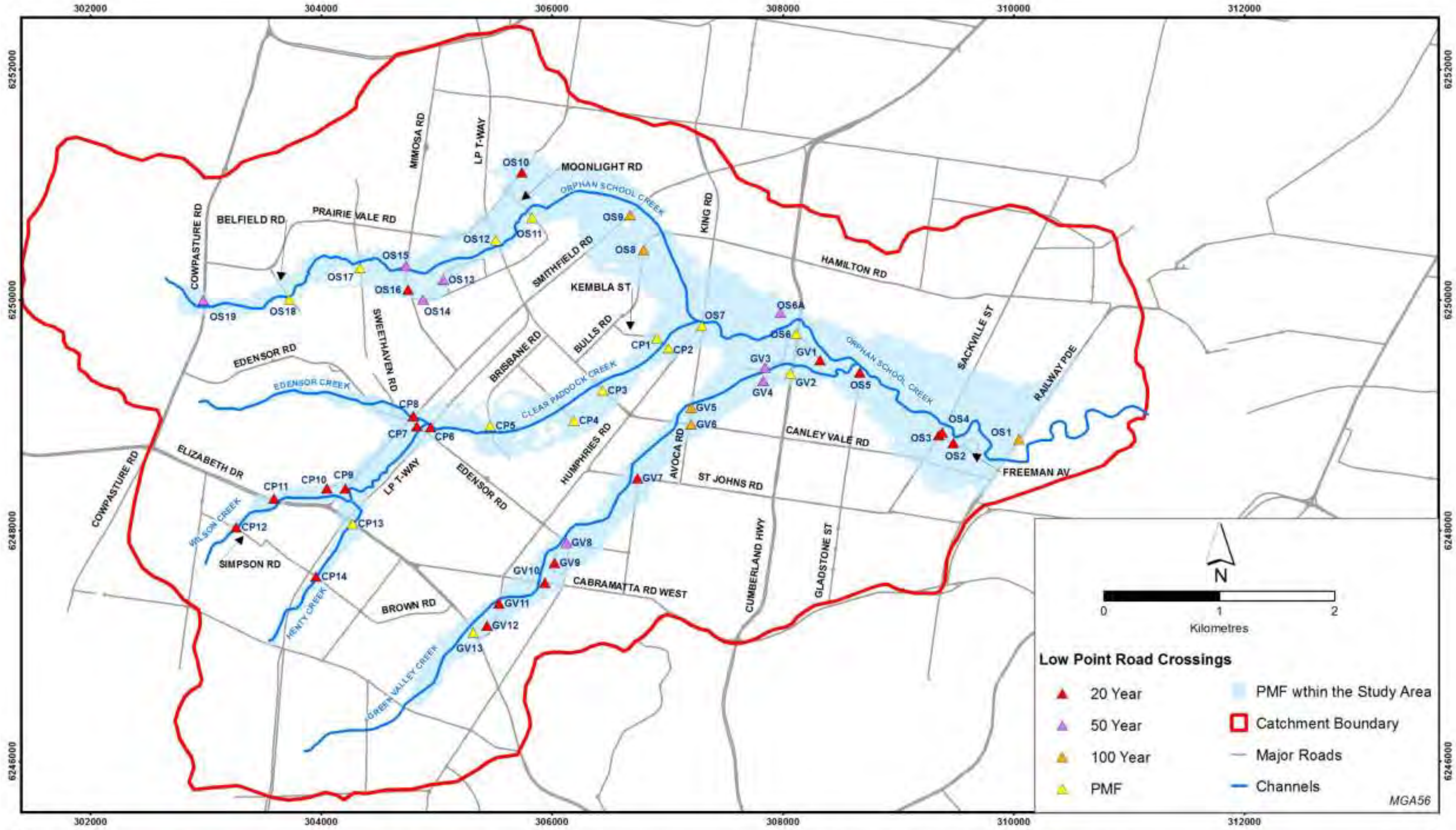
Carrying about 21,000 vehicles a day, Sackville Street would be cut at 'OS3' by floodwaters from Orphan School Creek in the 20 year flood.

Other significant roads to be flooded in the 20 year event but not necessarily to depths that would prevent traffic movements include Cabramatta Road West at Green Valley Creek ('GV10'), Mimosa Road below the basin ('OS16') and Prairie Vale Road below the basin ('OS10').

The Liverpool to Parramatta Transit-way near Edensor Road ('CP6') would be inundated, but could in theory be just trafficable in the 20 year ARI event (since depth < 0.3m and velocity < 0.7m/s), but would not be trafficable in the 50 year event.

A number of houses are isolated in a 20 year event including in Attilio Place ('CP10'), Avonlea Street ('GV1'), Cayley Place ('GV9'), Barook Place ('GV12'), Freeman Avenue ('OS2'), Sackville Street access road ('OS4') and Pitt Street ('OS5'). The areas isolated effectively constitute flood islands, though none of the houses in these streets are expected to be inundated in the 20 year event.

[1] http://www.waterride.net/Manager-Summary.html



Three Tributaries Floodplain Risk Management Study: Roads Subject to Inundation				
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Figure 29 – Frequency of inundation of road low points

Table 14 – Flood risk at road low points

ID (see accompanying figure)	**Creek**	**Road**	**20 year ARI** Time (hrs) first flooded	Depth (m) first flooded	Max depth (m)	**100 year ARI** Time (hrs) first flooded	Depth (m) first flooded	Max depth (m)	**PMF** Time (hrs) first flooded	Depth (m) first flooded	Max depth (m)	**Traffic count** (data for local roads from FCC; data for regional roads from RMS)	**Comment**
CP1	Clear Paddock Creek	Kembla Street	na	na	na	na	na	na	0.5	0.64	1.62	Kembla St, west of Humphries Rd Annual Average Daily Traffic (AADT) **1458** vehicles in Feb-2002	
CP2	Clear Paddock Creek	Kembla Street	na	na	na	na	na	na	0.5	0.57	1.41	Kembla St, west of Humphries Rd AADT **1458** vehicles in Feb-2002	
CP3	Clear Paddock Creek	Canley Vale Road	na	na	na	na	na	na	0.5	0.07	1.12	Not Available	
CP4	Clear Paddock Creek	Cnr Melbourne/ Canberra Streets	na	na	na	na	na	na	1	1.14	1.11	Canberra St near house no. 11A AADT **1657** vehicles in May-2011 and Melbourne Rd near no. 52 Glenroy Cr AADT **6324** vehicles in May-2011	Not the lowest point
CP5	Clear Paddock Creek	Brisbane Road	na	na	na	na	na	na	0.75	0.69	1.17	Brisbane Rd, between Brunswick Cres and Kedron PL AADT **2867** vehicles in Aug-2012	
CP6	Clear Paddock Creek	T-Way	5.25	0.22	0.26	5	0.18	0.44	0.75	1.5	1.49	Not Available	
CP7	Clear Paddock Creek	Edensor Road	5.25	0.07	0.07	5	0.07	0.18	0.5	0.04	0.98	Edensor Rd east of Smithfield Rd AADT **25195** vehicles in May-2005	
CP8	Clear Paddock Creek	Smithfield Road	4.75	0.07	0.16	4.75	0.13	0.18	0.5	0.38	0.66	Smithfield Rd at Fitzgerald Ave AADT **24518** vehicles in Jul-2010	
CP9	Clear Paddock Creek	Smithfield Road	4.75	0.12	0.39	3.75	0.13	0.55	0.5	1.34	1.54	Smithfield Rd at Fitzgerald Ave AADT **24518** vehicles in Jul-2010	
CP10	Clear Paddock Creek	Attilio Place	4.75	0.06	0.27	4.75	0.06	0.36	0.5	1.21	1.25	Not Available	Isolates 20y flood island (18 houses)
CP11	Clear Paddock Creek	Elizabeth Drive	5	0.12	0.13	4.75	0.15	0.17	0.5	0.83	0.86	Elizabeth Dr west of Bonnyrigg Ave AADT **37955** vehicles in Nov 2014 (combined directions)	
CP12	Clear Paddock Creek	Simpson Road	4.5	0.18	0.43	4.5	0.32	0.52	0.25	0.77	1.40	Simpson Rd, between Wilson Rd and Aplin Rd AADT **2039** vehicles in Aug-2007	
CP13	Clear Paddock Creek	Elizabeth Drive	na	na	na	na	na	na	0.5	1.14	1.61	Elizabeth Dr west of Bonnyrigg Ave AADT **37955** vehicles in Nov 2014 (combined directions)	
CP14	Clear Paddock Creek	Brown Road	4.75	0.11	0.11	4.75	0.23	0.24	0.25	0.37	0.94	Brown Rd, between Holdin St and Gemalla St AADT **7039** vehicles in Nov-2000	
GV1	Green Valley Creek	Avonlea Street	5.25	0.27	0.27	5	0.34	0.39	0.5	0.55	1.90	Avonlea St AADT **271** vehicles in Jun-2009	Isolates 20y flood island (10 houses)
GV2	Green Valley Creek	Cumberland Highway	na	na	na	na	na	na	0.5	0.38	1.72	Cumberland Hwy at Green Valley Creek AADT **38917** vehicles in Sep-2011 (combined directions)	
GV3	Green Valley Creek	Chelsea Drive	na	na	na	5	0.11	0.33	0.5	0.73	1.88	Not Available	Not lowest point on road but imp't local intersection
GV4	Green Valley Creek	Craigslea Place	na	na	na	5.25	0.21	0.42	0.5	1.2	2.69	Craigslea Place AADT **156** vehicles in Aug-2007	Isolates 50y flood island (16 houses)
GV5	Green Valley Creek	Avoca Road	na	na	na	5.75	0.15	0.23	0.5	0.72	1.58	Avoca Rd, between Canley Vale Rd and Humphries Rd AADT **9200** vehicles Jun-2010	
GV6	Green Valley Creek	Canley Vale Road	na	na	na	5.5	0.05	0.06	0.5	0.09	0.80	Canley Vale Rd, between Andrew Ave and Avoca Rd AADT **15992** vehicles in Jun-2010	
GV7	Green Valley Creek	St Johns Road	5	0.25	0.25	4.75	0.22	0.37	0.5	0.79	1.22	St Johns Rd, between Humphries Rd and Harrington St AADT **11368** vehicles Jun-2004	
GV8	Green Valley Creek	Edensor Road	na	na	na	4.75	0.06	0.16	0.5	0.7	1.10	Not Available	
GV9	Green Valley Creek	Cayley Place	5	0.26	0.31	4.75	0.01	0.46	0.5	0.75	1.12	Not Available	Isolates 20y flood island (14+ houses)
GV10	Green Valley Creek	Cabramatta Road West	5	0.16	0.16	4.75	0.18	0.18	0.5	0.36	0.55	Cabramatta Rd West east of Elizabeth Dr AADT **15659** vehicles in Apr-2005	
GV11	Green Valley Creek	Humphries Road	5	0.01	0.28	4.75	0.4	0.48	0.5	1.04	1.37	Humphries Rd near King Park Public School AADT **5783** vehicles in Nov-2001	Near entrance to Mounties Club

ID (see accompanying figure)	Creek	Road	20 year ARI			100 year ARI			PMF			Traffic count (data for local roads from FCC; data for regional roads from RMS)	Comment
			Time (hrs) first flooded	Depth (m) first flooded	Max depth (m)	Time (hrs) first flooded	Depth (m) first flooded	Max depth (m)	Time (hrs) first flooded	Depth (m) first flooded	Max depth (m)		
GV12	Green Valley Creek	Barook Place	5	0.31	0.30	4.75	0.34	0.39	0.5	1.34	1.51	Not Available	Isolates 20y flood island (10+ houses)
GV13	Green Valley Creek	Elizabeth Drive	na	na	na	na	na	na	0.5	1.54	1.62	Elizabeth Dr west of Bonnyrigg Ave AADT **37955** vehicles in Nov 2014 (combined directions); Elizabeth Dr at Cabramatta Creek Bridge AADT **44567** vehicles in Nov 2014 (combined directions)	
OS1	Orphan School Creek	Railway Parade	na	na	na	6.25	0.11	0.10	0.75	0.71	2.37	Railway Parade, north of Pevensey St AADT **11189** vehicles in Aug-2002	
OS2	Orphan School Creek	Freeman Avenue	5.25	0.22	0.80	5	0.32	1.12	0.75	1.37	2.43	Not Available	Isolates a major 20y flood island
OS3	Orphan School Creek	Sackville Street	5.25	0.26	0.37	5	0.14	0.60	0.75	0.42	2.00	Sackville St north of Queen St AADT **20774** vehicles in Feb-2008	
OS4	Orphan School Creek	Sackville Street access road	5	0.28	0.69	5	0.73	0.89	0.5	0.17	2.22	Not Available	Isolates a 20y flood island (4 houses)
OS5	Orphan School Creek	Pitt Street	5	0.29	0.52	4.75	0.32	0.75	0.5	0.86	2.33	Not Available	Isolates a 20y flood island (5 houses)
OS6	Orphan School Creek	Cumberland Highway	na	na	na	na	na	na	0.75	0.74	1.54	Cumberland Hwy at Canley Vale AADT **38774** vehicles in Jan-2014 (combined directions)	
OS6A	Orphan School Creek	Hawkesbury Street	na	na	na	5.25	0.34	0.44	0.5	0.80	2.99	Not Available	
OS7	Orphan School Creek	King Road	na	na	na	na	na	na	0.5	0.73	2.27	Avoca Rd/King Rd, between Canley Vale Rd and Humphries Rd AADT **9200** vehicles in Jun-2010	
OS8	Orphan School Creek	Bulls Road	na	na	na	6.25	0.15	0.17	0.75	0.83	1.04	Not Available	
OS9	Orphan School Creek	Smithfield Road	na	na	na	5.25	0.01	0.56	0.5	0.11	1.63	Not Available	
OS10	Orphan School Creek	Prairie Vale Road	4.75	0.14	0.17	4.75	0.36	0.34	0.25	0.28	0.74	Prairie Vale Rd, between Canley Vale Rd and Humphries Rd AADT **11970** vehicles in Oct-2009	
OS11	Orphan School Creek	Moonlight Road	na	na	na	na	na	na	0.5	0.37	0.94	Moonlight Rd between Prairie Vale Rd and Greenfield Rd AADT **799** vehicles in Aug-2011	
OS12	Orphan School Creek	T-Way	na	na	na	na	na	na	0.75	0.6	0.86	Not Available	
OS13	Orphan School Creek	Devenish Road	na	na	na	5.75	0.42	0.40	0.75	0.96	1.06	Not Available	Affects access to childcare centre
OS14	Orphan School Creek	Greenfield Road	na	na	na	5.25	0.24	0.32	0.5	0.02	0.88	Greenfield Rd at Devenish St AADT **6761** vehicles in Jun-2003	Adjacent to shopping centre
OS15	Orphan School Creek	Mimosa Road	na	na	na	5	0.27	0.57	0.5	1.25	1.48	Mimosa Rd between Smithfield Rd and Hornet St AADT **12442** vehicles in Feb-2010	
OS16	Orphan School Creek	Mimosa Road	5.5	0.04	0.08	5	0.24	0.27	0.5	0.53	0.80	Mimosa Rd between Smithfield Rd and Hornet St AADT **12442** vehicles in Feb-2010	
OS17	Orphan School Creek	Sweethaven Road	na	na	na	na	na	na	0.5	0.62	0.85	Sweethaven Rd at Allambie Rd AADT **3386** vehicles in Sep-2009	
OS18	Orphan School Creek	Belfield Road	na	na	na	na	na	na	0.5	0.31	0.50	Belfield Rd, between Prairie Vale Rd and Allambie Rd AADT **3132** vehicles in Jun-2009	
OS19	Orphan School Creek	Cowpasture Road	na	na	na	5.25	0.24	0.25	0.5	0.69	0.70	Cowpasture Rd at Orphan School Creek AADT **33608** in Apr-2005 and **28355** in Dec-2009	

Note: AADT = annual average daily traffic; na = not applicable

The duration of road inundation is generally expected to be relatively short (a few hours), though increasing with flood magnitude. This is evident in design flood hydrographs showing the flow crossing Sackville Street (excluding channel flows) (Figure 30), with a duration of road flooding of less than 2 hours for the 20 year event but approaching 3 hours for the 100 year event.

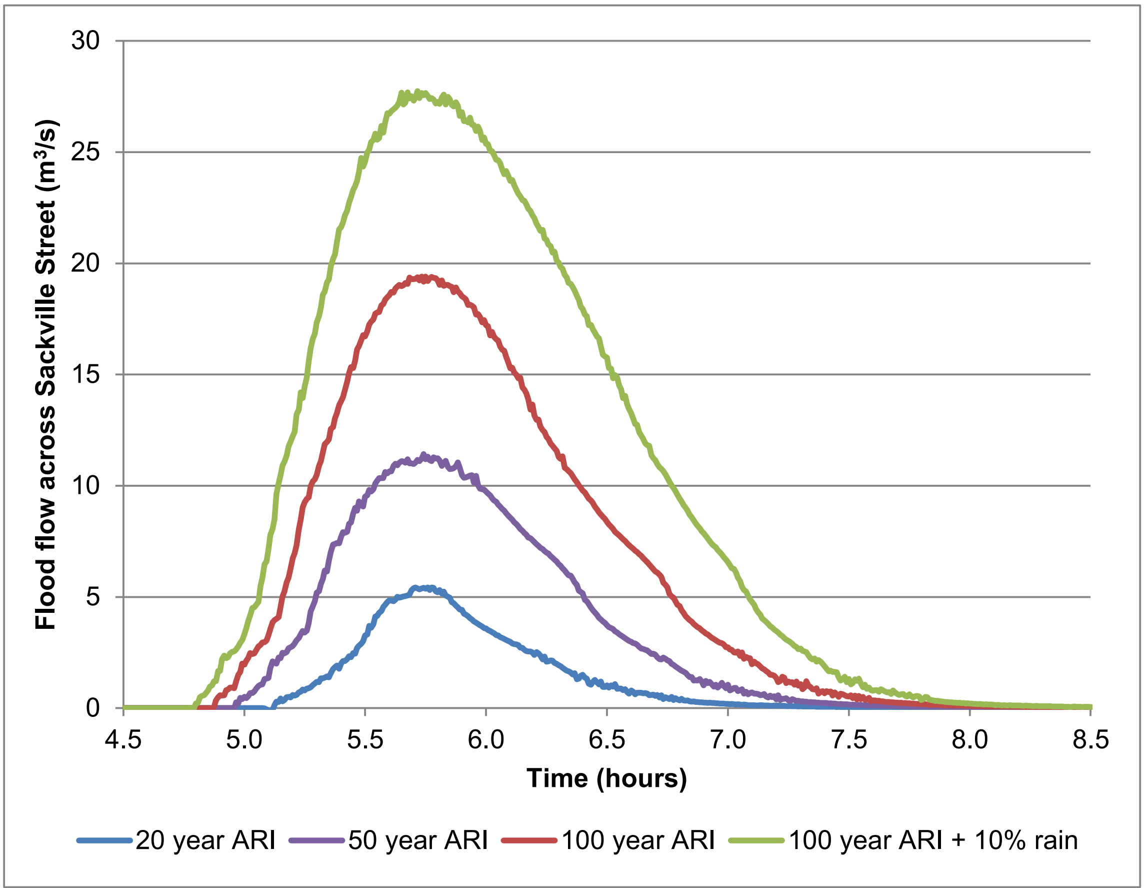


Figure 30 – Design flood hydrographs for floodwater crossing Sackville Street

8.4 EVACUATION HOT SPOTS

Attention is given to the flood emergency response planning (ERP) classification of communities set out in the *Flood Emergency Response Planning Classification of Communities* Floodplain Risk Management Guideline (DECC, 2007b). Building on the previous sections dealing with building and road inundation, this section summarises flood risk 'hot spots' based particularly on the difficulty of evacuation. These hot spots are mapped in Figure 31.

8.4.1 Clear Paddock Creek

a) Gregorace Place

Unless overland flows travelling down Somers Street are problematic, houses in Gregorace Place are expected to have 'Rising Road Access' in the 100 year ARI Henty Creek flood. In a PMF, Gregorace Place would be flooded, houses on its western side would be inundated (in a 'Low Flood Island' setting) and houses on its eastern side would be isolated (i.e. become a 'High Trapped Perimeter').

b) Attilio Place

Modelling shows floodwater from Wilson Creek escaping basin W3 and flowing along Attilio Place, Edensor Park, even in the 20 year ARI flood (to a depth of 0.3m), from 4.75 hours after the start of the storm. About 17 properties would be isolated (7 'High Flood Island', 10 'High Trapped Perimeter') and one would be inundated (not above floor). The PMF would reach a depth of about 1.3m in the street.

c) Smithfield Road

Smithfield Road between Elizabeth Drive and Edensor Road would be extensively flooded even in the 20 year ARI event (from the 5.0 hour mark), isolating some 15 residential properties and several businesses and institutions. Flooding is unsurprisingly deeper and more extensive in the 100 year ARI event, isolating more houses.

d) Edensor Road

Significant flooding of Edensor Road near the corner of Smithfield Road is observed in the 20 year ARI event. A number of properties would be inundated from the 5.0 hour mark, including the car park at Fred's Supermarket. Some 50 residential properties could be isolated by flooding of the roads. Floodwater in Edensor Road west of Smithfield Road is only slightly deeper in the 100 year flood.

8.4.2 Green Valley Creek

a) Humphries Road area

Inundation of a low-point in Barook Place isolates about 10 houses even in the 20 year ARI event. Floodwater then continues in a north-east direction along Barook Place and Humphries Road before rejoining Green Valley Creek, in the process isolating about 21 houses in Barook Place, Humphries Road and Fig Place, though relatively shallow depths suggest that access might be possible.

Some of the isolated properties would be flooded, or party-flooded, in the 20 year event, others in the 100 year event, and all would be flooded in the PMF, most above floor.

Six residential properties in Kewin Avenue and Young Street would be isolated in the 100 year flood. Highly hazardous conditions are expected at some of these properties in the PMF, based on the criteria for pedestrian stability set out in Smith and Cox (2009), with modelling showing a flow path cutting across from Barook Place to the corner of Kewin Avenue and Young Street.

The Humphries Road entrance to Mounties Club would be flooded in the 20 year event (see low point 'GV11' in Table 14). Much of the western car park, and the tennis courts, would be flooded in the 100 year event. It is possible that part of the main Club complex would be flooded above floor in the PMF (floor heights were assumed).

There is a solid wall along the Kewin Avenue and Young Street boundary to Mounties that evidently was not included in the catchment-wide Flood Study. This could potentially obstruct floodplain flows in the 50 year ARI and rarer floods, resulting in flooding on Kewin Avenue (and adjacent properties) that would be deeper than what the model suggests.

b) Cayley Place area

In the 20 year ARI event, floodwater breaks out of Green Valley Creek upstream of Cabramatta Road West at the 4.75 hour mark, crossing the road and cutting through properties to enter Cayley Place, where inundation of a low point isolates about 14 houses. Floodwater reaches a depth of about 0.5m in the Cayley Place cul-de-sac.

The flowpath described above would be highly hazardous in the PMF. It continues across Meadows Road, Moonshine Avenue, Edensor Road and along Katrina Crescent before rejoining the creek.

There would be a sizeable Low Flood Island, though the hazard at the centre of the flooded island would be low.

c) Harrington Street Public School

Part of the grounds of the Harrington Street Public School are inundated, or surrounded by shallow floodwater, in the 100 year ARI event. By the 45 minute mark of the PMF, the school would be inundated by highly hazardous floodwaters, based on the criteria for pedestrian stability set out in Smith and Cox (2009). Some buildings might be above the PMF (floor heights were assumed).

d) Avoca Road area

In the 100 year ARI event, floodwater from Green Valley Creek breaks out into the cul-de-sac of Ruth Street (depth 0.3m) isolating five or so houses. A shallow flowpath continues across Canley Vale Road, north along Avoca Road and into Coolibar Street, but would not be of sufficient depth to isolate the El Cortez Hotel. In the PMF, highly hazardous flooding would affect some areas.

e) Craigslea Place and Fernlea Place

Low point ‘GV4’ on Craigslea Place is expected to be inundated but still trafficable in the 50 year ARI event. By the 100 year event, about 16 houses would be isolated by a depth of 0.4m (Table 14).

Modelling shows that floodwater would pond to a depth of up to 0.8m in the Fernlea Place cul-de-sac in the 20 year ARI event, isolating some 7 houses. Depths could reach about 1.3m in the 50 year event and 1.5m in the 100 year event, though even in the 100 year event, only low hazard conditions are experienced on the private properties.

In the PMF, both Craigslea Place and Fernlea Place rapidly become highly hazardous to pedestrians prior to the conditions also becoming highly hazardous at many houses in the streets.

f) Avonlea Street

In the 20 year ARI event, floodwater breaks out of Green Valley Creek into the end of Avonlea Street and continues into Orphan School Creek, isolating about 10 houses. In the PMF, much of Avonlea Street would be subject to highly hazardous flooding within an hour of the commencement of the storm.

8.4.3 Orphan School Creek

a) Downstream Mimosa Road basin

In the existing 100 year ARI event, from the modelled 5.0 hour mark, floodwater from the Mimosa Road basin would spill across Comanche Road on the northern side of the basin, isolating about 6 properties in Comanche Road, 15 properties in Yuma Place and 8 in Mohave Place. Floodwater would cross Mimosa Road and inundate Aberdeen Street, isolating 1 property in Mimosa Road, 20 properties in Brahma Close (though an Overland Escape Route is available there), 5 properties in Aberdeen Street and 9 properties in Ayrshire Street.

The car park for Greenfield Shopping Centre is expected to be flooded in a 100 year ARI event to depths of up to 0.4m, mobilising vehicles. Patrons of the shopping centre[1] could be trapped inside (effectively a ‘High Flood Island’), but the shopping centre could be inundated if floodwater continues to rise (dangerous ‘Low Flood Island’ setting).

[1] WMAwater (2013) reckoned that the Population at Risk within the shopping centre is 800 persons.

The car park for St Hurmizd's Cathedral is also expected to be flooded in the 100 year event, and many of the townhouses downstream are expected to be flooded above floor.

This floodwater would continue as a flowpath down Devenish Street, isolating a childcare centre at 63 Devenish Street and 12 houses. Another flowpath forms through Ripple Close and crosses into Falcon Close, inundating two houses above floor and isolating 13 properties in Ripple Close, 13 in Falcon Close and 15 in Hair Close. Some 16 houses in the block formed by Devenish Street, Ripple Close and Falcon Close are effectively 'High Flood Island' in the 100 year flood but would be inundated above floor in the PMF ('Low Flood Island').

b) Downstream Prairiewood basin

In the existing 100 year ARI event, from the 4.75 hour mark, floodwater from the Prairiewood basin would spill across Prairie Vale Road and flow down Christie Street, Donahue Close and Moonlight Road. Depths are modelled to be relatively shallow, but possibly up to 12 properties in Prairie Vale Road, 12 in Christie Street, 23 in Donahue Close and 12 in Moonlight Road could be isolated.

Even in the PMF event (assuming the basin does not fail), modelled depths in this area do not exceed about 0.5m.

c) Downstream Golf Course basin

In the existing 100 year ARI event, from the 5.25 hour mark, floodwater from the Golf Course basin would spill across Smithfield Road and inundate Mary MacKillop College and properties in Mallacoota Street to shallow depths (less than 0.3m). Flows would continue down Bulls Road and Esperance Crescent before rejoining Orphan School Creek. Several houses would effectively be 'High Flood Island' in the 100 year flood, as would be Wakeley Shopping Centre at the corner of Bulls Road and Lomond Street.

Flood depths in the PMF are modelled to exceed 1.6m at the intersection of Bulls Road and Richards Road. A significant PMF flow path is seen along McPherson Street, the southern end of Brockman Street, the eastern end of Richards Road and Bulls Road, entering the King Road basin from the direction of Innisfail Road.

d) Downstream of Orphan School Creek and Green Valley Creek junction

Pitt Street is cut at Gladstone Street from the rest of Canley Heights, even in the existing 20 year ARI flood (see 'OS5' in Figure 29 and Table 14). Five residential properties are isolated in this event ('High Flood Island'). Two would be inundated in the 100 year event (not above floor) and all five would be subject to high hazard floodwater in the PMF.

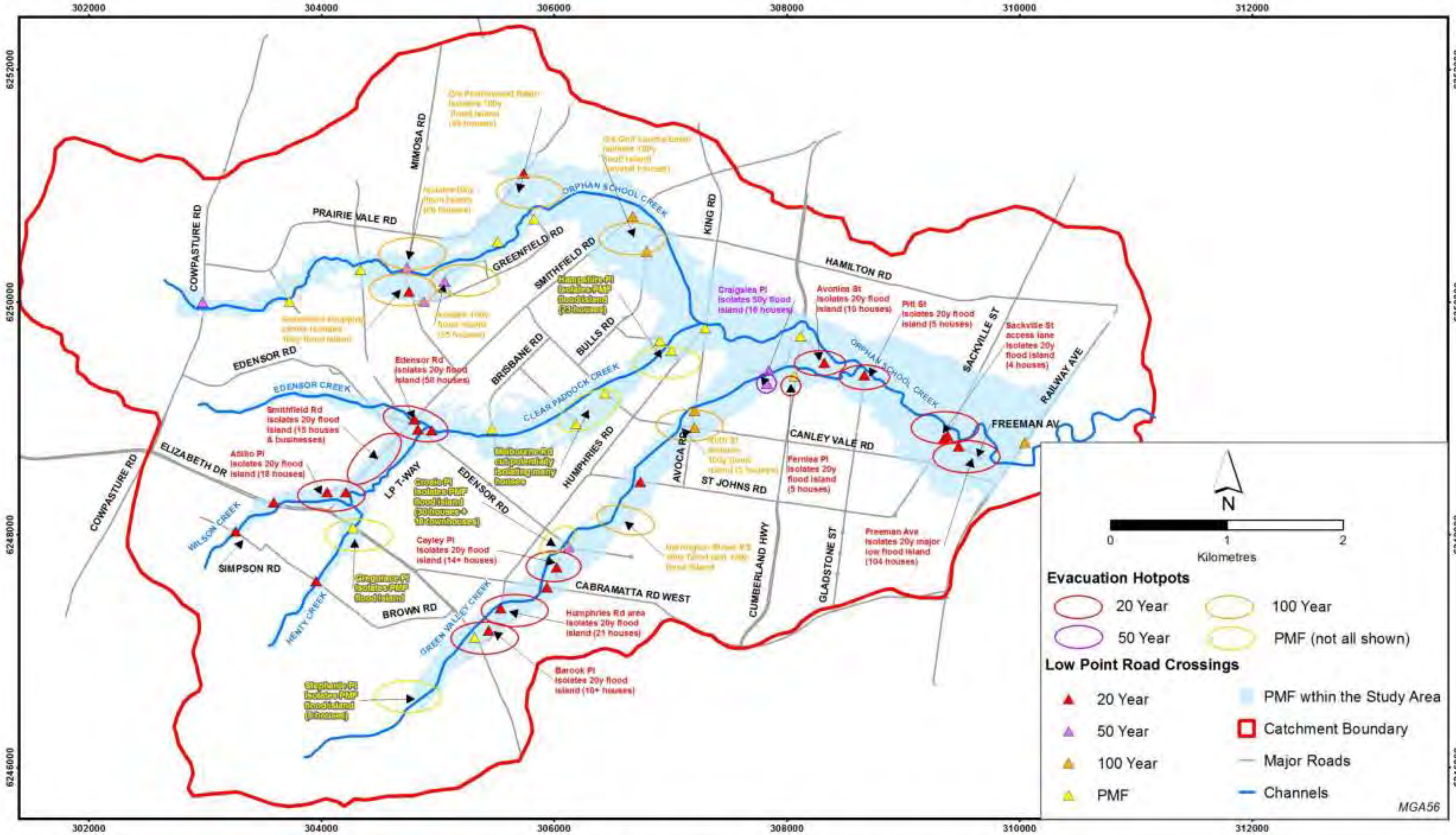
Other streets between Pitt Street and Sackville Street appear to have 'Rising Road Access' to the south and west, for all modelled flood magnitudes.

There is an access road servicing four properties on the downstream side of the right hand (southern) bank at the Sackville Street Bridge, which is flooded from the 4.75 hour mark in the 20 year flood iteration. Effectively these properties are 'Low Flood Islands' in the 20 year flood, since access is lost before inundation of the properties. However, only in the PMF iteration are these houses flooded above floor (to depths of up to about 1.2m), so taking floor levels into account, the dwellings represent 'High Flood Islands' up to and including the 100 year event.

e) Freeman Avenue

Freeman Avenue represents the most significant risk exposure within the Three Tributaries catchment, in part because it is serviced by a single road that is cut in frequent events (Figure 32). Although there is also a pedestrian walkway from near the Canley Vale nursing home to Canley Vale Road, this too is subject to frequent flooding (Figure 33). This loss of access in frequent floods is particularly concerning given the location of a nursing home at 43 Freeman Avenue, with 98 beds and many staff. Currently, ambulances would be unable to access the site during floods. Even excluding this site, recent intensification of land use means that some 91 dwellings (including Housing Commission and Seniors' Living accommodation) are located east of the road low point, which using the average household size from the Census translates to 282 persons. Figure 30 suggests that access would be lost for at least 2–3 hours during significant floods, and it would likely take longer for water to drain away from the Freeman Avenue low-point.

Much of Freeman Avenue is therefore classified as a 'Low Flood Island' in the 20 year event (though no floors are expected to be flooded in that event). However, the Seniors Living units at 31-41 Freeman Avenue and the neighbouring nursing home are not shown as flooded in the existing 100 year event (= 'High Flood Island'), but would be inundated above floor level in the PMF (= 'Low Flood Island'). In the case of the nursing home, above-floor flood depths could reach about 0.4m.



Three Tributaries Floodplain Risk Management Study: Evacuation Hotspots				
MOLINO STEWART ENVIRONMENT & NATURAL HAZARDS	Molino Stewart endeavours to ensure that the information provided in this map is correct at the time of publication. Molino Stewart does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.	Date: 05/12/2014	Checked By: S.Y.	Job No: 0429
		Filepath: Y:\Jobs\2010\0429 Three Tributaries Floodplain Risk Management Study\GIS\Workspace\Evacuation hotspots.mxd		

Figure 31 - Evacuation hot spots

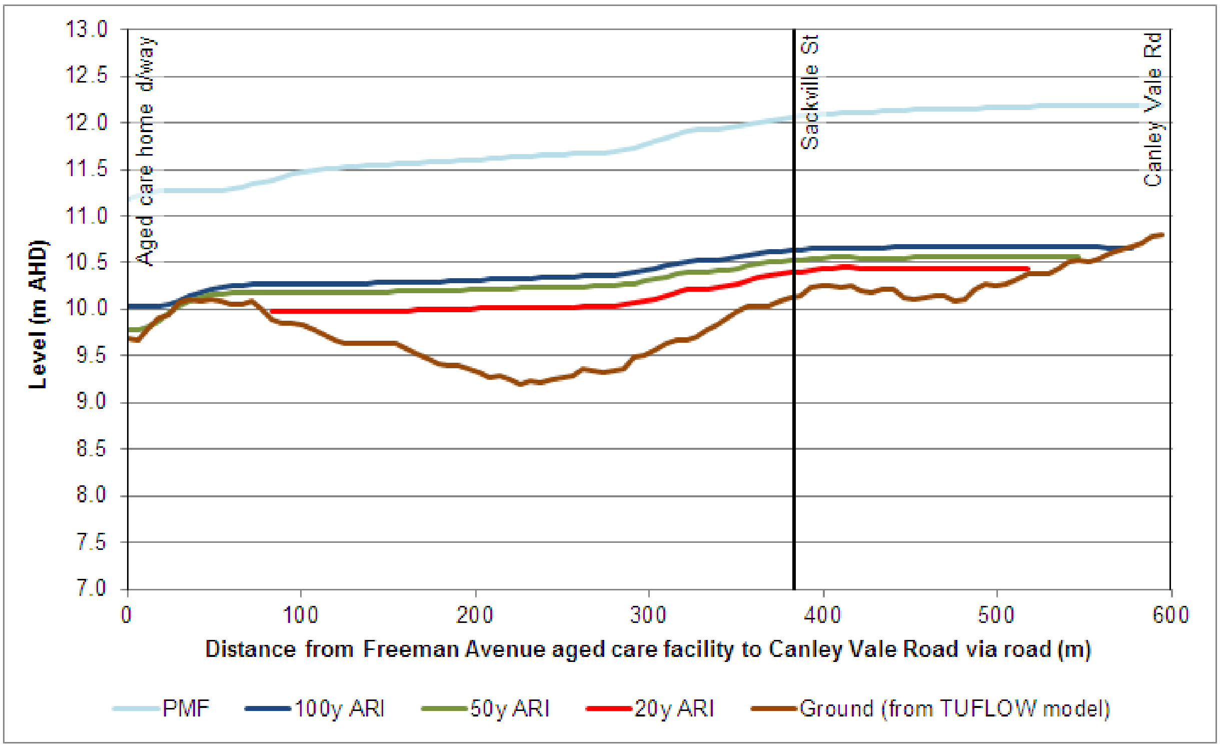


Figure 32 – Flood profile along Freeman Avenue

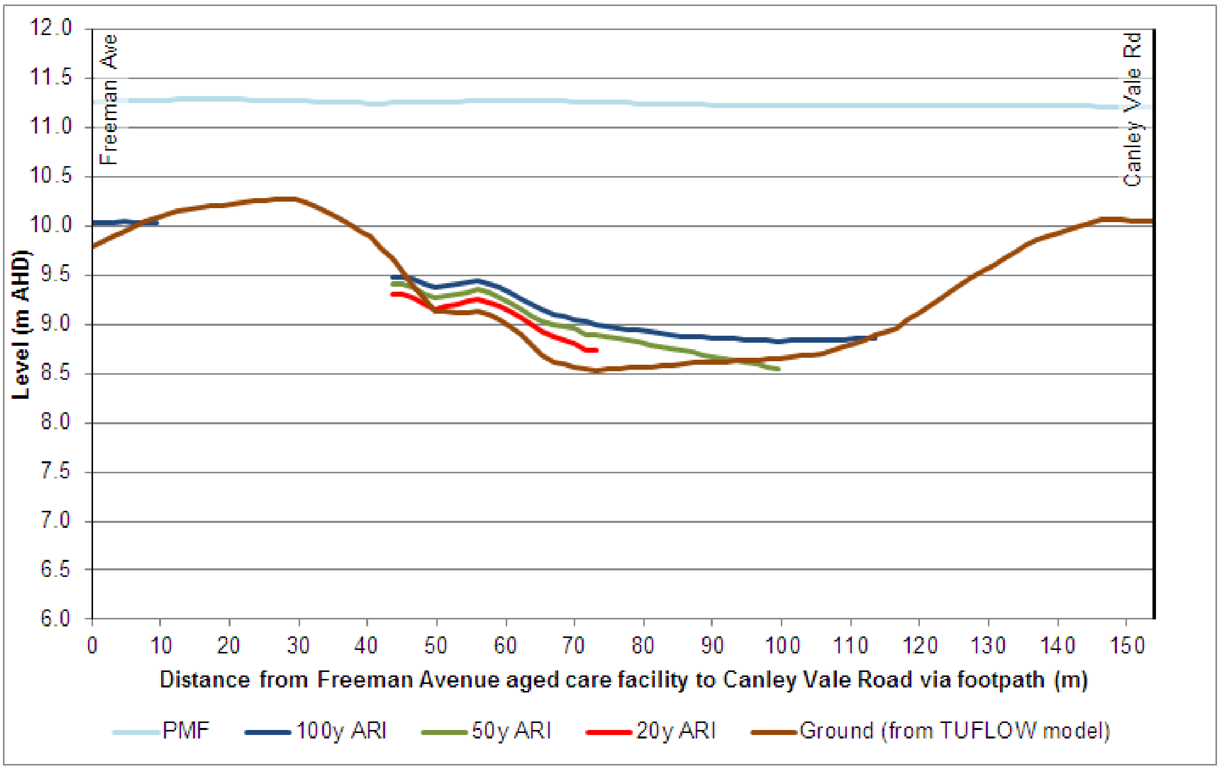


Figure 33 – Flood profile along Freeman Avenue walkway

8.5 DAMAGES ASSESSMENT

8.5.1 Types of Flood Damage

The definitions and methodology used in estimating flood damages are well established. Figure 34 summarises all the types of flood damages examined in this study. The two main categories are tangible and intangible damages. Tangible flood damages are those that can be more readily evaluated in monetary terms. Intangible damages relate to the social cost of flooding and are much more difficult to quantify.

Tangible flood damages are divided further into direct and indirect damages. Direct flood damages relate to the loss or loss in value of an object or a piece of property caused by direct contact with floodwaters, flood-borne debris or sediment deposited by the flood. Indirect flood damages relate to loss in production or revenue, loss of wages, additional accommodation and living expenses, and any extra outlays that occur because of the flood.

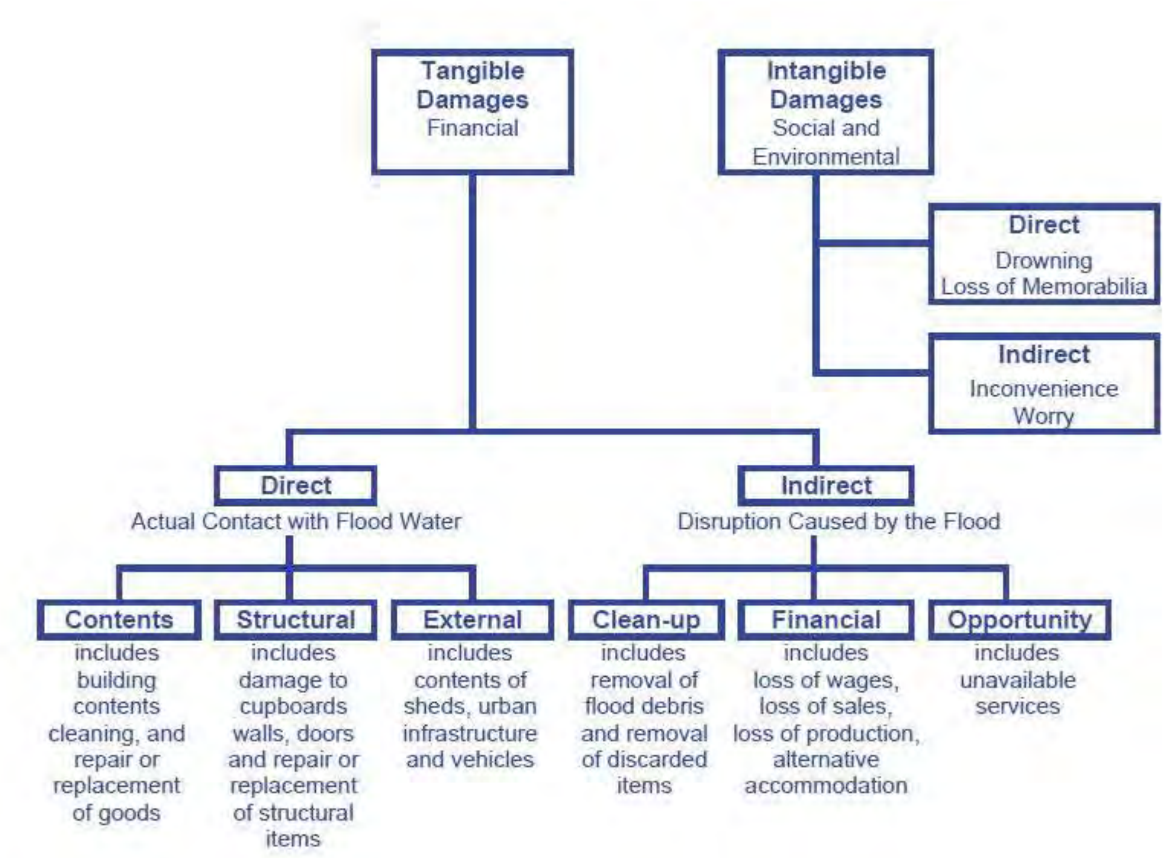


Figure 34 – Types of flood damage

Source: *Floodplain Development Manual* (DIPNR, 2005)

8.5.2 Basis of Flood Damages Calculations

Flood damages have been estimated by applying one of several stage-damage curves to every property included in the database. These curves relate the amount of flood damage that would potentially occur at different depths of inundation, for a particular property type, whether residential or commercial/industrial.

a) Residential

In October 2007, the then Department of Environment and Climate Change released Guidelines to facilitate a standard methodology for assessing residential flood damages. This involves tailoring stage-damage data for the particular floodplain of interest, and is recommended for use throughout NSW so that the results from one floodplain can be compared with another.

Inputs for the Three Tributaries floodplain are listed in Table 15. The flood model was used to select typical flood duration and warning time. An average house size of 190m^2 was adopted, based on a sample of 100 houses located within the 100 year ARI flood extent, from both the top and bottom of the catchment, and measured from the aerial photography. In addition, smaller dwellings such as townhouses were recorded in the property database, and a 25% reduction in flood damages for each stage was applied to these dwellings. The resultant stage-damage data are provided in Appendix G.

Table 15 – Input variables for residential damages assessment

Input	Value	Explanation
Regional Cost Variation Factor	1.0	Rawlinsons
Post late 2001 adjustments	1.66	Changes in AWE from Nov 2001 to May 2014
Post Flood Inflation Factor	1.40	Regional city
Typical Duration of Immersion	4 hours	Maximum duration in 100 year ARI event in lower floodplain
Building Damage Repair Limitation Factor	0.85	Short duration
Typical House Size	190 m^2	Sample of 100 houses within 100 year ARI extent
Contents Damage Repair Limitation Factor	0.75	Short duration
Level of Flood Awareness	Low	*Community Flood Education and Awareness in Fairfield City* report (MS, 2013)
Effective Warning Time	2 hours	Based on critical duration
Typical Table/Bench Height	0.90	Standard
External Damage	$6,700	Standard
Clean-up costs	$4,000	Standard
Likely Time in Alternative Accommodation	8 Weeks	Standard
Additional Accommodation Costs	$220	Standard

It is noted that the residential stage-damage curves make allowance for both clean-up costs ($4,000 per flooded house) and the cost of time in alternative accommodation. Recent research by Molino Stewart for Hawkesbury-Nepean flood mitigation assessments suggests that an allowance of only 5% is warranted for additional indirect costs for the residential sector, and this allowance has been applied here.

b) Commercial/Industrial

No standard stage-damage curves have been issued for *commercial* and *industrial* damages. The stage-damage relationships used to estimate these damages in this study are based on investigations by Water Studies (1992) and incorporated into WaterRIDE. Stage-damage data was factored up to September 2014 values using changes in CPI. The stage-damage data is reported in $\$/m^2$ for each of six value categories (see Section 8.1). Recent research by Molino Stewart for Hawkesbury-Nepean flood mitigation assessments suggests that an allowance of 50% for indirect costs is appropriate.

c) Other

In some floodplain risk management studies, an estimate of 15% of total residential and commercial/industrial damages has been added to make a provision for damages to infrastructure.

Some studies also include basic stage-damage assumptions to cater for damage to motor vehicles, though OEH has made clear that such damages should not influence the BCR of potential flood reducing measures, which are particularly intended to address damages to houses and to a lesser extent businesses (and associated livelihoods).

Some studies also include a tangible estimate (sometimes 20% of total residential and commercial/ industrial damages) in attempt to measure intangible, social damages. These include the impacts of flooding on health – physically and emotionally.

None of these other kinds of damages have been explicitly measured in this FRMS.

8.5.3 Economic Analysis

An economic appraisal is required for all proposed capital works in NSW, including flood mitigation measures, in order to attract funding from the State Government's Capital Works Program. The NSW Government has published two Treasury Policy Papers to guide this process: *NSW Government Guidelines for Economic Appraisal* (NSW Treasury, 2007a) and a summary in *Economic Appraisal Principles and Procedures Simplified* (NSW Treasury, 2007b).

An economic appraisal is a systematic means of analysing all the costs and benefits of a variety of proposals. In terms of flood mitigation measures, benefits of a proposal are generally quantified as *the avoided costs associated with flood damages*. The avoided costs of flood damage are then compared to the capital (and on-going) costs of a particular proposal in the economic appraisal process.

Average annual damage (AAD) is a measure of the cost of flood damage that could be expected each year by the community, on average. It is a convenient yardstick to compare the economic benefits of various proposed mitigation measures with each other and the existing situation. Figure 35 describes how AAD relates to actual flood losses recorded over a long period. For the current study, AAD is assessed using the potential damages derived for each design event. Based on an assessment that a house in the Henty Creek floodplain is inundated in the 5 year ARI event (WMAwater, 2013c), the calculation of AAD assumes that damages to buildings commence at the 5 year ARI event. The PMF is set to an ARI of 100,000 years.

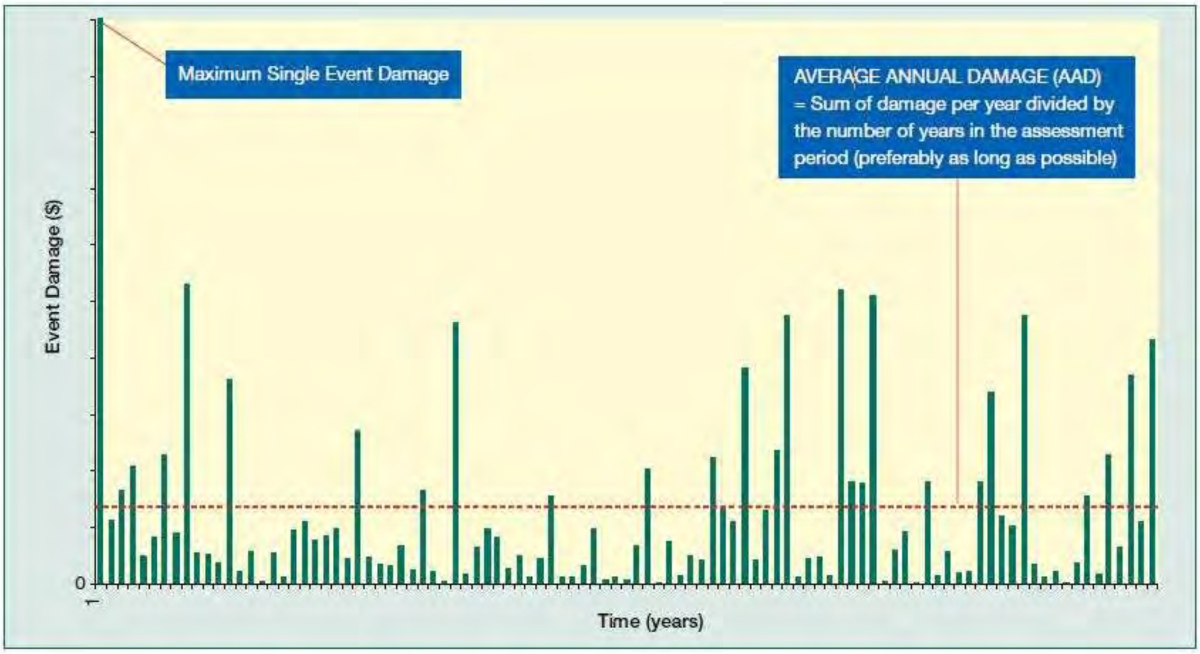


Figure 35 – Randomly occurring flood damage as annual average damage

Source: Managing Flood Risk through Planning Opportunities (HNFMSC, 2006)

The present value of flood damage is the sum of all future flood damages that can be expected over a fixed period (usually 20 years) expressed as a cost in today's value. The present value is determined by discounting the future flood damage costs back to the present day situation, using a discount rate (typically 7%).

A flood mitigation proposal may be considered to be potentially worthwhile if the benefit–cost ratio (the present value of benefits divided by the present value of costs) is greater than 1.0. In other words, the present value of benefits (in terms of flood damage avoided) exceeds the present value of (capital and on-going) costs of the project.

However, whilst this direct economic analysis is important, it is not unusual to proceed with urban flood mitigation schemes largely on social grounds, that is, on the basis of the reduction of intangible costs and social and community disruption. In other words, the benefit–cost ratio could be calculated to be less than 1.0.

8.5.4 Summary of Flood Damages

Calculated flood damages and AAD for the Three Tributaries floodplain are presented in Table 16. Distinctive features include:

- The annual average damage within the study area is about $1.9 million, which is a measure of the cost of flood damage that could be expected each year, on average, by the community;
- Overall, the damages for the 20 year, 50 year and 100 year ARI events are relatively constrained compared to other floodplains in Sydney and NSW, which points to the general effectiveness of Council's previous FRM practices;
- The PMF accounts for a substantial 85% of the average annual damages. This reflects a sharp jump in the number of buildings inundated for that rare event (Table 13). Modelling of an intermediate event such as the 200 year or 500 year ARI would provide a more refined picture of damages and emergency management issues;
- A high proportion of the direct commercial/industrial damages for the 100 year ARI event is attributed to inundation of a large building at Mary MacKillop College;
- The net present value of damages (discounted at 7% over a 50 year period) is $26.2 million, which represents the maximum sum that could be spent on flood mitigation measures if an economic benefit/cost ratio of 1.0 is required and all flood damages can be avoided. The reality is that mitigation works to address PMF damages are rarely pursued.

Table 16 – Flood damages and average annual damage

Event	Residential Direct Damage ($)	Residential Indirect Damage ($)	Commercial and Industrial Direct Damage ($)	Commercial and Industrial Indirect Damage ($)	Total ($)	Contribution to AAD ($)	(%)
20 Year	1,341,000	67,000	50,000	25,000	1,483,000	111,000	5.9%
50 Year	3,494,000	175,000	589,000	294,000	4,552,000	90,000	4.8%
100 Year	6,411,000	321,000	2,755,000	1,378,000	10,864,000	77,000	4.1%
PMF	243,622,000	12,181,000	38,299,000	19,150,000	313,252,000	1,619,000	85.3%
AAD $	1,472,000	74,000	235,000	118,000		**1,898,000**	

PART C: FLOODPLAIN RISK MANAGEMENT MEASURES

9 OPTIONS OVERVIEW

Floodplain management measures can be divided into three general groups:

- those that modify flood behaviour;
- those that modify property in order to minimise flood damage; and
- those that modify people's response to flooding.

Measures that modify flood behaviour usually include structural works that attempt to lower flood levels, or to divert floodwaters away from areas that would otherwise flood. These type of measures are often favoured by the community.

Measures that modify property in order to minimise flood damage include voluntary house purchase, voluntary house raising or house reconstruction, 'flood-proofing' and controls on new development through land use planning.

Measures that modify people's response to flooding include measures that improve flood warning systems, improve emergency management planning and improve community flood awareness and readiness.

A range of assessment criteria have been used for evaluating potential floodplain management measures within the study area. These are described in Table 17. A qualitative assessment has been undertaken for each floodplain risk management option according to these criteria.

Number of buildings protected in the 100 year flood

A prime indicator of the effectiveness of a measure in reducing the potential for flood damage and the risk to life is the reduction in the number of buildings that are affected by significant floods.

Financial feasibility

Measures proposed within the FRMP must be capable of being funded. There are various sources of funding that may be utilised, including funding related to new development (Section 94 Contributions) and funding from Council, with assistance from the Government's Floodplain Management Program administered by OEH, for the alleviation of existing flood problems.

Economic merit

The ratio of the benefit divided by the cost (i.e. the benefit/cost ratio) is a common measure of assessing economic feasibility. Theoretically, no investment should be made on a measure if the benefit/cost ratio does not exceed one (i.e. if the benefits do not exceed the costs). However, traditionally many floodplain risk management measures have been undertaken where this is not the case because the intangible benefits (i.e. social benefits and reduced risks to life, which are not readily quantified) are considerable. Benefit/cost ratios can also be useful in ranking competing options.

Reduced risk to life

An option may have significant intangible benefits as well as tangible benefits. The risk to life is one qualitative measure to aid consideration of the 'intangibles'.

Community acceptance

An understanding of community attitudes towards any proposed floodplain management measures is essential, since these exert an important influence in determining the success or otherwise of any proposed measure. Community views on potential floodplain management measures were assessed early in the study through distribution of the community questionnaire. These results are discussed in Section 5.5. Further opportunity for comment was provided during public exhibition of the draft Three Tributaries FRMP (Section 5.6).

Environmental impact

Floodplain management measures involving structural works often have significant environmental or heritage impacts, which must be considered.

Impact on flood behaviour

The impact on flood behaviour caused by any measure needs to be considered for upstream and downstream locations. These impacts can include changes in flood levels, changes in velocities or alteration of flow directions. Reducing impacts in one location can lead to adverse impacts elsewhere, which must be considered.

Performance during rare floods

All measures must be assessed in the knowledge that rare floods, i.e. higher than the 100 year ARI flood, or higher than any known historical flood, will happen at some time in the future. It is vital that the options do not expose the community to unacceptable risks by providing a false sense of security.

Technical feasibility

If the proposed measures involve structural works, these works must be able to be constructed and be free from major technical constraints.

Political/administrative feasibility

Any recommended measure will have more chance of success if it involves little if any disruption to current political and administrative structures, attitudes and responsibilities. Council and other authorities also have various strategic objectives concerning development within the study area.

Potential floodplain management measures for the Three Tributaries study area are discussed in subsequent chapters. Each measure has been included in a qualitative assessment matrix (Table 18) to assess its relative merits, thereby helping to assess whether it should be included in the draft Three Tributaries FRMP. The decisive factors for inclusion or exclusion are highlighted.

Table 17 – Explanation of assessment scores for qualitative assessment matrix

CRITERIA	RANKING SCORE				
	– –	–	Ω	+	+ +
REDUCTION IN NUMBER OF HOUSES FLOODED ABOVE FLOOR LEVEL IN 100Y ARI FLOOD	number of houses flooded above floor in 100y ARI flood would increase	number of houses flooded above floor in 100y ARI flood could increase	no existing houses protected from over-floor flooding in 100y ARI flood	1 or 2 existing houses protected from over-floor flooding in 100y ARI flood	> 2 existing houses protected from over-floor flooding in 100y ARI flood
FINANCIAL FEASIBILITY	Very unlikely to receive funding	May not receive funding	Neutral	Would possibly receive funding	Very likely to receive funding
ECONOMIC MERIT	Benefit–Cost Ratio less than 0.1	Benefit–Cost Ratio = 0.1–0.3	Benefit–Cost Ratio = 0.3–0.7	Benefit–Cost Ratio = 0.7–1.0	Benefit–Cost Ratio greater than 1.0
REDUCED RISK TO LIFE	Significantly increases risk	Some increase in risk	No change in risk	Some reduction in risk	Significant reduction in risk
COMMUNITY ACCEPTANCE	Strongly against in community survey and community workshop	Not supported in community survey and community workshop	Neutral	Supported in community survey and community workshop	Strongly supported in community survey and community workshop
ENVIRONMENTAL IMPACT AND ECOLOGICAL ENHANCEMENT	Significant negative environmental impact	Some negative environmental impact	No environmental impact and no opportunity for ecological enhancement	Some opportunity for ecological enhancement	Significant opportunity for ecological enhancement
IMPACT ON FLOOD BEHAVIOUR	Significantly increase flood levels and/or velocities	Some increase in flood levels and/or velocities	No change	Some reduction in flood levels and/or velocities	Significantly reduces flood levels and/or velocities
CONSEQUENCES IN EXTREME FLOODS	Significantly increases risk	Some increase in risk	No change in risk	Some reduction in risk	Significant reduction in risk
TECHNICAL FEASIBILITY	Very difficult	Difficult	Neutral	Easy	Very easy and straight forward
POLITICAL/ ADMINISTRATIVE / LEGAL IMPACT	Significant changes required which are very unlikely to be supported	Some changes required which may not be supported	No changes or impact	Some changes required are likely to be supported	Significant changes required which are likely to be strongly supported

Table 18 – Qualitative matrix assessment of floodplain risk management options

Note: Decisive factors for recommending or not recommending an option are highlighted in tan

CHAPTER NO.	MEASURE	DESCRIPTION OF OPTION	REDUCTION OF DWELLINGS FLOODED ABOVE FLOOR LEVEL IN 100Y ARI FLOOD		FINANCIAL FEASIBILITY		ECONOMIC MERIT		REDUCED RISK TO LIFE	COMMUNITY ACCEPTANCE	ENVIRON-MENTAL IMPACTS, ECOLOGICAL ENHANCE-MENTS	IMPACTS ON FLOOD BEHAVIOUR	CONSE-QUENCES IN EXTREME FLOODS	TECHNICAL FEASIB-ILITY OR DIFFICULTY	ADMINIS-TRATIVE / POLITICAL / LEGAL IMPACTS	RECOMMENDED FOR FURTHER CONSIDERATION
				NO. DWELLINGS		CAPITAL COST		BENEFIT–COST RATIO								
10	**FLOOD MODIFICATION MEASURES**															
10.1.2	**Detention basins**	Mimosa Road basin upgrade: raise crest	++	16	–	$1.1M	+	0.7-0.8	+	+	Ω	++	+	–	Ω	Yes
10.1.3		Prairiewood basin upgrade: option TBC	+	2		Not assessed		Not assessed	+	+	Ω	+	+	–	Ω	Study required
10.1.4		Fairfield Golf Course basin upgrade: raise crest	+	2		$550K	Ω	0.6-0.7	+	+	Ω	++	+	–	–	Yes
10.1.5		King Park basin upgrade: excavation	++	9	– –	$6.9M	– –	<0.1	+	+	–	+	+	–	Ω	No
10.1.6		Chisholm Park basin upgrade: excavation	Ω	Low	– –	$2.5M	– –	<0.1	+	+	–	Ω	+	–	–	No
10.1.7		Bunding between Basins W3 and C to reduce overflows towards Attilio Pl and Smithfield Rd	Ω	0	+	$40K	+	High	+	+	Ω	+	Ω	+	–	Yes (incl. study)
10.1.8a		New detention basin at Allambie Road Reserve, Bossley Park	Ω	0	–	High	–	Low	–	?	–	Ω	Ω	– –	–	No
10.1.8b		New detention basin at Terone Park, Bossley Park		Not assessed		Not assessed		Not assessed		?	Ω	Ω	Ω	+	–	No
10.1.8c		New detention basin at Endeavour Sports Reserve, Fairfield West		Not assessed		Not assessed		Not assessed		?	– –	Ω	Ω	– –	– –	No
10.1.9		Implement structural, functional and safety measures for all 14 basins		Not assessed		Not assessed		Not assessed	+	+	?	+	+	–	–	Yes

CHAPTER NO.	MEASURE	DESCRIPTION OF OPTION	REDUCTION OF DWELLINGS FLOODED ABOVE FLOOR LEVEL IN 100Y ARI FLOOD		FINANCIAL FEASIBILITY		ECONOMIC MERIT		REDUCED RISK TO LIFE	COMMUNITY ACCEPTANCE	ENVIRONMENTAL IMPACTS, ECOLOGICAL ENHANCEMENTS	IMPACTS ON FLOOD BEHAVIOUR	CONSEQUENCES IN EXTREME FLOODS	TECHNICAL FEASIBILITY OR DIFFICULTY	ADMINISTRATIVE / POLITICAL / LEGAL IMPACTS	RECOMMENDED FOR FURTHER CONSIDERATION
				NO. DWELLINGS		CAPITAL COST		BENEFIT–COST RATIO								
10.1.10a	**Detention basins**	Include all 14 existing basins in Council's existing inspection and maintenance plan	Ω	0	+	Staff costs	+	High	+	+	Ω	Ω	+	++	–	Yes
10.1.10b		Remove trees from basin embankments where these compromise basin integrity	Ω	0		Not assessed		Not assessed	+	–	–	Ω	+	–	–	Study required
10.2	**OSD Policy**	Revise policy	Ω	0		Staff costs	+	High	Ω	–	Ω	+	Ω	+	–	Yes
10.3	**Channel modification**	Channel realignment north of Freeman Avenue		Not assessed		Not assessed		Not assessed	Ω	++	–?	Ω?	Ω	+	–	Study required
10.4.1	**Riparian vegetation management**	Plant floodplains to detain floodwaters in upper catchment		Not assessed		Not assessed		Not assessed	Ω	+	++	Ω	Ω	+	Ω	No
10.4.2		Clear creeks		Not assessed		Not assessed		Not assessed	Ω	++	– –	+/– Worse d/s	Ω	–	– –	No
10.5.1	**Drainage upgrades**	Duplicate Edensor Creek pipes under Smithfield Road and T-way; daylight pipes between roads	1	+	–	$1.2M	–	0.1-0.2	+	+	+	+	Ω	–	–	No
10.5.2		Enlarging Railway Parade or Canley Vale–Fairfield Railway bridges over OSC	Ω	0?	–	High	–	Low	+	–	Ω	+/– Worse d/s	+	–	– –	No
10.5.3		Install flap gate on outlet to northern Sackville St 1200mm diameter pipe at OSC		Not assessed	+	$10K	+	High	+	++	Ω	+	+	+	Ω	Yes
10.6	**Debris control**	Manage vegetation upstream of OSC at Moonlight Road culvert	+	2^	+	Staff costs	+	High	Ω	+	–	+	Ω	+	–	Yes
		Maintain clear grates at Henty Creek at Elizabeth Drive culvert	++	7^	+	Staff costs	+	High	Ω	+	Ω	+	Ω	+	+	Yes
10.6	**Debris control**	Debris control structure upstream of Green Valley Creek at Cabramatta Road West culvert	++	19^	+	$135K	++	Very High	Ω	+	Ω	+	Ω	+	Ω	Yes

CHAPTER NO.	MEASURE	DESCRIPTION OF OPTION	REDUCTION OF DWELLINGS FLOODED ABOVE FLOOR LEVEL IN 100Y ARI FLOOD		FINANCIAL FEASIBILITY		ECONOMIC MERIT		REDUCED RISK TO LIFE	COMMUNITY ACCEPTANCE	ENVIRON-MENTAL IMPACTS, ECOLOGICAL ENHANCE-MENTS	IMPACTS ON FLOOD BEHAVIOUR	CONSE-QUENCES IN EXTREME FLOODS	TECHNICAL FEASIB-ILITY OR DIFFICULTY	ADMINIS-TRATIVE / POLITICAL / LEGAL IMPACTS	RECOMMENDED FOR FURTHER CONSIDERATION
				NO. DWELLINGS		CAPITAL COST		BENEFIT–COST RATIO								
10.7.1[#]	Levee	Levee along Gregorace Place[#]	++	6	+	$80-120K	++	5.0-7.5	–	–	Ω	– Overland flow issue	–	+	–	Yes
10.7.2		Bund at side of house at Katinka Street; seal soundwalls; speed hump	+	2	+	$60K	++	1.9-2.0	Ω	?	Ω	Ω	–	+	–	Yes
10.7.3		Levee along Green Valley Creek upstream of Cabramatta Road West	+	1	+	Low	+	High	–	–	–	– Worse at road and d/s	–	–	Ω	No
11	**PROPERTY MODIFICATION MEASURES**															
11.1	**Voluntary purchase**	Purchase Brown Road house flooded in 20y event	+	1	–	~$500K	–	0.2	+	Ω	+	+	+	+	–	No
11.2	**VHR, flood-proofing**	Provide varied subsidies to raise, redevelop or flood-proof 16 houses	++	16	+	$717K	+	<0.8	+	Ω	Ω	+	–	+	–	Yes
11.3.1	**Planning and develop-ment controls**	Consider amending Clause 6.3 of LEP to clarify within PMF extent	Ω	0	+	Staff costs	+	High	Ω	Ω	Ω	Ω	Ω	+	–	Yes
11.3.2		Backzone Freeman Avenue to Low Density Residential	Ω	0	+	Staff costs	+	High	++	–	Ω	Ω	++	+	– –	Yes
11.3.3		Amend Chapter 11 of DCP incl. for Very Low FRP	Ω	0	+	Staff costs	+	High	+	+	Ω	Ω	+	+	Ω	Yes
11.3.4		Amend S149 planning certificates incl. for Very Low FRP	Ω	0	+	Staff costs	+	High	+	+	Ω	Ω	+	+	Ω	Yes

Notes:
^ This records the number of houses that could be flooded if blockage occurred.
[#] Assessment taken from WMAwater (2013c).

CHAPTER NO.	MEASURE	DESCRIPTION OF OPTION	REDUCTION OF DWELLINGS FLOODED ABOVE FLOOR LEVEL IN 100Y ARI FLOOD		FINANCIAL FEASIBILITY		ECONOMIC MERIT		REDUCED RISK TO LIFE	COMMUNITY ACCEPTANCE	ENVIRON-MENTAL IMPACTS, ECOLOGICAL ENHANCE-MENTS	IMPACTS ON FLOOD BEHAVIOUR	CONSE-QUENCES IN EXTREME FLOODS	TECHNICAL FEASIB-ILITY OR DIFFICULTY	ADMINIS-TRATIVE / POLITICAL / LEGAL IMPACTS	RECOMMENDED FOR FURTHER CONSIDERATION
				NO. DWELLINGS		CAPITAL COST		BENEFIT–COST RATIO								
12	**RESPONSE MODIFICATION MEASURES**															
12.1	**Improve flood warning system**	Install 3 real-time rain gauges	Ω	0	+	$30K + $6K p.a. maintenance	+	High	+	+	Ω	Ω	+	+	Ω	Yes
		Alarm Sackville Street water level recorder	Ω	0	+	$1K + $600 p.a. maintenance	+	High	+	+	Ω	Ω	+	+	Ω	Yes
		Install 2 basin water level recorders	Ω	0	+	$50K + $10K p.a. maintenance	+	High	+	+	Ω	Ω	+	+	Ω	Yes
12.2.1	**Improve emergency response planning**	Construct high level emergency evacuation route to eastern Freeman Avenue	Ω	0	–	$630K+		n/a	++	?	Ω	Ω	+	–	–	Yes
12.2.2		Update NSW SES flood plans and intelligence	Ω	0	+	SES staff costs	+	High	++	+	Ω	Ω	+	+	Ω	Yes
12.2.3		Support the preparation of private flood plans	Ω	0	+	FCC/SES staff costs	+	High	++	+	Ω	Ω	+	+	Ω	Yes
12.3.1	**Improve community flood awareness and readiness**	Continue to implement the Fairfield community flood education action plan 2012-15	Ω	0			+	High	+	+	Ω	Ω	+	+	Ω	Yes
12.3.2		Regularly issue flood information	Ω	0		FCC staff costs	+	High	++	+	Ω	Ω	+	+	–	Yes
12.3.3		Conduct meet-the-street events	Ω	0		FCC/SES staff costs	+	High	++	+	Ω	Ω	+	+	Ω	Yes
12.3.4		Conduct a Business FloodSafe breakfast	Ω	0	+	$2K b/fast, venue hire	+	High	++	+	Ω	Ω	+	+	Ω	Yes
12.3.5		Prepare NSW SES FloodSafe guides for three creeks	Ω	0		$12K printing	+	High	+	+	Ω	Ω	+	+	Ω	Yes
12.3.6		Install flood depth indicators and evacuation route signage (five sites)	Ω	0	+	$25K	+	High	+	–	Ω	Ω	+	+	–	Yes

10 FLOOD MODIFICATION MEASURES

The purpose of flood modification measures is to modify the behaviour of the flood itself by reducing flood levels or velocities or by excluding floodwaters from areas under threat. It is essential that these measures are assessed, first, on an overall catchment basis, and second, from within the strategic framework of an overall floodplain risk management plan. If assessed individually or in isolation, there is the possibility that future land-use developments may reduce, if not eliminate, present mitigating effects. For example, detention basins must be assessed on a systems basis that incorporates the impact of future development and a range of flooding scenarios.

10.1 DETENTION BASINS

Recommendations:

1) Raise embankment at Mimosa Road Basin to contain 100 year ARI flood

2) Assess merits of increasing capacity of Prairiewood Basin

3) Raise embankment at Fairfield Golf Course Basin to contain 100 year ARI flood

4) Bunding between Basin W3 and Basin C to reduce flooding entering Kalang Road/Attilio Place and Smithfield Road

5) Implement structural, functional and safety measures for all 14 basins, on a priority basis and to improve flood mitigation and basin safety

6) Include all 14 basins in Council's Asset Management Policy/Strategy

7) Assess need and practicality of removing trees from basin embankments

10.1.1 Overview

Detention basins are areas of open space which collect and store stormwater runoff for release at a controlled rate. They tend to reduce peak flows and levels downstream of the basin sites. As shown in Figure 1, 14 formal detention basins have been constructed in the Three Tributaries catchment to control the hydrological effects of urbanisation. On the whole, the relatively modest impacts of a 100 year ARI flood suggest that these basins have been reasonably effective in mitigating flood peaks. Nevertheless, detention basins have a number of inherent limitations that should be carefully evaluated for each particular situation, including:

- They require a substantial area to achieve the necessary storage;
- Where they involve multi-purpose uses, safety aspects during flooding need to be addressed;
- Long duration or multi-peak storms (when the basin is filled in the first peak) can increase the likelihood of overtopping (when no alternative is available) or embankment breaching or failure, and the resulting personal danger and damage;
- Basins provide limited attenuation when overtopping occurs (though probably more than a channel and its floodplain); and
- The extended tail of the basin outflow hydrograph might have adverse effects of creek channel stability.

Consequently, it is important that detention basins are properly designed (including consideration of alternative storm patterns and flood recurrence intervals), constructed and maintained. Risk is reduced by complementary works (bypass spillways) or specific land use planning measures (downstream flowpaths). It is noted that with appropriately designed outlet works, detention basins may act as sediment traps thereby improving urban water quality by reducing the concentration of solids.

10.1.2 Upgrade Mimosa Road Basin

An option was modelled to assess the benefits of increasing the storage volume at the existing Mimosa Road Basin by raising the current embankment spill level (39.9m AHD) so that it does not overtop in the existing 100 year ARI event (40.69m AHD). This would require raising the current embankment by an average height of 0.9m over a distance of about 920m. A freeboard would also need to be included. This option was modelled as Scenario A, with the impacts presented in Appendix H.

This option would reduce the number of houses flooded above floor in the 100 year ARI event by 16, from 48 to 32. This shows that this measure alone would reduce above floor flooding in the Three Tributaries floodplain by one-third. Based on the reduction in net present value[1] of residential and commercial/industrial damages as a result of the alleviation of flooding immediately downstream of the basin, there would be a tangible benefit of in excess of $790K. Intangible benefits include reduced risk to life by removing inundation of the Greenfield Shopping Centre car park and many roads downstream of the basin that would currently be flooded in the 100 year ARI event.

An upgrade of this basin is also required for the purposes of basin safety (see WMAwater, 2013b). In addition to raising the basin embankment, the need to improve basin safety requires (i) reinforcement of the embankment with scour-resistant overflow spillway; and (ii) realignment of the lowest point of the embankment with the main channel of Orphan School Creek downstream.

Based on a length of crest raising of 920m at an average height of 0.9m, plus an allowance for a freeboard of 0.5m, J. Wyndham Prince estimated that 11040 m^3 of clean material would be required to raise the embankment at a cost of about $442K. Scour protection for all embankment slopes was estimated to cost $414K. Adding a 25% contingency, the total project cost was estimated at about $1.07M (see Appendix I). This includes a number of assumptions such as no adjustments to services, no removal of trees and easy access.

Based on the tangible benefits and estimated costs, the benefit-cost ratio is calculated as 0.7-0.8. Whilst this is a little below 1.0, the large number of houses which would no longer be flooded in the 100 year ARI event, the additional intangible benefits (improvements to safety) and the need for an upgrade to meet modern safety standards commends this option, which is therefore included in the proposed Floodplain Risk Management Plan.

10.1.3 Upgrade Prairiewood Basin

Prairiewood Basin is modelled to overtop its embankment in events as frequent as the 20 year ARI event (Table 8). This would have minimal impact on private property downstream and is unlikely to close Prairie Vale Road to traffic (Figure 29; Table 14). In the 50 year ARI event, about 22 yards would be flooded. In the 100 year ARI event, two houses downstream of the basin are predicted to be flooded above floor to very shallow depths (<2cm). Some 59 houses could be isolated for a short time (Section 8.4.3b)).

In terms of basin safety, the incremental consequence category for failure in a dam crest flood (20 year ARI) is assessed to be very low (WMAwater, 2013b). The consequences of failure during the PMF event are also assessed as not significant. Nevertheless, WMAwater propose that medium priority be given to remedial works given the overtopping in a relatively frequent event.

It is recommended that further investigation including modelling be undertaken to assess the merits of increasing basin capacity through either raising the long embankment or excavation. It is suspected that works may not be cost effective given the few properties flooded over floor (and to only shallow depths) up to and including the 100 year ARI event, though intangible benefits will also need to be

[1] Assuming 7% discount over 50 years, which has been used for all BCR estimates.

weighed. Another consideration is to ensure any increased basin footprint doesn't worsen flooding on the upstream side of the embankment such as at the Cerebral Palsy Alliance premises.

10.1.4 Upgrade Fairfield Golf Course Basin

An option was modelled to assess the benefits of increasing the storage volume at the existing Fairfield Golf Course Basin by raising the current embankment spill level (27.1m AHD) so that it does not overtop in the existing 100 year ARI event (27.49m AHD). This would require raising the current embankment by an average height of 0.75m over a distance of about 440m. A freeboard would also need to be included. This option was modelled as Scenario B, with the impacts presented in Appendix H.

This option would reduce the number of houses flooded above floor in the 100 year ARI event by two, from 48 to 46 and would also reduce flood depths at Mary MacKillop College (possibly to below floor level). Based on the reduction in net present value of residential and commercial/industrial damages as a result of the alleviation of flooding immediately downstream of the basin, there would be a tangible benefit of in excess of $380K. Intangible benefits include reduced risk to life by reducing inundation depths at Smithfield Road (by 0.13m in the modelled 100 year event) – flooding there is not removed entirely because water can escape from the basin outlet just upstream of Smithfield Road. In addition, the flow path along Mallacoota Street and Bulls Road would be removed in the 100 year event.

An upgrade of this basin is also required for the purposes of basin safety (see WMAwater, 2013b). In addition to raising the basin embankment, the need to improve basin safety requires (i) reinforcement of the embankment with scour-resistant overflow spillway; (ii) widening the concrete outlet weir structure to convey greater overtopping flow.

Based on a length of crest raising of 440m at an average height of 0.75m, plus an allowance for a freeboard of 0.5m, J. Wyndham Prince estimated that 4840 m^3 of clean material would be required to raise the embankment at a cost of about $194K. Scour protection for all embankment slopes was estimated to cost $198K and works to reinforce the embankment of the concrete outlet weir were estimated to cost about $45K. Adding a 25% contingency, the total project cost was estimated at about $550K (see Appendix I). This includes a number of assumptions such as no adjustments to services, no removal of trees and easy access.

Based on the tangible benefits and estimated costs, the benefit-cost ratio is calculated as 0.6-0.7. Whilst this is a little below 1.0, the removal or significant reduction of flooding in Wakeley including at a large school, plus the additional intangible benefits (improvements to safety) and the need for an upgrade to meet modern safety standards commends this option, which is therefore included in the proposed Floodplain Risk Management Plan.

10.1.5 Upgrade King Park Basin

An option was modelled to assess the benefits of increasing the storage volume at the existing King Park Basin (located at the junction of Orphan School and Clear Paddock Creeks) by excavating and removing about 44,000m^3 of material and reducing the outlet capacity by 50%. This option is also likely to require construction of a bund along Innisfail Road to prevent water stored in the basin backing up across the road and properties. Based on ground levels taken from the DEM used for flood modelling, this bund would need to be average of 0.65m high over a distance of 325m to contain the elevated 100 year ARI flood. It was modelled as Scenario M, with the impacts presented in Appendix H.

This option would result in a widespread reduction of 100 year ARI flood levels downstream of the basin by 0.05-0.15m. Whilst the magnitude of this reduction does not appear to be large, it would nonetheless reduce the number of houses flooded above floor in the 100 year ARI flood by nine, from

48 to 39. Based on the reduction in net present value of residential and commercial/industrial damages as a result of the alleviation of flooding downstream of the basin, there would be a tangible benefit of in excess of \$590K.[1] However, the option would do little to address evacuation issues at Freeman Avenue – the maximum depth of flooding at the Freeman Avenue low-point would be reduced from 1.12m to 1.02m in the 100 year ARI event.

J. Wyndham Prince estimated the total cost of this proposal to be about \$6.9M (Appendix I). The largest component of this cost is the excavation of material and its transport offsite to a tip (\$5.3M). Even this large cost assumes the excavated material is 'virgin excavated natural material' (VENM) and qualifies for 'excavated natural material' (ENM) exemption. The cost would be substantially higher if this is not the case. Bunding along Innisfail Road, including scour protection, was estimated to cost about \$200K.

Based on the tangible benefits and estimated costs, the benefit-cost ratio is calculated as less than 0.1. The project would be very unlikely to receive funding and is therefore not recommended.

10.1.6 Upgrade Chisholm Park Basin

An option was modelled to assess the benefits of increasing the storage volume at the existing Chisholm Park Basin on Green Valley Creek by lowering a 4.1 ha area upstream of the embankment by 0.5m (= additional 16,400m^3 volume). This was modelled as Scenario G, with the impacts presented in Appendix H.

Modelling showed that this option would have only limited benefits downstream of the basin, with a reduction of less than 0.05m.

Based on the rates used to assess the cost of excavation and disposal of material for the King Park basin, the cost of this at Chisholm Park would alone reach about \$2M.

With limited benefits, and a high cost, this option is not economically viable and is therefore not recommended.

10.1.7 Bunding between Basin W3 and Basin C

Flood modelling indicates that in the 20 year ARI event, floodwater in Basin W3 peaks at 43.42m AHD, overtopping the basin embankment (design crest level 43.3m AHD) for about one hour. The model shows 8.2 m^3/s flowing through the pipes exiting Basin W3 but 9.7 m^3/s spilling from the Basin partly into the 'Kalang' mini-basin and partly towards Attilio Place. Kalang mini-basin has a peak 20 year ARI flood level of 40.74m AHD, with flows spilling towards Smithfield Road, despite a sizeable outflow capacity (the model shows pipes conveying 14.1 m^3/s from the mini-basin to Basin C). The flooding of Attilio Place creates an island (Section 8.4.1) and the flooding of Smithfield Road poses a danger to the many vehicles using this important thoroughfare (see 'CP9' in Table 14).

It is understood that Council commissioned investigations into the performance of Basin W3 and the impacts on Smithfield Road in the late 1990s. It is recommended that these investigations be revisited and that further investigation including modelling be undertaken to identify the preferred option for controlling the spills from Basin W3 and the Kalang mini-basin. This could involve bunding through the Kalang Road Reserve to prevent spilling into Attilio Place and onto Smithfield Road. Figure 36 presents views towards the Reserve, showing that the entrance from Attilio Place is particularly low-lying. Potential constraints include doing works in a road reserve with heavy trucks requiring access across the site of the bund from Attilio Place, existing trees that might need removal, and on the Smithfield Road side, the location of an Assyrian monument which cannot be moved. A bund of an average height of 0.5m (to contain the 100 year ARI flood, including a freeboard) over a length of 40m

[1] A robust assessment requires modelling of 20 year and 50 year floods with changed basin configuration. Currently, the reduction in depth for the 100 year event was applied to the more frequent events, which may not be valid.

near the Attilio Place entrance is estimated to cost about $20K. An allowance of $40K is included in the draft FRMP including for a modelling investigation. Another option could be raising Basin W3's embankment.

Figure 36 – Views towards Kalang Road Reserve between Basins W3 and C

Source: Google Street View

a. View from Attilio Place

b. View from Smithfield Road

10.1.8 Potential new basins

A strategy of detention basin storage has been intensely pursued in the Three Tributaries catchment, with 14 basins now in place. Nevertheless, three additional locations providing open space that may be large enough to provide flood detention storage capable of mitigating downstream flooding have been identified:

- Allambie Road Reserve (Edensor Park) – Orphan School Creek;
- Terone Park (Bossley Park) – overland flow from the north and west; and
- Endeavour Sports Reserve (Fairfield West) – Orphan School Creek.

The selection of any potential sites excluded land in the Western Sydney Regional Park as the area of catchment controlled would be minimal and the environmental impact may be significant and unacceptable.

a) Allambie Road Reserve

Allambie Road Reserve in Edensor Park is located between the existing Stockdale and Mimosa Road basins on Orphan School Creek and could potentially be used for a new detention basin if an embankment across the creek was built upstream of Belfield Road. Whilst no houses between Belfield Road and Mimosa Road are flooded over floor level in the 100 year ARI event, it is conceivable that a basin at this site could reduce flood levels at Mimosa Road Basin and possibly obviate the need for the proposed upgrade at that basin.

A cross section through the potential basin site is shown in Figure 37. This indicates that the left bank floodplain is considerably lower than the right bank, suggesting that the existing topography would cause the grounds of Bossley Park High School to be flooded rather than Allambie Road Reserve. It appears that without excavation, it might not be possible to achieve much storage volume. This, however, would render the scheme unduly expensive (as per the estimated cost of excavation for increasing storage volume at the King Park basin). Construction of a basin embankment is also likely to impact upon endangered ecological communities including Cumberland Riverflat Forest (see Figure 6), which is undesirable.

Benefits downstream of Mimosa Road basin are likely to be more easily and efficiently achieved by the proposed upgrade to the Mimosa Road basin.

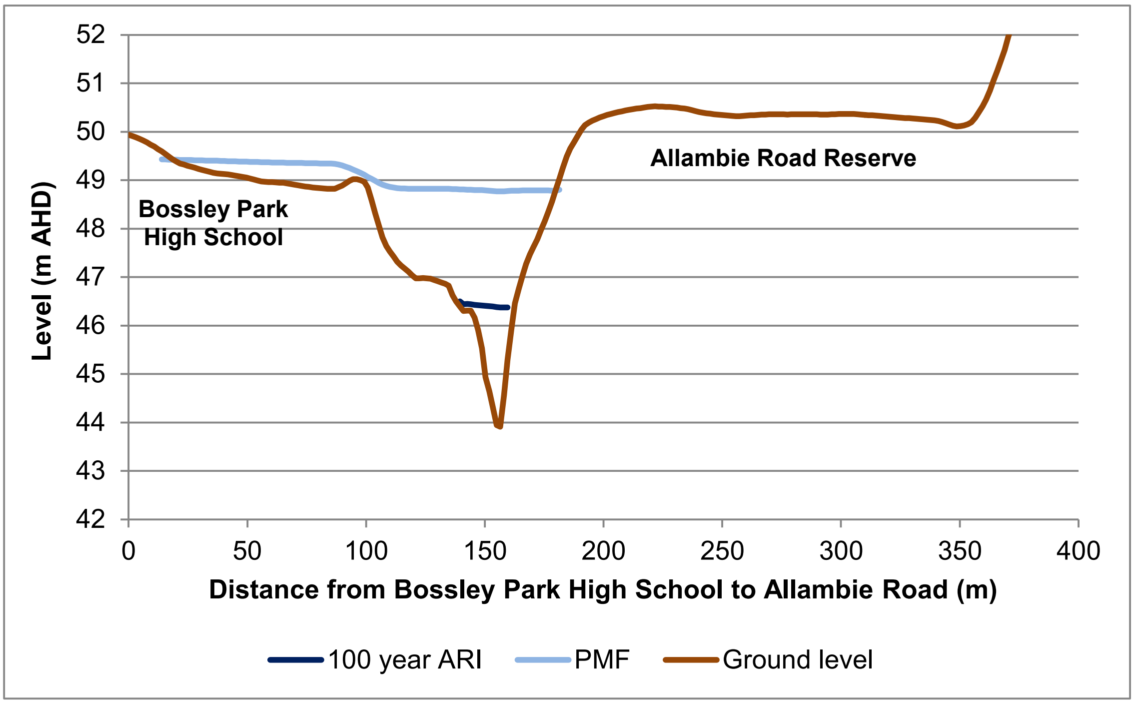


Figure 37 – Cross section through potential Allambie Road Reserve basin site

b) Terone Park

Terone Park in Bossley Park is not located on the main channel of Orphan School Creek but could possibly be used to capture and detain overland flows from the north and west. This area is beyond the extent of the hydraulic model so the benefits in the vicinity of Terone Park cannot be readily assessed. In terms of the benefits it could provide to the alleviation of mainstream flooding, it appears that a basin at Terone Park would replicate the function of the existing Prairiewood basin.

c) Endeavour Sports Reserve

Endeavour Sports Reserve in Fairfield West would have to be designed and operated as an off-line basin. It appears that it would be difficult to achieve flood storage and reduction in downstream flood levels much in addition to that which could accrue from the option to increase storage at the King Park basin upstream, unless there is substantial excavation to create a large basin volume. There is, however, a suspicion that the fill material in the reserve may contain environmental hazards. In addition, the reserve is a highly valued recreational facility where disturbance would be unwelcome.

10.1.9 Basin improvement

The 14 detention basins within the Three Tributaries floodplain play an important role in reducing the flood risk to life and property. It is therefore critical that each basin's structure, function and safety is maintained or improved to protect the downstream community, in-line with current guidelines and standards.

10.1.10 Basin maintenance

Council's Asset Management Policy/Strategy (2013/14-2022/23) includes inspection and maintenance of five detention basins including Comin Place, Stockdale Reserve, and Basins W2, W3 and C. It is recommended that all 14 basins within the Three Tributaries catchment be included in the Asset Management Policy/Strategy. It is suggested that in addition to the existing maintenance (including mowing and maintenance of tracks and footpaths), embankments, culverts, inlet drains, upstream and downstream concrete aprons must be inspected and maintained (including clearing of any accumulated debris) on at least a yearly basis and directly after a 5 year ARI rainfall event (see Douglas Partners, 2012, pp.30-31).

One particular issue is the growth of trees on basin embankments. Regular inspections would provide opportunity to remove any recent, self-sown seedlings. But it is understood that the Golf Course Basin embankment, in particular, has a significant number of mature trees. Tree roots represent water pathways and lead to erosion though piping. Basin safety requires a careful assessment of the risk of embankment failure posed by trees. It may not be necessary to remove trees where basins are incised or where the basins are wide and shallow and unlikely to fail due to trees. But for some basins it is expected that trees on embankments may need to be removed and the embankments be reinstated. Estimating the cost of this work is difficult because it will vary according to the depth and lateral extent of the root mass (often quite deep for gum trees) and involve both an arborist and a geotechnical expert (Douglas Partners, pers. comm.).

10.2 OSD POLICY

Recommendations:
1) Continue OSD Policy and update policy documents
2) Consider extending application of OSD to 'knock down and rebuild' type developments

On Site Detention (OSD) has been used in Fairfield LGA for many years in an attempt to ensure that the hydrological effects of urbanisation are managed – that is, that increases in downstream flood levels as a result of the loss of pervious surface cover in the catchment are minimised. OSD is not intended to reduce existing problems but to prevent flooding from getting worse. OSD is important to ensure that the mitigating benefits of the detention basins are not gradually eroded through an increase in hard surfaces. OSD is not a substitute for detention basin storage (just as detention basin storage is not a substitute for OSD) because OSD is of most benefit for short-duration, high frequency events whereas detention basins may be of benefit for somewhat longer-duration, lower frequency events.

It is recommended that:

- Council continues its current OSD policy, updating the policy documents to reflect changes in rainfall estimates and the potential impacts of climate change;
- Council consider extending the application of OSD to 'knock down and rebuild' type developments as well as to land subject to upzoning (more intense land use). It is understood that the development of catchment management plans for the Burns Creek and Smithfield catchments has included reviews of the OSD design criteria for those areas including the computer modelling of OSD as a means of reducing peak overland flows, not just preventing them from increasing.

10.3 CHANNEL MODIFICATIONS

Recommendation:
1) Assess merits of realignment of Orphan School Creek channel north of Freeman Avenue

Among the most popular approaches to addressing flood problems in the Three Tributaries study area are frequent suggestions to dredge, widen or straighten the creeks to improve conveyance of flows (see Section 5.2.1). There is also some support for channelizing or concrete-lining channels, and this approach was implemented for sections of Clear Paddock and Orphan School Creeks in the 1970s and 1980s. But these approaches are not generally consistent with contemporary best practice floodplain management because of the following disadvantages:

- Adverse hydraulic impacts downstream, since smoother channels will facilitate the transfer of floodwaters;
- Adverse impacts on biodiversity, with a loss of remnant vegetation (likely endangered ecological community – see Section 2.2) and habitat linkages;
- Adverse geomorphic impacts, with an increased potential for erosion of channel bed and banks, both upstream and downstream of the site;
- Adverse impacts on visual amenity when a naturally vegetated channel is replaced by a concrete-lined channel;
- A high cost of maintenance, since dredged natural channels will tend to return to their original state via accumulation of sediment in the modified portion of the channel; and
- Inconsistency with the principles of Ecologically Sustainable Development, which means using, conserving and enhancing natural resources so that ecological processes are maintained.

One particular suggestion is for a realignment of the Orphan School Creek channel north of Freeman Avenue and east of Council's Works Depot on Sackville Street. This option was investigated by Dalland and Lucas (1996). Based on their plan (key aspects are shown in Figure 38), the channel length would be reduced by about 150 metres. They found (using a now superseded HEC-RAS hydraulic model) a reduction in 100 year ARI flood levels of about 200mm adjacent to the Works Depot. The channel realignment and wetland construction was estimated to cost about $1M.

Given the previous investigation is now almost 20 years old, a new assessment of this option is desirable including modelling of the option using the latest flood model, and, if required, a new cost estimate. The last 20 years has also seen a growing understanding of the geomorphic and ecological sensitivity of creek channels, which might make channel works such as these more difficult to implement. It is also doubtful that this option would provide much relief to Freeman Avenue since floodwaters break out of the channel upstream of Sackville Street.

Figure 38 – Proposed channel realignment, Orphan School Creek near Freeman Avenue (after Dalland and Lucas, 1996)

10.4 RIPARIAN VEGETATION MANAGEMENT

Findings:

1) An option to increase the density of floodplain vegetation in attempt to reduce flood levels in downstream areas would replicate the function of the extensive drainage basin network

2) An option to clear creeks of vegetation in attempt to reduce flood levels locally could conflict with environmental objectives, exacerbate downstream problems and require ongoing maintenance costs

10.4.1 Riparian corridor plantings

The draft *Fairfield Urban Creeks Masterplan* (Eco Logical Australia, 2009), identifies and prioritises management actions along nine creek corridors within the Fairfield Local Government Area, including Orphan School, Clear Paddock and Green Valley Creeks and their tributaries. The Masterplan identifies land within the creek corridors that may be available for revegetation, regeneration or ongoing rehabilitation. The aim is to consolidate the better quality areas that have high conservation value before restoring more degraded land and waterways.

But while the environmental benefits of these programs are well recognised (see Section 2.2), the hydraulic impact of revegetation programs needs to be considered. The environmental benefits of creek corridor restoration need to be balanced with the hydraulic function of the creek and floodplain to convey floodwater. Council commissioned FloodMit (2012) to assess the impact on flood levels of increasing the density of vegetation on floodplains and in channels. For Prospect Creek, increasing floodplain roughness (Manning's 'n') from 0.07 to 0.10 results in increasing the 100 year ARI flood level by up to 0.20m. Increasing floodplain roughness from 0.07 to 0.12 results in more extensive increases to flood levels by up to 0.20m. Within-bank vegetation is believed to have a much larger impact on flood behaviour in Prospect Creek and an observed increased density of within-bank vegetation resulted in large increases to design flood levels between 1993 and 2001. Selective stream clearing measures may be required to lower flood levels in sensitive areas. This within-channel vegetation management could offset potential increases in flood levels from revegetating floodplains.

Although the hydraulic impacts of increasing floodplain roughness in the Three Tributaries catchment have not been modelled, the findings for upper Prospect Creek are considered representative. This suggests that sites for replanting would need to be very carefully selected so as not to create adverse effects on private property adjacent to the roughened floodplains. An inspection of the Three Tributaries floodplain shows that at most locations, flooding is already problematic and so revegetation cannot be accommodated, or the 100 year flood is contained within channel so planting on the floodplain would have no impact. Revegetation could possibly be beneficial in upper Green Valley Creek.

A more fundamental issue is that revegetation of floodplains would need to demonstrate a clear flood mitigation benefit in order to obtain funding under the State's Floodplain Management Program. It is generally recognised that slowing the passage of floodwaters in upper catchment areas may provide additional flow attenuation and reduce downstream flood levels (FloodMit, 2012). However, in the case of the Three Tributaries catchment, this option would be difficult to justify because riparian planting would replicate the function of the existing detention basins, of which there are 14.

10.4.2 Creek clearing

Among the most popular approaches to addressing flood problems in the Three Tributaries study area are frequent suggestions to 'clear' the creeks of debris and rubbish to improve conveyance of flows (see Sections 5.2.1 and 5.5e)). Removing urban waste such as supermarket trolleys from channels should certainly be encouraged. And managing in-channel vegetation to reduce the potential for culvert blockage at key locations is recommended (see Section 10.6). But a program for the broad-scale removal of within-channel riparian vegetation would conflict with environmental objectives (e.g. to provide continuous habitat linkages) and could also speed the delivery of floodwater to downstream areas, exacerbating flood problems there. Also, any clearing would need to be maintained to prevent the regrowth of weeds, and Council funding may not be available to support maintenance programs. For these reasons, creek clearing is not considered further.

10.5 DRAINAGE UPGRADES

Recommendation:

1) Install flap gate on the outlet to the northern Sackville Street 1200mm diameter pipe at Orphan School Creek

Increasing the flow conveyance capacity of a drainage structure typically involves an increase to the effective flow area of the structure via installation of larger or more pipes/culverts. This generally reduces flood levels upstream of the area where the modifications are made. The resulting increase in flow to downstream areas can cause increases to flood levels and inundation frequency downstream of the modifications, if the increased capacity is not matched throughout the downstream drainage system.

Areas in the lower portion of the study area are already developed, which suggests that it could be unacceptable to upgrade drainage infrastructure in the upper portion of the study area.

10.5.1 Edensor Creek at Smithfield Road and T-Way

Flood modelling and local experience indicates that flooding near the intersection of Edensor Road and Smithfield Road is problematic. Whilst relatively few buildings are expected to flood above floor level in the 100 year ARI event (Figure 28), these roads carry significant traffic and are subject to inundation even in the 20 year ARI flood (Table 14). For this reason, consideration has been given to increasing the capacity of pipes that carry flow in this area. Inspection of the relevant WaterRIDE project indicates that flooding at this intersection originates from where an 1800mm pipe carrying Edensor Creek flows commences just west of Smithfield Road. In the 20 year ARI flood, peak flow in the open channel prior to the pipe is 11.1 m^3/s, whereas peak flow in the pipe is 6.7 m^3/s, meaning the additional flow of 4.4 m^3/s, as well as a flow across the floodplain of 0.5 m^3/s at Sweethaven Road, drains towards the Edensor/Smithfield Roads intersection (Figure 39). In the 100 year ARI flood, peak flow in the open channel is 12.5 m^3/s and peak floodplain flow at Sweethaven Road is 0.7 m^3/s at Sweethaven Road, which when compared to the peak pipe flow of 6.9 m^3/s leaves a surplus of 6.3 m^3/s Edensor Creek flows draining towards the intersection (with additional flow from Clear Paddock Creek to the south in the 100 year ARI event).

Duplication of the existing 1800mm pipe that carries flow from west of Smithfield Road to Clear Paddock Creek at 'Restoring the Waters' would completely convey Edensor Creek flows up to the 100 year ARI flood. One way of reducing costs could be to duplicate the pipes only under Smithfield Road and the T-Way, and, if acceptable to the land-owners particularly RMS, to 'daylight' the pipes between Smithfield Road and the T-Way (Figure 40). Residual nuisance flooding at the intersection of Edensor and Smithfield Roads could also be mitigated by either raising the embankment at Bosnjak Park Downstream Basin to contain the 20 year ARI flood (or preferably the 100 year ARI flood) or by some minor works to the footpath along Edensor Road immediately downstream of the Basin or to increase inlet capacity in the road, so as to capture any overflows from the basin and direct them into the open channel rather than flow long the road.

J. Wyndham Prince estimated the cost of duplicating the 1800mm pipe under Smithfield Road and the T-Way and 'daylighting' the intermediate length of existing pipe, would cost about $1.2M (see Appendix I). When this is compared to tangible benefits of $165K (assessed as reduced direct and indirect residential damages), the benefit-cost ratio is calculated as only 0.1-0.2. Although there would also be some intangible benefits such as a reduced disruption to travel and reduced risk to life from inundation of roads, these are not sufficient to override the low economic feasibility. Even though the roads are flooded in relatively frequent events, investigation of maximum depths and velocities suggest that the roads here are still expected to be trafficable in the 100 year ARI event.

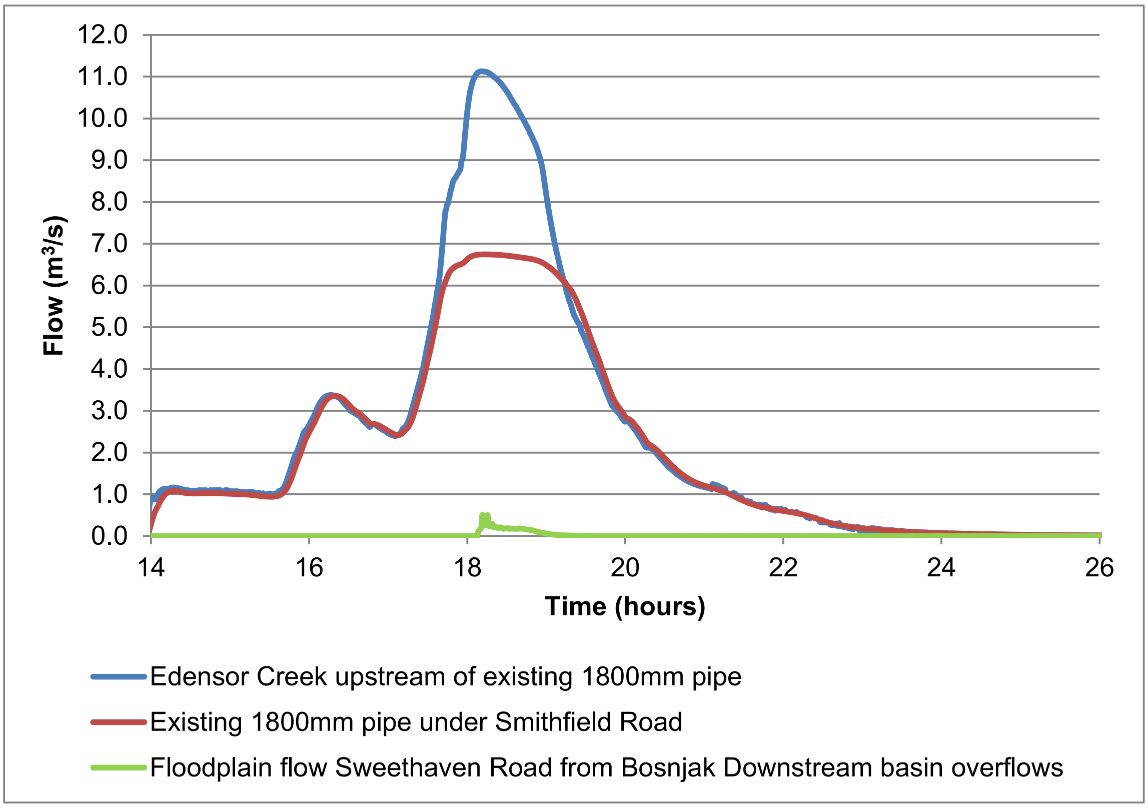


Figure 39 – 20 year ARI Edensor Creek flows near Smithfield Road

Figure 40 – Schematic plan of proposed pipe upgrade, Edensor Creek

10.5.2 Orphan School Creek at Railway Parade and Canley Vale-Fairfield Railway

Consideration was given to the influence on flood behaviour of the bridges over Orphan School Creek at Railway Parade and the Fairfield-Canley Vale Railway. Flood modelling indicates that the afflux across these structures in the 100 year ARI event is not serious (0.2m), suggesting that sufficient waterway area is available. In addition, the Railway viaduct is heritage listed.

10.5.3 Flap gate at Sackville Street pipe outlet

A 1200mm pipe carries flow from Delamere Street to Orphan School Creek parallel to Sackville Street. During floods, flow from Orphan School Creek has reportedly entered this pipe and surcharged through pits in Delamere Street causing localised flooding. This mode of inundation could be prevented by installing a flap on the outlet to the pipe in Sackville Street at a cost of about $10K.

10.6 DEBRIS CONTROL

Recommendations:
1) Manage vegetation upstream of culvert at Moonlight Road on Orphan School Creek
2) Maintain clear grates across culvert entrances at Elizabeth Drive on Henty Creek
3) Install debris control structure upstream of culvert at Cabramatta Road West on Green Valley Creek

Blockage of bridges and culverts can back up floodwater, causing flood levels to locally increase and diverting flows onto properties that would not otherwise flood. Debris control structures are designed to protect bridges and culverts from becoming blocked as a result of flood-borne debris. An alternative to actual structures is to reduce the potential for debris by conducting regular inspections in creeks upstream of certain culverts, removing urban rubbish (supermarket trolleys etc) and limiting within-bank vegetation. Council has a long running and successful program that is doing this.

The potential effect of blockage at culverts in the Three Tributaries study area was modelled in the 2008 Flood Study (SKM & FCS, 2008, pp.60-70). Open span bridges were considered unlikely to become significantly blocked and hence were excluded from the analysis.

The culverts modelled to be most sensitive to blockage (here judged to be those where blockage causes an afflux of >0.6m) are listed here in Table 19. Drawing on the damages database generated for this study, the consequences of the modelled blockage for house inundation are estimated for each site.

The consequences of the modelled blockage at Sweethaven Road and Belfield Road are low, so no further attention is given to those sites.

If the maximum increase in flood levels at Moonlight Road occurred, about two houses upstream of the culvert could be flooded above floor in the 100 year ARI event. A photo of the creek crossing (Figure 41a) suggests that the channel upstream of the culverts has substantial vegetation. It is suggested that this vegetation be regularly managed to reduce the potential for debris forming and blocking the culverts during floods.

If the maximum increase in flood levels at Elizabeth Drive were realised, more than 7 houses upstream of the culverts could be flooded above floor in the 100 year ARI event. Here, two grates have the potential to trap fine organic litter (grass, twigs) as well as urban rubbish and reduce the ability of water to enter the culverts (Figure 41b). This suggests that regular inspections of this site are required to check for litter and to clear the grates and their immediate vicinity.

If the maximum increase in flood levels at Cabramatta Road West occurred, some very serious effects could result, with inundation of more than 19 houses on both the upstream and downstream sides of the road as flow is diverted out of the channel. Although riparian vegetation is set back some 15m from the culverts, there is evidence of partial blockage in the past (Figure 41c). The very serious consequences of blockage commend the installation of a debris control structure to reduce the likelihood of this culvert becoming blocked in a flood. A possible design would be to install 'soldier posts' in a V-shaped arrangement pointing upstream, with the spacing of the posts smaller than the culvert width in order to trap the larger debris upstream of the protected culvert. The location for such a structure needs to be carefully considered to ensure that the consequences of blockage at the debris control structure are acceptable, and that Council can access the site to maintain it. In the case of the proposed Cabramatta Road West structure, a site about 110m upstream of the culverts appears to be most appropriate since Council owns land on both sides of the creek and has an existing access road from the left bank.

Capital costs for debris control structures vary according to design specifications. One council with much recent experience in installing debris control structures is Wollongong City Council, which reports that on average a structure costs about $10-15K for design and $120K for construction.

Table 19 – Culverts subject to significant blockage
Source: SKM & FCS (2008, p.62)

Creek	Culvert	Modelled blockage	Increase in flood levels (m)*	Consequences for house inundation
Orphan School Creek	Moonlight Road (culverts)	50%	0.86	Medium: possible flooding of 2 houses not currently affected in 100y ARI
Orphan School Creek	Sweethaven Road	50%	0.73	Low: house floor levels appear to have adequate clearance even if blocked
Orphan School Creek	Belfield Road	50%	1.28	Low: house floor levels appear to have adequate clearance even if blocked
Henty Creek	Elizabeth Drive (culverts and pipe)	100%/50%	1.24	High: possible flooding of 7+ houses in Elizabeth Dr and Gregorace Pl not currently flooded in 100y ARI
Green Valley Creek	Cabramatta Road West	50%	0.78	High: possible flooding of 19+ houses in Cabramatta Rd West not currently flooded in 100y ARI (some with low clearance), plus worse flooding at one house that is already flooded over floor

Notes:

* In 100 year ARI 2 hour event

Figure 41 – Photos of three creek crossings sensitive to blockage

a. Orphan School Creek upstream of Moonlight Road

Source: Google Street View

b. Henty Creek upstream of Elizabeth Drive

Source: FCC

c. Blockage at Green Valley Creek at Cabramatta Road West culverts

Source: SKM & FCC (2008, p.70)

10.7 LEVEES

Recommendations:

1) Flood barrier to protect six properties at southern end of Gregorace Place from Henty Creek flooding

2) Sealing of soundwall, bunding and speed hump to protect two properties near corner of Katinka Street and Lisa Crescent from Green Valley Creek flooding

Levee banks and flood barriers are a means of excluding floodwaters from areas that would otherwise be inundated. They can prevent inundation up to a designated design level (with a freeboard allowance of typically 0.5m) and have been widely used for this purpose. Levee banks are generally made of compacted earth and can usually be successfully landscaped to produce minimal visual impact. Flood barriers can be in the form of a vertical flood wall constructed from pre-fabricated concrete elements.

Levees and flood barriers are frequently the most economically attractive measure to protect existing development in flood prone areas.

However, a number of complicating factors need to be considered in evaluating the appropriateness of these measures:

- Loss of flood conveyance and storage. This typically causes flood levels to rise upstream of the barrier.
- Internal drainage. The ponding of local stormwater runoff behind levees is often problematic and may require flap gates or pumps to address it.
- Loss of amenity and visual impact. Residents may not welcome a barrier that breaks any connection they enjoy to a creek and attractive natural environs.
- False sense of security. Levees or barriers tend to induce a false sense of security among the people they ‘protect’. Unless a levee is designed to withstand a PMF, the common misperception that a levee solves all flood problems can result in catastrophic losses in the event of overtopping or breaching, since people are unlikely to be prepared for these rarer events.

10.7.1 Henty Creek at Gregorace Place

Based on the refined modelling presented in the *Brown Road Culvert Upgrade/Henty Creek Flood Mitigation* study (WMAwater, 2013c), six houses in Gregorace Place would be flooded over floor in the 100 year ARI event, the worst to a depth of 0.50m. Having evaluated several options, the *Henty Creek Flood Mitigation* study recommended a flood barrier (levee) be constructed to protect this concentrated risk exposure (see Figure 42). Modelling showed that the increase in 100 year ARI flood levels caused by the levee would exceed 0.5m on the upstream side of the structure, but that this increase would be confined to the creek corridor and not affect private properties. WMAwater (2013c) estimated a cost of $80-120K and a benefit-cost ratio of 5.0-7.5.

Consultation conducted as part of the investigation showed that an assessment of overland flows entering Gregorace Place from the direction of Somers Street is required, but that this would not necessarily disqualify the proposed levee scheme, because (i) the length of the levee could be abbreviated so that these overland flows can flow towards Henty Creek without obstruction, (ii) there is scope for additional inlet capacity in Gregorace Place, and (iii) there is scope for upgraded drainage at the rear of the properties (on the inside of the proposed wall).

Another issue to consider is the risk to life in floods that could overtop the levee. Design flood levels at the ‘bend’ in the levee are recorded in Table 20. It is noted that the PMF is only 0.8m higher than the

100 year ARI flood. This means that the levee would only need to be 0.3m higher than the standard 100 year plus 0.5m freeboard height to protect against the PMF.

Figure 42 – Proposed levee to protect houses at Gregorace Place

Source: WMAwater (2013c, p.21)

Table 20 – Design flood levels at the upstream end of the proposed levee

Design Flood	Flood Level (m AHD)
20 year	43.71
50 year	43.78
100 year	43.82
PMF	44.59

10.7.2 Green Valley Creek at Katinka Street

Based on the flood modelling and estimated floor heights, two houses near the corner of Katinka Street and Lisa Crescent, Bonnyrigg, could be inundated above floor level in a 50 year ARI event. It appears that a scheme to seal the Elizabeth Drive soundwalls at the rear of the houses and to construct bunding from the end of the soundwall along the property boundary to Katinka Street would prevent inundation (see Figure 43). A speed hump in the road might also be required to prevent flow gaining entry via the driveways. In order to provide immunity from 100 year ARI flooding, the bunding would need to be about 0.8m high where it commences at the soundwall to about 0.5m high at Katinka Street, which includes 0.3m freeboard (lower than normal to minimise impacts on visual amenity).

Damage savings (benefits) of $117K would accrue by keeping out floods up to and including the 100 year event. With an estimated cost of about $60K (estimated by J. Wyndham Prince – see Appendix I), the benefit-cost ratio is a favourable 1.9-2.0.

Flood modelling is required to assess the potential effect of the works on flood conveyance and storage. It would also be advisable to assess maximum overland flows coming down Lisa Crescent to ensure that the existing pit located just above the proposed speed hump is capable of draining the local catchment and not surcharging to flood the properties protected from mainstream flooding. RMS approvals could be required for any work on the soundwalls.

Figure 43 – Schematic plan showing proposal to protect two houses

10.7.3 Green Valley Creek at Cabramatta Road West

A proposal was developed to construct flood barriers on both sides of the open channel upstream of Cabramatta Road West, since this represents a serious breakout during Green Valley Creek flooding, with a number of exposed houses. This scheme to contain the 100 year ARI flows was modelled as Scenario H, with the impacts presented in Appendix H.

Because this scheme enhance conveyance in the area of the Cabramatta Road West culvert, the modelling shows that it would have an unacceptably adverse impact on flooding downstream of the Chisholm Park Basin, with some newly flooded areas. This alone is sufficient reason to disqualify the option.

It is also considered doubtful that the 100 year flow could be conveyed through the existing culvert since in the existing case about 64 m^3/s is conveyed through the culverts and 5-6 m^3/s flows across Cabramatta Road West. The effect of trying to force the floodplain flow through the culverts could be more hazardous inundation of the road.

Finally, the community's appetite for such a levee is not known. There is only limited space between the channel and private property, which would probably require a concrete block wall.

For these reasons, and particularly the adverse downstream effects, this levee scheme is not recommended.

11 PROPERTY MODIFICATION MEASURES

Property modification measures involve modifying or removing existing properties from flood affected areas and imposing controls on future property and infrastructure development. These are aimed at steering inappropriate development away from areas with a high potential for damage and ensuring that potential damage to developments likely to be affected by flooding is limited to acceptable levels by means of minimum floor levels, flood proofing requirements, etc.

11.1 VOLUNTARY HOUSE PURCHASE

Recommendation:
1) Council seek to VP serious flood risk exposures when implementing its Open Space Strategy

For existing properties which face a high flood hazard and where no significant reduction of the hazard is practicable, the physical removal of the building from the property, or its demolition, remains the only alternative. Voluntary house purchase (often referred to as 'VP') is an expensive option generally reserved for sites where the risk to life is unacceptable. Fairfield City Council has successfully operated a VP scheme for Prospect Creek since 1988. This has resulted in the demolition of 72 houses out of the 92 that were identified as eligible for inclusion in a VP scheme.

11.1.1 Catchment-wide

For houses on the Three Tributaries floodplain, eligibility for inclusion in a new VP scheme is assessed using the same criteria set out in the Lower Prospect Creek Floodplain Management Study (Willing & Partners, 1990). This system is based on points scored for high hydraulic hazard, location within a floodway, inundation above floor in a 20 year flood, the risk of building collapse and the difficulty of evacuation. By this assessment, no dwellings within the study area would qualify for VP, though floodways have not been mapped (but the High flood risk precinct represents a rough surrogate). Only one house near Henty Creek in Bonnyrigg scores, arguably, three points, with four required. It is flooded over floor in the 20 year event, it scores another point for high velocity flows in the 100 year ARI event and it could be difficult to evacuate. The modelled depth of flooding above floor is a relatively modest 0.3m in the 100 year event, however.[1] But even if the passing 'score' for VP was reached, other options appear to be available to address the risk to life, such as flood proofing. Refined modelling for Gregorace Place (WMAwater, 2013c) indicates that flood depths there are more serious than assessed via the catchment-wide flood modelling. But a levee is the preferred means for addressing the flood risk in that area.

11.1.2 Freeman Avenue

Given its serious evacuation constraints, VP has been considered for five old dwellings adjacent to the Freeman Avenue low-point. OEH's 'Guidelines for Voluntary Purchase Schemes' states that properties being considered for VP should be '*within high hazard areas where there is a significant risk to life for occupants and those who may have to evacuate or rescue them*'.

[1] A detailed investigation by WMAwater (2013b) subsequent to the conclusion of the catchment-wide flood modelling resulted in fine-tuning of the model in this area such that the above floor depth in the 100 year ARI flood is now judged to be 0.09m (and 0.75m in the PMF).

Reasons in favour of VP here include:

- Access is lost *early* in an Orphan School Creek (OSC) flood when the Freeman Avenue low-point is flooded, prior to inundation of the properties; it is possible that access could be lost earlier due to overland flows from the Canley Corridor catchment inundating the low-set road;
- Access is lost relatively *frequently*, with the Freeman Avenue low-point flooded to a depth of 0.8m in the 20 year ARI OSC flood (modelling for more frequent events was not undertaken) and to a depth of 0.6m in the 5 year ARI Canley Corridor event;
- Available warning times are generally very short, accentuating the constraints to evacuation;
- Rescuers' lives would be put at risk attempting to evacuate this area;
- Four older houses are flooded above floor in the 50 year ARI event;
- The hydraulic hazard in the PMF would present an extreme risk to the existing dwellings.

Reasons against VP here include:

- The actual properties are not located within an area of high hydraulic hazard in the 100 year ARI flood (this is largely confined to the street);
- The maximum above floor flooding depth in the 100 year event is 0.26m, which is not of a magnitude expected to threaten building integrity or people, if people were unable to evacuate;
- Depths in the 100 year + 20% increase in rainfall intensity event (believed to correspond to about a 300-500 year ARI flood) are only about 0.15m deeper than the 100 year event;
- VP is not usually justified on the basis of PMF hazard – were this standard applied, there could be thousands of eligible properties across the State, which is not affordable;
- The area is currently zoned for medium density development, suggesting there would be little appetite for VP unless the owners received recompense on the basis of development potential; this might be less of an obstacle if Council backzones this area to Low Density Residential, as we argue is a more appropriate zoning for this area (see Section 11.3.2);
- Whilst ideally VP would be available for these properties, other options may be available to reduce the risk to tolerable levels, including redevelopment of the site to meet current planning standards (e.g. a robust building structure that provides a PMF refuge; noting that flood durations are about 2-3 hours – see Figure 30) and improvements to flood warning and evacuation.

Based on this evaluation, it could be difficult to secure funding for VP for properties in Freeman Avenue under the NSW Government's floodplain management grants. Council might be able to fund a scheme through S94 developer contributions to meet open space requirements (see Section 11.1.3). This could be attractive because the affected properties are contiguous with Adams Park to the south. Whilst there is merit in Council exploring the possibility of purchasing these properties, for the purposes of this FRMP, no allowance is made for VP; rather, we cost what would appear to be a more palatable measure for decision makers – redevelopment of these properties to a flood-compatible standard (see Section 11.2).

11.1.3 Open Space

As described in Section 3.7.2, Council's Open Space Strategy has identified some areas for connecting existing open space including along riparian corridors. Some of these areas coincide with areas of significant flood risk, including some properties upstream of the Cabramatta Road West crossing of Green Valley Creek – which would be especially affected if the culvert there was partially blocked (Section 10.6) – and properties in Pitt Street which are cut off early in a flood event (Section 8.4.3). Although these properties would not be eligible for inclusion in a VP scheme funded by the NSW Government's floodplain management grants, Council could secure funding through S94 developer contributions. For the purposes of this FRMP, we recommend that Council take account of flood risks when implementing its Open Space Strategy, where possible acquiring properties that will serve both the objectives of reducing serious flood risk exposures as well as adding open space.

11.2 VOLUNTARY HOUSE RAISING, REDEVELOPMENT AND FLOOD-PROOFING

Recommendation:

1) Adopt a scheme to raise, redevelop or flood-proof 16 old houses inundated in the 20 year, 50 year or 100 year ARI event, where the flood risk is not treated by other measures

Fairfield City Council has a long history of reducing flood risk to property through voluntary house raising (VHR) schemes. By 2010, 204 houses out of 464 identified in the Prospect Creek catchment had been raised or otherwise treated for flooding (Bewsher Consulting, 2010, p.70). Various methods are available, including (after Frost & Rice, 2003; Bewsher Consulting, 2010):

- An owner is given a subsidy to raise an existing house, particularly suitable for structurally sound fibro or timber dwellings;
- For houses that are difficult to raise (e.g. brick), an owner is given a subsidy to demolish an existing house and build a new house with appropriate development controls ('redevelopment');
- Council purchases and demolishes a 'difficult to raise' house and sells the property on the market with any new dwelling required to comply with current development controls;
- Flood-proofing (replacement of floor coverings, use of solid core doors, modification to walls, lifting power points, etc) is sometimes implemented as an alternative to house raising.

An assessment of these options for the Three Tributaries floodplain has been undertaken for houses flooded over floor in events up to and including the 100 year ARI flood, where the flood risk is not recommended to be addressed through other measures including the proposed Mimosa Road Basin and Fairfield Golf Course Basin upgrades and flood barriers. The following points are noted:

- In general, the above floor depths of flooding in the 100 year flood are quite modest (maximum 0.3m). This suggests that a subsidy towards flood-proofing may be a more prudent investment than more expensive raising or redevelopment.
- According to OEH's 'Guidelines for Voluntary House Raising Schemes', State funding for raising (or redeveloping) *new* houses is unlikely to be made available. New houses in the Three Tributaries floodplain are also typically brick, two storey constructions and so would be difficult to raise. It is also unlikely that the owners would elect to redevelop a new home, and for duplexes this would require both owners agree to participate in a scheme. These reasons suggest there is little value evaluating the merits of raising or redeveloping these houses, though flood proofing may still be appropriate.
- The affordability and progress of existing schemes in Fairfield LGA, and the affordability and progress of existing schemes across NSW needs to be considered when deciding eligibility.
- Floor levels for several potentially VHR-eligible houses are currently estimated and require formal survey.

The economic assessment is presented in Table 21. Benefits are assessed in terms of reduced direct and indirect flood damages, and assume floors are raised to the PMF level (to allow provision for shelter-in-place, since the other emergency management option of early evacuation is difficult to guarantee in this catchment). The benefit-cost ratio (BCR) assumes a cost of $81K for raising each dwelling, which is the maximum subsidy that Fairfield City Council currently provides each owner for VHR. Actual costs will vary from house to house depending on the complexity of the task.

This assessment indicates that for only one property located in Brown Road is VHR economic (BCR > 1.0), but this is the property where a previous assessment found that flood-proofing such as raising of the driveway was the best approach to reducing the house's flood affectation (WMAwater, 2013c).[1] An

[1] A detailed investigation by WMAwater (2013b) subsequent to the conclusion of the catchment-wide flood modelling resulted in fine-tuning of the model in this area such that the above floor depth in the 100 year ARI flood is now judged to be 0.09m rather than 0.30m, such that the benefits and BCR would be reduced.

important principle to emerge from this is that if a more affordable approach can yield the same flood risk reducing outcome, it makes sense to implement the more cost-effective option. On the other hand, if in order to achieve a desired outcome higher-than-normal subsidies are required, a BCR of less than 1.0 should not necessarily be considered prohibitive. Certainly the concept of proportional subsidies advanced in the *Lower Prospect Creek Floodplain Management Study* (Willing & Partners, 1990, p.57) has merit, with a sliding scale of subsidies according to the frequency of above-floor inundation. However, the *Prospect Creek Floodplain Management Plan Review* (Bewsher Consulting, 2010, p.86) recommended a continuation of the VHR scheme there even though the BCR was less than 0.5. Consideration of options for Three Tributaries needs to be similarly outcome-focussed.

It is not desirable to be overly prescriptive about whether a particular house is more suited to house raising, knock down and rebuild or flood proofing. This depends on existing constraints, verification of floor levels where required and the attitudes of the homeowners. Council would do well to adopt a flexible, outcome-based approach. Nevertheless, a preliminary recommendation for each of the dwellings in Table 21 has been made, with the rationale for these recommendations provided in Table 22.

For dwellings flooded above floor in the 50 year ARI event, a full subsidy up to $81K could be provided for house raising, or more likely given the age of the dwellings and practice in the catchment, for redevelopment in accordance with current development controls. This is consistent with the recommendation of the *Prospect Creek FMP Review*.

In view of the very serious evacuation risks in Freeman Avenue, this subsidy could be offered to older dwellings flooded there in the 100 year ARI event too. This is consistent with the recommendation of the *Lower Prospect Creek FMS* that evacuation problems be given weight in prioritisation. In fact, in our opinion a higher subsidy could be offered if $81K was found to be insufficient incentive for the six landowners in Freeman Avenue to participate in a voluntary house redevelopment scheme. Since the only other option to address the risk is the considerably more expensive (but from a flood risk reduction perspective, superior) option of voluntary house purchase, a higher subsidy should be made available if this will achieve the desired outcome of reducing risk to property and life. However, a subsidy should not be offered for increasing the density of development on a lot, which would put more people into the floodplain representing an increased risk to life. The subsidy should be used as an incentive to retain a single dwelling – constructed to withstand the forces of floodwater, and including a PMF refuge – on each of the existing lots.

For other fibro and timber houses flooded above floor in a 100 year event, a subsidy of $20K towards the cost of redevelopment has been allowed, which is consistent with the approach recommended in the *Prospect Creek FMP Review*. This however may be insufficient incentive to persuade the landowner to participate in a scheme, and a subsidy of $30K is justified based on the damages averted as shown in Table 21.

The Brown Road and Henty Road houses, flooded above floor in relatively frequent events, could be given a subsidy to pay for flood-proofing such as raising the driveway to keep water out. This subsidy could be increased substantially if required, and still be economic.

Another three, brick houses are flooded by very shallow water in the 100 year event. For these, a reduced flood-proofing subsidy of $10K/house is proposed. An alternative measure could be for Council to prepare generic flood-proofing guidelines and to conduct education using these guidelines.

If the benefits shown in Table 21 were fully realised (admittedly unlikely to occur for the flood-proofed properties, since this would not treat PMF risk) as a result of the implementation of the provisionally recommended measures at a cost to Council of $717K, the BCR is about 0.8. It is not possible to estimate the true cost including landowner contributions, which could be sizeable. In the case of the Freeman Avenue properties at least, there would also be a significantly reduced risk to life. For the purposes of this FRMS&P, the scheme in Table 22 is recommended.

Table 21 – Assessment of VHR, sorted by BCR

ID	ARI at which floor flooded	Depth over floor in 100y flood (m)	Street (house numbers available in confidential list)	House type	Floor level source	Benefit	BCR	Recommendation
437	20y*	0.30*	Brown Rd	Brick	Surveyed	$117,000*	1.4*	Flood-proof subsidy* ($20K+)
2472	20y*	0.13*	Henty Pl	Brick	Surveyed	$72,000*	0.9*	Flood-proof subsidy* ($20K+)
1873	50y	0.17	Fernlea Pl	Fibro	Estimated	$45,000	0.6	Redevelopment subsidy ($81K)
1962	50y	0.26	Freeman Ave	Fibro	Surveyed	$37,000	0.5	Redevelopment subsidy ($81K)
1958	50y	0.25	Freeman Ave	Fibro	Surveyed	$36,000	0.4	Redevelopment subsidy ($81K)
1626	100y	0.06	Duke St	Fibro	Estimated	$36,000	0.4	Redevelopment subsidy ($20K)
1103	100y	0.05	Clarence St	Fibro	Estimated	$35,000	0.4	Redevelopment subsidy ($20K)
1960	50y	0.24	Freeman Ave	Fibro	Surveyed	$35,000	0.4	Redevelopment subsidy ($81K)
1627	100y	0.06	Duke St	Timber?	Estimated	$30,000	0.4	Redevelopment subsidy ($20K)
1956	50y	0.15	Freeman Ave	Fibro	Surveyed	$26,000	0.3	Redevelopment subsidy ($81K)
1947	50y	0.14	Freeman Ave	Fibro	Surveyed	$26,000	0.3	Redevelopment subsidy ($81K)
1871	100y	0.05	Fernlea Place	Brick	Estimated	$26,000	0.3	Flood-proof subsidy ($10K)
1618	100y	0.05	Duke St	Fibro	Surveyed	$25,000	0.3	Redevelopment subsidy ($20K)
1954	100y	0.03	Freeman Ave	Fibro	Surveyed	$18,000	0.2	Redevelopment subsidy ($81K)
1592	100y	0.02	Donahue Cl	Brick	Estimated	$6,000	0.1	Flood-proof subsidy ($10K)
3613	100y	0.01	Prairie Vale Rd	Brick	Estimated	$6,000	0.1	Flood-proof subsidy ($10K)

* The assessment for the Brown Road and Henty Place houses are based on the catchment-wide flood model (Nov 2012). WMAwater (2013c) subsequently refined the model, which yields reduced flood levels at these houses, so the benefits would be reduced from those shown here. The recommendation might also vary.

Table 22 – Proposed voluntary house redevelopment/flood-proofing subsidies

Category	Proposed subsidy per house	Number of houses	Cost
Redevelopment of houses flooded above floor in 50y ARI event, and/or in 100y ARI in Freeman Ave	$81K (possibly increased for Freeman Avenue)	7	$567K
Redevelopment of houses flooded above floor in 100y ARI event	$20K (possibly increased up to value of damage averted)	4	$80K
Flood-proofing subsidy for brick houses flooded above floor in 50y event	$20K+	2	$40K
Flood-proofing subsidy for brick houses flooded above floor in 100y ARI event	$10K	3	$30K
Total			**$717K**

11.3 PLANNING POLICY REVISION

Recommendation:

1) Consider amending Clause 6.3 of the LEP to clarify that it does not apply beyond the PMF extent

2) Backzone Freeman Avenue to a land use more compatible with its High flood risk

3) Amend Chapter 11 of the DCP as discussed, including incorporation of a Very Low flood risk precinct

4) Amend Section 149 planning certificates as discussed, including incorporation of a Very Low flood risk precinct

Planning measures govern what can be built on the floodplain in the future and can impose controls on the design, construction and operation of new developments to minimise or negate the impacts of flooding. These measures are usually regulated through planning instruments such as local environmental plans and development control plans but may be articulated in principle in a higher order document such as a policy or strategy.

Planning measures can be used to ensure that future development does not detrimentally impact on flood behaviour but are also commonly used to ensure that the impacts of flooding on development are acceptable or at least tolerable.

11.3.1 Fairfield LEP 2013

a) Background

The Fairfield Local Environmental Plan 2013 conforms to the NSW Standard LEP in most respects including Clause 6.3 which relates to flood planning. This clause applies to land at or below the flood planning level which it defines as 'the level of a 1:100 ARI (average recurrent interval) flood event plus 0.5 metre freeboard'. The clause prohibits development below the flood planning level unless the consent is satisfied that the impacts of the development on flooding and the impacts of flooding on the development and its occupants are satisfactory (see Section 3.5).

Fairfield City Council successfully applied to have 'exceptional circumstances' recognised in the LGA. This means that FCC may, if it decides it is appropriate, impose development controls on residential development which is between the 1 in 100 year ARI flood level (plus 0.5m freeboard) and the PMF level. In particular, Council wishes to ensure that risk to life including means for evacuation or shelter is adequately managed even for extreme floods. To this end Clause 6.4 was inserted in the LEP (see Section 3.5).

b) Very Low FRP

As discussed in Section 7.1.3c), Council is proposing to relax its application of development controls on certain land and land uses within the PMF floodplain where hazards in a PMF event are judged to be tolerable. For this reason a 'Very Low' flood risk precinct (FRP) has been mapped. Council is proposing to amend clause 6.4.3 of the LEP to remove reference to commercial premises, industries and residential accommodation, and to add seniors housing. However, this would not only strip Council of the authority to control controls on residential, commercial and industrial development located in the 'Very Low' FRP but in the Low FRP as well. While it is understood that Council would still attempt to control development for residential, commercial and industrial land uses located in the Low FRP through application of the DCP, a LEP generally prevails over a DCP, so a developer may not be required to meet flood controls if clause 6.4.3 is amended as Council is considering. In the Consultant's opinion, the current wording of the clause is appropriate because it enables Council to apply controls over as many land uses and risk precincts as possible. The DCP in effect codifies where proposed developments *satisfy* Council that the risk is properly addressed, including areas where no controls are required.

c) Flood planning level (FPL)

The standard LEP defines the flood planning level (FPL) as the level of the 100 year ARI flood plus 0.5m freeboard. This effectively bypasses the process described in the *Floodplain Development Manual* of balancing the costs of restricting land use with the benefits of reducing flood risks. Instead, the LEP sets a single FPL for all floodplains within the LGA.

However, the Manual does suggest that in general, the FPL for standard residential development would be the 100 year flood plus 0.5m freeboard, so in that respect the LEP is consistent. Using the 100 year ARI flood to set the FPL for residential floor levels is a common practice throughout Australia and there is no outstanding reason for varying this for the Three Tributaries floodplain. Freeboard is an allowance that is included to allow for uncertainties and to ensure that a 100 year flood will not enter buildings constructed to the FPL. The Manual lists the following variables that should be accounted for in the adopted freeboard:

- Modelling uncertainties;
- Local factors such as obstructions;
- Wave action;
- Climate change;
- Cumulative effect of subsequent infill development of existing zoned land.

In the case of the Three Tributaries floodplain, a freeboard of 0.5m is judged to be appropriate. This includes an allowance of 0.2m for a 20% increase in rainfall intensities (see Section 7.2). Given the uncertainty in the magnitude of potential changes to rainfall intensities, FloodMit (2011) recommended that no change be made to the design flood levels or to the freeboard allowance adopted for Council's planning and development controls.

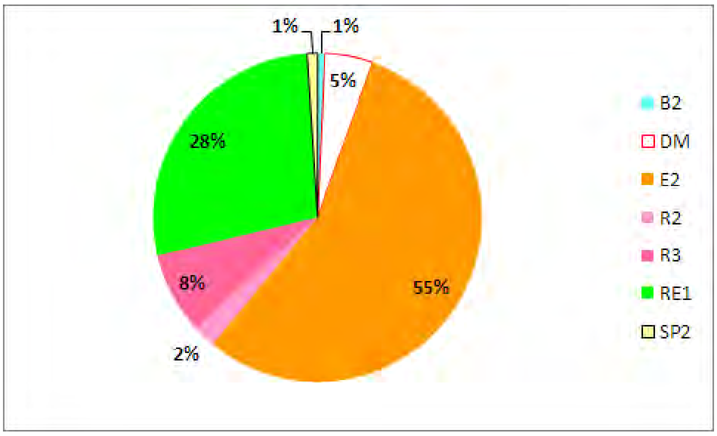
d) PMF level below FPL

Inspection of the flood surface grids shows that there are a few small areas in the upper catchment where the PMF is less than 0.5m above the 100 year ARI flood. This includes some areas immediately downstream of the Mimosa Road, Prairiewood and Bosnjak Park Downstream Basins, plus in the vicinity of Cabramatta Road West where it crosses Green Valley Creek. About 100 privately-owned properties fit within this category. According to the existing clauses 6.3 and 6.4, this means that in these areas clause 6.3 would apply rather than clause 6.4. But it is not appropriate to be applying controls to areas beyond the PMF floodplain. This could require an amendment to the existing clause 6.3.2, stating that 'this clause applies to land at or below the flood planning level, *where that land is within the PMF floodplain*' (amendment in italics). It is recommended that Council discuss the need to vary this clause with the Floodplain Management Association.

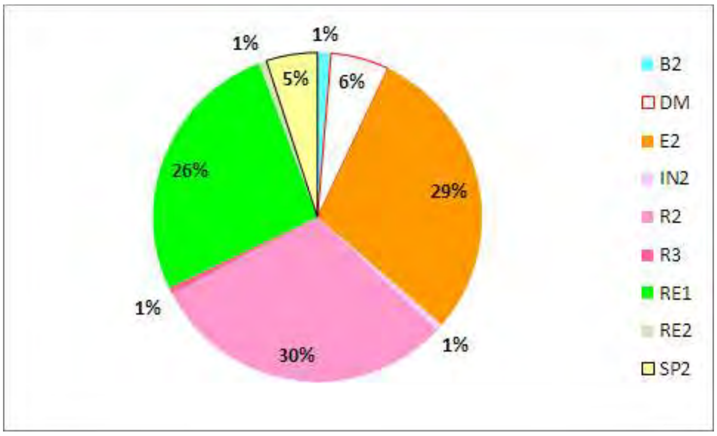
11.3.2 Fairfield LEP 2013 Zoning Maps

A map of current zoning in the study area is provided in Figure 10. An assessment was undertaken to establish what proportion of each flood risk precinct (as defined in Section 7.1.3c)) was given over to various land use zones (Figure 44). About 83% of land within the High FRP is zoned for Environmental Conservation (E2) or Public Recreation (RE2), which is fitting for land where there are significant flood risks. This is reduced to about 56% of land within the Medium FRP, which has a substantial area zoned for Low Density Residential (R2) and Medium Density Residential (R3). About 32% of land within the Low FRP is zoned for environmental or recreational uses, with 63% for residential. In the Very Low FRP, the proportion of land zoned for residential uses increases to about 78%.

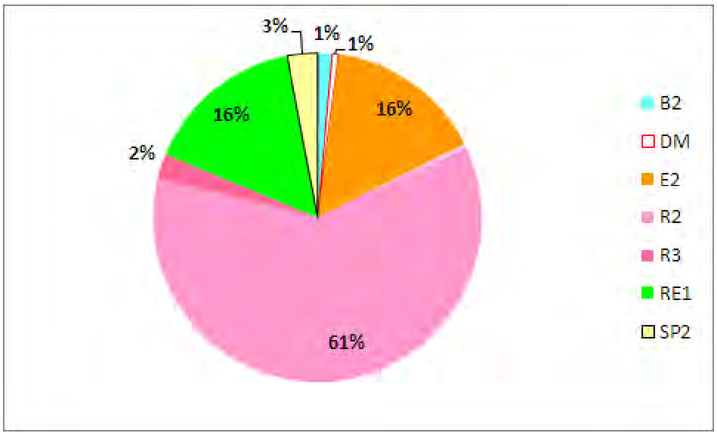
Although the general trend for an increasing area for environmental and recreational uses with increasing flood risk is noted, there are some areas where the existing land use is judged to be incompatible with the flood risk. This is particularly the case with Freeman Avenue, where due to evacuation constraints in frequent floods, and dangerous depths and velocities on residential land in events rarer than the 100 year ARI event, the flood risk is properly judged to be High (see Section 7.1.3c)). Indeed, adopted mapping already recognises this area to be a High FRP for Canley Corridor flooding. This risk category is not compatible with the area's current Medium Density Residential zoning. It is recommended that Freeman Avenue be backzoned to Low Density Residential to discourage further intensification of this area, which would place more people in an area that is a dangerous Low Flood Island in an extreme flood.



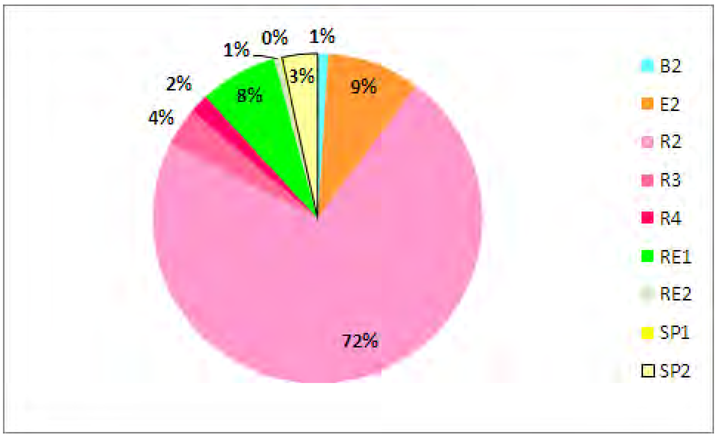
a. High FRP



b. Medium FRP



c. Low FRP



d. Very Low FRP

Figure 44 – Proportion of zoned land use within each flood risk precinct (FRP)

11.3.3 Fairfield City Wide DCP Chapter 11 – Flood Risk Management

In addition to Clauses 6.3 and 6.4 of the Fairfield City LEP 2013, specific land use planning measures in relation to flooding are controlled by Chapter 11 of the Fairfield City Wide Development Control Plan 2013 (DCP). The DCP's stated object is to 'supplement the statutory provisions contained in Fairfield Local Environmental Plan 2013.'

The DCP adopts a flood planning matrix based on earlier work on other floodplains in the LGA. That matrix works around four sets of information:

- Flood Risk Precincts (FRPs) – it currently divides the floodplain up to the PMF into three precincts: High, Medium and Low based on the probability of flooding and the corresponding hydraulic hazard, with some consideration of evacuation constraints too;
- Land use Categories – the matrix identifies land uses or land use types which are not appropriate within particular FRPs and others which are appropriate subject to suitable planning controls;
- Planning Controls – these are a mix of prescriptive planning controls and objective based solutions which are to be applied to particular land uses within particular FRPs to manage specific planning considerations.

Consideration is given to the suitability of Chapter 11 of the Fairfield City Wide DCP to manage flood risk in the Three Tributaries floodplain.

a) Flood risk precinct definitions

The creation of a 'Very Low' flood risk precinct (Section 7.1.3c)) will require amending Chapter 11 to add its definition and to vary the definition of the 'Low' flood risk precinct under clause 11.7. Suggested wording for the two definitions is provided below:

Low Flood Risk Precinct

This has been defined as land above the 100 year flood level but below the Probable Maximum Flood (PMF) level

- *and where in the PMF there is a significant hazard to children or a moderate-high hazard to buildings;*
- *or where the elevation is within 0.5m height of the adjacent 100 year flood level*

Note: The Low Flood Risk Precinct is where in the PMF, the depths and velocities are such that there is a significant hazard for children as defined in Australian Rainfall and Runoff Revision Project Book 9 Chapter 6 'Safety Design Criteria' (draft) prepared by Grantley Smith and Ron Cox <u>or</u> where buildings would require special engineering design and construction as defined in 'Updating National Guidance on Best Practice Flood Risk Management' prepared by McCluckie et al. (2014). The Low FRP is that area above the 100 year flood with a significant hazard to children or buildings in the PMF. Most land uses would be permitted within this precinct, subject to planning and development controls.

Very Low Flood Risk Precinct

This has been defined as land above the 100 year flood level but below the Probable Maximum Flood (PMF) level

- *and where in the PMF there is a low hazard to children and a low hazard to buildings;*
- *and where the elevation is not within 0.5m height of the adjacent 100 year flood level.*

Note: The Very Low Flood Risk Precinct is where even in the PMF, the depths and velocities are such that there is a low hazard for children as defined in Australian Rainfall and Runoff Revision Project Book 9 Chapter 6 'Safety Design Criteria' (draft) prepared by Grantley Smith and Ron Cox <u>and</u> a low hazard to buildings as defined in 'Updating National Guidance on Best Practice Flood Risk Management' prepared by McCluckie et al. (2014). The Very Low FRP is that area above the 100 year flood with a low hazard to children and buildings in the PMF. Most land uses would be permitted within this precinct, without planning and development controls.

b) Schedule 2 Land Use Categories

The planning matrix uses eight land use categories:

- Critical Uses and Facilities
- Sensitive Uses and Facilities
- Subdivision
- Residential
- Commercial and Industrial
- Tourist Related Development
- Recreation and Non-urban
- Concessional Development

Chapter 11 includes Schedule 2 which lists all of the land uses which fall within each of these categories.

The matrix lists critical uses and facilities as being unsuitable anywhere in the floodplain, sensitive uses and facilities being unsuitable in the medium flood risk precinct and all but recreation and non-urban, and concessional development being unsuitable in the high risk flood precinct.

Critical uses and facilities include emergency service facilities, hospitals and residential care facilities.

Sensitive uses and facilities include seniors housing, child care centres, correctional facilities, education establishments, respite day care centres, liquid fuel depots, electricity generating works and public utility undertakings which are essential during or after a flood.

Concessional development is development which continues an existing use without significantly increasing flood risks.

In general the land use categories and prohibitions are considered to be appropriate but consideration should be given to adding the following to the list of sensitive uses and facilities:

- Group homes – these often accommodate several people with physical, mental or behavioural disabilities which may create significant challenges in the occupants being able to respond safely and in a timely manner to a flood;
- Hazardous and offensive industries – these store significant quantities of hazardous substances or pollutants which can be at risk of being released to the environment in the event of a flood.

c) Schedule 7 Matrix

Using the existing Schedule 6 of Chapter 11 as a starting point, a draft matrix for the Three Tributaries floodplain including the new Very Low flood risk precinct has been prepared as Schedule 7 and is presented in Figure 45.

The draft matrix incorporates the following judgments for land uses and planning controls in the Very Low FRP:

- No controls are applied to 'Residential' uses. Since Residential uses are generally considered more sensitive than 'Commercial and Industrial', 'Tourist-Related' and 'Recreation and Non-Urban' uses, the latter uses are also exempt from any planning and development controls in this area of very low risk.
- For 'Sensitive Uses & Facilities' – including seniors housing and childcare centres – it is considered appropriate to condition development in a manner consistent with the Low FRP.
- 'Critical Uses & Facilities' – including emergency evacuation centres, emergency services facilities, hospitals and residential care facilities – remain marked as unsuitable land uses. Potentially these uses could be permitted with controls similar to those for Sensitive Uses & Facilities. However, in our opinion it remains appropriate to send a signal that best practice

teaches that such critical uses are fundamentally incompatible uses for a floodplain, no matter how rare a flood's occurrence.

- Concessional Development might be relevant for the Very Low FRP if there is an existing Sensitive Use, though perhaps not all the controls would be relevant.

A few minor amendments have been made to other controls within the schedule, as explained below:

- Under 'Car Parking and Driveway Access', best practice now indicates that when the water is not still, vehicles can float at depths as shallow as 0.1m (Figure 22). Nevertheless, it may be an unacceptable impost to make control no. 5 more conservative, so the wording of the note has been amended to indicate that the depth of 0.3m relates to a *still* water depth.
- Under 'Evacuation', because control no. 2 (which allows shelter-in-place) is currently permitted not only for 'dwellings', it seems appropriate to adopt the term 'buildings' in the text.

Several other changes should be considered but have yet to be incorporated, as explained below:

- It is noted that requirements for fencing are specified in clause 11.9 of the DCP. Since most development is assessed by reference to the planning matrix, there could be advantage in adding fencing to the matrix as a separate planning consideration. This could require flow-through fencing to be mandatory in a High FRP.
- Evacuation control no. 1 (mandating reliable access in a 100 year event) is currently required for Commercial and Industrial uses in a Medium FRP, whereas a PMF refuge is an acceptable alternative for Residential uses in a Medium FRP. This control can result in a significant impost on commercial and industrial developments including for simple changes of use in existing buildings to only slightly more intense uses (hence, not qualifying for Concessional Development). The reason for this more conservative requirement for Commercial and Industrial uses (relative to Residential uses) is not obvious, though it appears from a note on the original matrix prepared by Bewsher Consulting that no provision was allowed for shelter-in-place for commercial and industrial uses in a Medium FRP since access was anticipated to be available. We suggest that consideration be given to applying the same Evacuation requirements required for Commercial and Industrial uses in the Low FRP, namely that *either* reliable access *or* shelter-in-place be provided for.
- As noted in Section 4.2.3, the planning controls would be more consistent with current NSW SES policy if new *subdivisions* contained an evacuation control requiring 'reliable access for pedestrians or vehicles from the building, commencing at a minimum level equal to the lowest habitable floor level to an area of refuge above the PMF level' and did not allow for shelter-in-place.
- As noted in Section 4.2.3, if NSW SES adopts the draft version of Volume 1 of the 2013 Local Flood Plan, which does not include provision for shelter-in-place, many proposed developments could fall foul of the current evacuation control no. 3 stipulating that 'the development is to be consistent with any relevant flood evacuation strategy or similar plan'. If Council wishes to continue allowing shelter-in-place, it may need to remove this control from its DCP.

As discussed in Section 11.3.1c), a freeboard of 0.5m is judged to be appropriate for the Three Tributaries floodplain. In some areas this would put the floor level marginally above the PMF level, but in other areas where the PMF is considerably higher than the 100 year flood level (such as immediately upstream of the Canley Vale-Fairfield Railway), the freeboard could arguably be increased. Climate change model runs suggest that increasing rainfall intensities by 20% would increase flood levels by 0.1-0.2m for most of the floodplain (Section 7.2).

d) Other considerations

There are other matters which Council needs to consider before adopting a final matrix for Three Tributaries.

- While this draft matrix has been developed specifically for Three Tributaries, there must also be a consideration of how many separate matrices there should be for the LGA. Probably three matrices could suffice: one for mainstream river and creek flooding where shelter-in-place is not acceptable (Georges River and Prospect Creek below the Granville Railway); one for mainstream creek flooding where shelter-in-place may be permissible in certain circumstances (such as Three Tributaries), and one for overland flow areas where a lower freeboard may be accepted.

- Further consideration needs to be given to what controls and freeboards should apply for locations where mainstream floodplains overlap with overland flow areas (e.g. parts of Canley Vale affected by both flooding from Orphan School Creek and overland flows from Canley Corridor). Because mainstream flooding is typically deeper and faster, presumably the mainstream controls would prevail, though overland flows may rise more quickly and cut off evacuation earlier.
- It is also noted that *SEPP Exempt and Complying Development Codes 2008* prevails over the Fairfield City Wide DCP. Development which is defined as complying cannot be controlled by the DCP if it is in an area which is not a flood storage, a floodway, a flow path, a high hazard or a high risk area. That means that complying development will be permissible in many flood affected areas within Three Tributaries which would otherwise be controlled by the controls in the matrix. Having said that, the SEPP specifies various controls in relation to floor levels, flood compatible materials, structural stability, flood affectation, safe evacuation, car parking and driveways. This means that the SEPP can be regarded as a method of controlling concessional development. There may be benefit making further amendments to the matrix to ensure that the definitions of complying development in the SEPP and concessional development in the DCP fully align and that the planning controls for concessional development and complying development are identical.
- There may be benefit in providing more guidance to assist developers in preparing appropriate documentation showing how they meet the flood-related development controls.
- There is an argument for codifying what constitutes a significant adverse flood impact e.g. 10 mm rise if flood level outside a site boundary.

As such, the matrix remains a draft document and the recommendation in the Floodplain Risk Management Plan is that all land use considerations arising from flooding be considered on a City wide basis rather than having different conditions and different applications for each catchment or study area.

Matrix of Prescriptive Controls for Three Tributaries

Template: V4.5

Flood Risk Precincts (FRPs)

Very Low Flood Risk

Planning Consideration	Critical Uses & Facilities	Sensitive Uses & Facilities	Subdivision	Residential	Commercial & Industrial	Tourist Related Development	Recreation & Non-Urban	Concessional Development
Floor Level		3						4,7
Building Components		2						1
Structural Soundness		3						2
Flood Effects		2	2					2
Car Parking & Driveway Access		1,3,5,6,7						6,7,8
Evacuation		2,3,4	5					2,3
Management & Design		4,5	1					2,3,5

Low Flood Risk

Planning Consideration	Critical Uses & Facilities	Sensitive Uses & Facilities	Subdivision	Residential	Commercial & Industrial	Tourist Related Development	Recreation & Non-Urban	Concessional Development
Floor Level		3		2,6,7	5,6,7	2,6,7	1,6	4,7
Building Components		2		1	1	1	1	1
Structural Soundness		3		2	2	2	2	2
Flood Effects		2	2	2	2	2	2	2
Car Parking & Driveway Access		1,3,5,6,7		1,3,5,6,7	1,3,5,6,7	1,3,5,6,7	2,3,4,6,7	6,7,8
Evacuation		2,3,4	5	2,3	1 or 2, 3	2,3	4,3	2,3
Management & Design		4,5	1		2,3,5	2,3,5	2,3,5	2,3,5

Medium Flood Risk

Planning Consideration	Critical Uses & Facilities	Sensitive Uses & Facilities	Subdivision	Residential	Commercial & Industrial	Tourist Related Development	Recreation & Non-Urban	Concessional Development
Floor Level				2,6,7	5,6,7	2,6,7	1,6	4,7
Building Components				1	1	1	1	1
Structural Soundness				2	2	2	2	2
Flood Effects			1	2	2	2	2	2
Car Parking & Driveway Access				1,3,5,6,7	1,3,5,6,7	1,3,5,6,7	2,3,4,6,7	6,7,8
Evacuation			5	2,3	1,3	2,3	4,3	2,3
Management & Design			1		2,3,5	2,3,5	2,3,5	2,3,5

High Flood Risk

Planning Consideration	Critical Uses & Facilities	Sensitive Uses & Facilities	Subdivision	Residential	Commercial & Industrial	Tourist Related Development	Recreation & Non-Urban	Concessional Development
Floor Level							1,6	4,7
Building Components							1	1
Structural Soundness							1	1
Flood Effects							1	1
Car Parking & Driveway Access							2,3,4,6,7	6,7,8
Evacuation							4,3	2,3
Management & Design							2,3,5	2,3,5

COLOUR LEGEND: Not Relevant | Unsuitable Land Use

General Notes

1	*Freeboard* equals an additional height of 500mm.
2	The relevant environmental planning instruments (generally the Local Environmental Plan) identify development permissible with consent in various zones in the LGA. Notwithstanding, constraints specific to individual sites may preclude Council granting consent for certain forms of development on all or part of a site. This matrix identifies where flood risks are likely to determine where certain development types will be considered "unsuitable" due to flood related risks.
3	Filling of the site, where acceptable to Council, may change the FRP considered to determine the controls applied in the circumstances of individual applications.
4	Refer to Section 11.9 of the DCP for planning considerations for proposals involving only the erection of a fence. Any fencing that forms part of a proposed development is subject to the relevant flood effects and Structural Soundness planning considerations of the applicable landuse category.
5	Refer to Section 11.10 of the DCP for special considerations such as for house raising proposals and development of properties identified for voluntary acquisition.
6	Terms in italics are defined in the glossary of this plan and Schedule 2 specifies development types included in each land use category. These development types are generally as defined within Environmental Planning Instruments applying to the LGA.
7	From time to time, Council may adopt mapping showing the *Boundary of Significant Flow* and/or *Flood Storage Areas* for this floodplain. Refer to Council to find out if these areas have been defined and mapped for this floodplain.

Floor Level

1	All floor levels to be no lower than the 20 year flood level unless justified by site specific assessment.
2	*Habitable floor* levels to be no lower than the 100 year flood level plus *freeboard*.
3	*Habitable floor* levels to be no lower than the *PMF* level. Non-*habitable floor* levels to be no lower than the *PMF* level unless justified by a site specific assessment.
4	Floor levels to be no lower than the *design floor level*. Where this is not practical due to compatibility with the height of adjacent buildings, or compatibility with the floor level of existing buildings, or the need for access for persons with disabilities, a lower floor level may be considered. In these circumstances, the floor level is to be as high as practical, and, when undertaking alterations or additions, no lower than the existing floor level.
5	The level of *habitable floor areas* to be equal to or greater than the 100 year *flood* level plus *freeboard*. If this level is impractical for a development in a Business zone, the floor level should be as high as possible.
6	Non-habitable floor levels to be equal to or greater than the 100 year flood level plus freeboard where possible, or otherwise no lower than the 20 year flood level unless justified by site specific assessment.
7	A restriction is to be placed on the title of the land, pursuant to S.88B of the Conveyancing Act, where the lowest *habitable floor area* is elevated more than 1.5m above finished ground level, confirming that the undercroft area is not to be enclosed.

Building Components & Method

1	All structures to have *flood compatible building components* below the 100 year flood level plus *freeboard.*
2	All structures to have *flood compatible building components* below the *PMF* level.

Structural Soundness

1	Engineer's report to certify that the structure can withstand the forces of floodwater, debris and buoyancy up to and including a 100 year flood plus *freeboard,* or a *PMF* if required to satisfy evacuation criteria (see below).
2	Applicant to demonstrate that the structure can withstand the forces of floodwater, debris and buoyancy up to and including a 100 year flood plus *freeboard,* or a *PMF* if required to satisfy evacuation criteria (see below). An engineer's report may be required.
3	Applicant to demonstrate that any structure can withstand the forces of floodwater, debris and buoyancy up to and including a *PMF* An engineers report may be required.

Flood Effects

1	Engineer's report required to certify that the development will not increase flood effects elsewhere, having regard to: (i) loss of flood storage; (ii) changes in flood levels and velocities caused by alterations to the flood *conveyance*; and (iii) the cumulative impact of multiple potential developments in the floodplain.
2	The flood impact of the development to be considered to ensure that the development will not increase flood effects elsewhere, having regard to: (i) loss of flood storage; (ii) changes in flood levels and velocities caused by alterations to the flood *conveyance*; and (iii) the cumulative impact of multiple potential developments in the floodplain. An engineer's report may be required.

Note: (1) If a *Boundary of Significant Flow* has been defined for this floodplain, any development inside this area will normally be unacceptable as it will reduce flood *conveyance* and increase flood effects elsewhere. (2) If a *Flood Storage Area* has been defined for this floodplain, any filling of the floodplain inside this area (except where this occurs by compensatory excavation), will normally be unacceptable as it will reduce the volume of flood storage available on the floodplain and increase flood effects elsewhere. (3) Even where a *Boundary of Significant Flow* and/or a *Flood Storage Area* have been defined, development outside these areas may still increase flood effects elsewhere and therefore be unacceptable.

Car Parking and Driveway Access

1	The minimum surface level of open car parking spaces or carports shall be as high as practical, and not below: (i) the 20 year flood level; or (ii) the level of the crest of the road at the location where the site has access; (which ever is the lower). In the case of garages, the minimum surface level shall be as high as practical, but no lower than the 20 year flood level.
2	The minimum surface level of open car parking spaces, carports or garages, shall be as high as practical.
3	Garages capable of accommodating more than 3 motor vehicles on land zoned for urban purposes, or *enclosed car parking,* must be protected from inundation by floods equal to or greater than the 100 year flood.
4	The driveway providing access between the road and parking space shall be as high as practical and generally rising in the egress direction.
5	Where the level of the driveway providing access between the road and parking space is lower than 0.3m below the 100 year flood, the following condition must be satisfied. The depth of inundation on the driveway during a 100 year flood shall not be greater than the larger of: (i) the depth at the road; and (ii) the depth at the car parking space. A lesser standard may be accepted for single detached dwelling houses where it can be demonstrated that risk to human life would not be compromised.
6	*Enclosed car parking* and car parking areas accommodating more than 3 vehicles (other than on Rural zoned land), with a floor level below the 20 year flood level or more than 0.8m below the 100 year flood level, shall have *adequate warning systems, signage and exits*.
7	Restraints or vehicle barriers to be provided to prevent floating vehicles leaving a site during a 100 year flood
8	Driveway and parking space levels to be no lower than the *design ground/floor levels*. Where this is not practical , a lower level may be considered. In these circumstances, the level is to be as high as practical, and, when undertaking alterations or additions, no lower than the existing floor level.

Note: (1) A still water flood depth of 0.3m is sufficient to cause a small vehicle to float. (2) *Enclosed car parking* is defined in the glossary and typically refers to carparks in basements.

Evacuation

1	Reliable access for pedestrians or vehicles required during a 100 year flood.
2	Reliable access for pedestrians or vehicles is required from the building, commencing at a minimum level equal to the lowest *habitable floor* level to an area of refuge above the *PMF level*, or a minimum of 20% of the gross floor area of the building to be above the *PMF level*.
3	The development is to be consistent with any relevant *flood evacuation strategy* or similar plan.
4	The evacuation requirements of the development are to be considered. An engineers report will be required if circumstances are possible where the evacuation of persons might not be achieved within the *effective warning time*.
5	Applicant to demonstrate that evacuation in accordance with the requirements of this DCP is available for the potential development flowing from the subdivision proposal.

Management and Design

1	Applicant to demonstrate that potential development as a consequence of a subdivision proposal can be undertaken in accordance with this DCP.
2	*Site Emergency Response Flood Plan* required where floor levels are below the *design floor level,* (except for single dwelling-houses).
3	Applicant to demonstrate that area is available to store goods above the 100 year flood level plus *freeboard.*
4	Applicant to demonstrate that area is available to store goods above the *PMF* level.
5	No storage of materials below the *design floor level* which may cause pollution or be potentially hazardous during any flood.

Figure 45 – Proposed planning matrix for the Three Tributaries floodplain

11.3.4 Section 149 Planning Certificates

As discussed above, based on mapped hazards in the PMF, Council is proposing to distinguish a Very Low flood risk precinct (FRP) where development controls will not apply to standard residential development from the Low FRP where development controls would apply to all land uses. This change would require a number of changes to Section 149 planning certificates (refer to Section 3.6.2 for an introduction to the current practice of issuing these in Fairfield LGA).

These changes will include:

- Including advice on Section 149(2) planning certificates for residential, commercial and industrial, tourist-related and recreation and non-urban uses that there are no flood-related controls for lots where the highest order of flood risk affectation is the Very Low flood risk precinct;
- Amending the wording for Flood Policy 50015 to be consistent with the proposed changes to the planning matrix in Chapter 11 of the DCP – since the 'floodplain' is by definition the maximum extent of inundation, that is the PMF, the text here will need to be more nuanced since not all land uses will be subject to development controls out to the PMF;
- Amending the definition of Low FRP used throughout the suite of Section 149 notations to be consistent with the definition proposed in Section 7.1.3c);
- Adding a definition of Very Low FRP consistent with the definition proposed in Section 7.1.3c), to be used for Section 149(2) planning certificates (only for land uses where development controls would still apply) and Section 149(5) planning certificates and flood information sheets.

Council will also need to give consideration how to advise landowners located downstream of detention basins.

12 RESPONSE MODIFICATION OPTIONS

Response modification measures aim to reduce risks to life and property in the event of flooding through improvements to flood prediction and warning, through improvements to emergency management capabilities and planning, and through better flood-educated communities.

12.1 FLOOD WARNING

Recommendations:
1) Install three real-time rain gauges in the catchment
2) Alarm the existing water level recorder for Orphan School Creek at Sackville Street
3) Install basin water level recorders for the Mimosa Road and Fairfield Golf Course Basins

12.1.1 General

Because of the small size of the catchments in the Three Tributaries study area, floods tend to rise very quickly following the onset of flood-producing rainfall. The critical duration – the duration of the storm that produces the highest peak runoff, and therefore flooding – is about 2 hours. Typical warning times are considerably less, in the order of about 30 minutes.

For flash flood catchments, often defined as those where flooding occurs within 6 hours of rain, the provision of an effective flood warning service is problematic. The 'total flood warning system' has five components that need to be completed during a flood emergency – prediction, interpretation, message construction, communication and appropriate response (Commonwealth of Australia, 2009). But several challenges to the effective operation of such a system have been identified for flash flood catchments (McKay, 2004, 2008):

- Flash floods are less predictable than larger scale flooding. Rainfall over small catchments is usually not well predicted by numerical weather prediction models.
- For flash floods, there is insufficient time to develop reliable flood warnings and for effective dissemination and response to the flood warnings. More rapid user response is required, which necessitates specialised communication systems and a high level of public flood awareness and preparedness.
- A reliance on rainfall triggers increases the frequency of false alarms.
- The use of river level triggers does not allow sufficient time for response.

For these reasons, the Bureau of Meteorology traditionally has not issued specific flood predictions for flash flood catchments including the creeks within the current study area. The Bureau however does offer more general services that may be of some benefit in alerting the emergency services and community to the threat of flooding (see Table 23).

Table 23 – Bureau of Meteorology warning services of potential benefit in flash flood catchments

Sources: McKay (2004, p.3); www.bom.gov.au

General Weather forecast

General weather forecasts may indicate the likelihood of heavy rain from synoptic scale events, typically with more than 24 hours' notice.

Flood Watch

A Flood Watch is issued by the NSW Flood Warning Centre, typically providing 24 to 48 hours' notice that flooding is *possible* based upon current catchment conditions and future rainfall, which is predicted by computer models of the atmosphere. A Flood Watch issued for the Georges River would be relevant for Orphan School Creek, Clear Paddock Creek and Green Valley Creek.

Severe Weather Warning

A Severe Weather Warning is issued for synoptic scale events when one or more of the following hazardous phenomena are forecast:

- Sustained winds of gale force (63 km/h) or more
- Wind gusts of 90 km/h or more
- Very heavy rain that may lead to flash flooding
- Abnormally high tides (or storm tides) expected to exceed highest astronomical tide
- Unusually large surf waves expected to cause dangerous conditions on the coast
- Widespread blizzards in Alpine areas

Severe Thunderstorm Warning

A Severe Thunderstorm Warning is issued by the Severe Weather Team, typically providing 0.5 to 2 hours' notice of impending severe storms. These forecasts are based upon radar and, if available, data from field stations, reports from storm spotters, as well as an analysis of the synoptic situation. For the Greater Sydney region the Bureau issues more detailed graphical Severe Thunderstorm Warnings when actual thunderstorms have been detected.

Given the Bureau does not issue specific flood predictions for the three creeks, consideration has been given to the merit of Council developing its own flood warning systems. This could potentially facilitate pre-deployment of emergency management personnel, evacuation, road closures and property protection. Council commissioned Manly Hydraulics Laboratory (MHL, 2013) to evaluate the adequacy of the existing rain and stream gauge network within Fairfield LGA for the purposes of flood model calibration, flood warning and aiding in the design of creek bank stabilisation measures. MHL considered the distribution of existing rain gauges and water level recorders within Fairfield LGA (see Table 24 and Figure 46 for those in the vicinity of the Three Tributaries catchment) and recommended the installation of six additional pluviometers, including some for the Three Tributaries catchment. It also recommended that these gauges be alarmed to trigger emails and SMS messages when certain thresholds of rainfall are exceeded, such as 60mm of rain in three hours.[1] Also, the report suggests consideration be given to recommissioning the water level gauge that formerly operated on Orphan School Creek at Kings Road (213010), though this is given a lower priority than the recommendation concerning rain gauges.

Table 24 – Existing rain gauges and water level recorders in the Three Tributaries catchment

Site No.	Source	Site Name	Data type	Period
671140	Bureau of Meteorology	Fairfield City Farm	Rainfall	1995-ongoing
567169	Sydney Water Corporation	Abbotsbury	Rainfall	2001-ongoing

[1] Based on an analysis of Flood Studies from the Greater Sydney area, the Bureau of Meteorology suggests that a rainfall threshold for flooding is 70mm within three hours when more heavy rain is forecast. The Bureau states that the risk of major widespread flooding typically occurs if more than 150mm falls in a day or the event total (over more than 1 day) exceeds 250mm.

*213010**	NSW Office of Water	Orphan School Creek at King Road	Water level + discharge	1986-2010
213014	NSW Office of Water	Orphan School Creek at Sackville Street	Water level + discharge	1987-ongoing

*Site decommissioned

Figure 46 – Distribution of existing rain gauges and water level recorders in the Three Tributaries catchment

Source: MHL (2013)

12.1.2 Rain gauges

The Bureau offered the following opinion on rain gauges: *'The value of information from rain gauges would be to provide the SES and public with information on what is specifically happening in their small catchment. With some public education, say via a locally based web page, this data can give them an idea of how serious the flood threat is in real time'*.

An example of how this information can be used is the Northern Beaches Flood Warning and Information Network: http://new.mhl.nsw.gov.au/users/NBFloodWarning/

In addition to their benefits in the general flood warning process, rainfall gauges are essential for dam safety, since rainfall triggers monitoring and emergency management at Council's detention basins.

It is recommended that three new rain gauges be installed across the catchment, supplementing the coverage afforded by the existing gauges in the upper reach of Orphan School Creek. Three are considered necessary to provide adequate coverage of the three different sub-catchments. Potential locations are:

- Orphan School Creek catchment: near Prairiewood, perhaps at the Wetherill Park Police Station
- Clear Paddock Creek catchment: Bonnyrigg Shopping Centre
- Green Valley Creek catchment: site to be confirmed

The precise location for the new gauges will need to be confirmed in consultation with landowners and mindful of security needs. These gauges, as well as the gauge at Fairfield City Farm, should be telemetered and monitored by Council and NSW SES staff. MHL (2013) estimated the cost for new pluviometers/communications at $10K each, plus $2K annual maintenance cost per gauge.

12.1.3 Water level recorders

a) Existing Sackville Street gauge

The existing NSW Office of Water (NoW) gauge for Orphan School Creek at Sackville Street (213014) is located close to the most significant hotspot in the study area at Freeman Avenue. Near real-time readings for this water level recorder are available on the Bureau of Meteorology website.[1] This provides NSW SES, Council and members of the community the opportunity to remotely monitor water levels, so long as the gauge continues to function during a flood. Enquiries have been made with the NoW to ascertain the feasibility of alarming this gauge such that email or SMS alerts are issued to NSW SES and Council when pre-selected trigger levels are reached. This would give greater confidence that the emergency services would detect a rising flood compared to relying on occasional reference to a website. Figure 47 presents the concept using a 100 year stage hydrograph taken from the flood model. The digital elevation model indicates that Sackville Street south of the bridge is expected to be inundated from about 10.1m AHD. One option would be to adopt triggers using the flood levels expected 2 hours and 1 hour prior to the time 10.1m AHD is expected to be reached.

The NoW has indicated an ability to do this work subject to several disclaimers:

- It does not in itself constitute a flood warning service since the Bureau has that responsibility
- It is not guaranteed to work since NoW does not provide continuous 24/7 support
- The site is not guaranteed to continue, and if the funding situation with the site changes Council would be given the option of taking up the O&M costs - otherwise the site and service to them would be discontinued.

A nominal fee for the work is about $1K plus $600 per annum maintenance assuming just two alarm trigger values are selected and three phone numbers are programmed. The NoW would request a 3 year Service Level agreement with Council. Given the benefits for NSW SES, Council and the Sackville Street and Freeman Avenue communities of early warning, this measure is recommended.

[1] http://www.bom.gov.au/nsw/flood/greatersydney.shtml

Figure 47 – 100 year stage hydrograph immediately upstream of Sackville Street

b) Basin level recorders

Given the potentially serious flood impacts downstream of the Mimosa Road and Fairfield Golf Course basins, it is also recommended that water level alarms be installed and configured there to provide warning of overtopping. This infrastructure would still be useful if the embankments of those basins are raised, as is recommended, because flooding could still occur downstream of the embankments if an event larger than the raised embankment crest level occurred, and also to provide an indication of possible flood severities in the lower part of the study area at Canley Vale.

Installation of water level recorders is also recommended for the purposes of basin safety. The Dam Safety Emergency Plan (DESP) prepared for the 14 detention basins in the Three Tributaries catchment area recommends a series of remote sensing measures to be installed in each basin to allow early warning of flood-causing rainfall and various warning levels occurring in each basin. These measures are considered essential for the long-term management of flooding and the risks associated with the detention basins throughout the catchment.

For the purposes of the FRMP, an allowance has been made for the installation of telemetered water level recorders for two basins at a cost (per gauge) estimated by MHL (pers. comm.) at about $25-26K for initial set up and $5K per annum maintenance. Ultimately, similar recorders should be installed for each of the 14 basins. Priorities could be determined from WMAwater's (2013b) report.

12.2 EMERGENCY RESPONSE PLANNING

Recommendations:
1) Construct an elevated emergency evacuation route from Freeman Avenue to Canley Vale Road
2) Update Fairfield Local Flood Plan and Sackville Street gauge Flood Intelligence Card
3) Support key floodplain exposures to prepare and update private flood plans

12.2.1 Freeman Avenue emergency evacuation route

Freeman Avenue was badly flooded in the April 1988 event (Section 1.1.1). In existing conditions, eight dwellings are expected to be flooded above floor in the 100 year ARI design event (Section 8.2). A low-point in Freeman Avenue is flooded to a depth of 0.80m in the 20 year Three Tributaries flood and 0.60m in the 5 year Canley Corridor flood (Table 14). Some 91 dwellings including seniors' housing plus a 98-bed nursing home are located east of this low-point and are therefore cut off frequently and quite early in a flood event (Section 8.4.3).

Consideration has been given to improving access to the eastern end of Freeman Avenue in order to provide greater opportunity for evacuation during a flood emergency. Improved access could also enable the ambulance and fire services to access the area – especially the nursing home – if required during an event.

One possibility is to raise Freeman Avenue to provide a flood-free evacuation route up to at least the 20 year ARI flood. This would require raising both Freeman Avenue and Sackville Street over a distance of about 440 metres, including a height of 0.8m at the lowest point (see Figure 32). Two considerations count against this option:

- It could potentially trap flood flows on the upstream side of the raised road, increasing flood depths in properties located there; this includes properties located on the southern side of Freeman Avenue that could be worse affected by Canley Corridor overland flows and properties on the western side of Sackville Street that could be worse affected by Orphan School Creek flooding;
- It is probably impractical given access requirements – 53 dwellings using 29 driveways join Freeman Avenue where flood depths in the 20 year ARI event exceed 0.6m; many more driveways would require smaller adjustments.

Another option is to elevate and if possible widen the existing pedestrian/cycle route that commences from beside the nursing home at the eastern end of Freeman Avenue and ends at Canley Vale Road. This route is shown on Figure 48; a profile with flood levels is shown on Figure 49; photos along the existing route are shown in Figure 50. The existing path would be flooded in the 20 year ARI Orphan School Creek flood. The width of the path is about 2.8m, which if not obstructed could be just sufficient to accommodate an ambulance needing access to the nursing home. A proposal to build a narrow elevated bridge has been costed. For a length of 110 metres, and width of 3.0m this would cost about $990K including an allowance of $200K for adjusting existing services such as telegraph poles and removing trees that currently constrain the width, and including a 25% contingency (see Appendix I). A length of 110 metres is based on the higher bridge depicted in Figure 49, taken from the highest points along the existing path either side of the flood runner's floodplain. It is however conceivable that a shorter bridge could be built to the limits of the 100 year extent, over a distance of 70 metres and for a reduced cost of about $630K. Council has indicated that at some point in the future a road may be built between Railway Parade and Canley Vale Link Road. If this proposed Canley Vale bypass road is raised, it could afford the opportunity for a reduced length and cost, though the flooding of Canley Vale Link Road is noted. Because this elevated route is aimed at reducing risk to life in what is currently a severely evacuation constrained locality, it is not possible to quantify benefits in terms of a benefit-cost ratio. But given the significant benefits it provides for residents in Freeman Avenue and for the emergency services who may require access to Freeman Avenue, this proposal is recommended in the draft FRMP.

Figure 48 – Proposed Freeman Avenue emergency evacuation route

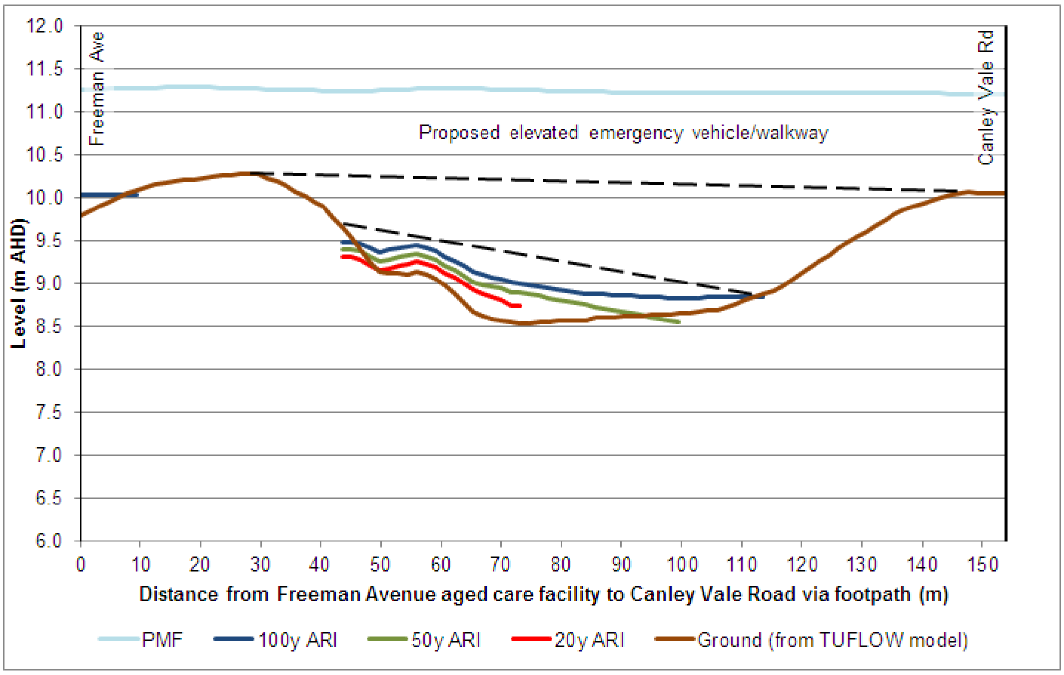


Figure 49 – Profile along proposed Freeman Avenue emergency evacuation route

Figure 50 – Views along existing pedestrian/cycle route between Freeman Avenue and Canley Vale Road

a. View south from Freeman Ave

b. View south looking towards Canley Vale Link Road

c. View north along route

12.2.2 Update NSW SES flood plans and intelligence

Chapter 4 presented the emergency management context for this FRMS&P. The Consultants argued that at least for areas in the Three Tributaries floodplain that are already developed, provision for a shelter-in-place strategy is appropriate both in the Fairfield City Local Flood Plan and in the Fairfield City Wide DCP. Below are recommended amendments to the NSW SES's flood plans and intelligence.

a) Fairfield City Local Flood Plan

A review of the 2005 edition of the Fairfield Local Flood Plan (LFP) was included in an early draft of this report. NSW SES (2014) responded to this review and indicated that many of the issues identified in the early draft had been addressed in the Volume 1 revision of the LFP (NSW SES, 2013). A brief review of the 2013 edition has also been undertaken and is included in Appendix J. Key points are summarised below:

- In the Consultant's opinion, the NSW SES's decision to remove any option for sheltering-in-place from Volume 1 of the 2013 edition fails to take adequate consideration of the circumstances likely to prevail in flooding of the Three Tributaries catchment including a rapid rate of rise, early inundation of roads and a short duration of isolation. While the principles behind the NSW SES stance are understandable, even with the recommendations in this FRMS&P for improvements to flood warning infrastructure and community education, the inescapable reality will be that many occupants of the floodplain will not evacuate the floodplain prior to flooding so the safest course of action in many circumstances will be to seek the highest level of a building rather than attempt to cross flooded roads. It is recommended that the NSW SES reconsider the exclusion of the common-sense clauses that had previously been included in the 2005 edition, conceding that while early evacuation away from the flooded area is optimal, shelter-in-place in a building designed to provide shelter in a PMF is often the safest course of action after flooding has commenced.
- One sensitive use that requires special attention and consideration is the Canley Vale nursing home in Freeman Avenue operated by SummitCare. The operator was consulted (Section 5.4) and indicated that because of high mortality rates associated with evacuation of elderly and frail patients, their preferred response was to remain on site. Because access is cut relatively frequently in Freeman Avenue (at least as often as a 5 year ARI event from overland flows and 20 year ARI event from Orphan School Creek flooding), if the authorities adopt a conservative position and insist upon entirely evacuating the facility prior to every flood, it could mean accepting about a 10% mortality rate at least every 5 years on average. Sheltering in place is by no means risk-free because although the main building floor level is about 0.65m higher than the existing 100 year ARI (or 1% chance in a year) flood level, it is about 0.43m below the modelled PMF level. Also, although the nursing home has an upper storey, this is not designed for residents and would not be easily accessed. The flood risk could be reduced by improving access (Section 12.2.1) or by SummitCare purchasing some form of flood barrier (~0.6m high) to block doorways etc. But given the limited effective warning time, the short duration of flooding, and the expected mortality arising from the evacuation process, in the Consultant's opinion, the strategy with the lesser risk to life would be to remain on site. It is recommended that NSW SES liaise with SummitCare, Council and NSW Health to confirm the preferred approach.
- It is also recommended that the NSW SES prepare the LFP with some consideration to the resources available to complete the various tasks, which will inform the time required to complete the various tasks and the practicality of doing so. It is understood that given only about 40 volunteers at the Fairfield Unit service an LGA population in excess of 200,000, the NSW SES will be spread very thinly across the LGA, with attention typically focussed on floodplains of the Georges River and Prospect Creek. Given the nature of a major flood event in the Sydney basin, it may not be possible to call on neighbouring Units as they will be employed in similar emergencies in their areas. It may be possible to call on Units outside the Sydney basin, however it is doubtful that they would arrive in time to assist with the Response phase of the operation.

- The LFP should also recognise the challenges to the effective delivery of flood warnings and evacuation warnings and orders to residents in Fairfield LGA due to the high levels of cultural and linguistic diversity.
- The LFP should incorporate the flood intelligence presented in this FRMS&P including:
  - Design flood extents (Figure 19);
  - Design flood depths (Figure 20);
  - Buildings inundated above floor in design events (Figure 28);
  - Roads inundated in design events (Figure 29 and Table 14);
  - Evacuation hotspots (Figure 31).

  The NSW SES could also be provided with access to WaterRIDE model workspaces for the 20 year ARI, 100 year ARI and PMF events. These enable the user to inspect flood depths, velocities, hydraulic hazard and extents at every 15 minute time step of the model.
- The LFP should incorporate any flood mitigation options implemented as an outcome of this FRMS&P, including basin upgrades, installation of a debris control structure and construction of a levee at Gregorace Place.
- The LFP should incorporate any improvements to flood warning implemented as an outcome of this FRMS&P, including installation of real-time rain gauges, alarming of Sackville Street water level recorder and installation of basin water level recorders.

b) Sackville Street gauge Flood Intelligence Card

A copy of a flood intelligence card (FIC) for the Sackville Street gauge was provided by NSW SES. This contained three entries showing the relationship between gauge heights and consequences. A WaterRIDE model file was interrogated to ascertain the approximate consequences of a rising flood at the gauge, and this has been used to add entries to a revised FIC in Appendix J. This intelligence should be updated and verified after every real flood.

12.2.3 Prepare and update private flood plans

As well as updating the Fairfield City Local Flood Plan, there would be benefit in NSW SES and FCC encouraging and helping key floodplain exposures to prepare and update their own flood emergency response plans. The process of preparing plans would in itself be an important process of raising awareness and preparedness, and could be linked to the proposed Business FloodSafe breakfast (Section 12.3.4).

Among the higher priorities for flood plans are:

- Greenfield Shopping Centre, Cathedral of St Hormisdas, townhouses and Devenish Street childcare centre, Greenfield Park;
- Fairfield Golf Course, Prairiewood;
- Mary MacKillop College, Wakeley;
- Wakeley Shopping Centre, Wakeley;
- Businesses and institutions along Smithfield Road between Elizabeth Drive and Edensor Road, Edensor Park (see Section 12.3.4);
- Mounties Club, Mt Pritchard (especially to address access to Humphries Road);
- Harrington Street Public School, Cabramatta West; and
- Canley Vale nursing home (SummitCare), Freeman Avenue, Canley Vale.

12.3 COMMUNITY EDUCATION

Recommendations:
1) Continue to implement the Fairfield City community flood education action plan 2012-15
2) Regularly issue flood information to all flood-affected residents
3) Conduct meet-the-street events for key risk sites (highest priority Freeman Avenue)
4) Conduct a Business FloodSafe breakfast for Smithfield Road
5) Prepare NSW SES FloodSafe guides for three creeks
6) Install flood depth indicators and evacuation route signage for five locations

12.3.1 General

Although there has been a considerable investment in floodplain management, communities living and working on the Three Tributaries floodplain will never be totally protected from the impacts of flooding. Nor can emergency authorities such as the NSW SES ensure the safety of all residents in all floods. Therefore, it is critical that through community education the flood-affected communities are aware of the flood risk, are prepared for floods, know how to respond appropriately and are able to recover as quickly as possible.

Molino Stewart (2012) prepared a report on Community Flood Education and Awareness for Fairfield City. The global literature indicates that education can significantly reduce damages and increase evacuation rates. Based on learnings from recent disasters, the focus of community disaster education has now turned from a concentration on raising awareness and preparedness to *building community resilience through learning*. Simply disseminating information to the community does not necessarily trigger changed attitudes and behaviours. Flood education programs are most effective when they:

- Are participatory i.e. not consisting only of top-down provision of information but where the community has input to the development, implementation and evaluation of education activities;
- Involve a range of learning styles including experiential learning (e.g. field trips, flood commemorations), information provision (e.g. via pamphlets, DVDs, the media), collaborative group learning (e.g. scenario role plays with community groups) and community discourse (e.g. forums, post-event de-briefs);
- Are aligned with structural and other non-structural methods used in floodplain risk management and with emergency management measures such as operations and planning; and
- Are ongoing programs rather than one-off, unintegrated ‘campaigns’, with activities varied for the learner.

Molino Stewart (2012) considered the particular requirements of Fairfield City and recommended the following Flood Education Action Plan, with priorities as listed:

1. Regularly write to all flood-affected residents to reinforce that they live in a flood-prone area and encourage preparedness activities e.g. development of emergency plans. (High priority)
2. Hold ‘meet-the-street’ events in high-risk areas to engage residents around the danger of flooding in their local area and encourage the development of street-based support networks (High)
3. Problem-solve flood scenarios with community groups. (High)
4. Conduct emergency drills and exercises involving communities and emergency agencies. (High)
5. Brief councillors about floodplain and emergency planning and provide them with information to speak to communities and answer enquiries. (High)

6. Use print media, radio and social media to run flood stories to raise flood awareness. Use interpreters and translated written material in a range of community languages relevant to the areas being targeted (High)
7. Hold post-flood community de-brief meetings. (High)
8. Engage with youth and multicultural networks about flood-related initiatives (e.g. flood studies, floodplain risk management studies and plans) using Council's reference groups. (Medium)
9. Train and support local community leaders to help their communities prepare, respond and recover. (Medium)
10. Prepare a FloodSafe Guide for Fairfield City. (Medium)
11. Use and/or hold community events (e.g. Council Open Day, centenary of the 1988 flood) to engage with communities about floodplain and emergency management. (Medium)
12. Prepare curriculum-based school teaching units for Primary and Secondary students related to aspects of flooding. (Medium)
13. Encourage and support businesses to complete the Business FloodSafe emergency plans. (Medium)
14. Erect signage in strategic locations to help raise awareness of flooding in the City (Low)
15. Maintain and update local flood information links on Council's website. (Low)

Consideration has been given to which of the above measures are particularly suited for communities living and working in the Three Tributaries' floodplains. Findings of the social profile (Section 2.5) that have particular relevance to this question include:

- High level of cultural and linguistic diversity;
- Relatively low levels of education;
- Low level of internet usage;
- Relatively low level of population mobility, though only a minority of the population would recall the significant floods of 1986 and 1988, and no one has experienced a flood as large as the 100 year ARI flood.

The following measures are specifically recommended.

12.3.2 Regularly write to all flood-affected residents

Best practice teaches that a key measure for raising and maintaining people's awareness of their flood risk is via the *regular* issuing of flood information to all occupiers of the floodplain. Flood certificates inform individual property owners of the flood situation at their particular property. It is the site-specific nature of this advice (i.e. not a generic brochure) that offers a chance of overcoming the scepticism typical of a community that has not experienced serious flooding for some years. Only after floodplain occupants accept that they could have a problem are they ready to take on board ideas about addressing that problem. From a community survey, 60% of respondents indicated that certificates were their preferred means of receiving flood information (Section 5.2.1). Typically certificates would record flood levels and ground levels. Additionally, engaging flood stories and tips could also be included to help people prepare for flooding. Translation services should be offered for the main non-English languages. As part of this activity it also may be useful to provide specific information linking property floor levels to flood gauge heights as a way of making people aware of their risk of flooding and what they should do when flooding reaches certain gauge heights. This would be especially useful for properties within the Sackville Street gauge flood reference area.

Council currently issues information only upon request for a Section 149 certificate. This process is initiated by an interested party (owner, prospective buyer, builder, real estate agent etc) so the release of this information is occasional and restricted. It is not designed for widespread community education. What is proposed is the *proactive* provision of flood information.

12.3.3 Conduct meet-the-street events

'Meet-the-street' events involve NSW SES and FCC setting up a 'stall' at an appropriate and visible location at a time that people will be at home. The 'meet-the-street' should be advertised through a specific letter box drop to the targeted neighbourhood or vulnerable site. The stall could consist of flood maps on boards, NSW SES banners, NSW SES materials (e.g. Orphan School Creek FloodSafe Guide when available) to hand out. These materials are used to engage with people and make them aware of flood risk, encourage preparedness behaviours (e.g. develop emergency plans) and help them understand what to do during and after a flood. A meeting could also encourage property owners to develop self-help networks and particularly people checking on neighbours if a flood is imminent. Longer-term residents with flood experience could be used to help provide other residents with an understanding of previous floods and how to prepare for future flooding.

Streets within the Three Tributaries floodplain where the current level of flood risk commends this approach includes:

- Ripple Close area;
- Mallacoota Street area;
- Gregorace Place;
- Attilio Place;
- Edensor Road near Smithfield Road area;
- Barook Place;
- Cayley Place;
- Craigslea/Fernlea Places;
- End of Avonlea Street;
- Duke Street;
- Queen/Sackville Streets; and
- Freeman Avenue (highest priority).

One point of caution for meet-the-street events relates to the potential for conflicting advice in relation to whether to attempt to evacuate or to shelter-in-place. Council and NSW SES will need to ensure that they are presenting a clear and consistent message for each location, so that residents know how they need to respond in a flood emergency.

12.3.4 Conduct a Business FloodSafe breakfast

Business FloodSafe is an on-line tool that helps businesses to develop flood emergency plans as part of their business continuity planning. The NSW SES has previously run Business FloodSafe breakfasts to introduce businesses to this resource, to help them understand their flood risk exposure and to identify measures to reduce risk to life and property, including an action plan.

A number of businesses and institutions along Smithfield Road between Elizabeth Drive and Edensor Road are subject to inundation or isolation in relatively frequent events, and access to these facilities would be compromised during flood, with corresponding safety risks for drivers. Included among these are Parkside Church, a Buddhist temple, a fruit warehouse, a clearance centre, an Assyrian College, and Fred's supermarket. One of the requirements for these businesses and institutions is to identify ways of educating staff and visitors to their premises *not* to enter floodwater on Smithfield Road.

It is recommended that a Business FloodSafe breakfast be organised for this area and that the various stakeholders be personally invited. The relevant Chamber of Commerce should be co-opted as a key partner in this process.

Other locations where a Business FloodSafe could be considered are the Greenfield shopping centre and the Wakeley shopping centre, though these are of lower priority, especially if the basin improvements works recommended in this study are implemented.

12.3.5 Prepare NSW SES FloodSafe guides for each creek

NSW SES FloodSafe guides provide communities with an understanding of flood scenarios and what to do before, during and after a flood. The tailored local FloodSafe guides can be handed out during engagement activities and are available on the NSW SES website. Because flood behaviour varies throughout the Fairfield LGA (e.g. deep and longer duration Georges River flooding; less deep and short duration tributary flows; typically shallow and short duration overland flows), requiring different responses (e.g. where early evacuation is imperative versus where shelter-in-place may be safer), we suggest that *several* FloodSafe guides be prepared for the LGA. More locally focussed FloodSafe guides are also more likely to engage local residents' interest.

For the Three Tributaries catchment, three FloodSafe guides are recommended, and these should also be translated into the main non-English languages. These guides could focus on:

- Clear Paddock Creek;
- Green Valley Creek;
- Orphan School Creek including Freeman Avenue.

12.3.6 Signage

Flood depth indicators up to 1m high could be of value where flood modelling shows important roads to be inundated to serious levels in relatively frequent events, although without accompanying education to highlight the dangers of attempting to cross floodwater, the effectiveness of the depth indicators may be limited. Four such sites have been identified for the Three Tributaries floodplain: 'CP9' on Smithfield Road, 'CP12' on Simpson Road, 'OS2' on Freeman Avenue and 'OS3' on Sackville Street (see Figure 29). Consultation may need to be conducted to gain the acceptance of communities, given fears of adverse impacts of signage on property values. This may be difficult to gain where the low-point is adjacent to private property, such as at Freeman Avenue.

Signage would also be useful to show flood evacuation routes, such as from Richards on the Park Hotel's car park in Canley Vale.

Signage may also be required at the 14 detention basins within the Three Tributaries catchment, to denote the potential for rapidly rising water in usually dry basins.

For the purposes of the Three Tributaries FRMP, a budget of $25K for five signs at an estimated cost of $5K each (including installation) has been included.

12.4 RECOVERY PLANNING

The Fairfield City Local Flood Plan sets out the various responsibilities of agencies when dealing with post-flood recovery. Following a flood:

- Council and other agencies will need to restore or clean up their own assets;
- Residents and commercial operators will commence clean-up, with the expectation that Council will provide some assistance, even if only in disposing of waste materials and debris, in the residential clean-up after a flood;
- Authorities such as Department of Community Services may provide some welfare services;
- Meetings to share experiences and trauma counselling could help people to recover emotionally;
- Data will be collected to help agencies and communities to better deal with the next flood event through recalibration of flood models, re-estimation of potential flood damages based on actual flood damage data, an assessment of the flood warning system and level of community flood readiness, and assessment of the effectiveness of the education program.

The final stage of the recovery is a full de-brief of all agencies and council(s) in the experiences of and results of the flood response actions. This is an essential step in upgrading and updating the Local Flood Plan to improve actions and reactions, that is, to raise the resilience of the Plan and community to flooding.

12.5 DISASTER RELIEF

Major disaster relief or assistance usually comes about following the declaration of a disaster by either the State or Commonwealth governments – it is usually the State that makes the initial declaration and then, based on the size and extent of the disaster, the Commonwealth may also declare a disaster.

Local Government Areas declared natural disasters are eligible for Natural Disaster Assistance Schemes. The following schemes are available under the NSW Disaster Assistance Arrangements (see http://www.emergency.nsw.gov.au/nddassistance):

- Personal Hardship and Distress Assistance
- Primary Producers – Loans
- Primary Producers – Transport Subsidies
- Small Businesses
- Trustees of Parks and Reserves
- Sporting Clubs
- Churches and Voluntary Non-Profit Organisations
- Motor Vehicle Stamp Duty Relief

The Natural Disaster Declaration also enables Council to claim for a fair and reasonable estimate for the cost of repair and restoration of public assets that have been damaged as a result of the natural disaster.

12.6 INSURANCE

Insurance is not strictly a response modification measure but is a means of mitigating the cost of the residual risk to property after all other mitigation measures have been implemented. Insurance can be taken out on private property as well as public infrastructure and buildings. It is available for residential, commercial and industrial property. However, the cost of insurance may be considered unaffordable by those who have to pay for it.

Flood insurance was not previously included in most residential property insurance policies and so there has been a negative reaction from community members to the increase in their insurance premiums when flood coverage has been included. However, premiums are reflective of the estimated annual average damages to a property from flooding and are a way to spread the financial burden across many years rather than have a single, unaffordable cost in a large flood.

Property owners in the Three Tributaries floodplain, particularly for those properties in the highest risk areas where an infrequent flood could result in a single unaffordable flood loss, should be encouraged to evaluate the benefits of flood insurance. Council's role would be to provide objective information about flood risks and costs for property owners to be able to make an informed choice.

PART D: DRAFT FLOODPLAIN RISK MANAGEMENT PLAN

13 DRAFT FLOODPLAIN RISK MANAGEMENT PLAN

13.1 OBJECTIVE

The overall objective of the Three Tributaries Floodplain Risk Management Plan (FRMP) is to develop a long-term approach to flood and floodplain management in the Three Tributaries catchment that addresses the existing and future flood risks in accordance with the general desires of the community and in line with the principles and guidelines laid out in the NSW *Floodplain Development Manual*.

This will ensure that the following broad needs are met:

- Reduce the flood hazard and risk to people and property, now and in the future; and
- Ensure floodplain risk management decisions integrate economic, environmental and social considerations.

13.2 RECOMMENDED MEASURES

The recommended measures for the FRMP have been selected from the suite of options introduced in Chapter 9 and evaluated in Chapters 10 to 12, after an assessment of each measure's impact on flood risk, as well as consideration of economic, environmental and social factors. The recommended measures are presented in Table 25 and summarised in Figure 51.

13.3 PLAN IMPLEMENTATION

13.3.1 Costs

The total capital cost of implementing the Plan is about $3.5M, comprised mainly of the Mimosa Road Basin upgrade ($1.1M), the Fairfield Golf Course Basin upgrade (~$0.6M), the Voluntary House Raising/Redevelopment/Flood-Proofing Scheme (~$0.7M) and the elevated emergency evacuation route from Freeman Avenue (~$0.6M). This would yield damage savings of at least $2.5M, resulting in an overall benefit-cost ratio of about 0.7. It would reduce the number of houses flooded above floor level in the 100 year ARI flood by 42. The stated benefits are regarded as minimums, since the proposed debris control structure would help to protect another 19 houses from above floor flooding, which could otherwise be inundated. Also, there are significant intangible benefits associated with the recommended basin upgrades and improvements to flood warning systems, emergency management planning and community flood awareness and readiness. Future risk will be contained, and with redevelopment existing risk can gradually be reduced, through the proposed revisions to Council's planning policies.

13.3.2 Priorities and Timing

Each measure in Table 25 includes a priority and a timeframe. The priority reflects the urgency of the option from a purely flood risk reducing perspective, particularly to reduce the risk to life. The estimated timing reflects what is likely to be practical given the required capital expenditure, or need for further investigation, or need for stakeholder and community consultation.

13.3.3 Resourcing

Plan implementation will be dependent on adequate resourcing of its implementation and maintenance. Resources may include financial and human resource and come from a number of sources. Potential contributors of resources include:

- Fairfield City Council – financial resources from capital and operating budgets, staff time;
- NSW State Government – financial grants for investigations, mitigations works and programs, OEH and SES staff time;
- Commonwealth Government – financial grants for investigations, mitigations works and programs;
- Developers – OSD construction and maintenance, Section 94 contributions for open space;
- Community – volunteer time.

13.4 PLAN MAINTENANCE

A FRMP plan is never truly finished. The Three Tributaries FRMP should be regarded as a dynamic instrument requiring review and modification over time. Catalysts for change could include flood events, revised flood modelling, better information about potential climate change flood impacts, social changes, legislative and planning changes or variations to the availability of funding. In any event, a thorough review every five years is warranted to ensure the ongoing relevance of the Plan.

It is envisaged that the Plan will be implemented progressively over a 5 to 10 year timeframe. The timing of the proposed works and measures will depend on the overall budgetary commitments of Council and the availability of funds from other sources.

Table 25 – Draft Three Tributaries Floodplain Risk Management Plan

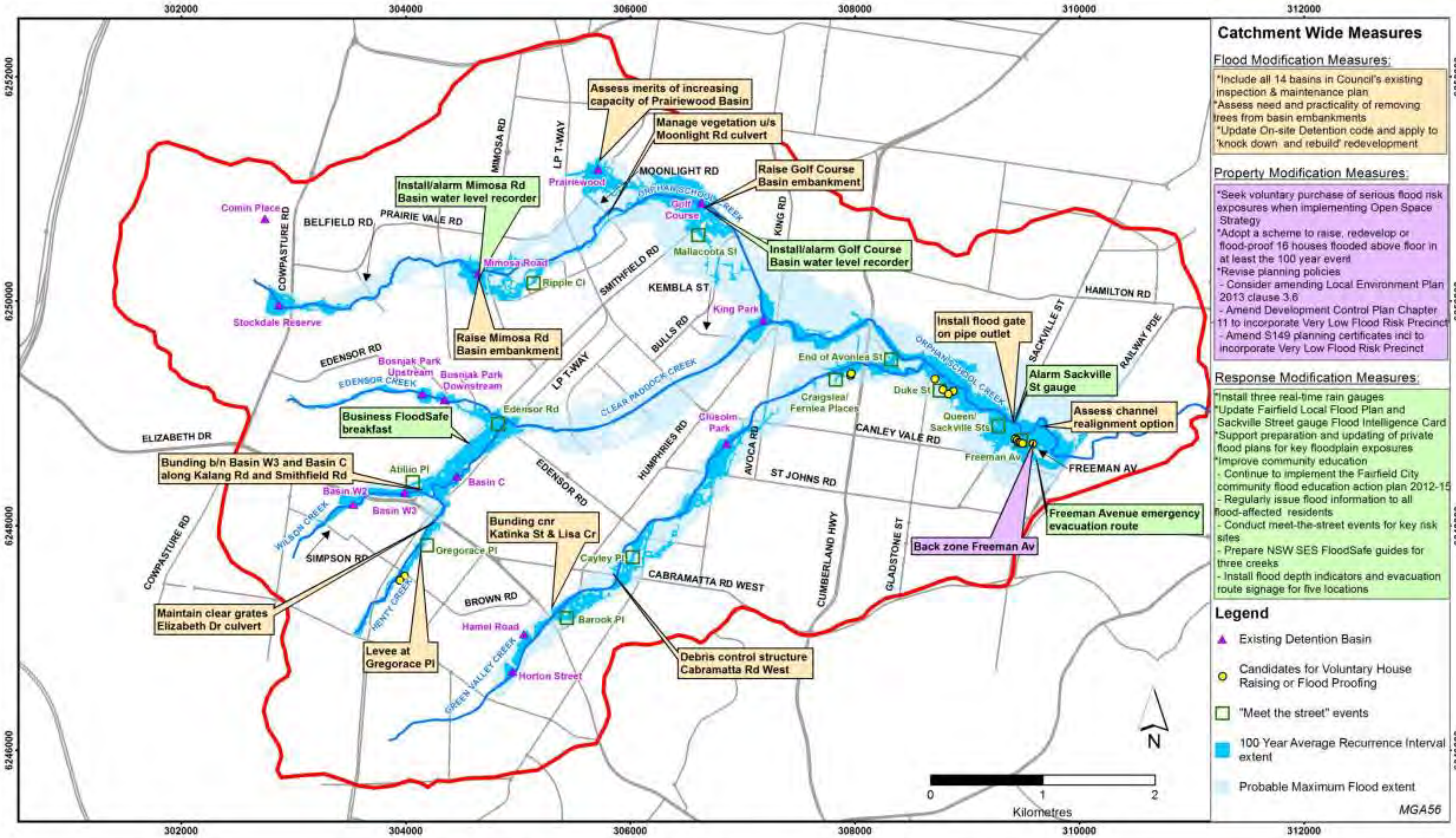
Report section	Floodplain Management Measure	Implementation Responsibility	Initial cost	Ongoing cost	Priority	Timing	Resourcing	Comments
	FLOOD MODIFICATION MEASURES							
10.1.2	Raise embankment at Mimosa Road Basin to contain 100 year ARI flood	FCC	$1.1M	$0	High	> 2 yrs	OEH, FCC	High priority reflects need for basin safety upgrade as well as scale of existing flood problem downstream.
10.1.3	Assess merits of increasing capacity of Prairiewood Basin	FCC	$10K	$0	High	1-2 yrs	OEH, FCC	Flood modelling required
10.1.4	Raise embankment at Fairfield Golf Course Basin to contain 100 year ARI flood	FCC	$550K	$0	High	> 2 yrs	OEH, FCC	High priority reflects need for basin safety upgrade as well as scale of existing flood problem downstream.
10.1.7	Bunding between Basin W3 and Basin C to reduce flooding entering Kalang Rd/Attilio Pl and Smithfield Rd	FCC	$40K	$0	High	> 2 yrs	OEH, FCC	This includes an allowance for an initial modelling investigation to assess different options.
10.1.9	Implement structural, functional and safety measures for all 14 basins, on a priority basis and to maintain or improve flood mitigation and basin safety	FCC	TBC	$0	High	> 2 yrs	OEH, FCC	Funding estimates for this option are to be confirmed at time of assessment.
10.1.10a	Include all 14 basins in Council's Asset Management Policy/Strategy	FCC	$0	minimal	High	0-1 yr	FCC	For basin safety
10.1.10b	Assess need and practicality of removing trees from basin embankments	FCC	$15K	$0	High	1-2 yrs	FCC	Allowance for investigation

Report section	Floodplain Management Measure	Implementation Responsibility	Initial cost	Ongoing cost	Priority	Timing	Resourcing	Comments
10.2	Update Urban Area On-Site Detention Code and apply to 'knock down and rebuild' developments	FCC	minimal	$0	Medium	1-2 yrs	FCC, Developers	This is dependent on completion of an investigation project which has been commenced by FCC. Developers would be responsible for the costs of complying with the final OSD Code.
10.3	Assess merits of realignment of Orphan School Creek channel north of Freeman Avenue	FCC	$10K	$0	High	1-2 yrs	OEH, FCC	Flood modelling required
10.5.3	Install flap gate on the outlet to the northern Sackville Street 1200mm diameter pipe at Orphan School Creek	FCC	$10K	$0	High	1-2 yrs	OEH, FCC	Humes quoted $5K ex-GST for the flood gate; Installation cost estimated
10.6	Manage vegetation upstream of culvert at Moonlight Rd on Orphan School Creek	FCC	$0	minimal	Medium	0-1 yr	FCC	
10.6	Maintain clear grates across culvert entrances at Elizabeth Dr on Henty Creek	FCC	$0	minimal	Medium	0-1 yr	FCC	
10.6	Install debris control structure upstream of culvert at Cabramatta Rd West on Green Valley Creek	FCC	$135K	minimal	Medium	> 2 yrs	OEH, FCC	
10.7.1	Flood barrier to protect six properties at southern end of Gregorace Pl from Henty Creek flooding	FCC	$80-120K	$0K	High	1-2 yrs	OEH, FCC	Further engagement with residents required.
10.7.2	Sealing of soundwall, bunding and speed hump to protect two properties near corner of Katinka St and Lisa Cr from Green Valley Creek flooding	FCC	$60K	$0K	High	1-2 yrs	OEH, FCC	Consultation with RMS is required regarding works on Elizabeth Drive soundwalls; engagement with residents is required regarding bunding.

Report section	Floodplain Management Measure	Implementation Responsibility	Initial cost	Ongoing cost	Priority	Timing	Resourcing	Comments
	PROPERTY MODIFICATION MEASURES							
11.1	Seek to VP serious flood risk exposures when implementing FCC's Open Space Strategy	FCC	$0	$0	Medium	> 2 yrs	FCC	An investigation of the potential for S94 contributions for open space to be used for VP of high risk properties in Three Tribs is recommended.
11.2	Adopt a scheme to raise, redevelop or flood-proof 16 old houses flooded above floor in the 20 year, 50 year or 100 year ARI events	FCC	$717K	$0K	Medium	> 2 yrs	OEH, FCC	A sliding scale of subsidies is proposed commensurate to the risk and site-specific circumstances for best managing the risk.
11.3	Revise Planning Policy • Consider amending Clause 6.3 of the LEP to clarify that it does not apply beyond the PMF extent • Backzone Freeman Ave to Low Density Residential, which would be more compatible with its High flood risk • Amend Chapter 11 of the DCP as discussed, including incorporation of a Very Low flood risk precinct • Amend Section 149 planning certificates as discussed, including incorporation of a Very Low flood risk precinct	FCC	$0	minimal	High	0-1 yr	FCC	

Report section	Floodplain Management Measure	Implementation Responsibility	Initial cost	Ongoing cost	Priority	Timing	Resourcing	Comments
	RESPONSE MODIFICATION MEASURES							
12.1.2	Install three real-time rain gauges in the catchment	FCC	$30K	$6K p.a.	Medium	0-1 yr	OEH, FCC	
12.1.3a	Alarm the existing water level recorder for Orphan School Creek at Sackville Street	FCC/NSW Office of Water	$1K	$600 p.a.	High	0-1 yr	OEH, FCC	NSW Office of Water would request a 3 year Service Level agreement with FCC, and the gauge could be transferred to FCC in the future.
12.1.3b	Install basin water level recorders for the Mimosa Road and Fairfield Golf Course Basins	FCC	$50K	$10K p.a.	High	1-2 yrs	OEH, FCC	
12.2.1	Construct an elevated emergency evacuation route from Freeman Ave to Canley Vale Rd	FCC	$0.5-$1.0M	$0	High	> 2 yrs	OEH, FCC	
12.2.2	Update Fairfield Local Flood Plan and Sackville Street gauge Flood Intelligence Card	SES	$0	$0	High	0-1 yr	SES, FCC	
12.2.3	Support preparation and updating of private flood plans for key floodplain exposures	SES	$0	$0	High	1-2 yrs	SES, FCC	
12.3.1	Continue to implement the Fairfield City community flood education action plan 2012-15	FCC, SES	not costed here	not costed here	High	0-1 yr	FCC, SES	
12.3.2	Regularly issue flood information to all flood-affected residents	FCC	minimal	minimal	High	0-1 yr	FCC	
12.3.3	Conduct meet-the-street events for key risk sites (highest priority Freeman Avenue)	SES	minimal	minimal	High	0-1 yr	SES, FCC	

Report section	Floodplain Management Measure	Implementation Responsibility	Initial cost	Ongoing cost	Priority	Timing	Resourcing	Comments
12.3.4	Conduct a Business FloodSafe breakfast for Smithfield Road	SES	$2K	$0	Medium	1-2 yrs	SES, FCC	
12.3.5	Prepare NSW SES FloodSafe guides for three creeks	SES	$12K	$0	Medium	1-2 yrs	SES	
12.3.6	Install flood depth indicators and evacuation route signage for five locations	FCC	$25K	$0	Low	1-2 yrs	OEH, FCC	Will need to gain community concurrence at each site.



Three Tributaries Floodplain Risk Management Study: Draft FRMP

MOLINO STEWART ENVIRONMENT & NATURAL HAZARDS	Molino Stewart endeavours to ensure that the information provided in this map is correct at the time of publication. Molino Stewart does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.	Date: 22/07/2015	Checked By: S.Y.	Job No: 0429
		Filepath: G:\Spatial\Projects\GIS_0429_Three_Tribs_FRMS\GIS\Workspace\Draft FRMP v2.mxd		

Figure 51 – Draft Three Tributaries Floodplain Risk Management Plan

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APPENDIX A – GLOSSARY AND ABBREVIATIONS

This Floodplain Risk Management Study utilises the terminology used in the NSW *Floodplain Development Manual* (2005). The following Glossary is drawn from that Manual.

acid sulfate soils	These are sediments which contain sulfidic mineral pyrite which may become extremely acid following disturbance or drainage as sulfur compounds react when exposed to oxygen to form sulfuric acid.
annual exceedance probability (AEP)	The chance of a flood of a given or larger size occurring in any one year, usually expressed as a percentage. For example, if a peak flood discharge of 500 m^3/s has an AEP of 5%, it means that there is a 5% chance (i.e., a one-in-20 chance) of a 500 m^3/s or larger events occurring in any one year (see ARI).
Australian Height Datum (AHD)	A common national surface level datum approximately corresponding to mean sea level.
average annual damage (AAD)	Depending on its size (or severity), each flood will cause a different amount of flood damage to a flood prone area. AAD is the average damage per year that would occur in a nominated development situation from flooding over a very long period of time.
average recurrence interval (ARI)	The long-term average number of years between the occurrence of a flood as big as or larger than the selected event. For example, floods with a discharge as great as or greater than the 20 year ARI flood event will occur on average once every 20 years. ARI is another way of expressing the likelihood of occurrence of a flood event.
BoM	Bureau of Meteorology
catchment	The land area draining through the main stream, as well as tributary streams, to a particular site. It always relates to an area above a specific location.
Consent authority	The council, government agency or person having the function to determine a development application for land use under the EP&A Act. The consent authority is most often the council, however legislation or an EPI may specify a Minister or public authority (other than a council), or the Director General of DPI, as having the function to determine an application.
Development	Defined in Part 4 of the EP&A Act: **Infill development**: refers to the development of vacant blocks of land that are generally surrounded by developed properties and is permissible under the current zoning of the land. Conditions such as minimum floor levels may be imposed on infill development **New development**: refers to development of a completely different nature to that associated with the former land use. For example, the urban subdivision of an area previously used for rural purposes. New developments involve re-zoning and typically require major extensions of existing urban services, such as roads, water supply, sewerage and electric power. **Redevelopment:** refers to rebuilding in an area. For example, as urban areas age, it may become necessary to demolish and reconstruct buildings on a relatively large scale. Redevelopment generally does not require either re-zoning or major extensions to urban services.
Disaster plan (DISPLAN)	A step by step sequence of previously agreed roles, responsibilities, functions, actions and management arrangements for the conduct of a single or series of connected emergency operations, with the object of ensuring the coordinated response by all agencies having responsibilities and functions in emergencies.
Discharge	The rate of flow of water measured in terms of volume per unit time, for example, cubic metres per second (m^3/s). Discharge is different from the speed or velocity of flow, which is a measure of how fast

	the water is moving for example, metres per second (m/s).
EP&A Act	The Environmental Planning & Assessment Act, the principal planning legislation in NSW.
EPI	Environmental Planning Instrument – a generic term for the suite of planning documents specified under the Environmental Planning & Assessment ACT and includes State Environmental Planning Policies (SEPP), Local Environmental Plans (LEP) and Development Control Plans (DCP).
Ecologically Sustainable Development (ESD)	Using, conserving and enhancing natural resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be maintained or increased. A more detailed definition is included in the Local Government Act, 1993.
Effective warning time	The time available after receiving advice of an impending flood and before the floodwaters prevent appropriate flood response actions being undertaken. The effective warning time is typically used to raise furniture, evacuate people and their possessions.
Emergency management	A range of measures to manage risks to communities and the environment. In the flood context it may include measures to prevent, prepare for, respond to and recover from flooding.
Flash flooding	Flooding which is sudden and unexpected. It is often caused by sudden local or nearby heavy rainfall. Often defined as flooding which peaks within six hours of the causative rain.
Flood	Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or local overland flooding associated with major drainage before entering a watercourse, and/or coastal inundation resulting from super-elevated sea levels and/or waves overtopping coastline defences excluding tsunami.
Flood awareness	Flood awareness is an appreciation of the likely effects of flooding and a knowledge of the relevant flood warning, response and evacuation procedures.
Flood education	Flood education seeks to provide information to raise awareness of the flood problem so as to enable individuals to understand how to manage themselves and their property in response to flood warnings and in a flood event. It invokes a state of flood readiness.
Flood fringe areas	The remaining area of flood prone land after floodway and flood storage areas have been defined.
Flood liable land	Is synonymous with flood prone land, i.e., land susceptible to flooding by the PMF event. Note that the term flood liable land covers the whole floodplain, not just that part below the FPL (see flood planning area).
Flood mitigation standard	The average recurrence interval of the flood, selected as part of the floodplain risk management process that forms the basis for physical works to modify the impacts of flooding.
Floodplain	Area of land which is subject to inundation by floods up to and including the probable maximum flood event, that is, flood prone land.
Floodplain risk management options	The measures that might be feasible for the management of a particular area of the floodplain. Preparation of a floodplain risk management plan requires a detailed evaluation of floodplain risk management options.
Floodplain risk management plan	A management plan developed in accordance with the principles and guidelines in this manual. Usually includes both written and diagrammatic information describing how particular areas of flood

	prone land are to be used and managed to achieve defined objectives.
Flood plan (local)	A sub-plan of a disaster plan that deals specifically with flooding. They can exist at state, division and local levels. Local flood plans are prepared by the SES.
Flood planning area (FPA)	The area of land below the FPL and thus subject to flood related development controls.
Flood planning levels (FPLs)	Are the combinations of flood levels and freeboards selected for floodplain risk management purposes, as determined in management studies and incorporated in management plans.
Flood proofing	A combination of measures incorporated in the design, construction and alteration of individual buildings or structures subject to flooding, to reduce or eliminate flood damages.
Flood prone land	Land susceptible to flooding by the PMF event. Flood prone land is synonymous with flood liable land.
Flood readiness	Readiness is an ability to react within the effective warning time. (see flood awareness)
Flood refuge	In an industrial or commercial situation: an area used for offices or to store valuable possessions susceptible to flood damage in the event of a flood.
flood risk	Potential danger to personal safety and potential damage to property resulting from flooding. The degree of risk varies with circumstances across the full range of floods. Flood risk in this manual is divided into 3 types, existing, future and continuing risks: **Existing flood risk:** the risk a community is exposed to as a result of its location on the floodplain. **Future flood risk:** the risk a community may be exposed to as a result of new development on the floodplain. Continuing flood risk: the risk a community is exposed to after floodplain risk management measures have been implemented.
Flood storage areas	Those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood.
Floodway areas	Those areas of the floodplain where a significant discharge of water occurs during floods. They are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flow, or a significant increase in flood levels.
Freeboard	It is a factor of safety typically used in relation to the setting of floor levels, levee crest levels, etc.
Habitable room	In a residential situation: a living or working area, such as a lounge room, dining room, rumpus room, kitchen, bedroom or workroom.
Hazard	A source of potential harm or a situation with a potential to cause loss. In relation to this manual the hazard is flooding which has the potential to cause damage to the community. Two levels of hazard are usually adopted in floodplain risk management planning: **High hazard:** possible danger to personal safety; evacuation by trucks difficult; able-bodied adults would have difficulty in wading to safety; potential for significant structural damage to buildings. **Low hazard:** should it be necessary, truck could evacuate people and their possessions; able-bodied adults would have little difficulty in wading to safety.
Hydraulics	The study of water flow in waterways; in particular, the evaluation of flow parameters such as water level and velocity.

Hydrograph	A graph which shows how the discharge or stage/flood level at any particular location varies with time during a flood.
Hydrology	The study of the rainfall and runoff process; in particular, the evaluation of peak flows, flow volumes and the derivation of hydrographs for a range of floods.
Local overland flooding	Inundation by local runoff rather than overbank discharge from a stream, river, estuary, lake or dam.
Local drainage	Smaller scale problems in urban areas. They are outside the definition of major drainage in this glossary.
Mainstream flooding	Inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam.
Major drainage	Councils have discretion in determining whether urban drainage problems are associated with major or local drainage. For the purposes of this study, major drainage involves: • the floodplains of original watercourses (which may now be piped, channelised or diverted), or sloping areas where overland flows develop along alternative paths once system capacity is exceeded; and/or • water depths generally in excess of 0.3m (in the major system design storm as defined in the current version of Australian Rainfall and Runoff). These conditions may result in danger to personal safety and property damage to both premises and vehicles; and/or • major overland flowpaths through developed areas outside of defined drainage reserves; and/or • the potential to affect a number of buildings along the major flow path.
Minor, moderate and major flooding	Both the SES and the BoM use the following definitions in flood warnings to give a general indication of the types of problems expected with a flood: **Minor flooding**: causes inconvenience such as closing of minor roads and the submergence of low level bridges. The lower limit of this class of flooding on the reference gauge is the initial flood level at which landholders and townspeople begin to be flooded. **Moderate flooding**: low-lying areas are inundated requiring removal of stock and/or evacuation of some houses. Main traffic routes may be covered. **Major flooding**: appreciable urban areas are flooded and/or extensive rural areas are flooded. Properties, villages and towns can be isolated.
Modification measures	Measures that modify either the flood or the property or the response to flooding. There are three generally recognised ways of managing floodplains to minimise the risk to life and to reduce flood losses: • By modifying the response of the population at risk to better cope with a flood event (Response Modification); • by modifying the behaviour of the flood itself (Flood Modification); and • by modifying or removing existing properties and/or by imposing controls on property and infrastructure development (Property Modification).
Peak discharge	The maximum discharge occurring during a flood event.
Probable maximum flood	The PMF is the largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation, and where applicable, snow melt, coupled with the

	worst flood producing catchment conditions. Generally, it is not physically or economically viable to provide complete protection against this event. The PMF defines the extent of flood prone land, that is, the floodplain. The extent, nature and potential consequences of flooding associated with a range of events rarer than the flood used for designing mitigation works and controlling development, up to and including the PMF event should be addressed in a floodplain risk management study.
Probable maximum precipitation	The PMP is the greatest depth of precipitation for a given duration meteorologically possible over a given size storm area at a particular location at a particular time of the year, with no allowance made for long-term climatic trends (World Meteorological Organisation, 1986). It is the primary input to PMF estimation.
Probability	A statistical measure of the expected chance of flooding (see AEP).
Risk	Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. In this context, it is the likelihood of consequences arising from the interaction of floods, communities and the environment.
Runoff	The amount of rainfall which actually ends up as streamflow, also known as rainfall excess.
SES	State Emergency Service
stage	Equivalent to water level (both measured with reference to a specified datum).
stage hydrograph	A graph that shows how the water level at a particular location changes with time during a flood. It must be referenced to a particular datum.
survey plan	A plan prepared by a registered surveyor.
water surface profile	A graph showing the flood stage along a watercourse at a particular time.

APPENDIX B – FLOOD HISTORY

Table B1 – Historical Flood Records for Lower Prospect Creek at Lansdowne Bridge

Date	Flood Level (m AHD)
May 1809	8.2*
April 1860	7.5
February 1873	8.0
May 1889	7.2
February 1898	5.5
June 1950	5.3
February 1956	5.7
November 1961	4.6
March 1978	3.7
March 1983	1.5
August 1986	5.1
April 1988	5.8
April 1989	1.3
February 1990	3.1
June 1991	4.7
August 1996	2.4
January 2001	4.2

Source: Bewsher Consulting (2010, p.11)

* Data reliability uncertain as bridge not yet constructed

Table B2 – Historical flood levels in the Three Tributaries catchment (mAHD)

Location	1986	1988	2001
ORPHAN SCHOOL CREEK			
Railway Parade Canley Vale	8.92	8.97	7.52
Sackville Street Canley Vale	10.39	11.00	10.32
Cumberland Highway Canley Heights	14.68	14.15	14.15
King Road Wakeley	19.64		18.17
GREEN VALLEY CREEK			
Avoca Road Wakeley	18.91		18.51
Canley Vale Road Wakeley	20.62		20.05
CLEAR PADDOCK CREEK			
Kembla Street, Waverley	19.19		18.80
Brisbane Road, St Johns Park	28.54		28.89

Source: SKM & FCS (2008, Appendix A)

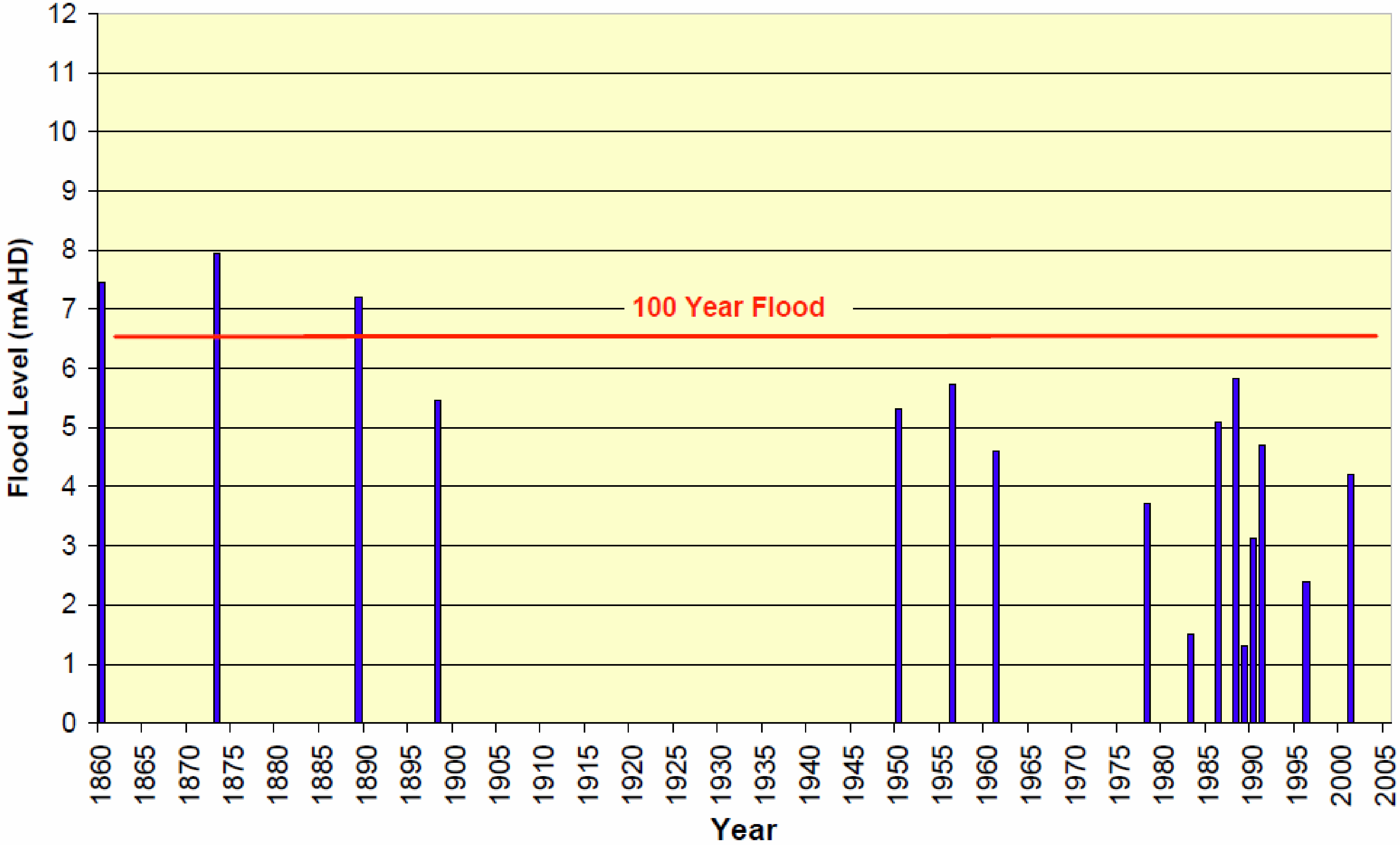

Figure B1 – Historical flood heights at Lansdowne Bridge

Source: Bewsher Consulting (2010, p.11)

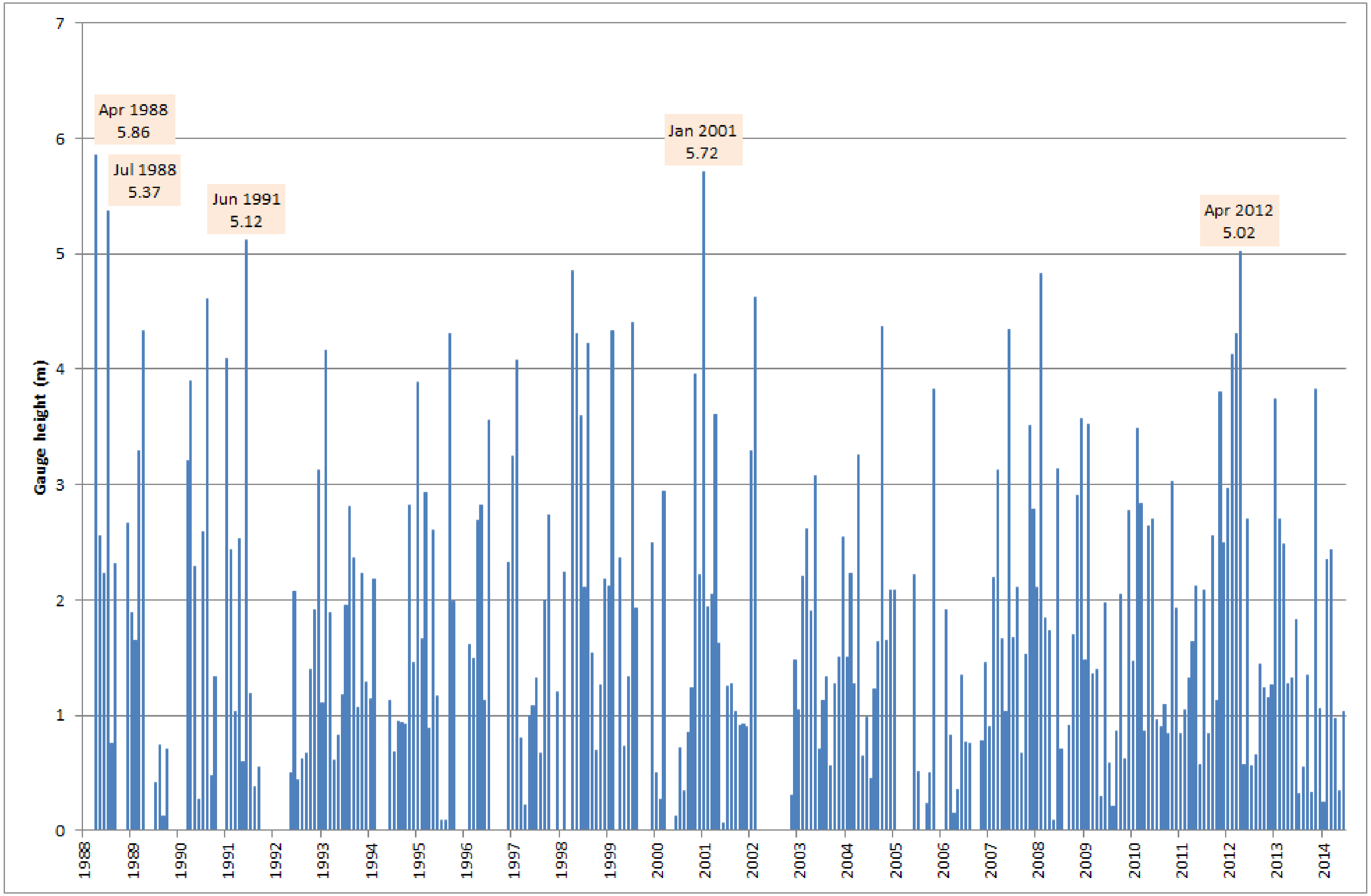

Figure B2 – Maximum monthly flood levels, Sackville Street at Orphan School Creek gauge, 1988-2014

Source: NSW Office of Water

APPENDIX C – EXISTING S149 WORDING FOR FLOOD NOTATIONS

Notes:

- Land affected by overland flow inundation is indicated by other notations not shown here. These need to be provided where land is affected by both mainstream and overland flow inundation.
- Text shaded in grey will need to be amended if and when Council adopts a Very Low flood risk precinct (FRP) where development controls will not apply to residential, commercial and industrial, tourist-related and recreation and non-urban development. This would also entail redefining the Low FRP such that it no longer extends to the PMF extent.

S149 Wording for Flood Notations	
Flood Policy 50015 *Development on the subject land (or part) for the purposes of dwelling houses, dual occupancies, multi-unit housing or residential flat buildings (not including development for the purposes of group homes or seniors housing) is subject to the Fairfield City-Wide Development Control Plan 2006 (which includes provisions for flood management) and applies to all of the Fairfield Local Government Area. Development controls will apply to residential development of the above types if the land (or part of the land) is within the floodplain.* *Development for any other purpose on the subject land (or part) is also subject to the Fairfield City-Wide Development Control Plan 2006 (which includes provisions for flood management) and applies to all of the Fairfield Local Government Area. Development controls will apply to development for any other purpose if the land (or part of the land) is within the floodplain.* *NOTE: These controls apply to development only if that form of development is permissible on the subject land. Please refer to the land use zone indicated in this certificate and then determine, based on the objectives of that zone and the list of prohibited uses, whether the proposed use is permissible.*	Included in all certificates.
High Flood Risk Precinct Mainstream 50016 *This parcel is within the floodplain and identified as being within a High Flood Risk Precinct as a result of mainstream flooding.* *The term mainstream flooding means inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam.* *The term High Flood Risk Precinct is defined as the area of land below the 100-year flood event that is either subject to a high hydraulic hazard or where there are significant evacuation difficulties.*	Additional note where catchment mapped and risk determined.
Medium Flood Risk Precinct Mainstream 50017 *This parcel is within the floodplain and identified as being within a Medium Flood Risk Precinct as a result of mainstream flooding.* *The term mainstream flooding means inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam.* *The term Medium Flood Risk Precinct is defined as land below the 100-year flood level that is not within a High Flood Risk Precinct. This is land that is not subject to a high hydraulic hazard or where there are no significant evacuation difficulties.*	
Low Flood Risk Precinct Mainstream 50018 *This parcel is within the floodplain and identified as being within a Low Flood Risk Precinct as a result of mainstream flooding.* *The term mainstream flooding means inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam.* *The term Low Flood Risk Precinct is defined as all land within the floodplain (i.e. within the extent of the probable maximum flood) but not identified within either a High Flood Risk or a Medium Flood Risk Precinct. The Low Flood Risk Precinct is that area above the 100-year flood event.*	
Partly High and Medium Risk Mainstream 50019 *This parcel is within the floodplain and identified as being partly within a High Flood Risk Precinct and partly within a Medium Flood Risk Precinct as a result of mainstream flooding.* *The term mainstream flooding means inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam.* *The term High Flood Risk Precinct is defined as the area of land below the 100-year flood event that is*	

S149 Wording for Flood Notations	
either subject to a high hydraulic hazard or where there are significant evacuation difficulties. *The term Medium Flood Risk Precinct is defined as land below the 100-year flood level that is not within a High Flood Risk Precinct. This is land that is not subject to a high hydraulic hazard or where there are no significant evacuation difficulties.*	
Partly Medium and Low Risk Mainstream 50026 *This parcel is within the floodplain and identified as being partly within a Medium Flood Risk Precinct and partly within a Low Flood Risk Precinct as a result of mainstream flooding.* *The term mainstream flooding means inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam.* *The term Medium Flood Risk Precinct is defined as land below the 100-year flood level that is not within a High Flood Risk Precinct. This is land that is not subject to a high hydraulic hazard or where there are no significant evacuation difficulties.* *The term Low Flood Risk Precinct is defined as all land within the floodplain (i.e. within the extent of the probable maximum flood) but not identified within either a High Flood Risk or a Medium Flood Risk Precinct. The Low Flood Risk Precinct is that area above the 100-year flood event.*	
Partly Low and No Risk Mainstream 50027 *This parcel is within the floodplain and identified as being partly within a Low flood risk precinct and partly not affected by mainstream flooding.* *The term mainstream flooding means inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam.* *The term Low Flood Risk Precinct is defined as all land within the floodplain (i.e. within the extent of the probable maximum flood) but not identified within either a High Flood Risk or a Medium Flood Risk Precinct. The Low Flood Risk Precinct is that area above the 100-year flood event.*	
Partly High, Medium, and Low Risk Mainstream 50028 *This parcel is within the floodplain and identified as being partly within a High flood risk precinct, partly within a Medium Flood Risk Precinct and partly within a Low Flood Risk Precinct as a result of mainstream flooding* *The term mainstream flooding means inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam.* *The term High Flood Risk Precinct is defined as the area of land below the 100-year flood event that is either subject to a high hydraulic hazard or where there are significant evacuation difficulties.* *The term Medium Flood Risk Precinct is defined as land below the 100-year flood level that is not within a High Flood Risk Precinct. This is land that is not subject to a high hydraulic hazard or where there are no significant evacuation difficulties.* *The term Low Flood Risk Precinct is defined as all land within the floodplain (i.e. within the extent of the probable maximum flood) but not identified within either a High Flood Risk or a Medium Flood Risk Precinct. The Low Flood Risk Precinct is that area above the 100-year flood event.*	
Partly Medium, Low and No Risk Mainstream 50029 *This parcel is within the floodplain and identified as being partly within a Medium Flood Risk Precinct, partly within a Low Flood Risk Precinct as a result of mainstream flooding and partly not affected by mainstream flooding.* *The term mainstream flooding means inundation of normally dry land occurring when water overflows*	

S149 Wording for Flood Notations	
the natural or artificial banks of a stream, river, estuary, lake or dam. *The term Medium Flood Risk Precinct is defined as land below the 100-year flood level that is not within a High Flood Risk Precinct. This is land that is not subject to a high hydraulic hazard or where there are no significant evacuation difficulties.* *The term Low Flood Risk Precinct is defined as all land within the floodplain (i.e. within the extent of the probable maximum flood) but not identified within either a High Flood Risk or a Medium Flood Risk Precinct. The Low Flood Risk Precinct is that area above the 100-year flood event.*	
Partly High, Medium, Low and No Risk Mainstream 50030 *This parcel is within the floodplain and identified as being partly within a High Flood Risk Precinct, partly within a Medium Flood Risk Precinct, partly within a Low Flood Risk Precinct as a result of mainstream flooding and partly not affected by mainstream flooding.* *The term mainstream flooding means inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam.* *The term High Flood Risk Precinct is defined as the area of land below the 100-year flood event that is either subject to a high hydraulic hazard or where there are significant evacuation difficulties.* *The term Medium Flood Risk Precinct is defined as land below the 100-year flood level that is not within a High Flood Risk Precinct. This is land that is not subject to a high hydraulic hazard or where there are no significant evacuation difficulties.* *The term Low Flood Risk Precinct is defined as all land within the floodplain (i.e. within the extent of the probable maximum flood) but not identified within either a High Flood Risk or a Medium Flood Risk Precinct. The Low Flood Risk Precinct is that area above the 100-year flood event.*	

APPENDIX D – FLOOD INFORMATION SHEET

[INSERT PDF SAMPLE FLOOD INFORMATION SHEET]

APPENDIX E – COMMUNITY CONSULTATION MATERIALS

- Initial letter and map
- Community flood survey (questionnaire)
- Community flood script
- Public exhibition materials

[INSERT PDF COMMUNITY CONSULTATION MATERIALS]

APPENDIX F – EMBEDDED DESIGN STORM MODELLING APPROACH

Source: WMAwater (2013b)

The selection of appropriate storm durations for design event modelling is complicated by the nature of the study catchment. In the Three Tributaries catchment, the catchment response is a function of runoff potential in combination with the available flood storage provided by the detention basins. As a result, the flood behaviour is dependant both upon the conveyance of the stormwater system and creeks (i.e. their capacity to discharge water from the catchment), and on the volume of runoff generated (resulting in filling of the basins).

In creek channels and overland flow areas, the flood response is primarily determined by the rainfall intensity - hence shorter duration storms (having higher intensity rainfalls) are generally responsible for major flooding. For detention basins, which have a finite storage volume, the total rainfall volume is the critical factor, and therefore longer duration storms with higher total rainfalls are important. This variability within the catchment complicates the selection of a critical duration storm that is appropriate for the whole catchment. For the study area, there is a significant chance that high-intensity short duration storm bursts (likely to cause flooding at culverts and other structures in the smaller urbanised catchments) will occur during the course of a broader, longer duration storm of reduced intensity that will partially fill flood mitigation basins.

It was decided to adopt a 2-hour peak burst duration as the critical storm duration for peak flows, as was adopted in the SKM & FCS (2008) Flood Study. However, for the FRMS modelling the peak burst was embedded in a longer duration storm (9-hour), to address storm volume considerations that are important for the assessment of basin failure. This takes into account the impact of antecedent rainfall on burst response for design events, reflecting the reality that the basins are likely to be partially full prior to the most intense portion of the storm occurring. Based on consideration of the modelled catchment response for a range of peak burst durations, for the revised modelling a 2-hour peak burst was embedded into 9-hour peak burst to form an Embedded Design Storm (EDS).

The EDS were prepared based on the procedures outlined in Phillips et al. (1994), Rigby and Bannigan (1996) and Rigby et al. (2003). This technique involves embedding the shorter duration peak burst storm into a longer duration storm so that the peaks of both patterns coincide. The volume of the longer storm prior to and following the peak was then adjusted so that the total volume was consistent with the overall design storm average intensity for the respective durations and ARIs of both bursts.

The embedded storm approach addresses a number of issues relating to the basin failure assessment for the Three Tributaries detention basins, combining reasonable consideration of antecedent conditions (such as filling of basins) with high peak burst intensities that produce critical flash flooding in urban environments.

APPENDIX G – FLOOD DAMAGES STAGE-DAMAGE DATA

Three Tributaries FRMS Residential Stage-Damage Data

	Single Storey High Set	Single Storey Slab/Low Set	2 Storey Houses	Small Single Storey High Set	Small Single Storey Slab/ Low Set	Small 2 Storey Houses
Code	**1**	**2**	**3**	**4**	**5**	**6**
Above floor depth from modelling	**Damage**	**Damage**	**Damage**	**Damage**	**Damage**	**Damage**
-5.00	$0	$0	$0	$0	$0	$0
-1.50	$11,122	$0	$0	$8,342	$0	$0
-1.40	$19,609	$0	$0	$14,707	$0	$0
-1.30	$20,638	$0	$0	$15,478	$0	$0
-1.20	$21,666	$0	$0	$16,250	$0	$0
-1.10	$22,695	$0	$0	$17,021	$0	$0
-1.00	$23,723	$0	$0	$17,792	$0	$0
-0.90	$24,752	$0	$0	$18,564	$0	$0
-0.80	$25,780	$0	$0	$19,335	$0	$0
-0.70	$26,809	$0	$0	$20,107	$0	$0
-0.60	$27,837	$0	$0	$20,878	$0	$0
-0.50	$28,866	$11,122	$11,122	$21,649	$8,342	$8,342
-0.40	$29,894	$11,122	$11,122	$22,421	$8,342	$8,342
-0.30	$30,923	$11,122	$11,122	$23,192	$8,342	$8,342
-0.20	$31,951	$11,122	$11,122	$23,963	$8,342	$8,342
-0.10	$32,980	$11,122	$11,122	$24,735	$8,342	$8,342
0.00	$63,282	$29,286	$23,837	$47,462	$21,965	$17,878
0.10	$66,282	$59,598	$45,055	$49,712	$44,698	$33,791
0.20	$69,282	$62,095	$46,803	$51,961	$46,571	$35,102
0.30	$72,282	$64,592	$48,551	$54,211	$48,444	$36,413
0.40	$75,281	$67,090	$50,299	$56,461	$50,317	$37,724
0.50	$78,281	$69,587	$52,047	$58,711	$52,190	$39,036
0.60	$81,281	$72,084	$53,796	$60,961	$54,063	$40,347
0.70	$84,281	$74,582	$55,544	$63,211	$55,936	$41,658
0.80	$87,280	$77,079	$57,292	$65,460	$57,809	$42,969
0.90	$90,280	$79,576	$59,040	$67,710	$59,682	$44,280
1.00	$93,280	$84,994	$62,832	$69,960	$63,745	$47,124
1.10	$96,280	$87,637	$64,683	$72,210	$65,728	$48,512
1.20	$99,279	$90,281	$66,533	$74,460	$67,711	$49,900
1.30	$102,279	$92,924	$68,383	$76,709	$69,693	$51,288
1.40	$105,279	$95,567	$70,234	$78,959	$71,676	$52,675
1.50	$108,279	$98,211	$72,084	$81,209	$73,658	$54,063
1.60	$111,278	$100,854	$73,934	$83,459	$75,641	$55,451
1.70	$114,278	$103,497	$75,785	$85,709	$77,623	$56,839
1.80	$117,278	$106,141	$77,635	$87,958	$79,606	$58,226
1.90	$120,278	$108,784	$79,486	$90,208	$81,588	$59,614
2.00	$123,278	$111,428	$81,336	$92,458	$83,571	$61,002
2.10	$124,306	$112,100	$81,806	$93,230	$84,075	$61,355
2.20	$125,335	$112,772	$82,277	$94,001	$84,579	$61,708
2.30	$126,363	$113,444	$82,747	$94,772	$85,083	$62,060
2.40	$127,392	$114,116	$83,218	$95,544	$85,587	$62,413
2.50	$128,420	$114,788	$83,688	$96,315	$86,091	$62,766
2.60	$129,449	$115,460	$84,159	$97,086	$86,595	$63,119
2.70	$130,477	$116,132	$126,633	$97,858	$87,099	$94,975
2.80	$131,506	$116,804	$127,373	$98,629	$87,603	$95,530
2.90	$132,534	$117,477	$128,112	$99,401	$88,107	$96,084
3.00	$133,563	$118,149	$128,851	$100,172	$88,611	$96,638
3.50	$138,705	$121,509	$132,548	$104,029	$91,132	$99,411
4.00	$143,848	$124,870	$136,245	$107,886	$93,652	$102,183
4.50	$148,990	$128,230	$139,941	$111,743	$96,173	$104,956
5.00	$154,133	$131,591	$143,638	$115,599	$98,693	$107,728

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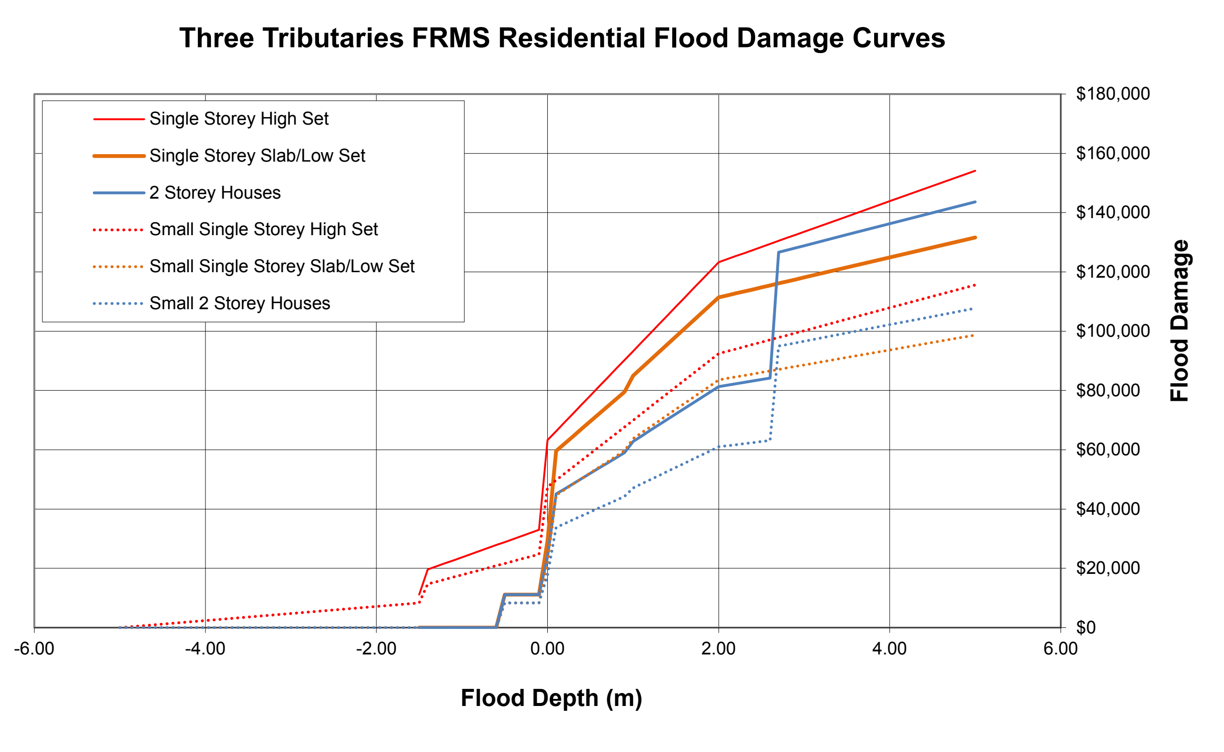

Three Tributaries FRMS Commercial/Industrial Premises Stage-Damage Data ($\$/m^2$)

Depth (m)	Commercial Low WS-C-low	Commercial Medium WS-C-med	Commercial High WS-C-high	Industrial Low WS-I-low	Industrial Medium WS-I-med	Industrial High WS-I-high
-999	0	0	0	0	0	0
0.1	$106	$187	$400	$106	$187	$852
0.2	$106	$187	$400	$106	$187	$852
0.3	$125	$248	$534	$138	$258	$941
0.5	$159	$373	$799	$200	$400	$1,119
0.6	$171	$405	$885	$216	$458	$1,194
0.75	$187	$453	$1,013	$240	$547	$1,306
1.0	$214	$493	$1,132	$267	$653	$1,492
1.5	$253	$519	$1,294	$293	$746	$1,812
2.0	$267	$547	$1,439	$320	$826	$2,105

APPENDIX H – MITIGATION OPTIONS IMPACT MAPPING

Source: WMAwater

A range of flood modification options specific to certain areas of the study area were modelled for the Three Tributaries FRMS&P by WMAwater. These options are described in Table H1. Each option was modelled for the 100 year ARI event using the hydraulic model revised from the Flood Study and updated to include changes to the floodplain since its completion.

Table H1 – Flood Mitigation Scenarios

Scenario	Description	Impact map
A	Mimosa Road Basin – raise embankment (adjacent to Mimosa Road, Comanche Road, Powhatan Street and Arrowhead Road) from current spilling level of 39.9 to 40.69 to contain the 100 year ARI flood (note, a freeboard has been costed but is not modelled)	Figure 45
B	Fairfield Golf Course Basin – raise embankment from current spilling level of 27.1 to 27.49 to contain the 100 year ARI flood (note, a freeboard has been costed but is not modelled)	Figure 46
C	Fairfield Golf Course Basin – lower 2.4 ha area upstream of embankment by 1 m	Figure 47
D	King Park Basin – lower 2.7 ha area upstream of embankment by 1 m	Figure 48
E	King Park Basin – remove embankment of basin adjacent to Innisfail Road	Figure 49
F	Combination of Scenario D & Scenario E	Figure 50
G	Chisholm Park Basin – lower 4.1 ha area upstream of embankment by 0.5 m	Figure 51
H	Flood Barrier – provide flood barriers/levees upstream of Cabramatta Road West on both sides of channel bank	Figure 52
J	Combination of Scenario G and Scenario H	Figure 53
M	King Park Basin – combination of Scenario F and reducing outlet capacity by 50%	Figure 54

The impact of each mitigation scenario on the peak 100 year ARI flood levels is shown in the following figures (as listed in Table H1).

[INSERT PDF 10 MITIGATION SCENARIOS IMPACTS MAPS FROM WMAWATER]

APPENDIX I – OPTIONS COST ESTIMATES

Source: J. Wyndham Prince

[INSERT PDF OPTIONS COST ESTIMATES FROM J. WYNDHAM PRINCE]

APPENDIX J – NSW SES FLOOD INTELLIGENCE UPDATES

Fairfield Local Flood Plan Review

Fairfield City Flood Emergency Sub Plan

Volume 1

February 2013

Section	Comment
1.3.1	**Area Covered by the Plan** Although the listing of suburbs helps to convey the area that is covered by the LFP, clarity would be improved by explicitly adding Clear Paddock Creek (and its tributaries) and Green Valley Creek after the mention of Orphan School Creek.
1.5.26g-m	**Responsibilities - Fairfield City Council** This needs to include basin monitoring.
1.5.27	**List of Prescribed Dams** This needs to be confirmed.
3.5	**Operations Centres** Given the current location of both the NSW SES Fairfield City Operations Centre and the Fairfield City Council EOC in a flood-prone area at Bareena Street, Canley Vale, a different location sited above the PMF would be preferable. If a new Centre is not possible, it is essential to ensure that the alternative locations (proposed to be Fairfield Showground and Cabramatta Police Station, respectively) are equipped with plug-in systems for radio/communications/computers, and that these systems are tested and maintained regularly. Access from Bareena Street to Fairfield Showground via St Johns Road, Avoca Road, Canley Vale Road and Smithfield Road is expected to be available for most events (but could be compromised by overland flows e.g. from Canley Corridor).

Section	Comment
3.8.4b	**Active Reconnaissance** A number of problem areas within the Three Tributaries floodplain could be added to the list for which NSW SES currently provides active reconnaissance (only Freeman Avenue is included from the study area). However, this depends on NSW SES resources being available, though possibly Fairfield City Council could take responsibility for monitoring some areas including its detention basins. Also, it is likely that in the headwaters, the creeks may respond so quickly to rainfall that any deployment for monitoring may be too late. Nonetheless, based on frequency of inundation and isolation, it is recommended that the following locations be added: • Brown Road (Henty Creek); • Gregorace Place (Henty Creek); • Smithfield Road between Elizabeth Drive and Edensor Road (Clear Paddock Creek); • Edensor Road (Clear Paddock Creek); • Barook Place cul-de-sac/Humphries Road (Green Valley Creek); • Cayley Place cul-de-sac (Green Valley Creek); • Craigslea Place/Fernlea Place cul-de-sacs (Green Valley Creek); • Avonlea Street cul-de-sac (Green Valley Creek); • Pitt Street cul-de-sac (Orphan School Creek); • Sackville Street (Orphan School Creek).
3.8.4e	**Sources of Information** NSW Office of Water monitors the Orphan School Creek at Sackville Street gauge (213014).
3.16.3	**Managing Property Protection** Given the rapid rate of rise, the likelihood of concurrent flooding across the LGA, and the limited number of NSW SES personnel, it is doubtful that lifting or moving of household furniture or commercial stock and equipment, or sandbagging, could be achieved.
3.18.12-21	**Delivery of Evacuation Warnings and Evacuation Orders** The new Volume 1 of the LFP does not appear to capture clause 3.8.6 from the 2005 LFP, which describes the high levels of cultural and linguistic diversity in Fairfield LGA. This will require provision of evacuation warnings and orders in 'plain English' and translations into the commonly spoken languages. Also, there should be explicit mention of evacuation warnings and orders being distributed to community ethnic radio stations as well as the ABC.
3.18.35	**Flood Evacuation Centres** Cabravale RSL Club, Bartley Street, Cabramatta, is likely to be the most accessible evacuation centre for affected residents of Canley Vale and Canley Heights located south of Orphan School Creek. Historically, some residents from Freeman Avenue have evacuated to Richard's on the Park Hotel in Canley Vale Road. Consideration should also be given to providing an evacuation centre to service areas that could be flooded in the western part of the LGA.
Attachment 3	The map should show the tributaries of Orphan School Creek – Clear Paddock Creek including its tributaries Edensor, Wilson and Henty Creeks, and Green Valley Creek.

Volume 2

In prep.

Annexes A and B of the 2005 Local Flood Plan need to be redrafted using the new SES template for the Local Flood Plan Volume 2. Specific recommendations include:

- Different sections need to be prepared to describe the landforms, river systems, flood characteristics, flood history, flood mitigation systems and extreme flooding *for the different catchments and sub-catchments*. There is currently considerable ambiguity in the text about what creeks and locations are being referred to.
- The design flood heights reported for the Sackville Street gauge have been superseded by the latest flood modelling – the 20 year ARI flood level is about 2.0m too low (see the amended Sackville Street gauge flood intelligence card).
- Local newspapers could be perused to learn of the consequences of the severe floods of 1986 and 1988, which are not described in the current edition of the LFP.
- The community profile needs to be updated using the latest Census data. The Three Tributaries floodplain could be treated as a specific risk area, with details about special risk exposures such as Mary MacKillop College and the Canley Vale nursing home, classification of floodplains according to their flood emergency response setting (e.g. Freeman Avenue low/high flood island), information about inundation and isolation, flood mitigation systems, consequences of dam failure, road closures, etc. Much of this information has been provided in this Floodplain Risk Management Study.
- Annex C of the new template should include the Sackville Street gauge (see the flood intelligence card).
- Annex J of the new template will require further detailed consideration of the safest course of action during floods (evacuation or shelter-in-place).

Sackville Street Flood Intelligence Card Review

Notes:

- Draft updates are indicated using grey highlight.
- The gauge zero and datum was extracted from the NSW Office of Water site summary report.
- The content has been updated using a WaterRIDE model for the 20 year, 100 year and PMF Three Tributary design flood events.
- The consequences at the same gauge height may vary for different design events depending on the rate of rise.

FLOOD INTELLIGENCE CARD

SACKVILLE STREET GAUGE - STATION NUMBER: 213014

24 July 2015

ACCURACY:

Use this information as a guide to the possible effects of a flood. The card is based on estimates of flood behaviour and particular effects may occur at heights different from those indicated here. They may also occur at slightly different heights in different floods.

CONFIDENTIALITY:

This card may contain sensitive information about the effects of flooding on private property. Specific reference to private addresses or business must be made directly to owners or other emergency services and NOT via broadcast or print media.

Stream: Orphan School Creek

Location: Upperside under bridge on pilon (Easting 309413.6, Northing 6238970.1, MGA94 Zone 56)

Minor:

Moderate:

Major: 5.70m

Gauge Zero: 4.61m

Datum Type: AHD

Levee Height: Not Applicable

Class	Height (m)	Consequences
	Note:	The road (Freeman Ave) to Canley Vale Nursing Home (98 beds) is susceptible to flooding from local overland flows and from poor drainage, before creek flooding affects the area which prevents vehicular access to nursing home for ambulances. Pedestrian access to temporary evacuation centre (Park Hotel at rear of Nursing Home) is via side walkway which can get cut by flooding from creek.
	2.70	Low Creek level (near to normal creek flows). Monitor for rises if heavy or prolonged rainfall in catchment
	3.80	High creek level. No bank overtopping.
	4.10	Channel storage areas filling up. No flooding of streets.
	4.41	By this height, car park behind Canley Vale shops just beginning to be affected by water backing up from creek.
	4.74	By this height, access road in front of No. 226 Sackville Street flooded.
	5.55	By this height, access road in front of Nos. 226, 228 and 230 Sackville Street flooded, and rear of property at No. 226 flooded. Car park behind Canley Vale shops more extensively flooded. Access to Pitt Street houses flooded. Endeavour Sports Reserve partly flooded near creek. Rear of properties at No. 1 Duke Street and No. 19 Prince Street flooded.

Class	Height (m)	Consequences
	5.64	By this height, access road in front of Nos. 226, 228, 230 and 232 Sackville Street flooded. Three community buildings at corner Prince Street and Chandos Street surrounded (< 0.2m at entrances).
MAJ	5.70	Underside of Sackville Street bridge deck. Water across Sackville Street.
MAJ	5.95	By this height, Freeman Avenue flooded to depth of up to ~0.4m between Sackville Street and No. 17 Freeman Avenue. Sackville Street flooded between Freeman Avenue and creek. Council depot partly flooded. Property with temple at 1 Stuart Street partly flooded. Low hazard to pedestrian flooding in 1) Queen Street east of Chandos Street, 2) in Burdett Street north of Prince Street, 3) in Adolphus Street north of George Street, and 4) in Duke Street east of Chatham Street.
MAJ	6.03	20 year ARI peak flood level. Floodwater up to about ~0.7m deep at low-point in Freeman Avenue with several properties inundated (not above floor level). A part of the car park behind Canley Vale shops affected by deep but low velocity water. Extensive though shallow flooding in Queen Street and Earl Street east of Chandos Street.
MAJ	6.14	50 year ARI peak flood level. Floodwater up to ~0.9m deep at low point in Freeman Avenue and 0.5m deep at low point in Sackville Street. Aged care centre and surrounding properties a high flood island. Avanel Street tennis courts flooded to shallow depths. Properties at eastern ends of Pitt, Clarence, Duke, George, Prince, Queen and Earl Streets flooded.
MAJ	6.22	100 year ARI peak flood level. Floodwater about 1.1m deep at low point in Freeman Avenue, 0.6m deep at low point in Sackville Street and 0.1m in Railway Parade. Aged care centre and surrounding properties a high flood island.
MAJ	6.29	100 year ARI + 10% increase in rainfall intensity peak flood level.
MAJ	6.52	Aged care centre and surrounding properties a (shrinking) high flood island.
MAJ	7.00	By this height, land on which aged care centre located is flooded.
MAJ	7.55	PMF peak level. Aged care centre flooded over floor to depth of 0.43m.