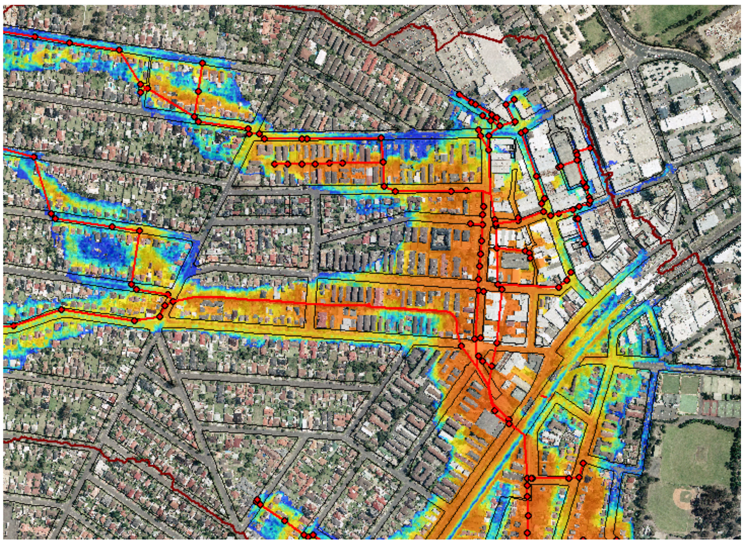
Fairfield Overland Flood Study



FINAL REPORT

- August 2010

In association with

FAIRFIELD CONSULTING SERVICES

A Division of Fairfield City Council

Fairfield Overland Flood Study

FINAL REPORT

- August 2010

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Executive Summary

The local government area of Fairfield City is crossed by several major creeks, all of which are prone to mainstream flooding. In addition, parts of Fairfield City are at risk of overland flooding from stormwater that runs off from urbanised catchments to the creeks. Both types of flooding present a significant risk to life and property.

In order to address and mitigate this flood risk, Fairfield City Council is following the NSW Government's 2005 Floodplain Development Manual. The manual outlines a floodplain risk management process, leading to the preparation and implementation of a floodplain risk management plan. Plans are to be prepared for both mainstream and local overland flooding.

A preliminary assessment of the risk of flooding from overland flows within the urban areas of Fairfield was undertaken in 2003-2004 as part of the *Fairfield City Overland Flood Study*. This study prioritised the 18 urban subcatchments for more detailed investigation. The Fairfield sub-catchment, centred on the Fairfield central business district (CBD), was ranked as the second highest priority.

In 2007, Sinclair Knight Merz, in association with Fairfield Consulting Services, was engaged to undertake a detailed flood study of the Fairfield subcatchment. The key objectives of the study were to describe the nature and extent of overland flooding within the subcatchment and to prepare flood risk precinct maps for several events including the probable maximum flood (PMF). This study would then provide the basis for preparing a floodplain risk management study and plan that would identify and recommend a range of measures to reduce the risk of overland flooding.

The methodology for undertaking the study was drawn from the *Canley Corridor Overland Flood Study*, completed in 2009. Modelling of the major trunk drainage network as well as selected 'trouble spots' was found to be the most efficient method of producing reliable results.

The 232 ha Fairfield overland flow catchment is located to the west of Prospect Creek and to the north of the downstream reach of Orphan School Creek. Encompassing the suburbs of Fairfield and Fairfield Heights, the catchment is highly urbanised and comprises both residential and commercial development.

The catchment generally drains in a south-easterly direction via a network of stormwater pipes and open channels before outfalling via St Elmo's Drain to Orphan School Creek. Because urban development has spread from east to west and up the catchment, parts of the stormwater network were not designed to cater for the progressive increase in impervious area. Flooding problems along the main overland flow paths within the catchment are exacerbated by stormwater pipes built under private property and by development extending to the top of bank of open channels.

A one dimensional DRAINS hydrologic and hydraulic model of key parts of the stormwater network within the catchment was initially established using topographic survey, spatial data and rainfall data. Relatively standard values for network and hydrologic parameters were assigned. A total of 190 pits and 211 pipes were represented in the model.

A two dimensional TUFLOW hydraulic model of the catchment was then established based on a two metre topographic grid. The TULFOW model also included the same one dimensional stormwater pits and pipe network as was established in the DRAINS model. Open channels were represented in the model but fencelines were excluded. Buildings were treated as solid objects within the floodplain in which floodwaters could not flow through. A downstream boundary condition was assigned based on the stage hydrographs developed for flood studies undertaken previously for Prospect Creek and Orphan School Creek.

The DRAINS model was run to provide initial flow inputs to the TUFLOW model. These flows are allowed to enter pits in TUFLOW up to the inlet capacity. Flows in excess of the inlet capacity, or flows that surcharge from the pipe network, form overland flow which are routed through the two dimensional TUFLOW model. Overland flows may enter the next downstream pit in TUFLOW if there is sufficient inlet capacity. This dynamic linking of the one dimensional pipe network and the two dimensional floodplain within TUFLOW was considered to provide the best representation of flood behaviour.

The TUFLOW model was initially stabilised by ensuring inflows were appropriately distributed over a number of inflow pits, representing open channels as 2D elements in large events and ensuring mass balance errors were minimised. Although the model could not be calibrated because of a lack of historical data, model results were compared and found to agree relatively well with the findings from previous drainage investigations and Council's database of known flooding trouble spots.

Sensitivity analyses revealed that the TUFLOW model was not sensitive to changes in Manning's n values and tailwater conditions. Increasing blockage factors of pits within the Fairfield CBD, however, significantly affected flood depths in this area.

The flood models were run for the 20, 100, 200, 500, 2000, 10,000 year average recurrence interval (ARI) events and the PMF, for a range of storm durations from 30 minutes to three hours. The peak water level and velocity for each storm duration at each 2D grid point were extracted and used to form a 'peak of peaks' grid that was subsequently used a basis for the flood mapping. Areas of nuisance or localised flooding less than 150 mm in depth were manually removed from the flood mapping.

Flood model results and the flood mapping for the 100 year ARI event indicate that:

- There are a number of flow paths in the upper catchment that flow into and converge at the Fairfield CBD. Floodwaters typically flow through properties, although parts of Hamilton Road, Nelson Street, Wrentmore Street and Barbara Street are significant flow paths.
- Overland flooding is generally deepest downstream of Harris Street, with depths exceeding 1m upstream of the railway embankment. Typical depths of flooding at properties in the mid and upper parts of the catchment are less than 0.3m. A number of properties downstream of the railway line are affected by overland flood depths between 0.5m and 1m.
- Flood depths in roads are typically less than 0.3m in the 100 year ARI event. Flood depths greater than 0.3m occur on Sackville Street, Hamilton Road, Wrentmore Street, Barbara Street, Railway Parade, York Street, Thomas Street, Fairlight Street, Wilga Street, North Street, Orchard Road and Riverview Road.
- Overland flooding in the Fairfield CBD area generally appears to be confined to the road corridors, however, floodwaters may flow through buildings depending on the presence and location of doorways and other openings.
- Flood velocities within properties are generally less than 0.5 m/s, with isolated areas of between 0.5 and 1.0 m/s across some properties in the upper catchment. The higher velocity flows (greater than 1m/s) are mainly contained within the roads, although higher flow velocities occur between Churchill Street and Macquarie Street.

Flood risk precinct maps have been prepared based on modelling of the 100 year ARI (medium risk) and PMF (low risk) events and using the flood risk precinct categories outlined in the Fairfield City-Wide Development Control Plan. The flood risk precinct mapping has identified:

- Approximately 2,000 properties are within the floodplain outline defined by the PMF event.
- Areas of high flood risk occur in the open concrete channel section between Sackville Street and Hamilton Road, at the lower part of the catchment adjacent to the natural creek channel of St Elmo's Drain, as well as at isolated pockets at the south end of Barbara Street and along Fairlight Avenue, which are above the box-culvert piped sections of St Elmo's Drain.
- In the upper section of the catchment, the medium flood risk precinct extends in a west to east direction along the main overland flow paths towards Barbara Street and along Barbara Street to the railway line. There is also some medium flood risk which extends in the low points east of Station and Ware Streets in the Fairfield CBD.
- In the lower section of the catchment, the medium flood risk precinct follows Fairlight Avenue on the east side of the railway line towards the creek. There is also a medium risk area which follows a low point across private properties east of Wilga Street towards Latty Street and

North Street. The minor overland flow path from Hampton Street is also within the medium flood risk precinct, which extends in a south-east direction towards the creek.

- The low flood risk precinct follows the outline of the medium flood risk precinct closely in the upper catchment, with the exception of a breakout during the PMF at Churchill and Eustace Streets. This breakout flows in a south-easterly direction through private property to Joyce Street. The low flood risk precinct starts to widen from Thomas and Harris Streets. The low flood risk precinct is wider east of Barbara Street and on the east side of the railway line.

The flood risk precinct maps only represent overland flooding from stormwater runoff within the Fairfield catchment. They do not cover areas in the lower catchment which are at risk of mainstream flooding from Orphan School Creek and Prospect Creek. Mainstream flood extents for Prospect Creek are reported in the 2006 *Prospect Creek Floodplain Management Plan, Flood Study Review*.

It is considered that the study has ultimately provided a good foundation from which to prepare the Fairfield Floodplain risk Management Study and Plan as the next step in the floodplain risk management process.

1. Introduction

1.1. Background

The Local Government Area (LGA) of Fairfield City covers an area of around 102.5 km^2 and is located on a number of floodplains. These floodplains comprises the low-lying land next to the Georges River and the city's eight major creeks. These creeks span over 80km in length and flow into both the Georges River and Hawkesbury-Nepean catchments. Being within a floodplain means that many suburbs in the LGA are prone to flooding.

In addition to the city's creeks, there are a number of watercourses and tributaries throughout the LGA that have been piped over the years, especially in the period between post-World War II and the 1970s, as part of the increasing urbanisation. Most of these piped flow paths are in urban areas. This gives rise to the potential for damage to properties and hazard to residents due to flooding.

Flooding in Fairfield LGA can occur in two different ways. These are mainstream flooding and local overland flooding. Mainstream flooding is the inundation of normally dry land due to flood waters overflowing the natural or artificial banks of a stream, river, estuary, lake or dam. Conversely, local overland flooding is the inundation caused by local runoff during heavy storms, usually from stormwater pits and pipes which have exceeded their capacities, rather than overbank discharge. Overland flows eventually end up in the local creek system.

Both types of flooding can cause significant damage. For example, major mainstream flooding occurred along lower Prospect Creek and Cabramatta Creek in August 1986 and April-May 1988. The 1986 flood caused an estimated total damage of $4.8 million. A smaller flood in January 2001 caused damage to the upper reach of Prospect Creek.

In addition, there are different scales of local flooding. At the lower end of the scale, minor flooding may result from a number of sources including blockage of drainage pits and pipes. At the upper end of the scale, major flooding can occur due to water flowing along natural floodways or across land due to the runoff exceeding the capacity of the trunk drainage system.

To mitigate the risk of flooding the NSW Government has adopted the Flood Prone Land Policy, as outlined in the 2005 NSW Floodplain Development Manual (FDM). The FDM describes the process by which Councils can undertake flood studies and prepare floodplain risk management studies and plans.

In accordance with the floodplain risk management process, Council has prepared a number of flood studies for both mainstream and overland flooding, as well as floodplain risk management plans for the Georges River and Cabramatta Creek. Council is also in the process of adopting a floodplain management plan for Prospect Creek. Eventually, flood studies and floodplain risk management plans will be prepared for all the city's sub-catchments for both mainstream and overland flooding. The plans detail a range of flood modification, property modification and emergency response measures that can be used to reduce flood risk. This may include voluntary house raising, vegetation management of the creeks, the construction of detention basins and floodways and implementation of development controls. Development controls are outlined in Council's City Wide Development Control Plan (DCP).

In the past, FCC concentrated primarily on studying mainstream flooding from the city's creeks as this was considered to be the main source of flood risk in the LGA. However, flooding from major overland flow paths and the resulting flood risk was not well understood. FCC has therefore embarked upon a program of undertaking overland flood studies in order to identify these major overland flow paths and to address the requirements of the FDM.

Identifying properties at risk of overland flooding within the entire LGA is a major undertaking. Instead of undertaking detailed assessment for the entire LGA in one step, FCC decided to undertake overland flood studies in a number of stages. In 2003-2004, Sinclair Knight Merz (SKM) was engaged by FCC to undertake the *Fairfield City Overland Flood Study* (SKM, 2004). This was a preliminary assessment of the flood risk from overland flows within the urban areas of the Fairfield LGA. The study divided the LGA into 18 sub-catchments and ranked each sub-catchment in terms of the potential severity of overland flooding.

The *Fairfield City Overland Flood Study* identified the Fairfield sub-catchment as the 2nd highest ranked out of the 18 sub-catchments in Fairfield LGA, in terms of the number of properties at high risk from flooding. Other high-priority sub-catchments identified included Old Guildford (1st), Smithfield (3rd) and the Canley Heights (4th) sub-catchments.

The *Canley Corridor Overland Flood Study* (SKM, 2009), which primarily covered the Canley Heights sub-catchment, was undertaken as the first of a series of detailed overland flood studies by FCC, as there was a large amount of asset data available, and because there was a significant amount of urban renewal occurring in the study area. The Canley Corridor study was undertaken as a pilot study to evaluate a number of alternative flood modelling and mapping methodologies, based on different assumptions made about the capacity of the stormwater drainage system. The Canley Corridor overland flood study defined the flood behaviour and identified the major overland flow paths within the Canley Corridor catchment, identified properties at risk of overland flooding for the preparation of flood risk precinct maps.

It was concluded from the Canley Corridor overland flood study that the Smithfield, Old Guildford and Fairfield Overland Flood Studies should be undertaken using a similar methodology that was developed and selected as the preferred approach in the Canley Corridor study.

FCC subsequently commissioned SKM in 2007 to undertake an overland flood study for the Fairfield sub-catchment. This study was undertaken in association with Fairfield Consulting Services (FCS), a business unit division of FCC.

The Fairfield Overland Flood Study will quantify the scale of local overland flooding in the Fairfield sub-catchment and will form the basis for preparing the floodplain risk management study and plan for the area. For the purposes of this study, the Fairfield sub-catchment will now be known as the Fairfield catchment.

1.2. Study Area

1.2.1. Description

The 232ha Fairfield overland flow catchment is located in the eastern portion of Fairfield LGA, to the west of Prospect Creek and to the north of the downstream reach of Orphan School Creek. The study area locality is shown on **Figure 1-1**.

Figure 1-2 shows the study area in detail. The lower reaches of Prospect Creek and Orphan School Creek bound the catchment to the south-east and the remaining catchment is bound by local streets. Suburbs located in the study area include Fairfield and Fairfield Heights. **Figure 1-2** also shows sections of open channel in the catchment.

Three main roads split the catchment in approximately three even sections in a north-south direction. These roads are The Boulevarde, Sackville Street and Railway Parade. Hamilton Road bisects the catchment in an east-west direction. The street layout generally follows an east-west and north-south grid. The Cumberland and South lines of the CityRail network traverse the catchment area just south-east of Fairfield CBD along Railway Parade.

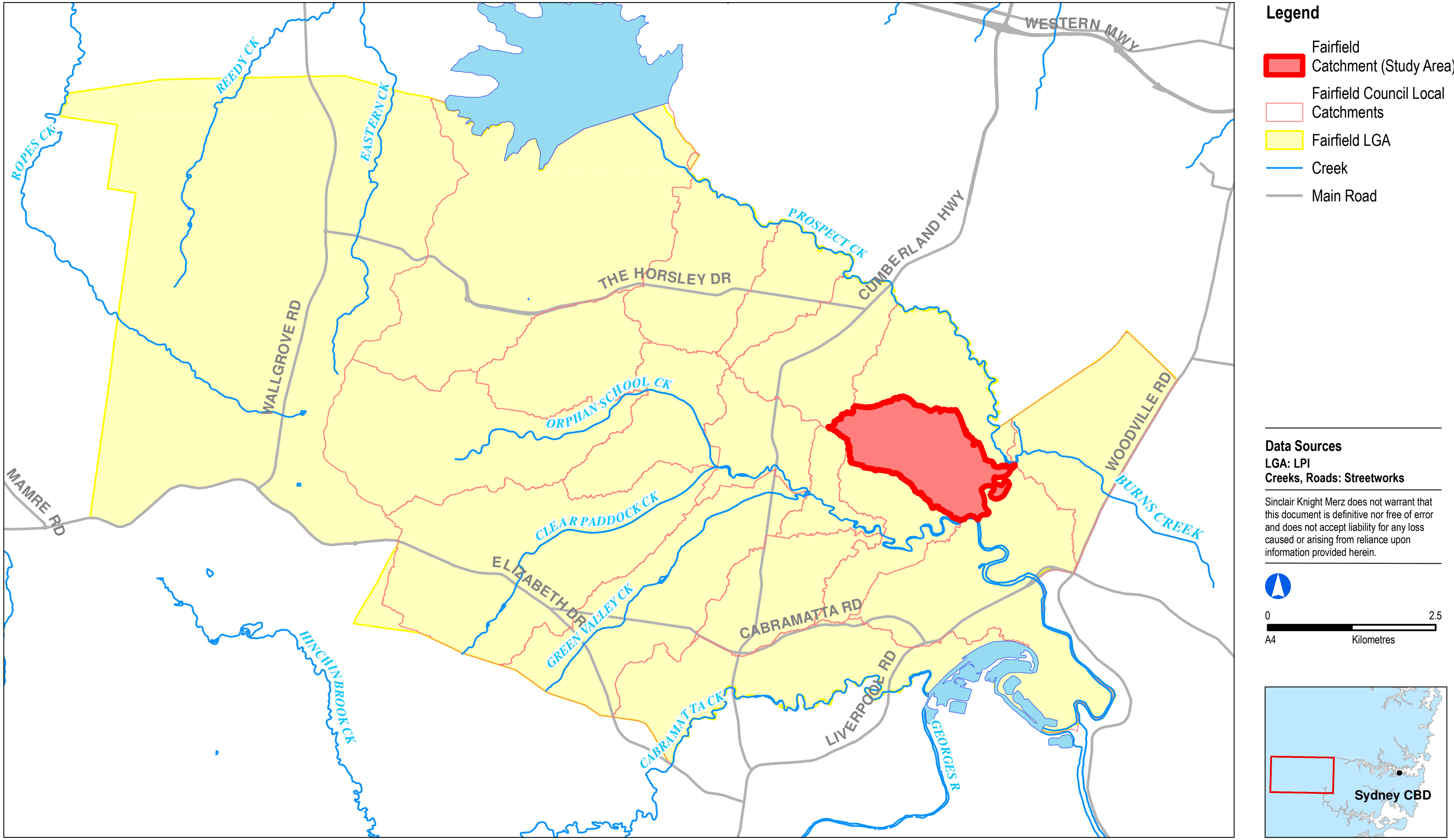

Figure 1-1 Locality

Fairfield Overland Flood Study

Version 1

GDA 1994 MGA Zone 56

February 3, 2010

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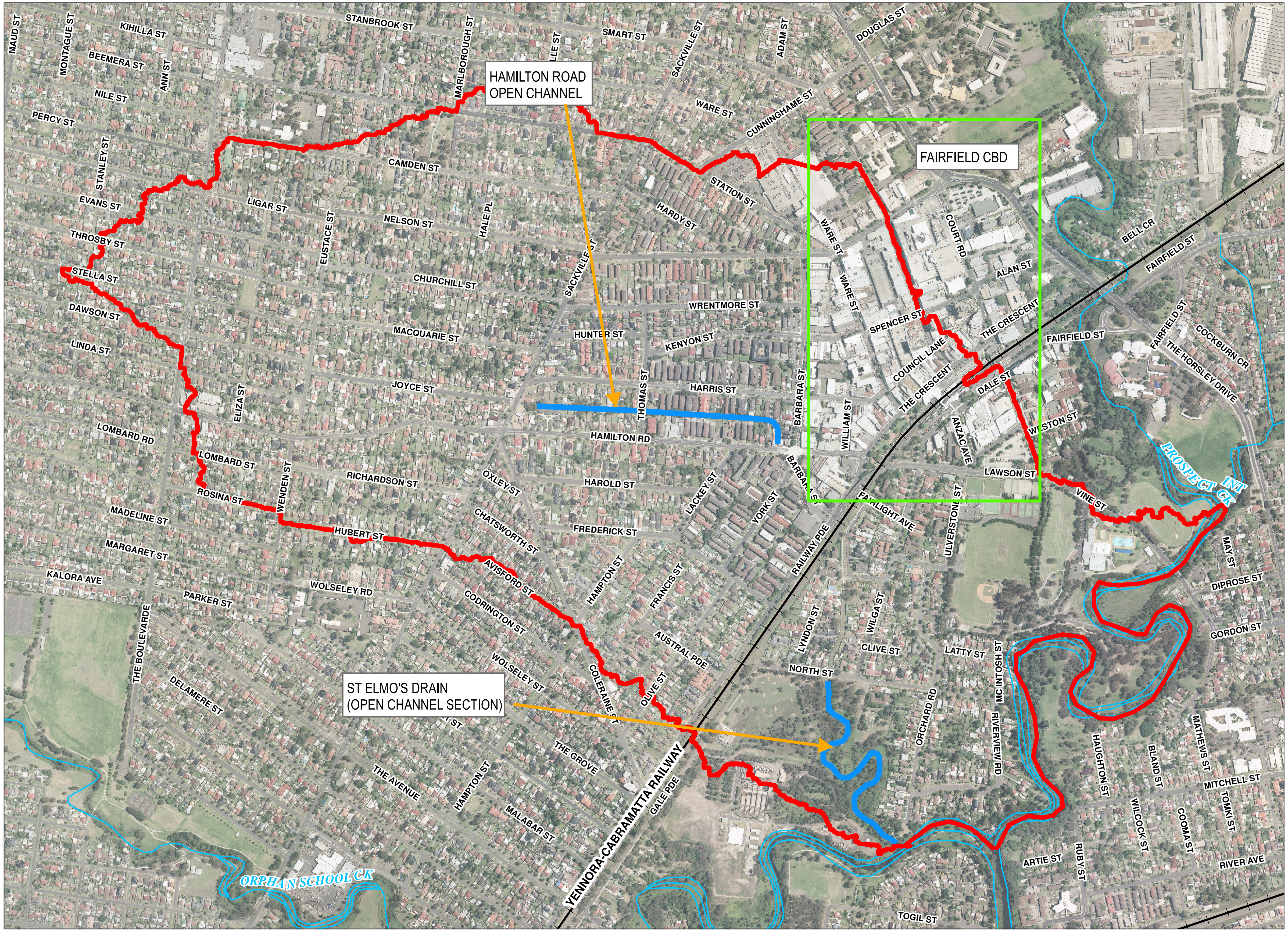

Legend

- Fairfield Catchment
- Railway
- Creeks

Data Sources

Aerial:AUSIMAGE
Creeks, Roads: Streetworks

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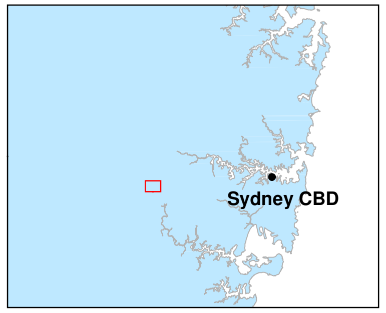

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Figure 1-2 Study Area

Fairfield Overland Flood Study

VERSION 1

GDA 1994 MGA Zone 56

February 3, 2010
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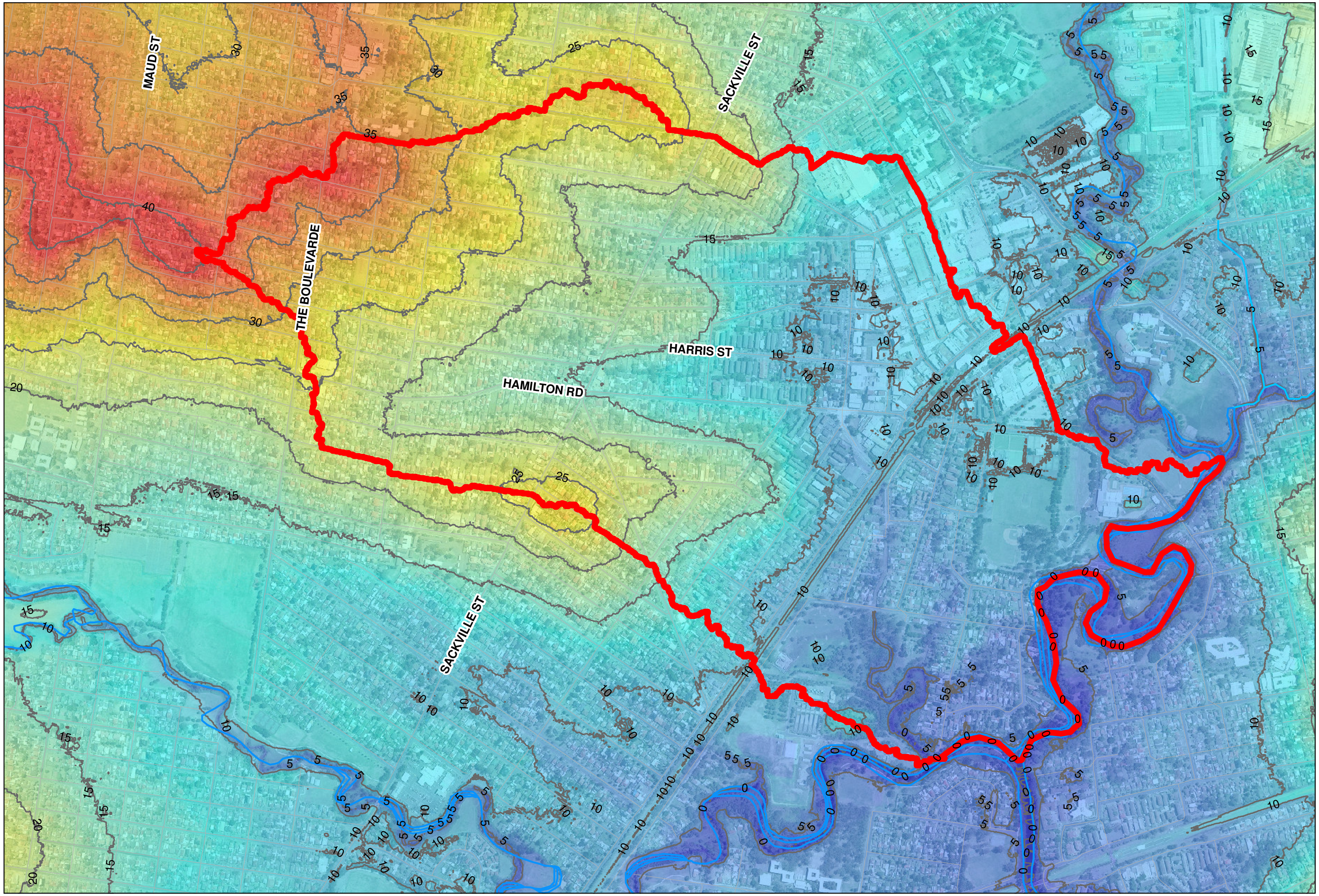
The topography of the study area is shown in **Figure 1-3**. The highest points in the catchment are at the intersection of The Boulevard and Ligar Street to the west (41m AHD), near the intersection of Granville and Ware Streets to the north (29m AHD) and near the intersection of Sackville and Avisford Streets to the south (27m AHD).

The Fairfield catchment is situated on relatively flat terrain but generally drains in a south-easterly direction and outfalls to St Elmo's Drain just north of its confluence with Orphan School Creek. There are typical slopes of around 3% in a south-easterly direction west of Sackville Street, approximately 0.5% east of Sackville Street in an easterly direction towards Prospect Creek and around 2% in a south-easterly direction from Avisford Street to the southern catchment outlet at St Elmo's Drain.

The land use in the study area is primarily residential, mostly characterised by medium-density dwellings. The suburb of Fairfield has a higher proportion of flats/units/apartments (34.3% according to the 2001 Census) than the rest of the LGA. There is a significant area of commercial land use located in north-east section of the catchment in the Fairfield CBD, which is the largest commercial area within the LGA. Three of Fairfield's major shopping malls are located in this catchment. There are also areas of recreational landuse, parklands and open space areas located in the lower catchment. Areas of significant vegetation are confined to the corridors along Prospect Creek, Orphan School Creek and St Elmo's Drain.

Rapid population increase after World War II saw the settlement of many ex-servicemen and European migrants in the Fairfield catchment. Large scale Housing Commission development and the expansion of the commercial centre occurred in the 1950s and swelled the population in the area. Fairfield CBD gradually spread along the streets leading from Fairfield railway station, however the spread was generally only on the northern side of the railway line, despite a concentration of new housing to the southern side. This northern expansion was likely due to the level crossing at Vine Street which inhibited buses and cars from proceeding to the southern side.

The stormwater drainage networks were, however, not designed to cater for the large increases in catchment imperviousness upstream as high density and commercial development in the catchment expanded from east to west and south to north (i.e. downstream to upstream). Pipes were also built under private properties in many locations and development extends to top of bank of open channels in the upper catchment. Today, the existing drainage network in the Fairfield catchment is ageing and undersized in relation to current standards and, for this reason, overland flooding is a major problem within this catchment.



Legend

Fairfield Catchment

5m Contour Level (m AHD)

Aerial Photo: AUSIMAGE

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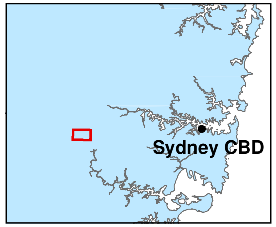

Figure 1-3 Topography

GDA 1994 MGA Zone 56

Fairfield Overland Flood Study

Version 1

February 4, 2010

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1.2.2. Drainage Conditions

The drainage conditions in the study area are described below and shown in **Figure 1-4**:

- A major overland flow path traverses the centre of the study area from west-east along Hamilton Road.
- A second major overland flow path traverses the northern section of the study area in a west-east direction, then turns south to pass through Fairfield CBD.
- Both the first and second overland flow paths converge in the CBD and continues southwards over and through (via culvert) the railway embankment, before discharging into St Elmo's Drain. Floodwaters ponds behind the railway embankment in large events.
- A third, smaller overland flow path is located in the southern section of the study area and also discharges into St Elmo's Drain.
- The pipe drainage network generally follows the overland flow paths through the study area, and includes trunk drainage lines (multiple box culverts) through and downstream of the CBD, in addition to a section of open concrete channel on the first major overland flow path between Sackville Street and Hamilton Road.

Areas within the south-eastern section of the study area are also affected by mainstream flooding from Prospect Creek and from Orphan School Creek.

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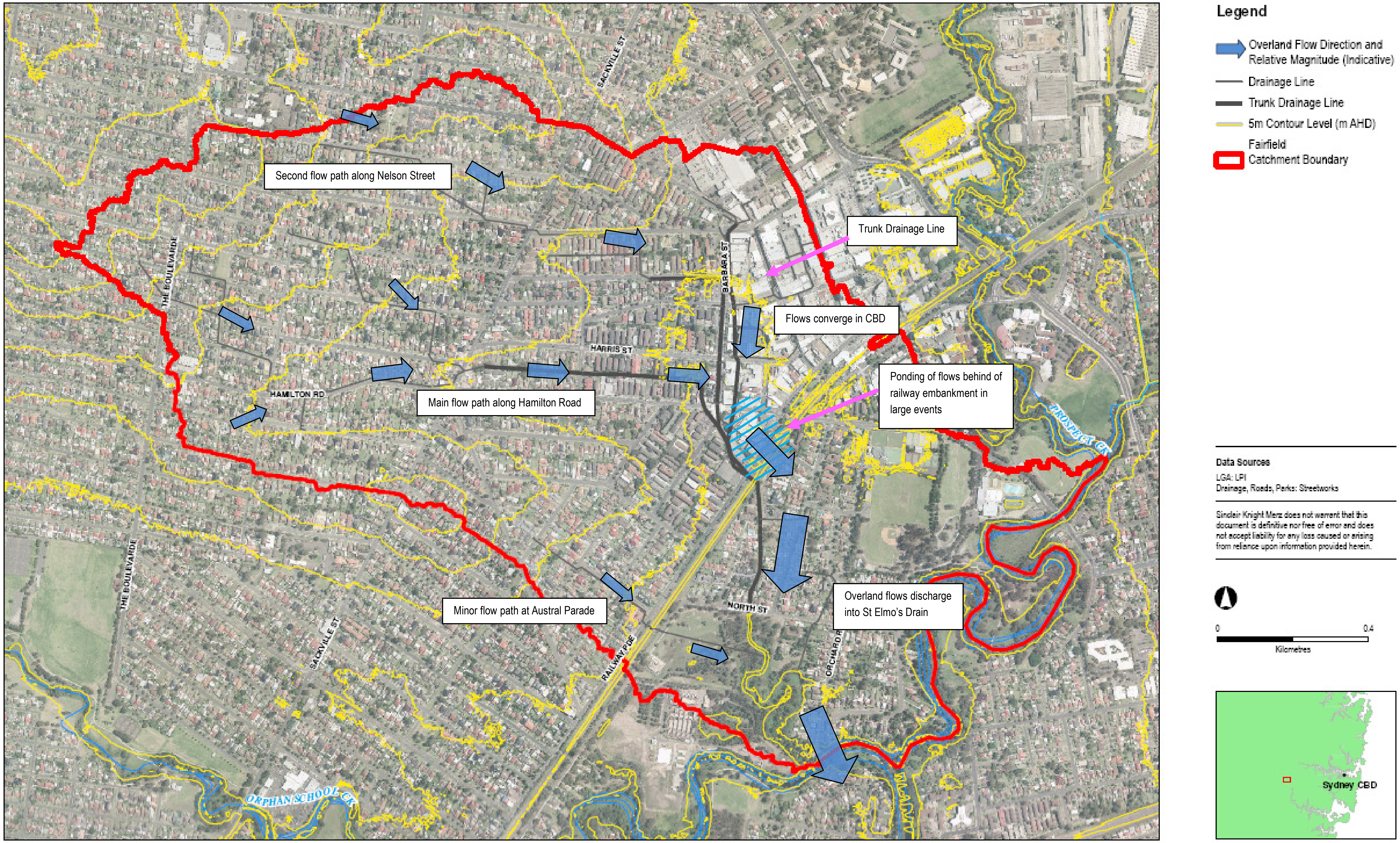
- **Figure 1-4 Overland Drainage Patterns**



1.3. Study Objectives

Key objectives of this study are to:

- Identify the major overland flow paths within the Fairfield catchment study area.
- Determine the nature and extent of overland flooding and flood risk in the study area.
- Identify properties at risk of local overland flooding and quantify the risk of flooding to these properties.
- Produce flood model results (flood level, velocity and flow) for the 20, 100, 200, 500, 2,000 and 10,000 year ARI and PMF storm events
- Prepare flood extent (depth and velocity) maps and flood risk precinct maps for the study area for the 100 year ARI and PMF events.
- Assess the sensitivity of flood behaviour to changes in hydrologic and hydraulic characteristics in the catchment.

Originally, it was intended to also identify "Zones of Significant Flow" to determine those sections of overland flow paths through properties which would need to be kept clear in order to reduce flood risk. Due to time constraints, these zones will be identified in the floodplain risk management study and plan.

2. Review of Available Data

2.1. Previous Studies

A number of previous studies are relevant to the study area, including the following:

- Willing & Partners (1986) *St Elmo's Drain Study.* Limited information is available on historic overland flooding in the Fairfield catchment, however one reference was found in the Willing & Partners 1986 study. A peak discharge was estimated at the Sackville Street and Hamilton Road intersection for the 1985 flood, however the study did not indicate the recurrence interval of the storm event. Findings of this report are discussed in further detail in **Section 3.6**.
- Willing & Partners (1986) *St Elmo's Drain Stage 2 Railway Pde to Wrentmore St Design.* Design drawings for drainage upgrades which were recommended in the *St Elmo's Drain Study* were referred to for this report.
- Bewsher Consulting (2006) *Prospect Creek Floodplain Management Plan, Flood Study Review.* Stage hydrograph results were extracted from the numerical model used for this study in order to model boundary conditions for the Fairfield overland flood study.
- Sinclair Knight Merz (2008) *Flood Study for Orphan School Creek, Green Valley Creek and Clear Paddock Creek.* Stage hydrograph results were extracted from the numerical model used for this study in order to model boundary conditions for the Fairfield overland flood study.
- SKM (2008) *Nelson Street Carpark Water Detention and Reuse Project*. A detailed assessment using a DRAINS model of this known flood problem area in the Fairfield CBD identified properties at risk to flooding up to the 10 year ARI event. Information from this study was used to compare results obtained from the Fairfield catchment TUFLOW model.

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 has subsequently been 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.

2.2.2. Ground Survey

Ground survey provides more accurate information than ALS in certain areas, particularly within waterway channels and in areas where there is dense vegetation. Ground survey was obtained by

FCC staff in June 2009 for the lower section of the open concrete channel, between Thomas Street and Hamilton Road. Cross section profiles of the channel were obtained, in addition to obvert and deck levels for two concrete slabs over the open channel, which have been placed to provide additional car parking for the apartments at 61 and 71 Harris Street, Fairfield.

Ground level data for the upstream section of the concrete channel, between Thomas Street and Sackville Street, was obtained from "works as executed" drawings (Plan No. MISC. 599) rather than ground survey. Field observations by FCC survey staff indicated that the profile of the concrete channel was slightly different to those shown on the work as executed plans, due to the channel walls being pushed inwards by the progressive slumping of the fill material behind the walls over time. Copies of selected WAE drawings are included in **Appendix A.**

Channel survey data of the heavily-vegetated St Elmo's Drain was not obtained for this study due to project constraints. It was agreed with FCC that, for the purposes of this study, ALS would be used to define the topography of the channel in the hydraulic model. The model topography will subsequently be updated with ground survey in the floodplain risk management study.

2.2.3. Design and Works as Executed Drawings

Design plans and works as executed (WAE) drawings were obtained for the following features for use in this study:

- Upstream section of the open concrete channel, between Thomas Street and Sackville Street.
- Design drawings D/L3/2 (Willing & Partners, May 1987) for trunk drainage/culvert sections of St Elmo's Drain (Stage 2 works) in and south of Fairfield CBD.

2.2.4. Pit and Pipe Survey

The levels and dimensions of key pits and pipes were surveyed by FCC surveyors in 2007/2008. Typical details surveyed include:

Pits

- Pit name/asset number
- Pit coordinates (Easting, Northing)
- Pit surface level (m AHD)
- Pit invert level (m AHD)
- Pit type
- Pit entry dimensions – lintel length and/or inlet grate dimensions.

Pipes

- Pipe name/asset number
- Upstream and downstream invert levels (m AHD)
- Pipe length
- Conduit type – circular pipe or box culvert
- Dimensions – diameter or width/height
- Upstream and downstream node.

Data on the pits and pipes is contained in **Appendix B**.

Not all pits and pipes in the stormwater network were surveyed. Only key/critical pits and pipes, as identified by FCC, were surveyed for the purpose of developing a simplified stormwater network model. This is discussed further in **Section 3.2.1**.

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 extent and risk maps. The aerial photography that was used was flown in March 2007. This photography is at a resolution of 0.15m.

2.4. Spatial Data

Various layers of GIS data were made available for this study from FCC, and through SKM's previous work within Fairfield LGA. These include:

- FCC digital cadastre and Local Environment Plan (LEP);
- Building polygon layer, derived in 2003/04 from 2002 aerial photography and updated based on recent aerial photography (where required); and
- Digital pit and pipe layer for the complete stormwater network.

Data from a surface impervious area (SIA) study undertaken for FCC by Lagen Spatial Pty Ltd became available in 2009 after the Fairfield Overland Flood Study commenced. The SIA study accurately identifies all impervious areas across the LGA, however it was not used in this study due to the late availability of the SIA data and project time constraints.

2.5. Rainfall Intensity-Frequency-Duration Data

This study uses design rainfall intensity-frequency-duration (IFD) data, derived for 33.875° S, 150.925° E (near Fairfield), issued April 1997 by the Hydrometeorological Advisory Service of the Bureau of Meteorology. The IFD data provides average rainfall intensities for events up to and including the 100 year ARI event. The data was extrapolated to derive average rainfall intensities for the 200 and 500 year ARI events. Further detail on rainfall data is provided in **Section 3.2.5**. The IFD data is provided in **Appendix C.**

2.6. Record of Historical of Overland Flow Problems

FCC has kept a record of 'trouble spots' where the public has identified past stormwater flooding problems. This record includes a number of locations within the Fairfield study area.

Based on investigations into these problem areas, FCC has subsequently developed their *Drainage Investigation Records* of properties historically affected by overland flooding since 1985.

Both these datasets have been made available for the study. They were used to identify the extent of the pipe network which required modelling, particularly where the trouble spot areas occur where pipe sizes are less than 900mm in diameter. The datasets were also used as a check for the final flood mapping.

3. Hydrologic and Hydraulic Model Development

3.1. Modelling Approach

The modelling approach adopted in the Fairfield Overland Flood Study consisted of the following aspects:

- Development of a DRAINS model to represent catchment hydrology and selected key/critical pits and pipes of the drainage network. Outputs from the DRAINS model included sub-catchment flow hydrographs for various storm events and estimates of the pit hydraulic loss coefficients
- Development of a TUFLOW model to represent the floodplain in 2D, and pits/pipes in 1D. The same key pits and pipes as in the DRAINS model were represented.
- Input sub-catchment flows (from DRAINS) into TUFLOW at the pit locations. Flows can enter the pits up to the inlet capacity. Flows in excess of the inlet capacity, or flows which surcharge from the system, form overland flooding.
- The excess or surcharging flows may flow downstream to the next pit, which they may enter if that pit has the capacity to accept flow.
- The TUFLOW model is run for the duration of the flood event. Maximum flood levels, depths, velocities, flow rates and flooding extents are output in results files.

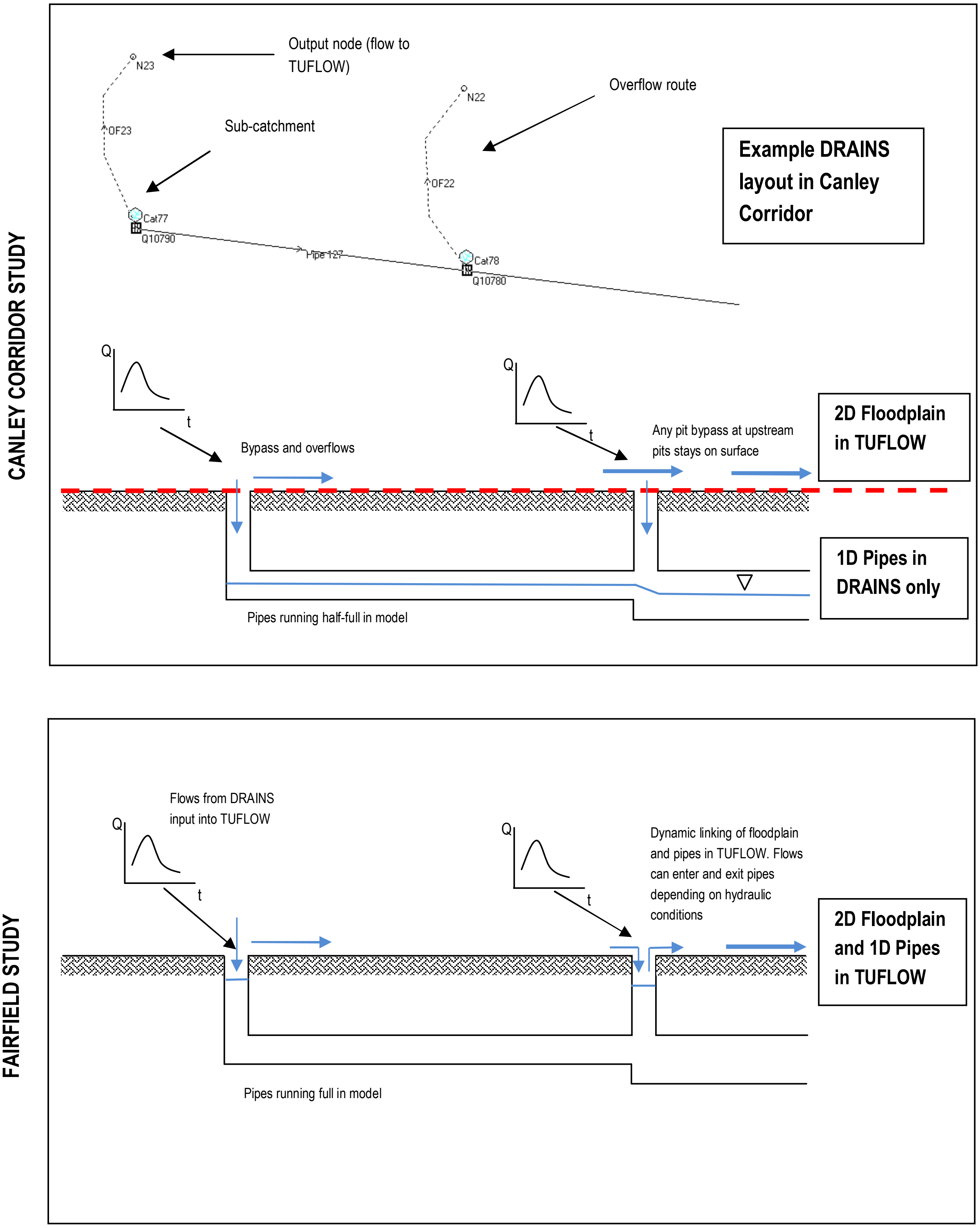
The adopted modelling approach in TUFLOW allows representation of the stormwater drainage system in 1D, in addition to the overland flow floodplain in 2D, with dynamic linking between the 1D and 2D domains in TUFLOW. This means that water is able to flow into the drainage system from the 2D floodplain and vice versa, depending on the hydraulic conditions.

Preliminary modelling undertaken for this study, using the same approach as in the previous Canley Corridor study, did not allow surcharged water to re-enter the system. This resulted in the pipes and trunk drainage to run only partially full in the 100 year ARI event and was considered to provide overly conservative estimates of overland flood behaviour.

The adopted approach described above rectifies this situation and hence provides a more accurate description of overland flood behaviour. A schematic representation comparing the Canley Corridor and the Fairfield study modelling approaches is shown in **Figure 3-1**.

The preferred modelling approach chosen for this study was to incorporate modelling of the limited drainage network together with 2D flood hydraulic modelling, with some modification to suit the needs of the study as discussed above. This approach could potentially be used for modelling the remaining catchments in Fairfield LGA.

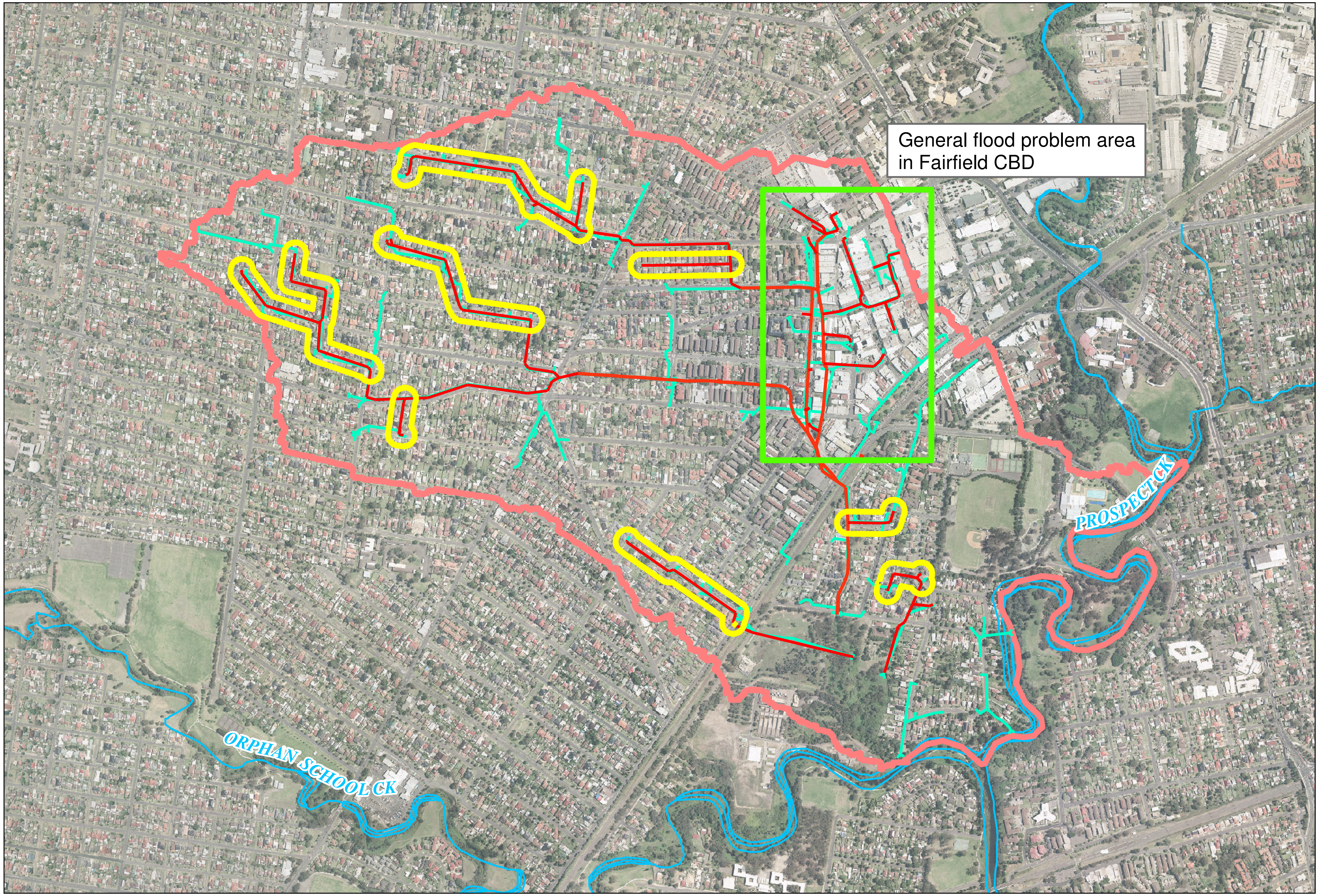
▪ **Figure 3-1 Comparison of Canley Corridor and Fairfield Overland Flood Study Modelling Approaches**



3.2. DRAINS Model Development

3.2.1. Drainage Network Layout

The limited drainage network to be modelled was selected by FCC staff, following a review of the data on the entire drainage network as well as the known drainage trouble spots. The modelled network typically comprised of pipes with a diameter greater than and equal to 900mm and their associated pits, with smaller pipes included as necessary at the known trouble spots to represent these locations in more detail. Sections of open concrete channel were also included in the DRAINS model. St Elmo's Drain, Orphan School Creek and Prospect Creek were excluded from the DRAINS model. The modelled pipes, trouble spots and the entire pipe network are shown in **Figure 3-2**. A total of 190 pits and 211 pipes are represented in the DRAINS model.



Legend

Modelled Drainage Network

Fairfield Catchment Pipes All (Approx)

Trouble Spots

Fairfield Catchment

Aerial Photo: AUSIMAGE

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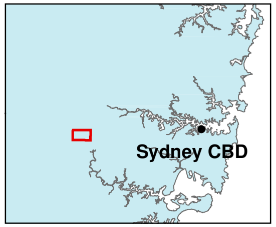

Figure 3-2 Modelled Pipe Network

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3.2.2. Stormwater Network Parameters

The layout, dimensions and levels of the stormwater network were extracted from the GIS layer prepared by FCC and imported into DRAINS. Stormwater network parameters were then chosen on the following basis:

- Initial values for the pressure loss K_u parameters were adopted for the pits based on guidance from the DRAINS User Manual, depending on whether they were at the head of a stormwater line (where a value of 4.8 was used) or a junction or inlet pit (where a value of 1.5 was used). The initial values were then revised using the Queensland Urban Drainage Manual (QUDM) automated procedure available in DRAINS to adjust the K_u value in each pit, based on the modelled pipe flow velocities.
- A minimal amount of ponding at each sag pit was assumed (5 m^3) in order to ensure stability of the DRAINS models. The actual storage volume within the street is more accurately represented within the TUFLOW model.
- The pit hydraulic characteristics were assumed to be similar to standard characteristics referenced in the DRAINS User Manual (2004), as FCC does not have its own standard pit characteristic. Pits in the study area typically are similar to the following DRAINS pits:
  - Hornsby Council pit database: 0.9, 1.2, 1.8, 2.4, 3.0, 3.6, 4.2m (internal dimensions) were selected for the kerb inlet pits
  - Sutherland Council's "Grated Sag" pits were selected for the sag pits
  - Department of Housing RM7 inlet pits with 3% cross fall and 4% grade were selected for the bolt down lid pits.
- Blocking factors for on-grade and sag pits adopted for the model were 30% in the 20 year ARI and 50% in events equal and greater than the 100 year ARI event, up to the Probable Maximum Flood (PMF) event.
- Extra inlet capacity was included at the upstream end of each truncated drainage line in the model. This accounted for the reduction in inlet capacity resulting from pipes upstream of the truncation point and their associated inlet pits being removed from the model. This avoids this artificial constraint on system inlet capacity.

A summary of the pit and pipe data is contained in **Appendix B.**

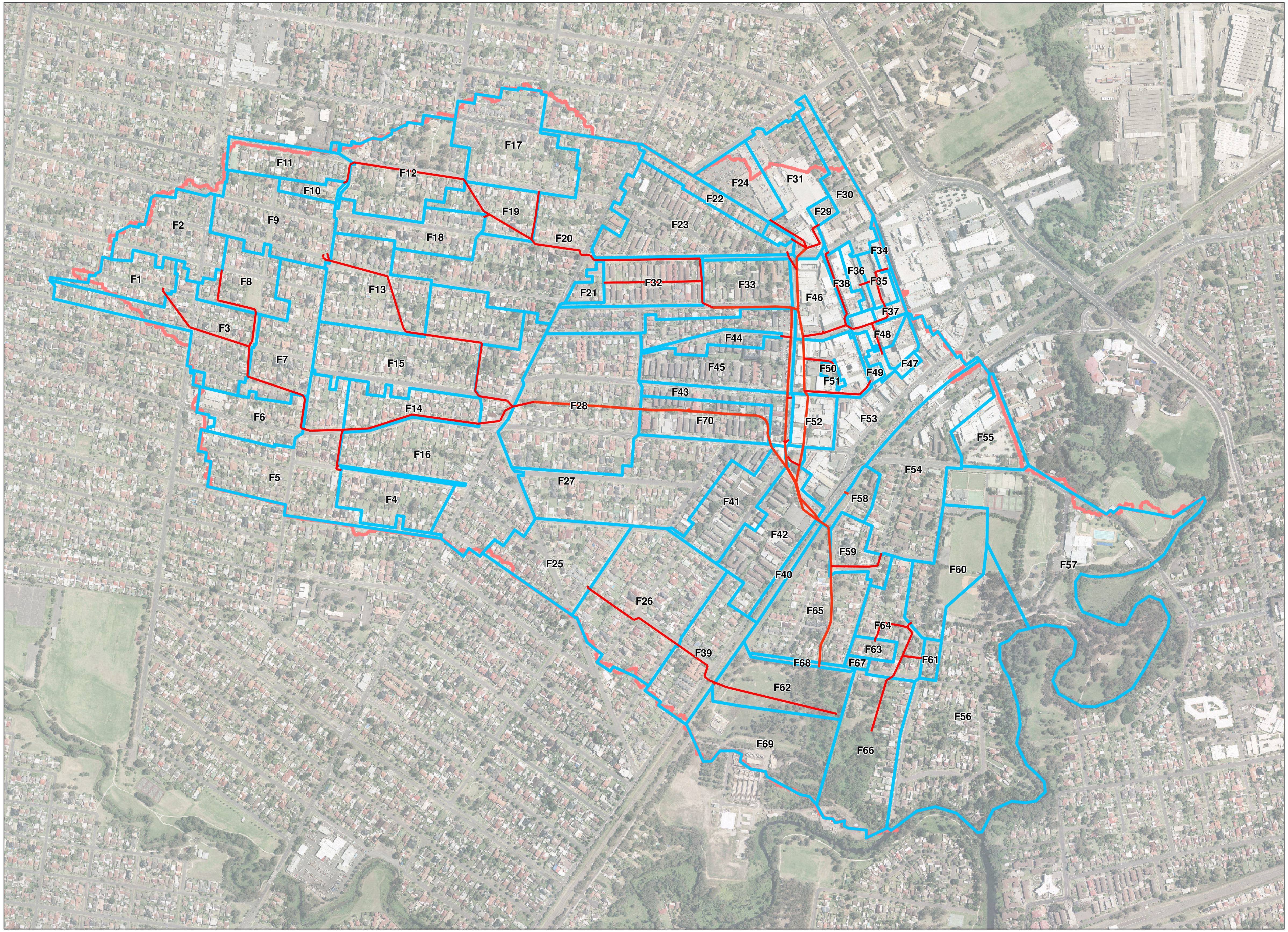
3.2.3. Sub-Catchment Data

Pit catchments were manually delineated by FCC for selected critical pits, based on topographic data, aerial photography, site observations and consideration of the likely connectivity of individual buildings to the kerb-and-gutter system and stormwater network. Model sub-catchments were only assigned to "critical pits" rather than all pits in the model. The critical pits were selected based on local knowledge of the study area, anecdotal evidence of problem areas and at most sag pits where ponding problems would occur. The pit sub-catchment boundaries were verified in the field by FCC staff.

Once the sub-catchment boundaries were finalised in GIS, the following parameters were measured or estimated for each sub-catchment:

- Sub-catchment areas were measured in GIS
- Impervious fractions were estimated using FCC LEP data on land use, plus estimated typical impervious fractions for each land use category.
- Runoff travel times (i.e. time of concentration) were estimated based on the length of each catchment and an estimated flow velocity of 1m/s for paved surfaces, and 0.5m/s for grassed surfaces.

The catchment layout is shown in **Figure 3-3** and detailed sub-catchment plans are presented in **Appendix D**. A summary of the sub-catchment data for the DRAINS model is included in **Appendix B**.



Legend

DRAINS Sub-Catchments

Modelled Drainage Network

Fairfield Catchment

Data Sources

Aerial Photo: AUSIMAGE

Sinclair Knight Merz does not warrant that this document is definitive nor free of error and does not accept liability for any loss caused or arising from reliance upon information provided herein.

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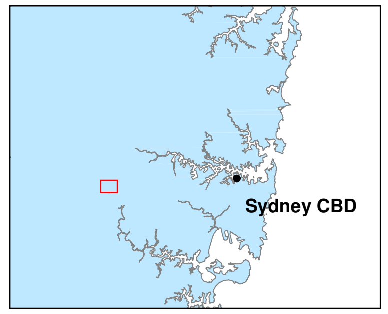

Figure 3-3 DRAINS Model Catchment Layout

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3.2.4. Hydrologic Parameters

The following hydrologic parameter values were adopted in the DRAINS modelling:

- Depression storage: Paved areas – 1mm; Grassed areas – 5mm.
- Soil type: Type 3
- Antecedent Moisture Condition: A value of 3 was adopted for storms up to and including the 500 year ARI event. It was assumed that the ground would be completely saturated in storms greater than the 500 year ARI even, therefore a value of 4 was adopted for storms between the 2,000 year ARI and the PMP events.

3.2.5. Design Rainfall

The storm events including the 20, 100, 200 and 500 year ARI events were modelled as Australian Rainfall and Runoff 1987 (ARR87) storms. Design storm time series were derived within DRAINS for these events based on the temporal patterns from *Australian Rainfall and Runoff Volume 2* (Institution of Engineers, 1987) for design storms in Australian Rainfall Zone 1, and from the average rainfall intensities produced by the FCC IFD data.

The average storm event rainfall intensity for storm events up to and including the 500 year ARI event are presented in **Appendix C**.

Design rainfall time series were derived for the Probable Maximum Precipitation (PMP) events, based on the Generalised Short Duration Method (GSDM) in *The Estimation of Probable Maximum Precipitation in Australia: Generalised Short Duration Method* (BOM, 2003).

The design rainfall time series for the 2,000 and 10,000 year ARI events were derived using the method for determining rainfall from extreme storm events (between 500 year ARI and the PMP) in *Australian Rainfall and Runoff –Volume 1 Book 6* (Institution of Engineers, 1997). A notional PMP event AEP of 10^{-7} was assumed given the catchment size and based on guidance in the method. A GSDM temporal pattern was adopted for all modelled extreme rainfall events, that is, the extreme storm events were assumed to have the same temporal pattern as the PMP event.

The average rainfall intensity for the extreme storm events are presented in **Appendix C**.

3.3. TUFLOW Model Development

3.3.1. Model Topography

The topography of the catchment is represented in the model using a 2m grid. This level of precision in the grid is considered necessary in order to represent detailed flood behaviour in a fully developed catchment. Representing individual buildings and roads requires a fine grid structure to be able to represent the full flow width of the road and with grid spacing at least as small as a typical opening between properties.

The basis of the topographic grid used in the TUFLOW model is the ALS survey. **Figure 1-3** shows ground elevations within the Fairfield catchment based on this data.

3.3.2. Stormwater Pits

The location of the stormwater pits and associated attributes were exported directly from the DRAINS model to GIS format. Surface levels for the pits were defined based on the pit and pipe survey undertaken by FCC surveyors.

TUFLOW version 2008-08-AH-isp allows the surface inflows into stormwater pits to be defined for different pits in the model. The data for the different pit inflow relationships is stored in a pit inflow relationship database in the model setup folders.

Pit inflow relationships were defined in terms of flow depths versus pit inflow. The pits in the study area are typically Hornsby-type kerb inlet pits (lintel and grate) of various lintel lengths, and grated Sutherland Council pits (0.9m x 0.5m grate). For these pit types, the pit inflow relationships adopted in the TUFLOW model were extracted from the DRAINS model default database. For large specialised pit inlets, the pit inflow relationships were derived as a depth versus inflow relationship assuming weir flow along the pit grate's perimeter.

Hydraulic loss coefficient values at the pits were taken from the DRAINS model, in which the pit loss coefficients were revised and confirmed using the QUDM method. The QUDM method iteratively adjusts the pit loss coefficient values based on the calculated pipe flow velocities in the DRAINS model.

3.3.3. Stormwater Pipes and Culverts

The simplified/truncated pipe network modelled in the DRAINS model was also modelled in TUFLOW. **Figure 3-2** shows the modelled pipe network, which includes the trunk drainage (box culverts) within and south of the Fairfield CBD. The trunk drainage lines consist of multiple, separate drainage lines, and were represented accordingly in the TUFLOW model.

Culverts under the railway embankment could not be surveyed due to restricted access. The culvert levels were therefore estimated from ALS and the dimensions estimated from field observations.

3.3.4. Open Channels

Open channels represented in the TUFLOW model include:

- The concrete open channel in the vicinity of Sackville Street and Hamilton Road was defined based on design drawings and survey. This channel was modelled as a 1D element in events up to the 500 year ARI event, and as a 2D feature in events between the 2,000 year ARI and PMF events in order to maintain model stability and satisfactory mass balance; and
- The natural section of St Elmo's Drain as a 2D feature was defined based on ALS. Ground survey was not available for this study to permit detailed representation of this channel.

Orphan School Creek and Prospect Creek were not modelled as open channels in the TUFLOW model. Rather, flooding in the creeks was represented using a tailwater hydrograph boundary (refer to **Section 3.4**).

3.3.5. Building Polygons

This study considers buildings as solid objects in the floodplain. This means that buildings form impermeable boundaries within the model, and that while water can flow around buildings, it cannot flow across their footprint. This approach is consistent with the other overland flow studies that are being undertaken or have been completed within Fairfield LGA.

This approach is considered to be more appropriate than the alternative approach of including these areas within the active floodplain. Given the number of buildings within the floodplain, it was not considered practical to verify whether each building would be likely to provide storage of floodwaters during a flood (e.g. slab on ground or raised with a clear understorey space) or would not allow flood storage (e.g. raised on fill or raised with an impermeable understorey). Further, whether floodwaters enter a particular building may vary between flood events depending on factors such as whether doors or windows are open, and whether these openings are exposed to the flows. Assuming each building in the floodplain is impermeable to floodwaters is expected to give a conservative and satisfactory estimate of flood behaviour.

The buildings were removed using a GIS dataset of building polygons generated by SKM. The building polygons were then superimposed on the model grid and used to make model computational cells inactive.

3.3.6. Property Fencelines

Fencelines have not been explicitly represented in the model and floodwaters can flow across them freely. Although fences may obstruct overland flood flows in some parts of the catchment, experience indicates that representing fences in the hydraulic model requires making unvalidated assumptions about depths at which fences overflow or fail. Also, including fence lines would have required on-site identification of fence type, blockage and structural strength for individual properties. Thins was beyond the scope of this study.

The potential obstruction to flow caused by fences has generally been represented by increasing the cell roughness (Manning's n values) for certain land uses, as described in **Section 3.3.7**. The limitation of this approach is that the flood levels may be slightly overestimated and flow velocities slightly underestimated for flooding within properties depending on the actual locations of obstructions and the interaction of flood flows with these obstructions. However, this approach does preserve the likely typical flooding behaviour, in which floodwaters use the road corridor as the preferential flow path.

3.3.7. Surface Roughness

All parts of the study area within the TUFLOW model were assigned hydraulic roughness values according to land use type and ground cover. These are based on standard reference values for Manning's n in *Open Channel Hydraulics* (Chow, 1959) and typical values used in previous FCC flood studies. The relatively high Manning's n values for the commercial, industrial and residential land uses account for expected obstructions such as minor structures (sheds, etc.) and fences.

- **Table 3-1 TUFLOW Model Grid Hydraulic Roughness Values**

Land Use Type	Assumed Manning's n Roughness
Roads or Car parks	0.02
Commercial / Industrial / High Density Residential	0.20
Open Space (with trees)	0.05
Open Space (grass only)	0.035
Medium and low density Residential	0.15
Heavily vegetated areas	0.10
Moderately dense vegetation along creek	0.08
In-channel section of St Elmo's Drain	0.04
Railway	0.04

3.4. Boundary Conditions

3.4.1. Model Inflows

Runoff generated in the pit sub-catchments from the DRAINS model was input to the TUFLOW model at the pits located at the outlet to each sub-catchment. The sub-catchment flow hydrograph was equally split and then assigned to each pit inlet at the catchment outlet. For example, if there are five pits at a sub-catchment outlet and the sub-catchment flow hydrograph has a peak flow of $5m^3/s$, a flow hydrograph with a peak flow of $1m^3/s$ and the same temporal pattern is assigned to each pit inlet. This is illustrated in **Figure 3-4.** Sealed pits are not assigned a flow.

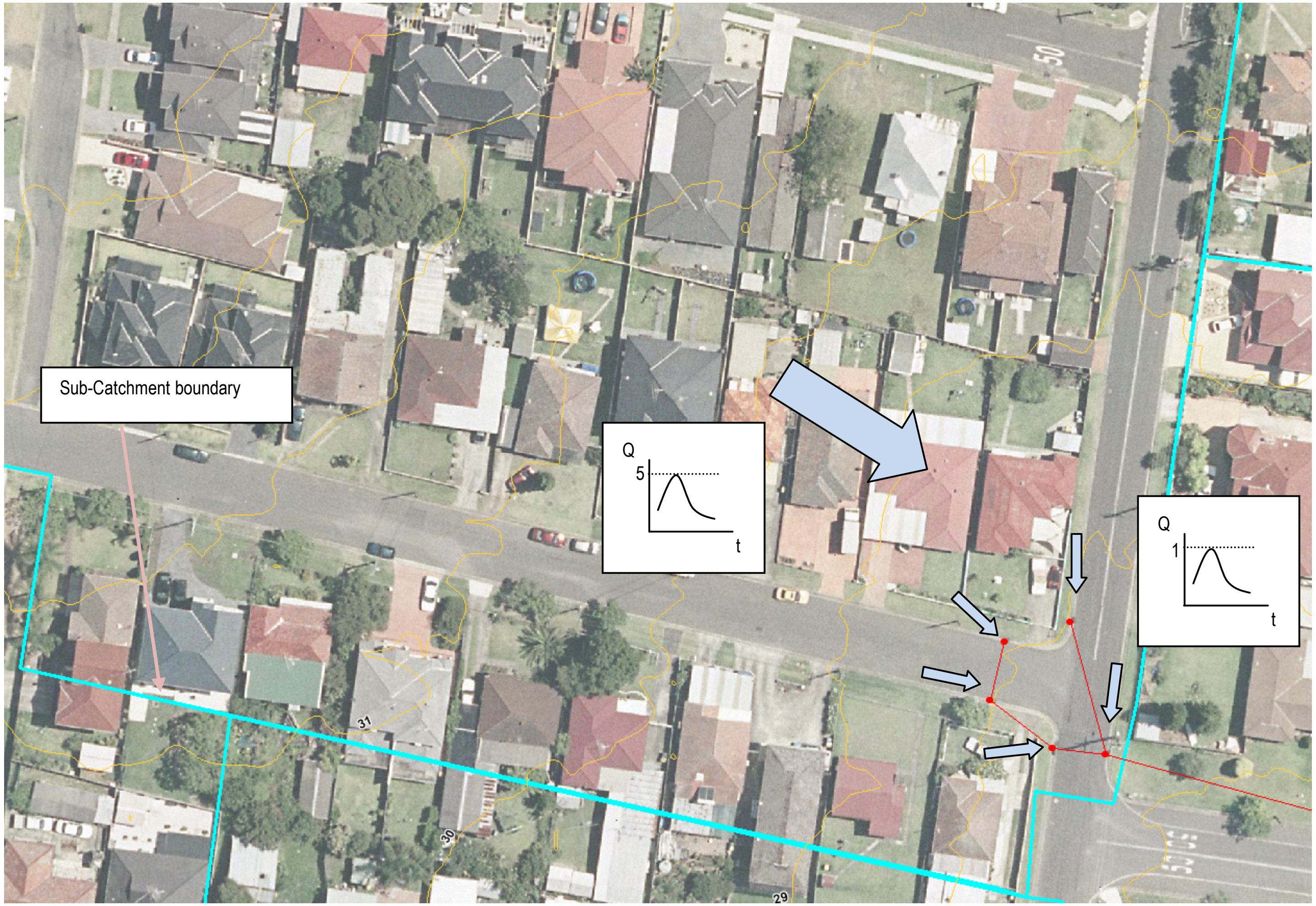
The amount of surface flow entering the pit is dictated by the pit inflow relationship. Flows in excess of the pit inlet capacity remain in the 2D model domain as point inflows, subsequently forming overland flow. Applying inflows onto a 2D grid in this way can sometimes overestimate the depth of the flooding in the vicinity of the inflow points due to flow accumulating in the grid cell, caused by the limited conveyance of the cell sides. However, in this instance the sub-catchments are relatively small and the catchment flows are typically input at multiple points. Hence the error associated with this simplification was found to be negligible.

Pit surcharge flows are caused when flows in the drainage network exceed network capacity and spill out of the pits and into the 2D domain. Pit surcharges would similarly form overland flow in the model. Depending on the hydraulic conditions in the pipe system, overland flows can re-enter the pipe system via the stormwater pits.

There are a number of sub-catchments with no modelled stormwater pits, located in the lower section of the catchment at the Orphan School Creek/Prospect Creek junction. This includes the area around Orchard Road/Riverview Road. Preliminary modelling indicated that overland flows from further upstream flowed through this area in larger storm events. The local sub-catchment flows were therefore input directly into the 2D domain in order to represent their contribution to overland flooding in the area.

The location of the open inlet pits and sub-catchment boundaries are shown in **Appendix D**.

■ **Figure 3-4 Illustration of sub-catchment flow inputs at pits in TUFLOW model**



In this example, there are 5 pits at the outlet to the sub-catchment. The sub-catchment's flow hydrograph (with a peak flow of 5 flow units) is equally split among the 5 pits and input into the 2D domain of the TUFLOW model. Excess flows above the pit inlet capacity remain on the surface and flow downstream, contributing to overland flow.

3.4.2. Downstream Boundaries

Water level hydrographs were extracted from the existing mainstream Orphan School Creek and Prospect Creek TUFLOW models and input as tailwater boundary conditions to the Fairfield overland flood model. As an example, **Figure 3-5** shows the stage hydrograph taken from the Prospect Creek and Orphan School Creek TUFLOW models for the 100 year ARI storm event for a 2 hour duration. The hydrograph curve shows two peaks – the first being the Prospect Creek flood wave and the second, higher peak being due to the Georges River backwater. The hydrograph for Prospect Creek and Orphan School Creek starts 13 hours after the start of storm event in the Georges River catchment. The model assumes that the overland flood and the creek local flood events start at the same time.

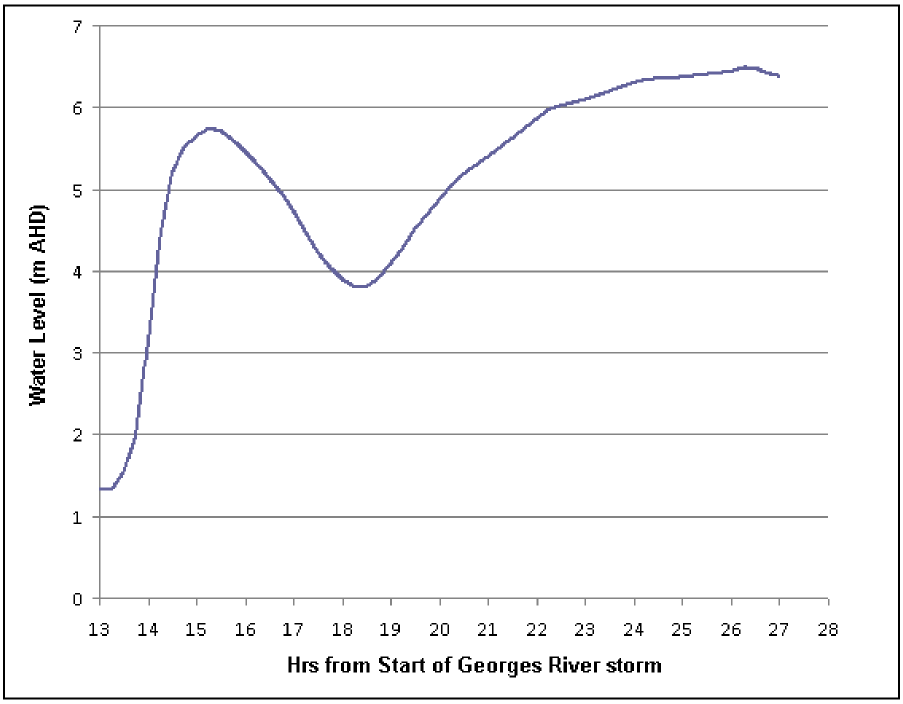
The overland flood event peak coincides with the Prospect Creek local flood peak for the critical overland events in the downstream area at 2 and 3 hours duration. Therefore, the overland flood modelling takes into account the overland flooding and the Prospect Creek/Orphan School Creek local flood peaks and the hydraulic interaction between the two events.

The Georges River flood peak was not modelled for two reasons:

- The peak occurs many hours after the storm event and local flood peaks have already occurred in the Fairfield and Prospect Creek catchments (and hence does not interact with the overland flood events); and
- Although it does create greater flood levels in the downstream area, it is a mainstream flood event which has already been modelled in detail in the Prospect Creek flood study and it is not the purpose of the overland flood model to replicate this flooding behaviour.

The adopted concurrent storm ARI's in the overland flooding and the mainstream creek catchments are summarised in **Table 3-2** and relate to the tailwater boundary conditions selected for each overland flood event. The time-series of water levels available which were suitable for use as boundary conditions for the Fairfield model were the Prospect Creek 25 minute and 2 hour duration events, for overland flood events between 30min and 3hr. The 25 minute water level boundary was used for overland flood events up to 1 hour duration, and the 2 hour water level boundary was used for overland flood events greater than 1 hour duration. The model considers the first 3 hours of the Prospect Creek hydrograph only.

- **Figure 3-5 Water level hydrograph at downstream boundary for 100 year ARI 2 hour mainstream flood event**



- **Table 3-2 Adopted Concurrent Storm Events**

Storm Event in Fairfield Local Catchment	Flooding in Orphan School Creek and Prospect Creek
20 year ARI	20 year ARI
50 year ARI	50 year ARI
100 year ARI	100 year ARI
200, 500, 2000 and 10,000 year ARI and PMF events	100 year ARI

For the purposes of this study, the modelling assumes a uniform water level along the tailwater boundary line, though in reality there would be some flood surface gradient along the line. The tailwater boundary line extends from Orphan School Creek, approximately 700m west of its confluence with Prospect Creek, along Prospect Creek to the top end of McIntosh Street. Checks of the mainstream flood modelling results were therefore conducted to verify that the flood surface gradient was not significant along the tailwater boundaries. The difference in the 100 year ARI flood level along the main tailwater boundary was determined to be 60mm over a length of approximately 2km, which was considered to be a minor and acceptable flood surface gradient along this boundary line, noting that it was not a modelling objective of this study to exactly replicate the mainstream flood surface profile. The tailwater boundaries for events less than the 100 year ARI event had a lesser flood surface gradient.

3.5. Initial Model Runs

3.5.1. Model Stability

TUFLOW models, if configured appropriately, are typically numerically stable. However, models often require "debugging" during their initial development in order to rectify issues in the model which cause model instability and inaccuracy. Several such issues were encountered in the Fairfield model. These issues are described below:

- Sub-catchment inflows: Overland sub-catchment inflows were initially input to the model at a single point (near selected stormwater pits). This underestimated the inflows into the drainage network in addition to producing a "lump" in the flood surface at the inflow point if it was placed on an area of high roughness, particularly for larger events. The lump is due to the flows being input into a single model cell and accumulating, due to limited cell side conveyance preventing flows from being released from the cell at the same rate as the inflow rate. These issues were rectified by distributing the sub-catchment inflows over an increased number of pit inflow points.
- Representation of Hamilton Road open channel: This open channel was initially modelled as a 1D element and behaved satisfactorily in events up to and including the 100 year ARI event. However, the model became unstable along the open channel in the PMF due to rapidly varying lateral flow fluctuations at the 1D/2D domain boundary. This issue was rectified by representing the channel as a 2D element for events between the 2,000 year ARI and PMF events. While the channel conveyance is not as well represented as with a 1D element, this solution was considered to be acceptable since the large majority of flows would be conveyed in the floodplain outside of the channel during these extreme events.
- Model mass balance errors at downstream boundary: Small cumulative mass balance errors of up to +/-3% in the 20 year ARI event were encountered at the downstream boundary, most likely caused by the exchange of flows into and out of the model at the boundary. These were considered to be acceptable due to their location at the downstream extremity of the model, in the portion of the study area dominated by mainstream flooding. Hence the mainstream flood model results for Prospect Creek would override any minor inaccuracies in flood levels at this location. Furthermore, the model configuration at this location did not cause model instability, and its influence was considered unlikely to propagate upstream and affect the accuracy of results in the main body of overland flooding.

  The mass balance error in model runs for the 100 year ARI event and up to the PMF were typically less than +/-1% and hence were considered acceptable.

3.5.2. Quality Assurance

An internal quality assurance review of the Fairfield Overland Flood Study TUFLOW model was undertaken to ensure that the model was configured appropriately. The recommendations from the model review are contained in **Appendix I**. The majority of these recommendations were adopted.

3.5.3. Initial Flood Mapping

After stabilising and reviewing the model, the model was run in order to produce initial results and to map the extent of flooding. The process of mapping flood extent was then refined in order to provide the most relevant and useful information.

For instance, the initial flood depth maps produced in TUFLOW were manually refined to remove isolated patches and minor fingers of shallow-depth flooding of less than 150 mm, and are not shown in the flood mapping presented in this report. The rationale for this is that such areas could be considered as areas of "nuisance" or "localised" flooding caused by local drainage rather than actual overland flooding. For example, ponding of stormwater within the roadway may not be a part of the main body of overland flood flows.

The 150mm threshold depth was chosen by FCC as it generally corresponds with the height of the road kerb, hence flow less than this depth would typically be contained in the roadway. Flooding less than 150mm depth but connected to the main flow paths was not removed from the mapping. Overall, there were very few areas of minor flooding that were removed from the flood mapping.

Results derived from the final flood mapping are discussed in **Section 4.**

3.6. Model Calibration

3.6.1. Historical Flood Events

Rigorous model calibration and verification of overland flood models cannot generally be carried out since direct measurements of overland flows are usually not available. Only one reference could be found to a historical overland flood event in the study area to permit a check of the TUFLOW model results. This information was contained in the Willing & Partners 1986 *St Elmo's Drain Study*, and is quoted below:

> "*In the October 1985 flood, residents indicated that water ponded at the Sackville Street/Hamilton Road intersection* ***to a depth of the order of 300mm****. This was confirmed by debris near the BP service station. The water then flowed into and along Hamilton Road towards the east. The flow continued down Hamilton Road, across the low point in York*

Street and through private property before entering the open channel upstream of Fairfield Bowl.

The estimated peak discharge at the Sackville Street intersection in the 1985 flood was 9.4m^3/s. Some of this flow would have been carried in the 1200 and 1050 mm pipes which converge at this point. Assuming that these pipes were flowing full, their total flow would be approximately 7.5m^3/s. The pipes may not have been flowing full due to restrictions further upstream but to determine this would require a detailed analysis of all pits and pipes of the upstream drainage system.

According to the FCC plans, there are four gully pits in the low section of Sackville Street, between Hamilton Road and Joyce Street. The capacity of each pit was estimated from formulae in Reference 4. For a standard 1.8m long gully pit under 0.3 m head, the inflow capacity is approximately 0.27m^3/s. The combined capacity of the four pits and two inflowing pipes is 8.6m^3/s. Thus there was a deficiency of the order of 0.8m^3/s in pit capacity, which would have contributed to the ponding."

The October 1985 storm event was estimated as being similar in magnitude and temporal distribution to a design 20 year ARI 12 minute storm event in the upper parts of the catchment (Willing & Partners, 1986).

The TUFLOW model results were reviewed and validated against the reported flood information. The 20 year ARI 30 minute event was reviewed as it is the most similar event out of all events modelled. The model produced depths of 300mm at the junction of Sackville Street and Hamilton Road, which is consistent with the reported observations for the 1985 event.

The modelled total flow at Sackville Street is 8.6m^3/s, which includes pipe and overland flow. This is comparable to the estimated 9.4m^3/s for the 1985 storm. However, the TUFLOW model indicates that only 4.2m^3/s of this flow would occur in the pipe, compared to 7.5m^3/s pipe flow estimated by Willing & Partners. This may be due to the Willing & Partners estimate assuming that full pipe flow is not affected by upstream system capacity or downstream tailwater conditions, whereas the TUFLOW model accounts for the tailwater conditions and possible flow constraints posed by the open channel downstream of Sackville Street, into which the pipes discharge. Hence, the TUFLOW model is thought to give a better representation of pipe flow conditions.

In summary, the TUFLOW model was able to closely replicate the observed historical overland flood depths at Sackville Street for the October 1985 storm, using a design storm event of similar magnitude to the historical storm. The model is, therefore, considered to provide a good representation of overland flood behaviour at this location.

3.6.2. Trouble Spots

FCC has maps showing past flooding 'trouble spots', which identify the location of known problems. These maps have been used to in this study to validate the performance of the TUFLOW model, and as an indication of whether the 2D hydraulic model extends far enough into the catchment.

3.6.3. Previous Flood Studies

Flood levels in Orphan School Creek and Prospect Creek in the Fairfield overland flood model were compared against the mainstream TUFLOW model results from the *Flood Study for Orphan School Creek, Green Valley Creek and Clear Paddock Creek* (SKM, 2008) and the *Prospect Creek Floodplain Management Plan – Flood Study Review* (Bewsher Consulting, 2006). A similar creek flood level was required in order to represent realistic tailwater conditions for the overland flooding entering the creeks, though it was not intended to exactly match the creek flood levels. The resulting flood extents and flood levels in the downstream section of the Fairfield catchment were considered appropriate when compared to those of the mainstream flooding studies.

3.7. Sensitivity Analysis

3.7.1. Overview

Sensitivity analyses were conducted to determine the sensitivity of the flood behaviour to variations in the adopted model parameters. The following scenarios were assessed for the 100 year ARI event:

- Catchment surface roughness: The impact of a 5% increase in Manning's n in the 2D model domain was assessed;
- Stormwater pit blockage: An increase in blockage factor from the design value of 50% blocked in the 100 year ARI event to 75% blocked in the sensitivity analysis scenario (i.e. the pit inlet has 25% capacity of an unblocked pit inlet); and
- Increased tailwater levels: A 10% increase in the tailwater levels was applied to the main tailwater boundary on Orphan School Creek and Prospect Creek.

The resulting flood depths were compared to the design 100 year ARI flood depths. The results are discussed below.

3.7.2. Impact of Increased Catchment Roughness

Flood depths are not sensitive to a 5% increase in catchment roughness. The change in flood level depth is typically less than +/- 20mm. There are some isolated locations where the change in depth is greater than 50mm.

3.7.3. Impact of Increased Pit Blockage

Flood behaviour is typically insensitive to increased pit inlet blockage in the catchment, with the following exceptions:

- Flood depths are up to 0.2m deeper in the Fairfield CBD area, upstream of the railway line to Kenyon Street. This is most likely due to the pit blockages further upstream in the catchment not permitting as much flow to enter the drainage network, hence resulting in increased overland flow.
- Flood depths are up to 0.5m shallower in the flow path downstream of the railway, in particular the area between Lyndon Street and Fairlight Avenue. This is presumed to be due to the additional flood volume being stored upstream of the railway.

3.7.4. Impact of Increased Tailwater Levels

The adjusted tailwater level hydrograph was derived by the following equation:

$$H_{adjusted,\ t=i} = (H_{unadjusted,\ t=i} - H_{unadjusted,\ t=0}) \times 1.1$$

This resulted in an approximately 0.5m increase in peak tailwater level during the 2 hour, 100 year ARI mainstream flood event.

The tailwater levels were increased in this manner rather than by increasing the recurrence interval of the mainstream flooding event, since there were no flood events modelled for Prospect Creek between the 100 year ARI event and the PMF. Selecting the PMF levels for the tailwater conditions was considered to be overly conservative.

The impact of increased tailwater levels on flood depths is limited to the part of the study area downstream of North Street, including residential properties on Orchard Road and Riverview Road. Flood depths typically increase by between 0.3 – 0.5m, with localised increases of greater than 0.5m. Flood depth increases upstream of North Street are unaffected by the increased tailwater conditions.

3.7.5. Conclusions from Sensitivity Analyses

In summary, flood behaviour in the overland floodplain in the Fairfield TUFLOW model is not sensitive to variations in Manning's n and tailwater conditions. Uncertainties about these parameters therefore are not likely to affect the outcomes of any overland floodplain management measures which are implemented.

Flood levels in the far downstream section of the model are sensitive to increased tailwater levels due to the flooding directly caused by the increased tailwater levels, though this is an expected outcome and may be considered a mainstream flooding issue.

Increased pit blockage significantly affects the overland flood depths in the Fairfield CBD area of the catchment. While some pit blockage has already been adopted in the design case, the occurrence of higher degrees of blockage is possible depending on catchment conditions and other circumstances which are not foreseeable. Council should take the potential increased flood depths into consideration in developing overland floodplain management strategies for Fairfield.