PENRITH CITY COUNCIL

# College, Orth and Werrington Creeks Catchment
## Floodplain Risk Management Study

### Final Report
Volume 1 of 2: Report Text & Appendices

October 2021

Catchment Simulation Solutions

# College, Orth and Werrington Creeks Catchment Floodplain Risk Management Study

## Final Report

| Client | Client Representative |
|---|---|
| Penrith City Council | Elias Ishak |

## REVISION HISTORY

| Revision # | Description | Prepared by | Reviewed by |
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| 2 | Draft report incorporating updates to address comments | D. Tetley | R. Ryan |
| 3 | Draft report for public exhibition | D. Tetley | R. Ryan |
| 4 | Final report | D. Tetley | R. Ryan |

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Penrith City Council has prepared this document with financial assistance from the NSW Government through its Floodplain Management Program. This document does not necessarily represent the opinions of the NSW Government or the Department of Planning Industry and Environment.

The preparation of the study was steered by Penrith City Council Floodplain Risk Management Committee whose members include councillors, council staff, community representatives and representatives from state agencies and adjacent councils. The study is the culmination of many months of investigation, analysis and flood modelling, which has been supported by valuable contributions from representatives of the Floodplain Risk Management Committee, community of Penrith and Penrith City Council.

It has been prepared by incorporating contributions from individuals from the local community and key stakeholders. Contributions from members of the Floodplain Risk Management Committee have been essential to the formation of management strategies that have been considered as part of the Study and are greatly appreciated. The collegial manner in which input has been provided to the project from representatives from the Penrith City Council has been critical to its success.

**Disclaimer**

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# 1 INTRODUCTION

## 1.1 Background

The College, Orth and Werrington Creeks catchment is located within the Penrith City Council Local Government Area. The catchment includes the suburbs of Orchard Hills, Caddens, Kingswood, Cambridge Park, Werrington and Werrington County. The extent of the catchment is shown on **Figure 1**. It drains an area of approximately 1,200 hectares into South Creek.

The area is significantly urbanised with a mix of residential and commercial properties as well as a small area of industrial properties. There are a number of important facilities within the catchment including the Nepean Hospital, Western Sydney University, TAFE NSW Nepean and Kingswood campuses and Cobham Youth Justice Centre. The catchment is also traversed by the Great Western Highway and the Western Railway Line that cuts across the catchment in an east to west direction.

Although the catchment is significantly urbanised there are still areas of undeveloped land primarily in the southern sections of the catchment. However, this is gradually changing with significant areas of the catchment having undergone further urban expansion over the past decade. This includes the Caddens, French Street and Victoria Street subdivisions.

The urbanised sections of the catchment are typically drained by a stormwater system that conveys runoff into College and Orth Creeks which, in turn, drain into Werrington Creek. During periods of heavy rainfall across the catchment, there is potential for the capacity of the stormwater system to be exceeded. In these circumstances, the excess water travels overland, potentially leading to inundation of roadways and properties. There is also potential for water to overtop the banks of the various creeks and inundate the adjoining floodplain. During major flooding, the lower parts of the catchment can also be inundated by backwater from South Creek. Elevated water levels in South Creek also inhibits water from draining from the catchment.

In recognition of the potential for flooding to occur, Penrith City Council completed the '*College, Orth and Werrington Creeks Catchments Overland Flow Flood Study'* (CSS, 2017). The flood study quantified the nature and extent of flood behaviour across the catchment for a range of different sized floods.

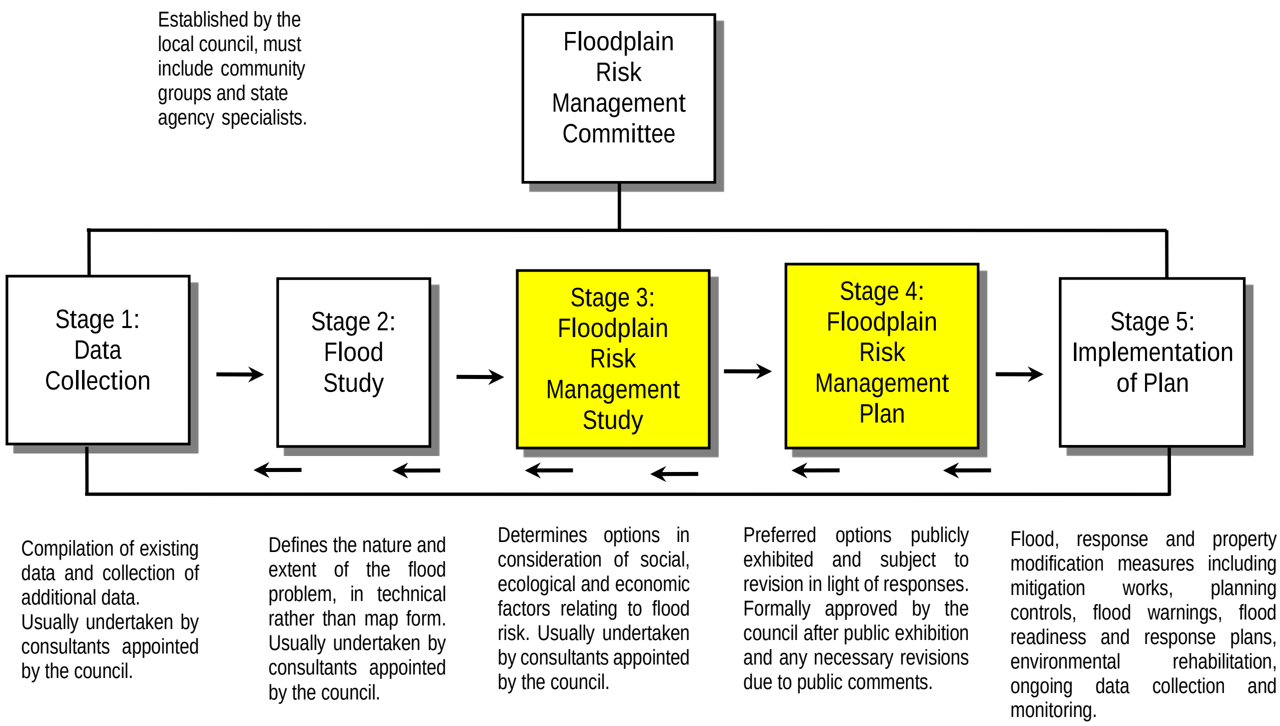
Penrith City Council subsequently engaged Catchment Simulation Solutions to prepare the College, Orth and Werrington Creeks Catchment Floodplain Risk Management Study and Plan (i.e., this document). The ultimate goal of the study and plan is to evaluate and recommend options that could be potentially implemented to best manage the flood risk across the catchment. The outcomes of these investigations are summarised in the following document.

## 1.2 The Floodplain Risk Management Process

The '*College, Orth and Werrington Creeks Catchment Floodplain Risk Management Study and Plan'* has been prepared in accordance with the requirements of the NSW Government's '*Floodplain Development Manual' (NSW Government, 2005).* The '*Floodplain Development Manual'* guides the implementation of the State Government's *Flood Policy*. The *Flood Policy* is directed towards providing management and mitigation measures to existing flooding problems in developed areas and ensuring that new development is compatible with the flood hazard and does not create additional flooding problems in other areas. The Policy is defined in the NSW Government's '*Floodplain Development Manual' (NSW Government, 2005)*.

Under the Policy, the management of flood liable land remains the responsibility of Local Government. The State Government provides specialist technical advice to assist Local Government in its floodplain management responsibilities and subsidies to councils to complete the floodplain management process, including the implementation of flood mitigation works, if feasible, to alleviate existing problems.

The Policy provides for technical and financial support by the State Government through the floodplain risk management process which is outlined below:




Stages 1 and 2 of this process were completed as part of the *'College, Orth and Werrington Creeks Catchment Overland Flow Flood Study'* (CSS, 2017). The current study represents stages 3 and 4 of the floodplain risk management process and will build upon the work that was completed as part of the 2017 Flood Study. This will include reviewing the previous study to ensure it provides the best possible representation of the existing flooding problem in the catchment. It will also identify, assess and compare various options for managing the flood risk across the catchment, culminating in the preparation of the College, Orth and Werrington Creeks Catchment Floodplain Risk Management Study. The Floodplain Risk Management Plan draws on the outcomes of the Study and provides a preferred set of recommended options that will outline how to best manage the existing, future and continuing flood risk across the College, Orth and Werrington Creeks catchment.

It is noted that there is potential for the lower parts of the catchment to be subject to inundation as a result of floodwaters 'backing up' along the Werrington Creek channel from South Creek. Although the impacts of South Creek flooding across the lower sections of the catchment was considered as part of the study, flooding and the management of the flood risk across the broader South Creek is addressed in a separate report titled *'South Creek Floodplain Risk Management Study and Plan'* (Advisian, 2020).

## 1.3 Report Structure

The following report forms the College, Orth and Werrington Creeks Catchments Floodplain Risk Management Study and Draft Plan. It has been divided into the following sections:

- Section 1 – Introduction: Provides an overview of the study including background information, main goals of the study and the floodplain risk management process, along with information on the report structure.
- Section 2 - Catchment Information: Provides general information on the catchment including available flooding information, potential constraints, key facilities and the makeup of the local community.
- Section 3 – Consultation: Summarises the consultation that was completed with key stakeholders and the community, and the outcomes of this consultation.
- Section 4 – The Existing Flood Risk: Describes the current impact of flooding on the community for a range of different floods. This includes an assessment of the impact of flooding on key facilities, the potential cost of flooding as well as the potential for floodwater to damage buildings or pose a danger to personal safety.
- Section 5 – Land Use Planning Information: Provides a review of current national, state and local legislation, policy and guidelines that affect the development of flood prone land within the catchment.
- Section 6 – Existing Emergency Management Information: Provides an overview of emergency management measures that are currently implemented across the catchment to assist in managing the flood risk. Opportunities to improve these existing protocols based on the flood risk ascertained in this study are also contained in this section.
- Section 7 – Options for Managing the Flood Risk: Provides an overview of potential options to manage the flood risk, and the options assessment approach undertaken in this study.
- Sections 8 to 10: Discusses the merits of a range of flood, property and response modification measures that could be potentially implemented to manage the existing, future and continuing flood risk across the catchment.

The Floodplain Risk Management Study report comprises two volumes:

- Volume 1 (this document): contains the report text and appendices; and
- Volume 2: contains all figures and maps that supplement the Volume 1 report.

# 2 CATCHMENT INFORMATION

## 2.1 Overview

The following chapter provides a summary of relevant information for the College, Orth and Werrington Creeks Catchments. This includes a description of the catchment, the makeup of the local community, critical and vulnerable facilities as well as an overview of previous flooding investigations.

## 2.2 Catchment Description

The College, Orth and Werrington Creeks catchment is located in the Penrith City Council (PCC) Local Government Area and occupies a total area of approximately 1,200 hectares (i.e., 12 $km^2$). As shown on **Figure 1**, the suburbs of Orchard Hills, Caddens, Kingswood, Cambridge Park, Werrington and Werrington County all fall within the catchment. The area is significantly urbanised with a mix of residential, commercial and industrial developments. There are areas of undeveloped land, primarily in the upstream sections of the catchment, although areas of open space and parkland also fringe the main creek lines.

The study area is traversed by several major transportation links including the Great Western Highway, Western Railway Line, Bringelly Road, Werrington Road and Dunheved Road. The railway embankment in particular, forms a significant barrier to flow being elevated at least 3 metres above the floodplain of Werrington Creek.

There are also several important facilities within the catchment including the Western Sydney University Penrith campuses (Werrington North, Werrington South and Kingswood), TAFE NSW Nepean and Kingswood campuses and the Nepean Hospital.

The headwaters of the catchment are located in Orchard Hills, just to the north of the M4 Motorway. College Creek drains in a northerly direction through this area where the land use transitions from rural to higher density residential, including the new Cadddens and Caddens Hill subdivisions. College Creek continues to drain north through the Western Sydney University Kingswood campus which includes large areas of open space immediately adjacent to the creek line. College Creek then passes under the Great Western Highway where it is joined by Orth Creek. Werrington Creek commences at the junction of College and Orth Creeks and continues to drain in a north-easterly direction and into South Creek.

Very little of the Orth Creek channel remains. Much of the original creek channel was replaced by a subsurface stormwater system to facilitate urban expansion across the Kingswood area.

There is an unnamed tributary that commences within the TAFE NSW Nepean College Kingswood site and drains in northerly direction through the newly constructed French Street subdivision, under the railway line and north into Werrington Creek. The location of all open watercourses are shown by the blue lines in **Figure 1**.

The variation in ground surface elevations across the catchment is shown in **Figure 2**. **Figure 2** shows that ground surface elevations vary from just over 80 mAHD just north of the M4 Western Motorway, down to 20 mAHD where Werrington Creek joins South Creek. It also illustrates that much of the suburb of Werrington is located well below 30 mAHD.

## 2.3 Land Uses

### 2.3.1 Existing Land Use

**Figure 3** shows the existing land zoning information for the catchment based upon information contained in the Penrith Local Environmental Plan (LEP) 2010. **Table 1** also summarises the different land use zonings across the catchment and the area occupied by each.

**Table 1 Summary of Catchment Land Use based on Penrith City Council LEP 2010**

| Land Use Zoning | | Area (ha) | Percentage of Catchment |
|---|---|---|---|
| Residential | R1 | 71.77 | 6% |
| | R2 | 347.45 | 29% |
| | R3 | 188.98 | 16% |
| | R4 | 35.41 | 3% |
| Industrial | IN1 | 19.19 | 2% |
| | IN2 | 17.02 | 1% |
| Rural | RU4 | 113.36 | 9% |
| Business and Mixed Use | B1 | 0.6 | 0% |
| | B2 | 14.23 | 1% |
| | B4 | 23.12 | 2% |
| | B6 | 0.93 | 0% |
| Environmental | E2 | 41.7 | 3% |
| Recreation | RE1 | 147.91 | 12% |
| | RE2 | 1.07 | 0% |
| Special Activities | SP1 | 7.46 | 1% |
| | SP2 | 121.99 | 10% |
| Other | 10(b) | 8.37 | 1% |
| | 5(a) | 32.57 | 3% |
| | 5(c) | 0.06 | 0% |
| | **TOTAL** | 1193 | 100% |

As shown in **Figure 3**, the catchment is largely urbanised with residential and industrial land uses covering 66% of the catchment. However, there are significant areas of open space, with over 12% of the catchment zoned RE1 (i.e., Public Recreation). 11% of the catchment is zoned as Special activities SP1 or SP2 and 9% of the catchment is zoned as Rural RU4.

Downstream (i.e., north) of the Great Western Highway, the catchment is primarily zoned for residential development. Large areas of the land adjacent to Werrington Creek is zoned as RE1 (i.e., Public Recreation) and contains the areas of Werrington Lakes and Shaw Park. Werrington Lakes were constructed during the 1980s to help manage the flood flows through the area. Werrington Lakes Reserve also includes a number of community-based recreation infrastructure, such as playgrounds, picnic facilities and walking tracks.

### 2.3.2 Potential Future Development

The study area contains large areas that have the potential to be developed in the future. Some of the areas have already been zoned for future development, such as the Caddens area, and some areas are still in the planning stages, such as the area between the Western Motorway and the Great Western Highway in Orchard Hills. Preliminary concepts for development in the Orchard Hills area indicate approximately 5,000 lots are being planned for this area.

The University of Western Sydney have also indicated draft plans to develop within their three campuses. These developments would involve significant residential development and areas of retail and commercial use with up to 8,000 dwellings.

There is also a lot of infill type development in the study area, such as the construction of granny flats. There is also evidence of low-density residential dwellings being knocked down and replaced by high density residential developments, such as duplexes or townhouses. Council have indicated that there is increasing development pressure around the Nepean Hospital.

### 2.3.3 Critical and Vulnerable Facilities

The catchment also includes a number of land uses that may be particularly vulnerable to the impacts of flooding (i.e., vulnerable facilities) as well as facilities that may play an important emergency response role during floods (i.e., critical facilities). The location of vulnerable and critical facilities are shown in **Figure 4**. These facilities are also summarised in **Table 2**.

**Table 2 Critical and Vulnerable Facilities**

| Facility | | | Address |
|---|---|---|---|
| Critical Facilities | Fire Stations | There are no fire stations located within the catchment | |
| | Police Stations | There are no police stations located within the catchment | |
| | State Emergency Service | There are no SES facilities located within the catchment | |
| | Ambulance Stations | There are no ambulance stations located within the catchment | |
| | Infrastructure | Pump station | 43A Princess Street, Werrington |
| | Hospitals | Nepean Hospital | Derby Street, Kingswood |

| Facility | | | Address |
| --- | --- | --- | --- |
| Vulnerable Facilities | Aged Care Facilities and Nursing Homes | Anglicare Newmarch House | 50-52 Manning St, Caddens |
| | | Heritage Kingswood Aged Care Facility | 29 George St, Kingswood |
| | Pre-Schools and Child Care | Learning Adventures Kingswood | 30 George St, Kingswood |
| | | Yoorami Cottage Before & After School Care | 1-5 Cottage St, Werrington |
| | | Kingswood World of Learning | 38 First St, Kingswood |
| | | Mission Australia Family Day Care | 46 Bringelly Rd, Kingswood |
| | | Falguni Family Day Care | 73A Princess St, Werrington |
| | | The Little Village Early Learning Centre | 33/35 Second Ave, Kingswood |
| | | The Learning Jungle | 137-139 Victoria St, Werrington |
| | | Orchard Hills Pre School | 122 Bringelly Rd, Orchard Hills |
| | | KU Penrith Preschool | 27 Bringelly Rd, Kingswood |
| | Primary Education | Werrington Public School | Armstein Cres, Werrington |
| | | Kingswood Public School | 46-54 Second Ave, Kingswood |
| | | Kingswood South Public School | 60-68 Smith St, Kingswood |
| | | St. Joseph's Primary School | 90-94 Joseph St, Kingswood |
| | | St Dominic's College | 54/94 Gascoigne St, Kingswood |
| | | Montgrove College | 140 Bringelly Rd, Orchard Hills |
| | Secondary Education | Wollemi College | 4 Gipps St, Werrington |
| | | Cambridge Park High School | Harrow Rd, Cambridge Park |
| | | Kingswood High School | 131 Bringelly Rd, Kingswood |
| | Tertiary Education | Western Sydney University Werrington South Campus | Great Western Hwy, Werrington |
| | | Western Sydney University Werrington North Campus | Great Western Hwy, Werrington |
| | | Western Sydney University Kingswood Campus | Second Avenue, Kingswood |
| | | TAFE Nepean Campus | 12-44 O'Connell St, Kingswood |
| | Churches | Grace Bible Church | 80 Joseph St, Kingswood |
| | | Real Life Church | 44 Second Ave, Kingswood |
| | | Penrith Baptist Church | Morello Terrace, Caddens |
| | | St. Philip's Anglican Church | Second Ave, Kingswood |
| | Other | Cobham Youth Justice Centre | Great Western Hwy & Water St, Werrington |
| | | Werrington train station | Werrington |

## 2.4 Local Environment

### 2.4.1 Landscape

The College, Orth and Werrington Creeks Catchments includes several areas of land mapped as 'Scenic and Landscape Value' in Council's LEP. The first of these is a large portion of the undeveloped land at the upstream extent of the catchment north of the M4 Western Motorway, stretching from the Northern Road in the west to Hermitage Court in the west.

The second area of land identified as 'Scenic and Landscape Value' is located between the Great Western Highway to the south, Morley Avenue to the west and north and Millen Street to the east. The third area is in the western extent of the catchment, bounded by the Northern Road in the west, Copeland Street to its north, Great Western Highway to its south and Phillip Street in its west.

The final area is in the most downstream section of the catchment, along the western riparian areas of South Creek, and the urban areas of Werrington which forms the western boundary of study area.

The potential for implementation of structural mitigation measures in these areas will have to take into account the visual impact the option may have on the area identified as having a particular scenic value.

### 2.4.2 Aboriginal Heritage Site

Eleven (11) Aboriginal heritage sites were identified as falling within the catchment as part of a search completed on the Aboriginal Heritage Information Management System. The location of the heritage sites is shown in **Figure 5**. A summary of these sites is also listed in **Table 3.**

Table 3 Summary of Aboriginal Heritage Sites

| ID | Site Name | Site Features |
|---|---|---|
| 1 | Cobham IF1 | Artefact |
| 2 | Cobham IF2 | Artefact |
| 3 | ASD1; Kingswood; | Artefact |
| 4 | ASD2; Kingswood; | Artefact |
| 5 | SW1 (Penrith) | Artefact |
| 6 | SW PAD | Potential Archaeological Deposit (PAD) |
| 7 | CRA3-6 | Artefact |
| 8 | CRA7+8 | Artefact |
| 9 | Caddens artefact reburial site | Artefact |
| 10 | 45-5-4873 reburial | Artefact |
| 11 | 229 Victoria Street | Artefact |

The declaration of an Aboriginal Place does not change the status of or affect ownership rights for the land. However, a declared Aboriginal Place must not be modified, harmed or desecrated without an Aboriginal Heritage Impact Permit issued under the NSW NPW Act 1974. Accordingly, any potential mitigation options in the vicinity of an Aboriginal Heritage location would be subject to these same restrictions.

### 2.4.3 Local Heritage Sites

There are a number of heritage items listed in the Environmental Planning Instrument (EPI) of the Council LEP. **Table 4** provides a summary of all heritage items listed in the Penrith City Council LEP 2010 that are located within the study area. The location of each heritage item in also shown in **Figure 5**.

Table 4 Summary of Heritage Sites listed by Penrith LEP 2010

| LEP Heritage Item Number | Address | Description |
|---|---|---|
| 315 | 653–729 Great Western Highway | Werrington Park House, garden and poplar avenue |
| 248 | 108 Rugby Street | Werrington House, dwelling, driveway and garden |
| 97 | Land bounded by Copeland and Phillips Streets, Richmond Road and Cox Avenue | Penrith General Cemetery |
| 101 | 32 Bringelly Road | St. Phillip's Anglican Church |
| 100 | 6 First Street | Federation house and garden |
| 98 | 46–54 Second Avenue | Kingswood Public School |
| 670 | 56 Second Avenue | Teacher's residence (former) |
| 860 | Fronting Lot 1, DP 866081 | Milestone |
| 861 | Fronting Lot 10, DP 719064 | Milestone |
| 155 | 80–88 Caddens Road | Brick farmhouse |
| 657 | 197–207 Castle Road | Water reservoir |
| 845 | 182–188 Caddens Road | "Lindfield" |

Schedule 5 of the Penrith LEP 2010 aims to conserve the environmental heritage of Penrith. This includes conserving the heritage significance of heritage items and heritage conservation areas, including associated fabric, settings and views, conserving archaeological sites and Aboriginal objects, and Aboriginal places of heritage significance. The clause lists several heads of consideration for when consent is or is not required for a development that may impact on a heritage item. The potential for implementation of structural mitigation options in areas with heritage listing will need to consider the effect of the proposed measure on the heritage significance of the item or area.

## 2.5 Demographics

Understanding the characteristics of the population living and working within the catchment is an important component of developing and assessing potential flood risk management options. For example, the availability of internet, the primary language spoken at home and the availability of a motor vehicle can have a strong bearing on the feasibility of different education, flood warning and evacuation strategies.

In this regard, the Australian Bureau of Statistics (ABS) provides a range of information for the suburbs contained within the catchment that was collected as part the 2016 census. A summary of pertinent information extracted from the ABS website (http://www.abs.gov.au/) is provided in **Table 5**. **Table 5** also includes equivalent information for the state of NSW.

The information presented in **Table 5** shows that:

- Approximately 27,055 people reside in the suburbs included in this study. However, the catchments of College, Orth and Werrington Creeks do not cover the full extent of each suburb. Based on the proportion of the suburbs falling within the catchment extent, it is estimated that the population contained within the catchment is about 21,000. However, information provided by Council (refer Section 2.3.2) suggests that this population is likely to increase in the future as a results of infill development, further urban expansion, and intensification of development in some areas.
- Approximately one third (i.e., 34%) of the population would be considered more vulnerable to the impacts of flooding (i.e., people under the age of 15 or over the age of 65). The median age of residents within the area is 35.
- The majority of households speak English at home. However, more than a quarter of the population have said they speak a language other than English at home. This includes Arabic, Mandarin, Cantonese, Punjabi, Tagalog (i.e., Filipino), Nepali, Malayalam, Greek, Italian and Hindi.
- Approximately 50% of the dwellings are rented in the Kingswood and Werrington suburbs, dropping to 30% in Cambridge Park and around 15% in the Orchard Hills, Caddens and Werrington County. The higher proportion of renters in Kingswood and Werrington indicates there is potential for greater 'turn over' of residents in these areas and less potential for flood exposure and awareness.
- Most properties (i.e., more than 80%) within the catchment have access to an internet connection. However, the suburbs of Kingswood and Werrington have a lower level of internet availability (i.e., less than 80%), which is also below the state average of 83%.
- The average household within the catchment has at least 2 people.
- Most households have access to at least 1 motor vehicle. However, there are around 11% of properties in Werrington and 13% of properties in Kingswood with no access to a motor vehicle.
- The median household income for all suburbs within the catchment is similar to the state average. However, Kingswood and Werrington, which are the largest suburbs in this study area, have household incomes less than the state average. Therefore, if a large flood occurred that resulted in significant financial losses across these areas, there would be less potential for the local community to financially recover.

**Table 5 Summary of Catchment Demographics**

| Statistic | | | Orchard Hills | Caddens | Kingswood | Cambridge Park | Werrington | Werrington County | NSW |
|---|---|---|---|---|---|---|---|---|---|
| Population Statistics | Total population | | 1,877 | 1,475 | 9,301 | 6,726 | 4,031 | 3,645 | 7,480,228 |
| | Age | Median Age | 43 | 30 | 34 | 35 | 33 | 36 | 38 |
| | | Less than 15 years of age | 15.4% | 21.7% | 20.8% | 21.1% | 20.8% | 19.8% | 18.5% |
| | | Greater than 65 years of age | 16.8% | 14.6% | 13.1% | 13.9% | 15.5% | 12.8% | 16.3% |
| | | Proportion of population that volunteers | 19.5% | 15.9% | 13.9% | 12.1% | 11.0% | 12.0% | 18.1% |
| | Education | Year 12 or equivalent | 54.9% | 69.5% | 55.2% | 51.7% | 57.2% | 55.0% | 53.9% |
| | | Year 10 or equivalent | 17.0% | 8.6% | 15.5% | 18.4% | 15.9% | 20.0% | 26.2% |
| | | Did not Complete Year 10 | 11.5% | 7.7% | 10.9% | 12.1% | 10.1% | 10.3% | 11.1% |
| Dwelling Statistics | Motor Vehicles | Dwellings with no vehicles | 1.1% | 3.4% | 13.3% | 6.6% | 10.9% | 2.8% | 9.2% |
| | | Dwellings with ≥ 1 vehicle | 95.6% | 92.8% | 82.7% | 90.4% | 85.6% | 94.2% | 87.1% |
| | | Average persons per dwelling | 3.4 | 3.1 | 2.5 | 2.7 | 2.5 | 2.9 | 2.6 |
| | The language spoken at home | Speaks English only | 71.5% | 66.9% | 69.7% | 84.0% | 70.1% | 89.2% | 68.5% |
| | | Other | Maltese 5.0% | Punjabi 4.2% | Punjabi 2.8% | Tagalog 0.7% | Tagalog 2.5% | Greek 0.5% | Mandarin 3.2% |
| | | | Arabic 4.6% | Malayalam 1.9% | Malayalam 1.9% | Arabic 0.7% | Nepali 2.0% | Italian 0.4% | Arabic 2.7% |
| | | | Italian 3.5% | Mandarin 1.9% | Mandarin 1.3% | Greek 0.6% | Arabic 1.7% | Hindi 0.4% | Cantonese 1.9% |

| Statistic | | Orchard Hills | Caddens | Kingswood | Cambridge Park | Werrington | Werrington County | NSW |
|---|---|---|---|---|---|---|---|---|
| | Proportion of renters | 14.0% | 18.9% | 52.0% | 31.8% | 46.9% | 15.8% | 31.8% |
| Dwelling Type | Separate house | 96.4% | 79.9% | 49.0% | 86.4% | 43.3% | 98.8% | 66.4% |
| | Semi-detached, row or terrace house, townhouse | 2.4% | 18.9% | 34.4% | 12.4% | 31.5% | 1.2% | 12.2% |
| | Flat, unit or apartment: | 0.0% | 0.0% | 15.7% | 0.8% | 24.8% | 0.0% | 19.9% |
| | Other dwelling (cabin, caravan): | 0.6% | 0.0% | 0.3% | 0.0% | 0.0% | 0.0% | 0.9% |
| Income | Median total household income ($/weekly) | $2,072 | $2,190 | $1,229 | $1,586 | $1,228 | $1,799 | $1,486 |
| | Median Rent ($/weekly) | $450 | $500 | $325 | $370 | $330 | $390 | $380 |
| Internet Statistics | No Internet connection | 13.1% | 8.4% | 18.8% | 15.1% | 18.9% | 10.0% | 14.7% |
| | Access to Internet connection | 84.2% | 89.3% | 78.5% | 83.2% | 78.6% | 87.2% | 82.5% |
| | Not Stated | 2.6% | 2.3% | 27.0% | 1.8% | 2.6% | 2.8% | 2.8% |

## 2.6 Past Studies

A number of flood investigations have been completed across various parts of the College, Orth and Werrington Creeks catchments over the past two decades. A detailed review of the following studies was completed as part of the *'College Orth and Werrington Creeks Catchment Overland Flow Flood Study'* (Catchment Simulation Solutions, 2017):

- Report on Hydrology and Hydraulics Study for Werrington Creek (Lyall & Macoun, 1990)
- Penrith Overland Flow Flood 'Overview Study' (Cardno Lawson Treloar, 2006)
- WELL Precinct Hydrology and Catchment Management Study (Cardno Willing, 2006)
- Flood Study for Land at Werrington Creek, Kingswood (Cardno Willing, 2006)
- Caddens Release Area – Catchment Management, Hydrology and Water Quality Report (Hughes Trueman, 2007)
- Werrington Subdivision, Corner of French Street & Great Western Highway, Kingswood – Civil, Flooding and Stormwater Management Report (Cardno ITC, 2011); and
- Caddens Knoll Stormwater Management Report (J. Wyndham Prince, 2013).

A separate review of each of these studies has not been completed as part of the current study as the results documented in each study have since been superseded by the *'College Orth and Werrington Creeks Catchment Overland Flow Flood Study'* (2017). Therefore, the review has focussed on this study as well as other relevant studies that have been completed since the flood study was completed. The outcomes of the review are provided below.

### 2.6.1 College, Orth and Werrington Creek flood Study (2017)

The *'College Orth and Werrington Creeks Catchment Overland Flow Flood Study'* was prepared by Catchment Simulation Solutions on behalf of Penrith City Council. The study was prepared to quantify the nature and extent of mainstream and overland flood behaviour across the College Orth and Werrington Creeks catchment. It was the first time both mainstream and overland flood behaviour had been defined across the full extent of the catchment.

A computer flood model of the College, Orth & Werrington Creeks catchment was developed using the TUFLOW software as part of the study. The model was developed to include a representation of all features that will influence the movement of floodwaters across the catchment. This included all stormwater pits and pipes, bridges, culverts, detention basins, buildings, road and rail embankments and fences.

The computer model was validated against historic flood information that was extracted from community consultation responses. This included twenty-five flood marks for the 2012 flood, seven flood marks for the 2010 flood and four flood marks for the 2011 flood. The outcomes of the validation process showed that the computer model was providing a reliable representation of flood behaviour across the catchment. A selection of historic photographs from these floods are included in **Appendix L**.

The validated flood model was then used to simulate a range of design floods across the catchment. This included the 1 in 2-year ARI, the 20%, 10% 5%, 2%, 1%, 0.5% and 0.2% AEP floods and the probable maximum flood. The outputs from the design flood simulation were used to prepare design floodwater depth, level, velocity, hazard, hydraulic category mapping, as well as emergency response precinct classification mapping. Flood planning level and flood planning area mapping was also prepared to assist Council in defining 'flood control lots' (i.e., properties subject to a flood-related development control) to ensure that future development and redevelopment is undertaken in a way that is compatible with the flood risk.

A number of flooding 'hot spots' were identified as part of the study and these are listed in **Table 6**. A list of potential flood mitigation options was prepared for the each of the flooding 'hot spots'. The goal of this assessment was to provide a list of potential measures that could be implemented to reduce the existing flood risk across these high hazard 'hot spots'. Those mitigation measures could then be shortlisted for a more comprehensive analysis as part of the current floodplain risk management study.

**Table 6 Summary of Potential Mitigation Measures for the College, Orth and Werrington Creeks Catchment (Catchment Simulation Solutions, 2017)**

| Hot Spot | | Potential Mitigation Options |
|---|---|---|
| 1 | Jamison Road (Somerset Street to Bringelly Road), Kingswood; | • Increase capacity of existing stormwater system<br>• Construct detention basins to temporarily store excess runoff |
| 2 | Cox Avenue, Kingswood | • Additional capacity to drain the sag point in Cox Avenue<br>• Reduce amount of runoff reaching this location (through detention basins or storage areas). |
| 3 | Chapman Gardens to Railway, Kingswood | • Elevate existing spillway and embankment to provide additional storage in north-eastern corner of Chapman Gardens<br>• Earthworks to create cascading basins with Chapman gardens and or lower sporting fields to provide additional storage<br>• Lowering of the Great Western Highway<br>• Increase main culvert outlet capacity, ensuring no adverse impacts on downstream properties<br>• Lowering vacant land between the highway and railway line to provide additional storage capacity<br>• Upgrading railway culvert conveyance capacity, ensuring no adverse impacts on downstream properties |
| 4 | Railway Street, Landers Street and Walker Street, Kingswood. | • Upgrade existing stormwater pipe beneath railway and downstream stormwater pipe system<br>• Block and redirect flow from culvert at north-west of Railway Street so runoff retained on north side of railway line<br>• Increase existing storage capacity in the existing basin south of Walker Street<br>• Potentially raise some of the low-lying dwellings. |

Overall, this study and the flood model produced as part of this study are considered to provide the best description of flood behaviour across the College, Orth and Werrington Creeks catchment. However, since the flood study was prepared, revised topographic datasets have become available and additional development has occurred. As a result, it was considered necessary to review the flood model to ensure it still provided a reliable description of contemporary flood behaviour across the catchment. The outcomes of this model review are summarised in **Section 4.2**.

### 2.6.2 Updated South Creek Flood Study (2015)

The *'Updated South Creek Flood Study'* was prepared by WorleyParsons Services Pty Ltd on behalf of Penrith City Council, acting in association with Liverpool, Blacktown and Fairfield City Councils. The study area extends from Bringelly Road in the south to the Richmond Road Bridge crossing in the north. The total study area is about 240 $km^2$ and lies within the Hawkesbury, Penrith, Blacktown, Liverpool and Fairfield Local Government Areas. The total catchment of South Creek, to its confluence with the Hawkesbury River near Windsor, is 414$km^2$. A small section in the north-eastern section of the study area included in the College, Orth and Werrington Creeks FRMS&P overlaps with the study area included in the South Creek Flood Study (2015).

The objective of the study was to update the hydrologic and hydraulic models that were previously developed for the catchment as part of the *'Flood Study Report, South Creek'* (DWR, 1990) and provide contemporary tools for the assessment of flood conditions across the South Creek catchment. The results of the study define the flood behaviour across the South Creek catchment for a range of design floods and provide more reliable estimates of flood planning levels for each local government area. The XP-RAFTS model represented the Werrington Creek catchment using two (2) sub-catchments and the critical duration of the Werrington Creek catchment was determined to be 2 hours.

A 2D hydraulic model of the South Creek system was developed using the RMA-2 software package to replace the previous 1D MIKE-11 and HEC-2 hydraulic models that were developed as part of the 1990 Flood Study. The model is based on a Digital Terrain Model (DTM) developed from ALS data that was gathered for the entire South Creek floodplain between 2002 and 2006. The RMA-2 model only includes the Werrington Creek floodplain from the William Street Footbridge, downstream to the confluence with South Creek. As such, it did not include hydraulic modelling of the entire College, Orth and Werrington Creeks Catchment that forms the study area for this project.

The XP-RAFTS and RMA-2 models were used to simulate a range of design floods, including the 5%, 2%, 1%, 0.5%, 0.2% AEP events and the Probable Maximum Flood. The report documents the findings from the modelling investigations, including details on flood flows, flood levels, flood depths, flow velocities, and provisional hydraulic and hazard categories for current catchment and floodplain conditions. RMA-2 model outputs were provided as part of the current study in WaterRIDE outputs. Accordingly, a range of spatial and temporal flood information could be extracted for each design event.

The results of the study indicate that the suburb of Werrington can be inundated from South Creek as a result of overtopping of the Werrington Road levee, the Werrington earthen levee, or failure of the flood gate on the earthen levee. More specifically, the study indicated that the Werrington Road levee and Werrington earthen levee would not be overtopped by floodwaters from South Creek during events up to and including the 0.5% AEP flood. However, inundation of Werrington is predicted during the 0.2% AEP event, however, the levee system acts to reduce the depth of inundation during events up to and including the PMF.

### 2.6.3 South Creek Floodplain Risk Management Study and Plan (2020)

This report was prepared by Advisian on behalf of Penrith City Council. The study area extends from Elizabeth Drive in the south to the Richmond Road Bridge crossing in the north, with a total catchment area of approximately 240 $km^2$. A small section in the north-eastern section of the study area included in the College, Orth and Werrington Creeks FRMS&P overlaps with the study area included in the South Creek Floodplain Risk Management Study and Plan (2020).

The study estimates the potential flood damage in the South Creek study area would be:

- 162 properties would be inundated above floor level during a 1% AEP flood.
- 245 properties would be inundated above floor level during a 0.5% AEP flood.
- 2,639 properties would be inundated above floor level during a PMF (residential properties make up for 90% of properties that are inundated above floor level in the PMF).
- The Average Annual Flood Damage cost for the study area was calculated as $985,000.

The suburbs most vulnerable to flooding were found to be St Marys, Werrington, St Clair, Llandilo, Berkshire Park and Oxley Park. For each of these areas, there was a significant 'jump' in the number of flood affected properties between the 0.5% AEP flood and the PMF.

Floodwaters from South Creek can start to 'back up' Werrington Creek during floods as frequent as a 5% AEP event. However, it was assumed that the levee and associated floodgates that afford protection to Werrington remained fully functional as part of this study. Therefore, floodwaters are contained to the creeks and undeveloped areas adjoining the creeks during floods up to the 0.5% AEP flood. However, during floods larger than the 0.5% AEP event, the levee is predicted to be overtopped and inundate parts of Werrington. The extent of flooding from South Creek determined as part of this study is shown in **Appendix J**.

A total of 38 structural and non-structural options were initially identified to assist in better managing the flood risk across the study area. The list of options was subsequently refined based on consideration of the expected hydraulic impact, cost of construction, social impacts, and environmental impacts. Nine (9) flood modification measures and two (2) property modification measures were ultimately selected for detailed assessment following the preliminary options assessment.

Based on the outcomes of the detailed assessment of each option (which considered flood impacts, economic impacts, social and environmental impacts), the following measures recommended as part of the Floodplain Risk Management Plan for South Creek were:

- FM1 – Measure F-1A – 'low cut' option for excavation downstream, of the western railway crossing of Ropes Creek.
- FM2 – Measure F-7B – upgrade to St Marys Levee plus installation of a flap gate.
- FM3 - Earthen levee at Oxley Park.
- Emergency response management measures.
- Updates to the flood related development controls within the Penrith DCP 2014.

### 2.6.4 Hawkesbury-Nepean Valley Regional Flood Study 2019.

The *'Hawkesbury-Nepean Valley Regional Flood Study'* was prepared by WMAwater for Infrastructure NSW. The objective of the project was to provide an updated description of flood behaviour across the Hawkesbury-Nepean Valley, which is considered one of the most exposed floodplains in Australia.

The study built upon the 1996 Nepean River Flood Study and included an updated flood frequency analysis. Hydrology was also defined using a RORB hydrologic model that was calibrated and validated using rainfall and stream flow information for 7 historic floods, which included the 1988 and 1990 floods.

A Monte Carlo modelling framework was used to define design flood hydrology as part of the study. This Monte Carlo approach was implemented in an attempt to better represent the observed variability in actual flood events. Variables that were randomly sampled as part of this assessment included rainfall intensity and frequency, spatial pattern of rainfall, temporal pattern of rainfall, initial loss, pre-burst rainfall, dam drawdown, relative timing of tributary inflows and tides. This approach is very computationally intensive and is not often completed as part of most flood studies. However, given the high potential flood risk, this more comprehensive approach was considered necessary.

The study provides updated flood levels, extents, depths, provisional hazard and hydraulic categories for the 1 in 5, 1 in 10, 1 in 20, 1 in 50, 1 in 100, 1 in 200, 1 in 200, 1 in 500, 1 in 1000, 1 in 2000, 1 in 5000 AEP floods as well the PMF. The updated results generated as part of the study compared well with the 1996 Flood Study at Warragamba and Windsor but was found to be lower around Penrith.

The study also generated information on the rate of rise, time to rise, rate of fall, time to fall, time above critical levels and travel time for key locations on the floodplain to assist in assessment of risk to life and inform emergency response. Climate change induced rainfall intensity increases, and sea level rise sensitivity analysis was also undertaken.

The study shows that Werrington Creek is also impacted by flooding during major flood events from back water flooding from the Nepean River via South Creek with floodwater predicted to overtop the Werrington Levee during PMF event.

The extent of backwater flooding from the Hawkesbury River in the 0.2% AEP flood and PMF is shown in **Appendix I** as **Figure I2**.

# 3 CONSULTATION

## 3.1 Community Consultation

### 3.1.1 Overview

Penrith City Council recognises that the community is an important part in the development of the floodplain risk management study and plan for the College, Orth and Werrington Creeks catchment. As a result, consultation was completed with the community as well as key stakeholders at multiple stages through the floodplain risk management process.

Consultation was initially completed as part of the *'College, Orth and Werrington Creeks Catchment Overland Flow Flood Study'* (2017). This was supplemented with additional consultation as part of the current study to obtain additional information that may not have been reported during the flood study or may have come to light since the flood study was prepared. A summary of the outcomes of all consultation that was completed is provided below.

### 3.1.2 Flood Study (2017)

Community consultation was undertaken during the early stages of the flood study to obtain local information on historical flood events, as well as during the public exhibition of the draft flood study report. There was a range of feedback received during the community consultation phases of the flood study, with approximately 15% of the respondents having experienced traffic disruptions and nearly 20% of respondents having experienced flooding on their properties. The information received was incorporated into the flood study where possible.

### 3.1.3 Floodplain Risk Management Study and Plan (current study)

Consultation with the community was also completed at two stages throughout the current project. The initial community consultation was undertaken during the beginning of the project with the intention of informing the community of Councils undertaking of the floodplain risk management study and plan. This phase of community consultation also intended to seek information from the community that may assist in the development of the floodplain risk management plan for College, Orth and Werrington Creek. The second stage of community consultation will be undertaken once the draft floodplain risk management study and plan have been prepared to seek feedback on the options recommended for implementation in the plan.

An information sheet and questionnaire were distributed to 8,400 households and businesses during the initial stage of the project. The information sheet informed people of the overall process involved in preparing a floodplain risk management study and plan for the catchment, as well as the major objectives of the project. The questionnaire asked targeted questions about potential floodplain risk management options that could be implemented in the College, Orth and Werrington Creeks catchment to help manage flooding. The questionnaire also asked questions on emergency management procedures and flood related planning controls, such as how people would respond during future floods and what key development and planning controls should be the focus of council's floodplain risk management objectives. A copy of the questionnaire is included in **Appendix A**.

A total of 585 questionnaire responses were received and a summary of all questionnaire responses is provided in **Appendix A Tables A1** to **A4**. A summary of the key outcomes of the questionnaire responses are provided below.

***About the Property***

Questions 1 to 3 of the questionnaire related to the type of development and the duration of residence at that property. The responses to these questions indicate that:

- The majority of respondents (i.e., 97%) indicated they are a resident and or own the property, with less than 2% of the respondents indicating they rent the property.
- Less than 1% of the respondents were business owners.
- Almost half of the respondents indicated they have resided in the area for more than 20 years, with another 28% indicating they have resided in the area between 5 and 20 years.
- Approximately 26% of the respondents have been in the area less than 5 years.

These responses indicate that there is a high degree of home ownership with long term tenancy in this catchment, which can be of benefit when planning community awareness and education opportunities in the future. However, with more than a quarter of the residents in the catchment residing for less than 5 years in the area, the likelihood of having experienced a flood of any significance is low, which can in turn influence people's behaviour in future flood events.

***Flood Awareness***

Question 4 aimed to gain an understanding of the level of flood awareness of people in the catchment. The spatial distribution of responses to this question are shown in **Figure A1** in **Appendix A**. The PMF extent is also provided on **Figure A1**. The responses to question 4 indicate that:

- The majority of respondents (289 out of 585) were not sure if their property could be flooded or not.
- Of those respondents who identified their property as being flood liable, 86 out of 123 respondents correctly identified their property as being located within the PMF extent. The remaining 37 respondents are located outside of the PMF extent and would not be considered flood liable.
- Of those responses that identified their property as not being flood liable, 111 out of 143 respondents were correct with their property being located outside of the PMF. However, the remaining 32 properties are located within the PMF extent and would be considered flood liable.

The fact that the majority of respondents did not know whether their property could be flooded or incorrectly identified their property as 'flood free' indicates a relatively low level of flood awareness.

### *Development Controls & Communication*

Questions 5 to 7 & 11 focussed on development controls and communications options. The responses to these questions indicate that:

- The community believes that options should target reducing the flood risk across residential properties as a priority followed by critical utilities.
- The community supported prohibiting all new development on potentially flood liable land.
- For communication options, the majority of respondents (greater than 70%) supported notifying all potentially flood affected properties on a regular basis. Providing no notifications was poorly supported (less than 2%).
- Articles in local newspaper closely followed by updates on Council's website were the communication modes most responses suggested for reporting project updates and obtaining feedback from the community regarding potential options.

### *Flood Response*

In terms of flood response (questions 8 to 10), the questionnaire responses indicate that:

- Most households (48%) would evacuate early to an evacuation centre during a future flood.
- 23% did not have a plan and did not know how they would response during a future flood.
- 22% of respondents said they would remain at home during a figure flood.
- For those intending to evacuate, safety of their family was the overriding concern.
- The primary reason for not evacuating (i.e., staying home) was concerns for the security of their property if they were to evacuate followed by the discomfort/inconvenience associated with evacuating.

The spatial distribution of responses that reported that they would evacuate versus staying home is provided in **Figure A2**.

### *Potential Flood Risk Management Measures*

In terms of options for better managing the flood risk (question 12), most of the suggested options were supported by the community. **Plate 1** summarises each potential flood risk management option and the level of support afforded to each by the community.

Overall, the following options were ranked highest by the community (highest ranked option is listed first):

- Ensuring all information about the flood risks is available to all residents and business owners.
- Upgrading the stormwater drainage system.
- Improve flood warning and evacuation procedures.
- Provide a Planning Certificate to purchasers in flood prone areas, stating that the property is flood affected.
- Management of vegetation along creek corridors.

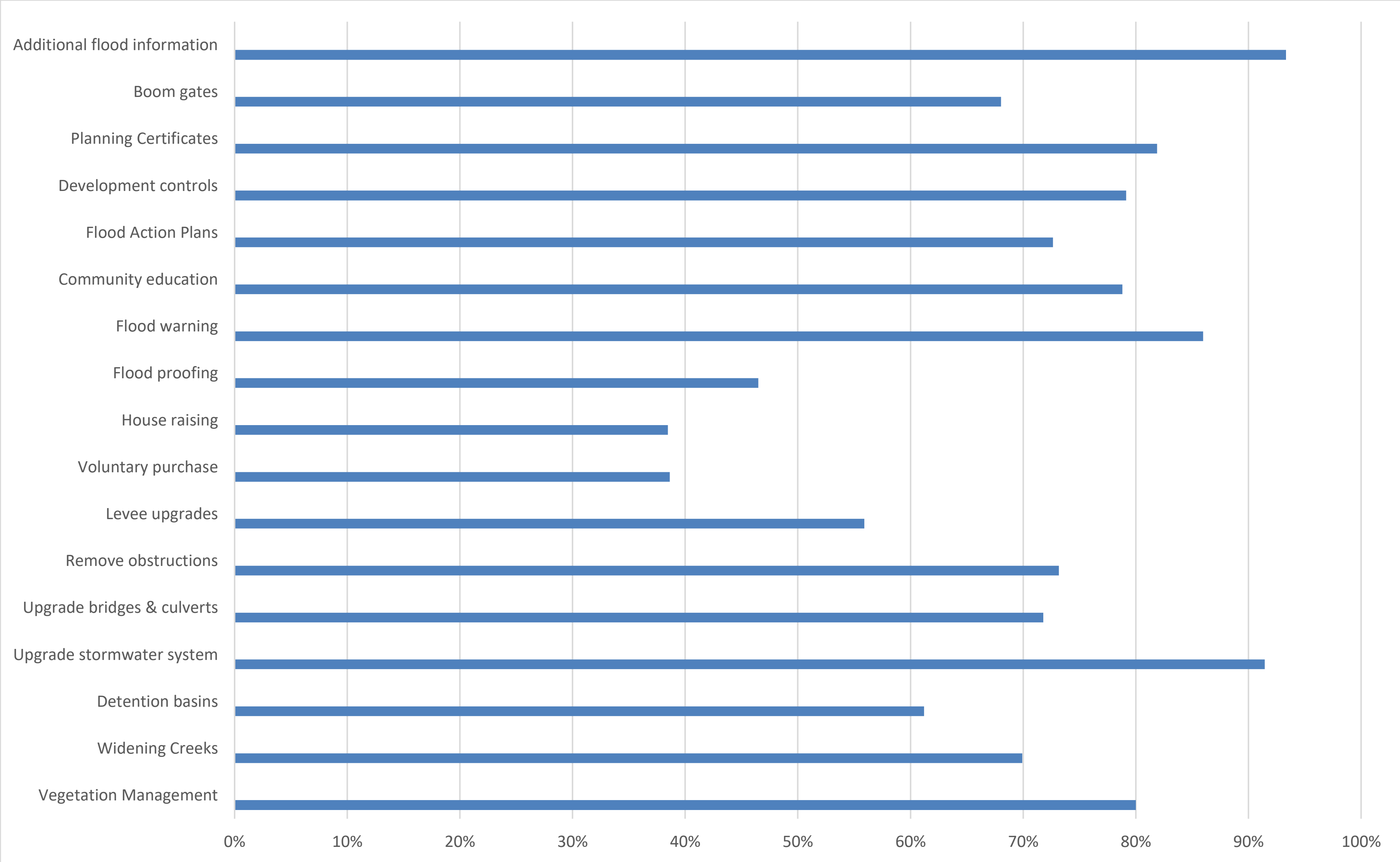



**Plate 1 Preferred flood risk reductions measures as nominated by the community**

As discussed, most of the suggested options were supported by the community. However, the following options were the least favoured by the community (lowest ranked option is listed first):

- Provide funding or subsidies to raise houses above major flood level.
- Voluntary purchase of the most severely affected flood-liable properties.
- Flood proofing of individual properties.

### 3.1.4 Public Exhibition

The draft 'College, Orth and Werrington Creeks Catchment Floodplain Risk Management Study' was placed on Public Exhibition from the 29 July 2021 until 26 August 2021. A copy of the draft report was made available for review on Council's www.yoursaypenrith.com.au website during the public exhibition period. There was a total of 166 visits to the Your Say webpage and 396 document downloads. The most popular downloads were:

- Fact sheet: 119 downloads
- Floodplain Risk Management Study & Plan Summary Report: 82 downloads

The previous 2017 Flood Study report was also downloaded on 66 occasions during the exhibition period.

It was intended to hold a community workshop during the public exhibition to allow the community to ask questions and raise any concerns directly with Council and Catchment Simulation Solutions staff. Unfortunately, the Covid-19 lock down prevented the in-person workshop. Therefore, an online meeting was arranged on the 18 August between 6pm and 8pm. The online meeting included a PowerPoint presentation which provided an overview of the study. Following the presentation, an opportunity for the community to ask questions/raise concerns was provided. Nine (9) people attended the online meeting.

A total of three (3) submissions were received during the public exhibition period. Each submission was reviewed to determine if modifications to the draft report were required to address each submission. The submissions generally related to the issues summarised in **Table 7**. **Table 7** also summarises the responses that were provided for each of the major concerns identified.

Table 7 Summary of Public Exhibition Comments and Responses

| Comment | Response |
| --- | --- |
| Flooding has not been experienced even during March 2021 flood so property should no longer be identified as "flood prone" | Although the March 2021 event was significant it was only likely to be a 20% AEP event across the catchment based on a review of recorded rainfall information. More than twice the amount of rainfall experienced during the March 2021 event would be required to approach a 1% AEP event which is used for planning purposes. |

| Comment | Response |
|---|---|
| Areas earmarked for detention basins should be retained as open space | The designs that have been prepared as part of the project for each detention basin are conceptual in nature. The specific form of each basin will be developed during subsequent detailed design investigations. However, maintaining these existing areas of open space for recreation purposes will be a critical input into the design process. |
| Additional measures to limit runoff from future development including additional ecologically sustainable measures should be explored (e.g., rainwater tanks) | The need for ecologically sustainable measures is already incorporated as part of Council's Water Sensitive Urban Design (WSUD) requirements detailed in Council's Development Control Plan 2014. Council will continue to enforce these requirements for larger development types.<br>Available DPIE guidelines recommend that "*rainwater tanks should not be considered as a floodplain risk management measure to significantly reduce downstream flood flows*". As a result, this floodplain risk management study did not include rainwater tanks as a mitigation option (however, they will remain an important component for future development in reducing potable water demand). |

Overall, no modifications to the draft 'College, Orth and Werrington Creeks Catchment Floodplain Risk Management Study' were required to address the submissions received.

## 3.2 Key Stakeholder Consultation

Targeted consultation was also completed with key stakeholders as part of the project. This included:

- Penrith City Council Engineers
- Penrith City Council Planners
- Penrith City Council Development Assessment
- Penrith City Council Floodplain Risk Management Committee
- Department of Planning, Industry & Environment (DPIE)
- NSW State Emergency Service (SES)
- Sydney Water
- Bureau of Meteorology
- Greater Sydney Local Land Services
- Water NSW
- Transport for NSW
- Infrastructure NSW
- Endeavour Energy
- Penrith Valley Chamber of Commerce; and
- Deerubbin Local Aboriginal Land Council.

Letters and emails were distributed to each of the above agencies during the initial stages of the project advertising the commencement of the project and seeking feedback on particular issues that each agency would like investigated as part of the study.

Key outcomes of the stakeholder consultation are provided below.

### 3.2.1 Council Engineers

Penrith City Council's Development Engineers noted the following flood related issues in the College, Orth and Werrington Creeks catchment:

- Council is receiving development applications for a number of properties in the vicinity of the Nepean Hospital. This includes applications with basement car parking where Council would appreciate guidance on setting suitable controls.
- Development applications for areas that would result in an increase in density of residents on a site that, in turn, may result in an increased reliance on potentially flood affected roads, should evacuation be required.
- Flood planning areas applicable to overland flooding, and appropriate freeboards. The relationship between freeboards applied within a flood planning area of mainstream flooding, and freeboards applied within the flood planning area of overland flow flooding need to be carefully considered. The 0.5m freeboard applied to a mainstream flood level is not always practical or suitable to be applied to overland flow flooding.
- Clearer definition of overland flowpaths through lots is required, particularly as development is increasing population densities on lots. The current types of redevelopment in the older parts of this catchment, particularly infill via knock down and rebuild, have the potential to redirect surface water flows with minimal current planning controls. Council require all overland flowpaths to be clearly mapped, and areas required for surface water conveyance and surface water storage to be identified. Suitable planning controls that would enshrine these flowpaths so that they are considered for all types of development should also be developed, so council can implement them into the current suite of flood related planning controls.
- Appropriate development controls for both overland and mainstream flooding are required, with a clear and concise definitions of each flooding type and mapping (or the like) that indicates where these controls apply.
- Appropriate development controls are required for applicable development and land use types that are located on land between the flood prone land extent and the flood planning area defined by the 1% AEP flood extent.
- There have been a number of development applications for more vulnerable developments, such as boarding houses around the various university campuses, in potentially flood affected areas. Council needs clearer and more definite flood related development controls for these types of developments, particularly where evacuation during flood events is already an issue along some of the roads in this catchment.
- There is the potential for some of the larger developments planned for this catchment to have significant impact on flood behaviour across the downstream sections of this catchment, such as the Orchard Hills development and the developments planned for the Western Sydney University land. The flood planning area mapping needs to be clear and concise so that future development proponents have a clear understanding of the flood constraints in the catchment.

### 3.2.2 Council Planners

Council planners noted the following flood related issues in the College, Orth and Werrington Creeks catchment:

- Currently a lot of development pressure around the Nepean Hospital and spot rezonings in flood prone areas of the catchment. A clear understanding of flooding characteristics in these areas is required, particularly related to the location of flowpaths and areas required for overland water conveyance.
- A lot of large-scale planning proposals are under development in the catchment, including those for Western Sydney University and Orchard Hills. Development in these areas has the potential to significantly modify the flooding characteristics in the remainder of the catchment.
- Evacuation during flood events is already a consideration for all planning and development assessments in the LGA. Clear guidance and mapping to support future decisions for evacuation planning would assist councils' planners, for both current and future developments.
- Council is intending to update the LEP and the DCP in the near future, so planning recommendations from the FRMS&P will be taken into consideration during that process.

### 3.2.3 Department of Planning, Industry and Environment (DPIE)

A representative from the Department's Environment, Energy and Science Group provides advice to Council in considering the best practice floodplain management principles and the Department's guidelines during the development of the study.

### 3.2.4 State Emergency Service (SES)

A representative from the State Emergency Service (SES) raised a number of issues for consideration during this study. The SES Hazard Planning Unit also provided information on the history of Requests for Assistance received during the period 2014 – 2017. This information shows that:

- Evacuation along floodprone roads is an issue in this catchment. SES are currently updating their evacuation planning though this catchment based on sectors.
- SES have provided formal comments to Council on recent planning proposals where evacuation in or around floodprone roads is an area of concern. The increasing densities in these areas, where the site itself may not be floodprone, but the access roads become inundated during a flood event, are a concern to the SES.

### 3.2.5 Sydney Water

Sydney Water have indicated that there is one sewer pump station within catchment, located at Princess Street, Werrington.

### 3.2.6 Infrastructure NSW

Infrastructure NSW have undertaken the Hawkesbury Nepean Valley Regional Flood Study (2019). At this point in time, Infrastructure NSW have indicated they do not have any additional information related to flooding that would assist this floodplain risk management study.

# 4 THE EXISTING FLOODING PROBLEM

## 4.1 Overview

In order to identify and evaluate potential options for managing the flood risk, it is first important to have an understanding of the nature and extent of the existing flood risk. This is typically achieved through the preparation of a flood study, which provides information on key flood characteristics (e.g., flood depths, levels, velocities) for a range of floods up to and including the probable maximum flood (PMF). Penrith City Council commissioned the *'College, Orth and Werrington Creeks Catchment Overland Flow Flood Study'* (2017) to fulfil this requirement.

Further information on the flood study and the associated outputs that were used to describe the existing flood risk are provided in the following sections. It also describes the nature and extent of the potential future flood risk by quantifying the potential impacts that climate change as well as future catchment development may have on flood behaviour.

## 4.2 Existing Flood Behaviour

### 4.2.1 Overview

The *'College, Orth and Werrington Creeks Catchment Overland Flow Flood Study'* was prepared by Catchment Simulation Solutions on behalf of Penrith City Council to define design flood behaviour across the College, Orth and Werrington Creeks catchment for a range of design floods.

A computer flood model of the catchment was developed using TUFLOW software as part of the study. The model was developed to include a representation of all features that will influence the movement of floodwaters across the catchment. This included all stormwater pits and pipes, bridges, culverts, detention basins, buildings, road and rail embankments and fences.

The TUFLOW model was validated against flood behaviour that was reported by the community during significant rainfall events in 2010, 2011 and 2012. The calibrated model was subsequently used to simulate the design 1 in 2-year ARI, the 20%, 10% 5%, 2%, 1%, 0.5% and 0.2% AEP floods and the Probable Maximum Flood (PMF) based upon hydrologic procedures set out in the 1987 version of 'Australian Rainfall and Runoff' (Engineers Australia, 1987).

The outputs from the design flood simulation were used to prepare a range of flood maps. These included maps showing floodwater depths, levels and velocities. Flood hazard and hydraulic category maps were also prepared.

Overall, the TUFLOW model and the associated outputs generated as part of this flood study are considered to represent the best available tools for defining design flood behaviour across the College, Orth and Werrington Creeks catchment and will serve as a suitable basis for defining the existing flood risk as part of the current study.

However, since the completion of the flood study, some changes have occurred within the catchment that were not reflected in the flood study models. Therefore, it was considered necessary to update the TUFLOW model to include these new developments to ensure it provided the best possible representation of contemporary flood behaviour.

In addition, a revised flood estimation guideline was released after publication of the flood study. The guideline is referred to as *'Australian Rainfall and Runoff – A Guide to Flood Estimation'* (Ball et al., 2019) and aims to provide improved estimates of flood behaviour. Accordingly, it was considered prudent to apply the updated flood estimation procedures across the College, Orth and Werrington Creeks catchment.

Further discussion on the model updates that were completed, and the outcomes of the revised design flood simulations are presented in the following sections.

### 4.2.2 Flood Model Updates

The flood study model utilised a range of datasets to represent the variation in topography in the TUFLOW model. This included 2011 LiDAR as well as information from design and work-as-executed plans to reflect recent development or future developments.

However, since the completion of the flood study, additional development has occurred that was not represented in the flood study model. This includes redevelopment in some areas (e.g., low density residential buildings being replaced by townhouses) as well as more significant subdivisions such as Victoria Street, French Street and Caddens Hill.

In addition, work-as-executed survey has become available that differs slightly from some of the 'design' information that was included in the flood model. Therefore, it was considered worthwhile to update the TUFLOW flood model to better reflect contemporary catchment conditions.

The following updates were completed to the TUFLOW model to best reflect current catchment conditions:

- Inclusion of 2019 LiDAR DEM to represent the variation in ground surface elevation across the catchment.
- Modifications to the representation of some detention basins, including:
    - Caddens Hill 'Basin A' was included (details of this basin were not available during the preparation of the flood study).
    - Adjustment of the 'standing' water level of the 'Caddens Pond' (the design water level in the flood study model was lower than the work as executed plans).
    - Caddens Basin 3 spillway elevation was modified (the work as executed survey showed a slightly lower elevation relative to the design plans).
- Additional stormwater pits and pipes were included across the following areas:
    - Eastern sections of the French Street subdivision.

- o Caddens Hills subdivision.
- o Victoria Street subdivision.
- Material changes to reflect modified rainfall losses, Manning's 'n' roughness values and the impediment to flow afforded by new buildings across new development and redevelopment areas.

The downstream boundary conditions in South Creek remained the same as those used in the '*College, Orth and Werrington Creeks Catchment Overland Flow Flood Study'* (2017).

A comparison between the DEM used in used in this study and the DEM used in the 2017 flood study is indicated in **Plate 2**.

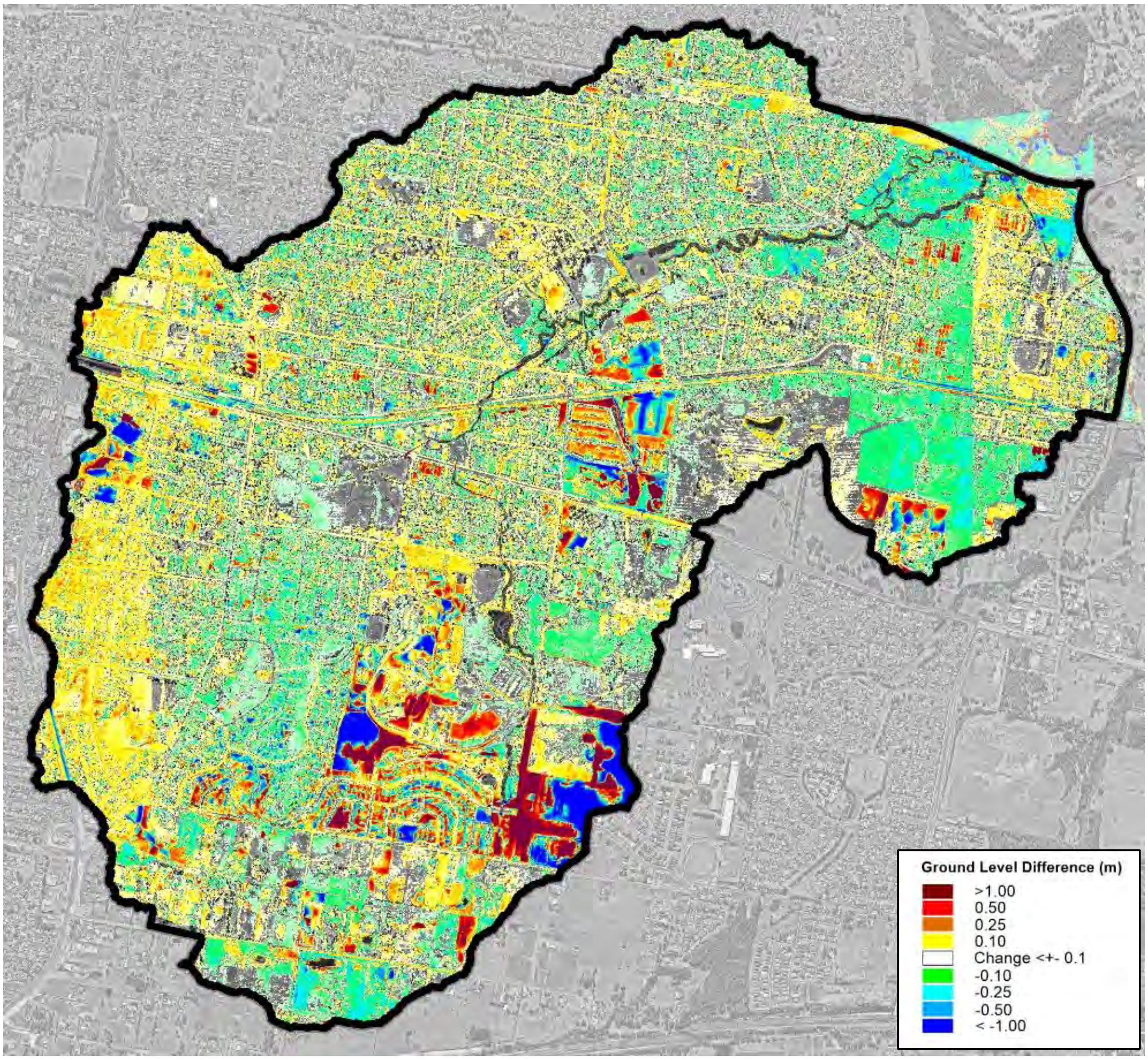



**Plate 2 Difference between 2019 DEM used in this study and DEM used in the 2017 flood study.**

**Plate 2** shows terrain differences across most of the catchment. However, the differences are most commonly no greater than ±0.1 metres. The most significant terrain differences (i.e., greater than 0.5 metres) are predicted around the new developments mentioned above (i.e., Caddens Hills, Victoria Street subdivision and French street subdivision and South Werrington Urban Village).

### 4.2.3 Australian Rainfall & Runoff 2019

Flood Behaviour across the Penrith City Council LGA for the past three decades has been defined based upon guidance contained in the 1987 version of *'Australian Rainfall and Runoff – A Guide to Flood Estimation'* (Engineers Australia). This included the '*College, Orth and Werrington Creeks Catchment Overland Flow Flood Study'* (2017).

In December 2016, a revised version of Australian Rainfall and Runoff was released (Ball et al. Australia, 2016). This guideline was further refined and released in 2019 (herein referred to as ARR2019). The 2019 version of *'Australian Rainfall and Runoff – A Guide to Flood Estimation'* (Ball et al. 2019) is considered to reflect modern best practice for flood estimation.

As outlined in the previous section, several updates were completed to the TUFLOW model as part of the study to ensure it reflected contemporary catchment conditions. Therefore, it was necessary to rerun the TUFLOW model to re-define existing flood behaviour across the catchment. As the model already needed to be re-run, it was considered worthwhile applying the revised ARR2019 procedures to ensure the flood estimation techniques reflected modern best practice. Storm Injector, propriety software developed to implement ARR2019 design storms, was utilised to run the ensemble of storms and carry out processing of the results in order to select appropriate critical storm durations for the catchment. Accordingly, the results that are presented in the following sections reflect the updated ARR2019 procedures.

Further information on the methodology and the parameters that were adopted as part of the ARR2019 analysis are included in **Appendix K**.

### 4.2.4 Design Rainfall Depths

Design rainfall depths for the College, Orth & Werrington Creeks catchment are provided in **Table 8**. This information can be potentially used by emergency services to determine the quantity of rainfall over different time periods that would produce floods of differing severities.

The outcomes of the *'College, Orth and Werrington Creeks Catchment Overland Flow Flood Study'* indicate that rainfall over a 15 minute to 6 hour period typically produced the worst case flooding across the study area (highlighted in blue in **Table 8**). Across the more urbanised sections of the catchments, rainfall over a 15 minute to 1 hour produces the worst case flooding, while areas located behind the Werrington levees as well as adjacent to Werrington Creek will likely experience worst case flooding from storms between 2 and 6 hours in duration.

**Table 8 Design Rainfall Depths**

| DURATION | Average Rainfall Depth (mm) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0.5EY | 20% AEP | 5% AEP | 1% AEP | 0.5% AEP | 0.2% AEP | PMP |
| **10 min** | 12.3 | 17.4 | 24.5 | 32.9 | 35.6 | 40.2 | N/A |
| **15 min** | 15.4 | 21.8 | 30.6 | 41.1 | 44.6 | 50.4 | 150 |
| **20 min** | 17.6 | 24.9 | 35 | 47 | 51.1 | 57.7 | N/A |
| **30 min** | 20.8 | 29.2 | 41 | 55.1 | 59.9 | 67.8 | 220 |
| **45 min** | 23.9 | 33.4 | 46.7 | 62.9 | 68.5 | 77.5 | 270 |
| **1 hour** | 26.2 | 36.4 | 50.7 | 68.4 | 74.6 | 84.4 | 320 |
| **1.5 hour** | 29.7 | 40.9 | 56.8 | 76.7 | 83.6 | 94.6 | 410 |
| **2 hours** | 32.5 | 44.4 | 61.6 | 83.4 | 90.7 | 103 | 480 |
| **3 hours** | 37.2 | 50.4 | 69.8 | 94.7 | 103 | 116 | 580 |
| **6 hours** | 47.9 | 64.8 | 90 | 122 | 132 | 149 | 780 |
| **12 hours** | 63.7 | 87.5 | 123 | 167 | 180 | 202 | N/A |
| **24 hours** | 85.8 | 121 | 171 | 233 | 253 | 286 | N/A |
| **48 hours** | 112 | 162 | 234 | 315 | 361 | 417 | N/A |
| **72 hours** | 127 | 186 | 269 | 361 | 406 | 464 | N/A |

NOTE: N/A indicates a design rainfall is not available for the nominated storm duration

A comparison of the rainfall depths between ARR2019 used in this study and those from ARR1987 used in the 2017 flood study are provided in **Table 9**. The ARR2019 design rainfall estimates take advantage of an additional 30 years of historic rainfall information and, therefore, should provide improved design rainfall estimates. The comparison shows that the ARR2019 rainfall depths are generally higher than the ARR1987 depths for storm durations less than 60 minutes. For storm durations greater than 60 minutes, the ARR1987 rainfall depths are most commonly higher. However, the average difference between the ARR1987 and ARR2019 rainfall depths is approximately 1% overall.

### 4.2.5 Design Discharges

The XP-RAFTS model was used to simulate rainfall-runoff processes for the design 0.5 EY, 20% AEP, 10% AEP, 5% AEP, 2% AEP, 1% AEP, 0.5% AEP, 0.2% AEP floods based upon ARR2019 hydrology. The PMF was also simulated. The hydrographs from the XP-RAFTS model were subsequently applied to the TUFLOW model to simulate the passage of water across the catchment during each design flood.

Peak discharges were extracted from the results of the TUFLOW modelling at key location across the catchment and are presented in **Table 10**. Also included in **Table 10** are the corresponding peak design discharges from the 2017 flood study for comparison purposes.

**Table 9 Comparison of rainfall depths from ARR1987 and ARR2019**

| Duration | Rainfall Depth (mm) | | | | | |
|---|---|---|---|---|---|---|
| | 20% AEP | | 5% AEP | | 1% AEP | |
| | ARR1987 | ARR2019 | ARR1987 | ARR2019 | ARR1987 | ARR2019 |
| **10 min** | 16.1 | 17.4 | 21.2 | 24.5 | 28.0 | 32.9 |
| **15 min** | 20.1 | 21.8 | 26.5 | 30.6 | 34.9 | 41.1 |
| **20 min** | 23.3 | 24.9 | 30.7 | 35.0 | 40.5 | 47.0 |
| **30 min** | 28.3 | 29.2 | 37.3 | 41.0 | 49.2 | 55.1 |
| **45 min** | 34.0 | 33.4 | 44.8 | 46.7 | 59.1 | 62.9 |
| **1 hour** | 38.4 | 36.4 | 50.6 | 50.7 | 66.8 | 68.4 |
| **1.5 hour** | 45.3 | 40.9 | 59.7 | 56.8 | 78.8 | 76.7 |
| **2 hours** | 50.9 | 44.4 | 66.9 | 61.6 | 88.2 | 83.4 |
| **3 hours** | 59.7 | 50.4 | 78.3 | 69.8 | 103 | 94.7 |
| **6 hours** | 78.2 | 64.8 | 102 | 90.0 | 134 | 122 |
| **12 hours** | 102 | 87.5 | 135 | 123 | 178 | 167 |
| **24 hours** | 133 | 121 | 179 | 171 | 239 | 233 |
| **48 hours** | 169 | 162 | 233 | 234 | 320 | 315 |
| **72 hours** | 189 | 186 | 265 | 269 | 368 | 361 |

**Table 10 Comparison between ARR1987 and ARR2019 design discharges**

| Location | Peak Discharges ($m^3/s$) | | | | | |
|---|---|---|---|---|---|---|
| | 20% AEP | | 5% AEP | | 1% AEP | |
| | 2017 FS | 2020 FRMS | 2017 FS | 2020 FRMS | 2017 FS | 2020 FRMS |
| Smith Street | 2.77 | 2.19 | 5.19 | 4.14 | 8.26 | 7.78 |
| Derby Street | 9.04 | 8.10 | 14.1 | 13.8 | 19.8 | 18.2 |
| Victoria Street | 31.2 | 29.3 | 43.8 | 41.6 | 62.3 | 67.0 |
| Burton Avenue | 44.1 | 41.5 | 62.1 | 58.9 | 82.4 | 85.9 |
| John Oxley Drive | 47.4 | 44.5 | 66.6 | 63.5 | 88.9 | 91.2 |
| Caddens Road | 5.53 | 4.32 | 8.71 | 8.20 | 12.7 | 12.9 |
| Second Avenue | 6.63 | 5.81 | 14.1 | 15.1 | 23.6 | 26.4 |

Peak discharges were also extracted at a more comprehensive set of locations (as shown in **Plate 3**) for each design flood and are provided in **Table 11**.

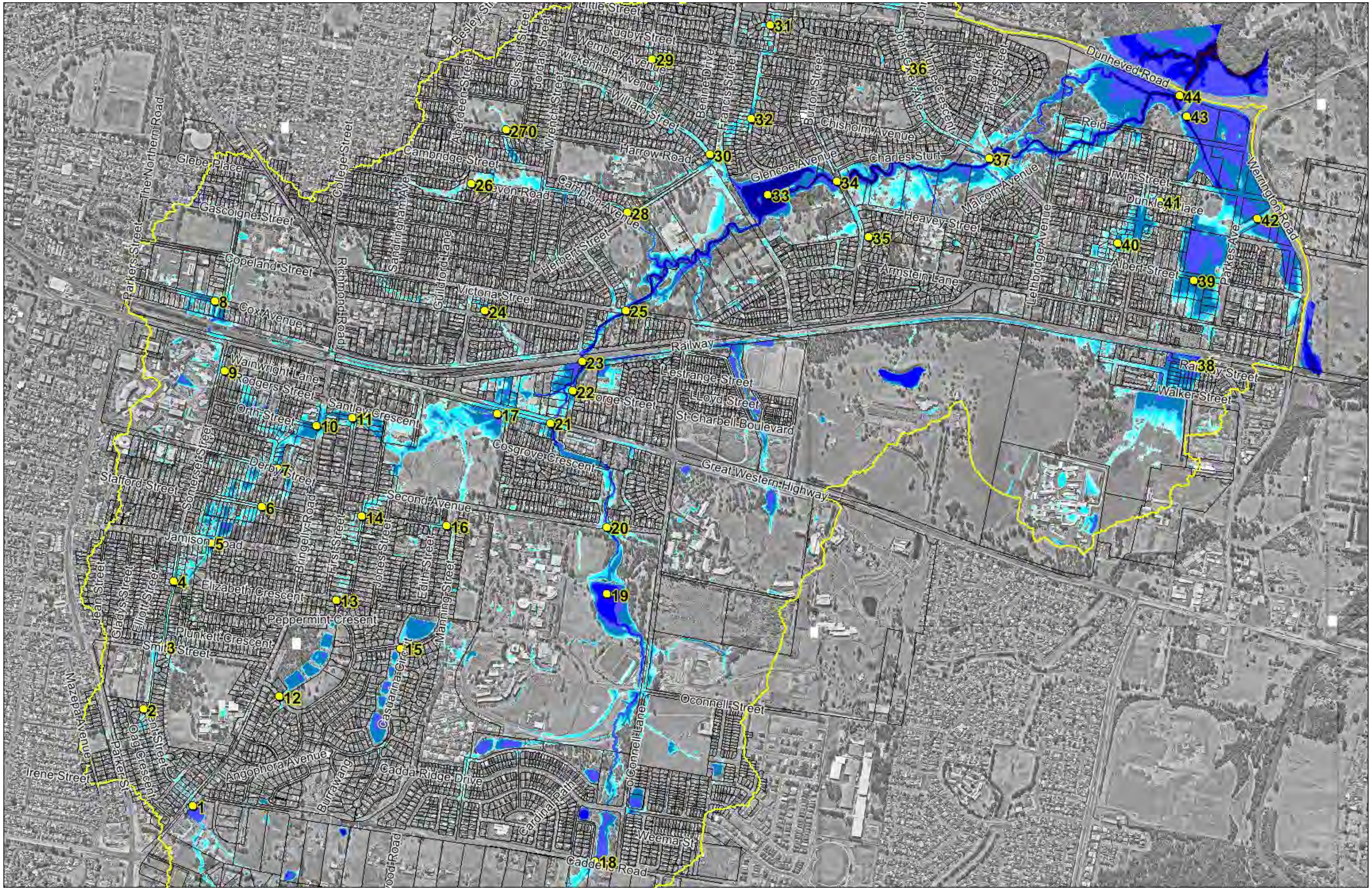


**Plate 3 Design Flood Reporting Locations**

Table 11 Peak Design Discharges ($m^3/s$) at Key Locations

| # | Location | 0.5EY | 20% AEP | 10% AEP | 5% AEP | 2% AEP | 1%AEP | 0.5% AEP | 0.2% AEP | PMF |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Montgrove College | 0.41 | 0.71 | 0.85 | 0.95 | 1.63 | 2.22 | 2.71 | 3.44 | 19.19 |
| 2 | Oag Cres | 2.24 | 3.57 | 4.63 | 5.82 | 7.35 | 9.01 | 10.04 | 11.70 | 56.08 |
| 3 | Smith St | 2.24 | 3.57 | 4.63 | 5.82 | 7.35 | 9.01 | 10.04 | 11.70 | 56.08 |
| 4 | Stapley St | 0.44 | 0.64 | 0.81 | 0.96 | 1.19 | 1.30 | 1.43 | 1.63 | 5.59 |
| 5 | Jamison Rd | 3.51 | 5.85 | 7.46 | 8.76 | 10.84 | 12.64 | 13.90 | 15.94 | 77.55 |
| 6 | Stafford St | 3.55 | 6.19 | 8.00 | 9.37 | 11.73 | 13.42 | 14.75 | 16.91 | 83.70 |
| 7 | Derby St | 3.95 | 6.77 | 8.71 | 10.49 | 12.96 | 15.25 | 16.77 | 19.13 | 91.75 |
| 8 | Cox Ave | 2.94 | 4.22 | 5.15 | 6.11 | 7.48 | 8.64 | 9.48 | 10.85 | 41.00 |
| 9 | Rodgers St | 3.61 | 5.13 | 6.33 | 7.59 | 9.31 | 10.66 | 11.68 | 13.35 | 54.50 |
| 10 | Orth St | 7.28 | 11.63 | 14.91 | 16.98 | 21.80 | 25.74 | 28.37 | 32.57 | 142.19 |
| 11 | First St | 7.60 | 12.08 | 15.38 | 17.92 | 22.40 | 26.31 | 28.96 | 33.23 | 150.59 |
| 12 | Peppermint Cres | 1.51 | 2.16 | 2.68 | 3.14 | 3.76 | 4.36 | 4.78 | 5.46 | 18.37 |
| 13 | Wandoo Glen | 0.78 | 1.24 | 1.64 | 2.17 | 2.99 | 3.70 | 4.13 | 4.85 | 24.97 |
| 14 | Stock Ave | 2.36 | 3.39 | 4.21 | 4.91 | 6.04 | 6.87 | 7.54 | 8.62 | 37.51 |
| 15 | Manning St | 1.02 | 1.71 | 2.54 | 3.15 | 4.01 | 4.71 | 5.17 | 5.89 | 24.14 |
| 16 | Edna St | 2.07 | 3.03 | 3.77 | 4.28 | 5.07 | 6.15 | 6.82 | 7.88 | 38.96 |
| 17 | Chapman Gardens | 10.10 | 17.10 | 21.68 | 26.35 | 32.72 | 38.35 | 42.29 | 48.59 | 243.19 |
| 18 | Caddens Rd | 1.97 | 3.88 | 5.10 | 6.10 | 7.89 | 9.44 | 10.51 | 12.20 | 62.90 |
| 19 | Western Sydney University | 5.13 | 9.60 | 11.96 | 14.30 | 16.98 | 19.23 | 20.66 | 27.12 | 147.60 |
| 20 | Second Ave | 5.30 | 9.91 | 12.33 | 14.51 | 17.35 | 19.61 | 21.04 | 27.59 | 152.14 |
| 21 | Great Western Hwy | 5.73 | 10.46 | 13.06 | 15.63 | 18.66 | 20.71 | 22.11 | 28.13 | 164.23 |
| 22 | George St | 15.85 | 28.53 | 35.95 | 42.32 | 52.27 | 61.40 | 67.19 | 76.10 | 440.05 |
| 23 | Railway Line | 15.85 | 28.53 | 35.95 | 42.32 | 52.27 | 61.40 | 67.19 | 76.10 | 440.05 |

| # | Location | 0.5EY | 20% AEP | 10% AEP | 5% AEP | 2% AEP | 1%AEP | 0.5% AEP | 0.2% AEP | PMF |
|---|---|---|---|---|---|---|---|---|---|---|
| 24 | Joseph Sr | 2.16 | 3.09 | 3.77 | 4.46 | 5.55 | 6.50 | 7.15 | 8.22 | 27.48 |
| 25 | Victoria St | 16.72 | 29.99 | 37.21 | 44.44 | 54.68 | 63.79 | 69.74 | 79.69 | 464.69 |
| 26 | Devon Park | 2.98 | 4.33 | 5.39 | 6.38 | 7.94 | 9.36 | 10.44 | 12.07 | 49.02 |
| 27 | Lincoln Drive Park | 0.71 | 1.11 | 1.38 | 1.73 | 2.21 | 2.61 | 2.88 | 3.35 | 12.82 |
| 28 | Herbert St | 3.04 | 4.44 | 5.51 | 6.57 | 8.13 | 9.61 | 10.60 | 12.63 | 51.25 |
| 29 | Wembley Ave | 1.17 | 1.72 | 2.14 | 2.67 | 3.25 | 3.73 | 4.08 | 4.66 | 15.70 |
| 30 | William St | 2.77 | 3.96 | 4.97 | 5.87 | 7.31 | 8.55 | 9.43 | 10.87 | 40.98 |
| 31 | Orleton Pl | 1.06 | 1.56 | 1.93 | 2.28 | 2.80 | 3.26 | 3.58 | 4.11 | 14.86 |
| 32 | Glencoe Ave | 1.90 | 2.83 | 3.55 | 4.18 | 5.17 | 6.05 | 6.59 | 7.63 | 30.36 |
| 33 | Lake Werrington | 18.93 | 34.47 | 42.88 | 51.68 | 64.00 | 73.67 | 78.66 | 91.46 | 539.30 |
| 34 | Burton St | 19.18 | 34.89 | 43.20 | 52.46 | 64.69 | 74.21 | 80.92 | 92.10 | 548.09 |
| 35 | Lack Pl | 0.15 | 0.22 | 0.27 | 0.32 | 0.40 | 0.42 | 0.46 | 0.52 | 1.74 |
| 36 | Rugby St | 2.54 | 3.62 | 4.38 | 5.25 | 6.51 | 7.58 | 8.24 | 9.39 | 33.12 |
| 37 | John Oxley Ave | 20.45 | 36.44 | 46.14 | 55.53 | 67.95 | 78.29 | 85.94 | 98.70 | 578.97 |
| 38 | Railwat St | 1.86 | 2.89 | 3.95 | 4.84 | 6.26 | 7.42 | 8.16 | 9.66 | 55.94 |
| 39 | Rance Oval | 2.40 | 3.55 | 4.65 | 5.71 | 7.39 | 8.60 | 9.76 | 11.46 | 65.25 |
| 40 | Chrisan Cl | 1.85 | 2.63 | 3.22 | 3.76 | 4.58 | 5.26 | 5.77 | 6.57 | 22.73 |
| 41 | Dunkley Pl | 2.05 | 3.02 | 3.74 | 4.43 | 5.42 | 6.28 | 6.90 | 7.91 | 29.05 |
| 42 | Parkes Ave | 0.55 | 0.78 | 0.95 | 1.11 | 1.34 | 1.44 | 1.57 | 1.78 | 5.89 |
| 43 | U/S Levee | 4.12 | 6.44 | 8.19 | 9.78 | 12.65 | 15.30 | 17.07 | 19.92 | 103.87 |
| 44 | Dunheved Rd | 20.20 | 41.34 | 52.48 | 62.75 | 76.96 | 88.07 | 96.65 | 111.10 | 654.65 |

### 4.2.6 Floodwater Depths, Levels and Velocities

Peak floodwater depths, flood levels and velocity contours were extracted from the results of the revised modelling and are presented in Volume 2:

- Floodwater depths: **Figures 6** to **14**.
- Flood levels: **Figures 15** to **23**.
- Flow velocities: **Figures 24** to **32**.

Peak flood levels, depths and velocities were also extracted at key locations throughout the catchment and are presented in **Table 12**, **Table 13** and **Table 14** respectively. The location where the results were extracted is shown in **Table 11**.

It should be noted that the primary objective of the study is to define the nature and extent of the flooding problem across the catchment. Therefore, there is a need to distinguish between areas of significant inundation depths and those areas subject to negligible inundation. In this regard, the design flood results were filtered using the following criteria before inclusion in the flood mapping:

- Water depths less than 0.15 metres were removed; and
- Isolated 'puddles' were also removed if they were less than 100 $m^2$.

During the preparation of the flood mapping, it was recognised that the lower parts of the College, Orth and Werrington Creeks Catchment can be impacted by flooding from South Creek as well as 'backwater' flooding from the Hawkesbury-Nepean River system. Flooding from these watercourses was not considered as part of the current study as it has previously been quantified as part of the *'South Creek Floodplain Risk Management Study'* (Advision, 2020) and *'Hawkesbury-Nepean Valley Regional Flood Study'* (WMAwater, 2019). However, to ensure the flood risk is not understated across the lower catchment, inundation extents from these previous studies are included in **Appendix J** where they extend into the College, Orth and Werrington Creeks Catchment. For more detailed information on flooding in the South Creek and Hawkesbury-Nepean catchment, please refer to the above studies.

The results presented in **Figures 6** to **32** shows that:

- During relatively frequent rainfall events, floodwater is generally concentrated within defined watercourses with only limited ponding in localised depressions. Very little inundation is predicted across private property during the 0.5EY flood (refer **Figure 6**).
- More extensive inundation is predicted during the 20% AEP flood with several continuous overland flow paths through private property becoming evident (refer **Figure 7**). This includes:
    - Jamison Road to Bringelly Road, Kingswood.
    - Cox Avenue to Orth Street, Kingswood.
    - Edward Close to Dunkley Place, Werrington.
    - Railway Street, Werrington.

Table 12 Peak Design Flood Levels (mAHD) at Key Locations

| # | Location | 0.5EY | 20% AEP | 10% AEP | 5% AEP | 2% AEP | 1%AEP | 0.5% AEP | 0.2% AEP | PMF |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Montgrove College | 63.26 | 63.41 | 63.67 | 63.98 | 64.02 | 64.05 | 64.06 | 64.08 | 64.33 |
| 2 | Oag Cres | - | - | - | 56.59 | 56.67 | 56.75 | 56.80 | 56.79 | 57.42 |
| 3 | Smith St | - | - | 54.10 | 54.12 | 54.14 | 54.17 | 54.19 | 54.19 | 54.64 |
| 4 | Stapley St | - | - | - | - | 50.71 | 50.78 | 50.83 | 50.86 | 51.45 |
| 5 | Jamison Rd | 49.11 | 49.26 | 49.31 | 49.35 | 49.38 | 49.41 | 49.43 | 49.46 | 49.96 |
| 6 | Stafford St | - | - | 46.63 | 46.71 | 46.75 | 46.81 | 46.83 | 46.86 | 47.33 |
| 7 | Derby St | 44.49 | 44.51 | 44.57 | 44.73 | 44.80 | 44.90 | 44.93 | 45.00 | 45.70 |
| 8 | Cox Ave | - | 42.67 | 42.82 | 42.91 | 42.96 | 43.06 | 43.11 | 43.20 | 44.19 |
| 9 | Rodgers St | - | 50.55 | 50.66 | 50.75 | 50.85 | 50.98 | 51.03 | 51.13 | 51.90 |
| 10 | Orth St | - | 46.69 | 46.75 | 46.79 | 46.81 | 46.83 | 46.85 | 46.85 | 46.93 |
| 11 | First St | - | 41.31 | 41.42 | 41.47 | 41.50 | 41.55 | 41.59 | 41.62 | 42.03 |
| 12 | Peppermint Cres | - | 56.73 | 56.77 | 56.83 | 56.92 | 56.96 | 56.96 | 56.99 | 57.28 |
| 13 | Wandoo Glen | - | - | - | - | 48.58 | 48.67 | 48.70 | 48.84 | 49.93 |
| 14 | Stock Ave | - | - | 43.27 | 43.37 | 43.45 | 43.54 | 43.59 | 43.59 | 44.27 |
| 15 | Manning St | - | - | 42.97 | 43.05 | 43.08 | 43.13 | 43.16 | 43.16 | 43.64 |
| 16 | Edna St | 36.73 | 37.41 | 37.50 | 37.54 | 37.57 | 37.59 | 37.60 | 37.61 | 38.09 |
| 17 | Chapman Gardens | - | - | 36.09 | 36.10 | 36.37 | 36.44 | 36.47 | 36.53 | 37.40 |
| 18 | Caddens Rd | - | - | - | 34.43 | 34.67 | 34.88 | 35.02 | 35.31 | 37.10 |
| 19 | Western Sydney University | - | - | 38.68 | 38.75 | 38.84 | 38.89 | 38.90 | 38.94 | 40.10 |
| 20 | Second Ave | - | - | 53.37 | 53.42 | 53.45 | 53.51 | 53.53 | 53.57 | 54.20 |
| 21 | Great Western Hwy | - | - | - | - | - | 31.78 | 31.80 | 31.83 | 32.85 |
| 22 | George St | - | - | 43.47 | 43.53 | 43.61 | 43.63 | 43.64 | 43.66 | 43.88 |
| 23 | Railway Line | - | - | - | 33.90 | 34.00 | 34.11 | 34.19 | 34.19 | 34.71 |

| # | Location | 0.5EY | 20% AEP | 10% AEP | 5% AEP | 2% AEP | 1%AEP | 0.5% AEP | 0.2% AEP | PMF |
|---|---|---|---|---|---|---|---|---|---|---|
| 24 | Joseph Sr | - | - | - | 31.06 | 31.12 | 31.17 | 31.21 | 31.22 | 31.55 |
| 25 | Victoria St | - | 38.37 | 38.48 | 38.56 | 38.63 | 38.68 | 38.70 | 38.72 | 39.03 |
| 26 | Devon Park | - | 33.26 | 33.37 | 33.47 | 33.52 | 33.57 | 33.61 | 33.62 | 34.11 |
| 27 | Lincoln Drive Park | - | 37.00 | 37.14 | 37.19 | 37.22 | 37.26 | 37.30 | 37.30 | 37.55 |
| 28 | Herbert St | 22.55 | 23.19 | 23.60 | 23.83 | 24.07 | 24.27 | 24.32 | 24.37 | 25.77 |
| 29 | Wembley Ave | 27.19 | 27.41 | 27.45 | 27.49 | 27.51 | 27.52 | 27.54 | 27.55 | 28.66 |
| 30 | William St | - | 21.72 | 21.78 | 21.84 | 21.95 | 22.00 | 22.03 | 22.06 | 22.94 |
| 31 | Orleton Pl | 20.74 | 21.28 | 21.68 | 21.84 | 21.92 | 21.96 | 21.98 | 22.02 | 22.94 |
| 32 | Glencoe Ave | 20.77 | 21.11 | 21.34 | 21.51 | 21.51 | 21.57 | 21.61 | 21.58 | 22.93 |
| 33 | Lake Werrington | - | 22.82 | 23.03 | 23.17 | 23.39 | 23.67 | 23.74 | 23.82 | 25.29 |
| 34 | Burton St | - | - | - | 21.38 | 21.41 | 21.46 | 21.48 | 21.48 | 22.93 |
| 35 | Lack Pl | 27.12 | 27.28 | 27.41 | 27.51 | 27.69 | 27.82 | 27.89 | 27.97 | 29.70 |
| 36 | Rugby St | 32.54 | 32.99 | 33.35 | 33.72 | 34.27 | 34.71 | 34.92 | 35.27 | 37.01 |
| 37 | John Oxley Ave | - | - | 40.98 | 41.04 | 41.13 | 41.19 | 41.22 | 41.22 | 41.43 |
| 38 | Railwat St | 42.37 | 42.62 | 42.94 | 43.06 | 43.11 | 43.17 | 43.19 | 43.22 | 43.85 |
| 39 | Rance Oval | - | 50.84 | 50.98 | 51.00 | 51.04 | 51.05 | 51.07 | 51.13 | 51.52 |
| 40 | Chrisan Cl | 20.51 | 20.91 | 21.09 | 21.32 | 21.34 | 21.36 | 21.36 | 21.37 | 22.34 |
| 41 | Dunkley Pl | 20.53 | 20.94 | 21.12 | 21.38 | 21.41 | 21.46 | 21.47 | 21.48 | 22.93 |
| 42 | Parkes Ave | - | - | - | - | 30.52 | 30.59 | 30.62 | 30.62 | 30.94 |
| 43 | U/S Levee | 25.83 | 26.46 | 26.84 | 27.06 | 27.31 | 27.46 | 27.51 | 27.57 | 28.94 |
| 44 | Dunheved Rd | - | 43.37 | 43.61 | 43.67 | 43.73 | 43.76 | 43.77 | 43.78 | 43.89 |

NOTE: a “-“ indicates the location is not predicted to be inundated during the nominated design flood

**Table 13 Peak Design Flood Depths (metres) at Key Locations**

| # | Location | 0.5EY | 20% AEP | 10% AEP | 5% AEP | 2% AEP | 1%AEP | 0.5% AEP | 0.2% AEP | PMF |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Montgrove College | 0.04 | 0.07 | 0.10 | 0.16 | 0.18 | 0.20 | 0.23 | 0.23 | 1.03 |
| 2 | Oag Cres | - | - | - | 0.28 | 0.34 | 0.34 | 0.34 | 0.34 | 0.54 |
| 3 | Smith St | - | - | 0.27 | 0.39 | 0.48 | 0.55 | 0.63 | 0.64 | 1.03 |
| 4 | Stapley St | - | - | - | - | 1.39 | 1.62 | 1.70 | 1.74 | 1.99 |
| 5 | Jamison Rd | 0.06 | 0.44 | 0.58 | 0.76 | 0.87 | 1.02 | 1.08 | 1.21 | 2.11 |
| 6 | Stafford St | - | 0.14 | 0.16 | 0.24 | 0.30 | 0.40 | 0.43 | 0.49 | 1.31 |
| 7 | Derby St | 0.19 | 0.29 | 0.30 | 0.28 | 0.28 | 0.28 | 0.30 | 0.26 | 0.32 |
| 8 | Cox Ave | - | 0.25 | 0.43 | 0.54 | 0.63 | 0.68 | 0.71 | 0.83 | 1.16 |
| 9 | Rodgers St | - | 0.22 | 0.32 | 0.34 | 0.30 | 0.44 | 0.44 | 0.46 | 0.44 |
| 10 | Orth St | - | 0.93 | 1.12 | 1.21 | 1.29 | 1.29 | 1.31 | 1.32 | 1.51 |
| 11 | First St | - | 0.54 | 0.64 | 0.75 | 0.89 | 1.05 | 1.16 | 1.27 | 2.27 |
| 12 | Peppermint Cres | - | 0.30 | 0.33 | 0.45 | 0.43 | 0.55 | 0.56 | 0.59 | 0.86 |
| 13 | Wandoo Glen | - | - | - | - | 0.07 | 0.09 | 0.09 | 0.26 | 1.44 |
| 14 | Stock Ave | - | - | 0.45 | 0.61 | 0.78 | 0.96 | 1.09 | 1.10 | 2.70 |
| 15 | Manning St | - | - | 0.43 | 0.29 | 0.24 | 0.33 | 0.33 | 0.37 | 0.41 |
| 16 | Edna St | 0.28 | 0.64 | 0.68 | 0.69 | 0.71 | 0.71 | 0.71 | 0.71 | 1.17 |
| 17 | Chapman Gardens | - | - | 1.85 | 1.97 | 2.00 | 2.03 | 2.06 | 2.07 | 2.08 |
| 18 | Caddens Rd | - | - | - | 0.04 | 0.39 | 0.78 | 0.86 | 0.94 | 2.14 |
| 19 | Western Sydney University | - | - | 0.09 | 0.23 | 0.36 | 0.42 | 0.43 | 0.43 | 2.91 |
| 20 | Second Ave | 0.10 | 0.25 | 0.92 | 1.20 | 1.35 | 1.56 | 1.61 | 1.71 | 2.61 |
| 21 | Great Western Hwy | - | - | 0.13 | - | 2.07 | 2.98 | 3.15 | 3.33 | 6.21 |
| 22 | George St | - | 0.28 | 0.35 | 0.43 | 0.53 | 0.58 | 0.60 | 0.62 | 1.17 |

| # | Location | 0.5EY | 20% AEP | 10% AEP | 5% AEP | 2% AEP | 1%AEP | 0.5% AEP | 0.2% AEP | PMF |
|---|---|---|---|---|---|---|---|---|---|---|
| 23 | Railway Line | - | - | - | 0.71 | 0.97 | 1.26 | 1.59 | 1.57 | 2.88 |
| 24 | Joseph Sr | - | - | - | 1.46 | 1.81 | 2.09 | 2.30 | 2.31 | 3.88 |
| 25 | Victoria St | - | 0.27 | 0.29 | 0.25 | 0.28 | 0.27 | 0.27 | 0.28 | 0.66 |
| 26 | Devon Park | - | 0.11 | 0.14 | 0.21 | 0.23 | 0.29 | 0.38 | 0.38 | 0.54 |
| 27 | Lincoln Drive Park | - | 0.09 | 0.08 | 0.09 | 0.09 | 0.10 | 0.10 | 0.12 | 0.29 |
| 28 | Herbert St | 1.44 | 1.42 | 1.40 | 1.44 | 1.47 | 1.48 | 1.48 | 1.48 | 1.53 |
| 29 | Wembley Ave | 0.11 | 0.12 | 0.13 | 0.25 | 0.18 | 0.31 | 0.34 | 0.41 | 1.39 |
| 30 | William St | - | 0.04 | 0.10 | 0.14 | 0.14 | 0.16 | 0.22 | 0.23 | 0.52 |
| 31 | Orleton Pl | 0.01 | 0.01 | 0.03 | 0.05 | 0.51 | 0.65 | 0.72 | 0.77 | 0.50 |
| 32 | Glencoe Ave | 0.09 | 0.02 | 1.37 | 2.87 | 2.72 | 2.84 | 3.40 | 2.99 | 0.24 |
| 33 | Lake Werrington | - | 0.13 | 0.21 | 0.26 | 0.37 | 0.39 | 0.38 | 0.51 | 0.52 |
| 34 | Burton St | - | - | - | 0.16 | 0.18 | 0.21 | 0.20 | 0.22 | 0.34 |
| 35 | Lack Pl | 0.17 | 0.54 | 0.72 | 0.98 | 1.32 | 1.35 | 1.56 | 1.64 | 1.78 |
| 36 | Rugby St | 1.31 | 1.40 | 1.45 | 1.44 | 1.44 | 1.45 | 1.44 | 1.30 | 1.61 |
| 37 | John Oxley Ave | - | 0.01 | 0.02 | 0.05 | 0.08 | 0.10 | 0.11 | 0.14 | 0.57 |
| 38 | Railwat St | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.22 | 0.25 | 0.81 |
| 39 | Rance Oval | - | 0.11 | 0.08 | 0.12 | 0.11 | 0.13 | 0.29 | 0.36 | 1.10 |
| 40 | Chrisan Cl | 0.32 | 0.44 | 0.54 | 0.58 | 0.70 | 0.86 | 0.92 | 0.96 | 3.20 |
| 41 | Dunkley Pl | 0.03 | 0.03 | 0.03 | 0.04 | 0.04 | 0.05 | 0.05 | 0.05 | 0.13 |
| 42 | Parkes Ave | - | - | - | - | 0.25 | 0.26 | 0.26 | 0.27 | 0.46 |
| 43 | U/S Levee | 0.72 | 0.63 | 0.62 | 0.66 | 0.76 | 0.85 | 0.88 | 0.93 | 1.95 |
| 44 | Dunheved Rd | - | 0.08 | 0.11 | 0.23 | 0.26 | 0.30 | 0.31 | 0.37 | 0.97 |

NOTE: “-“ indicates the location is not predicted to be inundated during the nominated design flood

**Table 14 Peak Design Flow Velocities (m/s) at Key Locations**

| # | Location | 0.5EY | 20% AEP | 10% AEP | 5% AEP | 2% AEP | 1%AEP | 0.5% AEP | 0.2% AEP | PMF |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Montgrove College | 0.04 | 0.07 | 0.10 | 0.16 | 0.18 | 0.20 | 0.23 | 0.23 | 1.03 |
| 2 | Oag Cres | - | - | - | 0.28 | 0.34 | 0.34 | 0.34 | 0.34 | 0.54 |
| 3 | Smith St | - | - | 0.27 | 0.39 | 0.48 | 0.55 | 0.63 | 0.64 | 1.03 |
| 4 | Stapley St | - | - | - | - | 1.39 | 1.62 | 1.70 | 1.74 | 1.99 |
| 5 | Jamison Rd | 0.06 | 0.44 | 0.58 | 0.76 | 0.87 | 1.02 | 1.08 | 1.21 | 2.11 |
| 6 | Stafford St | - | 0.14 | 0.16 | 0.24 | 0.30 | 0.40 | 0.43 | 0.49 | 1.31 |
| 7 | Derby St | 0.19 | 0.29 | 0.30 | 0.28 | 0.28 | 0.28 | 0.30 | 0.26 | 0.32 |
| 8 | Cox Ave | - | 0.25 | 0.43 | 0.54 | 0.63 | 0.68 | 0.71 | 0.83 | 1.16 |
| 9 | Rodgers St | - | 0.22 | 0.32 | 0.34 | 0.30 | 0.44 | 0.44 | 0.46 | 0.44 |
| 10 | Orth St | - | 0.93 | 1.12 | 1.21 | 1.29 | 1.29 | 1.31 | 1.32 | 1.51 |
| 11 | First St | - | 0.54 | 0.64 | 0.75 | 0.89 | 1.05 | 1.16 | 1.27 | 2.27 |
| 12 | Peppermint Cres | - | 0.30 | 0.33 | 0.45 | 0.43 | 0.55 | 0.56 | 0.59 | 0.86 |
| 13 | Wandoo Glen | - | - | - | - | 0.07 | 0.09 | 0.09 | 0.26 | 1.44 |
| 14 | Stock Ave | - | - | 0.45 | 0.61 | 0.78 | 0.96 | 1.09 | 1.10 | 2.70 |
| 15 | Manning St | - | - | 0.43 | 0.29 | 0.24 | 0.33 | 0.33 | 0.37 | 0.41 |
| 16 | Edna St | 0.28 | 0.64 | 0.68 | 0.69 | 0.71 | 0.71 | 0.71 | 0.71 | 1.17 |
| 17 | Chapman Gardens | - | - | 1.85 | 1.97 | 2.00 | 2.03 | 2.06 | 2.07 | 2.08 |
| 18 | Caddens Rd | - | - | - | 0.04 | 0.39 | 0.78 | 0.86 | 0.94 | 2.14 |
| 19 | Western Sydney University | - | - | 0.09 | 0.23 | 0.36 | 0.42 | 0.43 | 0.43 | 2.91 |
| 20 | Second Ave | 0.10 | 0.25 | 0.92 | 1.20 | 1.35 | 1.56 | 1.61 | 1.71 | 2.61 |
| 21 | Great Western Hwy | - | - | 0.13 | - | 2.07 | 2.98 | 3.15 | 3.33 | 6.21 |
| 22 | George St | - | 0.28 | 0.35 | 0.43 | 0.53 | 0.58 | 0.60 | 0.62 | 1.17 |

| # | Location | 0.5EY | 20% AEP | 10% AEP | 5% AEP | 2% AEP | 1%AEP | 0.5% AEP | 0.2% AEP | PMF |
|---|---|---|---|---|---|---|---|---|---|---|
| 23 | Railway Line | - | - | - | 0.71 | 0.97 | 1.26 | 1.59 | 1.57 | 2.88 |
| 24 | Joseph Sr | - | - | - | 1.46 | 1.81 | 2.09 | 2.30 | 2.31 | 3.88 |
| 25 | Victoria St | - | 0.27 | 0.29 | 0.25 | 0.28 | 0.27 | 0.27 | 0.28 | 0.66 |
| 26 | Devon Park | - | 0.11 | 0.14 | 0.21 | 0.23 | 0.29 | 0.38 | 0.38 | 0.54 |
| 27 | Lincoln Drive Park | - | 0.09 | 0.08 | 0.09 | 0.09 | 0.10 | 0.10 | 0.12 | 0.29 |
| 28 | Herbert St | 1.44 | 1.42 | 1.40 | 1.44 | 1.47 | 1.48 | 1.48 | 1.48 | 1.53 |
| 29 | Wembley Ave | 0.11 | 0.12 | 0.13 | 0.25 | 0.18 | 0.31 | 0.34 | 0.41 | 1.39 |
| 30 | William St | - | 0.04 | 0.10 | 0.14 | 0.14 | 0.16 | 0.22 | 0.23 | 0.52 |
| 31 | Orleton Pl | 0.01 | 0.01 | 0.03 | 0.05 | 0.51 | 0.65 | 0.72 | 0.77 | 0.50 |
| 32 | Glencoe Ave | 0.09 | 0.02 | 1.37 | 2.87 | 2.72 | 2.84 | 3.40 | 2.99 | 0.24 |
| 33 | Lake Werrington | - | 0.13 | 0.21 | 0.26 | 0.37 | 0.39 | 0.38 | 0.51 | 0.52 |
| 34 | Burton St | - | - | - | 0.16 | 0.18 | 0.21 | 0.20 | 0.22 | 0.34 |
| 35 | Lack Pl | 0.17 | 0.54 | 0.72 | 0.98 | 1.32 | 1.35 | 1.56 | 1.64 | 1.78 |
| 36 | Rugby St | 1.31 | 1.40 | 1.45 | 1.44 | 1.44 | 1.45 | 1.44 | 1.30 | 1.61 |
| 37 | John Oxley Ave | - | 0.01 | 0.02 | 0.05 | 0.08 | 0.10 | 0.11 | 0.14 | 0.57 |
| 38 | Railwat St | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.22 | 0.25 | 0.81 |
| 39 | Rance Oval | - | 0.11 | 0.08 | 0.12 | 0.11 | 0.13 | 0.29 | 0.36 | 1.10 |
| 40 | Chrisan Cl | 0.32 | 0.44 | 0.54 | 0.58 | 0.70 | 0.86 | 0.92 | 0.96 | 3.20 |
| 41 | Dunkley Pl | 0.03 | 0.03 | 0.03 | 0.04 | 0.04 | 0.05 | 0.05 | 0.05 | 0.13 |
| 42 | Parkes Ave | - | - | - | - | 0.25 | 0.26 | 0.26 | 0.27 | 0.46 |
| 43 | U/S Levee | 0.72 | 0.63 | 0.62 | 0.66 | 0.76 | 0.85 | 0.88 | 0.93 | 1.95 |
| 44 | Dunheved Rd | - | 0.08 | 0.11 | 0.23 | 0.26 | 0.30 | 0.31 | 0.37 | 0.97 |

NOTE: “-“ indicates the location is not predicted to be inundated during the nominated design flood

- During the 1% AEP flood, floodwater depths along the major overland flow paths discussed above are commonly predicted to exceed 0.5 metres and new overland flow paths become apparent (refer **Figure 11**). This includes:
    - Victoria Street to Heath Street, Kingswood.
    - Chapman Gardens to the railway line, Kingswood.
    - Sandringham Avenue & Lincoln Drive Park to Herbert Street, Cambridge Park.
    - Oxford Street, Cambridge Park.
    - Rugby Street to Oxford Street, Cambridge Park.
    - Orleton Place to Francis Street, Werrington County.
- During the PMF, overland water depths are predicted to exceed 1 metre at many locations (refer **Figure 14**). The impediment to flow afforded by the railway line is emphasised during the PMF with significant 'ponding' on the southern side of the railway at Kingswood and Werrington.

Flood level difference mapping was also prepared to quantify the differences between the revised flood modelling results and the results produced as part of the 2017 flood study. The flood level difference mapping is provided in **Plate 4**, **Plate 5** and **Plate 6** for the 5% AEP and 1% AEP floods as well as the PMF.

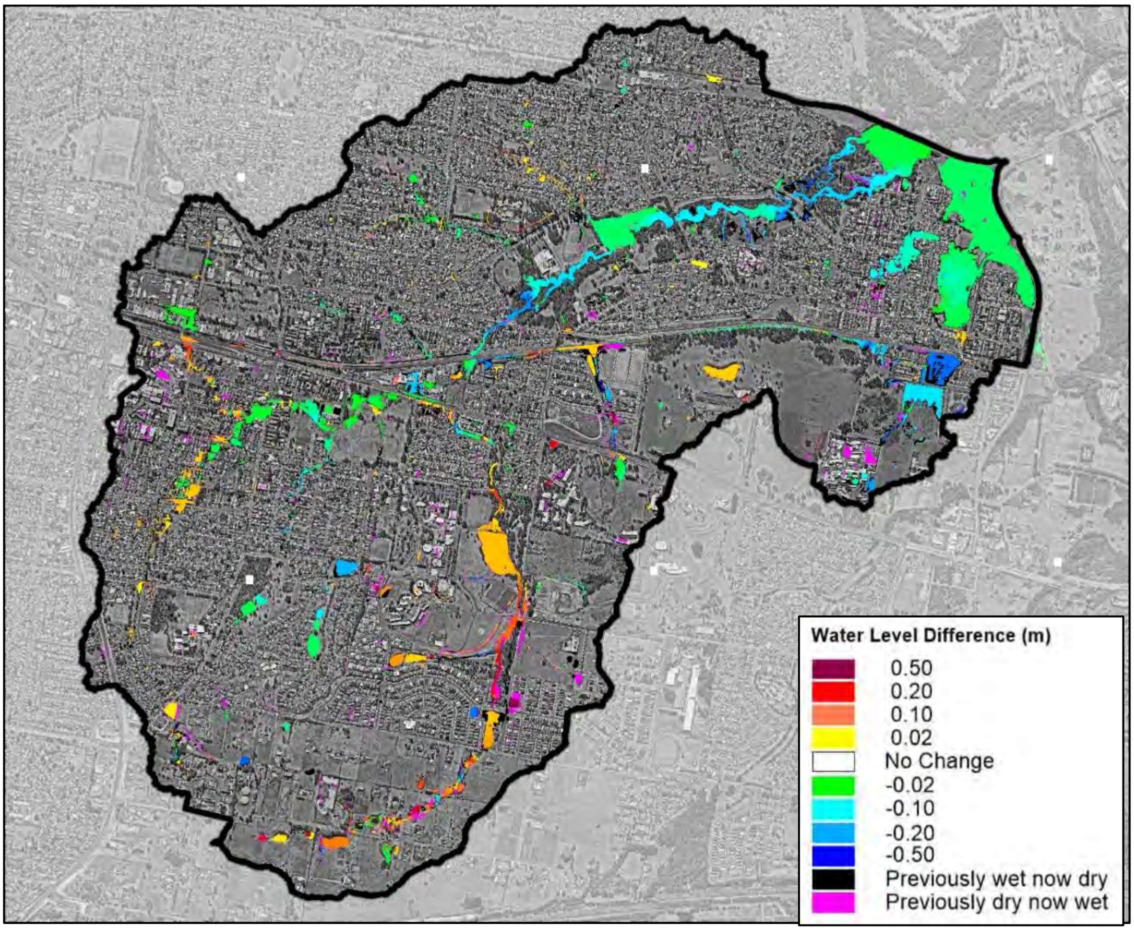



Plate 4 Flood level differences between current study and 2017 flood study for the 5% AEP design flood

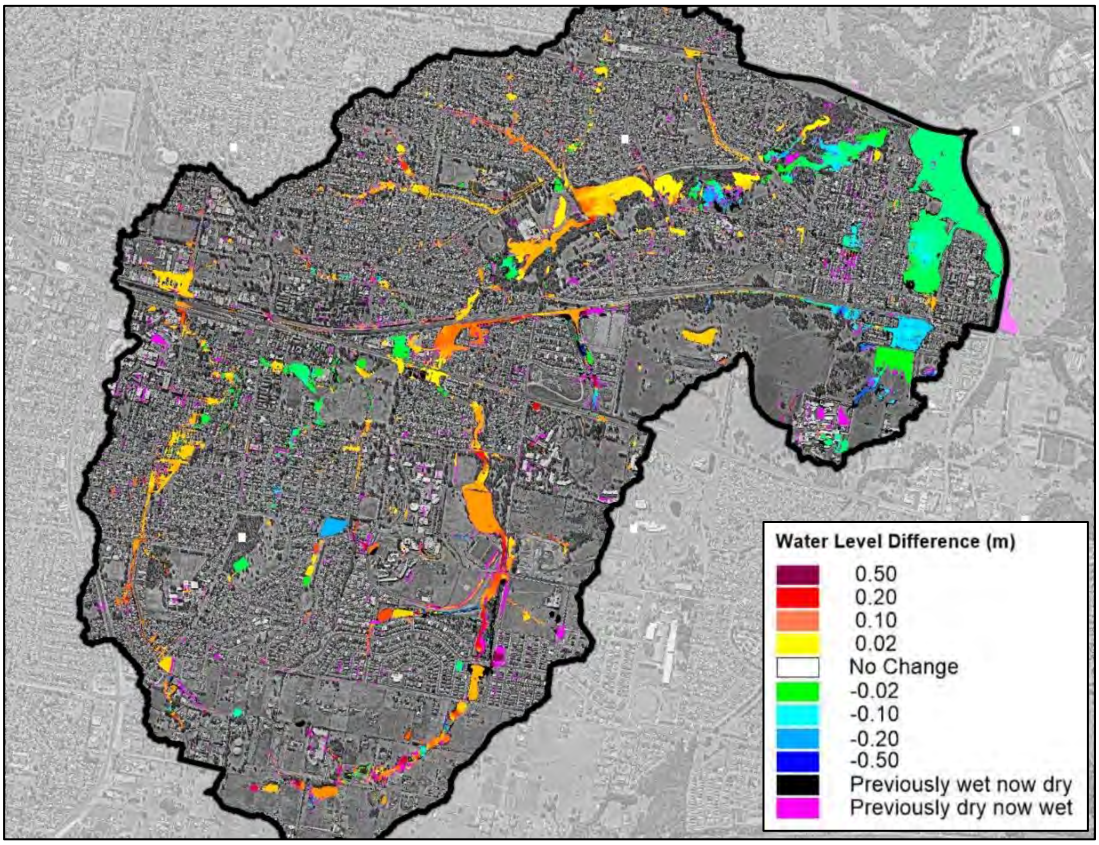



**Plate 5 Flood level differences between current study and 2017 flood study for the 1% AEP design flood**

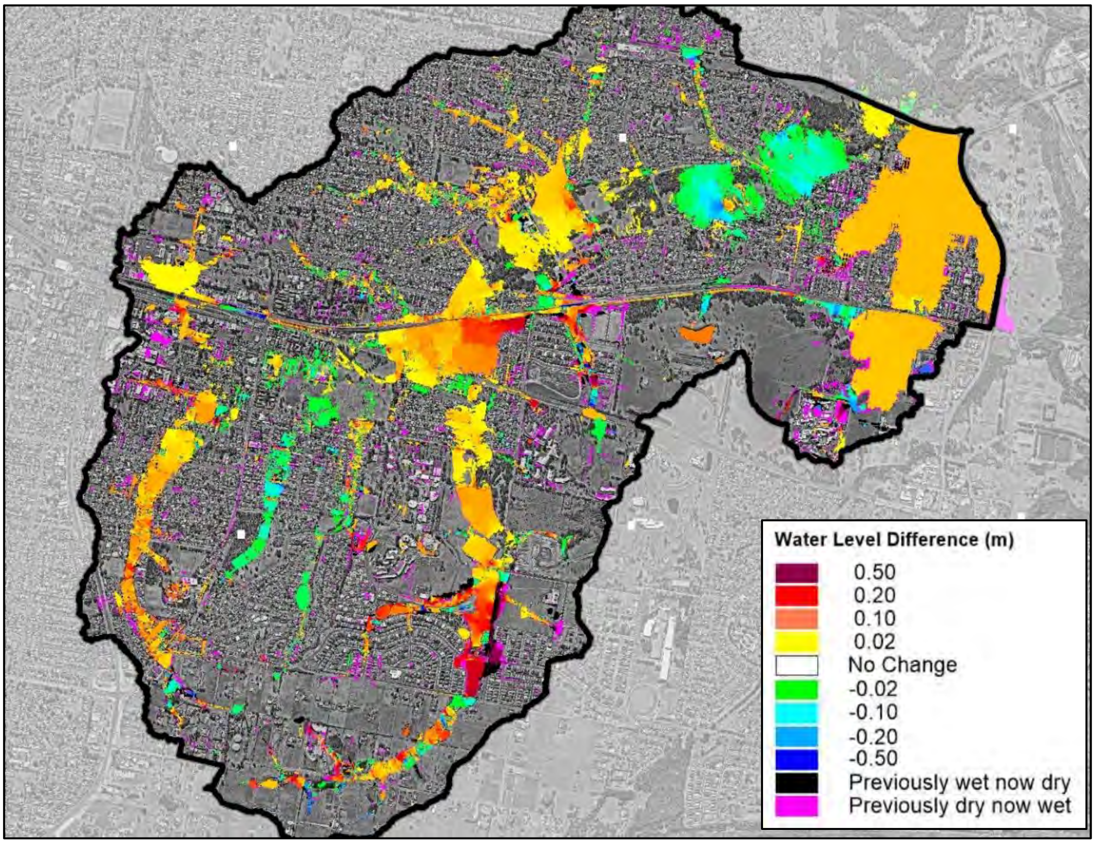



**Plate 6 Flood level differences between current study and 2017 flood study for the PMF design flood**

The flood level difference mapping shows localised increases and decreases in flood levels relative to the 2017 flood study. Across roads, shallow overland flow paths and open channel areas, the revised flood levels are generally higher (primarily associated with the higher rainfall depths for shorter storms under ARR2019). In volume sensitive areas, such as detention basins and upstream of culverts with constrained inlet capacity, the revised flood levels are slightly higher than the 2017 flood study. This is associated with the critical ARR2019 storm patterns being shorter relative to the ARR1987 design storms which results in less runoff volume. Some notable differences are also observed along the open channel areas adjacent to the Caddens subdivision as the natural creek line was modified through this section as part of the subdivision development.

Overall, the revised flood modelling results are considered to provide an improved description of contemporary flood behaviour across the College, Orth and Werrington Creeks Catchment, that is based on the most recent topographic information and hydrologic procedures.

### 4.2.7 Inundated Properties

The number of properties inundated during each design flood was also determined. This information is summarised in **Table 15** (there are 6,297 properties contained within the study area). The information presented in **Table 15** indicates that 16% of properties located within the catchment will be at least partly inundated to a depth of at least 0.15 metres at the peak of the 1% AEP flood. This is predicted to increase to nearly 40% during the PMF. Accordingly, major flooding has the potential to impact a significant number of properties within the catchment.

Table 15 Number of Inundated Properties

| Event | Number of Inundated Properties | Percentage of Total Number of Properties |
|---|---|---|
| 0.5EY | 234 | 4% |
| 20% AEP | 402 | 6% |
| 10% AEP | 552 | 9% |
| 5% AEP | 682 | 11% |
| 2% AEP | 834 | 13% |
| 1% AEP | 999 | 16% |
| 0.5% AEP | 1099 | 17% |
| 0.2% AEP | 1171 | 19% |
| PMF | 2362 | 38% |

### 4.2.8 Flood Hazard Categories

Flood hazard defines the potential impact that flooding will have on development, vehicles and people across different sections of the floodplain. More specifically, it describes the potential for floodwaters to cause damage to property or loss of life/injury (AIDR, 2014).

Provisional hazard categories were prepared as part of the *'College, Orth and Werrington Creeks Catchment Overland Flow Flood Study'* (Catchment Simulation Solutions, 2017) based on criteria contained in Appendix L of the *'Floodplain Development Manual'* (2005) (FDM). Since the preparation of the flood study, revised flood hazard categories were published in the Australian Institute for Disaster Resilience's (AIDR) *'Technical Flood Risk Management Guideline: Flood Hazard'* (2014) and Chapter 7 of Book 6 of *'Australian Rainfall and Runoff – A Guide to Flood Estimation'* (Geoscience Australia, 2019). The hazard curves are reproduced in **Plate 7** and are also described in **Table 16**. As shown in **Plate 7**, the hazard curves assess the potential vulnerability of people (of differing physical abilities), cars and structures based upon the depth and velocity of floodwaters at a particular location. Accordingly, this guideline is considered to provide a more detailed understanding of the potential flood hazard and was used as the basis for defining hazard categories as part of the current study. The resulting 'national' hazard category maps are included as **Figures 33** to **37** for the 5% AEP, 1% AEP, 0.5% AEP, 0.2% AEP floods and PMF.

The hazard maps show that during the 5% AEP flood, the higher hazard areas (i.e., H4 and above are generally contained to defined watercourses (refer **Figure 33**). H1 and H2 hazard are most common across overland flow path areas, although there are localised areas of H3 between Jamison Road to Bringelly Road at Kingswood that would present a danger to children and the elderly. Several roadways would also be exposed to hazards greater than H1 which would present a danger to vehicles. This includes sections of the Great Western Highway. Further discussion on traffic impacts is provided **in Section 4.3.1**.

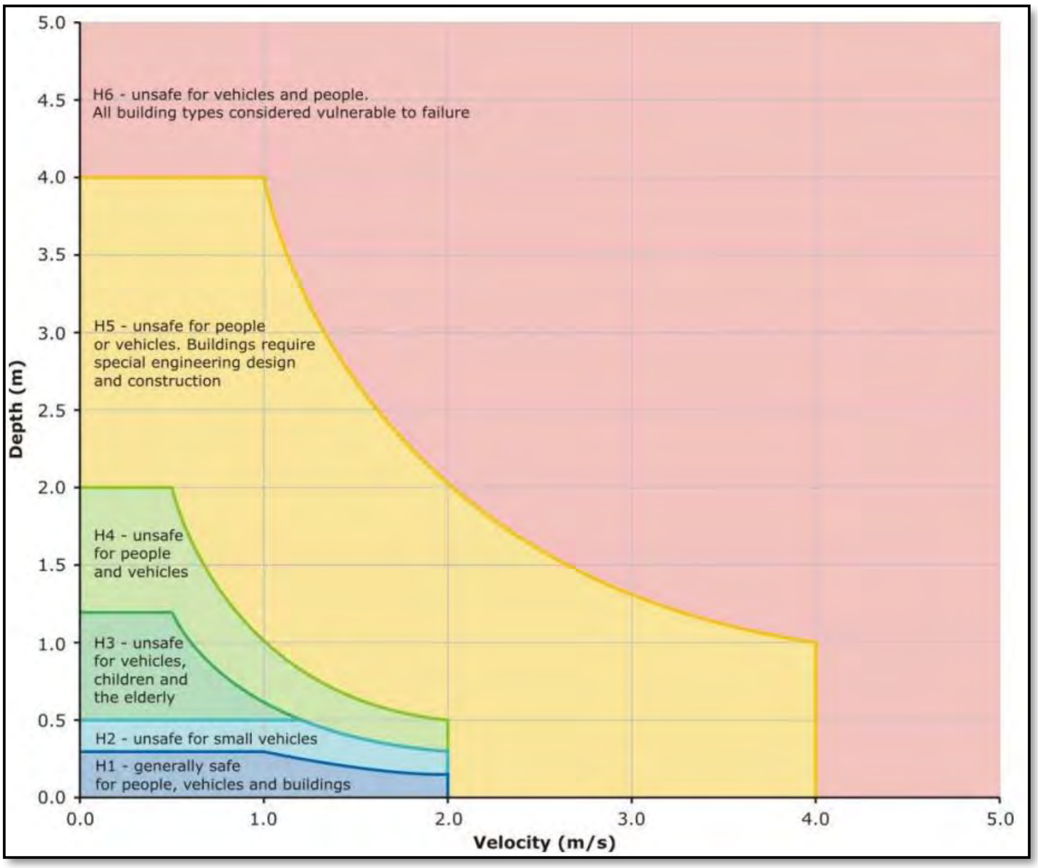



**Plate 7 Flood Hazard Vulnerability Curves (AIDR, 2014)**

**Table 16 Description of Adopted Flood Hazard Categories (Australian Government, 2014)**

| Hazard Category | Description |
|---|---|
| H1 | Generally safe for vehicles, people, and buildings. Relatively benign flood conditions. No vulnerability constraints |
| H2 | Unsafe for small vehicles |
| H3 | Unsafe for vehicles, children, and the elderly |
| H4 | Unsafe for vehicles and people |
| H5 | Unsafe for vehicles and people. All building types vulnerable to structural damage. Some less robust building types vulnerable to failure |
| H6 | Unsafe for vehicles and people. All building types considered vulnerable to failure. |

During the 1% AEP flood, H3 hazard areas become more extensive across overland flow areas with localised areas of H4 (refer **Figure 34**). Accordingly, during a 1% AEP flood, some sections of the catchment would not be safe for vehicles or people, regardless of their physical ability.

The hazard gradually increases across the catchment between the 1% AEP and 0.2% AEP floods. However, there is a noticeable 'jump' in flood hazard between the 0.2% AEP flood and PMF (refer **Figures 36** and **37**). More specifically, during events up to and including the 0.2% AEP, the flood hazard across most urbanised sections of the catchment does not exceed H4. However, during the PMF, a significant proportion of the floodplain would be exposed to H5 hazard conditions with isolated areas exposed to H6. Therefore, there is potential for structural damage to buildings and other infrastructure during the PMF. Of note are properties located in the following areas that would be impacted by H5 flood hazards:

- Jamison Road to Bringelly Road at Kingswood.
- Great Western Highway to Victoria Street at Kingswood.
- Railway Street and Walker Street at Werrington.

To assist in establishing the reason for the large 'jump' in flood hazard, peak 0.2% AEP and PMF discharges were extracted from the TUFLOW model at a selection of locations and are provided in **Table 17**. It shows that the peak PMF discharges are commonly six times larger than the corresponding 0.2% AEP discharges. The most significant difference occurs at the Great Western Highway (immediately north of Chapman Gardens) where the peak PMF discharge is more than ten times larger than the 0.2% AEP discharge. The more significant difference at this location is associated with the Chapman Gardens basin affording some attenuation of flows during the 0.2% AEP flood but providing minimal attenuation during the PMF Therefore, the large 'jump' in flood hazard is associated with the significant increase in flow during the PMF coupled with the various detention basins affording attenuation of flows during floods up to and including the 0.2% AEP event but providing little attenuation of flows during the PMF.

Table 17 Comparison between 0.2% AEP and PMF design discharges at key locations

| Location | Peak Discharges ($m^3/s$) | |
|---|---|---|
| | 0.2% AEP | PMF |
| Jamison Road | 13.50 | 78.40 |
| Bringelly Road | 20.43 | 133.4 |
| Great Western Highway | 19.21 | 204.9 |
| Railway Line | 49.40 | 289.7 |

### 4.2.9 Hydraulic Categories

Hydraulic categories highlight areas that should be retained for the conveyance and storage of floodwaters (failure to do so will likely have an adverse impact on existing flood behaviour). They also provide an indication of the potential for development across different sections of the floodplain to impact on existing flood behaviour.

Criteria for defining hydraulic categories across the College, Orth & Werrington Creeks catchment were previously established as part of the *'College, Orth and Werrington Creeks Catchment Overland Flow Flood Study'* (Catchment Simulation Solutions, 2017) and are summarised in **Table 18**. The flood study included various analyses to confirm the suitability of these criteria (e.g., encroachment analysis to confirm floodway extents). Therefore, these criteria were considered appropriate for application as part of the current study.

The resulting hydraulic category maps for the 5% AEP, 1% AEP, 0.5% and 0.2% floods as well as the PMF are shown in **Figures 38** to **42** inclusive.

The hydraulic category maps show that floodways are most commonly contained in close proximity to each of the main watercourses. However, several roadways would likely function as floodways during floods as frequent as the 5% AEP event. This includes:

- Bringelly Lane, Kingswood.
- Phillip Street, Kingswood.
- William Street and Campton Ave, Cambridge Park.
- Chapman Street, Werrington.

Floodways are also predicted to form through residential properties at the following locations:

- Jamison Road to Bringelly Road at Kingswood.
- Victoria Street to Heath Street at Kingswood.
- Lincoln Drive to Cambridge Street at Cambridge Park.

**Table 18 Qualitative and Quantitative Criteria for Hydraulic Categories**

| Hydraulic Category | Floodplain Development Manual Definition | Adopted Criteria |
|---|---|---|
| **Floodway** | • those areas where a significant volume of water flows during floods.<br>• often aligned with obvious natural channels and drainage depressions.<br>• they are areas that, even if only partially blocked, would have a significant impact on upstream water levels or would divert water from existing flowpaths resulting in the development of new flowpaths.<br>• they are often, but not necessarily, areas with deeper flow or areas where higher velocities occur. | • Minimum top of bank to top of bank (for mainstream areas)<br>**AND**<br>• VxD greater than 0.25 $m^2/s$ AND Velocity greater than or equal to 0.25 m/s<br>**OR**<br>• Velocity greater than = 1.0 m/s |
| **Flood Storage** | • those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood.<br>• if the capacity of a flood storage area is substantially reduced by, for example, the construction of levees or by landfill, flood levels in nearby areas may rise and the peak discharge downstream may be increased.<br>• substantial reduction of the capacity of a flood storage area can also cause a significant redistribution of flood flows. | • If not FLOODWAY and depth greater than or equal to 0.2 m |
| **Flood Fringe** | • the remaining area of land affected by flooding, after floodway and flood storage areas have been defined.<br>• development (e.g., filling) in flood fringe areas would not have any significant effect on the pattern of flood flows and/or flood levels. | • Remaining areas after FLOODWAY and FLOOD STORAGE are defined |

NOTES: V = Velocity, D = Depth

Several areas within the catchment are predicted to afford significant flood storage during large floods. The most notable storage areas are formed on the upstream side of the railway embankment as well as behind the Werrington earthen levee. In addition to the storage afforded by the various detention basins across the new subdivisions (e.g., Caddens), flood storage areas also extend across the following areas:

- Chapman Gardens, Kingswood.
- South of Walker Street, Werrington.
- Edwards Close to Dunkley Place, Werrington.

### 4.2.10 Flood Emergency Response Precincts

To understand the potential emergency response requirements across different sections of the floodplain, flood Emergency Response Precinct (ERP) classifications were prepared in accordance with the floodplain risk management and SES requirements (AEMI, 2014) following the flow chart shown in **Plate 8** (Australian Emergency Management Institute, 2014). The ERP classifications can be used to provide an indication of areas which may be inundated or isolated during floods. This information, in turn, can be used to quantify the type of emergency response that may be required across different sections of the floodplain during future floods. This information can be useful in emergency response planning.

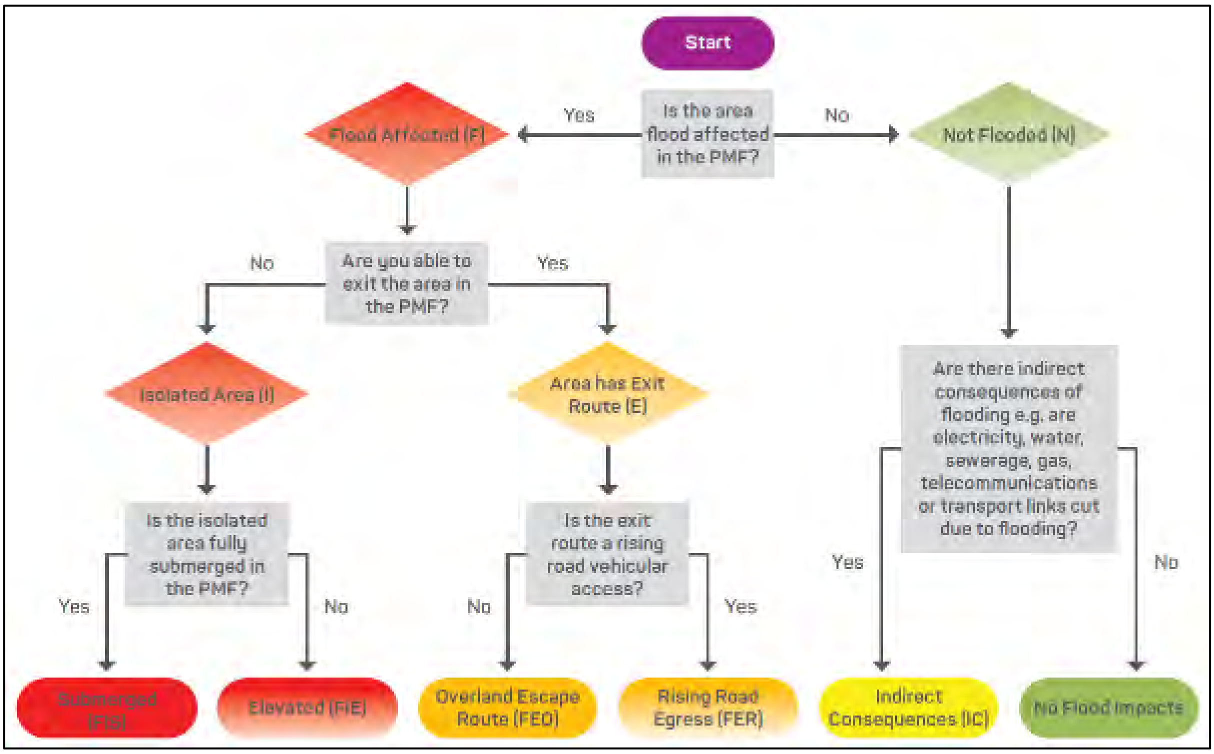



**Plate 8** Flow Chart for Determining Flood Emergency Response Classifications (AEMI, 2014).

NOTE: FIS – Flooded, Isolated and Fully Submerged in Design Flood
FIE – Flooded, Isolated with an Area Elevated Above PMF
FEO – Flooded, Exit Route via Overland Escape (vehicular access cut but evacuation on foot may be possible)
FER – Flooded, Exit Route via Rising Road (evacuation routes grade up and away from floodwaters)
IC – Not Flooded, Indirect Consequences (e.g., access cut)

Each lot within the College, Orth and Werrington Creeks Catchment Creek catchment was classified based upon the ERP flow chart for the 5% AEP, 1% AEP, 0.5% AEP, 0.2% AEP floods as well as the PMF. This was completed using the TUFLOW model results, digital elevation model and a road network GIS layer in conjunction with proprietary software that considered the following factors:

- Whether evacuation routes get 'cut off' by the depth of inundation (a 0.2 m depth threshold was used to define a 'cut' road).
- Whether evacuation routes continuously rise out of the floodplain. This criterion is applied to the nearest cross street or road, assuming it takes the flood free road to continue out of the floodplain.

- Whether properties become inundated. A property is considered inundated if more than 5% of the property is inundated by floodwaters. When a property is inundated by less than 5% of the total property area, it was considered 'elevated'.
- Indirect consequences are identified when the property is located completely outside of the flood extent. However, it is impacted by other external factors, such as roadways being cut by water which would prevent ingress and egress.

The resulting ERP classifications for the 5% AEP, 1% AEP, 0.5% AEP and 0.2% AEP floods, as well as the PMF, are provided in **Figures 43** to **47**. A range of other datasets were also generated as part of the classification process to assist Council and the SES. This includes roadway overtopping locations, which are discussed in more detail in **Section 4.3.1**.

**Figures 43** to **47** show that the most common ERP classification is 'Rising Road Egress', which indicates that evacuation routes grade up and out of the floodwaters (i.e., most people should be able to safely walk away from the floodwater to higher ground). However, there are several 'flooded isolated submerged' areas (i.e., low flood islands) and 'flooded isolated elevated' areas, which indicates that evacuation routes are likely to be cut during floods. This includes properties in the following areas:

- Hargrave Street, Kingswood.
- Bringelly Road to Paskin Street, Kingswood.
- Cox Avenue, Kingswood.
- Railway Street and Walker Street, Werrington.
- Albert Street, Werrington.
- Reid Street, Werrington.

**Figure 47** shows a significant increase in the number of 'flooded isolated submerged' (FIS) lots during the PMF. The sheer number of isolated lots and limited warning time indicates that emergency services are unlikely to have enough resources or time to assist with evacuation of all the identified lots. Therefore, a review of the flood hazard mapping was completed to determine whether the buildings located in these areas are likely to remain structurally stable should evacuation not be possible. It should be noted that the assessment was based on consideration of flood hazard categories only (i.e., properties exposed to H5 or H6 hazard) and did not include a structural assessment of individual buildings as this was beyond the scope of the current study. Therefore, the outcomes of this assessment can be considered approximate only.

This assessment determined that seven hundred and twenty seven (727) of the seven hundred and seventy two (772) Flooded Isolated Submerged (FIS) lots would not be exposed to a PMF hazard that exceeds H4. Therefore, buildings are likely to remain structurally stable across most FIS properties should evacuation not be completed. However, forty five (45) lots would be exposed to H5 or H6 hazard where the structural integrity of buildings cannot be guaranteed. A further detailed review of these lots indicates that the majority are vacant and are not zoned for urban development (e.g., Werrington Lake). However, the following locations contain buildings where evacuation is considered essential:

- Properties in Park Avenue and Heath Street at Kingswood located adjacent to Werrington Creek; and
- One property located at the western end of Irwin Street, Werrington (immediately south of Werrington Creek).

### 4.2.11 Flood Detention Basins

The College, Orth & Werrington Creeks catchment include a number of detention basins/flood storage areas. The detention basins attenuate downstream flows during storm events by temporarily storing runoff from the upstream catchment. The location of the detention basins is shown in **Plate 8**.

Peak design stages within each basin were extracted for each design storm and are provided in **Table 19**. **Table 19** also lists the basin spillway elevations (i.e., the level that water would need to reach before overtopping the basin and 'spilling' downstream). If a basin is predicted to overtop during a particular event, the corresponding cell in **Table 19** is highlighted in blue.

Peak flow velocities across the basin walls were also extracted. The velocities were extracted to gain an understanding of whether there was potential for scour and failure of the basin walls during large floods in the catchment. This information is presented in **Table 20**. It is noted that most basins located in the catchment comprise grassed embankments with no formal spillways. Information provided in the 'Queensland Urban Drainage Manual' (IPWEA, 2018) suggests that even well vegetated areas are liable to erode once the velocity exceeds 3 m/s. Therefore, overtopping velocities of more than 3 m/s are considered to pose a scour risk and are highlighted in **Table 20**

The information presented in **Table 19** shows that the level of service afforded by the detention basins differ considerably across the catchment with some basins predicted to 'spill' as frequently as the 0.5EY events while others do not overtop during floods equal to and larger than the 1% AEP flood. It is important to note that some individual basins form part of a larger 'cascading' basin arrangement (e.g., Peppermint Reserve basins). Therefore, the performance of the overall group is more important than the performance of individual basins within the grouping. In general, most basins provide sufficient capacity to cater for events up to and including the 20% AEP flood. However, very few provide capacity for floods equal to and greater than the 2% AEP flood. Of particular note is the Chapman Gardens basin which is predicted to overtop during a 20% AEP flood.

**Table 20** shows that peak basin overtopping velocities for most basins are contained well below 2 m/s. Therefore, there is likely to be a very minimal risk of erosion or scour and failure of basins within the catchment during most significant rainfall events. The one notable exception is the Chapman Gardens basin which is predicted to be exposed to velocities of around 3.5 m/s during the PMF. However, this basin does include a more formal spillway that includes a concrete apron that would be resistant to higher flow velocities. Therefore, the risk of failure during even the PMF is considered to be low.

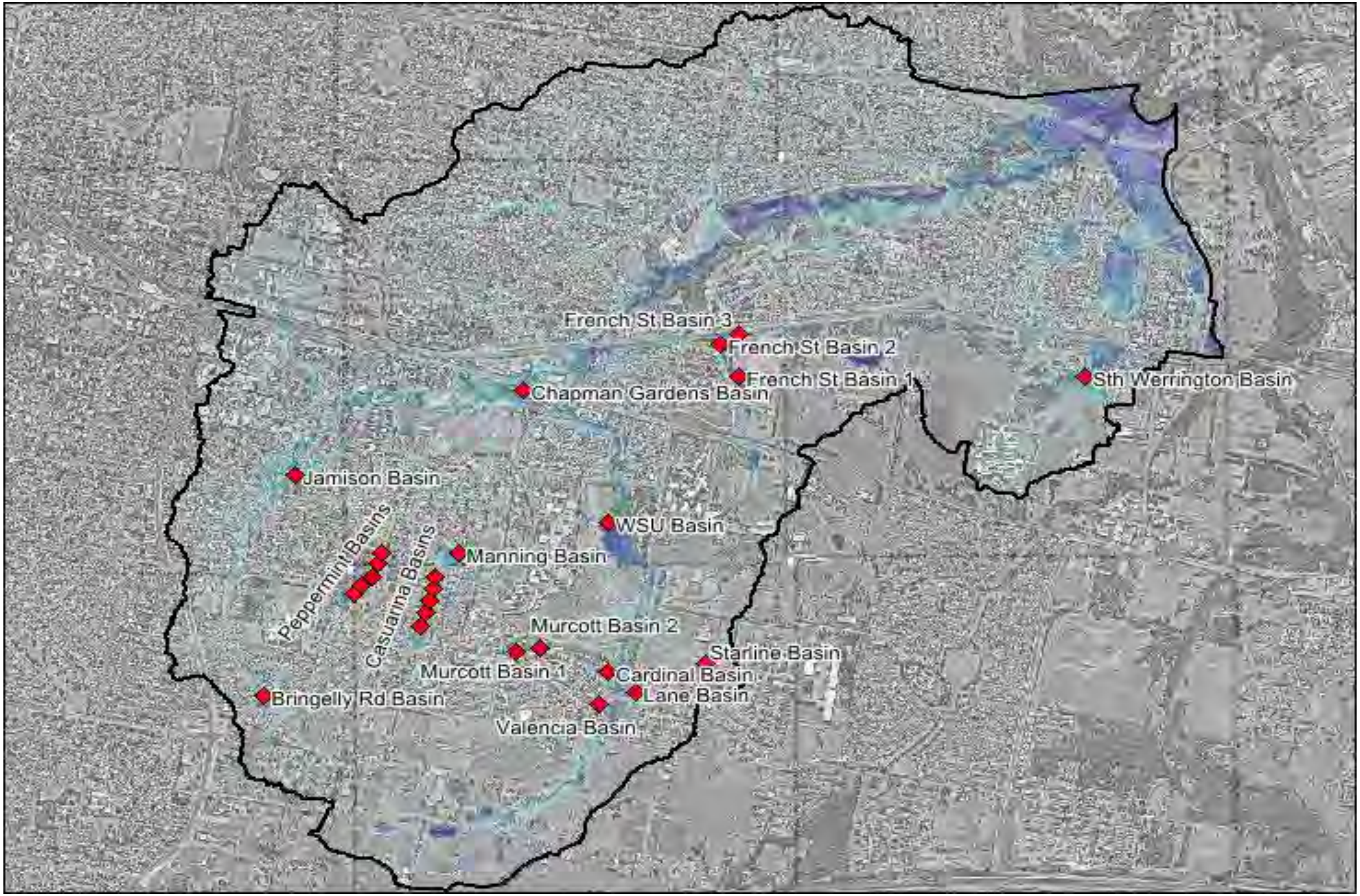



**Plate 9 Location of Flood Detention Basins**

**Table 19 Peak Design Water Levels in Flood Detention Basins**

| Basin | Basin Wall Elevation (mAHD) | Peak Water Level (mAHD) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 0.5EY | 20% AEP | 10% AEP | 5%AEP | 2%AEP | 1%AEP | 0.5% AEP | 0.2% AEP | PMF |
| Jamison Basin | 48.61 | 48.48 | 48.74 | 48.83 | 48.87 | 48.89 | 48.92 | 48.94 | 48.97 | 49.34 |
| Bringelly Rd Basin | 63.86 | 63.26 | 63.41 | 63.67 | 63.98 | 64.02 | 64.05 | 64.06 | 64.08 | 64.32 |
| Peppermint Basin 1 | 54.83 | 54.00 | 54.50 | 54.72 | 54.95 | 55.00 | 55.03 | 55.06 | 55.07 | 55.28 |
| Peppermint Basin 2 | 53.66 | 53.00 | 53.12 | 53.25 | 53.49 | 53.73 | 53.81 | 53.82 | 53.85 | 54.07 |
| Peppermint Basin 3 | 52.26 | 51.48 | 51.88 | 51.99 | 52.11 | 52.32 | 52.44 | 52.46 | 52.50 | 52.80 |
| Peppermint Basin 4 | 50.94 | 50.26 | 50.34 | 50.41 | 50.50 | 50.58 | 51.08 | 51.15 | 51.21 | 51.64 |
| Peppermint Basin 5 | 49.62 | 48.73 | 48.75 | 48.77 | 48.81 | 49.12 | 49.27 | 49.77 | 49.91 | 50.40 |
| Casuarina Basin 1 | 58.85 | 57.93 | 58.29 | 58.49 | 58.74 | 58.91 | 59.02 | 59.04 | 59.08 | 59.43 |
| Casuarina Basin 2 | 55.32 | 54.70 | 55.35 | 55.41 | 55.43 | 55.45 | 55.50 | 55.52 | 55.56 | 55.90 |
| Casuarina Basin 3 | 54.12 | 53.36 | 53.42 | 53.72 | 54.12 | 54.30 | 54.39 | 54.42 | 54.48 | 54.88 |
| Casuarina Basin 4 | 52.66 | 51.78 | 51.87 | 52.00 | 52.19 | 52.45 | 52.86 | 52.91 | 52.97 | 53.42 |
| Casuarina Basin 5 | 51.56 | 50.37 | 50.55 | 50.69 | 50.82 | 50.90 | 51.43 | 51.73 | 51.79 | 52.25 |
| Manning Basin | 50.51 | 48.82 | 49.17 | 49.36 | 49.49 | 49.60 | 49.88 | 50.03 | 50.20 | 50.97 |
| Valencia Basin | 52.69 | 52.30 | 52.22 | 52.43 | 52.63 | 52.80 | 52.83 | 52.85 | 52.86 | 53.31 |
| Cardinal Basin | 51.28 | 51.49 | 51.53 | 51.57 | 51.57 | 51.59 | 51.59 | 51.59 | 51.59 | 51.69 |
| Lane Basin | 53.50 | 51.92 | 52.12 | 52.25 | 52.37 | 52.53 | 52.57 | 52.62 | 52.69 | 53.12 |
| Murcott Basin 1 | 55.57 | 55.65 | 55.71 | 55.77 | 55.79 | 55.84 | 55.89 | 55.91 | 55.91 | 56.22 |
| Murcott Basin 2 | 54.51 | 54.14 | 54.72 | 54.86 | 54.94 | 55.04 | 55.07 | 55.11 | 55.12 | 55.40 |
| WSU Basin | 42.73 | 42.37 | 42.62 | 42.94 | 43.06 | 43.11 | 43.17 | 43.19 | 43.22 | 43.88 |
| Starline Basin | 58.55 | 57.98 | 58.17 | 58.23 | 58.33 | 58.52 | 58.63 | 58.73 | 58.74 | 59.09 |
| French St Basin 1 | 39.27 | 39.20 | 39.20 | 39.20 | 39.20 | 39.20 | 39.41 | 39.49 | 39.54 | 39.79 |
| French St Basin 2 | 36.45 | 36.63 | 36.67 | 36.71 | 36.74 | 36.76 | 36.76 | 36.77 | 36.84 | 37.40 |
| French St Basin 3 | 36.91 | 36.03 | 36.66 | 37.01 | 37.12 | 37.17 | 37.21 | 37.22 | 37.24 | 37.44 |
| Chapman Gardens Basin | 37.29 | 36.73 | 37.41 | 37.50 | 37.54 | 37.57 | 37.59 | 37.59 | 37.61 | 38.07 |
| Sth Werrington Basin | 23.88 | 23.09 | 23.64 | 23.84 | 23.96 | 24.06 | 24.11 | 24.13 | 24.17 | 25.30 |

**Table 20 Peak Overtopping Velocities for Flood Detention Basins**

| Basin | Peak Basin Overtopping Velocity (m/s) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 0.5EY | 20% AEP | 10% AEP | 5%AEP | 2%AEP | 1%AEP | 0.5% AEP | 0.2% AEP | PMF |
| Jamison Basin | | 0.4 | 1.0 | 1.2 | 1.3 | 1.4 | 1.5 | 1.5 | 2.5 |
| Bringelly Rd Basin | | | | 0.5 | 0.7 | 1.0 | 1.0 | 1.1 | 1.6 |
| Peppermint Basin 1 | | | | 0.4 | 0.7 | 0.8 | 1.0 | 1.0 | 1.5 |
| Peppermint Basin 2 | | | | | 0.2 | 0.6 | 0.7 | 0.8 | 1.4 |
| Peppermint Basin 3 | | | | | 0.1 | 0.7 | 0.8 | 0.9 | 1.6 |
| Peppermint Basin 4 | | | | | | 0.5 | 0.8 | 1.0 | 1.7 |
| Peppermint Basin 5 | | | | 0.2 | 0.2 | 0.3 | 0.6 | 1.3 | 2.3 |
| Casuarina Basin 1 | | | | | 0.2 | 0.7 | 0.8 | 1.0 | 1.8 |
| Casuarina Basin 2 | | | 0.2 | 0.3 | 0.4 | 0.7 | 0.8 | 1.0 | 1.6 |
| Casuarina Basin 3 | | | | | 0.5 | 0.9 | 1.0 | 1.1 | 1.8 |
| Casuarina Basin 4 | | | | | | 0.5 | 0.6 | 0.7 | 1.7 |
| Casuarina Basin 5 | | | | | | | 0.4 | 0.9 | 2.0 |
| Manning Basin | | | | | | | | | 1.9 |
| Valencia Basin | | | | | 0.5 | 0.7 | 0.9 | 1.1 | 1.8 |
| Cardinal Basin | 0.7 | 1.0 | 1.2 | 1.3 | 1.3 | 1.3 | 1.4 | 1.4 | 1.9 |
| Lane Basin | | | | | | | | | |
| Murcott Basin 1 | 0.1 | 0.4 | 0.6 | 0.6 | 0.7 | 0.9 | 0.9 | 0.9 | 1.7 |
| Murcott Basin 2 | | 0.3 | 0.5 | 0.7 | 0.9 | 0.9 | 1.0 | 1.0 | 1.4 |
| WSU Basin | | | 0.3 | 0.6 | 0.7 | 0.8 | 0.9 | 1.0 | 2.5 |
| Starline Basin | | | | | | 0.1 | 0.4 | 0.4 | 1.3 |
| French St Basin 1 | | | | | | 0.1 | 0.2 | 0.4 | 1.1 |
| French St Basin 2 | 0.2 | 0.3 | 0.3 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 1.3 |
| French St Basin 3 | | | 0.1 | 0.7 | 1.0 | 1.2 | 1.2 | 1.3 | 2.0 |
| Chapman Gardens Basin | | 0.9 | 1.4 | 1.6 | 1.7 | 1.8 | 1.8 | 1.9 | 3.5 |
| Sth Werrington Basin | | | | | 0.4 | 0.5 | 0.6 | 0.7 | 1.3 |

## 4.3 Impacts of Flooding on the Community

### 4.3.1 Transportation Links

There are several major roadways within the catchment which may be required for evacuation or emergency services access during floods. It is important to understand the impacts of flooding on these roads so that appropriate emergency response planning can occur.

An assessment of the location where roadways are first predicted to be overtopped was completed as part of the Flood Emergency Response Precinct classifications discussed in **Section 4.2.10**. The roadway overtopping locations are shown as yellow dots in **Figures 43** to **47**. The numbering on the yellow dots relates to the information presented in the Table included in **Appendix C** that includes details of the duration the roadway is cut, the time the roadway is first cut after the onset of rainfall, the peak depth and the peak velocity estimated at that location. This information is provided for the 0.5EY, 20% AEP, 10% AEP, 5% AEP, 1% AEP, 0.5% AEP, 0.2% AEP and PMF design flood events.

The flood modelling results were interrogated at each roadway overtopping location to confirm:

- The amount of time from the initial onset of rainfall until access is cut.
- The amount of time the roadway would be cut.
- The peak water depth.
- The peak flow velocity.

This information for the entire catchment is presented in **Appendix C**. This information is provided for the 0.5EY, 20% AEP, 10% AEP, 5% AEP, 1% AEP, 0.5% AEP, 0.2% AEP and PMF design flood events. The total number of road segments cut was also calculated and is presented in **Table 21**.

**Table 21 Number of Road Segments Where Access Would be Cut During Each Design Flood**

| Design Flood | Number of Road Segments Cut |
|---|---|
| 0.5EY | 5 |
| 20% AEP | 39 |
| 10% AEP | 61 |
| 5% AEP | 90 |
| 2%AEP | 122 |
| 1%AEP | 147 |
| 0.5% AEP | 150 |
| 0.2% AEP | 158 |
| PMF | 257 |

In addition to the detailed inundation information presented in **Appendix C** for each road in the catchment, road inundation depths for major and heavily trafficked roads in the College, Orth and Werrington Creeks Catchment where also extracted. The location where major roads are predicted to be cut by floodwaters is shown in **Plate 10** and the associated floodwater depths at each location during each design flood are presented in **Table 22**.

The information presented in **Appendix C** indicates that access would be cut along several roadways in events as frequent as the 0.5EY flood. The roadways most susceptible to inundation include:

- Balmoral Drive, Cambridge Park.
- Dunkley Place, Werrington.
- Railway Street, Werrington.
- Chapman Street, Werrington.

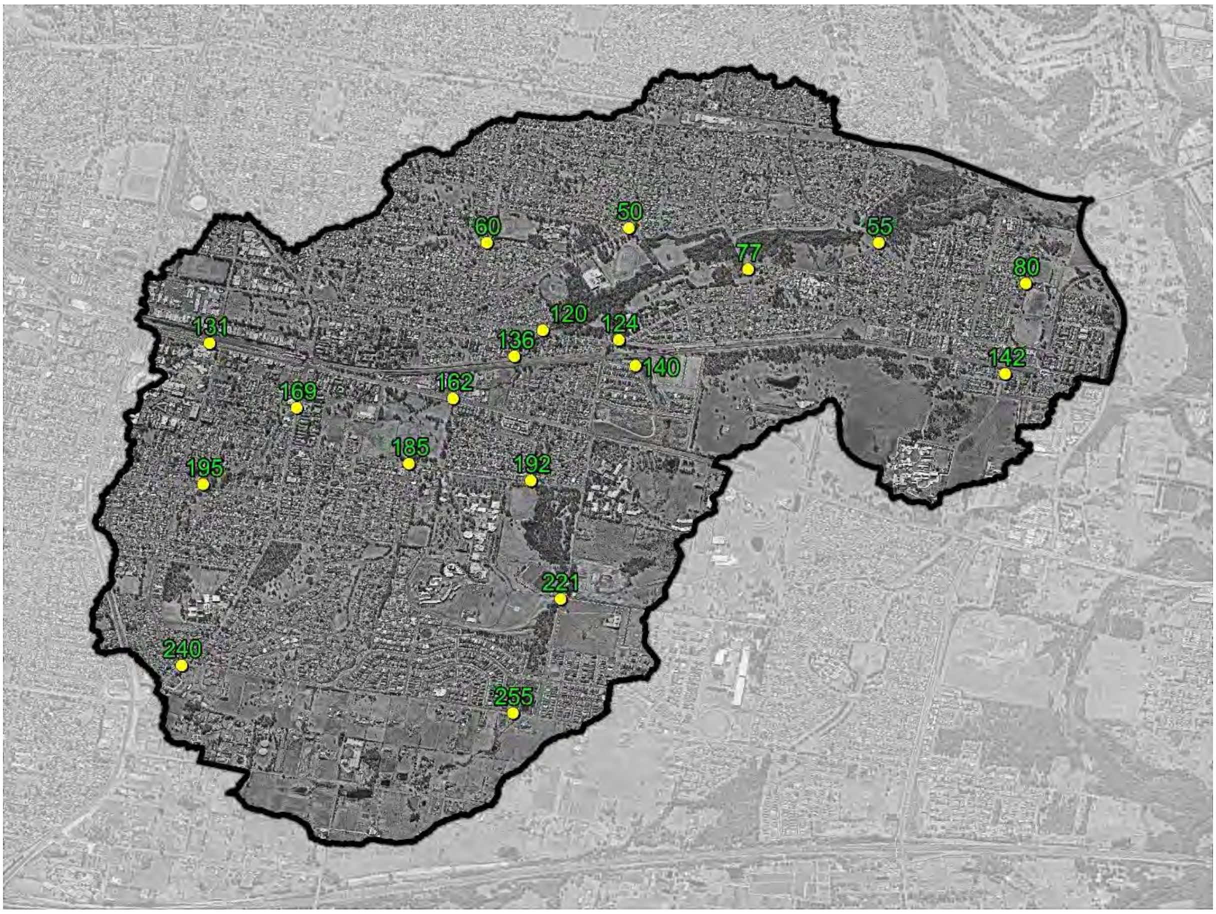



**Plate 10 Location of over topping on main road locations in College, Orth and Werrington Creeks Catchment**

**Table 22** shows that there are several major roads that extend through the catchment where inundation is likely to cause significant disruption and, owning to the highly trafficked nature of these roads, increases the potential for motorists to attempt to drive through floodwaters. These roads include (listed from most susceptible to least susceptible):

- Bringelly Road: Access would be cut during a 10% AEP event near Orth Street about 30 minutes after rainfall commences.
- John Oxley Avenue: Access would be cut during a 10% AEP event near Heavy Street about 30 minutes after rainfall commences.
- Dunheved Road: Access would be cut during a 5% AEP event near John Oxley Avenue about 10 minutes after rainfall commences.
- Jamison Road: Access would be cut during a 5% AEP event near Clemson Street approximately 15 minutes after rainfall commences.
- Great Western Highway: Access would be cut near Chapman Gardens during a 2% AEP event about 30 minutes after rainfall commences.
- Victoria Street: Access would be cut during a 0.2% AEP event near Shaw Street about 1 hour after rainfall commences.

**Table 22 Peak depths at road overtopping locations for main roads**

| Road Overtopping ID* | Road Name | Peak Depth (metres) | | | |
|---|---|---|---|---|---|
| | | 20% AEP | 5% AEP | 1% AEP | PMF |
| 50 | Herbert Street | - | 0.27 | 0.34 | 0.97 |
| 55 | John Oxley Ave | - | - | 0.44 | 1.78 |
| 60 | Wrench Street | - | 0.2 | 0.26 | 0.5 |
| 77 | Burton Street | - | 0.18 | 0.22 | 1.61 |
| 80 | Princess Street | 0.67 | 0.99 | 1.06 | 2.49 |
| 120 | Victoria Street | - | - | - | 2.04 |
| 124 | Victoria Street | - | 0.26 | 0.28 | 0.7 |
| 125 | Victoria Street | 0.14 | 0.18 | 0.2 | 1.5 |
| 131 | Great Western Hwy | 0.15 | 0.19 | 0.2 | 0.36 |
| 136 | Heath Street | - | - | 0.13 | 1.66 |
| 140 | Albacus Street | - | - | 0.22 | 0.54 |
| 142 | Landers Street | 0.37 | 0.68 | 1.17 | 2.8 |
| 162 | Great Western Hwy | - | - | 0.33 | 1.23 |
| 169 | Bringelly Road | - | 0.28 | 0.45 | 1.61 |
| 185 | Second Ave | - | | 0.15 | 0.66 |
| 192 | Second Ave | - | - | - | 1.43 |
| 195 | Jamison Road | - | - | 0.21 | 0.96 |
| 221 | O'Connell Street | - | 0.21 | 0.33 | 1.04 |
| 240 | Bringelly Road | - | - | 0.18 | 0.47 |
| 255 | Caddens Road | - | | - | 0.77 |

*Numbering maintained as per **Appendix C**. Refer to **Figures 43** to **47** for a full outline of all road overtopping locations.

It should be noted that when reviewing the road inundation information, the inundation times are based on the critical design floods. That is, the storm duration that produced the highest peak flood levels. However, no two rainfall events or floods are the same. Therefore, there is potential for extended periods of rainfall (i.e., longer than the critical duration for the catchment) to inundate roads for longer periods. Similarly, shorter rainfall 'bursts' may cut the roads sooner even if they do not generate the maximum inundation depths. Therefore, the road inundation times and depths should be taken as indicative rather than precise.

It should be noted that under no circumstances should vehicles attempt to drive through floodwaters, regardless of the floodwater depth or the type of vehicle they are driving.

### 4.3.2 Vulnerable and Critical Infrastructure

The College, Orth and Werrington Creeks catchment is home to a range of property types and infrastructure. This includes facilities where the occupants may be particularly vulnerable during floods, such as aged care facilities and schools. In addition, some facilities will play important roles for emergency response and evacuation purposes during future floods. Therefore, it is important to understand the potential vulnerability of these facilities during a range of floods.

A summary of vulnerable and critical facilities located within the catchment was provided in **Section 2.3.3** and the location of each facility is shown on **Figure 4**. **Figure 49** indicates the vulnerability of the critical and vulnerable facilities in relation to the 5% AEP, 1% AEP and PMF design flood events in the College, Orth and Werrington Creeks catchment.

The flood modelling results were interrogated to extract the following information in the vicinity of each facility during each design flood:

- Evacuation and accessibility
  - Whether access to or from the property is cut.
  - The amount of time before access if cut relative to the initial onset of rainfall.
  - How long access to and from the facility would be cut.
- Facility impacts
  - Amount of time before inundation of the property commences.
  - Amount of time the property would remain submerged.
  - Above floor flooding depth.
  - Maximum water depth.
  - Maximum flow velocity.
  - Maximum flood hazard.

This information is provided in **Appendix D** for the 5% AEP, 1% AEP floods as well as the PMF. **Figure 49** also represents the location of these critical and vulnerable facilities in relation to the 5% AEP, 1% AEP and PMF design flood extents.

The information presented in **Appendix D** shows that many critical and vulnerable facilities are subject to at least partial inundation during events as frequent as the 5% AEP flood. However, in most cases, the depth and velocity of floodwater is unlikely to be sufficient to pose a hazard to people (i.e., greater than H3 hazard). The main exceptions to this are part sections of the following facilities:

- Anglicare Newmarch House (H5); and
- Montgrove College (H5).

Access would also be cut to some of these facilities during the 5% AEP, including:

- Pump station at 43A Princess Street, Werrington
- Falguni Family Day Care.

There may be a propensity for parents of Falguni Family Day Care attendees to drive through flood waters to 'rescue' their children. Therefore, it is considered worthwhile educating parents to point out that the day care is subject to low hazard conditions and their children will be much safe sheltering in the existing building.

During the PMF, most critical and vulnerable facilities would be exposed to greater than H3 hazard conditions. Of note are the following facilities whose occupants are likely to be more susceptible to the impacts of flooding:

- Heritage Kingswood Aged Care Facility (29 George St, Kingswood)
- Learning Adventures Kingswood (30 George St, Kingswood)
- Kingswood World of Learning (38 First St, Kingswood); and
- Mission Australia Family Day Care (46 Bringelly Rd, Kingswood).

It should be noted that the reported hazard values refer to the hazard external to the buildings. It is likely that a much lower and more tolerable hazard will be experienced within the buildings. As an example, most buildings are not predicted to experience above floor flooding during floods up to and including the 1% AEP flood. Therefore, it is likely to be much safer to stay inside of the facilities than try to evacuate by driving through floodwaters, providing the buildings are not structurally damaged during the flood (as outlined above, this is unlikely to occur even during a PMF).

### 4.3.3 The Cost of Flooding

To assist in quantifying the current financial impacts of flooding on the community, a flood damage assessment was also completed. The flood damage assessment is intended to estimate flood damage costs across the catchment for existing conditions across the full range of design floods for residential, commercial and industrial properties as well as infrastructure. This includes damage associated with above floor inundation as well as damage to properties even when above floor flooding is not predicted (e.g., damage to garden sheds, fences etc). A detailed description of the approach used to establish the flood damage cost estimates is provided in **Appendix B**.

***Property Database***

A property database was developed as part of the study to enable damage calculations to be prepared across residential, commercial and industrial properties. The database was developed in GIS and included floor levels for all habitable buildings located within the PMF extent. For residential dwellings, the lowest habitable floor level was estimated, with the lowest operational or functioning floor level of commercial and industrial properties estimated.

Floor levels were estimated using a ‘drive by’ survey technique. This was completed using Google Street View and was supplemented with site visits where buildings were not visible in Street View. The floor level was estimated by counting the number of steps between the ground level of the property and the front door. The number of steps were then multiplied by the step riser height (170mm height for brick steps and variable height for concrete steps) which was then combined with the LiDAR DEM to provide the floor level estimate. A total of 2,336 properties were incorporated in the property database with approximately 300 of these properties visited in the field.

The property database also included characteristics of each building such as property type (i.e., residential, commercial or industrial), number of building floor levels, building floor area, number of storeys, building material types and the value of the contents for commercial and industrial properties (low, medium, high).

The property database also estimated the density of development per residential lot. The range of density of development include:

- single dwelling only per lot with an average building size of 150m$^2$.
- medium density with up to three buildings per lot. Generally, multi storey and a total average building size of 600m$^2$.
- high density with four or more buildings per lot with multi storey buildings and a total average building size of 720m$^2$.

### *Damage Calculations*

As outlined in **Appendix B**, flood damage estimates were prepared for each potentially flood liable property in the catchment by comparing the design flood level estimates with the floor levels for each property to determine an above floor flooding depth for each design flood. The above floor flooding depths were then combined with flood damages curves (relationships that describe the typical damage cost relative to the depth of above floor flooding) to provide a flood damage estimate for each property for each design flood.

The flood damage calculations account for the following types of damage that can be readily accounted for in monetary terms:

- Direct damage costs which are costs associated with water coming into direct contact with buildings and contents; and
- Indirect damage costs which are costs incurred outside of the specific inundation event, such as clean-up costs and loss of trade (for commercial and industrial properties).

Costs that cannot be readily accounted for in monetary terms (e.g., emotional stress) were not included in the damage calculations.

As part of the damage cost calculations, the number of properties subject to above floor inundation during each design flood was calculated. This information is summarised in **Table 23**. The number of properties subject to property damage (even if above floor flooding is not predicted) are also provided in **Table 23**. This includes damage to external items such as fences, sheds and garages. The frequency of above floor flooding (i.e., the design event at which above floor flooding is first predicted to occur) was also mapped and is shown in **Figure 48**.

**Table 23** shows that above floor inundation is not predicted to occur across any residential properties until the 20% AEP flood. During the 1% AEP event, nearly seventy (70) residential properties are predicted to experience above floor inundation (and more than hundred and eighty-nine (189) more are predicted to be damaged). During the PMF, nine hundred and twenty-eight (928) properties are predicted to be inundated above floor level and a further six hundred and twenty-four (624) are predicted to be damaged.

The damage estimates for each design flood are summarised in **Table 24** for existing conditions. It indicates that if a 1% AEP flood was to occur, nearly $9 million worth of damage could be expected. Most of the damage would be incurred across residential properties.

**Table 23 Number of Properties Subject to Above Floor Inundation and Property Damage**

| Flood Event | Residential | | Commercial and Industrial | | Total Number | |
|---|---|---|---|---|---|---|
| | External Damaged | Above Floor Inundation | External Damaged | Above Floor Inundation | External Damaged | Above Floor Inundation |
| 0.5EY | 10 | 0 | 1 | 1 | 6 | 1 |
| 20% AEP | 24 | 5 | 3 | 3 | 27 | 8 |
| 10% AEP | 69 | 12 | 9 | 9 | 78 | 21 |
| 5% AEP | 121 | 21 | 17 | 17 | 138 | 38 |
| 2% AEP | 144 | 45 | 21 | 21 | 165 | 66 |
| 1% AEP | 189 | 69 | 29 | 29 | 218 | 98 |
| 0.5% AEP | 215 | 81 | 33 | 33 | 248 | 114 |
| 0.2% AEP | 240 | 101 | 38 | 38 | 278 | 139 |
| PMF | 550 | 854 | 74 | 74 | 624 | 928 |

**Table 24 Summary of Flood Damages for Existing Conditions**

| Flood Event | **Flood Damages** ($ millions) | | | Incremental Contribution to Average Annual Damage |
|---|---|---|---|---|
| | Residential | Commercial and Industrial | Total Damages | |
| 0.5EY | 0.03 | 0.05 | **0.08** | $11,274 |
| 20% AEP | 0.51 | 0.08 | **0.60** | $100,534 |
| 10% AEP | 1.57 | 0.40 | **1.97** | $128,214 |
| 5% AEP | 2.86 | 0.97 | **3.83** | $144,899 |
| 2% AEP | 4.62 | 1.39 | **6.01** | $147,571 |
| 1% AEP | 6.99 | 1.96 | **8.95** | $74,790 |
| 0.5% AEP | 8.19 | 2.27 | **10.47** | $48,532 |
| 0.2% AEP | 10.31 | 2.94 | **13.25** | $35,571 |
| PMF | 83.90 | 12.33 | **96.23** | $109,428 |
| | | | **TOTAL AAD** | $800,812 |

The damage estimates were also used to prepare an Average Annual Damage (AAD) estimate for each property. The AAD provides an estimate of the average annual cost of inundation across the study area over an extended timeframe (in effect, how much money would be need to set aside each year in order to pay for flood damage costs). The AAD for the catchment was calculated as $800,812. Therefore, if the 'status quo' was maintained, residents and business owners within the catchment as well as infrastructure providers, such as Council, would likely be subject to cumulative flood damage costs of around $800,000 per annum (on average).

## 4.4 Impacts of Levee and Flood Gate Failure

The suburb of Werrington is protected from South Creek flooding by two levees:

- Werrington Road Levee (located in the eastern side of Werrington Road) which affords protection from South Creek flooding; and
- Werrington Earthen Levee (located between Reid Street and Dunheved Road) which affords protection from South Creek and Werrington Creek flooding.

Although the levees are designed to protect the community from flooding, it may increase the flood risk under certain circumstances, such as:

- The levee may impede floodwaters draining from the local catchment into Werrington and South Creeks (i.e., increasing flood levels on the upstream side of the levee).
- If the levee fails during a flood, it could result in a sudden release of water leading to high velocities and rapid increases in flood levels behind the levee.

To gain an understanding of these potential risks, two levee sensitivity simulations were completed. This included:

- <u>No earthen levee</u>: This was completed to determine if the existing levee may serve to impede local runoff; and
- <u>Failure of earthen levee</u>: This was completed to determine if sudden failure of the levee would increase the flood risk for those living behind the levee.

The levee failure simulations focussed on the Werrington earthen levee only as the Werrington Road levee was previously assessed as part of the 'South Creek Floodplain Risk Management Study' (Advisian, 2020). The tail water levels in South Creek remained at a static level during these simulations.

Runoff is drained through each levee via culverts that are fitted with flood gates. The flood gates are designed to close when there are elevated water levels in South Creek and in Werrington Creek, thereby preventing water 'backing up' through the culvert and inundating the area behind the levee. At the same time, when the water level behind the levee is elevated, it allows that water to drain from behind the levee. If the flood gates were fully closed (e.g., debris on the downstream end of culvert prevented the gates from opening), it would prevent the area behind the levee from draining freely. Therefore, an additional sensitivity simulation was completed assuming that both flood gates remained fully closed during each design flood.

### 4.4.1 No Levee Simulation

The 'no earthen levee' simulations were completed by removing the levee from the terrain representation in the TUFLOW model. The updated TUFLOW model was then re-run for the design 5% AEP, 1% AEP, 0.5% AEP and 0.2% AEP floods as well as the PMF. Flood level difference mapping was prepared to show the magnitude and extent of changes in flood levels associated with completely removing the levee. The difference mapping is presented in **Appendix E**.

Additional design simulations were also completed based on a 1% AEP South Creek water level and a 5% AEP local catchment flood. The difference mapping for this simulation is also provided towards the end of **Appendix E**.

As shown in **Appendix E**, removing the existing levee completely is predicted to reduce existing design flood levels on the upstream (i.e., southern side of the levee). In general, the magnitude of the reduction is proportional to the size of the flood (i.e., higher reductions in flood levels during larger floods). Flood level reductions during the 5% AEP, 1% AEP, 0.5% AEP and 0.2% AEP floods typically vary between 0.05 metres and 0.08 metres. However, during the PMF, the flood level reductions are predicted to exceed 0.4 metres.

Therefore, the Werrington earthen levee does appear to impede the "escape" of water from the local catchment into Werrington Creek. However, the magnitude of the flood level increases associated with the levee are minor during events up to and including the 0.2% AEP flood. It is only during the PMF that the flood level reductions are predicted to exceed 0.1 metres.

### 4.4.2 Levee Failure Simulation

The levee breach or failure simulation was completed by re-simulating the design 5% AEP, 1% AEP, 0.5% AEP and 0.2% AEP floods as well as the PMF. However, the terrain was dynamically modified to reflect the progressive failure of the levee embankment. It was assumed that the breach originated in the centre of the embankment and propagated to form a trapezoidal shape, as shown in **Plate 11.**

A range of alternate breach parameters were trialled as part of the assessment. The levee failure parameters (i.e., time and shape of the breach) were ultimately defined based upon recommendations in Von Thun and Gillette (1990) as they comprised the smallest breach development time and, therefore, are likely to provide the most conservative assessment of the impacts associated with levee failure. The adopted failure parameters are summarised in **Table 25** and **Plate 12.**

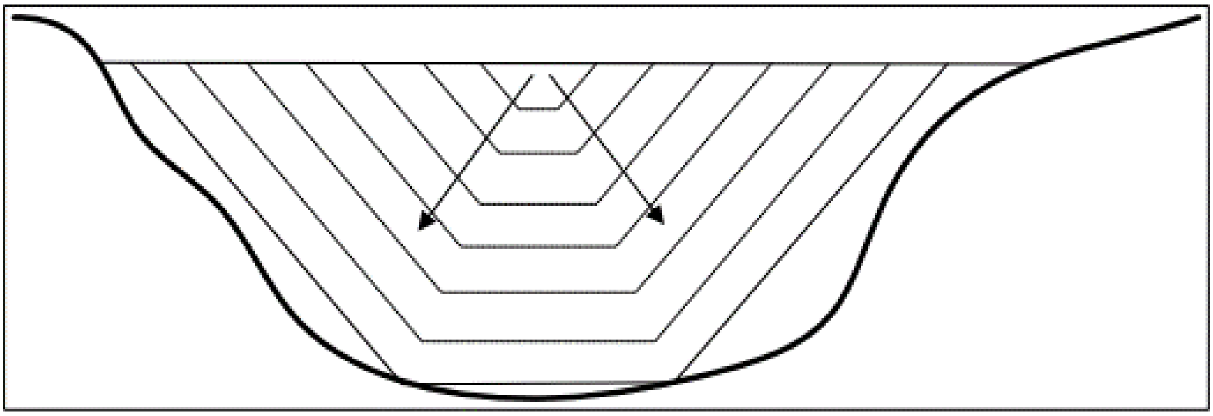


Plate 11 Adopted levee failure breach propagation.

**Table 25 Adopted Levee Breach Parameters**

| Breach Parameter | | Value |
|---|---|---|
| $W_b$ (metres) | Refer **Plate 12** | 9.3 |
| $B_t$ (metres) | | 13.5 |
| $H_b$ (metres) | | 2.1 |
| Side Slope | | 1:1 |
| Breach Development Time (minutes) | | 17.4 |

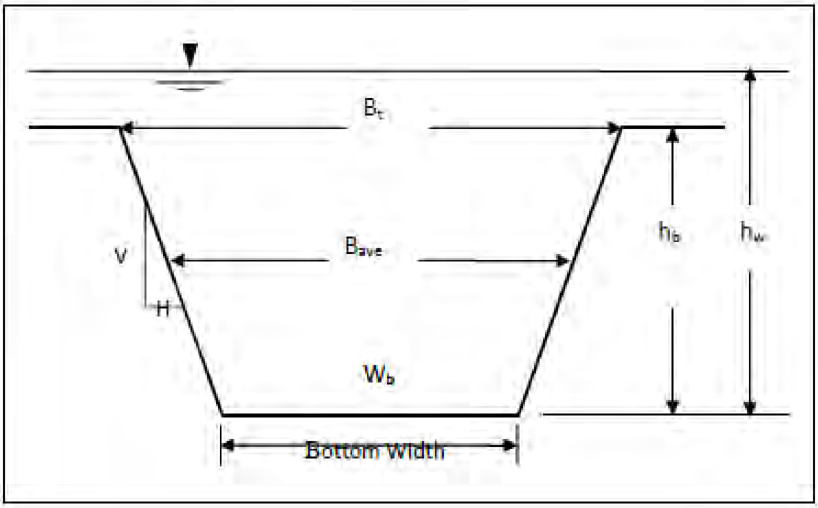



**Plate 12 Key levee failure parameters. The trapezoidal shape reflects the ultimate breach shape.**

Initial levee failure simulations were completed assuming the failure occurred at the same time as the peak water level behind the levee (i.e., peak local catchment water level). However, in all cases, the receiving water level within Werrington Creek was lower than the water level behind the levee resulting in the levee breach allowing water to 'escape' into Werrington Creek and South Creek rather than 'rushing' from Werrington Creek and South Creek into the area behind the levee. A variety of alternate breach times were also investigated but the outcomes were similar (i.e., breaching the levee allowed floodwaters to more readily escape from behind the levee).

**Appendix E** provides flood level difference mapping for a scenario where the levee breached 20 minutes after the onset of rainfall (approximately 2 hours before flood levels peaked behind the levee). The difference mapping shows similar flood level differences for events up to and including the 0.2% AEP flood. More specifically, it shows negligible changes in flood levels behind the levee, and small increases in flood level in Werrington Creek immediately north of the levee.

It should be noted that this study is focussed on flooding from the local Werrington Creek catchment. If a levee breach was to occur during a large South Creek flood, it is likely that elevated water levels would be experienced across the Werrington area. Therefore, the levee is still considered to be a valuable flood mitigation measure to protect against South Creek flooding even if it does not afford significant benefits during local catchment floods.

### 4.4.3 Levee Flood Gates 'Closed' Simulation

The 'flood gates closed' simulations were completed by fully blocking both the Werrington earthen levee and Werrington Road levee flood gates (i.e., flow cannot move in either direction through the levee culverts). The updated TUFLOW model was then re-run for the design 5% AEP, 1% AEP, 0.5% AEP and 0.2% AEP floods as well as the PMF. Flood level difference mapping was prepared to show the magnitude and extent of changes in flood levels associated with the flood gates remaining completely open during each design flood. The difference mapping is presented in **Appendix E**.

Additional design simulations were also completed based on a 1% AEP South Creek water level and a 5% AEP local catchment flood. The difference mapping for this simulation is also provided towards the end of **Appendix E**.

The difference mapping shows that if both flood gates were to remain fully closed, it would result in notable increases in flood level behind the levee. More specifically, flood level increases of between 0.2 to 0.3 metres are predicted across much of the Werrington area.

Therefore, if the levee flood gates were to remain closed during local catchment floods, it will likely increase flood levels and extents behind the levee. This highlights the importance of regular maintenance of the flood gates to ensure they function as designed (i.e., allow water to escape through the levee during local catchment floods and preventing backwater flooding during large South Creek and Werrington Creek floods.

## 4.5 Impacts of Future Catchment Development

The College, Orth & Werrington Creeks catchment is already significantly developed. However, there are parts of the catchment that are currently undeveloped and have the potential to be developed in the future. Furthermore, there are some areas where there is potential for intensification of development (e.g., single dwellings being replaced by townhouse developments).

This future development has the potential to alter existing flood behaviour which may impact on the existing flood risk across the catchment. Therefore, additional flood simulations were completed to determine what impacts this development may have on the existing flood risk.

The future catchment scenario was broken down into two main components:

- Areas that have the potential to be rezoned and newly developed in the future.
- Areas that are already developed but the current zoning (as detailed in the Penrith Local Environmental Plan 2010) would allow intensification of development.

Penrith City Council strategic planners were consulted to identify areas that have the potential to be rezoned in the future to promote further urban expansion. This included:

- Orchard Hills, south of Caddens Road (rezoned from RU4 to R1)
- Western Sydney University, Kingswood campus (no change of zoning but expansion of existing facilities)

- Western Sydney University, Werrington campus (rezoned from B7 and RE1 to R3, B2, SP2 and RE1); and
- Nepean TAFE (no change of zoning but expansion of existing facilities).

As the future 'make up' of these areas is not known, assumptions were made regarding the likely land use composition. This was informed based upon reviewing available planning documents as well as similar adjoining development (e.g., the future Orchard Hills area was assumed to comprise a similar land use to the Caddens subdivisions). This information, in turn, was used to calculate average impervious percentages for each land use that were used as the basis for updating the TUFLOW model (refer **Table 26**).

Table 26 Adopted land use information for future development assessment

| Land Use Zone | % of Catchment | Zone Description | Impervious Percentage | |
|---|---|---|---|---|
| | | | Current | Adopted Future |
| R1 | 10 | General residential | 65 | 70 |
| R2 | 40 | Low density residential | 52 | 65 |
| R3 | 17 | Medium density residential | 62 | 85 |
| R4 | 2.4 | High density residential | 71 | 95 |
| WSU (Kingswood) | 3.7 | Expansion of existing campus<br>New recreation area | 38 | 75<br>5 |
| WSU (Werrington) | 2.4 | R3 and B2<br>SP2<br>RE1 | 10 | 85<br>70<br>5 |
| Nepean TAFE | 1.9 | Expansion of existing campus | 34 | 70 |

Those areas that are already developed but are likely to be redeveloped in the future were also identified. This was completed by reviewing land use zoning information relative to contemporary aerial imagery. This review determined that redevelopment was already occurring across some R3 and R4 zoned areas but there was potential for that redevelopment to continue in other areas. Similarly, there was potential for further 'granny flat' type development across R2 zoned areas. To provide a conservative assessment of the potential impacts of this potential development, it was assumed that all R2, R3 and R4 areas would be developed to the full extent possible under the current zoning. The impervious proportions that were adopted are summarised in **Table 26**.

It should be noted that no provision for onsite detention was included in this assessment. Therefore, the results reflect no attempt to mitigate any increases in onsite runoff.

The updated impervious values were applied to an updated 'ultimate catchment development' version of the TUFLOW model. The updated model was used to re-simulate the 5% AEP, 1% AEP, 0.5% AEP and 0.2% AEP floods, as well as the PMF under potential future catchment development conditions.

Flood level difference mapping was also prepared to quantify the impact that future catchment development is predicted to have on 'existing' design flood levels across the catchment. The difference mapping is presented in **Appendix F**.

The difference mapping indicates that during the 5% AEP flood, future development is predicted to generate increases in flood levels along each of the main creeks as well as isolated increases along overland flow paths. However, the magnitude of the increases typically does not exceed 0.05 metres.

During the 1% AEP, 0.5% AEP and 0.2% AEP floods, flood level increases are predicted to be more prominent and extend across a larger area. However, across most areas, the magnitude of the flood level increases does not exceed 0.1 metres. The most notable exceptions are on the southern side of the railway line at the Werrington Creek culvert crossing as well as near the Werrington train station. At these locations, flood level increases of between 0.1 and 0.2 metres are anticipated. Accordingly, future catchment development does have the potential to increase the existing flood risk across these already problematic areas.

Relatively minor flood level increases are predicted during the PMF. This is associated with the sheer volume of runoff during the PMF which 'drowns out' the comparatively small increases in runoff from the future development areas.

Overall, the results of the future catchment simulations show that future catchment development with no onsite detention is predicted to cause increases in existing flood levels along each creek as well as most overland flow paths. Although the magnitude of the flood level increases typically does not exceed 0.1 metres, it is predicted to result in more significant flood level increases on the southern side of the railway line, which is already significantly impacted. Accordingly, any further increases in flood levels at these locations is undesirable and efforts will need to be made to ensure runoff from future catchment development is managed to ensure adverse flood impacts are mitigated.

### 4.5.1 Planning Proposal for Land at the Corner of Somerset Street and Rodgers Street, Kingswood

Penrith City Council lodged a planning proposal in 2018 to amend the Penrith LEP 2010 for 7 parcels of land located at the corner of Rodgers Street and Somerset Street at Kingswood. The planning proposal sought to rezone the parcels from RE1 (public recreation) to B4 (mixed use).

This area is subject to overland flooding. Therefore, the planning proposal included a stormwater and overland flow management plan (Martens, 2018). The proposed stormwater management system included:

- Realigning a 1.35 metre pipe that currently traverses the area diagonally.
- Provision of a new 0.9 metre diameter pipe near the intersection of Rogers Street and Somerset Street.
- Provision of additional stormwater inlets on Rodgers Street.

Due to the potential for the proposed rezoning and development of this land to impact on existing flood behaviour, a dedicated flood impact assessment was completed as part of the current study. The flood impact assessment considered the following scenarios:

- Scenario 1: Stormwater drainage modifications with no earthworks (i.e., existing ground surface elevations are retained). This was completed to gain an understanding of what impacts the stormwater modifications would have on existing flood behaviour in isolation.
- Scenario 2: Stormwater drainage modifications and filling of the site. This scenario was assessed to understand what potential impacts filling and earthworks along with potential obstructions such as buildings would have on existing flood behaviour when combined with the proposed stormwater drainage modifications. Although the final landform was not known at the time this assessment was completed, it was assumed that all land that forms part of the planning proposal would be filled to the level of the PMF to provide a conservative estimate of potential flood impacts.
- Scenario 3: Stormwater drainage upgrades. This assessment was completed to determine if there were opportunities to upgrade the existing stormwater system as part of the planning proposal to reduce the existing overland flooding problem. No earthworks were included as part of the assessment, so the benefits of the stormwater upgrade in isolation could be quantified. This scenario is analogous to 'FM15', as discussed as part of the potential stormwater upgrades in Chapters 7 and 8.

The TUFLOW computer model was first updated to include a representation of the stormwater modifications under Scenario 1. The updated TUFLOW model was then used to re-simulate a range of design floods. Floodwater difference maps were prepared for the 20% AEP, 5% AEP and 1% AEP events and the PMF and are provided in **Plate 13**.

**Plate 13** shows that small flood level reductions (i.e., 0.03 metres) are predicted within Rodgers Street during floods up to and including the 1% AEP event. However, there is little benefit to private properties in the area (although a small reduction in flood level is predicted within the Nepean Hospital site adjacent to Somerset Street during the 20% AEP flood). Similarly, no significant changes in flood levels are predicted during the PMF. Therefore, it is evident that while the drainage modifications are not predicted to adversely impact on existing flood behaviour, the proposed drainage arrangement does not offer a significant improvement to the existing flooding problem.

The TUFLOW model was then updated to incorporate filling of the land as part of the Scenario 2 assessment. The updated TUFLOW model was then used to re-simulate each design flood. Floodwater difference maps for Scenario 2 for the 1% AEP flood and PMF are provided in **Plate 14** and **Plate 15**.

**Plate 15** shows that inclusion of the filling is predicted to generate more significant flood impacts across the local area during the PMF. Although the filling is predicted to reduce flood levels across some Orth Street properties during the PMF, the reductions are typically less than 0.02 metres. Furthermore, the filling is predicted to produce significant adverse flood impacts (i.e., flood level increases approaching 0.5 metres) across Rogers Street and Somerset Street during the PMF. The flood level increases are also predicted to extend into adjoining residential properties as well as the Nepean Hospital, which is highly undesirable.

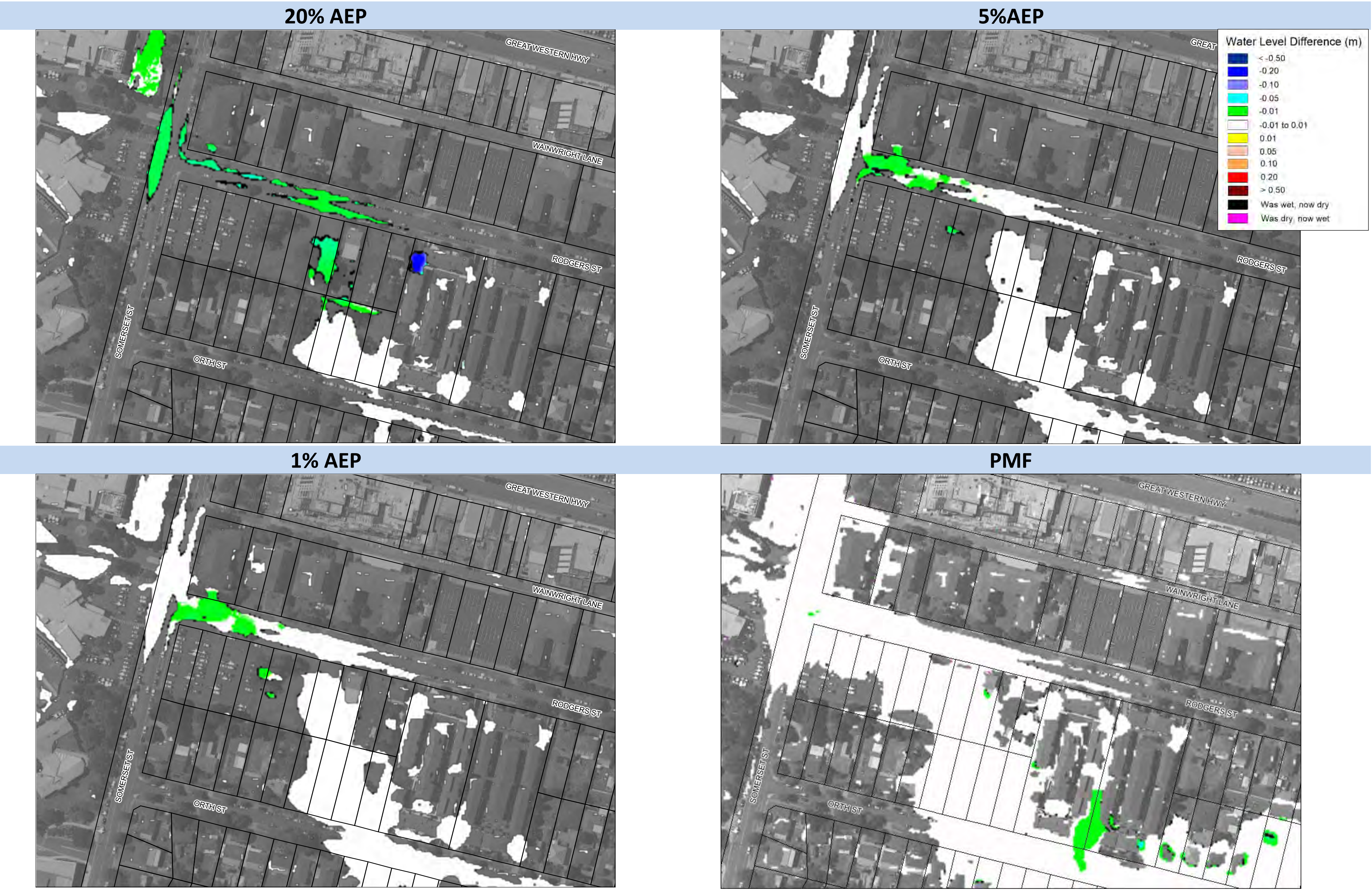



**Plate 13 Flood Level Difference Maps for Planning Proposal Scenario 1**

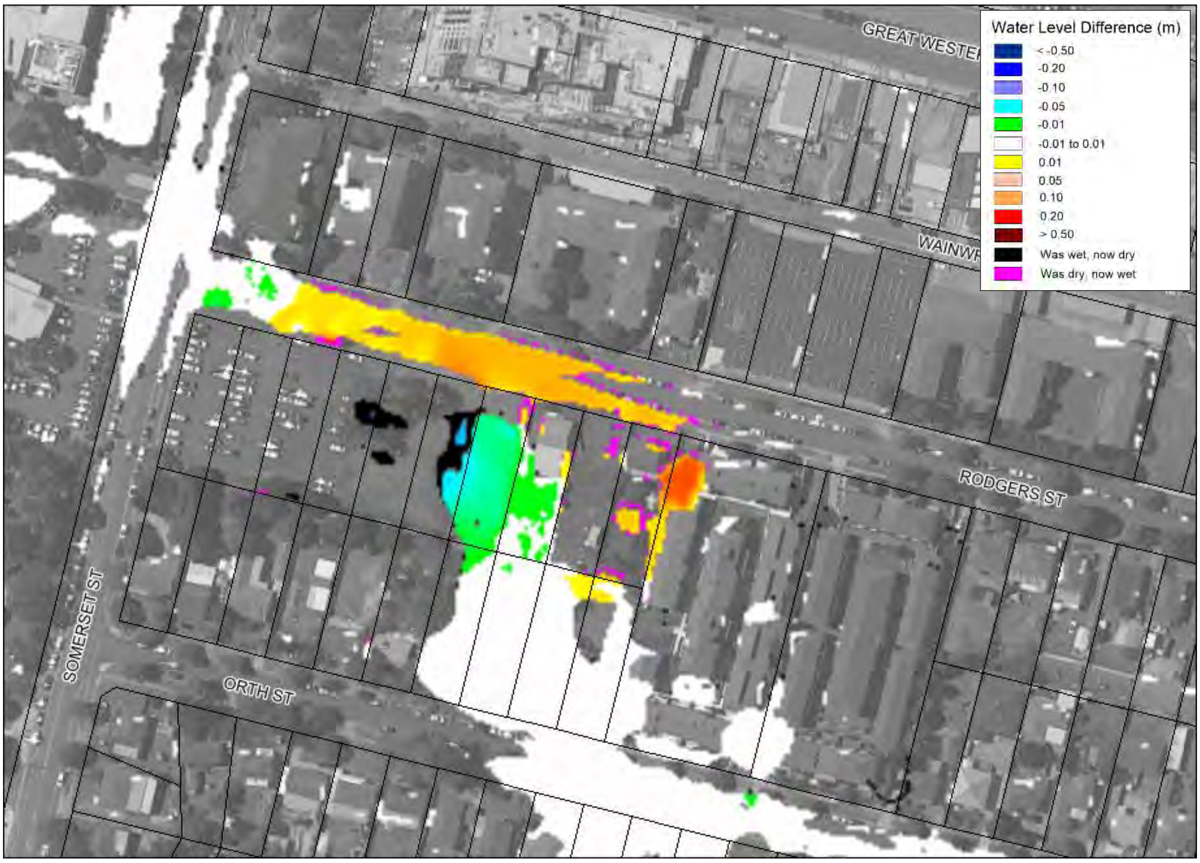



Plate 14 1% AEP Flood Level Difference Map for Planning Proposal Scenario 2

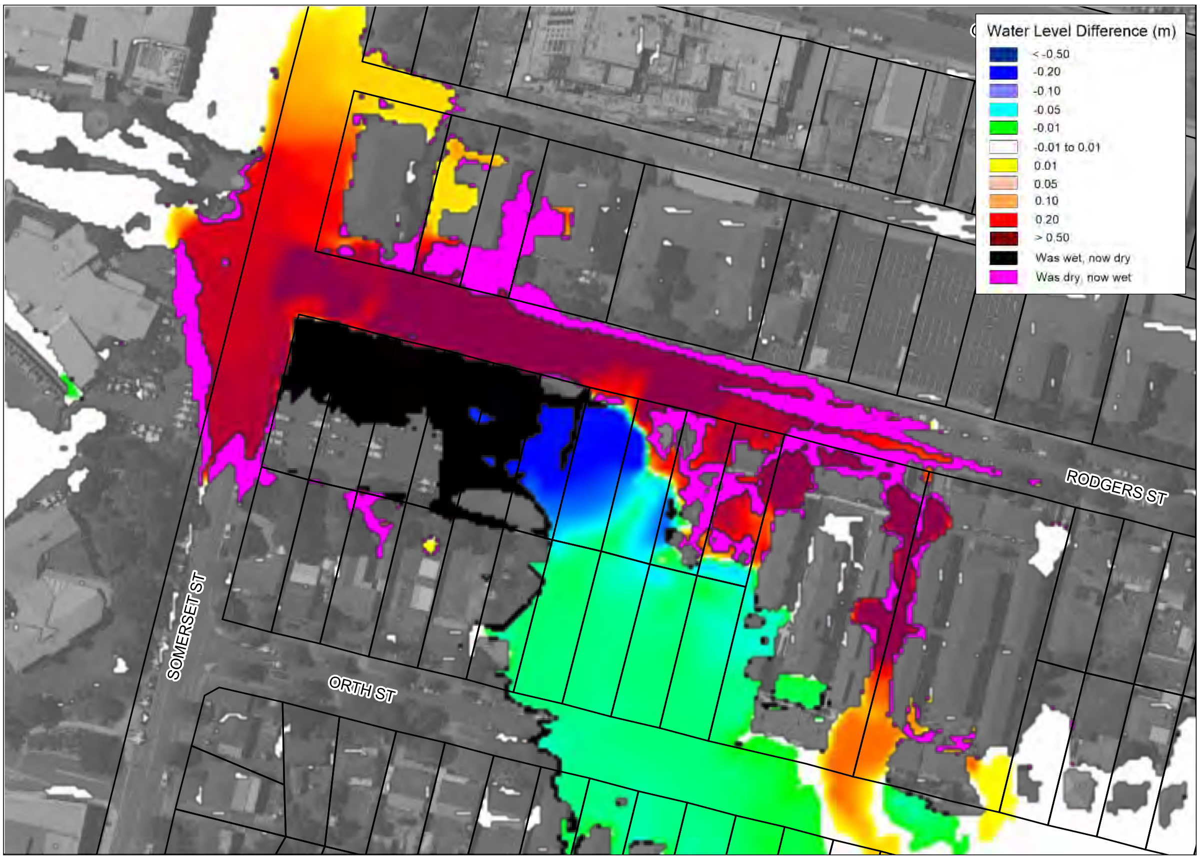



Plate 15 PMF Flood Level Difference Map for Planning Proposal Scenario 2

**Plate 14** shows that although the flood impacts during the 1% AEP flood are less extensive, flood level increases are still predicted within Rodgers Street as well as across adjoining residential properties to the east of the subject land parcels.

Therefore, any future development of this land that includes filling or other flow obstructions (such as large buildings), does have the potential to significantly impact on the existing flooding problem in the area.

Several drainage upgrade options were investigated as part of Scenario 3. The most hydraulically beneficial option for the Rodgers Street and Orth Street area included extending the proposed 1.35 metre diameter pipe down to First Street where it would discharge into Chapman Gardens. Although this did provide more significant reductions in flood levels during more frequent floods, the most significant reductions were contained to open space and roads near Orth Street (refer **Plate 16**). The reductions in flood levels during larger floods covered a more extensive area but generally did not exceed 0.05 metres (refer **Plate 17**).

Furthermore, **Plate 16** and **Plate 17** shows that the additional flow directed through the larger pipe system is predicted to increase flood levels across some First Street properties as well as multiple properties located downstream of Chapman Gardens.

Plate 16 20% AEP Flood Level Difference Map for Planning Proposal Scenario 3 (FM15)


**Plate 17 1% AEP Flood Level Difference Map for Planning Proposal Scenario 3 (FM15)**

Overall, the proposed drainage modifications appear to provide only small hydraulic improvements. Furthermore, any filling across the site does have the potential to significantly impact on existing flood behaviour across adjoining roads as well as neighbouring properties. Additional stormwater upgrades appear to afford minimal beneficial impacts for the local area, while adversely impacting on areas downstream of First Avenue. Therefore, any potential rezoning and development of this land will need to be undertaken with care, including a comprehensive assessment of the potential impacts on flooding during the full range of potential floods (not just the 1% AEP flood that was considered as part of the original stormwater and overland flow management plan).

## 4.6 Impacts of Climate Change

Climate change refers to a significant and lasting change in weather patterns arising from both natural and human induced processes. The Office of Environment and Heritage's *'Practical Consideration of Climate Change'* states that climate change is expected to have adverse impacts on rainfall intensities in the future.

Although there is considerable uncertainty associated with the impact that climate change may have on rainfall, it was considered important to provide an assessment of the potential impact that climate change induced rainfall intensity increases may have on the current flood risk across the study area. In this regard, the results of the 0.5% AEP and 0.2% AEP flood were compared to the results from the 1% AEP flood to gain an appreciation of the impacts of the rainfall intensity increases. The 0.5% AEP rainfall reflects a 9% average increase relative to current 1% AEP rainfall intensities, while the 0.2% AEP rainfall reflects a 23% increase relative to current 1% AEP rainfall intensities. Based on information contained on the Australian Rainfall & Runoff Data Hub, this roughly equates to the RCP4.5 2090 projection (9.5% increase in rainfall) and a little higher than the RCP8.5 2090 projection (19.7% increase in rainfall).

Flood level difference mapping was prepared to quantify the impacts that a 9% and 23% increase in rainfall would have on current 1% AEP flood level estimates. The difference mapping was prepared by subtracting the peak 1% AEP flood levels from the 0.5% and 0.2% AEP flood levels. The difference mapping is presented in **Plate 18** and **Plate 19**.

**Plate 18** and **Plate 19** show that rainfall increases will increase current 1% AEP flood level estimates across most of the catchment. A 9% increase in rainfall is predicted to increase 1% AEP flood levels by at least 0.05 metres along most watercourses and overland flow paths. The 23% increase in rainfall is predicted to increase existing 1% AEP flood levels by more than 0.1 metres at most locations.

The most significant increases in flood levels are predicted to occur on the southern side of the railway embankment. This includes flood level increases of between 0.2 and 0.5 metres along Werrington Ck at Kingswood (near George Street) and 0.1 to 0.2 metre increases across Railway St at Werrington.

Accordingly, the outcomes of the assessment show that increases in rainfall associated with climate change have the potential to produce a notable increase in the severity of flooding across the catchment.

## 4.7 Summary of Exitsing Flood Risk and Flooding 'Trouple Spots'

The information presented in this section indicates that the following areas are likely to experience significant property damage, risk to life or evacuation difficulties during floods within the catchment:

- Jamison Road to Bringelly Road, Kingswood.
- Cox Avenue to Orth Street, Kingswood.
- Chapman Gardens to Victoria Street, Kingswood (in particular, the area located immediately south of the railway line).
- Victoria Street to Heath Street, Kingswood.
- Sandringham Avenue & Lincoln Drive Park to Herbert Street, Cambridge Park.
- Oxford Street, Cambridge Park.
- Rugby Street to Oxford Street, Cambridge Park.
- Orleton Place to Francis Street, Werrington County.
- Edward Close to Dunkley Place, Werrington.
- Railway Street and Walker Street, Werrington.

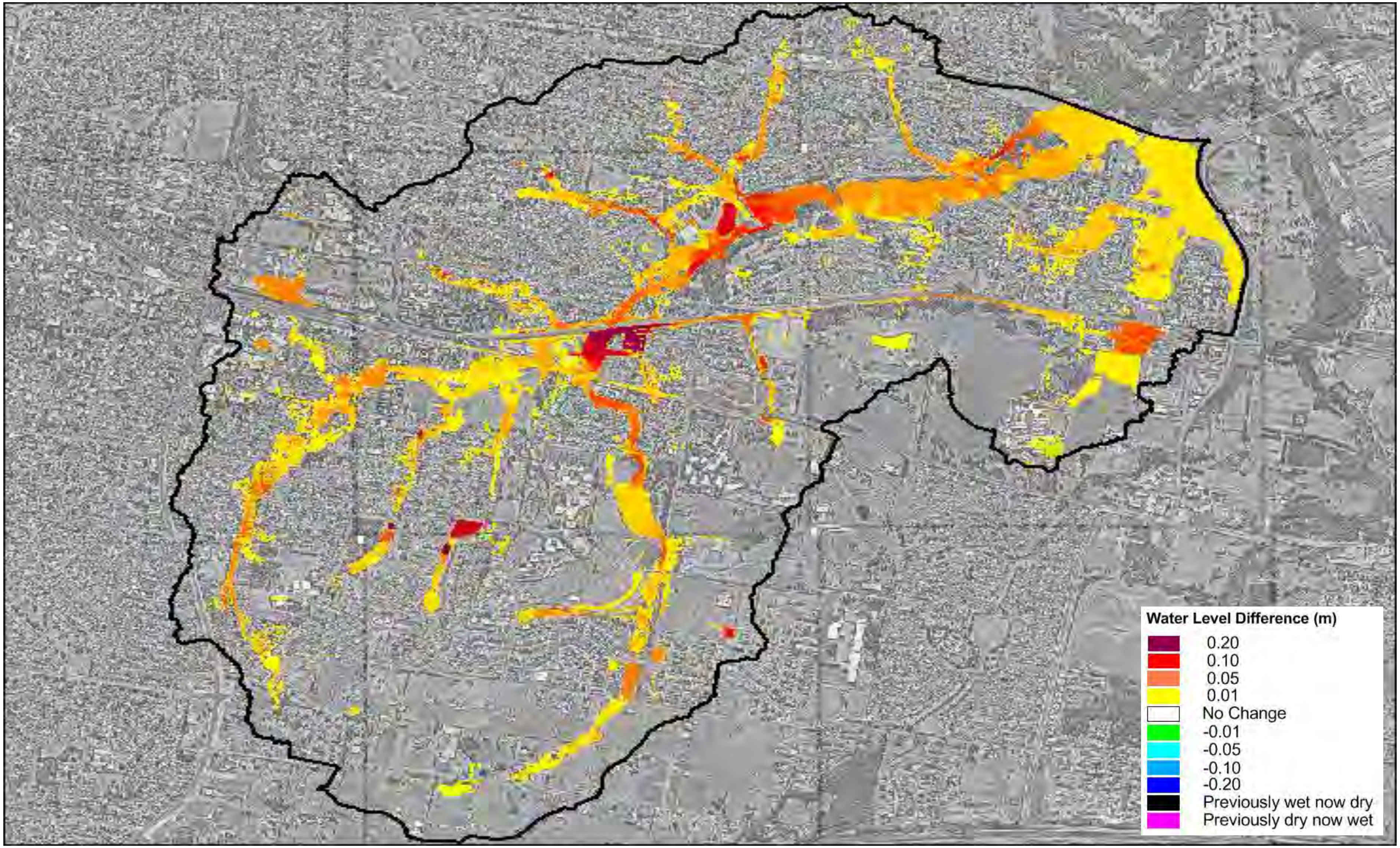



**Plate 18 Flood level difference map for 9% increase in 1%AEP rainfall intensity**

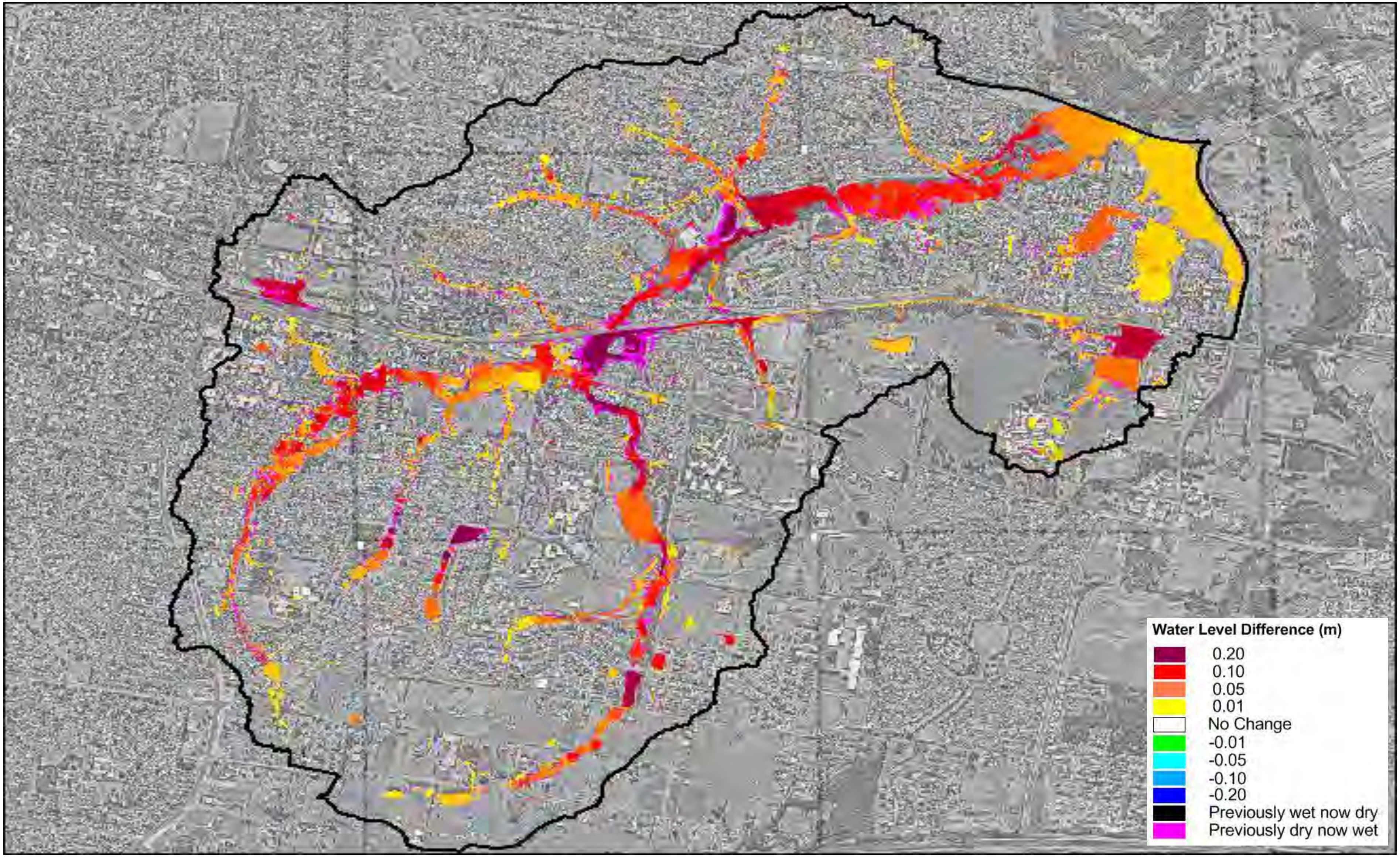



**Plate 19 Flood level difference map for 23% increase in 1%AEP rainfall intensity**

# 5 LAND USE PLANNING INFORMATION

## 5.1 Overview

Appropriate land use planning is one of the most effective measures available to floodplain managers, especially to control future risk but also to reduce existing flood risks as redevelopment occurs. The following sections discuss existing planning legislation and policies that affect the development of land within the Penrith City Council Local Government Area. Where appropriate, recommendations for ways in which Council's planning documents could be modified to better manage the existing and future flood risk are provided.

## 5.2 NSW State Planning Provisions

### 5.2.1 Environmental Planning and Assessment Act 1979

The NSW *Environmental Planning and Assessment Act 1979* (EP&A Act) provides the over-arching legislative framework for planning and development in NSW. It creates the mechanism for development assessment and protection of the environment from adverse impacts arising from development. The EP&A Act 1979 outlines the level of assessment required under State, regional and local planning legislation and identifies the responsible assessing authority.

***Section 9.1 Directions – Direction No. 4.3 (Flood Prone Land)***

NSW flood related planning requirements for local councils are set out in Ministerial Direction No. 4.3 Flood Prone Land, issued in 2007 under the then Section 117 (now Section 9.1) of the EP&A Act 1979. It requires councils to ensure that development of flood prone land is consistent with the NSW Government's Flood Prone Land Policy, as set out in the *Floodplain Development Manual* (NSW Government, 2005). It requires provisions in a Local Environmental Plan on flood prone land to be commensurate with the flood hazard of that land. In particular, a planning proposal must not contain provisions that:

- 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; and
- Permit development to be carried out without development consent except for the purposes of agriculture, roads or exempt development.

The Direction also requires that councils must not impose flood related development controls above the flood planning level (FPL, typically the 1% AEP flood plus 0.5m freeboard) for residential development, unless a relevant planning authority provides 'adequate justification' for those controls to the satisfaction of the Director-General.

The question as to whether flood behaviour in the College, Orth & Werrington Creeks catchment warrants the imposition of flood related development controls above the residential flood planning level is considered in Section 5.2.4.

At the time of preparing this report, the NSW Department of Planning, Industry and Environment was undertaking a review of the Direction related to Flood Prone Land. This is discussed further in Section 5.2.4.

***Guideline on Development Controls on Low Flood Risk Areas, 2007***

The '*Guideline on Development Controls on Low Flood Risk Areas – Floodplain Development Manual'* stipulates that *"unless there are exceptional circumstances, councils should adopt the 100-year flood as the flood planning level (FPL) for residential development"* and that "*unless there are exceptional circumstances, councils should not impose flood related development controls on residential development on land … that is above the residential FPL*".

The Guideline states that councils should not include a notation for residential development on Section 10.7 certificates for land above the residential flood planning level if no flood related development controls apply to the land. However, the Guideline does include the reminder that councils can include "such other relevant factors affecting the land that the council may be aware of under Section 10.7(5) of the *EP&A Act 1979"*.

In proposing a case for exceptional circumstances, a council would need to demonstrate that a different Flood Planning Level was required for the management of residential development due to local flood behaviour, flood history, associated flood hazards or a particular historic flood. Justification for exceptional circumstances would need to be agreed by relevant State Government departments prior to exhibition of a draft local environmental plan or a draft development control plan that proposes to introduce flood related development controls on residential development above the default FPL.

At the time of preparing this report, the Guideline was under review by the NSW State Government. The information presented by the NSW State Government on the proposed updates to the Floodprone Land Policy indicate that exceptional circumstances will not be required in future if development controls are applied to properties between the FPA and PMF, as long as appropriate floodplain risk management processes have been undertaken to support the need for these development controls.

### 5.2.2 Environmental Planning and Assessment Regulation 2000

The *Environmental Planning and Assessment Regulation 2000* supports the implementation of the *Environmental Planning and Assessment Act 1979 (*EP&A Act 1979). It provides a number of key provisions for the state-based planning legislation, including planning instruments and development control plans, planning proposals, planning certificates and requirements for environmental assessment under Part 5 of the EP&A Act 1979.

Planning certificates are a means of disclosing information about a parcel of land by providing information on how the land may be used and the restrictions on development of that land. Two types of information are provided in planning certificates: information under Section

10.7(2) and information under Section 10.7(5) of the EP&A Act 1979. The information that can be included on a Section 10.7(2) certificate is prescribed by the *Environmental Planning and Assessment Regulation 2000 (Schedule 4).*

A planning certificate under Section 10.7(2) discloses matters relating to the land, including whether or not the land is affected by a policy that restricts the development of land. Those policies can be based on identified hazard risks (*Environmental Planning and Assessment Regulation 2000*, Clause 279 and Schedule 4 Clause 7), and whether development on the land is subject to flood-related development controls (EP&A Regulation, Schedule 4 Clause 7A). A lot that is a 'flood control lot' under the Codes SEPP is a prescribed matter for the purpose of a certificate under Section 10.7(2). If no flood-related development controls apply to the land (such as for residential development in areas above the flood planning level), information describing the flood affectation of the land would not be indicated under Section 10.7(2).

A planning certificate may also include information under Section 10.7(5). This allows a council to provide advice on other relevant matters affecting land. This can include past, current or future issues that are considered relevant to that parcel of land.

Inclusion of a planning certificate containing information prescribed under Section 10.7(2) is a mandatory part of the property conveyancing process in NSW. The conveyancing process does not mandate the inclusion of information under Section 10.7(5) but any purchaser may request such information be provided, often pending payment of a fee to the issuing council. Some councils choose to issue the Section 10.7(5) certificate concurrently with the Section 10.7(2) certificate.

### 5.2.3 State Environmental Planning Policies

#### *SEPP (Housing for Seniors or People with a Disability) 2004*

*State Environmental Planning Policy (Housing for Seniors or People with a Disability) 2004* aims to encourage the provision of housing (including residential care facilities) that will increase the supply of residences that meet the needs of seniors or people with a disability. This is achieved by setting aside local planning controls that would prevent such development.

Clause 4(6) and Schedule 1 indicate that the policy does not apply to land identified in another environmental planning instrument (such as Penrith LEP 2010) as being, amongst other descriptors, a floodway or high flooding hazard area.

#### *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. *SEPP (Infrastructure) 2007* overrules local planning provisions, including Penrith LEP 2010. *SEPP (Infrastructure) 2007* allows Council to undertake stormwater and flood mitigation work without development consent and the TfNSW to undertake certain roadworks without development consent.

### *SEPP (Exempt and Complying Development Codes) 2008*

*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.

Clause 1.5 of this 'Codes' SEPP defines a 'flood control lot' as:

*"a lot to which flood related development controls apply in respect of development for the purposes of industrial buildings, commercial premises, dwelling houses, dual occupancies, multi dwelling housing or residential flat buildings (other than development for the purposes of group homes or seniors housing)"*.

**Note.** *This information is a prescribed matter for the purpose of a certificate under section 10.7(2) of the Act.*

These development controls may apply through a LEP or DCP. Exempt development is not permitted on flood control lots, but some complying development is permitted.

Part 3 of the 'Codes' SEPP relates to the *General Housing Code*, which applies to land zoned R1, R3, R4 or RU5.

Clause 3.1 to 3.6 relates to development that is considered as complying development under the 'Codes' SEPP, with Clause 3.5 related to complying development on flood control lots. Clause 3.5 states that 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.

The Codes SEPP specifies various controls in relation to floor levels, flood compatible materials, structural stability (up to the PMF if on-site refuge is proposed), flood affectation, access, and car parking (see **Plate 20**).

In addition, Clause 1.18(1)(c) of the Codes SEPP indicates that complying development must meet the relevant provisions of the Building Code of Australia.

In order to facilitate the process of applying for complying development, the following map has been prepared as part of the study:

- land where Council is confident a Complying Development Certificate (CDC) could be issued, that is, where the land in a flood control lot is not a flood storage area, floodway area, flow path, high hazard area or high-risk area. A map was prepared to identify these areas (refer to **Figure 51**) based upon the following assumptions:

- o Areas that are a floodway or flood storage during the 1% AEP flood; and
- o Areas exposed to a high flood hazard during the 1% AEP flood (for this study, high hazard is considered inclusive of H4–H6 categories).

- Areas that function as a major flow path in the 1% AEP flood (a velocity depth product greater than 0.4 $m^2/s$ was used for this purpose).
- A 'high risk' area was defined as an area that becomes isolated early in a flood and then becomes inundated (flooded, isolated, submerged emergency response classification).

> (2) If complying development under this code is carried out on any part of a flood control lot, the following development standards also apply in addition to any other development standards:
> (a) if there is a minimum floor level adopted in a development control plan by the relevant council for the lot, the development must not cause any habitable room in the dwelling house to have a floor level lower than that floor level,
> (b) any part of the dwelling house or any attached development or detached development that is erected at or below the flood planning level is constructed of flood compatible material,
> (c) any part of the dwelling house and any attached development or detached development that is erected is able to withstand the forces exerted during a flood by water, debris and buoyancy up to the flood planning level (or if an on-site refuge is provided on the lot, the probable maximum flood level),
> (d) the development must not result in increased flooding elsewhere in the floodplain,
> (e) the lot must have pedestrian and vehicular access to a readily accessible refuge at a level equal to or higher than the lowest habitable floor level of the dwelling house,
> (f) vehicular access to the dwelling house will not be inundated by water to a level of more than 0.3m during a 1:100 ARI (average recurrent interval) flood event,
> (g) the lot must not have any open car parking spaces or carports lower than the level of a 1:20 ARI (average recurrent interval) flood event.

**Plate 20 Extract from 'Codes' SEPP 2008 Clause 3.5(2) (note: version dated 22 December 2017)**

### 5.2.4 NSW Floodplain Development Manual

***Flood Prone Land Policy and Floodplain Development Manual, 2005***

The overarching policy context for floodplain management in NSW is provided by the NSW Flood Prone Land Policy, contained within the '*Floodplain Development Manual'* (NSW Government, 2005). The Policy 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, using ecologically positive methods wherever possible. The Manual promotes a merit approach for development decisions in the floodplain, taking into account social, economic, ecological and flooding considerations. The primary responsibility for management of flood risk rests with local councils. The Manual 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.

At the time of preparing this report, the NSW Floodplain Development Manual was under review by the NSW Department of Planning, Industry and Environment.

## 5.3 Local Provisions

### 5.3.1 Penrith Local Environmental Plan 2010

Penrith LEP 2010 outlines the zoning of land, permissible development within each land use zone and any special provisions that apply to land within the LGA.

Flood planning is addressed in Clause 7.2 of Penrith LEP 2010. The appropriateness of the Penrith LEP 2010 for managing flood risk in the College, Orth & Werrington Creeks catchment is considered in the following sections.

***Flood planning level***

Flood planning levels (FPLs) and the flood planning area (FPA) are important tools in the management of flood risk. The flood planning area is used to define the area where flood-related development controls apply over development. For those areas contained within the flood planning area, the flood planning levels are frequently used to establish the elevation of key components of a development, such as minimum floor levels.

The flood planning level is typically derived by adding a freeboard to a specific design flood. This specified design flood is frequently referred to as the 'planning' flood. The freeboard is intended to account for any uncertainties in the derivation of the planning flood level. Flood planning levels, as well as the freeboard component itself, can be specified for different land uses or types of development (residential, commercial or industrial, based on the vulnerability of the development to flooding) and for different flooding sources (riverine or local overland flooding).

Flood planning levels and the flood planning area can be used to assist in managing the existing and future flood risk by setting design levels for flood mitigation works and identifying the land where flood related development controls apply.

The NSW Government's Floodplain Development Manual 2005 states that in NSW, the flood planning level for standard residential development is generally based upon the 1% AEP design flood plus a freeboard, typically 0.5 metres. The Penrith City Council LEP 2010 defines the flood planning level (FPL) across the Penrith City Council LGA as "the level of a 1:100 ARI (average recurrent interval) flood event plus 0.5 metre freeboard". This wording is taken from the standard LEP template for NSW and effectively applies a "one size fits all" approach for defining the flood planning level across the LGA.

The suitability of the current flood planning level defined in the LEP 2010 was evaluated and the outcomes of this evaluation is summarised in **Appendix G**. This included an assessment of the suitability of the planning flood (i.e., 1% AEP flood) and freeboard (i.e., 0.5 metres).

The assessment determined that there is no obvious reason for deviating from adoption of the 1% AEP flood for defining flood planning levels for the catchment.

The assessment also determined that there is potential to adopt a freeboard of 0.3 metres in some areas subject to overland flooding, while a 0.5 metre freeboard would be required in most areas subject to 'mainstream' flooding. At the same time, a constant freeboard of 0.5 metres would be suitable for application to the whole catchment if a variable freeboard cannot be implemented (this is discussed further below).

#### *Wording of clause 7.2 of Penrith Local Environmental Plan 2010*

As outlined above, clause 7.2 of Penrith Local Environmental Plan 2010 stipulates a flood planning level that includes a 1% AEP design flood level and a 0.5 m freeboard. Explicitly defining both the planning flood event and the freeboard in the clause does not allow flexibility in the determination of the flood planning level. Therefore, the FPL definition provided in the LEP 2010 provides little scope to decrease the standard 0.5 metre freeboard across areas of overland flow.

This clause is consistent with the NSW Government's Department of Planning, Industry and Environments' Model clause 7.3 Flood Planning. 'Model clauses' are also referred to as 'local provisions' and have been settled by the NSW Parliamentary Counsel's Office. However, they are a non-mandatory and non-compulsory clause issued with the NSW Standard Instrument for a LEP. Minor alterations of the model clause can be made to suit local conditions with appropriate justification.

It is therefore recommended that Clause 7.2 of Penrith LEP 2010 be updated so that all land where flood related controls apply based on the recommended flood planning area would be appropriately notated. Currently, Clause 7.2 of Penrith LEP 2010 currently states that "This clause applies to land at or below the flood planning level" with the flood planning level defined as "the level of the 1:100 ARI flood event plus 0.5 metres freeboard".

Potential updates to the wording of this clause to provide flexibility in the selection of a flood planning level and area include:

i) This clause applies to land at or below the flood planning level.
   Where the flood planning level is defined as the level of the 1:100 ARI (average recurrence interval) flood event plus 0.5 metres freeboard or another design flood or freeboard as determined by an adopted floodplain risk management plan by the Council prepared in accordance with the NSW Government's Floodplain Development Manual. or:

ii) This clause applies to:
   a) land that is shown as flood planning area, as defined on the flood planning area map, and
   b) other land at or below the flood planning level
   Where the flood planning area has been defined in an adopted floodplain risk management plan and is publicly available.

Further information on how the flood planning area mapping may be presented is provided below.

#### *Flood planning area mapping and Penrith Local Environmental Plan 2010*

The current flood planning area or flood planning level map related to the Penrith Local Environmental Plan 2010 is not available as a single source. It is recommended that Council make the flood planning area map related to flood related development controls publicly available in an easy to find and easy to understand location. This could be as a single mapping layer available on the council or the NSW ePlanning portal website or within the development control plan.

It is noted that the flood planning area maps were previously incorporated as part of the Penrith LEP 2010 gazetted maps, however, were separated from this map set circa. 2015. It is recommended to continue to provide the flood planning area map as a separate document to the Penrith LEP 2010 maps. Excluding the flood planning area map from the formal and gazetted LEP mapping enables the information associated with the flood planning map to be updated as frequently as needed (i.e., as new flood studies and floodplain risk management studies are adopted) and without the requirement of a Planning Proposal. Planning Proposals can be expensive and timely, often taking more than twelve (12) months to complete. If the maps are incorporated within the development control plan, there is still legislative process to be followed under Part 3, Division 3.6 of the *Environmental Planning and Assessment Act 1979* and Part 3 of the *Environmental Planning and Assessment Regulation 2000* with a minimum 28 day public exhibition period.

***Floods greater than the planning flood event***

Council could also consider introducing a LEP clause related to 'floodplain risk management' with the objectives of:

- Better managing the land between the flood planning area and the limit of the floodplain (i.e., PMF extent).
- Protect critical and vulnerable developments.
- Consider evacuation and emergency response requirements across the entire floodplain as part of the development planning and approval processes, making them legally enforceable during a flood event.

Suggested wording for this clause is provided in **Plate 21**.

It is also to be noted that the NSW Government Department of Planning, Industry and Environment are currently in the process of working to update advice and guidance to NSW councils on flood planning as a component of land use planning. The update of this guidance includes revised Local Environment Plan flood clauses, and a new guideline on *Considering Flooding in Land Use Planning (2020).* The update to the LEP clause includes a clause similar to that presented in **Plate 21**, which is referred to as the '*Special Flood Considerations*'. That clause applies to land between the flood planning area and up to the level of the probable maximum flood with specific considerations for sensitive, vulnerable and critical uses, hazardous industry or hazardous material storage establishments and any other land uses requiring controls in relation to risk to life considerations.

***Compatibility of current LEP zones with flood hazard***

The current land zoning (as defined in the LEP) within the College, Orth and Werrington Creeks Catchment presented in **Figure 3**. shows that the upstream portions of the catchment upstream of the Great Western Highway is primarily zoned General Residential 'R1', Low Density Residential 'R2', Medium density Residential 'R3', Mixed Use 'B4', two small sections of High Density Residential, 'R4' with some small pockets zoned Public Recreation 'RE1' and a small section of Local centre 'B2'. The Great Western Highway, the Western Railway Line along with the University of Western Sydney and the TAFE campus are zoned Special Activities 'SP2'.

**Clause XXX Floodplain risk management**

(1) The objectives of this clause are as follows—
  (a) in relation to development of particular evacuation or emergency response issues, to enable evacuation of land subject to flooding in events in excess of 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 area and the level of the probable maximum or extreme flood.

(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) childcare centres or facilities
  (b) correctional centres
  (c) education facilities
  (d) emergency services facilities
  (e) group homes
  (f) health service facilities
  (g) residential care facilities
  (h) seniors housing

(4) In this clause—
***flood planning area*** means the area of land at or below the flood planning level.
***flood planning level*** means the level of a 1:100 ARI (average recurrent interval) flood event plus a freeboard or as defined in adopted floodplain risk management plan.
***probable maximum flood*** has the same meaning as it has in the NSW Government's *Floodplain Development Manual (*ISBN 0 7347 5476 0*)* published by the NSW Government in 2005.

**Plate 21- Potential Floodplain Risk Management Clause**

The area of the catchment between the Great Western Highway and the Western railway line is primarily zoned Light Industrial 'IN2', Medium density Residential 'R3', General Residential 'R1', Business Park 'B7', High Density Residential 'R4', with some small pockets zoned Public Recreation 'RE1'. Some of the area along the Western Railway line is zoned Environmental Conservation 'E2'.

The most downstream part of the catchment, north of the Western railway line, is primarily zoned Low Density Residential 'R2', Medium density Residential 'R3', General Industrial 'IN1', with some small pockets of High Density Residential 'R4' and Public Recreation 'RE1'. There is one small section of Enterprise Corridor 'B6'. The area along Werrington Creek is primarily zoned Public Recreation 'RE1', and Kingswood Cemetery is zoned Special Activities 'SP1'.

An assessment of the compatibility of the existing land use zoning (under Penrith Local Environmental Plan 2010) with the national flood hazard categories was undertaken. The results of this assessment for the 1% AEP and the PMF design flood events are presented on **Figures 53** and **54** respectively and a summary is also presented in **Table 27.**

Of most interest in reviewing the information presented in **Table 27** is land zoned for urban and habitable development within flood hazard H6, as the depth and velocity of floodwater in these areas is likely to be sufficient to cause structural failure of buildings regardless of their design. Of interest also, are H5 areas where there is still potential for structural damage to buildings and H4 where all vehicles and people would be exposed to a significant flood risk.

The results indicate that the current zoning is broadly compatible with the flood hazard during the 1% AEP flood with no residential 'R1', 'R2', 'R3'and 'R4' and commercial 'B1', 'B2'and 'B4' being exposed to a H4, H5 or H6 hazard during the 1% AEP flood. There is a very small section of the area zoned 'R3', 'B2' and 'R3' that is exposed to H5 flood hazard during the 1% AEP design flood event, with larger parts of the 'B7'and 'E2' that is exposed to H5 flood hazard during the 1% AEP design flood. Hotel or Motel accommodation is permitted in the area zoned 'B7', so has been included as habitable development.

Greater areas are predicted to be exposed to a H4, H5 and H6 hazard during the PMF design flood event. Of concern is the amount of residential zoned areas potentially exposed to these higher hazards, particularly areas zoned Medium Density Residential 'R3' where approximately two (2) hectares are predicted to experience 'H6' hazard during the PMF. Small section of land use areas that permit habitable development (B1, B2, B4, B7, E2, R1, R2, R3, R4, and RU4) are predicted to be exposed to H5 flooding during the PMF. H5 flooding is not considered safe for people or vehicles, and buildings unless they are designed to structurally withstand the flood forces.

This review indicates that there are some current land use zones that are not compatible with the current flood risk during the 1% AEP flood and PMF. Although the PMF is typically not used for planning purposes, it is considered desirable to amend the LEP zones to ensure habitable areas are not exposed to a high flood hazard during the 1% AEP flood (i.e., the planning flood as defined in the LEP 2010). A list of lots that are currently zoned for habitable development where at least 25% of the lot area is exposed to high flood hazard in the 1% AEP is provided below:

- Lot 73, DP 1166546, Caddens – currently zoned R1.
- Lot 3, DP 589848, Kingswood - currently zoned R3.
- Lot 201, DP 850552, Kingswood - currently zoned R3.
- Lot 118, DP 129177, Kingswood - currently zoned IN2.
- Lots 12, 13, 14, 15, 16 & 17, DP 935, Kingswood - currently zoned IN2.
- Lot 45, DP 1605, Werrington – currently zoned R3.
- Lot 2, DP 502127, Werrington - currently zoned R3.

Table 27 Compatibility of Current Land Use Zones with National Flood Hazard Categories During the 1% AEP and PMF design flood events

| LEP Zone | | Area (ha) | Hazard Category | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | PMF | | | | | | | 1%AEP | | | | | | |
| | | | No Hazard | H1 | H2 | H3 | H4 | H5 | H6 | No Hazard | H1 | H2 | H3 | H4 | H5 | H6 |
| Business Zones | B1 | 0.6 | 9% | 5% | 15% | 29% | 15% | 27% | 0% | 82% | 14% | 4% | 0% | 0% | 0% | 0% |
| | B2 | 14.0 | 85% | 4% | 2% | 1% | 2% | 6% | 0% | 94% | 3% | 1% | 1% | 0% | 1% | 0% |
| | B4 | 23.8 | 69% | 8% | 6% | 6% | 5% | 6% | 0% | 88% | 6% | 3% | 2% | 0% | 0% | 0% |
| | B6 | 0.9 | 93% | 6% | 1% | 0% | 0% | 0% | 0% | 97% | 3% | 0% | 0% | 0% | 0% | 0% |
| | B7 | 35.5 | 93% | 2% | 1% | 1% | 0% | 3% | 0% | 96% | 1% | 1% | 1% | 0% | 2% | 0% |
| Environ. Protect-ion Zones | E2 | 41.4 | 42% | 5% | 4% | 3% | 6% | 34% | 6% | 64% | 7% | 5% | 10% | 6% | 7% | 1% |
| Industrial Zones | IN1 | 19.1 | 76% | 7% | 4% | 7% | 4% | 2% | 0% | 90% | 4% | 3% | 2% | 0% | 0% | 0% |
| | IN2 | 17.0 | 46% | 9% | 5% | 10% | 6% | 16% | 8% | 81% | 8% | 5% | 5% | 1% | 1% | 1% |
| Residential Zones | R1 | 72.0 | 89% | 4% | 2% | 1% | 2% | 3% | 0% | 95% | 2% | 1% | 1% | 1% | 0% | 0% |
| | R2 | 350.7 | 83% | 6% | 3% | 2% | 2% | 4% | 0% | 95% | 3% | 1% | 0% | 0% | 0% | 0% |
| | R3 | 195.4 | 57% | 8% | 6% | 11% | 7% | 9% | 1% | 87% | 6% | 3% | 2% | 1% | 1% | 0% |
| | R4 | 35.6 | 60% | 7% | 6% | 14% | 10% | 3% | 0% | 89% | 7% | 3% | 2% | 0% | 0% | 0% |
| Recrea-tion Zones | RE1 | 146.0 | 30% | 6% | 5% | 5% | 12% | 36% | 7% | 62% | 10% | 7% | 11% | 5% | 4% | 1% |
| | RE2 | 1.0 | 13% | 7% | 7% | 4% | 22% | 47% | 0% | 40% | 47% | 10% | 1% | 0% | 3% | 0% |
| Rural Zones | RU4 | 113.9 | 86% | 3% | 2% | 1% | 2% | 5% | 0% | 93% | 3% | 1% | 1% | 1% | 1% | 0% |
| Special Purpose Zones | SP1 | 7.3 | 85% | 9% | 3% | 2% | 1% | 0% | 0% | 98% | 2% | 0% | 0% | 0% | 0% | 0% |
| | SP2 | 122.4 | 75% | 7% | 5% | 4% | 3% | 6% | 1% | 91% | 4% | 2% | 1% | 1% | 0% | 0% |

If the opportunity arises, downzoning of the above lots should be strongly considered. 'Downzoning' refers to rezoning the land such that only less dense development would be permitted in the future. Ideally this would involve removing residential uses completely from the floodplain, however this may not be feasible, therefore reducing the intensity of residential development (for example, from a R3 zone to an R1 Zone) may be more achievable.

Overall, the intensification of land uses within the floodplain should be discouraged. In the short term, intensification of development within these H4-H6 hazard areas (and the broader flood liable areas within the catchment) should be discouraged to ensure the existing flood risk is not increased in the future. In addition, allowing critical or vulnerable facilities within the high hazard areas should be avoided.

***Need for 'Exceptional Circumstances'***

An assessment was completed to determine if and where 'exceptional circumstances' may be appropriate for flood related development controls on residential development on land outside of the FPA. Exceptional circumstance may be triggered when there is an unacceptably high flood risk above and beyond the FPL and FPA. This was completed by determining if there were any H6 hazard areas during the PMF in areas located beyond the FPA. It is acknowledged the NSW State Government is currently reviewing the need for 'exceptional circumstance' as part of the '*Flood Prone Land Package*' that is currently on public exhibition. Once the NSW Government formally releases the guideline '*Considering Flooding in Land Use Planning (2020)',* the requirement to apply for 'exceptional circumstance' may change from the current process.

**Plate 22**, **Plate 23** and **Plate 24** shows the extent of PMF H6 areas (red) superimposed on the flood planning area for the catchment (blue). It indicates that most areas exposed to a PMF H6 hazard would fall within the FPA. There are some areas where the PMF hazard is predicted to reach H6 outside of the FPA. However, these areas are relatively small and include:

- Open space areas
- The edges of the railway corridor, and
- A small section between the Great Western Highway and the railway line that is zoned 'In2' (Light Industrial).

The areas listed above are very small and most of these areas are not zoned for habitable development. As a result, there does not appear to be sufficient evidence to support exceptional circumstances, and application of appropriate development controls within the FPA can continue to be used to manage the flood risk. However, it would still be considered desirable to apply more stringent controls across the H6 hazard areas to better manage the higher flood hazard during extreme floods.

***Flood Planning Constraints Categories***

Australian Disaster Resilience Handbook 7 '*Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia* (AIDR 2017)' identifies the essential role of land-use planning in limiting the growth in flood risk associated with new land uses and development in the floodplain. Guideline 7-5, *Flood Information to Support Land Use Planning*, sets out a method for translating products from flood studies into Flood Planning Constraint Categories (FPCCs) to better inform land-use planning activities.

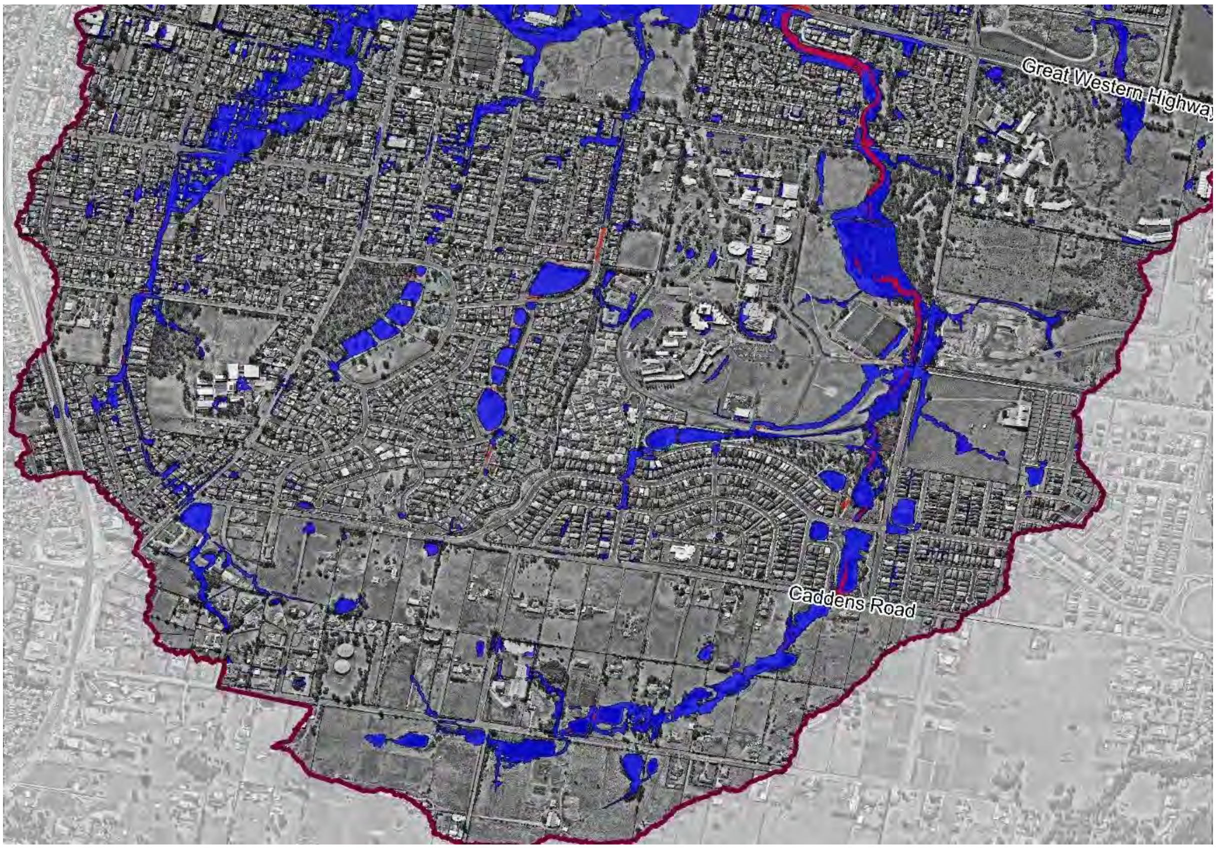



**Plate 22 PMF H6 hazard (red) superimposed on the FPA (blue) (Area 1 of 3)**

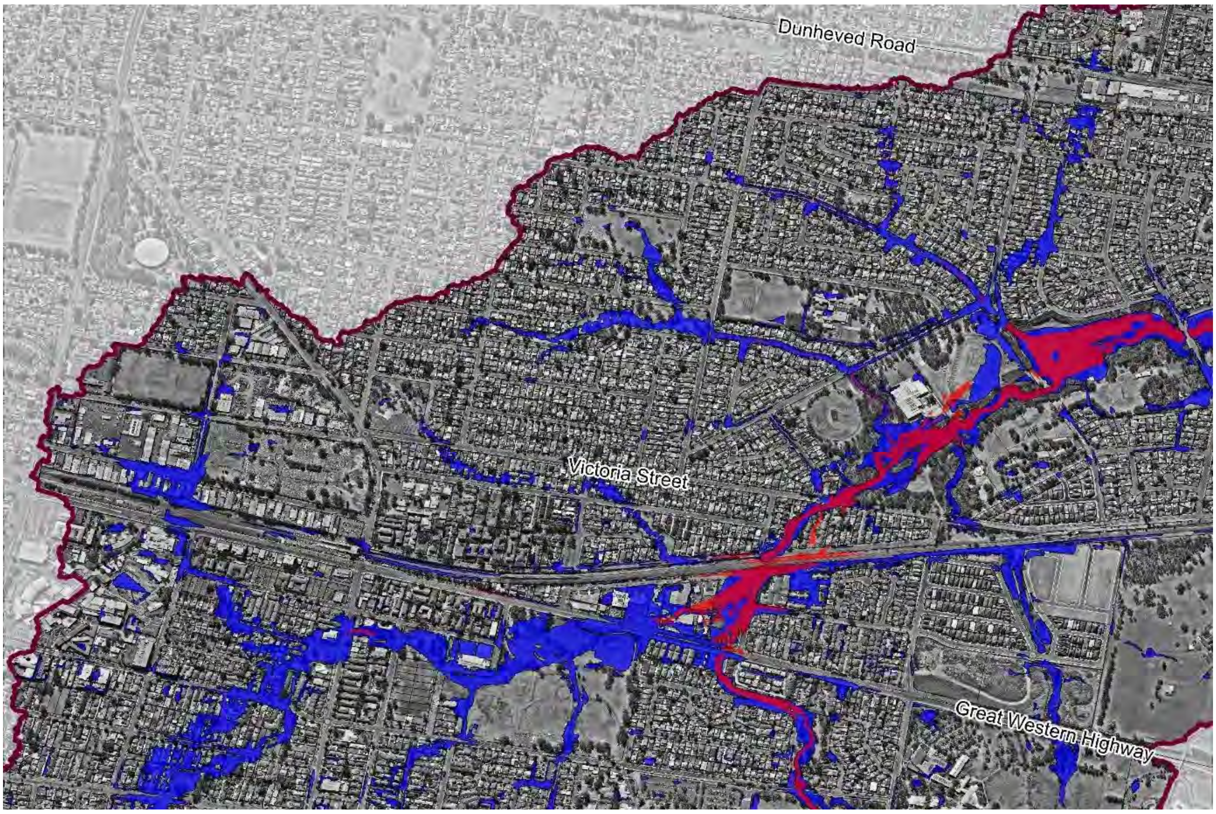



**Plate 23 PMF H6 hazard (red) superimposed on the FPA (blue) (Area 2 of 3)**

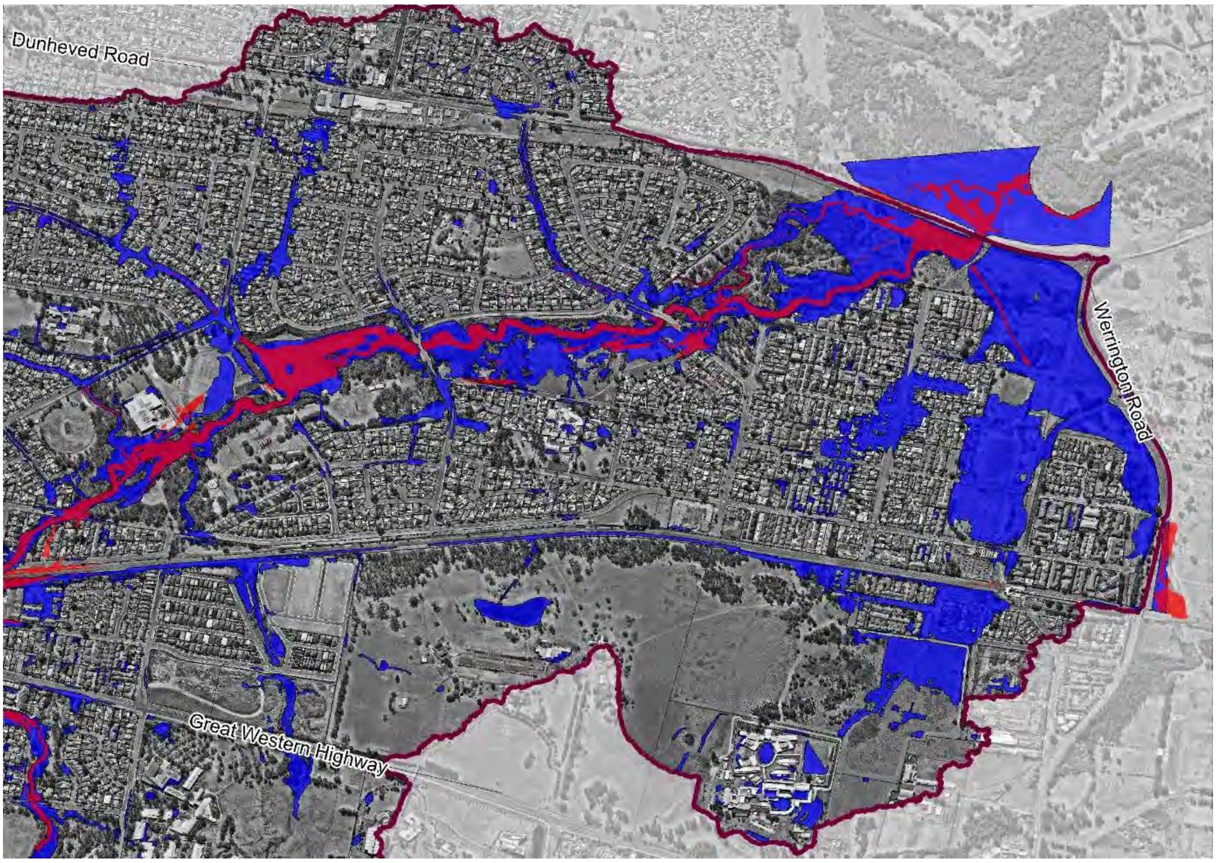



Plate 24 PMF H6 hazard (red) superimposed on the FPA (blue) (Area 3 of 3)

This guideline delineates flood liable land into one of four major 'constraint' categories (with several subcategories) based upon key flooding considerations such as flood hazard, flood function and emergency response. The resulting categories can serve to inform land use planning activities. The guideline notes that the categorisation is intended to support community and precinct scale decisions where flow paths and flood extents can be readily defined and was not developed to support change of land use or development at the lot scale.

The Flood Planning Constraint Categories Guidelines are set out in **Table 28**. A FPCC of '1' implies a more flood constrained section of land relative to FPCC category '2', and so on.

Flood Planning Constraints Categories have been mapped and are included in **Figure 54.** This mapping has been prepared based on a range of mapping produced as part of the current study. This includes flood hazard, hydraulic categories, emergency response classifications and the flood planning area.

Areas indicated as Flood Planning Constraint Category (FPCC) 1 and 2 will require careful consideration for future planning and development. Any future development in catchment needs to be compatible with the flood risks represented in this study and FPCC. Categories 1 and 2 indicate that any type of critical or vulnerable development would not be suitable in these areas. Strategic planning activities such as up zoning or subdivision should also be limited in FPCC Category 1 and 2 areas to minimise the potential population and property at risk of significant flood impacts.

**Table 28 Flood Planning Constraint Categories (AIDR, 2017)**

| FPCC | Description | Discussion |
|---|---|---|
| 1a | Flow conveyance and storage areas in the DFE | Majority of development and uses vulnerable to failure or likely to have adverse flood impacts. Most development in these areas should be limited and any development must be designed to maintain the current flood function. |
| 1b | H6 hazard in the DFE | |
| 2a | Flow conveyance in events larger than the DFE | Many uses in these areas will be vulnerable to high flood hazard during large floods or have the potential to be isolated leading to evacuation difficulties. Vulnerable land uses not suitable for these areas and new development of any type should be limited to those compatible with higher hazard conditions (i.e., special development conditions should be applied). |
| 2b | Flood hazard H5 in the DFE | |
| 2c | Emergency response—isolated and submerged areas | |
| 2d | Emergency response—isolated but elevated areas | |
| 2e | Flood hazard H6 in floods larger than the DFE | |
| 3 | Outside FPCC2 — generally below the DFE and the freeboard | Compatible with most development types and land uses subject to appropriate development controls being applied to reduce potential for flood damage. Generally, not suitable for vulnerable land uses. |
| 4 | Outside FPCC3, but within the probable maximum or extreme flood | Compatible with most development types. Vulnerable facilities may still require development controls |

### 5.3.2 Penrith Development Control Plan 2014

The Penrith Development Control Plan 2014 (Penrith DCP 2014) applies to all land zoned for residential and business uses within the Penrith LGA, including the College, Orth and Werrington Creeks catchment. Section 3.5 of Part C of the DCP refers to Flood Planning and includes a lengthy background discussion as well as listing a number of objectives.

The flood related development controls listed in Part C of the DCP are wide-ranging and extensive. However, this study presents a good opportunity to update and consolidate these controls to current best practice, in conjunction with other floodplain risk management studies and plans that have recently been completed across the LGA.

General comments have been provided across the current controls, with more specific ones listed if required.

**General Comments**

i. The current requirements for a flood study are considered onerous as it is required for all development applications on land that is identified as fully or partially flood affected. Subjective words such as 'unacceptable' and 'unreasonable' should be avoided in development controls. Instead, clearly defined prescriptive controls or parameters should be listed.

**ii.** The DCP should include clear prescriptive controls. If an applicant wants to vary these prescriptive controls, then the DCP could include a list of 'heads of consideration' for the items that would be considered under a 'Merits Based Assessment'. A Merits Based Assessment could include items such as floor levels, structural soundness and flood compatible building materials, flood affectation, emergency management and environmental impacts.

ii. The defined flood planning event is not identified in the opening section of the current controls, which leaves interpretation open. It is recommended to use the 1% AEP design flood event as the defined flood event for residential, commercial and industrial development and the PMF for all other developments. These include critical infrastructure, vulnerable uses such as childcare centres, education facilities, emergency services facilities, group homes, health service facilities, aged care facilities, residential care facilities and seniors housing.

iii. Planning proposals for substantial or significant planning or development applications, such as subdivision and rezoning, should consider the full range of design flood events up to and including the PMF. In addition, all strategic planning activities should consider the full range of design flood events up to and including the PMF.

iv. It may be beneficial to define a list of development types and the category they would be treated as for flood related development controls. For example, schools, childcare centres and aged care facilities would be considered as vulnerable developments, emergency services and telecommunication infrastructure would be considered as critical infrastructure. There are a range of residential zoning types within this catchment, from low to medium to high density. Therefore, the potential to apply different flood development controls based on the expected residential density of development should also be considered (noting the compatibility of the current land use zones with the predicted flood hazard is documented in **Section 5.3**).

v. Adherence to the 'Construction of Buildings in Flood Hazard Areas' (ABCB, 2012) could be listed in the initial stages of the controls. This would assist in streamlining many development controls, such as structural soundness of buildings, up to the planning level for the defined flood event.

vi. Reference should always be made to the flood planning level, not just a design flood level.

vii. Updates are required to the hazard classifications that are referenced so they are consistent with recently completed flood studies and floodplain risk management plans in the LGA. This includes the terminology used in the Australian Institute for Disaster Resilience's (AIDR) *'Technical Flood Risk Management Guideline: Flood Hazard'* (2014) as completed in this study, which uses the flood hazard categories in the H1 to H6 format. These are considered current best practice and are also recommended in ARR2019. This would enable land that is impacted by either mainstream riverine or overland flooding to be appropriately categorised.

viii. It is also recommended that flood planning constraint categories (FPCC) are used to clearly define and distinguish the areas where the different types or categories of flood related development controls apply. The FPCC takes into account a range of information including those floods more infrequent than the 1% AEP design flood level, as well as emergency management considerations. FPCC mapping is provided in **Figure 55**.

ix. Development controls associated with the change of use of a building should clearly state what minimum standards are acceptable for flood impacts or resultant flood risk. These controls and associated thresholds could be based on the FPCC or the hazard category the site is located within.

x. Any redevelopment on a lot that is located within the floodplain should not result in an increased flood risk to existing communities or to the new development or an increased reliance on emergency services during time of flood. To help mitigate this risk, controls could include limiting the number of bedrooms or footprint of the new development to be equivalent to what was on the lot previously.

xi. The DCP currently lists requirements for minor residential developments for a once only extension of 35metres squared. It is recommended that this control is strengthened by excluding the addition of a bedroom or other liveable area within this allowance, that may lead to a permanent increase in residential population at risk on the site.

xii. Where redevelopment is to occur in flood storage areas where rezoning to a ‘less dense’ land use is not possible, the footprint of the building should not increase from the existing development. This will help minimise the cumulative impacts of developments in the flood storage areas of the catchment.

xiii. Controls associated with the filling of land should be based on a catchment wide analysis completed in the floodplain risk management study for each catchment. These controls should clearly state in what areas filling would be permissible and what areas it would not. These areas could be based on FPCC or hazard categories or other decisions based on the recommendations of current floodplain risk management plans. These controls should clearly state the allowable impact on properties external to the development site. It is recommended thresholds are applied to changes in flood level and velocity.

xiv. Current DCP controls state that the allowable flood impact of filling of an individual development should not exceed 0.1 metres. It does not state what the planning flood event is. It is recommended that the 0.1 metres be revised to something smaller. In its current form, an allowance of 0.1 metres per development could lead to significant cumulative impacts across the whole catchment, counteracting the purpose of the freeboard in the flood planning level. The ‘South Creek Floodplain Risk Management Study’ (Advisian, 2020) recommends a threshold increase of no more than 0.02m for impacts outside of the development site. This is considered a reasonable threshold as it is ‘small’ but still within the computational limits of most modern flood modelling software.

### 5.3.3 Other Floodplain Risk Management Plans Completed and Adopted in Penrith LGA

***South Creek Floodplain Risk Management Study***

The ‘South Creek Floodplain Risk Management Study’ was adopted by Council on 27 April 2020. The study focusses on ‘mainstream’ flooding along South Creek and several of its major tributaries.

The Study outlines a number of planning modification recommendations, including:

- Update true flood hazard mapping and hydraulic category mapping in the DCP
- Use Flood Planning Constraints Category Mapping (FPCC) in DCP once FPCC mapping is available across the whole LGA
- Amend development controls regarding:
  - Extensions to existing developments to permit no increase to the population at risk
  - Consider location, proposed use and evacuation in the change of use controls
  - Consider evacuation in rural development.
- Revise the DCP regarding assessment of impact including:
  - Reduce criteria for maximum allowable increase in peak flood levels
  - Remove control for velocity and flow distribution and replace with a hazard control
  - Update control for additional flood storage where it can be shown there is no offsite impact
  - Require assessment of impact criteria to all development (not just existing buildings or potential development sites)
  - Specify that controls must be met for the 1% AEP flood, however, Council may request additional events to be assessed at their discretion.
- Additions to the DCP including:
  - Additional controls for critical facilities (e.g., schools, hospitals, aged care facilities etc.)
  - Require consideration of evacuation from the proposed development as well as the effect of new development on evacuation from existing areas
  - Requirement for a Flood Impact Assessment and Flood Risk Assessment commensurate to development size, type and flood risk
  - Need to include consideration of climate change.
- Revise the format of the DCP to set out different development types and flood risk into a matrix approach.

***St Marys Byrnes Creek Catchment Floodplain Risk Management Study and Plan***

The 'St Marys Byrnes Creek Catchment Floodplain Risk Management Study and Plan' was adopted by Penrith Council on 23 March 2020.

The Study outlines planning modification recommendations, including:

- Improvements to planning and development controls for future development in floodprone areas. This includes dividing the floodplain into six (6) categories, including:
  - Inner floodplain (Hazard category 1)
  - Inner floodplain (Hazard category 2)
  - Intermediate floodplain
  - Outer floodplain
  - High hazard floodway, and
  - Low hazard floodway and flood fringe.

- Update wording in Penrith LEP 2010 to include consideration of evacuation or emergency response issues
- Inclusion of a new floodplain risk management clause that would apply to land identified as 'Outer Floodplain' (land between the FPA and the extent of the PMF).

***Penrith CBD Floodplain Risk Management Study and Plan***

The 'Penrith CBD Floodplain Risk Management Study and Plan' was completed in March 2020. The study area focusses on the Penrith CBD which is located immediately west of the College, Orth and Werrington Creeks catchment and is subject to both mainstream and overland flooding.

The Study outlines several planning modification recommendations, including:

- Council to undertake a comprehensive review of the DCP (PDCP 2014)
- DCP to include a comprehensive set of flood maps (including flood planning area maps)
- DCP to include flood risk zoning addressing mainstream and overland flood risks
- DCP to use controls reliant on the adoption of multiple FPLs in the LEP
- Consider amending the LEP to include provision for variable FPLs
- Consider applying for 'exceptional circumstances' to ensure variable FPL is consistent with the 2007 NSW Government Flood Planning Circular (PS 07 003).

# 6 Existing Emergency Management Information

## 6.1 Overview

It is generally not economical to provide 'structural' flood risk management options that address the flood risk for all events up to and including the PMF. Therefore, emergency management measures such as evacuation planning and community education are typically employed to manage the residual flood risk during both frequent as well as very rare floods.

The following chapter outlines current emergency management strategies for the College, Orth and Werrington Creeks Catchment. Where appropriate, it also makes suggestions on ways in which the current emergency management strategies could be potentially improved.

These suggestions and comments are based on engineering judgment and not on emergency management expertise. As such, it is up to SES, the agency responsible for flood emergency management in NSW, to review these suggestions and apply them as they see fit, into their planning and response strategies for the College, Orth and Werrington Creeks catchment.

## 6.2 Current Local Flood Plan

The *Penrith City Local Flood Plan* (NSW SES, 2012) (LFP) sets out procedures to follow before, during and after a flood including who is responsible for each of these activities within the Penrith LGA.

The Penrith City LFP is a sub-plan of the *Hawkesbury Nepean Flood Plan 2015* and the *Penrith Local Emergency Management Plan September 2015*. Both documents are administered by the NSW State Emergency Service (SES).

The *Penrith City LFP 2012* is prepared in accordance with the standard NSW SES flood plan template and was last reviewed in April 2012.

Part 1 of the LFP includes the introduction to the local flood plan, including details about organisational responsibilities and supporting services for managing flooding risks. It currently says very little about flooding risks from local overland flow, including the College, Orth and Werrington Creeks Catchment, which has a history of overland flooding.

Part 2 is in need of an update to incorporate flood intelligence from more recent flood studies, floodplain risk management studies, and actual floods. An annex to the flood plan could be provided, that details the flood risks in the College, Orth and Werrington Creeks Catchment (e.g., PMF hazards on Great Western Highway and upstream of the railway line at Werrington train station), and include specific details such as the location of vulnerable facilities, roads subject to flooding and the vulnerability of properties to above floor flooding.

Part 3 of the LFP describes response arrangements. The section does not include any considerations of flood emergency management response as a result of local overland flooding. Therefore, more specific and localised information should be included for the College, Orth and Werrington Creeks Catchment based on information from this report. Part 3 also refers to evacuation, however, no evacuation centres are listed. It is recommended this section is updated to include this information should those impacted by overland or mainstream flooding in this catchment (and the wider LGA) require evacuation.

A summary of pertinent components of the LFP for update for the College, Orth and Werrington Creeks Catchment are provided in **Table 29.**

Table 29 Comments on Current Penrith City Local Flood Plan

| Section | Description | Comment |
|---|---|---|
| ***Part 1 – Introduction*** | | |
| 1.1 | Purpose | Local overland flooding needs to be included in the purposes of the Penrith City Flood Plan. Currently the flood plan lists flood risk from the Nepean River only. |
| 1.1 | Purpose | It is anticipated local overland flooding risks included from this floodplain risk management study and plan will not comprise reference to a "Level 1"and "Level 2" flood risk thresholds for emergency management. Therefore, appropriate thresholds for categorising the flood risk, such as minor, moderate and major, should be included. |
| 1.2 | Authority | References in this section should be reviewed to ensure they remain current and correct. This is especially important for the links to the Hawkesbury Nepean Flood Plan 2015 as it is updated. |
| 1.3 | Area coved by the Plan | Refences to the population of Penrith City and SES planning districts should be reviewed to ensure they remain current and correct. |
| 1.4 | Description of flooding and its Effects | It is recommended an Annex describing the nature and effects of flooding in the College, Orth and Werrington Creeks is included. |
| 1.5 | Responsibilities | The names and responsibilities of the NSW Government Agencies and other groups in this section should be reviewed to ensure they remain current and correct. |
| ***Part 2 – Preparedness*** | | |
| 2.3 | Development of flood Intelligence | Flood intelligence for the College, Orth and Werrington Creeks Catchment should be included based on the information in this report. Catchment specific information could be included in the form of an Annex, and include information such as:<br>• Characteristics of flooding in the College, Orth and Werrington Creeks Catchment (**Section 4.2** of this report) for the full range of design storm events, up to and including the PMF.<br>• Flood history (**Section 5.2** and **5.2** and **Figures 8, 9, 10, 11** of the College, Orth and Werrington Catchment Flood Study 2017). |

| Section | Description | Comment |
|---|---|---|
| | | • Available gauges in the vicinity of the catchment that could be used for flood intelligence (**Table 1** and **Figure 3** of the College, Orth and Werrington Catchment Flood Study 2017).<br>• Location of vulnerable facilities (**Appendix D** and **Figure 4** and **Figure 49** of this report)<br>• Roads subject to flooding (**Appendix C** of this report)<br>• Vulnerability of floor levels of properties to flooding i.e. when each floor level is anticipated to be impacted by over floor flooding (**Figure 30** of this report).<br>• Existing flood mitigation systems, including the Werrington Road levee and Werrington earthen levee.<br>• Flood emergency response planning classifications, as indicated on **Figures 30 – 34** of this report.<br>• Maps of potential flooding should be included in the Local Flood Plan. From this report, the following maps may be beneficial to include:<br>- **Figures 6** to **14** show floodwater depths<br>- **Figures 15** to **23** show flood levels.<br>- **Figures 24** to **32** show flow velocities.<br>- **Figures 33** to **37** show flood hazard. . |
| ***Part 3 – Response Arrangements*** | | |
| 3.1 – 3.28 | | Each section of Part 3 will need a review and update to include consideration of local overland flooding within the Penrith LGA. Specific areas for consideration are listed below. |
| 3.1 | Control Arrangements | Include College, Orth and Werrington Creeks catchment in the list of potential flooding mechanisms and associated flood risk categorisation and thresholds (low, medium and high or the like). |
| 3.2 | Start of Response Operations | This section will need updating to include considerations of when “response operations” will begin for local overland flooding issues in the College, Orth and Werrington Creeks Catchment. Currently, the Penrith LFP uses flood warning or flood watch information from the Nepean River only. As stated above, gauges in the vicinity of the catchment that could be used for flood intelligence are included in **Table 1** and **Figure 3** of the ‘College, Orth and Werrington Creeks Catchment Flood Study’ 2017. |
| 3.3 | Designation of Start Time | This section will need updating to include considerations of when “start time” will begin for local overland flooding issues in the College, Orth and Werrington Creeks Catchment. |
| 3.6 | Operational Management | This section will need updating to include considerations of local overland flooding issues in the College, Orth and Werrington Creeks catchment. This could also include consideration of safe refuge in place for parts of the |

| Section | Description | Comment |
|---|---|---|
| | | catchment, as discussed in **Section 6.4.2** of this report. |
| 3.10 | Providing Information | It is anticipated that there would be minimal opportunity to provide adequate flood warning for the catchment based on the "flashy" nature of the flooding, so warning products such as severe weather warnings or flood watches could be used as the basis for designing appropriate flood template messaging. Currently the College, Orth and Werrington Creeks Catchment are located within the Bureau of Meteorology "Flood Watch" Area 57, which covers Hawkesbury and lower Nepean Rivers. There may be opportunity to provide more localised information based on local rainfall.<br>Recommend a local flood warning system is established that caters for the "flashy" flooding nature of this local overland flooding in the College, Orth and Werrington Creeks Catchment. This could include provision of a website or similar and would eliminate the need for the community to "phone in" to the SES during a flood event, as listed in **Section 3.10.9** of the current local flood plan. The website could include local and current information, such as<br>- Local rainfall.<br>- River heights of South Creek and Nepean River to provide some local context to potential flooding.<br>- Road conditions.<br>- Closure of roads.<br>- Advice on how private property owners could protect their residential, commercial or industrial property. |
| 3.10 | Providing Information | Recommend the list of media outlets for warning dissemination be reviewed to ensure they remain current and correct. |
| 3.12 and 3.13 | Road and Traffic Control | There are a number of roads that are affected by flooding in the College, Orth and Werrington Creeks Catchment. Council, the SES, TfNSW and NSW Police have the authority to close roads as a part of the flood management planning process. Council may act as an agent for the TfNSW and close relevant roads as well as closing and re-opening council owned roads. Details of what agency is responsible for closing what roads should be included in this section. |
| 3.17 | Affected communities | Include details of flood evacuation centres should those impacted by overland flooding need evacuation. |
| ***Part 4 - Recovery*** | | |

| Section | Description | Comment |
|---|---|---|
| Part 4.1 to 4.3 | | It is recommended Part 4 is updated to include recovery considerations as a result of local overland flooding in the College, Orth and Werrington Creeks Catchment. |

## 6.3 Emergency Services' Capability

The Penrith SES unit has their local headquarters based in 27 Fowler Street, Claremont Meadows and would be the emergency services unit most likely to offer support to the community during floods in the College, Orth and Werrington Creeks catchment.

However, given the size of the at-risk communities in the LGA, and the speed with which flash flooding can occur, adverse consequences are likely to occur across the College, Orth and Werrington Creeks catchment before emergency services personnel can be deployed. As a result, it will be critical that the at-risk communities are able to cope with flooding without reliance on the emergency services. In the short term, this will require development of meaningful flood awareness information and community education campaigns to be designed for the local community and undertaken on a regular basis, possibly annually or bi-annually, coupled with the implementation of appropriate development controls over the medium to long term.

## 6.4 Response Strategy

### 6.4.1 Response and Evacuation Strategy theory

A major point of contention in contemporary flood emergency management planning relates to the advantages and disadvantages of evacuation compared to seeking on-refuge in place.

The Australian Fire and Emergency Services Authorities Council (AFAC) (2013) '*Guideline on Emergency Planning and Response to Protect Life in Flash Flood Events'* is considered to represent best practice on this issue. It recognises that the safest place to be in a flood is well away from the affected area. Provided that evacuation can be safely implemented, this is the most effective strategy. <u>Properly planned and executed evacuation is the most effective strategy in terms of a reliable public safety outcome</u>.

However, AFAC recognises that evacuating too late may be worse than not evacuating at all because of the dangers inherent in moving through floodwaters. If evacuation has not occurred prior to the arrival of floodwater, taking refuge inside a building may be safer than trying to escape by entering the floodwater.

Nevertheless, AFAC argues that remaining in buildings likely to be affected by flooding is not low risk and should never be a default strategy for pre-incident planning: 'where the available warning time and resources permit, evacuation should be the primary response strategy' (p.4). The risks of a 'on-site refuge' strategy include:

- Floodwater reaching the place of shelter (unless the shelter is above the extreme flood 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 an extreme flood event)
- 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 immobility (not being able to reach the highest part of the building)
- The difficulty of servicing medical emergencies (pre-existing condition or sudden onset e.g., heart attack) during a flood; and
- The difficulty of servicing other hazards (e.g., fire) during a flood.

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 (Opper et al., 2011). Pre-incident planning therefore needs to include a realistic assessment of evacuation timelines (both time available and time required for evacuation), including assessment of 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.

### 6.4.2 College Orth and Werrington Creek Response and Evacuation Practice

The Penrith Local Flood Plan 2012 does not include consideration of emergency management requirements as a result of local overland flooding. Therefore, comment cannot be made on the appropriateness or otherwise of the emergency management and evacuation practices in the College Orth and Werrington Creek catchment. However, it is likely that flooding will be occurring, and parts of the catchment will be isolated prior to the effective mobilisation of the emergency services. The quick response of the local urbanised area to runoff after the onset of rainfall and "flashy" nature of flooding in the catchment would make it difficult to provide timely evacuation warnings once the rain has commenced for many parts of the catchment. While evacuation is generally the primary and preferred strategy for the NSW SES, , the Penrith Local Flood Plan 2012 contains no details on how this may be enacted for overland flooding scenarios and it may not be the most appropriate flood emergency response strategy for the College, Orth and Werrington Creeks Catchment.

The national hazard mapping (refer **Figures 33** to **37**) indicates the maximum hazard during the 1% AEP flood is most often between H1 to H3, which would not cause damage to buildings and is unlikely to present a serious risk to able-bodied adults. However, more extensive areas would be exposed to a hazard classification of at least H5 hazard during the PMF event which would be unsafe for people and buildings may be susceptible to failure if they are not specifically designed to withstand the forces of the floodwaters. Those properties that would exposed to H5 or H6 hazard during the PMF are shown in **Plate 25**, **Plate 26** and **Plate 27**.

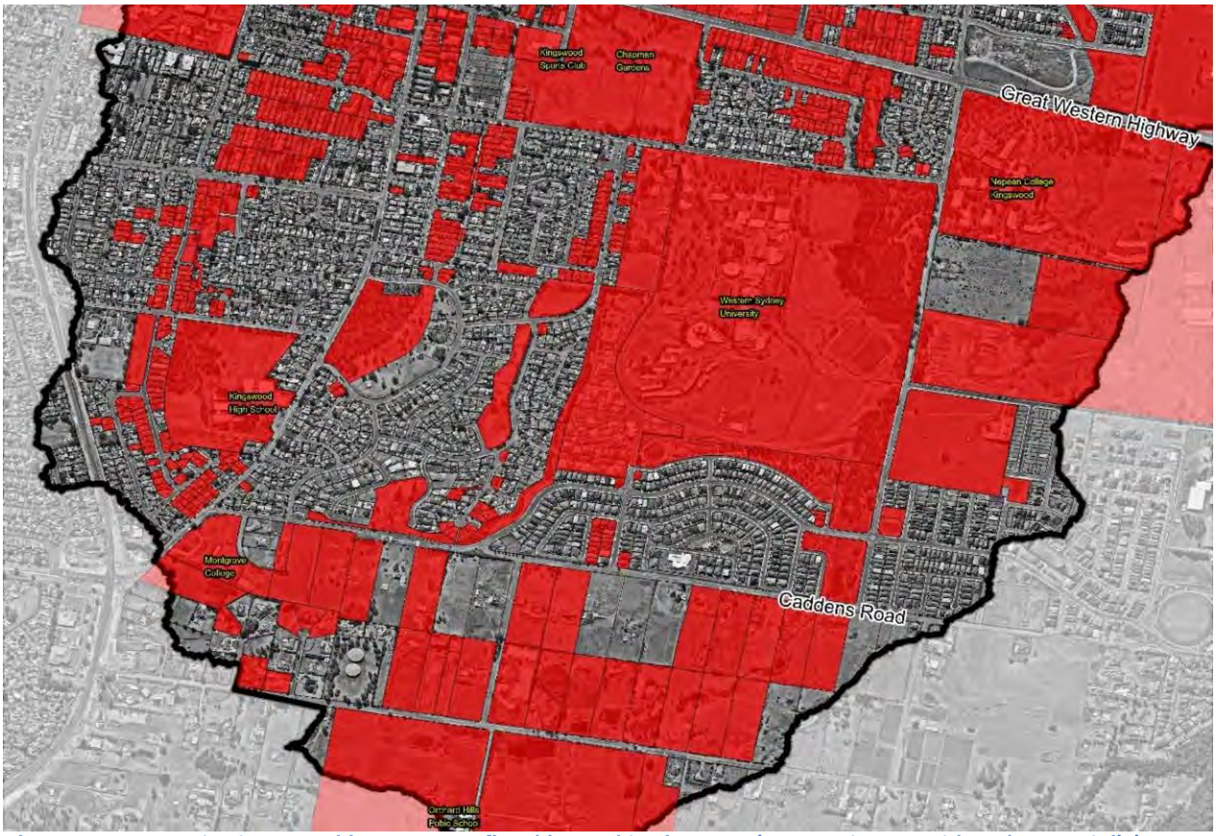



**Plate 25 Properties impacted by H5 or H6 flood hazard in the PMF (evacuation considered essential) (area 1 of 3)**


**Plate 26 Properties impacted by H5 or H6 flood hazard in the PMF (evacuation considered essential) (area 2 of 3)**

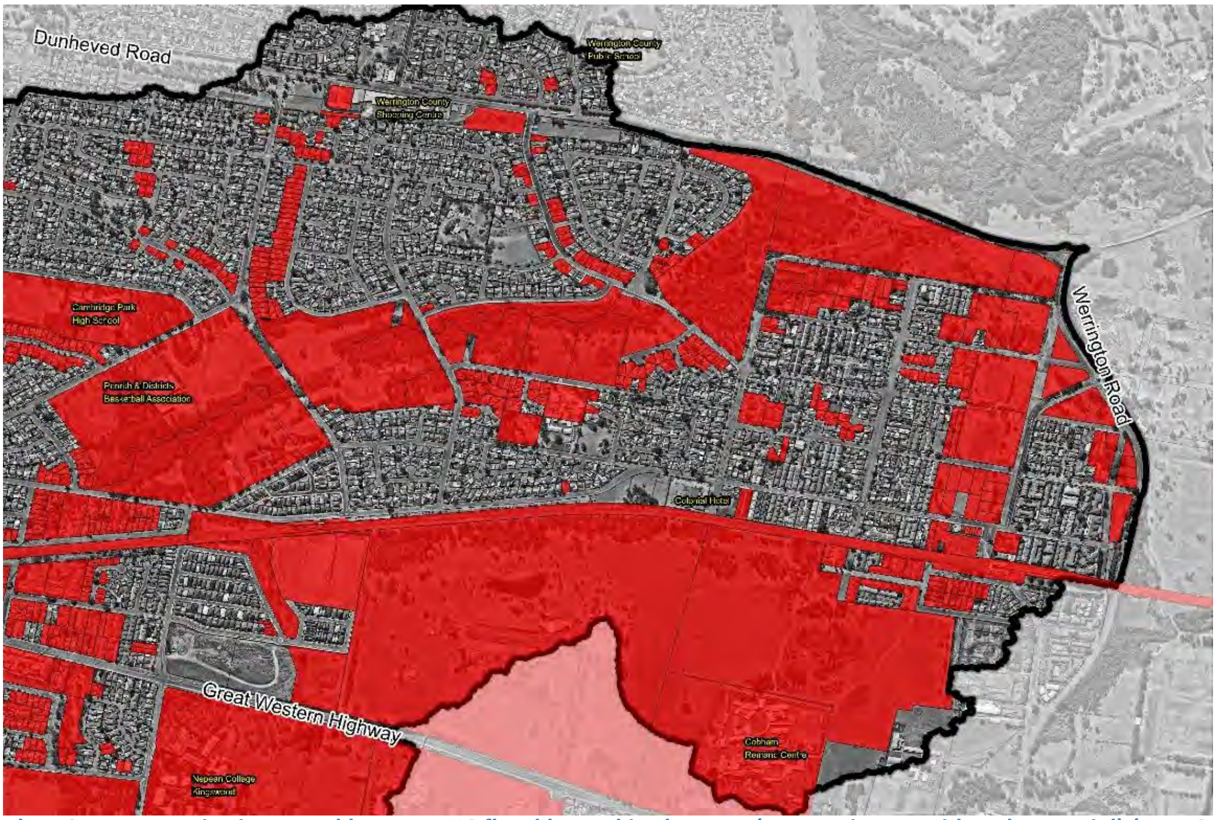



**Plate 27 Properties impacted by H5 or H6 flood hazard in the PMF (evacuation considered essential) (area 3 of 3)**

Those properties where depths of above-floor inundation in the PMF are estimated to be greater than 1.2 metres, which is considered unsafe for adults to shelter inside, is shown on **Plate 28**, **Plate 29** and **Plate 30**. However, it needs to be acknowledged when reviewing the plates that the floor levels are estimated. As a result, above floor flooding depths are also estimates.

Early evacuation is considered essential for any of the properties identified in **Plate 25** to **Plate 30.** A particular focus should be placed on the properties identified in **Plate 28, Plate 29** and **Plate 30** as the significant above floor flooding depths will mean that it will be highly hazardous within these properties as well as outside of the properties.

In addition to the properties identified in **Plate 28**, **Plate 29** and **Plate 30**, evacuation is also recommended for people whose prior medical condition means any isolation from medical help cannot be tolerated and would be considered unsafe for their health.

Further discussion on potential evacuation strategies for these properties are provided in Section 10.2.5


**Plate 28 Properties estimated to have flood depths above floor level greater than 1.2 meters in the PMF (evacuation considered essential) (Area 1 of 3)**


**Plate 29 Properties estimated to have flood depths above floor level greater than 1.2 meters in the PMF (evacuation considered essential) (Area 2 of 3)**


**Plate 30 Properties estimated to have flood depths above floor level greater than 1.2 meters in the PMF (evacuation considered essential) (Area 3 of 3)**

If the NSW SES wishes to maintain an evacuation strategy, then significant work needs to be undertaken to ensure that evacuation can be successfully achieved. This includes at a minimum:

- The identification of appropriate evacuation centres. With different areas of the catchment potentially isolated from each other, several evacuation centres are required to prevent evacuees from entering floodwaters in an attempt to reach the evacuation centre. There are a number of potential evacuation centres located within or adjacent to the catchment that are located outside of the PMF such as:
  - Colonial Hotel (located at 156 Victoria Street, Werrington).
  - Henry Sports Club (144 Henry Lawson Avenue, Werrington County).
  - St Dominic’s College (94 Gascoigne Street, Kingswood).
  - St Joseph’s Primary School (90-94 Joseph Street, Kingswood).
  - TAFE Nepean Campus (12-44 O’Connell Street, Kingswood).
- Evacuation centres would need to be suitably sized and stocked with supplies to cater for evacuees. However, given the relatively small population at risk and the short duration of flooding, the requirements for space and supplies at evacuation centres should not be extensive. It is also likely that a significant proportion of the population at risk will evacuate to private residences such as family and friends, further reducing the potential requirements of local evacuation centres.

- The positioning of emergency services in different sections of the catchment (say one north and one south of the railway or Great Western Highway). If an evacuation is enacted, it is likely that in each of the different sections of the catchments there will be occupants that require assistance from emergency services to evacuate. Therefore, it is important that there are emergency service personnel located within each of the isolated sections prior to the access becoming cut.

# 7 OPTIONS FOR MANAGING THE FLOOD RISK

## 7.1 General

As outlined in Chapter 4, a large number of properties across the College, Orth and Werrington Creeks catchment are potentially exposed to a significant flood risk and/or significant financial impacts during floods within the catchment. Accordingly, the following chapters outline options that could be implemented to better manage the flood risk.

## 7.2 Potential Options for Managing the Flooding Risk

### 7.2.1 Types of Options

Options for managing the flood risk can be broadly grouped into one of the following categories:

- **Flood Modification Options**: are measures that aim to modify existing flood behaviour, thereby reducing the extent, depth or velocity of floodwater across flood liable areas. Flood modification measures will generally benefit a number of properties and are primarily aimed at reducing the existing flood risk. However, they can also be designed to mitigate potential increases in flood risk associated with future catchment development.
- **Property Modification Options**: refers to modifications to planning controls and modifications to individual properties to reduce the potential for inundation in the first instance or improve the resilience of properties should inundation occur. Modifications to individual properties is typically used to manage existing flood risk while planning measures (e.g., land use and development controls) are employed to manage future flood risk.
- **Response Modification Options**: are measures that can be implemented to change the way in which emergency services as well as the public responds before, during and after a flood. Response modification measures are the key measures employed to manage the continuing flood risk particularly for very large floods such as the PMF.

## 7.3 Options Considered as Part of Current Study

An initial list of potential flood risk management options was prepared for consideration by Council. The risk management measures were developed based upon consideration of the following factors:

- Location of high flood risk and high flood damage properties
- Preliminary mitigation measures identified in the *'College, Orth and Werrington Creeks Catchment Overland Flow Flood Study'* (Catchment Simulation Solutions, 2017)
- Council recommendations; and
- Feedback provided by the community.

The list of options that were identified are summarised in **Table 30** (flood modification options), **Table 31** (property modification options) and **Table 32** (response modification options).

Table 30 Preliminary List of Flood Modification Options Considered for Managing the Flood Risk

| Potential Flood Modification Options | Description of Option |
|---|---|
| **Detention Basins** | |
| Werrington Lake upgrades | Provide additional storage capacity in *Werrington Lake* to reduce discharges downstream of the lake by elevating existing basin embankment and modifying the outlet structure. |
| Lincoln Drive Park basin | Provide additional storage capacity in existing open space within Lincoln Drive Park at Cambridge Park to reduce overland flooding downstream of the park by elevating existing embankment. |
| Devon Park basin | Construct a new detention basin in existing open space at Devon Park at Cambridge Park to reduce overland flooding downstream of the park. |
| Harold Corr Oval basin | Modify existing oval at Cambridge Park to provide additional detention capacity and reduce overland flooding downstream of the oval. |
| Chapman Gardens basin | Modify existing Chapman Gardens detention basin at Kingswood to provide additional detention capacity and reduce overland flooding across Great Western Highway and adjoining car yards. |
| Great Western Highway basin | Construct a new detention basin between the Great Western Highway and Railway Line at Kingswood to reduce overland flooding downstream of the railway line. |
| Western Sydney University (WSU) basin #1 | Provide additional storage capacity in existing lake within WSU Kingswood Campus by elevating existing basin embankment and modifying the outlet structure. |
| Western Sydney University basin #2 | Construct a new detention basin on College Creek immediately south of Second Avenue to reduce overland flooding downstream to Great Western Highway. |
| Wainwright Park basin | Construct a new detention basin near the corner of Bringelly Road and Orth Street at Kingswood to reduce overland flooding through commercial area. |
| Stafford Street basin #1 | Construct a new detention basin within existing open space north of Stafford Street at Kingswood to reduce overland flooding through downstream area. |
| Stafford Street basin #2 | Construct a new detention basin within existing open space south of Stafford Street at Kingswood to reduce overland flooding through downstream area. |
| Jamison Road basin modifications | Augment existing basin located north of Jamison Road at Kingswood to provide additional storage capacity. |
| Clemson Street basin | Construct a new detention basin within existing open space west of Clemson Street at Kingswood to reduce overland flooding through downstream area. |

| Potential Flood Modification Options | Description of Option |
|---|---|
| Stapley Street basin | Construct a new detention basin within existing open space east of Stapley Street at Kingswood to reduce overland flooding through downstream area. |
| Tent Street basin | Construct a new detention basin within existing open space west of Tent Street (near Smith Street intersection) at Kingswood to reduce overland flooding through downstream area. |
| Kingswood High School basin | Construct a new detention basin in north-western corner of Kingswood High School to reduce overland flooding through downstream area. |
| Peppermint Reserve basin modifications | Modify existing detention basins located within Peppermint Reserve to provide additional storage capacity and or modified outlet configuration to reduce downstream flooding. |
| Montgrove College basin modifications | Modify existing Montgrove College Basin to provide additional storage capacity and or modified outlet configuration to reduce downstream flooding. |
| **Culverts and Bridges Modifications** | |
| Dunheved Road Bridge upgrade | Upgrade of the existing bridge crossing of Werrington Creek at Werrington to reduce upstream water levels and improve level of service and evacuation access. |
| Victoria Street culvert upgrade #1 | Upgrade of the main Werrington Creek culvert to reduce frequency and depth of roadway overtopping at Victoria Street, Kingswood. |
| Victoria Street culvert upgrade #2 | Upgrade of the secondary Victoria Street culvert located near Cottage Street to reduce frequency and depth of roadway overtopping at Victoria Street, Kingswood. |
| Great Western Highway culvert upgrade | Upgrade of existing culvert between Chapman Gardens and Orth Creek at Kingswood to reduce ponding depths across industrial properties. |
| Cox Avenue railway culvert upgrade | Upgrade of existing Railway culvert located south of Cox Street, Kingswood to reduce ponding depths across industrial properties. |
| Werrington Creek railway culvert upgrade #1 | Upgrade of the main Railway culvert crossing of Werrington Creek. |
| Werrington Creek railway culvert upgrade #2 | Upgrade of the secondary Railway culvert crossing near French Street subdivision. |
| Werrington Railway Station culvert upgrade | Upgrade of the culvert draining runoff beneath the railway embankment near Werrington train station. |
| **Stormwater Modifications** | |
| John Oxley Drive stormwater upgrades | Stormwater pit and pipe upgrades along John Oxley Drive between Dunheved Road and Prince Street at Werrington County to reduce frequency and depth of overland flooding. |
| Dunkley Place stormwater upgrades | Stormwater pit and pipe upgrades at low point in Dunkley Place at Werrington to reduce ponding depths. |
| Chrisan Close stormwater upgrades | Stormwater pit and pipe upgrades at low point in Chrisan Close at Werrington to reduce ponding depths. |
| Edward Close stormwater upgrades | Stormwater pit and pipe upgrades at low point in Edward Close at Werrington to reduce ponding depths. |

| Potential Flood Modification Options | Description of Option |
|---|---|
| Lack Place stormwater upgrades | Stormwater pit and pipe upgrades at low point in Lack Place at Werrington to reduce ponding depths. |
| Campton Avenue stormwater upgrades | Stormwater pit and pipe upgrades along Campton Avenue between Devon Park and Herbert Street at Cambridge Park to reduce frequency and depth of overland flooding. |
| Orleton Place to Francis Street stormwater upgrades | Stormwater pit and pipe upgrades between Orleton Place and Francis Street (including Glencoe Avenue) at Cambridge Park to reduce frequency and depth of overland flooding. |
| Rugby Street to Herbert Street stormwater upgrades | Stormwater pit and pipe upgrades between Rugby Street and Herbert Street (including Wembley Avenue, Twickenham Avenue and William Street) at Cambridge Park to reduce frequency and depth of overland flooding. |
| Victoria Street to Joseph Street stormwater upgrades | Stormwater pit and pipe upgrades between Victoria Street and Joseph Street at Kingswood to reduce frequency and depth of overland flooding. |
| Stapley Street to Bringelly Road stormwater upgrades | Stormwater pit and pipe upgrades between Stapley Street and Bringelly Road (including Jamison Road, Stafford Street, Derby Street and Hargrave Street) at Kingswood to reduce frequency and depth of overland flooding. |
| Somerset Street to Orth Street stormwater upgrades | Stormwater pit and pipe upgrades between Somerset Street and Orth Street (including Rodgers Street) at Kingswood to reduce frequency and depth of overland flooding. |
| Edna Street stormwater upgrades | Stormwater pit and pipe upgrades at low point in Edna Street at Kingswood to reduce frequency and depth of overland flooding. |
| **Channel Modifications** | |
| Epping Close Swale upgrade | Increase capacity of existing overland flow path that extends parallel to Epping Close between Sandringham Avenue and Devon Park at Cambridge Park. |
| Park Avenue Swale | Provision of overland flow path in existing open space between Joseph Street and Park Avenue at Kingswood. |
| College Creek and Orth Creek channel enlargement | Enlarge College Creek and Orth Creek channel between Great Western Highway and railway at Kingswood. |
| Heavy Street channel realignment | Realignment of existing open channel located north of Heavy Street at Werrington (the channel currently drains runoff from the local stormwater system into Werrington Creek) to reduce backwater flooding along the channel and allow local stormwater system to drain more readily. |
| Werrington Creek vegetation maintenance | Removal and maintenance of dense vegetation within Werrington Creek channel (between railway line and Werrington Lake) to improve flow carrying capacity of the channel. |
| College Creek vegetation maintenance | Removal and maintenance of dense vegetation within College Creek channel (between Second Avenue and Great Western Highway) to improve flow carrying capacity of the channel. |
| **Levee Modifications** | |

| Potential Flood Modification Options | Description of Option |
|---|---|
| Werrington Earthen Levee Upgrade | Increase height of existing earthen levee at Werrington to provide additional protection against elevated water levels in Werrington Creek, South Creek and the Hawkesbury-Nepean River. |
| Levee outlet upgrades | Increase size of existing gated culverts that drain local catchment runoff beneath Werrington Earthen levee and Werrington Road levee at Werrington to reduce flood levels from local catchment runoff. |
| Floodgate maintenance plan | Develop maintenance plan to ensure the Werrington Earthen levee floodgate and Werrington Road levee floodgates are regularly maintained and remain operational during all future floods. |
| **Miscellaneous Modifications** | |
| Great Western Highway Median Modification | Remove part sections of Great Western Highway median strip at Kingswood to reduce ponding depths on southern side of road and allow water to discharge downstream more readily |
| Open fencing | Replace existing "solid" fencing in overland flow areas with open fencing. |

**Table 31 Preliminary List of Property Modification Options Considered for Managing the Flood Risk**

| Potential Property Modification Options | Description of Option |
|---|---|
| **Planning Modifications** | |
| Updates to LEP | Update Council LEP to reflect the detailed review completed as part of the current study. This review will also take into consideration the NSW Government's "*Flood Prone Land Package*" that is currently on public exhibition. |
| Updates to DCP | Update Council DCP to reflect the detailed review completed as part of the current study. This will include recommendations for appropriate controls for new development in the "hospital precinct" of Kingswood. |
| Updates to Section 10.7 certificates | Update Council Section 10.7 certificates to include updated floodprone land information generated as part of the current study. |
| **Residential Property Modifications** | |
| Voluntary purchase of select properties | Voluntary purchase of select properties in high hazard, floodway areas as per eligibility requirements in NSW Government Guidelines. |
| Voluntary flood proofing of select properties | Flood proofing of select residential properties subject to frequent above floor inundation in low hazard areas |
| Voluntary raising of select residential properties | Voluntary raising of select houses subject to frequent above floor inundation in low hazard areas as per eligibility requirements in NSW Government Guidelines. |
| Flood barriers | Installation of temporary flood barriers to afford protection from flooding for commercial properties |

Table 32 Preliminary List of Response Modification Options Considered for Managing the Flood Risk

| Potential Response Modification Options | Description of Option |
|---|---|
| **Education** | |
| Community education activities | Various community education activities to increase flood awareness and allow residents to be more self-sufficient during future floods |
| Make property level flood information available | Increase the availability and access to the most contemporary property level flood information for all residents and businesses within the LGA to increase flood awareness |
| **Flood Plans** | |
| Preparation of residential flood plans | Preparation of flood plans by residential property occupiers to identify actions to be taken before, during and after a flood |
| Preparation of business flood plans | Preparation of flood plans by business owners to identify actions to be taken before, during and after a flood |
| Local flood plan updates | Update NSW SES local flood plan to take advantage of updated flood information generated as part of the current study |
| **Evacuation Route Upgrades** | |
| Great Western Highway upgrade | Upgrade Great Western Highway at Kingswood to improve level of service |
| John Oxley Avenue upgrade | Upgrade John Oxley Avenue at Cambridge Park to improve level of service |
| Burton Street upgrade | Upgrade Burton Street at Werrington County to improve level of service |
| William Street upgrade | Upgrade William Street at Werrington County to improve level of service |
| **Miscellaneous** | |
| Flood warning system | Development of a flood warning system (and associated recommendations for supporting infrastructure, such as stream gauges) for the catchment to provide additional evacuation time |
| Safe refuge in place strategy | Develop a strategy to allow for safe refuge in place at suitable locations within the catchment. At the same time, identify areas where refuge in place is not safe and, therefore, where evacuation is considered essential |

## 7.4 Qualitative Assessment of Options

### 7.4.1 Raw Assessment

It was not considered feasible to undertake a detailed assessment of all options - forty-nine (49) flood modification options, seven (7) property modification options and eleven (11) response modification options. Therefore, a qualitative assessment of each potential option was completed to provide an initial assessment of the potential feasibility of each option and to determine which measures showed merit for further detailed assessment. The evaluation criteria that was employed to complete this assessment is summarised in **Table 33.**

Table 33 Adopted Evaluation Criteria and Scoring System for Qualitative Assessment of Flood Risk Management Options

| **Score**: | Impact on flood behaviour | Technical Feasibility | Environmental Impacts | Economic Benefit | Cost | Impacts on Emergency Response | Community Support |
|---|---|---|---|---|---|---|---|
| **-2** | Anticipated to result in significant increase in flood levels or extents | Anticipated to involve significant technical challenges | Significant negative environmental impact | Significant increase in flood damage cost or increase in flood risk | More than $1 million | Significant adverse impact on emergency services response | Majority of community opposed |
| **-1** | Anticipated to result in minor increase on flood levels or extents | Anticipated to involve moderate technical challenges | Small negative environmental impact | Minor increase in flood damage cost or increase in flood risk | More than $500k | Small adverse impact on emergency services response | Some community opposed |
| **0** | Anticipated to have a negligible impact on flood levels or extents | Anticipated to involve minor technical challenges | Negligible environmental impacts | No change in damages | More than $100k | Negligible impact on emergency services response | Neutral |
| **1** | Anticipated to result in a minor decrease in flood levels or extents (impacts 1-5 lots) | Anticipated to involve negligible technical challenges | Small opportunity for environmental enhancement | Minor reduction in flood damage cost or reduction in flood risk | More than $50k | Small improvement to emergency services response | Some community support |
| **2** | Anticipated to result in a significant decrease in flood levels or extents (impacts 5 or more lots) | Anticipated to involve no technical challenges | Significant opportunity for environmental enhancement | Major reduction in flood damage cost or reduction in flood risk | Less than $50k | Significant improvement to emergency services response | Majority of community support |

In general, where an option had a beneficial impact against the evaluation criteria, it was assigned a positive score (either +1 or +2). Where an option had negligible impact, it was assigned a score of 0. And where there was a perceived negative impact, a negative value was assigned (either -1 or -2).

Each potential option was 'scored' against each of the evaluation criteria using the following approach:

- Impact on Flood Behaviour: detailed modelling of each individual option was not possible. Therefore, the qualitative assessment utilised outcomes from detailed assessments of similar options in other floodplain risk management studies.
- Technical feasibility: Any potential technical 'hurdles' were assessed based on the proximity of each option to other infrastructure or obstructions that would hinder implementation.
- Environmental Impacts: The 'footprint' of each option was reviewed relative to environmental constraint mapping to determine if there was potential for adverse impacts (in which case a negative score was assigned). If an option has the potential to offer environmental benefits, this was noted by a positive score.
- Economic Benefit: was established by estimating the likely change in flood damage costs. This assessment drew from the outcomes of the assessment of other similar option in other floodplain risk management studies as well as the likely number of properties that would experience flood level reductions.
- Cost: A 'ballpark' cost was estimated for each option based on detailed cost estimates prepared for similar options in other floodplain risk management studies. This included potential land acquisition costs if required.
- Impact on Emergency Response: Assessment of this criterion considered how an option might alter the evacuation requirements, such as length of time or depth of floodwaters across inundated roads, and opportunities for alternate evacuation routes.
- Community Support: The information received during the first stage of the community consultation was used to provide an understanding of the level support for each potential floodplain risk management option.

The outcomes of the initial assessment of each option are presented in **Table H1** in **Appendix H**.

It should be reinforced that this assessment was relative in nature only and was only used to prepare a shortlist of options to be assessed in detail as part of the detailed flood risk management options investigations.

### 7.4.2 Weighted Assessment

It was noted each of the evaluation criteria listed in **Table 33** would not always be considered equal and that higher weightings should be given to some of the evaluation criteria relative to others. Therefore, "weightings" were developed for each of the evaluation criteria to reflect the relative important of each criterion in best managing the flood risk.

The weightings that were developed and applied to each evaluation criteria are represented in **Table 34.** As shown in **Table 34**, hydraulic performance and impact on flood behaviour was assigned the highest weighting. This was followed by community support, technical feasibility and then economic benefits, cost, environmental impacts, and emergency response impacts. Although emergency response and environmental impacts were assigned a lower weighting, they are both important elements of the assessment process and support the triple bottom line evaluation and management of residual risk.

Table 34 Weightings applied to Scoring Criteria for Assessment of Potential Floodplain Risk Management Options

| Scoring Criteria | Weighting |
|---|---|
| Impact on Flood Behaviour | 25% |
| Technical Feasibility | 15% |
| Environmental Impacts | 10% |
| Economic Benefit | 10% |
| Cost | 10% |
| Impacts on Emergency Response | 10% |
| Community support | 20% |

Each of the weightings in **Table 34** were applied to the "raw" scores for each option (refer **Table H1** in **Appendix H**) to develop weighted scores for each evaluation criteria. The weighted scores are also provided in in **Table H2** in **Appendix H.**

### 7.4.3 Ranking of Options

The weighted and non-weighted scores for each option were summed to provide an overall score for each option. This served as the basis for ranking each flood modification, property modification and response modification options. The rankings assigned to each option are presented in **Table H3** in **Appendix H** (higher overall scores were assigned a higher ranking relative to lower overall scores).

The rankings provided in **Table H3** in **Appendix H** show that the top ten rankings and bottom ten rankings are similar regardless of whether the weighted of raw scores are used. However, the inclusion of the weightings does have an impact on the order of the ranking.

The raw scores also provide a large number of equal total scores making it difficult to differentiate between some of the options. The weighted scores provide a better basis for ranking of the options and, specifically, which should be carried forward for detailed assessment, which is discussed below.

## 7.5 Options to be Assessed in Detail

As outlined in the previous sections, a qualitative assessment of each potential option was completed to provide an initial appraisal of the likely feasibility of each option and which options should be assessed in detail. The outcomes of this assessment are presented in **Appendix H**.

As discussed, both 'raw' and 'weighted' scores were calculated for each option. It was determined that the weighted scores provide a better means of distinguishing between the options and it is the weighted score that formed the basis for determining which option was carried forward for detailed assessment. A summary of the options recommended for detailed analysis are presented in **Table 35** for flood modification options, **Table 36** for property modification options and **Table 37** for response modification options.

**Table 35 Flood Modification Options Recommended for Detailed Assessment**

| Option ID | Flood Modification Options | Description of Option |
|---|---|---|
| FM1 | Chapman Gardens basin | Modify existing Chapman Gardens detention basin at Kingswood to provide additional detention capacity and reduce overland flooding across Great Western Highway and adjoining car yards. |
| FM2 | Great Western Highway basin | Construct a new detention basin between the Great Western Highway and the Railway Line at Kingswood to reduce overland flooding downstream of the railway line. |
| FM3 | Lincoln Drive Park basin | Provide additional storage capacity in existing open space within Lincoln Drive Park at Cambridge Park to reduce overland flooding downstream of the park by elevating existing embankment. |
| FM4* | South Werrington basin augmentation* | Augment detention basin that is proposed as part of the South Werrington Urban development to increase storage capacity and reduce flood depths and extents south of the railway line*. |
| *NOTE: During the detailed assessment of this FM4 option, it was determined that this option could not be assessed in detail due to the advanced progression of the planning and development application at the South Werrington Urban Village site. Therefore, this option was subsequently replaced with the Stafford Street basin listed below. This outcome is discussed further in Section 8.3.6. | | |
| FM4 | Stafford Street Basins | Creating additional storage in existing open space on north or south or both sides of Stafford Street to reduce overland flooding through downstream area. |
| FM5 | Jamison Road basin modifications | Augment existing basin located north of Jamison Road at Kingswood to provide additional storage capacity. |
| FM6 | Victoria Street culvert upgrade #1 | Upgrade of the main Werrington Creek culvert to reduce frequency and depth of roadway overtopping at Victoria Street, Kingswood. |
| FM7 | Great Western Highway culvert upgrade | Upgrade of existing culvert between Chapman Gardens and Orth Creek at Kingswood to reduce ponding depths across industrial properties. |
| FM8 | Werrington Creek railway culvert upgrade #1 | Upgrade of the main railway culvert crossing of Werrington Creek. |
| FM9 | Werrington Creek railway culvert upgrade #2 | Upgrade of the secondary railway culvert crossing near French Street subdivision. |
| FM10 | Werrington Railway Station culvert upgrade | Upgrade of the culvert draining runoff beneath the railway embankment near Werrington train station. |
| FM11 | Dunkley Place stormwater upgrades | Stormwater pit and pipe upgrades at low point in Dunkley Place at Werrington to reduce ponding depths. |

| Option ID | Flood Modification Options | Description of Option |
|---|---|---|
| FM12 | Orleton Place to Francis Street stormwater upgrades | Stormwater pit and pipe upgrades between Orleton Place and Francis Street (including Glencoe Avenue) at Cambridge Park to reduce frequency and depth of overland flooding. |
| FM13 | Rugby Street to William Street stormwater upgrades | Stormwater pit and pipe upgrades between Rugby Street and William Street (including Wembley Avenue and Twickenham Avenue) at Cambridge Park to reduce frequency and depth of overland flooding. |
| FM14 | Victoria Street to Joseph Street stormwater upgrades | Stormwater pit and pipe upgrades between Victoria Street and Joseph Street at Kingswood to reduce frequency and depth of overland flooding. |
| FM15 | Somerset Street to Orth Street stormwater upgrades | Stormwater pit and pipe upgrades between Somerset Street and Orth Street (including Rodgers Street) at Kingswood to reduce frequency and depth of overland flooding. |
| FM16 | Stapley Street to Bringelly Road stormwater upgrades | Stormwater pit and pipe upgrades between Stapley Street and Bringelly Road (including Jamison Road, Stafford Street, Derby Street and Hargrave Street) at Kingswood to reduce frequency and depth of overland flooding. |
| FM17 | College Creek and Orth Creek channel enlargement | Enlarge College Creek and Orth Creek channel between Great Western Highway and railway at Kingswood. |
| FM18 | Great Western Highway Median Modification | Remove part sections of Great Western Highway median strip at Kingswood to reduce ponding depths on southern side of road and allow water to discharge downstream more readily. |

Table 36 Property Modification Options Recommended for Detailed Assessment

| Option ID | Property Modification Option | Description of Option |
|---|---|---|
| PM1 | Updates to LEP | Update Council LEP to reflect the detailed review completed as part of the current study. This will target development located beyond the FPA but within the PMF, such as critical and vulnerable developments, large scale infrastructure, subdivision and rezoning. |
| PM2 | Updates to DCP | Update Council DCP to reflect the detailed review completed as part of the current study. |
| PM3 | Updates to Section 10.7 certificates | Update Council Section 10.7 certificates to include updated flood prone land information generated as part of the current study. |
| PM4 | Voluntary purchase of select properties | Voluntary purchase of select properties in high hazard or floodway areas as per eligibility requirements in NSW Government Guidelines. |

**Table 37 Response Modification Options Recommended for Detailed Assessment**

| Option ID | Property Modification Option | Description of Option |
|---|---|---|
| RM1 | Community education activities | Various community education activities to increase flood awareness and allow residents to be more self-sufficient during future floods. |
| RM2 | Make property level flood information available | Increase the availability and access to the most contemporary property level flood information for all residents and businesses within the LGA to increase flood awareness. |
| RM3 | Local flood plan updates | Update NSW SES local flood plan to take advantage of updated flood information generated as part of the current study. |
| RM4 | Preparation of residential flood plans | Preparation of flood plans by residential property occupiers to identify actions to be taken before, during and after a flood. |
| RM5 | Preparation of business flood plans | Preparation of flood plans by business owners to identify actions to be taken before, during and after a flood. |
| RM6 | Develop a Focussed Education and Evacuation Strategy for High Flood Hazard Areas | Develop a strategy to educate the community and establish evacuation protocols for areas exposed to H5 and H6 hazard in the PMF |
| RM7 | Flash flood warning system | Development of a flood warning system (and associated recommendations for supporting infrastructure, such as rain gauges) for the catchment to provide additional evacuation time. |
| RM8 | Great Western Highway upgrade | Upgrade to Great Western Highway to improve level of service. |
| RM9 | Victoria Street upgrade | Upgrade to Victoria Street at Werrington Creek crossing to improve level of service. |

The outcomes of the detailed evaluation of each option are presented in Chapter 8 (flood modification options), Chapter 9 (property modification options) and Chapter 10 (response modification options.

# 8 Flood Modification Options

## 8.1 Introduction

Flood modification options are measures that aim to modify existing flood behaviour, thereby, reducing the extent, depth and velocity of floodwater across developed areas. Flood modification measures will generally benefit a number of properties and are primarily aimed at reducing the existing flood risk.

Flood modification options considered as part of the study included:

- Basin Upgrades:
  - FM1 – Chapman Gardens Basin: Section 8.3.1;
  - FM2 – Great Western Highway Basin: Section 8.3.2;
  - FM3 – Lincoln Drive Park Basin: Section 8.3.3;
  - FM4 – Stafford Street Basins: Section 8.3.4; and
  - FM5 – Jamison Road Basin Modifications: Section 8.3.5.
- Culvert Upgrades:
  - FM6 – Victoria Street Culvert Upgrade: Section 8.4.1;
  - FM7 – Great Western Highway Culvert Upgrade: Section 8.4.2;
  - FM8 – Werrington Creek Culvert Upgrade #1: Section 8.4.3;
  - FM9 – Werrington Creek Culvert Upgrade #2: Section 8.4.4; and
  - FM10 – Werrington Railway Station Culvert Upgrade: Section 8.4.5.
- Drainage Upgrades:
  - FM11 – Dunkley Place Stormwater Upgrades: Section 8.5.1;
  - FM12 – Orleton Place to Francis Street Stormwater Upgrades: Section 8.5.2;
  - FM13 – Rugby Street to Neeta Avenue Stormwater Upgrades: Section 8.5.3;
  - FM14 – Victoria Street to Joseph Street Stormwater Upgrades: Section 8.5.4; and
  - FM16 - Stafford Street to First Street Stormwater Upgrades: Section 8.5.5.
- Channel Modifications:
  - FM17 – College Creek and Orth Creek Channel Enlargement: Section 8.6.1.
- Roadworks:
  - FM18 – Great Western Highway Median Modification: Section 8.7.1.
- Combined Options:
  - FM19 – FM1 + FM4 + FM5: Section 8.8.1; and
  - FM20 - FM1 + FM4 + FM5 + FM6 + FM9: Section 8.8.2.

The location of each flood modification option is shown in **Figure 57**.

Further discussion on how each option was assessed is provided below. The outcomes of the assessment of each option are provided in subsequent sections.

FM15 (Somerset Street to Orth Street Stormwater Upgrades) was assessed as part of 'Scenario 3' in the 'Impacts of Future Catchment Development', which is included in Section 4.5.1.

## 8.2 Assessment Approach

### 8.2.1 Hydraulic Factors

Each of the measures under consideration will likely alter the distribution of floodwaters. Although this aims to reduce the extent and depth of inundation across populated areas, it may divert floodwaters elsewhere, thereby increasing the flooding risk across other areas. Therefore, it is important that the potential flood impacts associated with implementing each option is understood.

The hydraulic benefits of each flood modification option were assessed by including a representation of each option in the hydraulic model and using the updated model to re-simulate each design flood. The hydraulic benefits were then quantified by preparing flood level difference mapping for each option for the 20%, 5% AEP and 1% AEP floods as well as the PMF (the flood level difference mapping shows the magnitude and extent of changes to existing flood levels and the expected flood extents if the option was implemented). The difference mapping is included under the detailed discussion on each option.

Flood level differences were also extracted at a number of locations across the catchment for the 20% AEP, 5% AEP and 1% AEP floods along with the PMF and are summarised in **Table 38**, **Table 39**, **Table 40** and **Table 41**. The locations where the flood level differences were extracted is also provided in **Plate 31.**

It was noted that options that reduce flood levels in one area often increased flood levels elsewhere in the catchment. Any option that results in flood level increases across private property is unlikely to secure state government funding. Therefore, each option was refined as part of the hydraulic assessment process to maximise hydraulic benefits while ensuring that adverse flood impacts were minimised. This often meant that the hydraulic benefits provided by an option needed to be reduced to ensure adverse flood impacts were reduced across private property.

### 8.2.2 Financial Feasibility

A preliminary economic assessment was completed to assist in determining the financial viability of each measure. The assessment was completed by estimating the 'costs' and 'benefits' that could be expected if the options were implemented. This enabled a benefit cost ratio (BCR) to be prepared for each option. The BCR provides the following economic insights:

- BCR greater 1: The economic benefits (i.e., reduction in flood damage costs) are predicted to be greater than the cost to implement the option.

**Table 38 Flood level differences for 20% AEP flood with flood modification options in place**

| Location (refer Plate 25) | Flood Level Differences (m) | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | FM 1 | FM 2 | FM 3 | FM 4 | FM 5 | FM 6 | FM 7 | FM 8 | FM 9 | FM 10 | FM 11 | FM 12 | FM 13 | FM 14 | FM 16 | FM 17 | FM 18 | FM 19 | FM 20 |
| 1 | 0 | 0 | 0 | 0 | -0.17 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -0.17 | -0.17 |
| 2 | 0 | 0 | 0 | 0 | Dry | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Dry | Dry |
| 3 | 0 | 0 | 0 | -0.02 | -0.10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -0.02 | 0 | 0 | -0.10 | -0.10 |
| 4 | 0 | 0 | 0 | -0.03 | Dry | 0 | 0 | 0 | 0 | 0 | Dry | Dry | Dry | Dry | Dry | 0 | 0 | Dry | Dry |
| 5 | 0 | 0 | 0 | -0.01 | 0.02 | 0 | 0 | 0 | 0 | 0 | Dry | Dry | Dry | Dry | Dry | 0 | 0 | 0 | 0.01 |
| 6 | Dry | 0 | 0 | 0 | 0.05 | 0 | Dry | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Dry | Dry |
| 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8 | -0.06 | 0.06 | 0 | 0 | 0.07 | 0 | -0.03 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.01 | 0.01 | 0 | -0.06 | -0.06 |
| 9 | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry |
| 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11 | 0.06 | -0.02 | 0 | 0 | 0.02 | -0.01 | 0.07 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -0.02 | 0 | 0.08 | 0.07 |
| 12 | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry |
| 13 | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry |
| 14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Dry | Dry | Dry | Dry | 0 | 0 | 0 | 0 | 0 |
| 15 | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry |
| 16 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Dry | Dry | Dry | Dry | 0 | 0 | 0 | 0 | 0 |
| 17 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -0.18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Table 39 Flood level differences for 5% AEP flood with flood modification options in place**

| Location (refer Plate 25) | Flood Level Differences (m) | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | FM 1 | FM 2 | FM 3 | FM 4 | FM 5 | FM 6 | FM 7 | FM 8 | FM 9 | FM 10 | FM 11 | FM 12 | FM 13 | FM 14 | FM 16 | FM 17 | FM 18 | FM 19 | FM 20 |
| 1 | 0 | 0 | 0 | 0 | -0.15 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -0.15 | -0.15 |
| 2 | 0 | 0 | 0 | 0 | -0.26 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -0.26 | -0.26 |
| 3 | 0 | 0 | 0 | -0.02 | -0.1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -0.01 | 0 | 0 | -0.11 | -0.11 |
| 4 | 0 | 0 | 0 | -0.05 | -0.13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -0.04 | 0 | 0 | -0.15 | -0.16 |
| 5 | 0 | 0 | 0 | -0.02 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -0.09 | 0 | 0 | -0.01 | -0.01 |
| 6 | -0.27 | 0 | 0 | 0 | 0.02 | 0 | -0.07 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -0.16 | -0.20 |
| 7 | -0.22 | 0 | 0 | -0.01 | 0.07 | 0 | -0.17 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -0.22 | -0.22 |
| 8 | -0.37 | 0.21 | 0 | 0 | 0 | 0 | -0.09 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -0.02 | 0 | -0.37 | -0.37 |
| 9 | 0 | Dry | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.04 | 0 | 0 | 0 |
| 10 | 0 | 0 | 0 | 0 | 0.02 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11 | -0.03 | -0.03 | 0 | 0 | 0.03 | -0.1 | 0 | 0.01 | -0.02 | 0 | 0 | 0 | 0 | 0 | 0 | -0.02 | 0 | -0.02 | -0.12 |
| 12 | 0 | 0 | Dry | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Dry | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -0.23 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 15 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -0.06 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 16 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -0.04 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 17 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -0.13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Table 40 Flood level differences for 1% AEP flood with flood modification options in place**

| Location (refer Plate 25) | Flood Level Differences (m) | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | FM 1 | FM 2 | FM 3 | FM 4 | FM 5 | FM 6 | FM 7 | FM 8 | FM 9 | FM 10 | FM 11 | FM 12 | FM 13 | FM 14 | FM 16 | FM 17 | FM 18 | FM 19 | FM 20 |
| 1 | 0 | 0 | 0 | 0 | -0.09 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -0.09 | -0.09 |
| 2 | 0 | 0 | 0 | 0 | -0.17 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -0.17 | -0.17 |
| 3 | 0 | 0 | 0 | -0.02 | -0.22 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -0.02 | 0 | 0 | -0.24 | -0.24 |
| 4 | 0 | 0 | 0 | -0.08 | -0.07 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -0.02 | 0 | 0 | -0.14 | -0.14 |
| 5 | 0 | 0 | 0 | -0.06 | -0.02 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -0.09 | 0 | 0 | -0.06 | -0.06 |
| 6 | -0.01 | 0 | 0 | 0 | 0 | 0 | -0.06 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -0.07 | -0.07 |
| 7 | -0.21 | 0 | 0 | -0.01 | 0 | 0 | -0.09 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -0.28 | -0.31 |
| 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -0.05 | 0 | 0 |
| 9 | -0.04 | -0.17 | 0 | -0.03 | 0 | 0 | 0.02 | -0.06 | -0.02 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -0.06 | -0.09 |
| 10 | -0.06 | -0.04 | 0 | -0.05 | -0.02 | 0 | 0.01 | -0.15 | -0.04 | 0 | 0 | 0 | 0 | 0 | 0 | -0.01 | 0 | -0.10 | -0.16 |
| 11 | -0.03 | -0.02 | 0 | -0.02 | 0 | -0.1 | 0 | 0.01 | -0.02 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -0.04 | -0.17 |
| 12 | 0 | 0 | -0.32 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -0.34 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -0.07 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 15 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -0.08 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 16 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -0.09 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 17 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -0.06 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Table 41 Flood level differences for the PMF with flood modification options in place**

| **Location** (refer Plate 25) | **Flood Level Differences (m)** | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **FM 1** | **FM 2** | **FM 3** | **FM 4** | **FM 5** | **FM 6** | **FM 7** | **FM 8** | **FM 9** | **FM 10** | **FM 11** | **FM 12** | **FM 13** | **FM 14** | **FM 16** | **FM 17** | **FM 18** | **FM 19** | **FM 20** |
| 1 | 0 | 0 | 0 | 0.00 | -0.05 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -0.05 | -0.05 |
| 2 | 0 | 0 | 0 | -0.02 | -0.04 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -0.06 | -0.06 |
| 3 | 0 | 0 | 0 | 0.01 | -0.01 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -0.01 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -0.02 | 0 | 0 | 0 | 0 |
| 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -0.03 | 0 | 0 | 0 | 0 |
| 6 | -0.04 | 0 | 0 | 0 | 0 | 0 | -0.03 | 0 | 0.01 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -0.04 | -0.04 |
| 7 | 0 | 0 | 0 | 0 | 0 | 0 | -0.03 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8 | -0.01 | -0.02 | 0 | 0 | 0 | 0 | -0.01 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -0.01 | -0.01 | -0.01 |
| 9 | 0 | 0.01 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.02 | 0 | 0 | 0 |
| 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.01 | 0 | 0 | 0 |
| 11 | 0 | 0 | 0 | 0 | 0 | -0.03 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -0.04 |
| 12 | 0 | 0 | -0.01 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -0.04 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -0.01 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 15 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 16 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 17 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

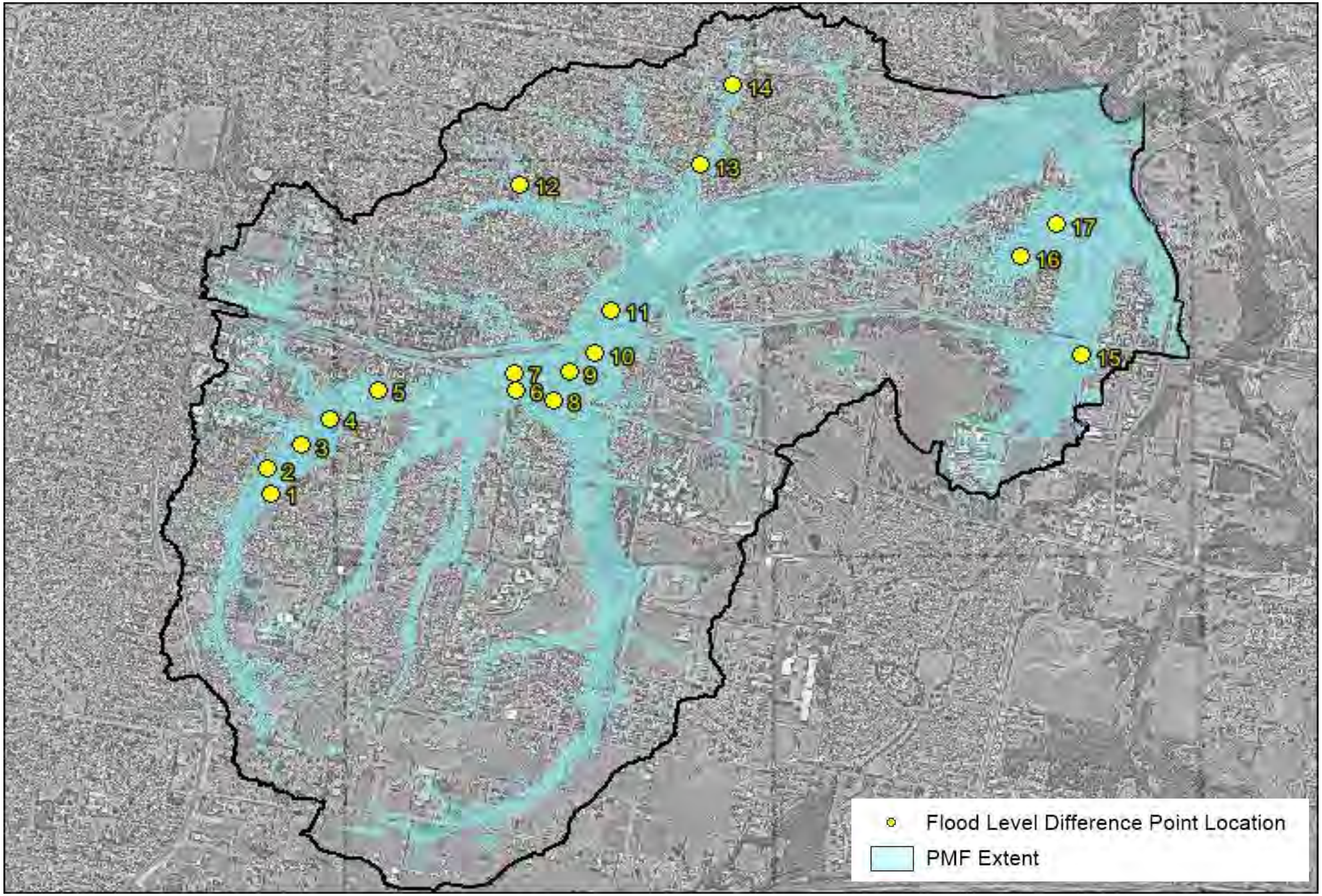


Plate 31 – Locations where flood level differences were extracted

- BCR between 1 and 0: There is still an economic benefit (i.e., reduction in flood damage costs). However, the cost of implementing the option is greater than the economic benefit.
- BCR equal to 0: There is no economic benefit (i.e., no reduction in flood damage costs) associated with implementing the option.
- BCR is negative: Implementing the option is predicted to generate a negative economic impact (i.e., increase flood damage costs).

From a flooding perspective, economic 'benefits' were quantified as the reduction in flood damage costs if the option is implemented. This was estimated by preparing damage estimates for each design flood event with the option in place and using this information to prepare a revised average annual damage (AAD) estimate. In order for a BCR to be estimated, it is necessary to modify the 'base' AAD estimates (which reflect the average damage that is likely to be incurred in a single year) to a total damage that could be expected to occur over the life of each flood modification option. Accordingly, the AAD estimates were accumulated over a 50-year period and then discounted to a present-day value by applying a discount rate of 7%.

Cost estimates have also been prepared for each option based on initial concept designs. The concept design plans are provided in Volume 2 and the cost estimates are included in **Appendix I**. The cost estimates were prepared using the best available information. However, precise cost estimates can only be prepared following detailed investigations and once detailed design plans have been prepared. Therefore, the costs presented in this report should be considered an estimate only. Nevertheless, they are considered suitable for providing an appraisal of the financial viability of each option.

A summary of the costs to implement each option and the reduction in flood damage costs that could be expected with each option in place is provided in **Table 42**. Further information on the economic performance of each option (including implementation costs and predicted reductions in flood damages) is included as part of the discussion on each option.

In instances where no obvious hydraulic improvement was provided by the option or the option was demonstrating increases in flood levels and extents across private property, an economic assessment was not always completed for the following reasons:

- The lack of positive hydraulic impacts indicates the option is not worth pursuing and would likely yield a poor economic outcome.
- It is highly unlikely the option would be eligible for state government funding (due to adverse flood impacts across private property).

### 8.2.3 Change in Number of Buildings Inundated Above Floor Level

An assessment of the change in the number of buildings subject to above floor inundation during each design flood was also completed for each option. This was completed by comparing peak design flood levels from the revised simulations with each mitigation measure in place against building floor levels in the property database to determine the number of buildings with above floor flooding. This number was then compared against the number of buildings with above floor flooding for the "existing" scenario to determine the change in above floor flooding.

Table 42 Economic Assessment for Flood Modification Options

| Flood Modification Option | Present Value of Costs and Damages ($ Millions) | | Benefit-Cost Ratio |
|---|---|---|---|
| | Cost Estimate | Reduction in Damage with Option in Place | |
| **Basin upgrades** | | | |
| **FM1 -** Chapman Gardens basin | $1.14 | $0.25 | 0.2 |
| **FM2 -** Great Western Highway basin | $0.80 | $0.00 | Less than 0.1 |
| **FM3 -** Lincoln Drive Park basin | $0.05 | $0.03 | 0.6 |
| **FM4 –** Stafford Street Basins | $0.52 | $0.38 | 0.7 |
| **FM5 -** Jamison Road basin modifications | $0.58 | $2.47 | 4.3 |
| **Culvert Upgrades** | | | |
| **FM6** - Victoria Street culvert upgrade #1 | $2.11 | $0.01 | Less than 0.1 |
| **FM7** - Great Western Highway culvert upgrade | $2.45 | $0.08 | Less than 0.1 |
| **FM8** - Werrington Creek railway culvert upgrade #1 | $1.12 | $0.02 | Less than 0.1 |
| **FM9** - Werrington Creek railway culvert upgrade #2 | $1.33 | $0.01 | Less than 0.1 |
| **FM10** - Werrington Railway Station culvert upgrade | $0.85 | $0.10 | 0.1 |
| **Stormwater Drainage Upgrades** | | | |
| **FM11** - Dunkley Place stormwater upgrades | $1.29 | $0.23 | 0.2 |
| **FM12** - Orleton Place to Francis Street stormwater upgrades | $1.51 | $0.18 | Less than 0.1 |
| **FM13** - Rugby Street to William Street stormwater upgrades | $0.84 | $0.02 | Less than 0.1 |
| **FM14** - Victoria Street to Joseph Street stormwater upgrades | $0.78 | $0.23 | 0.3 |
| **FM16** - Stafford Street to First Street Stormwater Upgrades | $3.59 | $0.13 | Less than 0.1 |
| **Topographic modifications** | | | |
| **FM17** - College Creek and Orth Creek channel enlargement | $0.31 | $0.02 | Less than 0.1 |
| **FM18** - Great Western Highway Median Modification | $0.06 | $0.02 | 0.3 |
| **Combined Options** | | | |
| **FM19** – FM1 + FM4 + FM5 | $2.24 | $2.74 | 1.2 |
| **FM20** – FM1 + FM4 + FM5 + FM6 + FM9 | $5.68 | $2.77 | 0.5 |

The outcomes of this assessment are summarised in **Table 43**. A negative value indicates a reduction in above floor flooding and a positive value indicates an increase in above floor flooding.

Table 43 Change in Number of Properties Subject to Above Floor Flooding for Each Flood Modification Option for Design Catchment Conditions

| Flood Modification Option | Change in Number of Properties with Above Floor Inundation* | | | |
|---|---|---|---|---|
| | 20% AEP | 5% AEP | 1% AEP | PMF |
| **Basin upgrades** | | | | |
| **FM1 -** Chapman Gardens basin | 0 | -1 | -5 | 0 |
| **FM2 -** Great Western Highway basin | 0 | 0 | 0 | 0 |
| **FM3 -** Lincoln Drive Park basin | 0 | 0 | 0 | -1 |
| **FM4 –** Stafford Street Basins | 0 | 0 | -2 | 0 |
| **FM5 -** Jamison Road basin modifications | -3 | -6 | -6 | -1 |
| **Culvert Upgrades** | | | | |
| **FM6** - Victoria Street culvert upgrade #1 | 0 | 0 | 0 | -1 |
| **FM7** - Great Western Highway culvert upgrade | 0 | -1 | -3 | 1 |
| **FM8** - Werrington Creek railway culvert upgrade #1 | 0 | 0 | 1 | -1 |
| **FM9** - Werrington Creek railway culvert upgrade #2 | 0 | 0 | 0 | -2 |
| **FM10** - Werrington Railway Station culvert upgrade | 0 | 0 | -2 | 1 |
| **Stormwater Drainage Upgrades** | | | | |
| **FM11** - Dunkley Place stormwater upgrades | 0 | 0 | -1 | 0 |
| **FM12** - Orleton Place to Francis Street stormwater upgrades | 0 | 0 | 0 | -3 |
| **FM13** - Rugby Street to William Street stormwater upgrades | 0 | 0 | -1 | 0 |
| **FM14** - Victoria Street to Joseph Street stormwater upgrades | 0 | -2 | -2 | -2 |
| **FM16** - Stafford Street to First Street Stormwater Upgrades | 0 | 0 | -3 | 0 |
| **Topographic Modifications** | | | | |
| **FM17** - College Creek and Orth Creek channel enlargement | 0 | 0 | 0 | 1 |
| **FM18** - Great Western Highway Median Modification | 0 | 0 | 0 | 0 |
| **Combined Options** | | | | |
| **FM19** – FM1 + FM4 + FM5 | -3 | -7 | -12 | -2 |
| **FM20** – FM1 + FM4 + FM5 + FM6 + FM9 | -3 | -7 | -12 | -2 |

### 8.2.4 Emergency Response Impacts

Emergency response is arguably one of the most important measures for managing the continuing flood risk across any catchment, particularly during very large floods where flood modification options may not be as effective. Therefore, the potential for each option to impact on current emergency response processes was considered as part of the assessment of each option.

Due to the "flashy" nature of flooding in the catchment, there is typically minimal advanced warning of an impending flood and, therefore, reduced opportunities for evacuation. Therefore, a focus was placed on identifying options that would result in less frequent and deep inundation of roads and, therefore, would provide improved opportunities for vehicular evacuation.

**Table 44** summarises the outcomes of this assessment and documents the design flood where access would first be cut along major roads in the catchment. A road was defined as "cut" if the flood hazard exceeded "H1" across at all lanes of the road. If an option provides an improved emergency response outcome (i.e., results in roadways being cut less frequently) this is shown as green text in **Table 44**).

### 8.2.5 Technical Feasibility

If a structural measure is proposed, it needs to be physically possible to construct the measure considering the option itself as well as any local constraints (services, environmental, heritage etc). Therefore, an assessment of any technical impediments was completed for each measure to determine if there would be any "showstoppers" that may render the option impractical.

## 8.3 Basin Upgrades

### 8.3.1 FM1 - Chapman Gardens Basin

As outlined in Chapter 3, the Great Western Highway near Chapman Gardens is predicted to be completely cut during floods as frequent as the 2% AEP event with at least one lane of traffic being cut in each direction during floods as frequent as the 10% AEP event. This can result in significant traffic impacts and the frequency of the road overtopping increases the potential for drivers to be tempted to drive through floodwaters. Furthermore, any floodwaters that overtop the highway enter car yards on the northern side of the highway potentially damaging many vehicles (i.e., potential for high financial losses).

Flooding in this area is strongly influenced by the existing Chapman Gardens basin. The basin is designed to temporarily store floodwater from the significant upstream catchment thereby reducing floodwater spilling onto the highway. However, as discussed in Section 4.2.11, the Chapman Gardens basin is predicted to be overtopped during floods equal to or greater than the 20% AEP event. Therefore, the basin only provides significant benefits during relatively small floods.

Table 44 Change in Roadway Inundation for Each Flood Modification Options

| Options | Event that Road is First Cut | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Jamison Road | Bringelly Road | Great Western Highway | Victoria Street (west) | Victoria Street (east) | Campton Avenue | Glencoe Avenue | John Oxley Avenue | Gibson Avenue | Railway Street |
| Existing | 20%AEP | 10%AEP | 5%AEP | 10%AEP | 0.2% AEP | 5% AEP | 20%AEP | 2%AEP | 20%AEP | 20%AEP |
| **Basin Upgrades** | | | | | | | | | | |
| FM1 – Chapman Gardens Basin | 20%AEP | 10%AEP | 2%AEP | 5%AEP | 0.2% AEP | 5% AEP | 20%AEP | 2%AEP | 20%AEP | 20%AEP |
| FM2 – Great Western Highway Basin | 20%AEP | 10%AEP | 2%AEP | 5%AEP | 0.2% AEP | 5% AEP | 20%AEP | 2%AEP | 20%AEP | 20%AEP |
| FM3 – Lincoln Drive Park Basin | 20%AEP | 10%AEP | 5%AEP | 10%AEP | 0.2% AEP | 5%AEP | 20%AEP | 2%AEP | 20%AEP | 20%AEP |
| FM4 – Stafford Street Basins | 20%AEP | 10%AEP | 5%AEP | 10%AEP | 0.2% AEP | 5% AEP | 20%AEP | 2%AEP | 20%AEP | 20%AEP |
| FM5 – Jamison Road Basin Modifications | 5%AEP | 10%AEP | 2%AEP | 5%AEP | 0.2% AEP | 5% AEP | 20%AEP | 2%AEP | 20%AEP | 20%AEP |
| **Culvert Upgrades** | | | | | | | | | | |
| FM6 – Victoria Street Culvert Upgrade | 20%AEP | 10%AEP | 5%AEP | 5%AEP | 0.2% AEP | 5% AEP | 20%AEP | 2%AEP | 20%AEP | 20%AEP |
| FM7 – Great Western Highway Culvert Upgrade | 20%AEP | 10%AEP | 5%AEP | 10%AEP | 0.2% AEP | 5% AEP | 20%AEP | 2%AEP | 20%AEP | 20%AEP |
| FM8 – Werrington Creek Culvert Upgrade #1 | 20%AEP | 10%AEP | 2%AEP | 5%AEP | 0.2% AEP | 5% AEP | 20%AEP | 2%AEP | 20%AEP | 20%AEP |
| FM9 – Werrington Creek Culvert Upgrade #2 | 20%AEP | 10%AEP | 5%AEP | 10%AEP | PMF | 5% AEP | 20%AEP | 2%AEP | 20%AEP | 20%AEP |
| FM10 – Werrington Railway Station Culvert Upgrade | 20%AEP | 10%AEP | 5%AEP | 10%AEP | 0.2% AEP | 5% AEP | 20%AEP | 2%AEP | 20%AEP | 20%AEP |
| **Drainage Upgrades** | | | | | | | | | | |
| FM11 – Dunkley Place Stormwater Upgrades | 20%AEP | 10%AEP | 5%AEP | 10%AEP | 0.2% AEP | 5% AEP | 20%AEP | 2%AEP | 10%AEP | 20%AEP |
| FM12 – Orleton Place to Francis Street Stormwater Upgrades | 20%AEP | 10%AEP | 5%AEP | 10%AEP | 0.2% AEP | 5%AEP | 2%AEP | 2%AEP | 20%AEP | 20%AEP |
| FM13 – Rugby Street to Neeta Avenue Stormwater Upgrades | 20%AEP | 10%AEP | 5%AEP | 10%AEP | 0.2% AEP | 5% AEP | 20%AEP | 2%AEP | 20%AEP | 20%AEP |

| Options | Event that Road is First Cut | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Jamison Road | Bringelly Road | Great Western Highway | Victoria Street (west) | Victoria Street (east) | Campton Avenue | Glencoe Avenue | John Oxley Avenue | Gibson Avenue | Railway Street |
| FM14 – Victoria Street to Joseph Street Stormwater Upgrades | 20%AEP | 10%AEP | 5%AEP | 10%AEP | 0.2% AEP | 5% AEP | 20%AEP | 2%AEP | 20%AEP | 20%AEP |
| FM16 - Stafford Street to First Street Stormwater Upgrades | 20%AEP | 5%AEP | 5%AEP | 10%AEP | 0.2% AEP | 5% AEP | 20%AEP | 2%AEP | 20%AEP | 20%AEP |
| **Channel Modifications** | | | | | | | | | | |
| FM17 – College Creek and Orth Creek Channel Enlargement | 20%AEP | 10%AEP | 2%AEP | 5%AEP | 0.2% AEP | 5% AEP | 20%AEP | 2%AEP | 20%AEP | 20%AEP |
| **Road Works** | | | | | | | | | | |
| FM18 – Great Western Highway Median Modification | 20%AEP | 10%AEP | 5%AEP | 10%AEP | 0.2% AEP | 5% AEP | 20%AEP | 2%AEP | 20%AEP | 20%AEP |
| **Combined Options** | | | | | | | | | | |
| FM19 – FM1 + FM4 + FM5 | 5%AEP | 10%AEP | 2%AEP | 5%AEP | 0.2%AEP | 5% AEP | 20%AEP | 2%AEP | 20%AEP | 20%AEP |
| FM20 - FM1 + FM4 + FM5 + FM6 + FM9 | 5%AEP | 10%AEP | 2%AEP | 5%AEP | PMF | 5% AEP | 20%AEP | 2%AEP | 20%AEP | 20%AEP |

As shown in **Figure 57**, FM1 involves upgrading the existing Chapmans Garden basin to provide greater attenuation of flows during more significant floods in the catchment. This involves lowering the elevation of the existing basin by an average of approximately 1.5 meters and elevating the existing basin wall by about 0.6 metres to provide additional storage capacity of around 15,000m$^3$ (cubic meters). When establishing the potential excavation "footprint", care was taken not to encroach on existing drainage infrastructure or established trees and vegetation.

Six (6) existing pits will also need to be upgraded (converted from junctions to grated inlets), and two (2) new inlets will need to be installed and connected by new pipes to the existing basin outlet structure. These new drainage features were determined to be required to more effectively drain the basin area during the early parts of a flood so that the available storage capacity is maximised at the peak of the flood.

The outcomes of the existing design flood simulations showed that the existing basin was predicted to overtop west of the official basin spillway indicating that some settlement of the basin embankment has occurred over time. Therefore, it was also assumed that some minor earthworks would be required along the embankment to elevate the basin wall to 37.7 m AHD. This would require increasing the elevation of the existing embankment by up to 0.2 metres. The existing spillway will be maintained at the existing level to ensure overflows are directed away from properties.

A cost estimate for FM1 was prepared and is enclosed in **Appendix I**. It shows that FM1 expected to have a capital cost of just over $1.1 million.

The hydraulic model that was used to define design flood conditions was updated to include a representation of FM1. The updated TUFLOW model was then used to re-simulate a range of design floods. Floodwater difference maps were prepared for the 20% AEP, 5% AEP and 1% AEP events and the PMF and are provided in **Plate 32**.

**Plate 32** shows that during the 20% AEP flood, the basin upgrades are sufficient eliminate inundation of the Great Western Highway. During the 5% AEP flood, inundation of the Great Western Highway is also effectively eliminated and reductions in flood levels of up to 0.20 metres can be expected within the car yards and within College Creek upstream of the Great Western Highway. Flood level reductions also extend along Werrington Creek downstream of the railway line during the 5% AEP flood. However, the reductions are predicted to be less than 0.1 metres. Flood level increases of up to 0.1 metres are predicted in the Orth Creek and Werrington Creek channels during the 20% AEP flood due to the additional stormwater infrastructure that is able to more efficiently 'charge' the culvert system between Chapman Gardens and Orth Creek.

**Plate 32** also shows that during the 1% AEP flood, flood level reductions of 0.15 metres are predicted within the car sales yards and across the Great Western Highway. However, the flood level reductions would not be sufficient to prevent the highway from being cut during the 1% AEP event.

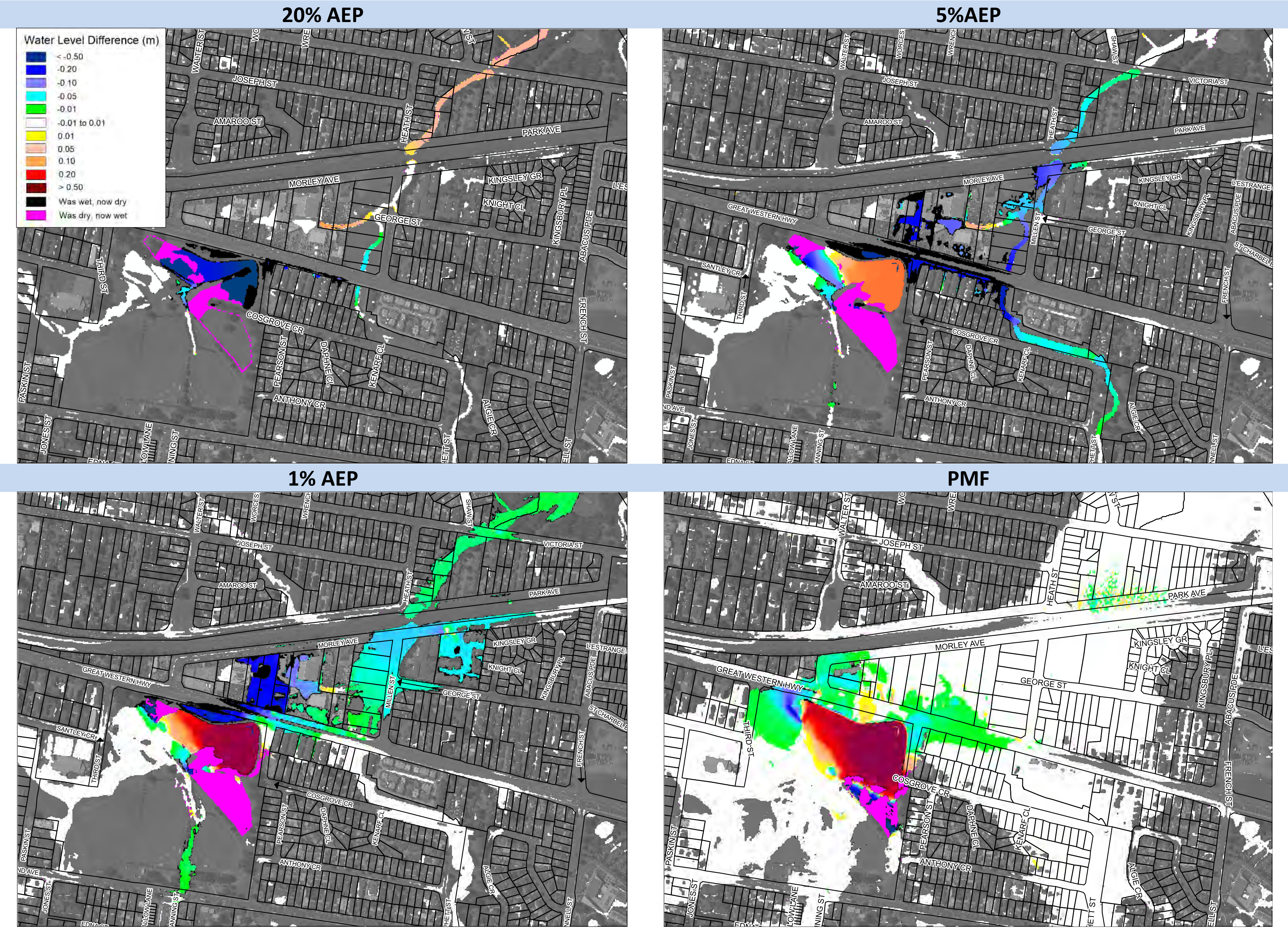



**Plate 32 Flood Level Difference Maps for FM1**

However, as shown in **Table 44**, the flood immunity of the highway will be improved (currently access is cut in 5% AEP flood but this will improve to a 2% AEP flood). Furthermore, access along Victoria Street will also be improved (currently cut in a 10% AEP flood which will improve to a 5% AEP flood). As these are the main east-west evacuation routes in the catchment, the emergency response benefits of FM1 are significant.

Furthermore, as the roadways will be subject to less frequent inundation, FM1 will also likely reduce the frequency of people driving through floodwaters thereby reducing the risk to life associated with vehicles being mobilised and washed into downstream watercourses (as shown in **Plate 33**, there have been multiple examples of people attempting to drive through floodwaters in this area).

**Plate 33 Example of vehicles driving through floodwaters on Great Western Highway in 2012 (mrruready via YouTube, 2012)**

Less frequent and severe flooding of the highway and Victoria Street will also have positive impacts on the broader community (access to and from work, homes, shops etc will be cut less frequently). Asset owners (e.g., Council and RMS) will also benefit as road repairs etc will be less frequently required.

Smaller reductions of up to 0.05 metres are predicted over a number of properties on the southern side of the highway during the 1% AEP flood and PMF (although the flood level reductions during the PMF are typically small). No significant changes in flood behaviour are predicted downstream of the railway line.

As noted in **Table 43**, the flood level reductions would result in one (1) fewer building being subject to inundation during the 5% AEP flood and 5 fewer buildings being flooded above floor level during the 1% AEP flood.

An Endeavour Energy line runs through the north-eastern corner of Chapmans Garden and would likely need to be relocated to accommodate the basin modifications.

A revised flood damage assessment was completed based on the updated flood results to determine if the predicted flood level reductions are likely to afford a significant reduction in flood damage costs. This showed implementation of the basin upgrades was predicted to reduce existing flood damages by about $250,000 over the next 50 years. This yields a preliminary BCR of 0.2. Therefore, although the option provides a significant reduction in flood damage costs, those savings are predicted to be significantly lower than the implementation cost.

Although FM1 does not perform well from an economic standpoint, it provides significant flood level reductions across several commercial and residential properties between Chapman Gardens and Victoria Street during a range of floods. More importantly, it is predicted to reduce flood levels along the Great Western Highway and Victoria Street thereby providing improved opportunities for evacuation along both major roads. The flood level reductions across these roadways will also reduce the frequency and potential danger associated with people driving through floodwaters (highly probable based on the highly trafficked nature of the roads). Therefore, strong consideration should be given to completing the Chapman Gardens basin modifications in isolation or in conjunction with other options. The potential benefits of combining FM1 with other options is discussed further in Section 8.8.

### 8.3.2 FM2 - Great Western Highway Basin

As discussed in Chapter 4, the railway embankment serves as a significant impediment to flow at multiple locations across the College, Orth and Werrington Creeks catchment. One of the areas that is most significantly impacted by the railway embankment is the main Werrington Creek crossing of the railway line located north of the Great Western Highway at Kingswood. At this location, a build-up of water is predicted across a significant area contained between the railway line and highway. Although much of this area is open space and not developed, floodwaters are predicted to encroach into an aged care facility located near the corner of George Street and Millen Street.

Although the railway embankment does impede flow and increase inundation extents and depths to the south of the railway line, this impediment serves to attenuate flows, thereby reducing downstream water levels. Therefore, FM2 attempted to take better advantage of this storage area by lowering ground surface elevation across existing open space between the highway and railway line. This would aim to reduce flood levels upstream of the railway while still affording attenuation benefits for properties located downstream of the railway.

As shown in **Figure 58**, FM2 would involve earthworks to provide approximately 27,000 $m^3$ (cubic metres) of storage capacity. Minor reshaping of the open channels through this area would also be required.

The potential for the basin to be full independent of the railway line was explored (i.e., incorporating a downstream basin wall and outlet structure). However, it was determined that the railway embankment dominated the flood behaviour in the area and “drowned out” the basin outlet structure and wall. Inclusion of a downstream basin wall would also remove some flood storage volume. Therefore, the existing railway embankment and culverts were utilised as the downstream basin wall and outlet.

It is expected that FM2 would have a capital cost of about $0.8 million. A breakdown of the cost estimate is provided in **Appendix I**.

The hydraulic model that was used to define design flood conditions was updated to include a representation of FM2. The updated TUFLOW model was then used to re-simulate a range of design floods. Floodwater difference maps were prepared for the 20% AEP, 5% AEP and 1% AEP events and the PMF and are provided in **Plate 34**.

**Plate 34** shows that in the 20% AEP, 5% AEP and 1% AEP floods, reductions of up to 0.05 metres are expected within the properties on Heath Street (i.e., downstream of the railway line). Flood levels reductions of up to 0.04 metres are predicted within the properties located at the western end of George Street (including the aged care facility) during the 1% AEP flood. Reductions of up to 0.18 metres are also predicted around the Millen Street and George Street intersection during the 1% AEP flood. No flood level increases are predicted at any location during floods up to and including the 1% AEP flood.

**Plate 34** shows that in the PMF, the earthwork associated with the basin is predicted to result in flood level increases across some Millen Street and George Street properties. Some small flood level reductions are also predicted to extend across the Great Western Highway as well as the car yards on the northern side of the highway. This shows the highly sensitive nature of flooding in the area contained between the highway and the railway line and illustrates that great care will need to be exercised if any works are undertaken in this area in the future to ensure there are no adverse flood impacts during the full range of potential floods.

As shown in **Table 43**, the flood level reductions are not sufficient to reduce the number of buildings subject to above floor flooding during any of the simulated design floods. This outcome is mirrored in the revised flood damage assessment outcomes which indicates that FM2 is predicted to reduce existing flood damages by less than $10,000 over the next 50 years. This provides a very low benefit cost ratio (i.e., less than 0.1) and indicates the implementation costs would be well in excess of the reduction in flood damage costs.

However, FM2 will afford emergency response benefits for Victoria Street which is currently cut in a 10% AEP event (implementation of FM2 will result in Victoria Street not being cut unto the 5% AEP flood). However, FM1 still affords better emergency response benefits for this area overall.

A Sydney Water sewer and water main extends in close proximity to the basin footprint. Both mains would likely need to be relocated if FM2 was to proceed.

Although FM2 is predicted to afford flood level reductions, the most substantial reductions are predicted to occur in areas of open space or the main creek channels. Only small flood level reductions are predicted across private property which yields a poor financial performance. As a result of these outcomes, FM2 is not recommended for implementation.

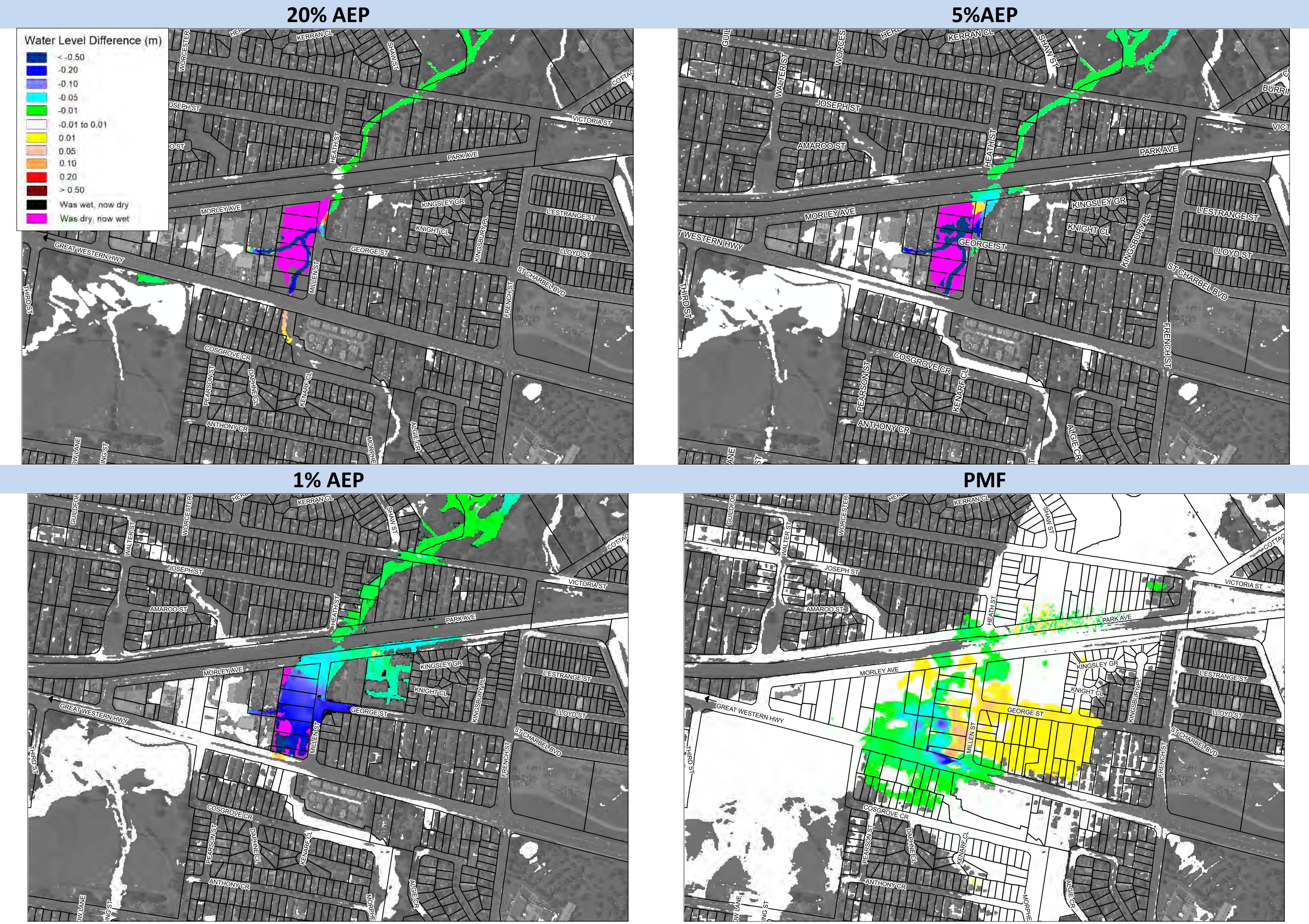



**Plate 34 Flood Level Difference Maps for FM2**

However, although a detention basin at this location is not recommended for implementation, this remains a high flood risk area. Furthermore, the results of the PMF simulations demonstrates that any modifications in this area have the potential to adversely impact on flood behaviour across nearby properties (including an aged care facility). Therefore, it is important that this area is retained as open space (which is compatible with the flood risk). Furthermore, it is important that the area is not subject to significant earthworks that may adversely impact on existing flood behaviour and this area is not developed in the future (as shown in **Figure 56**, this land is highly constrained by flooding and is not suitable for urban uses). As discussed in Section 5.3.1, consideration should be given by Council to rezone this land to a more compatible use to discourage future development.

### 8.3.3 FM3 - Lincoln Drive Park Basin

Lincoln Drive Park is in the north-western sections of the College, Orth and Werrington Creeks catchment. A low-level (i.e., approximately 0.2 metres) embankment located on the southern side of the park serves as a small detention area during rainfall in the catchment. However, as shown in **Figure 34**, some properties located between Lincoln Drive and Cambridge Street would be exposed to H4 hazard during the 1% AEP flood. The flood hazard is predicted to increase to H5 during the PMF indicating there is potential for structural damage or failure of the impacted buildings (refer **Figure 37**).

FM3 involves elevating the existing embankment to create a larger, formal detention basin. This will involve elevating the existing embankment by around 0.5 metres to provide a basin crest level of 44.4m AHD.

A cost estimate was prepared for FM3 and is provided in **Appendix I**. It shows that this option is expected to have an implementation cost of about $50,000. Therefore, FM3 is one of the lowest cost options investigated as part of the study.

The hydraulic model that was used to define design flood conditions was updated to include a representation of FM3. The updated TUFLOW model was then used to re-simulate a range of design floods. Floodwater difference maps were prepared for the 20% AEP, 5% AEP and 1% AEP events and the PMF and are provided in **Plate 35**.

**Plate 35** shows that no significant changes in flood behaviour are predicted during the 20% AEP flood. However, during the 5% AEP flood, flood level reductions of up to 0.06 metres are predicted within a number of properties on Cambridge Street. Flood level reductions of 0.02 metres are also predicted within the roadway reserve on Campton Avenue.

**Plate 35** shows that in the 1% AEP flood, flood level reductions of between 0.1 and 0.3 metres are predicted within properties on Cambridge Street. Flood level reductions of up to 0.04 metres are predicted on Campton Avenue and the reductions are predicted to extend downstream of Herbert Street and into Shaw Park. However, these reductions are primarily contained to the road reserve or open space and do not benefit many private properties.

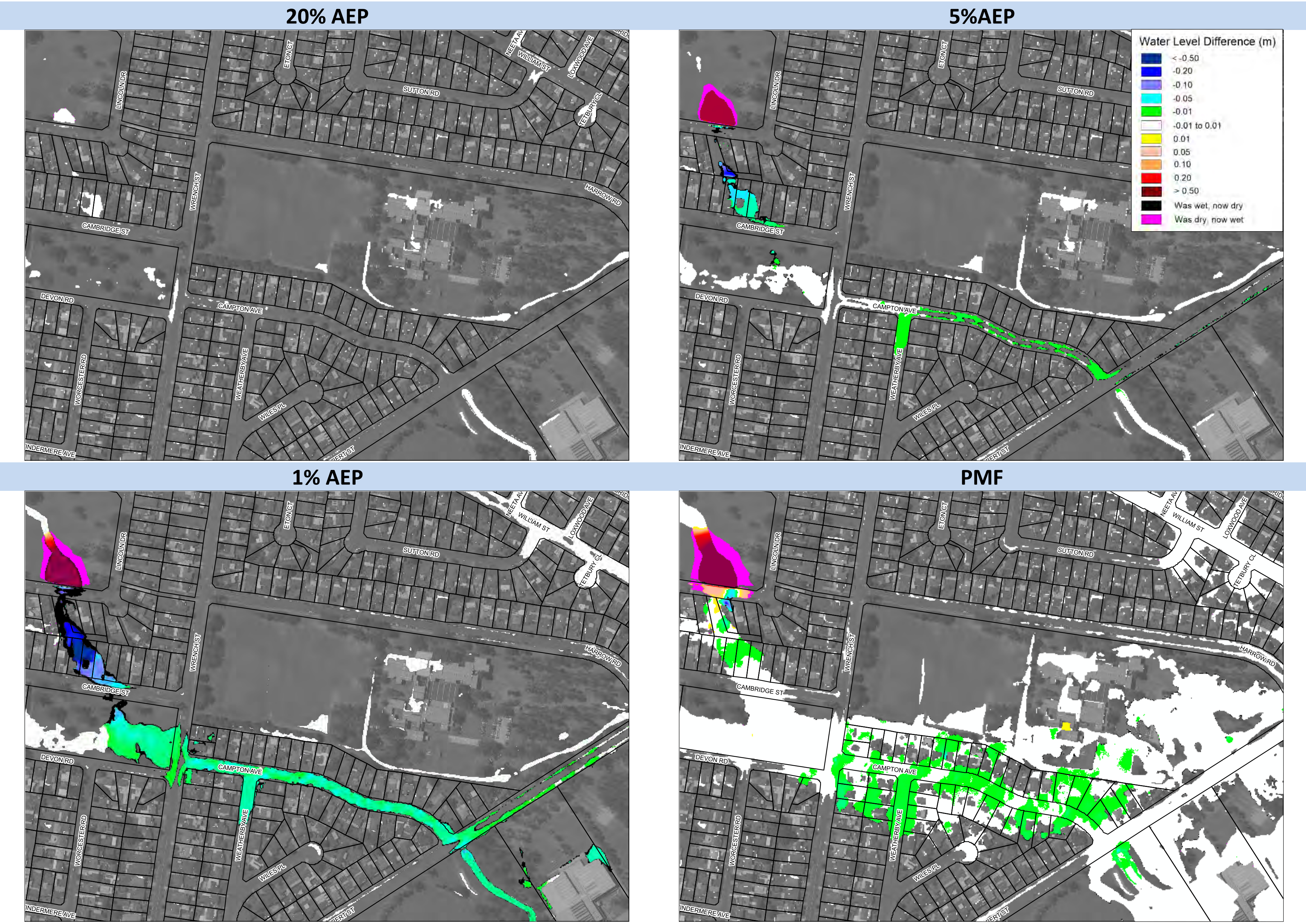



Plate 35 Flood Level Difference Maps for FM3

Small flood level reductions are also predicted during the PMF, however, they typically do not exceed 0.05 metres.

The flood level reductions are sufficient to ensure that Lincoln Drive would remain trafficable during floods up to and including the 1% AEP flood.

A revised flood damage assessment was completed based on the updated flood results. This showed implementation of drainage upgrades are predicted to reduce existing flood damages by about $30,000 over the next 50 years. This yields a preliminary BCR of about 0.6. Therefore, the reduction in flood damage costs is not sufficient to fully cover the implementation costs. However, FM3 would still provide a significant reduction in flood damage costs over its design life for a relatively small capital investment.

A review of the PMF flood hazard with FM3 in place showed that inclusion of the basin was not predicted to significantly reduce the existing flood hazard across Cambridge Street properties (although one (1) fewer property is predicted to experience above floor flooding). That is, there is still potential for structural damage to these properties during the PMF. However, a review of the 1% AEP flood hazard shows that inclusion of FM3 is predicted to remove all H4 hazard areas and significantly reduce the extent of H3 hazard areas.

Although the benefit cost ratio of this option is predicted to be less than 1, it does afford some significant reductions in flood damages, flood levels and flood hazard during events up to and including the 1% AEP flood across multiple Cambridge Street properties. In addition, this is a relatively low-cost option. Therefore, it is recommended that this option be investigated in more detail to refine the design and cost estimates and confirm the associated economic feasibility.

### 8.3.4 FM4 - Stafford Street Basins

As noted in Section 4.7, the area of Kingswood located between Jamison Road and Bringelly Road is considered one of the most significant flood 'hot spots' within the catchment. Multiple residential properties are predicted to be exposed to overland flooding during floods as frequent as the 0.5EY event.

FM4 would take advantage of existing open space on either side of Stafford Street to construct two detention basins. This will require lowering the existing ground surface by between 0.1 and 0.5 metres for the southern basin and lowering the ground surface of the northern basin by between 0.2 and 1.1. The downstream embankments of both basins would be in the order of 1 metre high. This will afford around 5,000 $m^3$ of additional storage volume in total.

It was noted that an existing swale located downstream of the existing Jamison Road basin (located south of the southern Stafford Street basin) was predicted to overtop and spill through some adjoining properties. Therefore, the swale was enlarged as part of the option to direct additional flow into the new basins.

A cost estimates for FM5 was prepared and is enclosed in **Appendix I**. It shows that FM4 expected to have a capital cost of just over $500,000.

The hydraulic model that was used to define design flood conditions was updated to include a representation of FM4. The updated model was then used to re-simulate a range of design floods. Floodwater difference maps were prepared for the 20% AEP, 5% AEP and 1% AEP events and the PMF and are provided in **Plate 36**.

**Plate 36** shows that in the 20% AEP and 5% AEP floods, flood level reductions of over 0.1 metres are predicted within properties to the west of the upstream basin. Flood level decreases of up to 0.08 metres are also predicted as far downstream as Derby Street. Flood level reductions of over 0.15 metres are also predicted across properties on Hargrave Street in addition to flood level reductions of 0.02 metres down to Chapman Gardens. Some isolated flood level increases of up to 0.12 metres are anticipated to the south of the upstream basin during the 5% AEP flood and these increases are predicted to extend partly into private property.

**Plate 36** shows that in the 1% AEP event, flood level reductions are predicted to extend across a similar area as the 20% AEP and 5% AEP floods. This includes:

- Reductions of over 0.1 metres within properties to the west of the upstream basin.
- Reductions of between 0.02 and 0.07 metres between Stafford Street and Derby Street.
- Reductions of between 0.06 and 0.1 metres across large areas between Derby Street and Bringelly Road.
- Reductions of up to 0.03 metres across Chapman Gardens.

Changes in flood levels are also predicted during the PMF. However, the changes typically do not exceed 0.1 metres and are contained to the immediate vicinity of the basins.

A revised flood damage assessment was completed based on the updated flood results. This showed implementation of drainage upgrades as predicted to reduce existing flood damages by just under $400,000 over the next 50 years. This yields a preliminary BCR of 0.7. This indicates that implementation of this option is likely to be higher than the reductions in flood damages costs (although not significantly so).

In addition, two (2) fewer properties are predicted to experience above floor flooding during the 1% AEP flood.

Overall, the broader social benefits of this option are notable with less frequent above floor flooding and less frequent inundation of yards, garages and sheds not only reducing the financial impacts of flooding but also reducing mental stress and anguish associated with frequent flooding.

A Sydney Water sewer does extend through the proposed basin footprint. This service may need to be relocated depending on the extent of excavation that is ultimately selected for the basin.

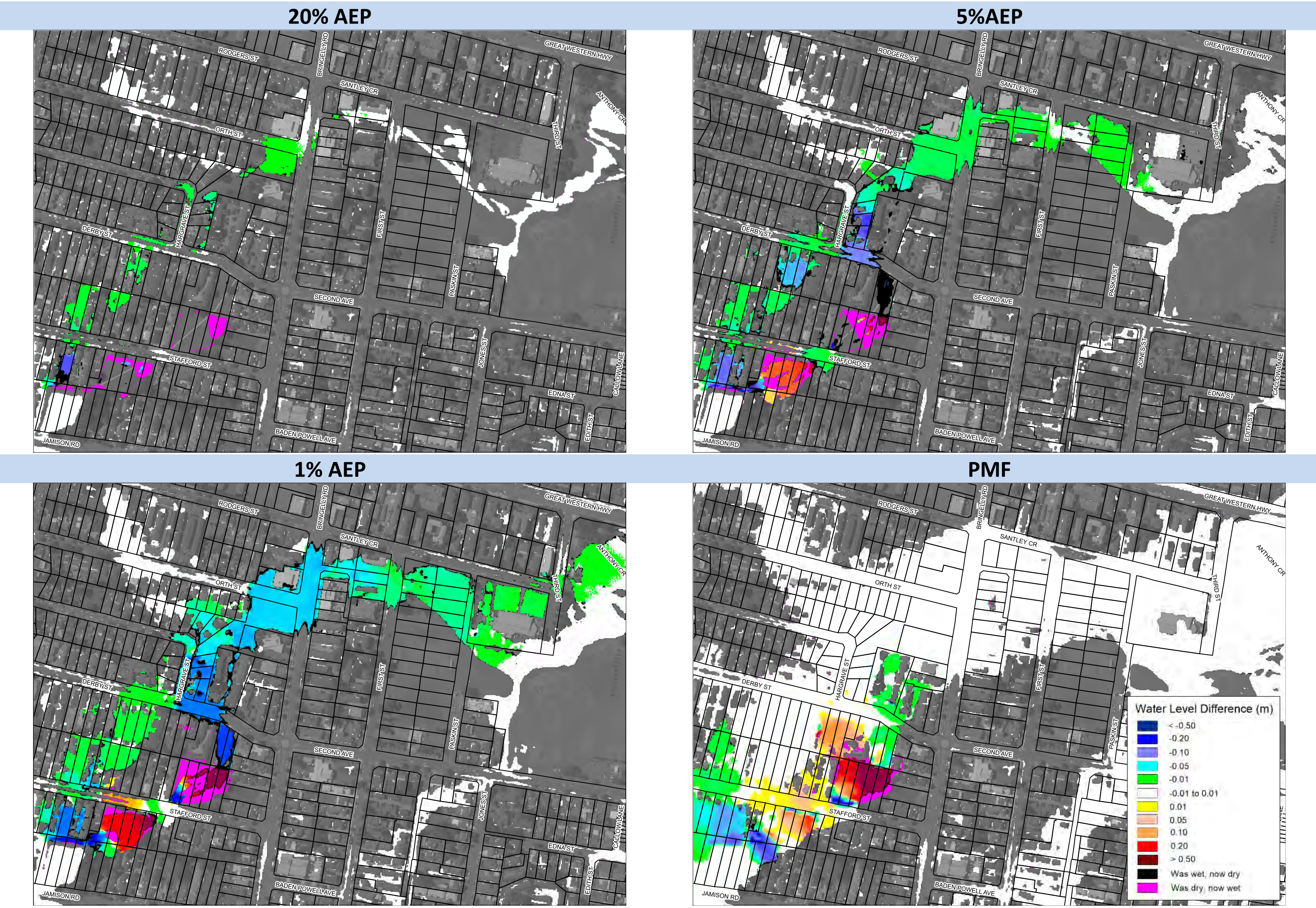



**Plate 36 Flood Level Difference Maps for FM4**

Despite a BCR of 0.7, there seems to be considerable merit in further detailed investigations and potential implementation of this option. In particular, the investigations will need to investigate options for reducing the flood level increases that are predicted across some private properties. This could be achieved through additional local earthworks or by combining FM4 with another mitigation option, such as FM5 which is discussed below. The potential benefits of combining FM4 with other options is discussed further in Section 8.8.

### 8.3.5 FM5 - Jamison Road Basin Modifications

As noted in Section 8.3.4, the area of Kingswood located between Jamison Road and Bringelly Road is considered one of the most problematic flooding areas in the catchment. An existing detention basin is located on the northern side of Bringelly Road and serves to attenuate downstream flows during more frequent rainfall events. However, the basin analysis included in Section 4.2.11 shows the capacity of the basin is predicted to be exceeded during the 20% AEP flood. Further investigation of the stormwater system in this area along with the hydraulic modelling outputs also shows that the local stormwater system 'surcharge' into this basin. This reduces the efficiency of the local drainage system including the ability of the upstream stormwater system to freely drain during more frequent flood.

As shown in **Figure 61**, FM5 will involve lowering the bottom of the existing basin to provide around 4,000m$^3$ of additional storage volume. A new 0.525 metre diameter low flow pipe will be required from the existing surcharge pit on the southern side of the basin and will extend down to the existing triple 1.5 metre diameter outlet pipes. However, one of these existing outlet pipes will be blocked to 'free up' capacity in the downstream pipe system and take better advantage of the additional storage volume provided.

A cost estimates for FM5 was prepared and is enclosed in **Appendix I**. It shows that FM5 expected to have a capital cost of just under $600,000.

The hydraulic model that was used to define design flood conditions was updated to include a representation of FM5. The updated TUFLOW model was then used to re-simulate a range of design floods. Floodwater difference maps were prepared for the 20% AEP, 5% AEP and 1% AEP events and the PMF and are provided in **Plate 37**.

**Plate 37** shows that during the 20% AEP and 5% AEP flood, significant areas surrounding the basin are predicted to experience reductions in peak flood level of between 0.1 and 0.3 metres. The flood level reductions are predicted to extend as far upstream as Stapley Street and as far downstream as Hargrave Street. The flood level reductions upstream of the basin are associated with the new low flow pipe that allows the upstream stormwater system to drain in a more efficient manner. However, this more efficient drainage is predicted to direct additional flow towards Chapman Gardens resulting in flood level increases of up to 0.03 metres. Although these flood level increases are contained to open space, it is predicted to result in additional flow spilling from the Chapman Gardens basin and across the Great Western Highway and adjoining car yards. Flood level increases are also predicted along Werrington Creek as far downstream as Lake Werrington. However, the increase are typically less than 0.05 metres. The only exception being the Great Western Highway car sale yards where increases of up to 0.07 metres are predicted.

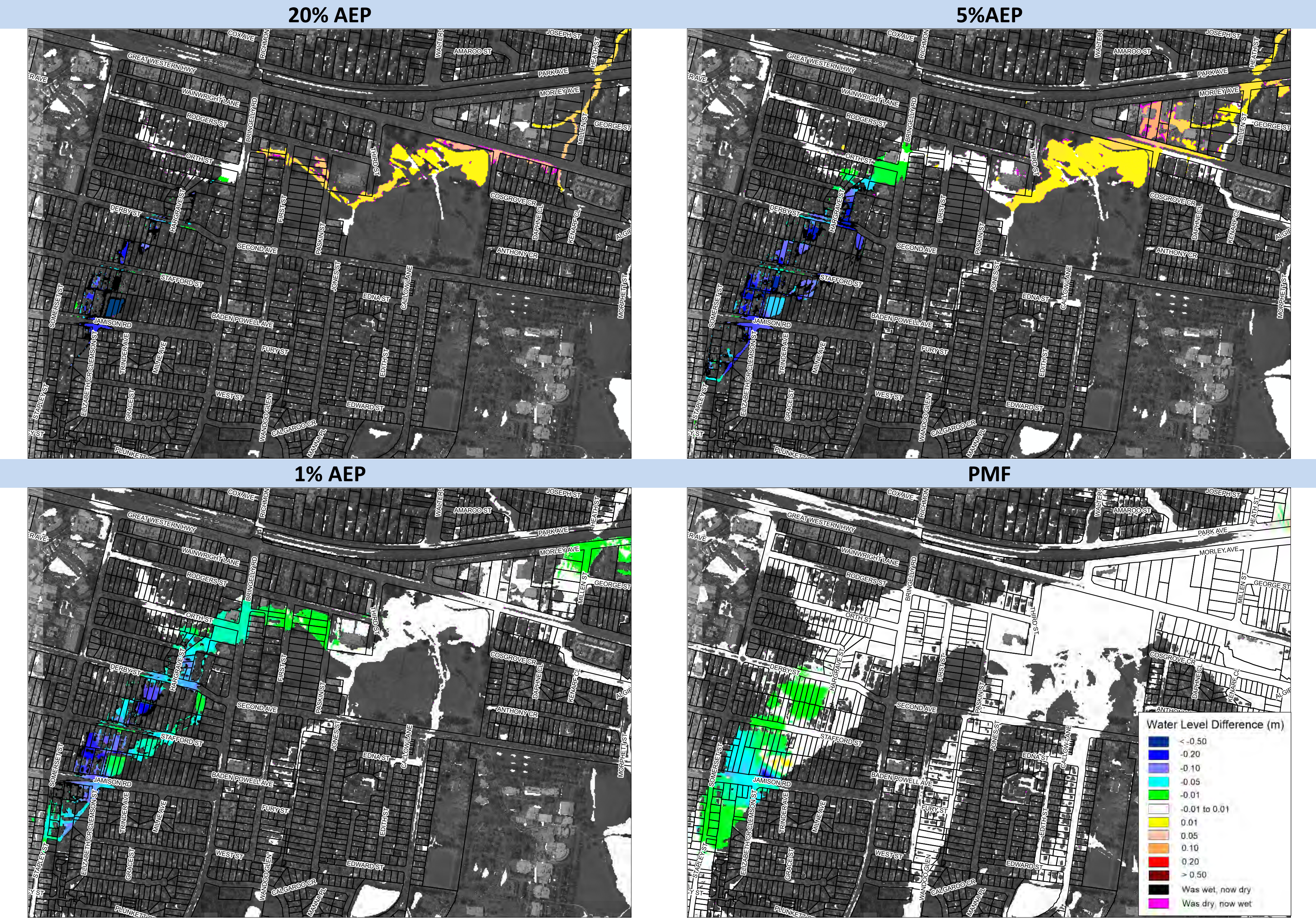



**Plate 37 Flood Level Difference Maps for FM5**

**Plate 35** shows that in the 1% AEP flood, reductions of between 0.1 and 0.2 metres are predicted between Stapley Street and Bringelly Road across a large number of private properties. No flood level increases are predicted during the 1% AEP flood. Therefore, the hydraulic benefits in the catchment during the 1% AEP flood are predicted to be significant (although the hydraulic benefits during the PMF are more modest).

FM5 is also predicted to afford some notable emergency response benefits to properties around Jamison Road as well as people that use Jamison Road frequently when transiting through the catchment. More specifically, Jamison Road is currently cut in a 20% AEP flood which is predicted to improve to a 5% AEP flood with FM5 in place.

Like FM4, the flood level reductions that are provided by FM5 will result in less frequent inundation of yards, sheds, garages and habitable buildings across multiple residential properties. This will provide a significant reduction in financial losses and emotional stress associated with flooding for properties owners and occupiers in the area.

A revised flood damage assessment was completed based on the updated flood results. This showed implementation of FM5 is predicted to reduce existing flood damages by nearly $2.5 million over the next 50 years. This yields a preliminary BCR of more than 4. This indicates implementation of FM5 is likely to yield a significant positive economic outcome. It also shows that FM5 yields the most significant reduction in flood damage costs of all the individual options considered as part of the study.

**Table 43** also shows that FM5 is predicted to reduce the number of properties exposed to above floor flooding during a range of floods. This includes six (6) fewer properties with above floor flooding in the 5% AEP and 1% AEP floods. Therefore, FM5 provides the most significant reduction in above floor flooding of all the individual options considered as part of the study.

Overall, FM5 is predicted to afford some significant hydraulic and financial benefits. As a result, it is recommended for further detailed investigation and potential implementation. These future investigations will need to address the predicted flood level increases across areas downstream of Chapman Gardens. This could most likely be addressed by combining FM5 with FM4 and or FM1. The potential benefits of combining FM5 with other options is discussed in Section 8.8.

### 8.3.6 South Werrington Basin Augmentation

The South Werrington Urban Village is a new development that is soon to commence construction within the College, Orth and Werrington Creeks catchment. The proposed development includes the construction of detention basins to attenuate runoff from the new development and ensure that downstream areas would not be adversely impacted.

As discussed in Section 4.7, the area of Werrington located between Walker Street and the railway line is considered one of the more significantly flood affected areas of the catchment. Therefore, the preliminary options analysis documented in Chapter 7 recommended considering modifying the basins proposed as part of the South Werrington Urban Village as part of the detailed options assessment. This aimed to determine if the basins could be modified to not only attenuate flows from the new development but also reduce the extent of the existing flooding problem to the north of Walker Street.

Therefore, a review was completed of the development application and subdivision plans that have been approved as part of this South Werrington Urban Village development. Information for this review was contained in the 'Civil Engineering and Infrastructure Report, 16 Chapman Street, Werrington', prepared by Cardno (21 July 2020).

As discussed, the aim of the basin augmentation was to reduce the flood hazard south of Werrington train station. This would most likely require expansion of the proposed basins to provide additional flood storage volume. However, a review of the plans submitted as part of the development approval process indicates there is minimal opportunity for expansion of the proposed OSD basins. More specifically, the designs use almost all of the open space available, leaving minimal room for basin expansion. There is also minimal grade available from the outlet of these basins to the downstream stormwater network, so there would be no significant opportunity to increase the depths of the basins to provide additional storage capacity.

Ecological constraints in the location of the basins would also limit the opportunity to expand the basin footprints. The Cardno report states that the proposed OSD basins are designed to ensure adequate storage can be provided whilst minimising the loss of natural vegetation.

Discussions with Council also indicated that design for the basins were well advanced which further limited the opportunities for basin modifications at this time.

Therefore, the South Werrington basin augmentation was not investigated in further detail as part of this study.

It is noted that the results documented in the Cardno report do indicate that the proposed basins as they currently stand are predicted to afford reductions in existing (pre-development) flood discharges during significant rainfall events (e.g., greater than 20% AEP flood – refer **Plate 38**). Therefore, even without further augmentation, the proposed basins are still likely to afford some benefits during larger floods.

| AEP (%) | Pre-development Flow ($m^3/s$) | Post-development Flow ($m^3/s$) | Basin A Storage ($m^3$) | Basin B Storage ($m^3$) |
|---|---|---|---|---|
| 50% | 0.66 | 0.66 | 5600 | 1300 |
| 20% | 1.81 | 1.23 | 6600 | 1800 |
| 5% | 3.20 | 2.00 | 75000 | 1900 |
| 1% | 4.80 | 3.64 | 11900 | 3660 |

Plate 38 Predicted discharges from South Werrington Urban Village (Cardno, 2020)

## 8.4 Culvert Upgrades

### 8.4.1 FM6 - Victoria Street Culvert Upgrade

Victoria Street is one of the main east-west roadways located north of the railway line. As such, it serves as an important evacuation route for the northern parts of the College, Orth and Werrington Creeks catchment. The existing flood results documented in Chapter 4 indicate that the edges of the road are predicted to be inundated during the 20% AEP flood and access would be cut during the 10% AEP flood.

FM6 would involve upgrading the existing Werrington Creek culvert crossing of Victoria Street to provide additional flow carrying capacity, thereby reducing upstream water levels and the frequency of road overtopping. As shown in **Figure 62**, this would involve replacing the existing 5 x 3.35m wide x 1.8m high box culverts with 6 x 3.6m wide x 2.1m high box culverts. This option would also include elevating the roadway surface by 0.2 metres to accommodate the higher culverts which would also assist in reducing the frequency of road overtopping.

The hydraulic model that was used to define design flood conditions was updated to include a representation of FM5. The updated TUFLOW model was then used to re-simulate a range of design floods. Floodwater difference maps were prepared for the 20% AEP, 5% AEP and 1% AEP events and the PMF and are provided in **Plate 39**.

**Plate 39** shows that no changes in flood behaviour are predicted during the 20% AEP. This indicates that the existing channel and culvert has sufficient capacity to cater for floods up to and including the 20% AEP flood.

However, in the 5% AEP flood, reductions in flood levels of up to 0.10m can be expected immediately upstream of the culvert crossing within Werrington Creek. The reductions in flood levels combined with the elevated roadway results in Victoria Street becoming completely flood free during the 5% AEP flood.

**Plate 39** also shows that in the 1% AEP flood, reductions of over 0.1 metres are predicted within the open channel upstream of the culverts. These changes are sufficient to ensure the crest of the road would remain dry during the 1% AEP flood. Although, parts of both travel lanes would still be partly inundated, it is likely that one (1) car in each direction could pass along Victoria Street at the peak of the 1% AEP flood, if required.

Only small flood level changes are predicted during the PMF indicating that even the larger culvert is completely overwhelmed during this very large flood.

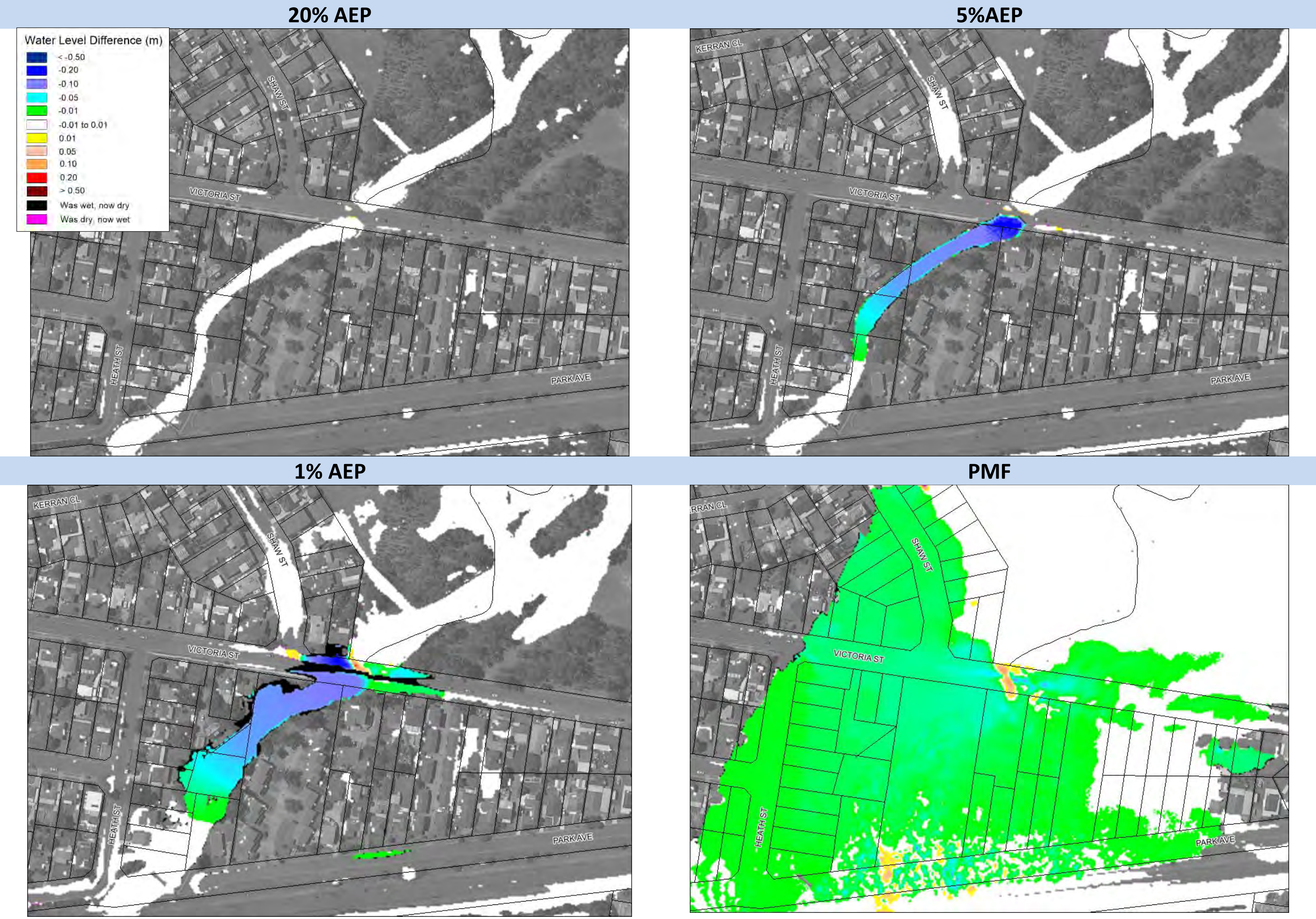



**Plate 39 Flood Level Difference Maps for FM**

Given the importance of this road for evacuation purposes, the improved immunity that this option provides is significant from an evacuation and emergency response perspective. In addition, there is potential for further subdivision and development of land between the railway line and Werrington Creek in the future. Therefore, there will likely be a higher reliance on this road in the future which adds further importance and value to this option in providing improved evacuation opportunities for the future population in this area.

As the flood level reductions are mainly concentrated in the Werrington Creek channel, FM6 is not predicted to change the number of buildings with above floor flooding during events up to and including the 0.2% AEP flood. However, one (1) fewer property would benefit from a reduction in above floor flooding during the PMF.

A cost estimate for FM6 was prepared and is enclosed in **Appendix I**. It shows that FM6 would be costly to implement, having an anticipated cost of more than $2.1 million.

A revised flood damage assessment was completed based on the updated flood results. This showed implementation of drainage upgrades as predicted to reduce existing flood damages by just over $10,000 over the next 50 years. This yields a preliminary BCR of well below 0.1.

Several services extend across the culvert alignment and would likely need to be relocated as part of the culvert upgrade. This includes:

- Sydney Water sewer and water mains
- Optus telecommunications
- NBN.

The high implementation cost and low BCR make this option difficult to support from a financial perspective. However, the significant emergency response and evacuation improvements that this option affords the existing population as well as the potential future population are significant positives. Therefore, this option should remain on the table for consideration particularly if further development proceeds between Werrington Creek and the railway line.

### 8.4.2 FM7 - Great Western Highway Culvert Upgrades

The Great Western Highway is the most heavily trafficked transportation link in the catchment. It serves as the major east-west transportation route south of the railway line. Therefore, it plays an important role as an evacuation route during floods. The results of the design flood simulations showed that the highway would be at least partly impacted during floods as frequent the 10% AEP flood and would be completely cut by floodwaters during a 5% AEP flood.

Most of the floodwater approaching the highway drains through a triple 2.7m diameter culvert that extends from the north-eastern corner of Chapmans Garden towards the Orth Creek channel. As shown in **Figure 63**, FM7 would involve roughly doubling the capacity of the existing culvert system by providing a new 3.2m wide x 2.1m high box culvert from the outlet of the Chapman Gardens basin, along the Great Western Highway and into College Creek just upstream of the Orth and Werrington Creeks confluence.

A cost estimate for FM7 was prepared and is enclosed in **Appendix I**. It shows that FM7 expected to have a capital cost of nearly $2.5 million. Therefore, this option is one of the most expensive options considered as part of the study.

The hydraulic model that was used to define design flood conditions was updated to include a representation of FM7. The updated TUFLOW model was then used to re-simulate a range of design floods. Floodwater difference maps were prepared for the 20% AEP, 5% AEP and 1% AEP events and the PMF and are provided in **Plate 40**.

**Plate 40** shows that although the Great Western Highway was only subject to inundation along its southern edge during the 20% AEP flood, FM7 is predicted to largely eliminate all inundation along the highway during smaller floods. Therefore, all travel lanes will remain trafficable along the highway during floods up to and including the 20% AEP flood.

**Plate 40** also shows that in the 5% AEP flood, reductions in flood levels of up to 0.1m can be expected within the Chapman Gardens basin and reductions of up to 0.17 metres are predicted within the car sale yards on the northern side of the Great Western Highway. Flood level increases within Werrington Creek of up to 0.13 metres are predicted within the immediate vicinity of the new culvert outlet, however these increases dissipate quickly and do not extend over private property.

During the 1% AEP flood, flood level reductions of 0.03 metres are predicted within the Chapman Gardens basin, and reductions of up to 0.1 metres are predicted within the car yards. Flood level increases are predicted within the Werrington Creek downstream of the culvert outlet. The flood level increases are predicted to extend across the Millen Street and George Street intersection and extend marginally into the adjoining aged care facility (however, the magnitude of the increases is not predicted to exceed 0.02 metres).

To mitigate the flood level increases that were observed across the Millen Street and George Street, an additional FM7 simulation was completed with a levee around the western edge of Millen Street to attempt to contain the flood level increases to the existing open space between the highway and railway line. The 1% AEP flood level difference map from this simulation is provided in **Plate 41**. It shows that inclusion of the levee is predicted to remove the previous flood level increases, however, it forces the additional water towards the railway line resulting in flood level increases across properties located immediately south of the railway line. Therefore, the levee effectively “just shifts” the problem elsewhere. It is likely that an additional levee would need to be included to protect properties located south of the railway line. However, this also introduces the potential complication of then providing additional culverts to drains the area behind the levee, inclusion of flood gates on the culverts and maintenance of the flood gates. This would add significant additional costs and maintenance requirements.

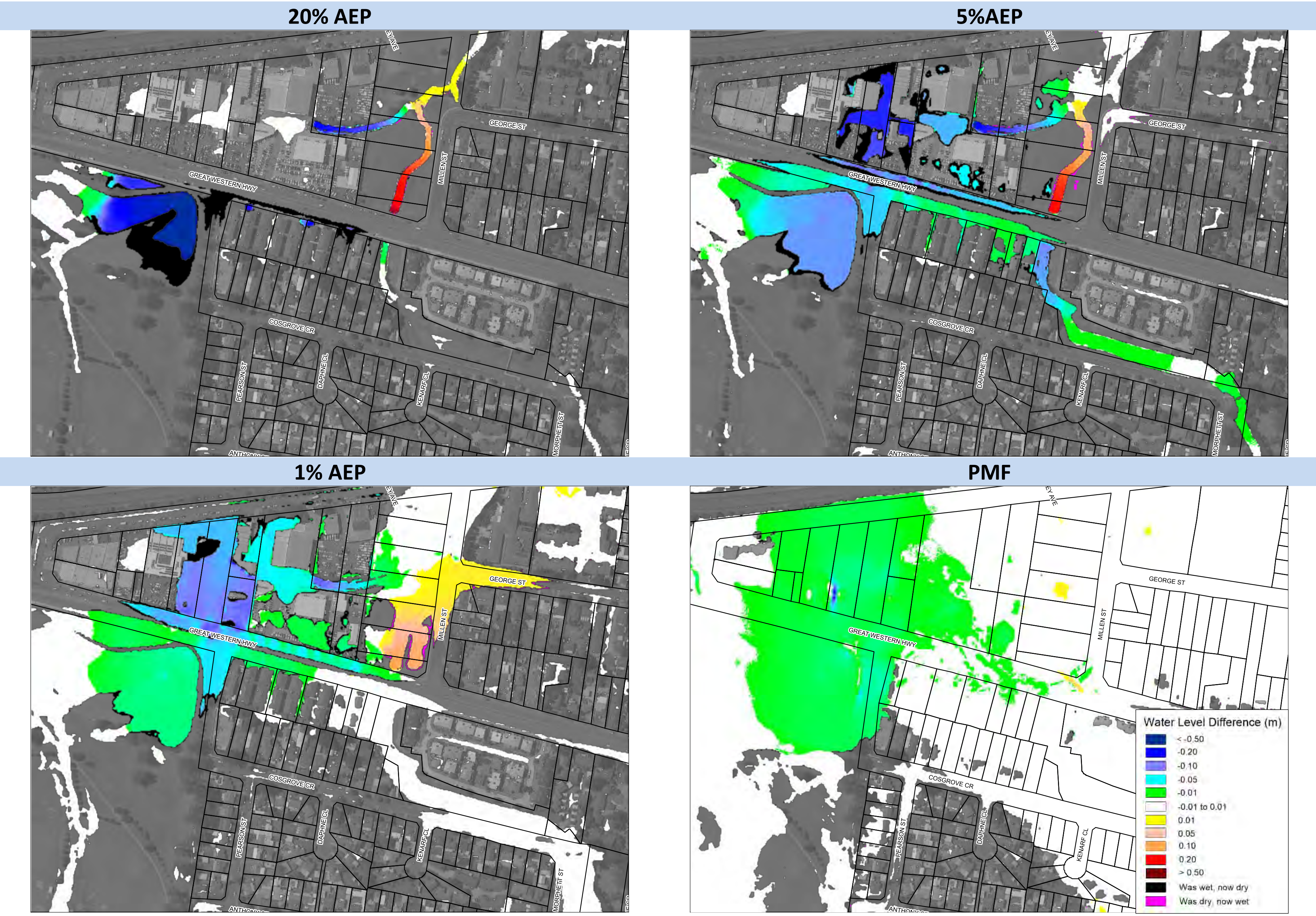



**Plate 40 Flood Level Difference Maps for FM7**

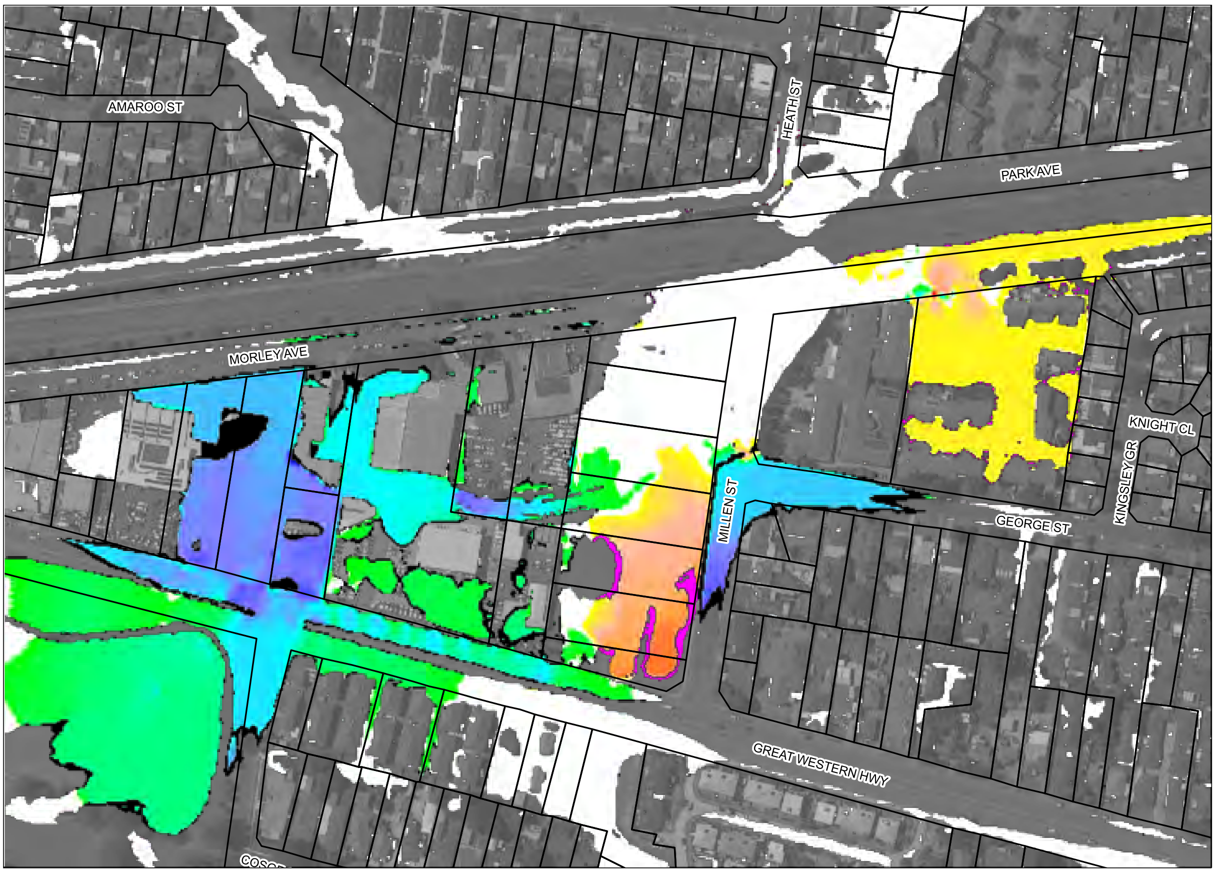



**Plate 41 1% AEP Flood Level Difference Map for FM7 with Levee**

Implementation of FM7 is predicted to reduce above floor flooding. More specifically, one (1) fewer property is predicted to be exposed to above floor flooding in the 5% AEP flood and three (3) fewer properties are predicted to experience above floor flooding in the 1% AEP flood. However, the additional flow directed through the culvert is predicted to result in one (1) additional property being exposed to above floor flooding in the PMF.

A revised flood damage assessment was completed based on the updated flood results. This showed implementation of FM7 is predicted to reduce existing flood damages by about $80,000 over the next 50 years. Therefore, the reduction in flood costs is not sufficient to cover the implementation costs and yields a BCR of less than 0.1.

A number of services extend across the culvert alignment and would likely need to be relocated as part of the culvert upgrade. This includes:

- Sydney Water sewer and water mains
- Jemena gas line
- NBN.

FM7 does provide some hydraulic and emergency response benefits. But it also comprises a significant implementation cost, provides a poor BCR and generates adverse flood impacts south of the railway line. As a result, it is recommended that other flood modifications options (e.g., FM19 and FM20) which also afford benefits across the Great Western Highway are pursued in preference to this option.

### 8.4.3 FM8 - Werrington Creek Railway Culvert Upgrade #1

As previously documented, flooding in the College, Orth and Werrington Creeks catchment is significantly influenced by the railway embankment as well as the existing culverts that drain floodwaters through the embankment. In particular, the culverts that drain Werrington Creek beneath the railway line at Kingswood are a major hydraulic control and result in a significant build-up of floodwater on the southern side of the railway line.

As shown in **Figure 64**, FM8 would involve replacing the existing 4 x 2.25m diameter culverts under the railway line with 3 x 3m wide x 1.8m high box culverts. As part of the investigation larger culvert sizes were trialled (e.g., 3 x 2.4m wide x 2.1m high box culverts and 4 x 3m wide x 2.4m high box culverts). However, the outcomes of these investigations determined that this area was highly sensitive to changes culvert sizes (i.e., providing larger culverts produced flood level increases across private property located between the railway line and Victoria Street). Therefore, the box culvert arrangement shown in **Figure 64** was determined to provide the best compromise between maximising flood level reductions south of the railway line while minimising adverse flood level impacts north of the railway line.

A cost estimate for FM8 was prepared and is enclosed in **Appendix I**. It shows that FM7 is expected to have a capital cost of about $1.1 million.

The hydraulic model that was used to define design flood conditions was updated to include a representation of FM8. The updated TUFLOW model was then used to re-simulate a range of design floods. Floodwater difference maps were prepared for the 20% AEP, 5% AEP and 1% AEP events and the PMF and are provided in **Plate 42**.

**Plate 42** shows that in the 20% AEP and 5% AEP floods, reductions in flood levels of up to 0.2 metres can be expected on the upstream side of the railway. Some isolated increases of 0.01 metres are predicted within the College Creek channel downstream of the railway during the 5% AEP flood but do not impact any private property.

**Plate 42** also shows that during the 1% AEP flood, flood level reductions of over 0.15 metres are predicted across a large area upstream of the railway line, including across private properties on George Street as well as Millen Street. However, increases of 0.01 metres are predicted within a large part of the College Creek channel downstream of the railway line and are predicted to propagate all the way down to Lake Werrington. These increases extend across part sections of a number of private properties immediately downstream of the railway line. This is predicted to result in 1 additional property being exposed to above floor flooding during the 1% AEP flood.

An alternate version of FM8 was investigated which included reductions in creek channel roughness between the railway line and Victoria Street. This was completed in an attempt to offset the flood level increases that were observed during the 1% AEP flood. The 1% AEP flood level difference map for this simulation is provided in **Plate 43** and shows the channel roughness reductions are sufficient to offset the additional flow that is directed through the railway culverts (although very small flood level increases are predicted across Victoria Street). Therefore, modifications to the channel between the railway line and Victoria Street may be a valid supplement to FM8.

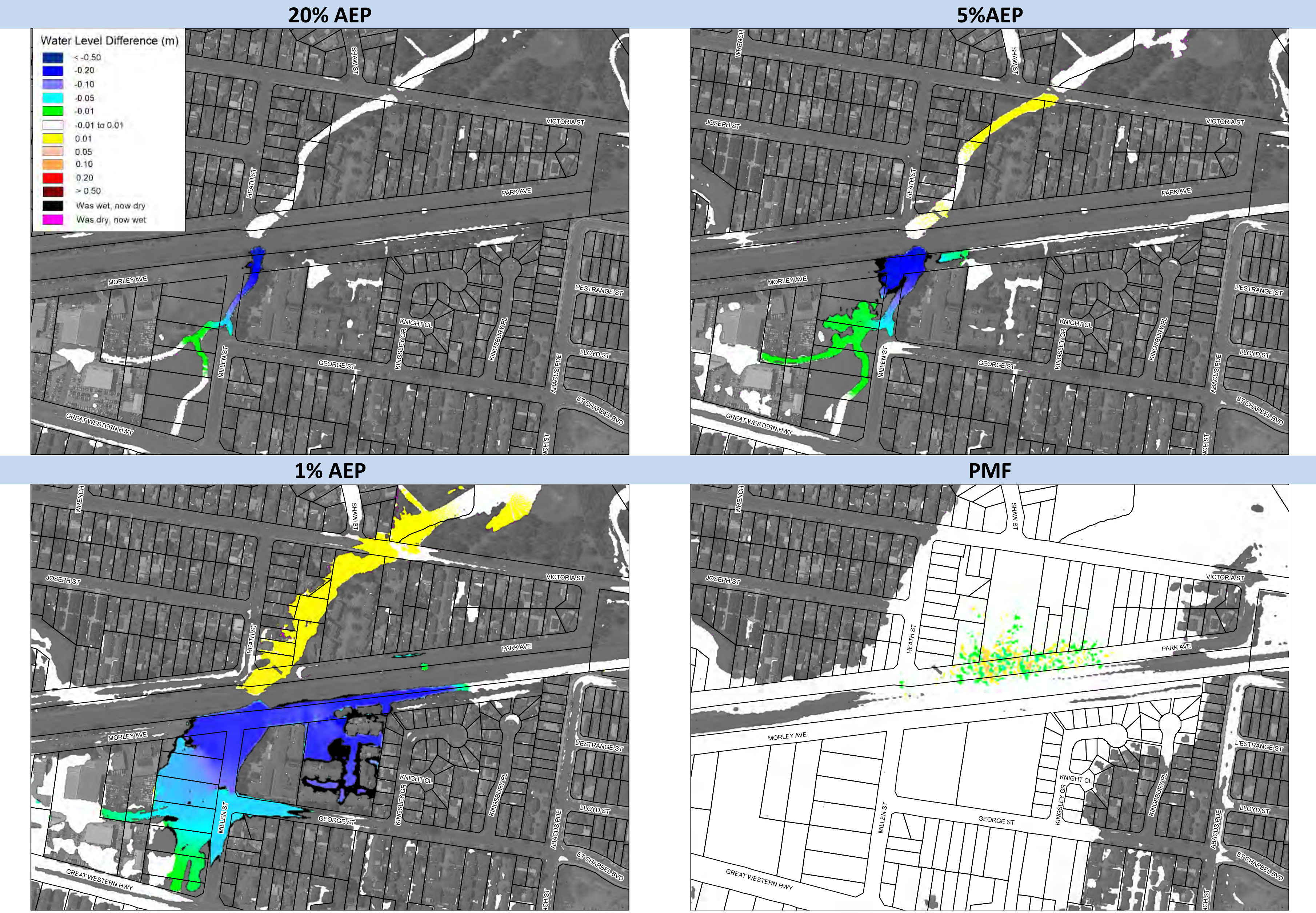



Plate 42 Flood Level Difference Maps for FM

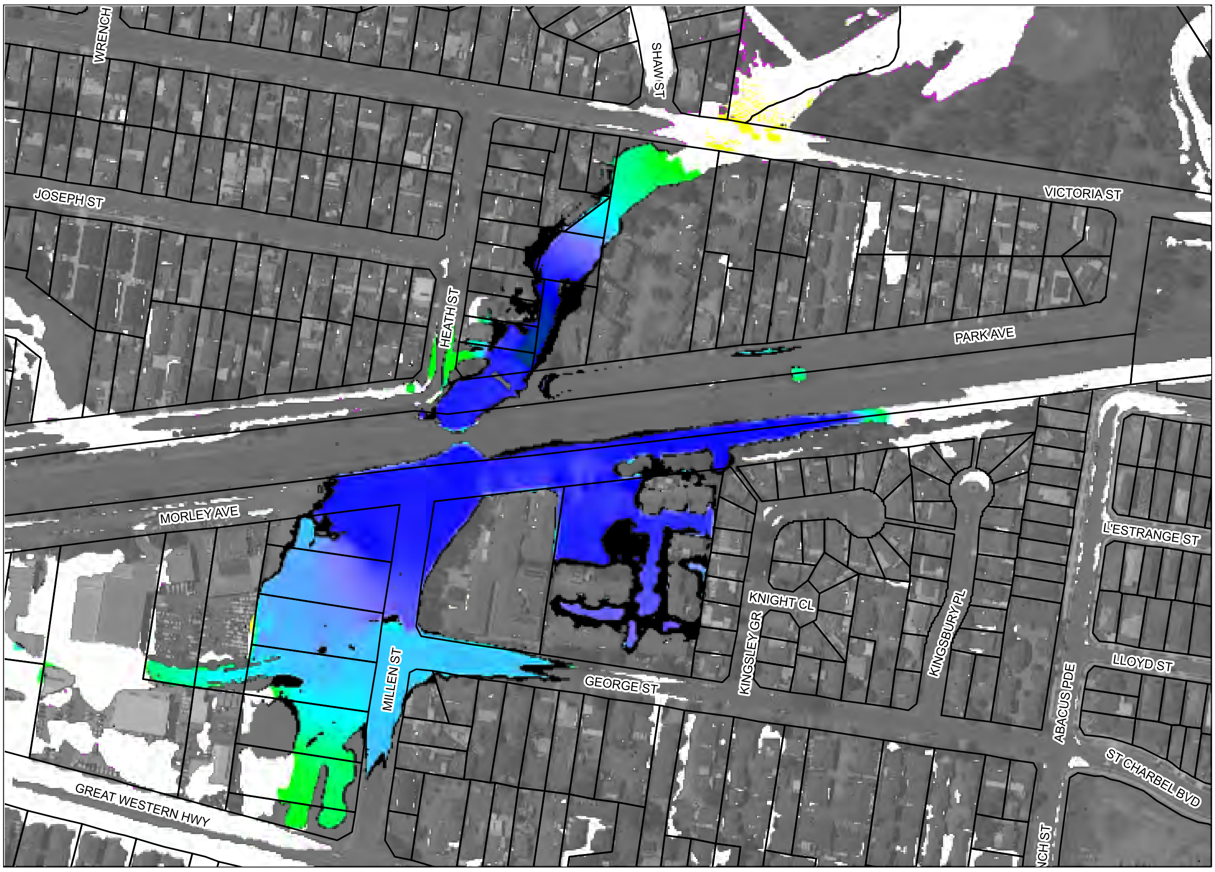



**Plate 43 1% AEP Flood Level Difference Map for FM8 with reduced channel roughness**

A revised flood damage assessment was completed based on the updated flood results. This showed implementation of the culvert upgrade is predicted to reduce existing flood damages by $25,000 over the next 50 years. This yields a preliminary BCR of less than 0.1.

This option would also present some technical challenges. More specifically, it is unlikely that the railway line can be closed during construction. Although this is not necessarily a 'showstopper', it would increase the technical challenges associated with implementation as well as the overall implementation costs. A Sydney Water sewer and water main also extends through the likely construction footprint and may need to be relocated or protected as part of construction works.

Overall, the results of the assessment of FM8 show that flood behaviour in this area is highly sensitive to changes to the existing culvert arrangement. Although enlarging the existing culvert would reduce flood levels and flood damage costs to the south of the railway line, it would increase flood levels and flood damage costs to the north of the railway line without supplementary works (e.g., reducing vegetation density along parts of the railway line). Therefore, there is little hydraulic and economic incentive to implement this option now. But the option could be revisited if Sydney Trains plans to undertake replacement of these culverts at any point in the future.

### 8.4.4 FM9 - Werrington Creek Railway Culvert Upgrade #2

As noted above, the existing railway embankment serves as a notable flow impediment during large floods in the catchment. As also noted above, the main Werrington Creek culvert crossing is a particularly sensitive location of the catchment, with any changes in this area having a notable impact on flood behaviour upstream and downstream of the railway.

The results of the existing hydraulic model simulations indicate that the capacity of a smaller 1.5 metre diameter culvert located to the east of the main Werrington Creek culvert (i.e., downstream of the 'French Street' subdivision) can often be exceeded. In such cases, the excess runoff drains in a westerly direction towards the main Werrington Creek culvert where it exacerbates the existing flooding problem at this location.

As shown in **Figure 65**, FM9 would involve the installation of an additional 1.5 metre diameter culvert that would extend from upstream of the railway line to Victoria Street. The existing culvert would also be extended to create a more hydraulically efficient system. The dual 1.5m diameter culverts would feed into 2 new 3m wide x 0.9m high box culverts under Victoria Street that would discharge into an existing open channel on the northern side of the road. The box culverts would aim to direct additional flow below Victoria Street thereby reducing the frequency of roadway overtopping.

A cost estimates for FM8 was prepared and is enclosed in **Appendix I**. It shows that FM8 is expected to have a capital cost of about $1.3 million.

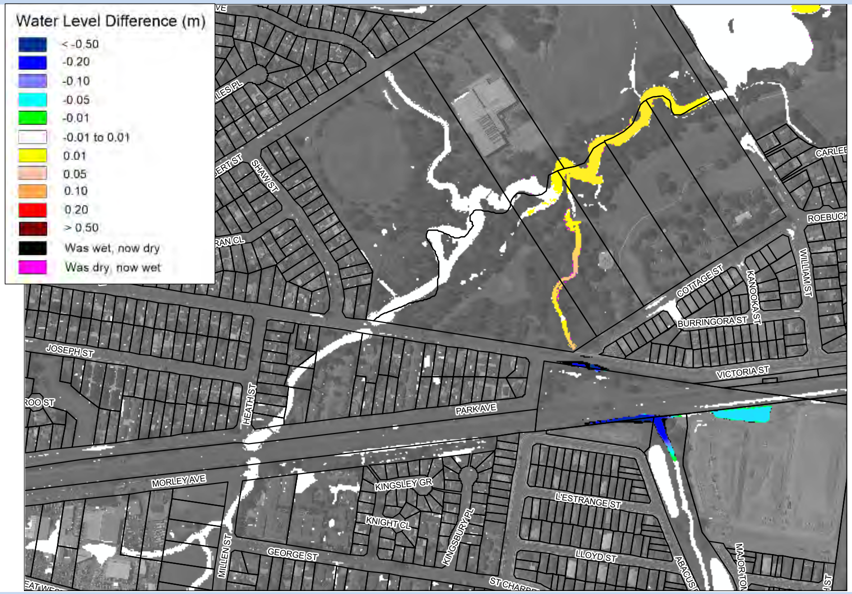
The hydraulic model that was used to define design flood conditions was updated to include a representation of FM8. The updated TUFLOW model was then used to re-simulate a range of design floods. Floodwater difference maps were prepared for the 20% AEP, 5% AEP and 1% AEP events and the PMF and are provided in **Plate 44**.

**Plate 44** shows that in the 20% AEP flood, reductions in flood levels of up to 0.2 metres can be expected on the upstream side of the railway line. Flood level increases of up to 0.1 metres are predicted in the channel located north of Victoria Street, however, these increases are fully contained to the channel.

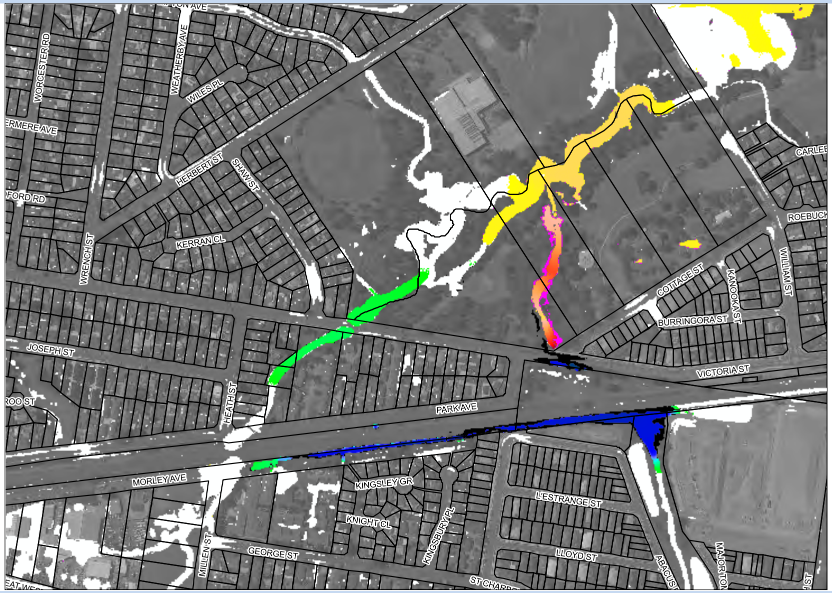
During the 5% AEP flood, flood level reductions of up to 0.3 metres are predicted south of the railway line between the French Street subdivision and main Werrington Creek channel. Small flood level reductions are also predicted within the main Werrington Creek channel either side of Victoria Street. Flood level increases of up to 0.15 metres are predicted in the open channel downstream of Victoria Street but do not impact any private property.

**Plate 44** also shows that in the 1% AEP flood, reductions of 0.35 metres are predicted on the upstream side of the railway line. The flood level reductions are predicted to extend across a substantial area including the main Werrington Creek channel between the Great Western Highway and Lake Werrington. However, the flood level reductions across this broader area most commonly do not exceed 0.05 metres. Flood level increases are again predicted in the open channel downstream of Victoria Street, but dissipate by the time this channel joins the main Werrington Creek channel.

## 20% AEP




## 5%AEP




## 1% AEP


## PMF

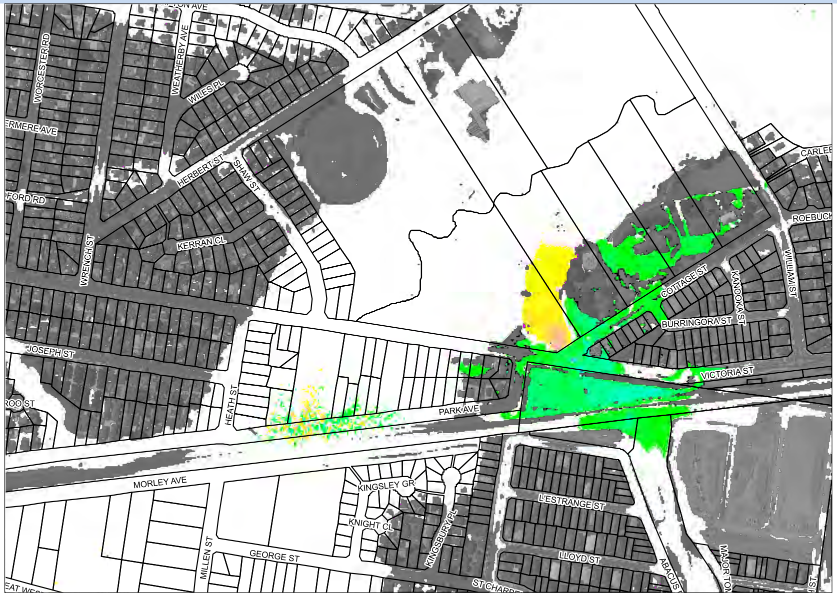



**Plate 44 Flood Level Difference Maps for FM9**

During the PMF, localised flood level reductions are predicted around the railway line and localised flood level increases are predicted on the northern side of Victoria Street. However, the flood level differences generally do not exceed 0.05 metres.

A revised flood damage assessment was completed based on the updated flood results. This showed implementation of culvert upgrade is predicted to reduce existing flood damages by less than $7,000 over the next 50 years. This yields a preliminary BCR of well below 0.1.

FM9 is predicted to reduce water levels and extents along Victoria Street so would afford emergency response benefits. More specifically, the section of Victoria Street that is benefited by this option is currently inundated during floods as frequent 10% AEP flood and is cut by floodwaters in the 0.2% AEP flood. With FM9 in place, evacuation will only be cut during the PMF. As noted in Section 8.4.3, it is anticipated that this road will service a larger population as new development progresses in the area. Therefore, the reliance of the community on this roadway to serve as an evacuation route will grow in the future. Therefore, any improvements to the level of service afforded by Victoria Street during floods is a significant advantage moving forward.

Two existing services may also require relocation as part of the culvert upgrade. This includes a Jemena gas line and Sydney Water supply main.

This option extends across land and infrastructure that is owned and operated by a range of agencies including Council, Transport for NSW and Railcorp. Therefore, consultation and coordination with each of these agencies will be required should this option be further explored in the future. In addition, consultation with the SES will be required to confirm the potential emergency response impacts.

Although FM9 provides a relatively poor economic return, it affords flood level reductions across a large area. It also reduces the frequency and depth of overtopping of Victoria Street and, therefore, provides evacuation and emergency response benefits. Therefore, consideration should be given to implementing this option to support the future population growth in this area and ensure this population does not increase the reliance on emergency services for rescue during floods.

### 8.4.5 FM10 - Werrington Railway Station Culvert Upgrade

As noted elsewhere in this report, the area located south of the Werrington railway station is one of the most significantly impacted flooding areas within the catchment. This outcome is a result of the railway embankment at this location which significantly impedes flow coupled with an existing 1.2 metre diameter culvert that does not have sufficient capacity to convey flows from this area.

FM10 would involve the installation of a new 0.9 metre diameter culvert through the railway (starting near the northern extent of Landers Street) and extending into the Parkes Avenue Sporting Complex where it connects into the existing trunk drainage network. An existing 0.75m diameter culvert further to the west (that currently directs runoff to the south of the railway) will be decommissioned and a link into the new culvert would be established on the northern side of the railway line.

Several iterations of pipe sizes were trialled as part of the concept design. Like the FM8 culvert assessment, this area was determined to be highly sensitive to the adopted culvert size. The final concept design documented in **Figure 66** reflects the best comprise between flood level reductions to the south of the railway line and adverse flood level increases to the north of the railway line.

A cost estimate for FM10 was prepared and is enclosed in **Appendix I**. It shows that FM10 is expected to cost about $850,000 to implement.

The hydraulic model that was used to define design flood conditions was updated to include a representation of FM8. The updated TUFLOW model was then used to re-simulate a range of design floods. Floodwater difference maps were prepared for the 20% AEP, 5% AEP and 1% AEP events and the PMF and are provided in **Plate 45**.

**Plate 45** shows that during the 20% AEP and 5% AEP floods, reductions in flood levels of 0.06 metres are predicted across a large area south of the railway line (east of Landers Street and north of Walker Street). Some localised increases of up to 0.02 metres are predicted within the Parkes Avenue Sporting Complex during the 5% AEP flood, however, these do not extend onto private property. No flood level increases are predicted during the 20% AEP flood.

During the 1% AEP flood, flood level reductions of between 0.07 and 0.1 metres are predicted across a large area contained on the southern side of the railway line. Localised flood level increases of 0.01 to 0.02 metres are again predicted within the Parkes Avenue Sporting Complex but do not impact any private property.

**Plate 45** shows that no changes in flood level are predicted during the PMF.

A revised flood damage assessment was completed based on the updated flood results. This showed implementation of FM10 is predicted to reduce existing flood damages by about $100,000 over the next 50 years. This yields a preliminary BCR of about 0.1.

Two existing services may also require relocation as part of the culvert upgrade. This includes a Jemena gas line and Sydney Water supply main.

Although flood level reductions in Railway Street are predicted, FM10 is not predicted to improve the level of service afforded. That is, even with FM10 in place, Railway Street is still predicted to be cut during a 20% AEP flood.

Although the potential reductions in flood levels and damage costs could be increased further on the southern side of the railway line, this would always come at the expense of flood level increases and potential increases in flood damage on the northern side of the railway. As a result of this outcome, FM10 is not recommended for implementation.

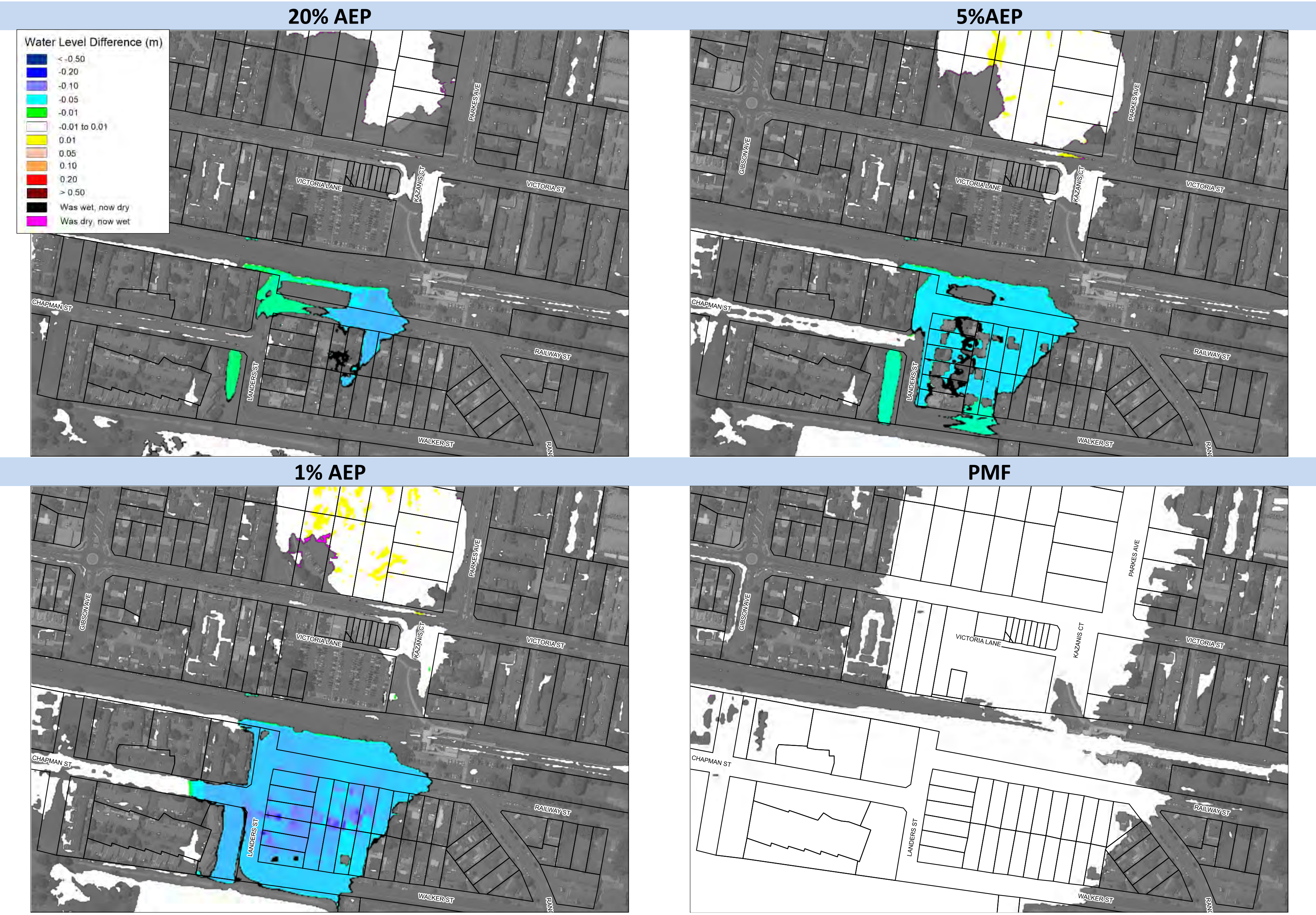



Plate 45 Flood Level Difference Maps for FM10

## 8.5 Drainage Upgrades

### 8.5.1 FM11 - Dunkley Place Stormwater Upgrades

Dunkley Place as well as Gibson Avenue and Princess Street at Werrington comprise a 'trapped low point'. As a result, once the capacity of the local stormwater system is exceeded, the excess water is predicted to pond within the roadway and extend into adjoining properties. Inundation depths across this area during the 1% AEP flood are predicted to exceed 0.5 metres with Dunkley Place exposed to inundation depths of more than 1 metre.

FM11 would involve upgrading the local stormwater system to allow water to drain from the local area more readily. As shown in **Figure 67**, the upgrades would include:

- Six (6) new inlet pits and connecting pipes within Dunkley Place
- Two (2) new pits with connecting pipes within Gibson Avenue
- A new 0.9 metre diameter trunk drainage line from Chrisan Close to Gibson Avenue
- A new 1.2 metre diameter pipe from Gibson Avenue to the existing trunk drainage system located within the Parkes Avenue Sporting Complex oval.

It is expected that implemented of FM11 would cost about $1.3 million to implement. A breakdown of the cost estimate is provided in **Appendix I**.

The TUFLOW computer model that was used to define design conditions was updated to include the drainage upgrades. The updated TUFLOW model was then used to re-simulate a range of design floods. Floodwater difference maps were prepared for the 20% AEP, 5% AEP and 1% AEP events and the PMF and are provided in **Plate 46**.

**Plate 46** shows that during the 20% AEP flood, notable reductions in flood levels and extents are predicted in Dunkley Place, Gibson Avenue, Process Street and Chrisan Close. More specifically, flood level reductions of up to 0.18 metres are predicted along each roadway with FM11 in place. The flood level reductions are sufficient to result in each road remaining trafficable during floods up to and including the 10% AEP event (currently these roads are predicted to be cut in a 20% AEP flood). Small increases in flood level (i.e., 0.02 metres) are predicted across the Parkes Avenue Sporting Complex ovals. Although the flood level increases are largely contained to open space, some existing residential properties located on the western side of the sports fields are predicted to be impacted.

During the 5% AEP flood, reductions in flood levels of more than 0.1 metres are predicted within Dunkley Place and Gibson Avenue. More modest reduction of up to 0.05 metres are predicted within Chrisan Close. Small flood level increases of between 0.01 and 0.02 metres are predicted across the Parkes Avenue Sporting Complex ovals.

During the 1% AEP flood, reductions of 0.1 metres are predicted across a significant proportion of Dunkley Place, Gibson Avenue and Chrisan Close. The flood level reductions are sufficient to result in one (1) fewer property with above floor flooding in the 1% AEP flood (no above floor flood level reductions are predicted during other design floods).

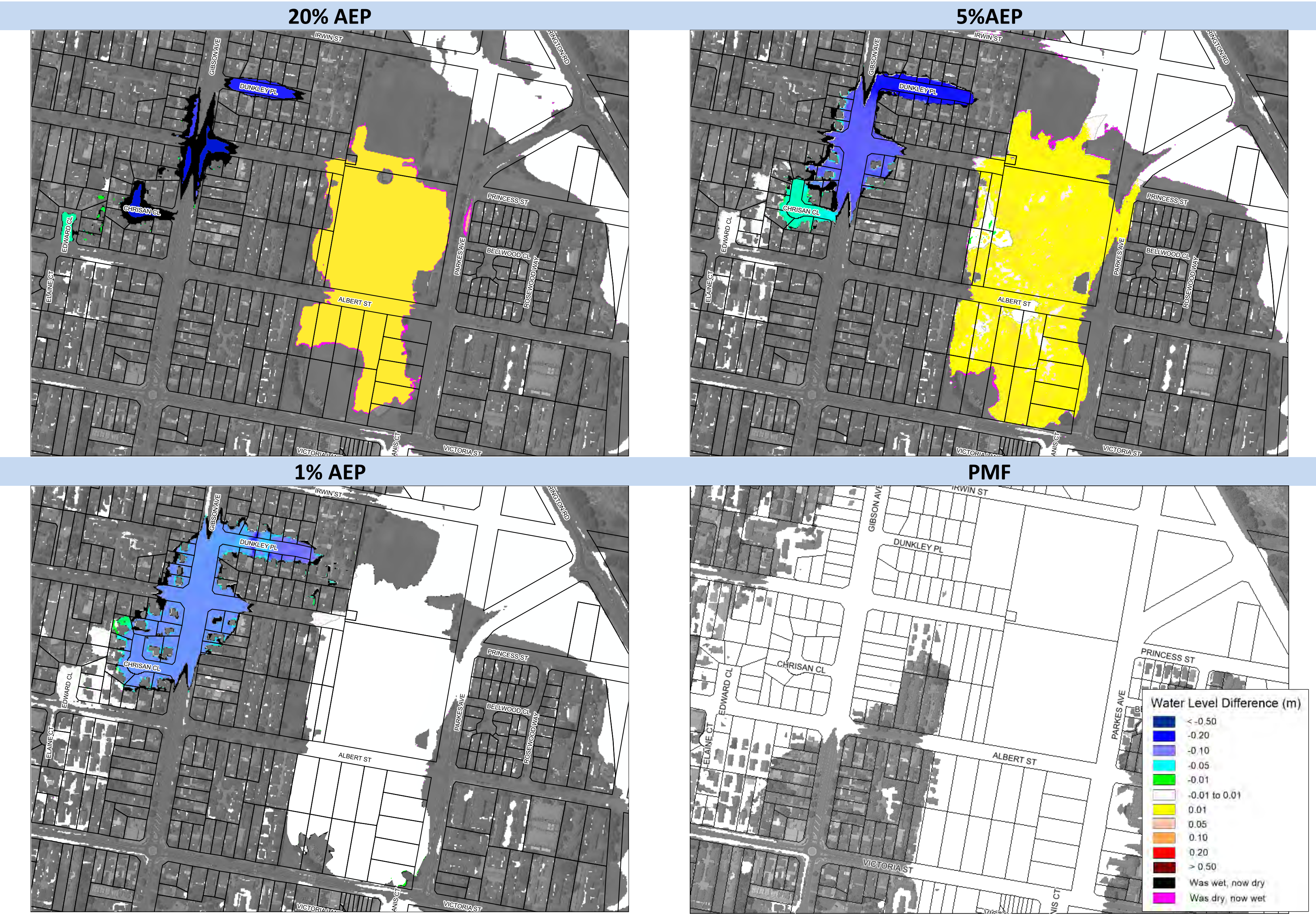



**Plate 46 Flood Level Difference Maps for FM11**

No changes in flood level are predicted during the PMF as the whole area is 'drowned out' during this much larger flood.

A revised flood damage assessment was completed based on the updated flood results. This showed implementation of FM11 is predicted to reduce existing flood damages by around $230,000 over the next 50 years. This yields a preliminary BCR of about 0.2. Therefore, FM11 is one of the better performing drainage upgrade options. However, the costs are still predicted to outweigh the potential financial benefits of this option.

There are a number of services in the area that may be impacted by any drainage upgrade works. This includes:

- Sydney Water sewer and water mains
- Jemena gas line
- NBN.

This option is predicted to provide the most significant benefits during smaller floods. This will afford emergency response benefits (i.e., reducing the frequency and depth of roadway inundation). It will also significantly reduce the frequency of 'nuisance' flooding which will have beneficial impacts to the local community (i.e., less frequent inundation of yards, sheds etc).

FM11 is predicted to afford some notable reductions in flood levels across the Dunkley Place area during each simulated design flood. The economic assessment indicates that there is currently insufficient economic evidence to support implementing this option in the short term. However, Council will need to replace these drainage assets in the medium to long term. Due to the hydraulic and emergency response benefits afforded by this option, it is recommended that opportunities to upgrade this drainage infrastructure (rather than replace 'like for like') be explored when the service life of these assets is reached.

### 8.5.2 FM12 - Orleton Place to Francis Street Stormwater Upgrades

Orleton Place to Francis Street in Werrington County is considered a flooding 'hot spot'. This whole area comprises a topographic 'low point'. As a result, flow that exceeds the capacity of the stormwater system is concentrated in this area as overland flow and is predicted to discharge through multiple properties. Furthermore, during the PMF, the depth and velocity of floodwaters are sufficient to produce H5 hazard through a number of properties located between Glencoe Avenue and Francis Street (refer **Figure 37**).

FM12 involves upgrading the existing stormwater system between Orleton Place and Francis Street. As shown in **Figure 68**, this would include the following upgrades:

- A new 0.6 metre diameter pipeline from north of Orleton Place to Orleton Place
- Five (5) new stormwater inlet pits and connecting pipes within Orleton Place
- Duplication of the pipeline from Orleton Place to Rugby Street and Glencoe Avenue intersection
- A new 1.05 metre diameter pipeline from Rugby Street and Glencoe Avenue intersection down Glencoe Avenue to Lake Werrington

- Six (6) new stormwater pits at the intersection of Glencoe Avenue and Romaine Avenue.

As shown in **Appendix I**, FM12 is expected to have an implementation cost of about $2.5 million. Therefore, it is one of the most expensive options considered.

The TUFLOW computer model that was used to define design conditions was updated to include the drainage upgrades. The updated TUFLOW model was then used to re-simulate a range of design floods. Floodwater difference maps were prepared for the 20% AEP, 5% AEP and 1% AEP events and the PMF and are provided in **Plate 47**.

**Plate 47** shows that the stormwater upgrades would be sufficient to eliminate inundation across the whole area during the 20% AEP flood. This is a significant improvement over the existing scenario where Glencoe Ave would be cut by floodwaters during a 20% AEP flood.

During the 5% AEP flood, reductions in flood levels of over 0.2 metres are predicted within Orleton Place and over 0.35 metres at the intersection of Glencoe and Romaine Avenue. A number of properties between Glencoe Avenue and Francis Street are predicted to be 'flood free' during the 5%AEP event.

**Plate 47** shows that during the 1% AEP flood, the following flood level reductions are predicted:

- Orleton Place: 0.07 metres
- Rugby Street: 0.13 metres
- Glencoe Avenue: between 0.1 and 0.2 meters
- Glencoe Avenue and Francis Street properties: between 0.1 and 0.3 metres.

During the PMF, flood level reductions are predicted across a large number of properties. The reductions are most commonly less than 0.05 metres although localised reductions approaching 0.1 metres are predicted within some Glencoe Avenue and Francis Street properties. However, the flood level reductions are not sufficient to reduce the PMF hazard below H5.

Despite the flood level reductions, FM12 is not predicted to reduce the number of properties exposed to above floor flooding during floods up to and including the 1% AEP event. However, three (3) fewer properties are predicted to be exposed to above floor flooding during the PMF.

As discussed, the stormwater upgrades are predicted to eliminate inundation across the area during floods up to and including the 20% AEP event. Furthermore, the drainage improvements would result in Glencoe St, which is currently cut during a 20% AEP flood, remaining trafficable until a 2% AEP flood. Therefore, this option does provide local emergency response benefits and well as broader social benefits associated with less frequent inundation of roadways and properties.

A revised flood damage assessment was completed based on the results from the updated modelling. This showed implementation of the drainage upgrades is predicted to reduce existing flood damages by about $180,000 over the next 50 years. This yields a preliminary BCR of about 0.1.

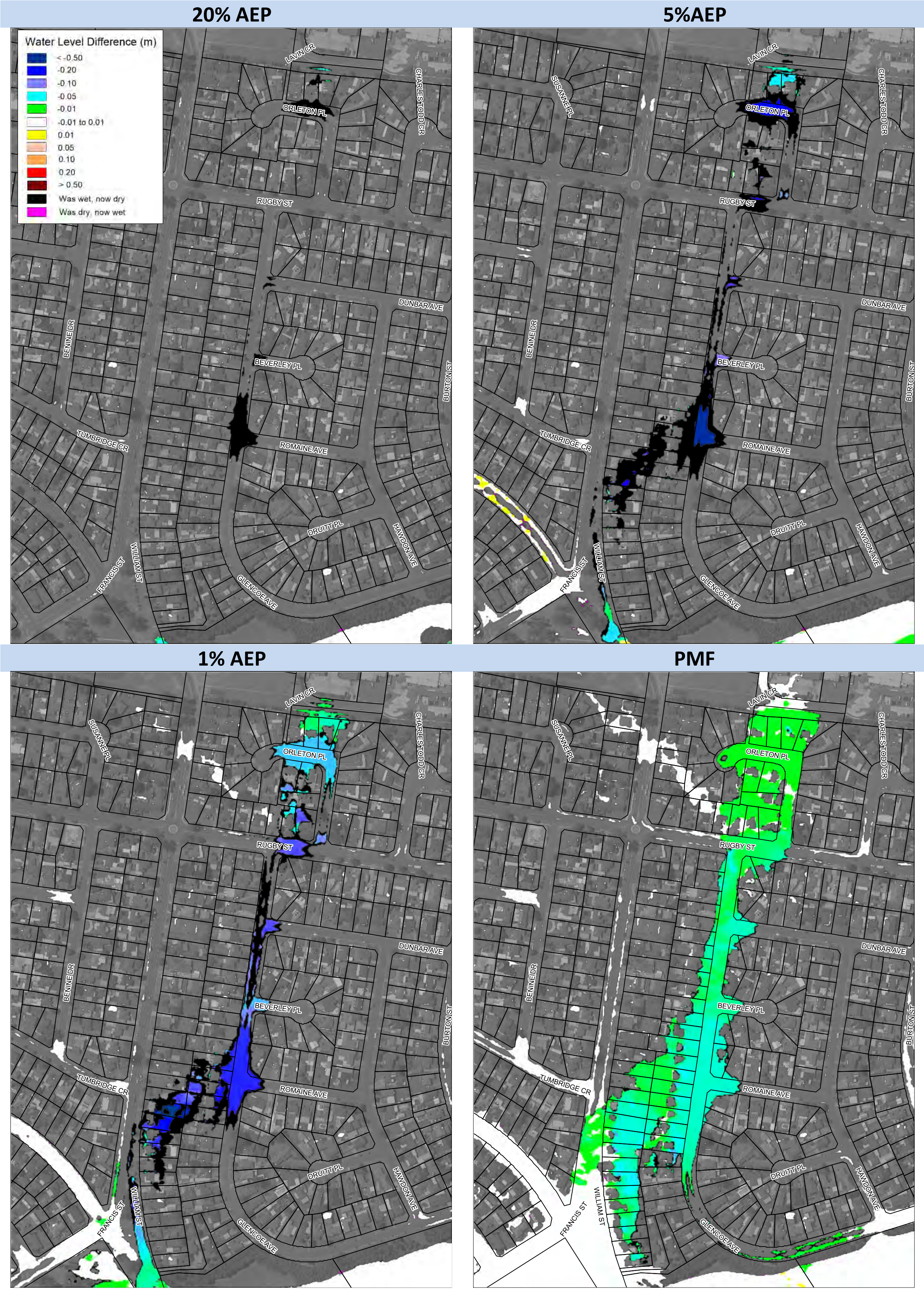



**Plate 47 Flood Level Difference Maps for FM12**

There are a number of services in the area that may to be relocated as part of any drainage upgrade works. This includes:

- Sydney Water sewer and water mains
- Jemena gas line
- Optus telecommunications
- Endeavour Energy.

FM12 is predicted to be one of the most expensive options and does not provide a sufficient reduction in flood damage costs to offset this significant implementation cost. However, it is predicted to provide emergency response benefits and will eliminate 'nuisance' flooding across many properties and local roads. Therefore, Council could consider these stormwater upgrades (or a variation of these upgrades) as part of its asset replacement or capital works program over the medium to long term.

### 8.5.3 FM13 - Rugby Street to Neeta Avenue Stormwater Upgrades

The area contained between Rugby Street and Neeta Avenue at Cambridge Park (in particular, the area between Wembley Avenue and Twickenham Avenue) is predicted to be subject to overland flooding during floods as frequent as the 5% AEP event.

As shown in **Figure 69**, FM13 would involve upgrading the local stormwater system to reduce the frequency and depth of overland flooding. The upgrades would include:

- Six (6) new stormwater pits and connecting pipes on Rugby Street
- A new 0.75 metre diameter pipeline from Rugby Street to Wembley Avenue
- Five (5) new pits and connecting pipes in Wembley Avenue
- A new 0.9 metre diameter pipe running from Wembley Avenue to Neeta Avenue (near the intersection with Twickenham Avenue).

It is expected that FM13 would have a capital cost of nearly $850,000. A breakdown of the cost estimate is provided in **Appendix I**.

The TUFLOW computer model that was used to define design conditions was updated to include the drainage upgrades. The updated TUFLOW model was then used to re-simulate a range of design floods. Floodwater difference maps were prepared for the 20% AEP, 5% AEP and 1% AEP events and the PMF and are provided in **Plate** 48**.**

**Plate** 48 shows that in the 20% AEP flood, the stormwater upgrades will eliminate flooding in Rugby Street and produce small flood level reductions (i.e., 0.05 metres) in Wembley Avenue. Negligible flood level changes are predicted elsewhere during the 20% AEP flood.

During the 5% AEP flood, reductions in flood levels of up to 0.1 metres are predicted within Rugby Street. Flood level reductions are also predicted in Wembley Avenue, Neeta Avenue and William Street but most commonly do not exceed 0.02 metres.

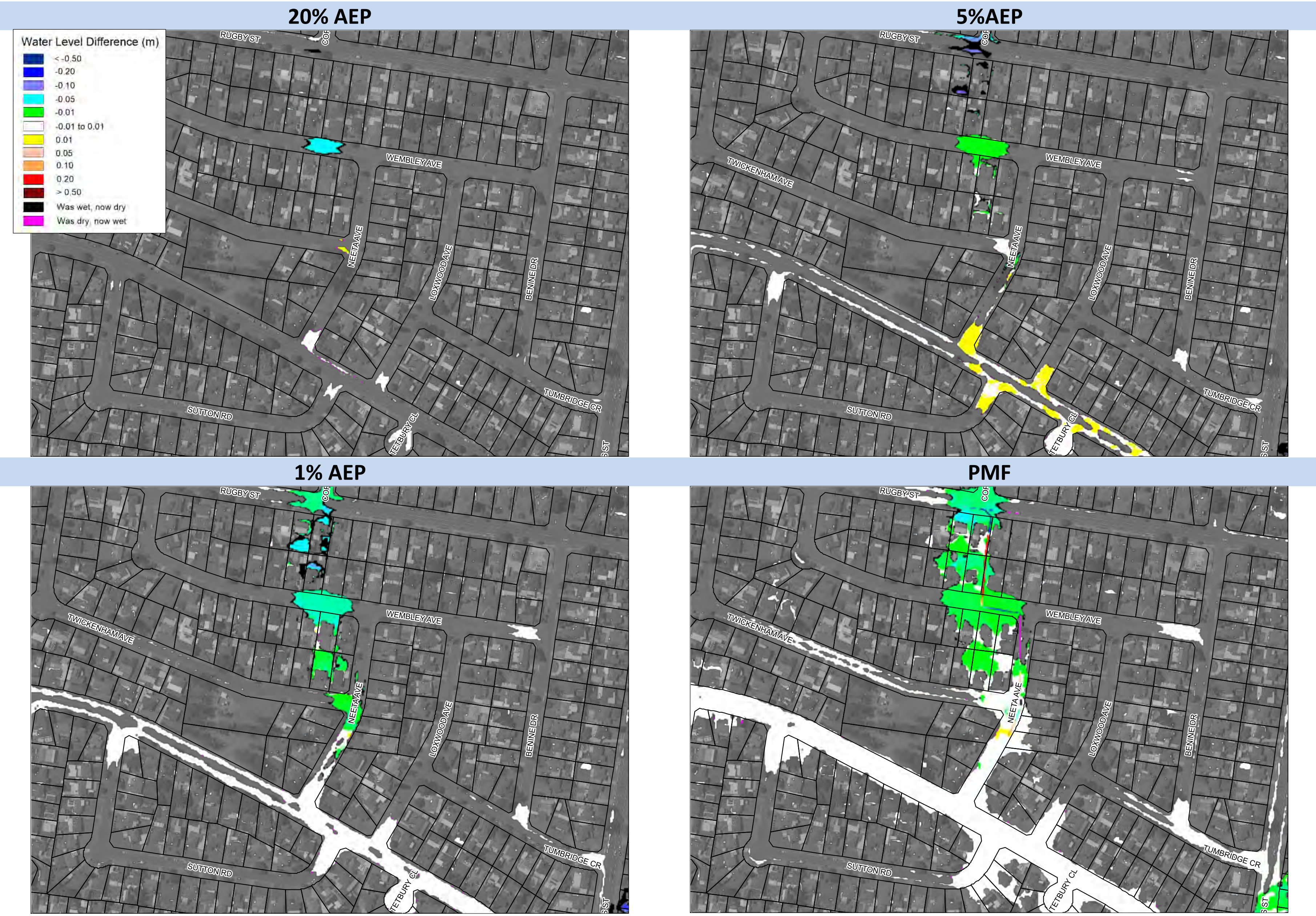



**Plate** 48 **Flood Level Difference Maps for FM1**

Plate 48 shows that in the 1% AEP flood, reductions of 0.03 metres are predicted within Rugby Street and Wembley Avenue. More modest reductions of 0.01 metres are predicted at the intersection of Neeta Street and Twickenham Avenue. Reductions of between 0.02 and 0.05 metres are predicted across a number of private properties. Small flood level increases (i.e., 0.01 metres) are predicted across some downstream roadways including Neeta Avenue and William Street. This is sufficient to result in one (1) fewer property being exposed to above floor flooding in the 1% AEP event.

Small flood level reductions are also predicted during the PMF across a larger number of residential properties as well as several roads. However, the reductions most commonly do not exceed 0.02 metres.

A revised flood damage assessment was completed based on the updated flood model results. This showed implementation of the drainage upgrades is only predicted to reduce existing flood damages by about $20,000 over the next 50 years. This yields a preliminary BCR of well below 0.1.

There are a number of services in the area that may to be relocated as part of any drainage upgrade works in this area. This includes:

- Sydney Water sewer and water mains
- Jemena gas line
- Optus telecommunications
- Endeavour Energy.

Overall, the flood level reductions afforded by FM13 are not predicted to exceed 0.1 metres. As a result, this option is not predicted to yield a significant reduction in flood damage costs. As a result of the poor financially viability of this option, it is not recommended for implementation.

### 8.5.4 FM14 - Victoria Street to Joseph Street Stormwater Upgrades

Multiple properties between Victoria Street and Joseph Street at Kingswood are predicted to experience overland flooding during the 1% AEP flood. The flood hazard during the 1% AEP flood is predicted to reach H3 in some areas while during the PMF, the flood hazard is predicted to reach H5 (i.e., unsafe for people and vehicles and potential for structural damage to buildings).

As shown in **Figure 70**, FM14 would provide the following drainage upgrades for the area in an attempt to reduce the depth and frequency of overland flooding:

- Four (4) new stormwater pits on Victoria Street.
- A new 0.75 metre diameter pipeline running along Victoria Street and Walter Street that discharges into the existing stormwater system to the south of Joseph Street.
- Upgrading the inlet capacity of a number of existing pits on Joseph Street.

It is expected that the upgrades would have a capital cost of just under $800,000. A breakdown of the cost estimate is provided in **Appendix I**.

The hydraulic model that was used to define design flood conditions was updated to include a representation of FM14. The updated model was then used to re-simulate a range of design floods. Floodwater difference maps were prepared for the 20% AEP, 5% AEP and 1% AEP events and the PMF and are provided in **Plate 49**.

**Plate 49** shows that negligible changes in flood levels and extents are anticipated in the 20% AEP flood. This indicates that the existing stormwater system is sufficiently sized to cater for floods up to and including the 20% AEP flood.

In the 5% AEP flood, reductions in flood levels of between 0.05 and 0.15 metres are predicted across a number of properties between Victoria Street and Joseph Street. Some flood level increases of up to 0.03 metres are predicted within the open space downstream of Joseph Street and are predicted to extend south to Park Avenue. However, the flood level increases do not extend into private property.

During the 1% AEP flood, flood level reductions of between 0.05 and 0.1 metres are predicted across several properties between Victoria and Joseph Streets. Like the 5% AEP event, flood level increases of up to 0.03 metres are predicted within the open space located downstream of Joseph Street as well as on Park Avenue.

During the PMF, small flood level reductions (typically 0.03 to 0.05 metres) are predicted across a number of properties between Victoria Street and Walter Street. A limited number of properties fronting Victoria Street are also predicted to experience flood level reductions of more than 0.1 metres. No flood level increases are predicted during the PMF.

The flood level reductions are sufficient to result in two (2) fewer properties being exposed to above floor flooding during the 5% AEP and 1% AEP floods as well as the PMF. Therefore, FM14 provides the greatest overall reduction in above floor flooding of all the drainage upgrade options investigated.

FM14 is not predicted to afford any major emergency responses improvements. However, evacuation is not a major concern for this particular area with roads remaining trafficable up to and including the 1% AEP flood.

The hydraulic benefits afforded by this option are also reflected in the economic performance. More specifically, the results of a revised flood damage assessment with FM14 in place indicates that this option is predicted to reduce existing flood damages by more $230,000 over the next 50 years. Therefore, this option is predicted to afford the greatest overall reduction in flood damages of all the drainage upgrade options considered (marginally ahead of FM11). The BCR of 0.3 is also the highest of all the drainage upgrade options considered.

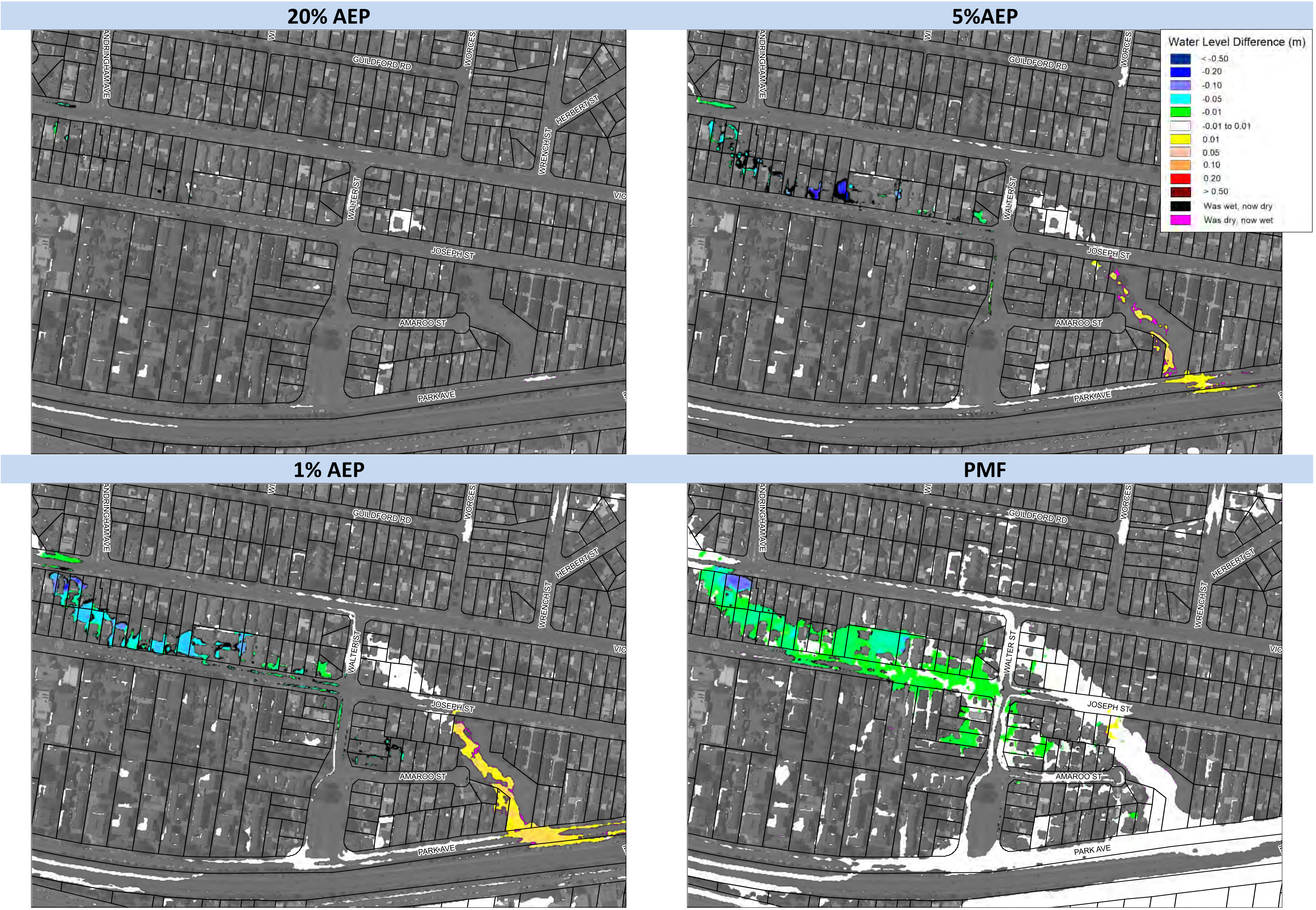



Plate 49 Flood Level Difference Maps for FM14

There are a number of services in the area that may to be relocated as part of any drainage upgrade works in this area. This includes:

- Sydney Water sewer and water mains
- Jemena gas line
- Optus telecommunications
- Endeavour Energy.

Although FM14 is the best performing drainage upgrade option from an economic perspective, the BCR is still well below 1. Therefore, it will be difficult to gain funding support under the State Government's Floodplain Management Program. However, the option does provide some notable reductions in flood level and above floor flooding during a range of different sized floods. Therefore, it is recommended that Council looks to implement this option (or a variation of the option) as part of its long-term asset replacement for the area.

### 8.5.5 FM16 - Stafford Street to First Street Stormwater Upgrades

As noted throughout this report, the area of Kingswood contained between Bringelly Road and First Street is one of the biggest flooding hot spots in the catchment. Multiple detention basins options have been investigated to assist with the flooding problem in this area (refer Section 8.3.4 and Section 8.3.5). However, a stormwater upgrade option was also investigated to verify if it may offer an improvement mitigation option for the area.

As shown in **Figure 72**, FM16 would involve duplicating the existing pipe system between the existing Jamison Road detention basin (south of Stafford Street) and First Street. Additional stormwater pits and connecting pipes would also be incorporated on Stafford Street. Initial simulations with the pipe upgrades only showed the hydraulic performance was limited by the receiving swale located to the east of First Avenue. Therefore, to improve the hydraulic performance of this option, the existing swale was also widened to 6 metres over a length of approximately 300 metres.

It is expected that FM16 would have a capital cost of about $3.5 million (refer **Appendix I**), making it the most expensive option that was investigated as part of the study. The higher cost of this option relative to the other drainage upgrade options is attributed to a large number of services that would likely need to be relocated (discussed further below) as well as the considerable lengths of large pipes that would need to be installed.

The TUFLOW computer model was updated to include a representation of FMF 16 and the updated TUFLOW model was then used to re-simulate a range of design floods. Floodwater difference maps were prepared for the 20% AEP, 5% AEP and 1% AEP events and the PMF and are provided in **Plate 50**.

**Plate 50** shows that flood level reductions are predicted across a large area between Stafford Street and Chapman Gardens. This includes:

- Stafford Street: reductions of between 0.02 and 0.03m during the full range of floods.

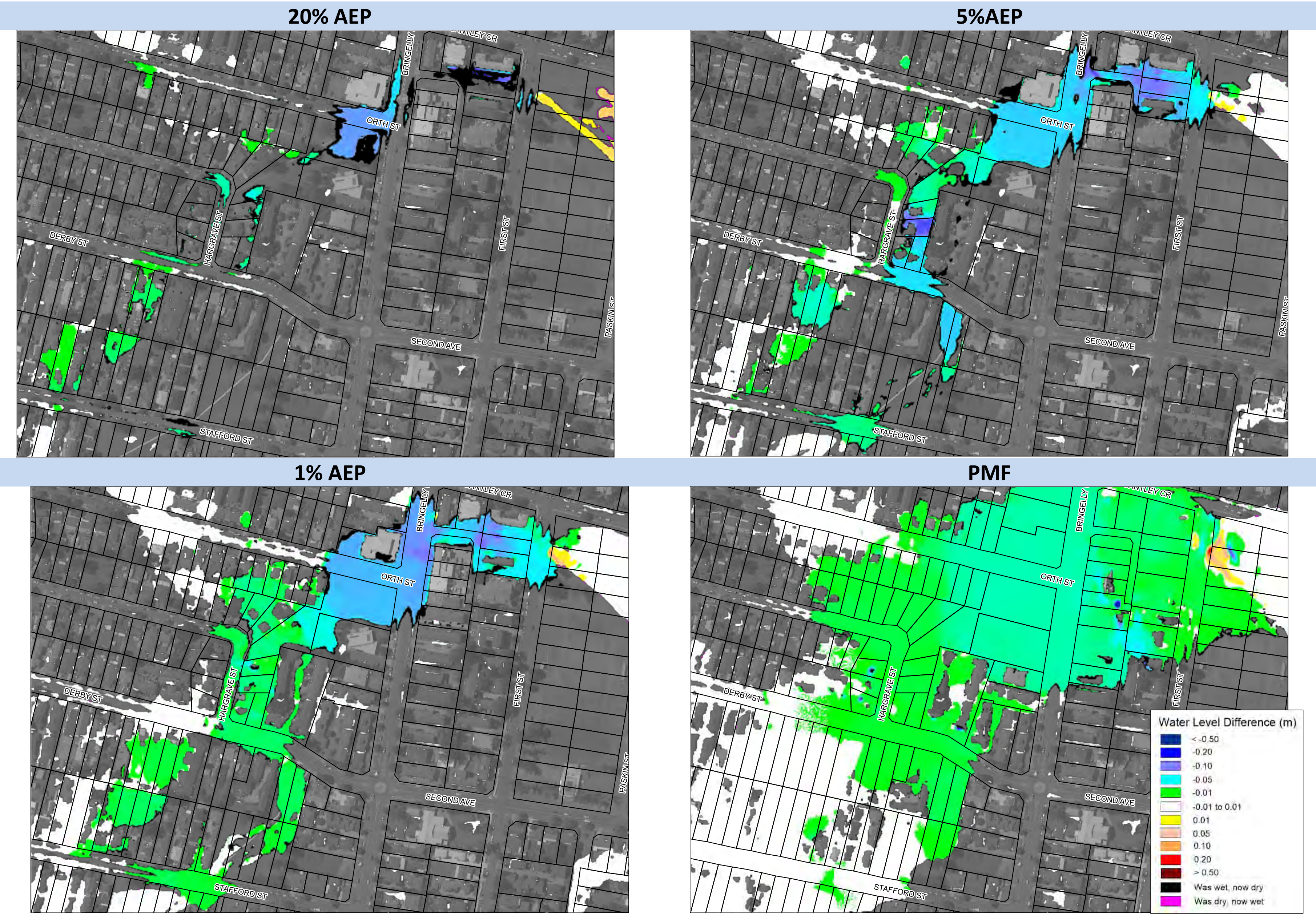



**Plate 50 Flood Level Difference Maps for FM1**

- Properties between Stafford Street and Derby Street: reductions up to 0.04m during the 20% AEP and 5% AEP floods and reductions of 0.02m during the 1% AEP flood. Reductions of around 0.01 metres are anticipated during the PMF.
- Derby Street: 20% AEP reductions of 0.03 metres, 5%AEP reductions of 0.06 metres, 1%AEP reductions of 0.03 metres and PMF reductions of 0.02 metres.
- Hargrave Street properties: 20% AEP reductions of up to 0.08 metres, 5% AEP reductions of between 0.06 and 0.15 metres, 1% AEP reductions of 0.03 metres and PMF reductions of about 0.02 metres.
- Bringelly Road: 20% AEP reductions of 0.08 metres, 5% AEP reductions of 0.06 metres, 1% AEP reductions of 0.09 metres and PMF reductions of 0.04 metres.
- Santley Lane and adjacent properties: 0.05 to 0.1 metre reductions in both 5% and 1% AEP events. Reductions of more than 0.1 metres are predicted in the 20% AEP flood while during the PMF, the reductions typically do not exceed 0.03 metres.
- First Street: 0.08 metre reductions during the 20% AEP flood, 0.05 metre reductions during both 5% and 1% AEP events and 0.03 metre reductions in the PMF.

In general, the flood level reductions afforded by FM16 are small. As a result, FM16 is not predicted to provide significant reductions in roadway inundation and, therefore, minimal emergency response benefits.

A revised flood damage assessment was completed based on the updated flood model results. This showed implementation of the drainage upgrades is predicted to reduce existing flood damages by about $133,000 over the next 50 years. This yields a preliminary BCR of less than 0.1.

As discussed, there are a considerable number of services in the area that may to be relocated as part of any drainage upgrade works in this area. This includes:

- Sydney Water sewer and water mains
- Jemena gas line
- NBN
- AARNet telecommunication.

Therefore, although FM16 is predicted to afford flood level reductions across a large area, the detention basins options documented in Section 8.3.4 and Section 8.3.5 are preferred for this area as they are likely to be cheaper to implement while providing improved hydraulic performance.

## 8.6 Channel Modifications

### 8.6.1 FM17 - College Creek and Orth Creek Channel Enlargement

As shown in **Figure 73**, FM17 would involve enlarging the College and Orth Creek channels downstream of the Great Western Highway. The width of the College Creek channel would be increased to approximately 20 metres wide and the width of the Orth Creek channel would be increased to approximately 15 metres wide. The channel enlargement would aim to reduce water levels in this area thereby improving the performance of the upstream drainage system (e.g., culvert system draining Chapman Gardens and College Creek culvert crossing of the Great Western Highway). The potential to enlarge the Werrington Creek channel all the way down to the railway line was also explored but this was determined to direct additional flow to the railway line and adversely impact on some George Street properties.

It is expected that the channel enlargement would cost in the order of $300,000 to complete. A breakdown of the cost estimate is provided in **Appendix I**.

The TUFLOW computer model was updated to include the proposed channel enlargement and the updated TUFLOW model was then used to re-simulate each design flood. Floodwater difference maps were prepared for the 20% AEP, 5% AEP and 1% AEP events and the PMF and are provided in **Plate 51**.

**Plate 51** shows that in the 20% AEP and 5% AEP floods, reductions in flood levels of up to 0.02 metres are predicted along College Creek upstream and downstream of the Great Western Highway. However, the reductions are contained to the creek channel and open space and are not predicted to directly benefit private property. Some increases in flood level and extent are predicted between the highway and railway but are also contained to open space.

In the 1% AEP flood, reductions of 0.05 metres are predicted on Millen Street. However, most of the flood level changes are again contained to open space and, with the exception of some very small (i.e., 0.02 metre) reductions across parts of one George Street property, do not benefit private landowners.

More substantial changes in flood levels are predicted during the PMF. This includes flood level reduction of over 0.2 metres across the northern side of the Great Western Highway. However, the larger channel 'pushes' additional flow towards the railway line as well as across George and Millen Streets resulting in flood level increases of up to 0.05 metres across multiple private properties. This highlights the very sensitive nature of the area contained between the highway and railway line and emphasis that any future works in this area needs to be completed with great care to ensure properties are not adversely impacted.

No flood level reductions are predicted across Chapman Gardens which indicates that flood behaviour in this basin is 'inlet controlled'. Therefore, additional modifications to the basin outlet structure (e.g., additional pits and pipes) would likely be needed in addition to the channel modifications discussed to afford any flood level reductions in the basin area.

A revised flood damage assessment was completed based on the updated flood model results. This showed implementation of FM17 is predicted to reduce existing flood damages by $20,000 over the next 50 years. This yields a preliminary BCR of less than 0.1.

As this option provides a poor economic return and yields minimal hydraulic benefits across private property (as well as adverse flood impacts during the PMF) it is not recommended for implementation.

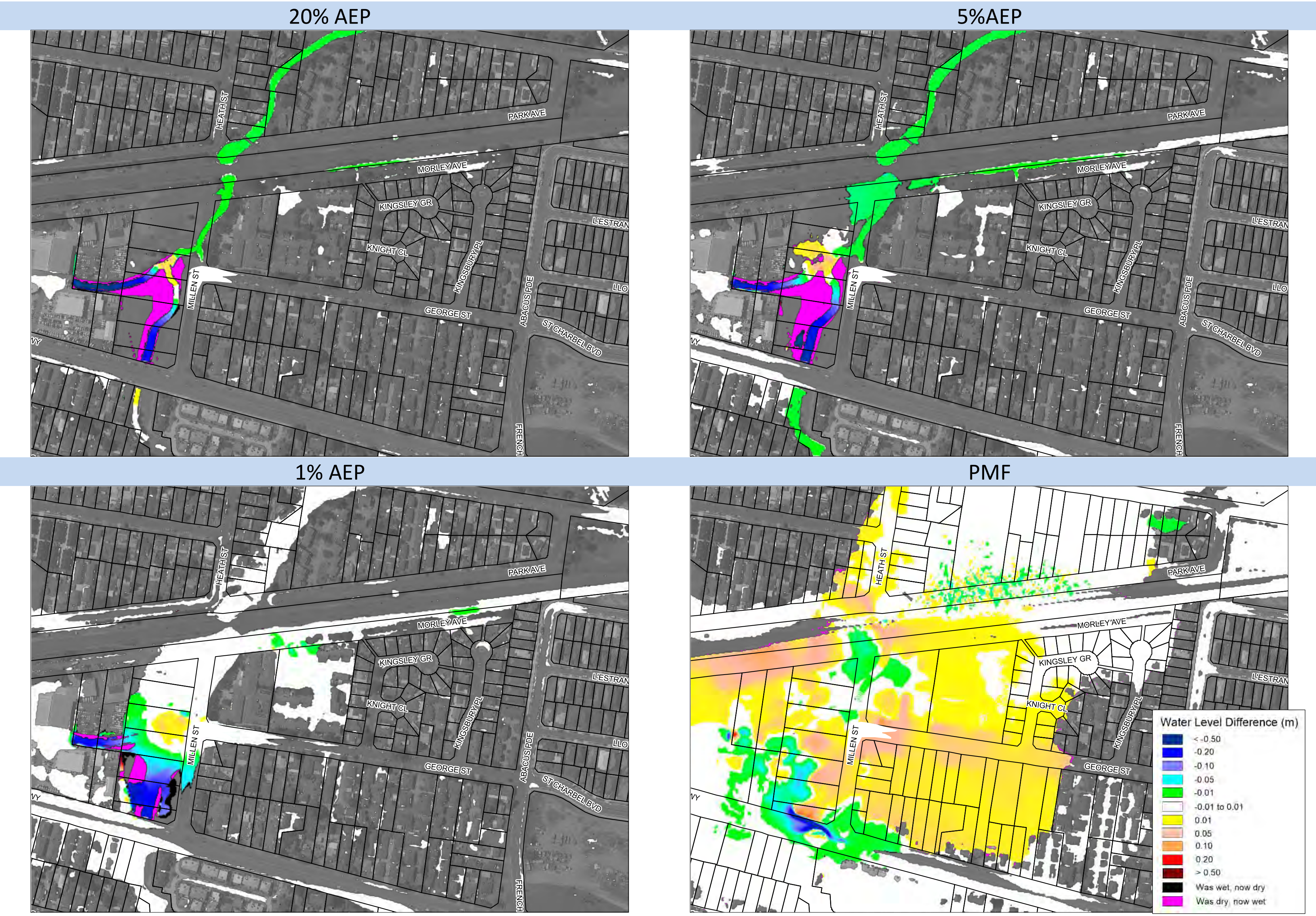



**Plate 51 Flood Level Difference Maps for FM1**

However, as discussed in Section 8.3.2, it needs to be recognised that this area is highly flood constrained. Therefore, although channel modification works are not recommended, it is strongly recommended that this area is retained as 'open space' and is not modified or developed in the future so that the existing flood function of the area is retained, and existing flood behaviour is not adversely impacted.

## 8.7 Road Works

### 8.7.1 FM18 - Great Western Highway Median Modification

The Great Western Highway is the main east-west transportation link and the most heavily trafficked road in the College, Orth and Werrington Creeks catchments. Inundation of the road is predicted during even frequent floods. Not only does this cause significant disruption to traffic along this important road, it increases the potential for people to attempt to drive through floodwaters. Although flood deaths have been steadily declining since the 1960s, motor vehicle related deaths in floodwaters are rising (Haynes et al, 2016).

The Great Western Highway travel lanes are separated by a median strip. The median strip is elevated above the road surface. As a result, the median strip serves as a barrier to flow and exacerbates "ponding" depths on the southern side of the highway.

FM18 would involve removing a section of the median to reduce ponding depths and allow water to discharge in a northerly direction more freely towards the open space adjacent to Millen Street. The extent of the median changes is shown in **Figure 74**.

A representation of FM18 was included in the hydraulic model and the updated model was used to re-simulate each design flood. Floodwater difference maps were prepared for the 20% AEP, 5% AEP and 1% AEP events and the PMF and are provided in **Plate 52.**

**Plate 52** shows that no significant changes in flood behaviour are predicted during the 20% AEP and 5% AEP floods. The lack of impacts during the 5% AEP flood is associated with water not being sufficiently elevated during smaller events to spill across the highway thereby 'activating' the new median gap.

However, **Plate 52** shows that more extensive changes in flood levels are predicted in the 1% AEP flood. More specifically:

- Flood level reductions of up to 0.07 metres are predicted on the westbound lanes of the Great Western Highway
- Flood level reductions of between 0.02 and 0.05 metres across a number of private properties located on the southern side of the highway
- Flood level reductions of 0.02 metres also propagate upstream along the College Creek channel and across Cosgrove Crescent
- Flood level increases of 0.02 to 0.05 metres are predicted within the open space north of the Great Western Highway

Flood level increases of 0.08 metres are predicted across a small area of the eastbound travel lanes.

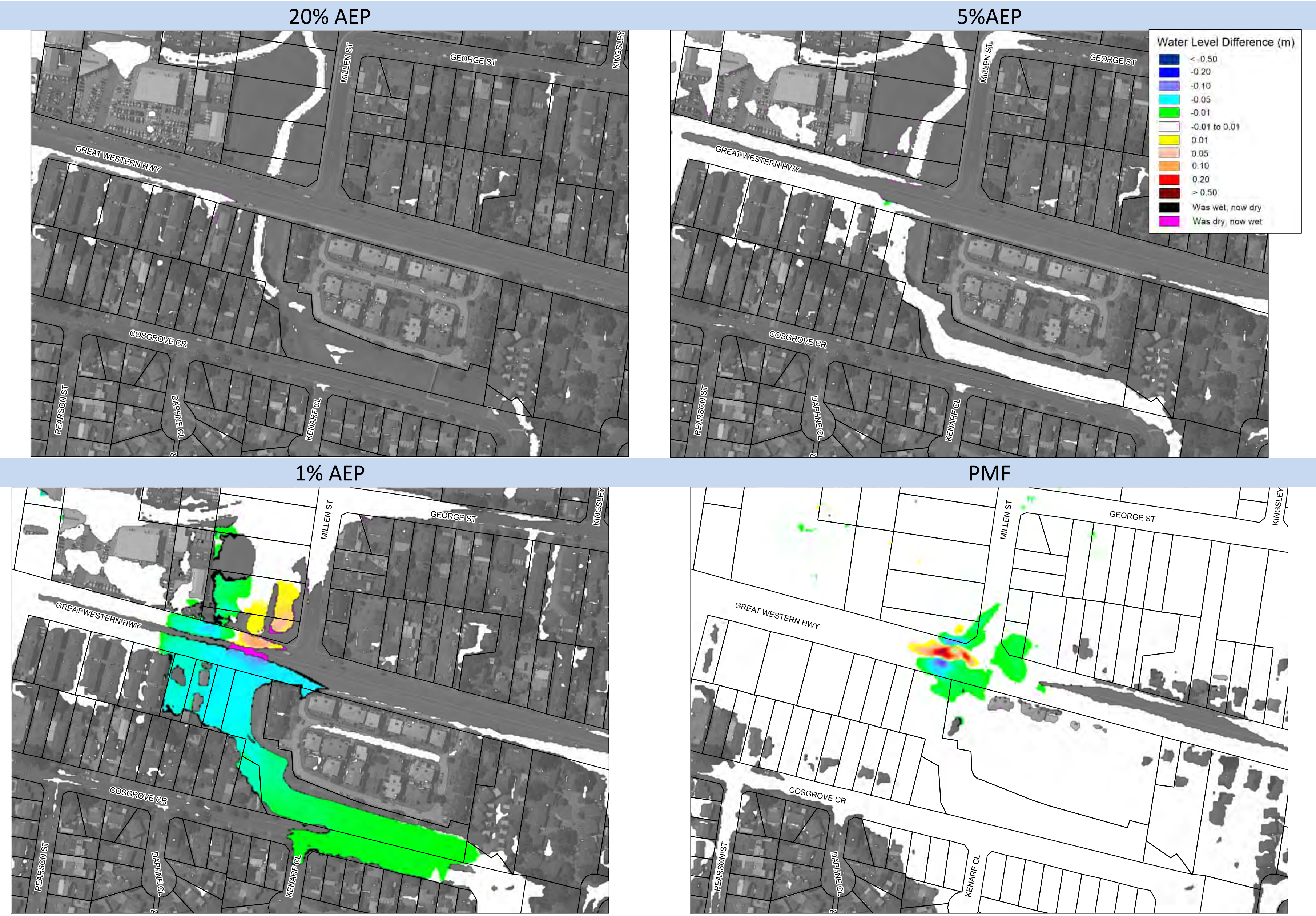



**Plate 52 Flood Level Difference Maps for FM18**

Small changes in flood level are also predicted during the PMF across the Great Western Highway. This includes flood level reduction of up to 0.15 on the southern side of the highway as well as flood level increases of more than 0.2 metres on the northern side of the highway. Small reductions (0.02 metres) are also predicted to extend across some nearby residential properties but most of the flood levels changes are contained to the road reserve.

As noted above, FM18 is not predicted to afford significant benefits during smaller floods. Therefore, it is not predicted to improve the current emergency response situation with the Great Western Highway still predicted to be cut during a 5% AEP flood.

The Great Western Highway is operated by TfNSW. Therefore, coordination with TfNSW would be required for this option to proceed and will be subject to further detailed investigations, hydraulic analysis and condition assessment.

Opportunities to expand the median removal were investigated. Although this did improve the magnitude and extent of flood level reductions south of the highway, these changes were also shown to increase flood levels across existing properties south of the railway line. Therefore, the option shown in **Figure 74** was determined to provide the best compromise in terms of maximising flood level reductions and minimising flood level increases.

It is expected that the median modifications would cost about $60,000 to implement (refer cost estimate included in **Appendix I**). A revised flood damages assessment determined that the median modifications would likely reduce flood damage costs by about $20,000 over the next 50 years. This yields a preliminary BCR of 0.3.

As the BCR is predicted to be well under 1, FM17 is unlikely to be eligible for funding under the Floodplain Management Program. However, it is predicted to reduce flood levels across multiple properties to the south of the Great Western Highway during larger floods. Therefore, Council and TfNSW could consider including the suggested median modifications as part of any highway modifications or upgrades that may be needed in the long term.

## 8.8 Combined Options

### 8.8.1 FM19 - FM1 + FM4 + FM5

The first combined option explored the benefits of combining the following individual measures which all demonstrated a significant hydraulic benefit:

- FM1: Chapman Gardens Basin (refer Section 8.3.1)
- FM4: Stafford Street Basins (refer Section 8.3.4), and
- FM5: Jamison Road Basin (refer Section 8.3.5).

Based on the individual cost estimates that were prepared, implementation of the combined option is likely to cost in the order $2.2 million.

The TUFLOW hydraulic model was updated to include a representation of the combined option and the updated TUFLOW model was used to re-simulate each design flood with the combined option in place. Peak flood level difference mapping for the 20% AEP, 5% AEP and 1% AEP events along with the PMF were also prepared and are presented in **Plate 53.**

**Plate 53** shows that FM19 is predicted to afford reductions in flood levels across a large area contained between Stapley Street and Victoria Street at Kingswood during most design floods. This includes flood level reductions of up to 0.2 metres across some Jamison Road and Stafford Street properties during the 20% AEP flood, reduction of nearly 0.3 metres across some Derby Street and Great Western Highway properties during the 5% AEP flood, reductions of nearly 0.1 metres across Bringelly Road during the 1% AEP flood. Implementation of FM19 is predicted to result in nearly 150 properties experiencing flood level and flood damage cost reductions during the 1% AEP flood.

Flood level reductions during the PMF are more modest. Nevertheless, PMF flood level reductions of more than 0.1 metres are predicted across multiple properties between Jamison Road and Stafford Street.

**Plate 53** also shows that the flood level increases that were observed during the 5% AEP flood downstream of Chapman Gardens when FM5 was implemented in isolation are no longer evident. Therefore, inclusion of the additional options with FM5 will ensure there are no flood level increases are roadways of private property during any of the simulated design flood.

The predicted flood level reductions are sufficient to result in three (3) fewer properties with above floor flooding in the 20% AEP flood, seven (7) fewer properties with above floor flooding in the 5% AEP flood and twelve (12) fewer properties with above floor flooding in the 1% AEP flood.

Therefore, the overall hydraulic benefits of implementation of this combined option are significant and are predicted to benefit a large number of properties across one of the most flood-affected areas of the catchment.

A revised flood damages assessment was completed based on the results of the flood simulations with FM19 in place. This determined that FM19 is likely reduce flood damage costs by more than $2.7 million over the next 50 years. This yields a preliminary BCR of 1.2. Therefore, the reduction in flood damage costs is more than sufficient to cover the implementation cost.

The emergency response benefits of FM19 are predicted to be significant. More specifically:

- Jamison Road is currently cut during a 20% AEP flood. This is predicted to improve to a 5% AEP flood
- Great Western Highway is currently cut during a 5% AEP flood. This is predicted to improve to a 2% AEP flood
- Victoria Street is currently cut during a 10% AEP flood. This is predicted to improve to a 5% AEP flood.

As discussed, FM19 is predicted to provide flood level reductions across a large number of properties. Therefore, the social benefits of this combined option are also significant with the stress and anguish associated with relatively frequent inundation of yards, sheds and homes being significantly reduced.

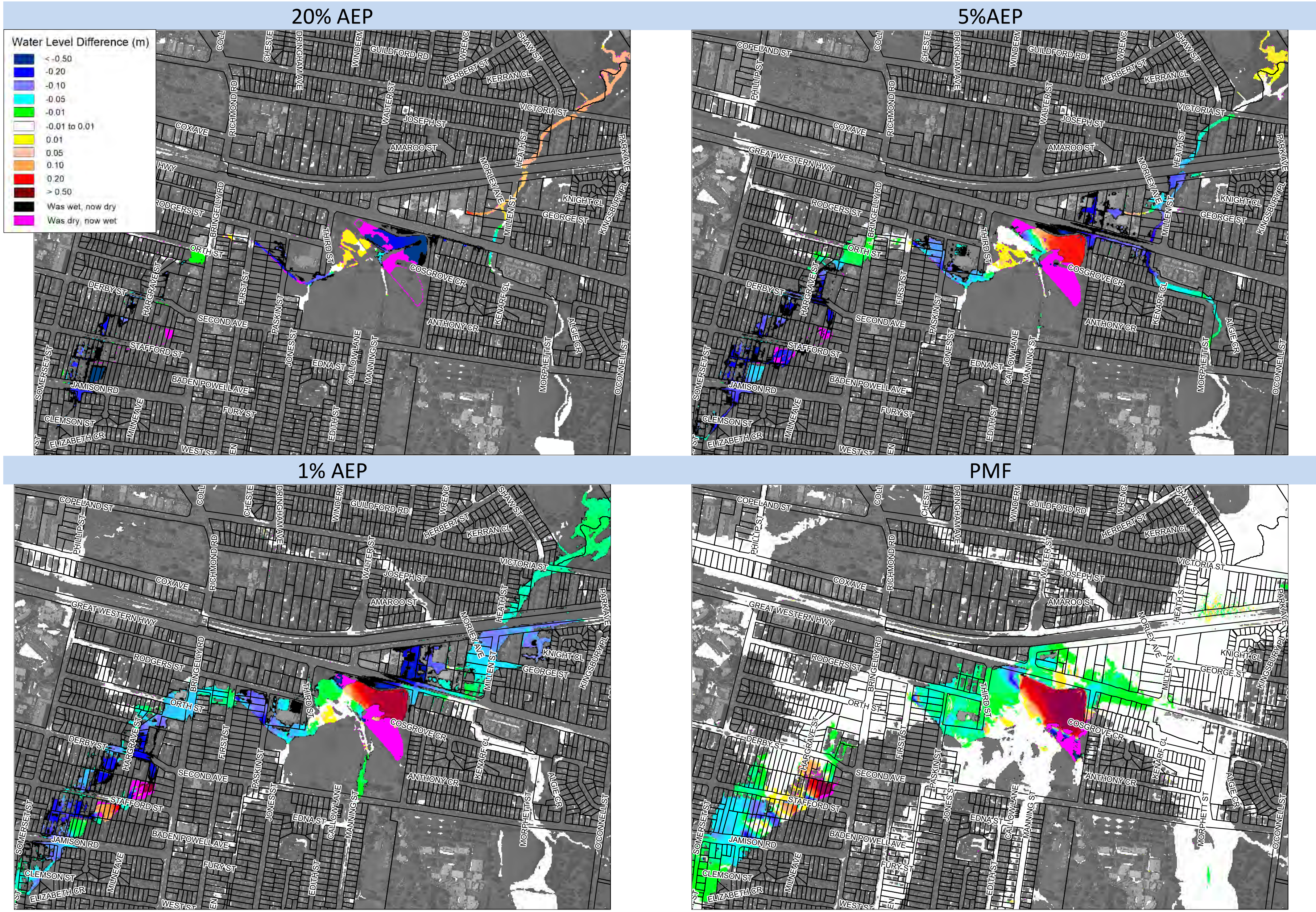



**Plate 53 Flood Level Difference Maps for FM19**

Less frequent and severe flooding of roadways will also have positive impacts on the community (access to and from work, homes, shops etc will be cut less frequently). Asset owners (e.g., Council and TfNSW) will also benefit as repairs to roads, fences etc will be less frequently required.

Implementation of FM19 is likely to face the same technical challenges as each of the individual options. However, as most of the works are above ground, these challenges are not likely to pose a significant impediment to implementation relative to some of the other options considered, such as drainage upgrades where multiple services need to be relocated. Each of the individual options that make up FM19 are predicted to provide some notable benefits if implemented in isolation. However, combining the individual options together is predicted to enhance the overall hydraulic outcomes by ensuring that no private properties or roadways are subject to any adverse flood level impacts while providing significant reductions in flood level, above floor flooding and inundation of roadways. As a result, further investigation and potential implementation of this combined option is recommended. As this will be a costly exercise and works will likely need to be staged, the additional investigations should also determine the optimal staging of works to ensure the hydraulic benefits are optimised and ensuring no properties are adversely impacted.

### 8.8.2 FM20 - FM1 + FM4 + FM5 + FM6 + FM9

As outlined in the previous section, the first combined option (FM19) is predicted to provide significant hydraulic, financial, social and emergency response benefits across a large area of Kingswood. Therefore, the second combined option (referred to as FM20), investigated expanding FM19 to include additional individual options that are focussed on further improving the existing emergency response situation around Victoria Street. The included FM6 (refer Section 8.4.1) as well as FM9 (refer Section 8.4.4).

The TUFLOW hydraulic model was updated to include a representation of the combined option and the updated TUFLOW model was used to re-simulate each design flood with the combined option in place. Peak flood level difference mapping for the 20% AEP, 5% AEP and 1% AEP events along with the PMF were also prepared and are presented in **Plate 54**.

The difference maps in **Plate 54** shows that FM20 provides broadly similar hydraulic benefits to FM19. This includes reductions in flood levels across a large area between Stapley Street and Victoria Street at Kingswood during most design floods. However, inclusion of the FM6 and FM9 components provides even greater reductions in flood levels at Victoria Street (i.e., the main Werrington Creek crossing location as well as the smaller tributary crossing to the east). As shown in **Table 44**, these flood level reductions will ensure that Victoria Street remains trafficable during floods up to and including the 1% AEP event.

As discussed in previous sections, Victoria Street serves as the main east-west evacuation route for areas located between the railway line and Werrington Creek. Therefore, this outcome provides a significant emergency response improvement for the existing population that is serviced by this roadway. There are also plans for further urban expansion in this area. Therefore, the emergency response benefits are likely to improve further when the potential future population that will be serviced by this road is considered.

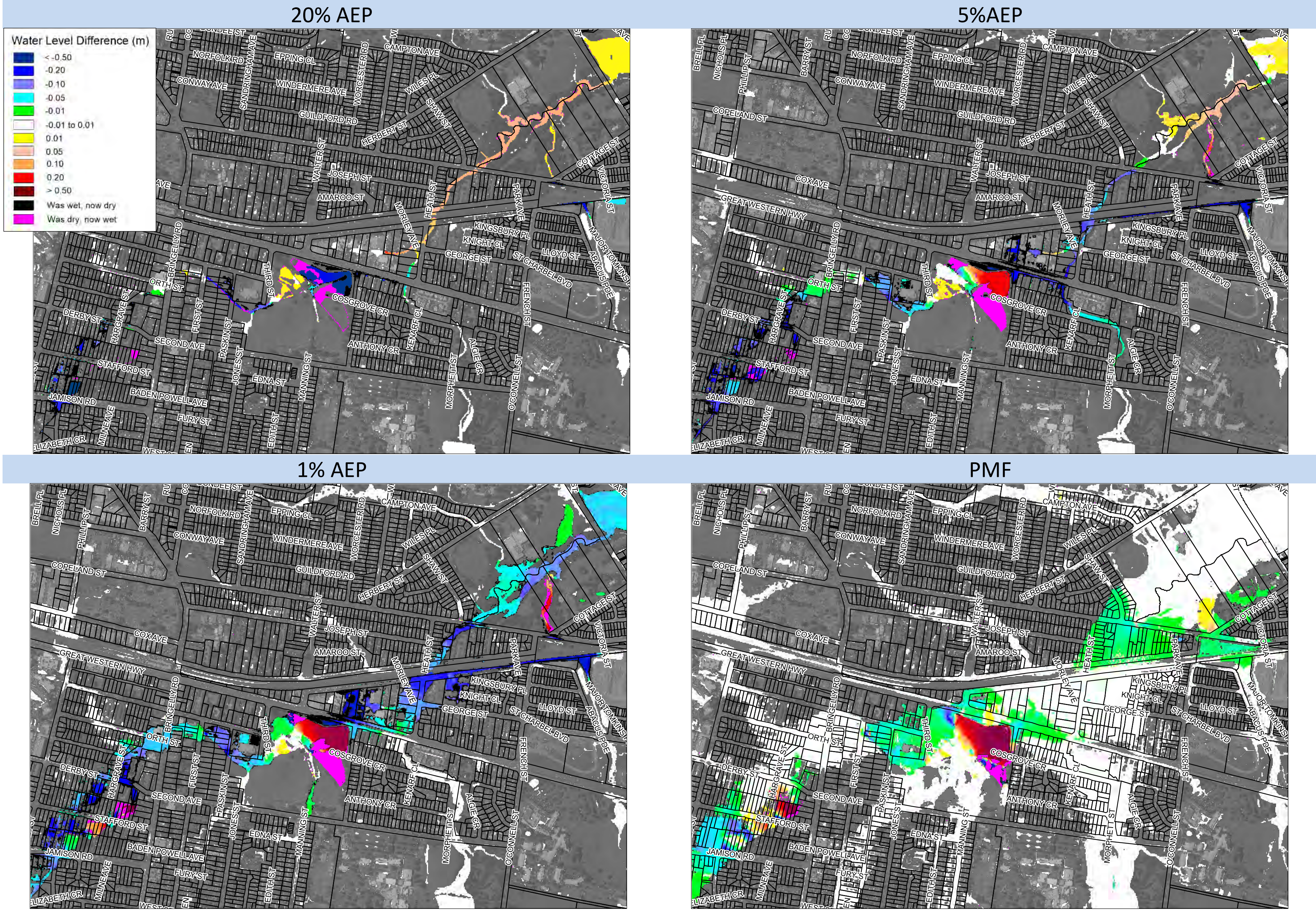



**Plate 54 Flood Level Difference Maps for FM20**

The predicted flood level reductions are sufficient to result in three (3) fewer properties with above floor flooding in the 20% AEP flood, seven (7) fewer properties with above floor flooding in the 5% AEP flood and twelve (12) fewer properties with above floor flooding in the 1% AEP flood.

Therefore, the overall hydraulic benefits of implementation of this combined option are significant and are predicted to benefit a large number of properties across one of the most flood-affected areas of the catchment.

Based on the individual cost estimates that were prepared, implementation of the combined option is likely to cost in the order $3.9 million. Therefore, FM20 is predicted to be an expensive option.

A revised flood damages assessment was completed based on the results of the flood simulations with FM19 in place. This determined that FM19 is likely reduce flood damage costs by nearly $2.8 million over the next 50 years. This yields a preliminary BCR of 0.5. Therefore, although the financial benefits of this option are not sufficient to fully offset the implementation costs, the cost savings are predicted to be significant.

Overall, it is recommended that the individual components of FM19 are investigated and potentially implemented in the sort to medium term and the additional components from FM20 are investigated and implemented over the longer term to support emergency response across the potential future urban expansion between the railway line and Werrington Creek.

## 8.9 Multi Criteria Assessment

The options evaluation presented in the preceding sections focussed primarily on criteria that can be readily quantified such as economic and hydraulic performance. However, it is acknowledged that each option can also have impacts on important but less tangible aspects such as community support and environmental impacts. Therefore, to enable the relative advantages and disadvantages of each to be more fully understood, a multi-criteria assessment (MCA) was completed. The assessment criteria that were used for the MCA is summarised in **Table 45**.

Like the qualitative assessment of options that was presented in **Section 7.4,** different weightings were assigned to each of the criteria reflecting the relative important of each criterion in best managing the flood risk. The weighting assigned to each criterion is summarised in **Table 45**.

The scoring system that was used to evaluate each criterion is also provided in **Table 45**. In general, the best performing option was assigned a score of +2. The worst performing options or those options that demonstrated significant negative impacts were assigned a score of -2. Those options that demonstrated no significant positive or negative impacts were assigned a score of 0.

The raw scores that were determined for each option are provided in **Table 46**. The weighted score and the overall ranking of each option based on the weighted score are provided in **Table 47**.

**Table 45 Multi-Criteria Assessment Scoring and Weighting Criteria**

| Criteria | Score | Weight |
|---|---|---|
| **Flood Impacts** | | |
| Hydraulic Impacts | Flood level reductions of more than 0.2 metres = +2<br>Flood level reductions of less than 0.2 metres = +1<br>No significant change in flood levels = 0<br>Flood level increases of less than 0.2 metres = -1<br>Flood level increases of more than 0.2 metres = -2 | x5 |
| Reduction in Above Floor Flooding | Significant reduction in above floor flooding = +2<br>Small reduction in above floor flooding = +1<br>No change in above floor flooding = 0<br>Small increase in above floor flooding = -1<br>Significant increase in above floor flooding = -2 | x4 |
| **Economic Impacts** | | |
| Cost | Less than $0.25 million = +2<br>Between $0.25 and $0.5 million = +1<br>Between $0.5 and $1 million = 0<br>Between $1 and $2.5 million = -1<br>Greater than $2.5 million = -2 | x4 |
| Reduction in Flood Damages | Greater than $2.5 million = +2<br>Between $1 and $2.5 million = +1<br>Between $0.5 and $1 million = 0<br>Between $0.25 and $0.5 million = -1<br>Less than $0.25 million = -2 | x4 |
| **Social Impacts** | | |
| Impact on Community<br>(e.g., disruption during construction, impacts to visual amenity) | Significant positive impact = +2<br>Small positive impact = +1<br>Neutral = 0<br>Small negative impact = -1<br>Significant negative impact = -2 | x3 |
| **Other Impacts** | | |
| Emergency Response Impacts | Significant positive impact = +2<br>Small positive impact = +1<br>Neutral = 0<br>Small negative impact = -1<br>Significant negative impact = -2 | x4 |
| Ecological and Environmental Impacts | Significant positive impact = +2<br>Small positive impact = +1<br>Neutral = 0<br>Small negative impact = -1<br>Significant negative impact = -2 | x3 |

**Table 46 Raw Multi-Criteria Assessment Scores and Ranking of Options**

| Criteria | FM1 | FM2 | FM3 | FM4 | FM5 | FM6 | FM7 | FM8 | FM9 | FM10 |
|---|---|---|---|---|---|---|---|---|---|---|
| | Chapman Gardens Basin | Great Western Highway Basin | Lincoln Drive Park Basin | Stafford Street Basins | Jamison Road Basin Modifications | Victoria Street Culvert Upgrade | Great Western Highway Culvert Upgrades | Werrington Creek Culvert Upgrade #1 | Werrington Creek Culvert Upgrade #2 | Werrington Railway Station Culvert Upgrade |
| **Flood Impacts** | | | | | | | | | | |
| Hydraulic Impacts | 1 | 1 | 1 | 2 | 2 | 1 | 1 | 1 | 1 | 1 |
| Reduction in Above Floor Flooding | 2 | 0 | 1 | 0 | 2 | 0 | 1 | 0 | 0 | 0 |
| **Economic Impacts** | | | | | | | | | | |
| Cost | -1 | 0 | 2 | 0 | 0 | -1 | -1 | -1 | -1 | 0 |
| Reduction in Flood Damages | -1 | -2 | -2 | -1 | 2 | -2 | -2 | -2 | -2 | -2 |
| **Social Impacts** | | | | | | | | | | |
| Impact on Community | 1 | 0 | 1 | 1 | 1 | 1 | -1 | 1 | 1 | 1 |
| **Other Impacts** | | | | | | | | | | |
| Emergency Response Impacts | 2 | 1 | 0 | 0 | 1 | 1 | 0 | 2 | 1 | 0 |
| Ecological and Environmental Impacts | 0 | -1 | -1 | 0 | -1 | 0 | 0 | 0 | 0 | 0 |
| **TOTAL SCORE** | 4 | -1 | 2 | 2 | 7 | 0 | -2 | 1 | 0 | 0 |
| **RANK** | 3 | =7 | =4 | =4 | 2 | =6 | 8 | =5 | =6 | =6 |

| Criteria | FM11 | FM12 | FM13 | FM14 | FM16 | FM17 | FM18 | FM19 | FM20 |
|---|---|---|---|---|---|---|---|---|---|
| | Dunkley Place Stormwater Upgrades | Orleton Place to Francis Street Stormwater Upgrades | Rugby Street to Neeta Avenue Stormwater Upgrades | Victoria Street to Joseph Street Stormwater Upgrades | Stafford Street to First Street Stormwater Upgrades | College Creek and Orth Creek Channel Enlargement | Great Western Highway Median Modification | FM1 + FM4 + FM5 | FM1 + FM4 + FM5 + FM6 + FM9 |
| **Flood Impacts** | | | | | | | | | |
| Hydraulic Impacts | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 2 | 2 |
| Reduction in Above Floor Flooding | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 2 |
| **Economic Impacts** | | | | | | | | | |
| Cost | -1 | -1 | 0 | 0 | -2 | 1 | 2 | -1 | -2 |
| Reduction in Flood Damages | -2 | -2 | -2 | -2 | -2 | -2 | -2 | 2 | 2 |
| **Social Impacts** | | | | | | | | | |
| Impact on Community | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 2 | 2 |
| **Other Impacts** | | | | | | | | | |
| Emergency Response Impacts | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 2 | 2 |
| Ecological and Environmental Impacts | 0 | 0 | 0 | 0 | 0 | -1 | 0 | -1 | -1 |
| **TOTAL SCORE** | 1 | 1 | 0 | 1 | -1 | 0 | 1 | 8 | 7 |
| **RANK** | =5 | =5 | =6 | =5 | =7 | =6 | =5 | 1 | 2 |

Table 47 Weighted Multi-Criteria Assessment Scores and Ranking of Options

| Criteria | Weight | FM1 Chapman Gardens Basin | FM2 Great Western Highway Basin | FM3 Lincoln Drive Park Basin | FM4 Stafford Street Basins | FM5 Jamison Road Basin Modifications | FM6 Victoria Street Culvert Upgrade | FM7 Great Western Highway Culvert Upgrades | FM8 Werrington Creek Culvert Upgrade #1 | FM9 Werrington Creek Culvert Upgrade #2 | FM10 Werrington Railway Station Culvert Upgrade |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Flood Impacts** | | | | | | | | | | | |
| Hydraulic Impacts | x5 | 5 | 5 | 5 | 10 | 10 | 5 | 5 | 5 | 5 | 5 |
| Reduction in Above Floor Flooding | x4 | 8 | 0 | 4 | 0 | 8 | 0 | 4 | 0 | 0 | 0 |
| **Economic Impacts** | | | | | | | | | | | |
| Cost | x4 | -4 | 0 | 8 | 0 | 0 | -4 | -4 | -4 | -4 | 0 |
| Reduction in Flood Damages | x4 | -4 | -8 | -8 | -4 | 8 | -8 | -8 | -8 | -8 | -8 |
| **Social Impacts** | | | | | | | | | | | |
| Impact on Community | x3 | 3 | 0 | 3 | 3 | 3 | 3 | -3 | 3 | 3 | 3 |
| **Other Impacts** | | | | | | | | | | | |
| Emergency Response Impacts | x4 | 8 | 4 | 0 | 0 | 4 | 4 | 0 | 8 | 4 | 0 |
| Ecological and Environmental Impacts | x3 | 0 | -3 | -3 | 0 | -3 | 0 | 0 | 0 | 0 | 0 |
| **TOTAL SCORE** | | 16 | -2 | 9 | 9 | 30 | 0 | -6 | 4 | 0 | 0 |
| **RANK** | | 4 | 10 | =5 | =5 | 2 | =9 | 12 | =7 | =9 | =9 |

| Criteria | Weight | FM11 | FM12 | FM13 | FM14 | FM16 | FM17 | FM18 | FM19 | FM20 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Dunkley Place Stormwater Upgrades | Orleton Place to Francis Street Stormwater Upgrades | Rugby Street to Neeta Avenue Stormwater Upgrades | Victoria Street to Joseph Street Stormwater Upgrades | Stafford Street to First Street Stormwater Upgrades | College Creek and Orth Creek Channel Enlargement | Great Western Highway Median Modification | FM1 + FM4 + FM5 | FM1 + FM4 + FM5 + FM6 + FM9 |
| **Flood Impacts** | | | | | | | | | | |
| Hydraulic Impacts | x5 | 10 | 10 | 5 | 5 | 5 | 5 | 5 | 10 | 10 |
| Reduction in Above Floor Flooding | x4 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 8 | 8 |
| **Economic Impacts** | | | | | | | | | | |
| Cost | x4 | -4 | -4 | 0 | 0 | -8 | 4 | 8 | -4 | -8 |
| Reduction in Flood Damages | x4 | -8 | -8 | -8 | -8 | -8 | -8 | -8 | 8 | 8 |
| **Social Impacts** | | | | | | | | | | |
| Impact on Community | x3 | 3 | 3 | 3 | 3 | 3 | 0 | 0 | 6 | 6 |
| **Other Impacts** | | | | | | | | | | |
| Emergency Response Impacts | x4 | 4 | 4 | 0 | 0 | 4 | 4 | 0 | 8 | 8 |
| Ecological and Environmental Impacts | x3 | 0 | 0 | 0 | 0 | 0 | -3 | 0 | -3 | -3 |
| **TOTAL SCORE** | | 5 | 5 | 0 | 4 | -4 | 2 | 5 | 33 | 29 |
| **RANK** | | =6 | =6 | =9 | =7 | 11 | 8 | =6 | 1 | 3 |

The results of the multi-criteria assessment determined that FM19 provided the highest raw and weighted scores, followed by FM5 and FM20.

## 8.10 Recommendations

Based on the assessment presented in this chapter, the flood modification options included in **Table 48** are recommended for implementation.

**Table 48 Flood Modification Options Recommended for Implementation**

| Priority | Option | | Comments |
|---|---|---|---|
| 1 | FM1 | Chapman Gardens Basin | This option primarily provides flood level reductions across the Great Western Highway and adjoining properties. Although it does not provide a higher BCR, it provides some notable emergency response benefits and is required to offset some adverse flood impacts that are predicted if FM5 was implemented in isolation. Therefore, subject to the outcomes of additional detailed feasibility investigations, it is recommended that FM1 is installed before, or at least no later, than FM5 |
| 2 | FM5 | Jamison Road Basin Augments | FM5 provides, the most significant reductions in flood levels and above floor flooding of all of the individual options investigated. It also provides the highest BCR (i.e., >4). Therefore, this option is recommended for further investigations and potential implementation. |
| 3 | FM4 | Stafford Street Basins | FM4 affords notable reductions in flood levels. When combined with FM1 and FM5, it provides significant reductions in flood levels, reduced frequency of inundation of roads and greatly reduced above floor flooding |
| 4 | FM3 | Lincoln Drive Basin | FM3 does afford some significant reductions in flood damages, flood levels and flood hazard during events up to and including the 1% AEP flood across multiple Cambridge Street properties. In addition, this is a relatively low-cost option to implement. |
| 5 | FM6 | Victoria Street Culvert Upgrade | Although FM6 and FM8 do not provide high BCRs, they afford significant emergency response benefits for Victoria Street. This will prove valuable for the current population in this area, but its value will be increased by the expected future urban expansion between Werrington Creek and the railway line |
| 6 | FM9 | Werrington Creek Railway Culvert Upgrade #2 | |

Although individual options are listed in **Table 48**, the outcomes of the combined options assessment (refer Section 8.8) demonstrated some important benefits when the individual options are combined. For example, FM1, FM4 and FM5 (referred to as 'Combined Option 1') affords notable combined benefits across a large area of the catchment. But, more importantly, combining the options helps to ensure no properties and roadway are adversely impacted (which could occur is FM5 was implemented in isolation). The priorities listed in **Table 48** provide a recommended implementation priority such that hydraulic benefits are maximised in the short term and adverse impact are avoided at all stages.

Other options were found to afford some notable reductions in flood levels and extents, particularly during more frequent floods (i.e., they are predicted to significantly reduce 'nuisance' flooding). Council and asset owners (e.g., TfNSW or NSW Trains) should consider these options for implementation as part of ongoing works programs, road upgrades etc:

- FM7 – Great Western Highway Culvert Upgrades
- FM10 – Werrington Railway Station Culvert Upgrade
- FM11 – Dunkley Place Stormwater Upgrades
- FM12 – Orleton Place to Francis Street Stormwater Upgrades
- FM13 – Victoria Street to Joseph Street Stormwater Upgrades
- FM17 – Great Western Highway Median Modifications.

# 9 Property Modification Options

## 9.1 Introduction

Property modification options refer to modifications to planning controls and/or modifications to individual properties to reduce the potential for inundation in the first instance or improve the resilience of properties should inundation occur. Modifications to individual properties are typically used to manage existing flood risk while planning measures are employed to manage future flood risk.

Property modification options considered as part of the study included:

- Planning Modifications:
  - PM1 – Changes to Penrith City Council LEP: Section 9.2.2.
  - PM2 – Changes to Penrith City Council DCP: Section 9.2.3.
  - PM3 – Update Section 10.7 Certificate Information: Section 9.2.4.
- Property Modifications:
  - PM4 – Voluntary House Purchase: Section 9.3.1.
  - PM5 – Voluntary House Raising or Flood Proofing: Section 9.3.2.

Further discussion on each of the above options is provided in the following sections.

## 9.2 Planning Modifications

### 9.2.1 Adequacy of Existing Planning Documents in Addressing the Full Range of Flood Risks

As discussed, appropriate planning controls are one of the most effective methods available to reduce the flood risk as redevelopment occurs in the future. A review of Council's LEP and DCP was completed as part of the study and the outcomes of this review are provided in Chapter 5 of this document. A summary of recommended updates to the LEP and DCP are provided in this chapter in Sections 9.2.2 and 9.2.3.

However, Council's existing LEP and flood-related planning controls are focussed on the 'planning flood' (i.e., 1% AEP event). It needs to be acknowledged that there is potential for much larger floods to occur and this may still result in an unacceptably high flood risk despite the application of planning controls (and potential implementation of flood modifications options documented in Chapter 8).

Therefore, to determine whether the existing LEP and DCP will suitably manage the flood risk across the full range of potential floods in the future, additional investigations were completed. This aimed to determine if an unacceptably high flood risk and hazard may persist in the College, Orth and Werrington Creeks catchment assuming the current development controls only are maintained and determine if additional controls may assist in reducing this flood risk to more acceptable levels.

The additional investigations involved the following work and assumptions:

- The floor level of all buildings located within the flood planning areas (FPA) were elevated to the flood planning level. This was intended to reflect future redevelopment of all properties located within the flood planning area based on floor levels being elevated 0.5 metres above the 1% AEP flood in accordance with the existing DCP.
- The floor level of all buildings located outside of the FPA were assumed to be maintained at current levels (this is again consistent with the LEP and DCP which does not currently apply development controls beyond the FPA).

The peak PMF level at each property was then compared against the ‘future’ floor levels calculated above. This allowed an above floor flooding depth to be calculated for each property during the PMF assuming all properties are re-developed in accordance with the DCP2014. A focus was placed on identifying properties where the above floor flooding depth was predicted to exceed 1.2 metres as this depth of water would produce H4 hazard inside of the building (i.e., unsafe for all people). Therefore, this check aimed to determine if unacceptably high hazard will exist within buildings during the PMF if they were built in accordance with the current DCP and people choose not to evacuate or were unable to evacuate. This also assumes that future dwellings would only comprise a single story (i.e., there is no second storey to evacuate up to).

The outcome of this assessment is presented in **Plate 55**. It shows:

- Buildings where the above floor flooding depth during the PMF is predicted to be less than 1.2 metres (i.e., less than H4 hazard) as black points.
- Buildings where the above floor flooding depth during the PMF is predicted to exceed 1.2 meters (i.e., H4 hazard or higher) and, therefore, where it would be unsafe inside the building (yellow points).

This determined that forty three (43) buildings located near the railway line at Kingswood and Werrington along with one (1) commercial property fronting Bringelly Road at Kingswood would likely be exposed to internal flood hazard of at least H4 during the PMF and, therefore, would not be safe for any person. If only single level dwellings were provided for these properties, above floor flooding depths of more than 1.8 metres could be expected for some properties. As a result, there is a significant danger to life if future occupants of these buildings did not have an opportunity to evacuate or chose not to evacuate.

Therefore, application of Council’s current minimum floor level requirement (1% AEP flood level plus a 0.5 metres freeboard for properties located within the FPA) would not reduce the flood hazard inside of some buildings to tolerable levels during the PMF. This could be potentially improved upon by including the following additional development requirements for each building identified in yellow in **Plate 55**.

- Include structure controls beyond the FPA up to the limit of the PMF.

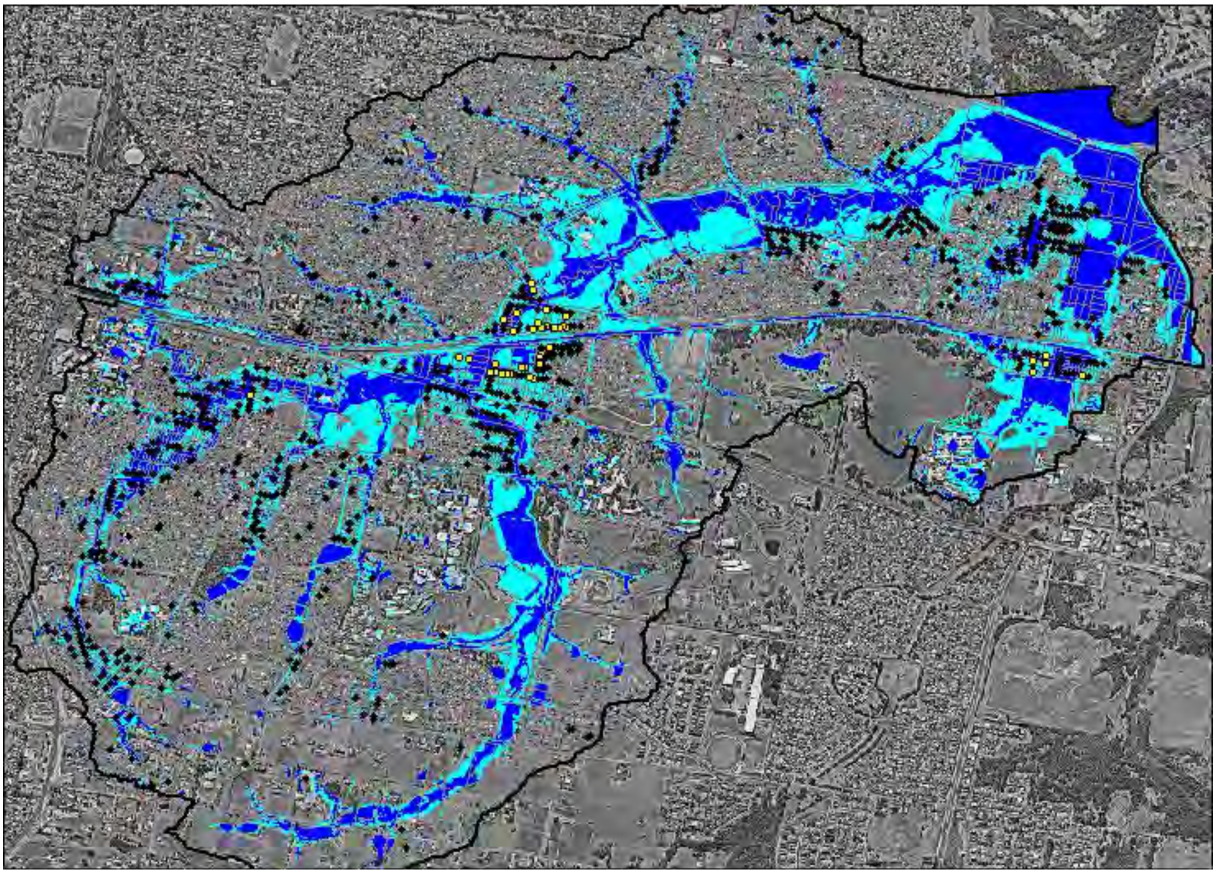


**Plate 55 Buildings exposed to above floor flooding (black) and H4 internal flood flooding (yellow) in PMF. The PMF extent is show in aqua and the flood planning area is shown in dark blue**

- Include an elevated mezzanine level or second storey in a structurally sounds building as part of any new development. Although evacuation is always the preferred response strategy, providing a mezzanine level or second storey as part of any new development will allow future occupants to 'evacuate vertically' to a higher elevation if traditional evacuation cannot be safely completed or completed in a timely manner (particularly if the flood occurs at night when people are asleep).
- A requirement that all bedrooms be located on the second storey of residential dwellings. This is intended to improve the safety to residents should a PMF occur at night when they are asleep.
- Inclusion of a balcony on the second level to allow emergency boat rescue in emergencies (e.g., medical emergency) or should the area be isolated for an extended period.

The ability for people to safely refuge inside a building, should they not be able to evacuate, is not only dependent on a tolerable hazard inside of the building but also on the building remaining structurally stable during all floods up to and including the PMF. As noted in Section 4.2.7, a flood hazard category of H5 indicates that there is potential for structural damage and failure of buildings if they are not specifically designed to withstand the forces of floodwaters during the PMF. A flood hazard of H6 indicates that the depth and velocity of water is sufficient to result in failure of all buildings regardless of how they are designed. A review of the PMF hazard mapping determined that there are no existing buildings that are exposed to H6 hazard but there are some buildings exposed to H5 hazard.

As H6 hazard is not predicted around existing buildings, it is possible that future buildings in the same areas could remain structurally stable if they were specifically designed to withstand the dynamic and hydrostatic forces of floodwaters during the PMF (this assumes that all future buildings are kept clear of H6 hazard areas). Therefore, it is recommended that additional development requirements are targeted for properties located in H5 hazard areas during the PMF.

A review of the flood planning area (FPA) relative to the PMF H5 and H6 hazard was completed and is presented in in **Plate 56**. It shows that most PMF H5 and H6 hazard areas fall within the FPA. Therefore, it is likely that most of the 'at risk' properties would be captured by Council's current FPA and this risk could be managed by incorporating additional controls in the DCP for properties identified in **Plate 56** that fall within the FPA:

- All buildings should be kept clear of all areas exposed to H6 hazard during the PMF
- All buildings located within H5 hazard areas during the PMF should be supported by an engineer's report. The report is to certify that the structure can withstand the forces of floodwater, debris and buoyancy up to and including a PMF plus freeboard.

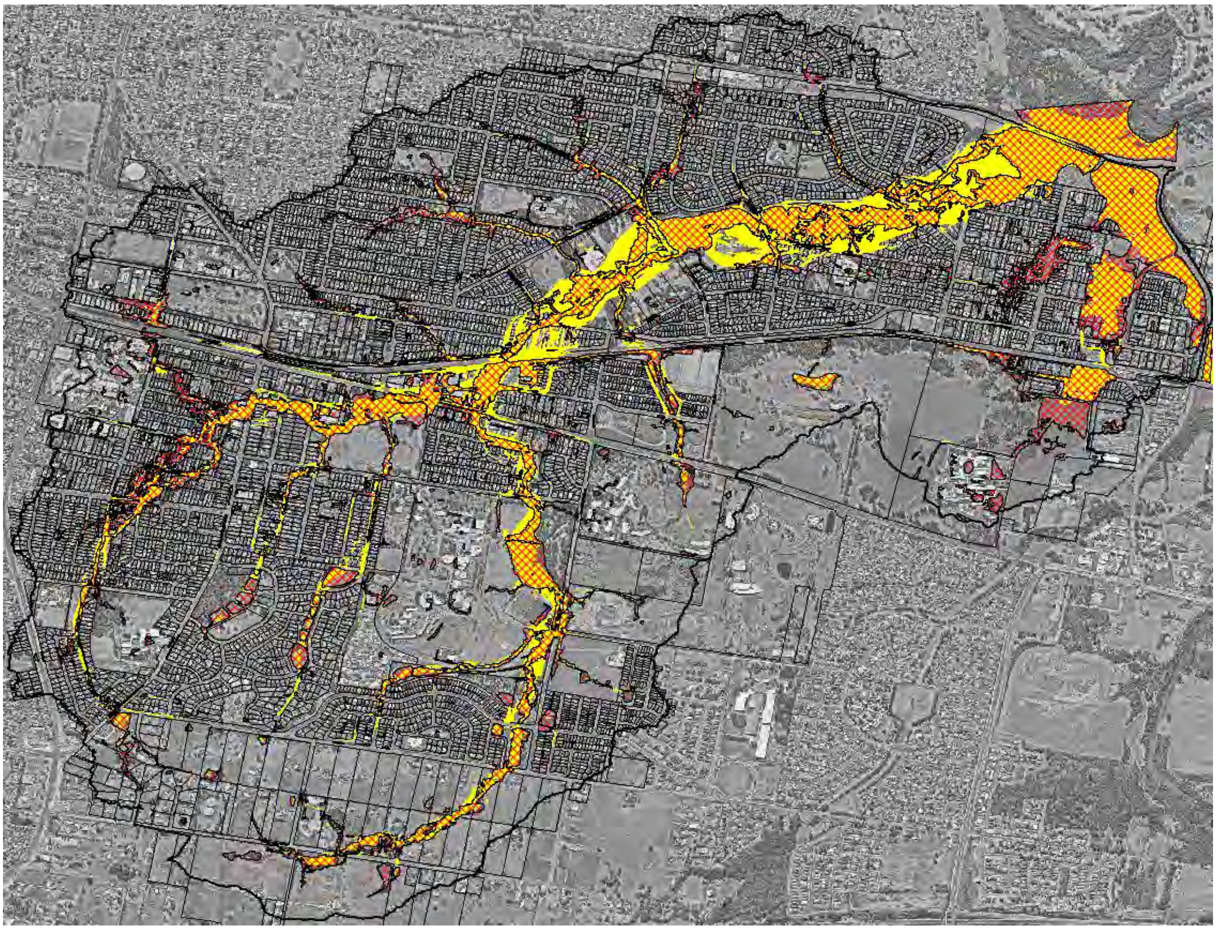


**Plate 56 Extent of H5 or H6 hazard in the PMF (yellow). The flood planning area is shown as hatched**

It is noted that there are some H5 areas that extend beyond the limits of the FPA. This is most common along Werrington Creek north of the railway line, which is generally not zoned for urban development. However, there are several residential properties located between the railway line and Victoria Street that would be exposed to at least H5 hazard and currently fall outside of the FPA. Although it would be desirable to also include additional development requirements for these properties, the fact that they fall outside of the FPA makes this process more difficult. More specifically, inclusion of development controls for these properties would require a case for 'adequate justification' for those controls to the satisfaction of the NSW Director-General (although it is acknowledged the NSW State Government is currently reviewing the need for 'exceptional circumstance' as part of the '*Flood Prone Land Package*' that is currently on public exhibition). Therefore, it is suggested that the additional controls are restricted to just those properties that fall within the FPA which will still capture most high-risk properties while simplifying the implementation process.

A structural assessment of all buildings was beyond the scope of this study. However, it is unlikely that the older housing stock in the catchment would have been designed to withstand the force of floodwaters during the PMF. As the structural integrity of these buildings cannot be guaranteed, early evacuation is currently the best flood risk reduction option for these properties in the short term. This is discussed further in Section 10.2.5.

Overall, it is considered that the existing flood-related development controls do not suitably manage the flood risk across all potential floods. Therefore, it is recommended that additional controls are placed on properties likely to be exposed to significant above floor flooding depths or H5 hazard or higher in the PMF. This is discussed further in Section 9.2.3.

### 9.2.2 PM1 - Changes to Penrith Council LEP 2010

A review of the Penrith City Council LEP (2010) was completed and the outcomes of this review are summarised in **Section 5.3**. As discussed in **Section 5.3**, it is recommended that any future updates of the LEP consider the following changes:

- Make the flood planning area map related to flood related development controls publicly available in an easy to find and easy to understand location. It is recommended that these are provided as a separate document to the gazetted Penrith LEP 2010 maps so they can be updated as frequently as required when updated flood study and floodplain risk management study information becomes available.
- The existing Clause 7.2 of Penrith LEP 2010 currently states "This clause applies to land at or below the flood planning level", with the flood planning level defined as "the level of the 1:100 ARI flood event plus 0.5 metres freeboard". The current definition of the flood planning event and freeboard does not allow flexibility in defining the flood planning level throughout the different catchments in the LGA should this freeboard not be appropriate. A potential option for providing more flexibility in the description of the flood planning level is:
    - ***flood planning level*** *means the level of a 1:100 ARI (average recurrence interval) flood event plus 0.5 metres freeboard or other freeboard as determined by an adopted floodplain risk management plan by the Council in accordance with the NSW Governments Floodplain Development Manual.*

- More flexibility can be incorporated into Clause 7.2 by redefining how land subject to this clause is selected. Currently, the clause employs the following wording:
  *(a) land at or below the flood planning level,*
  *(b) land identified as "Flood planning land" on the Clause Application Map.*

  Suggested changes to the wording in the existing clause to provide more flexibility are provided below:

  *(a) land at or below the flood planning level,*

  or

  *(a) land at or below the flood planning level, and*
  *(b) land identified as "Flood planning area" on the flood planning area map.*

- Include an additional "Floodplain Risk Management" clause in the LEP (i.e., Clause 7.3) which would would relate to the areas between the flood planning area and the edge of the floodplain (i.e., PMF extent). Suggested wording for this clause is provided below in **Plate 57** of this report (this is taken directly from the standard instrument LEP template).

**Clause XXX Floodplain risk management**

(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 in excess of 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 area and the level of the probable maximum or extreme flood.

(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) childcare centres or facilities
- (b) correctional centres
- (c) education facilities
- (d) emergency services facilities
- (e) group homes
- (f) health service facilities
- (g) residential care facilities
- (h) seniors housing

(4) In this clause—

***flood planning area*** means the area of land at or below the flood planning level.

***flood planning level*** means the level of a 1:100 ARI (average recurrent interval) flood event plus a freeboard or as defined in adopted floodplain risk management plan.

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

Plate 57 Potential Floodplain Risk Management Clause

### 9.2.3 PM2 - Changes to Penrith Council Development Control Plan

A review of the relevant Penrith DCP 2014 was completed and a detailed discussion on the outcomes of this review are documented in Section 5.3.2. As discussed, it is recommended that any future updates of this DCP consider the following changes:

- Clear prescriptive controls with defined thresholds for acceptable planning and development applicants
- Clearly defined flood planning level, including the defined flood event and freeboard, for the various development categories, such as residential, commercial, industrial, vulnerable and critical infrastructure
- Consideration of the full range of design flood events, up to and including the PMF, for strategic planning purposes, and for vulnerable developments and critical infrastructure.
- Provide updated H1-H6 flood hazard mapping from this study and other recently adopted floodplain risk management plans in the LGA and consideration of the use of flood planning constraint categories (FPCC) mapping.
- Clear controls for change of use and concessional development in floodprone areas.
- Clear controls for filling in the floodplain, based on catchment wide analysis.
- Minimising the potential for increased flood risk via increased density as a result of redevelopment of a site located in the floodplain.
- The DCP does not currently include considerations for flood mitigation works. Flood mitigation works may have a flood planning level that is higher or lower than the proposed residential flood planning level and should be determined via a merits-based assessment. The full range of design flood events should be used when assessing the potential failure of the flood mitigation works.

In addition, it is recommended that the following additional modifications are made to the DCP to address the significant flood hazard during the PMF that is predicted across a number of properties located near the railway line at Kingswood and Werrington:

- Include an elevated mezzanine level or second storey as part of any new development. This is intended to allow for vertical evacuation if safe evacuation from the dwelling cannot be completed
- A requirement that all bedrooms be located on the second storey for residential dwellings. This is intended to ensure that residents would remain safe should a PMF occur at night when they are asleep
- Inclusion of a balcony on the second level to allow emergency boat rescue in emergencies (e.g., medical emergency) or should the area be isolated for an extended period
- Engineering report to certify that the structure can withstand the forces of floodwater, debris and buoyancy up to and including a PMF plus freeboard.

### 9.2.4 Update Section 10.7 Certificate Information (PM3)

It is recommended that Council update Section 10.7 certificates to reference the updated design flood information generated as part of the current study. This will help to ensure the most up-to-date information is available and used for properties located within the College, Orth and Werrington Creeks catchment.

This needs to be implemented with the other changes identified in the preceding sections of this report regarding the updating of the LEP and DCP flood mapping information to include all flood constraints up to and including the PMF.

## 9.3 Modification Options for Individual Properties

### 9.3.1 PM4 - Voluntary House Purchase

Voluntary house purchase (VHP) refers to the voluntary purchase of an existing property on a high-risk area of the floodplain. The purchased property is typically demolished, and the land is rezoned so that it can be retained as open space or an equivalent land use that is more compatible with the flood risk.

Due to the high capital costs associated with this option, VHP is typically only considered appropriate in high hazard, floodway areas where there is extreme risk to life and other flood risk reduction strategies are impractical or uneconomic. Moreover, NSW Government funding is only available for VHP for properties that were approved and constructed prior to 1986 when the original Floodplain Development Manual was gazetted (Office of Environment and Heritage, 2013a). .

The computer flood modelling outputs were interrogated with existing building footprints to identify houses that may be eligible for VHP. More specifically, buildings that fell within the following areas at the peak of the 1% AEP flood were considered potentially eligible for VHP:

- High flood hazard areas, and
- Floodway areas.

The ARR2019 hazard categories have been adopted as part of the current study (refer Section 4.2.7) to identify properties in 'high hazard' area. In this regard, it was assumed that the H1, H2 and H3 categories would fall under the 'low' hazard category in the NSW Government's 'Floodplain Development Manual (2005)' and the national H4, H5 and H6 categories would fall under the 'high' hazard category in the Manual.

The review showed that areas of high hazard floodway are generally contained to the main creek channels, roadways as well as areas of open space. However, there are some localised high hazard floodway areas that do extend through residential areas. Therefore, there may be some properties within the catchment that will meet the eligibility criteria for voluntary house purchase.

To gain an understanding of the potential hydraulic benefits of VHP, a modified version of the TUFLOW model was established. This modified version of the model removed all buildings located in high hazard floodway areas and replaced this with grass or open space. The modified version of the model was used to re-simulate the 5% AEP and 1% AEP floods. Flood level difference mapping was prepared based on the results of the revised flood simulations.

The difference mapping showed that flood levels in some areas were predicted to reduce with VHP. However, flood levels in other areas were predicted to increase. More specifically, removing buildings was predicted to afford more efficient overland flow in some areas, which resulted in reduced flood levels in the immediate vicinity of the purchased properties but higher flood levels downstream of the purchased properties.

It is also recognised that VHP would be a very expensive option to pursue (i.e., tens of millions of dollars) and funding such an expensive scheme may not be possible.

As outlined above, VHP is also generally only considered in areas subject to a high flood hazard where other measures are not considered to be viable. In this regard, some of the flood modification options discussed in Chapter 8 (e.g., FM3, FM4 and or FM5) afford benefits across similar areas that a VHP would benefit. As a result, VHP is not recommended for implementation and the flood modification options should be investigated in the first instance.

### 9.3.2 PM5 - Voluntary House Raising

Voluntary house raising (VHR) is a well-established method of reducing the frequency, depth and duration of above floor inundation. VHR can be a suitable measure for reducing the flood damage for individual dwellings or can be used as a compensatory measure where other flood mitigation works are predicted to adversely impact on flood behaviour across individual dwellings. An example of house raising is provided in **Plate 58**.

VHR is best suited to single-storey, timber or clad walled houses with a pier and beam foundation in areas of low flood hazard where structural mitigation works are impractical or uneconomic. It should also be noted that Government funding is only available for VHR for <u>residential</u> properties that were approved and constructed prior to 1986 when the original Floodplain Development Manual was gazetted (Office of Environment and Heritage, 2013b).

The computer flood modelling outputs were interrogated in conjunction with building footprints to identify houses that may be eligible for VHR. Specifically, houses that met the following criteria were pursued:

- Subject to frequent above floor inundation, and
- Low flood hazard area at the peak of the 1% AEP event.

As noted in Section 9.3.1, it was assumed that the H1, H2 and H3 hazard categories would fall under the 'low' hazard category in the NSW Government's 'Floodplain Development Manual (2005)'. The extent of the low hazard areas at the peak of the 1% AEP flood based on this definition is shown **Plate 59**.

The low hazard extent was intersected with the property database developed as part of the flood damages assessment to determine properties that may be subject to frequent above floor flooding but are contained in a low hazard area of the floodplain at the peak of the 1%

AEP flood. In this regard, properties that were predicted to be inundated above floor level during events equal to or more frequent than the 5% AEP flood were selected.

**Plate 58 Examples of houses before (top image), during (middle image) and after (bottom image) house raising (photos courtesy of Fairfield City Council)**

The outcomes of the assessment revealed that five (5) buildings are located in areas of the floodplain that satisfy the above criteria. However, three of these buildings are constructed on a concrete slab, so would not be suitable for house raising. As a result, there are only two (2) properties within the College, Orth and Werrington Creeks catchment that are considered suitable or eligible for voluntary house raising.

The cost associated with raising a house will vary depending on the location, size and complexity of the house. However, recent house raising projects completed by Fairfield City Council indicates a typical cost of just over $80,000 per building. This cost estimate is based on an average floor area of 130 $m^2$ and raising the house by 2.5 metres. Installation of a car port and garage etc could be accommodated on the lower level, but this is not included in the cost estimate.

A review of the identified houses in Werrington and Kingswood indicates that the value of the structures (i.e., not including land value) may be less than the cost to raise the property. Therefore, allocating funds for house raising would likely be overcapitalising. That is, the financial viability of this option is considered low. Furthermore, there are concerns regarding whether the dwellings are structurally suitable for house raising. As a result, voluntary house raising is not recommended for implementation.

The area around the Kingswood property has experienced recent re-development. Therefore, there is potential that this property may be re-developed in the future. If this is the case, the flood risk for this property can be best managed through the application of appropriate development controls through the planning and development process.

***Voluntary Flood Proofing***

Those houses located within low hazard areas that are not suitable for house raising could be considered for voluntary flood proofing. As shown in **Plate 59**, three (3) properties were identified as being potentially suitable for flood proofing.

Two types of flood proofing are available:

- ‘dry’ flood proofing, which aims to prevent the ingress of water into houses, and
- ‘wet’ flood proofing, which permits water to enter houses but reduces the damage to the structure of the house through the use of flood resilient materials.

‘Dry’ flood proofing aims to reduce inundation damages by completely preventing the ingress of water. In this regard, ‘dry’ flood proofing affords several benefits over ‘wet’ flood proofing as it avoids the potential for damage to building contents, reduces the clean-up efforts after an event and significantly reduces the stress associated with frequent above floor inundation.

‘Wet’ flood proofing is the cheapest and most straight forward flood proofing option to implement and therefore, tends to be the most common. A typical wet flood proofing cost of $60,000 would flood proof a typical residential building up to one (1) metre above ground level. However, flood proofing would generally not be eligible for full funding as part of the NSW Government’s Floodplain Risk Management program. Therefore, at least part of the implementation would need to be covered by the property owner which reduces the likelihood of implementation. Furthermore, wet flood proofing will not remove the potential for ingress of floodwaters. Therefore, there is still potential for damage to contents if they are not stored sufficient high nor does it remove the mental anguish associated with flooding.

A review of the potentially eligible properties shows that one property adjoining the Great Western Highway is a villa while the other (on Joseph Street) is a stand-alone dwelling. The Joseph Street property, appears to be low-lying and may be a good target for a voluntary flood proofing scheme.

**Plate 59 1% AEP low hazard areas (aqua) and properties potentially eligible for voluntary raising (yellow) or voluntary flood proofing (pink).**

Although there are limitations associated with voluntary flood proofing, it is considered worthwhile opening a dialog with the property owners to discuss potential options for reducing the impacts of flooding. As a minimum, there is an opportunity for Council and the SES to target the identified properties as part of the community education program (discussed in Section 10.2.1) to make the residents more aware of the flood risk to their property and educate them on measures they can take to make their property more flood resilient.

## 9.4 Recommendations

Based on the assessment presented in this chapter, the property modification options included in **Table 49** are recommended for implementation.

Table 49 Property Modification Options Recommended for Implementation

| Option | | Comments |
|---|---|---|
| PM1 | Changes to LEP | • Make the flood planning area map related to flood related development controls publicly available in an easy to find and easy to understand location.<br>• Update Clause 7.2 to better cater for all land impacted by flood related development controls and all land affected by flooding.<br>• Include an additional 'Floodplain Risk Management' clause for areas between the flood planning area and the limit of the floodplain. |
| PM2 | Changes to DCP | • Amend Penrith DCP 2014 considering the detailed review presented in Section 5.3.2 of this report and other adopted floodplain risk management plans.<br>• Incorporate additional controls in the DCP for high flood risk properties contained near the railway line at Kingswood and Werrington to ensure structural integrity of buildings during the PMF. |
| PM3 | Update Section 10.7 Certificates | • Update Section 10.7 certificate to reference updated design flood information generated as part of the current study. |

# 10 Response Modification Options

## 10.1 Introduction

It is generally not economically feasible to treat all flood risk up to and including the PMF through flood modification and property modification measures. Therefore, response modification measures are implemented to manage the continuing flood risk by improving the way in which emergency services and the public respond before, during and after floods. Response modification measures are often the simplest and most cost-effective measures that can be implemented and, therefore, form a critical component of the flood risk management strategy for the College, Orth and Werrington Creeks catchment.

Response modifications options considered as part of the study include:

- Options to improve emergency response planning (i.e., planning before a flood):
  - RM1 – Community education strategy: Section 10.2.1
  - RM2 – Make property level flood information available: Section 10.2.2
  - RM3 – Local flood plan updates: Section 6.2
  - RM4 and RM5 – Flood emergency response plans: Section 10.2.4
  - RM6 – Develop a Focussed Education and Evacuation Strategy for High Flood Hazard Areas: Section 10.2.5.
- Options to improve emergency response during a flood:
  - RM7 – Flash flood warning system: Section 10.3.1
  - RM8 – Upgrade of Great Western Highway: Section 10.3.2
  - RM9 – Upgrade of Victoria Street: Section 10.3.3
- Options to assist in post-flood recovery:
  - RM10: Recovery Planning: Section 10.4.1.

Further discussion on each response modification option that could be potentially implemented is provided below.

## 10.2 Emergency Response Planning

Effective planning for emergency response is a vital way of reducing risks to life and property, particularly for infrequent floods that are not managed through flood or property modification measures. Potential opportunities for improvements to existing emergency response planning are discussed below.

### 10.2.1 RM1 - Community Education Strategy

An effective community education program is often the most effective emergency response planning strategy as it allows individuals to become more self-sufficient and less reliant on emergency services.

As discussed in **Section 4.3.3**, more than three hundred (300) properties would likely be inundated during a 1% AEP flood in the College, Orth and Werrington Creeks catchment. During the PMF, around one thousand and five hundred (1500) properties are potentially at risk of inundation. It is unlikely that the local SES unit has sufficient resources to assist all 'at risk' properties within this catchment as well as adjoining catchments, particularly during very rare floods (e.g., the PMF). The main emergency response challenge in this catchment is relatively quick inundation times which provide minimal advanced warning time to implement flood damage reduction and evacuation measures. There is also a number of roads that can become inundated relatively quickly, including the Great Western Highway, O'Connell Street, Victoria Street, William Street, John Oxley Drive, Albert Street, Walker Street and Railway Street. Due to the flashy nature of flooding, many roads are likely to be at least partly inundated by the time people may choose to evacuate. As a result, there is an increased risk of people driving though floodwaters in an attempt to evacuate or to 'rescue' others (e.g., parents driving through floodwater to pick up school children). This emphasises the importance of the at-risk communities being equipped to respond appropriately to flooding without reliance on emergency services.

A community survey conducted for this floodplain risk management study indicated nearly 50% of respondents planned to evacuate to an evacuation centre during future floods. This is a positive outcome as other studies completed by the authors indicate evacuation would often be completed by less than 30% of impacted properties. However, more than 20% of respondents had no plan and were unsure of how they would respond during a future flood. Therefore, there is still a need to educate the community so they can better understand the flood risk as well as their level of exposure which will assist in promoting appropriate planning such as the preparation of flood emergency response plans, as discussed in Section 0.

From the flood hazard assessments and the outcomes of the community questionnaire, a number of key messages need to be disseminated to the community in this catchment, as well as other catchments in the Penrith LGA, as part of future education activities:

- "Never drive, ride, walk or play in floodwaters." The need to continue broadcasting this message is suggested by the knowledge that motorists in Australia continue to lose their lives when attempting to cross floodwaters, particularly given the susceptibility of the Great Western Highway and Glossop Street (i.e., the major roadways in the catchment) being subject to relatively frequent inundation. Messages could also provide technical information to dissuade drivers from crossing or driving through flooded roads, such as the depths at which cars float. Messages could also target the motivations for crossing water, such as by encouraging childcare centres and schools to advise parents during storms or floods that their children are safe.
- "One day a bigger, faster flood will happen than what anyone has ever seen. Council has modelled what these floods might be like. Learn whether your house or access to your business could be flooded in an extreme flood. Identify whether it is safe for you to stay or whether you need to evacuate before flooding. Plan ahead to keep your family and staff safe". A message such as this is important to encourage evacuation, knowing that the hazard during particularly large floods may be sufficient to result in failure of some

residential buildings, particularly around Hobart Street where evacuation is considered essential.

- "Flooding can occur away from rivers and creeks". This message aims to reinforce that overland flooding is a risk away from defined watercourses.
- "The safest place to be in a flood is away from the floodwaters. Therefore, early evacuation is recommended for flood prone properties." As the duration of local catchment flooding is relatively short, messaging such as "Wait a few hours rather than go out in the rain" may assist in discouraging driving through floodwaters.

Flood education program is primarily the responsibility of the NSW SES, with Councils supporting the SES to maintain community flood awareness and readiness, especially in the absence of major floods that serve as a natural reminder of the risk. In addition, the dynamics of communities can lead to people with no prior knowledge or experience of flooding moving into a flood prone area.

It is also suggested that the SES could prepare Floodsafe documents for the local area to provide general flood education information. The documents could be developed to be generic enough to indicate how residents can plan for floods even if their property is not flood prone, what to do during a flood, such as evacuation routes and centres, and what options are available to residents and business owners to assist with post-flood recovery.

### 10.2.2 RM2 - Make Property Level Flood Information Available

A starting point for improving people's readiness for floods is to help them better understand how they could be directly affected by floods. Knowing how their house or business could be directly affected by floods is more likely to cut through the scepticism that can grow when communities are not flooded for some years, than more generic advice.

The provision of additional flood information was listed as one of the most preferred flood risk mitigation strategies by the community as part of a questionnaire distributed for the current study (refer Section 3.1.3). Therefore, there appears to be a willingness for the community to improve their understanding of the flood risk by becoming more informed.

Council currently makes the following information available to the public on its website in PDF format:

- Flood study, floodplain risk management study and floodplain risk management plan reports and appendices
- 1% AEP floodwater level map
- Flood planning area map; and
- Full set of flood maps are also provided as a separate download.

Therefore, Council already makes a considerable amount of flood information available on its website. However, there are some limitations with the current arrangement:

- The complete PDF map set often comprises a very large file size. This can reduce the potential for the general public to access all available maps, particularly if trying to gain access from a mobile device.
- The mapping is generally not consistent between studies. This can mean that standard mapping outputs such as depths and velocities are presented with different colour schemes and ranges for each catchment which can prove confusing or difficult to interpret for the public.
- The mapping is generally not to a consistent scale. In particular, some studies provide results at the catchment scale only, making it very difficult to identify results at the property level.

If Council would like to continue to use the website and PDF mapping as their preferred approach for providing flood information to the community, they could consider arranging for future studies to provide mapping at a consistent scale (e.g., 1:5,000) and provide standard mapping outputs in a consistent colour scheme. In the short term, Council could consider using their internal GIS resources to prepare a standardised set of maps based on the GIS outputs that have been produced as part of each current study.

However, over the medium to long term, there would be value in taking advantage of the more detailed spatial outputs that are produced as part of flood studies and floodplain risk management studies by collating and incorporating this information on an online mapping webpage. This would help to ensure that results are presented in a consistent manner regardless of who completed the study, would ensure all available flood information is provided on a single webpage and would overcome scaling issues as the community can use the interface to zoom in and out, as required. There is also potential to include other flood information and links such as BoM warnings, live information on nearby rain gauges, and the latest advice from relevant organisations such as NSW SES and RMS. Therefore, if well maintained, a website can serve as a central repository for a range of contemporary flood information.

It is suggested that this mapping page could include design flood depths, flood levels and flood hazard, in addition to information describing when and where access to individual properties will be cut during a flood. This would also assist with providing proponents or purchasers of property in the catchment with the full suite of flood information related to flood constrains that council is aware of for each property in this catchment.

Discussions with Council indicate that consolidating of all flood data and development of an online mapping page are currently under consideration. It is recommended that Council continue with the development of this online mapping, taking on board the recommendations provided above.

Council advised that flood mapping information is not available for the full LGA. Therefore, it will not be possible to provide a consistent set of mapping information for all catchments. However, it is recommended that Council make the best available information accessible even if that mapping does not cover all catchments. In areas where this mapping is not available, hatching (or similar) could be included with a note to state that detailed flood mapping is not available for this area at the moment, but Council will ultimately prepare additional flood studies for areas where there is a significant flood risk, and the mapping will be updated in due course as the studies are completed.

In addition to resources required to complete the development of the mapping website, additional Council resources and training may also be necessary to answer inquiries about what this information means and how it could be used to assist in the preparation of property-level flood response plans (discussed in Section 10.2.4).

A 'Frequently Asked Questions' (FAQ) document may also need to be developed and updated to accompany any upscaling of flood information availability. For example, people are often concerned about the perceived impact of flood information on property values and insurance premiums. Potential answers have been developed by Floodplain Management Australia and the Insurance Council of Australia could be used as a starting point for preparation of a specific FAQ sheet.

### 10.2.3 RM3 - Local Flood Plan Updates

The *Penrith City Local Flood Plan* (NSW SES, 2012) (LFP) was reviewed as part of the current study and the outcomes of this review are summarised in **Table 29**. This review identified areas of the LFP requiring revision, especially to Volume 2, which needs to be updated to include information from recently completed flood studies and floodplain risk management studies as well as actual floods. The LFP does not include any specific consideration of the College, Orth and Werrington Creeks catchment or local overland flooding in the Penrith LGA, so it is currently not representing the full range of flood risks throughout the LGA.

Flood intelligence generated as part of the current study that could be incorporated into the LFP includes:

- Design flood extents, depths, velocities, hazard and warning times
- Predicted building inundation in design floods up to PMF
- Predicted road inundation in design floods up to PMF, and
- Evacuation constraints in design floods up to PMF.

As the SES is the agency responsible for flood emergency management, it is recommended that they undertake the suggested updates to the LFP based upon the recommendations documented in this study as well as other recently adopted floodplain risk management plans for other catchments in the LGA.

### 10.2.4 RM4 and RM5 - Flood Emergency Response Plans

This floodplain risk management study has estimated that nearly one hundred (100) properties are predicted to be impacted by over floor flooding in a 1% AEP event. During the PMF, over nine hundred (900) properties are predicted to experience above floor flooding, with more than 600 additional properties impacted by yard flooding.

The flood emergency response classifications documented in Section 4.2.10 indicate that there are relatively few isolated areas during the 1% AEP flood. Therefore, evacuation during more frequent floods can most commonly occur by people walking from their property to higher ground. However, there are a number of areas that become isolated early during the PMF, in addition to a number of roads that would be cut by floodwaters making evacuation a more difficult prospect.

Accordingly, the flood risks are considered largely manageable during floods up to and including 1% AEP event but increase significantly during the PMF event. The size of the PMF, the number of impacted properties and the flashy nature of flooding demonstrates that the SES would not be able to provide sufficient assistance during a PMF for all properties.

As such, the preparation of residential and commercial and business flood plans are considered to be a highly valuable option and are discussed in further detail below.

***Home Flood Plan Preparation (RM3)***

It is unlikely that many private dwellings within the flood prone areas have formal flood emergency response plans. Accordingly, the preparation of home flood plans is encouraged as a way of making the broader community more "flood aware" and allowing the community to be more proactive during future floods and less reliant on emergency services. The plan should set out protocols to follow by the household before, during and after a flood to help mitigate damages and the potential for risk to life at the property level. The Home Flood Plans in this catchment should clearly highlight the roads vulnerable to flooding in the area and the need to stay off flooded roads.

The SES has developed an online Home Emergency Plan website that can guide homeowners through the development of the plan:
http://www.seshomeemergencyplan.com.au/index.php

It is anticipated that more than two hundred and fifty (250) road segments would be cut by floodwaters during a PMF. Therefore, even if properties are not directly impacted by floodwaters, there will be a lot more people who will be indirectly impacted by flooding. As such, the preparation of the SES' Home Flood Plan could be extended to the wider community of the College, Orth and Werrington Creeks catchment to focus on the likely disruption to the road network expected during flooding and the need to travel on roads.

Implementation of this option will require innovative approaches to persuade residents to plan ahead for floods. It is considered that the most effective method, albeit a labour-intensive method, will be via direct outreach from the NSW SES to particular residents. It is acknowledged that this would be an extensive undertaking and sufficient resources may not be available to implement such as extensive consultation exercise. Therefore, SES with the support of Council may consider undertaking a limited number of workshops for interested residents. This could be focused on the College, Orth and Werrington Creek catchment or could be expanded to cover multiple catchments depending on the level of interest. Council could staff the workshops with laptops enabling the inspection of flood risks at property scales (booking times might be required to ensure adequate resources are made available), and SES personnel could then help homeowners translate that information into effective home emergency plans for the homeowners to prepare.

***Business Flood Plan Preparation (RM4)***

There are a number of commercial and industrial properties that will be directly and indirectly impacted by flooding in the College, Orth and Werrington Creeks catchment. As such, businesses across flood liable sections of the catchment would also benefit from preparing and maintaining flood plans. These plans set out protocols to follow by the business before, during and after a flood to help mitigate damages and the potential for risk to life at the property level. A well implemented flood plan will also help with the recovery process and ensure businesses will be "back on their feet" sooner rather than later which will assist in minimising the potential for longer term financial impacts.

As for private home flood plans, Council should be able to provide significant information describing the flood risk at the property scale based on the outputs from this study including the potential frequency and depth of inundation as well which roadways will be cut and the likely duration of any isolation (e.g., Great Western Highway).

The SES has developed a Business FloodSafe Toolkit to assist with the preparation of Business FloodSafe plans. These can be completed either online or as a hardcopy (see http://www.floodsafe.com.au/what-floodsafe-means-for-you/business).

A SES Business Breakfast could be hosted to promote the development of Business FloodSafe Plans, with sufficient Council and SES staff present to help guide business owners through the process. This could be potentially hosted at the Kingswood Sports Club which is located in close proximity to both the Kingswood shops on Bringelly Road as well as the Great Western Highway car yards (two of the more significantly impacted commercial precincts).

### 10.2.5 RM6 - Develop a Focussed Education and Evacuation Strategy for High Flood Hazard Areas

A number of existing residential properties located within the catchment are predicted to be exposed to H5 external hazard and H4 hazard inside of buildings during the PMF. Those properties exposed to H4 internal hazard would not be safe for any person to seek refuge inside (i.e., there is a significant risk to life for any person) while buildings exposed to H5 hazard have the potential to suffer structural damage or failure (i.e., also potentially unsafe for people to seek refuge inside).

Those properties with buildings exposed to at least H5 external hazard are shown in red on **Plate 60** while those properties with buildings exposed to at least H4 internal hazard are shown in yellow. **Plate 60** identifies one hundred and seventy-six (176) buildings that would be at least partly exposed to at least H5 hazard and fifteen (15) single storey buildings that would be subject to at least H4 internal hazard during the PMF. Therefore, all properties shown on **Plate 60** are likely be unsafe for occupation during a PMF based on existing flood behaviour.

Application of suitable development controls will assist in reducing the flood risk across these properties as redevelopment occurs (refer to Section 9.2 for further discussion on this topic). However, until this occurs, the current flood risk will remain. Furthermore, it is unlikely that any of the flood modification options discussed in Chapter 8 will reduce the flood hazard during the PMF to more tolerable levels should they be implemented in the future. Therefore, evacuation is considered the best risk reduction measure for these properties during large floods in the short term.

However, due to the minimal warning times, residents in high risk areas will need to be ready to act on an evacuation order issued by the SES. Therefore, it is important that residents in the high flood hazard areas are aware of their potential flood exposure and are ready to evacuate on short notice.

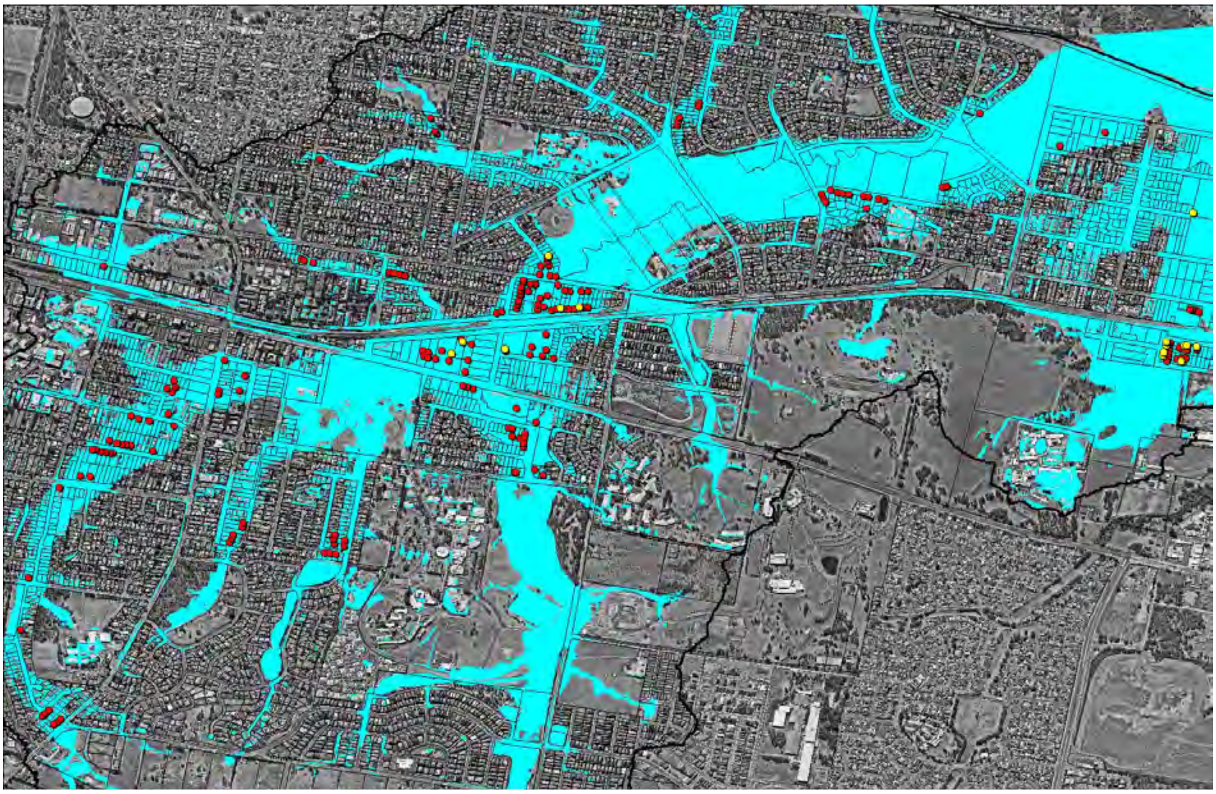


**Plate 60 Properties with buildings exposed to H5 or H6 hazard (red) or high hazard internal flooding (yellow) in PMF where evacuation is considered essential (PMF extent shown in aqua)**

As outlined in Section 10.2.2, a starting point for improving people's readiness for floods is to help them better understand how they could be directly affected by floods. Although the general education strategies summarised in Section 10.2.1 are also relevant to this area, a more targeted education strategy is considered necessary to assist the community in better understanding the extremity of flooding that could be experienced in the area during the PMF. This will likely require one-on-one interaction with households from SES and Council staff to present the available information, answer questions and assist in the preparation of flood emergency response (i.e., evacuation) plans.

A 'meet the street' event could also have value where the flood risk could be explained with the assistance of flood maps and animations produced as part of the current study. This may also assist in establishing a greater sense of community and begin 'planting the seeds' for establishing communication groups across the higher risk sections of the catchment to assist in promoting more coordinated evacuation efforts.

A review of the hazard mapping for floods that are still rare but less severe than the PMF (e.g., 0.2% AEP flood) shows that the flood hazard is more tolerable. More specifically, during floods up to and including the 0.2% AEP event, the maximum floor hazard around the buildings identified in **Plate 60** rarely exceeds H3. Therefore, although evacuation is always the preferred emergency response strategy, if evacuation was not completed it is unlikely to result in unacceptable hazard conditions during floods up to and including the 0.2% AEP flood.

As discussed, there is likely to be minimal advanced warning time during large floods in the College, Orth and Werrington Creeks catchment. Therefore, having an emergency kit pre-prepared in advance and ready for use will save valuable time during a future flood. The emergency kit should include (SES, 2020):

- Portable radio with spare batteries
- Power bank with USB cables
- Torch with spare batteries
- First aid kit (with supplies necessary for your household)
- Candles and waterproof matches
- Important papers including emergency contact numbers
- Copy of Home Emergency Flood Plan; and
- Waterproof bag for valuables.

When preparing to leave and evacuate from a property, the following additional items should be included in the emergency kit (SES, 2020):

- A good supply of required medications
- Any special requirements and supplies for babies, the disabled, infirm and/or elderly
- Appropriate clothing and footwear; and
- Fresh food and drinking water.

The emergency kit should be checked on a regular basis to confirm batteries and electrical devices are charged and working and to restock any perishable items (e.g., rubber gloves). At a minimum, checks should be completed yearly.

The SES would be responsible for leading evacuation efforts. However, the short warning times may make it difficult for the SES to mobilise resources and undertake safe evacuation in a timely manner using a traditional 'door knock' approach. Therefore, there may be advantages in the SES looking at expanding its repertoire to taking advantage of modern communication techniques. The goal of this would be to promote more efficient and timely communication and evacuation. In this regard, the SES could look at setting up a communication group for the local high risk area (e.g., SMS, Facebook group, Viber/WhatsApp group) that would allow rapid communication between the SES and households and would assist in promoting more efficient evacuation efforts. These communication channels could be used to:

- Re-iterate severe weather and thunderstorm warnings (refer to 10.3.1 for further information of these warnings). This would provide initial advice of the potential for a flood and recommend that households ensure their emergency kits are in order.
- Advise that evacuation will likely be necessary in the immediate future. This would likely be issued during the initial phases of a severe rainfall event (and may be enhanced by the installation of a rainfall gauge in the upper catchment, as discussed in Section 10.3.1). This would request that households be ready for imminent evacuation.
- Advise that evacuation will be necessary and ask that residents move to their front door ready for evacuation and await further instructions from SES staff.

By providing the additional "lead up" information it will assist the high risk areas in staying informed of an impending flood and it will help to ensure that households are ready to evacuate as soon as the SES initiates the evacuation order.

If a significant rainfall event were to occur at night, the effectiveness of a system that relies on households making observations can be limited. This can be due to either a lack of sunlight making observations more difficult or people being asleep when the flood occurs. Therefore, there would be benefits in exploring an automated alert system. Although a formal flood warning system is unlikely to be viable for the catchment as a whole (refer discussion in Section 10.3.1), the installation of a sub-daily (i.e., 'tipping bucket' type) rainfall gauge in the upper catchment may assist in providing additional guidance on when evacuation may be required. The gauge could be setup with a telemetry system with predefined rainfall triggers (e.g., once rainfall approaches or exceeds the 0.2% AEP rainfall depths documented in **Table 8**), it could send an automated message (via the Facebook or WhatsApp groups discussed above), or phone call or text message to potentially vulnerable properties.

Overall, it is recommended that:

- SES (with assistance from Council) initiate a focussed education strategy for the high-risk areas within Kingswood and Werrington so these households can fully understand their level of flood exposure during very rare floods.
- Households should be encouraged to prepare emergency kits and complete checks of this kit on an annual basis.
- Households should be encouraged to prepare flood emergency response plan. As the evacuation and response strategy for most properties will be very similar, the SES and Council can 'pre-fill' much of the information necessary.
- SES to consider setting up communication groups with high risk sections of the community to assist in providing additional advice before and during a flood and promote more efficient evacuation processes.

- Council and BoM could explore the potential for installing a rainfall gauge that could serve to issue automated flood warnings based on rainfall depth triggers.

## 10.3 Emergency Response Modifications

### 10.3.1 RM7 - Flash flood warning system

This option considered the feasibility of installing a flash or local flood warning system throughout the College, Orth and Werrington Creeks catchment. The goal of such a system is to provide sufficient advanced warning of an impending flood that would allow residents and business owners to safely evacuate before floodwaters arrive and take action to reduce the potential impacts of flooding on their property (e.g., elevate stock and belongings to higher ground).

Penrith City Council does not currently operate a flash flood warning system for any of its local catchments (including the College, Orth and Werrington Creeks catchment). Therefore, the only warnings that people in the College, Orth and Werrington Creeks catchment are likely to receive in relation to flooding would be issued by the Bureau of Meteorology and could be either:

- A severe weather warning for flash flooding – this will provide 6 to 24 hours' notice but is unlikely to be more specific than being for 'Western Sydney' and a general time frame of when it may occur.
- A severe thunderstorm warning – this could be more location specific but probably not better than at an LGA level and will be issued between 30 and 60 minutes before the event.

Neither of these warnings can provide an indication of the intensity of rainfall and the magnitude of flooding likely to occur. Observation of Bureau of Meteorology Radar images will give some indication as to the location and intensity of imminent and actual rainfall and may provide up to 30 minutes of warning. Observation of actual rainfall and runoff will give a better indication of the likelihood of flooding, however, by this time there may be limited time to respond appropriately.

Placing a rainfall gauge within the upstream parts of the College, Orth and Werrington Creeks catchment to facilitate broadcasting a warning would likely provide less than 60 minutes warning to downstream catchment areas (noting that the most 'at risk' overland flooding areas are located within the middle and upper areas of the catchment). In some of the larger flood events, roads are cut in less than 30 minutes which would not be sufficient time for people to organise themselves and their household to evacuate, particularly if they were asleep at the time. Accordingly, a flash flood warning system is not recommended for implementation as it is unlikely to yield sufficient additional warning time to allow residents to respond to any warnings that are issued.

Nevertheless, installation of additional sub-daily rainfall gauges could be considered by Council to potentially serve as inputs to a wider flood warning system that would benefit multiple local catchments in the LGA. Installation of additional rainfall gauges is also likely to assist in providing valuable inputs as part of future flood study revisions for the catchment.

Regardless of whether such gauges are installed in the future, the practicality of evacuation will be highly reliant on individual households interpreting available warning information and taking appropriate actions. In this regard, providing education materials on what warning information is available (severe weather or storm warnings from the BOM), where this information can be accessed and how this information is to be interpreted would be beneficial. Having household or business flood plans enacted, as discussed in Section 10.2.4, would also be critical to ensure required evacuation actions are identified before the flood. In summary, flood warning in the College, Orth and Werrington Creeks catchment should focus on helping occupants in the catchment in better understanding the potential flood implications for their properties and responding appropriately to severe weather warnings from the Bureau of Meteorology and their own observations.

### 10.3.2 RM8 - Upgrade of Great Western Highway

The Great Western Highway is the most highly trafficked road in the College, Orth and Werrington Creeks catchment and the main east-west transportation link located south of the railway line. The section of the highway that is contained within the catchment is predicted to be impacted during floods as frequent as the 10% AEP event (and would be completely cut during the 2% AEP flood). This presents a number of potential issues:

- Relatively frequent disruption to local traffic.
- Reduced potential for people of evacuate away from floodwaters.
- More frequent temptation for people to drive through floodwaters.

As discussed in Chapter 8, a number of flood modification options were explored to reduce the frequency and depth of inundation across the highway (refer Section 8.3.1, Section 8.4.2, Section 8.6.1 and Section 8.7.1). Although these options served to reduce inundation depths across the road, they were not sufficient to remove the potential for inundation. Therefore, raising the road level was investigated.

Several different road raising options were explored. This included elevating the entire roadway to the level of the 1% AEP flood as well as the PMF. The flood level difference mapping shown in **Plate 61** shows the flood level impacts associated with elevating the highway to the 1% AEP flood level. It shows that raising the road level by this amount would result in significant adverse flood impacts across multiple properties to the south of the highway.

It is acknowledged that the Great Western Highway is the most heavily trafficked road in the catchment and is also one of the most flood liable. Therefore, any works that result in less frequent and deep inundation of the highway will provide a significant emergency response improvement. However, it is difficult to support elevating the highway to the level of the 1% AEP flood based on the adverse flood impacts that are predicted. Although it may be possible to elevate the highway to a more modest elevation to reduce the magnitude of the flood level impacts (e.g., elevating to the level of the 5% AEP flood), it is noted that FM1, FM5, FM19 and

FM20 (all discussed in Chapter 8) will afford this level of flood immunity for the highway along with broader flood level reductions and no associated adverse flood impacts. Therefore, it is recommended that these flood modifications are pursued in preference to elevating the highway in isolation.

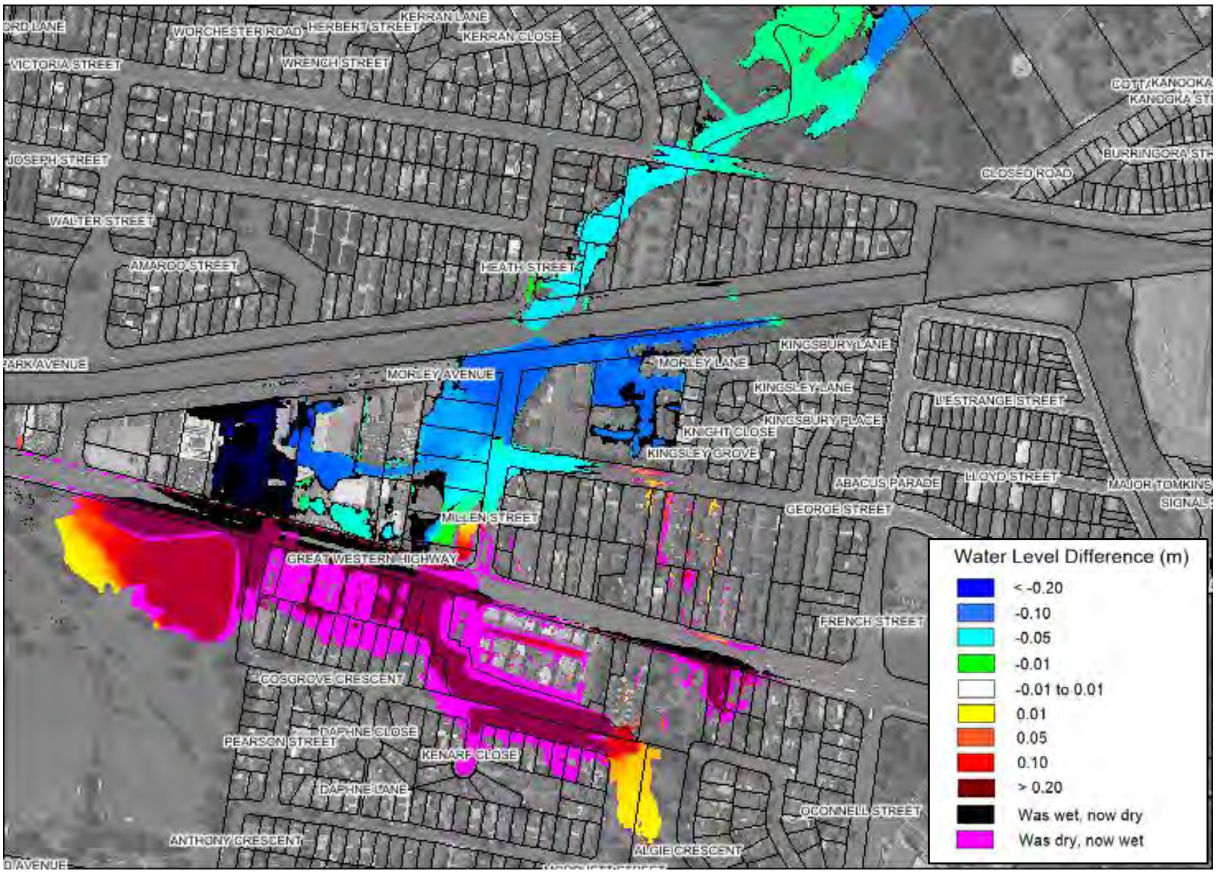



**Plate 61 1% AEP flood level difference map for RM8 (elevated roadway only)**

Notwithstanding, there may be scope to accommodate minor road raising as part of any future roadworks in the area. This will need to be carefully balanced with the other flood modification options being considered as part of this study.

### 10.3.3 RM9 - Upgrade of Victoria Street

Victoria Street is one of the main east-west roadways located north of the railway line. As such, it serves as an important evacuation route for the northern parts of the College, Orth & Werrington Creeks catchment. The edges of the road are predicted to be inundated during the 5% AEP flood and access would be completely cut during the 1% AEP flood.

The potential impacts associated with elevating the roadway along with the installation of a new culvert are discussed in Section 8.4.1. This determined that it would be possible to provide flood free access along Victoria Street during floods up to and including the 1% AEP flood by elevating the roadway by approximately 0.2 metres and providing a larger culvert system to ensure upstream properties and not adversely impacted.

An alternate Victoria Street upgrade option was also explored which investigated raising of Victoria Street but with no culvert upgrade (i.e., the existing culvert was retained). This involved elevating the highway by approximately 0.4 metres to ensure it remained flood free during the 1% AEP flood. The flood level difference mapping for this option is provided in **Plate 62**. It shows that raising the road level by this amount would generate flood level increases on the southern side of Victoria Street at both crossing locations (i.e., Werrington Creek and the smaller tributary further east). The maximum increase in level at both locations is approximately 0.2 metres during the 1% AEP flood. The flood level increases are predicted to extend across multiple private properties adjoining Werrington Creek and also extend upstream of the railway line. Therefore, it is evident that any raising of Victoria Street would need to be supplemented with culvert upgrades to minimise the potential for adverse flood impacts across nearby properties (as detailed in Section 8.4.1).


**Plate 62 1% AEP flood level difference map for RM9 (elevated roadway only)**

As noted above, Victoria Street serves as the major evacuation route for existing properties located between the railway line and Werrington Creek. However, as outlined in Chapter 8, there may be future urban expansion in this area. Therefore, it is likely that Victoria Street will also serve as the major evacuation route for an expanded population in the future. Therefore, any improvements to the level of service that are afforded by Victoria Street are likely to be beneficial from an emergency response perspective, but the benefits are also likely to escalate in the future. Therefore, it is recommended that Victoria Street is upgraded in the medium to long term to support the ongoing urban expansion in the area and ensure the reliance on emergency service is not unduly increased.

It is noted that upgrading of Victoria Street is unlikely to occur in the short term. Therefore, there is still potential for overtopping of the road which may expose motorists to a flood risk should they choose to drive through floodwaters. Therefore, it is worth reinforcing the flood liability of this road (as well as the Great Western Highway) and the dangers of driving through floodwaters as part of community education activities. These education activities should also identify alternate evacuation routes for the local community. During flood events, these alternate access routes must be clearly signposted, whilst ensuring there are no opportunity for vehicles to drive through the inundated segments of roads i.e., certifying that 'road closed' infrastructure such as signs or barricades cannot be circumnavigated.

## 10.4 Options to Assist in Post-Flood Recovery

### 10.4.1 RM10 - Recovery Planning

The *Penrith City Local Flood Plan* (NSW SES, 2012) (LFP) sets out the responsibilities of various agencies in post-flood recovery. Recovery, as outlined in the LFP, largely rests with the SES with assistance from other agencies, as required.

It is suggested that additional, specific items could be included in the LFP to further assist emergency services and the community to expedite post-flood recovery, including:

- Service providers to ensure vital facilities such as power, water and sewer are restored and operational.
- Council to aid in removing waste and debris as part of clean-up activities.
- Appropriate agencies to ensure vital utilities such as power and gas are restored and operational.
- Appropriate agencies to offer welfare assistance and counselling services; and
- Various agencies to record post-flood information to assist in future updates and calibration of flood models and flood studies.

## 10.5 Recommendations

Based on the assessment presented in this chapter, the response modification options included in **Table 50** are recommended for implementation.

Some roadway upgrade options were explored and yielded some notable emergency response improvements. However, they also produced adverse flood impacts across some properties. Furthermore, some of the flood modification options that are recommended for investigation and potential implementation afford similar emergency response benefits without adverse flood impacts. Therefore, the flood modification options are recommended in preference to the roadway upgrades. Nevertheless, opportunities for elevating major roadways such as the Great Western Highway and Victoria Street could be explored to supplement the flood modification options if roadway modifications are proposed in the future.

**Table 50 Response Modification Options Recommended for Implementation**

| Option | | Comments |
|---|---|---|
| RM1 | Community education strategy | • Develop local FloodSafe documents, develop educational messages targeting dangerous behaviours during a flood.<br>• Undertake localised and tailored education campaigns for high hazard areas, particularly the Hobart Street area. |
| RM2 | Make property level flood information available | • Develop a standardised approach for presenting flooding information across all catchments.<br>• Work towards incorporating available flood information into an online flood portal. |
| RM3 | Local flood plan updates to accommodate response planning | • Update Penrith Local Flood Plan to align with new SES LFP template and to incorporate the review findings documented in Section 10.2.3 this study. |
| RM4 | Home flood plans | • Promote the preparation of Home Emergency Flood Plans.<br>• These plans should highlight the vulnerability of and disruption to the road network during flood times and provide advice on potential alternate evacuation routes. |
| RM5 | Business flood plans | • Host a Business FloodSafe Breakfast to promote the preparation of Business FloodSafe Plans. |
| RM6 | Develop a Focussed Education and Evacuation Strategy for High Flood Hazard Areas | • Council and SES to arrange targeted education activities to highlight nature and extent of flood behaviour for high-risk properties.<br>• Promote the preparation of flood emergency kits and home flood plans.<br>• Council to discuss willingness of local facilities to serve as temporary flood evacuation shelters during extreme flood events.<br>• Establish triggers for evacuation (based on recorded rainfall or water depths in properties).<br>• Develop an online communication system (Facebook, WhatsApp etc) to allow rapid dissemination of flood and evacuation information. |
| RM10 | Local Flood Plan Updates to Accommodate Recovery Planning | • Update Local Flood Plan to reflect additional flood recovery responsibilities for various agencies. |

A flood warning system is unlikely to yield sufficient additional warning time flood to be of significant value to the local community. Nevertheless, there may be benefits in installing additional sub-daily rainfall gauges as part of a broader warning system in addition to providing a potential trigger system for the implementation of RM6.

# 11 RECOMMENDATIONS

## 11.1 Recommended Options

This Floodplain Risk Management Study has assessed a range of structural and non-structural options for better managing the existing, future and continuing flood risk across the College, Orth and Werrington Creeks catchment.

Based on the outcomes of the assessment, a number of options are recommended to move forward into the Floodplain Risk Management Plan for the catchment. These options are summarised in:

- Flood Modification (FM) Options: **Table 51**
- Property Modification (PM) Options: **Table 52**
- Emergency Response Modification (RM)Options: **Table 53**

As a medium to long term goal, it is recommended that all flood modification options listed in **Table 51** are ultimately implemented as a 'combined' option. If each of the individual options are implemented progressively, care will need to be taken with the implementation schedule to ensure that there are no adverse flood impacts (i.e., FM1 is implemented before FM5).

## 11.2 Other Options that Could Be Considered

In addition, several flood modification options were determined to provide reductions in flood levels but did not perform well from an economic standpoint. Therefore, Council and asset owners (e.g., TfNSW) should consider these options for implementation as part of ongoing works programs, asset replacement, road upgrades etc. These options are summarised below:

- FM7 – Great Western Highway Culvert Upgrades.
- FM10 – Werrington Railway Station Culvert Upgrade.
- FM11 – Dunkley Place Stormwater Upgrades.
- FM12 – Orleton Place to Francis Street Stormwater Upgrades.
- FM13 – Victoria Street to Joseph Street Stormwater Upgrades.
- FM17 – Great Western Highway Median Modifications.

**Table 51 Flood Modification Options Recommended for Floodplain Risk Management Plan**

| Priority | Option | | Description of Option | Economic Assessment | | | Comments |
|---|---|---|---|---|---|---|---|
| | | | | Cost of proposed work ($ millions) | Reduction in Flood Damages Costs ($ millions) | Benefit Cost Ratio | |
| 1 | FM1 | Chapman Gardens Basin | Providing additional flood storage volume in existing Chapmans Gardens basin at Kingswood by elevating basin wall by approximately 0.6 metres plus lowering basin invert by 1.5 metres | $1.14 | $0.25 | 0.2 | This option primarily provides flood level reductions across the Great Western Highway and adjoining properties. Although it does not provide a high BCR, it provides some notable emergency response benefits and is required to offset some adverse flood impacts that are predicted if FM5 was implemented in isolation. Therefore, subject to the outcomes of additional detailed feasibility investigations, it is recommended that FM1 is installed before, or at least no later, than FM5. |
| 2 | FM5 | Jamison Road Basin Augments | Lower existing basin invert to provide additional storage volume and provide new 525mm diameter low flow pipe | $0.58 | $2.47 | 4.3 | FM5 provides the most significant reductions in flood levels and above floor flooding of all of the individual options investigated. It also provides a BCR of more than 4 (the highest BCR of all options). Therefore, this option is recommended for further investigations and potential implementation. |
| 3 | FM4 | Stafford Street Basins | Create two new detention basins in existing open space on either side of Stafford Street at Kingswood. | $0.52 | $0.38 | 0.7 | FM4 affords notable reductions in flood levels. When combined with FM1 and FM5, it provides significant reductions in flood levels, reduced frequency of inundation of roads and greatly reduced above floor flooding. |
| 4 | FM3 | Lincoln Drive Basin | Provide additional flood storage volume in Lincoln Drive Park by elevating the existing embankment by around 0.5 metres | $0.05 | $0.03 | 0.6 | FM3 does afford some significant reductions in flood damages, flood levels and flood hazard during events up to and including the 1% AEP flood across multiple Cambridge Street properties. In addition, this is a relatively low-cost option to implement. |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 5 | FM6 | Victoria Street Culvert Upgrade | Replace the existing 5 x 3.35m wide x 1.8m high box culverts with 6 x 3.6m wide x 2.1m high box culverts and elevate road surface by 200mm | $2.11 | $0.01 | Less than 0.1 | Although FM6 and FM9 do not provide high BCRs, they afford significant emergency response benefits for Victoria Street. This will prove valuable for the current and future population, considering the expected urban expansion between Werrington Creek and the railway line. |
| 6 | FM9 | Werrington Creek Railway Culvert Upgrade #2 | Installation of an additional 1.5 metre diameter culvert that would extend from upstream of the railway line near French Street subdivision to northern Victoria Street. 2 new 3m wide x 0.9m high box culverts would also be installed under Victoria Street | $1.33 | $0.01 | Less than 0.1 | |

**Table 52 Property and Planning Modification Options Recommended for Floodplain Risk Management Plan**

| Option | | Comments |
|---|---|---|
| PM1 | Changes to LEP | • Make the flood planning area map related to flood related development controls publicly available in an easy to find and easy to understand location.<br>• Update Clause 7.2 to better cater for all land impacted by flood related development controls and all land affected by flooding.<br>• Include an additional 'Floodplain Risk Management' clause for areas between the flood planning area and the limit of the floodplain. |
| PM2 | Changes to DCP | • Amend Penrith DCP 2014 considering the detailed review presented in Section 5.3.2 of this report and other adopted floodplain risk management plans.<br>• Incorporate additional controls in DCP for high flood risk properties contained near railway line at Kingswood and Werrington to ensure structural integrity of buildings during the PMF. |
| PM3 | Update Section 10.7 Certificates | • Update Section 10.7 certificate to reference updated design flood information generated as part of the current study. |

**Table 53 Emergency Response Modification Options Recommended for Floodplain Risk Management Plan**

| Option | | Comments |
|---|---|---|
| RM1 | Community education strategy | • Develop local FloodSafe documents, develop educational messages targeting dangerous behaviours during a flood.<br>• Undertake localised and tailored education campaigns for high hazard areas, particularly the Hobart Street area. |
| RM2 | Make property level flood information available | • Develop a standardised approach for presenting flooding information across all catchments.<br>• Work towards incorporating available flood information into an online flood portal. |
| RM3 | Local flood plan updates to accommodate response planning | • Update Penrith Local Flood Plan to align with new SES LFP template and to incorporate the review findings documented in Section 10.2.3 of this study. |
| RM4 | Home flood plans | • Promote the preparation of Home Emergency Flood Plans.<br>• These plans should highlight the vulnerability of and disruption to the road network during flood times and provide advice on potential alternate evacuation routes. |
| RM5 | Business flood plans | • Host a Business FloodSafe Breakfast to promote the preparation of Business FloodSafe Plans. |
| RM6 | Develop a Focussed Education and Evacuation Strategy for High Flood Hazard Areas | • Council and SES to arrange targeted education activities to highlight nature and extent of flood behaviour for high-risk properties and areas.<br>• Promote the preparation of flood emergency kits and home flood plans. |

| Option | | Comments |
|---|---|---|
| | | • Council and SES to discuss willingness of local facilities to serve as temporary flood evacuation shelters during extreme flood events.<br>• Establish triggers for evacuation (based on recorded rainfall or water depths in properties).<br>• Develop an online communication system (Facebook, WhatsApp etc) to allow rapid dissemination of flood and evacuation information. |
| RM10 | Local Flood Plan Updates to Accommodate Recovery Planning | • Update Local Flood Plan to reflect additional flood recovery responsibilities for various agencies. |

# 12 REFERENCES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# APPENDIX A

## COMMUNITY CONSULTATION

PENRITH

# COLLEGE, ORTH AND WERRINGTON CREEKS FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN

## INFORMATION SHEET

### INTRODUCTION

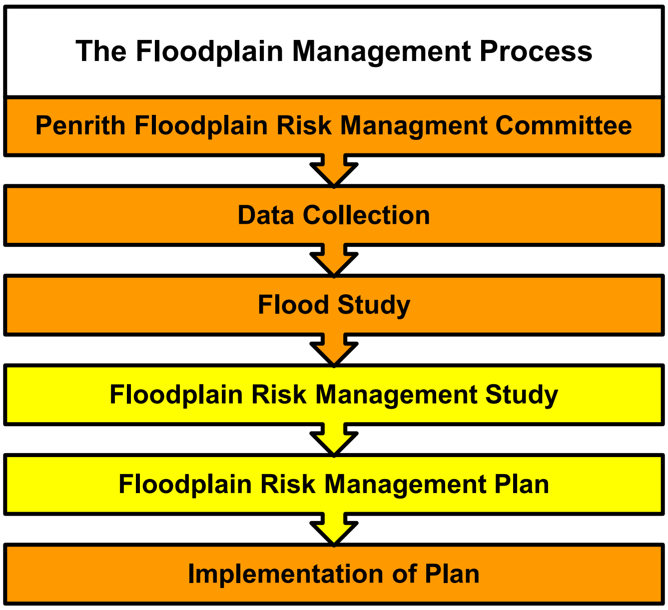
In 2017, Penrith City Council completed a detailed flood study for your local catchment. Council is now preparing a Floodplain Risk Management Study and Plan for the College, Orth and Werrington Creeks catchment, and we would like your help. The study will inform us about the flood management measures needed and help us plan for and manage known flood risks. Sound flood management based on local knowledge will help Council reduce flood damage, enhance resilience and improve social and economic opportunities.

Council has appointed engineering consultants Catchment Simulation Solutions to prepare the study and plan on our behalf. The study will be overseen by the Penrith Floodplain Risk Management Committee and receive financial support from the State Government under its Floodplain Management Program.

### WHY HAVE A FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN?

The Penrith Local Government Area (LGA) is dominated by rivers, creeks and waterways and has wide floodplains. The risk of flood is real, and Council wants to ensure proper plans are in place in accordance with the NSW Government Flood Prone Land Policy.

The policy sets out the staged process we are following, which includes data collection; a flood study; a floodplain risk management study and plan; and the implementation of the plan. Council is now starting the floodplain risk management phase for the College, Orth and Werrington Creeks catchment as highlighted in yellow below.





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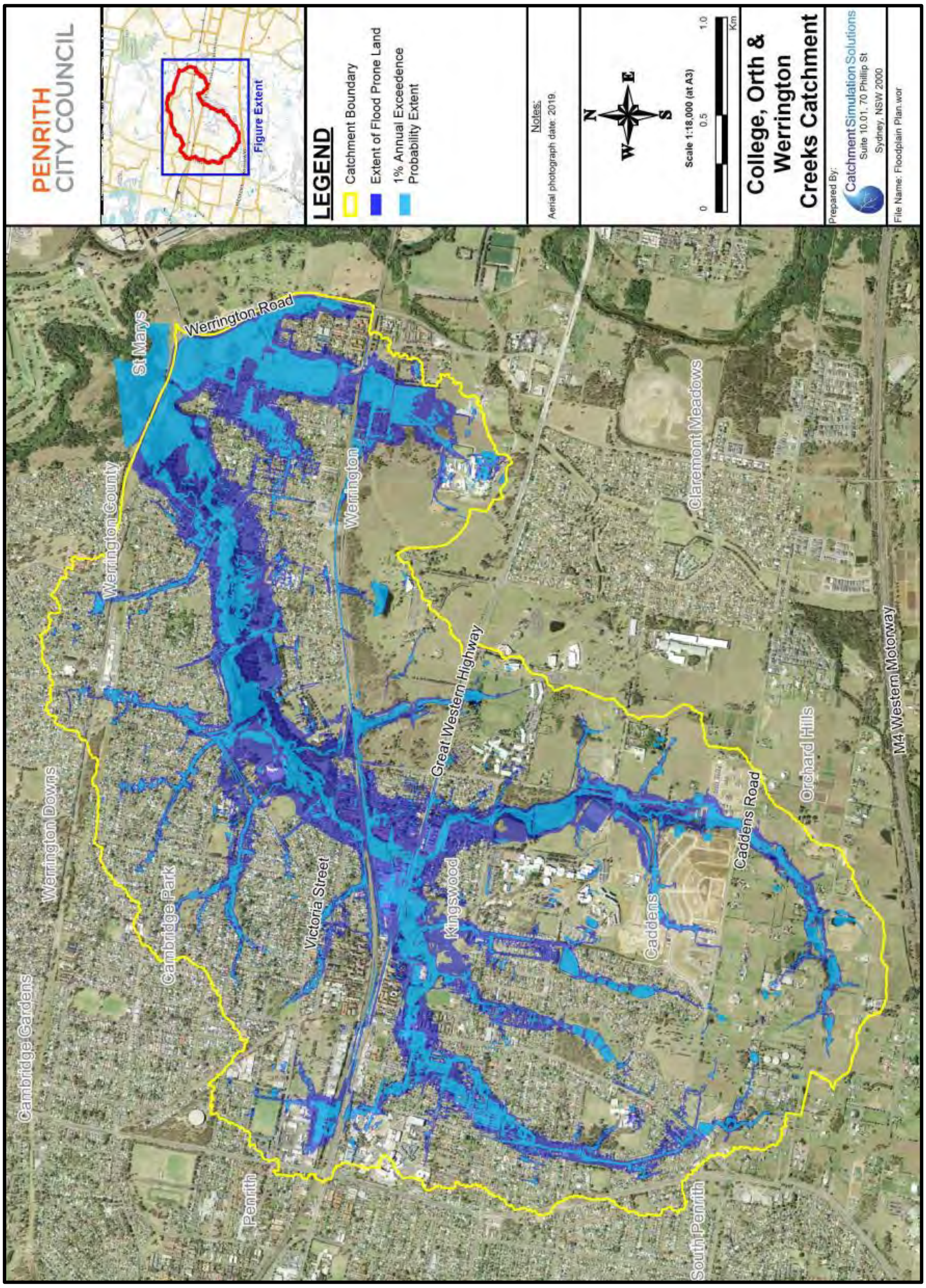
The Floodplain Risk Management Study identifies and evaluates measures that could be incorporated into the Floodplain Risk Management Plan to reduce the risk and cost of flooding to the community; assist with emergency management and guide future development. The process also looks at making the community more resilient and prepared, including evacuation, education and preparation.

## MAP OF CATCHMENT AREA UNDER CONSIDERATION





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## WHAT'S INVOLVED IN PREPARING A FLOODPLAIN RISK MANAGEMENT STUDY?

A considerable amount of work goes into preparing a Floodplain Risk Management Study and Plan, including:

- identifying areas at risk of flooding, through the use of the computer modelling (completed in 2017) and from information you provide in the community questionnaire.
- developing a range of options for managing flood risk, such as: modifying creek channels, stormwater upgrades, constructing levees, enforcing planning controls for new development and planning for evacuation, education and awareness.
- analysing the options, considering environmental, social and economic benefits, as well as their potential to reduce flood risk.
- preparing a Floodplain Risk Management Report; which summarises the outcome of all stages of the investigation and makes recommendations to be carried forward to the Floodplain Risk Management Plan.

## HOW CAN YOU BE INVOLVED?

Your local knowledge and personal experience of living in the area is invaluable when identifying flood 'trouble spots' and developing floodplain risk management measures that are practical, comprehensive and effective.

The study team will consult with the community in two stages:

1. **Questionnaire** – Please complete the questionnaire included with this information sheet and share with us your experiences of local flooding and opinions on flood management options. This study is focusing on the local and overland flooding associated with the College, Orth and Werrington Creeks Catchment rather than flooding from South Creek (being undertaken through a separate process).
2. **Community drop-in session** – once the draft Floodplain Risk Management Study report is prepared, a community drop-in session will be held to give you an opportunity to review the report and ask questions about the flood management options investigated. Any comments and feedback received during this community drop-in session will be reviewed and addressed as part of the final report.

## STAY UP TO DATE

Our website will be updated throughout the study and plan process to provide the latest available information including details of the above community consultations. Go to the Flood Management page of www.penrith.city

## MORE INFORMATION

If you have any questions or would like to submit any information you think may be helpful to the study, please contact:

**Dr Elias Ishak - Penrith City Council**
PO Box 60, Penrith NSW 2751
Phone: 4732 7777
Email: Elias.Ishak@penrith.city

PENRITH

# COMMUNITY QUESTIONNAIRE

## COLLEGE, ORTH AND WERRINGTON CREEKS FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN

### COMPLETING THE QUESTIONNAIRE

In 2017, Council completed a detailed flood study for your local catchment. Council is now seeking your assistance in the creation of a Floodplain Risk Management Study and Plan for the College, Orth and Werrington Creeks Catchment. Giving information based on your local knowledge and experience will help us to create a Plan that is shaped by local knowledge and information that would otherwise go unrecorded.

**Please complete the survey and return it by Thursday 24 October 2019.**

You can do this by:

- going online to yoursaypenrith.com.au, and completing it there
- filling out the enclosed survey and emailing it to david.tetley@ccse.com.au, or
- filling out the enclosed survey and post it to us, using the enclosed pre-paid envelope.

Council has appointed Catchment Simulation Solutions to prepare the study and there are more details in the enclosed Information Sheet and on the "Flood Management" page of the Penrith City Council web page www.penrith.city .

Please answer as many questions as you can and give as much detail as possible (attach additional pages if necessary).

If you have any questions or require further information, please contact:

1. Council's Senior Engineer – Stormwater, Dr Elias Ishak on 4732 7777, or
2. Catchment Simulation Solutions - Director, Mr David Tetley on 8355 5501.

### CONTACT DETAILS

Please provide your street and suburb details.

**Street Address:** ____________________________________________

____________________________________________________________

**Suburb:** ______________________________ **Postcode:** ___________

Providing full contact details is optional, but useful so we can contact you for more information if required. If you choose to provide full contact details, this information will remain confidential at all times and will not be published.

Name: ______________________________________________________

Phone number: _______________________________________________

Email: ______________________________________________________

Please indicate if and how you would like us to contact you for more information or to provide you with study updates:

☐ Yes – telephone/ email/ mail (circle your preferred method of contact)

☐ No

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## ABOUT YOUR PROPERTY

1. Please select as appropriate:

- ☐ I am a resident
- ☐ I am a business owner
- ☐ I own the property
- ☐ I rent the property
- ☐ Other – please describe

2. How long have you been at this address?

- ☐ Less than 1 year
- ☐ 1 to 5 years
- ☐ 5 to 20 years
- ☐ More than 20 years

3. Property type:

- ☐ House
- ☐ Villa/ townhouse
- ☐ Unit/ flat/ apartment
- ☐ Industrial unit or warehouse
- ☐ Vacant land
- ☐ Shop/ retail
- ☐ Other

4. Do you know if your property has a risk of being flooded?

- ☐ My property is beyond the extent of all potential floods
- ☐ My property could be flooded
- ☐ No, I don't know/I'm not sure whether my property could be flooded

## DEVELOPMENT CONTROLS AND COMMUNICATION

5. Please rank the following development types according to which you think are the most important to protect from floods

**1=highest priority to 6= lowest priority**

- ☐ Commercial
- ☐ Residential
- ☐ Essential community facilities
- ☐ Critical Utilities
- ☐ Minor developments and additions
- ☐ New residential developments

6. What level of control do you think Council should place on new development to minimise flood-related risks?

**Tick only one box**

(In addition to being favoured by the community, these options would also need to comply with legislation)

- ☐ Prohibit all new development on land with any potential to flood
- ☐ Prohibit all new development only in those locations that would be extremely hazardous to persons or property due to the depth and/or velocity of floodwaters, or evacuation difficulties
- ☐ Place restrictions on developments which reduce the potential for flood damage (e.g. minimum floor level controls or using flood compatible building materials)
- ☐ Advise of the flood risks, but allow the individual a choice about developing or not, provided steps are taken to minimise potential flood risks
- ☐ Provide no advice about potential flood risks or measures that could minimise those risks
- ☐ Don't know

7. What notifications do you think Council should give about the potential flood affectation of individual properties?

**Tick one or more boxes**

- ☐ Advise every resident and property owner on a regular basis of the known potential flood threat
- ☐ Advise only those who enquire to Council about the known potential flood threat
- ☐ Advise prospective purchasers of property of the known potential flood threat.
- ☐ Provide no notifications
- ☐ Other – please describe

---

## FLOOD RESPONSE

8. How would you respond in a major flood in the area?

**Tick one box**

- ☐ Evacuate early to an evacuation centre
- ☐ Remain at my house
- ☐ Don't know/not sure
- ☐ Other – please describe

---

9. If you are likely to evacuate, what factors are most important?

**Tick one or more boxes**

- ☐ Discomfort/inconvenience/cost of being isolated by floodwater
- ☐ Need for access to medical facilities
- ☐ Safety of our family
- ☐ Other – please describe:

---

10. If you are likely to remain at your house, what factors are most important?

**Tick one or more boxes**

- ☐ Discomfort/inconvenience/cost of evacuating
- ☐ Need to care for animals
- ☐ My house cannot be flooded, and we can cope with isolation
- ☐ Concern for security of my property if I evacuate
- ☐ Other – please describe:

---

## OTHER INFORMATION

11. What do you think is the best way for us to get input and feedback from the local community about the results and proposals from this study?

**Tick one or more boxes**

- ☐ Council's website
- ☐ Articles in local newspaper
- ☐ Open days or drop-in days
- ☐ Community workshops
- ☐ Public meetings
- ☐ Council's Floodplain Management Committee
- ☐ Other (please specify)

---

## FLOODPLAIN RISK MANAGEMENT MEASURES AND CONTROLS

12. Below is a list of possible options that may be looked at to try to minimise the effects of flooding in the Study Area (see plan on attached Fact Sheet).

This list is not in any order of importance and there may be other options that you think should be considered. For each of the options listed, please indicate "yes", or "no" to indicate if you favour the option or "don't know" if undecided. (In addition to being favoured by the Community, management options would also need to comply with legislation and be capable of being funded).

| **Option** | **Yes** | **No** | **Don't Know** |
|---|---|---|---|
| Management of vegetation along creek corridors | | | |
| Widening and/or concrete lining of watercourses | | | |
| Construct detention basins | | | |
| Upgrade stormwater drainage system | | | |
| Upgrade bridges & culverts | | | |
| Removal of floodplain obstructions | | | |
| Levee upgrades | | | |
| Voluntary purchase of the most severely affected flood-liable properties | | | |
| Provide funding or subsidies to raise houses above major flood level | | | |
| Flood proofing of individual properties | | | |
| Improve flood warning and evacuation procedures | | | |
| Community education, participation and flood awareness programs. | | | |
| Ensuring all residents and business owners have Flood Action Plans | | | |
| Specify controls on future development in flood-liable areas (e.g. extent of filling, minimum floor levels, etc.) | | | |
| Provide a Planning Certificate to purchasers in flood prone areas, stating that the property is flood affected. | | | |
| Installation of signs/boom gates at roadway overtopping locations | | | |
| Ensuring all information about the flood risks is available to all residents and business owners | | | |

## THANK YOU

Thank you for taking the time to complete this questionnaire. This means your Council is now better informed about your local area and, as a result, our decisions about managing flooding in your neighbourhood will be better informed.

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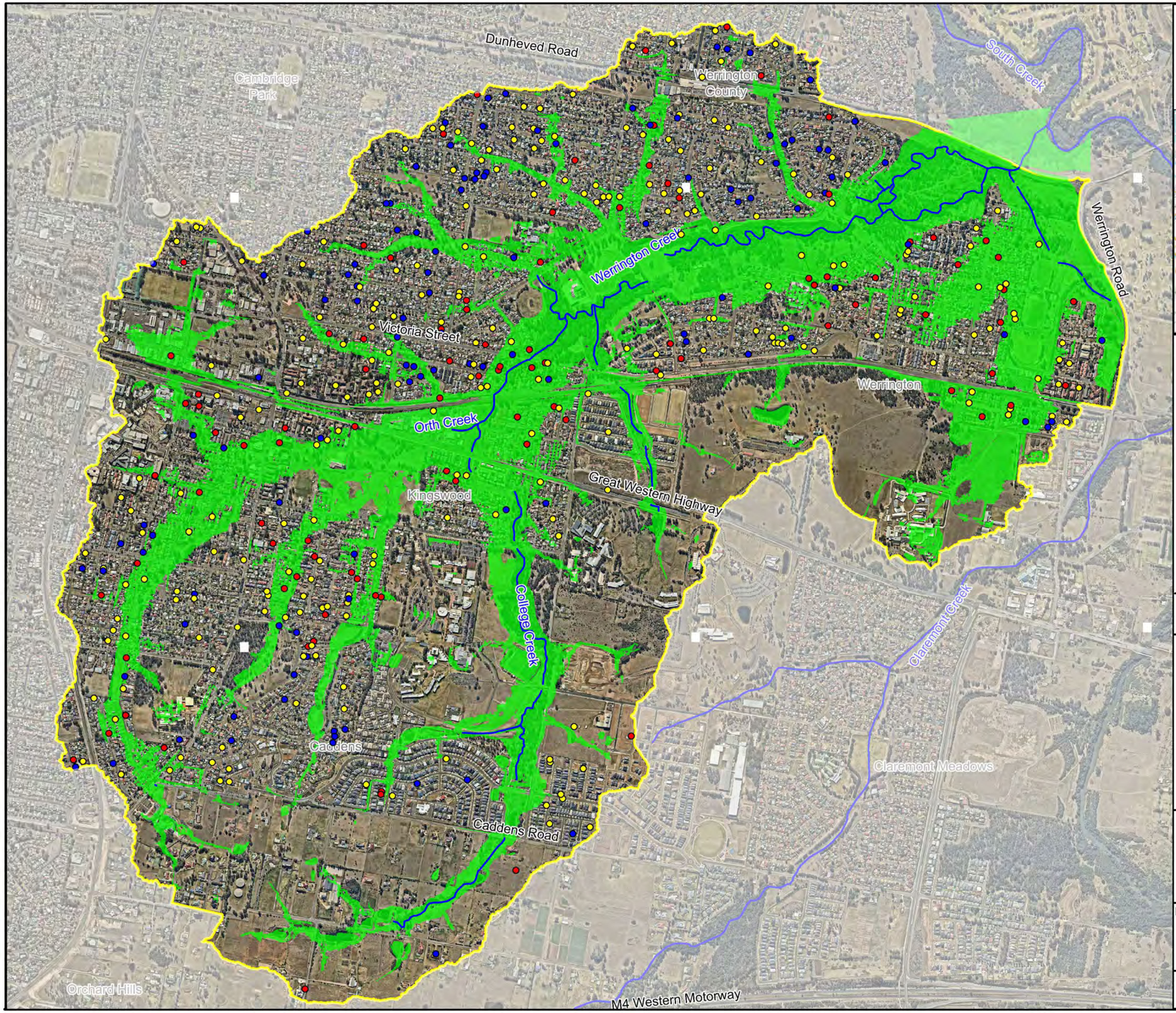
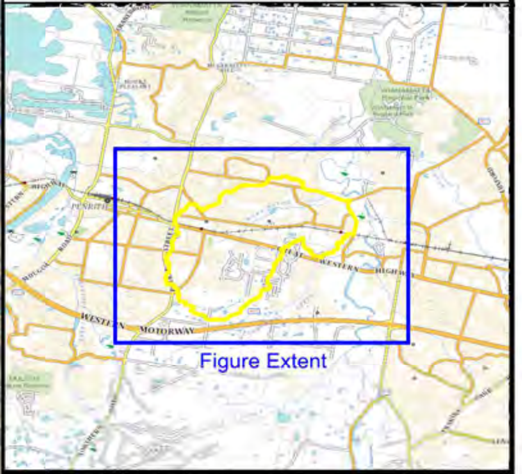



## LEGEND

Catchment Extent

PMF Extent

Questionnaire Response Locations
Do you know if your property has a risk of being flooded?

- Yes
- No
- I don't know

Notes:

Aerial photograph date: 2019

N, E, S, W

Scale 1:16,000 (at A3)

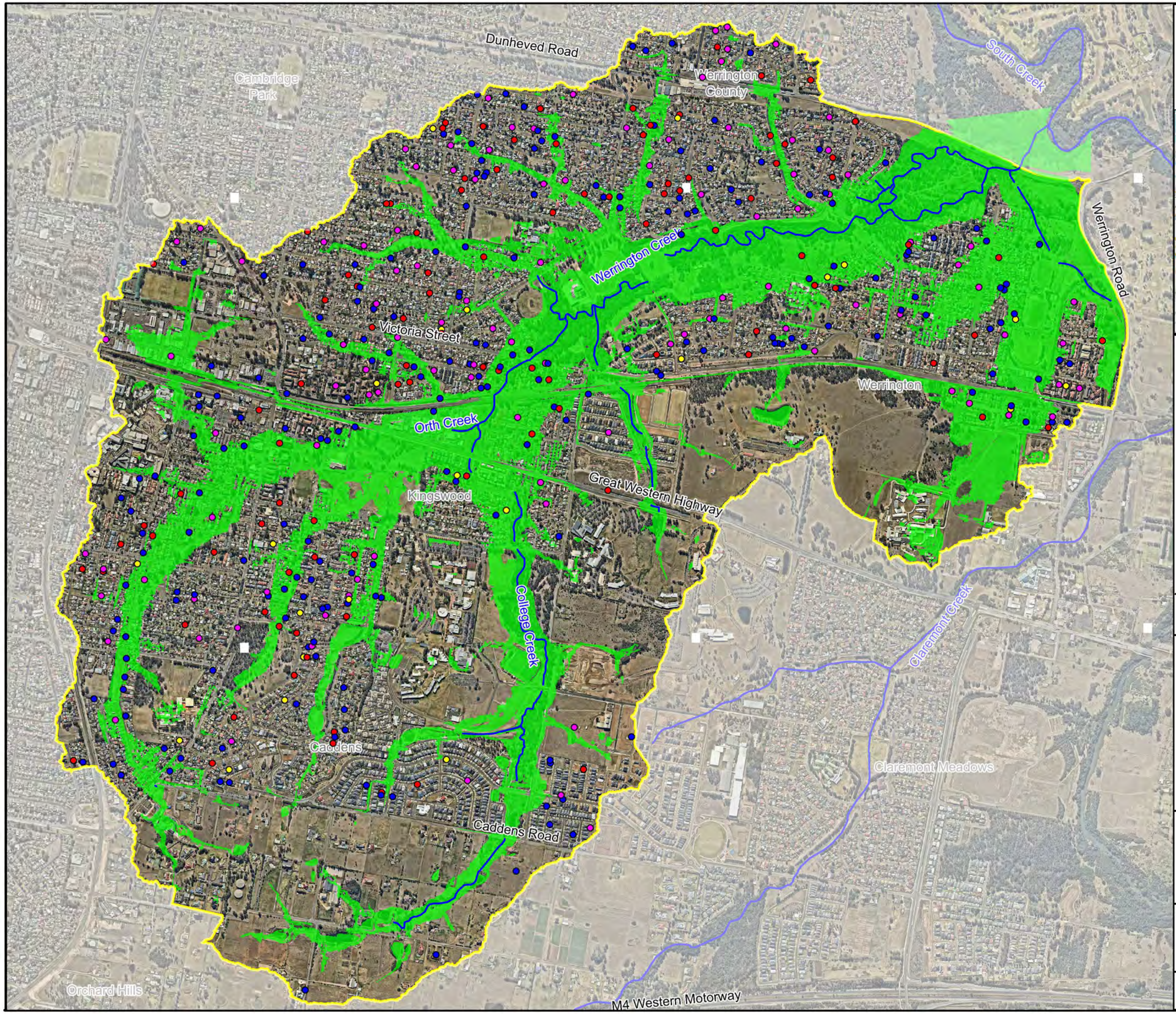
0 0.5 1.0 Km

**Figure A1: Flood Awareness**

Prepared By:

Catchment Simulation Solutions
Suite 2.01, 210 George St
Sydney, NSW 2000

File Name: Flood awareness.wor

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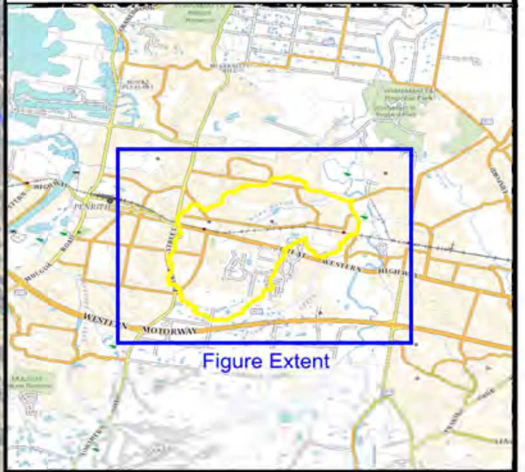


**LEGEND**

- Catchment Extent
- PMF Extent

Questionnaire Response Locations
How would you respond in a major flood in the area?

- Don't know/not sure
- Remain at my house
- Evacuate early to an evacuation centre
- Other

Notes:

Aerial photograph date: 2019

N W E S

Scale 1:16,000 (at A3)

0 0.5 1.0 Km

## Figure 2: Spatial distribution of flood response types

Prepared By:

Catchment Simulation Solutions
Suite 2.01, 210 George St
Sydney, NSW 2000

File Name: Spatial distribution of flood response types.wor

## Table A1 - Property Information

| # | Please indicate if and how you would like us to contact you for more information or to provide you with study updates | About your property | | | | Please rank the following development types according to which you think are the most important to protect from floods | | | | | | What level of control do you think Council should place on new development to minimise flood-related risks? | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Please select as appropriate | How long have you been at this address? | Property Type | Do you know if your property has a risk of being flooded? | Commercial | Residential | Essential community facilities | Critical Utilities | Minor developments and additions | New residential developments | Prohibit all new development on land with any potential to flood | Prohibit all new development only in those locations that would be extremely hazardous to persons or property due to the depth and/or velocity of floodwaters, or evacuation difficulties | Place restrictions on developments which reduce the potential for flood damage (e.g. minimum floor level controls or using flood compatible building materials) | Advise of the flood risks, but allow the individual a choice about developing or not, provided steps are taken to minimise potential flood risks | Provide no advice about potential flood risks or measures that could minimise those risks | Don't know |
| 1 | Yes | I am a resident | More than 20 years | House | My property is beyond the extent of all potential floods | 4 | 1 | 5 | 2 | 6 | 3 | | Yes | | | | |
| 2 | Yes | I own the property | 5 to 20 years | House | My property could be flooded | 5 | 4 | 2 | 3 | 1 | 6 | | | | Yes | | |
| 3 | No | I own the property | 5 to 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 3 | 2 | 4 | 1 | 5 | 6 | | Yes | | | | |
| 4 | Yes | I own the property | 5 to 20 years | Villa/ townhouse | No, I don't know/I'm not sure whether my property could be flooded | 1 | 2 | 3 | 4 | 5 | 6 | Yes | | | | | |
| 5 | Yes | I own the property | 1 to 5 years | Villa/ townhouse | My property could be flooded | 4 | 1 | 3 | 2 | 5 | 6 | | | | Yes | | |
| 6 | Yes | I am a resident | More than 20 years | House | My property is beyond the extent of all potential floods | 4 | 3 | 2 | 1 | 5 | 6 | | Yes | | | | |
| 7 | Yes | I own the property | Less than 1 year | House | No, I don't know/I'm not sure whether my property could be flooded | | | | | | | | Yes | | | | |
| 8 | No | I own the property | 5 to 20 years | House | My property is beyond the extent of all potential floods | 1 | 2 | 3 | 4 | 6 | 5 | Yes | | | | | |
| 9 | Yes | I am a resident | 1 to 5 years | House | My property could be flooded | 3 | 2 | 4 | 1 | 5 | 6 | | Yes | | | | |
| 10 | Yes | I own the property | Less than 1 year | House | No, I don't know/I'm not sure whether my property could be flooded | 5 | 3 | 2 | 1 | 4 | 6 | | | | Yes | | |
| 11 | No | I own the property | 1 to 5 years | Vacant land | My property is beyond the extent of all potential floods | 4 | 1 | 2 | 3 | 5 | 6 | | | | Yes | | |
| 12 | Yes | I own the property | 1 to 5 years | House | No, I don't know/I'm not sure whether my property could be flooded | 5 | 1 | 2 | 3 | 6 | 4 | | | Yes | | | |
| 13 | Yes | I own the property | 1 to 5 years | Duplex House | My property could be flooded | 4 | 2 | 5 | 1 | 6 | 3 | | Yes | | | | |
| 14 | Yes | I am a resident | 5 to 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 5 | 2 | 3 | 1 | 6 | 4 | | | Yes | | | |
| 15 | Yes | I am a resident | 5 to 20 years | Villa/ townhouse | My property could be flooded | 4 | 2 | 3 | 1 | 5 | 6 | | Yes | | | | |
| 16 | Yes | I own the property | 5 to 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 4 | 2 | 5 | 1 | 6 | 3 | | | | Yes | | |
| 17 | Yes | I own the property | Less than 1 year | Vacant land | No, I don't know/I'm not sure whether my property could be flooded | 4 | 1 | 2 | 3 | 5 | 6 | | | | Yes | | |
| 18 | No | I am a resident | 1 to 5 years | House | No, I don't know/I'm not sure whether my property could be flooded | 3 | 2 | 5 | 1 | 6 | 4 | | | Yes | | | |
| 19 | No | I own the property | More than 20 years | House | My property is beyond the extent of all potential floods | 4 | 3 | 2 | 1 | 6 | 5 | | | Yes | | | |
| 20 | Yes | I own the property | 1 to 5 years | House | No, I don't know/I'm not sure whether my property could be flooded | 6 | 2 | 3 | 4 | 5 | 1 | Yes | | | | | |
| 21 | Yes | I am a resident | 1 to 5 years | Villa/ townhouse | No, I don't know/I'm not sure whether my property could be flooded | 4 | 2 | 5 | 1 | 6 | 3 | | Yes | | | | |
| 22 | No | I own the property | 1 to 5 years | Villa/ townhouse | My property is beyond the extent of all potential floods | 4 | 2 | 3 | 1 | 6 | 5 | Yes | | | | | |
| 23 | No | I am a resident | 5 to 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 3 | 1 | 4 | 2 | 5 | 6 | | Yes | | | | |
| 24 | No | I own the property | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 4 | 2 | 3 | 1 | 6 | 5 | | Yes | | | | |
| 25 | Yes | I am a resident | 1 to 5 years | House | My property could be flooded | 5 | 1 | 3 | 2 | 6 | 4 | | Yes | | | | |
| 26 | No | I own the property | 5 to 20 years | House | My property is beyond the extent of all potential floods | | | | | | | Yes | | | | | |
| 27 | Yes | I am a resident | 1 to 5 years | House | My property is beyond the extent of all potential floods | 5 | 2 | 4 | 1 | 6 | 3 | | | Yes | | | |
| 28 | Yes | I am a resident | 5 to 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 5 | 1 | 3 | 2 | 6 | 4 | | | Yes | | | |
| 29 | Yes | I own the property | 5 to 20 years | Villa/ townhouse | My property could be flooded | 4 | 1 | 3 | 2 | 5 | 6 | | | Yes | | | |
| 30 | No | I own the property | 5 to 20 years | Unit/ flat/ apartment | My property could be flooded | 3 | 1 | 4 | 2 | 5 | 6 | | | | Yes | | |
| 31 | No | I own the property | Less than 1 year | House | No, I don't know/I'm not sure whether my property could be flooded | 2 | 1 | 3 | 4 | 5 | 6 | | | | Yes | | |
| 32 | No | I own the property | 5 to 20 years | Unit/ flat/ apartment | No, I don't know/I'm not sure whether my property could be flooded | 3 | 1 | 4 | 2 | 5 | 6 | | | Yes | | | |
| 33 | No | I own the property | 5 to 20 years | House | My property is beyond the extent of all potential floods | 4 | 2 | 5 | 1 | 6 | 3 | | | Yes | | | |
| 34 | Yes | I am a resident | More than 20 years | House | My property could be flooded | 5 | 2 | 4 | 1 | 6 | 3 | | Yes | | | | |
| 35 | | I am a resident | 1 to 5 years | House | My property could be flooded | 4 | 1 | 3 | 2 | 5 | 6 | | | Yes | | | |
| 36 | No | I rent the property | 1 to 5 years | House | No, I don't know/I'm not sure whether my property could be flooded | 3 | 1 | 4 | 2 | 5 | 6 | | | | Yes | | |
| 37 | Yes | I own the property | 1 to 5 years | Villa/ townhouse | My property could be flooded | 3 | 1 | 2 | 4 | 6 | 5 | | | | Yes | | |
| 38 | Yes | I own the property | 1 to 5 years | Vacant land | My property could be flooded | 5 | 3 | 2 | 1 | 6 | 4 | | | | Yes | | |
| 39 | Yes | I own the property | 1 to 5 years | House | My property could be flooded | 4 | 1 | 3 | 2 | 6 | 5 | Yes | | | | | |
| 40 | | I am a resident | 5 to 20 years | Villa/ townhouse | My property could be flooded | 4 | 2 | 3 | 1 | 5 | 6 | Yes | | | | | |
| 41 | Yes | I am a resident | 1 to 5 years | Villa/ townhouse | My property could be flooded | | | | | | | | Yes | | | | |
| 42 | Yes | I own the property | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 3 | 1 | 4 | 2 | 5 | 6 | Yes | | | | | |
| 43 | No | I am a resident | 5 to 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 4 | 1 | 3 | 2 | 6 | 5 | | | Yes | | | |
| 44 | Yes | I rent the property | 1 to 5 years | House | My property is beyond the extent of all potential floods | 5 | 3 | 1 | 2 | 6 | 4 | | | | Yes | | |
| 45 | No | I own the property | 1 to 5 years | House | My property could be flooded | 3 | 4 | 1 | 2 | 5 | 6 | | Yes | | | | |
| 46 | Yes | I own the property | Less than 1 year | Villa/ townhouse | No, I don't know/I'm not sure whether my property could be flooded | 4 | 1 | 2 | 3 | 5 | 6 | | | Yes | | | |
| 47 | No | I own the property | 1 to 5 years | Villa/ townhouse | No, I don't know/I'm not sure whether my property could be flooded | 4 | 2 | 3 | 1 | 6 | 5 | Yes | | | | | |
| 48 | No | I own the property | Less than 1 year | Villa/ townhouse | No, I don't know/I'm not sure whether my property could be flooded | | | | | | | | Yes | | | | |
| 49 | No | I own the property | More than 20 years | Villa/ townhouse | No, I don't know/I'm not sure whether my property could be flooded | 4 | 3 | 2 | 1 | 6 | 5 | | | | Yes | | |
| 50 | Yes | I am a resident | 5 to 20 years | Villa/ townhouse | No, I don't know/I'm not sure whether my property could be flooded | 4 | 1 | 3 | 2 | 6 | 5 | Yes | | | | | |
| 51 | Yes | I am a resident | 5 to 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 4 | 3 | 2 | 1 | 5 | 6 | | | | Yes | | |
| 52 | Yes | I own the property | 1 to 5 years | House | No, I don't know/I'm not sure whether my property could be flooded | 5 | 1 | 4 | 2 | 6 | 3 | | | | Yes | | |
| 53 | Yes | I am a resident | 1 to 5 years | House | No, I don't know/I'm not sure whether my property could be flooded | 3 | 1 | 4 | 2 | 5 | 6 | | | Yes | | | |
| 54 | Yes | I own the property | More than 20 years | House | My property could be flooded | 4 | 1 | 3 | 2 | 5 | 6 | | Yes | | | | |
| 55 | Yes | I own the property | 5 to 20 years | Villa/ townhouse | No, I don't know/I'm not sure whether my property could be flooded | 4 | 2 | 3 | 1 | 5 | 6 | | | Yes | | | |
| 56 | No | I am a resident | 5 to 20 years | House | My property is beyond the extent of all potential floods | 5 | 1 | 4 | 3 | 6 | 2 | | | Yes | | | |
| 57 | Yes | I own the property | 1 to 5 years | House | No, I don't know/I'm not sure whether my property could be flooded | 4 | 2 | 3 | 5 | 1 | 6 | Yes | | | | | |
| 58 | Yes | I own the property | 5 to 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 5 | 2 | 3 | 1 | 4 | 6 | Yes | | | | | |
| 59 | Yes | I own the property | 1 to 5 years | Unit/ flat/ apartment | No, I don't know/I'm not sure whether my property could be flooded | 6 | 2 | 3 | 4 | 5 | 1 | | | | Yes | | |
| 60 | Yes | I am a resident | 1 to 5 years | Villa/ townhouse | My property could be flooded | 4 | 1 | 2 | 3 | 5 | 6 | | | Yes | | | |
| 61 | Yes | owner but tenanted | 5 to 20 years | Unit/ flat/ apartment | No, I don't know/I'm not sure whether my property could be flooded | | | | | | | Yes | | | | | |
| 62 | Yes | I am a resident | More than 20 years | House | My property could be flooded | 6 | 1 | 3 | 2 | 5 | 4 | | Yes | | | | |
| 63 | Yes | I own the property | 5 to 20 years | Unit/ flat/ apartment | My property could be flooded | | | | | | | | | Yes | | | |
| 64 | Yes | I own the property | More than 20 years | House | My property is beyond the extent of all potential floods | 4 | 1 | 2 | 3 | 5 | 6 | Yes | | | | | |
| 65 | No | I own the property | 5 to 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 6 | 1 | 3 | 2 | 4 | 5 | | | Yes | | | |
| 66 | Yes | I own the property | 1 to 5 years | Villa/ townhouse | No, I don't know/I'm not sure whether my property could be flooded | 6 | 3 | 2 | 1 | 4 | 5 | | | | Yes | | |
| 67 | Yes | I own the property | More than 20 years | House | My property is beyond the extent of all potential floods | 5 | 3 | 4 | 1 | 6 | 2 | | | Yes | | | |
| 68 | Yes | I own the property | 1 to 5 years | Duplex | No, I don't know/I'm not sure whether my property could be flooded | | | | | | | | | | Yes | | |
| 69 | No | I own the property | 5 to 20 years | Villa/ townhouse | My property could be flooded | 2 | 1 | 3 | 4 | 5 | 6 | | Yes | | | | |
| 70 | No | I own the property | 1 to 5 years | Unit/ flat/ apartment | No, I don't know/I'm not sure whether my property could be flooded | | | | | | | | Yes | | | | |
| 71 | No | I own the property | 5 to 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 4 | 3 | 2 | 1 | 5 | 6 | | | Yes | | | |
| 72 | No | I own the property | 5 to 20 years | House | My property could be flooded | 4 | 2 | 5 | 1 | 6 | 3 | | Yes | | | | |
| 73 | Yes | Not for profit organisation | More than 20 years | Vacant land | No, I don't know/I'm not sure whether my property could be flooded | 6 | 1 | 3 | 2 | 4 | 5 | | | Yes | | | |
| 74 | Yes | Not for profit organisation | More than 20 years | Office Premises, industrial unit and | No, I don't know/I'm not sure whether my property could be flooded | 6 | 1 | 3 | 2 | 4 | 5 | | | Yes | | | |
| 75 | Yes | I own the property | 1 to 5 years | Villa/ townhouse | No, I don't know/I'm not sure whether my property could be flooded | 4 | 3 | 2 | 1 | 6 | 5 | | | | Yes | | |
| 76 | Yes | I am a resident | 5 to 20 years | Villa/ townhouse | No, I don't know/I'm not sure whether my property could be flooded | | | | | | | | Yes | | | | |
| 77 | No | I am a resident | More than 20 years | House | My property could be flooded | 3 | 2 | 4 | 5 | 6 | 1 | Yes | | | | | |
| 78 | No | I own the property | 5 to 20 years | House | My property could be flooded | 1 | 2 | 3 | 4 | 5 | 6 | | | Yes | | | |
| 79 | Yes | I am a resident | 1 to 5 years | Villa/ townhouse | No, I don't know/I'm not sure whether my property could be flooded | 2 | 1 | 3 | 4 | 5 | 6 | | | Yes | | | |
| 80 | Yes | I am a resident | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | | | | | | | | Yes | | | | |
| 81 | Yes | I own the property | 1 to 5 years | Villa/ townhouse | My property could be flooded | 4 | 2 | 5 | 1 | 6 | 3 | | Yes | | | | |
| 82 | Yes | I own the property | 5 to 20 years | Villa/ townhouse | No, I don't know/I'm not sure whether my property could be flooded | 5 | 1 | 4 | 2 | 6 | 3 | Yes | | | | | |

| # | Please indicate if and how you would like us to contact you for more information or to provide you with study updates | About your property | | | | Please rank the following development types according to which you think are the most important to protect from floods | | | | | | What level of control do you think Council should place on new development to minimise flood-related risks? | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Please select as appropriate | How long have you been at this address? | Property Type | Do you know if your property has a risk of being flooded? | Commercial | Residential | Essential community facilities | Critical Utilities | Minor developments and additions | New residential developments | Prohibit all new development on land with any potential to flood | Prohibit all new development only in those locations that would be extremely hazardous to persons or property due to the depth and/or velocity of floodwaters, or evacuation difficulties | Place restrictions on developments which reduce the potential for flood damage (e.g. minimum floor level controls or using flood compatible building materials) | Advise of the flood risks, but allow the individual a choice about developing or not, provided steps are taken to minimise potential flood risks | Provide no advice about potential flood risks or measures that could minimise those risks | Don't know |
| 83 | Yes | I own the property | 1 to 5 years | House | No, I don't know/ I'm not sure whether my property could be flooded | 3 | 1 | 4 | 2 | 5 | 6 | Yes | | | | | |
| 84 | No | I own the property | More than 20 years | House | My property could be flooded | 6 | 3 | 2 | 1 | 5 | 4 | | | Yes | | | |
| 85 | No | I am a resident | More than 20 years | House | My property is beyond the extent of all potential floods | 6 | 1 | 2 | 4 | 5 | 3 | Yes | | | | | |
| 86 | Yes | I own the property | 5 to 20 years | House | No, I don't know/ I'm not sure whether my property could be flooded | 4 | 1 | 3 | 2 | 5 | 6 | | | | Yes | | |
| 87 | | I own the property | 5 to 20 years | House | No, I don't know/ I'm not sure whether my property could be flooded | | | | | | | Yes | | | | | |
| 88 | Yes | I am a resident | More than 20 years | House | My property is beyond the extent of all potential floods | 5 | 1 | 4 | 3 | 6 | 2 | Yes | | | | | |
| 89 | Yes | I am a resident | More than 20 years | House | My property is beyond the extent of all potential floods | 6 | 3 | 2 | 1 | 6 | 4 | Yes | | | | | |
| 90 | Yes | I am a resident | More than 20 years | House | My property is beyond the extent of all potential floods | 3 | 4 | 5 | 1 | 6 | 2 | | | | Yes | | |
| 91 | Yes | I am a resident | More than 20 years | House | My property is beyond the extent of all potential floods | 4 | 3 | 2 | 1 | 6 | 5 | | Yes | | | | |
| 92 | | I own the property | More than 20 years | House | No, I don't know/ I'm not sure whether my property could be flooded | 1 | 1 | 1 | 1 | 6 | 1 | Yes | | | | | |
| 93 | Yes | I own the property | 5 to 20 years | House | No, I don't know/ I'm not sure whether my property could be flooded | 4 | 1 | 3 | 2 | 5 | 6 | Yes | | | | | |
| 94 | No | I am a resident | More than 20 years | House | My property is beyond the extent of all potential floods | 6 | 3 | 1 | 2 | 4 | 5 | | Yes | | | | |
| 95 | Yes | I am a resident | More than 20 years | House | My property is beyond the extent of all potential floods | 3 | 4 | 1 | 2 | 3 | 6 | | Yes | | | | |
| 96 | No | I am a resident | More than 20 years | House | My property is beyond the extent of all potential floods | 5 | 1 | 4 | 3 | 6 | 2 | | | Yes | | | |
| 97 | Yes | I am a resident | 5 to 20 years | House | No, I don't know/ I'm not sure whether my property could be flooded | 4 | 1 | 2 | 3 | 5 | 6 | | Yes | | | | |
| 98 | Yes | I am a business owner | More than 20 years | Other | My property could be flooded | 3 | 2 | 4 | 1 | 5 | 6 | | | Yes | | | |
| 99 | Yes | I am a resident | More than 20 years | House | No, I don't know/ I'm not sure whether my property could be flooded | 4 | 1 | 3 | 2 | 5 | 6 | Yes | | | | | |
| 100 | | I own the property | More than 20 years | House | My property is beyond the extent of all potential floods | | | | | Y | | Yes | | | | | |
| 101 | Yes | I am a resident | More than 20 years | House | My property is beyond the extent of all potential floods | 4 | 1 | 2 | 3 | 5 | 6 | Yes | | | | | |
| 102 | No | I am a resident | 5 to 20 years | House | No, I don't know/ I'm not sure whether my property could be flooded | 2 | 1 | 4 | 3 | 5 | 6 | | Yes | | | | |
| 103 | | I own the property | 5 to 20 years | House | My property could be flooded | 4 | 3 | 2 | 1 | 5 | 6 | Yes | | | | | |
| 104 | Yes | I am a resident | 5 to 20 years | House | My property could be flooded | 3 | 2 | 4 | 1 | 6 | 5 | | | Yes | | | |
| 105 | Yes | I own the property | More than 20 years | House | My property is beyond the extent of all potential floods | | | | | | | | | Yes | | | |
| 106 | No | I am a resident | Less than 1 year | Unit/ flat/ apartment | No, I don't know/ I'm not sure whether my property could be flooded | | | | X | | | Yes | Yes | Yes | Yes | | |
| 107 | Yes | I am a resident | More than 20 years | House | My property could be flooded | 4 | 2 | 3 | 1 | 6 | 5 | | | Yes | | | |
| 108 | Yes | I am a resident | More than 20 years | House | My property could be flooded | 4 | 1 | 5 | 3 | 6 | 2 | | | | Yes | | |
| 109 | Yes | I own the property | More than 20 years | House | | | | | | | | Yes | | | | | |
| 110 | Yes | I rent the property | More than 20 years | House | No, I don't know/ I'm not sure whether my property could be flooded | 3 | 1 | 5 | 6 | 2 | 4 | | | | Yes | | |
| 111 | Yes | I own the property | Less than 1 year | House | My property is beyond the extent of all potential floods | 6 | 3 | 2 | 1 | 4 | 5 | | Yes | Yes | | | |
| 112 | Yes | I own the property | 5 to 20 years | Villa/ townhouse | My property is beyond the extent of all potential floods | 6 | 2 | 3 | 1 | 6 | 4 | | Yes | | | | |
| 113 | Yes | I am a resident | More than 20 years | House | No, I don't know/ I'm not sure whether my property could be flooded | 2 | 1 | 2 | 1 | 6 | 1 | Yes | | | | | |
| 114 | Yes | I am a resident | 5 to 20 years | Villa/ townhouse | My property could be flooded | 3 | 1 | 4 | 5 | 6 | 2 | Yes | | | | | |
| 115 | Yes | I am a resident | 5 to 20 years | Villa/ townhouse | No, I don't know/ I'm not sure whether my property could be flooded | 3 | 5 | 4 | 4 | 5 | 4 | Yes | | | | | |
| 116 | No | I am a resident | 5 to 20 years | House | No, I don't know/ I'm not sure whether my property could be flooded | 4 | 3 | 2 | 1 | 6 | 5 | | | | | | Yes |
| 117 | Yes | I am a resident | More than 20 years | House | No, I don't know/ I'm not sure whether my property could be flooded | 4 | 2 | 3 | 1 | 6 | 5 | Yes | | | | | |
| 118 | Yes | I own the property | More than 20 years | House | | 5 | 6 | 1 | 2 | 3 | 4 | | Yes | | | | |
| 119 | Yes | I own the property | 5 to 20 years | House | No, I don't know/ I'm not sure whether my property could be flooded | 4 | 3 | 2 | 1 | 5 | 6 | | Yes | | | | |
| 120 | Yes | I am a resident | More than 20 years | House | My property is beyond the extent of all potential floods | 4 | 1 | 2 | 3 | 5 | 6 | | Yes | | | | |
| 121 | Yes | I own the property | More than 20 years | House | No, I don't know/ I'm not sure whether my property could be flooded | 3 | 1 | 5 | 2 | 6 | 4 | Yes | | | | | |
| 122 | | I own the property | 5 to 20 years | Villa/ townhouse | No, I don't know/ I'm not sure whether my property could be flooded | 4 | 1 | 2 | 3 | 6 | 5 | | Yes | | | | |
| 123 | No | I am a resident | More than 20 years | House | My property is beyond the extent of all potential floods | 5 | 1 | 2 | 4 | 6 | 3 | Yes | | | | | |
| 124 | Yes | I own the property | More than 20 years | House | My property is beyond the extent of all potential floods | | | | | | X | | | | Yes | | |
| 125 | Yes | I am a resident | 1 to 5 years | Villa/ townhouse | | 4 | 1 | 3 | 2 | 6 | 5 | Yes | | | | | |
| 126 | | I own the property | 1 to 5 years | Villa/ townhouse | | 4 | 1 | 3 | 2 | 6 | 5 | Yes | | | | | |
| 127 | | I am a resident | More than 20 years | House | My property is beyond the extent of all potential floods | | | | | | | Yes | | | | | |
| 128 | Yes | I am a resident | More than 20 years | House | My property is beyond the extent of all potential floods | | | | | | | | | | | | Yes |
| 129 | Yes | I own the property | 5 to 20 years | House | My property could be flooded | 4 | 1 | 3 | 2 | 6 | 5 | | | Yes | | | |
| 130 | Yes | I own the property | 1 to 5 years | Unit/ flat/ apartment | My property could be flooded | 6 | 3 | 2 | 1 | 5 | 4 | | | Yes | | | |
| 131 | Yes | I own the property | 5 to 20 years | Villa/ townhouse | My property could be flooded | 4 | 1 | 3 | 2 | 5 | 6 | | | Yes | | | |
| 132 | Yes | I own the property | 5 to 20 years | Unit/ flat/ apartment | My property could be flooded | | | | | | | Yes | | Yes | | | |
| 133 | Yes | I own the property | 5 to 20 years | House | My property is beyond the extent of all potential floods | 6 | 5 | 4 | 3 | 1 | 2 | | | | Yes | | |
| 134 | Yes | I own the property | More than 20 years | House | No, I don't know/ I'm not sure whether my property could be flooded | | | | | | | Yes | | | | | |
| 135 | Yes | I own the property | 1 to 5 years | House | No, I don't know/ I'm not sure whether my property could be flooded | 4 | 1 | 2 | 3 | 5 | 6 | | | | | | Yes |
| 136 | | I own the property | 1 to 5 years | House | No, I don't know/ I'm not sure whether my property could be flooded | 4 | 1 | 3 | 2 | 5 | 6 | | | | Yes | | |
| 137 | Yes | I own the property | 5 to 20 years | House | No, I don't know/ I'm not sure whether my property could be flooded | 6 | 1 | 4 | 3 | 5 | 2 | | | | | | Yes |
| 138 | No | I own the property | More than 20 years | House | My property is beyond the extent of all potential floods | 4 | 3 | 2 | 1 | 5 | 6 | Yes | | | | | |
| 139 | | I am a resident | 1 to 5 years | House | No, I don't know/ I'm not sure whether my property could be flooded | 3 | 1 | 4 | 2 | 5 | 6 | Yes | | | | | |
| 140 | Yes | I am a resident | 5 to 20 years | Villa/ townhouse | My property is beyond the extent of all potential floods | 4 | 2 | 3 | 1 | 5 | 6 | | Yes | | | | |
| 141 | Yes | I own the property | 5 to 20 years | House | My property could be flooded | 4 | 3 | 2 | 1 | 6 | 5 | Yes | | | | | |
| 142 | Yes | I own the property | More than 20 years | House | No, I don't know/ I'm not sure whether my property could be flooded | | | | | | | Yes | | | | | |
| 143 | | | | | | | | | | | | | | | | | |
| 144 | No | I own the property | 1 to 5 years | House | No, I don't know/ I'm not sure whether my property could be flooded | 3 | 1 | 4 | 2 | 6 | 6 | | Yes | | | | |
| 145 | Yes | I own the property | More than 20 years | Vacant land | My property is beyond the extent of all potential floods | | 2 | | | | 1 | | | | Yes | | |
| 146 | Yes | I own the property | 5 to 20 years | Villa/ townhouse | My property could be flooded | 1 | 1 | 1 | 1 | 6 | 6 | Yes | | | | | |
| 147 | No | I own the property | More than 20 years | House | My property is beyond the extent of all potential floods | 5 | 2 | 4 | 3 | 6 | 1 | Yes | | | | | |
| 148 | No | I own the property | More than 20 years | House | My property is beyond the extent of all potential floods | 4 | 5 | 1 | 2 | 3 | 6 | Yes | | | | | |
| 149 | No | I own the property | 1 to 5 years | House | No, I don't know/ I'm not sure whether my property could be flooded | 5 | 3 | 2 | 1 | 6 | 4 | | | | Yes | | |
| 150 | | I am a resident | More than 20 years | House | My property is beyond the extent of all potential floods | 4 | 1 | 3 | 2 | 6 | 5 | | | Yes | | | |
| 151 | | I own the property | 5 to 20 years | House | No, I don't know/ I'm not sure whether my property could be flooded | 5 | 2 | 4 | 1 | 6 | 3 | | | | | | Yes |
| 152 | | I am a resident | More than 20 years | House | No, I don't know/ I'm not sure whether my property could be flooded | | | | | | | | Yes | | | | |
| 153 | | I am a resident | More than 20 years | House | My property is beyond the extent of all potential floods | 6 | 1 | 2 | 4 | 3 | 5 | Yes | | | | | |
| 154 | Yes | I am a resident | 1 to 5 years | Villa/ townhouse | No, I don't know/ I'm not sure whether my property could be flooded | 2 | 1 | 3 | 4 | 5 | 6 | Yes | | | | | |
| 155 | No | I own the property | 1 to 5 years | House | No, I don't know/ I'm not sure whether my property could be flooded | 4 | 1 | 5 | 3 | 6 | 2 | | | Yes | | | |
| 156 | Yes | I own the property | More than 20 years | House | My property could be flooded | 5 | 1 | 2 | 3 | 4 | 6 | | Yes | | | | |
| 157 | Yes | I own the property | 1 to 5 years | House | No, I don't know/ I'm not sure whether my property could be flooded | 3 | 1 | 4 | 2 | 6 | 5 | | | Yes | | | |
| 158 | Yes | I own the property | More than 20 years | House | My property is beyond the extent of all potential floods | 6 | 5 | 3 | 2 | 4 | 1 | Yes | | | | | |
| 159 | No | I own the property | 5 to 20 years | House | No, I don't know/ I'm not sure whether my property could be flooded | 6 | 2 | 1 | 5 | 3 | 4 | | | Yes | | | |
| 160 | Yes | I own the property | 5 to 20 years | Villa/ townhouse | No, I don't know/ I'm not sure whether my property could be flooded | 3 | 1 | 5 | 4 | 6 | 2 | Yes | | | | | |
| 161 | Yes | I am a resident | More than 20 years | House | My property is beyond the extent of all potential floods | 3 | 2 | 4 | 1 | 5 | 6 | | Yes | | | | |
| 162 | Yes | I own the property | 5 to 20 years | House | No, I don't know/ I'm not sure whether my property could be flooded | 4 | 3 | 1 | 2 | 6 | 5 | Yes | | | | | |
| 163 | No | I own the property | More than 20 years | | | | | | | | | | | | | | Yes |
| 164 | Yes | I own the property | 5 to 20 years | House | My property is beyond the extent of all potential floods | 6 | 1 | 3 | 5 | 4 | 2 | | Yes | | | | |
| 165 | No | I am a resident | 5 to 20 years | House | No, I don't know/ I'm not sure whether my property could be flooded | 4 | 3 | 2 | 1 | 6 | 5 | | | | Yes | | |
| 166 | Yes | I own the property | 5 to 20 years | Unit/ flat/ apartment | No, I don't know/ I'm not sure whether my property could be flooded | 4 | 1 | 2 | 3 | 6 | 5 | Yes | | | | | |
| 167 | No | I own the property | More than 20 years | House | My property is beyond the extent of all potential floods | 2 | 1 | 3 | 4 | 5 | 6 | Yes | | | | | |
| 168 | Yes | I own the property | 1 to 5 years | House | No, I don't know/ I'm not sure whether my property could be flooded | 5 | 2 | 1 | 3 | 4 | 6 | | | Yes | | | |
| 169 | | I rent the property | 5 to 20 years | House | My property is beyond the extent of all potential floods | 4 | 1 | 3 | 2 | 6 | 5 | | | Yes | | | |
| 170 | Yes | I own the property | More than 20 years | House | My property is beyond the extent of all potential floods | 5 | 6 | 2 | 1 | 4 | 3 | | | | Yes | | |
| 171 | No | I am a resident | More than 20 years | House | No, I don't know/ I'm not sure whether my property could be flooded | 4 | 3 | 2 | 1 | 6 | 5 | | | Yes | | | |
| 172 | N | I own the property | 5 to 20 years | House | My property could be flooded | 5 | 4 | 2 | 3 | 6 | 1 | | | Yes | | | |

| # | Please indicate if and how you would like us to contact you for more information or to provide you with study updates | About your property | | | | Please rank the following development types according to which you think are the most important to protect from floods | | | | | | What level of control do you think Council should place on new development to minimise flood-related risks? | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Please select as appropriate | How long have you been at this address? | Property Type | Do you know if your property has a risk of being flooded? | Commercial | Residential | Essential community facilities | Critical Utilities | Minor developments and additions | New residential developments | Prohibit all new development on land with any potential to flood | Prohibit all new development only in those locations that would be extremely hazardous to persons or property due to the depth and/or velocity of floodwaters, or evacuation difficulties | Place restrictions on developments which reduce the potential for flood damage (e.g. minimum floor level controls or using flood compatible building materials) | Advise of the flood risks, but allow the individual a choice about developing or not, provided steps are taken to minimise potential flood risks | Provide no advice about potential flood risks or measures that could minimise those risks | Don't know |
| 173 | Yes | I own the property | 5 to 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 6 | 1 | 3 | 2 | 4 | 5 | | | | Yes | | |
| 174 | Yes | I own the property | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 4 | 2 | 3 | 1 | 6 | 5 | Yes | | | | | |
| 175 | No | I am a resident | More than 20 years | House | My property is beyond the extent of all potential floods | 6 | 5 | 4 | 3 | 2 | 1 | Yes | | | | | |
| 176 | | I am a resident | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 4 | 1 | 3 | 2 | 6 | 5 | Yes | | | | | |
| 177 | Yes | I am a resident | More than 20 years | House | My property could be flooded | | | | | | | Yes | | | | | |
| 178 | Yes | I own the property | 5 to 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | | 1 | | | | | | | | | | Yes |
| 179 | Yes | I am a resident | More than 20 years | House | My property is beyond the extent of all potential floods | 4 | 1 | 2 | 3 | 6 | 5 | | | Yes | | | |
| 180 | Yes | I am a resident | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 4 | 1 | 3 | 2 | 6 | 5 | | Yes | | | | |
| 181 | | I am a resident | More than 20 years | House | | 4 | 3 | 2 | 1 | 6 | 5 | | Yes | | | | |
| 182 | Yes | I am a resident | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 5 | 1 | 4 | 2 | 3 | 6 | | Yes | Yes | | | |
| 183 | Yes | I am a business owner | More than 20 years | Industrial unit or warehouse | My property could be flooded | 6 | 2 | 4 | 5 | 3 | 1 | | | | Yes | | |
| 184 | Yes | I am a resident | More than 20 years | House | My property is beyond the extent of all potential floods | 3 | 2 | 4 | 6 | 5 | 1 | Yes | | | | | |
| 185 | Yes | I own the property | 1 to 5 years | Unit/ flat/ apartment | No, I don't know/I'm not sure whether my property could be flooded | 4 | 1 | 2 | 3 | 5 | 6 | | | Yes | | | |
| 186 | Yes | I own the property | More than 20 years | House | My property could be flooded | 4 | 1 | 2 | 3 | 5 | 6 | | | Yes | | | |
| 187 | Yes | I am a resident | 1 to 5 years | House | No, I don't know/I'm not sure whether my property could be flooded | 4 | 3 | 1 | 2 | 6 | 5 | Yes | | | | | |
| 188 | No | I am a resident | More than 20 years | House | | | | | | | | Yes | | | | | |
| 189 | Yes | I own the property | 5 to 20 years | Unit/ flat/ apartment | No, I don't know/I'm not sure whether my property could be flooded | 5 | 4 | 2 | 1 | 6 | 3 | | | | Yes | | |
| 190 | Yes | I am a resident | More than 20 years | House | My property is beyond the extent of all potential floods | 2 | 1 | 2 | 1 | 4 | 6 | | | Yes | | | |
| 191 | Yes | I own the property | 5 to 20 years | Villa/ townhouse | No, I don't know/I'm not sure whether my property could be flooded | | | | | | | Yes | | | | | |
| 192 | Yes | I am a resident | More than 20 years | House | My property is beyond the extent of all potential floods | | | 1 | 1 | | | Yes | | | | | |
| 193 | | I am a resident | More than 20 years | House | My property could be flooded | | | | | | | Yes | | | | | |
| 194 | Yes | I am a resident | Less than 1 year | House | No, I don't know/I'm not sure whether my property could be flooded | 2 | 1 | 3 | 4 | 5 | 6 | | Yes | | | | |
| 195 | Yes | I am a resident | 1 to 5 years | House | My property could be flooded | | | | | | | Yes | | Yes | | | |
| 196 | Yes | I own the property | Less than 1 year | House | No, I don't know/I'm not sure whether my property could be flooded | | | | | | | | | Yes | | | |
| 197 | Yes | I am a resident | 5 to 20 years | Unit/ flat/ apartment | No, I don't know/I'm not sure whether my property could be flooded | | | | | | | Yes | | | | | |
| 198 | Yes | I own the property | More than 20 years | House | My property is beyond the extent of all potential floods | 3 | 1 | 4 | 5 | 6 | 2 | | | | Yes | | |
| 199 | Yes | I own the property | More than 20 years | House | My property could be flooded | 6 | 1 | 4 | 3 | 5 | 2 | | | Yes | | | |
| 200 | Yes | I am a resident | More than 20 years | House | My property could be flooded | 3 | 2 | 5 | 1 | 6 | 4 | Yes | | | | | |
| 201 | Yes | I am a resident | 5 to 20 years | Villa/ townhouse | My property could be flooded | 4 | 1 | 2 | 3 | 5 | 6 | | Yes | | | | |
| 202 | Yes | I am a resident | More than 20 years | House | My property is beyond the extent of all potential floods | 5 | 3 | 4 | 2 | 6 | 1 | Yes | | | | | |
| 203 | Yes | I am a resident | 5 to 20 years | Villa/ townhouse | No, I don't know/I'm not sure whether my property could be flooded | 2 | 1 | 3 | 4 | 6 | 5 | Yes | | | | | |
| 204 | Yes | I own the property | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 5 | 1 | 3 | 2 | 6 | 4 | | | | Yes | | |
| 205 | Yes | I own the property | 1 to 5 years | Villa/ townhouse | No, I don't know/I'm not sure whether my property could be flooded | 3 | 5 | 1 | 4 | 6 | 2 | | | Yes | | | |
| 206 | No | I own the property | More than 20 years | House | My property could be flooded | 4 | 2 | 3 | 1 | 6 | 5 | Yes | | | | | |
| 207 | Yes | I am a resident | 1 to 5 years | House | No, I don't know/I'm not sure whether my property could be flooded | 4 | 3 | 2 | 1 | 5 | 6 | | | | | | |
| 208 | Yes | I own the property | More than 20 years | Vacant land | My property is beyond the extent of all potential floods | 3 | 4 | 2 | 5 | 6 | 1 | | | | Yes | | |
| 209 | Yes | I am a resident | 5 to 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 4 | 1 | 5 | 2 | 6 | 3 | | | Yes | | | |
| 210 | Yes | I own the property | More than 20 years | House | My property could be flooded | 4 | 2 | 3 | 1 | 5 | 6 | Yes | | | | | |
| 211 | Yes | I own the property | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 5 | 1 | 4 | 3 | 6 | 2 | | | | | | Yes |
| 212 | Yes | I own the property | More than 20 years | Villa/ townhouse | My property could be flooded | 6 | 4 | 3 | 2 | 6 | 1 | | | Yes | | | |
| 213 | Yes | I am a resident | 5 to 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 4 | 1 | 5 | 2 | 6 | 3 | | | Yes | | | |
| 214 | Yes | | | | | | | | | | | | | | | | |
| 215 | Yes | I own the property | More than 20 years | House | My property could be flooded | 4 | 2 | 3 | 1 | 5 | 6 | Yes | | | | | |
| 216 | Yes | I own the property | Less than 1 year | Villa/ townhouse | My property is beyond the extent of all potential floods | 3 | | 6 | 1 | 5 | 5 | | | | Yes | | |
| 217 | Yes | I own the property | More than 20 years | Villa/ townhouse | My property could be flooded | 4 | 1 | 2 | 3 | 6 | 5 | Yes | | | | | |
| 218 | No | I am a resident | More than 20 years | House | My property is beyond the extent of all potential floods | | | | | | | | | | Yes | | |
| 219 | Yes | I own the property | 1 to 5 years | Villa/ townhouse | No, I don't know/I'm not sure whether my property could be flooded | 1 | 1 | 1 | 1 | 1 | 1 | Yes | | | | | |
| 220 | No | I am a resident | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 4 | 2 | 3 | 1 | 6 | 5 | | | | Yes | | |
| 221 | Yes | I am a resident | Less than 1 year | Unit/ flat/ apartment | No, I don't know/I'm not sure whether my property could be flooded | 5 | 1 | 4 | 3 | 6 | 2 | Yes | | | | | |
| 222 | Yes | I am a resident | Less than 1 year | House | No, I don't know/I'm not sure whether my property could be flooded | 4 | 1 | 3 | 2 | 6 | 5 | | | Yes | | | |
| 223 | | I am a resident | More than 20 years | House | My property could be flooded | 5 | 1 | 3 | 2 | 6 | 4 | Yes | | | | | |
| 224 | Yes | I rent the property | 5 to 20 years | House | My property is beyond the extent of all potential floods | 4 | 3 | 2 | 1 | 5 | 6 | | Yes | | | | |
| 225 | No | I own the property | 5 to 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 4 | 3 | 2 | 1 | 5 | 6 | Yes | | | | | |
| 226 | | Other – please describe | 5 to 20 years | Other | My property could be flooded | 4 | 3 | 2 | 1 | 6 | 5 | | Yes | | | | |
| 227 | Yes | Other – please describe | More than 20 years | House | My property is beyond the extent of all potential floods | 2 | 1 | 4 | 3 | 6 | 5 | | | Yes | | | |
| 228 | No | I am a resident | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 4 | 1 | 3 | 2 | 6 | 5 | | Yes | | | | |
| 229 | Yes | I own the property | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 5 | 1 | 3 | 2 | 6 | 4 | | | | Yes | | |
| 230 | No | I own the property | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 4 | 5 | 1 | 2 | 3 | 6 | | | Yes | | | |
| 231 | Yes | I own the property | 1 to 5 years | House | My property is beyond the extent of all potential floods | | | | | | | Yes | | | | | |
| 232 | Yes | I am a business owner | More than 20 years | House | My property is beyond the extent of all potential floods | 4 | 2 | 1 | 3 | 5 | 6 | | | Yes | | | |
| 233 | Yes | I am a resident | More than 20 years | House | My property is beyond the extent of all potential floods | 4 | 3 | 6 | 5 | 1 | 2 | | Yes | | | | |
| 234 | Yes | I own the property | 1 to 5 years | Villa/ townhouse | No, I don't know/I'm not sure whether my property could be flooded | 1 | 2 | 5 | 4 | 6 | 3 | | | | Yes | | |
| 235 | Yes | I own the property | 5 to 20 years | Villa/ townhouse | No, I don't know/I'm not sure whether my property could be flooded | 6 | 2 | 3 | 1 | 4 | 5 | Yes | | | | | |

| # | Please indicate if and how you would like us to contact you for more information or to provide you with study updates | About your property | | | | Please rank the following development types according to which you think are the most important to protect from floods | | | | | | What level of control do you think Council should place on new development to minimise flood-related risks? | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Please select as appropriate | How long have you been at this address? | Property Type | Do you know if your property has a risk of being flooded? | Commercial | Residential | Essential community facilities | Critical Utilities | Minor developments and additions | New residential developments | Prohibit all new development on land with any potential to flood | Prohibit all new development only in those locations that would be extremely hazardous to persons or property due to the depth and/or velocity of floodwaters, or evacuation difficulties | Place restrictions on developments which reduce the potential for flood damage (e.g. minimum floor level controls or using flood compatible building materials) | Advise of the flood risks, but allow the individual a choice about developing or not, provided steps are taken to minimise potential flood risks | Provide no advice about potential flood risks or measures that could minimise those risks | Don't know |
| 236 | Yes | I am a resident | 5 to 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 4 | 3 | 2 | 1 | 5 | 6 | | Yes | | | | |
| 237 | No | I am a resident | 5 to 20 years | Villa/ townhouse | No, I don't know/I'm not sure whether my property could be flooded | 4 | 3 | 2 | 1 | 6 | 5 | | | Yes | | | |
| 238 | No | I am a resident | Less than 1 year | House | No, I don't know/I'm not sure whether my property could be flooded | 4 | 1 | 3 | 5 | 6 | 2 | Yes | | | | | |
| 239 | No | I own the property | More than 20 years | House | | 6 | 1 | 3 | 2 | 4 | 5 | Yes | | | | | |
| 240 | Yes | I am a resident | More than 20 years | House | My property could be flooded | 5 | 1 | 3 | 2 | 6 | 4 | Yes | | | | | |
| 241 | Yes | I own the property | 5 to 20 years | House | My property is beyond the extent of all potential floods | 4 | 2 | 1 | 3 | 5 | 6 | | | Yes | | | |
| 242 | Yes | I own the property | More than 20 years | House | My property could be flooded | 2 | 1 | 3 | 5 | 6 | 4 | | | Yes | | | |
| 243 | Yes | I own the property | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | | | | | | | Yes | | | | | |
| 244 | Yes | I own the property | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 6 | 1 | 2 | 1 | 2 | 6 | Yes | | | | | |
| 245 | No | I own the property | 5 to 20 years | House | My property is beyond the extent of all potential floods | 2 | 1 | 6 | 3 | 5 | 4 | | | Yes | | | |
| 246 | Yes | I own the property | 5 to 20 years | Villa/ townhouse | No, I don't know/I'm not sure whether my property could be flooded | 2 | 1 | 3 | 4 | 6 | 5 | | | | Yes | | |
| 247 | Yes | I own the property | 1 to 5 years | Unit/ flat/ apartment | No, I don't know/I'm not sure whether my property could be flooded | 4 | 3 | 2 | 1 | 5 | 6 | | | | Yes | | |
| 248 | Yes | I own the property | 1 to 5 years | House | My property could be flooded | 4 | 2 | 5 | 1 | 6 | 3 | | Yes | | | | |
| 249 | Yes | I own the property | 5 to 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 2 | 1 | 4 | 3 | 5 | 6 | | | | Yes | | |
| 250 | Yes | I am a resident | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 4 | 3 | 2 | 1 | 6 | 5 | | | | Yes | | |
| 251 | Yes | I am a resident | 1 to 5 years | House | No, I don't know/I'm not sure whether my property could be flooded | 4 | 1 | 2 | 3 | 6 | 5 | | Yes | | | | |
| 252 | Yes | I own the property | 1 to 5 years | House | | 5 | 1 | 4 | 3 | 6 | 2 | Yes | | | | | |
| 253 | Yes | I am a resident | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | | | | | | | Yes | | | | | |
| 254 | No | I own the property | 1 to 5 years | Villa/ townhouse | No, I don't know/I'm not sure whether my property could be flooded | 4 | 1 | 5 | 3 | 6 | 2 | | | Yes | | | |
| 255 | Yes | I am a resident | More than 20 years | House | My property is beyond the extent of all potential floods | 6 | 1 | 4 | 5 | 2 | 3 | Yes | | | | | |
| 256 | No | I own the property | More than 20 years | House | My property could be flooded | 5 | 2 | 4 | 1 | 6 | 3 | Yes | | | | | |
| 257 | | I own the property | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | | | | | | | Yes | | | | | |
| 258 | | I am a resident | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | | | | | | | | | | | | Yes |
| 259 | No | I am a resident | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 4 | 5 | 2 | 1 | 3 | 6 | Yes | | | | | |
| 260 | Yes | I own the property | More than 20 years | House | My property could be flooded | 6 | 5 | 2 | 1 | 3 | 4 | Yes | | | | | |
| 261 | | | | | | | | | | | | | | | | | |
| 262 | | | | | | | | | | | | | | | | | |
| 263 | Yes | I own the property | More than 20 years | House | My property could be flooded | 5 | 1 | 4 | 3 | 6 | 2 | Yes | Yes | Yes | | | |
| 264 | No | I own the property | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 3 | 1 | 2 | 4 | 6 | 5 | Yes | | | | | |
| 265 | | I own the property | Less than 1 year | House | No, I don't know/I'm not sure whether my property could be flooded | | | | | | | | Yes | | | | |
| 266 | No | I am a resident | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 4 | 1 | 5 | 3 | 6 | 2 | | Yes | | | | |
| 267 | No | I own the property | More than 20 years | House | My property is beyond the extent of all potential floods | | | | | | | Yes | | | | | |
| 268 | Yes | I am a resident | More than 20 years | House | My property is beyond the extent of all potential floods | | | | | | | Yes | | | | | |
| 269 | Yes | I rent the property | 5 to 20 years | Villa/ townhouse | No, I don't know/I'm not sure whether my property could be flooded | 5 | 1 | 4 | 3 | 6 | 2 | Yes | | | | | |
| 270 | Yes | I am a resident | 1 to 5 years | House | No, I don't know/I'm not sure whether my property could be flooded | 5 | 3 | 2 | 1 | 6 | 4 | | | | Yes | | |
| 271 | Yes | I own the property | More than 20 years | House | My property is beyond the extent of all potential floods | | | | | | | | | | | | Yes |
| 272 | No | I own the property | 5 to 20 years | Unit/ flat/ apartment | My property could be flooded | 3 | 2 | 4 | 5 | 6 | 1 | Yes | | | | | |
| 273 | Yes | I am a resident | 1 to 5 years | House | My property is beyond the extent of all potential floods | 5 | 1 | 4 | 3 | 6 | 2 | Yes | | | | | |
| 274 | | I own the property | 5 to 20 years | Villa/ townhouse | My property could be flooded | 4 | 1 | 3 | 2 | 5 | 6 | Yes | | | | | |

| # | Please indicate if and how you would like us to contact you for more information or to provide you with study updates | About your property | | | | Please rank the following development types according to which you think are the most important to protect from floods | | | | | | What level of control do you think Council should place on new development to minimise flood-related risks? | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Please select as appropriate | How long have you been at this address? | Property Type | Do you know if your property has a risk of being flooded? | Commercial | Residential | Essential community facilities | Critical Utilities | Minor developments and additions | New residential developments | Prohibit all new development on land with any potential to flood | Prohibit all new development only in those locations that would be extremely hazardous to persons or property due to the depth and/or velocity of floodwaters, or evacuation difficulties | Place restrictions on developments which reduce the potential for flood damage (e.g. minimum floor level controls or using flood compatible building materials) | Advise of the flood risks, but allow the individual a choice about developing or not, provided steps are taken to minimise potential flood risks | Provide no advice about potential flood risks or measures that could minimise those risks | Don't know |
| 275 | No | I am a resident | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | | | | | | | | | | | | |
| 276 | Yes | Other – please describe | More than 20 years | | | 6 | 4 | 2 | 3 | 1 | 5 | Yes | | | | | |
| 277 | | I own the property | More than 20 years | House | My property could be flooded | 2 | 1 | 1 | 1 | 1 | 1 | | | Yes | Yes | | |
| 278 | Yes | I own the property | More than 20 years | House | My property is beyond the extent of all potential floods | | | | 1 | | | Yes | | | | | |
| 279 | Yes | I am a resident | 1 to 5 years | Villa/ townhouse | My property could be flooded | 3 | 4 | 2 | 1 | 6 | 5 | | | Yes | | | |
| 280 | Yes | I am a resident | Less than 1 year | House | No, I don't know/I'm not sure whether my property could be flooded | | | | | | | Yes | | | | | |
| 281 | | I am a resident | More than 20 years | House | My property could be flooded | 3 | 1 | 2 | 4 | 6 | 5 | | Yes | | | | |
| 282 | No | I own the property | 5 to 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 5 | 1 | 3 | 2 | 6 | 4 | | | Yes | | | |
| 283 | | I am a resident | 5 to 20 years | House | My property is beyond the extent of all potential floods | | | | | | | | | Yes | | | |
| 284 | Yes | I own the property | More than 20 years | House | My property is beyond the extent of all potential floods | | 1 | | | | | Yes | | | | | |
| 285 | Yes | I am a resident | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | | | | | | | Yes | | | | | |
| 286 | Yes | I own the property | 1 to 5 years | House | My property could be flooded | 6 | 1 | 4 | 3 | 5 | 2 | | Yes | | | | |
| 287 | | I am a resident | 5 to 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 3 | 2 | 4 | 1 | 6 | 5 | | Yes | | | | |
| 288 | Yes | I am a resident | 1 to 5 years | House | My property could be flooded | 6 | 2 | 4 | 5 | 3 | 1 | | Yes | | | | |
| 289 | Yes | I own the property | 1 to 5 years | House | No, I don't know/I'm not sure whether my property could be flooded | 5 | 1 | 3 | 2 | 6 | 4 | | | Yes | | | |
| 290 | Yes | I own the property | 5 to 20 years | Villa/ townhouse | My property could be flooded | 6 | 1 | 3 | 2 | 4 | 5 | | Yes | | | | |
| 291 | | I am a resident | 5 to 20 years | Villa/ townhouse | My property is beyond the extent of all potential floods | 6 | 1 | 3 | 4 | 5 | 2 | | Yes | | | | |
| 292 | Yes | I rent the property | 5 to 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 4 | 2 | 3 | 1 | 6 | 5 | Yes | | | | | |
| 293 | Yes | I am a resident | More than 20 years | House | My property is beyond the extent of all potential floods | 4 | 1 | 3 | 2 | 5 | 6 | Yes | | | | | |
| 294 | | I am a resident | 1 to 5 years | House | No, I don't know/I'm not sure whether my property could be flooded | 4 | 1 | 2 | 3 | 6 | 5 | | | Yes | | | |
| 295 | No | I am a resident | 1 to 5 years | Villa/ townhouse | My property could be flooded | 4 | 2 | 3 | 1 | 5 | 6 | | Yes | | | | |
| 296 | Yes | I own the property | 5 to 20 years | Unit/ flat/ apartment | No, I don't know/I'm not sure whether my property could be flooded | 3 | 2 | 4 | 5 | 6 | 1 | | | | Yes | | |
| 297 | No | I own the property | 5 to 20 years | House | My property could be flooded | | | | | | | Yes | | | | | |
| 298 | Yes | I own the property | | House | No, I don't know/I'm not sure whether my property could be flooded | | | | | | | | Yes | | | | |
| 299 | Yes | I am a resident | 5 to 20 years | Villa/ townhouse | My property could be flooded | 3 | 1 | 4 | 2 | 6 | 5 | | Yes | | | | |
| 300 | Yes | I own the property | 1 to 5 years | House | No, I don't know/I'm not sure whether my property could be flooded | 4 | 1 | 2 | 3 | 5 | 6 | | | | Yes | | |
| 301 | | I am a resident | 5 to 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 5 | 1 | 3 | 2 | 6 | 4 | Yes | | | | | |
| 302 | Yes | I own the property | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 3 | 2 | 4 | 1 | 6 | 5 | Yes | | Yes | | | Yes |
| 303 | Yes | I own the property | Less than 1 year | Vacant land | No, I don't know/I'm not sure whether my property could be flooded | 6 | 5 | 3 | 1 | 2 | 4 | | | | Yes | | |
| 304 | Yes | I own the property | 1 to 5 years | House | No, I don't know/I'm not sure whether my property could be flooded | 4 | 2 | 3 | 1 | 5 | 6 | Yes | | | | | |
| 305 | Yes | I am a resident | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 5 | 1 | 4 | 3 | 6 | 2 | Yes | | | | | |
| 306 | No | I am a resident | More than 20 years | House | My property is beyond the extent of all potential floods | 3 | 1 | 4 | 2 | 6 | 5 | | | | Yes | | |
| 307 | Yes | I am a resident | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | | | | | | | Yes | | | | | |
| 308 | No | I am a resident | More than 20 years | House | My property could be flooded | 4 | 3 | 1 | 2 | 5 | 6 | Yes | | | | | |
| 309 | | I own the property | More than 20 years | House | My property is beyond the extent of all potential floods | 6 | 3 | 1 | 2 | 5 | 4 | Yes | | | | | |
| 310 | Yes | I own the property | 1 to 5 years | Industrial unit or warehouse | No, I don't know/I'm not sure whether my property could be flooded | 1 | 2 | 3 | 4 | 5 | 6 | Yes | | | | | |
| 311 | | I own the property | 5 to 20 years | Villa/ townhouse | My property could be flooded | 4 | 1 | 6 | 5 | 3 | 2 | | Yes | | | | |
| 312 | Yes | I own the property | 5 to 20 years | Unit/ flat/ apartment | My property is beyond the extent of all potential floods | | | | | | | | | Yes | | | |
| 313 | Yes | I am a resident | 1 to 5 years | House | My property is beyond the extent of all potential floods | | | | | | | | | Yes | | | |
| 314 | No | I own the property | 5 to 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | | | | | | | | | | | | Yes |

| # | Please indicate if and how you would like us to contact you for more information or to provide you with study updates | About your property | | | | Please rank the following development types according to which you think are the most important to protect from floods | | | | | | What level of control do you think Council should place on new development to minimise flood-related risks? | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Please select as appropriate | How long have you been at this address? | Property Type | Do you know if your property has a risk of being flooded? | Commercial | Residential | Essential community facilities | Critical Utilities | Minor developments and additions | New residential developments | Prohibit all new development on land with any potential to flood | Prohibit all new development only in those locations that would be extremely hazardous to persons or property due to the depth and/or velocity of floodwaters, or evacuation difficulties | Place restrictions on developments which reduce the potential for flood damage (e.g. minimum floor level controls or using flood compatible building materials) | Advise of the flood risks, but allow the individual a choice about developing or not, provided steps are taken to minimise potential flood risks | Provide no advice about potential flood risks or measures that could minimise those risks | Don't know |
| 315 | No | I am a resident | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 4 | 1 | 3 | 2 | 5 | 6 | | Yes | | | | |
| 316 | Yes | I own the property | 5 to 20 years | Villa/ townhouse | No, I don't know/I'm not sure whether my property could be flooded | 4 | 3 | 2 | 1 | 6 | 5 | | | | | | Yes |
| 317 | Yes | I own the property | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | | | | | | | | | | | | Yes |
| 318 | Yes | I own the property | 1 to 5 years | Villa/ townhouse | No, I don't know/I'm not sure whether my property could be flooded | 4 | 1 | 3 | 2 | 6 | 5 | | Yes | | | | |
| 319 | No | I own the property | More than 20 years | House | My property is beyond the extent of all potential floods | 3 | 2 | 6 | 5 | 4 | 1 | | | Yes | | | |
| 320 | No | I own the property | More than 20 years | House | My property could be flooded | 3 | 2 | 6 | 5 | 4 | 1 | | | Yes | | | |
| 321 | Yes | Other – please describe | More than 20 years | House | My property is beyond the extent of all potential floods | 3 | 2 | 6 | 5 | 4 | 1 | | | Yes | | | |
| 322 | Yes | Other – please describe | More than 20 years | House | My property is beyond the extent of all potential floods | 3 | 2 | 6 | 5 | 4 | 1 | | | Yes | | | |
| 323 | Yes | I own the property | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 5 | 3 | 2 | 1 | 6 | 4 | Yes | | | | | |
| 324 | Yes | I own the property | More than 20 years | House | My property is beyond the extent of all potential floods | 6 | 1 | 3 | 2 | 5 | 4 | Yes | | | | | |
| 325 | Yes | I am a resident | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 4 | 1 | 2 | 3 | 6 | 5 | Yes | | | | | |
| 326 | No | I am a resident | 1 to 5 years | Unit/ flat/ apartment | No, I don't know/I'm not sure whether my property could be flooded | | | | | | | Yes | | | | | |
| 327 | No | I am a resident | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 4 | 2 | 3 | 1 | 6 | 5 | | | Yes | | | |
| 328 | | I am a resident | Less than 1 year | House | No, I don't know/I'm not sure whether my property could be flooded | 3 | 1 | 4 | 2 | 6 | 5 | | | | | | Yes |
| 329 | No | I own the property | More than 20 years | Vacant land | My property could be flooded | 3 | 2 | 6 | 5 | 4 | 1 | | | Yes | | | |
| 330 | Yes | I own the property | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 2 | 1 | 6 | 5 | 4 | 3 | | Yes | | | | |
| 331 | Yes | I own the property | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | | | | | | | | | | Yes | | |
| 332 | | I am a resident | 5 to 20 years | House | My property could be flooded | | | | | | 1 | Yes | | | | | |
| 333 | Yes | I own the property | 5 to 20 years | House | My property is beyond the extent of all potential floods | | | | | | | Yes | | | | | |
| 334 | No | I own the property | More than 20 years | Villa/ townhouse | No, I don't know/I'm not sure whether my property could be flooded | 5 | 3 | 2 | 1 | 6 | 4 | Yes | | | | | |
| 335 | No | I own the property | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 2 | 4 | 3 | 1 | 5 | 6 | Yes | | | | | |
| 336 | | I own the property | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 4 | 1 | 1 | 2 | 2 | 5 | Yes | Yes | | | | |
| 337 | Yes | I own the property | Less than 1 year | House | No, I don't know/I'm not sure whether my property could be flooded | 6 | 1 | 2 | 3 | 4 | 5 | | | Yes | | | |
| 338 | | I am a resident | 5 to 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | | | 1 | 1 | | | Yes | | | | | |
| 339 | No | I own the property | 1 to 5 years | | | 6 | 1 | 5 | 4 | 3 | 2 | | | | | | Yes |
| 340 | | I own the property | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 2 | 1 | 2 | 1 | 3 | 3 | Yes | | | | | |
| 341 | Yes | I own the property | 1 to 5 years | Unit/ flat/ apartment | No, I don't know/I'm not sure whether my property could be flooded | 5 | 1 | 4 | 3 | 6 | 2 | | | Yes | | | |
| 342 | Yes | I own the property | 1 to 5 years | Unit/ flat/ apartment | No, I don't know/I'm not sure whether my property could be flooded | 4 | 1 | 2 | 3 | 6 | 5 | | Yes | | | | |
| 343 | Yes | I own the property | 1 to 5 years | Villa/ townhouse | My property could be flooded | 3 | 2 | 6 | 5 | 4 | 1 | | | | | | Yes |
| 344 | Yes | I am a resident | More than 20 years | House | My property is beyond the extent of all potential floods | 2 | 1 | 3 | 4 | 5 | 6 | Yes | | | | | |
| 345 | | I am a resident | More than 20 years | House | My property is beyond the extent of all potential floods | | | | | | | Yes | Yes | Yes | | | |
| 346 | Yes | I own the property | More than 20 years | House | My property could be flooded | 4 | 1 | 2 | 3 | 5 | 6 | | | | Yes | | |
| 347 | Yes | I am a resident | More than 20 years | House | My property is beyond the extent of all potential floods | 4 | 2 | 3 | 1 | 6 | 5 | | Yes | | | | |
| 348 | Yes | I am a resident | More than 20 years | House | | 2 | 1 | 3 | 4 | 6 | 5 | | Yes | | Yes | | |
| 349 | Yes | I own the property | 5 to 20 years | Villa/ townhouse | My property is beyond the extent of all potential floods | 1 | 3 | 1 | 2 | 6 | 5 | Yes | | | | | |
| 350 | Yes | I am a resident | More than 20 years | House | My property is beyond the extent of all potential floods | 2 | 1 | 3 | 4 | 6 | 5 | Yes | | | | | |
| 351 | Yes | I own the property | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 5 | 1 | 2 | 3 | 6 | 4 | Yes | | | | | |
| 352 | Yes | I own the property | Less than 1 year | House | No, I don't know/I'm not sure whether my property could be flooded | 4 | 1 | 3 | 2 | 6 | 5 | Yes | | | | | |

| # | Please indicate if and how you would like us to contact you for more information or to provide you with study updates | About your property | | | | Please rank the following development types according to which you think are the most important to protect from floods | | | | | | What level of control do you think Council should place on new development to minimise flood-related risks? | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Please select as appropriate | How long have you been at this address? | Property Type | Do you know if your property has a risk of being flooded? | Commercial | Residential | Essential community facilities | Critical Utilities | Minor developments and additions | New residential developments | Prohibit all new development on land with any potential to flood | Prohibit all new development only in those locations that would be extremely hazardous to persons or property due to the depth and/or velocity of floodwaters, or evacuation difficulties | Place restrictions on developments which reduce the potential for flood damage (e.g. minimum floor level controls or using flood compatible building materials) | Advise of the flood risks, but allow the individual a choice about developing or not, provided steps are taken to minimise potential flood risks | Provide no advice about potential flood risks or measures that could minimise those risks | Don't know |
| 353 | Yes | I own the property | More than 20 years | House | My property could be flooded | | | | | | | Yes | | | | | |
| 354 | Yes | I own the property | More than 20 years | House | My property could be flooded | | | | | | | | Yes | | | | |
| 355 | Yes | I am a resident | More than 20 years | House | My property could be flooded | 6 | 3 | 2 | 1 | 5 | 4 | | Yes | | | | |
| 356 | No | I am a resident | 5 to 20 years | House | My property could be flooded | 4 | 1 | 3 | 5 | 6 | 2 | Yes | | | | | |
| 357 | Yes | I am a resident | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 4 | 3 | 2 | 1 | 6 | 5 | Yes | | | | | |
| 358 | | I own the property | 5 to 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 4 | 2 | 3 | 1 | 5 | 6 | Yes | | | | | |
| 359 | Yes | I own the property | 5 to 20 years | Unit/ flat/ apartment | No, I don't know/I'm not sure whether my property could be flooded | 5 | 3 | 2 | 1 | 6 | 4 | | | Yes | | | |
| 360 | Yes | I am a resident | More than 20 years | Villa/ townhouse | My property could be flooded | 4 | 3 | 2 | 1 | 5 | 6 | Yes | | | | | |
| 361 | Yes | I own the property | 5 to 20 years | Villa/ townhouse | No, I don't know/I'm not sure whether my property could be flooded | 4 | 2 | 5 | 1 | 6 | 3 | | Yes | Yes | | | |
| 362 | Yes | I own the property | More than 20 years | House | | 5 | 3 | 2 | 1 | 6 | 4 | | | Yes | | | |
| 363 | No | I own the property | 1 to 5 years | House | My property is beyond the extent of all potential floods | 2 | 1 | 4 | 3 | 5 | 6 | Yes | | | | | |
| 364 | | | | | | | | | | | | | | | | | |
| 365 | Yes | I am a resident | 1 to 5 years | House | My property could be flooded | 6 | 1 | 2 | 3 | 5 | 4 | Yes | | | | | |
| 366 | Yes | I am a resident | 5 to 20 years | Villa/ townhouse | My property could be flooded | 5 | 1 | 3 | 2 | 4 | 6 | Yes | | | | | |
| 367 | Yes | I own the property | 5 to 20 years | Villa/ townhouse | No, I don't know/I'm not sure whether my property could be flooded | 4 | 1 | 3 | 2 | 5 | 6 | | Yes | | | | |
| 368 | No | I own the property | 5 to 20 years | Villa/ townhouse | No, I don't know/I'm not sure whether my property could be flooded | | | | | | | | | | Yes | | |
| 369 | Yes | I own the property | 1 to 5 years | House | No, I don't know/I'm not sure whether my property could be flooded | 5 | 6 | 1 | 3 | 4 | 2 | | Yes | | | | |
| 370 | Yes | I am a resident | 5 to 20 years | Unit/ flat/ apartment | No, I don't know/I'm not sure whether my property could be flooded | 6 | 1 | 3 | 4 | 5 | 2 | | Yes | | | | |
| 371 | No | I own the property | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 4 | 1 | 3 | 2 | 6 | 5 | | | Yes | | | |
| 372 | No | I own the property | More than 20 years | House | My property is beyond the extent of all potential floods | 4 | 2 | 1 | 3 | 5 | 6 | | Yes | | | | |
| 373 | Yes | I own the property | Less than 1 year | Unit/ flat/ apartment | My property could be flooded | 6 | 1 | 4 | 3 | 5 | 2 | | | Yes | | | |
| 374 | Yes | I am a resident | More than 20 years | | My property is beyond the extent of all potential floods | 4 | 2 | 3 | 1 | 6 | 5 | | Yes | | | | |
| 375 | Yes | I own the property | More than 20 years | House | My property is beyond the extent of all potential floods | 6 | 1 | 5 | 4 | 3 | 2 | | | | Yes | | |
| 376 | Yes | I own the property | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 2 | 1 | 3 | 4 | 5 | 6 | | | | Yes | | |
| 377 | Yes | I am a resident | 1 to 5 years | Villa/ townhouse | No, I don't know/I'm not sure whether my property could be flooded | 1 | 4 | 2 | 5 | 3 | 6 | | | | | | Yes |
| 378 | Yes | I own the property | Less than 1 year | House | My property could be flooded | 6 | 1 | 3 | 2 | 5 | 4 | | | | Yes | | |
| 379 | No | I own the property | 5 to 20 years | Villa/ townhouse | No, I don't know/I'm not sure whether my property could be flooded | 6 | 5 | 2 | 3 | 1 | 4 | | Yes | | | | |
| 380 | | I am a resident | More than 20 years | House | My property is beyond the extent of all potential floods | 4 | 3 | 2 | 1 | 6 | 5 | Yes | | | | | |
| 381 | Yes | I own the property | 1 to 5 years | Unit/ flat/ apartment | No, I don't know/I'm not sure whether my property could be flooded | 3 | 5 | 2 | 1 | 4 | 6 | Yes | | | | | |
| 382 | | I am a resident | More than 20 years | House | My property is beyond the extent of all potential floods | 4 | 2 | 3 | 1 | 5 | 6 | Yes | | | | | |
| 383 | Yes | I own the property | 1 to 5 years | House | No, I don't know/I'm not sure whether my property could be flooded | 2 | 1 | 3 | 4 | 6 | 5 | | Yes | | | | |
| 384 | Yes | I own the property | 5 to 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 4 | 2 | 1 | 3 | 5 | 6 | | | | Yes | | |
| 385 | Yes | I own the property | More than 20 years | Unit/ flat/ apartment | No, I don't know/I'm not sure whether my property could be flooded | 6 | 2 | 5 | 3 | 4 | 1 | | | Yes | | | |
| 386 | Yes | I own the property | More than 20 years | House | | 4 | 1 | 2 | 3 | 5 | 6 | | Yes | | | | |
| 387 | No | I am a resident | More than 20 years | House | My property is beyond the extent of all potential floods | | | | | | | Yes | Yes | Yes | | | |
| 388 | Yes | I own the property | More than 20 years | House | My property is beyond the extent of all potential floods | 4 | 2 | 3 | 1 | 6 | 5 | | | Yes | | | |
| 389 | Yes | I own the property | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 6 | 1 | 5 | 4 | 3 | 2 | Yes | | | | | |
| 390 | Yes | I am a resident | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 3 | 1 | 1 | 1 | 6 | 1 | Yes | | | | | |
| 391 | Yes | I am a resident | More than 20 years | House | My property is beyond the extent of all potential floods | 4 | 3 | 2 | 1 | 5 | 6 | Yes | | | | | |

| # | Please indicate if and how you would like us to contact you for more information or to provide you with study updates | About your property | | | | Please rank the following development types according to which you think are the most important to protect from floods | | | | | | What level of control do you think Council should place on new development to minimise flood-related risks? | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Please select as appropriate | How long have you been at this address? | Property Type | Do you know if your property has a risk of being flooded? | Commercial | Residential | Essential community facilities | Critical Utilities | Minor developments and additions | New residential developments | Prohibit all new development on land with any potential to flood | Prohibit all new development only in those locations that would be extremely hazardous to persons or property due to the depth and/or velocity of floodwaters, or evacuation difficulties | Place restrictions on developments which reduce the potential for flood damage (e.g. minimum floor level controls or using flood compatible building materials) | Advise of the flood risks, but allow the individual a choice about developing or not, provided steps are taken to minimise potential flood risks | Provide no advice about potential flood risks or measures that could minimise those risks | Don't know |
| 392 | Yes | I am a resident | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 4 | 3 | 2 | 1 | 6 | 5 | | Yes | | | | |
| 393 | No | I own the property | More than 20 years | House | My property is beyond the extent of all potential floods | 6 | 1 | 3 | 2 | 5 | 4 | Yes | | | | | |
| 394 | Yes | I own the property | More than 20 years | Other | My property is beyond the extent of all potential floods | 4 | 2 | 3 | 1 | 5 | 6 | Yes | | | | | |
| 395 | Yes | I am a resident | 5 to 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 5 | 3 | 4 | 2 | 6 | 1 | | | Yes | | | |
| 396 | Yes | I am a resident | 5 to 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 4 | 1 | 3 | 2 | 6 | 5 | Yes | | | | | |
| 397 | Yes | I own the property | 5 to 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 4 | 1 | 3 | 2 | 6 | 5 | Yes | | | | | |
| 398 | Yes | I own the property | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 4 | 3 | 2 | 1 | 5 | 6 | | Yes | | | | |
| 399 | No | I own the property | More than 20 years | Unit/ flat/ apartment | No, I don't know/I'm not sure whether my property could be flooded | | | | | | | | | | Yes | | |
| 400 | Yes | I own the property | 5 to 20 years | Villa/ townhouse | My property could be flooded | 3 | 6 | 2 | 1 | 4 | 5 | | | Yes | | | |
| 401 | Yes | I own the property | 5 to 20 years | Villa/ townhouse | My property is beyond the extent of all potential floods | | | | | | | | | | Yes | | |
| 402 | No | I own the property | Less than 1 year | Villa/ townhouse | My property could be flooded | 6 | 1 | 5 | 4 | 3 | 2 | | | Yes | | | |
| 403 | Yes | I am a resident | More than 20 years | House | My property is beyond the extent of all potential floods | 6 | 1 | 3 | 5 | 4 | 2 | | Yes | | | | |
| 404 | Yes | I own the property | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 6 | 1 | 3 | 2 | 5 | 4 | | | | Yes | | |
| 405 | Yes | I own the property | 5 to 20 years | Industrial unit or warehouse | My property could be flooded | 1 | 2 | 4 | 3 | 6 | 5 | | | | Yes | | |
| 406 | Yes | I am a resident | More than 20 years | House | My property could be flooded | 5 | 3 | 2 | 1 | 6 | 4 | | | | Yes | | |
| 407 | Yes | I am a resident | 5 to 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 4 | 2 | 3 | 5 | 6 | 1 | | | Yes | | | |
| 408 | Yes | I own the property | 1 to 5 years | Unit/ flat/ apartment | No, I don't know/I'm not sure whether my property could be flooded | 1 | 1 | 1 | 1 | 6 | 1 | | Yes | | | | |
| 409 | | I am a resident | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 4 | 2 | 3 | 1 | 5 | 6 | | Yes | | | | |
| 410 | Yes | I am a resident | 5 to 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | | | | | | | | | | | | Yes |
| 411 | No | I am a business owner | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 4 | 3 | 2 | 1 | 6 | 5 | | Yes | | | | |
| 412 | | I own the property | 1 to 5 years | Villa/ townhouse | No, I don't know/I'm not sure whether my property could be flooded | | | | | | | | | Yes | | | |
| 413 | | I own the property | More than 20 years | House | My property could be flooded | | 2 | 3 | 1 | | | | | | Yes | | |
| 414 | | I am a resident | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 4 | 1 | 2 | 3 | | | Yes | | | | | |
| 415 | Yes | I am a resident | More than 20 years | House | My property could be flooded | 4 | 1 | 2 | 3 | 5 | 6 | Yes | | | | | |
| 416 | Yes | Other – please describe | More than 20 years | House | My property is beyond the extent of all potential floods | 6 | 4 | 3 | 1 | 5 | 2 | | | Yes | Yes | | |
| 417 | No | I am a resident | 5 to 20 years | Villa/ townhouse | No, I don't know/I'm not sure whether my property could be flooded | 5 | 1 | 2 | 3 | 4 | 6 | | | | Yes | | |
| 418 | Yes | I am a resident | 1 to 5 years | House | No, I don't know/I'm not sure whether my property could be flooded | 4 | 1 | 3 | 2 | 5 | 6 | | Yes | | | | |
| 419 | | I am a resident | Less than 1 year | House | No, I don't know/I'm not sure whether my property could be flooded | 3 | 1 | 1 | 1 | 3 | 2 | | Yes | | | | |
| 420 | Yes | I own the property | 5 to 20 years | House | My property is beyond the extent of all potential floods | | 3 | | | 2 | 1 | | | Yes | Yes | | |
| 421 | No | I own the property | 1 to 5 years | House | My property is beyond the extent of all potential floods | | | | | | | | | | Yes | | |
| 422 | Yes | I am a resident | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 4 | 1 | 3 | 2 | 6 | 5 | | Yes | | | | |
| 423 | Yes | I own the property | 5 to 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 4 | 3 | 2 | 1 | 6 | 5 | | Yes | | | | |
| 424 | No | I am a resident | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | | | | | | | | | | | | Yes |
| 425 | Yes | I am a resident | 1 to 5 years | Villa/ townhouse | No, I don't know/I'm not sure whether my property could be flooded | 5 | 1 | 3 | 2 | 6 | 4 | | | | Yes | | |
| 426 | | I own the property | More than 20 years | House | My property is beyond the extent of all potential floods | 4 | 2 | 3 | 1 | 6 | 5 | | | Yes | | | |
| 427 | | | | | | | | | | | | | | | | | |
| 428 | No | I am a resident | More than 20 years | House | My property is beyond the extent of all potential floods | 3 | 1 | 4 | 2 | 6 | 5 | | | | Yes | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Please select as appropriate | How long have you been at this address? | Property Type | Do you know if your property has a risk of being flooded? | Commercial | Residential | Essential community facilities | Critical Utilities | Minor developments and additions | New residential developments | Prohibit all new development on land with any potential to flood | Prohibit all new development only in those locations that would be extremely hazardous to persons or property due to the depth and/or velocity of floodwaters, or evacuation difficulties | Place restrictions on developments which reduce the potential for flood damage (e.g. minimum floor level controls or using flood compatible building materials) | Advise of the flood risks, but allow the individual a choice about developing or not, provided steps are taken to minimise potential flood risks | Provide no advice about potential flood risks or measures that could minimise those risks | Don't know |
| 429 | | I own the property | 1 to 5 years | House | No, I don't know/I'm not sure whether my property could be flooded | 4 | 2 | 1 | 3 | 6 | 5 | Yes | | | | | |
| 430 | Yes | I own the property | More than 20 years | House | My property is beyond the extent of all potential floods | 5 | 3 | 2 | 1 | 6 | 4 | | | | Yes | | |
| 431 | Yes | I am a resident | More than 20 years | House | My property could be flooded | | | | | | | | | Yes | | | |
| 432 | Yes | I am a resident | More than 20 years | House | My property is beyond the extent of all potential floods | | | | | | | Yes | | | | | |
| 433 | Yes | I am a resident | 5 to 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 4 | 3 | 2 | 1 | 6 | 5 | Yes | | | | | |
| 434 | No | I am a business owner | More than 20 years | Industrial unit or warehouse | My property is beyond the extent of all potential floods | 1 | 1 | 1 | 1 | 6 | 6 | Yes | | Yes | | | |
| 435 | Yes | I own the property | 5 to 20 years | Villa/ townhouse | My property could be flooded | 5 | 1 | 3 | 4 | 2 | 6 | Yes | | | | | |
| 436 | Yes | I own the property | 5 to 20 years | House | My property is beyond the extent of all potential floods | 4 | 3 | 2 | 1 | 5 | 6 | | Yes | | | | |
| 437 | Yes | I own the property | More than 20 years | House | My property is beyond the extent of all potential floods | 3 | 4 | 2 | 1 | 6 | 5 | | | | Yes | | |
| 438 | | | | | | | | | | | | | | | | | |
| 439 | Yes | I own the property | More than 20 years | Shop/ retail | No, I don't know/I'm not sure whether my property could be flooded | 1 | 4 | 2 | 3 | 5 | 6 | | | | Yes | | |
| 440 | Yes | I am a resident | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | | | | | | | | Yes | | | | |
| 441 | | I own the property | More than 20 years | House | My property is beyond the extent of all potential floods | 5 | 2 | 1 | 3 | 6 | 4 | Yes | | | | | |
| 442 | Yes | I own the property | 5 to 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | | | | | | | Yes | | | | | |
| 443 | Yes | I own the property | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 2 | 1 | 3 | 4 | 5 | 6 | | Yes | | | | |
| 444 | | I am a resident | More than 20 years | House | My property is beyond the extent of all potential floods | | | | | | | | Yes | | | | |
| 445 | | I am a resident | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 5 | 2 | 6 | 4 | 3 | 1 | | Yes | | | | |
| 446 | Yes | I am a resident | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 6 | 1 | 4 | 2 | 3 | 5 | Yes | | | | | |
| 447 | Yes | I am a resident | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 4 | 3 | 2 | 1 | 5 | 6 | Yes | | | | | |
| 448 | Yes | I am a resident | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | | | | | | | Yes | | | | | |
| 449 | | | | | | | | | | | | | | | | | |
| 450 | | I am a resident | 5 to 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 6 | 1 | 5 | 4 | 3 | 2 | Yes | | | | | |
| 451 | Yes | I am a resident | More than 20 years | House | My property could be flooded | 5 | 1 | 3 | 2 | 6 | 4 | Yes | | | | | |
| 452 | No | I am a resident | 5 to 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 4 | 3 | 2 | 1 | 6 | 5 | | Yes | | | | |
| 453 | Yes | I own the property | 5 to 20 years | Villa/ townhouse | My property is beyond the extent of all potential floods | 4 | 1 | 3 | 2 | 5 | 6 | Yes | | | | | |
| 454 | Yes | I own the property | More than 20 years | Shop/ retail | No, I don't know/I'm not sure whether my property could be flooded | | | | | | | | | | Yes | | |
| 455 | Yes | I am a resident | 5 to 20 years | Unit/ flat/ apartment | No, I don't know/I'm not sure whether my property could be flooded | 5 | 1 | 4 | 3 | 6 | 2 | Yes | | | | | |
| 456 | Yes | I rent the property | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | | 1 | | | 2 | | Yes | Yes | | Yes | | |
| 457 | No | I am a resident | More than 20 years | House | My property is beyond the extent of all potential floods | 4 | 3 | 2 | 1 | 5 | 6 | Yes | | | | | |
| 458 | Yes | I own the property | More than 20 years | House | My property could be flooded | 3 | 2 | 5 | 1 | 6 | 4 | | | Yes | | | |
| 459 | | I am a resident | 5 to 20 years | | | | | | | | | | | | Yes | | |
| 460 | | I own the property | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 4 | 1 | 5 | 3 | 6 | 2 | Yes | | | | | |
| 461 | No | I am a resident | 5 to 20 years | House | My property could be flooded | 6 | 4 | 2 | 1 | 3 | 5 | Yes | | | | | |
| 462 | Yes | I am a resident | 5 to 20 years | House | My property could be flooded | 4 | 2 | 1 | 3 | 5 | 6 | | | Yes | | | |
| 463 | | I own the property | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 4 | 3 | 1 | 2 | 5 | 6 | Yes | | | | | |
| 464 | Yes | I own the property | 1 to 5 years | House | My property is beyond the extent of all potential floods | 6 | 1 | 2 | 3 | 4 | 5 | Yes | | | | | |
| 465 | Yes | I am a resident | 5 to 20 years | Villa/ townhouse | No, I don't know/I'm not sure whether my property could be flooded | 4 | 1 | 3 | 2 | 6 | 5 | | | Yes | | | |
| 466 | Yes | I own the property | More than 20 years | House | My property could be flooded | 4 | 5 | 2 | 1 | 6 | 3 | | | Yes | Yes | | |
| 467 | Yes | I own the property | 1 to 5 years | House | My property is beyond the extent of all potential floods | | | | | | 1 | | Yes | | | | |
| 468 | | I own the property | More than 20 years | House | My property could be flooded | | 1 | | | | | Yes | | | | | |

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| 469 | Yes | I own the property | 1 to 5 years | Villa/ townhouse | No, I don't know/I'm not sure whether my property could be flooded | | 1 | 2 | 3 | 5 | 4 | Yes | | | | | |
| 470 | Yes | I own the property | | House | My property could be flooded | | | | | | | Yes | | | | | |
| 471 | Yes | I am a resident | More than 20 years | House | My property could be flooded | | | | | | | Yes | | | | | |
| 472 | Yes | I own the property | More than 20 years | House | My property could be flooded | 5 | 4 | 2 | 1 | 3 | 6 | Yes | | | | | |
| 473 | Yes | I am a resident | More than 20 years | House | My property is beyond the extent of all potential floods | | | | | | | | | Yes | | | |
| 474 | Yes | I am a resident | 1 to 5 years | Villa/ townhouse | My property could be flooded | 5 | 4 | 2 | 1 | 3 | 6 | | | | Yes | | |
| 475 | Yes | I am a resident | More than 20 years | House | My property could be flooded | 4 | 2 | 5 | 3 | 6 | 1 | | | Yes | | | |
| 476 | Yes | I am a resident | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | | | | | | | | | | | | Yes |
| 477 | Yes | I own the property | 5 to 20 years | Villa/ townhouse | No, I don't know/I'm not sure whether my property could be flooded | 5 | 3 | 1 | 2 | 6 | 4 | | | Yes | | | |
| 478 | Yes | I own the property | 1 to 5 years | House | No, I don't know/I'm not sure whether my property could be flooded | 6 | 2 | 3 | 5 | 4 | 1 | | | | Yes | | |
| 479 | | I own the property | 1 to 5 years | Villa/ townhouse | My property could be flooded | 5 | 2 | 3 | 1 | 6 | 4 | Yes | | | | | |
| 480 | | I own the property | More than 20 years | House | | 3 | 1 | 4 | 2 | 6 | 5 | Yes | | | | | |
| 481 | Yes | I own the property | 1 to 5 years | House | No, I don't know/I'm not sure whether my property could be flooded | 5 | 1 | 3 | 2 | 6 | 4 | | | | Yes | | |
| 482 | | I own the property | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | | | | | | | | | | | | Yes |
| 483 | Yes | I am a resident | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | | | | | | | Yes | | | | | |
| 484 | No | I own the property | 5 to 20 years | Villa/ townhouse | No, I don't know/I'm not sure whether my property could be flooded | 5 | 3 | 2 | 1 | 6 | 4 | | | | | | Yes |
| 485 | Yes | I am a resident | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 5 | 1 | 2 | 3 | 6 | 4 | Yes | | | | | |
| 486 | Yes | I own the property | More than 20 years | House | My property could be flooded | 3 | 4 | 2 | 1 | 6 | 5 | | | | Yes | | |
| 487 | Yes | I am a resident | More than 20 years | House | My property is beyond the extent of all potential floods | | | | | | | Yes | | | | | |
| 488 | Yes | I am a resident | 1 to 5 years | House | My property is beyond the extent of all potential floods | 3 | 2 | 4 | 1 | 6 | 5 | | | Yes | | | |
| 489 | Yes | I own the property | More than 20 years | House | My property is beyond the extent of all potential floods | 2 | 4 | 3 | 1 | 6 | 5 | | | | Yes | | |
| 490 | Yes | I own the property | 1 to 5 years | Unit/ flat/ apartment | No, I don't know/I'm not sure whether my property could be flooded | | | | | | | | | | Yes | | |
| 491 | Yes | I rent the property | 5 to 20 years | House | My property could be flooded | 4 | 2 | 3 | 1 | 6 | 5 | Yes | | | | | |
| 492 | Yes | I am a resident | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 5 | 4 | 2 | 1 | 6 | 3 | | | Yes | | | |
| 493 | Yes | I own the property | 5 to 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | | | | | | | | | | Yes | | |
| 494 | Yes | I rent the property | More than 20 years | Unit/ flat/ apartment | No, I don't know/I'm not sure whether my property could be flooded | 4 | 2 | 3 | 1 | 6 | 5 | Yes | | | | | |
| 495 | Yes | I own the property | More than 20 years | House | My property is beyond the extent of all potential floods | 4 | 1 | 3 | 2 | 6 | 5 | Yes | | | | | |
| 496 | No | I am a resident | 5 to 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | | | | | | | | | Yes | | | |
| 497 | Yes | I own the property | 1 to 5 years | House | My property could be flooded | | | | | | | | Yes | | | | |
| 498 | | I own the property | More than 20 years | House | My property could be flooded | 4 | 3 | 1 | 2 | 5 | 6 | Yes | | | | | |
| 499 | Yes | I am a resident | 5 to 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 4 | 1 | 2 | 3 | 6 | 5 | Yes | | | | | |
| 500 | | I am a resident | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 5 | 1 | 3 | 2 | 4 | 6 | Yes | | | | | |
| 501 | Yes | I am a resident | More than 20 years | House | My property is beyond the extent of all potential floods | 2 | 1 | 3 | 4 | 6 | 5 | Yes | | | | | |
| 502 | Yes | I own the property | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 5 | 2 | 3 | 4 | 6 | 1 | | Yes | | | | |
| 503 | Yes | I own the property | More than 20 years | Unit/ flat/ apartment | No, I don't know/I'm not sure whether my property could be flooded | 6 | 2 | 4 | 5 | 3 | 1 | | | Yes | | | |
| 504 | No | I am a resident | Less than 1 year | House | My property is beyond the extent of all potential floods | 5 | 1 | 3 | 4 | 6 | 2 | | Yes | | | | |
| 505 | | I am a resident | 5 to 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 4 | 1 | 3 | 2 | 5 | 6 | | | Yes | | | |
| 506 | No | I own the property | Less than 1 year | Unit/ flat/ apartment | No, I don't know/I'm not sure whether my property could be flooded | 5 | 1 | 3 | 2 | 6 | 4 | | | | Yes | | |
| 507 | Yes | I own the property | 5 to 20 years | Villa/ townhouse | No, I don't know/I'm not sure whether my property could be flooded | 3 | 4 | 2 | 1 | 5 | 6 | | | Yes | | | |

| # | Please indicate if and how you would like us to contact you for more information or to provide you with study updates | About your property | | | | Please rank the following development types according to which you think are the most important to protect from floods | | | | | | What level of control do you think Council should place on new development to minimise flood-related risks? | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Please select as appropriate | How long have you been at this address? | Property Type | Do you know if your property has a risk of being flooded? | Commercial | Residential | Essential community facilities | Critical Utilities | Minor developments and additions | New residential developments | Prohibit all new development on land with any potential to flood | Prohibit all new development only in those locations that would be extremely hazardous to persons or property due to the depth and/or velocity of floodwaters, or evacuation difficulties | Place restrictions on developments which reduce the potential for flood damage (e.g. minimum floor level controls or using flood compatible building materials) | Advise of the flood risks, but allow the individual a choice about developing or not, provided steps are taken to minimise potential flood risks | Provide no advice about potential flood risks or measures that could minimise those risks | Don't know |
| 508 | Yes | I am a resident | 1 to 5 years | House | My property is beyond the extent of all potential floods | 5 | 1 | 3 | 4 | 6 | 2 | | Yes | | | | |
| 509 | Yes | I am a resident | Less than 1 year | Villa/ townhouse | No, I don't know/I'm not sure whether my property could be flooded | 4 | 1 | 3 | 2 | 5 | 6 | | | | Yes | | |
| 510 | Yes | I own the property | 5 to 20 years | House | My property is beyond the extent of all potential floods | 4 | 2 | 3 | 1 | 5 | 6 | | Yes | | | | |
| 511 | No | I own the property | 5 to 20 years | House | My property could be flooded | 4 | 2 | 3 | 1 | 5 | 6 | | Yes | | | | |
| 512 | Yes | I am a resident | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 2 | 5 | 4 | 6 | 3 | 1 | Yes | | | | | |
| 513 | | I am a resident | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 5 | 1 | 2 | 3 | 4 | 6 | Yes | | | | | |
| 514 | Yes | I am a resident | More than 20 years | House | My property is beyond the extent of all potential floods | 2 | 1 | 4 | 3 | 6 | 5 | | | | Yes | | |
| 515 | No | I am a resident | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 6 | 2 | 4 | 3 | 5 | 1 | | | Yes | | | |
| 516 | Yes | I am a resident | | House | My property is beyond the extent of all potential floods | 4 | 1 | 3 | 2 | 6 | 5 | Yes | | | | | |
| 517 | Yes | I own the property | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 3 | 1 | 4 | 2 | 5 | 6 | | Yes | | | | |
| 518 | | I own the property | | Villa/ townhouse | No, I don't know/I'm not sure whether my property could be flooded | 2 | 2 | 1 | 1 | 6 | 4 | Yes | | | | | |
| 519 | Yes | I am a resident | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | | | | | | | Yes | | | | | |
| 520 | | I own the property | Less than 1 year | House | No, I don't know/I'm not sure whether my property could be flooded | 3 | 1 | 4 | 2 | 5 | 6 | | | Yes | | | |
| 521 | Yes | I own the property | More than 20 years | House | My property is beyond the extent of all potential floods | 4 | 1 | 2 | 3 | 5 | 6 | | Yes | | | | |
| 522 | Yes | I own the property | 5 to 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 4 | 3 | 2 | 1 | 6 | 5 | | | Yes | | | |
| 523 | Yes | I am a resident | Less than 1 year | House | My property is beyond the extent of all potential floods | 4 | 1 | 5 | 2 | 6 | 3 | Yes | | | | | |
| 524 | Yes | I own the property | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 5 | 2 | 3 | 1 | 4 | 6 | Yes | | | | | |
| 525 | Yes | I own the property | 5 to 20 years | Villa/ townhouse | No, I don't know/I'm not sure whether my property could be flooded | | | | | | | | | Yes | | | |
| 526 | Yes | I am a resident | More than 20 years | House | My property is beyond the extent of all potential floods | 3 | 2 | 4 | 5 | 2 | 1 | | | | Yes | | |
| 527 | Yes | I own the property | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 4 | 1 | 2 | 3 | 6 | 5 | | Yes | | | | |
| 528 | | I own the property | 1 to 5 years | House | My property is beyond the extent of all potential floods | 5 | 2 | 3 | 1 | 6 | 4 | | Yes | | | | |
| 529 | Yes | I own the property | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 4 | 1 | 2 | 3 | 6 | 5 | | | | Yes | | |
| 530 | No | I am a resident | More than 20 years | House | My property is beyond the extent of all potential floods | 1 | 3 | 4 | 5 | 6 | 2 | Yes | | | | | |
| 531 | Yes | I own the property | 1 to 5 years | Villa/ townhouse | No, I don't know/I'm not sure whether my property could be flooded | 3 | 1 | 4 | 2 | 5 | 6 | | Yes | Yes | Yes | | |
| 532 | Yes | I own the property | More than 20 years | House | | | | | | | | | | Yes | | | |
| 533 | Yes | I own the property | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 4 | 3 | 1 | 2 | 5 | 6 | Yes | | | | | |
| 534 | Yes | I own the property | 1 to 5 years | Villa/ townhouse | My property could be flooded | 6 | 1 | 2 | 3 | 4 | 5 | Yes | | | | | |
| 535 | Yes | I own the property | 1 to 5 years | House | No, I don't know/I'm not sure whether my property could be flooded | | | | | | | | Yes | | | | |
| 536 | Yes | I own the property | 5 to 20 years | House | My property is beyond the extent of all potential floods | 6 | 1 | 3 | 5 | 4 | 2 | Yes | | | | | |
| 537 | Yes | I am a resident | More than 20 years | House | My property is beyond the extent of all potential floods | 4 | 1 | 3 | 2 | 5 | 6 | Yes | | | | | |
| 538 | Yes | I own the property | 1 to 5 years | | | 4 | 1 | 3 | 2 | 5 | 6 | | | Yes | | | |
| 539 | Yes | I own the property | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 4 | 1 | 3 | 2 | 5 | 6 | | | Yes | | | |
| 540 | Yes | I am a resident | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 3 | 1 | 1 | 1 | 3 | 1 | Yes | | | | | |
| 541 | Yes | I own the property | 5 to 20 years | Unit/ flat/ apartment | No, I don't know/I'm not sure whether my property could be flooded | | 2 | 1 | | | | | Yes | | | | |
| 542 | Yes | I own the property | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 4 | 1 | 3 | 2 | 6 | 5 | | Yes | | | | |
| 543 | No | I am a resident | 1 to 5 years | Villa/ townhouse | No, I don't know/I'm not sure whether my property could be flooded | 4 | 5 | 2 | 1 | 6 | 3 | Yes | | | | | |
| 544 | No | I am a resident | 1 to 5 years | Villa/ townhouse | My property could be flooded | 4 | | 2 | 1 | | 3 | Yes | | | | | |
| 545 | Yes | I own the property | More than 20 years | House | My property is beyond the extent of all potential floods | 3 | 2 | 4 | 5 | 6 | 1 | | | | Yes | | |

| # | Please indicate if and how you would like us to contact you for more information or to provide you with study updates | About your property | | | | Please rank the following development types according to which you think are the most important to protect from floods | | | | | | What level of control do you think Council should place on new development to minimise flood-related risks? | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Please select as appropriate | How long have you been at this address? | Property Type | Do you know if your property has a risk of being flooded? | Commercial | Residential | Essential community facilities | Critical Utilities | Minor developments and additions | New residential developments | Prohibit all new development on land with any potential to flood | Prohibit all new development only in those locations that would be extremely hazardous to persons or property due to the depth and/or velocity of floodwaters, or evacuation difficulties | Place restrictions on developments which reduce the potential for flood damage (e.g. minimum floor level controls or using flood compatible building materials) | Advise of the flood risks, but allow the individual a choice about developing or not, provided steps are taken to minimise potential flood risks | Provide no advice about potential flood risks or measures that could minimise those risks | Don't know |
| 546 | Yes | I own the property | 1 to 5 years | House | No, I don't know/I'm not sure whether my property could be flooded | 4 | 2 | 3 | 1 | 5 | 6 | | | | Yes | | |
| 547 | Yes | I own the property | 5 to 20 years | Villa/ townhouse | No, I don't know/I'm not sure whether my property could be flooded | 3 | 2 | 4 | 1 | 5 | 6 | | Yes | | | | |
| 548 | Yes | I own the property | 1 to 5 years | House | No, I don't know/I'm not sure whether my property could be flooded | | | | | | | | | | | Yes | |
| 549 | | I own the property | 5 to 20 years | House | My property could be flooded | 5 | 1 | 3 | 2 | 6 | 4 | | | | Yes | | |
| 550 | Yes | I own the property | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 5 | 1 | 6 | 4 | 3 | 2 | Yes | | | | | |
| 551 | | | | | | | | | | | | | | | | | |
| 552 | Yes | I own the property | 1 to 5 years | House | My property could be flooded | 6 | 2 | 4 | 1 | 5 | 3 | | | Yes | | | |
| 553 | Yes | I own the property | More than 20 years | House | My property is beyond the extent of all potential floods | 5 | 2 | 3 | 1 | 6 | 4 | | Yes | | | | |
| 554 | Yes | I own the property | More than 20 years | House | My property is beyond the extent of all potential floods | | | | | | | Yes | | | | | |
| 555 | | | | | | | | | | | | | | | | | |
| 556 | | | | | | | | | | | | | | | | | |
| 557 | | I own the property | 5 to 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | 6 | 1 | 2 | 3 | 5 | 4 | Yes | | | | | |
| 558 | No | I own the property | More than 20 years | House | My property is beyond the extent of all potential floods | | | | | | | Yes | | | | | |
| 559 | | | | | | | | | | | | | | | | | |
| 560 | Yes | I am a resident | 5 to 20 years | Villa/ townhouse | My property could be flooded | 5 | 1 | 3 | 2 | 6 | 4 | | | Yes | | | |
| 561 | Yes | I own the property | 1 to 5 years | House | My property could be flooded | 4 | 1 | 3 | 2 | 5 | 6 | | Yes | | | | |
| 562 | Yes | I rent the property | 1 to 5 years | House | No, I don't know/I'm not sure whether my property could be flooded | 1 | 1 | | | | 1 | Yes | Yes | Yes | | Yes | |
| 563 | No | I own the property | 1 to 5 years | Villa/ townhouse | No, I don't know/I'm not sure whether my property could be flooded | 2 | 1 | 4 | 3 | 6 | 5 | | Yes | | | | |
| 564 | Yes | I own the property | Less than 1 year | Villa/ townhouse | No, I don't know/I'm not sure whether my property could be flooded | 4 | 2 | 5 | 3 | 6 | 1 | | | Yes | | | |
| 565 | Yes | I own the property | 1 to 5 years | House | My property is beyond the extent of all potential floods | 1 | 4 | 3 | 2 | 5 | 6 | | | | Yes | | |
| 566 | No | I own the property | 5 to 20 years | House | My property is beyond the extent of all potential floods | 4 | 3 | 1 | 2 | 6 | 5 | | Yes | | | | |
| 567 | Yes | I own the property | 5 to 20 years | House | My property is beyond the extent of all potential floods | 3 | 4 | 2 | 1 | 6 | 5 | | | Yes | | | |
| 568 | Yes | I am a resident | More than 20 years | House | My property could be flooded | 4 | 3 | 2 | 1 | 6 | 5 | | Yes | | | | |
| 569 | Yes | I am a resident | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | | | | | | | Yes | Yes | Yes | Yes | | |
| 570 | No | I own the property | 5 to 20 years | Unit/ flat/ apartment | No, I don't know/I'm not sure whether my property could be flooded | | | | | | 1 | Yes | Yes | | | | |
| 571 | | I am a resident | More than 20 years | | My property is beyond the extent of all potential floods | 6 | 3 | 2 | 1 | 5 | 4 | Yes | | | | | |
| 572 | Yes | I own the property | More than 20 years | House | My property is beyond the extent of all potential floods | 4 | 3 | 5 | 1 | 6 | 2 | | | Yes | | | |
| 573 | Yes | I am a resident | More than 20 years | House | No, I don't know/I'm not sure whether my property could be flooded | | | | | | | | | Yes | | | |
| 574 | Yes | I own the property | Less than 1 year | House | No, I don't know/I'm not sure whether my property could be flooded | 5 | 1 | 4 | 3 | 6 | 2 | Yes | | | | | |
| 575 | No | I own the property | More than 20 years | Villa/ townhouse | No, I don't know/I'm not sure whether my property could be flooded | | | | | | | | | | | | Yes |
| 576 | Yes | I own the property | Less than 1 year | House | No, I don't know/I'm not sure whether my property could be flooded | 6 | 1 | 2 | 3 | 4 | 5 | | | | | | Yes |
| 577 | Yes | I own the property | 1 to 5 years | House | My property could be flooded | 5 | 1 | 4 | 2 | | 5 | | Yes | | | | |
| 578 | Yes | I am a resident | 5 to 20 years | Unit/ flat/ apartment | No, I don't know/I'm not sure whether my property could be flooded | 4 | 3 | 1 | 2 | 6 | 5 | Yes | | | | | |
| 579 | No | I own the property | 1 to 5 years | House | No, I don't know/I'm not sure whether my property could be flooded | 5 | 1 | 2 | 3 | 6 | 4 | | Yes | | | | |
| 580 | No | I am a resident | 5 to 20 years | Villa/ townhouse | No, I don't know/I'm not sure whether my property could be flooded | 4 | 1 | 3 | 2 | 6 | 5 | | Yes | | | | |
| 581 | No | I own the property | 1 to 5 years | Unit/ flat/ apartment | My property could be flooded | 4 | 1 | 3 | 2 | 6 | 5 | Yes | | | | | |
| 582 | Yes | I am a resident | 5 to 20 years | Villa/ townhouse | No, I don't know/I'm not sure whether my property could be flooded | | | | | | | Yes | | | Yes | | |
| 583 | Yes | I own the property | More than 20 years | House | My property is beyond the extent of all potential floods | 2 | 1 | 4 | 3 | 6 | 5 | | | Yes | | | |
| 584 | Yes | I am a resident | 5 to 20 years | Villa/ townhouse | My property could be flooded | 4 | 1 | 3 | 2 | 5 | 6 | Yes | | | | | |
| 585 | | I own the property | 1 to 5 years | House | No, I don't know/I'm not sure whether my property could be flooded | 5 | 1 | 3 | 2 | 6 | 4 | | | | | | Yes |

## Table A2 - Communication and Flood Response

| # | What notifications do you think Council should give about the potential flood affectation of individual properties? | | | | | How would you respond in a major flood in the area | | | | If you are likely to evacuate, what factors are most important? | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Advise every resident and property owner on a regular basis of the known potential flood threat | Advise only those who enquire to Council about the known potential flood threat | Advise prospective purchasers of property of the known potential flood threat. | Provide no notifications | Other – please describe | Evacuate early to an evacuation centre | Remain at my house | Don't know/not sure | Other – please describe | Discomfort/inconvenience/cost of being isolated by floodwater | Need for access to medical facilities | Safety of our family | Other – please describe |
| 1 | | | Yes | | | | Yes | | | Yes | | | |
| 2 | Yes | | | | | Yes | | | | | | Yes | |
| 3 | Yes | | | | | Yes | | | | | | Yes | |
| 4 | | | Yes | | | Yes | | | | Yes | | | |
| 5 | Yes | | | | | Yes | | | | | | Yes | |
| 6 | | Yes | | | | | Yes | | | | | Yes | |
| 7 | Yes | | | | | Yes | | | | | | Yes | |
| 8 | Yes | | | | | | Yes | | | | | Yes | |
| 9 | | | Yes | | | | Yes | | | | | Yes | |
| 10 | Yes | | | | | Yes | | | | | | Yes | |
| 11 | Yes | | | | | Yes | | | | Yes | | | |
| 12 | Yes | | | | | Yes | | | | | | Yes | |
| 13 | Yes | | | | | Yes | | | | | | Yes | |
| 14 | Yes | | | | | | Yes | | | | | Yes | |
| 15 | Yes | | | | | | | Yes | | | | Yes | |
| 16 | | Yes | | | | | | Yes | | | | Yes | |
| 17 | Yes | | | | | Yes | | | | | Yes | | |
| 18 | Yes | | | | | | Yes | | | Yes | | | |
| 19 | | | Yes | | | | Yes | | | | | | |
| 20 | Yes | | | | | Yes | | | | | | Yes | |
| 21 | | | | | | Yes | | | | | | Yes | |
| 22 | | Yes | | | | | | Yes | | | | Yes | |
| 23 | Yes | | | | | | | | | | | Yes | |
| 24 | Yes | | | | | Yes | | | | | | Yes | |
| 25 | Yes | | | | | Yes | | | | | | Yes | |
| 26 | Yes | | | | | | Yes | | | Yes | | | |
| 27 | Yes | | | | | | Yes | | | | | Yes | |
| 28 | Yes | | | | | | | Yes | | | | Yes | |
| 29 | Yes | | | | | | Yes | | | Yes | | | |
| 30 | Yes | | | | | | | | | | | Yes | |
| 31 | Yes | | | | | Yes | | | | Yes | | | |
| 32 | Yes | | | | | Yes | | | | Yes | | | |
| 33 | Yes | | | | | | Yes | | | | | Yes | |
| 34 | Yes | | | | | | Yes | | | Yes | | | |
| 35 | Yes | | | | | Yes | | | | | | Yes | |
| 36 | Yes | | | | | Yes | | | | | | Yes | |
| 37 | | | Yes | | | | | Yes | | Yes | | | |
| 38 | | Yes | | | | Yes | | | | | | Yes | |
| 39 | Yes | | | | | | Yes | | | Yes | | | |
| 40 | Yes | | | | | Yes | | | | | Yes | | |
| 41 | Yes | | | | | Yes | | | | | | Yes | |
| 42 | Yes | | | | | | | Yes | | | | Yes | |
| 43 | Yes | | | | | Yes | | | | | | Yes | |
| 44 | Yes | | | | | | | Yes | | | | Yes | |
| 45 | Yes | | | | | Yes | | | | Yes | | | |

| # | What notifications do you think Council should give about the potential flood affectation of individual properties? | | | | | How would you respond in a major flood in the area | | | | If you are likely to evacuate, what factors are most important? | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Advise every resident and property owner on a regular basis of the known potential flood threat | Advise only those who enquire to Council about the known potential flood threat | Advise prospective purchasers of property of the known potential flood threat. | Provide no notifications | Other – please describe | Evacuate early to an evacuation centre | Remain at my house | Don't know/not sure | Other – please describe | Discomfort/inconvenience/cost of being isolated by floodwater | Need for access to medical facilities | Safety of our family | Other – please describe |
| 46 | | | Yes | | | Yes | | | | | | Yes | |
| 47 | Yes | | | | | | | Yes | | | | Yes | |
| 48 | Yes | | | | | Yes | | | | | | Yes | |
| 49 | Yes | | | | | | | Yes | | Yes | | | |
| 50 | Yes | | | | | Yes | | | | | | Yes | |
| 51 | Yes | | | | | | Yes | | | Yes | | | |
| 52 | Yes | | | | | Yes | | | | | | Yes | |
| 53 | Yes | | | | | | | Yes | | | | Yes | |
| 54 | | | | Yes | | | | | | | | Yes | |
| 55 | Yes | | | | | Yes | | | | | | Yes | |
| 56 | | | Yes | | | | | Yes | | | | Yes | |
| 57 | Yes | | | | | Yes | | | | | | Yes | |
| 58 | Yes | | | | | | | Yes | | | | | |
| 59 | Yes | | | | | Yes | | | | | | Yes | |
| 60 | | | Yes | | | | | Yes | | | | Yes | |
| 61 | Yes | | | | | Yes | | | | Yes | | | |
| 62 | Yes | | | | | | | Yes | | Yes | | | |
| 63 | Yes | | | | | Yes | | | | Yes | | | |
| 64 | Yes | | | | | | Yes | | | | | Yes | |
| 65 | Yes | | | | | | | Yes | | | | Yes | |
| 66 | Yes | | | | | | | Yes | | | | Yes | |
| 67 | | Yes | | | | | Yes | | | | Yes | | |
| 68 | Yes | | | | | | Yes | | | | | | |
| 69 | Yes | | | | | | | Yes | | | | Yes | |
| 70 | Yes | | | | | Yes | | | | Yes | | | |
| 71 | Yes | | | | | Yes | | | | | | Yes | |
| 72 | | | Yes | | | Yes | | | | | | Yes | |
| 73 | Yes | | | | | Yes | | | | | Yes | | |
| 74 | Yes | | | | | Yes | | | | | | Yes | |
| 75 | Yes | | | | | Yes | | | | | | Yes | |
| 76 | | Yes | | | | | | Yes | | | | Yes | |
| 77 | Yes | | | | | Yes | | | | Yes | | | |
| 78 | | | Yes | | | Yes | | | | Yes | | | |
| 79 | Yes | | | | | Yes | | | | | | Yes | |
| 80 | Yes | | | | | | | | | | | Yes | |
| 81 | Yes | | | | | Yes | | | | | | Yes | |
| 82 | Yes | | | | | | | Yes | | | | Yes | |
| 83 | | | Yes | | | Yes | | | | | | Yes | |
| 84 | Yes | | | | | | | Yes | | | | Yes | |
| 85 | | Yes | | | | | Yes | | | | | Yes | |
| 86 | Yes | | | | | | | Yes | | | | Yes | |
| 87 | | Yes | | | | Yes | | | | Yes | | | |
| 88 | | | Yes | | | | Yes | | | | | Yes | |
| 89 | Yes | | | | | | Yes | | | | Yes | Yes | |
| 90 | Yes | | Yes | | | Yes | | | | | | Yes | |
| 91 | Yes | | Yes | | | | | Yes | | Yes | | Yes | |
| 92 | Yes | | Yes | | | Yes | | | | | Yes | Yes | |
| 93 | Yes | | | | | | Yes | | | Yes | | Yes | |
| 94 | Yes | | | | | | Yes | | | | | | |
| 95 | | | Yes | | | | Yes | | | Yes | | | |
| 96 | Yes | | Yes | | | Yes | | | | | | Yes | |
| 97 | Yes | | | | | Yes | | | | Yes | Yes | Yes | |

| # | What notifications do you think Council should give about the potential flood affectation of individual properties? | | | | | How would you respond in a major flood in the area | | | | If you are likely to evacuate, what factors are most important? | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Advise every resident and property owner on a regular basis of the known potential flood threat | Advise only those who enquire to Council about the known potential flood threat | Advise prospective purchasers of property of the known potential flood threat. | Provide no notifications | Other – please describe | Evacuate early to an evacuation centre | Remain at my house | Don't know/not sure | Other – please describe | Discomfort/inconvenience/cost of being isolated by floodwater | Need for access to medical facilities | Safety of our family | Other – please describe |
| 98 | Yes | | | | | | | | | | | | As Above |
| 99 | Yes | | | | | | Yes | | | | Yes | Yes | |
| 100 | | Yes | | | | | | Yes | | | | | Yes |
| 101 | Yes | | | | | Yes | | | | | Yes | Yes | |
| 102 | Yes | | Yes | | | Yes | | | | | | Yes | |
| 103 | Yes | | Yes | | | | | Yes | | Yes | | | |
| 104 | Yes | Yes | Yes | | | | | Yes | | Yes | | | |
| 105 | | | Yes | | | | Yes | | | | | Yes | |
| 106 | Yes | | | | | Yes | | | | | | Yes | |
| 107 | Yes | | Yes | | | | | Yes | | | | Yes | |
| 108 | Yes | | Yes | | | | Yes | | | Yes | | Yes | |
| 109 | Yes | | | Yes | | | | Yes | | | Yes | Yes | |
| 110 | Yes | Yes | Yes | | | | | Yes | | | Yes | Yes | |
| 111 | | Yes | | | | | Yes | | | Yes | Yes | | |
| 112 | Yes | | | | | | Yes | | | | | | If I needed to evacuate it whole of penrith is likely to |
| 113 | Yes | | Yes | | | | | Yes | | | | Yes | |
| 114 | Yes | | Yes | | | Yes | | | | | | Yes | |
| 115 | Yes | | | | | | Yes | | | | Yes | Yes | |
| 116 | Yes | | | | | | | Yes | | | | Yes | |
| 117 | Yes | | Yes | | | | Yes | | | Yes | | | |
| 118 | Yes | | | | | Yes | | | | | Yes | | |
| 119 | Yes | | | | | Yes | | | | Yes | | Yes | |
| 120 | Yes | | | | | | | Yes | | Yes | | Yes | |
| 121 | Yes | | | | | Yes | | | | | | Yes | |
| 122 | Yes | | | | | Yes | | | | | Yes | Yes | |
| 123 | Yes | | | | | | | | | | | Yes | |
| 124 | | | Yes | | | | Yes | | | | | Yes | |
| 125 | Yes | | | | | | Yes | | | Yes | | | |
| 126 | Yes | | Yes | | | | Yes | | | | Yes | Yes | |
| 127 | | Yes | | | | | Yes | | | | | | |
| 128 | Yes | | | | | Yes | | | | Yes | | | |
| 129 | Yes | | Yes | | | Yes | | | | Yes | | Yes | |
| 130 | Yes | | | | | | Yes | | | | | | |
| 131 | Yes | | | | | Yes | | | | Yes | | | |
| 132 | Yes | | | | | Yes | | | | | Yes | Yes | |
| 133 | | | | Yes | | | Yes | | | | | Yes | |
| 134 | Yes | | | | | Yes | | | | Yes | Yes | Yes | |
| 135 | Yes | | | | | | | Yes | | Yes | | | |
| 136 | | Yes | | | | | | Yes | | | | Yes | |
| 137 | | | | | | | | Yes | | | Yes | | |
| 138 | Yes | | | | | Yes | | | | Yes | Yes | Yes | |
| 139 | Yes | | | | | | | Yes | | | | Yes | |
| 140 | Yes | | Yes | | | | | | Rely on emergency service advice | Yes | | Yes | |
| 141 | Yes | | | | | | | Yes | | | Yes | | |
| 142 | | Yes | | | | | | Yes | | | Yes | | |
| 143 | | | | | | | | | | | | | |
| 144 | Yes | | Yes | | | Yes | | | | | | Yes | |
| 145 | Yes | | | | | | | Yes | | | | Yes | |
| 146 | Yes | Yes | Yes | | | | | Yes | | | | Yes | |
| 147 | Yes | | Yes | | | | | Yes | | Yes | Yes | Yes | |
| 148 | | | Yes | | | Yes | | | | | Yes | | |
| 149 | Yes | | Yes | | | | | Yes | | | | Yes | Safety at pets |

| # | What notifications do you think Council should give about the potential flood affectation of individual properties? | | | | | How would you respond in a major flood in the area | | | | If you are likely to evacuate, what factors are most important? | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
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| 150 | | Yes | Yes | | | | Yes | | | | Yes | Yes | |
| 151 | Yes | | Yes | | | | | | Evacate only if life threatning | | | Yes | |
| 152 | Yes | | Yes | | | Yes | | | | Yes | Yes | Yes | |
| 153 | Yes | | | | | | Yes | | | | | Yes | |
| 154 | | | Yes | | | | | | go to parents/brother who live close | Yes | Yes | Yes | |
| 155 | Yes | | Yes | | | | | Yes | | | | Yes | |
| 156 | Yes | | | | | Yes | | | | Yes | | | |
| 157 | Yes | | Yes | | | Yes | | | | Yes | | Yes | |
| 158 | Yes | | Yes | | | | Yes | | | | | Yes | |
| 159 | Yes | | | | | Yes | | | | | | Yes | |
| 160 | Yes | | | | | Yes | | | | | | Yes | |
| 161 | | | Yes | | | | Yes | | | | | Yes | |
| 162 | Yes | | Yes | | | | Yes | | | | | Yes | |
| 163 | Yes | | Yes | | | Yes | | | | | | Yes | |
| 164 | | | | | Yes(A&C) | | Yes | | | | | Yes | |
| 165 | Yes | | | | | Yes | | | | Yes | | Yes | |
| 166 | | Yes | Yes | | | Yes | | | | | Yes | Yes | |
| 167 | | | Yes | | | | | Yes | | Yes | | | |
| 168 | Yes | Yes | | | | | | Yes | | | | Yes | |
| 169 | | Yes | Yes | | | | Yes | | | | Yes | Yes | |
| 170 | | Yes | | | | Yes | | | | Yes | | Yes | |
| 171 | Yes | | Yes | | | Yes | | | | | Yes | Yes | |
| 172 | Yes | | Yes | | | | | | Evcate to family memvers have at the area | | | Yes | |
| 173 | Yes | Yes | | | | | Yes | | | Yes | Yes | Yes | |
| 174 | Yes | | | | | | | Yes | | | Yes | | |
| 175 | | Yes | | | | Yes | | | | | | Yes | |
| 176 | Yes | | Yes | | | | Yes | | | | | Yes | |
| 177 | Yes | | | | | | Yes | | | | | Yes | |
| 178 | Yes | | Yes | | | | | Yes | | | Yes | Yes | |
| 179 | | Yes | | | | | | Yes | | | | Yes | |
| 180 | Yes | | | | | Yes | | | | | | Yes | |
| 181 | | Yes | | | | Yes | | | | | | Yes | |
| 182 | | Yes | Yes | | | | Yes | | | | | Yes | |
| 183 | Yes | | | | | | | | STAY WITH A RELATIVE | | | Yes | |
| 184 | Yes | | | | | | Yes | | | | Yes | Yes | |
| 185 | Yes | Yes | Yes | | | Yes | | | | | Yes | Yes | |
| 186 | Yes | | Yes | | | Yes | | | | Yes | Yes | Yes | |
| 187 | | | Yes | | | | | Yes | | | | Yes | |
| 188 | Yes | | | | | Yes | | | | Yes | | | |
| 189 | Yes | | | | | Yes | | | | | Yes | Yes | |
| 190 | | | | Yes | | | Yes | | | | | Yes | |
| 191 | Yes | | | | | Yes | | | | | | Yes | |
| 192 | | | Yes | | | | Yes | | | | | | |
| 193 | Yes | | Yes | | | Yes | | | | | | Yes | |
| 194 | | | Yes | | | Yes | | | | | | Yes | |
| 195 | Yes | | Yes | | Yes | Yes | | | | | Yes | Yes | |
| 196 | Yes | Yes | Yes | | | Yes | | | | | | Yes | |
| 197 | Yes | | | | | Yes | | | | Yes | | | |
| 198 | | | Yes | | Yes | | | Yes | Drive at if I Could | Yes | | Yes | Loss of everything |
| 199 | Yes | | | | | | | Yes | | | | Yes | |
| 200 | Yes | | | | | | | Yes | | | | Yes | |
| 201 | Yes | | Yes | | | | | Yes | | Yes | | | |

| # | What notifications do you think Council should give about the potential flood affectation of individual properties? | | | | | How would you respond in a major flood in the area | | | | If you are likely to evacuate, what factors are most important? | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
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| 202 | Yes | | Yes | | | | Yes | | | | | Yes | |
| 203 | | | Yes | | | Yes | | | | Yes | Yes | Yes | |
| 204 | Yes | | Yes | | | | | Yes | | Yes | Yes | | |
| 205 | Yes | | Yes | | | Yes | | | | Yes | Yes | Yes | |
| 206 | Yes | | Yes | | | Yes | | | | Yes | Yes | Yes | |
| 207 | Yes | | | | | Yes | | | | | Yes | Yes | |
| 208 | | | | Yes | | Yes | | | | Yes | | | |
| 209 | Yes | | | | | | | Yes | | | | Yes | |
| 210 | Yes | | Yes | | | Yes | | | | | Yes | Yes | |
| 211 | Yes | | | | | | | Yes | | | | Yes | |
| 212 | Yes | | | | | | | Yes | | Yes | | | Pet Friendly (cats) |
| 213 | Yes | | | | | | | Yes | | | | Yes | |
| 214 | | | | | | | | | | | | | |
| 215 | Yes | | Yes | | | Yes | | | | | Yes | Yes | |
| 216 | Yes | | | | | Yes | | | | | | Yes | |
| 217 | Yes | | | | | | Yes | | | Yes | | Yes | |
| 218 | | | Yes | | | | Yes | | | | | Yes | |
| 219 | Yes | | | | | Yes | | | | | | Yes | |
| 220 | Yes | | | | | Yes | | | | | | Yes | |
| 221 | Yes | | | | | Yes | | | | | | Yes | |
| 222 | | Yes | Yes | | | | | | Yes | Yes | | Yes | |
| 223 | Yes | | Yes | | | | Yes | | | Yes | Yes | Yes | |
| 224 | Yes | | | | | Yes | | | | Yes | | | |
| 225 | Yes | | Yes | | | Yes | | | | Yes | | Yes | |
| 226 | | | Yes | | | Yes | | | | | | Yes | |
| 227 | Yes | | Yes | | | | Yes | | | Yes | Yes | Yes | |
| 228 | Yes | | Yes | | | Yes | | | | | | Yes | |
| 229 | Yes | | | | | Yes | | | | | | Yes | |
| 230 | Yes | | | | | Yes | | | | | | Yes | |
| 231 | | | Yes | | | Yes | | | | | | | Yes |

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| 232 | | | Yes | | | | Yes | | | | | Yes | |
| 233 | Yes | | | | | | | | Yes | | | Yes | |
| 234 | Yes | | | | | | | Yes | | Yes | | | |
| 235 | | | Yes | | | Yes | | | | Yes | | | |
| 236 | Yes | | Yes | | | | | Yes | | Yes | Yes | Yes | |
| 237 | Yes | | Yes | | | Yes | | | | Yes | Yes | | |
| 238 | Yes | | | | | Yes | | | | Yes | | Yes | |
| 239 | Yes | | | | | Yes | | | | Yes | | | |
| 240 | Yes | | | | | Yes | | | | | | Yes | |
| 241 | | | Yes | | | | Yes | | | | | Yes | |
| 242 | Yes | | | | | | Yes | Yes | Yes | Yes | | | |
| 243 | Yes | | Yes | | | Yes | | | | | Yes | Yes | |
| 244 | Yes | Yes | | | | | Yes | | | Yes | | | |
| 245 | | | Yes | | | Yes | | | | | | | Yes |
| 246 | Yes | | Yes | | | Yes | | | | Yes | | Yes | |
| 247 | Yes | | Yes | | | Yes | | | | | Yes | Yes | |
| 248 | Yes | | | | | | | | Yes | | | Yes | |
| 249 | Yes | | | | | | | Yes | | Yes | | Yes | |
| 250 | Yes | | Yes | | | | Yes | | | | | Yes | |
| 251 | Yes | | | | | | | Yes | | | | Yes | |
| 252 | Yes | | Yes | | | Yes | | | | | | Yes | |
| 253 | Yes | | | | | | | Yes | | | | Yes | |

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| 254 | | Yes | Yes | | | | | Yes | | Yes | | Yes | |
| 255 | Yes | | Yes | | | Yes | | | | Yes | Yes | Yes | |
| 256 | Yes | | | | | Yes | | | | | | Yes | |
| 257 | | Yes | | | | Yes | | | | Yes | | | |
| 258 | Yes | | Yes | | | Yes | | | | Yes | Yes | | |
| 259 | Yes | | Yes | | | Yes | | | | | Yes | | |
| 260 | | | Yes | | | Yes | | | | Yes | | Yes | |
| 261 | | | | | | | | | | | | | |
| 262 | | | | | | | | | | | | | |
| 263 | Yes | | Yes | | | | | | Yes | Yes | Yes | Yes | |
| 264 | Yes | | | | | | | Yes | | | | Yes | |
| 265 | Yes | | Yes | | | Yes | | | | | | Yes | |
| 266 | Yes | | | | | | | Yes | | Yes | Yes | Yes | |
| 267 | Yes | | | | | | Yes | | | | | Yes | |
| 268 | Yes | | Yes | | | | Yes | | | | | Yes | |
| 269 | Yes | Yes | Yes | | Yes | | Yes | | | Yes | | Yes | |
| 270 | Yes | | Yes | | Yes | Yes | Yes | | | Yes | Yes | Yes | |
| 271 | Yes | | Yes | | | Yes | | | | | | Yes | |
| 272 | Yes | | Yes | | | | | | Yes | | | Yes | |
| 273 | | Yes | Yes | | | Yes | | | | | | Yes | |
| 274 | Yes | | Yes | | | Yes | | | | | | Yes | |
| 275 | | | | | | | | | | | | | |
| 276 | Yes | | | | | Yes | | | | Yes | | | |
| 277 | Yes | Yes | Yes | | | Yes | | | | | Yes | Yes | |

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| 278 | | | Yes | | | Yes | | | | | Yes | Yes | |
| 279 | Yes | | Yes | | | | Yes | | | Yes | Yes | Yes | |
| 280 | Yes | | Yes | | | Yes | | | | | | Yes | |
| 281 | Yes | | | | | | | Yes | | Yes | | Yes | |
| 282 | | | Yes | | | Yes | | | | | | Yes | |
| 283 | | | Yes | | | | Yes | | | | | | NOT IN FLOOD ZONE |
| 284 | Yes | | | | | Yes | | | | | Yes | Yes | |
| 285 | Yes | | Yes | | | | Yes | Yes | | | | Yes | |
| 286 | Yes | | Yes | | | Yes | | | | Yes | | Yes | |
| 287 | Yes | | Yes | | | Yes | | | | | | Yes | |
| 288 | | Yes | Yes | | | Yes | | | | | | Yes | |
| 289 | Yes | | | | | Yes | | | | | | Yes | |
| 290 | Yes | | | | | Yes | | | | | Yes | Yes | |
| 291 | Yes | | | | | Yes | | | | | | Yes | |
| 292 | Yes | | Yes | | | Yes | | | | | | Yes | |
| 293 | Yes | | Yes | | | | Yes | | | Yes | | Yes | |
| 294 | Yes | | | | | Yes | | | | | | Yes | |
| 295 | Yes | | Yes | | SMS FLOOD TEXT WARNINGS, LIKE THEY DO WITH FIRES | Yes | | | | | Yes | Yes | |
| 296 | | | Yes | | | Yes | | | | | Yes | Yes | |
| 297 | Yes | | | | | Yes | | | | Yes | | | |
| 298 | | Yes | | | | | | Yes | | | | Yes | |
| 299 | Yes | | Yes | | | Yes | | | | Yes | | | |
| 300 | | | Yes | | | | | Yes | | | | Yes | |
| 301 | Yes | | Yes | | | | | | Yes | | Yes | Yes | |

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| 302 | Yes | | | | | Yes | | | | Yes | | Yes | |
| 303 | Yes | | | | | Yes | | | | | | Yes | |
| 304 | Yes | | Yes | | | | Yes | | | Yes | | Yes | |
| 305 | Yes | | Yes | | | Yes | | | | | | Yes | |
| 306 | | | Yes | | | | Yes | | | | | Yes | Yes |
| 307 | Yes | | | | | | | Yes | | Yes | Yes | Yes | |
| 308 | Yes | | | | | Yes | | | | | Yes | Yes | |
| 309 | | Yes | Yes | | | | Yes | | | | | Yes | |
| 310 | Yes | | Yes | | | Yes | | | | | | Yes | |
| 311 | Yes | Yes | Yes | | | | Yes | | | | | Yes | |
| 312 | Yes | | | | | | Yes | | | | Yes | | |
| 313 | | Yes | | | | Yes | | | | Yes | Yes | | |
| 314 | Yes | | | | | Yes | | | | | | Yes | |
| 315 | Yes | | Yes | | | | | Yes | | Yes | | Yes | |
| 316 | Yes | | | | | | | Yes | | Yes | | | |
| 317 | Yes | | | | | | | Yes | | | | Yes | |
| 318 | Yes | | Yes | | | Yes | | | | Yes | Yes | Yes | |
| 319 | | Yes | Yes | | | Yes | | | | Yes | | Yes | |
| 320 | | Yes | Yes | | | Yes | | | | Yes | | Yes | |
| 321 | | Yes | Yes | | | Yes | | | | Yes | | Yes | |
| 322 | | Yes | Yes | | | Yes | | | | Yes | | Yes | |

| # | What notifications do you think Council should give about the potential flood affectation of individual properties? | | | | | How would you respond in a major flood in the area | | | | If you are likely to evacuate, what factors are most important? | | | |
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| 323 | Yes | | | | | Yes | | | | | Yes | Yes | |
| 324 | Yes | | Yes | | | | | Yes | | Yes | | Yes | |
| 325 | Yes | | Yes | | | | Yes | | | Yes | Yes | | |
| 326 | | | Yes | | | | | Yes | | | | Yes | |
| 327 | Yes | | | | | Yes | | | | | | Yes | |
| 328 | Yes | | | | | Yes | | | | Yes | Yes | Yes | |
| 329 | | Yes | Yes | | | Yes | | | | Yes | | Yes | |
| 330 | | | Yes | | | Yes | | | | | | Yes | |
| 331 | Yes | | Yes | | | Yes | | | | Yes | Yes | Yes | |
| 332 | Yes | | Yes | | | Yes | | | | Yes | | Yes | |
| 333 | | | Yes | | | | Yes | | | | | | |
| 334 | Yes | | Yes | | | Yes | | | | Yes | Yes | Yes | |
| 335 | Yes | Yes | Yes | | | Yes | | | | | | | |
| 336 | Yes | | | | | Yes | | | | Yes | | Yes | |
| 337 | Yes | | Yes | | | | | Yes | | Yes | Yes | Yes | |
| 338 | Yes | | Yes | | | Yes | | | | | | Yes | |
| 339 | Yes | | Yes | | | Yes | | | | | | Yes | |
| 340 | | | Yes | | | Yes | | | | | Yes | Yes | |
| 341 | Yes | | | | | Yes | | | | | | Yes | |
| 342 | Yes | | | | | Yes | | | | | | Yes | |
| 343 | Yes | | | | | | | Yes | | Yes | | Yes | |

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| 344 | Yes | | Yes | | | Yes | | | | | | Yes | |
| 345 | Yes | | Yes | | | Yes | | | | | Yes | Yes | |
| 346 | | Yes | Yes | | | | | | | Yes | Yes | Yes | |
| 347 | Yes | | Yes | | Yes | | Yes | | | | Yes | Yes | Yes |
| 348 | Yes | | Yes | | | Yes | | | | Yes | Yes | Yes | Yes |
| 349 | Yes | | Yes | | | | | Yes | | Yes | | Yes | |
| 350 | Yes | | | | | Yes | | | | | | Yes | |
| 351 | Yes | | | | | Yes | | | | | | Yes | |
| 352 | Yes | | Yes | | | Yes | | | | | | Yes | |
| 353 | Yes | | | | | Yes | | | | Yes | Yes | Yes | |
| 354 | Yes | | | | | Yes | | | | Yes | Yes | Yes | |
| 355 | Yes | | | | | | | | Yes | Yes | | | |
| 356 | Yes | | Yes | | | Yes | | | | Yes | | Yes | |
| 357 | Yes | | Yes | | | | Yes | | | | | Yes | |
| 358 | Yes | | Yes | | | | | Yes | | | | | |
| 359 | Yes | | Yes | | PROVIDE A WEBSITE WITH A MAP OF FLOOD ZONES | Yes | | | | Yes | | Yes | |
| 360 | | | Yes | | | | Yes | | | Yes | | | |
| 361 | Yes | | Yes | | | | | Yes | | Yes | | | |
| 362 | Yes | | Yes | | | | Yes | | | | | Yes | |
| 363 | | | Yes | | | Yes | | | | | | Yes | |
| 364 | | | | | | | | | | | | | |
| 365 | Yes | Yes | Yes | | | Yes | | | | Yes | Yes | Yes | |
| 366 | Yes | | | | | Yes | | | | Yes | Yes | Yes | |
| 367 | Yes | | Yes | | | Yes | | | | Yes | Yes | Yes | |
| 368 | Yes | | | | | | Yes | | | | | Yes | |

| # | What notifications do you think Council should give about the potential flood affectation of individual properties? | | | | | How would you respond in a major flood in the area | | | | If you are likely to evacuate, what factors are most important? | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Advise every resident and property owner on a regular basis of the known potential flood threat | Advise only those who enquire to Council about the known potential flood threat | Advise prospective purchasers of property of the known potential flood threat. | Provide no notifications | Other – please describe | Evacuate early to an evacuation centre | Remain at my house | Don't know/not sure | Other – please describe | Discomfort/inconvenience/cost of being isolated by floodwater | Need for access to medical facilities | Safety of our family | Other – please describe |
| 369 | | | | | | Yes | | | | | | Yes | |
| 370 | Yes | | | | | | | Yes | | | | Yes | |
| 371 | Yes | | | | | | | Yes | | | | Yes | |
| 372 | Yes | | Yes | | | | Yes | | | | Yes | Yes | |
| 373 | | | Yes | | | Yes | | | | | | Yes | |
| 374 | | | | | | | Yes | | | | | | |
| 375 | | | Yes | | | Yes | | | | | | Yes | |
| 376 | | | Yes | | | | Yes | | | | | Yes | |
| 377 | | | | | | Yes | | | | | | Yes | |
| 378 | Yes | | | | | | | Yes | | | | Yes | |
| 379 | Yes | | Yes | | | Yes | | | | | Yes | | |
| 380 | Yes | | | | | Yes | | | | | Yes | | |
| 381 | Yes | | | | | Yes | | | | | | Yes | |
| 382 | Yes | | | | | | Yes | | | | | Yes | |
| 383 | Yes | | | | | | | Yes | | Yes | | | |
| 384 | Yes | | | | | | | Yes | | | | Yes | |
| 385 | Yes | | Yes | | | Yes | | | | | Yes | Yes | |
| 386 | Yes | | Yes | | | | | Yes | | | Yes | Yes | |
| 387 | Yes | | | | | | | Yes | | Yes | | Yes | |
| 388 | | | Yes | | | | Yes | | | Yes | | | |
| 389 | Yes | | | | | Yes | | | | | Yes | Yes | |

| # | What notifications do you think Council should give about the potential flood affectation of individual properties? | | | | | How would you respond in a major flood in the area | | | | If you are likely to evacuate, what factors are most important? | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Advise every resident and property owner on a regular basis of the known potential flood threat | Advise only those who enquire to Council about the known potential flood threat | Advise prospective purchasers of property of the known potential flood threat. | Provide no notifications | Other – please describe | Evacuate early to an evacuation centre | Remain at my house | Don’t know/not sure | Other – please describe | Discomfort/inconvenience/cost of being isolated by floodwater | Need for access to medical facilities | Safety of our family | Other – please describe |
| 390 | Yes | | Yes | | | Yes | | | | Yes | | Yes | |
| 391 | Yes | | Yes | | | | Yes | | | Yes | | | |
| 392 | Yes | | | | | Yes | | | | | | Yes | |
| 393 | | | Yes | | | Yes | | | | Yes | | Yes | |
| 394 | Yes | | Yes | | | | Yes | | | | | | |
| 395 | Yes | | | | | | | Yes | | | Yes | Yes | |
| 396 | Yes | | | | | Yes | | | | Yes | | | |
| 397 | Yes | | | | | Yes | | | | | | Yes | |
| 398 | | | | | | | Yes | | | | Yes | | |
| 399 | | Yes | | | | Yes | | | | | | | |
| 400 | Yes | | | | | Yes | | | | | | Yes | |
| 401 | Yes | | | | | Yes | | | | Yes | Yes | Yes | |
| 402 | Yes | | | | | Yes | | | | Yes | Yes | Yes | |
| 403 | Yes | | Yes | | | Yes | | | | | Yes | | |
| 404 | Yes | | | | | | | Yes | | Yes | | | |
| 405 | Yes | | Yes | | | | | Yes | | Yes | | | |
| 406 | Yes | Yes | Yes | | | | Yes | | | Yes | Yes | Yes | |
| 407 | Yes | | Yes | | | | | | Yes | | | Yes | |
| 408 | Yes | | Yes | | | Yes | | | | | Yes | Yes | |
| 409 | Yes | | Yes | | | | Yes | | | | | Yes | |
| 410 | | | | Yes | | Yes | | | | | | Yes | |

| # | What notifications do you think Council should give about the potential flood affectation of individual properties? | | | | | How would you respond in a major flood in the area | | | | If you are likely to evacuate, what factors are most important? | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Advise every resident and property owner on a regular basis of the known potential flood threat | Advise only those who enquire to Council about the known potential flood threat | Advise prospective purchasers of property of the known potential flood threat. | Provide no notifications | Other – please describe | Evacuate early to an evacuation centre | Remain at my house | Don't know/not sure | Other – please describe | Discomfort/inconvenience/cost of being isolated by floodwater | Need for access to medical facilities | Safety of our family | Other – please describe |
| 411 | Yes | | Yes | | | Yes | | | | Yes | | | |
| 412 | Yes | | | | | | Yes | | | | Yes | | |
| 413 | | | Yes | | | Yes | | | | Yes | | Yes | |
| 414 | Yes | | | | | Yes | | | | | Yes | Yes | |
| 415 | Yes | | | | | | | | Yes | Yes | Yes | Yes | |
| 416 | | Yes | Yes | | | Yes | | | | Yes | Yes | Yes | |
| 417 | | | Yes | | | Yes | | | | | Yes | Yes | |
| 418 | | | Yes | | Yes | | | Yes | | | | Yes | Yes |
| 419 | | | Yes | | | | Yes | | | Yes | Yes | Yes | |
| 420 | Yes | | | | | | Yes | | | Yes | | | |
| 421 | | | Yes | | | | | | Yes | Yes | Yes | Yes | Yes |
| 422 | Yes | | | | | Yes | | | | | | Yes | |
| 423 | Yes | | | | | | Yes | | | | | | |
| 424 | | | | Yes | | | | Yes | | | | | Yes |
| 425 | Yes | | | | | | | | | | | Yes | |
| 426 | Yes | | Yes | | | Yes | | | | Yes | Yes | Yes | |
| 427 | | | | | | | | | | | | | |
| 428 | | Yes | Yes | | | | Yes | | | | | Yes | |
| 429 | Yes | | | | | Yes | | | | | | Yes | |
| 430 | Yes | | Yes | | | | Yes | | | Yes | | | |
| 431 | | Yes | | | | Yes | | | | | Yes | Yes | |
| 432 | | | | Yes | | | | Yes | | | | Yes | |

| # | What notifications do you think Council should give about the potential flood affectation of individual properties? | | | | | How would you respond in a major flood in the area | | | | If you are likely to evacuate, what factors are most important? | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Advise every resident and property owner on a regular basis of the known potential flood threat | Advise only those who enquire to Council about the known potential flood threat | Advise prospective purchasers of property of the known potential flood threat. | Provide no notifications | Other – please describe | Evacuate early to an evacuation centre | Remain at my house | Don't know/not sure | Other – please describe | Discomfort/inconvenience/cost of being isolated by floodwater | Need for access to medical facilities | Safety of our family | Other – please describe |
| 433 | Yes | | | | | | Yes | | | Yes | | | |
| 434 | Yes | Yes | | | | Yes | | | | | | Yes | |
| 435 | Yes | | Yes | | | | | Yes | | Yes | | Yes | |
| 436 | Yes | | Yes | | | | Yes | | | Yes | Yes | Yes | |
| 437 | | | Yes | | | Yes | | | | | | Yes | |
| 438 | | | | | | | | | | | | | |
| 439 | | | | Yes | | | | Yes | | Yes | | | |
| 440 | Yes | | | | | | Yes | | | | Yes | | |
| 441 | | | Yes | | | | Yes | | | | | Yes | |
| 442 | Yes | | | | | | Yes | | | | | Yes | |
| 443 | Yes | | | | | | Yes | | | | | Yes | |
| 444 | Yes | | | | | Yes | | | | | | Yes | |
| 445 | Yes | | | | | | Yes | | | | | Yes | |
| 446 | | | Yes | | | Yes | | | | | Yes | Yes | |
| 447 | Yes | | Yes | | Yes | | | | | Yes | | Yes | Yes |
| 448 | | | Yes | | | | | Yes | | | | | |
| 449 | | | | | | | | | | | | | |
| 450 | Yes | | Yes | | | | | Yes | | | | Yes | |
| 451 | Yes | | Yes | | | | | Yes | | | | Yes | |
| 452 | Yes | | Yes | | | Yes | | | | | Yes | Yes | |
| 453 | Yes | | Yes | | | | Yes | | | | | | SECURE PROPERTY FROM LOOTERS |
| 454 | | | Yes | | | | | Yes | | | | Yes | |

| # | What notifications do you think Council should give about the potential flood affectation of individual properties? | | | | | How would you respond in a major flood in the area | | | | If you are likely to evacuate, what factors are most important? | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Advise every resident and property owner on a regular basis of the known potential flood threat | Advise only those who enquire to Council about the known potential flood threat | Advise prospective purchasers of property of the known potential flood threat. | Provide no notifications | Other – please describe | Evacuate early to an evacuation centre | Remain at my house | Don't know/not sure | Other – please describe | Discomfort/inconvenience/cost of being isolated by floodwater | Need for access to medical facilities | Safety of our family | Other – please describe |
| 455 | | | | | Yes | | | | Yes | | | | Yes |
| 456 | Yes | | | | | | | Yes | | Yes | Yes | Yes | |
| 457 | Yes | | Yes | | | Yes | | | | | | Yes | |
| 458 | Yes | | Yes | | | Yes | | | | Yes | | Yes | |
| 459 | Yes | | | | | Yes | | | | | | Yes | |
| 460 | Yes | | | | | Yes | | | | | | Yes | |
| 461 | Yes | | | | | | | Yes | | | | Yes | |
| 462 | Yes | | | | | | Yes | | | Yes | | Yes | |
| 463 | Yes | | | | | Yes | | | | | | Yes | |
| 464 | Yes | | Yes | | | | Yes | | | | | Yes | |
| 465 | Yes | | | | | | | Yes | | | | Yes | |
| 466 | | | Yes | | Yes | Yes | | | | Yes | | Yes | |
| 467 | | | Yes | | | Yes | | | | | Yes | | |
| 468 | | | Yes | | | Yes | | | | | | Yes | |
| 469 | Yes | | | | | Yes | | | | | | Yes | |
| 470 | | | Yes | | | Yes | | | | | Yes | Yes | |
| 471 | Yes | | | | | | Yes | | | Yes | | | |
| 472 | Yes | | Yes | | | Yes | | | | Yes | Yes | Yes | |
| 473 | | | Yes | | | | Yes | | | | | Yes | |
| 474 | Yes | | | | | Yes | | | | | Yes | Yes | |
| 475 | Yes | | Yes | | | Yes | | | | | Yes | Yes | |
| 476 | Yes | | Yes | | | Yes | | | | | Yes | | |
| 477 | Yes | | Yes | | | | | Yes | | | Yes | Yes | |
| 478 | | | | Yes | | | | Yes | | | | Yes | |
| 479 | Yes | | | | | | | Yes | | Yes | | | |
| 480 | | | Yes | | | Yes | | | | | | Yes | |

| # | What notifications do you think Council should give about the potential flood affectation of individual properties? | | | | | How would you respond in a major flood in the area | | | | If you are likely to evacuate, what factors are most important? | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
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| 481 | Yes | | | | | Yes | | | | | Yes | | |
| 482 | Yes | | | | | | | Yes | | Yes | | | |
| 483 | Yes | | Yes | | | Yes | | | | Yes | Yes | Yes | |
| 484 | | Yes | | | | Yes | | | | Yes | | Yes | |
| 485 | Yes | | Yes | | | | | Yes | | | | | |
| 486 | Yes | Yes | Yes | | | | | | Yes | Yes | Yes | Yes | |
| 487 | Yes | | | | | | | Yes | | | | Yes | |
| 488 | | | | | Yes | | | Yes | | | | Yes | |
| 489 | | Yes | Yes | | | Yes | | | | Yes | Yes | | |
| 490 | Yes | | | | | | | Yes | | | | Yes | |
| 491 | Yes | Yes | Yes | | | Yes | | | | | | Yes | |
| 492 | Yes | | Yes | | | Yes | | | | | | Yes | |
| 493 | Yes | | | | | Yes | | | | | | Yes | |
| 494 | Yes | | Yes | | | Yes | | | | | | Yes | |
| 495 | Yes | | | | | | Yes | | | | | Yes | |
| 496 | | | Yes | | | Yes | | | | | | Yes | |
| 497 | | Yes | Yes | | | Yes | Yes | | | Yes | | Yes | |
| 498 | | | Yes | | | | | | Yes | | Yes | Yes | |
| 499 | Yes | | | | | Yes | | | | Yes | | Yes | |
| 500 | Yes | | Yes | | | | | Yes | | Yes | Yes | Yes | |
| 501 | Yes | | | | | | Yes | | | Yes | Yes | Yes | |
| 502 | Yes | | Yes | | | | | Yes | | | | Yes | |

| # | What notifications do you think Council should give about the potential flood affectation of individual properties? | | | | | How would you respond in a major flood in the area | | | | If you are likely to evacuate, what factors are most important? | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Advise every resident and property owner on a regular basis of the known potential flood threat | Advise only those who enquire to Council about the known potential flood threat | Advise prospective purchasers of property of the known potential flood threat. | Provide no notifications | Other – please describe | Evacuate early to an evacuation centre | Remain at my house | Don't know/not sure | Other – please describe | Discomfort/inconvenience/cost of being isolated by floodwater | Need for access to medical facilities | Safety of our family | Other – please describe |
| 503 | Yes | | Yes | | | Yes | | | | Yes | Yes | Yes | |
| 504 | Yes | | Yes | | | | | Yes | | | | Yes | |
| 505 | Yes | | | | | Yes | | | | Yes | | | |
| 506 | Yes | | | | | | | Yes | | Yes | | Yes | |
| 507 | Yes | | Yes | | | Yes | | | | | | Yes | |
| 508 | Yes | | Yes | | | | Yes | | | | Yes | Yes | |
| 509 | Yes | | | | | | Yes | | | | | Yes | |
| 510 | Yes | | | | | | | Yes | | Yes | | Yes | |
| 511 | Yes | | Yes | | | Yes | | | | | | Yes | |
| 512 | Yes | | Yes | | | Yes | | | | | | Yes | |
| 513 | Yes | | Yes | | | Yes | | | | | | Yes | |
| 514 | | | Yes | | | | Yes | | | Yes | Yes | | |
| 515 | Yes | | | | | Yes | | | | Yes | Yes | Yes | |
| 516 | | | Yes | | | | | | Yes | | | Yes | |
| 517 | Yes | | Yes | | | | | Yes | | Yes | Yes | Yes | |
| 518 | Yes | | Yes | | | | | Yes | | Yes | Yes | Yes | |
| 519 | Yes | | | | | | Yes | | | | | Yes | |
| 520 | Yes | | | | | Yes | | | | | | Yes | |
| 521 | Yes | | Yes | | | | Yes | | | Yes | | | |
| 522 | Yes | | Yes | | | | Yes | | | | Yes | Yes | |
| 523 | Yes | | Yes | | | | Yes | | | Yes | Yes | Yes | |

| # | What notifications do you think Council should give about the potential flood affectation of individual properties? | | | | | How would you respond in a major flood in the area | | | | If you are likely to evacuate, what factors are most important? | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
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| 524 | Yes | | Yes | | | Yes | | | | Yes | Yes | Yes | |
| 525 | Yes | | | | | Yes | | | | Yes | Yes | | |
| 526 | Yes | | | | | | Yes | | | | | Yes | |
| 527 | Yes | | Yes | | | | | | Yes | Yes | | Yes | |
| 528 | Yes | | | | | Yes | | | | | | Yes | |
| 529 | Yes | | | | | | | Yes | | | | Yes | |
| 530 | Yes | | Yes | | | Yes | | | | | | Yes | |
| 531 | Yes | | Yes | | | Yes | | | | Yes | | Yes | |
| 532 | | | Yes | | | Yes | | | | | | Yes | |
| 533 | Yes | | Yes | | | Yes | | | | | Yes | Yes | |
| 534 | Yes | | Yes | | | Yes | | | | Yes | | | |
| 535 | Yes | | | | | Yes | | | | | | Yes | |
| 536 | Yes | | | | | Yes | | | | Yes | | | |
| 537 | Yes | | Yes | | | Yes | | | | Yes | | | |
| 538 | Yes | | | | | Yes | | | | | | Yes | |
| 539 | Yes | | | | | | | Yes | | Yes | | Yes | |
| 540 | Yes | | | | | | | | Yes | | | Yes | |
| 541 | Yes | | | | | Yes | | | | | Yes | Yes | |
| 542 | Yes | | Yes | | | | Yes | | | | | Yes | |
| 543 | | Yes | Yes | | | | Yes | | | Yes | | Yes | |
| 544 | | | Yes | | | | Yes | | | | | Yes | |
| 545 | Yes | | | | | | Yes | | | | | Yes | |

| # | What notifications do you think Council should give about the potential flood affectation of individual properties? | | | | | How would you respond in a major flood in the area | | | | If you are likely to evacuate, what factors are most important? | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
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| 546 | Yes | | | | | | | Yes | | Yes | | Yes | |
| 547 | Yes | | | | | | | | Yes | | | | AS PER Q8 |
| 548 | | | Yes | | | | | Yes | | | Yes | | |
| 549 | Yes | | Yes | | | Yes | | | | Yes | | Yes | |
| 550 | Yes | | | | | Yes | | | | | | Yes | |
| 551 | | | | | | | | | | | | | |
| 552 | | | Yes | | | Yes | | | | | Yes | Yes | |
| 553 | | Yes | | | | | | | Yes | | | Yes | |
| 554 | | | Yes | | | Yes | | | | | Yes | | |
| 555 | | | | | | | | | | | | | |
| 556 | | | | | | | | | | | | | |
| 557 | Yes | | | | | Yes | | | | Yes | | Yes | |
| 558 | Yes | | Yes | | | Yes | | | | | | Yes | |
| 559 | | | | | | | | | | | | | |
| 560 | Yes | | Yes | | | | | Yes | | | Yes | Yes | |
| 561 | Yes | Yes | Yes | | | | | Yes | | Yes | Yes | Yes | |
| 562 | Yes | | | | | Yes | | | | Yes | | Yes | |
| 563 | Yes | | | | | | | Yes | | Yes | Yes | | |
| 564 | Yes | | Yes | | | | | Yes | | Yes | | | |
| 565 | | | Yes | | | | | Yes | | | | Yes | |
| 566 | | | | | Yes | | Yes | | | | Yes | | Yes |
| 567 | | Yes | Yes | | | | Yes | | | | Yes | Yes | |
| 568 | Yes | Yes | Yes | | | Yes | | | | Yes | Yes | Yes | |
| 569 | Yes | | | | | | | Yes | | Yes | Yes | Yes | |
| 570 | Yes | | | | | Yes | | | | Yes | | | |
| 571 | | Yes | Yes | | | | Yes | | | | | Yes | |

| # | What notifications do you think Council should give about the potential flood affectation of individual properties? | | | | | How would you respond in a major flood in the area | | | | If you are likely to evacuate, what factors are most important? | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Advise every resident and property owner on a regular basis of the known potential flood threat | Advise only those who enquire to Council about the known potential flood threat | Advise prospective purchasers of property of the known potential flood threat. | Provide no notifications | Other – please describe | Evacuate early to an evacuation centre | Remain at my house | Don't know/not sure | Other – please describe | Discomfort/inconvenience/cost of being isolated by floodwater | Need for access to medical facilities | Safety of our family | Other – please describe |
| 572 | Yes | | Yes | | | Yes | | | | | | Yes | |
| 573 | Yes | | | | | Yes | | | | | Yes | | |
| 574 | Yes | | | | | | | Yes | | Yes | | | |
| 575 | Yes | | | | | | | Yes | | | | Yes | |
| 576 | Yes | | | | | Yes | | | | | | Yes | |
| 577 | Yes | | Yes | | | | | Yes | | Yes | Yes | Yes | |
| 578 | Yes | | | | | | | Yes | | | | Yes | |
| 579 | Yes | | | | | Yes | | | | | | Yes | |
| 580 | Yes | | Yes | | Yes | | | | Yes | | | Yes | |
| 581 | Yes | | | | | | | Yes | | | | Yes | |
| 582 | | | | Yes | | | Yes | | | | | | |
| 583 | Yes | | Yes | | | Yes | | | | Yes | Yes | Yes | |
| 584 | Yes | | | | | Yes | | | | | | Yes | |
| 585 | Yes | | Yes | | | | | Yes | | | Yes | | |

# Table A3 - Flood Response and Project Updates

| # | If you are likely to remain at your house, what factors are most important? | | | | | 11.What do you think is the best way for us to get input and feedback from the local community about the results and proposals from this study? | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Discomfort/inconvenience/cost of evacuating | Need to care for animals | My house cannot be flooded, and we can cope with isolation | Concern for security of my property if I evacuate | Other – please describe: | Council's website | Articles in local newspaper | Open days or drop-in days | Community workshops | Public meetings | Council's Floodplain Management Committee | Other (please specify) |
| 1 | | | Yes | | | | | | | | | |
| 2 | | | | Yes | | | | | | Yes | | |
| 3 | Yes | | | | | | Yes | | | | | |
| 4 | | | | Yes | | | | | Yes | | | |
| 5 | | | | Yes | | | | | | | | |
| 6 | Yes | | | | | Yes | | | | | | |
| 7 | | | | Yes | | | | | | | | |
| 8 | | | | Yes | | Yes | | | | | | |
| 9 | Yes | | | | | | | | Yes | | | |
| 10 | | | | Yes | | | | | | | Yes | |
| 11 | | | | Yes | | | | | | | Yes | |
| 12 | | | Yes | | | Yes | | | | | | |
| 13 | Yes | | | | | | | | Yes | | | |
| 14 | | | | Yes | | | Yes | | | | | |
| 15 | | Yes | | | | Yes | | | | | | |
| 16 | | | | Yes | | Yes | | | | | | |
| 17 | | | | Yes | | Yes | | | | | | |
| 18 | | | | Yes | | Yes | | | | | | |
| 19 | Yes | | | | | | | | | | Yes | |
| 20 | | | | Yes | | Yes | | | | | | |
| 21 | | | | | | | | | | | | 1. engage them asking for their opinion such as this survey; 2. public meetings; 3. through council's website providing residents are notified |
| 22 | Yes | | | | | Yes | | | | | | |
| 23 | Yes | | | | | Yes | | | | | | |
| 24 | Yes | | | | | Yes | | | | | | |
| 25 | | | | Yes | | Yes | | | | | | |
| 26 | | | Yes | | | Yes | | | | | | |
| 27 | | | Yes | | | | | | | Yes | | |
| 28 | | | | Yes | | | | | | | | |
| 29 | | | | | | | Yes | | | | | |
| 30 | | Yes | | | | Yes | | | | | | |
| 31 | | | | Yes | | Yes | | | | | | |
| 32 | | | | Yes | | | Yes | | | | | |
| 33 | | | Yes | | | | | | | | Yes | |
| 34 | | Yes | | | | Yes | | | | | | |
| 35 | Yes | | | | | | | | Yes | | | |
| 36 | | | Yes | | | Yes | | | | | | |
| 37 | | | | Yes | | Yes | | | | | | |
| 38 | | | | | | Yes | | | | | | |
| 39 | | Yes | | | | | Yes | | | | | |
| 40 | | Yes | | | | | Yes | | | | | |
| 41 | Yes | | | | | | Yes | | | | | |
| 42 | | | | Yes | | | Yes | | | | | |
| 43 | Yes | | | | | | | Yes | | | | |
| 44 | | | | | | | | | | Yes | | |
| 45 | Yes | | | | | Yes | | | | | | |
| 46 | Yes | | | | | | | | | | Yes | |
| 47 | | Yes | | | | Yes | | | | | | |
| 48 | Yes | | | | | Yes | | | | | | |
| 49 | Yes | | | | | Yes | | | | | | |
| 50 | | | Yes | | | Yes | | | | | | |

| # | If you are likely to remain at your house, what factors are most important? | | | | | 11.What do you think is the best way for us to get input and feedback from the local community about the results and proposals from this study? | | | | | | |
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| 51 | | Yes | | | | Yes | | | | | | |
| 52 | | | | Yes | | | | | | | | |
| 53 | | | | Yes | | | | | | Yes | | |
| 54 | | | Yes | | | | | | | | | |
| 55 | | | | | | | | | | | Yes | |
| 56 | | | Yes | | | Yes | | | | | | |
| 57 | | | | Yes | | Yes | | | | | | |
| 58 | | | | | | Yes | | | | | | |
| 59 | | | Yes | | | | Yes | | | | | |
| 60 | | | | Yes | | Yes | | | | | | |
| 61 | | | | | | | | | | Yes | | |
| 62 | Yes | | | | | | | | | Yes | | |
| 63 | Yes | | | | | | Yes | | | | | |
| 64 | | | Yes | | | | Yes | | | | | |
| 65 | | | | Yes | | | Yes | | | | | |
| 66 | Yes | | | | | Yes | | | | | | |
| 67 | | | Yes | | | Yes | | | | | | |
| 68 | Yes | | | | | Yes | | | | | | |
| 69 | | Yes | | | | Yes | | | | | | |
| 70 | | | | Yes | | | | | | | Yes | |
| 71 | | | | | | | | | | | | |
| 72 | | | | Yes | | | Yes | | | | | |
| 73 | Yes | | | | | | | | Yes | | | |
| 74 | Yes | | | | | | | | Yes | | | |
| 75 | | | | Yes | | | | | | | Yes | |
| 76 | | | | Yes | | Yes | | | | | | |
| 77 | | | | Yes | | | | | Yes | | | |
| 78 | Yes | | | | | Yes | | | | | | |
| 79 | | | | Yes | | | | | | Yes | | |
| 80 | Yes | | | | | | Yes | | | | | |
| 81 | | | | Yes | | | | | | Yes | | |
| 82 | | | | Yes | | Yes | | | | | | |
| 83 | Yes | | | | | | Yes | | | | | |
| 84 | | Yes | | | | Yes | | | | | | |
| 85 | | | Yes | | | Yes | | | | | | |
| 86 | Yes | | | | | Yes | | | | | | |
| 87 | | | | | | | Yes | | | | | |
| 88 | Yes | | Yes | Yes | | Yes | Yes | | | | | |
| 89 | | | Yes | | | | Yes | | | | | |
| 90 | | | | Yes | | | Yes | | | | | |
| 91 | Yes | Yes | | Yes | | | Yes | | | Yes | | |
| 92 | | | | Yes | | Yes | Yes | | | | Yes | |
| 93 | | | | Yes | | | | | Yes | Yes | | |
| 94 | | | | Yes | | | Yes | | | | | |
| 95 | | | Yes | | | | Yes | | | | | |
| 96 | | | | Yes | | Yes | | Yes | Yes | | | |
| 97 | | Yes | | Yes | | Yes | Yes | | | Yes | | |
| 98 | | | | | As Above | | | | | | | Mail out residents and property onwers |
| 99 | Yes | | Yes | | | Yes | Yes | Yes | Yes | Yes | Yes | |
| 100 | | | | | Yes | Yes | | | | | | |
| 101 | | | Yes | | | Yes | Yes | Yes | Yes | Yes | | |
| 102 | | | | Yes | | | | | Yes | | | |
| 103 | Yes | | | Yes | | Yes | Yes | Yes | Yes | Yes | Yes | |
| 104 | Yes | | | Yes | | Yes | Yes | Yes | Yes | Yes | | |
| 105 | Yes | | | | | | Yes | | | | | |
| 106 | | | Yes | | Yes | Yes | Yes | | | | | |
| 107 | Yes | | | | | Yes | Yes | | | | | |
| 108 | Yes | | | Yes | | Yes | Yes | | | | | |

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| 109 | | Yes | | Yes | | Yes | Yes | | | | Yes | |
| 110 | Yes | | | Yes | | | Yes | | | | | |
| 111 | | | Yes | Yes | | Yes | | | | Yes | | |
| 112 | | | Yes | | | Yes | | Yes | Yes | Yes | | |
| 113 | | | | Yes | | | Yes | | | | | |
| 114 | | Yes | | | | | Yes | Yes | | Yes | | |
| 115 | | Yes | Yes | Yes | | Yes | Yes | | | | | |
| 116 | | | | Yes | | Yes | Yes | | | | Yes | |
| 117 | | | | Yes | | | Yes | | | | | |
| 118 | | | | Yes | | | | | | | Yes | |
| 119 | | | | Yes | | Yes | Yes | | | Yes | | |
| 120 | | | Yes | | | | | | | | Yes | |
| 121 | Yes | | | | | | | | | | | BY MAIL or Email to Residents |
| 122 | Yes | | | Yes | | | | | | | | Info in LetterBox |
| 123 | | | Yes | | | | Yes | | | | | |
| 124 | | | | | Never Flooded in 40 years we have lived here | | Yes | | | | | |
| 125 | | | | Yes | | Yes | Yes | Yes | | | | |
| 126 | Yes | | | Yes | | | Yes | | Yes | | | |
| 127 | | | Yes | | | | | | | | | I have work on Drains for Long time I have offered my |
| 128 | | | | | | | Yes | | | | | |
| 129 | | Yes | | Yes | | Yes | Yes | | | | | |
| 130 | Yes | | | | | Yes | | | | Yes | | Information mail out through post or preferably email |
| 131 | Yes | | | | | Yes | Yes | | | | | |
| 132 | | | | Yes | | Yes | Yes | Yes | | Yes | | |
| 133 | | | Yes | | | Yes | Yes | | | | | Local Knowledge |
| 134 | Yes | Yes | | Yes | | Yes | Yes | | | Yes | | |
| 135 | | | | | Cannot comment as we do not live in the house | | | | | | | Please send mail to our home address in newington |
| 136 | | | | Yes | | Yes | | | | | | |
| 137 | | | | | | Yes | Yes | | | | | |
| 138 | | | Yes | | | | Yes | | | | Yes | |
| 139 | | Yes | | Yes | | Yes | Yes | | | | | |
| 140 | | | Yes | Yes | | Yes | Yes | | | Yes | | |
| 141 | | | | Yes | | | Yes | | | | | |
| 142 | | | Yes | | | | | | | | Yes | |
| 143 | | | | | | | | | | | | |
| 144 | | Yes | Yes | Yes | | Yes | | Yes | | Yes | | |
| 145 | | | Yes | | | Yes | | | | | | |
| 146 | | | | Yes | | | Yes | Yes | | | | |
| 147 | Yes | | | Yes | | | Yes | Yes | Yes | Yes | | |
| 148 | | | Yes | | | | Yes | | | | | |
| 149 | Yes | Yes | | Yes | | Yes | Yes | Yes | | | Yes | |
| 150 | | Yes | | Yes | | Yes | Yes | Yes | Yes | Yes | | |
| 151 | Yes | | | Yes | | Yes | Yes | | | | | |
| 152 | Yes | Yes | | Yes | | | Yes | | | | Yes | |
| 153 | | | Yes | | | Yes | | | | | | |
| 154 | | Yes | | Yes | | | | Yes | Yes | Yes | Yes | |
| 155 | Yes | | | Yes | | Yes | | | | | | |
| 156 | | | | Yes | | | | Yes | | | | |
| 157 | Yes | Yes | | | | | | | | | | LETTERS IN MAIL |
| 158 | | | Yes | Yes | | | | | | | | LETTER |
| 159 | Yes | | | | | | Yes | | | | | |
| 160 | | | | Yes | | | | | | | Yes | |
| 161 | | | Yes | | | | Yes | | | | | |
| 162 | | | | Yes | | | Yes | | | | | |
| 163 | | | | Yes | | | | | | | Yes | |
| 164 | | | Yes | | | | | | | | | All of the above is need to be made available |
| 165 | Yes | Yes | | Yes | | Yes | | | | | | |
| 166 | Yes | | | Yes | | Yes | Yes | | | | | |

| # | If you are likely to remain at your house, what factors are most important? | | | | | 11.What do you think is the best way for us to get input and feedback from the local community about the results and proposals from this study? | | | | | | |
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| | Discomfort/inconvenience/cost of evacuating | Need to care for animals | My house cannot be flooded, and we can cope with isolation | Concern for security of my property if I evacuate | Other – please describe: | Council's website | Articles in local newspaper | Open days or drop-in days | Community workshops | Public meetings | Council's Floodplain Management Committee | Other (please specify) |
| 167 | | | Yes | Yes | | | | | | | | Mail out to everyone |
| 168 | Yes | Yes | | Yes | | Yes | Yes | Yes | | Yes | Yes | |
| 169 | | | Yes | Yes | | Yes | Yes | Yes | Yes | Yes | | |
| 170 | | | | | | Yes | Yes | | | | | |
| 171 | Yes | | | Yes | | | Yes | Yes | | | Yes | |
| 172 | | Yes | | | | Yes | Yes | | | | | Letters /Mail |
| 173 | Yes | | | Yes | | Yes | | | | Yes | Yes | |
| 174 | Yes | | | | | | | | | | | Mail out like this questionare |
| 175 | | | Yes | | | | Yes | | | | | |
| 176 | | | | Yes | | | Yes | | | | | |
| 177 | | | Yes | | | Yes | | | | | | |
| 178 | | Yes | | Yes | | | Yes | | | | | |
| 179 | | | Yes | | | | Yes | | | | Yes | |
| 180 | | | | Yes | | Yes | Yes | | | Yes | | |
| 181 | | Yes | Yes | Yes | | Yes | | | | | | |
| 182 | Yes | | | Yes | | Yes | Yes | | | | | Excat Areas which would flood if(warr camba not useable) |
| 183 | Yes | | | | | Yes | | | | | | |
| 184 | | Yes | Yes | Yes | | | Yes | | | | | Send information by mail as part this survey |
| 185 | | Yes | Yes | Yes | | Yes | Yes | | | | Yes | |
| 186 | Yes | Yes | | Yes | | Yes | Yes | | | | | |
| 187 | | | | Yes | | | Yes | | | | | |
| 188 | | | | Yes | | | | | | | | |
| 189 | Yes | | | Yes | | Yes | Yes | Yes | Yes | Yes | Yes | EMAIL |
| 190 | | | Yes | | | Yes | | | | | | |
| 191 | Yes | | | | | Yes | | | | | | |
| 192 | | | Yes | | | | Yes | | | | | |
| 193 | | | | Yes | | Yes | | | | Yes | Yes | |
| 194 | | | | Yes | | Yes | | | | | | |
| 195 | Yes | | | Yes | | Yes | Yes | | | Yes | Yes | |
| 196 | Yes | | | Yes | | Yes | Yes | Yes | Yes | Yes | Yes | Mobile phone warning if flood is schedual to be happening |
| 197 | | | | Yes | | | | | Yes | | | |
| 198 | | | Yes | | | Yes | Yes | Yes | | | | Letter to all residents as you posted this at so our high |
| 199 | | | | Yes | | Yes | Yes | | | | | |
| 200 | | | | Yes | | | Yes | | | | | BY MAIL |
| 201 | | | | Yes | | | | | | | | WRITE TO US |
| 202 | | | Yes | Yes | | | Yes | | | | | |
| 203 | | | | Yes | | Yes | Yes | Yes | | | | |
| 204 | Yes | | | Yes | | Yes | Yes | | | | | |
| 205 | | Yes | | Yes | KEEP FAMILY MEMBERS SAFE FIRSTLY | Yes | Yes | | Yes | Yes | Yes | |
| 206 | Yes | | | Yes | | Yes | Yes | Yes | | Yes | | |
| 207 | | | Yes | | | Yes | Yes | Yes | Yes | Yes | Yes | |
| 208 | | | Yes | | | | Yes | | | | | |
| 209 | | | | Yes | | Yes | Yes | Yes | Yes | Yes | Yes | Mail outs to all residents.You should make every effort to |
| 210 | Yes | | | Yes | | Yes | Yes | | Yes | Yes | Yes | |
| 211 | | | Yes | | | | | | | Yes | | |
| 212 | Yes | Yes | Yes | Yes | | Yes | | Yes | | Yes | Yes | |
| 213 | | | | Yes | | Yes | Yes | Yes | Yes | Yes | Yes | Mail outs to all residents.You should make every effort to |
| 214 | | | | | | | | | | | | |
| 215 | Yes | | | Yes | | Yes | Yes | | Yes | Yes | Yes | |
| 216 | Yes | | | | | Yes | | | | | | |
| 217 | Yes | Yes | | Yes | | Yes | Yes | | | Yes | | |
| 218 | | | Yes | | | | Yes | | | | | |
| 219 | | | | | Yes | | | | | | | Yes |

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| 220 | | | | Yes | | | | | | | | Yes |
| 221 | | | | Yes | | Yes | | | | | | |
| 222 | | | | Yes | | Yes | Yes | | | | | |
| 223 | | | | Yes | Yes | Yes | Yes | | | Yes | Yes | |
| 224 | Yes | | | | | | | | | | Yes | |
| 225 | Yes | | | | | Yes | | | | | | Yes |
| 226 | | | | | | Yes | Yes | | | | | |
| 227 | Yes | Yes | Yes | Yes | | Yes | Yes | Yes | Yes | | | |
| 228 | Yes | | | | | Yes | Yes | | Yes | | Yes | |
| 229 | | | | Yes | | Yes | Yes | | | | | |
| 230 | | | | Yes | | Yes | Yes | | | | | |
| 231 | | Yes | | | | | Yes | | | | | |
| 232 | | | Yes | | | | Yes | | | | | |
| 233 | | | | Yes | | Yes | | | | | | Yes |
| 234 | Yes | | | | | | Yes | | | | | |
| 235 | | Yes | | | | | | | | Yes | | |
| 236 | Yes | Yes | | Yes | | Yes | Yes | Yes | Yes | Yes | Yes | |
| 237 | Yes | | | Yes | | Yes | Yes | | | | Yes | |
| 238 | Yes | Yes | | | | | | | Yes | Yes | | |
| 239 | Yes | | | Yes | | | Yes | | | Yes | | |
| 240 | | | | Yes | | Yes | Yes | | Yes | | | |
| 241 | | | Yes | | | | Yes | | | | | |
| 242 | Yes | | | Yes | | | Yes | Yes | Yes | Yes | Yes | |
| 243 | | | | Yes | | | Yes | | | Yes | | |

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| 244 | | | | Yes | | Yes | | Yes | Yes | Yes | Yes | |
| 245 | | | Yes | | | Yes | Yes | | | | | |
| 246 | | | | Yes | | Yes | Yes | | | | | |
| 247 | | | | Yes | | Yes | Yes | | | | Yes | |
| 248 | | Yes | | Yes | | Yes | Yes | | | | | |
| 249 | Yes | Yes | | Yes | | | Yes | | | Yes | | |
| 250 | | | | Yes | Yes | Yes | Yes | | | | Yes | |
| 251 | Yes | | | Yes | | | | | Yes | Yes | | |
| 252 | | | | | | | Yes | Yes | | Yes | | |
| 253 | | Yes | | Yes | | | Yes | Yes | | | | |
| 254 | | | | | | Yes | | | | | Yes | Yes |
| 255 | | | | | Yes | Yes | | Yes | | | | |
| 256 | | | | Yes | | | | | | Yes | | |
| 257 | | | Yes | | | Yes | | | | | | |
| 258 | | | Yes | Yes | | | Yes | | | | Yes | |
| 259 | | | | Yes | | Yes | Yes | | | | | |
| 260 | Yes | | | Yes | | | | | | Yes | Yes | |
| 261 | | | | | | | | | | | | |
| 262 | | | | | | | | | | | | |
| 263 | Yes | Yes | | Yes | | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 264 | Yes | | | Yes | | Yes | Yes | | | | | |
| 265 | | | Yes | Yes | | Yes | Yes | | Yes | | | |
| 266 | | Yes | | | | | Yes | | | | | |
| 267 | | Yes | | | | | Yes | | | | | |
| 268 | | | Yes | | | | Yes | | | | | |

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| 269 | | | | Yes | | Yes | Yes | | | Yes | | Yes |
| 270 | Yes | | | Yes | | Yes | Yes | Yes | Yes | Yes | | Yes |
| 271 | | | Yes | | | Yes | Yes | | | | | |
| 272 | Yes | | | Yes | | Yes | Yes | Yes | | | | |
| 273 | | | Yes | | | Yes | Yes | | | | | |
| 274 | | | | Yes | | Yes | | | | | | |
| 275 | | | | | | | | | | | | |
| 276 | | | Yes | Yes | | Yes | | | | Yes | Yes | |
| 277 | | Yes | | Yes | | Yes | Yes | | | | Yes | |
| 278 | | | Yes | Yes | | | Yes | Yes | | | | |
| 279 | Yes | | | Yes | | | | | | Yes | Yes | Yes |
| 280 | Yes | | Yes | Yes | | Yes | Yes | Yes | Yes | Yes | Yes | |
| 281 | Yes | | | Yes | | | | Yes | | Yes | | |
| 282 | Yes | Yes | | Yes | | Yes | Yes | | | | | |
| 283 | | Yes | Yes | | | | | | | | | SURVEYS |
| 284 | | Yes | Yes | | | | Yes | | | | | |
| 285 | | | | Yes | | | | | Yes | Yes | Yes | |
| 286 | Yes | | | Yes | | | | Yes | | Yes | | |
| 287 | | | | Yes | | Yes | | Yes | Yes | | | |
| 288 | Yes | | | Yes | | Yes | Yes | | Yes | | | |
| 289 | | | | | | Yes | | | Yes | | | |
| 290 | Yes | | | Yes | | Yes | Yes | | | | | |
| 291 | Yes | Yes | Yes | Yes | | Yes | Yes | | | | | |
| 292 | | | | Yes | | Yes | Yes | Yes | Yes | Yes | Yes | |
| 293 | | | Yes | | | | | | | | Yes | |
| 294 | | | | Yes | | | | | | | Yes | |
| 295 | | | | Yes | | | Yes | | | | | POP UP STORE FRONTS IN LOCAL SHOPPING CENTRES |

| # | If you are likely to remain at your house, what factors are most important? | | | | | 11.What do you think is the best way for us to get input and feedback from the local community about the results and proposals from this study? | | | | | | |
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| 296 | | | | Yes | | Yes | Yes | | | Yes | | |
| 297 | Yes | | | | | Yes | Yes | | | | | |
| 298 | | | | Yes | | Yes | Yes | | | | Yes | |
| 299 | Yes | | | | | Yes | | | Yes | | Yes | |
| 300 | Yes | | | | | | Yes | | | | | |
| 301 | | | | | Yes | Yes | Yes | Yes | Yes | Yes | Yes | |
| 302 | Yes | | | Yes | | Yes | Yes | | | Yes | | |
| 303 | | | | Yes | | Yes | | | Yes | | Yes | |
| 304 | Yes | | | Yes | | Yes | Yes | | | | Yes | |
| 305 | | | Yes | | | Yes | Yes | Yes | | | | |
| 306 | | | Yes | | | Yes | Yes | Yes | | Yes | Yes | |
| 307 | | | | Yes | | | | Yes | Yes | Yes | | |
| 308 | | Yes | Yes | Yes | | Yes | Yes | Yes | Yes | Yes | Yes | |
| 309 | | | Yes | | | Yes | | | | Yes | | MAIL OUT TO ALL AFFECTED PROPERTY OWNERS EVERY 2 YEARS |
| 310 | | | | Yes | | Yes | Yes | | | | | DISTRIBUTING LEAFLETS |
| 311 | | | | Yes | | Yes | | | | | | |
| 312 | | | Yes | | | | | | | | Yes | |
| 313 | | | Yes | | | | Yes | | | | | |
| 314 | | | | Yes | | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 315 | Yes | | | Yes | | | Yes | | | | Yes | |
| 316 | Yes | | | | | | | | | Yes | | |
| 317 | | | Yes | | | | Yes | | | Yes | | |
| 318 | | Yes | | Yes | | Yes | Yes | Yes | Yes | Yes | Yes | |
| 319 | Yes | | | Yes | | Yes | Yes | Yes | | Yes | | |

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| 320 | Yes | | | Yes | | Yes | Yes | Yes | | Yes | | |
| 321 | Yes | | | Yes | | Yes | Yes | Yes | | Yes | | |
| 322 | Yes | | | Yes | | Yes | Yes | Yes | | Yes | | |
| 323 | | | | Yes | | Yes | Yes | | | | | MAIL |
| 324 | Yes | | | Yes | | Yes | Yes | | | | | |
| 325 | Yes | | | Yes | | | Yes | Yes | | | | |
| 326 | | | | Yes | | | | Yes | | | | |
| 327 | | | | | SAFETY OF ALL CONCERNED | | Yes | | | Yes | | |
| 328 | Yes | | | Yes | | Yes | | | | Yes | Yes | |
| 329 | Yes | | | Yes | | Yes | Yes | Yes | | Yes | | |
| 330 | | | | Yes | | | Yes | | | Yes | | |
| 331 | Yes | Yes | | Yes | | Yes | Yes | | | Yes | | |
| 332 | Yes | | | Yes | | | Yes | Yes | Yes | | | |
| 333 | | | Yes | | | Yes | | | | | | |
| 334 | Yes | | | Yes | | Yes | Yes | Yes | | Yes | | |
| 335 | | Yes | | | | Yes | Yes | | | | Yes | |
| 336 | | | | Yes | | | | | | | | Yes |
| 337 | Yes | | | Yes | | Yes | | | Yes | Yes | | |
| 338 | | | | | | | Yes | | | | | |
| 339 | | | Yes | | | | Yes | | | | Yes | |
| 340 | | | | Yes | | | Yes | | | | Yes | |
| 341 | | | Yes | | | | | Yes | | | Yes | |
| 342 | | | | | SAFETY OF BUILDING & SUPPLIES | Yes | | | | | | |
| 343 | | | | Yes | | Yes | | | | Yes | | Yes |

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| 344 | | | Yes | | | Yes | Yes | | | | Yes | |
| 345 | | | Yes | | | Yes | Yes | | | | | |
| 346 | Yes | | | Yes | | Yes | | Yes | Yes | | Yes | |
| 347 | | | | Yes | Yes | | Yes | Yes | | Yes | | Yes |
| 348 | Yes | Yes | | Yes | | | | | | | | Yes |
| 349 | Yes | | | Yes | | | | | | | | |
| 350 | | | Yes | | | | Yes | | | | | |
| 351 | | | | Yes | | Yes | Yes | | | Y | Y | |
| 352 | Yes | | | Yes | | Yes | | | | | | |
| 353 | | | | | | Yes | Yes | | Yes | | Yes | Yes |
| 354 | Yes | | | Yes | | Yes | Yes | | Y | | Y | |
| 355 | Yes | | | Yes | Yes | | Yes | | | | | |
| 356 | | Yes | | Yes | | Yes | Yes | | | | | |
| 357 | Yes | Yes | | | | Yes | Yes | | | | | EMAIL NOTIFICATION |
| 358 | | | | | | | Yes | | | | | |
| 359 | Yes | | | Yes | | Yes | | | | | | |
| 360 | Yes | | | | | | Yes | | | | | |
| 361 | | | | Yes | | Yes | Yes | Yes | | | | |
| 362 | | | | Yes | | | Yes | Yes | | | Yes | |
| 363 | | | | | I WOULD MOVE | Yes | Yes | | | | | |
| 364 | | | | | | | | | | | | |
| 365 | Yes | | Yes | Yes | | Yes | Yes | Yes | Yes | | Yes | |
| 366 | Yes | Yes | Yes | Yes | | Yes | | Yes | | Yes | | |
| 367 | Yes | | | | | Yes | Yes | Yes | Yes | Yes | Yes | |
| 368 | | | | Yes | | | | | | | Yes | |
| 369 | Yes | | | Yes | | Yes | | | | | Yes | |
| 370 | Yes | | | | | Yes | | | | | | VIA EMAIL |

| # | If you are likely to remain at your house, what factors are most important? | | | | | 11.What do you think is the best way for us to get input and feedback from the local community about the results and proposals from this study? | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Discomfort/inconvenience/cost of evacuating | Need to care for animals | My house cannot be flooded, and we can cope with isolation | Concern for security of my property if I evacuate | Other – please describe: | Council's website | Articles in local newspaper | Open days or drop-in days | Community workshops | Public meetings | Council's Floodplain Management Committee | Other (please specify) |
| 371 | | | | Yes | | Yes | Yes | | | | | |
| 372 | | Yes | Yes | Yes | | Yes | | | Yes | Yes | | |
| 373 | | | | Yes | MY OWN SAFETY | | | | | | | SEND MAIL/EMAIL RESIDENTS |
| 374 | | | | | THIS PROPERTY DOES NOT FLOOD, WE HAVE AT ALL TIME HAD ACCESS TO THE RAILWAY STATION | | | | | Yes | | |
| 375 | | | Yes | | | | Yes | | | | | LETTERS & UPDATES SENT TO ALL OWNERS OF PROPERTIES |
| 376 | | | | Yes | | | | | | Yes | | |
| 377 | | | | Yes | | | | | | | | |
| 378 | | | | Yes | | Yes | Yes | | | Yes | Yes | |
| 379 | | | | Yes | | Yes | Yes | | | Yes | Yes | |
| 380 | | | | Yes | | Yes | Yes | Yes | Yes | Yes | Yes | |
| 381 | | | | Yes | | Yes | | | | | | |
| 382 | | | Yes | | | | Yes | | | | | |
| 383 | Yes | | | Yes | | | Yes | | | Yes | | |
| 384 | | | | Yes | | | | | | | | |
| 385 | Yes | Yes | | Yes | | Yes | Yes | Yes | Yes | Yes | Yes | |
| 386 | Yes | Yes | | Yes | | Yes | | | | | | SOCIAL MEDIA |
| 387 | Yes | | Yes | Yes | | Yes | Yes | | | | | |
| 388 | | | Yes | | | | Yes | | | | | |
| 389 | Yes | | | Yes | | | Yes | | | | | |
| 390 | Yes | | | Yes | | Yes | Yes | | | Yes | | |
| 391 | | | Yes | | | Yes | Yes | | | | | |
| 392 | | | | Yes | | | Yes | | | | | |
| 393 | | | Yes | Yes | | | Yes | | Yes | | Yes | |
| 394 | | | Yes | | | | Yes | Yes | | | | |

| # | If you are likely to remain at your house, what factors are most important? | | | | | 11.What do you think is the best way for us to get input and feedback from the local community about the results and proposals from this study? | | | | | | |
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| | Discomfort/inconvenience/cost of evacuating | Need to care for animals | My house cannot be flooded, and we can cope with isolation | Concern for security of my property if I evacuate | Other – please describe: | Council's website | Articles in local newspaper | Open days or drop-in days | Community workshops | Public meetings | Council's Floodplain Management Committee | Other (please specify) |
| 395 | Yes | | Yes | | | Yes | Yes | Yes | | | | |
| 396 | Yes | | | Yes | | Yes | Yes | Yes | Yes | Yes | | |
| 397 | | | | Yes | | Yes | Yes | Yes | Yes | Yes | Yes | |
| 398 | | | | Yes | | | Yes | | Yes | | | |
| 399 | | | | | | Yes | Yes | | | | | |
| 400 | Yes | | | | | Yes | Yes | | | | | |
| 401 | | Yes | | Yes | | Yes | Yes | | | | | |
| 402 | Yes | | | Yes | | Yes | | | | | | |
| 403 | | | | Yes | | | | | Yes | | | |
| 404 | Yes | | | | | | | | | Yes | | |
| 405 | | | | Yes | | | | | | | Yes | |
| 406 | | | | Yes | | | | | | | | LETTER TO RESIDENCE "POST" |
| 407 | Yes | | | | | | | | | | | Yes |
| 408 | Yes | Yes | | Yes | | Yes | Yes | | | | Yes | |
| 409 | | Yes | | Yes | | Yes | Yes | | | | | |
| 410 | | Yes | Yes | | | | Yes | | | | | |
| 411 | Yes | | | Yes | | | Yes | | | | Yes | |
| 412 | Yes | Yes | | | | | Yes | | | Yes | | |
| 413 | Yes | | | | | Yes | Yes | | | | | |
| 414 | | | | Yes | | Yes | Yes | | | Yes | | |
| 415 | Yes | Yes | | Yes | | | | | | | Yes | |
| 416 | Yes | | Yes | | | | | | | | | ALL OT THE ABOVE + EMAIL |
| 417 | Yes | Yes | | | | | Yes | | | | | |

| # | If you are likely to remain at your house, what factors are most important? | | | | | 11.What do you think is the best way for us to get input and feedback from the local community about the results and proposals from this study? | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Discomfort/inconvenience/cost of evacuating | Need to care for animals | My house cannot be flooded, and we can cope with isolation | Concern for security of my property if I evacuate | Other – please describe: | Council's website | Articles in local newspaper | Open days or drop-in days | Community workshops | Public meetings | Council's Floodplain Management Committee | Other (please specify) |
| 418 | Yes | Yes | | | Yes | Yes | Yes | | | Yes | | |
| 419 | Yes | Yes | | Yes | | Yes | Yes | Yes | | | Yes | |
| 420 | | | Yes | | | Yes | Yes | | | | | |
| 421 | | | Yes | | | Yes | Yes | Yes | Yes | Yes | Yes | |
| 422 | | | | Yes | | | Yes | | | | | |
| 423 | | Yes | | | | Yes | Yes | | Yes | Yes | | |
| 424 | | | Yes | | | | | | | | | Yes |
| 425 | | | | | | | Yes | | Yes | Yes | | |
| 426 | | Yes | | Yes | | Yes | | | | | Yes | |
| 427 | | | | | | | | | | | | |
| 428 | | | Yes | | | Yes | Yes | | | | | |
| 429 | | | | Yes | | | | | | Yes | | |
| 430 | | Yes | Yes | Yes | | Yes | Yes | | | | | |
| 431 | Yes | | | Yes | | | Yes | | | | Yes | |
| 432 | | | | Yes | | | | | | | Yes | |
| 433 | Yes | | | | | | Yes | | | | | |
| 434 | | | | Yes | | | Yes | | | | | |
| 435 | | Yes | | Yes | | | Yes | | | | | |
| 436 | Yes | | Yes | Yes | | Yes | Yes | | | | | |
| 437 | | Yes | | Yes | | Yes | Yes | | | Yes | | |
| 438 | | | | | | | | | | | | |
| 439 | | | | Yes | | | | Yes | | | | |
| 440 | | | | Yes | | | | | | | | PAPER SURVEY |
| 441 | | Yes | | | | | Yes | | | | | |
| 442 | | | | Yes | | Yes | | | | | | |
| 443 | | | | Yes | | Yes | | | | | | |

| # | If you are likely to remain at your house, what factors are most important? | | | | | 11.What do you think is the best way for us to get input and feedback from the local community about the results and proposals from this study? | | | | | | |
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| | Discomfort/inconvenience/cost of evacuating | Need to care for animals | My house cannot be flooded, and we can cope with isolation | Concern for security of my property if I evacuate | Other – please describe: | Council's website | Articles in local newspaper | Open days or drop-in days | Community workshops | Public meetings | Council's Floodplain Management Committee | Other (please specify) |
| 444 | | | | Yes | | | Yes | | | | | |
| 445 | | | | Yes | | | | | | | Yes | |
| 446 | | | | | | Yes | Yes | Yes | | Yes | Yes | |
| 447 | Yes | | | Yes | Yes | Yes | Yes | Yes | Yes | Yes | | |
| 448 | Yes | Yes | Yes | Yes | WE HAVE PETS | | Yes | | | | | DELIVERY OF INFORMATION TO HOUSE HOLD |
| 449 | | | | | | | | | | | | |
| 450 | | | | Yes | | | | Yes | Yes | | | |
| 451 | Yes | Yes | Yes | Yes | | | | | | | | LOCAL FACEBOOK GROUPS OR PERHAPS A P.C.C FACEBOOK GROUP PAGE. |
| 452 | | | | Yes | | | | | | | Yes | |
| 453 | | | | Yes | | | | | | | Yes | |
| 454 | | | Yes | | | Yes | | | | | | |
| 455 | Yes | | | Yes | | | | | | | | |
| 456 | Yes | | | Yes | | | | | | | Yes | |
| 457 | | | | | | Yes | Yes | Yes | Yes | Yes | | |
| 458 | Yes | Yes | | Yes | | | Yes | | | | | Yes |
| 459 | | | | | | | | | | | | EMAIL INDIVIDUALS |
| 460 | | | Yes | | | | Yes | | | | | |
| 461 | | | | Yes | | Yes | | | | | | |
| 462 | Yes | Yes | | Yes | | | | | | | | Yes |
| 463 | | Yes | | | | | Yes | | | Yes | Yes | |
| 464 | | | Yes | | | | | | | | | SEND RESULTS TO EVERYONE THESEFORMS ARE SEND TOO |
| 465 | | Yes | | Yes | | | | Yes | | | | |
| 466 | | | | | Yes | | | | | | | Yes |
| 467 | | | | Yes | | | Yes | | | | | |
| 468 | | | | Yes | | | Yes | | | | | |

| # | If you are likely to remain at your house, what factors are most important? | | | | | 11.What do you think is the best way for us to get input and feedback from the local community about the results and proposals from this study? | | | | | | |
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| 469 | | Yes | | Yes | | | Yes | | | Yes | | |
| 470 | | | | Yes | | Yes | | | | | Yes | |
| 471 | | | | Yes | | | Yes | | | | | |
| 472 | Yes | | | Yes | | Yes | Yes | Yes | | Yes | Yes | |
| 473 | | | Yes | | | | Yes | | | | Yes | |
| 474 | | | | Yes | | Yes | Yes | | | Yes | | |
| 475 | | Yes | Yes | Yes | | Yes | Yes | Yes | Yes | Yes | Yes | |
| 476 | | Yes | | | | | Yes | | | | Yes | |
| 477 | | | | Yes | | Yes | Yes | | Yes | | | |
| 478 | | | | Yes | | Yes | | | | | | |
| 479 | Yes | | | | | Yes | | | | | | |
| 480 | Yes | | | Yes | | | Yes | | | | | |
| 481 | | | | | Yes | Yes | | | | | | |
| 482 | | | | Yes | | | Yes | Yes | | | | |
| 483 | | | | Yes | | | | Yes | | | | |
| 484 | Yes | | | Yes | | | Yes | | | | | |
| 485 | | | | Yes | | | Yes | | | Yes | | |
| 486 | Yes | | | | | Yes | Yes | Yes | | Yes | Yes | Yes |
| 487 | | | | Yes | | | Yes | | | | | |
| 488 | Yes | | | Yes | | Yes | Yes | | | | | |
| 489 | Yes | | Yes | Yes | | Yes | | | | | Yes | |
| 490 | | | Yes | | | Yes | | | | | | |
| 491 | | | | Yes | | Yes | Yes | Yes | Yes | Yes | Yes | |
| 492 | Yes | | | | | Yes | | Yes | | | | |
| 493 | | | | Yes | | | Yes | | | | | |
| 494 | | | | | Yes | Yes | Yes | Yes | Yes | Yes | | |

| # | If you are likely to remain at your house, what factors are most important? | | | | | 11.What do you think is the best way for us to get input and feedback from the local community about the results and proposals from this study? | | | | | | |
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| | Discomfort/inconvenience/cost of evacuating | Need to care for animals | My house cannot be flooded, and we can cope with isolation | Concern for security of my property if I evacuate | Other – please describe: | Council's website | Articles in local newspaper | Open days or drop-in days | Community workshops | Public meetings | Council's Floodplain Management Committee | Other (please specify) |
| 495 | Yes | Yes | | Yes | | Yes | | | | | | Yes |
| 496 | | Yes | | | | Yes | | | | | | |
| 497 | | Yes | | Yes | | | | | | | Yes | |
| 498 | Yes | | | Yes | | Yes | | | | | | Yes |
| 499 | Yes | Yes | | Yes | | Yes | Yes | | | Yes | | |
| 500 | Yes | | | Yes | | Yes | Yes | | | Yes | Yes | |
| 501 | | | Yes | Yes | | Yes | Yes | | | | Yes | |
| 502 | | | | Yes | | Yes | Yes | | | | | |
| 503 | | Yes | | Yes | | Yes | Yes | Yes | Yes | Yes | Yes | |
| 504 | Yes | Yes | | Yes | | | | | | | | DOOR KNOCKING |
| 505 | Yes | | | | | | Yes | | | | | |
| 506 | Yes | | | | | Yes | | | | | Yes | |
| 507 | | | | Yes | | Yes | | | | | | |
| 508 | | Yes | Yes | | | Yes | Yes | | | Yes | | |
| 509 | | | | Yes | | | | | | | Yes | |
| 510 | Yes | Yes | | Yes | | Yes | | | | | | |
| 511 | | Yes | | | | Yes | Yes | Yes | Yes | Yes | | |
| 512 | | | | | | Yes | Yes | Yes | | | | |
| 513 | | | | Yes | | Yes | Yes | | | | | |
| 514 | Yes | | | Yes | | | Yes | | | | | |
| 515 | Yes | Yes | Yes | Yes | | Yes | | | | | | |
| 516 | | | | | Yes | | | | | | | Yes |
| 517 | Yes | | | Yes | | Yes | Yes | Yes | Yes | Yes | Yes | |
| 518 | Yes | Yes | | Yes | | Yes | Yes | | | Yes | | |

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| 519 | | | | Yes | | | Yes | | | | | |
| 520 | Yes | | | Yes | | Yes | | Yes | | | Yes | |
| 521 | | | Yes | | | Yes | | | | | | |
| 522 | | | | Yes | | Yes | | Yes | | Yes | Yes | |
| 523 | | | Yes | | | | | | | | | Yes |
| 524 | Yes | | | Yes | | Yes | Yes | | | | Yes | |
| 525 | | | | Yes | | | Yes | | | | | |
| 526 | | | Yes | | | | Yes | | | | | |
| 527 | Yes | Yes | | Yes | | | Yes | | | Yes | Yes | |
| 528 | Yes | | | | | | | | | | | FACEBOOK |
| 529 | | | | Yes | | Yes | Yes | | | | | |
| 530 | Yes | | | | | Yes | Yes | Yes | | Yes | Yes | |
| 531 | Yes | | | Yes | | Yes | | | | | Yes | EMAILS |
| 532 | | | Yes | | | | | | | | Yes | |
| 533 | | Yes | | Yes | | Yes | | | | Yes | | EMAIL AND /OR POSTAL SURVEYS |
| 534 | Yes | Yes | | Yes | | | | | | | | |
| 535 | | Yes | | Yes | | | | | Yes | | Yes | |
| 536 | | | Yes | | | | | | | | | LETTER BOX DROP |
| 537 | | | | Yes | | Yes | Yes | Yes | | | | |
| 538 | | | Yes | | | Yes | | | Yes | | Yes | |
| 539 | Yes | | | Yes | | Yes | Yes | | | | Yes | |
| 540 | Yes | | | | | | | Yes | Yes | Yes | | |
| 541 | Yes | Yes | | | | Yes | Yes | | | | | |
| 542 | | | | Yes | | Yes | | | | Yes | | |

| # | If you are likely to remain at your house, what factors are most important? | | | | | 11.What do you think is the best way for us to get input and feedback from the local community about the results and proposals from this study? | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Discomfort/inconvenience/cost of evacuating | Need to care for animals | My house cannot be flooded, and we can cope with isolation | Concern for security of my property if I evacuate | Other – please describe: | Council's website | Articles in local newspaper | Open days or drop-in days | Community workshops | Public meetings | Council's Floodplain Management Committee | Other (please specify) |
| 543 | Yes | | Yes | | | Yes | | | | Yes | Yes | Yes |
| 544 | | | Yes | | | Yes | Yes | | | | | |
| 545 | | | Yes | | | | Yes | | | | | |
| 546 | | | | Yes | | | | | | Yes | | THIS WAY |
| 547 | | | | | AS PER Q8 | Yes | | | | | | |
| 548 | | | | Yes | | | | | | | Yes | |
| 549 | Yes | Yes | | Yes | | Yes | | Yes | | Yes | Yes | |
| 550 | | | | Yes | | | Yes | | | | | |
| 551 | | | | | | | | | | | | |
| 552 | | | | Yes | | Yes | Yes | Yes | Yes | Yes | Yes | |
| 553 | | | | Yes | | | | | | Yes | | |
| 554 | | | Yes | | | | Yes | | | | | |
| 555 | | | | | | | | | | | | |
| 556 | | | | | | | | | | | | |
| 557 | Yes | | | Yes | | Yes | | Yes | | | | |
| 558 | | | | Yes | | Yes | Yes | | | | | |
| 559 | | | | | | | | | | | | |
| 560 | Yes | Yes | | | | Yes | Yes | | | Yes | | |
| 561 | | | Yes | Yes | | Yes | | Yes | | Yes | | |
| 562 | Yes | | | Yes | | | Yes | Yes | | | | VIA EMAIL |
| 563 | Yes | | Yes | | | Yes | Yes | | | | | |
| 564 | Yes | | | Yes | | Yes | Yes | | Yes | | Yes | |
| 565 | | | | Yes | | Yes | Yes | | | | | |
| 566 | | Yes | Yes | | | Yes | | | | | | Yes |
| 567 | | Yes | Yes | Yes | | Yes | Yes | Yes | | | Yes | |
| 568 | Yes | | | Yes | | Yes | | | Yes | Yes | Yes | |
| 569 | Yes | | Yes | Yes | | | Yes | | | | | |
| 570 | Yes | | | | | Yes | Yes | | | Yes | Yes | |
| 571 | | | Yes | | | Yes | | | | Yes | | Yes |

| # | If you are likely to remain at your house, what factors are most important? | | | | | 11.What do you think is the best way for us to get input and feedback from the local community about the results and proposals from this study? | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Discomfort/inconvenience/cost of evacuating | Need to care for animals | My house cannot be flooded, and we can cope with isolation | Concern for security of my property if I evacuate | Other – please describe: | Council's website | Articles in local newspaper | Open days or drop-in days | Community workshops | Public meetings | Council's Floodplain Management Committee | Other (please specify) |
| 572 | | | Yes | Yes | | Yes | Yes | Yes | Yes | Yes | Yes | |
| 573 | | | Yes | | | Yes | | Yes | | | | |
| 574 | | | | Yes | | | Yes | | | | | |
| 575 | | | | Yes | | | | | | Yes | | |
| 576 | Yes | | | | | Yes | | | | | | |
| 577 | | | Yes | | | Yes | Yes | Yes | Yes | | | |
| 578 | | | | Yes | | | | | | | | Yes |
| 579 | | | | Yes | | Yes | Yes | | | | | |
| 580 | | | | | Yes | Yes | Yes | | | | | Yes |
| 581 | Yes | | | | | Yes | | | | | | |
| 582 | | | | | | | | | | Yes | | |
| 583 | | | Yes | Yes | | | Yes | | | | | |
| 584 | | | | Yes | | Yes | | | | | | |
| 585 | Yes | | | | | Yes | Yes | Yes | Yes | Yes | | |

| # | Table A4 - Potential Flood Risk Management Options | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Below is a list of possible options that may be looked at to try to minimise the effects of flooding in the Study Area (see plan on attached Fact Sheet) | | | | | | | | | | | | | | | | |
| | Management of vegetation along creek corridors | Widening and/or concrete lining of watercourses | Construct detention basins | Upgrade stormwater drainage system | Upgrade bridges & culverts | Removal of floodplain obstructions | Levee upgrades | Voluntary purchase of the most severely affected flood-liable properties | Provide funding or subsidies to raise houses above major flood level | Flood proofing of individual properties | Improve flood warning and evacuation procedures | Community education, participation and flood awareness programs. | Ensuring all residents and business owners have Flood Action Plans | Specify controls on future development in flood-liable areas (e.g. extent of filling, minimum floor levels, etc.) | Provide a Planning Certificate to purchasers in flood prone areas, stating that the property is flood affected. | Installation of signs/boom gates at roadway overtopping locations | Ensuring all information about the flood risks is available to all residents and business owners |
| 1 | Yes | Don't know | Don't know | Yes | Yes | Yes | Don't know | Yes | Yes | Yes | Yes | Yes | Don't know | Yes | Yes | Yes | Yes |
| 2 | Yes | Don't know | No | Yes | Yes | Yes | Don't know | Don't know | Don't know | Don't know | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 3 | Yes | Yes | Yes | Yes | Yes | Don't know | Yes | Don't know | Don't know | Don't know | Yes | Yes | Yes | Yes | Yes | Don't know | Yes |
| 4 | Yes | Don't know | Yes | Yes | Yes | Yes | Yes | Don't know | Yes | Don't know | Yes | Yes | Yes | Don't know | Yes | Yes | Yes |
| 5 | No | Yes | Don't know | Yes | Yes | Yes | No | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 6 | Yes | Yes | Don't know | Yes | Yes | Yes | Don't know | Yes | Don't know | Don't know | Yes | Yes | Yes | Yes | Yes | Don't know | Yes |
| 7 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 8 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 9 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't know | Don't know | No | Yes | Don't know | No | Don't know | Don't know | No | Yes |
| 10 | Yes | Yes | Don't know | Yes | Yes | Yes | Don't know | No | No | Don't know | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 11 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 12 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 13 | No | No | Don't know | Yes | Yes | Don't know | Don't know | Don't know | Don't know | Don't know | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 14 | Yes | Yes | Don't know | Yes | Yes | Don't know | Yes | Yes | Yes | Yes | Yes | Yes | Don't know | Yes | Yes | Yes | Yes |
| 15 | Don't know | Don't know | Yes | Yes | | Yes | Yes | Don't know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't know | Yes |
| 16 | No | Yes | Don't know | Yes | Don't know | Don't know | No | No | Yes | Don't know | Yes | Yes | Yes | Yes | No | Yes | Yes |
| 17 | Yes | Yes | Yes | Yes | Yes | Yes | No | Don't know | Don't know | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 18 | Yes | No | Yes | No | Yes | Yes | No | No | Yes | No | Don't know | No | No | Yes | Yes | Yes | Yes |
| 19 | Yes | No | Yes | Yes | Yes | Yes | Don't know | Don't know | Don't know | Don't know | Yes | Yes | Don't know | Yes | Yes | Yes | Yes |
| 20 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 21 | Yes | Yes | Don't know | Yes | Yes | Don't know | Don't know | No | No | No | Yes | Yes | No | Yes | Yes | No | Yes |
| 22 | Yes | No | Don't know | Yes | Don't know | Yes | No | Yes | Don't know | Don't know | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 23 | Yes | No | Yes | Yes | Don't know | Yes | Yes | Don't know | No | No | Yes | Yes | Yes | Yes | Yes | No | Yes |
| 24 | Don't know | Yes | Don't know | Yes | Don't know | Yes | Don't know | Don't know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't know | Yes |
| 25 | Yes | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 26 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | Yes | Yes | Yes | Yes | Yes | Yes | No | Yes |
| 27 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | No | No | Yes | Yes | No | Yes | Yes | No | Yes |
| 28 | Don't know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 29 | Yes | Yes | Yes | Yes | Yes | | Yes | No | No | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 30 | Don't know | Yes | Don't know | Yes | Don't know | Yes | Don't know | No | No | Yes | Yes | Yes | Yes | Yes | Yes | Don't know | Yes |
| 31 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 32 | No | Yes | Yes | Yes | Yes | Yes | Yes | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 33 | Yes | No | No | Yes | No | Yes | No | No | No | No | Yes | No | Yes | Yes | No | Yes | Yes |
| 34 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't know | Don't know | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 35 | Yes | No | Yes | Yes | Yes | Yes | Yes | No | No | Yes | Yes | No | Yes | Yes | Yes | No | Yes |
| 36 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't know | Don't know | Yes | Yes | Yes | Yes | Don't know | Don't know | Yes | Yes |
| 37 | Yes | Yes | Yes | Yes | Yes | Yes | No | Yes | Don't know | Don't know | Yes | Yes | Yes | Yes | Yes | Don't know | Yes |
| 38 | Yes | Yes | Yes | Yes | Yes | Yes | Don't know | No | Yes | Yes | Yes | Yes | Don't know | Yes | Yes | Don't know | Yes |
| 39 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't know | Don't know | Don't know | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 40 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | No | No | Yes | Yes | Yes | Yes | Yes | No | Yes |
| 41 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 42 | Yes | Yes | Don't know | Yes | Yes | Yes | Yes | Don't know | Don't know | No | Yes | Yes | Don't know | Yes | Yes | Don't know | Yes |
| 43 | Yes | Yes | No | Yes | Yes | Don't know | No | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | Yes |
| 44 | | Yes | Yes | Yes | | | | | | | | | | | | | Yes |
| 45 | Yes | Yes | Yes | Yes | Don't know | Yes | Yes | Yes | No | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 46 | Yes | No | No | Yes | Yes | Yes | No | Don't know | No | No | Yes | Yes | Yes | Yes | Yes | Don't know | Yes |
| 47 | Yes | No | Yes | Yes | Yes | Yes | Yes | Don't know | Don't know | Yes | Yes | Yes | Don't know | Yes | Yes | Yes | Yes |
| 48 | Don't know | Yes | Don't know | Yes | Don't know | Don't know | Yes | Don't know | Yes | Yes | Yes | Yes | Yes | Don't know | Yes | Yes | Yes |
| 49 | Don't know | Don't know | Don't know | Yes | Don't know | Yes | Don't know | Yes | Don't know | Don't know | Don't know | Don't know | Don't know | Don't know | Don't know | Yes | Yes |
| 50 | Yes | Don't know | Don't know | Yes | Yes | Yes | Don't know | No | Don't know | Yes | Yes | Yes | Yes | Yes | Yes | Don't know | Yes |
| 51 | Yes | Yes | Don't know | Yes | | Yes | | No | No | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 52 | Yes | Yes | Don't know | Yes | Yes | Don't know | Don't know | Don't know | No | Don't know | Yes | Yes | Don't know | Yes | Yes | No | Yes |
| 53 | Don't know | Yes | Yes | Yes | Yes | Don't know | Don't know | Don't know | Don't know | Don't know | Yes | Yes | Yes | Yes | Yes | Don't know | Yes |
| 54 | Yes | Yes | Don't know | Yes | No | Yes | Yes | Don't know | Yes | No | Yes | No | No | No | No | No | Yes |
| 55 | Yes | Don't know | Don't know | Yes | Yes | Yes | Yes | No | Yes | Don't know | Yes | Yes | No | Don't know | Yes | Don't know | Yes |
| 56 | | Yes | Yes | Yes | Don't know | Yes | Yes | No | No | No | No | No | No | Yes | Yes | Yes | Don't know |
| 57 | Yes | Yes | Yes | Yes | Yes | Yes | Don't know | No | Yes | Yes | Yes | Don't know | Yes | Yes | Yes | Yes | Yes |
| 58 | Don't know | No | Don't know | Yes | Yes | Yes | | Yes | Yes | Yes | Yes | Yes | Yes | Don't know | Yes | Yes | Yes |
| 59 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 60 | Don't know | Yes | Yes | Yes | Don't know | Don't know | Don't know | Don't know | Don't know | Don't know | Yes | Don't know | Don't know | Yes | Yes | Don't know | Don't know |
| 61 | Yes | Don't know | Don't know | Yes | Yes | Yes | Don't know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 62 | Yes | No | Yes | Yes | Yes | Yes | Don't know | No | No | No | Yes | Yes | Yes | Yes | No | Don't know | Yes |

| # | Below is a list of possible options that may be looked at to try to minimise the effects of flooding in the Study Area (see plan on attached Fact Sheet) | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Management of vegetation along creek corridors | Widening and/or concrete lining of watercourses | Construct detention basins | Upgrade stormwater drainage system | Upgrade bridges & culverts | Removal of floodplain obstructions | Levee upgrades | Voluntary purchase of the most severely affected flood-liable properties | Provide funding or subsidies to raise houses above major flood level | Flood proofing of individual properties | Improve flood warning and evacuation procedures | Community education, participation and flood awareness programs. | Ensuring all residents and business owners have Flood Action Plans | Specify controls on future development in flood-liable areas (e.g. extent of filling, minimum floor levels, etc.) | Provide a Planning Certificate to purchasers in flood prone areas, stating that the property is flood affected. | Installation of signs/boom gates at roadway overtopping locations | Ensuring all information about the flood risks is available to all residents and business owners |
| 63 | Don't know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 64 | Yes | Don't know | Yes | Yes | Yes | Yes | Don't know | Yes | No | Don't know | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 65 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 66 | Yes | Yes | Don't know | Yes | Don't know | Yes | Don't know | Yes | Don't know | Don't know | Yes | Yes | Don't know | Don't know | Yes | Don't know | Yes |
| 67 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't know | Don't know | Yes | Don't know | No | Yes | Don't know | Don't know | Yes |
| 68 | Yes | Don't know | Yes | Yes | Don't know | Yes | Yes | Yes | No | Yes | Yes | Yes | Yes | Don't know | Don't know | Don't know | Don't know |
| 69 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 70 | Don't know | Don't know | Don't know | Yes | Yes | Don't know | Don't know | Don't know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 71 | Yes | Don't know | Yes | Yes | Yes | Yes | Don't know | Don't know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 72 | Yes | Yes | Yes | Yes | Yes | Don't know | Don't know | Yes | Don't know | Don't know | Yes | Yes | Don't know | Yes | Yes | Yes | Yes |
| 73 | Don't know | Yes | Yes | Yes | Yes | Don't know | No | Don't know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 74 | Don't know | Yes | Yes | Yes | Yes | Don't know | No | Don't know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 75 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 76 | Yes | Don't know | Don't know | Yes | Yes | Yes | Yes | | | | Yes | Don't know | Don't know | Don't know | Yes | Yes | Yes |
| 77 | Yes | Yes | Yes | Yes | Don't know | Yes | Don't know | Don't know | Yes | Yes | Don't know | Don't know | Yes | Yes | Don't know | No | Yes |
| 78 | Yes | Yes | Yes | Yes | Yes | No | Yes | Don't know | Don't know | No | Yes | Yes | Don't know | Yes | Yes | No | Yes |
| 79 | Don't know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't know | Don't know | Don't know | Yes | Yes | Yes | Yes | Yes | Yes |
| 80 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 81 | Don't know | Yes | Yes | Yes | Yes | Yes | | Don't know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 82 | Yes | Yes | Don't know | Yes | Don't know | Yes | Yes | Don't know | Don't know | Don't know | Yes | Don't know | Don't know | Don't know | Don't know | Yes | Yes |
| 83 | Yes | Yes | Yes | Yes | Yes | Yes | Don't know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 84 | Yes | Yes | Don't know | Yes | Yes | Don't know | Don't know | No | No | Don't know | Yes | Yes | Don't know | Yes | Yes | Yes | Yes |
| 85 | Yes | Yes | Don't know | Yes | Don't know | Yes | Don't know | No | No | No | Don't know | Don't know | Don't know | Don't know | Yes | Don't know | Yes |
| 86 | Yes | Yes | Don't know | Yes | Don't know | Yes | Don't know | Yes | No | Yes | Yes | Yes | Yes | Yes | No | No | Yes |
| 87 | Yes | Don't Know | | | Yes | Yes | Yes | Don't Know | Don't Know | Yes | Don't Know | Don't Know | Don't Know | Yes | Yes | Don't Know | Yes |
| 88 | No | No | Yes | Yes | Don't Know | Don't Know | Yes | Don't Know | No | No | No | Yes | No | Yes | Yes | Yes | Yes |
| 89 | Yes | No | Yes | Yes | Yes | No | No | Yes | No | No | Yes | Yes | No | Yes | Yes | Yes | Yes |
| 90 | Yes | Yes | Yes | Yes | Yes | Yes | No | Yes | Yes | Yes | Yes | Yes | No | Yes | Yes | Yes | Yes |
| 91 | Yes | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Yes | Yes | Yes | Don't Know | Yes | Don't Know | Yes | Yes | Yes | Yes |
| 92 | Yes | Yes | Yes | Yes | | Yes | Yes | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 93 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | Don't Know | Yes | Yes |
| 94 | Yes | Don't Know | Yes | Yes | Yes | Yes | No | No | No | Yes | Yes | Yes | Yes | Yes | No | Don't Know | Yes |
| 95 | Yes | Yes | Don't Know | Yes | No | No | Yes | No | No | No | No | No | No | Yes | Yes | No | Yes |
| 96 | Yes | No | Yes | Yes | Yes | Yes | Don't Know | No | No | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 97 | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 98 | Yes | Yes | | Yes | | Yes | Yes | | | | | Yes | Yes | Yes | Yes | | Yes |
| 99 | Yes | Yes | Don't Know | Yes | Yes | Yes | Yes | Don't Know | No | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 100 | Don't Know | Don't Know | No | Yes | No | Yes | Yes | No | No | No | Yes | Yes | No | Yes | Yes | Yes | No |
| 101 | Yes | Yes | No | Yes | Yes | Yes | No | No | No | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 102 | Don't Know | Yes | Yes | Yes | Yes | Yes | Don't Know | Don't Know | No | Don't Know | Yes | Yes | Yes | Don't Know | Yes | Yes | Yes |
| 103 | Yes | Yes | Don't Know | Yes | Yes | Don't Know | Yes | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 104 | Yes | Don't Know | Don't Know | Don't Know | Don't Know | Don't Know | Don't Know | Yes | Don't Know | Don't Know | Yes | Yes | Don't Know | Yes | Yes | Yes | Yes |
| 105 | Yes | Yes | | Yes | Don't Know | Yes | | No | Don't Know | No | Don't Know | Don't Know | Don't Know | Yes | Yes | Don't Know | Yes |
| 106 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 107 | Yes | Don't Know | Don't Know | Yes | Yes | Don't Know | Don't Know | Don't Know | Don't Know | Don't Know | Don't Know | Don't Know | Don't Know | Yes | Yes | No | Yes |
| 108 | Yes | Yes | Don't Know | Yes | Yes | Yes | Don't Know | Yes | Yes | Don't Know | Yes | Don't Know | | | Yes | Yes | Yes |
| 109 | Yes | Yes | Don't Know | Yes | Yes | Yes | Yes | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 110 | Yes | Yes | Don't Know | Yes | Yes | Yes | Yes | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 111 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | No | Yes | No | Yes | Yes | Don't Know | Don't Know | Yes |
| 112 | Yes | No | Don't Know | Yes | Yes | Yes | Yes | No | No | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 113 | Yes | Yes | Yes | Yes | Yes | Yes | | Yes | No | No | | | | No | Yes | | Yes |
| 114 | Yes | Yes | Don't Know | Yes | Don't Know | No | No | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 115 | Yes | Don't Know | Don't Know | Yes | Yes | Yes | Yes | No | | Yes | Yes | Yes | No | Don't Know | Yes | Yes | Yes |
| 116 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | No | Don't Know | Yes | Yes | Don't Know | Yes | Don't Know | Don't Know | Yes |
| 117 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Don't Know | | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 118 | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes | Yes | Yes | Yes | Don't Know | Yes | Yes | Yes | Yes |
| 119 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 120 | Yes | Don't Know | Yes | Yes | | Yes | Don't Know | Yes | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 121 | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes | Don't Know | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 122 | Yes | Don't Know | Don't Know | Yes | Don't Know | Yes | Don't Know | No | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 123 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | Yes | No | No | Yes | Yes | Yes | Yes | No | Yes |
| 124 | Yes | Yes | Don't Know | Yes | Yes | Yes | No | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes | Yes | Yes |
| 125 | Yes | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 126 | Yes | Yes | Don't Know | Yes | Yes | Yes | No | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes |
| 127 | | Yes | Yes | Yes | | Yes | | Yes | | | | | | | | | |
| 128 | Yes | Yes | Don't Know | | Yes | Yes | Yes | | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 129 | Yes | Yes | No | Yes | No | Yes | Yes | Don't Know | No | Yes | Yes | Don't Know | Yes | Yes | Don't Know | Yes | Yes |
| 130 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | No | No | Yes | Yes | | Yes | No | No | Yes |
| 131 | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Don't Know | Yes | Yes |
| 132 | | | | Yes | | | | | | | | | | | | | |

| # | Below is a list of possible options that may be looked at to try to minimise the effects of flooding in the Study Area (see plan on attached Fact Sheet) | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Management of vegetation along creek corridors | Widening and/or concrete lining of watercourses | Construct detention basins | Upgrade stormwater drainage system | Upgrade bridges & culverts | Removal of floodplain obstructions | Levee upgrades | Voluntary purchase of the most severely affected flood-liable properties | Provide funding or subsidies to raise houses above major flood level | Flood proofing of individual properties | Improve flood warning and evacuation procedures | Community education, participation and flood awareness programs. | Ensuring all residents and business owners have Flood Action Plans | Specify controls on future development in flood-liable areas (e.g. extent of filling, minimum floor levels, etc.) | Provide a Planning Certificate to purchasers in flood prone areas, stating that the property is flood affected. | Installation of signs/boom gates at roadway overtopping locations | Ensuring all information about the flood risks is available to all residents and business owners |
| 133 | Yes | Yes | No | Yes | No | Yes | Yes | Yes | Don't Know | Yes | Don't Know | Yes | Don't Know | No | No | No | Yes |
| 134 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 135 | Don't Know | Yes | Yes | Don't Know | Yes | Yes | Don't Know | Don't Know | Don't Know | Yes | Yes | Don't Know | Yes | Yes | Yes | Yes | Yes |
| 136 | Yes | Yes | Don't Know | Yes | Don't Know | Don't Know | Yes | No | No | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes | Yes |
| 137 | Yes | | | | | | | | | | | Yes | Yes | Yes | | | |
| 138 | No | No | No | Yes | Yes | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 139 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | No | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 140 | Don't Know | Don't Know | Don't Know | Yes | Don't Know | Yes | Yes | Don't Know | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 141 | Yes | No | Don't Know | Don't Know | Don't Know | Don't Know | No | Don't Know | Yes | Don't Know | Yes | Don't Know | Yes | Yes | Don't Know | Don't Know | Yes |
| 142 | Yes | Don't Know | Don't Know | Yes | No | No | Yes | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 143 | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 144 | Yes | Yes | Don't Know | Yes | Yes | Yes | Don't Know | Don't Know | Don't Know | Don't Know | Yes | Yes | Don't Know | Don't Know | Yes | No | Don't Know |
| 145 | Yes | No | Yes | Yes | Don't Know | Yes | Don't Know | Yes | No | No | Yes | Yes | Don't Know | Yes | Yes | No | Yes |
| 146 | Yes | Don't Know | Don't Know | Yes | Yes | Yes | Don't Know | Yes | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes |
| 147 | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes | Yes | No | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 148 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | | Yes | Yes | No | Yes | Don't Know | Yes | Yes | Yes |
| 149 | No | No | Don't Know | Yes | Yes | Don't Know | Yes | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 150 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 151 | Don't Know | Don't Know | Don't Know | Yes | Yes | Yes | Don't Know | Don't Know | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 152 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes | Don't Know | Yes | Yes | Yes | Don't Know | Yes |
| 153 | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes | Don't Know | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Don't Know | Yes | Yes |
| 154 | Yes | Yes | Don't Know | Yes | Yes | Yes | No | Yes | Don't Know | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 155 | Yes | No | Yes | Yes | Yes | Yes | Yes | No | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 156 | No | Yes | No | Yes | | Yes | Yes | Yes | Yes | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 157 | Yes | Yes | Don't Know | Yes | Yes | Yes | No | No | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Yes |
| 158 | Yes | Don't Know | Don't Know | Yes | Yes | Don't Know | Don't Know | Don't Know | Don't Know | Don't Know | Yes | Yes | Yes | Don't Know | Yes | No | Yes |
| 159 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 160 | Yes | Yes | Don't Know | Yes | No | Yes | Don't Know | Don't Know | Don't Know | No | Yes | Yes | Yes | No | Yes | Yes | Yes |
| 161 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | Don't Know | No | Yes | Yes | No | Yes | Yes | Yes | Yes |
| 162 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 163 | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes | Don't Know | Don't Know | Don't Know | Yes | Don't Know | Yes | Don't Know | Yes | Don't Know | Yes |
| 164 | Yes | Don't Know | Yes | Yes | Yes | Yes | Yes | Don't Know | No | No | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes |
| 165 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 166 | Yes | Yes | Don't Know | Yes | Yes | Yes | Yes | Don't Know | No | Yes | Yes | Yes | Yes | Yes | Yes | | Yes |
| 167 | Yes | Yes | Yes | Yes | Don't Know | Yes | Don't Know | Yes | Don't Know | No | Don't Know | Yes | Yes | Yes | Don't Know | Yes | Yes |
| 168 | Don't Know | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Don't Know | Yes | Yes | Yes | No |
| 169 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 170 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes | Yes | Yes | Don't Know | | Yes | Yes | Yes |
| 171 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 172 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 173 | Yes | Don't Know | Yes | Yes | Don't Know | Yes | No | Yes | No | Yes | Yes | Yes | Yes | Don't Know | No | Yes | Yes |
| 174 | Yes | Yes | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes |
| 175 | Yes | Yes | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | No | Don't Know | Don't Know | Yes | Yes |
| 176 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 177 | Yes | Don't Know | Yes | Yes | Don't Know | Yes | Don't Know | Don't Know | Don't Know | Don't Know | Don't Know | Don't Know | Don't Know | Yes | Don't Know | Don't Know | Don't Know |
| 178 | Yes | Yes | | Yes | Yes | Yes | Don't Know | Don't Know | Don't Know | | Yes | Yes | Yes | Don't Know | Don't Know | Yes | Yes |
| 179 | Don't Know | Yes | Yes | Yes | Yes | Don't Know | Yes | Yes | Don't Know | No | Yes | Yes | Don't Know | Yes | Yes | Yes | Yes |
| 180 | Yes | Don't Know | Don't Know | Yes | No | Yes | | Don't Know | Don't Know | Don't Know | Yes | Yes | Don't Know | Yes | Don't Know | No | Yes |
| 181 | Yes | Yes | Don't Know | Yes | Don't Know | Don't Know | Don't Know | Don't Know | Don't Know | No | Yes | Don't Know | Yes | Yes | Yes | Don't Know | Yes |
| 182 | Yes | Don't Know | Don't Know | Yes | Yes | Yes | Don't Know | Don't Know | Yes | | Yes | Don't Know | Don't Know | Don't Know | Yes | Yes | Yes |
| 183 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Yes | Yes | Don't Know | Yes | Yes | Don't Know | Don't Know | Yes |
| 184 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 185 | Don't Know | Don't Know | Don't Know | Yes | No | Yes | Yes | Don't Know | Don't Know | Don't Know | Yes | Yes | Yes | No | Yes | Yes | Yes |
| 186 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 187 | Don't Know | Don't Know | Don't Know | Yes | Don't Know | Don't Know | Don't Know | Don't Know | No | Yes | Yes | Don't Know | Yes | Don't Know | Yes | Yes | Yes |
| 188 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 189 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 190 | Yes | Yes | Yes | Yes | Don't Know | Yes | Don't Know | No | No | No | Don't Know | No | No | Yes | Yes | Yes | Yes |
| 191 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 192 | Don't Know | Yes | Don't Know | Yes | Yes | Don't Know | Yes | Yes | No | No | Don't Know | Don't Know | No | Yes | Yes | Yes | |
| 193 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 194 | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes | Yes |
| 195 | Don't Know | Yes | Yes | Yes | Yes | Don't Know | Yes | Yes | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 196 | Yes | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 197 | Yes | Yes | | Yes | | | Yes | | | | | Yes | Yes | | Yes | Yes | Yes |
| 198 | Don't Know | Yes | Don't Know | Yes | | Yes | Don't Know | Don't Know | No | No | Yes | Don't Know | Don't Know | Yes | Yes | Don't Know | Yes |
| 199 | Yes | Don't Know | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 200 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 201 | Yes | Yes | Don't Know | Yes | Yes | Yes | Don't Know | Yes | No | Don't Know | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes |
| 202 | Yes | Don't Know | Don't Know | Yes | Yes | Yes | Yes | | | | | | | | | | |

| # | Below is a list of possible options that may be looked at to try to minimise the effects of flooding in the Study Area (see plan on attached Fact Sheet) | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Management of vegetation along creek corridors | Widening and/or concrete lining of watercourses | Construct detention basins | Upgrade stormwater drainage system | Upgrade bridges & culverts | Removal of floodplain obstructions | Levee upgrades | Voluntary purchase of the most severely affected flood-liable properties | Provide funding or subsidies to raise houses above major flood level | Flood proofing of individual properties | Improve flood warning and evacuation procedures | Community education, participation and flood awareness programs. | Ensuring all residents and business owners have Flood Action Plans | Specify controls on future development in flood-liable areas (e.g. extent of filling, minimum floor levels, etc.) | Provide a Planning Certificate to purchasers in flood prone areas, stating that the property is flood affected. | Installation of signs/boom gates at roadway overtopping locations | Ensuring all information about the flood risks is available to all residents and business owners |
| 203 | | | | Yes | Yes | | | Yes | | | Yes | Yes | | | Yes | | Yes |
| 204 | Yes | Don't Know | Yes | Yes | No | Yes | Yes | No | No | No | Yes | Yes | Yes | Don't Know | Don't Know | Don't Know | Yes |
| 205 | Don't Know | Yes | Yes | Yes | Don't Know | No | Yes | Yes | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 206 | Yes | Don't Know | Yes | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 207 | Yes | Yes | Yes | Yes | Yes | Yes | No | Yes | No | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 208 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | No | No | No | No | No | No | No |
| 209 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 210 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 211 | Don't Know | Yes | Yes | Yes | Yes | Yes | No | Don't Know | Don't Know | Yes | Don't Know | Don't Know | Don't Know | Don't Know | Yes | Don't Know | Don't Know |
| 212 | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes | No | No | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 213 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 214 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 215 | | | | | | | | | | | | | | | | | |
| 216 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | Yes | Yes | No | No | Yes |
| 217 | Yes | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Yes | Yes | Don't Know | Yes | Yes | Don't Know | Yes |
| 218 | Yes | Yes | Yes | Yes | Yes | No | No | No | No | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 219 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 220 | Yes | No | Yes | Yes | Yes | Yes | No | Don't Know | No | No | Yes | Yes | Yes | Don't Know | Yes | Yes | Yes |
| 221 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 222 | Yes | Don't Know | Yes | Don't Know | Don't Know | Don't Know | No | Don't Know | No | Don't Know | Yes | Don't Know | Don't Know | Yes | Yes | Yes | Yes |
| 223 | Yes | | Yes | Yes | Don't Know | Yes | Yes | No | No | | Yes | Yes | No | Yes | Yes | Yes | Yes |
| 224 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 225 | Yes | Don't Know | Don't Know | Yes | Yes | Yes | | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 226 | Yes | Yes | Yes | Yes | Don't Know | Yes | Yes | No | Don't Know | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 227 | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 228 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes | No | Yes | Yes | Yes | Don't Know | Yes | Yes | Yes |
| 229 | Yes | Don't Know | Don't Know | Yes | Yes | Yes | Don't Know | Yes | No | No | Yes | Yes | Yes | No | Yes | Don't Know | Yes |
| 230 | Yes | Yes | No | Yes | Yes | Yes | Yes | No | Yes | | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 231 | Yes | Yes | No | Yes | Yes | | Yes | Yes | No | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 232 | Yes | Yes | Don't Know | Yes | Don't Know | Yes | Don't Know | Don't Know | Don't Know | Don't Know | Don't Know | Yes | Don't Know | Yes | Yes | Yes | Yes |
| 233 | Yes | No | No | Yes | Don't Know | Yes | Yes | No | No | Yes | Yes | Yes | Yes | Yes | Yes | No | Yes |
| 234 | Yes | Yes | Don't Know | Yes | Yes | Yes | Don't Know | Don't Know | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 235 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 236 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 237 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 238 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes | Yes | Don't Know | Don't Know | Don't Know | Yes | Yes |

| # | Below is a list of possible options that may be looked at to try to minimise the effects of flooding in the Study Area (see plan on attached Fact Sheet) | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Management of vegetation along creek corridors | Widening and/or concrete lining of watercourses | Construct detention basins | Upgrade stormwater drainage system | Upgrade bridges & culverts | Removal of floodplain obstructions | Levee upgrades | Voluntary purchase of the most severely affected flood-liable properties | Provide funding or subsidies to raise houses above major flood level | Flood proofing of individual properties | Improve flood warning and evacuation procedures | Community education, participation and flood awareness programs. | Ensuring all residents and business owners have Flood Action Plans | Specify controls on future development in flood-liable areas (e.g. extent of filling, minimum floor levels, etc.) | Provide a Planning Certificate to purchasers in flood prone areas, stating that the property is flood affected. | Installation of signs/boom gates at roadway overtopping locations | Ensuring all information about the flood risks is available to all residents and business owners |
| 239 | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Yes | | Yes | Yes | Don't Know | Don't Know | Yes | Don't Know | Yes |
| 240 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 241 | Yes | Yes | Don't Know | Yes | Don't Know | Yes | Don't Know | Don't Know | Don't Know | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes |
| 242 | No | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 243 | Yes | No | No | No | | Yes | | Yes | No | No | | Yes | Yes | Yes | Yes | | Yes |
| 244 | Yes | Don't Know | Yes | Yes | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Yes | Yes | Don't Know | Yes |
| 245 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 246 | Yes | Yes | Don't Know | Yes | Yes | Don't Know | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 247 | Don't Know | Don't Know | Don't Know | Yes | Yes | Yes | Don't Know | No | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 248 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes |
| 249 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 250 | Yes | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Don't Know | Don't Know | No | Yes | Yes | Yes | Yes | | Don't Know | Yes |
| 251 | Don't Know | No | No | Yes | Don't Know | Yes | Yes | Don't Know | No | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 252 | Yes | Yes | Yes | Yes | Yes | Yes | | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 253 | | | | Yes | Yes | | Yes | Don't Know | Don't Know | | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 254 | Don't Know | Yes | Yes | Yes | Don't Know | Yes | Don't Know | Yes | No | Don't Know | Don't Know | Don't Know | Yes | Yes | Yes | Don't Know | Yes |
| 255 | Yes | Yes | No | Yes | Yes | Yes | Yes | Yes | Don't Know | No | Yes | Yes | Yes | Yes | | Yes | |
| 256 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | No | Yes | Yes | No | Yes | Yes | Yes | Yes | Yes |
| 257 | Yes | Yes | Don't Know | Yes | Don't Know | Don't Know | Yes | Yes | Don't Know | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes |
| 258 | Yes | Don't Know | Don't Know | Yes | Don't Know | Yes | Yes | Yes | Don't Know | Don't Know | Don't Know | Don't Know | Don't Know | Don't Know | Don't Know | Don't Know | Yes |
| 259 | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 260 | Yes | Yes | Don't Know | Yes | Don't Know | Yes | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Don't Know |
| 261 | | | | | | | | | | | | | | | | | |
| 262 | | | | | | | | | | | | | | | | | |
| 263 | Yes | Yes | Yes | Yes | | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 264 | Yes | Yes | | Yes | Yes | Yes | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 265 | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Don't Know | No | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes | Yes | Yes |
| 266 | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Don't Know | Don't Know | Yes | Yes | Yes | Don't Know | Don't Know | Don't Know | Yes | Yes | Yes |
| 267 | Yes | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 268 | Yes | | | | | Yes | | | | | Yes | | | | Yes | Yes | Yes |

| # | Below is a list of possible options that may be looked at to try to minimise the effects of flooding in the Study Area (see plan on attached Fact Sheet) | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Management of vegetation along creek corridors | Widening and/or concrete lining of watercourses | Construct detention basins | Upgrade stormwater drainage system | Upgrade bridges & culverts | Removal of floodplain obstructions | Levee upgrades | Voluntary purchase of the most severely affected flood-liable properties | Provide funding or subsidies to raise houses above major flood level | Flood proofing of individual properties | Improve flood warning and evacuation procedures | Community education, participation and flood awareness programs. | Ensuring all residents and business owners have Flood Action Plans | Specify controls on future development in flood-liable areas (e.g. extent of filling, minimum floor levels, etc.) | Provide a Planning Certificate to purchasers in flood prone areas, stating that the property is flood affected. | Installation of signs/boom gates at roadway overtopping locations | Ensuring all information about the flood risks is available to all residents and business owners |
| 269 | No | Yes | No | Yes | Yes | Yes | No | No | No | Yes | No | No | No | Yes | Yes | No | Yes |
| 270 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 271 | Yes | | Don't Know | Yes | No | Yes | Yes | Don't Know | No | Yes | Yes | Yes | Yes | Don't Know | No | Yes | Yes |
| 272 | Yes | Yes | Yes | Yes | ?,Don't Know | Yes | ?,Don't Know | Don't Know | Don't Know | Don't Know | Yes | Yes | Yes | | Yes | Yes | Yes |
| 273 | Yes | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Yes | No | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 274 | | | Yes | Yes | | | | | | | Yes | | Yes | | Yes | | Yes |
| 275 | Don't Know | Don't Know | Don't Know | Don't Know | Don't Know | Don't Know | Don't Know | Don't Know | Don't Know | Don't Know | Don't Know | Don't Know | Don't Know | Don't Know | Don't Know | Don't Know | Don't Know |
| 276 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Yes | Yes | Yes |
| 277 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 278 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | No | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 279 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes | Don't Know | Don't Know | Yes | Don't Know | Yes | Yes | Yes | Yes |
| 280 | Yes | Yes | Yes | Yes | Yes | Yes | No | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 281 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 282 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 283 | Yes | No | No | Yes | Yes | Yes | Yes | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 284 | Yes | Yes | Yes | Yes | Yes | Yes | No | No | No | No | Yes | Yes | Yes | Don't Know | Yes | Yes | Yes |
| 285 | Yes | Yes | Yes | Yes | | Yes | | Yes | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 286 | No | Yes | Yes | Yes | No | No | Yes | No | No | Yes | Yes | Yes | Yes | Yes | Yes | No | Yes |
| 287 | Yes | Don't Know | Don't Know | Yes | No | Yes | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 288 | Don't Know | Don't Know | Don't Know | Yes | Don't Know | Yes | Don't Know | Don't Know | Don't Know | Don't Know | Yes | Don't Know | Don't Know | Yes | Don't Know | Yes | Don't Know |
| 289 | Yes | Don't Know | Yes | Yes | Yes | Yes | Don't Know | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes |
| 290 | Don't Know | Don't Know | Don't Know | Yes | Yes | Yes | | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 291 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 292 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes | Yes |
| 293 | Yes | Yes | No | Yes | Yes | Yes | No | No | No | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 294 | Yes | Yes | Yes | Yes | Yes | Yes | No | Yes | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 295 | Yes | No | No | Yes | Yes | Yes | Don't Know | Yes | Yes | Don't Know | Yes | Yes | Yes | Yes | Don't Know | Yes | Yes |
| 296 | Yes | Don't Know | Yes | Don't Know | No | Yes | Yes | Don't Know | Don't Know | Don't Know | Yes | Don't Know | Yes | Yes | Yes | Yes | Yes |
| 297 | Yes | Yes | No | Yes | Yes | Yes | | Don't Know | Don't Know | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 298 | Yes | Yes | Yes | Yes | Don't Know | Yes | Yes | Don't Know | Don't Know | No | Yes | Yes | Yes | Yes | No | Yes | Yes |
| 299 | Yes | No | Yes | Don't Know | Don't Know | Don't Know | Don't Know | Yes | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 300 | Yes | Yes | No | Yes | Yes | Yes | No | Yes | No | Yes | Yes | Yes | Yes | Yes | Yes | No | Yes |

| # | Below is a list of possible options that may be looked at to try to minimise the effects of flooding in the Study Area (see plan on attached Fact Sheet) | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Management of vegetation along creek corridors | Widening and/or concrete lining of watercourses | Construct detention basins | Upgrade stormwater drainage system | Upgrade bridges & culverts | Removal of floodplain obstructions | Levee upgrades | Voluntary purchase of the most severely affected flood-liable properties | Provide funding or subsidies to raise houses above major flood level | Flood proofing of individual properties | Improve flood warning and evacuation procedures | Community education, participation and flood awareness programs. | Ensuring all residents and business owners have Flood Action Plans | Specify controls on future development in flood-liable areas (e.g. extent of filling, minimum floor levels, etc.) | Provide a Planning Certificate to purchasers in flood prone areas, stating that the property is flood affected. | Installation of signs/boom gates at roadway overtopping locations | Ensuring all information about the flood risks is available to all residents and business owners |
| 301 | Don't Know | Don't Know | Yes | Yes | Yes | Don't Know | Yes | Yes | Yes | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 302 | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Don't Know | | Yes | Yes | Yes | | Yes | Yes | Yes |
| 303 | Yes | Yes | Yes | Yes | Yes | No | Don't Know | | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 304 | Yes | Yes | Don't Know | Yes | Yes | Don't Know | Don't Know | No | No | Don't Know | Yes | Yes | Yes | Yes | Yes | No | Yes |
| 305 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 306 | Yes | No | Don't Know | Yes | Yes | Don't Know | Yes | No | No | No | Yes | Yes | No | Yes | Yes | Yes | Yes |
| 307 | Yes | Don't Know | Yes | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes |
| 308 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 309 | Yes | No | Yes | Yes | Yes | Yes | No | Yes | No | No | Yes | Yes | Yes | No | Yes | Yes | Yes |
| 310 | Don't Know | Don't Know | Don't Know | Yes | Yes | Yes | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 311 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Don't Know | Don't Know | Don't Know | Don't Know | Yes |
| 312 | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes | Don't Know | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 313 | | | | Yes | | | | | | | | | | | | | |
| 314 | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes | Yes | Yes | Yes | Yes |
| 315 | Yes | Don't Know | Yes | Yes | Yes | Yes | Don't Know | Yes | Don't Know | Don't Know | Yes | Don't Know | No | Don't Know | Yes | Don't Know | Yes |
| 316 | Yes | Yes | Don't Know | Yes | Don't Know | Yes | Don't Know | Yes | Don't Know | Don't Know | Yes | Yes | Don't Know | Yes | Yes | Yes | Yes |
| 317 | Yes | Yes | Yes | Yes | Yes | | | | Yes | Yes | Yes | | Yes | Yes | Don't Know | | Yes |
| 318 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 319 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 320 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 321 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 322 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 323 | Yes | Yes | Don't Know | Don't Know | Don't Know | Yes | Yes | No | No | No | Yes | Yes | No | Yes | No | No | Yes |
| 324 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 325 | Yes | Yes | Don't Know | Yes | Yes | Don't Know | Yes | Don't Know | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes |
| 326 | Don't Know | Yes | Yes | Yes | Yes | Yes | No | Don't Know | Yes | Yes | Don't Know | Don't Know | Don't Know | Don't Know | Yes | Don't Know | Yes |
| 327 | Yes | Don't Know | Yes | Yes | Don't Know | Yes | | Don't Know | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 328 | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes | Don't Know | Yes | No | Yes | Yes | Yes | No | No | Don't Know | Yes |

| # | Below is a list of possible options that may be looked at to try to minimise the effects of flooding in the Study Area (see plan on attached Fact Sheet) | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Management of vegetation along creek corridors | Widening and/or concrete lining of watercourses | Construct detention basins | Upgrade stormwater drainage system | Upgrade bridges & culverts | Removal of floodplain obstructions | Levee upgrades | Voluntary purchase of the most severely affected flood-liable properties | Provide funding or subsidies to raise houses above major flood level | Flood proofing of individual properties | Improve flood warning and evacuation procedures | Community education, participation and flood awareness programs. | Ensuring all residents and business owners have Flood Action Plans | Specify controls on future development in flood-liable areas (e.g. extent of filling, minimum floor levels, etc.) | Provide a Planning Certificate to purchasers in flood prone areas, stating that the property is flood affected. | Installation of signs/boom gates at roadway overtopping locations | Ensuring all information about the flood risks is available to all residents and business owners |
| 329 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 330 | Yes | Yes | | Yes | | | | | | | Yes | | Yes | | Yes | Yes | Yes |
| 331 | Yes | | | Yes | | Yes | | | | | Yes | | Yes | Yes | Yes | | Yes |
| 332 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 333 | Yes | No | Yes | Yes | Yes | Yes | Yes | No | No | No | No | Yes | No | Yes | Yes | Yes | Yes |
| 334 | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 335 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes | Yes | Yes |
| 336 | Yes | Yes | Don't Know | Yes | Yes | | Yes | Don't Know | Don't Know | Don't Know | Yes | Yes | Yes | Don't Know | Don't Know | Don't Know | Yes |
| 337 | Yes | Yes | Yes | Yes | Yes | | | | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 338 | Yes | Yes | Don't Know | Yes | Yes | Yes | Yes | No | No | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes |
| 339 | Yes | Don't Know | Yes | Yes | Yes | Yes | Don't Know | Yes | No | No | Don't Know | Don't Know | Don't Know | Yes | Don't Know | Yes | Yes |
| 340 | Yes | Yes | Yes | Yes | Yes | No | Yes | No | No | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 341 | Yes | Don't Know | Don't Know | Yes | No | Yes | Don't Know | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 342 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 343 | Don't Know | Yes | Don't Know | Yes | No | Yes | Don't Know | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Don't Know | No | No | Yes |
| 344 | Yes | No | Yes | Yes | Yes | Yes | Yes | Yes | No | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 345 | Yes | Yes | | Yes | Yes | | | Yes | Yes | Yes | | Yes | | | Yes | Yes | Yes |
| 346 | Yes | | | Yes | | Yes | | | | | Yes | Yes | Yes | | | Yes | Yes |
| 347 | Yes | No | Yes | Yes | Yes | Yes | Yes | Yes | No | No | Yes | Yes | No | Yes | Yes | Yes | Yes |
| 348 | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | No | Yes | | Yes | No | Don't Know | Yes | Don't Know | Yes | Yes |
| 349 | Yes | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Don't Know | No | Don't Know | Yes | Don't Know | Yes | Yes | Yes | Yes |
| 350 | Yes | No | No | Yes | Yes | Yes | Yes | Yes | No | No | | Yes | Yes | Yes | Yes | Yes | Yes |
| 351 | Yes | Don't Know | Don't Know | Don't Know | Don't Know | Yes | Don't Know | Don't Know | No | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 352 | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 353 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | No | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 354 | Yes | Yes | Yes | Yes | Yes | | Yes | No | No | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 355 | Yes | Don't Know | | Yes | | Yes | Yes | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 356 | Yes | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 357 | Yes | Yes | Don't Know | Don't Know | Yes | Yes | Yes | Don't Know | Don't Know | | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 358 | Yes | Yes | Don't Know | Yes | Yes | Yes | Don't Know | No | No | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 359 | Yes | Yes | Yes | Yes | Yes | No | Yes | Yes | Yes | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes |

| # | Below is a list of possible options that may be looked at to try to minimise the effects of flooding in the Study Area (see plan on attached Fact Sheet) | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Management of vegetation along creek corridors | Widening and/or concrete lining of watercourses | Construct detention basins | Upgrade stormwater drainage system | Upgrade bridges & culverts | Removal of floodplain obstructions | Levee upgrades | Voluntary purchase of the most severely affected flood-liable properties | Provide funding or subsidies to raise houses above major flood level | Flood proofing of individual properties | Improve flood warning and evacuation procedures | Community education, participation and flood awareness programs. | Ensuring all residents and business owners have Flood Action Plans | Specify controls on future development in flood-liable areas (e.g. extent of filling, minimum floor levels, etc.) | Provide a Planning Certificate to purchasers in flood prone areas, stating that the property is flood affected. | Installation of signs/boom gates at roadway overtopping locations | Ensuring all information about the flood risks is available to all residents and business owners |
| 360 | Yes | No | Don't Know | Yes | Yes | Don't Know | Yes | No | No | No | No | No | No | Yes | Yes | Yes | Yes |
| 361 | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Don't Know | Don't Know | Yes | Yes | Yes | Yes | No | No | Yes |
| 362 | Yes | Yes | | Yes | Don't Know | Don't Know | Yes | Don't Know | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 363 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | No | Yes | No | No | Yes | Yes | Yes | Yes |
| 364 | | | | | | | | | | | | | | | | | |
| 365 | Yes | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 366 | Yes | Yes | Don't Know | Yes | Yes | Don't Know | Yes | No | Yes | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Don't Know | Yes |
| 367 | Don't Know | Yes | Don't Know | Yes | Yes | Yes | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes | Yes |
| 368 | Yes | Don't Know | Don't Know | Don't Know | Yes | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 369 | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Don't Know | Don't Know | Yes | Don't Know | Yes | Yes | Don't Know | Don't Know | Yes |
| 370 | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 371 | Yes | No | Yes | Yes | Yes | Yes | Yes | No | No | No | Yes | Yes | Don't Know | Yes | Yes | Don't Know | Yes |
| 372 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | No | Don't Know | Yes | Don't Know | No | Don't Know | Yes | Don't Know | Yes |
| 373 | Don't Know | Yes | Don't Know | Yes | Don't Know | Don't Know | Don't Know | Yes | Don't Know | Yes | Yes | Yes | Yes | Don't Know | Yes | Don't Know | Yes |
| 374 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | No | No | No | Yes | No | Yes | Yes | No | Yes |
| 375 | Yes | Yes | Don't Know | Yes | Yes | Yes | Yes | No | No | No | Yes | Yes | Yes | Yes | Yes | No | Yes |
| 376 | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes | No | Don't Know | Don't Know | Yes | Yes | Yes | Don't Know | Don't Know | Don't Know | Yes |
| 377 | Don't Know | Don't Know | Don't Know | No | Don't Know | Don't Know | Don't Know | No | No | No | Don't Know | Don't Know | No | Yes | Yes | Yes | Yes |
| 378 | Yes | Yes | Yes | Yes | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 379 | Yes | No | Don't Know | Yes | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes |
| 380 | Yes | Yes | Yes | Yes | Yes | Yes | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 381 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 382 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | No | No | Yes | Yes | Don't Know | Yes | Yes | Yes | Don't Know |
| 383 | Yes | Yes | Don't Know | Yes | Yes | Yes | Yes | Yes | Don't Know | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 384 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Yes |
| 385 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 386 | Don't Know | Yes | Yes | Yes | Yes | Don't Know | Don't Know | No | Yes | Yes | Yes | Don't Know | Yes | Don't Know | Yes | Yes | Yes |
| 387 | Yes | Yes | Yes | Yes | | | | Yes | | | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 388 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | No | Yes | Yes | Yes | Yes | Yes | Yes |
| 389 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |

| # | Below is a list of possible options that may be looked at to try to minimise the effects of flooding in the Study Area (see plan on attached Fact Sheet) | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Management of vegetation along creek corridors** | **Widening and/or concrete lining of watercourses** | **Construct detention basins** | **Upgrade stormwater drainage system** | **Upgrade bridges & culverts** | **Removal of floodplain obstructions** | **Levee upgrades** | **Voluntary purchase of the most severely affected flood-liable properties** | **Provide funding or subsidies to raise houses above major flood level** | **Flood proofing of individual properties** | **Improve flood warning and evacuation procedures** | **Community education, participation and flood awareness programs.** | **Ensuring all residents and business owners have Flood Action Plans** | **Specify controls on future development in flood-liable areas (e.g. extent of filling, minimum floor levels, etc.)** | **Provide a Planning Certificate to purchasers in flood prone areas, stating that the property is flood affected.** | **Installation of signs/boom gates at roadway overtopping locations** | **Ensuring all information about the flood risks is available to all residents and business owners** |
| 390 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 391 | Yes | Yes | Don't Know | Yes | Yes | Don't Know | Yes | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 392 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 393 | No | No | Yes | Yes | No | Yes | Yes | No | No | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 394 | | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 395 | Yes | Yes | Yes | Yes | | | | | | | | Yes | | Yes | Yes | | Yes |
| 396 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Don't Know | Yes | Don't Know | Don't Know | Don't Know | Don't Know | Don't Know |
| 397 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 398 | Yes | Don't Know | Don't Know | Yes | Yes | Yes | Don't Know | Don't Know | Don't Know | Don't Know | Yes | Yes | Don't Know | Yes | Yes | Don't Know | Yes |
| 399 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | No | No | Yes | No | Yes | Yes | Yes | Yes | Yes |
| 400 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 401 | Yes | Yes | Yes | Don't Know | Don't Know | Yes | No | Yes | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 402 | Don't Know | Don't Know | Don't Know | Yes | Yes | Yes | Don't Know | Don't Know | Yes | Don't Know | Yes | No | No | Don't Know | Don't Know | Yes | Don't Know |
| 403 | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 404 | No | Yes | No | Yes | No | No | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 405 | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | Yes | Yes | Yes | Yes | Yes | No | No | Yes |
| 406 | Yes | No | No | Yes | No | Yes | No | Don't Know | No | No | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes |
| 407 | Yes | No | No | Yes | Yes | Yes | No | No | No | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 408 | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Don't Know | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 409 | Yes | Yes | Don't Know | Don't Know | No | Yes | Don't Know | No | Yes | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 410 | Don't Know | | | | | | | | | | Yes | Yes | | | | | Yes |
| 411 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 412 | Don't Know | Don't Know | Don't Know | | Yes | Yes | Yes | Don't Know | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes | Yes | Yes |
| 413 | Yes | Yes | Yes | Yes | Yes | Yes | | | Yes | | Yes | | | | Yes | | Yes |
| 414 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes | Yes | Yes | Yes | Don't Know | Yes | Don't Know | Yes |
| 415 | Yes | No | Don't Know | Don't Know | Don't Know | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 416 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 417 | No | No | No | Yes | Yes | Yes | | Yes | No | No | Yes | No | Yes | Yes | Yes | Yes | Yes |

| # | Below is a list of possible options that may be looked at to try to minimise the effects of flooding in the Study Area (see plan on attached Fact Sheet) | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Management of vegetation along creek corridors | Widening and/or concrete lining of watercourses | Construct detention basins | Upgrade stormwater drainage system | Upgrade bridges & culverts | Removal of floodplain obstructions | Levee upgrades | Voluntary purchase of the most severely affected flood-liable properties | Provide funding or subsidies to raise houses above major flood level | Flood proofing of individual properties | Improve flood warning and evacuation procedures | Community education, participation and flood awareness programs. | Ensuring all residents and business owners have Flood Action Plans | Specify controls on future development in flood-liable areas (e.g. extent of filling, minimum floor levels, etc.) | Provide a Planning Certificate to purchasers in flood prone areas, stating that the property is flood affected. | Installation of signs/boom gates at roadway overtopping locations | Ensuring all information about the flood risks is available to all residents and business owners |
| 418 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes |
| 419 | Yes | No | Don't Know | Yes | Yes | Yes | Don't Know | Don't Know | Yes | Don't Know | Yes | Yes | Yes | Don't Know | Yes | No | Yes |
| 420 | Don't Know | Yes | Yes | Yes | | | Don't Know | Don't Know | Don't Know | Yes | Don't Know | Yes | Yes | Yes | No | No | Yes |
| 421 | Don't Know | Don't Know | Don't Know | Don't Know | Don't Know | Don't Know | Don't Know | Don't Know | Don't Know | Don't Know | Don't Know | Don't Know | Don't Know | Don't Know | Don't Know | Don't Know | Don't Know |
| 422 | Yes | Don't Know | Don't Know | | No | Yes | Yes | Don't Know | No | No | Yes | Yes | Yes | Don't Know | No | Yes | Yes |
| 423 | Yes | No | No | Yes | Yes | Yes | Yes | | | No | Yes | Yes | Yes | Yes | No | No | Yes |
| 424 | Don't Know | | | | | | | | | | | | | | | | |
| 425 | Don't Know | No | No | Yes | No | Yes | Don't Know | Don't Know | No | No | Yes | Yes | Don't Know | Yes | Yes | No | Yes |
| 426 | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 427 | | | | | | | | | | | | | | | | | |
| 428 | Yes | Yes | Don't Know | Yes | Don't Know | Yes | Yes | Don't Know | Don't Know | Don't Know | Yes | Don't Know | Don't Know | Yes | Yes | Don't Know | Yes |
| 429 | Don't Know | Yes | Don't Know | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Don't Know | Yes | Don't Know | Yes | Yes | Yes | Don't Know | Yes |
| 430 | Yes | Yes | Yes | No | No | Yes | Yes | No | No | | Yes | | Yes | Yes | Yes | Yes | Yes |
| 431 | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Don't Know | No | | Yes | Yes | Don't Know | Don't Know | Yes | No | Yes |
| 432 | Yes | Yes | Yes | | Yes | | | Yes | Yes | | Yes | | | Yes | | | Yes |
| 433 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 434 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 435 | Yes | Yes | | Yes | No | No | No | No | No | Yes | Yes | No | Yes | Yes | Yes | No | Yes |
| 436 | Yes | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | No | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 437 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | | | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 438 | | | | | | | | | | | | | | | | | |
| 439 | No | Yes | Yes | Yes | Yes | Yes | Don't Know | Don't Know | No | Yes | Yes | Don't Know | Yes | No | No | Don't Know | Yes |
| 440 | Yes | Don't Know | No | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes |
| 441 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Yes | Don't Know | Yes | Yes | No | Yes |
| 442 | Yes | Yes | Don't Know | Don't Know | Don't Know | Yes | Don't Know | Don't Know | Don't Know | No | Yes | Yes | Yes | Don't Know | Yes | Don't Know | Yes |
| 443 | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes | Yes | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 444 | Yes | Yes | Don't Know | Yes | Yes | Yes | Don't Know | Don't Know | Yes | Don't Know | Yes | Don't Know | Yes | Don't Know | Yes | Yes | Yes |
| 445 | Yes | Yes | Yes | Yes | No | Yes | No | No | No | Don't Know | No | Yes | No | Yes | Yes | Don't Know | Yes |
| 446 | Don't Know | Yes | Yes | Yes | Don't Know | Yes | Yes | Don't Know | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes |
| 447 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes | Yes | Yes | Yes | Don't Know | Yes | Yes | Yes | Yes |

| # | Below is a list of possible options that may be looked at to try to minimise the effects of flooding in the Study Area (see plan on attached Fact Sheet) | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Management of vegetation along creek corridors | Widening and/or concrete lining of watercourses | Construct detention basins | Upgrade stormwater drainage system | Upgrade bridges & culverts | Removal of floodplain obstructions | Levee upgrades | Voluntary purchase of the most severely affected flood-liable properties | Provide funding or subsidies to raise houses above major flood level | Flood proofing of individual properties | Improve flood warning and evacuation procedures | Community education, participation and flood awareness programs. | Ensuring all residents and business owners have Flood Action Plans | Specify controls on future development in flood-liable areas (e.g. extent of filling, minimum floor levels, etc.) | Provide a Planning Certificate to purchasers in flood prone areas, stating that the property is flood affected. | Installation of signs/boom gates at roadway overtopping locations | Ensuring all information about the flood risks is available to all residents and business owners |
| 448 | Don't Know | No | Don't Know | Yes | Yes | | | | Yes | Yes | Yes | Yes | Yes | No | Yes | Yes | Yes |
| 449 | | | | | | | | | | | | | | | | | |
| 450 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 451 | Don't Know | Yes | Don't Know | Yes | Yes | Don't Know | Yes | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Yes | Yes | Yes | Yes |
| 452 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | No | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 453 | Yes | Yes | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes | Don't Know | Yes | Yes | Yes | Yes | Yes |
| 454 | Yes | Yes | Don't Know | Yes | Yes | Yes | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 455 | Yes | Yes | Don't Know | Yes | Yes | Yes | Don't Know | No | No | No | Yes | Yes | Don't Know | Yes | Yes | Yes | Yes |
| 456 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | No | Yes | Yes |
| 457 | | No | | Yes | | | Yes | | | Yes | | Yes | | | Yes | | |
| 458 | Yes | Yes | Don't Know | Yes | Don't Know | Yes | Don't Know | Yes | Don't Know | Don't Know | Don't Know | | Don't Know | Yes | Yes | Don't Know | Yes |
| 459 | Yes | Yes | Yes | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | Yes | Yes |
| 460 | Yes | Yes | | Yes | Yes | Yes | Don't Know | | Yes | Yes | | | Yes | | | | |
| 461 | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | No | Yes | Yes | Yes | Yes | Don't Know | Yes | Yes | Yes | Yes |
| 462 | Don't Know | Don't Know | Don't Know | Yes | Yes | Don't Know | Don't Know | Don't Know | Don't Know | Don't Know | Yes | Don't Know | Don't Know | Yes | Yes | Don't Know | Yes |
| 463 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | No | Yes | Yes | Yes | No | Yes | Yes | Yes |
| 464 | Yes | No | Yes | Yes | Yes | Yes | No | Yes | No | No | Yes | Don't Know | Don't Know | Yes | No | Yes | Yes |
| 465 | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 466 | Yes | Don't Know | Don't Know | Yes | Don't Know | Don't Know | Don't Know | Don't Know | No | No | Yes | Yes | Don't Know | Yes | Yes | Yes | Yes |
| 467 | Yes | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 468 | Yes | | Yes | | | | | | | | Yes | | | Yes | Yes | Yes | Yes |
| 469 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Don't Know | Yes |
| 470 | Yes | Yes | Yes | | | | | | | | | | Yes | | | | Yes |
| 471 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 472 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 473 | Yes | | | Yes | | | | Yes | | | | Yes | | | Yes | | Yes |
| 474 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes | | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 475 | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes | No | No | No | Yes | Yes | Don't Know | Yes | Yes | Yes | Yes |
| 476 | | | | Yes | Yes | | | | | | | | Yes | | Yes | Yes | Yes |
| 477 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | | | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 478 | Yes | Don't Know | Yes | Don't Know | Yes | Don't Know | Don't Know | Yes | Yes | Don't Know | Yes | Yes | Don't Know | Don't Know | Yes | No | Yes |
| 479 | Yes | Yes | Don't Know | Yes | Yes | Yes | Don't Know | Don't Know | No | Yes | Yes | No | Yes | Yes | Yes | Yes | Yes |
| 480 | Yes | Yes | Yes | Yes | | | | Yes | Yes | Yes | Yes | No | No | Yes | Yes | No | Yes |

| # | Below is a list of possible options that may be looked at to try to minimise the effects of flooding in the Study Area (see plan on attached Fact Sheet) | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Management of vegetation along creek corridors | Widening and/or concrete lining of watercourses | Construct detention basins | Upgrade stormwater drainage system | Upgrade bridges & culverts | Removal of floodplain obstructions | Levee upgrades | Voluntary purchase of the most severely affected flood-liable properties | Provide funding or subsidies to raise houses above major flood level | Flood proofing of individual properties | Improve flood warning and evacuation procedures | Community education, participation and flood awareness programs. | Ensuring all residents and business owners have Flood Action Plans | Specify controls on future development in flood-liable areas (e.g. extent of filling, minimum floor levels, etc.) | Provide a Planning Certificate to purchasers in flood prone areas, stating that the property is flood affected. | Installation of signs/boom gates at roadway overtopping locations | Ensuring all information about the flood risks is available to all residents and business owners |
| 481 | No | No | Don't Know | Yes | Yes | Don't Know | Yes | Don't Know | No | No | Yes | Yes | Don't Know | Yes | Don't Know | Don't Know | Yes |
| 482 | Don't Know | Yes | Don't Know | Yes | Yes | Yes | Don't Know | Don't Know | Yes | Yes | Yes | Don't Know | Yes | Yes | Yes | Yes | Yes |
| 483 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Don't Know | | Yes | Yes | Yes | Yes | Yes | Yes |
| 484 | Yes | Yes | Don't Know | Yes | Don't Know | Don't Know | Don't Know | Don't Know | Yes | Yes | Don't Know | No | No | No | No | Don't Know | Yes |
| 485 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 486 | Yes | Yes | Yes | Yes | Yes | Yes | | No | No | Don't Know | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes |
| 487 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 488 | | Yes | Don't Know | Yes | Yes | Don't Know | Don't Know | Don't Know | No | Don't Know | Yes | Yes | Yes | Yes | Yes | No | Yes |
| 489 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | No | Yes | Yes | No | Yes | Yes | Yes | Yes | Yes |
| 490 | | Yes | Yes | Yes | Yes | Don't Know | Yes | Don't Know | | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes | Yes |
| 491 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 492 | Yes | Yes | Yes | Yes | Don't Know | Yes | No | No | Yes | No | Yes | Yes | Don't Know | Yes | Yes | Yes | Yes |
| 493 | Yes | Don't Know | Yes | Yes | Yes | Don't Know | Yes | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 494 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Yes |
| 495 | Yes | No | Yes | Yes | Don't Know | Don't Know | Don't Know | No | No | No | Yes | Yes | Yes | | Yes | Yes | Yes |
| 496 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Yes | Yes | Yes | Don't Know | Yes | Yes | Yes | Don't Know |
| 497 | Yes | Yes | Don't Know | Yes | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 498 | Yes | Yes | Don't Know | Yes | Yes | Don't Know | Yes | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 499 | Don't Know | Don't Know | Don't Know | Yes | Don't Know | Don't Know | Don't Know | Yes | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 500 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 501 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 502 | Yes | Yes | Don't Know | Yes | Yes | Don't Know | Yes | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 503 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 504 | Yes | Don't Know | Don't Know | Yes | Yes | Yes | No | Yes | Yes | No | Yes | No | No | Yes | Yes | Yes | Yes |
| 505 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 506 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Don't Know | Yes | Don't Know | Don't Know | Don't Know | Don't Know | Don't Know | Yes |
| 507 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 508 | Yes | Yes | Yes | Yes | Don't Know | Yes | Yes | Don't Know | Yes | Yes | Yes | Yes | No | Yes | Yes | Yes | Yes |

| # | Below is a list of possible options that may be looked at to try to minimise the effects of flooding in the Study Area (see plan on attached Fact Sheet) | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Management of vegetation along creek corridors | Widening and/or concrete lining of watercourses | Construct detention basins | Upgrade stormwater drainage system | Upgrade bridges & culverts | Removal of floodplain obstructions | Levee upgrades | Voluntary purchase of the most severely affected flood-liable properties | Provide funding or subsidies to raise houses above major flood level | Flood proofing of individual properties | Improve flood warning and evacuation procedures | Community education, participation and flood awareness programs. | Ensuring all residents and business owners have Flood Action Plans | Specify controls on future development in flood-liable areas (e.g. extent of filling, minimum floor levels, etc.) | Provide a Planning Certificate to purchasers in flood prone areas, stating that the property is flood affected. | Installation of signs/boom gates at roadway overtopping locations | Ensuring all information about the flood risks is available to all residents and business owners |
| 509 | Yes | Yes | Yes | Yes | Yes | Don't Know | Don't Know | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes |
| 510 | Don't Know | Yes | Don't Know | Yes | Don't Know | Don't Know | Don't Know | Don't Know | Yes | Yes | Yes | Don't Know | Yes | Don't Know | Don't Know | Don't Know | Yes |
| 511 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 512 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | No | Don't Know | Yes | Yes | Yes | Yes | Yes | No | Yes |
| 513 | Yes | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes |
| 514 | Don't Know | Don't Know | No | Yes | Don't Know | Yes | Don't Know | Don't Know | No | No | Yes | Don't Know | No | Yes | Yes | Yes | Yes |
| 515 | Yes | Yes | Don't Know | Yes | Don't Know | Don't Know | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 516 | Yes | Yes | Yes | Yes | Yes | Yes | | | | | | Yes | | Yes | Yes | | Yes |
| 517 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 518 | Yes | No | No | Yes | Yes | Yes | Don't Know | Yes | No | No | Yes | Yes | Don't Know | Yes | Yes | Yes | Yes |
| 519 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Don't Know | Yes | Don't Know | Don't Know | Yes | Yes | Yes | Yes |
| 520 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | | Yes | Yes | Yes | Yes | | Yes | Yes | Yes |
| 521 | Yes | Yes | Yes | Yes | Don't Know | Yes | Yes | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 522 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 523 | Yes | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes | Yes | Yes | Yes | Yes |
| 524 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 525 | Yes | Yes | Yes | Yes | | Yes | Yes | | Yes | | | | Yes | | | Yes | Yes |
| 526 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | Yes | Yes | No | No | Yes | Yes | No | Yes |
| 527 | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Don't Know | Don't Know | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 528 | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes | Yes | No | No | Yes | Yes | Yes | Yes | Yes | No | Yes |
| 529 | Yes | Don't Know | Don't Know | Yes | Don't Know | Don't Know | | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 530 | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 531 | Don't Know | Don't Know | Yes | Yes | Don't Know | Yes | Don't Know | Don't Know | Yes | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 532 | Don't Know | Don't Know | Don't Know | Don't Know | Don't Know | Don't Know | Don't Know | Don't Know | Don't Know | Don't Know | Don't Know | Don't Know | No | Don't Know | Don't Know | No | Yes |
| 533 | Yes | Don't Know | Don't Know | Yes | Yes | Yes | Yes | No | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 534 | Yes | Yes | Yes | Yes | Yes | Yes | No | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 535 | Yes | Don't Know | Yes | Yes | Don't Know | Don't Know | Yes | Don't Know | No | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes | Yes |
| 536 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Don't Know | Don't Know | Don't Know | Yes | Yes | Yes | Yes |
| 537 | Yes | Yes | Don't Know | Yes | Don't Know | Yes | Don't Know | No | No | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 538 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | No | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes | Yes |

| # | Below is a list of possible options that may be looked at to try to minimise the effects of flooding in the Study Area (see plan on attached Fact Sheet) | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Management of vegetation along creek corridors | Widening and/or concrete lining of watercourses | Construct detention basins | Upgrade stormwater drainage system | Upgrade bridges & culverts | Removal of floodplain obstructions | Levee upgrades | Voluntary purchase of the most severely affected flood-liable properties | Provide funding or subsidies to raise houses above major flood level | Flood proofing of individual properties | Improve flood warning and evacuation procedures | Community education, participation and flood awareness programs. | Ensuring all residents and business owners have Flood Action Plans | Specify controls on future development in flood-liable areas (e.g. extent of filling, minimum floor levels, etc.) | Provide a Planning Certificate to purchasers in flood prone areas, stating that the property is flood affected. | Installation of signs/boom gates at roadway overtopping locations | Ensuring all information about the flood risks is available to all residents and business owners |
| 539 | Yes | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 540 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 541 | | Yes | Yes | Yes | | | | | | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 542 | Yes | Yes | Don't Know | Yes | Yes | Don't Know | Yes | Yes | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 543 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 544 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 545 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | Yes | Yes | No | No | Yes | Yes | No | Yes |
| 546 | Yes | Yes | Yes | Yes | Don't Know | Don't Know | No | Don't Know | No | Yes | Yes | Yes | Yes | Yes | Yes | No | Yes |
| 547 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 548 | Yes | Yes | Yes | Yes | Yes | Don't Know | | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 549 | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | No | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 550 | Yes | Yes | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 551 | | | | | | | | | | | | | | | | | |
| 552 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 553 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 554 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 555 | | | | | | | | | | | | | | | | | |
| 556 | | | | | | | | | | | | | | | | | |
| 557 | Don't Know | Yes | Don't Know | Don't Know | Don't Know | Yes | Yes | Don't Know | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes |
| 558 | X | X | X | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | Yes |
| 559 | | | | | | | | | | | | | | | | | |
| 560 | Yes | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 561 | | Yes | Yes | Yes | | Yes | Yes | Yes | Yes | Yes | | | | | Yes | | Yes |
| 562 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 563 | Yes | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 564 | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Yes | Don't Know | Yes | Don't Know | Yes | Yes | Don't Know | Yes | Yes | Don't Know | Yes |
| 565 | No | Yes | Yes | Yes | Yes | No | No | No | No | No | Yes | No | No | No | Yes | No | Yes |
| 566 | Yes | No | Don't Know | No | Yes | Yes | No | No | No | No | Yes | Yes | Yes | Yes | Don't Know | Yes | Yes |
| 567 | Yes | Yes | Don't Know | Yes | Yes | Don't Know | Don't Know | Yes | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 568 | Yes | Yes | Yes | Don't Know | Don't Know | Don't Know | Yes | Yes | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes |
| 569 | | | | Yes | | Yes | Yes | | | | | Yes | | Yes | Yes | Yes | Yes |
| 570 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 571 | Yes | No | Yes | Yes | Yes | Yes | No | Yes | No | No | Yes | Yes | Yes | No | Yes | Yes | Yes |

| # | Below is a list of possible options that may be looked at to try to minimise the effects of flooding in the Study Area (see plan on attached Fact Sheet) | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Management of vegetation along creek corridors | Widening and/or concrete lining of watercourses | Construct detention basins | Upgrade stormwater drainage system | Upgrade bridges & culverts | Removal of floodplain obstructions | Levee upgrades | Voluntary purchase of the most severely affected flood-liable properties | Provide funding or subsidies to raise houses above major flood level | Flood proofing of individual properties | Improve flood warning and evacuation procedures | Community education, participation and flood awareness programs. | Ensuring all residents and business owners have Flood Action Plans | Specify controls on future development in flood-liable areas (e.g. extent of filling, minimum floor levels, etc.) | Provide a Planning Certificate to purchasers in flood prone areas, stating that the property is flood affected. | Installation of signs/boom gates at roadway overtopping locations | Ensuring all information about the flood risks is available to all residents and business owners |
| 572 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 573 | Yes | Yes | Don't Know | Yes | Yes | Yes | No | Don't Know | Yes | | Yes | Yes | Don't Know | Yes | Yes | Yes | Yes |
| 574 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 575 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 576 | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 577 | Yes | Yes | Yes | Yes | Yes | No | No | Yes | Yes | Yes | Yes | Yes | No | Yes | Yes | No | Yes |
| 578 | Don't Know | Don't Know | Don't Know | Don't Know | Don't Know | Yes | Don't Know | No | No | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 579 | Yes | Yes | Don't Know | Yes | Yes | Yes | Yes | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 580 | Yes | No | No | Yes | No | Yes | No | No | No | No | Yes | No | No | No | Yes | No | Yes |
| 581 | Yes | Don't Know | Yes | Yes | Don't Know | Don't Know | | No | No | No | Yes | Yes | Yes | Yes | Yes | No | Yes |
| 582 | | Yes | | Yes | | | Yes | | | | | | | | | | |
| 583 | Yes | Yes | | Yes | | | | No | No | | Yes | Yes | | | Yes | | Yes |
| 584 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 585 | Yes | Don't Know | Don't Know | Yes | Yes | Don't Know | Don't Know | Don't Know | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Don't Know | Yes |

# APPENDIX B

## FLOOD DAMAGE CALCULATIONS

# B1 - Flood Damage Calculations - College, Orth and Werrington Creeks Catchment FRMS&P

## 1.1 Introduction

To quantify the likely financial impact that flooding has on residents, business owners and infrastructure providers within the College, Orth & Werrington Creeks catchment, the number of properties subject to over floor flooding and the flood damage cost that would likely be incurred during the full range of design floods was calculated. The approach that was adopted to estimate the flood damage costs is presented below.

## 1.2 Property Database

A property database was developed as part of the study to enable damage calculations to be prepared across residential, commercial and industrial properties. The database was developed in GIS and included the details of all building floor levels located within potentially flood liable sections of the catchment (i.e., properties contained within the PMF extent). For residential dwellings, the lowest habitable floor level was estimated, with the lowest operation or functioning floor level of commercial and industrial properties also estimated.

The following information was included as fields within the database for each building:

- Property type (i.e., residential, commercial or industrial);
- Building floor level;
- Building floor area (average or large);
- Residential building type (i.e., two story, single level high set, single level low set or multi-dwelling);
- Building material type (brick, weatherboard, cladded);
- Number of buildings on the lot;
- Commercial and industrial property contents value (low, medium or high value);
- A photo of the building.

In general, the information listed above was populated using a "drive by" survey. This was completed using Google Street View and was supplemented with site visits where buildings were not visible in Street View. A total of 2,336 properties were incorporated in the property database with approximately 300 of these properties visited in the field.

### 1.2.1 Building Floor Levels

As outlined above, it is necessary to have information describing the floor height / level of every building within the PMF extent. Floor levels were estimated using the following approach:

1. The height of the floor of each building above the adjoining ground level was estimated. This was most commonly determined by counting the number of bricks or steps from the ground to floor (a brick height of 85mm or a step height of 170mm was most commonly adopted although unique heights were estimated for concrete and irregular steps);
2. The ground level at the point where the floor height was estimated was extracted from the 2019 LiDAR data;

3. The floor level was subsequently estimated by adding the floor height (calculated in step 1) to the ground elevation (calculated in step 2).

It was acknowledged that the floor level elevations were estimates only. Therefore, a floor level sensitivity assessment was completed to understand how variations in the floor levels may impact on the flood damage calculations. The outcomes of this assessment are discussed in Section 1.7.

## 1.3 Types of Damage Costs

The damage costs associated with floodwater inundation can be broken down into a number of categories, as shown in **Plate 1**. However, broadly speaking, damage costs fall under two major categories;

- tangible damages; and
- intangible damages.

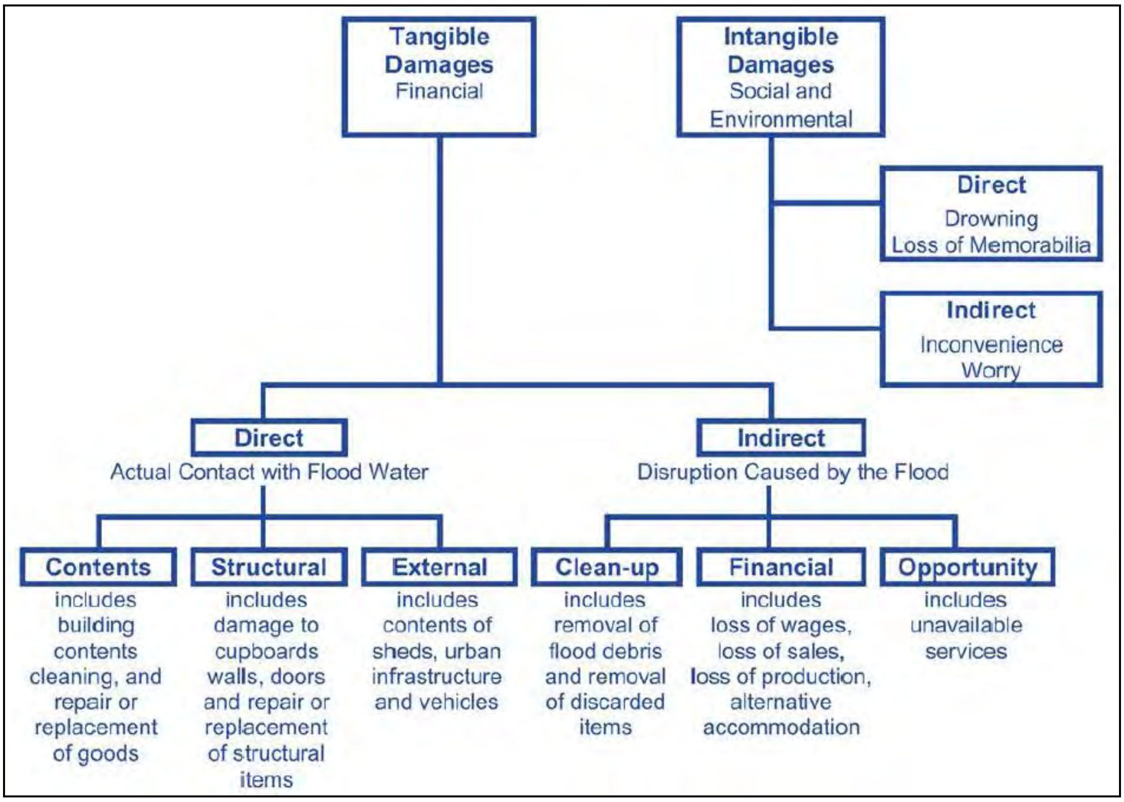



Plate 1 Flood Damage Categories (NSW Government, 2005)

Tangible damages are those which can be quantified in monetary terms (e.g., cost to replace household items damaged by waters). Intangible damages cannot be as readily quantified in monetary terms and include items such as inconvenience and emotional stress.

Tangible damages can be further broken down into direct and indirect damage costs. Direct costs are associated with water coming into direct contact with buildings and contents. Indirect flood damage costs are costs incurred outside of the specific inundation event. This can include clean-up costs, loss of trade (for commercial/industrial properties) and/or alternate accommodation costs while clean-up/repairs are undertaken.

Only tangible damages costs were estimated as part of the study due to the difficulty/uncertainty associated with assigning dollar values to intangible items.

## 1.4 Flood Damage Calculations

Flood damages are most commonly estimated using curves that relate the damage costs relative to the depth of above floor flooding for residential, commercial and industrial properties. Further information on the flood damage curves that were used as part of the study is provided below.

### 1.4.1 Residential Properties

The NSW Department of Planning, Industry and Environment (DPIE) has prepared a spreadsheet that provides a standardised approach for deriving depth-damage curves for residential properties (version 3.00, October 2007). The spreadsheet requires a range of parameters to be defined to enable a meaningful damage estimate to be derived. The parameters that were adopted for the current study are provided in Plate 2 on the following page.

As shown on the following page, building floor area serves as one of the residential damage curve inputs that must be adapted to the local catchment. Building floor areas for each residential building in the catchment were calculated using building footprints within GIS. Average building floor areas were calculated for:

- Single dwellings where there is only one building per lot. The average building area was determined to be 150m$^2$,
- Medium density residential development comprising two or three buildings on the lot (these lots were assumed to have six residential dwellings with two storeys per dwelling). The average building area was determined to be 600m$^2$
- High density residential development comprising four or more buildings on the lot (these lots were assumed have eight dwellings on them with two storeys per dwelling). The average building area was determined to be 720m$^2$

The damage curves for medium and high density residential properties were developed using the two storey residential damage curves as a 'base'. However, the floor area was adjusted in line with the assumptions listed above to reflect the higher density development levels and the associated increased damage potential.

The resulting residential depth-damage curves (shown on the following pages) incorporate a damage allowance for 'negative' above floor flooding depths. This is intended to reflect that property damage can be incurred when the water level is below floor level (e.g., damage to fences, sheds, belongings stored below the building floor). The damage curves for 'single storey low set' and 'two storey' properties and 'single storey high set' commence at -0.9 metres in the College, Orth & Werrington Creeks catchment. This value was based on comparing the building floor levels of properties within the PMF extent against the minimum ground elevation within each cadastral lot (i.e., the minimum elevation within each cadastral lot at which inundation will first occur and, therefore, where damage is likely to commence). This determined that the median difference between the building floor level and minimum ground level within the corresponding lot was about 0.9 metres. Accordingly, all residential damage curves were adjusted so that damage commenced only when the flood water was at a level less than 0.9metres below the floor level.

On top of the direct flood damage costs, additional factors are incorporated in the residential damage curves to help quantify the indirect damages that may be incurred as a result of flood damage at a residential property. This includes the time and cost associated with alternate accommodation and costs associated with cleaning up after the flood. These factors are included in the residential damage curves presented on the following pages.

| | | | | | | |
|---|---|---|---|---|---|---|
| **SITE SPECIFIC INFORMATION FOR RESIDENTIAL DAMAGE CURVE DEVELOPMENT** | | | | | | |
| Version 3.00 October 2007 | | | | | | |
| **PROJECT** | **DETAILS** | | | **DATE** | **JOB No.** | |
| College, Orth and Werrington Creek FRMS&P | Residential Buildings Flood Damages Assessment | | | 5/03/2020 | | |
| **BUILDINGS** | | | | | | |
| Regional Cost Variation Factor | 1.00 | *From Rawlinsons* | | | | |
| Post late 2001 adjustments | 1.87 | *Changes in AWE see AWE Stats Worksheet* | | | | |
| Post Flood Inflation Factor | 1.00 | *1.0* | *to* | *1.5* | | |
| *Multiply overall structural costs by this factor* | | *Judgement to be used. Some suggestions below* | | | | |
| | *Regional City Houses Affected* | | *Factor* | *Regional Town Houses Affected* | | *Factor* |
| *Small scale impact* | *<* | *50* | *1.00* | *<* | *10* | *1.00* |
| *Medium scale impacts in Regional City* | | *100* | *1.20* | | *30* | *1.30* |
| *Large scale impacts in Regional City* | *>* | *150* | *1.40* | *>* | *50* | *1.50* |
| Typical Duration of Immersion | 2 | hours | | | | |
| Building Damage Repair Limitation Factor | 0.85 | *due to no insurance* | | *short duration* | | *long duration* |
| | | *Suggested range* | | *0.85* | *to* | *1.00* |
| Typical House Size | 150 | m^2 | *240 m^2 is Base* | | | |
| Building Size Adjustment | 0.6 | | | | | |
| **Total Building Adjustment Factor** | **1.00** | | | | | |
| **CONTENTS** | | | | | | |
| Average Contents Relevant to Site | $ 59,758 | | *Base for 240 m^2 house* | | *$ 60,000* | |
| Post late 2001 adjustments | 1.87 | *From above* | | | | |
| Contents Damage Repair Limitation Factor | 0.75 | *due to no insurance* | | *short duration* | | *long duration* |
| Sub-Total Adjustment Factor | 1.41 | *Suggested range* | | *0.75* | *to* | *0.90* |
| Level of Flood Awareness | low | *low or high only. Low default unless otherwise justifiable.* | | | | |
| Effective Warning Time | 0 | hour | | | | |
| Interpolated DRF adjustment (Awareness/Time) | 1.00 | IDRF = Interpolated Damage Reduction Factor | | | | |
| Typical Table/Bench Height (TTBH) | 0.90 | *0.9m is typical height. If typical is 2 storey house use 2.6m.* | | | | |
| **Total Contents Adjustment Factor AFD <= TTBH** | **1.41** | AFD = Above Floor Depth | | | | |
| **Total Contents Adjustment Factor AFD > TTBH** | **1.41** | | | | | |
| ***Most recent advice from Victorian Rapid Assessment Method*** | | | | | | |
| *Low level of awareness is expected norm (long term average) any deviation needs to be justified.* | | | | | | |
| *Basic contents damages are based upon a DRF of* | *0.9* | | | | | |
| *Effective Warning time (hours)* | ***0*** | ***3*** | ***6*** | ***12*** | ***24*** | |
| *RAM Average IDRF Inexperienced (Low awareness)* | *0.90* | *0.80* | *0.80* | *0.80* | *0.70* | |
| *DRF (ARF/0.9)* | *1.00* | *0.89* | *0.89* | *0.89* | *0.78* | |
| *RAM AIDF Experienced (High awareness)* | *0.80* | *0.80* | *0.60* | *0.40* | *0.40* | |
| *DRF (ARF/0.9)* | *0.89* | *0.89* | *0.67* | *0.44* | *0.44* | |
| *Site Specific DRF (DRF/0.9) for Awareness level for iteration* | *1.00* | *0.89* | *0.89* | *0.89* | *0.78* | |
| *Effective Warning time (hours)* | *0* | *3* | *0* | | | |
| *Site Specific iterations* | *1.00* | *0.89* | *1.00* | | | |
| **ADDITIONAL FACTORS** | | | | | | |
| Post late 2001 adjustments | 1.87 | *From above* | | | | |
| External Damage | $ 6,700 | *$6,700 recommended without justification* | | | | |
| Clean Up Costs | $ 4,000 | *$4,000 recommended without justification* | | | | |
| Likely Time in Alternate Accommodation | 4 | weeks | | | | |
| Additional accommodation costs /Loss of Rent | $ 220 | *$220 per week recommended without justification* | | | | |
| **TWO STOREY HOUSE BUILDING & CONTENTS FACTORS** | | | | **-0.5** | | |
| Up to Second Floor Level, less than | 2.6 | m | 70% | Single Storey Slab on Ground | | |
| From Second Storey up, greater than | 2.6 | m | 110% | Single Storey Slab on Ground | | |
| **Base Curves** | | AFD = Above Floor Depth | | | | |
| **Single Storey Slab/Low Set** | 13164 | + | 4871 | x | AFD in metres | |
| Structure with GST | AFD | greater than | -0.9 | m | | |
| Validity Limits | AFD | less than or equal to | | 6 | m | |
| **Single Storey High Set** | 16586 | + | 7454 | x | AFD | |
| Structure with GST | AFD | greater than | -0.9 m | | | |
| Validity Limits | AFD | less than or equal to | | 6 | m | |
| **Contents** | 20000 | + | 20000 | x | AFD | |
| Contents with GST | AFD | greater than | | 0 | | |
| Validity Limits | AFD | less than or equal to | | 2 | | |

**Plate 2 Residential Flood damage curve inputs**

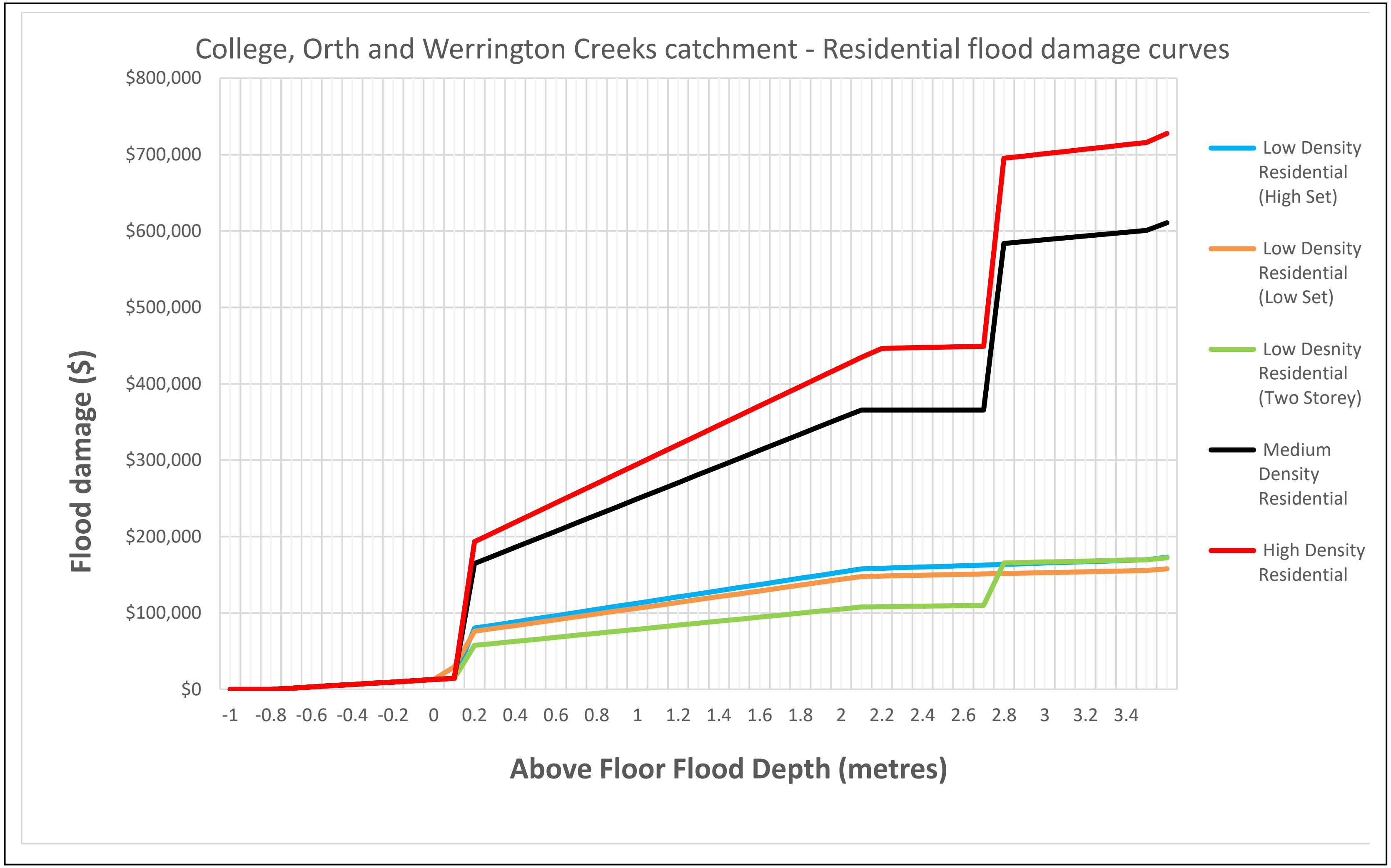



**Plate 3 Residential Flood damage curves**

The NSW Government flood damage curves do not explicitly account for multi-unit dwellings which are common across the College Orth & Werrington Creek catchment (e.g., dual occupancies or townhouse style developments on a single lot). Therefore, separate damage curves were calculated for these types of developments using the two storey residential curves as a base. The size of each individual residence, along with the number of individual residences per building, and the number of buildings per lot were estimated based on desktop site analysis and field visits. This provided additional flood damage curves for "medium density" and "high density" developments.

### 1.4.2 Commercial/Industrial Properties

Unlike residential flood damage calculations, there are no standard curves available for estimating commercial and industrial flood damages in NSW. Commercial property types include offices and shops, and industrial properties include facilities such as warehouses and automotive repairs.

The flood damage curves that had been applied for other recently completed floodplain risk management study and plans in the Penrith LGA were reviewed to determine whether they were appropriate for use in the College, Orth & Werrington Creeks catchment. This review determined that flood damage curve information was not available for the 'St Marys (Byrnes Creek) Floodplain Risk Management Study and Plan' (Lyall and Associates, July 2019). However, the 'Penrith CBD Floodplain Risk Management Study and Plan' (Molino Stewart, March 2020) contained a range of information on flood damage estimates for non-residential damages. The flood damage curves used the following categories for these non-residential damages:

- commercial
- industrial
- education
- healthcare
- emergency services
- police

After reviewing the commercial and industrial land uses in the College, Orth & Werrington Creeks catchment, it was evident that there was a large range of commercial and industrial properties types and the use of a single damage curve for commercial and industrial properties (as was adopted in the Penrith CBD study) would not provide a reliable representation of the variation in flood damage potential across the catchment. There is also significant variation in the value of the contents contained within each commercial and industrial development (e.g., some properties have high value contents such as car sales showrooms, with others having low value contents such as community halls).

The 'South Creek Floodplain Risk Management Study' (Advisian, 2020) included low, medium and high commercial and industrial damage curves based on the size of the footprint of the building within each lot. This provided a better representation of the potential flood damage costs, however, does not account for the value of the contents within each building. Therefore, more catchment-specific flood damage curves were developed so the variation in commercial and industrial property values were better represented.

.

Catchment Simulation Solutions has prepared flood damage curves as part of floodplain risk management studies for other local government areas. These damage curves were originally developed based on flood damage information that was compiled following the Nyngan and Inverell floods during the 1990s, as well as data gained from interviews of 41 businesses in Gloucester. The curves were subsequently adjusted based upon new flood damage information that was collected by Tweed Shire Council following the 2017 floods at Murwillumbah (the “old” curves were found to underestimate the reported damages). It was considered appropriate to use these curves for the current study, which are based on recorded flood damage information, for the current study. However, the base damage curves were updated to 2019 dollars using Consumer Price Index (CPI) values published by the Australian Bureau of Statistics (ABS) before application to the catchment calculations.

In order to apply the damage curves, it was necessary to categorise each commercial and industrial property according to the use of the land and the associated value of the contents contained within each building (i.e. low, medium, high and very high value contents/damage potential). **Table 1** provides a summary of common commercial and industrial property types and the associated contents value that each would fall under.

**Table 1 Content Value Categories for Commercial and Industrial Property Types**

| Low Value | Medium Value | High Value | Very High Value |
|---|---|---|---|
| Recreation Uses | Mixed commercial such as chemists, food shops, clothing stores, newsagencies or electrical shops | Medium sized industrial developments | Industrial with a Gross Floor Area over 2,000m$^2$ |
| Environmental Uses | Police Station | High Schools | High value and large commercial properties such as car yard sales and showrooms |
| Church | SES building | Primary school | |
| Ambulance station | Electricity sub-substation | Aged care | |
| Fire Stations | Office | Child care / pre school | |
| | Heritage sites | Water and sewer infrastructure i.e. sewer pump station | |
| | | Medical facilities | |
| | | Areas zoned as special activity (SP1 and SP2) | |
| | | University / TAFE | |

Land uses that are non -residential, however not necessarily commercial or industrial, were considered as part of the commercial and industrial damage land uses. These include parks and recreation areas, as well as buildings such a fire stations and ambulance stations. Each of these facilities were considered as a low value commercial/industrial development for the flood damage calculation process.

No specific allowance is included in the commercial and industrial damage curves for indirect losses, such as clean-up costs and loss of income while clean-up occurs. The indirect losses for large industrial properties can be significant, as floodwaters can damage large scale machinery or assets that would require significant time to repair/replace and return to full working condition. The recovery for commercial and small-scale industrial developments is typically less of a financial impact as the contents of these developments are generally smaller and simpler to replace.

In line with other floodplain risk management studies, indirect damage costs were estimated as 20% of the direct flood damages for commercial and small industrial developments and 50% of the direct flood damages for medium and large industrial developments. These inflation factors were added to the direct damage costs to determine the total flood damage cost curves for commercial and industrial properties.

The adopted commercial and industrial depth-damage curves are presented on the following page.

### 1.4.3 Infrastructure Damage

Infrastructure damage refers to damage to public infrastructure and utilities such as roads, water supply, sewerage, gas, internet, electricity and telephone. Where major assets are known to exist (e.g. sewer pump stations), they were included as part of the commercial/industrial damages. For the remainder of the infrastructure that are distributed across the catchment, such as roads and telecommunication assets, the damage was incorporated as a percentage of the total residential, commercial and industrial damages. More specifically, the base flood damage estimates were inflated by a further 15% to account for infrastructure damage.

### 1.4.4 Potential versus Actual Damages

The residential, commercial and industrial damage calculations outlined above assume that no actions are taken by residents and business owners to reduce the potential damage. However, if some warning is provided of the impending flood, there may be sufficient time for residents and business owners to undertake actions to reduce the potential damage costs incurred during a flood. For example, residents/business owners could potentially ‘sandbag’ properties to prevent the ingress of floodwaters, relocate vehicles to high ground and/or elevate belongings onto tables or shelves. As a result, actual flood damages will typically be lower than the potential calculated flood damages.

Only very limited data has been collected in Australia to assist in quantifying how flood warnings can reduce potential flood damages. Information presented by Water Studies (1992) infers that direct residential property damages can be reduced by up to 50% with some effective warning time (although no specific information is provided on the minimum warning time required to achieve this).

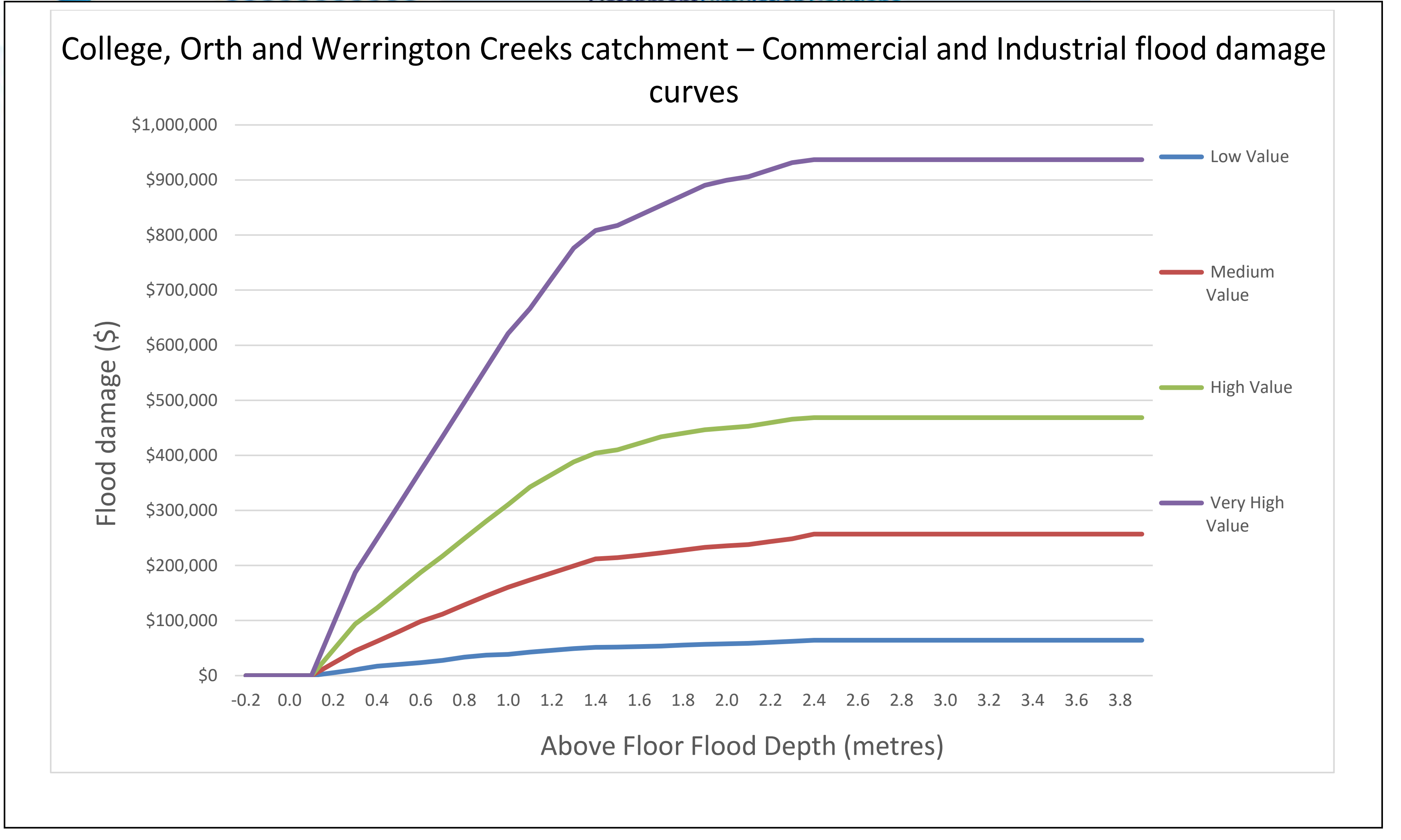



**Plate 4 Commercial and Industrial Flood damage curves**

More extensive research in flood damage reductions associated with effective flood warning has been completed across Europe. This research notes that the flood damage reduction potential is not only dependent on the amount of warning time provided, but also how effectively this warning information is disseminated, the reliability of the warning information, the proportion of households that are proactive with the warning information and how well these households respond to the warning information (Parker, 1991). The Flood Hazard Research Centre (FHRC) also published the following table which relates the potential flood damages avoided (PFA) with respect to variations in depth of flooding and flood warning time for short duration floods (Penning-Rowsell et al, 2013).

*Table 8.3: Calculation of Potential Flood Damages Avoided (PFA) for a short duration flood (<12 hour) for residential property*

| Depth of Flooding (m) | Total Potential Damage £ | Total Potential Household Inventory Damage £ | Flood warning lead times | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Up to 2hours | | 2-4 hours | | 6 hours | | 8 hours | |
| | | | PFA £ | PFA % of Total Damage | PFA £ | PFA % of Total Damage | PFA £ | PFA % of Total Damage | PFA £ | PFA % of Total Damage |
| 1.2 | 33,040 | 20,423 | 8,359 | 25.3 | 11,795 | 35.7 | 12,786 | 38.7 | 13,447 | 40.7 |
| 0.9 | 31,265 | 20,237 | 8,254 | 26.4 | 11,756 | 37.6 | 12,694 | 40.6 | 13,319 | 42.6 |
| 0.6 | 29,268 | 19,051 | 7,463 | 25.5 | 10,888 | 37.2 | 11,766 | 40.2 | 12,351 | 42.2 |
| 0.3 | 26,105 | 18,046 | 7,832 | 30.0 | 10,990 | 42.1 | 11,774 | 45.1 | 12,296 | 47.1 |
| 0.1 | 13,507 | 9,977 | 3,309 | 24.5 | 4,430 | 32.8 | 4,835 | 35.8 | 5,105 | 37.8 |

It indicates that reductions in direct flood damages of around 25% are typical with up to 2 hours warning time increasing to reductions of over 40% with 8 hours warning time. The FHRC also noted that reductions in potential flood damages above 50% are unlikely as only 40-50% of potentially damageable items can be relocated/moved.

Flooding in the College, Orth & Werrington Creeks catchment is very “flashy” with floodwaters typically peaking within 30 minutes to 60 minutes of the onset of rainfall. This is considered to be insufficient warning time for residents or business owners to undertake sufficient preparations to reduce flood damages, such as lifting objects from the ground or moving vehicles. As such, it was considered inappropriate to apply any flood damage reduction factors within the College, Orth & Werrington Creeks catchment.

## 1.5 Summary of Flood Damage Costs

### 1.5.1 Damage Costs

Above floor flooding depths were estimated for each design flood for each potentially flood affected property within the catchment. This was completed using peak design flood levels generated by the TUFLOW model in conjunction with the building floor level information discussed in Section 0. This enabled the number of residential, commercial and industrial properties subject to above floor flooding during each design flood to be estimated, which is summarised in **Table 2**. The number of properties subject to property damage (even if above floor flooding is not predicted) are also provided in **Table 2**. This includes damage to external items such as fences, sheds and garages.

**Table 2 Number of Properties Incurring Flood Damages**

| Flood Event | Residential | | Commercial/ Industrial | | Total Number | |
|---|---|---|---|---|---|---|
| | External Damage only | Above Floor Inundation | External Damage only | Above Floor Inundation | External Damaged only | Above Floor Inundation |
| 0.5EY | 5 | 0 | 1 | 1 | 6 | 1 |
| 20% AEP | 24 | 5 | 3 | 3 | 27 | 8 |
| 10% AEP | 69 | 12 | 9 | 9 | 78 | 21 |
| 5% AEP | 121 | 21 | 17 | 17 | 138 | 38 |
| 2% AEP | 144 | 45 | 21 | 21 | 165 | 66 |
| 1% AEP | 189 | 69 | 29 | 29 | 218 | 98 |
| 0.5% AEP | 215 | 81 | 33 | 33 | 248 | 114 |
| 0.2% AEP | 240 | 101 | 38 | 38 | 278 | 139 |
| PMF | 550 | 854 | 74 | 74 | 624 | 928 |

The above floor flooding depths were combined with the appropriate depth-damage curves to estimate the damage cost incurred at each property during each design flood. The individual property damage estimates were subsequently summed with infrastructure damage cost estimates to calculate the total flood damages for each design event, which is summarised in **Table 3.**

**Table 3 Total Flood Damage Cost Estimates**

| Flood Event | Flood Damages ($ millions) | | | Incremental Contribution to Average Annual Damage |
|---|---|---|---|---|
| | Residential | Commercial/ Industrial | Total Damages | |
| 0.5EY | 0.03 | 0.05 | **0.08** | $11,274 |
| 20% AEP | 0.51 | 0.08 | **0.60** | $100,534 |
| 10% AEP | 1.57 | 0.40 | **1.97** | $128,214 |
| 5% AEP | 2.86 | 0.97 | **3.83** | $144,899 |
| 2% AEP | 4.62 | 1.39 | **6.01** | $147,571 |
| 1% AEP | 6.99 | 1.96 | **8.95** | $74,790 |
| 0.5% AEP | 8.19 | 2.27 | **10.47** | $48,532 |
| 0.2% AEP | 10.31 | 2.94 | **13.25** | $35,571 |
| PMF | 83.90 | 12.33 | **96.23** | $109,428 |
| | | | **TOTAL AAD** | $800,812 |

The flood damage estimates provided in **Table 3** shows that if a 1% AEP type flood was to occur, nearly $9 million worth of damage could be expected to occur. The majority of the damages are predicted across residential properties. Therefore, residential property owners would largely be responsible for the flood damage bill.

It was noted that there is a significant "jump" in the number of impacted properties during the PMF. However, a review of these properties indicates that they are only subject to minor inundation (i.e., the inundation varies from between 5 and 20 $m^2$ on each lot). These properties do not experience inundation in any other flood event other than the PMF. As noted previously, the damage calculations in this study were based on the assumption that damage starts to be incurred to each residential lot when floodwaters reach a depth of 0.9 metres below the floor level. Examination of the floor levels and the areas impacted by this minor flooding in the PMF indicate that the depth of flooding on these lots is at levels less than 0.9 metres below the floor level of the building. As such, the flood damage across these lots are considered negligible and have not been included in the flood damage calculations of this study.

### 1.5.2 Average Annual Damages

The total flood damages for each flood event was subsequently used to estimate the Average Annual Damage (AAD) cost for the College, Orth & Werrington Creeks catchment. The AAD provides an estimate of the average annual cost of inundation across the study area over an extended timeframe. The AAD for the study area for existing conditions was calculated as **$800,812**.

## 1.6 Limitations of Damage Costs

The damage costs presented in this document are based on the best information that was available at the time this report was prepared. However, it must be stressed that ese are estimates only. Actual damage costs during future floods may vary. Land uses may also change in future, which would impact on potential flood damages.

It should also be noted that the damage estimates do not include damages that may be incurred as a result of flooding from South Creek or the Hawkesbury Nepean River. Therefore, the damages that are reported above may underestimates the total flood damage costs that would be incurred in the lower reaches of the College, Orth & Werrington Creeks catchment during and after a flood event.

## 1.7 Sensitivity Assessment

As discussed in Section 1.2.1, the floor levels that were used as part of the damage assessment were estimated based on a "drive by" survey. To gain an understanding of how inaccuracies in the floor level estimate may impact on the results of the damages assessment, a floor level sensitivity assessment was completed. This involved changing the estimated floor level elevations by ±0.1 metres and re-calculating the flood damage results. The 0.1 metre bounds were considered to provide upper and lower limits of the actual floor levels.

The outcomes of the floor level sensitivity assessment are summarised in **Table 4**. It shows that changing the floor levels by 0.1 metres will alter AAD by around ±$300,000. This reflects a change of 30-40%.

**Table 4 Building Floor Level Damage Sensitivity Results**

| Flood Event | Total Flood Damages ($ millions) | | |
|---|---|---|---|
| | "Base" Case Floor Levels | Floor Levels -0.1 metres | Floor Levels +0.1 metres |
| 0.5EY | 0.08 | 0.08 | 0.02 |
| 20% AEP | 0.60 | 0.90 | 0.32 |
| 10% AEP | 1.97 | 2.85 | 1.07 |
| 5% AEP | 3.83 | 5.26 | 2.19 |
| 2% AEP | 6.01 | 7.88 | 3.53 |
| 1% AEP | 8.95 | 11.38 | 5.52 |
| 0.5% AEP | 10.47 | 13.22 | 6.46 |
| 0.2% AEP | 13.25 | 16.14 | 8.39 |
| PMF | 96.23 | 109.39 | 78.63 |
| **TOTAL AAD** | **$0.80** | **$1.07** | **$0.48** |

In general, all floor levels are considered to be accurate to better than 0.1 metres and the actual differences would be located well within the upper and lower bounds indicated in **Table 4**. As a result, it is likely that that the "true" flood damage estimates are contained within 30% of the damage costs estimates as part of the current study.

# APPENDIX C

## ROAD OVERTOPPING DETAILS

| Road Overtopping Point ID* | 0.5EY | | | | 20% AEP | | | | 10% AEP | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Duration Cut (hours) | Time Road First Cut (hours) | Peak Depth | Peak Velocity | Duration Cut (hours) | Time Road First Cut (hours) | Peak Depth | Peak Velocity | Duration Cut (hours) | Time Road First Cut (hours) | Peak Depth | Peak Velocity |
| 1 | | | | | | | | | | | | |
| 2 | | | | | | | | | | | | |
| 3 | | | | | | | | | | | | |
| 4 | | | | | | | | | 0.12 | 1.30 | 0.15 | 0.96 |
| 5 | | | | | | | | | | | | |
| 6 | | | | | | | | | | | | |
| 7 | | | | | | | | | | | | |
| 8 | | | | | | | | | | | | |
| 9 | | | | | | | | | | | | |
| 10 | | | | | | | | | | | | |
| 11 | | | | | | | | | | | | |
| 12 | | | | | | | | | | | | |
| 13 | | | | | | | | | | | | |
| 14 | | | | | | | | | | | | |
| 15 | | | | | | | | | | | | |
| 16 | | | | | | | | | | | | |
| 17 | | | | | 0.20 | 0.53 | 0.25 | 0.32 | 0.45 | 1.54 | 0.28 | 0.24 |
| 18 | | | | | 1.14 | 0.53 | 0.36 | 0.27 | 1.47 | 1.54 | 0.47 | 0.29 |
| 19 | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | |
| 21 | | | | | | | | | | | | |
| 22 | | | | | | | | | | | | |
| 23 | | | | | | | | | | | | |
| 24 | | | | | | | | | | | | |
| 25 | | | | | | | | | | | | |
| 26 | | | | | | | | | | | | |
| 27 | | | | | | | | | | | | |
| 28 | | | | | 0.20 | 0.03 | 0.15 | 0.39 | 0.38 | 1.64 | 0.27 | 0.37 |
| 29 | | | | | 1.91 | 0.44 | 0.15 | 0.48 | 2.13 | 1.19 | 0.17 | 0.44 |
| 30 | | | | | | | | | | | | |
| 31 | | | | | | | | | | | | |
| 32 | | | | | | | | | | | | |
| 33 | | | | | | | | | | | | |
| 34 | | | | | | | | | | | | |
| 35 | | | | | 1.35 | 0.78 | 0.26 | 0.43 | 1.16 | 1.62 | 0.34 | 0.23 |
| 36 | | | | | | | | | | | | |
| 37 | | | | | | | | | 0.11 | 0.95 | 0.17 | 0.64 |
| 38 | | | | | | | | | | | | |
| 39 | | | | | | | | | | | | |
| 40 | | | | | | | | | | | | |
| 41 | | | | | | | | | | | | |
| 42 | | | | | | | | | | | | |
| 43 | | | | | | | | | 0.63 | 1.10 | 0.15 | 0.20 |
| 44 | | | | | | | | | | | | |
| 45 | 6.49 | 3.46 | 2.94 | 0.70 | 3.99 | 1.47 | 3.48 | 0.78 | 3.99 | 1.49 | 3.76 | 0.84 |
| 46 | | | | | | | | | | | | |

| Road Overtopping Point ID* | 0.5EY | | | | 20% AEP | | | | 10% AEP | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Duration Cut (hours) | Time Road First Cut (hours) | Peak Depth | Peak Velocity | Duration Cut (hours) | Time Road First Cut (hours) | Peak Depth | Peak Velocity | Duration Cut (hours) | Time Road First Cut (hours) | Peak Depth | Peak Velocity |
| 47 | | | | | | | | | | | | |
| 48 | | | | | | | | | | | | |
| 49 | | | | | 3.98 | 0.02 | 0.63 | 0.01 | 3.98 | 0.00 | 0.81 | 0.01 |
| 50 | | | | | | | | | | | | |
| 51 | | | | | | | | | | | | |
| 52 | | | | | | | | | | | | |
| 53 | | | | | | | | | | | | |
| 54 | | | | | | | | | 0.29 | 1.70 | 0.20 | 0.67 |
| 55 | | | | | | | | | | | | |
| 56 | 3.46 | 0.40 | 0.17 | 0.35 | 1.63 | 0.34 | 0.21 | 0.36 | 1.81 | 0.44 | 0.22 | 0.32 |
| 57 | | | | | | | | | | | | |
| 58 | | | | | 0.25 | 0.90 | 0.16 | 1.10 | 0.35 | 0.94 | 0.17 | 1.00 |
| 59 | | | | | | | | | 0.80 | 2.03 | 0.34 | 0.36 |
| 60 | | | | | 0.12 | 0.57 | 0.15 | 0.70 | 0.34 | 1.05 | 0.19 | 0.90 |
| 61 | | | | | | | | | | | | |
| 62 | | | | | | | 0.12 | 0.43 | | | | |
| 63 | | | | | 3.97 | 0.00 | 0.46 | 0.02 | 3.98 | 0.00 | 0.65 | 0.01 |
| 64 | | | | | | | | | 0.45 | 1.63 | 0.42 | 0.55 |
| 65 | | | | | 0.17 | 0.48 | 0.22 | 0.50 | 0.32 | 1.56 | 0.25 | 0.43 |
| 66 | | | | | | | | | | | | |
| 67 | 6.49 | 5.18 | 0.48 | 0.01 | 4.00 | 1.08 | 1.03 | 0.01 | 4.00 | 1.45 | 1.43 | 0.04 |
| 68 | | | | | 3.99 | 0.00 | 1.47 | 0.01 | | | | |
| 69 | | | | | | | | | | | | |
| 70 | | | | | | | | | | | | |
| 71 | | | | | | | | | | | | |
| 72 | | | | | | | | | | | | |
| 73 | | | | | | | | | | | | |
| 74 | | | | | | | | | | | | |
| 75 | | | | | | | | | 0.03 | 1.64 | 0.15 | 0.10 |
| 76 | | | | | | | | | | | | |
| 77 | | | | | | | | | 0.46 | 1.75 | 0.18 | 0.43 |
| 78 | | | | | 1.69 | 0.28 | 0.20 | 0.44 | 1.75 | 0.94 | 0.25 | 0.42 |
| 79 | | | | | | | | | | | | |
| 80 | 3.43 | 0.00 | 0.27 | 0.06 | 3.98 | 2.32 | 0.73 | 0.02 | 3.98 | 2.09 | 0.94 | 0.02 |
| 81 | | | | | | | | | | | | |
| 82 | | | | | | | | | 0.32 | 1.64 | 0.34 | 0.30 |
| 83 | | | | | 0.38 | 0.94 | 0.23 | 0.26 | 0.59 | 1.62 | 0.25 | 0.31 |
| 84 | | | | | | | | | | | | |
| 85 | | | | | 0.40 | 1.96 | 0.18 | 0.06 | 3.08 | 1.52 | 0.31 | 0.08 |
| 86 | | | | | 3.98 | 0.00 | 0.88 | 0.01 | 3.99 | 0.00 | 1.09 | 0.01 |
| 87 | | | | | | | | | | | | |
| 88 | | | | | | | | | | | | |
| 89 | | | | | | | | | | | | |
| 90 | | | | | | | | | | | | |
| 91 | | | | | | | | | | | | |
| 92 | | | | | | | | | 0.11 | 0.58 | 0.18 | 1.14 |

| Road Overtopping Point ID* | 0.5EY | | | | 20% AEP | | | | 10% AEP | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Duration Cut (hours) | Time Road First Cut (hours) | Peak Depth | Peak Velocity | Duration Cut (hours) | Time Road First Cut (hours) | Peak Depth | Peak Velocity | Duration Cut (hours) | Time Road First Cut (hours) | Peak Depth | Peak Velocity |
| 93 | | | | | | | | | | | | |
| 94 | | | | | | | | | | | | |
| 95 | | | | | | | | | | | | |
| 96 | | | | | | | | | | | | |
| 97 | | | | | | | | | | | | |
| 98 | | | | | | | | | | | | |
| 99 | | | | | | | | | | | | |
| 100 | | | | | 3.98 | 0.00 | 0.80 | 0.01 | 3.99 | 0.00 | 1.01 | 0.01 |
| 101 | | | | | | | | | | | | |
| 102 | | | | | | | | | | | | |
| 103 | | | | | | | | | | | | |
| 104 | | | | | | | | | | | | |
| 105 | | | | | 3.95 | 2.32 | 0.49 | 0.02 | 3.97 | 2.09 | 0.70 | 0.26 |
| 106 | | | | | | | | | | | | |
| 107 | | | | | | | | | | | | |
| 108 | | | | | | | | | | | | |
| 109 | | | | | | | | | | | | |
| 110 | | | | | | | | | | | | |
| 111 | | | | | | | | | | | | |
| 112 | | | | | | | | | | | | |
| 113 | | | | | | | | | | | | |
| 114 | | | | | | | | | | | | |
| 115 | | | | | 0.35 | 0.96 | 0.24 | 0.64 | 0.61 | 1.57 | 0.35 | 0.35 |
| 116 | | | | | | | | | | | | |
| 117 | | | | | | | | | | | | |
| 118 | | | | | | | | | | | | |
| 119 | | | | | | | | | | | | |
| 120 | | | | | | | | | | | | |
| 121 | | | | | | | | | | | | |
| 122 | | | | | | | | | | | | |
| 123 | | | | | | | | | | | | |
| 124 | | | | | 3.38 | 2.07 | 0.16 | 0.20 | 3.53 | 1.58 | 0.24 | 0.46 |
| 125 | | | | | | | | | | | | |
| 126 | | | | | | | | | | | | |
| 127 | | | | | | | | | | | | |
| 128 | 1.15 | 4.47 | 0.26 | 0.11 | 2.50 | 1.37 | 0.32 | 0.13 | 2.95 | 1.21 | 0.36 | 0.12 |
| 129 | | | | | | | | | | | | |
| 130 | | | | | | | | | | | | |
| 131 | | | | | 0.33 | 1.34 | 0.17 | 0.34 | 0.61 | 1.66 | 0.20 | 0.55 |
| 132 | | | | | | | | | | | | |
| 133 | | | | | | | | | | | | |
| 134 | | | | | | | | | | | | |
| 135 | | | | | | | | | | | | |
| 136 | | | | | | | | | | | | |
| 137 | | | | | | | | | | | | |
| 138 | | | | | | | | | | | | |

| Road Overtopping Point ID* | 0.5EY | | | | 20% AEP | | | | 10% AEP | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Duration Cut (hours) | Time Road First Cut (hours) | Peak Depth | Peak Velocity | Duration Cut (hours) | Time Road First Cut (hours) | Peak Depth | Peak Velocity | Duration Cut (hours) | Time Road First Cut (hours) | Peak Depth | Peak Velocity |
| 139 | | | | | | | | | | | | |
| 140 | | | | | 0.02 | 0.29 | 0.15 | 0.10 | 0.09 | 0.18 | 0.17 | 0.11 |
| 141 | | | | | | | | | | | | |
| 142 | 0.24 | 5.28 | 0.15 | 0.66 | 1.75 | 1.81 | 0.41 | 1.11 | 2.44 | 1.67 | 0.59 | 1.10 |
| 143 | 0.93 | 4.29 | 0.15 | 0.34 | 1.58 | 1.05 | 0.20 | 0.46 | 1.49 | 1.77 | 0.27 | 0.69 |
| 144 | | | | | | | | | 0.23 | 0.22 | 0.15 | 0.18 |
| 145 | | | | | | | | | | | | |
| 146 | | | | | | | | | | | | |
| 147 | | | | | 0.31 | 0.38 | 0.17 | 0.60 | 0.59 | 1.64 | 0.21 | 0.63 |
| 148 | | | | | | | | | | | | |
| 149 | | | | | | | | | | | | |
| 150 | | | | | 0.39 | 1.47 | 0.18 | 0.17 | 0.65 | 1.36 | 0.21 | 0.43 |
| 151 | | | | | | | | | | | | |
| 152 | | | | | | | | | | | | |
| 153 | | | | | | | | | | | | |
| 154 | | | | | | | | | 0.22 | 1.62 | 0.17 | 0.32 |
| 155 | | | | | | | | | | | | |
| 156 | | | | | | | | | | | | |
| 157 | | | | | | | | | | | | |
| 158 | | | | | | | | | | | | |
| 159 | | | | | | | | | | | | |
| 160 | | | | | | | | | | | | |
| 161 | | | | | | | | | | | | |
| 162 | | | | | | | | | | | | |
| 163 | | | | | | | | | 0.16 | 1.82 | 0.16 | 0.46 |
| 164 | | | | | | | | | | | | |
| 165 | | | | | | | | | 0.68 | 1.90 | 0.25 | 0.68 |
| 166 | | | | | 3.55 | 1.52 | 0.46 | 0.39 | 3.66 | 1.54 | 0.61 | 0.42 |
| 167 | | | | | | | | | | | | |
| 168 | | | | | | | | | | | | |
| 169 | | | | | | | | | 0.53 | 1.95 | 0.24 | 0.56 |
| 170 | | | | | | | | | | | | |
| 171 | | | | | 0.06 | 1.18 | 0.16 | 0.58 | 0.62 | 1.80 | 0.20 | 0.63 |
| 172 | | | | | 0.78 | 1.69 | 0.31 | 0.84 | 0.99 | 1.63 | 0.36 | 0.86 |
| 173 | | | | | | | | | | | | |
| 174 | | | | | | | | | | | | |
| 175 | | | | | | | | | | | | |
| 176 | | | | | | | | | 2.99 | 1.06 | 0.15 | 0.80 |
| 177 | | | | | | | | | | | | |
| 178 | | | | | | | | | 0.30 | 1.61 | 0.17 | 1.75 |
| 179 | | | | | | | | | | | | |
| 180 | | | | | | | | | | | | |
| 181 | | | | | | | | | 0.21 | 0.64 | 0.16 | 0.18 |
| 182 | | | | | | | | | | | | |
| 183 | | | | | | | | | | | | |
| 184 | | | | | | | | | | | | |

| Road Overtopping Point ID* | 0.5EY | | | | 20% AEP | | | | 10% AEP | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Duration Cut (hours) | Time Road First Cut (hours) | Peak Depth | Peak Velocity | Duration Cut (hours) | Time Road First Cut (hours) | Peak Depth | Peak Velocity | Duration Cut (hours) | Time Road First Cut (hours) | Peak Depth | Peak Velocity |
| 185 | | | | | | | | | | | | |
| 186 | | | | | | | | | 0.36 | 1.88 | 0.21 | 0.45 |
| 187 | | | | | | | | | | | | |
| 188 | | | | | | | | | | | | |
| 189 | | | | | | | | | | | | |
| 190 | | | | | | | | | | | | |
| 191 | | | | | | | | | | | | |
| 192 | | | | | | | | | | | | |
| 193 | | | | | | | | | 0.53 | 1.59 | 0.46 | 0.57 |
| 194 | | | | | | | | | | | | |
| 195 | | | | | | | | | | | | |
| 196 | | | | | 2.38 | 0.77 | 0.16 | 0.44 | 2.60 | 0.91 | 0.18 | 0.44 |
| 197 | | | | | | | | | | | | |
| 198 | | | | | | | | | | | | |
| 199 | | | | | | | | | | | | |
| 200 | | | | | | | | | | | | |
| 201 | | | | | | | | | | | | |
| 202 | | | | | 0.20 | 0.57 | 0.34 | 0.43 | 0.38 | 1.56 | 0.41 | 0.42 |
| 203 | | | | | | | | | | | | |
| 204 | | | | | | | | | 0.18 | 0.55 | 0.18 | 0.44 |
| 205 | | | | | | | | | | | | |
| 206 | | | | | | | | | | | | |
| 207 | | | | | | | | | | | | |
| 208 | | | | | | | | | | | | |
| 209 | | | | | | | | | | | | |
| 210 | | | | | | | | | | | | |
| 211 | | | | | | | | | | | | |
| 212 | | | | | | | | | | | | |
| 213 | | | | | | | | | | | | |
| 214 | | | | | | | | | | | | |
| 215 | | | | | | | | | | | | |
| 216 | | | | | | | | | | | | |
| 217 | | | | | | | | | | | | |
| 218 | | | | | | | | | | | | |
| 219 | | | | | | | | | | | | |
| 220 | | | | | | | | | | | | |
| 221 | | | | | 1.50 | 1.51 | 0.17 | 1.01 | 1.90 | 1.56 | 0.19 | 1.10 |
| 222 | | | | | 0.01 | 0.22 | 0.15 | 0.55 | 0.12 | 1.04 | 0.19 | 0.54 |
| 223 | | | | | | | | | | | | |
| 224 | | | | | | | | | | | | |
| 225 | | | | | | | | | | | | |
| 226 | | | | | | | | | | | | |
| 227 | | | | | | | | | | | | |
| 228 | | | | | | | | | | | | |
| 229 | | | | | | | | | | | | |
| 230 | | | | | | | | | | | | |

| Road Overtopping Point ID* | 0.5EY | | | | 20% AEP | | | | 10% AEP | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Duration Cut (hours) | Time Road First Cut (hours) | Peak Depth | Peak Velocity | Duration Cut (hours) | Time Road First Cut (hours) | Peak Depth | Peak Velocity | Duration Cut (hours) | Time Road First Cut (hours) | Peak Depth | Peak Velocity |
| 231 | | | | | | | | | 2.22 | 1.64 | 0.20 | 0.62 |
| 232 | | | | | | | | | | | | |
| 233 | | | | | | | | | | | | |
| 234 | | | | | | | | | | | | |
| 235 | | | | | | | | | 0.20 | 0.33 | 0.15 | 0.84 |
| 236 | | | | | | | | | | | | |
| 237 | | | | | | | | | | | | |
| 238 | | | | | | | | | | | | |
| 239 | | | | | | | | | | | | |
| 240 | | | | | | | | | | | | |
| 241 | | | | | | | | | | | | |
| 242 | | | | | | | | | | | | |
| 243 | | | | | | | | | | | | |
| 244 | | | | | | | | | | | | |
| 245 | | | | | | | | | | | | |
| 246 | | | | | | | | | | | | |
| 247 | 0.03 | 0.12 | 0.15 | 0.51 | 0.14 | 0.35 | 0.18 | 0.24 | 0.21 | 1.30 | 0.20 | 0.26 |
| 248 | 0.14 | 0.22 | 0.21 | 0.24 | 0.38 | 0.45 | 0.40 | 0.36 | 0.60 | 1.56 | 0.47 | 0.45 |
| 249 | | | | | | | | | | | | |
| 250 | | | | | | | | | | | | |
| 251 | | | | | | | | | | | | |
| 252 | | | | | | | | | | | | |
| 253 | | | | | | | | | | | | |
| 254 | | | | | | | | | | | | |
| 255 | | | | | | | | | | | | |
| 256 | | | | | | | | | | | | |
| 257 | | | | | | | | | | | | |

| Road Overtopping Point ID* | 5% AEP | | | | 2% AEP | | | | 1% AEP | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Duration Cut (hours) | Time Road First Cut (hours) | Peak Depth | Peak Velocity | Duration Cut (hours) | Time Road First Cut (hours) | Peak Depth | Peak Velocity | Duration Cut (hours) | Time Road First Cut (hours) | Peak Depth | Peak Velocity |
| 1 | | | | | | | | | 0.05 | 0.16 | 0.16 | 0.54 |
| 2 | | | | | | | | | | | | |
| 3 | | | | | | | | | | | | |
| 4 | 0.28 | 1.38 | 0.17 | 1.03 | 0.36 | 1.29 | 0.20 | 1.23 | 0.53 | 0.99 | 0.22 | 1.33 |
| 5 | 2.75 | 0.25 | 0.15 | 1.12 | 2.54 | 0.35 | 0.22 | 1.06 | 2.64 | 0.53 | 0.24 | 0.93 |
| 6 | 0.13 | 0.48 | 0.17 | 0.46 | 0.23 | 0.62 | 0.22 | 0.47 | 0.36 | 1.20 | 0.25 | 0.46 |
| 7 | | | | | 0.07 | 0.26 | 0.18 | 0.08 | 0.11 | 0.25 | 0.21 | 0.10 |
| 8 | | | | | 0.03 | 0.19 | 0.16 | 0.48 | 0.06 | 0.18 | 0.17 | 0.37 |
| 9 | | | | | 2.15 | 0.33 | 0.20 | 0.65 | 2.13 | 0.53 | 0.22 | 0.64 |
| 10 | | | | | | | | | | | | |
| 11 | | | | | 0.09 | 0.35 | 0.20 | 0.74 | 0.14 | 0.44 | 0.22 | 0.77 |
| 12 | | | | | | | | | | | | |
| 13 | | | | | | | | | | | | |
| 14 | | | | | 0.03 | 0.32 | 0.18 | 0.45 | 0.05 | 0.31 | 0.20 | 0.36 |
| 15 | | | | | | | | | 1.64 | 0.49 | 0.15 | 0.72 |
| 16 | | | | | | | | | | | | |
| 17 | 0.50 | 1.62 | 0.31 | 0.27 | 0.69 | 1.20 | 0.33 | 0.26 | 0.82 | 0.68 | 0.34 | 0.32 |
| 18 | 1.52 | 1.63 | 0.55 | 0.28 | 1.73 | 1.21 | 0.63 | 0.28 | 1.76 | 0.70 | 0.68 | 0.29 |
| 19 | | | | | | | | | 0.03 | 0.23 | 0.17 | 0.55 |
| 20 | 1.53 | 0.21 | 0.16 | 0.22 | 1.83 | 0.35 | 0.22 | 0.22 | 1.69 | 0.46 | 0.24 | 0.17 |
| 21 | | | | | | | | | | | | |
| 22 | 0.11 | 0.71 | 0.21 | 1.27 | 0.16 | 0.61 | 0.27 | 1.30 | 0.25 | 0.77 | 0.30 | 1.28 |
| 23 | | | | | 0.13 | 0.61 | 0.24 | 1.49 | 0.29 | 1.23 | 0.35 | 2.07 |
| 24 | | | | | | | | | | | | |
| 25 | | | | | | | | | | | | |
| 26 | | | | | | | | | | | | |
| 27 | | | | | | | | | 0.03 | 0.17 | 0.17 | 1.01 |
| 28 | 0.55 | 1.75 | 0.41 | 0.40 | 0.60 | 1.48 | 0.48 | 0.37 | 0.82 | 1.10 | 0.50 | 0.43 |
| 29 | 2.03 | 1.25 | 0.22 | 0.52 | 2.03 | 0.99 | 0.25 | 0.64 | 2.04 | 1.04 | 0.27 | 0.69 |
| 30 | | | | | | | | | | | | |
| 31 | | | | | 0.01 | 0.12 | 0.15 | 0.55 | 0.02 | 0.30 | 0.17 | 0.60 |
| 32 | | | | | | | | | | | | |
| 33 | | | | | 1.86 | 0.40 | 0.15 | 1.47 | 1.71 | 0.49 | 0.17 | 1.48 |
| 34 | | | | | | | | | | | | |
| 35 | 1.46 | 1.70 | 0.48 | 0.25 | 1.81 | 1.30 | 0.56 | 0.29 | 1.59 | 0.78 | 0.62 | 0.30 |
| 36 | | | | | 2.13 | 0.34 | 0.17 | 0.48 | 2.18 | 0.32 | 0.21 | 0.64 |
| 37 | 0.35 | 1.00 | 0.28 | 0.62 | 0.43 | 0.91 | 0.37 | 0.66 | 0.64 | 1.14 | 0.43 | 0.72 |
| 38 | | | | | 0.09 | 0.40 | 0.21 | 0.60 | 0.19 | 0.45 | 0.29 | 0.69 |
| 39 | | | | | 0.08 | 0.27 | 0.16 | 0.45 | 0.17 | 0.56 | 0.18 | 0.47 |
| 40 | | | | | | | | | | | | |
| 41 | | | | | 0.04 | 0.39 | 0.20 | 1.16 | 0.19 | 0.48 | 0.25 | 1.28 |
| 42 | 0.09 | 0.26 | 0.16 | 1.02 | 0.11 | 0.48 | 0.22 | 1.00 | 0.17 | 0.32 | 0.23 | 1.01 |
| 43 | 1.09 | 0.82 | 0.15 | 0.19 | 0.92 | 0.81 | 0.16 | 0.20 | 1.03 | 0.66 | 0.16 | 0.17 |
| 44 | | | | | 0.11 | 0.40 | 0.19 | 0.79 | 0.28 | 1.16 | 0.25 | 1.03 |
| 45 | 4.00 | 1.11 | 3.90 | 0.89 | 4.00 | 1.27 | 4.04 | 0.98 | 4.00 | 1.02 | 4.18 | 1.09 |
| 46 | | | | | | | | | 0.12 | 0.59 | 0.17 | 0.25 |

| Road Overtopping Point ID* | 5% AEP | | | | 2% AEP | | | | 1% AEP | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Duration Cut (hours) | Time Road First Cut (hours) | Peak Depth | Peak Velocity | Duration Cut (hours) | Time Road First Cut (hours) | Peak Depth | Peak Velocity | Duration Cut (hours) | Time Road First Cut (hours) | Peak Depth | Peak Velocity |
| 47 | | | | | | | | | | | | |
| 48 | | | | | | | | | | | | |
| 49 | 3.99 | 0.00 | 1.07 | 0.02 | 3.99 | 0.00 | 1.11 | 0.02 | 3.99 | 2.08 | 1.15 | 0.02 |
| 50 | 0.37 | 1.96 | 0.29 | 0.66 | 0.45 | 0.96 | 0.32 | 1.14 | 0.69 | 1.14 | 0.36 | 1.53 |
| 51 | | | | | | | | | | | | |
| 52 | | | | | | | | | 0.06 | 0.32 | 0.17 | 1.81 |
| 53 | | | | | | | | | | | | |
| 54 | 0.50 | 1.74 | 0.25 | 0.69 | 0.77 | 1.50 | 0.29 | 0.68 | 0.82 | 1.03 | 0.33 | 0.70 |
| 55 | | | | | 0.93 | 2.08 | 0.34 | 0.32 | 1.49 | 1.56 | 0.49 | 0.57 |
| 56 | 1.77 | 0.46 | 0.24 | 0.34 | 1.75 | 0.63 | 0.26 | 0.37 | 1.82 | 0.82 | 0.27 | 0.37 |
| 57 | | | | | | | | | | | | |
| 58 | 0.47 | 0.80 | 0.20 | 1.02 | 0.71 | 0.62 | 0.24 | 1.11 | 0.67 | 0.41 | 0.26 | 1.17 |
| 59 | 1.30 | 2.02 | 0.57 | 0.60 | 1.77 | 1.85 | 0.81 | 0.85 | 1.95 | 1.36 | 0.94 | 0.96 |
| 60 | 0.47 | 1.10 | 0.24 | 1.01 | 0.77 | 0.92 | 0.28 | 1.19 | 0.83 | 1.09 | 0.31 | 1.27 |
| 61 | | | | | | | | | | | | |
| 62 | 0.29 | 0.87 | 0.17 | 0.74 | 0.32 | 0.75 | 0.20 | 0.83 | 0.51 | 0.90 | 0.23 | 0.97 |
| 63 | 3.98 | 0.00 | 0.91 | 0.03 | 3.98 | 0.00 | 0.94 | 0.04 | 3.98 | 2.07 | 0.98 | 0.04 |
| 64 | 0.60 | 1.72 | 0.53 | 0.60 | 1.00 | 1.29 | 0.60 | 0.61 | 0.90 | 0.93 | 0.67 | 0.64 |
| 65 | 0.46 | 1.65 | 0.30 | 0.53 | 0.56 | 1.28 | 0.35 | 0.58 | 0.82 | 0.92 | 0.36 | 0.65 |
| 66 | | | | | | | | | | | | |
| 67 | 4.00 | 1.45 | 1.58 | 0.07 | 4.00 | 1.26 | 1.66 | 0.51 | 4.00 | 1.01 | 1.72 | 0.90 |
| 68 | 3.99 | 0.00 | 1.92 | 0.01 | 3.99 | 0.00 | 1.95 | 0.01 | 3.99 | 2.06 | 1.99 | 0.02 |
| 69 | 1.25 | 0.28 | 0.23 | 0.59 | 1.48 | 0.63 | 0.35 | 0.54 | 1.37 | 0.56 | 0.40 | 0.52 |
| 70 | | | | | | | | | | | | |
| 71 | 2.97 | 0.80 | 0.21 | 1.49 | 2.86 | 1.01 | 0.30 | 1.91 | 2.86 | 1.21 | 0.40 | 2.16 |
| 72 | | | | | 0.18 | 0.65 | 0.22 | 0.79 | 0.31 | 1.30 | 0.31 | 1.01 |
| 73 | 2.02 | 1.35 | 0.19 | 0.73 | 2.03 | 0.90 | 0.25 | 0.71 | 2.08 | 1.05 | 0.29 | 0.77 |
| 74 | | | | | | | | | | | | |
| 75 | 0.57 | 1.70 | 0.18 | 0.21 | 1.12 | 1.66 | 0.20 | 0.28 | 1.70 | 1.12 | 0.23 | 0.39 |
| 76 | 0.02 | 0.15 | 0.15 | 0.44 | 0.10 | 0.28 | 0.24 | 0.43 | 0.18 | 0.29 | 0.31 | 0.43 |
| 77 | 0.60 | 1.74 | 0.20 | 0.65 | 1.13 | 1.49 | 0.22 | 0.82 | 1.52 | 1.07 | 0.24 | 1.01 |
| 78 | 1.76 | 0.99 | 0.30 | 0.44 | 1.68 | 0.84 | 0.33 | 0.48 | 1.88 | 1.06 | 0.34 | 0.41 |
| 79 | | | | | | | | | | | | |
| 80 | 3.99 | 0.00 | 1.05 | 0.04 | 3.99 | 2.10 | 1.08 | 0.07 | 3.99 | 1.44 | 1.12 | 0.11 |
| 81 | | | | | | | | | | | | |
| 82 | 0.64 | 1.72 | 0.49 | 0.36 | 0.82 | 1.49 | 0.57 | 0.35 | 1.15 | 1.01 | 0.63 | 0.38 |
| 83 | 0.66 | 1.68 | 0.27 | 0.39 | 1.13 | 1.24 | 0.29 | 0.41 | 1.34 | 0.81 | 0.30 | 0.42 |
| 84 | | | | | 0.08 | 0.27 | 0.16 | 0.41 | 0.13 | 0.38 | 0.19 | 0.53 |
| 85 | 3.96 | 0.00 | 0.46 | 0.22 | 3.96 | 2.17 | 0.49 | 0.23 | 3.96 | 1.65 | 0.53 | 0.25 |
| 86 | 3.99 | 0.00 | 1.32 | 0.02 | 3.99 | 0.00 | 1.35 | 0.02 | 3.99 | 2.07 | 1.39 | 0.03 |
| 87 | | | | | | | | | | | | |
| 88 | 0.07 | 0.20 | 0.16 | 0.34 | 0.10 | 0.31 | 0.22 | 0.41 | 0.16 | 0.35 | 0.25 | 0.45 |
| 89 | | | | | | | | | | | | |
| 90 | 1.74 | 0.23 | 0.16 | 0.25 | 1.91 | 0.73 | 0.22 | 0.59 | 1.76 | 0.54 | 0.25 | 0.28 |
| 91 | | | | | | | | | | | | |
| 92 | 0.32 | 0.60 | 0.22 | 1.30 | 0.39 | 0.80 | 0.28 | 1.51 | 0.60 | 1.02 | 0.32 | 1.51 |

| Road Overtopping Point ID* | 5% AEP | | | | 2% AEP | | | | 1% AEP | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Duration Cut (hours) | Time Road First Cut (hours) | Peak Depth | Peak Velocity | Duration Cut (hours) | Time Road First Cut (hours) | Peak Depth | Peak Velocity | Duration Cut (hours) | Time Road First Cut (hours) | Peak Depth | Peak Velocity |
| 93 | 2.66 | 0.20 | 0.15 | 1.10 | 2.53 | 0.71 | 0.18 | 1.37 | 2.57 | 0.89 | 0.20 | 1.52 |
| 94 | | | | | | | | | | | | |
| 95 | | | | | | | | | | | | |
| 96 | | | | | | | | | | | | |
| 97 | | | | | | | | | | | | |
| 98 | | | | | | | | | | | | |
| 99 | | | | | 2.27 | 0.34 | 0.17 | 0.78 | 2.31 | 0.33 | 0.19 | 0.75 |
| 100 | 3.99 | 0.00 | 1.24 | 0.01 | 3.99 | 0.00 | 1.27 | 0.02 | 3.99 | 2.08 | 1.31 | 0.03 |
| 101 | | | | | | | | | 0.14 | 0.50 | 0.15 | 0.53 |
| 102 | | | | | | | | | | | | |
| 103 | | | | | | | | | | | | |
| 104 | | | | | | | | | 0.11 | 0.51 | 0.17 | 0.92 |
| 105 | 3.98 | 0.00 | 0.81 | 0.90 | 3.98 | 2.11 | 0.87 | 0.58 | 3.98 | 1.77 | 0.91 | 0.63 |
| 106 | | | | | | | | | | | | |
| 107 | | | | | | | | | | | | |
| 108 | | | | | 1.79 | 0.53 | 0.18 | 0.14 | 1.63 | 0.46 | 0.19 | 0.14 |
| 109 | | | | | | | | | | | | |
| 110 | | | | | | | | | 0.03 | 0.24 | 0.16 | 0.21 |
| 111 | | | | | | | | | | | | |
| 112 | 2.42 | 0.00 | 0.19 | 0.51 | 2.82 | 0.00 | 0.22 | 0.55 | 3.15 | 2.07 | 0.26 | 0.61 |
| 113 | | | | | | | | | | | | |
| 114 | | | | | | | | | | | | |
| 115 | 0.80 | 1.63 | 0.44 | 0.37 | 1.22 | 1.19 | 0.54 | 0.38 | 1.53 | 0.78 | 0.67 | 0.42 |
| 116 | | | | | | | | | | | | |
| 117 | 2.68 | 0.54 | 0.15 | 0.85 | 2.54 | 0.68 | 0.19 | 0.88 | 2.56 | 0.83 | 0.21 | 0.86 |
| 118 | 3.83 | 0.80 | 0.22 | 0.99 | 3.65 | 0.94 | 0.33 | 1.32 | 3.75 | 1.14 | 0.46 | 1.43 |
| 119 | | | | | 0.09 | 0.34 | 0.16 | 0.52 | 0.34 | 1.03 | 0.22 | 0.26 |
| 120 | | | | | | | | | | | | |
| 121 | | | | | | | | | | | | |
| 122 | | | | | | | | | | | | |
| 123 | | | | | | | | | | | | |
| 124 | 3.63 | 1.72 | 0.26 | 0.55 | 3.56 | 1.44 | 0.27 | 0.60 | 3.55 | 1.12 | 0.28 | 0.65 |
| 125 | | | | | | | | | | | | |
| 126 | | | | | | | | | | | | |
| 127 | | | | | | | | | | | | |
| 128 | 3.85 | 0.00 | 0.40 | 0.05 | 3.79 | 0.99 | 0.42 | 0.08 | 3.83 | 1.34 | 0.43 | 0.09 |
| 129 | | | | | | | | | | | | |
| 130 | | | | | 1.30 | 1.67 | 0.16 | 0.49 | 2.38 | 1.14 | 0.17 | 0.50 |
| 131 | 0.81 | 1.72 | 0.21 | 0.63 | 1.26 | 1.30 | 0.21 | 0.67 | 1.51 | 0.90 | 0.22 | 0.71 |
| 132 | | | | | | | | | 0.27 | 0.55 | 0.17 | 0.51 |
| 133 | | | | | | | | | | | | |
| 134 | | | | | | | | | | | | |
| 135 | | | | | 0.06 | 0.26 | 0.17 | 0.52 | 0.10 | 0.43 | 0.17 | 0.53 |
| 136 | | | | | | | | | 2.93 | 0.75 | 0.17 | 0.70 |
| 137 | | | | | 0.03 | 0.25 | 0.19 | 0.77 | 0.07 | 0.32 | 0.24 | 0.68 |
| 138 | 0.16 | 1.12 | 0.17 | 0.60 | 0.26 | 0.93 | 0.21 | 0.69 | 0.42 | 1.13 | 0.24 | 0.69 |

| Road Overtopping Point ID* | 5% AEP | | | | 2% AEP | | | | 1% AEP | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Duration Cut (hours) | Time Road First Cut (hours) | Peak Depth | Peak Velocity | Duration Cut (hours) | Time Road First Cut (hours) | Peak Depth | Peak Velocity | Duration Cut (hours) | Time Road First Cut (hours) | Peak Depth | Peak Velocity |
| 139 | 0.12 | 0.48 | 0.15 | 0.54 | 0.15 | 0.64 | 0.16 | 0.59 | 0.41 | 1.12 | 0.19 | 0.54 |
| 140 | 0.15 | 0.20 | 0.20 | 0.14 | 0.24 | 0.79 | 0.24 | 0.19 | 0.35 | 1.01 | 0.27 | 0.23 |
| 141 | | | | | | | | | | | | |
| 142 | 3.03 | 1.38 | 0.72 | 1.07 | 2.80 | 1.31 | 0.93 | 1.06 | 3.06 | 1.02 | 1.21 | 1.04 |
| 143 | 2.14 | 1.84 | 0.31 | 0.83 | 1.99 | 1.41 | 0.33 | 0.95 | 2.07 | 1.06 | 0.34 | 1.04 |
| 144 | 0.24 | 0.56 | 0.19 | 0.45 | 0.28 | 0.81 | 0.25 | 0.46 | 0.42 | 0.96 | 0.28 | 0.45 |
| 145 | | | | | | | | | | | | |
| 146 | | | | | | | | | | | | |
| 147 | 0.85 | 1.56 | 0.24 | 0.79 | 1.25 | 1.21 | 0.26 | 0.87 | 1.49 | 1.05 | 0.29 | 0.96 |
| 148 | | | | | | | | | | | | |
| 149 | | | | | | | | | | | | |
| 150 | 0.79 | 1.40 | 0.24 | 0.48 | 1.18 | 0.99 | 0.25 | 0.46 | 1.42 | 0.85 | 0.27 | 0.51 |
| 151 | | | | | | | | | | | | |
| 152 | | | | | | | | | | | | |
| 153 | | | | | 1.08 | 2.31 | 0.25 | 0.25 | 2.45 | 1.58 | 0.52 | 0.27 |
| 154 | 0.88 | 1.81 | 0.28 | 0.34 | 1.47 | 1.78 | 0.52 | 0.39 | 1.81 | 1.14 | 0.73 | 0.75 |
| 155 | | | | | | | | | | | | |
| 156 | | | | | | | | | | | | |
| 157 | | | | | | | | | | | | |
| 158 | | | | | | | | | | | | |
| 159 | | | | | | | | | | | | |
| 160 | | | | | | | | | | | | |
| 161 | | | | | | | | | | | | |
| 162 | | | | | 0.56 | 1.84 | 0.25 | 1.24 | 0.85 | 1.29 | 0.34 | 1.36 |
| 163 | 0.71 | 2.18 | 0.24 | 0.54 | 1.13 | 1.68 | 0.27 | 0.57 | 1.40 | 1.20 | 0.32 | 0.59 |
| 164 | | | | | | | | | 0.06 | 0.31 | 0.20 | 0.62 |
| 165 | 0.82 | 1.90 | 0.30 | 0.84 | 1.29 | 1.48 | 0.33 | 0.90 | 1.47 | 1.13 | 0.39 | 1.02 |
| 166 | 3.75 | 0.79 | 0.70 | 0.48 | 3.56 | 1.10 | 0.76 | 0.53 | 3.60 | 0.80 | 0.86 | 0.59 |
| 167 | | | | | | | | | | | | |
| 168 | | | | | | | | | | | | |
| 169 | 0.72 | 1.94 | 0.33 | 0.62 | 1.18 | 1.52 | 0.39 | 0.65 | 1.36 | 1.15 | 0.49 | 0.87 |
| 170 | | | | | | | | | | | | |
| 171 | 0.69 | 1.82 | 0.23 | 0.35 | 1.24 | 1.38 | 0.25 | 0.67 | 1.31 | 1.07 | 0.29 | 0.76 |
| 172 | 1.07 | 1.70 | 0.38 | 0.88 | 1.57 | 1.25 | 0.40 | 0.87 | 1.62 | 1.03 | 0.45 | 1.24 |
| 173 | | | | | | | | | | | | |
| 174 | | | | | 2.29 | 0.72 | 0.17 | 1.18 | 2.29 | 0.91 | 0.18 | 1.30 |
| 175 | | | | | | | | | | | | |
| 176 | 3.03 | 1.12 | 0.16 | 0.86 | 2.90 | 0.99 | 0.17 | 0.93 | 2.82 | 0.67 | 0.20 | 1.05 |
| 177 | | | | | | | | | 0.39 | 1.69 | 0.24 | 0.37 |
| 178 | 0.44 | 1.60 | 0.22 | 1.87 | 0.80 | 1.27 | 0.27 | 1.98 | 1.03 | 1.27 | 0.36 | 2.06 |
| 179 | | | | | | | | | | | | |
| 180 | | | | | | | | | | | | |
| 181 | 0.24 | 0.67 | 0.17 | 0.21 | 0.45 | 0.49 | 0.19 | 0.31 | 0.58 | 1.00 | 0.21 | 0.45 |
| 182 | | | | | | | | | | | | |
| 183 | | | | | | | | | | | | |
| 184 | 0.19 | 0.68 | 0.18 | 0.97 | 0.33 | 0.93 | 0.20 | 1.13 | 0.46 | 1.15 | 0.23 | 1.22 |

| Road Overtopping Point ID* | 5% AEP | | | | 2% AEP | | | | 1% AEP | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Duration Cut (hours) | Time Road First Cut (hours) | Peak Depth | Peak Velocity | Duration Cut (hours) | Time Road First Cut (hours) | Peak Depth | Peak Velocity | Duration Cut (hours) | Time Road First Cut (hours) | Peak Depth | Peak Velocity |
| 185 | | | | | | | | | 0.11 | 0.40 | 0.18 | 1.01 |
| 186 | 0.61 | 1.93 | 0.29 | 0.31 | 1.02 | 1.59 | 0.33 | 0.36 | 1.19 | 1.12 | 0.39 | 0.47 |
| 187 | | | | | | | | | | | | |
| 188 | | | | | | | | | | | | |
| 189 | 0.19 | 0.83 | 0.15 | 0.72 | 0.28 | 0.77 | 0.17 | 0.99 | 0.43 | 0.96 | 0.18 | 1.24 |
| 190 | | | | | | | | | | | | |
| 191 | | | | | | | | | 0.26 | 0.81 | 0.15 | 0.95 |
| 192 | | | | | | | | | 0.27 | 1.26 | 0.16 | 2.37 |
| 193 | 0.67 | 1.64 | 0.54 | 0.57 | 1.13 | 1.22 | 0.57 | 0.56 | 1.17 | 0.86 | 0.62 | 0.64 |
| 194 | | | | | 0.08 | 0.54 | 0.17 | 1.74 | 0.18 | 0.69 | 0.19 | 1.77 |
| 195 | 0.22 | 0.83 | 0.16 | 2.05 | 0.38 | 0.94 | 0.19 | 2.32 | 0.57 | 1.11 | 0.25 | 3.03 |
| 196 | 2.61 | 0.69 | 0.20 | 0.54 | 2.48 | 0.89 | 0.23 | 0.75 | 2.51 | 1.11 | 0.25 | 0.84 |
| 197 | | | | | 0.08 | 0.11 | 0.16 | 1.08 | 0.20 | 1.16 | 0.21 | 1.27 |
| 198 | | | | | | | | | 0.04 | 0.28 | 0.15 | 1.49 |
| 199 | | | | | | | | | 0.05 | 0.25 | 0.17 | 1.77 |
| 200 | | | | | | | | | 0.02 | 0.28 | 0.15 | 1.76 |
| 201 | | | | | | | | | | | | |
| 202 | 0.54 | 1.65 | 0.45 | 0.42 | 0.88 | 1.22 | 0.49 | 0.42 | 0.87 | 0.72 | 0.51 | 0.42 |
| 203 | 3.11 | 1.61 | 0.21 | 0.67 | 2.94 | 0.94 | 0.26 | 0.87 | 3.00 | 1.12 | 0.33 | 0.96 |
| 204 | 0.19 | 0.49 | 0.25 | 0.48 | 0.35 | 0.79 | 0.30 | 0.48 | 0.48 | 1.04 | 0.32 | 0.48 |
| 205 | | | | | | | | | | | | |
| 206 | | | | | | | | | | | | |
| 207 | | | | | | | | | | | | |
| 208 | | | | | 0.08 | 0.41 | 0.16 | 0.79 | 0.15 | 0.52 | 0.17 | 0.33 |
| 209 | | | | | | | | | | | | |
| 210 | | | | | | | | | 1.79 | 0.32 | 0.15 | 0.37 |
| 211 | | | | | | | | | | | | |
| 212 | | | | | 3.53 | 0.98 | 0.19 | 1.69 | 3.49 | 1.17 | 0.27 | 2.01 |
| 213 | | | | | | | | | | | | |
| 214 | | | | | | | | | | | | |
| 215 | | | | | | | | | | | | |
| 216 | | | | | | | | | | | | |
| 217 | | | | | | | | | 2.63 | 0.44 | 0.15 | 0.61 |
| 218 | | | | | | | | | | | | |
| 219 | | | | | 0.10 | 0.67 | 0.15 | 2.21 | 0.26 | 0.81 | 0.19 | 2.30 |
| 220 | 0.14 | 0.20 | 0.16 | 0.59 | 0.23 | 0.69 | 0.19 | 0.66 | 0.33 | 0.89 | 0.20 | 0.70 |
| 221 | 2.34 | 1.68 | 0.25 | 1.18 | 2.51 | 1.82 | 0.33 | 1.24 | 2.64 | 1.17 | 0.37 | 1.19 |
| 222 | 0.30 | 1.10 | 0.26 | 0.61 | 0.40 | 0.85 | 0.34 | 0.60 | 0.56 | 1.07 | 0.38 | 0.63 |
| 223 | | | | | | | | | | | | |
| 224 | 0.32 | 1.86 | 0.24 | 0.35 | 0.41 | 0.90 | 0.32 | 0.41 | 0.73 | 1.09 | 0.40 | 0.41 |
| 225 | | | | | | | | | | | | |
| 226 | | | | | | | | | | | | |
| 227 | 0.08 | 0.54 | 0.16 | 0.40 | 0.20 | 0.97 | 0.24 | 0.63 | 0.33 | 1.17 | 0.28 | 0.33 |
| 228 | | | | | | | | | | | | |
| 229 | | | | | | | | | | | | |
| 230 | | | | | 0.01 | 0.25 | 0.15 | 0.74 | 0.03 | 0.29 | 0.17 | 0.80 |

| Road Overtopping Point ID* | 5% AEP | | | | 2% AEP | | | | 1% AEP | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Duration Cut (hours) | Time Road First Cut (hours) | Peak Depth | Peak Velocity | Duration Cut (hours) | Time Road First Cut (hours) | Peak Depth | Peak Velocity | Duration Cut (hours) | Time Road First Cut (hours) | Peak Depth | Peak Velocity |
| 231 | 2.37 | 1.70 | 0.27 | 0.31 | 2.45 | 2.02 | 0.33 | 0.35 | 2.36 | 1.09 | 0.39 | 0.36 |
| 232 | | | | | | | | | | | | |
| 233 | | | | | 0.11 | 0.49 | 0.22 | 1.63 | 0.15 | 0.55 | 0.28 | 1.86 |
| 234 | | | | | | | | | | | | |
| 235 | 0.23 | 0.08 | 0.17 | 0.89 | 0.33 | 0.45 | 0.18 | 0.91 | 0.25 | 0.30 | 0.20 | 0.91 |
| 236 | | | | | | | | | | | | |
| 237 | | | | | | | | | | | | |
| 238 | | | | | | | | | 0.02 | 0.28 | 0.16 | 2.06 |
| 239 | | | | | | | | | 0.03 | 0.29 | 0.18 | 1.47 |
| 240 | 0.10 | 0.53 | 0.15 | 0.85 | 0.33 | 1.94 | 0.20 | 0.76 | 0.60 | 1.25 | 0.24 | 0.85 |
| 241 | | | | | | | | | | | | |
| 242 | | | | | | | | | | | | |
| 243 | | | | | | | | | | | | |
| 244 | | | | | | | | | | | | |
| 245 | | | | | | | | | | | | |
| 246 | | | | | | | | | | | | |
| 247 | 0.32 | 1.39 | 0.22 | 0.26 | 0.43 | 1.13 | 0.25 | 0.26 | 0.53 | 1.03 | 0.27 | 0.26 |
| 248 | 0.78 | 1.64 | 0.52 | 0.47 | 1.17 | 1.23 | 0.61 | 0.50 | 1.45 | 0.75 | 0.65 | 0.54 |
| 249 | 0.02 | 0.14 | 0.16 | 0.74 | 0.06 | 0.33 | 0.18 | 0.77 | 0.08 | 0.32 | 0.20 | 0.75 |
| 250 | | | | | | | | | | | | |
| 251 | | | | | | | | | | | | |
| 252 | | | | | | | | | | | | |
| 253 | | | | | | | | | | | | |
| 254 | | | | | | | | | 0.01 | 0.11 | 0.15 | 0.52 |
| 255 | | | | | | | | | | | | |
| 256 | | | | | | | | | 0.02 | 0.12 | 0.16 | 0.68 |
| 257 | | | | | | | | | | | | |

| Road Overtopping Point ID* | 0.5% AEP | | | | 0.2% AEP | | | | PMF | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Duration Cut (hours) | Time Road First Cut (hours) | Peak Depth | Peak Velocity | Duration Cut (hours) | Time Road First Cut (hours) | Peak Depth | Peak Velocity | Duration Cut (hours) | Time Road First Cut (hours) | Peak Depth | Peak Velocity |
| 1 | 0.07 | 0.16 | 0.15 | 0.52 | 0.11 | 0.29 | 0.16 | 0.55 | 1.49 | 0.37 | 0.26 | 0.91 |
| 2 | 2.24 | 0.27 | 0.15 | 0.90 | 1.98 | 0.12 | 0.16 | 0.96 | 6.10 | 0.89 | 0.28 | 1.49 |
| 3 | | | | | | | | | 0.31 | 0.39 | 0.23 | 0.61 |
| 4 | 0.62 | 0.84 | 0.23 | 1.36 | 0.70 | 0.61 | 0.23 | 1.38 | 4.79 | 0.99 | 0.42 | 1.66 |
| 5 | 2.65 | 0.95 | 0.24 | 0.93 | 2.34 | 0.93 | 0.25 | 0.94 | 6.11 | 0.67 | 0.48 | 1.35 |
| 6 | 0.40 | 0.99 | 0.27 | 0.48 | 0.57 | 0.98 | 0.27 | 0.49 | 4.75 | 0.68 | 0.49 | 0.75 |
| 7 | 0.17 | 0.24 | 0.20 | 0.09 | 0.20 | 0.23 | 0.22 | 0.10 | 2.44 | 1.07 | 0.31 | 0.24 |
| 8 | 0.09 | 0.17 | 0.16 | 0.36 | 0.12 | 0.09 | 0.17 | 0.26 | 1.61 | 0.43 | 0.24 | 0.51 |
| 9 | 2.14 | 0.69 | 0.21 | 0.63 | 1.87 | 0.94 | 0.22 | 0.63 | 6.12 | 0.66 | 0.36 | 0.81 |
| 10 | 0.04 | 0.36 | 0.17 | 1.72 | 0.03 | 0.24 | 0.17 | 1.63 | 1.36 | 1.00 | 0.44 | 2.33 |
| 11 | 0.16 | 0.35 | 0.21 | 0.75 | 0.21 | 0.24 | 0.22 | 0.82 | 2.94 | 0.92 | 0.42 | 1.04 |
| 12 | | | | | | | | | 0.77 | 0.30 | 0.22 | 1.79 |
| 13 | | | | | | | | | 1.29 | 0.84 | 0.40 | 1.55 |
| 14 | 0.09 | 0.31 | 0.18 | 0.47 | 0.12 | 0.16 | 0.20 | 0.66 | 1.43 | 0.93 | 0.29 | 0.43 |
| 15 | | | | | | | | | 6.04 | 0.41 | 0.25 | 0.56 |
| 16 | | | | | | | | | 0.25 | 0.23 | 0.27 | 1.25 |
| 17 | 1.00 | 0.39 | 0.34 | 0.30 | 1.04 | 0.27 | 0.35 | 0.33 | 5.67 | 0.46 | 0.47 | 0.61 |
| 18 | 1.78 | 0.42 | 0.70 | 0.29 | 1.68 | 0.27 | 0.71 | 0.31 | 5.95 | 0.49 | 1.03 | 0.78 |
| 19 | 0.06 | 0.28 | 0.16 | 0.54 | 0.06 | 0.18 | 0.17 | 0.56 | 1.87 | 0.71 | 0.36 | 0.74 |
| 20 | 1.84 | 0.35 | 0.24 | 0.46 | 1.30 | 0.49 | 0.25 | 0.17 | 6.05 | 0.73 | 0.38 | 0.28 |
| 21 | | | | | | | | | 3.49 | 1.79 | 0.87 | 1.55 |
| 22 | 0.30 | 0.63 | 0.29 | 1.29 | 0.40 | 0.85 | 0.31 | 1.30 | 4.36 | 0.63 | 0.50 | 1.54 |
| 23 | 0.34 | 1.05 | 0.36 | 2.23 | 0.47 | 0.99 | 0.36 | 2.22 | 4.32 | 0.69 | 0.73 | 3.36 |
| 24 | | | | | | | | | 0.41 | 0.24 | 0.22 | 1.58 |
| 25 | | | | | | | | | 2.65 | 1.96 | 0.69 | 1.70 |
| 26 | | | | | | | | | 0.28 | 0.26 | 0.22 | 2.88 |
| 27 | 0.09 | 0.40 | 0.20 | 1.11 | 0.10 | 0.31 | 0.21 | 1.12 | 2.85 | 1.03 | 0.52 | 2.16 |
| 28 | 1.04 | 0.87 | 0.51 | 0.43 | 1.15 | 0.34 | 0.53 | 0.45 | 5.31 | 0.55 | 0.67 | 0.61 |
| 29 | 2.04 | 0.83 | 0.26 | 0.67 | 1.78 | 0.29 | 0.27 | 0.70 | 6.10 | 0.66 | 0.40 | 1.09 |
| 30 | | | | | | | | | 5.64 | 2.75 | 0.56 | 0.28 |
| 31 | 0.04 | 0.18 | 0.15 | 0.56 | 0.05 | 0.09 | 0.16 | 0.59 | 1.31 | 0.55 | 0.28 | 1.23 |
| 32 | | | | | | | | | 3.80 | 2.83 | 0.47 | 0.18 |
| 33 | 1.90 | 0.29 | 0.16 | 1.49 | 1.42 | 0.26 | 0.16 | 1.21 | 6.04 | 0.80 | 0.32 | 1.35 |
| 34 | | | | | | | | | 3.54 | 3.08 | 0.34 | 0.21 |
| 35 | 1.81 | 0.47 | 0.68 | 0.30 | 1.48 | 0.31 | 0.68 | 0.31 | 6.01 | 0.54 | 1.14 | 0.40 |
| 36 | 2.15 | 0.32 | 0.21 | 0.67 | 1.88 | 0.24 | 0.22 | 0.73 | 6.11 | 0.94 | 0.41 | 1.93 |
| 37 | 0.73 | 0.94 | 0.48 | 0.74 | 0.82 | 0.90 | 0.48 | 0.74 | 5.36 | 0.63 | 1.01 | 1.32 |
| 38 | 0.26 | 0.67 | 0.34 | 0.63 | 0.35 | 0.98 | 0.35 | 0.75 | 4.20 | 0.72 | 0.77 | 1.74 |
| 39 | 0.26 | 0.53 | 0.21 | 0.45 | 0.36 | 0.55 | 0.22 | 0.46 | 4.99 | 0.78 | 0.83 | 1.22 |
| 40 | | | | | | | | | 0.64 | 0.37 | 0.26 | 2.25 |
| 41 | 0.23 | 0.98 | 0.25 | 1.28 | 0.33 | 0.96 | 0.27 | 1.29 | 4.18 | 0.84 | 0.50 | 1.48 |
| 42 | 0.23 | 0.48 | 0.24 | 1.02 | 0.30 | 0.78 | 0.24 | 1.02 | 3.75 | 0.79 | 0.38 | 1.39 |
| 43 | 1.25 | 0.43 | 0.16 | 0.20 | 1.06 | 0.38 | 0.16 | 0.20 | 5.55 | 2.40 | 0.72 | 0.25 |
| 44 | 0.33 | 0.78 | 0.30 | 1.25 | 0.46 | 1.04 | 0.30 | 1.21 | 5.15 | 0.78 | 1.19 | 3.43 |
| 45 | 4.00 | 0.88 | 4.17 | 1.08 | 4.00 | 0.84 | 4.24 | 1.13 | 6.50 | 0.70 | 5.51 | 1.46 |
| 46 | 0.24 | 0.76 | 0.22 | 0.37 | 0.36 | 0.82 | 0.23 | 0.51 | 4.21 | 0.91 | 0.71 | 2.13 |

| Road Overtopping Point ID* | 0.5% AEP | | | | 0.2% AEP | | | | PMF | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Duration Cut (hours) | Time Road First Cut (hours) | Peak Depth | Peak Velocity | Duration Cut (hours) | Time Road First Cut (hours) | Peak Depth | Peak Velocity | Duration Cut (hours) | Time Road First Cut (hours) | Peak Depth | Peak Velocity |
| 47 | | | | | | | | | 1.38 | 1.91 | 0.52 | 2.08 |
| 48 | | | | | | | | | 1.84 | 1.68 | 0.41 | 1.46 |
| 49 | 3.99 | 2.13 | 1.15 | 0.02 | 3.99 | 1.54 | 1.17 | 0.02 | 6.49 | 1.01 | 2.62 | 0.14 |
| 50 | 0.73 | 0.98 | 0.39 | 1.91 | 0.83 | 0.96 | 0.40 | 2.00 | 5.51 | 0.68 | 0.99 | 4.03 |
| 51 | | | | | | | | | 0.80 | 1.10 | 0.24 | 2.41 |
| 52 | 0.12 | 0.40 | 0.20 | 1.87 | 0.17 | 0.40 | 0.20 | 1.84 | 3.16 | 0.67 | 0.36 | 3.07 |
| 53 | | | | | | | | | 4.56 | 1.47 | 1.19 | 2.67 |
| 54 | 0.84 | 0.93 | 0.34 | 0.70 | 0.90 | 0.90 | 0.37 | 0.72 | 5.68 | 0.63 | 0.79 | 0.98 |
| 55 | 1.62 | 1.45 | 0.49 | 0.57 | 1.83 | 1.33 | 0.58 | 0.74 | 5.74 | 0.89 | 1.84 | 2.71 |
| 56 | 1.76 | 0.45 | 0.26 | 0.37 | 1.60 | 0.23 | 0.26 | 0.37 | 5.94 | 0.43 | 0.33 | 0.50 |
| 57 | | | | | | | | | 4.08 | 2.47 | 0.64 | 1.14 |
| 58 | 0.88 | 0.32 | 0.25 | 1.17 | 0.66 | 0.32 | 0.25 | 1.19 | 4.35 | 0.93 | 0.40 | 1.33 |
| 59 | 2.24 | 1.27 | 0.95 | 0.97 | 2.03 | 1.19 | 1.03 | 1.00 | 5.62 | 0.96 | 2.22 | 1.24 |
| 60 | 1.10 | 0.94 | 0.32 | 1.39 | 1.04 | 0.91 | 0.32 | 1.39 | 5.53 | 0.71 | 0.58 | 2.08 |
| 61 | | | | | | | | | 0.31 | 0.25 | 0.24 | 1.29 |
| 62 | 0.59 | 0.81 | 0.25 | 1.15 | 0.65 | 0.79 | 0.25 | 1.20 | 5.05 | 0.80 | 0.48 | 1.87 |
| 63 | 3.98 | 2.13 | 0.99 | 0.05 | 3.98 | 1.54 | 1.01 | 0.05 | 6.48 | 1.01 | 2.46 | 0.12 |
| 64 | 0.94 | 0.88 | 0.72 | 0.65 | 1.21 | 0.48 | 0.72 | 0.65 | 5.80 | 0.58 | 1.17 | 0.74 |
| 65 | 0.89 | 0.43 | 0.36 | 0.62 | 0.96 | 0.29 | 0.37 | 0.65 | 5.60 | 0.49 | 0.47 | 1.10 |
| 66 | | | | | | | | | 4.12 | 2.42 | 0.67 | 0.53 |
| 67 | 4.00 | 0.86 | 1.73 | 0.97 | 4.00 | 0.80 | 1.78 | 0.97 | 6.50 | 0.69 | 2.68 | 0.54 |
| 68 | 3.99 | 2.12 | 2.00 | 0.02 | 3.99 | 1.54 | 2.02 | 0.02 | 6.49 | 1.01 | 3.47 | 0.16 |
| 69 | 1.70 | 0.73 | 0.45 | 0.50 | 1.18 | 0.87 | 0.47 | 0.42 | 5.95 | 0.65 | 0.62 | 0.71 |
| 70 | | | | | | | | | 1.08 | 1.08 | 0.25 | 1.12 |
| 71 | 2.88 | 1.05 | 0.47 | 2.46 | 2.66 | 1.02 | 0.47 | 2.44 | 6.02 | 0.71 | 0.96 | 3.54 |
| 72 | 0.36 | 1.11 | 0.38 | 1.14 | 0.53 | 1.06 | 0.38 | 1.14 | 4.73 | 0.74 | 0.76 | 1.91 |
| 73 | 2.03 | 0.91 | 0.29 | 0.78 | 1.74 | 0.86 | 0.31 | 0.82 | 6.13 | 0.60 | 0.51 | 1.19 |
| 74 | | | | | | | | | 0.72 | 0.39 | 0.29 | 1.12 |
| 75 | 2.05 | 1.18 | 0.23 | 0.41 | 1.87 | 0.94 | 0.26 | 0.49 | 5.91 | 0.67 | 1.58 | 2.10 |
| 76 | 0.28 | 0.54 | 0.33 | 0.44 | 0.33 | 0.77 | 0.37 | 0.44 | 4.21 | 0.78 | 0.68 | 0.45 |
| 77 | 1.79 | 0.98 | 0.26 | 1.16 | 1.59 | 0.92 | 0.27 | 1.20 | 5.83 | 0.70 | 1.63 | 1.59 |
| 78 | 1.91 | 0.77 | 0.33 | 0.41 | 1.97 | 0.30 | 0.34 | 0.42 | 5.29 | 0.67 | 0.43 | 0.58 |
| 79 | | | | | | | | | 0.74 | 1.02 | 0.19 | 0.48 |
| 80 | 3.99 | 1.45 | 1.13 | 0.09 | 3.99 | 1.23 | 1.14 | 0.10 | 6.49 | 0.89 | 2.55 | 0.14 |
| 81 | | | | | | | | | 1.04 | 0.38 | 0.28 | 0.55 |
| 82 | 1.18 | 0.89 | 0.65 | 0.39 | 1.28 | 0.52 | 0.67 | 0.40 | 5.95 | 0.59 | 1.04 | 0.50 |
| 83 | 1.68 | 0.49 | 0.30 | 0.44 | 1.26 | 0.33 | 0.31 | 0.47 | 5.89 | 0.57 | 0.41 | 0.67 |
| 84 | 0.15 | 0.55 | 0.20 | 0.56 | 0.25 | 0.47 | 0.21 | 0.56 | 4.22 | 0.72 | 0.32 | 1.04 |
| 85 | 3.96 | 1.49 | 0.54 | 0.25 | 3.96 | 1.26 | 0.55 | 0.26 | 6.46 | 0.91 | 1.97 | 0.27 |
| 86 | 3.99 | 2.10 | 1.40 | 0.03 | 3.99 | 1.54 | 1.42 | 0.04 | 6.49 | 1.01 | 2.87 | 0.11 |
| 87 | | | | | | | | | 0.36 | 0.25 | 0.20 | 2.31 |
| 88 | 0.19 | 0.49 | 0.25 | 0.43 | 0.32 | 0.77 | 0.26 | 0.46 | 4.21 | 0.87 | 0.37 | 1.07 |
| 89 | | | | | | | | | 4.26 | 2.29 | 0.77 | 1.22 |
| 90 | 1.93 | 0.84 | 0.24 | 0.29 | 1.51 | 0.91 | 0.25 | 0.29 | 6.11 | 0.64 | 0.41 | 0.48 |
| 91 | | | | | | | | | 0.69 | 0.40 | 0.30 | 2.39 |
| 92 | 0.67 | 0.80 | 0.33 | 1.54 | 0.77 | 0.45 | 0.33 | 1.56 | 5.21 | 0.76 | 0.54 | 1.65 |

| Road Overtopping Point ID* | 0.5% AEP | | | | 0.2% AEP | | | | PMF | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Duration Cut (hours) | Time Road First Cut (hours) | Peak Depth | Peak Velocity | Duration Cut (hours) | Time Road First Cut (hours) | Peak Depth | Peak Velocity | Duration Cut (hours) | Time Road First Cut (hours) | Peak Depth | Peak Velocity |
| 93 | 2.54 | 0.91 | 0.21 | 1.57 | 2.29 | 0.87 | 0.22 | 1.71 | 6.08 | 0.69 | 0.34 | 2.47 |
| 94 | | | | | | | | | 4.22 | 2.44 | 0.74 | 0.94 |
| 95 | 0.09 | 0.24 | 0.16 | 0.39 | 0.12 | 0.20 | 0.16 | 0.39 | 3.10 | 0.94 | 0.35 | 0.57 |
| 96 | | | | | | | | | 6.10 | 0.40 | 0.19 | 1.09 |
| 97 | | | | | | | | | 6.00 | 3.04 | 0.31 | 1.23 |
| 98 | | | | | | | | | 1.86 | 3.67 | 0.20 | 0.20 |
| 99 | 2.28 | 0.43 | 0.19 | 0.74 | 2.02 | 0.53 | 0.20 | 0.74 | 6.11 | 1.01 | 0.31 | 0.91 |
| 100 | 3.99 | 2.10 | 1.32 | 0.03 | 3.99 | 1.55 | 1.34 | 0.03 | 6.49 | 1.01 | 2.79 | 0.08 |
| 101 | 0.17 | 0.43 | 0.17 | 0.60 | 0.22 | 0.44 | 0.17 | 0.60 | 5.04 | 1.03 | 0.38 | 0.94 |
| 102 | | | | | 0.04 | 0.07 | 0.15 | 0.46 | 0.93 | 0.41 | 0.21 | 0.87 |
| 103 | | | | | | | | | 3.02 | 3.27 | 0.29 | 0.26 |
| 104 | 0.16 | 0.44 | 0.18 | 0.94 | 0.25 | 0.87 | 0.18 | 0.97 | 3.76 | 0.67 | 0.23 | 1.17 |
| 105 | 3.98 | 1.41 | 0.91 | 0.92 | 3.98 | 1.27 | 0.95 | 0.76 | 6.48 | 0.89 | 2.31 | 0.17 |
| 106 | | | | | | | | | 0.29 | 0.23 | 0.19 | 1.52 |
| 107 | | | | | | | | | 3.98 | 2.58 | 0.57 | 1.28 |
| 108 | 1.82 | 0.53 | 0.19 | 0.14 | 1.27 | 0.50 | 0.19 | 0.13 | 6.01 | 0.60 | 0.26 | 0.26 |
| 109 | | | | | | | | | 6.10 | 0.40 | 0.20 | 1.81 |
| 110 | 0.08 | 0.24 | 0.16 | 0.19 | 0.09 | 0.18 | 0.17 | 0.06 | 1.89 | 0.57 | 0.25 | 0.11 |
| 111 | | | | | | | | | 1.04 | 0.35 | 0.23 | 1.46 |
| 112 | 3.47 | 2.08 | 0.27 | 0.62 | 3.20 | 1.53 | 0.29 | 0.62 | 5.89 | 0.93 | 1.74 | 0.88 |
| 113 | | | | | | | | | 0.21 | 0.28 | 0.19 | 1.90 |
| 114 | | | | | | | | | 6.01 | 0.38 | 0.22 | 0.63 |
| 115 | 1.72 | 0.48 | 0.72 | 0.44 | 1.73 | 0.32 | 0.82 | 0.46 | 5.95 | 0.55 | 1.59 | 0.53 |
| 116 | | | | | | | | | 1.03 | 0.50 | 0.28 | 0.96 |
| 117 | 2.56 | 0.69 | 0.23 | 0.87 | 2.31 | 0.68 | 0.24 | 0.88 | 6.07 | 0.83 | 0.35 | 1.11 |
| 118 | 3.89 | 1.00 | 0.51 | 1.43 | 3.90 | 0.98 | 0.61 | 1.48 | 6.08 | 0.67 | 1.38 | 2.14 |
| 119 | 0.38 | 0.88 | 0.24 | 0.25 | 0.53 | 0.99 | 0.24 | 0.26 | 4.43 | 0.84 | 0.38 | 0.35 |
| 120 | | | | | 0.19 | 0.99 | 0.15 | 1.04 | 5.55 | 0.97 | 2.07 | 1.38 |
| 121 | | | | | | | | | 1.37 | 1.06 | 0.37 | 2.37 |
| 122 | | | | | | | | | 0.30 | 0.22 | 0.21 | 2.38 |
| 123 | | | | | | | | | 6.06 | 0.50 | 0.43 | 2.47 |
| 124 | 3.61 | 1.06 | 0.28 | 0.66 | 3.75 | 0.99 | 0.32 | 0.79 | 6.06 | 0.75 | 0.72 | 1.61 |
| 125 | | | | | | | | | 5.22 | 1.38 | 1.45 | 0.68 |
| 126 | | | | | | | | | 0.52 | 0.57 | 0.26 | 1.44 |
| 127 | | | | | | | | | 4.59 | 1.99 | 1.04 | 0.63 |
| 128 | 3.90 | 1.84 | 0.45 | 0.08 | 3.90 | 0.97 | 0.46 | 0.09 | 6.36 | 0.72 | 1.91 | 0.19 |
| 129 | | | | | | | | | 4.22 | 1.28 | 1.24 | 1.84 |
| 130 | 2.54 | 1.18 | 0.17 | 0.52 | 2.78 | 1.03 | 0.18 | 0.50 | 5.71 | 1.18 | 1.44 | 1.71 |
| 131 | 1.70 | 0.87 | 0.22 | 0.74 | 1.68 | 0.41 | 0.22 | 0.76 | 5.85 | 0.68 | 0.38 | 1.51 |
| 132 | 0.34 | 0.86 | 0.18 | 0.58 | 0.41 | 1.05 | 0.19 | 0.64 | 4.31 | 0.77 | 0.26 | 1.05 |
| 133 | | | | | | | | | 1.68 | 1.06 | 0.28 | 1.69 |
| 134 | | | | | | | | | 1.81 | 1.72 | 0.31 | 1.87 |
| 135 | 0.16 | 0.78 | 0.17 | 0.52 | 0.24 | 0.78 | 0.17 | 0.52 | 5.70 | 1.51 | 1.10 | 0.60 |
| 136 | 2.90 | 0.65 | 0.21 | 0.71 | 2.85 | 1.54 | 0.26 | 0.97 | 6.12 | 0.83 | 1.70 | 3.26 |
| 137 | 0.13 | 0.27 | 0.23 | 0.80 | 0.12 | 0.23 | 0.25 | 0.68 | 0.75 | 0.25 | 0.28 | 1.56 |
| 138 | 0.50 | 0.96 | 0.24 | 0.67 | 0.62 | 0.95 | 0.24 | 0.69 | 5.11 | 0.69 | 0.32 | 1.08 |

| Road Overtopping Point ID* | 0.5% AEP | | | | 0.2% AEP | | | | PMF | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Duration Cut (hours) | Time Road First Cut (hours) | Peak Depth | Peak Velocity | Duration Cut (hours) | Time Road First Cut (hours) | Peak Depth | Peak Velocity | Duration Cut (hours) | Time Road First Cut (hours) | Peak Depth | Peak Velocity |
| 139 | 0.44 | 0.62 | 0.21 | 0.58 | 0.57 | 0.96 | 0.22 | 0.60 | 4.33 | 1.10 | 0.68 | 1.65 |
| 140 | 0.41 | 0.60 | 0.27 | 0.20 | 0.53 | 0.91 | 0.28 | 0.24 | 4.84 | 0.74 | 0.59 | 0.58 |
| 141 | | | | | | | | | 1.61 | 1.15 | 0.67 | 2.25 |
| 142 | 3.46 | 0.91 | 1.20 | 1.00 | 3.28 | 0.83 | 1.38 | 0.96 | 5.90 | 0.72 | 2.84 | 1.18 |
| 143 | 2.32 | 1.02 | 0.36 | 1.10 | 2.09 | 0.98 | 0.37 | 1.13 | 5.86 | 0.76 | 0.86 | 2.12 |
| 144 | 0.45 | 0.96 | 0.29 | 0.46 | 0.69 | 0.82 | 0.31 | 0.45 | 5.99 | 0.59 | 1.43 | 0.44 |
| 145 | | | | | | | | | 2.55 | 0.81 | 0.22 | 2.73 |
| 146 | | | | | | | | | 5.96 | 0.27 | 0.47 | 0.03 |
| 147 | 1.72 | 1.01 | 0.32 | 0.99 | 1.64 | 0.88 | 0.32 | 1.03 | 5.88 | 0.71 | 0.61 | 1.97 |
| 148 | | | | | | | | | 4.76 | 1.81 | 0.58 | 0.39 |
| 149 | | | | | | | | | 0.84 | 0.37 | 0.23 | 1.15 |
| 150 | 1.60 | 0.79 | 0.29 | 0.49 | 1.75 | 0.73 | 0.30 | 0.50 | 5.71 | 1.00 | 0.59 | 1.07 |
| 151 | | | | | | | | | 4.85 | 1.06 | 0.63 | 1.29 |
| 152 | | | | | 0.27 | 1.81 | 0.27 | 0.32 | 5.42 | 1.10 | 1.76 | 1.51 |
| 153 | 2.50 | 1.59 | 0.52 | 0.28 | 2.68 | 1.36 | 0.70 | 0.42 | 5.53 | 1.00 | 2.16 | 0.75 |
| 154 | 2.31 | 0.98 | 0.80 | 0.82 | 1.91 | 0.94 | 1.15 | 0.91 | 5.97 | 0.63 | 2.96 | 2.10 |
| 155 | | | | | | | | | 5.28 | 1.25 | 1.41 | 0.31 |
| 156 | | | | | | | | | 0.99 | 0.78 | 0.23 | 2.34 |
| 157 | | | | | | | | | 6.15 | 0.40 | 0.43 | 2.89 |
| 158 | | | | | | | | | 1.92 | 1.37 | 0.64 | 1.80 |
| 159 | | | | | | | | | 3.00 | 1.33 | 0.71 | 1.14 |
| 160 | | | | | | | | | 5.35 | 1.19 | 1.46 | 2.08 |
| 161 | | | | | | | | | 0.86 | 0.31 | 0.24 | 1.51 |
| 162 | 1.16 | 1.20 | 0.36 | 1.37 | 0.96 | 1.11 | 0.41 | 1.37 | 5.37 | 0.94 | 1.24 | 2.56 |
| 163 | 1.80 | 1.12 | 0.35 | 0.59 | 1.44 | 1.03 | 0.38 | 0.60 | 5.83 | 0.76 | 0.79 | 2.34 |
| 164 | 0.11 | 0.35 | 0.19 | 0.60 | 0.13 | 0.55 | 0.19 | 0.61 | 3.97 | 0.91 | 0.56 | 1.39 |
| 165 | 1.84 | 1.01 | 0.42 | 1.03 | 1.48 | 0.93 | 0.47 | 1.13 | 5.75 | 0.78 | 0.95 | 2.03 |
| 166 | 3.85 | 0.59 | 0.90 | 0.60 | 3.86 | 0.34 | 0.99 | 0.63 | 6.06 | 0.56 | 2.00 | 1.07 |
| 167 | | | | | | | | | 0.26 | 0.23 | 0.31 | 1.88 |
| 168 | | | | | | | | | 4.85 | 1.19 | 0.79 | 2.60 |
| 169 | 1.71 | 1.06 | 0.54 | 0.97 | 1.41 | 0.97 | 0.63 | 1.15 | 5.73 | 0.80 | 1.65 | 1.48 |
| 170 | 0.20 | 0.55 | 0.18 | 1.21 | 0.45 | 1.35 | 0.23 | 1.16 | 5.26 | 0.99 | 1.18 | 1.52 |
| 171 | 1.76 | 0.93 | 0.32 | 0.77 | 1.36 | 0.87 | 0.36 | 0.80 | 5.79 | 0.73 | 1.00 | 1.03 |
| 172 | 2.12 | 0.83 | 0.48 | 1.44 | 1.68 | 0.72 | 0.53 | 1.71 | 5.90 | 0.65 | 1.16 | 1.92 |
| 173 | | | | | | | | | 2.16 | 0.38 | 0.32 | 1.47 |
| 174 | 2.29 | 0.76 | 0.20 | 1.40 | 2.02 | 0.73 | 0.20 | 1.40 | 6.12 | 0.87 | 0.35 | 1.92 |
| 175 | 0.04 | 0.29 | 0.15 | 0.76 | 0.09 | 0.39 | 0.16 | 0.77 | 3.93 | 0.83 | 0.36 | 1.43 |
| 176 | 2.88 | 0.60 | 0.20 | 1.06 | 2.63 | 0.94 | 0.20 | 1.06 | 6.13 | 0.74 | 0.33 | 1.63 |
| 177 | 0.44 | 1.55 | 0.30 | 0.42 | 0.70 | 1.40 | 0.43 | 0.67 | 5.59 | 1.02 | 1.55 | 1.41 |
| 178 | 1.24 | 1.24 | 0.40 | 2.08 | 1.09 | 1.17 | 0.47 | 2.10 | 5.66 | 0.84 | 1.19 | 2.53 |
| 179 | | | | | | | | | 1.08 | 0.41 | 0.36 | 2.05 |
| 180 | | | | | | | | | 1.36 | 0.82 | 0.30 | 1.39 |
| 181 | 0.64 | 0.77 | 0.22 | 0.48 | 0.58 | 0.68 | 0.22 | 0.52 | 4.96 | 0.72 | 0.32 | 1.15 |
| 182 | | | | | | | | | 0.17 | 0.17 | 0.18 | 1.17 |
| 183 | | | | | | | | | 1.08 | 0.56 | 0.29 | 2.16 |
| 184 | 0.57 | 1.00 | 0.25 | 1.24 | 0.76 | 0.96 | 0.25 | 1.25 | 5.62 | 0.69 | 0.62 | 1.63 |

| Road Overtopping Point ID* | 0.5% AEP | | | | 0.2% AEP | | | | PMF | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Duration Cut (hours) | Time Road First Cut (hours) | Peak Depth | Peak Velocity | Duration Cut (hours) | Time Road First Cut (hours) | Peak Depth | Peak Velocity | Duration Cut (hours) | Time Road First Cut (hours) | Peak Depth | Peak Velocity |
| 185 | 0.16 | 0.56 | 0.21 | 1.09 | 0.28 | 0.49 | 0.21 | 1.09 | 5.48 | 0.82 | 0.73 | 2.90 |
| 186 | 1.69 | 1.10 | 0.41 | 0.50 | 1.21 | 1.03 | 0.44 | 0.57 | 5.84 | 0.77 | 0.91 | 1.42 |
| 187 | | | | | | | | | 5.10 | 1.05 | 1.23 | 3.04 |
| 188 | | | | | | | | | 1.02 | 0.58 | 0.27 | 1.85 |
| 189 | 0.51 | 0.81 | 0.18 | 1.19 | 0.61 | 0.80 | 0.19 | 1.28 | 4.65 | 0.52 | 0.27 | 1.95 |
| 190 | 2.57 | 0.37 | 0.15 | 0.76 | 2.30 | 0.36 | 0.15 | 0.76 | 6.09 | 0.55 | 0.20 | 1.10 |
| 191 | 0.27 | 0.69 | 0.15 | 0.99 | 0.42 | 0.67 | 0.15 | 0.99 | 4.40 | 1.14 | 0.57 | 1.27 |
| 192 | 0.33 | 1.16 | 0.18 | 2.59 | 0.48 | 1.06 | 0.21 | 2.98 | 5.31 | 1.03 | 1.46 | 2.95 |
| 193 | 1.65 | 0.86 | 0.65 | 0.63 | 1.15 | 0.68 | 0.65 | 0.66 | 5.99 | 0.54 | 1.14 | 0.79 |
| 194 | 0.20 | 0.56 | 0.18 | 1.78 | 0.27 | 0.54 | 0.19 | 1.87 | 2.60 | 0.38 | 0.34 | 2.38 |
| 195 | 0.70 | 1.00 | 0.27 | 3.17 | 0.82 | 0.98 | 0.31 | 2.86 | 5.33 | 0.82 | 0.99 | 4.61 |
| 196 | 2.49 | 0.94 | 0.26 | 0.88 | 2.23 | 0.90 | 0.27 | 0.90 | 6.09 | 0.65 | 0.43 | 1.75 |
| 197 | 0.26 | 0.94 | 0.23 | 1.35 | 0.36 | 0.96 | 0.23 | 1.36 | 5.70 | 0.72 | 0.91 | 3.20 |
| 198 | 0.03 | 0.29 | 0.15 | 1.48 | 0.08 | 0.16 | 0.16 | 1.49 | 1.27 | 0.89 | 0.28 | 1.71 |
| 199 | 0.09 | 0.27 | 0.16 | 1.74 | 0.07 | 0.23 | 0.17 | 1.77 | 2.63 | 0.98 | 0.35 | 2.30 |
| 200 | | | | | 0.05 | 0.29 | 0.15 | 1.75 | 1.37 | 0.82 | 0.23 | 2.01 |
| 201 | | | | | | | | | 4.96 | 0.93 | 0.80 | 2.99 |
| 202 | 1.08 | 0.43 | 0.53 | 0.43 | 1.15 | 0.28 | 0.54 | 0.43 | 5.74 | 0.48 | 0.69 | 0.50 |
| 203 | 2.97 | 0.97 | 0.39 | 0.99 | 2.91 | 0.95 | 0.41 | 1.03 | 6.13 | 0.68 | 0.97 | 1.70 |
| 204 | 0.48 | 0.77 | 0.31 | 0.49 | 0.67 | 0.73 | 0.32 | 0.49 | 4.89 | 0.62 | 0.43 | 0.50 |
| 205 | | | | | | | | | 6.12 | 0.38 | 0.21 | 1.23 |
| 206 | | | | | | | | | 0.64 | 0.16 | 0.20 | 2.04 |
| 207 | | | | | | | | | 0.11 | 0.30 | 0.22 | 0.94 |
| 208 | 0.17 | 0.42 | 0.17 | 0.30 | 0.19 | 0.27 | 0.17 | 0.32 | 2.14 | 0.39 | 0.25 | 0.71 |
| 209 | | | | | | | | | 0.56 | 0.63 | 0.36 | 0.48 |
| 210 | | | | | 1.30 | 0.12 | 0.15 | 0.36 | 6.06 | 0.39 | 0.22 | 0.73 |
| 211 | | | | | | | | | 4.16 | 0.96 | 0.69 | 1.34 |
| 212 | 3.81 | 1.02 | 0.33 | 2.25 | 3.83 | 0.97 | 0.35 | 2.28 | 6.03 | 0.69 | 0.95 | 3.24 |
| 213 | | | | | | | | | 0.46 | 0.34 | 0.22 | 1.29 |
| 214 | | | | | | | | | 2.60 | 0.76 | 0.31 | 2.05 |
| 215 | 0.11 | 0.43 | 0.18 | 1.22 | 0.23 | 0.66 | 0.18 | 1.25 | 4.57 | 1.00 | 0.68 | 2.70 |
| 216 | | | | | | | | | 4.01 | 1.04 | 0.47 | 1.90 |
| 217 | | | | | | | | | 6.11 | 0.39 | 0.29 | 0.90 |
| 218 | | | | | | | | | 0.17 | 0.24 | 0.20 | 1.82 |
| 219 | 0.38 | 0.72 | 0.22 | 2.40 | 0.51 | 0.93 | 0.26 | 2.69 | 5.41 | 0.91 | 0.96 | 3.66 |
| 220 | 0.35 | 0.70 | 0.19 | 0.69 | 0.46 | 0.87 | 0.19 | 0.70 | 3.91 | 0.61 | 0.27 | 0.90 |
| 221 | 2.90 | 1.05 | 0.40 | 1.26 | 2.62 | 0.98 | 0.45 | 1.24 | 5.96 | 0.68 | 1.09 | 1.73 |
| 222 | 0.69 | 0.89 | 0.39 | 0.64 | 0.73 | 0.32 | 0.41 | 0.67 | 5.07 | 0.56 | 0.71 | 0.84 |
| 223 | | | | | | | | | 6.10 | 0.69 | 0.22 | 0.97 |
| 224 | 0.82 | 0.94 | 0.45 | 0.42 | 0.88 | 0.91 | 0.44 | 0.42 | 5.69 | 0.63 | 1.08 | 0.71 |
| 225 | | | | | | | | | 0.53 | 0.28 | 0.21 | 1.87 |
| 226 | | | | | | | | | 1.13 | 0.81 | 0.23 | 1.22 |
| 227 | 0.38 | 0.98 | 0.29 | 0.33 | 0.54 | 0.95 | 0.30 | 0.33 | 4.69 | 0.67 | 0.50 | 0.43 |
| 228 | | | | | | | | | 0.91 | 0.36 | 0.20 | 0.45 |
| 229 | | | | | | | | | 6.11 | 0.38 | 0.21 | 1.71 |
| 230 | 0.08 | 0.23 | 0.16 | 0.77 | 0.09 | 0.14 | 0.17 | 0.79 | 1.48 | 0.88 | 0.29 | 1.47 |

| Road Overtopping Point ID* | 0.5% AEP | | | | 0.2% AEP | | | | PMF | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Duration Cut (hours) | Time Road First Cut (hours) | Peak Depth | Peak Velocity | Duration Cut (hours) | Time Road First Cut (hours) | Peak Depth | Peak Velocity | Duration Cut (hours) | Time Road First Cut (hours) | Peak Depth | Peak Velocity |
| 231 | 2.50 | 0.93 | 0.43 | 0.36 | 2.30 | 0.90 | 0.45 | 0.37 | 6.07 | 0.62 | 0.99 | 0.45 |
| 232 | | | | | | | | | 0.23 | 0.13 | 0.19 | 1.39 |
| 233 | 0.23 | 0.73 | 0.28 | 1.89 | 0.33 | 0.95 | 0.30 | 1.96 | 4.15 | 0.67 | 0.67 | 2.84 |
| 234 | | | | | | | | | 1.13 | 0.33 | 0.34 | 4.38 |
| 235 | 0.34 | 0.35 | 0.19 | 0.91 | 0.32 | 0.21 | 0.20 | 0.91 | 2.44 | 0.96 | 0.31 | 0.96 |
| 236 | 0.04 | 0.09 | 0.15 | 1.39 | 0.18 | 0.88 | 0.19 | 1.72 | 4.33 | 1.00 | 0.49 | 2.28 |
| 237 | | | | | | | | | 0.80 | 0.69 | 0.25 | 2.20 |
| 238 | 0.06 | 0.31 | 0.16 | 2.06 | 0.07 | 0.18 | 0.18 | 2.08 | 1.81 | 0.74 | 0.41 | 2.39 |
| 239 | 0.08 | 0.31 | 0.17 | 1.43 | 0.07 | 0.29 | 0.18 | 1.36 | 1.59 | 0.89 | 0.53 | 1.48 |
| 240 | 0.86 | 1.22 | 0.24 | 0.82 | 0.77 | 1.05 | 0.27 | 1.01 | 5.67 | 0.88 | 0.55 | 2.17 |
| 241 | | | | | | | | | 1.58 | 0.30 | 0.22 | 3.28 |
| 242 | | | | | | | | | 0.68 | 0.37 | 0.23 | 0.50 |
| 243 | | | | | | | | | 0.66 | 0.34 | 0.25 | 1.64 |
| 244 | | | | | | | | | 0.56 | 0.32 | 0.26 | 2.92 |
| 245 | | | | | | | | | 2.79 | 1.14 | 0.70 | 1.40 |
| 246 | | | | | 0.02 | 0.04 | 0.15 | 0.11 | 1.28 | 0.36 | 0.26 | 0.35 |
| 247 | 0.68 | 0.57 | 0.25 | 0.26 | 0.66 | 0.28 | 0.27 | 0.27 | 4.94 | 0.48 | 0.38 | 0.29 |
| 248 | 1.83 | 0.36 | 0.64 | 0.55 | 1.52 | 0.20 | 0.66 | 0.56 | 6.07 | 0.45 | 0.77 | 0.73 |
| 249 | 0.12 | 0.31 | 0.18 | 0.76 | 0.14 | 0.16 | 0.19 | 0.63 | 2.02 | 0.98 | 0.32 | 0.86 |
| 250 | | | | | | | | | 4.94 | 0.53 | 0.25 | 0.90 |
| 251 | | | | | | | | | 0.11 | 0.16 | 0.17 | 1.86 |
| 252 | | | | | | | | | 0.99 | 0.31 | 0.27 | 1.66 |
| 253 | | | | | | | | | 0.75 | 0.30 | 0.27 | 1.51 |
| 254 | | | | | 0.03 | 0.05 | 0.15 | 0.50 | 1.00 | 0.25 | 0.25 | 0.69 |
| 255 | | | | | 0.07 | 0.51 | 0.15 | 0.35 | 4.27 | 0.96 | 0.82 | 1.73 |
| 256 | 0.05 | 0.40 | 0.16 | 0.65 | 0.05 | 0.32 | 0.16 | 0.64 | 1.34 | 0.97 | 0.28 | 0.88 |
| 257 | | | | | | | | | 1.37 | 0.74 | 0.47 | 2.20 |

# APPENDIX D

## CRITICAL FACILITY ASSESSMENT

| Facility Type | Name and Address of Facility | | | 5%AEP | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Is access to/from facility cut? | Amount of time before access is cut (hours) | Amount of time after access is cut that facility is isolated (hours) | Time at which inundation of facility first commences (hours) | Total duration of inundation of facility (hours) | Maximum depth of inundation across facility (m) | Maximum flow velocity across facility (m/s) | Maximum flood hazard | Above Floor Flooding Depth (m) |
| Critical Facilities | Infrastructure | Pump station | 43A Princess Street, Werrington | Yes | 1.68 | 2.27 | 1.96 | 3.99 | 1.08 | 0.20 | H3 | 0.03 |
| | Hospitals | Nepean Hospital | Derby Street, Kingswood | | | | 2.89 | 3.79 | 1.50 | 1.77 | H4 | |
| Vulnerable Facilities | Facilities Aged Care Facilities / Nursing Homes | Anglicare Newmarch House | 50-52 Manning St, Caddens | | | | 1.82 | 3.69 | 0.87 | 2.02 | H5 | 0.08 |
| | | Heritage Kingswood Aged Care Facility | 29 George St, Kingswood | | | | 2.39 | 3.77 | 0.21 | 1.59 | H1 | |
| | Pre-Schools / Child Care | Learning Adventures Kingswood | 30 George St, Kingswood | | | | 1.72 | 2.67 | 0.32 | 1.30 | H2 | |
| | | Yoorami Cottage Before & After School Care | 1-5 Cottage St, Werrington | | | | | | 0.10 | 0.29 | H1 | |
| | | Kingswood World of Learning | 38 First St, Kingswood | | | | 1.57 | 3.50 | 0.32 | 0.84 | H2 | |
| | | Mission Australia Family Day Care | 46 Bringelly Rd, Kingswood | | | | 1.72 | 3.11 | 0.35 | 1.15 | H2 | |
| | | Falguni Family Day Care | 73A Princess St, Werrington | Yes | 0.91 | 3.09 | 1.53 | 1.89 | 0.21 | 0.48 | H1 | |
| | | The Little Village Early Learning Centre | 33/35 Second Ave, Kingswood | | | | 1.84 | 3.32 | 0.34 | 1.09 | H2 | |
| | | The Learning Jungle | 137-139 Victoria St, Werrington | | | | 1.43 | 2.44 | 0.24 | 0.85 | H1 | |
| | | Orchard Hills Pre School | 122 Bringelly Rd, Orchard Hills | | | | 0.90 | 1.93 | 0.19 | 1.07 | H1 | |
| | | KU Penrith Preschool | 27 Bringelly Rd, Kingswood | | | | 1.03 | 3.23 | 0.26 | 0.72 | H1 | |
| | Primary Education | Werrington Public School | Armstein Cres, Werrington | | | | 1.71 | 3.48 | 0.25 | 0.91 | H1 | 0.02 |
| | | Kingswood Public School | 46-54 Second Ave, Kingswood | | | | 1.68 | 3.74 | 0.41 | 1.04 | H2 | |
| | | Kingswood South Public School | 60-68 Smith St, Kingswood | | | | 1.42 | 3.58 | 0.56 | 1.04 | H3 | |
| | | St. Joseph's Primary School | 90-94 Joseph St, Kingswood | | | | 1.40 | 3.88 | 0.60 | 1.54 | H3 | |
| | | St Dominic's College | 54/94 Gascoigne St, Kingswood | | | | 1.62 | 3.22 | 0.54 | 0.89 | H3 | |
| | | Montgrove College | 140 Bringelly Rd, Orchard Hills | | | | 2.06 | 3.87 | 1.01 | 3.09 | H5 | |
| | Secondary Education | Wollemi College | 4 Gipps St, Werrington | | | | 1.58 | 1.62 | 0.16 | 0.62 | H1 | |
| | | Cambridge Park High School | Harrow Rd, Cambridge Park | | | | 1.91 | 3.72 | 0.62 | 1.25 | H3 | |
| | | Kingswood High School | 131 Bringelly Rd, Kingswood | | | | 1.80 | 3.58 | 0.49 | 1.55 | H2 | |
| | Tertiary Education | Western Sydney University Werrington South Campus | Great Western Hwy, Werrington | | | | 1.81 | 3.81 | 0.72 | 0.73 | H3 | |
| | | Western Sydney University Werrington North Campus | Great Western Hwy, Werrington | | | | 1.95 | 3.89 | 0.65 | 0.94 | H3 | |
| | | Western Sydney University Kingswood Campus | Second Avenue, Kingswood | | | | 1.99 | 3.69 | 0.44 | 0.74 | H2 | |
| | | TAFE Nepean Campus | 12-44 O'Connell St, Kingswood | | | | 2.29 | 3.96 | 1.30 | 1.96 | H4 | |
| | Churches | Grace Bible Church | 80 Joseph St, Kingswood | | | | 1.28 | 3.65 | 0.28 | 0.69 | H1 | |
| | | Real Life Church | 44 Second Ave, Kingswood | | | | 1.23 | 1.85 | 0.18 | 0.88 | H1 | |
| | | Penrith Baptist Church | Morello Terrace, Caddens | | | | 0.26 | 3.22 | 0.24 | 1.75 | H1 | |
| | | St. Philip's Anglican Church | Second Ave, Kingswood | | | | 1.69 | 3.61 | 0.24 | 0.78 | H1 | |
| | Other | Cobham Youth Justice Centre | Great Western Hwy & Water St, Werrington | | | | 3.37 | 3.89 | 0.53 | 1.36 | H3 | |
| | | Werrington train station | Werrington | | | | 2.37 | 3.97 | 0.64 | 0.62 | H3 | |

| Facility Type | Name and Address of Facility | | | 1%AEP | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Is access to/from facility cut? | Amount of time before access is cut (hours) | Amount of time after access is cut that facility is isolated (hours) | Time at which inundation of facility first commences (hours) | Total duration of inundation of facility (hours) | Maximum depth of inundation across facility (m) | Maximum flow velocity across facility (m/s) | Maximum flood hazard | Above Floor Flooding Depth (m) |
| Critical Facilities | Infrastructure | Pump station | 43A Princess Street, Werrington | Yes | 1.43 | 2.56 | 1.82 | 3.99 | 1.15 | 0.25 | H3 | 0.11 |
| | Hospitals | Nepean Hospital | Derby Street, Kingswood | | | | 2.22 | 3.97 | 1.70 | 1.97 | H4 | |
| Vulnerable Facilities | Facilities Aged Care Facilities / Nursing Homes | Anglicare Newmarch House | 50-52 Manning St, Caddens | | | | 1.24 | 3.96 | 0.87 | 2.73 | H5 | 0.14 |
| | | Heritage Kingswood Aged Care Facility | 29 George St, Kingswood | Yes | 1.05 | 2.85 | 1.88 | 3.90 | 1.05 | 3.03 | H5 | |
| | Pre-Schools / Child Care | Learning Adventures Kingswood | 30 George St, Kingswood | | | | 1.11 | 2.89 | 0.34 | 1.36 | H2 | |
| | | Yoorami Cottage Before & After School Care | 1-5 Cottage St, Werrington | | | | | | 0.11 | 0.30 | H1 | |
| | | Kingswood World of Learning | 38 First St, Kingswood | | | | 0.97 | 3.71 | 0.34 | 1.47 | H2 | |
| | | Mission Australia Family Day Care | 46 Bringelly Rd, Kingswood | | | | 1.10 | 3.12 | 0.42 | 1.68 | H2 | |
| | | Falguni Family Day Care | 73A Princess St, Werrington | Yes | 0.72 | 3.38 | 0.90 | 1.94 | 0.22 | 0.54 | H1 | |
| | | The Little Village Early Learning Centre | 33/35 Second Ave, Kingswood | Yes | 1.57 | 0.26 | 1.28 | 3.50 | 0.42 | 1.27 | H2 | |
| | | The Learning Jungle | 137-139 Victoria St, Werrington | | | | 1.06 | 2.45 | 0.27 | 0.92 | H1 | |
| | | Orchard Hills Pre School | 122 Bringelly Rd, Orchard Hills | | | | 0.63 | 1.94 | 0.20 | 1.46 | H1 | |
| | | KU Penrith Preschool | 27 Bringelly Rd, Kingswood | | | | 1.58 | 3.43 | 0.45 | 0.93 | H2 | |
| | Primary Education | Werrington Public School | Armstein Cres, Werrington | | | | 1.19 | 3.62 | 0.28 | 0.98 | H1 | 0.04 |
| | | Kingswood Public School | 46-54 Second Ave, Kingswood | | | | 1.09 | 3.91 | 0.49 | 1.51 | H2 | |
| | | Kingswood South Public School | 60-68 Smith St, Kingswood | | | | 1.22 | 3.68 | 0.56 | 1.27 | H3 | |
| | | St. Joseph's Primary School | 90-94 Joseph St, Kingswood | | | | 0.90 | 3.90 | 0.60 | 1.98 | H3 | |
| | | St Dominic's College | 54/94 Gascoigne St, Kingswood | | | | 1.01 | 3.24 | 0.54 | 1.16 | H3 | |
| | | Montgrove College | 140 Bringelly Rd, Orchard Hills | | | | 1.32 | 3.88 | 1.07 | 3.51 | H5 | 0.11 |
| | Secondary Education | Wollemi College | 4 Gipps St, Werrington | | | | 1.06 | 1.87 | 0.19 | 0.77 | H1 | |
| | | Cambridge Park High School | Harrow Rd, Cambridge Park | | | | 1.67 | 3.89 | 0.64 | 1.50 | H3 | |
| | | Kingswood High School | 131 Bringelly Rd, Kingswood | | | | 1.28 | 3.78 | 0.51 | 1.90 | H3 | |
| | Tertiary Education | Western Sydney University Werrington South Campus | Great Western Hwy, Werrington | | | | 1.26 | 3.99 | 0.73 | 1.25 | H3 | 0.06 |
| | | Western Sydney University Werrington North Campus | Great Western Hwy, Werrington | | | | 1.33 | 3.99 | 0.67 | 1.10 | H3 | |
| | | Western Sydney University Kingswood Campus | Second Avenue, Kingswood | | | | 1.39 | 3.97 | 0.44 | 0.97 | H2 | |
| | | TAFE Nepean Campus | 12-44 O'Connell St, Kingswood | | | | 1.65 | 3.99 | 1.32 | 1.96 | H4 | |
| | Churches | Grace Bible Church | 80 Joseph St, Kingswood | | | | 0.63 | 3.67 | 0.28 | 0.80 | H1 | |
| | | Real Life Church | 44 Second Ave, Kingswood | | | | 0.59 | 1.90 | 0.19 | 1.25 | H1 | |
| | | Penrith Baptist Church | Morello Terrace, Caddens | | | | 0.51 | 3.23 | 0.24 | 1.75 | H1 | |
| | | St. Philip's Anglican Church | Second Ave, Kingswood | | | | 1.02 | 3.62 | 0.26 | 1.08 | H1 | |
| | Other | Cobham Youth Justice Centre | Great Western Hwy & Water St, Werrington | | | | 3.51 | 3.93 | 0.55 | 1.56 | H3 | |
| | | Werrington train station | Werrington | | | | 2.26 | 4.00 | 0.65 | 1.06 | H3 | |

| Facility Type | Name and Address of Facility | | | PMF: Is access to/from facility cut? | PMF: Amount of time before access is cut (hours) | PMF: Amount of time after access is cut that facility is isolated (hours) | PMF: Time at which inundation of facility first commences (hours) | PMF: Total duration of inundation of facility (hours) | PMF: Maximum depth of inundation across facility (m) | PMF: Maximum flow velocity across facility (m/s) | PMF: Maximum flood hazard | PMF: Above Floor Flooding Depth (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Critical Facilities | Infrastructure | Pump station | 43A Princess Street, Werrington | Yes | 0.89 | 6.48 | 1.67 | 6.49 | 2.58 | 0.13 | H5 | 1.53 |
| | Hospitals | Nepean Hospital | Derby Street, Kingswood | | | | 2.43 | 6.23 | 2.17 | 3.05 | H5 | |
| Vulnerable Facilities | Facilities Aged Care Facilities / Nursing Homes | Anglicare Newmarch House | 50-52 Manning St, Caddens | Yes | 0.57 | 4.73 | 6.09 | 6.22 | 1.18 | 3.82 | H5 | 0.52 |
| | | Heritage Kingswood Aged Care Facility | 29 George St, Kingswood | Yes | 0.79 | 5.77 | 1.53 | 6.20 | 3.08 | 2.41 | H5 | |
| | Pre-Schools / Child Care | Learning Adventures Kingswood | 30 George St, Kingswood | Yes | 0.95 | 5.54 | 1.66 | 6.18 | 2.16 | 1.95 | H5 | 1.42 |
| | | Yoorami Cottage Before & After School Care | 1-5 Cottage St, Werrington | Yes | 0.42 | 6.07 | | | 0.13 | 0.46 | H1 | |
| | | Kingswood World of Learning | 38 First St, Kingswood | Yes | 0.29 | 0.18 | 1.70 | 6.14 | 1.15 | 3.72 | H5 | 0.51 |
| | | Mission Australia Family Day Care | 46 Bringelly Rd, Kingswood | Yes | 0.34 | 0.76 | 1.06 | 6.08 | 0.57 | 3.21 | H5 | |
| | | Falguni Family Day Care | 73A Princess St, Werrington | Yes | 1.33 | 5.96 | 2.79 | 6.16 | 1.07 | 0.61 | H3 | 0.64 |
| | | The Little Village Early Learning Centre | 33/35 Second Ave, Kingswood | Yes | 0.61 | 5.85 | 1.00 | 6.12 | 0.78 | 1.88 | H3 | 0.30 |
| | | The Learning Jungle | 137-139 Victoria St, Werrington | Yes | 0.39 | 4.91 | 1.11 | 5.92 | 0.36 | 1.76 | H2 | |
| | | Orchard Hills Pre School | 122 Bringelly Rd, Orchard Hills | Yes | 0.16 | 0.22 | 0.86 | 6.06 | 0.32 | 2.50 | H5 | |
| | | KU Penrith Preschool | 27 Bringelly Rd, Kingswood | Yes | 0.67 | 1.12 | 1.45 | 6.01 | 0.99 | 2.59 | H5 | 0.24 |
| | Primary Education | Werrington Public School | Armstein Cres, Werrington | Yes | 1.18 | 5.16 | 2.01 | 6.15 | 0.65 | 2.07 | H5 | 0.32 |
| | | Kingswood Public School | 46-54 Second Ave, Kingswood | Yes | 0.76 | 5.14 | 1.06 | 6.15 | 0.65 | 2.22 | H5 | |
| | | Kingswood South Public School | 60-68 Smith St, Kingswood | | | | 0.92 | 6.15 | 0.59 | 1.96 | H3 | |
| | | St. Joseph's Primary School | 90-94 Joseph St, Kingswood | | | | 1.06 | 6.20 | 0.61 | 1.37 | H3 | |
| | | St Dominic's College | 54/94 Gascoigne St, Kingswood | | | | 0.98 | 6.12 | 0.55 | 2.08 | H5 | |
| | | Montgrove College | 140 Bringelly Rd, Orchard Hills | | | | 1.77 | 6.15 | 1.35 | 5.61 | H6 | 0.62 |
| | Secondary Education | Wollemi College | 4 Gipps St, Werrington | | | | 2.96 | 5.83 | 0.70 | 1.10 | H3 | |
| | | Cambridge Park High School | Harrow Rd, Cambridge Park | | | | 1.22 | 6.15 | 0.89 | 2.68 | H5 | 0.33 |
| | | Kingswood High School | 131 Bringelly Rd, Kingswood | Yes | 0.64 | 5.77 | 1.20 | 6.15 | 0.62 | 2.37 | H5 | |
| | Tertiary Education | Western Sydney University Werrington South Campus | Great Western Hwy, Werrington | | | | 2.73 | 6.49 | 0.79 | 2.21 | H4 | 0.15 |
| | | Western Sydney University Werrington North Campus | Great Western Hwy, Werrington | | | | 1.29 | 6.49 | 0.83 | 1.58 | H3 | |
| | | Western Sydney University Kingswood Campus | Second Avenue, Kingswood | | | | 1.31 | 6.22 | 0.44 | 1.75 | H2 | |
| | | TAFE Nepean Campus | 12-44 O'Connell St, Kingswood | Yes | 0.76 | 5.94 | 2.36 | 6.48 | 1.47 | 3.44 | H5 | |
| | Churches | Grace Bible Church | 80 Joseph St, Kingswood | | | | 0.80 | 6.16 | 0.29 | 1.17 | H1 | |
| | | Real Life Church | 44 Second Ave, Kingswood | Yes | 1.19 | 1.93 | 0.64 | 5.84 | 0.23 | 1.70 | H1 | |
| | | Penrith Baptist Church | Morello Terrace, Caddens | Yes | 0.28 | 0.65 | 0.37 | 5.29 | 0.24 | 1.85 | H1 | |
| | | St. Philip's Anglican Church | Second Ave, Kingswood | Yes | 0.62 | 1.75 | 0.90 | 6.09 | 0.29 | 1.42 | H1 | |
| | Other | Cobham Youth Justice Centre | Great Western Hwy & Water St, Werrington | | | | 2.79 | 6.18 | 0.77 | 2.24 | H5 | 0.05 |
| | | Werrington train station | Werrington | Yes | 0.75 | 5.95 | 3.54 | 6.50 | 1.01 | 1.98 | H3 | |

# APPENDIX E

## LEVEE SENSITIVITY DIFFERENCE MAPS

# No Werrington Earthen Levee

## Figure E1: 5% AEP Flood Level Difference Map

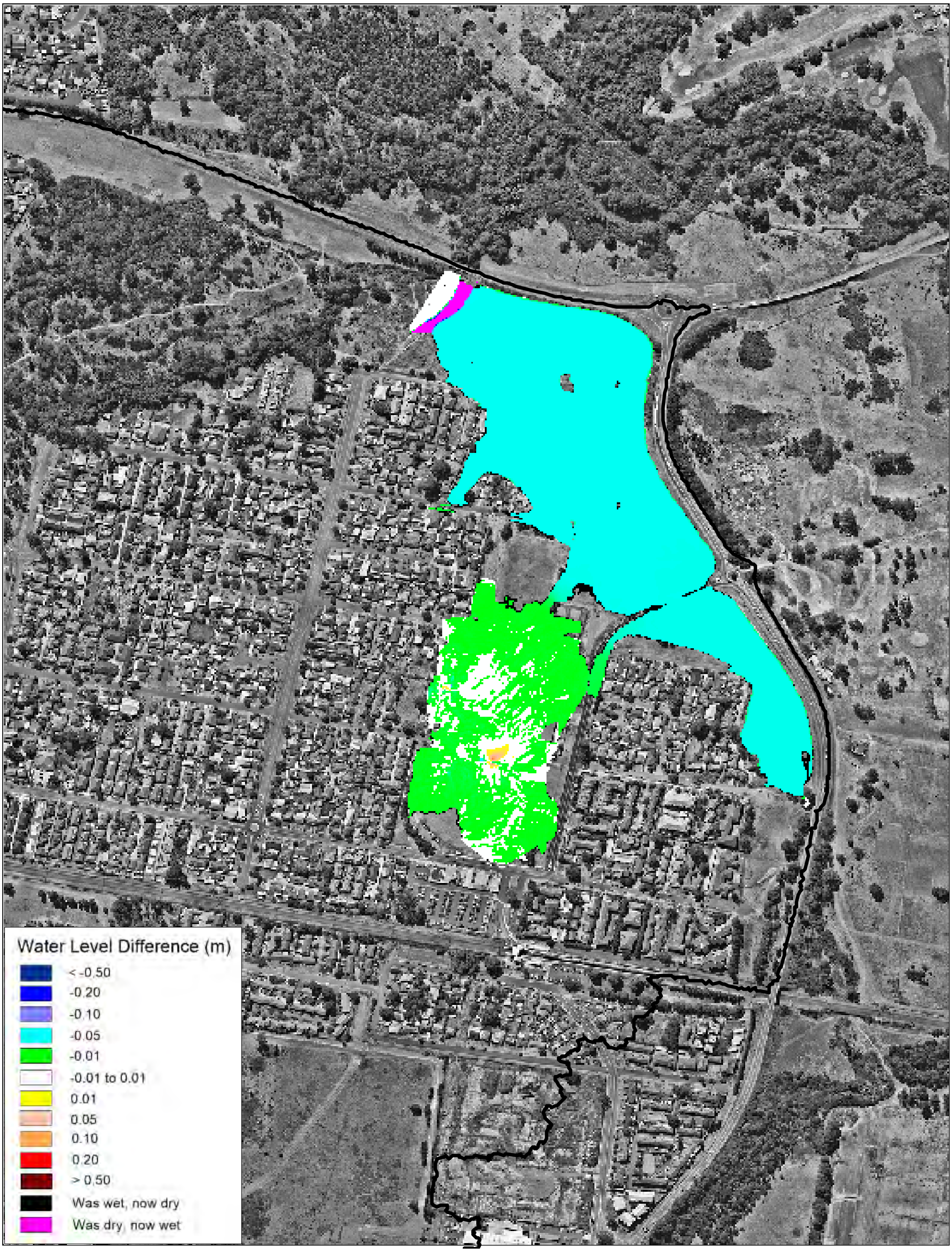


Figure E2: 1% AEP Flood Level Difference Map

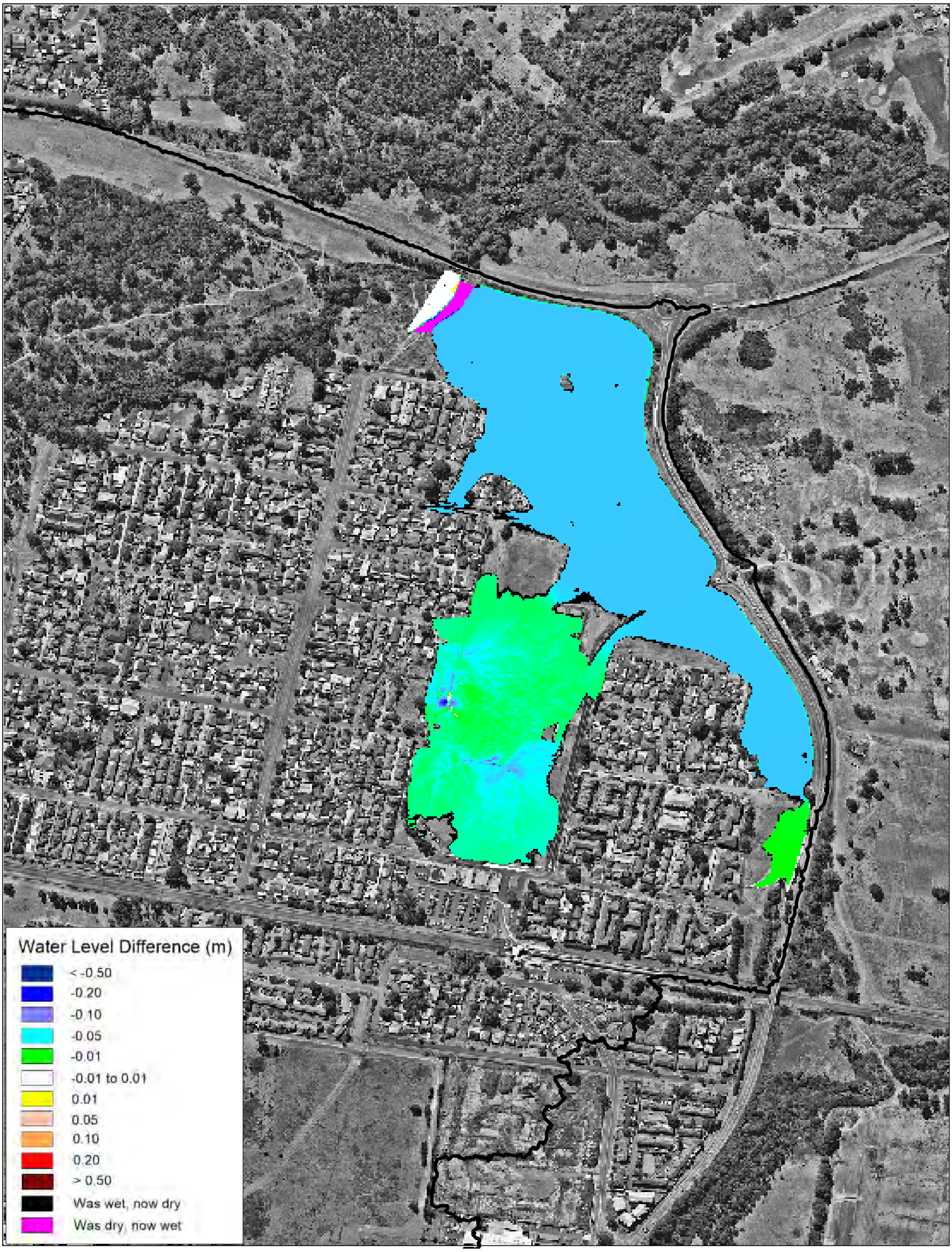
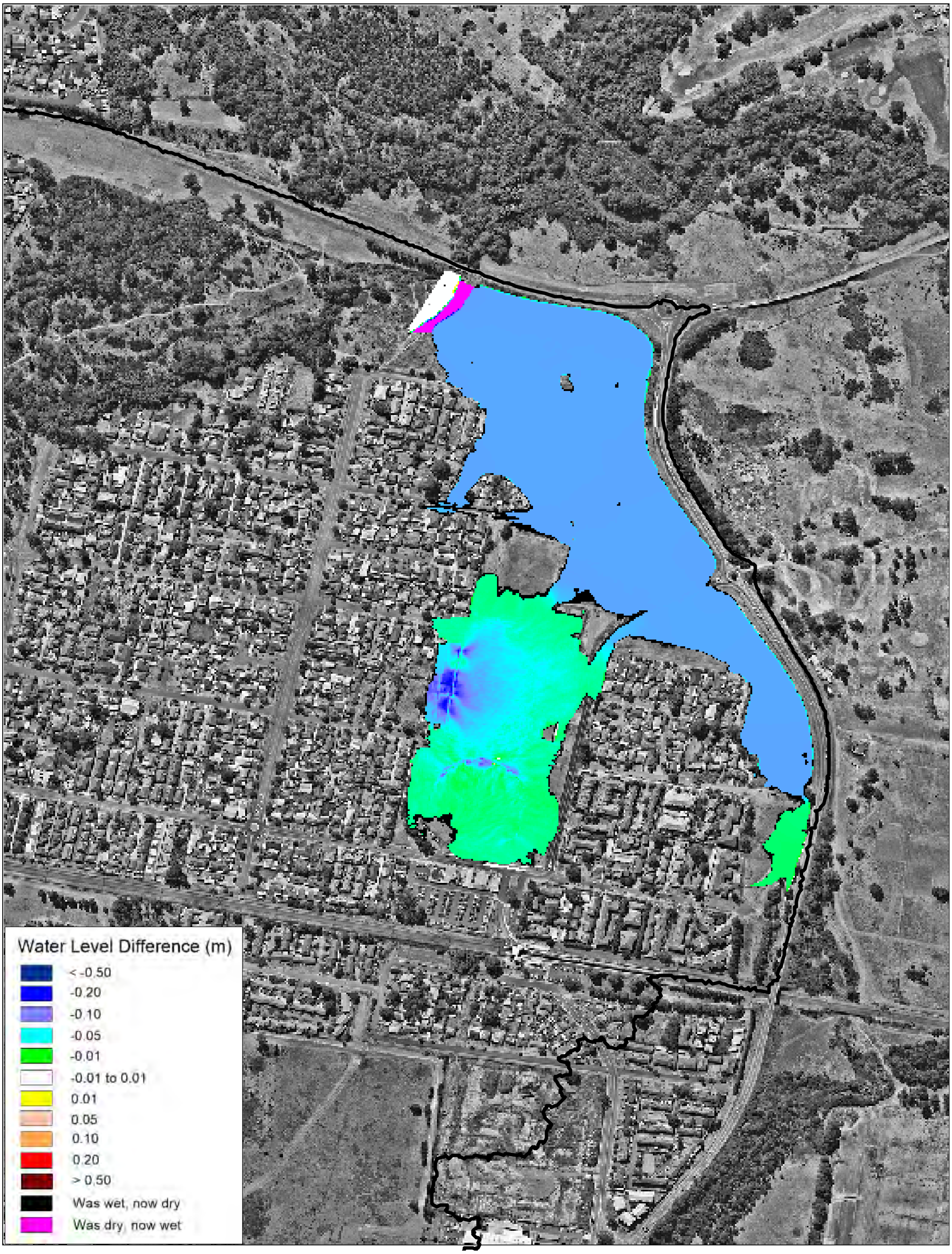
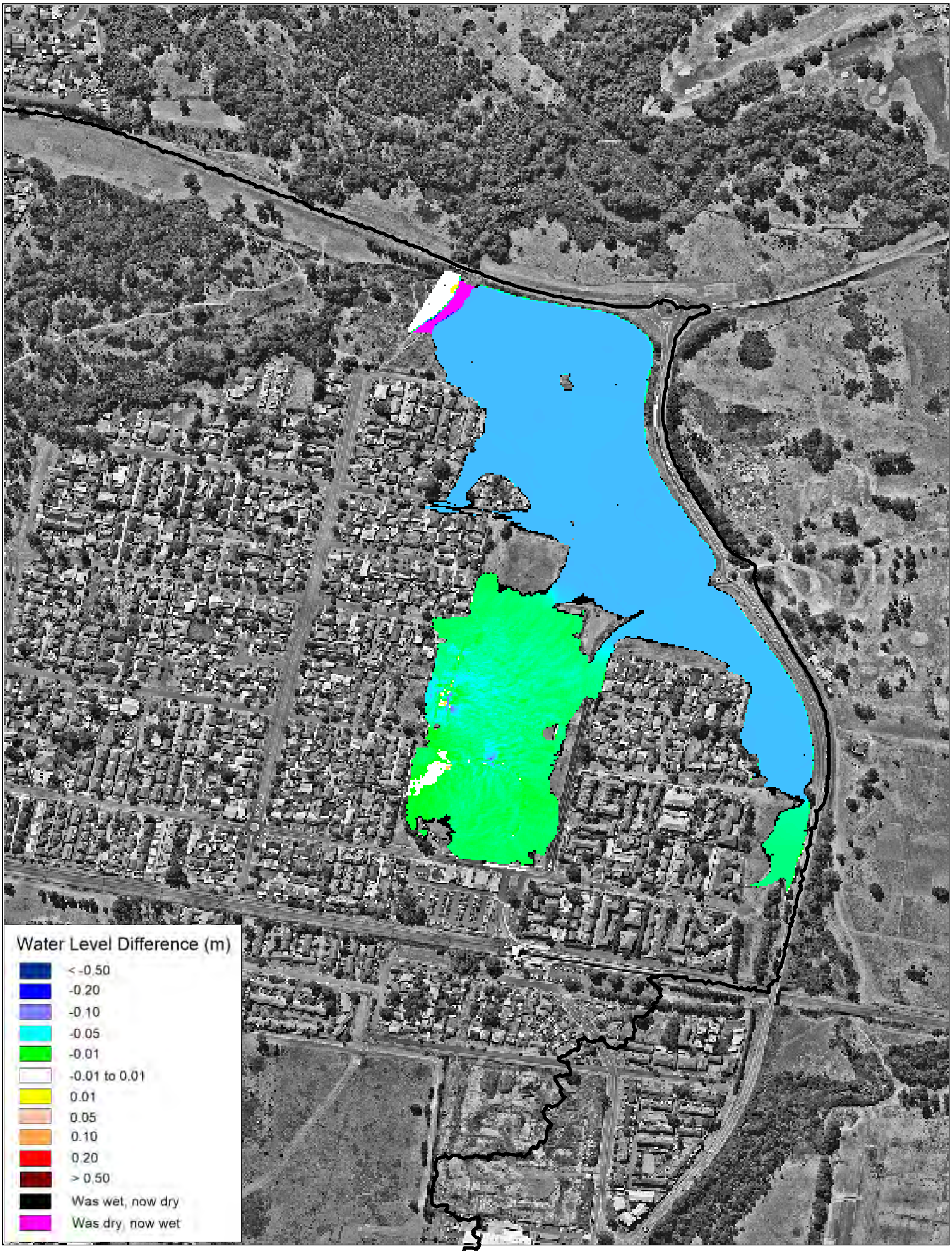


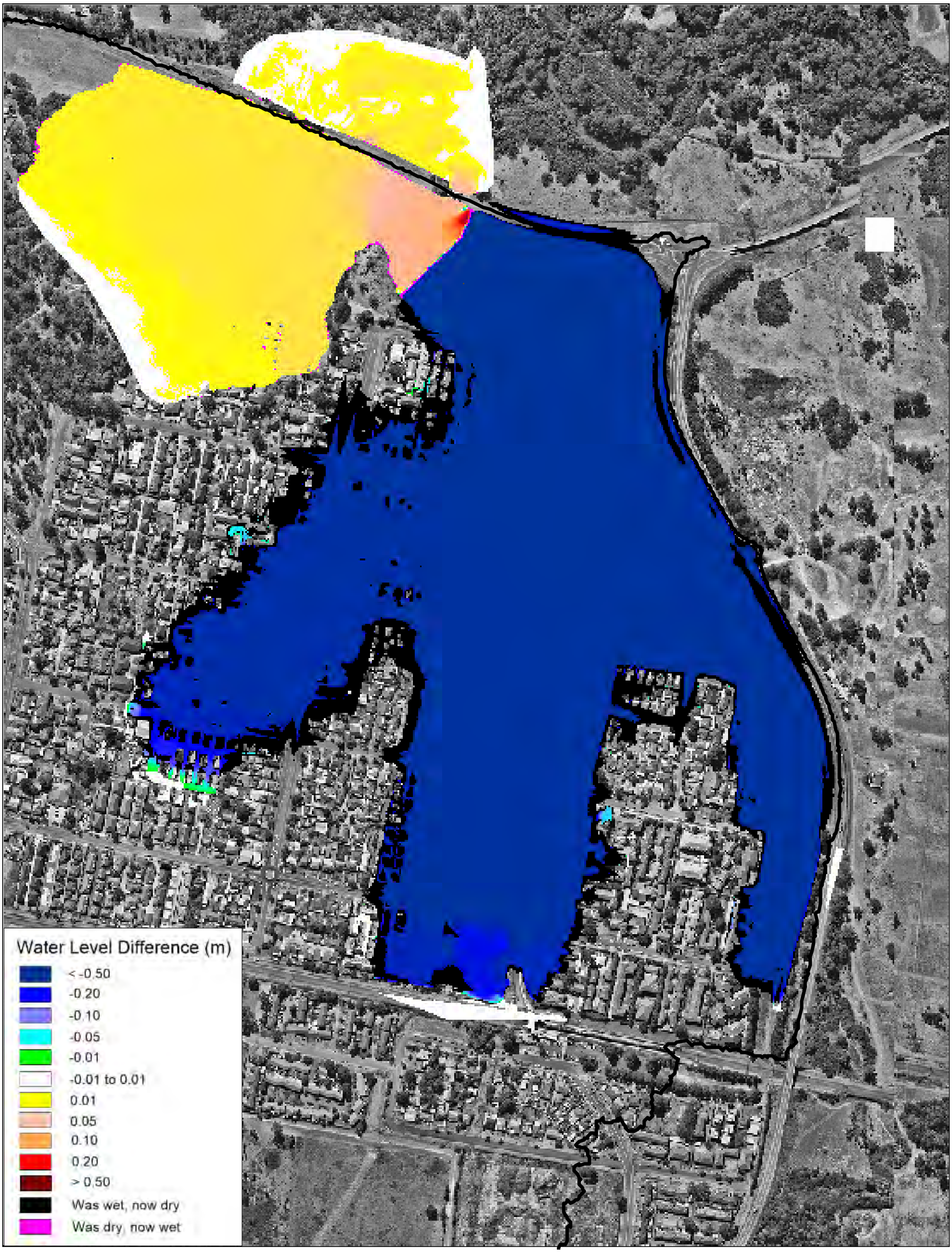
Figure E3: 0.5% AEP Flood Level Difference Map



## Figure E4: 0.2% AEP Flood Level Difference Map



## Figure E5: PMF Flood Level Difference Map



## Failure/Breach of Werrington Earthen Levee

### Figure E6: 5% AEP Flood Level Difference Map

## Figure E7: 1% AEP Flood Level Difference Map

Figure E8: 0.5% AEP Flood Level Difference Map

Figure E9: 0.2% AEP Flood Level Difference Map

## Non-operational Flood Gates (ie: jammed closed)

### Figure E10: 5% AEP Flood Level Difference Map

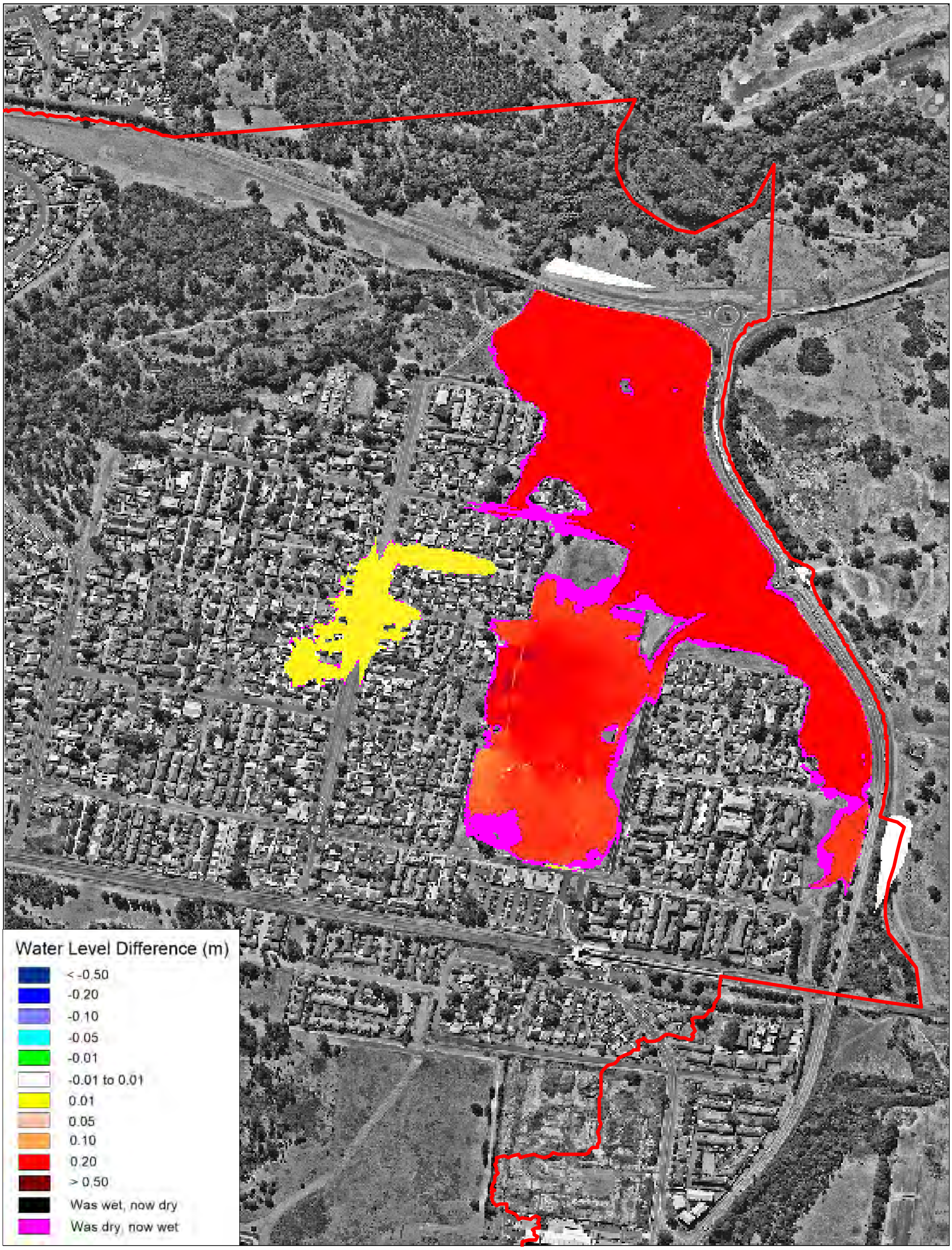


Figure E11: 1% AEP Flood Level Difference Map

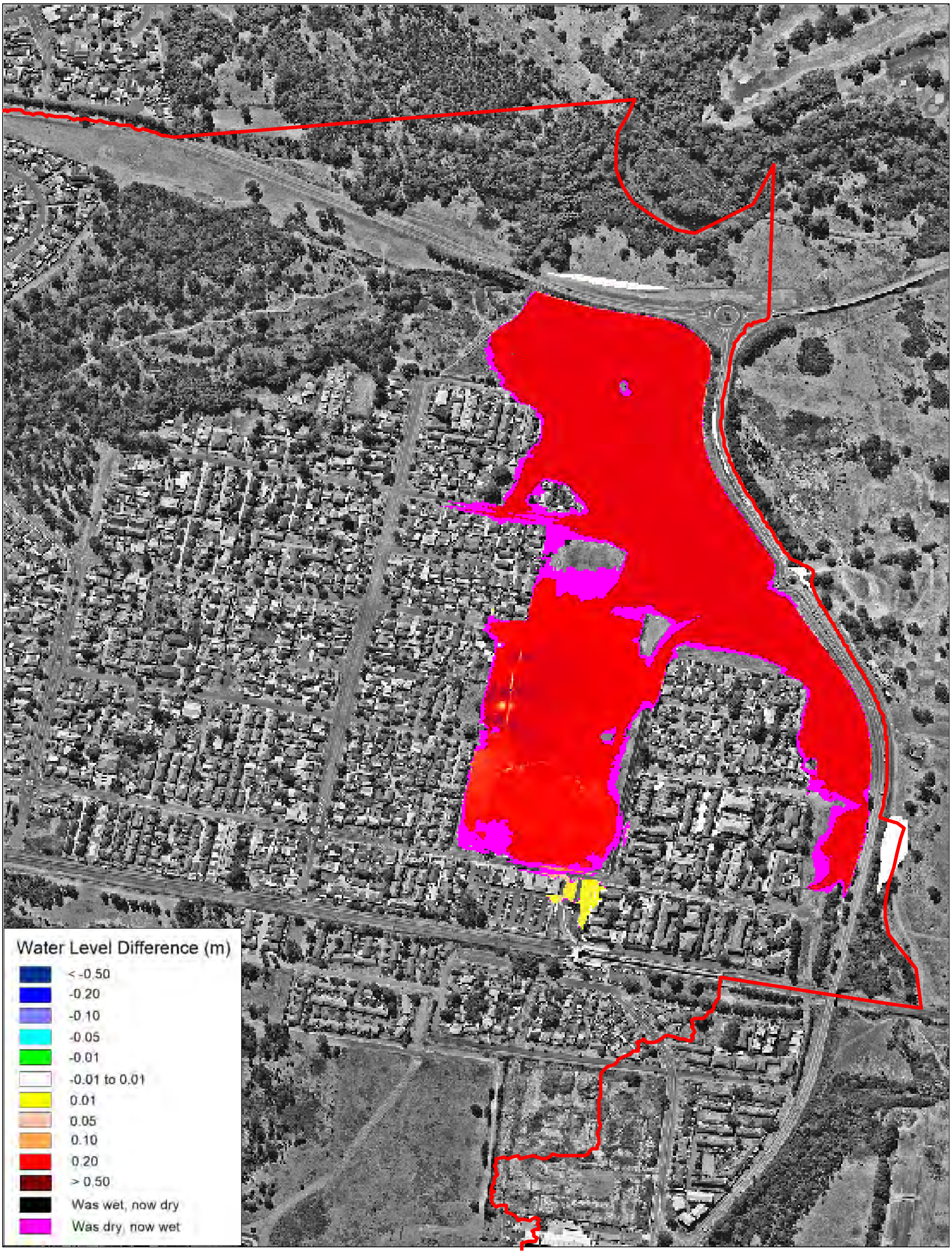
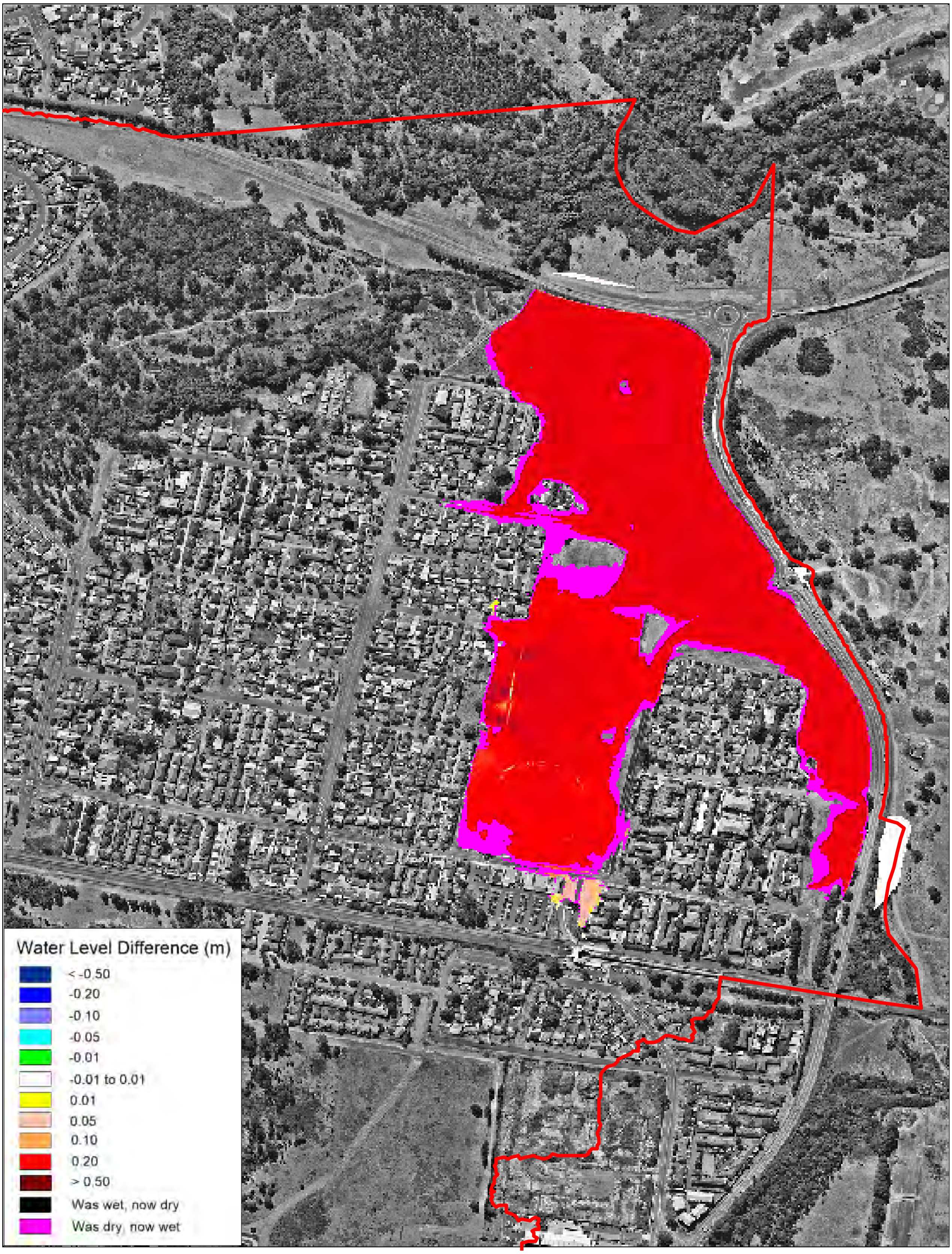


Figure E12: 0.5% AEP Flood Level Difference Map



## Figure E13: 0.2% AEP Flood Level Difference Map

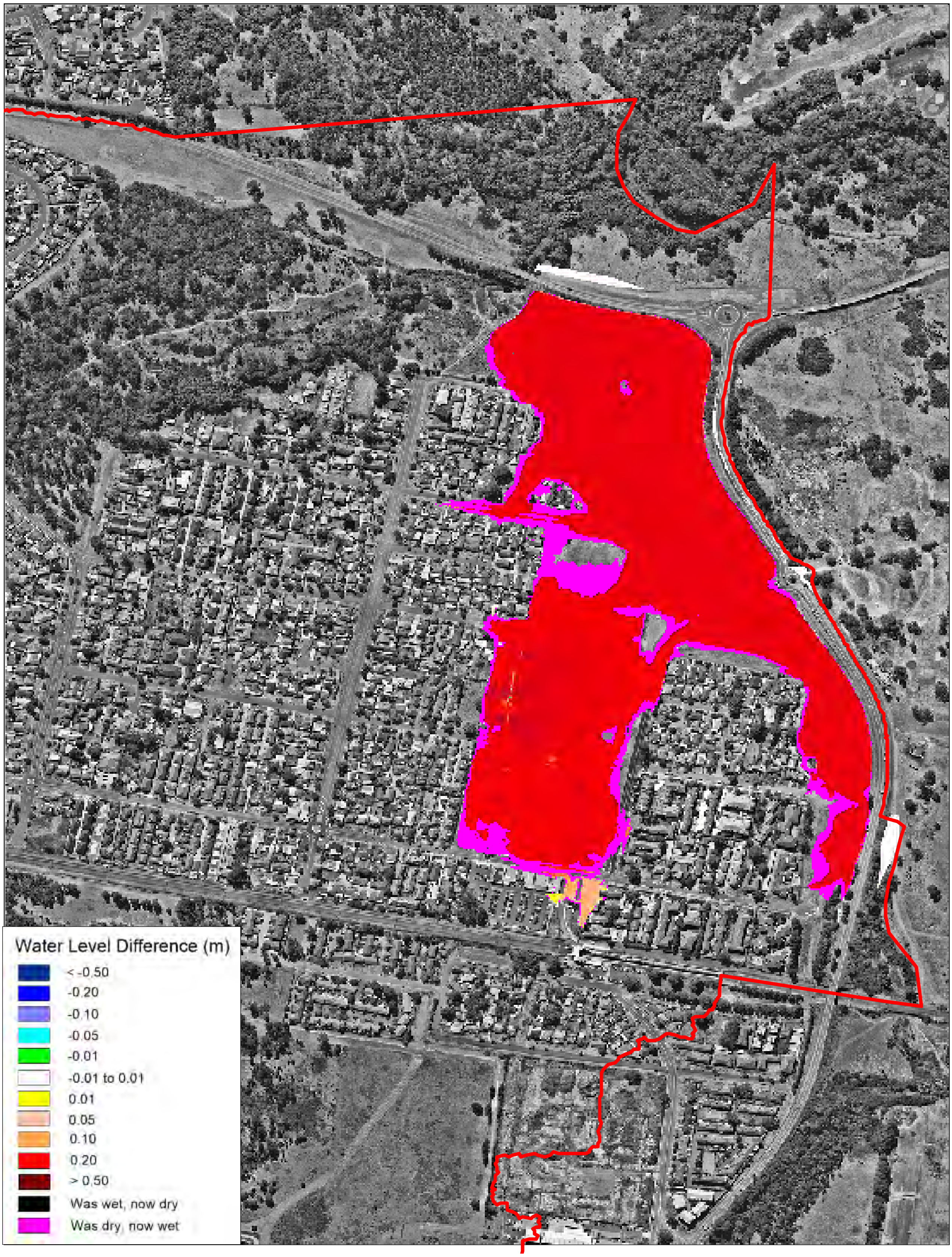
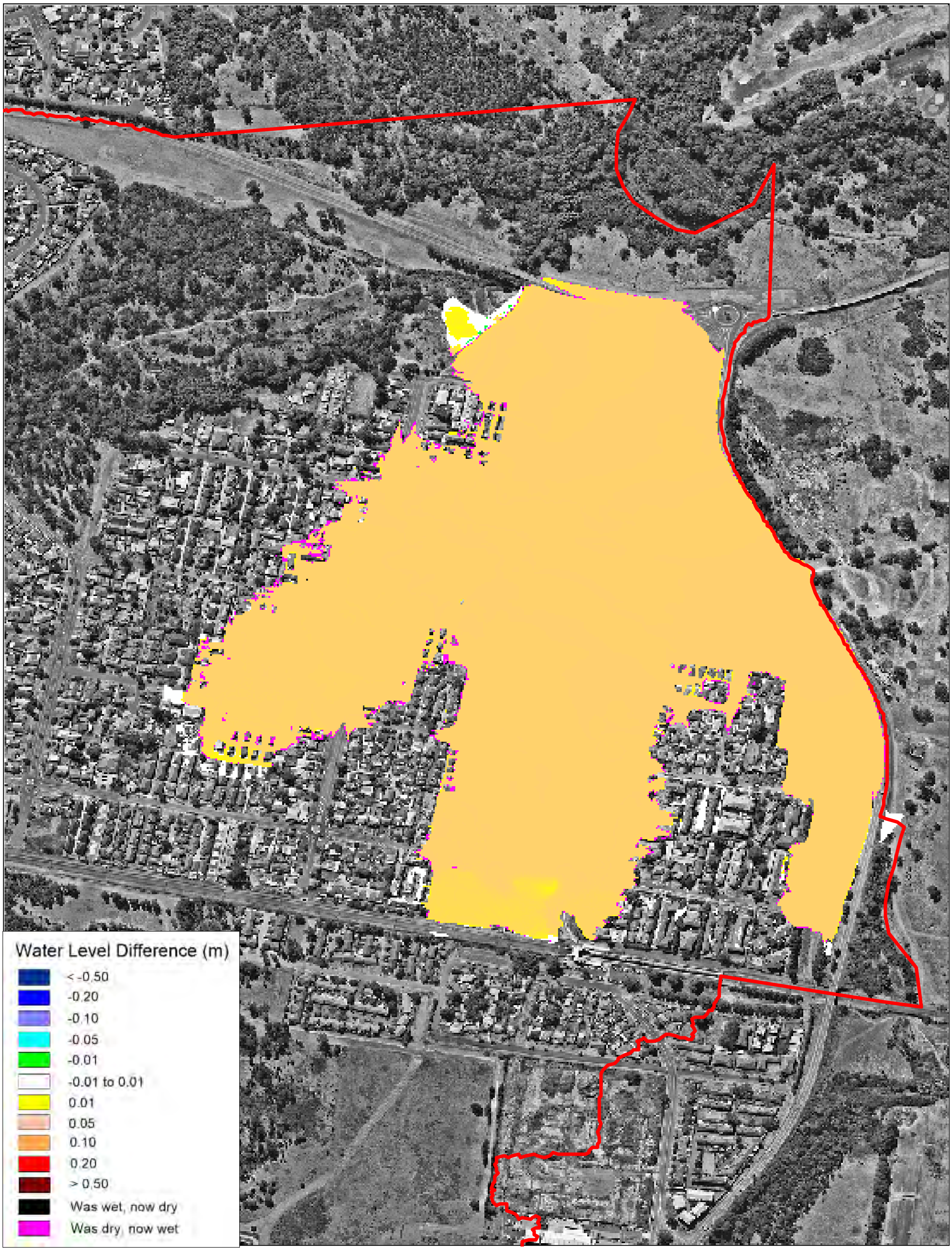


Figure E14: PMF Flood Level Difference Map



## 5%AEP Local Runoff with 1%AEP South Creek Tailwater Level

### Figure E15: No Werrington Earthen Levee Flood Level Difference Map (5%AEP local catchment runoff, 1%AEP South Creek tailwater)

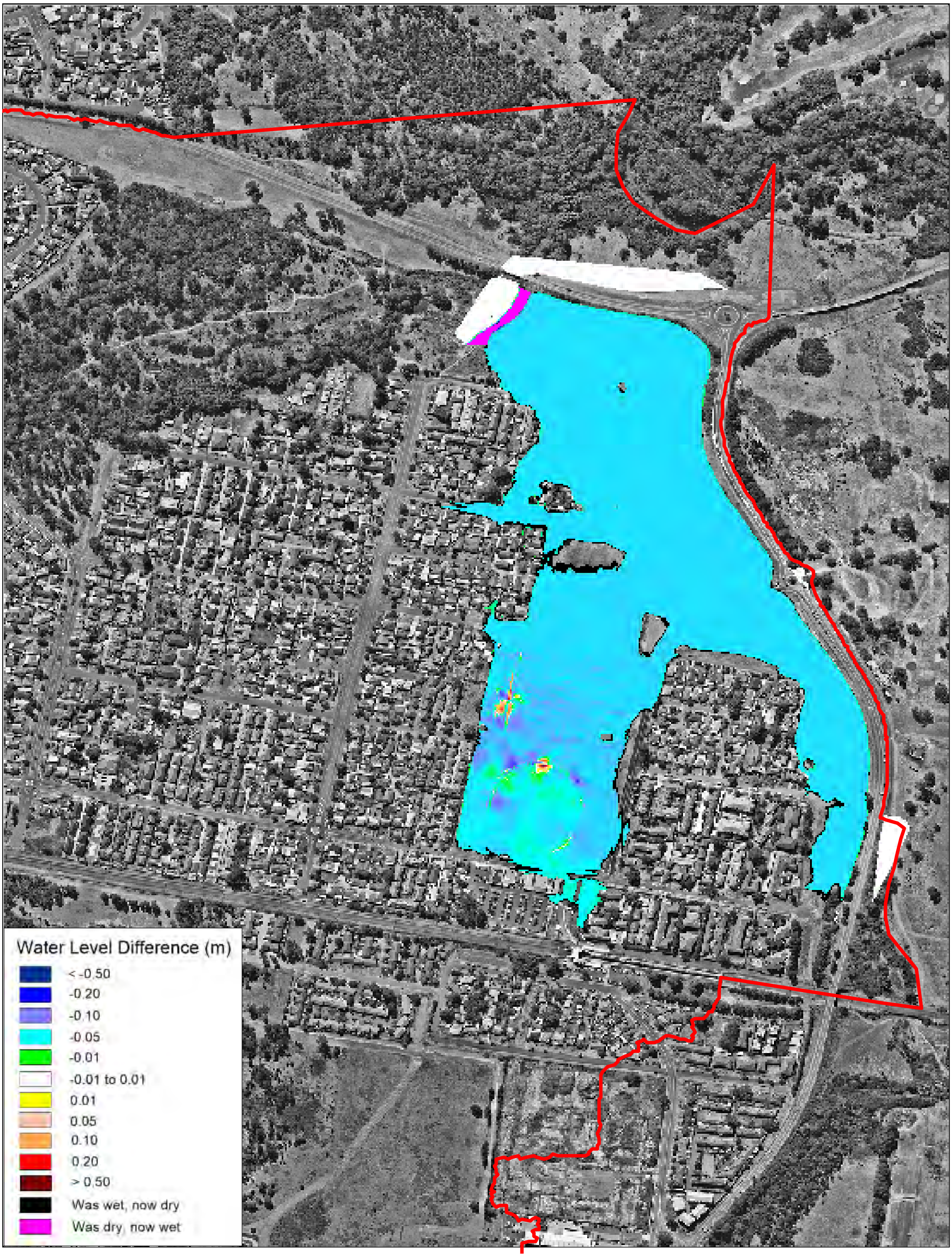


Figure E16: Failure/Breach of Werrington earthen Levee Flood Level Difference Map (5%AEP local catchment runoff, 1%AEP South Creek tailwater)

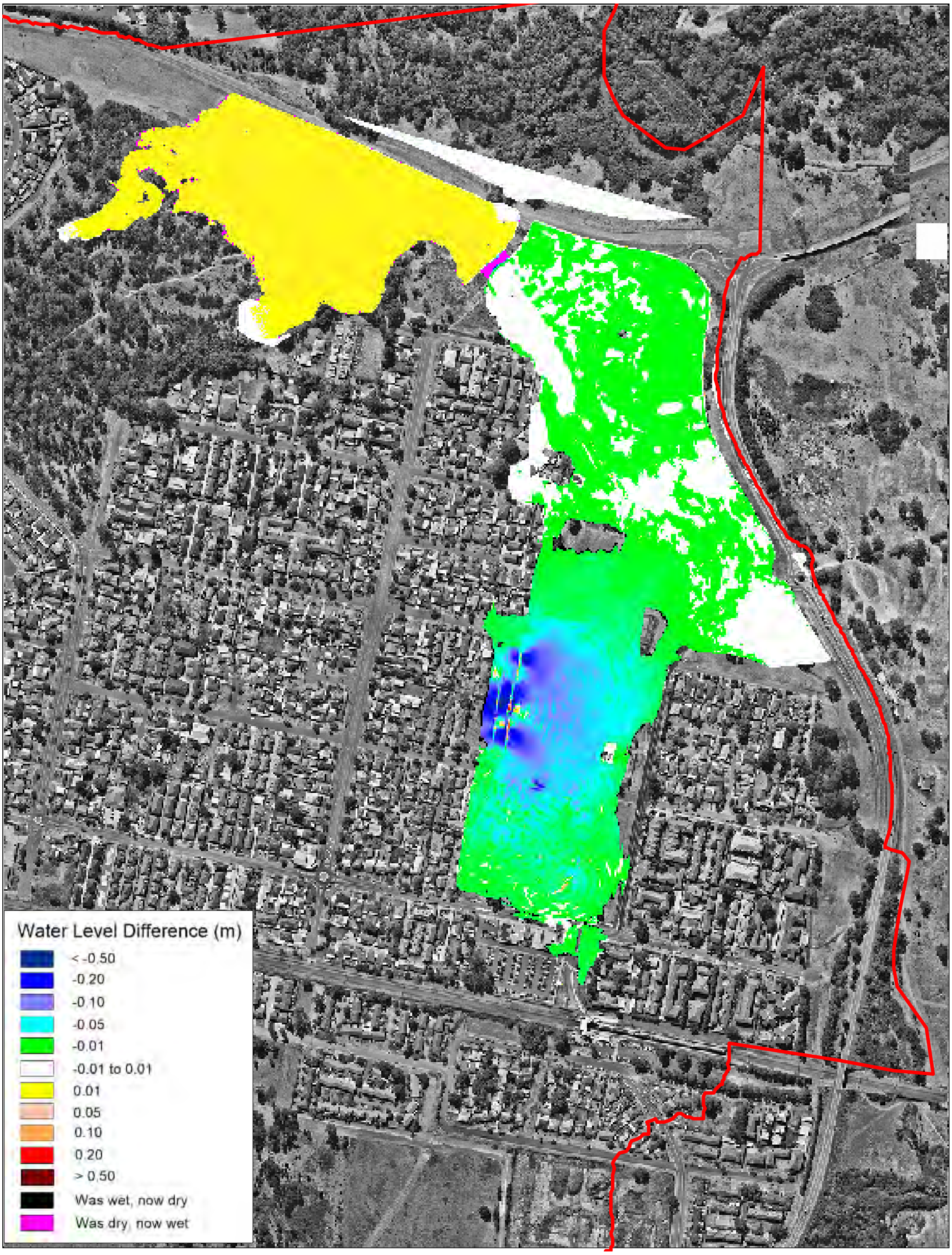
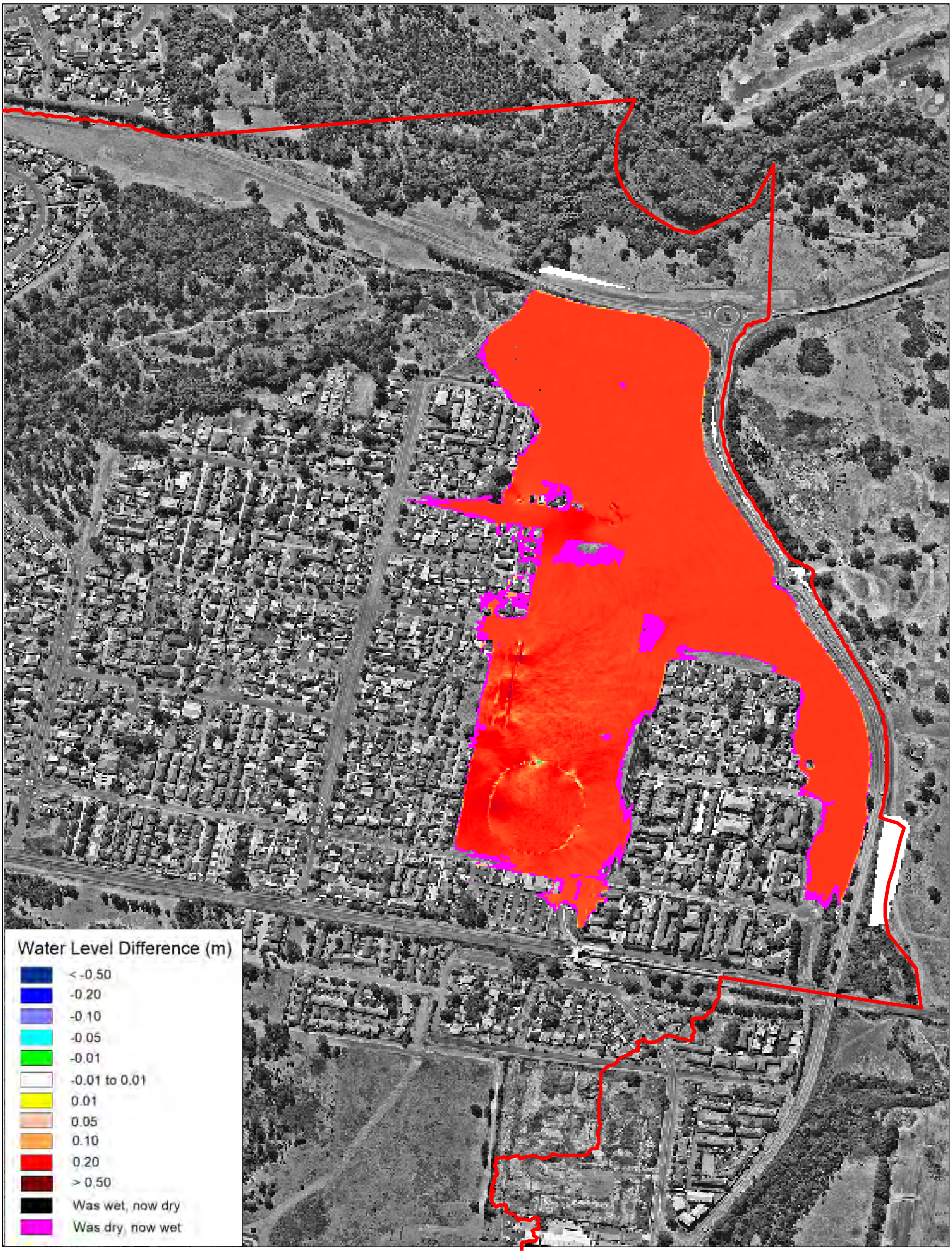


Figure E17: Non-operational flood gates Flood Level Difference Map (5%AEP local catchment runoff, 1%AEP South Creek tailwater)



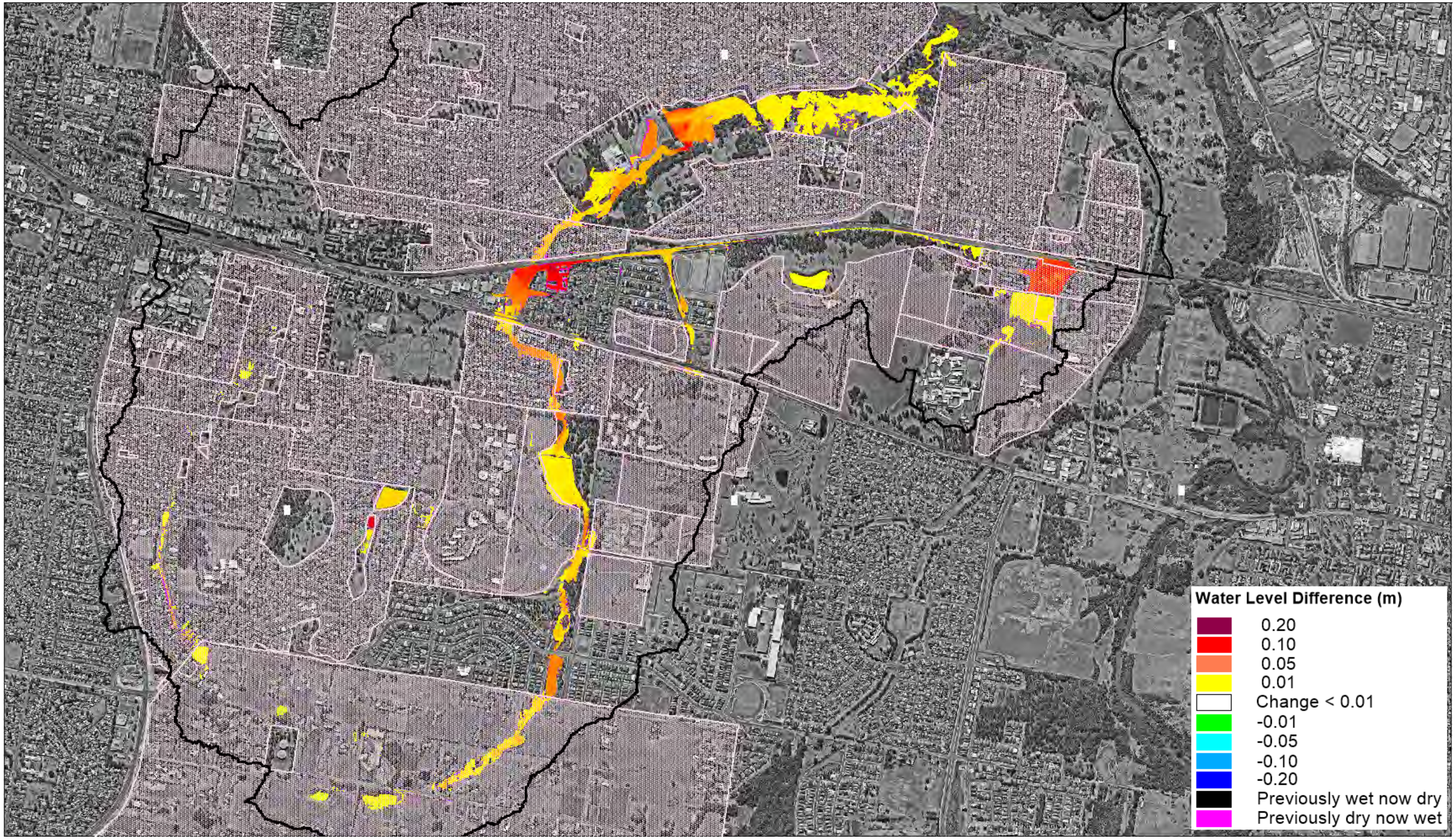
# APPENDIX F

## FUTURE CATCHMENT DIFFERENCE MAPS

# Future Catchment Development

## Figure F1: 5% AEP Flood Level Difference Map

Figure F2: 1% AEP Flood Level Difference Map



## Figure F3: 0.5% AEP Flood Level Difference Map

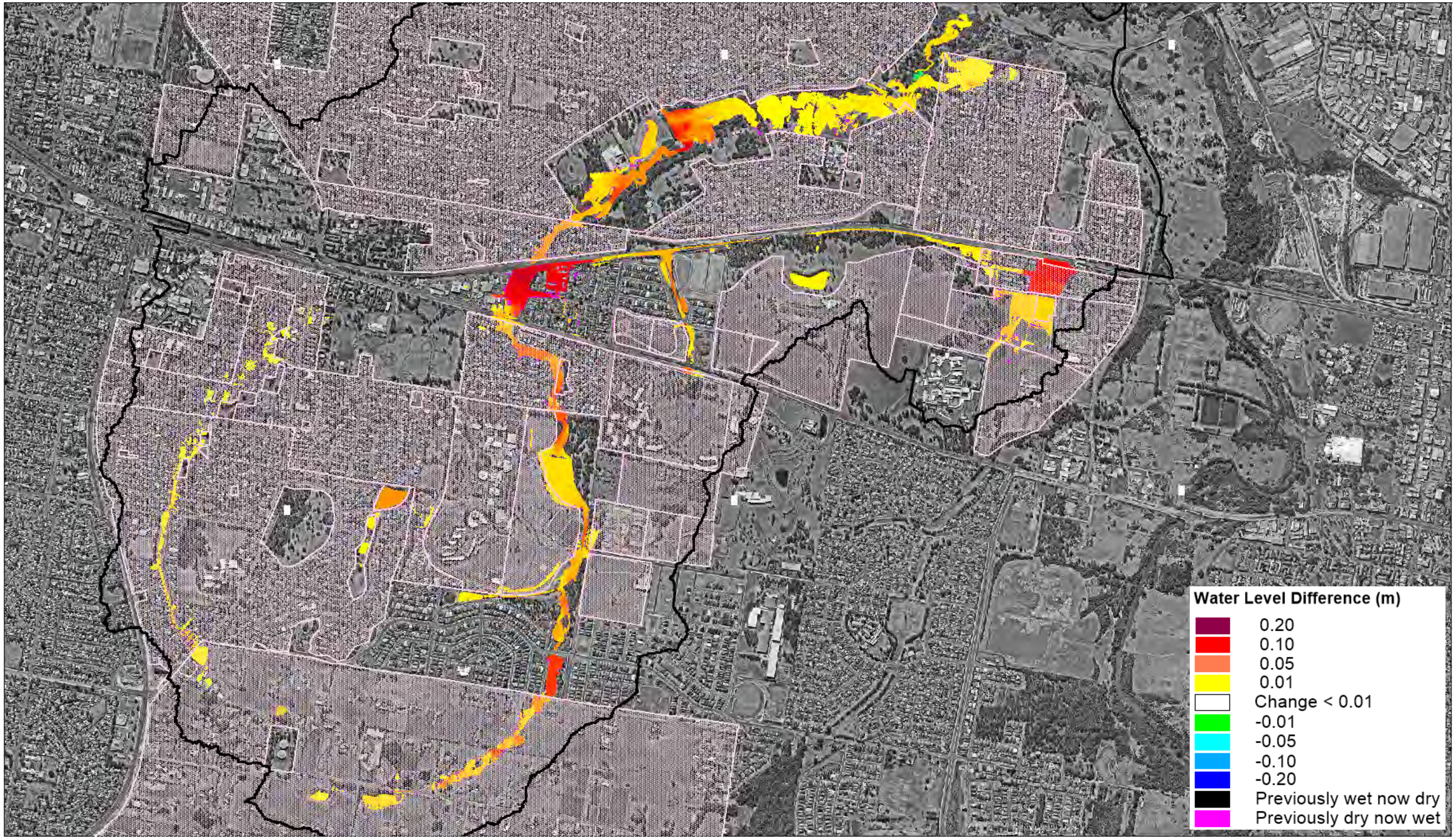


Figure F4: 0.2% AEP Flood Level Difference Map

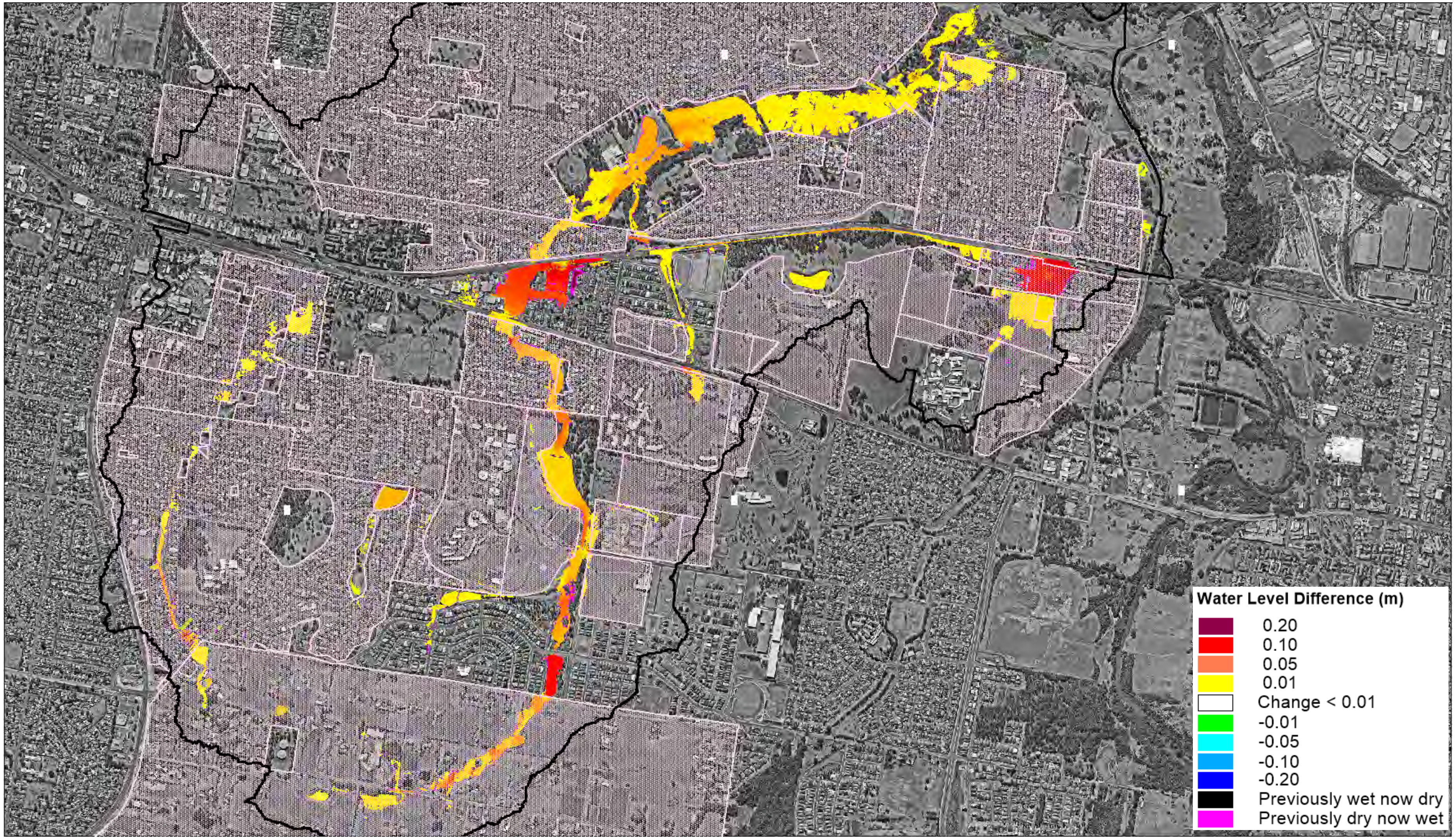


Figure F5: PMF Flood Level Difference Map

# APPENDIX G

## FLOOD PLANNING LEVEL ASSESSMENT

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(02) 8355 5500
(02) 8355 5505
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# G1 Flood Planning Level Assessment

Flood Planning Levels (FPLs) are an important tool in the management of flood risk. FPLs are typically derived by adding a freeboard to the "planning" flood. The suitability of Council's current planning flood and freeboard in managing the existing and future flood risk across the full range of possible floods is discussed below.

For the purposes of this assessment, the following definitions of flooding are provided:

- **Mainstream Flooding**: inundation associated with defined creeks/watercourses overtopping their banks. This includes the main Little Creek channel extending from Kurrajong Road down to South Creek.
- **Overland Flooding**: inundation of normally dry areas that are located away from defined channels and watercourses. Overland flooding is most common in "built up" areas and is typically associated with the capacity of the local stormwater/drainage system being exceeded.

## 1.1 Suitability of Planning Flood

A major consideration of this study involved the determination of an appropriate flood planning level for the College, Orth and Werrington Creeks catchment. Therefore, a review of the suitability of the current standard outlined in the Penrith City Council LEP 2010 was completed as part of the current study.

The NSW Government's *'Floodplain Development Manual'* (2005) states that "…FPLs are the combinations of flood levels (derived from significant historical flood events or floods of specific AEPs) and freeboards selected for floodplain risk management purposes, as determined in risk management studies and incorporated in risk management plans." The Manual also notes that it is generally not feasible or justifiable to adopt the PMF as the planning flood.

The Penrith City Council LEP 2010 defines the flood planning level (FPL) across the Penrith City Council LGA as "the level of a 1:100 ARI (average recurrent interval) flood event plus 0.5 metre freeboard". This wording is taken from the standard LEP template for NSW and effectively applies a "one size fits all" approach for defining the flood planning level across the LGA.

Using the 1% AEP flood for deriving flood planning levels is common across Australia. It is considered to provide a reasonable compromise between the risk associated with occupation of flood liable areas and the value that this occupation provides in most areas.

Although this approach is easy to apply and understand, it fails to consider the variable flood characteristics that are evident across the LGA and does not follow the merits-based approach that is encouraged in the *'Floodplain Development Manual'* (NSW Government, 2005). More specifically, the Manual advocates consideration of a range of factors in determining the most appropriate flood planning event. These include the risk to life across the full range of design flood events, flood behaviour, social issues, land availability/needs, duration of flooding, the value of land, existing level of development and the current FPL for planning purposes.

As noted in Section 9.2.1 of the report, there are some areas where application of the "standard" flood planning level (1% AEP level + 0.5 metres freeboard) as the basis for defining minimum floor levels may expose some properties to an internal flood hazard of greater than H4 during the PMF. This hazard categorisation may be sufficient to result in loss of life. Accordingly, for these properties, the standard FPL to define minimum floor levels may not be sufficient to adequately manage the full range of potential flood risks.

However, as it currently stands, there are no properties located outside of the standard flood planning area that would be exposed to H4 internal hazard during the PMF. That is, the standard flood planning area captures all properties where this is potential for a significant flood hazard during all potential floods and there does not appear to be a need to further expand the flood planning area (e.g., through application of a larger planning flood).

However, development types whose occupants may be particularly vulnerable to floodwaters such as childcare centres and aged care facilities would likely benefit from being located outside of the floodplain completely/located above the peak level of the PMF. However, it is considered that controls such as minimum floor levels for vulnerable and critical facilities can best be managed through the Development Control Plan (DCP) rather than expanding the flood planning area to be based on, for example, the PMF plus freeboard.

Appropriate development controls are also considered to be the best way to manage the flood risk across properties that may be exposed to a significant internal or external hazard during the PMF. This is discussed in more detailed in Section 9.2.1 of this report.

Overall, it is considered that the 1% AEP flood is suitable for defining the flood planning area. Not only does it capture all potentially flood liable properties during floods up to and including the 1% AEP but also identifies properties that may be exposed to a very high hazard during floods larger than the 1% AEP up to the largest flood that could occur.

Notwithstanding, it is still necessary to appropriately manage the flood risk within the flood planning area. Potential modifications to the LEP and DCP to accommodate this are discussed in Section 9.2 of the report.

## 1.2 Suitability of Freeboard

As outlined above, the 1% AEP flood is considered to be suitable for defining the "planning flood". However, there may be a case to support adopting a freeboard that is lower than 0.5 metres across some areas. The freeboard is, in essence, a "factor of safety" that is used to cater for uncertainties in the estimation of the planning flood (1% AEP flood). The uncertainties that are accounted for in the freeboard include:

- Modelling uncertainty (i.e., uncertainty associated with modelling inputs such as topography, Manning's "n" roughness and potential blockage of stormwater pits):
- Factors that can't be explicitly represented in the modelling (e.g., parked cars, flow obstructions from debris mobilised during a flood: refer **Plate G1**).
- Changes in future flood behaviour associated with climate change (e.g., increases in rainfall intensity and sea level rise).

Plate G1 Examples of urban flow obstructions that cannot be explicitly represented in computer model

Modelling sensitivity and climate change uncertainty can be quantified by undertaking various simulations and using the outputs from these simulations to prepare a "confidence limit" layer. This "confidence limit" layer effectively quantifies how much confidence we can place in the "base" 1% AEP flood levels at various locations and therefore, how much of an allowance needs to be incorporated within the freeboard to ensure we can cater for this modelling uncertainty. A 99% confidence interval layer was previously prepared as part *the 'College, Orth & Werrington Creeks Catchment Overland Flow Flood Study'* (2017) and is reproduced in **Plate G2**. Yellow colours indicate small confidence limits (i.e., high confidence in results) and magenta colours indicate higher confidence limits (i.e., less confidence in results).

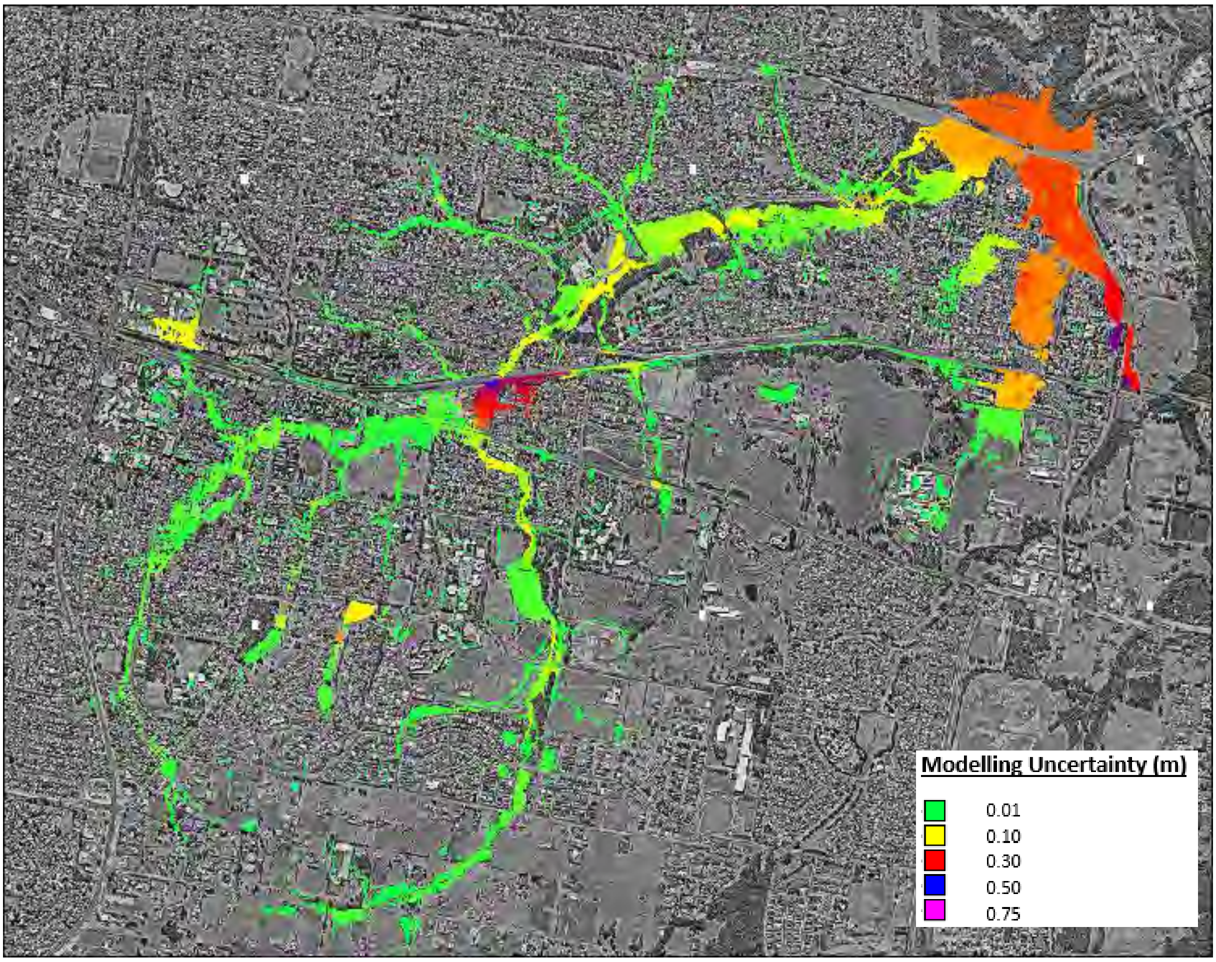


Plate G2 99% confidence interval grid for 1% AEP water levels (quantifies modelling uncertainty) based on 2017 flood study results

**Plate G2** shows that across the upper catchment, where overland flooding is the dominant flooding mechanism, the model confidence is generally high (i.e., < 0.1 metres confidence). The confidence limits increase to more than 0.3 metres in some mainstream flooding areas, such as upstream of the railway line at Kingswood and Werrington and across the downstream reaches of the catchment. The higher levels of uncertainty across the downstream sections of the catchment are primarily driven by the uncertainty associated with the prevailing South Creek water level. The higher uncertainty upstream of the railway line is driven by blockage of the railway culverts.

Unfortunately, it is more difficult to quantify an allowance for factors that cannot be explicitly represented by the model such as parked cars (refer **Plate G1**). However, it is argued that the potential impact of these "other" factors is proportional to the flow velocity. That is, there is a greater potential for a flow obstruction to alter flood behaviour in areas of faster moving water relative to areas of "ponded" water. Therefore, a greater allowance should be made for "other" factors in areas of fast-moving water.

The impacts of flow obstructions that are commonly encountered in flood modelling (e.g., bridge piers) is quantified by multiplying an empirical loss coefficient (K) by the velocity head ($v^2/2g$) at a particular location. The velocity head can be calculated at any location using the computer model outputs for the 1% AEP flood. The appropriate loss coefficient will vary depending on the location and the type of obstruction. Unfortunately, loss coefficients are not readily documented for the types of flow obstructions typically encountered in an urban environment where above ground flow is the predominant conveyance mechanism. Furthermore, Franz and Melching (1997) note that flow through an abrupt transition is a complex phenomenon and evaluation of hydraulic losses is difficult. It also notes that the adoption of a loss coefficient / velocity head to calculate hydraulic losses is an approximation only, however there is currently no suitable replacement or alternative method that is readily available. Therefore, the velocity head approach was employed as it is considered to be a useful appraisal of potential freeboard factors.

The *'HEC-RAS River Analysis System - Hydraulic Reference Manual'* (US Army Corp of Engineers, 2016) notes that loss coefficients will not exceed 1.0 and will generally be higher for subcritical flows than supercritical flows. It goes on to note that:

- A contraction/expansion coefficient of 0.8 is generally appropriate for "abrupt" transitions in cross-sectional area where subcritical flow is evident.
- A contraction/expansion coefficient of 0.2 is generally appropriate for "abrupt" transitions in cross-sectional area where supercritical flow is evident.

It was considered that the types of flow obstructions shown in **Plate G1** would represent an "abrupt" change in flow conveyance so the above loss coefficients were considered appropriate to use to assist in quantifying the potential uncertainty in flood level estimates associated with these "other" factors. The following steps were subsequently employed for developing a layer describing the potential variation in 1% AEP water levels associated with "other" factors.

- Calculate the 1% AEP Froude number and velocity head at each model grid cell;
- If the Froude number is greater than 1 (i.e., supercritical flow), multiply the velocity head by a loss coefficient of 0.2
- If the Froude number is less than 1 (i.e., subcritical flow), multiply the velocity head by a loss coefficient of 0.8

However, the above approach did introduce some discontinuities in areas that transitioned between supercritical and subcritical flow. Therefore, the approach was refined so that the loss coefficient was linearly transitioned between 0.8 and 0.2 when the Froude number was between 0.9 and 1.1. The resulting water level uncertainty grid associated with "other" factors is shown in Plate G3. It shows that the uncertainty associated with other factors is predicted to be less than 0.1 metres across most of the catchment. However, there are areas located within and adjacent to defined watercourses where "other" uncertainty is predicted to exceed 0.3 metres (e.g., Werrington Creek channel north of Victoria Road).

The impact of wave action cannot be calculated using model results. However, across the study area, the wind fetch length is small, water depths are generally shallow and any boats or cars travelling through floodwaters would typically be operating at low speeds. As shown in **Plate G4**, under these circumstances, the waves generated by cars are unlikely to exceed 0.15 metres and dissipate significantly in height by the time the wave reaches the edges of the road. Therefore, a wave action allowance of 0.15 metres is considerd to be sufficient.

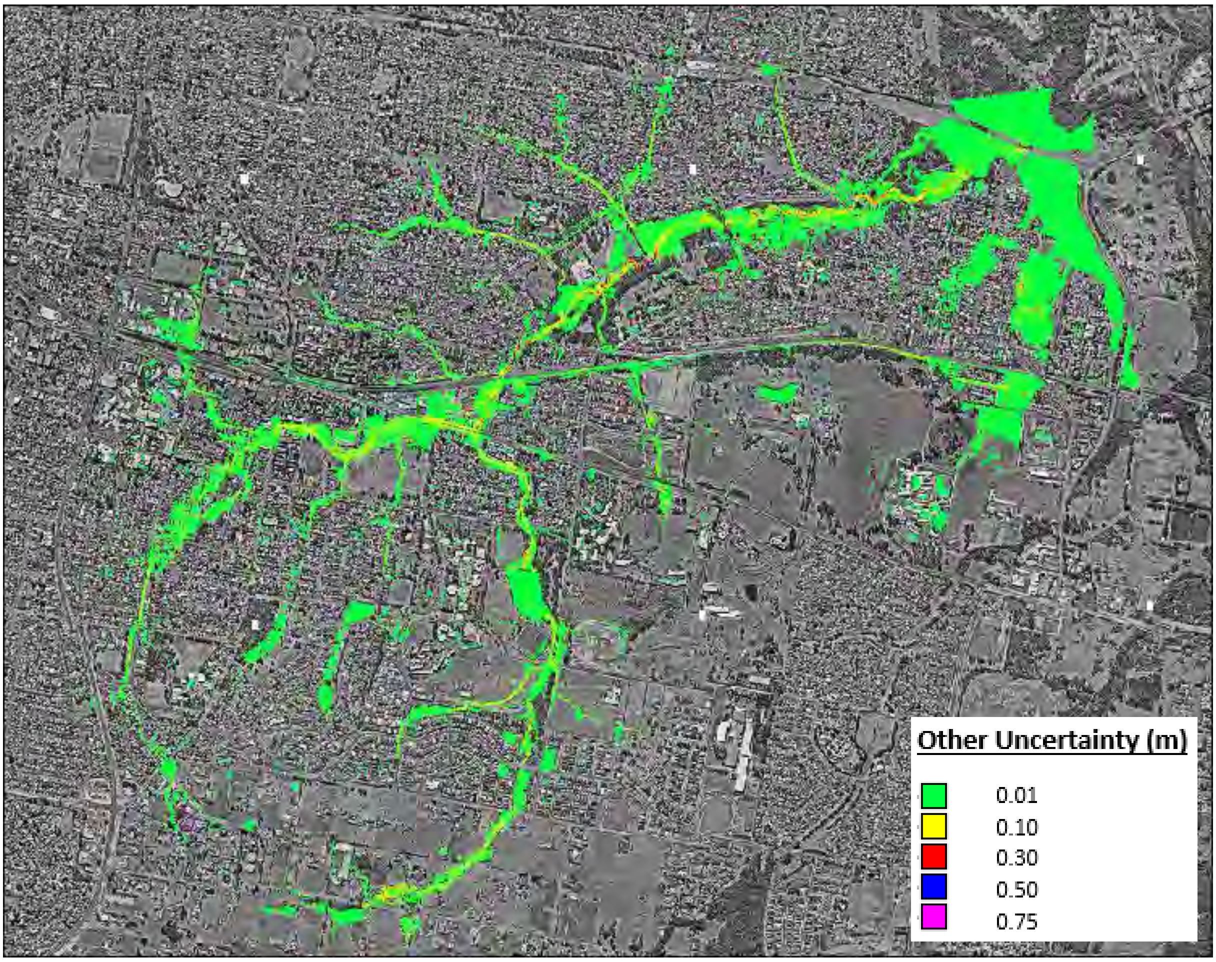



Plate G3 Water level uncertainty grid for other factors that cannot be represented in flood model


Plate G4 Example of cars driving through flood waters and generating waves

The following approach was then used to calculate the minimum required freeboard for each location in the catchment:

- The modelling/climate change confidence limit grid was added to the uncertainty grid for 'other' factors to represent the total water level uncertainty at a particular location.
- An additional 0.15 metre allowance was adopted to account for wave action for all locations. This was added to the uncertainty grid calculated in the previous step to determine the minimum required freeboard at all locations

The resulting minimum freeboard grid is shown in Plate G5. It shows that the minimum freeboard across much of the upper catchment (i.e., overland flooding areas) is less than 0.3 metres (i.e., yellow & orange areas). However, the minimum freeboard requirement exceeds 0.3 metres and approaches 0.5 metres across a number of areas (i.e., red & blue areas). This includes areas adjacent to Werrington Creek as well as much of the suburb of Werrington.

Plate G5 also shows that the area located between the Great Western Highway and the railway line at Kingswood will require more than a 0.3 metre freeboard. In fact, a small area immediately upstream of the railway line requires more than a 0.5 metre freeboard. However, this quickly dissipates to less than 0.5 metres by the time it reaches adjoining commercial and residential properties. Therefore, a 0.5 metre freeboard is considered sufficient to cater for uncertainty across mainstream areas (this includes areas adjacent to South Creek).

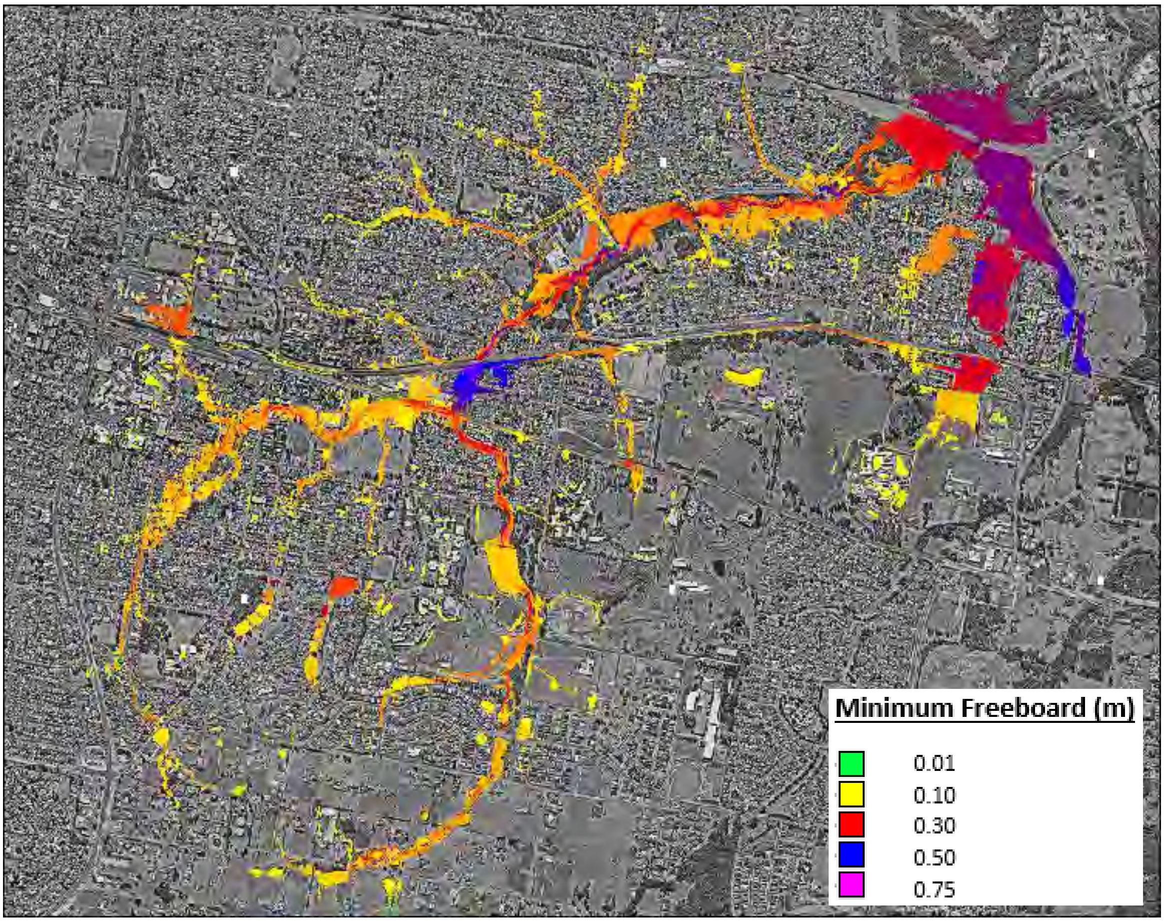



**Plate G5 Minimum required freeboard grid that considers model uncertainty, climate change uncertainty as well as other uncertainty that cannot be explicitly represented in the modelling.**

Away from mainstream areas (i.e., areas subject to overland flow), the minimum required freeboard is well below 0.5 metres and, in most cases, less than 0.3 metres. Therefore, there appears to be merit in adopting a freeboard of less than 0.5 metres in overland flooding areas in the College, Orth and Werrington Creeks catchment. This would be combined with a freeboard of 0.5 metres for mainstream flooding areas to form the flood planning level for the catchment.

The practicalities of adopting a lower freeboard are discussed in the main report.

# APPENDIX H

## QUALITATIVE ASSESSMENT OF OPTIONS

**TABLE H1 - Raw score of flood modification options for COW Creeks Catchment**

| Option | | Impact on flood behaviour or flood risk | Technical feasibility | Environmental Impacts | Economic Benefit | Cost | Impacts on Emergency Response | Community Support | Score |
|---|---|---|---|---|---|---|---|---|---|
| | | Raw Score | | | | | | | |
| **Detention Basins** | | | | | | | | | |
| 1 | Werrington Lake upgrades | 1 | 0 | -1 | 1 | 0 | 0 | 0 | **1** |
| 2 | Lincoln Drive Park basin | 1 | 1 | 0 | 1 | 0 | 2 | 0 | **5** |
| 3 | Devon Park basin | 1 | -1 | 0 | 1 | -1 | 1 | 0 | **1** |
| 4 | Harold Corr Oval basin | 1 | -1 | -1 | 1 | 0 | 1 | 0 | **1** |
| 5 | Chapman Gardens basin | 2 | 1 | 0 | 2 | 0 | 2 | 0 | **7** |
| 6 | Great Western Highway basin | 2 | 1 | 0 | 2 | -1 | 2 | 0 | **6** |
| 7 | Western Sydney University basin #1 | 1 | -1 | -1 | -1 | 1 | 1 | 0 | **0** |
| 8 | Western Sydney University basin #2 | 1 | -2 | -2 | -2 | | 1 | 0 | **-4** |
| 9 | Wainwright Park basin | 2 | -2 | -1 | -2 | -2 | 2 | 0 | **-3** |
| 10 | Stafford Street basin #1 | 2 | 1 | -1 | 2 | -2 | 2 | 0 | **4** |
| 11 | Stafford Street basin #2 | 2 | 1 | -1 | 2 | -2 | 2 | 0 | **4** |
| 12 | Jamison Road basin modifications | 1 | 1 | 0 | 1 | 0 | 2 | 0 | **5** |
| 13 | Clemson Street basin | 1 | -1 | -1 | 1 | -2 | 1 | 0 | **-1** |
| 14 | Stapley Street basin | 1 | -2 | -2 | 1 | -2 | 1 | 0 | **-3** |
| 15 | Tent Street basin | 1 | -1 | -1 | 1 | -2 | 1 | 0 | **-1** |
| 16 | Kingswood High School basin | 1 | -2 | -1 | 1 | 0 | 1 | 0 | **0** |
| 17 | Peppermint Reserve basin modifications | 1 | 0 | -1 | 1 | 0 | 0 | 0 | **1** |
| 18 | Montgrove College basin modifications | 1 | -1 | 0 | 1 | -1 | 1 | 0 | **1** |
| **Culverts/Bridges Modifications** | | | | | | | | | |
| 19 | Dunheved Road Bridge upgrade | 1 | -2 | -1 | 1 | -1 | 2 | 2 | **2** |
| 20 | Victoria Street culvert upgrade #1 | 1 | -1 | 0 | 1 | 0 | 2 | 2 | **5** |
| 21 | Victoria Street culvert upgrade #2 | 1 | -1 | 0 | 1 | 0 | 0 | 2 | **3** |
| 22 | Great Western Highway culvert upgrade | 2 | -1 | 0 | 1 | 0 | 2 | 2 | **6** |
| 23 | Cox Avenue/railway culvert upgrade | 1 | -2 | 0 | 1 | -1 | 1 | 2 | **2** |
| 24 | Werrington Creek railway culvert upgrade #1 | 2 | -2 | 0 | 1 | 0 | 2 | 2 | **5** |
| 25 | Werrington Creek railway culvert upgrade #2 | 2 | -2 | -1 | 2 | 0 | 1 | 2 | **4** |
| 26 | Werrington Railway Station culvert upgrade | 2 | -2 | 0 | 1 | 0 | 2 | 2 | **5** |
| **Stormwater Modifications** | | | | | | | | | |
| 27 | John Oxley Drive stormwater upgrades | 1 | -2 | 0 | -1 | 1 | 1 | 2 | **2** |
| 28 | Dunkley Place stormwater upgrades | 2 | -1 | 0 | -1 | 1 | 1 | 2 | **4** |
| 29 | Chrisan Close stormwater upgrades | 1 | -2 | 0 | -1 | 1 | 1 | 2 | **2** |
| 30 | Edward Close stormwater upgrades | 1 | -2 | 0 | -1 | 1 | 1 | 2 | **2** |
| 31 | Lack Place stormwater upgrades | 1 | -2 | 0 | -1 | 1 | 1 | 2 | **2** |
| 32 | Campton Avenue stormwater upgrades | 1 | -2 | 0 | -1 | 1 | 1 | 2 | **2** |
| 33 | Orleton Place to Francis Street stormwater upgrades | 2 | -1 | 0 | -2 | 1 | 2 | 2 | **4** |
| 34 | Rugby Street to Herbert Street stormwater upgrades | 2 | -1 | 0 | -1 | 1 | 2 | 2 | **5** |

| Option | | Impact on flood behaviour or flood risk | Technical feasibility | Environmental Impacts | Economic Benefit | Cost | Impacts on Emergency Response | Community Support | Score |
|---|---|---|---|---|---|---|---|---|---|
| 35 | Victoria Street to Joseph Street stormwater upgrades | 2 | -1 | 0 | -1 | 1 | 0 | 2 | **3** |
| 36 | Stapley Street to Bringelly Road stormwater upgrades | 1 | -1 | 0 | -1 | 1 | 2 | 2 | **4** |
| 37 | Somerset Street to Orth Street stormwater upgrades | 2 | -1 | 0 | -1 | 1 | 2 | 2 | **5** |
| 38 | Edna Street stormwater upgrades | 1 | -1 | 0 | -1 | 1 | 1 | 2 | **3** |

| Option | | Impact on flood behaviour or flood risk | Technical feasibility | Environmental Impacts | Economic Benefit | Cost | Impacts on Emergency Response | Community Support | Score |
|---|---|---|---|---|---|---|---|---|---|
| **Channel Modifications** | | | | | | | | | |
| 39 | Epping Close Swale upgrade | 1 | -1 | 0 | 1 | 0 | 0 | 2 | **3** |
| 40 | Park Avenue Swale | 1 | -1 | 0 | 1 | 0 | 0 | 2 | **3** |
| 41 | College Creek and Orth Creek channel enlargement | 2 | -2 | -1 | 2 | -1 | 1 | 2 | **3** |
| 42 | Heavy Street channel realignment | 1 | -2 | -1 | 1 | -1 | 0 | 0 | **-2** |
| 43 | Werrington Creek vegetation removal/maintenance | 1 | -1 | -1 | 1 | 1 | 0 | 2 | **3** |
| 44 | College Creek vegetation removal/maintenance | 1 | -1 | -1 | 1 | 1 | 0 | 2 | **3** |
| **Levee Modifications** | | | | | | | | | |
| 45 | Werrington Earthen Levee Upgrade | 0 | -1 | -1 | -1 | 0 | 2 | 1 | **0** |
| 46 | Levee outlet upgrades | 0 | -1 | -1 | -1 | 0 | 0 | 1 | **-2** |
| **Miscellaneous Flood Modifications** | | | | | | | | | |
| 47 | Great Western Highway Median Modification | 2 | 2 | 2 | -1 | 0 | 2 | 2 | **9** |
| 48 | Open fencing | 1 | -1 | 0 | 1 | 1 | 0 | 0 | **2** |
| **Evacuation Route Upgrades** | | | | | | | | | |
| 49 | Great Western Highway upgrade | 2 | -2 | 0 | 2 | -1 | 2 | 2 | **5** |
| 50 | John Oxley Avenue upgrade | 2 | -2 | 0 | 1 | -1 | 1 | 2 | **3** |
| 51 | Burton Street upgrade | 1 | -2 | 0 | 1 | -1 | 2 | 2 | **3** |
| 52 | William Street upgrade | 1 | -2 | 0 | 1 | 0 | 2 | 2 | **4** |
| 53 | Flood warning system | 0 | -1 | 0 | 0 | 1 | 1 | 2 | **3** |

TABLE H2 - Weighted score of flood modification options for COW Creeks Catchment

| Option | | Weighted Score | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Impact on flood behaviour or flood risk | Technical feasibility | Environmental Impacts | Economic Benefit | Cost | Impacts on Emergency Response | Community Support | Score |
| **Detention Basins** | | | | | | | | | |
| 1 | Werrington Lake upgrades | 0.25 | 0 | -0.1 | 0.1 | 0 | 0 | 0 | 0.25 |
| 2 | Lincoln Drive Park basin | 0.25 | 0.15 | 0 | 0.1 | 0 | 0.2 | 0 | 0.7 |
| 3 | Devon Park basin | 0.25 | -0.15 | 0 | 0.1 | -0.1 | 0.1 | 0 | 0.2 |
| 4 | Harold Corr Oval basin | 0.25 | -0.15 | -0.1 | 0.1 | 0 | 0.1 | 0 | 0.2 |
| 5 | Chapman Gardens basin | 0.5 | 0.15 | 0 | 0.2 | 0 | 0.2 | 0 | 1.05 |
| 6 | Great Western Highway basin | 0.5 | 0.15 | 0 | 0.2 | -0.1 | 0.2 | 0 | 0.95 |
| 7 | Western Sydney University basin #1 | 0.25 | -0.15 | -0.1 | -0.1 | 0.1 | 0.1 | 0 | 0.1 |
| 8 | Western Sydney University basin #2 | 0.25 | -0.3 | -0.2 | -0.2 | 0 | 0.1 | 0 | -0.35 |
| 9 | Wainwright Park basin | 0.5 | -0.3 | -0.1 | -0.2 | -0.2 | 0.2 | 0 | -0.1 |
| 10 | Stafford Street basin #1 | 0.5 | 0.15 | -0.1 | 0.2 | -0.2 | 0.2 | 0 | 0.75 |
| 11 | Stafford Street basin #2 | 0.5 | 0.15 | -0.1 | 0.2 | -0.2 | 0.2 | 0 | 0.75 |
| 12 | Jamison Road basin modifications | 0.25 | 0.15 | 0 | 0.1 | 0 | 0.2 | 0 | 0.7 |
| 13 | Clemson Street basin | 0.25 | -0.15 | -0.1 | 0.1 | -0.2 | 0.1 | 0 | 0 |
| 14 | Stapley Street basin | 0.25 | -0.3 | -0.2 | 0.1 | -0.2 | 0.1 | 0 | -0.25 |
| 15 | Tent Street basin | 0.25 | -0.15 | -0.1 | 0.1 | -0.2 | 0.1 | 0 | 0 |
| 16 | Kingswood High School basin | 0.25 | -0.3 | -0.1 | 0.1 | 0 | 0.1 | 0 | 0.05 |
| 17 | Peppermint Reserve basin modifications | 0.25 | 0 | -0.1 | 0.1 | 0 | 0 | 0 | 0.25 |
| 18 | Montgrove College basin modifications | 0.25 | -0.15 | 0 | 0.1 | -0.1 | 0.1 | 0 | 0.2 |
| **Culverts/Bridges Modifications** | | | | | | | | | |
| 19 | Dunheved Road Bridge upgrade | 0.25 | -0.3 | -0.1 | 0.1 | -0.1 | 0.2 | 0.4 | 0.45 |
| 20 | Victoria Street culvert upgrade #1 | 0.25 | -0.15 | 0 | 0.1 | 0 | 0.2 | 0.4 | 0.8 |
| 21 | Victoria Street culvert upgrade #2 | 0.25 | -0.15 | 0 | 0.1 | 0 | 0 | 0.4 | 0.6 |
| 22 | Great Western Highway culvert upgrade | 0.5 | -0.15 | 0 | 0.1 | 0 | 0.2 | 0.4 | 1.05 |
| 23 | Cox Avenue/railway culvert upgrade | 0.25 | -0.3 | 0 | 0.1 | -0.1 | 0.1 | 0.4 | 0.45 |
| 24 | Werrington Creek railway culvert upgrade #1 | 0.5 | -0.3 | 0 | 0.1 | 0 | 0.2 | 0.4 | 0.9 |
| 25 | Werrington Creek railway culvert upgrade #2 | 0.5 | -0.3 | -0.1 | 0.2 | 0 | 0.1 | 0.4 | 0.8 |
| 26 | Werrington Railway Station culvert upgrade | 0.5 | -0.3 | 0 | 0.1 | 0 | 0.2 | 0.4 | 0.9 |
| **Stormwater Modifications** | | | | | | | | | |
| 27 | John Oxley Drive stormwater upgrades | 0.25 | -0.3 | 0 | -0.1 | 0.1 | 0.1 | 0.4 | 0.45 |
| 28 | Dunkley Place stormwater upgrades | 0.5 | -0.15 | 0 | -0.1 | 0.1 | 0.1 | 0.4 | 0.85 |
| 29 | Chrisan Close stormwater upgrades | 0.25 | -0.3 | 0 | -0.1 | 0.1 | 0.1 | 0.4 | 0.45 |
| 30 | Edward Close stormwater upgrades | 0.25 | -0.3 | 0 | -0.1 | 0.1 | 0.1 | 0.4 | 0.45 |
| 31 | Lack Place stormwater upgrades | 0.25 | -0.3 | 0 | -0.1 | 0.1 | 0.1 | 0.4 | 0.45 |
| 32 | Campton Avenue stormwater upgrades | 0.25 | -0.3 | 0 | -0.1 | 0.1 | 0.1 | 0.4 | 0.45 |
| 33 | Orleton Place to Francis Street stormwater upgrades | 0.5 | -0.15 | 0 | -0.2 | 0.1 | 0.2 | 0.4 | 0.85 |
| 34 | Rugby Street to Herbert Street stormwater upgrades | 0.5 | -0.15 | 0 | -0.1 | 0.1 | 0.2 | 0.4 | 0.95 |
| 35 | Victoria Street to Joseph Street stormwater upgrades | 0.5 | -0.15 | 0 | -0.1 | 0.1 | 0 | 0.4 | 0.75 |
| 36 | Stapley Street to Bringelly Road stormwater upgrades | 0.25 | -0.15 | 0 | -0.1 | 0.1 | 0.2 | 0.4 | 0.7 |
| 37 | Somerset Street to Orth Street stormwater upgrades | 0.5 | -0.15 | 0 | -0.1 | 0.1 | 0.2 | 0.4 | 0.95 |
| 38 | Edna Street stormwater upgrades | 0.25 | -0.15 | 0 | -0.1 | 0.1 | 0.1 | 0.4 | 0.6 |

| Option | | Impact on flood behaviour or flood risk | Technical feasibility | Environmental Impacts | Economic Benefit | Cost | Impacts on Emergency Response | Community Support | Score |
|---|---|---|---|---|---|---|---|---|---|
| **Channel Modifications** | | | | | | | | | |
| 39 | Epping Close Swale upgrade | 0.25 | -0.15 | 0 | 0.1 | 0 | 0 | 0.4 | 0.6 |
| 40 | Park Avenue Swale | 0.25 | -0.15 | 0 | 0.1 | 0 | 0 | 0.4 | 0.6 |
| 41 | College Creek and Orth Creek channel enlargement | 0.5 | -0.3 | -0.1 | 0.2 | -0.1 | 0.1 | 0.4 | 0.7 |
| 42 | Heavy Street channel realignment | 0.25 | -0.3 | -0.1 | 0.1 | -0.1 | 0 | 0 | -0.15 |
| 43 | Werrington Creek vegetation removal/maintenance | 0.25 | -0.15 | -0.1 | 0.1 | 0.1 | 0 | 0.4 | 0.6 |
| 44 | College Creek vegetation removal/maintenance | 0.25 | -0.15 | -0.1 | 0.1 | 0.1 | 0 | 0.4 | 0.6 |
| **Levee Modifications** | | | | | | | | | |
| 45 | Werrington Earthen Levee Upgrade | 0 | -0.15 | -0.1 | -0.1 | 0 | 0.2 | 0.2 | 0.05 |
| 46 | Levee outlet upgrades | 0 | -0.15 | -0.1 | -0.1 | 0 | 0 | 0.2 | -0.15 |
| **Miscellaneous Flood Modifications** | | | | | | | | | |
| 47 | Great Western Highway Median Modification | 0.5 | 0.3 | 0.2 | -0.1 | 0 | 0.2 | 0.4 | 1.5 |
| 48 | Open fencing | 0.25 | -0.15 | 0 | 0.1 | 0.1 | 0 | 0 | 0.3 |
| **Evacuation Route Upgrades** | | | | | | | | | |
| 49 | Great Western Highway upgrade | 0.5 | -0.3 | 0 | 0.2 | -0.1 | 0.2 | 0.4 | 0.9 |
| 50 | John Oxley Avenue upgrade | 0.5 | -0.3 | 0 | 0.1 | -0.1 | 0.1 | 0.4 | 0.7 |
| 51 | Burton Street upgrade | 0.25 | -0.3 | 0 | 0.1 | -0.1 | 0.2 | 0.4 | 0.55 |
| 52 | William Street upgrade | 0.25 | -0.3 | 0 | 0.1 | 0 | 0.2 | 0.4 | 0.65 |
| 53 | **Flood warning system** | 0 | -0.15 | 0 | 0 | 0.1 | 0.1 | 0.4 | 0.45 |

## Table H3 - Ranking of FM options for COW Creeks catchment with and without weightings applied

| Rank Raw | Option Name | Rank weighted | Option Name |
|---|---|---|---|
| 1 | Great Western Highway Median Modification | 1 | Great Western Highway Median Modification |
| 2 | Chapman Gardens basin | =2 | Chapman Gardens basin |
| =3 | Great Western Highway basin | | Great Western Highway culvert upgrade |
| | Great Western Highway culvert upgrade | =4 | Great Western Highway basin |
| =5 | Lincoln Drive Park basin | | Rugby Street to William Street stormwater upgrades |
| | Jamison Road basin modifications | | Somerset Street to Orth Street stormwater upgrades |
| | Victoria Street culvert upgrade #1 | =7 | Werrington Creek railway culvert upgrade #1 |
| | Werrington Creek railway culvert upgrade #1 | | Werrington Railway Station culvert upgrade |
| | Werrington Railway Station culvert upgrade | | Great Western Highway upgrade |
| | Rugby Street to William Street stormwater upgrades | =10 | Dunkley Place stormwater upgrades |
| | Somerset Street to Orth Street stormwater upgrades | | Orleton Place to Francis Street stormwater upgrades |
| | Great Western Highway upgrade | =12 | Victoria Street culvert upgrade #1 |
| =13 | Stafford Street basin #1 | | Werrington Creek railway culvert upgrade #2 |
| | Stafford Street basin #2 | =14 | Stafford Street basin #1 |
| | Werrington Creek railway culvert upgrade #2 | | Stafford Street basin #2 |
| | Dunkley Place stormwater upgrades | | Victoria Street to Joseph Street stormwater upgrades |
| | Orleton Place to Francis Street stormwater upgrades | 17 | College Creek and Orth Creek channel enlargement |
| | Stapley Street to Bringelly Road stormwater upgrades | =18 | Lincoln Drive Park basin |
| | William Street upgrade | | Jamison Road basin modifications |
| =20 | Victoria Street culvert upgrade #2 | | Stapley Street to Bringelly Road stormwater upgrades |
| | Victoria Street to Joseph Street stormwater upgrades | 21 | John Oxley Avenue upgrade |
| | Edna Street stormwater upgrades | 22 | William Street upgrade |

| Rank Raw | Option Name | Rank weighted | Option Name |
|---|---|---|---|
| | Epping Close Swale upgrade | =23 | Victoria Street culvert upgrade #2 |
| | Park Avenue Swale | | Edna Street stormwater upgrades |
| | College Creek and Orth Creek channel enlargement | | Epping Close Swale upgrade |
| | Werrington Creek vegetation removal/maintenance | | Park Avenue Swale |
| | College Creek vegetation removal/maintenance | | Victoria Street culvert upgrade #2 |
| | John Oxley Avenue upgrade | | Victoria Street culvert upgrade #2 |
| | Burton Street upgrade | 29 | Burton Street upgrade |
| 30 | John Oxley Avenue upgrade | 30 | Dunheved Road Bridge upgrade |
| =31 | Dunheved Road Bridge upgrade | =31 | Cox Avenue/railway culvert upgrade |
| | Cox Avenue/railway culvert upgrade | | John Oxley Drive stormwater upgrades |
| | John Oxley Drive stormwater upgrades | | Chrisan Close stormwater upgrades |
| | Chrisan Close stormwater upgrades | | Edward Close stormwater upgrades |
| | Edward Close stormwater upgrades | | Lack Place stormwater upgrades |
| | Lack Place stormwater upgrades | | Campton Avenue stormwater upgrades |
| | Campton Avenue stormwater upgrades | 37 | Flood warning system |
| | Open fencing | 38 | Open fencing |
| =39 | Werrington Lake upgrades | =39 | Werrington Lake upgrades |
| | Devon Park basin | | Peppermint Reserve basin modifications |
| | Harold Corr Oval basin | =41 | Devon Park basin |
| | Peppermint Reserve basin modifications | | Harold Corr Oval basin |
| | Montgrove College basin modifications | | Montgrove College basin modifications |
| =44 | Western Sydney University basin #1 | 44 | Western Sydney University basin #1 |
| | Kingswood High School basin | 45 | Werrington Earthen Levee Upgrade |
| | Werrington Earthen Levee Upgrade | 46 | Kingswood High School basin |

| Rank Raw | Option Name | Rank weighted | Option Name |
|---|---|---|---|
| =47 | Clemson Street basin | =47 | Clemson Street basin |
| | Tent Street basin | | Tent Street basin |
| =49 | Heavy Street channel realignment | 49 | Wainwright Park basin |
| | Levee outlet upgrades | 50 | Levee outlet upgrades |
| =51 | Wainwright Park basin | 51 | Heavy Street channel realignment |
| | Stapley Street basin | 52 | Stapley Street basin |
| 53 | Western Sydney University basin #2 | 53 | Western Sydney University basin #2 |

# APPENDIX I

## COST ESTIMATES

# PRELIMINARY COST ESTIMATE

**Description of Works** Revision: 1

FM1 - Chapman Gardens Basin Modification

**Note:** The preliminary costs estimates outlined below have been prepared for comparing and evaluating the feasibility of different drainage mitigation options. They are approximate only and should not be relied upon for budgetting purposes. Detailed costings can only be prepared once detailed design plans are prepared.
Cost estimates only include capital costs and no ongoing maintenance costs are included unless specifically noted.

Reference: Rawlinsons 'Australian Construction Handbook' - Edition 36, 2018

Reg. Index: 1

| Item | | Description | Unit | Quantity | Base Rate | Amount |
|---|---|---|---|---|---|---|
| 1 | | **PRELIMINARY ITEMS** | | | | **$20,850** |
| | 1.01 | Site Establishment (allowance only) | Lump sum | 1 | 3,000 | $3,000 |
| | 1.02 | QA & ITP | Lump sum | 1 | 1,000 | $1,000 |
| | 1.03 | Water Management Plan incl. Erosion and Sediment Control Plan | Lump sum | 1 | 1,000 | $1,000 |
| | 1.04 | OHS&R Plan | Lump sum | 1 | 1,000 | $1,000 |
| | 1.05 | Erosion and Sediment control - Geotextile Silt Fence around site | m | 900 | 16.50 | $14,850 |
| 2 | | **SERVICES** | | | | **$15,000** |
| | 2.01 | Services investigation and management of existing electricity within park | Lump sum | 1 | 15000 | $15,000 |
| 2 | | **EARTHWORKS** | | | | **$750,023** |
| | 2.01 | Excavate over site to reduce levels - in clay) | m3 | 20107 | 30.80 | $619,296 |
| | 2.02 | Disposal of excess excavated fill (transport and deposit within 5km of site) | $m^3$ | 19304 | 3.10 | $59,842 |
| | 2.03 | Constructing wall and spillway from excavated clay (including consolidation) | m3 | 803 | 70.00 | $56,210 |
| | 2.04 | Labour forming sloping edge to basin crest/spillway | m | 398 | 2.65 | $1,055 |
| | 2.05 | Excavation of trenches for new 1.35m pipes and new pits (in clay up to 2m deep) | $m^3$ | 166 | 70.00 | $11,620 |
| | 2.06 | Basin safety mechanisms (Depth indicators, spillway/fencing signage) | Lump sum | 1 | 2000 | $2,000 |
| 3 | | **DRAINAGE INFRASTRUCTURE** | | | | **$160,472** |
| | 3.01 | Inlet with grates - includes square precast concrete pit and Class D cast iron gully grating (900mm squares x number as required) | No. | 43 | 2,787 | $119,841 |
| | 3.02 | 1.35m RCP (Class 2) | m | 41 | 991 | $40,631 |
| 4 | | **LANDSCAPING** | | | | **$6,656** |
| | 4.01 | Sprayed Grass Seed Compound Hydro Mulch | m2 | 20800 | 0.32 | $6,656 |
| | | | | | **SUBTOTAL** | **$953,001** |
| 5 | | **ENGINEERING DESIGN** | | | | **$46,900** |
| | 5.01 | Preparation of engineering design plans (5%) | | | | $46,900 |
| 6 | | **PROJECT MANAGEMENT** | | | | **$46,900** |
| | 6.01 | Supervision, Project Management etc (5%) | | | | $46,900 |
| 7 | | **OTHER CONTINGENCIES** | | | | **$93,800** |
| | 7.01 | General (10%) | | | | $93,800 |
| | | | **TOTAL at 7% NPV** (Rounded to nearest $10,000) | | | **$1,140,000** |

# PRELIMINARY COST ESTIMATE

**Description of Works** Revision: 1

FM2 - Great Western Highway Basin Construction

**Note:** The preliminary costs estimates outlined below have been prepared for comparing and evaluating the feasibility of different drainage mitigation options. They are approximate only and should not be relied upon for budgetting purposes. Detailed costings can only be prepared once detailed design plans are prepared.
Cost estimates only include capital costs and no ongoing maintenance costs are included unless specifically noted.

Reference: Rawlinsons 'Australian Construction Handbook' - Edition 36, 2018

Reg. Index: 1

| | Item | Description | Unit | Quantity | Base Rate | Amount |
|---|---|---|---|---|---|---|
| 1 | | **PRELIMINARY ITEMS** | | | | **$15,735** |
| | 1.01 | Site Establishment (allowance only) | Lump sum | 1 | 3,000 | $3,000 |
| | 1.02 | QA & ITP | Lump sum | 1 | 1,000 | $1,000 |
| | 1.03 | Water Management Plan incl. Erosion and Sediment Control Plan | Lump sum | 1 | 1,000 | $1,000 |
| | 1.04 | OHS&R Plan | Lump sum | 1 | 1,000 | $1,000 |
| | 1.05 | Erosion and Sediment control - Geotextile Silt Fence around site | m | 590 | 16.50 | $9,735 |
| 2 | | **SERVICES** | | | | **$35,000** |
| | 2.01 | Services investigation and management of existing water and sewer at north-eastern corner of works | Lump sum | 1 | 35000 | $35,000 |
| 2 | | **EARTHWORKS** | | | | **$607,864** |
| | 2.01 | Excavate over site to reduce levels - in clay) and form 1:4 side slope batters | m3 | 17760 | 30.80 | $547,008 |
| | 2.02 | Disposal of excess excavated fill (transport and deposit within 5km of site) | $m^3$ | 17760 | 3.10 | $55,056 |
| | 2.03 | Rock scour protection around culvert inlets/outlets (gabion rock mattress) | $m^3$ | 10 | 380 | $3,800 |
| | 2.04 | Basin safety mechanisms (Depth indicators, spillway/fencing signage) | Lump sum | 1 | 2000 | $2,000 |
| 3 | | **LANDSCAPING** | | | | **$4,412** |
| | 3.01 | Sprayed Grass Seed Compound Hydro Mulch | m2 | 13787 | 0.32 | $4,412 |
| | | | | | **SUBTOTAL** | **$663,011** |
| 4 | | **ENGINEERING DESIGN** | | | | **$33,151** |
| | 4.01 | Preparation of engineering design plans (5%) | | | | $33,151 |
| 5 | | **PROJECT MANAGEMENT** | | | | **$33,151** |
| | 5.01 | Supervision, Project Management etc (5%) | | | | $33,151 |
| 6 | | **OTHER CONTINGENCIES** | | | | **$66,301** |
| | 6.01 | General (10%) | | | | $66,301 |
| | | | **TOTAL at 7% NPV** (Rounded to nearest $10,000) | | | **$800,000** |

# PRELIMINARY COST ESTIMATE

**Description of Works** Revision: 1

FM3 - Lincoln Drive Basin Modification

**Note:** The preliminary costs estimates outlined below have been prepared for comparing and evaluating the feasibility of different drainage mitigation options. They are approximate only and should not be relied upon for budgetting purposes. Detailed costings can only be prepared once detailed design plans are prepared.
Cost estimates only include capital costs and no ongoing maintenance costs are included unless specifically noted.

Reference: Rawlinsons 'Australian Construction Handbook' - Edition 36, 2018

Reg. Index: 1

| Item | Description | Unit | Quantity | Base Rate | Amount |
|---|---|---|---|---|---|
| 1 | **PRELIMINARY ITEMS** | | | | **$9,960** |
| 1.01 | Site Establishment (allowance only) | Lump sum | 1 | 3,000 | $3,000 |
| 1.02 | QA & ITP | Lump sum | 1 | 1,000 | $1,000 |
| 1.03 | Water Management Plan incl. Erosion and Sediment Control Plan | Lump sum | 1 | 1,000 | $1,000 |
| 1.04 | OHS&R Plan | Lump sum | 1 | 1,000 | $1,000 |
| 1.05 | Erosion and Sediment control - Geotextile Silt Fence around site | m | 240 | 16.50 | $3,960 |
| 2 | **EARTHWORKS** | | | | **$19,614** |
| 2.01 | Fill Material for construction of Basin crest/spillway (clay sourced locally) | m3 | 109 | 86.00 | $9,374 |
| 2.02 | Constructing wall and spillway from clay (including consolidation) | m3 | 109 | 70.00 | $7,630 |
| 2.03 | Labour forming sloping edge to basin crest/spillway | m | 230 | 2.65 | $610 |
| 2.04 | Basin safety mechanisms (Depth indicators, spillway/fencing signage) | Lump sum | 1 | 2000 | $2,000 |
| 3 | **LANDSCAPING** | | | | **$141** |
| 3.01 | Sprayed Grass Seed Compound Hydro Mulch | m2 | 440 | 0.32 | $141 |
| | | | | **SUBTOTAL** | **$29,714** |
| 4 | **ENGINEERING DESIGN** | | | | **$8,914** |
| 4.01 | Preparation of engineering design plans (30%) | | | | $8,914 |
| 5 | **PROJECT MANAGEMENT** | | | | **$5,943** |
| 5.01 | Supervision, Project Management etc (20%) | | | | $5,943 |
| 6 | **OTHER CONTINGENCIES** | | | | **$5,943** |
| 6.01 | General (20%) | | | | $5,943 |
| | | | | **TOTAL at 7% NPV** (Rounded to nearest $10,000) | **$50,000** |

# PRELIMINARY COST ESTIMATE

**Description of Works** Revision: 1

FM4 - Stafford Street Basin

**Note:** The preliminary costs estimates outlined below have been prepared for comparing and evaluating the feasibility of different drainage mitigation options. They are approximate only and should not be relied upon for budgetting purposes. Detailed costings can only be prepared once detailed design plans are prepared.
Cost estimates only include capital costs and no ongoing maintenance costs are included unless specifically noted.

Reference: Rawlinsons 'Australian Construction Handbook' - Edition 36, 2018

Reg. Index: 1

| Item | | Description | Unit | Quantity | Base Rate | Amount |
|---|---|---|---|---|---|---|
| 1 | | **PRELIMINARY ITEMS** | | | | **$22,831** |
| | 1.01 | Site Establishment (allowance only) | Lump sum | 1 | 3,000 | $3,000 |
| | 1.02 | QA & ITP | Lump sum | 1 | 1,000 | $1,000 |
| | 1.03 | Water Management Plan incl. Erosion and Sediment Control Plan | Lump sum | 1 | 5,000 | $5,000 |
| | 1.04 | OHS&R Plan | Lump sum | 1 | 2,000 | $2,000 |
| | 1.05 | Erosion and Sediment control - Geotextile Silt Fence around site | m | 717 | 16.50 | $11,831 |
| 2 | | **SERVICES** | | | | **$15,000** |
| | 2.01 | Services investigation and management of existing sewer at southern end of works | Lump sum | 1 | 15000 | $15,000 |
| 2 | | **EARTHWORKS** | | | | **$96,654** |
| | 2.01 | Excavate over site to reduce levels - in clay) | m3 | 2560 | 30.80 | $78,848 |
| | 2.02 | Disposal of excess excavated fill (transport and deposit within 5km of site) | $m^3$ | 2451 | 3.10 | $7,598 |
| | 2.03 | Constructing wall and spillway from clay (including consolidation) | m3 | 109 | 70.00 | $7,630 |
| | 2.04 | Labour forming sloping edge to basin crest/spillway | m | 218 | 2.65 | $578 |
| | 2.05 | Basin safety mechanisms (Depth indicators, spillway/fencing signage) | Lump sum | 1 | 2000 | $2,000 |
| 3 | | **DRAINAGE INFRASTRUCTURE** | | | | **$13,935** |
| | 3.01 | Rework grated pits - includes square precast concrete pit and Class D cast iron gully grating (900mm squares x number as required) | No. | 5 | 2,787 | $13,935 |
| 4 | | **LANDSCAPING** | | | | **$2,418** |
| | 4.01 | Sprayed Grass Seed Compound Hydro Mulch | m2 | 7557 | 0.32 | $2,418 |
| 5 | | **ENGINEERING CERTIFICATION** | | | | **$310,000** |
| | 5.01 | Dam break assessment and monthly inspections over 50 year life cycle | no | 1 | 310,000 | $310,000 |
| | | | | | **SUBTOTAL** | **$460,838** |
| 6 | | **ENGINEERING DESIGN** | | | | **$13,584** |
| | 6.01 | Preparation of engineering design plans (10%) | | | | $13,584 |
| 7 | | **PROJECT MANAGEMENT** | | | | **$13,584** |
| | 7.01 | Supervision, Project Management etc (10%) | | | | $13,584 |
| 8 | | **OTHER CONTINGENCIES** | | | | **$27,168** |
| | 8.01 | General (20%) | | | | $27,168 |
| | | | | | **TOTAL at 7% NPV** (Rounded to nearest $10,000) | **$520,000** |

# PRELIMINARY COST ESTIMATE

**Description of Works** Revision: 1

FM5 - Jamison Road Basin Modification

**Note:** The preliminary costs estimates outlined below have been prepared for comparing and evaluating the feasibility of different drainage mitigation options. They are approximate only and should not be relied upon for budgetting purposes. Detailed costings can only be prepared once detailed design plans are prepared.
Cost estimates only include capital costs and no ongoing maintenance costs are included unless specifically noted.

Reference: Rawlinsons 'Australian Construction Handbook' - Edition 36, 2018

Reg. Index: 1

| Item | Description | Unit | Quantity | Base Rate | Amount |
|---|---|---|---|---|---|
| 1 | **PRELIMINARY ITEMS** | | | | **$14,003** |
| 1.01 | Site Establishment (allowance only) | Lump sum | 1 | 3,000 | $3,000 |
| 1.02 | QA & ITP | Lump sum | 1 | 1,000 | $1,000 |
| 1.03 | Water Management Plan incl. Erosion and Sediment Control Plan | Lump sum | 1 | 5,000 | $5,000 |
| 1.04 | OHS&R Plan | Lump sum | 1 | 2,000 | $2,000 |
| 1.05 | Erosion and Sediment control - Geotextile Silt Fence around site | m | 182 | 16.50 | $3,003 |
| 2 | **EARTHWORKS** | | | | **$96,729** |
| 2.01 | Excavate over site to reduce levels - in clay) | m3 | 2673 | 30.80 | $82,328 |
| 2.02 | Disposal of excess excavated fill (transport and deposit within 5km of site) | $m^3$ | 2673 | 3.10 | $8,286 |
| 2.05 | Labour forming sloping edge to basin crest/spillway | m | 138 | 2.65 | $366 |
| 2.06 | Excavation of trenches for new 0.525m pipes and outlet (in clay up to 2m deep) | $m^3$ | 54 | 70 | $3,749 |
| 2.07 | Basin safety mechanisms (Depth indicators, spillway/fencing signage) | Lump sum | 1 | 2000 | $2,000 |
| 3 | **DRAINAGE INFRASTRUCTURE** | | | | **$57,140** |
| 3.01 | Grated surcharge pit - includes square precast concrete pit and Class D cast iron gully grating (900mm squares x number as required) | No. | 14 | 2,787 | $38,708 |
| 3.02 | Orriface plate over 1x 1.5m culvert and installation | Lump sum | 1 | 3,200 | $3,200 |
| 3.03 | 0.525m RCP (Class 2) | m | 68 | 224 | $15,232 |
| 4 | **LANDSCAPING** | | | | **$649** |
| 4.01 | Sprayed Grass Seed Compound Hydro Mulch | m2 | 2027 | 0.32 | $649 |
| 5 | **ENGINEERING CERTIFICATION** | | | | **$310,000** |
| 5.01 | Dam break assessment and monthly inspections over 50 year life cycle | no | 1 | 310,000 | $310,000 |
| | | | | **SUBTOTAL** | **$478,521** |
| 5 | **ENGINEERING DESIGN** | | | | **$33,704** |
| 5.01 | Preparation of engineering design plans (20%) | | | | $33,704 |
| 6 | **PROJECT MANAGEMENT** | | | | **$33,704** |
| 6.01 | Supervision, Project Management etc (20%) | | | | $33,704 |
| 7 | **OTHER CONTINGENCIES** | | | | **$33,704** |
| 7.01 | General (20%) | | | | $33,704 |
| | | | | **TOTAL at 7% NPV** (Rounded to nearest $10,000) | **$580,000** |

# PRELIMINARY COST ESTIMATE

**Description of Works** Revision: 1

FM6 - Enlargement of Victoria St culverts and roadway surface elevating

**Note:** The preliminary costs estimates outlined below have been prepared for comparing and evaluating the feasibility of different drainage mitigation options. They are approximate only and should not be relied upon for budgetting purposes. Detailed costings can only be prepared once detailed design plans are prepared.
Cost estimates only include capital costs and no ongoing maintenance costs are included unless specifically noted.

Reference: Rawlinsons 'Australian Construction Handbook' - Edition 36, 2018

Reg. Index: 1

| Item | Description | Unit | Quantity | Base Rate | Amount |
|---|---|---|---|---|---|
| 1 | **PRELIMINARY ITEMS** | | | | **$63,003** |
| 1.01 | Site Establishment (allowance only) | Lump sum | 2 | 10000 | $20,000 |
| 1.02 | QA & ITP | Lump sum | 1 | 1,000 | $1,000 |
| 1.03 | Water Management Plan incl. Erosion and Sediment Control Plan | Lump sum | 1 | 1,000 | $1,000 |
| 1.04 | Erosion and Sediment control - Geotextile Silt Fence around site | m | 182 | 16.50 | $3,003 |
| 1.05 | Traffic/Pedestrian Management | Lump sum | 1 | 30000 | $30,000 |
| 1.06 | OHS&R Plan | Lump sum | 1 | 8000 | $8,000 |
| 2 | **SERVICES** | | | | **$55,000** |
| 2.01 | Services investigation and management (water main, sewer, Optus and NBN) | Lump sum | 1 | 55000 | $55,000 |
| 3 | **EARTHWORKS** | | | | **$702,552** |
| 3.01 | Excavate roadway, base and ground along culvert alignment (including backfilling/compaction) (trench of 21m width) (Excavate trench >2m deep in soft rock) | m3 | 3208 | 219 | $702,552 |
| 4 | **DRAINAGE INFRASTRUCTURE** | | | | **$755,402** |
| | **Box Culverts** | | | | |
| 4.01 | 3.6m W x 2.1m H RCBC (Class 2) x 6 lengths | m | 162 | 4621 | $748,602 |
| | **Culvert Headwall** | | | | |
| 4.02 | Placed in-situ Concrete Culvert Headwall at Upstream and Downstream of Culverts | m3 | 2 | 3400 | $6,800 |
| 5 | **ROAD WORKS** | | | | **$45,220** |
| 5.01 | Roadway Plates to cover open trenches during roadway opening times | Lump sum | 4800 | 4800 | $4,800 |
| 5.02 | Additional pavement base to raise roadway by 0.2 metres | m3 | 171 | 36.2 | $6,193 |
| 5.03 | Install new pavement (40mm thick hot mix bitumen over new 300mm yellow sand basecourse) covering excavated trenches | m2 | 855 | 36.2 | $30,964 |
| 5.04 | Formation of kerb (Extruded in situ concrete kerb, 600x225mm kerb and gutter) | m | 63 | 51.5 | $3,263 |
| | | | | **SUBTOTAL** | **$1,621,177** |
| 6 | **ENGINEERING DESIGN** | | | | **$81,059** |
| 6.01 | Preparation of engineering design plans (5%) | | | | $81,059 |
| 7 | **PROJECT MANAGEMENT** | | | | **$81,059** |
| 7.01 | Supervision, Project Management etc (5%) | | | | $81,059 |
| 8 | **OTHER CONTINGENCIES** | | | | **$324,235** |
| 8.01 | General (20%) | | | | $324,235 |
| | | | | **TOTAL at 7% NPV** (Rounded to nearest $10,000) | **$2,110,000** |

# PRELIMINARY COST ESTIMATE

**Description of Works** — Revision: 1

FM7 - New culvert from Chapman Gardes Basin to Werrington Creek

**Note:** The preliminary costs estimates outlined below have been prepared for comparing and evaluating the feasibility of different drainage mitigation options. They are approximate only and should not be relied upon for budgetting purposes. Detailed costings can only be prepared once detailed design plans are prepared.
Cost estimates only include capital costs and no ongoing maintenance costs are included unless specifically noted.

Reference: Rawlinsons 'Australian Construction Handbook' - Edition 36, 2018

Reg. Index: 1

| Item | Description | Unit | Quantity | Base Rate | Amount |
|---|---|---|---|---|---|
| 1 | **PRELIMINARY ITEMS** | | | | **$93,003** |
| 1.01 | Site Establishment (allowance only) | Lump sum | 2 | 10000 | $20,000 |
| 1.02 | QA & ITP | Lump sum | 1 | 1,000 | $1,000 |
| 1.03 | Water Management Plan incl. Erosion and Sediment Control Plan | Lump sum | 1 | 1,000 | $1,000 |
| 1.04 | Erosion and Sediment control - Geotextile Silt Fence around site | m | 182 | 16.50 | $3,003 |
| 1.05 | Traffic/Pedestrian Management | Lump sum | 1 | 60000 | $60,000 |
| 1.06 | OHS&R Plan | Lump sum | 1 | 8000 | $8,000 |
| 2 | **SERVICES** | | | | **$80,000** |
| 2.01 | Services investigation (water main, sewer, gas and NBN) within Great Western Highway | Lump sum | 1 | 80000 | $80,000 |
| 3 | **EARTHWORKS** | | | | **$718,977** |
| 3.01 | Excavate roadway, base and ground along culvert alignment (including backfilling/compaction) (trench of 4m width) (Excavate trench >2m deep in soft rock) | m3 | 3283 | 219 | $718,977 |
| 4 | **DRAINAGE INFRASTRUCTURE** | | | | **$957,580** |
| | **Box Culverts** | | | | |
| 4.01 | 3.2m W x 2.1m H RCBC (Class 2) | m | 228 | 4185 | $954,180 |
| | **Culvert Headwall** | | | | |
| 4.02 | Placed in-situ Concrete Culvert Headwall at Upstream and Downstream of Culverts | m3 | 1 | 3400 | $3,400 |
| 4.03 | Inlet with grates - includes square precast concrete pit and Class D cast iron gully grating (900mm squares x number as required) | No. | 19 | 2,787 | $52,953 |
| 5 | **ROAD WORKS** | | | | **$33,014** |
| 5.01 | Install new pavement (40mm thick hot mix bitumen over new 300mm yellow sand basecourse) covering excavated trenches | m2 | 912 | 36.2 | $33,014 |
| | | | | **SUBTOTAL** | **$1,882,574** |
| 6 | **ENGINEERING DESIGN** | | | | **$94,129** |
| 6.01 | Preparation of engineering design plans (5%) | | | | $94,129 |
| 7 | **PROJECT MANAGEMENT** | | | | **$94,129** |
| 7.01 | Supervision, Project Management etc (5%) | | | | $94,129 |
| 8 | **OTHER CONTINGENCIES** | | | | **$376,515** |
| 8.01 | General (20%) | | | | $376,515 |
| | | | | **TOTAL at 7% NPV** (Rounded to nearest $10,000) | **$2,450,000** |

# PRELIMINARY COST ESTIMATE

**Description of Works** Revision: 1

FM8 - New culverts on Werrington Creek under railway line (and removal of existing)

**Note:** The preliminary costs estimates outlined below have been prepared for comparing and evaluating the feasibility of different drainage mitigation options. They are approximate only and should not be relied upon for budgetting purposes. Detailed costings can only be prepared once detailed design plans are prepared.
Cost estimates only include capital costs and no ongoing maintenance costs are included unless specifically noted.

Reference: Rawlinsons 'Australian Construction Handbook' - Edition 36, 2018

Reg. Index: 1

| Item | Description | Unit | Quantity | Base Rate | Amount |
|---|---|---|---|---|---|
| **1** | **PRELIMINARY ITEMS** | | | | **$48,000** |
| 1.01 | Site Establishment (allowance only) | Lump sum | 1 | 10000 | $10,000 |
| 1.02 | Rail Management | Lump sum | 1 | 30000 | $30,000 |
| 1.03 | OHS&R Plan | Lump sum | 1 | 8000 | $8,000 |
| **2** | **SERVICES** | | | | **$35,000** |
| 2.01 | Services investigation and management of existing water and sewer at railway crossing | Lump sum | 1 | 35000 | $35,000 |
| **2** | **CULVERT TUNNEL JACKING/BORING** | | | | **$405,000** |
| 2.01 | Tunnel Coring under Railway line and lining (3 x 3m x 1.8m) including site establishment costs, microtunnelling, insertion of jacking culverts/lining and connections | m | 15 | 27,000 | $405,000 |
| **3** | **DRAINAGE INFRASTRUCTURE** | | | | **$159,400** |
| 3.01 | Disposal of removed 4 x 2.25m dia culverts and spoil | m3 | 60 | 50 | $3,000 |
| | **Culverts** | | | | |
| 3.02 | 3m W x 1.8m H RCBC (Class 2) | m | 45 | 3400 | $153,000 |
| | **Culvert Headwall** | | | | |
| 3.03 | Placed in-situ Concrete Culvert Headwall at upstream and Downstream of Culverts | m3 | 1 | 3400 | $3,400 |
| **4** | **RAIL WORKS** | | | | **$50,000** |
| 4.01 | Safety mechanism and formwork to support railway during work | Lump sum | 1 | 50000 | $50,000 |
| | | | | **SUBTOTAL** | **$697,400** |
| **5** | **ENGINEERING DESIGN** | | | | **$69,740** |
| 5.01 | Preparation of engineering design plans (10%) | | | | $69,740 |
| **6** | **PROJECT MANAGEMENT** | | | | **$69,740** |
| 6.01 | Supervision, Project Management etc (10%) | | | | $69,740 |
| **7** | **OTHER CONTINGENCIES** | | | | **$278,960** |
| 7.01 | General (40%) | | | | $278,960 |
| | | | | **TOTAL at 7% NPV** (Rounded to nearest $10,000) | **$1,120,000** |

# PRELIMINARY COST ESTIMATE

**Description of Works** Revision: 1

FM9 - New culvert under railway line near French St subdivision

**Note:** The preliminary costs estimates outlined below have been prepared for comparing and evaluating the feasibility of different drainage mitigation options. They are approximate only and should not be relied upon for budgetting purposes. Detailed costings can only be prepared once detailed design plans are prepared.
Cost estimates only include capital costs and no ongoing maintenance costs are included unless specifically noted.

Reference: Rawlinsons 'Australian Construction Handbook' - Edition 36, 2018

Reg. Index: 1

| Item | Description | Unit | Quantity | Base Rate | Amount |
|---|---|---|---|---|---|
| 1 | **PRELIMINARY ITEMS** | | | | **$48,000** |
| 1.01 | Site Establishment (allowance only) | Lump sum | 1 | 10000 | $10,000 |
| 1.02 | Rail Management | Lump sum | 1 | 30000 | $30,000 |
| 1.03 | OHS&R Plan | Lump sum | 1 | 8000 | $8,000 |
| 2 | **SERVICES** | | | | **$25,000** |
| 2.01 | Services investigation and management (water main and gas along Victoria Street) | Lump sum | 1 | 25000 | $25,000 |
| 3 | **EARTHWORKS** | | | | **$206,955** |
| 3.01 | Excavate ground along new culvert alignment (including backfilling/compaction) (trench of 3m width) (Excavate trench >2m deep in soft rock) | m3 | 351 | 219 | $76,869 |
| 3.02 | Excavate roadway, base and ground along culvert alignment (including backfilling/compaction) (trench of 9m width) (Excavate trench >2m deep in soft rock) | m3 | 594 | 219 | $130,086 |
| 4 | **CULVERT TUNNEL JACKING/BORING** | | | | **$315,000** |
| 4.01 | Tunnel Coring under Railway line and lining (1.5m diameter) including site establishment costs, microtunnelling, insertion of jacking culverts/lining and connections | m | 35 | 9,000 | $315,000 |
| 5 | **DRAINAGE INFRASTRUCTURE** | | | | **$285,565** |
| 5.01 | Disposal of removed 2 x 0.9m dia culverts | m3 | 66 | 50 | |
| | **Culverts** | | | | |
| 5.02 | 1.5m RCP (Class 2) | m | 113 | 1,200 | $135,600 |
| 5.03 | 3m W x 0.9m H RCBC (Class 2) | m | 66 | 2094 | $138,204 |
| 5.04 | Grated pit - includes square precast concrete pit and Class D cast iron gully grating (900mm squares x number as required) | No. | 3 | 2,787 | $8,361 |
| | **Culvert Headwall** | | | | |
| 5.05 | Placed in-situ Concrete Culvert Headwall at Downstream of Culverts at Victoria St | m3 | 1 | 3400 | $3,400 |
| 6 | **RAIL WORKS** | | | | **$50,000** |
| 6.01 | Safety mechanism and formwork to support railway during work | Lump sum | 1 | 50000 | $50,000 |
| 7 | **ROAD WORKS** | | | | **$16,478** |
| 7.01 | Roadway Plates to cover open trenches during roadway opening times | Lump sum | 4800 | 4800 | $4,800 |
| 7.02 | Install new pavement (40mm thick hot mix bitumen over new 300mm yellow sand basecourse) covering excavated trenches | m2 | 297 | 36.2 | $10,751 |
| 7.03 | Formation of kerb (Extruded in situ concrete kerb, 600x225mm kerb and gutter) | m | 18 | 51.5 | $927 |
| | | | | **SUBTOTAL** | **$946,998** |
| 8 | **ENGINEERING DESIGN** | | | | **$94,700** |
| 8.01 | Preparation of engineering design plans (10%) | | | | $94,700 |
| 9 | **PROJECT MANAGEMENT** | | | | **$94,700** |
| 9.01 | Supervision, Project Management etc (10%) | | | | $94,700 |
| 10 | **OTHER CONTINGENCIES** | | | | **$189,400** |
| 10.01 | General (20%) | | | | $189,400 |
| | | | | **TOTAL at 7% NPV** (Rounded to nearest $10,000) | **$1,330,000** |

# PRELIMINARY COST ESTIMATE

**Description of Works** Revision: 1

FM10 - New culvert under railway line near Werrington station to parkland

**Note:** The preliminary costs estimates outlined below have been prepared for comparing and evaluating the feasibility of different drainage mitigation options. They are approximate only and should not be relied upon for budgetting purposes. Detailed costings can only be prepared once detailed design plans are prepared.
Cost estimates only include capital costs and no ongoing maintenance costs are included unless specifically noted.

Reference: Rawlinsons 'Australian Construction Handbook' - Edition 36, 2018

Reg. Index: 1

| Item | Description | Unit | Quantity | Base Rate | Amount |
|---|---|---|---|---|---|
| 1 | **PRELIMINARY ITEMS** | | | | **$78,000** |
| 1.01 | Site Establishment (allowance only) | Lump sum | 1 | 10000 | $10,000 |
| 1.02 | Rail Management | Lump sum | 1 | 30000 | $30,000 |
| 1.03 | OHS&R Plan | Lump sum | 1 | 8000 | $8,000 |
| 1.04 | Traffic/Pedestrian Management | Lump sum | 1 | 30000 | $30,000 |
| 2 | **SERVICES** | | | | **$25,000** |
| 2.01 | Services investigation and management (water main and gas along Victoria Street) | Lump sum | 1 | 25000 | $25,000 |
| 3 | **EARTHWORKS** | | | | **$114,099** |
| 3.01 | Excavate ground/roadway along new culvert alignment (including backfilling/compaction) (trench of 1.5m width) (Excavate trench >2m deep in soft rock) | m3 | 521 | 219 | $114,099 |
| 4 | **CULVERT TUNNEL JACKING/BORING** | | | | **$189,000** |
| 4.01 | Tunnel Coring under Railway line and lining (0.525m diameter) including site establishment costs, microtunnelling, insertion of jacking culverts/lining and connections | m | 27 | 7,000 | $189,000 |
| 5 | **DRAINAGE INFRASTRUCTURE** | | | | **$136,537** |
| 5.01 | Disposal of removed 0.75m dia pipe | m3 | 35 | 50 | |
| | **Culverts** | | | | |
| 5.02 | 0.525m RCP (Class 2) | m | 27 | 224 | $6,048 |
| 5.03 | 0.75m RCP (Class 2) | m | 35 | 366 | $12,810 |
| 5.04 | 0.9m RCP (Class 2) | m | 228 | 489 | $111,492 |
| 5.05 | Grated pit - includes square precast concrete pit and Class D cast iron gully grating (900mm squares x number as required) | No. | 1 | 2,787 | $2,787 |
| | **Culvert Headwall** | | | | |
| 5.06 | Placed in-situ Concrete Culvert Headwall at Upstream of new railway culvert | m3 | 1 | 3400 | $3,400 |
| 6 | **RAIL WORKS** | | | | **$50,000** |
| 6.01 | Safety mechanism and formwork to support railway during work | Lump sum | 1 | 50000 | $50,000 |
| 7 | **ROAD WORKS** | | | | **$11,750** |
| 7.01 | Roadway Plates to cover open trenches during roadway opening times | Lump sum | 4800 | 4800 | $4,800 |
| 7.02 | Install new pavement (40mm thick hot mix bitumen over new 300mm yellow sand basecourse) covering excavated trenches | m2 | 192 | 36.2 | $6,950 |
| | | | | **SUBTOTAL** | **$604,386** |
| 8 | **ENGINEERING DESIGN** | | | | **$60,439** |
| 8.01 | Preparation of engineering design plans (10%) | | | | $60,439 |
| 9 | **PROJECT MANAGEMENT** | | | | **$60,439** |
| 9.01 | Supervision, Project Management etc (10%) | | | | $60,439 |
| 10 | **OTHER CONTINGENCIES** | | | | **$120,877** |
| 10.01 | General (20%) | | | | $120,877 |
| | | | | **TOTAL at 7% NPV** (Rounded to nearest $10,000) | **$850,000** |

# PRELIMINARY COST ESTIMATE

**Description of Works** Revision: 1

FM11 - Dunkley Place and Gibson St Stormwater Upgrades

**Note:** The preliminary costs estimates outlined below have been prepared for comparing and evaluating the feasibility of different drainage mitigation options. They are approximate only and should not be relied upon for budgetting purposes. Detailed costings can only be prepared once detailed design plans are prepared.
Cost estimates only include capital costs and no ongoing maintenance costs are included unless specifically noted.

Reference: Rawlinsons 'Australian Construction Handbook' - Edition 36, 2018

Reg. Index: 1

| Item | Description | Unit | Quantity | Base Rate | Amount |
|---|---|---|---|---|---|
| **1** | **PRELIMINARY ITEMS** | | | | **$48,000** |
| 1.01 | Site Establishment (allowance only) | Lump sum | 1 | 10000 | $10,000 |
| 1.02 | OHS&R Plan | Lump sum | 1 | 8000 | $8,000 |
| 1.03 | Traffic/Pedestrian Management | Lump sum | 1 | 30000 | $30,000 |
| **2** | **SERVICES** | | | | **$65,000** |
| 2.01 | Services investigation and management (water main, sewer, gas and NBN on Princess St) | Lump sum | 1 | 65000 | $65,000 |
| **3** | **EARTHWORKS** | | | | **$384,345** |
| 3.01 | Excavate roadway, base and ground along culvert alignment (including backfilling/compaction) (Excavate trench >2m deep in soft rock) | m3 | 1755 | 219 | $384,345 |
| **4** | **DRAINAGE INFRASTRUCTURE** | | | | **$419,960** |
| | **Culverts** | | | | |
| 4.01 | 0.45m RCP (Class 2) | m | 221 | 192 | $42,245 |
| 4.02 | 0.6m RCP (Class 2) | m | 55 | 231 | $12,705 |
| 4.03 | 0.9m RCP (Class 2) | m | 145 | 489 | $70,905 |
| 4.04 | 1.2m RCP (Class 2) | m | 323 | 807 | $260,661 |
| 4.05 | Grated pit - includes square precast concrete pit and Class D cast iron gully grating (900mm squares x number as required) | No. | 12 | 2,787 | $33,444 |
| **5** | **ROAD WORKS** | | | | **$40,095** |
| 5.01 | Roadway Plates to cover open trenches during roadway opening times | Lump sum | 4800 | 4800 | $4,800 |
| 5.02 | Install new pavement (40mm thick hot mix bitumen over new 300mm yellow sand basecourse) covering excavated trenches | m2 | 975 | 36.2 | $35,295 |
| | | | | **SUBTOTAL** | **$957,400** |
| **6** | **ENGINEERING DESIGN** | | | | **$47,870** |
| 6.01 | Preparation of engineering design plans (5%) | | | | $47,870 |
| **7** | **PROJECT MANAGEMENT** | | | | **$95,740** |
| 7.01 | Supervision, Project Management etc (10%) | | | | $95,740 |
| **8** | **OTHER CONTINGENCIES** | | | | **$191,480** |
| 8.01 | General (20%) | | | | $191,480 |
| | | | **TOTAL at 7% NPV** (Rounded to nearest $10,000) | | **$1,290,000** |

# PRELIMINARY COST ESTIMATE

**Description of Works** Revision: 1

FM12 - Orleton Place to Glencoe Avenue Stormwater Upgrades

**Note:** The preliminary costs estimates outlined below have been prepared for comparing and evaluating the feasibility of different drainage mitigation options. They are approximate only and should not be relied upon for budgetting purposes. Detailed costings can only be prepared once detailed design plans are prepared.
Cost estimates only include capital costs and no ongoing maintenance costs are included unless specifically noted.

Reference: Rawlinsons 'Australian Construction Handbook' - Edition 36, 2018

Reg. Index: 1

| Item | Description | Unit | Quantity | Base Rate | Amount |
|---|---|---|---|---|---|
| **1** | **PRELIMINARY ITEMS** | | | | **$48,000** |
| 1.01 | Site Establishment (allowance only) | Lump sum | 1 | 10000 | $10,000 |
| 1.02 | OHS&R Plan | Lump sum | 1 | 8000 | $8,000 |
| 1.03 | Traffic/Pedestrian Management | Lump sum | 1 | 30000 | $30,000 |
| **2** | **SERVICES** | | | | **$30,000** |
| 2.01 | Services investigation (water main, sewer, gas, Optus and electricity), non-destructive excavation and additional protection works during culvert installation | Lump sum | 1 | 30000 | $30,000 |
| **3** | **EARTHWORKS** | | | | **$484,428** |
| 3.01 | Excavate roadway, base and ground along culvert alignment (including backfilling/compaction) (Excavate trench >2m deep in soft rock) | m3 | 2212 | 219 | $484,428 |
| **4** | **DRAINAGE INFRASTRUCTURE** | | | | **$508,703** |
| | **Culverts** | | | | |
| 4.01 | 0.375m RCP (Class 2) | m | 134 | 157 | $21,038 |
| 4.02 | 0.525m RCP (Class 2) | m | 69 | 224 | $15,456 |
| 4.03 | 0.6m RCP (Class 2) | m | 150 | 231 | $34,650 |
| 4.04 | 0.75m RCP (Class 2) | m | 33 | 366 | $12,078 |
| 4.05 | 1.05m RCP (Class 2) | m | 570 | 634 | $361,380 |
| 4.06 | Grated pit - includes square precast concrete pit and Class D cast iron gully grating (900mm squares x number as required) | No. | 23 | 2,787 | $64,101 |
| **5** | **ROAD WORKS** | | | | **$48,240** |
| 5.01 | Roadway Plates to cover open trenches during roadway opening times | Lump sum | 4800 | 4800 | $4,800 |
| 5.02 | Install new pavement (40mm thick hot mix bitumen over new 300mm yellow sand basecourse) covering excavated trenches | m2 | 1200 | 36.2 | $43,440 |
| | | | | **SUBTOTAL** | **$1,119,371** |
| **6** | **ENGINEERING DESIGN** | | | | **$55,969** |
| 6.01 | Preparation of engineering design plans (5%) | | | | $55,969 |
| **7** | **PROJECT MANAGEMENT** | | | | **$111,937** |
| 7.01 | Supervision, Project Management etc (10%) | | | | $111,937 |
| **8** | **OTHER CONTINGENCIES** | | | | **$223,874** |
| 8.01 | General (20%) | | | | $223,874 |
| | | | | **TOTAL at 7% NPV** (Rounded to nearest $10,000) | **$1,510,000** |

# PRELIMINARY COST ESTIMATE

**Description of Works** Revision: 1

FM13 - Rugby St to Neeta St Stormwater Upgrades

**Note:** The preliminary costs estimates outlined below have been prepared for comparing and evaluating the feasibility of different drainage mitigation options. They are approximate only and should not be relied upon for budgetting purposes. Detailed costings can only be prepared once detailed design plans are prepared.
Cost estimates only include capital costs and no ongoing maintenance costs are included unless specifically noted.

Reference: Rawlinsons 'Australian Construction Handbook' - Edition 36, 2018

Reg. Index: 1

| Item | Description | Unit | Quantity | Base Rate | Amount |
|---|---|---|---|---|---|
| **1** | **PRELIMINARY ITEMS** | | | | **$48,000** |
| 1.01 | Site Establishment (allowance only) | Lump sum | 1 | 10000 | $10,000 |
| 1.02 | OHS&R Plan | Lump sum | 1 | 8000 | $8,000 |
| 1.03 | Traffic/Pedestrian Management | Lump sum | 1 | 30000 | $30,000 |
| **2** | **SERVICES** | | | | **$20,000** |
| 2.01 | Services investigation (water main, sewer, gas, Optus and electricity), non-destructive excavation and additional protection works during culvert installation | Lump sum | 1 | 20000 | $20,000 |
| **3** | **EARTHWORKS** | | | | **$229,731** |
| 3.01 | Excavate roadway, base and ground along culvert alignment (including backfilling/compaction) (Excavate trench >2m deep in soft rock) | m3 | 1049 | 219 | $229,731 |
| **4** | **DRAINAGE INFRASTRUCTURE** | | | | **$294,123** |
| | **Culverts** | | | | |
| 4.01 | 0.375m RCP (Class 2) | m | 68 | 157 | $10,676 |
| 4.02 | 0.45m RCP (Class 2) | m | 38 | 192 | $7,277 |
| 4.03 | 0.75m RCP (Class 2) | m | 409 | 366 | $149,584 |
| 4.04 | 0.9m RCP (Class 2) | m | 151 | 489 | $73,839 |
| 4.05 | Grated pit - includes square precast concrete pit and Class D cast iron gully grating (900mm squares x number as required) | No. | 19 | 2,787 | $52,747 |
| **5** | **ROAD WORKS** | | | | **$31,117** |
| 5.01 | Roadway Plates to cover open trenches during roadway opening times | Lump sum | 4800 | 4800 | $4,800 |
| 5.02 | Install new pavement (40mm thick hot mix bitumen over new 300mm yellow sand basecourse) covering excavated trenches | m2 | 727 | 36.2 | $26,317 |
| | | | | **SUBTOTAL** | **$622,971** |
| **6** | **ENGINEERING DESIGN** | | | | **$31,149** |
| 6.01 | Preparation of engineering design plans (5%) | | | | $31,149 |
| **7** | **PROJECT MANAGEMENT** | | | | **$62,297** |
| 7.01 | Supervision, Project Management etc (10%) | | | | $62,297 |
| **8** | **OTHER CONTINGENCIES** | | | | **$124,594** |
| 8.01 | General (20%) | | | | $124,594 |
| | | | **TOTAL at 7% NPV** (Rounded to nearest $10,000) | | **$840,000** |

# PRELIMINARY COST ESTIMATE

**Description of Works** Revision: 1

FM14 - Victoria St to Joseph St Stormwater Upgrades

**Note:** The preliminary costs estimates outlined below have been prepared for comparing and evaluating the feasibility of different drainage mitigation options. They are approximate only and should not be relied upon for budgetting purposes. Detailed costings can only be prepared once detailed design plans are prepared.
Cost estimates only include capital costs and no ongoing maintenance costs are included unless specifically noted.

Reference: Rawlinsons 'Australian Construction Handbook' - Edition 36, 2018

Reg. Index: 1

| Item | Description | Unit | Quantity | Base Rate | Amount |
|---|---|---|---|---|---|
| **1** | **PRELIMINARY ITEMS** | | | | **$48,000** |
| 1.01 | Site Establishment (allowance only) | Lump sum | 1 | 10000 | $10,000 |
| 1.02 | OHS&R Plan | Lump sum | 1 | 8000 | $8,000 |
| 1.03 | Traffic/Pedestrian Management | Lump sum | 1 | 30000 | $30,000 |
| **2** | **SERVICES** | | | | **$15,000** |
| 2.01 | Services investigation (water main, sewer, gas, Optus and electricity), non-destructive excavation and additional protection works during culvert installation | Lump sum | 1 | 15000 | $15,000 |
| **3** | **EARTHWORKS** | | | | **$210,678** |
| 3.01 | Excavate roadway, base and ground along culvert alignment (including backfilling/compaction) (Excavate trench >2m deep in soft rock) | m3 | 962 | 219 | $210,678 |
| **4** | **DRAINAGE INFRASTRUCTURE** | | | | **$276,815** |
| | **Culverts** | | | | |
| 4.01 | 0.75m RCP (Class 2) | m | 570 | 366 | $208,620 |
| 4.02 | Grated pit - includes square precast concrete pit and Class D cast iron gully grating (900mm squares x number as required) | No. | 24 | 2,787 | $68,195 |
| **5** | **ROAD WORKS** | | | | **$28,004** |
| 5.01 | Roadway Plates to cover open trenches during roadway opening times | Lump sum | 4800 | 4800 | $4,800 |
| 5.02 | Install new pavement (40mm thick hot mix bitumen over new 300mm yellow sand basecourse) covering excavated trenches | m2 | 641 | 36.2 | $23,204 |
| | | | | **SUBTOTAL** | **$578,498** |
| **6** | **ENGINEERING DESIGN** | | | | **$28,925** |
| 6.01 | Preparation of engineering design plans (5%) | | | | $28,925 |
| **7** | **PROJECT MANAGEMENT** | | | | **$57,850** |
| 7.01 | Supervision, Project Management etc (10%) | | | | $57,850 |
| **8** | **OTHER CONTINGENCIES** | | | | **$115,700** |
| 8.01 | General (20%) | | | | $115,700 |
| | | | | **TOTAL at 7% NPV** (Rounded to nearest $10,000) | **$780,000** |

# PRELIMINARY COST ESTIMATE

**Description of Works** Revision: 1

FM16 - Jamison Rd to Bringelly Road Stormwater Upgrades

**Note:** The preliminary costs estimates outlined below have been prepared for comparing and evaluating the feasibility of different drainage mitigation options. They are approximate only and should not be relied upon for budgetting purposes. Detailed costings can only be prepared once detailed design plans are prepared.
Cost estimates only include capital costs and no ongoing maintenance costs are included unless specifically noted.

Reference: Rawlinsons 'Australian Construction Handbook' - Edition 36, 2018

Reg. Index: 1

| | Item | Description | Unit | Quantity | Base Rate | Amount |
|---|---|---|---|---|---|---|
| 1 | | **PRELIMINARY ITEMS** | | | | **$58,000** |
| | 1.01 | Site Establishment (allowance only) | Lump sum | 1 | 10000 | $10,000 |
| | 1.02 | OHS&R Plan | Lump sum | 1 | 8000 | $8,000 |
| | 1.03 | Traffic/Pedestrian Management | Lump sum | 1 | 40000 | $40,000 |
| 2 | | **SERVICES** | | | | **$100,000** |
| | 2.01 | Services investigation and management (extensive water main and sewer, gas, extensive NBN on most roadway crossings, and AARNet on Derby St) | Lump sum | 1 | 100000 | $100,000 |
| 3 | | **EARTHWORKS** | | | | **$1,775,433** |
| | 3.01 | Excavate roadway, base and ground along culvert alignment (including backfilling/compaction) (Excavate trench >2m deep in soft rock) | m3 | 8107 | 219 | $1,775,433 |
| 4 | | **DRAINAGE INFRASTRUCTURE** | | | | **$1,055,672** |
| | | **Culverts** | | | | |
| | 4.01 | 0.45m RCP (Class 2) | m | 257 | 192 | $49,216 |
| | 4.02 | 1.5m RCP (Class 2) | m | 500 | 1,200 | $600,000 |
| | 4.03 | 1.8m RCP (Class 2) | m | 221 | 1,695 | $374,595 |
| | 4.04 | Grated pit - includes square precast concrete pit and Class D cast iron gully grating (900mm squares x number as required) | No. | 11 | 2,787 | $31,861 |
| 5 | | **ROAD WORKS** | | | | **$57,000** |
| | 5.01 | Roadway Plates to cover open trenches during roadway opening times | Lump sum | 4800 | 4800 | $4,800 |
| | 5.02 | Install new pavement (40mm thick hot mix bitumen over new 300mm yellow sand basecourse) covering excavated trenches | m2 | 1442 | 36.2 | $52,200 |
| | | | | | **SUBTOTAL** | **$3,046,105** |
| 6 | | **ENGINEERING DESIGN** | | | | **$91,383** |
| | 6.01 | Preparation of engineering design plans (3%) | | | | $91,383 |
| 7 | | **PROJECT MANAGEMENT** | | | | **$152,305** |
| | 7.01 | Supervision, Project Management etc (5%) | | | | $152,305 |
| 8 | | **OTHER CONTINGENCIES** | | | | **$304,611** |
| | 8.01 | General (10%) | | | | $304,611 |
| | | | | | **TOTAL at 7% NPV** (Rounded to nearest $10,000) | **$3,590,000** |

# PRELIMINARY COST ESTIMATE

**Description of Works** Revision: 1

FM17 - College and Orth Creek Channel Enlargement

**Note:** The preliminary costs estimates outlined below have been prepared for comparing and evaluating the feasibility of different drainage mitigation options. They are approximate only and should not be relied upon for budgetting purposes. Detailed costings can only be prepared once detailed design plans are prepared. Cost estimates only include capital costs and no ongoing maintenance costs are included unless specifically noted.

Reference: Rawlinsons 'Australian Construction Handbook' - Edition 36, 2018

Reg. Index: 1

| Item | | Description | Unit | Quantity | Base Rate | Amount |
|---|---|---|---|---|---|---|
| 1 | | **PRELIMINARY ITEMS** | | | | **$13,260** |
| | 1.01 | Site Establishment (allowance only) | Lump sum | 1 | 3,000 | $3,000 |
| | 1.02 | QA & ITP | Lump sum | 1 | 1,000 | $1,000 |
| | 1.03 | Water Management Plan incl. Erosion and Sediment Control Plan | Lump sum | 1 | 1,000 | $1,000 |
| | 1.04 | OHS&R Plan | Lump sum | 1 | 1,000 | $1,000 |
| | 1.05 | Erosion and Sediment control - Geotextile Silt Fence around site | m | 440 | 16.50 | $7,260 |
| 2 | | **EARTHWORKS** | | | | **$243,473** |
| | 2.01 | Excavate over site to reduce levels - in clay) and form 1:4 side slope batters | m3 | 7070 | 30.80 | $217,756 |
| | 2.02 | Disposal of excess excavated fill (transport and deposit within 5km of site) | $m^3$ | 7070 | 3.10 | $21,917 |
| | 2.03 | Rock scour protection around culvert outlets (gabion rock mattress) | $m^3$ | 10 | 380 | $3,800 |
| 3 | | **LANDSCAPING** | | | | **$2,470** |
| | 3.01 | Sprayed Grass Seed Compound Hydro Mulch | m2 | 7720 | 0.32 | $2,470 |
| | | | | | **SUBTOTAL** | **$259,203** |
| 4 | | **ENGINEERING DESIGN** | | | | **$12,960** |
| | 4.01 | Preparation of engineering design plans (5%) | | | | $12,960 |
| 5 | | **PROJECT MANAGEMENT** | | | | **$12,960** |
| | 5.01 | Supervision, Project Management etc (5%) | | | | $12,960 |
| 6 | | **OTHER CONTINGENCIES** | | | | **$25,920** |
| | 6.01 | General (10%) | | | | $25,920 |
| | | | **TOTAL at 7% NPV** (Rounded to nearest $10,000) | | | **$310,000** |

# PRELIMINARY COST ESTIMATE

**Description of Works** Revision: 1

FM18 - Great Western Highway Median Modification

**Note:** The preliminary costs estimates outlined below have been prepared for comparing and evaluating the feasibility of different drainage mitigation options. They are approximate only and should not be relied upon for budgetting purposes. Detailed costings can only be prepared once detailed design plans are prepared.
Cost estimates only include capital costs and no ongoing maintenance costs are included unless specifically noted.

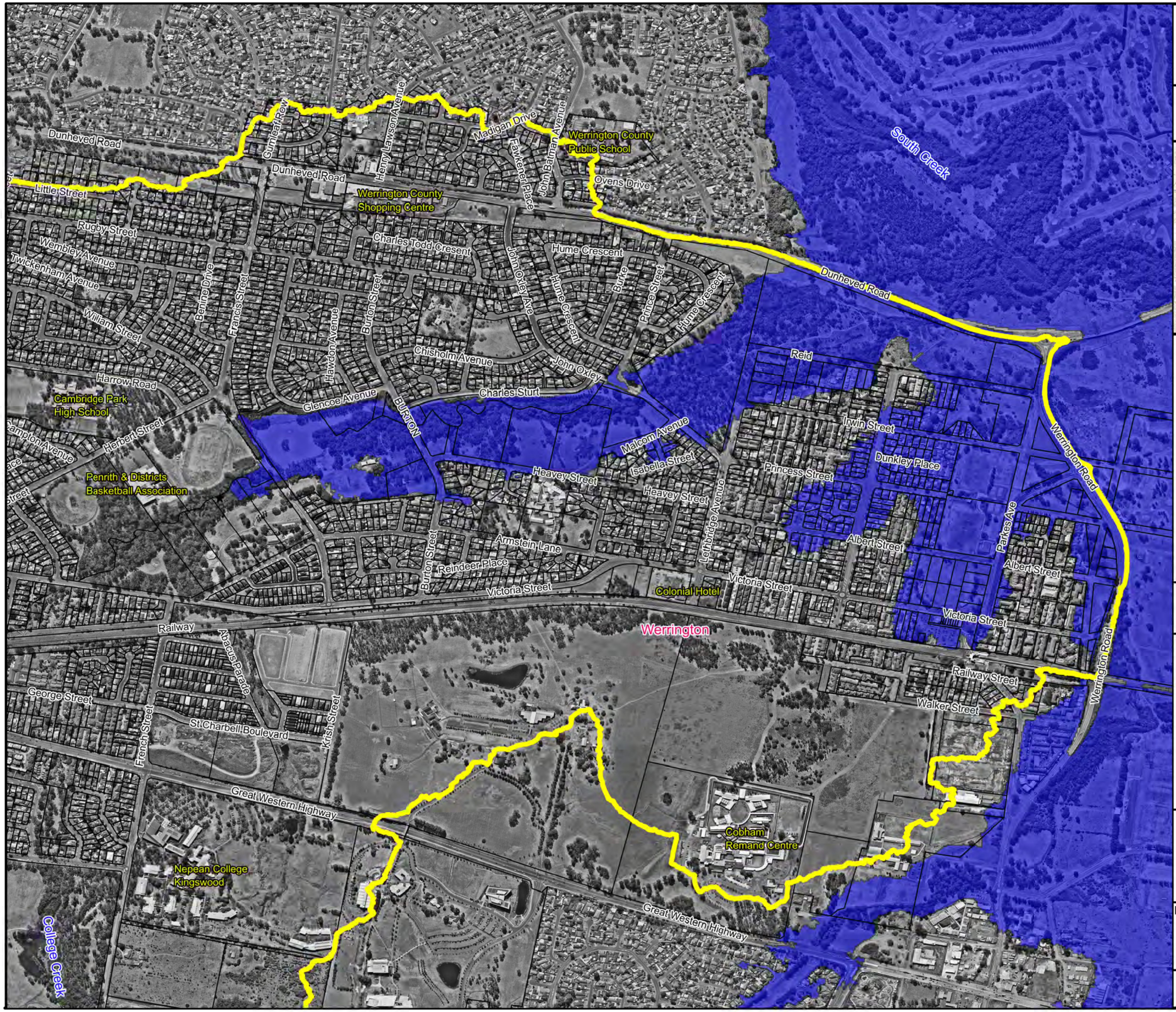
Reference: Rawlinsons 'Australian Construction Handbook' - Edition 36, 2018

Reg. Index: 1

| Item | Description | Unit | Quantity | Base Rate | Amount |
|---|---|---|---|---|---|
| **1** | **PRELIMINARY ITEMS** | | | | **$28,000** |
| 1.01 | Site Establishment (allowance only) | Lump sum | 1 | 10000 | $10,000 |
| 1.02 | OHS&R Plan | Lump sum | 1 | 8000 | $8,000 |
| 1.03 | Traffic/Pedestrian Management | Lump sum | 1 | 10000 | $10,000 |
| **2** | **EARTHWORKS** | | | | **$5,475** |
| 2.01 | Excavate median, roadway, base and ground in median footprint (Excavate trench >2m deep in soft rock) | m3 | 25 | 219 | $5,475 |
| **3** | **ROAD WORKS** | | | | **$9,303** |
| 3.01 | Install new pavement (40mm thick hot mix bitumen over new 300mm yellow sand basecourse) covering removed median | m2 | 257 | 36.2 | $9,303 |
| | | | | **SUBTOTAL** | **$42,778** |
| **4** | **ENGINEERING DESIGN** | | | | **$4,278** |
| 4.01 | Preparation of engineering design plans (10%) | | | | $4,278 |
| **5** | **PROJECT MANAGEMENT** | | | | **$4,278** |
| 5.01 | Supervision, Project Management etc (10%) | | | | $4,278 |
| **6** | **OTHER CONTINGENCIES** | | | | **$8,556** |
| 6.01 | General (20%) | | | | $8,556 |
| | | | | **TOTAL at 7% NPV** (Rounded to nearest $10,000) | **$60,000** |

# APPENDIX J

## SOUTH CREEK AND HAWKESBURY-NEPEAN INUNDATION MAPS




PENRITH CITY COUNCIL

**College, Orth and Werrington Creek Catchment Flood Risk Management Study and Plan**

## LEGEND

- Catchment Boundary
- South Creek 0.2% AEP Extent
  Please refer to 'South Creek Floodplain Risk Management Study' (Advisian, 2020) for more information

Notes:

N W E S

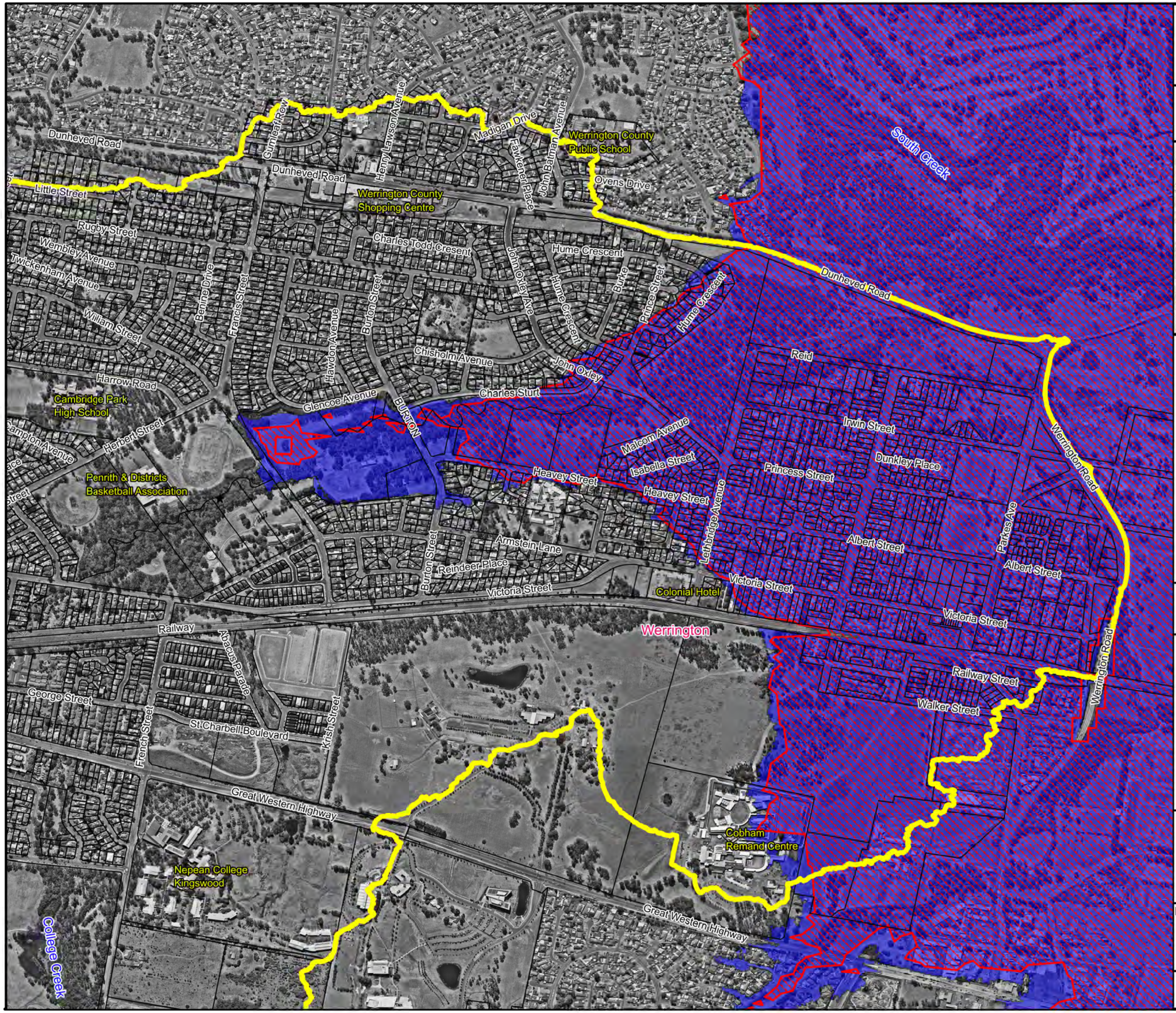
Scale 1:9,000 (at A3)

0 0.25 0.5 Km

**Figure J1:**
**South Creek Inundation Extent for the 0.2% AEP Flood**

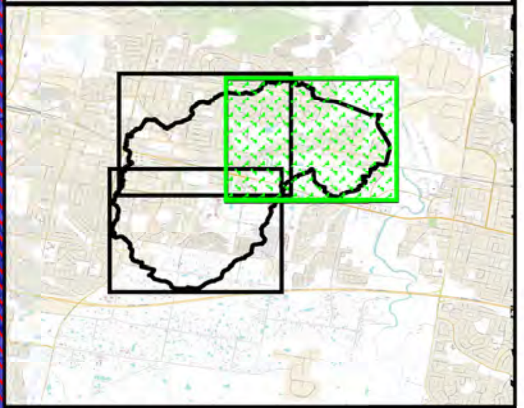
Prepared By:
Catchment Simulation Solutions
Suite 10.01, 70 Phillip St
Sydney, NSW 2000

File Name: Figure J1 South Creek Inundation Extent for the 0.2% AEP Flood.wor




PENRITH CITY COUNCIL

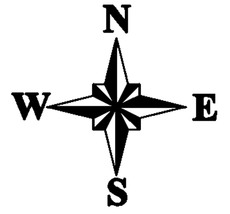
**College, Orth and Werrington Creek Catchment Flood Risk Management Study and Plan**



## LEGEND

- Catchment Boundary
- Hawkesbury-Nepean PMF extent
  Please refer to 'Hawkesbury-Nepean Valley Regional Flood Study' (WMAwater,2019) for more information
- South Creek PMF Extent
  Please refer to 'South Creek Floodplain Risk Management Study' (Advisian, 2020) for more information

Notes:




Scale 1:9,000 (at A3)

0 0.25 0.5 Km

**Figure J2: South Creek and Hawkesbury-Nepean Inundation Extent for the PMF**

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File Name: Figure J2 South Creek and Hawkesbury-Nepean Inundation Extent for the PMF.wor

# APPENDIX K

## ARR2019 ASSESSMENT

## 1.1 Introduction

The following appendix describe the inputs and methodology that was employed to develop updated design flood estimates for the College, Orth and Werrington Creeks catchments. The design flood estimates were developed based on *'Australian Rainfall and Runoff: A Guide to Flood Estimation'* (Ball et al, 2019) (ARR2019).

As discussed in the main report, a direct rainfall TUFLOW model was developed as part of the original flood study and was retained (with updates) as part of the floodplain risk management study to simulate flood hydrology and hydraulics. However, it was noted that full application of the ARR2019 procedures using this direct rainfall model would not be possible due to the large number of storms that require assessment and the long simulation times for the TUFLOW model. Therefore, the initial hydrologic assessment was completed using an XP-RAFTS hydrologic model that was also developed as part of the flood study for verification purposes. This allowed the large number of storms to be simulated in a timely manner and the outputs from the XP-RAFTS modelling could be used to select the critical durations and temporal patterns to apply to the TUFLOW model.

## 1.2 Hydrology

### 1.2.1 Rainfall

Point design rainfall depths for the catchment were downloaded from the Bureau of Meteorology's 2016 IFD webpage for a range of storm frequencies and durations. A copy of the design rainfall depths are provided in **Table 1**.

Probable Maximum Precipitation (PMP) depth estimates were not re-extracted as the PMP procedures have not been revised as part of the ARR2019 updates. However, the PMP depths are included in **Table 1** for comparison purposes.

### 1.2.2 Areal Reduction Factors

The design rainfall intensities presented in the preceding section are only applicable for catchment areas of up to 1 km$^2$. Therefore, ARR2019 includes areal reduction factors that recognise that there is unlikely to be a uniformly high rainfall intensity across all sections of large catchments.

The primary input variable to calculate the areal reduction factors is the contributing catchment area. A review of the subcatchment areas was completed and determined that most subcatchments located in flooding "trouble spots" (as identified in the original flood study) have a contributing upstream catchment of less than 1 km$^2$. Therefore, to ensure the flood risk was not underrepresented in the most problematic flooding areas, no areal reduction factors were applied as part of the assessment.

Table 1 Design Rainfall Depths

| DURATION | Average Rainfall Depth (mm) | | | | | | |
|---|---|---|---|---|---|---|---|
| | **0.5EY** | **20% AEP** | **5% AEP** | **1% AEP** | **0.5% AEP** | **0.2% AEP** | **PMP** |
| **10 min** | 12.3 | 17.4 | 24.5 | 32.9 | 35.6 | 40.2 | N/A |
| **15 min** | 15.4 | 21.8 | 30.6 | 41.1 | 44.6 | 50.4 | 150 |
| **20 min** | 17.6 | 24.9 | 35 | 47 | 51.1 | 57.7 | N/A |
| **30 min** | 20.8 | 29.2 | 41 | 55.1 | 59.9 | 67.8 | 220 |
| **45 min** | 23.9 | 33.4 | 46.7 | 62.9 | 68.5 | 77.5 | 270 |
| **1 hour** | 26.2 | 36.4 | 50.7 | 68.4 | 74.6 | 84.4 | 320 |
| **1.5 hour** | 29.7 | 40.9 | 56.8 | 76.7 | 83.6 | 94.6 | 410 |
| **2 hours** | 32.5 | 44.4 | 61.6 | 83.4 | 90.7 | 103 | 480 |
| **3 hours** | 37.2 | 50.4 | 69.8 | 94.7 | 103 | 116 | 580 |
| **6 hours** | 47.9 | 64.8 | 90 | 122 | 132 | 149 | 780 |
| **12 hours** | 63.7 | 87.5 | 123 | 167 | 180 | 202 | N/A |
| **24 hours** | 85.8 | 121 | 171 | 233 | 253 | 286 | N/A |
| **48 hours** | 112 | 162 | 234 | 315 | 361 | 417 | N/A |
| **72 hours** | 127 | 186 | 269 | 361 | 406 | 464 | N/A |

NOTE: N/A indicates a design rainfall is not available for the nominated storm duration

### 1.2.3 Effective Impervious Area

Historically, impervious areas in hydrologic models were represented as the "total impervious area" (TIA). This concept assumes that with the exception of the initial wetting of the catchment, all impervious areas contribute fully to runoff. However, research dating back to the 1970s (e.g., Cherkaver, 1975, Beard and Shin, 1979) highlights the importance of using the "Effective Impervious Area" (EIA) in preference to the TIA to better account for impervious areas that are not directly connected to the drainage system (referred to as indirectly connected impervious areas).

An example of an indirectly connected impervious area is a foot path which is adjoined by a grassed area. In instances such as this, any runoff from the footpath will flow onto the grassed area and this runoff will have an additional opportunity to infiltrate into the underlying soils, thereby reducing the contribution of runoff.

Accordingly, Book 5 of ARR2016 advocates the use of EIA when modelling urbanised catchments to ensure urban runoff volumes and peak flows are not overestimated. Although ARR2016 presents a range of approaches for estimating the EIA, the most straight forward approach is estimating the EIA as a percentage of the TIA. Section 3.4.2.2 of Book 5 outlines that EIA will typically be 50% to 70% of the TIA. That is, only 50% to 70% of the total impervious area is directly connected to the drainage system. The remaining 30% to 50% of the impervious area is, therefore, indirectly connected and has additional infiltration opportunity.

For this study, the 70% adjustment factor (i.e., the most conservative factor) was adopted. That is, the total impervious areas that were calculated for each subcatchment were multiplied by 0.7 to develop a revised “EIA version” of the model.

### 1.2.4 Rainfall Losses

*Initial Losses*

Initial rainfall losses for pervious catchment areas were applied using probability neutral burst loss information extracted from the ARR2019 data hub. However, the data hub rainfall loss information is applicable for rural catchments only. A review of Section 3.5.3.2.1 of Book 5 of ARR2019 suggests that for catchments with an urban component (such as Werrington Creek), the pervious storm initial loss should be 60 to 80% of the rural storm initial loss to account for the reduced infiltration potential across catchments with an urban proportion (most notably from indirectly connected impervious areas). For this study, the 70% factor was adopted providing adjusted probability neutral burst losses which are summarised in Table 2.

For impervious areas, Section 3.5.3.1.2 of Book 5 of ARR2019 recommends a storm initial loss of 1 mm. However, the storm loss of 1 mm needs to be adjusted to a burst loss by subtracting the pre burst rainfall. This yielded an impervious burst loss of 0 mm for all storm durations.

*Continuing Loss Rates*

The ARR2019 data hub rainfall loss information for the College, Orth and Werrington Creeks Catchment indicates a rural continuing loss rate of 3.4 mm/hr. However, ARR2019 recommends that, in the absence of reliable calibrated continuing loss data, that the published data hub continuing loss rates be adjusted by a factor of 0.4. As such, an adjusted pervious/indirectly connected impervious continuing loss rate of 1.36 mm/hr was adopted.

For impervious areas, Section 3.5.3.1.2 of Book 5 of ARR2019 recommends a continuing loss rate of 0 mm/hr.

Table 2 Pervious Burst Losses

| Storm Duration | Burst Rainfall Loss (mm) | | | | | |
|---|---|---|---|---|---|---|
| | 0.5EY | 20% AEP | 10% AEP | 5% AEP | 2% AEP | 1% AEP |
| Less than 1 hour | 18.4 | 12.9 | 11.6 | 11.7 | 10.7 | 8.5 |
| 1 hour | 18.4 | 12.9 | 11.6 | 11.7 | 10.7 | 8.5 |
| 1.50 hour | 20.9 | 14.1 | 12.0 | 11.7 | 10.9 | 10.5 |
| 2 hours | 22.8 | 12.3 | 10.8 | 10.3 | 9.3 | 8.9 |
| 3 hours | 22.1 | 11.6 | 10.1 | 10.0 | 9.5 | 7.1 |
| 6 hours | 21.7 | 12.4 | 10.5 | 9.5 | 8.1 | 4.9 |
| 12 hours | 22.1 | 15.3 | 14.3 | 13.3 | 11.8 | 6.5 |
| 18 hours | 23.6 | 17.2 | 16.1 | 15.1 | 13.0 | 8.0 |
| 24 hours | 26.8 | 20.9 | 19.6 | 19.3 | 17.3 | 11.1 |
| 36 hours | 27.5 | 22.9 | 22.2 | 22.7 | 19.5 | 9.5 |
| 48 hours | 31.1 | 27.2 | 27.2 | 30.0 | 24.1 | 12.0 |
| 72 hours | 33.8 | 29.5 | 28.6 | 31.8 | 26.5 | 17.9 |

### 1.2.5 Temporal Patterns

ARR2019 employs 10 different temporal patterns for each AEP/storm duration to define the time variation in rainfall during each storm. The use of a variety of different temporal patterns is intended to reflect the natural variability of a typical rainfall event (i.e., no two storms will be the same).

The temporal patterns for the study area were downloaded from the ARR data hub and were used to simulate the temporal distribution of rainfall for each design storm. In accordance with ARR2019 for catchments with an area less than 75 $km^2$, the "point" temporal patterns rather than "areal" temporal patterns were selected to describe the temporal variation in rainfall.

ARR2019 groups the temporal patterns into "frequent", "intermediate" and "rare" bins, which were applied to each design storm as follows:

- Frequent temporal patterns: 0.5EY and 20% AEP
- Intermediate temporal patterns: 10% AEP and 5% AEP
- Rare temporal patterns: 2% AEP, 1% AEP, 0.5% AEP and 0.2% AEP

### 1.2.6 Results

The XP-RAFTS model was used to simulate rainfall runoff processes for the complete suite of ARR2019 design storms. The design 0.5EY, 20% AEP, 10% AEP, 5% AEP, 2% AEP, 1% AEP, 0.5% AEP and 0.2% AEP storms were simulated in addition to the PMP.

As discussed, a suite of ten temporal patterns were used to represent the temporal variation in rainfall for each design storm frequency up to and including the 0.2% AEP event. The peak discharges from the full suite of temporal patterns for each design event were reviewed to determine the critical storm duration for each subcatchment. The critical storm duration was defined by calculating the average discharge for each storm duration for each subcatchment (based on all 10 temporal patterns). The storm duration that generated the highest average discharge was selected as the critical duration for that particular subcatchment. The resulting critical storm durations for each subcatchment are presented at the end of this appendix. The results of the hydrologic analysis indicate that the critical duration across the catchment generally varies between 15 minutes and 12 hours with storm durations of equal to or less than 3 hours being most commonly critical.

Once the critical duration was determined, a representative temporal pattern was selected for that duration. The temporal pattern that generated the peak discharge immediately above the mean discharge was selected as the most representative temporal pattern for each subcatchment. The adopted temporal pattern and the associated design discharge for each subcatchment is also provided at the end of this appendix.

The hydrologic results presented at the end of this appendix show many unique, critical storms for each AEP.

ARR2019 box plots for each AEP event were also prepared for the 8 "focus locations" to better display the full range of results produced as part of the ARR2019 hydrologic analysis. The focus locations are shown in **Plate 1** and the box plots are provided at the end of this appendix. The box plots show:

- Median discharge for each storm duration (represented by the blue horizontal line contained within each green box);
- Mean discharge for each storm duration (defined by the "✳");
- The first and third quartiles (defined by the green box), which illustrated the 25$^{th}$ percentile and 75$^{th}$ percentile discharge values;
- The highest and lowest discharge value (represented by the "T" attached to the end of the green box)
- The critical storm duration is highlighted in yellow

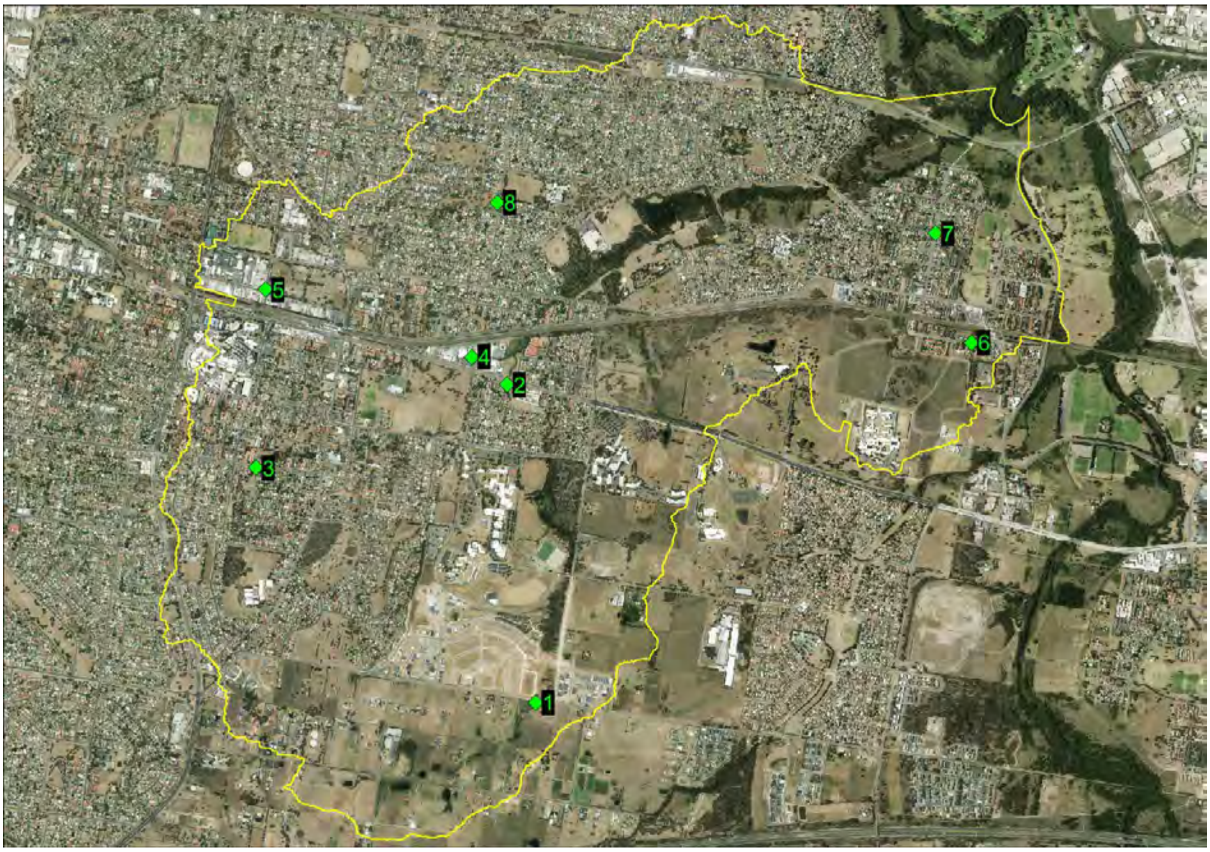



Plate 1 "Focus" locations (green) selected for critical duration & temporal pattern analysis

## 1.3 Hydraulics

### 1.3.1 Boundary Conditions

***Inflow Boundaries***

As discussed in the previous sections, an XP-RAFTS model was used to undertake the initial ARR2019 hydrologic assessment and determine the critical storm durations and temporal patterns for various locations in the catchment for each design storm. The outputs from the XP-RAFTS model was used to define inflow boundary conditions for the TUFLOW model.

However, as noted above, a large number of unique critical durations and temporal patterns were determined as part of the initial hydrologic analysis. Although the XP-RAFTS model runs all required storms in a matter of seconds, the TUFLOW model takes several hours to run a single storm. Therefore, it was not considered feasible to run all unique combinations of storm durations and temporal patterns through the TUFLOW model in a timely manner.

Therefore, the assessment of critical durations and temporal patterns was restricted to the "focus" locations shown in **Plate 1**.

Once the assessment of critical durations and temporal patterns was reduced from every subcatchments (i.e., 206 locations) down to just focus locations, the number of unique durations and temporal patterns was significantly reduced. The temporal patterns and storm durations that were ultimately selected for each AEP are summarised in **Table 3**.

The TUFLOW model was subsequently used to simulate design flood behaviour for each of the temporal patterns and storm durations in **Table 3**. .

***Downstream Water Level Boundary***

In addition to flooding from local catchment runoff generated by the College, Orth and Werrington Creeks catchment, flooding across the downstream sections of the catchment can also be influenced by elevated water levels in South Creek.

The *'College, Orth and Werrington Creeks Catchment Overland Flow Flood Study'* (2017) adopted the following peak flood levels in South Creek along the downstream model boundary. These levels were retained as part of the current study:

- 0.5EY: 20.50 mAHD
- 20% AEP: 20.89 mAHD
- 10% AEP: 21.06 mHD
- Equal to and greater than 5% AEP: 21.29mAHD

### 1.3.2 Blockage

Table 3 Adopted temporal patterns and storm durations for hydraulic analysis

| Design Storm | Storm Durations and Temporal Pattern ID | | | | | | |
|---|---|---|---|---|---|---|---|
| | 15 mins | 20 mins | 25 mins | 45 mins | 60 mins | 90 mins | 120 mins |
| 0.5EY | 4421 | 4445 | | 4545 | | | |
| 0.2EY | 4421 | 4444 | | 4550 | 4577 | | 4624, 4628 |
| 10% AEP | 4421 | 4444 | | 4550 | 4577 | | 4630 |
| 5% AEP | 4400 | 4367 | | 4528 | 4557 | | 4499 |
| 2% AEP | 4400 | 4432 | | 4528 | 4569 | | 4618 |
| 1% AEP | 4400 | 4432 | | 4528 | 4555 | | 4614 |
| 0.5% AEP | 4400 | 4433 | 4467 | 4528 | 4558 | 4585 | 4431 |
| 0.2% AEP | 4400 | 4433 | 4456 | 4528 | 4405, 4555 | 4585 | |

### *Culvert and Bridge Blockage*

Blockage factors for each bridge and culvert were estimated as part of the *'College, Orth and Werrington Creeks Catchment Overland Flow Flood Study'* (2017) based upon recommendations in 'Blockage of Hydraulic Structures' (Engineers Australia, 2015). The blockage factors were reviewed and were determined to be appropriate for application as part of the current study.

### *Stormwater Blockage*

Stormwater pit and grate blockage factors were assigned in the TUFLOW model based upon Penrith City Council's blockage policy. The adopted blockage factors are summarised in **Table 4**.

Table 4 Adopted Stormwater Pit Blockage Factors

| Pit Type | Blockage Factor |
|---|---|
| Side entry (Sag) | 20% |
| Grated (Sag) | 50% |
| Combination (Sag) | Side inlet capacity only (i.e., complete blockage of grate) |
| Letterbox (Sag) | 50% |
| Side entry (On-Grade) | 20% |
| Grated (On-Grade) | 50% |
| Combination (On-Grade) | 10% |

### 1.3.3 Design Flood Envelope

As discussed, a range of design storms were simulated for each design flood. Therefore, the results from each simulation for each design flood were combined to form a "design flood envelope" for each design flood. It is this "design flood envelope" comprising the most critical depths, velocities and levels from a risk management perspective that forms the basis for the results documented Chapter 4 of the report.

# XP-RAFTS Results

## ARR2019 Results for 0.5EY Event

| Subcatch ID | ARR2019 Discharge Statistics for All Durations and Temp. Patterns | | | |
|---|---|---|---|---|
| | Critical Duration (mins) | Adopted Temp. Pattern | Discharge ($m^3/s$) | |
| | | | Average | Adopted |
| 1.01 | 360 | 4737 (TP5) | 0.19 | 0.17 |
| 1.02 | 360 | 4738 (TP6) | 0.56 | 0.53 |
| 1.03 | 360 | 4737 (TP5) | 0.73 | 0.73 |
| 1.04 | 360 | 4737 (TP5) | 0.78 | 0.79 |
| 1.05 | 360 | 4737 (TP5) | 1.00 | 1.03 |
| 1.06 | 360 | 4737 (TP5) | 1.10 | 1.13 |
| 1.07 | 360 | 4737 (TP5) | 1.90 | 1.97 |
| 1.08 | 20 | 4450 (TP5) | 2.58 | 2.55 |
| 1.09 | 15 | 4419 (TP3) | 4.48 | 4.48 |
| 1.1 | 360 | 4737 (TP5) | 4.73 | 4.78 |
| 1.11 | 360 | 4737 (TP5) | 5.02 | 5.13 |
| 1.12 | 360 | 4737 (TP5) | 5.20 | 5.30 |
| 1.13 | 360 | 4737 (TP5) | 5.39 | 5.46 |
| 1.14 | 360 | 4737 (TP5) | 5.44 | 5.49 |
| 1.15 | 360 | 4737 (TP5) | 5.65 | 5.73 |
| 1.16 | 360 | 4737 (TP5) | 5.71 | 5.79 |
| 1.17 | 360 | 4737 (TP5) | 15.15 | 15.85 |
| 1.18 | 360 | 4737 (TP5) | 15.87 | 16.72 |
| 1.19 | 360 | 4737 (TP5) | 17.16 | 18.08 |
| 1.2 | 360 | 4737 (TP5) | 18.08 | 18.93 |
| 1.21 | 360 | 4737 (TP5) | 18.38 | 19.18 |
| 1.22 | 360 | 4737 (TP5) | 19.47 | 20.45 |
| 1.23 | 360 | 4737 (TP5) | 19.59 | 20.62 |
| 1.24 | 360 | 4737 (TP5) | 19.62 | 20.65 |
| 1.25 | 360 | 4737 (TP5) | 19.97 | 21.13 |
| 1.26 | 720 | 4809 (TP7) | 22.06 | 20.20 |
| 2.01 | 1080 | 4833 (TP1) | 0.00 | 0.00 |
| 3.01 | 360 | 4738 (TP6) | 0.18 | 0.17 |
| 3.02 | 60 | 4582 (TP9) | 0.30 | 0.32 |
| 4.01 | 1080 | 4833 (TP1) | 0.00 | 0.00 |
| 5.01 | 15 | 4425 (TP9) | 1.82 | 1.91 |
| 5.02 | 15 | 4421 (TP5) | 2.27 | 2.31 |
| 6.01 | 360 | 4738 (TP6) | 0.08 | 0.07 |
| 6.02 | 360 | 4738 (TP6) | 0.33 | 0.31 |
| 7.01 | 15 | 4425 (TP9) | 0.76 | 0.80 |
| 8.01 | 15 | 4425 (TP9) | 0.70 | 0.73 |
| 9.01 | 360 | 4737 (TP5) | 0.41 | 0.41 |
| 9.02 | 20 | 4450 (TP5) | 0.86 | 0.84 |
| 9.03 | 20 | 4448 (TP3) | 0.98 | 0.98 |
| 9.04 | 15 | 4424 (TP8) | 1.53 | 1.51 |
| 9.05 | 20 | 4455 (TP10) | 1.98 | 2.00 |
| 9.06 | 30 | 4517 (TP3) | 2.24 | 2.24 |
| 9.07 | 30 | 4516 (TP2) | 2.46 | 2.48 |
| 9.08 | 15 | 4423 (TP7) | 3.08 | 3.19 |
| 9.09 | 45 | 4553 (TP9) | 3.46 | 3.51 |
| 9.1 | 45 | 4553 (TP9) | 3.46 | 3.46 |
| 9.11 | 45 | 4552 (TP8) | 3.55 | 3.55 |
| 9.12 | 45 | 4547 (TP3) | 3.91 | 3.95 |
| 9.13 | 45 | 4548 (TP4) | 3.97 | 4.02 |
| 9.14 | 45 | 4552 (TP8) | 7.23 | 7.28 |
| 9.15 | 45 | 4549 (TP5) | 7.49 | 7.60 |
| 9.16 | 45 | 4546 (TP2) | 8.63 | 8.73 |
| 9.17 | 45 | 4545 (TP1) | 10.04 | 10.10 |
| 9.18 | 45 | 4545 (TP1) | 10.06 | 10.11 |
| 9.19 | 45 | 4545 (TP1) | 10.08 | 10.13 |
| 10.01 | 15 | 4425 (TP9) | 0.35 | 0.37 |
| 11.01 | 15 | 4423 (TP7) | 0.35 | 0.37 |
| 11.02 | 15 | 4426 (TP10) | 0.44 | 0.43 |
| 11.03 | 15 | 4421 (TP5) | 0.51 | 0.50 |
| 12.01 | 15 | 4418 (TP2) | 0.31 | 0.32 |
| 12.02 | 15 | 4418 (TP2) | 0.70 | 0.74 |
| 13.01 | 15 | 4425 (TP9) | 0.64 | 0.68 |
| 13.02 | 15 | 4418 (TP2) | 0.89 | 0.93 |
| 14.01 | 15 | 4418 (TP2) | 0.45 | 0.48 |
| 15.01 | 15 | 4423 (TP7) | 0.43 | 0.44 |
| 16.01 | 15 | 4425 (TP9) | 0.87 | 0.91 |
| 17.01 | 15 | 4423 (TP7) | 0.14 | 0.14 |
| 18.01 | 15 | 4423 (TP7) | 0.08 | 0.08 |
| 19.01 | 15 | 4423 (TP7) | 0.10 | 0.10 |
| 19.02 | 20 | 4448 (TP3) | 0.72 | 0.71 |
| 19.03 | 15 | 4421 (TP5) | 1.60 | 1.62 |
| 19.04 | 15 | 4421 (TP5) | 2.71 | 2.73 |
| 19.05 | 20 | 4451 (TP6) | 2.95 | 2.94 |
| 19.06 | 20 | 4449 (TP4) | 3.03 | 3.00 |

| Subcatch ID | ARR2019 Discharge Statistics for All Durations and Temp. Patterns | | | |
|---|---|---|---|---|
| | Critical Duration (mins) | Adopted Temp. Pattern | Discharge ($m^3/s$) | |
| | | | Average | Adopted |
| 19.07 | 20 | 4445 (TP1) | 3.53 | 3.55 |
| 19.08 | 30 | 4523 (TP9) | 3.63 | 3.61 |
| 20.01 | 15 | 4423 (TP7) | 0.23 | 0.23 |
| 21.01 | 15 | 4423 (TP7) | 0.01 | 0.01 |
| 22.01 | 15 | 4425 (TP9) | 1.11 | 1.17 |
| 23.01 | 15 | 4423 (TP7) | 0.38 | 0.39 |
| 23.02 | 15 | 4418 (TP2) | 1.43 | 1.51 |
| 23.03 | 25 | 4485 (TP4) | 0.45 | 0.45 |
| 23.04 | 45 | 4547 (TP3) | 0.45 | 0.45 |
| 23.05 | 180 | 4677 (TP8) | 0.44 | 0.46 |
| 23.06 | 360 | 4737 (TP5) | 0.47 | 0.48 |
| 23.07 | 360 | 4737 (TP5) | 0.48 | 0.49 |
| 23.08 | 60 | 4578 (TP5) | 0.54 | 0.54 |
| 23.09 | 60 | 4578 (TP5) | 0.76 | 0.78 |
| 23.1 | 60 | 4578 (TP5) | 0.85 | 0.86 |
| 23.11 | 15 | 4426 (TP10) | 2.34 | 2.36 |
| 24.01 | 15 | 4425 (TP9) | 0.37 | 0.38 |
| 24.02 | 15 | 4418 (TP2) | 1.32 | 1.40 |
| 25.01 | 15 | 4423 (TP7) | 0.00 | 0.00 |
| 26.01 | 1440 | 4877 (TP4) | 0.00 | 0.00 |
| 26.02 | 15 | 4423 (TP7) | 0.16 | 0.17 |
| 26.03 | 20 | 4448 (TP3) | 1.08 | 1.06 |
| 26.04 | 20 | 4445 (TP1) | 1.17 | 1.17 |
| 26.05 | 20 | 4449 (TP4) | 1.10 | 1.10 |
| 26.06 | 45 | 4547 (TP3) | 0.85 | 0.84 |
| 26.07 | 45 | 4547 (TP3) | 0.89 | 0.91 |
| 26.08 | 45 | 4552 (TP8) | 0.89 | 0.91 |
| 26.09 | 60 | 4575 (TP2) | 1.01 | 1.02 |
| 26.1 | 60 | 4580 (TP7) | 0.92 | 0.91 |
| 26.11 | 60 | 4577 (TP4) | 0.95 | 0.96 |
| 26.12 | 60 | 4578 (TP5) | 1.99 | 2.07 |
| 26.13 | 60 | 4578 (TP5) | 2.11 | 2.19 |
| 26.14 | 60 | 4578 (TP5) | 2.14 | 2.22 |
| 27.01 | 15 | 4425 (TP9) | 0.21 | 0.22 |
| 28.01 | 15 | 4425 (TP9) | 0.34 | 0.36 |
| 28.02 | 15 | 4420 (TP4) | 0.51 | 0.51 |
| 29.01 | 15 | 4425 (TP9) | 0.30 | 0.31 |
| 30.01 | 360 | 4737 (TP5) | 0.46 | 0.45 |
| 30.02 | 360 | 4737 (TP5) | 0.54 | 0.53 |
| 30.03 | 360 | 4737 (TP5) | 0.83 | 0.82 |
| 31.01 | 360 | 4738 (TP6) | 0.17 | 0.16 |
| 32.01 | 15 | 4423 (TP7) | 0.02 | 0.02 |
| 33.01 | 15 | 4425 (TP9) | 0.29 | 0.30 |
| 33.02 | 20 | 4448 (TP3) | 0.68 | 0.68 |
| 33.03 | 20 | 4454 (TP9) | 1.92 | 2.01 |
| 33.04 | 15 | 4425 (TP9) | 2.08 | 2.16 |
| 33.05 | 15 | 4423 (TP7) | 2.16 | 2.16 |
| 33.06 | 20 | 4445 (TP1) | 3.09 | 3.23 |
| 34.01 | 15 | 4425 (TP9) | 0.98 | 1.03 |
| 35.01 | 15 | 4425 (TP9) | 0.74 | 0.78 |
| 35.02 | 20 | 4451 (TP6) | 2.99 | 2.98 |
| 35.03 | 20 | 4451 (TP6) | 3.03 | 3.03 |
| 35.04 | 20 | 4451 (TP6) | 3.04 | 3.04 |
| 36.01 | 15 | 4425 (TP9) | 0.39 | 0.41 |
| 36.02 | 15 | 4421 (TP5) | 0.74 | 0.71 |
| 36.03 | 15 | 4426 (TP10) | 1.26 | 1.26 |
| 37.01 | 15 | 4425 (TP9) | 0.29 | 0.30 |
| 38.01 | 15 | 4425 (TP9) | 0.41 | 0.43 |
| 39.01 | 15 | 4425 (TP9) | 0.46 | 0.48 |
| 40.01 | 15 | 4425 (TP9) | 0.40 | 0.42 |
| 41.01 | 15 | 4418 (TP2) | 0.46 | 0.49 |
| 41.02 | 15 | 4418 (TP2) | 0.70 | 0.74 |
| 42.01 | 15 | 4425 (TP9) | 0.20 | 0.22 |
| 43.01 | 15 | 4425 (TP9) | 0.22 | 0.23 |
| 44.01 | 360 | 4737 (TP5) | 0.04 | 0.04 |
| 45.01 | 15 | 4425 (TP9) | 0.73 | 0.77 |
| 45.02 | 15 | 4422 (TP6) | 1.06 | 1.06 |
| 45.03 | 15 | 4418 (TP2) | 1.69 | 1.69 |
| 45.04 | 15 | 4424 (TP8) | 1.87 | 1.86 |
| 45.05 | 15 | 4424 (TP8) | 1.88 | 1.87 |
| 45.06 | 20 | 4446 (TP2) | 1.89 | 1.90 |
| 45.07 | 30 | 4519 (TP5) | 2.25 | 2.23 |
| 45.08 | 25 | 4487 (TP6) | 5.04 | 5.10 |
| 46.01 | 15 | 4425 (TP9) | 0.24 | 0.25 |
| 47.01 | 15 | 4425 (TP9) | 0.46 | 0.49 |
| 48.01 | 15 | 4425 (TP9) | 0.36 | 0.37 |

| Subcatch ID | ARR2019 Discharge Statistics for All Durations and Temp. Patterns | | | |
|---|---|---|---|---|
| | Critical Duration (mins) | Adopted Temp. Pattern | Discharge ($m^3/s$) | |
| | | | Average | Adopted |
| 48.02 | 20 | 4454 (TP9) | 0.84 | 0.87 |
| 48.03 | 15 | 4420 (TP4) | 1.28 | 1.30 |
| 48.04 | 20 | 4451 (TP6) | 2.73 | 2.75 |
| 48.05 | 20 | 4448 (TP3) | 2.74 | 2.77 |
| 49.01 | 15 | 4418 (TP2) | 0.77 | 0.81 |
| 49.02 | 15 | 4418 (TP2) | 1.04 | 1.10 |
| 49.03 | 15 | 4421 (TP5) | 1.18 | 1.17 |
| 50.01 | 15 | 4425 (TP9) | 0.24 | 0.25 |
| 51.01 | 15 | 4425 (TP9) | 1.01 | 1.06 |
| 52.01 | 15 | 4425 (TP9) | 0.30 | 0.32 |
| 52.02 | 15 | 4421 (TP5) | 0.43 | 0.42 |
| 53.01 | 15 | 4425 (TP9) | 0.73 | 0.78 |
| 53.02 | 15 | 4418 (TP2) | 1.32 | 1.38 |
| 54.01 | 15 | 4425 (TP9) | 0.25 | 0.27 |
| 55.01 | 15 | 4425 (TP9) | 0.14 | 0.15 |
| 56.01 | 360 | 4738 (TP6) | 0.00 | 0.00 |
| 57.01 | 360 | 4737 (TP5) | 0.21 | 0.21 |
| 57.02 | 360 | 4737 (TP5) | 0.47 | 0.46 |
| 57.03 | 360 | 4737 (TP5) | 0.48 | 0.47 |
| 57.04 | 20 | 4453 (TP8) | 0.71 | 0.72 |
| 57.05 | 20 | 4445 (TP1) | 0.92 | 0.92 |
| 58.01 | 360 | 4738 (TP6) | 0.10 | 0.10 |
| 59.01 | 15 | 4425 (TP9) | 0.10 | 0.11 |
| 60.01 | 15 | 4423 (TP7) | 0.01 | 0.01 |
| 61.01 | 15 | 4425 (TP9) | 0.09 | 0.10 |
| 62.01 | 15 | 4425 (TP9) | 1.74 | 1.82 |
| 62.02 | 15 | 4423 (TP7) | 2.50 | 2.54 |
| 62.03 | 15 | 4424 (TP8) | 2.66 | 2.59 |
| 62.04 | 15 | 4424 (TP8) | 2.85 | 2.78 |
| 62.05 | 20 | 4453 (TP8) | 2.86 | 2.81 |
| 62.06 | 20 | 4453 (TP8) | 2.86 | 2.81 |
| 63.01 | 20 | 4445 (TP1) | 0.38 | 0.38 |
| 64.01 | 15 | 4423 (TP7) | 0.22 | 0.23 |
| 65.01 | 15 | 4425 (TP9) | 0.94 | 0.99 |
| 66.01 | 15 | 4425 (TP9) | 0.18 | 0.19 |
| 67.01 | 15 | 4425 (TP9) | 0.35 | 0.37 |
| 67.02 | 15 | 4418 (TP2) | 0.78 | 0.83 |
| 67.03 | 15 | 4426 (TP10) | 1.11 | 1.10 |
| 68.01 | 15 | 4425 (TP9) | 0.42 | 0.45 |
| 69.01 | 15 | 4418 (TP2) | 1.10 | 1.16 |
| 69.02 | 20 | 4448 (TP3) | 1.75 | 1.77 |
| 69.03 | 15 | 4421 (TP5) | 1.89 | 1.86 |
| 69.04 | 15 | 4418 (TP2) | 2.29 | 2.34 |
| 69.05 | 25 | 4487 (TP6) | 2.40 | 2.40 |
| 69.06 | 30 | 4520 (TP6) | 2.51 | 2.52 |
| 69.07 | 45 | 4550 (TP6) | 4.06 | 4.12 |
| 70.01 | 15 | 4425 (TP9) | 0.15 | 0.15 |
| 71.01 | 15 | 4425 (TP9) | 0.47 | 0.50 |
| 71.02 | 20 | 4448 (TP3) | 1.14 | 1.16 |
| 71.03 | 15 | 4421 (TP5) | 1.84 | 1.85 |
| 71.04 | 20 | 4451 (TP6) | 2.06 | 2.05 |
| 71.05 | 20 | 4446 (TP2) | 2.16 | 2.15 |
| 72.01 | 15 | 4423 (TP7) | 0.00 | 0.01 |
| 73.01 | 15 | 4418 (TP2) | 0.52 | 0.55 |

## ARR2019 Results for 0.2EY Event

| Subcatch ID | ARR2019 Discharge Statistics for All Durations and Temp. Patterns | | | |
|---|---|---|---|---|
| | Critical Duration (mins) | Adopted Temp. Pattern | Discharge ($m^3/s$) | |
| | | | Average | Adopted |
| 1.01 | 60 | 4568 (TP16) | 0.42 | 0.44 |
| 1.02 | 120 | 4621 (TP11) | 1.22 | 1.22 |
| 1.03 | 120 | 4625 (TP15) | 1.50 | 1.51 |
| 1.04 | 120 | 4625 (TP15) | 1.58 | 1.59 |
| 1.05 | 120 | 4625 (TP15) | 2.03 | 2.10 |
| 1.06 | 120 | 4625 (TP15) | 2.19 | 2.27 |
| 1.07 | 120 | 4626 (TP16) | 3.82 | 3.88 |
| 1.08 | 120 | 4643 (TP8) | 4.70 | 4.75 |
| 1.09 | 120 | 4628 (TP17) | 8.59 | 8.39 |
| 1.1 | 120 | 4625 (TP15) | 9.58 | 9.45 |
| 1.11 | 120 | 4625 (TP15) | 9.57 | 9.60 |
| 1.12 | 120 | 4625 (TP15) | 9.87 | 9.91 |
| 1.13 | 120 | 4625 (TP15) | 10.17 | 10.17 |
| 1.14 | 120 | 4625 (TP15) | 10.22 | 10.23 |
| 1.15 | 120 | 4628 (TP17) | 10.46 | 10.46 |
| 1.16 | 180 | 4659 (TP14) | 10.56 | 10.73 |
| 1.17 | 180 | 4663 (TP16) | 28.07 | 28.53 |
| 1.18 | 180 | 4679 (TP9) | 29.60 | 29.99 |
| 1.19 | 180 | 4679 (TP9) | 32.13 | 32.92 |
| 1.2 | 180 | 4667 (TP19) | 33.72 | 34.47 |
| 1.21 | 180 | 4667 (TP19) | 34.20 | 34.89 |
| 1.22 | 180 | 4658 (TP13) | 36.20 | 36.44 |
| 1.23 | 180 | 4658 (TP13) | 36.42 | 36.87 |
| 1.24 | 180 | 4658 (TP13) | 36.47 | 36.92 |
| 1.25 | 180 | 4667 (TP19) | 37.09 | 37.70 |
| 1.26 | 180 | 4677 (TP8) | 40.72 | 41.34 |
| 2.01 | 1440 | 4877 (TP4) | 0.00 | 0.00 |
| 3.01 | 60 | 4565 (TP13) | 0.44 | 0.43 |
| 3.02 | 60 | 4565 (TP13) | 0.74 | 0.74 |
| 4.01 | 1440 | 4877 (TP4) | 0.00 | 0.00 |
| 5.01 | 15 | 4411 (TP15) | 2.69 | 2.78 |
| 5.02 | 15 | 4422 (TP6) | 3.25 | 3.25 |
| 6.01 | 120 | 4625 (TP15) | 0.17 | 0.17 |
| 6.02 | 60 | 4577 (TP4) | 0.76 | 0.78 |
| 7.01 | 60 | 4581 (TP8) | 1.52 | 1.49 |
| 8.01 | 15 | 4418 (TP2) | 1.01 | 1.05 |
| 9.01 | 180 | 4669 (TP2) | 0.70 | 0.71 |
| 9.02 | 60 | 4574 (TP1) | 1.39 | 1.42 |
| 9.03 | 60 | 4565 (TP13) | 1.51 | 1.53 |
| 9.04 | 60 | 4581 (TP8) | 2.19 | 2.19 |
| 9.05 | 20 | 4436 (TP14) | 2.91 | 2.91 |
| 9.06 | 60 | 4565 (TP13) | 3.52 | 3.57 |
| 9.07 | 30 | 4512 (TP17) | 3.93 | 3.89 |
| 9.08 | 45 | 4554 (TP10) | 5.11 | 5.10 |
| 9.09 | 45 | 4550 (TP6) | 5.82 | 5.85 |
| 9.1 | 45 | 4553 (TP9) | 5.92 | 5.99 |
| 9.11 | 45 | 4553 (TP9) | 6.16 | 6.19 |
| 9.12 | 60 | 4573 (TP20) | 6.77 | 6.77 |
| 9.13 | 60 | 4581 (TP8) | 6.89 | 7.00 |
| 9.14 | 45 | 4554 (TP10) | 11.46 | 11.63 |
| 9.15 | 45 | 4552 (TP8) | 11.98 | 12.08 |
| 9.16 | 45 | 4541 (TP17) | 14.15 | 14.14 |
| 9.17 | 60 | 4577 (TP4) | 16.99 | 17.10 |
| 9.18 | 60 | 4577 (TP4) | 17.04 | 17.14 |
| 9.19 | 60 | 4577 (TP4) | 17.08 | 17.16 |
| 10.01 | 60 | 4475 (TP11) | 0.70 | 0.70 |
| 11.01 | 15 | 4416 (TP20) | 0.53 | 0.56 |
| 11.02 | 15 | 4426 (TP10) | 0.63 | 0.64 |
| 11.03 | 15 | 4421 (TP5) | 0.74 | 0.74 |
| 12.01 | 15 | 4418 (TP2) | 0.46 | 0.47 |
| 12.02 | 15 | 4411 (TP15) | 1.03 | 1.05 |
| 13.01 | 15 | 4418 (TP2) | 0.94 | 0.97 |
| 13.02 | 15 | 4418 (TP2) | 1.32 | 1.36 |
| 14.01 | 15 | 4415 (TP19) | 0.68 | 0.70 |
| 15.01 | 15 | 4415 (TP19) | 0.63 | 0.64 |
| 16.01 | 15 | 4410 (TP14) | 1.24 | 1.27 |
| 17.01 | 15 | 4423 (TP7) | 0.20 | 0.20 |
| 18.01 | 15 | 4416 (TP20) | 0.12 | 0.12 |
| 19.01 | 15 | 4423 (TP7) | 0.15 | 0.15 |
| 19.02 | 15 | 4417 (TP1) | 1.05 | 1.08 |
| 19.03 | 15 | 4418 (TP2) | 2.31 | 2.36 |
| 19.04 | 15 | 4424 (TP8) | 3.92 | 3.90 |
| 19.05 | 20 | 4436 (TP14) | 4.22 | 4.22 |
| 19.06 | 20 | 4439 (TP17) | 4.43 | 4.39 |

| Subcatch ID | ARR2019 Discharge Statistics for All Durations and Temp. Patterns | | | |
|---|---|---|---|---|
| | Critical Duration (mins) | Adopted Temp. Pattern | Discharge ($m^3/s$) | |
| | | | Average | Adopted |
| 19.07 | 25 | 4479 (TP20) | 5.11 | 5.16 |
| 19.08 | 30 | 4516 (TP2) | 5.21 | 5.13 |
| 20.01 | 15 | 4416 (TP20) | 0.33 | 0.34 |
| 21.01 | 15 | 4425 (TP9) | 0.01 | 0.01 |
| 22.01 | 15 | 4415 (TP19) | 1.62 | 1.64 |
| 23.01 | 15 | 4416 (TP20) | 0.56 | 0.58 |
| 23.02 | 15 | 4411 (TP15) | 2.11 | 2.16 |
| 23.03 | 45 | 4539 (TP15) | 1.03 | 1.05 |
| 23.04 | 45 | 4554 (TP10) | 1.00 | 0.99 |
| 23.05 | 60 | 4569 (TP17) | 0.97 | 0.98 |
| 23.06 | 60 | 4569 (TP17) | 0.91 | 0.90 |
| 23.07 | 120 | 4623 (TP13) | 0.87 | 0.92 |
| 23.08 | 120 | 4630 (TP19) | 0.94 | 0.96 |
| 23.09 | 120 | 4625 (TP15) | 1.22 | 1.24 |
| 23.1 | 120 | 4625 (TP15) | 1.33 | 1.31 |
| 23.11 | 15 | 4411 (TP15) | 3.39 | 3.39 |
| 24.01 | 15 | 4415 (TP19) | 0.53 | 0.54 |
| 24.02 | 15 | 4415 (TP19) | 1.93 | 1.97 |
| 25.01 | 15 | 4425 (TP9) | 0.00 | 0.00 |
| 26.01 | 1440 | 4875 (TP2) | 0.01 | 0.00 |
| 26.02 | 25 | 4488 (TP7) | 0.32 | 0.31 |
| 26.03 | 15 | 4408 (TP12) | 1.59 | 1.63 |
| 26.04 | 20 | 4440 (TP18) | 1.70 | 1.71 |
| 26.05 | 45 | 4552 (TP8) | 1.89 | 1.89 |
| 26.06 | 45 | 4550 (TP6) | 1.88 | 1.86 |
| 26.07 | 45 | 4550 (TP6) | 1.99 | 2.02 |
| 26.08 | 60 | 4572 (TP19) | 1.62 | 1.55 |
| 26.09 | 60 | 4475 (TP11) | 1.72 | 1.71 |
| 26.1 | 60 | 4574 (TP1) | 1.20 | 1.20 |
| 26.11 | 60 | 4579 (TP6) | 1.27 | 1.25 |
| 26.12 | 60 | 4565 (TP13) | 3.09 | 3.03 |
| 26.13 | 60 | 4565 (TP13) | 3.26 | 3.22 |
| 26.14 | 60 | 4565 (TP13) | 3.37 | 3.34 |
| 27.01 | 15 | 4415 (TP19) | 0.32 | 0.32 |
| 28.01 | 15 | 4418 (TP2) | 0.52 | 0.54 |
| 28.02 | 60 | 4565 (TP13) | 0.74 | 0.75 |
| 29.01 | 15 | 4410 (TP14) | 0.43 | 0.44 |
| 30.01 | 60 | 4568 (TP16) | 0.99 | 0.99 |
| 30.02 | 60 | 4568 (TP16) | 1.16 | 1.16 |
| 30.03 | 120 | 4628 (TP17) | 1.76 | 1.77 |
| 31.01 | 45 | 4552 (TP8) | 0.48 | 0.47 |
| 32.01 | 15 | 4421 (TP5) | 0.04 | 0.03 |
| 33.01 | 15 | 4415 (TP19) | 0.43 | 0.44 |
| 33.02 | 20 | 4440 (TP18) | 1.00 | 1.00 |
| 33.03 | 20 | 4444 (TP20) | 2.78 | 2.83 |
| 33.04 | 15 | 4418 (TP2) | 3.00 | 3.09 |
| 33.05 | 15 | 4410 (TP14) | 3.12 | 3.19 |
| 33.06 | 15 | 4426 (TP10) | 4.49 | 4.36 |
| 34.01 | 15 | 4415 (TP19) | 1.41 | 1.45 |
| 35.01 | 15 | 4415 (TP19) | 1.10 | 1.13 |
| 35.02 | 20 | 4451 (TP6) | 4.37 | 4.33 |
| 35.03 | 20 | 4434 (TP12) | 4.47 | 4.41 |
| 35.04 | 20 | 4434 (TP12) | 4.50 | 4.44 |
| 36.01 | 15 | 4415 (TP19) | 0.57 | 0.59 |
| 36.02 | 15 | 4425 (TP9) | 1.10 | 1.11 |
| 36.03 | 15 | 4416 (TP20) | 1.82 | 1.83 |
| 37.01 | 15 | 4415 (TP19) | 0.42 | 0.43 |
| 38.01 | 15 | 4415 (TP19) | 0.60 | 0.62 |
| 39.01 | 15 | 4415 (TP19) | 0.68 | 0.69 |
| 40.01 | 15 | 4415 (TP19) | 0.59 | 0.60 |
| 41.01 | 15 | 4415 (TP19) | 0.69 | 0.72 |
| 41.02 | 15 | 4415 (TP19) | 1.03 | 1.06 |
| 42.01 | 15 | 4415 (TP19) | 0.30 | 0.31 |
| 43.01 | 15 | 4415 (TP19) | 0.32 | 0.33 |
| 44.01 | 120 | 4640 (TP5) | 0.08 | 0.08 |
| 45.01 | 15 | 4410 (TP14) | 1.06 | 1.08 |
| 45.02 | 15 | 4421 (TP5) | 1.54 | 1.56 |
| 45.03 | 15 | 4416 (TP20) | 2.45 | 2.46 |
| 45.04 | 15 | 4408 (TP12) | 2.73 | 2.72 |
| 45.05 | 15 | 4408 (TP12) | 2.75 | 2.74 |
| 45.06 | 20 | 4449 (TP4) | 2.82 | 2.83 |
| 45.07 | 30 | 4516 (TP2) | 3.41 | 3.40 |
| 45.08 | 25 | 4483 (TP3) | 7.71 | 7.79 |
| 46.01 | 15 | 4418 (TP2) | 0.36 | 0.38 |
| 47.01 | 15 | 4415 (TP19) | 0.67 | 0.68 |
| 48.01 | 15 | 4415 (TP19) | 0.52 | 0.53 |

| Subcatch ID | ARR2019 Discharge Statistics for All Durations and Temp. Patterns | | | |
|---|---|---|---|---|
| | Critical Duration (mins) | Adopted Temp. Pattern | Discharge ($m^3/s$) | |
| | | | Average | Adopted |
| 48.02 | 15 | 4418 (TP2) | 1.20 | 1.22 |
| 48.03 | 15 | 4420 (TP4) | 1.85 | 1.86 |
| 48.04 | 15 | 4412 (TP16) | 3.93 | 3.93 |
| 48.05 | 15 | 4412 (TP16) | 3.96 | 3.96 |
| 49.01 | 15 | 4415 (TP19) | 1.14 | 1.18 |
| 49.02 | 15 | 4415 (TP19) | 1.54 | 1.59 |
| 49.03 | 15 | 4426 (TP10) | 1.74 | 1.72 |
| 50.01 | 15 | 4415 (TP19) | 0.36 | 0.36 |
| 51.01 | 15 | 4415 (TP19) | 1.47 | 1.50 |
| 52.01 | 15 | 4413 (TP17) | 0.45 | 0.47 |
| 52.02 | 15 | 4415 (TP19) | 0.63 | 0.62 |
| 53.01 | 15 | 4418 (TP2) | 1.08 | 1.13 |
| 53.02 | 15 | 4418 (TP2) | 1.94 | 2.00 |
| 54.01 | 15 | 4418 (TP2) | 0.37 | 0.38 |
| 55.01 | 15 | 4415 (TP19) | 0.21 | 0.22 |
| 56.01 | 60 | 4565 (TP13) | 0.01 | 0.01 |
| 57.01 | 120 | 4628 (TP17) | 0.40 | 0.41 |
| 57.02 | 120 | 4623 (TP13) | 0.95 | 0.96 |
| 57.03 | 120 | 4640 (TP5) | 0.98 | 0.98 |
| 57.04 | 120 | 4621 (TP11) | 1.35 | 1.35 |
| 57.05 | 120 | 4626 (TP16) | 1.55 | 1.55 |
| 58.01 | 60 | 4568 (TP16) | 0.23 | 0.24 |
| 59.01 | 15 | 4413 (TP17) | 0.16 | 0.16 |
| 60.01 | 60 | 4581 (TP8) | 0.01 | 0.01 |
| 61.01 | 15 | 4416 (TP20) | 0.14 | 0.14 |
| 62.01 | 15 | 4415 (TP19) | 2.51 | 2.56 |
| 62.02 | 15 | 4423 (TP7) | 3.60 | 3.62 |
| 62.03 | 15 | 4421 (TP5) | 3.84 | 3.78 |
| 62.04 | 15 | 4421 (TP5) | 4.16 | 4.06 |
| 62.05 | 20 | 4453 (TP8) | 4.17 | 4.12 |
| 62.06 | 20 | 4453 (TP8) | 4.21 | 4.17 |
| 63.01 | 20 | 4445 (TP1) | 0.55 | 0.54 |
| 64.01 | 15 | 4415 (TP19) | 0.33 | 0.33 |
| 65.01 | 15 | 4415 (TP19) | 1.36 | 1.39 |
| 66.01 | 15 | 4411 (TP15) | 0.28 | 0.28 |
| 67.01 | 15 | 4415 (TP19) | 0.52 | 0.54 |
| 67.02 | 15 | 4418 (TP2) | 1.14 | 1.18 |
| 67.03 | 15 | 4413 (TP17) | 1.62 | 1.61 |
| 68.01 | 15 | 4418 (TP2) | 0.61 | 0.64 |
| 69.01 | 120 | 4624 (TP14) | 1.66 | 1.61 |
| 69.02 | 120 | 4640 (TP5) | 2.80 | 2.74 |
| 69.03 | 120 | 4624 (TP14) | 2.96 | 2.89 |
| 69.04 | 15 | 4424 (TP8) | 3.35 | 3.37 |
| 69.05 | 25 | 4487 (TP6) | 3.57 | 3.55 |
| 69.06 | 120 | 4625 (TP15) | 3.84 | 3.73 |
| 69.07 | 45 | 4550 (TP6) | 6.41 | 6.44 |
| 70.01 | 15 | 4418 (TP2) | 0.22 | 0.23 |
| 71.01 | 15 | 4415 (TP19) | 0.69 | 0.70 |
| 71.02 | 15 | 4418 (TP2) | 1.60 | 1.62 |
| 71.03 | 15 | 4414 (TP18) | 2.66 | 2.63 |
| 71.04 | 20 | 4451 (TP6) | 3.01 | 3.02 |
| 71.05 | 25 | 4485 (TP4) | 3.22 | 3.24 |
| 72.01 | 15 | 4425 (TP9) | 0.01 | 0.01 |
| 73.01 | 15 | 4410 (TP14) | 0.76 | 0.78 |

## ARR2019 Results for 10% AEP Event

| Subcatch ID | ARR2019 Discharge Statistics for All Durations and Temp. Patterns | | | |
|---|---|---|---|---|
| | Critical Duration (mins) | Adopted Temp. Pattern | Discharge ($m^3/s$) | |
| | | | Average | Adopted |
| 1.01 | 60 | 4579 (TP6) | 0.59 | 0.63 |
| 1.02 | 60 | 4577 (TP4) | 1.75 | 1.80 |
| 1.03 | 60 | 4569 (TP17) | 2.05 | 2.12 |
| 1.04 | 60 | 4569 (TP17) | 2.12 | 2.16 |
| 1.05 | 90 | 4602 (TP2) | 2.69 | 2.72 |
| 1.06 | 90 | 4608 (TP8) | 2.89 | 2.92 |
| 1.07 | 120 | 4625 (TP15) | 4.96 | 5.10 |
| 1.08 | 120 | 4630 (TP19) | 6.13 | 6.16 |
| 1.09 | 120 | 4626 (TP16) | 11.05 | 10.83 |
| 1.1 | 120 | 4628 (TP17) | 12.34 | 12.22 |
| 1.11 | 120 | 4625 (TP15) | 11.94 | 11.96 |
| 1.12 | 120 | 4625 (TP15) | 12.29 | 12.33 |
| 1.13 | 120 | 4628 (TP17) | 12.69 | 12.84 |
| 1.14 | 120 | 4628 (TP17) | 12.76 | 12.88 |
| 1.15 | 120 | 4628 (TP17) | 13.08 | 13.06 |
| 1.16 | 120 | 4628 (TP17) | 13.16 | 13.09 |
| 1.17 | 90 | 4593 (TP16) | 35.38 | 35.95 |
| 1.18 | 90 | 4605 (TP5) | 37.02 | 37.21 |
| 1.19 | 180 | 4679 (TP9) | 39.94 | 41.17 |
| 1.2 | 180 | 4681 (TP10) | 42.19 | 42.88 |
| 1.21 | 180 | 4658 (TP13) | 42.85 | 43.20 |
| 1.22 | 180 | 4658 (TP13) | 45.48 | 46.14 |
| 1.23 | 180 | 4668 (TP20) | 45.78 | 46.56 |
| 1.24 | 180 | 4668 (TP20) | 45.84 | 46.59 |
| 1.25 | 180 | 4677 (TP8) | 46.68 | 47.31 |
| 1.26 | 180 | 4665 (TP17) | 51.50 | 52.48 |
| 2.01 | 1440 | 4866 (TP14) | 0.02 | 0.02 |
| 3.01 | 45 | 4541 (TP17) | 0.61 | 0.61 |
| 3.02 | 45 | 4536 (TP12) | 1.00 | 0.99 |
| 4.01 | 1440 | 4866 (TP14) | 0.02 | 0.02 |
| 5.01 | 15 | 4417 (TP1) | 3.35 | 3.42 |
| 5.02 | 15 | 4422 (TP6) | 4.02 | 4.01 |
| 6.01 | 60 | 4568 (TP16) | 0.25 | 0.26 |
| 6.02 | 45 | 4540 (TP16) | 1.10 | 1.12 |
| 7.01 | 60 | 4567 (TP15) | 2.10 | 2.10 |
| 8.01 | 15 | 4411 (TP15) | 1.25 | 1.30 |
| 9.01 | 180 | 4663 (TP16) | 0.83 | 0.85 |
| 9.02 | 45 | 4478 (TP11) | 1.80 | 1.78 |
| 9.03 | 45 | 4552 (TP8) | 1.96 | 1.96 |
| 9.04 | 45 | 4542 (TP18) | 2.87 | 2.83 |
| 9.05 | 45 | 4542 (TP18) | 3.78 | 3.83 |
| 9.06 | 45 | 4547 (TP3) | 4.64 | 4.63 |
| 9.07 | 45 | 4547 (TP3) | 4.99 | 5.00 |
| 9.08 | 45 | 4542 (TP18) | 6.51 | 6.50 |
| 9.09 | 45 | 4550 (TP6) | 7.40 | 7.46 |
| 9.1 | 45 | 4553 (TP9) | 7.56 | 7.61 |
| 9.11 | 45 | 4536 (TP12) | 7.89 | 8.00 |
| 9.12 | 60 | 4577 (TP4) | 8.64 | 8.71 |
| 9.13 | 60 | 4581 (TP8) | 8.81 | 8.91 |
| 9.14 | 45 | 4545 (TP1) | 14.66 | 14.91 |
| 9.15 | 45 | 4538 (TP14) | 15.30 | 15.38 |
| 9.16 | 45 | 4552 (TP8) | 18.07 | 18.04 |
| 9.17 | 60 | 4577 (TP4) | 21.61 | 21.68 |
| 9.18 | 60 | 4577 (TP4) | 21.68 | 21.72 |
| 9.19 | 60 | 4577 (TP4) | 21.73 | 21.75 |
| 10.01 | 45 | 4540 (TP16) | 0.96 | 0.91 |
| 11.01 | 15 | 4413 (TP17) | 0.67 | 0.68 |
| 11.02 | 15 | 4415 (TP19) | 0.79 | 0.79 |
| 11.03 | 15 | 4421 (TP5) | 0.92 | 0.92 |
| 12.01 | 15 | 4413 (TP17) | 0.58 | 0.61 |
| 12.02 | 15 | 4417 (TP1) | 1.27 | 1.32 |
| 13.01 | 15 | 4411 (TP15) | 1.17 | 1.20 |
| 13.02 | 15 | 4418 (TP2) | 1.62 | 1.66 |
| 14.01 | 15 | 4411 (TP15) | 0.84 | 0.86 |
| 15.01 | 15 | 4418 (TP2) | 0.78 | 0.81 |
| 16.01 | 15 | 4415 (TP19) | 1.50 | 1.54 |
| 17.01 | 15 | 4416 (TP20) | 0.24 | 0.25 |
| 18.01 | 15 | 4418 (TP2) | 0.15 | 0.15 |
| 19.01 | 15 | 4418 (TP2) | 0.18 | 0.19 |
| 19.02 | 15 | 4417 (TP1) | 1.28 | 1.31 |
| 19.03 | 15 | 4418 (TP2) | 2.86 | 2.89 |
| 19.04 | 15 | 4410 (TP14) | 4.82 | 4.79 |
| 19.05 | 20 | 4436 (TP14) | 5.19 | 5.15 |
| 19.06 | 20 | 4439 (TP17) | 5.49 | 5.44 |

| Subcatch ID | ARR2019 Discharge Statistics for All Durations and Temp. Patterns | | | |
|---|---|---|---|---|
| | Critical Duration (mins) | Adopted Temp. Pattern | Discharge ($m^3/s$) | |
| | | | Average | Adopted |
| 19.07 | 25 | 4447 (TP11) | 6.28 | 6.34 |
| 19.08 | 30 | 4508 (TP13) | 6.43 | 6.33 |
| 20.01 | 15 | 4418 (TP2) | 0.42 | 0.43 |
| 21.01 | 15 | 4425 (TP9) | 0.01 | 0.01 |
| 22.01 | 15 | 4415 (TP19) | 1.97 | 2.04 |
| 23.01 | 15 | 4418 (TP2) | 0.71 | 0.72 |
| 23.02 | 15 | 4417 (TP1) | 2.60 | 2.68 |
| 23.03 | 45 | 4552 (TP8) | 1.51 | 1.53 |
| 23.04 | 45 | 4539 (TP15) | 1.49 | 1.50 |
| 23.05 | 60 | 4569 (TP17) | 1.49 | 1.57 |
| 23.06 | 60 | 4572 (TP19) | 1.48 | 1.52 |
| 23.07 | 60 | 4475 (TP11) | 1.43 | 1.46 |
| 23.08 | 90 | 4597 (TP19) | 1.48 | 1.52 |
| 23.09 | 120 | 4626 (TP16) | 1.65 | 1.64 |
| 23.1 | 120 | 4621 (TP11) | 1.74 | 1.77 |
| 23.11 | 15 | 4415 (TP19) | 4.15 | 4.21 |
| 24.01 | 15 | 4418 (TP2) | 0.65 | 0.66 |
| 24.02 | 15 | 4418 (TP2) | 2.35 | 2.43 |
| 25.01 | 15 | 4425 (TP9) | 0.00 | 0.00 |
| 26.01 | 1440 | 4870 (TP17) | 0.05 | 0.05 |
| 26.02 | 20 | 4449 (TP4) | 0.46 | 0.46 |
| 26.03 | 15 | 4408 (TP12) | 1.98 | 2.00 |
| 26.04 | 45 | 4542 (TP18) | 2.15 | 2.15 |
| 26.05 | 45 | 4478 (TP11) | 2.45 | 2.48 |
| 26.06 | 45 | 4550 (TP6) | 2.46 | 2.45 |
| 26.07 | 45 | 4478 (TP11) | 2.63 | 2.67 |
| 26.08 | 45 | 4550 (TP6) | 2.48 | 2.48 |
| 26.09 | 45 | 4478 (TP11) | 2.53 | 2.54 |
| 26.1 | 60 | 4569 (TP17) | 1.22 | 1.22 |
| 26.11 | 60 | 4580 (TP7) | 1.36 | 1.37 |
| 26.12 | 60 | 4565 (TP13) | 3.82 | 3.77 |
| 26.13 | 60 | 4565 (TP13) | 4.03 | 4.00 |
| 26.14 | 60 | 4565 (TP13) | 4.18 | 4.17 |
| 27.01 | 15 | 4418 (TP2) | 0.39 | 0.41 |
| 28.01 | 15 | 4417 (TP1) | 0.66 | 0.69 |
| 28.02 | 45 | 4478 (TP11) | 0.89 | 0.91 |
| 29.01 | 15 | 4415 (TP19) | 0.53 | 0.54 |
| 30.01 | 60 | 4581 (TP8) | 1.40 | 1.44 |
| 30.02 | 60 | 4568 (TP16) | 1.64 | 1.67 |
| 30.03 | 60 | 4579 (TP6) | 2.38 | 2.46 |
| 31.01 | 45 | 4536 (TP12) | 0.66 | 0.66 |
| 32.01 | 20 | 4440 (TP18) | 0.05 | 0.05 |
| 33.01 | 15 | 4418 (TP2) | 0.53 | 0.55 |
| 33.02 | 20 | 4445 (TP1) | 1.30 | 1.30 |
| 33.03 | 20 | 4444 (TP20) | 3.46 | 3.50 |
| 33.04 | 20 | 4440 (TP18) | 3.75 | 3.77 |
| 33.05 | 20 | 4448 (TP3) | 3.86 | 3.86 |
| 33.06 | 15 | 4426 (TP10) | 5.55 | 5.50 |
| 34.01 | 15 | 4418 (TP2) | 1.72 | 1.78 |
| 35.01 | 15 | 4418 (TP2) | 1.37 | 1.41 |
| 35.02 | 20 | 4453 (TP8) | 5.45 | 5.39 |
| 35.03 | 20 | 4444 (TP20) | 5.57 | 5.47 |
| 35.04 | 20 | 4444 (TP20) | 5.62 | 5.51 |
| 36.01 | 15 | 4418 (TP2) | 0.71 | 0.74 |
| 36.02 | 20 | 4439 (TP17) | 1.41 | 1.38 |
| 36.03 | 15 | 4416 (TP20) | 2.29 | 2.29 |
| 37.01 | 15 | 4418 (TP2) | 0.52 | 0.54 |
| 38.01 | 15 | 4418 (TP2) | 0.75 | 0.77 |
| 39.01 | 15 | 4416 (TP20) | 0.84 | 0.88 |
| 40.01 | 15 | 4418 (TP2) | 0.73 | 0.76 |
| 41.01 | 15 | 4411 (TP15) | 0.86 | 0.88 |
| 41.02 | 15 | 4418 (TP2) | 1.27 | 1.30 |
| 42.01 | 15 | 4413 (TP17) | 0.37 | 0.39 |
| 43.01 | 15 | 4411 (TP15) | 0.40 | 0.41 |
| 44.01 | 90 | 4593 (TP16) | 0.10 | 0.10 |
| 45.01 | 15 | 4415 (TP19) | 1.29 | 1.32 |
| 45.02 | 15 | 4422 (TP6) | 1.90 | 1.93 |
| 45.03 | 15 | 4408 (TP12) | 3.05 | 3.06 |
| 45.04 | 15 | 4422 (TP6) | 3.39 | 3.38 |
| 45.05 | 15 | 4422 (TP6) | 3.43 | 3.42 |
| 45.06 | 20 | 4441 (TP19) | 3.53 | 3.55 |
| 45.07 | 30 | 4484 (TP1) | 4.29 | 4.28 |
| 45.08 | 30 | 4512 (TP17) | 9.75 | 9.73 |
| 46.01 | 20 | 4444 (TP20) | 0.47 | 0.47 |
| 47.01 | 15 | 4415 (TP19) | 0.82 | 0.85 |
| 48.01 | 15 | 4418 (TP2) | 0.65 | 0.68 |

| Subcatch ID | ARR2019 Discharge Statistics for All Durations and Temp. Patterns | | | |
|---|---|---|---|---|
| | Critical Duration (mins) | Adopted Temp. Pattern | Discharge ($m^3/s$) | |
| | | | Average | Adopted |
| 48.02 | 20 | 4439 (TP17) | 1.47 | 1.48 |
| 48.03 | 15 | 4420 (TP4) | 2.28 | 2.30 |
| 48.04 | 15 | 4421 (TP5) | 4.83 | 4.80 |
| 48.05 | 20 | 4449 (TP4) | 4.93 | 4.97 |
| 49.01 | 15 | 4418 (TP2) | 1.41 | 1.45 |
| 49.02 | 15 | 4418 (TP2) | 1.90 | 1.95 |
| 49.03 | 15 | 4425 (TP9) | 2.16 | 2.14 |
| 50.01 | 15 | 4418 (TP2) | 0.44 | 0.46 |
| 51.01 | 15 | 4418 (TP2) | 1.80 | 1.86 |
| 52.01 | 15 | 4417 (TP1) | 0.58 | 0.59 |
| 52.02 | 15 | 4426 (TP10) | 0.78 | 0.80 |
| 53.01 | 15 | 4411 (TP15) | 1.35 | 1.39 |
| 53.02 | 15 | 4418 (TP2) | 2.38 | 2.43 |
| 54.01 | 15 | 4418 (TP2) | 0.45 | 0.46 |
| 55.01 | 15 | 4418 (TP2) | 0.26 | 0.27 |
| 56.01 | 45 | 4550 (TP6) | 0.02 | 0.02 |
| 57.01 | 60 | 4569 (TP17) | 0.55 | 0.56 |
| 57.02 | 60 | 4577 (TP4) | 1.32 | 1.36 |
| 57.03 | 60 | 4577 (TP4) | 1.35 | 1.39 |
| 57.04 | 60 | 4581 (TP8) | 1.84 | 1.85 |
| 57.05 | 60 | 4568 (TP16) | 2.08 | 2.11 |
| 58.01 | 60 | 4568 (TP16) | 0.33 | 0.34 |
| 59.01 | 20 | 4446 (TP2) | 0.21 | 0.21 |
| 60.01 | 25 | 4476 (TP18) | 0.02 | 0.02 |
| 61.01 | 15 | 4413 (TP17) | 0.17 | 0.18 |
| 62.01 | 15 | 4418 (TP2) | 3.06 | 3.17 |
| 62.02 | 15 | 4422 (TP6) | 4.43 | 4.38 |
| 62.03 | 15 | 4421 (TP5) | 4.72 | 4.68 |
| 62.04 | 15 | 4421 (TP5) | 5.15 | 5.09 |
| 62.05 | 20 | 4454 (TP9) | 5.23 | 5.22 |
| 62.06 | 20 | 4454 (TP9) | 5.29 | 5.24 |
| 63.01 | 20 | 4451 (TP6) | 0.70 | 0.69 |
| 64.01 | 15 | 4418 (TP2) | 0.41 | 0.42 |
| 65.01 | 15 | 4415 (TP19) | 1.66 | 1.72 |
| 66.01 | 15 | 4417 (TP1) | 0.35 | 0.36 |
| 67.01 | 15 | 4418 (TP2) | 0.65 | 0.67 |
| 67.02 | 15 | 4411 (TP15) | 1.40 | 1.44 |
| 67.03 | 15 | 4426 (TP10) | 2.00 | 1.99 |
| 68.01 | 15 | 4411 (TP15) | 0.75 | 0.77 |
| 69.01 | 120 | 4624 (TP14) | 2.27 | 2.21 |
| 69.02 | 120 | 4640 (TP5) | 3.80 | 3.76 |
| 69.03 | 120 | 4626 (TP16) | 4.00 | 3.95 |
| 69.04 | 120 | 4626 (TP16) | 4.29 | 4.22 |
| 69.05 | 120 | 4625 (TP15) | 4.75 | 4.65 |
| 69.06 | 120 | 4626 (TP16) | 5.10 | 5.01 |
| 69.07 | 45 | 4553 (TP9) | 8.14 | 8.19 |
| 70.01 | 15 | 4413 (TP17) | 0.28 | 0.29 |
| 71.01 | 15 | 4418 (TP2) | 0.84 | 0.87 |
| 71.02 | 20 | 4453 (TP8) | 1.95 | 1.99 |
| 71.03 | 15 | 4414 (TP18) | 3.25 | 3.22 |
| 71.04 | 20 | 4437 (TP15) | 3.72 | 3.74 |
| 71.05 | 25 | 4488 (TP7) | 3.99 | 4.01 |
| 72.01 | 15 | 4425 (TP9) | 0.01 | 0.01 |
| 73.01 | 15 | 4410 (TP14) | 0.92 | 0.95 |

## ARR2019 Results for 5% AEP Event

| Subcatch ID | ARR2019 Discharge Statistics for All Durations and Temp. Patterns | | | |
|---|---|---|---|---|
| | Critical Duration (mins) | Adopted Temp. Pattern | Discharge ($m^3/s$) | |
| | | | Average | Adopted |
| 1.01 | 45 | 4531 (TP17) | 0.76 | 0.76 |
| 1.02 | 60 | 4565 (TP3) | 2.22 | 2.23 |
| 1.03 | 60 | 4569 (TP7) | 2.64 | 2.65 |
| 1.04 | 60 | 4558 (TP17) | 2.73 | 2.71 |
| 1.05 | 60 | 4475 (TP1) | 3.38 | 3.36 |
| 1.06 | 60 | 4405 (TP12) | 3.58 | 3.57 |
| 1.07 | 60 | 4569 (TP7) | 6.03 | 6.10 |
| 1.08 | 120 | 4617 (TP18) | 7.34 | 7.27 |
| 1.09 | 60 | 4405 (TP12) | 13.19 | 13.14 |
| 1.1 | 60 | 4559 (TP18) | 14.96 | 14.89 |
| 1.11 | 90 | 4588 (TP20) | 14.00 | 14.30 |
| 1.12 | 120 | 4611 (TP14) | 14.40 | 14.51 |
| 1.13 | 120 | 4628 (TP7) | 14.88 | 15.05 |
| 1.14 | 120 | 4628 (TP7) | 14.98 | 15.10 |
| 1.15 | 120 | 4499 (TP12) | 15.43 | 15.63 |
| 1.16 | 120 | 4626 (TP6) | 15.54 | 15.74 |
| 1.17 | 60 | 4405 (TP12) | 42.11 | 42.32 |
| 1.18 | 90 | 4593 (TP6) | 44.07 | 44.44 |
| 1.19 | 90 | 4594 (TP7) | 47.85 | 48.06 |
| 1.2 | 120 | 4629 (TP8) | 50.33 | 51.68 |
| 1.21 | 180 | 4667 (TP9) | 51.04 | 52.46 |
| 1.22 | 180 | 4599 (TP12) | 54.38 | 55.53 |
| 1.23 | 180 | 4599 (TP12) | 54.80 | 56.07 |
| 1.24 | 180 | 4599 (TP12) | 54.87 | 56.17 |
| 1.25 | 180 | 4666 (TP8) | 55.95 | 57.18 |
| 1.26 | 180 | 4665 (TP7) | 62.10 | 62.75 |
| 2.01 | 720 | 4443 (TP11) | 0.02 | 0.02 |
| 3.01 | 45 | 4528 (TP16) | 0.76 | 0.74 |
| 3.02 | 20 | 4429 (TP18) | 1.27 | 1.27 |
| 4.01 | 720 | 4443 (TP11) | 0.03 | 0.02 |
| 5.01 | 15 | 4393 (TP13) | 4.02 | 4.02 |
| 5.02 | 15 | 4408 (TP2) | 4.81 | 4.86 |
| 6.01 | 45 | 4541 (TP7) | 0.32 | 0.32 |
| 6.02 | 45 | 4531 (TP17) | 1.42 | 1.43 |
| 7.01 | 45 | 4478 (TP1) | 2.57 | 2.61 |
| 8.01 | 15 | 4393 (TP13) | 1.48 | 1.53 |
| 9.01 | 180 | 4663 (TP6) | 0.98 | 0.95 |
| 9.02 | 45 | 4539 (TP5) | 2.17 | 2.12 |
| 9.03 | 45 | 4539 (TP5) | 2.38 | 2.36 |
| 9.04 | 45 | 4542 (TP8) | 3.46 | 3.40 |
| 9.05 | 45 | 4533 (TP18) | 4.55 | 4.56 |
| 9.06 | 60 | 4573 (TP10) | 5.76 | 5.82 |
| 9.07 | 60 | 4463 (TP13) | 6.14 | 6.15 |
| 9.08 | 45 | 4542 (TP8) | 7.82 | 7.85 |
| 9.09 | 45 | 4536 (TP2) | 8.77 | 8.76 |
| 9.1 | 45 | 4536 (TP2) | 8.95 | 9.00 |
| 9.11 | 45 | 4528 (TP16) | 9.35 | 9.37 |
| 9.12 | 60 | 4405 (TP12) | 10.55 | 10.49 |
| 9.13 | 60 | 4405 (TP12) | 10.72 | 10.72 |
| 9.14 | 60 | 4475 (TP1) | 17.43 | 16.98 |
| 9.15 | 60 | 4405 (TP12) | 18.25 | 17.92 |
| 9.16 | 60 | 4569 (TP7) | 21.82 | 21.69 |
| 9.17 | 60 | 4555 (TP14) | 26.25 | 26.35 |
| 9.18 | 60 | 4558 (TP17) | 26.32 | 26.43 |
| 9.19 | 60 | 4557 (TP16) | 26.38 | 26.48 |
| 10.01 | 25 | 4460 (TP15) | 1.20 | 1.20 |
| 11.01 | 15 | 4393 (TP13) | 0.81 | 0.82 |
| 11.02 | 15 | 4381 (TP1) | 0.96 | 0.97 |
| 11.03 | 15 | 4403 (TP19) | 1.11 | 1.13 |
| 12.01 | 15 | 4393 (TP13) | 0.69 | 0.72 |
| 12.02 | 15 | 4393 (TP13) | 1.51 | 1.55 |
| 13.01 | 15 | 4411 (TP5) | 1.39 | 1.44 |
| 13.02 | 15 | 4411 (TP5) | 1.92 | 1.98 |
| 14.01 | 15 | 4411 (TP5) | 1.00 | 1.04 |
| 15.01 | 15 | 4413 (TP7) | 0.94 | 0.96 |
| 16.01 | 15 | 4416 (TP10) | 1.77 | 1.81 |
| 17.01 | 15 | 4411 (TP5) | 0.29 | 0.30 |
| 18.01 | 15 | 4413 (TP7) | 0.18 | 0.19 |
| 19.01 | 15 | 4381 (TP1) | 0.22 | 0.22 |
| 19.02 | 15 | 4408 (TP2) | 1.53 | 1.56 |
| 19.03 | 15 | 4392 (TP12) | 3.42 | 3.46 |
| 19.04 | 15 | 4398 (TP16) | 5.71 | 5.63 |
| 19.05 | 20 | 4433 (TP20) | 6.12 | 6.11 |
| 19.06 | 20 | 4440 (TP8) | 6.51 | 6.47 |

| Subcatch ID | ARR2019 Discharge Statistics for All Durations and Temp. Patterns | | | |
|---|---|---|---|---|
| | Critical Duration (mins) | Adopted Temp. Pattern | Discharge ($m^3/s$) | |
| | | | Average | Adopted |
| 19.07 | 25 | 4477 (TP9) | 7.44 | 7.43 |
| 19.08 | 25 | 4477 (TP9) | 7.61 | 7.59 |
| 20.01 | 15 | 4413 (TP7) | 0.51 | 0.52 |
| 21.01 | 15 | 4410 (TP4) | 0.01 | 0.01 |
| 22.01 | 15 | 4381 (TP1) | 2.32 | 2.39 |
| 23.01 | 15 | 4413 (TP7) | 0.85 | 0.87 |
| 23.02 | 15 | 4393 (TP13) | 3.10 | 3.14 |
| 23.03 | 45 | 4541 (TP7) | 1.94 | 1.89 |
| 23.04 | 45 | 4540 (TP6) | 1.93 | 1.91 |
| 23.05 | 60 | 4569 (TP7) | 2.00 | 2.07 |
| 23.06 | 60 | 4569 (TP7) | 2.02 | 2.06 |
| 23.07 | 60 | 4569 (TP7) | 2.02 | 2.05 |
| 23.08 | 60 | 4569 (TP7) | 2.08 | 2.10 |
| 23.09 | 60 | 4569 (TP7) | 2.16 | 2.17 |
| 23.1 | 120 | 4623 (TP3) | 2.22 | 2.23 |
| 23.11 | 15 | 4411 (TP5) | 4.92 | 4.91 |
| 24.01 | 15 | 4411 (TP5) | 0.76 | 0.78 |
| 24.02 | 15 | 4381 (TP1) | 2.78 | 2.85 |
| 25.01 | 15 | 4398 (TP16) | 0.00 | 0.00 |
| 26.01 | 720 | 4443 (TP11) | 0.07 | 0.06 |
| 26.02 | 20 | 4433 (TP20) | 0.59 | 0.59 |
| 26.03 | 15 | 4408 (TP2) | 2.38 | 2.37 |
| 26.04 | 30 | 4509 (TP4) | 2.57 | 2.54 |
| 26.05 | 30 | 4513 (TP8) | 2.93 | 2.97 |
| 26.06 | 30 | 4513 (TP8) | 2.95 | 2.97 |
| 26.07 | 45 | 4362 (TP11) | 3.12 | 3.11 |
| 26.08 | 45 | 4362 (TP11) | 3.05 | 3.04 |
| 26.09 | 45 | 4538 (TP4) | 3.14 | 3.15 |
| 26.1 | 60 | 4555 (TP14) | 1.35 | 1.35 |
| 26.11 | 60 | 4565 (TP3) | 1.41 | 1.42 |
| 26.12 | 45 | 4536 (TP2) | 4.31 | 4.28 |
| 26.13 | 45 | 4541 (TP7) | 4.54 | 4.49 |
| 26.14 | 45 | 4541 (TP7) | 4.74 | 4.68 |
| 27.01 | 15 | 4413 (TP7) | 0.47 | 0.48 |
| 28.01 | 20 | 4444 (TP10) | 0.81 | 0.82 |
| 28.02 | 45 | 4540 (TP6) | 1.02 | 1.00 |
| 29.01 | 15 | 4416 (TP10) | 0.62 | 0.64 |
| 30.01 | 60 | 4558 (TP17) | 1.78 | 1.78 |
| 30.02 | 60 | 4565 (TP3) | 2.06 | 2.07 |
| 30.03 | 60 | 4559 (TP18) | 3.03 | 3.13 |
| 31.01 | 25 | 4474 (TP7) | 0.84 | 0.83 |
| 32.01 | 15 | 4401 (TP18) | 0.06 | 0.05 |
| 33.01 | 15 | 4411 (TP5) | 0.63 | 0.65 |
| 33.02 | 20 | 4429 (TP18) | 1.59 | 1.60 |
| 33.03 | 20 | 4444 (TP10) | 4.15 | 4.14 |
| 33.04 | 20 | 4433 (TP20) | 4.44 | 4.46 |
| 33.05 | 20 | 4433 (TP20) | 4.56 | 4.54 |
| 33.06 | 15 | 4410 (TP4) | 6.63 | 6.78 |
| 34.01 | 15 | 4411 (TP5) | 2.03 | 2.07 |
| 35.01 | 15 | 4411 (TP5) | 1.63 | 1.69 |
| 35.02 | 20 | 4438 (TP6) | 6.49 | 6.38 |
| 35.03 | 20 | 4444 (TP10) | 6.64 | 6.51 |
| 35.04 | 20 | 4444 (TP10) | 6.70 | 6.57 |
| 36.01 | 15 | 4381 (TP1) | 0.85 | 0.87 |
| 36.02 | 15 | 4393 (TP13) | 1.71 | 1.73 |
| 36.03 | 15 | 4413 (TP7) | 2.76 | 2.75 |
| 37.01 | 15 | 4413 (TP7) | 0.62 | 0.64 |
| 38.01 | 15 | 4381 (TP1) | 0.89 | 0.91 |
| 39.01 | 15 | 4381 (TP1) | 1.00 | 1.03 |
| 40.01 | 15 | 4411 (TP5) | 0.87 | 0.90 |
| 41.01 | 15 | 4411 (TP5) | 1.03 | 1.06 |
| 41.02 | 15 | 4411 (TP5) | 1.51 | 1.56 |
| 42.01 | 15 | 4381 (TP1) | 0.44 | 0.46 |
| 43.01 | 15 | 4411 (TP5) | 0.47 | 0.49 |
| 44.01 | 90 | 4532 (TP15) | 0.13 | 0.13 |
| 45.01 | 15 | 4416 (TP10) | 1.52 | 1.55 |
| 45.02 | 15 | 4400 (TP17) | 2.27 | 2.28 |
| 45.03 | 15 | 4403 (TP19) | 3.64 | 3.65 |
| 45.04 | 15 | 4358 (TP11) | 4.04 | 4.04 |
| 45.05 | 15 | 4358 (TP11) | 4.09 | 4.09 |
| 45.06 | 15 | 4398 (TP16) | 4.18 | 4.18 |
| 45.07 | 30 | 4504 (TP19) | 5.14 | 5.13 |
| 45.08 | 30 | 4498 (TP15) | 11.68 | 11.74 |
| 46.01 | 20 | 4367 (TP12) | 0.59 | 0.59 |
| 47.01 | 15 | 4381 (TP1) | 0.96 | 0.99 |
| 48.01 | 15 | 4413 (TP7) | 0.78 | 0.80 |

| Subcatch ID | ARR2019 Discharge Statistics for All Durations and Temp. Patterns | | | |
|---|---|---|---|---|
| | Critical Duration (mins) | Adopted Temp. Pattern | Discharge ($m^3/s$) | |
| | | | Average | Adopted |
| 48.02 | 15 | 4393 (TP13) | 1.76 | 1.75 |
| 48.03 | 15 | 4412 (TP6) | 2.72 | 2.73 |
| 48.04 | 15 | 4407 (TP20) | 5.76 | 5.79 |
| 48.05 | 15 | 4407 (TP20) | 5.85 | 5.87 |
| 49.01 | 15 | 4411 (TP5) | 1.68 | 1.74 |
| 49.02 | 15 | 4411 (TP5) | 2.26 | 2.34 |
| 49.03 | 15 | 4392 (TP12) | 2.58 | 2.67 |
| 50.01 | 15 | 4413 (TP7) | 0.53 | 0.55 |
| 51.01 | 15 | 4381 (TP1) | 2.13 | 2.18 |
| 52.01 | 20 | 4444 (TP10) | 0.71 | 0.71 |
| 52.02 | 15 | 4381 (TP1) | 0.94 | 0.96 |
| 53.01 | 15 | 4411 (TP5) | 1.61 | 1.67 |
| 53.02 | 15 | 4411 (TP5) | 2.82 | 2.90 |
| 54.01 | 15 | 4381 (TP1) | 0.54 | 0.55 |
| 55.01 | 15 | 4411 (TP5) | 0.31 | 0.32 |
| 56.01 | 45 | 4536 (TP2) | 0.02 | 0.02 |
| 57.01 | 60 | 4558 (TP17) | 0.70 | 0.71 |
| 57.02 | 60 | 4569 (TP7) | 1.68 | 1.71 |
| 57.03 | 60 | 4565 (TP3) | 1.72 | 1.76 |
| 57.04 | 60 | 4558 (TP17) | 2.26 | 2.25 |
| 57.05 | 60 | 4565 (TP3) | 2.57 | 2.59 |
| 58.01 | 45 | 4541 (TP7) | 0.42 | 0.42 |
| 59.01 | 20 | 4433 (TP20) | 0.27 | 0.27 |
| 60.01 | 20 | 4433 (TP20) | 0.02 | 0.02 |
| 61.01 | 15 | 4413 (TP7) | 0.21 | 0.22 |
| 62.01 | 15 | 4381 (TP1) | 3.62 | 3.69 |
| 62.02 | 15 | 4407 (TP20) | 5.28 | 5.25 |
| 62.03 | 15 | 4397 (TP15) | 5.60 | 5.47 |
| 62.04 | 15 | 4397 (TP15) | 6.13 | 6.05 |
| 62.05 | 15 | 4397 (TP15) | 6.15 | 6.08 |
| 62.06 | 15 | 4397 (TP15) | 6.19 | 6.13 |
| 63.01 | 20 | 4429 (TP18) | 0.86 | 0.85 |
| 64.01 | 15 | 4413 (TP7) | 0.49 | 0.50 |
| 65.01 | 15 | 4381 (TP1) | 1.97 | 2.03 |
| 66.01 | 15 | 4393 (TP13) | 0.42 | 0.43 |
| 67.01 | 15 | 4413 (TP7) | 0.78 | 0.80 |
| 67.02 | 15 | 4411 (TP5) | 1.66 | 1.73 |
| 67.03 | 15 | 4397 (TP15) | 2.37 | 2.35 |
| 68.01 | 15 | 4411 (TP5) | 0.90 | 0.93 |
| 69.01 | 120 | 4624 (TP4) | 2.76 | 2.79 |
| 69.02 | 120 | 4624 (TP4) | 4.64 | 4.70 |
| 69.03 | 120 | 4624 (TP4) | 4.86 | 4.84 |
| 69.04 | 120 | 4622 (TP2) | 5.18 | 5.20 |
| 69.05 | 120 | 4628 (TP7) | 5.70 | 5.71 |
| 69.06 | 120 | 4628 (TP7) | 6.11 | 6.15 |
| 69.07 | 45 | 4534 (TP19) | 9.75 | 9.78 |
| 70.01 | 15 | 4393 (TP13) | 0.33 | 0.34 |
| 71.01 | 15 | 4381 (TP1) | 0.99 | 1.01 |
| 71.02 | 15 | 4401 (TP18) | 2.33 | 2.33 |
| 71.03 | 15 | 4401 (TP18) | 3.84 | 3.76 |
| 71.04 | 20 | 4439 (TP7) | 4.41 | 4.43 |
| 71.05 | 25 | 4394 (TP11) | 4.76 | 4.82 |
| 72.01 | 15 | 4398 (TP16) | 0.01 | 0.01 |
| 73.01 | 15 | 4410 (TP4) | 1.08 | 1.11 |

## ARR2019 Results for 2% AEP Event

| Subcatch ID | ARR2019 Discharge Statistics for All Durations and Temp. Patterns | | | |
|---|---|---|---|---|
| | Critical Duration (mins) | Adopted Temp. Pattern | Discharge ($m^3/s$) | |
| | | | Average | Adopted |
| 1.01 | 45 | 4531 (TP17) | 1.01 | 1.00 |
| 1.02 | 45 | 4540 (TP6) | 2.99 | 3.02 |
| 1.03 | 60 | 4558 (TP17) | 3.46 | 3.43 |
| 1.04 | 60 | 4475 (TP1) | 3.59 | 3.57 |
| 1.05 | 60 | 4572 (TP9) | 4.47 | 4.44 |
| 1.06 | 60 | 4475 (TP1) | 4.73 | 4.73 |
| 1.07 | 60 | 4559 (TP18) | 7.84 | 7.89 |
| 1.08 | 90 | 4594 (TP7) | 9.21 | 9.37 |
| 1.09 | 60 | 4559 (TP18) | 17.15 | 16.98 |
| 1.1 | 60 | 4360 (TP11) | 19.37 | 19.42 |
| 1.11 | 60 | 4569 (TP7) | 16.92 | 16.98 |
| 1.12 | 60 | 4569 (TP7) | 17.32 | 17.35 |
| 1.13 | 120 | 4499 (TP12) | 17.79 | 17.97 |
| 1.14 | 120 | 4631 (TP10) | 17.91 | 18.02 |
| 1.15 | 120 | 4618 (TP19) | 18.51 | 18.66 |
| 1.16 | 120 | 4618 (TP19) | 18.68 | 18.69 |
| 1.17 | 60 | 4558 (TP17) | 52.08 | 52.27 |
| 1.18 | 90 | 4564 (TP2) | 54.32 | 54.68 |
| 1.19 | 90 | 4594 (TP7) | 59.44 | 59.98 |
| 1.2 | 120 | 4619 (TP20) | 62.45 | 64.00 |
| 1.21 | 120 | 4623 (TP3) | 63.20 | 64.69 |
| 1.22 | 120 | 4618 (TP19) | 67.37 | 67.95 |
| 1.23 | 120 | 4624 (TP4) | 67.70 | 68.19 |
| 1.24 | 120 | 4624 (TP4) | 67.78 | 68.26 |
| 1.25 | 120 | 4629 (TP8) | 68.83 | 69.32 |
| 1.26 | 180 | 4666 (TP8) | 76.43 | 76.96 |
| 2.01 | 360 | 4726 (TP7) | 0.04 | 0.03 |
| 3.01 | 30 | 4510 (TP5) | 1.00 | 1.00 |
| 3.02 | 20 | 4433 (TP20) | 1.68 | 1.69 |
| 4.01 | 720 | 4801 (TP10) | 0.04 | 0.04 |
| 5.01 | 20 | 4444 (TP10) | 5.08 | 5.08 |
| 5.02 | 15 | 4392 (TP12) | 5.93 | 5.90 |
| 6.01 | 45 | 4539 (TP5) | 0.42 | 0.43 |
| 6.02 | 45 | 4541 (TP7) | 1.89 | 1.83 |
| 7.01 | 45 | 4531 (TP17) | 3.42 | 3.42 |
| 8.01 | 15 | 4393 (TP13) | 1.82 | 1.86 |
| 9.01 | 120 | 4499 (TP12) | 1.62 | 1.63 |
| 9.02 | 30 | 4510 (TP5) | 2.73 | 2.71 |
| 9.03 | 45 | 4536 (TP2) | 2.98 | 2.97 |
| 9.04 | 30 | 4509 (TP4) | 4.34 | 4.30 |
| 9.05 | 45 | 4534 (TP19) | 5.80 | 5.76 |
| 9.06 | 45 | 4525 (TP13) | 7.38 | 7.35 |
| 9.07 | 45 | 4542 (TP8) | 7.84 | 7.85 |
| 9.08 | 45 | 4540 (TP6) | 9.76 | 9.78 |
| 9.09 | 45 | 4528 (TP16) | 10.86 | 10.84 |
| 9.1 | 45 | 4528 (TP16) | 11.07 | 11.14 |
| 9.11 | 60 | 4572 (TP9) | 11.58 | 11.73 |
| 9.12 | 60 | 4405 (TP12) | 13.09 | 12.96 |
| 9.13 | 60 | 4475 (TP1) | 13.32 | 13.24 |
| 9.14 | 45 | 4538 (TP4) | 21.75 | 21.80 |
| 9.15 | 60 | 4405 (TP12) | 22.78 | 22.40 |
| 9.16 | 60 | 4569 (TP7) | 27.23 | 27.18 |
| 9.17 | 60 | 4569 (TP7) | 32.58 | 32.72 |
| 9.18 | 60 | 4569 (TP7) | 32.66 | 32.82 |
| 9.19 | 60 | 4569 (TP7) | 32.72 | 32.90 |
| 10.01 | 20 | 4433 (TP20) | 1.63 | 1.65 |
| 11.01 | 15 | 4408 (TP2) | 1.01 | 0.99 |
| 11.02 | 15 | 4393 (TP13) | 1.20 | 1.22 |
| 11.03 | 20 | 4436 (TP4) | 1.40 | 1.36 |
| 12.01 | 15 | 4393 (TP13) | 0.86 | 0.87 |
| 12.02 | 15 | 4393 (TP13) | 1.85 | 1.86 |
| 13.01 | 15 | 4393 (TP13) | 1.71 | 1.79 |
| 13.02 | 15 | 4411 (TP5) | 2.35 | 2.46 |
| 14.01 | 15 | 4393 (TP13) | 1.23 | 1.29 |
| 15.01 | 15 | 4393 (TP13) | 1.16 | 1.19 |
| 16.01 | 15 | 4381 (TP1) | 2.12 | 2.16 |
| 17.01 | 15 | 4413 (TP7) | 0.35 | 0.37 |
| 18.01 | 15 | 4393 (TP13) | 0.22 | 0.23 |
| 19.01 | 15 | 4393 (TP13) | 0.27 | 0.28 |
| 19.02 | 15 | 4410 (TP4) | 1.87 | 1.89 |
| 19.03 | 15 | 4392 (TP12) | 4.22 | 4.23 |
| 19.04 | 15 | 4398 (TP16) | 6.98 | 6.89 |
| 19.05 | 20 | 4444 (TP10) | 7.48 | 7.48 |
| 19.06 | 20 | 4427 (TP16) | 7.97 | 7.91 |

| Subcatch ID | ARR2019 Discharge Statistics for All Durations and Temp. Patterns | | | |
|---|---|---|---|---|
| | Critical Duration (mins) | Adopted Temp. Pattern | Discharge ($m^3/s$) | |
| | | | Average | Adopted |
| 19.07 | 25 | 4459 (TP14) | 9.08 | 9.08 |
| 19.08 | 25 | 4459 (TP14) | 9.31 | 9.31 |
| 20.01 | 15 | 4408 (TP2) | 0.63 | 0.63 |
| 21.01 | 15 | 4410 (TP4) | 0.01 | 0.01 |
| 22.01 | 15 | 4411 (TP5) | 2.81 | 2.88 |
| 23.01 | 15 | 4393 (TP13) | 1.06 | 1.05 |
| 23.02 | 15 | 4408 (TP2) | 3.81 | 3.76 |
| 23.03 | 45 | 4528 (TP16) | 2.55 | 2.55 |
| 23.04 | 45 | 4540 (TP6) | 2.55 | 2.47 |
| 23.05 | 45 | 4531 (TP17) | 2.69 | 2.63 |
| 23.06 | 60 | 4475 (TP1) | 2.73 | 2.73 |
| 23.07 | 60 | 4475 (TP1) | 2.75 | 2.75 |
| 23.08 | 60 | 4475 (TP1) | 2.86 | 2.86 |
| 23.09 | 60 | 4563 (TP2) | 2.98 | 2.99 |
| 23.1 | 60 | 4563 (TP2) | 3.00 | 3.03 |
| 23.11 | 15 | 4381 (TP1) | 6.00 | 6.04 |
| 24.01 | 15 | 4393 (TP13) | 0.93 | 0.96 |
| 24.02 | 15 | 4411 (TP5) | 3.37 | 3.45 |
| 25.01 | 15 | 4398 (TP16) | 0.01 | 0.01 |
| 26.01 | 360 | 4726 (TP7) | 0.11 | 0.10 |
| 26.02 | 20 | 4433 (TP20) | 0.74 | 0.73 |
| 26.03 | 20 | 4434 (TP2) | 2.94 | 3.00 |
| 26.04 | 30 | 4509 (TP4) | 3.17 | 3.16 |
| 26.05 | 30 | 4513 (TP8) | 3.62 | 3.65 |
| 26.06 | 30 | 4513 (TP8) | 3.64 | 3.67 |
| 26.07 | 45 | 4527 (TP15) | 3.84 | 3.83 |
| 26.08 | 45 | 4526 (TP14) | 3.81 | 3.81 |
| 26.09 | 45 | 4537 (TP3) | 3.97 | 4.01 |
| 26.1 | 90 | 4465 (TP13) | 1.52 | 1.50 |
| 26.11 | 120 | 4625 (TP5) | 1.58 | 1.58 |
| 26.12 | 20 | 4429 (TP18) | 5.25 | 5.07 |
| 26.13 | 45 | 4539 (TP5) | 5.53 | 5.45 |
| 26.14 | 45 | 4539 (TP5) | 5.79 | 5.71 |
| 27.01 | 15 | 4413 (TP7) | 0.58 | 0.60 |
| 28.01 | 20 | 4444 (TP10) | 1.06 | 1.07 |
| 28.02 | 45 | 4496 (TP12) | 1.49 | 1.45 |
| 29.01 | 15 | 4381 (TP1) | 0.75 | 0.77 |
| 30.01 | 45 | 4531 (TP17) | 2.37 | 2.40 |
| 30.02 | 45 | 4539 (TP5) | 2.73 | 2.73 |
| 30.03 | 60 | 4475 (TP1) | 4.01 | 4.07 |
| 31.01 | 20 | 4433 (TP20) | 1.12 | 1.12 |
| 32.01 | 15 | 4358 (TP11) | 0.07 | 0.07 |
| 33.01 | 15 | 4413 (TP7) | 0.78 | 0.82 |
| 33.02 | 20 | 4434 (TP2) | 2.04 | 2.01 |
| 33.03 | 20 | 4444 (TP10) | 5.15 | 5.07 |
| 33.04 | 20 | 4439 (TP7) | 5.51 | 5.55 |
| 33.05 | 20 | 4433 (TP20) | 5.67 | 5.67 |
| 33.06 | 15 | 4410 (TP4) | 8.14 | 8.33 |
| 34.01 | 15 | 4411 (TP5) | 2.46 | 2.54 |
| 35.01 | 15 | 4413 (TP7) | 2.00 | 2.11 |
| 35.02 | 20 | 4428 (TP17) | 8.05 | 7.94 |
| 35.03 | 20 | 4428 (TP17) | 8.23 | 8.05 |
| 35.04 | 20 | 4428 (TP17) | 8.32 | 8.13 |
| 36.01 | 15 | 4411 (TP5) | 1.04 | 1.08 |
| 36.02 | 20 | 4434 (TP2) | 2.21 | 2.21 |
| 36.03 | 25 | 4473 (TP6) | 3.49 | 3.59 |
| 37.01 | 15 | 4413 (TP7) | 0.77 | 0.80 |
| 38.01 | 15 | 4411 (TP5) | 1.09 | 1.14 |
| 39.01 | 15 | 4411 (TP5) | 1.23 | 1.28 |
| 40.01 | 15 | 4413 (TP7) | 1.08 | 1.13 |
| 41.01 | 15 | 4393 (TP13) | 1.26 | 1.32 |
| 41.02 | 15 | 4411 (TP5) | 1.85 | 1.94 |
| 42.01 | 15 | 4411 (TP5) | 0.54 | 0.56 |
| 43.01 | 15 | 4393 (TP13) | 0.58 | 0.59 |
| 44.01 | 60 | 4570 (TP8) | 0.17 | 0.17 |
| 45.01 | 15 | 4381 (TP1) | 1.83 | 1.88 |
| 45.02 | 15 | 4358 (TP11) | 2.78 | 2.80 |
| 45.03 | 15 | 4398 (TP16) | 4.50 | 4.51 |
| 45.04 | 15 | 4393 (TP13) | 4.98 | 4.98 |
| 45.05 | 15 | 4393 (TP13) | 5.06 | 5.06 |
| 45.06 | 15 | 4358 (TP11) | 5.17 | 5.17 |
| 45.07 | 30 | 4504 (TP19) | 6.38 | 6.34 |
| 45.08 | 30 | 4457 (TP12) | 14.59 | 14.69 |
| 46.01 | 20 | 4433 (TP20) | 0.77 | 0.77 |
| 47.01 | 15 | 4411 (TP5) | 1.16 | 1.20 |
| 48.01 | 15 | 4413 (TP7) | 0.96 | 1.00 |

| Subcatch ID | ARR2019 Discharge Statistics for All Durations and Temp. Patterns | | | |
|---|---|---|---|---|
| | Critical Duration (mins) | Adopted Temp. Pattern | Discharge ($m^3/s$) | |
| | | | Average | Adopted |
| 48.02 | 15 | 4411 (TP5) | 2.15 | 2.15 |
| 48.03 | 15 | 4412 (TP6) | 3.35 | 3.37 |
| 48.04 | 15 | 4408 (TP2) | 7.07 | 7.19 |
| 48.05 | 15 | 4407 (TP20) | 7.20 | 7.31 |
| 49.01 | 15 | 4411 (TP5) | 2.07 | 2.17 |
| 49.02 | 15 | 4411 (TP5) | 2.77 | 2.91 |
| 49.03 | 15 | 4392 (TP12) | 3.18 | 3.25 |
| 50.01 | 15 | 4413 (TP7) | 0.65 | 0.68 |
| 51.01 | 15 | 4411 (TP5) | 2.58 | 2.65 |
| 52.01 | 20 | 4444 (TP10) | 0.92 | 0.93 |
| 52.02 | 15 | 4408 (TP2) | 1.18 | 1.17 |
| 53.01 | 15 | 4393 (TP13) | 1.98 | 2.07 |
| 53.02 | 15 | 4411 (TP5) | 3.44 | 3.57 |
| 54.01 | 15 | 4411 (TP5) | 0.66 | 0.67 |
| 55.01 | 15 | 4411 (TP5) | 0.38 | 0.40 |
| 56.01 | 30 | 4498 (TP15) | 0.03 | 0.03 |
| 57.01 | 60 | 4569 (TP7) | 0.90 | 0.90 |
| 57.02 | 60 | 4569 (TP7) | 2.20 | 2.24 |
| 57.03 | 60 | 4569 (TP7) | 2.25 | 2.30 |
| 57.04 | 45 | 4542 (TP8) | 2.95 | 2.95 |
| 57.05 | 60 | 4565 (TP3) | 3.34 | 3.42 |
| 58.01 | 45 | 4539 (TP5) | 0.56 | 0.55 |
| 59.01 | 20 | 4433 (TP20) | 0.36 | 0.36 |
| 60.01 | 20 | 4433 (TP20) | 0.03 | 0.03 |
| 61.01 | 15 | 4393 (TP13) | 0.26 | 0.26 |
| 62.01 | 15 | 4411 (TP5) | 4.37 | 4.52 |
| 62.02 | 15 | 4407 (TP20) | 6.45 | 6.51 |
| 62.03 | 15 | 4407 (TP20) | 6.86 | 6.78 |
| 62.04 | 15 | 4398 (TP16) | 7.55 | 7.45 |
| 62.05 | 20 | 4383 (TP1) | 7.63 | 7.73 |
| 62.06 | 25 | 4471 (TP4) | 7.69 | 7.68 |
| 63.01 | 20 | 4435 (TP3) | 1.06 | 1.04 |
| 64.01 | 15 | 4393 (TP13) | 0.60 | 0.62 |
| 65.01 | 15 | 4411 (TP5) | 2.39 | 2.44 |
| 66.01 | 15 | 4393 (TP13) | 0.52 | 0.52 |
| 67.01 | 15 | 4393 (TP13) | 0.96 | 0.99 |
| 67.02 | 15 | 4393 (TP13) | 2.03 | 2.09 |
| 67.03 | 15 | 4398 (TP16) | 2.91 | 2.88 |
| 68.01 | 15 | 4411 (TP5) | 1.10 | 1.15 |
| 69.01 | 120 | 4624 (TP4) | 3.61 | 3.63 |
| 69.02 | 120 | 4614 (TP16) | 5.99 | 6.04 |
| 69.03 | 120 | 4614 (TP16) | 6.28 | 6.26 |
| 69.04 | 120 | 4622 (TP2) | 6.68 | 6.65 |
| 69.05 | 120 | 4628 (TP7) | 7.33 | 7.39 |
| 69.06 | 120 | 4628 (TP7) | 7.84 | 7.93 |
| 69.07 | 60 | 4360 (TP11) | 12.51 | 12.65 |
| 70.01 | 15 | 4408 (TP2) | 0.42 | 0.41 |
| 71.01 | 15 | 4411 (TP5) | 1.20 | 1.24 |
| 71.02 | 15 | 4401 (TP18) | 2.82 | 2.80 |
| 71.03 | 15 | 4401 (TP18) | 4.66 | 4.58 |
| 71.04 | 20 | 4371 (TP13) | 5.40 | 5.42 |
| 71.05 | 25 | 4394 (TP11) | 5.84 | 5.90 |
| 72.01 | 15 | 4398 (TP16) | 0.01 | 0.01 |
| 73.01 | 15 | 4410 (TP4) | 1.31 | 1.34 |

## ARR2019 Results for 1% AEP Event

| Subcatch ID | ARR2019 Discharge Statistics for All Durations and Temp. Patterns | | | |
|---|---|---|---|---|
| | Critical Duration (mins) | Adopted Temp. Pattern | Discharge ($m^3/s$) | |
| | | | Average | Adopted |
| 1.01 | 45 | 4534 (TP9) | 1.24 | 1.27 |
| 1.02 | 45 | 4528 (TP6) | 3.66 | 3.67 |
| 1.03 | 45 | 4496 (TP2) | 4.21 | 4.22 |
| 1.04 | 60 | 4405 (TP2) | 4.40 | 4.31 |
| 1.05 | 60 | 4405 (TP2) | 5.47 | 5.40 |
| 1.06 | 60 | 4558 (TP7) | 5.81 | 5.77 |
| 1.07 | 60 | 4555 (TP4) | 9.43 | 9.44 |
| 1.08 | 90 | 4588 (TP10) | 10.84 | 11.06 |
| 1.09 | 60 | 4360 (TP1) | 20.29 | 20.28 |
| 1.1 | 60 | 4559 (TP8) | 22.89 | 23.16 |
| 1.11 | 60 | 4405 (TP2) | 19.32 | 19.23 |
| 1.12 | 60 | 4405 (TP2) | 19.70 | 19.61 |
| 1.13 | 60 | 4405 (TP2) | 19.97 | 19.88 |
| 1.14 | 120 | 4617 (TP8) | 20.06 | 20.52 |
| 1.15 | 120 | 4618 (TP9) | 20.76 | 20.71 |
| 1.16 | 120 | 4618 (TP9) | 20.92 | 20.74 |
| 1.17 | 60 | 4561 (TP10) | 61.09 | 61.40 |
| 1.18 | 60 | 4556 (TP5) | 63.52 | 63.79 |
| 1.19 | 90 | 4586 (TP9) | 68.87 | 69.34 |
| 1.2 | 120 | 4611 (TP4) | 71.65 | 73.67 |
| 1.21 | 120 | 4611 (TP4) | 72.44 | 74.21 |
| 1.22 | 120 | 4619 (TP10) | 77.43 | 78.29 |
| 1.23 | 120 | 4619 (TP10) | 77.83 | 78.55 |
| 1.24 | 120 | 4619 (TP10) | 77.93 | 78.63 |
| 1.25 | 120 | 4619 (TP10) | 79.16 | 79.60 |
| 1.26 | 120 | 4571 (TP3) | 87.88 | 88.07 |
| 2.01 | 360 | 4587 (TP3) | 0.05 | 0.06 |
| 3.01 | 25 | 4464 (TP8) | 1.25 | 1.25 |
| 3.02 | 20 | 4433 (TP10) | 2.07 | 2.06 |
| 4.01 | 360 | 4721 (TP8) | 0.06 | 0.07 |
| 5.01 | 20 | 4371 (TP3) | 6.18 | 6.36 |
| 5.02 | 25 | 4460 (TP5) | 6.99 | 7.11 |
| 6.01 | 45 | 4528 (TP6) | 0.52 | 0.53 |
| 6.02 | 30 | 4498 (TP5) | 2.32 | 2.34 |
| 7.01 | 30 | 4503 (TP8) | 4.20 | 4.15 |
| 8.01 | 20 | 4359 (TP1) | 2.09 | 2.15 |
| 9.01 | 60 | 4556 (TP5) | 2.24 | 2.22 |
| 9.02 | 90 | 4532 (TP5) | 3.36 | 3.45 |
| 9.03 | 90 | 4585 (TP8) | 3.55 | 3.65 |
| 9.04 | 30 | 4498 (TP5) | 5.18 | 5.08 |
| 9.05 | 45 | 4533 (TP8) | 6.87 | 6.81 |
| 9.06 | 45 | 4525 (TP3) | 8.93 | 9.01 |
| 9.07 | 45 | 4531 (TP7) | 9.49 | 9.49 |
| 9.08 | 45 | 4527 (TP5) | 11.49 | 11.62 |
| 9.09 | 45 | 4528 (TP6) | 12.60 | 12.64 |
| 9.1 | 45 | 4528 (TP6) | 12.83 | 12.98 |
| 9.11 | 60 | 4558 (TP7) | 13.44 | 13.42 |
| 9.12 | 60 | 4558 (TP7) | 15.31 | 15.25 |
| 9.13 | 60 | 4405 (TP2) | 15.60 | 15.53 |
| 9.14 | 45 | 4362 (TP1) | 25.60 | 25.74 |
| 9.15 | 60 | 4559 (TP8) | 26.83 | 26.31 |
| 9.16 | 60 | 4556 (TP5) | 32.11 | 32.06 |
| 9.17 | 60 | 4558 (TP7) | 38.36 | 38.35 |
| 9.18 | 60 | 4558 (TP7) | 38.45 | 38.50 |
| 9.19 | 60 | 4558 (TP7) | 38.52 | 38.61 |
| 10.01 | 20 | 4371 (TP3) | 2.04 | 2.05 |
| 11.01 | 15 | 4393 (TP3) | 1.15 | 1.11 |
| 11.02 | 15 | 4358 (TP1) | 1.40 | 1.38 |
| 11.03 | 20 | 4429 (TP8) | 1.66 | 1.64 |
| 12.01 | 20 | 4371 (TP3) | 1.04 | 1.07 |
| 12.02 | 20 | 4371 (TP3) | 2.15 | 2.22 |
| 13.01 | 15 | 4392 (TP2) | 1.95 | 1.86 |
| 13.02 | 15 | 4392 (TP2) | 2.67 | 2.60 |
| 14.01 | 15 | 4358 (TP1) | 1.41 | 1.36 |
| 15.01 | 15 | 4358 (TP1) | 1.33 | 1.30 |
| 16.01 | 15 | 4392 (TP2) | 2.38 | 2.35 |
| 17.01 | 15 | 4392 (TP2) | 0.41 | 0.39 |
| 18.01 | 15 | 4358 (TP1) | 0.25 | 0.25 |
| 19.01 | 15 | 4358 (TP1) | 0.30 | 0.30 |
| 19.02 | 15 | 4358 (TP1) | 2.12 | 2.06 |
| 19.03 | 15 | 4393 (TP3) | 4.94 | 4.91 |
| 19.04 | 15 | 4398 (TP6) | 8.09 | 7.98 |
| 19.05 | 20 | 4433 (TP10) | 8.65 | 8.64 |
| 19.06 | 20 | 4428 (TP7) | 9.21 | 9.11 |

| Subcatch ID | ARR2019 Discharge Statistics for All Durations and Temp. Patterns | | | |
|---|---|---|---|---|
| | Critical Duration (mins) | Adopted Temp. Pattern | Discharge ($m^3/s$) | |
| | | | Average | Adopted |
| 19.07 | 25 | 4467 (TP10) | 10.40 | 10.35 |
| 19.08 | 25 | 4467 (TP10) | 10.70 | 10.66 |
| 20.01 | 15 | 4393 (TP3) | 0.73 | 0.71 |
| 21.01 | 15 | 4392 (TP2) | 0.01 | 0.01 |
| 22.01 | 15 | 4392 (TP2) | 3.17 | 3.09 |
| 23.01 | 15 | 4393 (TP3) | 1.21 | 1.18 |
| 23.02 | 20 | 4371 (TP3) | 4.36 | 4.36 |
| 23.03 | 25 | 4460 (TP5) | 3.14 | 3.17 |
| 23.04 | 45 | 4528 (TP6) | 3.07 | 3.16 |
| 23.05 | 45 | 4534 (TP9) | 3.30 | 3.35 |
| 23.06 | 45 | 4534 (TP9) | 3.34 | 3.36 |
| 23.07 | 45 | 4534 (TP9) | 3.35 | 3.36 |
| 23.08 | 60 | 4360 (TP1) | 3.49 | 3.50 |
| 23.09 | 60 | 4559 (TP8) | 3.65 | 3.70 |
| 23.1 | 60 | 4463 (TP3) | 3.67 | 3.71 |
| 23.11 | 20 | 4399 (TP4) | 6.98 | 6.87 |
| 24.01 | 15 | 4392 (TP2) | 1.05 | 1.00 |
| 24.02 | 15 | 4392 (TP2) | 3.80 | 3.71 |
| 25.01 | 15 | 4392 (TP2) | 0.01 | 0.01 |
| 26.01 | 360 | 4587 (TP3) | 0.17 | 0.18 |
| 26.02 | 20 | 4429 (TP8) | 0.88 | 0.84 |
| 26.03 | 20 | 4371 (TP3) | 3.56 | 3.59 |
| 26.04 | 25 | 4394 (TP1) | 3.77 | 3.79 |
| 26.05 | 30 | 4498 (TP5) | 4.21 | 4.25 |
| 26.06 | 30 | 4498 (TP5) | 4.24 | 4.27 |
| 26.07 | 45 | 4362 (TP1) | 4.47 | 4.49 |
| 26.08 | 45 | 4362 (TP1) | 4.45 | 4.51 |
| 26.09 | 45 | 4535 (TP10) | 4.65 | 4.71 |
| 26.1 | 60 | 4558 (TP7) | 2.08 | 2.06 |
| 26.11 | 60 | 4558 (TP7) | 2.09 | 2.07 |
| 26.12 | 20 | 4359 (TP1) | 6.15 | 6.15 |
| 26.13 | 20 | 4359 (TP1) | 6.49 | 6.39 |
| 26.14 | 20 | 4359 (TP1) | 6.73 | 6.63 |
| 27.01 | 15 | 4358 (TP1) | 0.66 | 0.64 |
| 28.01 | 20 | 4367 (TP2) | 1.32 | 1.30 |
| 28.02 | 30 | 4498 (TP5) | 1.96 | 1.92 |
| 29.01 | 15 | 4392 (TP2) | 0.84 | 0.84 |
| 30.01 | 45 | 4528 (TP6) | 2.96 | 3.00 |
| 30.02 | 45 | 4528 (TP6) | 3.38 | 3.47 |
| 30.03 | 60 | 4558 (TP7) | 4.86 | 4.72 |
| 31.01 | 20 | 4404 (TP5) | 1.39 | 1.40 |
| 32.01 | 15 | 4396 (TP4) | 0.08 | 0.08 |
| 33.01 | 15 | 4358 (TP1) | 0.89 | 0.85 |
| 33.02 | 20 | 4399 (TP4) | 2.49 | 2.40 |
| 33.03 | 20 | 4359 (TP1) | 6.11 | 6.10 |
| 33.04 | 20 | 4433 (TP10) | 6.49 | 6.50 |
| 33.05 | 20 | 4433 (TP10) | 6.69 | 6.64 |
| 33.06 | 20 | 4428 (TP7) | 9.52 | 9.24 |
| 34.01 | 15 | 4392 (TP2) | 2.77 | 2.66 |
| 35.01 | 15 | 4358 (TP1) | 2.29 | 2.20 |
| 35.02 | 20 | 4429 (TP8) | 9.43 | 9.36 |
| 35.03 | 20 | 4429 (TP8) | 9.67 | 9.50 |
| 35.04 | 20 | 4429 (TP8) | 9.78 | 9.61 |
| 36.01 | 15 | 4392 (TP2) | 1.18 | 1.15 |
| 36.02 | 20 | 4371 (TP3) | 2.67 | 2.61 |
| 36.03 | 25 | 4458 (TP3) | 4.26 | 4.33 |
| 37.01 | 15 | 4358 (TP1) | 0.88 | 0.86 |
| 38.01 | 15 | 4392 (TP2) | 1.24 | 1.20 |
| 39.01 | 15 | 4392 (TP2) | 1.40 | 1.36 |
| 40.01 | 15 | 4358 (TP1) | 1.23 | 1.19 |
| 41.01 | 15 | 4358 (TP1) | 1.44 | 1.38 |
| 41.02 | 15 | 4392 (TP2) | 2.10 | 2.04 |
| 42.01 | 15 | 4392 (TP2) | 0.62 | 0.60 |
| 43.01 | 20 | 4371 (TP3) | 0.66 | 0.68 |
| 44.01 | 60 | 4405 (TP2) | 0.21 | 0.21 |
| 45.01 | 15 | 4392 (TP2) | 2.06 | 2.05 |
| 45.02 | 15 | 4358 (TP1) | 3.22 | 3.26 |
| 45.03 | 15 | 4407 (TP10) | 5.28 | 5.27 |
| 45.04 | 15 | 4393 (TP3) | 5.82 | 5.83 |
| 45.05 | 15 | 4393 (TP3) | 5.93 | 5.94 |
| 45.06 | 15 | 4393 (TP3) | 6.05 | 6.05 |
| 45.07 | 30 | 4495 (TP3) | 7.49 | 7.58 |
| 45.08 | 30 | 4498 (TP5) | 17.17 | 17.32 |
| 46.01 | 20 | 4433 (TP10) | 0.95 | 0.94 |
| 47.01 | 15 | 4392 (TP2) | 1.31 | 1.27 |
| 48.01 | 15 | 4358 (TP1) | 1.10 | 1.07 |

| Subcatch ID | ARR2019 Discharge Statistics for All Durations and Temp. Patterns | | | |
|---|---|---|---|---|
| | Critical Duration (mins) | Adopted Temp. Pattern | Discharge ($m^3/s$) | |
| | | | Average | Adopted |
| 48.02 | 15 | 4392 (TP2) | 2.50 | 2.48 |
| 48.03 | 15 | 4401 (TP8) | 3.90 | 3.92 |
| 48.04 | 20 | 4359 (TP1) | 8.25 | 8.42 |
| 48.05 | 20 | 4359 (TP1) | 8.43 | 8.55 |
| 49.01 | 15 | 4392 (TP2) | 2.36 | 2.26 |
| 49.02 | 15 | 4392 (TP2) | 3.16 | 3.06 |
| 49.03 | 15 | 4392 (TP2) | 3.67 | 3.73 |
| 50.01 | 15 | 4358 (TP1) | 0.74 | 0.72 |
| 51.01 | 15 | 4392 (TP2) | 2.91 | 2.83 |
| 52.01 | 20 | 4367 (TP2) | 1.14 | 1.14 |
| 52.02 | 20 | 4429 (TP8) | 1.43 | 1.40 |
| 53.01 | 15 | 4358 (TP1) | 2.26 | 2.16 |
| 53.02 | 15 | 4392 (TP2) | 3.90 | 3.81 |
| 54.01 | 15 | 4392 (TP2) | 0.74 | 0.73 |
| 55.01 | 15 | 4392 (TP2) | 0.43 | 0.42 |
| 56.01 | 25 | 4394 (TP1) | 0.03 | 0.03 |
| 57.01 | 60 | 4558 (TP7) | 1.08 | 1.06 |
| 57.02 | 45 | 4534 (TP9) | 2.68 | 2.69 |
| 57.03 | 45 | 4534 (TP9) | 2.75 | 2.77 |
| 57.04 | 45 | 4528 (TP6) | 3.61 | 3.64 |
| 57.05 | 45 | 4528 (TP6) | 4.04 | 4.02 |
| 58.01 | 45 | 4528 (TP6) | 0.68 | 0.68 |
| 59.01 | 20 | 4433 (TP10) | 0.43 | 0.43 |
| 60.01 | 20 | 4429 (TP8) | 0.04 | 0.04 |
| 61.01 | 20 | 4371 (TP3) | 0.31 | 0.31 |
| 62.01 | 15 | 4392 (TP2) | 4.92 | 4.74 |
| 62.02 | 15 | 4392 (TP2) | 7.45 | 7.58 |
| 62.03 | 15 | 4407 (TP10) | 8.01 | 7.97 |
| 62.04 | 25 | 4459 (TP4) | 8.83 | 9.02 |
| 62.05 | 20 | 4399 (TP4) | 8.96 | 9.15 |
| 62.06 | 20 | 4399 (TP4) | 9.02 | 9.20 |
| 63.01 | 20 | 4367 (TP2) | 1.26 | 1.23 |
| 64.01 | 15 | 4358 (TP1) | 0.69 | 0.69 |
| 65.01 | 15 | 4392 (TP2) | 2.69 | 2.63 |
| 66.01 | 20 | 4371 (TP3) | 0.63 | 0.64 |
| 67.01 | 15 | 4358 (TP1) | 1.11 | 1.10 |
| 67.02 | 20 | 4371 (TP3) | 2.32 | 2.37 |
| 67.03 | 15 | 4398 (TP6) | 3.40 | 3.33 |
| 68.01 | 15 | 4392 (TP2) | 1.25 | 1.21 |
| 69.01 | 120 | 4614 (TP6) | 4.17 | 4.21 |
| 69.02 | 120 | 4614 (TP6) | 6.95 | 7.18 |
| 69.03 | 120 | 4614 (TP6) | 7.28 | 7.42 |
| 69.04 | 120 | 4614 (TP6) | 7.79 | 7.77 |
| 69.05 | 120 | 4614 (TP6) | 8.54 | 8.60 |
| 69.06 | 60 | 4559 (TP8) | 9.27 | 9.41 |
| 69.07 | 60 | 4558 (TP7) | 15.06 | 15.30 |
| 70.01 | 20 | 4371 (TP3) | 0.49 | 0.49 |
| 71.01 | 15 | 4392 (TP2) | 1.36 | 1.31 |
| 71.02 | 15 | 4400 (TP7) | 3.24 | 3.20 |
| 71.03 | 15 | 4401 (TP8) | 5.35 | 5.26 |
| 71.04 | 20 | 4371 (TP3) | 6.23 | 6.28 |
| 71.05 | 25 | 4394 (TP1) | 6.75 | 6.83 |
| 72.01 | 15 | 4392 (TP2) | 0.01 | 0.01 |
| 73.01 | 15 | 4392 (TP2) | 1.46 | 1.44 |

## ARR2019 Results for 0.5% AEP Event

| Subcatch ID | ARR2019 Discharge Statistics for All Durations and Temp. Patterns | | | |
|---|---|---|---|---|
| | Critical Duration (mins) | Adopted Temp. Pattern | Discharge ($m^3/s$) | |
| | | | Average | Adopted |
| 1.01 | 45 | 4534 (TP9) | 1.39 | 1.42 |
| 1.02 | 45 | 4528 (TP6) | 4.09 | 4.09 |
| 1.03 | 45 | 4496 (TP2) | 4.73 | 4.73 |
| 1.04 | 60 | 4405 (TP2) | 4.91 | 4.82 |
| 1.05 | 60 | 4405 (TP2) | 6.12 | 6.03 |
| 1.06 | 60 | 4405 (TP2) | 6.50 | 6.45 |
| 1.07 | 60 | 4555 (TP4) | 10.50 | 10.51 |
| 1.08 | 90 | 4588 (TP10) | 12.05 | 12.28 |
| 1.09 | 60 | 4360 (TP1) | 22.59 | 22.70 |
| 1.1 | 60 | 4559 (TP8) | 25.50 | 25.70 |
| 1.11 | 60 | 4558 (TP7) | 20.75 | 20.66 |
| 1.12 | 60 | 4558 (TP7) | 21.13 | 21.04 |
| 1.13 | 120 | 4617 (TP8) | 21.60 | 21.77 |
| 1.14 | 120 | 4617 (TP8) | 21.78 | 21.82 |
| 1.15 | 120 | 4618 (TP9) | 22.53 | 22.11 |
| 1.16 | 120 | 4571 (TP3) | 22.68 | 22.16 |
| 1.17 | 60 | 4556 (TP5) | 66.98 | 67.19 |
| 1.18 | 60 | 4556 (TP5) | 69.69 | 69.74 |
| 1.19 | 90 | 4586 (TP9) | 75.72 | 76.06 |
| 1.2 | 90 | 4586 (TP9) | 78.55 | 78.66 |
| 1.21 | 120 | 4611 (TP4) | 79.34 | 80.92 |
| 1.22 | 120 | 4619 (TP10) | 84.88 | 85.94 |
| 1.23 | 120 | 4619 (TP10) | 85.32 | 86.21 |
| 1.24 | 120 | 4619 (TP10) | 85.42 | 86.30 |
| 1.25 | 120 | 4619 (TP10) | 86.75 | 87.36 |
| 1.26 | 120 | 4571 (TP3) | 96.55 | 96.65 |
| 2.01 | 180 | 4651 (TP7) | 0.06 | 0.06 |
| 3.01 | 25 | 4464 (TP8) | 1.41 | 1.40 |
| 3.02 | 20 | 4433 (TP10) | 2.32 | 2.30 |
| 4.01 | 360 | 4721 (TP8) | 0.07 | 0.07 |
| 5.01 | 20 | 4371 (TP3) | 6.86 | 7.02 |
| 5.02 | 25 | 4458 (TP3) | 7.70 | 7.83 |
| 6.01 | 45 | 4528 (TP6) | 0.58 | 0.59 |
| 6.02 | 30 | 4498 (TP5) | 2.60 | 2.62 |
| 7.01 | 30 | 4503 (TP8) | 4.72 | 4.66 |
| 8.01 | 20 | 4359 (TP1) | 2.31 | 2.38 |
| 9.01 | 60 | 4405 (TP2) | 2.71 | 2.71 |
| 9.02 | 60 | 4558 (TP7) | 4.04 | 4.11 |
| 9.03 | 60 | 4557 (TP6) | 4.25 | 4.33 |
| 9.04 | 30 | 4498 (TP5) | 5.71 | 5.61 |
| 9.05 | 30 | 4497 (TP4) | 7.59 | 7.48 |
| 9.06 | 45 | 4525 (TP3) | 9.93 | 10.04 |
| 9.07 | 45 | 4531 (TP7) | 10.55 | 10.54 |
| 9.08 | 45 | 4496 (TP2) | 12.72 | 12.84 |
| 9.09 | 45 | 4528 (TP6) | 13.89 | 13.90 |
| 9.1 | 60 | 4558 (TP7) | 14.15 | 14.06 |
| 9.11 | 60 | 4558 (TP7) | 14.80 | 14.75 |
| 9.12 | 60 | 4558 (TP7) | 16.82 | 16.77 |
| 9.13 | 60 | 4405 (TP2) | 17.14 | 17.05 |
| 9.14 | 45 | 4362 (TP1) | 28.18 | 28.37 |
| 9.15 | 60 | 4559 (TP8) | 29.56 | 28.96 |
| 9.16 | 60 | 4556 (TP5) | 35.34 | 35.18 |
| 9.17 | 60 | 4558 (TP7) | 42.21 | 42.29 |
| 9.18 | 60 | 4558 (TP7) | 42.31 | 42.45 |
| 9.19 | 60 | 4558 (TP7) | 42.38 | 42.57 |
| 10.01 | 20 | 4371 (TP3) | 2.29 | 2.27 |
| 11.01 | 15 | 4393 (TP3) | 1.26 | 1.21 |
| 11.02 | 15 | 4401 (TP8) | 1.54 | 1.52 |
| 11.03 | 20 | 4429 (TP8) | 1.84 | 1.81 |
| 12.01 | 20 | 4371 (TP3) | 1.15 | 1.19 |
| 12.02 | 20 | 4371 (TP3) | 2.38 | 2.45 |
| 13.01 | 15 | 4358 (TP1) | 2.13 | 2.03 |
| 13.02 | 15 | 4392 (TP2) | 2.93 | 2.84 |
| 14.01 | 15 | 4358 (TP1) | 1.55 | 1.50 |
| 15.01 | 15 | 4358 (TP1) | 1.45 | 1.43 |
| 16.01 | 15 | 4392 (TP2) | 2.60 | 2.54 |
| 17.01 | 15 | 4358 (TP1) | 0.45 | 0.43 |
| 18.01 | 15 | 4358 (TP1) | 0.28 | 0.27 |
| 19.01 | 15 | 4358 (TP1) | 0.33 | 0.32 |
| 19.02 | 15 | 4358 (TP1) | 2.32 | 2.26 |
| 19.03 | 15 | 4393 (TP3) | 5.43 | 5.38 |
| 19.04 | 15 | 4398 (TP6) | 8.85 | 8.73 |
| 19.05 | 20 | 4433 (TP10) | 9.48 | 9.48 |
| 19.06 | 20 | 4428 (TP7) | 10.09 | 9.97 |

| Subcatch ID | ARR2019 Discharge Statistics for All Durations and Temp. Patterns | | | |
|---|---|---|---|---|
| | Critical Duration (mins) | Adopted Temp. Pattern | Discharge ($m^3/s$) | |
| | | | Average | Adopted |
| 19.07 | 25 | 4467 (TP10) | 11.39 | 11.33 |
| 19.08 | 25 | 4467 (TP10) | 11.73 | 11.68 |
| 20.01 | 15 | 4400 (TP7) | 0.81 | 0.77 |
| 21.01 | 15 | 4392 (TP2) | 0.01 | 0.02 |
| 22.01 | 15 | 4392 (TP2) | 3.45 | 3.35 |
| 23.01 | 15 | 4393 (TP3) | 1.32 | 1.28 |
| 23.02 | 20 | 4371 (TP3) | 4.80 | 4.78 |
| 23.03 | 25 | 4460 (TP5) | 3.52 | 3.59 |
| 23.04 | 45 | 4528 (TP6) | 3.42 | 3.52 |
| 23.05 | 45 | 4534 (TP9) | 3.70 | 3.74 |
| 23.06 | 45 | 4534 (TP9) | 3.76 | 3.77 |
| 23.07 | 45 | 4534 (TP9) | 3.78 | 3.77 |
| 23.08 | 60 | 4360 (TP1) | 3.93 | 3.99 |
| 23.09 | 60 | 4463 (TP3) | 4.12 | 4.13 |
| 23.1 | 60 | 4463 (TP3) | 4.14 | 4.14 |
| 23.11 | 20 | 4428 (TP7) | 7.67 | 7.54 |
| 24.01 | 15 | 4392 (TP2) | 1.15 | 1.10 |
| 24.02 | 15 | 4392 (TP2) | 4.15 | 4.03 |
| 25.01 | 15 | 4392 (TP2) | 0.01 | 0.01 |
| 26.01 | 180 | 4651 (TP7) | 0.20 | 0.17 |
| 26.02 | 20 | 4429 (TP8) | 0.97 | 0.92 |
| 26.03 | 20 | 4371 (TP3) | 3.94 | 3.99 |
| 26.04 | 25 | 4394 (TP1) | 4.16 | 4.18 |
| 26.05 | 30 | 4498 (TP5) | 4.62 | 4.68 |
| 26.06 | 30 | 4498 (TP5) | 4.65 | 4.69 |
| 26.07 | 45 | 4362 (TP1) | 4.90 | 4.94 |
| 26.08 | 45 | 4362 (TP1) | 4.89 | 4.97 |
| 26.09 | 45 | 4535 (TP10) | 5.12 | 5.17 |
| 26.1 | 60 | 4558 (TP7) | 2.57 | 2.54 |
| 26.11 | 60 | 4558 (TP7) | 2.57 | 2.55 |
| 26.12 | 30 | 4500 (TP6) | 6.75 | 6.82 |
| 26.13 | 20 | 4359 (TP1) | 7.10 | 7.02 |
| 26.14 | 30 | 4500 (TP6) | 7.41 | 7.42 |
| 27.01 | 15 | 4358 (TP1) | 0.72 | 0.71 |
| 28.01 | 20 | 4433 (TP10) | 1.47 | 1.44 |
| 28.02 | 30 | 4498 (TP5) | 2.22 | 2.17 |
| 29.01 | 15 | 4392 (TP2) | 0.92 | 0.91 |
| 30.01 | 45 | 4528 (TP6) | 3.32 | 3.37 |
| 30.02 | 45 | 4528 (TP6) | 3.79 | 3.90 |
| 30.03 | 60 | 4360 (TP1) | 5.43 | 5.33 |
| 31.01 | 20 | 4428 (TP7) | 1.55 | 1.56 |
| 32.01 | 15 | 4400 (TP7) | 0.09 | 0.09 |
| 33.01 | 15 | 4358 (TP1) | 0.98 | 0.94 |
| 33.02 | 20 | 4399 (TP4) | 2.76 | 2.68 |
| 33.03 | 20 | 4359 (TP1) | 6.72 | 6.72 |
| 33.04 | 20 | 4433 (TP10) | 7.14 | 7.15 |
| 33.05 | 20 | 4433 (TP10) | 7.36 | 7.31 |
| 33.06 | 20 | 4359 (TP1) | 10.47 | 10.14 |
| 34.01 | 15 | 4392 (TP2) | 3.04 | 2.91 |
| 35.01 | 15 | 4358 (TP1) | 2.52 | 2.43 |
| 35.02 | 25 | 4467 (TP10) | 10.43 | 10.44 |
| 35.03 | 20 | 4429 (TP8) | 10.65 | 10.47 |
| 35.04 | 20 | 4429 (TP8) | 10.78 | 10.60 |
| 36.01 | 15 | 4392 (TP2) | 1.29 | 1.25 |
| 36.02 | 20 | 4371 (TP3) | 2.97 | 2.88 |
| 36.03 | 25 | 4458 (TP3) | 4.73 | 4.81 |
| 37.01 | 15 | 4358 (TP1) | 0.97 | 0.95 |
| 38.01 | 15 | 4392 (TP2) | 1.36 | 1.31 |
| 39.01 | 15 | 4392 (TP2) | 1.54 | 1.48 |
| 40.01 | 15 | 4358 (TP1) | 1.35 | 1.31 |
| 41.01 | 15 | 4358 (TP1) | 1.58 | 1.52 |
| 41.02 | 15 | 4392 (TP2) | 2.31 | 2.23 |
| 42.01 | 15 | 4392 (TP2) | 0.68 | 0.66 |
| 43.01 | 20 | 4371 (TP3) | 0.73 | 0.76 |
| 44.01 | 60 | 4405 (TP2) | 0.24 | 0.24 |
| 45.01 | 15 | 4392 (TP2) | 2.24 | 2.22 |
| 45.02 | 15 | 4358 (TP1) | 3.52 | 3.58 |
| 45.03 | 15 | 4397 (TP5) | 5.80 | 5.79 |
| 45.04 | 15 | 4403 (TP9) | 6.38 | 6.38 |
| 45.05 | 15 | 4403 (TP9) | 6.51 | 6.51 |
| 45.06 | 25 | 4394 (TP1) | 6.66 | 6.59 |
| 45.07 | 30 | 4495 (TP3) | 8.24 | 8.34 |
| 45.08 | 30 | 4498 (TP5) | 18.94 | 19.10 |
| 46.01 | 20 | 4433 (TP10) | 1.06 | 1.05 |
| 47.01 | 15 | 4392 (TP2) | 1.43 | 1.37 |
| 48.01 | 15 | 4358 (TP1) | 1.20 | 1.17 |

| Subcatch ID | ARR2019 Discharge Statistics for All Durations and Temp. Patterns | | | |
|---|---|---|---|---|
| | Critical Duration (mins) | Adopted Temp. Pattern | Discharge ($m^3/s$) | |
| | | | Average | Adopted |
| 48.02 | 20 | 4429 (TP8) | 2.74 | 2.74 |
| 48.03 | 15 | 4401 (TP8) | 4.28 | 4.31 |
| 48.04 | 20 | 4359 (TP1) | 9.07 | 9.29 |
| 48.05 | 20 | 4359 (TP1) | 9.27 | 9.43 |
| 49.01 | 15 | 4358 (TP1) | 2.59 | 2.47 |
| 49.02 | 15 | 4392 (TP2) | 3.47 | 3.34 |
| 49.03 | 15 | 4392 (TP2) | 4.03 | 4.08 |
| 50.01 | 15 | 4358 (TP1) | 0.82 | 0.80 |
| 51.01 | 15 | 4392 (TP2) | 3.18 | 3.07 |
| 52.01 | 20 | 4367 (TP2) | 1.27 | 1.26 |
| 52.02 | 20 | 4429 (TP8) | 1.58 | 1.56 |
| 53.01 | 15 | 4358 (TP1) | 2.48 | 2.38 |
| 53.02 | 15 | 4392 (TP2) | 4.26 | 4.15 |
| 54.01 | 15 | 4392 (TP2) | 0.82 | 0.80 |
| 55.01 | 15 | 4392 (TP2) | 0.48 | 0.46 |
| 56.01 | 25 | 4460 (TP5) | 0.04 | 0.04 |
| 57.01 | 45 | 4496 (TP2) | 1.20 | 1.21 |
| 57.02 | 45 | 4534 (TP9) | 3.00 | 3.01 |
| 57.03 | 45 | 4534 (TP9) | 3.07 | 3.10 |
| 57.04 | 45 | 4528 (TP6) | 4.03 | 4.05 |
| 57.05 | 45 | 4528 (TP6) | 4.51 | 4.51 |
| 58.01 | 30 | 4498 (TP5) | 0.76 | 0.77 |
| 59.01 | 20 | 4433 (TP10) | 0.48 | 0.47 |
| 60.01 | 20 | 4429 (TP8) | 0.04 | 0.04 |
| 61.01 | 20 | 4371 (TP3) | 0.34 | 0.34 |
| 62.01 | 15 | 4392 (TP2) | 5.37 | 5.13 |
| 62.02 | 15 | 4392 (TP2) | 8.16 | 8.24 |
| 62.03 | 15 | 4407 (TP10) | 8.78 | 8.78 |
| 62.04 | 25 | 4459 (TP4) | 9.74 | 9.93 |
| 62.05 | 25 | 4459 (TP4) | 9.87 | 10.18 |
| 62.06 | 25 | 4459 (TP4) | 9.94 | 10.28 |
| 63.01 | 20 | 4433 (TP10) | 1.40 | 1.36 |
| 64.01 | 15 | 4393 (TP3) | 0.76 | 0.76 |
| 65.01 | 15 | 4392 (TP2) | 2.93 | 2.85 |
| 66.01 | 20 | 4371 (TP3) | 0.70 | 0.71 |
| 67.01 | 20 | 4371 (TP3) | 1.22 | 1.22 |
| 67.02 | 20 | 4371 (TP3) | 2.56 | 2.61 |
| 67.03 | 15 | 4407 (TP10) | 3.73 | 3.67 |
| 68.01 | 15 | 4392 (TP2) | 1.37 | 1.32 |
| 69.01 | 120 | 4614 (TP6) | 4.66 | 4.73 |
| 69.02 | 90 | 4532 (TP5) | 7.75 | 7.89 |
| 69.03 | 90 | 4532 (TP5) | 8.11 | 8.16 |
| 69.04 | 120 | 4614 (TP6) | 8.65 | 8.65 |
| 69.05 | 60 | 4559 (TP8) | 9.58 | 9.76 |
| 69.06 | 60 | 4559 (TP8) | 10.39 | 10.55 |
| 69.07 | 60 | 4558 (TP7) | 16.81 | 17.07 |
| 70.01 | 20 | 4371 (TP3) | 0.54 | 0.53 |
| 71.01 | 15 | 4392 (TP2) | 1.48 | 1.42 |
| 71.02 | 15 | 4400 (TP7) | 3.53 | 3.51 |
| 71.03 | 20 | 4367 (TP2) | 5.85 | 5.77 |
| 71.04 | 20 | 4371 (TP3) | 6.83 | 6.90 |
| 71.05 | 25 | 4394 (TP1) | 7.40 | 7.49 |
| 72.01 | 15 | 4392 (TP2) | 0.01 | 0.01 |
| 73.01 | 15 | 4392 (TP2) | 1.60 | 1.57 |

## ARR2019 Results for 0.2% AEP Event

| Subcatch ID | ARR2019 Discharge Statistics for All Durations and Temp. Patterns | | | |
|---|---|---|---|---|
| | Critical Duration (mins) | Adopted Temp. Pattern | Discharge ($m^3/s$) | |
| | | | Average | Adopted |
| 1.01 | 45 | 4534 (TP9) | 1.62 | 1.64 |
| 1.02 | 45 | 4528 (TP6) | 4.77 | 4.80 |
| 1.03 | 45 | 4496 (TP2) | 5.56 | 5.57 |
| 1.04 | 60 | 4405 (TP2) | 5.73 | 5.63 |
| 1.05 | 60 | 4463 (TP3) | 7.14 | 7.05 |
| 1.06 | 60 | 4405 (TP2) | 7.60 | 7.54 |
| 1.07 | 60 | 4555 (TP4) | 12.21 | 12.20 |
| 1.08 | 90 | 4588 (TP10) | 13.99 | 14.23 |
| 1.09 | 60 | 4360 (TP1) | 26.26 | 26.57 |
| 1.1 | 60 | 4559 (TP8) | 29.65 | 29.81 |
| 1.11 | 60 | 4405 (TP2) | 27.11 | 27.12 |
| 1.12 | 60 | 4405 (TP2) | 27.61 | 27.59 |
| 1.13 | 60 | 4405 (TP2) | 27.96 | 27.91 |
| 1.14 | 60 | 4405 (TP2) | 28.01 | 27.95 |
| 1.15 | 60 | 4405 (TP2) | 28.20 | 28.13 |
| 1.16 | 60 | 4405 (TP2) | 28.24 | 28.17 |
| 1.17 | 60 | 4556 (TP5) | 76.19 | 76.10 |
| 1.18 | 60 | 4559 (TP8) | 79.42 | 79.69 |
| 1.19 | 90 | 4465 (TP3) | 86.55 | 86.59 |
| 1.2 | 120 | 4611 (TP4) | 90.07 | 91.46 |
| 1.21 | 120 | 4611 (TP4) | 90.94 | 92.10 |
| 1.22 | 120 | 4619 (TP10) | 97.30 | 98.70 |
| 1.23 | 120 | 4619 (TP10) | 97.78 | 99.04 |
| 1.24 | 120 | 4619 (TP10) | 97.90 | 99.14 |
| 1.25 | 120 | 4619 (TP10) | 99.43 | 100.36 |
| 1.26 | 120 | 4431 (TP1) | 111.06 | 111.10 |
| 2.01 | 120 | 4613 (TP5) | 0.08 | 0.09 |
| 3.01 | 25 | 4460 (TP5) | 1.66 | 1.65 |
| 3.02 | 20 | 4433 (TP10) | 2.71 | 2.68 |
| 4.01 | 180 | 4651 (TP7) | 0.09 | 0.09 |
| 5.01 | 20 | 4371 (TP3) | 7.95 | 8.10 |
| 5.02 | 25 | 4458 (TP3) | 8.80 | 8.88 |
| 6.01 | 30 | 4498 (TP5) | 0.69 | 0.69 |
| 6.02 | 25 | 4461 (TP6) | 3.07 | 3.11 |
| 7.01 | 30 | 4503 (TP8) | 5.59 | 5.52 |
| 8.01 | 20 | 4359 (TP1) | 2.67 | 2.75 |
| 9.01 | 60 | 4463 (TP3) | 3.41 | 3.44 |
| 9.02 | 60 | 4558 (TP7) | 5.08 | 5.18 |
| 9.03 | 60 | 4558 (TP7) | 5.34 | 5.44 |
| 9.04 | 60 | 4405 (TP2) | 6.65 | 6.89 |
| 9.05 | 30 | 4503 (TP8) | 8.81 | 8.68 |
| 9.06 | 45 | 4525 (TP3) | 11.56 | 11.70 |
| 9.07 | 45 | 4531 (TP7) | 12.28 | 12.23 |
| 9.08 | 45 | 4496 (TP2) | 14.72 | 14.84 |
| 9.09 | 45 | 4528 (TP6) | 15.98 | 15.94 |
| 9.1 | 60 | 4558 (TP7) | 16.28 | 16.18 |
| 9.11 | 60 | 4558 (TP7) | 16.98 | 16.91 |
| 9.12 | 60 | 4558 (TP7) | 19.23 | 19.13 |
| 9.13 | 60 | 4405 (TP2) | 19.58 | 19.49 |
| 9.14 | 45 | 4362 (TP1) | 32.32 | 32.57 |
| 9.15 | 60 | 4558 (TP7) | 33.89 | 33.23 |
| 9.16 | 60 | 4556 (TP5) | 40.57 | 40.55 |
| 9.17 | 60 | 4555 (TP4) | 48.30 | 48.59 |
| 9.18 | 60 | 4555 (TP4) | 48.41 | 48.73 |
| 9.19 | 60 | 4555 (TP4) | 48.49 | 48.83 |
| 10.01 | 20 | 4429 (TP8) | 2.68 | 2.65 |
| 11.01 | 15 | 4401 (TP8) | 1.44 | 1.37 |
| 11.02 | 15 | 4401 (TP8) | 1.78 | 1.76 |
| 11.03 | 20 | 4399 (TP4) | 2.12 | 2.10 |
| 12.01 | 20 | 4371 (TP3) | 1.33 | 1.37 |
| 12.02 | 20 | 4371 (TP3) | 2.75 | 2.82 |
| 13.01 | 15 | 4358 (TP1) | 2.45 | 2.35 |
| 13.02 | 15 | 4392 (TP2) | 3.35 | 3.24 |
| 14.01 | 15 | 4358 (TP1) | 1.78 | 1.73 |
| 15.01 | 15 | 4358 (TP1) | 1.66 | 1.63 |
| 16.01 | 15 | 4392 (TP2) | 2.96 | 2.91 |
| 17.01 | 15 | 4358 (TP1) | 0.51 | 0.50 |
| 18.01 | 15 | 4358 (TP1) | 0.32 | 0.31 |
| 19.01 | 15 | 4358 (TP1) | 0.38 | 0.37 |
| 19.02 | 15 | 4358 (TP1) | 2.65 | 2.60 |
| 19.03 | 25 | 4458 (TP3) | 6.25 | 6.29 |
| 19.04 | 15 | 4398 (TP6) | 10.13 | 10.00 |
| 19.05 | 20 | 4433 (TP10) | 10.85 | 10.85 |
| 19.06 | 20 | 4429 (TP8) | 11.52 | 11.37 |

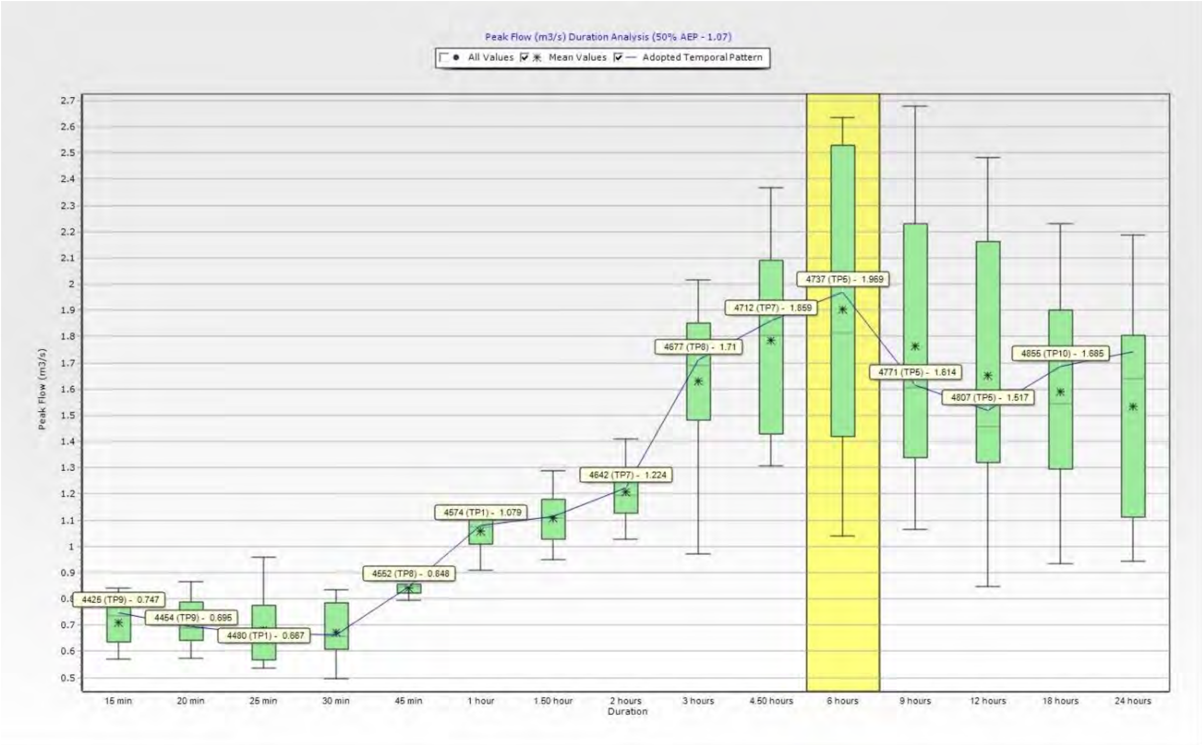
| Subcatch ID | ARR2019 Discharge Statistics for All Durations and Temp. Patterns | | | |
|---|---|---|---|---|
| | Critical Duration (mins) | Adopted Temp. Pattern | Discharge ($m^3$/s) | |
| | | | Average | Adopted |
| 19.07 | 25 | 4456 (TP2) | 12.99 | 12.93 |
| 19.08 | 25 | 4467 (TP10) | 13.41 | 13.35 |
| 20.01 | 15 | 4400 (TP7) | 0.93 | 0.89 |
| 21.01 | 15 | 4392 (TP2) | 0.02 | 0.02 |
| 22.01 | 15 | 4392 (TP2) | 3.93 | 3.77 |
| 23.01 | 15 | 4393 (TP3) | 1.51 | 1.45 |
| 23.02 | 20 | 4371 (TP3) | 5.50 | 5.46 |
| 23.03 | 25 | 4462 (TP7) | 4.14 | 4.23 |
| 23.04 | 30 | 4498 (TP5) | 4.02 | 4.02 |
| 23.05 | 45 | 4534 (TP9) | 4.35 | 4.36 |
| 23.06 | 45 | 4534 (TP9) | 4.43 | 4.40 |
| 23.07 | 45 | 4496 (TP2) | 4.46 | 4.42 |
| 23.08 | 60 | 4463 (TP3) | 4.62 | 4.65 |
| 23.09 | 60 | 4556 (TP5) | 4.87 | 4.85 |
| 23.1 | 60 | 4559 (TP8) | 4.90 | 4.88 |
| 23.11 | 20 | 4428 (TP7) | 8.81 | 8.62 |
| 24.01 | 15 | 4392 (TP2) | 1.32 | 1.25 |
| 24.02 | 15 | 4392 (TP2) | 4.73 | 4.56 |
| 25.01 | 15 | 4392 (TP2) | 0.01 | 0.01 |
| 26.01 | 120 | 4613 (TP5) | 0.25 | 0.29 |
| 26.02 | 15 | 4392 (TP2) | 1.12 | 1.03 |
| 26.03 | 20 | 4371 (TP3) | 4.56 | 4.62 |
| 26.04 | 25 | 4394 (TP1) | 4.79 | 4.82 |
| 26.05 | 30 | 4498 (TP5) | 5.32 | 5.37 |
| 26.06 | 30 | 4498 (TP5) | 5.35 | 5.39 |
| 26.07 | 45 | 4362 (TP1) | 5.61 | 5.66 |
| 26.08 | 45 | 4362 (TP1) | 5.60 | 5.70 |
| 26.09 | 45 | 4535 (TP10) | 5.88 | 5.89 |
| 26.1 | 60 | 4463 (TP3) | 3.33 | 3.30 |
| 26.11 | 60 | 4463 (TP3) | 3.34 | 3.31 |
| 26.12 | 30 | 4504 (TP9) | 7.85 | 7.88 |
| 26.13 | 30 | 4500 (TP6) | 8.22 | 8.16 |
| 26.14 | 30 | 4500 (TP6) | 8.60 | 8.48 |
| 27.01 | 15 | 4358 (TP1) | 0.83 | 0.82 |
| 28.01 | 20 | 4433 (TP10) | 1.71 | 1.68 |
| 28.02 | 30 | 4498 (TP5) | 2.64 | 2.56 |
| 29.01 | 15 | 4392 (TP2) | 1.04 | 1.03 |
| 30.01 | 45 | 4528 (TP6) | 3.91 | 3.97 |
| 30.02 | 45 | 4528 (TP6) | 4.47 | 4.60 |
| 30.03 | 45 | 4528 (TP6) | 6.35 | 6.40 |
| 31.01 | 20 | 4428 (TP7) | 1.81 | 1.81 |
| 32.01 | 15 | 4400 (TP7) | 0.10 | 0.10 |
| 33.01 | 15 | 4358 (TP1) | 1.12 | 1.09 |
| 33.02 | 20 | 4399 (TP4) | 3.22 | 3.14 |
| 33.03 | 20 | 4359 (TP1) | 7.73 | 7.72 |
| 33.04 | 20 | 4433 (TP10) | 8.20 | 8.22 |
| 33.05 | 20 | 4433 (TP10) | 8.45 | 8.40 |
| 33.06 | 20 | 4359 (TP1) | 12.01 | 11.64 |
| 34.01 | 15 | 4392 (TP2) | 3.48 | 3.33 |
| 35.01 | 15 | 4358 (TP1) | 2.89 | 2.81 |
| 35.02 | 25 | 4467 (TP10) | 12.10 | 12.07 |
| 35.03 | 25 | 4467 (TP10) | 12.26 | 12.27 |
| 35.04 | 30 | 4504 (TP9) | 12.45 | 12.63 |
| 36.01 | 15 | 4358 (TP1) | 1.48 | 1.42 |
| 36.02 | 20 | 4429 (TP8) | 3.46 | 3.35 |
| 36.03 | 25 | 4458 (TP3) | 5.51 | 5.60 |
| 37.01 | 15 | 4358 (TP1) | 1.11 | 1.09 |
| 38.01 | 15 | 4358 (TP1) | 1.56 | 1.49 |
| 39.01 | 15 | 4358 (TP1) | 1.76 | 1.70 |
| 40.01 | 15 | 4358 (TP1) | 1.55 | 1.51 |
| 41.01 | 15 | 4358 (TP1) | 1.81 | 1.76 |
| 41.02 | 15 | 4392 (TP2) | 2.64 | 2.54 |
| 42.01 | 15 | 4392 (TP2) | 0.77 | 0.75 |
| 43.01 | 20 | 4359 (TP1) | 0.85 | 0.88 |
| 44.01 | 45 | 4531 (TP7) | 0.29 | 0.29 |
| 45.01 | 15 | 4392 (TP2) | 2.55 | 2.51 |
| 45.02 | 15 | 4358 (TP1) | 4.03 | 4.11 |
| 45.03 | 15 | 4397 (TP5) | 6.68 | 6.68 |
| 45.04 | 15 | 4392 (TP2) | 7.32 | 7.34 |
| 45.05 | 15 | 4407 (TP10) | 7.48 | 7.49 |
| 45.06 | 30 | 4497 (TP4) | 7.68 | 7.63 |
| 45.07 | 30 | 4495 (TP3) | 9.50 | 9.61 |
| 45.08 | 30 | 4498 (TP5) | 21.87 | 22.06 |
| 46.01 | 20 | 4433 (TP10) | 1.24 | 1.22 |
| 47.01 | 15 | 4392 (TP2) | 1.63 | 1.55 |
| 48.01 | 15 | 4358 (TP1) | 1.38 | 1.35 |

| Subcatch ID | ARR2019 Discharge Statistics for All Durations and Temp. Patterns | | | |
|---|---|---|---|---|
| | Critical Duration (mins) | Adopted Temp. Pattern | Discharge ($m^3/s$) | |
| | | | Average | Adopted |
| 48.02 | 20 | 4429 (TP8) | 3.16 | 3.16 |
| 48.03 | 15 | 4401 (TP8) | 4.91 | 4.95 |
| 48.04 | 20 | 4399 (TP4) | 10.42 | 10.68 |
| 48.05 | 20 | 4359 (TP1) | 10.64 | 10.87 |
| 49.01 | 15 | 4358 (TP1) | 2.97 | 2.86 |
| 49.02 | 15 | 4392 (TP2) | 3.98 | 3.81 |
| 49.03 | 15 | 4392 (TP2) | 4.62 | 4.66 |
| 50.01 | 15 | 4358 (TP1) | 0.94 | 0.92 |
| 51.01 | 15 | 4392 (TP2) | 3.63 | 3.46 |
| 52.01 | 20 | 4433 (TP10) | 1.49 | 1.47 |
| 52.02 | 20 | 4429 (TP8) | 1.84 | 1.81 |
| 53.01 | 15 | 4358 (TP1) | 2.84 | 2.76 |
| 53.02 | 15 | 4392 (TP2) | 4.87 | 4.73 |
| 54.01 | 15 | 4392 (TP2) | 0.93 | 0.91 |
| 55.01 | 15 | 4358 (TP1) | 0.55 | 0.52 |
| 56.01 | 25 | 4461 (TP6) | 0.04 | 0.04 |
| 57.01 | 45 | 4496 (TP2) | 1.41 | 1.42 |
| 57.02 | 45 | 4534 (TP9) | 3.51 | 3.52 |
| 57.03 | 45 | 4534 (TP9) | 3.59 | 3.62 |
| 57.04 | 45 | 4528 (TP6) | 4.70 | 4.73 |
| 57.05 | 45 | 4528 (TP6) | 5.28 | 5.31 |
| 58.01 | 30 | 4498 (TP5) | 0.90 | 0.91 |
| 59.01 | 20 | 4371 (TP3) | 0.56 | 0.54 |
| 60.01 | 20 | 4429 (TP8) | 0.05 | 0.05 |
| 61.01 | 20 | 4371 (TP3) | 0.40 | 0.39 |
| 62.01 | 15 | 4392 (TP2) | 6.13 | 5.78 |
| 62.02 | 15 | 4400 (TP7) | 9.35 | 9.39 |
| 62.03 | 15 | 4407 (TP10) | 10.07 | 10.11 |
| 62.04 | 25 | 4459 (TP4) | 11.24 | 11.44 |
| 62.05 | 25 | 4459 (TP4) | 11.39 | 11.71 |
| 62.06 | 25 | 4459 (TP4) | 11.46 | 11.83 |
| 63.01 | 20 | 4433 (TP10) | 1.61 | 1.58 |
| 64.01 | 15 | 4393 (TP3) | 0.87 | 0.86 |
| 65.01 | 15 | 4392 (TP2) | 3.34 | 3.22 |
| 66.01 | 20 | 4371 (TP3) | 0.81 | 0.81 |
| 67.01 | 20 | 4371 (TP3) | 1.40 | 1.39 |
| 67.02 | 20 | 4371 (TP3) | 2.95 | 2.99 |
| 67.03 | 25 | 4466 (TP9) | 4.31 | 4.43 |
| 68.01 | 15 | 4392 (TP2) | 1.57 | 1.50 |
| 69.01 | 120 | 4614 (TP6) | 5.47 | 5.61 |
| 69.02 | 90 | 4532 (TP5) | 9.18 | 9.34 |
| 69.03 | 90 | 4532 (TP5) | 9.59 | 9.66 |
| 69.04 | 120 | 4614 (TP6) | 10.12 | 10.14 |
| 69.05 | 60 | 4559 (TP8) | 11.28 | 11.46 |
| 69.06 | 60 | 4559 (TP8) | 12.20 | 12.38 |
| 69.07 | 60 | 4558 (TP7) | 19.62 | 19.92 |
| 70.01 | 20 | 4371 (TP3) | 0.62 | 0.60 |
| 71.01 | 15 | 4392 (TP2) | 1.69 | 1.60 |
| 71.02 | 15 | 4400 (TP7) | 4.03 | 4.01 |
| 71.03 | 20 | 4399 (TP4) | 6.68 | 6.57 |
| 71.04 | 20 | 4371 (TP3) | 7.82 | 7.91 |
| 71.05 | 25 | 4394 (TP1) | 8.47 | 8.57 |
| 72.01 | 15 | 4392 (TP2) | 0.02 | 0.02 |
| 73.01 | 15 | 4392 (TP2) | 1.81 | 1.78 |

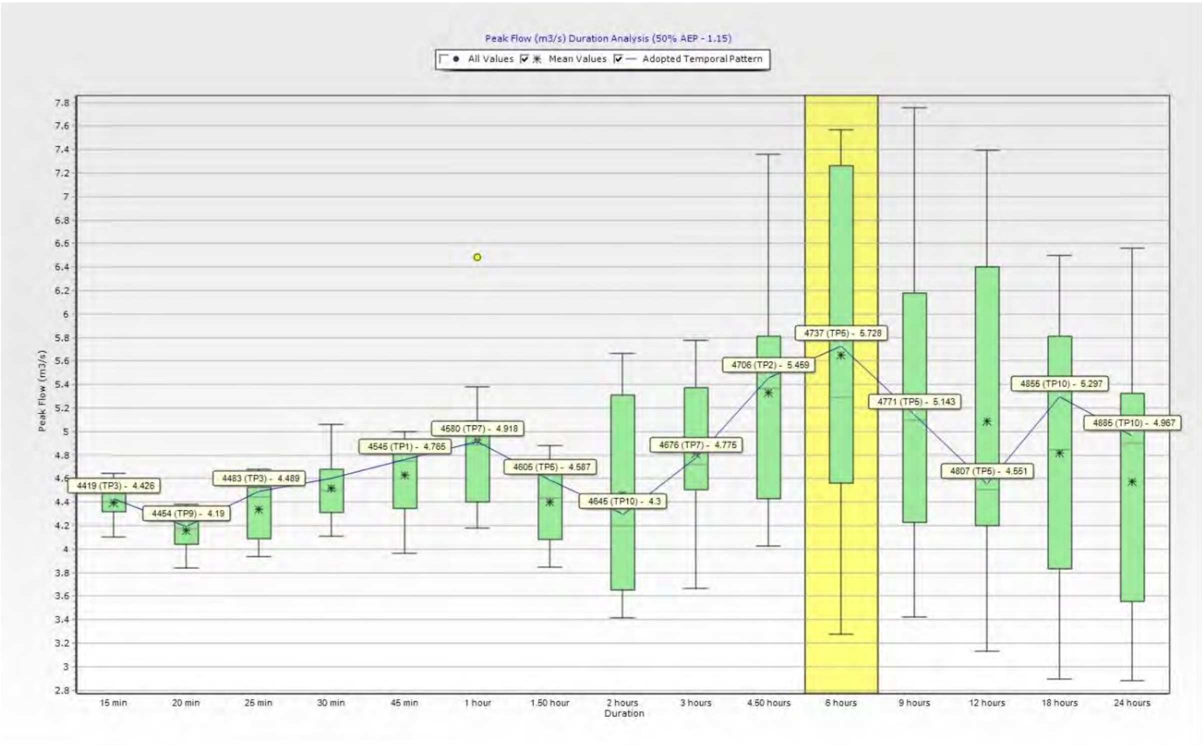
# ARR2019 Box Plots

## 0.5EY

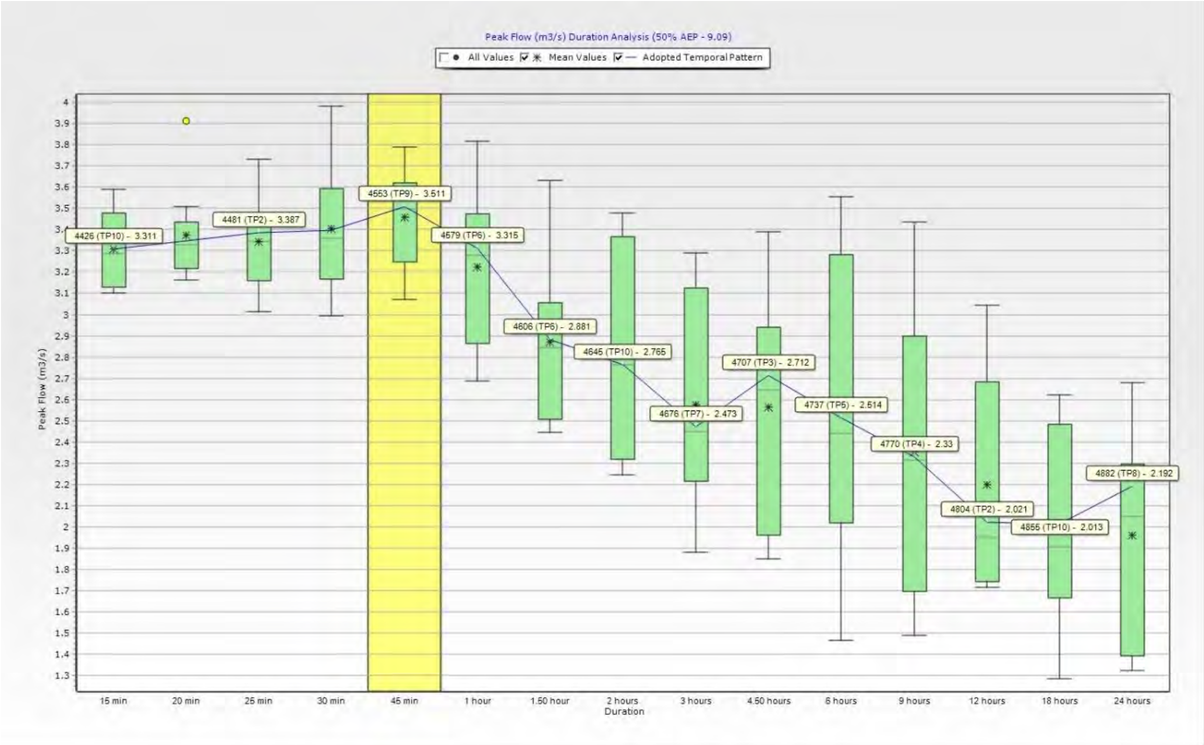
## RAFTS Node: 1.07



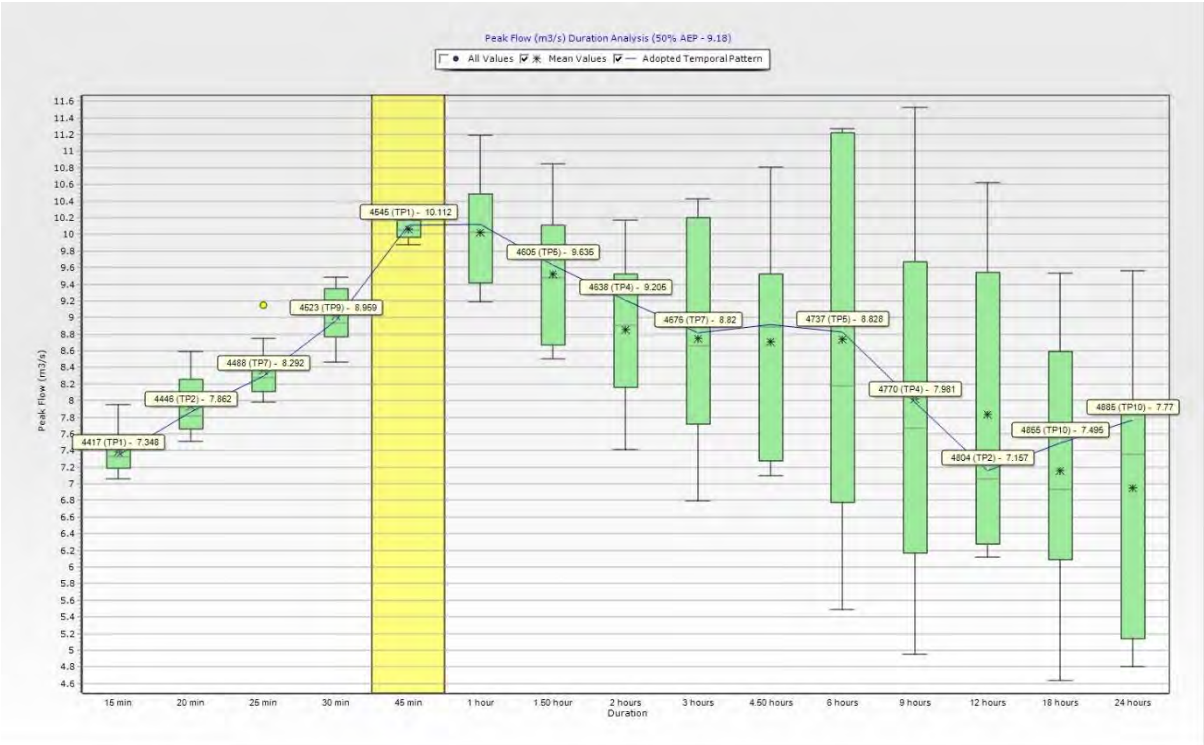

## RAFTS Node: 1.15



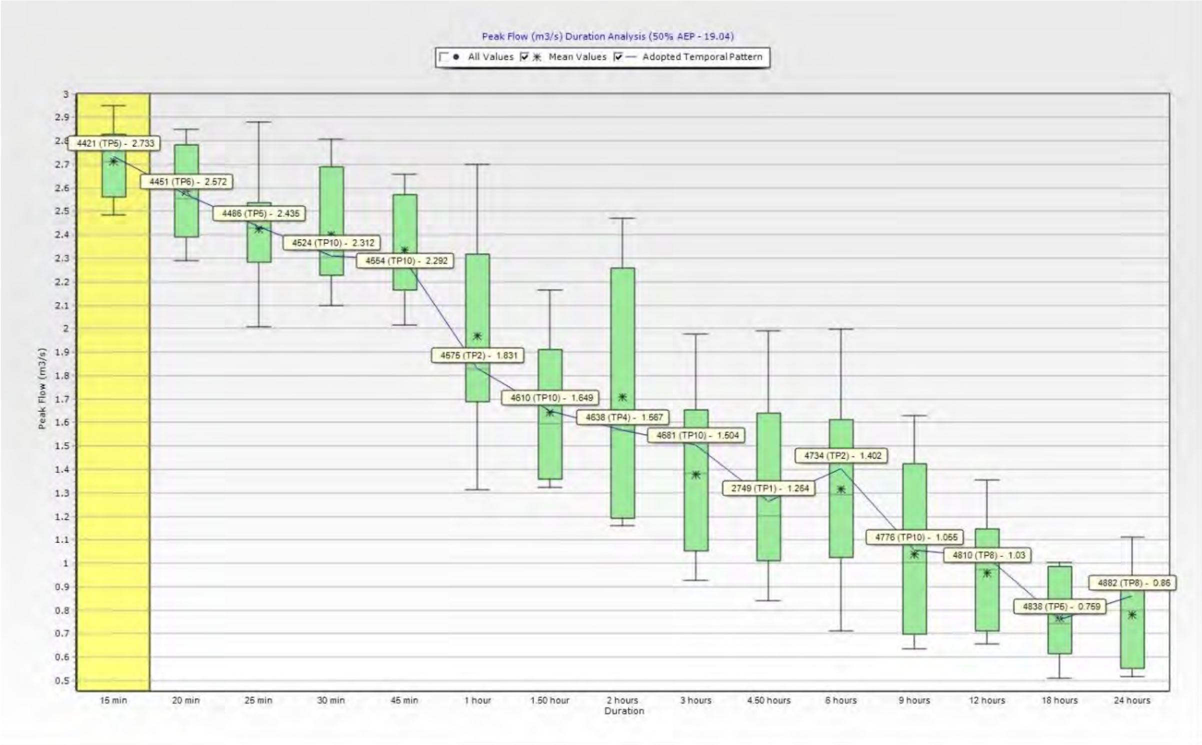
## RAFTS Node: 9.09



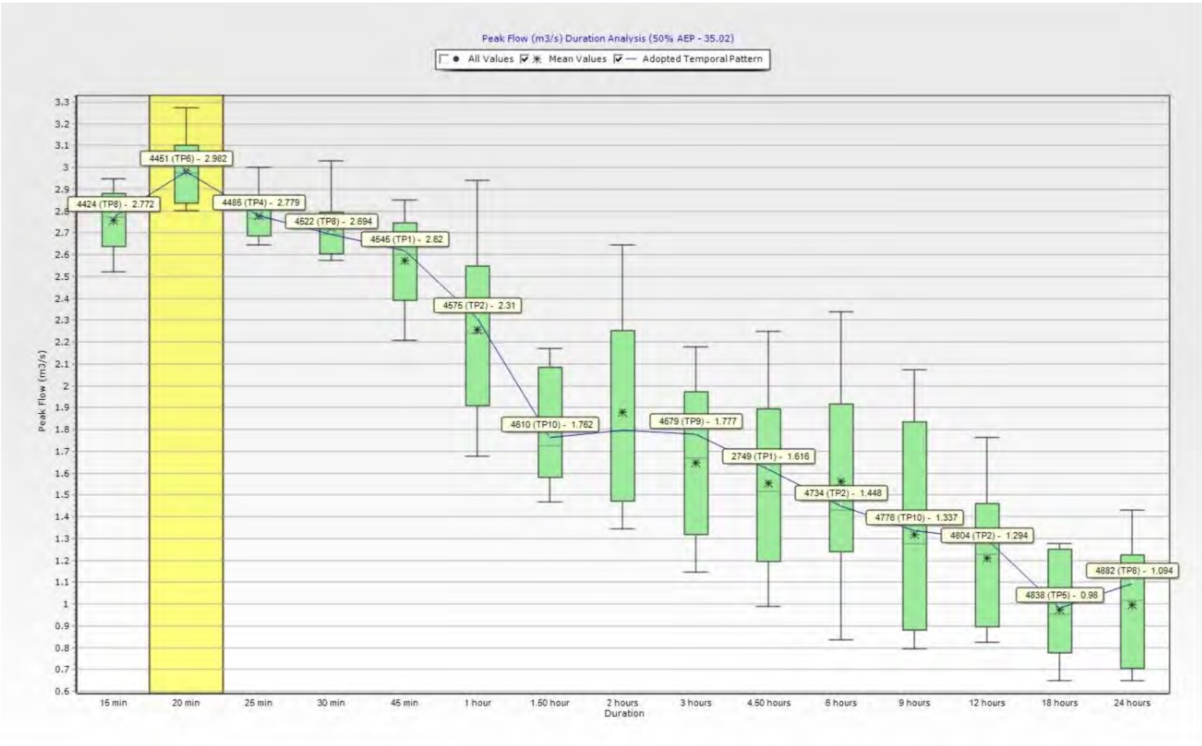

## RAFTS Node: 9.18



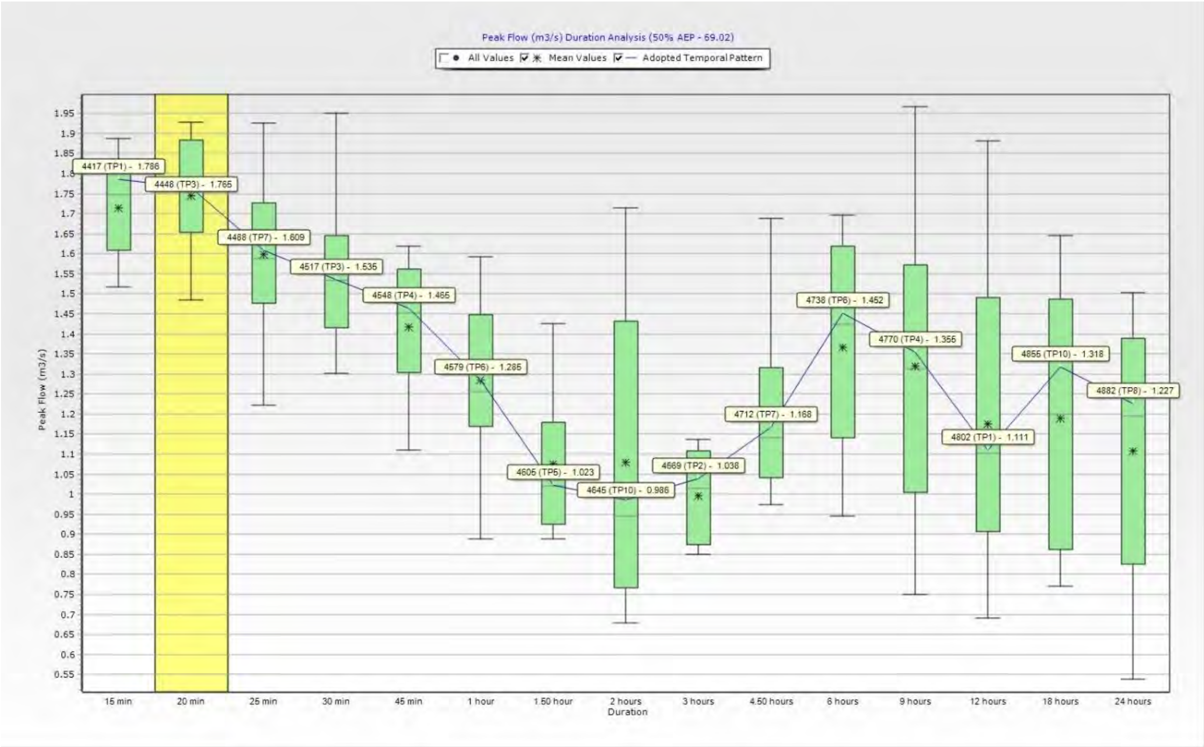
## RAFTS Node: 19.04



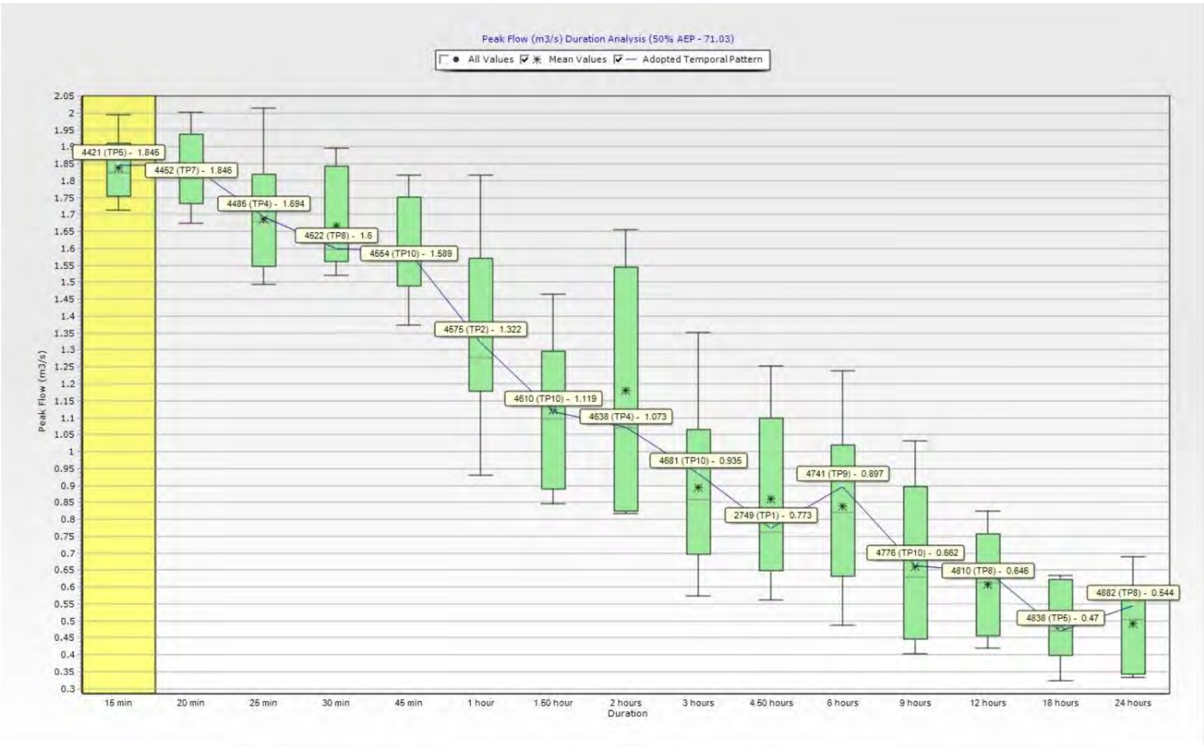

## RAFTS Node: 35.02



## RAFTS Node: 69.02



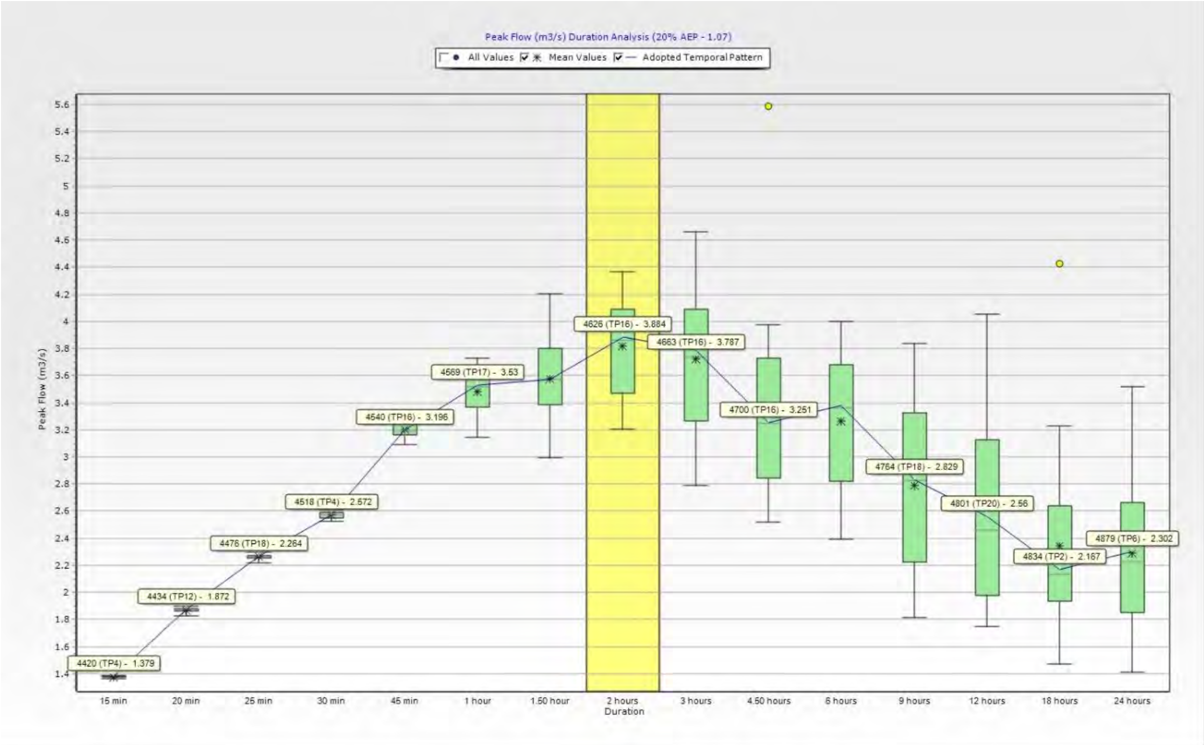

## RAFTS Node: 71.03



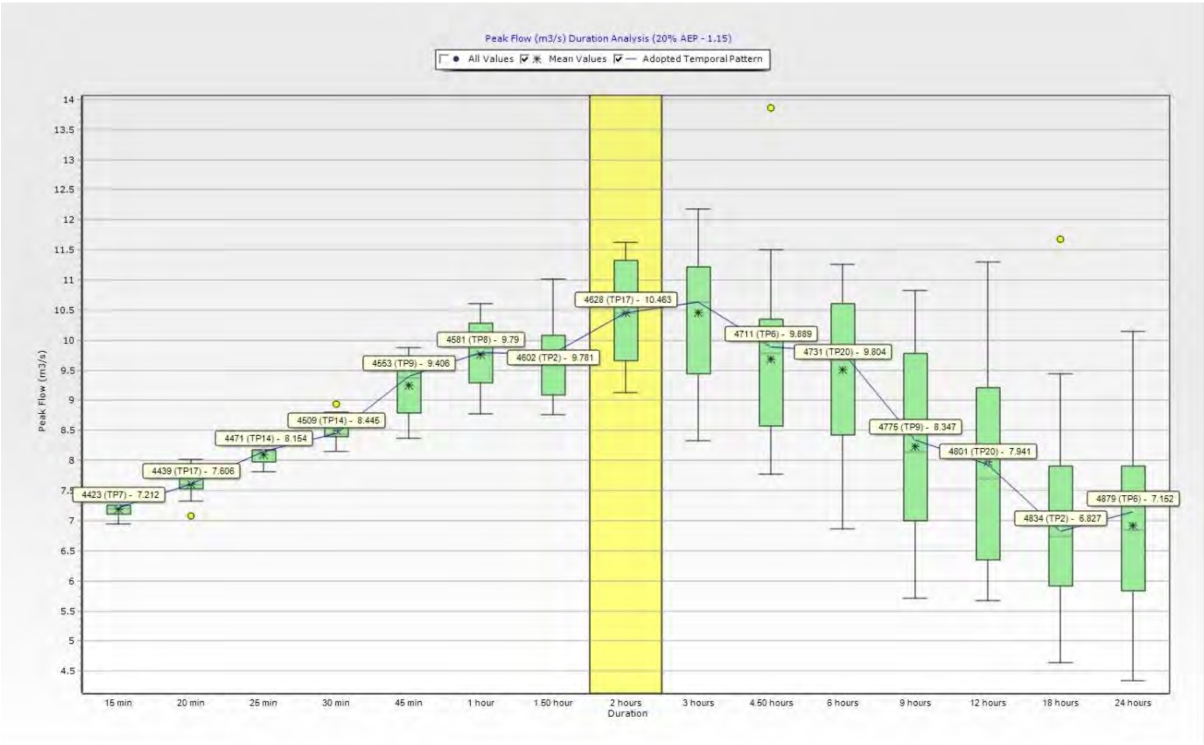
# ARR2019 Box Plots

## 0.2EY

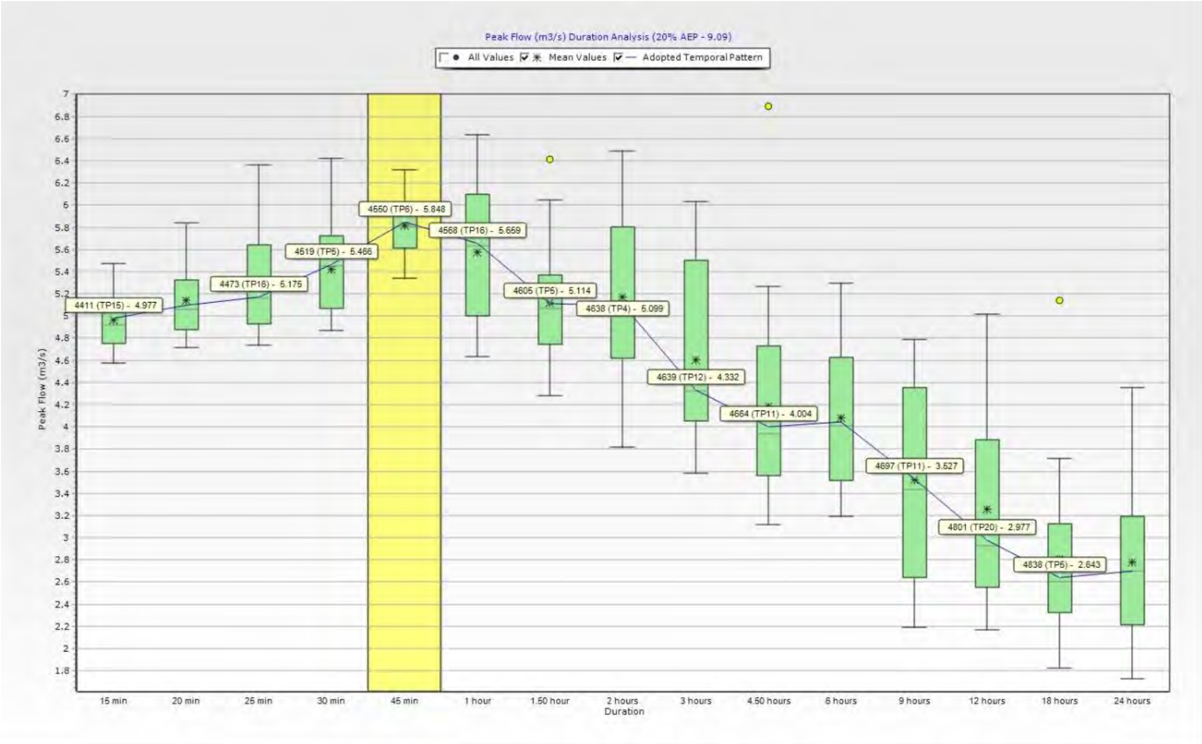
## RAFTS Node: 1.07



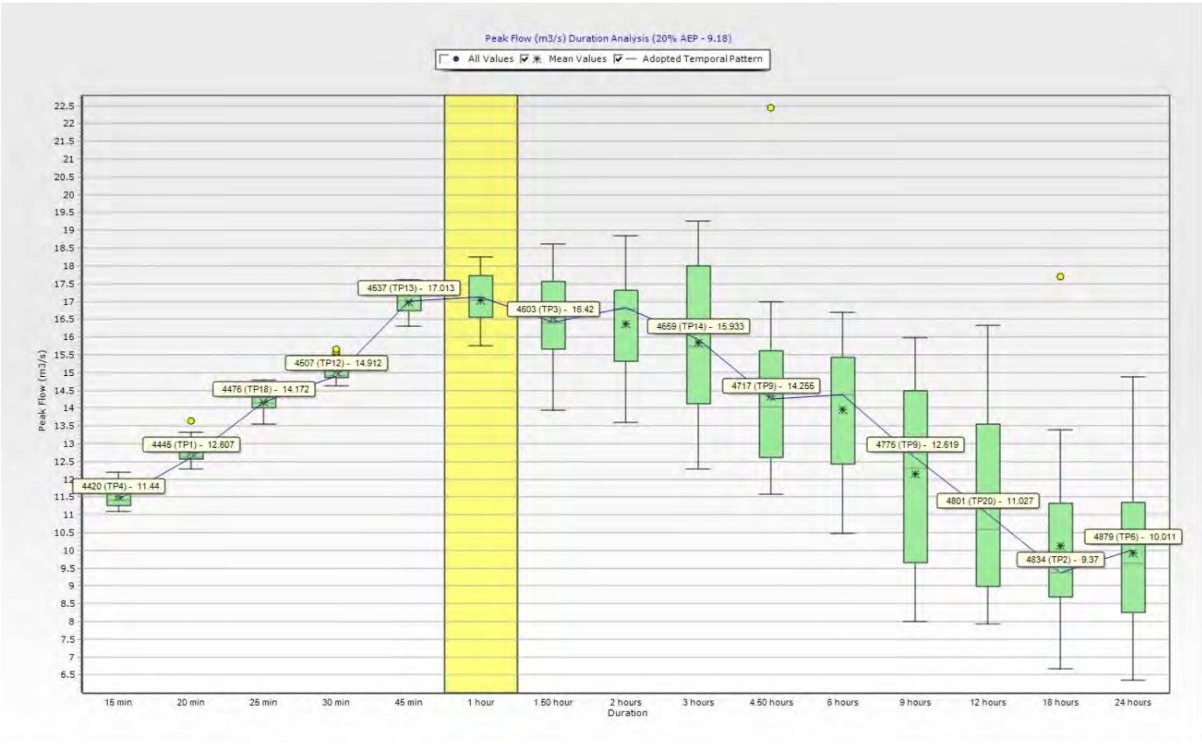

## RAFTS Node: 1.15



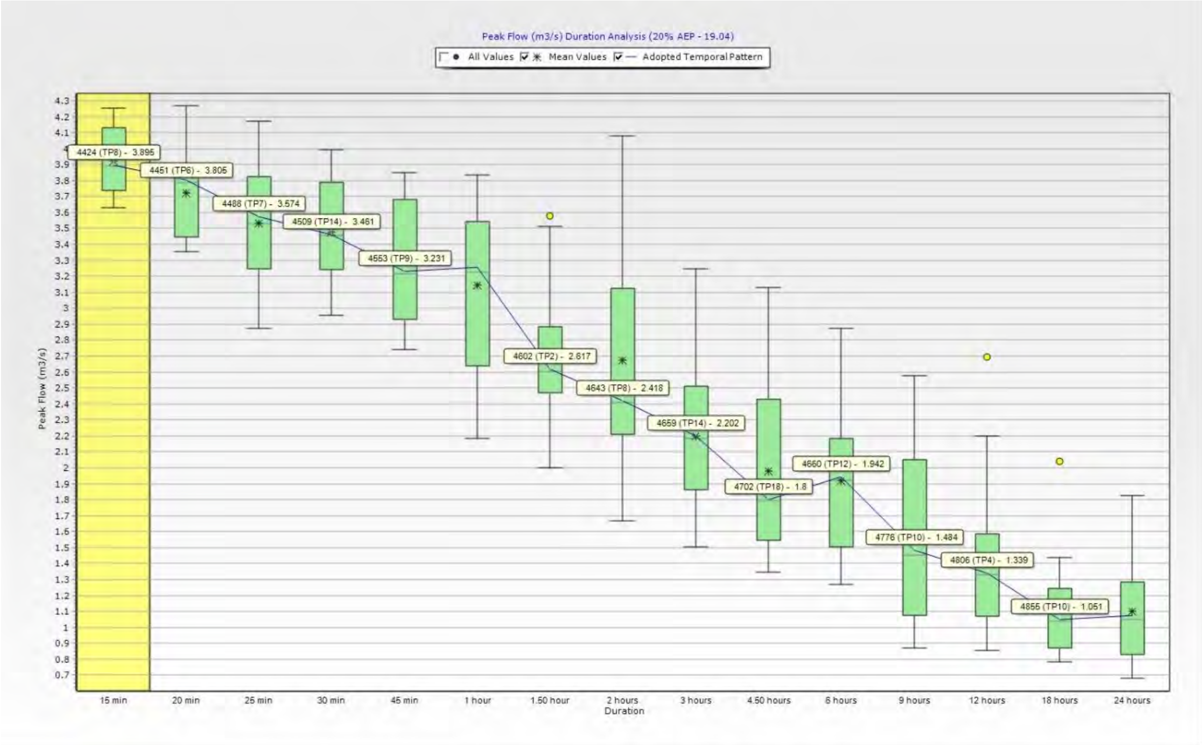
## RAFTS Node: 9.09



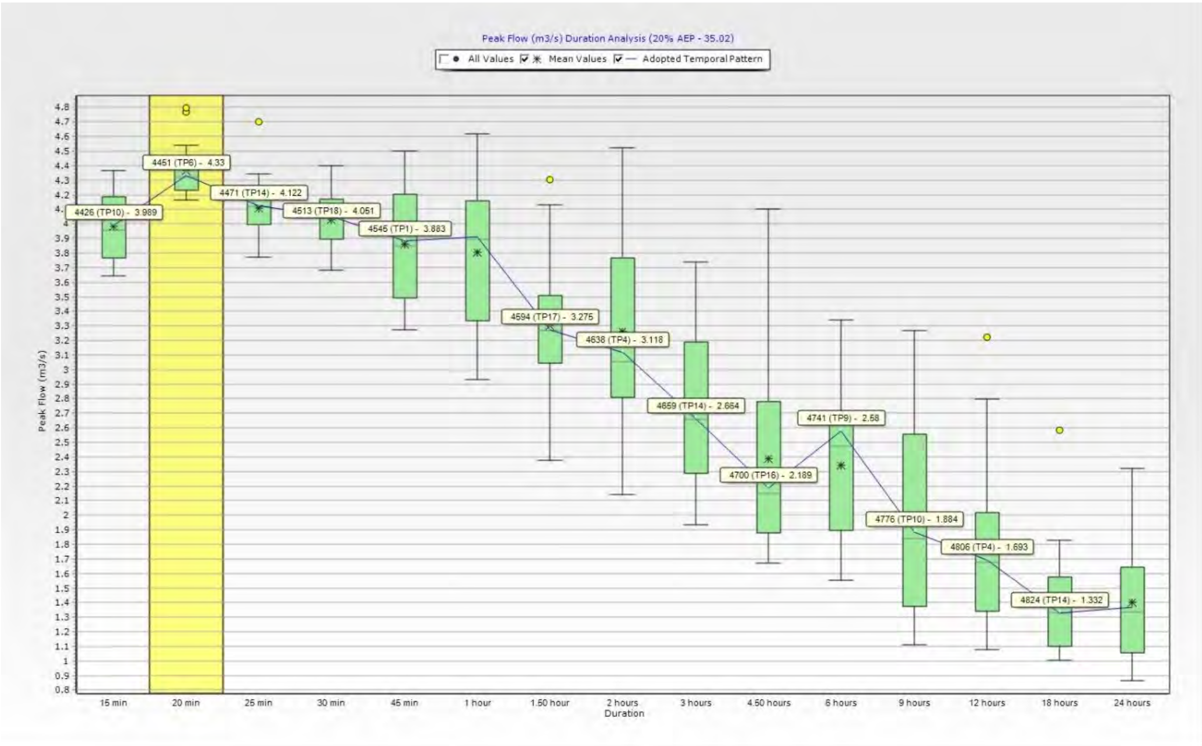

## RAFTS Node: 9.18



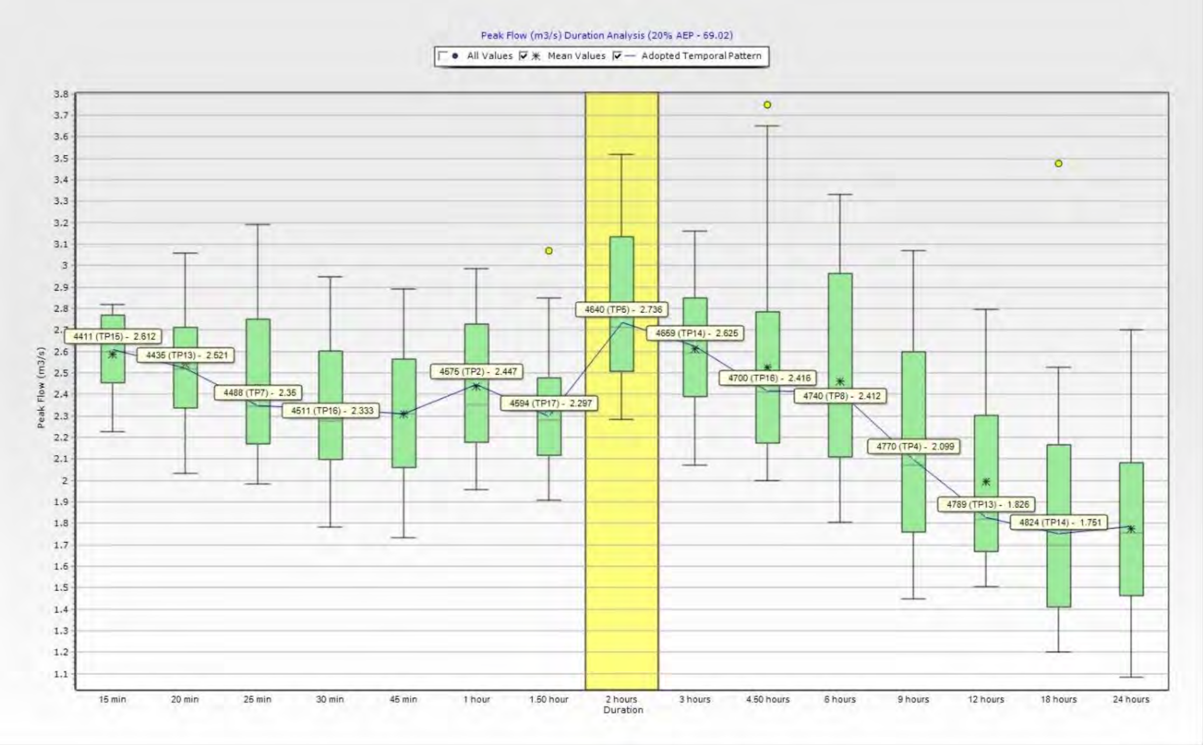
## RAFTS Node: 19.04



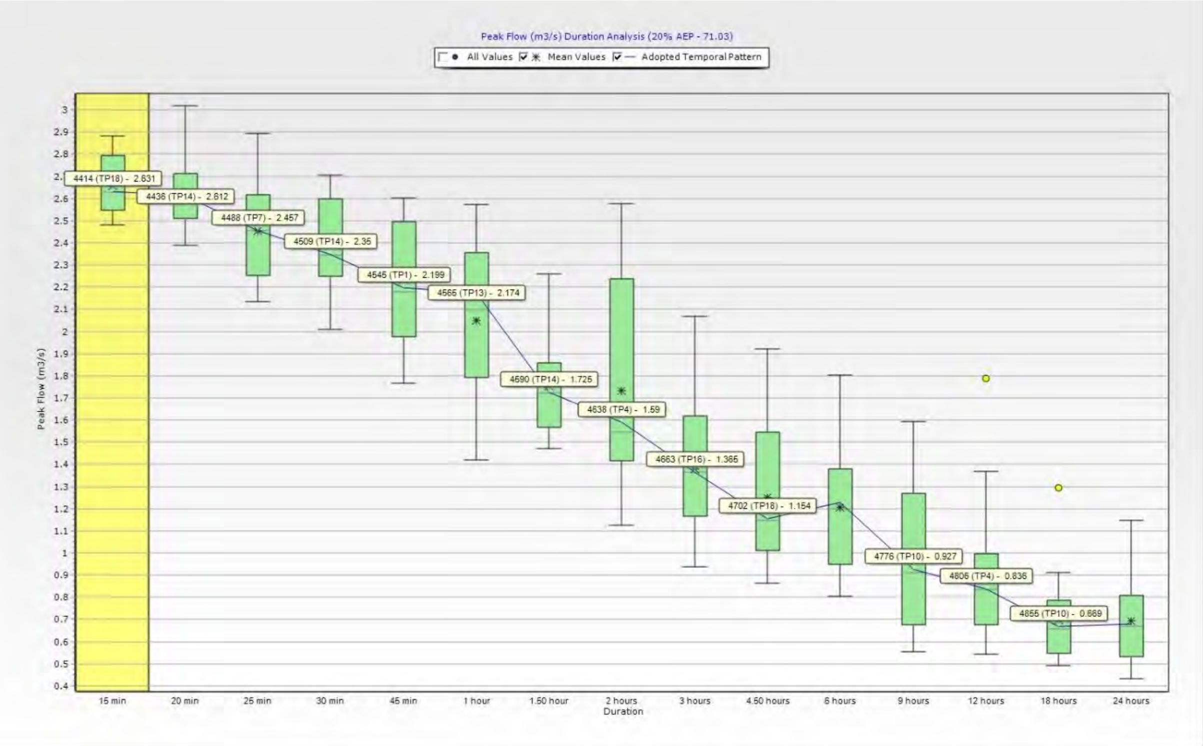

## RAFTS Node: 35.02



## RAFTS Node: 69.02



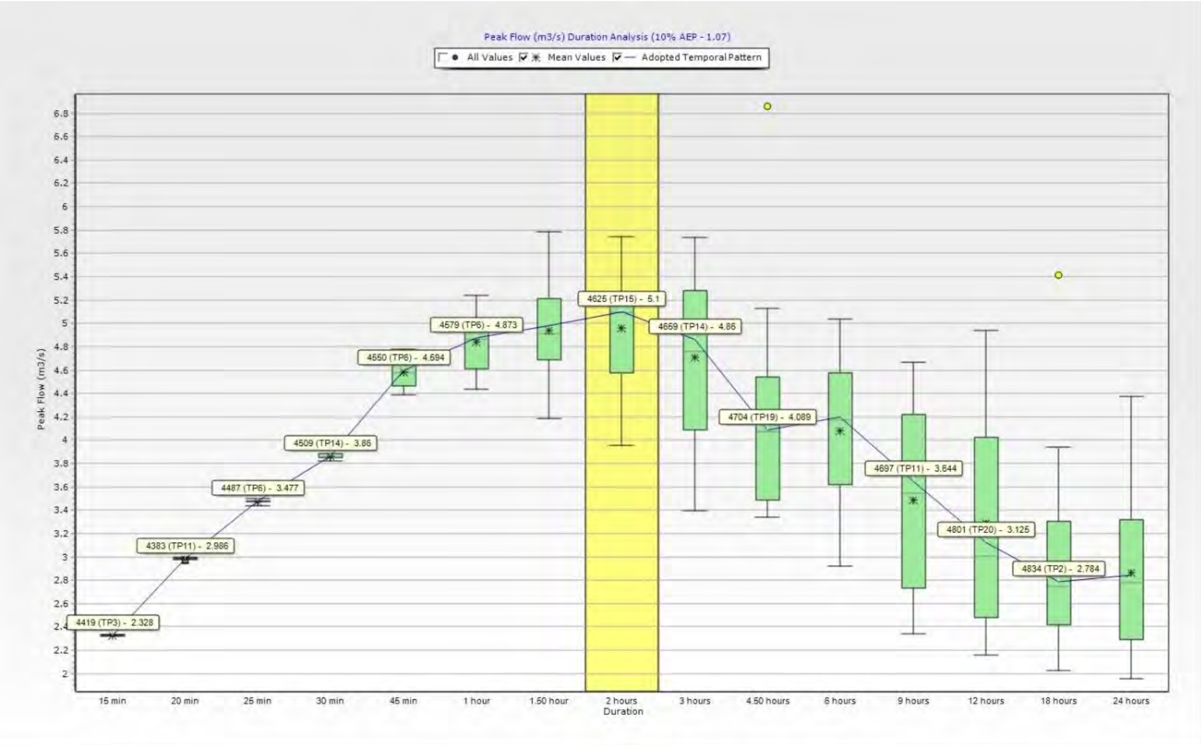

## RAFTS Node: 71.03



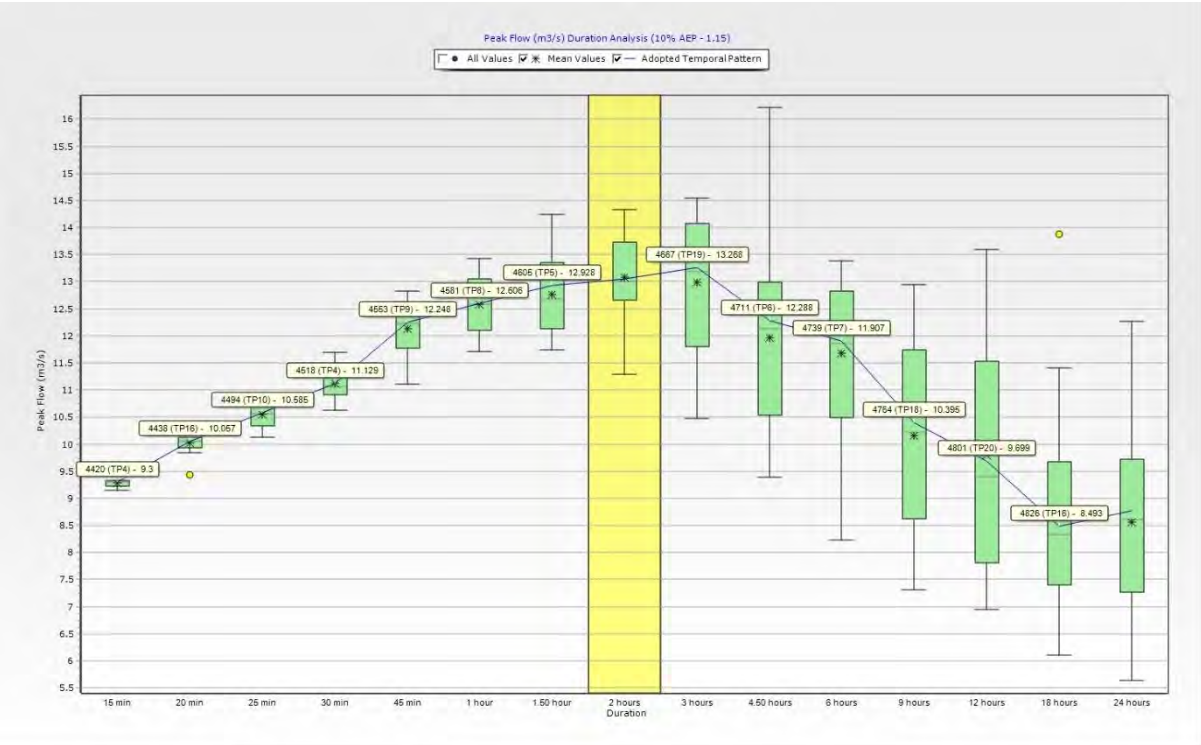
# ARR2019 Box Plots

## 10% AEP

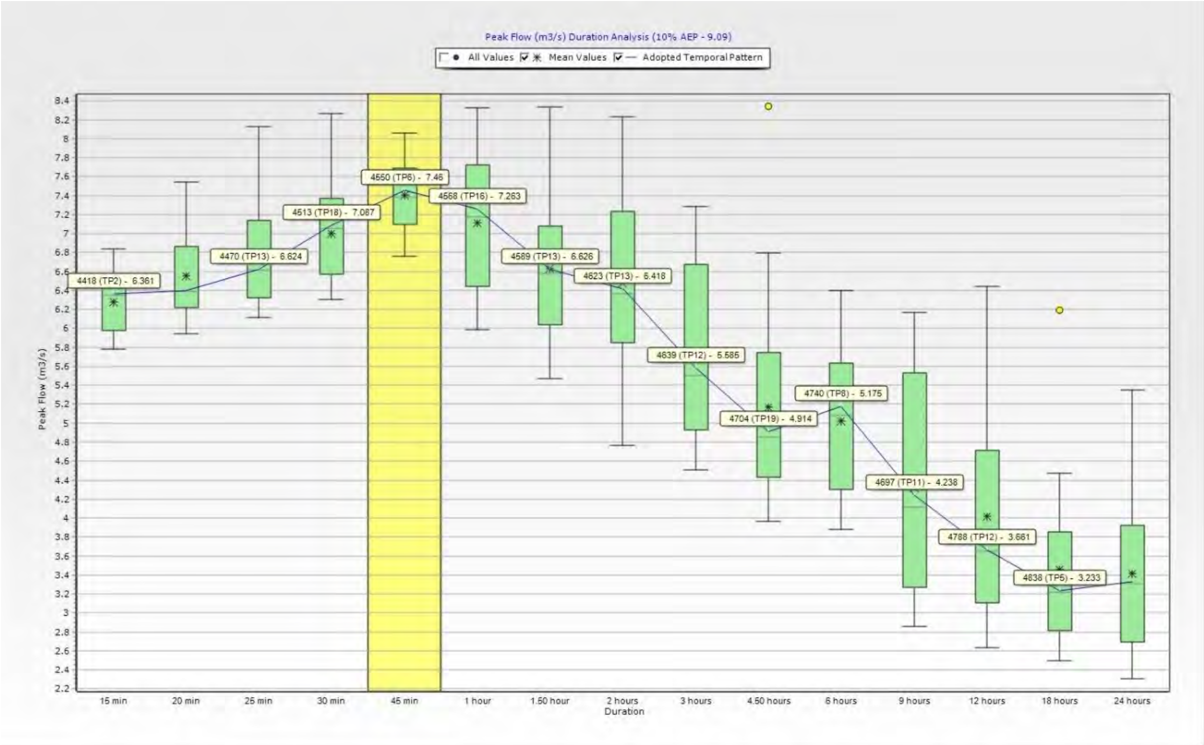
## RAFTS Node: 1.07



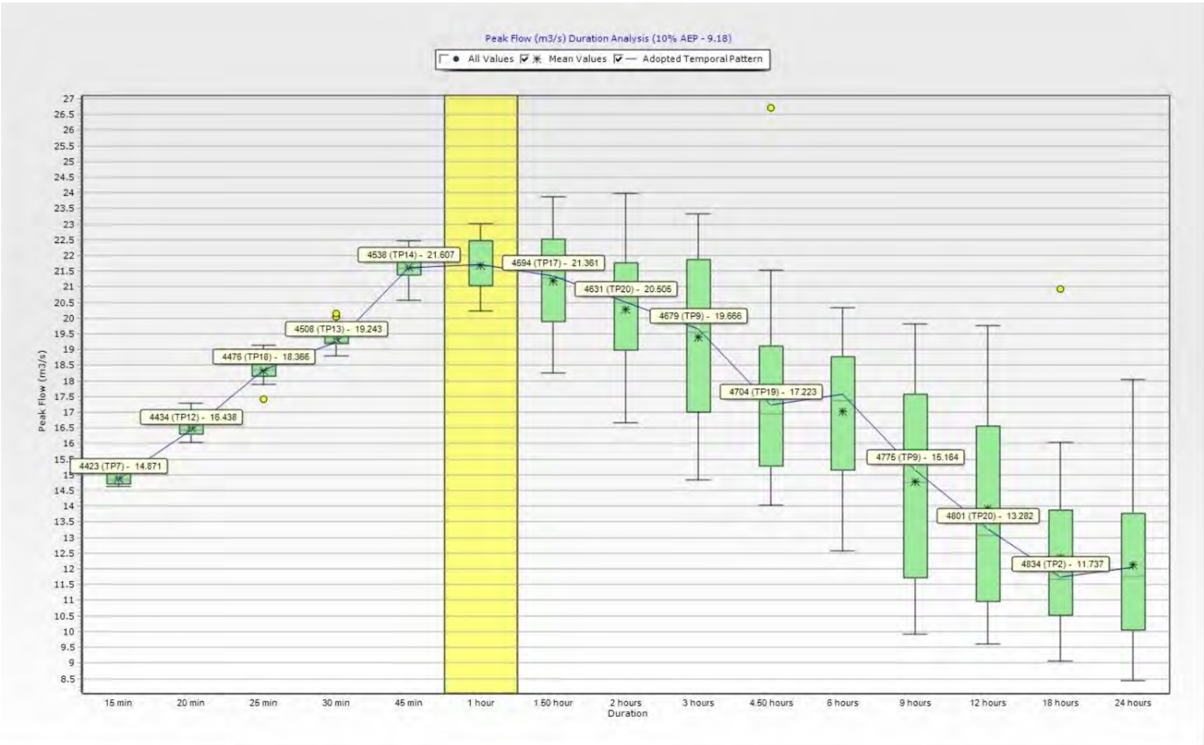

## RAFTS Node: 1.15



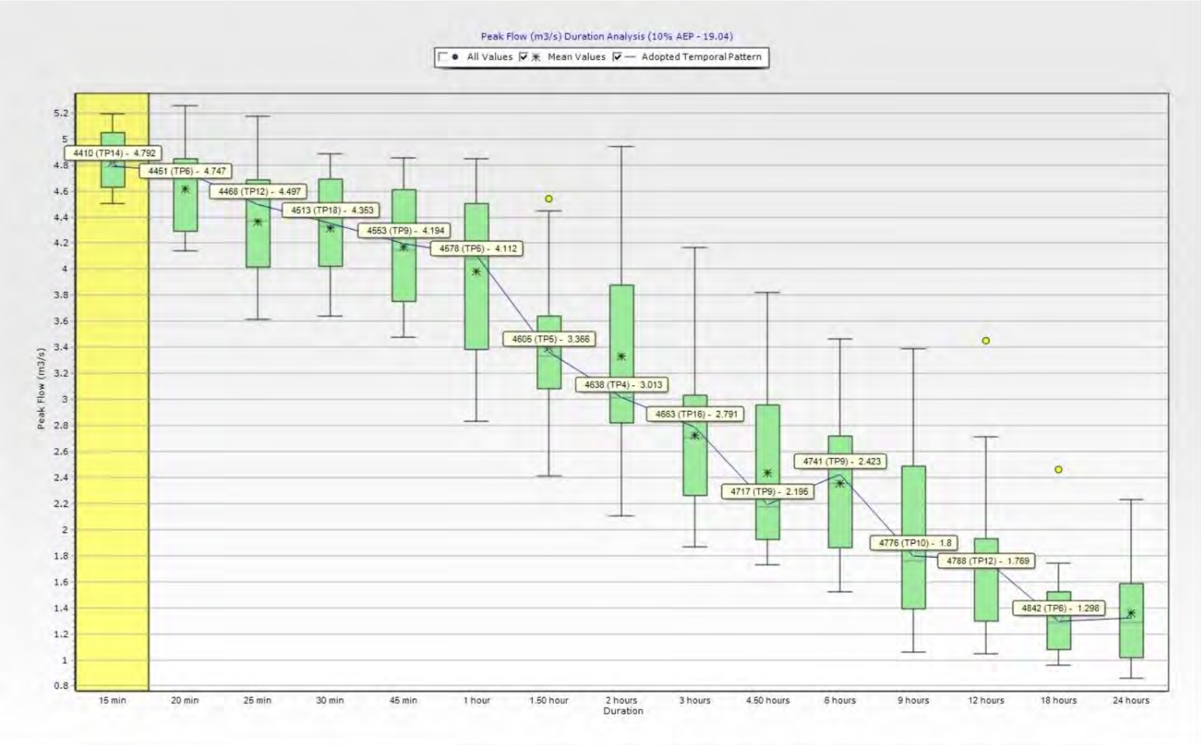
## RAFTS Node: 9.09



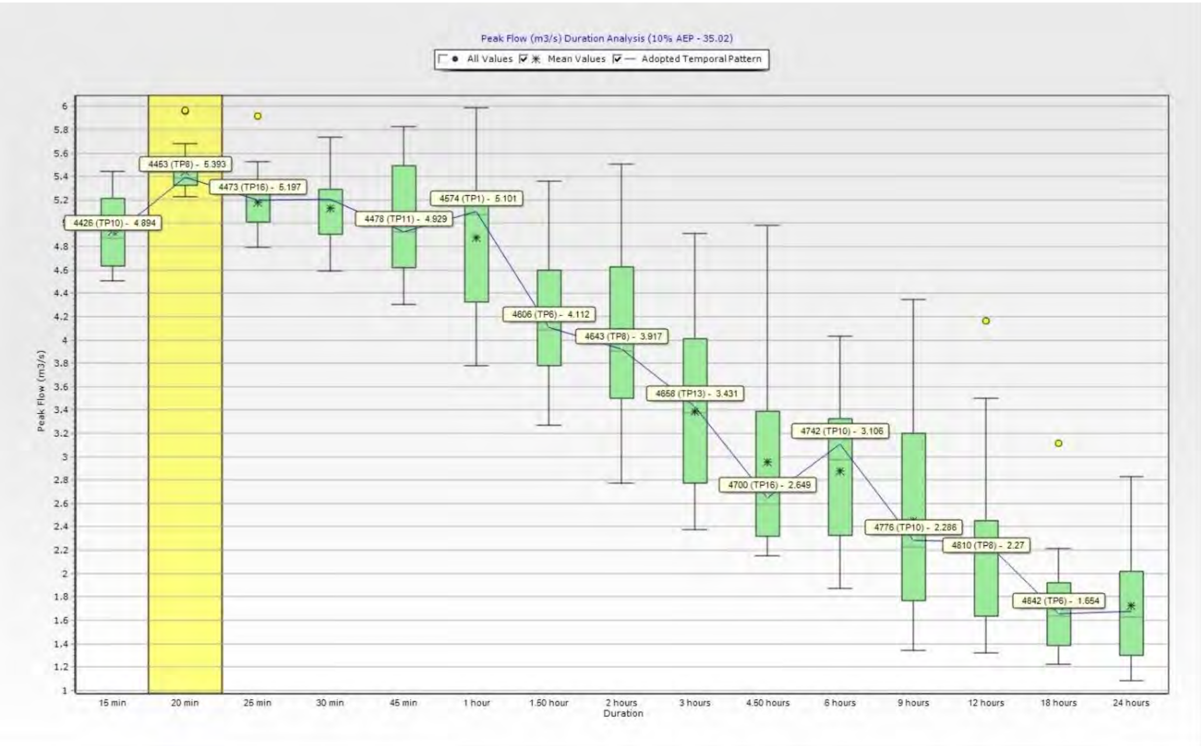

## RAFTS Node: 9.18



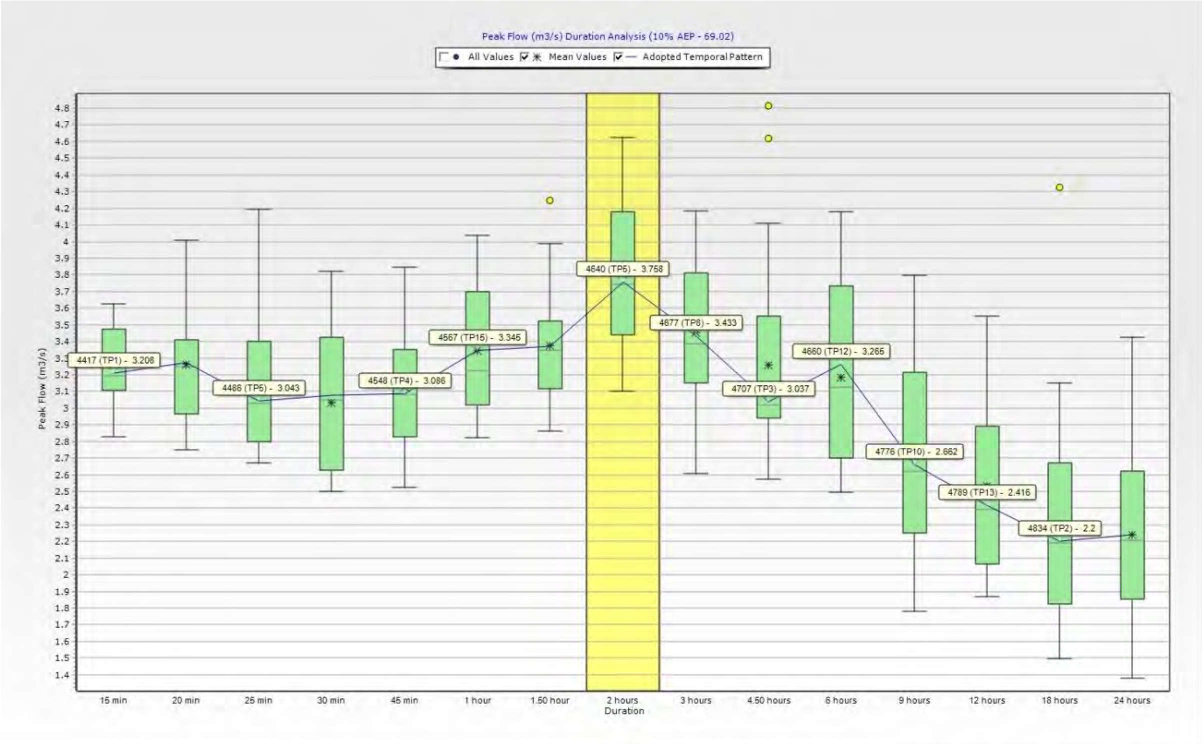
## RAFTS Node: 19.04



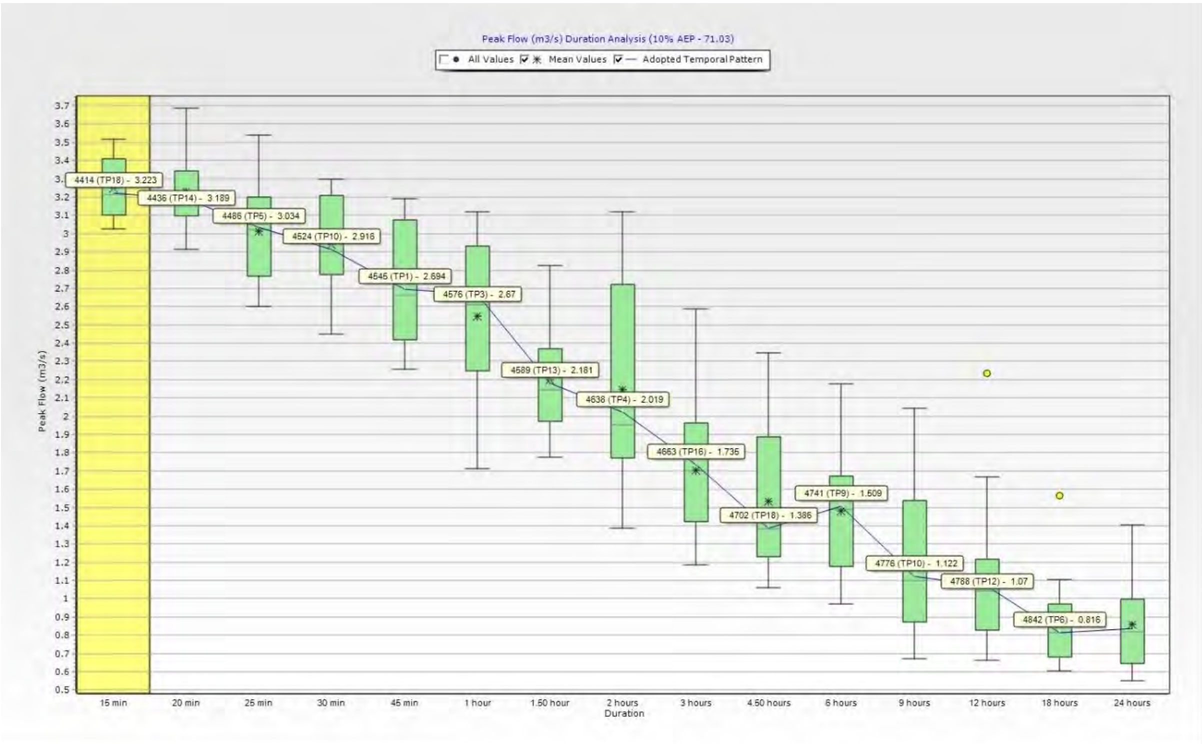

## RAFTS Node: 35.02



## RAFTS Node: 69.02



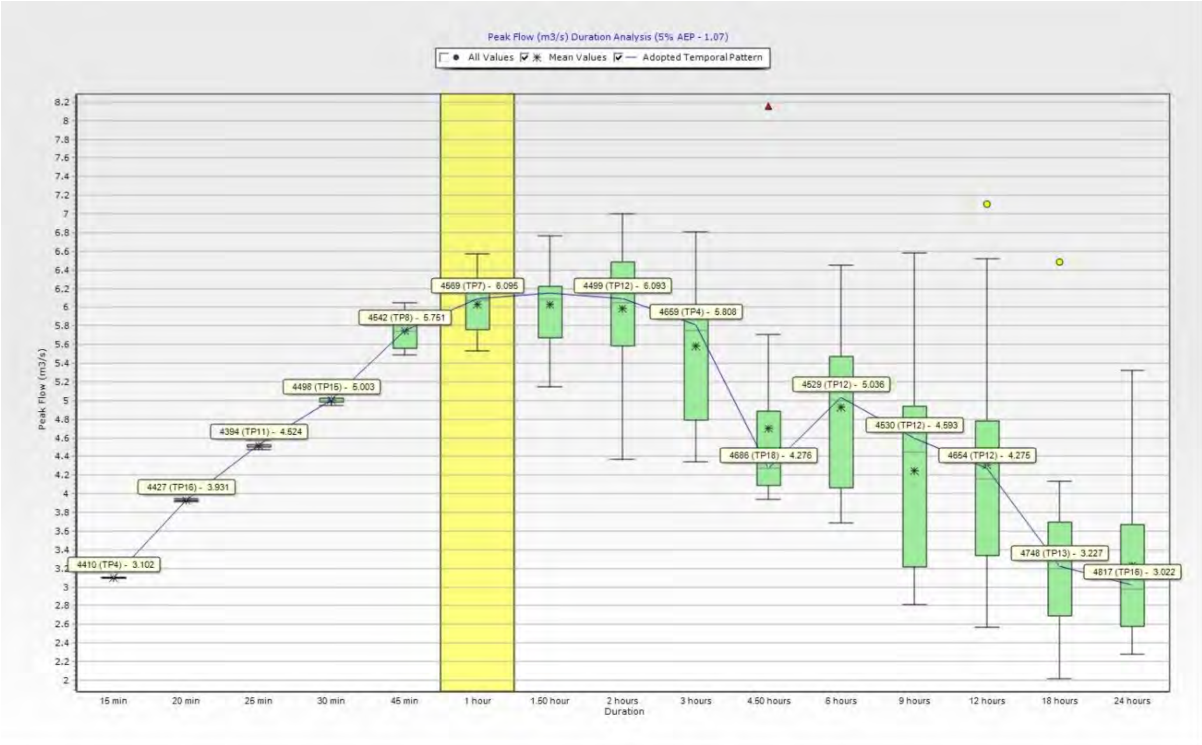

## RAFTS Node: 71.03



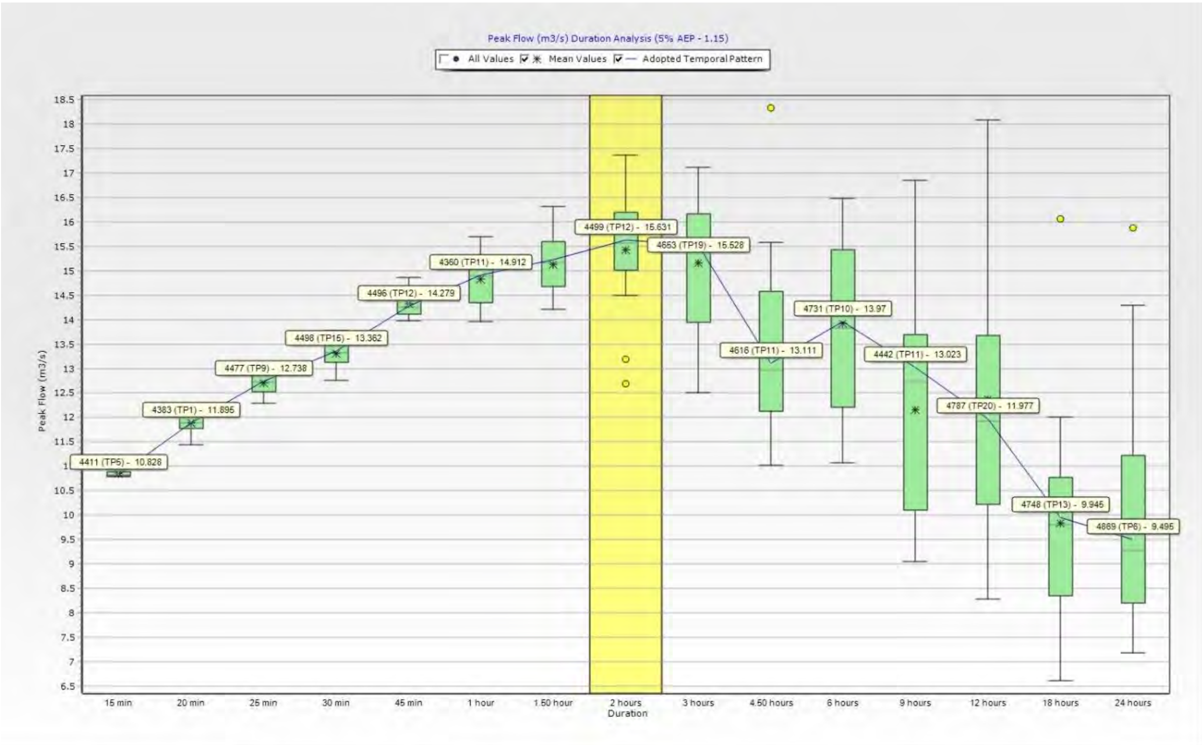
# ARR2019 Box Plots

## 5% AEP

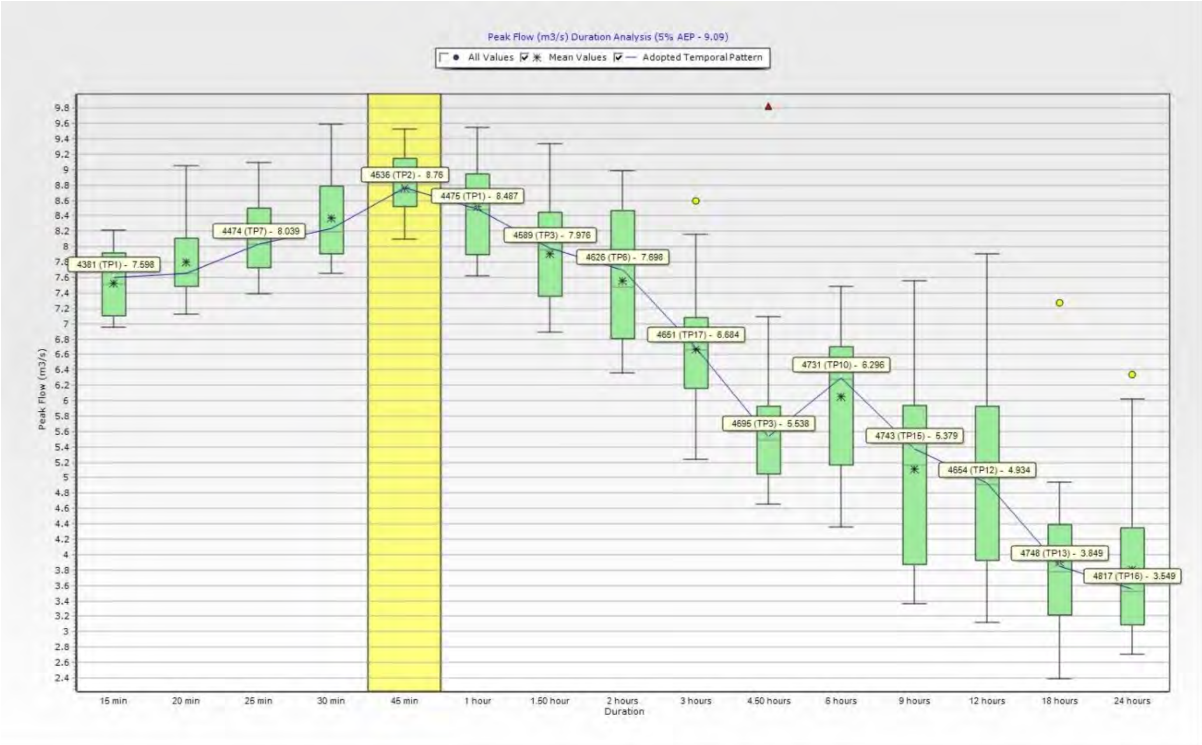
## RAFTS Node: 1.07



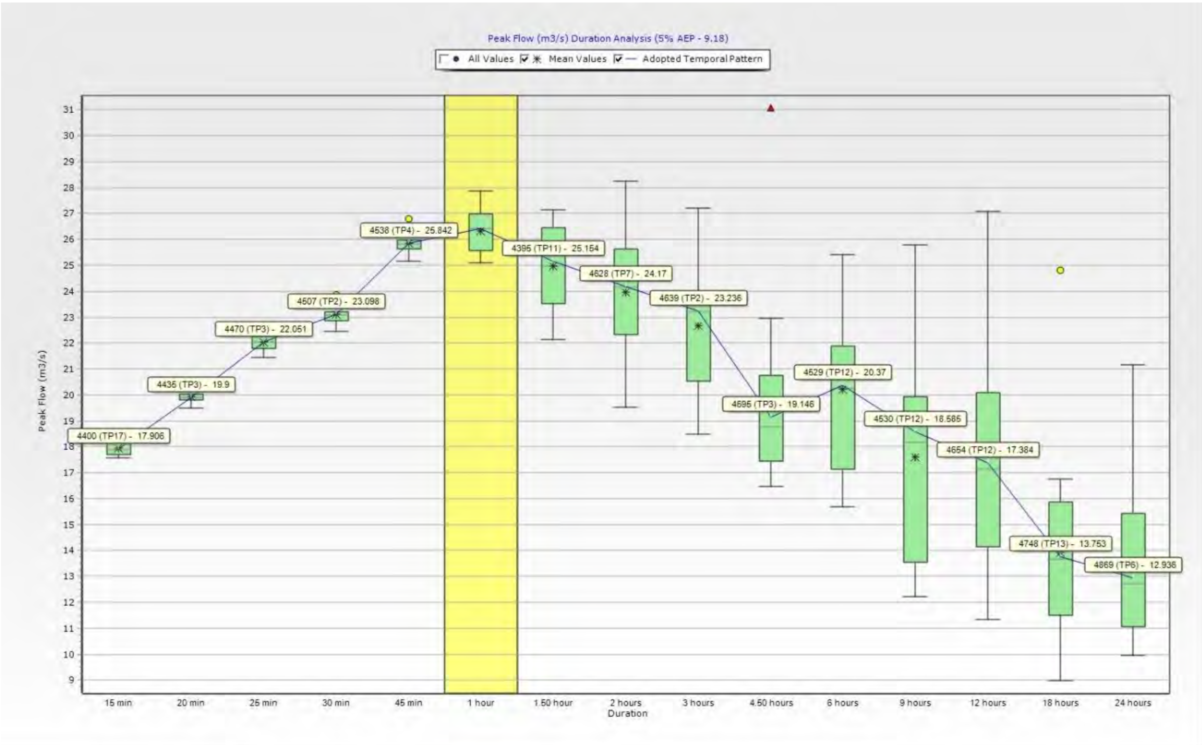

## RAFTS Node: 1.15



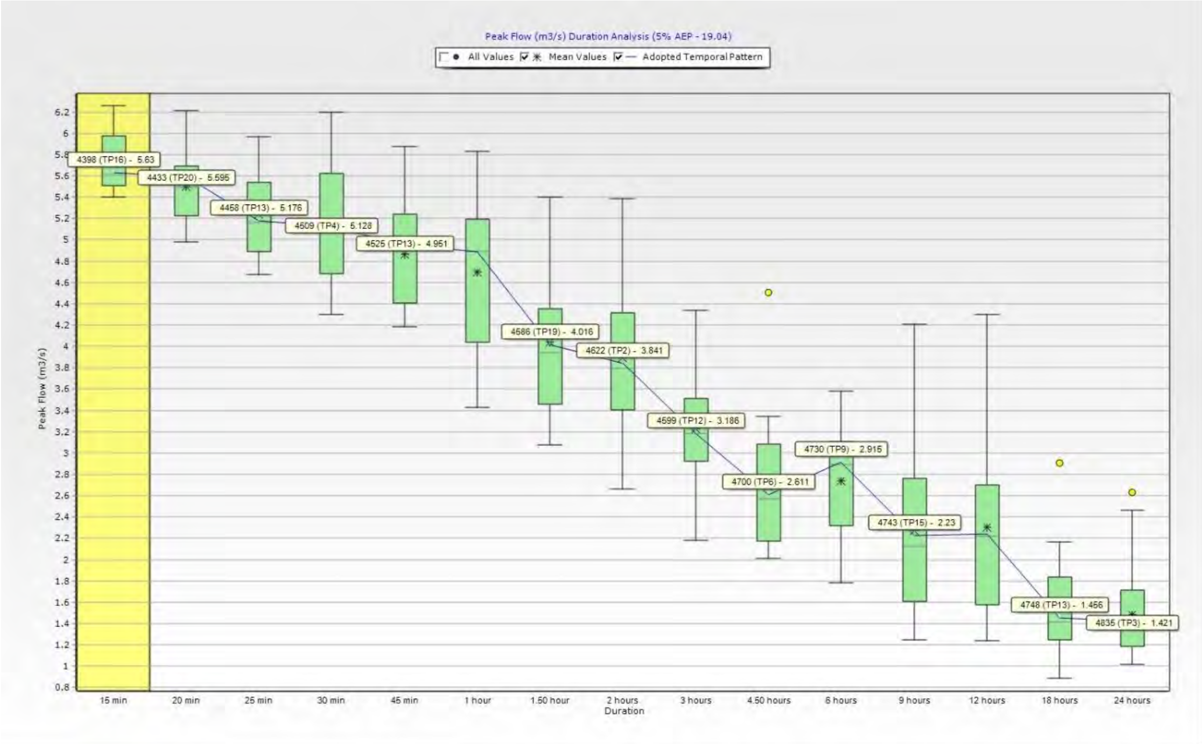
## RAFTS Node: 9.09



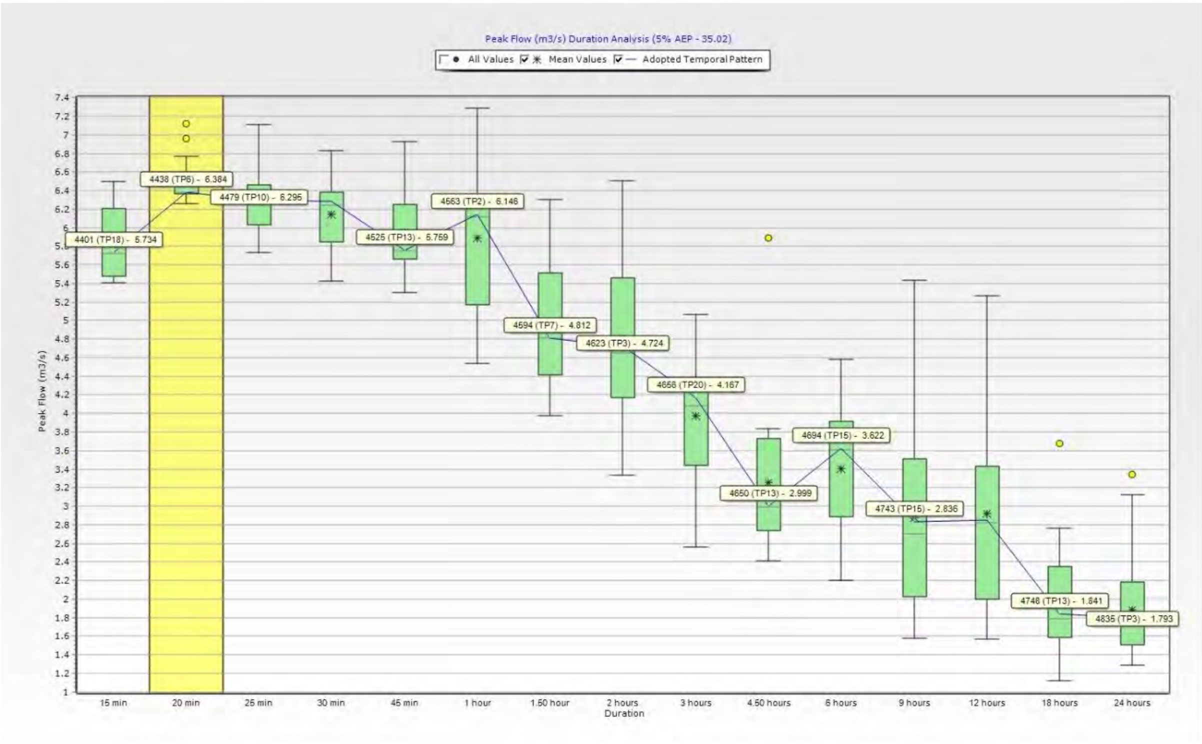

## RAFTS Node: 9.18



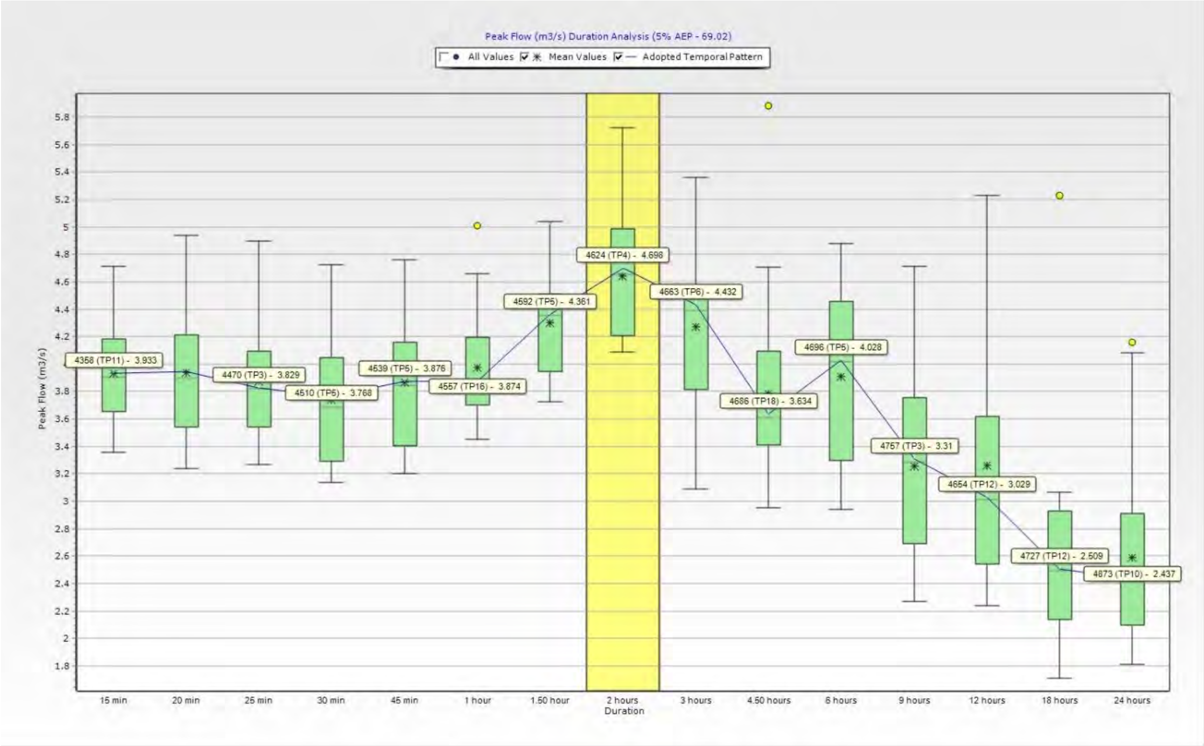
## RAFTS Node: 19.04



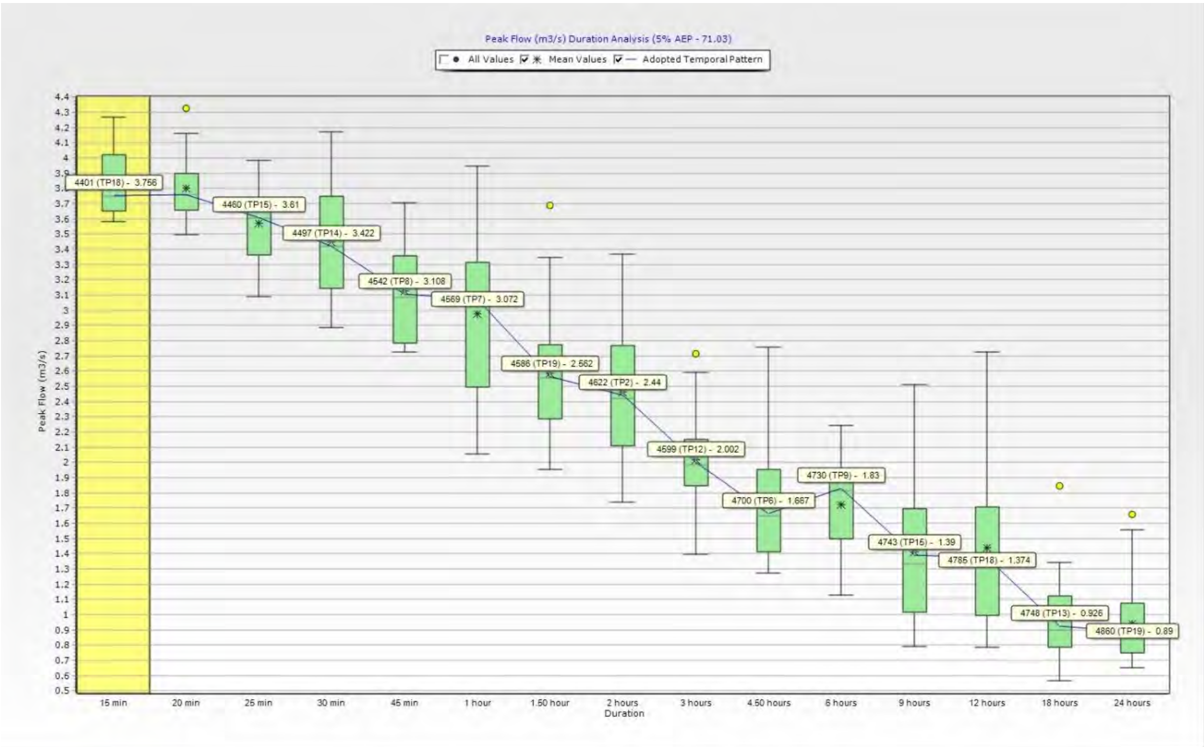

## RAFTS Node: 35.02



## RAFTS Node: 69.02



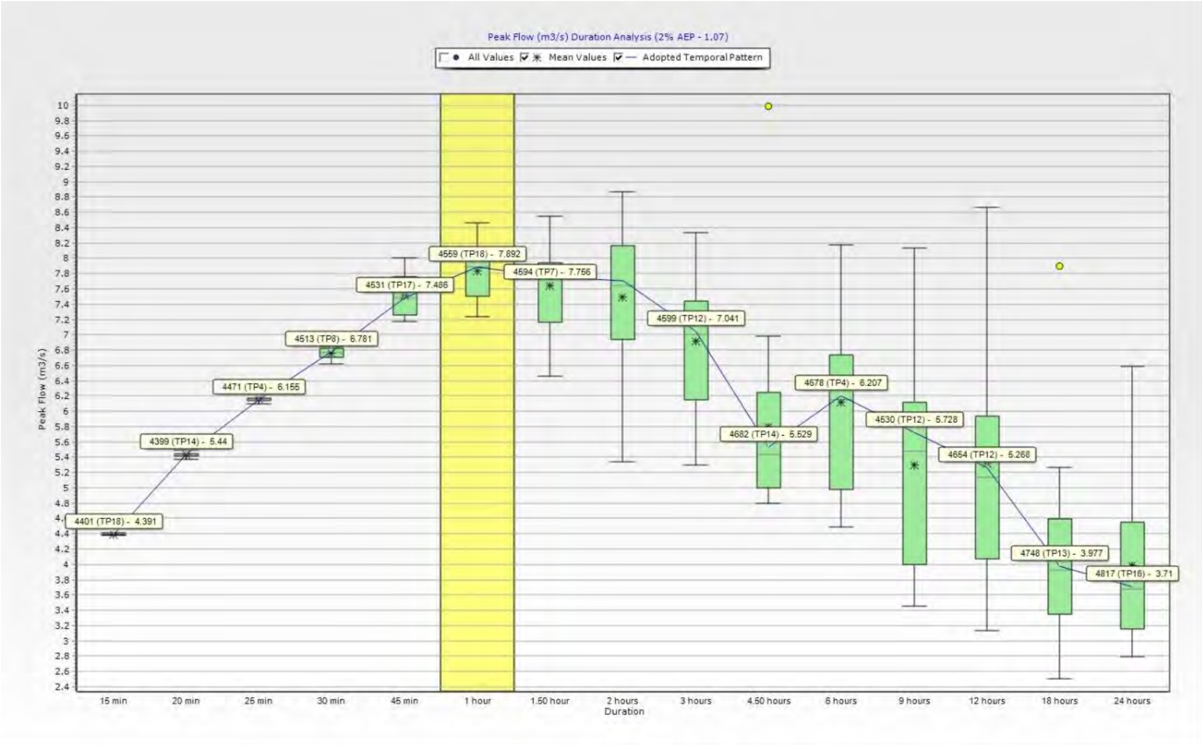

## RAFTS Node: 71.03



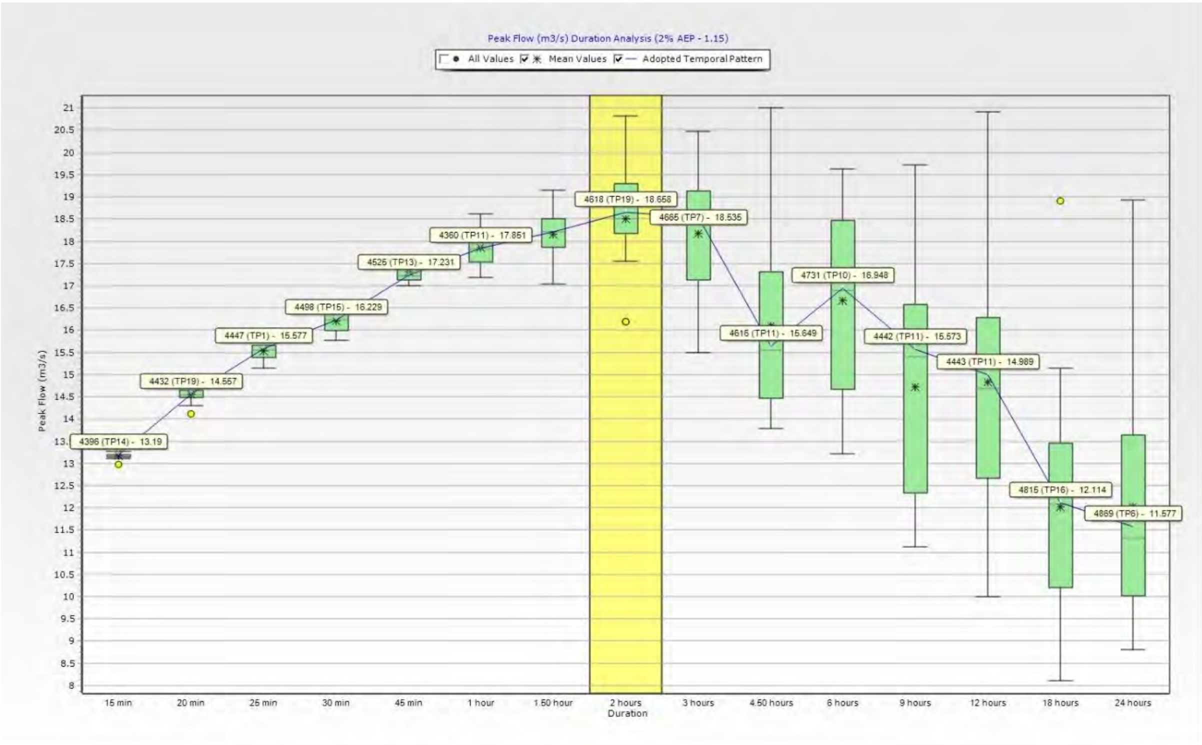
# ARR2019 Box Plots

## 2% AEP

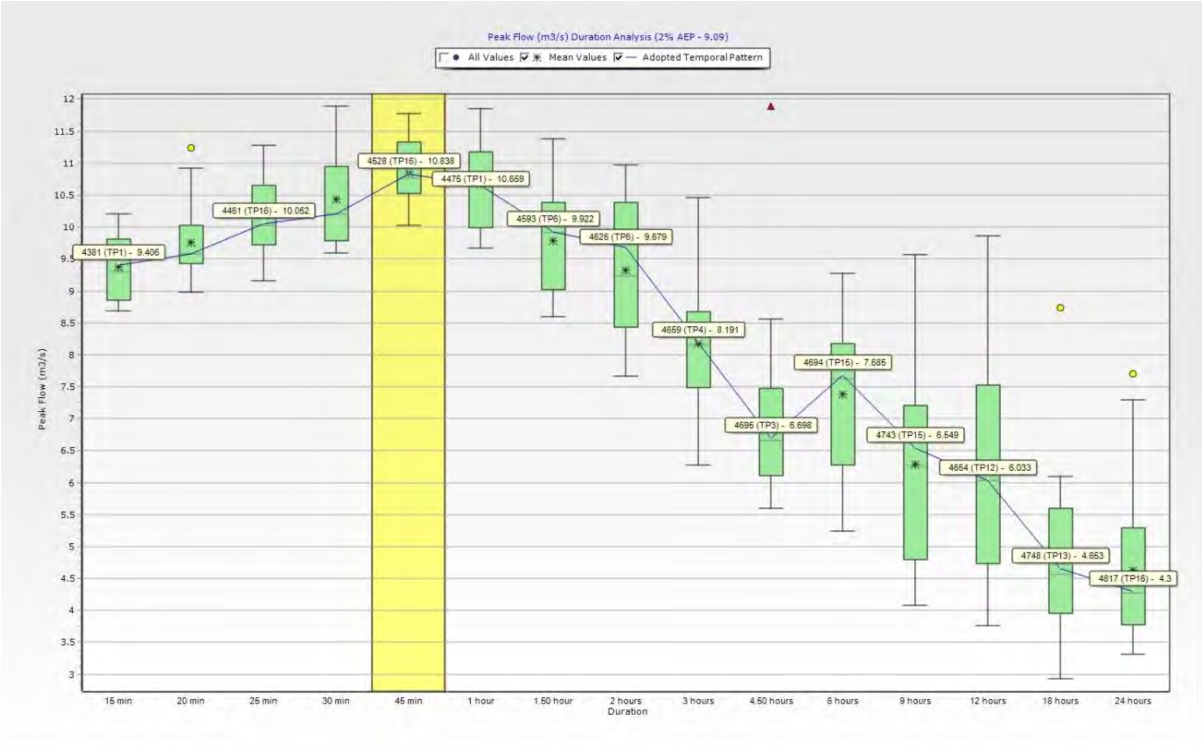
## RAFTS Node: 1.07



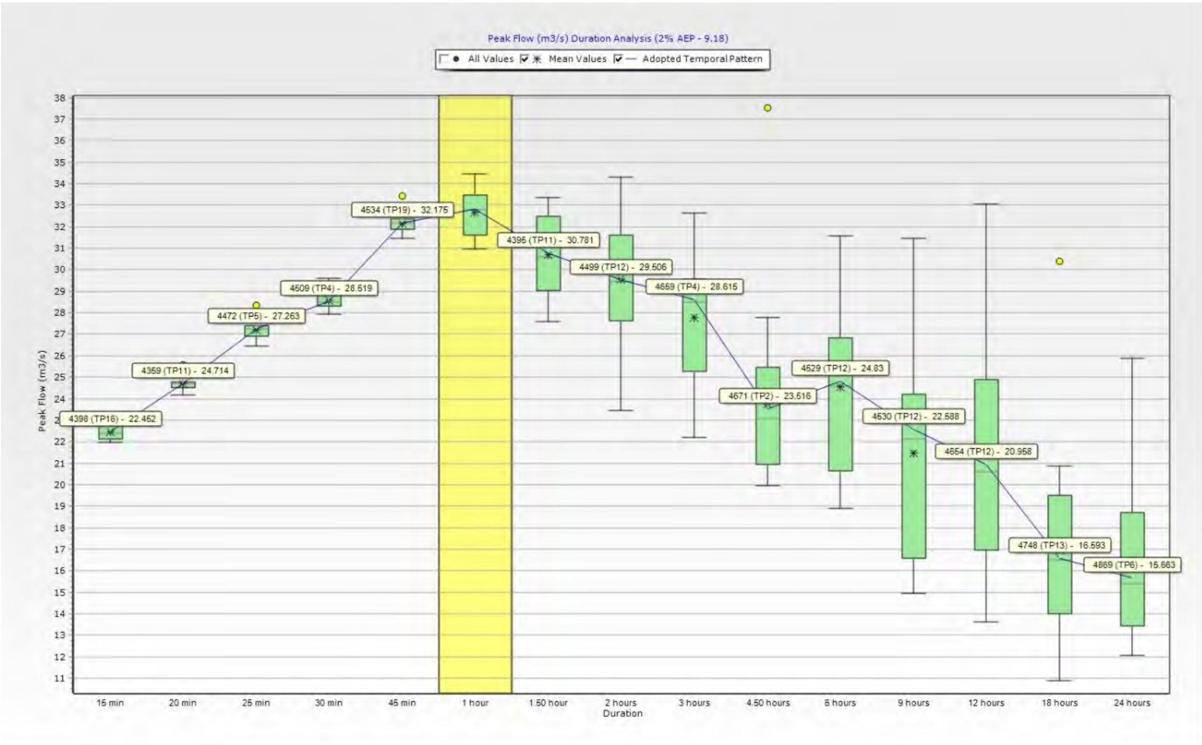

## RAFTS Node: 1.15



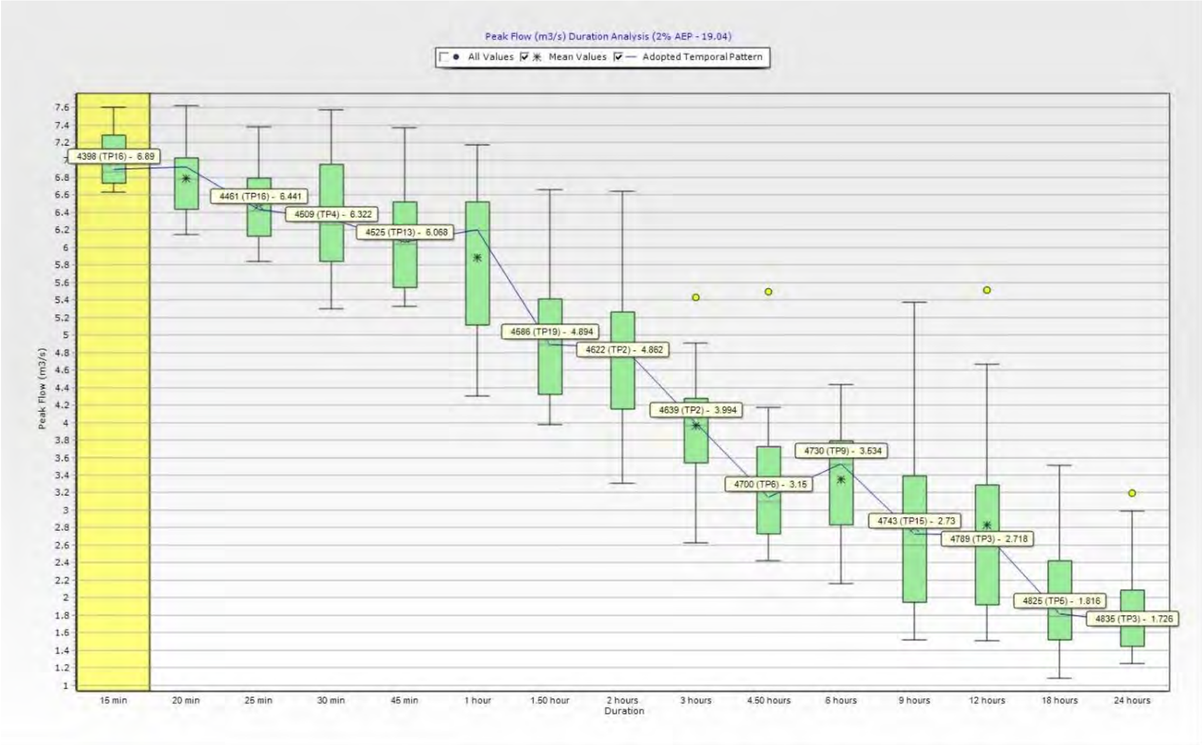
## RAFTS Node: 9.09



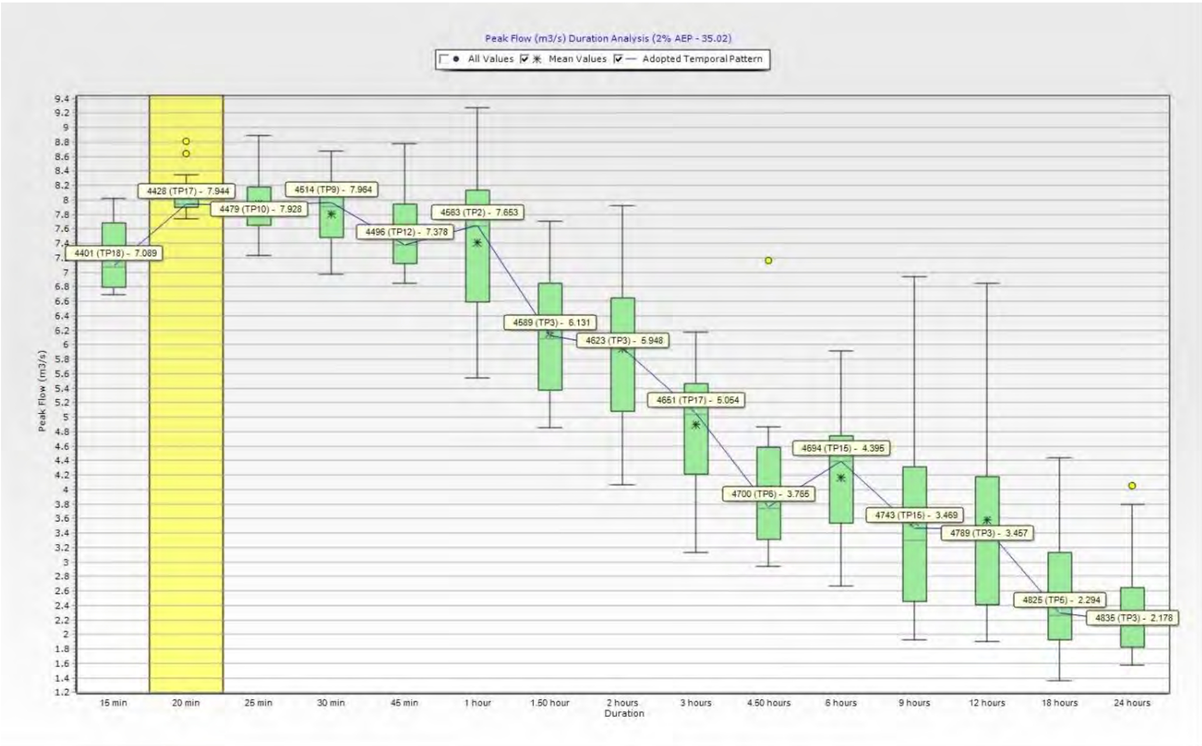

## RAFTS Node: 9.18



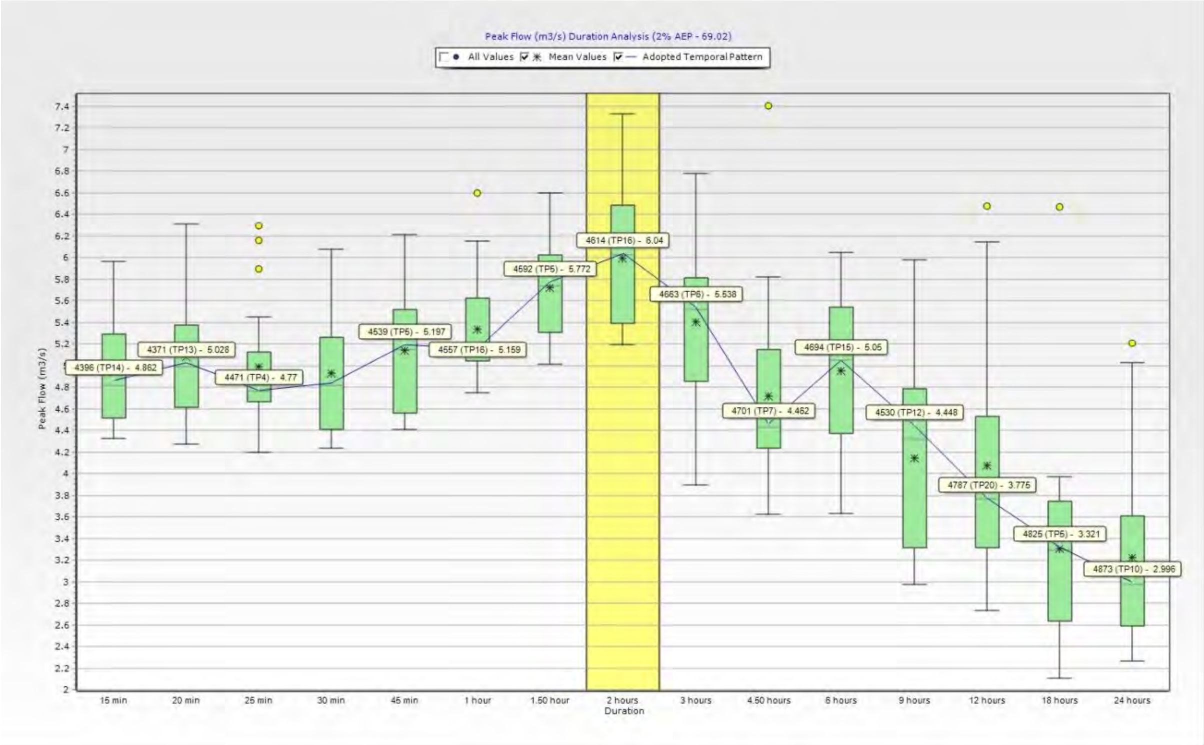
## RAFTS Node: 19.04



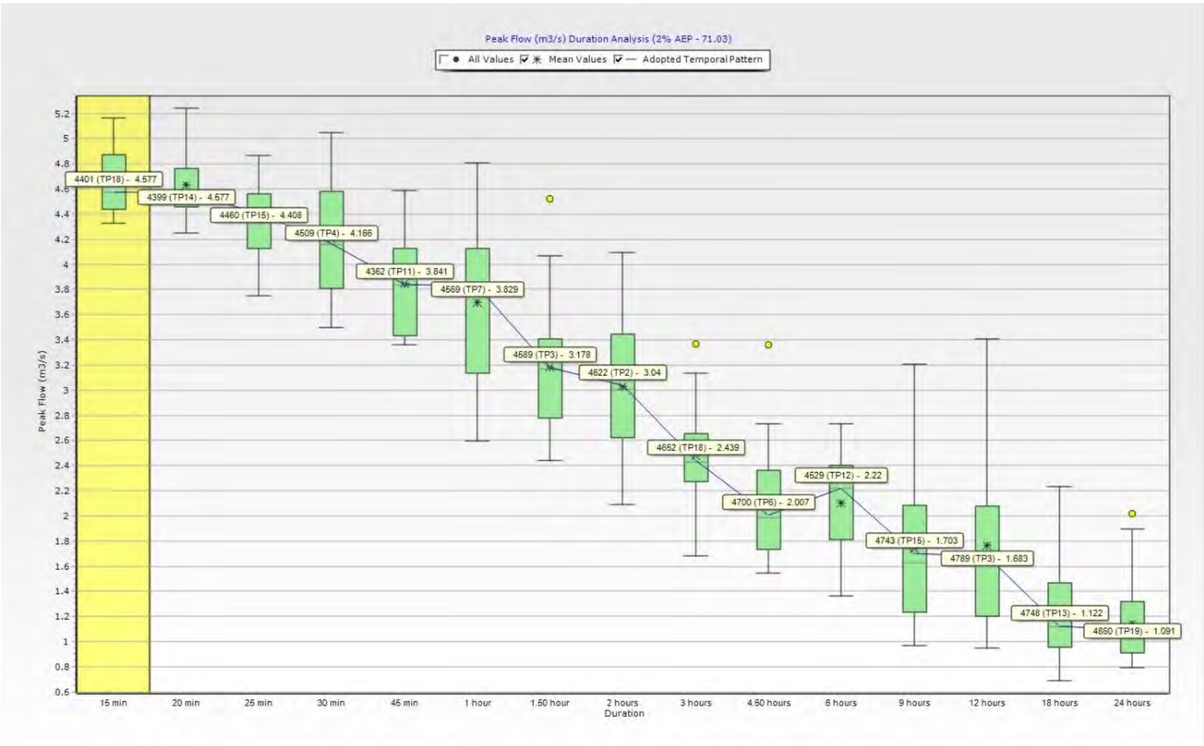

## RAFTS Node: 35.02



## RAFTS Node: 69.02



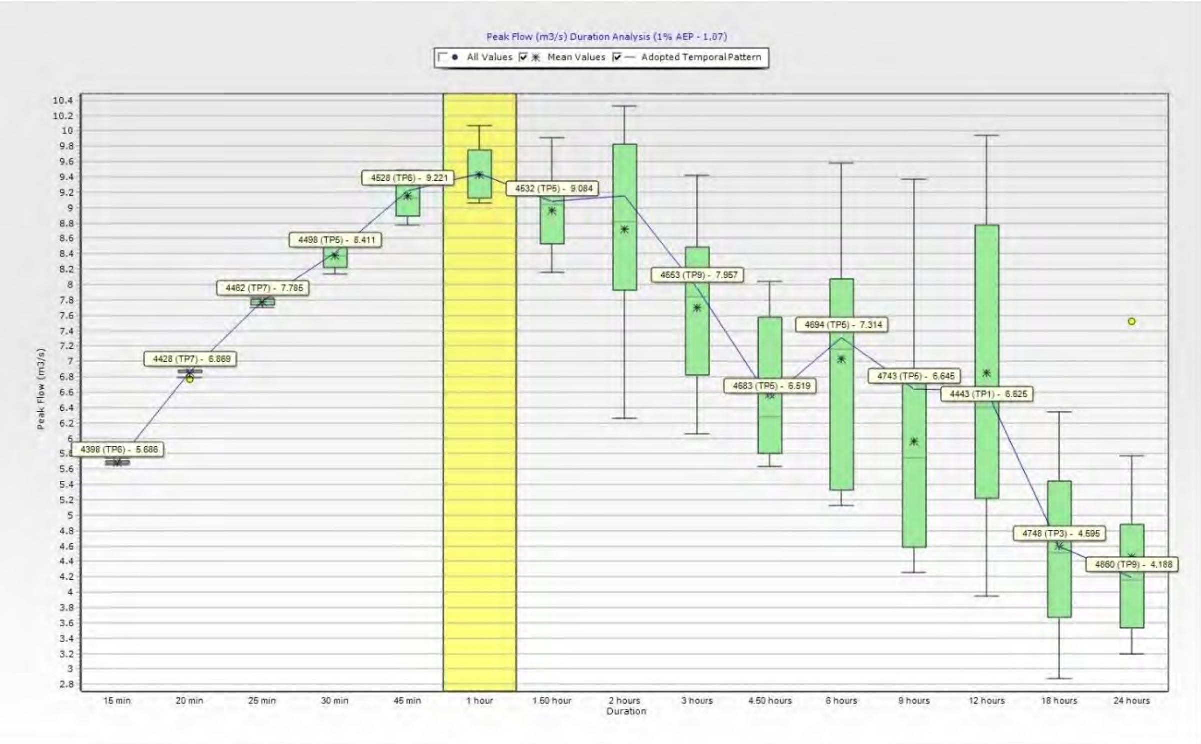

## RAFTS Node: 71.03



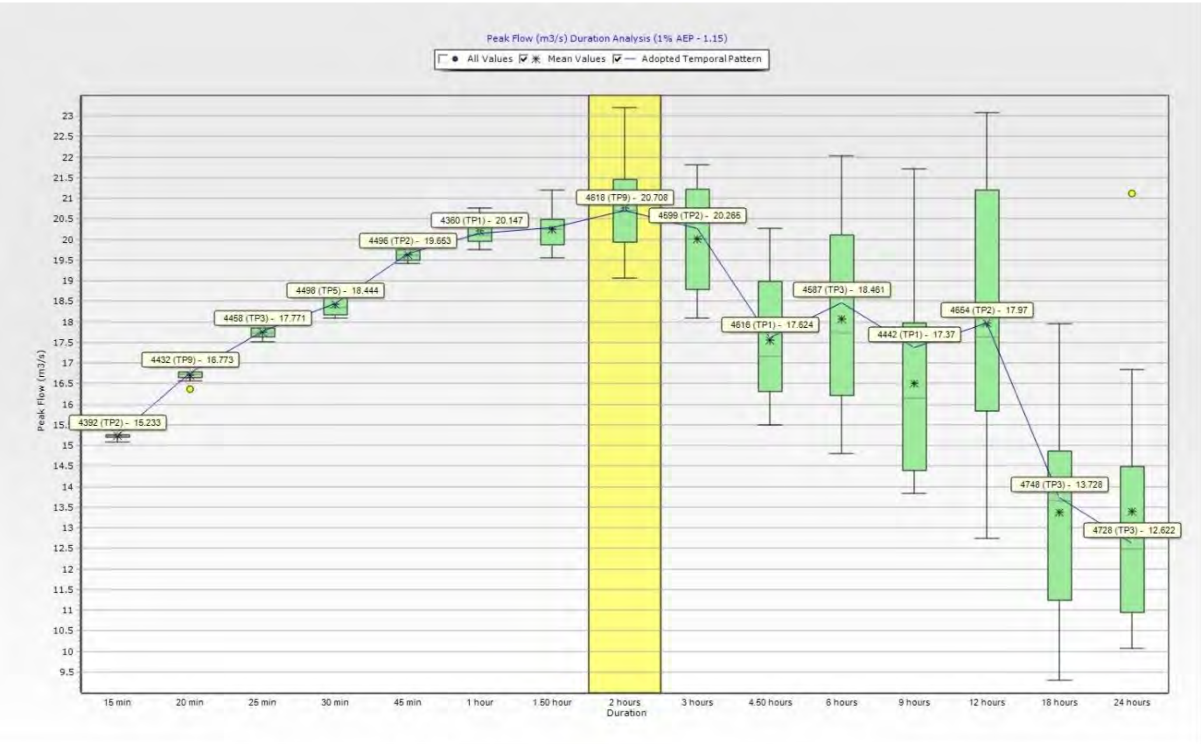
# ARR2019 Box Plots

## 1% AEP

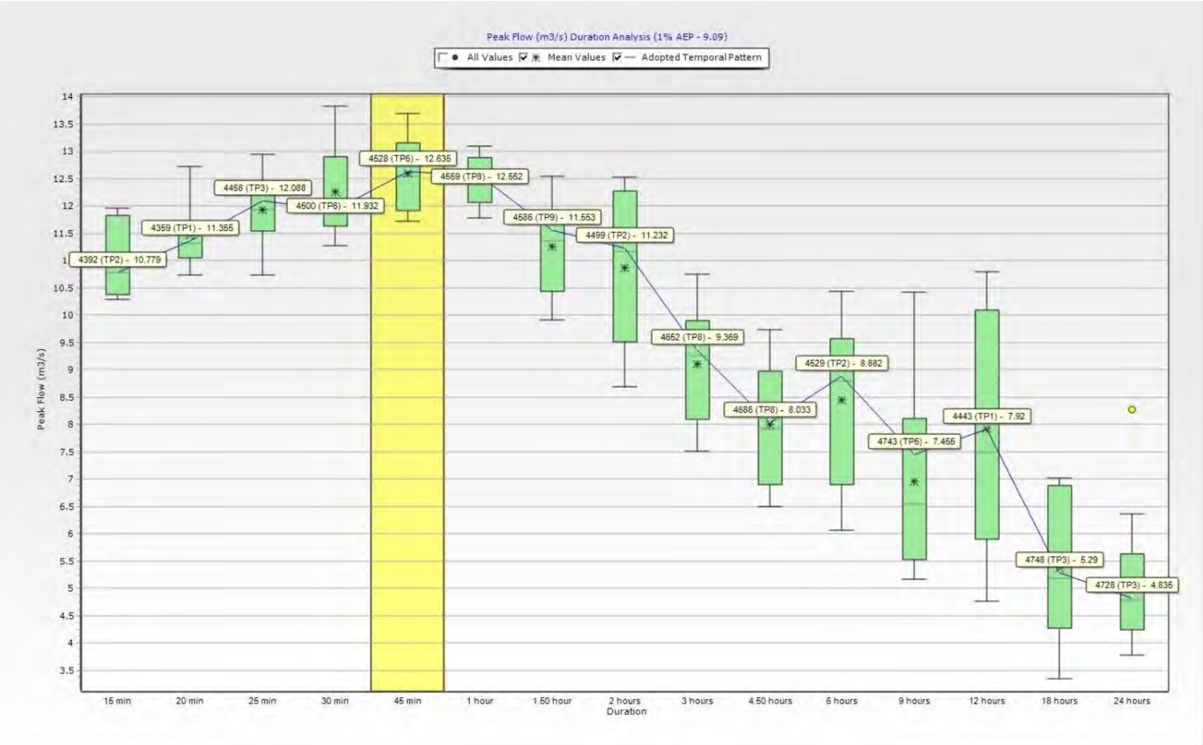
## RAFTS Node: 1.07



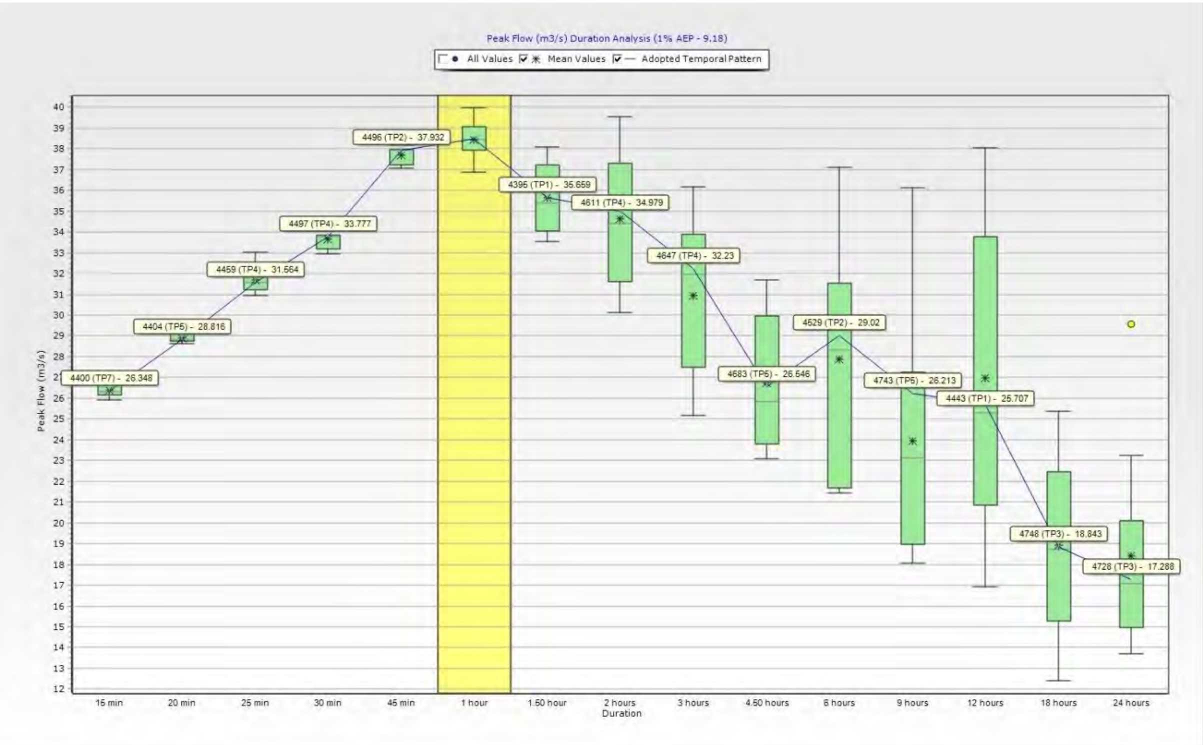

## RAFTS Node: 1.15



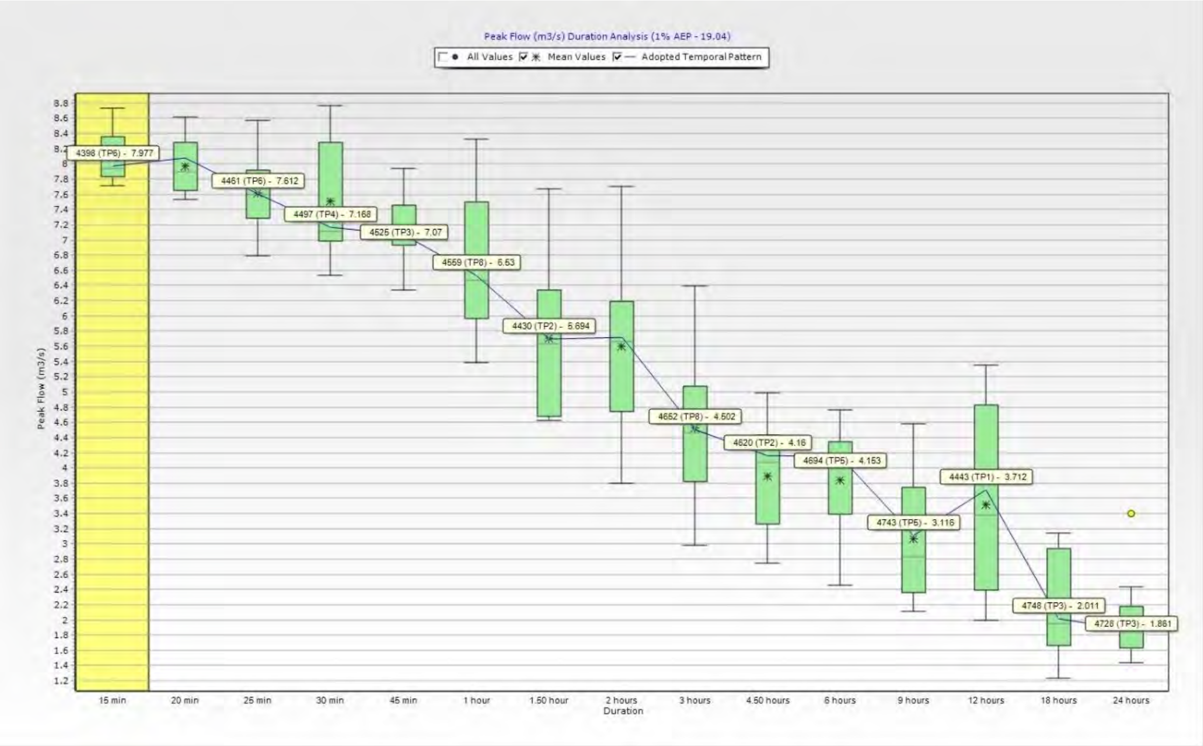
## RAFTS Node: 9.09



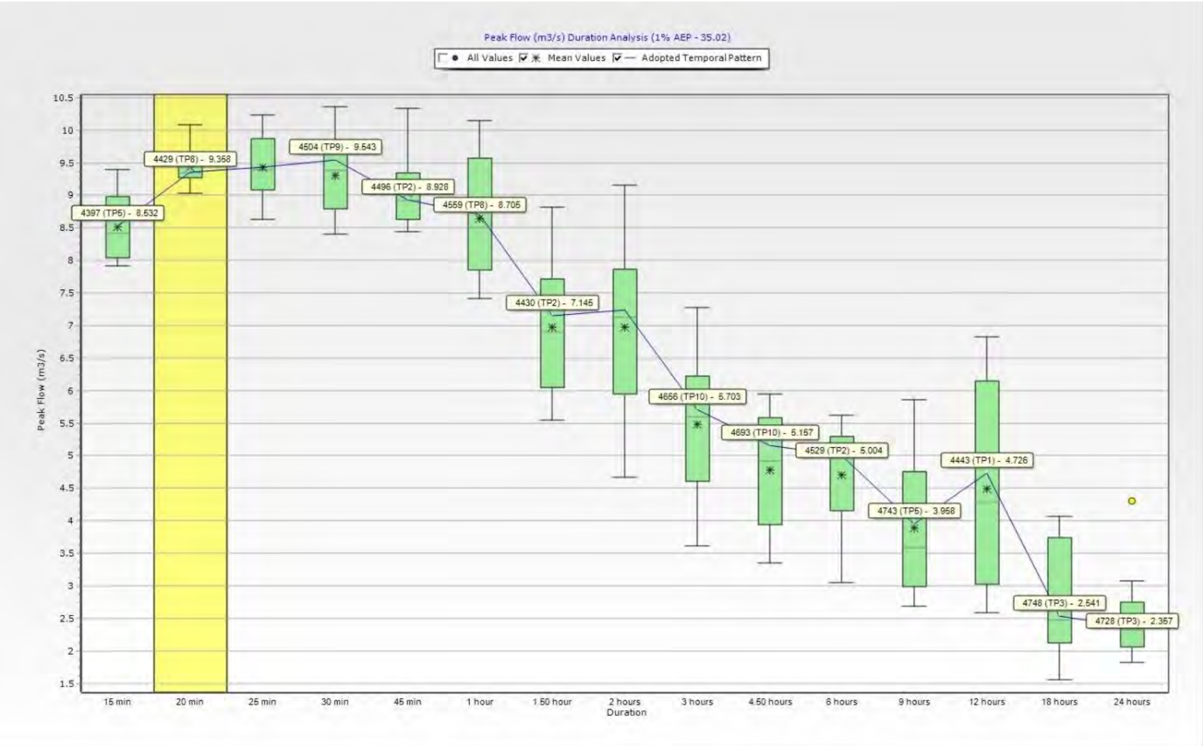

## RAFTS Node: 9.18



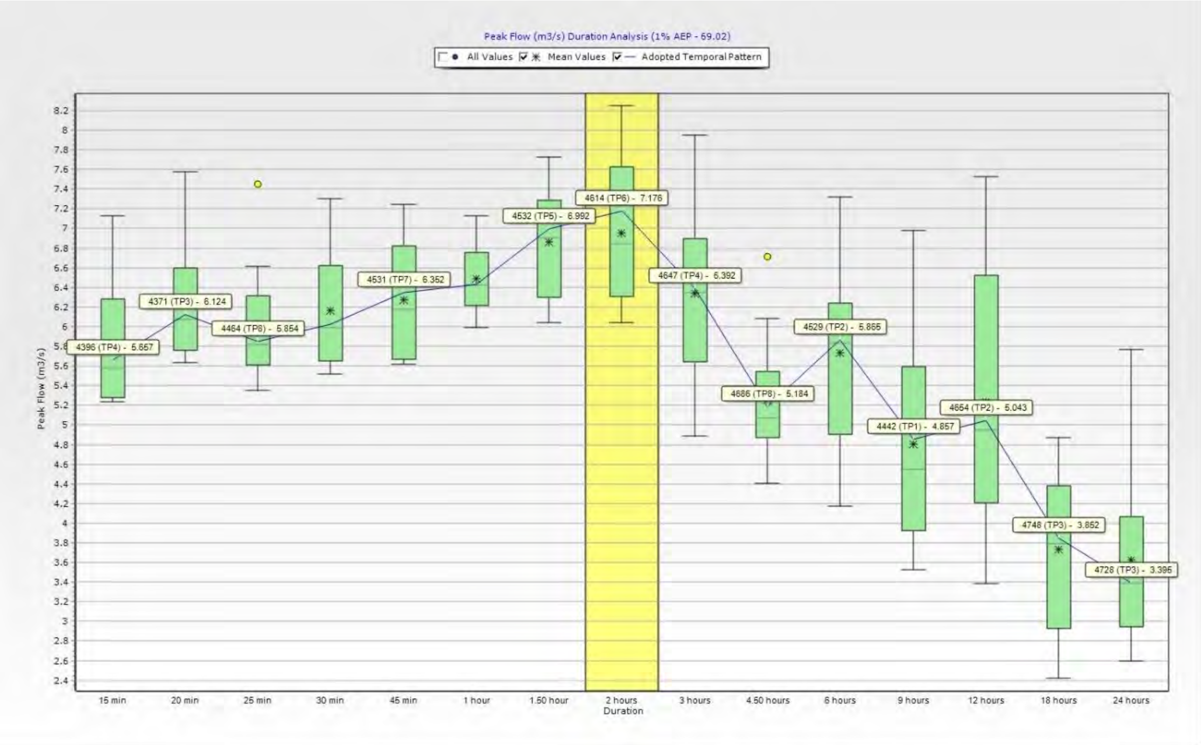
## RAFTS Node: 19.04



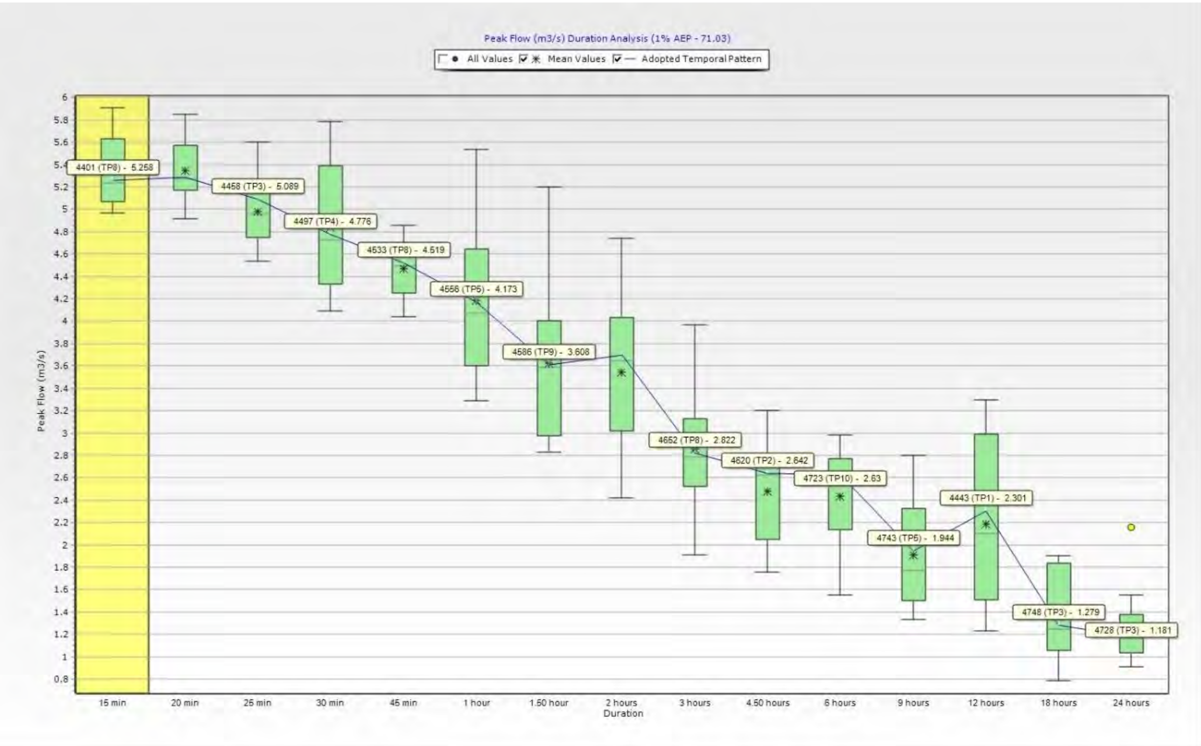

## RAFTS Node: 35.02



## RAFTS Node: 69.02



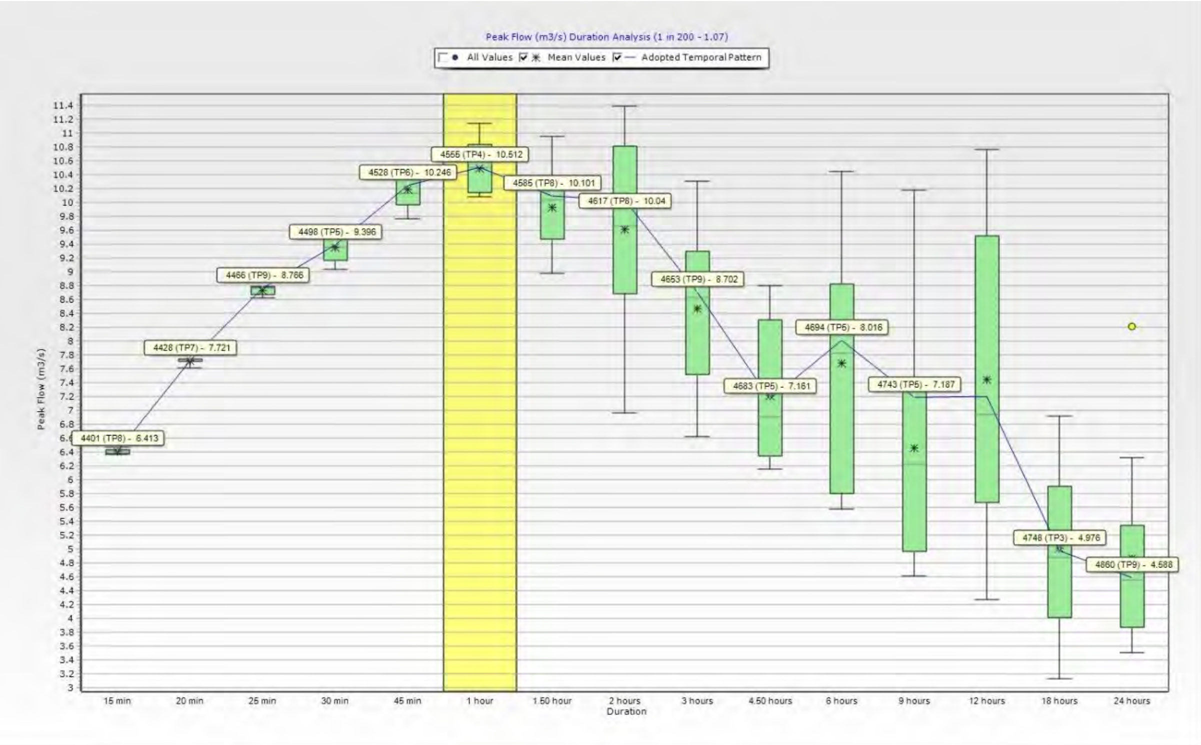

## RAFTS Node: 71.03



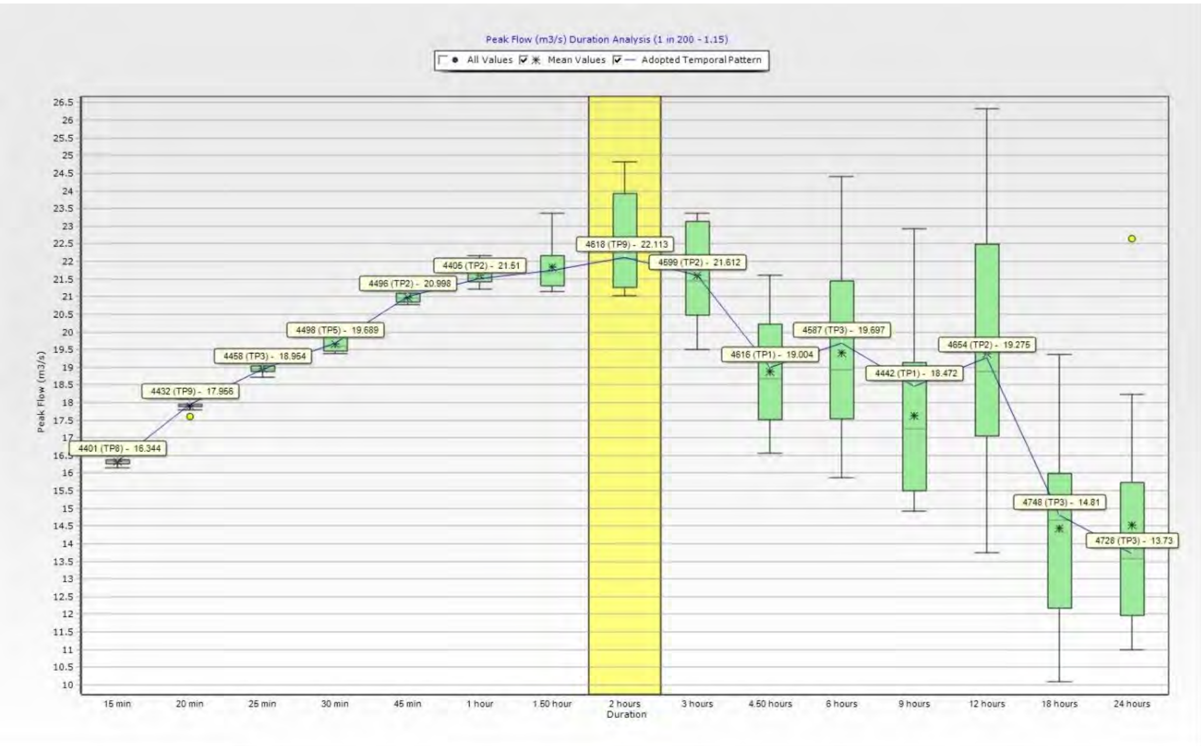
# ARR2019 Box Plots

## 0.5% AEP

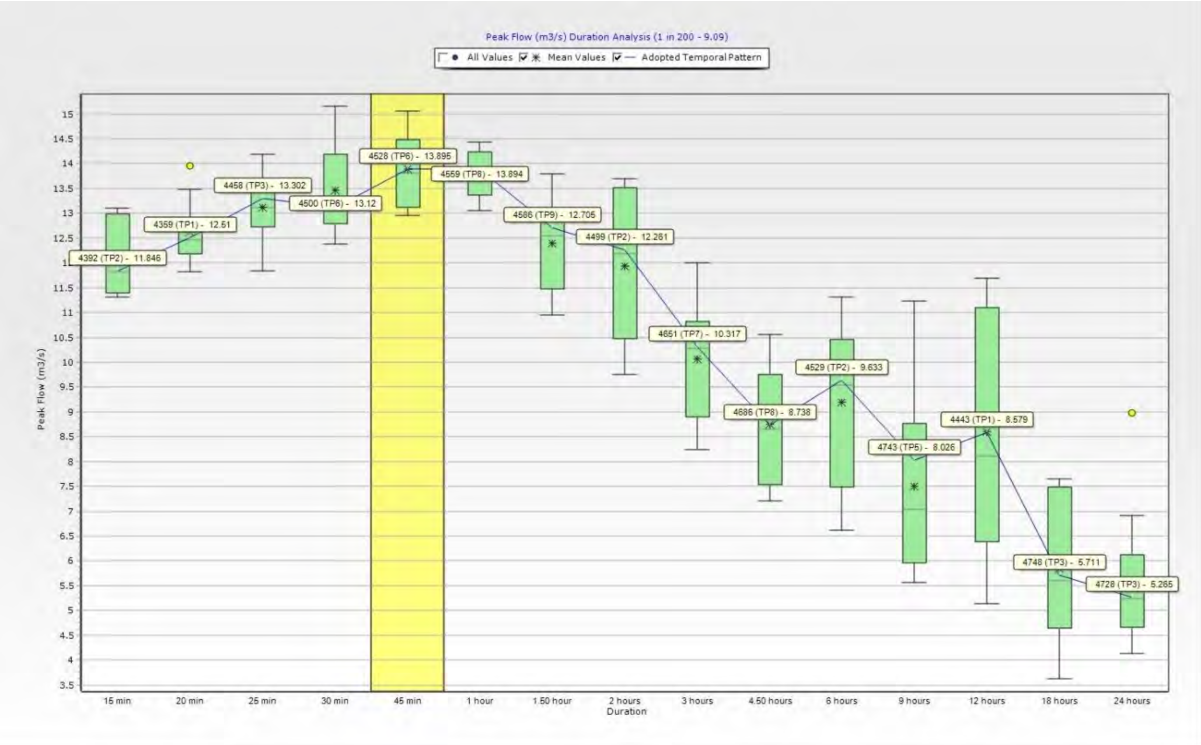
## RAFTS Node: 1.07



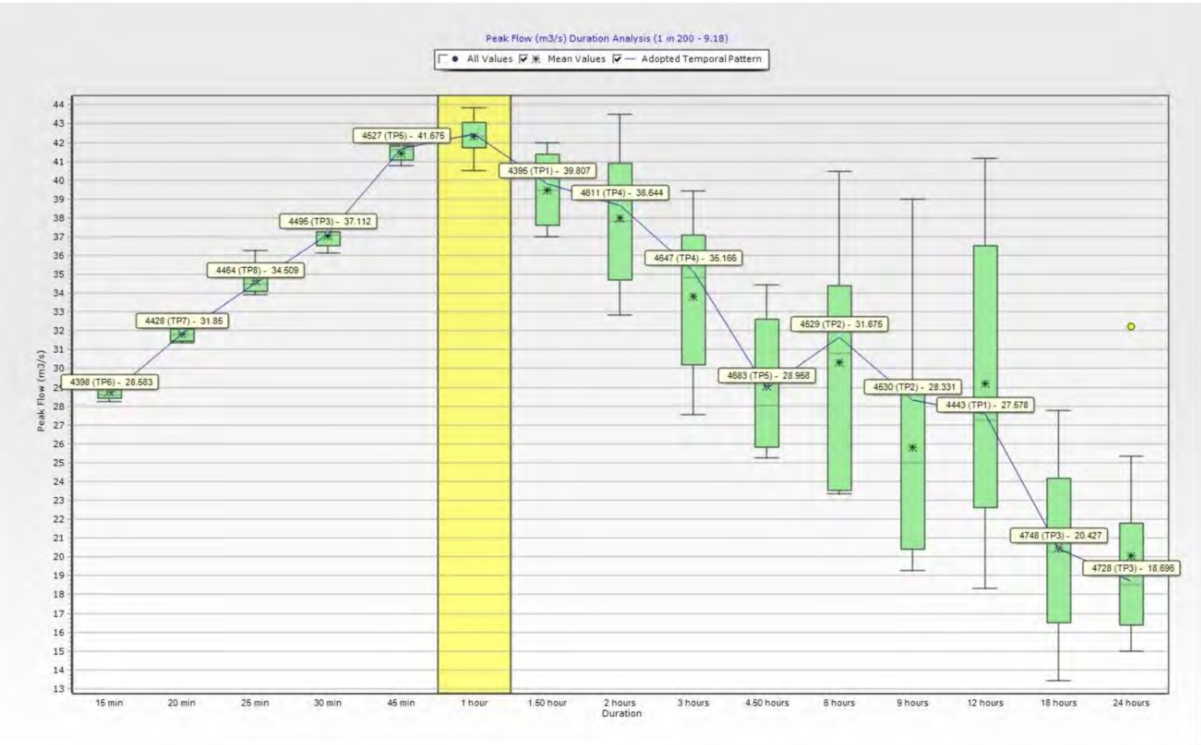

## RAFTS Node: 1.15



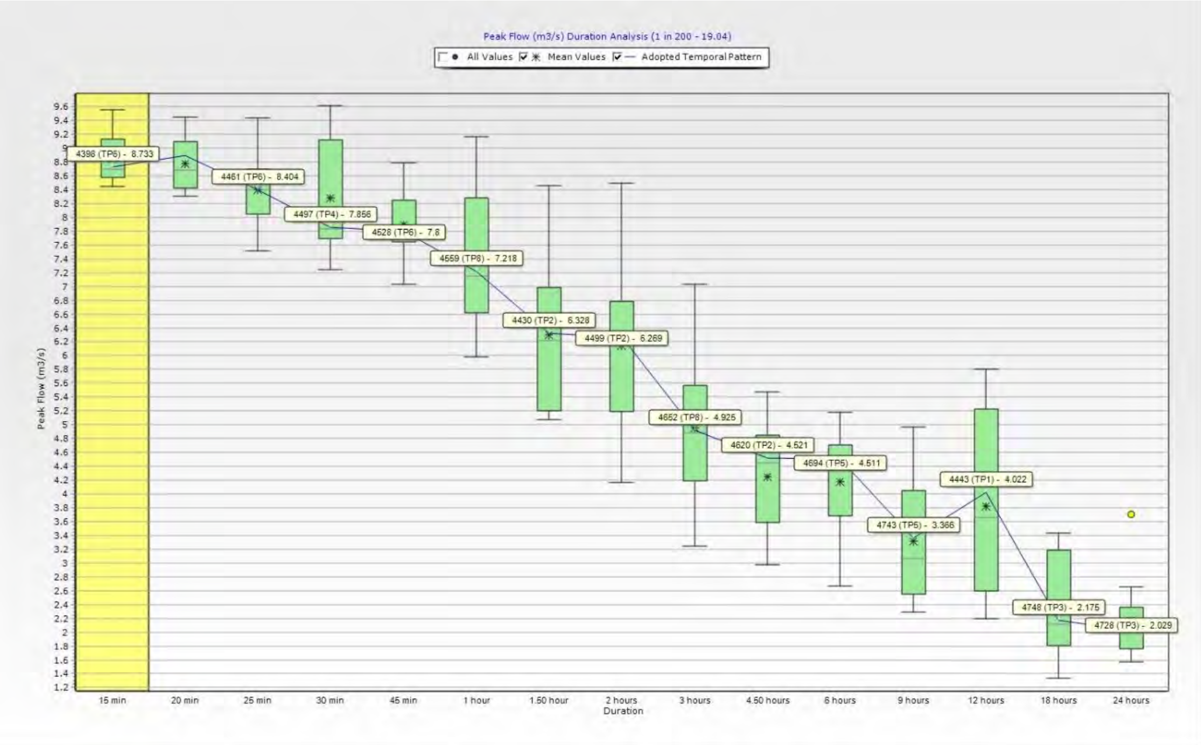
## RAFTS Node: 9.09



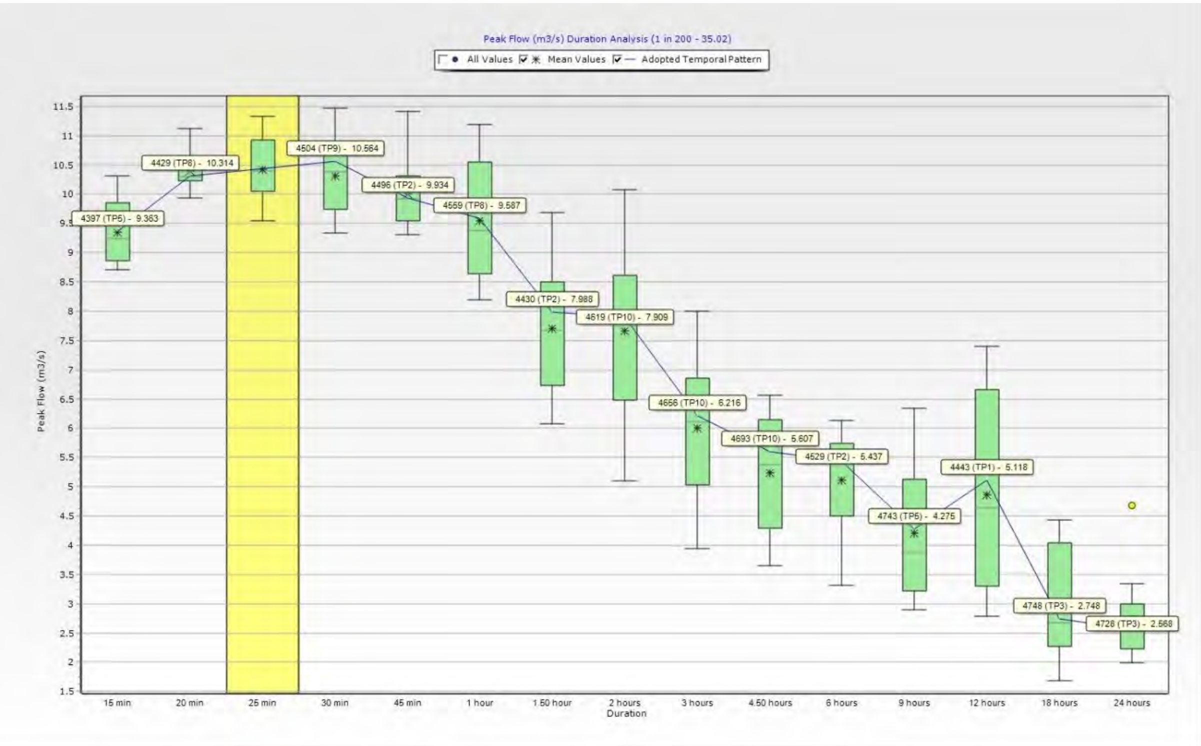

## RAFTS Node: 9.18



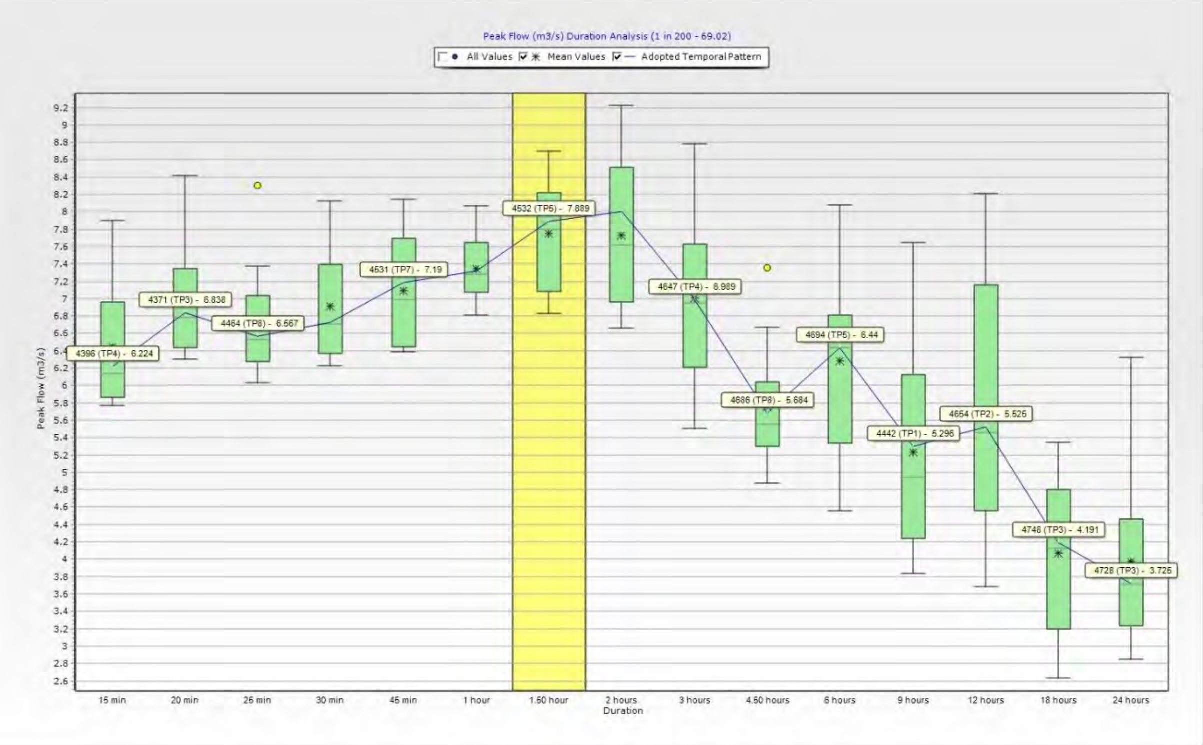
## RAFTS Node: 19.04



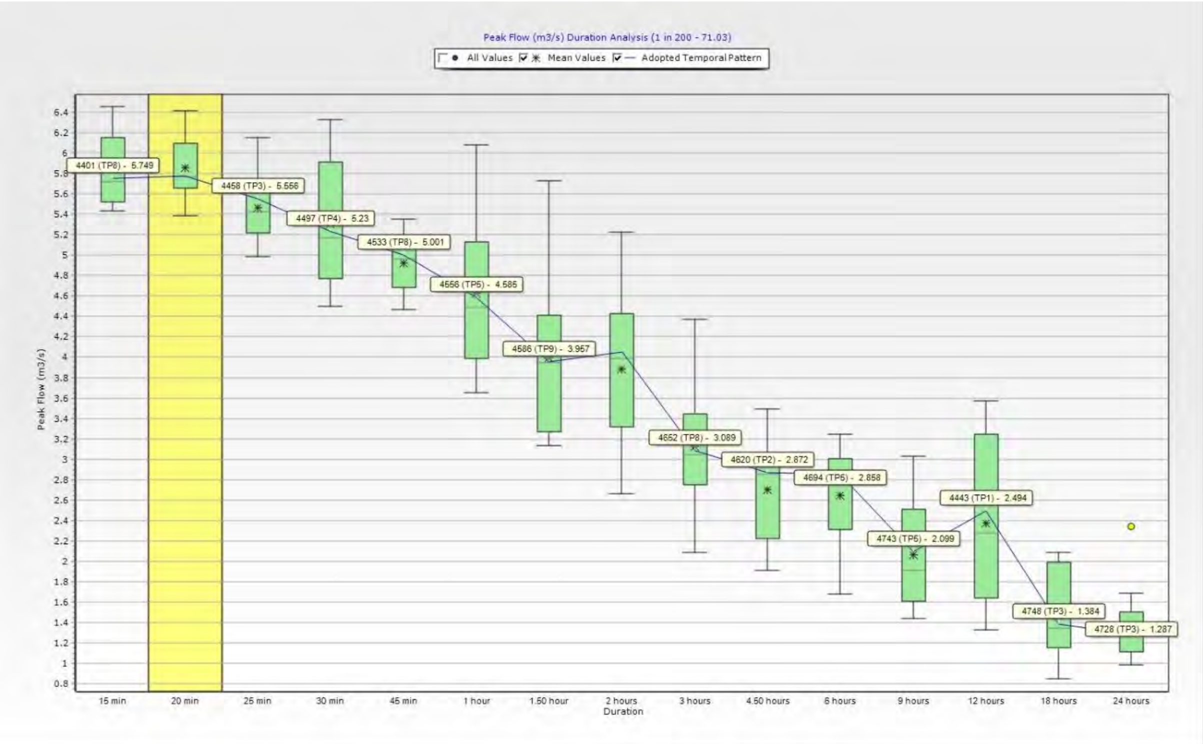

## RAFTS Node: 35.02



## RAFTS Node: 69.02



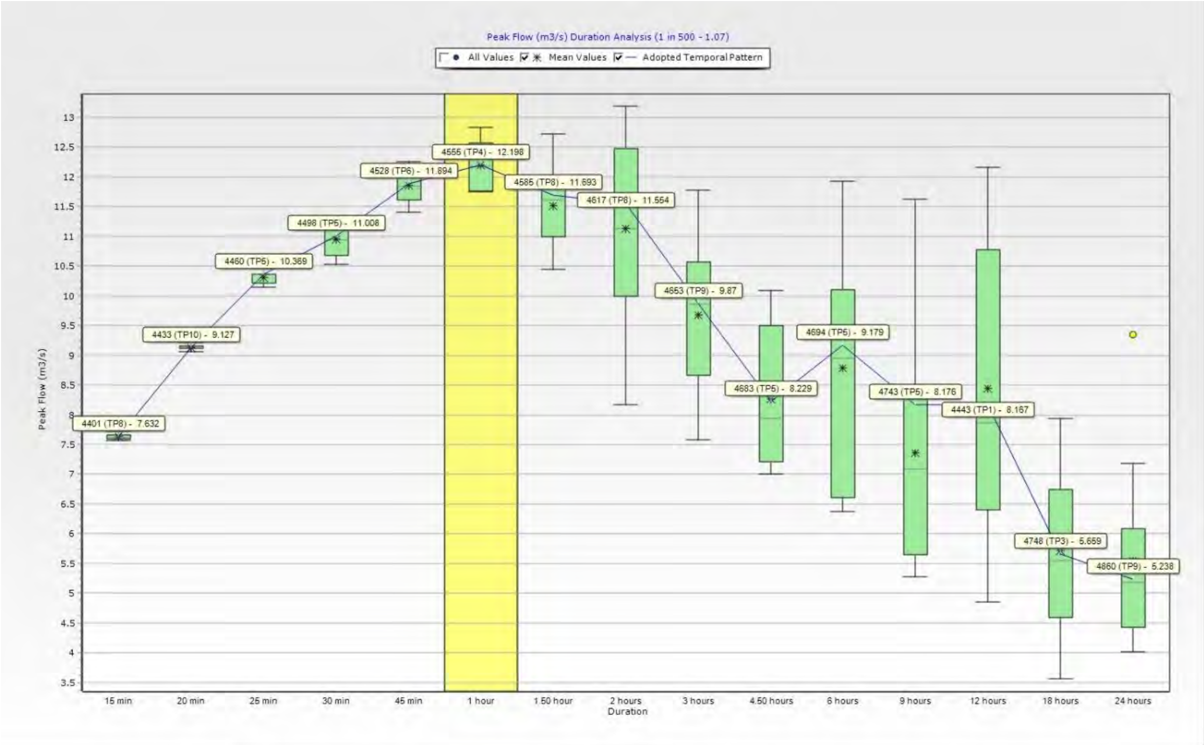

## RAFTS Node: 71.03



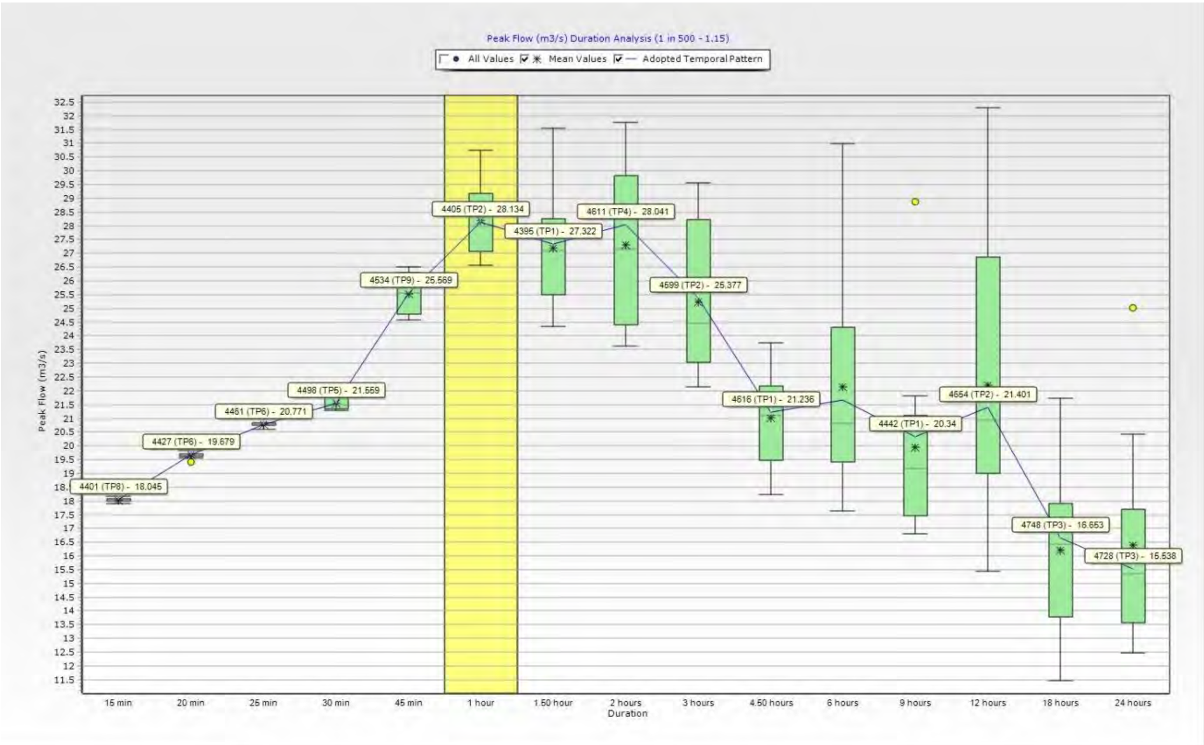
# ARR2019 Box Plots

## 0.2% AEP

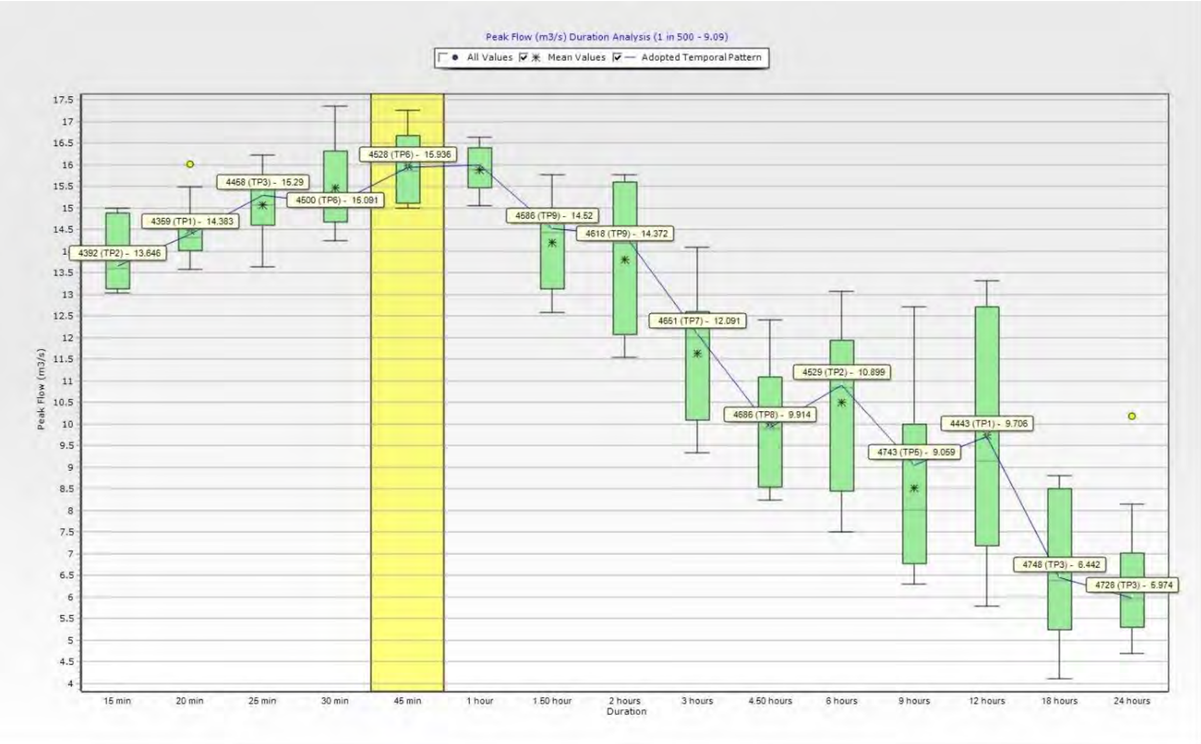
## RAFTS Node: 1.07



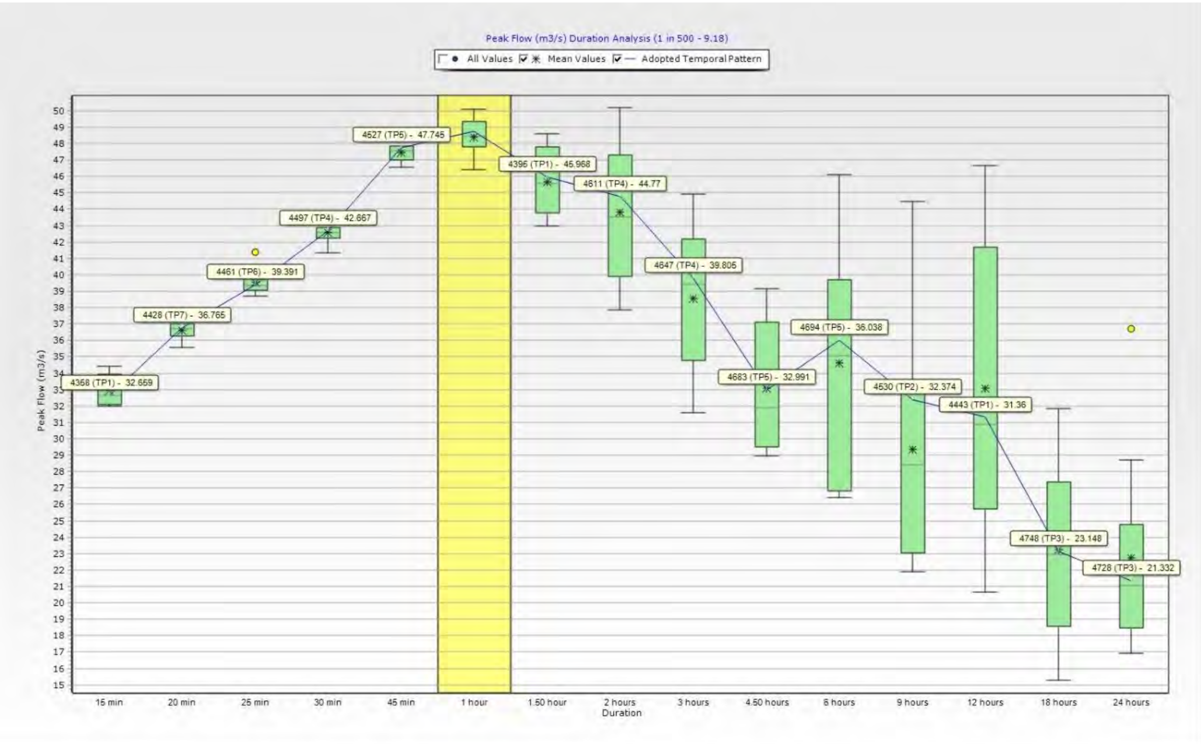

## RAFTS Node: 1.15



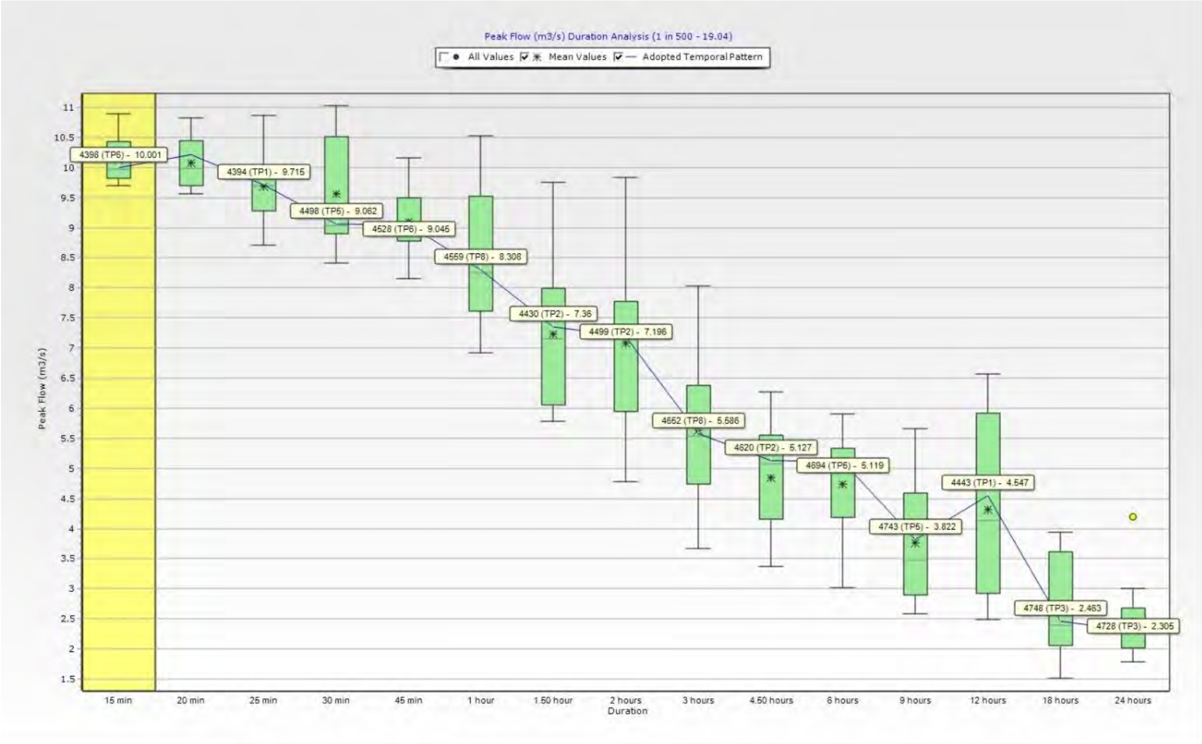
RAFTS Node: 9.09



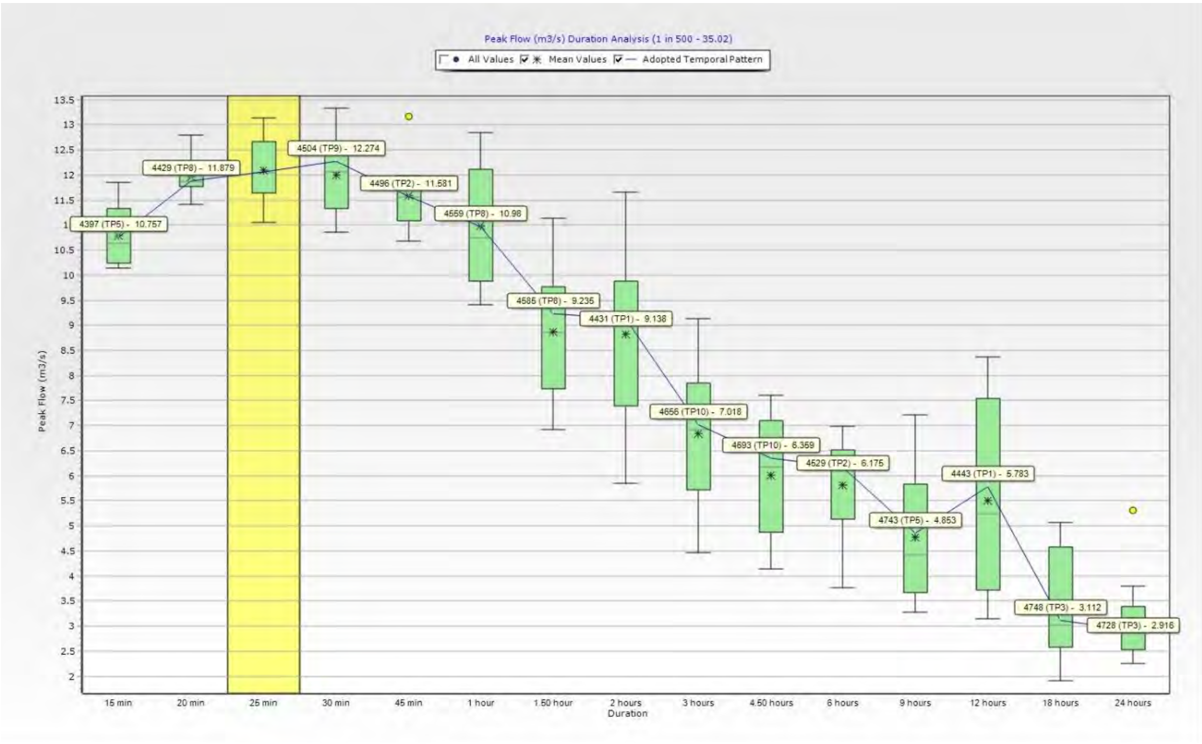

RAFTS Node: 9.18



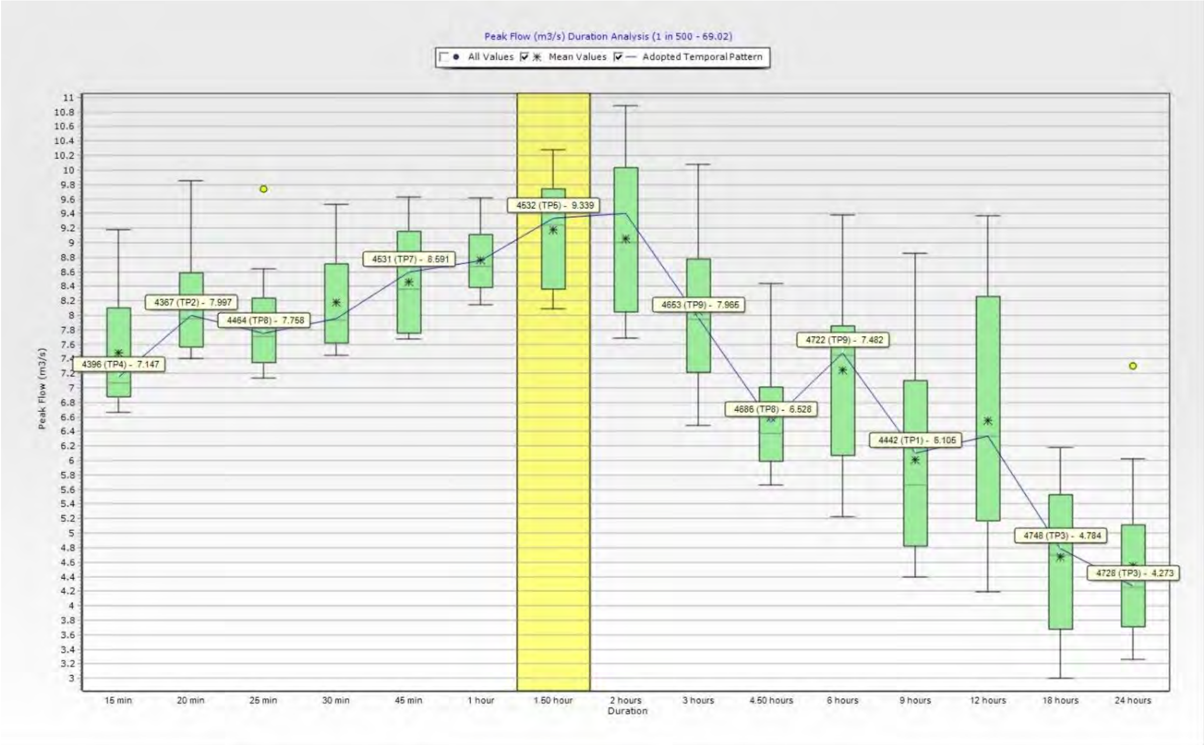
## RAFTS Node: 19.04



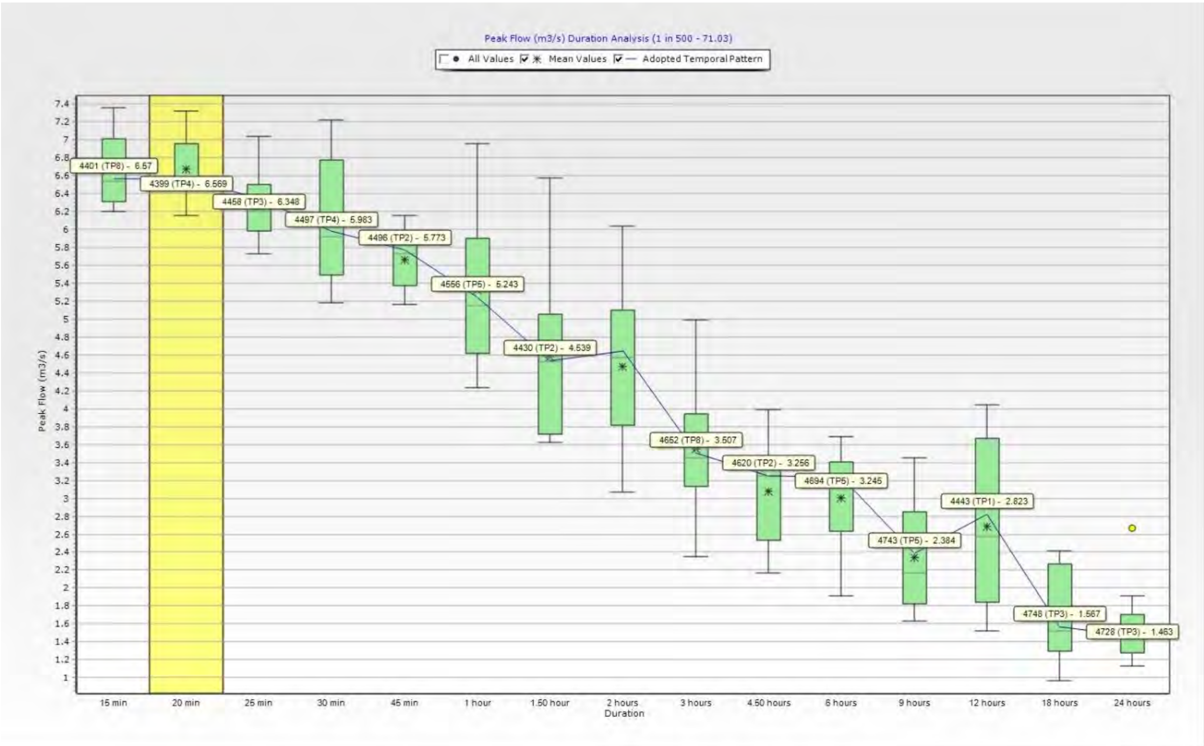

## RAFTS Node: 35.02



## RAFTS Node: 69.02




## RAFTS Node: 71.03



# APPENDIX L

## HISTORIC FLOOD PHOTOS

## FEBRUARY 2012 FLOOD PHOTOS

**Above floor inundation at Stafford Crescent**

Above floor inundation at Stafford Crescent


Water depths of ~0.15 metres alongside of property at Stafford Crescent


Debris mark approximately 0.4 metres above ground level at Morley Ave, Kingswood

Above floor inundation at Morley Ave, Kingswood

Debris mark approximately 0.2 metres above ground level at Morley Ave, Kingswood

Western Sydney University Fence adjoining Second Ave showing debris mark approximately 0.5 metres high

Fence at O'Connell St entrance to Western Sydney University

Above floor inundation at Western Sydney University


Debris mark in switch room of Kingswood Sports Club

**Sediment deposited across floor of Building R at Western Sydney University after above floor inundation was experienced.**

Flooding under floor at Shaw Street (estimated to be 50cm depth)


Debris marks across driveway culverts at Cosgrove Cres

## FEBRUARY 2011 FLOOD PHOTOS

Fence at Victoria Street

Chisholm Avenue, Werrington County

## 1986 Flood Photos

View from in front of 32 Heavey Street, Werrington looking towards Werrington Creek (1986).

## FLOOD PHOTOS WITH UNKNOWN DATES

Inundation of back yard at Kingsbury Place (date not nominated)

Inundation of northern end of Kingsbury Place (date not nominated)

Upstream of Victoria Street culvert (date not nominated)

Inundation near Epping Close, Cambridge Park (date not nominated)