ATTACHMENT K

Flood Constraints Review

Randwick HIAs

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RANDWICK HOUSING INVESTIGATION AREAS FLOOD CONSTRAINTS REVIEW

FINAL REPORT

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MAY 2022

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RANDWICK HOUSING INVESTIGATION AREAS FLOOD CONSTRAINTS REVIEW

FINAL REPORT

MAY 2022

Project **Randwick Housing Investigation Areas Flood Constraints Review**	Project Number **121076**
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RANDWICK HOUSING INVESTIGATION AREAS
FLOOD CONSTRAINTS REVIEW

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EXECUTIVE SUMMARY

Randwick City Council is preparing a Planning Proposal to amend zoning, building height and density allowances for five areas in its Local Government Area (LGA). Council's preferred options for the proposal have been outlined in Urban Design Analysis reports for each of the five Housing Investigation Areas (HIAs). Some portions of these HIAs are flood prone, and it is therefore necessary to determine whether the Planning Proposal meets the relevant legislative requirements relating to flooding.

Council engaged WMAwater to review the available flood information for the relevant land, and assess the recommended options from the Urban Design Analysis reports against relevant strategic planning and environmental legislation.

Some lots within each HIA are constrained by flood affectation to various degrees. The details of the specific flood behaviour and constraints within each HIA are discussed in Sections 4.1 to 4.5. The flood constraints identified for specific development lots in this assessment do not prohibit development of those sites, either under the existing LEP/DCP or under the amended LEP/DCP resulting from the Planning Proposal. Either way, future development applications will be required to demonstrate compliance with the flood-related development controls.

The nature of these constraints and the solutions to satisfy the development controls are not significantly altered by the Planning Proposal. However, as with the current LEP zoning, height allowances and maximum FSR, the flood constraints may preclude full development of some sites to the maximum allowable density. This is because compliance with various flood controls (such as not obstructing a flow path, or not building a basement in a hazardous area, or building the ground floor at a minimum level) may reduce the achievable building footprint or number of building storeys within a given site. Generally however, the preferred building layout for each HIA appears to provide sufficient building set-back allowances to allow the requirements to be met without major design compromises.

WMAwater identified one localised component of Council's preferred strategy which is not consistent with the flooding clause of the Local Planning Directions:

- There are some lots affected by floodway in the Arthur Street HIA, between Blenheim Street and High Street, where the preferred strategy indicates a contiguous block of buildings across the floodway (see Section 4.3.4). This will not be feasible without diverting flow and adversely affecting the flood affectation of neighbouring lots. WMAwater would recommend that this building mass layout be reviewed and altered to take into account the 1% AEP floodway, by allowing for separation between the buildings. The separation will need to be similar to the width of the current 1% AEP flow path for the affected lots as shown on Figure C4, although it may be possible for developers to optimise this arrangement and reduce the required width. This would require a localised flood modelling assessment at the time of the development application.

Outside of this localised area, there are other sites where future development applications will

need to address flood-related development controls, but the controls are unlikely to significantly compromise the development potential. The controls (as outlined in the DCP) primarily relate to mitigating flood damage to new development by requiring minimum floor level heights and entry crests to basements, as well as ensuring that new development does not exacerbate existing flood problems for others by diverting or blocking overland flow paths.

Potential developers should be aware that even though the flood constraints are likely to be manageable, in some instances design compromises may be required to meet the controls. The most likely areas where the flood constraints will need to be a primary design constraint are:

- Commercial properties fronting Alison Road, where the building facades are along the property boundary, and minimum floor level controls might have implications for accessibility (such as ramps or other solutions) within the building.
- Most properties in the Kensington North precinct, where flood depths in the adjacent road reserves are significant, and the minimum floor level controls are in some cases more than 1 m above the typical ground level of the site. These sites may also require open space design solutions that avoid net filling of ground levels in order to retain temporary flood storage within the site.
- Some properties in each of the precincts, where the existing 1% AEP overland flow paths through the site may need to be retained.
- Some properties fronting Jacques Street in the Kingsford South HIA, where minimum floor levels and basement entry points may be a constraint on ground floor and basement access configurations.

Although the localised flood constraints discussed above will likely involve design compromise for some lots, it is likely the Planning Proposal will improve the feasibility of redevelopment in those lots where it would currently be impractical to meet the flood-related development controls. This is because consolidation of lots and permissibility of larger, taller buildings provides more flexibility in the development design to accommodate flow paths through part of the consolidated site, while fully developing the remainder with minimum floor levels that meet requirements. This is less likely to be feasible with lower density development involving fragmented lots and separate buildings. The consolidation of lots and increased density will likely improve the viability of the most heavily flood-constrained sites identified herein.

WMAwater considers that the Planning Proposal is generally consistent with the Ministerial Directions for flood prone land (see Section 2.2 and Section 5 for detailed discussion). The Planning Proposal is consistent with other relevant legislation and Council's strategic planning framework for flood planning, in that the flood-related development controls enforced through that framework are not significantly altered by the Planning Proposal.

This review does not include detailed flood modelling of potential development or building layouts, and does not constitute a flood impact assessment for specific development sites. Future development proposals for flood prone sites will need to be accompanied by site specific flood assessments demonstrating compliance with Council's flood-related development controls.

1. INTRODUCTION

1.1. Overview

Randwick City Council is preparing a Planning Proposal to amend zoning, building height and density allowances for five areas in its Local Government Area (LGA). Council's preferred options for the proposal have been outlined in Urban Design Analysis reports for each of the five Housing Investigation Areas (HIAs). Some portions of these HIAs are flood prone, and it is therefore necessary to determine whether the Planning Proposal meets the relevant legislative requirements relating to flooding.

Council engaged WMAwater to review the available flood information for the relevant land, and assess the recommended options from the Urban Design Analysis reports against relevant strategic planning and environmental legislation. WMAwater has reviewed and summarised the flood constraints with a view to providing sufficient information for the relevant Planning Proposal to proceed to public exhibition, as required by the Department of Planning, Industry and Environment's Gateway Determination conditions issued on 12 September 2021.

This review does not include detailed flood modelling of potential development or building layouts, and does not constitute a flood impact assessment for specific development sites. Future development proposals for flood prone sites will need to be accompanied by site specific flood assessments demonstrating compliance with Council's flood-related development controls.

1.2. Study Areas

This assessment covers five separate Housing Investigation Areas (HIAs) within the Randwick Local Government Area (LGA):

- The "West Randwick HIA," a triangular-shaped precinct bounded by King Street, William Street and Alison Road (Figure A1);
- The "Kensington North HIA," defined by Alison Road, Anzac Parade, Doncaster Avenue and Carlton Street to the east, with an additional area encompassing parts of Kensington Road, Salisbury Road and Boronia Street to the west (Figure B1);
- The "Arthur Street HIA," bounded by Arthur Street, Clara Street, High Street and Wansey Road (Figure C1);
- The "Magill Street HIA," bounded by Willis Street, Magill Street, Hospital Road and Barker Street (Figure D1); and
- The "Kingsford South HIA," bounded by Rainbow Street, Botany Street, Apsley Street, Bunnerong Road, Sturt Street, Wallace Street and Anzac Parade (Figure E1).

2. BACKGROUND

2.1. Planning Proposal Description

The Planning Proposal to be prepared will seek to amend height and floor space planning controls in the Randwick Local Environmental Plan 2012 (LEP).

Council provided an Urban Design Report for each HIA (References 1 to 5) which recommends a preferred option for each HIA, outlining the indicative built form and proposed strategy for the allowable building heights and Floor Space Ratio (FSR). A brief summary of Council's preferred option for each HIA is provided in the relevant section reviewing the flood constraints (Sections 4.1 to 4.5). The preferred built form option is overlaid on the map of hydraulic categories for each HIA (the fourth map in each appendix).

2.2. Relevant Legislation

The Planning Proposal is required to comply with Directions issued by the Minister for Planning under section 9.1(2) of the Environmental Planning and Assessment Act 1979 (previously section 117(2)). The applicable directions for flood prone land are found in Direction 4.3 (Reference 6), which was originally issued 1 July 2009. The requirements are reproduced below.

LOCAL PLANNING DIRECTIONS
Section 9.1(2) of the *Environmental Planning and Assessment Act 1979*

4.3 Flooding

Objectives

(1) The objectives of this direction are:

(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.

(b) to ensure that the provisions of a local environmental plan that apply to flood prone land are commensurate with flood behaviour and include consideration of the potential flood impacts on and off the subject land.

Where this direction applies

(2) This direction applies to all relevant planning authorities that are responsible for flood prone land.

When this direction applies

(3) This direction applies when a planning proposal authority prepares a planning proposal that creates, removes or alters a zone or a provision that affects flood prone land.

What a planning proposal authority must do if this direction applies

(4) A planning proposal must include provisions that give effect to and are consistent with:

(a) the NSW Flood Prone Land Policy,

(b) the principles of the Floodplain Development Manual 2005,

(c) the *Considering flooding in land use planning guideline 2021,* and

(d) any adopted flood study and/or floodplain risk management plan prepared in accordance with the principles of the Floodplain Development Manual 2005 and adopted by the relevant council.

(5) A planning proposal must not rezone land within the flood planning area from Recreation, Rural, Special Purpose or Environmental Protection Zones to a Residential, Business, Industrial or Special Purpose Zones.

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

(a) permit development in floodway areas,
(b) permit development that will result in significant flood impacts to other properties,
(c) permit development for the purposes of residential accommodation in high hazard areas,
(d) permit a significant increase in the development and/or dwelling density of that land,
(e) permit development for the purpose of centre-based childcare facilities, hostels, boarding houses, group homes, hospitals, residential care facilities, respite day care centres and seniors housing in areas where the occupants of the development cannot effectively evacuate,
(f) permit development to be carried out without development consent except for the purposes of exempt development or agriculture. Dams, drainage canals, levees, still require development consent,
(g) are likely to result in a significantly increased requirement for government spending on emergency management services, flood mitigation and emergency response measures, which can include but are not limited to the provision of road infrastructure, flood mitigation infrastructure and utilities, or
(h) permit hazardous industries or hazardous storage establishments where hazardous materials cannot be effectively contained during the occurrence of a flood event.

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

(a) permit development in floodway areas,
(b) permit development that will result in significant flood impacts to other properties,
(c) permit a significant increase in the dwelling density of that land,
(d) permit the development of centre-based childcare facilities, hostels, boarding houses, group homes, hospitals, residential care facilities, respite day care centres and seniors housing in areas where the occupants of the development cannot effectively evacuate,
(e) are likely to affect the safe occupation of and efficient evacuation of the lot, or
(f) are likely to result in a significantly increased requirement for government spending on emergency management services, and flood mitigation and emergency response measures, which can include but not limited to road infrastructure, flood mitigation infrastructure and utilities.

(8) For the purposes of preparing a planning proposal, the flood planning area must be consistent with the principles of the Floodplain Development Manual 2005 or as otherwise determined by a Floodplain Risk Management Study or Plan adopted by the relevant council.

Consistency

(9) A planning proposal may be inconsistent with the terms of this direction only if the planning proposal authority can satisfy the Secretary of the Department of Planning, Industry and Environment (or their nominee) that:

(a) the planning proposal is in accordance with a floodplain risk management study or plan adopted by the relevant Council in accordance with the principles and guidelines of the Floodplain Development Manual 2005, or

(b) where there is no council adopted floodplain risk management study or plan, the planning proposal is consistent with the flood study adopted by the council prepared in accordance with the principles of the Floodplain Development Manual 2005 or

(c) the planning proposal is supported by a flood and risk impact assessment accepted by the relevant planning authority and is prepared in accordance with the principles of the Floodplain Development Manual 2005 and consistent with the relevant planning authorities' requirements, or

(d) the provisions of the planning proposal that are inconsistent are of minor significance as determined by the relevant planning authority.

Note: In this direction:

(a) "flood prone land" "flood storage" "floodway" and "high hazard" have the same meaning as in the Floodplain Development Manual 2005.

(b) "flood planning level" "flood behaviour" and "flood planning area" has the same meaning as in the Considering flooding in land use planning guideline 2021.

(c) Special flood considerations are outlined in the Considering flooding in land use planning guideline 2021 and an optional clause in the Standard Instrument (Local Environmental Plans) Order 2006.

(d) Under the floodplain risk management process outlined in the NSW Government's *Floodplain Development Manual 2005*, councils may produce a flood study followed by a floodplain risk management study and floodplain risk management plan.

Direction 4.3 – issued 14 July 2021

The directions require the development to be consistent with the NSW Flood Prone Land Policy and the principles of the Floodplain Development Manual 2005 (Reference 7), and other instruments as per clause 4. The primary objective of the NSW Flood Risk Management framework, as expressed within the NSW Flood Prone Lands Policy (Reference 7, page 1) is as follows:

> "*To reduce the impact of flooding and flood liability on individual owners and occupiers of flood prone property, and to reduce private and public losses resulting from floods, utilising ecologically positive methods wherever possible*."

The NSW Flood Prone Land Policy, as produced within Section 1.1 of the Floodplain Development Manual (2005), places the primary responsibility for implementation on local councils. The practical implementation of flood risk management in the relevant areas of Randwick City Council is primarily through the Randwick Local Environmental Plan 2012 (LEP, Reference 8) and Randwick Development Control Plan 2013 (DCP, Reference 9). The flood planning controls contained in the DCP are designed to ensure that there is no adverse flood impact on adjacent properties and that a development is compatible with the flood hazard of the land. Hence, enforcing compliance with the DCP is the primary mechanism by which Council ensures that any future development will be consistent with the NSW Flood Prone Land Policy and the principles of the Floodplain Development Manual 2005.

The flooding component of the DCP identifies the following objectives, which are supplemented by prescriptive controls for specific development types and circumstances:

Objectives

- To control development at risk of flooding in accordance with the NSW Government's Floodplain Development Manual.
- To ensure that the economic and social costs which may arise from damage to property due to flooding is minimised and can be reasonably managed by the property owner and general community.
- To reduce the risk to human life and damage to property caused by flooding by controlling development on land impacted by potential floods.
- To ensure that development is appropriately sited and designed according to the site's sensitivity to flood risk.

2.3. Previous Flood Studies, Floodplain Risk Management Studies and Plans

The following studies have previously been prepared for the catchments relevant to the study areas in this Planning Proposal:

- *Kensington / Centennial Park Floodplain Management Study and Plan* (KCP FRMSP), WMAwater, February 2019 (Reference 10), which applies to the Kensington North and West Randwick HIAs.
- *Birds Gully and Bunnerong Road Flood Study* (Birds Gully FS), WMAwater, June 2018 (Reference 11), which applies to the Arthur Street, Magill Street and Kingsford South HIAs.

For each of these catchments, a Flood Study with 2D flood modelling has been completed, but a Floodplain Risk Management Study/Plan has only been completed for Kensington/Centennial Park. Council has engaged WMAwater to complete a FRMSP for the Birds Gully/Bunnerong Road catchment, but this is not due for completion until early 2023. The mapping and discussion of flood behaviour in this assessment is derived from the catchment design flood modelling, as per the studies listed above.

The Birds Gully catchment modelling from Reference 11 did not include the expansion to the Prince of Wales hospital immediately north of the Magill Street HIA (bounded by Magill St, Hospital Road, Botany Street and High Street), which is currently under construction. This area is also immediately to the south of the Arthur Street HIA. Flood modelling of this development was completed as part of the approvals process (Reference 12), and this development is presently being incorporated into the updated catchment flood modelling for the Birds Gully FRMSP. However WMAwater does not yet have comprehensive mapping of the changes for all the outputs considered here (such as flood hazard and hydraulic categorisation).

The results available at this stage indicate that although the hospital development will improve the flood situation by reducing depths slightly, the hospital development does not significantly change the flood behaviour or constraints to development within and around the Magill Street or Arthur St HIAs. Based on the flood report for the hospital development approval, and WMAwater's preliminary results for the flood modelling updates, the new infrastructure lowers flood levels slightly in High Street and further downstream at Barker Street. However these reductions are only in the order of a few centimetres, and the same overland flow paths will still occur in the 1% AEP event. The constraints as discussed in this report will not change significantly. Therefore, the mapping and discussion provided in this report is based on the older catchment modelling from Council's adopted Flood Study (Reference 11).

3. FLOOD CONSTRAINTS BACKGROUND

3.1. Overview of Flood Behaviour and Risks

Generally, the areas under consideration are subject to flood behaviour that is usually referred to as "overland flow." In urban environments with significant impervious surfaces and a pit/pipe drainage network for stormwater, overland flow occurs when the amount of runoff from the catchment exceeds the capacity of the sub-surface drainage network (stormwater pits and pipes).

In most of the older developed areas of Sydney (including these areas), the drainage network capacity is typically only sufficient for rainfall events up to around 20% or 10 AEP (1 in 5 or 1 in 10 chance per year, respectively). In more intense events, such as the 1% AEP event generally used as the risk standard for new development in NSW, overland flow will occur along whatever remains of the pre-development creek-line or valley. Depending on the development layout, this overland flow may occur along remnant creek lines through parks/reserves, down roadways, or through private development.

Overland flow flood affectation is usually characterised as "flash flooding." It is of relatively short duration and often relatively shallow and fast flowing. It can occur with little to no warning prior to the occurrence of an intense flood-producing storm.

Often in older areas where the layout of the road network, private development lots and stormwater system was set decades ago, the capital costs of broad-scale upgrades to the drainage infrastructure are prohibitive. Typical floodplain management practice in these areas is to rely on development controls to maintain existing overland flow paths by ensuring they are not obstructed or diverted by new development. The risks to new development are managed by ensuring that floor levels of new buildings are sufficiently above the relevant flood risk standard. In many flash flood areas of Sydney where existing development does not meet these standards, the most effective long-term measure to reduce the flood risk is through redevelopment. This is frequently facilitated by consolidation of development lots for higher intensity uses, since the larger development scale provides more flexibility for retaining the existing overland flow paths, while meeting the required standards for the new buildings.

The main objectives for flood-related controls on new development, as reflected in the relevant planning legislation discussed in Section 2.2, are:

- Ensuring that new development does not exacerbate flooding problems elsewhere,
- Mitigating the risk of damage to new development by raising building floor levels and basement entry points to minimum heights above the flood levels, and
- Mitigating the risk to life for occupants/users of new development, by ensuring the development is compatible the flood hazard of the land. This includes consideration of evacuation requirements and structural soundness of the building for the full range of flood risk, including extremely rare events with more severe flooding than the primary 1% AEP standard.

Flood planning concepts relevant to achieving these objectives are discussed in the following

sections (3.2 to 3.5). A review of the relevant flood information specific to each HIA is provided in Sections 4.1 to 4.5.

3.2. Hydraulic Categories

The mapping of hydraulic categories as part of catchment-wide flood studies provides a broad scale estimate of the areas that could potentially exacerbate existing flood risk if redeveloped. This categorisation is defined by the Floodplain Development Manual as:

- **Floodway** – 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 flows, or a significant increase in flood levels.
- **Flood Storage** – 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.
- **Flood Fringe** – The remaining area of flood prone land after floodway and flood storage areas have been defined.

Definition of hydraulic categories is somewhat subjective, particularly in an urban catchment where the depths of inundation are relatively shallow and the peak flows are relatively small. However blocking even a minor overland flow path can re-direct flow onto adjoining properties and cause damage by flowing through buildings, adversely affecting the adjoining property, and therefore be considered floodway. This is frequently the case where the historical creek line and the stormwater drainage network runs through private property. Floodways are not necessarily always defined as high hazard areas. Hazard reflects the potential harm to life and property due to flooding, whilst floodways reflect areas where if filled or modified will produce a significant adverse hydraulic impact on others.

While hydraulic categories can provide an indication of where obstruction of filling of flow paths may be problematic, it does not mean that the area cannot be developed. For minor flow paths (even if classified as floodway), it may be possible to divert or modify the flow path within the development extent such that adverse impacts off-site are avoided. This can be demonstrated by doing a “flood impact assessment” whereby the catchment flood models are altered to represent the new development, and the resulting flood behaviour is compared with existing flood behaviour to demonstrate it is not worsened. Council generally endeavours to ensure that any new development takes this into account by requiring a flood study to be undertaken to assess the potential hydraulic impacts of the development.

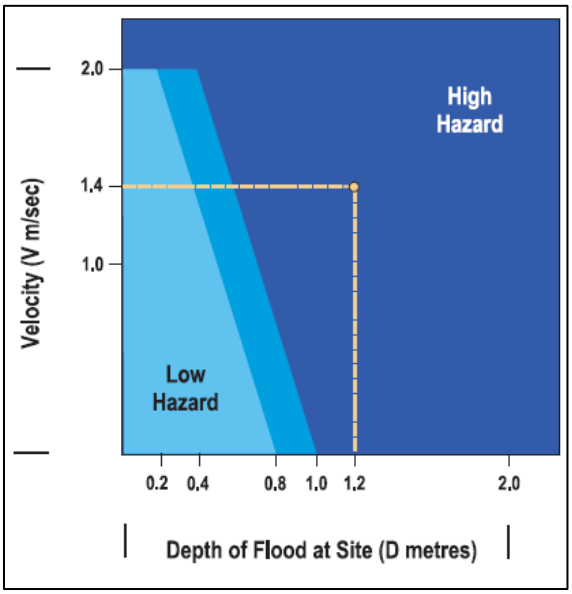
Any filling on the floodplain or blocking of a flow path will affect flood levels to some degree, however it is impractical for Council to monitor every development on the floodplain as many will have only a very minor impact. This constraints review focuses on those areas where a flood impact assessment is likely to be required for any redevelopment, both under the current LEP and for the changes under the Planning Proposal.

3.3. Flood Hazard Classification

Hydraulic hazard is a measure of potential risk to life and property damage from flood. Hydraulic hazard is typically determined by considering the depth and velocity of floodwaters.

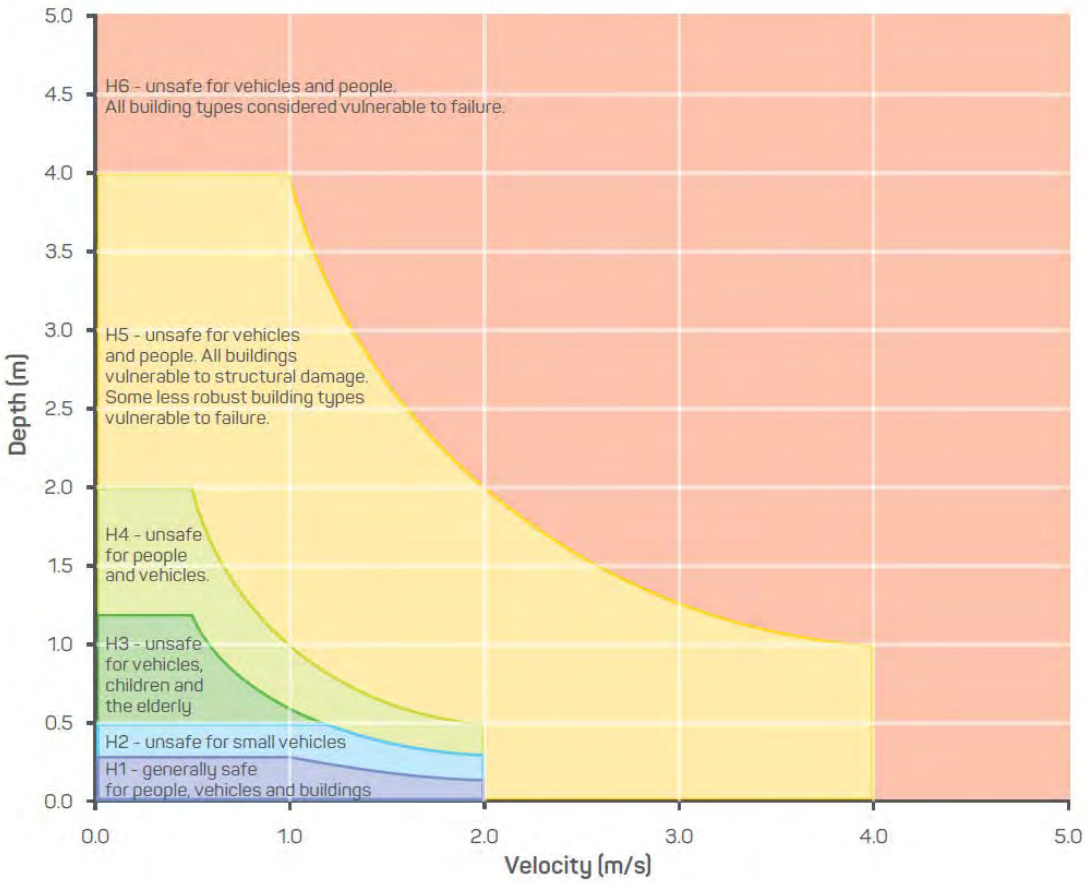
Appendix L of the NSW Floodplain Development Manual (FDM, Reference 7) gives one method for hydraulic hazard, which is shown in Diagram 1.

Diagram 1: Provisional "L2" Hydraulic Hazard Categories (FDM)



In recent years (since the publication of the Floodplain Development Manual in 2005), there have been a number of developments in the classification of hazards. Research has been undertaken to assess the hazard to people, vehicles and buildings based on flood depth, velocity and velocity depth product. The findings of this research are incorporated into revised categories for hazard classification presented in the Australian Disaster Resilience Handbook Collection (*Handbook 7 – Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia*). The supporting guideline 7-3 (Reference 13) contains information relating to the categorisation of flood hazard. A summary of this categorisation is provided in Diagram 2.

Diagram 2: General flood hazard vulnerability curves (ADR)



This classification provides a more detailed distinction and practical application of hazard categories, identifying the following 6 classes of hazard:

- H1 – No constraints, generally safe for vehicles, people and buildings;
- H2 – Unsafe for small vehicles;
- H3 – Unsafe for all vehicles, children and the elderly;
- H4 – Unsafe for all people and all vehicles;
- H5 – Unsafe for all people and all vehicles. All building types vulnerable to structural damage. Some less robust building types vulnerable to failure. Buildings require special engineering design and construction; and
- H6 – Unsafe for all people and all vehicles. All building types considered vulnerable to failure.

Areas classified as, H4 or greater under the ADR classification roughly correspond to areas of high hazard under the FDM classification method. The maps and associated discussion of flood hazard in this review use the ADR classification.

3.4. Emergency Management and Risk to Life

Flooding in these catchments will generally occur quite rapidly in response to very heavy rain (referred to as “flash flooding”). The Bureau of Meteorology (BoM) does not issue quantitative flood warnings for flash-flood catchments, defined as rain-to-flood times of less than six hours.

The BoM does not issue quantitative warnings for these study areas. The BoM does issue severe weather warnings whenever severe weather is occurring in an area or expected to develop or move into an area. This includes very heavy rain that may lead to flash flooding. The warnings describe the area under threat and the expected hazards. Warnings are issued with varying lead-times, depending on the weather situation, and can be from 1 hour to 24 hours or more. The Bureau also issues detailed severe thunderstorm warnings that include thunderstorms producing heavy rainfall which may cause flash flooding.

The SES is the legislated Combat Agency for floods and is responsible for the control of flood operations. This includes the coordination of other agencies and organisations for flood management tasks. The SES Local Controller is responsible for dealing with floods as detailed in the State Flood Plan.

Given the flash flood nature of the catchment and the lack of warning time for flooding, the SES is unlikely to mobilise volunteers to any specific locations in the area in anticipation of flooding, except possibly at major roads with significant flood affectation such as Bexley Road. The SES will generally only respond to specific calls for assistance or observed flooding in flash flood areas.

Generally, the most effective way to mitigate flood risk to human life in this environment is to ensure that buildings are built to withstand flood forces to enable people to remain indoors during the intense storm events, and to discourage people from attempting to drive through floodwaters. This is best achieved by effective design of each building to ensure it remains flood free without requiring active measures such as the deployment of barriers or flood gates, so that people can remain inside until flooding has subsided. Since flash flooding is usually of relatively short duration, the risks arising from isolation during flooding are relatively low.

3.5. Extreme Flood Events and the Probable Maximum Flood

Generally, planning controls in NSW are focussed on a 1% AEP or “1 in 100” standard for development, with a freeboard allowance above the 1% AEP level for setting floor levels. However the NSW Floodplain Development Manual (Reference 7) emphasises that the residual or “continuing” risk of more extreme events must be considered as part of development planning.

Above the Flood Planning Level a continuing flood risk extends to the limit of the floodplain that would be covered by the Probable Maximum Flood. In this area development controls are not prescribed for most types of development, but there may be a need for planning considerations, such as evacuation planning, in some circumstances. Specific controls may also be required if a major development could seriously affect the behaviour of the PMF, and for critical facilities which must continue to operate during and after an extreme flood event.

For this reason, mapping of the hazard for the PMF has been included in this assessment and is considered in the discussion of each HIA. The PMF requires measured consideration, because it represents risk that is a combination of extremely low probability (in the order of a 1 in 10 million chance per year for this study area), combined with extreme consequences (because the PMF often involves widespread high hazard flooding in places that are flood free up to the 1% AEP

development standard). It is necessary to remember that even relatively extreme events such as a 1 in 1000 (0.1% AEP) design event will generally be significantly closer to the 1% AEP than the PMF in terms of flood extents and hazard. The purpose of considering the PMF flood behaviour is to identify and manage the full range of residual risk above the 1% AEP development standard, for land uses where there is a lower tolerance for risk than for typical development. It is not feasible or appropriate to try and eliminate all flood risk by prohibiting development based on the PMF hazard. As the NSW Flood Prone Land Policy (within Reference 7) states:

> *The primary objective of the New South Wales Flood Prone Land Policy, as outlined below, recognises the following two important facts:*
>
> - *flood prone land is a valuable resource that should not be sterilised by unnecessarily precluding its development; and*
> - *if all development applications and proposals for rezoning of flood prone land are assessed according to rigid and prescriptive criteria, some appropriate proposals may be unreasonably disallowed or restricted, and equally, quite inappropriate proposals may be approved.*

4. FLOOD CONSTRAINTS ASSESSMENT

4.1. West Randwick HIA

4.1.1. Preferred Planning Strategy

Council's preferred building density and height strategy for this HIA (Reference 1) is shown on Diagram 3. The zoning is a mixture of B1 Neighbourhood Centre and R3 Medium Density Residential.

Diagram 3: West Randwick HIA – Preferred Changes to Built Form and Height Restrictions

4.1.2. Site Characteristics and Flood Behaviour

Mapping of relevant design flood information is provided in Appendix B as follows:

- Peak flood depths and levels – Figure A2 (5% AEP) and Figure A3 (1% AEP)
- Hydraulic categories – Figure A4 (1% AEP)
- Hydraulic Hazard – Figure A5 (1% AEP) and Figure A6 (PMF)

The topography in this HIA slopes downwards from north-east to south-west, draining towards Randwick Racecourse. The local catchment area upstream of this HIA is reasonably small, and most of overland flow from upstream is contained within the kerb/gutter and road reserve of King Street, some of which is then discharged through the centre of the HIA via John Street (see Diagram 4, and Photo 1).

Diagram 4: 1% AEP overland flow directions – West Randwick HIA

The catchment-wide modelling indicates that there is some risk of overland flow overtopping the gutter of King Street and flowing through the properties east of John Street, with water potentially accumulating in trapped low areas around the eastern end of John Lane, and the western end of William Lane. Some of the lots in these areas are affected by shallow overland flow inundation in the 1% AEP event (see Figure E3). There is a stormwater line that discharges from this area (see Figure A1), then runs along the northern side of Alison Road towards Centennial Park.

There is also a sag point on the northern side of Alison Road (Photo 2) where the 1% AEP depths are up to 0.5 m in the gutter and could affect buildings near the western corner of the HIA.

Photo 1: John Street and Alison Road – West Randwick HIA

Photo 2: Sag point in northern side of Alison Road, near western corner of HIA

4.1.3. Floor Level Requirements

The lots within this HIA subject to minimum floor level controls would include:

- Lots facing Alison Road, due to ponding of overland flow in the gutter and sag point, and

- Lots affected by overland flow between King/William Street and Alison Road (as indicated on Figure A4).

These requirements would likely not be onerous for any of the development lots in this HIA, in light of the preferred building massing shown in Diagram 3. Generally, the minimum requirements will be less than 0.5 m above surrounding ground or footpaths. These requirements may require steps/ramps up from the footpath level particularly for buildings fronting Alison Road, which may affect accessibility, but it is anticipated these constraints would be manageable. There are examples of how these constraints have been managed for existing development in the Kensington North precinct in Section 4.2.2.

4.1.4. Impact Considerations

Some of the lots within this HIA are affected by shallow inundation in the 1% AEP event, with a mixture of floodway and flood storage/fringe (see Figure A4). Development applications for the lots affected by flood storage or floodway areas will need to allow for overland flow through the site and demonstrate how the existing flow rates can be managed. Lots affected by flood fringe only are not significantly constrained. It can likely be demonstrated as part of individual development proposals that excluding this shallow inundation from the lot is unlikely to significantly increase flood risks in the road reserve or for existing development.

The indicative-built form footprints shown on Diagram 3 typically provide sufficient setbacks from the property boundaries that maintaining these overland flow paths is likely to be manageable with the proposed footprints. Compliance with these requirements would need to be assessed on a case-by-case basis for each development proposal, as would also be required under the current LEP and DCP, but is unlikely to present a major hurdle for development in line with Council's strategy. It is probably feasible to re-direct the overland flow down John Street rather than through the mid-block, but it would need to be demonstrated that it won't make flooding worse for other development (as per the LEP and DCP). It would require modelling of a specific proposal to determine whether it is acceptable (beyond the scope of this strategic assessment0. This could be proposed as part of either the development proposals, or as part of the FRMS that is underway if Council has the appetite to undertake this work. Normally localised measures like this would be the responsibility of the landholder since they are the primary beneficiary.

4.1.5. Hazard Considerations

In the 1% AEP design event the hazard classification of development lots in the West Randwick HIA is generally low (H1/H2, see Figure A5).

Flood hazard is significantly higher for the PMF event (Figure A6), with H5 hazard along John St (primarily caused by the high velocity of flow, even though depths remain relatively shallow). This is primarily a risk to vehicular traffic, and this hazard would not affect the buildings or people dwelling within them. During extreme events more intense than the 1% AEP, occupants of buildings within the HIA may become isolated and will not be able to evacuate the area on foot or by vehicle. Isolation would be of relatively short duration and the risks of occupants requiring

emergency evacuation or supplies during the flood would typically be low.

This hazard situation would be unchanged by Council's preferred planning strategy for the area, and the hazard will not limit the feasibility of achieving the desired built form footprints or FSR.

4.2. Kensington North HIA

4.2.1. Preferred Planning Strategy

Council's preferred building density and height strategy for this HIA (Reference 2) is shown on Diagram 5. The zoning is R3 Medium Density Residential.

Diagram 5: Kensington North HIA – Preferred Changes to Built Form and Height Restrictions

4.2.2. Site Characteristics and Flood Behaviour

Mapping of relevant design flood information is provided in Appendix B as follows:

- Peak flood depths and levels – Figure B2 (5% AEP) and Figure B3 (1% AEP)
- Hydraulic categories – Figure B4 (1% AEP)
- Hydraulic Hazard – Figure B5 (1% AEP) and Figure B6 (PMF)

The roadways around the Kensington North HIA are major overland flow paths with significant flood affectation, although flood inundation of the lots themselves is generally limited due to higher

ground levels within the HIA itself. The HIA lies just downstream of the confluence of two significant upstream catchment areas:

1. The Queens Park / Centennial Park catchment to the north-east, which flows through Centennial Park. Runoff from this catchment is detained with the series of ponds through Centennial Park, and flooding is mitigated to some degree by the retention of water in the ponds. This mitigation was improved by the construction of the light rail corridor and the concomitant raising of the embankment wall in Centennial Park, resulting in more water being detained by the ponds. However in major flood events, water will spill from the pond outlet structures, flowing across Alison Road, and then down Doncaster Avenue and Anzac Parade.
2. The Moore Park/Paddington/Entertainment Precinct catchment to the north-west, from which overland flow occurs down Anzac Parade in major storm events. This overland flow arrives at the north-western corner of the HIA and joins the flow from the main Centennial Park catchment.

Diagram 6: 1% AEP overland flow directions – Kensington North HIA

The flow from upstream generally flows around the site via Doncaster Avenue and Anzac Parade, from north to south (see Diagram 6). In a 1% AEP flood event, some inundation of the lots occurs, primarily at the front of the lots where flooding is deepest in the roadways, as indicated on Figure B3. The flood modelling excludes flow from within existing building footprints, so the inundation of the natural ground surface would be deeper than what is shown on Figure B3 if the existing development was not built up to current levels.

The primary outcome of this flow behaviour is that most of the development within this HIA will need minimum floor level controls to prevent flooding above floor level or into basements. The indicative-built form footprints should be feasible, although some of the area around the buildings will need to remain low to ensure no net filling of flood-prone areas within each lot.

Photo 3: Raised development at 17-19 Alison Road adjacent to sag point

Photo 4: Raised development at 10-20 Anzac Parade adjacent to Tay Lane sag point

The existing development within the HIA is indicative of the kind of design requirements that will be required to address the flood constraints. The examples below of development on Alison Road (Photo 3), Anzac Parade (Photo 4) and Doncaster Avenue (Photo 5) show significantly raised ground floor levels above surrounding ground.

Photo 5: Raised development at 9 Doncaster Avenue

It appears likely that the development at 20 Anzac Parade Kensington (Photo 4) was under construction at the time the aerial survey was obtained for flood modelling. The flood modelling indicates most of the site is empty with significant depth of inundation, but this most likely reflects the site conditions during construction when excavation of the ground levels had occurred. The site with the current development would not be affected by the degree of flood inundation shown in Appendix B.

4.2.3. Floor Level Requirements

Each of the flood-affected blocks in this HIA will require minimum floor level controls on future development due to the significant 1% AEP and PMF flow depths within the adjacent road reserves.

These controls will generally be between 1 m to 2 m above the gutter level in the adjacent road reserve, and will require finished floor levels and basement entry points to be raised significantly above surrounding ground as per the examples of existing development in Photo 3 to Photo 5. The exact and height above ground will be dependent on the specific site location. It is unlikely

these requirements will present a major constraint to development under the assumed amalgamation and building patterns, although they will need to be a major consideration in the building design and arrangement of entry points. Accessibility requirements such as ramps will also require a significant footprint due to the differences between ground and floor levels. This requirement may also affect the feasibility of achieving the proposed number of storeys while still remaining below building height requirements from the LEP.

4.2.4. Impact Considerations

Most of the lots within this HIA are affected by shallow inundation in the 1% AEP event, with a mixture of floodway and flood storage/fringe (see Figure B4). These lots will need to demonstrate that the flood storage volume within each site will be retained as part of each individual development proposal, to be achieved by no net filling of ground levels within the site. Where building footprints are increased relative to current footprints, this will require lowering of remaining areas of the site to compensate.

There is one lot with a section of floodway, at the corner of Alison Road and Doncaster Avenue, signifying that significant overland flow occurs through the rear of this lot. This lot may need to retain a clear overland flow path with similar capacity as the existing flow path, to be demonstrated by flood modelling of any proposed development.

Further technical analysis will be required at the DA stage for individual developments, including modelling of flood impacts to demonstrate compliance in some cases. However, it appears that the indicative building footprints provide for reasonable set-backs and open space which could conceivably be used to provide similar volumes of temporary flood storage volume as currently exists within the lots.

4.2.5. Hazard Considerations

In the 1% AEP design event the hazard classification within the lots of the HIA is generally low (H1/H2, see Figure B5), and does not present any significant constraint to redevelopment, although there would be a higher degree of hydraulic hazard in the roads (H3/H4) which would restrict access during the flood.

Flood hazard is significantly higher for the PMF event (Figure B6), with most of the development lots affected by H3 to H5 hazard, and sections of extremely hazardous H6 hazard in the road reserves due to very dangerous combinations of depth and velocity.

This means that during severe flood events including the 1% AEP and larger, occupants of buildings in the area will become isolated and will not be able to evacuate the area on foot or by vehicle. Isolation would be of relatively short duration and the risks of occupants requiring emergency evacuation or supplies during the flood would typically be low. However some buildings will need to be structurally designed to consider extreme flood conditions up to the PMF, and possibly to provide flood-free refuge on higher floors in certain cases. These issues will need to be addressed at the Development Application stage by each individual development proposal,

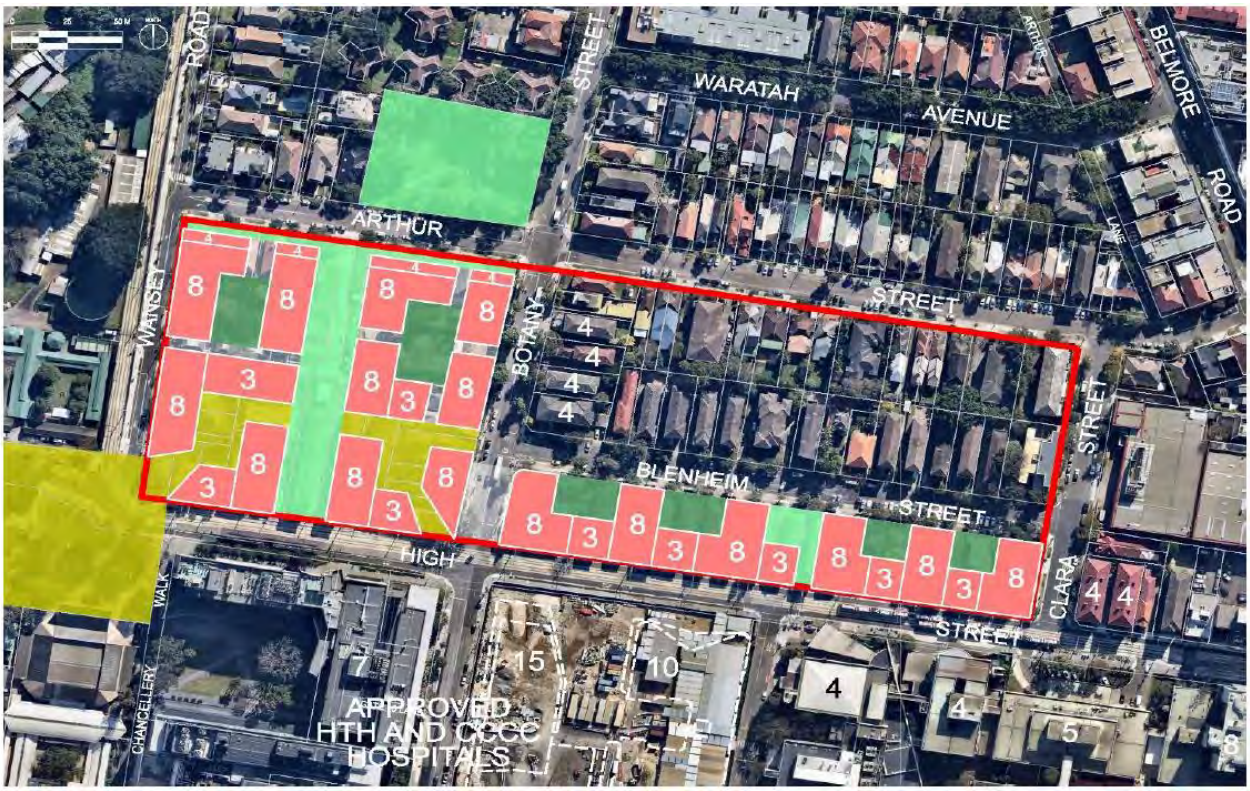
but they are unlikely to impede the development of the HIA in line with Council's preferred strategy. Higher density development with higher allowable building heights is more likely to be able to address these flood risks than lower density low-rise dwellings.

4.3. Arthur Street HIA

4.3.1. Preferred Planning Strategy

Council's preferred building density and height strategy for this HIA (Reference 3) is shown on Diagram 7. The zoning is R3 Medium Density Residential.

Diagram 7: Arthur Street HIA – Preferred Changes to Built Form and Height Restrictions



4.3.2. Site Characteristics and Flood Behaviour

Mapping of relevant design flood information is provided in Appendix C as follows:

- Peak flood depths and levels – Figure C2 (5% AEP) and Figure C3 (1% AEP)
- Hydraulic categories – Figure C4 (1% AEP)
- Hydraulic Hazard – Figure C5 (1% AEP) and Figure C6 (PMF)

Flood risk in the Arthur Street HIA is localised to a single overland flow path, which runs from north to south through from the sag point in Arthur Street, across Blenheim Street to High Street, between Botany Street and Clara Street. This overland flow path occurs along the natural gully in the topography, above the stormwater line shown on Figure C1. The overland flow will occur in intense storm events when runoff from the upstream area exceeds the capacity of the stormwater network. Figure C2 and Figure C3 show that shallow overland flow will occur through private

property along this alignment in the 5% AEP and larger events (see Diagram 8 for flow direction).

Diagram 8: 1% AEP overland flow directions – Arthur Street HIA

Photo 6: Overland flow path from sag point at 32-24 Arthur Street (looking downstream)

The existing developments along this flow path incorporate design features that are appropriate for and consistent with this flood risk (Photo 6 to Photo 8). Each of these developments has non-habitable ground floor uses (garages), with habitable floor levels only on the upper storeys. There are wide easements along the access driveways that would allow the passage of overland flow in severe flood events.

Photo 7: Existing overland flow path from sag point at 5 Blenheim Street (looking upstream)

Photo 8: Existing overland flow path from sag point at 4-6 Blenheim Street (looking downstream)

The majority of the HIA will not be subject to flood-related development controls, apart from the lots affected by this overland flow path. Discussion of the requirements for the affected lots is provided below.

4.3.3. Floor Level Requirements

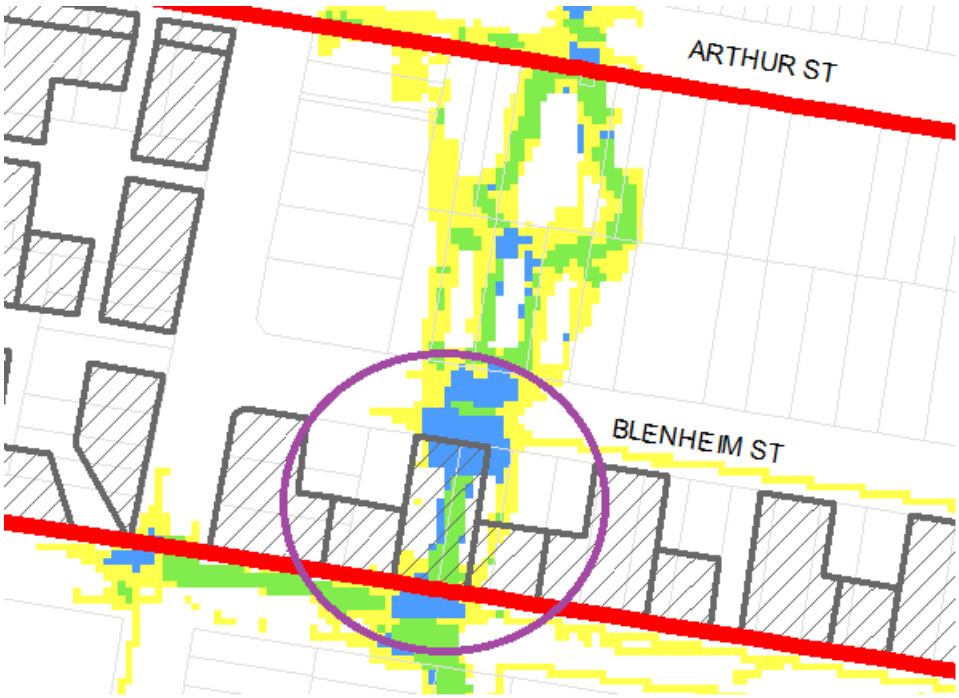
New development along this flow path will require raised floor levels to provide above floor inundation of habitable areas. Basement car parks and garages may also be subject to minimum entry level or finished level requirements according to the DCP. This would usually involve crests on vehicle, stairway and lift entry points to the basement. The DCP does not explicitly comment on flood gates as a potential mitigation measure in these situations. WMAwater does not typically endorse the use of flood gates for new development, although they may be an appropriate solution as a retrofit for existing development where flooding is a recurring problem.

4.3.4. Impact Considerations

New development along this flow path will require similar provisions of open space to prevent obstruction of overland flow. Detailed flood modelling of proposed future development along the overland flow path will be required under the LEP/DCP to demonstrate that flooding is not exacerbated upstream or downstream.

The current preferred building massing would not allow for the passage of overland flow, due to the contiguous block of buildings along High Street (see Diagram 9 for a close-up of the relevant area from Figure C4).

Diagram 9: Close-up of floodway area where contiguous building mass is proposed



This will be a serious constraint and will likely prevent development approval being obtained for

the preferred building mass due to inability of this scheme to comply with the LEP/DCP requirements. There will need to be a gap in the buildings somewhere to allow for the unobstructed passage of overland flow from Blenheim Street to High Street. This gap would need to allow for passage of the 1% AEP flow path without exacerbating flooding on other properties. I would not be necessary to take the PMF into account for designing of this flow path width. The separation will need to be similar to the width of the current 1% AEP flow path for the affected lots as shown on Figure C4, although it may be possible for developers to optimise this arrangement and reduce the required width. This would require a localised flood modelling assessment at the time of the development application. It is unlikely that the overland flow path can be eliminated by construction of additional stormwater pipe and inlet capacity. The buildings will require some separation of a few metres at least to allow overland flow passage.

4.3.5. Hazard Considerations

Hydraulic hazards associated with the overland flow path are very low for the 1% AEP (typically H1, see Figure C5), and are generally low even for the PMF event (typically H1/H2 with a localised area of H3 due to deeper flooding in the Blenheim Street sag point, Figure C6). These hazards will not present a significant constraint for the risk to life considerations of proposed development in this HIA.

4.4. Magill Street HIA

4.4.1. Preferred Planning Strategy

Council's preferred building density and height strategy for this HIA (Reference 4) is shown on Diagram 10. The existing zoning is primarily R2 Low Density Residential, except for two lots which are zoned R3 Medium Density Residential. The majority of the area of proposed change is to be rezoned to R3.

Diagram 10: Magill Street HIA – Preferred Changes to Built Form and Height Restrictions

4.4.2. Site Characteristics and Flood Behaviour

Mapping of relevant design flood information is provided in Appendix D as follows:

- Peak flood depths and levels – Figure D2 (5% AEP) and Figure D3 (1% AEP)
- Hydraulic categories – Figure D4 (1% AEP)
- Hydraulic Hazard – Figure D5 (1% AEP) and Figure D6 (PMF)

Flood risk in the Magill Street HIA is fairly localised to a single overland flow path, which runs from north to south through from the sag point in Magill Street (Photo 9), across the end of the Hay Street cul-de-sac (Photo 10), to Hospital Road, before flowing down Young Street. The direction of flow is indicated on Diagram 11.

Diagram 11: 1% AEP overland flow directions – Magill Street HIA

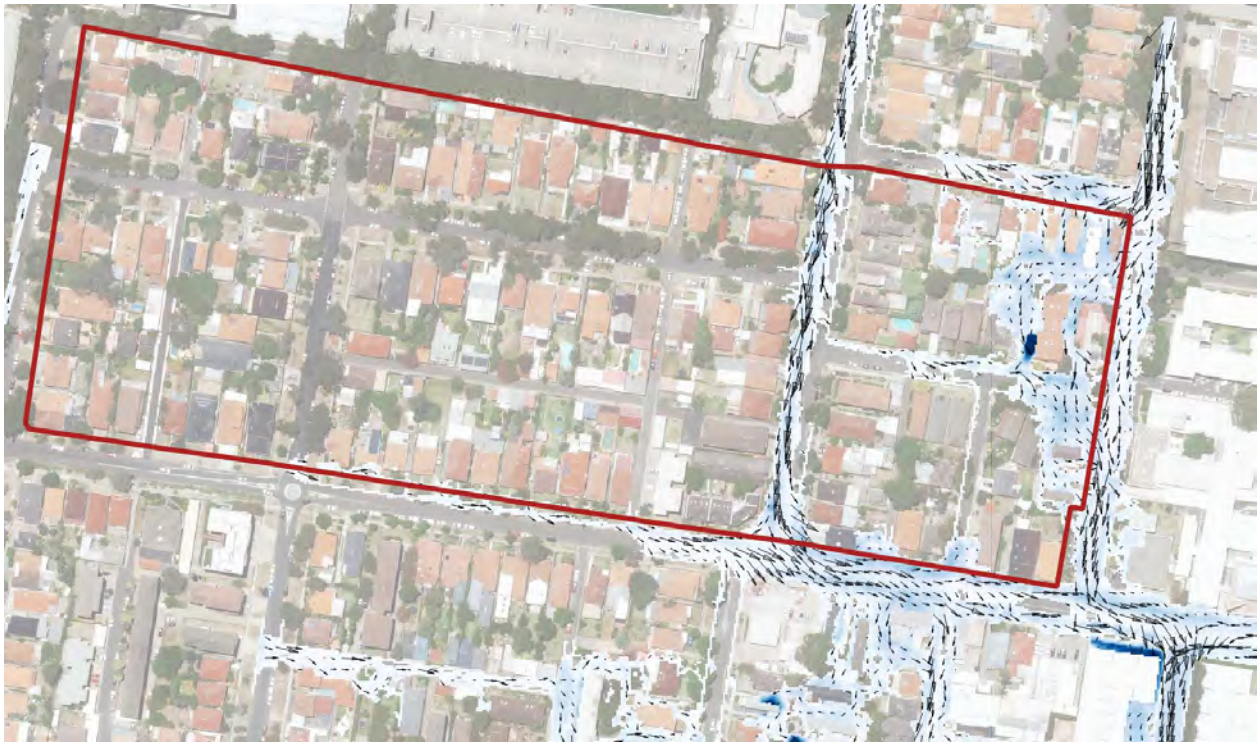


Photo 9: Sag point in Magill Street, downstream of the new Prince of Wales Hospital complex

Photo 10: Sag point in Hay Street cul-de-sac

There is also an overland flow path through the centre of the HIA in Botany Street, which is largely contained within the road reserve and does not affect any of the development lots. The overland flow will occur in intense storm events when runoff from the upstream area exceeds the capacity of the local stormwater network. Figure D2 and Figure D3 show that shallow overland flow will occur through private property along this alignment in the 5% AEP and larger events.

The majority of the HIA will not be subject to flood-related development controls, apart from the lots affected by this overland flow path from Magill Street to Hospital Road (via Hay Street). Discussion of the requirements for the affected lots is provided below.

4.4.3. Floor Level Requirements

New development along the flow path will require raised floor levels to provide above floor inundation of habitable areas. Basement car parks and garages may also be subject to minimum entry level or finished level requirements according to the DCP.

4.4.4. Impact Considerations

New development along this flow path will require similar provisions of open space to prevent obstruction of overland flow or filling of flood storage areas (Figure D4). Detailed flood modelling of proposed future development along the overland flow path will be required under the LEP/DCP to demonstrate that flooding is not exacerbated upstream or downstream.

The indicative built form footprints shown on Diagram 10 typically provide sufficient setbacks from

the property boundaries that maintaining these overland flow paths is likely to be manageable with the proposed footprints. Compliance with these requirements would need to be assessed on a case by case basis for each development proposal, as would also be required under the current LEP and DCP, but is unlikely to present a major hurdle for development in line with Council's strategy.

4.4.5. Hazard Considerations

Hydraulic hazards associated with the overland flow path are very low for the 1% AEP (typically H1, see Figure D5), and are generally low to moderate for the PMF event (typically H2/H3 with a localised area of H4/H5 due to deeper and faster flow at Hay Street, Figure D6). These hazards will not present a significant constraint for the risk to life considerations of proposed development in this HIA.

Therefore, during extreme events more intense than the 1% AEP, occupants of buildings within the HIA may become isolated and will not be able to evacuate the area on foot or by vehicle, particularly those relying an access/egress to Young Street or Magill Street. Isolation would be of relatively short duration and the risks of occupants requiring emergency evacuation or supplies during the flood would typically be low.

This hazard situation would be unchanged by Council's preferred planning strategy for the area, and the hazard will not limit the feasibility of achieving the desired built form footprints or FSR.

4.5. Kingsford South HIA

4.5.1. Preferred Planning Strategy

The Kingsford South HIA comprises two separate areas on either side of Anzac Parade. Council's preferred building density and height strategy for this HIA (Reference 5) is shown on Diagram 12. The existing zoning is a mixture of R2/R3 Low/Medium Density Residential, with a small area zoned SP2 Infrastructure relating to electricity generation. Generally the proposed change is to rezone to R3 with a small area of B1.

Diagram 12: Kingsford South HIA – Preferred Changes to Built Form and Height Restrictions

4.5.2. Site Characteristics and Flood Behaviour

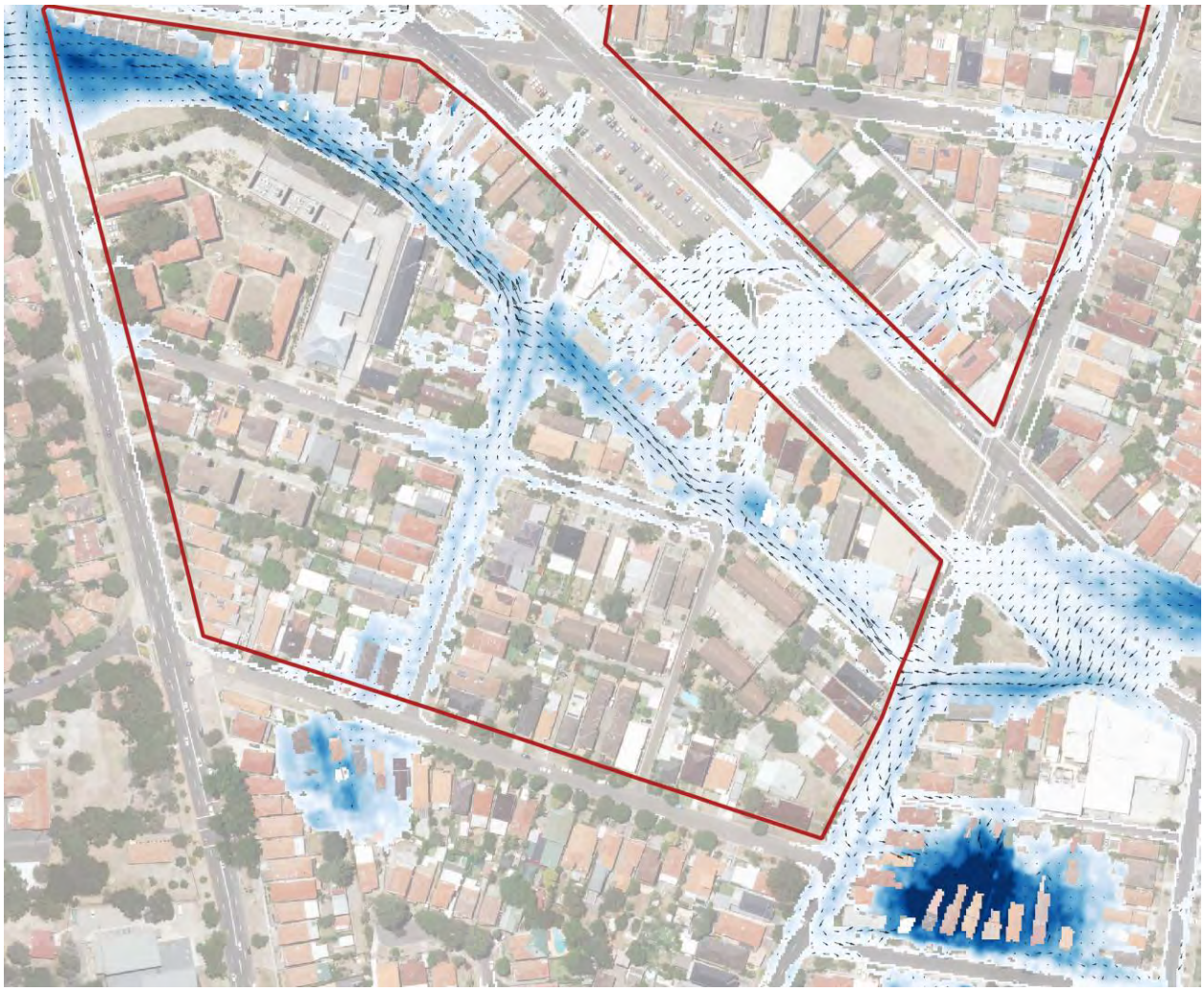
Mapping of relevant design flood information is provided in Appendix E as follows:

- Peak flood depths and levels – Figure E2 (5% AEP) and Figure E3 (1% AEP)
- Hydraulic categories – Figure E4 (1% AEP)
- Hydraulic Hazard – Figure E5 (1% AEP) and Figure E6 (PMF)

Flooding considerations for this HIA primarily apply to the area south of Anzac Parade, on Jacques Street. The primary Birds Gully catchment trunk drainage stormwater line (owned by Sydney Water) runs underneath Jacques Street. This pipe drains a significant catchment area to the north-

west, extending up to The Spot (Perouse Road and St Pauls Street, Randwick). In severe storm events like the 1% AEP, runoff will exceed the capacity of this trunk drainage line forming a major overland flow path along Jacques Street (see Diagram 13).

Diagram 13: 1% AEP overland flow directions – Kingsford South HIA



Development along Jacques Street will need minimum floor level and entry controls to prevent flooding above floor level or into basements. The indicative built form footprints should be feasible, although some of the area around the buildings will need to remain low to ensure no net filling of flood-prone areas within each lot.

The existing development within the HIA is indicative of the kind of design requirements that will be required to address the flood constraints. The examples below of existing development on Jacques Street (Photo 11 and Photo 12) show significantly raised ground floor levels above surrounding ground.

There is an additional minor overland flow path associated with a smaller localised catchment that drains to the sag point in Sturt Lane, adjacent to 144 Botany Street (Photo 13). Shallow overland flow will occur along the gully in the topography from this sag point, through private property to Anzac parade, across Anzac Parade, and then through private property to Jacques Street.

Photo 11: Elevated existing development adjacent to Jacques Street sag point

Photo 12: Jacques Street overland flow path, looking downstream near Bunnerong Road

Photo 13: Sag point in Sturt Lane, showing new kerb/guttering and inlets

4.5.3. Floor Level Requirements

Lots fronting Jacques Street or otherwise affected by overland flow (see Figure E2 and Figure E3) will be subject to minimum floor level controls for the ground floor and any basement entry points. These minimum levels will depend on the nature of the proposed building use and the adjacent depths of flooding in the road reserves, and will need to be assessed on a case by case basis for future development proposals.

For development along Jacques Street, these controls will generally be between 1 m to 2 m above the gutter level in the road reserve, and will require finished floor levels and basement entry points to be raised significantly above surrounding ground as per the examples of existing development in Photo 11 and Photo 12. The exact and height above ground will be dependent on the specific site location. It is unlikely these requirements will present a major constraint to development under the assumed amalgamation and building patterns, although they will need to a major consideration in the building design and arrangement of entry points. Accessibility requirements such as ramps will also require a significant footprint due to the differences between ground and floor levels.

For the sites affected by shallow minor overland flow, the floor level requirements are unlikely to be onerous.

The implementation of these controls will not be altered by the changes in the planning strategy, and are unlikely to present a major constraint or risk for the strategy being implemented.

4.5.4. Impact Considerations

The indicative-built form footprints shown on Diagram 12 typically provide sufficient setbacks from the property boundaries that maintaining the overland flow paths in this HIA is likely to be manageable with the proposed footprints. It will be necessary to ensure that development does not obstruct or divert areas of floodway or fill in flood storage (Figure E4), thereby increasing flood affectation for neighbouring lots. Compliance with these requirements would need to be assessed on a case by case basis for each development proposal, as would also be required under the current LEP and DCP, but is unlikely to present a major hurdle for development in line with Council's strategy.

4.5.5. Hazard Considerations

Apart from the major overland flow path along Jacques Street, hydraulic hazard in this HIA is very low (H1), even for the PMF (see Figure E5 and Figure E6).

Along Jacques Street, there would be a higher degree of hydraulic hazard in the roads (H3/H4 in the 1% AEP event) which would restrict access during a flood. Flood hazard is significantly higher for the PMF event, with lots on Jacques Street affected by H3 to H5 hazard, indicating dangerous combinations of depth and velocity.

This means that during severe flood events including the 1% AEP and larger, occupants of buildings relying on egress via Jacques Street will become isolated and will not be able to evacuate the area on foot or by vehicle. Isolation would be of relatively short duration and the risks of occupants requiring emergency evacuation or supplies during the flood would typically be low. However some buildings will need to be structurally designed to consider extreme flood conditions up to the PMF, and possibly to provide flood-free refuge on higher floors in certain cases. These issues will need to be addressed at the Development Application stage by each individual development proposal, but they are unlikely to impede the development of the HIA in line with Council's preferred strategy. Higher density development with higher allowable building heights is more likely to be able to address these flood risks than lower density low-rise dwellings.

4.5.6. Special Purpose Zoning

The Ministerial Directions contain specific provisions relating to Special Purpose zoning which Council will need to consider in the Planning Proposal. The SP2 area cannot be rezoned to a Residential, Business, Industrial, or Special Purpose Zone unless the "Consistency" provisions in Clause (9) can be met to the satisfaction of the DPIE Secretary.

Council indicated to WMAwater that it is not intended to rezone the SP2 area in this HIA, so the proposal will meet this requirement.

5. CONSISTENCY WITH MINISTERIAL DIRECTIONS

The preferred strategy outlined by Council in the relevant Urban Design Analysis reports does not generally include any land currently zoned Special Use, Special Purpose, Recreation, Rural or Environmental Protection Zone, and therefore it satisfies part 4.3(5) of the Directions.

The single exception to the above is the small area of SP2 zoning in the Kingsford South HIA. Council indicated to WMAwater that it is not intended to rezone the SP2 area in this HIA, so the proposal will meet this requirement.

With regard to the items in part 4.3(6), WMAwater observes the following:

a) Some of the land within the Planning Proposal extents is affected by floodway. However the Planning Proposal will not automatically permit development of the floodway areas. Development controls for assessment of floodway modification or development are contained within Council's strategic planning framework under the Flood Risk Management Policy, LEP and DCP. These controls already apply to the land under consideration, and the nature of the controls and the development constraints presented by the controls would not be altered by the Planning Proposal. The approval of the Planning Proposal does not provide a guarantee or an implication that these requirements can be waived at subsequent development approval stages. However, it should be noted that the current building massing proposed for the Arthur Street HIA will likely not be feasible if the floodway is to be maintained (see Section 4.3.4) for discussion. WMAwater would recommend that this building mass layout be reviewed and altered to take into account the floodway, by allowing for significant separation between the buildings.
b) It will be necessary for future development applications to demonstrate the proposed works will not result in significant flood impacts to other developments, through modelling as part of a flood impact assessment where appropriate. As with part 4.3-6(a) above, satisfaction of this requirement depends on the details of the proposed development as is enforced through Council's strategic planning and approvals framework at the Development Application stage. These controls already apply to the land under consideration, and the nature of the controls and the development constraints presented by the controls would not be altered by the Planning Proposal. The approval of the Planning Proposal does not provide a guarantee or an implication that these requirements can be waived at subsequent development approval stages.
c) Specific hydraulic hazard considerations for each HIA are discussed in the relevant sections above. For the purposes of this clause, hazard classifications of H4 and above can be considered "High." High hazard flooding occurs within the roadways adjacent to the Kensington North and Kingsford South HIAs in the 1% AEP event, and within part of most of the HIAs in the PMF event. This is a fairly typical situation for urbanised catchments where the roadways are the primary overland flow paths for drainage in major storms. The high hazard areas generally do not directly affect the locations of the proposed building footprints. The hazard levels can be addressed by appropriate minimum floor level and emergency response development controls being applied through the DCP at the Development Application stage, as is the case for the current

residential zoning in these HIAs. The planning proposal will not change the nature of development controls required to mitigate risk to life from hazardous flow.

d) It is unclear in this context what "significant increase in the development of the land" means. From the perspective of flood risk, the land is generally fully urbanised, and primarily covered by hardstand and buildings. The Planning Proposal does not "significantly increase the development" with regards to existing levels of urbanisation and how much runoff will occur from the area, and will not exacerbate flood issues in this regard which is presumably the intent of the direction in this context. However, the proposed development will certainly increase the development of the land in terms of intensity of floor space and the population/building density in the area – that is one of the primary purposes of the Planning Proposal. With regards to flood risk, this increase in population density is largely offset by the following considerations:
    i. The increase in floor space will be primarily related to additional building storeys that are not at risk of damage from flooding.
    ii. In some areas the increase in population density will be associated with higher density land use zoning (e.g. R2 to R3), which will involve consolidation of single-storey dwellings into multi-unit and multi-storey developments. It is more likely that consolidated high-density re-development of these lots would be able to resolve the flood issues, compared to redevelopment under lower density zoning such as R2. Rezoning of the flood affected lots and consolidation of the lots would generally be the most effective long term strategy for reducing flood risks in the areas under consideration, as a higher density development proposal with a larger lot size is more likely to be able to provide a design solution that complies with the LEP/DCP requirements.
    iii. New buildings would need to comply with minimum floor level controls and protection of basement areas, which in many cases are not satisfied by the existing buildings. Redevelopment of the land will therefore reduce the likely flood damages for the ground floor and basement levels, as well as reducing the risk to life to people within the buildings, despite the concurrent increase in total population.

Re-development of urbanised areas is an inevitable result of increases to population in the Sydney metropolitan area. The NSW Flood Prone Land Policy recognises that:

> *"Flood prone land is a valuable resource that should not be sterilised by unnecessarily precluding its development"*

The Floodplain Development Manual indicates that development within the floodplain should be undertaken on a merit-based approach, ensuring that the development is compatible with the flood hazard of the land. Based on the review of available flood information as part of this assessment, the Planning Proposal improves the likelihood that redevelopment of the subject land can meet the required development controls and be compatible with the flood hazard, relative to existing zoning and height/FSR controls.

e) Development of child-care facilities, hostels, boarding houses, group homes, residential care facilities and seniors housing would currently be permissible in some parts of the HIAs under current land use zoning, and would likely by permissible under some circumstances under the proposed changes (subject to typical development consent

requirements including flood-related development controls). The directions indicate that evacuation is a key consideration, but in urban flash flood environments evacuation is not the best way to mitigate risk for vulnerable residents (such as children or the elderly). In these circumstances, where there will be little or no warning of impending flooding, and where the most hazardous flooding occurs in roadways (both immediately adjacent to and beyond the HIAs), it is unreasonable to expect that evacuation to alternative accommodation can be effected prior to flooding occurring (see Section 3.4 for more discussion). The risk to life for remaining in building during flash floods can be appropriately mitigated by applying minimum floor level and structural soundness controls such as those currently in place in the DCP, which would still apply.

f) The development is unlikely to result in substantially increased requirement for government spending on flood mitigation measures, infrastructure or services. The primary flood risk mitigation measure to reduce existing flood risks in this region would be to redevelop land to be consistent with the planning controls, including increasing the building floor levels up to the relevant standard, which is achieved through re-development of the land in accordance with the Planning Proposal.

g) WMAwater understands that the developments indicated in the Planning Proposal will require development consent, and the proposal does not include agriculture, road or exempt development components.

h) The planning proposal does not make any changes to permissions about the storage of hazardous materials.

The same comments for Direction 4.3(6) above also apply to Direction 4.3(7).

With regard to Direction 4.3(8), the relevant flood planning areas are already specified by Council's LEP/DCP and will not be altered by the Planning Proposal. This is consistent with the Floodplain Development Manual.

6. SUMMARY AND CONCLUSIONS

Some lots within the investigation areas are constrained by flood affectation to various degrees. The details of the specific flood behaviour and constraints within each HIA are discussed in Sections 4.1 to 4.5. The flood constraints identified for specific development lots in this assessment do not prohibit development of those sites, either under the existing LEP/DCP or under the amended LEP/DCP resulting from the Planning Proposal. Either way, future development applications will be required to demonstrate compliance with the flood-related development controls.

The nature of these constraints and the solutions to satisfy the development controls are not significantly altered by the Planning Proposal. However, as with the current LEP zoning, height allowances and maximum FSR, the flood constraints may preclude full development of some sites to the maximum allowable density. This is because compliance with various flood controls (such as not obstructing a flow path, or not building a basement in a hazardous area, or building the ground floor at a minimum level) may reduce the achievable building footprint or number of building storeys within a given site. Generally however, the preferred building layout for each HIA appears to provide sufficient building set-back allowances to allow the requirements to be met without major design compromises.

WMAwater identified one localised component of Council's preferred strategy which is not consistent with the flooding clause of the Local Planning Directions:

- There are some lots affected by floodway in the Arthur Street HIA, between Blenheim Street and High Street, where the preferred strategy indicates a contiguous block of buildings across the floodway (see Section 4.3.4). This will not be feasible without diverting flow and adversely affecting the flood affectation of neighbouring lots. WMAwater would recommend that this building mass layout be reviewed and altered to take into account the 1% AEP floodway, by allowing for separation between the buildings. The separation will need to be similar to the width of the current 1% AEP flow path for the affected lots as shown on Figure C4, although it may be possible for developers to optimise this arrangement and reduce the required width. This would require a localised flood modelling assessment at the time of the development application.

Outside of this localised area, there are other sites where future development applications will need to address flood-related development controls, but the controls are unlikely to significantly compromise the development potential. The controls (as outlined in the DCP) primarily relate to mitigating flood damage to new development by requiring minimum floor level heights and entry crests to basements, as well as ensuring that new development does not exacerbate existing flood problems for others by diverting or blocking overland flow paths.

Potential developers should be aware that even though the flood constraints are likely to be manageable, in some instances design compromises may be required to meet the controls. The most likely areas where the flood constraints will need to be a primary design constraint are:

- Commercial properties fronting Alison Road, where the building facades are along the property boundary, and minimum floor level controls might have implications for

accessibility (such as ramps or other solutions) within the building.

- Most properties in the Kensington North precinct, where flood depths in the adjacent road reserves are significant, and the minimum floor level controls are in some cases more than 1 m above the typical ground level of the site. These sites may also require open space design solutions that avoid net filling of ground levels in order to retain temporary flood storage within the site.
- Some properties in each of the precincts, where the existing 1% AEP overland flow paths through the site may need to be retained.
- Some properties fronting Jacques Street in the Kingsford South HIA, where minimum floor levels and basement entry points may be a constraint on ground floor and basement access configurations.

Although the localised flood constraints discussed above will likely involve design compromise for some lots, it is likely the Planning Proposal will improve the feasibility of redevelopment in those lots where it would currently be impractical to meet the flood-related development controls. This is because consolidation of lots and permissibility of larger, taller buildings provides more flexibility in the development design to accommodate flow paths through part of the consolidated site, while fully developing the remainder with minimum floor levels that meet requirements. This is less likely to be feasible with lower density development involving fragmented lots and separate buildings. Consolidation of several lots and concentration of building mass into higher buildings usually results in larger set-backs and open space areas from the consolidated boundary, which provides design flexibility to have lower areas for compensatory flood storage, or larger ramps for footprints of access ramps and other requirements. It is often easier for a larger lot to address the flooding constraints than for a smaller lot. The consolidation of lots and increased density will likely improve the viability of the most heavily flood-constrained sites identified herein.

WMAwater considers that the Planning Proposal is generally consistent with the Ministerial Directions for flood prone land (see Section 2.2 and Section 5 for detailed discussion). The Planning Proposal is consistent with other relevant legislation and Council's strategic planning framework for flood planning, in that the flood-related development controls enforced through that framework are not significantly altered by the Planning Proposal.

Council has indicated that further consultation can be undertaken with relevant public agencies (such as the State Emergency Service, the Department of Energy, Environment and Science, and the Department of Industry, planning and Environment) following Gateway determination at the Local Planning Panel. Council expects that comments from these public agencies regarding specific constraints or development controls can be addressed as part of the site-specific DCPs to be prepared for each of the study areas.

7. REFERENCES

Randwick City Council
1. **West Randwick Housing Investigation Area – Urban Design Report**
May 2021

Randwick City Council
2. **Kensington North Housing Investigation Area – Urban Design Report**
May 2021

Randwick City Council
3. **Arthur Street Housing Investigation Area – Urban Design Report**
May 2021

Randwick City Council
4. **Magill Street Housing Investigation Area – Urban Design Report**
May 2021

Randwick City Council
5. **Kingsford South Housing Investigation Area – Urban Design Report**
May 2021

NSW Government
6. **Section 9.1 Directions**
Directions issued by the Minister for Planning to relevant planning authorities under section 9.1(2) of the *Environmental Planning and Assessment Act 1979*.

NSW Government
7. **Floodplain Development Manual**
NSW Government, April 2005

Randwick City Council
8. **Randwick Local Environmental Plan 2012**
Effective February 2012, last modified 14 July 2021

Randwick City Council
9. **Randwick Development Control Plan 2013**
Effective June 2013

WMAwater
10. **Kensington – Centennial Park Floodplain Management Study and Plan Post Light Rail Version**
Prepared for Randwick City Council, February 2019.

WMAwater

11. **Birds Gully and Bunnerong Road Flood Study**
Prepared for Randwick City Council, June 2018

BMT WBM

12. **RCR PRINCE OF WALES, RANDWICK**
FLOOD AND STORMWATER MODELLING
COUNCIL QUERY, PMF CONDITIONS IN BOTANY STREET
Lend Lease, 17 March 2019

Australian Institute for Disaster Resilience

13. **Guideline 7-3 Flood Hazard**
Supporting document for Handbook 7 Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia
Australian Government, 2017

8. GLOSSARY

LIST OF ACRONYMS

AEP	Annual Exceedance Probability
ARR	Australian Rainfall and Runoff
BOM	Bureau of Meteorology
DCP	Development Control Plan
DPIE	Department of Planning Industry and Environment
FDM	Floodplain Development Manual
LEP	Local Environment Plan
LHS	Local Housing Strategy
LSPS	Local Strategic Planning Statement
mAHD	meters above Australian Height Datum
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
PP	Planning Proposal

ADOPTED TERMINOLOGY

Australian Rainfall and Runoff (ARR, 2019) recommends terminology that is not misleading to the public and stakeholders. Therefore the use of terms such as “recurrence interval” and “return period” are no longer recommended as they imply that a given event magnitude is only exceeded at regular intervals such as every 100 years. However, rare events may occur in clusters. For example there are several instances of an event with a 1% chance of occurring within a short period, for example the 1949 and 1950 events at Kempsey. Historically the term Average Recurrence Interval (ARI) has been used.

ARR 2019 recommends the use of Annual Exceedance Probability (AEP). Annual Exceedance Probability (AEP) is the probability of an event being equalled or exceeded within a year. AEP may be expressed as either a percentage (%) or 1 in X. Floodplain management typically uses the percentage form of terminology. Therefore a 1% AEP event or 1 in 100 AEP has a 1% chance of being equalled or exceeded in any year.

The Probable Maximum Flood is the largest flood that could possibly occur on a catchment. It is related to the Probable Maximum Precipitation (PMP). The PMP has an approximate probability in the order of 1 in 10 million chance per year for the areas considered in this study.

GLOSSARY

Taken from the Floodplain Development Manual (April 2005 edition)

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. For example, 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 event occurring in any one year (see ARI).
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.
caravan and moveable home parks	Caravans and moveable dwellings are being increasingly used for long-term and permanent accommodation purposes. Standards relating to their siting, design, construction and management can be found in the Regulations under the LG Act.
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 Environmental Planning and Assessment Act (EP&A Act). **infill development:** 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. **new development:** refers to development of a completely different nature to that associated with the former land use. For example, the urban subdivision of an area previously used for rural purposes. New developments involve rezoning and typically require major extensions of existing urban services, such as roads, water supply, sewerage and electric power. **redevelopment:** refers to rebuilding in an area. For example, as urban areas age, it may become necessary to demolish and reconstruct buildings on a relatively large scale. Redevelopment generally does not require either rezoning 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 before entering a watercourse, and/or coastal inundation resulting from super-elevated sea levels and/or waves overtopping coastline defences excluding tsunami.
flood awareness	Flood 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 an 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 (i.e. land susceptible to flooding by the probable maximum flood (PMF) event). Note that the term flood liable land covers the whole of the floodplain, not just that part below the flood planning level (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 diagrammetic 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 State Emergency Service.
flood planning area	The area of land below the flood planning level 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)	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	Is land susceptible to flooding by the Probable Maximum Flood (PMF) event. Flood prone land is synonymous with flood liable land.
flood readiness	Flood 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. **existing flood risk:** the risk a community is exposed to as a result of its location on the floodplain. **future flood risk:** the risk a community may be exposed to as a result of new development on the floodplain. **continuing flood risk:** 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 flows, or a significant increase in flood levels.

Freeboard	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. 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. Definitions of high and low hazard categories are provided in the Manual.
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	Are 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 purpose 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 0.3 m (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 flow paths 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 floodplain risk management policy and EPIs.
minor, moderate and major flooding	Both the State Emergency Service and the Bureau of Meteorology 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. **major flooding:** 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. Examples are indicated in Table 2.1 with further discussion in the Manual.
peak discharge	The maximum discharge occurring during a flood event.
Probable Maximum Flood (PMF)	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 (PMP)	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.

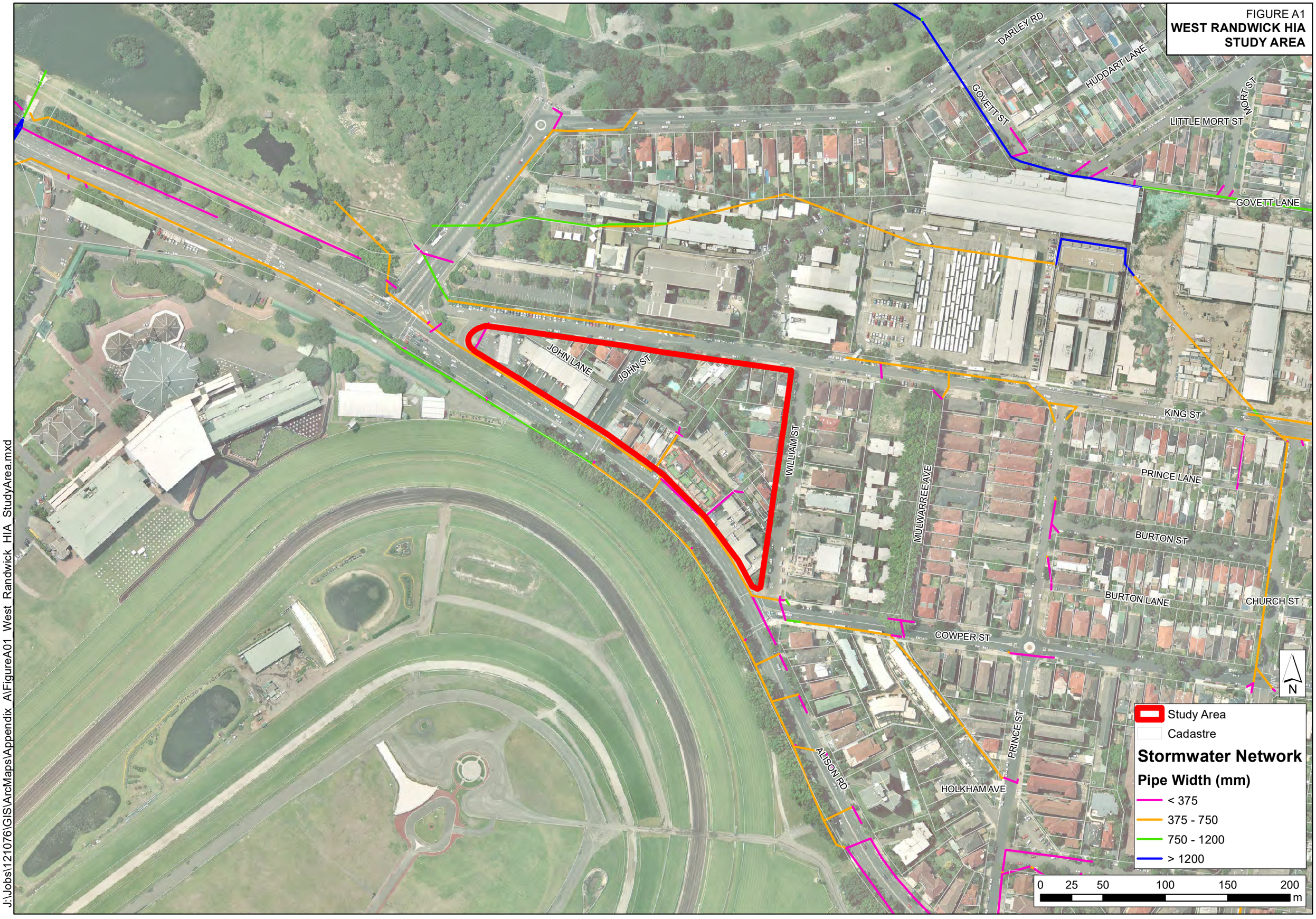
Runoff	The amount of rainfall which actually ends up as streamflow, also known as rainfall excess.
Stage	Equivalent to water level. Both are measured with reference to a specified datum.
stage hydrograph	A graph that shows how the water level at a particular location changes with time during a flood. 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.

Figures

APPENDIX A. West Randwick HIA Flood Mapping

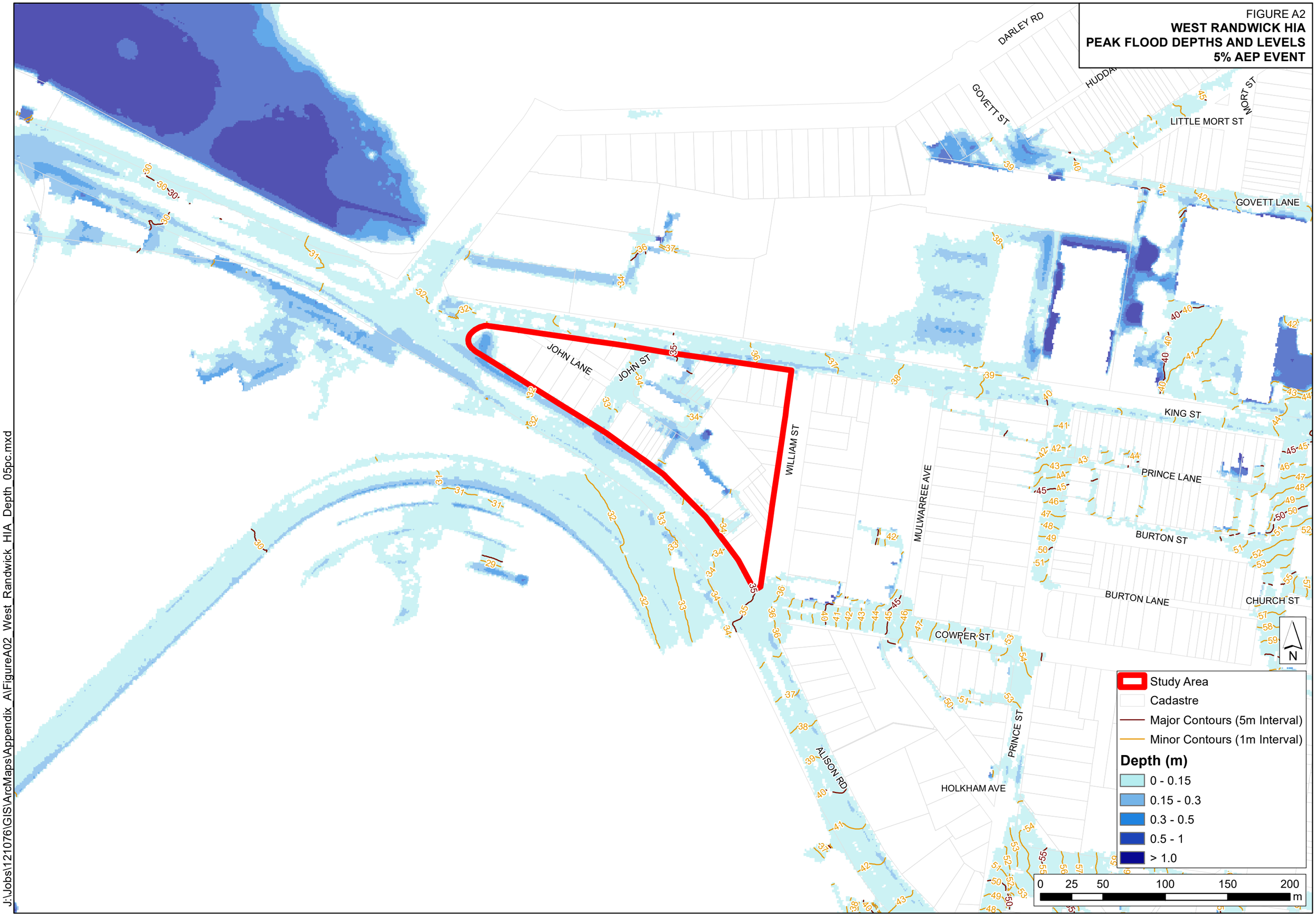
Appendix A

FIGURE A1
WEST RANDWICK HIA STUDY AREA



J:\Jobs\121076\GIS\ArcMaps\Appendix_A\FigureA01_West_Randwick_HIA_StudyArea.mxd

FIGURE A2
WEST RANDWICK HIA
PEAK FLOOD DEPTHS AND LEVELS
5% AEP EVENT



J:\Jobs\121076\GIS\ArcMaps\Appendix_A\FigureA02_West_Randwick_HIA_Depth_05pc.mxd

FIGURE A3
WEST RANDWICK HIA
PEAK FLOOD DEPTHS AND LEVELS
1% AEP EVENT

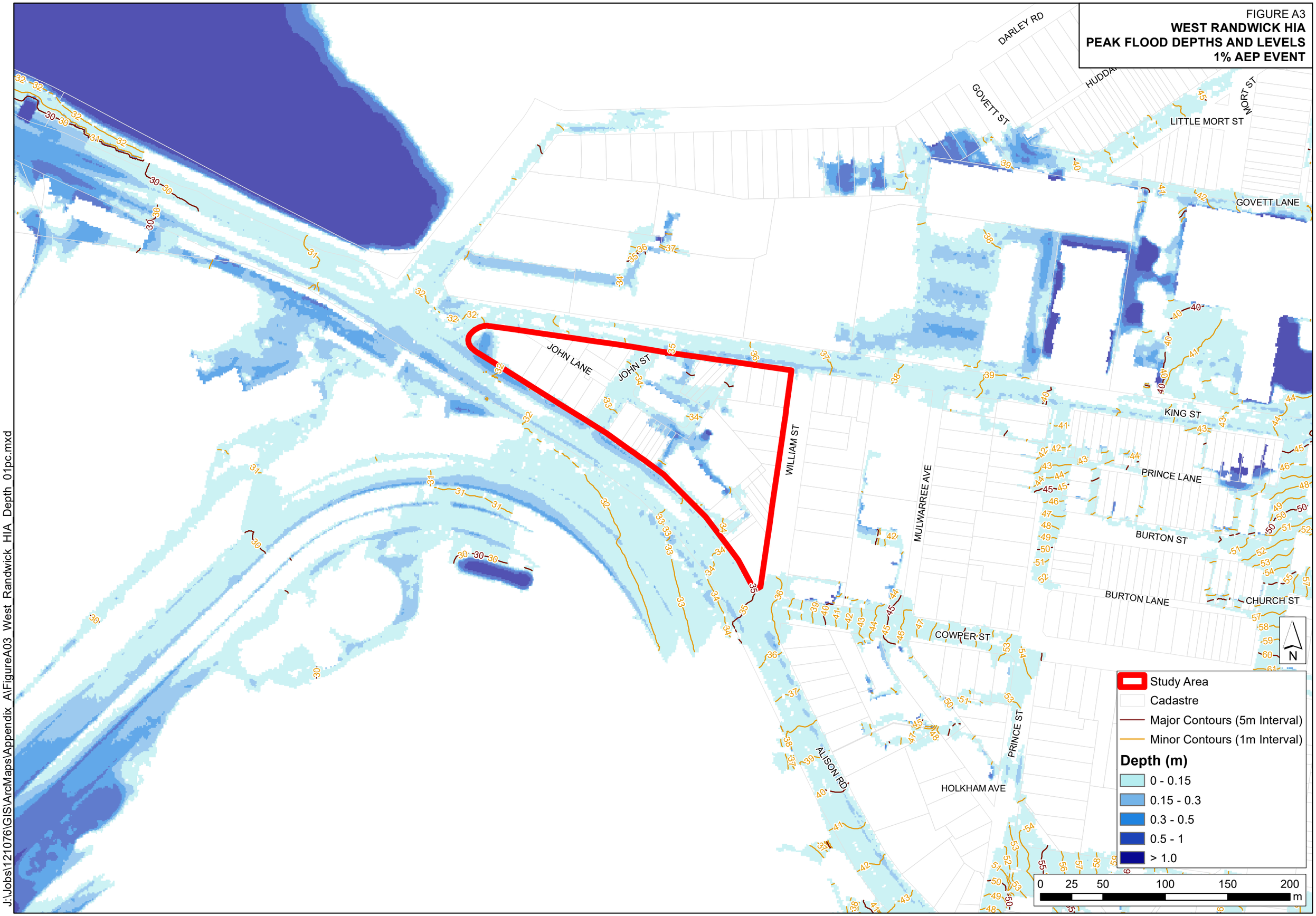


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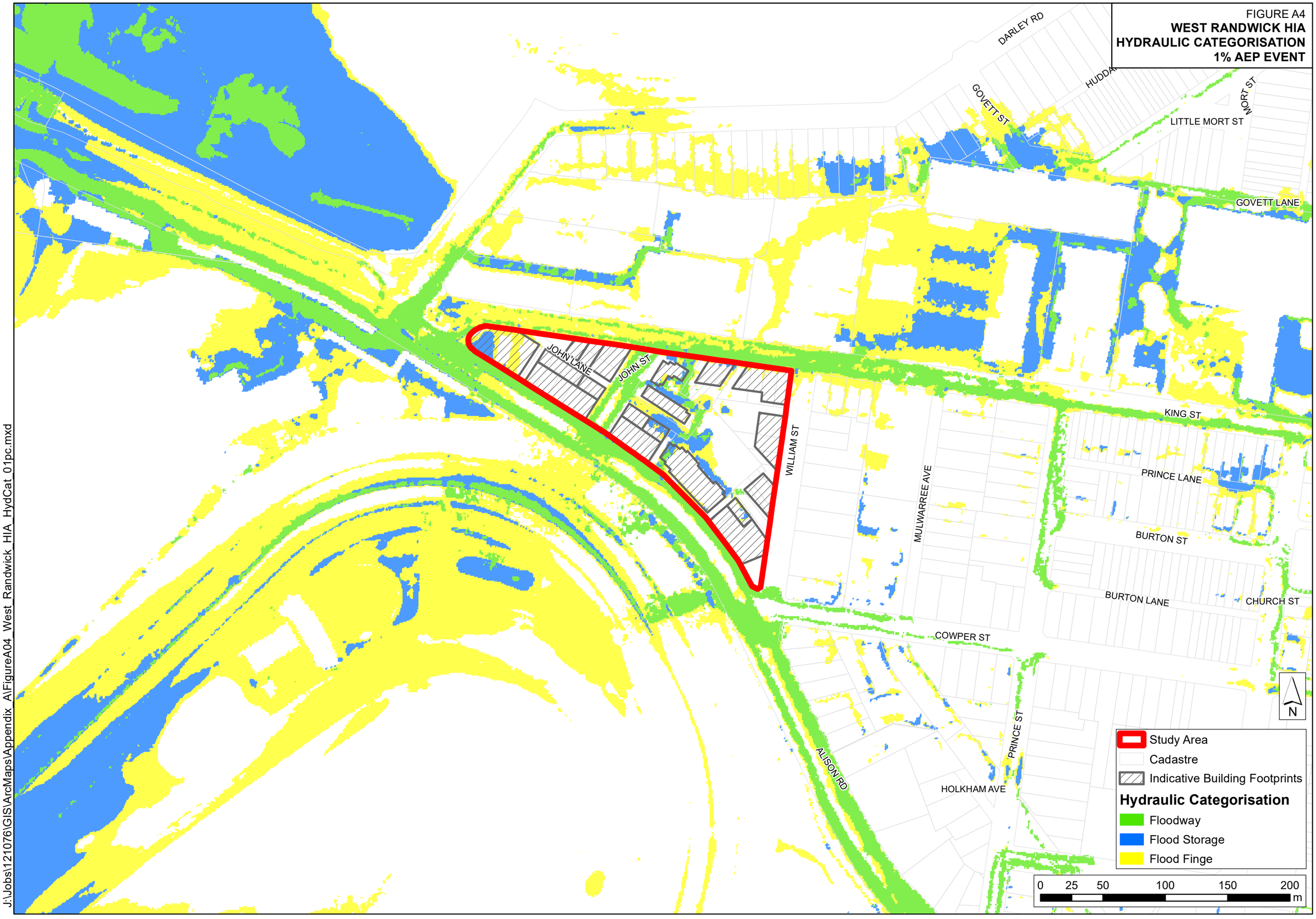
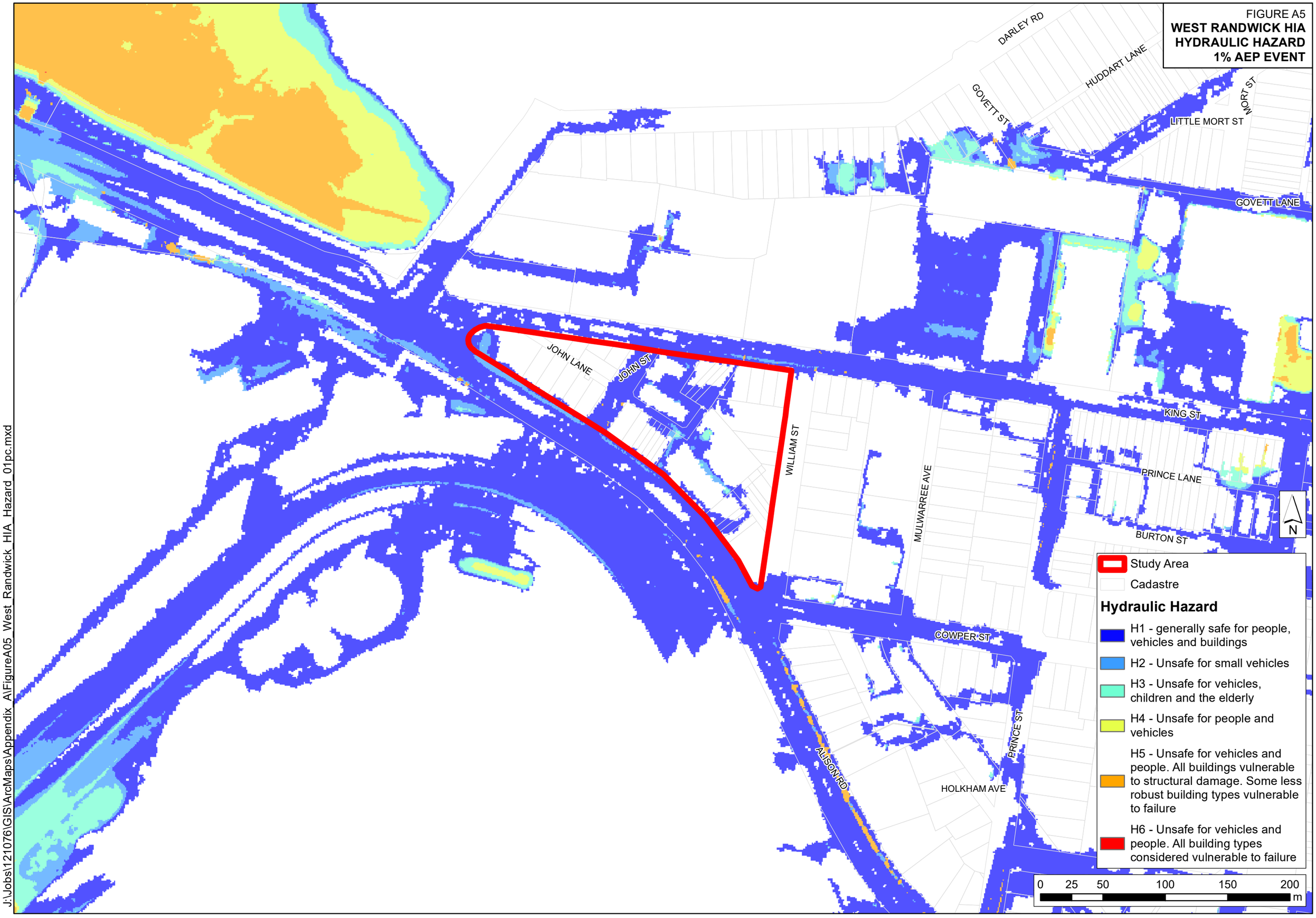
FIGURE A4
WEST RANDWICK HIA
HYDRAULIC CATEGORISATION
1% AEP EVENT



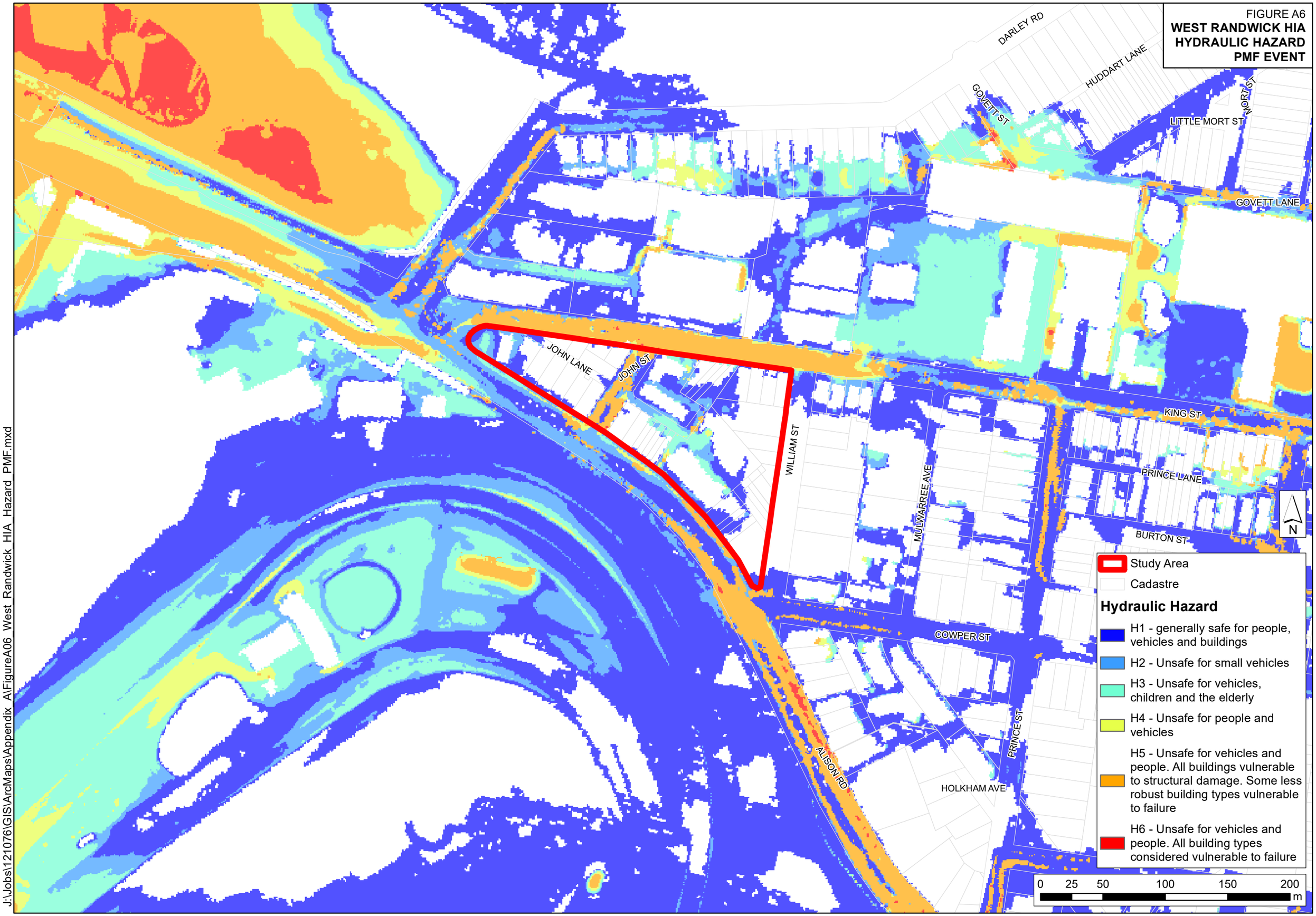
J:\Jobs\121076\GIS\ArcMaps\Appendix_A\FigureA04_West_Randwick_HIA_HydCat_01pc.mxd

FIGURE A5
WEST RANDWICK HIA
HYDRAULIC HAZARD
1% AEP EVENT



J:\Jobs\121076\GIS\ArcMaps\Appendix_A\FigureA05_West_Randwick_HIA_Hazard_01pc.mxd

FIGURE A6
WEST RANDWICK HIA
HYDRAULIC HAZARD
PMF EVENT



J:\Jobs\121076\GIS\ArcMaps\Appendix_A\FigureA06_West_Randwick_HIA_Hazard_PMF.mxd

APPENDIX B. Kensington North HIA Flood Mapping

Appendix B

FIGURE B1
KENSINGTON NORTH STUDY AREA

J:\Jobs\121076\GIS\ArcMaps\Appendix_B\FigureB01_Kensington_North_StudyArea.mxd

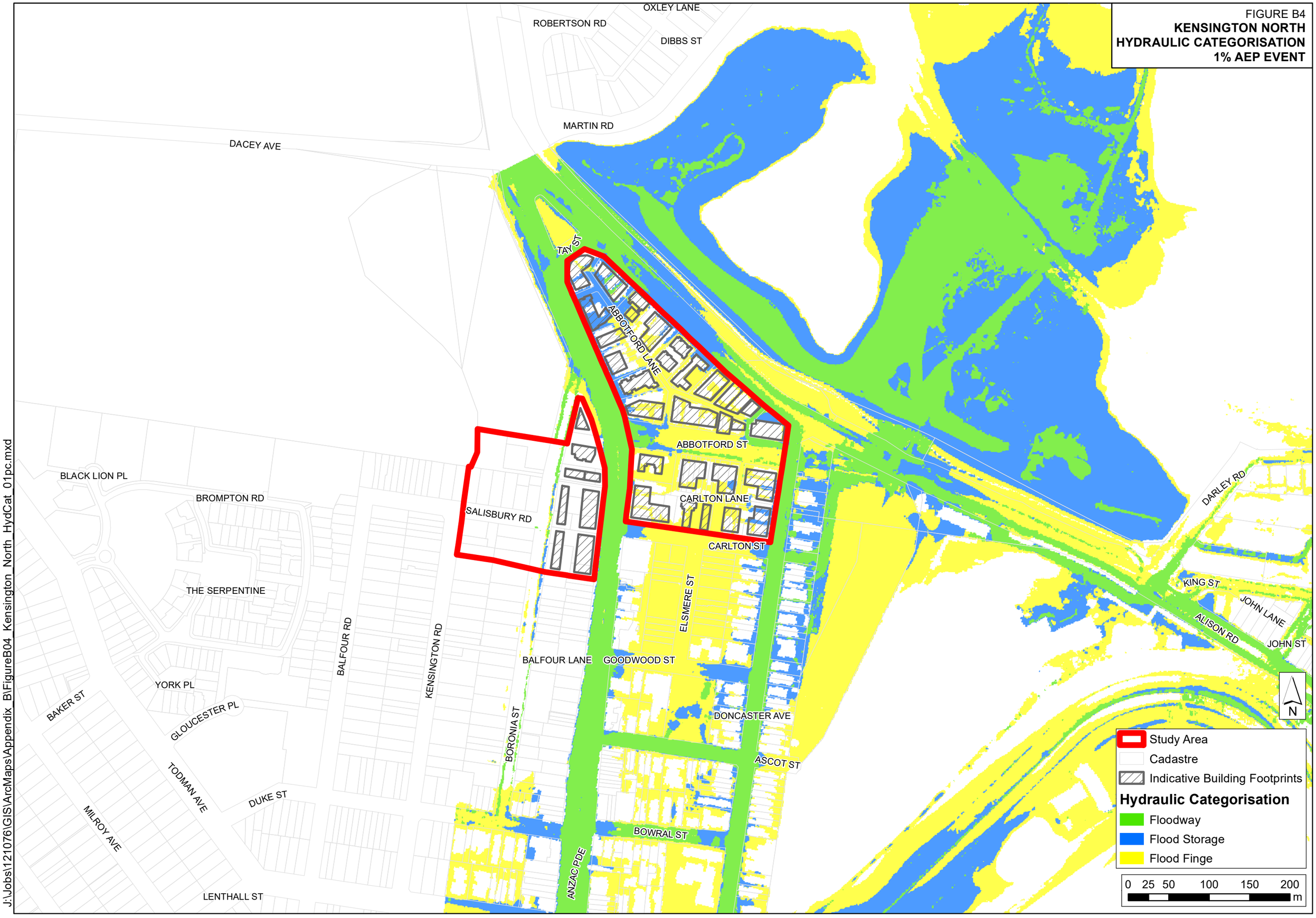
FIGURE B2
KENSINGTON NORTH
PEAK FLOOD DEPTHS AND LEVELS
5% AEP EVENT

J:\Jobs\121076\GIS\ArcMaps\Appendix_B\FigureB02_Kensington_North_Depth_05pc.mxd

FIGURE B3
KENSINGTON NORTH
PEAK FLOOD DEPTHS AND LEVELS
1% AEP EVENT

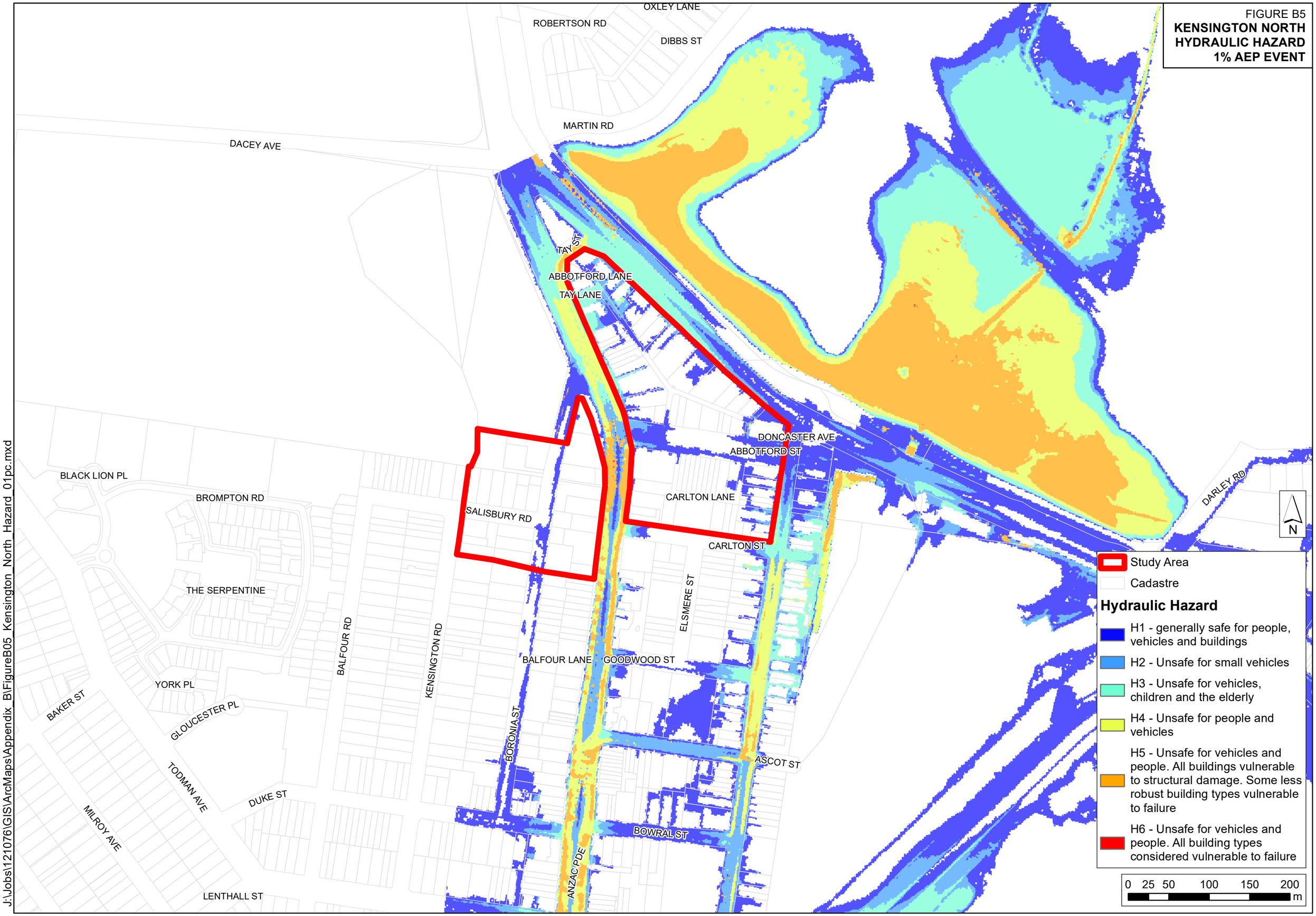
J:\Jobs\121076\GIS\ArcMaps\Appendix_B\FigureB03_Kensington_North_Depth_01pc.mxd

FIGURE B4
KENSINGTON NORTH
HYDRAULIC CATEGORISATION
1% AEP EVENT



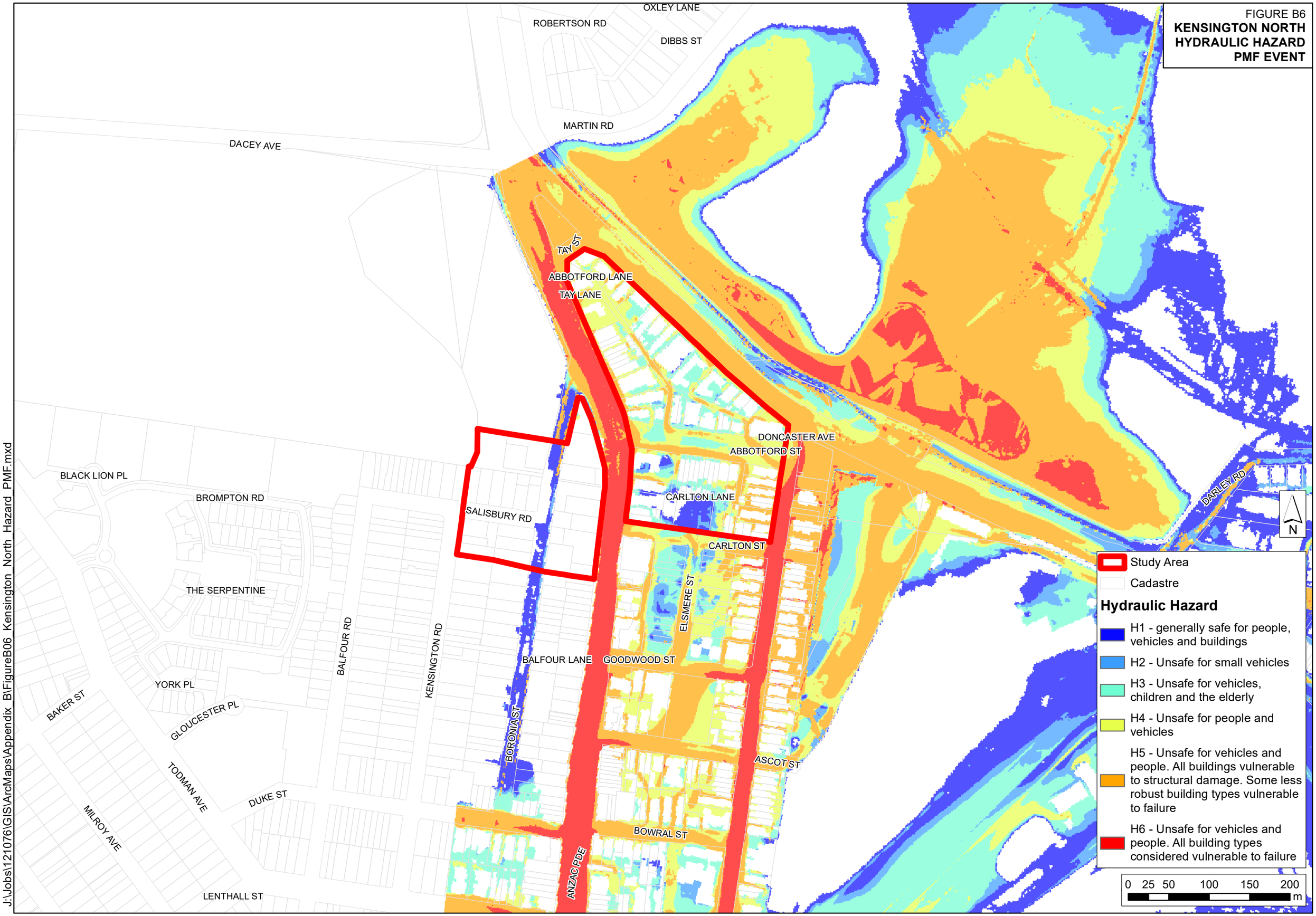
J:\Jobs\121076\GIS\ArcMaps\Appendix_B\FigureB04_Kensington_North_HydCat_01pc.mxd

FIGURE B5
KENSINGTON NORTH HYDRAULIC HAZARD 1% AEP EVENT



J:\Jobs\121076\GIS\ArcMaps\Appendix_B\FigureB05_Kensington_North_Hazard_01pc.mxd

FIGURE B6
KENSINGTON NORTH HYDRAULIC HAZARD PMF EVENT

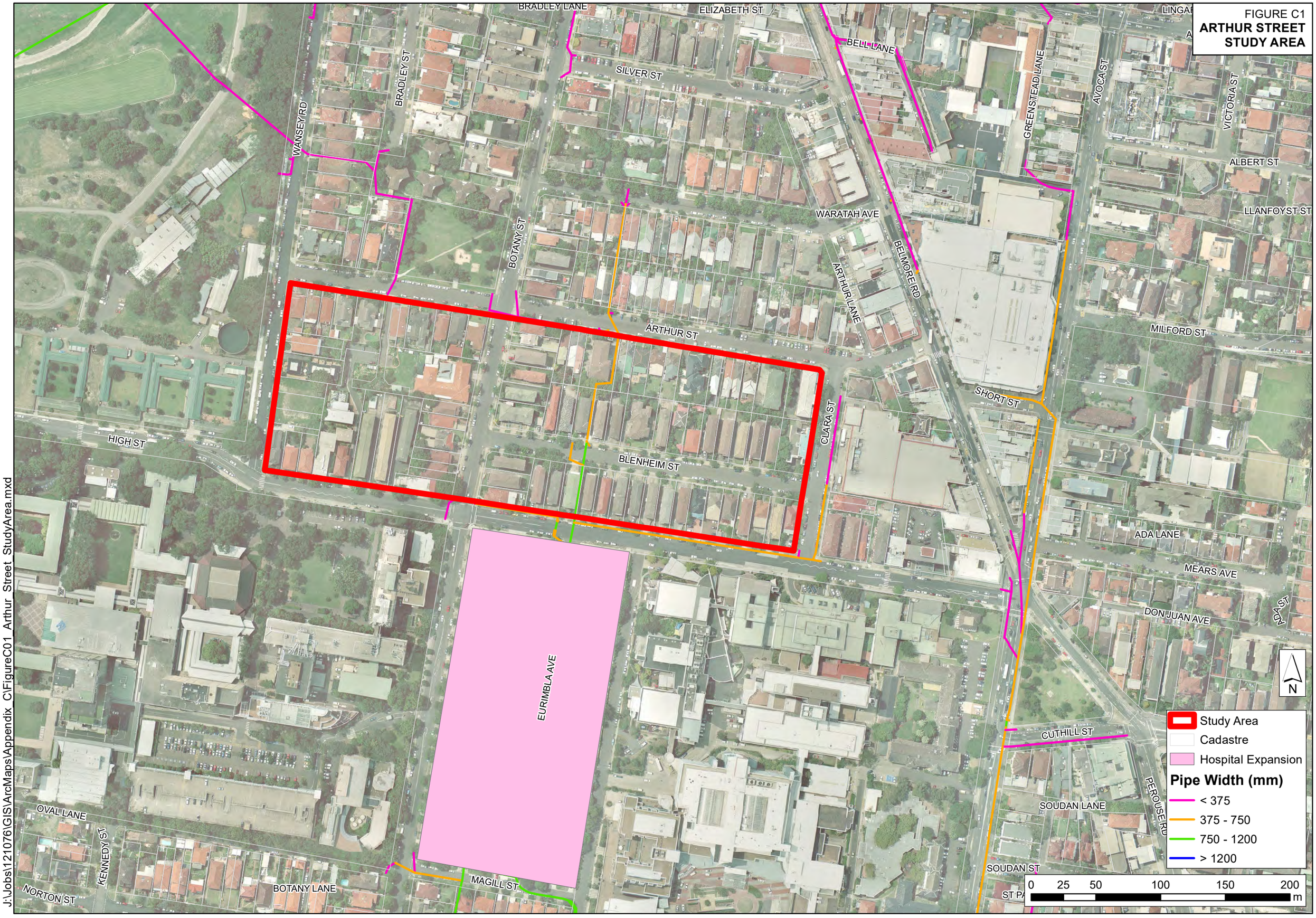


J:\Jobs\121076\GIS\ArcMaps\Appendix_B\FigureB06_Kensington_North_Hazard_PMF.mxd

APPENDIX C. Arthur Street HIA Flood Mapping

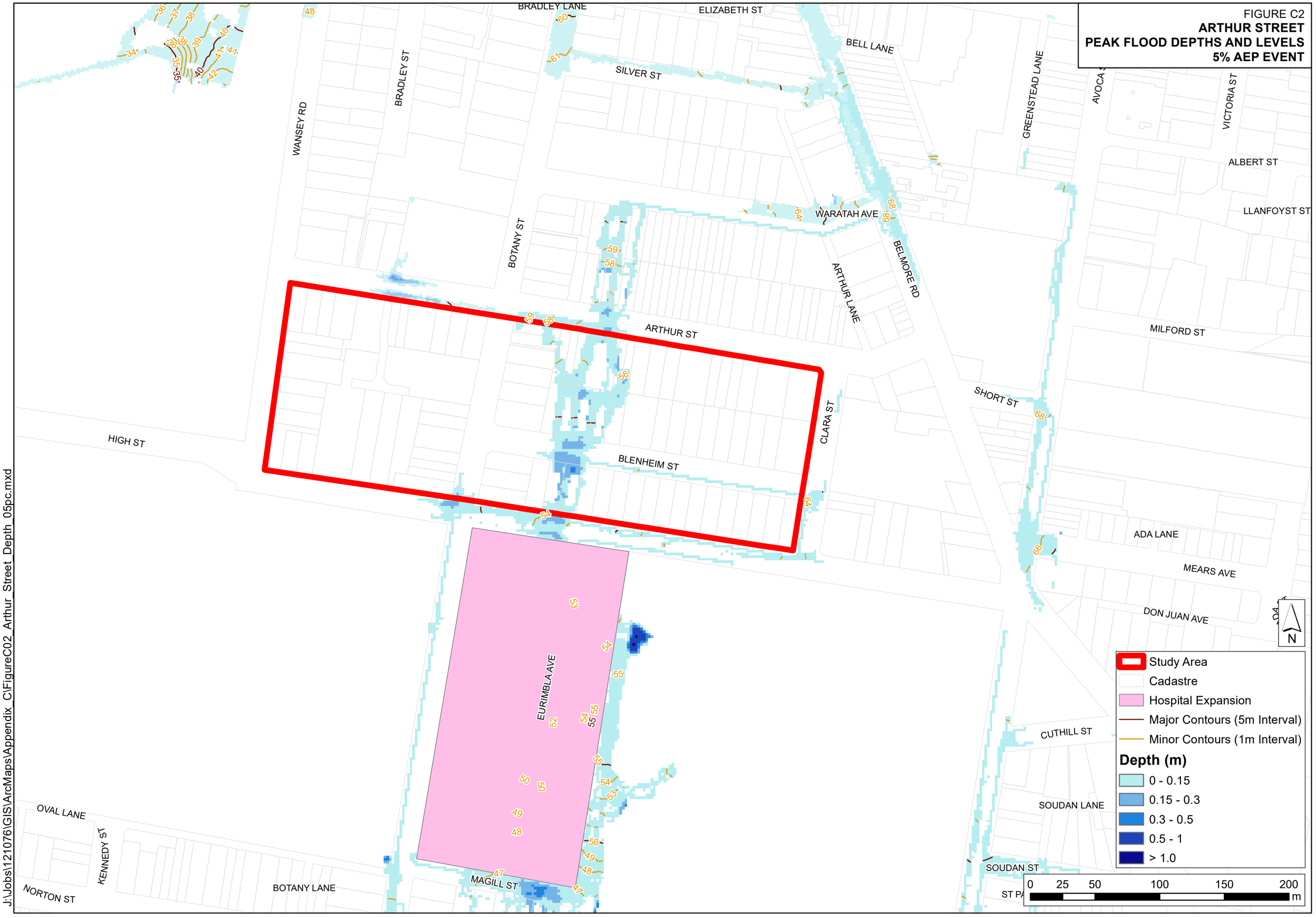
Appendix C

FIGURE C1
ARTHUR STREET STUDY AREA



J:\Jobs\121076\GIS\ArcMaps\Appendix_C\FigureC01_Arthur_Street_StudyArea.mxd

FIGURE C2
ARTHUR STREET
PEAK FLOOD DEPTHS AND LEVELS
5% AEP EVENT

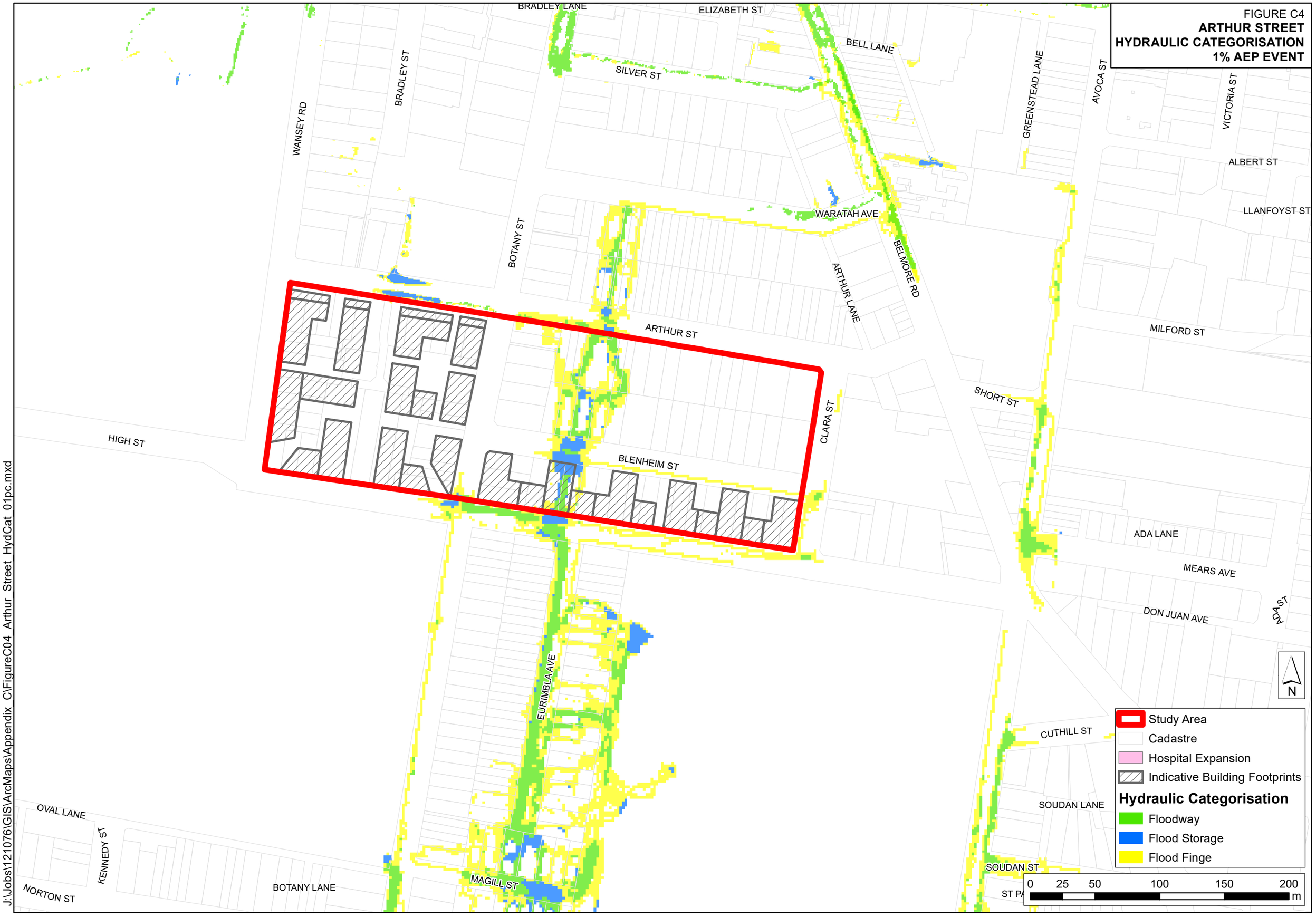


J:\Jobs\121076\GIS\ArcMaps\Appendix_C\FigureC02_Arthur_Street_Depth_05pc.mxd

FIGURE C3
ARTHUR STREET
PEAK FLOOD DEPTHS AND LEVELS
1% AEP EVENT

J:\Jobs\121076\GIS\ArcMaps\Appendix_C\FigureC03_Arthur_Street_Depth_01pc.mxd

FIGURE C4
ARTHUR STREET
HYDRAULIC CATEGORISATION
1% AEP EVENT



J:\Jobs\121076\GIS\ArcMaps\Appendix_C\FigureC04_Arthur_Street_HydCat_01pc.mxd

FIGURE C5
ARTHUR STREET HYDRAULIC HAZARD 1% AEP EVENT

BRADLEY LANE
ELIZABETH ST
BELL LANE
SILVER ST
WANSEY RD
BRADLEY ST
GREENSTEAD LANE
AVOCA ST
VICTORIA ST
ALBERT ST
LLANFOYST ST
WARATAH AVE
BOTANY ST
BELMORE RD
ARTHUR LANE
ARTHUR ST
MILFORD ST
SHORT ST
CLARA ST
HIGH ST
BLENHEIM ST
EURIMBLA AVE
CUTHILL ST
SOUDAN LAN
SOUDAN ST
ST PA
OVAL LANE
KENNEDY ST
NORTON ST
BOTANY LANE
MAGILL ST

N

Study Area
Cadastre
Hospital Expansion

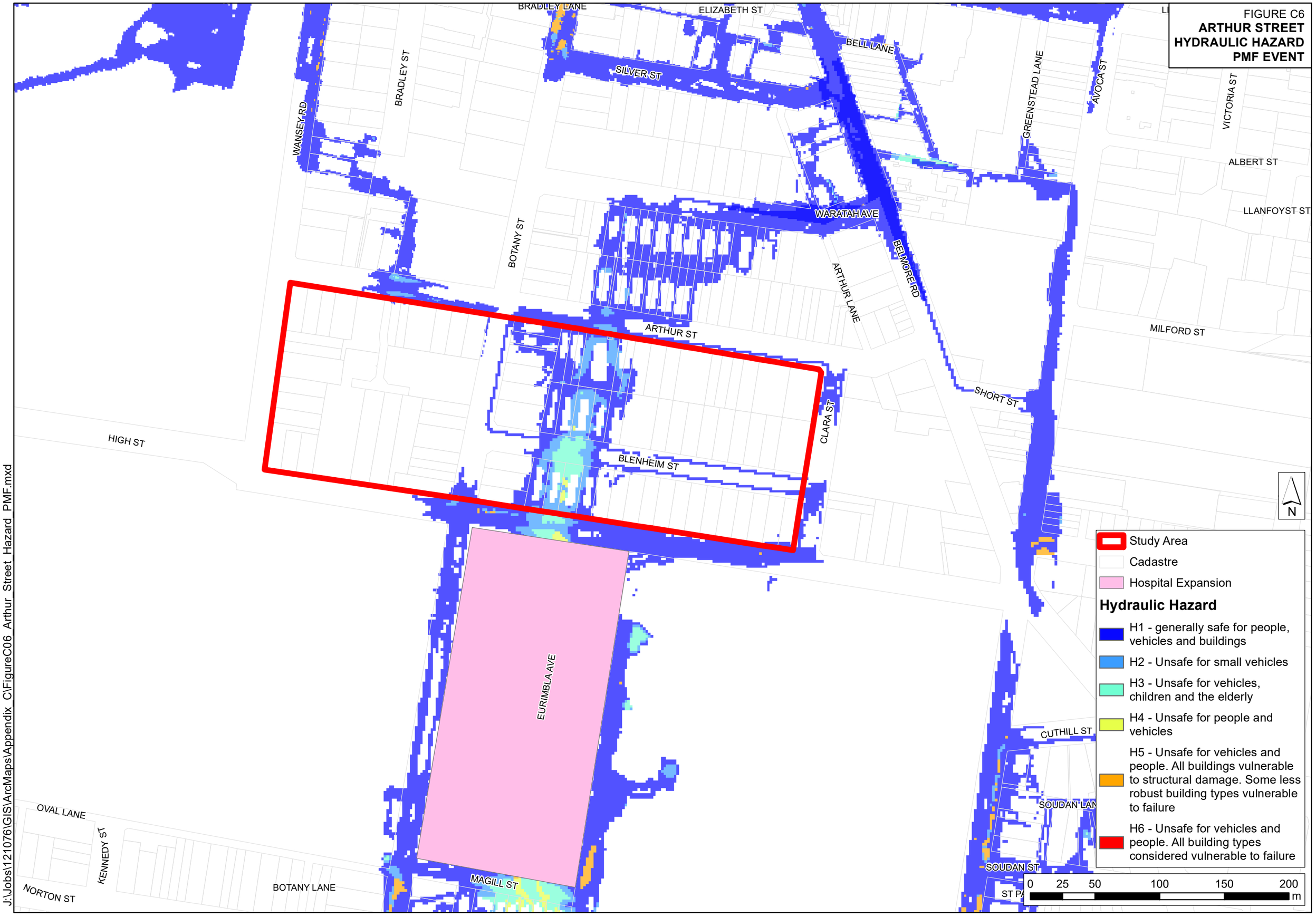
Hydraulic Hazard

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

0 25 50 100 150 200 m

J:\Jobs\121076\GIS\ArcMaps\Appendix_C\FigureC05_Arthur_Street_Hazard_01pc.mxd

FIGURE C6
ARTHUR STREET HYDRAULIC HAZARD PMF EVENT

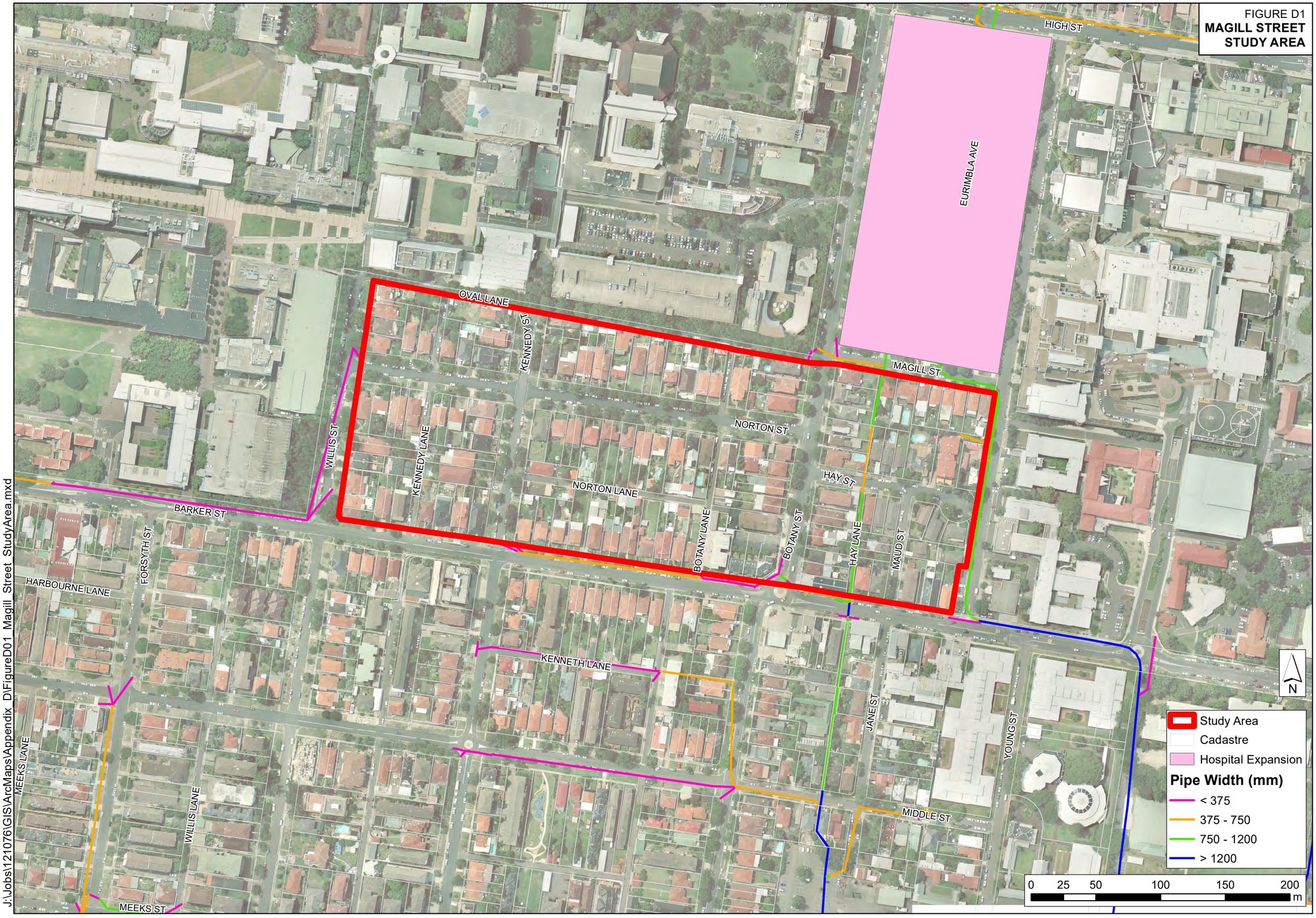


J:\Jobs\121076\GIS\ArcMaps\Appendix_C\FigureC06_Arthur_Street_Hazard_PMF.mxd

APPENDIX D. Magill Street HIA Flood Mapping

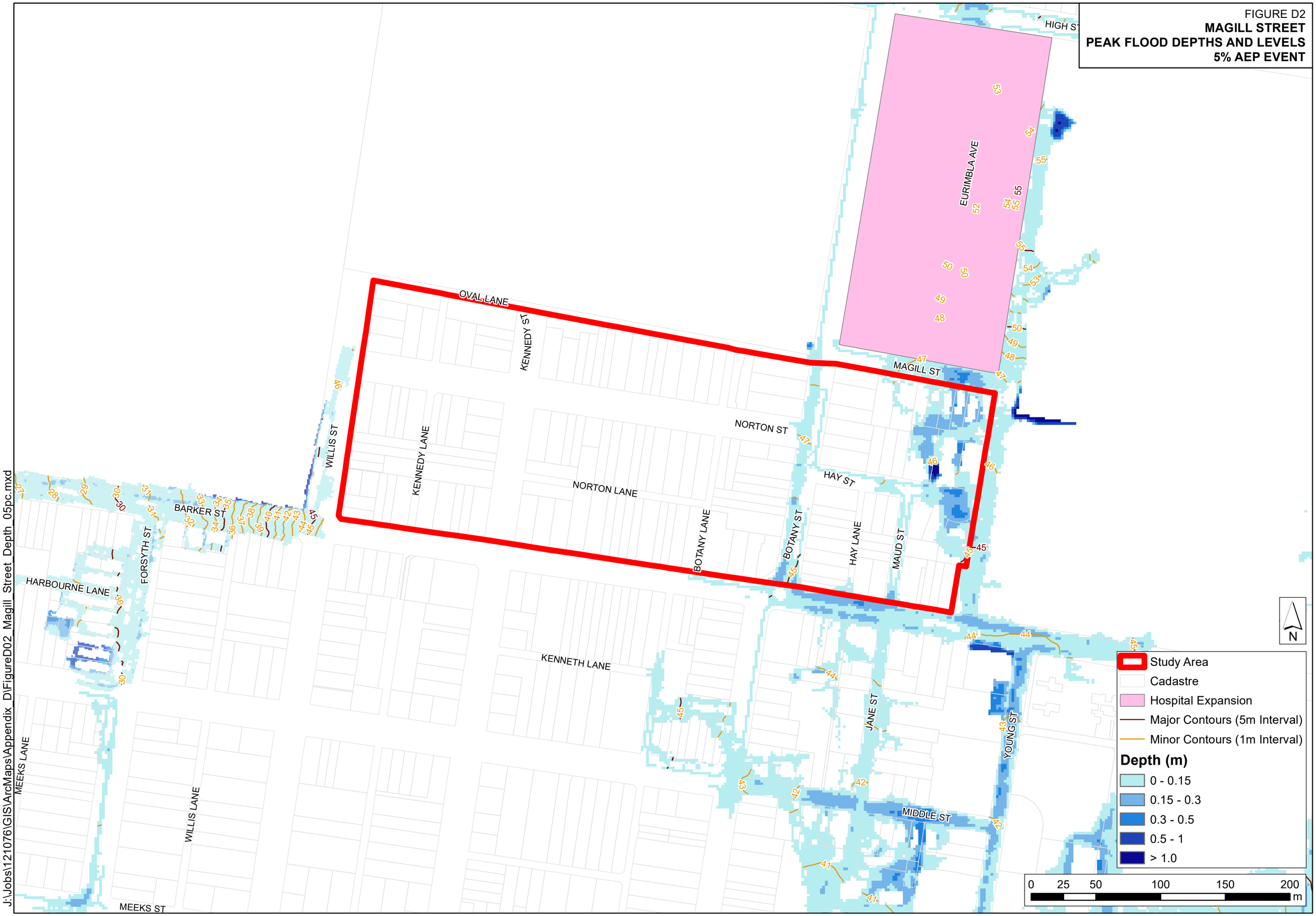
Appendix D

FIGURE D1
MAGILL STREET STUDY AREA



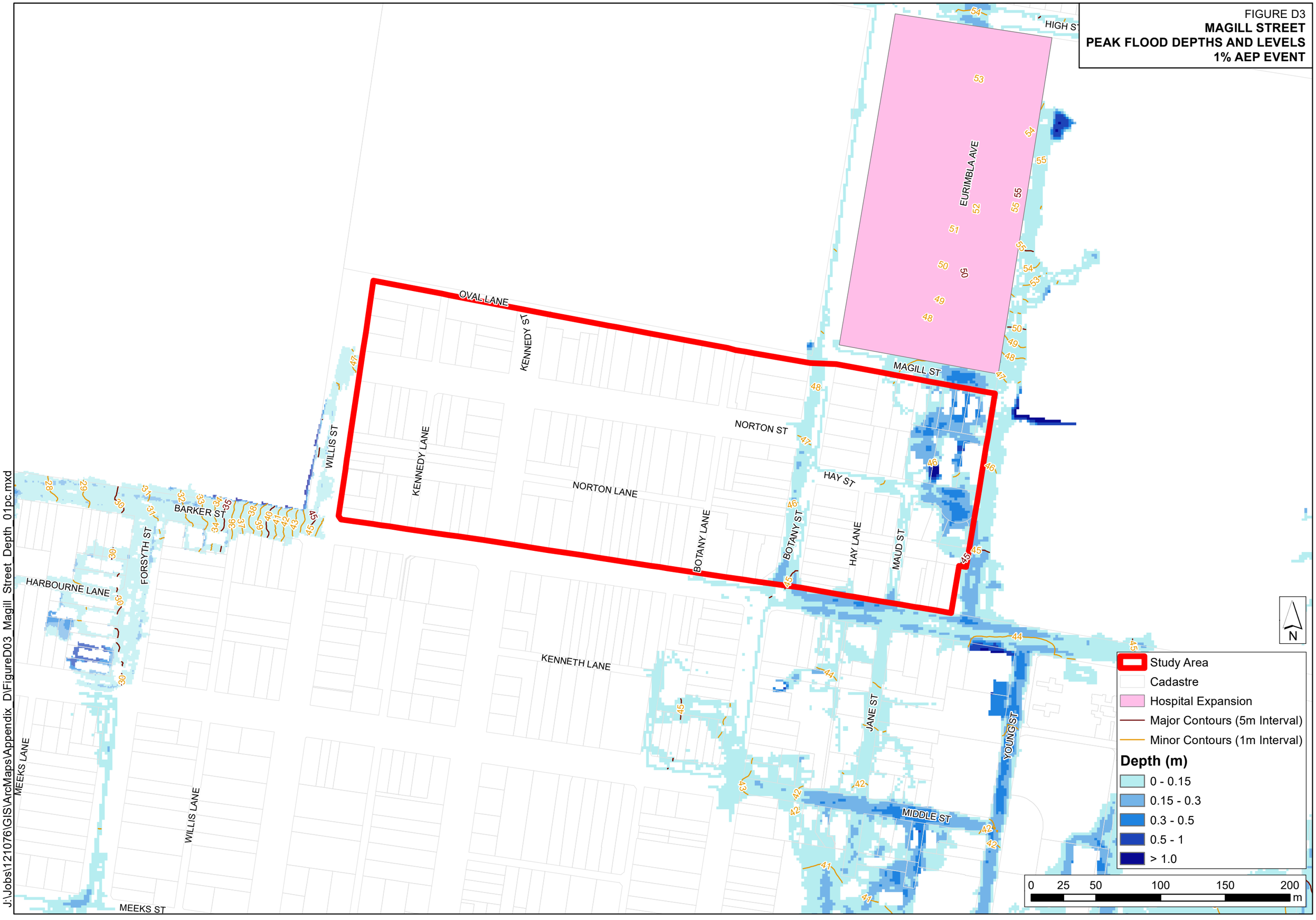
J:\Jobs\121076\GIS\ArcMaps\Appendix_D\FigureD01_Magill_Street_StudyArea.mxd

FIGURE D2
MAGILL STREET
PEAK FLOOD DEPTHS AND LEVELS
5% AEP EVENT



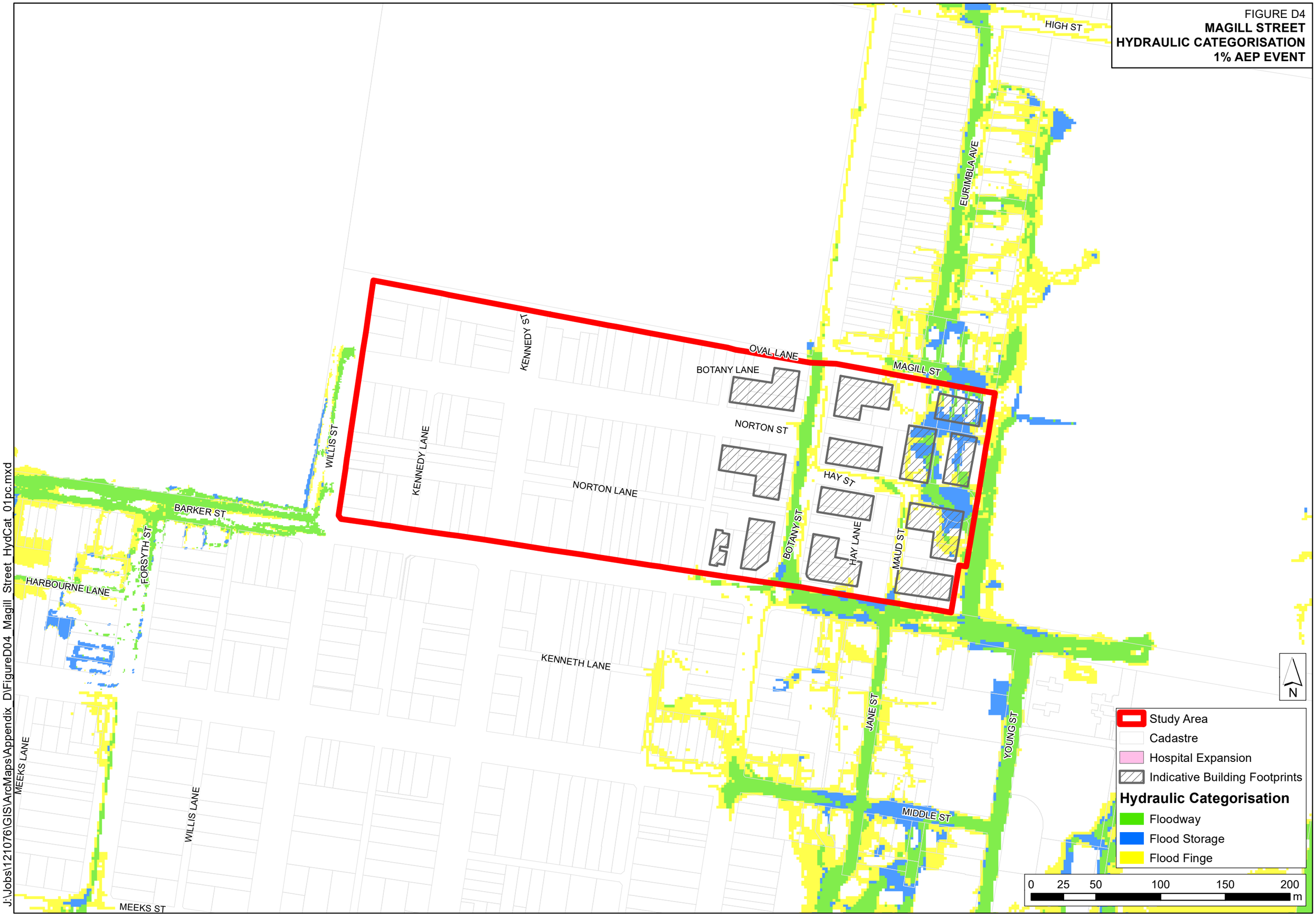
J:\Jobs\121076\GIS\ArcMaps\Appendix_D\FigureD02_Magill_Street_Depth_05pc.mxd

FIGURE D3
MAGILL STREET
PEAK FLOOD DEPTHS AND LEVELS
1% AEP EVENT



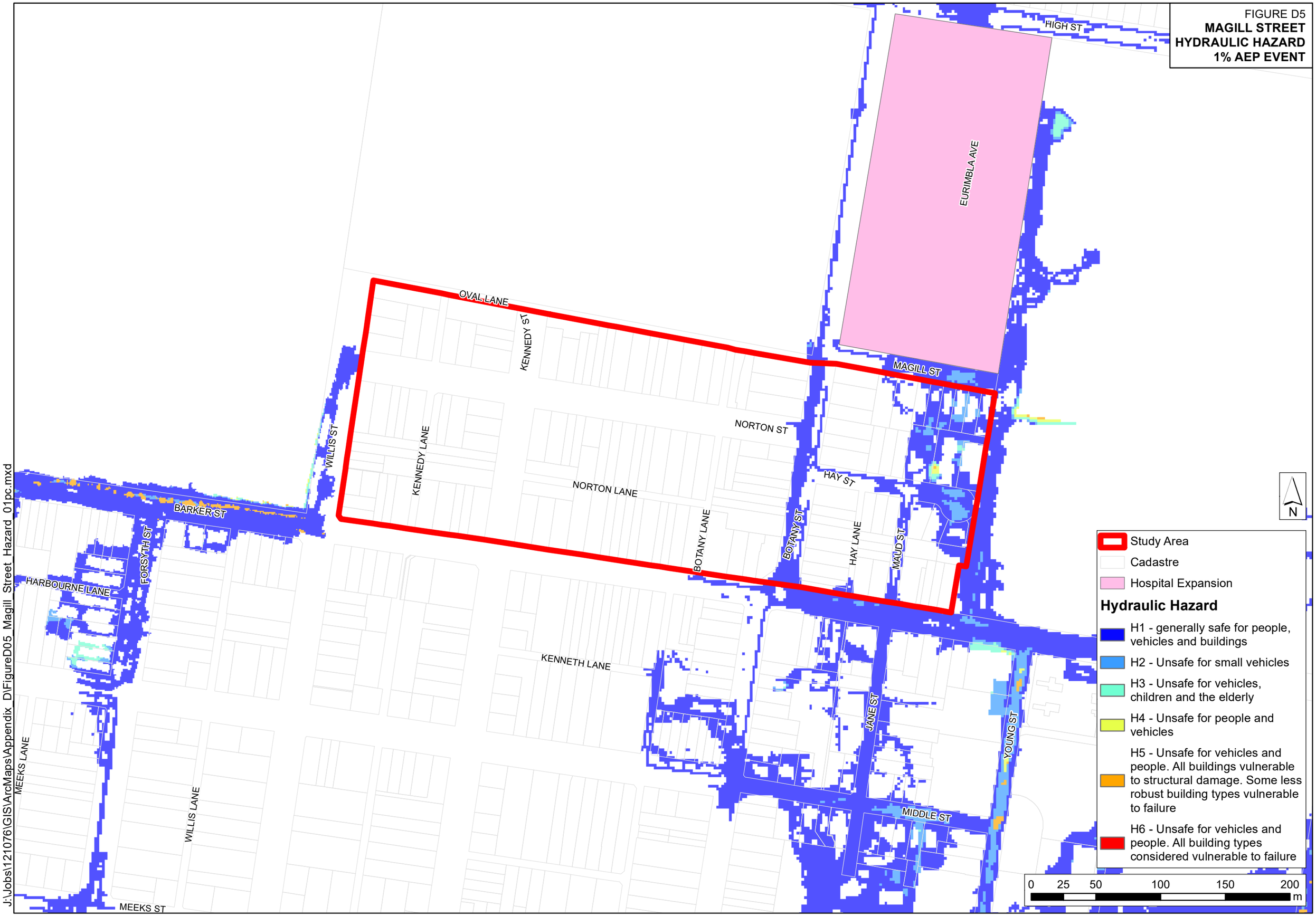
J:\Jobs\121076\GIS\ArcMaps\Appendix_D\FigureD03_Magill_Street_Depth_01pc.mxd

FIGURE D4
MAGILL STREET
HYDRAULIC CATEGORISATION
1% AEP EVENT



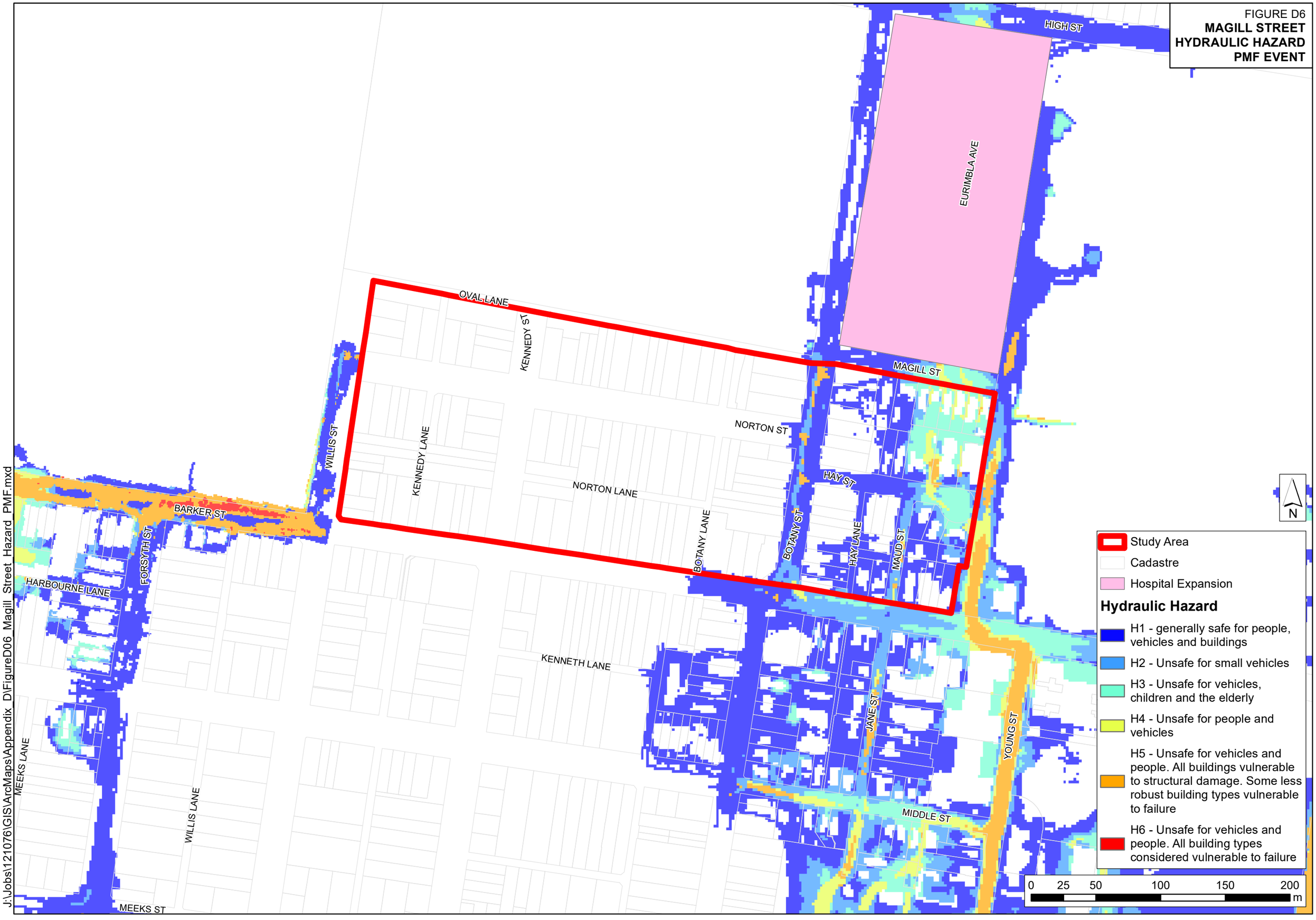
J:\Jobs\121076\GIS\ArcMaps\Appendix_D\FigureD04_Magill_Street_HydCat_01pc.mxd

FIGURE D5
MAGILL STREET
HYDRAULIC HAZARD
1% AEP EVENT



J:\Jobs\121076\GIS\ArcMaps\Appendix_D\FigureD05_Magill_Street_Hazard_01pc.mxd

FIGURE D6
MAGILL STREET
HYDRAULIC HAZARD
PMF EVENT



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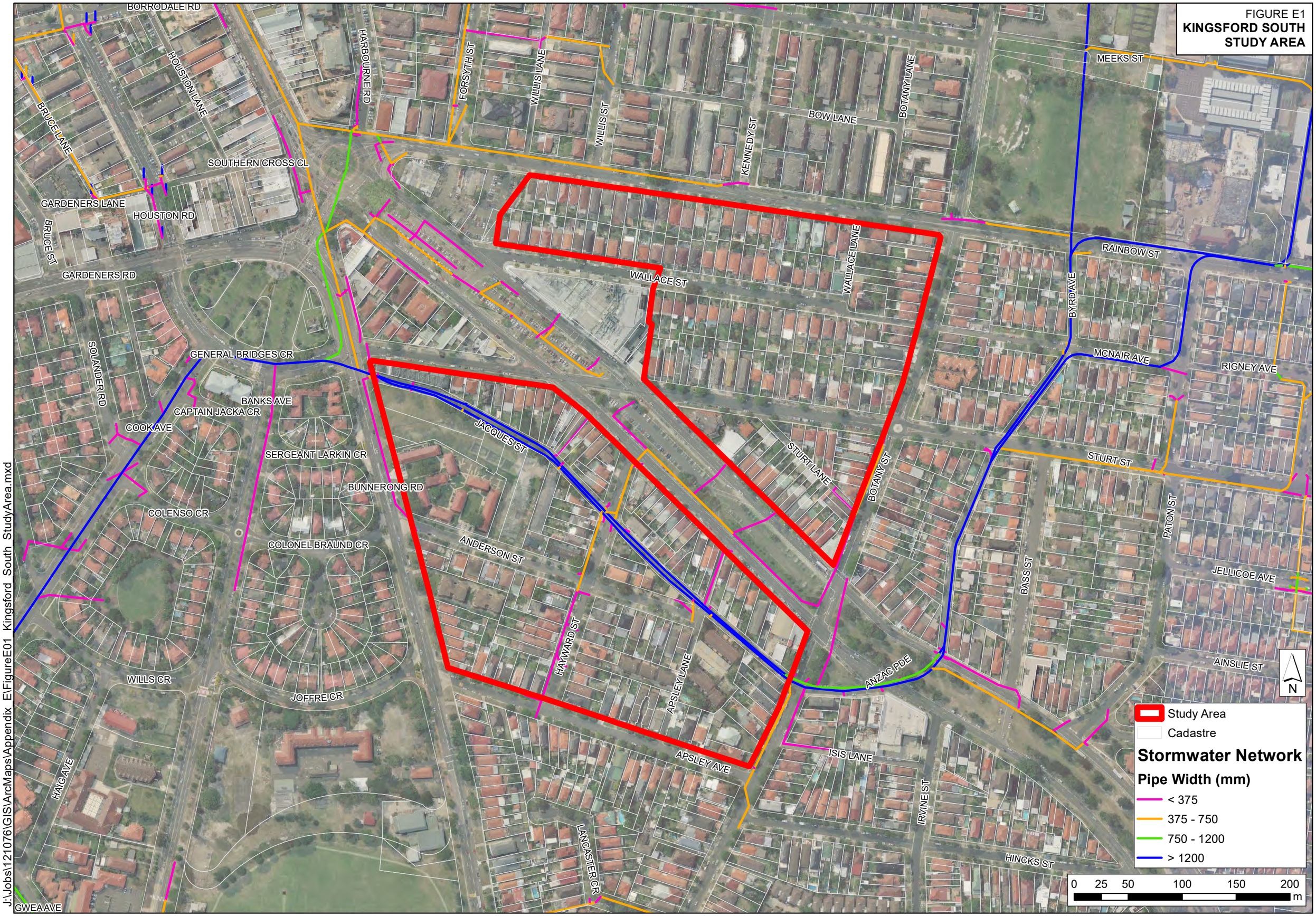
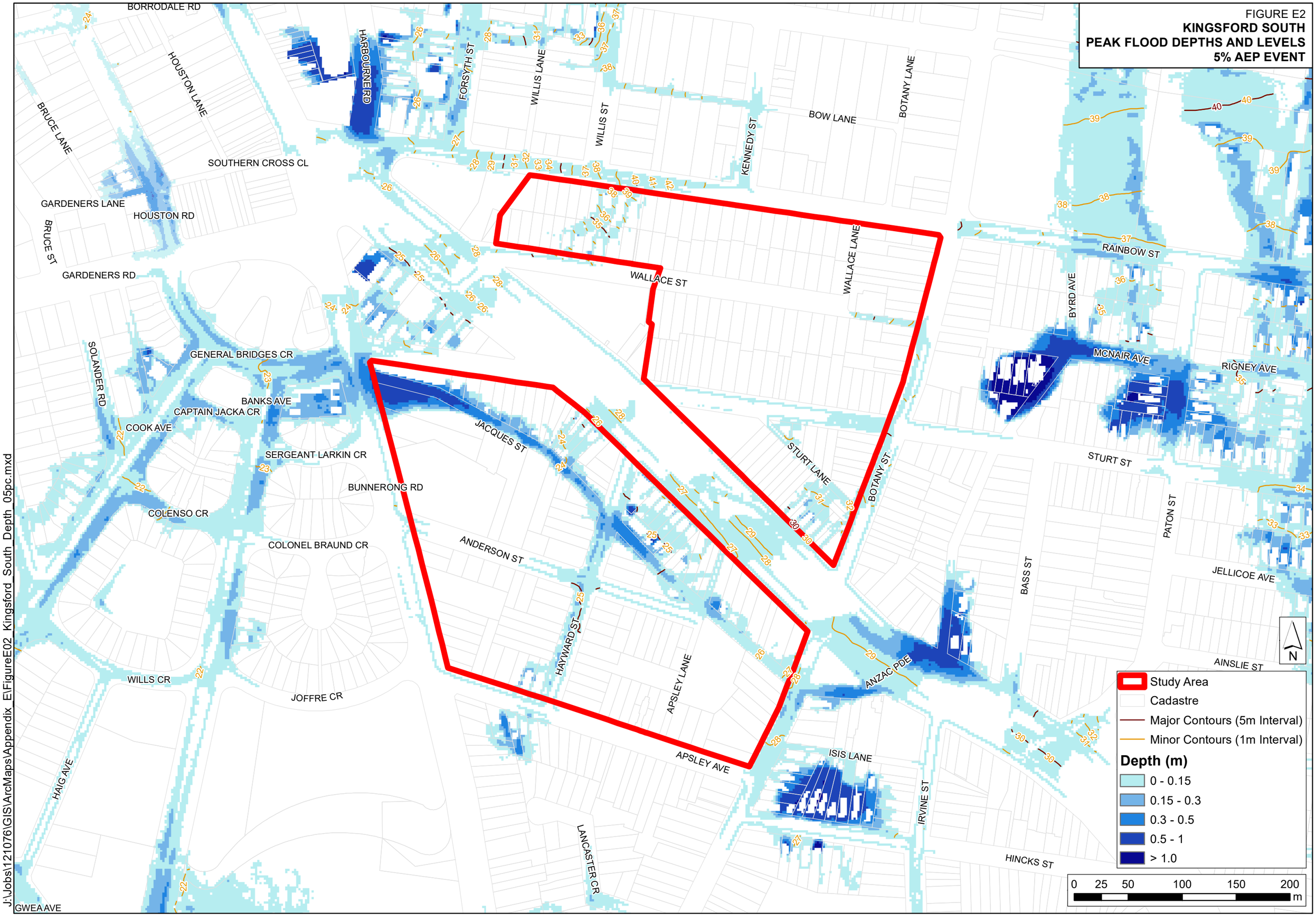
APPENDIX E. Kingsford South HIA Flood Mapping

Appendix E



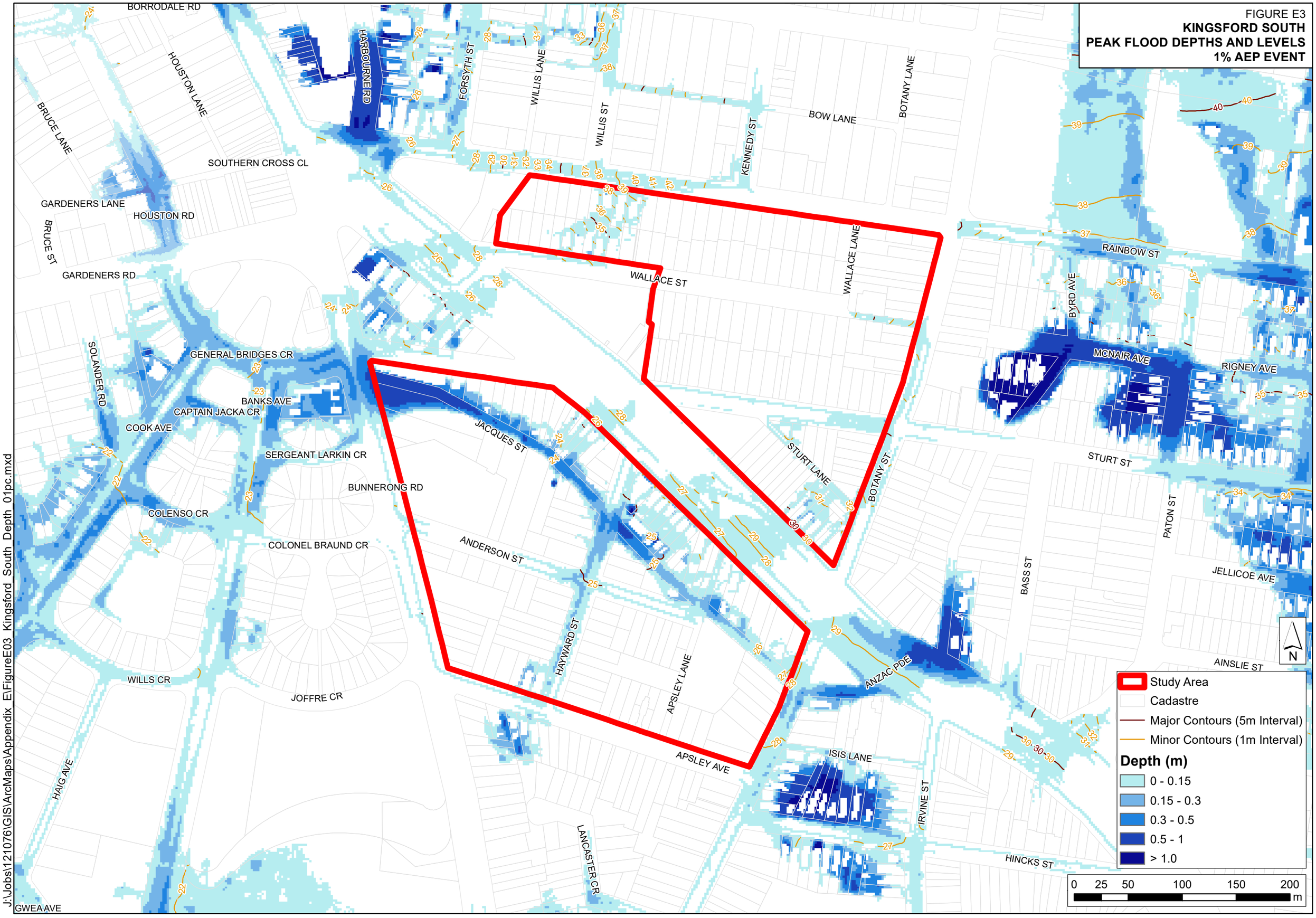
J:\Jobs\121076\GIS\ArcMaps\Appendix_E\FigureE01_Kingsford_South_StudyArea.mxd

FIGURE E2
KINGSFORD SOUTH
PEAK FLOOD DEPTHS AND LEVELS
5% AEP EVENT



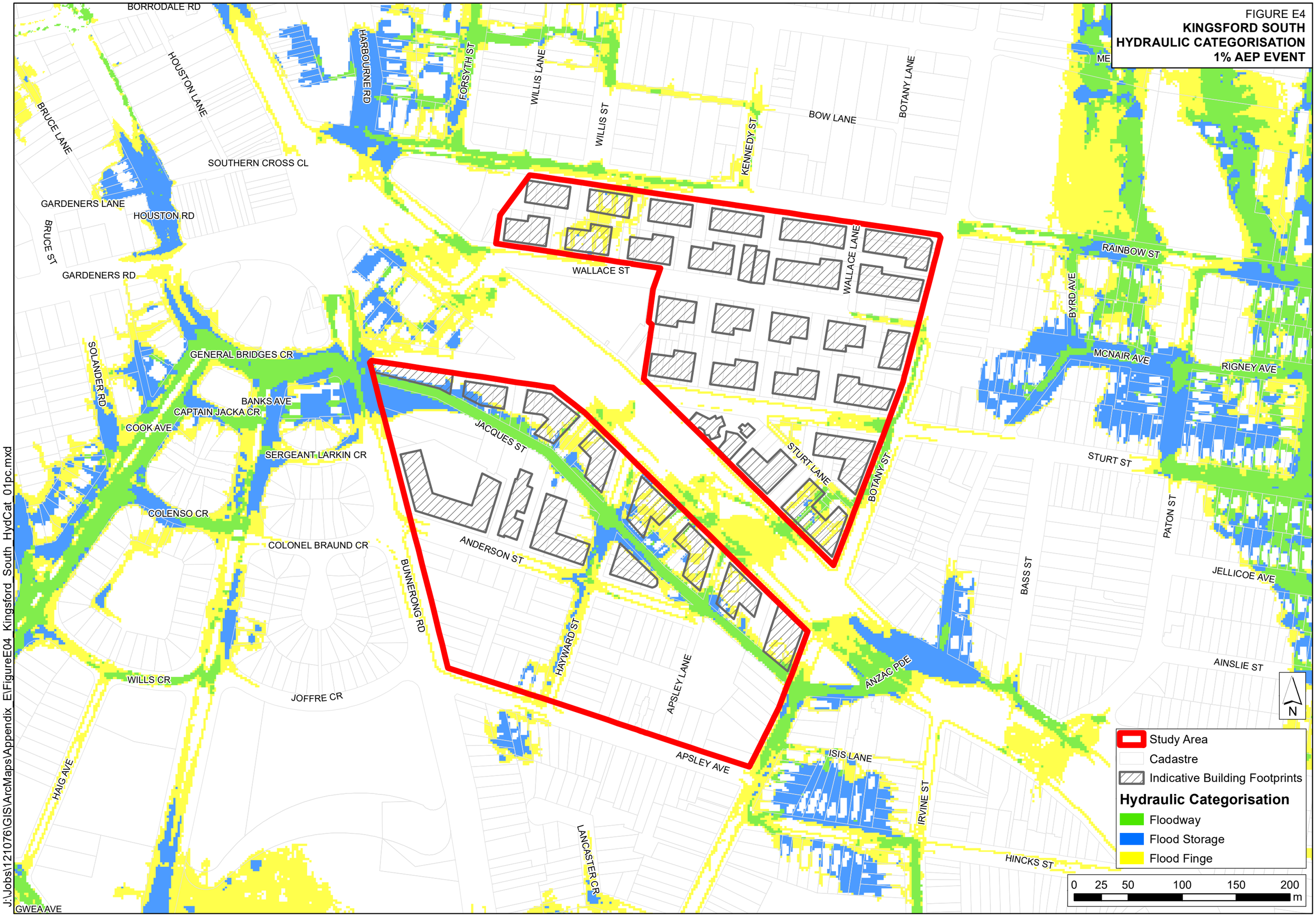
J:\Jobs\121076\GIS\ArcMaps\Appendix_E\FigureE02_Kingsford_South_Depth_05pc.mxd

FIGURE E3
KINGSFORD SOUTH
PEAK FLOOD DEPTHS AND LEVELS
1% AEP EVENT



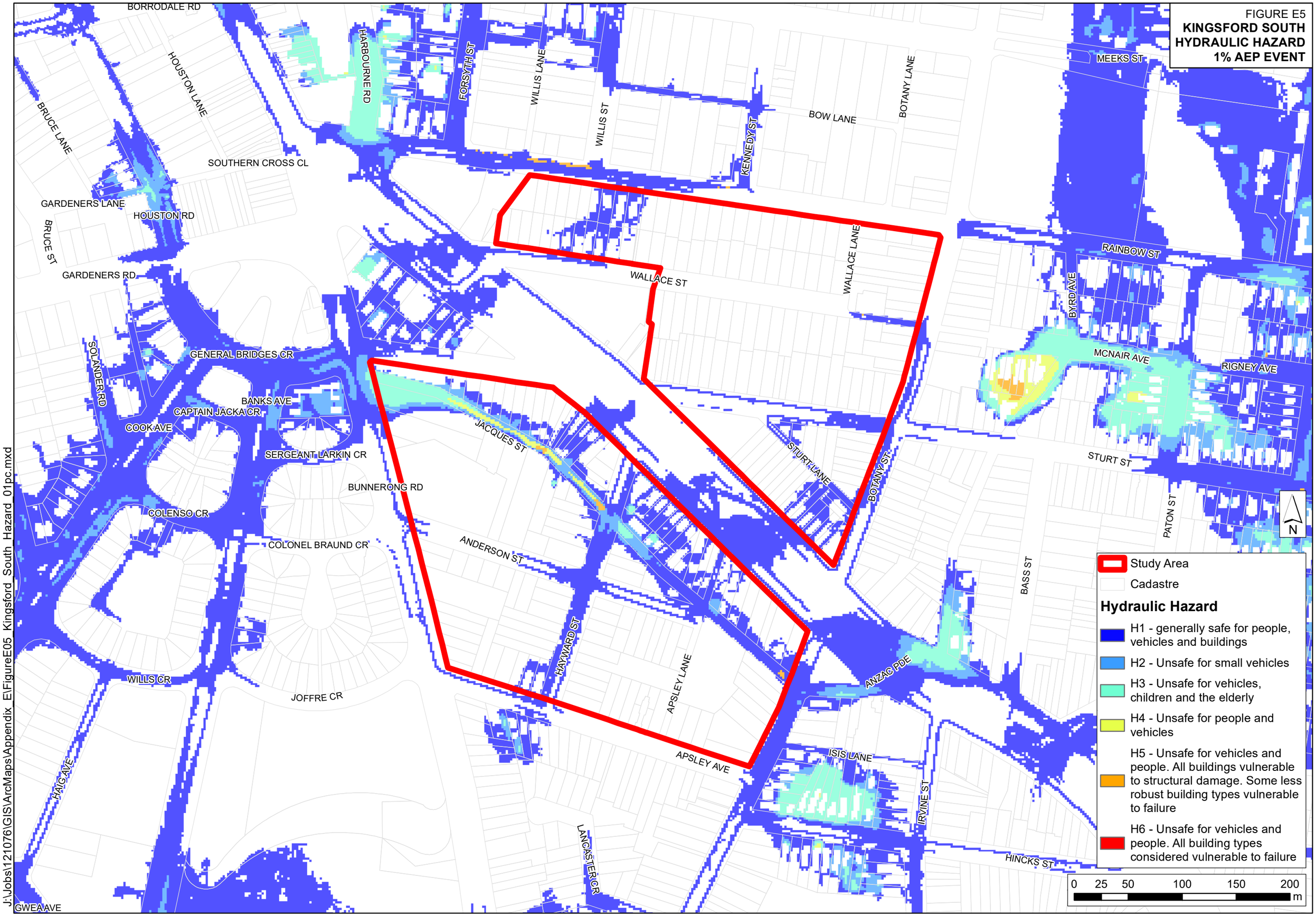
J:\Jobs\121076\GIS\ArcMaps\Appendix_E\FigureE03_Kingsford_South_Depth_01pc.mxd

FIGURE E4
KINGSFORD SOUTH
HYDRAULIC CATEGORISATION
1% AEP EVENT



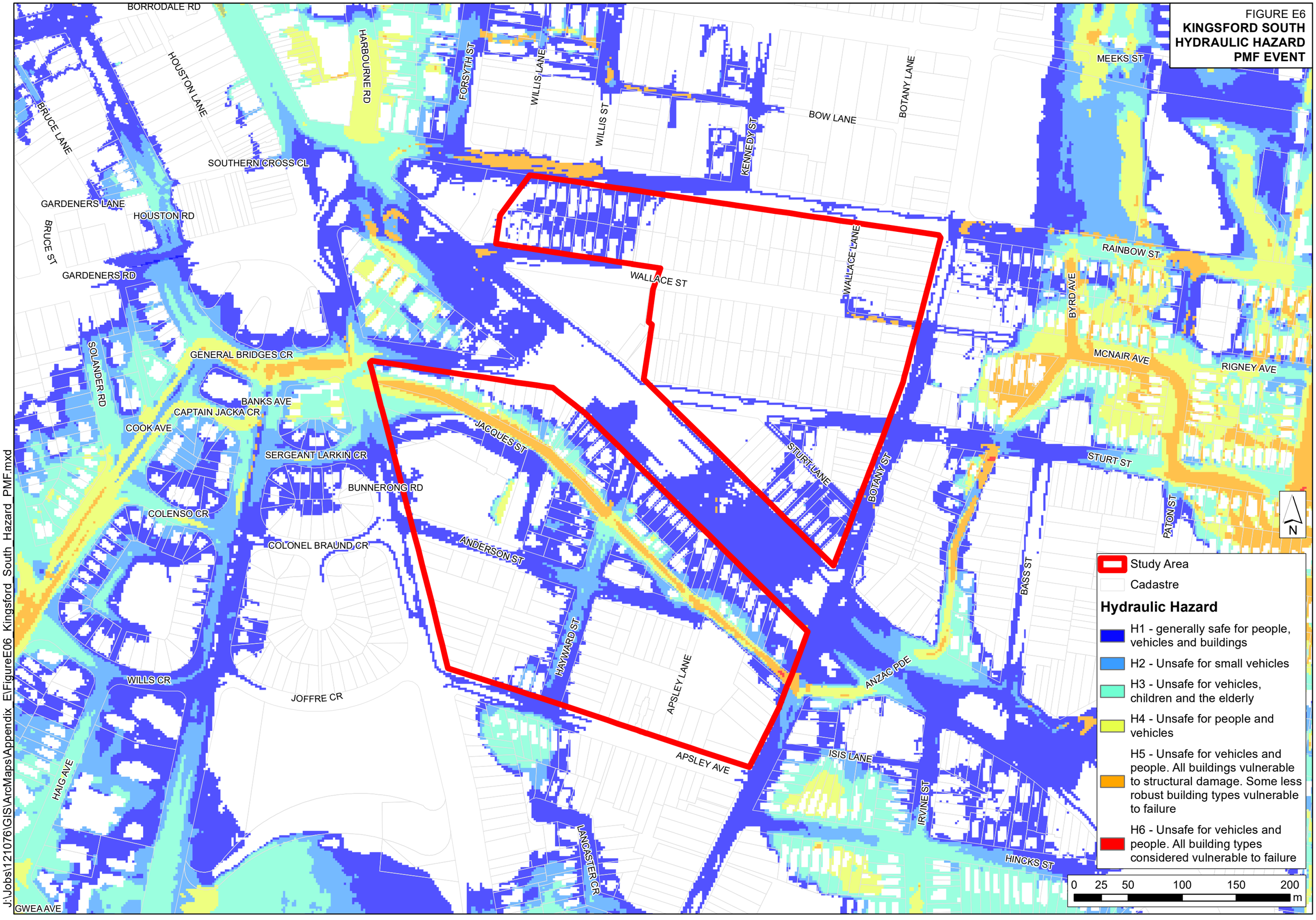
J:\Jobs\121076\GIS\ArcMaps\Appendix_E\FigureE04_Kingsford_South_HydCat_01pc.mxd

FIGURE E5
KINGSFORD SOUTH HYDRAULIC HAZARD 1% AEP EVENT



J:\Jobs\121076\GIS\ArcMaps\Appendix_E\FigureE05_Kingsford_South_Hazard_01pc.mxd

FIGURE E6
KINGSFORD SOUTH HYDRAULIC HAZARD PMF EVENT



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