Orchard Hills Precinct

Flood Impact Assessment

Department of Planning, Housing and Infrastructure

RR-05-1730-02

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Cover image: Wianamatta South Creek. Near Samual Marsden Rd. (J. Stewart, 2 February, 2023)

Executive Summary

The Orchard Hills Precinct comprises a 1,395 ha parcel of land bounded by the M4 Motorway to the north, Wianamatta-South Creek to the east, the Defence Establishment Orchard Hills to the south and the Northern Road to the west. The northernmost portion of the Precinct extends past the M4 Motorway to Caddens Road. The entirety of the Precinct is located within the Penrith City Council local government area (LGA). The Stage 1 Indicative Layout Plan (ILP) covers the eastern portion of the Precinct area (**Figure ES1**).

Existing and future flood risk within the Stage 1 rezoning area will be generally managed by locating proposed residential areas outside of the floodplain. The proposed rezoning is consistent with Planning Direction 4.1 (See **Section 3.5)**.

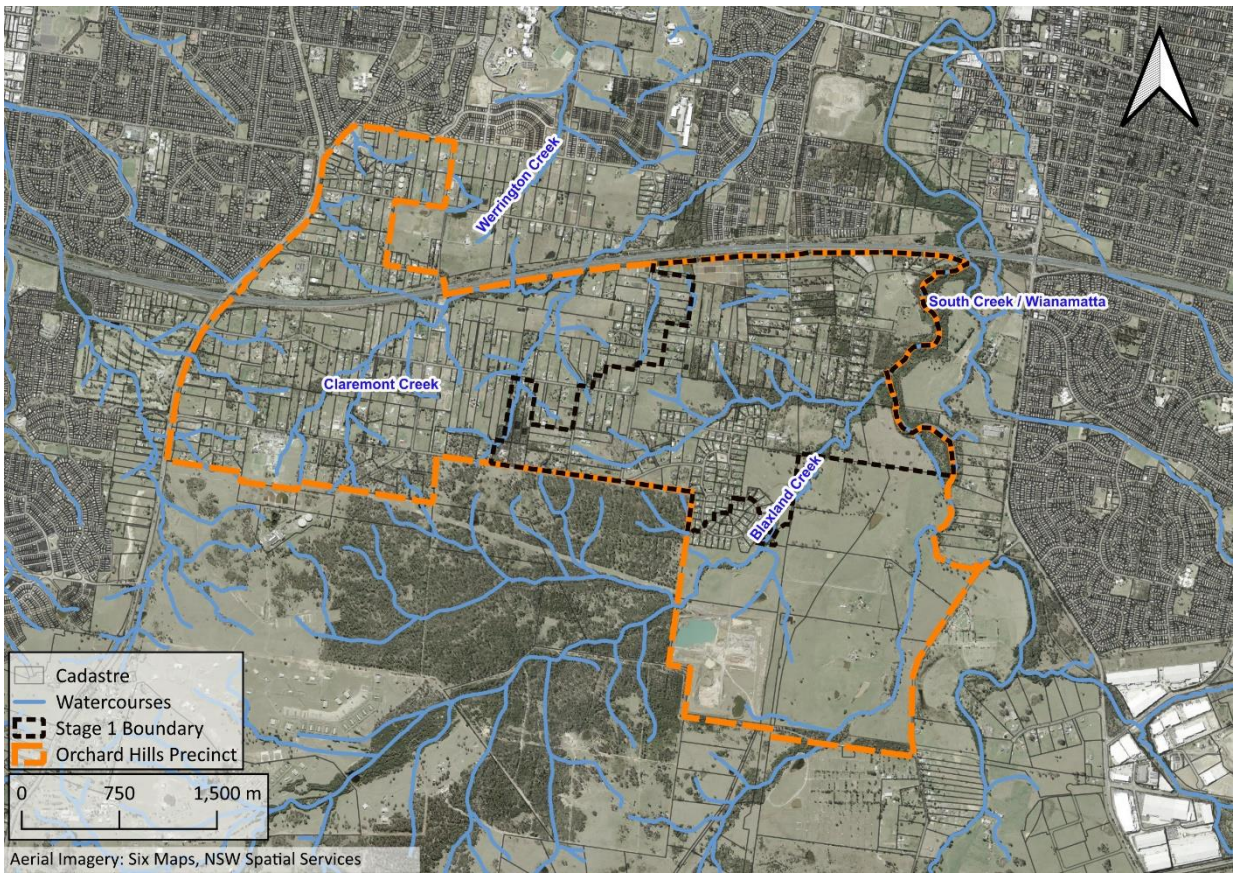

Figure ES1 Orchard Hills Precinct Extent, Staging and Watercourses

Hydrological Context

The Precinct contains a number of watercourses, the most significant being ***Wianamatta-South Creek*** (a tributary of ***Dyarubbin***, the Hawkesbury-Nepean River system) which flows in a northerly direction along the eastern boundary of the Precinct. Other major watercourses include:

- ***Blaxland Creek***, which traverses the south-eastern portion of the Precinct; and
- ***Claremont Creek*** which drains through the western portion of the site to a culvert crossing underneath the M4 Motorway.

These creeks, as well as the majority of minor watercourses within the Precinct, feed into Wianamatta-South Creek.

There are also a number of minor watercourses in the western portion of the Precinct that flow to the west to the Nepean River (not associated with Stage 1 of the Precinct, being the subject of this report).

Backwater flooding from the Hawkesbury Nepean River system (a 500 square kilometre floodplain, with a 21,400 km^2 catchment) largely has its limit at the M4 Motorway (at the Precinct boundary) and does not directly affect the Precinct.

Background - Flood Studies for the Locality

A number of flood assessments have been prepared for the locality, most recently being:

- *Penrith Overland Flow Flood Overview Study* (Cardno, 2006) (studies of ***overland flow*** that cover the entire Penrith Local Government Area).
- *Updated South Creek Flood Study* (Worley Parsons, 2015) (a study of ***mainstream flooding*** commissioned by Penrith Council on behalf of the Councils within the wider (upstream) catchment, being Liverpool Council and Camden Council).
- *Sydney Metro – Western Sydney Airport – EIS Flooding, hydrology and water quality* (Arup, 2020) (a flood impact assessment of the Metro, currently under construction, that traverses the Precinct).
- *South Creek Floodplain Risk Management Study* (Advisian, 2020) (an evaluation of potential options to manage flood risk in the South Creek floodplain).
- *Wianamatta South Creek Catchment Flood Study – Existing Conditions* (Advisian, 2022) (an update to the 2015 Worley Parsons study).
- *Wianamatta South Creek Catchment Flood Study – Cumulative Impact Assessment* (Advisian, 2023) (an evaluation of the effects of various developments in the catchment, including the Aerotropolis, using the 2022 Advisian study).
- *Hawkesbury-Nepean Flood Study* (Rhelm/Catchment Simulation Solutions, 2024) (a study of ***mainstream flooding*** to characterise flood risk in the wider river system, of which Wianamatta South Creek is a tributary. The study focuses on longer duration flood events, given the large nature of the catchment, but included consideration of a range of developments, including the Orchard Hills Precinct).

Further details of the studies can be found in **Section 2** of this report.

Flood Planning Context

The NSW Local Planning Direction 4.1 Flooding (2022) forms the foundational basis for the flood planning context for the Precinct.

The core objectives of this direction are to:

- Ensure that development of flood prone land is consistent with the NSW Government's Flood Prone Land Policy and the principles of the *Floodplain Development Manual* 2005 (now the *Flood Risk Management Manual*, 2023); and
- Ensure that the provisions of an LEP that apply to flood prone land are commensurate with flood behaviour and includes consideration of the potential flood impacts both on and off the subject land.

Further details of the flood planning context can be found in **Section 3** of this report.

Using the Precinct flood model (see below), careful consideration of this Direction has been made in the development of the Indicative Layout Plan (ILP) for the Precinct.

Precinct Flood Assessments

The various Wianamatta South Creek studies listed above, whilst directly relevant to the Precinct, either are not a suitable scale for flood impact assessment (such as the overland flow study), do not cover the whole Precinct (such as the Wianamatta-South Creek focused studies) or are very large models considering a much more expansive area (also the Wianamatta-South Creek focused studies). As such a bespoke flood model was created for the Precinct (the **Precinct flood model**) for the purposes of testing potential Precinct configurations, considering the effects of potential flood risk management measures and evaluating flood impact.

The Precinct flood model (being a hydrological RAFTS software model and a hydraulic TUFLOW software model) draws upon the various flood assessments listed above (including hydrological inputs) and allows for consideration of:

- flows ***from the Precinct*** (to both Wianamatta South Creek and to the Nepean River)
- flows ***in Wianamatta South Creek*** (that encroach on the eastern areas of the Precinct and form a constraint on the extent of development)
- ***backwater flooding*** from the Hawkesbury Nepean River (that can affect the potential for flows to be conveyed in South Creek).

Details of the development and validation of the model(s) for the baseline assessment are outlined in **Section 4** of this report.

Flood Risk Management Approach

The implementation of the following measures is proposed to manage flood risk in the Precinct:

- Ensure flood function is maintained, by locating future development outside areas identified as floodway and flood storage;
- Allow for projected climate change impacts in setting flood planning levels;
- Provide safe access routes during long duration flood events;
- Ensure occupants can safely shelter in-place during local rainfall event flash flooding.

By adhering to these strategies, the proposed development can effectively manage flood risk while facilitating flood-compatible and sustainable urban growth in the Orchard Hills Stage 1 rezoning area.

The extent of the proposed flood planning area in the context of the proposed ILP is shown in **Figure ES2**. The flood planning area extent represents the 1%AEP flood event with an allowance for climate change (as a rainfall intensity increase of 35%) and a freeboard of 0.5 m. The extent of the flood planning area has been limited to the PMF extent (where a freeboard of 0.5 m on the 0.2%AEP flood extent would otherwise result in an artificially larger flood extent than the known limit of the floodplain, as defined by the PMF).

Lands within the flood planning area are proposed to be zoned either RE1 (Recreational Use) or SP2 (Special purposes, such as drainage or roads, where the road will form the local overland flow path). Minor encroachments (on small un-named tributaries) on any other lands will be managed through local cut and fill arrangements.

Further details of the ILP are provided in **Section 5** of this report.

Details of the flood impact assessment of the proposed ILP are provided in **Section 6** of this report.

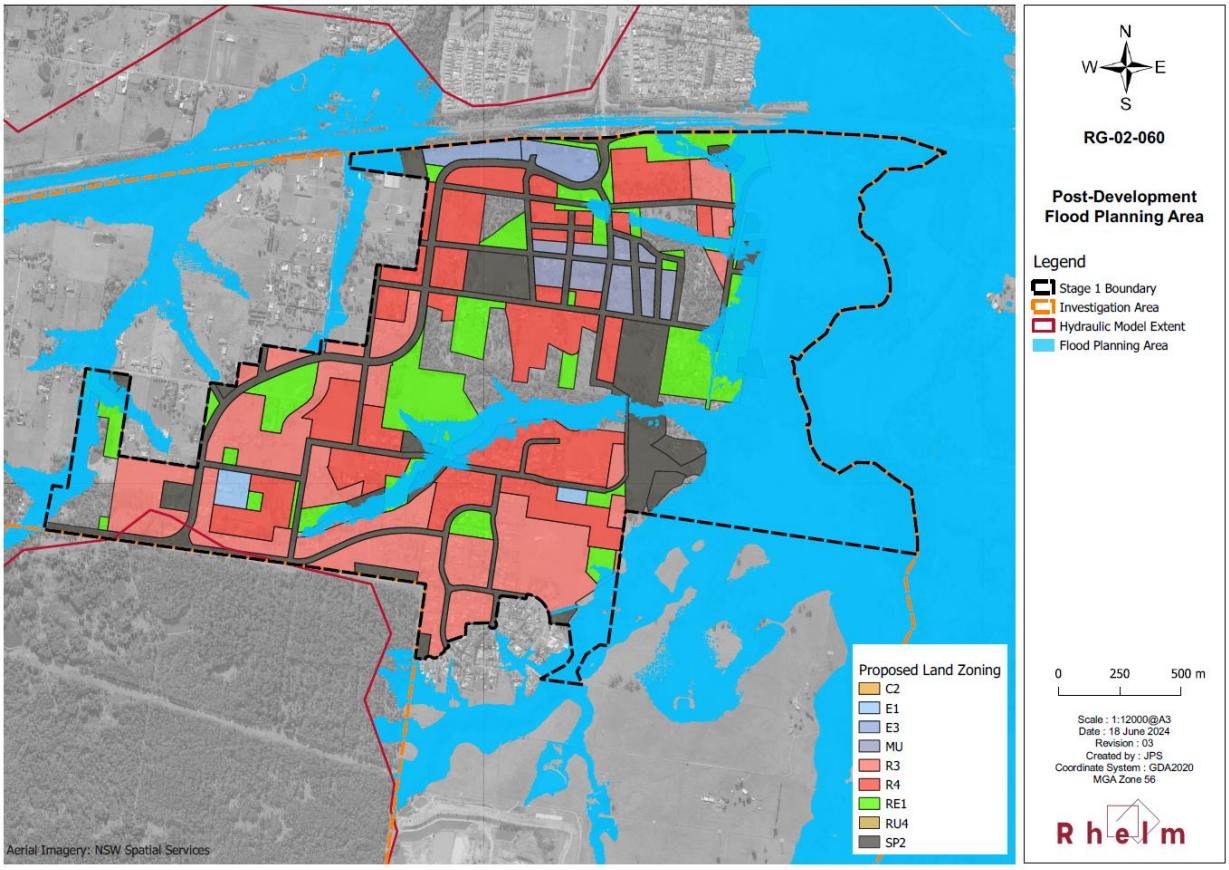

Figure ES2 Flood Planning Area overlaid on Indicative Layout Plan Proposed Land Zoning for Stage 1

Figure ES2 demonstrates that the majority of development within the Orchard Hills Precinct is proposed to be set outside of the floodplain associated with flood behaviour associated with both Wianamatta South Creek and the Hawkesbury-Nepean River system to meet the core objectives of the Local Planning Direction. Details of the overall alignment between the ILP and the planning framework are set out in **Section 7** of this report.

Flood risk management for rare and extreme events, primarily as emergency management measures, are discussed in **Section 8** of this report.

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1 Introduction

The Greater Penrith to Eastern Creek area (GPEC) has been identified for future homes and jobs growth to support the Western Sydney Aerotropolis. The Orchard Hills precinct (the Precinct) is one of six areas within GPEC and has been identified as a priority urban release area.

Rhelm Pty Ltd (Rhelm) have been engaged by the Department of Planning, Housing and Infrastructure (DPHI) to undertake a flooding assessment to inform the development of the Orchard Hills Stage 1 Indicative Layout Plan (ILP).

This assessment addresses:

- Hydrologic modelling;
- Hydraulic modelling;
- Flood impacts; and
- Flood risk and emergency response.

1.1 Study Area

The Orchard Hills Precinct comprises a 1,395 ha parcel of land bounded by the M4 Motorway to the north, Wianamatta-South Creek to the east, the Defence Establishment Orchard Hills to the south and the Northern Road to the west. The northernmost portion of the Precinct extends past the M4 Motorway to Caddens Road. The entirety of the Precinct is located within the Penrith City Council local government area (LGA). The Stage 1 Indicative Layout Plan (ILP) covers the eastern portion of the Precinct area.

The Precinct contains a number of watercourses, the most significant being Wianamatta-South Creek (a tributary of Dyarubbin, the Hawkesbury-Nepean River system) which drains in a northerly direction along the eastern boundary of the Precinct. Other major watercourses include:

- Blaxland Creek, which traverses the south-eastern portion of the Precinct and
- Claremont Creek which drains through the western portion of the site to a culvert crossing underneath the M4 Motorway.

Both creeks, as well as the majority of minor watercourses within the Precinct, feed into Wianamatta-South Creek. There are also a number of minor watercourses in the western portion of the Precinct that drain to the west to the Nepean River.

The overall Precinct area and the Stage 1 ILP study area and relevant watercourses are shown in **Figure 1-1**. The proposed zoning for the Stage 1 ILP and release boundaries are shown in **Figure 1-2.**

The floodplain includes all land susceptible to flooding by the Probable Maximum Flood (PMF). The Precinct is affected by both mainstream flooding and overland flow.

Mainstream flooding is caused by flooding from open channels, creeks or rivers.

Overland flow flooding occurs following heavy rainfall along topographical depressions or from surcharging stormwater drainage systems.

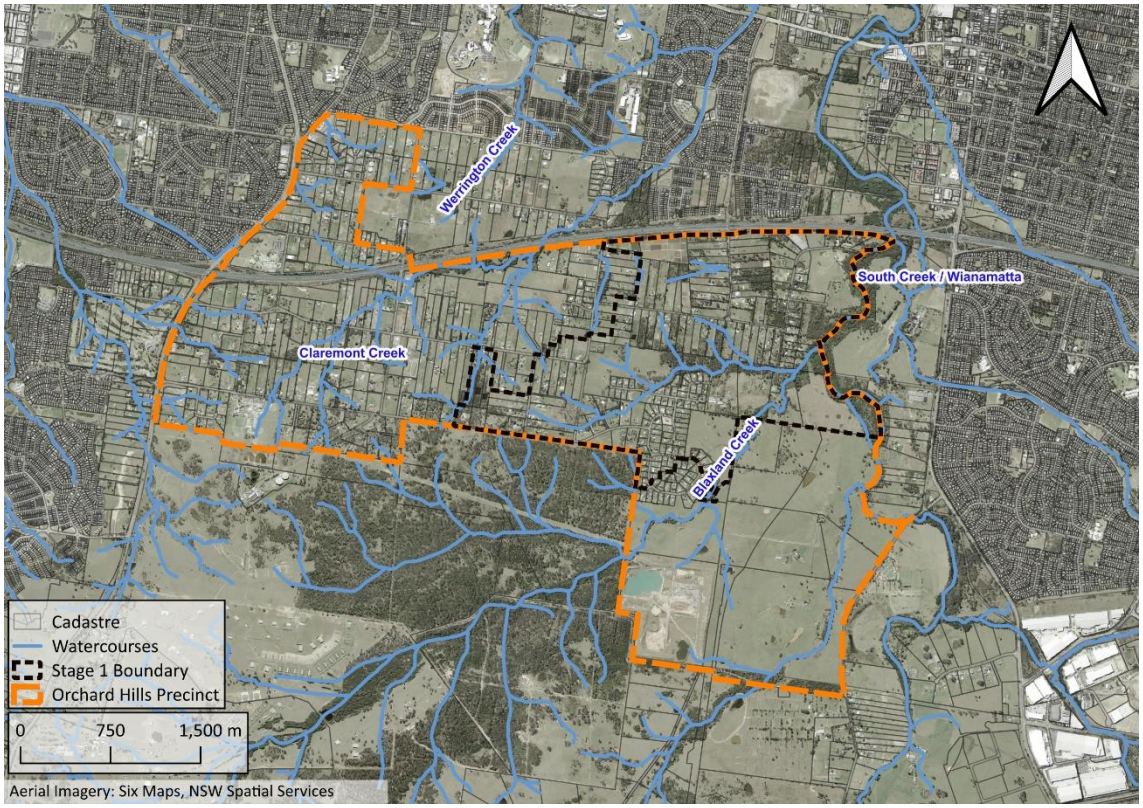

Figure 1-1 Study Area

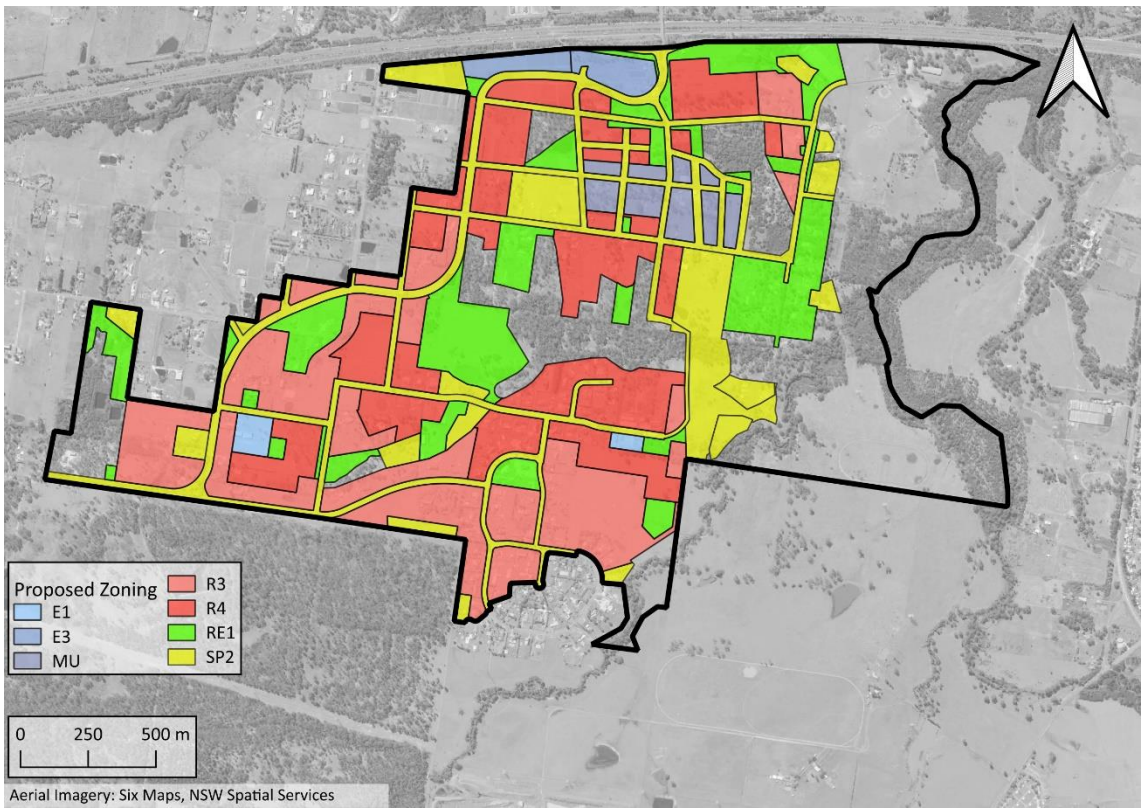

Figure 1-2 Proposed Rezoning within the Orchard Hills Stage 1 ILP

1.2 Report Structure

The report is structured as follows:

- Data Review (**Section 2**)
- Flood-related Planning and Policy Review (**Section 3**)
- Baseline Flood Modelling (**Section 4)**
- Indicative Layout Plan (**Section 4.1)**
- Post-Development Flood Impact Assessment (**Section 6)**
- Flood Planning Considerations (**Section 7)**
- Flood Emergency Response (**Section 8**)
- Conclusion and Recommendations (**Section 9**).

2 Data Review

2.1 Site Inspection

A site inspection was undertaken on 2 February 2023 to gain an appreciation of the character of the study area. Given the scale of the overall Precinct, the tour was largely conducted via bus and thus detailed inspection of key site features relevant to flooding (such as watercourses and culvert/bridge crossings) was limited. A further site inspection of key drainage crossings on the southern side of the M4 Motorway was completed on 12 May 2023 to confirm the details of accessible cross drainage. **Figure 2-1** shows examples of those cross-drainage structures.

Figure 2-1 Claremont Creek: Culverts Under M4 Motorway (left). Samuel Marsden Drive. Twin Circular Culverts (Right)

2.2 Previous Flood Studies and Reports

Previous studies undertaken for the locality relevant to the Precinct flooding assessment are summarised below.

2.2.1 Updated South Creek Flood Study (Worley Parsons, 2015)

Penrith City Council commissioned the *Updated South Creek Flood Study* (Worley Parsons, 2015). This study involved the establishment of an XP-RAFTS hydrological model and RMA-2 hydraulic model to define the existing flood behaviour of Wianamatta-South Creek and its major tributaries, inclusive of Blaxland Creek and Claremont Creek (north of the M4 Motorway).

The models were validated using the results from the *Flood Study Report South Creek* (NSW Department of Water Resources, 1990), *Austral Floodplain Risk Management Study and Plan* (Perrens Consultants, 2003) and *South Creek Floodplain Risk Management Study and Plan* (Bewsher Consulting, 2004).

Design flood behaviour was modelled and assessed for the 5%, 2%, 1%, 0.5% and 0.2% Annual Exceedance Probability (AEP) and Probable Maximum Flood (PMF) events. Australian Rainfall and Runoff 1987 (ARR1987) rainfalls and temporal patterns were utilised for the design flood analysis.

Mapped results include flood levels, depths, velocities, provisional hazard and hydraulic categorisation.

The modelling used in this study has since been superseded (refer **Section 2.2.3**).

2.2.2 South Creek Floodplain Risk Management Study (Advisian, 2020)

The *South Creek Floodplain Risk Management Study* (Advisian, 2020) was commissioned by Penrith City Council and uses the results of the *Updated South Creek Flood Study* (Worley Parsons, 2015) to examine flooding and emergency management issues in the Wianamatta-South Creek floodplain.

As part of this study, provisional flood hazard mapping from the Worley Parsons (2015) flood study was updated based on the H1-H6 hazard categorisation from Australian Rainfall and Runoff 2019 (ARR2019) and modified to account for additional contributing factors (such as evacuation potential) to produce 'true hazard' mapping. Additionally, Flood Planning Constraint Categories (FPCCs) were defined across the floodplain. This categorisation considers the frequency of flooding, hydraulic categorisation, flood hazard and evacuation constraints.

The study recommended a number of potential flood mitigation measures throughout the region; however, none of these measures are located within the Precinct.

2.2.3 Wianamatta South Creek Catchment Flood Study – Existing Conditions (Advisian, 2022)

This study involved an update of the models from the *Updated South Creek Flood Study* (Worley Parsons, 2015) to better reflect present day conditions. Significant modifications to model input include the utilisation of more recent 2019 LiDAR data, as well as a revision of catchment roughness and imperviousness assumptions using 2020 aerial imagery. The study is based on the methods outlined in Australian Rainfall and Runoff (1987).

A climate change sensitivity assessment was undertaken as part of this study by comparing the results of the 0.5% AEP and 0.2% AEP scenarios with those of the 1% AEP flood event. The 0.5% AEP and 0.2% AEP events represent 15% and 35% respective increases in rainfall intensity compared to the 1% AEP and have been used as a proxy for projected increases in rainfall associated with climate change.

Updated mapping is provided for the 5% AEP, 1% AEP and PMF events; inclusive of flood levels, depths, velocities, provisional hazard and hydraulic categorisation.

2.2.4 Wianamatta South Creek Catchment Flood Study – Cumulative Impact Assessment (Advisian, 2023)

The *Wianamatta South Creek Catchment Flood Study - Cumulative Impact Assessment* (CIA, Advisian, 2023) was prepared for Infrastructure NSW (now NSW Reconstruction Authority) in recognition of the significant development pressures in the catchment. The assessment included a review of flood constraints that could impact on land use planning across the Wianamatta-South Creek catchment to inform the management of future development in the catchment and floodplains of Wianamatta-South Creek.

The CIA considered a range of future development urbanisation, vegetation and fill scenarios, for catchments upstream of the Orchard Hills Precinct (noting that a portion of the Blaxland Creek catchment is located on the southern boundary of the Orchard Hills Precinct).

Key findings for each of these scenarios are summarised in the following sections.

2.2.4.1 Urbanisation/Changes to Flows

The CIA found that efforts to attenuate flood discharges from certain tributary catchments can serve to delay the arrival of the flood peak at the tributary confluences with Wianamatta-South Creek. As a result, efforts to attenuate peak flows would likely lead to increases in peak 1% AEP flood levels along South Creek.

Of relevance to the Orchard Hills Precinct, the CIA found that aligning peak flows from Blaxland Creek and Wianamatta-South Creek could see an increase in flow of between 5% to 17% along Wianamatta-South Creek in a 1% AEP flood event, depending on the level of alignment of peaks from other tributaries. The worst-case scenario, where hydrograph peaks from all major tributaries were aligned, equated to a 1% AEP flood level increase of 0.33 m at the Western Motorway (M4). Whilst this scenario where all tributary peaks become aligned is unlikely, the CIA notes that partial alignment of peaks remains a concern.

The CIA concluded that it is necessary to, where possible, minimise the attenuation of tributary flows to avoid potential increases in flows along Wianamatta-South Creek.

The Orchard Hills Precinct is similar in characteristics to the catchments of a number of tributaries in which the CIA findings in relation to detention were based upon, namely greenfield land in the mid to lower portion of the broader Wianamatta-South Creek catchment. It can thus be reasonably deduced that similar principles would apply to the Precinct. However, it should be noted that the recommendations regarding detention (**Section 7.2.1**) have not been derived from the findings of the CIA, but rather a detailed site-specific hydrologic and hydraulic analysis as detailed in **Section 4** and **Section 6**.The CIA therefore supports the findings of this study.

2.2.4.2 Vegetation/Floodplain Roughness Changes

The CIA assessed the impacts of increases in floodplain roughness associated with vegetation 'densification' within the Aerotropolis Precinct. The densification scenario was found to increase 1% AEP flood levels by up to 0.1m for sections of Wianamatta-South Creek (for the reach between Bringelly Road and the Orchard Hills Precinct). This consequently resulted in a minor reduction in flood levels of 0.04m adjacent to the Orchard Hills Precinct, at the downstream extent of the densification testing.

Based on the results of this assessment, the CIA recommends vegetation management within the core Wianamatta-South Creek floodway and critical storages to avoid adverse flood impacts on adjacent land.

2.2.4.3 Floodplain Filling

The CIA assessed the impacts of floodplain filling outside of areas mapped as 'high-level' floodways and critical flood storages identified within the Aerotropolis Precinct. This scenario was found to increase 1% AEP flood levels by up to 0.05m within the Orchard Hills Precinct.

Similar to the vegetation densification scenario (**Section 2.2.4.2**), the recommendations of the CIA regarding floodplain filling were to preserve sections of the floodway critical for flow conveyance and storage. This is consistent with state-wide planning directions regarding development in the floodway (**Section 3.5**).

2.2.5 Penrith Overland Flow Flood Overview Study (Cardno, 2006)

The *Penrith Overland Flow Flood Overview Study* (Cardno, 2006) involved the development of a variable resolution (3m – 45m grid cell size) SOBEK 1D/2D direct rainfall model to broadly define overland flood behaviour for all major overland flow paths across the Penrith LGA, inclusive of the Precinct. The flood behaviour of riverine flooding (i.e. South Creek) was not the focus of this study. The study did not include survey of all cross-drainage structures in the LGA.

Design flood behaviour was modelled and assessed for the 5% AEP, 1% AEP and PMF events. Australian Rainfall and Runoff 1987 (ARR1987) rainfalls and temporal patterns were utilised for the design flood analysis.

Results were validated anecdotally using "past experience of Council representatives" (Cardno, 2006) as well as using the results of previous flood studies within the study area. No calibration/validation to historic events was undertaken as part of this study.

Mapped results for the 5% AEP, 1% AEP and PMF events only include flood extents.

The results of this study have been used as a basis for defining overland flooding within the Precinct in this baseline analysis, as well as mainstream flooding associated with Claremont Creek and minor watercourses.

2.2.6 Hawkesbury-Nepean Flood Study (Rhelm/Catchment Simulation Solutions, 2024)

Rhelm/CSS (2024) prepared updated hydrologic and hydraulic models of the Hawkesbury-Nepean Valley that provide more refined flood information than the *Regional Flood Study* (WMAwater, 2019).

Modelling results from this study indicate that floodwaters from the Nepean River can cause backwater flooding along South Creek into the Precinct. However, results from the study generally align with those reported in the *Wianamatta South Creek Catchment Flood Study – Existing Conditions* (Advisian, 2022) (**Section 2.2.3**) and indicate that the peak flood levels within the Precinct are dominated by catchment flooding rather than Nepean River backwater, with the exception of the PMF where backwater and catchment flood levels are of a similar magnitude (refer to **Section 8.2**). As such, the effects of Nepean River flooding has not been considered in this analysis.

Part of the *Hawkesbury-Nepean Flood Study* (Rhelm/CSS, 2024) involved the assessment of a future development scenario where it was assumed that **all projected land release areas** in the Hawkesbury-Nepean catchment would be fully developed, inclusive of the Orchard Hills Precinct (refer **Figure 2-2**).

The approach adopted was to represent a worst-case scenario in terms of increased catchment imperviousness and runoff, with the assumption of no detention provided in any of the development areas.

The results of the analysis of this scenario (**Figure 2-2**) show minor increases in flood levels of up to 0.05m and 0.1m around Windsor in the 1% AEP and 20% AEP events, respectively. Negligible flood impacts were observed along the Hawkesbury and Nepean Rivers in the 0.5% AEP event.

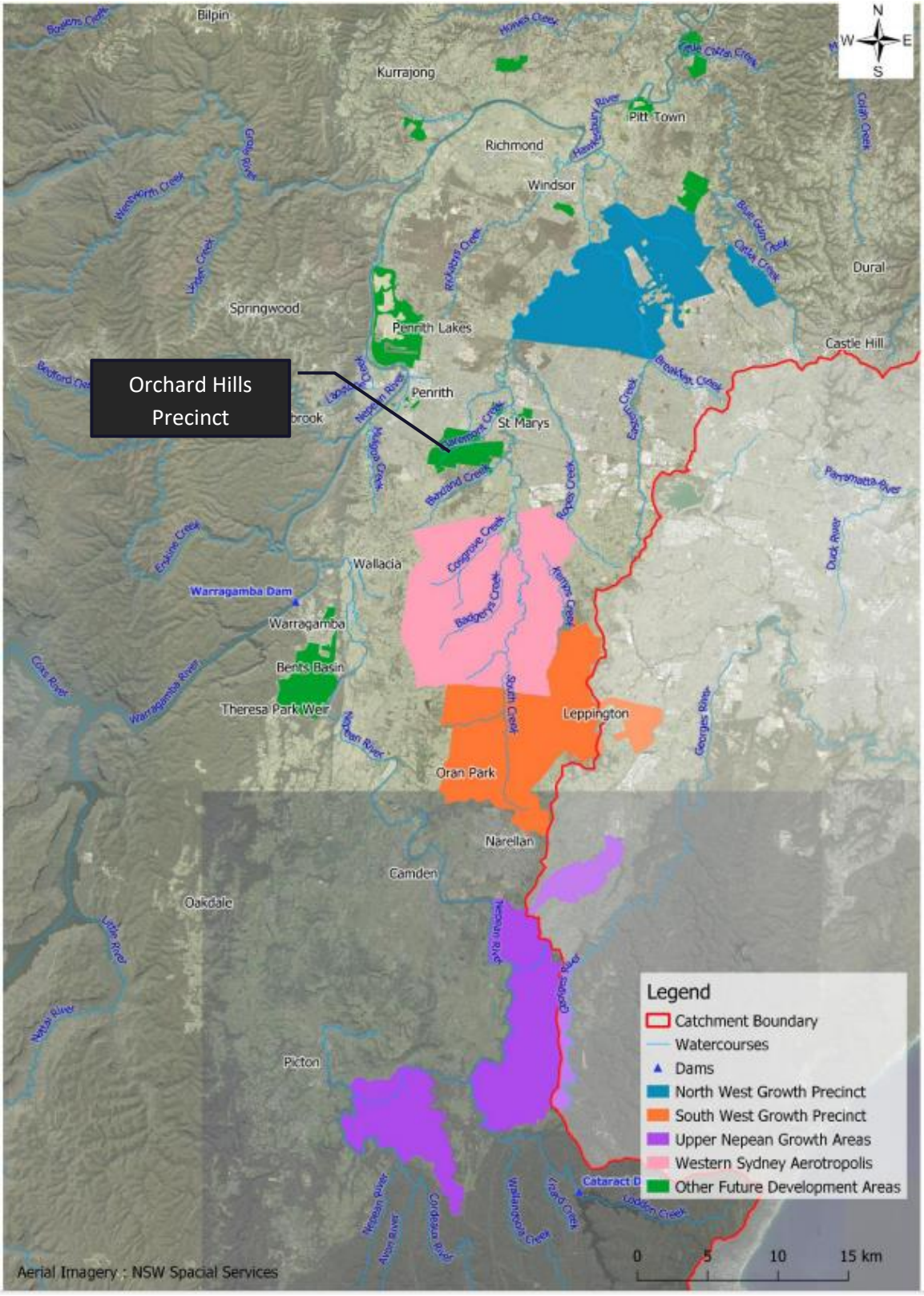

Figure 2-2 Future Development in the Hawkesbury-Nepean Catchment (Source: Rhelm/CSS, 2024)

2.2.7 Sydney Metro – Western Sydney Airport – EIS Flooding, hydrology and water quality (Arup, 2020)

The Arup (2020) study assessed potential flooding impacts along the proposed Western Sydney Airport Metro alignment (now under construction). The Metro alignment runs along the western edge of the South Creek floodplain and crosses Blaxland Creek. The study found the Metro project has the potential to increase peak flood levels by up to 200mm (0.2 m) upstream of the proposed bridge (or viaduct) over Blaxland Creek.

The study is based on Australian Rainfall and Runoff (2019) (ARR2019), while other studies including Advisian (2022) are based on ARR1987 hydrology. Upstream of the M4 motorway along South Creek, the EIS study found the 1% AEP levels to be 1.2 m lower than Council adopted flood levels (Advisian, 2020). The EIS flood study states the differences are primarily a result of reduced design rainfall for ARR2019 compared to ARR1987. Further differences in flood behaviour between the project flood modelling and the Advisian (2020) were attributed to:

- LiDAR data;
- Bed roughness values;
- Hydrodynamic model software: RMA-2 compared with TUFLOW.

2.3 Existing Flood Modelling Data

A summary of available flood modelling data relevant to the Precinct and the use of this data in this assessment is provided in **Table 2-1**.

Table 2-1 Available Flood Modelling Data

Data Source	Data Type	Relevance to the Precinct Assessment
Wianamatta South Creek Catchment Flood Study – Existing Conditions (Advisian, 2022)	XP-RAFTS model	This model forms the basis of hydrological modelling undertaken during this study (**Section 4.1)**
	RMA-2 flood model results rasters	Used to validate hydraulic model **(Section 4.3)**
Penrith Overland Flow Flood Overview Study (Cardno, 2006) and *Updated South Creek Flood Study* (Worley Parsons, 2015) (assumed)	Penrith City Council's GIS 1% AEP flood and PMF extents	Used to validate hydraulic model **(Section 4.3)**
Penrith Overland Flow Flood Overview Study (Cardno, 2006)	Flood model results rasters	Used to validate hydraulic model **(Section 4.3)**

2.4 Terrain Data

2.4.1 LiDAR

LiDAR data for the Precinct was provided by DPHI. The LiDAR data was captured in July 2019 and has a 1m resolution with a vertical accuracy of +/-0.3m and a horizontal accuracy of +/-0.8m.

The coverage of the provided 2019 LiDAR does not include the westernmost portion of the Precinct. As such, equivalent LIDAR data dated May 2017 for this area was obtained from the Geoscience Australia Elevation Dataset (known as ELVIS).

This 2019 LiDAR data was used as the base Digital Elevation Model (DEM) in the TUFLOW hydraulic model for the Precinct.

2.4.2 Point Cloud

Point cloud data from July 2019 has also been provided by DPHI. This data has a vertical accuracy of +/-0.3m, horizontal accuracy of +/-0.8m and a minimum point density of 4 points per square metre.

Given the grid cell resolution of the new TUFLOW model is 3m, the point cloud data would not provide any substantial benefit over the 2019 LiDAR 1m DEM in defining the flood model terrain. However, the point cloud data also contains surface type classifications which assisted with surface roughness delineation.

2.5 Stormwater and Hydraulic Structure Data

2.5.1 Council GIS Data

Council's GIS stormwater network database was provided by DPHI. This database contains details of Council drainage lines in the study area including pit inlet types, pipe dimensions and invert levels. It should be noted that this database only includes dimensions of Council drainage networks in the western portion of the Precinct and does not include details of cross drainage culverts in the central and eastern portions of the Precinct. Dimensions of key structures in these areas were obtained from site measurements.

2.5.2 Transport for NSW Data

Details of key cross drainage structures along The Northern Road and the Western Motorway were obtained from Work as Executed drawings provided by Transport for NSW.

Details of longitudinal drainage networks were not provided.

2.6 Proposed Major Infrastructure Data/Reports

2.6.1 Sydney Metro – Western Sydney Airport

The *Sydney Metro – Western Sydney Airport State Significant Infrastructure Assessment* (DPE, 2021) was provided to the project team by DPHI, as well as GIS linework of the proposed metro alignment that traverses the Orchard Hills precinct (under construction at the time of this assessment). It is noted that none of the provided reports/data contain any concept or detailed design information for infrastructure associated with the Sydney Metro project. Of relevance to the flood assessment are design details of the proposed Blaxland Creek bridge/culvert crossing and 3D digital design surface information for above-ground features of the project.

3 Planning and Policy Review - Flooding

Within the Orchard Hills Precinct, development is presently controlled primarily through the Penrith Local Environmental Plan 2010 (PLEP 2010) and Penrith Development Control Plan (DCP) 2014. The LEP is an environmental planning instrument (EPI) which designates land uses and development in the study area, while the DCP regulates development in the relevant zones with specific guidelines and parameters.

The flood-related planning and policy review for the Orchard Hills Precinct Planning is structured as follows:

- **Section 3.1** outlines the purpose of the flood planning and policy review for the Orchard Hills Precinct planning.
- **Section 3.2** summarises the strategic context of the Orchard Hills Precinct within the Greater Sydney Region.
- **Section 3.3** summarises the flood related environmental planning instruments that currently apply to the land. Specifically, the PLEP (2010) and PDCP (2014).
- **Section 3.4** reviews the findings and recommendations of the NSW Flood Inquiry and details any potential implications related to the Precinct.
- **Section 3.6** outlines the Hawkesbury-Nepean Valley Flood Strategy and its relevance to the Precinct.

3.1 Purpose

The purpose of the planning and policy review is to:

- Summarise the existing flood-related planning provisions that apply to the Precinct;
- Assess the adequacy of the existing policy settings based on existing flood behaviour and the latest flood-related planning guidance;
- Review the findings of the NSW Flood Inquiry (August 2022) and summarise any implications related to the Orchard Hills Precinct Planning; and
- Determine what additional flood-related development controls may be warranted in a future precinct DCP.

This review does not specifically deal with matters related to building construction (such as the National Construction Code, which includes the Building Code of Australia, both of which are updated every three years by the Australian Building Codes Board). However, it is important to note that these types of controls are sometimes called or referenced in planning controls and therefore their content and direction are of relevance. In this regard, how they are applied is directed under the NSW Planning System via numerous mechanisms but primarily via Building System Circulars issued by the Department of Planning, Housing and Infrastructure. The most relevant circular is BS 13-004, dated 16 July 2013 entitled *The NSW Planning System and the Building Code of Australia 2013: Construction of Buildings in Flood Hazard Areas*. Importantly the BCA deals with the concept of the 'defined flood event' (DFE) and imposes minimum a construction standard across Australia for specified building classifications 'flood hazard areas' (FHA) up to the DFE. These requirements have been considered in the policy and planning approaches within the Precinct (**Section 7**).

3.2 Strategic Context

The principal strategic plans and frameworks relevant to the Orchard Hills Precinct are:

- A Metropolis of Three Cities – The Greater Sydney Region Plan - The Greater Sydney Region;
- Western City District Plan;
- Western Parkland City Draft Blueprint;
- Greater Penrith to Eastern Creek Strategic Framework (Framework); and
- The Cumberland Plain Conservation Plan (CPCP).

3.2.1 A Metropolis of Three Cities – The Greater Sydney Region Plan - The Greater Sydney Region

The plan seeks to manage growth and change across Greater Sydney and repositions Sydney as a metropolis of 3 cities:

- the Western Parkland City;
- the Central River City; and
- the Eastern Harbour City.

Orchard Hills is within the Western Parkland City and the Greater Penrith to Eastern Creek Investigation Area (GPEC).

3.2.2 Western City District Plan

The district plan sets out the planning priorities and actions for growth and development in the Western City District and identifies GPEC as an area for growth. It details the planned investment in the airport and transport infrastructure, the potential of the Western Economic Corridor and better linking Greater Penrith, Parramatta, Liverpool and Campbelltown.

The Plan includes 22 planning priorities. Of relevance to flooding are:

- Planning Priority W12 – Protecting and improving the health and enjoyment of the District's waterways
- Planning Priority W20 – Adapting to the impacts of urban and natural hazards and climate change.

The planning priorities are supported by 38 objectives. Key objectives relevant to flooding are:

- Objective 25 – The coast and waterways are protected and healthier.
- Objective 36 – People and places adapt to climate change and future shocks and stresses.
- Objective 37 – Exposure to natural and urban hazards is reduced.

The Western District Plan includes flood related planning principles when considering flooding in the Hawkesbury-Nepean Valley:

- avoiding intensification and new urban development on land below the current 1 in 100 chance per year flood event (1 per cent annual exceedance probability flood event)
- applying flood-related development controls on land between the 1 in 100 chance per year flood level and the PMF level
- providing for less intensive development or avoiding certain urban uses in areas of higher risk and allowing more intensive development in areas of lower flood risk, subject to an assessment of the cumulative impact of urban growth on regional evacuation road capacity and operational complexity of emergency management

- balancing desired development outcomes in strategic centres with appropriate flood risk management outcomes
- avoiding alterations to flood storage capacity of the floodplain and flood behaviour through filling and excavation ('cut and fill') or other earthworks
- applying more flood-compatible building techniques and subdivision design for greater resilience to flooding.

3.2.3 Western Parkland City Blueprint

The Western Parkland City Blueprint (2022) supports the district plan vision and sets out a long-term strategy for a green parkland city, that is physically, socially and culturally connected and economically advanced.

Orchard Hills will contribute to achieving these outcomes through the provision of new neighbourhoods defined by landscapes of green corridors, connected by a network of public open space with walking and cycling paths. It will also achieve it by delivering housing close to the adjoining centres of Penrith, Parramatta, Liverpool and Campbelltown.

The Blueprint includes visions with directions and priorities. The key vision relevant to flooding is:

- Delivering a Green City.

The key direction relevant to flooding is:

> *Strengthen resilience to climate change and natural hazards with a focus on floods, bushfires, severe storms and extreme heat and designing systems that are resilient to climate change, reduce the urban heat island effect and support decarbonisation.*

Within this direction, key priorities relevant to flooding are:

> *Priority G4*
>
> *Develop and finalise the Regional Land Use Planning Framework for the Hawkesbury-Nepean Valley*
>
> *Summary: DPHI is developing a Regional Land Use Planning Framework for the Hawkesbury-Nepean Valley floodplain. This framework will deliver greater consideration of flood risk and the careful management of population growth in the valley, to assist in improving the resilience of the valley to floods. SES is working closely with DPHI to finalise the framework.*
>
> *G10 Priority*
>
> *Plan and respond to climate change – including increased frequency and severity of bushfires, extreme heat, hot days, severe storms and flooding events.*

3.2.4 Greater Penrith to Eastern Creek Strategic Framework (Framework)

The strategic framework identifies areas within GPEC where there is capacity for new housing and urban renewal. Under the framework, Orchard Hills is identified as a priority urban release area due to its potential for a diversity of housing, with access to infrastructure, services and a new Orchard Hills metro station.

3.2.5 The Cumberland Plain Conservation Plan (CPCP)

The Cumberland Plain Conservation Plan (CPCP) is a strategic conservation plan for Western Sydney. It has been approved under the NSW *Biodiversity Conservation Act*, 2016 and applies in Orchard Hills. The

CPCP also was approved under the Commonwealth *Environmental Protection and Biodiversity Conservation Act (1999)* in March 2024. The CPCP removes the need for many landholders to seek the biodiversity approvals needed as part of the development process. It does this by identifying areas suitable for housing and areas that will continue to play an important role in maintaining the region's unique plants and animals.

3.3 Environmental Planning Instruments

3.3.1 Penrith Local Environment Plan 2010

The Penrith Local Environmental Plan 2010 (PLEP 2010) is a legal document that sets the direction for land use and development in the study area by providing controls and guidelines for development. It determines what can be built, where it can be built and what activities can occur on land.

The PLEP 2010 is based on a standard format used by all Councils in NSW and can be viewed on the NSW legislation website (www.legislation.nsw.gov.au).

The standard flood planning clauses are included in Section 5.21.

5.21 Flood planning

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

(a) to minimise the flood risk to life and property associated with the use of land,

(b) to allow development on land that is compatible with the flood function and behaviour on the land, taking into account projected changes as a result of climate change,

(c) to avoid adverse or cumulative impacts on flood behaviour and the environment,

(d) to enable the safe occupation and efficient evacuation of people in the event of a flood.

(2) Development consent must not be granted to development on land the consent authority considers to be within the flood planning area unless the consent authority is satisfied the development—

(a) is compatible with the flood function and behaviour on the land, and

(b) will not adversely affect flood behaviour in a way that results in detrimental increases in the potential flood affectation of other development or properties, and

(c) will not adversely affect the safe occupation and efficient evacuation of people or exceed the capacity of existing evacuation routes for the surrounding area in the event of a flood, and

(d) incorporates appropriate measures to manage risk to life in the event of a flood, and

(e) will not adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses.

(3) In deciding whether to grant development consent on land to which this clause applies, the consent authority must consider the following matters—

(a) the impact of the development on projected changes to flood behaviour as a result of climate change,

(b) the intended design and scale of buildings resulting from the development,

(c) whether the development incorporates measures to minimise the risk to life and ensure the safe evacuation of people in the event of a flood,

(d) the potential to modify, relocate or remove buildings resulting from development if the surrounding area is impacted by flooding or coastal erosion.

(4) A word or expression used in this clause has the same meaning as it has in the Considering Flooding in Land Use Planning Guideline unless it is otherwise defined in this clause.

(5) In this clause—

***Considering Flooding in Land Use Planning Guideline** means the Considering Flooding in Land Use Planning Guideline published on the Department's website on 14 July 2021.*

***flood planning area** has the same meaning as it has in the Floodplain Development Manual.*

***Floodplain Development Manual** means the Floodplain Development Manual(ISBN 0 7347 5476 0) published by the NSW Government in April 2005.*

In 2021, DPHI invited Councils in NSW to self-nominate to include the 'special flood considerations' clause within their LEPs. Penrith did not nominate to include the clause. In response to the NSW Flood Inquiry **(See Section 3.4),** DPHI sought feedback in early 2023 on applying the clause to all NSW councils, by inserting the clause in either:

- all NSW council LEPs; or
- the State Environment Planning Policy (Resilience and Hazards) 2021.

The special flood considerations are:

5.22 Special flood considerations

The changes will apply additional planning controls to land at risk of flooding. This will help reduce the extent of property damage and potential loss of life and build greater resilience into our communities.

The standard special flood considerations clauses are:

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

(a) to enable the safe occupation and evacuation of people subject to flooding,

(b) to ensure development on land is compatible with the land's flood behaviour in the event of a flood,

(c) to avoid adverse or cumulative impacts on flood behaviour,

(d) to protect the operational capacity of emergency response facilities and critical infrastructure during flood events,

(e) to avoid adverse effects of hazardous development on the environment during flood events.

(2) This clause applies to—

(a) for sensitive and hazardous development—land between the flood planning area and the probable maximum flood, and

(b) for development that is not sensitive and hazardous development—land the consent authority considers to be land that, in the event of a flood, may—

(i) cause a particular risk to life, and

(ii) require the evacuation of people or other safety considerations.

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

(a) will not affect the safe occupation and efficient evacuation of people in the event of a flood, and

(b) incorporates appropriate measures to manage risk to life in the event of a flood, and

(c) will not adversely affect the environment in the event of a flood.

(4) A word or expression used in this clause has the same meaning as it has in the Considering Flooding in Land Use Planning Guideline unless it is otherwise defined in this clause.

(5) In this clause—

***Considering Flooding in Land Use Planning Guideline**—see clause 5.21(5).*

***flood planning area**—see clause 5.21(5).*

***Floodplain Development Manual**—see clause 5.21(5).*

***probable maximum flood** has the same meaning as it has in the Floodplain Development Manual.*

***sensitive and hazardous development** means development for the following purposes—*

(a) [list land uses]

***Direction**— Only the following land uses are permitted to be included in the list—*

(a) boarding houses,

(b) caravan parks,

(c) correctional centres,

(d) early education and care facilities,

(e) eco-tourist facilities,

(f) educational establishments,

(g) emergency services facilities,

(h) group homes,

(i) hazardous industries,

(j) hazardous storage establishments,

(k) hospitals,

(l) hostels,

(m) information and education facilities,

(n) respite day care centres,

(o) seniors housing,

(p) sewerage systems,

(q) tourist and visitor accommodation,

(r) water supply systems.

3.3.1.1 Existing Zoning

Figure 3-1 shows the existing land zoning within the Orchard Hill Precinct as defined in the PLEP (2010). Much of the Precinct is zoned RU4 – Primary Production – Small Lots. This includes 'the Vines' area that includes some relatively small lots (for the existing zoning) of approximately 4,000m^2. In the south-east of the Precinct, there are some relatively large lots zoned RU2 – Rural Landscape. Land zoned RE1 – Public recreation is located along the east of the Precinct, around Wianamatta South Creek. The RE1 land is generally flood-affected. Land zoned C2 – Environmental Conservation is located along Wianamatta South Creek and Blaxland Creek in the east of the Precinct.

Figure 3-1 also shows the M4 motorway (running east-west) and Sydney Metro alignment (running south-north, in red). Within the Precinct, small pockets of land zoned SP2 – Infrastructure is for water supply and wastewater system infrastructure.

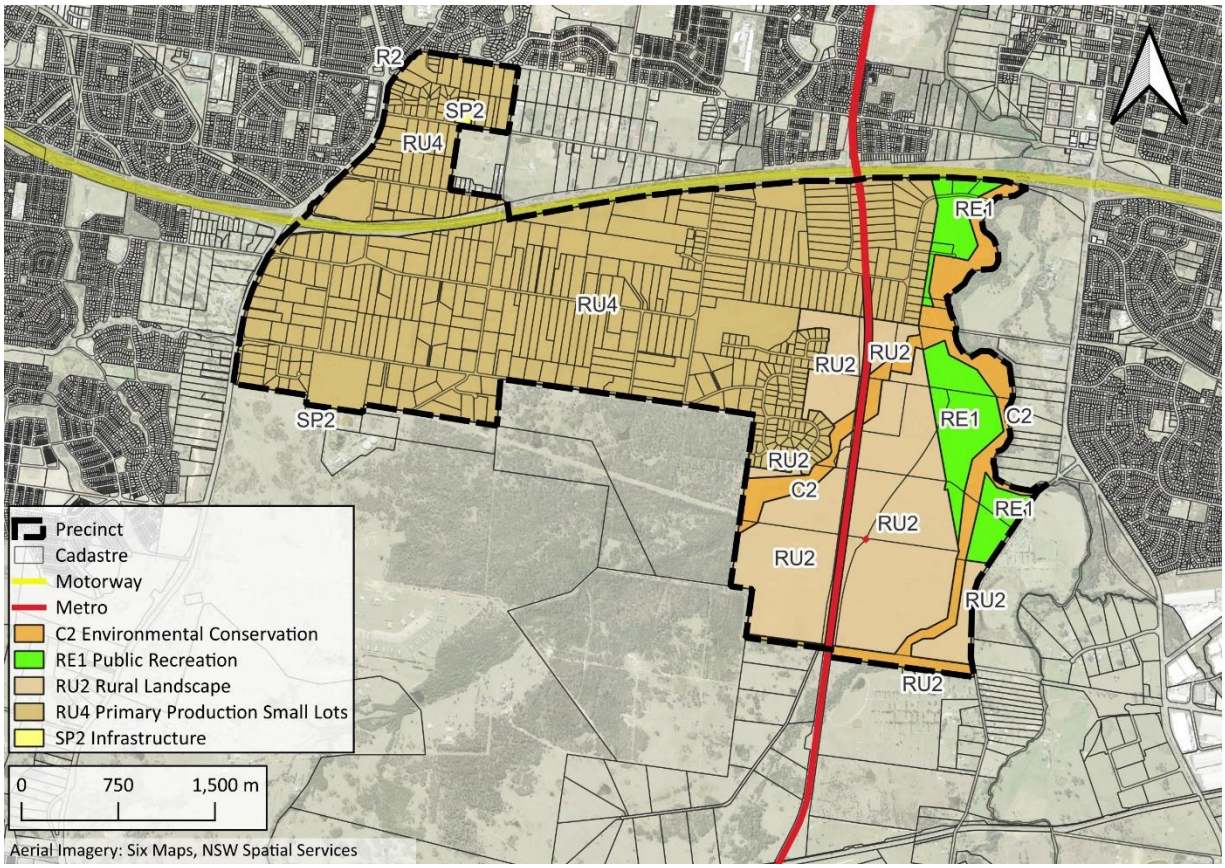

Figure 3-1 PLEP 2010 Land Zoning

3.3.1.2 Flood Mitigation Works

The PLEP (2010) permits flood mitigation works with consent in the following zones:

- RU2 Rural Landscape
- RU4
- C2 Environmental Conservation
- RE1.

Flood mitigation work *means work designed and constructed for the express purpose of mitigating flood impacts. It involves changing the characteristics of flood behaviour to alter the level, location, volume, speed or timing of flood waters to mitigate flood impacts. Types of works may include excavation, construction or enlargement of any fill, wall, or levee that will alter riverine flood behaviour, local overland flooding, or tidal action so as to mitigate flood impacts.*

It is noted that flood mitigation work may be carried out by or on behalf of a public authority without consent on any land under *State Environmental Planning Policy (Transport and Infrastructure) 2021*.

3.3.2 Penrith DCP

The Penrith Development Control Plan 2014 (PDCP 2014) has been prepared to support all planning instruments applying to the Penrith Local Government Area (LGA), including the PLEP 2010.

Part C provides city-wide controls. The primary objectives of Part C3 – Water Management are:

a) To adopt an integrated approach that takes into account all aspects of the water cycle in determining impacts and enhancing water resources;
b) To promote sustainable practices in relation to the use of water resources for human activities;
c) To minimise water consumption for human uses by using best practice site planning, design and water efficient appliances;
d) To address water resources in terms of the entire water catchment;
e) To protect water catchments and environmental systems from development pressures and potential pollution sources;
f) To protect and enhance natural watercourses, riparian corridors, wetlands and groundwater dependent ecosystems;
g) To protect, conserve and enhance surface and groundwater resources;
h) To integrate water management with stormwater, drainage and flood conveyance requirements; and
i) To utilise principles of Water Sensitive Urban Design in designing new developments or infill development in existing areas.

Part C Water Management of the PDCP (2010) provides further objectives, controls and performance criteria specific to the following categories:

- *The water cycle/water conservation;*
- *Catchment management and water quality;*
- *Watercourses, wetlands and riparian corridors;*
- *Groundwater;*
- *Flood planning;*
- *Stormwater management and drainage.*

- *Water retention basins/dams*
- *Rainwater / storage tanks.*

While each of these categories are interlinked, this assessment focuses on Flood planning as integrated water cycle management and riparian corridors are being considered by others.

3.3.2.1 Part 3C - 3.5 Flood Planning

The flood planning objectives are:

a) To ensure floodplain risk management minimises the potential impact of development and other activity upon the aesthetic, recreational and ecological value of the waterway corridors;

b) To maintain the existing flood regime and flow conveyance capacity and avoid significant adverse impacts on flood behaviour

c) To avoid significant adverse effects on the floodplain environment that would cause erosion, siltation, destruction of riparian vegetation or a reduction in the stability of the riverbank/watercourse;

d) To reduce the impact of flooding and flood liability on individual owners and occupiers;

e) To limit the potential risk to life and property resulting from flood events;

f) To contain the potential for flood losses in all new developed areas by the application of effective planning and development controls;

g) To apply a "merit approach" to all development and building decisions, which takes account of social, economic and ecological factors as well as flooding considerations;

h) To prevent the introduction of unsuitable land uses on land subject to the flood planning provisions of the LEP; and

i) To deal equitably and consistently (where possible) with applications for development on land affected by potential floods, in accordance with the principles contained in the Floodplain Development Manual, issued by the NSW Government.

Table 3-1 summarises the key flood-related clauses from the PDCP (2014) relevant to the Orchard Hills Precinct Planning.

Table 3-1 Flood-related Clauses from the PDCP (2014) Relevant to the Orchard Hills Precinct Planning

Clause	Relevance to Orchard Hills Precinct Planning
3.5.10 Subdivision Generally, subdivision of land below the flood planning level will not be supported.	The PDCP (2014) defines the Flood Planning Level as the 1% AEP plus 0.5 m freeboard. Future rezoning for residential and commercial land use should be above the flood planning level. The 2023 Flood Risk Management Manual promotes using a defined flood event (DFE) to set the flood planning level. The DFE should be defined through a merit and risk-based approach and include consideration of the effects of climate change.
3.5.14 Filling of Land at or Below the Flood Planning Level a) Council will not grant consent to filling of floodways or high hazard areas. The filling of other land at or below the flood planning level will generally not be supported; however, Council will adopt a merits-based approach. In particular, an application to fill land shall also describe the purpose for which the filling is to be undertaken. Council may consider such an application when the following criteria are met: i) Flood levels are not increased by more than 0.1m by the proposed filling; ii) Downstream velocities are not increased by more than 10% by the proposed filling; iii) Proposed filling does not redistribute flows by more than 15%; iv) The potential for cumulative effects of possible filling proposals in that area is minimal; v) There are alternative opportunities for flood storage; vi) The development potential of surrounding properties is not adversely affected by the filling proposal; vii) The flood liability of buildings on surrounding properties is not increased; viii) No local drainage flow/runoff problems are created by the filling; and ix) The filling does not occur within the drip line of existing trees.	Filling of all land below the flood planning level should be minimised. The Cumulative Impacts Assessment (Advisian, 2023) supports filling within flood fringe to create opportunities for development. Advisian (2023) recommends that encroachment or filling within the floodway and critical flood storages should not be permitted For precinct planning purposes, it has been assumed there is no net filling below the 1% AEP flood level for residential development.

Clause	Relevance to Orchard Hills Precinct Planning
b) The above criteria can only be addressed and satisfied by the submission of a detailed flood study report by an appropriate consulting engineer. The flood study report would involve both hydrologic and hydraulic analysis of the watercourse and the effects of the proposed filling on flood levels, flow velocities and distribution of flows as listed in i) to iii) above. In addition, the report needs to address items iv) to ix) listed above. Any filling of land also needs to be in accordance with the other provisions in this Plan.	
3.5.15 Rezoning of Land a) Council will not support the rezoning of any land located in a floodway or high hazard area. b) Council will generally not support the rezoning of rural land situated below the 1% AEP (100 year ARI) flood where the development of that land may require or permit the erection of buildings or works even if the surface of the land can be raised to a level above the 1% AEP (100 year ARI) flood by means of filling. c) Where land below the flood planning level is currently zoned to permit urban development, Council will generally not support the rezoning of land to permit a higher economic use or an increase in the density of development.	It is assumed that Clauses a and b do not apply to back-zoning RU2 and RU4 land within the flood planning area to more flood compatible zones such as: • C3 – Environmental Management • C2 – Environmental Conservation • RE1 – Public Recreation For precinct planning purposes, the effect of applying these clauses is that there should be no 'up-zoning' of land situated below the 1% AEP level inclusive of floodways and high hazard areas.
3.5.13 Overland Flow Council has undertaken a Penrith Overland Flow Flood 'Overview' Study. Consideration must be given to the impact on any overland flow path. Generally, Council will not support development obstructing overland flow paths. Development is required to demonstrate that any overland flow is maintained for the 1% AEP (100 year ARI) overland flow. A merit-based approach will be taken when assessing development applications that affect the overland flow. Council's Stormwater Drainage Specification for Building Developments provides information on the details required in the preparation of an overland flow study. The following key principles shall also be considered in the overland flow flood study: • All levels shown shall be to the Australian Height Datum (AHD)	Much of the site is affected by overland flow. Most overland flow paths are within land currently zoned RU4. Orchard Hills precinct planning seeks to make appropriate provisions for overland flow based on detailed assessment including consideration of flood function and flood impact. This may include, for example, aligning road networks with flow paths and provision of trunk drainage corridors. In some cases, it may also be appropriate to consider rezoning overland flow paths to a suitable flood-compatible zone such as: • C3 – Environmental Management; • C2 – Environmental Conservation; • RE1 – Public Recreation; or • SP2 – Infrastructure.

Clause	Relevance to Orchard Hills Precinct Planning
• The development shall not adversely impact on surrounding properties through the diversion, concentration or ponding of overland flows (i.e. the extent, velocity and the depth of overland flow shall remain unchanged); • The development shall not impede the passage of overland flow to cause a rise (afflux) in the water levels and / or increase velocities of flow on adjoining lands; • The development shall accommodate the passage of overland flow over the site and, where applicable, shall be designed to withstand damage due to scour, debris and buoyancy forces; • The development must not be sited where overland flows may result in a hazardous situation for future occupants in terms of depth and velocity of overland flows through the property (i.e. velocity-depth product greater than 0.4 is not acceptable); • Overland flows shall be directed through common areas and not through private courtyards or on-site detention systems; • The overland flow path must not be obstructed by landscaping, kerbing, retaining walls, fencing or the like; • No structures and / or filling are permitted within the overland flow path unless suitable flood mitigation measures approved by Council are to be implemented; • Any fencing (including boundary fencing) over the extent of the overland flow path must be replaced with open style fencing or similar to allow the free passage of overland flows; • Design elements such as concrete or paving shall be used to fix critical levels in overland flow paths to minimise interference by future occupiers; and • Provision of adequate freeboard to finished floor levels in accordance with Section 3.1.2 of the policy. Where considered necessary, Council may impose conditions of consent on a proposed development to protect overland flow paths. A Restriction on the Use of Land and Positive Covenant may also be required to protect overland flow paths. The standard terms of Restriction on the Use of Land and Positive Covenant are available in Appendix F of the DCP.	Design Flow (2024) details the first order watercourses that are proposed to be decommissioned following the rezoning. Where first order watercourses are rezoned, land may be suitable for residential rezoning or SP2 zoning for overland flow conveyance.

3.4 NSW Flood Inquiry

Following the major flood disasters in 2022, the NSW Government established an independent flood inquiry to investigate the causes, planning, preparedness, response and recovery from the 2022 catastrophic flood events. As a result of the findings, the inquiry provided 28 recommendations to improve emergency management arrangements, land management and planning, equipment and technology, capacity and capability building and research. The findings of the NSW Flood Inquiry were released in July, 2022[1]. The NSW Government supported 6 recommendations and supported in Principle 22 recommendations.

The recommendations from the Inquiry are that there is the potential for changes to practices and policies related to:

- Land use, planning and zoning within floodplains;
- The determination of appropriate Flood Planning Levels (FPLs), particularly for locations with a high flood risk;
- Flood warning; and
- Flood evacuation.

While the Inquiry outcomes are still being pursued in policy settings, there is a need to apply a risk-based approach to determining flood planning levels, managing evacuation and ensuring the future rezoning and land-uses align with the flood risk.

Key general findings relevant to Orchard Hills are:

- There is clear evidence of rain intensifying at daily and sub-daily scales;
- The intensity of short duration, or hourly, extreme rainfall events has increased;
- As the climate warms, heavy rainfall events are expected to continue to become more intense, with subsequent implications for flash flooding; and
- New buildings must be out of harm's way and made more resilient to the impacts of floods and other extreme weather events.

The findings and recommendations of the NSW Flood Inquiry are interlinked and their relevance to the Orchard Hills Precinct vary. Key recommendations relevant to the Precinct planning are:

- **Recommendation 18:** Risk-based approach to calculating flood planning level
- **Recommendation 20:** Treat floodplains as assets
- **Recommendation 21:** Simplify the planning system disaster provisions
- **Recommendation 28:** Essential services and floodplain infrastructure.

The findings, recommendations and relevance to the Orchard Hills Stage 1 ILP are summarised in **Table 3-2.**

[1] https://www.nsw.gov.au/sites/default/files/noindex/2022-08/VOLUME_ONE_Summary.pdf, accessed 15 February 2023.

Table 3-2 NSW Flood Inquiry - Findings, Recommendations and Relevance to the Orchard Hills Precinct Planning

Finding	Recommendation	Relevance to Orchard Hills Stage 1 ILP
Finding O. risk based approach to calculating flood planning level Using the 1% AEP for calculation of the flood planning level for planning purposes in NSW is not adequate, especially in the light of changing rainfall patterns including the intensification of intraday rainfall, with the consequent risk of greater flash flooding. To understand risk, especially for major flooding events, knowledge of floods at a catchment wide scale is needed. Councils are generally not adequately resourced or organised to manage either whole of catchment models or high quality, risk based flood planning level estimations. Responsibility for this matter needs to return to the State Government. Redetermining flood planning levels will be relatively straightforward in some cases with the result remaining close to the 1% AEP but will need substantial adjustment in others depending on local rainfall intensities, catchment shape and other risk factors. Intensities, catchment shape and other risk factors.	**18. Recommendation – risk-based approach to calculating flood planning level** That, to take account of greater knowledge of climate change, Government account of greater knowledge of climate change, Government reinforce its adoption of a risk risk-based approach to calculating the flood planning level for planning purposes and, through the NSWRA, immediately start a process of revising all flood planning level calculations in the state's high-risk catchments. Flood planning level re-determinations for all high high-risk catchments should be completed within 3 years. These revised flood planning levels will need to be factored into all development applications (in in-progress and new) in those high high-risk catchments. The risk profile of high-risk catchments should be revisited at appropriate time intervals to check that levels are current. A review should take place if there has been a significant trigger event (i .e. changed rainfall, development) or at least every 5 years. As well as reviewing the flood planning level, this 5-yearly review should include reviewing any floodplain lease conditions and adjusting them as necessary in the light of better knowledge of climate change impacts. In working out a tolerable risk-based flood planning level, consideration should be given to the PMF, 1% AEP, 0.02% AEP for existing development, approved but not yet constructed developments, and existing and approved but not yet constructed evacuation routes.	In NSW, there is a risk-based approach to determining flood planning levels. The Flood Risk Management Manual (2023) promotes a merit-based approach to flood risk management and the setting of flood planning levels. A number of flood risk management guidelines were released with the Flood Risk Management Manual (2023). The Understanding and Managing Flood Risk FB01 sets out the process for setting flood planning levels (FPLs) based on a Defined Flood Event (DFE). Different FPLs may apply in different areas as the DFE and freeboard selected for an area may be different due to the varying flood behaviour (e.g. shallow flooding from local overland flooding rather than deep flooding from waterways) and risks. Some key considerations when selecting a DFE are: • Climate change • Floor function and hazard • Evacuation and Isolation • Flood function and hazard in rarer events. In March 2024, the Department of Planning, Housing and Infrastructure released the Planning Circular PS 24-001 - Update on addressing flood risk in planning decisions. This circular supplements PS 21-006 Considering flooding in land use planning: guidance and statutory requirements. The circular outlines existing flood-related planning policies and provides further information and advice on their application in planning. The circular also provides updates on flood-related policy initiatives underway, including action taken in response to the 2022 NSW Flood Inquiry. The circular recommends that a planning proposal should consider the flood risk profile of the application. Considerations include: • whether the proposal is in a high-risk catchment

Finding	Recommendation	Relevance to Orchard Hills Stage 1 ILP

		• the location of the proposal in relation to flood behaviour and constraints including:
		  ○ floodway, flood storage area or flood fringe area
		  ○ the hazard vulnerability classification of the land
		  ○ frequency of inundation
		• whether the proposal provides for safe occupation and efficient and effective evacuation in flood events and how it is to be achieved
		• any known evacuation constraints such as the flood emergency response classification for the area and available warning times (including rate of rise and when the evacuation route is cut by floodwater)
		• whether the proposal is for a sensitive or hazardous land use, or other higher risk uses and what controls (if any) are proposed to reduce any identified risks
		• whether there may be adverse flooding impacts on surrounding properties
		• potential impacts of cut and fill and other building works on flood behaviour
		• ability of proposed development to withstand flood impacts.
		
		The full range of flood events and the potential impacts of climate change will need to be considered when setting the flood planning level for the Precinct.
		
		A robust and defendable approach could be achieved using the 'defined flood event' (DFE) concept.
		
		Sensitive land uses within the ILP such as early education and care facilities, educational establishments and seniors housing would need to be located above the PMF. The full list of hazardous uses are provided in **Section 3.3.1**.
		
		The precinct also needs to allow safe evacuation of the floodplain for areas impacted by long duration flooding. Shelter in place should be considered only for areas affected by flash flooding.

Finding	Recommendation	Relevance to Orchard Hills Stage 1 ILP
		The approach outlined above does not prohibit development below the FPL, rather it encourages development that is compatible with the flood risk applying appropriate flood related controls.
Q – Flooding Floodplain as asset At the moment, there is no coherent or principled approach to proactive, appropriate development of NSW floodplains. Practice to this point has created tensions between the urgent need for more housing and keeping people safe. There is pressure on developers to provide housing, and there is pressure on consent authorities to approve the development, whilst ensuring it is safe and appropriate to do so. Climate change, though not yet fully understood, is increasing this tension. The tension particularly affects those who can't afford to live in suburbs out of the floodplain.	**20. Floodplain as assets** That, to establish the capacity and maximise the economic, social and environmental potential and consequently unlock the value of NSW floodplains, Government adopt the following guiding principles for floodplain management: • treat floodplains as an asset, specialising in uses that are productive and minimise risk to life during major weather events. Such uses would include sporting and recreational activities, garden plots and community gardens, agriculture and forestry, renewable energy production, biodiversity offsets, parks and outdoor education activities. Government should progressively move floodplain ownership to Government leasehold with lessees using the land under appropriately specified conditions. The management of the process of conversion to leasehold would be a Special Project of the NSWRA but over time handing the floodplain asset over to management by another government agency. The NSRWA should prioritise rapid conversion to leasehold in cases where houses and business businesses are in high high-risk areas – this may be accomplished by land swaps or buy backs. In doing so Government achieves early wins for new uses. In other cases, the conversion should occur as a condition of development, of a type that is consistent with safe evacuation or safety in place in the case of flash flooding that recedes rapidly	Rezoning within the floodplain should consider flood compatible uses such as sports fields, community gardens, parks and passive recreation. Appropriate zoning below the flood planning level may include: • RE1 – Public Recreation • C2 – Environmental Conservation • C3 – Environmental Management. It may be appropriate to rezone land between the flood planning level and PMF for residential use where flood risk can be managed in the built form e.g.; • R2 Low Density Residential, • R3 Medium Density Residential • R4 High Density Residential Similarly, "E or MU" zoned land may be appropriate on land located between the flood planning level and PMF where risks associated with flooding can be managed in the built form.

Finding	Recommendation	Relevance to Orchard Hills Stage 1 ILP
	• treat development of the floodplain in parallel with development of urban structures (houses, business businesses and industry) that are built near to the edge of the floodplain. Examples of connection could include high-rise housing developments where apartment owners are granted automatic rights and access to community garden and community recreation facilities. Structures within the floodplain and surrounding development should be connected by a layer of sustainable transport • favour letting watercourses largely flow naturally rather than implementing engineering barriers such as flood levees and mitigation schemes to stop floods.	
R. Finding - simplify the planning system disaster provisions • The new disaster adaptation plans and risk based approaches to calculating flood planning levels will need to have a clear connection to the development assessment and infrastructure delivery process. It will be critical for new controls to create more resilient buildings to be enforced through development decisions, just as decisions to retreat from high risk areas require support through public space and other infrastructure funding. Achieving these outcomes needs a clear line of sight between policy imperatives for disaster	That, to simplify and improve the state planning processes especially when anticipating and recovering from a disaster, Government: • ensure there is a clear line of sight directing councils and planning authorities to include disaster response and resilient settlement outcomes in long term strategic plans (Regional and District Plans as well as Local Strategic Planning Statements). This may require more prominence to be given to Planning for a more resilient NSW: A strategic guide to planning for natural hazards (Department of Planning, Industry and the Environment) as well as a clear link to the risk-based approach to hazard identification and the disaster adaptation plans • ensure the NSWRA provides the necessary tools and advice to enable planning authorities to incorporate cumulative impacts of potential	Any proposed changes will need to be considered at exhibition stage. Any tools will need to be considered when released.

Finding	Recommendation	Relevance to Orchard Hills Stage 1 ILP
avoidance and adoption, the strategic plans that shape settlement decisions, and the operational decisions (like development assessment and spending) that achieve these outcomes. With multiple inputs to the preparation of local planning controls, the line of sight necessary to ensure effective adaptation and resilience to disasters can be obscured. Shifting the responsibility for flood risk management planning to the proposed NSWRA also raises the question of where the development controls for flooding should sit along with the policies that support the inclusion of disaster adaptation plans into strategic planning. • The division of the planning system into two parts strategic and development control and its operation across two levels of government makes it at times challenging in relation to addressing flooding (and natural disasters more generally).	natural disasters into strategic plans. These tools should ensure the disaster adaptation plans can be given real effect in strategic plans for settlement and local planning controls • ensure that Ministerial Directions on hazard and natural disasters (directions 4.1 and 4.6 inclusive) are updated to reflect the new risk-based approach to flood planning levels and deliver the disaster adaptation plans to the zoning process • create specific flood planning provisions as a new chapter in the SEPP (Resilience and Hazards). These provisions would draw the existing flood planning clauses (5.21 and 5.22 in the standard instrument) up into the SEPP • put the natural disaster clause (5.9 in the standard instrument) into a new chapter in the SEPP Resilience and Hazards, along with objectives to assist councils to use the clause to build back to more resilient standard • update planning guidance so that wherever possible community facilities, such as might be used for evacuation centres, are located above the probable maximum flood and essential services are located above the flood planning level • ensure that the strategic land use frameworks and related controls permit new developments only in line with the evacuation capacity both individually and cumulatively • ensure that the strategic land use frameworks enable higher density flood resilient precincts to locate more development at or above the PMF and use a higher flood planning level to avoid catastrophic costs from extreme	Future SEPP provisions will need to be considered when exhibited. Any updates to the Ministerial Directions will need to be considered. Any possible SEPP provisions will need to be considered when exhibited. The Flood planning clauses are being considered including 5.22 – special flood considerations. Any possible SEPP provisions will need to be considered when exhibited. Future guidance will need to be considered when exhibited. At Precinct planning stage, ensuing schools are located above the PMF is a sensible starting point. Any guidance may inform the future Precinct DCP. Emergency response strategies have been considered as part of this assessment **(Section 8).** Higher density precincts should be located above the PMF where possible.

Finding	Recommendation	Relevance to Orchard Hills Stage 1 ILP
	flooding, as well as deliver cost effective controls for individual structures.	
W. Finding – essential services and floodplain infrastructure • Essential services disruption in the floods was exacerbated by critical infrastructure being situated in low-lying areas and consequently being flooded. • Many hospitals, medical centres, nursing homes, aged care facilities and police stations are situated below the flood planning level. Several of these were affected in the recent floods. • Some detrimental impacts of floods come from built structures which are supposed to provide flood mitigation not being maintained and consequently malfunctioning after heavy rain, making floods worse at a local level. Many are the responsibility of several agencies and are maintained by none.	**28. Recommendation – essential services and floodplain infrastructure** That, to minimise disruption to essential services (power, communications, water, sewerage) and to ensure flood infrastructure is fully serviceable before flooding, Government ensure: • essential services infrastructure (communications, water, power and sewerage) is situated as much as possible above the flood planning level. And to minimise disruption to medical services, aged care aged care services and the police, Government ensure hospitals, medical centres, nursing homes, aged care facilities and police stations are situated above the probable maximum flood level. • floodplain infrastructure (drains, levees, flood gates) items are all assigned to an appropriate lead agency which has responsibility for ensuring they are fully maintained and functioning especially when floods are likely.	Essential infrastructure and services should be designed and constructed to be serviceable in the full range of floods up to the PMF.

3.5 Local Planning Directions

The Minister for Planning can issue Ministerial Directions to planning authorities about the preparation of planning schemes and amendments to planning schemes.

Planning authorities must comply with the Ministerial Direction on the Form and Content of Planning Schemes, issued under Section 9.1(2) of the *Environmental Planning and Assessment Act 1979*. The direction applies to planning scheme layout and required information - including amendments to those planning schemes - and should be read together with the Planning Provisions.

On 1 March 2022, revised Local Planning Directions were issued relating to, in part, flood resilience and hazard. The Directions (Direction 4.1 Flooding) were issued to commence 1 March 2022 (replacing previous Direction 4.3).

The objectives of this direction are to:

(a) Ensure that development of flood prone land is consistent with the NSW Government's Flood Prone Land Policy and the principles of the Floodplain Development Manual 2005, and

(b) Ensure that the provisions of an LEP that apply to flood prone land are commensurate with flood behaviour and includes consideration of the potential flood impacts both on and off the subject land.

Of relevance to the Orchard Hills Precinct, the Directions stated under Direction 4.1(3) and 4.1(4)

Direction 4.1(3) states that:

A planning proposal must not contain provisions that apply to the flood planning area which:

(a) permit development in floodway areas,

(b) permit development that will result in significant flood impacts to other properties,

(c) permit development for the purposes of residential accommodation in high hazard areas,

(d) permit a significant increase in the development and/or dwelling density of that land,

(e) permit development for the purpose of centre-based childcare facilities, hostels, boarding houses, group homes, hospitals, residential care facilities, respite day care centres and seniors housing in areas where the occupants of the development cannot effectively evacuate,

(f) permit development to be carried out without development consent except for the purposes of exempt development or agriculture. Dams, drainage canals, levees, still require development consent,

(g) are likely to result in a significantly increased requirement for government spending on emergency management services, flood mitigation and emergency response measures, which can include but are not limited to the provision of road infrastructure, flood mitigation infrastructure and utilities, or

(h) permit hazardous industries or hazardous storage establishments where hazardous materials cannot be effectively contained during the occurrence of a flood event.

Direction 4.1(4) states that:

A planning proposal must not contain provisions that apply to areas between the flood planning area and probable maximum flood to which Special Flood Considerations apply which:

(i) permit development in floodway areas,

(j) permit development that will result in significant flood impacts to other properties,

(k) permit a significant increase in the dwelling density of that land,

(l) permit the development of centre-based childcare facilities, hostels, boarding houses, group homes, hospitals, residential care facilities, respite day care centres and seniors housing in areas where the occupants of the development cannot effectively evacuate,

(m) are likely to affect the safe occupation of and efficient evacuation of the lot, or

(n) are likely to result in a significantly increased requirement for government spending on emergency management services, and flood mitigation and emergency response measures, which can include but not limited to road infrastructure, flood mitigation infrastructure and utilities.

3.6 Hawkesbury-Nepean Valley Flood Strategy

The Hawkesbury-Nepean Valley covers around 500 square kilometres from Bents Basin, near Wallacia, to the ocean at Pittwater. Floods in the Hawkesbury-Nepean Valley pose a significant flood risk due to the valley's unique landscape and the size of its population. There is no simple solution to managing or reducing the valley's existing high flood risk.

The NSW Government is delivering *Resilient Valley, Resilient Communities – Hawkesbury-Nepean Valley Flood Risk Management Strategy* (Flood Strategy). The Flood Strategy is being led by the NSW Reconstruction Authority (formerly Infrastructure NSW, INSW) together with local councils, businesses, and the community (INSW, 2017). Managing existing and future flood risk in the Hawkesbury-Nepean Valley requires an integrated approach to infrastructure, land use and emergency management planning.

Future decisions on flooding policy, including building in the Hawkesbury-Nepean, will be guided by the recommendations of the NSW Flood Inquiry (2022) (**Section 3.4**).

Any necessary evacuation from the Orchard Hills precinct in times of flood will need to consider the evacuation needs of wider Hawkesbury-Nepean valley, particularly the use of the M4 and the Northern Road that form part of the wider Hawkesbury-Nepean Flood evacuation routes.

Ideally, all development within the Orchard Hills Precinct will be set outside of the floodplain associated with the Hawkesbury Nepean (or above the flood level) to avoid the risk of long duration inundation and to avoid placing additional evacuation traffic on the regional road network.

4 Baseline Flood Behaviour

The following section describes the hydrologic and hydraulic modelling that was used to inform the Stage 1 ILP and assess any potential adverse flooding impacts of future development.

4.1 Hydrologic Modelling

4.1.1 Model Development

The XP-RAFTS model from the *Wianamatta South Creek Catchment Flood Study – Existing Conditions* (Advisian, 2022) was used as a basis for hydrologic modelling undertaken as part of the subject assessment. Model assumptions and inputs were left largely un-altered from the Advisian (2022) model; however, a number of refinements were required to make the model suitable for assessing flows along the Precinct's watercourses and overland flow paths. Key updates to the model included:

- Refinement of the sub-catchment delineation to provide a higher sub-catchment resolution across the Stage 1 ILP and wider Orchard Hills Precinct. The Precinct sub-catchment delineation from the *Integrated Water Cycle Management Strategy* (Design Flow, 2024) was adopted in the regional hydrologic model to maximise the consistency between the two studies. The sub-catchment delineation used in the updated XP-RAFTS model is shown in **Figure 4-1**.
- Sub-catchment percentage impervious and slope values were updated to suit the refined delineation, with adopted parameters remaining consistent with the Integrated Water Cycle Management Strategy (Design Flow, 2024).
- Alternate initial and continuing loss values were adopted for the sub-catchments draining to Claremont Creek and west towards the Nepean River to remain consistent with parameters adopted in the more localised modelling undertaken as part of the *Water Cycle Management Strategy* (Design Flow, 2024) and *Stormwater and Flood Management Strategy – Orchard Hills North Precinct* (J. Wyndham Prince, 2023). The following loss values were adopted for these for these catchments:
    - Initial loss = 15 mm
    - Continuing loss = 2.5 mm/hour

The *Wianamatta South Creek Catchment Flood Study – Existing Conditions* (Advisian, 2022) notes that design event flows derived using ARR1987 hydrologic modelling inputs are better aligned with local gauge data than those produced using more contemporary ARR2019 procedures. As such, the ARR1987 rainfall depths and temporal patterns from the *Wianamatta South Creek Catchment Flood Study – Existing Conditions* (Advisian, 2022) were retained in updated hydrologic modelling.

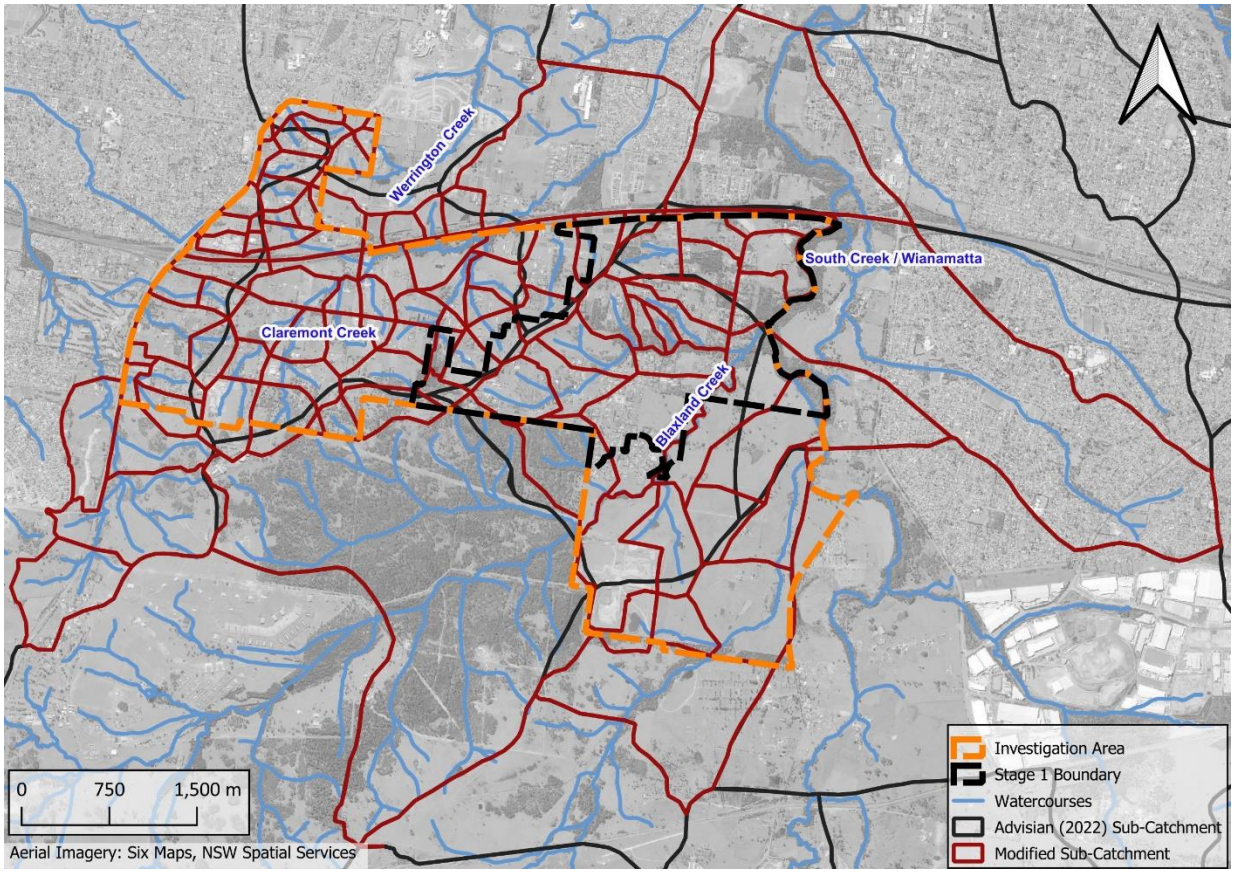

Figure 4-1 Sub-Catchment Delineation

4.1.2 Probable Maximum Flood Estimation

Given the significant difference in catchment area and critical duration of the local Precinct catchments compared to the Wianamatta-South Creek catchment, a local catchment PMF model was established using the Generalised Short Duration Method (BoM, 2003) with PMP ellipses centred over the study area. This was used in conjunction with the regional Wianamatta-South Creek model to generate critical PMF flows across the study area. It should be noted that regional PMF model was used to generate Blaxland Creek flows, consistent with the *Wianamatta South Creek Catchment Flood Study – Existing Conditions* (Advisian, 2022), and thus the critical duration PMF flows are not captured along the full length of this watercourse. This approach should be refined for future stages, particularly to the south of The Vines estate. The critical duration for the PMF has been modelled for all watercourses within the Stage 1 Boundary.

PMP depths for the local catchment model are shown in **Table 4-1**.

Table 4-1 PMP Rainfall Depths

Duration	Depth (mm)
15 min	140
30 min	210
60 min	270
90 min	310

Duration	Depth (mm)
120 min	400
150 min	520
180 min	570

4.1.3 Design Storm Hydrographs

The XP-RAFTS model was used to generate inflows into the TUFLOW hydraulic model (refer **Section 4.2**) for the 0.5 Exceedance per Year (EY), 20%, 1%, 0.5% and 0.2% AEP events and the PMF event. A range of durations from 30 minutes to 36 hours were assessed in the updated XP-RAFTS model to determine the critical durations across both minor and major site watercourses.

4.2 Hydraulic Modelling

4.2.1 Model Development

A 1D/2D TUFLOW model was developed to evaluate flood behaviour across the study area. The model input data and assumptions are summarised in **Table 4-2.** Features of the model setup are shown in **Figure 4-2.**

Table 4-2 Hydraulic Model Input Data

Parameter	Data Source/Assumptions
Model Area	The hydraulic model domain covers the entirety of the Precinct as well as the section of Wianamatta-South Creek floodplain from the Warragamba pipeline (approximately 3 km upstream of the Precinct) to the Great Western Highway (approximately 1.8 km downstream of the Precinct).
Digital Elevation Model (DEM)	The base case model DEM is generally comprised of: • 2019 1m LiDAR data over the majority of the study area. • 2017 1m LiDAR data for the westernmost potion of the Precinct, outside of the Stage 1 rezoning area. Refer to **Section 2.4.1** for further details of the LiDAR data used in the hydraulic model. One of the important components in the development of hydraulic models is to ensure that key hydraulic controls and flow paths are defined appropriately within the DEM. This includes features such as road crests and channel inverts. These have been incorporated where appropriate through the use of breaklines. Portions of Wianamatta-South Creek where the presence of permanent water is apparent in the LiDAR data have been lowered by 0.5m to approximate the invert levels.
Grid Cell Resolution	A 3m x 3m grid was adopted over the hydraulic model extent. This was deemed sufficient to adequately define the hydraulic behaviour around both major and minor site watercourses whilst maintaining reasonable model run times. TUFLOW's sub-grid sampling (SGS) feature was applied at a resolution of 1m x 1m to improve the terrain representation.
Roughness	Surface roughness delineation for the existing scenario model was based on point cloud classifications (refer **Section 2.4.2)** with manual adjustments made where considered necessary (such as road reserves and urban blocks). The Manning's 'n' values adopted were informed by the typical ranges from Table 6.2.1 and 6.2.2 of ARR2019 and were: • Open Space 0.030 • Light Vegetation 0.045 • Medium Vegetation 0.060

Parameter	Data Source/Assumptions
	• Dense Vegetation 0.100 • Urban 0.060 • Buildings 0.500 • Open Water 0.020 • Road reserve/Pavement 0.020 • Sydney Metro 0.050
Hydraulic Structures	Cross drainage culverts have been included as 1D elements nested in the 2D domain. Dimensions of the majority of these culverts were obtained via site measurements, with some cross drainage details sourced from TfNSW GIS data and work as executed drawings. Council pit and pipe stormwater networks in the western portion of the Precinct were also incorporated into the model and based on Council's GIS stormwater network data. A risk-based approach has been taken for culvert blockage in accordance with Book 6, Chapter 6 of ARR2019. Blockage has been applied using a matrix approach which assigns varying blockage factors based on the structure opening width and Annual Exceedance Probability (AEP). A medium debris potential has been adopted due to the presence of vegetation in close vicinity to the watercourses, but relatively flat to moderate bed slopes. Adopted blockage factors are shown in **Table 4-3**. Bridges across Wianamatta-South Creek were modelled as 2D layered flow constrictions with blockage and form loss values estimated based on site observations. It should be noted that no bridge details for the Great Western Highway crossing were provided and thus parameters were assumed based on LiDAR data, aerial imagery and Street View observations. This crossing is located a sufficient distance downstream such that minor changes to the parameters would not have a significant impact on Precinct flood levels.
Inflows	Inflows were applied to the hydraulic model via a combination of the following: • Inflows located on the upstream boundary of Wianamatta-South Creek, Blaxland Creek and major tributaries originating upstream of the Precinct, • Standard source-area (SA) polygons whereby flows are applied to the lowest cell within the polygon, and • SA polygons with streamlines to distribute inflows along the centreline of key watercourses and overland flow paths. Given the significant difference in critical duration of the Wianamatta-South Creek catchment (36 hours) and local Precinct sub-catchments (30 minutes to 9 hours), the joint occurrence of regional and local catchment flooding needs to be considered. Given the long duration of the critical Wianamatta-South Creek (regional) event, a constant flow was assumed to occur in the river at the same time as the tributary peak flood events for the 30 minute to 9 hour durations. The assumed joint occurrence is shown in **Table 4-4**.
Downstream Boundaries	Stage-discharge boundary was applied to the downstream extent of the model. These boundaries are located a sufficient distance downstream of the site such that minor variations in downstream water levels do not impact site flood behaviour.

Table 4-3 Culvert Blockage Factors

Clear Opening Width (m)	AEP Adjusted Debris Potential at Structure		
	High (AEP<0.2%)	Medium (5% AEP to 0.2% AEP)	Low (>5% AEP)
W < 1.5m	100%	50%	25%
1.5m < W < 4.5m	20%	10%	0%
W > 4.5m	10%	0%	0%

Table 4-4 Assumed Joint Occurrence – Local Catchment and Regional Flows

Tributary Event	Regional Event Flow	
	Regional Event	Flow (m^3/s)
0.5 EY	1 EY	224
20% AEP	0.5 EY	370
1% AEP – 0.2% AEP	5% AEP	821
PMF	1% AEP	1,079

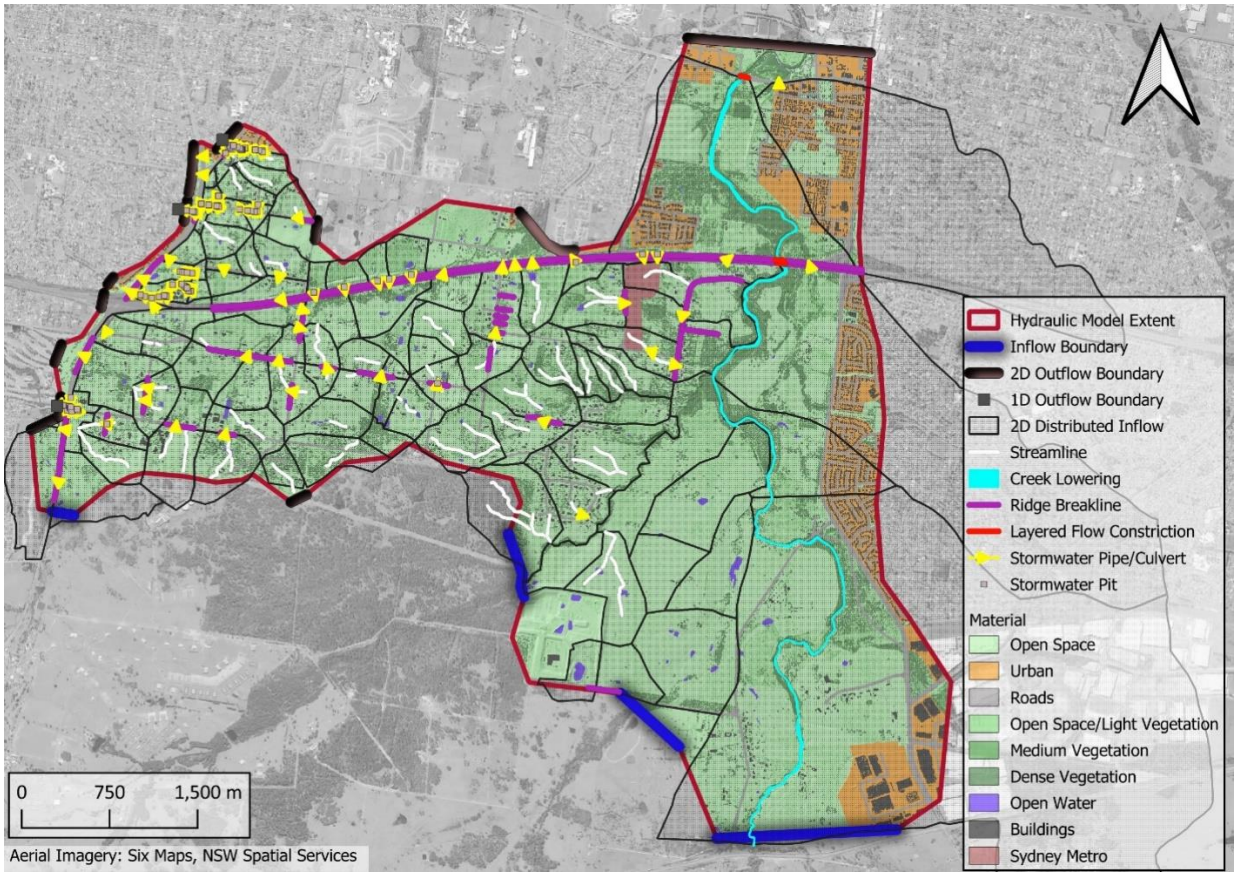

Figure 4-2 TUFLOW Model Setup – Existing Scenario

4.2.2 Hydraulic Model Results

The existing scenario TUFLOW model was run for the 0.5 EY, 20%, 1%, 0.5% and 0.2% AEP events and the PMF event. Existing scenario flood maps have been attached in **Appendix A** of this report. The maps represent an envelope of the different critical durations across the Precinct.

4.2.2.1 Peak Depth and Velocity

Peak depths and elevations are shown in maps **RG-01-001** to **RG-01-006**. The 0.2% AEP is proposed as the defined flood event (DFE) for Precinct flood planning considerations (refer **Section 7.1**).

Results for the 0.2% AEP (DFE) and PMF events are also shown in **Figure 4-3** and **Figure 4-4** below.

Peak velocities are shown in maps **RG-01-010** to **RG-01-015**.

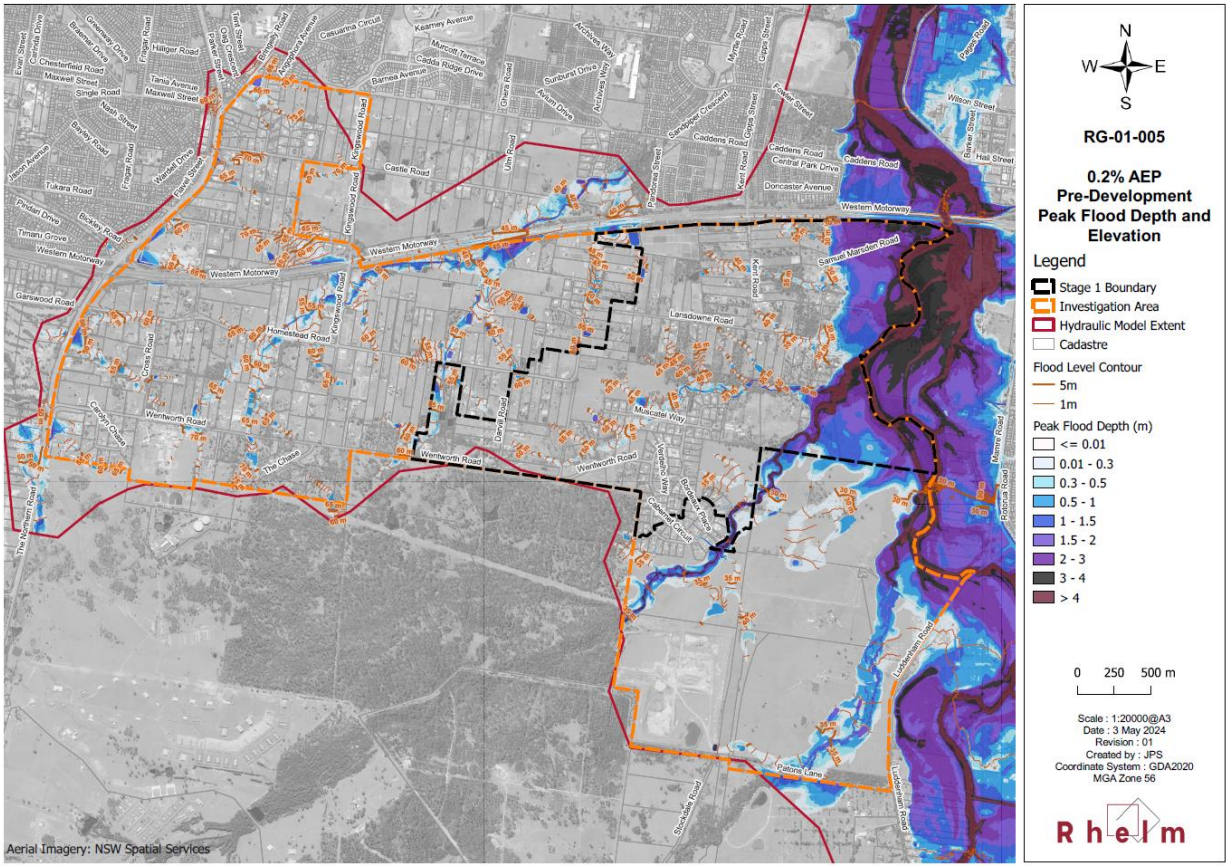

Figure 4-3 0.2% AEP Flood Depth and Elevation – Existing Scenario

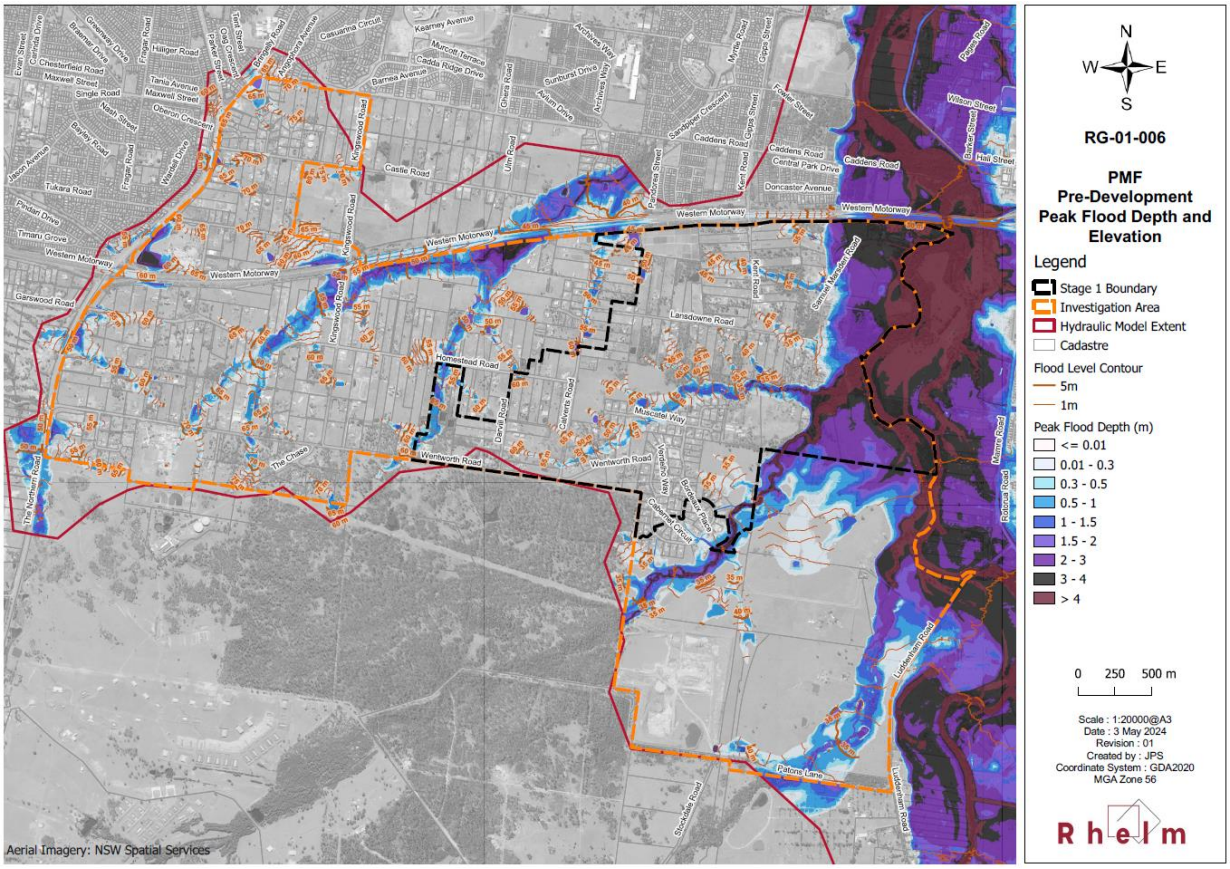

Figure 4-4 PMF Depth and Elevation – Existing Scenario

4.2.2.2 Flood Hazard

Flood hazard (a function of flood depth and velocity) varies with flood severity (i.e., for the same location, the rarer the flood the more severe the hazard) and location within the floodplain for the same flood event. This varies with both flood behaviour and the interaction of the flood with the topography.

It is important to understand the varying degree of hazard and the drivers for the hazard, as these may require different management approaches. Flood hazard maps can inform emergency and flood risk management for existing communities, and strategic and development scale planning for future areas.

The hazard categories mapped are summarised in **Figure 4-5**. These are based on the categories as defined in the AIDR (2017) Guideline.

Flood hazard mapping for the design events is shown in maps **RG-01-020 to RG-01-025**.

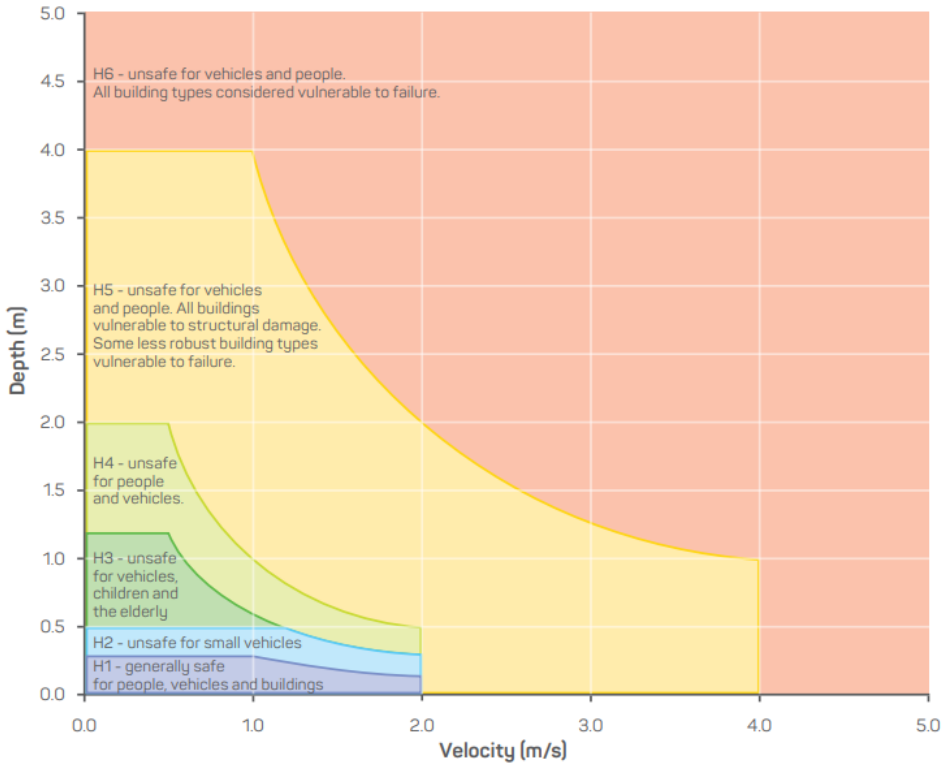

Figure 4-5 Flood Hazard Categories (Source: AIDR, 2017)

4.2.2.3 Flood Function

Identifying the flood functions of the floodplain is a key objective of best practice in flood risk management in Australia, because it is essential to understanding flood behaviour. The flood function across the floodplain will vary with the magnitude in an event. An area which may be dry in small floods may be part of the flood fringe or flood storage in larger events and may become an active flow conveyance area in an extreme event. In general flood function is examined in the defined flood event (DFE), so it can be accommodated as part of floodplain development, and in the PMF changes in function relative to the DFE can be considered in flood risk management.

The hydraulic categories (also known as flood function), as defined in the Flood Risk Management Manual (2023), are:

- Floodway - areas that convey a significant portion of the flow. These are areas that, even if partially blocked, would cause a significant increase in flood levels or a significant redistribution of flood flows, which may adversely affect other areas.
- Flood Storage - areas that are important in the temporary storage of the floodwater during the passage of the flood. If the area is substantially removed by levees or fill it will result in elevated water levels and/or elevated discharges.
- Flood Fringe - remaining area of flood prone land, after Floodway and Flood Storage areas have been defined. Blockage or filling of this area will not have any significant effect on the flood pattern or flood levels.

An initial classification of flood function for this study was undertaken using a combination of criterion set out in Thomas and Golaszewski (2012) and the *Wianamatta South Creek Catchment Flood Study – Existing Conditions* (Advisian, 2022) (referred to as 'indicator' techniques):

- Floodway – Velocity x Depth Product is greater than 0.5m^2/s,
- Flood Storage – Velocity x Depth product is less than 0.5m^2/s and depth is greater than 0.3m, and
- Flood Fringe – areas in the flood extent outside of the above criteria.

The mapping is provided in **RG-01-030** and **RG-01-031** for the 0.2% AEP (DFE) and PMF events, respectively.

Advisian (2023) further refined flood function mapping for the locality from the Advisian (2022) mapping based on encroachment testing as part of the Cumulative Impact Assessment (CIA, see **Section 2.2.4**). A comparison between the flood function mapped in this study (see **RG-01-030**) for baseline conditions (using 'indicator' techniques) and the Advisian (2023) mapping using encroachment testing is provided in **Figure 4-6**. **Figure 4-6** shows the flood function mapping from this study using indicator techniques is conservative when compared to the encroachment testing (Advisian, 2023), in particular when considering the floodway extent. This more conservative approach is considered appropriate for Precinct planning.

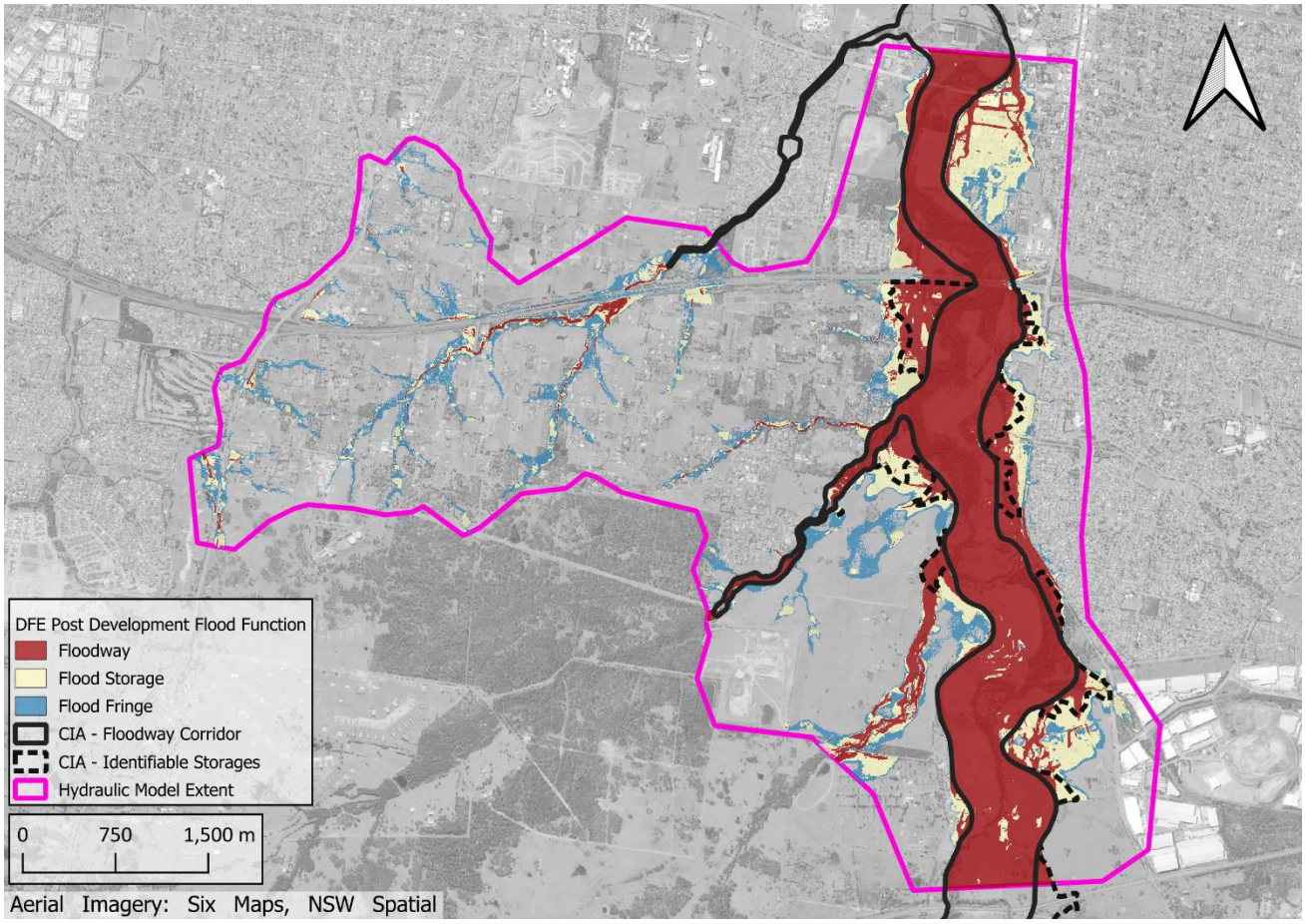

Figure 4-6 Post-development flood function from this study and the Cumulative Impact Assessment (CIA, Advisian, 2023)

4.2.2.4 Flood Planning Precinct Category

Many councils have a preferred approach to identifying and structuring flood-related controls and information in their planning controls (generally within the DCP). Informed decisions involve considering multiple flood constraints and can be complex.

AIDR (2017) provides advice on grouping flood related planning constraints into flood planning constraint categories (FPCCs). FPCC mapping allows the relative severity of flood risks to be compared throughout the floodplain via considering floods of varying size, the variation in flood hazards across the floodplain, hydraulic categories and potential constraints to emergency response and evacuation.

The FPCCs approach divides the floodplain using the following definitions:

- FPCC1 – Floodway, key storage areas or H6 hazard in the defined flood event (DFE)
- FPCC2 – New floodways in larger floods than the DFE, H5 hazard in DFE, H6 hazard in floods larger than the DFE, low flood islands and high flood islands
- FPCC3 – Areas outside FPCC2 typically below the FPL
- FPCC4 – Areas outside FPCC3, but within the PMF or extreme flood.

FPCC mapping across the Stage 1 area is provided in **RG-01-040** and reproduced in **Figure 4-7**.

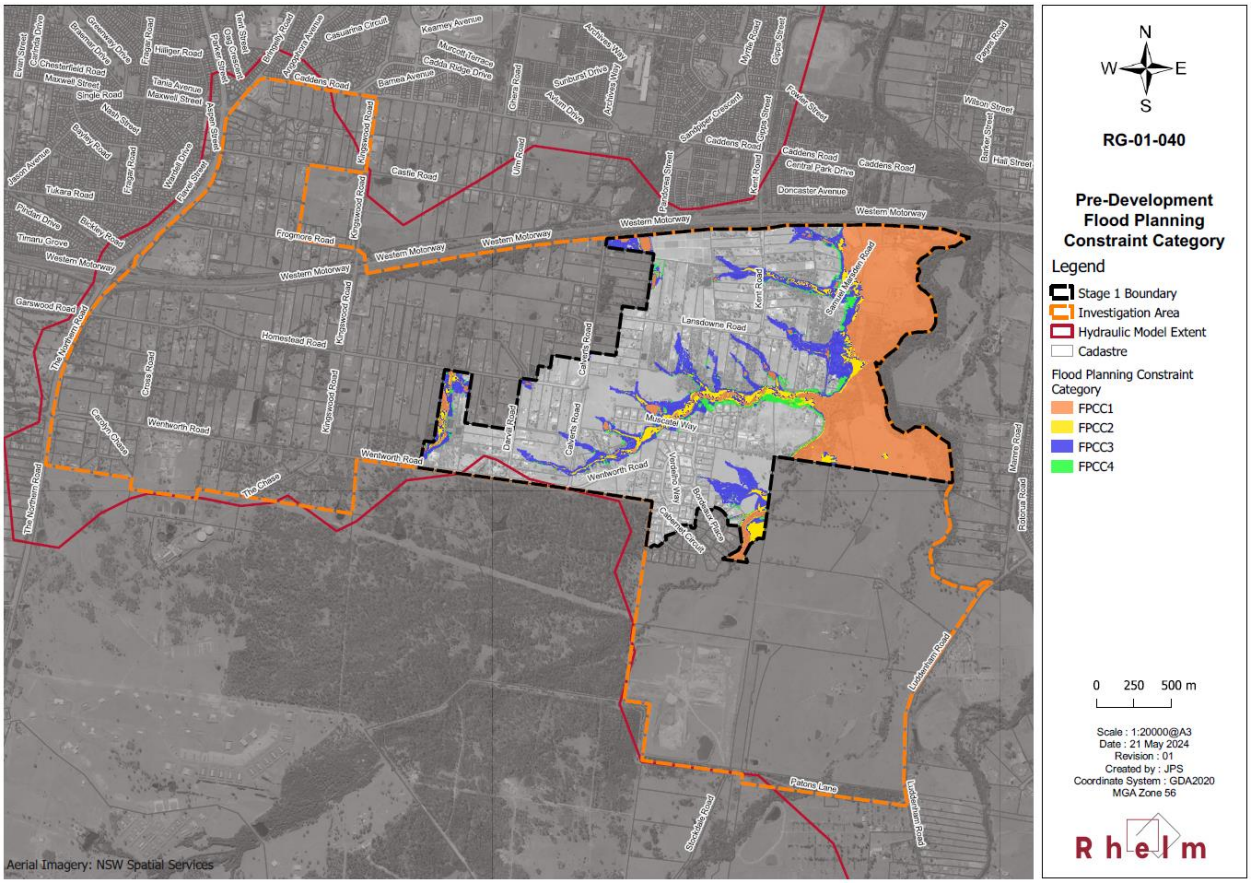

Figure 4-7 FPCC Categories – Existing Scenario

Table 4-5 provides some general relative flood-related controls and land-use categories reported in AIDR (2017). Land use categories are typically defined in an environmental planning instrument (such as a DCP) or floodplain risk management study and plan.

The relative flood controls are defined as:

- **Minor Controls:** Minor flood-related controls apply (e.g. Site FloodSafe Plan required)
- **Moderate Controls:** Moderate flood-related controls apply (e.g. floor levels to be above the flood planning level, flood impact assessment and flood evacuation plan required
- **Significant Controls:** Floor levels to be above the PMF, flood impact assessment and flood evacuation plan required, Reliable access and egress for pedestrians and vehicles required during a PMF.
- **Unsuitable:** the land use will not be supported in the Stage 1 ILP.

A detailed consideration of flood planning for the Precinct in the context of the broader site considerations and the provisions of the NSW legislative and policy context is set out in **Section 7**.

Table 4-5 Relative Flood Related Controls and Land-Use Categories (Source: Adapted from Table 17 of Flood risk management guideline FB01, DPE, 2023)

Land use category	FPCC Category			
	1	2	3	4
Critical use and facilities	Unsuitable	Unsuitable	Unsuitable	Significant Controls
Sensitive use and facilities	Unsuitable	Unsuitable	Unsuitable	Significant Controls
Subdivision	Unsuitable	Significant Controls	Moderate Controls	Minor Controls
Commercial and industrial	Unsuitable	Significant Controls	Moderate Controls	Minor Controls
Tourist related	Unsuitable	Significant Controls	Moderate Controls	Minor Controls
Recreation & non-urban[1]	Significant Controls	Significant Controls	Minor Controls	Minor Controls

[1] Some non-urban uses such as recreation areas and public reserves may have minor controls for FPCC Category 1 and 2 where it can be demonstrated the use is compatible with the flood function and risk.

4.2.2.5 Climate Change Impacts

The 0.5% AEP and 0.2% AEP events have been used as **proxies** for the 1% AEP with an allowance for increase in rainfall intensity associated with projected climate change scenarios. For the subject catchment, these events approximately correspond with 15% and 35% respective increases in rainfall intensity compared to the 1% AEP event (Advisian, 2022). Climate change impact mapping is provided in maps **RG-01-050** and **RG-01-051.**

The climate change impact mapping shows the 0.5% AEP flood levels increase in the order of 0.02 to 0.05m across the majority of Precinct watercourses and up to approximately 0.2m in Wianamatta-South Creek, Blaxland Creek and upstream of where Claremont Creek crosses the Western Motorway.

In the 0.2% AEP event, increases generally in the order of 0.04 to 0.1m (over the 1%AEP flood levels) are observed across the majority of Precinct watercourses, increasing to approximately 0.3 – 0.5m in the major waterways and upstream of major culvert crossings.

Representing a 35% increase in rainfall intensity over the existing 1%AEP rainfall intensity (i.e. at approximately a planning horizon of greater than 75 years based on Ball et al, 2019), the 0.2% AEP is therefore proposed as the defined flood event (DFE) for Precinct flood planning considerations (refer **Section 7.1**).

4.3 Model Validation

In order to provide confidence in the model, a validation assessment has been undertaken through comparing the 1% AEP flood levels with those from the Advisian (2022) and Cardno (2006) modelling. This comparison is illustrated in **Figure 4-8** and **Figure 4-9.** Positive values show where the Tuflow results from this study are higher than the previous modelling, while negative values show where the results are lower than the previous results.

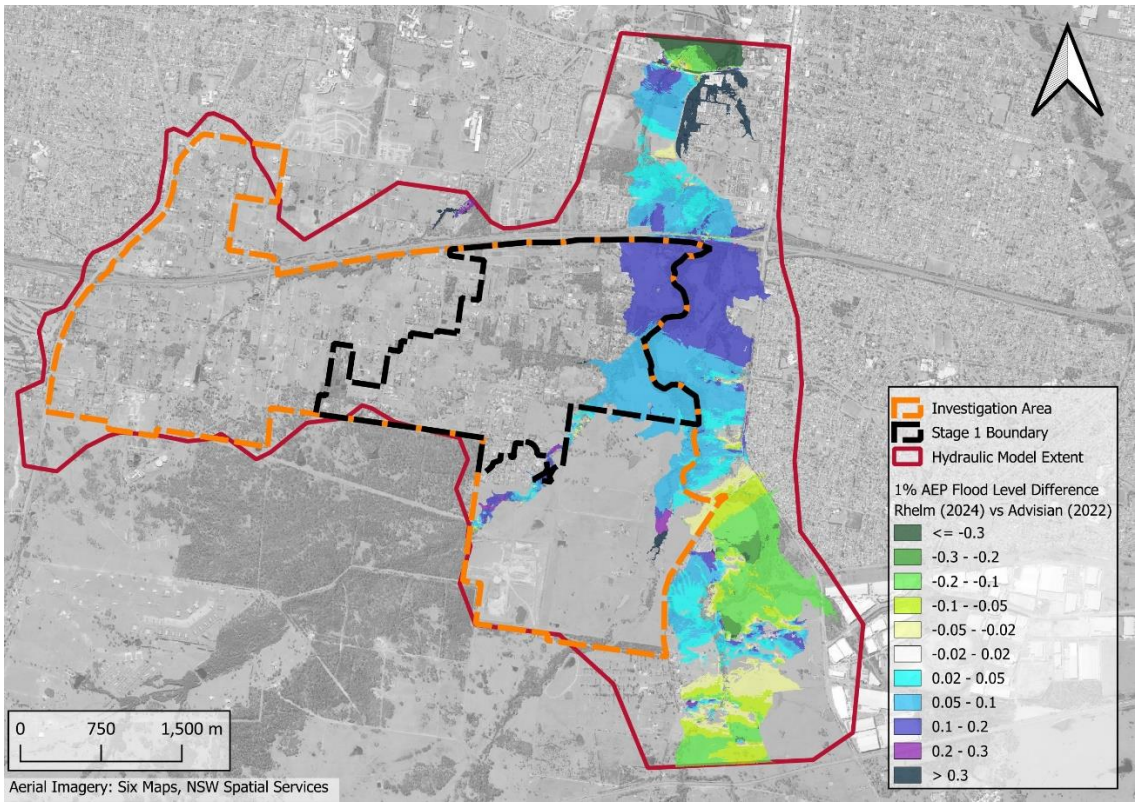

Figure 4-8 Advisian (2022) Flood Level Comparison – 1% AEP Results

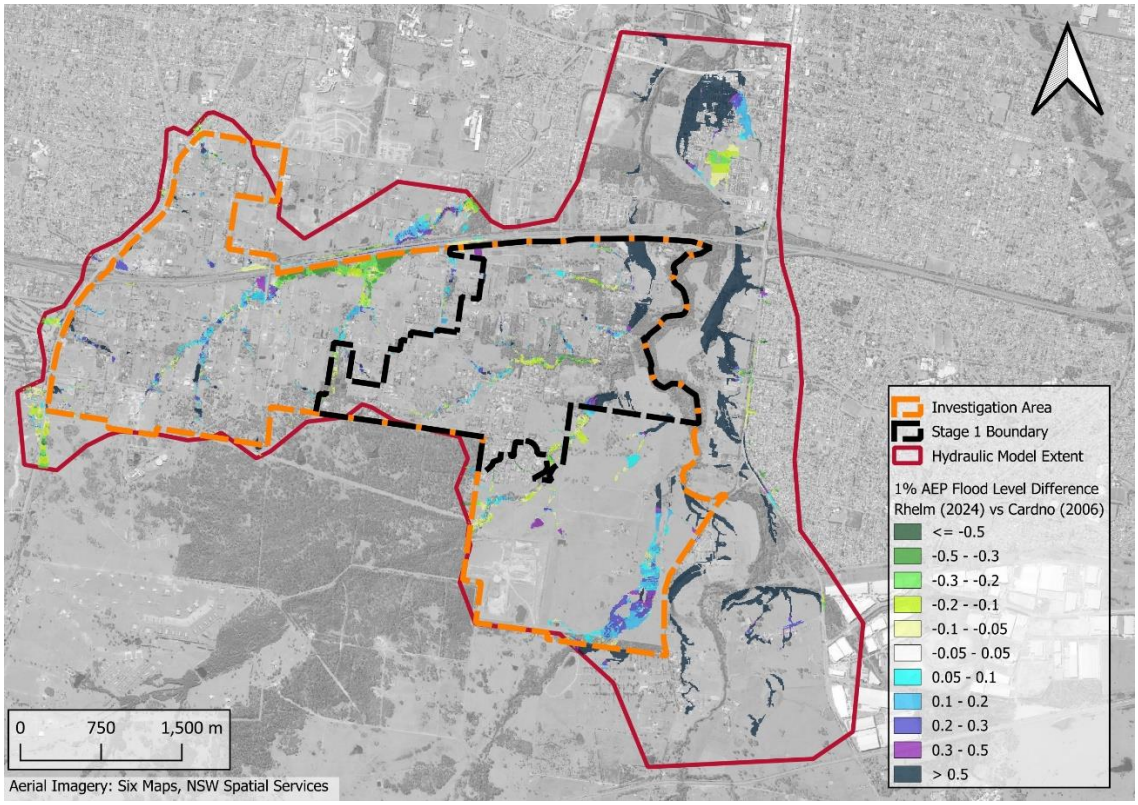

Figure 4-9 Cardno (2006) Comparison – 1% AEP Results

The comparison in **Figure 4-8** shows a high degree of consistency in 1% AEP results between the Precinct flood model and the Advisian (2022) Wianamatta-South Creek flood model, with differences in flood levels adjacent to the Precinct generally less than 0.2m. The results are considered a close match given the high flood depths and differing bridge hydraulic calculations applied in RMA (Advisian, 2022) and Tuflow (this study).

The comparison with the Cardno (2006) modelling (**Figure 4-9**) shows generally good agreement in 1% AEP flood levels (within 0.2m) along the eastern watercourses, but some significant variations (over 1m) along a number of western watercourses/drainage lines. These larger differences are likely due to a combination of modelling shorter duration events in the subject assessment (which are critical for these minor flowpaths), different terrain data and different modelling software/approaches. Substantial differences are also observed in Claremont Creek, upstream of the Western Motorway culverts. These differences are likely due to the incorporation of measured culvert details at this location compared to the assumed dimensions from the Cardno (2006) study.

Overall, the current model is considered sufficiently robust for the purpose of informing the layout and assessing flood impacts and risk associated with the Stage 1 ILP.

5 Indicative Layout Plan

An Indicative Layout Plan (ILP) has been developed by DPHI with consideration to the outcomes of baseline constraints analysis (including a range of multi-disciplinary assessments) and the findings of a collaborative Enquiry by Design (EBD) workshop.

A version of the ILP (Revision E, dated 19 March 24) was used as a basis for post-development land use and zoning characteristics adopted in the flood modelling. It should be noted that the ILP has been refined subsequent to the post-development flood modelling; however, the changes are only minor and would not be expected to significantly influence modelled flood behaviour.

The proposed land zoning for the most recent iteration of the ILP (Dated 19 March 2024) is shown in **Figure 5-1.**

Note that with respect to the management of watercourses and riparian lands, both flood and biodiversity requirements require consideration. The approach taken in the ILP regarding higher order watercourses and their associated riparian corridors (Strahler Order 2 or greater) is to either:

- Exclude the vegetated riparian zone (VRZ) from the rezoning, thus maintaining the existing rural zoning under the Penrith LEP 2010, or
- Rezone the VRZ to RE1 Public Recreation, with these parcels of land to be acquired by Council as links between or adjacent to other open space areas.

For Strahler Order 1 streams a maximum catchment criterion is proposed within Orchard Hills to determine which waterways will be retained within the development. A criterion of 15 hectares being the largest (pre-development) catchment that can convey stormwater through underground pipes is to be applied. This means stormwater from every catchment larger than 15 hectares will be conveyed in an open watercourse regardless of Stream Order while Strahler Order 1 streams with catchments below 15 ha within the development area could potentially be piped.

This Strahler Order 1 stream criterion is consistent with the planning approach for the Mamre Road and Aerotropolis precincts. This criterion does not apply to areas of mapped Cumberland Plain Conservation Plan (CPCP) avoided land where riparian corridors will be retained or rehabilitated were necessary. It is also understood that the zoning preference for CPCP avoided land areas will be for it to eventually be zoned C2 – Environmental Conservation or RE1 Public Recreation, to allow passive recreation activities.

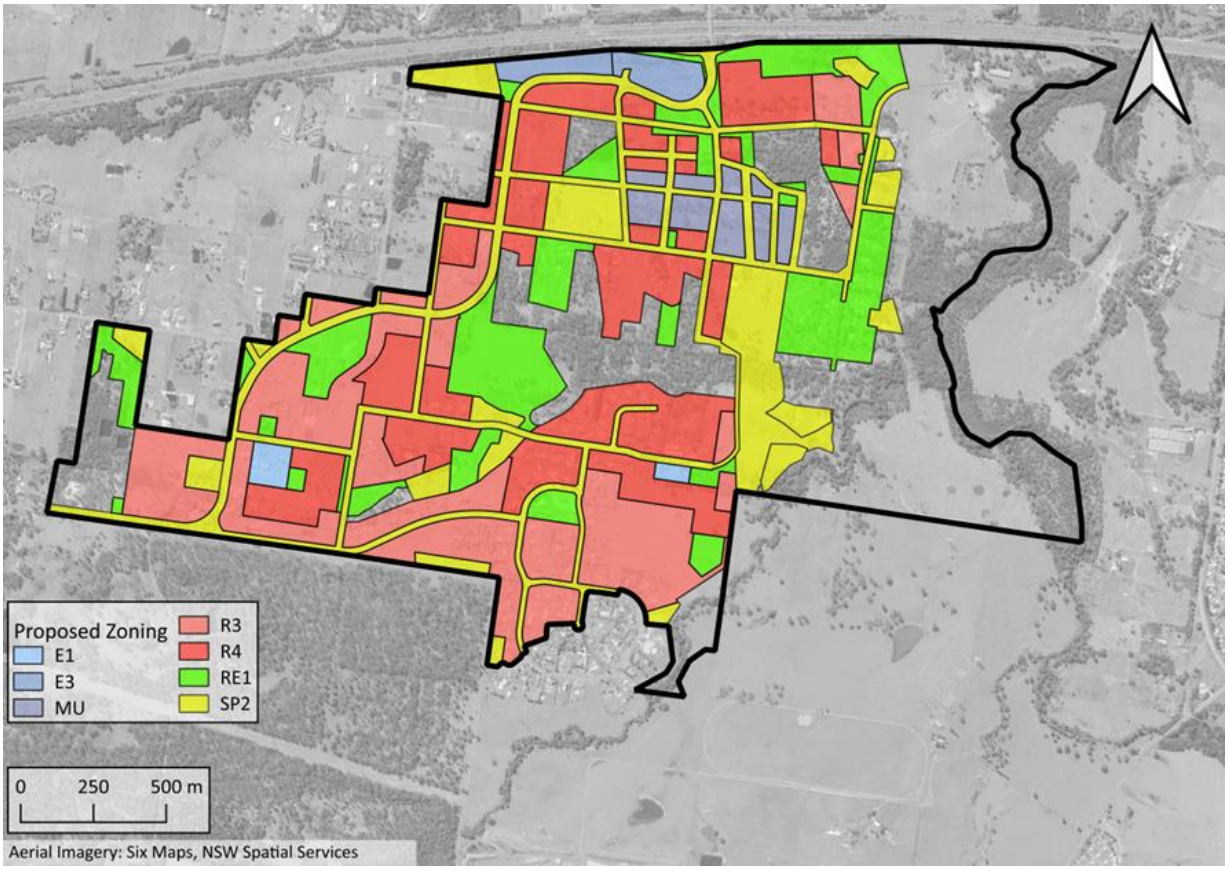

Figure 5-1 Proposed Zoning

6 Post Development Impact Assessment

6.1 Flood Mitigation Strategy

Flood risk is a combination of the *likelihood* of occurrence of a flood event and the *consequences* of that event when it occurs. It is the human interaction with a flood that results in a flood risk to the community. This risk will vary with the frequency of exposure to this hazard, the severity of the hazard, and the vulnerability of the community and its supporting infrastructure to the hazard. Understanding this interaction can inform decisions on which treatments to use in managing flood risk.

As defined in the *Australian Disaster Resilience Handbook 7 – Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia* (AIDR, 2017), there are three types of flood risk:

- **Existing flood risk** – the risk associated with current development in the floodplain. Knowing the likelihood and consequences of various scales of floods can assist with decisions on whether to treat this risk and, if so, how.
- **Future flood risk** – the risk associated with any new development of the floodplain. Knowing the likelihood and consequences of flooding can inform decisions on where not to develop and where and how to develop the floodplain to ensure risks to new development and its occupants are acceptable. This information can feed into strategic land-use planning.
- **Residual flood risk** – the risk remaining in both existing and future development areas after management measures, such as works and land-use planning and development controls, are implemented. This is the risk from rarer floods than the management measures were designed for. Residual risk can vary significantly within and between floodplains. Emergency management and recovery planning, supported by systems and infrastructure, can assist to reduce residual risk.

Existing and future flood risk within the Stage 1 rezoning area will be generally managed by ***locating proposed residential areas outside of PMF extents***. However, there remains a level of risk associated with flooding of the Precinct roadways as well as small areas of proposed residential zoning that are currently impacted by PMF floodwaters. The following structural mitigation measures are proposed to manage this risk:

- Raising key internal roads and upgrading cross drainage culverts at **three** key locations to provide flood immunity in the DFE (1% AEP with climate change or 0.2% AEP event). It should be noted that hydrologic and hydraulic design criteria for minor drainage systems (longitudinal pit and pipe networks) would be as per Council's engineering design specifications.
- Filling selected residential areas to reduce PMF hazard to a level that would not pose a significant risk to life of future residents and visitors.

The locations of these measures are illustrated in **Figure 6-1**.

Additionally, on-site detention measures have been proposed for catchments draining north to Claremont Creek and south to Blaxland Creek to mitigate downstream impacts associated with increased flows from the developed catchment. Refer to the *Water Cycle Management Strategy* (Design Flow, 2024) for details of these measures.

The *Water Cycle Management Strategy* (Design Flow, 2024) also proposes the decommissioning of first order watercourses with a catchment area less than 15 hectares and replacement with piped drainage lines and/or engineered overland flow paths. Future design of these drainage lines will need to ensure

that they are adequately sized to convey DFE flows and that PMF flooding would not pose a significant risk to life or property.

The flood modelling approach to remove first order watercourses will be refined post-exhibition. All watercourses within Cumberland Plain conservation plan (CPCP) areas will be retained within the model. This is not expected to have a significant impact on modelled flood behaviour downstream of these locations.

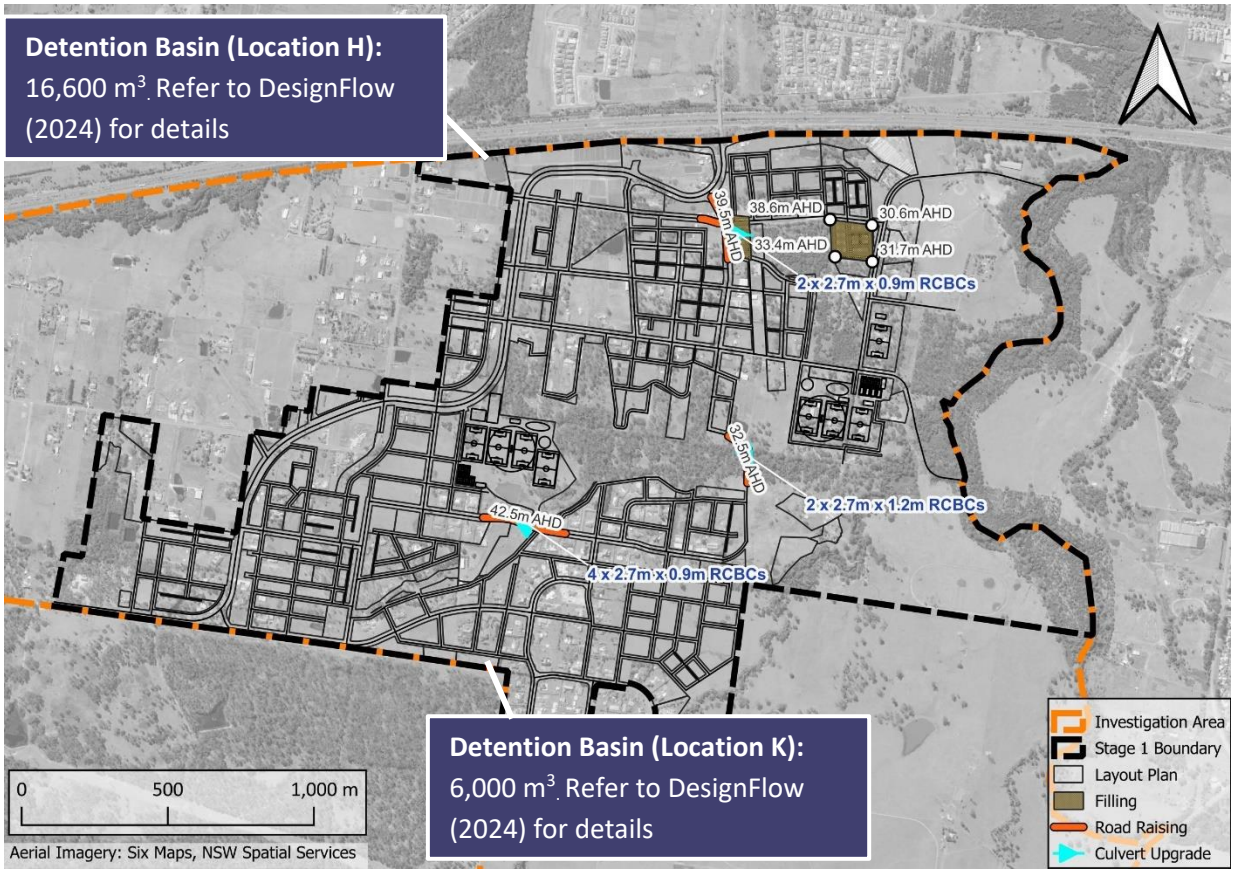

Figure 6-1 Overview of Flood Mitigation Measures

6.2 Hydrologic Modelling

The existing scenario XP-RAFTS model (**Section 4.1**) was updated to reflect the change in sub-catchment imperviousness associated with the proposed Stage 1 layout plan. Adopted fraction impervious assumptions are consistent with the Water Cycle Management Plan (Design Flow, 2024) and are shown in **Table 6-1**.

It should be noted that the existing imperviousness was assumed for the small portions of the Precinct along the southern boundary that drain to Blaxland Creek. These areas represent a small portion of the corresponding XP-RAFTS sub-catchments and flow increases associated with the developed catchment will be managed via detention basins. This assumption would thus not have a significant impact on modelled flood behaviour.

Table 6-1 Catchment Imperviousness Assumptions

Land Use	Percentage Impervious
Proposed Residential	80
Proposed Community/Neighbourhood Centre	90
Proposed School	50
Proposed District Park	10
Proposed Road Reserve	65
Proposed Conservation	0

6.3 Hydraulic Modelling

6.3.1 Hydraulic Model Setup

The existing conditions TUFLOW model (**Section4.2**)) was updated to represent the proposed Stage 1 development, inclusive of roughness changes and the proposed flood management measures (**Section 6.1**). Model updates to reflect the post-development scenario are summarised in **Table 6-2**. Features of the model setup are shown in **Figure 6-2.**

Table 6-2 Post-Development Model Updates

Parameter	Data Source/Assumptions
Digital Elevation Model (DEM)	Modifications to the model DEM were made to represent: • Proposed filling, • Proposed road raising, and • The proposed detention basin (**Figure 6-1,** Location H**).** For the northern detention basin, a 3D surface was generated using 12D civil design software. The remainder of topography modifications were incorporated into the model using TUFLOW 'z shapes'.
Roughness	Surface roughness mapping was updated across the precinct to reflect the ILP. Adopted Manning's 'n' values specific to the developed Stage 1 area include: • Urban[2] 0.100 • School 0.060 • Parks / open space 0.050 • Stormwater basin 0.050
Hydraulic Structures	The TUFLOW 1D network was updated to incorporate the proposed cross drainage upgrades and new culverts shown in **Figure 6-1**, as well as the primary outlet of the detention basin adjacent to the northern boundary. Blockage assumptions for upgraded/new culverts are as per the existing scenario model; whereas nil blockage has been applied to detention basin outlet as this is more conservative in terms of downstream flood impacts.
Inflows	The SA polygons were updated to remove local inflows along first order watercourses with a catchment area less than 15 ha (refer **Section 6.1**). However, it is understood that first order watercourses within the CPCP area will be retained and thus model inflows in these areas will need to be revised following public exhibition.

[2] A higher roughness has been applied to account for proposed buildings not being explicitly represented in the flood model.

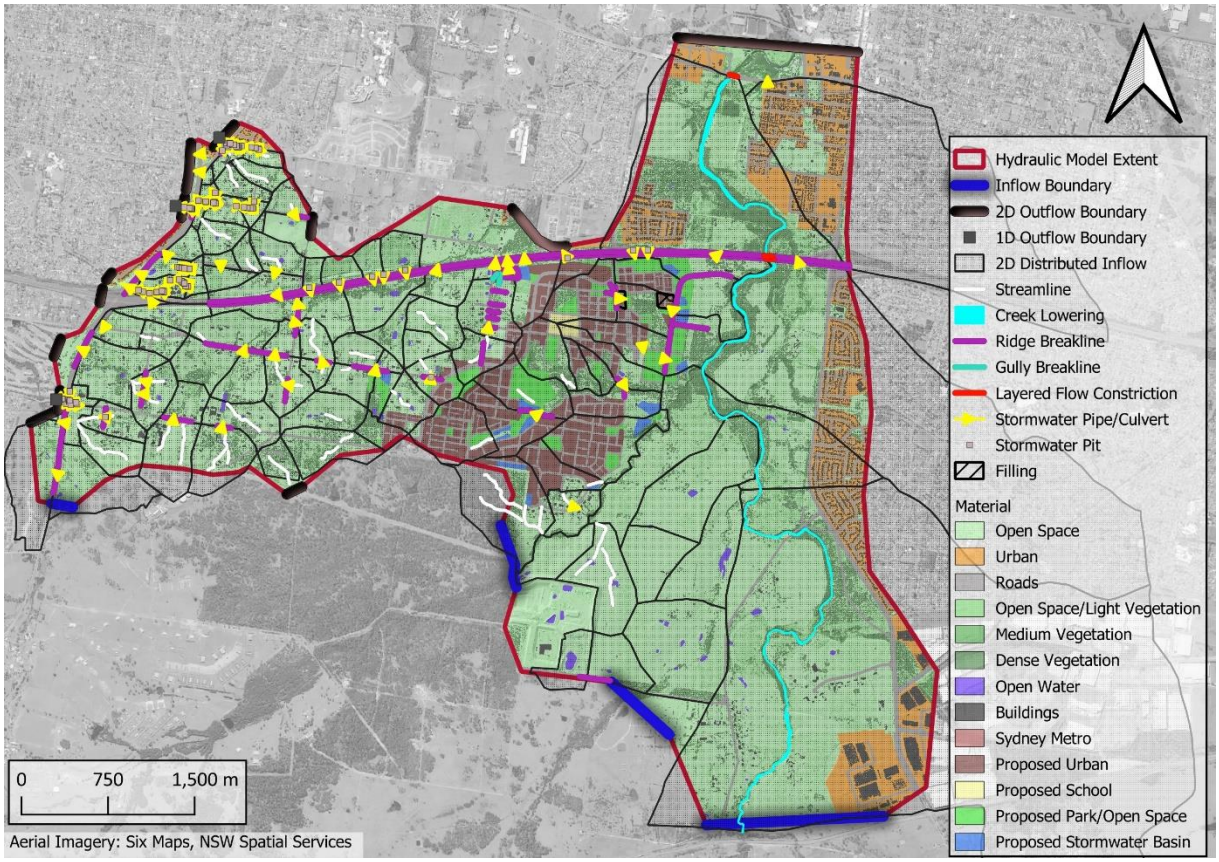

Figure 6-2 TUFLOW Model Setup – Post-Development Scenario (Refer to Table 4-2 and Figure 4-2 for further details regarding the TUFLOW model setup)

6.3.2 Hydraulic Model Results

The post-development TUFLOW model was run for the 0.5 EY, 20%, 1%, 0.5% and 0.2% AEP events and the PMF event.

Post-development scenario flood maps have been attached in **Appendix B** of this report and include the following:

- Map RG-02-001 to RG-02-006 showing peak depths and elevations for all events,
- Map RG-02-010 to RG-02-015 showing peak velocity for all events,
- Map RG-02-020 to RG-02-025 showing peak hazard for all events,
- Map RG-02-030 to RG-02-031 showing flood function for the 0.2% AEP and PMF events,
- Map RG-02-040 to RG-02-045 showing flood level impacts for all events,
- Map RG-02-050 to RG-02-055 showing flood velocity impacts for all events, and
- Map RG-01-060 showing flood planning area for the 0.2% AEP event.

Within the Stage 1 ILP boundary itself, there are changes to peak flood levels along a number of unnamed tributaries of Blaxland and Wianamatta-South Creek. The changes are typically less than 0.2 m for all events. The changes are largely a result of the removal of first order watercourses. Velocity within the unnamed tributaries is typically 0.5 – 1 m/s in the existing and post development scenario. The removal of flooding shown as "was wet, now dry" along a number of first order watercourses has been informed by the Water Cycle Management Strategy (Design Flow, 2024). First order watercourses with a catchment area less than 15 hectares are proposed to be decommissioned and replaced with piped drainage lines and/or engineered overland flow paths. However, this approach does not apply to areas of CPCP mapped *avoided land* where riparian corridors will be retained or rehabilitated were necessary. Future concept design of the internal watercourses/drainage lines will need to ensure that they are adequately sized to convey DFE flows and that PMF flooding would not pose a significant risk to life or property.

The post development flood levels have been used to inform the Stage 1 ILP (See **Section 5).**

6.3.3 Offsite Impacts

The proposed Stage 1 ILP does not cause any material offsite adverse impacts.

Minor effects, that can be attended to through minor design amendments at later stages of the Precinct planning process, have been identified for a portion of the M4 (east and west of the Kent Road overpass). As a guide, in a 1% AEP event, impacts are limited to 0.04-0.08 m, affecting the shoulder and left lane of the three-lane westbound M4 Motorway. **Figure 6-3** shows the extent of these minor impacts. Note that flood hazard in the travel lanes are present under existing conditions and remain at Hazard Category 1 (H1) for all events up to the PMF under the Stage 1 ILP, which is generally considered safe for vehicles and people.

It is important to note that the TUFLOW model does not account for the longitudinal drainage along the M4 (it has been assumed to be fully blocked). Although hydraulic structure information was requested from Transport for NSW, details of the longitudinal drainage were not made available. Including this drainage in the model may have the effect of reducing or eliminating the flooding and the modelled impacts along the westbound left-hand travel lane. Alternatively, modifications to the finished landform in the RE1 zoned lands along the northern boundary of the Stage 1 ILP could be incorporated to reduce the minor impacts to the M4 Motorway, as the depth, velocity, and volume of water affecting the road are low.

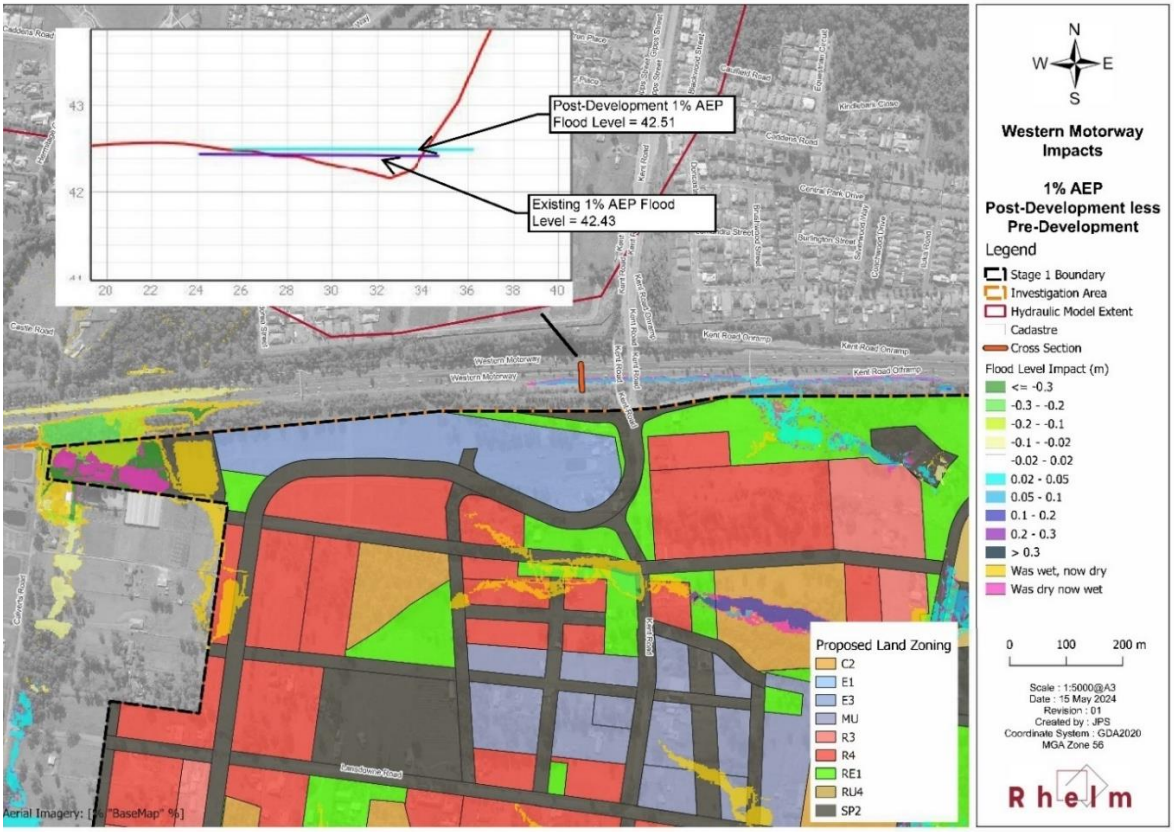

Figure 6-3 Minor Impacts Along the M4 Motorway

7 Flood Planning Considerations

7.1 Defined Flood Event

The existing range of flood planning controls that are anticipated to apply to the Stage 1 ILP are set out in **Section 3**.

The development of the ILP (**Section 5**) has sought to ensure that future development can meet these requirements, by:

- ***Locating*** residential development generally outside of flood-affected areas being both:
  - mainstream flooding from either short duration (or flash-flooding) associated with intense rainfall in the local catchment (Blaxland Creek and unnamed watercourses);
  - Longer duration flooding from Wianamatta-South Creek - the intended outcome is that the development is predominantly located above the Probable Maximum Flood level of the river, avoiding the need for any evacuation of development arising from the ILP.
- ***Managing*** overland flows via aligning the local road network in a manner that is compatible with the topography of the land. Overland flows up to the PMF event require consideration to ensure that future dwellings are compatible with overland flow flood risks.
- ***Incorporating*** the projected effects of climate change by setting the defined flood event to be the 0.2% AEP (or 1 in 500 AEP) (the 0.2% AEP event is representative of the existing 1%AEP design flood event with an increase in rainfall intensity of 35% to allow for climate change in accordance with Ball et al, 2019 beyond a 75 year planning period).
- ***Setting*** roads affected by flash flooding at the 0.2% AEP flood event to ensure that all occupants and emergency services can access the M4 Motorway, Northern Road or the Stage 1 ILP area during flash flood events.

For the Orchard Hills Stage 1 ILP, the recommended defined flood event (DFE) is the 0.2% AEP for mainstream and overland flow flooding. Adopting the 0.2% AEP as the DFE to account for projected climate change is consistent with the objectives of the Western Sydney District Plan (**Section 3.2.2**), Western Parkland City Blueprint (**Section 3.2.3**) and NSW Flood Enquiry (Section 3.4). Refer to **Section 4.2.2.5** for a discussion on differences between existing 1% and 0.2% AEP modelled flood levels across the Precinct.

Other aspects of flood risk management include consideration of essential services, such as electricity, water, sewerage and communications, if located in flood prone areas, are effectively flood proofed. Note that there are numerous existing essential services to the west of the Precinct that will not be flood proofed and their functionality may be affected in the event of a rare or extreme flood event in the region. This in turn may affect servicing of the Precinct, which is outside of the scope of the planning for the Precinct.

Flood planning area mapping (0.2% AEP + 0.5m freeboard) for the post-development scenario is shown in **Figure 7-1**. The extent of the flood planning area has been limited to the PMF extent (where a freeboard of 0.5 m on the 0.2%AEP flood extent would otherwise result in an artificially larger flood extent than the known limit of the floodplain, as defined by the PMF).

There are minor areas where the flood planning area encroaches within land that is proposed to be rezoned R3 – Medium Density Residential and R4 – High Density Residential. In these areas, flooding in the DFE (0.2% AEP) event is flood hazard H1 – low hazard (See **Map RG-02-024**) and could be adequately

managed via minor regrading and/or increases in potential conveyance in adjacent road reserves. The proposed rezoning is therefore consistent with Planning Direction 4.1(3) and 4.1(4) (See **Section 3.5)**.

Conventional building design and landscaping will allow the construction of buildings outside of the flood planning area with floor levels above the PMF where necessary (such as sensitive or hazardous development, as defined in Clause 5.22 of the Standard Local Environment Plan template).

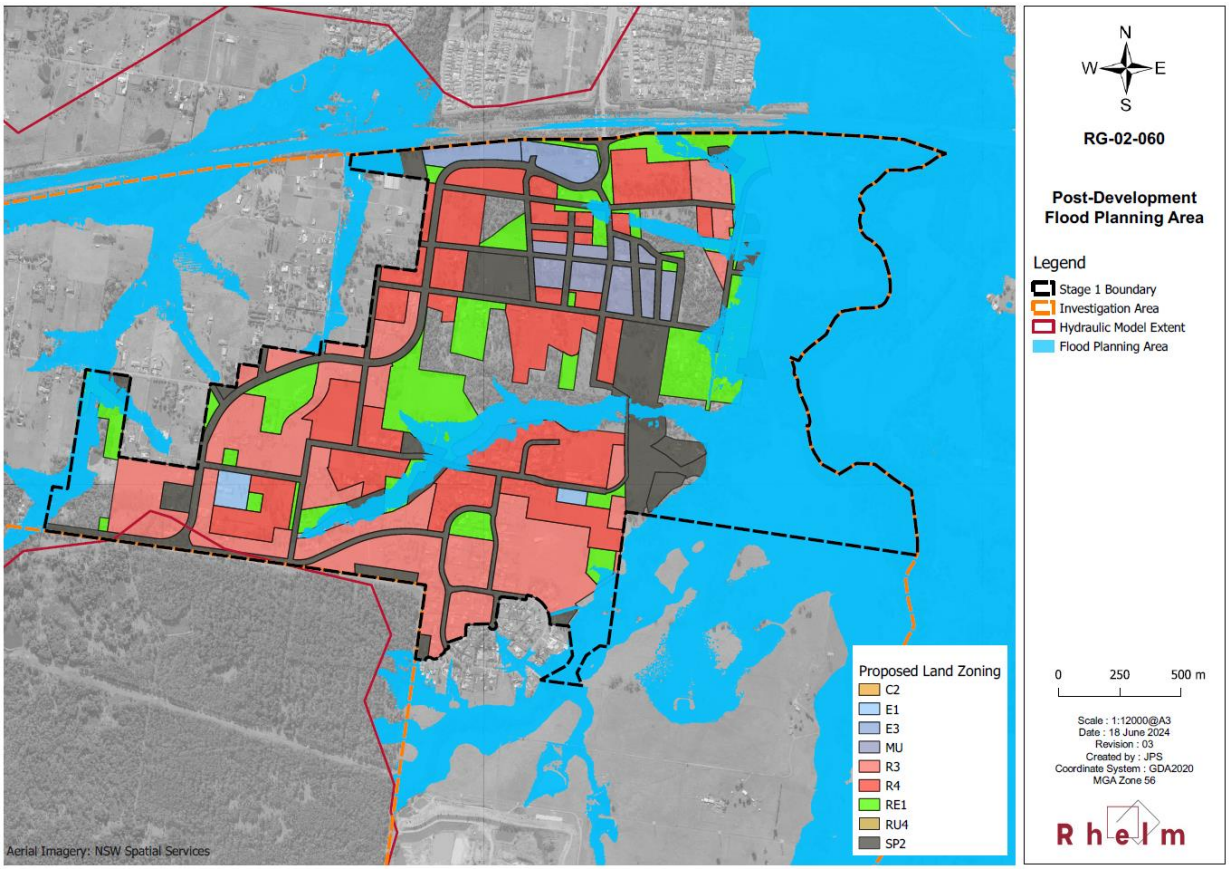

Figure 7-1 Flood Planning Area

7.2 Regional and Onsite Detention

7.2.1 Catchment Hydrograph Timing

The hydrologic modelling (**Sections 4.1** and **6.2**) revealed that the timing differential between the local catchment and Wianamatta-South Creek hydrograph peak is significant, with the local peak arriving several hours before the regional peak. This is due to the large size of the overall catchment (approximately 624 km^2, the watercourse length being 80km), compared to the size and location of the Precinct (approximately < 2 km^2, being 2% of the catchment, reach of watercourse along the boundary of the Precinct is approximately 2.5 km).

A 1% AEP and 20% AEP hydrograph timing comparison using XP-RAFTS outputs was undertaken for the 2 hour, 9 hour and 36 hour durations, as illustrated in **Figure 7-2** to **Figure 7-7**. These figures compare the timing of flows from the eastern local Precinct catchment, namely the aggregate of developed sub-catchments in the eastern portion of Stage 1 draining either directly to Wianamatta South Creek or via local tributaries, and the regional Wianamatta-South Creek system.

Due to this timing differential between local and regional flows, no adverse Wianamatta-South Creek flood impacts are observed as a result of the development downstream of the site. This finding forms the primary basis for the on-site detention recommendations discussed in the following section and is also consistent with the findings of the Cumulative Impact Assessment (Advisian, 2023) (refer **Section 2.2.4**).

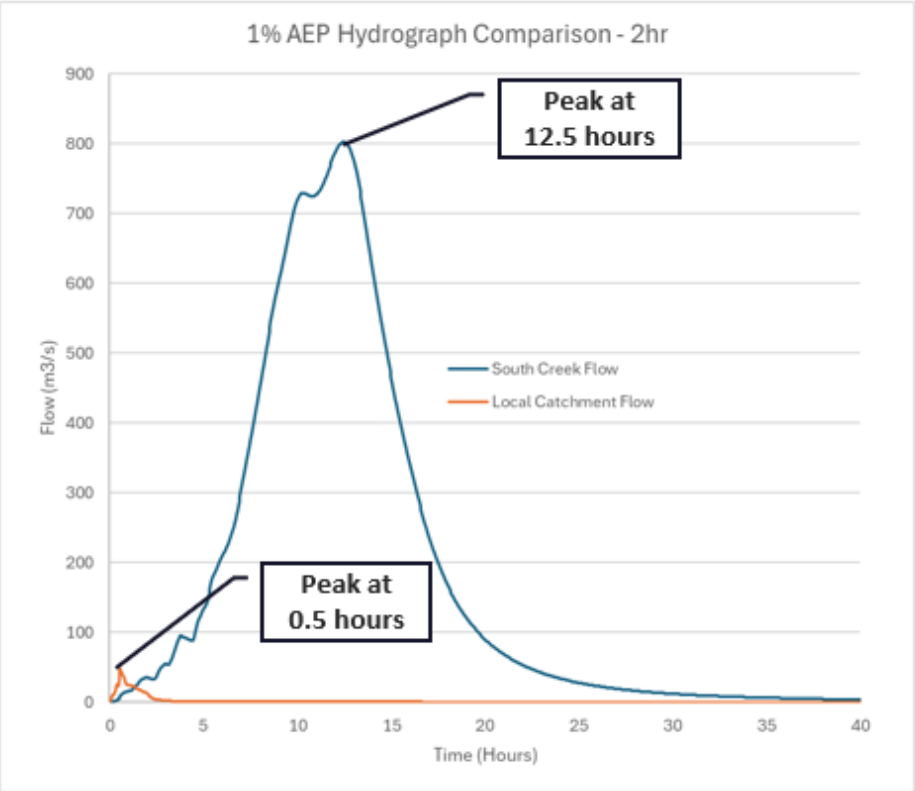

Figure 7-2 1% AEP Hydrograph Comparison – 2 Hour Event

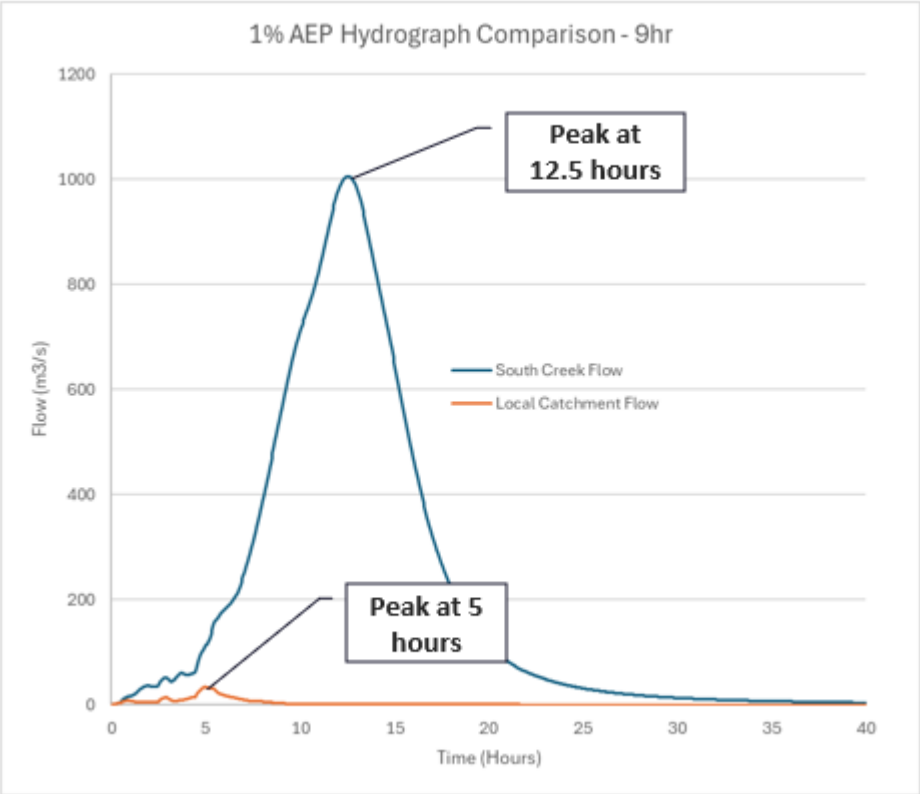

Figure 7-3 1% AEP Hydrograph Comparison – 9 Hour Event

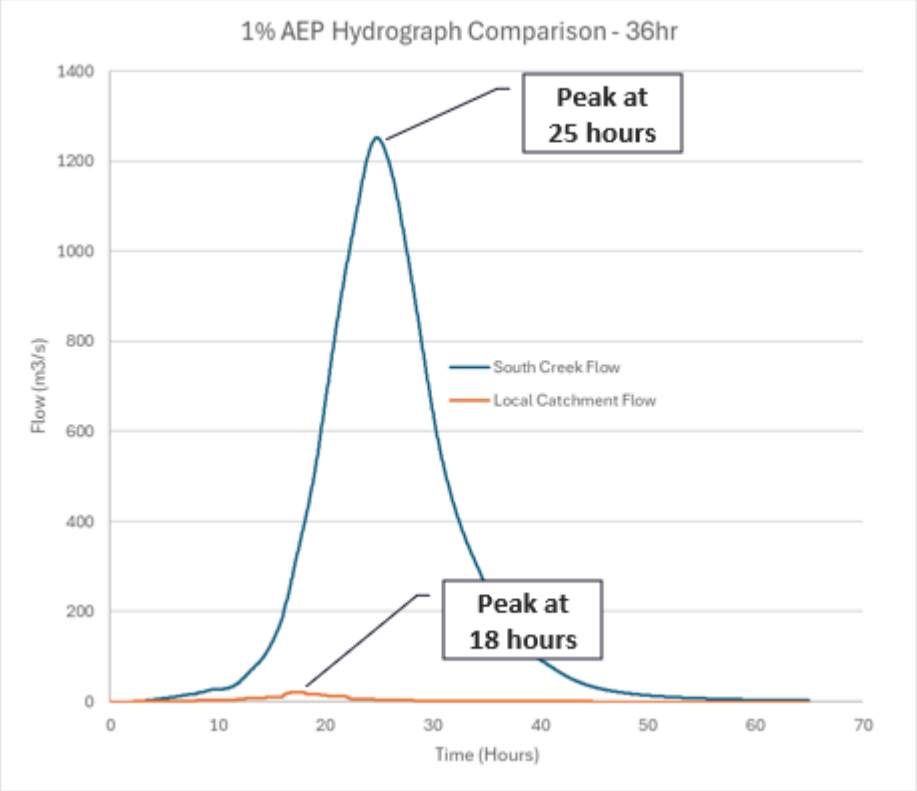

Figure 7-4 1% AEP Hydrograph Comparison – 36 Hour Event

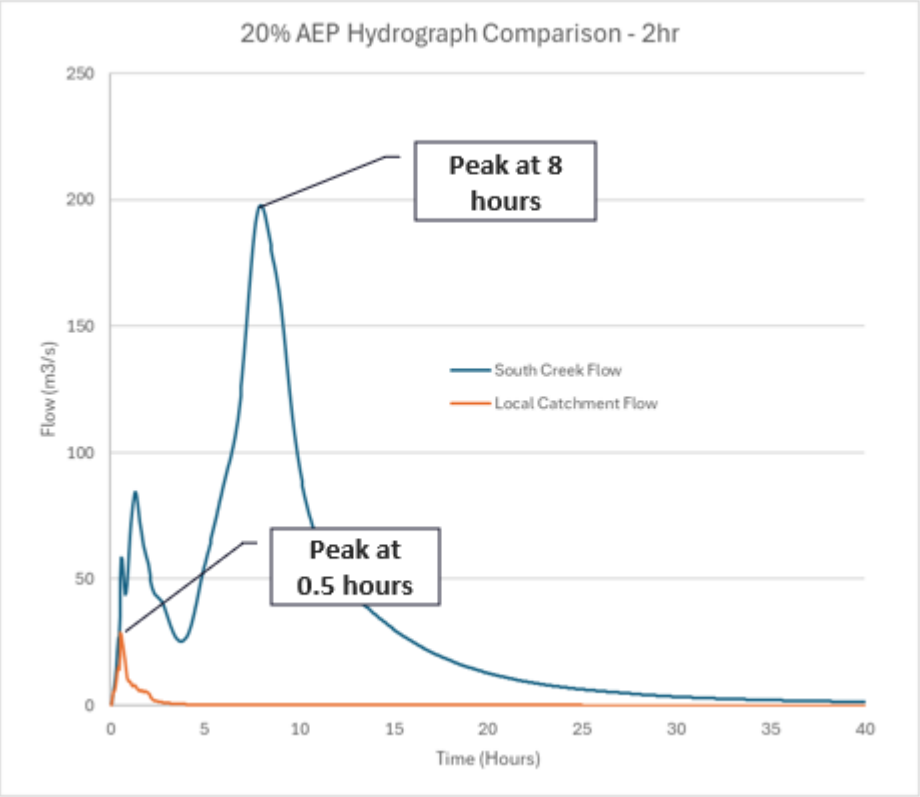

Figure 7-5 20% AEP Hydrograph Comparison – 2 Hour Event

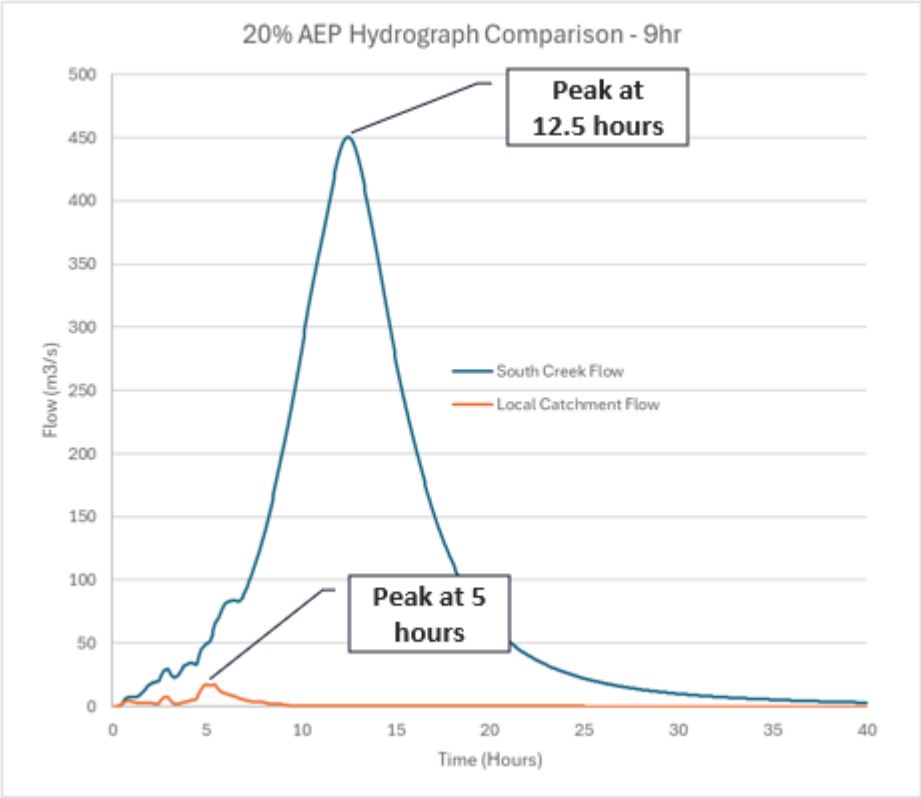

Figure 7-6 20% AEP Hydrograph Comparison – 9 Hour Event

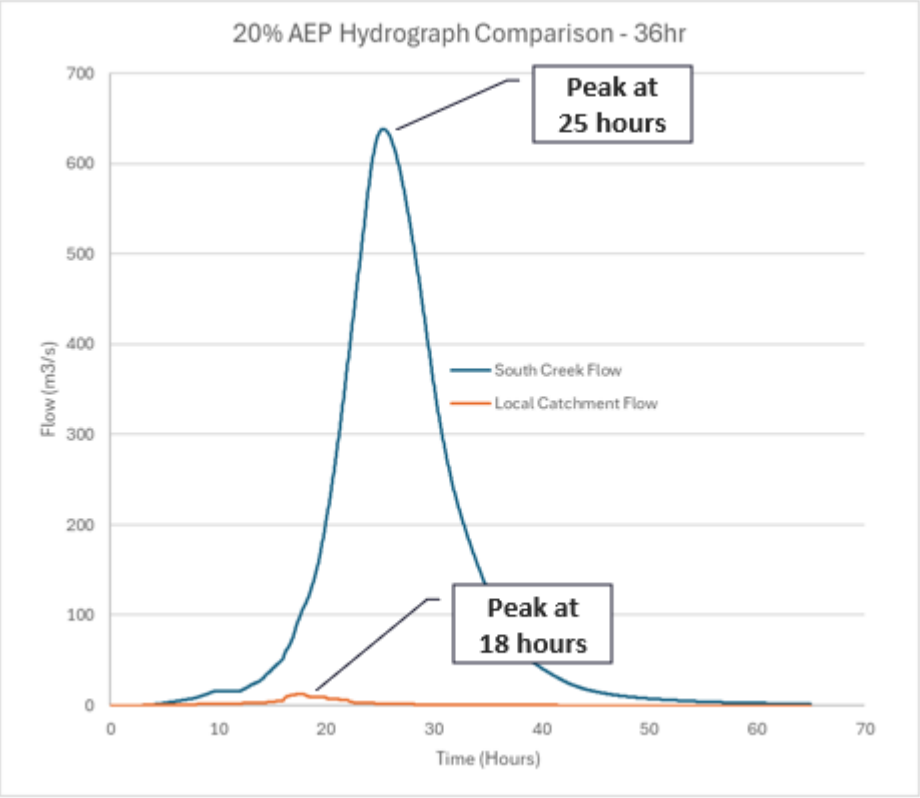

Figure 7-7 20% AEP Hydrograph Comparison – 36 Hour Event

As outlined above, the Wianamatta-South Creek catchment has a total area of 624 km^2. Upstream of the Orchard Hills Stage 1 ILP, the Wianamatta South Creek Catchment is approximately 305 km^2. The total area proposed for residential, commercial, and infrastructure development within the Stage 1 ILP is less than 2 km^2.

Water levels and flows along Wianamatta-South Creek are not sensitive to the proposed changes within the Stage 1 ILP due to the significantly different catchment sizes and misalignment of flood peaks from equivenet storms shown in **Figure 7-2** to **Figure 7-7**. As outlined in **Section 2.2.4**, the Cumulative Impact Assessment (Advisian, 2023) found that efforts to attenuate flood discharges from certain tributary catchments can serve to delay the arrival of the flood peak at the tributary confluences with Wianamatta - South Creek. As a result, efforts to attenuate peak flows may actually lead to increases in peak flood levels along Wianamatta - South Creek.

7.2.2 OSD and Detention Exemption

Of relevance to the Orchard Hills Precinct, Advisian (2023) found that detaining peak flows from the Blaxland Creek Catchment could inadvertently align flood peaks along Wianamatta - South Creek. Advisian (2023) found detention in the Blaxland Creek Catchment has the potential to increase flows by 5% to 17% along Wianamatta South Creek in a 1% AEP flood event depending on the level of alignment of upstream tributary peaks. This equates to a level difference of up to 0.33 m at the Western Motorway (M4).

Advisian (2023) recommends that it is necessary to minimise the attenuation of tributary flows to avoid potential increases along Wianamatta - South Creek where possible.

The results of this investigation demonstrate that urbanisation within Stage 1 ILP area is not expected to cause flood level or velocity impacts in a range of flood events offsite or within Wianamatta – South Creek.

The stormwater management scheme proposed by Design Flow (2024) includes wetlands and bioretention basins and is considered to be appropriate for managing stormwater runoff volume and achieving water quality treatment targets and effectively manages frequent flows.

Based on the results of site-specific hydrologic and hydraulic modelling undertaken as part of this assessment it is recommended that those areas within the Orchard Hills Stage 1 ILP **draining directly to Wianamatta-South Creek do not require OSD or regional detention**. This recommendation is supported by the Cumulative Impact Assessment (Advisian, 2023).

However, **detention is recommended** for areas that drain to private property or where increases in flows would result in unacceptable increases in flood levels on private property or critical infrastructure, such as the western portion of the Precinct and the south-eastern portion of Stage 1.

It should be noted that the recommendation regarding Wianamatta-South Creek OSD exemption is specific to the Orchard Hills Stage 1 ILP and consequently does not establish a precedent for OSD exemptions elsewhere in the Penrith LGA.

In this regard, currently there are no OSD exemption zones mapped within the Penrith LGA, whilst many other Councils in NSW do identify OSD exemption zones. OSD exemptions may exist where:

- a site is located in a flood prone area;
- stormwater discharge from a site will not enter the stormwater drainage system (i.e. it is direct to a watercourse);
- stormwater from a site does not result in adverse downstream effects; or
- a development uses another type of stormwater source control technique instead of OSD.

In these circumstances, peak runoff from future development does not result in adverse offsite impacts. **Table 7-1** provides some examples from local government authorities in NSW that include provisions for OSD exemption.

Table 7-1 Examples of OSD Exemptions

Local Government Area	OSD Exemption
City of Sydney / Sydney Water	The development site is at the lower section of the catchment. This aims to ensure peak flows from local runoff does not align with peak flow from the wider catchment.
City of Ryde	Designated OSD exclusion zone along the foreshore of the Parramatta and Lane Cove Rivers.
Willoughby City Council	OSD is not required if the discharge of stormwater does not pass through any council owned drainage infrastructure before reaching the receiving waters of Middle Harbour or the Lane Cove River.
Blacktown City Council	Within the Northwest Growth Centre (where regional basins are provided).
Fairfield Council	Within the Wetherill Park Industrial Area.

Local Government Area	OSD Exemption
Liverpool	If the increased discharge for all storms up to and including a 100-year event can be accommodated by the existing downstream stormwater pipe or waterway system.
Wollongong	Mapped OSD concession zones are located at the lower reaches of catchments throughout the LGA. This aims to ensure peak flows from local runoff does not align with peak flow from the wider catchment.

7.3 Vegetation Management

Based on the findings of the Cumulative Impact Assessment (Advisian, 2023), it is recommended that a Vegetation Management Plan is developed to maintain flow conveyance and storage for the portion of the Precinct that falls within the Wianamatta-South Creek floodplain. However, this would be more appropriate as a broader plan covering the area assessed as part of the Cumulative Impact Assessment (Advisian, 2023) rather than a site-specific plan for the Orchard Hills Stage 1 rezoning.

The majority of local watercourses within the Stage 1 area are currently well vegetated and thus significant increases in floodplain roughness associated with the Stage 1 ILP for these watercourses are not considered likely.

There is potential for planting densification along more sparsely vegetated watercourses to improve the amenity, erosion control and environmental outcomes at these locations. Investigations into the planting of these corridors would need to be accompanied by updated flood modelling to confirm the extent of associated flood impacts. It is not expected that localised roughness changes within these watercourses would necessitate changes to the ILP or have any adverse impacts on Wianamatta-South Creek flood behaviour.

8 Flood Emergency Response

8.1 Long Duration Flooding from Wianamatta – South Creek

The critical duration (the rainfall duration that produces peak flows/flood levels at a particular location) for flooding from Wianamatta – South Creek at the Precinct is 36 hours for the 1% AEP and 6 hours for the PMF. Longer duration extreme event flooding also has the potential to result in creek levels to be elevated for several hours.

Due to the potential for long duration flooding from Wianamatta – South Creek, most development proposed as part of the Orchard Hills Stage 1 ILP **has been located entirely outside of the PMF extent**. This approach seeks to ensure safe occupation for future residents and no additional burden for evacuation on the NSW State Emergency Service.

If required, flood-free access or egress in a long duration Wianamatta-South Creek flood event would be available via the Northern Road to the west of the Precinct. Further, there will be local centres within the Stage 1 area where residents could obtain supplies during a long duration event.

8.2 Long Duration Backwater Flooding from the Hawkesbury – Nepean River

The potential for backwater flooding from the Hawkesbury – Nepean River was considered. Upstream of the M4 adjacent to the Stage 1 ILP, Wianamatta South-Creek has the potential to be affected by backwater flooding from the Hawkesbury – Nepean River. However, the PMF from the Hawkesbury – Nepean River at this location (30.6m AHD, Rhelm/CSS, 2024) is of a similar magnitude to the Wianamatta – South Creek PMF level from the subject catchment modelling (30.3m AHD directly upstream of the M4, Advisian, 2022).

Therefore, planning decisions relating to the PMF have focused on catchment flooding from Wianamatta – South Creek.

8.3 Flash Flooding from Blaxland Creek, Claremont Creek and Smaller Tributaries

Flooding from Blaxland Creek, Claremont Creek and smaller unnamed watercourses is associated with intense local rainfall (referred to as 'flash flooding'). This type of flooding is usually very intense but short lived and is likely to rise and fall over a period of minutes to a few hours (no more than 6 hours). Whilst these types of events are often embedded in regional weather systems (such as an East Coast Low weather system), there can be very little warning of this type of flooding and there is insufficient time to issue warnings or take action. In these circumstances, sheltering in place is usually the safest option as the risk to life is primarily posed by flooding of roads.

Ensuring residential apartments with basements have the basement entry set above the local overland flow PMF level and setting floor levels at or above the Probable Maximum Flood level is an achievable outcome for the Precinct and avoids the need for formal emergency response measures.

Locations where watercourses pass under roads should be marked with flood depth markers where the road can be inundated in rare and extreme floods greater than the DFE. This would assist drivers in understanding the depth of flooding in the rare and extreme circumstances that the road might be inundated.

9 Conclusions and Recommendations

A comprehensive flood impact and risk assessment has been conducted for the proposed re-zoning and development of Orchard Hills Stage 1 ILP. Through rigorous hydrologic and hydraulic modelling, flood risk across the Stage 1 ILP has been defined, and the potential impacts of the proposed development have been evaluated. It has been determined that flood risk and associated impacts can be effectively mitigated to an acceptable level through the implementation of the following measures:

- Ensure flood function is maintained;
- Allow for projected climate change impacts in setting flood planning levels;
- Provide safe access routes during long duration flood events;
- Ensure occupants can safely shelter in-place during flash flooding.

By adhering to these strategies, the proposed development can effectively manage flood risk while facilitating safe and sustainable urban growth in the Orchard Hills Stage 1 rezoning area.

The post-development flood modelling has incorporated, both directly and indirectly, relevant features of the Water Cycle Management Strategy (Design Flow, 2024), inclusive of a number of proposed on-site detention basins where required to limit flows on private property or critical infrastructure. If changes to this strategy are proposed, flood model updates will be required to reflect these changes.

The results of site-specific flood modelling revealed that post-development increases in eastern local catchment flows do not have an adverse impact on Wianamatta-South Creek flood behaviour. It has therefore been recommended that sub-catchments draining directly to Wianmatta-South Creek are exempt from the requirement for on-site detention. This is consistent with the Cumulative Impact Assessment (Advisian, 2023) which recommends minimising the attenuation of tributary flows to avoid potential increases in flows along Wianamatta-South Creek.

10 References

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Appendix A

Existing Flood Conditions

N
W E
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RG-01-001

0.5 EY Pre-Development Peak Flood Depth and Elevation

Legend

- Stage 1 Boundary
- Investigation Area
- Hydraulic Model Extent
- Cadastre

Flood Level Contour
- 5m
- 1m

Peak Flood Depth (m)
- <= 0.01
- 0.01 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 3
- 3 - 4
- > 4

0 250 500 m

Scale : 1:20000@A3
Date : 21 May 2024
Revision : 01
Created by : JPS
Coordinate System : GDA2020
MGA Zone 56

Rhelm

Aerial Imagery: NSW Spatial Services

N
W E
S

RG-01-002

20% AEP Pre-Development Peak Flood Depth and Elevation

Legend

- Stage 1 Boundary
- Investigation Area
- Hydraulic Model Extent
- Cadastre

Flood Level Contour
- 5m
- 1m

Peak Flood Depth (m)
- <= 0.01
- 0.01 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 3
- 3 - 4
- > 4

0 250 500 m

Scale : 1:20000@A3
Date : 21 May 2024
Revision : 01
Created by : JPS
Coordinate System : GDA2020
MGA Zone 56

Rhelm

Aerial Imagery: NSW Spatial Services

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W E
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RG-01-003

1% AEP Pre-Development Peak Flood Depth and Elevation

Legend

- Stage 1 Boundary
- Investigation Area
- Hydraulic Model Extent
- Cadastre

Flood Level Contour
- 5m
- 1m

Peak Flood Depth (m)
- <= 0.01
- 0.01 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 3
- 3 - 4
- > 4

0 250 500 m

Scale : 1:20000@A3
Date : 21 May 2024
Revision : 01
Created by : JPS
Coordinate System : GDA2020
MGA Zone 56

Rhelm

Aerial Imagery: NSW Spatial Services

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RG-01-004

0.5% AEP Pre-Development Peak Flood Depth and Elevation

Legend

- Stage 1 Boundary
- Investigation Area
- Hydraulic Model Extent
- Cadastre

Flood Level Contour
- 5m
- 1m

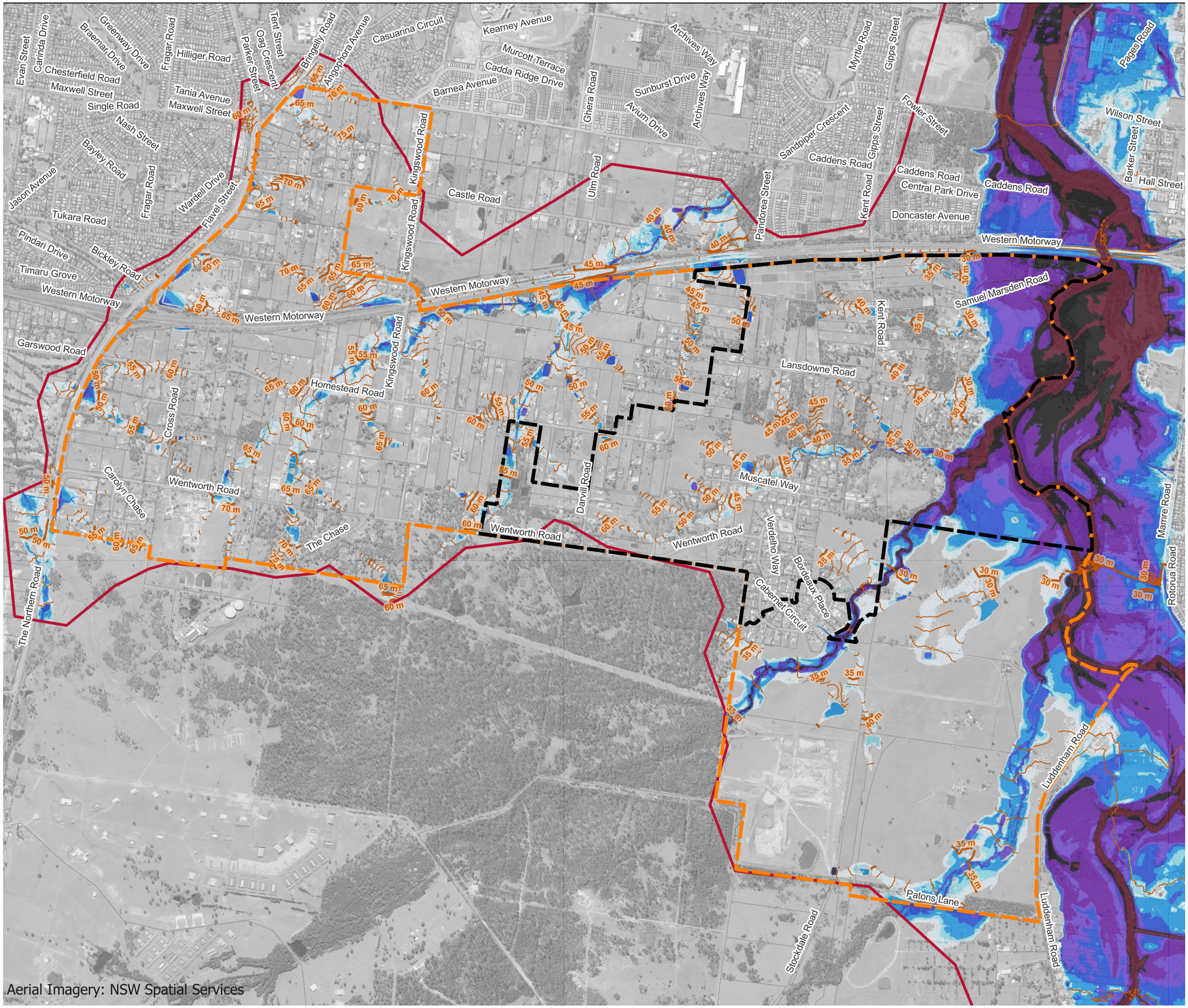
Peak Flood Depth (m)
- <= 0.01
- 0.01 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 3
- 3 - 4
- > 4

0 250 500 m

Scale : 1:20000@A3
Date : 21 May 2024
Revision : 01
Created by : JPS
Coordinate System : GDA2020
MGA Zone 56

Rhelm

Aerial Imagery: NSW Spatial Services



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RG-01-005

0.2% AEP Pre-Development Peak Flood Depth and Elevation

Legend

- Stage 1 Boundary
- Investigation Area
- Hydraulic Model Extent
- Cadastre

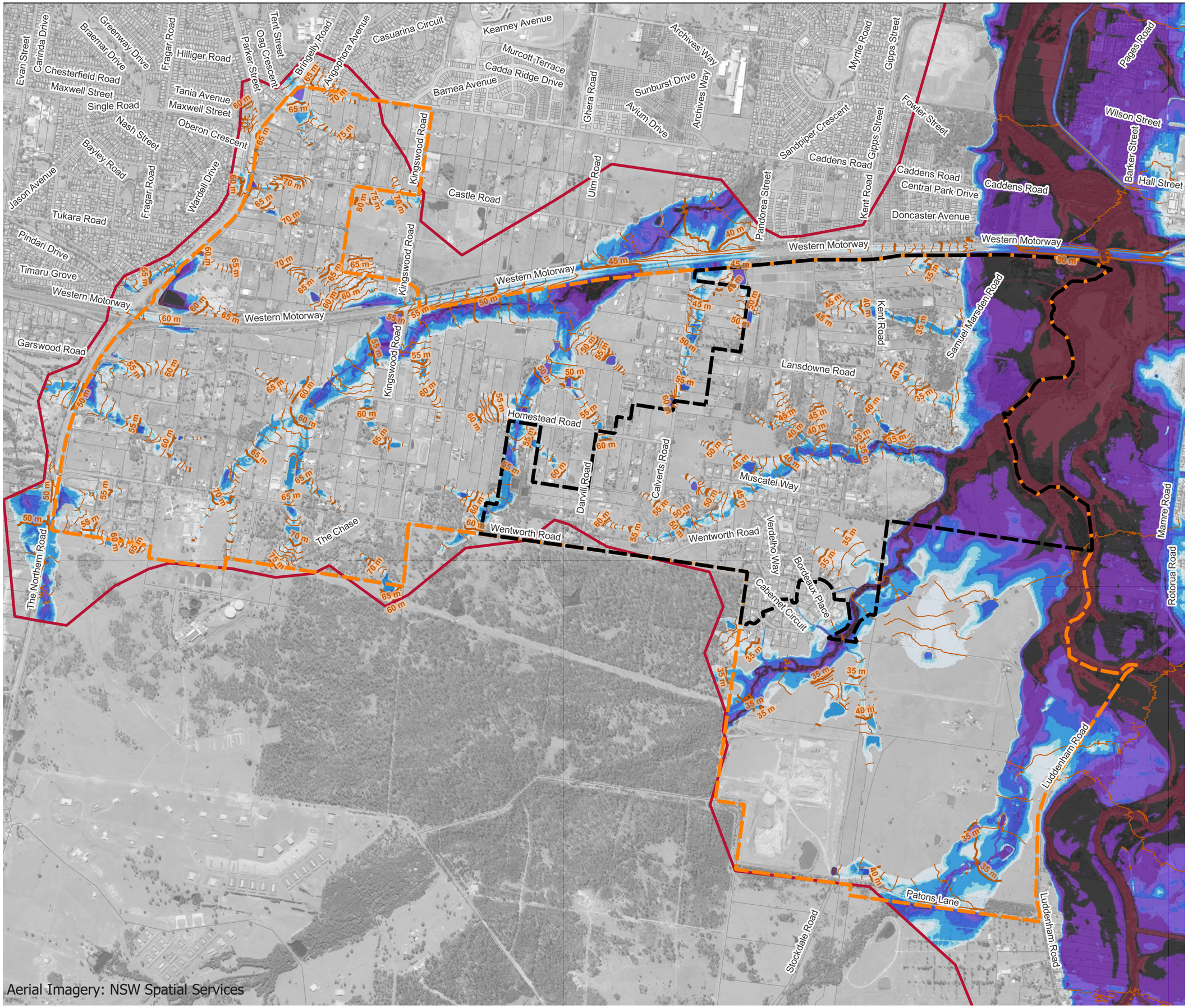
Flood Level Contour
- 5m
- 1m

Peak Flood Depth (m)
- <= 0.01
- 0.01 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 3
- 3 - 4
- > 4

0 250 500 m

Scale : 1:20000@A3
Date : 21 May 2024
Revision : 01
Created by : JPS
Coordinate System : GDA2020
MGA Zone 56

Rhelm



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RG-01-006

PMF Pre-Development Peak Flood Depth and Elevation

Legend

- Stage 1 Boundary
- Investigation Area
- Hydraulic Model Extent
- Cadastre

Flood Level Contour

- 5m
- 1m

Peak Flood Depth (m)

- <= 0.01
- 0.01 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 3
- 3 - 4
- > 4

0 250 500 m

Scale : 1:20000@A3
Date : 21 May 2024
Revision : 01
Created by : JPS
Coordinate System : GDA2020
MGA Zone 56

Rhelm

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RG-01-010

0.5 EY Pre-Development Peak Velocity

Legend

- Stage 1 Boundary
- Investigation Area
- Hydraulic Model Extent
- Cadastre

Peak Flood Velocity (m/s)

- <=0.01
- 0.01 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- > 4

0 250 500 m

Scale : 1:20000@A3
Date : 21 May 2024
Revision : 01
Created by : JPS
Coordinate System : GDA2020
MGA Zone 56

Rhelm

Aerial Imagery: NSW Spatial Services

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RG-01-011

20% AEP Pre-Development Peak Velocity

Legend

- Stage 1 Boundary
- Investigation Area
- Hydraulic Model Extent
- Cadastre

Peak Flood Velocity (m/s)

- <=0.01
- 0.01 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- > 4

0 250 500 m

Scale : 1:20000@A3
Date : 21 May 2024
Revision : 01
Created by : JPS
Coordinate System : GDA2020
MGA Zone 56

Rhelm

Aerial Imagery: NSW Spatial Services

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RG-01-012

1% AEP Pre-Development Peak Velocity

Legend

- Stage 1 Boundary
- Investigation Area
- Hydraulic Model Extent
- Cadastre

Peak Flood Velocity (m/s)

- <=0.01
- 0.01 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- > 4

0 250 500 m

Scale : 1:20000@A3
Date : 21 May 2024
Revision : 01
Created by : JPS
Coordinate System : GDA2020
MGA Zone 56

Rhelm

Aerial Imagery: NSW Spatial Services

N
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RG-01-013

0.5% AEP Pre-Development Peak Velocity

Legend

- Stage 1 Boundary
- Investigation Area
- Hydraulic Model Extent
- Cadastre

Peak Flood Velocity (m/s)

- <=0.01
- 0.01 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- > 4

0 250 500 m

Scale : 1:20000@A3
Date : 21 May 2024
Revision : 01
Created by : JPS
Coordinate System : GDA2020
MGA Zone 56

Rhelm

Aerial Imagery: NSW Spatial Services

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RG-01-014

0.2% AEP Pre-Development Peak Velocity

Legend

- Stage 1 Boundary
- Investigation Area
- Hydraulic Model Extent
- Cadastre

Peak Flood Velocity (m/s)

- <=0.01
- 0.01 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- > 4

0 250 500 m

Scale : 1:20000@A3
Date : 21 May 2024
Revision : 01
Created by : JPS
Coordinate System : GDA2020
MGA Zone 56

Rhelm

Aerial Imagery: NSW Spatial Services

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RG-01-015

PMF
Pre-Development
Peak Velocity

Legend

- Stage 1 Boundary
- Investigation Area
- Hydraulic Model Extent
- Cadastre

Peak Flood Velocity (m/s)

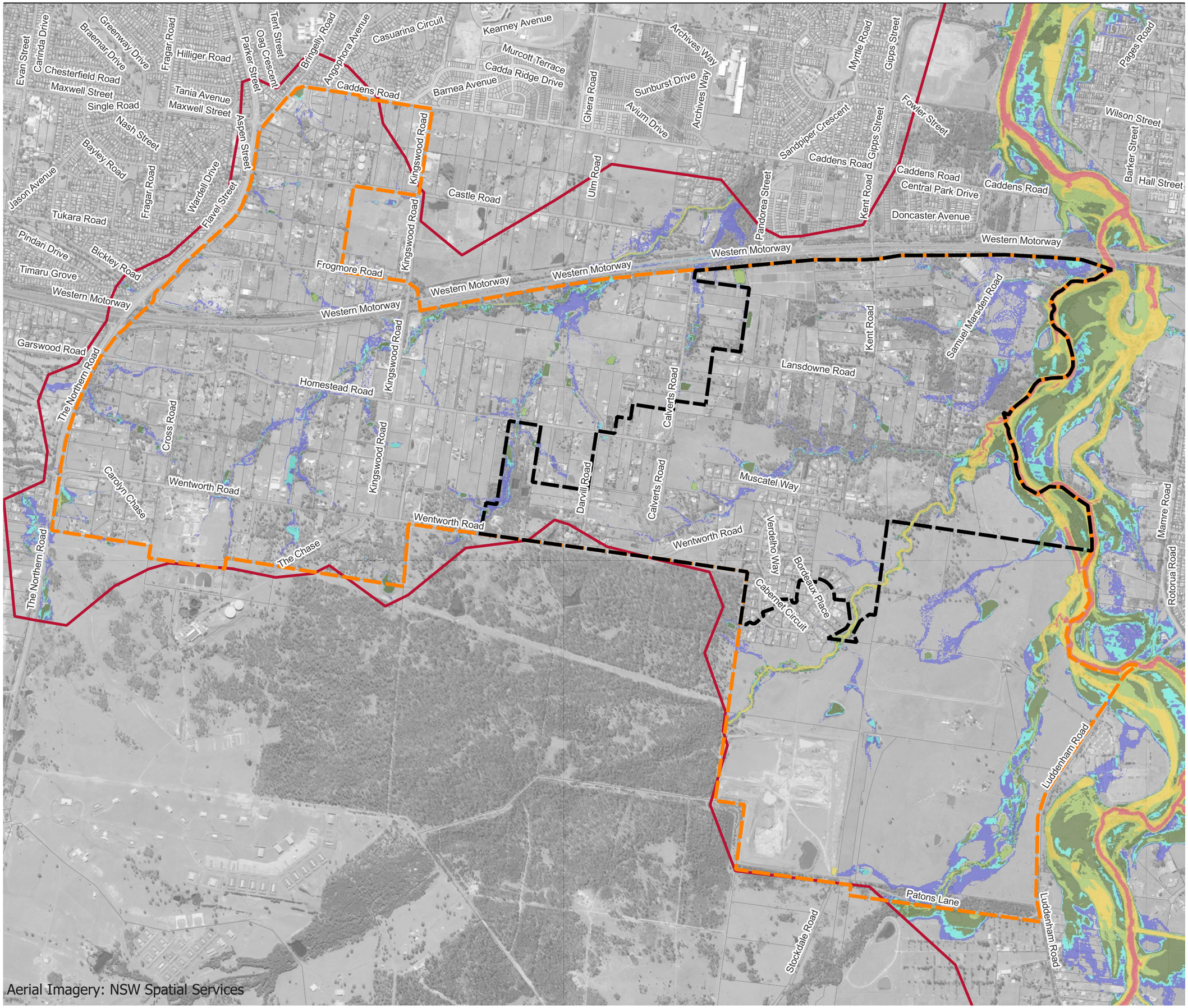
- <=0.01
- 0.01 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- > 4

0 250 500 m

Scale : 1:20000@A3
Date : 21 May 2024
Revision : 01
Created by : JPS
Coordinate System : GDA2020
MGA Zone 56

Rhelm

Aerial Imagery: NSW Spatial Services



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RG-01-020

0.5 EY
Pre-Development
Peak Flood Hazard

Legend

- Stage 1 Boundary
- Investigation Area
- Hydraulic Model Extent
- Cadastre

Peak Flood Hazard

- H1 - Generally safe for vehicles, people & buildings
- H2 - Unsafe for small vehicles
- H3 - Unsafe for vehicles, children and the elderly
- H4 - Unsafe for vehicles and people
- H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure
- H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure

0 250 500 m

Scale : 1:20000@A3
Date : 21 May 2024
Revision : 01
Created by : JPS
Coordinate System : GDA2020
MGA Zone 56

Rhelm

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RG-01-021

20% AEP
Pre-Development
Peak Flood Hazard

Legend

- Stage 1 Boundary
- Investigation Area
- Hydraulic Model Extent
- Cadastre

Peak Flood Hazard

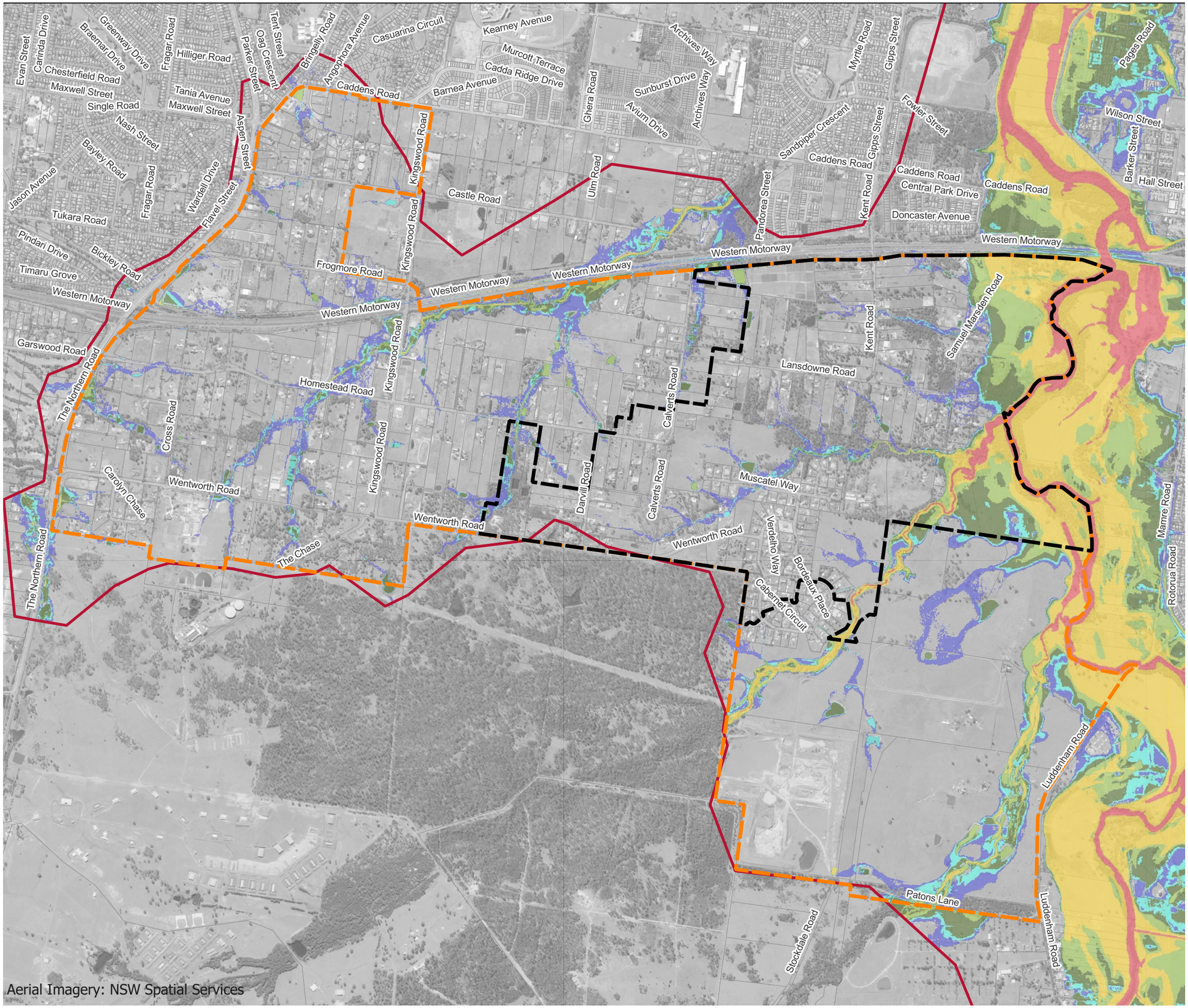
- H1 - Generally safe for vehicles, people & buildings
- H2 - Unsafe for small vehicles
- H3 - Unsafe for vehicles, children and the elderly
- H4 - Unsafe for vehicles and people
- H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure
- H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure

0 250 500 m

Scale : 1:20000@A3
Date : 21 May 2024
Revision : 01
Created by : JPS
Coordinate System : GDA2020
MGA Zone 56

Rhelm

Aerial Imagery: NSW Spatial Services



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RG-01-022

1% AEP Pre-Development Peak Flood Hazard

Legend

- Stage 1 Boundary
- Investigation Area
- Hydraulic Model Extent
- Cadastre

Peak Flood Hazard

- H1 - Generally safe for vehicles, people & buildings
- H2 - Unsafe for small vehicles
- H3 - Unsafe for vehicles, children and the elderly
- H4 - Unsafe for vehicles and people
- H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure
- H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure

0 250 500 m

Scale : 1:20000@A3
Date : 21 May 2024
Revision : 01
Created by : JPS
Coordinate System : GDA2020
MGA Zone 56

Rhelm

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RG-01-023

0.5% AEP
Pre-Development
Peak Flood Hazard

Legend

- Stage 1 Boundary
- Investigation Area
- Hydraulic Model Extent
- Cadastre

Peak Flood Hazard

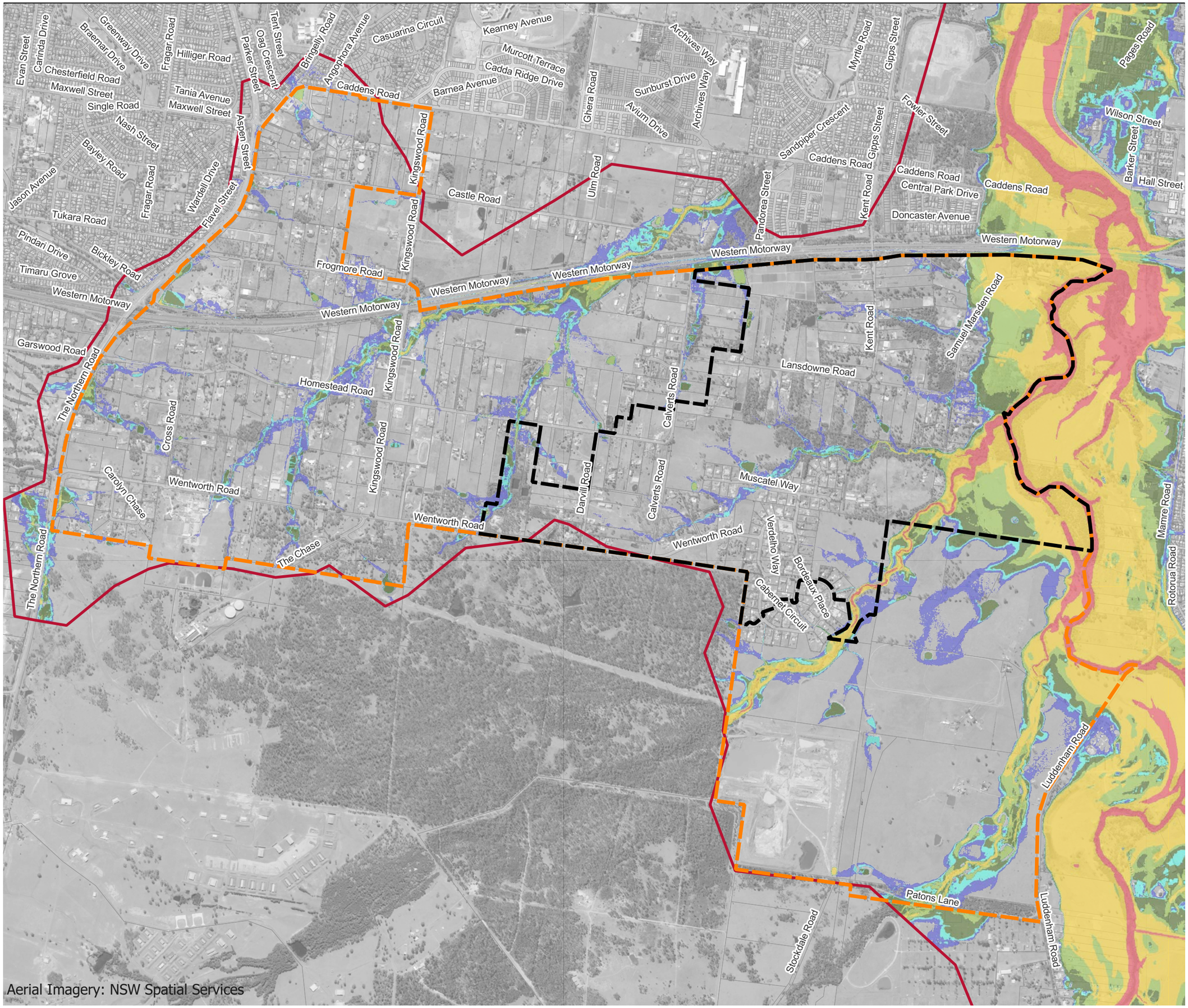
- H1 - Generally safe for vehicles, people & buildings
- H2 - Unsafe for small vehicles
- H3 - Unsafe for vehicles, children and the elderly
- H4 - Unsafe for vehicles and people
- H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure
- H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure

0 250 500 m

Scale : 1:20000@A3
Date : 21 May 2024
Revision : 01
Created by : JPS
Coordinate System : GDA2020
MGA Zone 56

Rhelm

Aerial Imagery: NSW Spatial Services



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RG-01-024

0.2% AEP
Pre-Development
Peak Flood Hazard

Legend

- Stage 1 Boundary
- Investigation Area
- Hydraulic Model Extent
- Cadastre

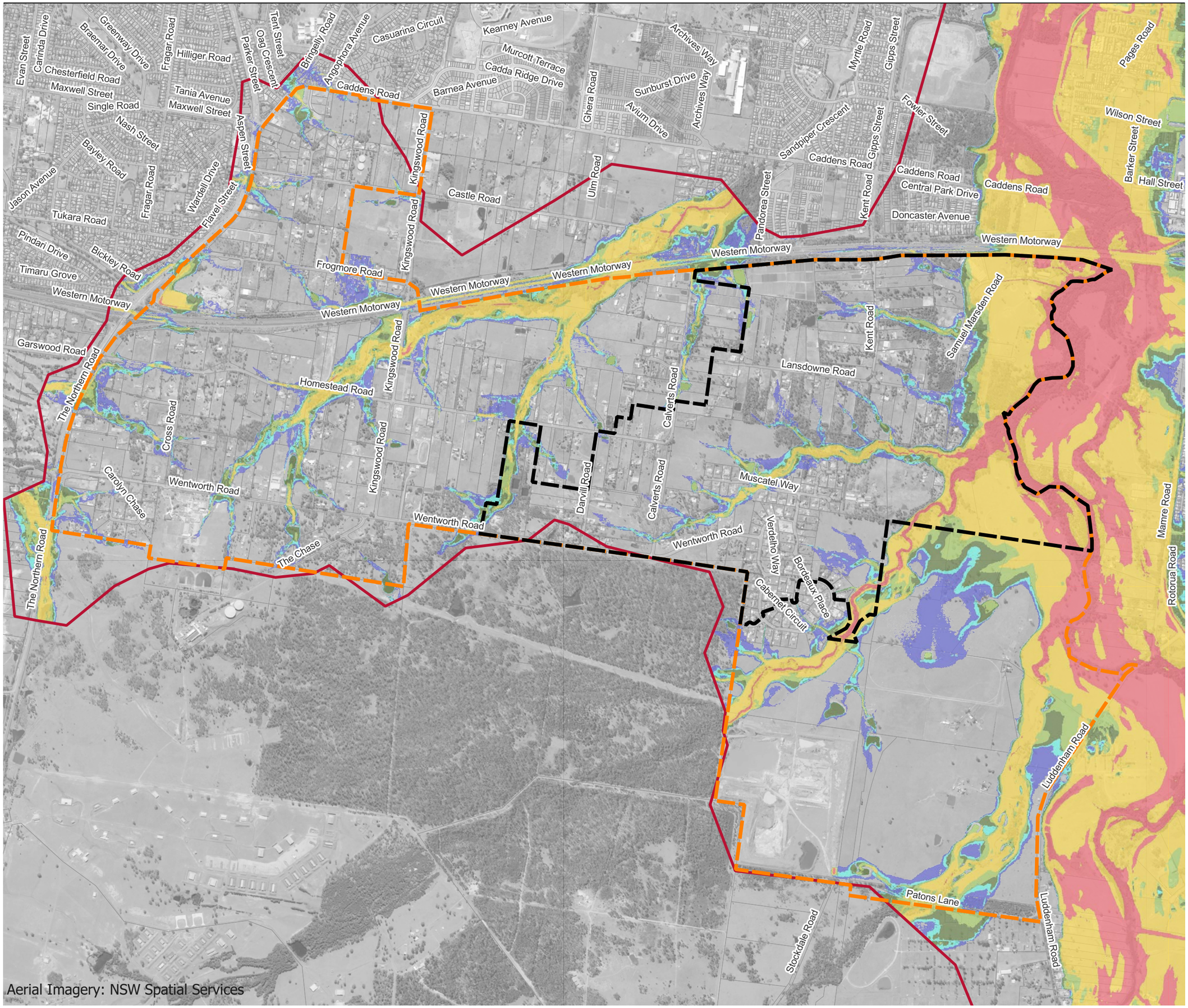
Peak Flood Hazard

- H1 - Generally safe for vehicles, people & buildings
- H2 - Unsafe for small vehicles
- H3 - Unsafe for vehicles, children and the elderly
- H4 - Unsafe for vehicles and people
- H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure
- H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure

0 250 500 m

Scale : 1:20000@A3
Date : 21 May 2024
Revision : 01
Created by : JPS
Coordinate System : GDA2020
MGA Zone 56

Rhelm



N

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RG-01-025

PMF
Pre-Development
Peak Flood Hazard

Legend

- Stage 1 Boundary
- Investigation Area
- Hydraulic Model Extent
- Cadastre

Peak Flood Hazard

- H1 - Generally safe for vehicles, people & buildings
- H2 - Unsafe for small vehicles
- H3 - Unsafe for vehicles, children and the elderly
- H4 - Unsafe for vehicles and people
- H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure
- H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure

0 250 500 m

Scale : 1:20000@A3
Date : 21 May 2024
Revision : 01
Created by : JPS
Coordinate System : GDA2020
MGA Zone 56

Rhelm

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W E

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RG-01-030

0.2% AEP Pre-Development Flood Function

Legend

- Stage 1 Boundary
- Investigation Area
- Hydraulic Model Extent
- Cadastre

Flood Function

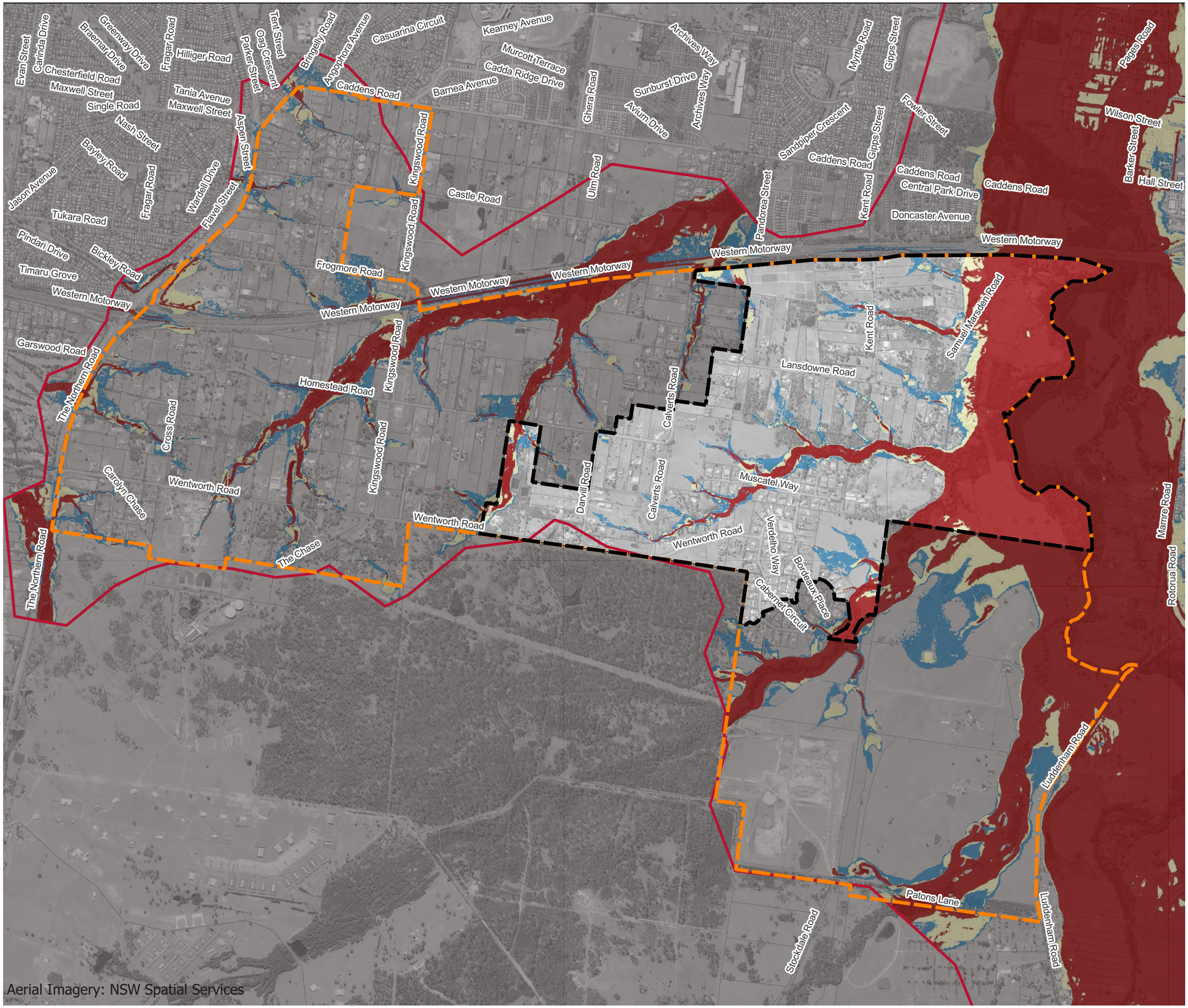
- Floodway
- Flood Storage
- Flood Fringe

0 250 500 m

Scale : 1:20000@A3
Date : 21 May 2024
Revision : 01
Created by : JPS
Coordinate System : GDA2020
MGA Zone 56

Rhelm

Aerial Imagery: NSW Spatial Services



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RG-01-031

PMF
Pre-Development
Flood Function

Legend

- Stage 1 Boundary
- Investigation Area
- Hydraulic Model Extent
- Cadastre

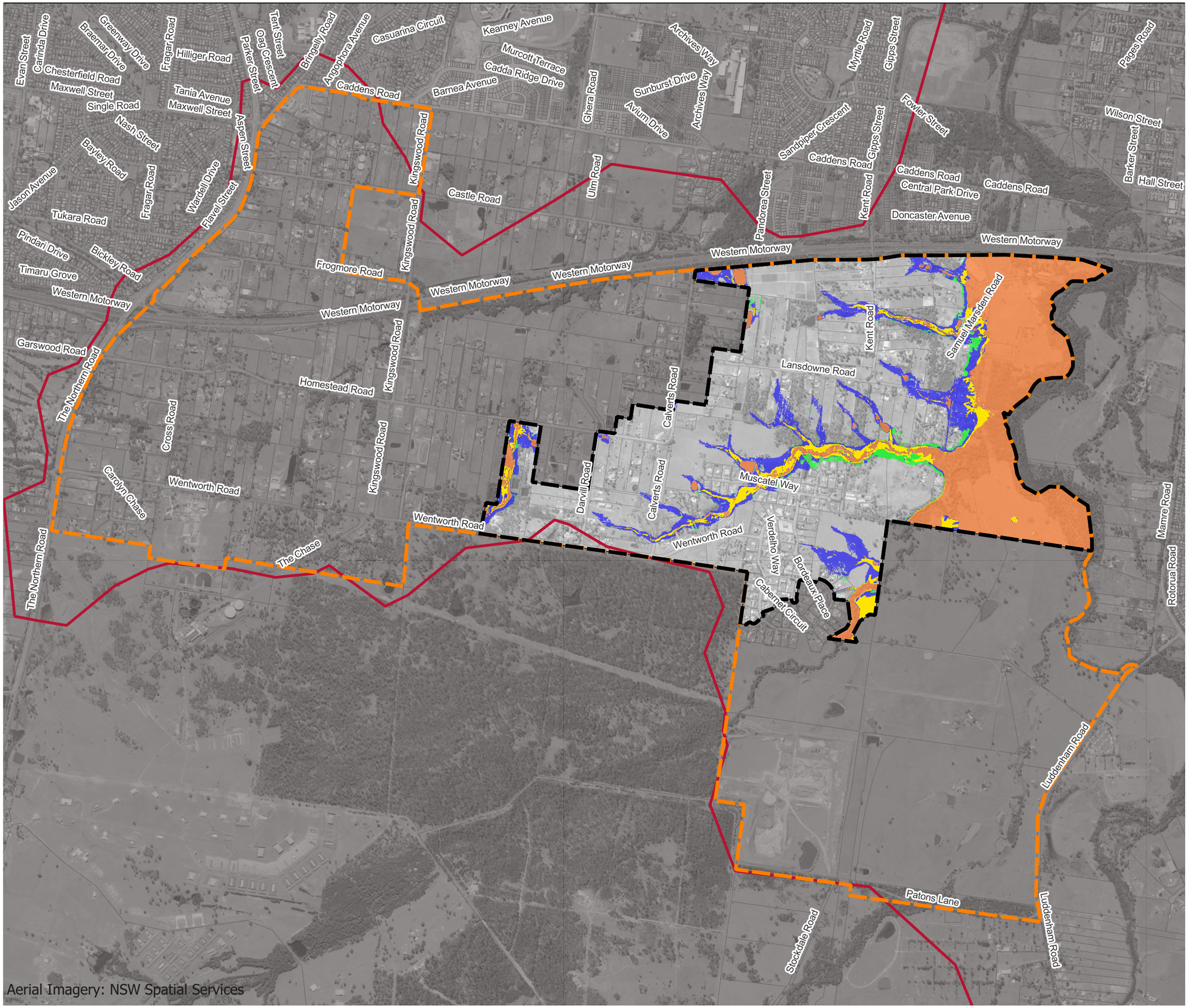
Flood Function

- Floodway
- Flood Storage
- Flood Fringe

0 250 500 m

Scale : 1:20000@A3
Date : 21 May 2024
Revision : 01
Created by : JPS
Coordinate System : GDA2020
MGA Zone 56

Rhelm



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RG-01-040

Pre-Development Flood Planning Constraint Category

Legend

- Stage 1 Boundary
- Investigation Area
- Hydraulic Model Extent
- Cadastre

Flood Planning Constraint Category

- FPCC1
- FPCC2
- FPCC3
- FPCC4

0 250 500 m

Scale : 1:20000@A3
Date : 21 May 2024
Revision : 01
Created by : JPS
Coordinate System : GDA2020
MGA Zone 56

Rhelm

N

W E

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RG-01-050

0.5% AEP less 1% AEP Pre-Development Climate Change Impacts

Legend

- Stage 1 Boundary
- Investigation Area
- Hydraulic Model Extent
- Cadastre

Flood Level Impact (m)

- 0 - 0.01
- 0.01 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- > 0.3

0 250 500 m

Scale : 1:20000@A3
Date : 21 May 2024
Revision : 01
Created by : JPS
Coordinate System : GDA2020
MGA Zone 56

Rhelm

Aerial Imagery: NSW Spatial Services

N
W E
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RG-01-051

0.2% AEP less 1% AEP Pre-Development Climate Change Impacts

Legend

- Stage 1 Boundary
- Investigation Area
- Hydraulic Model Extent
- Cadastre

Flood Level Impact (m)

- 0 - 0.01
- 0.01 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- > 0.3

0 250 500 m

Scale : 1:20000@A3
Date : 21 May 2024
Revision : 01
Created by : JPS
Coordinate System : GDA2020
MGA Zone 56

Rhelm

Aerial Imagery: NSW Spatial Services

Appendix B

Post Development Flood Conditions and Impacts

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RG-02-001

0.5 EY Post-Development Peak Flood Depth and Elevation

Legend

Stage 1 Boundary
Investigation Area
Hydraulic Model Extent

Flood Level Contour
5m
1m

Peak Flood Depth (m)
<= 0.01
0.01 - 0.3
0.3 - 0.5
0.5 - 1
1 - 1.5
1.5 - 2
2 - 3
3 - 4
> 4

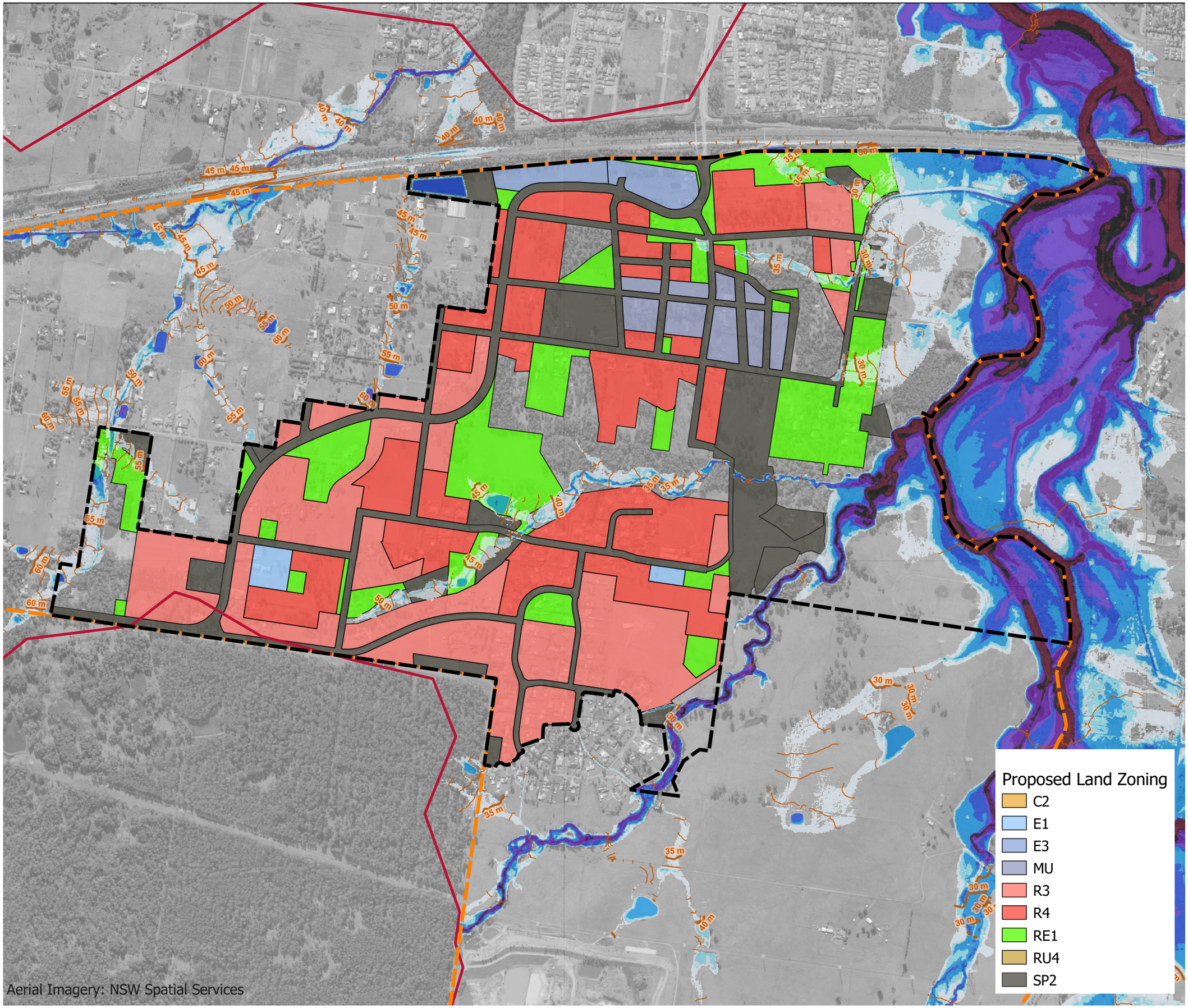
Proposed Land Zoning
C2
E1
E3
MU
R3
R4
RE1
RU4
SP2

0 250 500 m

Scale : 1:12000@A3
Date : 18 June 2024
Revision : 03
Created by : JPS
Coordinate System : GDA2020
MGA Zone 56

Rhelm

Aerial Imagery: NSW Spatial Services



N

W E

S

RG-02-002

20% AEP Post-Development Peak Flood Depth and Elevation

Legend

Stage 1 Boundary

Investigation Area

Hydraulic Model Extent

Flood Level Contour

5m

1m

Peak Flood Depth (m)

<= 0.01

0.01 - 0.3

0.3 - 0.5

0.5 - 1

1 - 1.5

1.5 - 2

2 - 3

3 - 4

> 4

0 250 500 m

Scale : 1:12000@A3
Date : 18 June 2024
Revision : 03
Created by : JPS
Coordinate System : GDA2020
MGA Zone 56

Rhelm

N

W E

S

RG-02-003

1% AEP Post-Development Peak Flood Depth and Elevation

Legend

Stage 1 Boundary

Investigation Area

Hydraulic Model Extent

Flood Level Contour

5m

1m

Peak Flood Depth (m)

<= 0.01

0.01 - 0.3

0.3 - 0.5

0.5 - 1

1 - 1.5

1.5 - 2

2 - 3

3 - 4

> 4

Proposed Land Zoning

C2

E1

E3

MU

R3

R4

RE1

RU4

SP2

0 250 500 m

Scale : 1:12000@A3
Date : 18 June 2024
Revision : 03
Created by : JPS
Coordinate System : GDA2020
MGA Zone 56

Rhelm

Aerial Imagery: NSW Spatial Services

N

W E

S

RG-02-004

0.5% AEP Post-Development Peak Flood Depth and Elevation

Legend

Stage 1 Boundary

Investigation Area

Hydraulic Model Extent

Flood Level Contour

5m

1m

Peak Flood Depth (m)

<= 0.01

0.01 - 0.3

0.3 - 0.5

0.5 - 1

1 - 1.5

1.5 - 2

2 - 3

3 - 4

> 4

Proposed Land Zoning

C2

E1

E3

MU

R3

R4

RE1

RU4

SP2

0 250 500 m

Scale : 1:12000@A3
Date : 18 June 2024
Revision : 03
Created by : JPS
Coordinate System : GDA2020
MGA Zone 56

Rhelm

Aerial Imagery: NSW Spatial Services

N

W E

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RG-02-005

0.2% AEP Post-Development Peak Flood Depth and Elevation

Legend

Stage 1 Boundary

Investigation Area

Hydraulic Model Extent

Flood Level Contour

5m

1m

Peak Flood Depth (m)

<= 0.01

0.01 - 0.3

0.3 - 0.5

0.5 - 1

1 - 1.5

1.5 - 2

2 - 3

3 - 4

> 4

Proposed Land Zoning

C2

E1

E3

MU

R3

R4

RE1

RU4

SP2

0 250 500 m

Scale : 1:12000@A3
Date : 18 June 2024
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Aerial Imagery: NSW Spatial Services

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RG-02-006

PMF Post-Development Peak Flood Depth and Elevation

Legend

- Stage 1 Boundary
- Investigation Area
- Hydraulic Model Extent

Flood Level Contour

- 5m
- 1m

Peak Flood Depth (m)

- <= 0.01
- 0.01 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 3
- 3 - 4
- > 4

Proposed Land Zoning

- C2
- E1
- E3
- MU
- R3
- R4
- RE1
- RU4
- SP2

0 250 500 m

Scale : 1:12000@A3
Date : 18 June 2024
Revision : 03
Created by : JPS
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RG-02-010

0.5 EY
Post-Development
Peak Velocity

Legend

- Stage 1 Boundary
- Investigation Area
- Hydraulic Model Extent

Peak Flood Velocity (m/s)

- <=0.01
- 0.01 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- > 4

Proposed Land Zoning

- C2
- E1
- E3
- MU
- R3
- R4
- RE1
- RU4
- SP2

0 250 500 m

Scale : 1:12000@A3
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RG-02-011

20% AEP
Post-Development
Peak Velocity

Legend

- Stage 1 Boundary
- Investigation Area
- Hydraulic Model Extent

Peak Flood Velocity (m/s)

- <=0.01
- 0.01 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- > 4

Proposed Land Zoning

- C2
- E1
- E3
- MU
- R3
- R4
- RE1
- RU4
- SP2

0 250 500 m

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RG-02-012

1% AEP
Post-Development
Peak Velocity

Legend

- Stage 1 Boundary
- Investigation Area
- Hydraulic Model Extent

Peak Flood Velocity (m/s)

- <=0.01
- 0.01 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- > 4

Proposed Land Zoning

- C2
- E1
- E3
- MU
- R3
- R4
- RE1
- RU4
- SP2

0 250 500 m

Scale : 1:12000@A3
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RG-02-013

0.5% AEP Post-Development Peak Velocity

Legend

- Stage 1 Boundary
- Investigation Area
- Hydraulic Model Extent

Peak Flood Velocity (m/s)

- <=0.01
- 0.01 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- > 4

Proposed Land Zoning

- C2
- E1
- E3
- MU
- R3
- R4
- RE1
- RU4
- SP2

0 250 500 m

Scale : 1:12000@A3
Date : 18 June 2024
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RG-02-014

0.2% AEP Post-Development Peak Velocity

Legend

- Stage 1 Boundary
- Investigation Area
- Hydraulic Model Extent

Peak Flood Velocity (m/s)

- <=0.01
- 0.01 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- > 4

Proposed Land Zoning

- C2
- E1
- E3
- MU
- R3
- R4
- RE1
- RU4
- SP2

0 250 500 m

Scale : 1:12000@A3
Date : 18 June 2024
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RG-02-015

PMF
Post-Development
Peak Velocity

Legend

- Stage 1 Boundary
- Investigation Area
- Hydraulic Model Extent

Peak Flood Velocity (m/s)

- <=0.01
- 0.01 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- > 4

Proposed Land Zoning

- C2
- E1
- E3
- MU
- R3
- R4
- RE1
- RU4
- SP2

0 250 500 m

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RG-02-020

0.5 EY
Post-Development
Peak Flood Hazard

Legend

- Stage 1 Boundary
- Investigation Area
- Hydraulic Model Extent

Peak Flood Hazard

- H1 - Generally safe for vehicles, people & buildings
- H2 - Unsafe for small vehicles
- H3 - Unsafe for vehicles, children and the elderly
- H4 - Unsafe for vehicles and people
- H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure
- H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure

Proposed Land Zoning

- C2
- E1
- E3
- MU
- R3
- R4
- RE1
- RU4
- SP2

0 250 500 m

Scale : 1:12000@A3
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RG-02-021

20% AEP
Post-Development
Peak Flood Hazard

Legend

- Stage 1 Boundary
- Investigation Area
- Hydraulic Model Extent

Peak Flood Hazard

- H1 - Generally safe for vehicles, people & buildings
- H2 - Unsafe for small vehicles
- H3 - Unsafe for vehicles, children and the elderly
- H4 - Unsafe for vehicles and people
- H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure
- H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure

Proposed Land Zoning

- C2
- E1
- E3
- MU
- R3
- R4
- RE1
- RU4
- SP2

0 250 500 m

Scale : 1:12000@A3
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Aerial Imagery: NSW Spatial Services

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RG-02-022

1% AEP Post-Development Peak Flood Hazard

Legend

- Stage 1 Boundary
- Investigation Area
- Hydraulic Model Extent

Peak Flood Hazard

- H1 - Generally safe for vehicles, people & buildings
- H2 - Unsafe for small vehicles
- H3 - Unsafe for vehicles, children and the elderly
- H4 - Unsafe for vehicles and people
- H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure
- H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure

Proposed Land Zoning

- C2
- E1
- E3
- MU
- R3
- R4
- RE1
- RU4
- SP2

0 250 500 m

Scale : 1:12000@A3
Date : 18 June 2024
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RG-02-023

0.5% AEP Post-Development Peak Flood Hazard

Legend

- Stage 1 Boundary
- Investigation Area
- Hydraulic Model Extent

Peak Flood Hazard

- H1 - Generally safe for vehicles, people & buildings
- H2 - Unsafe for small vehicles
- H3 - Unsafe for vehicles, children and the elderly
- H4 - Unsafe for vehicles and people
- H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure
- H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure

Proposed Land Zoning

- C2
- E1
- E3
- MU
- R3
- R4
- RE1
- RU4
- SP2

0 250 500 m

Scale : 1:12000@A3
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RG-02-024

0.2% AEP Post-Development Peak Flood Hazard

Legend

- Stage 1 Boundary
- Investigation Area
- Hydraulic Model Extent

Peak Flood Hazard

- H1 - Generally safe for vehicles, people & buildings
- H2 - Unsafe for small vehicles
- H3 - Unsafe for vehicles, children and the elderly
- H4 - Unsafe for vehicles and people
- H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure
- H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure

Proposed Land Zoning

- C2
- E1
- E3
- MU
- R3
- R4
- RE1
- RU4
- SP2

0 250 500 m

Scale : 1:12000@A3
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Aerial Imagery: NSW Spatial Services

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RG-02-025

PMF
Post-Development
Peak Flood Hazard

Legend

- Stage 1 Boundary
- Investigation Area
- Hydraulic Model Extent

Peak Flood Hazard

- H1 - Generally safe for vehicles, people & buildings
- H2 - Unsafe for small vehicles
- H3 - Unsafe for vehicles, children and the elderly
- H4 - Unsafe for vehicles and people
- H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure
- H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure

Proposed Land Zoning

- C2
- E1
- E3
- MU
- R3
- R4
- RE1
- RU4
- SP2

0 250 500 m

Scale : 1:12000@A3
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Aerial Imagery: NSW Spatial Services

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RG-02-030

0.2% AEP Post-Development Flood Function

Legend

- Stage 1 Boundary
- Investigation Area
- Hydraulic Model Extent

Flood Function

- Floodway
- Flood Storage
- Flood Fringe

Proposed Land Zoning

- C2
- E1
- E3
- MU
- R3
- R4
- RE1
- RU4
- SP2

0 250 500 m

Scale : 1:12000@A3
Date : 18 June 2024
Revision : 03
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Coordinate System : GDA2020
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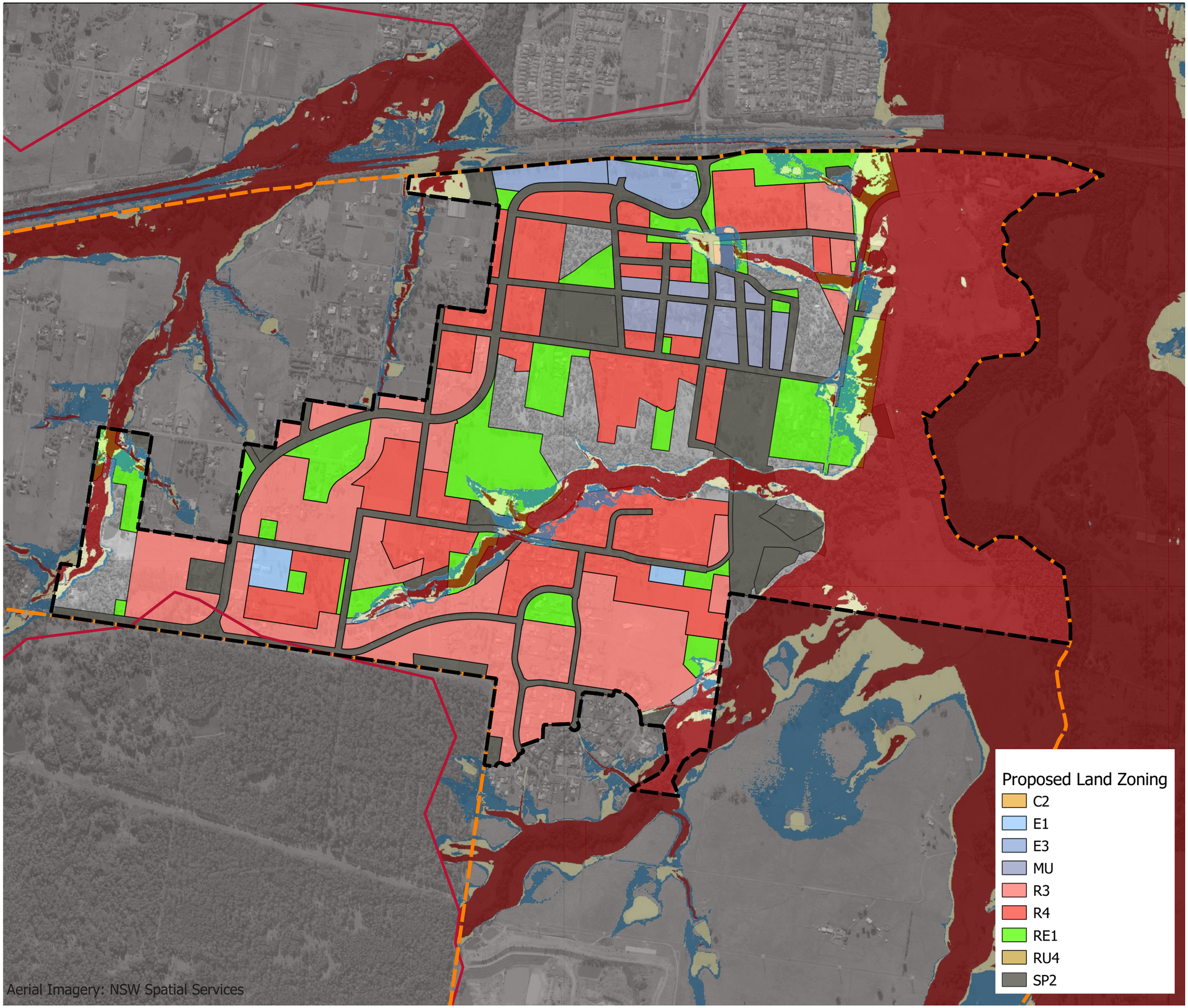

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RG-02-031

PMF
Post-Development
Flood Function

Legend

- Stage 1 Boundary
- Investigation Area
- Hydraulic Model Extent

Flood Function

- Floodway
- Flood Storage
- Flood Fringe

0 250 500 m

Scale : 1:12000@A3
Date : 18 June 2024
Revision : 03
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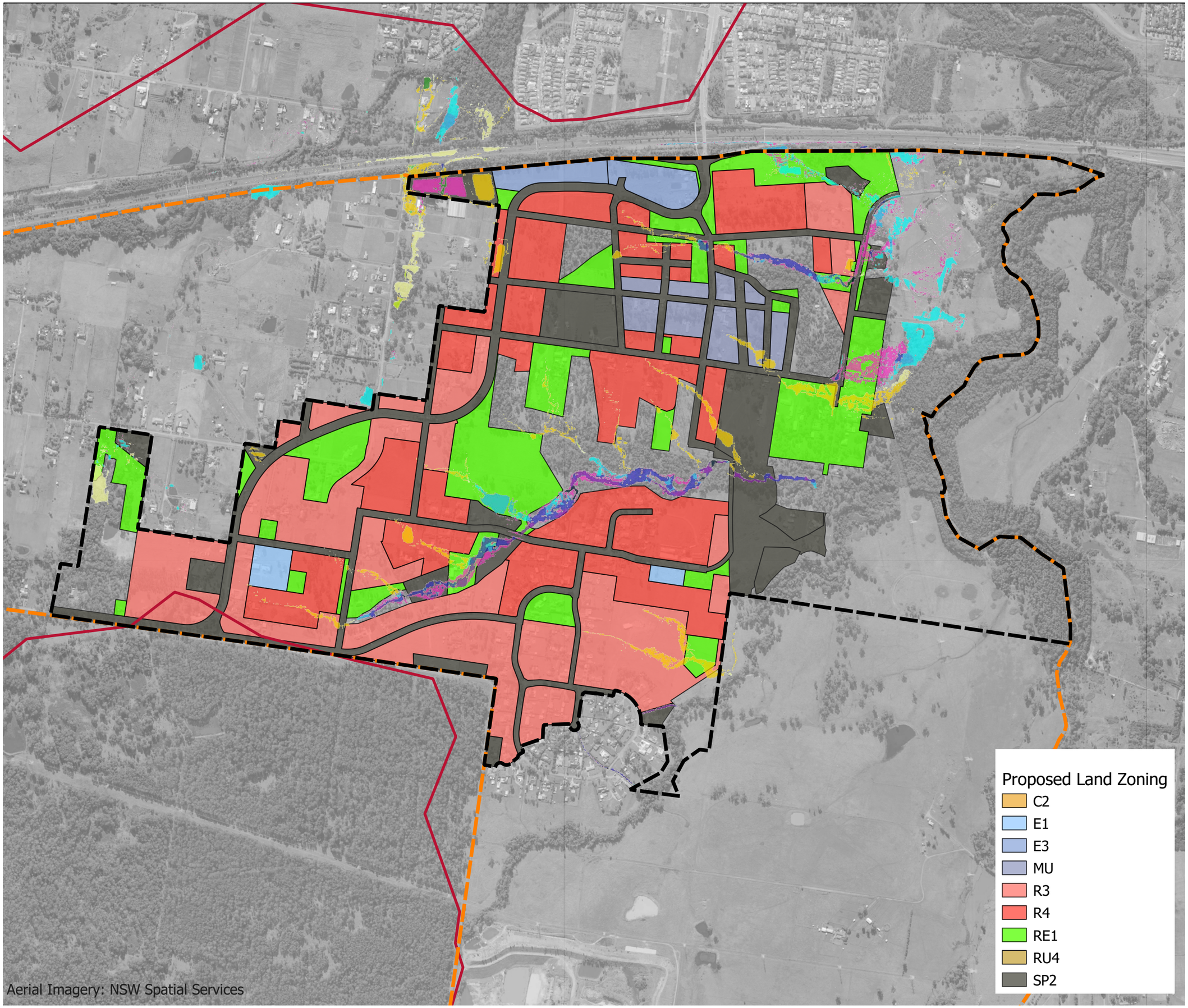

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RG-02-040

0.5 EY
Post-Development less
Pre-Development
Flood Level Impact

Legend

- Stage 1 Boundary
- Investigation Area
- Hydraulic Model Extent

Flood Level Impact (m)

- <= -0.3
- -0.3 - -0.2
- -0.2 - -0.1
- -0.1 - -0.02
- -0.02 - 0.02
- 0.02 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- > 0.3
- Was wet, now dry
- Was dry now wet

0 250 500 m

Scale : 1:12000@A3
Date : 18 June 2024
Revision : 03
Created by : JPS
Coordinate System : GDA2020
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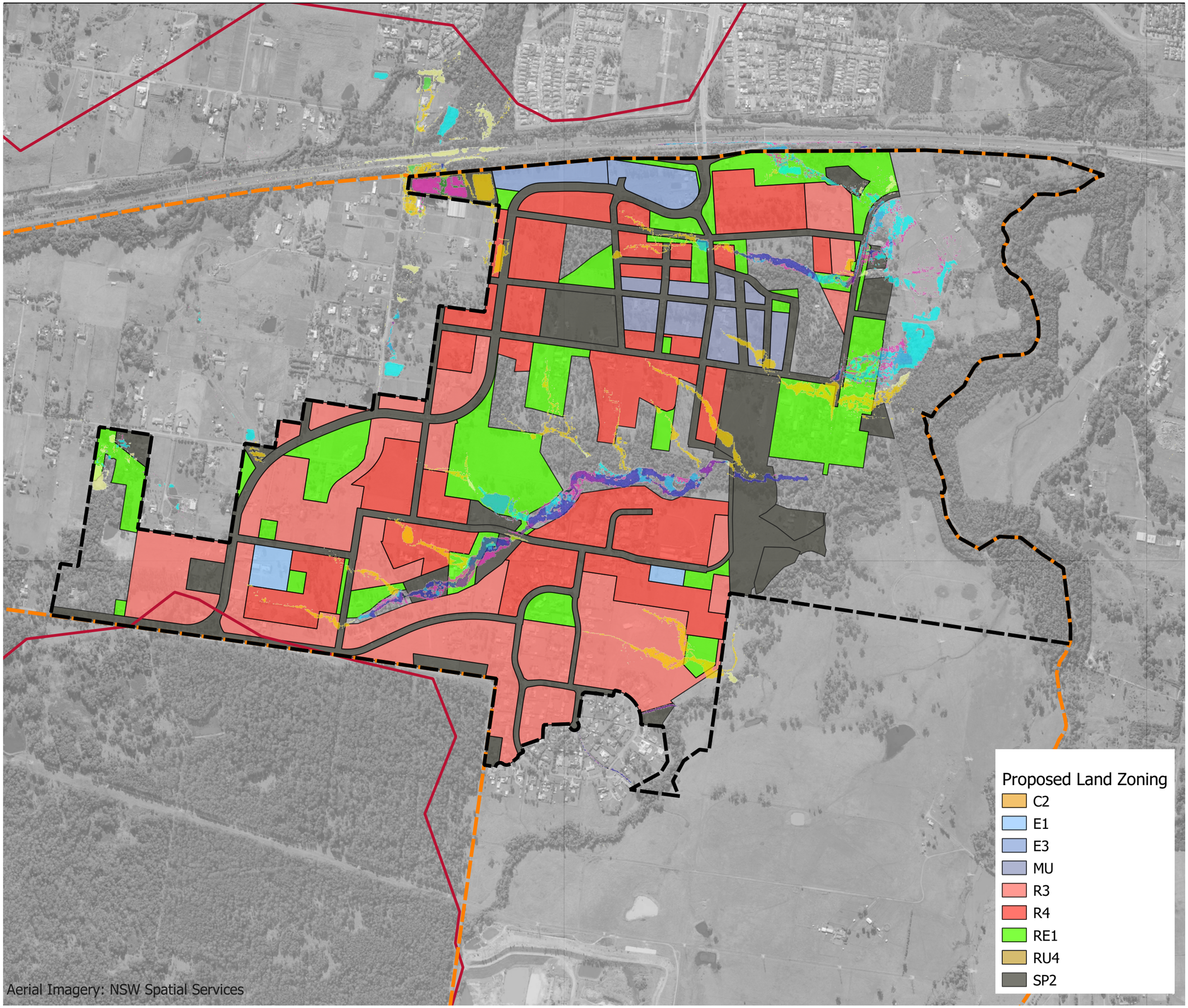

N
W E
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RG-02-041

20% AEP
Post-Development less
Pre-Development
Flood Level Impact

Legend

- Stage 1 Boundary
- Investigation Area
- Hydraulic Model Extent

Flood Level Impact (m)

- <= -0.3
- -0.3 - -0.2
- -0.2 - -0.1
- -0.1 - -0.02
- -0.02 - 0.02
- 0.02 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- > 0.3
- Was wet, now dry
- Was dry now wet

0 250 500 m

Scale : 1:12000@A3
Date : 18 June 2024
Revision : 03
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RG-02-042

1% AEP
Post-Development less
Pre-Development
Flood Level Impact

Legend

- Stage 1 Boundary
- Investigation Area
- Hydraulic Model Extent

Flood Level Impact (m)

- <= -0.3
- -0.3 - -0.2
- -0.2 - -0.1
- -0.1 - -0.02
- -0.02 - 0.02
- 0.02 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- > 0.3
- Was wet, now dry
- Was dry now wet

Proposed Land Zoning

- C2
- E1
- E3
- MU
- R3
- R4
- RE1
- RU4
- SP2

0 250 500 m

Scale : 1:12000@A3
Date : 18 June 2024
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RG-02-043

0.5% AEP Post-Development less Pre-Development Flood Level Impact

Legend

- Stage 1 Boundary
- Investigation Area
- Hydraulic Model Extent

Flood Level Impact (m)

- <= -0.3
- -0.3 - -0.2
- -0.2 - -0.1
- -0.1 - -0.02
- -0.02 - 0.02
- 0.02 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- > 0.3
- Was wet, now dry
- Was dry now wet

Proposed Land Zoning

- C2
- E1
- E3
- MU
- R3
- R4
- RE1
- RU4
- SP2

0 250 500 m

Scale : 1:12000@A3
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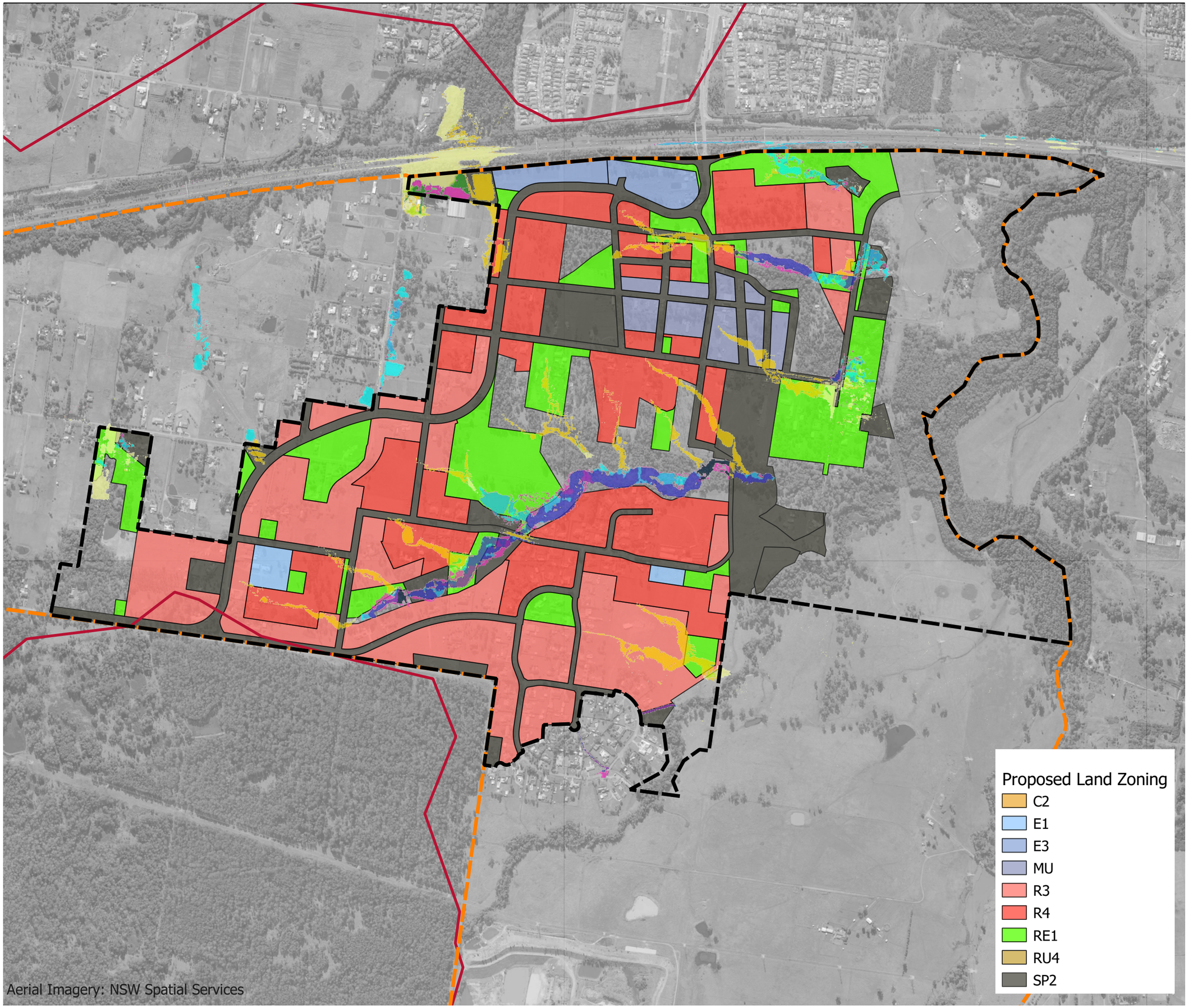

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RG-02-044

0.2% AEP Post-Development less Pre-Development Flood Level Impact

Legend

- Stage 1 Boundary
- Investigation Area
- Hydraulic Model Extent

Flood Level Impact (m)

- <= -0.3
- -0.3 - -0.2
- -0.2 - -0.1
- -0.1 - -0.02
- -0.02 - 0.02
- 0.02 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- > 0.3
- Was wet, now dry
- Was dry now wet

0 250 500 m

Scale : 1:12000@A3
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RG-02-045

PMF
Post-Development less Pre-Development
Flood Level Impact

Legend

- Stage 1 Boundary
- Investigation Area
- Hydraulic Model Extent

Flood Level Impact (m)

- <= -0.3
- -0.3 - -0.2
- -0.2 - -0.1
- -0.1 - -0.02
- -0.02 - 0.02
- 0.02 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- > 0.3
- Was wet, now dry
- Was dry now wet

Proposed Land Zoning

- C2
- E1
- E3
- MU
- R3
- R4
- RE1
- RU4
- SP2

0 250 500 m

Scale : 1:12000@A3
Date : 18 June 2024
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Aerial Imagery: NSW Spatial Services

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RG-02-050

0.5EY
Post-Development less Pre-Development
Flood Velocity Impact

Legend

- Stage 1 Boundary
- Investigation Area
- Hydraulic Model Extent

Flood Velocity Impact (m/s)

- <= -1
- -1 - -0.5
- -0.5 - -0.2
- -0.2 - -0.1
- -0.1 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1
- > 1

Proposed Land Zoning

- C2
- E1
- E3
- MU
- R3
- R4
- RE1
- RU4
- SP2

0 250 500 m

Scale : 1:12000@A3
Date : 18 June 2024
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RG-02-051

20% AEP
Post-Development less Pre-Development
Flood Velocity Impact

Legend

- Stage 1 Boundary
- Investigation Area
- Hydraulic Model Extent

Flood Velocity Impact (m/s)

- <= -1
- -1 - -0.5
- -0.5 - -0.2
- -0.2 - -0.1
- -0.1 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1
- > 1

Proposed Land Zoning

- C2
- E1
- E3
- MU
- R3
- R4
- RE1
- RU4
- SP2

0 250 500 m

Scale : 1:12000@A3
Date : 18 June 2024
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RG-02-052

1% AEP
Post-Development less
Pre-Development
Flood Velocity Impact

Legend

- Stage 1 Boundary
- Investigation Area
- Hydraulic Model Extent

Flood Velocity Impact (m/s)

- <= -1
- -1 - -0.5
- -0.5 - -0.2
- -0.2 - -0.1
- -0.1 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1
- > 1

Proposed Land Zoning

- C2
- E1
- E3
- MU
- R3
- R4
- RE1
- RU4
- SP2

0 250 500 m

Scale : 1:12000@A3
Date : 18 June 2024
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Aerial Imagery: NSW Spatial Services

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RG-02-053

0.5% AEP
Post-Development less
Pre-Development
Flood Velocity Impact

Legend

- Stage 1 Boundary
- Investigation Area
- Hydraulic Model Extent

Flood Velocity Impact (m/s)

- <= -1
- -1 - -0.5
- -0.5 - -0.2
- -0.2 - -0.1
- -0.1 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1
- > 1

Proposed Land Zoning

- C2
- E1
- E3
- MU
- R3
- R4
- RE1
- RU4
- SP2

0 250 500 m

Scale : 1:12000@A3
Date : 18 June 2024
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RG-02-054

0.2% AEP Post-Development less Pre-Development Flood Velocity Impact

Legend

- Stage 1 Boundary
- Investigation Area
- Hydraulic Model Extent

Flood Velocity Impact (m/s)

- <= -1
- -1 - -0.5
- -0.5 - -0.2
- -0.2 - -0.1
- -0.1 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1
- > 1

Proposed Land Zoning

- C2
- E1
- E3
- MU
- R3
- R4
- RE1
- RU4
- SP2

0 250 500 m

Scale : 1:12000@A3
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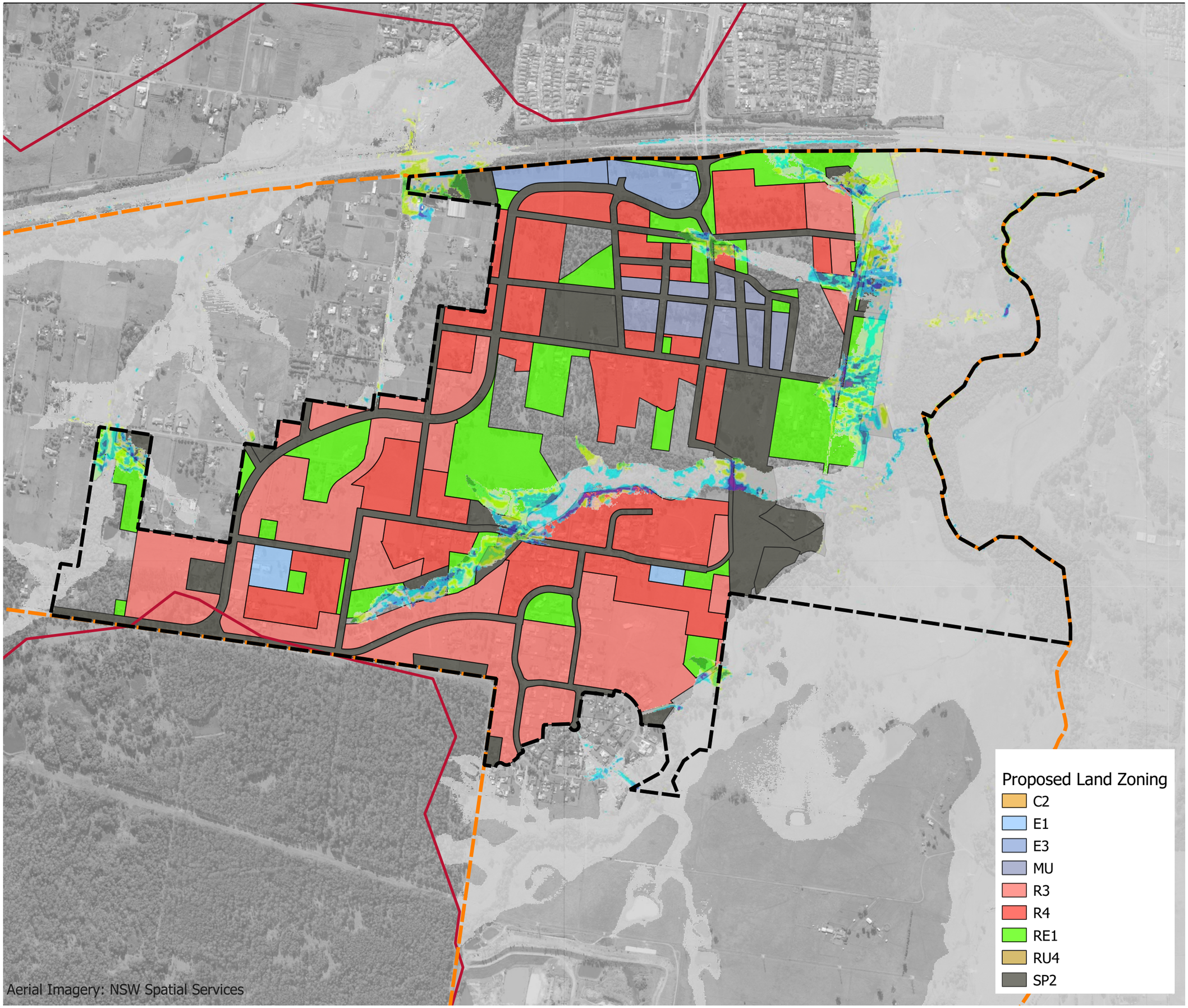

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RG-02-055

PMP Post-Development less Pre-Development Flood Velocity Impact

Legend

- Stage 1 Boundary
- Investigation Area
- Hydraulic Model Extent

Flood Velocity Impact (m/s)

- <= -1
- -1 - -0.5
- -0.5 - -0.2
- -0.2 - -0.1
- -0.1 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1
- > 1

0 250 500 m

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RG-02-060

Post-Development Flood Planning Area

Legend

- Stage 1 Boundary
- Investigation Area
- Hydraulic Model Extent
- Flood Planning Area

Proposed Land Zoning

- C2
- E1
- E3
- MU
- R3
- R4
- RE1
- RU4
- SP2

0 250 500 m

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ACN 616 964 517

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