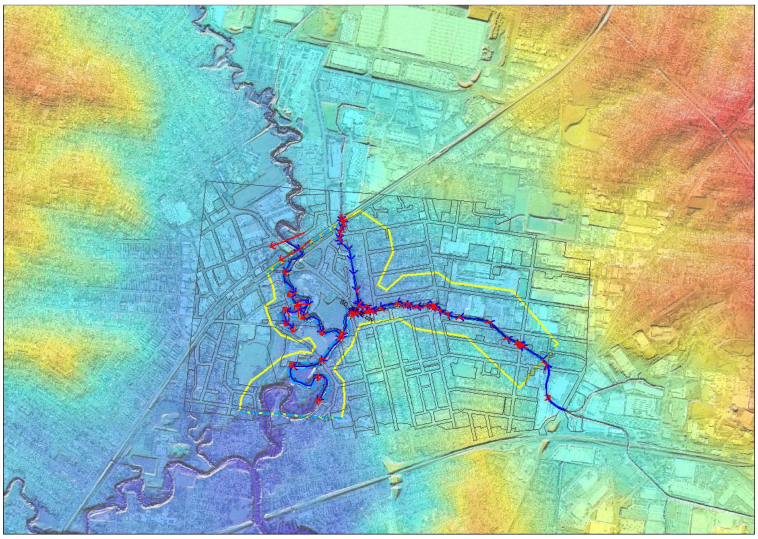
Burns Creek Flood Study



FINAL REPORT

- July 2011

In association with

Burns Creek Flood Study

FINALREPORT

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Executive Summary

Sinclair Knight Merz (SKM), in association with Fairfield Consulting Services (FCS), was engaged by Fairfield City Council (FCC) to undertake a flood study for Burns Creek that is consistent with the requirements of the NSW Government's *Floodplain Development Manual* (NSW Government, 2005) and State Government Policy. The study was also initiated in response to the January 2001 flood event, which caused significant damage within the Burns Creek catchment and the broader Fairfield Local Government Area (LGA).

Burns Creek generally flows from south-east to north-west and drains a catchment area of 13.5 km^2 into Prospect Creek. The catchment area includes parts of the local government areas of Bankstown, Fairfield and Holroyd. The greatest area of the catchment has residential land use (approximately 50%), followed by industrial land use. Open space accounts for approximately 15% of the catchment, and generally comprises a small number of larger areas.

The study area is comprised of the Burns Creek catchment downstream (west) of Woodville Road to the junction of Burns Creek and Prospect Creek (western boundary), and includes Stimsons Creek. The floodplain for this Study is considered as all land that is potentially at risk from flooding up to the Probable Maximum Flood (PMF), as defined in the Floodplain Development Manual (NSW Government, 2005). Hence all flood events up to, and including, the PMF are required to be assessed as part of this Flood Study.

Previous flooding in Burns Creek has typically coincided with flooding within the broader Prospect Creek catchment. Major flooding occurred along Prospect Creek and its tributaries in August 1986, April-May 1988 and February 2001. These floods caused serious financial losses and hardship to a large number of families and businesses in the area. The 1986 flood caused a total damage of approximately $4.8 million on Prospect Creek alone. The 1986 and 1988 floods produced strong community pressure for measures to control flooding in the area. The storm event of February 2001, which caused over-floor flooding on a number of properties in the study area, was one of the factors which prompted the commissioning of this study.

This flood study involved numerical modelling catchment hydrology and creek and floodplain hydraulics in order to determine flood behaviour. As a first step, an XP-RAFTS hydrologic model was developed of the entire Burns Creek catchment to derive flow hydrographs from the study sub-catchments for the selected flood events, including the 20, 50 and 100 year ARI and Probable Maximum Flood (PMF) events, in addition to the January 2001 calibration flood event.

A hydraulic model of Burns Creek was developed in the hydrodynamic modelling package TUFLOW, and included Stimsons Creek. The model was set up as a 1D stream network nested in a 2D domain to accurately represent the in-channel hydraulics and any two-dimensional flow

patterns on the floodplain, particularly on the lower reaches of Burns Creek where complex interaction with Prospect Creek floodwaters is expected. The model extended from just upstream of the Fairfield LGA boundary on Burns Creek (Woodville Road) and on Stimsons Creek (Granville – Fairfield Railway line) and included a section of Prospect Creek and its floodplain.

No streamflow gauging data exists for Burns Creek, hence precluding the direct calibration of the XP-RAFTS hydrologic model. Observed flood levels from the January 2001 flood event were used to undertake a joint-calibration of the XP-RAFTS and TUFLOW model.

Sensitivity analyses revealed that the TUFLOW model was not overly sensitive to changes in Manning's n values. Increasing blockage factors of the culverts at Woodville Road on Burns Creek, and Fairfield Road on Stimsons Creek, increased the 100 year ARI flood levels locally upstream of the culverts by up to 350mm.

The TUFLOW model was run for the selected design events, and flood maps prepared from the maximum envelope of flood inundation extents for the 20 and 100 year ARI and PMF events.

The TUFLOW model indicated the following flood behaviour:

- On Burns Creek, floodwaters break out of the creek upstream of Woodville Road and flow overland during events greater than and including the 20 year ARI event. In flood events up to the 100 year ARI event, flows re-enter the main channel in the vicinity of Malta Street. Roadways form the main flow path for floodplain flows, including: Tangerine Street; Mandarin Street; Montrose Avenue; and Malta Street.
- In the 100 year ARI event the floodplain is up to 300m wide on Burns Creek, just downstream of Woodville Road. The floodplain is up to 540m wide during the PMF event, in the vicinity of Malta Street.
- Flows are generally confined to the channel downstream of Malta Street, apart from minor breakouts upstream and downstream of Normanby Street. Sections of the industrial area on the north bank of the creek, between Mandarin Street and Crown Street, are affected by fringe flooding above the 20 year ARI event.
- The road bridges at Mandarin Street, Normanby Street and The Horsley Drive, are not overtopped in floods up to, and including, the 100 year ARI event. All bridges are overtopped in the PMF event.
- On Stimsons Creek, flows break out of the channel upstream of the Fairfield Street culvert in events greater than and including the 20 year ARI event, causing inundation of the area between Stimsons Creek and Prospect Creek. These overflows flow westward and drain into Prospect Creek.

- For flood events of magnitude 20 year ARI and greater, flood levels are at, or above, bankfull in the Creek downstream of Fairfield Street. Overbank flooding occurs downstream of James Street in events greater than, and including, the 100 year ARI event, due to backwater effects at the Burns Creek junction.
- During the PMF event, flow will break out of Stimsons Creek, upstream of the Granville – Fairfield railway line, due to the hydraulic obstruction caused by the railway bridge and the foot bridge immediately upstream. Flow breaking out upstream of the railway line, would be impeded from flowing southward into the study area by the railway embankment, and hence, would be forced to the west towards Prospect Creek.

Interim Flood Risk Precinct mapping has been prepared based on the TUFLOW modelling results. The mapping shows the outlines of the Interim High, Medium and Low Flood Risk Precincts, which have been delineated based on GIS analysis and interpretation of the flood outlines. The mapping has been labelled as "Interim" as they have not yet been reviewed as part of a floodplain risk management study process, and also, as evacuation planning considerations have not yet been included in the Precinct outlines.

The High Flood Risk Precinct reflects areas of excessively hazardous high flood depth or flow velocity, or a combination of both. The high flood risk areas typically occur within the Burns Creek and Stimsons Creek channels, extending onto the overbank areas in the vicinity of Malta Street and Montrose Avenue. Parts of Fairfield Street and Tangerine Street are also affected by high flood risk areas. The parking lot area surrounding the Bunning's Warehouse premises on Woodville Road, Villawood, are also high flood risk areas since these are active floodways during the 100 year ARI flood event.

The Medium and Low Flood Risk Precincts follow the same spatial extents as the 100 year ARI and PMF event flood inundation patterns, respectively.

The Interim Flood Risk Precinct Mapping indicates that an estimated:

- 133 lots are affected by the High Flood Risk Precinct
- 269 lots are affected by the Medium Flood Risk Precinct
- 615 lots are affected by the Low Flood Risk Precinct.

Note that individual lots may contain areas of High, Medium and Low Flood Risk flooding. Overall, an estimated total of 702 lots are affected by flooding up to the PMF event.

The flood risk precinct maps only represent flooding originating from mainstream flooding from Burns Creek and Stimsons Creek. They do not indicate the flood risk precincts resulting from mainstream flooding from Prospect Creek nor overland flooding from the Old Guildford local catchment (which surrounds Burns Creek). Mainstream flood extents for Prospect Creek are reported in the 2006 *Prospect Creek Floodplain Management Plan, Flood Study Review*. Overland flooding behaviour is reported in the 2010 *Old Guildford Overland Flood Study*.

Using the flood modelling results produced by this study, FCC can identify those properties in the study area affected by flooding from Burns Creek and update the Section 149 Certificates for these properties.

The findings and outcomes from this study can be used as a basis for development of management strategies in the subsequent Burns Creek Floodplain Risk Management Study.

1. Introduction

1.1. Background

Fairfield City Council (FCC) commissioned Sinclair Knight Merz (SKM) to undertake a flood study for Burns Creek that is consistent with the requirements of the NSW Government's *Floodplain Development Manual* (NSW Government, 2005) and State Government Policy. The study was also initiated in response to the January 2001 flood event, which caused significant damage within the Burns Creek catchment and the broader Fairfield Local Government Area (LGA).

The NSW Office of Environment and Heritage (OEH), formerly the Department of Environment, Climate Change and Water (DECCW), and FCC jointly funded this project. SKM would like to acknowledge the invaluable contribution of both FCC and OEH to this project. This study was jointly undertaken by SKM and Fairfield Consulting Services (FCS), a business unit of FCC.

Fairfield LGA covers an area of around 102.5km^2. Within the LGA there are typically old watercourses and tributaries that have been piped over the years. Unfortunately, most of the flow paths are in urban areas resulting in direct impacts and potential to both damage properties and be a hazard to residents.

There are two major catchments in the Fairfield LGA – the Georges River Catchment and the Hawkesbury Nepean Catchment. Each of these larger regional catchments contains sub-catchments and a variety of rivers, creeks, lakes and wetlands.

The eastern section of Fairfield City is part of the Prospect Creek sub-catchment that flows into the Georges River (which eventually flows into Botany Bay). This is the largest catchment in the Fairfield LGA, covering an area of 98km^2. The waterways in the Prospect Creek sub-catchment are a mix of natural creeks, concrete lined channels and enclosed pipe drainage systems.

1.2. Study Area

Burns Creek drains a catchment area of 13.5 km^2 into Prospect Creek. The catchment area includes parts of the local government areas of Bankstown, Fairfield and Holroyd. The greatest area of the catchment has residential land use (approximately 50%), followed by industrial land use. Open space accounts for approximately 15% of the catchment, and generally comprises a small number of larger areas.

The study area is comprised of the Burns Creek catchment downstream (west) of Woodville Road to the junction of Burns Creek and Prospect Creek (western boundary), and includes Stimsons

Creek. This makes up approximately 40% of the total catchment area of Burns Creek. The study area is shown in **Figure 1-1**.

The floodplain for this Study is considered as all land that is potentially at risk from flooding up to the Probable Maximum Flood (PMF), as defined in the Floodplain Development Manual (NSW Government, 2005). Hence all flood events up to, and including, the PMF are required to be assessed as part of this Flood Study.

The section of Burns Creek within the study area is an earthen channel between Prospect Creek (west) and Tangerine Street (east). It is moderately vegetated on its banks along most of this reach and is heavily vegetated particularly around its confluence with Stimsons Creek and also downstream of The Horsley Drive. Overbank areas within the creek corridor are typically grassed with some trees. The boundaries of adjacent residential and commercial/industrial private property are typically located at the top of bank or set back by up to 10 metres.

The creek channel meanders in the vicinity of its confluence with Stimsons Creek, and a grassed high flow bypass floodway has been constructed across this meander bend.

There are road bridges at Normanby Street and Mandarin Street, both of which are open span bridges, and an additional road bridge at The Horsley Drive, which has two rows of piers. There is a footbridge at Campbell Street in addition to a water pipe crossing in the vicinity.

A series of box culverts replace the waterway between Tangerine Street and Woodville Road. Upstream of Woodville Road, the waterway is a concrete-lined rectangular channel, which splits into several tributaries.

Stimsons Creek joins Burns Creek approximately 70m upstream of The Horsley Drive. The tributary is concrete lined between the confluence and the Fairfield Street road crossing culvert, and is an earthen channel upstream of the culvert. Residential private property extends to the top of bank of the concrete channel. The Granville – Fairfield Railway Line crosses Stimsons Creek via a six-opening brick arch bridge, upstream of Fairfield Street. A footbridge is located just upstream of the railway bridge. Both these bridges are on, or outside, the study area boundary, but have been considered in the flood modelling.

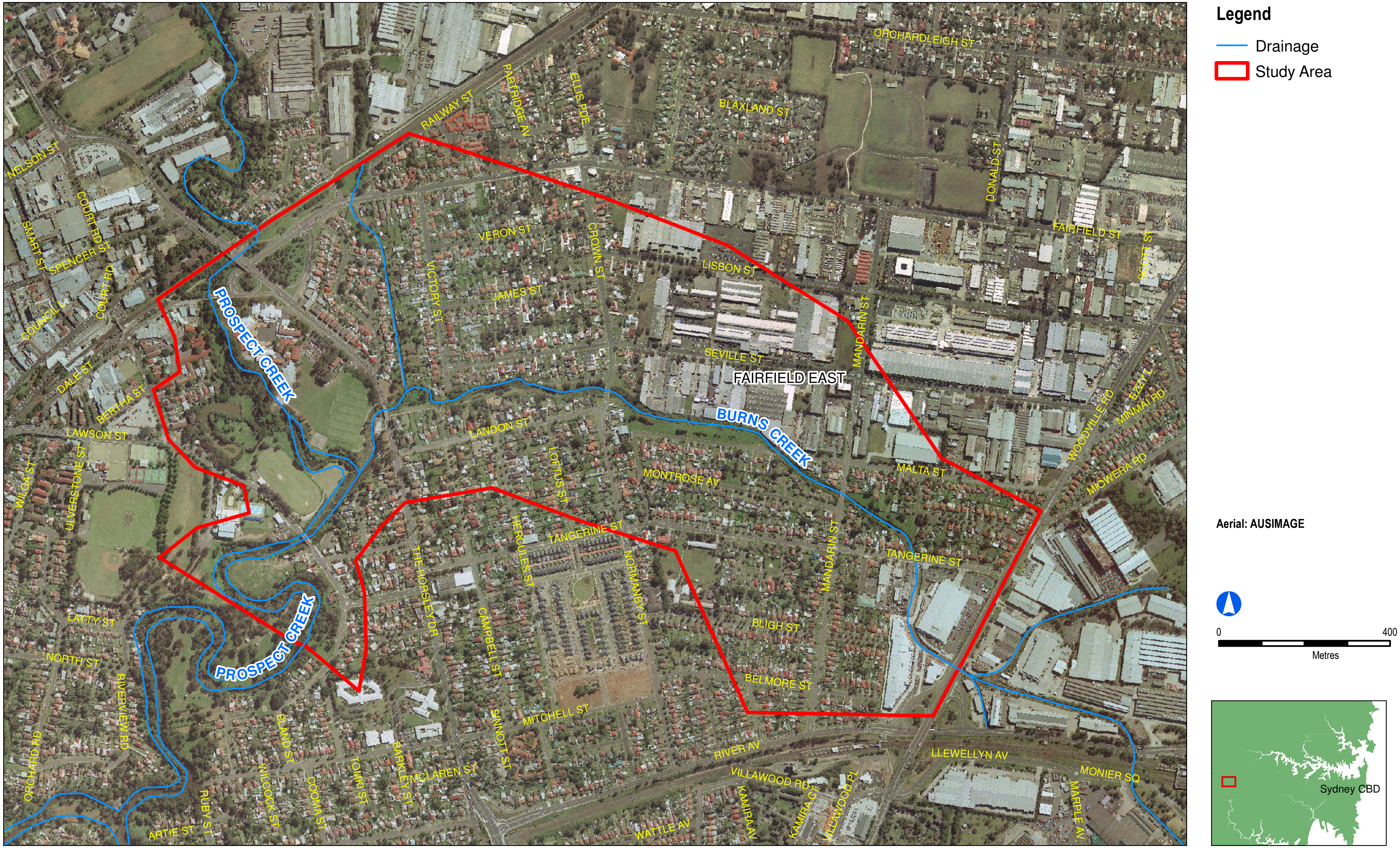

Figure 1-1 Flood Study Location Plan

Burns Creek Flood Study

v001

MGA 94 Zone 56

26 June 2008

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SKM

1.3. History of Flooding in the Catchments

Previous flooding in Burns Creek has typically coincided with flooding within the broader Prospect Creek catchment. Major flooding occurred along Prospect Creek and its tributaries in August 1986, April-May 1988 and January 2001. These floods caused serious financial losses and hardship to a large number of families and businesses in the area. The 1986 flood caused a total damage of approximately $4.8 million on Prospect Creek alone (Willing & Partners, 1990). The 1986 and 1988 floods produced strong community pressure for measures to control flooding in the area. Previous to this, the last known major flood in Fairfield was in 1956 (Willing & Partners, 1990).

The storm event of January 2001, which caused over-floor flooding on a number of properties in the study area, was one of the factors which prompted the commissioning of this study. A report on the storm event, prepared by FCC's Catchment Management Branch, is presented in **Appendix A.**

1.4. Purpose of the Study

FCC has undertaken a number of recent mainstream flood studies, including:

- Cabramatta Creek Flood Study
- Prospect Creek Flood Study
- Georges River (FCC section) Flood Study
- Orphan School Creek, Green Valley Creek and Clear Paddock Creek Flood Study.

These studies provide accurate flood levels that are invaluable for planning development on, and close to, floodplains. However, there are many other areas in Fairfield that are potentially flood prone but have not been studied or mapped, including areas in the current study area. Those areas in the study area, which have been previously assessed, were considered between 10 and 20 years ago using different modelling techniques and to varying levels of detail. Hence, the present understanding of flooding conditions in the current study area is not one that is fully integrated.

This current study, therefore, aims to determine the mainstream flooding conditions, including flood levels, flow rates and flood risk, in the study area in an integrated manner, in line with the previous studies recently undertaken for Prospect Creek, Cabramatta Creek and the Georges River. Further, this study also intends to account for any physical changes within the catchment that have occurred since the previous flood studies, which would contribute to changes in the design 100 year ARI flood levels. Subsequently, FCC intends to use the latest flood information from this study to update the Section 149 Certificates for the flood affected properties within the study area.

As per the floodplain management framework set out in the *Floodplain Development Manual 2005*, this Flood Study is part of a process that subsequently involves the undertaking of a Floodplain Risk Management Study and development of a Floodplain Risk Management Plan. The Flood Study will be used as the basis for developing a Floodplain Risk Management Study and Plan for the Flood prone land within the study area, in which the end result of the process will be the development of management measures so future flood risk can be managed, reduced or eliminated.

2. Available Data

2.1. Previous Studies

Two previous studies were relevant to the study area. They were:

- Kinhill Engineers Pty Ltd, 1991, *Burns Creek/Barrass Drain Catchment Management Study*, Water Board, South Western Stormwater Business Unit.
- Willing & Partners Pty Ltd, 1994, *Burns Creek & Villawood Drain Hydrologic, Hydraulic and Structural Assessment*, Bankstown City Council & Fairfield City Council.

The Willing & Partners study established a hydraulic (HEC-2) model of a reach of Burns Creek. The study recommended flood mitigation works to a total $3.6 million (1994 prices) in the reach within the Fairfield LGA, and to a total of $1.8 million (1994 prices) in the Commonwealth owned reach.

The recommended flood mitigation works included:

- Channalising the creek from Tangerine Street downstream to at least Malta Street
- Augmentation of the Woodville Road culverts
- Augmentation of drain downstream of Woodville Road.

Council planned at the time to implement the strategy progressively.

In 1995, due to creek improvement works from Normanby Street downstream to The Horsley Drive, and increased development within the catchment, Fairfield City Council extended the hydraulic model in order to estimate the 100 year ARI flood levels along the entire length of Burns Creek. Unfortunately, the flood levels from the extended model were not available at the time of this current study.

2.2. Topographic Survey

2.2.1. Airborne Laser Survey

Airborne Laser Survey (ALS), conducted in January 2003 was used to generate a Digital Terrain Model (DTM) for the entire Fairfield LGA. The DTM was subsequently used in a number of projects undertaken for FCC, including this current study.

The ALS data used had been filtered to reduce the density of points and to remove non-ground points such as buildings, bridges and over/underpasses. A validation process was carried out on this data at the outset of this study, by generating 0.5m contours over the area and ground-truthing 100 random points over the data area.

2.2.2. Ground Survey

Ground survey was undertaken to provide more accurate information than the ALS could provide for cross sections along the waterways. This is because the ALS is not accurate in waterway areas and in areas where there is dense vegetation.

Approximately 35 cross sections were taken along Burns Creek alone, and a further 15 cross sections on Stimsons Creek. Further ground survey was taken of all crossings including bridges, culverts and pipes with an approximate total of eight crossings throughout the model. Additional cross section survey data was obtained from the *Prospect Creek Floodplain Management Study, Flood Study Review* (Bewsher Consulting, 2006) for the modeling of sections of Prospect Creek in this study.

Site visits were undertaken by members of the study team to record observations on the characteristics of the creeks for input into the hydraulic model. The creek characteristics recorded included the presence and type of creek and bank vegetation, pools and riffles and estimation of Manning's n.

2.3. AUSIMAGE™ Aerial Photography

AUSIMAGE™ Aerial photography was used extensively in this study, mainly for data validation and presentation of results in the preparation of flood inundation and risk maps. The aerial photography that was used has been flown for FCC by SKM several times over the course of the study at two-yearly intervals, with the latest capture date in January 2009. This photography is at a resolution of 0.15m.

2.4. GIS Data

Various layers of GIS data were made available for this study from FCC, and through SKM's previous work with the Fairfield LGA. Most notably including:

- FCC digital Cadastre;
- Flow Accumulation Grids;
- Flow Accumulation Network.

2.5. Rainfall Data

Historic rainfall data was obtained from Sydney Water's Fairfield Sewage Treatment Plant (Station 567077) for use in model calibration. Design rainfall Intensity-Frequency-Duration (IFD) data was obtained from BOM by FCC specifically for hydrologic analyses and hydraulic design in the Fairfield LGA (BOM, 1987).

2.6. Historical Flood Levels

As mentioned in **Section 1**, one of the drivers for this study was the storm event of January 2001, which caused above floor flooding to properties along Burns Creek. The exact ARI of the flood event has not been ascertained, but it is estimated to have been between a 10 year and 20 year ARI flood event (FCC 2001).

Two flood complaints were received by Council following this event:

- 93 – 94 Malta Street (industrial workshop): 0.06m depth above-floor flooding
- 66 Malta Street (residential): above floor flooding (no depth reported).

It is possible that other properties in the area experienced above-floor flooding, however, no further flooding complaints were received. Site inspections by Council engineers following the flood, revealed damage to fences and backyards on adjacent properties.

High water marks were also observed and surveyed by Council engineers on the upstream and downstream sides of Mandarin Street and Normanby Street bridges. Damage to fences is illustrated in **Plate 1**.

- *Plate 1 Damage to fences and backyards on properties on Malta Street following January 2001 flood event*

3. Hydrologic Modelling

3.1. Development of the Hydrologic Model

Hydrologic modelling was required to estimate rainfall-runoff from the study catchment for the selected flood events. The aims of the hydrological modelling were to:

- Assemble a detailed catchment rainfall/runoff model for Burns Creek, based on the hydrologic model developed for Prospect Creek
- Estimate flood hydrographs for the 20, 50 and 100 year ARI and PMP design storms under existing conditions for use in subsequent hydraulic modelling, for storm durations between 30 minutes and 36 hours.

The hydrologic model of the Prospect Creek catchment for the *Prospect Creek Floodplain Management Plan, Flood Study Review* (Bewsher Consulting, 2006) (hereafter the 2006 Study) was developed using XP-RAFTS. XP-RAFTS is a non-linear rainfall-runoff flood routing model developed by XP Software. It is a well-proven model, recommended by *Australian Rainfall & Runoff* (Institute of Engineers, 2003). Hence, XP-RAFTS was used to develop a detailed hydrologic model for the study catchment.

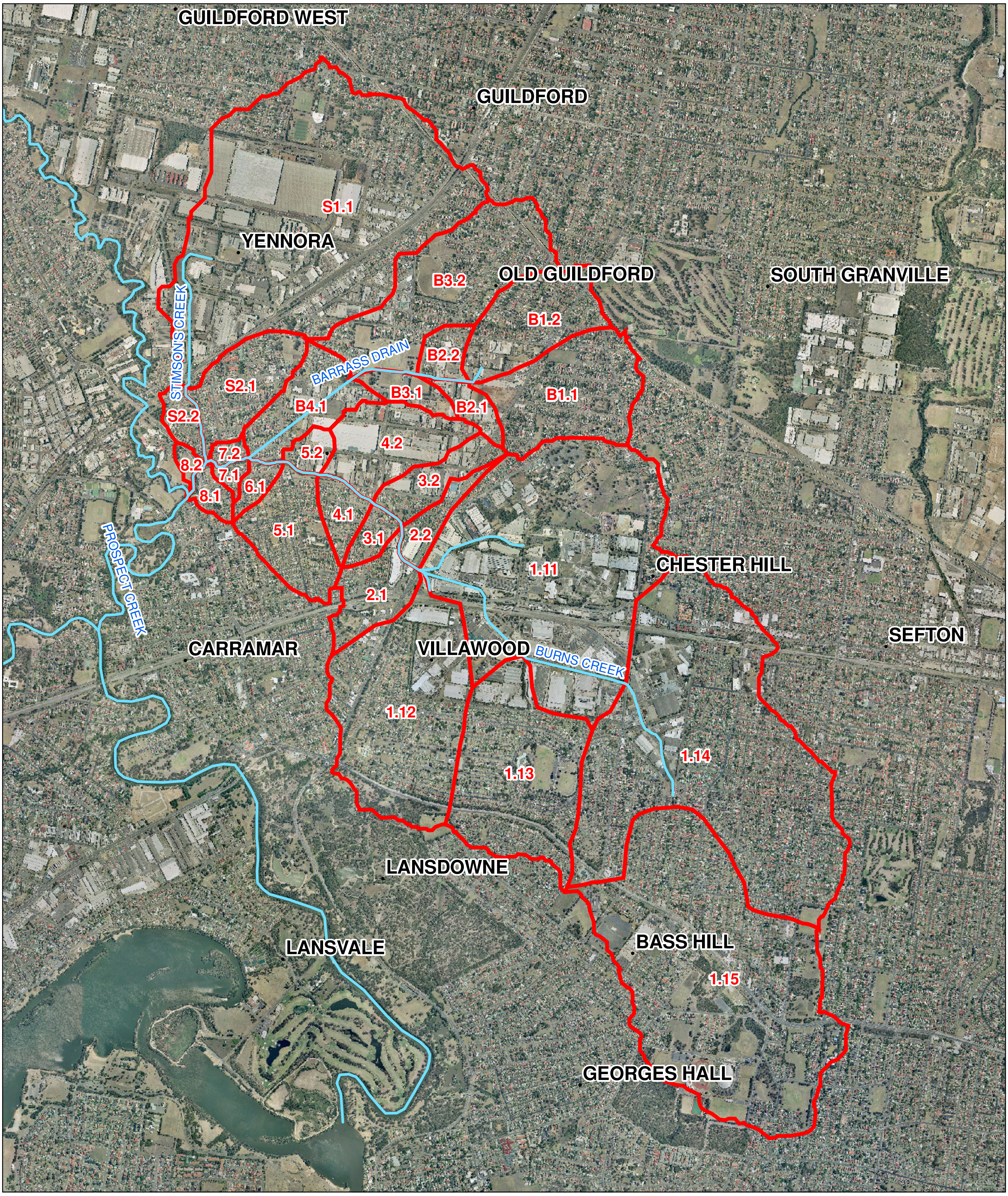
3.2. Model Configuration

3.2.1. Sub-Catchments

The Burns Creek catchment is 13.5km^2 in area. A catchment flow accumulation grid was created from the DTM in GIS. Sub-catchment boundaries and flow paths were derived based on the catchment flow patterns. Vectored slopes for each sub-catchment were derived from the DTM in GIS. The sub-catchments are shown in **Figure 3-1**. The XP-RAFTS model layout is shown diagrammatically in **Appendix B**.

3.2.2. Impervious Fractions

The impervious fraction of the XP-RAFTS sub-catchments were estimated in GIS using LEP zoning layers and nominal impervious fractions for different land uses within Fairfield and Holroyd LGA. These values are listed in **Table 3-1**. The LEP data was not available for the Burns Creek catchment area within Bankstown LGA. Aerial photos were then used to determine the pervious and impervious ratios for this area.



Legend

Sub-Catchment Boundaries

Drainage

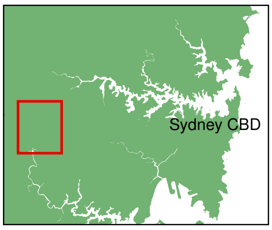


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Figure 3-1 XP-RAFTS Sub-Catchments

MGA 94 Zone 56

Burns Creek Flood Study V001

9 July 2007

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Table 3-1 Sub-catchment zoning, landuse and impervious fractions

Zoning Code	Land Use	% Impervious
2a	Residential	50
2b	Residential	50
3c	Local Business Centre	90
4a	General Industrial	90
4b	Light Industrial	90
4c	Special Industrial	90
5a	Special Use	90
5c	Sub Arterial Road	90
6a	Existing & Proposed Recreation	10

3.2.3. Vectored Slope

The vectored slope for each sub-catchment was determined in GIS from the ALS data. The range of catchment slopes is summarised below:

Table 3-2 Vectored slope ranges for sub-catchments

Vectored Slope	Number of Sub-Catchments
0.5 – 1%	4
1 – 1.5%	10
1.5 – 2%	5
2 – 2.5%	2
2.5 – 3%	6
>3%	1

3.2.4. Sub-Catchment Roughness

A uniform surface roughness (Manning's n) was adopted for the pervious (n = 0.025) and impervious (n = 0.02) portions of each sub-catchment.

3.2.5. Detention Basins

There are two detention basins in the Burns Creek catchment, Knight Park Basin (node B3.1) and Springfield Park Basin (node B3.2). Both basins were modelled using a normal spillway configuration and the stage-storage details from the updated Prospect Creek XP-RAFTS model were used after data verification.

3.2.6. Routing Method and Hydrograph Lag Times

Hydrograph routing times along the open channel in Burns Creek were automatically determined by XP-RAFTS by adopting a HEC-2 type channel, using surveyed cross section data and Manning's n of n = 0.04 for main channel flow, and n = 0.03 for overbank flow.

For other links in the model, a simple hydrograph translation was assumed with lag times of 5 – 15 minutes adopted.

3.3. Model Calibration

No streamflow gauging stations are located within Burns Creek catchment. Hence, it was not possible to calibrate the XP-RAFTS model against recorded streamflow data. The recorded rainfall data for the January 2001 event was obtained from Fairfield STP and used to estimate rainfall runoff for this event using the XP-RAFTS model. Inflow hydrographs simulated by the XP-RAFTS model were used in the hydraulic computer model to simulate peak flood levels in Burns Creek downstream of Woodville Road.

3.4. Design Input

Input data used for events between 20 year ARI and 100 year ARI are discussed in **Sections 3.4.1** to **3.4.4** below. Input data used in the XP-RAFTS model for events rarer than the 100 year ARI events are discussed in **Section 3.4.5**.

3.4.1. Rainfall Intensity- Frequency-Duration Data

The Burns Creek XP-RAFTS model used the Intensity-Frequency-Duration (IFD) data adopted by FCC. Adoption of these standard values was considered desirable for consistency with other studies that have been undertaken. The IFD data is shown in **Appendix B**.

3.4.2. Rainfall Temporal Pattern

Temporal patterns for the synthetic design storms were derived from Book II of *Australian Rainfall and Runoff* (Institution of Engineers, 2003).

3.4.3. Rainfall Loss Rates

In keeping with the basic, storm duration-independent approach taken from the updated Prospect Creek model, an initial/continuing loss rate model was adopted for Burns Creek. Loss rates adopted from the calibrated XP-RAFTS model of Prospect Creek were used in the current model and are summarised in **Table 3-3**.

- **Table 3-3 Adopted Rainfall Losses**

	Initial Loss (mm)	Continuing Loss (mm/hr)
Pervious Areas	15	1.5
Impervious Areas	1.5	0

3.4.4. Areal Reduction Factors

The Burns Creek catchment is relatively small, hence, the rainfall was applied uniformly across the catchment without applying any areal reduction factors.

3.4.5. Extreme Storm Events

Estimates of the Probable Maximum Precipitation (PMP) for the Burns Creek Catchment was derived using the procedures given in *The Estimation of Probable Maximum Precipitation in Australia: Generalised Short Duration Method* (Bureau of Meteorology, 2003). The PMP depths adopted for the various storm durations are tabulated in **Table 3-4**.

- **Table 3-4 Probable Maximum Precipitation Estimate for Burns Creek Catchment**

PMP Duration (hrs)	Adopted PMP Depth (mm)
0.25	140
0.5	210
1	320
1.5	370
2	410
3	460
6	590

3.5. Verification of Design Flow Estimates

Design inflows simulated by the XP-RAFTS model for the 100 year ARI event were verified by comparing them to the results of the ILSAX modelling completed by Willing and Partners in 1994. Whilst the catchment is not newly developed, there have been recent increases in the impervious area since the 1994 study. This leads to an expectation of an increase in the peak discharges. This was found to be the case when the discharges from the XP-RAFTS model were compared to the previous ILSAX model. The XP-RAFTS discharges generally followed the same trend for the different storm events modelled.

The peak 100 year ARI event flows from the previous ILSAX and current XP-RAFTS models are compared in **Table 3-5** at selected locations for a number of storm durations.

▪ **Table 3-5 Comparison of Peak 100 year ARI Discharges for ILSAX & XP-RAFTS models**

Event Duration	Model	Peak 100 year ARI flows (m^3/s)[1]		
		Woodville Rd[2]	Tangerine St[3]	Normanby St[4]
1 hour	ILSAX	94.6	86.9	89.2
	XP-RAFTS	86.4	87.6	93.6
1.5 hour	ILSAX	94.4	87.5	91.4
	XP-RAFTS	102.8	104.6	105.3
2 hour	ILSAX	92.4	97.7	102.8
	XP-RAFTS	105.0	107.7	113.8
3 hour	ILSAX	88.3	87.4	91.1
	XP-RAFTS	96.0	98.9	105.7

1) The flows presented in the cells in Table 3-5 are from the 1994 ILSAX model (top value) and from the current XP-RAFTS model (lower value).

2) Corresponds to ILSAX node A33 and XP-RAFTS node Dum13.

3) Corresponds to ILSAX node A36 and XP-RAFTS node Dum1.

4) Corresponds to ILSAX node A40 and XP-RAFTS node Dum4.

3.6. Peak Design Discharges

The peak discharge at each of the XP-RAFTS nodes is tabulated in **Appendix B** for each storm ARI and storm duration analysed in the model.

3.7. Model Sensitivity

The values of certain parameters in the XP-RAFTS model were varied to determine the sensitivity of the model. The relative influence of these parameters on the model results is discussed briefly in the following sections. Tabulated results are presented in **Table B-2** in **Appendix B**.

3.7.1. Initial and Continuing Losses

The initial and continuing losses were varied for the pervious and impervious portions of each sub-catchment. When pervious portion losses were varied, impervious portion losses were maintained at their design values, and vice versa. **Table 3-6** summarises the design losses adopted in the model, and the reduced and increased losses used in the sensitivity analysis.

Table 3-6 Sensitivity Analysis – Modelled Hydrologic Losses

Hydrologic Losses		Sub-catchment portion	
		Pervious	Impervious
Initial Losses	Design Reduced Increased	15mm 10mm 20mm	1.5mm 0.75mm 3mm
Continuing Losses	Design Reduced Increased	1.5mm/hr 1mm/hr 3mm/hr	0mm/hr 0mm/hr 0mm/hr

Varying the losses resulted in relatively small changes in the peak flows (0.2 – 4.9%). Furthermore, the model was only sensitive to variations in the pervious area losses, while the model did not respond to variations in the impervious area losses, with 0% change to peak flows resulting from the increased and decreased impervious area losses. This may be due to the small magnitude of the change in losses for the impervious areas – a maximum of 1.5mm increase in initial losses, with no change to continuing losses.

3.7.2. Catchment Roughness

The catchment roughness was varied by up to n = ± 0.01 in both the pervious and impervious areas of the catchment. This did not result in any change to the modelled flows, however, it is anticipated that greater variation to the catchment roughness would have some minor impact on the peak flows.

3.7.3. Detention Basin Storage Volume

The detention basin volumes at Knight Park and Springfield Park were varied during the sensitivity analysis, and it was found that the model inflows to Burns Creek from the basins were not sensitive to the variation in storage volume.

4. Hydraulic Modelling

4.1. Development of Hydraulic Model

A hydraulic model of Burns Creek was developed in the hydrodynamic modelling package TUFLOW. The TUFLOW model is a DOS-based program with a GIS based interface and is useful for simulating depth-averaged 2D (Dimensional) and 1D free surface flows. It has capability of dynamically linking 1D networks with 2D model domains and has the ability to model 1D culvert and bridge structures within the 1D and 2D domains.

The model was set up as a 1D stream network nested in a 2D domain to accurately represent the in-channel hydraulics and any two-dimensional flow patterns on the floodplain, particularly on the lower reaches of Burns Creek where complex interaction with Prospect Creek floodwaters is expected. The model was set up and run using TUFLOW version 2010-10-AA-w32.

4.2. 1D Domain Setup

The stream reaches were digitised based on the DEM and aerial photography. The stream reaches include open channel (natural profiles and concrete-lined), hydraulic structures (culverts and bridges) and associated overflows when the structures are overtopped (modelled as weirs).

The streams and tributary channels represented in the model include:

- Burns Creek downstream of Woodville Road (including a short section upstream of Woodville Road and the rectangular box culvert reach between Woodville Road and Tangerine Street)
- Stimsons Creek from 100m upstream of the Granville – Fairfield Railway line
- Prospect Creek between the Granville – Fairfield Railway line and Fairfield Park, downstream of Gordon Street, Fairfield.

The in-channel geometry was defined using survey data collected by Fairfield City Council staff in August 2005. The survey data included channel cross section transects, and levels and dimensions of hydraulic structures. The modelling of hydraulic structures is discussed further in **Section4.5**.

Figure 4-1 shows the model stream reaches and the model cross section locations. Also shown is the 2D model domain boundary, refer to **Section 4.3**. In general, the cross sections inside the 2D domain are confined to inside the creek channel as the overbank terrain is defined by the 2D cells. Outside the 2D domain, the cross sections define both the in-channel and floodplain geometry. A bypass channel on Burns Creek, located between Normanby Street and The Horsley Drive, is also included in the 1D model domain. The water mains pipe, which crosses the creek just upstream of The Horsley Drive, was omitted due to computation stability issues, and was accounted for by increasing the channel roughness.

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Figure 4-1 TUFLOW Model 1D and 2D Elements

Burns Creek Flood Study

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4.3. 2D Domain Setup

The 2D domain was set up to represent flow patterns and flood storage in the floodplain. The 2D domain consists of a grid of cells with a five (5) metre spacing, which contain elevation and roughness data. The grid size was selected to allow the features of the floodplain to be represented with sufficient accuracy. The grid size of 5m is considered to allow adequate representation of structures, floodplain topography and overland flow paths, including roads. The grid size is consistent with, and finer than, that of other mainstream flood studies in Fairfield LGA, including Orphan School Creek (10m) and Prospect Creek (20m).

The extent of the 2D domain is shown in **Figure 4-1**. In general, the 2D domain encompasses the Burns Creek and Prospect Creek floodplain below the PMF level, with the following boundaries:

- Upstream boundary: Granville – Fairfield Railway line (Prospect Creek and Stimsons Creek branches) and downstream of Woodville Road (Burns Creek branch)
- Downstream boundary: a location approximately 400m upstream of the Prospect Creek/Georges River confluence.

The grid was aligned with the general direction of flow of Burns Creek.

The detention basins in the study area (Knight Park and Springfield Park) are located off-line from the creek channels. The TUFLOW model considers mainstream flooding only, and hence the detention basins were not represented in the TUFLOW model. The effects of the detention basins in attenuating storm event flows were accounted for in the XP-RAFTS hydrologic model, refer to **Section 3.2.5**.

4.4. Model Hydraulic Roughness

4.4.1. 1D domain

The roughness of the 1D model reaches was estimated based on knowledge of the channel type and observations of in-channel condition. Typical values used are summarised in **Table 4-1**.

- **Table 4-1 Reach roughness,1D model reaches**

Channel	Manning's n	Description
Concrete-line open channel, concrete culverts	0.013	Concrete channels on Stimsons Creek and Burns Creek upstream of Woodville Road. Concrete culvert on Burns Creek between Woodville Road and Tangerine Street
Vegetated open channel – Burns Creek	0.06 – 0.1	Typically straight reaches, very little flow during dry periods, moderately to heavily vegetated channel banks and bed.
Vegetated open channel – Prospect Creek	0.04 – 0.1	Channel form varies from straight reaches to sharp meanders, extended stretches of open water, moderately to heavily vegetated channel banks.

Note that on meandering reaches of Prospect Creek, the Manning's n was increased by up to 0.02, to account for bend losses. The roughness of reaches on Prospect Creek where a road bridge was omitted from the model (due to unavailability of survey data), were also increased to n = 0.1 to account for bridge losses.

On some reaches of the concrete channel upstream of Woodville Road, a Manning's n of 0.025 was required to achieve model stability. Although some increases in modelled flood levels were expected, the change was considered necessary to achieve a valid result.

4.4.2. 2D Domain

The 2D model cells were assigned roughness values, based on land use in the study area. A catchment materials plan was derived based on cadastral and LEP data in GIS, and aerial photography. The catchment materials plan is displayed in **Figure 4-2**.

The cell roughness was assigned by reading the catchment materials data into the model and by making reference to the following roughness values (refer **Table 4-2**).

- **Table 4-2 Catchment Materials and Roughness Values, 2D domain**

Landuse / Catchment Material	Manning's n
Roads and Carparks	0.02
Commercial/Industrial/High Density Residential	0.20
Open Space, with Trees	0.05
Open Space, Grassed only	0.035
Railway Corridor	0.04
Residential	0.15
Prospect Creek Floodway	0.03

The Manning's n values were assigned at a block-scale, and are typically representative of the average roughness across each block and account for on-lot obstructions to flow, such as, buildings, miscellaneous structures and fences (note that buildings were not explicitly represented in the model as obstructions). This approach was considered to be appropriate for this catchment-scale study. The model results were reviewed to verify that the adoption of surface roughness in this manner satisfactorily represented the general flooding behaviour throughout the model domain.

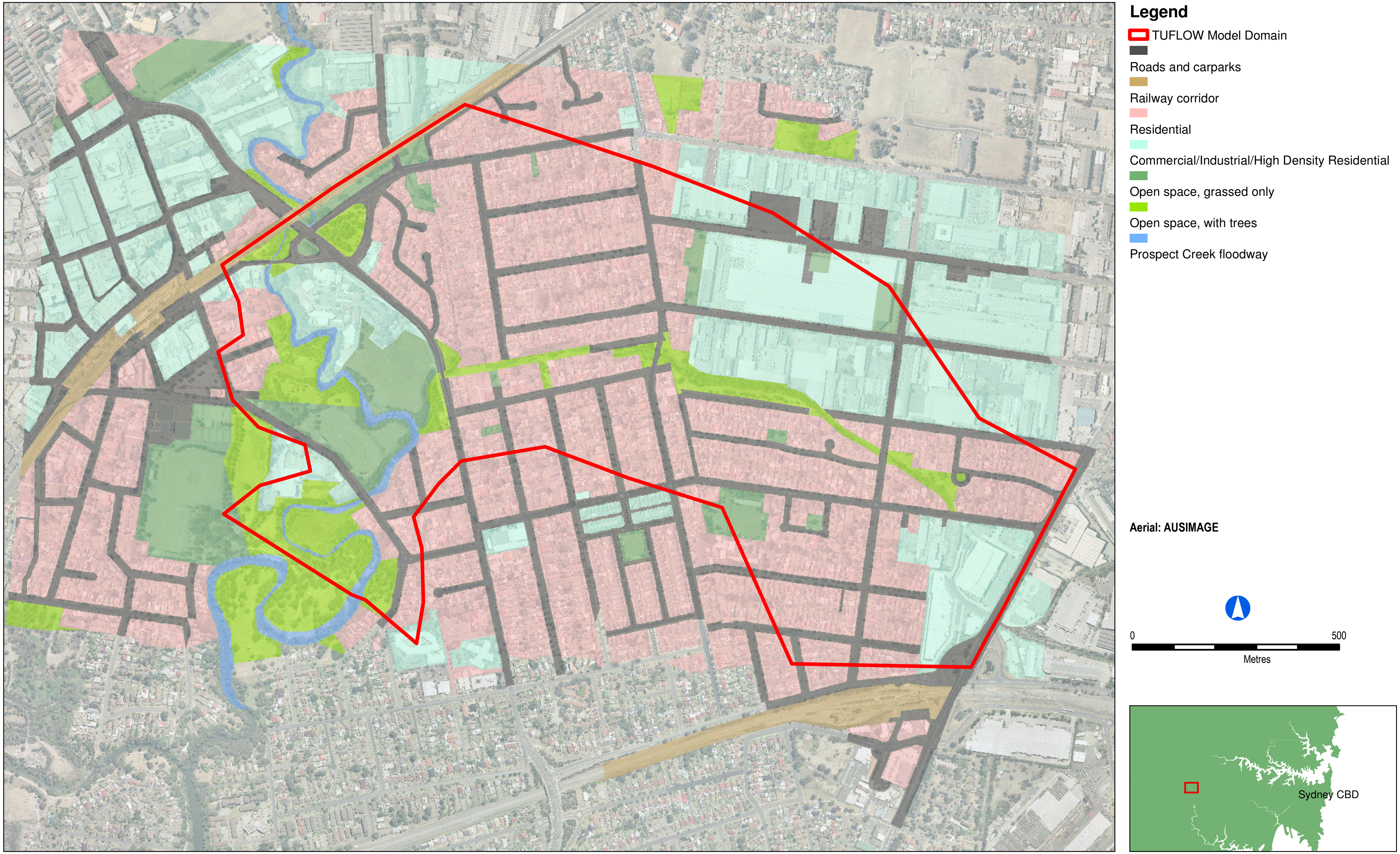

Figure 4-2 TUFLOW Model Catchment Materials

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4.5. Hydraulic Structures

4.5.1. Bridges and Culverts

Survey data for bridges and culverts was collected mainly during the channel cross section survey during August 2005. Data on the invert and obvert levels, pier widths, footpath levels and railing heights was collected for the upstream and downstream ends of each structure and input into the model.

Bridges and culverts were typically modelled as a 1D reach object with a parallel 1D weir object representing the overflow path over the bridge deck during high flows. The weir geometry was defined as either a simple weir (weir level and length only) or with a cross section derived from the DEM.

Hand railings on the road and foot bridges were assumed to be fully blocked if the spacing between bars was less than 150mm. Other hand railings with greater than 150mm bar spacing were assumed unblocked, refer to **Plate 2** below.

- *Plate 2 Bridge railing examples: Campbell Street footbridge (left) modelled as an unblocked railing. Mandarin Street (right) modelled as a blocked railing*

Note that survey data could not be collected for the buried culvert located between Woodville Road and Tangerine Street due to access issues. This culvert was installed along the old open creek channel underneath an overland floodway within the carpark area when the site was redeveloped as the current Bunning's Warehouse site. It was assumed that the buried culvert has the same dimensions as the inlet at the upstream side of Woodville Road. The long, grated surcharge pit in the car park was omitted from the model, as the predicted flow conditions in the culvert are not likely to cause the pit to surcharge.

4.5.2. Fences on the Floodplain

A number of house fences located in the lower sections of the floodplain were included in the model using elevated levee lines in the 2D domain to raise the cell elevation. The fences running along the creek corridor are typically "Colorbond"-type steel fencing or wooden paling fencing up to 1.6m high. Fences were assumed to be impermeable. Fences, which experienced significant head difference across the fence (approximately 0.5m differential was adopted), were assumed to collapse during a flood event, and hence, were not represented.

A cyclone-type fence, located along the footpath on the upstream side of Woodville Road, extends for some distance upstream along Burns Creek from the culvert entrance. The overflow from the channel is modelled as a 1D weir defined by a cross section, with the section of the fence facing upstream being represented in the cross section as a "wedge", to simulate a higher blockage at the bottom with decreasing blockage with height. This type of fence is likely to experience significant blockage due to debris in the flood flow. Blockage of the fence facing laterally to the flow was represented using high roughness in the weir cross section (n = 0.1).

4.6. Boundary Conditions

4.6.1. Inflow Hydrographs and Concurrent Events

A stage hydrograph boundary condition was applied to both the upstream and downstream ends of the Prospect Creek branch. The stage hydrographs were taken from the 1D results of the TUFLOW model for Prospect Creek, derived as part of the 2006 Study. Stage hydrograph boundaries were used in this current study in preference to discharge hydrograph boundaries as they could more readily replicate the water levels simulated in the Prospect Creek Flood Study. The concurrent flood events, adopted for the Prospect Creek boundary stage hydrographs for each Burns Creek flood event, are summarised in **Table 4-3**.

Table 4-3 Adopted Prospect Creek Boundary Flood Event ARI's

Burns Creek flood ARI	Prospect Creek boundary flood ARI
20 year	20 year
50 year	50 year
100 year	100 year
PMF	100 year
2001 event*	2001 event

* Model calibration event

The adopted combinations of events were selected in consultation with Council in order to represent the peak backwater flooding from Prospect Creek within the lower section of Burns Creek for the 20 to 100 year ARI events. The 100 year ARI Prospect Creek event was adopted for the Burns Creek PMF run, as coincident PMF events was considered overly conservative.

The Prospect Creek and Burns Creek inflows have been configured such that the flood peaks at the junction do not coincide. It is assumed that the flood event starts at the same time in each catchment, with Prospect Creek taking a longer time to peak than Burns Creek due to the relative sizes of the catchments. Hence, the backwater flooding impacts on Burns Creek flows are not overly conservative. This approach is consistent with that adopted for Orphan School Creek (SKM, 2007).

Flow hydrographs were used for the upstream boundary conditions for the Burns Creek and Stimsons Creek branches. Refer to **Section 4.6.2** for further detail.

4.6.2. Location of Inflows

Inflow locations into the model were determined based on the sub-catchment delineation used for the hydrologic modelling. Depending on the catchment configuration, the inflow hydrographs were input into the model as a point inflow or a uniform lateral inflow. All inflows were input into the 1D model nodes. The inflow hydrographs were derived from the XP-RAFTS model, described in **Section 3**, for the entire Burns Creek catchment. Inflow locations are shown in **Figure 4-3**. Point inflows are shown as stars, and uniform lateral inflows as shaded polygons.

4.7. Model Calibration and Verification

4.7.1. Calibration against 2001 Flood Event

The TUFLOW model was calibrated to observed high water marks from the 2001 flood event, which is considered a minor flood event. In this event, floodwaters did break the Creek's banks, particularly in the area between Mandarin Street and Normanby Street.

Six high water marks were recorded in this area by Council staff during the 2001 flood event. These observed peak water levels are presented and compared to modelled peak water levels in **Table 4-4**. The flood profile and recorded high water marks are plotted on **Figure 4-4**.

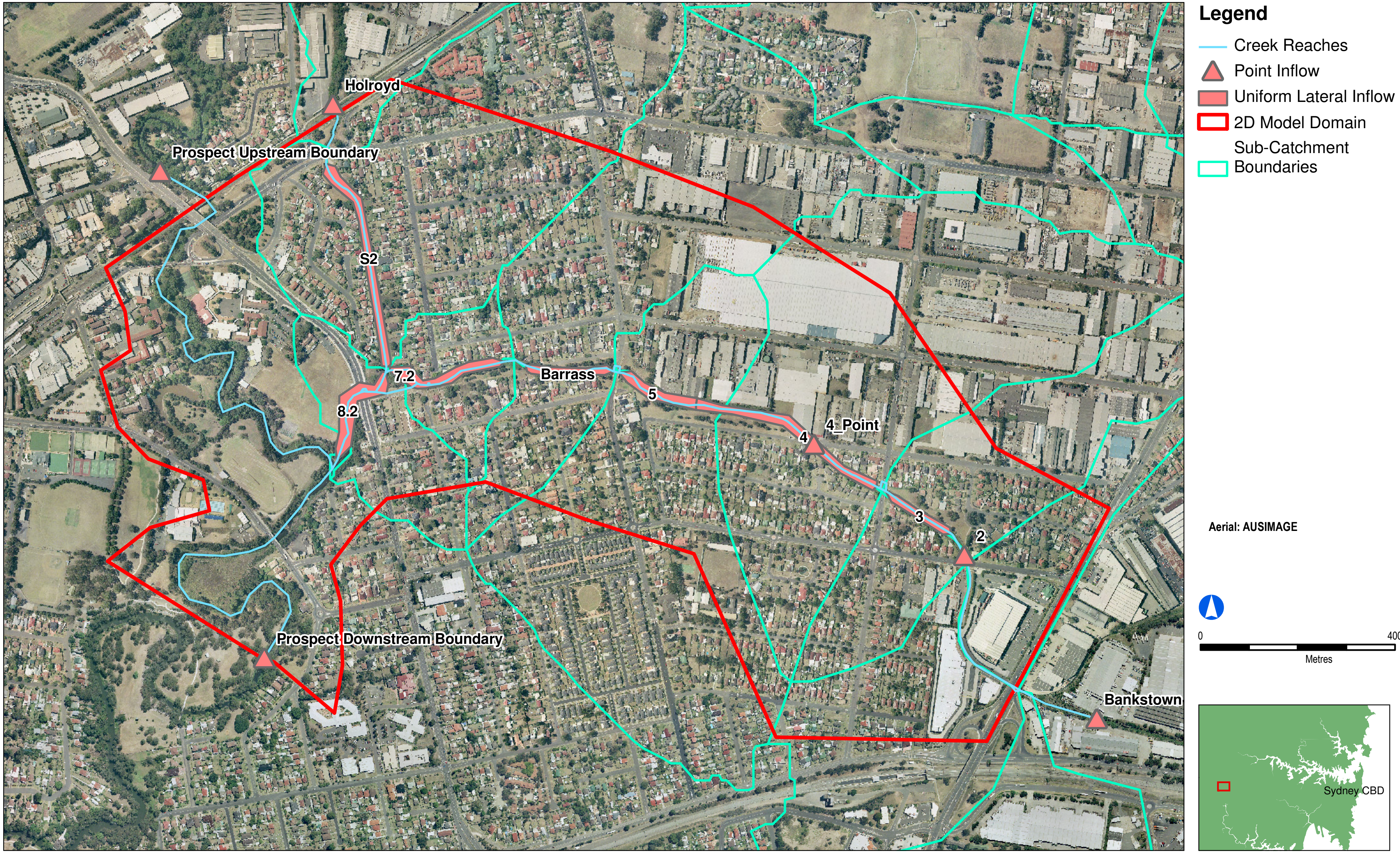

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Figure 4-3 Inflow Points and Boundaries

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Burns Creek Flood Study

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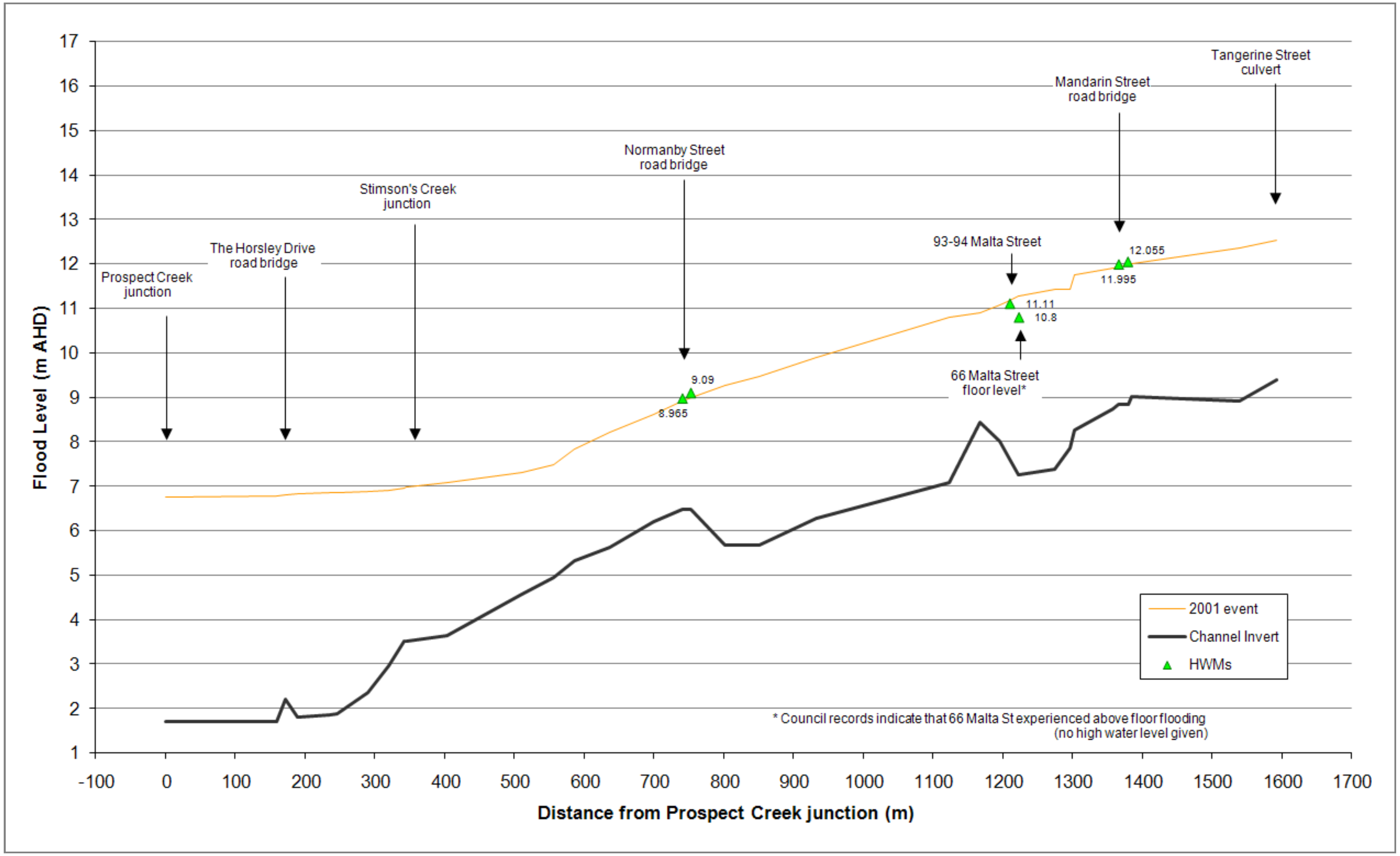
■ **Figure 4-4 January 31st 2001 Flood Event – Flood Profile**



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- **Table 4-4 Observed and Modelled High Water Levels for the 2001 flood event**

Location	High Water Level (m AHD)		Comment
	Observed	Modelled	
Mandarin Street bridge – upstream face	12.06	11.98	
Mandarin Street bridge – downstream face	12.00	11.94	
93 – 94 Malta Street	11.11	11.01-11.10	0.06m flood depth observed inside industrial workshop
66 Malta Street	> 10.80	11.20-11.22	Reported as "flooded above floor". Floor level 10.8m AHD
Normanby Street bridge – upstream face	9.09	9.00	
Normanby Street bridge – downstream face	8.97	8.92	

The modelled water levels in **Table 4-4** are generally within 100mm of the recorded high water levels, indicating a satisfactory model calibration. Discussion of the model calibration is provided below:

- Inflows into the TUFLOW model were derived from XP-RAFTS modelling of the Burns Creek catchment, undertaken by FCS. In the absence of stream gauging data on Burns Creek, the XP-RAFTS model could not be calibrated to the 2001 event. To achieve a better fit in the TUFLOW model calibration, the input inflow hydrographs were increased by 10%.
- The inclusion of impermeable fences along Burns Creek was found to significantly improve the calibration results. Omission of the fences resulted in flood levels 200 – 300mm lower than when included.
- Calibration to the high water marks at Normanby Street and Malta Street was readily achieved with Manning's n values of 0.08 – 0.10 for the in-channel roughness of Burns Creek downstream of Malta Street. These values reasonably reflect the irregular nature of the channel, including the influence of thick vegetation and obstructions in some sections,
- Manning's n values of up to 0.12 were used between Malta Street and Mandarin Street to achieve a good calibration. This is acceptable due to the increased irregularity of the creek channel in this reach.
- The Prospect Creek reach of the current model was validated using the results from the 2006 Study. Similar peak flood levels and stage hydrographs were achieved by adjusting the model parameters for the modelled sections of Prospect Creek.

4.7.2. Verification of Prospect Creek Flood Levels for the 2001 Flood Event

Prospect Creek flood levels from the current model were compared to those from the 2006 Study for consistency. The stage hydrographs at the Burns Creek – Prospect Creek confluence, in addition to locations upstream and downstream of the confluence, were compared for the 2001 calibration flood event in Prospect Creek to ensure that the tailwater levels for the Burns Creek system were consistent with the previous study. Manning's n values were adjusted accordingly and within acceptable limits to achieve comparable flood levels along the Prospect Creek reach. Bend losses at meanders were also taken into account.

4.7.3. Other Historic Flood Events

In addition to the January 2001 flood event, two other relatively recent flood events occurred in August 1986 and April/May 1988. However, no streamflow data is available for these events. In addition, a number of changes in the floodplain have occurred following these two events, including the construction of detention basins at Knights Park and Springfield Park and changes in landuse, which would have added further uncertainty to the hydrologic modelling of these events. Therefore, these flood events were considered unsuitable for model calibration.

5. Flood Modelling Results

5.1. Design Events

The calibrated Burns Creek TUFLOW model was run for the 20, 50 and 100 year ARI and PMF events for a range of storm durations, including the 0.5, 1, 1.5, 2 and 3 hour storms. The 2 hour storm was identified as being the critical storm and produces peak flood levels along the majority of the Creek. Tabulated hydraulic model results are presented in **Appendix C**.

Peak flood levels in the extreme downstream reaches of Burns Creek, are influenced by backwater flooding from Prospect Creek. The critical storm at the Burns Creek/Prospect Creek confluence is the 12 hour storm. Hence, the 12 hour storm in Burns Creek was also run for the 20, 50 and 100 year ARI events, to estimate the peak flood levels in the downstream reaches of Burns Creek.

Flood inundation maps for the 20 and 100 year ARI and PMF events are shown on **Figure 5-1**. Flood depth mapping and flow velocity mapping is presented for the 100 year ARI event on **Figure C-1**and **Figure C-2**, respectively, in **Appendix C**.

Note that the downstream parts of the Burns Creek floodplain, west of Crown Street, are impacted by flooding from Prospect Creek. Hence, the flood extents shown on the map have been adjusted to ensure consistency with the outcomes of the *Prospect Creek Floodplain Management Plan, Flood Study Review* (Bewsher Consulting, 2006).

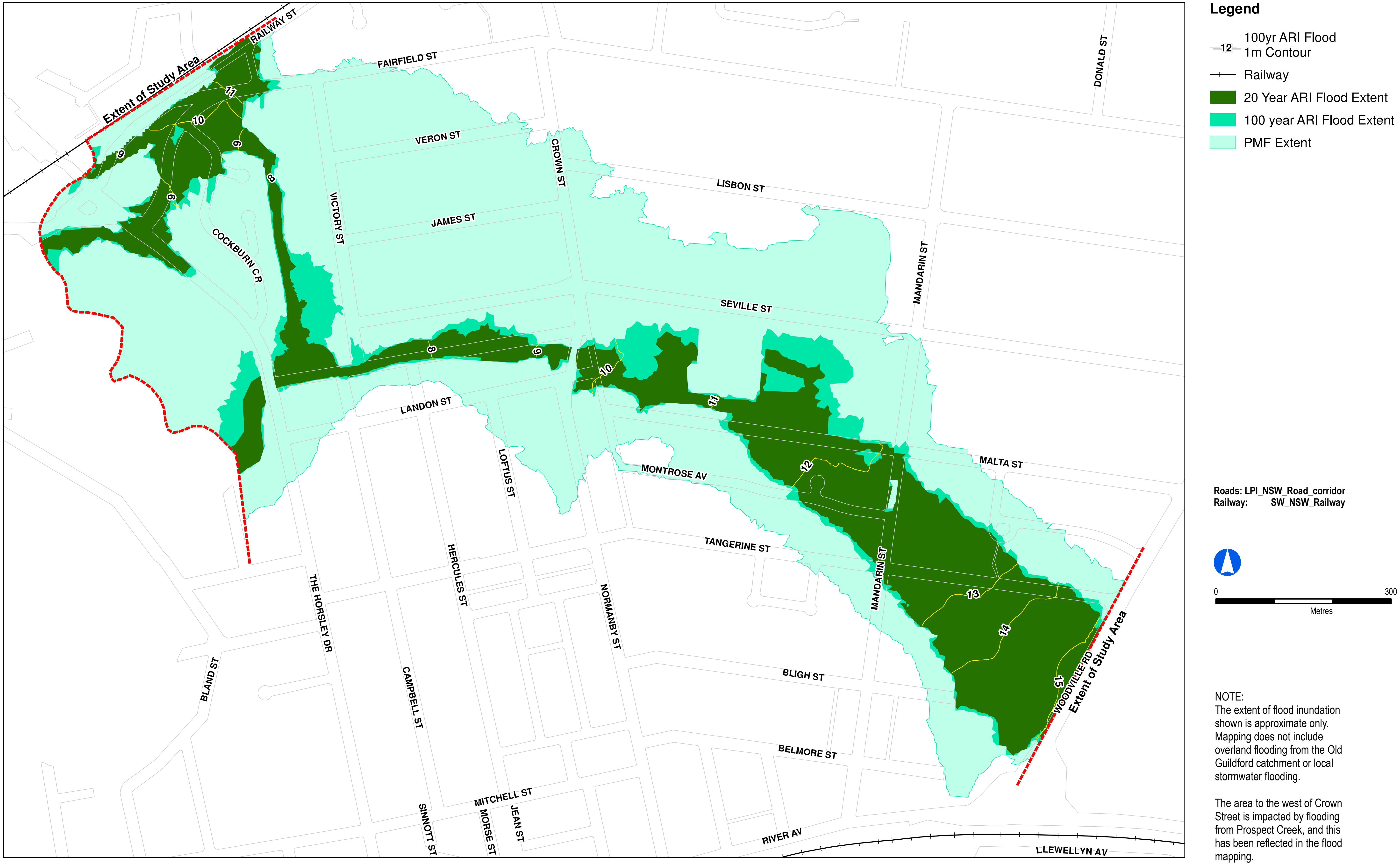
5.2. Discussion of Design Flood Behaviour

5.2.1. Events up to 100 year ARI

Burns Creek Main Branch

For flood events of magnitude 20 year ARI and greater, floodwaters break out of the creek upstream of Woodville Road. Note that as the sag in the road is not aligned with Burns Creek, the inundated section of Woodville Road extends a considerable distance north of the Burns Creek culvert (up to 200m in the 100 year ARI event).

The majority of flows pass around the western side of Woodville Road, between Tangerine Street and Bligh Street (to the north of Bunnings Warehouse) with some flow conveyed in the accessway in the carpark to the south. Downstream of Woodville Road, flows in the floodplain generally follow the direction of the main channel. In flood events up to the 100 year ARI event, flows re-enter the main channel in the vicinity of Malta Street.



NOTE:
The extent of flood inundation shown is approximate only. Mapping does not include overland flooding from the Old Guildford catchment or local stormwater flooding.

The area to the west of Crown Street is impacted by flooding from Prospect Creek, and this has been reflected in the flood mapping.

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Figure 5-1 Flood Inundation Map

Burns Creek Flood Study

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Roadways form the main flow path for floodplain flows, including: Tangerine Street; Mandarin Street; Montrose Avenue; and Malta Street. Flows are generally confined to the channel downstream of Malta Street, apart from minor breakouts upstream and downstream of Normanby Street. Sections of the industrial area on the north bank of the creek, between Mandarin Street and Crown Street, are affected by fringe flooding above the 20 year ARI event.

The road bridges at Mandarin Street, Normanby Street and The Horsley Drive, are not overtopped in floods up to, and including, the 100 year ARI event. **Figure 5-2** indicates that The Horsley Drive bridge and road embankment do not significantly impact on the water surface profile for flood events up to, and including, the 100 year ARI event.

Stimsons Creek

For flood events of magnitude 20 year ARI and greater, flow breaks out of the channel upstream of the Fairfield Street culvert causing inundation of:

- Fairfield Street between Stimsons Creek and The Horsley Drive;
- A section of The Horsley Drive;
- A number of properties along Cockburn Crescent; and
- The eastern link road of the Fairfield Street interchange.

For flood events of magnitude 20 year ARI and greater, flood levels are at, or above, bankfull in the Creek downstream of Fairfield Street. Overbank flooding occurs downstream of James Street in events greater than, and including, the 100 year ARI event, due to backwater effects at the Burns Creek junction.

5.2.2. PMF Event

Burns Creek Main Branch

For the PMF event, flow breaks out at Woodville Road and flows on the floodplain roughly parallel to the main channel, re-entering near the Stimsons Creek junction. Some flows on the right bank enter Stimsons Creek via Victory Street. Several roadways act as flow paths including: Tangerine Street; Mandarin Street; Montrose Avenue; Malta Street; Seville Street; Normanby Street; Hanson Street; Langdon Street; and Victory Street.

The bridges at Mandarin Street and Normanby Street are overtopped in the PMF, with flows breaking out upstream of each bridge. **Figure 5-2** indicates the impact on the PMF water surface profile caused by the two bridges. The impact on the flood profile of the Normanby Street bridge, in particular, appears to be quite considerable, a situation exacerbated by the irregularity of the channel bed in this area.

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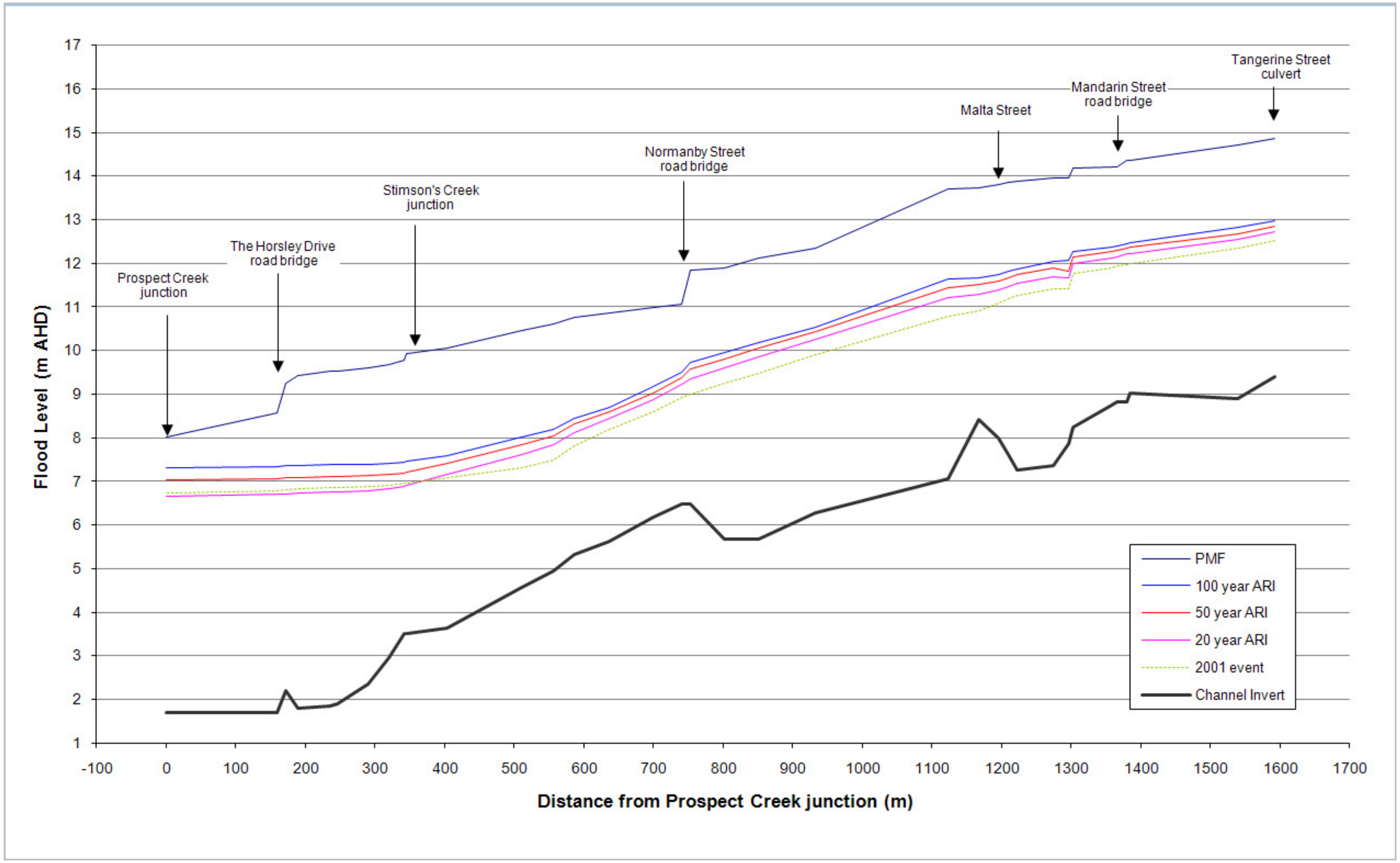
■ Figure 5-2 Comparison of peak water surface profiles – design floods and 2001 flood event



During the PMF event, significant head loss (approximately 1.5m) occurs in the reach between The Horsley Drive and Victory Street, due to the flow constriction at the road bridge, as well as, the channel meander in this reach. The Horsley Drive road bridge (deck level 8.6m AHD) is expected to be overtopped in the PMF event (flood level 9.3m AHD).

Stimsons Creek

The modelling indicates that flow will break out upstream of Fairfield Street and flow west and south-west towards Prospect Creek along Fairfield Street, Cockburn Crescent, Banksia Avenue and The Horsley Drive. Other breakouts will flow east along Fairfield Street and then south along Victory Street.

During extreme flood events, flow will break out of Stimsons Creek, upstream of the Granville – Fairfield railway line, due to the hydraulic obstruction caused by the railway bridge and the foot bridge immediately upstream. Flow breaking out upstream of the railway line, would be impeded from flowing southward into the study area by the railway embankment, and hence, would be forced to the west towards Prospect Creek (not shown on the flood mapping).

5.2.3. Comparison to 2001 Flood Event

Peak flood levels for the design events were plotted along with the results from the 2001 event, and are shown in **Figure 5-2**. The plot shows that, for the majority of Burns Creek, the 2001 flood profile was below the 20 year ARI flood profile, confirming Council's initial estimates of the 2001 flood event being between a 10 and 20 year ARI flood event (FCC, 2001). This estimate is valid for the reach of Burns Creek upstream of the Stimsons Creek junction.

In the reach of Burns Creek downstream of Stimsons Creek, the 2001 event flood profile converges towards the 50 year ARI flood profile. In this area, flood behaviour is dominated by the Prospect Creek tailwater level. Comparison to the previous modelled water levels at the Burns Creek/Prospect Creek confluence (from the 2006 Study), indicated that the 2001 flood levels were between the 20 and 50 year ARI flood levels in this area.

It was therefore concluded, that the 2001 flood event was below a 20 year ARI event in the reach upstream of Stimsons Creek due to local flooding, and between a 20 and 50 year ARI flood event downstream of Stimsons Creek, due to backwater effects from Prospect Creek.

5.3. Validation of Design Results

Results from the previous flood study undertaken in 1994 were plotted against the peak 100 year ARI model flood profile from the current study in **Figure 5-3**. It should be noted that the 1994 study extends upstream of Normanby Street and does not fully overlap with the current study area. Comparison is made with the 1994 study, as it utilised the design flows estimated during the 1991 Water Board study.

Comparison of the two plots indicates that the current 100 year ARI flood level estimates are up to 0.8m higher than the 1994 estimates. This is attributed primarily to the in-channel roughness adopted by each study. The 1994 study adopted a value of n = 0.02 for the natural channel between Tangerine Street and Normanby Street, compared to typical adopted roughness values of n = 0.07 – 0.10 for the same reach in the current model. The adopted Manning's n in the current study is considered more appropriate considering the denseness of the in-channel vegetation and the irregularity of the channel bed.

It also appears that the peak 100 year ARI inflows were approximately 8% lower in the previous study (95m^3/s immediately upstream of Woodville Road in the 1994 study, compared to 103m^3/s in the current study). This may be due to the hydrologic model in the 1994 study accounting for the storage effects at the railway embankment upstream of Llewellyn Avenue, Villawood (approximately 600m upstream of Woodville Road).

The inclusion of this flood storage was initially considered in this study, however, since there is no streamflow gauge in the Burns Creek catchment, it was not possible to calibrate the hydrologic model. Hence, there is uncertainty in the flow estimates and performance of this detention storage. It was therefore decided to adopt the conservative flow estimates (without detention at Llewellyn Avenue) in the TUFLOW model, which provided a reasonable fit to the observed flood levels in the February 2001 calibration event. Note that the calibrated flood levels are slightly lower than the observed flood levels (refer to **Table 4-4**), suggesting that if a reduced flow rate, incorporating Llewellyn Avenue flood storage were to be used, then this would produce a lower quality calibration outcome.

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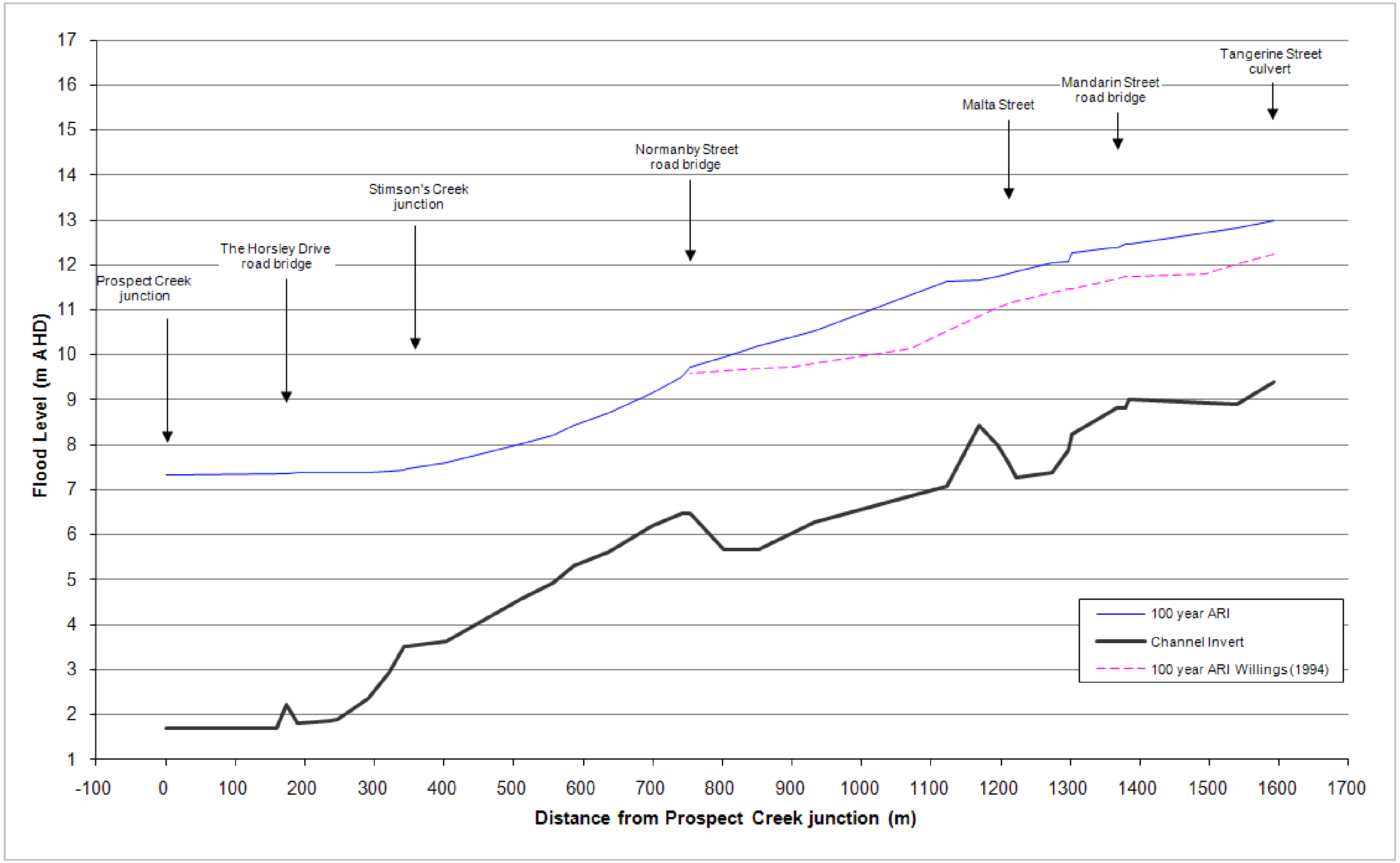
▪ **Figure 5-3 Comparison of previous and current 100 year ARI flood level estimates**



5.4. Flood Risk Precincts

Interim Flood Risk Precinct mapping has been prepared for the Burns Creek study area. This mapping is based on GIS analysis of the 100 year and PMF peak depth and velocity grids. The GIS analysis is based on the FCC Flood Risk Precinct categories described in **Table 5-1**.

- **Table 5-1 FCC Flood Risk Precincts (Fairfield City Wide DCP, 2006)**

Risk Precinct	Description
High	The area of land below the 100 year ARI flood outline that is subject to high hydraulic hazard (for preparation of the draft flood risk precincts, this has been taken as the provisional 'High Hazard' zone Figure L2 of Appendix L in the NSW Floodplain Development Manual (2005))
Medium	Land below the 100 year ARI flood outline that is not in the High Risk Flood Precinct
Low	All other land within the floodplain (i.e. within the extent of the PMF) but not identified within either the High Risk or Medium Risk Precincts.

The interim Flood Risk Precinct Map is included in **Appendix D**. The map shows the precinct outlines, which have been drawn based on GIS analysis and interpretation of the flood outlines. This has included some smoothing of the flood extent to account for local irregularities in the modelled ground surface, and street and property outlines. The map has been labelled as "Interim" as the Precincts have not yet been reviewed as part of a floodplain risk management study process, and also, as evacuation planning considerations have not yet been included in the Precinct outlines.

The flood risk precinct mapping has also been adjusted to achieve consistency with risk precincts delineated for the broader Prospect Creek floodplain, as presented in the *Prospect Creek Floodplain Risk Management Study – Flood Study Review*(Bewsher Consulting, 2006).

The High Flood Risk Precinct reflects areas of excessively hazardous high flood depth or flow velocity, or a combination of both. The high flood risk areas typically occur within the Burns Creek and Stimsons Creek channels, extending onto the overbank areas in the vicinity of Malta Street and Montrose Avenue. Parts of Fairfield Street and Tangerine Street are also affected by high flood risk areas. The parking lot area surrounding the Bunning's Warehouse premises on Woodville Road, Villawood, are also high flood risk areas since these are active floodways during the 100 year ARI flood event.

The Medium and Low Flood Risk Precincts follow the same spatial extents as the 100 year ARI and PMF event flood inundation patterns, respectively.

The Interim Flood Risk Precinct Mapping indicates that an estimated:

- 133 lots are affected by the High Flood Risk Precinct
- 269 lots are affected by the Medium Flood Risk Precinct
- 615 lots are affected by the Low Flood Risk Precinct.

Note that individual lots may contain areas of High, Medium and Low Flood Risk flooding. Overall, a total of 702 lots are affected by flooding up to the PMF event.

5.5. Sensitivity Analysis

The sensitivity of the model was tested by altering two input variables, as agreed with FCC, to gain an understanding of the effect of varying the Manning's n values:

- The Manning's n roughness in the 2D domain. The assumed roughness of the different materials was varied, separately; and
- Removing the z-lines, which were used to model fences along certain watercourse reaches.

The analysis was done for information only, and was not undertaken to inform the selection of the adopted Manning's n values. A total of eight (8) sensitivity scenarios were considered, with a summary of each scenario listed in **Table 5-2**. The changes in 100 year ARI peak flood levels along Burns Creek, between Woodville Road and The Horsley Drive, are plotted in **Figure 5-4**.

The sensitivity of the model to variations in surface roughness for different material types varies, depending on the prevalence of the material types within the active flow paths. The greater the occurrence of a particular material type, and the greater the variation in Manning's n, then the greater the effect on flood levels.

While a change in the surface roughness may have a localised effect on the flood levels, there is generally an opposite effect on flood levels downstream of the location. For example, an increase in flood levels due to increased roughness is typically accompanied by a downstream decrease in flood levels, due to increased flood storage in the area of varied roughness. Similarly, a decrease in flood levels due to decreased roughness is typically accompanied by a downstream increase in flood levels, due to increased flow conveyance in the area of varied roughness.

The sensitivity analysis results indicate the likely outcomes and impacts on flood levels if the existing surface roughness is modified, for example, due to:

- Changes in land use;
- Changes in management of floodway areas (erection or removal of fences); or
- Changes to vegetation density as a result of the introduction or cessation of vegetation management (clearing).

The outcomes of the sensitivity analysis also indicate the potential impact on flood levels if the actual floodplain surface Manning's n values are different from those adopted in the model.

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Table 5-2 Details on Sensitivity Scenarios

Sensitivity Scenario	Original Model Material Type	Sensitivity Run	Percent Change	Comments
1	Open Space, n = 0.05	n = 0.065	30 %	Change of up to +0.04m particularly between Malta Street and Normanby Street.
2	Open Space, n = 0.05	n = 0.04	-20%	Change of up to -0.03m particularly between Malta Street and Normanby Street.
3	Roads, n = 0.020	n = 0.04	100%	Change up to +0.05m in areas of overland flow between Woodville Road and Mandarin Street, due to reduced conveyance of Tangerine Street, which is a major flow path. Localised decrease (-0.03m) downstream of this area.
4	Commercial/Industrial , n = 0.20	n = 0.30	50%	Change of up to +0.03m between Woodville Road and Tangerine Street due to large commercial areas in this location. Widespread changes of up to -0.03m downstream of Tangerine Street due to increased floodplain storage in the area of increased flood levels.
5	Grassed, n = 0.035	n = 0.05	42%	Model is not sensitive (<0.01m change) as areas denoted as “grassed” are not prevalent within active flow areas.
6	Residential, n = 0.15	n = 0.30	100%	Changes of up to +0.09m particularly between Tangerine Street and Mandarin Street. Minor deviations (both increases and decreases) downstream of Mandarin Street.
7	Heavily Vegetated, n = 0.10	n = 0.20	100%	Model is not sensitive (<0.01m change) as there are no large areas considered to be heavily vegetated along Burns Creek (upstream of The Horsley Drive).
Fence Z-lines	Active	Inactive	N/A	Changes of +0.12m between Tangerine Street and Mandarin Street, due to a number of fence lines in the active flow area. Minor differences elsewhere.

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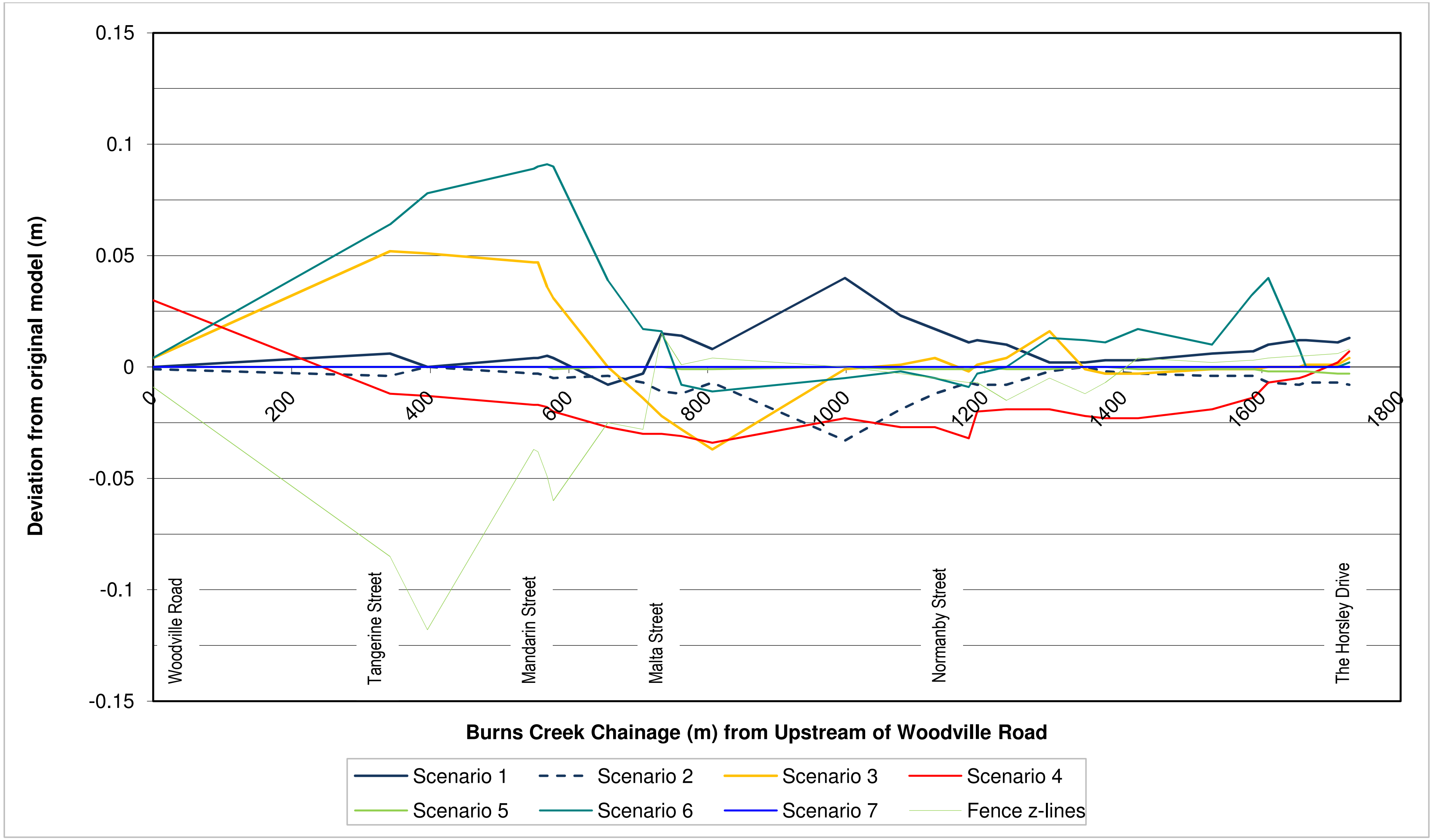
- **Figure 5-4 Changes in 100 year ARI Peak Water Levels in Burns Creek**



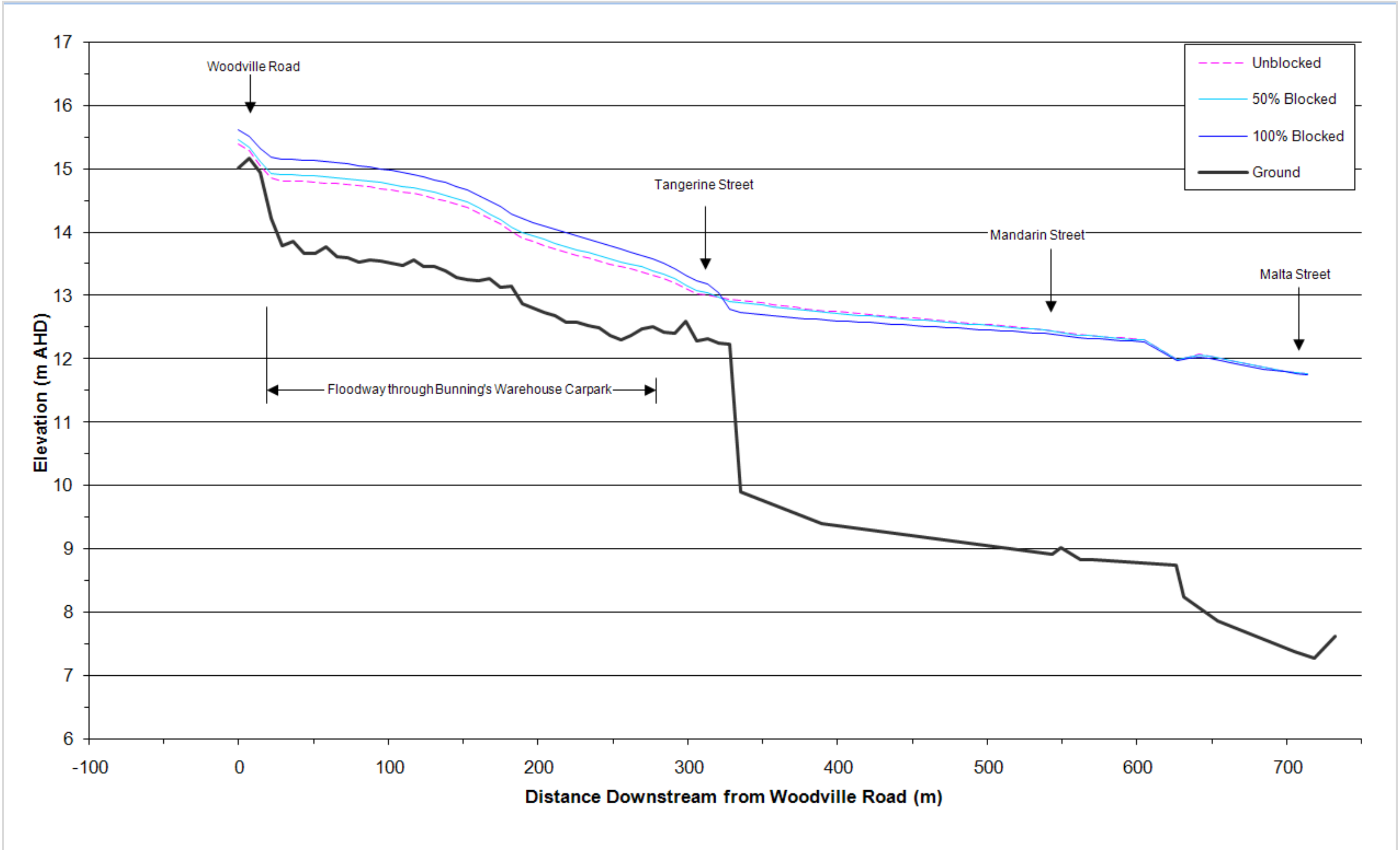
5.6. Blockage Analysis

The TUFLOW model was run with the scenarios of 50% and 100% blockage of key waterway crossings to assess the impact on flood behaviour. Discussions with Council staff revealed that the Woodville Road culvert was the most likely structure in the study area to become blocked. Blockage of the Fairfield Street culvert on Stimsons Creek was also investigated. The crossings at Normanby Street and Mandarin Street have open span bridges and are considered unlikely to become blocked.

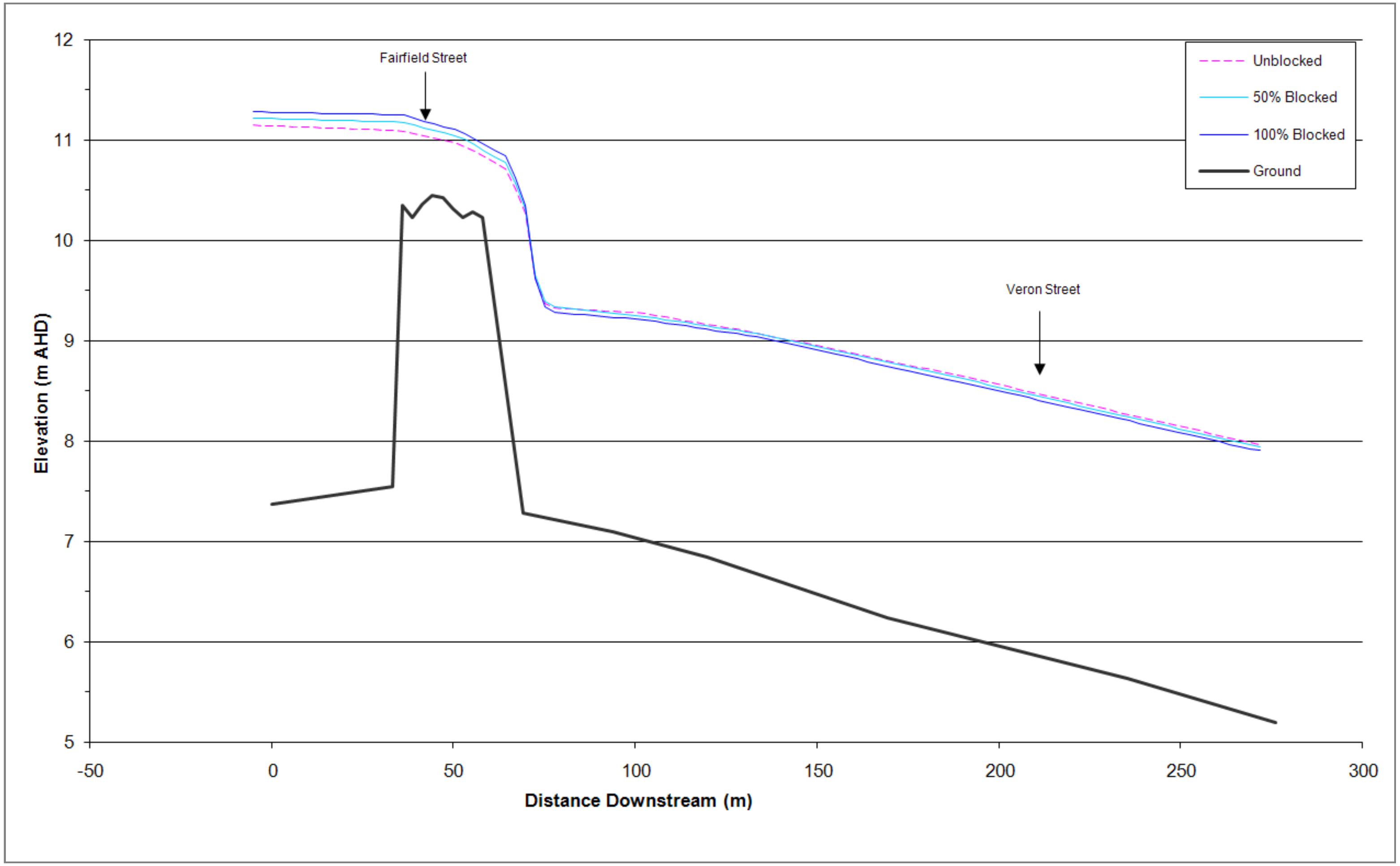
Figure 5-5 compares the water level profiles on Burns Creek for the unblocked, 50% blocked and 100% blocked scenarios from Woodville Road to Malta Street along the centreline of the floodway and creek. The results are discussed in **Section 5.6.1**. **Figure 5-6** compares the water level profiles on Stimsons Creek for the unblocked, 50% blocked and 100% blocked scenarios from just upstream of Fairfield Street to Veron Street along the centreline of the Creek. The results are discussed in **Section 5.6.2**.

- *Plate 3 Upstream face of Woodville Road culvert on Burns Creek*

■ **Figure 5-5 Blockage Scenario Flood Profiles, Burns Creek Downstream of Woodville Road**



■ **Figure 5-6 Blockage Scenario Flood Profiles, Stimsons Creek Downstream of Fairfield Street**



5.6.1. Burns Creek

Figure 5-5 indicates that the greatest difference in flooding between the unblocked and 50% and 100% blocked scenarios in Burns Creek occurs at Woodville Road and immediately downstream. There is a difference of approximately 100mm and 350mm in flood levels on Woodville Road between the 50% and 100% blocked and unblocked scenarios, respectively.

The difference in flood levels between the three scenarios diminishes with distance downstream from Woodville Road, as flows begin to converge on the creek channel. In **Figure 5-5**, the flood level is slightly higher downstream of Tangerine Street for the unblocked case, due to more flow being retained in the channel. There is no appreciable difference in flood levels downstream of Malta Street.

The relatively small increase in peak flood levels resulting from the various blockage scenarios is attributed to a significant portion of flows breaking out of the channel upstream of Woodville Road. **Table 5-3** summarises the breakout flow rate for the three blockage scenarios.

- **Table 5-3 Breakout Flows over Woodville Road for Blockage Scenarios**

Blockage Scenario	Breakout Flow	
	Peak Flow Rate of Breakout (m^3/s)	% of Total Flow*
Unblocked	52	50%
50% Blocked	64	62%
100% Blocked	97	94%

* Compared to $103m^3/s$ total flow upstream of Woodville Road

Hence, the Woodville Road culverts appear to be a major obstruction to flow, although only a short reach upstream of the culverts was modelled in coarse detail in this study.

5.6.2. Stimsons Creek

Figure 5-6 indicates that the greatest increase in flooding arising from blockage is immediately upstream of Fairfield Street. There is a difference of approximately 70mm and 160mm in flood levels on Fairfield Street between the 50% and 100% blocked and unblocked scenarios, respectively.

A large proportion of flows that break out from Stimsons Creek upstream of Fairfield Street overflow to Prospect Creek, rather than returning to Stimsons Creek. Hence, the flood surface profiles do not converge with distance from Fairfield Street. The 100 year ARI flood levels remain 30mm and 60mm lower in the channel for the 50% and 100% blocked scenarios, respectively.

6. Summary and Recommendations

6.1. Summary of Study Outcomes

The existing flooding conditions in the Burns Creek Catchment were assessed utilising XP-RAFTS and TUFLOW computer modelling packages. Information included up-to-date topographic survey and design data on existing hydraulic structures, including bridges, culverts and detention basins. The TUFLOW model was calibrated using stream gauging data and high water marks from the 31 January 2001 flood event. Catchment flows and flood levels were subsequently estimated using the calibrated models for the 20, 50 and 100 year ARI and PMF events for a range of storm durations. The modelling confirmed previous estimates by FCC that the 2001 flood event was of a lower magnitude than the 20 year ARI event for parts of the Creek not influenced by backwater effects from Prospect Creek.

The flood inundation extents during the 20 and 100 year ARI and PMF events were mapped, and are displayed in **Figure 5-1**. The Interim Flood Risk Precincts were also mapped, and are displayed in **Figure D-1**.

The 100 year ARI flood levels and discharges were compared to those from a previous study undertaken in the catchment. Flood levels in the this study are up to 0.8m higher than the previous study, which is attributed to the higher adopted in-channel roughness and higher flows in the current study. The design flood levels from the current study are supported by the 2001 calibration event flood levels.

Review of the patterns of flood inundation for events up to, and including, the 100 year ARI event, indicate that the floodplain is confined close to Burns Creek downstream of the Malta St Crossing. Upstream of Malta St, the floodplain is several blocks wide and affects a number of houses and other properties. During the PMF, a corridor up to approximately 550m wide becomes inundated by floodwaters.

Some roads are flood affected in events from the 20 year ARI up to the 100 year ARI due to flow breakouts at Woodville Road and Fairfield Street, leading to overland flow. All road crossings and numerous other roads on the floodplain, in addition to a section of the Guildford– Fairfield Railway line, are affected by the PMF. The exact impact of flooding on the Guildford– Fairfield Railway line was not ascertained, as the area upstream of the Railway is outside the Fairfield LGA, and hence, was not modelled in detail.

The Interim Flood Risk Precinct Mapping (**Appendix D**) indicates that an estimated 133 lots are affected by the High Flood Risk Precinct; 269 lots are affected by the Medium Flood Risk Precinct; and 615 lots are affected by the Low Flood Risk Precinct. The High Flood Risk Precinct reflects areas of hazardous high flood depth or flow velocity, or a combination of both. The Medium and Low Flood Risk Precincts follow the same spatial extents as the 100 year ARI and PMF event flood inundation patterns, respectively. Note that individual lots may contain areas of High, Medium and Low risk flooding. Overall, a total of 702 lots are affected by flooding up to the PMF event.

A blockage analysis indicated that for a 100% blockage of the Woodville Road culvert, there would be localised increases of less than 0.35m in flood levels. There is no appreciable difference in flood levels downstream of Malta Street. Blockage of Fairfield Street culvert on Stimsons Creek would locally increase flooding upstream of the culvert by up to 0.16m.

Sensitivity analysis indicates that flood levels are:

- Generally not sensitive to the adopted variations in Manning's n in the 2D domain for the various surface materials (except residential areas) or change in the storage capacity of the detention basins; and
- Relatively sensitive to both the increase in residential area roughness and the removal of the fences lines from the model.

6.2. Recommendations based on Study Outcomes

- Using the flood modelling results produced by this study, FCC can identify those properties in the study area affected by flooding from Burns Creek and update the Section 149 Certificates for these properties.
- The findings and outcomes from this study can be used as a basis for development of management strategies in the subsequent Burns Creek Floodplain Risk Management Study.
- As a part of the subsequent Floodplain Risk Management Study, the Interim Flood Risk Precincts should be reviewed to consider the categorisation of any 'islands' in each precinct. It may be appropriate to upgrade each of these isolated areas to a higher flood risk to match the surrounding flood risk precinct, as per FCC's requirements. The adjusted flood risk in these locations would have implications on flood evacuation planning.

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7. Glossary

Term	Description
Annual Exceedance Probability (AEP)	Term used to describe the chance of a flood of a given or larger size occurring in any one year, expressed as a percentage. Eg. a 1% AEP flood means there is a 1% (ie. one-in-100) chance of a flood of that size or larger occurring in any one year (see ARI).
Australian Height Datum (AHD)	A common national plain of level corresponding approximately to mean sea level. All flood levels, floor levels and ground levels are normally provided in metres AHD (m AHD)
Average Recurrence Interval (ARI)	The long-term average number of years between the occurrence of a flood as big as, or larger than, the selected event. For example, floods with a discharge as great as, or greater than, the 20 year ARI flood event will occur on average once every 20 years. ARI is another way of expressing the likelihood of occurrence of a flood event.
catchment	A catchment is the area of land from which rainwater drains into a common point such as a reservoir, pond, lake, river or creek. In urban areas such as Fairfield, the majority of the rainwater is collected by gutters and pipes and then flows through stormwater drains into the stormwater system.
conveyance	A direct measure of the flow carrying capacity of a particular cross-section of a stream or stormwater channel. (For example, if the conveyance of a channel cross-section is reduced by half, then the flow carrying capacity of that channel cross-section will also be halved).
discharge	The rate of flow of water measured in terms of volume per unit time, eg. cubic metres per second (m^3/s). Also known as flow. Discharge is different from the speed/velocity of flow which is a measure of how fast the water is moving.
extreme flood	An estimate of the probable maximum flood, which is the largest flood likely to ever occur.
flood	A relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or local overland flooding associated with major drainage as defined by the FDM before entering a watercourse.
flood awareness	An appreciation of the likely effects of flooding and knowledge of the relevant flood warning and evacuation procedures.
flood hazard	The potential for damage to property or harm to persons during a flood or a situation with a potential to cause loss. In relation to this plan, the hazard is flooding which has the potential to cause harm or loss to the community. Flood hazard is a key tool used to determine flood severity and is used for assessing the suitability of future types of land use.
flood level	The height of the flood described as either a depth of water above a particular location (eg. 1m above floor level) or as a depth of water related to a standard level such as Australian Height Datum (eg. flood level is 5m AHD).
flood liable/flood prone land	Land susceptible to flooding up to the PMF. The term flood liable or flood prone land covers the entire floodplain.

Term	Description
floodplain	The area of land that is subject to inundation by floods up to and including the PMF event.
Floodplain Development Manual (FDM)	Refers to the document dated April 2005, published by the New South Wales Government and entitled "Floodplain Development Manual: the management of flood liable land".
Floodplain Risk Management Plan (FRMP)	A plan prepared for one or more floodplains in accordance with the requirements of the FDM or its predecessors.
Floodplain Risk Management Study (FRMS)	A study prepared for one or more floodplains in accordance with the requirements of the FDM or its predecessors.
flood risk	The chance of something happening that will have an impact. It is measured in terms of consequences and probability (likelihood). In the context of this plan, it is the likelihood of consequences arising from the interaction of floods, communities and the environment.
flood risk precinct	An area of land with similar flood risks and where similar development controls may be applied by a Council to manage the flood risk. The flood risk is determined based on the existing development in the precinct or assuming the precinct is developed with normal residential uses. Usually the floodplain is categorised into three flood risk precincts 'low', 'medium' and 'high', although other classifications can sometimes be used. *High Flood Risk: T*his has been defined as the area of land below the 100 year ARI flood event that is either subject to a high hydraulic hazard or where there are significant evacuation difficulties. *Medium Flood Risk:* This has been defined as land below the 100 year ARI flood level that is not within a High Flood Risk Precinct. This is land that is not subject to a high hydraulic hazard or where there are no significant evacuation difficulties. *Low Flood Risk:* This has been defined as all land within the floodplain (i.e. within the extent of the probable maximum flood) but not identified within either a High Flood Risk or a Medium Flood Risk Precinct. The Low Flood Risk Precinct is that area above the 100 year ARI flood event.
flood study	A study that investigates flood behaviour, including identification of flood extents, flood levels and flood velocities for a range of flood events.
hydraulics	The study of water flow in waterways; in particular, the evaluation of flow parameters such as water level and velocity.
hydraulic hazard	The hazard as determined by the provisional criteria outlined in the FDM in a 100 year ARI flood event.
hydrology	The study of rainfall and runoff process; in particular, the evaluation of peak discharges, flow volumes and the derivation of hydrographs (graphs that show how the discharge or stage/flood level at any particular location varies with time during a flood).

Term	Description
local drainage	Term given to small scale inundation in urban areas outside the definition of major drainage as defined in the FDM. Local drainage problem invariably involve shallow depths (less than 0.3m) with generally little danger to personal safety.
local overland flooding	The inundation by local runoff rather than overbank discharge from a stream, river, estuary, lake or dam.
mainstream flooding	The inundation of normally dry land by local runoff rather than overbank discharge from a stream, river, estuary, lake or dam.
overland flow path	The path that floodwaters can follow if they leave the confines of the main flow channel or pipe system. Overland flow paths can occur through private properties or along roads.
peak discharge	The maximum discharge or flow during a flood measured in cubic metres per second (m^3/s).
probable maximum flood (PMF)	The largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation.
probable maximum precipitation (PMP)	The greatest depth of precipitation for a given duration meteorologically possible over a given size storm area at a particular location at a particular time of the year, with no allowance made for long-term climatic trends (World Meteorological Organisation, 1986). It is the primary input to the estimation of the probable maximum flood.
probability	A statistical measure of the expected chance of flooding (see ARI).
risk	See *flood risk.*
runoff	The amount of rainfall that ends up as flow in a stream. Also known as rainfall excess.
velocity	The term used to describe the speed of floodwaters, usually in metres per second (m/s).
water level	See *flood level.*
water surface profile	A graph showing the height of the flood (ie. water level or flood level) at any given location along a watercourse at a particular time.

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XP Software (2002) *XP-RAFTS User Manual*

Appendix A Council Report on Storms of 30 – 31 January 2001

SERVICES COMMITTEE

61

Meeting Date: 6 March 2001 **Item Number: [#]**

SUBJECT:

Storms of 30-31 January 2001

FILE NUMBER: G03-26-005

SUMMARY:

During the 24-hour period from 9 am on 30 January to 9am 31 January 2001, Fairfield was subjected to a storm that resulted in 161 mm of rainfall. This is the most significant storm event in the Fairfield area, since the floods of 1986 and 1988 and is classified as a minor flood. A table which compares the observed flood levels of 1986 and 1988 with this recent storm has been included as Attachment "A". Except for an isolated number of locations, this flood was not as severe as in 1986 and 1988. Preliminary examination of the flood levels indicate that this event was between a 1 in 10 year and 1 in 20-year Average Recurrence Interval storm.

The water level in all creeks in the Fairfield area was high with some localised flooding in certain areas that resulted in flood damage to residents properties. The damage would have been significantly worse if not for the flood mitigation works carried out by Council. This report details the flooding and flood damage on each creek and the investigation carried out by the Engineering Services Division in the aftermath of the flood.

REPORT BY: **N. DESILVA, SENIOR PROFESSIONAL ENGINEER CATCHMENT MANAGEMENT**

BACKGROUND

On the morning of 31 January 2001, Council officers from the Engineering Services Division visited the creeks, detention basins and other locations where construction works are currently being carried out, to document the flooding. Photos were taken and high water levels and debris marks were noted at bridges and channel banks. These marks will be levelled and documented as part of our historic flood database. This will serve as a useful resource in the future and help us to better predict flood levels in our creeks.

Council officers also visited the residents who live alongside the creeks and documented the flooding that occurred both internally and externally on their properties. These results will be passed on to the Department of Land and Water Conservation for use in their flood damages data base.

Upper Prospect Creek

The Upper Prospect Creek catchment extends from the Prospect Reservoir to the Fairfield railway crossing. A flood study was completed in September 1993 after the 1986 and 1988 floods. The study recommended that flood mitigation works be carried out to minimise the impact of flooding in the Upper Prospect Creek catchment. These included modifications to the Hassal Street and Rosford Street basins, stream clearing, and waterway improvements in the form of a by-pass floodway at Justin Street. This work is now complete.

Due to the flood mitigation work carried out on Upper Prospect Creek, a new flood study was commissioned last year to review the work carried out. This is almost complete. The new study will help refine flood levels in this creek and give us a better indication of flood levels through here.

Flood waters on Upper Prospect Creek broke the banks at several locations and some residents and small businesses experienced flooding above the floor levels of their houses and buildings. The creek overtopped the road crossings at Widemere Road and Fairfield Road but did not overtop at Gipps Road and the Cumberland Highway. However, the Cumberland Highway did experience flooding at Kenyons bridge due to local overland flow. The creek did not overtop the railway crossing.

The investigation has shown that in many residential areas, flooding was due to the stormwater pipes surcharging. As the floodwaters in the creeks rose, the stormwater pipes could not discharge into the creek and this resulted in water ponding in the adjacent streets till the floodwaters receded. At Ace Avenue the stormwater pipeline from the low point in the road to the creek was blocked, which did not allow stormwater from the road to drain to the creek.

The following table lists the properties adjacent to Upper Prospect Creek that were flood affected above floor level:

42 Ace Avenue	0.36m
44 Ace Avenue	0.40m
46 Ace Avenue	0.40m
48 Ace Avenue	0.25m
7 Cawarra Place	(1.59m above garage floor level)
19 Vineyard Avenue	0.15m (rumpus room)
303 The Horsley Drive	0.34m (commercial)
51 Justin Street	1 m from ground level (repair shed)
Little Street	1.8m above ground level at end of street

Lower Prospect Creek

Lower Prospect Creek extends from the Cabramatta-Granville railway line to the Georges River. Major flooding occurred along Lower Prospect Creek in August 1986 and April-May 1988. The 1986 flood caused a total damage of approximately $4.8 million on Prospect Creek. The 1986 and 1988 floods produced strong community pressures for measures to control flooding in the area.

A Floodplain Management Study was also carried out for the Lower Prospect Creek in 1990 and a number of strategies were proposed to improve the flooding problems here. The recommended works included a levee at Vincent Crescent, channel improvements and dredging on Orphan School Creek and Prospect Creek, widening of the channel of Prospect Creek, construction of a floodway at Fairfield Park, and improvements to Burns Creek, downstream of Normanby Street. The report also recommended that homes in Sandal Crescent be flood proofed and other flood affected properties were recommended for voluntary purchase and house raising. These works will reduce flood damage and were estimated to benefit 130 properties.

Most of the flood mitigation works recommended have now been completed and as a result of these works the flooding in Lower Prospect Creek was a lot less severe than might have been expected. Most of the residents adjacent to the creek were visited and the information gathered indicates than no internal flooding was experienced in this area. No major road crossings were overtopped although the creek did break its banks in places and residents did have flooded garages and grounds. Knight Street was cut off but residents were able to access Hollywood Drive, which had been raised some years ago to provide high level access out of the Lansvale peninsula.

The nets around the hammer throw rings at the Little Athletic Group grounds in the Makepeace Oval were damaged from the floods, mainly due to the fact that they are in a high level floodway. The damage was mostly due to debris getting caught in the nets. This blockage caused water to build up behind them which resulted in them being pushed over.

Orphan School Creek

Orphan School Creek extends from Cowpasture Road to its confluence with Prospect Creek just upstream of the Carramar railway line. There are two upstream detention basins on Orphan School Creek, both of which were working well. The Stockdale Reserve detention basin filled up to R.L. 54.63m AHD, approximately 1.2m below the spillway level. This basin just starts to spill during the 1-50 year ARI event. Construction of the Comin Place detention basin was completed just before the January flood. This proved to be quite fortunate for the residents in the area who would have experienced significant flooding if the basin had not been in place. The basin filled up to R.L. 66.5 m AHD, approximately 1m below the spillway level. The basin is expected to provide flood protection up to the 100-year ARI storm event. These upstream detention basins help to detain the flood waters and delay its release into Orphan School Creek.

We have not had any reported incidents of internal flooding on properties adjacent to Orphan School Creek, although some properties experienced external flooding to grounds and garages. The creek did not overtop any of the major bridge crossings.

Clear Paddock Creek

Clear Paddock Creek extends from just upstream of Elizabeth Drive to its confluence with Orphan School Creek. The most recent project on Clear Paddock Creek was "Restoring the Waters", where part of the concrete channel was converted to a natural stream. The project performed well during the recent storms and functioned according to design. A few properties experienced external flooding but no internal flooding was reported.

Green Valley Creek

Green Valley Creek extends from North Liverpool Road to its confluence with Orphan School Creek. Flood mitigation works to widen the waterway area have been completed for some years. No major problems were experienced along Green Valley Creek. A few properties experienced flooding of the grounds, but no internal flooding was reported.

Cabramatta Creek

Cabramatta Creek is the southern border of the local government area of Fairfield City Council. There was some flooding experienced along Cabramatta Creek but no major bridge crossings were overtopped. Our investigations indicate that no residents experienced internal flooding although a few properties are likely to have experienced external flooding. The most serious flooding along Cabramatta Creek was in the vicinity of the Cabramatta Leagues Club. They had a significant amount of flooding in their parking lot and some of their gym equipment, which was housed in the ground floor area of the building, was affected. We did not receive any calls from residents along Cabramatta Creek.

Burns Creek

Burns Creek is located in the eastern part of Fairfield City Council's local government area and flows into Prospect Creek just upstream of the Vine Street bridge. Engineering consultants were commissioned in 1993 to prepare flood mitigation options for Burns Creek. Several options were investigated and it was decided to construct a high level floodway at Hanson Street. In addition, channel improvement by means of stream clearing with some minor modifications to the creek alignment were also recommended. The improvements were intended to ensure that floor levels were above the 100-year flood elevation although the grounds outside might be flooded.

Most of the damage from the recent storm was to peoples backyards, fences and garages. One property on Malta Street and an industrial property had flooding above floor level. These properties are located very close to the creek. There was also some damage to residents' fences on Spring Street as they back on to Burns Creek.

The following table lists the properties adjacent to Burns Creek that were flood affected above floor level:

93-94 Malta (industrial workshop)	0.06 m
66 Malta	Internal flooding

CONCLUSION

As mentioned previously, preliminary examination of the flood levels indicate that this was between a 1 in 10 year and 1 in 20-year Average Recurrence Interval storm. This was the most severe storm event since the floods experienced in 1986 and 1988. The flooding that resulted from this storm was much less than it might have been due to the flood mitigation works carried out by Fairfield City Council. However, localised flooding was experienced in Ace Avenue and Malta Street and these areas are currently being investigated to determine the reason for the flooding.

During the next few weeks, all of the information resulting from this recent storm will be collated and analysed. This information will be an invaluable resource for future flood mitigation planning. It will also be forwarded to the Department of Land and Water Conservation (DLWC) for use in their flood damages data base and to the State Emergency Service (SES) for use in their emergency planning.

RECOMMENDATION:

1. That this report be received and noted.

SUPPORTING DOCUMENTS ATTACHED:

AT-A Flood levels of January 2001, 1986 and 1988 storm events.

N. DESILVA
SENIOR PROFESSIONAL ENGINEER CATCHMENT MANAGEMENT
27 February 2001

Catchment Management Co-ordinator 28/2/01
Manager Engineering Services

Services Committee - 6 March 2001

SECTION B

FN:C066NBAX.530 ****** END OF ITEM [#] ******

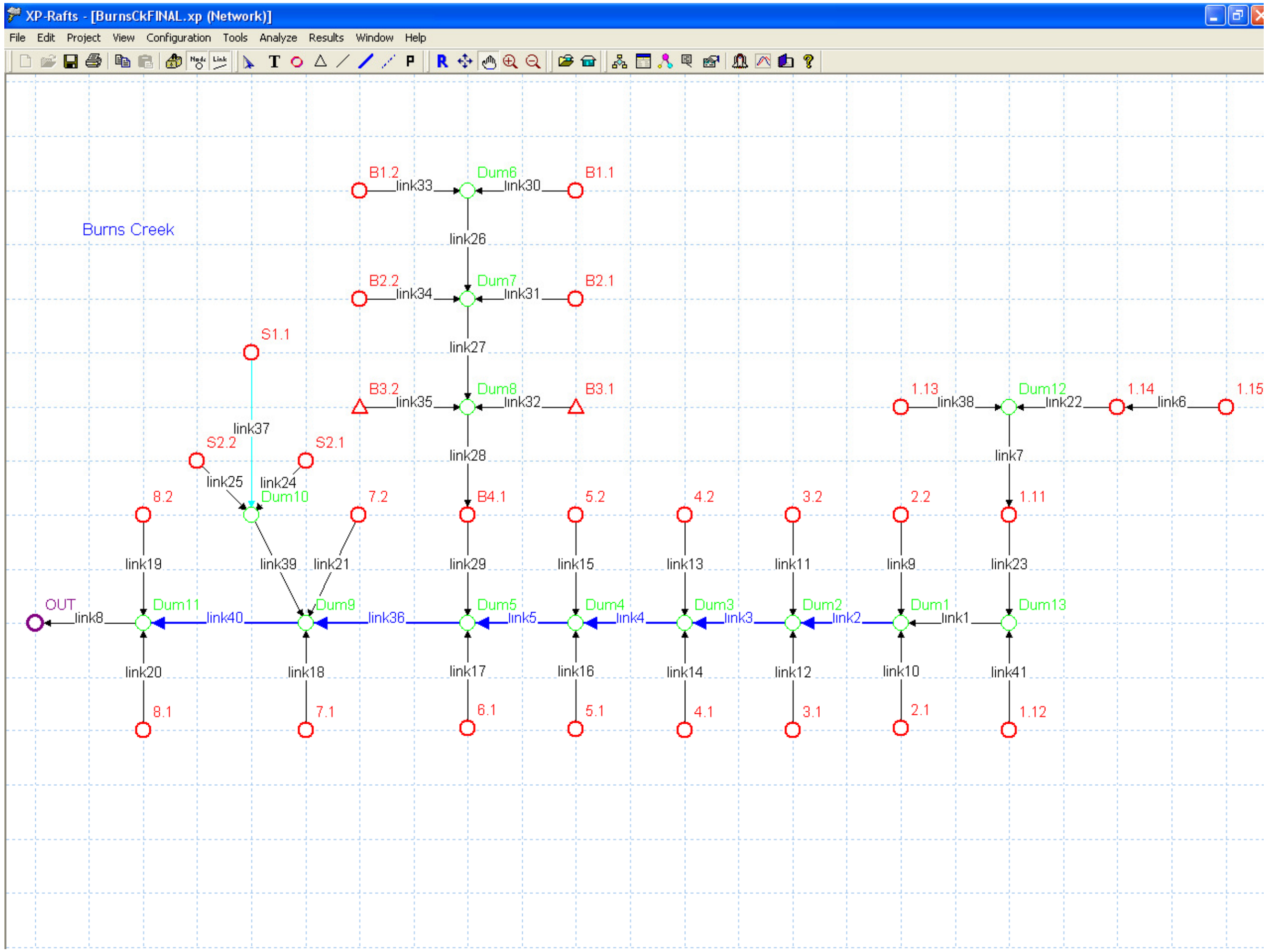
ATTACHMENT 'A' - Flood Levels of Jan 2001, 1986 and 1988 Storm Events

LOCALITY	Storm of 31/01/2001 (Levels to A.H.D)	1986 Flood	1988 Flood
GEORGES RIVER			
Fairlawn Cres, Lansvale	2.13	5.50	5.81
PROSPECT CREEK			
Day Street, Lansvale	3.62	5.06	5.72
Lansdowne Bridge, Lansvale	4.23	5.06	-
Sandal Cres, Carramar	5.02	6.08	6.24
Vine Street, Fairfield	6.44	7.29	6.86
The Horsley Drive, Fairfield	8.62	9.97	8.80
Polding Street North, Fairfield	12.18	12.55	11.93
Cumberland Hwy, Smithfield	17.77	18.75	18.72
CABRAMATTA CREEK			
Hume Hwy, Cabramatta	4.07	5.77	6.32
Sussex Street, Cabramata	5.81	5.96	6.66
Elizabeth Drive, Mt Pritchard	11.75	12.46	12.27
ORPHAN SCHOOL CREEK			
Railway Parade, Canley Vale	7.52	8.92	8.97
Sackville Street, Canley Vale	10.32	10.39	11.00
Cumberland Hwy, Canley Heights	14.15	14.68	14.15
King Road, Wakeley	18.17	19.64	-
Smithfield Road, Prairiewood	26.09	-	-
Stockdale Cres Reserve, Abbotsbury	54.60	-	-
GREEN VALLEY CREEK			
Avoca Road, Wakeley	18.51	18.91	-
Canley Vale Road, Wakeley	20.05	20.62	-
CLEAR PADDOCK CREEK			
Kembla Street, Wakeley	18.80	19.19	-
Canley Vale Road, St Johns Park	20.05	22.64	-
Brisbane Road, St Johns Park	28.89	28.54	-

Appendix B   Hydrologic Model Data and Results

SKM

▪ Figure B-1 Burns Creek XP-RAFTS model layout



FAIRFIELD CITY COUNCIL

Rainfall Intensity (mm/hr) for Various Durations and Return Periods

Based on data for location 33.875 S 150.925 E (near Fairfield) issued April 1997 by Hydrometeorological Advisory Service (Melbourne). (C) Commonwealth of Australia, Bureau of Meteorology, 1987.

DURATION		RETURN PERIOD						
Min	Hrs	1 Year	2 Year	5 Year	10 Year	20 Year	50 Year	100 Year
5	0.083	82.47	105.54	133.59	149.43	170.89	198.58	219.37
6	0.100	77.14	98.63	125.09	140.05	160.24	186.25	205.89
7	0.117	72.78	93.02	118.04	132.20	151.25	175.79	194.38
8	0.133	69.11	88.30	112.05	125.48	143.54	166.80	184.44
9	0.150	65.94	84.25	106.85	119.64	136.82	158.97	175.76
10	0.167	63.16	80.69	102.28	114.49	130.91	152.06	168.11
11	0.183	60.69	77.53	98.22	109.92	125.65	145.92	161.30
12	0.200	58.47	74.70	94.58	105.81	120.92	140.41	155.19
13	0.217	56.46	72.13	91.28	102.10	116.66	135.43	149.66
14	0.233	54.63	69.79	88.27	98.72	112.77	130.90	144.64
15	0.250	52.95	67.64	85.52	95.62	109.22	126.76	140.04
16	0.267	51.40	65.66	82.99	92.77	105.95	122.95	135.82
17	0.283	49.96	63.83	80.64	90.14	102.93	119.43	131.92
18	0.300	48.63	62.13	78.46	87.69	100.12	116.17	128.31
19	0.317	47.38	60.54	76.44	85.42	97.52	113.14	124.95
20	0.333	46.22	59.05	74.54	83.29	95.08	110.30	121.81
21	0.350	45.12	57.65	72.76	81.29	92.80	107.65	118.88
22	0.367	44.09	56.33	71.09	79.42	90.65	105.16	116.12
23	0.383	43.12	55.09	69.51	77.65	88.64	102.82	113.53
24	0.400	42.20	53.91	68.02	75.99	86.73	100.60	111.09
25	0.417	41.32	52.80	66.61	74.41	84.93	98.51	108.78
26	0.433	40.50	51.74	65.27	72.92	83.23	96.53	106.59
27	0.450	39.71	50.74	64.00	71.50	81.61	94.65	104.51
28	0.467	38.96	49.78	62.80	70.15	80.06	92.87	102.54
29	0.483	38.25	48.87	61.64	68.86	78.60	91.16	100.66
30	0.500	37.56	48.00	60.55	67.63	77.20	89.54	98.87
31	0.517	36.91	47.16	59.50	66.46	75.86	87.99	97.16
32	0.533	36.28	46.37	58.49	65.34	74.58	86.51	95.52
33	0.550	35.69	45.60	57.53	64.26	73.36	85.09	93.96
34	0.567	35.11	44.87	56.60	63.23	72.18	83.73	92.46
35	0.583	34.56	44.16	55.72	62.25	71.06	82.43	91.02
36	0.600	34.03	43.48	54.86	61.30	69.98	81.17	89.64
37	0.617	33.51	42.83	54.04	60.38	68.93	79.97	88.31
38	0.633	33.02	42.20	53.25	59.50	67.93	78.81	87.03
39	0.650	32.55	41.59	52.49	58.65	66.97	77.69	85.80
40	0.667	32.09	41.01	51.76	57.83	66.04	76.61	84.61
41	0.683	31.64	40.44	51.05	57.05	65.14	75.57	83.46
42	0.700	31.22	39.90	50.36	56.28	64.27	74.57	82.36
43	0.717	30.80	39.37	49.70	55.55	63.43	73.60	81.29
44	0.733	30.40	38.86	49.06	54.83	62.62	72.66	80.25
45	0.750	30.01	38.36	48.44	54.14	61.83	71.75	79.25
46	0.767	29.64	37.88	47.84	53.47	61.07	70.87	78.28
47	0.783	29.27	37.42	47.26	52.83	60.34	70.02	77.34
48	0.800	28.92	36.97	46.69	52.20	59.62	69.19	76.43
49	0.817	28.58	36.53	46.15	51.59	58.93	68.39	75.55

DURATION		RETURN PERIOD						
Min	Hrs	1 Year	2 Year	5 Year	10 Year	20 Year	50 Year	100 Year
50	0.833	28.24	36.10	45.61	50.99	58.25	67.61	74.69
51	0.850	27.92	35.69	45.10	50.42	57.60	66.86	73.86
52	0.867	27.60	35.29	44.59	49.86	56.96	66.12	73.05
53	0.883	27.30	34.90	44.11	49.32	56.35	65.41	72.26
54	0.900	27.00	34.52	43.63	48.79	55.74	64.71	71.50
55	0.917	26.71	34.15	43.17	48.27	55.16	64.04	70.75
56	0.933	26.43	33.79	42.72	47.77	54.59	63.38	70.03
57	0.950	26.15	33.44	42.28	47.28	54.03	62.74	69.32
58	0.967	25.88	33.10	41.85	46.81	53.49	62.11	68.63
59	0.983	25.62	32.76	41.43	46.34	52.97	61.50	67.96
60	1.000	25.37	32.44	41.03	45.89	52.45	60.91	67.31
61	1.017	25.12	32.12	40.63	45.45	51.95	60.33	66.67
62	1.033	24.87	31.81	40.24	45.02	51.46	59.76	66.05
63	1.050	24.64	31.51	39.86	44.60	50.98	59.21	65.44
64	1.067	24.40	31.21	39.49	44.19	50.52	58.67	64.85
65	1.083	24.18	30.92	39.13	43.79	50.06	58.15	64.27
66	1.100	23.96	30.64	38.78	43.40	49.61	57.63	63.70
67	1.117	23.74	30.36	38.44	43.01	49.18	57.13	63.15
68	1.133	23.53	30.09	38.10	42.64	48.75	56.64	62.60
69	1.150	23.32	29.83	37.77	42.27	48.33	56.15	62.07
70	1.167	23.12	29.57	37.44	41.91	47.93	55.68	61.55
71	1.183	22.92	29.32	37.13	41.56	47.53	55.22	61.05
72	1.200	22.72	29.07	36.82	41.22	47.14	54.77	60.55
73	1.217	22.53	28.83	36.52	40.88	46.75	54.33	60.06
74	1.233	22.35	28.59	36.22	40.55	46.38	53.89	59.59
75	1.250	22.17	28.36	35.93	40.23	46.01	53.47	59.12
76	1.267	21.99	28.13	35.64	39.91	45.65	53.05	58.66
77	1.283	21.81	27.91	35.36	39.60	45.30	52.65	58.21
78	1.300	21.64	27.69	35.09	39.29	44.95	52.25	57.77
79	1.317	21.47	27.47	34.82	38.99	44.61	51.85	57.34
80	1.333	21.30	27.26	34.56	38.70	44.28	51.47	56.92
81	1.350	21.14	27.05	34.30	38.41	43.95	51.09	56.50
82	1.367	20.98	26.85	34.05	38.13	43.63	50.72	56.09
83	1.383	20.83	26.65	33.80	37.85	43.31	50.36	55.69
84	1.400	20.67	26.46	33.55	37.58	43.01	50.00	55.30
85	1.417	20.52	26.26	33.31	37.32	42.70	49.65	54.91
86	1.433	20.37	26.08	33.08	37.05	42.40	49.31	54.53
87	1.450	20.23	25.89	32.84	36.80	42.11	48.97	54.16
88	1.467	20.08	25.71	32.62	36.54	41.82	48.64	53.80
89	1.483	19.94	25.53	32.39	36.29	41.54	48.31	53.44
90	1.500	19.81	25.35	32.17	36.05	41.26	47.99	53.08
91	1.517	19.67	25.18	31.96	35.81	40.99	47.67	52.74
92	1.533	19.54	25.01	31.74	35.57	40.72	47.36	52.39
93	1.550	19.40	24.84	31.53	35.34	40.46	47.06	52.06
94	1.567	19.28	24.68	31.33	35.11	40.20	46.76	51.73
95	1.583	19.15	24.52	31.13	34.89	39.94	46.46	51.40
96	1.600	19.02	24.36	30.93	34.66	39.69	46.17	51.08
97	1.617	18.90	24.20	30.73	34.45	39.44	45.88	50.77
98	1.633	18.78	24.05	30.54	34.23	39.20	45.60	50.46
99	1.650	18.66	23.89	30.35	34.02	38.96	45.33	50.15
100	1.667	18.54	23.74	30.16	33.81	38.72	45.05	49.85
101	1.683	18.43	23.60	29.98	33.61	38.49	44.78	49.56

DURATION		RETURN PERIOD						
Min	Hrs	1 Year	2 Year	5 Year	10 Year	20 Year	50 Year	100 Year
102	1.700	18.31	23.45	29.80	33.41	38.26	44.52	49.26
103	1.717	18.20	23.31	29.62	33.21	38.03	44.26	48.98
104	1.733	18.09	23.17	29.44	33.01	37.81	44.00	48.69
105	1.750	17.98	23.03	29.27	32.82	37.59	43.75	48.42
106	1.767	17.87	22.89	29.10	32.63	37.38	43.50	48.14
107	1.783	17.77	22.76	28.93	32.44	37.16	43.25	47.87
108	1.800	17.67	22.63	28.76	32.26	36.95	43.01	47.60
109	1.817	17.56	22.50	28.60	32.08	36.75	42.77	47.34
110	1.833	17.46	22.37	28.44	31.90	36.54	42.54	47.08
111	1.850	17.36	22.24	28.28	31.72	36.34	42.31	46.83
112	1.867	17.26	22.12	28.13	31.55	36.14	42.08	46.58
113	1.883	17.17	21.99	27.97	31.38	35.95	41.85	46.33
114	1.900	17.07	21.87	27.82	31.21	35.76	41.63	46.08
115	1.917	16.98	21.75	27.67	31.04	35.57	41.41	45.84
116	1.933	16.88	21.63	27.52	30.88	35.38	41.19	45.60
117	1.950	16.79	21.52	27.37	30.71	35.19	40.98	45.37
118	1.967	16.70	21.40	27.23	30.55	35.01	40.77	45.14
119	1.983	16.61	21.29	27.09	30.39	34.83	40.56	44.91
120	2	16.52	21.18	26.95	30.24	34.65	40.36	44.68
150	2.5	14.33	18.38	23.44	26.34	30.22	35.23	39.04
180	3	12.74	16.35	20.91	23.51	27.00	31.51	34.94
210	3.5	11.53	14.81	18.97	21.36	24.54	28.67	31.81
240	4	10.57	13.59	17.44	19.65	22.59	26.42	29.32
270	4.5	9.79	12.60	16.19	18.25	21.00	24.59	27.30
300	5	9.14	11.77	15.15	17.09	19.68	23.05	25.61
360	6	8.12	10.47	13.50	15.26	17.59	20.63	22.94
420	7	7.34	9.48	12.26	13.87	16.00	18.80	20.91
480	8	6.73	8.70	11.28	12.77	14.75	17.35	19.31
540	9	6.24	8.07	10.48	11.88	13.73	16.17	18.01
600	10	5.83	7.54	9.81	11.14	12.89	15.19	16.92
660	11	5.48	7.09	9.25	10.51	12.17	14.36	16.01
720	12	5.18	6.71	8.76	9.97	11.55	13.64	15.21
780	13	4.92	6.37	8.34	9.49	11.01	13.01	14.52
840	14	4.69	6.08	7.97	9.08	10.53	12.46	13.91
900	15	4.48	5.81	7.63	8.71	10.11	11.97	13.37
960	16	4.30	5.58	7.34	8.37	9.73	11.53	12.88
1020	17	4.13	5.36	7.07	8.07	9.38	11.13	12.44
1080	18	3.98	5.17	6.82	7.80	9.07	10.76	12.04
1140	19	3.84	4.99	6.60	7.55	8.78	10.43	11.68
1200	20	3.71	4.83	6.39	7.32	8.52	10.13	11.34
1260	21	3.60	4.68	6.20	7.10	8.28	9.84	11.03
1320	22	3.49	4.54	6.02	6.90	8.05	9.58	10.74
1380	23	3.39	4.41	5.86	6.72	7.84	9.34	10.47
1440	24	3.29	4.28	5.70	6.55	7.65	9.11	10.22
1500	25	3.20	4.17	5.56	6.39	7.46	8.90	9.98
1560	26	3.12	4.06	5.43	6.24	7.29	8.69	9.76
1620	27	3.04	3.96	5.30	6.09	7.13	8.50	9.55
1680	28	2.97	3.87	5.18	5.96	6.97	8.33	9.35
1740	29	2.90	3.78	5.06	5.83	6.83	8.16	9.16
1800	30	2.83	3.69	4.96	5.71	6.69	8.00	8.99
1860	31	2.77	3.61	4.85	5.59	6.56	7.84	8.82
1920	32	2.71	3.54	4.76	5.48	6.43	7.70	8.65

DURATION		RETURN PERIOD						
Min	Hrs	1 Year	2 Year	5 Year	10 Year	20 Year	50 Year	100 Year
1980	33	2.66	3.46	4.66	5.38	6.31	7.56	8.50
2040	34	2.60	3.39	4.57	5.28	6.20	7.42	8.35
2100	35	2.55	3.33	4.49	5.19	6.09	7.30	8.21
2160	36	2.50	3.26	4.41	5.09	5.98	7.17	8.08
2220	37	2.45	3.20	4.33	5.01	5.88	7.06	7.95
2280	38	2.41	3.14	4.25	4.92	5.79	6.94	7.82
2340	39	2.36	3.09	4.18	4.84	5.69	6.84	7.70
2400	40	2.32	3.03	4.11	4.76	5.60	6.73	7.59
2460	41	2.28	2.98	4.05	4.69	5.52	6.63	7.48
2520	42	2.24	2.93	3.98	4.61	5.43	6.53	7.37
2580	43	2.20	2.88	3.92	4.54	5.35	6.44	7.26
2640	44	2.17	2.84	3.86	4.48	5.28	6.35	7.16
2700	45	2.13	2.79	3.80	4.41	5.20	6.26	7.07
2760	46	2.10	2.75	3.75	4.35	5.13	6.17	6.97
2820	47	2.07	2.71	3.69	4.29	5.06	6.09	6.88
2880	48	2.03	2.66	3.64	4.23	4.99	6.01	6.79
2940	49	2.00	2.63	3.59	4.17	4.92	5.93	6.70
3000	50	1.97	2.59	3.54	4.11	4.86	5.86	6.62
3060	51	1.94	2.55	3.49	4.06	4.79	5.78	6.54
3120	52	1.92	2.51	3.44	4.00	4.73	5.71	6.46
3180	53	1.89	2.48	3.40	3.95	4.67	5.64	6.38
3240	54	1.86	2.44	3.35	3.90	4.61	5.57	6.30
3300	55	1.84	2.41	3.31	3.85	4.56	5.51	6.23
3360	56	1.81	2.38	3.27	3.80	4.50	5.44	6.16
3420	57	1.79	2.35	3.23	3.76	4.45	5.38	6.09
3480	58	1.76	2.32	3.19	3.71	4.40	5.32	6.02
3540	59	1.74	2.29	3.15	3.67	4.34	5.26	5.95
3600	60	1.72	2.26	3.11	3.62	4.29	5.20	5.89
3660	61	1.69	2.23	3.07	3.58	4.25	5.14	5.82
3720	62	1.67	2.20	3.04	3.54	4.20	5.08	5.76
3780	63	1.65	2.18	3.00	3.50	4.15	5.03	5.70
3840	64	1.63	2.15	2.97	3.46	4.11	4.97	5.64
3900	65	1.61	2.12	2.93	3.42	4.06	4.92	5.58
3960	66	1.59	2.10	2.90	3.38	4.02	4.87	5.52
4020	67	1.57	2.07	2.87	3.35	3.97	4.82	5.47
4080	68	1.55	2.05	2.84	3.31	3.93	4.77	5.41
4140	69	1.53	2.03	2.80	3.28	3.89	4.72	5.36
4200	70	1.52	2.00	2.77	3.24	3.85	4.67	5.30
4260	71	1.50	1.98	2.74	3.21	3.81	4.63	5.25
4320	72	1.48	1.96	2.71	3.17	3.77	4.58	5.20

Table B-2 XP-RAFTS sensitivity analysis results

General Data OUTLET		Decreased Pervious Losses		Increased Pervious Losses		Decreased Impervious Losses		Increased Impervious Losses		Doubled Lag		Halved lag	
Storm	Outflow	Outflow	% Change	Outflow	% Change	Outflow	% Change	Outflow	% Change	Outflow	% Change	Outflow	% Change
1% 0.5hr	259.99	265.89	2.3	252.43	-2.9	259.99	0.0	259.99	0.0	239.48	-7.9	290.34	11.7
1% 1hr	236.55	242.96	2.7	229.98	-2.8	236.55	0.0	236.55	0.0	221.93	-6.2	266.73	12.8
1%1.5 hr	223.95	232.29	3.7	214.55	-4.2	223.95	0.0	223.95	0.0	210.18	-6.1	251.52	12.3
1% 2hr	239.79	247.29	3.1	230.92	-3.7	239.79	0.0	239.79	0.0	233.14	-2.8	268.43	11.9
1% 3hr	185.07	192.61	4.1	177.08	-4.3	185.07	0.0	185.07	0.0	178.28	-3.7	201.44	8.8
1% 6hr	167.56	173.42	3.5	159.37	-4.9	167.56	0.0	167.56	0.0	157.4	-6.1	176.34	5.2
1% 8hr	122.06	123	0.8	119.33	-2.2	122.06	0.0	122.06	0.0	112.71	-7.7	124.6	2.1
1% 12hr	163.74	164.65	0.6	161	-1.7	163.74	0.0	163.74	0.0	145.5	-11.1	171.58	4.8
1% 24hr	122.63	123.47	0.7	120.1	-2.1	122.63	0.0	122.63	0.0	117.77	-4.0	124.19	1.3
1% 36hr	102.27	103.04	0.8	99.937	-2.3	102.27	0.0	102.27	0.0	101.88	-0.4	102.36	0.1
5% 9hr	150.01	150.94	0.6	147.23	-1.9	150.01	0.0	150.01	0.0	143.65	-4.2	156.84	4.6
5% 12 hr	156.11	157.01	0.6	153.29	-1.8	156.11	0.0	156.11	0.0	138.11	-11.5	163.94	5.0
5% 18hr	116.22	117.23	0.9	113.18	-2.6	116.22	0.0	116.22	0.0	106.07	-8.7	118.9	2.3
5% 36hr	97.378	98.153	0.8	95.056	-2.4	97.378	0.0	97.378	0.0	96.962	-0.4	97.486	0.1
PMP 25min	1451	1466.5	1.1	1438.4	-0.9	1451	0.0	1451	0.0	1316.9	-9.2	1690.5	16.5
PMP 1hr	1148.7	1163.9	1.3	1136.2	-1.1	1148.7	0.0	1148.7	0.0	1053.2	-8.3	1314.1	14.4
PMP 1.5hr	1263.5	1276.5	1.0	1250.7	-1.0	1263.5	0.0	1263.5	0.0	1181.3	-6.5	1386.7	9.8
PMP 2hr	1364.3	1375.6	0.8	1352.4	-0.9	1364.3	0.0	1364.3	0.0	1296.3	-5.0	1488.2	9.1
PMP 3hr	1093.8	1106.3	1.1	1082.5	-1.0	1093.8	0.0	1093.8	0.0	1037.6	-5.1	1232.2	12.7
PMP 6hr	883.44	884.98	0.2	881.43	-0.2	883.44	0.0	883.44	0.0	856.15	-3.1	935.23	5.9
Changes		Initial	10	Initial	20	Initial	0.75	Initial	3				
		Continuous	1	Continuous	3	Continuous	0	Continuous	0				

■ **Table B-2 XP-RAFTS sensitivity analysis results (con't)**

General Data OUTLET		Roughness Increase		Roughness Increase #2		Roughness Decrease		Roughness Decrease #2		Stage Discharge	
Storm	Outflow	Outflow	% Change	Outflow	% Change	Outflow	% Change	Outflow	% Change	Outflow	% Change
1% 0.5hr	259.99	259.99	0	259.99	0	259.99	0	259.99	0	259.41	-0.2
1% 1hr	236.55	236.55	0	236.55	0	236.55	0	236.55	0	236.2	-0.1
1%1.5 hr	223.95	223.95	0	223.95	0	223.95	0	223.95	0	223.41	-0.2
1% 2hr	239.79	239.79	0	239.79	0	239.79	0	239.79	0	239.3	-0.2
1% 3hr	185.07	185.07	0	185.07	0	185.07	0	185.07	0	184.82	-0.1
1% 6hr	167.56	167.56	0	167.56	0	167.56	0	167.56	0	167.58	0.0
1% 8hr	122.06	122.06	0	122.06	0	122.06	0	122.06	0	122.09	0.0
1% 12hr	163.74	163.74	0	163.74	0	163.74	0	163.74	0	163.74	0.0
1% 24hr	122.63	122.63	0	122.63	0	122.63	0	122.63	0	122.64	0.0
1% 36hr	102.27	102.27	0	102.27	0	102.27	0	102.27	0	102.26	0.0
5% 9hr	150.01	150.01	0	150.01	0	150.01	0	150.01	0	150	0.0
5% 12 hr	156.11	156.11	0	156.11	0	156.11	0	156.11	0	156.09	0.0
5% 18hr	116.22	116.22	0	116.22	0	116.22	0	116.22	0	116.25	0.0
5% 36hr	97.378	97.378	0	97.378	0	97.378	0	97.378	0	97.378	0.0
PMP 25min	1451	1451	0	1451	0	1451	0	1451	0	1452.3	0.1
PMP 1hr	1148.7	1148.7	0	1148.7	0	1148.7	0	1148.7	0	1149.1	0.0
PMP 1.5hr	1263.5	1263.5	0	1263.5	0	1263.5	0	1263.5	0	1263.1	0.0
PMP 2hr	1364.3	1364.3	0	1364.3	0	1364.3	0	1364.3	0	1364.9	0.0
PMP 3hr	1093.8	1093.8	0	1093.8	0	1093.8	0	1093.8	0	1095.2	0.1
PMP 6hr	883.44	883.44	0	883.44	0	883.44	0	883.44	0	884.06	0.1
Changes		0.02 to 0.025		0.02 to 0.03		0.02 to 0.015		0.02 to 0.01		Node B3.2	
		0.025 to 0.035		0.025 to 0.03		0.025 to 0.02		0.025 to 0.015		Springfield Park Basin	

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Table B-3 XP-RAFTS Peak Total Flow – 20 year ARI Event (m^3/s)

Node	Event Duration							
	30 min	1 hr	90 min	2 hr	3 hr	6 hr	9 hr	12 hr
Dum1	75.395	66.337	79.897	83.344	77.609	70.856	70.806	64.027
Dum2	74.666	67.187	80.317	84.282	79.073	71.358	71.238	64.223
Dum3	74.221	69.527	78.355	85.784	80.774	73.184	72.98	67.432
Dum4	79.47	73.256	80.233	87.995	82.305	75.439	75.079	70.964
Dum5	87.577	91.79	103.49	107.11	103.06	95.849	95.299	89.692
Dum9	110.29	133.59	136.52	134.55	123.37	120.44	119.74	120.88
Dum11	109.74	131.38	134.86	133.18	124.06	121.11	120.37	121.01
OUT	109.74	131.38	134.86	133.18	124.06	121.11	120.37	121.01
2.2	2.936	2.543	3.218	3.3	2.052	1.44	1.275	1.284
2.1	6.286	4.998	5.785	6.4	3.944	2.942	2.597	2.642
3.2	5.21	4.513	5.659	5.835	3.604	2.419	2.135	2.148
3.1	1.648	1.613	1.988	2.072	1.361	0.9845	0.8721	0.8789
4.2	12.172	9.461	10.95	11.917	7.319	4.893	4.32	4.348
4.1	2.082	1.957	2.244	2.488	1.609	1.416	1.242	1.275
5.2	2.011	1.634	1.931	2.09	1.295	0.8982	0.7939	0.7993
5.1	6.629	5.935	6.891	7.685	4.879	4.287	3.761	3.863
6.1	1.169	1.1	1.317	1.422	0.9196	0.7668	0.6729	0.6847
7.1	0.6585	0.731	0.87	0.937	0.6285	0.4478	0.3948	0.3985
8.2	0.6632	0.6222	0.7932	0.8202	0.5337	0.3901	0.3435	0.3473
8.1	1.397	1.386	1.709	1.779	1.169	0.83	0.732	0.7374
7.2	0.62	0.5852	0.7182	0.7614	0.494	0.3999	0.3503	0.3559
S1.1	58.924	52.28	51.749	58.588	40.674	29.092	26.179	27.103
Dum10	62.262	56.995	56.199	62.788	44.021	32.892	29.946	31.126
S2.1	6.647	5.725	6.58	7.343	4.652	3.993	3.511	3.62
S2.2	1.62	1.463	1.714	1.888	1.184	1.013	0.8885	0.9068
Dum6	20.389	17.658	20.629	22.796	14.389	12.076	10.612	10.901
Dum7	22.237	19.971	22.134	24.603	15.811	13.692	12.214	12.44
Dum8	24.437	26.496	28.688	31.711	21.16	21.512	19.932	20.648
B4.1	24.991	27.658	30.796	33.598	23.763	24.168	22.565	21.824
B1.1	11.325	9.857	11.35	12.622	8.065	6.916	6.082	6.279
B2.1	2.841	2.424	2.946	2.94	1.801	1.209	1.078	1.068
B3.1	1.302	1.519	1.628	1.733	1.34	1.221	1.101	1.126
B1.2	9.064	7.8	9.278	10.174	6.324	5.16	4.53	4.622
B2.2	2.566	2.273	2.9	2.914	1.823	1.249	1.106	1.114
B3.2	2.054	5.431	6.111	6.802	6.749	6.94	7.034	7.472
1.12	22.484	18.171	18.989	22.294	14.513	11.537	10.561	11.153
Dum13	71.958	65.496	78.653	81.384	75.421	69.247	69.291	62.95
1.11	53.177	57.94	71.252	72.687	65.426	59.99	60.178	51.797
Dum12	49.419	48.148	58.679	57.35	46.661	45.282	45.03	44.686
1.13	16.24	13.363	13.937	16.414	10.76	8.922	8.328	8.873
1.14	43.224	42.801	52.238	50.763	40.955	37.695	37.587	39.858
1.15	32.012	27.17	28.524	32.489	21.798	18.753	18.625	20.21

■ Table B-4 XP-RAFTS Peak Total Flow – 50 year ARI Event (m^3/s)

Node	Event Duration							
	30 min	1 hr	90 min	2 hr	3 hr	6 hr	9 hr	12 hr
Dum1	83.391	78.159	93.423	96.261	88.052	80.909	79.411	64.027
Dum2	84.386	79.425	94.419	97.612	89.814	81.567	80.029	64.223
Dum3	82.449	80.554	93.215	99.896	92.361	83.671	81.957	67.432
Dum4	90.187	83.742	94.326	101.37	94.046	86.295	84.502	70.964
Dum5	100.92	112.62	122.18	126.41	118.32	109.01	107.19	89.692
Dum9	134.47	153.88	154.01	152.69	143.5	137.01	134.47	120.88
Dum11	133.65	151.58	151.33	153.44	143.93	137.72	135.26	121.01
OUT	133.65	151.58	151.33	153.44	143.93	137.72	135.26	121.01
2.2	3.152	2.889	3.592	3.678	2.293	1.577	1.397	1.284
2.1	6.742	5.606	6.464	7.153	4.373	3.226	2.854	2.642
3.2	5.643	5.147	6.259	6.515	3.967	2.651	2.346	2.148
3.1	1.798	1.862	2.269	2.347	1.539	1.074	0.9561	0.8789
4.2	13.083	10.586	12.093	13.182	8.097	5.413	4.735	4.348
4.1	2.274	2.255	2.581	2.858	1.853	1.566	1.371	1.275
5.2	2.17	1.843	2.139	2.348	1.424	0.981	0.8735	0.7993
5.1	7.18	6.972	7.861	8.769	5.6	4.713	4.165	3.863
6.1	1.291	1.299	1.506	1.662	1.07	0.8447	0.7424	0.6847
7.1	0.7494	0.8756	1.018	1.086	0.7169	0.49	0.434	0.3985
8.2	0.7174	0.7287	0.8832	0.9301	0.6065	0.4271	0.3789	0.3473
8.1	1.524	1.603	1.965	2.007	1.333	0.9075	0.8046	0.7374
7.2	0.6677	0.6839	0.8099	0.8739	0.57	0.4372	0.3868	0.3559
S1.1	65.788	57.913	58.168	65.064	44.671	32.452	28.979	27.103
Dum10	70.28	63.763	63.538	70.089	48.67	36.718	33.125	31.126
S2.1	7.166	6.598	7.415	8.347	5.236	4.429	3.885	3.62
S2.2	1.779	1.728	1.969	2.178	1.39	1.112	0.9819	0.9068
Dum6	22.127	20.386	23.44	25.663	16.424	13.335	11.73	10.901
Dum7	24.585	23.117	25.216	27.712	17.866	15.145	13.493	12.44
Dum8	29.749	32.222	34.211	36.874	25.413	24.541	22.183	20.648
B4.1	30.462	33.711	36.767	39.185	28.407	27.563	25.132	21.824
B1.1	12.287	11.328	12.889	14.186	9.149	7.662	6.726	6.279
B2.1	3.044	2.721	3.235	3.227	1.987	1.323	1.178	1.068
B3.1	1.466	1.78	1.875	2.002	1.54	1.346	1.199	1.126
B1.2	9.839	9.057	10.551	11.477	7.275	5.673	5.004	4.622
B2.2	2.759	2.584	3.238	3.24	2.034	1.377	1.214	1.114
B3.2	4.104	7.712	7.857	8.331	8.041	8.243	7.898	7.472
1.12	24.465	20.532	21.468	24.88	16.172	13.135	11.742	11.153
Dum13	78.696	77.078	91.769	93.822	85.449	79.064	77.654	62.95
1.11	60.473	67.226	82.723	83.383	73.813	68.723	67.478	51.797
Dum12	55.89	57.23	67.328	65.844	52.914	52.219	50.537	44.686
1.13	17.791	15.25	15.748	18.435	12.101	10.203	9.264	8.873
1.14	49.704	50.194	59.356	57.362	45.598	43.695	42.216	39.858
1.15	35.092	30.939	32.201	36.788	24.648	21.832	20.847	20.21

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■ Table B-5 XP-RAFTS Peak Total Flow – 100 year ARI Event (m^3/s)

Node	Event Duration							
	30 min	1 hr	90 min	2 hr	3 hr	6 hr	9 hr	12 hr
Dum1	92.859	87.592	104.63	107.71	98.923	91.556	88.882	81.45
Dum2	94.472	88.847	106.1	109.42	100.82	92.435	89.624	81.86
Dum3	91.744	90.465	105.21	112.05	103.72	94.428	91.629	86.009
Dum4	100.46	93.633	105.32	113.84	105.71	97.527	94.559	90.691
Dum5	113.04	127.74	137.86	144.98	132.64	123.02	120.02	113.91
Dum9	152.49	172.37	172.79	175.14	161.58	154.06	150.57	152.5
Dum11	152.4	171.46	168.82	175.53	161.67	155.06	151.43	153.52
OUT	152.4	171.46	168.82	175.53	161.67	155.06	151.43	153.52
2.2	3.525	3.312	4.044	4.125	2.573	1.759	1.56	1.577
2.1	7.456	6.327	7.299	8.04	4.937	3.609	3.184	3.248
3.2	6.347	5.85	7.053	7.25	4.475	2.949	2.627	2.644
3.1	2.038	2.107	2.575	2.659	1.738	1.198	1.063	1.076
4.2	14.475	11.859	13.535	14.727	9.082	6.064	5.344	5.405
4.1	2.556	2.574	2.947	3.281	2.138	1.756	1.538	1.583
5.2	2.437	2.062	2.423	2.637	1.6	1.089	0.9721	0.9774
5.1	8.056	7.906	9.036	9.872	6.49	5.26	4.641	4.756
6.1	1.451	1.499	1.736	1.89	1.26	0.9452	0.8336	0.8463
7.1	0.8583	0.9991	1.174	1.225	0.8228	0.5466	0.4857	0.4901
8.2	0.8298	0.8307	1.013	1.055	0.6806	0.4759	0.423	0.426
8.1	1.728	1.79	2.217	2.252	1.484	1.01	0.8988	0.9051
7.2	0.7542	0.7811	0.9215	0.9945	0.6429	0.4878	0.4325	0.4387
S1.1	73.678	64.363	65.215	73.365	50.175	36.434	32.374	33.41
Dum10	78.948	71.03	71.377	79.108	54.773	41.279	37.061	38.388
S2.1	8.037	7.564	8.494	9.463	6.11	4.94	4.361	4.479
S2.2	1.998	1.956	2.272	2.48	1.61	1.242	1.1	1.117
Dum6	24.688	22.928	26.551	29.072	18.753	14.913	13.132	13.475
Dum7	27.438	25.967	28.501	31.332	20.408	16.934	15.073	15.444
Dum8	34.839	36.677	39.241	42.136	29.504	27.789	24.839	25.8
B4.1	35.642	38.308	42.049	44.653	33.016	31.144	28.15	27.359
B1.1	13.719	12.748	14.582	16.15	10.456	8.584	7.542	7.768
B2.1	3.389	3.017	3.609	3.562	2.217	1.471	1.312	1.311
B3.1	1.686	2.04	2.141	2.289	1.759	1.502	1.336	1.372
B1.2	10.969	10.18	11.969	12.922	8.297	6.329	5.59	5.706
B2.2	3.088	2.979	3.625	3.617	2.268	1.537	1.359	1.374
B3.2	5.917	9.166	9.141	9.578	9.163	9.778	8.935	9.47
1.12	27.194	22.965	24.195	27.985	18.203	14.949	13.237	13.947
Dum13	87.531	86.402	102.82	105.01	96.038	89.495	86.913	79.981
1.11	67.743	75.299	92.655	93.345	83.005	77.992	75.573	66.035
Dum12	62.522	64.753	75.737	74.901	60.425	59.391	56.782	56.422
1.13	19.823	17.114	17.856	20.7	13.634	11.647	10.416	11.106
1.14	55.897	56.847	66.419	65.206	51.378	49.89	47.474	50.348
1.15	39.372	34.849	36.483	41.637	28.02	25.108	23.452	25.552

Table B-6 XP-RAFTS Peak Total Flow – PMF Event (m^3/s)

Node	Event Duration						
	15 min	30 min	1 hr	90 min	2 hr	3 hr	6 hr
Dum1	422.01	386.82	494.7	519.32	539.93	420.01	299.36
Dum2	408.19	409.78	497.68	530	548.19	430.94	306.98
Dum3	374.2	443.23	504.64	546.38	565.99	450.28	322.04
Dum4	397.43	470.99	513.43	561.04	582.94	468.98	335.12
Dum5	494.28	552.09	718.28	718.81	748.43	594.93	418.35
Dum9	604.24	845.34	915.39	915.63	920.9	724.97	521.3
Dum11	606.23	841.31	916.56	914.8	925.17	729.3	524.41
OUT	606.23	841.31	916.56	914.8	925.17	729.3	524.41
2.2	18.051	15.319	12.614	10.315	9.966	6.895	4.444
2.1	36.444	30.178	24.971	20.647	20.122	13.345	9.145
3.2	32.16	26.968	21.077	17.583	17.187	11.636	7.475
3.1	11.098	10.161	8.724	6.979	6.72	4.628	3.028
4.2	69.407	55.389	44.753	34.257	33.779	23.759	15.089
4.1	13.576	13.538	12.264	10.321	10.005	6.504	4.471
5.2	12.013	9.829	7.771	6.282	6.104	4.289	2.759
5.1	42.393	40.686	36.791	30.988	30.103	19.552	13.466
6.1	7.87	7.603	6.641	5.464	5.345	3.454	2.374
7.1	4.954	4.808	3.97	3.306	3.145	2.147	1.385
8.2	4.456	4.06	3.446	2.803	2.669	1.823	1.205
8.1	9.489	8.721	7.305	5.957	5.772	3.913	2.548
7.2	4.161	4.059	3.513	2.828	2.789	1.813	1.236
S1.1	339.46	327.22	248.66	205.39	203.54	135.56	92.924
Dum10	359.97	369.89	291.36	238.5	236.88	157.17	107.7
S2.1	41.103	37.305	34.144	28.91	28.289	18.344	12.629
S2.2	10.578	9.801	8.689	7.253	7.021	4.537	3.154
Dum6	127.09	114.24	103.13	86.982	84.763	54.953	37.988
Dum7	132.85	128.61	119.47	101.74	99.86	65.193	44.529
Dum8	159.43	188.4	195.42	167.59	166.14	112.26	75.715
B4.1	160.84	191.89	206.93	187.35	185.76	128.94	86.648
B1.1	70.654	64.273	59.461	50.13	49.272	31.919	21.957
B2.1	16.509	13.165	10.779	8.388	8.228	5.636	3.595
B3.1	5.439	6.909	7.438	6.91	6.89	5.27	3.647
B1.2	56.44	49.967	44.033	36.851	35.766	23.034	16.03
B2.2	15.872	13.546	10.924	9.057	8.816	6.017	3.873
B3.2	58.86	69.81	71.62	61.84	61.53	42.17	27.54
1.12	130.66	113.88	99.085	84.914	85.024	58.431	37.911
Dum13	417.41	366.64	483.74	509.48	526.96	406.19	288.83
1.11	292.12	318.56	431.46	446.25	458.9	356.02	251.63
Dum12	284.08	303.24	393.1	363.01	368.01	272.27	186.77
1.13	96.211	84.731	78.671	68.394	69.251	47.573	30.941
1.14	251.69	277.31	333.16	311.48	312.18	233.6	156.16
1.15	191.71	173.82	174.93	157.47	158.6	113.76	75.17

Appendix C Hydraulic Model Results

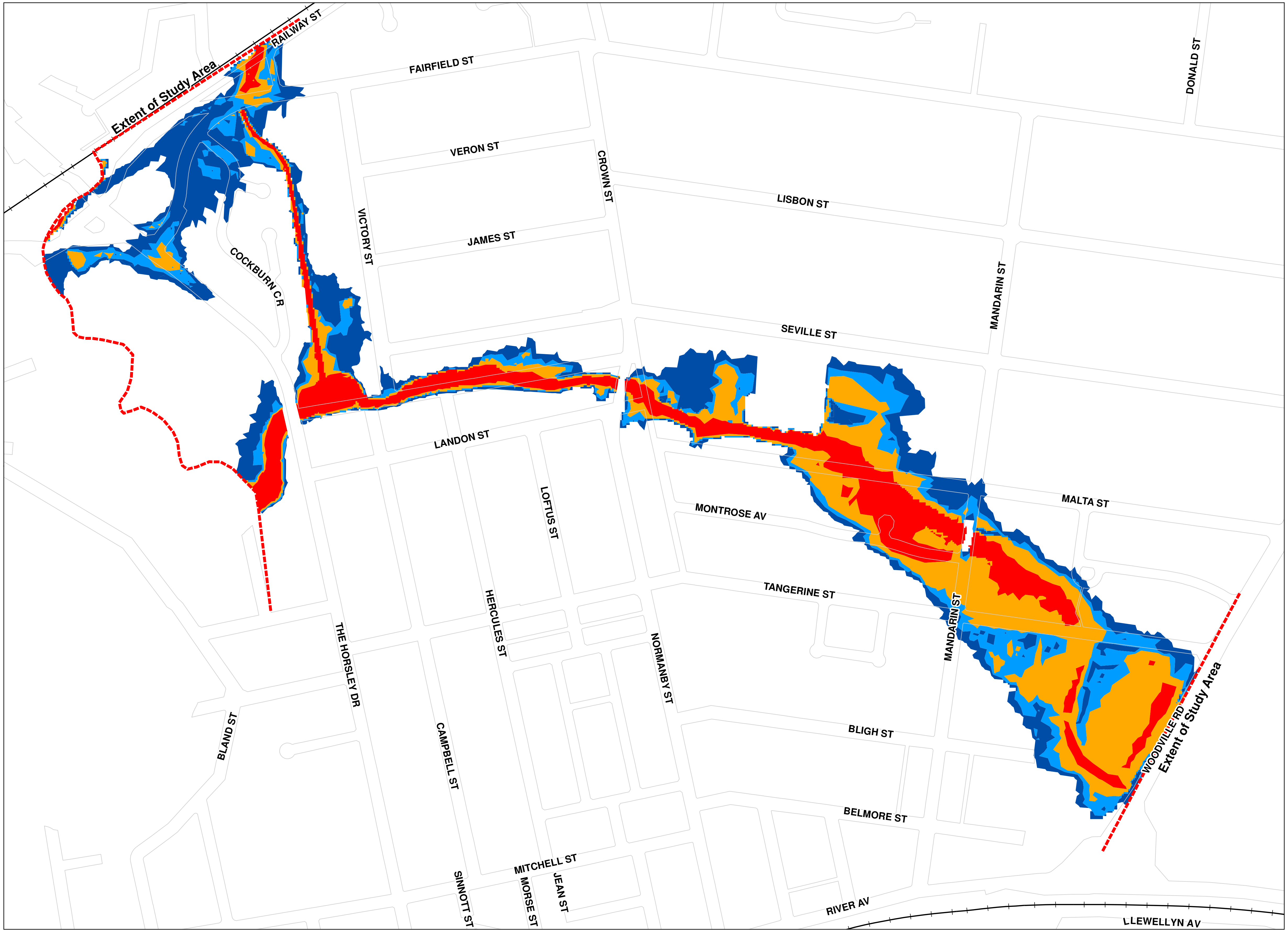
Table C-1 Peak Water Level at Selected Locations

Location	20 year ARI Event	50 year ARI Event	100 year ARI Event	PMF Event
Burns Creek				
Woodville Road D/S	14.55	14.69	14.81	16.50
Tangerine Street U/S	12.96	13.05	13.13	15.00
Tangerine Street D/S	12.73	12.85	12.94	14.87
Mandarin Street U/S	12.23	12.36	12.47	14.37
Malta Street	11.35	11.56	11.72	13.79
Mid Malta Normanby	10.49	10.68	10.81	12.68
Normanby Street U/S	9.40	9.62	9.77	11.85
Hanson Street	8.14	8.33	8.46	10.76
Hercules Street	7.46	7.69	7.85	10.24
Campbell Street Footbridge	6.98	7.26	7.50	9.94
The Horsley Drive U/S	6.72	7.08	7.36	9.22
Stimsons Creek				
Fairfield Street U/S	11.01	11.05	11.10	11.77
Fairfield Street D/S	9.26	9.26	9.32	9.78
Dunrossil Avenue	7.95	8.01	8.09	9.62
James Street	7.34	7.41	7.51	9.61
Stimpsons Creek D/S at Seville Street	6.76	7.11	7.38	9.54

Table C-2 Peak Flow and Critical Storm Duration*

Location	20 year ARI event		50 year ARI event		100 year ARI event		PMF Event	
	Peak Flow (m^3/s)	Critical Storm Duration	Peak Flow (m^3/s)	Critical Storm Duration	Peak Flow (m^3/s)	Critical Storm Duration	Peak Flow (m^3/s)	Critical Storm Duration
Burns Creek								
Tangerine Street	67	2 hr	80	2 hr	91	2 hr	544	2h
Malta Street	73	2 hr	86	2 hr	95	2 hr	504	2h
Normanby Street	68	2 hr	73	2 hr	81	2 hr	455	2h
Stimsons Creek								
Fairfield Street	65	30 min	69	30 min	75	30 min	151	15 min
James Street	58	30 min	62	30 min	68	30 min	137	30 min

* Peak flow estimates presented above were derived from TUFLOW model 1D and 2D flow results at each location for each ARI/ duration storm event. The critical storm duration at each location was then determined for each ARI event by comparing the peak flows over the range of storm durations.



Legend

100yr ARI Flood Depth

- 0 - 0.3m
- 0.3 - 0.5m
- 0.5 - 1.0m
- > 1.0m
- Railway

Roads: LPI_NSW_Road_corridor
Railway: SW_NSW_Railway

0 300
Metres

NOTE:
The extent of flood depths shown are approximate only. Mapping does not include overland flooding from the Old Guildford catchment or local stormwater flooding.

The area to the west of Crown Street is impacted by flooding from Prospect Creek, and this has been reflected in the flood mapping.

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Figure C-1 Flood Depth Map, 100 Year ARI Event

Burns Creek Flood Study

GDA_1994_MGA_Zone_56

7 July 2011
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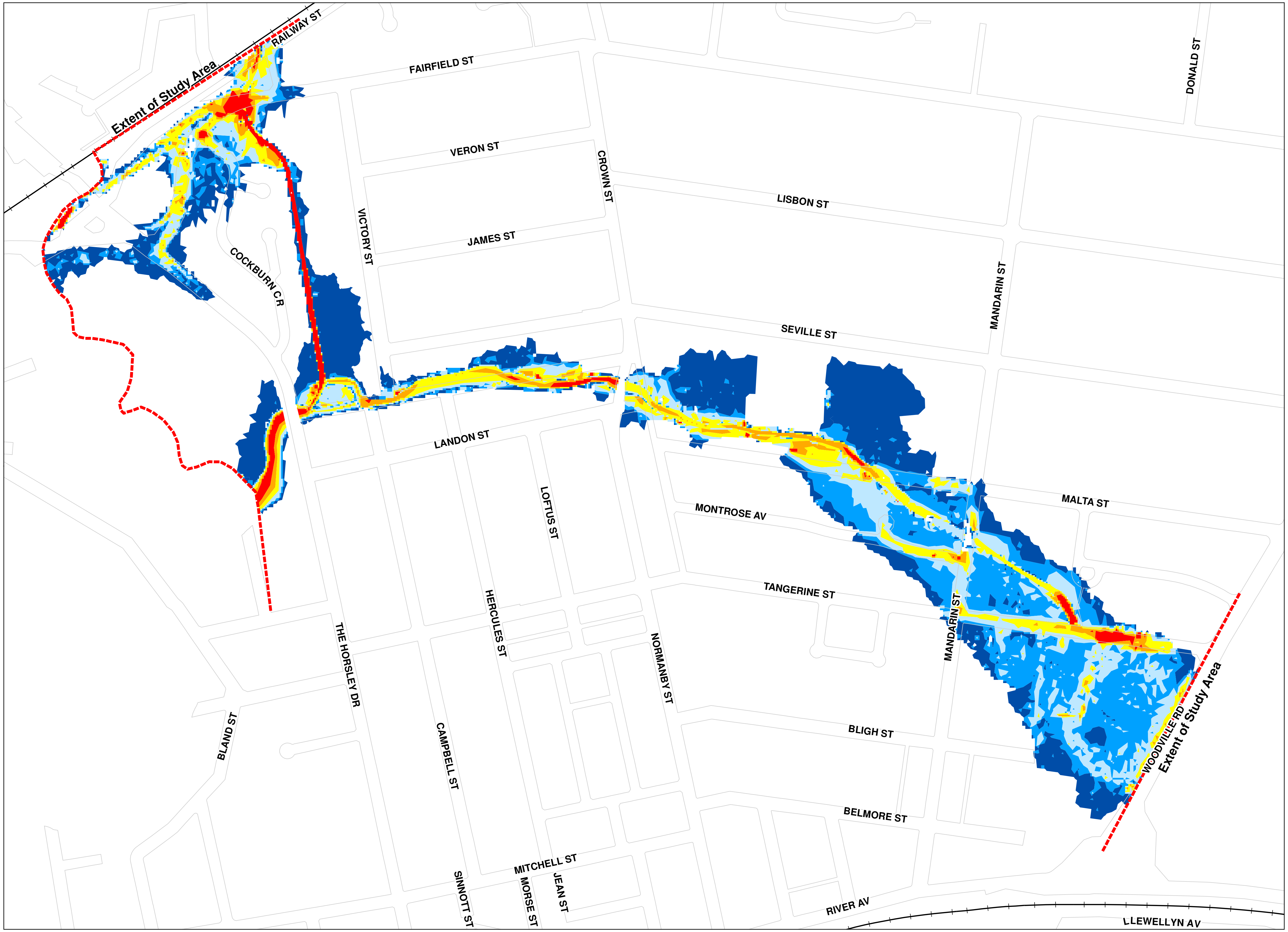

Legend

100yr ARI Flow Velocity

- 0 - 0.25m/s
- 0.25 - 0.5m/s
- 0.5 - 1.0m/s
- 1.0 - 1.5m/s
- 1.5 - 2.0m/s
- > 2.0m/s
- Railway

Roads: LPI_NSW_Road_corridor
Railway: SW_NSW_Railway

0 300
Metres

NOTE:
The extent of flood velocities shown are approximate only. Mapping does not include overland flooding from the Old Guildford catchment or local stormwater flooding.

The area to the west of Crown Street is impacted by flooding from Prospect Creek, and this has been reflected in the flood mapping.

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Figure C-2 Flood Velocity Map, 100 Year ARI Event

Burns Creek Flood Study

GDA_1994_MGA_Zone_56

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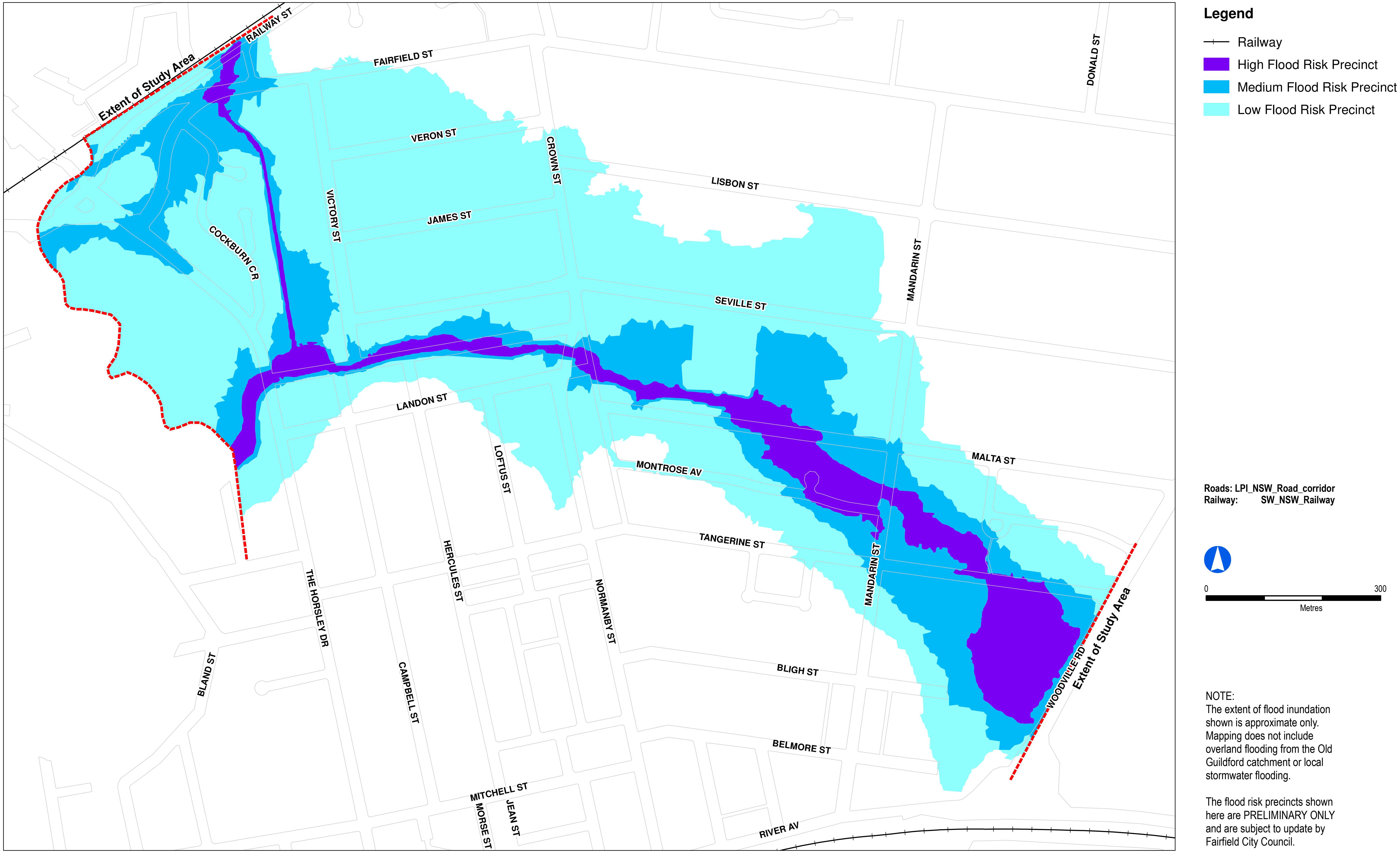
Appendix D Interim Flood Risk Precinct Mapping



NOTE:
The extent of flood inundation shown is approximate only. Mapping does not include overland flooding from the Old Guildford catchment or local stormwater flooding.

The flood risk precincts shown here are PRELIMINARY ONLY and are subject to update by Fairfield City Council.

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Figure D-1 Interim Flood Risk Precinct Map

Burns Creek Flood Study

GDA_1994_MGA_Zone_56

12 May 2011

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