

Five Dock Precinct – Flood Risk Assessment

Final Report





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EXECUTIVE SUMMARY

This report sets out a Flood Risk Assessment undertaken by GRC Hydro on behalf of Canada Bay Council, for the Five Dock Precinct. The assessment has been undertaken in conjunction with the Sydney Metro West Precincts, Five Dock Masterplan. The Masterplan has been developed to increase the housing supply in the precinct via increased density, alongside improved connections, through-site links, streetscapes and public spaces. The precinct is centred on the planned Metro station on Great North Road, and extends to Park Street to the east, Lyons Road to the north, Harris Road to the west and Queens Road to the south.

The assessment uses flooding information from an expanded version of an existing hydrologic and hydraulic model. The flood information is used to assess flooding in the precinct, which spans three small overland flow catchments. Design flood behaviour has been assessed with regard to depths and level, flood hazard categories and hydraulic categories, while rate of rise, duration and other factors have also been considered.

Flood risk across the precinct is generally low. No creek or watercourse flooding affects the precinct. Flooding occurs when very localised rainfall causes runoff that exceeds the capacity of the pit and pipe network, and flows overland. This leads to a handful of locations where an overland flowpath passes across the precinct. Flowpaths are localised and the large majority of the precinct has very low or negligible flood risk. However, along the flowpaths, significant depths of inundation can occur that can lead to property damage or pose a risk to pedestrians or vehicles.

The assessment found that proposed higher density in the area is suitable from a flood risk perspective. Council's DCP and LEP, and relevant state government policies have been considered with respect to development of flood-prone areas. The report sets out relevant planning controls that are currently in the DCP that will manage flood risk, but notes that the area the DCP controls apply to should be expanded. These controls will ensure flood risk is incorporated into the design of new buildings and associated development, and that flooding outside of the precinct is not impacted as a result of the development.

Regarding proposed building footprints, it is recommended to proceed with the proposed zonings and to treat building footprints as indicative at this time, and allow each of the impacts to be fully resolved during subsequent design stages. In some locations on the identified overland flowpaths, the concept-level building footprints may not be possible as the overland flowpath will need to be maintained. Further guidance is on Figure 13 of this report, from which the following advice is copied below:

"All flood-affected lots require flood impact assessment to be carried out as part of the approval process. Flood-affected lots are those with flood fringe, flood storage or floodway shown [on Figure 13].

**Note that lots with major overland flowpath may require significant revision to the concept-level building footprints in order to achieve compliant flood impacts."*

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1. INTRODUCTION

Planning is being undertaken to increase housing supply in the Five Dock area, as part of a wider program to address housing shortages in Sydney and NSW. The increased density is planned to utilise the improved transport access afforded by the Metro West project, currently under construction and which includes a station at Five Dock. The planning process at Five Dock consists of Council preparing a masterplan for the precinct where changes will occur, that sets out the overall vision and objective, before detailing the urban design with regards to zoning, setbacks, open spaces, public domain. The masterplan is then supported by a number of technical studies, of which the flood risk assessment is one.

Flood risk in the Five Dock Precinct has been assessed by the current study. Flood risk is an important consideration when developing or rezoning land. Changes to the precinct must suitably incorporate flood risk and follow the local and state flood planning controls. These controls prohibit or constrain development in areas with significant flood risk.

The flood assessment has been based on an updated and expanded Council flood model that covers the precinct. The current study assesses design flood behaviour in the area for a range of design flood events, using hydrologic and hydraulic models. The study then models and assesses a high-level schematisation of a future development case, including its impact on flood behaviour. The study then reviews and recommends necessary flood mitigation measures including planning controls.

2. BACKGROUND

2.1 Study Area

The study area, referred to as the Five Dock Precinct, is bounded by Harris Road and Park Road to the west and east, and Lyons Road and Queens Road to the north and south. The study area is comprised of three catchments, affected by overland flow flooding. The nature of flooding in each is provided below. The area broadly consists of fully-developed low to medium density urban area with a mix of residential and commercial land. As part of the Sydney Metro West project, the Five Dock Metro Station will be located on Great North Road in the centre of the study area and is expected to open in 2032.

The three general catchments are shown in Image 1 below, with arrows indicating overland flow direction. A natural ridgeline separates the three areas.



Image 1 Three Catchments and Overland Flow Paths

2.1.1 Kings Bay Catchment

The southwest part of the Five Dock Precinct is located in the Kings Bay Catchment.

An overview of the catchment features is given below:

- Catchment area: 1.18 km²
- Watercourses: Barnwell Park Canal (downstream of the study area)
- Catchment outlet: Kings Bay on Parramatta River

The area of interest is located in the upper catchment around Queens Road and Harris Road. Flooding at this location is limited due to the small catchment but some shallow overland flow is present. The area of interest is not affected by sea level rise associated with climate change.

The previous studies which have been utilised for this catchment are the St Lukes, William St and Exile Bay Flood Study (WMAwater, 2019) and the updated model from Parramatta Road Corridor - Flood Risk Assessment For City of Canada Bay Council (WMAwater, 2020).

2.1.2 Five Dock Catchment

The northern half of the Five Dock Precinct is referred to by Council as the Five Dock catchment. The area has a catchment extending east to Five Dock Park. Overland flow occurs on roads and some properties when the stormwater drainage capacity is exceeded. The area of interest is not affected by sea level rise associated with climate change.

An overview of the catchment features is given below:

- Catchment area: 0.8 km²
- Watercourses: None
- Catchment outlet: Hen and Chicken Bay in Sydney Harbour

The catchment was not included in a previous study, so the St Lukes, William Street and Exile Bay Flood Study (WMAwater, 2019) and the updated model from Parramatta Road Corridor - Flood Risk Assessment for City of Canada Bay Council (WMAwater, 2020) was expanded to cover this additional area.

2.1.3 Five Dock East Catchment

The south-eastern part of the precinct is referred to by Council as the Five Dock East catchment. It consists of a small area around Ramsay Road that drains to the south-east, towards Dobroyd Canal. The catchment area and flooding are both limited. An overview of the catchment is given below:

- Catchment area: 0.2 km²
- Watercourses: Iron Cove Creek/Dobroyd Canal (downstream of the study area)
- Catchment outlet: Iron Cove in Sydney Harbour

The catchment was partially included in the most recent Inner West Council study of Dobroyd Canal, but only in the hydrologic model. For consistency in the modelling, the area was instead added to the expanded St Lukes, William Street and Exile Bay Flood Study model described above.

2.2 Flooding Mechanisms

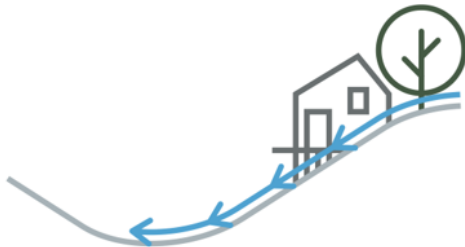
The catchment overviews provided above refer to overland flow flooding. The other common type of flooding is mainstream flooding. These are types of flooding as set out in the NSW Flood Risk Management Manual (2023) and earlier guidelines.

Mainstream flooding occurs from rising water on a defined watercourse causing the watercourse to break its banks and inundate areas that are usually dry. This mechanism typically occurs over a long period of time and generally results in deep, slow moving floodwaters. Image 2 (right hand side) depicts this mechanism. In the Canada Bay LGA, mainstream flooding occurs when either a natural creek or concrete stormwater channel floods the adjacent land.

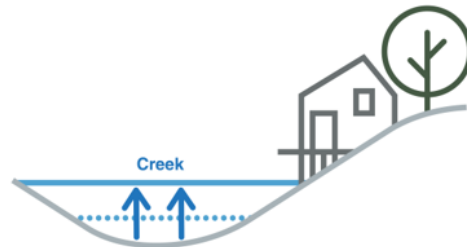
Overland flow flooding occurs when runoff has not yet reached the creek or channel. In urban areas it most commonly occurs along topographic sags which are typically serviced by a pit and pipe network. When the pipes' capacity is exceeded, above-ground flowpaths form. Overland flow is typically shallower and faster moving than mainstream flooding and occurs with less warning. NSW guidelines note that the two types of flooding can be indistinguishable to people experiencing flooding and that overland flow can cause significant property damage and flood risk, despite not originating from a major watercourse.

Image 2: Flood Mechanisms in the Study Area

Overland Flow Flooding



Mainstream Flooding



3. AVAILABLE DATA

3.1 Overview

The current study utilised a number of data sets in defining and assessing existing flood behaviour in the study area. This data largely consists of previous studies and Council GIS data. The study then assessed future development based on the available draft masterplan for the Five Dock precinct areas. A summary of each data set is provided below.

3.2 Previous Studies

3.2.1 St Lukes, William St and Exile Bay Flood Study (WMAwater, 2019)

The study was undertaken on behalf of Burwood Council and assessed overland flow flooding in the portion of the three catchments in Burwood Council, which was up to Parramatta Road on the northern boundary of the study area. Mainstream flooding is only present in the lower of each catchment, outside of the study area. The study used a DRAINS hydrologic model and TUFLOW hydraulic model, which were verified against two previous studies' design flood estimates. The study modelled six design flood events including the 1% AEP and PMF. Hydrologic modelling was based on the ARR2019 methodology and model parameters, including IFD.

3.2.2 Parramatta Road Corridor - Flood Risk Assessment For City of Canada Bay Council (WMAwater, 2020)

The study utilised previous models to assess flooding for the PRCUTS Stage 1 Precincts in Canada Bay Council. The Burwood precinct was located in the St Lukes catchment and the Kings Bay precinct was located in the William Street catchment. The study modified the existing model from the 2019 study to capture the areas of interest in more detail, and then assessed design flood mapping and assessment for the 5% AEP, 1% AEP and PMF events. As with the current study, a future development scenario was assessed for the precincts and mitigation measures including planning controls were reviewed and recommended.

3.2.3 Parramatta Road Corridor Urban Transformation Study (PRCUTS) – Stage 2 Flood Risk Assessment

The study utilised previous models to assess flooding for the PRCUTS Stage 2 Precincts in Canada Bay Council. The stage 2 Burwood precinct was located across Excel Bay Catchment and St Lukes Catchment; The west part of stage 2 Kings Bay precinct was located in St Lukes Catchment and the east part was located across William Street Catchment and Dobroyd Canal Catchment. The study modified the existing model from the 2020 PRCUTS stage 1 study and Dobroyd Canal and Hawthorne Canal FRMSP to capture the areas of interest in more detail, and then assessed design flood mapping and assessment for the 5% AEP, 1% AEP and PMF events. As with the current study, a future development scenario was assessed for the precincts and mitigation measures including planning controls were reviewed and recommended.

3.3 GIS Data

GIS data was provided by Council and was used to confirm or update model features in the areas of interest. The following data was provided:

- Council pit and pipe network (drainagepit.shp and drainagepipe.shp)
- Land zoning and road centrelines (road_centerline.shp and land_zoning.shp)

3.4 Site Visit

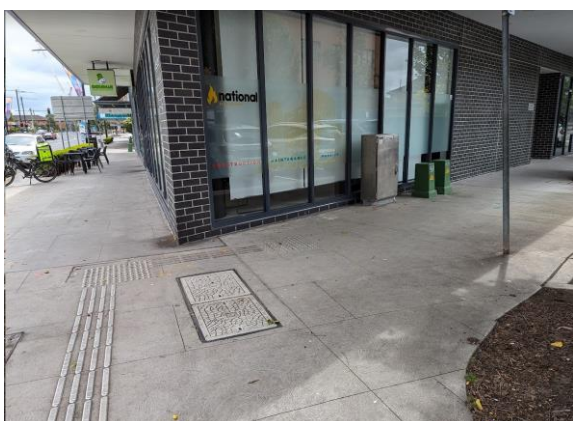
Site visit was undertaken in November 2024 to confirm above-ground features in the precinct areas, and to familiarise with the broader catchments. Photos of typical features observed are provided in Image 3 below. Beyond confirming modelled overland flowpaths against the actual topography and built features (kerbs, buildings, etc.) the main utility was adjusting building footprints in the model.



Area of overland flow between house at downstream end of Lyons Road West



Potential Inundation at Carpark Entrance on Rodd Road, near Great North Road



Corner of Rodd Road and Great North Road where overland flow can occur



Stormwater drainage on Great North Road near Ramsay Road.

Image 3: Selection of photos from site visit

3.5 Five Dock Masterplan

The current assessment has been undertaken in conjunction with the masterplan for the precinct; 'Sydney Metro West Precincts, Five Dock Masterplan' (Studio GL for City of Canada Bay, 2025). The

Masterplan describes the overall vision and objective for development of the precinct, before detailing the proposed changes. The masterplan sets out the proposed LEP zonings for the area, as well as proposed LEP and DCP changes. The masterplan shows a concept building layout that was used to assess a future development scenario. The masterplan also describes various aspects of the proposed urban design that are not specifically relevant to the flood assessment including building setbacks, street walls, yield estimates and Floor Space Ratios. The most pertinent features with regards to flooding are the change in zoning to allow for higher density residential/commercial development, the change in the built environment to replace/expand/reduce current building footprints, and the preservation of roads/open space in areas of significant overland flow. The assessment of the masterplan is presented in Section 5.

4. DESIGN FLOOD MODELLING

4.1 Overview

New catchment modelling was used to define flood behaviour at a precinct scale. The modelling, consisting of a hydrologic and hydraulic model, was undertaken by expanding the nearby models that were used in the PRCUTS Stage 2 assessment (DRAINS hydrologic model and TUFLOW hydraulic model). The models partially covered the south-west portion of the study area while the majority of the precinct was not available in any modelling. In order to produce consistent results from a single model, the hydrologic and hydraulic models from PRCUTS Stage 2 were expanded to cover the Five Dock and Five Dock East catchments. The change is shown in Image 4 below.



Image 4: Five Dock Precinct with coverage of previous modelling from PRCUTS

4.2 Model Updates

The existing model schematisation was followed when extending the model. An overview of the model updates are provided in Table 1 below. The model was then re-run for the design events of interest and the updated results were reviewed.

Table 1: Model Updates

Models	Model Update	Explanation
DRAINS	Refined subcatchment definition and additional subcatchments	Subcatchments were slightly more coarsely defined in the area of interest compared to other areas, or were not present. New subcatchments for Five Dock and Five Dock East were added with subcatchment sizes of approximately 1-2 ha, to produce consistent flood mapping.
TUFLOW	Pit and pipe layer updated	Minor updates were made to pits and pipes to include features in the Council GIS dataset. To be consistent PRUCTS stage 2 model, blockage of the structure is set to be 0. Sensitivity of the blockage assessment will be shown in Section 4.4.7
	Local inflow layer updated	Local inflow locations were updated to correspond to refined and added subcatchments
	Existing Building layer updated	Existing building footprints in the area of interest were refined based on site visit and to add buildings not previously included in the model
	Road crest breakline layer added	Road crest breaklines were added for the areas of interest
	Road Gutter breakline layer added	Road gutter breaklines were added for the areas of interest
	Model Boundary Extended	Model downstream boundaries were extended to model the Five Dock precinct. Downstream boundary was set same as t
	Road Topography updated	Ground levels were slightly raised on Newcastle Street after site visit indicated model results were slightly overestimating property inundation..

4.3 Design Events

The design events of interest were 5% AEP, 1% AEP and Probable Maximum Flood, representing a range of design flood behaviour. The following design model events were run:

- 5% AEP 15 mins storm (storm 1 temporal pattern)
- 1% AEP 10 mins storm (storm 6 temporal pattern)
- PMF 15 mins storm

The critical duration is the duration which produces the peak flood levels in the area of interest. In a catchment wide study the critical duration will vary. A similar critical approach was undertaken in the PRCUTS stage 2 study based on Australian Rainfall and Runoff 2019. The areas of interest in this study are the key flooding area within Five Dock Precinct which are:

- Scotts Street and Lyons Road West Intersection
- Park Street sag point
- Great North Road and Lyons Road Intersection

4.3.1 Climate Change

The hydrologic and hydraulic models were adjusted to assess the effect of climate change on design flood behaviour. Climate change is expected to worsen flood risk over time as higher greenhouse gas concentrations lead to increases in high intensity rainfall and sea levels. The assessment used the IPCC (Intergovernmental Panel on Climate Change) greenhouse gas concentration scenarios and subsequent modelling estimating each scenario's effect on rare rainfall events. There are four IPCC greenhouse gas concentration projections named RCP 2.5, 4.5, 6.0 and 8.5, with the RCP 2.5 being the most optimistic (emissions plateau and then decline) and 8.5 the least optimistic (emissions continue to grow). For the RCP4.5 and 8.5 scenarios, the projected increase in precipitation intensity were obtained from the ARR Data Hub and shown in Table 2 for the 2090 estimate, which were then modelled for the 1% AEP event.

Table 2: Climate Change Factors – Percentage Increase in Rainfall Intensity in 2090

Year	RCP 4.5	RCP 8.5
2090	+9.5 %	+19.7%

Sea level rise as a result of climate change affects the catchment's tailwater conditions at the catchment outlets in Sydney Harbour and can affect flood behaviour in the lower catchment. An estimate of sea level rise is 0.4 m by 2050 and 0.9 m by 2100, as set out in the NSW government Practical Consideration of Climate Change guideline (2007). These sea level rise (SLR) scenarios were modelled for the 1% AEP event.

For each scenario the peak flood levels were then tabulated and compared to the base case (i.e., no climate change), as presented in Section 4.4.7

4.4 Model Results – Existing Case

4.4.1 Flood Behaviour – Depth and Levels

The models were used to present produce flood mapping for a range of outputs and design events, for the study area. Peak flood depth maps with levels contours for the design events are shown on Figure 6 (5% AEP), Figure 7 (1% AEP) and Figure 8 (PMF) Table 3 summarises design flood levels for a number of locations in the study area, while Table 3 shows the equivalent depths. Flood hazard is shown on Figures 9 to 11. The locations in Table 2 are a range of reporting locations along each of the flowpaths, and the locations are shown on Figures 9 to 11.

Table 3: Design Flood Levels

ID	Location	Ground Level (mAHD)	Peak Flood Level (mAHD) per design event		
			5% AEP	1% AEP	PMF
A	Lyons Rd near Udall Ave	2.84	3.37	3.42	4.18
B	Lyons Rd near West St	3.17	3.55	3.56	4.19
C	Great North Rd near Lyons Rd	6.11	6.58	6.65	7.28
D	Rodd Rd near Great North Rd	6.85	7.47	7.53	8.15
E	Rodd Rd near Jersey Ln	6.91	7.48	7.55	8.35
F	Barnstaple Rd near Waterview St	10.14	10.59	10.62	10.77
G	Sutton St	12.79	12.99	13.02	13.16
H	Park Rd	16.78	17.02	17.04	17.15
I	Great North Rd near Kings Rd	20.29	20.48	20.52	20.76
J	First Ave near Waterview St	19.34	19.64	19.65	19.78
K	Lancelot St near Scott St	11.18	11.54	11.56	11.75
L	Harris Rd near Garfield St	6.28	6.67	6.69	6.84
M	Newcastle Street near Scott Street	6.21	6.28	6.68	6.70
N	Garfield Street near Cross Street	14.24	14.44	14.48	14.68

Table 4: Design Flood Depth

ID	Location	Ground Level (mAHD)	Peak Flood Depth (m) per design event		
			5% AEP	1% AEP	PMF
A	Lyons Rd near Udall Ave	2.84	0.5	0.6	1.3
B	Lyons Rd near West St	3.17	0.4	0.4	1.0
C	Great North Rd near Lyons Rd	6.11	0.5	0.5	1.2
D	Rodd Rd near Great North Rd	6.85	0.6	0.7	1.3
E	Rodd Rd near Jersey Ln	6.91	0.6	0.6	1.4
F	Barnstaple Rd near Waterview St	10.14	0.4	0.5	0.6
G	Sutton St	12.79	0.2	0.2	0.4
H	Park Rd	16.78	0.2	0.3	0.4
I	Great North Rd near Kings Rd	20.29	0.2	0.2	0.5
J	First Ave near Waterview St	19.34	0.3	0.3	0.4
K	Lancelot St near Scott St	11.18	0.4	0.4	0.6
L	Harris Rd near Garfield St	6.28	0.4	0.4	0.6
M	Newcastle Street near Scott Street	6.21	0.1	0.5	0.5

ID	Location	Ground Level (mAHD)	Peak Flood Depth (m) per design event		
			5% AEP	1% AEP	PMF
N	Garfield Street near Cross Street	14.46	0.2	0.2	0.4

The flood depth in Table 4 is calculated from the flood levels in Table 3, for example, the flood depth at location N is 0.2 m (14.44 flood level – 14.24 ground level = 0.2 m). Thus, Table 4 shows,

- In a relatively common flood such as the 5% AEP, the greatest depths of flooding are at location A, B, D and E (~0.6 m), where runoff accumulates on Rodd Road, location K and L (~ 0.4 m), where overland flowpath passes through.
- In a 1% AEP event, commonly used as the design event, nearly all locations have only 0-0.1 m increase in depth, relative to the 5% AEP. This shows most locations do not scale significantly between flood events. The exception is at location M near Scott Street where the flood depth increased 0.4 m, due to the topographic low point in Five Dock Catchment draining to Hen and Chicken Bay.
- In a PMF event, there is similar minimal scaling at most locations. Location A to E show a significant increase in depth in extreme events.

4.4.2 Flood Behaviour – Flow Rates

Peak overland flow rate at key locations are tabulated in Table 5 below,

Table 5 Peak Flow Rates by key locations

ID	Location	Overland Peak Flow(m ³ /s) per design event		
		5% AEP	1% AEP	PMF
A	Lyons Rd near Udall Ave	0.64	0.86	18.32
B	Lyons Rd near West St	5.27	6.11	28.67
C	Great North Rd near Lyons Rd	3.73	5.13	36.63
D	Rodd Rd near Great North Rd	3.75	5.21	31.62
E	Rodd Rd near Jersey Ln	4.23	5.80	28.50
F	Barnstaple Rd near Waterview St	1.40	2.00	10.70
G	Sutton St	0.33	0.44	1.23
H	Park Rd	0.96	1.31	6.14
I	Great North Rd near Kings Rd	0.37	0.52	2.48
J	First Ave near Waterview St	0.30	0.36	0.81
K	Lancelot St near Scott St	0.28	0.65	7.12
L	Harris Rd near Garfield St	4.43	6.04	27.94
M	Newcastle Street near Scott Street	2.02	2.61	14.30
N	Garfield Street near Cross Street	1.65	2.45	13.86

Peak Flow Rate for each catchment are also shown in Table 6, with a breakdown of the above ground and piped flow in each design event.

Table 6 Peak Flow Rates by Catchments

Catchment	5% AEP (m ³ /s)				1% AEP (m ³ /s)			PMF (m ³ /s)		
	Location See Image 4,5,6	Pipes Peak flow	Overland Peak flow	Total	Pipes Peak flow	Overland Peak flow	Total	Pipes Peak flow	Overland Peak flow	Total
Kings Bay	1	0.04	2.60	2.64	0.52	3.45	3.97	0.52	15.69	16.21
	2	1.00	5.14	6.14	1.00	6.87	7.86	1.00	34.19	35.19
Five Dock	3	0.95	2.68	3.63	0.96	3.78	4.74	0.99	24.68	25.67
	4	0.00	0.97	0.97	0.00	1.26	1.26	0.12	5.13	5.25
	5	0.51	3.75	4.26	0.56	5.14	5.70	0.71	36.80	37.51
Five Dock East	6	0.37	1.59	1.96	0.40	2.13	2.52	0.80	13.62	14.42
	7	No pipe	0.09	0.09	No pipe	0.14	0.14	No pipe	1.08	1.08

The table shows that as with flood depths, there is minimal scaling between events at most locations, with similar flow in the 5% and 1% AEP events. Relatively smaller upstream catchment such as Five Dock East have around 1-3 m³/s total flow. Even with small upstream catchment, the majority of flow is above ground, i.e. the pipes are at capacity. Higher flow rates are at location 2 in King Bay catchment and location 5 in Five Dock Catchment, which has close to 8 m³/s and 6 m³/s peak flow in the 1% AEP respectively, with ~15 % of the total flow in the trunk drainage. The flow rates are typical of urban areas with overland flow and are small enough that trunk drainage upgrades would be feasible for mitigating flood risk.

Image 5 Flow measure locations - Kings Bay

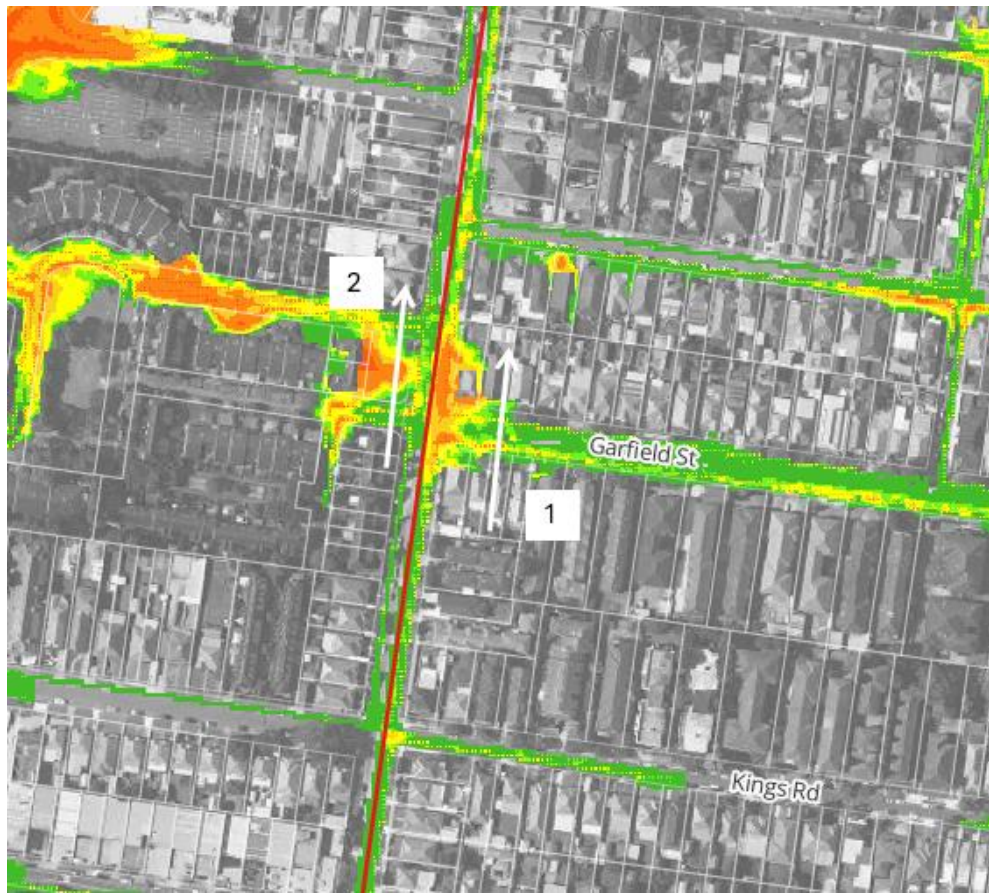


Image 6 Flow Measure Locations - Five Dock



Image 7 - Flow Measure locations - Five Dock East



4.4.3 Flood Behaviour – Hazard

Flood hazard mapping has been developed through application of ARR2019 and Australian Emergency Management Institute (AEMI) flood hazard guidelines. The guidelines consider the threat to people, vehicles and buildings based on flood depth and velocity at a specific location. The AEMI flood hazard mapping can be used to assess the flood hazard for site occupants and proposed site usage, as well as for the community surrounding the site.

Chart 1 and Table 7 present the relationship between the velocity and depth of floodwaters and the corresponding classification.

Chart 1: Flood Hazard Curves (Australian Emergency Management Handbook 7)

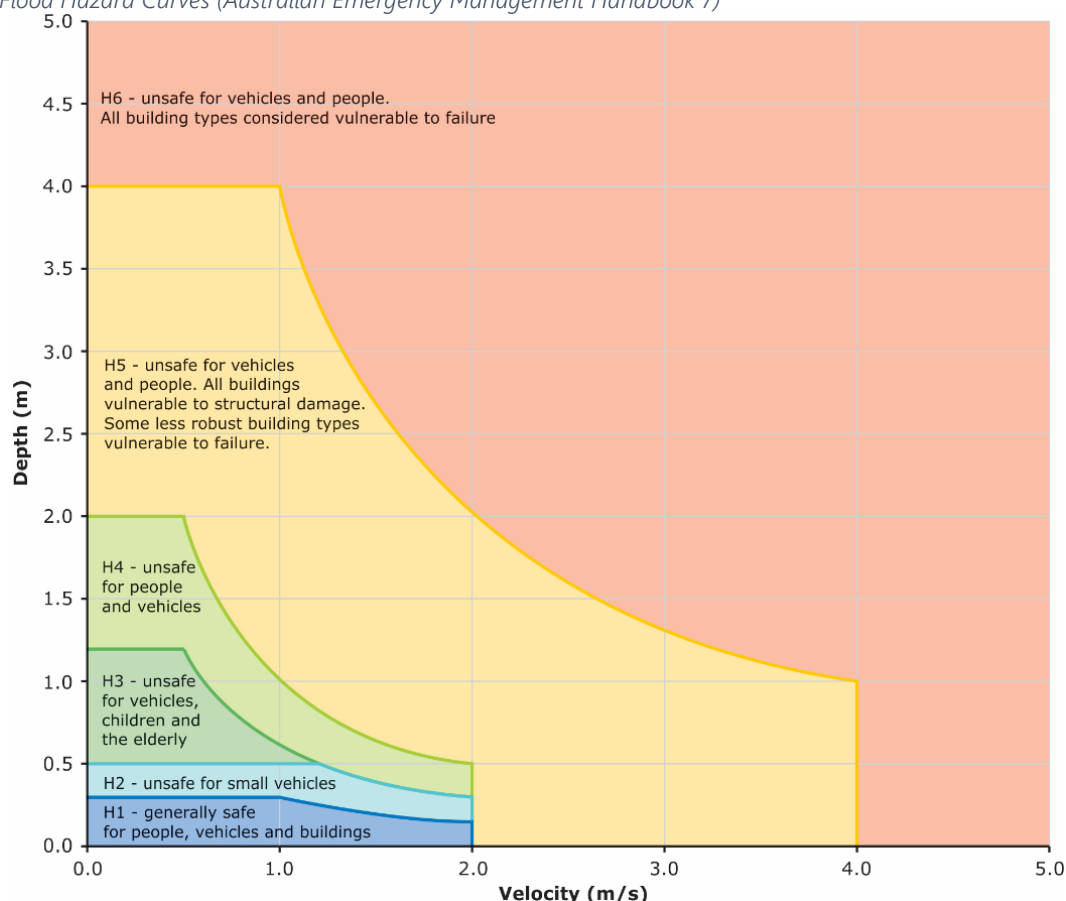


Table 7: Flood Hazard – Vulnerability Thresholds

Hazard Classification	Description
H1	Generally safe for vehicles, people and 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 buildings subject to failure.
H6	Unsafe for vehicles and people. All building types considered vulnerable to failure.

The hazard is shown on Figures 9, 10 and 11 for the 5% AEP, 1% AEP and PMF. The figures show the majority of each precinct is only affected by H1 hazard (the lowest level) in most flood events, while roadways in some areas contain higher hazard of around H2-H3. The hazard mapping does not identify any high hazard flowpaths through lots in a 1% AEP event. Further assessment of the flood hazard in each precinct is presented in Section 5.1.

4.4.4 Flood Behaviour – Flood Function/Hydraulic Categories

Flood Function (also referred to as 'Hydraulic Categories') refers to the classification of floodwaters into three categories: floodway/flow conveyance, flood storage and flood fringe. These categories help to describe the nature of flooding across the floodplain and aid planning when assessing

developable areas. According to the Australian Emergency Management Handbook 7, these three categories can be defined as:

- Floodway – the areas where a significant proportion of the floodwaters flow and typically align with defined channels. If these areas are blocked or developed, there will be significant redistribution of flow and increased flood levels across the floodplain. Generally, floodways have deep and/or fast moving floodwaters.
- Flood storage – areas where, during a flood, a significant proportion of floodwaters extend into, water is stored and then recedes after a flood. Significant filling or development in these areas may increase flood levels nearby; and
- Flood fringe – areas that make up the remainder of the flood extent. Development in these areas are unlikely to alter flood behaviour in the surrounding area.

The large majority of flood-affected land in the study area is overland flow, for which the guideline states:

- Defining flood function is complex
- It is important to define a continuous flowpath or floodway once it has formed
- Conveyance and encroachment techniques are difficult to use, and the indicator technique likely more appropriate (this means using depth and velocity, or similar outputs, to estimate areas of flood function)
- Large flood storage areas are not common and may not be present

On this basis, the flood function criteria in the PRCUTS Stage 2 assessment (WMAwater, 2020) using depth, velocity and depth-velocity thresholds has been adopted for the current assessment. The thresholds are as follows:

1. Floodway = Velocity x Depth > 0.25 m²/s AND Velocity > 0.25 m/s OR Velocity > 1 m/s
2. Flood Storage = Areas that are not floodway, with depth of >0.5 m
3. Flood Fringe = All remaining areas

The flood function is shown on Figure 12, 13 and 14 for the 5% AEP, 1% AEP and PMF.

4.4.5 Flood Risk Precincts

Flood Risk Precincts categorise the flood-affected area into areas of Low, Medium and High Risk. The categories, which are also referred to as Flood Risk Categories in Council's DCP, combine and simplify two outputs: 1% flood hazard and the PMF flood extent. The DCP does not define each category but their definition is generally similar across different LGAs, and for the Five Dock precinct, the definition used by the Stage 2 flood assessment has been adopted, of:

High Risk: Areas with high hazard (H4-H6) flooding in the 1% AEP event, or with significant evacuation difficulties

Medium Risk: Areas with low hazard (H1-H3) flooding in the 1% AEP event, with no significant evacuation difficulties

Low Risk: Areas not flooded in the 1% AEP but within the PMF flood extent

Risk categories for the Five Dock precinct are shown on Figure 15. Flood planning controls in the DCP are then set based on the proposed land use and a site's risk precinct.

4.4.6 Flood Planning Area

The Flood Planning Area is traditionally the area to which flood planning controls apply. Following recent NSW Ministerial Directions, flood planning controls more specifically now apply up to the PMF. The Flood Planning Area is still referred to in the policy and guidelines so has been included in this assessment.

The Flood Planning Area (FPA) is typically based on a flood extent equivalent to a flood height 0.5 m above the 1% AEP flood level. In areas of overland flow, this may exaggerate the flood affectation and so often a lot by lot determination is made based on the depth of inundation on each lot in the 1% AEP. Council's Development Control Plan has mapped the FPA and it appears to be based on a lot selection such as selecting lots with 10% of the lot having more than 0.15 m depth. There is no FPA currently defined for the Five Dock precinct as previous Council studies did not extend to this area, which is likely because there is generally low flood risk in the area.

It is important to note that the FPA does not designate properties with a certain level of flood risk, as lots can have minor affection (e.g. ~0.2 m depth over part of the backyard) and be included in the FPA, or alternatively have very significant affection (e.g. high hazard flow through the dwelling in frequent floods). Rather than a designation of flood risk, the FPA is simply a determination of where flooding needs to be considered in future development on a particular lot.

The FPA is recommended to be updated in the Five Dock Precinct, as described in Section 5.5

4.4.7 Model Results - Sensitivity Analysis

Sensitivity analysis describes the sensitivity of model results to changes in the modelling parameters. These parameters include structure blockage, hydraulic roughness and climate change (rainfall increase, and sea level rise). Each parameter is estimated based on the available data, but, due to the complexity of the catchment and flood-producing rainfall, the estimate will involve a series of assumptions and therefore has a degree of uncertainty. The sensitivity analysis therefore qualifies the assumptions by measuring their effect on the modelled flood behaviour. Large changes in the flood behaviour indicates a higher degree of uncertainty in the model results.

The sensitivity is tested by varying each parameter within a reasonable estimate range, and then re-running the hydraulic models (and hydrologic model for losses) to determine the peak flood level results for each scenario, for the 1% AEP event. The sensitivity is then quantified by measuring the impact on the peak flood level at a series of reporting locations.

The parameters tested and the results of the sensitivity analysis are presented below in Table 8 for roughness and blockage, and Table 9 for climate change.

Table 8: Sensitivity Analysis - Roughness and Blockage

Change in 1% AEP flood level					
ID	Location	Roughness Decreased by 20%	Roughness Increased by 20%	Blockage (pipes) by 20%	Blockage (pipes) by 50%
A	Lyons Rd near Udall Ave	0.03	-0.03	0.00	0.01
B	Lyons Rd near West St	0.00	-0.01	0.00	0.00
C	Great North Rd near Lyons Rd	0.00	0.00	0.02	0.04
D	Rodd Rd near Great North Rd	0.00	0.00	0.01	0.04
E	Rodd Rd near Jersey Ln	0.00	0.00	0.02	0.04
F	Barnstaple Rd near Waterview St	0.00	0.00	0.00	0.01
G	Sutton St	0.00	0.00	0.00	0.01
H	Park Rd	-0.01	0.00	0.00	0.00
I	Great North Rd near Kings Rd	-0.01	0.01	0.01	0.03
J	First Ave near Waterview St	0.00	0.00	0.00	0.00
K	Lancelot St near Scott St	0.00	0.00	0.00	0.01
L	Harris Rd near Garfield St	0.00	0.00	0.00	0.00
M	Newcastle Street near Scott Street	-0.01	0.01	0.00	0.01
N	Garfield Street near Cross Street	0.02	0.03	0.03	0.04

Table 8 shows that there is very minimal sensitivity to both hydraulic roughness and pipe blockage, with all locations having +/-0.05 m change. This is expected given the pipe drainage in the areas conveys a limited portion of the flow, and sensitivity to roughness is typically only where flow velocities are high.

Table 9: Sensitivity Analysis – Climate Change

Change in 1% AEP flood level						
ID	Location	RF + 10%	RF + 20%	RF + 30%	SLR 0.4m	SLR 0.9m
A	Lyons Rd near Udall Ave	0.05	0.09	0.13	0.01	0.01
B	Lyons Rd near West St	0.01	0.02	0.04	0.00	0.00
C	Great North Rd near Lyons Rd	0.04	0.08	0.11	0.00	0.00
D	Rodd Rd near Great North Rd	0.03	0.06	0.09	0.00	0.00
E	Rodd Rd near Jersey Ln	0.04	0.07	0.11	0.00	0.00
F	Barnstaple Rd near Waterview St	0.01	0.01	0.02	0.00	0.00
G	Sutton St	0.01	0.02	0.02	0.00	0.00
H	Park Rd	0.01	0.01	0.02	0.00	0.00

I	Great North Rd near Kings Rd	0.02	0.03	0.04	0.00	0.00
J	First Ave near Waterview St	0.00	0.01	0.01	0.00	0.00
K	Lancelot St near Scott St	0.01	0.01	0.02	0.00	0.00
L	Harris Rd near Garfield St	0.01	0.02	0.02	0.00	0.00
M	Newcastle Street near Scott Street	0.01	0.02	0.03	0.00	0.00
N	Garfield Street near Cross Street	0.03	0.05	0.06	0.02	0.02

The analysis shows climate change will not significantly change flood behaviour or flood risk in the Precinct. Most locations have too small upstream catchment to allow the increase in rainfall to accumulate to a significant degree, and are far upstream of the interface with tidal flows where sea level rise has an effect.

5.FLOOD RISK ASSESSMENT OF PROPOSED REZONING

The proposed rezoning for Five Dock Precinct is set out in Sydney Metro West Precincts Five Dock Master Plan. The designs set out in the masterplan has been assessed with regard to flooding, specifically to determine:

- The compatibility of the proposed land-uses with the flood hazard of the area. Local and state policies require tailoring a site's land use to fit the flood hazard.
- The impact of the indicative building envelopes on flood risk in the area, and whether any flood impacts require specific mitigation measures.
- The suitability of Council's LGA flood planning controls in mitigating flood risk associated with future development in the precinct, and whether additional planning controls are required.
- The compliance of the proposal with each of the specific requirements of Council policy, specifically the Local Environmental Plan (LEP) and Development Control Plan, and each of the requirements of state government policy, specifically:
 - March 2022 Local Planning Directions
 - Considering flooding in land use planning (guideline) dated July 2021
 - Considering flooding in land use planning: guidance and statutory requirements (planning circular) dated July 2021
 - NSW Flood Risk Management Manual (2023), which replaces the earlier Floodplain Development Manual

5.1 Flood Hazard Compatibility

A primary consideration in assessing development of flood-affected land is the flood hazard. Flood hazard refers to the threat posed to people, vehicles and buildings in an area of flooding, and is based on the depth and velocity of floodwaters across the range of flood events. Deeper and faster

flow has the potential to carry away people or vehicles, causing potential injury, death or financial loss, and similarly, deep and/or fast flow can damage and in some cases destroy buildings. Section 4.4.3 presents the thresholds of depth and velocity that separate the hazard categories from H1 (lowest level) to H6 (highest level).

As set out in Section 4.4.3, flood hazard has been mapped for the precinct, for the 5% AEP, 1% AEP and PMF event. The area has predominantly low hazard in most events including the 1% AEP. In the 5% AEP and 1% AEP most areas are H1 hazard with very localised sections of H2-H3. Two exceptions are on Garfield Street and Lyons Road West of high hazard H5 due to high velocity (but shallow) flow in the gutter, caused by the steep street profile. In the PMF event, there is high hazard of up to H4-H5 along most of the main flowpaths

The proposed rezoning has been shown on Figure 19, overlaid on the 1% AEP flood hazard. With respect to the main flowpaths, the proposed changes are:

- R2 to R4 (low to medium density residential) in the Scott Street/Lyons Road West area
- R2 to R3 downstream/north of Barnstaple Road, R3 to R4 upstream/south of Barnstaple Road
- R3 to R4 of the flowpath on Garfield Street
- No rezoning along the other overland flowpaths

The flood hazard mapping shows none of the four areas have areas of high hazard over lots that would be unsuitable for typical urban land uses such as residential and commercial developments, including medium or high density multi-storey dwellings. Areas of increased hazard, which are mostly H2 and H3 in a 1% AEP, are located on roadways which will be maintained in the proposed case. One road (Rodd Road at Great North Road) is proposed for a pedestrian area and has H2-H3 hazard on the road in the 1% AEP. This is considered an appropriate use given that it will flood following very heavy rainfall (as happens currently) and it can be expected that people will avoid the water. The choice of street furniture and plants (if any are proposed) can incorporate potential flooding, to minimise damage. Further consideration of flood hazard and flood risk is given in Section 5.3 and 5.4

5.2 Hydraulic Modelling Assessment

Hydraulic modelling of the concept-level proposed building footprints was undertaken to quantify the impact of future works on existing flood behaviour. Development in an area affected by flooding is required to assess the magnitude and location of flood impacts, which are changes to the existing flood behaviour that increase flood risk for neighbouring properties.

The assessment is primarily based on the change in flood level under a 1% AEP flood event, and is assessed using the hydraulic models. Changes in ground levels and building extents have the potential to change how overland flowpaths occur and increase the flow and/or flood level at a location either upstream or downstream of the subject site. For example, obstructing a flowpath through the site will tend to increase flood levels upstream, while re-directing or diverting flow can lead to slightly more flow being directed to one area and likewise increasing the flood level. Advice in state guidelines generally indicates an increase of more than 0.01 m in the 1% AEP flood level is considered a significant flood impact (i.e. lesser increases are considered negligible).

The hydraulic modelling assessment was based on the 'existing case' 1% AEP results from the hydraulic model, and then compared to the 1% AEP results of a 'proposed case' model. The 5% AEP and PMF were also modelled to ensure results are similar across different flood events. The proposed case consisted of modifying building footprints in each precinct in accordance with those set out in the masterplan. In nearly all locations the change consists of replacing the existing buildings (mostly houses) with amalgamated building footprints. An example is shown in the masterplan, reproduced in Image 8 below. The Masterplan notes the amalgamations are indicative and that other options are possible.



Image 8: Illustration of amalgamation of four lots into one building, from the masterplan

The hydraulic modelling assessment is a concept-level assessment that is only intended to show the broad effects of proposed development, with future stages to further assess the suitability of any proposed works with regards to flood impacts. The modelled proposed case does not include small-scale changes to road and footpath levels, or stormwater pits and pipes, that would be expected to be included in future detailed design stages. The assessment is suitable to show the general impact of the proposed layout and to assess its overall suitability.

The results of the hydraulic modelling assessment are shown in Figure 16 for the 5% AEP, Figure 17 for the 1% AEP and Figure 18 for the PMF. The results show generally similar impacts across the three sizes of flood event. Along the main flowpaths, there are predominantly small scale impacts of less than 0.1 m where the new building footprints have a localised effect on the shallow overland flow. There are generally no impacts away from the flowpaths and importantly, in the 5% AEP and 1% AEP, there are no impacts downstream of the precinct that are considered significant. While there are impacts in the PMF, they are minor and it is important to note the PMF is not typically given equal weighting to designs floods such as the 5% AEP and 1% AEP, when assessing impacts.

The very localised nature of the impacts indicates that while they are significant, they are likely to be readily resolved during the future design and assessment of individual buildings. Given that the current assessment is relatively coarse and ground levels (i.e. open space, footpath and road levels) around the new buildings are a significant factor, it is recommended to proceed with the proposed zonings and to treat building footprints as indicative at this time, and allow each of the impacts to be fully resolved during subsequent design stages. In some locations on the identified overland flowpaths, the concept-level building footprints may not be possible as the overland flowpath will

need to be maintained. An example is shown in Image 9 at the corner of Barnstable Road and Waterview Street. The other main finding of the assessment is that the small, localised impacts are in a fully-developed area and so large-scale stormwater trunk upgrades or detention basins are not feasible to mitigate them.

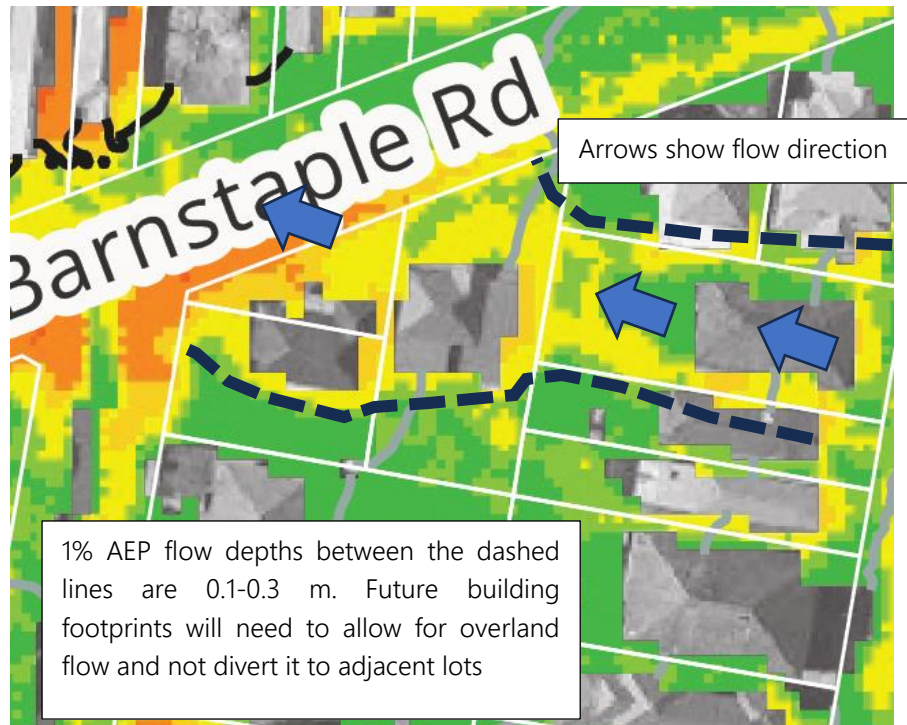


Image 9: Example of overland flowpath where future building footprint will need to incorporate flowpath

5.2.1 On-Site Detention

On-site Detention (OSD) refers to the temporary storage of stormwater flows within a lot in a tank or similar feature. OSD requirements are set out in Council's DCP and are aimed at ensuring new developments do not increase runoff as a result of increased impermeable areas relative to pre-development conditions. The OSD requirements are set out separately to the flood planning controls. However, OSD can influence flood behaviour. OSD controls will likely lead to some benefit regarding flooding in the area, given that there are OSD requirements for sites that already have 80-100% impervious area, as the DCP requires that "Where OSD is required, the permissible site discharge shall be based on a "greenfields" site with an impervious area of 0%.". That is, sites will be required to have OSD that mimics a greenfield site where grass/open space absorbs a percentage of the rainfall. OSD features such as tanks will be incorporated into new buildings and will be included in the flood impact assessment at DA stage.

5.3 Compliance with City of Canada Bay Policy

Development of flood-prone land in the City of Canada Bay LGA must be in accordance with the Local Environmental Plan (2013). The Development Control Plan then contains more specific controls to be followed to ensure compliance with the LEP.

The LEP has two standard clauses related to flooding, 5.21 and 5.22. Clause 5.21 applies to all development on flood-prone land while 5.22 was added in late-2023 to apply additional controls to

critical and sensitive land-uses for land between the Flood Planning Area and the PMF flood extent, which are termed Special Flood Considerations. The objectives of the LEP clauses are to:

- Minimise flood risk to life and to property
- Allow development on flood-affected land that is compatible with the area's flood function and behaviour, including climate change
- To avoid adverse or cumulative impacts on flood behaviour and the environment
- to enable the safe occupation and efficient evacuation of people in the event of a flood

The compliance of the masterplan with the LEP is set out in Table 10.

Table 10: LEP Compliance

LEP Planning Control	Compliance Comment
(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.	Rezoning to higher density residential/commercial would meet the LEP objectives, provided that new development follows the applicable flood planning controls. The precinct does not have high flood risk and the flood risk to life and property is readily managed. The flood behaviour consists of shallow overland flow with significant flowpaths forming on some roads in large floods, as typically occurs in an urban area. New buildings can be designed to be safely occupied during a flood with evacuation consisting of a shelter in place strategy.
(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	a) The flood function consists of flood fringe with some floodway areas on roads, and no flood storage. All future development is only proposed for areas of flood fringe, with existing roads to be maintained under the proposed layout. The flood behaviour consists of shallow overland flow with significant flow forming on some roads in large floods. Flood hazard is low in events up to and including the 1% AEP. b) Flood impact assessment has been carried out using concept-level building footprints. Assessment shows no downstream impacts in the 5% AEP and 1% AEP, but in many

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.	locations there are localised adverse impacts on other properties. The assessment shows that the future works are generally suitable but will required to be designed to avoid any such flood impacts. This requirement is a flood planning control already in place (see Section 5.5 Recommended Measures) c) Evacuation is not a significant risk factor as the areas have low hazard overland flow. Any new buildings can be designed to be safely occupied during a flood event, with a Shelter In Place evacuation strategy. Emergency access during a 1% AEP flood event will be possible to most areas, through low hazard flooding on roads. d) At the rezoning stage, risk to life measures consist of appropriate zoning based on the flood risk, and ensuring suitable flood planning controls are to be applied. Rezoning is suitable for the area and buildings can be designed to ensure risk to life is managed, see Section 5.5 Recommended Measures. e) There are no waterways in the vicinity of the proposed changes
(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.	a) Projected changes to flood behaviour as a result of climate change have been assessed, with regards to rainfall increase and sea level rise. Both are shown to have very minimal effect on flood behaviour in the precinct, which is well above sea level, and has small upstream catchments that tend to be insensitive to future increases in rainfall intensity. b) The intended design and scale of buildings is, at some locations, a significant increase from what currently exists, with a series of new multistorey buildings. The increase is suitable, from a flood risk perspective. c) See above. d) Building relocation would not be required at the location, given the low flood risk under current and future climate scenarios, and the elevated location.
[Clause 5.22] (2) This clause applies to— (a) for sensitive and hazardous development—land between the flood planning area and the probable maximum flood, and	a) Sensitive and hazardous development such as aged care, schools and childcare are not proposed as part of the rezoning proposal.

(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 has considered whether the development— (a) will 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 adversely affect the environment in the event of a flood.	b) Land is not present in the Five Dock precinct that has a particular risk to life or require the evacuation of people. On this basis the clause is not relevant to the project. The clause would be revisited if sensitive or hazardous development is proposed in the future.
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The table overview shows the proposed rezoning is compliant with the objectives and requirements of the LEP.

Table 11 summarises the Development Control Plan (DCP) flooding section and the project's compliance with it. The DCP contains objectives, design principles and then a matrix of specific planning controls. Many of the DCP controls pertain to building design and so would apply again for the design of any individual building. The assessment of the masterplan is a broader review of compliance and to identify the relevant controls to be applied in the future.

Table 11: DCP Compliance

DCP Section	Compliance Comment
DCP Design Principles D1. Development should not result in any increased risk to human life. D2. The additional economic and social costs which may arise from damage to property from flooding should not be greater than that which can reasonably be managed by the property owner, property occupants and general community. D3. Development should only be permitted where effective warning time is available for the evacuation of an area potentially affected by floods to an area free of risk from flooding. D4. Development should only be permitted where reliable egress is available for the evacuation of an area	D1. The precinct does not have high flood risk and the flood risk to life and property is readily managed. The flood behaviour consists of shallow overland flow with significant flowpaths forming on some roads in large floods, as typically occurs in an urban area. New buildings can be designed to be safely occupied during a flood with evacuation consisting of a shelter in place strategy. The current assessment has found that following the DCP applicable flood planning controls will ensure there is no increased risk to human life. D2. Economic and social costs arising from damage to property would be expected to significantly decrease as development occurs

potentially affected by floods to an area free of risk from flooding.

D5. Evacuation should be consistent with any relevant flood evacuation strategy or flood risk management plan where in existence.

D6. Development should not adversely increase the potential flood affectation on other development or properties, either individually or in combination with similar developments(s) that are likely to occur within the same catchment.

D7. Developments must make allowances for motor vehicles to be relocated to an area with substantially less risk from flooding within an effective warning time.

D8. Developments must provide an evacuation plan detailing procedures that would be in place for an emergency (such as warning systems, signage or evacuation drills).

D9. Flood mitigation measures associated with new developments should not result in significant impacts upon the amenity of an area by way of unacceptable overshadowing of adjoining properties, privacy impacts (eg. by unsympathetic house raising), alienation of otherwise usable open space or by being incompatible with the streetscape or character of the locality (including heritage).

D10. Raised structures shall be designed to cater for the forces of floodwaters. An Engineer's Certificate will be required for the structural design.

D11. Development is to be compatible with any relevant Floodplain Risk Management Study, Floodplain Risk Management Plan, Flood Studies, or Sub-Catchment Management Plan.

D12. Development must not divert flood waters, nor interfere with floodwater storage or the natural function of waterways.

D13. Filling of land up to the Probable Maximum Flood (PMF) must not adversely impact upon flood behaviour. This must be demonstrated by appropriate modelling.

D14. Development must consider the impact of flooding resulting from local overland flooding whether it is a result of Local Drainage or Major Drainage.

D15. Where hydraulic flood modelling is required, flow hazard categories should be identified and adequately addressed in the design of the development.

D16. Council strongly discourages basement car parks on properties within the floodplain. Where site conditions require a basement car park on a property within the floodplain, development applications must

and buildings are designed to be at or above the flood planning level. Use of the FPL will ensure minimal flood damage that can be reasonably managed by the property owner and general community.

D3 -D5. Evacuation of the area is not required during a flood, given the low flood risk. Emergency access will be possible in a 1% AEP event with low hazard on most roads.

D6 and D12. Flood impact assessment has been carried out using concept-level building footprints. Assessments shows that amalgamating buildings into larger footprints will cause localised adverse impacts on other properties, along the flowpaths. The assessment shows that the future works are generally suitable but will required to be designed to avoid any such flood impacts. Impacts can be resolved via changes to the building design, as necessary. This requirement is a flood planning control already in place (see Section 5.5 Recommended Measures)

D7. Flooding would occur with little to no warning in the area. However, the precinct has generally low flood risk and any basement car parking would have protection against flooding.

D8. This is readily achievable as part of design and occupation of new buildings.

D9. Any specific mitigation measures can avoid these impacts. Overshadowing, privacy, alienation of open space and compatibility with the streetscape have all been considered as part of the masterplan.

D10. No raised structures are proposed

D11. Development is assessed to be compatible with the three relevant flood studies.

D13: The effect of filling has been included in the impact assessment. No broadscale filling is proposed as the area has shallow flooding in the design event.

D14: The impact assessment has considered local overland flooding.

provide a detailed hydraulic flood study and design demonstrating that the proposed basement car park has been protected from all flooding up to and including the PMF event. An adequate emergency response and evacuation plan must also be provided where basement car parks are proposed in the floodplain.	D15: Flow hazard categories have been assessed in Section 5.1 D16: Any future basement car parks could be designed to be protected against PMF flooding, given the relatively shallow depth of the PMF. The basement car parking requirements would be incorporated into the design of any buildings.
DCP Planning Controls for Residential Development in Medium Risk Precincts [Medium has been chosen but slightly different controls apply to Low and High Risk Precincts, however, there are no lots with High Risk proposed for new buildings, and Low Risk areas have the same or lesser controls]. 1. Floor level: Habitable floor levels to be equal to or greater than the 100 year ARI flood level plus freeboard. A restriction is to be placed on the title of the land, pursuant to S.88B of the Conveyancing Act, where the lowest habitable floor area is elevated more than 1.5m above finished ground level, confirming that the subfloor space is not to be enclosed. 2. Building components: All structures to have flood compatible building components below the 100 year ARI flood level plus freeboard. 3. Structural Soundness. An Engineer's report is required to certify that the structure can withstand the forces of floodwater, debris and buoyancy up to and including a 100 year ARI flood level plus freeboard. 4. Flood Affection: An Engineer's report is required to demonstrate how and certify that the development will not increase flood affection elsewhere, having regard to: a) loss of flood storage; b) changes in flood levels, flows and velocities caused by alterations to flood flows; and c) the cumulate impact of multiple potential developments in the vicinity. 5. Car Parking and Driveway Access The minimum surface level of open parking spaces or carports shall be as high as practical, but no lower than 0.1m below the 100 year ARI flood level. In the case of garages, the minimum surface level shall be as high as practical, but no lower than the 100 year ARI flood level. Garages capable of accommodating more than 3 motor vehicles on land zoned for urban purposes, or enclosed car parking, must be protected from	1. Floor levels for all new buildings will be required to be set at or above the site's FPL. This will be incorporated in the design stage. See Section 5.5 on recommended FPL. 2. This is readily achievable and can be incorporated in the design stage of each new building. 3. As above 4. As above in this table, flood impacts do not occur outside the precinct but localised impacts are possible along overland flowpaths, but will required to be designed to avoid any such flood impacts. Impacts can be resolved via changes to the building design, as necessary 5. Car parking and driveway access requirements are readily achievable and will be incorporated into the design stage of each new building. 6. A shelter in place strategy in new buildings will provide a suitable evacuation area. In most locations the ground floor will be above the PMF level, however, in some instances evacuation of the ground floor may be needed to the first floor or above. A shelter in place strategy will ensure occupants are not venturing out on to flooded roads and will ensure no additional reliance on the SES or others. 7. A Site Emergency Response Flood Plan can be prepared on an as-needed basis but is not expected to be required for most new buildings. Requirements for storage of goods and materials are readily achievable

inundation by floods equal to or greater than the 100 year ARI flood. Ramp levels to be no lower than 0.5m above the 100 year ARI flood level. The level of the driveway providing access between the road and parking spaces shall be no lower than 0.2m below the 100 year ARI flood level. Restraints or vehicle barriers to be provided to prevent floating vehicles leaving a site during a 100 year ARI flood. Enclosed underground car parks shall have all potential water entry points protected from the PMF. The intent of this requirement is to mitigate the creation of life threatening circumstances and very high economic loss such as may occur with the complete inundation of an underground car park. Council may consider relaxation of this requirement if it can be shown by modelling that the catchment characteristics are such that the maximum depth of inundation is less than 300mm. Because of the particular catchment characteristics of the Concord West Precinct, an additional requirement within that precinct is for habitable floor levels to be at a minimum of RL 3.0m AHD. 6. Evacuation Reliable access for pedestrians and vehicles is required from the site to an area of refuge above the PMF level, either on site (eg. second storey) or off site. Applicant is to demonstrate the development is consistent with any relevant flood evacuation strategy or similar plan. Adequate flood warning is available to allow safe and orderly evacuation without increased reliance upon SES or other authorised emergency services personnel. 7. Management and Design Site Emergency Response Flood Plan required where the site is affected by the 100 year ARI flood level (except for single dwelling-houses). Applicant is to demonstrate that area is available to store goods above the 100 year flood level plus freeboard. No storage of materials below the 100 year ARI flood level.	and will be incorporated into the design stage of each new building.
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The masterplan is assessed to be in accordance with the design principles in the DCP, with regards to flooding. The relevant planning controls relating to building design are discussed in more detail in Section 5.5.

5.4 Compliance with NSW Policy

Management of flood risk is overseen by the state government in conjunction with local governments, with the state government providing technical guidelines for understanding and managing flood risk. These guidelines are collected in the NSW Flood Risk Management Manual (2023) which has superseded the earlier Floodplain Development Manual (2005). The overarching legislation is the NSW Environmental Planning and Assessment Act 1979 (EP&A Act), which tasks Councils with implementing the NSW government's flood prone land policy, with the objectives:

(a) 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, and

(b) to ensure that the provisions of an LEP on flood prone land is commensurate with flood hazard and includes consideration of the potential flood impacts both on and off the subject land.

The policy has requirements prohibiting development in areas of floodway, ensuring development does not adversely impact others, and requirements for development of the FPA. These requirements are then set out in the LEP clauses (see previous report section).

In addition to the two guidelines and overarching policy, three recent policies have been released with specific direction on flooding and land use planning including rezoning. These are:

- Considering flooding in land use planning: guidance and statutory requirements (planning circular) dated July 2021
- Considering flooding in land use planning (guideline) dated July 2021
- March 2022 Local Planning Directions

The first guidance sets out the various statutory requirements including the new LEP clauses (assessed above), and the two other guidelines above.

The second is a 9 page guideline for Councils on how to consider flooding in land use planning, which instructs Councils to:

- Consider flood function, flood hazard, extent and flooding behaviour for the full range of flood events, and risk to life
- Recommends Councils produce a Flood Planning Area for their LGA
- Use a freeboard of 0.5 m when setting Flood Planning Levels, or a lower freeboard in some cases where the consequences of flooding are lower
- Consider Special Flood Considerations (of which the details are set out in LEP Clause 5.22, which was only adopted into LEPs in late 2023).
- Map areas of flooding as part of the assessment

These considerations have all been included in the current assessment.

Lastly, March 2022 Local Planning Directions requirements are set out below in Table 12.

Table 12: March 2022 Local Planning Directions

Planning Directions	Compliance Comment
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A planning proposal must include provisions that give effect to and are consistent with the NSW Flood Prone Land Policy and the principles of the Floodplain Development Manual 2005 (including the Guideline on Development Controls on Low Flood Risk Areas).	Consideration of a range of flood events up to the PMF, including flood hazard and flood function classification, has been undertaken. Further, site access and the potential for isolation and emergency vehicle access issues are considered. The analysis and findings are consistent with the objectives of the Floodplain Development Manual 2005 and the newer Flood Risk Management Manual.
A planning proposal must not rezone land within the flood planning areas from Special Use, Special Purpose, Recreation, Rural or Environmental Protection Zones to a Residential, Business, Industrial, Special Use or Special Purpose Zone.	The rezoning proposed in the masterplan does not apply to any Flood Planning Areas.
A planning proposal must not contain provisions that apply to the flood planning areas which: - permit development in floodway areas, - permit development that will result in significant flood impacts to other properties, - permit a significant increase in the development of that land, - are likely to result in a substantially increased requirement for government spending on flood mitigation measures, infrastructure or services, or - permit development to be carried out without development consent except for the purposes of agriculture (not including dams, drainage canals, levees, buildings or structures in floodways or high hazard areas), roads or exempt development.	The planning proposal does not apply to areas of Flood Planning Area. In any case: -The large majority of the precinct's area are flood fringe, with only localised instances of floodway confined to the roadway and where flow passes between some residential lots, due to slightly deeper and higher velocity flow. Floodway in all affected lots is either H1 or H2 hazard (i.e. low hazard) in the 1% AEP event and is present due to the low thresholds used in defining floodway. - Flood impact assessment has been carried out using concept-level building footprints. Assessments shows most areas have no adverse impact on flooding, however, along flowpaths there is potential for localised adverse impact on other properties. The assessment shows that the future works are generally suitable but will be required to be designed to avoid any such flood impacts. This requirement is a flood planning control already in place (see Section 5.5 Recommended Measures -No increase in government spending on mitigation, infrastructure or services would be expected. -Development consent would be required for new buildings in the precinct via the DA process.
A planning proposal must not impose flood related development controls above the residential flood planning level for residential development on land, unless a relevant planning authority provides adequate justification for those controls to the satisfaction of the Director-General (or an officer of the Department nominated by the Director-General). For the purposes of a planning proposal, a relevant planning authority must not determine a flood planning level that is inconsistent with the Floodplain Development Manual 2005 (including the Guideline on Development Controls on Low Flood Risk Areas) unless a relevant planning	Flood-related development controls above the residential FPL are not proposed. The recommended FPL is provided in Section 5.5 and is consistent with the Floodplain Development Manual and newer Flood Risk Management Manual.

authority provides adequate justification for the proposed departure from that Manual to the satisfaction of the Director-General (or an officer of the Department nominated by the Director-General).	
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The assessment finds that the re-zoning is fully compliant with the planning directions. The planning directions are focussed on Flood Planning Areas, where a previous study has mapped the extent of a known flooding issue. The directions seek to avoid certain types of development in these areas. The Five Dock Precinct does not have a Flood Planning Area, likely due to the low to negligible flood risk that is present across the area. Areas of overland flow, even in a 1% AEP flood, are largely 'H1' hazard (the lowest level). Rezoning such areas is appropriate from a flooding perspective and following the recommended measures below will ensure this low flood risk is suitably managed.

5.5 Recommended Measures including Flood Planning Controls

The current assessment has found that rezoning across the Five Dock precinct is suitable in relation to the area's flood behaviour, but has identified various requirements that must be met in subsequent stages in the design of new buildings and associated development. These requirements are captured by the LEP and DCP flood planning controls, which have been recently updated and are assessed to comprehensively manage flood risk. However, currently the DCP controls only apply to lots in the mapped FPA in the DCP, which does not extend to the Precinct. It is recommended that the FPA be updated to expand the applicability of the controls to all lots with Medium or High Risk Category (as shown on Figure 15 and similarly mapped as part of the nearby PRCUTS assessments).

Once the FPA is expanded to cover these additional lots, the assessment identifies the most important controls being:

- Flood impact assessment is to be carried out to ensure no increase in flood risk on adjoining areas as a result of new development. Assessment of the concept building footprints shows flood impacts may occur if this is not incorporated into the design.
- Use of Flood Planning Levels for new development, see below.

Flood Planning Levels (FPLs) are one of the primary mitigation controls that will ensure new development in the Five Dock precinct is sufficiently protected against flooding. The FPL is a level at any new building entrance that the floor level is required to be at or above to be sufficiently protected from ingress of floodwaters. The level varies depending on the flood level (flood levels will typically vary within a site), the proposed land use (e.g. residential floors require more protection than a ground level carport) and the type of flooding, with mainstream/creek flooding requiring a higher freeboard than shallow overland flooding. These considerations are all captured in the table of FPLs in Council's DCP, reproduced below.

Table 13: FPL Table in DCP Section SW25

Freeboard requirements above 1% AEP water surface level				
Finished Floor Level (B)	Adopted Flood planning area	Overland flow path identified by Council as "Minor"	Overland flow paths other than ones identified by Council as "Minor"	Mainstream flooding
Residential – Habitable rooms	As per the adopted Plan	300mm	500mm	500mm
Residential – Non-habitable rooms	As per the adopted Plan	300mm	300mm	500mm
Commercial or Industrial – All internal areas	As per the adopted Plan	300mm	500mm	500mm
Carport open on 3 or 4 sides (At Ground Level)	As per the adopted Plan	150mm [†]	150mm	300mm
Entrance to Basement	As per the adopted Plan	300mm*	Difference between the 100-yr ARI Level and the PMF Level	Difference between the 100-yr ARI Level and the PMF Level
Critical Infrastructure	As per the adopted Plan	300mm	Difference between the 100-yr ARI Level and the PMF Level	Difference between the 100-yr ARI Level and the PMF Level

* **Note:** At Council's discretion, may be reduced

The DCP does not define when a flowpath is categorised as "Minor". Flood mapping as part of the current assessment shows the main flowpaths have shallow flooding in a range of flood events, and would be considered Minor by GRC Hydro. Our recommendation for the use of FPLs in the precinct is:

- Use the DCP FPL table for setting FPLs in each precinct.
 - New buildings with, or directly adjacent to, High Risk Precinct in the Five Dock precinct are recommended to use the second last column, i.e. 0.5 m freeboard for habitable rooms in residential areas, 0.5 m for commercial areas, etc.
 - New buildings in other areas, with Medium or Low Risk Category, as shown on Figure 15, should be considered as Minor overland flowpaths and use the third-last column in setting FPLs, i.e. 0.3 m for habitable rooms in residential areas, 0.3 m for commercial areas, etc.
- This would encompass the large majority of buildings along the main flowpaths.

As discussed above, the DCP does not appear to require that buildings outside of the current FPA apply a FPL. The recommendation to expand the FPA to all areas with a Medium or High flood risk category will ensure all lots with a degree of flood risk are sufficiently protected.

The other DCP controls regarding use of flood compatible materials, structural soundness, car parking and evacuation are also important in managing flood risk. Table 14 lists each of the controls in the Medium Flood Risk Category and provides advice on applying the controls to new development in each precinct.

Table 14: Advice on application of DCP Planning Controls

DCP Planning Controls for Residential Development in Medium Risk Precincts	Advice on Application
[Medium has been chosen but slightly different controls apply to Low and High Risk Precincts, however, there are no lots with High Risk proposed for new buildings, and Low Risk areas have the same or lesser controls]. 1. Floor level: Habitable floor levels to be equal to or greater than the 100 year ARI flood level plus freeboard. A restriction is to be placed on the title of the land, pursuant to S.88B of the Conveyancing Act, where the lowest habitable floor area is elevated more than 1.5m above finished ground level, confirming that the subfloor space is not to be enclosed.	Advice on the recommended FPLs is provided above this table. 1% AEP flood depths and levels can be read from the mapping provided in this report. The required FPL of buildings in all areas should be considered early in the building design process. Building entrances cannot sit flush with the footpath level in most locations and will require some level of step up or ramp.
2. Building components: All structures to have flood compatible building components below the 100 year ARI flood level plus freeboard.	Flood compatible building components include common building materials with an example list in City of Sydney's Interim Floodplain Management Policy.
3. Structural Soundness. An Engineer's report is required to certify that the structure can withstand the forces of floodwater, debris and buoyancy up to and including a 100 year ARI flood level plus freeboard.	Structural engineer's advice and report is required. To be confirmed by a structural engineer, but modelling generally indicates that the forces of floodwater in each precinct are unlikely to require additional structural design features than what would otherwise be required.
4. Flood Affection: An Engineer's report is required to demonstrate how and certify that the development will not increase flood affection elsewhere, having regard to: a) loss of flood storage; b) changes in flood levels, flows and velocities caused by alterations to flood flows; and c) the cumulate impact of multiple potential developments in the vicinity.	Flood impacts should be considered early in the design process where a flowpath may be blocked or diverted by a new building and associated works. Building footprints may have to be reduced or otherwise adjusted, if impacts are still present once proposed ground levels and building footprint are modelled.
5. Car Parking and Driveway Access The minimum surface level of open parking spaces or carports shall be as high as practical, but no lower than 0.1m below the 100 year ARI flood level. In the case of garages, the minimum surface level shall be as high as practical, but no lower than the 100 year ARI flood level.	Car parking requirements particularly for basement car parks should be considered early in the building design process. Basement car parks in flood affected areas are generally discouraged by Council. For some sites, locating the entrance away from the areas of

Garages capable of accommodating more than 3 motor vehicles on land zoned for urban purposes, or enclosed car parking, must be protected from inundation by floods equal to or greater than the 100 year ARI flood. Ramp levels to be no lower than 0.5m above the 100 year ARI flood level. The level of the driveway providing access between the road and parking spaces shall be no lower than 0.2m below the 100 year ARI flood level. Restraints or vehicle barriers to be provided to prevent floating vehicles leaving a site during a 100 year ARI flood. Enclosed underground car parks shall have all potential water entry points protected from the PMF. The intent of this requirement is to mitigate the creation of life threatening circumstances and very high economic loss such as may occur with the complete inundation of an underground car park. Council may consider relaxation of this requirement if it can be shown by modelling that the catchment characteristics are such that the maximum depth of inundation is less than 300mm. Because of the particular catchment characteristics of the Concord West Precinct, an additional requirement within that precinct is for habitable floor levels to be at a minimum of RL 3.0m AHD.	deepest flooding will simplify the design requirements.
6. Evacuation Reliable access for pedestrians and vehicles is required from the site to an area of refuge above the PMF level, either on site (eg. second storey) or off site. Applicant is to demonstrate the development is consistent with any relevant flood evacuation strategy or similar plan. Adequate flood warning is available to allow safe and orderly evacuation without increased reliance upon SES or other authorised emergency services personnel.	Evacuation requirements are likely to be straightforward if a shelter-in-place strategy is followed. Additional effort will be required for any new buildings where the PMF level is above the ground floor. See Section 4.3.1 for PMF and 1% AEP levels.
7. Management and Design Site Emergency Response Flood Plan required where the site is affected by the 100 year ARI flood level (except for single dwelling-houses). Applicant is to demonstrate that area is available to store goods above the 100 year flood level plus freeboard. No storage of materials below the 100 year ARI flood level.	A Site Emergency Response Flood Plan may be required in some instances but is not likely to be a factor in the initial design of the building. Any new buildings that potentially involve storage of goods and materials in an area below the Flood Planning Level should consider higher storage areas in the design of the building.

In summary the recommendations are:

- Ensure all new development in the Five Dock precinct with Medium/High Risk Category on the lot follows the applicable DCP controls based on the risk category and proposed land use.
- Flood assessments to be undertaken at DA stage of individual or multiple buildings can build on the advice offered in this section in Table 14. As set out in the table, certain requirements should be considered early in the design process of new buildings.
- Amend the FPA to expand the flood planning controls application to beyond just the current FPA map. The new FPA should include all lots with Medium and High Risk Precincts. The same approach was followed for the PRCUTS project.

APPENDIX A

Glossary of Key Terminology

annual exceedance probability (AEP)	the chance of a flood of a given or larger size occurring in any one year, usually expressed as a percentage. Eg, if a peak flood discharge of 500 m ³ /s has an AEP of 5%, it means that there is a 5% chance (that is one-in-20 chance) of a 500 m ³ /s or larger events occurring in any one year (see ARI). (see Table 15, Appendix A)
Australian Height Datum (AHD)	a common national surface level datum approximately corresponding to mean sea level.
average annual damage (AAD)	depending on its size (or severity), each flood will cause a different amount of flood damage to a flood prone area. AAD is the average damage per year that would occur in a nominated development situation from flooding over a very long period of time.
average recurrence interval (ARI)	the long-term average number of years between the occurrence of a flood as big as or larger than the selected event. For example, floods with a discharge as great as or greater than the 20 year ARI flood event will occur on average once every 20 years. ARI is another way of expressing the likelihood of occurrence of a flood event.
catchment	the land area draining through the main stream, as well as tributary streams, to a particular site. It always relates to an area above a specific location.
consent authority	the council, government agency or person having the function to determine a development application for land use under the EP&A Act. The consent authority is most often the council, however legislation or an EPI may specify a Minister or public authority (other than a council), or the Director General of DIPNR, as having the function to determine an application.
development	is defined in Part 4 of the EP&A Act <u>infill development</u>: refers to the development of vacant blocks of land that are generally surrounded by developed properties and is permissible under the current zoning of the land. Conditions such as minimum floor levels may be imposed on infill development <u>new development</u>: refers to development of a completely different nature to that associated with the former land use. Eg, the urban subdivision of an area previously used for rural purposes. New developments involve re-zoning and typically require major extensions of existing urban services, such as roads, water supply, sewerage and electric power.

	<u>redevelopment</u> : refers to rebuilding in an area. Eg, as urban areas age, it may become necessary to demolish and reconstruct buildings on a relatively large scale. Redevelopment generally does not require either re-zoning or major extensions to urban services.
disaster plan (DISPLAN)	a step by step sequence of previously agreed roles, responsibilities, functions, actions and management arrangements for the conduct of a single or series of connected emergency operations, with the object of ensuring the coordinated response by all agencies having responsibilities and functions in emergencies.
discharge	the rate of flow of water measured in terms of volume per unit time, for example, cubic metres per second (m ³ /s). Discharge is different from the speed or velocity of flow, which is a measure of how fast the water is moving for example, metres per second (m/s).
effective warning time	the time available after receiving advice of an impending flood and before the floodwaters prevent appropriate flood response actions being undertaken. The effective warning time is typically used to move farm equipment, move stock, raise furniture, evacuate people and transport their possessions.
emergency management	a range of measures to manage risks to communities and the environment. In the flood context it may include measures to prevent, prepare for, respond to and recover from flooding.
flash flooding	flooding which is sudden and unexpected. It is often caused by sudden local or nearby heavy rainfall. Often defined as flooding which peaks within six hours of the causative rain.
flood	relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or local overland flooding associated with major drainage (refer Section C6) before entering a watercourse, and/or coastal inundation resulting from super-elevated sea levels and/or waves overtopping coastline defences excluding tsunami.
flood awareness	Awareness is an appreciation of the likely effects of flooding and a knowledge of the relevant flood warning, response and evacuation procedures.
flood education	flood education seeks to provide information to raise awareness of the flood problem so as to enable individuals to understand how to manage themselves and their property in response to flood warnings and in a flood event. It invokes a state of flood readiness.
flood fringe areas	the remaining area of flood prone land after floodway and flood storage areas have been defined.
flood liable land	is synonymous with flood prone land (ie) land susceptible to flooding by the PMF event. Note that the term flood liable land covers the whole floodplain, not just that part below the FPL (see flood planning area).

flood mitigation standard	the average recurrence interval of the flood, selected as part of the floodplain risk management process that forms the basis for physical works to modify the impacts of flooding.
floodplain	area of land which is subject to inundation by floods up to and including the probable maximum flood event, that is, flood prone land.
floodplain risk management options	the measures that might be feasible for the management of a particular area of the floodplain. Preparation of a floodplain risk management plan requires a detailed evaluation of floodplain risk management options.
floodplain risk management plan	a management plan developed in accordance with the principles and guidelines in this manual. Usually includes both written and diagrammatic information describing how particular areas of flood prone land are to be used and managed to achieve defined objectives.
flood plan (local)	A sub-plan of a disaster plan that deals specifically with flooding. They can exist at state, division and local levels. Local flood plans are prepared under the leadership of the SES.
flood planning area	the area of land below the FPL and thus subject to flood related development controls. The concept of flood planning area generally supersedes the "flood liable land" concept in the 1986 Manual.
flood planning levels (FPLs)	are the combinations of flood levels (derived from significant historical flood events or floods of specific AEPs) and freeboards selected for floodplain risk management purposes, as determined in management studies and incorporated in management plans. FPLs supersede the "standard flood event" in the 1986 manual.
flood proofing	a combination of measures incorporated in the design, construction and alteration of individual buildings or structures subject to flooding, to reduce or eliminate flood damages.
flood prone land	land susceptible to flooding by the PMF event. Flood prone land is synonymous with flood liable land.
flood readiness	Readiness is an ability to react within the effective warning time.
flood risk	potential danger to personal safety and potential damage to property resulting from flooding. The degree of risk varies with circumstances across the full range of floods. Flood risk in this manual is divided into 3 types, existing, future and continuing risks. They are described below: <u>existing flood risk</u>: the risk a community is exposed to as a result of its location on the floodplain. <u>future flood risk</u>: the risk a community may be exposed to as a result of new development on the floodplain.

	<u>continuing flood risk</u>: the risk a community is exposed to after floodplain risk management measures have been implemented. For a town protected by levees, the continuing flood risk is the consequences of the levees being overtopped. For an area without any floodplain risk management measures, the continuing flood risk is simply the existence of its flood exposure.
flood storage areas	those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood. The extent and behaviour of flood storage areas may change with flood severity, and loss of flood storage can increase the severity of flood impacts by reducing natural flood attenuation. Hence, it is necessary to investigate a range of flood sizes before defining flood storage areas.
floodway areas	those areas of the floodplain where a significant discharge of water occurs during floods. They are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flow, or a significant increase in flood levels.
freeboard	provides reasonable certainty that the risk exposure selected in deciding on a particular flood chosen as the basis for the FPL is actually provided. It is a factor of safety typically used in relation to the setting of floor levels, levee crest levels, etc. (See Section K5). Freeboard is included in the flood planning level.
habitable room	in a residential situation: a living or working area, such as a lounge room, dining room, rumpus room, kitchen, bedroom or workroom. in an industrial or commercial situation: an area used for offices or to store valuable possessions susceptible to flood damage in the event of a flood.
hazard	a source of potential harm or a situation with a potential to cause loss. In relation to this manual the hazard is flooding which has the potential to cause damage to the community.
hydraulics	term given to the study of water flow in waterways; in particular, the evaluation of flow parameters such as water level and velocity.
hydrograph	a graph which shows how the discharge or stage/flood level at any particular location varies with time during a flood.
hydrology	term given to the study of the rainfall and runoff process; in particular, the evaluation of peak flows, flow volumes and the derivation of hydrographs for a range of floods.
local overland flooding	inundation by local runoff rather than overbank discharge from a stream, river, estuary, lake or dam.
local drainage	smaller scale problems in urban areas. They are outside the definition of major drainage in this glossary.

mainstream flooding

inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam.

major drainage

councils have discretion in determining whether urban drainage problems are associated with major or local drainage. For the purposes of this manual major drainage involves:

- the floodplains of original watercourses (which may now be piped, channelised or diverted), or sloping areas where overland flows develop along alternative paths once system capacity is exceeded; and/or
- water depths generally in excess of 0.3m (in the major system design storm as defined in the current version of Australian Rainfall and Runoff). These conditions may result in danger to personal safety and property damage to both premises and vehicles; and/or
- major overland flowpaths through developed areas outside of defined drainage reserves; and/or
- the potential to affect a number of buildings along the major flow path.

mathematical/computer models

the mathematical representation of the physical processes involved in runoff generation and stream flow. These models are often run on computers due to the complexity of the mathematical relationships between runoff, stream flow and the distribution of flows across the floodplain.

merit approach

the merit approach weighs social, economic, ecological and cultural impacts of land use options for different flood prone areas together with flood damage, hazard and behaviour implications, and environmental protection and well being of the State's rivers and floodplains. The merit approach operates at two levels. At the strategic level it allows for the consideration of social, economic, ecological, cultural and flooding issues to determine strategies for the management of future flood risk which are formulated into council plans, policy, and EPIs. At a site specific level, it involves consideration of the best way of conditioning development allowable under the floodplain risk management plan, local flood risk management policy and EPIs.

minor, moderate and major flooding

both the SES and the BoM use the following definitions in flood warnings to give a general indication of the types of problems expected with a flood:

minor flooding: causes inconvenience such as closing of minor roads and the submergence of low level bridges. The lower limit of this class of flooding on the reference gauge is the initial flood level at which landholders and townspeople begin to be flooded.

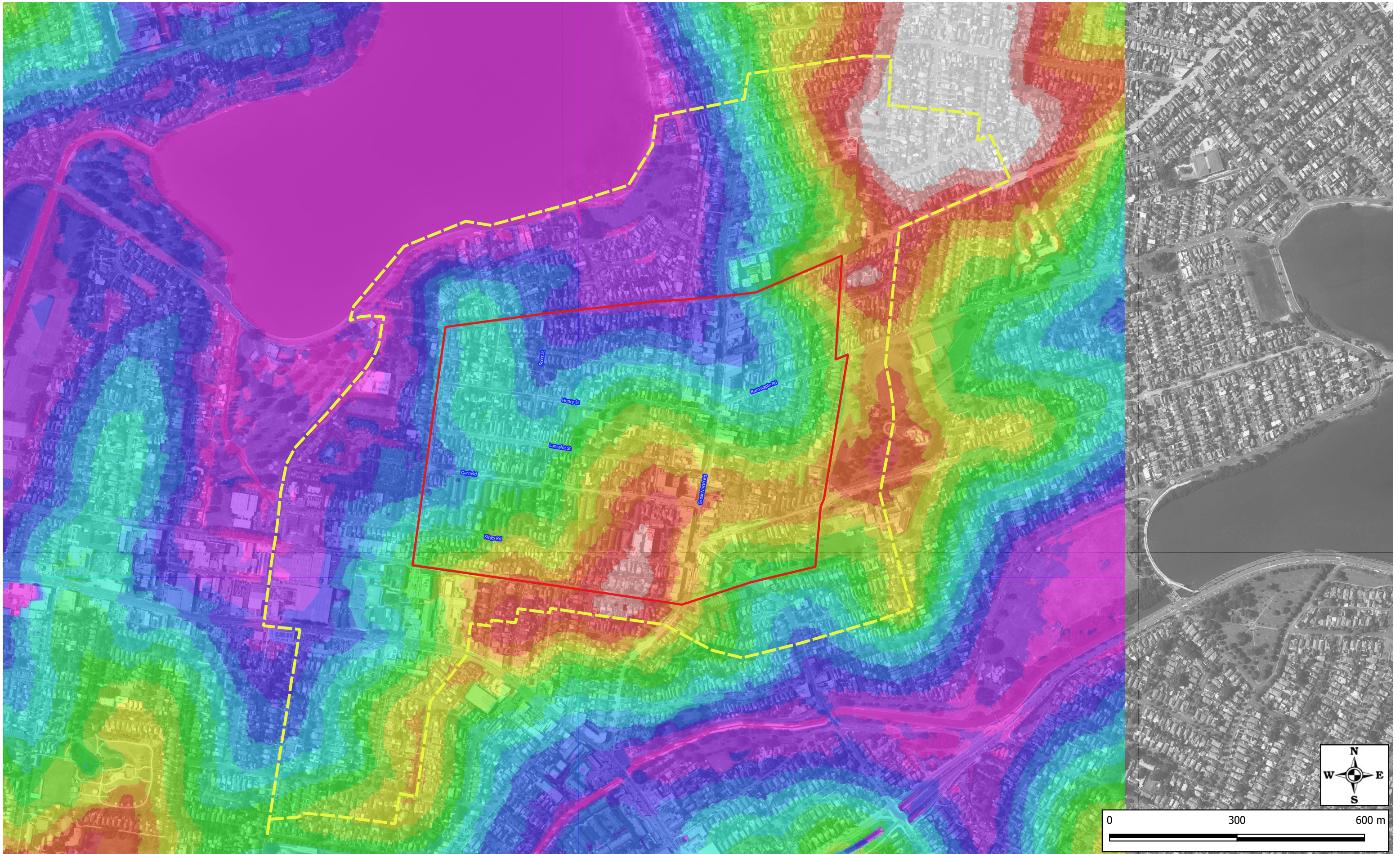
moderate flooding: low-lying areas are inundated requiring removal of stock and/or evacuation of some houses. Main traffic routes may be covered.

	<u>major flooding</u> : appreciable urban areas are flooded and/or extensive rural areas are flooded. Properties, villages and towns can be isolated.
modification measures	measures that modify either the flood, the property or the response to flooding.
peak discharge	the maximum discharge occurring during a flood event.
probable maximum flood	the PMF is the largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation, and where applicable, snow melt, coupled with the worst flood producing catchment conditions. Generally, it is not physically or economically possible to provide complete protection against this event. The PMF defines the extent of flood prone land, that is, the floodplain. The extent, nature and potential consequences of flooding associated with a range of events rarer than the flood used for designing mitigation works and controlling development, up to and including the PMF event should be addressed in a floodplain risk management study.
probable maximum precipitation	the PMP is the greatest depth of precipitation for a given duration meteorologically possible over a given size storm area at a particular location at a particular time of the year, with no allowance made for long-term climatic trends (World Meteorological Organisation, 1986). It is the primary input to PMF estimation.
probability	a statistical measure of the expected chance of flooding (see AEP).
risk	chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. In the context of the manual it is the likelihood of consequences arising from the interaction of floods, communities and the environment.
runoff	the amount of rainfall which actually ends up as streamflow, also known as rainfall excess.
stage	equivalent to water level (both measured with reference to a specified datum).
stage hydrograph	a graph that shows how the water level at a particular location changes with time during a flood. It must be referenced to a particular datum.
survey plan	a plan prepared by a registered surveyor.
water surface profile	a graph showing the flood stage at any given location along a watercourse at a particular time.

Table 15: ARR 2016 Preferred Terminology

Frequency Descriptor	EY	AEP (%)	AEP	ARI
			(1 in x)	
Very Frequent	12			
	6	99.75	1.002	0.17
	4	98.17	1.02	0.25
	3	95.02	1.05	0.33
	2	86.47	1.16	0.5
	1	63.21	1.58	1
Frequent	0.69	50	2	1.44
	0.5	39.35	2.54	2
	0.22	20	5	4.48
	0.2	18.13	5.52	5
	0.11	10	10	9.49
	0.05	5	20	20
Rare	0.02	2	50	50
	0.01	1	100	100
	0.005	0.5	200	200
Very Rare	0.002	0.2	500	500
	0.001	0.1	1000	1000
	0.0005	0.05	2000	2000
	0.0002	0.02	5000	5000
Extreme				
			PMP/ PMPDF	

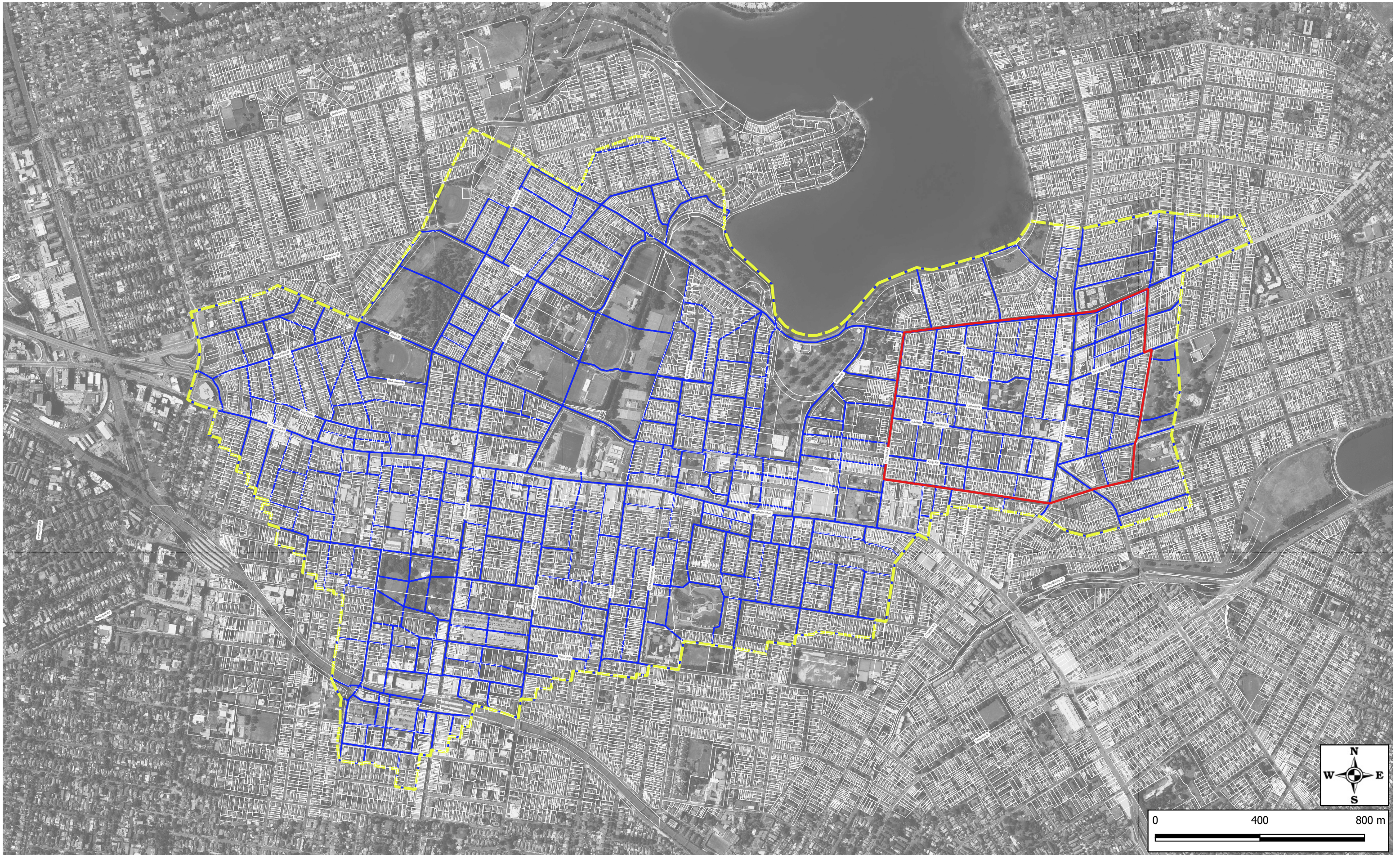
FIGURES



Precinct Five Dock Catchment	Elevation (mAHD)			TITLE: Study Area and Digital Elevation Model		
	<= 2.0	6.0 - 8.0	14.0 - 16.0	PROJECT: Five Dock Precinct Flood Assessment		
	2.0 - 4.0	8.0 - 10.0	16.0 - 18.0	PROJECT No. 240063		
	4.0 - 6.0	10.0 - 12.0	18.0 - 20.0	DATE: 10-2024	SCALE: 1:8,000	FIGURE No. 01
	12.0 - 14.0	20.0 - 22.0	> 28.0	grc HYDRO		



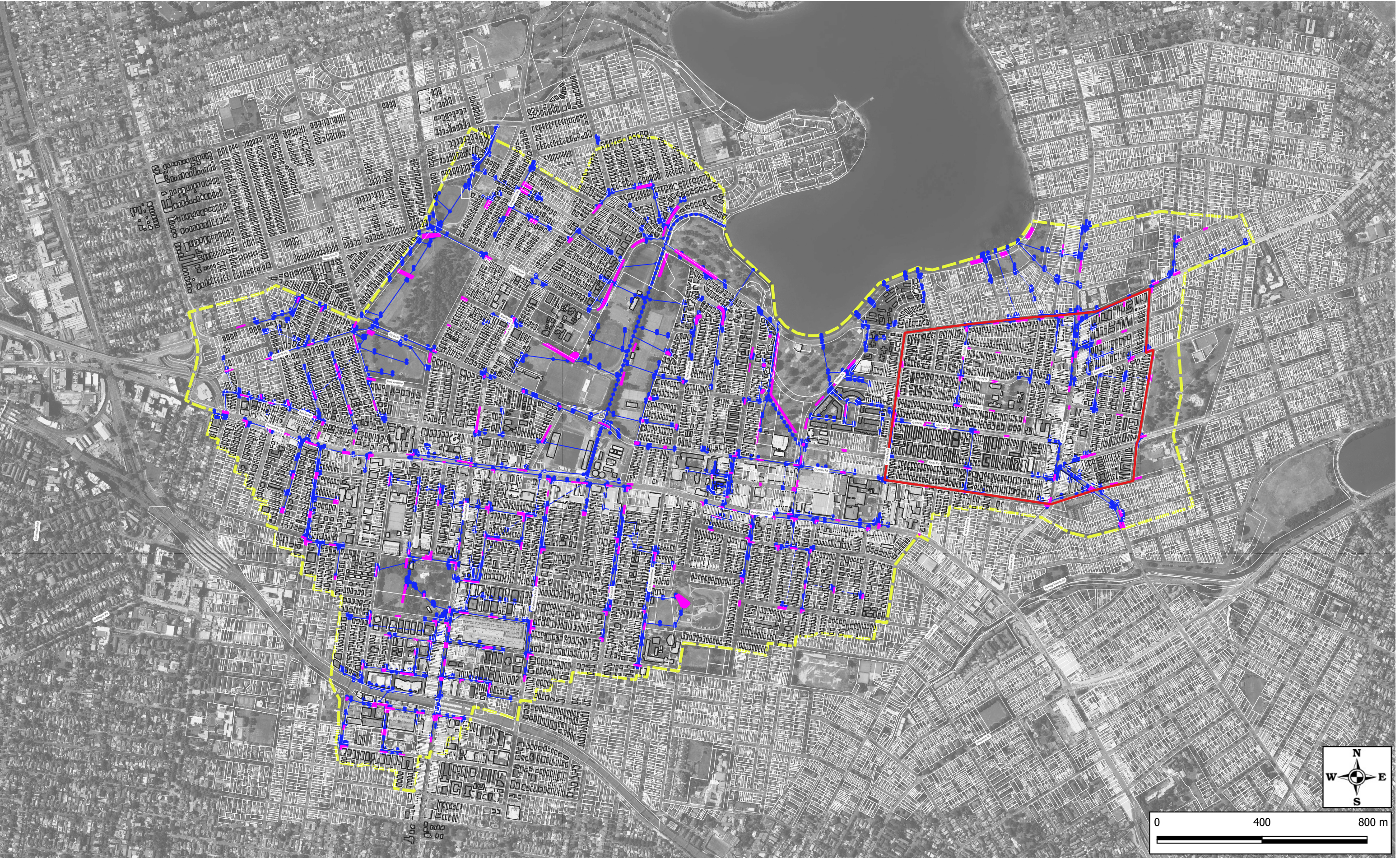
Precinct Cadastre Existing Buildings	TITLE: Five Dock Precinct Buildings Outlines			
	PROJECT: Five Dock Precinct Flood Assessment			
	PROJECT No. 240063			
	DATE: 10-2024	SCALE: 1:4,000	FIGURE No. 02	



 Precinct  Hydraulic Model Boundary
 Hydrologic Subcatchments

TITLE: Subcatchment Delineation		
PROJECT: Five Dock Precinct Flood Assessment		
PROJECT No. 240063		
DATE: 10-2024	SCALE: 1:13,000	FIGURE No. 03

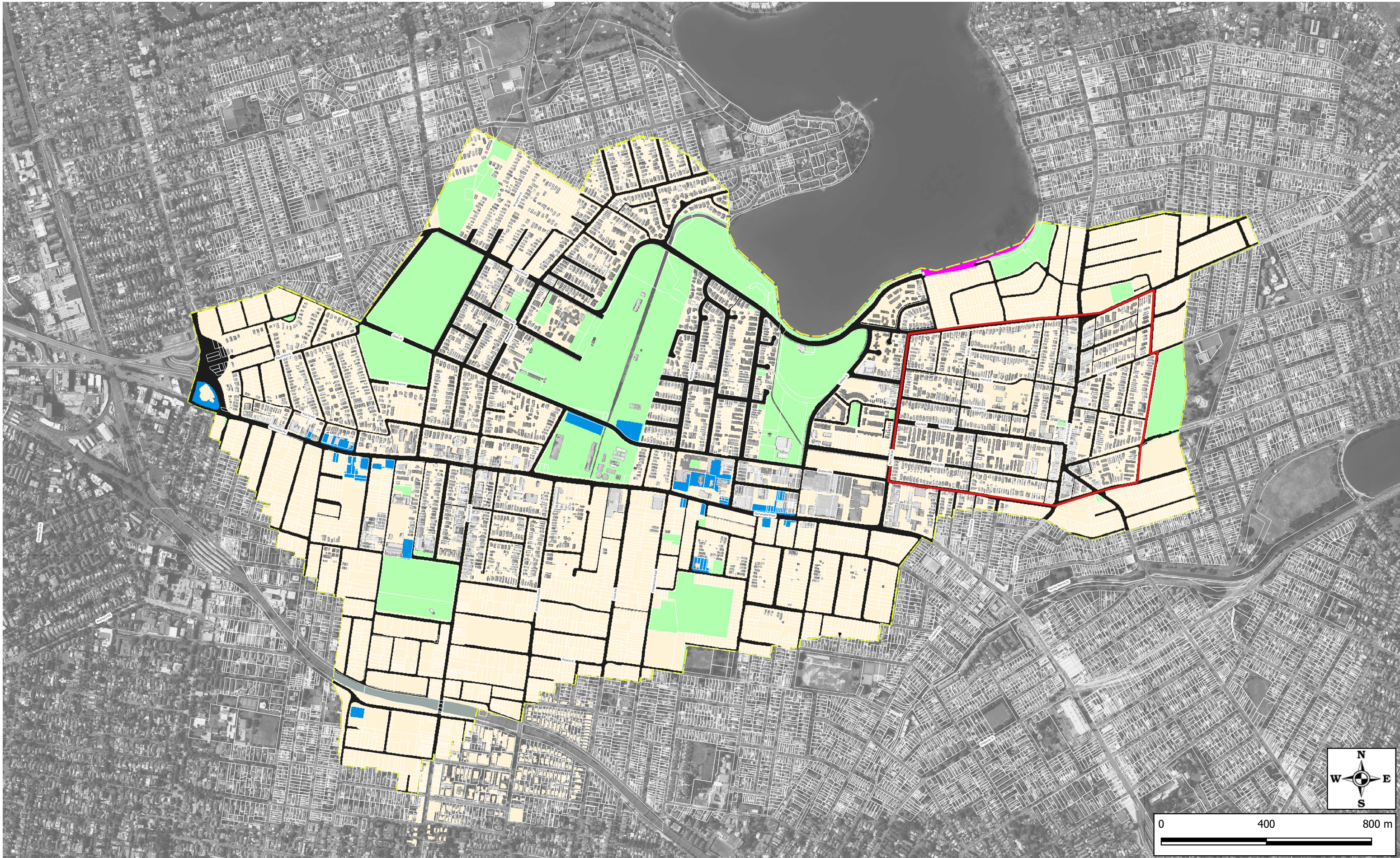




 Precinct  Buildings  Stormwater Pipes
 Cadastre  Catchment Inflows  Stormwater Pits

TITLE: Hydraulic Model Schematisation		
PROJECT: Five Dock Precinct Flood Assessment		
PROJECT No. 240063		
DATE: 10-2024	SCALE: 1:13,000	FIGURE No. 04





Precinct Cadastre Hydraulic Model Boundary	Railway (n = 0.05) Open Space (n = 0.03) Proporties (n = 0.05) Roads (n = 0.02) Light Vegetation (n = 0.03)	TITLE: Hydraulic Model Roughness PROJECT: Five Dock Precinct Flood Assessment PROJECT No. 240063 DATE: 10-2024 SCALE: 1:13,000 FIGURE No. 05			grc HYDRO



Precinct Cadastre	Flood Depth (m)	0.2 - 0.3	1.5 - 2.0	Major Flood Level Contour (Spacing = 5m) Minor Flood Level Contours (Spacing = 1m)
	0 - 0.05	0.3 - 0.5	> 2.0	
	0.05 - 0.1	0.5 - 1.0		
	0.1 - 0.2	1.0 - 1.5		

TITLE: 5% AEP Flood Depths and Levels		
PROJECT: Five Dock Precinct Flood Assessment		
PROJECT No. 240063		
DATE: 11-2024	SCALE: 1:4,000	FIGURE No. 06

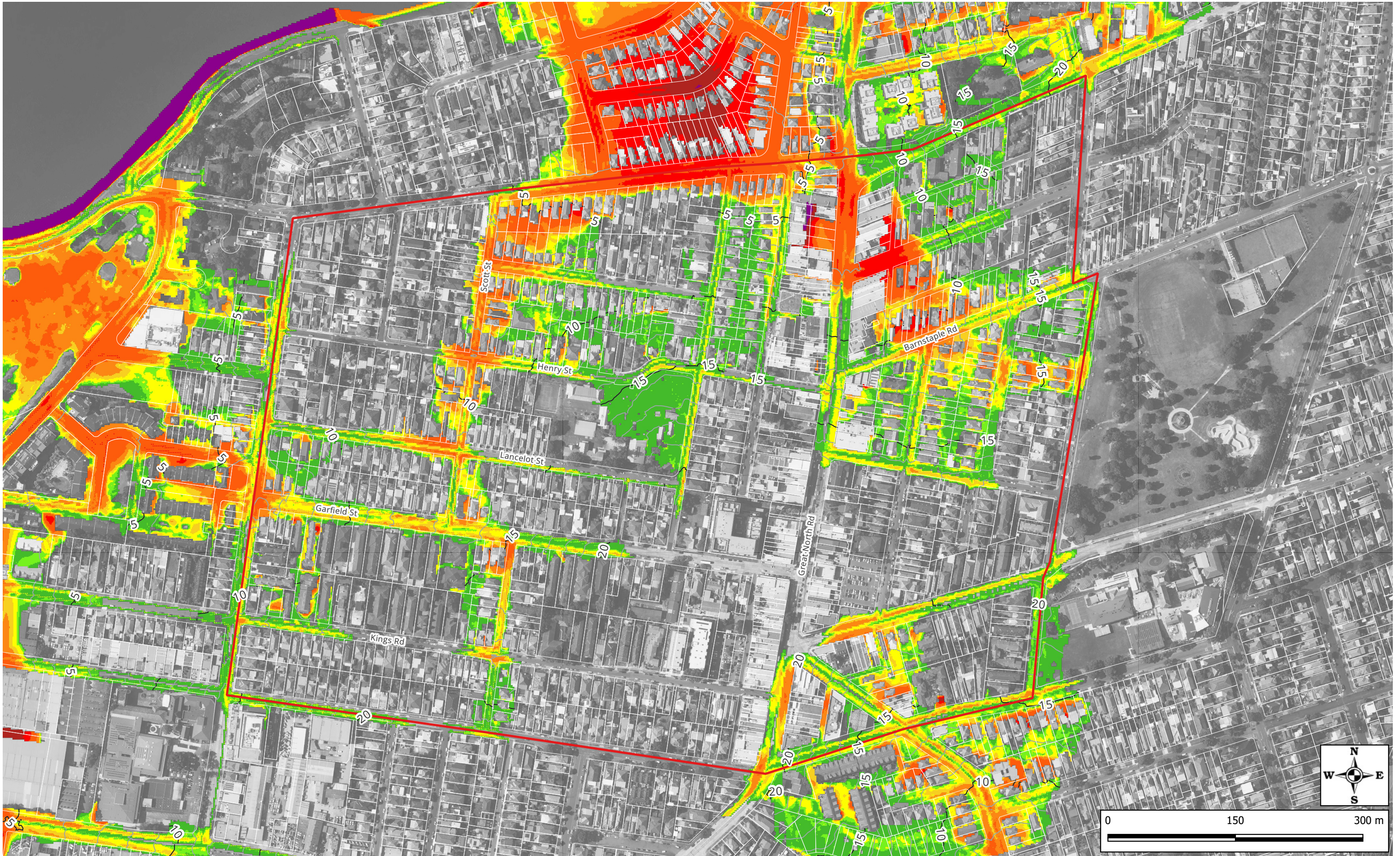




Precinct Cadastre	Flood Depth (m)	0.2 - 0.3	1.5 - 2.0	Major Flood Level Contour (Spacing = 5m) Minor Flood Level Contours (Spacing = 1m)
	0 - 0.05	0.3 - 0.5	> 2.0	
	0.05 - 0.1	0.5 - 1.0		
	0.1 - 0.2	1.0 - 1.5		

TITLE: 1% AEP Flood Depths and Levels		
PROJECT: Five Dock Precinct Flood Assessment		
PROJECT No. 240063		
DATE: 11-2024	SCALE: 1:4,000	FIGURE No. 07





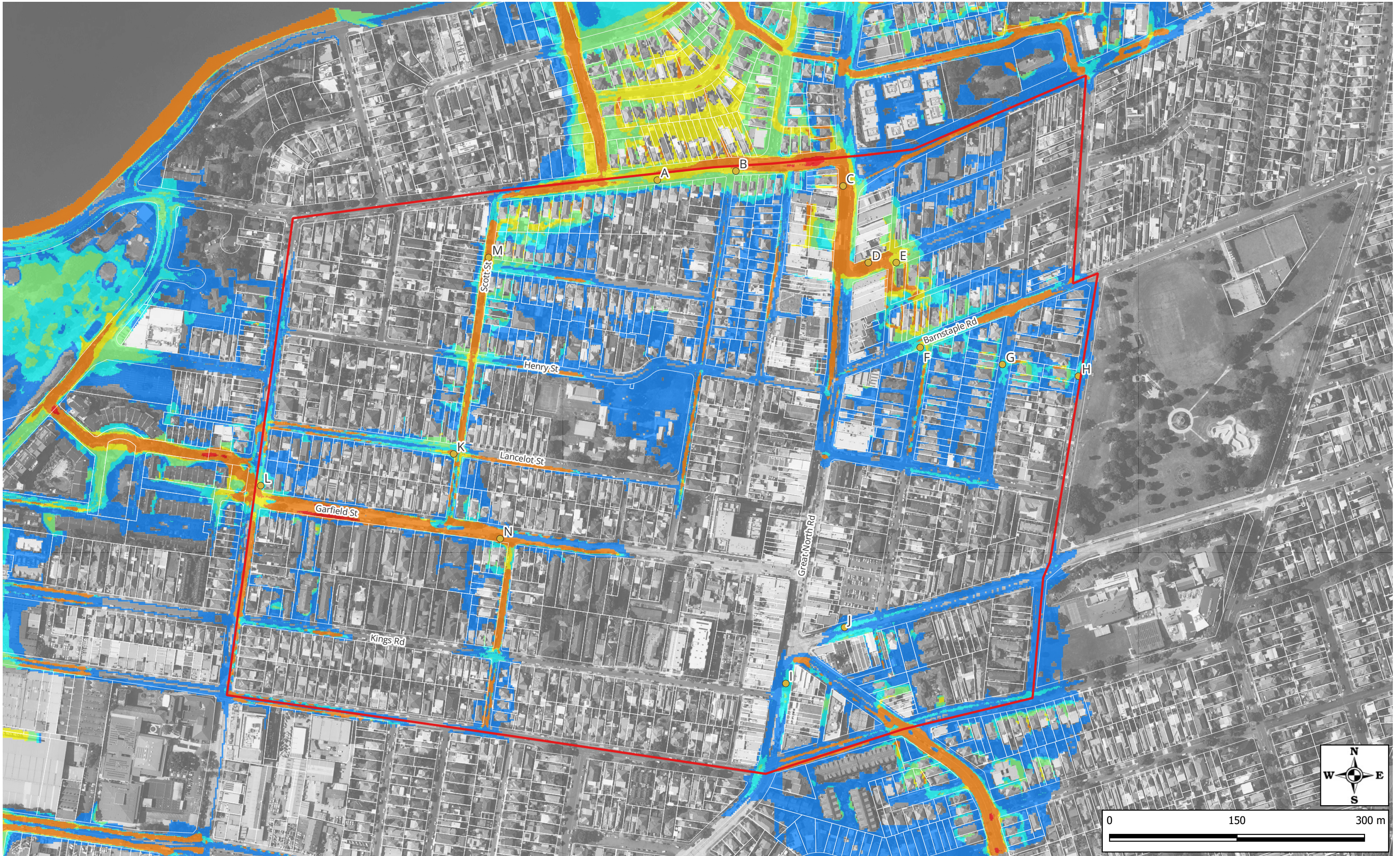
Precinct Cadastre	Flood Depth (m) 0 - 0.05 0.05 - 0.1 0.1 - 0.2 0.2 - 0.3 0.3 - 0.5 0.5 - 1.0 1.0 - 1.5 1.5 - 2.0 > 2.0
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Precinct Cadastre	Flood Hazard		H3	H6
	H1	H4		
	H2	H5		
TITLE: 5% AEP Flood Hazard				
PROJECT: Five Dock Precinct Flood Assessment				
PROJECT No. 240063				
DATE: 02-2025		SCALE: 1:4,000	FIGURE No. 09	



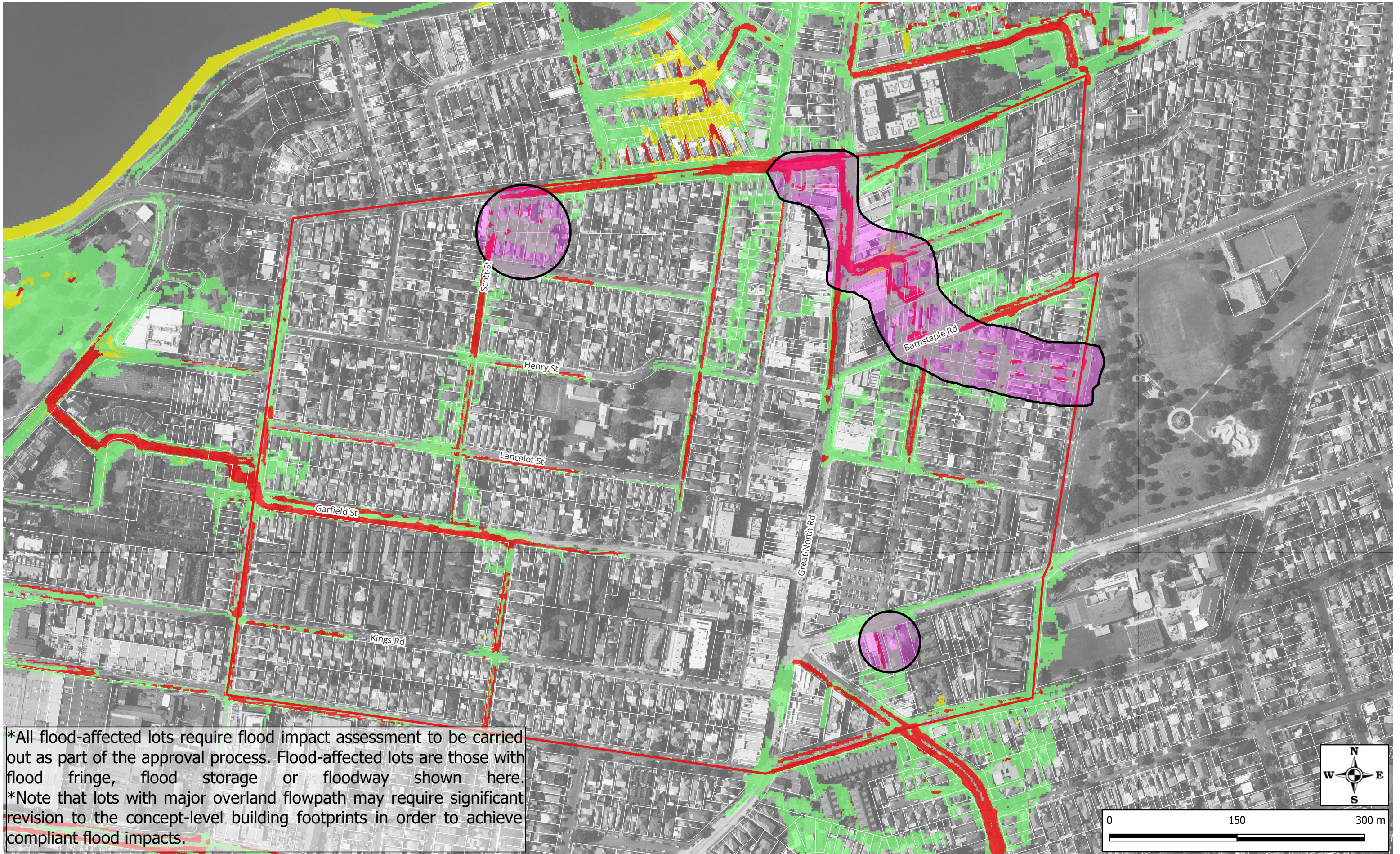
Precinct Cadastre	Flood Hazard H1 H2 H3 H4 H5 H6
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Precinct Cadastre	Flood Hazard H1 H2 H3 H4 H5 H6
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Precinct Cadastre	Flood Function	TITLE: 5% AEP Hydraulic Categorisation			
	Flow Conveyance	PROJECT: Five Dock Precinct Flood Assessment			
	Flood Storage	PROJECT No. 240063			
	Flood Fringe	DATE: 02-2025	SCALE: 1:4,000	FIGURE No. 12	

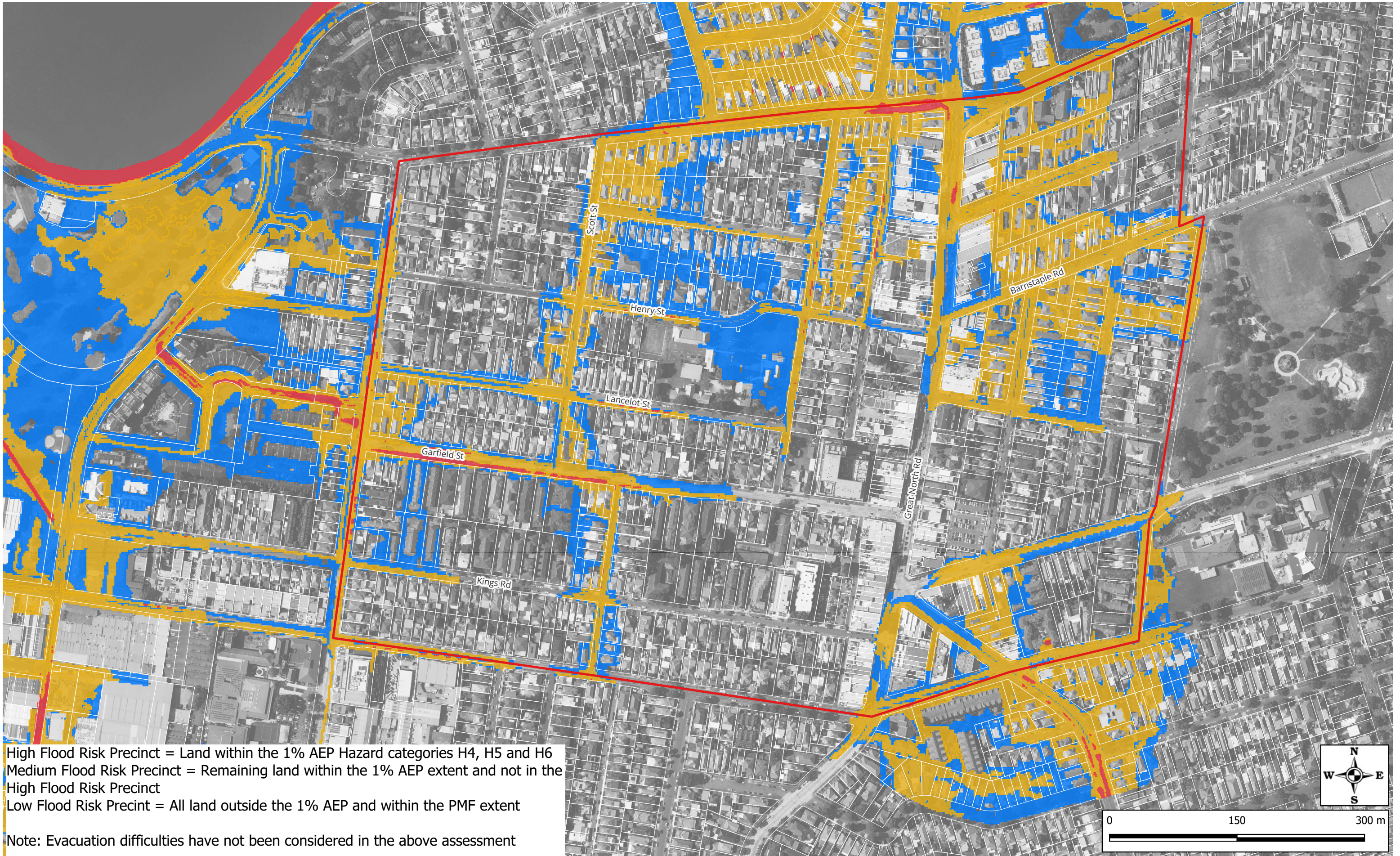


*All flood-affected lots require flood impact assessment to be carried out as part of the approval process. Flood-affected lots are those with flood fringe, flood storage or floodway shown here.
*Note that lots with major overland flowpath may require significant revision to the concept-level building footprints in order to achieve compliant flood impacts.

Precinct Cadastre Lots with Major Overland Flowpath	Flood Function Flow Conveyance Flood Storage Flood Fringe
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Precinct Cadastre Flood Function Flow Conveyance Flood Storage Flood Fringe	TITLE: PMF Hydraulic Categorisation		
	PROJECT: Five Dock Precinct Flood Assessment		
	PROJECT No. 240063		
	DATE: 02-2025	SCALE: 1:4,000	



Precinct Cadastre Flood_High_Risk Flood_Medium_Risk Flood_Low_Risk	TITLE: Flood Risk Precinct		
	PROJECT: Five Dock Precinct Flood Assessment		
	PROJECT No. 240063		
	DATE: 02-2025	SCALE: 1:4,000	FIGURE No. 15



Precinct	Impact (m)	-0.1 to -0.01	0.2 to 0.3
Cadastre	< -0.3	No Impact	> 0.3
Proposed Buildings	-0.3 to -0.2	0.01 to 0.1	No Longer Flooded
Existing Building Retained	-0.2 to -0.1	0.1 to 0.2	Newly Flooded

TITLE: Change in Peak Flood Level Proposed Development vs Existing 5% AEP		
PROJECT: Five Dock Precinct Flood Assessment		
PROJECT No. 240063		
DATE: 09-2025	SCALE: 1:4,000	FIGURE No. 16





Precinct	Impact (m)	-0.1 to -0.01	0.2 to 0.3
Cadastre	< -0.3	No Impact	> 0.3
Proposed Buildings	-0.3 to -0.2	0.01 to 0.1	No Longer Flooded
Existing Building Retained	-0.2 to -0.1	0.1 to 0.2	Newly Flooded

TITLE: Change in Peak Flood Level Proposed Development vs Existing 1% AEP		
PROJECT: Five Dock Precinct Flood Assessment		
PROJECT No. 240063		
DATE: 09-2025	SCALE: 1:4,000	FIGURE No. 17

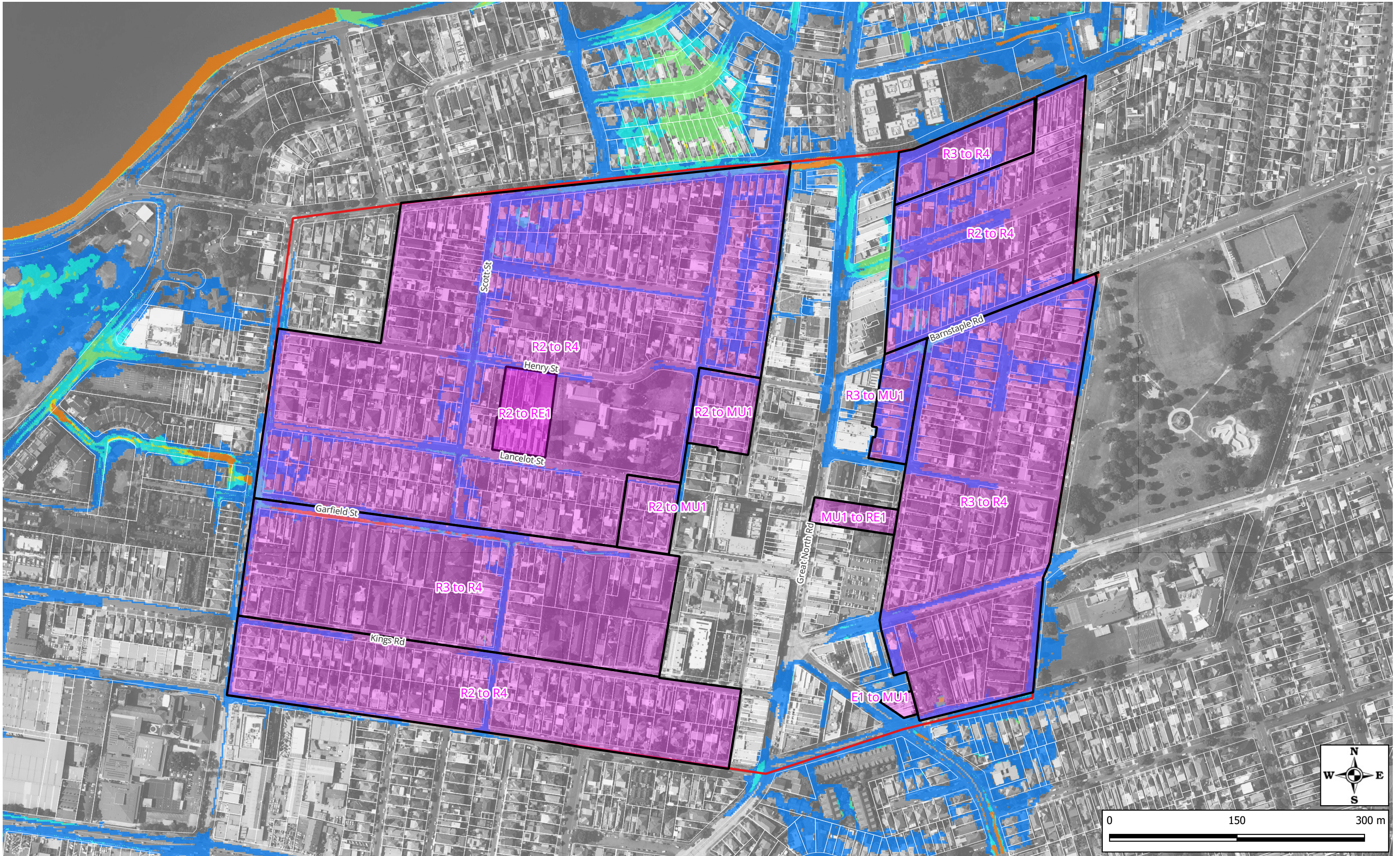




Precinct	Impact (m)	-0.1 to -0.01	0.2 to 0.3
Cadastre	< -0.3	No Impact	> 0.3
Proposed Buildings	-0.3 to -0.2	0.01 to 0.1	No Longer Flooded
Existing Building Retained	-0.2 to -0.1	0.1 to 0.2	Newly Flooded

TITLE: Change in Peak Flood Level Proposed Development vs Existing PMF		
PROJECT: Five Dock Precinct Flood Assessment		
PROJECT No. 240063		
DATE: 09-2025	SCALE: 1:4,000	FIGURE No. 18





Precinct Cadastre Areas potentially to be rezone	Flood Hazard		H3	H6	
	H1	H4			
	H2	H5			
TITLE: Change in Zoning and 1% AEP Flood Hazard PROJECT: Five Dock Precinct Flood Assessment PROJECT No. 240063 DATE: 09-2025 SCALE: 1:4,000 FIGURE No. 19					grc HYDRO