Fairfield City
Celebrating diversity

Fairfield Residential Development Strategy

Flood Assessment of Planning Proposal Seeking to Increase Residential Densities in Fairfield, Fairfield Heights, Fairfield East and Villawood

Revision 6
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Catchment Simulation Solutions

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1 INTRODUCTION

Fairfield City Council is currently implementing a residential development strategy that aims to accommodate 24,000 additional residential dwellings by 2031. As the Fairfield City Council Local Government Area does not contain any new release areas, for residential areas in Fairfield City that are located east of the Cumberland Highway, Council has a long-term plan that will allow more people to live around town centres and areas that have good public transport and are close to railway stations. As part of this strategy, Council has investigated areas where it can increase the number of homes in the Fairfield, Fairfield Heights, Fairfield East and Villawood neighbourhoods.

Council at its meeting held on 28 July 2015 resolved to exhibit a Planning Proposal that aims to amend Fairfield Local Environmental Plan 2013 by rezoning certain land in the following suburbs:

- Fairfield – from Zone R3 Medium Density Residential to Zone R4 High Density Residential (apartment buildings up to six storeys in height);
- Fairfield Heights – from Zone R2 Low Density Residential to Zone R3 Medium Density Residential (villas and townhouses up to two storeys);
- Fairfield East - from Zone R2 Low Density Residential to Zone R3 Medium Density Residential (villas and townhouses up to two storeys) and from Zone R3 Medium Density Residential to Zone R4 High Density Residential (apartment buildings up to six storeys in height); and
- Villawood – from Zone R3 Medium Density Residential to Zone R4 High Density Residential.

The location of the areas where upzoning is proposed is shown in **Figure F1** and **V1** which are contained in **Appendix A** and **Appendix B** respectively.

The Planning Proposal was forwarded to the Office of Environment & Heritage (OEH) for review. OEH subsequently raised some issues that Council needed to address prior to the Planning Proposal moving forward, including the potential impact of flooding

Accordingly, Fairfield City Council engaged Catchment Simulation Solutions to undertake a flood assessment to satisfy the OEH requirements. This report summarises the outcomes of the investigation, including:

- An assessment of flood behaviour across the upzoning areas during all events up to and including the Probable Maximum Flood;
- An assessment of the potential for the proposed upzoning to impact on existing flood behaviour across adjoining areas;
- Identification and evaluation of appropriate mitigation measures to offset any potential adverse flood impacts; and,
- Assessment of the potential impact that climate change may have on flood behaviour.

Further detailed information on the outcomes of the study are provided in the following sections.

For the purposes of this assessment, the Fairfield and Fairfield Heights precincts will be collectively referred to as “Fairfield” and the Fairfield East and Villawood precincts will be referred to as “Villawood”.

2 EXISTING FLOOD ASSESSMENT

2.1 Existing Flood Models

The first step in the assessment involved defining flood behaviour across each of the rezoning areas for existing topographic and development conditions. "Existing" flood behaviour across the Fairfield and Villawood areas was previously defined using TUFLOW computer flood models that were developed as part of the following overland flood studies for Fairfield City Council:

- Fairfield Overland Flood Study (SKM, 2010); and,
- Old Guildford Overland Flood Study (SKM, 2010)

Fairfield City Council provided copies of both models to assist in confirming existing flood behaviour across the Fairfield and Villawood areas. Key features of each TUFLOW model included:

- A 2 metre grid size was used to represent the variation in topography and key hydraulic properties (e.g., Manning's "n" roughness) across the 2D model domain.
- All major conveyance areas (e.g., creeks/open channels were represented as 1-dimensional elements defined using surveyed cross-sections.
- All major bridges and culverts were represented in the models as 1-dimensional elements.
- All major stormwater pits and pipes were included in the models.
- A representation of all major overland flow obstructions, such as buildings, were included in the models.
- Hydrology (i.e., rainfall-runoff processes) were represented using a "direct rainfall" approach.

Each of the TUFLOW models was calibrated/verified as part of the original flood studies and the models are considered to provide the best and most contemporary description of overland flood behaviour across each study area. Accordingly, the TUFLOW models were considered to be suitable to use as the basis for defining existing flood behaviour across each study area. The results of the existing flood simulations are presented below.

2.2 Results for Existing Conditions

The TUFLOW models were used to simulate flood behaviour across the Fairfield and Villawood rezoning areas for the design 20-year, 100-year and Probable Maximum Flood (PMF) events. A range of storm durations were simulated for each design storm to confirm the critical storm duration for each area (i.e., the storm duration that produced the highest flood levels/depths across each area). The outcomes of the critical duration assessment are summarised in **Table 1**.

Table 1 Critical Storm Durations

Design Storm	Critical Duration	
	Fairfield	Villawood
20-year ARI	120-minutes	120-minutes
100-year ARI	120-minutes	120-minutes
PMF	15,30 & 45-minutes	60-minutes

As shown in **Table 1**, the critical duration for the 20 and 100- year ARI floods across both areas is predicted to be 120-minutes. During the PMF, the critical duration is predicted to be 60-minutes for Villawood and the critical duration is predicted to vary between 15 and 45 minutes across Fairfield.

The TUFLOW models were used to simulate each of the design floods summarised in **Table 1**. For the Fairfield study area, the results from each of the PMF simulations were combined to form a final design flood envelope.

2.2.1 Presentation of Results

It should be noted that the hydrologic approach adopted in the TUFLOW modelling involves applying rainfall directly to each cell in the computer model and routing the rainfall excess based on the physical characteristics of the catchment (e.g., variation in terrain, stormwater system). Once the rain falling on each grid cell exceeds the rainfall losses, each cell will be “wet”. However, water depths across the majority of the study area are very shallow and would not present a significant flooding problem. Therefore, it was necessary for the results of the computer simulations to be “filtered” to distinguish between areas of significant inundation depth / flood risk and those areas subject to negligible inundation.

For this study a floodwater depth cut off of 0.15 metres has been used to filter the raw TUFLOW model results. That is, areas subject to inundation depths of less than 0.15 metres are not shown as inundated in the mapping. The 0.15 metre cut off was selected as it has been adopted across all of Fairfield City Council’s overland flood study areas for the following reasons:

- Council’s standard kerb height is generally 0.15 metres. Therefore, water depths less than 0.15 metre will typically be contained to roadways and will not travel overland through properties;
- Section 3.1.2.3(b) of the Building Code of Australia (BCA) (2016), requires the floor level of buildings in poorly drained areas to be elevated 0.15 metres above the finished ground level. Accordingly, there is minimal chance of over floor flooding when water depths are less than 0.15 metres.
- Removing areas inundated by more than 0.15 metres typically resulted in many isolated “puddles” and was considered to underestimate the flood risk.

2.2.2 Fairfield and Fairfield Heights

Peak floodwater depths were extracted from the results of the Fairfield TUFLOW modelling and are presented in **Figures F2** to **F4** in **Appendix A**.

Figures F2 to **F4** show three major overland flow paths and one smaller overland flow path that extend through the area where rezoning is proposed. These include (refer **Plate 1**):

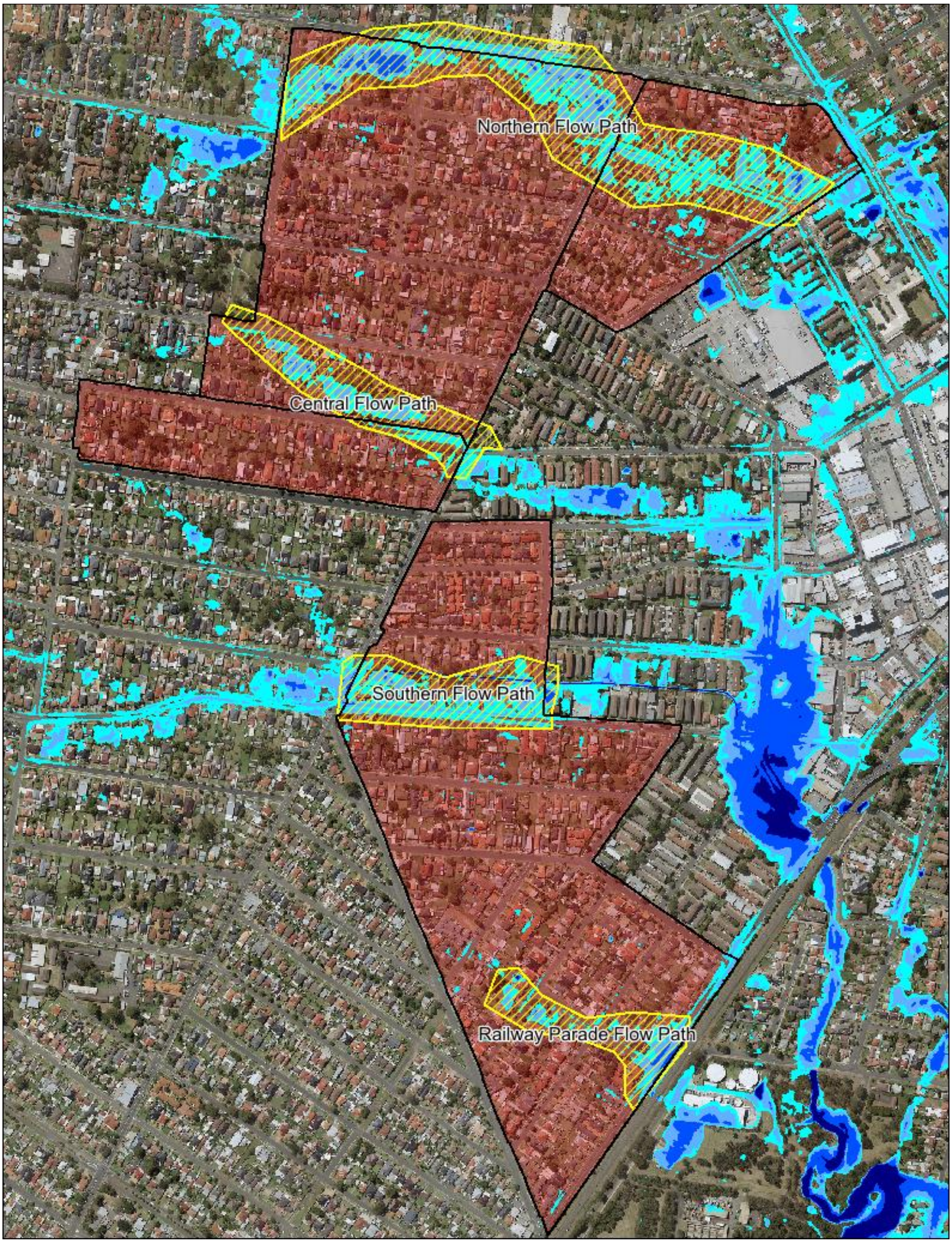

Plate 1 Fairfield Overland Flow Paths

- Northern Flow Path – the northern flow path is the most significant overland flow path in the Fairfield upzoning area. It enters the northern section of the upzoning area near the intersection of Marlborough and Smart Streets and drains in a north-easterly direction before "turning" back in the vicinity of Polding Street and draining in a south-easterly direction. The flow path exits the rezoning area near the intersection of Smart Street and Cunninghame Street. This flow path continues through the Fairfield CBD and across The Horsley Drive towards Prospect Creek. Overland flow depths along this flow path are predicted to generally be less than 0.5 metres during the 20-year ARI but increase to over 1 metres at some locations during the PMF.

- <u>Central Flow Path</u> – the central flow path enters the upzoning area near Fairfield Heights Park. It generally drains in an east by south easterly direction through existing residential properties before exiting the rezoning area near the intersection of Sackville Street and Nelson Street. The flow path continues to travel in an easterly direction before joining with the southern flow path (discussed below) and continuing in a south-easterly direction towards the Fairfield CBD and railway line. Overland flow depths along this flow path are predicted to generally be less than 0.3 metres during the 20-year ARI but are predicted to exceed 0.5 metres during the PMF.
- <u>Southern Flow Path</u> – The southern flow path enters the upzoning area near the intersection of Sackville Street, Hamilton Road and Coleraine Streets. It flows in an easterly direction and exits the rezoning area in Thomas Street. Part of the flow is conveyed along an open channel (referred to as the "Hamilton channel") with the remainder being conveyed along Hamilton Road and through residential properties between Hamilton Road and the open channel. Most of the flow is contained to the channel during the 20-year ARI event with overland flow depths generally being less than 0.3 metres. During the PMF, overland flow depths are predicted to exceed 0.5 metres.
- <u>Railway Parade Flow Path</u> – the Railway Parade flow path originates in a small subcatchment that is fully contained to the upzoning area. Inundation depths and extents during the 20 and 100-year ARI floods are typically minor, with the exception of Railway Parade where the railway embankment causes a localised build-up of water. In Railway Parade, inundation depths are predicted to approach 0.5 metres during the 20-year ARI flood while during the PMF, the depths are predicted to exceed 1 metre. However, as the railway embankment is effectively "damming" the water, flow velocities are predicted to remain low.

2.2.3 Villawood and Fairfield East

Peak floodwater depths were extracted from the results of the Villawood TUFLOW modelling and are presented in **Figures V2** to **V4** in **Appendix B**.

Figures V2 to **V4** shows three overland flow paths plus an area subject to main stream inundation from Burns Creek. This includes (refer **Plate 2**):

- <u>Burns Creek Flow Path</u>: This flow path occurs as a result of floodwaters overtopping the banks of Burns Creek near the intersection of Tangerine Street and Woodville Road. In general, floodwaters are not predicted to enter the upzoning area during the 20-year and 100-year ARI floods. However, depths are predicted to exceed 0.5 metres across the north-eastern corner of the rezoning area during the PMF.
- <u>Mandarin Street Flow Path</u>: The Mandarin Street flow path originates near the intersection of Mandarin Street and Belmore Street. The subcatchment for this flow path is fully contained to the upzoning area. Overland flows along this flow path travel in an east-north easterly direction towards an existing indoor commercial area that fronts Woodville Road before it turns north and joins flow from Burns Creek. Overland

flow depths along this flow path are predicted to be less than 0.3 metres during the 20-year and 100-year ARI events. Some localised increases in depth of up to 0.4 metres are anticipated during the PMF.

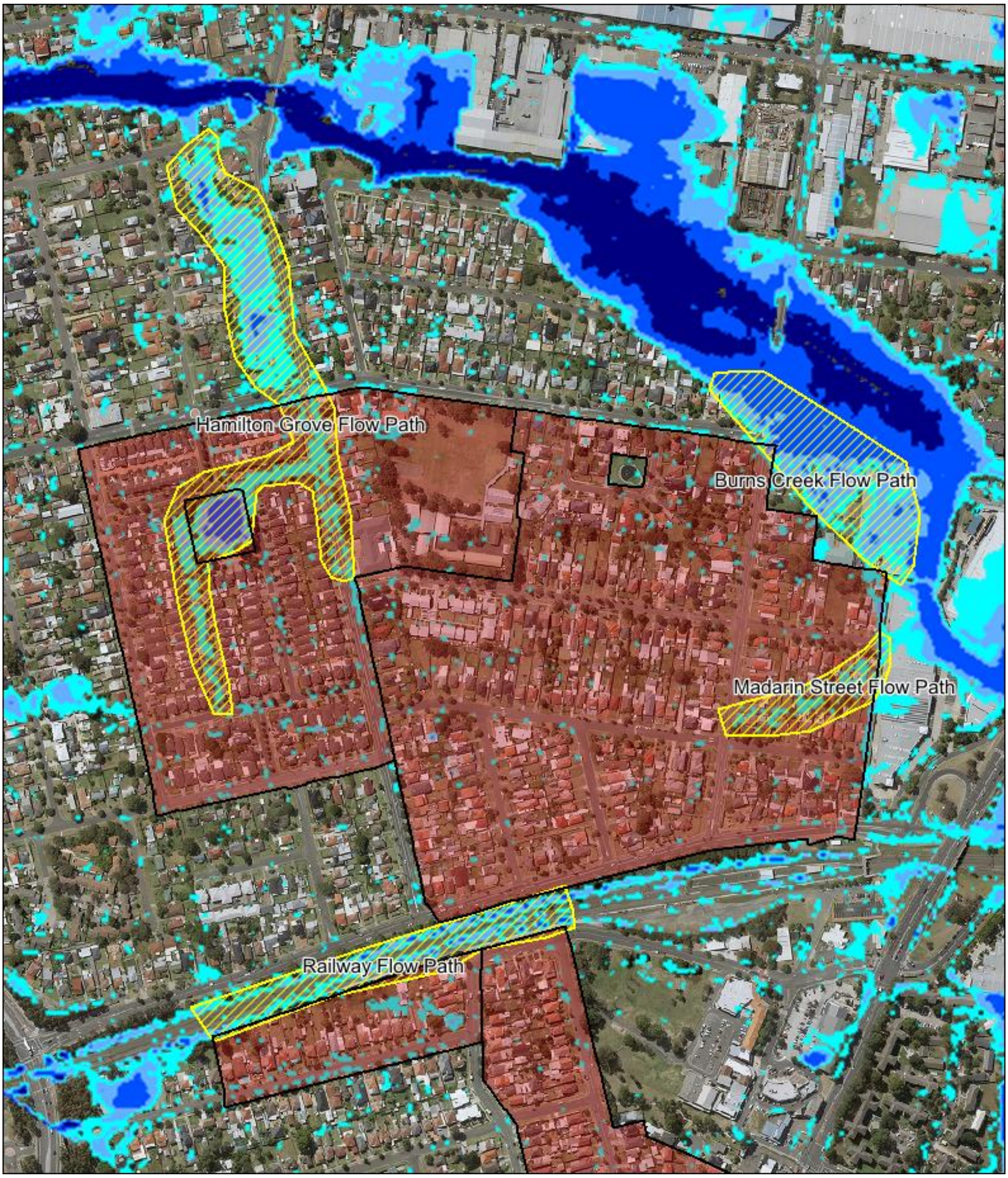

Plate 2 Fairfield East and Villawood Overland Flow Paths

- Hamilton Grove Flow Path: The Hamilton Grove Flow Path originates from a subcatchment that is fully contained to the upzoning area. It comprises two flow path “branches” that travel north along Laurina Avenue and Normanby Street and converge near Peppercorn Avenue. The flow path continues to travel north exiting the upzoning area near the corner of Tangerine Street and Normanby Street. The flow path ultimately discharges into Burns Creek approximately 300 metres north of the upzoning area. Overland flows during all floods are primarily contained to the roadway and are less than 0.5 metres even during the PMF. More significant depths of inundation are predicted across Hamilton Grove Park which serves as a pseudo-detention basin.

- Railway Flow Path: the railway flow path is a small overland flow path that is generally contained between the railway embankment and existing residential properties fronting Wattle Avenue. Overland flows from this flow path are generally not predicted to extend into the upzoning area during the 20-year and 100-year ARI events. However, during the PMF, two overland flow paths are predicted to extend from Wattle Avenue diagonally through the upzoning areas and join the main flow path to the north of these properties.

2.3 Climate Change Impacts

To gain an understanding of the potential impacts that climate change may have on design flood behaviour in the future, an additional 1% AEP climate change simulation was completed for each study area.

The upzoning areas are elevated well above sea level (i.e., ground surface elevations are located well above 10 mAHD). Therefore, climate change induced sea level rise is unlikely to have a significant impact on existing flood behaviour.

However, there is potential for future increases in rainfall intensity to have an impact on flood behaviour. Therefore, an additional 1%AEP flood simulation was completed incorporating a rainfall intensity increase.

There is considerable uncertainty associated with future climate change and rainfall intensity projections. Interim rainfall intensity increase factors are available on the Australian Rainfall and Runoff 2016 Data Hub for different representative concentration pathways (RCP) (refer **Plate 3**). Given the uncertainty associated with the climate change projections, a conservative rainfall intensity increase factor was selected. As shown in **Plate 3**, the predicted increase in rainfall intensity associated with the RCP 8.5, 2090 projection is 18.6%. Therefore, it was felt that a 20% increase in rainfall intensity would provide a reasonable upper limit for the likely increase in climate change induced rainfall intensity increases.

The TUFLOW model was updated to reflect the increase in rainfall intensity of 20%. The updated model was used to re-simulate the 1% AEP flood for existing conditions. Peak floodwater depths were extracted from the results of the updated modelling and are presented in **Figures F5** and **V5** for Fairfield and Villawood respectively.

As expected, increasing the rainfall intensity by 20% is predicted to increase the extent and depth of inundation across each of the overland flow paths. However, the overland flow path depths do not begin to approach those that are predicted during the PMF.

In general, the rainfall intensity increases are predicted to increase 1% AEP flood levels/depths along the Fairfield overland flow paths by between 0.05 and 0.1 metres. Along the Villawood overland flow paths, flood level/depth increases are generally predicted to be less than 0.05 metres (with increases between 0.02 and 0.03 metres being most common).

Interim Climate Change Factors

Values are of the format temperature increase in degrees Celcius (% increase in rainfall)

	RCP 4.5	RCP6	RCP 8.5
2030	0.892 (4.5%)	0.775 (3.9%)	0.979 (4.9%)
2040	1.121 (5.6%)	1.002 (5.0%)	1.351 (6.8%)
2050	1.334 (6.7%)	1.28 (6.4%)	1.765 (8.8%)
2060	1.522 (7.6%)	1.527 (7.6%)	2.23 (11.2%)
2070	1.659 (8.3%)	1.745 (8.7%)	2.741 (13.7%)
2080	1.78 (8.9%)	1.999 (10.0%)	3.249 (16.2%)
2090	1.825 (9.1%)	2.271 (11.4%)	3.727 (18.6%)

Plate 3 Interim Climate Change Factors for the Fairfield, Fairfield East and Villawood study areas

Accordingly, Fairfield appears to be more sensitive to rainfall intensity increases than Villawood. However, across both areas, the anticipated increases in inundation depths and extents are not substantial.

2.4 Hydraulic Categories

The NSW Government's *'Floodplain Development Manual'* (NSW Government, 2005) characterises flood prone areas according to the hydraulic categories presented in **Table 2**Error! Reference source not found.. The hydraulic categories provide an understanding of areas that should be retained for the conveyance of flood flows as well as areas that are important for the temporary storage of floodwaters during the passage of a flood. Accordingly, it was considered important to map the existing hydraulic categories across the rezoning areas.

The *"Floodplain Development Manual"* (NSW Government, 2005) does not provide explicit quantitative criteria for defining hydraulic categories. This is because the extent of floodway, flood storage and flood fringe areas are typically specific to a particular catchment. As part of the current study, a literature review was completed. The literature review aimed to identify velocity, depth and VxD criteria that has been used to define hydraulic categories across other similar catchments. The outcomes of this assessment is presented in **Appendix C** and the resulting hydraulic category maps are presented in **Figure F6** and **F7** for the Fairfield and Fairfield Heights area, and in **Figure V6** an **V7** for the Villawood and Fairfield East area.

Table 2 Qualitative Criteria for Hydraulic Categories

Hydraulic Category	Floodplain Development Manual Definition
Floodway	• those areas where a significant volume of water flows during floods • often aligned with obvious natural channels and drainage depressions • they are areas that, even if only partially blocked, would have a significant impact on upstream water levels and/or would divert water from existing flowpaths resulting in the development of new flowpaths. • they are often, but not necessarily, areas with deeper flow or areas where higher velocities occur.
Flood Storage	• those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood • if the capacity of a flood storage area is substantially reduced by, for example, the construction of levees or by landfill, flood levels in nearby areas may rise and the peak discharge downstream may be increased. • substantial reduction of the capacity of a flood storage area can also cause a significant redistribution of flood flows.
Flood Fringe	• the remaining area of land affected by flooding, after floodway and flood storage areas have been defined. • development (e.g., filling) in flood fringe areas would not have any significant effect on the pattern of flood flows and/or flood levels.

Figures F6 and **F7** indicate that the vast majority of the areas where rezoning is proposed do not fall within floodway or flood storage areas during the 100-year ARI flood and PMF. However, the hydraulic category mapping does show that there are some areas that are predicted to fall within floodway and flood storage areas. Accordingly, any future development within areas designated as flood storage or floodway does have the potential to displace or redirect floodwaters. **Figures F6** and **F7** also show that floodways are typically aligned with roadways, however, floodways are also predicted to extend between some buildings (particularly near the Fairfield CBD during the PMF) and across front and back yards of some existing properties.

Figure V6 shows that some sections of the Villawood rezoning areas would fall within flood storage areas at the peak of the 100-year ARI flood. Some limited floodways areas are also predicted across part sections of Fairfield East. However, they are generally contained within roadways.

Figure V7 shows some more extensive floodways are anticipated across part sections of Villawood and Fairfield East at the peak of the PMF. Across Fairfield East, the floodways are primarily contained to roadways. However, some floodways are also predicted to extend through properties adjoining Wattle Avenue, Mandarin Street and Bligh Street at Villawood.

3 Post-Upzoning Flood Assessment

3.1 Overview

While no final decision has been made by Council, the rezoning of certain land is proposed to occur in the following suburbs:

- Fairfield – from Zone R3 Medium Density Residential to Zone R4 High Density Residential (apartment buildings up to six storeys in height);
- Fairfield Heights – from Zone R2 Low Density Residential to Zone R3 Medium Density Residential (villas and townhouses up to two storeys);
- Fairfield East - from Zone R2 Low Density Residential to Zone R3 Medium Density Residential (villas and townhouses up to two storeys) and from Zone R3 Medium Density Residential to Zone R4 High Density Residential (apartment buildings up to six storeys in height); and
- Villawood – from Zone R3 Medium Density Residential to Zone R4 High Density Residential.

Note: For the purposes of this study, a maximum development potential has been used for Fairfield Heights to determine the maximum probable flood impact should planning decisions (either at local or state level) change in the future to permit higher densities. This precautionary approach also acknowledges the proposed R4 High Density Residential Zoning proposed for the Fairfield Heights precinct in the public survey preceding the formal Planning Proposal exhibition. The difference in site coverage is marginal between the two types of housing.

This upzoning and the associated development that will follow it has the potential to impact on overland flooding in a number of ways:

- It will typically involve an increase in impervious surfaces, which decreases the potential for rainfall to infiltrate into the underlying soils leading to greater runoff volumes and higher peak flows across downstream areas;
- For those rezoning areas located within the flood planning area, it will likely involve filling to ensure all habitable floor levels are elevated above the peak levels of the 1% AEP flood. This may alter the distribution of overland flows and force water into adjoining areas; and,
- It will typically involve a change in surface runoff as well as inclusion of more overland flow impediments (e.g., larger building footprints). These changes may also alter the distribution of overland flows.

To gain an understanding of what these changes may have on existing flood behaviour, the TUFLOW models that were developed to quantify existing flood behaviour were updated to include a representation of the fully developed, upzoned areas. The updated models were used to re-simulate each design flood and the results of the simulations were analysed to confirm the extent of changes in flood levels and extents. The outcomes of this assessment are presented below.

3.2 Flood Impact Assessment

3.2.1 Model Updates to Reflect Upzoning

The TUFLOW models that were used to defined existing flood behaviour were modified to reflect full development across each area to the full extent possible under the proposed zoning.

The TUFLOW material types across the upzoned area were updated to reflect a decreased infiltration potential as well as increased overland flow impediments. This was completed by calculating a weighted average "n" value and a weighted average initial rainfall loss and continuing loss rate for the upzoned areas assuming the following land use composition:

- Buildings occupy 80% of land area (100% impervious, "n"=1.00)
- Concrete occupies 10% of land area (100% impervious, "n"=0.015
- Grass/open space occupies 10% of land area (0% impervious, "n"=0.035)

Based upon these assumptions, the following "n" and rainfall losses values were adopted for the upzoned areas:

- "n" = 0.805 (i.e., significant overland flow impediment);
- Initial rainfall loss = 1.0 mm
- Continuing loss rate = 0.25 mm/hour

In addition to the land use changes described above, the topography of the upzoned areas was modified to reflect future filling to elevate habitable areas above the flood planning level. Fairfield City Council has prepared flood planning level and flood planning area layers for each of their flood study areas. Council defines the flood planning level as the level of the 100-year ARI flood plus 0.5 metres freeboard.

Therefore, the flood planning level layer was used to elevate all areas within the upzoned areas to the flood planning level. This results in the ground surface elevations across some areas being elevated by over 1 metre. Elevations for areas located outside of the flood planning area were not altered.

It should be noted that there is no guarantee that this quantity of earthworks would be undertaken as part of the future development of the area. For example, filling may only be completed in the immediate vicinity of the building footprint or the existing terrain may be retained at close to existing levels and habitable areas placed on the first floor and above. However, this approach was considered to provide a conservative estimate of the impact of the potential for future filling to impact on existing flood behaviour.

It should also be noted that the above changes were not completed to the Hamilton Grove Park area of Villawood (refer **Plate 4**) as this area has recently been re-developed and the upzoning is being completed to reflect the current building stock. That is, future intensification of development across this area is not anticipated.

3.2.2 Results

The updated TUFLOW models were used to simulate design flood behaviour for the 20-year, 100-year and Probable Maximum Flood (PMF) events for post-upzoning conditions. A summary of the simulation results is provided below.

Fairfield and Fairfield Heights

Peak floodwater depths were extracted from the results of the updated TUFLOW modelling and are presented in **Figures F8**, **F9** and **F10** for the 20-year ARI, 100-year ARI and PMF events respectively. The climate change scenario was also simulated and the peak depths from this simulation are provided in **Figure F11**.

Flood level difference mapping was prepared to quantify the impact that the upzoning and development is predicted to have on existing flood levels and extents. The difference mapping was prepared by subtracting peak "post-development" water levels from "existing" water levels. The resulting difference maps show the magnitude and location of changes in flood level associated with the proposed development and are presented in **Figures F12** to **F15**.

Plate 4 Area where existing topographic and development conditions were retained.

Figures F12 and **F13** show localised changes in flood levels in the vicinity of each overland flow path during the 20-year and 100-year ARI events. **Figure F14** shows some more substantial changes in flood levels during the PMF. In general, flood level increases are predicted upstream and immediately adjacent to the upzoning areas and reductions in flood levels are predicted downstream of the upzoning areas.

The most significant increases in existing flood levels are predicted to occur at the following locations:

- Northern flow path: A significant build-up of water is predicted in Marlborough Street (near Smart Streets) immediately upstream of the upzoning area. Increases in existing flood levels are predicted to vary between 0.3 metres during the 20-year ARI flood, 0.4 metres during the 100-year ARI flood and 0.85 metres during the PMF. Localised increases in flood level are also predicted across sections of Polding Street. Some smaller flood level increases (i.e., <0.05 metres) are also expected across a section of The Horsley Drive.
- Southern flow path: a notable increase in flood level is also predicted in Sackville Road (between Hamilton Road and Joyce Street). These flood level increases are predicted to extend west into existing residential properties. The magnitude of the increase in Sackville Road is predicted to vary between 0.15m in the 20-year ARI event, 0.2 m during the 100-year ARI event and 0.65m during the PMF. Increases in flood level are also predicted to extend east along Hamilton Road and extend into some existing medium density residential properties located east of Thomas Street.

In general, the central and Railway Parade flow paths are not predicted to be significantly impacted by the upzoning. This is primarily associated with the upstream catchment areas being much smaller and, in the case of the Railway Parade flow path, fully contained to the upzoning area. Therefore, there is a much smaller quantity of overland flow.

Overall, the results show that the upzoning is likely to have a significant impact on two of the major overland flow paths extending through the Fairfield upzoning area.

Hydraulic Category Impacts

Hydraulic categories were also mapped based upon the results of the updated TUFLOW modelling and are presented in **Figures F16** and **F17** for the100-year ARI and PMF events. In addition, the hydraulic categories in **Figures F16** and **F17** were compared with the hydraulic categories for "existing" conditions presented in **Figures F6** and **F7** to identify:

- Areas where the rezoning/development is likely to reduce the extent of flood storage areas; and
- Areas where the rezoning/development is predicted to change (i.e., increase or decrease) the extent of the existing floodways.

The resulting hydraulic category "difference maps" are presented in **Figures F18** and **F19**.

Figure F18 shows that the proposed rezoning is predicted to cause localised decreases in the extent of flood storage areas as well as increases to floodway extents across the Fairfield area during the 100 year ARI flood. In general, the increases in floodways are contained to roadways that are located within the rezoning are, however, there are predicted to be some increases in floodway extents extending beyond the rezoning areas. In particular, an increase in floodway extent is predicted to near the corner of Hamilton Road and Thomas Street (located along the "southern" flow path). Most of the floodway increases are predicted to extend across an existing petrol station although small increases are also predicted to extend across neighbouring residential properties. Accordingly, the future rezoning/development of the area does have the potential to increase the floodway extents across nearby properties.

Figure F19 also shows that the future development of the area has the potential to increase floodway extents across areas outside of the rezoning area. Although the increases are typically contained to roadways, increases in floodway extent are predicted existing residential properties adjoining Hamilton Road and Lackey Street.

Villawood

Peak floodwater depths were extracted from the results of the updated TUFLOW modelling and are presented in **Figures V8**, **V9** and **V10** for the 20-year ARI, 100-year ARI and PMF events respectively. The climate change scenario was also simulated and the peak depths from this simulation are provided in **Figure V11**. Flood level difference mapping was also prepared for each event and is provided in **Figures V12** to **V15**.

In general, only relatively small changes in overland flood levels are expected during all events up to and including the 100-year ARI plus 20% increase in rainfall event. In all cases the increases in flood levels are predicted to be less than 0.05 metres.

Some localised increases of 0.05 metres are predicted downstream of the Mandarin Street flow path during the PMF and a 0.2 metres increase is predicted along the Burns Creek flow path during the PMF.

Overall, the upzoning and future development across the Villawood area is predicted to generate some small, localised changes in flood levels and inundation extents.

Hydraulic Category Impacts

Hydraulic categories were also mapped based upon the results of the updated TUFLOW modelling and are presented in **Figures V16** and **V17** for the100-year ARI and PMF events respectively. Hydraulic category difference maps were also to quantify areas where flood storage areas are predicted to reduce and where floodway extents are predicted to change as a result of the rezoning/development and are presented in **Figures V18** and **V19**.

Figure V18 shows that some decreases in flood storage are predicted across the rezoning areas and some increases in floodway extents are also anticipated at the peak of the 100-year ARI flood. However, the changes are very localised and are typically contained within road reserves.

Figure V19 shows that more significant reductions in storage areas and increases in floodway extents are predicted during the PMF. Most of the floodway increases are contained within roadways within the rezoning area. However, the floodway extent is predicted to increase along Wattle Street, Villawood and is this increase is predicted to extend into the frontages of some adjoining residential properties.

3.2.3 Summary

The results documented in the previous sections show that if upzoning and development was to proceed across the Fairfield and Villawood areas, it does have the potential to adversely impact on existing flood behaviour across external areas. In most cases the changes to existing flood levels and extents are small during all events up to and including the 1% AEP event.

Nevertheless, there are some areas where more significant impacts are predicted. Some of these impacts are predicted to extend across existing residential and commercial properties. Therefore, it is considered necessary to implement mitigation options as part of the upzoning and future development of the area to assist in reducing the impacts across external properties. A summary of the mitigation options that were investigated as part of the study are summarised in the following sections.

3.3 Flood Mitigation Assessment

3.3.1 Overview

As discussed in the previous sections, the future rezoning and development of land within the Fairfield and Villawood areas has the potential to adversely impact on existing flood behaviour. Therefore, mitigation options were investigated in an attempt to offset the predicted adverse impacts.

A range of different flood mitigation options were investigated as part of the study including regional detention basins, onsite detention systems, provision of overland flow paths and stormwater upgrades. Each mitigation option was included in an updated version of the TUFLOW model and this updated model was used to quantify the hydraulic benefits that each option would afford. Those options that showed merit were carried forward and were included in a "combined" mitigation option TUFLOW model. Further details on the mitigation options that were considered viable for implementation as part of the future development of each area are summarised in the following sections.

3.3.2 Model Updates to Reflect Mitigation Options

Fairfield and Fairfield Heights

The following options were included in the TUFLOW model to assist in mitigating adverse flood impacts across the Fairfield-Fairfield Heights area (refer **Figure F20**):

- Implementation of an onsite detention (OSD) system across all upzoned areas. It was assumed that future development across these areas would implement a system that complies with Council's current OSD requirements, namely:
  - Peak discharges from each area is no greater than 140 l/s/hectare; and,
  - No greater than existing discharges.
- Inclusion of a new 1.8mW x 0.9mH culvert extending along Smart Street from Marlborough Street to Sackville Street. Additional minor stormwater pipes and pits were also included around the intersection of Marlborough Street and Smart Street to assist in capturing runoff and distributing it into the new pipe system.
- Inclusion of a new detention basin between Polding Street and Smart Street. The basin covers an area of 6,240 m^2 and provides a maximum storage depth of 1.3 metres and maintains 1V:6H batter side slopes. The outlet from the basin discharges through two 0.9m diameter pipes, the first discharging into the existing stormwater network, and the second into the upgraded pipe system described in the previous bullet point. The potential "footprint" for the detention basin in this area is shown in **Plate 5**.

Plate 5 Potential detention basin location between Polding Street and Smart Street, Fairfield Heights.

- Provision of an unobstructed overland flow path (6 metres wide) from Sackville Street to the upstream end of the existing Hamilton channel.
- Inclusion of a new detention basin near the intersection of Sackville Street and Harris Street. The basin covers an area of 6,980 m^2 and provides a maximum storage depth of 1.3 metres and maintains 1V:6H batter side slopes. Additional pipes and pits were also included in Sackville Street to capture overland flows and distribute this into the basin. A new outlet pipe would drain the basin under gravity into the Hamilton channel. The potential location of the detention basin in this area is shown in **Plate 6**.
- Some minor regrading of Sackville Road between Hamilton Road and Harris Street was also included to promote overland flow movement towards the new basin and overland flow path described in the previous bullet points.
- Inclusion of a new 2.1 m diameter pipe extending from The Horsley Drive, through Fairfield High School and into Prospect Creek
- Inclusion of stormwater pits/pipes on Polding St/Polding St North near the intersection of The Horsley Drive to capture additional surface runoff at this location and distribute this through pipes along The Horsley Drive and into the upgraded stormwater system through Fairfield High School

Plate 6 Potential detention basin location near the intersection of Sackville Street and Harris Street, Fairfield

Villawood

The following options were included in the TUFLOW model to assist in mitigating adverse flood impacts across the Villawood area (refer **Figure V20**):

- Implementation of an onsite detention (OSD) system consistent with Council's current OSD requirements across all areas that have the potential to be developed in the future (refer hatched areas in **Figure V20**).
- Inclusion of a detention basin on Belmore Street (just east of its intersection with Mandarin Street). The detention basin would cover an area of about 3,500 m^2 and would provide 0.5 metres of storage depth and maintains 1V:6H batter side slopes. The potential location of the basin is shown in **Plate 7**.

3.3.3 Model Results

The updated TUFLOW models were used to simulate each design flood with the upzoning/future development and mitigation options in place. The results of the simulations are discussed below.

Fairfield

Peak floodwater depths were extracted from the results of updated TUFLOW modelling and are presented in **Figures F21**, **F22** and **F23** for the 20-year ARI, 100-year ARI and PMF events respectively. The climate change scenario was also simulated and the peak depths from this simulation are provided in **Figure F24**. Flood level difference mapping was also prepared for each event and is provided in **Figures F25** to **F28**.

Plate 7 Potential detention basin location near the intersection of Belmore and Mandarin Street, Villawood.

Figures F25 to **F26** shows that proposed mitigation measures are predicted to offset the majority of the adverse flood impacts during all events up to the 1% AEP flood. Some small increases in flood level are predicted in localised areas, however, they are typically less than 0.05 metres and are contained to the road reserves. In most areas downstream (i.e., east) of the upzoning areas, decreases in existing flood levels are predicted.

Some more significant impacts in flood level are predicted in the vicinity of the northern flow path, where flood levels are predicted to increase by 0.3 metres in the 1% AEP flood and 0.8 metres in the PMF along Marlborough Street. Increases of up to 0.2 metres are also predicted in Polding Street during the PMF. The most significant of these impacts are contained within the roadway. However, some increases in flood levels are also predicted to extend into existing residential properties adjoining Marlborough Street and Polding Street. Increases in existing PMF flood levels of 0.05 metres are also anticipated in Sackville Street (southern flow path).

The flood level increases near Marlborough Street and Polding Street are primarily a result of the impediment to flow afforded by the upzoned area in the hydraulic model. Therefore, it is possible to reduce or eliminate these predicted increases by allowing overland flow to move more freely though the upzoned area. In this regard, an overland flowpath should be maintained through the area bound by Marlborough St, Polding St, Smart St and Granville St.

This area is shown in **Plate 8**. The future alignment and arrangement of the flowpath can vary from that shown below (e.g., all flow could be conveyed overland or via a combination of overland and subsurface drainage). However, the overall flowpath capacity should be conserved. This will require a system that can convey a peak 1% AEP flow of at least 9 m^3/s and should also be designed to ensure the peak PMF flow of 49 m^3/s can be safely conveyed through the area.

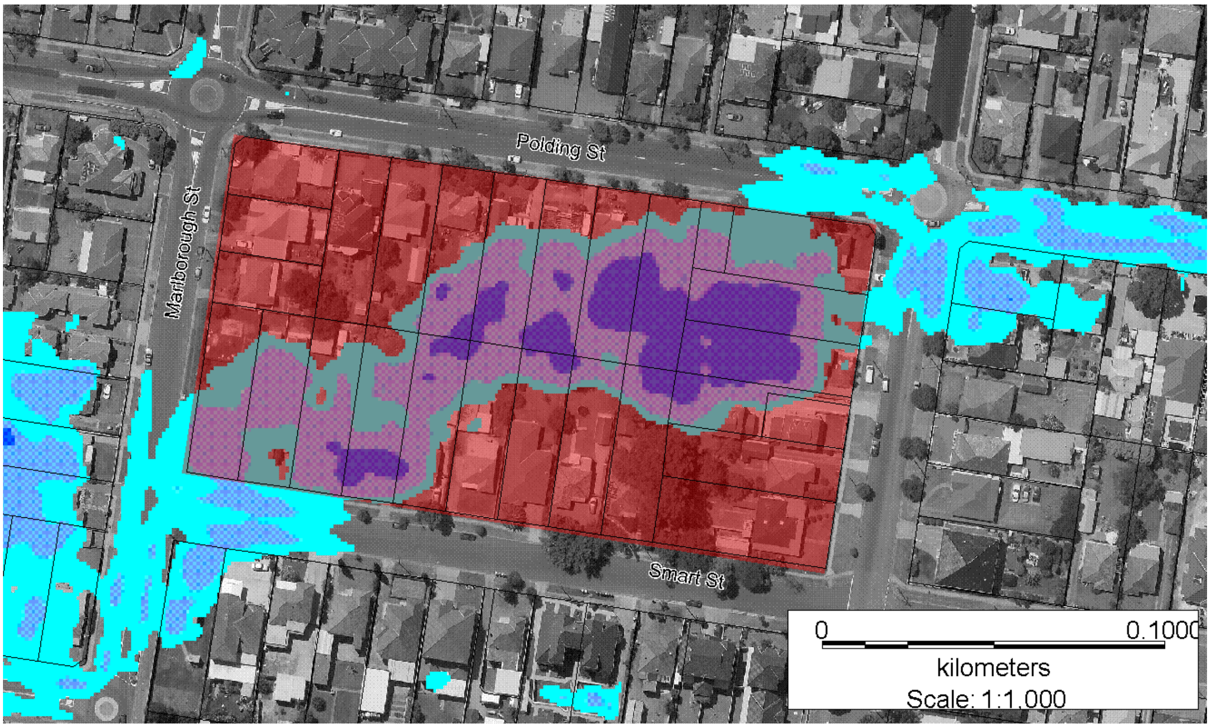

Plate 8 Area where existing overland flowpath should be maintained (superimposed on peak existing 1% AEP flood depths).

In addition, it is suggested that the impacts during the PMF could be further reduced by limiting the extent of filling along the edges of the upzoned areas as well as strategic placement of buildings. As noted in Section 3.2.1, the extent of filling adopted as part of this investigation is considered to be conservative and may not reflect what will be implemented in the future. In addition, the obstruction afforded by future buildings was assumed to be uniformly distributed (i.e., no building set backs were represented).

Given the rarity of the PMF and the uncertainty of the future landforms and building locations, it is suggested that further potential to offset the PMF flood level impacts could be explored as part of future detailed flooding investigations to support development of the area.

Hydraulic Category Impacts

Hydraulic categories were also mapped based upon the results of the updated TUFLOW modelling and are presented in **Figures F29** and **F30** for the100-year ARI and PMF events respectively. Hydraulic category difference maps were also to quantify areas where flood storage areas are predicted to reduce and where floodway extents are predicted to change as a result of the rezoning/development and are presented in **Figures F31** and **F32**.

Figure F31 shows that with the mitigation measures in place, the notable increase in floodway extent near the corner of Hamilton Road and Thomas Street shown in **Figure F18** is largely removed during the 100-year ARI. There are also predicted to be some reductions in floodway extent at the rear of these Hamilton Road properties as well as properties located between Nelson Street and Wrentmore Street. Accordingly, the upzoning with the mitigation measures in place typically produce localised increases in floodway extents across roadways but reductions in floodway extents across existing residential properties.

Figure F31 and **Figure F32** also shows an increase in floodway extent near the corner of Marlborough Street and Stanbrook Street. However, this increase is associated with the inclusion of the detention basin at this location (i.e., floodwaters are intended to be directed across this area). In general, the areas where floodway extents are predicted to reduce outweigh the areas where floodway extents are predicted to increase. Therefore, the upzoning is anticipated to provide a net flood benefit across areas adjoining the rezoning.

Villawood

Peak floodwater depths were extracted from the results of updated TUFLOW modelling and are presented in **Figures V21**, **V22** and **V23** for the 20-year ARI, 100-year ARI and PMF events respectively. The climate change scenario was also simulated and the peak depths from this simulation are provided in **Figure V24**. Flood level difference mapping was also prepared for each event and is provided in **Figures V25** to **V28**.

Figures V25 to **V26** shows that proposed mitigation measures are predicted to offset the majority of the adverse flood impacts during all events up to the 1% AEP event. Some small increases in flood level are predicted in localised areas, however, they are typically less than 0.05 metres and are contained to the road reserves.

Figures V27 shows that the mitigation options do not fully ameliorate the flood impacts during the PMF. The most significant impacts are predicted to occur near the western edge of the rezoning area where flood level increases of up to 0.15 metres are predicted. However, these increases are localised and are generally contained to roadways or car parking areas.

As with the Fairfield PMF impacts, it is suggested that the increases in flood levels that are predicted during the PMF could be reduced by limiting the extent of filling in areas that are sensitive to potential flood level increases.

Hydraulic Category Impacts

Hydraulic categories were also mapped based upon the results of the updated TUFLOW modelling and are presented in **Figures V29** and **V30** for the100-year ARI and PMF events respectively. Hydraulic category difference maps were also to quantify areas where flood storage areas are predicted to reduce and where floodway extents are predicted to change as a result of the rezoning/development and are presented in **Figures V31** and **V32**.

Figures V31 and **V32** show that the rezoning/development with mitigation measures will produce localised reductions in flood storage as well as changes to floodway extents. But, in general, the floodway extents are predicted to reduce across external areas. Most notably the inclusion of the Belmore Street detention basin has produced a notable reduction in floodway extent to the west of Belmore and Bligh Streets.

Figure V32 shows an increase on floodway extent us predicted along Wattle Street at the peak of the PMF and this increase is predicted to extend into the front yards of some existing residential properties. However, **Figure V32** also shows that there is predicted to be a reduction in floodway extent across the rear of these same properties. Therefore, there is predicted to be negligible change in the overall affectation of these properties.

3.4 Other Flood Risk and Future Design Considerations

3.4.1 Evacuation

The upzoning of the Fairfield and Villawood areas will introduce more people into the area. In areas subject to overland flooding, this could increase the existing flood risk.

As noted in previous sections, some significant overland flow paths are predicted to extend through parts of Fairfield and Villawood under existing topographic and development conditions. This includes overland flow paths that extend through existing residential properties. As discussed, the future development of the areas will require the future buildings to have floor levels elevated 0.5 metres above the 100-year ARI flood level. Accordingly, there is potential for the redevelopment of the area in accordance with Council's minimum floor level requirements to reduce the potential for property damage and risk to life.

Nevertheless, above floor inundation could still occur during a PMF and evacuation may be necessary. Given the "flashy" nature of flooding across both areas (i.e., storm durations less than 3 hours are critical), the potential for advanced warning and evacuation will be limited. In such instances, future residents are likely to be safer to shelter-in-place rather than trying to wade or drive through floodwaters. Assuming that the future buildings can be designed to withstanding the force of floodwater during the PMF and can provide a refuge above the level of the PMF, this is considered to be an effective flood risk reduction strategy.

3.4.2 Detention Basins and Community Safety

The Queensland Urban Drainage Manual (Fourth Edition, 2016) provides guidance on detention basins and community safety. While detention basins are generally less hazardous than drainage channels with respect to water velocity, they are typically much deeper. The safety hazards associated with detention/retention basins are, however, often less obvious to the public. Safety hazards associated with submerged outlet structures can be significant—consequently, measures usually need to be made to prevent the public approaching these structures while the basins are in operation. The hazards associated with off-stream basins (i.e. basins not directly connected to a watercourse) are likely to be less obvious than those associated with on-stream basins, thus greater consideration may need to be given to safe egress from off-stream basins.

Detention Basins and dual use activities such as passive or active recreation

The side slopes of basins should preferably be 1 on 6 or flatter to allow easy egress up the likely wet surface. Areas with slopes steeper than 1 on 4 will require steps and a handrail to assist egress. These recommendations especially apply to basins that incorporate dual use activities such as passive or active recreation. The provision of exclusion fencing around open water stormwater detention/retention systems should be considered a last resort. Wherever practical, the first preference should be to minimise the safety risk through appropriate design.

Where suitable land is available, basin depths should be restricted to 1.2 m at the 1 in 20 year AEP level and, if possible, for a greater recurrence interval. In cases where this is neither practical nor economical, and the provision of a detention basin is considered to be better on safety grounds than other alternatives, greater depths may be acceptable. Notwithstanding this, detention basin design should:

- investigate the overall safety risks associated with the basin
- minimise safety risks through design and landscaping
- satisfy any safety requirements specified by government regulation
- consider ongoing responsibility for maintaining any safety standards

Suitable safety provisions, such as fences and warning signs, should be provided for deeper basins. Depth indicators should be installed within the basin and in the channel downstream of the embankment for basins with a storage depth of greater than one (1) metre. The indicator within the basin should have its zero level relative to the lowest point in the basin floor.

Special attention should be paid to basin outlets to ensure that persons trapped in the basin's water are not drawn into the basin's outlet system. Rails, fences, anti-vortex devices, trash racks or grates should be provided where necessary.

Outlet systems should be located well away from the water's edge of the flooded basin such that a person wading along the edge of the basin cannot be drawn into the basin's outlet. This usually requires the outlet system to be located well away from the embankments.

A risk assessment process will be followed during the detailed design phase to ensure that the sites provide the required engineering functionality and community safety requirements at each location.

In selecting the detention basin sites, sufficient area has been provided to allow basins to be designed with community safety in mind for dual use activities such as passive or active recreation.

4 SUMMARY

This report has summarised the outcomes of a flooding assessment that was completed across areas in Fairfield and Villawood where rezoning is proposed. The assessment was completed using TUFLOW models that were originally developed as part of Government-funded overland flood studies for Fairfield City Council.

The TUFLOW models were used to simulate flood behaviour for a range of design floods up to and including the Probable Maximum Flood (PMF) for existing topographic and development conditions. The results of the existing flood simulations showed several overland flow paths extending through the areas where rezoning is proposed. In general, the flow paths within the Villawood were shallow and primarily contained to roadways. Some more significant overland flow paths are predicted through the Fairfield area with two flow paths showing water depths of more than 0.3 metres during large design floods.

The models were updated to include a representation of the upzoned areas being developed to the full extent possible under the proposed zoning. The results from these simulations showed that there is potential for this development to adversely impact on flood behaviour across external areas. Therefore, flood mitigation options were explored to assist in reducing the predicted flood impacts.

The flood mitigation options recommended for implementation incorporate stormwater drainage system upgrades and the provision of detention basins, including:

- Fairfield:
    - Inclusion of a 6,970m^2 detention basin of on Harris Street (just south east of its intersection with Sackville Street) that provides a maximum storage depth of 1.3 metres with 1V:6H batter side slopes.
    - Provision of an unobstructed overland flow path (6 metres wide) from Sackville Street to the upstream end of the existing Hamilton channel currently located to the rear of properties on Hamilton Road and Harris Street and subject to an easement for stormwater drainage (as shown below).

- Some minor regrading of Sackville Road between Hamilton Road and Harris Street to promote overland flow movement towards the new basin and overland flow path described above.
- Inclusion of a new 2.1 m diameter pipe extending from The Horsley Drive, through Fairfield High School and into Prospect Creek.

- Fairfield Heights
  - Inclusion of a new 6,240m^2 detention basin between Polding Street and Smart Street with a maximum storage depth of 1.3 metres and 1V:6H batter side slopes.
  - Inclusion of a new 1.8mW x 0.9mH culvert extending along Smart Street from Marlborough Street to Sackville Street. Additional minor stormwater pipes and pits are also required around the intersection of Marlborough Street and Smart Street to assist in capturing runoff and distributing it into the new pipe system.

- Villawood
  - Inclusion of a new detention basin of 3,500 m^2 on Belmore Street (just east of its intersection with Mandarin Street) with a storage depth of 0.5 metres and 1V:6H batter side slopes.

Implementation of an onsite detention (OSD) system consistent with Council's current OSD requirements across all areas that have the potential to be developed in the future is recommended across all precincts.

Note: The provision of detention basins in greenfield and renewal areas are often provided in tandem with open space requirements that result from the demand arising from new population associated with increased development. This could be explored while giving due regard to the safety considerations outlined in Section 3.4. Therefore, to accommodate the detention basins and open space needs, it would be prudent to include additional area for flexibility in detention basin design and the location of some recreational equipment outside of the detention basin.

The mitigation options outlined above were included in the TUFLOW models and the results from these simulations showed that the mitigation options are predicted to reduce the adverse flood impacts during all events up to and including the 1% AEP flood.

Some more significant increases in existing flood levels and hydraulic categories are anticipated across both rezoning areas during the PMF. Opportunities to reduce the PMF impacts could be explored in future, including:

- For Fairfield PMF impacts, given the rarity of the PMF and the uncertainty of the future landforms and building locations, it is suggested that further potential to offset the PMF flood level impacts could be explored as part of future detailed flooding investigations to support development of the area.
- For Fairfield and Villawood PMF impacts, it is suggested that the increases in flood levels that are predicted during the PMF could be reduced by limiting the extent of filling in areas that are sensitive to potential flood level increases.

5 REFERENCES

- Fairfield City Council (2015) Planning Proposal Residential Density Increases in Fairfield, Fairfield Heights, Fairfield East and Villawood http://leptracking.planning.nsw.gov.au/PublicDetails.aspx?Id=2248
- NSW Government. (2005). Floodplain Development Manual: the Management of Flood Liable Land. ISBN: 0 7347 5476 0
- Queensland Government (2016). Queensland Urban Drainage Manual (4th Edition, 2016)
- SKM (2010). *Fairfield Overland Flood Study*. Prepared for Fairfield City Council in association with Fairfield Consulting Services. Final Report.
- SKM (2010). *Old Guildford Overland Flood Study*. Prepared for Fairfield City Council in association with Fairfield Consulting Services. Final Report.

APPENDIX A
FAIRFIELD AND FAIRFIELD HEIGHTS FIGURES

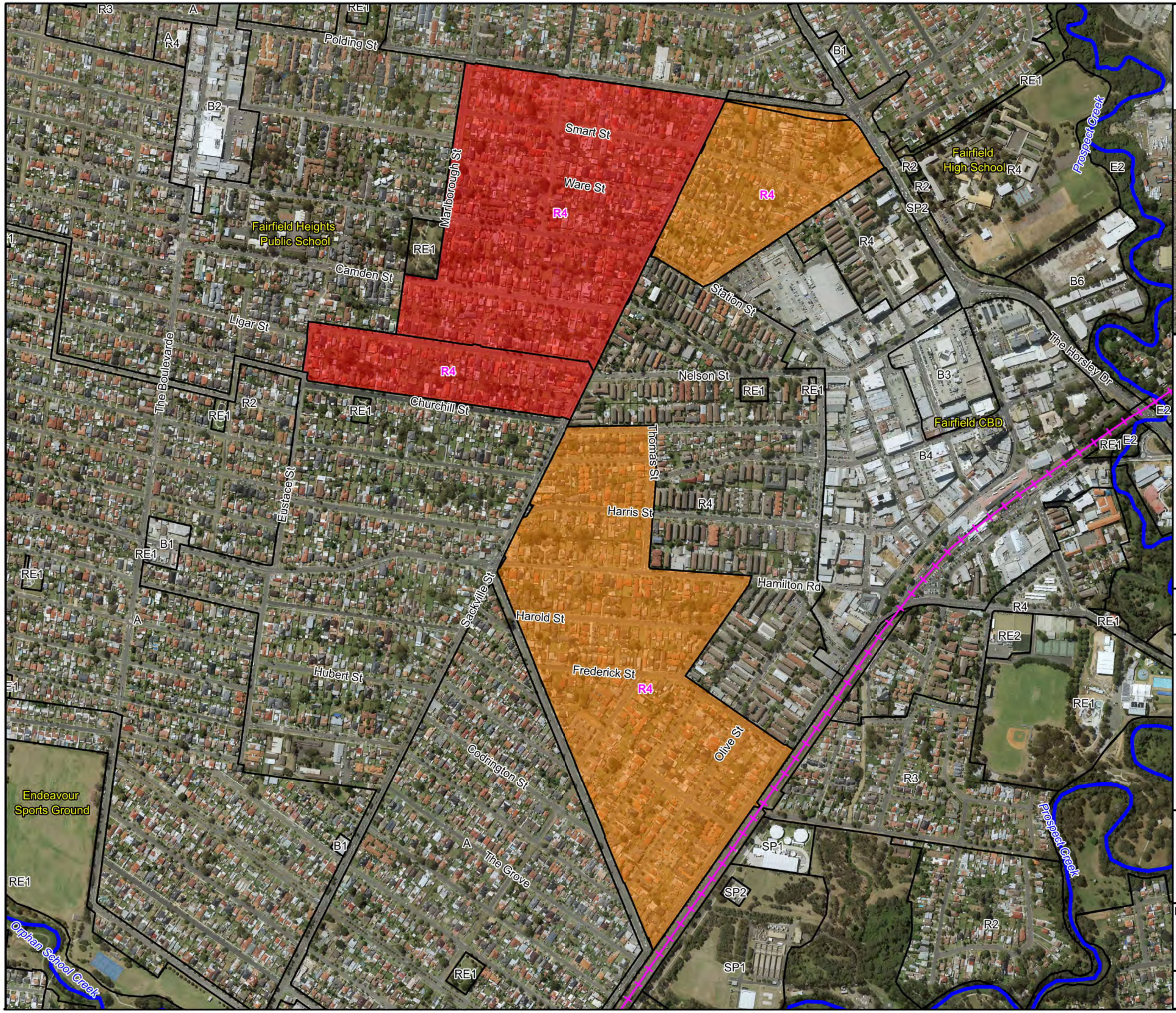

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Figure Extent

LEGEND

Current Zone

Proposed Upzoning

R2 to R4

R3 to R4

Notes:

N W E S

Scale 1:8,000 (at A3)

0 0.25 0.5 Km

Figure F1: Extent of Proposed Fairfield Upzoning

Prepared By:

Catchment Simulation Solutions
Suite 2.01, 210 George St
Sydney, NSW 2000

File Name: Extent of Proposed Fairfield Upzoning.wor

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LEGEND

- Extent of Proposed Upzoning

Depth (m)

- 0.15 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- > 1.0

Notes:

N W E S

Scale 1:8,000 (at A3)

0 0.25 0.5 Km

Figure F2: Peak 20-Year ARI Floodwater Depths for Existing Conditions

Prepared By:
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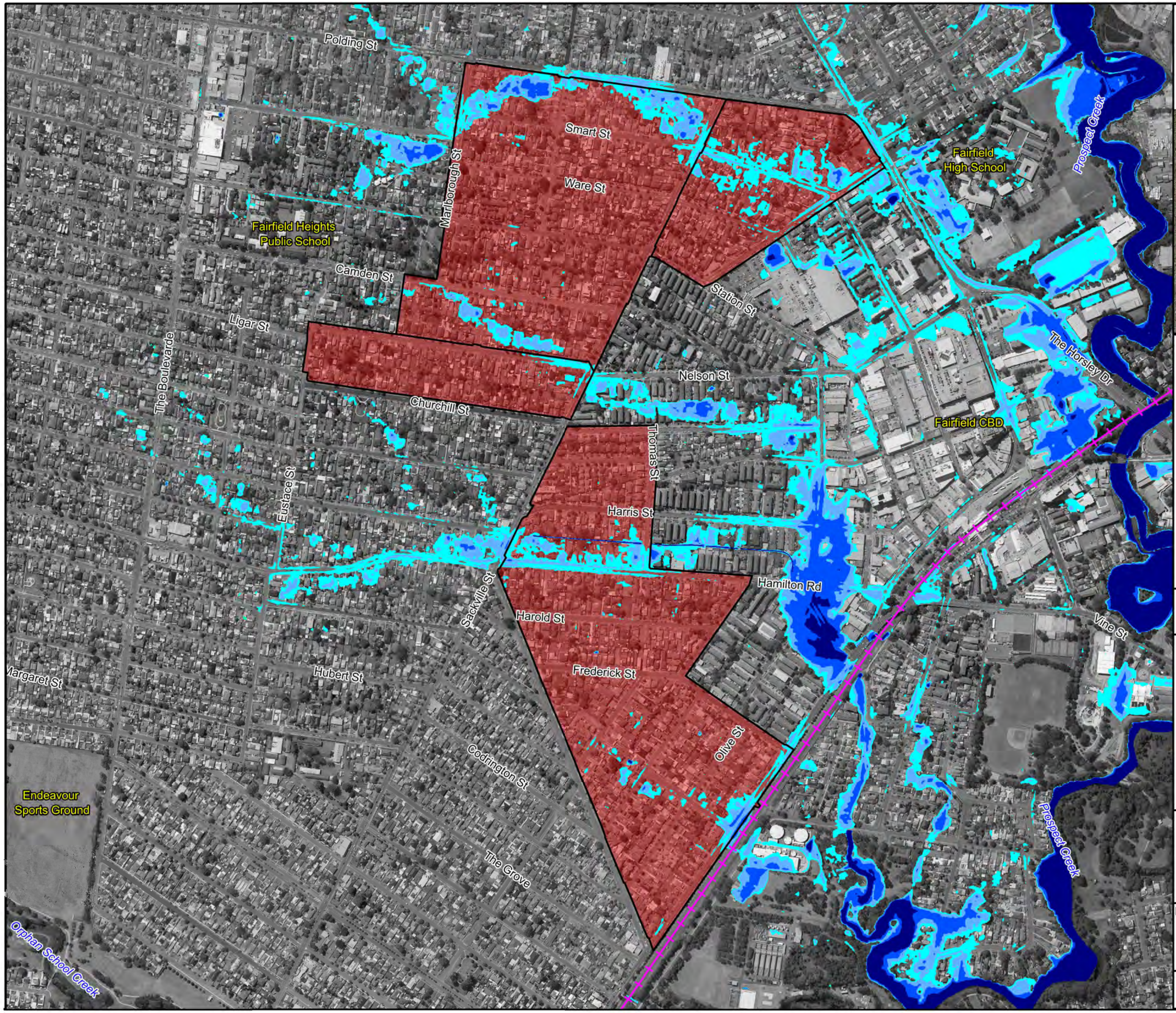
Sydney, NSW 2000

File Name: 20-Year Depths Existing.wor



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LEGEND

Extent of Proposed Upzoning

Depth (m)

- 0.15 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- > 1.0

Notes:

N W E S

Scale 1:8,000 (at A3)

0 0.25 0.5 Km

Figure F3: Peak 100-Year ARI Floodwater Depths for Existing Conditions

Prepared By:
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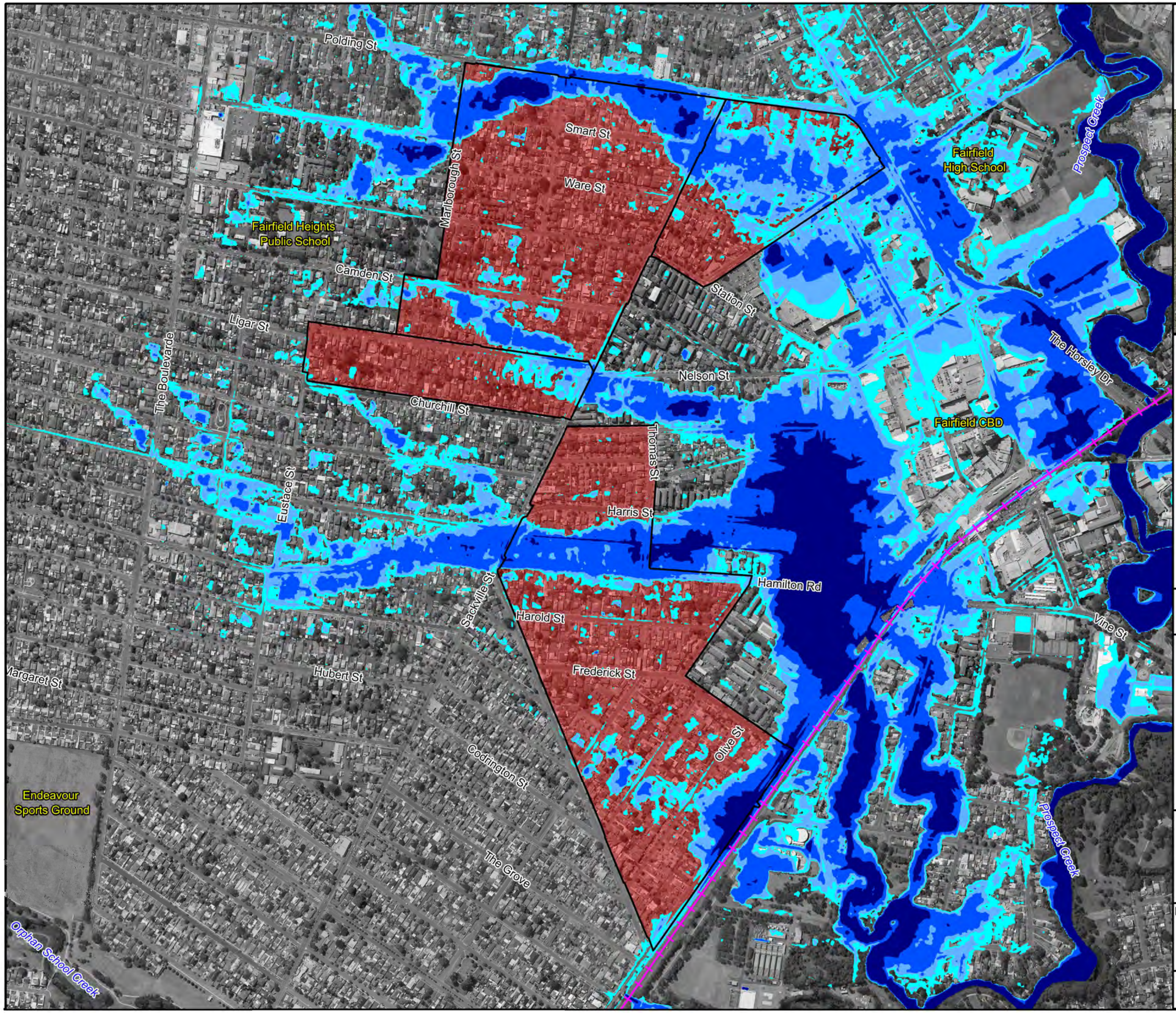
Sydney, NSW 2000

File Name: 100-Year Depths Existing.wor



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LEGEND

Extent of Proposed Upzoning

Depth (m)

- 0.15 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- > 1.0

Notes:

N W E S

Scale 1:8,000 (at A3)

0 0.25 0.5 Km

Figure F4: Peak PMF Floodwater Depths for Existing Conditions

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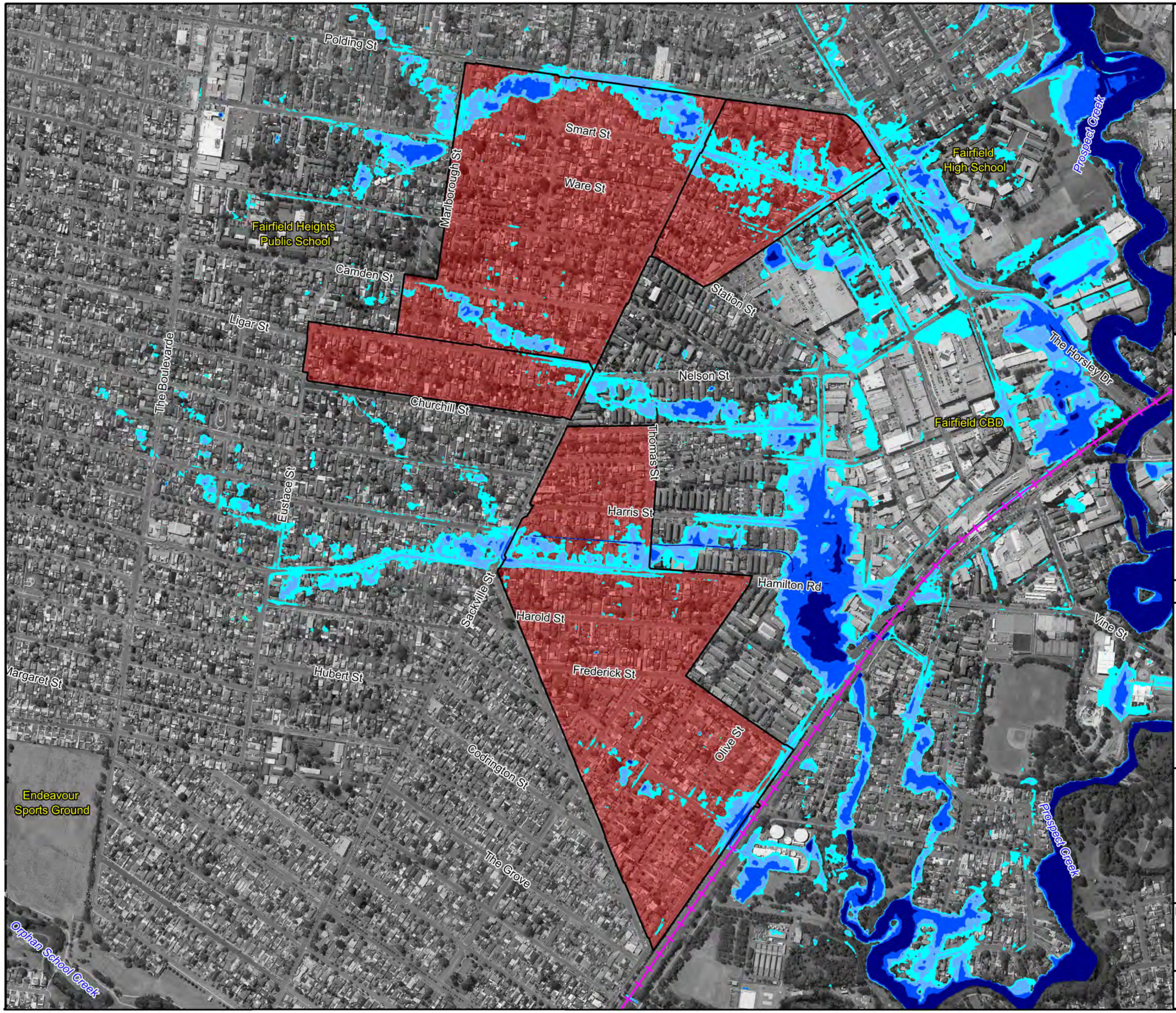
Sydney, NSW 2000

File Name: PMF Depths Existing.wor



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LEGEND

Extent of Proposed Upzoning

Depth (m)

- 0.15 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- > 1.0

Notes:

N W E S

Scale 1:8,000 (at A3)

0 0.25 0.5 Km

Figure F5: Peak 100-Year ARI with 20% Increase in Rainfall Floodwater Depths for Existing Conditions

Prepared By:

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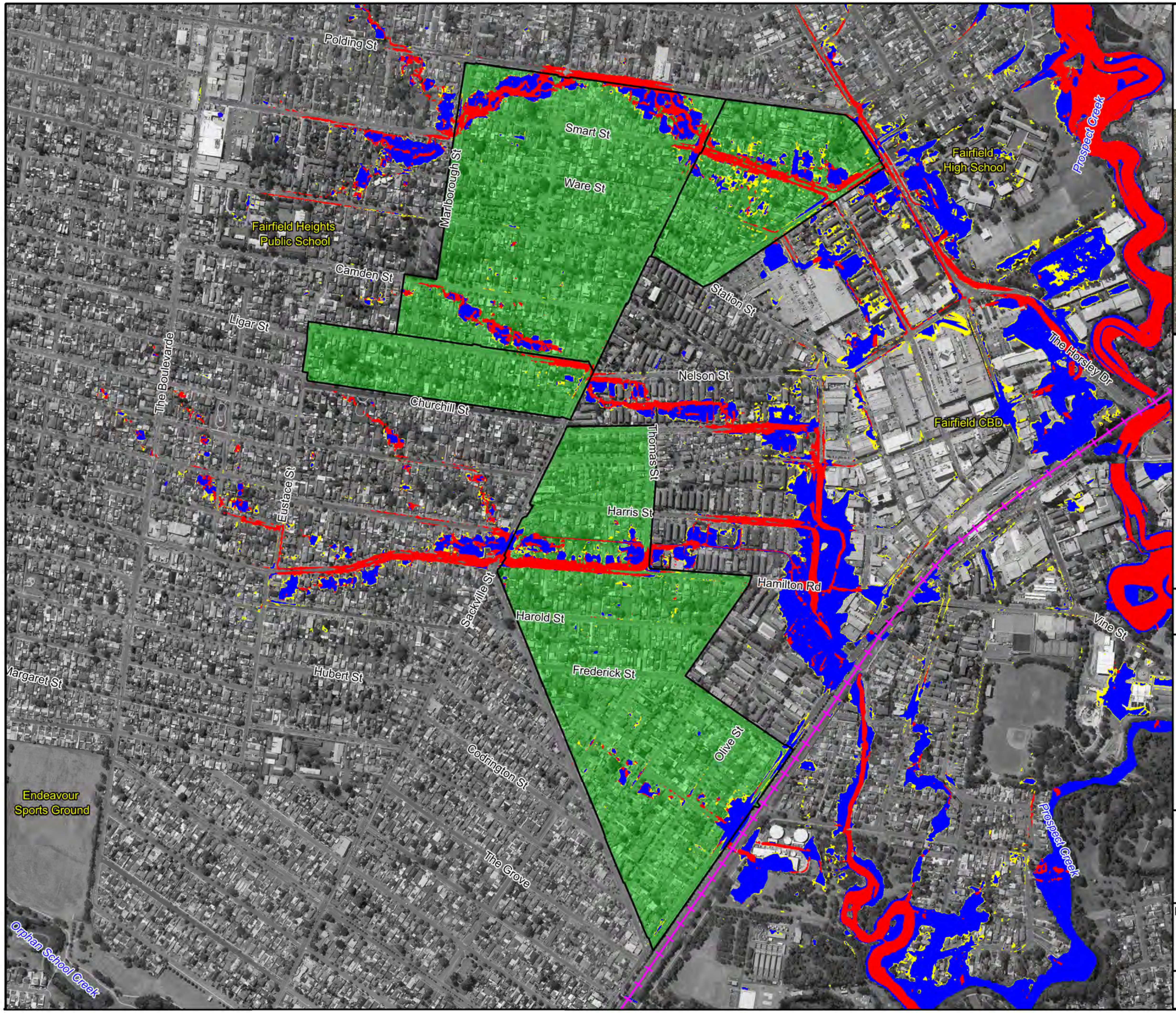
Sydney, NSW 2000

File Name: CC20 Depths Existing.wor



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LEGEND

Extent of Proposed Upzoning

Hydraulic Category

- Flood Fringe
- Flood Storage
- Floodway

Notes:
Areas not shown with any category are considered to be Flood Fringe

N
W E
S

Scale 1:8,000 (at A3)

0 0.25 0.5
Km

**Figure F6:
100-Year ARI
Hydraulic Categories for
Existing Conditions**

Prepared By:
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Suite 2.01, 210 George St
Sydney, NSW 2000

File Name: 100-Year HydCat Existing.wor

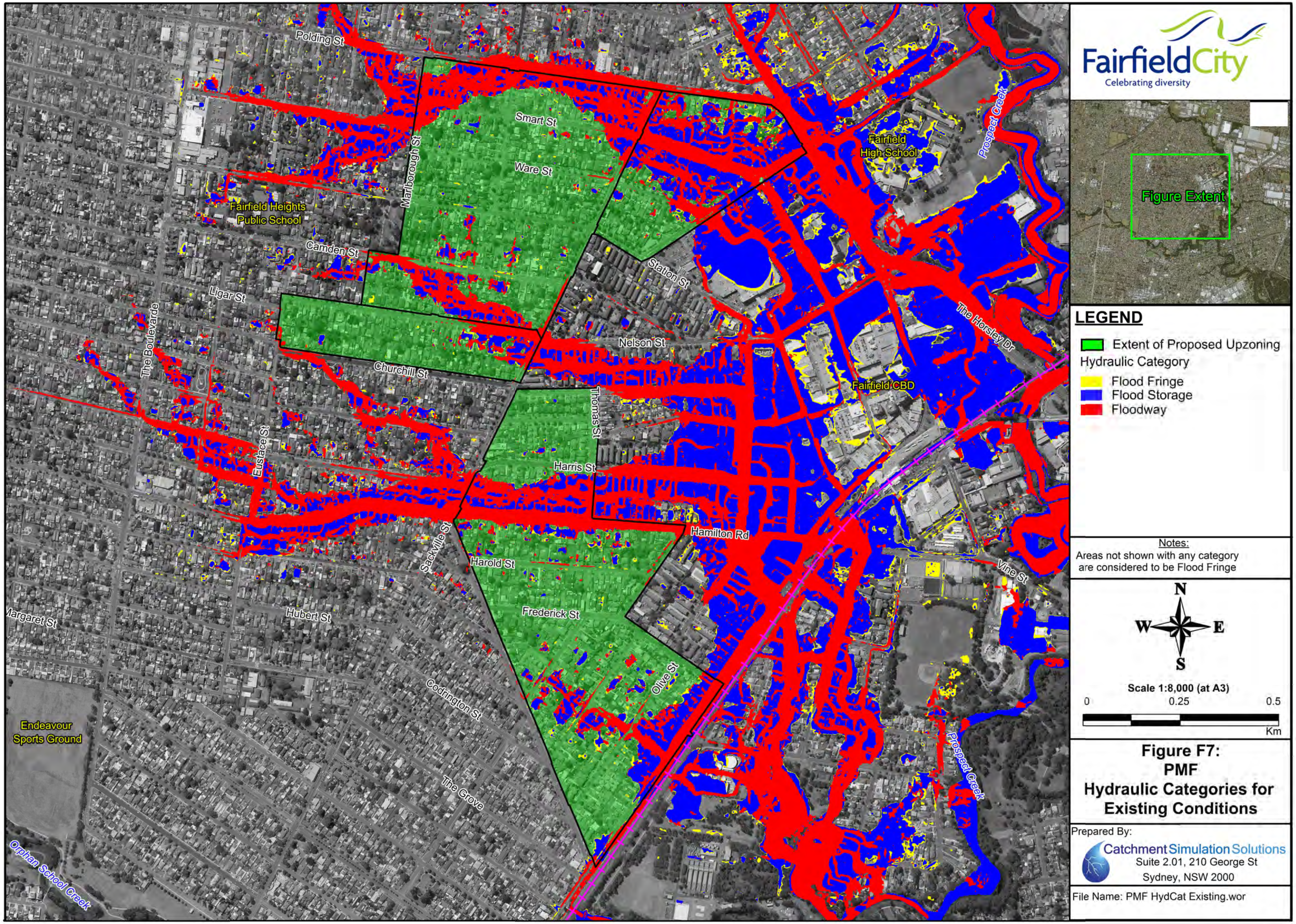
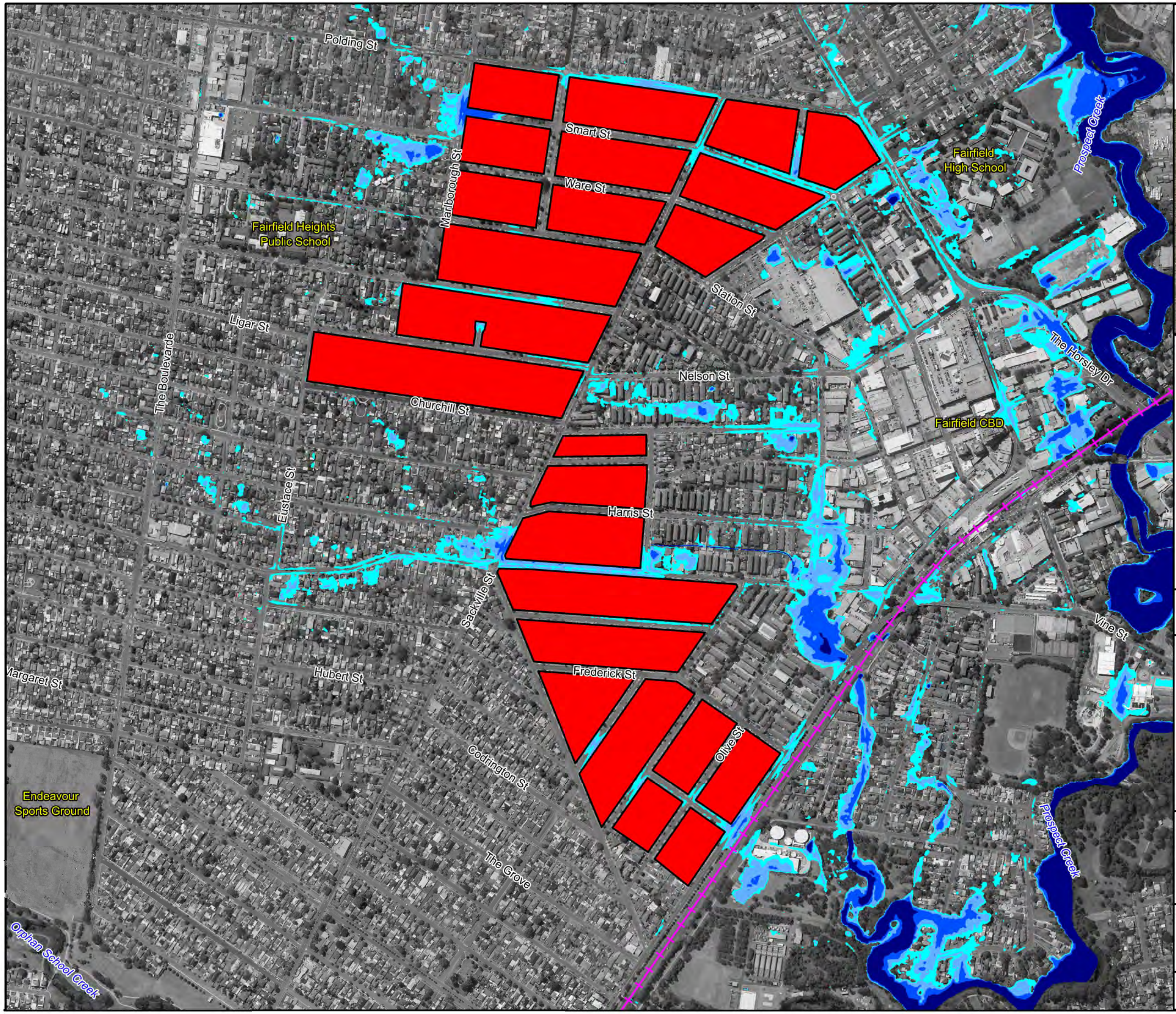


Figure F7: PMF Hydraulic Categories for Existing Conditions



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LEGEND

Extent of adopted filling for upzoning

Depth (m)

- 0.15 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- > 1.0

Notes:

N W E S

Scale 1:8,000 (at A3)

0 0.25 0.5 Km

Figure F8: Peak 20-Year ARI Floodwater Depths for Upzoned Conditions

Prepared By:
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Sydney, NSW 2000

File Name: 20-Year Depths Upzoned.wor

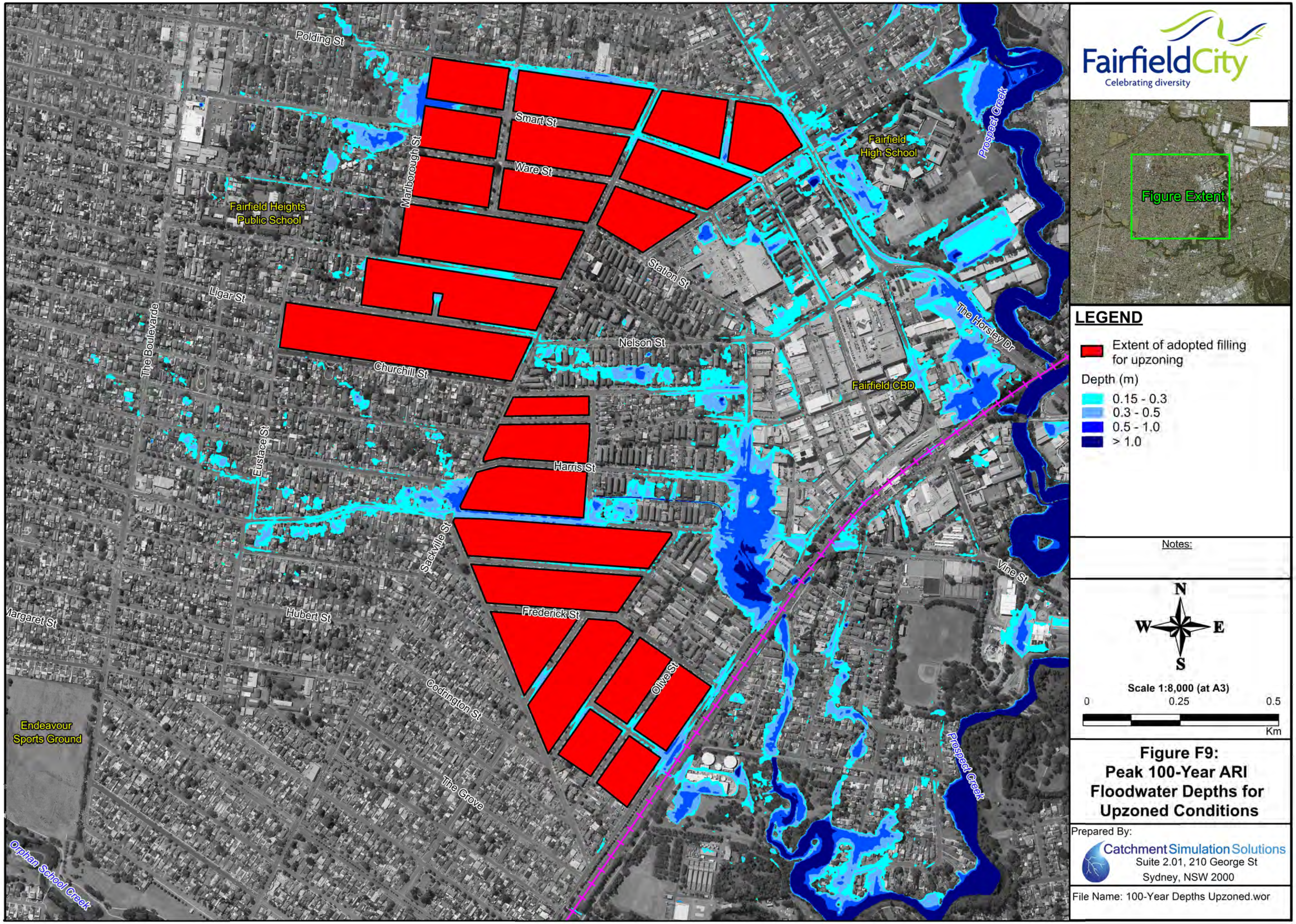
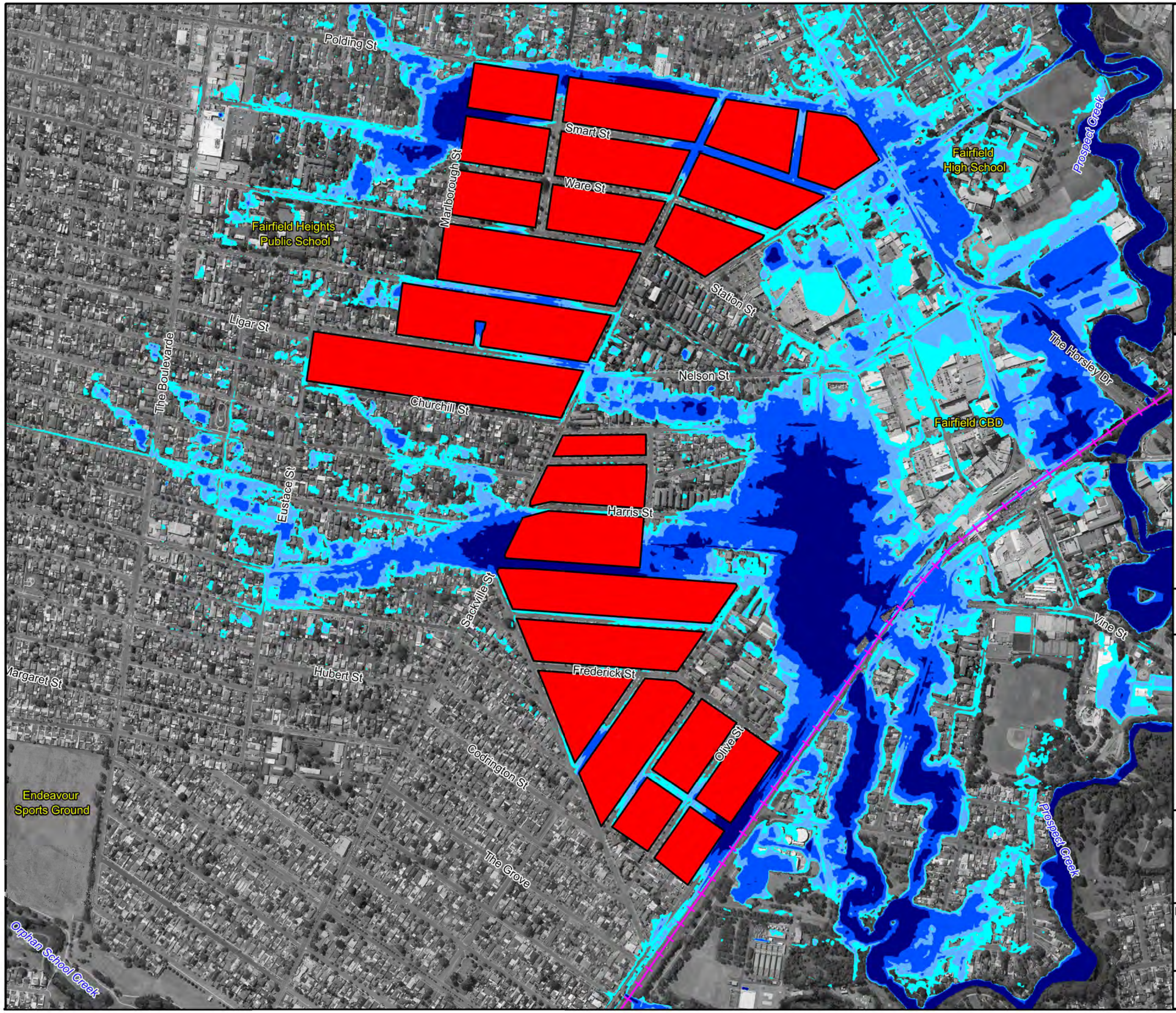


Figure F9: Peak 100-Year ARI Floodwater Depths for Upzoned Conditions



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LEGEND

Extent of adopted filling for upzoning

Depth (m)

- 0.15 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- > 1.0

Notes:

N
W E
S

Scale 1:8,000 (at A3)

0 0.25 0.5
Km

Figure F10:
Peak PMF
Floodwater Depths for
Upzoned Conditions

Prepared By:

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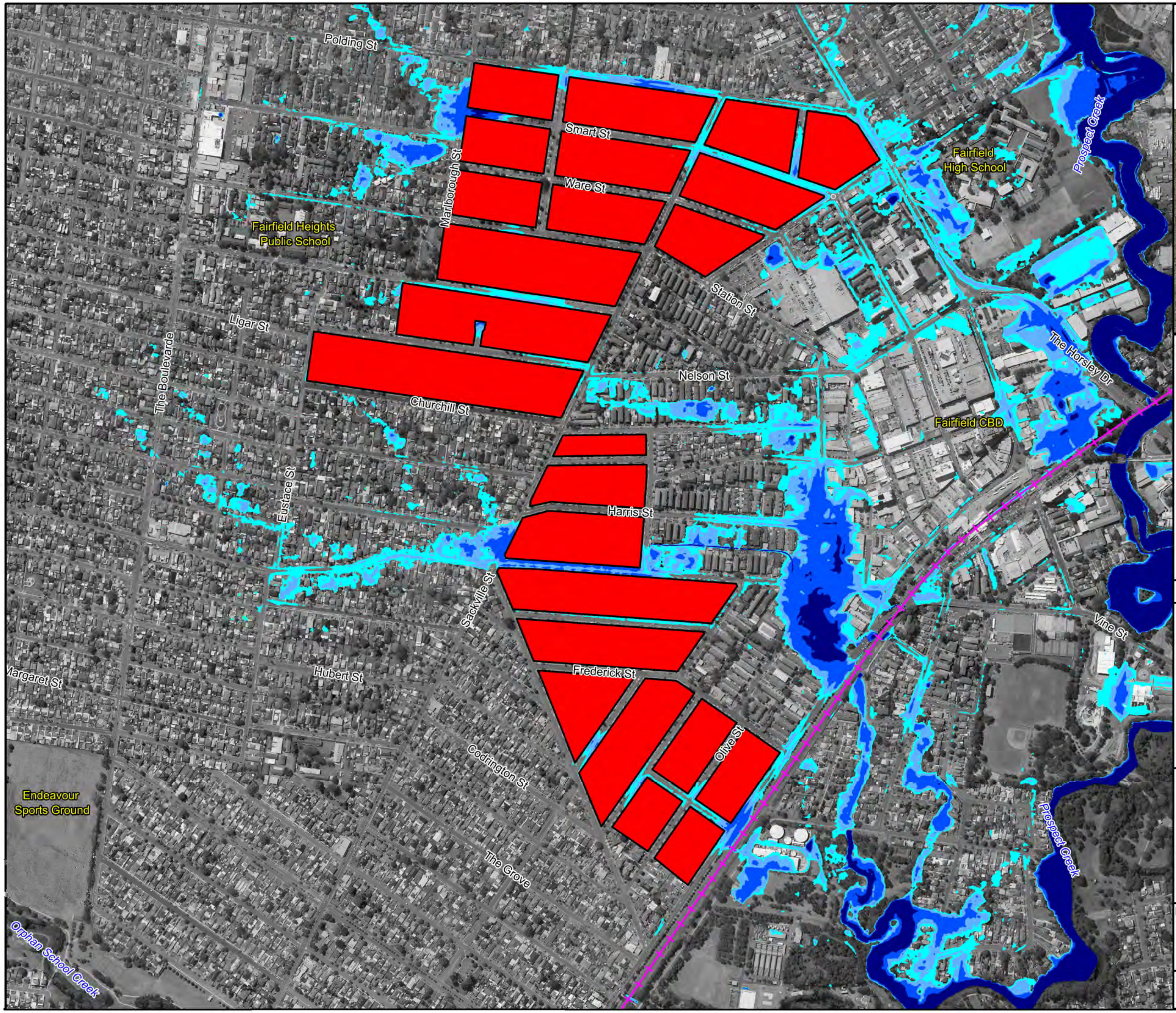
Sydney, NSW 2000

File Name: PMF Depths Upzoned.wor



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LEGEND

Extent of adopted filling for upzoning

Depth (m)
- 0.15 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- > 1.0

Notes:

N
W E
S

Scale 1:8,000 (at A3)
0 0.25 0.5
Km

Figure F11: Peak 100-Year ARI with 20% Increase in Rainfall Floodwater Depths for Upzoned Conditions

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Sydney, NSW 2000

File Name: CC20 Depths Upzoning.wor

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LEGEND

- Extent of upzoning

Water Level Difference (m)

- 0.50
- 0.20
- 0.10
- 0.02
- No Change
- -0.02
- -0.10
- -0.20
- -0.50
- Previously wet now dry
- Previously dry now wet

Notes:

N
W E
S

Scale 1:8,000 (at A3)

0 0.25 0.5
Km

Figure F12: Predicted Change in Peak 20-Year ARI Flood Levels Associated with Upzoning

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Sydney, NSW 2000

File Name: 20-Year Diff Upzoned.wor

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LEGEND

- Extent of upzoning

Water Level Difference (m)

- 0.50
- 0.20
- 0.10
- 0.02
- No Change
- -0.02
- -0.10
- -0.20
- -0.50
- Previously wet now dry
- Previously dry now wet

Notes:

N W E S

Scale 1:8,000 (at A3)

0 0.25 0.5 Km

Figure F13: Predicted Change in Peak 100-Year ARI Flood Levels Associated with Upzoning

Prepared By:
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Sydney, NSW 2000

File Name: 100-Year Diff Upzoned.wor

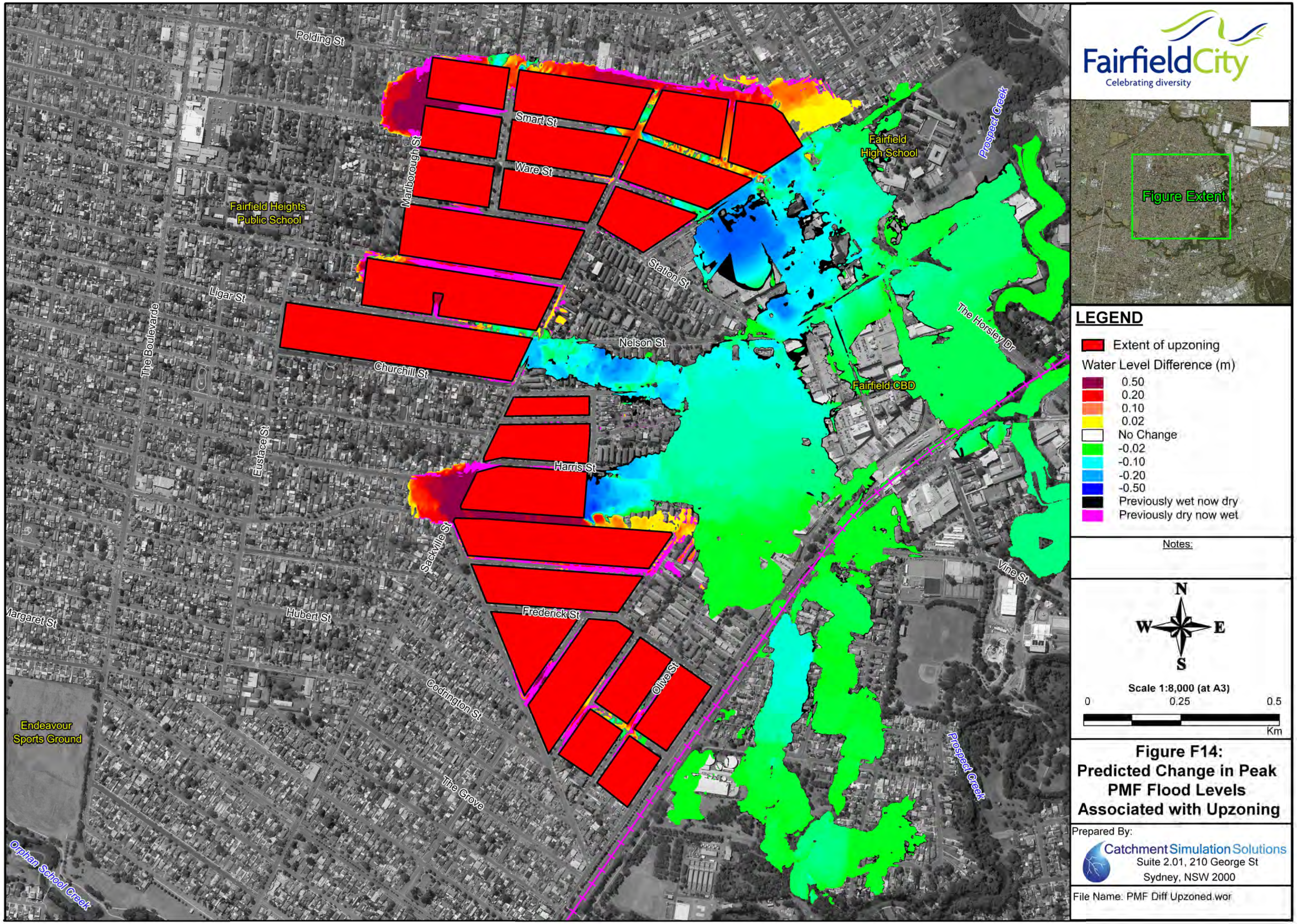


Figure F14: Predicted Change in Peak PMF Flood Levels Associated with Upzoning

Prepared By:
Catchment Simulation Solutions
Suite 2.01, 210 George St
Sydney, NSW 2000

File Name: PMF Diff Upzoned.wor

FairfieldCity
Celebrating diversity

LEGEND

Extent of upzoning	
Water Level Difference (m)	
	0.50
	0.20
	0.10
	0.02
	No Change
	-0.02
	-0.10
	-0.20
	-0.50
	Previously wet now dry
	Previously dry now wet

Notes:

N W E S

Scale 1:8,000 (at A3)

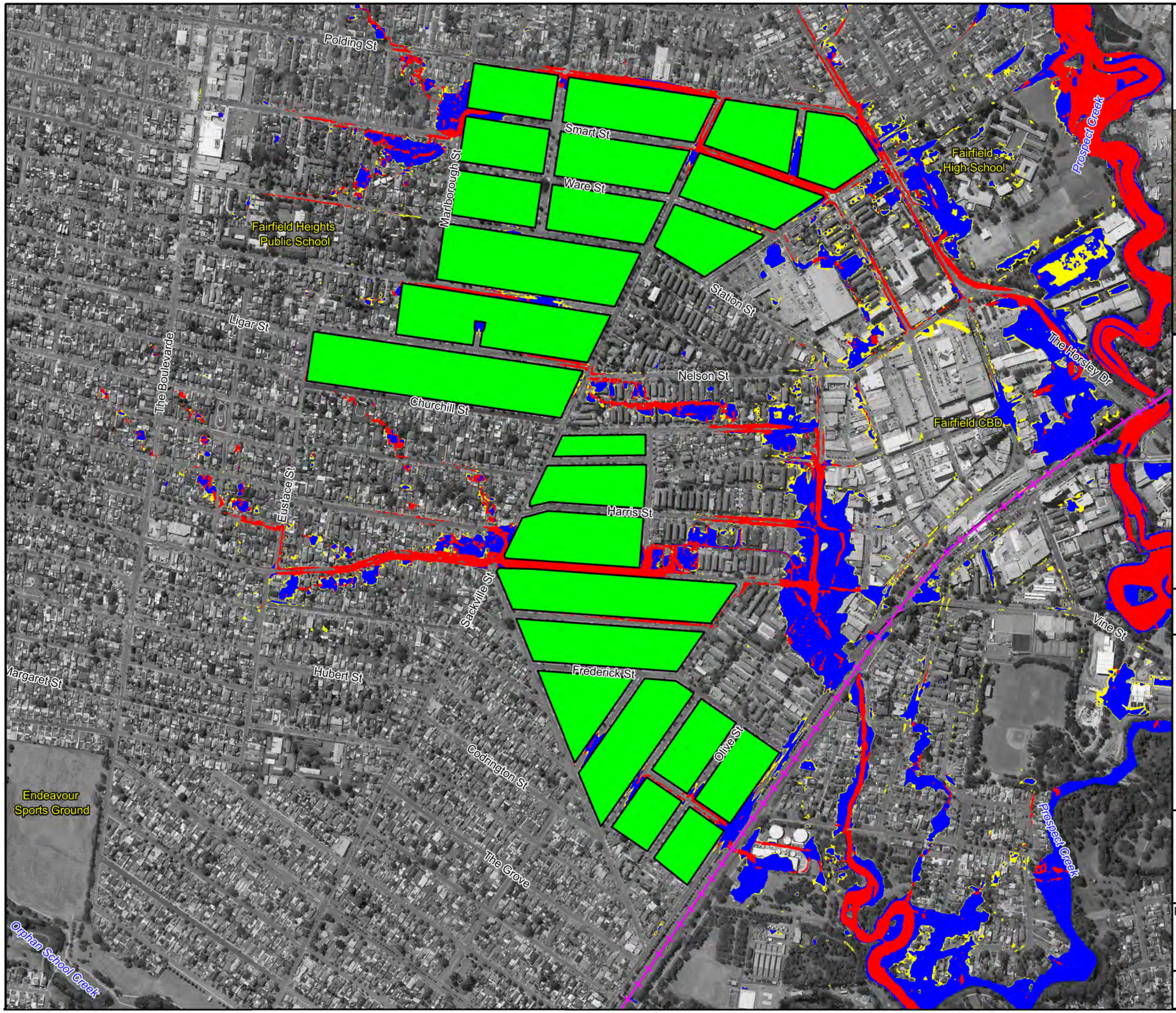
0 0.25 0.5 Km

Figure F15: Predicted Change in Peak 100-Year ARI with 20% Increase in Rainfall Flood Levels Associated with Upzoning

Prepared By:
Catchment Simulation Solutions
Suite 2.01, 210 George St
Sydney, NSW 2000

File Name: CC20 Diff Upzoned.wor

FairfieldCity
Celebrating diversity



LEGEND

- Extent of Proposed Upzoning

Hydraulic Category

- Flood Fringe
- Flood Storage
- Floodway

Notes:
Areas not shown with any category are considered to be Flood Fringe

N, W, E, S

Scale 1:8,000 (at A3)

0 — 0.25 — 0.5 Km

Figure F16:
100-Year ARI
Hydraulic Categories for Upzoned Conditions

Prepared By:
Catchment Simulation Solutions
Suite 2.01, 210 George St
Sydney, NSW 2000

File Name: 100-Year HydCat Upzoned.wor

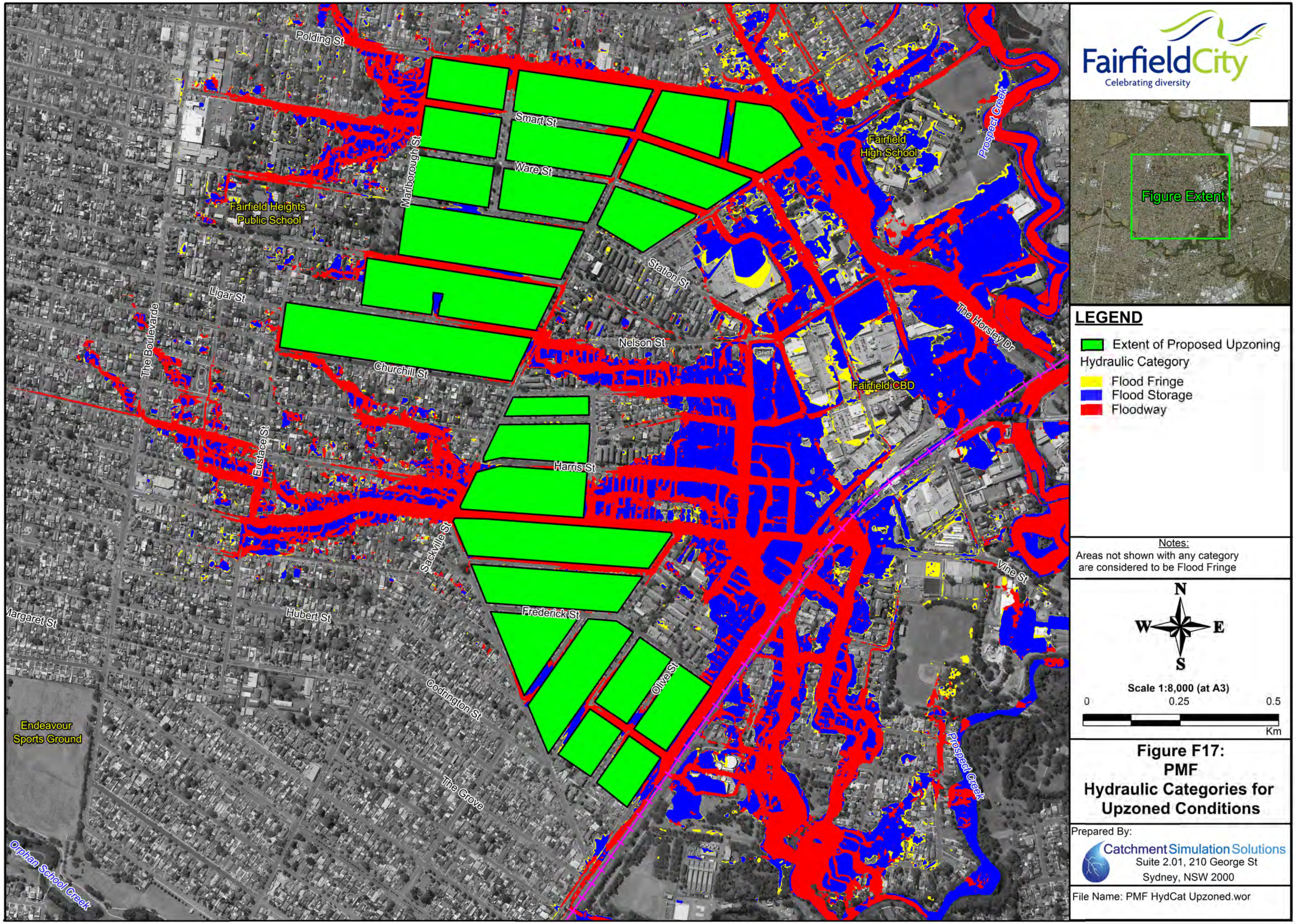


Figure F17: PMF Hydraulic Categories for Upzoned Conditions

Prepared By:
Catchment Simulation Solutions
Suite 2.01, 210 George St
Sydney, NSW 2000

File Name: PMF HydCat Upzoned.wor

Fairfield City
Celebrating diversity

LEGEND

- Extent of zoning changes

Hydraulic Category Changes

- Increase in Floodway
- Decrease in Floodway
- Decrease in Flood Storage

Notes:

N W E S

Scale 1:8,000 (at A3)

0 0.25 0.5 Km

Figure F18: Predicted Change in Peak 100yr Hydraulic Categories for Upzoned Conditions

Prepared By:
Catchment Simulation Solutions
Suite 2.01, 210 George St
Sydney, NSW 2000

File Name: 100yr HydroDiff Upzoned.wor

LEGEND

- Extent of zoning changes

Hydraulic Category Changes

- Increase in Floodway
- Decrease in Floodway
- Decrease in Flood Storage

Notes:

N W E S

Scale 1:8,000 (at A3)

0 0.25 0.5 Km

Figure F19: Predicted Change in Peak PMF Hydraulic Categories for Upzoned Conditions

Prepared By:
Catchment Simulation Solutions
Suite 2.01, 210 George St
Sydney, NSW 2000

File Name: PMF HydroDiff Upzoned.wor

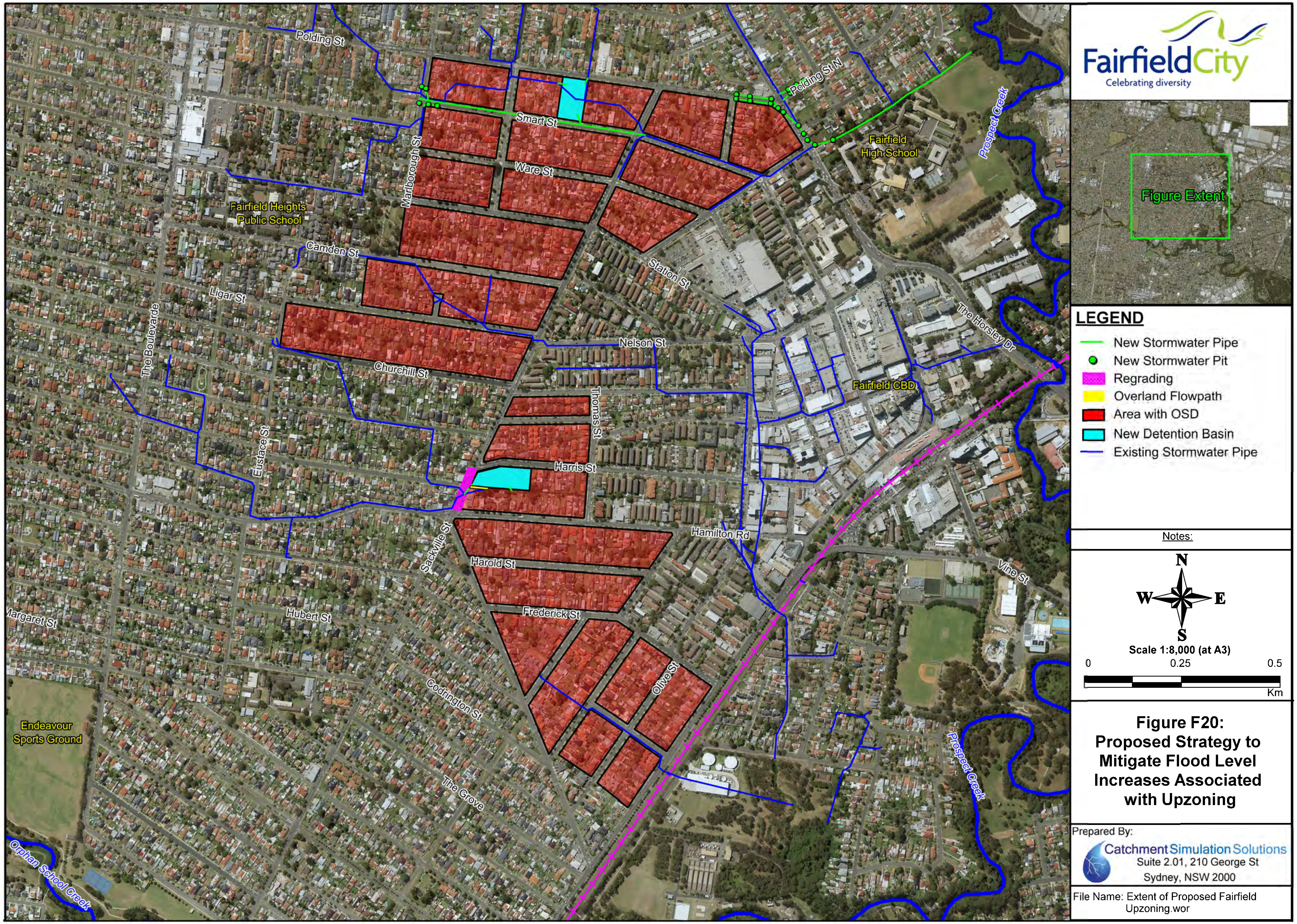


Figure F20: Proposed Strategy to Mitigate Flood Level Increases Associated with Upzoning

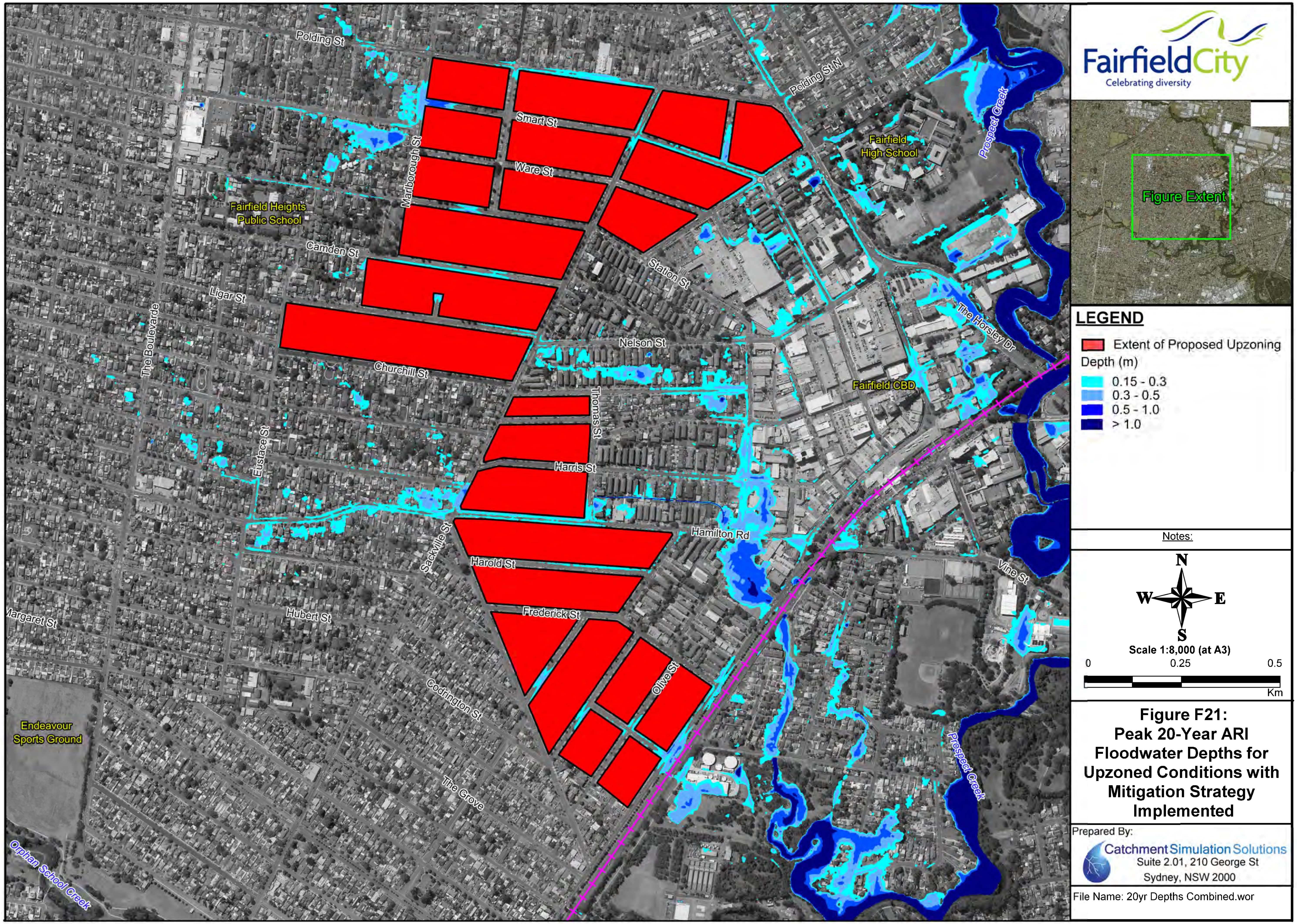
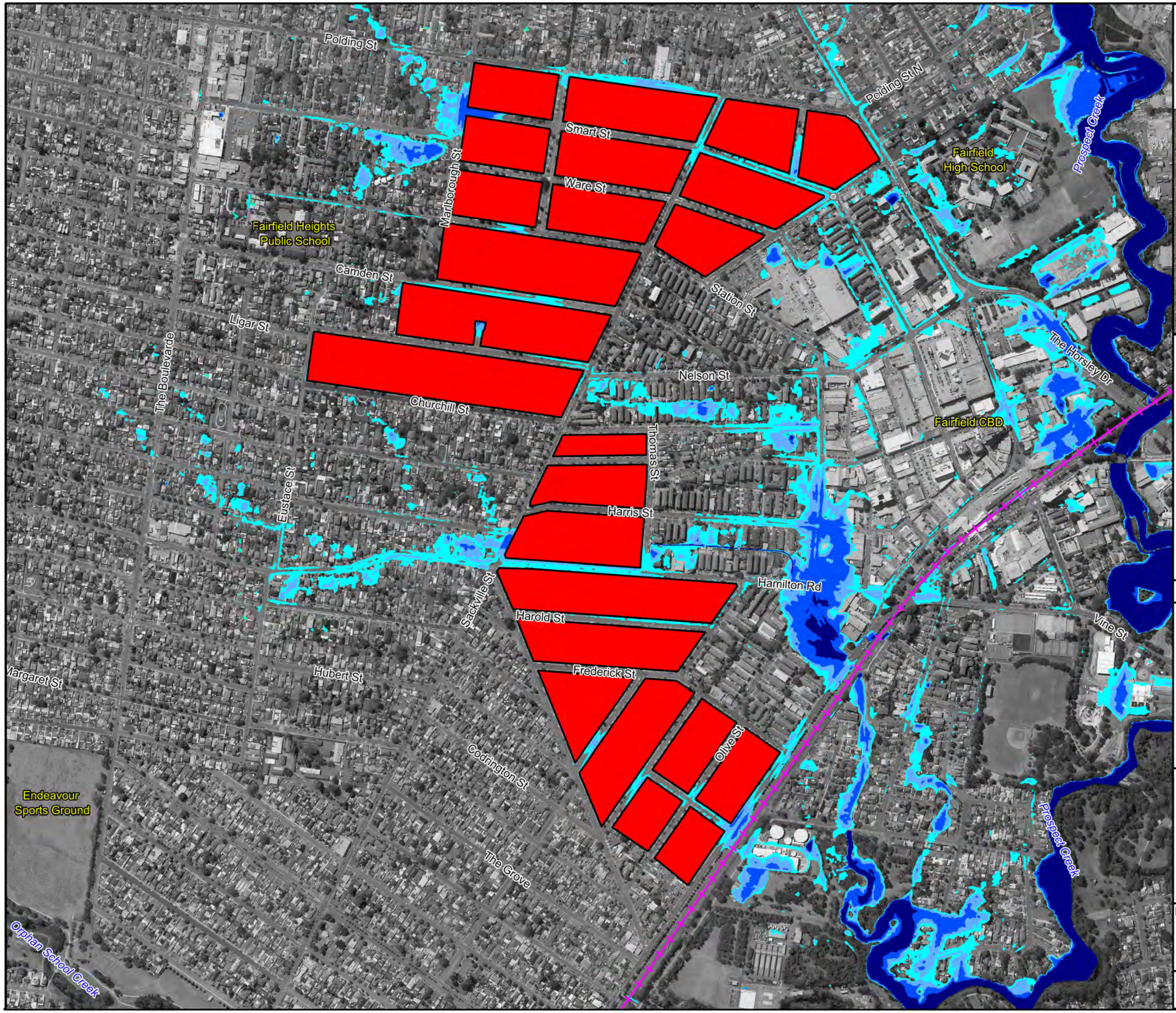


Figure F21: Peak 20-Year ARI Floodwater Depths for Upzoned Conditions with Mitigation Strategy Implemented



Fairfield City
Celebrating diversity

LEGEND

Extent of Proposed Upzoning

Depth (m)

- 0.15 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- > 1.0

Notes:

N
W E
S

Scale 1:8,000 (at A3)

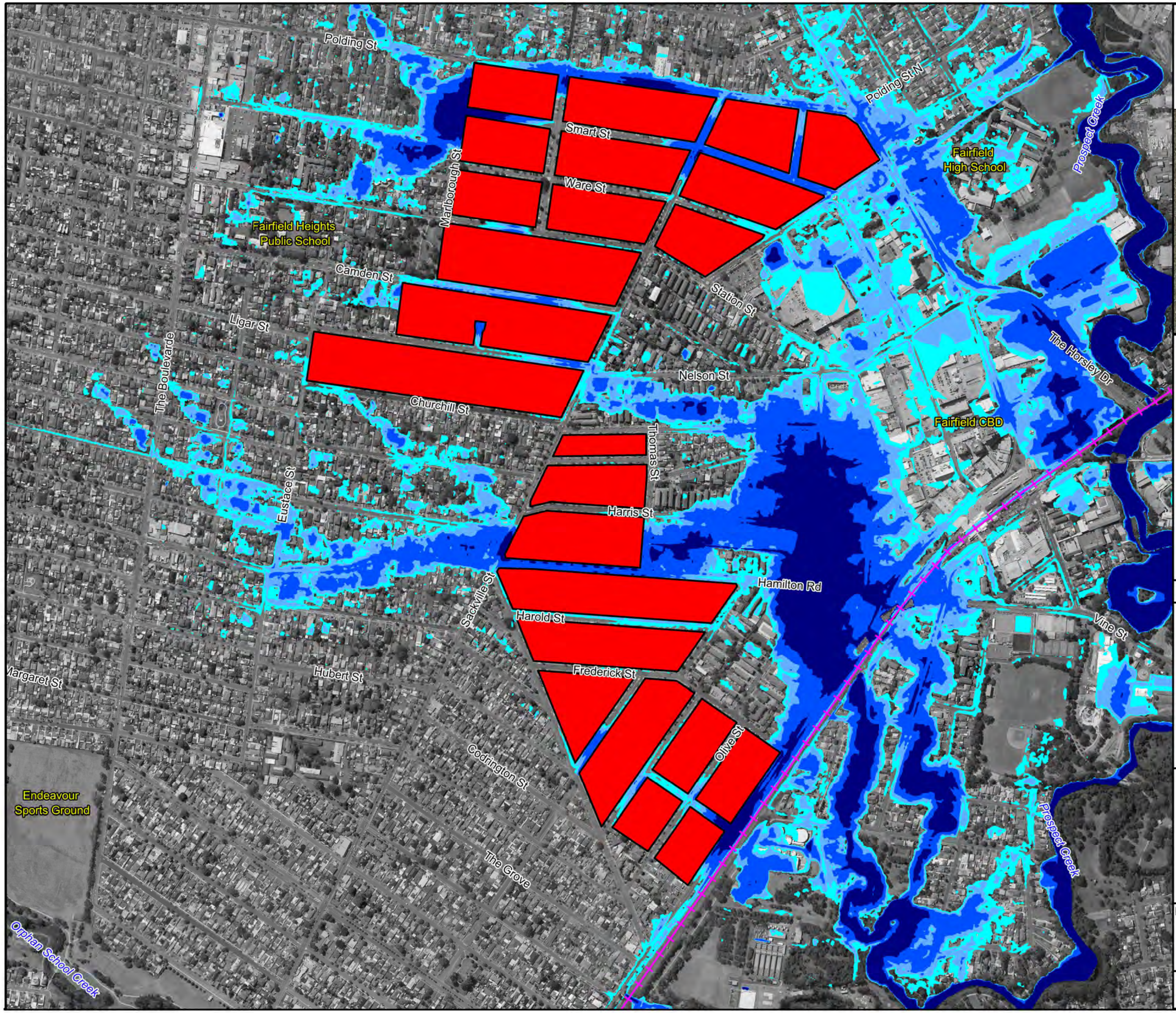
0 0.25 0.5
Km

**Figure F22:
Peak 100-Year ARI
Floodwater Depths for
Upzoned Conditions with
Mitigation Strategy
Implemented**

Prepared By:

Catchment Simulation Solutions
Suite 2.01, 210 George St
Sydney, NSW 2000

File Name: 100yr Depths Combined.wor



Fairfield City
Celebrating diversity

LEGEND

Extent of Proposed Upzoning

Depth (m)

- 0.15 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- > 1.0

Notes:

N W E S

Scale 1:8,000 (at A3)

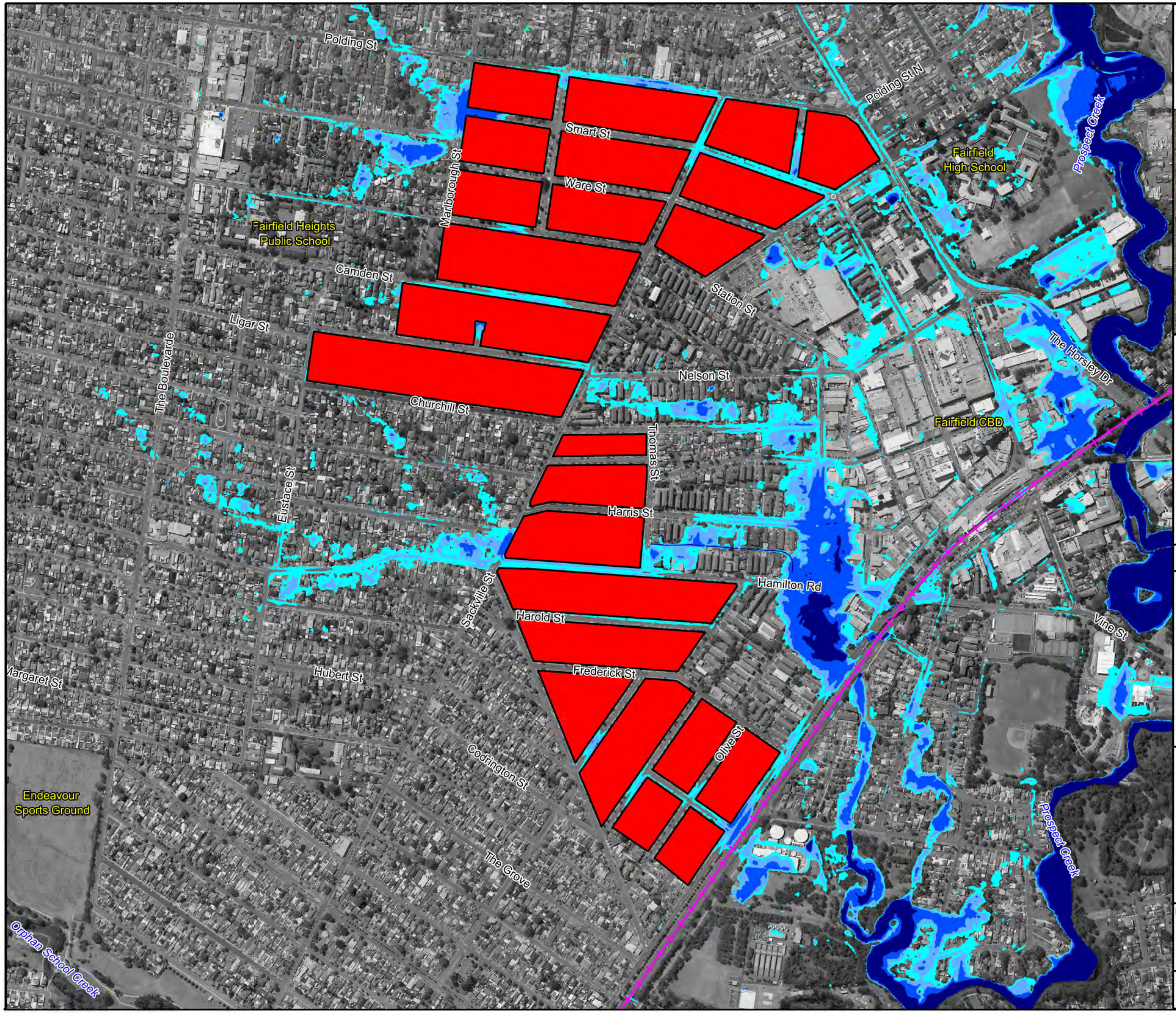
0 0.25 0.5 Km

Figure F23: Peak PMF Floodwater Depths for Upzoned Conditions with Mitigation Strategy Implemented

Prepared By:

Catchment Simulation Solutions
Suite 2.01, 210 George St
Sydney, NSW 2000

File Name: PMF Depths Combined.wor



Fairfield City
Celebrating diversity

LEGEND

- Extent of Proposed Upzoning

Depth (m)

- 0.15 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- > 1.0

Notes:

N W E S

Scale 1:8,000 (at A3)

0 0.25 0.5 Km

Figure F24: Peak 100-Year ARI with 20% Increase in Rainfall Floodwater Depths for Upzoned \Conditions with Mitigation Strategy Implemented

Prepared By:

Catchment Simulation Solutions
Suite 2.01, 210 George St
Sydney, NSW 2000

File Name: PMF Depths Combined.wor

FairfieldCity
Celebrating diversity

LEGEND

- Extent of upzoning

Water Level Difference (m)

- 0.50
- 0.20
- 0.10
- 0.02
- No Change
- -0.02
- -0.10
- -0.20
- -0.50
- Previously wet now dry
- Previously dry now wet

Notes:

N W E S

Scale 1:8,000 (at A3)

0 0.25 0.5 Km

Figure F25: Predicted Change in Peak 20-Year ARI Flood Levels Associated with Upzoning and Mitigation Strategy Implemented

Prepared By:
Catchment Simulation Solutions
Suite 2.01, 210 George St
Sydney, NSW 2000

File Name: 20-Year Diff Upzoned.wor

FairfieldCity
Celebrating diversity

LEGEND

- Extent of upzoning

Water Level Difference (m)

- 0.50
- 0.20
- 0.10
- 0.02
- No Change
- -0.02
- -0.10
- -0.20
- -0.50
- Previously wet now dry
- Previously dry now wet

Notes:

N
W E
S

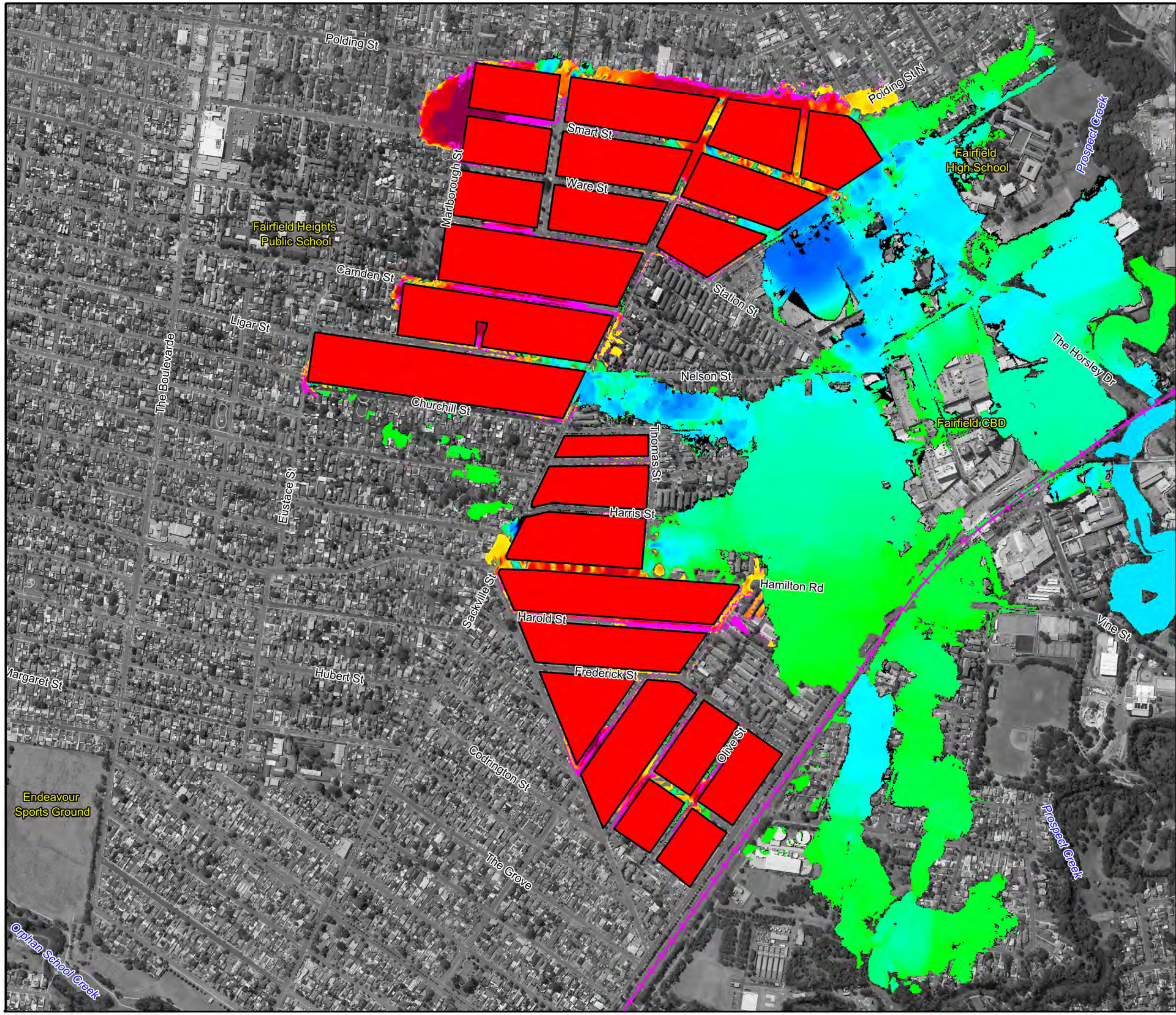
Scale 1:8,000 (at A3)

0 0.25 0.5
Km

Figure F26: Predicted Change in Peak 100-Year ARI Flood Levels Associated with Upzoning and Mitigation Strategy Implemented

Prepared By:
Catchment Simulation Solutions
Suite 2.01, 210 George St
Sydney, NSW 2000

File Name: 100-Year Diff Upzoned.wor



LEGEND

Extent of upzoning

Water Level Difference (m)

- 0.50
- 0.20
- 0.10
- 0.02
- No Change
- -0.02
- -0.10
- -0.20
- -0.50
- Previously wet now dry
- Previously dry now wet

Notes:

N W E S

Scale 1:8,000 (at A3)

0 0.25 0.5 Km

Figure F27: Predicted Change in Peak PMF Flood Levels Associated with Upzoning and Mitigation Strategy Implemented

Prepared By:

Catchment Simulation Solutions
Suite 2.01, 210 George St
Sydney, NSW 2000

File Name: PMF Diff Upzoned.wor

Fairfield City
Celebrating diversity

LEGEND

- Extent of upzoning
- Water Level Difference (m)
  - 0.50
  - 0.20
  - 0.10
  - 0.02
  - No Change
  - -0.02
  - -0.10
  - -0.20
  - -0.50
  - Previously wet now dry
  - Previously dry now wet

Notes:

N
W E
S

Scale 1:8,000 (at A3)

0 0.25 0.5 Km

Figure F28: Predicted Change in Peak 100-Year ARI with 20% Increase in Rainfall Flood Levels Associated with Upzoning and Mitigation Strategy Implemented

Prepared By:
Catchment Simulation Solutions
Suite 2.01, 210 George St
Sydney, NSW 2000

File Name: 100CC20 Diff Upzoned.wor

FairfieldCity
Celebrating diversity

LEGEND

- Extent of Proposed Upzoning
- Hydraulic Category
  - Flood Fringe
  - Flood Storage
  - Floodway

Notes:

N
W E
S

Scale 1:8,000 (at A3)

0 0.25 0.5
Km

Figure F29: Peak 100-Year ARI Hydraulic Categories for Upzoned Conditions with Mitigation Strategy Implemented

Prepared By:
Catchment Simulation Solutions
Suite 2.01, 210 George St
Sydney, NSW 2000

File Name: 100yr HydroCat Combined.wor

Fairfield City
Celebrating diversity

Figure Extent

LEGEND

Extent of Proposed Upzoning

Hydraulic Category

Flood Fringe

Flood Storage

Floodway

Notes:

N W E S

Scale 1:8,000 (at A3)

0 0.25 0.5 Km

Figure F30:
Peak PMF
Hydraulic Categories for Upzoned Conditions with Mitigation Strategy Implemented

Prepared By:
Catchment Simulation Solutions
Suite 2.01, 210 George St
Sydney, NSW 2000

File Name: PMF HydroCat Combined.wor

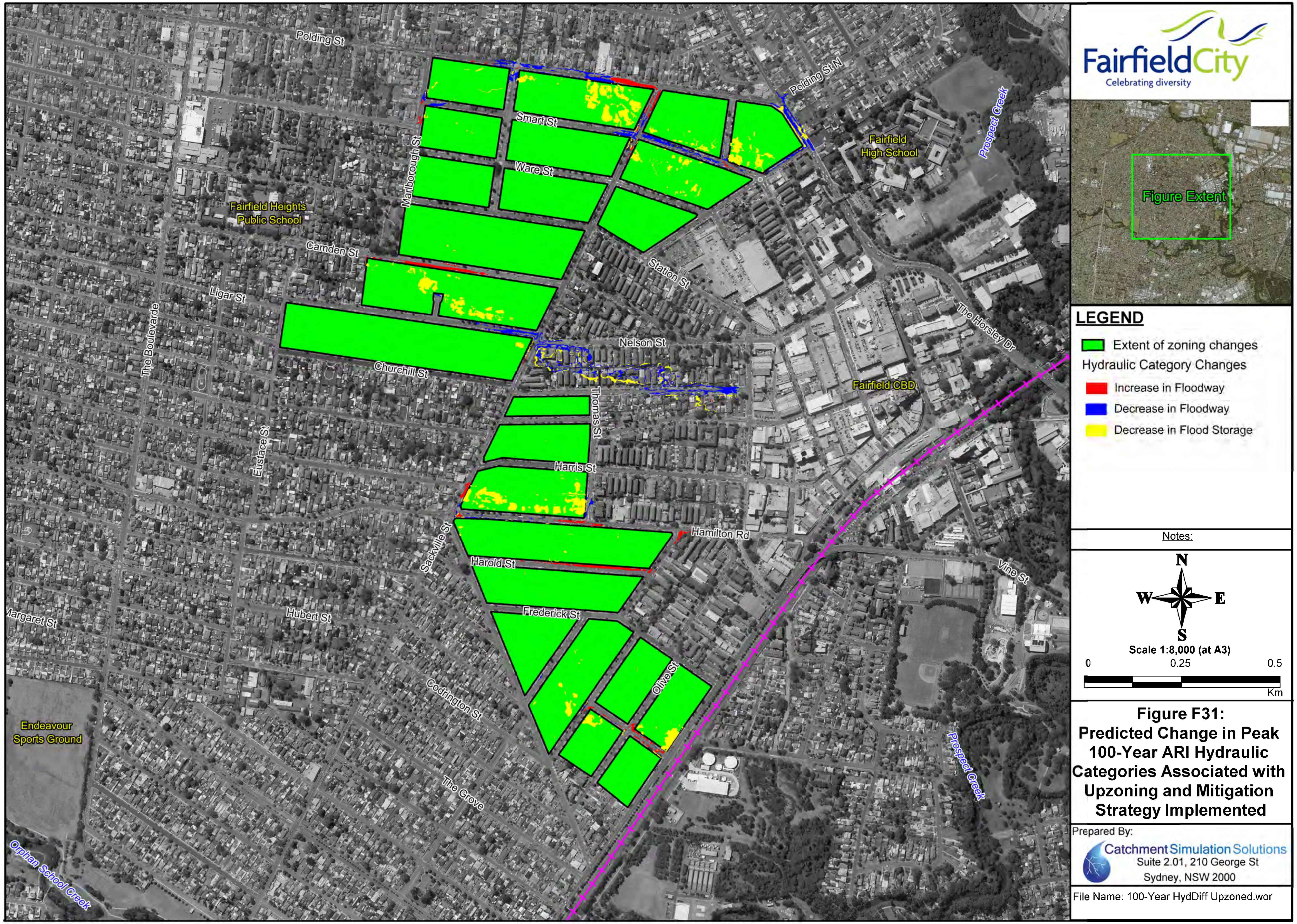


Figure F31: Predicted Change in Peak 100-Year ARI Hydraulic Categories Associated with Upzoning and Mitigation Strategy Implemented

Prepared By:
Catchment Simulation Solutions
Suite 2.01, 210 George St
Sydney, NSW 2000

File Name: 100-Year HydDiff Upzoned.wor

FairfieldCity
Celebrating diversity

LEGEND

- Extent of zoning changes

Hydraulic Category Changes

- Increase in Floodway
- Decrease in Floodway
- Decrease in Flood Storage

Notes:

N
W E
S

Scale 1:8,000 (at A3)

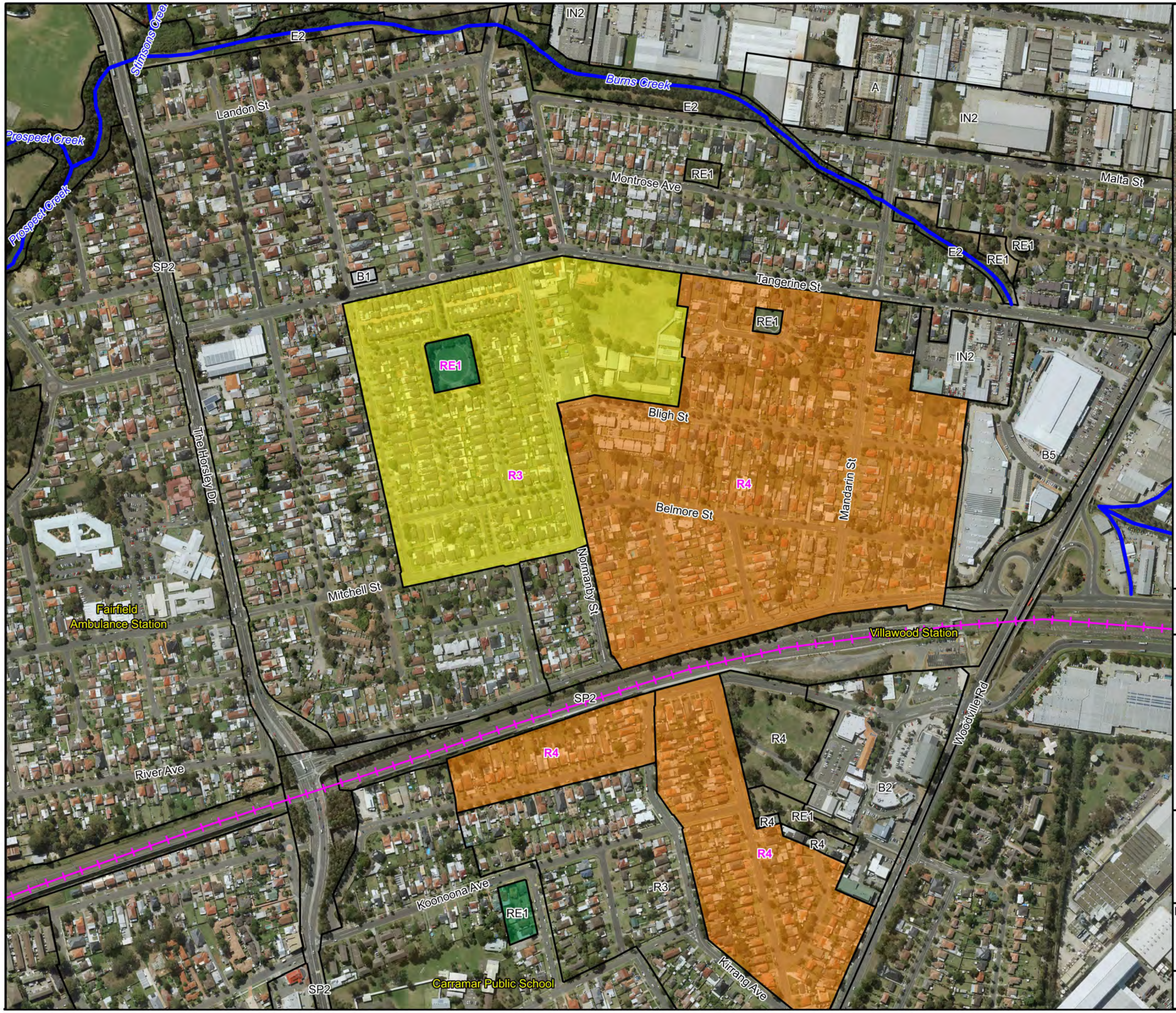
0 0.25 0.5
Km

Figure F32: Predicted Change in Peak PMF Hydraulic Categories Associated with Upzoning and Mitigation Strategy Implemented

Prepared By:
CatchmentSimulationSolutions
Suite 2.01, 210 George St
Sydney, NSW 2000

File Name: PMF HydDiff Upzoned.wor

APPENDIX B
FAIRFIELD EAST AND VILLAWOOD FIGURES



FairfieldCity
Celebrating diversity

Figure Extent

LEGEND

- Current Zone
- Proposed Upzoning
- R2 to R3
- R3 to R4
- R2 to RE1

Notes:

N W E S

Scale 1:5,000 (at A3)

0 0.15 0.3 Km

Figure V1: Extent of Proposed Villawood Upzoning

Prepared By:
Catchment Simulation Solutions
Suite 2.01, 210 George St
Sydney, NSW 2000

File Name: Extent of Proposed Villawood Upzoning.wor

FairfieldCity
Celebrating diversity

LEGEND

- Extent of Proposed Upzoning
- Depth (m)
  - 0.15 - 0.3
  - 0.3 - 0.5
  - 0.5 - 1.0
  - > 1.0

Notes:

N
W E
S

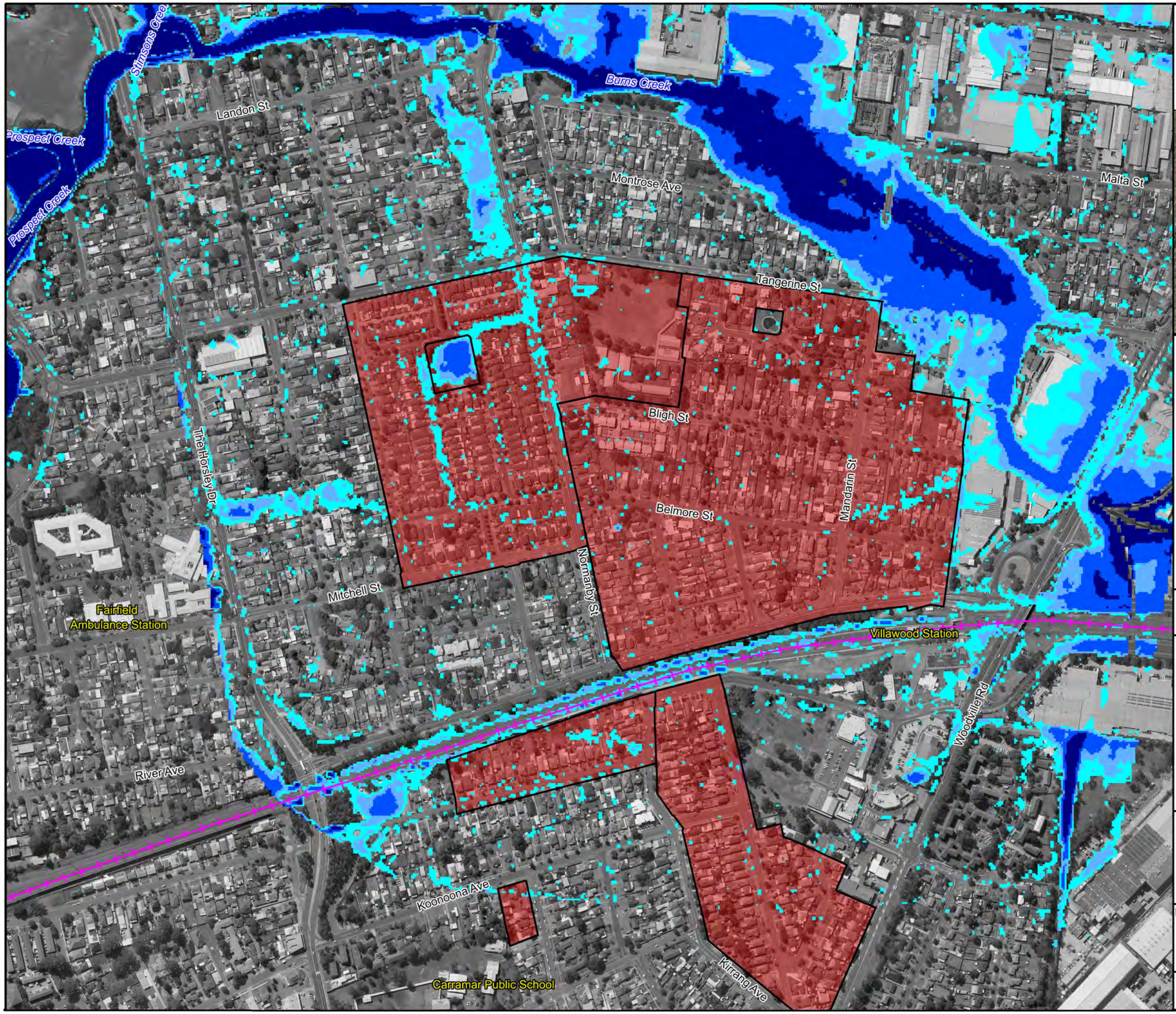
Scale 1:5,000 (at A3)

0 0.15 0.3
Km

Figure V2:
Peak 20-Year ARI Floodwater Depths for Existing Conditions

Prepared By:
Catchment Simulation Solutions
Suite 2.01, 210 George St
Sydney, NSW 2000

File Name: 20-Year Depths Existing.wor



FairfieldCity
Celebrating diversity

LEGEND

- Extent of Proposed Upzoning

Depth (m)

- 0.15 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- > 1.0

Notes:

N E S W

Scale 1:5,000 (at A3)

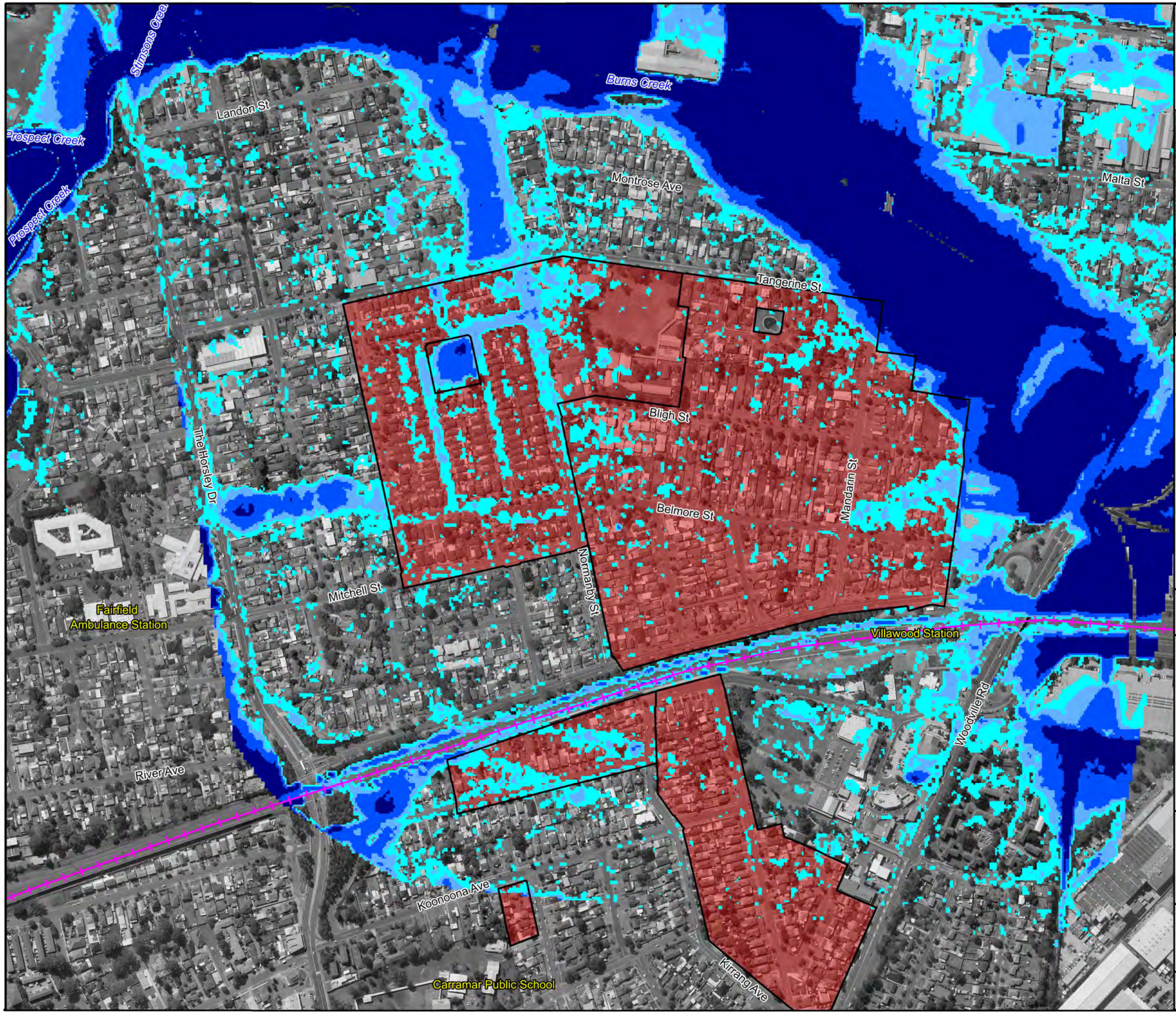
0 0.15 0.3 Km

Figure V3: Peak 100-Year ARI Floodwater Depths for Existing Conditions

Prepared By:

Catchment Simulation Solutions
Suite 2.01, 210 George St
Sydney, NSW 2000

File Name: 100-Year Depths Existing.wor



FairfieldCity
Celebrating diversity

LEGEND

Extent of Proposed Upzoning

Depth (m)

- 0.15 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- > 1.0

Notes:

N W E S

Scale 1:5,000 (at A3)

0 0.15 0.3 Km

Figure V4:
Peak PMF
Floodwater Depths for
Existing Conditions

Prepared By:

Catchment Simulation Solutions
Suite 2.01, 210 George St
Sydney, NSW 2000

File Name: PMF Depths Existing.wor

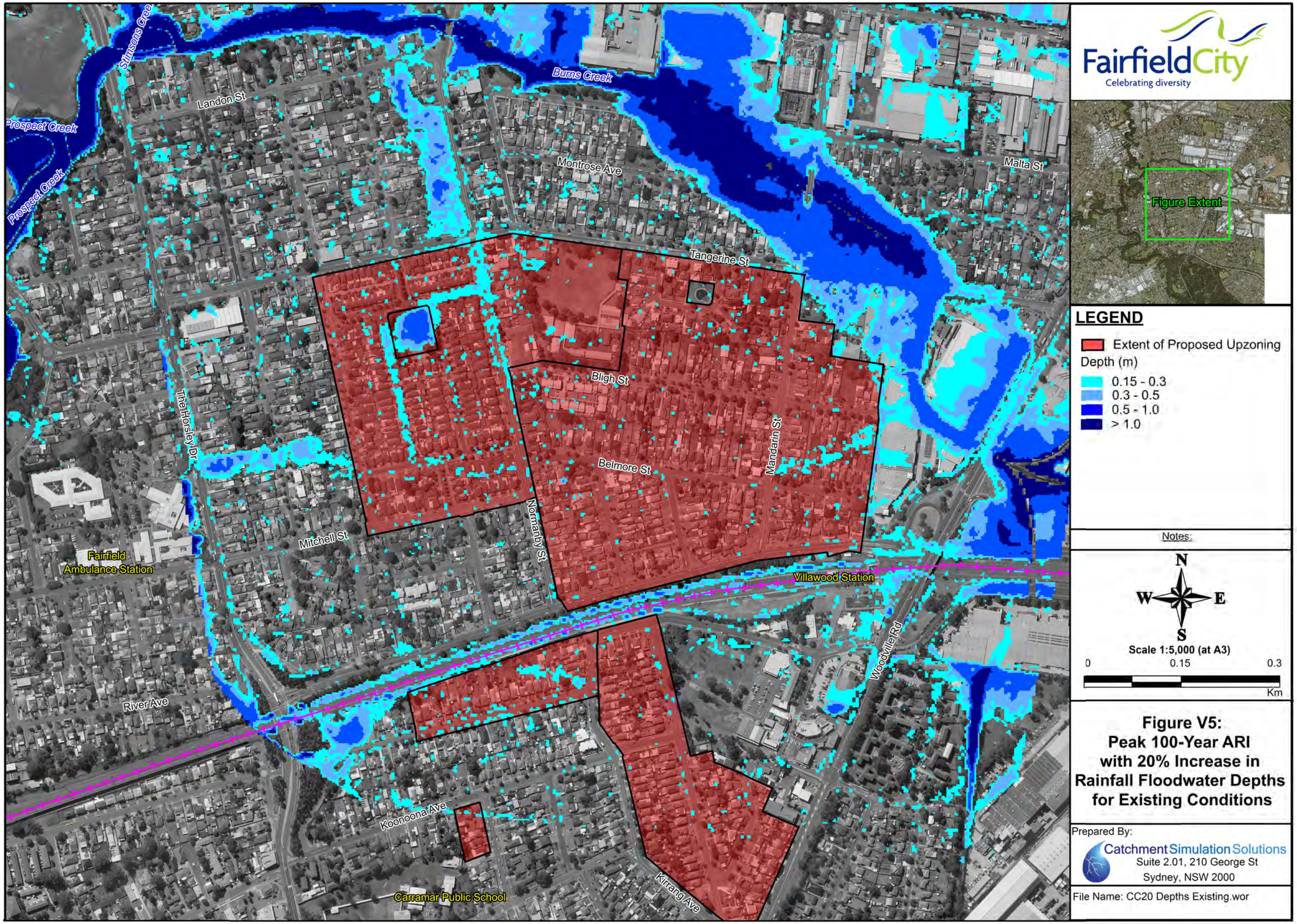
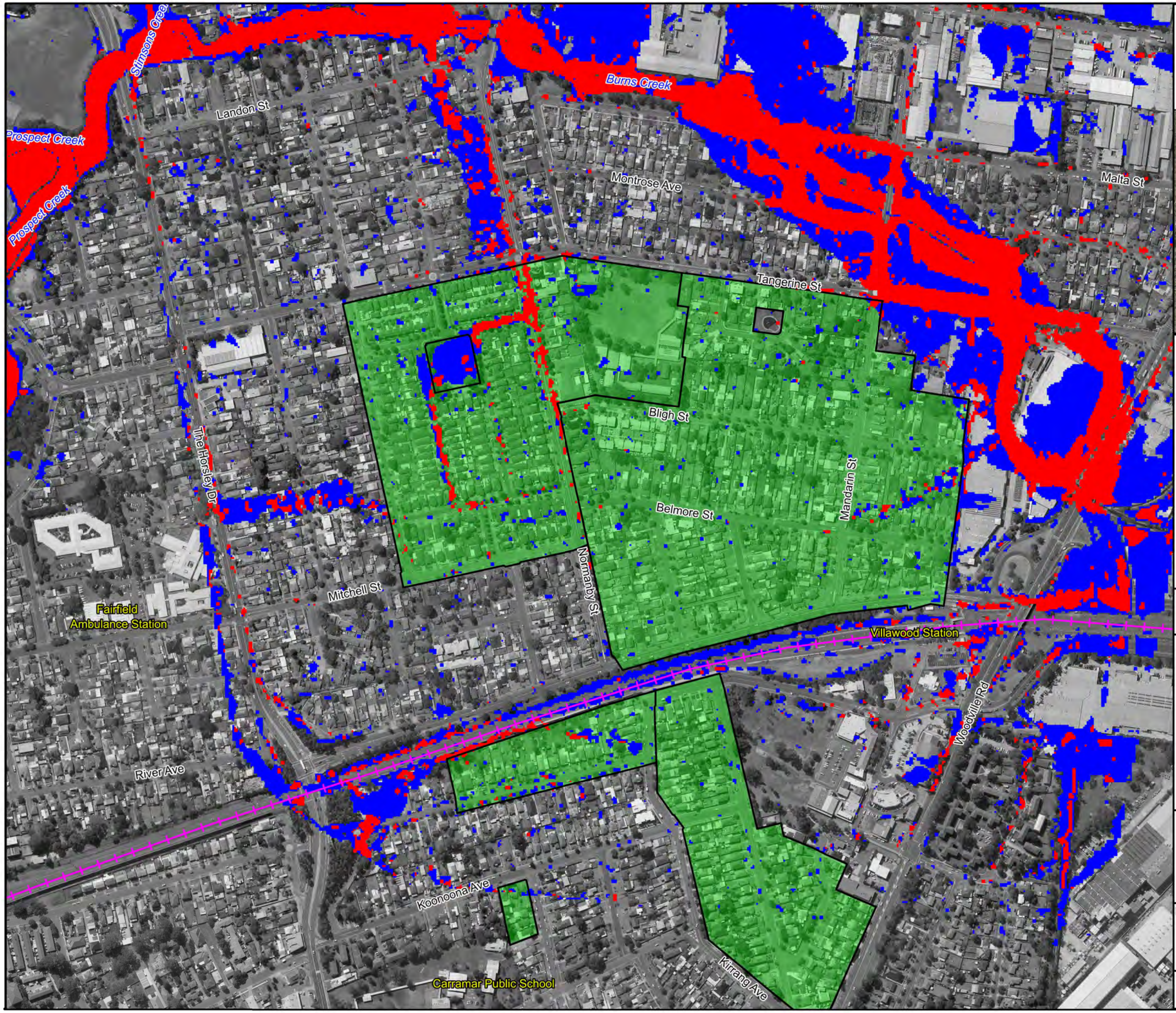


Figure V5: Peak 100-Year ARI with 20% Increase in Rainfall Floodwater Depths for Existing Conditions



FairfieldCity
Celebrating diversity

LEGEND

Extent of Proposed Upzoning

Hydraulic Category

- Flood Fringe
- Flood Storage
- Floodway

Notes:
Areas not shown with any category are considered to be Flood Fringe

N
W E
S

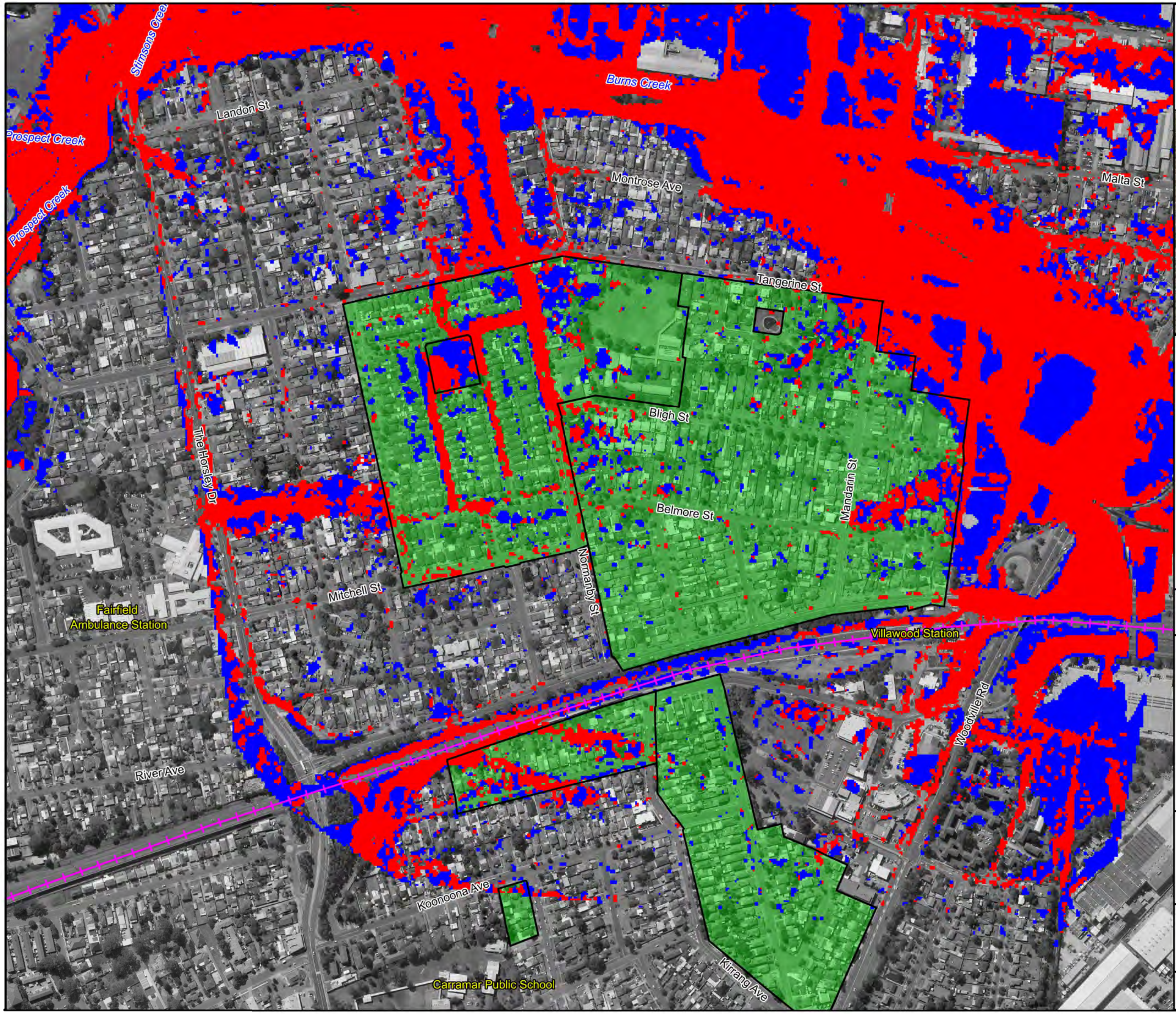
Scale 1:5,000 (at A3)

0 0.15 0.3
Km

Figure V6:
100-Year ARI
Hydraulic Categories for Existing Conditions

Prepared By:
Catchment Simulation Solutions
Suite 2.01, 210 George St
Sydney, NSW 2000

File Name: 100-Year HydCat Existing.wor



Fairfield City
Celebrating diversity

LEGEND

- Extent of Proposed Upzoning
- Hydraulic Category
  - Flood Fringe
  - Flood Storage
  - Floodway

Notes:
Areas not shown with any category are considered to be Flood Fringe

N W E S

Scale 1:5,000 (at A3)
0 0.15 0.3 Km

Figure V7:
PMF
Hydraulic Categories for Existing Conditions

Prepared By:
Catchment Simulation Solutions
Suite 2.01, 210 George St
Sydney, NSW 2000

File Name: PMF HydCat Existing.wor

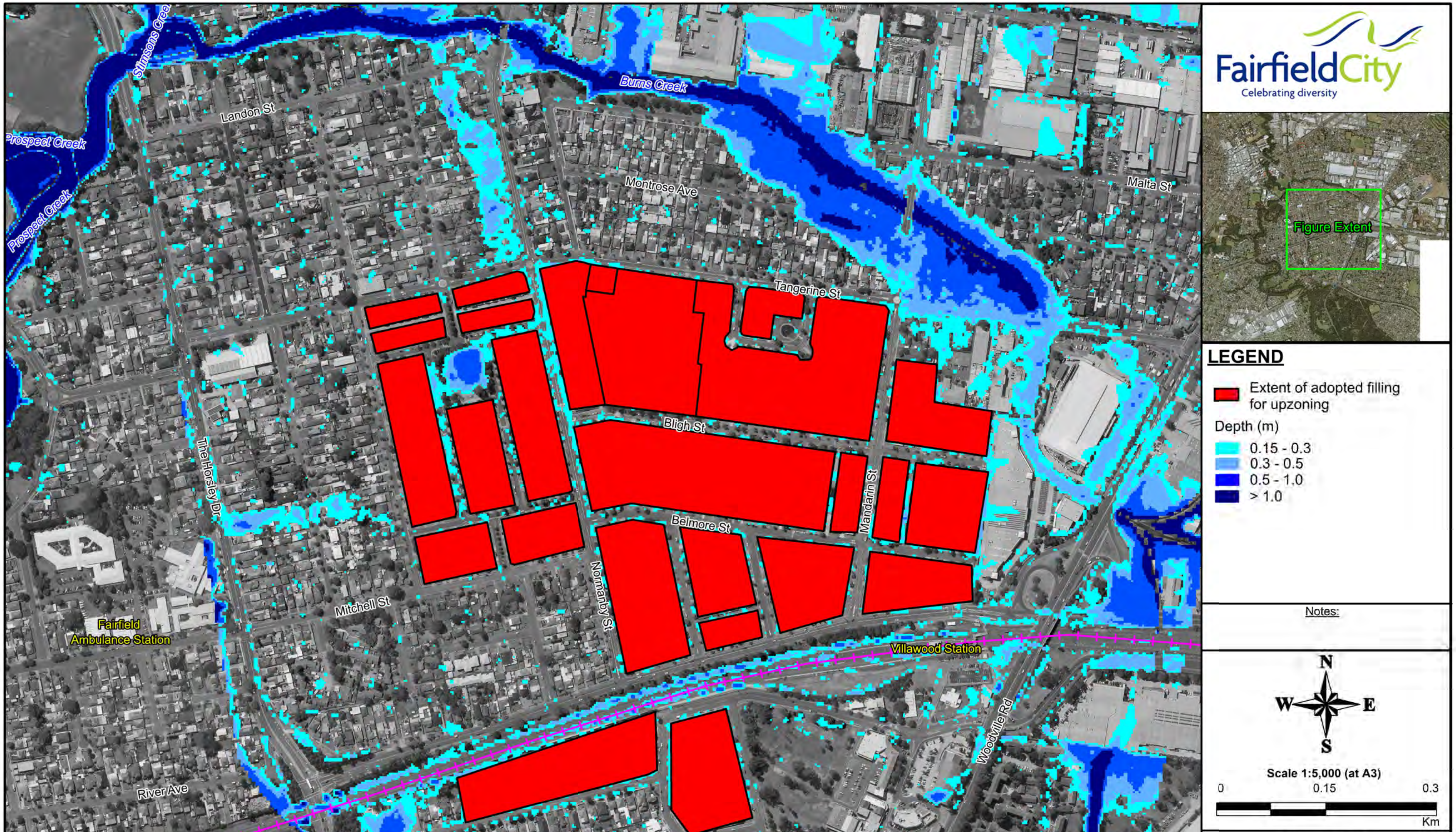


Figure V8: Peak 20-Year ARI Floodwater Depths for Upzoned Conditions

Prepared By:
Catchment Simulation Solutions
Suite 2.01, 210 George St
Sydney, NSW 2000

File Name: 20-Year Depths Upzoned.wor

FairfieldCity
Celebrating diversity

LEGEND

- Extent of adopted filling for upzoning

Depth (m)

- 0.15 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- > 1.0

Notes:

N
W E
S

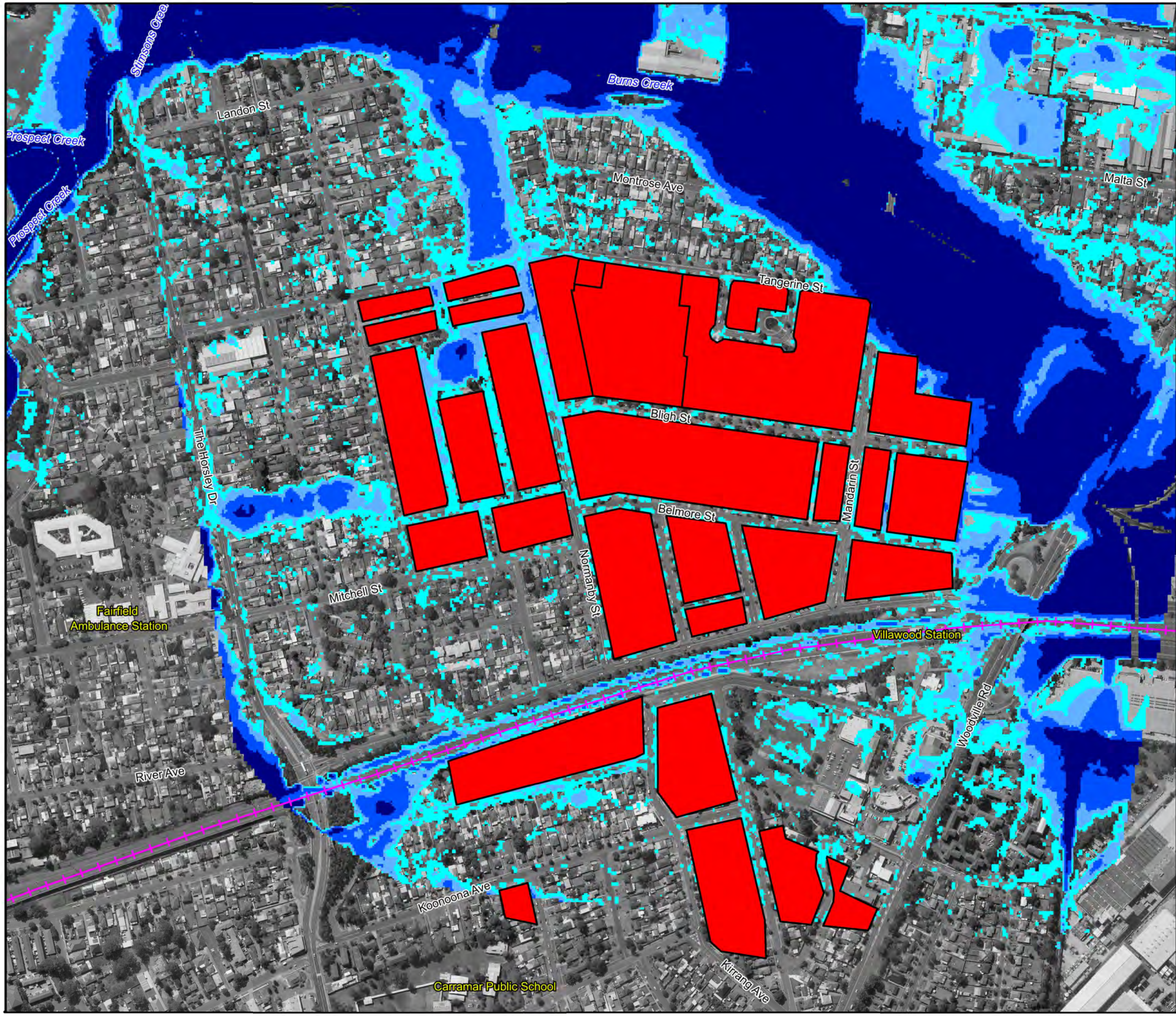
Scale 1:5,000 (at A3)

0 0.15 0.3
Km

Figure V9: Peak 100-Year ARI Floodwater Depths for Upzoned Conditions

Prepared By:
Catchment Simulation Solutions
Suite 2.01, 210 George St
Sydney, NSW 2000

File Name: 100-Year Depths Upzoned.wor



Fairfield City
Celebrating diversity

LEGEND

- Extent of adopted filling for upzoning

Depth (m)

- 0.15 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- > 1.0

Notes:

N W E S

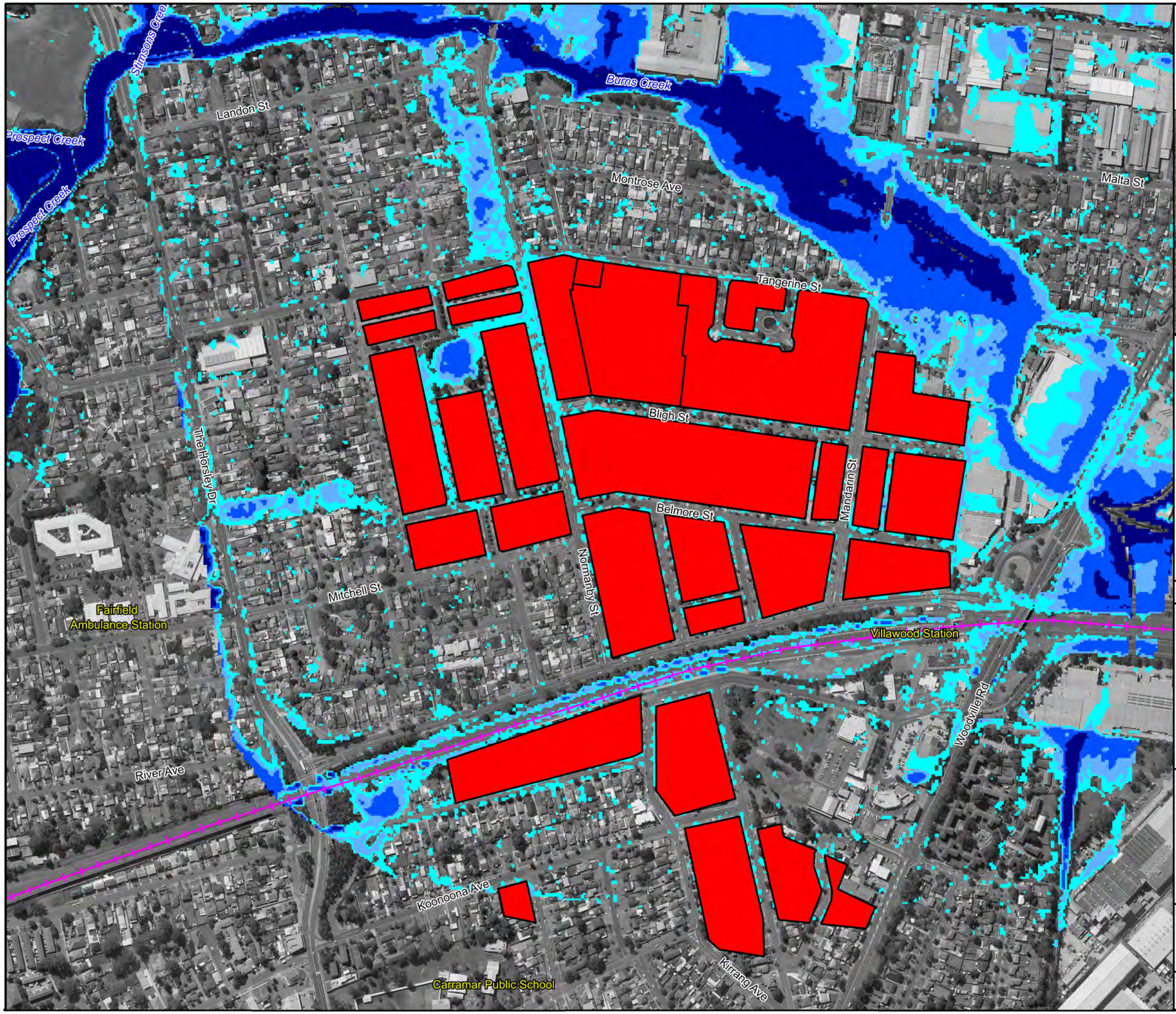
Scale 1:5,000 (at A3)

0 0.15 0.3 Km

Figure V10: Peak PMF Floodwater Depths for Upzoned Conditions

Prepared By:
Catchment Simulation Solutions
Suite 2.01, 210 George St
Sydney, NSW 2000

File Name: PMF Depths Upzoned.wor



FairfieldCity
Celebrating diversity

LEGEND

Extent of adopted filling for upzoning

Depth (m)
- 0.15 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- > 1.0

Notes:

N W E S

Scale 1:5,000 (at A3)

0 0.25 0.5 Km

Figure V11:
Peak 100-Year ARI with 20% Increase in Rainfall Floodwater Depths for Upzoned Conditions

Prepared By:
Catchment Simulation Solutions
Suite 2.01, 210 George St
Sydney, NSW 2000

File Name: CC20 Depths Upzoning.wor

Fairfield City
Celebrating diversity

LEGEND

- Extent of upzoning

Water Level Difference (m)

- 0.50
- 0.20
- 0.10
- 0.02
- No Change
- -0.02
- -0.10
- -0.20
- -0.50
- Previously wet now dry
- Previously dry now wet

Notes:

N W E S

Scale 1:5,000 (at A3)

0 0.15 0.3 Km

Figure V12: Predicted Change in Peak 20-Year ARI Flood Levels Associated with Upzoning

Prepared By:

Catchment Simulation Solutions
Suite 2.01, 210 George St
Sydney, NSW 2000

File Name: 20-Year Diff Upzoned.wor

Fairfield City
Celebrating diversity

LEGEND

Extent of upzoning

Water Level Difference (m)

- 0.50
- 0.20
- 0.10
- 0.02
- No Change
- -0.02
- -0.10
- -0.20
- -0.50
- Previously wet now dry
- Previously dry now wet

Notes:

N W E S

Scale 1:5,000 (at A3)

0 0.15 0.3 Km

Figure V13: Predicted Change in Peak 100-Year ARI Flood Levels Associated with Upzoning

Prepared By:

Catchment Simulation Solutions
Suite 2.01, 210 George St
Sydney, NSW 2000

File Name: 100-Year Diff Upzoned.wor

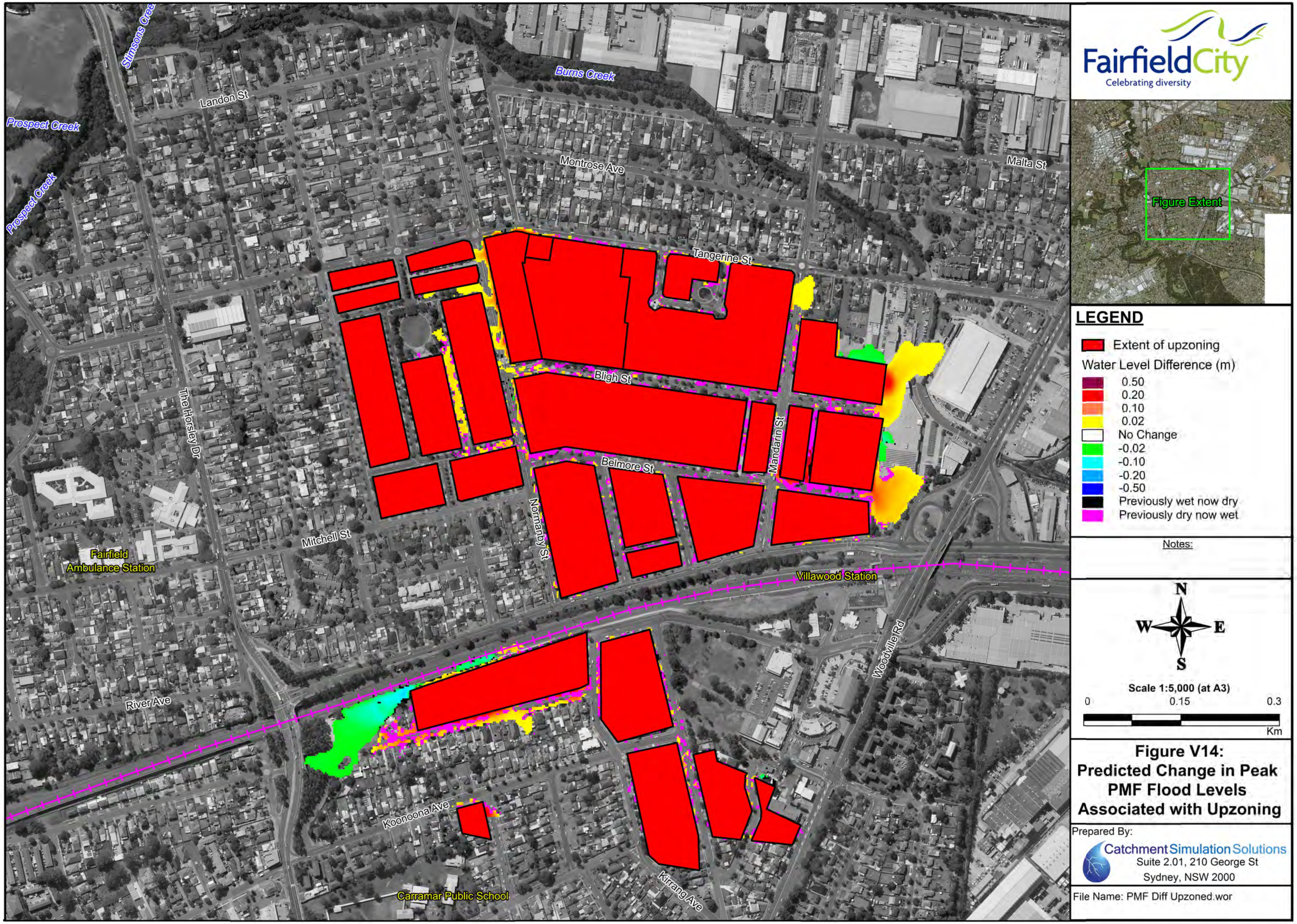


Figure V14: Predicted Change in Peak PMF Flood Levels Associated with Upzoning

FairfieldCity
Celebrating diversity

LEGEND

- Extent of upzoning

Water Level Difference (m)

- 0.50
- 0.20
- 0.10
- 0.02
- No Change
- -0.02
- -0.10
- -0.20
- -0.50
- Previously wet now dry
- Previously dry now wet

Notes:

N
W E
S

Scale 1:5,000 (at A3)

0 0.25 0.5
Km

Figure V15: Predicted Change in Peak 100-Year ARI with 20% Increase in Rainfall Flood Levels Associated with Upzoning

Prepared By:
Catchment Simulation Solutions
Suite 2.01, 210 George St
Sydney, NSW 2000

File Name: CC20 Diff Upzoned.wor

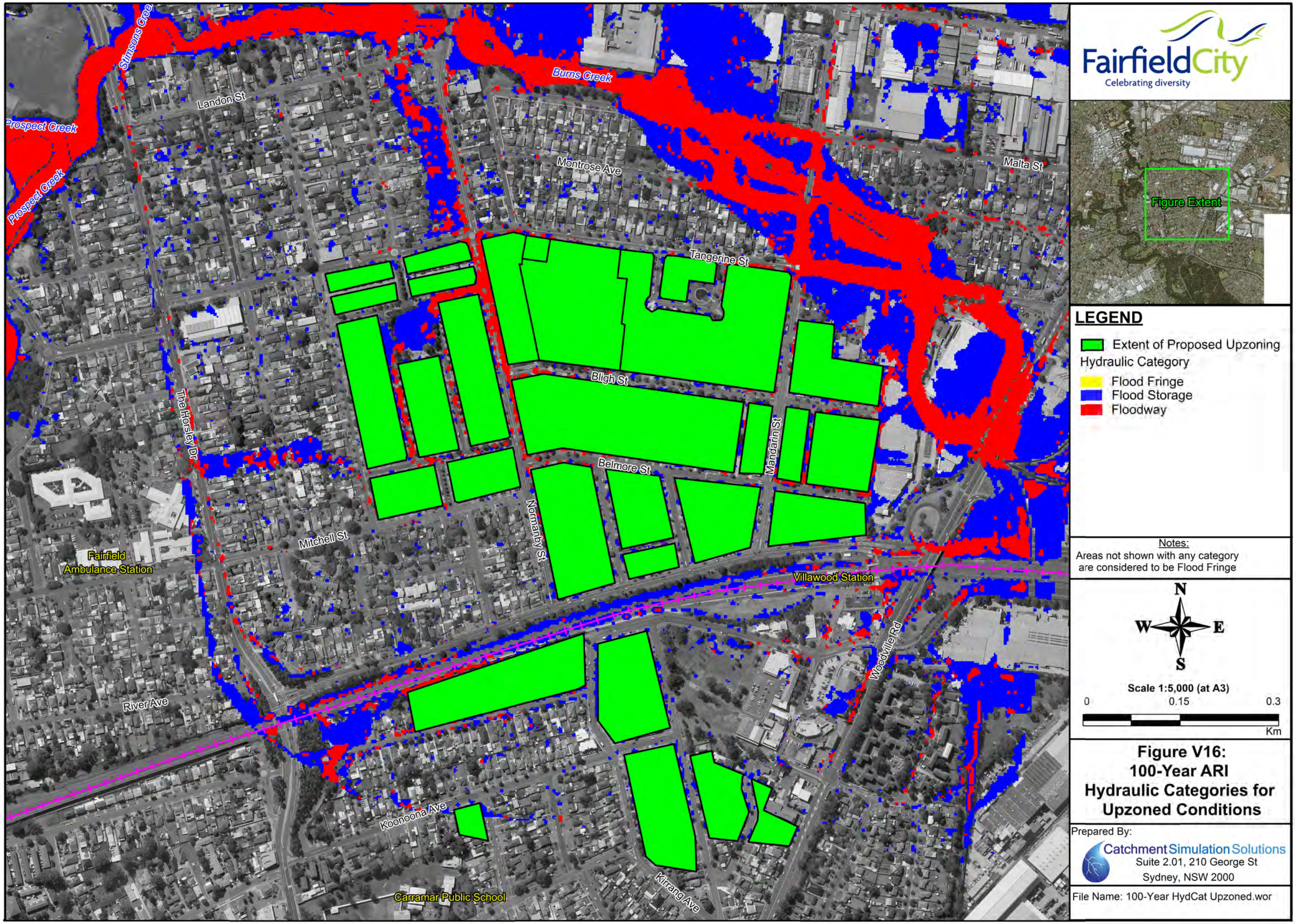
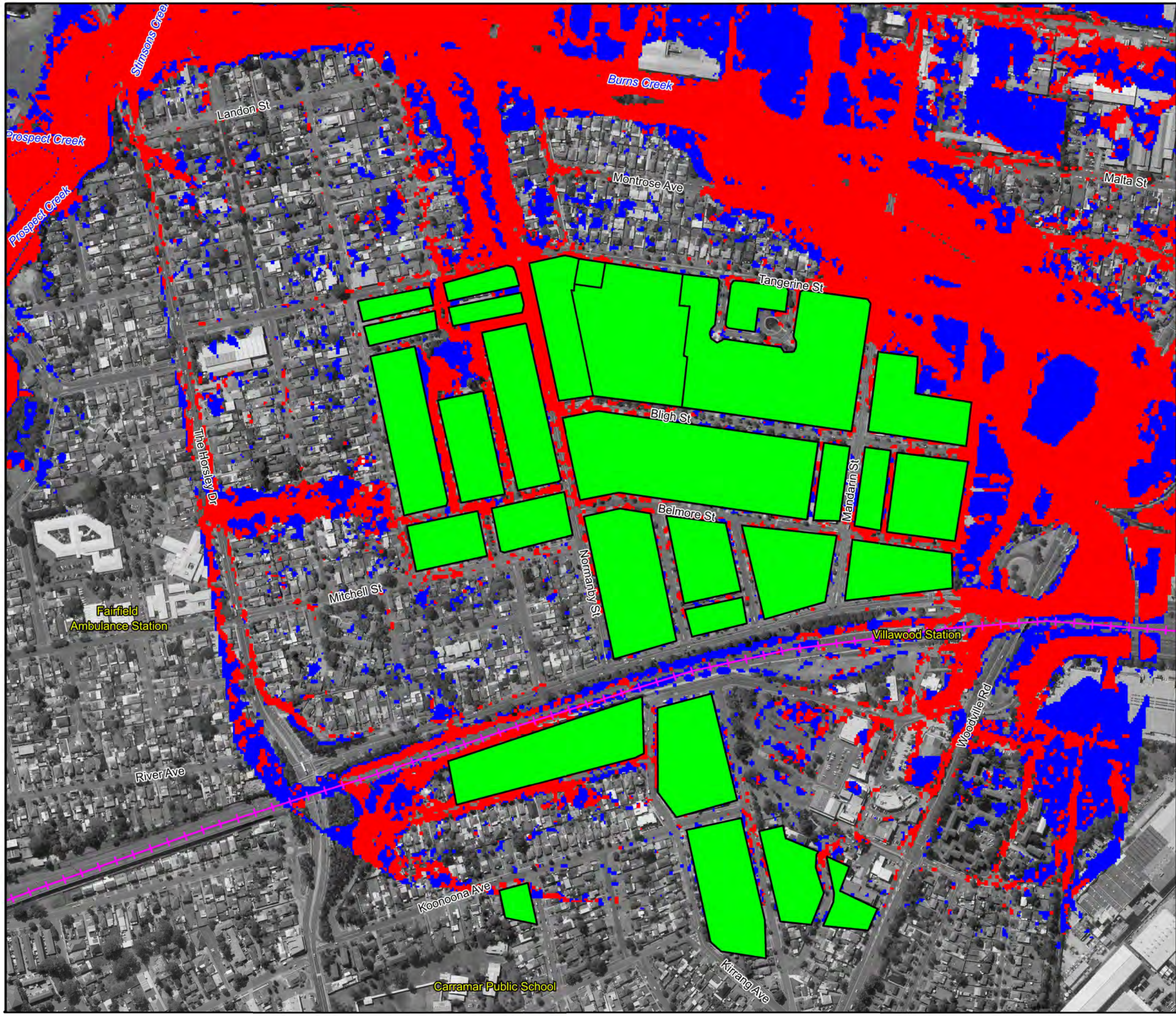


Figure V16: 100-Year ARI Hydraulic Categories for Upzoned Conditions



FairfieldCity
Celebrating diversity

LEGEND

Extent of Proposed Upzoning

Hydraulic Category

- Flood Fringe
- Flood Storage
- Floodway

Notes:
Areas not shown with any category are considered to be Flood Fringe

N
W E
S

Scale 1:5,000 (at A3)

0 0.15 0.3
Km

**Figure V17:
PMF
Hydraulic Categories for Upzoned Conditions**

Prepared By:

Catchment Simulation Solutions
Suite 2.01, 210 George St
Sydney, NSW 2000

File Name: PMF HydCat Upzoned.wor

Fairfield City
Celebrating diversity

LEGEND

- Extent of zoning changes

Hydraulic Category Changes

- Increase in Floodway
- Decrease in Floodway
- Decrease in Flood Storage

Notes:

N
W E
S

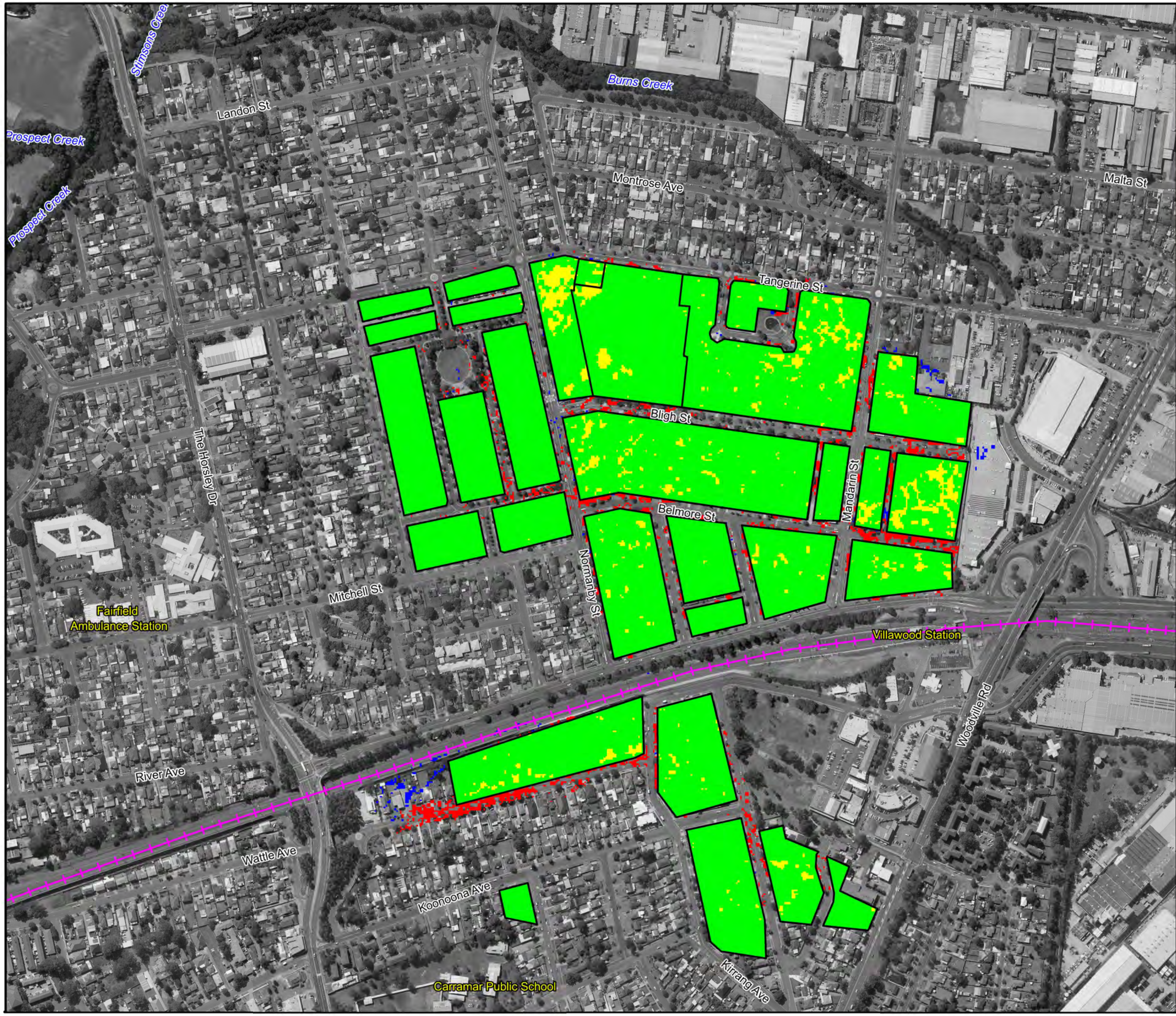
Scale 1:5,000 (at A3)

0 0.15 0.3
Km

Figure V18: Predicted Change in Peak 100-Year ARI Hydraulic Categories Associated with Upzoning

Prepared By:
Catchment Simulation Solutions
Suite 2.01, 210 George St
Sydney, NSW 2000

File Name: 100-Year Diff Upzoned.wor



Fairfield City
Celebrating diversity

LEGEND

- Extent of zoning changes

Hydraulic Category Changes

- Increase in Floodway
- Decrease in Floodway
- Decrease in Flood Storage

Notes:

N
W E
S

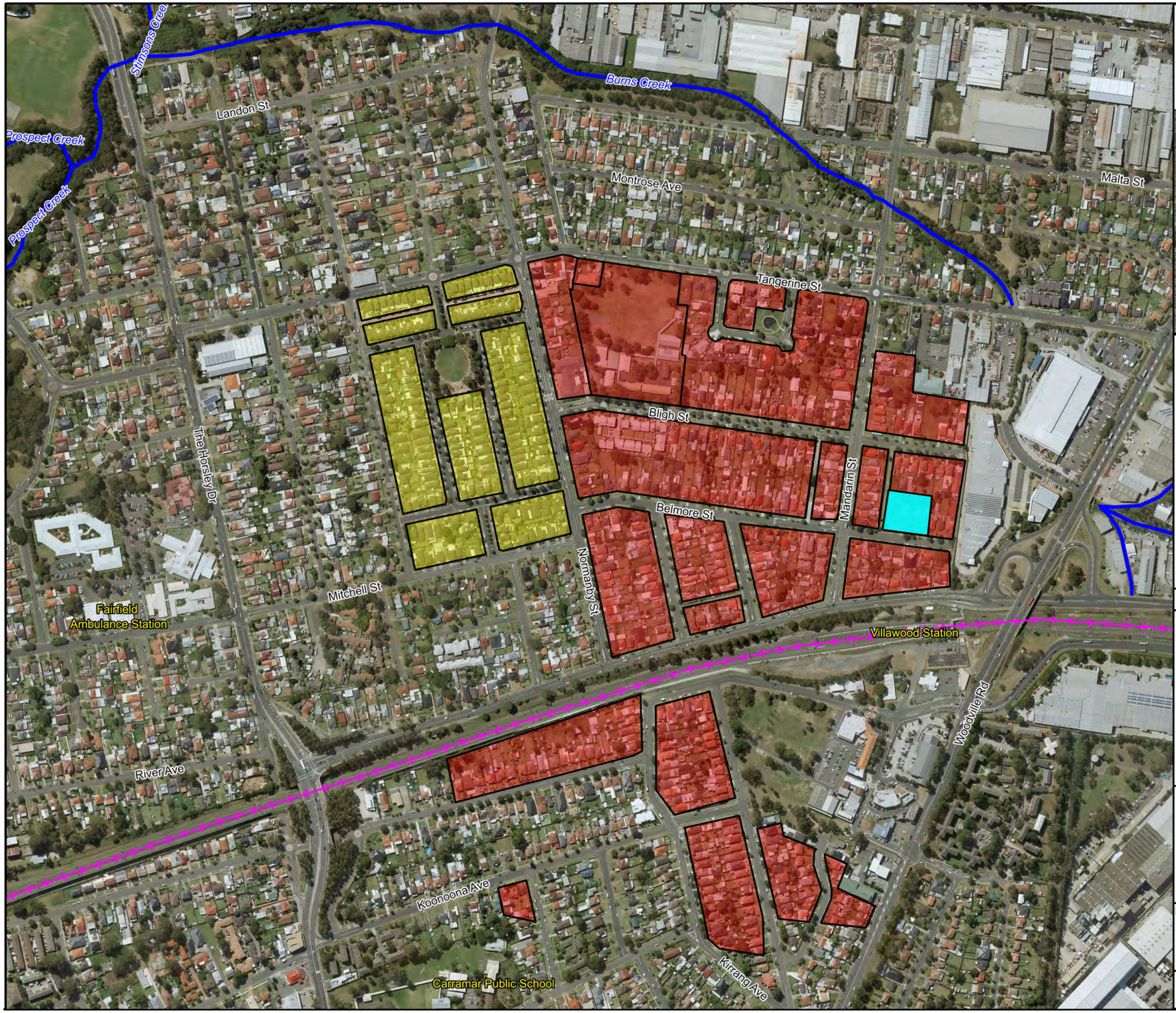
Scale 1:5,000 (at A3)

0 0.15 0.3
Km

Figure V19: Predicted Change in Peak PMF Hydraulic Categories Associated with Upzoning

Prepared By:
Catchment Simulation Solutions
Suite 2.01, 210 George St
Sydney, NSW 2000

File Name: PMF HydDiff Upzoned.wor



FairfieldCity
Celebrating diversity

LEGEND

- Area with OSD
- Upzoned but not redeveloped (No OSD)
- New Detention Basin

Notes:

N
W E
S

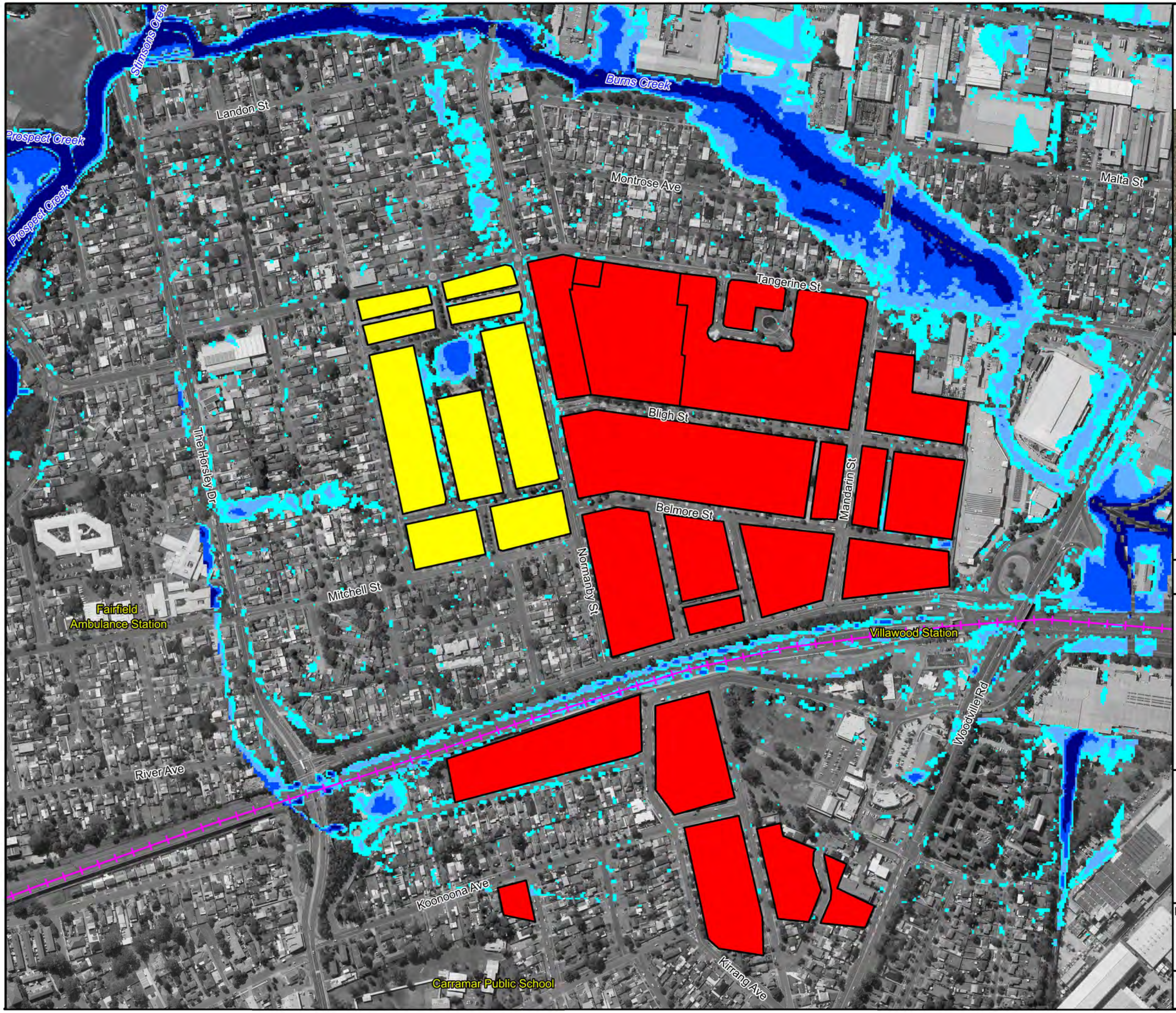
Scale 1:5,000 (at A3)

0 0.15 0.3
Km

Figure V20: Proposed Strategy to Mitigate Flood Level Increases Associated with Upzoning

Prepared By:
Catchment Simulation Solutions
Suite 2.01, 210 George St
Sydney, NSW 2000

File Name: Strategy to Mitigate Flood Upzoning.wor



FairfieldCity
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LEGEND

- Extent of adopted filling for upzoning
- Upzoned but not redeveloped

Depth (m)

- 0.15 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- > 1.0

Notes:

N W E S

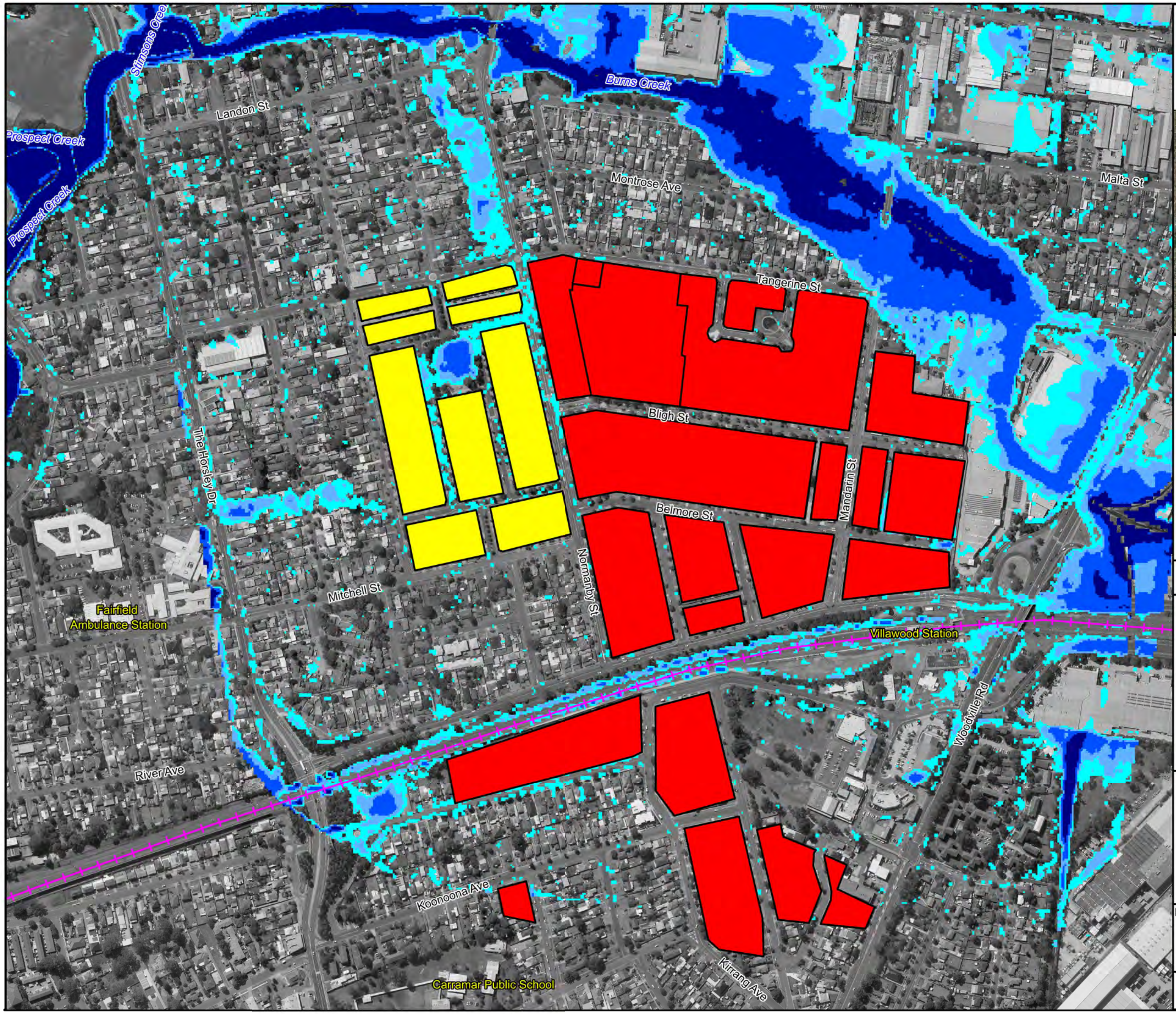
Scale 1:5,000 (at A3)

0 0.15 0.3 Km

Figure V21: Peak 20-Year ARI Floodwater Depths for Upzoned Conditions with Mitigation Strategy Implemented

Prepared By:
Catchment Simulation Solutions
Suite 2.01, 210 George St
Sydney, NSW 2000

File Name: 20-Year Depths Upzoned Mitigation Strategy.wor



FairfieldCity
Celebrating diversity

LEGEND

- Extent of adopted filling for upzoning
- Upzoned but not redeveloped

Depth (m)

- 0.15 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- > 1.0

Notes:

N
W E
S

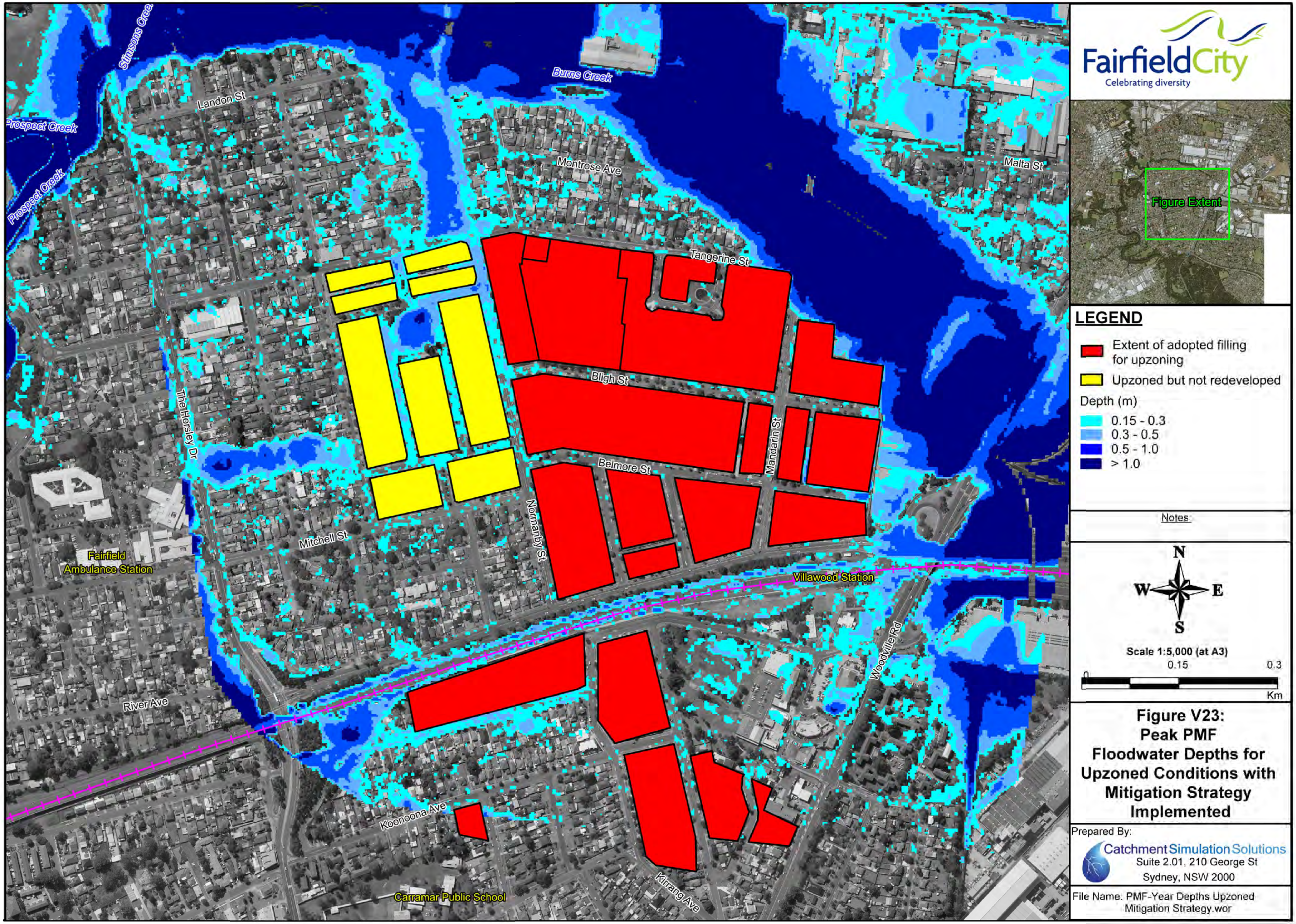
Scale 1:5,000 (at A3)

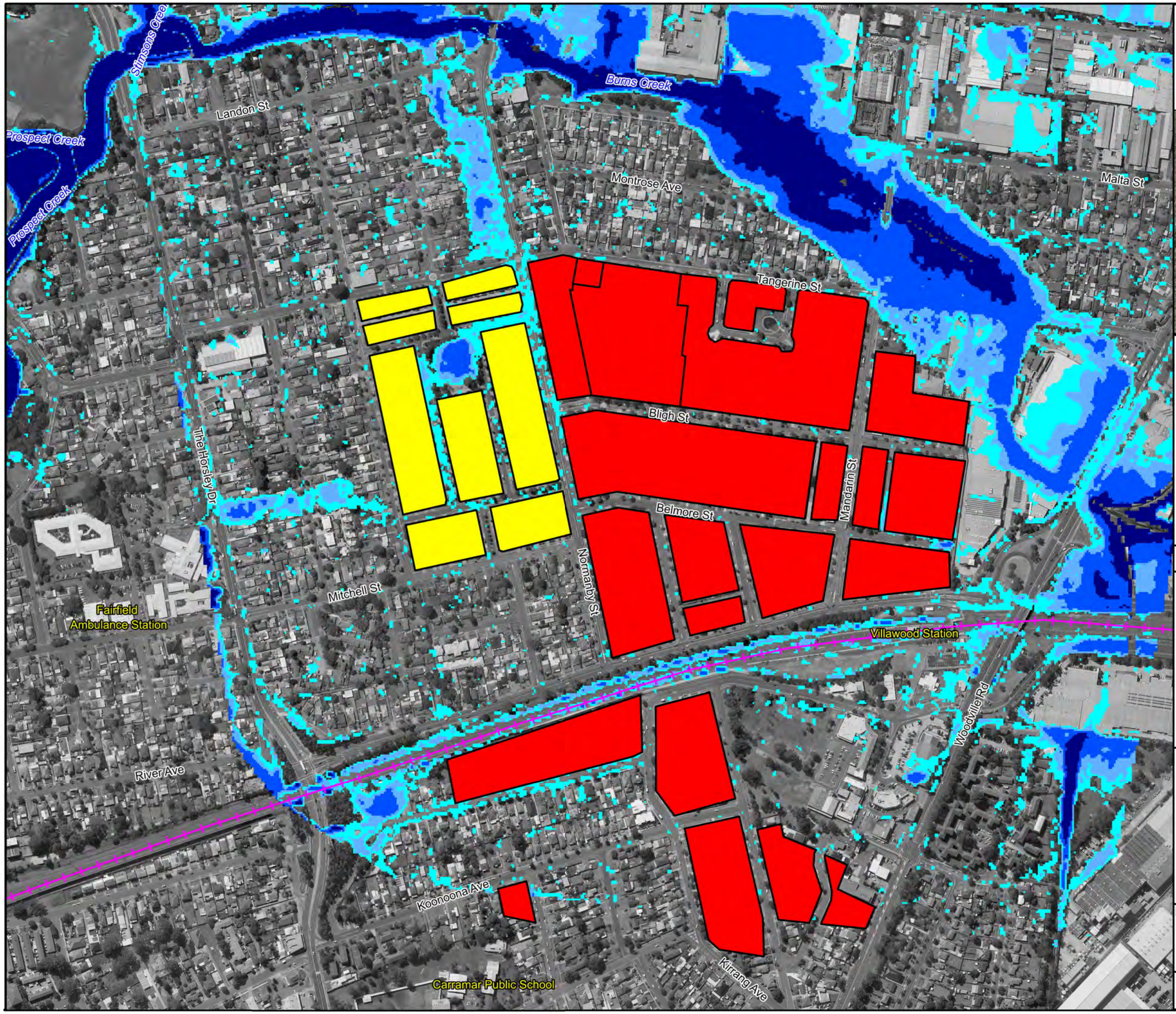
0 0.15 0.3 Km

Figure V22: Peak 100-Year ARI Floodwater Depths for Upzoned Conditions with Mitigation Strategy Implemented

Prepared By:
Catchment Simulation Solutions
Suite 2.01, 210 George St
Sydney, NSW 2000

File Name: 100-Year Depths Upzoned Mitigation Strategy.wor


Stimsons Creek
Burns Creek
Prospect Creek
Prospect Creek
Landon St
Montrose Ave
Malta St
Tangerine St
Bligh St
Belmore St
Mandarin St
Normanby St
The Horsley Dr
Mitchell St
Fairfield Ambulance Station
Villawood Station
Woodville Rd
River Ave
Koonoona Ave
Kirrang Ave
Carramar Public School
Figure Extent
FairfieldCity
Celebrating diversity
LEGEND
Extent of adopted filling for upzoning
Upzoned but not redeveloped
Depth (m)
0.15 - 0.3
0.3 - 0.5
0.5 - 1.0
> 1.0
Notes:
N
W
E
S
Scale 1:5,000 (at A3)
0
0.15
0.3
Km
Figure V23: Peak PMF Floodwater Depths for Upzoned Conditions with Mitigation Strategy Implemented
Prepared By:
Catchment Simulation Solutions
Suite 2.01, 210 George St
Sydney, NSW 2000
File Name: PMF-Year Depths Upzoned Mitigation Strategy.wor



FairfieldCity
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Figure Extent

LEGEND

- Extent of adopted filling for upzoning
- Upzoned but not redeveloped

Depth (m)

- 0.15 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- > 1.0

Notes:

N W E S

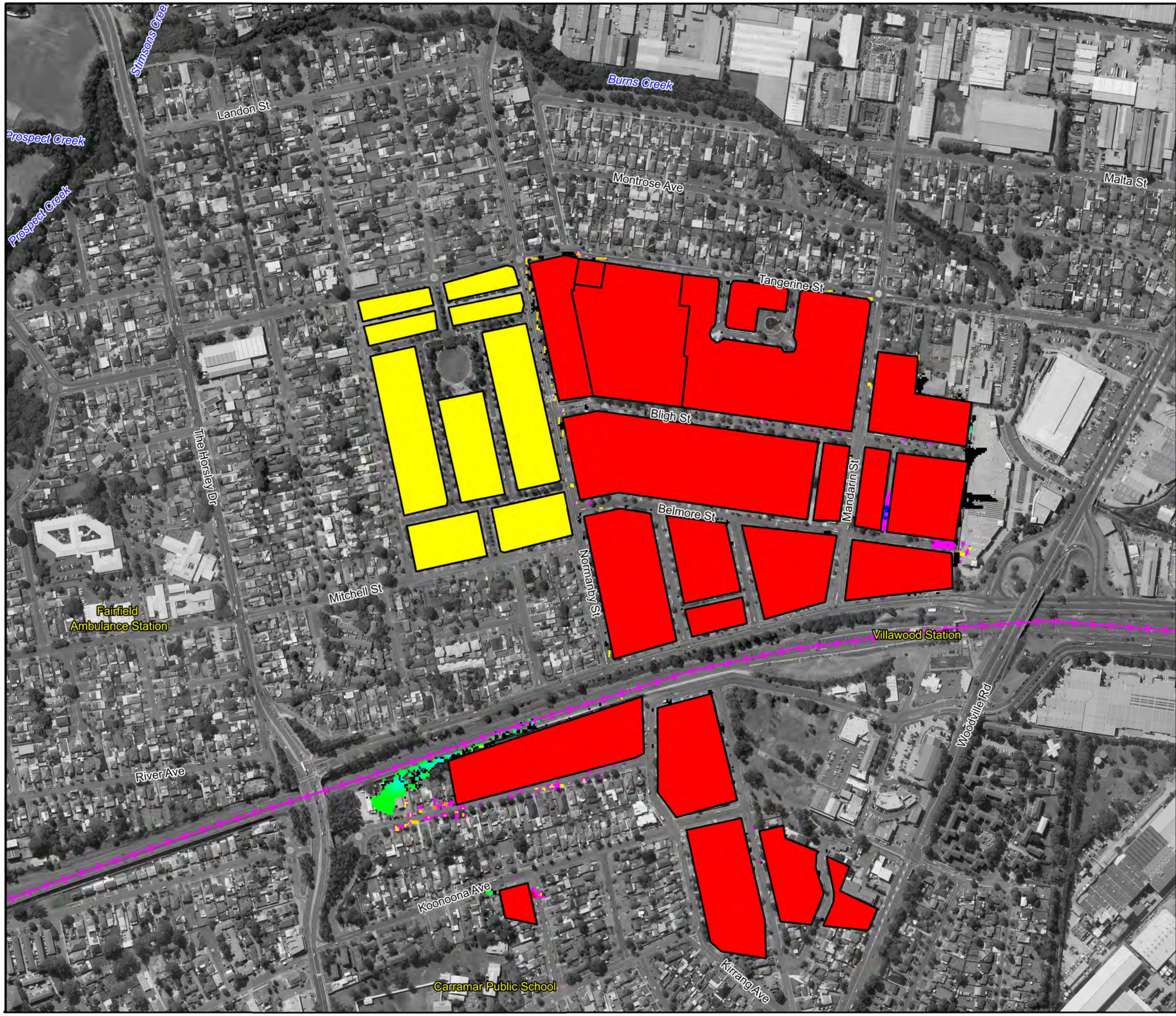
Scale 1:5,000 (at A3)

0 0.15 0.3 Km

Figure V24: Peak 100-Year ARI with 20% Increase in Rainfall Floodwater Depths for Upzoned \Conditions with Mitigation Strategy Implemented

Prepared By:
Catchment Simulation Solutions
Suite 2.01, 210 George St
Sydney, NSW 2000

File Name: Peak 100-Yr CC20 Depths Upzoned Mitigation Strategy.wor



FairfieldCity
Celebrating diversity

LEGEND

- Extent of upzoning
- Upzoned but not redeveloped

Water Level Difference (m)

- 0.50
- 0.20
- 0.10
- 0.02
- No Change
- -0.02
- -0.10
- -0.20
- -0.50
- Previously wet now dry
- Previously dry now wet

Notes:

N
W E
S

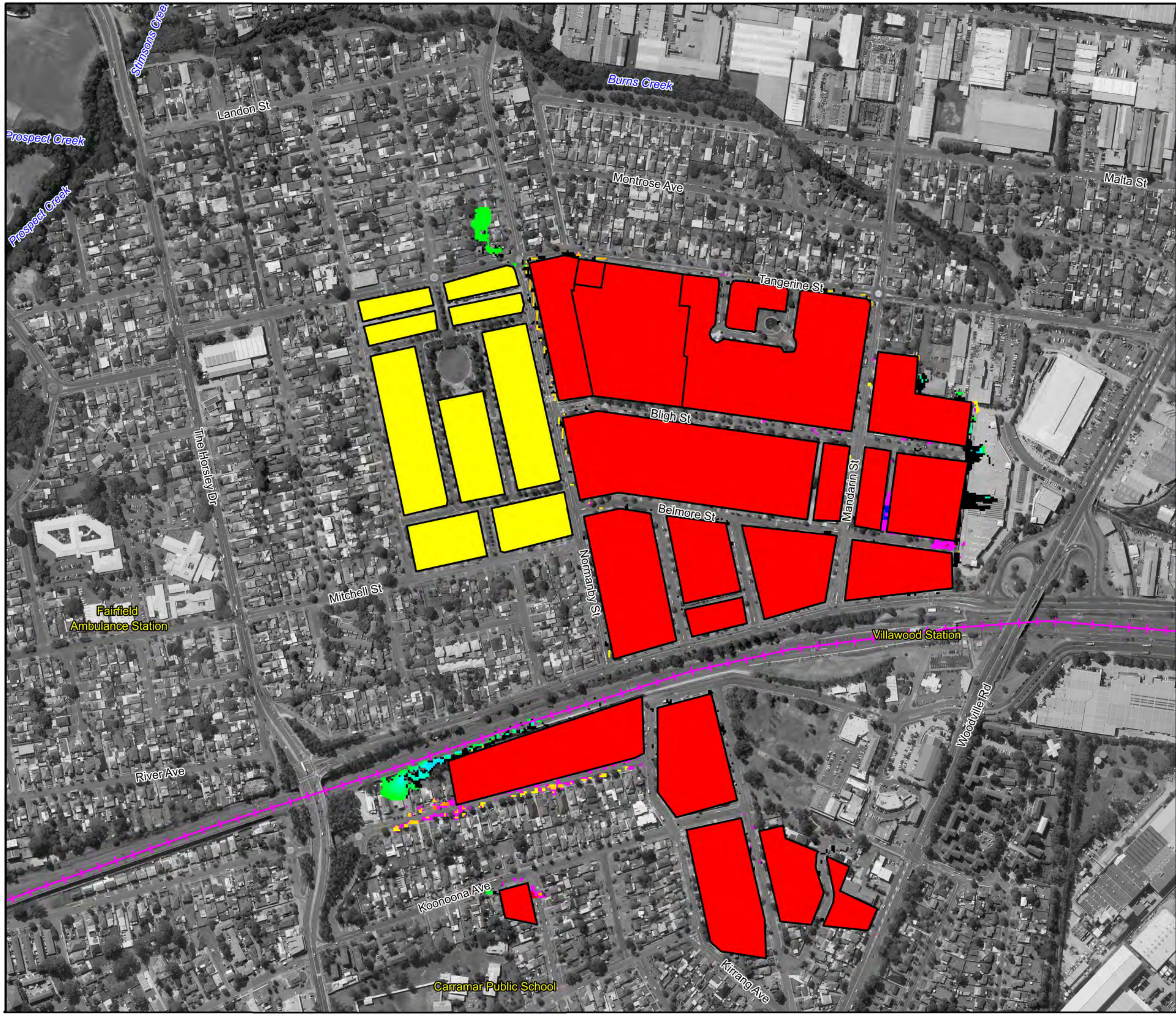
Scale 1:5,000 (at A3)

0 0.15 0.3 Km

Figure V25:
Predicted Change in Peak 20-Year ARI Flood Levels Associated with Upzoning and Mitigation Strategy Implemented

Prepared By:
Catchment Simulation Solutions
Suite 2.01, 210 George St
Sydney, NSW 2000

File Name: 20-Year Diff Upzoned.wor



Fairfield City
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LEGEND

- Extent of upzoning
- Upzoned but not redeveloped

Water Level Difference (m)

- 0.50
- 0.20
- 0.10
- 0.02
- No Change
- -0.02
- -0.10
- -0.20
- -0.50
- Previously wet now dry
- Previously dry now wet

Notes:

N
W E
S

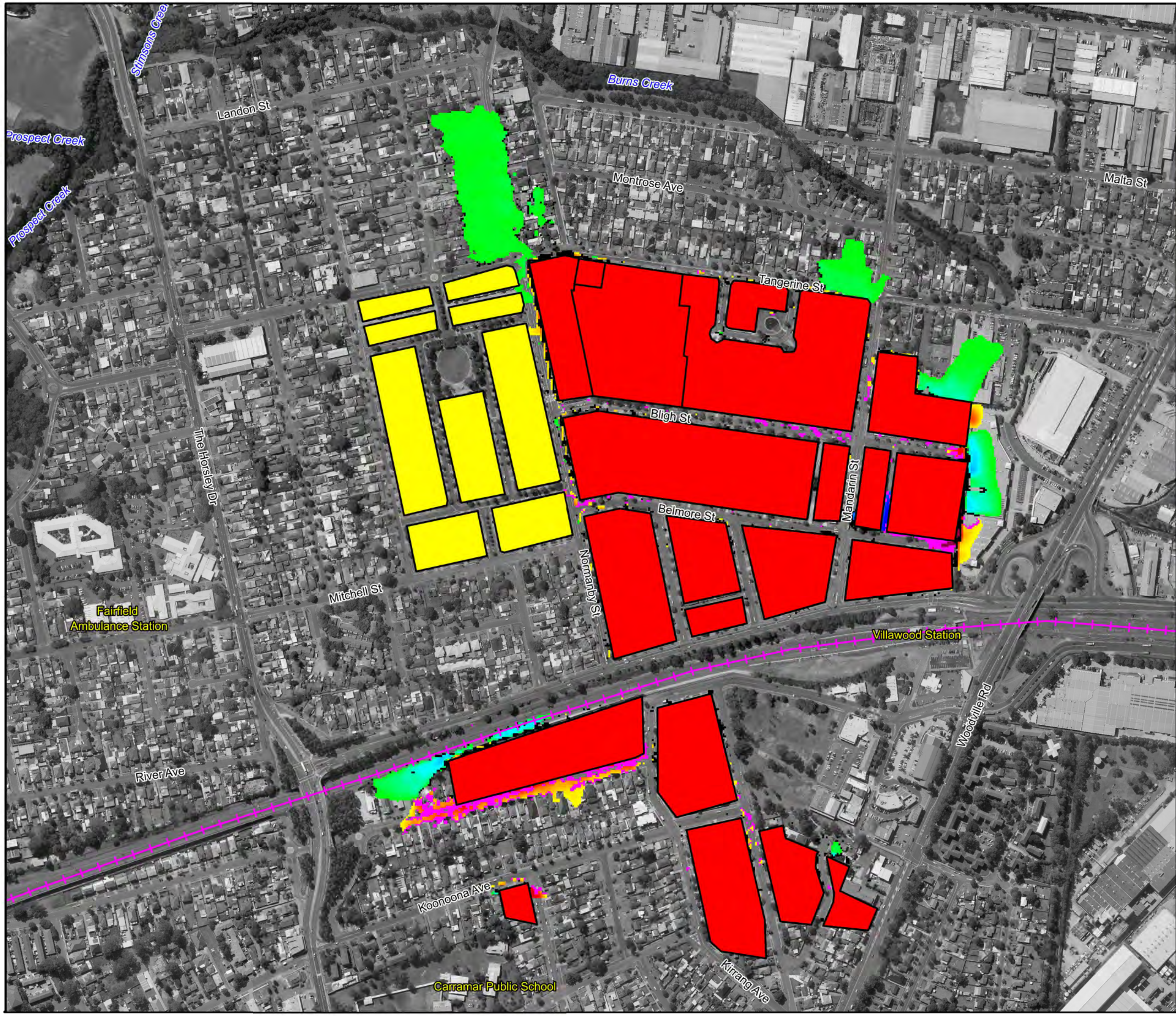
Scale 1:5,000 (at A3)

0 0.15 0.3
Km

Figure V26: Predicted Change in Peak 100-Year ARI Flood Levels Associated with Upzoning and Mitigation Strategy Implemented

Prepared By:
Catchment Simulation Solutions
Suite 2.01, 210 George St
Sydney, NSW 2000

File Name: 100-Year Diff Upzoned.wor



Fairfield City
Celebrating diversity

LEGEND

- Extent of upzoning
- Upzoned but not redeveloped

Water Level Difference (m)

- 0.50
- 0.20
- 0.10
- 0.02
- No Change
- -0.02
- -0.10
- -0.20
- -0.50
- Previously wet now dry
- Previously dry now wet

Notes:

N
W E
S

Scale 1:5,000 (at A3)

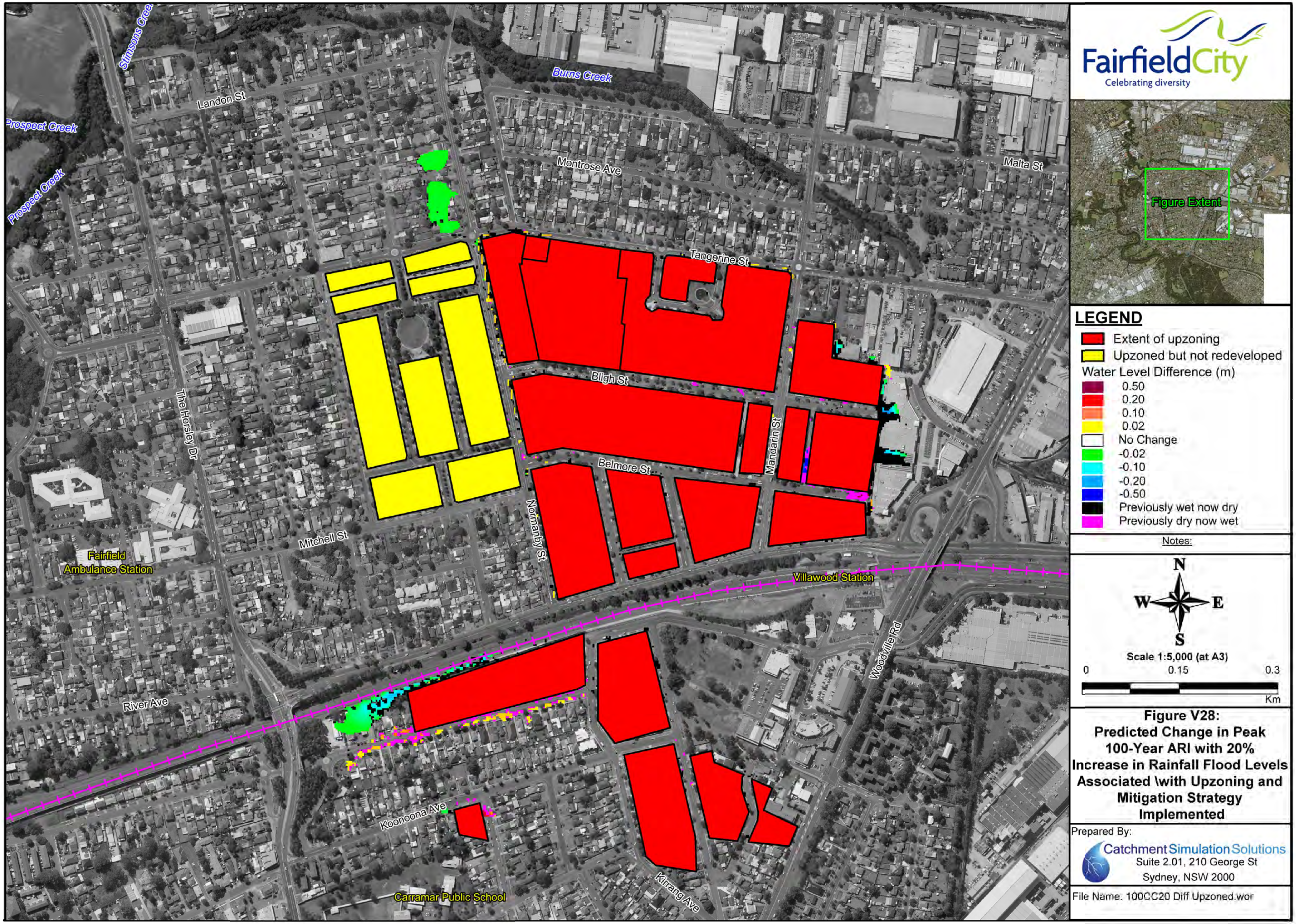
0 0.15 0.3
Km

Figure V27: Predicted Change in Peak PMF Flood Levels Associated with Upzoning and Mitigation Strategy Implemented

Prepared By:

Catchment Simulation Solutions
Suite 2.01, 210 George St
Sydney, NSW 2000

File Name: PMF-Year Diff Upzoned.wor



FairfieldCity
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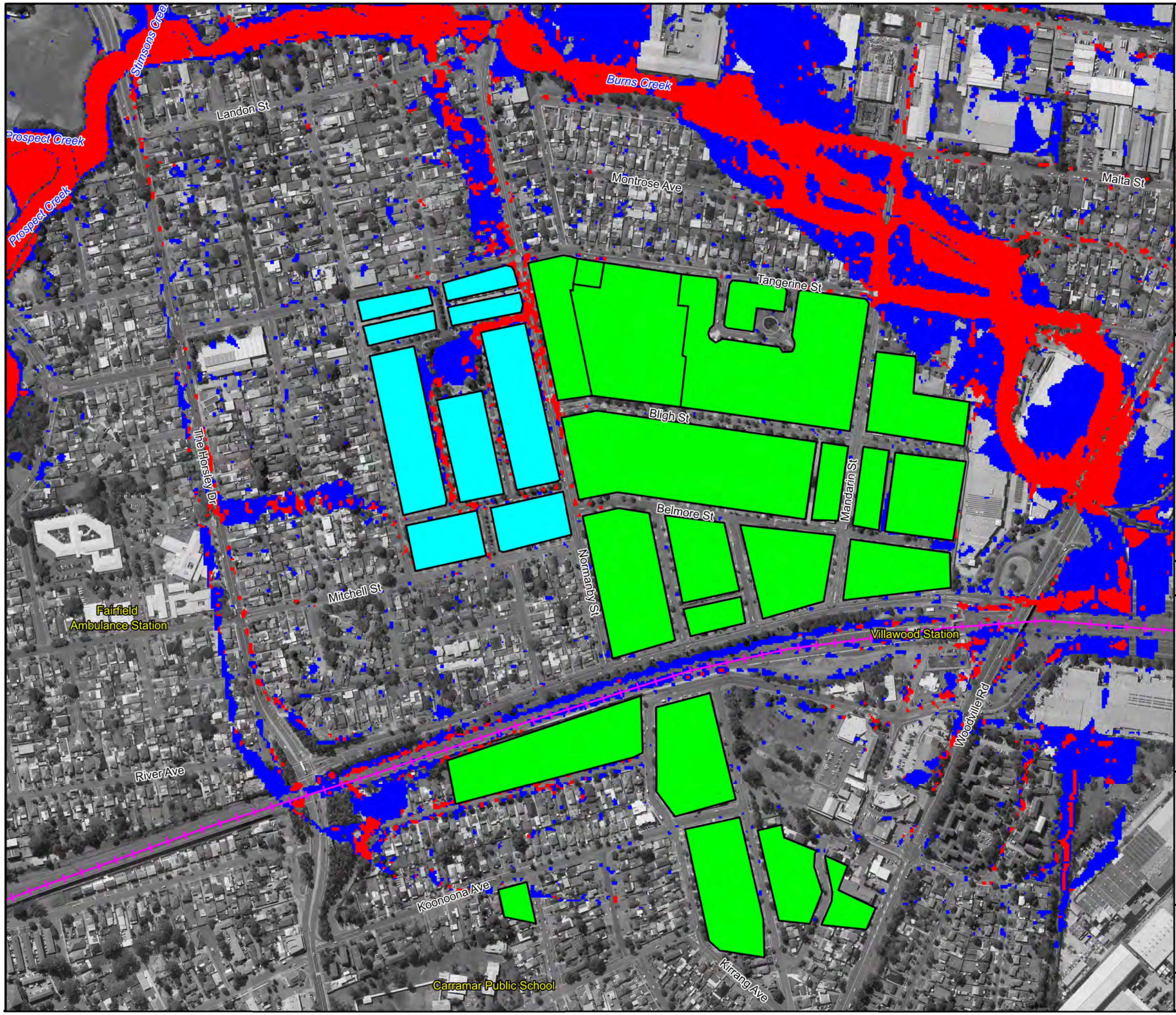
Figure V28: Predicted Change in Peak 100-Year ARI with 20% Increase in Rainfall Flood Levels Associated \with Upzoning and Mitigation Strategy Implemented

Prepared By:
Catchment Simulation Solutions
Suite 2.01, 210 George St
Sydney, NSW 2000

File Name: 100CC20 Diff Upzoned.wor



FairfieldCity
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LEGEND

- Extent of Proposed Upzoning
- Upzoned but not redeveloped

Hydraulic Category

- Flood Fringe
- Flood Storage
- Floodway

Notes:

N
W E
S

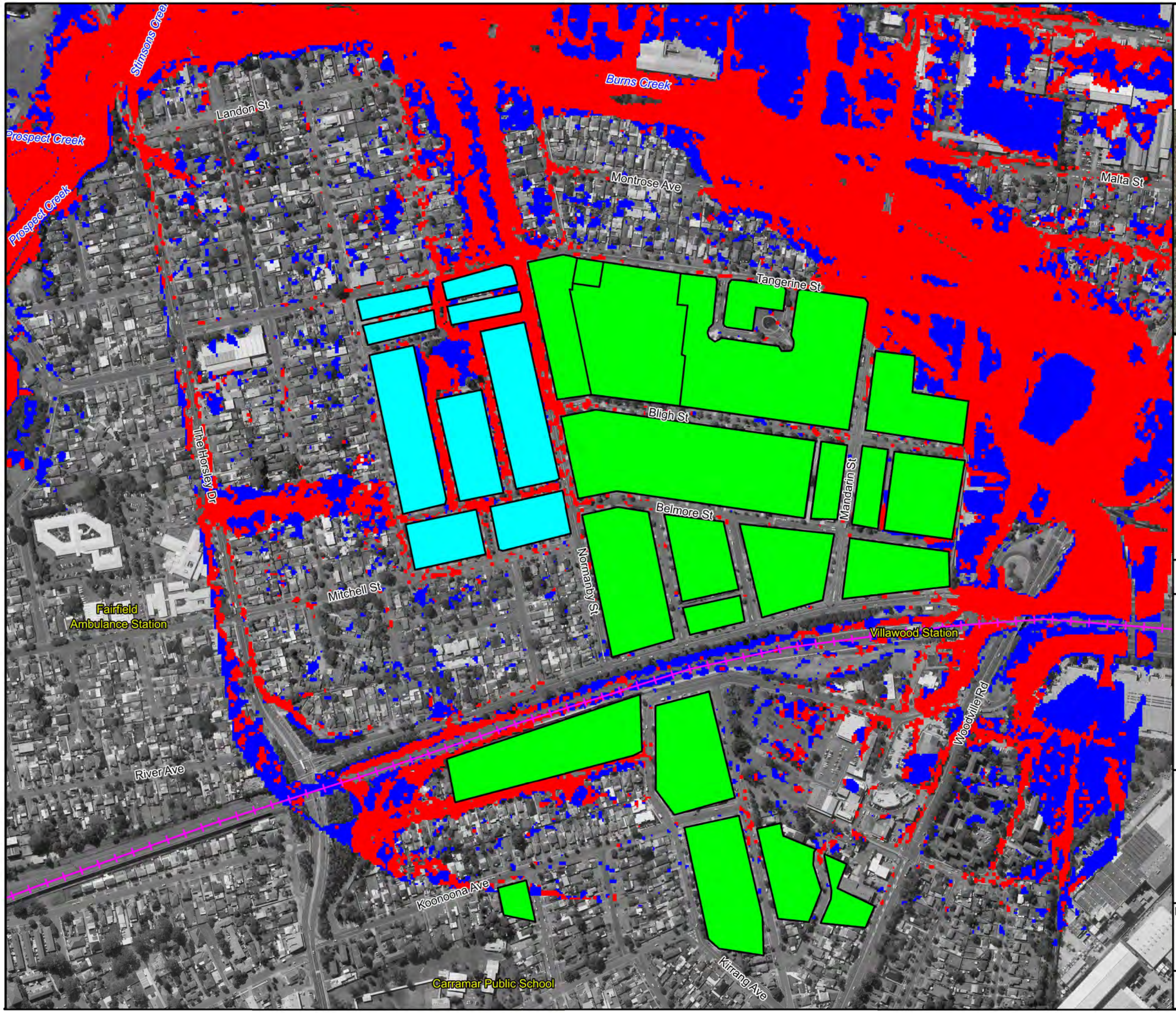
Scale 1:5,000 (at A3)

0 0.15 0.3
Km

Figure V29:
Peak 100-Year ARI Hydraulic Categories for Upzoned Conditions with Mitigation Strategy Implemented

Prepared By:
Catchment Simulation Solutions
Suite 2.01, 210 George St
Sydney, NSW 2000

File Name: 100-Year HydroCat Upzoned Mitigation Strategy.wor



Fairfield City
Celebrating diversity

LEGEND

- Extent of Proposed Upzoning
- Upzoned but not redeveloped

Hydraulic Category

- Flood Fringe
- Flood Storage
- Floodway

Notes:

N
W E
S

Scale 1:5,000 (at A3)

0 0.15 0.3 Km

Figure V30:
Peak PMF
Hydraulic Categories for Upzoned Conditions with Mitigation Strategy Implemented

Prepared By:

Catchment Simulation Solutions
Suite 2.01, 210 George St
Sydney, NSW 2000

File Name: PMF-Year HydroCat Upzoned Mitigation Strategy.wor

Fairfield City
Celebrating diversity

LEGEND

- Extent of zoning changes
- Upzoned but not redeveloped

Hydraulic Category Changes

- Increase in Floodway
- Decrease in Floodway
- Decrease in Flood Storage

Notes:

N W E S

Scale 1:5,000 (at A3)

0 0.15 0.3 Km

Figure V31: Predicted Change in Peak 100-Year ARI Hydraulic Categories Associated with Upzoning and Mitigation Strategy Implemented

Prepared By:
Catchment Simulation Solutions
Suite 2.01, 210 George St
Sydney, NSW 2000

File Name: 100-Year HydDiff Comb.wor

Fairfield City
Celebrating diversity

LEGEND

- Extent of zoning changes
- Upzoned but not redeveloped

Hydraulic Category Changes

- Increase in Floodway
- Decrease in Floodway
- Decrease in Flood Storage

Notes:

N
W E
S

Scale 1:5,000 (at A3)

0 0.15 0.3
Km

Figure V32: Predicted Change in Peak PMF Hydraulic Categories Associated with Upzoning and Mitigation Strategy Implemented

Prepared By:
Catchment Simulation Solutions
Suite 2.01, 210 George St
Sydney, NSW 2000

File Name: PMF HydDiff Comb.wor

APPENDIX C
HYDRAULIC CATEGORISATION

1 HYDRAULIC CATEGORIES

1.1 Overview

The NSW Government's *'Floodplain Development Manual'* (NSW Government, 2005) characterises flood prone areas according to the qualitative description of hydraulic categories presented in **Table 1** The hydraulic categories provide an indication of the potential for development across different sections of the floodplain to impact on existing flood behaviour and highlights areas that should be retained for the conveyance and storage of floodwaters.

Table 1 Qualitative Criteria for Hydraulic Categories

Hydraulic Category	Floodplain Development Manual Definition
Floodway	• those areas where a significant volume of water flows during floods • often aligned with obvious natural channels and drainage depressions • they are areas that, even if only partially blocked, would have a significant impact on upstream water levels and/or would divert water from existing flowpaths resulting in the development of new flowpaths. • they are often, but not necessarily, areas with deeper flow or areas where higher velocities occur.
Flood Storage	• those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood • if the capacity of a flood storage area is substantially reduced by, for example, the construction of levees or by landfill, flood levels in nearby areas may rise and the peak discharge downstream may be increased. • substantial reduction of the capacity of a flood storage area can also cause a significant redistribution of flood flows.
Flood Fringe	• the remaining area of land affected by flooding, after floodway and flood storage areas have been defined. • development (e.g., filling) in flood fringe areas would not have any significant effect on the pattern of flood flows and/or flood levels.

The *'Floodplain Development Manual'* (NSW Government, 2005) does not provide explicit quantitative criteria for defining hydraulic categories. This is because the extent of floodway, flood storage and flood fringe areas are specific to a particular catchment.

1.1.1 Options for Defining Hydraulic Categories

In an effort to define quantitative criteria that could be used to assist in defining hydraulic categories across Villawood and Fairfield, a literature review was completed. The literature review aimed to identify velocity, depth and VxD criteria that has been used to define hydraulic categories across other similar catchments. The outcomes of this assessment are provided in **Table 2**.

Table 2 Quantitative criteria used to define hydraulic categories in other studies

Study	Criteria		
	Floodway	**Flood Storage**	**Flood Fringe**
Cabravale Overland Flood Study (CSS, 2018)	VxD >= 0.25, or V >= 0.5	not floodway and d> =0.15m	remaining area
Werrington Creek (CSS, 2016)	VxD >=0.25 and V >=0.25 or V>=1	not floodway and d> 0.2m	remaining area
Penrith CBD Detailed Overland Flow Flood Study (Cardno, 2015)	VxD >=0.25 and V >=0.25 Or V>=1	not floodway and d> 0.2m	remaining area
Blackwattle Bay Catchment Flood Study (WMAwater, 2015)	VxD >=0.25 and V >=0.25 or V>=1	not floodway and d> 0.2m	remaining area
Coogee Bay Flood Study (BMT WBM 2013)	VxD > 0.3 or V > 0.5	not floodway and d > 0.15	remaining area

NOTES: V = Velocity, D = Depth, VxD = Velocity-Depth Product

In general, floodways in each of the above studies have been defined based upon criteria presented by Howell et al (2003) (or slight variations thereof). This approach involved defining floodways based on minimum floodwater velocity and velocity depth product thresholds. These criteria were thought to provide a suitable starting point for defining floodways as part of the current assessment. However, an additional criterion was added so that all areas contained within a major waterway (i.e., from top of bank to top of bank) were also defined as floodways (in accordance with the Floodplain Development Manual definition).

Table 2 also shows some similarities when defining flood storage and flood fringe areas. More specifically, flood storages are defined as areas that are located outside of the floodways that meet a minimum depth threshold while flood fringe are those remaining flood liable areas that are not classified as floodway or flood storage. Again, these criteria were used as a starting point for defining flood storage and flood fringe areas as part of the current assessment.

1.1.2 Adopted Hydraulic Categories

Using the methodology of Howell et al (2003), preliminary floodway areas were defined for Villawood and Fairfield based on the results of the 1% AEP simulations. The resulting floodway areas were reviewed against the qualitative definitions of floodway as per the *'Floodplain Development Manual'* (NSW Government, 2005), and it was determined that the extent of floodways was likely being underrepresented with these criteria. As such, the Howell et al (2003) criteria was refined in an attempt to better represent the floodway extents. The resulting criteria is shown in **Table 3**.

Table 3 Adopted Quantitative Criteria for Hydraulic Categories within the Fairfield and Villawood study areas

Hydraulic Category	Catchment	Adopted Criteria
Floodway	Fairfield	• VxD >= 0.25 m^2/s OR • V >= 0.60 m/s
	Villawood	• VxD >= 0.25 m^2/s OR • V >= 0.40 m/s
Flood Storage	Fairfield	• If not FLOODWAY and D >=0.20 m
	Villawood	• If not FLOODWAY and D >=0.15 m
Flood Fringe	Fairfield and Villawood	• Remaining areas after FLOODWAY and FLOOD STORAGE are defined

NOTES: V = Velocity, D = Depth, VxD = Velocity-Depth Product

Flood storage areas were then defined as those areas located outside of floodways but where the depth of inundation was greater than 0.15 metres (Villawood study area) and greater than 0.20 metres (Fairfield study area). This aimed to identify areas where a significant amount of flow was not necessarily conveyed, however, the depths of water indicate a significant amount of storage capacity was being provided. Those areas remaining after the floodways and flood storage was defined were classified as flood fringe

As per the original 'Fairfield Overland Flood Study' (SKM, 2010) and 'Old Guildford Overland Flood Study' (SKM, 2010), "filtering" of the raw modelling results was completed to remove areas of insignificant inundation from the flood mapping. As this filtering removed all areas subject to inundation depths less than 0.15m, all flood fringe areas were removed from the Villawood mapping (i.e., flood fringe areas are only mapped in the Fairfield area for those areas subject to depths of more than 0.15m but less than 0.2m).

The resulting hydraulic category maps for the 1% AEP flood for the Fairfield and Villawood study areas are shown in **Figures CF1** and **CV1**. Hydraulic categories were also mapped for the PMF and are shown in **Figures CF2** and **CV2**.

1.1.3 Floodway Verification

As described in **Table 1**, a floodway is an area that if only partially blocked would produce a significant impact on upstream water levels and/or would divert water from existing flowpaths resulting in the development of new flowpaths (NSW Government, 2005). Accordingly, the suitability of the delineated floodways was verified by partially blocking the floodways and quantifying the impact that this blockage had on peak 1% AEP flood levels and the distribution of flood flows. This approach is in accordance with recommendations outlined in the Office of Environment and Heritage's 'Floodway Definition' guideline (2007).

The TUFLOW hydraulic models were updated to include partial blockage of the delineated floodways at several locations across each of the catchments. The models were then re-run for the 1% AEP event. The peak flood level, depth and velocity results were interrogated and compared against 'existing' results to quantify the impact of the blockage of flood behaviour.

Peak 1% AEP depth results from the floodway blockage simulations at select locations across the Villawood study area are shown in **Plate 1** to **Plate 3**. **Plate 1** to **Plate 3** also include velocity vectors from the 'blocked' (black vectors) and 'non-blocked' (red vectors) simulations so the redistribution of floodwaters could be visualised

Plate 1 through **Plate 3** show that the blockages cause significant redistribution of flood flows (as indicated by the difference in the size and direction of the red and black velocity vectors). The areas of significant flow re-distribution are circled in purple on **Plate 1** through **Plate 3** and indicates that blockage of the floodways would divert floodwaters laterally and often create new, high velocity flow paths. Accordingly, the floodway blockages appear to be causing a significant redistribution of flow and would satisfy this floodway criteria as defined in the *'Floodplain Development Manual'* (NSW Government, 2005).

The peak 1% AEP 'floodway blockage' flood levels were also compared against the 'non-blocked' 1% AEP flood levels to produce a flood level difference map for the Villawood area (the map shows the location and magnitude of changes in flood level associated with the floodway blockage). The difference map is shown in **Plate 4**.

Plate 4 shows that the blockages typically increase peak 1% AEP flood levels by between 0.1 and 0.2 metres. This is considered to be a 'significant impact' on upstream water levels, particularly as these areas experience "no blockage" floodwater depths of about 0.5 metres. Accordingly, the flood level impacts are also considered to fit the floodway definition criteria defined in the in the *'Floodplain Development Manual'* (NSW Government, 2005).

Therefore, it is suggested that the criteria provided in **Table 3** is suitable for defining hydraulic categories across the Villawood area.

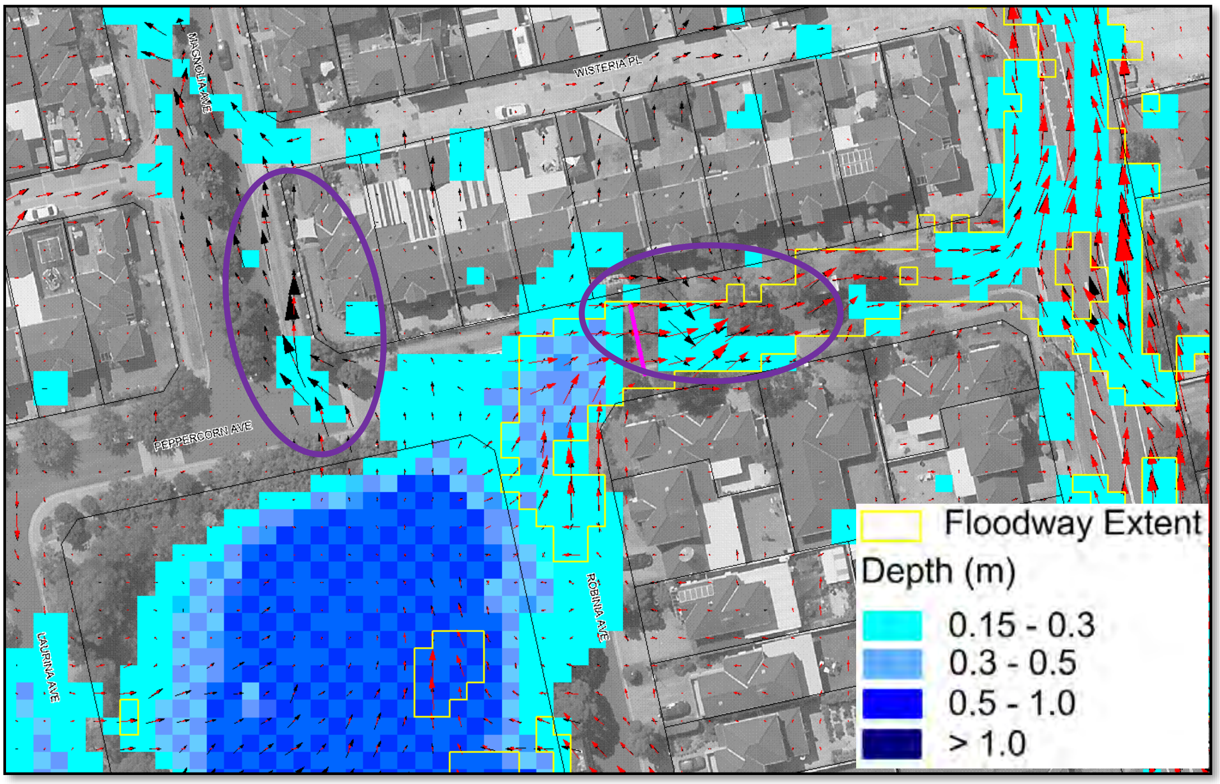


Plate 1 1% AEP Depths and Velocities in the vicinity of a floodway blockage (pink line) located near the intersection of Peppercorn and Robina Ave, Fairfield East.

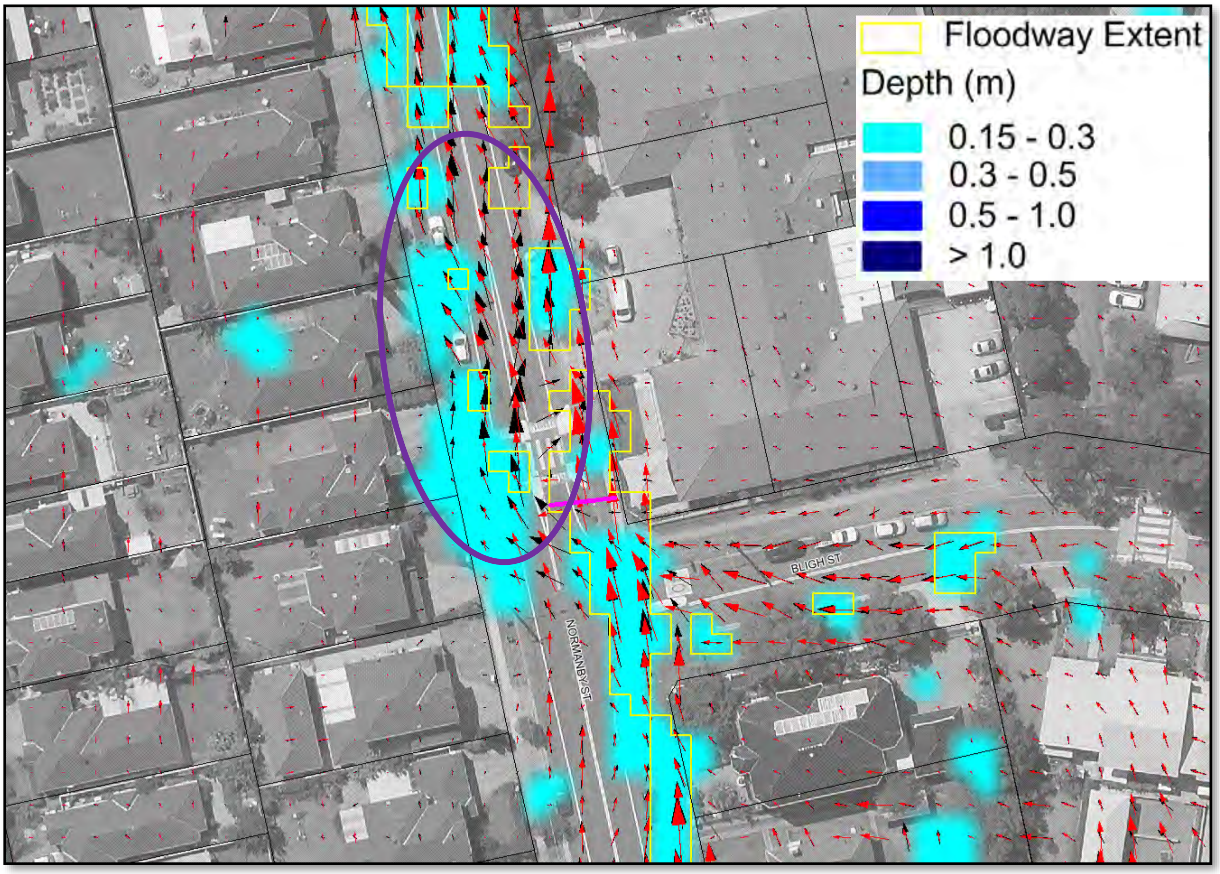


Plate 2 1% AEP Depths and Velocities in the vicinity of a floodway blockage (pink line) located near the intersection of Normanby and Bligh St, Fairfield East.

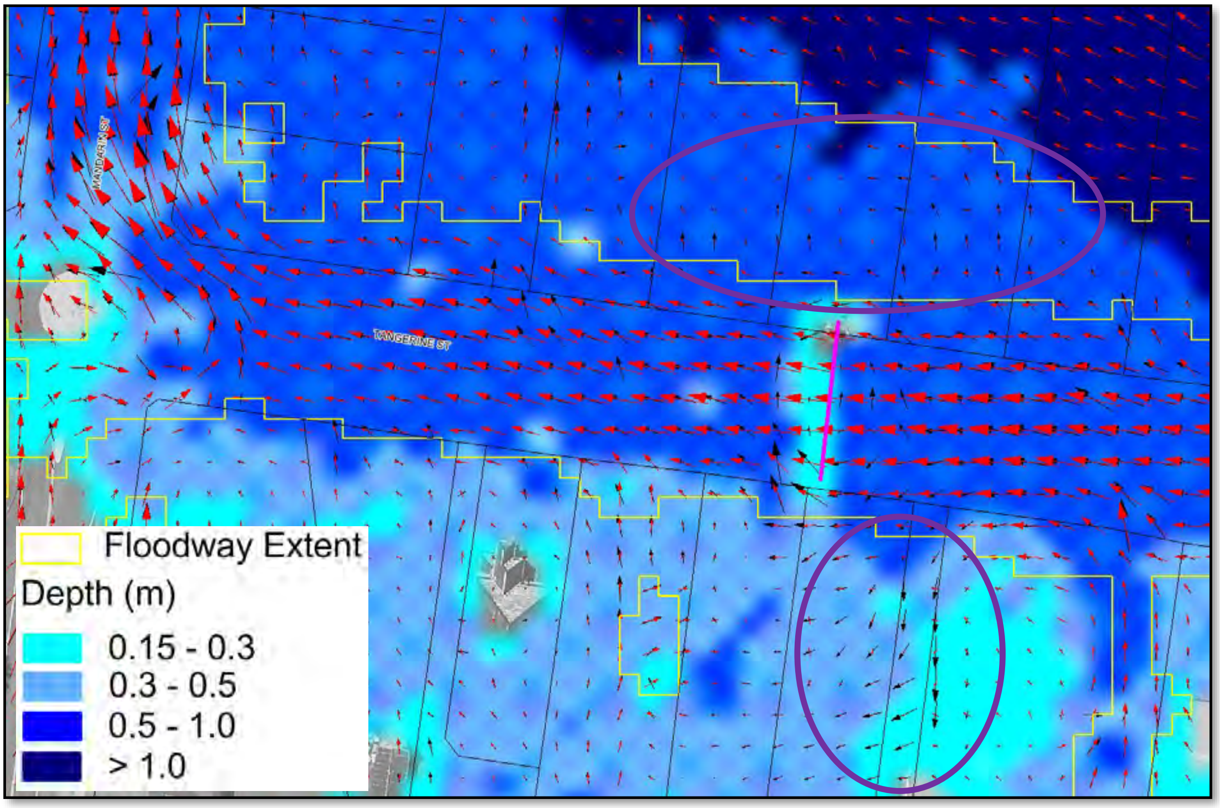


Plate 3 1% AEP Depths and Velocities in the vicinity of a floodway blockage (pink line) located on Tangerine St, Fairfield East.

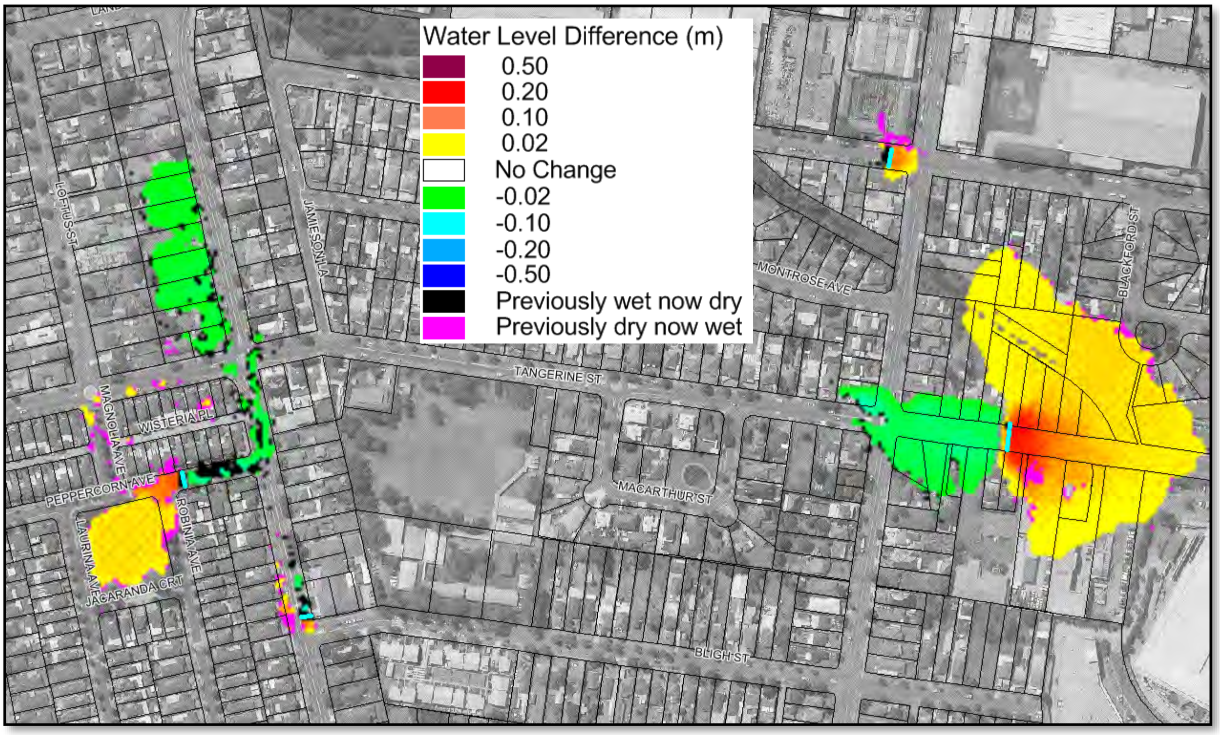


Plate 4 1% AEP Flood Level Differences in the vicinity of floodway blockage locations (aqua lines).

Peak 1% AEP depth results from the floodway blockage simulations were also extracted at select locations across the Fairfield study area and are shown in **Plate 5** to **Plate 8**. **Plate 5** to **Plate 8** also include velocity vectors from the 'blocked' (black vectors) and 'non-blocked' (red vectors).

The comparison of the velocity vectors in **Plates 5** to **8** indicates that blockage of the floodway is predicted to cause a notable redistribution of flows in the immediate vicinity of the blockage (refer purple circles areas). **Plates 7** and **8** also show that the blockage is predicted to impact on the distribution of floodwaters well downstream of the blockage. Accordingly, it is considered that this contributes a "significant" redistribution of flow.

The peak 1% AEP 'floodway blockage' flood levels were also compared against the 'non-blocked' 1% AEP flood levels to produce a flood level difference map for the Fairfield model area. The difference map is shown in **Plate 9**.

The information presented in **Plate 9** was interrogated in detail. This determined that flood levels are predicted to increase upstream of the blockage by between 0.15 and 0.35 metres (with increases of 0.2 metres being most typical. This is again considered to be a significant impact on flood levels and is in keeping with the floodway definition in the Floodplain Development Manual. Therefore, it is suggested that the criteria provided in **Table 3** is also suitable for defining hydraulic categories across the Fairfield area.

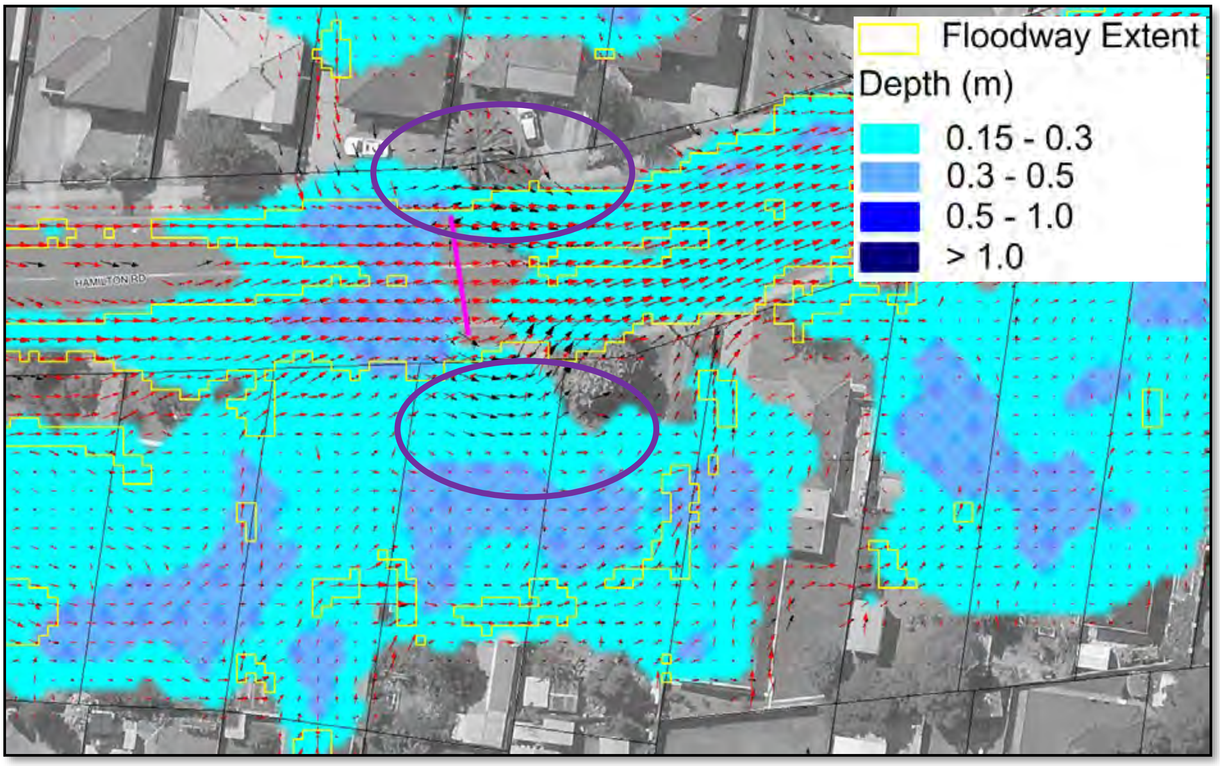


Plate 5 1% AEP Depths and Velocities in the vicinity of a floodway blockage (pink line) located on Hamilton Rd, Fairfield.

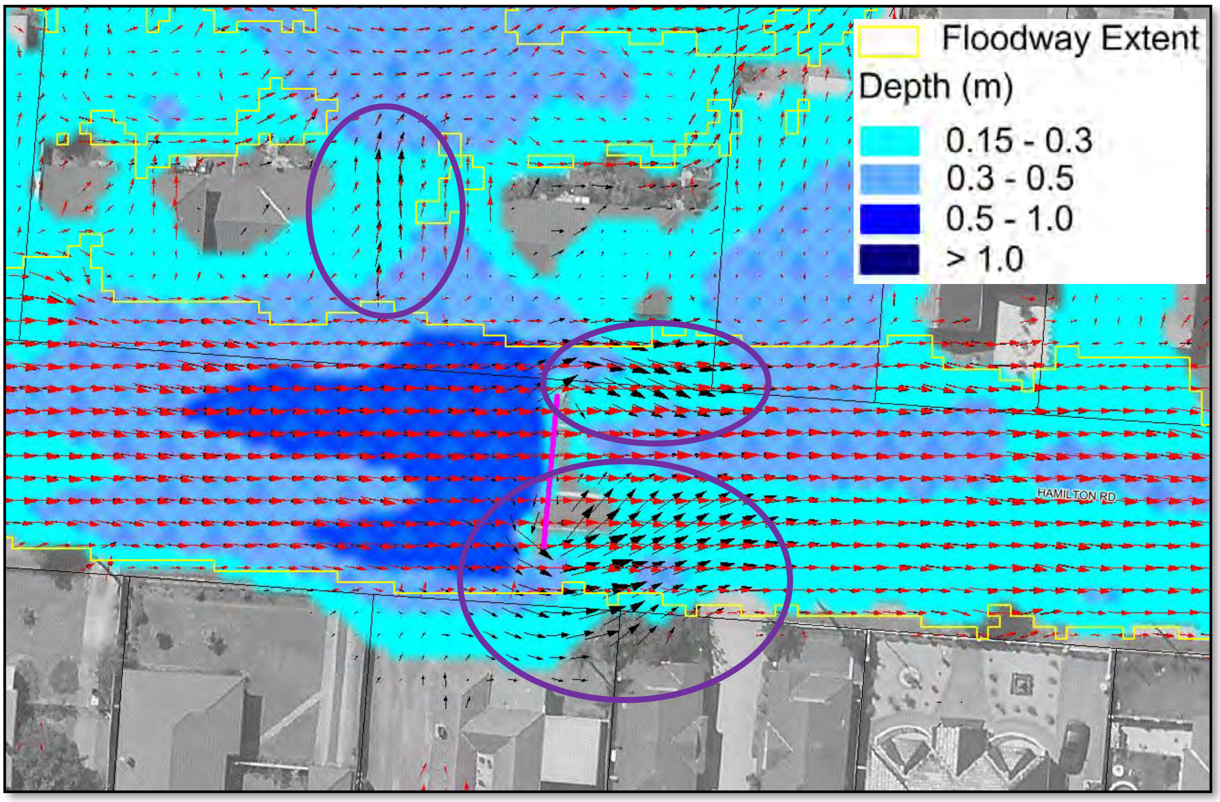


Plate 6 1% AEP Depths and Velocities in the vicinity of a floodway blockage (pink line) located on Hamilton Rd, Fairfield.

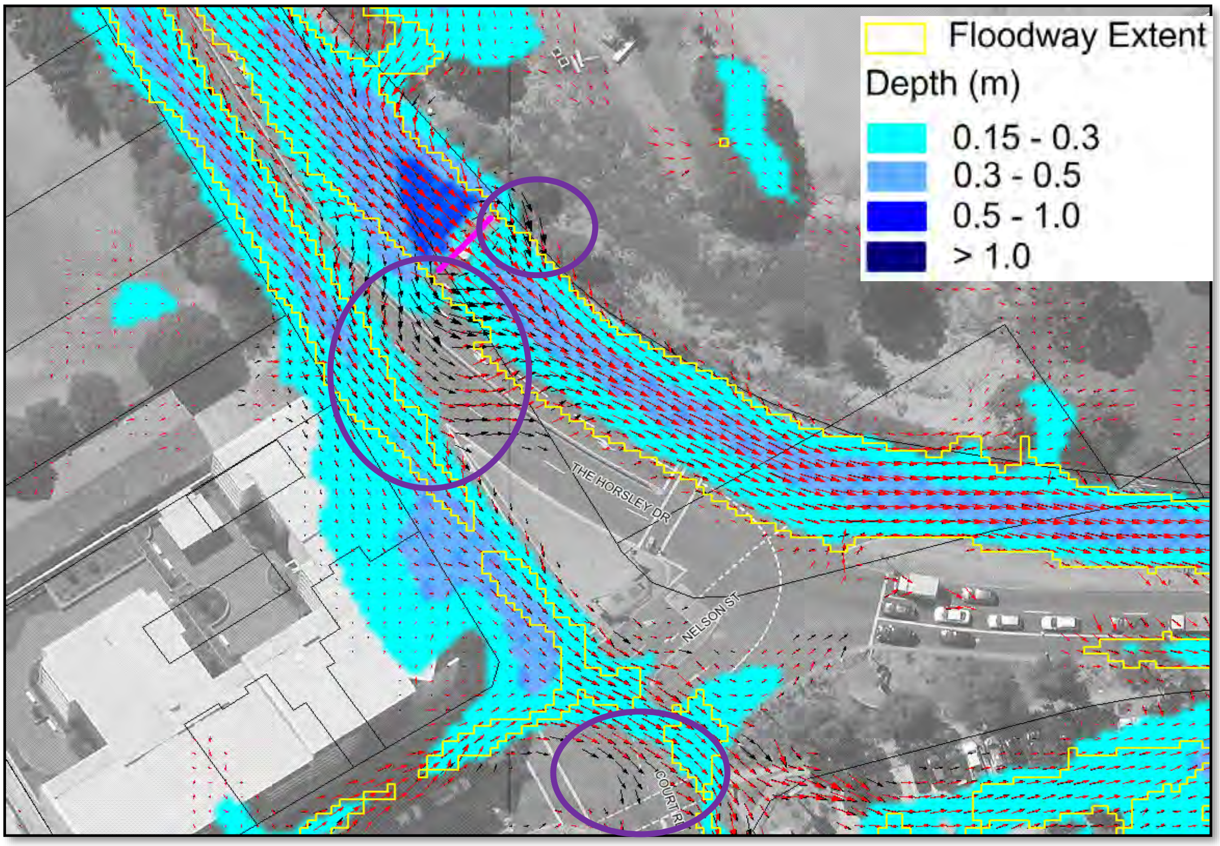


Plate 7 1% AEP Depths and Velocities in the vicinity of a floodway blockage (pink line) located on The Horsley Drive near Nelson St, Fairfield.

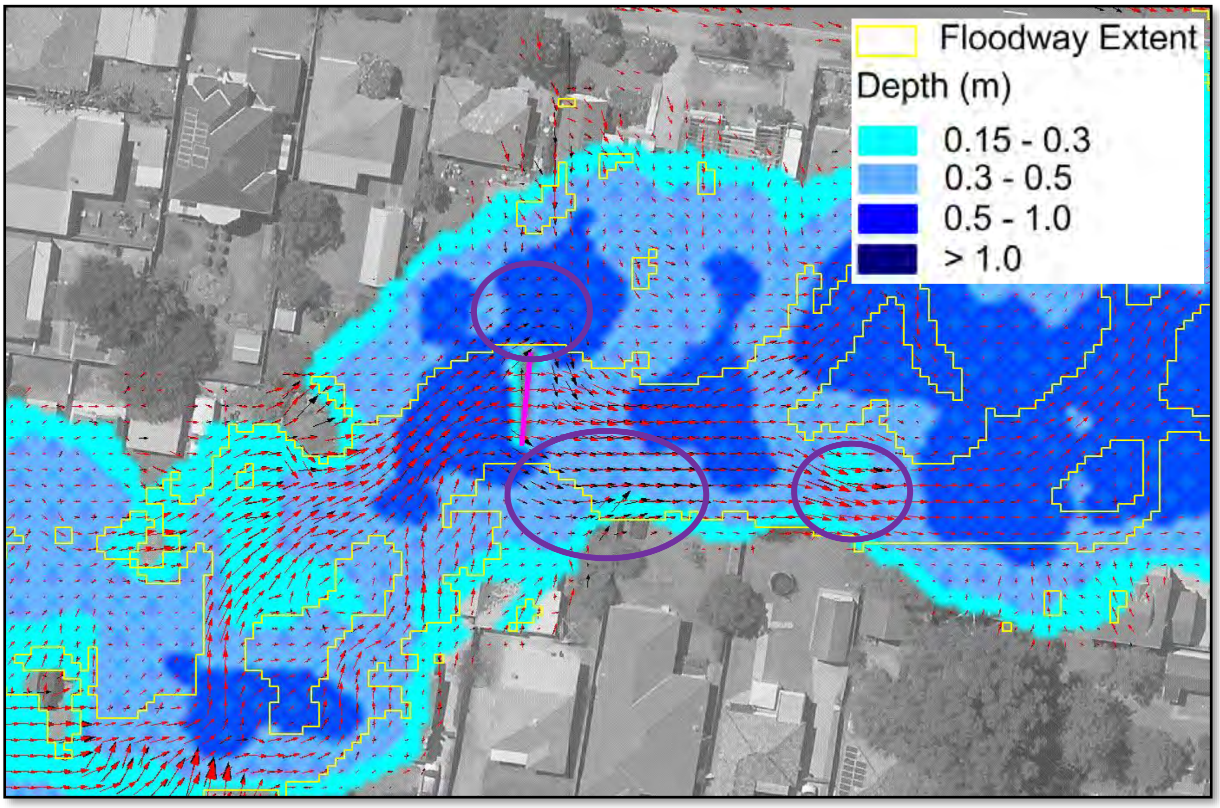


Plate 8 1% AEP Depths and Velocities in the vicinity of a floodway blockage (pink line) located within properties on Polding St, Fairfield Heights.

Overall, it is considered that the hydraulic category criteria provided in **Table 3** is consistent with criteria adopted in other similar studies and is consistent with definitions and guidance provided in the 'Floodway Definition' guideline (2007) and Floodplain Development Manual' (2005). Accordingly, it is considered appropriate to adopt these criteria to map hydraulic categories across the Fairfield and Villawood areas as part of the current study.

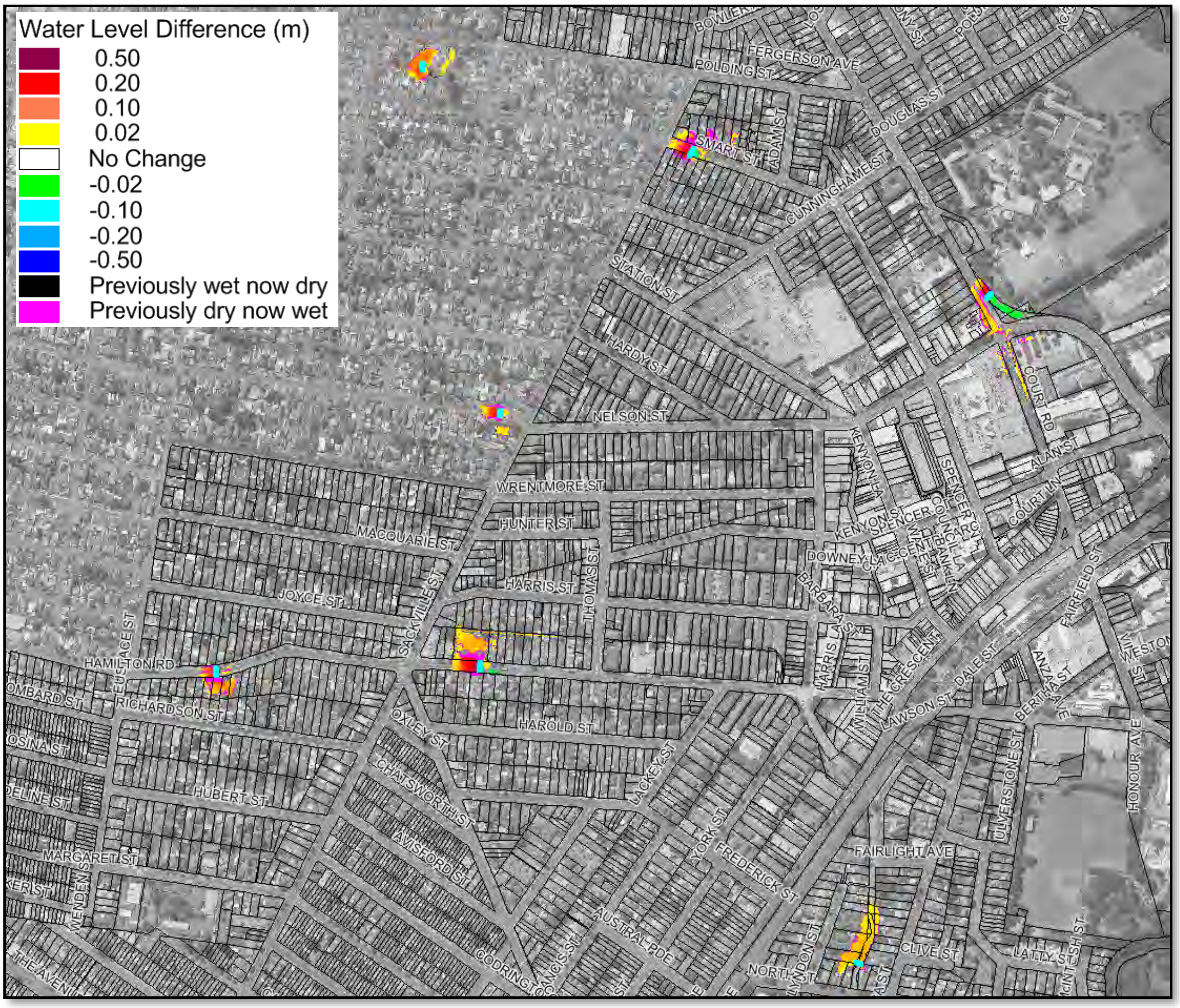
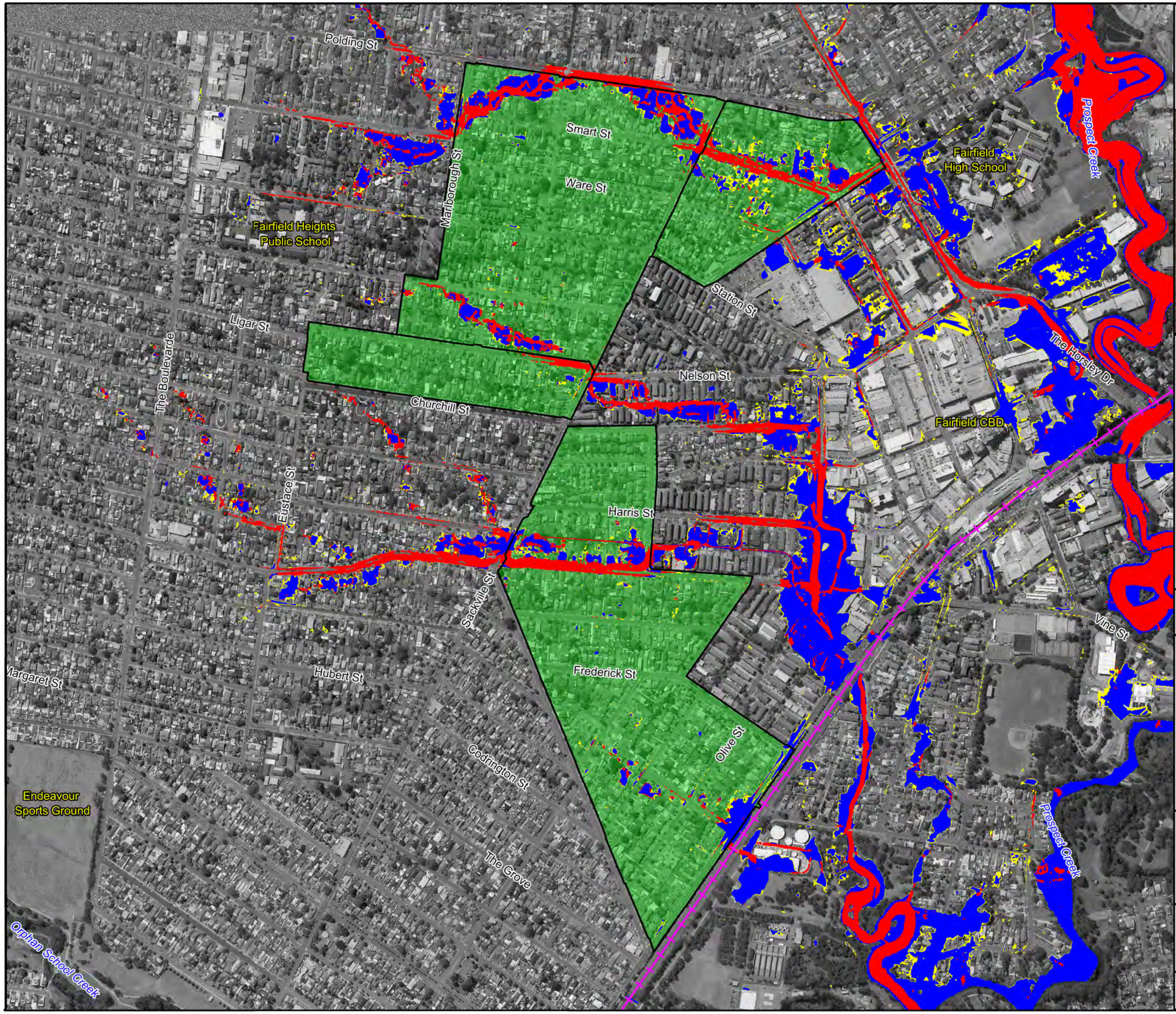


Plate 9 1% AEP Flood Level Differences in the vicinity of floodway blockage locations (aqua lines).



LEGEND

- Extent of Proposed Upzoning

Hydraulic Category

- Flood Fringe
- Flood Storage
- Floodway

Notes:

Areas not shown with any category are considered to be Flood Fringe

N W E S

Scale 1:8,000 (at A3)

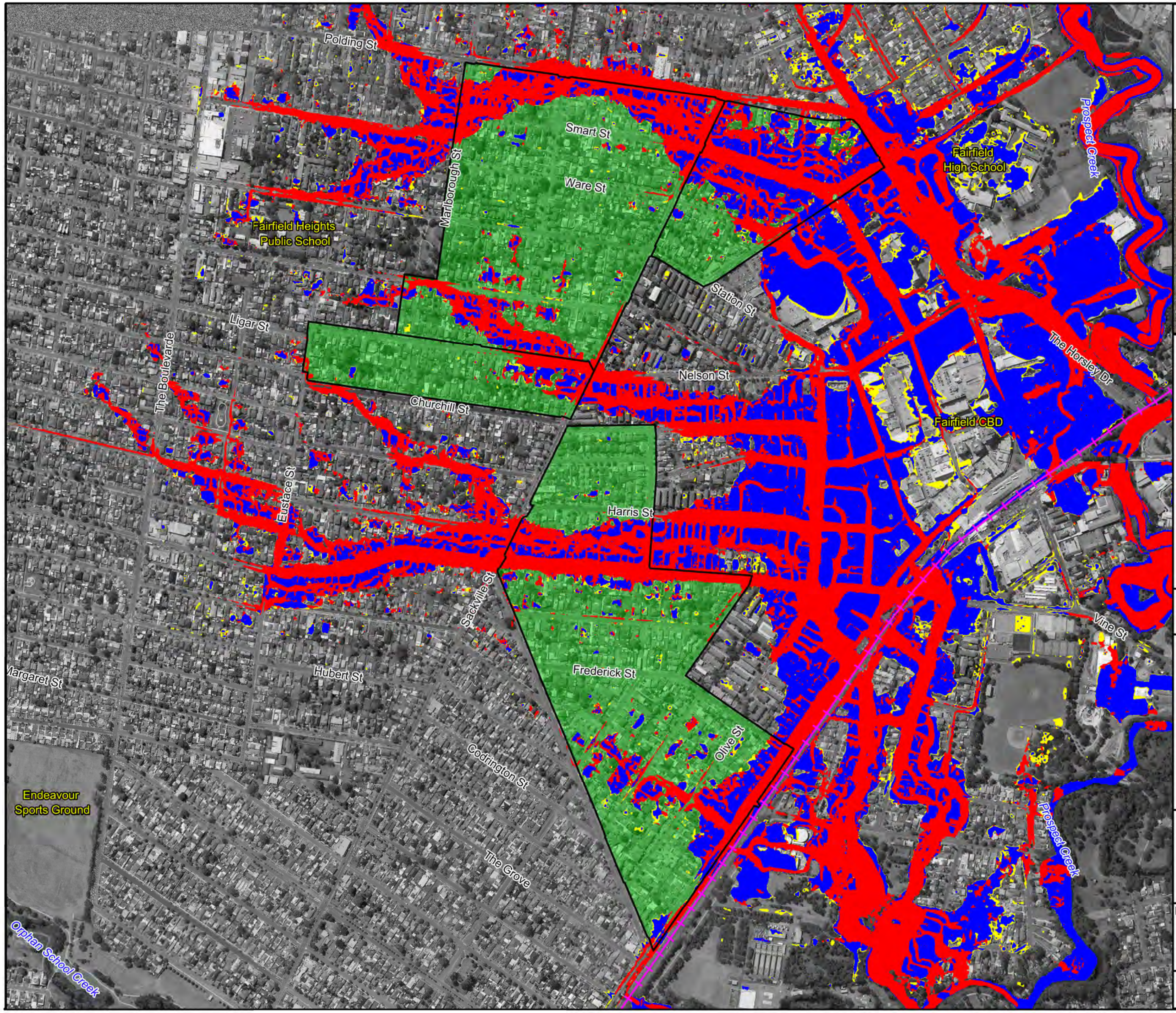
0 0.25 0.5 Km

Figure CF1: 100-Year ARI Hydraulic Categories for Existing Conditions

Prepared By:

Catchment Simulation Solutions
Suite 2.01, 210 George St
Sydney, NSW 2000

File Name: 100-Year HydCat Existing.wor



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LEGEND

Extent of Proposed Upzoning

Hydraulic Category

- Flood Fringe
- Flood Storage
- Floodway

Notes:
Areas not shown with any category are considered to be Flood Fringe

N W E S

Scale 1:8,000 (at A3)

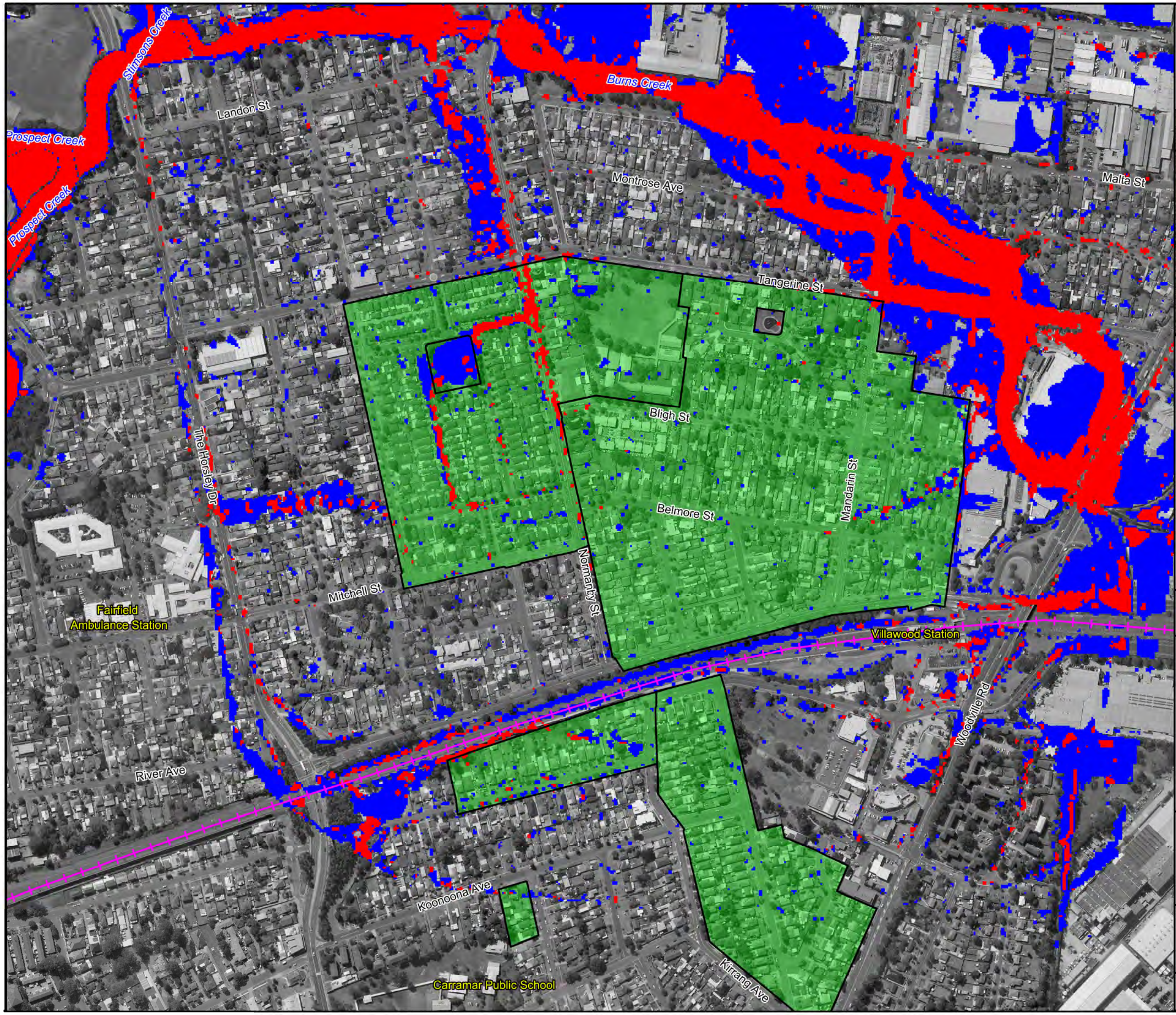
0 0.25 0.5 Km

Figure CF2: PMF Hydraulic Categories for Existing Conditions

Prepared By:
Catchment Simulation Solutions
Suite 2.01, 210 George St
Sydney, NSW 2000

File Name: PMF HydCat Existing.wor

FairfieldCity
Celebrating diversity



LEGEND

Extent of Proposed Upzoning

Hydraulic Category

- Flood Fringe
- Flood Storage
- Floodway

Notes:
Areas not shown with any category are considered to be Flood Fringe

N W E S

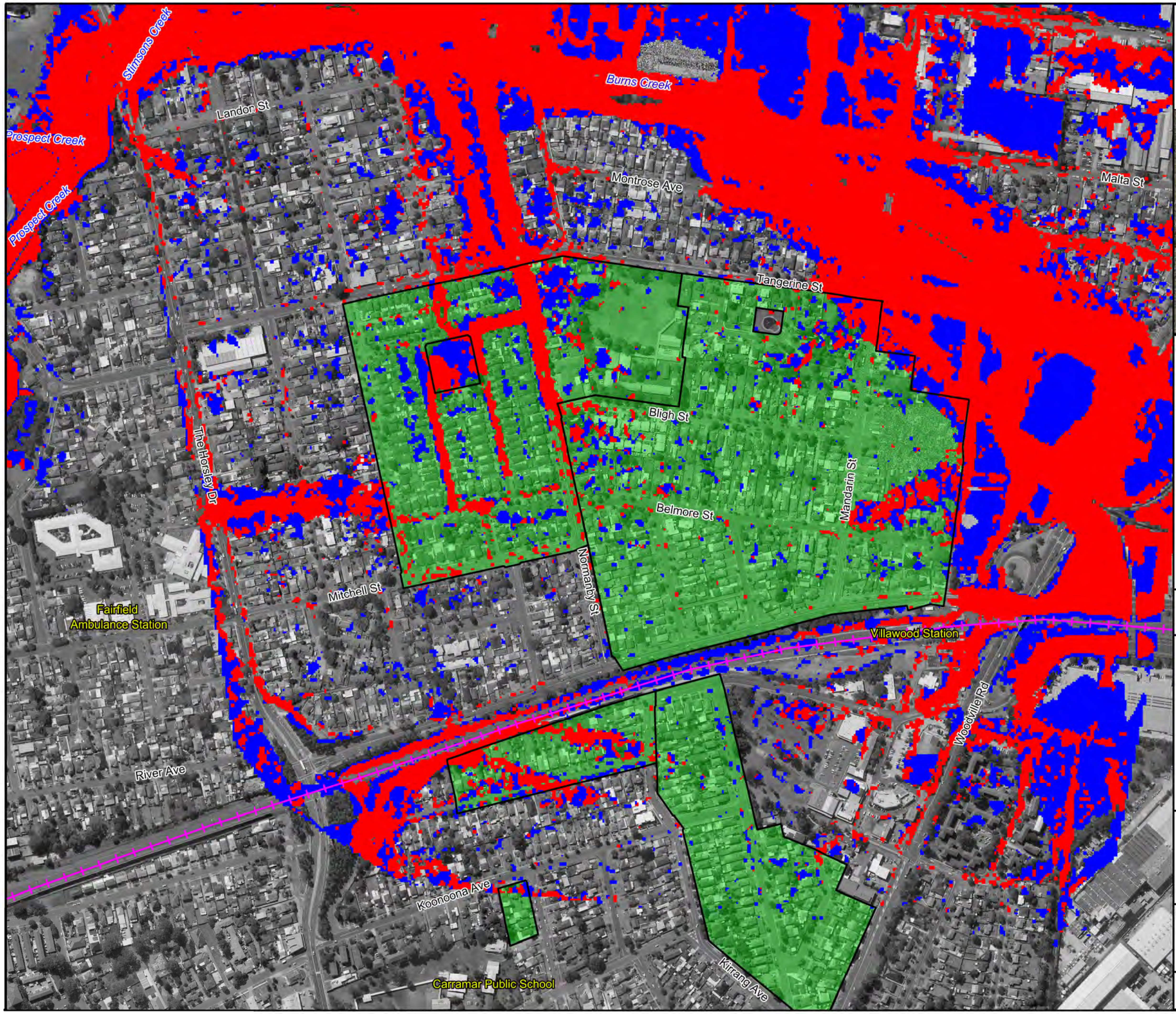
Scale 1:5,000 (at A3)

0 0.15 0.3 Km

**Figure CV1:
100-Year ARI
Hydraulic Categories for
Existing Conditions**

Prepared By:
Catchment Simulation Solutions
Suite 2.01, 210 George St
Sydney, NSW 2000

File Name: 100-Year HydCat Existing.wor



FairfieldCity
Celebrating diversity

LEGEND

Extent of Proposed Upzoning

Hydraulic Category

- Flood Fringe
- Flood Storage
- Floodway

Notes:
Areas not shown with any category are considered to be Flood Fringe

N / W / E / S

Scale 1:5,000 (at A3)
0 0.15 0.3 Km

Figure CV2:
PMF
Hydraulic Categories for Existing Conditions

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File Name: PMF HydCat Existing.wor