Leichhardt Floodplain Risk Management Study and Plan

APPENDICES

Leichhardt Floodplain Risk Management Study and Plan

APPENDIX A
FLOOD STUDY ADDENDUM

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Version	Effective Date	Description of Revision	Prepared by:	Reviewed by:
1	8 September 2016	Draft for Council Review	Matthew Prumm Bala Kilaparty	Emma Maratea
2	17 March 2017	Updated Draft (included in preliminary draft FRMS)	Bala Kilaparty	Emma Maratea
3	22 May 2017	Draft for Public Exhibition	Bala Kilaparty	Emma Maratea
4	01 August 2017	Public Exhibition	Bala Kilaparty Scott Mortimer	Emma Maratea
5	November 2017	Final	Bala Kilaparty	David Whyte

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Attachment

1 Introduction

Since the modelling undertaken in 2010 – 2014 as part of the Leichhardt LGA Flood Study (Cardno, 2014) there have been several upgrades to drainage infrastructure and confirmation of drainage infrastructure connections, sizes and location that were previously uncertain. This addendum report provides the outcomes of the updated modelling undertaken to incorporate these upgrades.

Modifications to the hydraulic model were only required in four of the nine model zones. The model zones are shown in **Figure 5-1** of the FRMS (also see Figure 6.2 in the Flood Study).

This Addendum presents the outcomes of additional flood modelling undertaken within the following model zones:

- Rozelle Bay Catchment;
- Whites Creek Catchment;
- White Bay Catchment; and
- Mort Bay Catchment.

The impacts on the flood levels as a result of this modelling are provided in **Section 2** and the updated model results are presented in **Section 3**, with the replacement figures for the Flood Study provided in **Attachment A**.

As an outcome of the revised modelling, the flood control lots were also reviewed. The changes to flood control lots are described in **Section 4**, with the updated mapping provided in **Attachment A**.

<u>This document should be read in conjunction with the Leichhardt LGA Flood Study (Cardno, 2014)</u>.

2 Updated Modelling

2.1 Rozelle Bay Catchment

2.1.1 Model Updates

The following drainage infrastructure details were updated as a result of additional information becoming available:

- Updated details of the drainage system within the Railyards between Lilyfield Road and Brennan Street became available to Council.
- Updated details of the drainage system between Pritchard Street and Railway Parade became available to Council.

A significant stormwater culvert was identified running from the Rozelle Railyards into Whites Creek. This culvert was previously not surveyed and was not included in the Flood Study. The flood model was updated to include this. This update impacted both the Rozelle Bay Catchment and the Whites Creek Catchment.

2.1.2 Impacts on Peak Flood Levels

The impacts of the revised modelling on peak flood levels on the 5 and 100 Year ARI and PMF events in the Rozelle Bay Catchment are shown in **Figures 2-1** to **2-3**.

The most significant impact on the flood behaviour was as a result of the inclusion of the major drainage culvert from Rozelle, under the railyards and into Whites Creek. When the Flood Study was undertaken, the presence of this culvert was unknown and as a result of the updated flood model a significant volume of flow is conveyed from the north of the railyards into Whites Creek resulting in a reduction of flood levels to the south of Lilyfield Road and an increase of flood levels in Whites Creek. The impacts become more significant and widespread in the larger events.

2.2 Whites Creek Catchment

2.2.1 Model Updates

Drainage works were recently completed at Young Street and Parramatta Road. The details of the upgraded pipe system were incorporated into the flood model.

Council stormwater database did not show a pipe between 28 Alfred Street and Whites Creek. Due to the fact that a pipe must exist at this location, the Flood Study made assumptions on the pipe locations and diameter. Council provided surveyed details of this pipe, which were incorporated into the flood model.

A significant stormwater culvert was identified running from the Rozelle Railyards into Whites Creek as discussed further in Section 2.1. This culvert was previously not surveyed and was not included in the Flood Study. The flood model was updated to include this.

2.2.2 Impacts on Peak Flood Levels

The impacts of the revised modelling on peak flood levels on the 5 and 100 Year ARI and PMF events in the Whites Creek Catchment are shown in **Figure 2-4** to **2-6**.

The impacts of the culvert through the railyards is discussed in **Section 2.1.2**. In addition to the increases in flood levels in Whites Creek at the downstream end, near Railway Parade, flood levels can also be seen to have increased further up Whites Creek, especially in the larger events.

The inclusion of the completed works at Parramatta Road result in a minor reduction in the flood level in this area in the 5 and 100 Year ARI events.

2.3 White Bay Catchment

2.3.1 Model Updates

The following drainage infrastructure details were updated as a result of additional information becoming available:

- Updated pipe details within the drainage easement at 7 Rosebery Place became available to Council.
- Inclusion of the Sydney Water pipeline located in Evans Street, Goodsir Street, Moore Street and the laneway between Mansfield Street and Parsons Street.

2.3.2 Impacts on Peak Flood Levels

The impacts of the revised modelling on peak flood levels on the 5 and 100 Year ARI and PMF events in the White Bay Catchment are shown in **Figure 2-7** to **2-9**.

The updated drainage details result in a reduction in flooding on Beattie Street and a subsequent minor increase in flood levels downstream of this location.

2.4 Mort Bay Catchment

2.4.1 Model Updates

Upgrade works to the drainage system at Curtis Road were recently completed. The details of these works were included in the flood model.

Council undertook detailed survey of the piped drainage network in the vicinity of Cameron Street between Church Street and College Street. The details varied slightly from those in the Flood Study model and the updated details were included in the flood model.

2.4.2 Impacts on Peak Flood Levels

The impacts of the revised modelling on peak flood levels on the 5 and 100 Year ARI and PMF events in the Mort Bay Catchment are shown in **Figure 2-10** to **2-12**.

The upgraded drainage system at Curtis Road resulted in a minor decrease in flooding in the area, primarily along Clayton Street.

3 Updated Modelling Results

3.1 Flood Extents, Depths and Velocities

The results for the 5 and 100 year ARI and Probable Maximum Flood (PMF) events are presented in the following Figures in **Attachment A**.

> Flood extents and depths are shown in **Figures 8.1 to 8.3.**

> Flood velocities are shown in **Figures 8.4 to 8.6.**

3.2 Provisional Flood Hazard

Provisional flood hazard is determined through a relationship developed between the depth and velocity of floodwaters (Figure L2, NSW Government, 2005). The Floodplain Development Manual (2005) defines two categories for provisional hazard - High and Low.

The model results were processed using an in-house developed program, which utilises the model results of flood level and velocity to determine hazard. Provisional flood hazard was prepared for four design events, namely 5 and 100 year ARI and PMF design events. The provisional hazard is based on the envelope of the hazard at each location for each ARI.

Flood hazard for the 5 year ARI, 100 year ARI and PMF events is shown in **Attachment A** as **Figures 9.1 to 9.3.**

3.3 Major Road Flooding

The analysis of road flooding provided in the Floodplain Risk Management Study (**Section 8.6** of the FRMS document) supersedes the data presented in the Flood Study (Cardno, 2014). This discussion includes the revised flood modelling results.

4 Flood Control Lots

Flood control lots are those properties within the LGA that should be referred to Council's development controls because of their potential to be flood affected. This does not necessarily mean that the properties are flood affected, simply that they have the potential to be flood affected.

Typically, flood control lots may experience one or more of the following types of flooding:

> Mainstream flooding;

> Flooding by overland flows; and/ or,

> Estuarine inundation and wave impact.

Mainstream flooding is generally defined as overflow along Whites Creek and Johnstons Creek in Annandale and Hawthorne Canal in Leichhardt. Flooding by overland flows generates the majority of the flood control lots within the Leichhardt Local Government Area and is generally defined as flooding that occurs within natural depressions and along surface flowpaths along the streets or through properties.

Estuarine inundation and wave impact is associated storm tide, wave run-up and overtopping effects on water level for the foreshore areas of the Leichhardt Council LGA.

The flood control lot mapping was reviewed for all areas where the revised flood modelling resulted in altered flood levels. The revision of flood control lots was undertaken in accordance with the criteria outlined in **Section 12** of the Flood Study (Cardno, 2014).

This review resulted in some minor amendments to the flood control lot mapping presented in the Flood Study (Cardno, 2014). The updated flood control lot mapping is provided in **Attachment A in Figures 12.1 to 12.5.**

5 Conclusions

This Addendum report was prepared based on modelling undertaken in 2016 using the Sobek model originally developed in 2010 for the purpose of the Leichhardt LGA Flood Study (Cardno, 2014).

The information presented in this Addendum Report supersedes the equivalent data presented in the Leichhardt LGA Flood Study (Cardno, 2014).

This Addendum report should be read in conjunction with the Leichhardt LGA Flood Study (Cardno, 2014).

FIGURES

Figure 2-1 - 5yr ARI WLDifference
2016 Less 2014 results
Rozelle Bay

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Figure 2-2 - 100yr ARI WLDifference
2016 Less 2014 results
Rozelle Bay

Figure 2-3 - PMF WLDifference
2016 Less 2014 results
Rozelle Bay

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Figure 2-4 - 5yr ARI WLDifference
2016 Less 2014 results
Whites Creek

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Figure 2-5 - 100yr ARI WLDifference
2016 Less 2014 results
Whites Creek

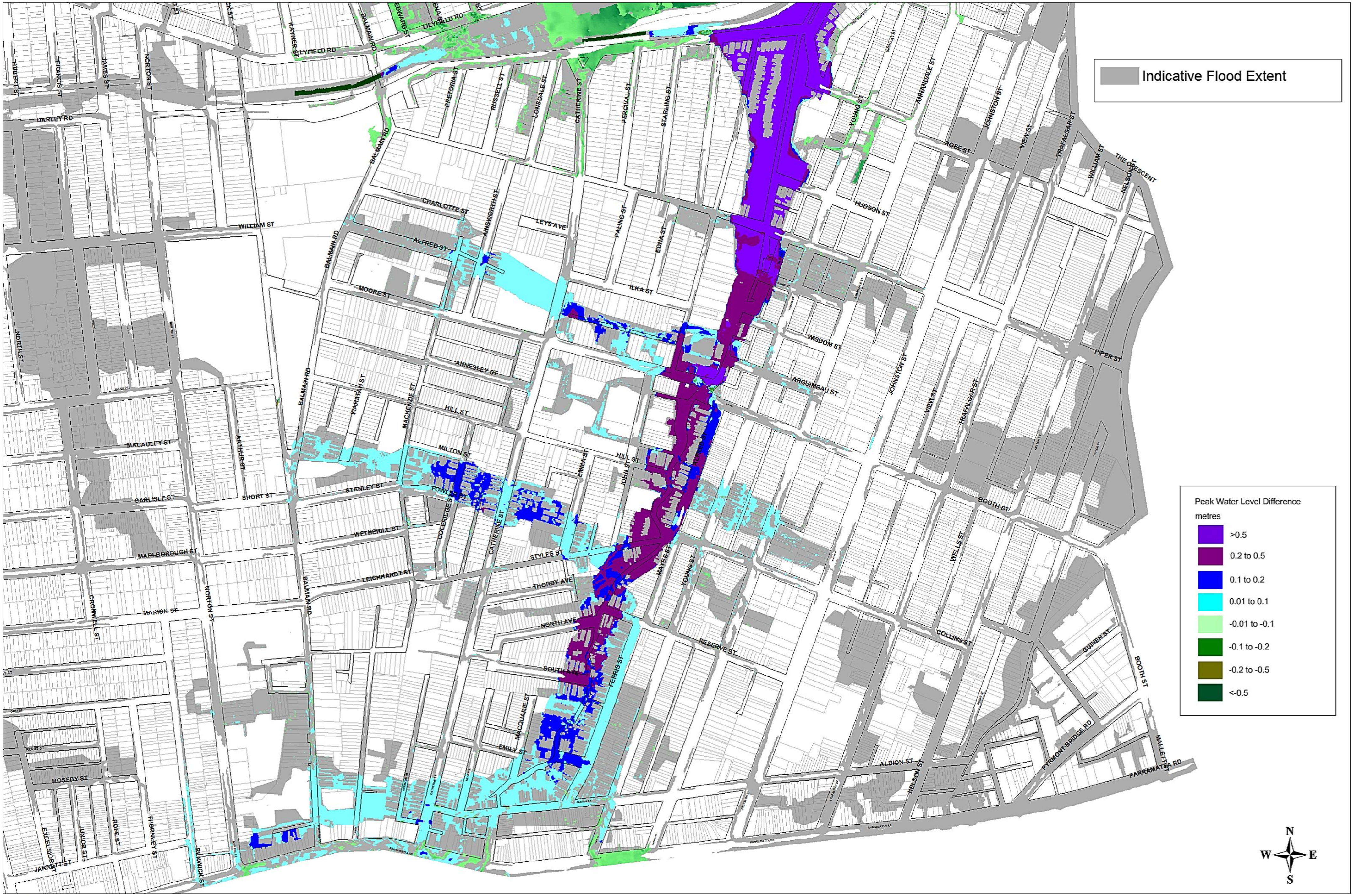

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Figure 2-6 - PMF WLDifference
2016 Less 2014 results
Whites Creek

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Figure 2-7 - 5yr ARI WLDifference
2016 Less 2014 results
Whites Bay

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Figure 2-8 - 100yr ARI WLDifference
2016 Less 2014 results
Whites Bay

Figure 2-9 - PMF WLDifference
2016 Less 2014 results
Whites Bay

Figure 2-10 - 5yr ARI WLDifference
2016 Less 2014 results
Mort Bay

Figure 2-11 - 100yr ARI WLDifference
2016 Less 2014 results
Mort Bay

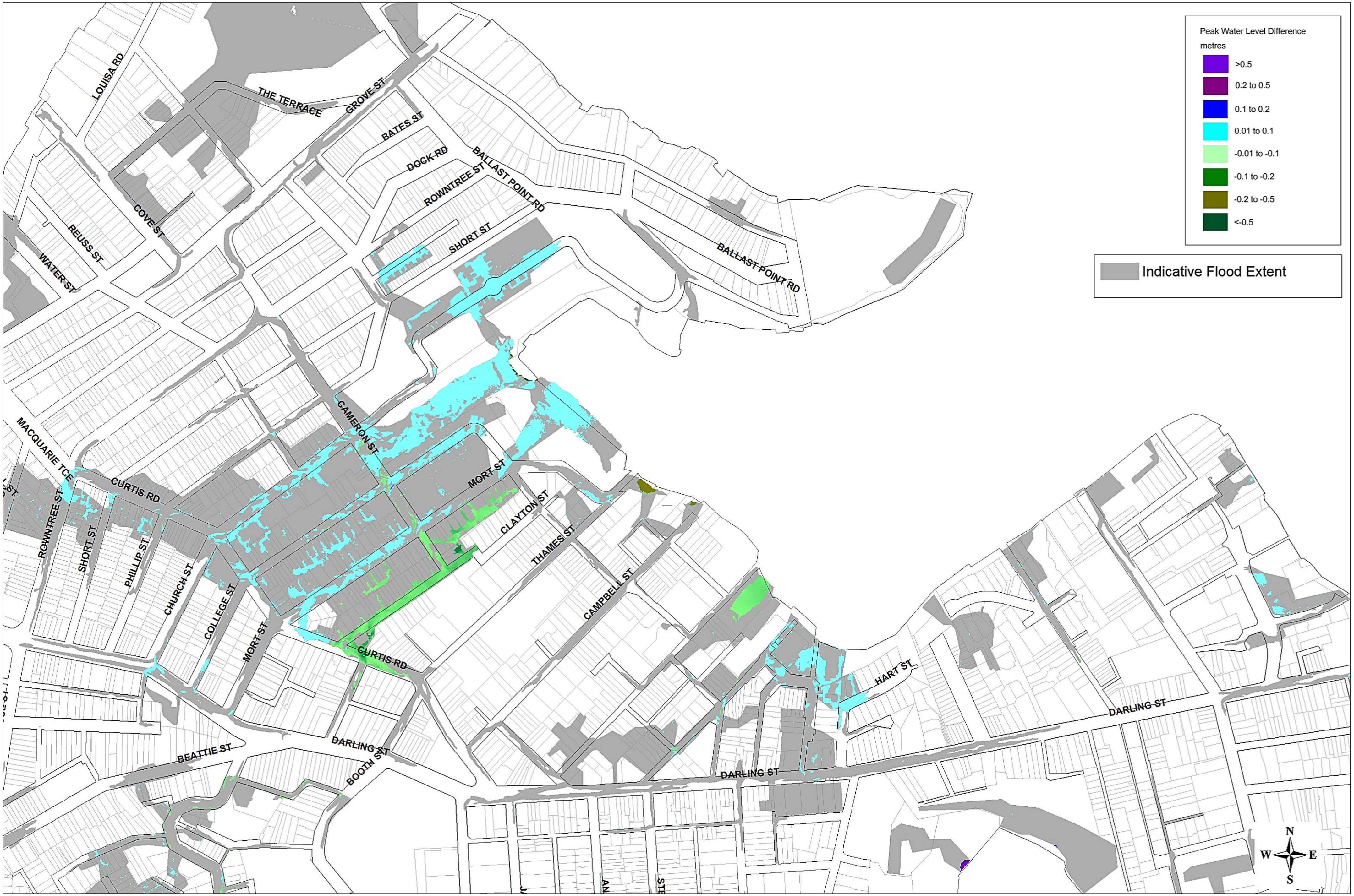

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Figure 2-12 - PMF WLDifference
2016 Less 2014 results
Mort Bay

APPENDIX A
REVISED FLOOD STUDY FIGURES

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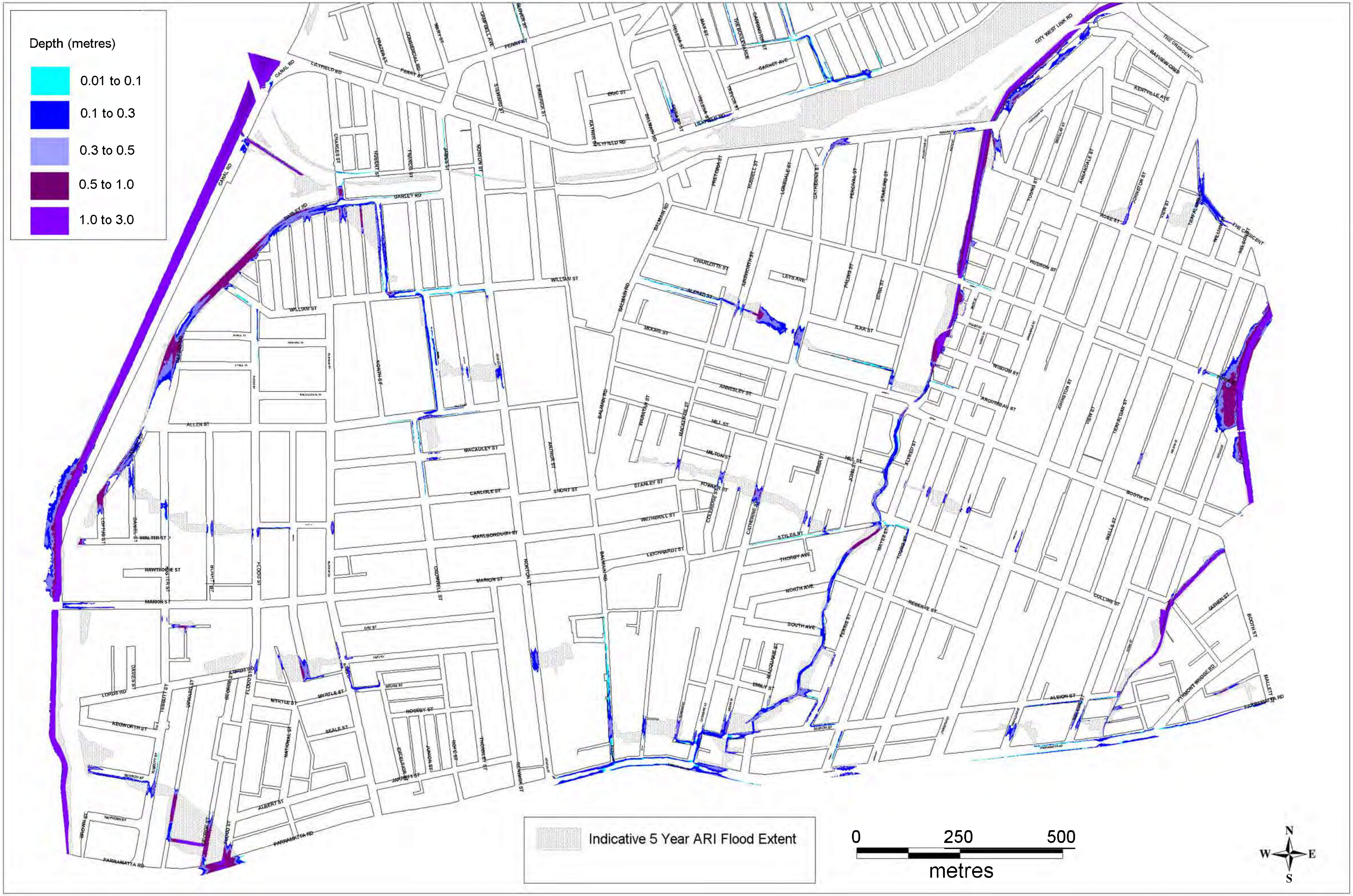

Figure 8.1- 5yr ARI Peak Depth
Sheet1

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Figure 8.1- 5yr ARI Peak Depth
Sheet2

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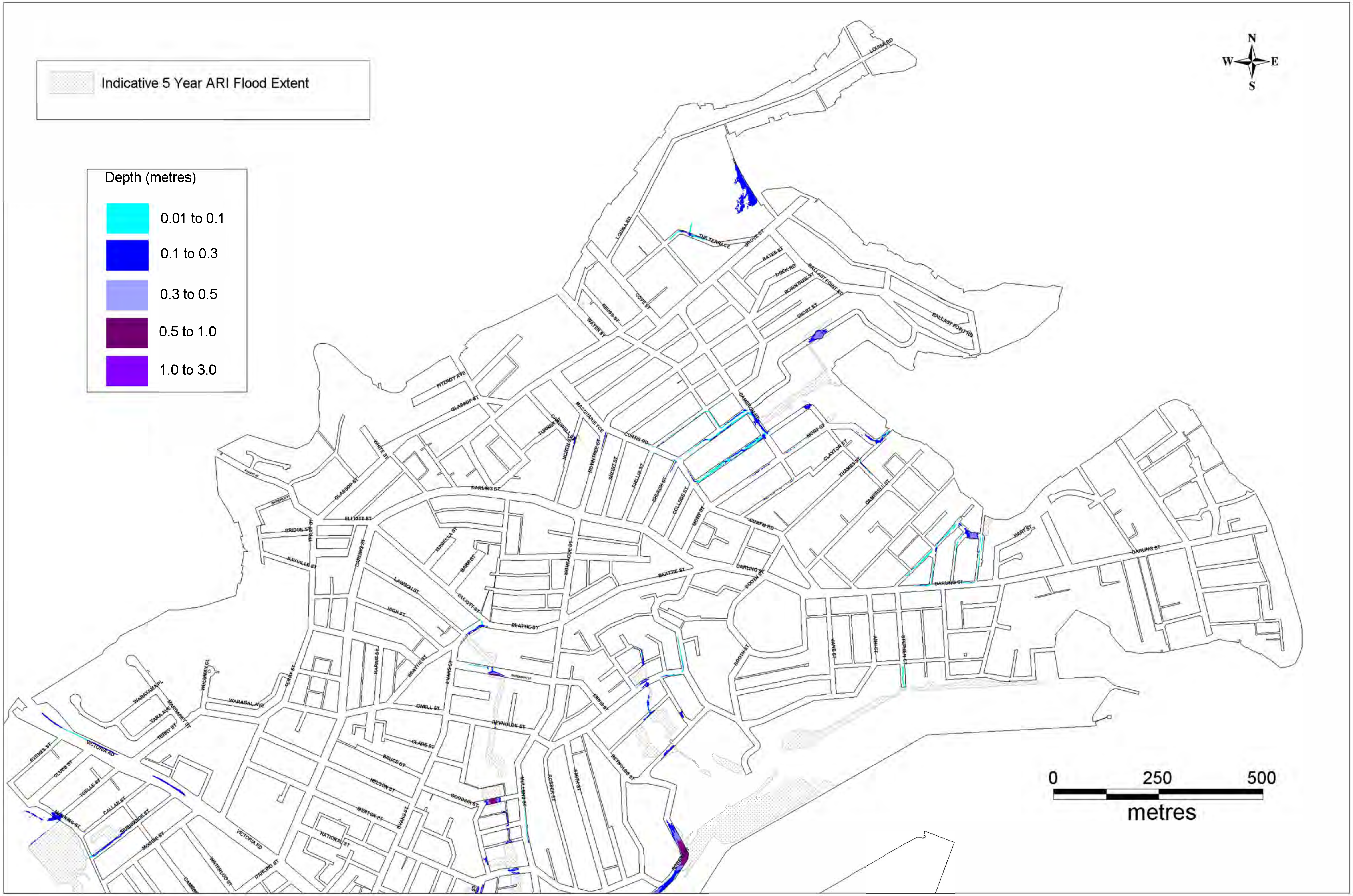

Figure 8.1 - 5yr ARI Peak Depth
Sheet3

Figure 8.2- 100yr ARI Peak Depth
Sheet1

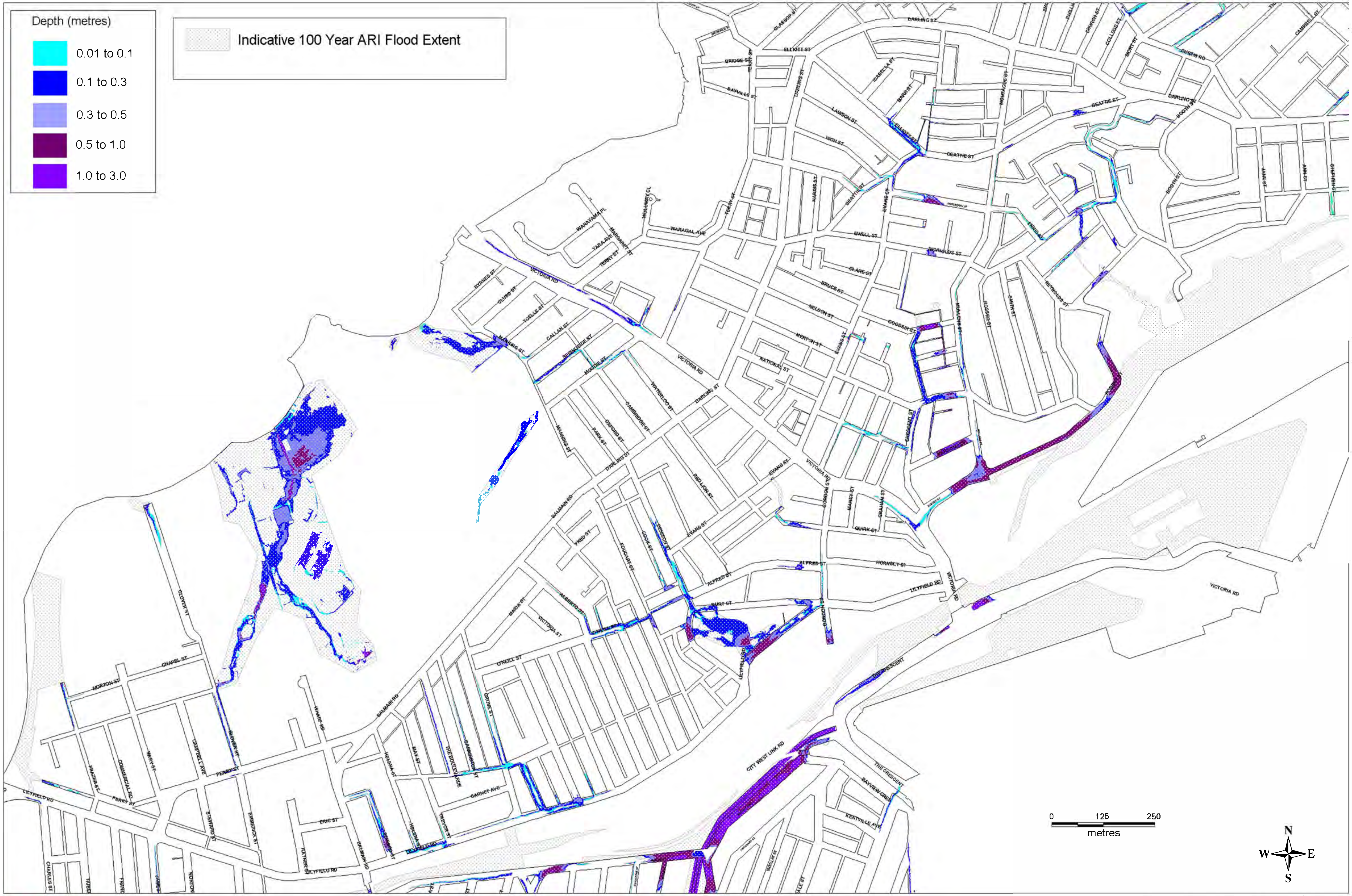

Figure 8.2- 100yr ARI Peak Depth
Sheet2

Figure 8.2 - 100yr ARI Peak Depth
Sheet3

Figure 8.3- PMF Peak Depth
Sheet1

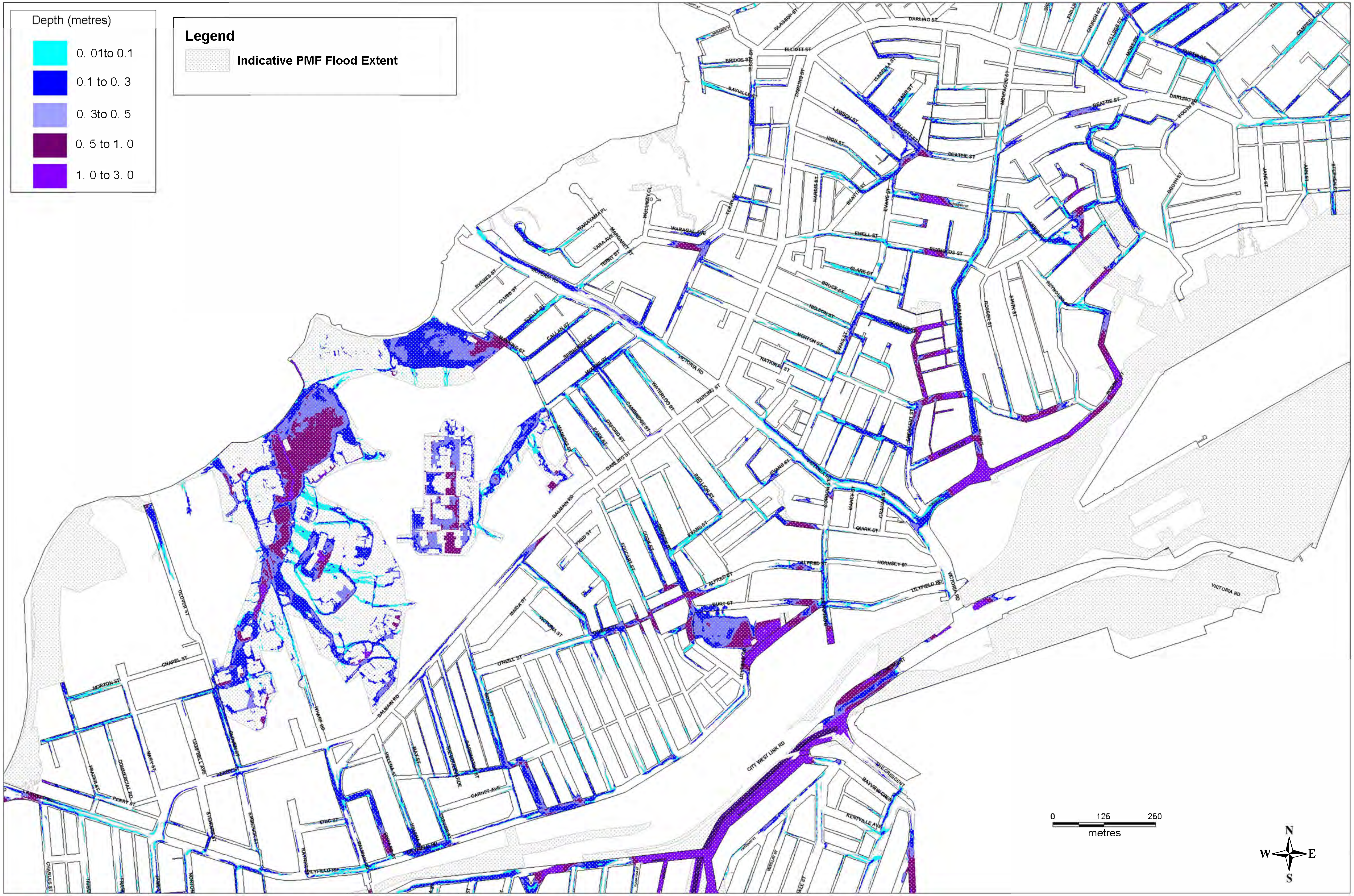

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Figure 8.3- PMF Peak Depth
Sheet2

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Figure 8.3 - PMF Peak Depth
Sheet3

Figure 8.4- 5yr ARI Peak Velocity
Sheet1

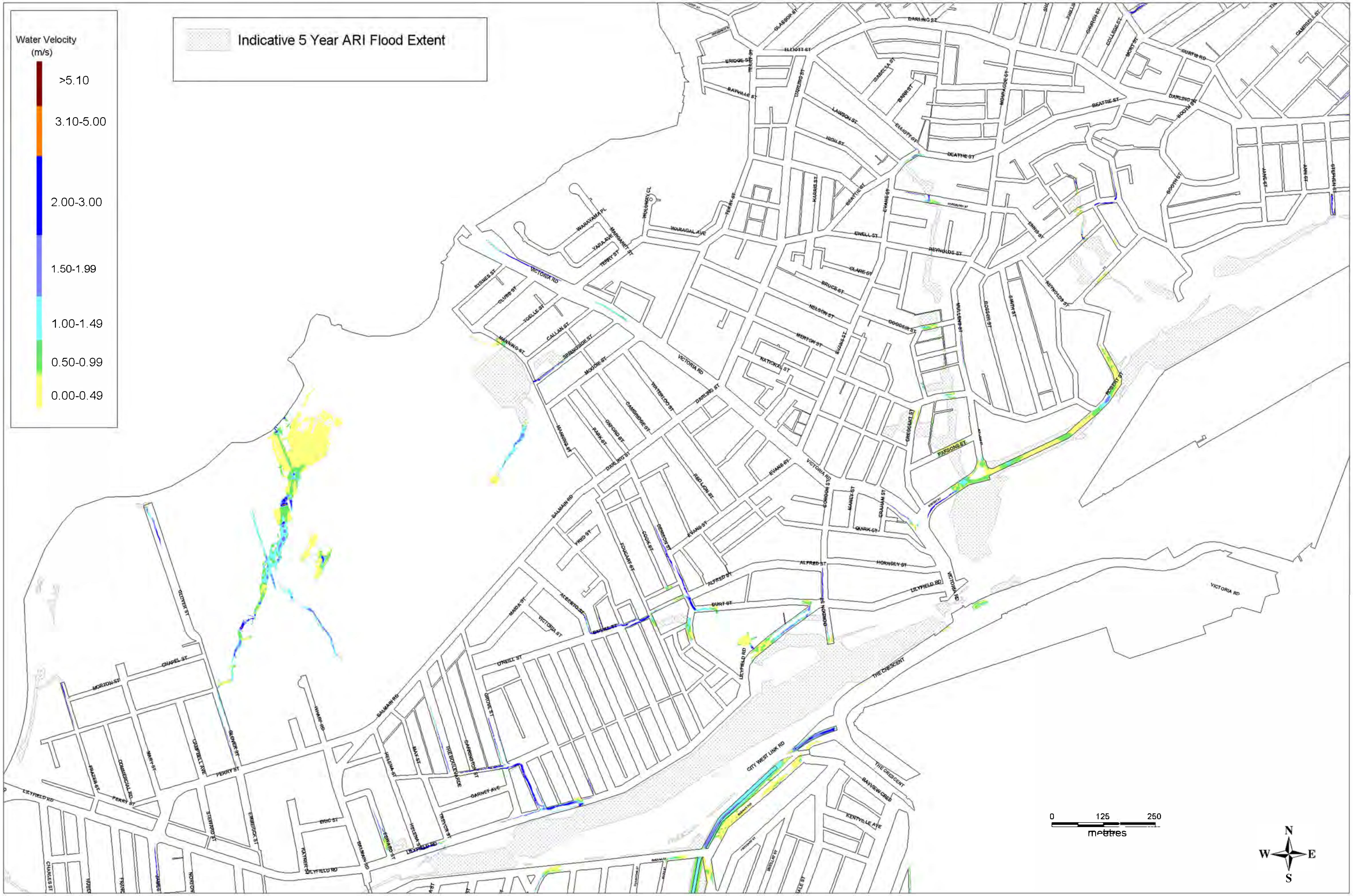

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Figure 8.4- 5yr ARI Peak Velocity
Sheet2

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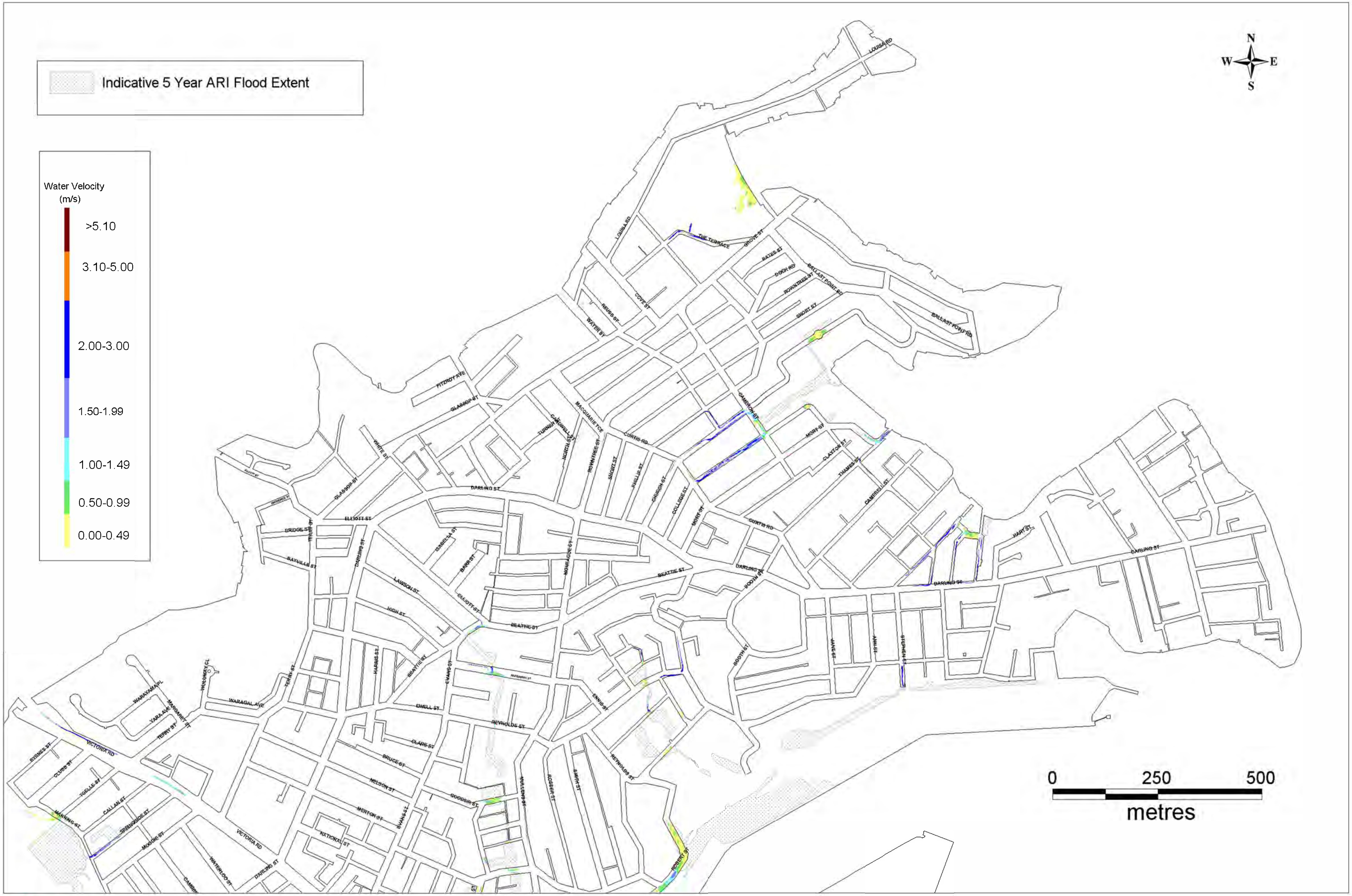

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Figure 8.4 - 5yr ARI Peak Velocity
Sheet3

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Figure 8.5- 100yr ARI Peak Velocity
Sheet1

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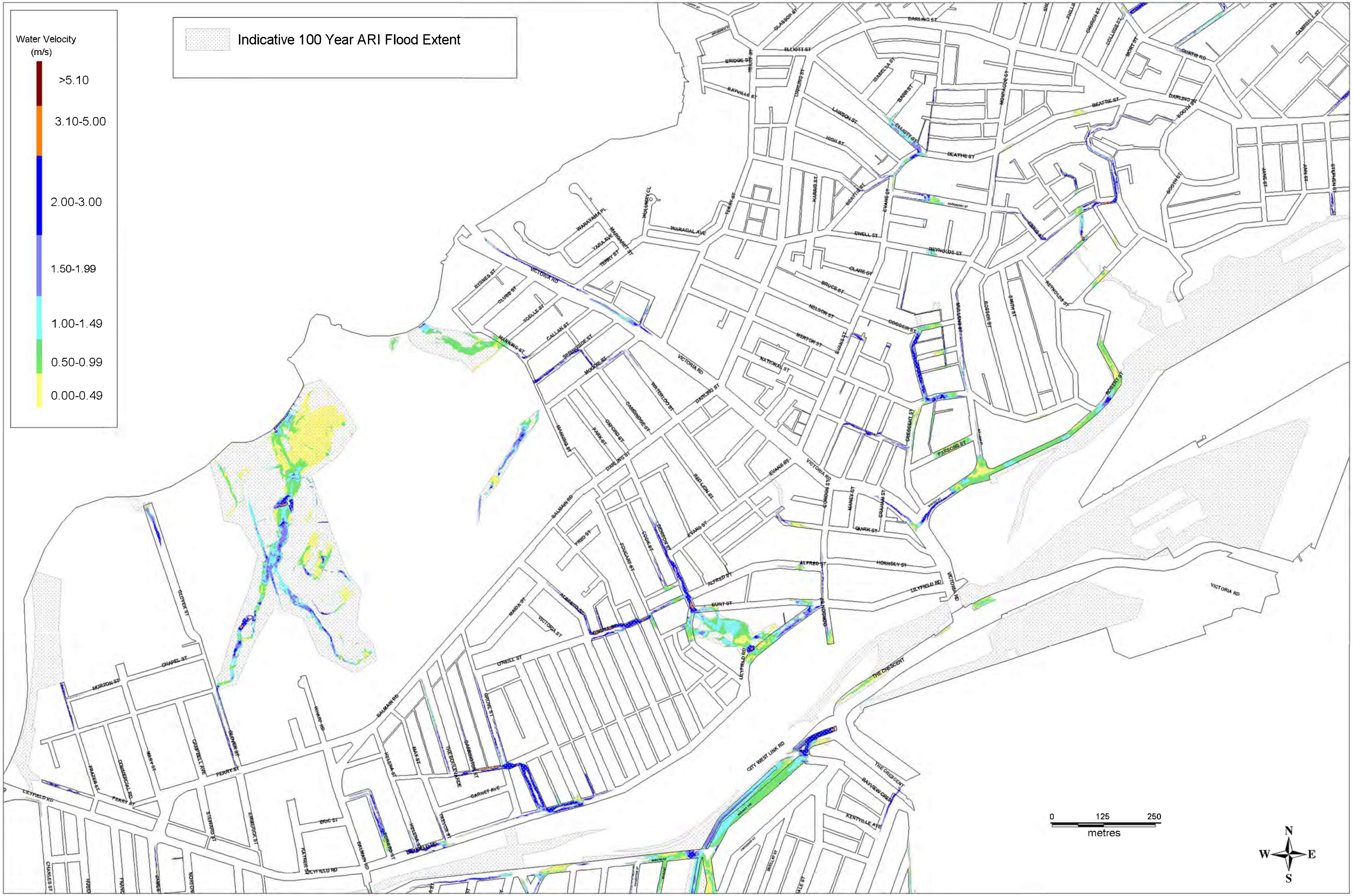

Figure 8.5- 100yr ARI Peak Velocity
Sheet2

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Figure 8.5 - 100yr ARI Peak Velocity
Sheet3

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Figure 8.6- PMF Peak Velocity
Sheet1

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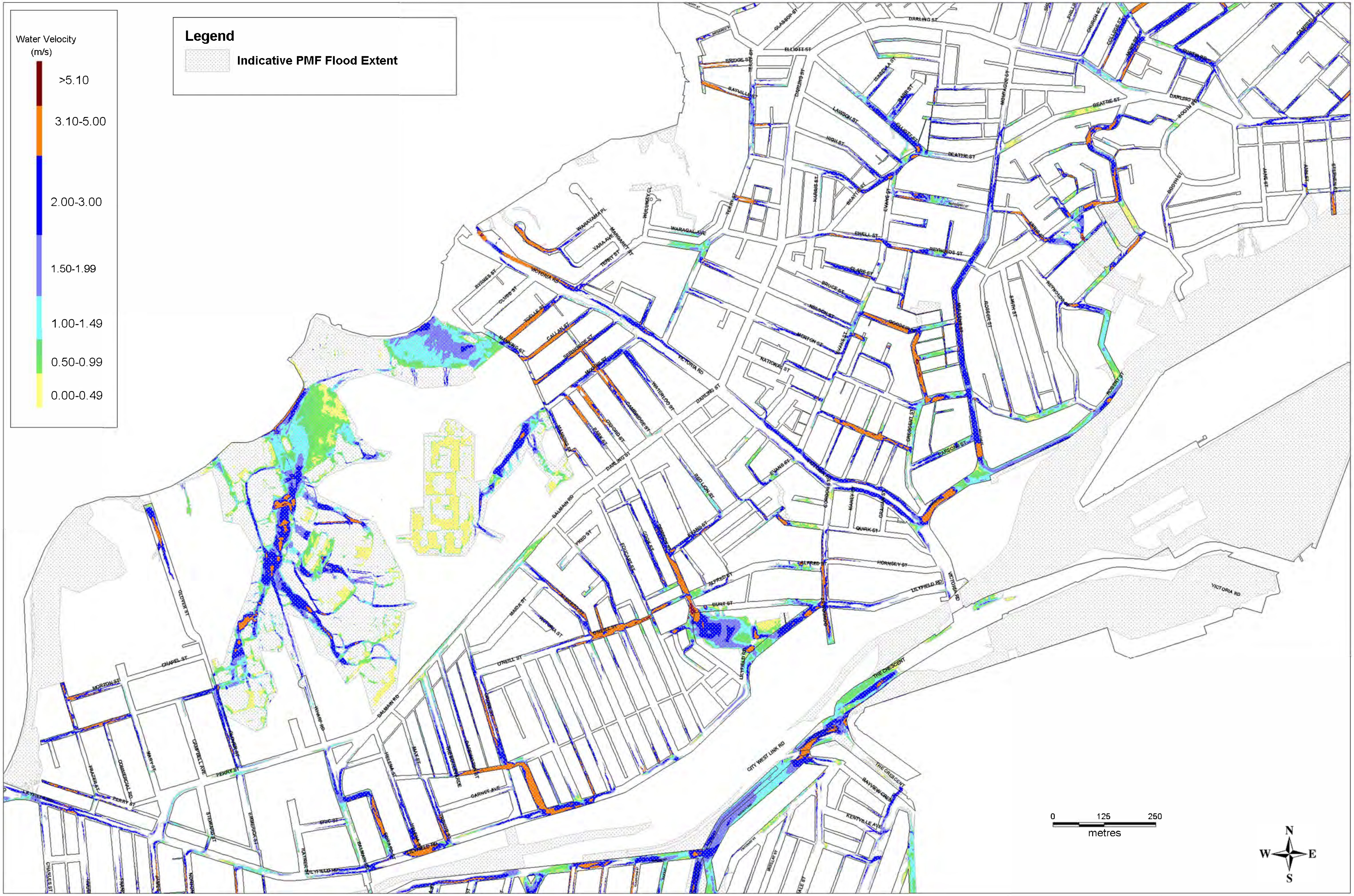

Figure 8.6- PMF Peak Velocity
Sheet2

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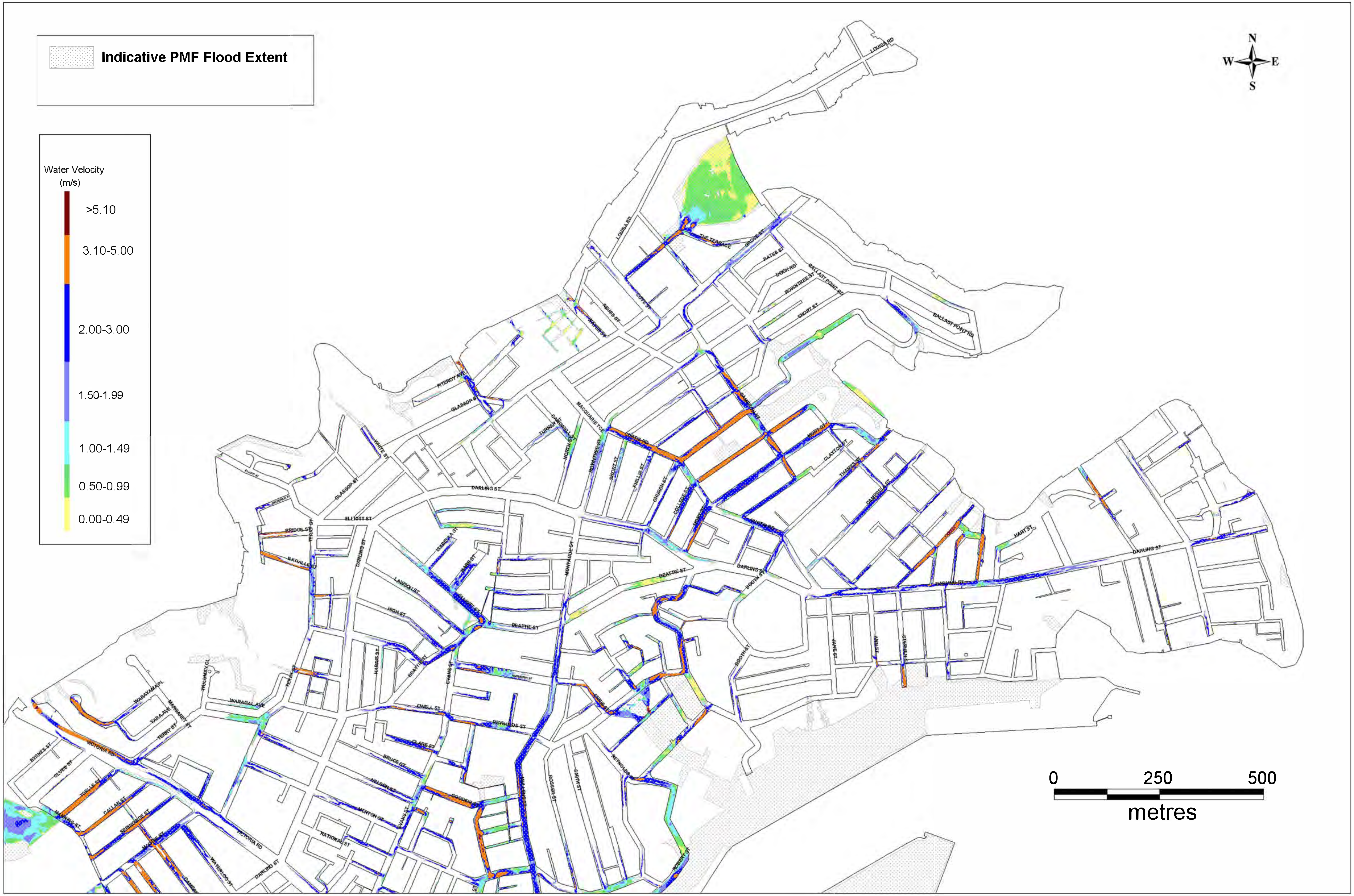

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Figure 8.6 - PMF Peak Velocity
Sheet3

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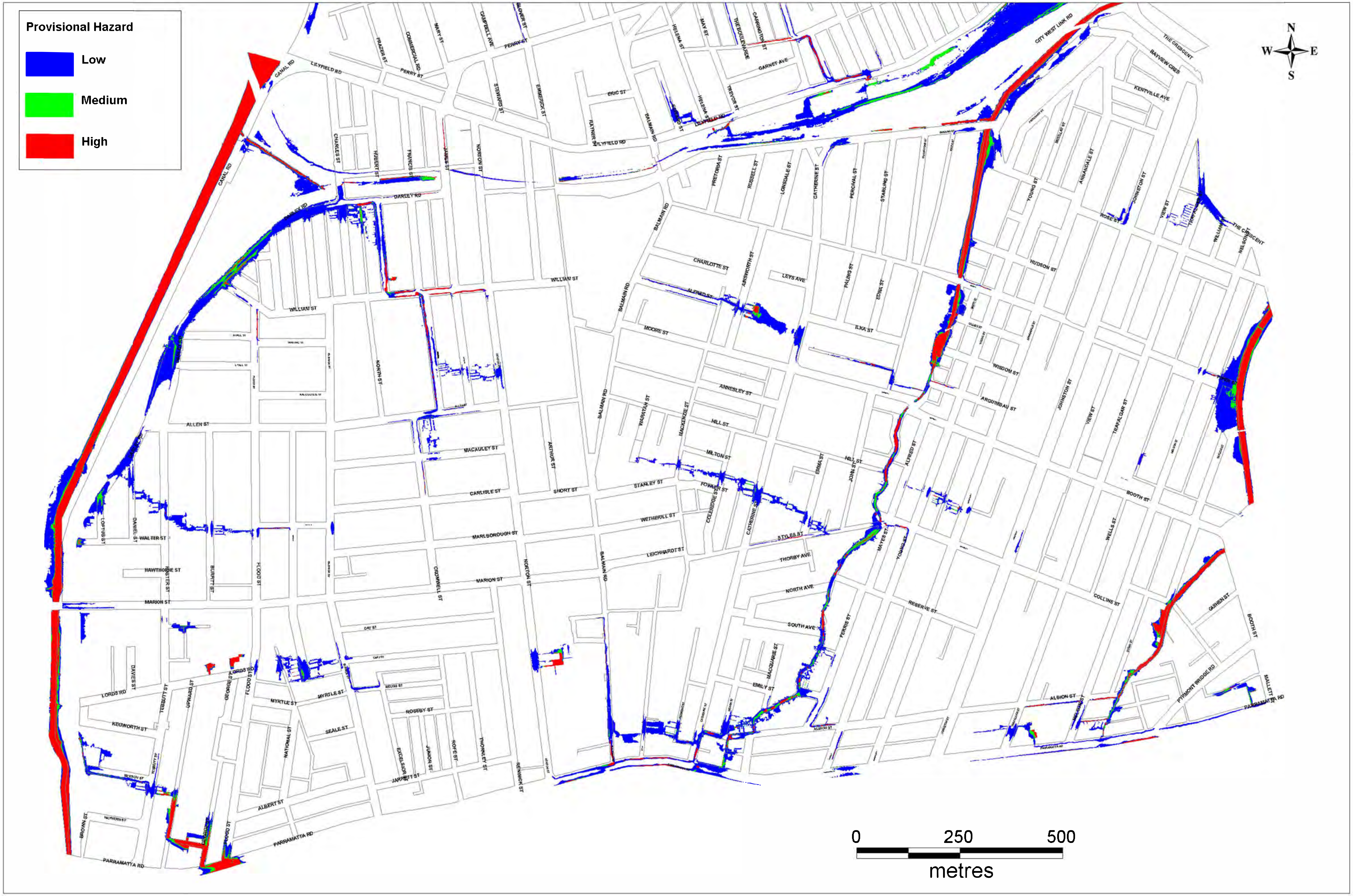

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Figure 9.1 - 5yr ARI - Hazard
Sheet1

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Figure 9.1 - 5yr ARI - Hazard
Sheet2

Figure 9.1 - 5yr ARI - Hazard
Sheet3

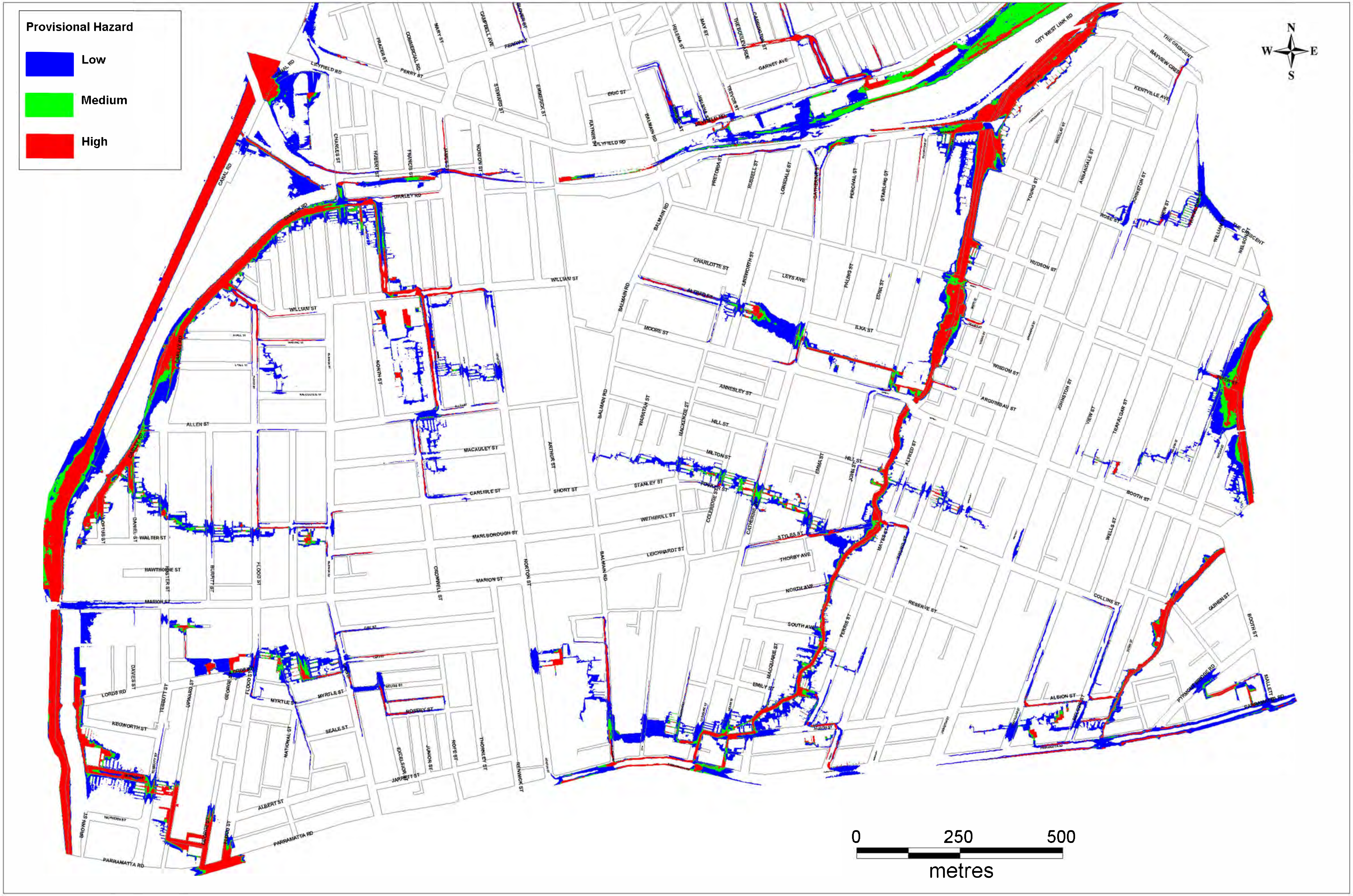

Figure 9.2 - 100yr ARI - Hazard
Sheet1

Figure 9.2 - 100yr ARI - Hazard
Sheet2

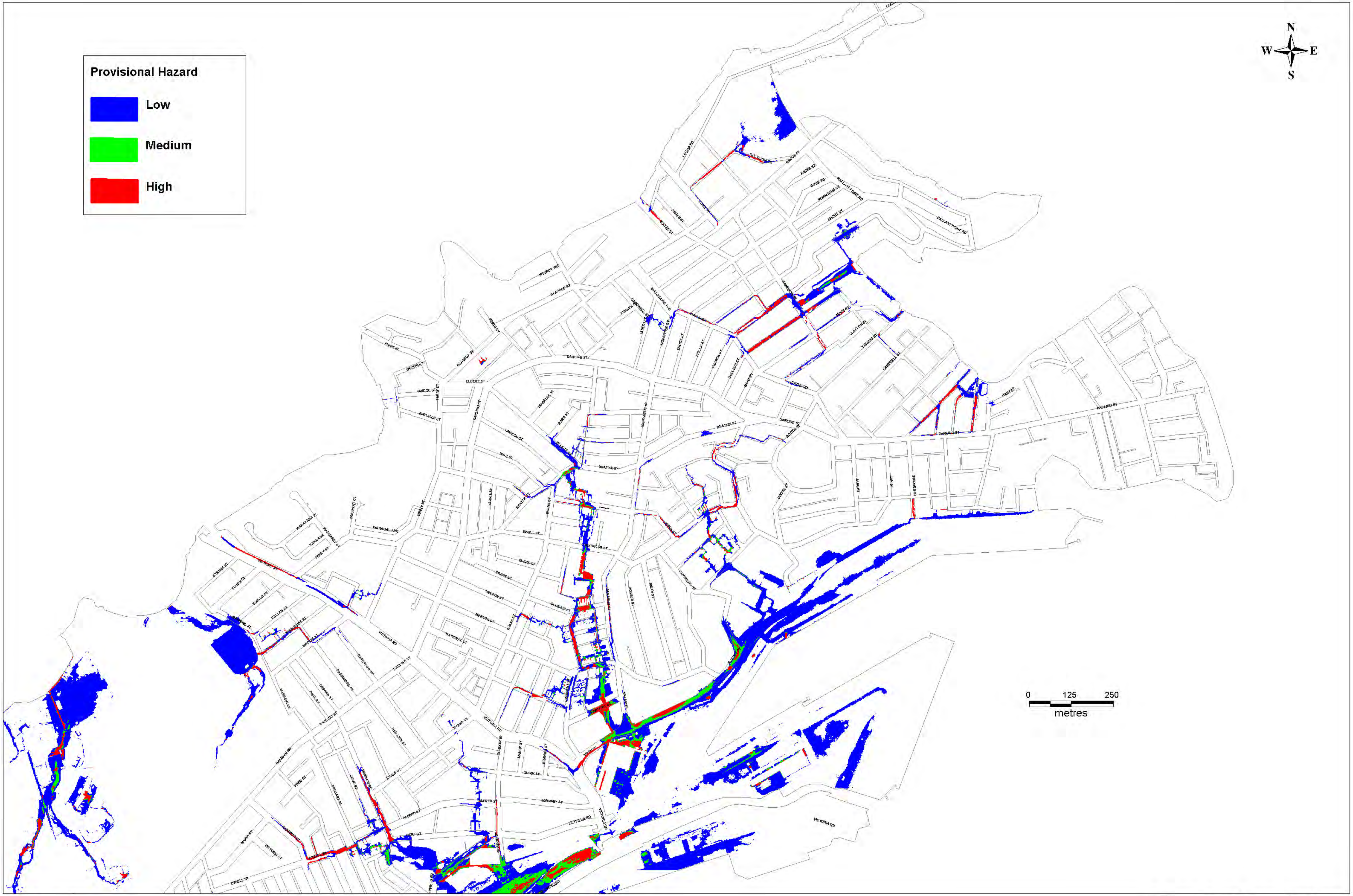

Figure 9.2 - 100yr ARI - Hazard
Sheet3

Figure 9.3 - PMF - Hazard
Sheet1

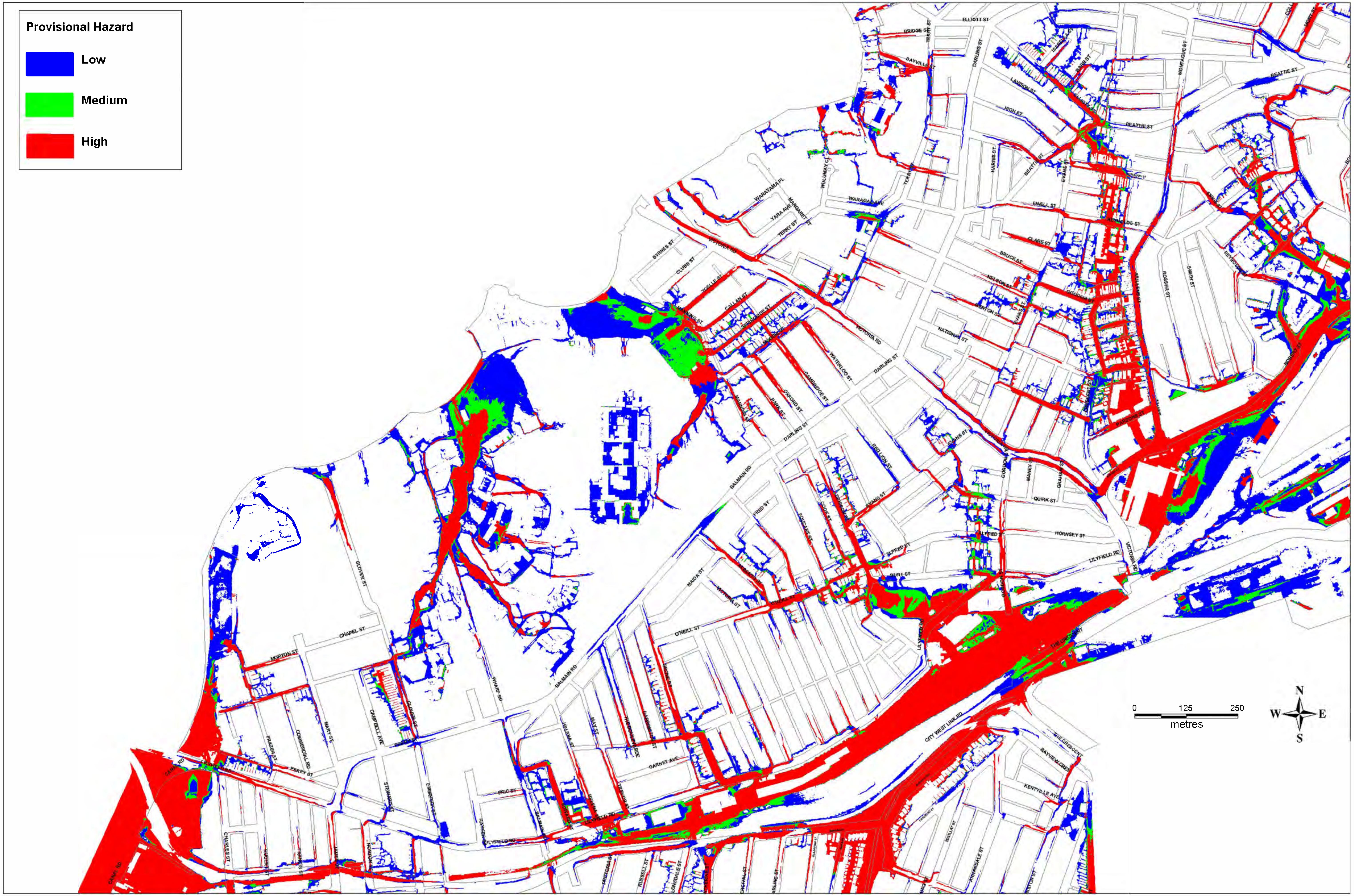

Figure 9.3 - PMF - Hazard
Sheet2

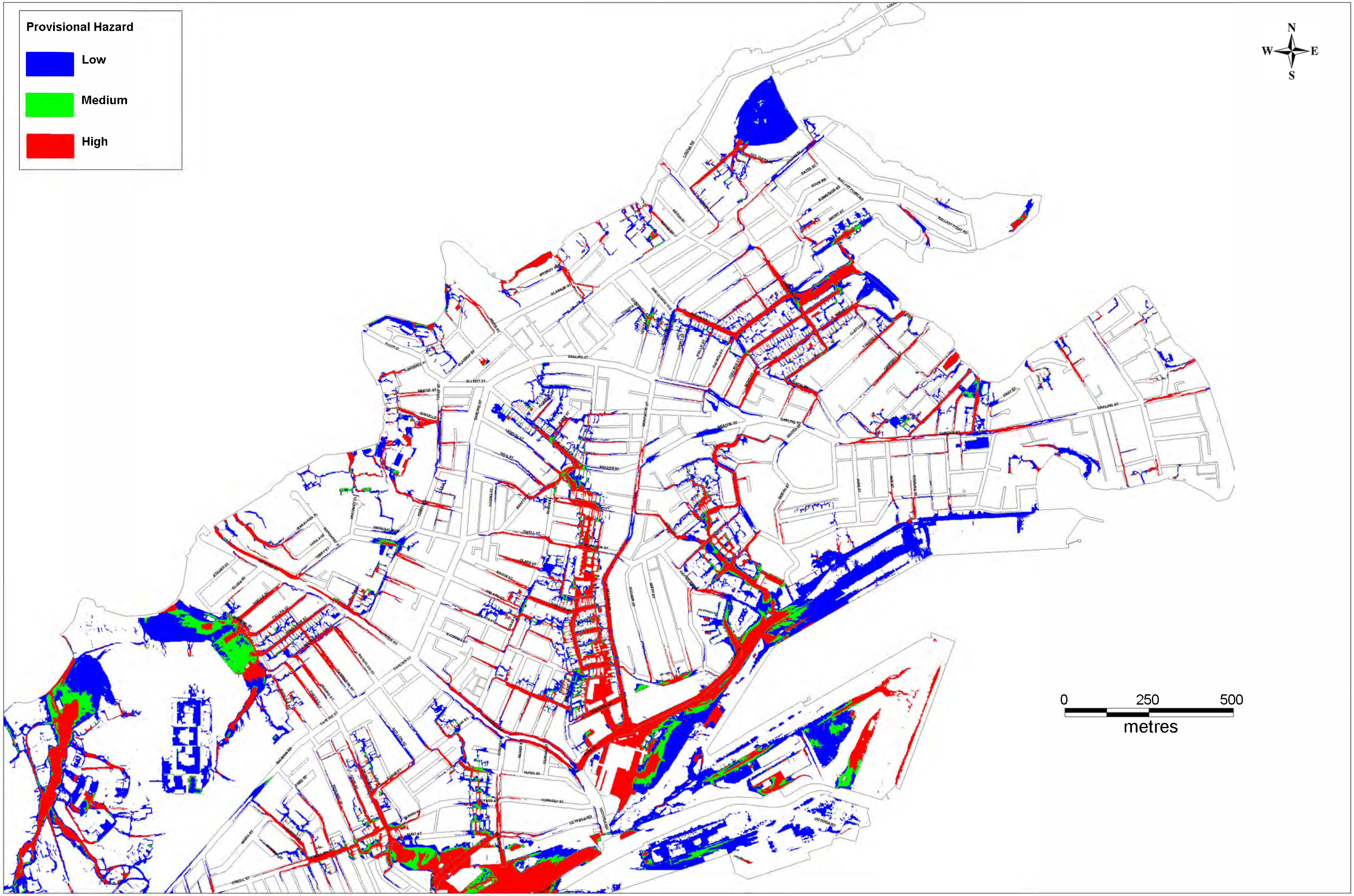

Figure 9.3 - PMF - Hazard
Sheet3

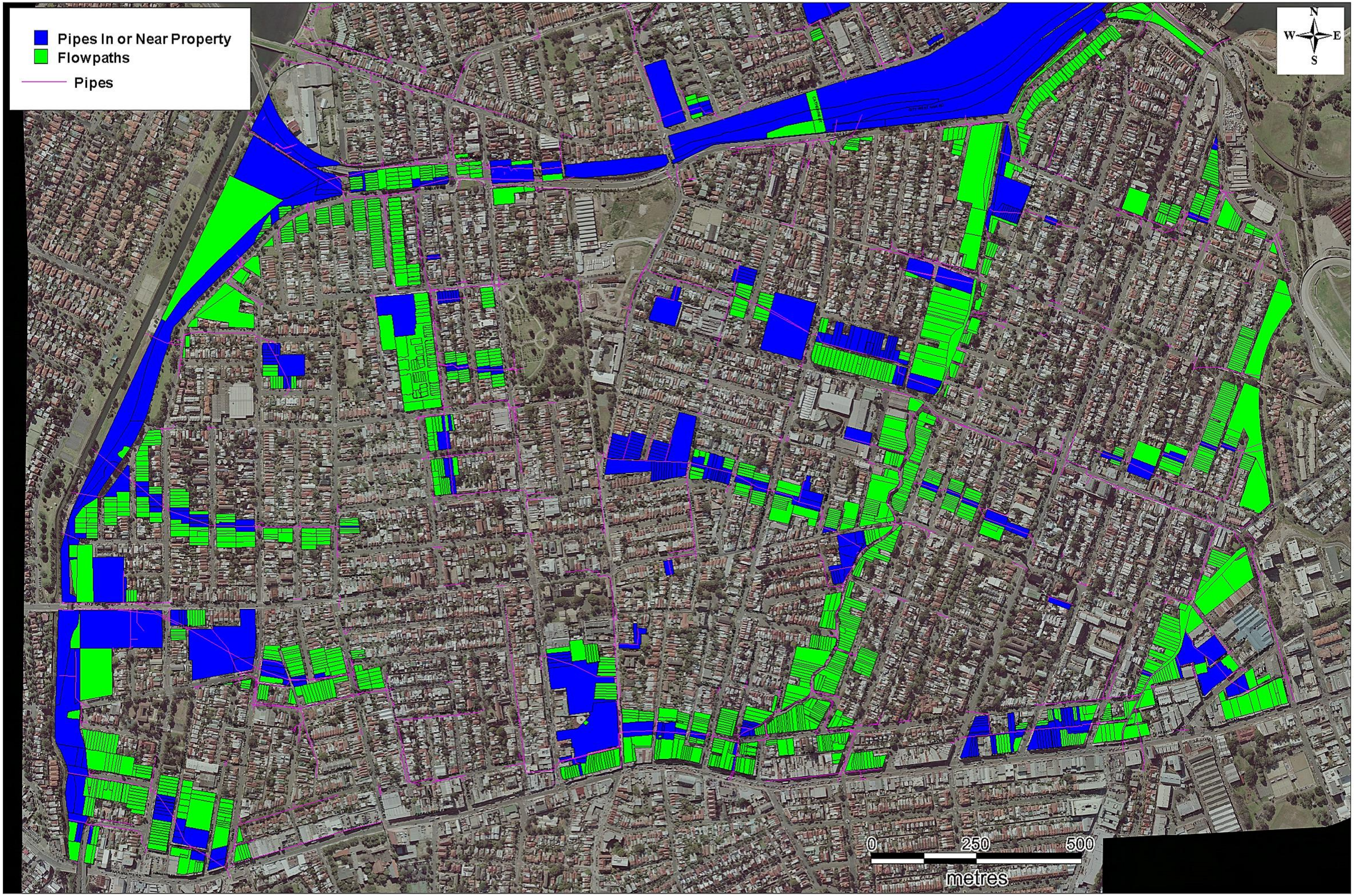

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Figure 12.1 - Flood Control Lots
Sheet 1

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Pipes In or Near Property
Flowpaths
Pipes
N
W
E
S
0
125
250
metres

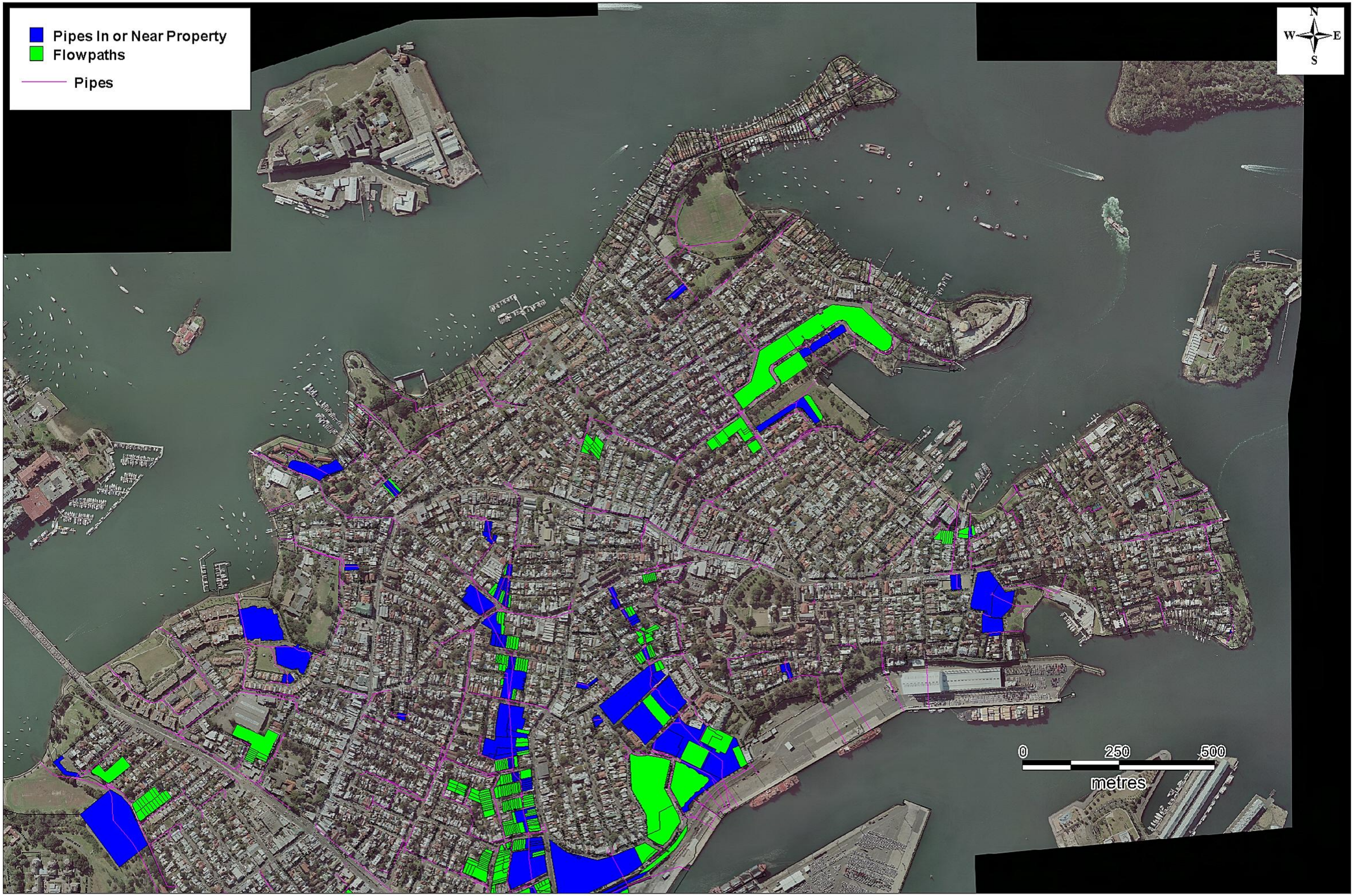

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Figure 12.3 - Flood Control Lots
Sheet 3

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Figure 12.4 - Foreshore Mapping
Sheet 2

Figure 12.5 - Foreshore Mapping
Sheet 3

Leichhardt Floodplain Risk Management Study and Plan

APPENDIX B
ENVIRONMENTAL AND SOCIAL CHARACTERISTICS

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1 Introduction

Floodplain management can impose a variety of social and environmental costs on flood affected communities and areas. For example the relocation or disruption of a community, the clearing of vegetation or reshaping of a waterway to improve hydraulic efficiency and lower flood levels or the construction of levees can all have various social and environmental implications. Further, the implementation of risk management measures may disadvantage some groups of the community, but advantage others. In some cases, floodplain management can be used to enhance environmental or social aspects of a community. For example creek rehabilitation in conjunction with improved hydraulic efficiency.

In order to objectively compare issues and management measures, it is necessary to gather a variety of social and environmental data. The following discussion provides the details of the base line assessment undertaken to inform the floodplain management option identification and assessment process.

The following data has been collected:

- Demographic, ethnic and socio-economic data.
- Topography, geology and soils.
- Flora and Fauna.
- Aboriginal and Non-Aboriginal Heritage.

2 Social Assessment

The demographic characteristics of the study area presented in this report includes the suburbs of Annandale, Balmain, Balmain East, Birchgrove, Leichhardt, Lilyfield and Rozelle. Population data was sourced primarily from the Australian Bureau of Statistics (ABS) 2011 Census. The data was then aggregated to produce an overall summary for the region of interest.

In summary, the data revealed that:

- The median age of people in the study area is 37 years as of 2011 census, which is a similar figure to Australia's median age. In fact almost 40% of people living in the study area are within 25-44 age group, only 4% are above 75 year age and children under 14 year age comprise 16.8%. This results is a community which may be primarily able-bodied, able to evacuate effectively and/or assist with evacuation procedures.
- In the study area, 79.4% of people only speak English at home. The most common languages spoken at home other than English include Italian 3.0%, Greek 1.4%, Spanish 1.0%, Cantonese 0.8% and Mandarin 0.7%. Flood information provided to the community should consider the range of languages spoken.
- The median weekly personal income for people aged 15 years and over in the study area was $1,086 as of 2011 Census, compared to the NSW average of $561. This trend of well above average income for the region compared to the NSW average was also evident for family and household incomes. This may have implications for the economic damages incurred on property contents during a flood event.
- When the social assessment was undertaken in 2013, the median house price in the study area was $805,000, and the median unit price was $612,500. In NSW, the median house price was $440,000, and median unit price was $445,000 (APM, 2012). This information has implications for the economic damages incurred during a flood event.

An overview of the demographic data is provided in **Tables 2.1 to 2.4**.

Table 2.1 Age Structure of the Study Area (the former Leichhardt LGA) (ABS, 2011)

Age Group (Years)	Persons in the study area	% of total persons in the study area	% of total persons in NSW
0-4 years	4,299	8.34	6.6
5-14 years	4,486	8.70	12.6
15-19 years	1,642	3.18	6.4
20-24 years	2,592	5.03	6.5
25-34 years	9,801	19.01	13.6
35-44 years	10,988	21.31	14.1
45-54 years	7,109	13.79	13.8
55-64 years	5,893	11.43	11.7
65-74	3,111	6.03	7.8
75-84	1,645	3.19	4.9
85 years and over	631	1.22	2
Total	51,566		

Table 2.2 Languages Spoken at Home in the Study Area (former Leichhardt) LGA (ABS, 2011)

Languages Spoken at Home	Persons in the study area	%of total persons in the study area	% of total persons in NSW
English Only	41,457	79.4	72.5
Greek	729	1.4	1.3
Italian	1,586	3	1.2
Spanish	534	1.0	0.8
Cantonese	431	0.8	2
Mandarin	377	0.7	2
Total	52,197		

Table 2.3 Average Median Income in the Study Area (former Leichhardt LGA) (ABS, 2011)

Income (For Population Aged 15 Years and Over)	Study Area ($)	New South Wales ($)
Average Median Individual Income (weekly)	1,086	561
Average Median Family Income (weekly)	2,738	1,477
Average Median Household Income (weekly)	2,234	1,237

Table 2.4 Median House and Unit Prices within the Study Area (former Leichhardt LGA) (realestate.com.au, 2013)

Suburb	Median House Price ($)	Median Unit Price ($)
Annandale	950,000	542,500
Balmain	1,047,500	730,000
Balmain East	1,600,000	590,000
Birchgrove	1,182,500	661,500
Leichhardt	815,000	612,500
Lilyfield	910,000	527,500
Rozelle	947,000	667,000

3 Environmental Issues

3.1 Topography, Geology and Soils

3.1.1 Topography

The study area partly lies over the Cumberland Plain region, a relatively flat region which lies to the south and west of Sydney Harbour. The topography of the study area reflects rolling hills intersected by shallow valleys through which waterways including Hawthorne Canal, Whites Creek and Johnsons Creek flow.

3.1.2 Geology

When developing floodplain management options it is important to understand the geology of the study area to ensure appropriate locations for management options are selected and to assist with the planning of suitable foundations and other constructions to cope with the geology present.

The study area is comprised of the shale and sandstone layers of The Wianamatta Group and Hawkesbury Sandstone. The Wianamatta Group directly overlies the older (but still Triassic in age) Hawkesbury sandstone.

The Wianamatta Group comprises siltstones, interbedded siltstones and fine-grained sandstone, and fine grained lithic sandstone. Weathering of the shale units produces a rich clayey soil, often with poor drainage. These clay soils are recognised as being reactive with appreciable Shrink-Swell Capacity. Low lying areas where groundwater is close to the surface are also susceptible to dryland salinity. Groundwater quality can range from fresh to highly saline, with the deeper groundwater generally less saline.

Hawkesbury Sandstone is a fine to medium and course grained quartz sandstone with some interbeds of laminated siltstone and very fine sandstones. It is a conspicuous rock unit in the Sydney region. It has occurred as exposures in sea-cliff and quarries took place throughout the suburban areas of Sydney. Hawkesbury sandstone is generally some 200 metres thick, with shale lenses and fossil riverbeds dotted throughout it. Hawkesbury Sandstone is considered a safer bedrock than the (less stable and laminated) Wianamatta Group for building construction

3.1.3 Soil Landscapes

According to the Soil Landscape Map of Sydney (Scale 1:100,000), the study area occurs within the Birrong (bg), Blacktown (bt), Gymea (gy), and Hawkesbury (ha) soil landscape groups.

The Birrong soil landscape group is dominated by silt and clay sized alluvial materials derived from the Wianamatta Group. Deep yellow podzolic soils and yellow solodic soils occur on older alluvial (terraces); deep solodic soils and yellow solonetzic soils occur on the current floodplain.

The Blacktown soil landscape group has been formed by residual geomorphic processes. It usually occurs on gently undulating rises over Wianamatta Group shales. The ground slopes are usually less than 5% and the vegetation typically comprises partly cleared eucalypt, woodlands and tall open forests. The soils depths range from shallow to moderately deep (less than 1m thick) and are hard setting mottled textured clay soils. The soils are typically moderately reactive with highly plastic subsoil, have a low soil fertility and poor soil drainage.

The Gymea soil landscape is present on broad, convex ridge-tops on Hawkesbury Sandstone with little outcropping rock (less than 25%). Slopes are mostly 10-25%. The soils are yellow earths and earthy sands and are shallow stony, moderately acidic and highly permeable, with very low nutrient levels. The soil is subject to high erosion risk when exposed.

The Hawkesbury soil landscape occurs on Hawkesbury Sandstone where slopes are mostly greater than 25%. It consists of narrow ridges, deep, narrow valleys, and steep slopes with a characteristic sequence of benches and rocky scarps, like a staircase. The deeper soils are earthy sands, yellow earths and some yellow podzolic soils. The shallow, discontinuous soils associated with the extensive rock outcrops are lithosols and siliceous sands. Localised yellow and red podzolic soils occur on shale lenses, and siliceous sands and secondary yellow earths occur along drainage lines.

3.1.4 Acid Sulfate Soils

Along the NSW coast, Acid Sulfate Soils (ASS) are widespread in estuarine flood plains and coastal lowlands. ASS distribution is diverse and includes urban areas, farmlands, mangrove tidal flats, salt marshes and tea-tree swamps These types of soils contain iron sulfides (actual ASS), and soils that can potentially become acid producing are known as Potential Acid Sulfate Soils (PASS).

Acid Sulfate Soils (ASS) occur when soils containing iron sulfides are exposed to air and the sulfides oxidise producing sulphuric acid (DECC, 2008). This usually occurs when soils are disturbed through excavation of drainage works. The production of sulfuric acid results in numerous environmental problems. It is therefore important to be aware of the distribution of ASS within the study area, so that potential management options are developed and assessed in a manner that is sensitive to the problem of ASS (potential and actual acid sulfate soils).

The Parramatta River, which surrounds much of the study area, and Hawthorne Canal have a high probability of ASS, within 1m of the ground surface (severe environmental risk if ASS materials are disturbed by activities such as shallow drainage, excavation or clearing). If high risk materials were to be disturbed there may be a severe environmental risk and any structure would need to be designed to ensure integrity of the structure against acid sulfate soils. Soil investigations would be necessary to assess these areas for acid sulfate potential should any flood management actions be proposed in these locations.

3.1.5 Contaminated Land and Licensed Discharges

Contaminated land refers to any land which contains a substance at such concentrations as to present a risk of harm to human or environmental health, as defined in the Contaminated Land Management Act 1997. The Office of Environment and Heritage (OEH) is authorised to regulate contaminated land sites and maintains a record of written notices issued by the Environment Protection Authority (EPA) in relation to the investigation or remediation of site contamination. A search of the OEH Contaminated Land Record on 11 February 2013 showed 7 known contaminated sites within the study area as shown in **Table 3.1**. Flood modification works within the study area should consider the impacts that may be caused due to these contaminated sites and further investigation may be necessary.

Table 3.1 Items listed on the OEH Contaminated Land Record (OEH, 2013)

Suburb/City	Site Description and address	Activity that caused contamination
Annandale	Mobil Service State, 198 Parramatta Road	Service Station
Annandale	Shell Coles Express Service Station, 124-126 Johnston Street	Service Station
Leichhardt	7 Darley Road	Other Industry
Leichhardt	Bus Depot (Area E), Cnr Balmain Rd and City West Link	Other Industry
Leichhardt	SRA Land, 10-11 Balmain Road	Other Industry
Rozelle	BP Service Station, cnr Darling Street and Thornton Street	Service Station
Rozelle	Caltex Service Stations, 121 Victoria Rd	Service Station
Rozelle	Kennards Rozelle, 15-39 Wellington street	Other Petroleum
Rozelle	Mobil Service Station, 178-180 Victoria Road	Service Station
Rozelle	White Bay Power Station, Robert Street	Other Industry

A search of the PoEO licensed premises public register on 25 January 2013 identified three licensed premises within the LGA as shown in **Table 3.2**.

Table 3.2 Items listed on the PoEO Licensed Premises Register (OEH, 2013)

Suburb/City	Organisation name and address	Location	Type of License
Leichhardt	APPAREL FITTINGS AUSTRALASIA PTY LTD C/- STAR DEAN-WILLCOCKS	67 John Street	POEO licence no longer in force; S 58 Licence Variation issued on 08 Feb 2005
Leichhardt	STATE TRANSIT AUTHORITY OF NSW	Corner William & Derbyshire Streets	POEO licence no longer in force; S 58 Licence Variation issued on 05 Jul 2004
Leichhardt	SYDNEY SOUTH WEST AREA HEALTH SERVICE	Corner Glover & Church Streets	POEO licence no longer in force; S 58 Licence Variation issued on 25 Jul 2002 and 21 Sep 2005

Any flood modification works within Leichhardt suburb should both consider the protection of these facilities from flood damages and the compatibility of the flood works with the operations of the facilities.

3.2 Flora and Fauna

Due to the highly urbanised nature of the study area, most of the original native vegetation has been cleared and modified and no substantial natural areas remain. Many of the plant and animal species that used to occur in this area are no longer present.

A search of the NPWS Atlas of Wildlife database (OEH, 2012a) on 12 February 2013 for threatened flora species recorded since 1980 showed no known threatened flora species with a 10km by 10km search area surrounding the study area.

A search of the NPWS Atlas of Wildlife database (OEH, 2012a) on 12 February 2013 for threatened fauna species recorded since 1980 showed no known threatened fauna species with a 10km by 10km search area surrounding the study area.

A search of the Environment Protection and Biodiversity Conservation (EPBC) Protected Matters database identified 33 threatened species known to occur within the study area. The results of this search can be found in main report. There is very limited habitat for threatened species in the study area, and the Grey-headed Flying-fox is the only listed threatened species that is seen regularly around Iron Cove. A range of visiting shore birds has also been seen wading and feeding on Iron Cove's mudflats.

Any proposed flood modification options or flood protection works should consider the number and type of species the modification may affect.

3.3 Heritage

3.3.1 Aboriginal Heritage

The study area was once the area inhabited by the Wangal band of the Dharug (Eora) language group. Wangal country was known as wanne and it originally extended from the suburbs of Balmain and Birchgrove in the east to Silverwater and Auburn in the west. The northern boundary was the Parramatta River. Neighbouring Darug bands were the Cadigal to the east, the Wallumattagal on the northern shore of the Parramatta River and the Bediagal to the south.

A preliminary investigation of indigenous heritage was undertaken by searching the Aboriginal Heritage Information Management System (AHIMS) (2012b) in January 2013 for known or potential indigenous archaeological or cultural heritage sites within the study area. The relevant AHIMS search results are presented in **Table 3.3**. This information is useful in the development and feasibility assessment of floodplain management options. However, a more detailed heritage assessment should be undertaken prior to implementation of any management actions to ensure that any proposed flood mitigation works will not impact heritage items or places.

Table 3.3 Items Identified under the NPWS Aboriginal Heritage Information Management System for the Study Area (OEH, 2012b)

Site ID	Site Name	Site Type
45-6-2278	Lilyfield Cave	Shelter with midden
45-6-0283	Rozelle Hospital 1	Shelter with midden
45-6-1900	White Horse Pt.	Midden
45-6-0618	Rozelle Hospital 2, Rozelle Hospital 1	Midden
45-6-1481	Rozelle Hospital 3	Midden
45-6-1971	Rozelle Hospital 5, Rozelle Hospital 3	Shelter with midden
45-6-1972	Rozelle Hospital 4	Shelter with midden
45-6-2676	Johnstons Creek	Art (pigment or engraved), artefact
45-6-1809	Birchgrove	Midden, Shelter with Art

The following qualifications apply to an AHIMS search:

- AHIMS only includes information on Aboriginal objects and Aboriginal places that have been provided to OEH;
- Large areas of New South Wales have not been the subject of systematic survey or recording of Aboriginal history. These areas may contain Aboriginal objects and other heritage values which are not recorded on AHIMS;
- Recordings are provided from a variety of sources and may be variable in their accuracy. When an AHIMS search identifies Aboriginal objects in or near the area it is recommended that the exact location of the Aboriginal object be determined by re-location on the ground; and
- The criteria used to search AHIMS are derived from the information provided by the client and OEH assumes that this information is accurate.

Middens that are composed predominantly of shells are essentially the remains of shellfish meals eaten on the spot by Aboriginal people over a long period of time. Fish and shellfish were the main foods of Aboriginal people living around the harbour, with fishing being an important activity of daily life for both men and women.

The middens that can be found in the study area are dated at approximately 4, 500 years old, and are recognised as significant by the Metropolitan Local Aboriginal Land Council and archaeologists. A series of interpretive signs can be found at these sites recognising the traditional owners of the study area.

All Aboriginal sites are protected under the National Parks and Wildlife Act 1974 and therefore any management considerations that impact upon Aboriginal sites must include this in their design. Known Aboriginal sites should be left undisturbed if possible, however if a management option requires their destruction, an Aboriginal Heritage Impact Permit (AHIP) must be sought from OEH. Under the National Parks and Wildlife Act 1974 it is a requirement that any developments show “due diligence” with regard to Aboriginal heritage in the area

Land Rights and Native Title Claims

Land rights and Native Title are two different forms in which traditional land owners can gain access to land or claim compensation for previous dispossession of their land.

Under the Aboriginal Land Rights Act 1983, local Aboriginal land councils can claim Crown lands provided the lands are vacant and not otherwise required for an essential public purpose. A search on the Land Claims

Register maintained by the Office of the Registrar, Aboriginal Land Rights Act 1983 (ORALRA), on 4 February 2013 found no Native Title claims in the study area.

3.3.2 Non-Aboriginal Heritage

There are three different types of statutory heritage listings of Non-Aboriginal origin; local, state and national heritage items. A property, item or place is a heritage item if it falls into a listings category. The category an item falls into depends on whether it is considered to be significant to the nation, state or a local area. The significance of an item is a status determined by assessing its historical, scientific, cultural, social, archaeological, architectural, natural or aesthetic value.

A desktop review of Non-Aboriginal heritage was undertaken for the study area. Searches were undertaken on a number of databases to determine the cultural heritage within this area. Databases searched include:

- Australian Heritage Database (incorporates World Heritage List; National Heritage List; Commonwealth Heritage List);
- NSW Heritage Office – State Heritage Register; and
- Leichhardt Local Environment Plan (LEP) 2000 Heritage Listings.

Table 3.4 contains 21 items that are found within the study area which have been listed by the Heritage Council under the NSW Heritage Act. This includes listing on the state heritage register, an interim heritage order or protected under Section 136 of the NSW Heritage Act. This information has been provided by the NSW Heritage Branch. No items were found to be included on the World Heritage List, Commonwealth Heritage List, or National Heritage List.

The Leichhardt LEP 2000 lists 669 heritage items of significance that are found within the study area under Schedule 2 of the LEP. There are also numerous heritage conservation areas with the study area. Part 3, Clause 16 of the Leichhardt LEP 2000 outlines the provisions which must be followed in relation to heritage items and Part 3, Clause 16 (8) outlines the provisions which must be followed in relation to conservation areas within the study area.

Table 3.4 Items listed under the NSW Heritage Act (OEH, 2012c)

Item name	Address	Suburb
Balmain Hospital - Main Building	Booth Street	Balmain
Callan Park Conservation Area & Buildings	Balmain Road	Lilyfield
Callan Park House - Rozelle Hospital	Balmain Road	Lilyfield
Dawn Fraser Swimming Pool	Glassop Street	Balmain
Ewenton	6 Ewenton Street	Balmain
Fenwick & Co Boat Store	2-8 Weston Street	Balmain
Goodman's Buildings	2-12 Johnston Street	Annandale
Hampton Villa	12B Grafton Street	Balmain
Hunter Baillie Memorial Presbyterian Church	Johnston Street	Annandale
Johnston's Creek Sewer Aqueduct	Taylor Street (Off), Hogan Park	Annandale
Louisaville	2 Wells Street	Balmain
Mort's Dock	Thames, Mort, College, McKell, Cameron, Yeend Streets	Balmain

Item name	Address	Suburb
Railway electricity tunnel under Sydney Harbour		Birchgrove / Greenwich
Raywell	144 Louisa Road	Birchgrove
Rozelle Hospital - Broughton Hall	Balmain Road	Lilyfield
Sewage Pumping Station 27	Callan Park	Rozelle
Substation	182 Johnston Street	Annandale
Waterview Wharf Workshops	37 Nicholson Street	Balmain
White Bay Power Station	Victoria Road	Rozelle
White's Creek Aqueduct	Piper Street	Lilyfield
Wyoming	25 Wharf Road	Birchgrove

The information contained within this Appendix has been used in the development and feasibility assessment of Floodplain Management Options. However, due to the extensive heritage found with the study area, a detailed heritage assessment should be undertaken prior to detailed design or implementation of any management options, as there are development restrictions and procedures which need to be followed.

4 Conclusions

The study area is a highly urbanised environment resulting in some key urban related constraints to floodplain management. However, there are also several environmental constraints that need to be considered in the preparation of a Floodplain Risk Management Plan. The key environmental and social constraints identified in this assessment include:

- The high probability of Acid Sulfate Soils in the Parramatta River and Hawthorne Canal, which if disturbed could cause serious environmental risk;
- 7 known contaminated sites which may require further investigation;
- Potential for the grey-headed flying fox to be disturbed; and
- 9 Aboriginal sites listed under the National Parks and Wildlife Act 1974, 21 non-Aboriginal heritage sites found on the State Heritage Register and 669 heritage items of significance under the Leichhardt LEP.

5 References

ABS (2011) *2011 Census*. Australian Government.

APM (2012) Australian Property Monitors. [online] URL: http://apm.com.au/

OEH (2012a) *NPWS Atlas of NSW Wildlife*, NSW Government.

OEH (2012b) *Aboriginal Heritage Information Management System*, NSW Government.

OEH (2012c) *State Heritage Register*, NSW Government.

Leichhardt Floodplain Risk Management Study and Plan

APPENDIX C

ONSITE DETENTION ASSESSMENT

1 Introduction

On-site detention (OSD) is the temporary storage of site stormwater so as to restrict the discharge leaving the site to a predetermined rate. The purpose of OSD is to either ensure no worsening of downstream flooding issues as a result of a development or it can also be used to decrease flooding downstream.

Leichhardt Council has Requirements for OSD within the former Leichhardt Local Government Area (study area) are set out in the Leichhardt Development Control Plan DCP 2013. These requirements currently aim to reduce flooding within the study area by applying OSD to significant proposed developments.

A review has been undertaken as part of the Leichhardt Floodplain Risk Management Study to incorporate the findings of Leichhardt LGA Flood Study into Council's OSD Policy and to review Council's Policy against current best practice. Catchment based analysis has been undertaken to determine the effectiveness of the current OSD policies as a flood mitigation / management tool. The purpose of the assessment is to identify:

- Site storage requirements (SSR);
- Permissible site discharge (PSD);
- Appropriate on-site detention offsets using on-site retention (rainwater tanks);
- Appropriate requirements for properties drainage against grade to the street above; and
- An OSD calculation sheet (provided to Council separately).

2 Desktop Review of Current OSD Policies

2.1 Leichhardt Council OSD Policy

2.1.1 Current Guidelines

Leichhardt DCP 2013 requires that residential and non-residential developments incorporate OSD in accordance with Council's Stormwater Management Policy (outlined in the Draft Drainage Code, 1995).

On-site detention is required for the following development types:

- Single residential (except for cases where increased roof and paved areas is less than 40m2).
- Dual occupancy.
- Villa, flats, town houses etc.
- Commercial, industrial and institutional.
- Tennis courts,
- Some paving (depending on the details of the development).

Design Values and Calculation Methods

Hydraulic calculations are required to demonstrate the 100 Year Average Recurrence Interval (ARI) post development site run-off does not exceed the 5 year ARI pre-development site runoff.

Calculation methods considered acceptable for this demonstration are:

- Triangular Hydrographs.
- Swinburne.
- Time Area models such as Ilsax.
- Other methods may be accepted at the discretion of Council's Engineer.

Times of concentration are to be calculated using the kinematic wave equation from p300 of Australian Rainfall and Runoff (1987).

Other Design Requirements

Council's Draft Drainage Code (1995) outlines the following design requirements:

- The outflow control structure is to be designed to control variable outflow rate in accordance with the storage discharge relationship (calculated as above).
- All roof and paved areas are to drain through the storage.
- Storages are to be located separate from any external surface flow paths.
- Finished ground levels are to be constructed so that impervious area runoff, in excess of the pipe system capacity, drains to the storages.
- The maximum storage level is to be such that habitable floor levels are at least 0.3m above the maximum water level, and garages 0.15m above.
- An emergency overflow with flowpath is to be provided, and is to be free of obstructions such as fences.
- Maximum ponding depths for above ground storages are to be 0.15m in parking areas, 0.3m in landscaping and 1m in a fenced off area.
- Storage volumes in landscaping areas are to be doubled to allow for vegetation growth.
- Surface storage areas in strata or community title development are not be in privately controlled areas such as courtyards.
- Hydraulic control devices are to be constructed to be non-removable.
- Existing stormwater storages can be incorporated into the new design.

2.1.2 On-Site Retention

DCP 2013 allows for the volume of OSD to be reduced where on-site retention (OSR) facilities for rainwater reuse and/or stormwater reuse are proposed to service all toilets, laundries and outdoor usage. Where OSR is proposed in lieu of OSD, Council requires the offset to be calculated at a rate of 1m^3 from the OSD storage volume, for every 2.5m^3 of OSR storage provided (up to a maximum OSD offset of 10m^3).

2.1.3 Areas not Draining to OSD

Whilst Council's Policy requires "all roof and paved areas are to drain through the storage", it is acknowledged that this is not always possible. Council does not have a formal policy regarding properties which cannot completely or at all discharge to OSD (e.g. properties which discharge against the grade to the street and have no free discharge from the OSD orifice). However, it is understood that Council assesses application relating to properties of this type on a merits based approach. Council accepts that in many cases, new developments on the low side of the road will not be able to obtain easements, and consequently will need to drain against the grade to the street above. Council currently looks at the context of the nature and scale of the proposed development and its position within the catchment to determine an appropriate approach to OSD. Typically, an existing building that is to the replaced or renovated already has a portion of the front roof area that drains out to the street. In these cases, Council generally applies OSD on the principal of limiting the site discharge rate to at least the existing rate. Where no existing surfaces currently drain to the street, the criteria are often based on a typical area.

2.2 OSD Guidelines in Similar Governance Areas

The following OSD guidelines have been summarised for comparison and use in this review:

- Upper Parramatta River Catchment Trust;
- Auburn City Council (former); and
- Kogarah Council.

The relevant components of these guidelines have been summarised in the table below.

	Upper Parramatta River Trust	Auburn City Council (former)	Kogarah Council (former)
Source Document	On-site Stormwater Detention Handbook – Fourth Edition (Upper Parramatta River Catchment Trust, 2005)	Auburn Development Control Plan 2010 (Auburn City Council, 2012)	Water Management Policy: Site Drainage and Flood Management – Practice Note #1 (Kogarah Council, 2006)
Purpose of the Guidelines	To ensure that new developments and redevelopments do not increase peak stormwater flows in any downstream area during major storms up to and including 100 year ARI events. The secondary aims of the policy are to reduce post development peaks throughout the catchment in the 1.5 year ARI event to be as close to natural levels as practical and to encourage the integration of OSD with other water quality measures.	To ensure that through the OSD of stormwater, discharge is controlled thereby ensuring the development does not increase the risk of downstream flooding of roads and properties, or erosion of unstable waterways. Sufficient storage is provided to ensure peak flow rates at any point within the downstream drainage system do not increase as a result of the development during all storm events up to the 100 year ARI.	To ensure that a development does not increase the risk of flooding on downstream properties.
Development to which OSD Applies	OSD requirements generally apply to all types of development and redevelopment on both flood liable and flood-free sites. These include the following: • subdivisions (including residential) approved after 1991; • single dwellings on lots created by a subdivision approved after 1991, unless a communal OSD system was constructed as part of the subdivision; • all commercial, industrial and special-use developments and buildings; • town houses, villas, home units, duplexes and dual occupancies; • semi-detached residential/commercial and residential/industrial properties; • buildings, car parks and other sealed areas of public sport and recreational facilities; • single dwellings, extensions and additions (In the Parramatta City Council area only where the proposed development involves an increase in impervious area greater than 150 m2 and the land is within a designated catchment area which drains to a location of a known drainage problem area); • sites that include WSUD and water re-use. • tennis courts; • roads, car parks, paths and other sealed areas; and • public buildings.	All development except those noted below.	All development except those noted below.
Development to which OSD does not apply	OSD policy does not apply to: • most development types on subdivisions and lots created prior to 1991. Exceptions apply; • dual occupancy residences on a lot with an existing residence involving less than 150 m2 of development area; • sub-divisions of existing dual occupancies where no changes to the buildings or site are proposed; • boundary adjustments and consolidations of allotments where no a additional lots are created; • one-off minor developments, minor additions and repairs where the proposed development area is less than 150 m2 (subsequent minor developments or additions shall require OSD). This exclusion is aimed principally at small areas within large commercial or industrial sites. It does not apply to any developments	OSD is not required where: • The proposal is a one-off extension up to: o 50m2 of impervious area for a single dwelling or an outbuilding; or o 150 m2 impervious area for industrial development. Note: Subsequent extensions require OSD facility. • The proposal is a single dwelling where the site coverage exceeds Section 2.2 Development Control D1 in the Dwellings and Dual Occupancies DCP; • The applicant can demonstrate to Council's satisfaction, the development is subject to mainstream flooding or is subjected to major overland flow. A flood report	OSD will not be required when: • The Water Management Policy only applies to the proposed development instead of the whole site. • The discharge from the property does not pass through any drainage structure before reaching the receiving bays. These drainage structures include any pipe, culvert, lined channel or other restrictive structure. • When the property is wholly within a flood-affected area. For properties which are partly flood affected by the 100 year design flood, the area of the floodway and the area of the site discharging to the floodway would be exempted from the provision of OSD. • The total coverage by impervious area is less than 50% of the site area. The impervious area for the site should include roofs, paving and driveways.

	Upper Parramatta River Trust	Auburn City Council (former)	Kogarah Council (former)
	where the development area includes more than 150 m2 of impervious surfaces nor to dual occupancies; • change of use where no physical changes to the outside of the property are proposed; • areas within large properties (usually commercial or industrial but may be residential) not covered by the development application or construction certificate; • new developments in subdivisions where OSD has already been provided for the entire subdivision; • buildings in Rural/Non-urban areas (Baulkham Hills Shire Council does require OSD for buildings in Rural/Non-urban areas. Contact Council's Subdivision Section to obtain the OSD requirements); • the grassed playing field and vegetated area of public sports and recreational facilities that are not part of a development.	prepared by a suitably qualified engineer is required in this case; or • The property falls within zones 6, 7 and 8.	• Single dwelling sites discharging to an absorption system, which is sized to cater to the 100 year ARI design storm.
Control Standards	• SRD_L = 40 L/s/ha • SRD_U = 150 L/s/ha • SSR = 455 m^3/ha (partitioned into extended detention (lower) and flood detention (upper) storages. Maximum SSR for the extended detention is 300 m^3/ha. • Minimum outlet size = 25mm • Maximum ponding depths above ground = 600 mm (allowable depth of ponding will be varied depending on the nature of the development and the location of the storage).	The SSR and PSD values vary across the catchments within the LGA as follows: PSD = • Zone 1: 80 L/s/ha • Zone 2: 100 L/s/ha • Zone 3: 130 L/s/ha • Zone 4: 150 L/s/ha • Zone 5: 130 L/s/ha SSR = • Zone 1: 530 m3/ha • Zone 2: 455 m3/ha • Zone 3: 370 m3/ha • Zone 4: 325 m3/ha • Zone 5: 370 m3/ha Minimum outlet size: Pipes or orifices with a diameter less than 150mm shall not be acceptable except where protected against blockages using a removable, rustproof screen or wire cage installed around the outlet.	The OSD system shall be designed in accordance with the storage discharge relationships presented in Figure 2.1 below that shows the Site Storage Requirements (SSR) and the Permissible Site Discharge (PSD) relevant to the site's impervious area. The relationships in Figure 2.1 were derived based on catchment investigation undertaken by Kogarah Council.
Rainwater Tank Offsets for OSD	Dedicated Airspace The following reductions in the SSR values may be allowed subject to Council approval: • 50% of the dedicated airspace can be credited against the SSRL; • 100% of the dedicated airspace can be credited against the SSRT; Subject to: • a maximum dedicated airspace credit no greater than the ratio of the area of roof discharging to the rainwater tank to the lot area times the overall site storage volume that is required;	No guidelines provided.	When a rainwater tank is used on the property and is connected to supply toilet flushing and laundry demands, 1/3 of the provided storage volume can be used to offset the required volume for OSD (i.e. SSR).

	Upper Parramatta River Trust	Auburn City Council (former)	Kogarah Council (former)
	• the rainwater tank has a dedicated outlet to ensure that the dedicated airspace is recovered after a storm event and the maintenance schedule specifically requires checking and cleaning of the outlet; • the PSD for the dedicated rainwater tank outlet is no greater than 40 L/s/ha; • all outflows from the rainwater tank (outflows from the dedicated outlet and overflows from the rainwater tank) are discharged to the OSD storage. Dynamic Airspace The reduced SSR values due to dynamic rainwater tank airspace is calculated using: • SSR_L = 300 - (1,950 x Dynamic Airspace (kL) 2.1 x Roof Area (m2) -1.5) • SSR_T = 455 - (1,650 x Dynamic Airspace (kL) 2.3 x Roof Area (m2) -1.5) Subject to: • the development being residential, or its water usage can be considered to approximate that of a residence; • the design is in accordance with Sydney water requirements (visit the Sydney Water website for the current requirements); and • all overflows from the rainwater tanks are directed to the OSD storage.		
Site Area not Draining to OSD	When it is not feasible to direct runoff from the entire site to the OSD system (pending Council's approval) up to 30% of the residual site area may be permitted to bypass the OSD systems. The storage volume is still calculated on the entire site area while the SRD is adjusted downwards.	A portion of the new impervious areas (excluding roof area) shall discharge directly to Council's system if it cannot be drained to the storage facility, provided that the PSD is reduced to compensate for the smaller catchment. No more than 15% of the total site area shall be permitted to bypass the basin. The modified PSD shall be selected from the figure in the OSD calculation sheet. The calculation of storage requirement shall be based on the area which bypasses the basin.	Where possible, the drainage system shall be designed to direct runoff from all the impervious area of the site to the OSD system. If this is not feasible, then up to 20% of the impervious area of the site can bypass the OSD system provided that all the roof runoff is directed to the OSD and the PSD is modified according to the procedure below. The modified SSR (m3/ha) is calculated as = SSR for the whole site / ((1 – X/ total site area) where X is the area of the site bypassing the detention facility. The new PSD is then calculated from Figure 2.1 against the modified SSR. The total provided OSD volume should not be less than that originally calculated for the whole site.
Calculation Methods	An On-Site Detention Calculation spreadsheet has been prepared to ensure that calculations are undertaken in a manner consistent with the procedures described in the guidelines by all OSD designers.	Alternative values for the required storage volume shall be permitted if the applicant can demonstrate to Council's satisfaction, using appropriate computer modelling, that the relevant PSD shall be satisfied. Computation methods based on the approximate triangular method or the rational method shall not be acceptable.	For more complex situations, more detailed modelling can be undertaken using models such as DRAINS to demonstrate meeting the required PSD for the site.

SRD_L – Site Reference Discharge for primary (lower) orifice outlet.

SRD_U – Site Reference Discharge for secondary (upper) orifice outlet.

SSR – Site Storage Requirements

SSR_L – Extended Detention Volume

SSR_T – Overall Detention Volume

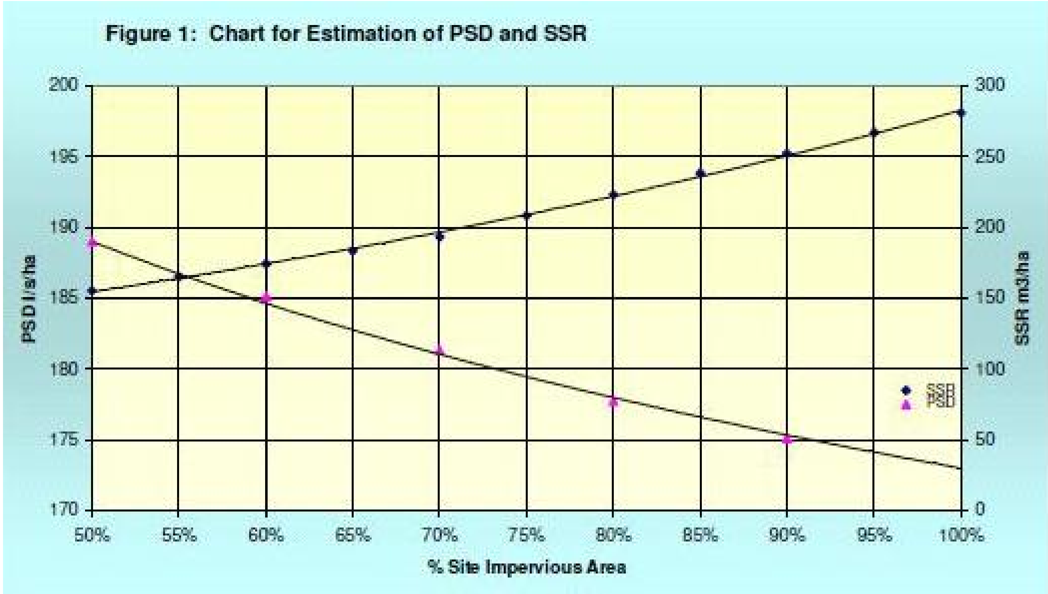


Figure 2-1 Kogarah Council SSR and PSD relationships depending on-site's impervious area

3 Onsite Retention Offsets – Existing Industry Research

Studies have been done within the stormwater industry assessing the appropriateness of incorporating rainwater tanks and OSD. Several key studies and their findings have been discussed briefly below.

Impact of Rainwater Tank and On-site Detention Options on Stormwater Management in the Upper Parramatta River Catchment (Coombes, P., Frost, A. and Kuczera, G., 2001)

In 2000 the Upper Parramatta River Catchment Trust (UPRCT) engaged Associate Professor George Kuczera, Peter Coombes and Dr Geoff O'Loughlin to determine how much of the volume of a rainwater tank, whose water is used for non-potable purposes, can be included in the site's OSD storage, without compromising the OSD system's flood mitigation performance.

The investigation involved generating a 1000-year rainfall record at six-minute intervals for the upper Parramatta River catchment. The record has been applied to a computer model of water usage on individual properties to simulate the performance over 1000 years of different combinations of OSD-only, rainwater tank only and combined systems.

The principal objective of this study is to determine by how much do rainwater tanks reduce the amount of OSD storage required to satisfy UPRCT's policy.

The study identified an average percentage of rainwater tank volume that could be counted as storage for OSD for various allotment scenarios as shown in Table 3.1.

Table 3.1 Average percentage of rainwater tank volume that can be counted as OSD site storage Volume of rainwater tank counting as OSD storage (%)

Scenario	No airspace in tank	50% airspace in tank
Allotment	42	65
Duplex	50	72
Townhouses	40	53
Walk up apartments	32	51

The study also found that on the lot scale the OSD systems reduced the peak discharge as required, but the on-site retention only reduced the volume of discharge, the peak flows remained the same. It was argued that peak discharges at the lot scale had little or no bearing on the floods at a catchment scale, as flooding is a volume driven process. However, a management measure that may reduce peak discharges at the lot scale but also reduces flood volumes can make an important contribution to reduce flooding.

Study on the Combined Effects of OSD and Rainwater Tanks on the Upper Parramatta River Catchment at Varying Sub-Catchment Scales (Cardno Willing, 2002, Additional Assessments: 2004, Supplementary Assessments: 2005)

The results provided by Coombes et al (2001) were considered to provide only an interim answer because the study only looked at individual sites and did not investigate the cumulative impact on peak discharges from groups of dwellings with rainwater tanks. As part of further detailed analysis of the cumulative impacts on peak discharges was undertaken by Cardno Willing in 2003 and 2004, the interaction of rainwater tanks and OSD tanks was investigated. Analyses were undertaken of both rainwater tanks with dedicated airspace and dynamic airspace.

Based on the analysis of the results reported in Cardno Willing, 2004 the SSR values in the UPRCT OSD Handbook – Fourth Edition (2005), were reduced based on the dedicated airspace of rainwater tanks.

Based on the analyses of the results of various rainwater tank simulations undertaken in 2004 and reported by Cardno Willing, 2005, the procedures outlined in Table 2.1 and used in the UPRCT OSD Handbook (2005) were allowed to calculate reductions in the SSR values as a result of likely dynamic airspace.

Rainwater Tanks for On-site Detention in Urban Developments in Western Sydney: An Overview (van der Sterren, M., Rahman, A., Barker, G., Ryan, G. and Shrestha, S., 2007)

This paper presents a brief overview of the on-site detention and retention practices adopted in greater Western Sydney. It has been found that policies differ significantly for different councils.

Since 1991, the UPRCT has conducted stormwater modelling works using XP-RAFTS model for 100 year average recurrence interval (ARI) flow which resulted in a permissible site discharge (PSD) and site storage requirement (SSR) (UPRCT, 2005). These requirements are used to design the OSD system, which generally results in very large detention tanks.

Some Councils have followed the lead by UPRCT and conducted modelling to determine PSD. Penrith City Council, for example, has conducted a simulation, which resulted in different PSDs for different areas of the Council. On the other hand, Councils such as the Blue Mountains City Council and Hawkesbury City Council have not conducted such modelling, and use the pre-development run-off as the constraint to design the OSD system (Hawkesbury City Council, 2000; Blue Mountain City Council, 2005). Furthermore, Hawkesbury City Council and Blue Mountain City Council do not have a significant local catchment flooding problem and have therefore not implemented the UPRCT requirements.

Mains Water Savings and Stormwater Management Benefits from Large Architecturally-Designed

Under-Floor Rainwater Storages **(Lucas, L. and Coombes, P., 2009)**

This paper provides monitoring of water use between January 2008 and December 2008 at a residential home in Hornsby Heights (NSW) that employs large architecturally-designed under-floor rainwater storages (4 x 16 kL cells). Water demand was continuously monitored using smart water meters to reveal intra-daily water use patterns. Based on this data, the PURRS model was used to continuously simulate the performance of the rainwater harvesting system using long-term climate records (at 6-minute timesteps) at the Hornsby House. The attributes of the rainwater harvesting strategy at this house was then applied to Adelaide, Brisbane, Canberra, Darwin, Hobart, Melbourne, Sydney and Perth; and simulated using PURRS with appropriate water demands (3-person household) and long-term rainfall records. Results indicate significant mains water savings and stormwater management benefits, such as reduced requirements for OSD, can be obtained using large architecturally-designed under-floor rainwater storages in all Australian capital cities.

The long-term rainfall record for Sydney (BOM data, Observatory Hill) and attributes of the Hornsby house, such as water demand, diurnal water use pattern and lot, roof and impervious areas, were used in the PURRS to determine reductions in runoff volumes and peak discharge.

Five different scenarios were investigated:

- BAU: “business-as-usual” (no demand management or rainwater storage);
- DM Only: demand management only (water saving appliances such as dual-flush toilets, and rated shower heads, dishwasher and washing machine);
- DM+5kL: Demand Management and 5kL rainwater storage;

- DM+16kL: Demand Management and 16kL rainwater storage; and
- DM+64kL: Demand Management and 64kL rainwater storage.

Table 3.2 shows the % reduction in runoff volumes compared to BAU. Note that "DM only" does not reduce stormwater runoff volumes. The use of larger rainwater storages only slightly reduced stormwater runoff volumes when compared to the DM+5kL scenario.

Table 3.2: Reduction in Runoff Volumes from the Allotment (Lucas et al, 2009)

	DM Only	DM + 5kL	DM + 16kL	DM + 64 kL
% reduction compared to BAU	0	18	24	26

The results showed that when allotment-scale rainwater storages are present there is a considerable reduction in peak discharge over a range of ARI values. However, the significance of these reductions depends on the criteria used to design stormwater treatment structures (i.e. sediment control, street drainage or flood management). It was found that only the 64kL rainwater storage provided significant benefits with regards flood management and reduce the requirement for OSD.

***The Use of Rainwater Tanks as a Supplement or Replacement for On-site Stormwater Detention (OSD) in the Knox area of Victoria* (Coombes, 2009)**

This study investigated the use of rainwater tanks to supplement or replace on-site detention for stormwater management in the Knox City Council area in Victoria. The performance of a range of infill development scenarios is compared to the objectives outlined in Knox City Council's stormwater drainage guidelines that require on-site detention to limit peak stormwater discharges from 5 year ARI storm events as indicated by a weighted runoff coefficient of 0.4. The use of discrete rational method assessments reliant on weighted runoff coefficients is compared to the results of continuous simulation using local rainfall. This study has assumed that an effective impervious area of 0% coincides with a weighted runoff coefficient of 0.4.

Many local government authorities (including Knox City Council) currently recommend the use of discrete triangular hydrograph methods for evaluation of on-site detention systems. However, methods that employ design storms based on annual series evaluation of peak discharges cannot replicate the actual performance of volume sensitive systems. Actual rainfall events contain greater range of rainfall volumes than design storms; include many peaks in each storm event and a number of significant peak discharges in any year.

The PURRS model utilises real continuous rainfall records (6 minute time steps) and partial series analysis of peak discharges (a process which includes a maximum peak discharge from each storm event rather than a single maximum peak discharge for each year in the analysis) to understand the impact of on-site detention and rainwater tanks.

Analysis of duplex, triplex, townhouse, unit and warehouse developments reveals that rainwater tanks can provide a similar service to on-site detention systems whilst also providing significant water conservation. The on-site detention service provided by rainwater tanks is primarily dependent on rainwater use from the tank and roof areas connected to the tanks. Tank size was found to be a secondary variable.

An additional important aspect of designing rainwater harvesting systems for the management of peak stormwater discharges highlighted by this study is that there are optimum combinations of rainwater demands and connected roof areas. Reducing the area of roof connected to each rainwater tank for a given rainwater demand can improve the performance of the system. Up to a threshold, reductions in connected roof areas can allow water levels in rainwater tanks to be drawn down more frequently allowing greater reductions in peak discharges. Connection of large roof areas to rainwater tanks can produce a situation

where runoff into tanks from roof catchments overwhelms water demands from the tanks resulting in limited reductions in peak stormwater discharges.

The retention number proposed in this study in combination with the proportion of the development that is roof area connected to rainwater tanks was shown to be an indicator of the performance of rainwater tanks for stormwater detention. This study has also utilised the concept of "effective impervious area" to bridge the technical void between continuous simulation and discrete Rational Method assessments. It is noted that this study is limited to several development scenarios at a single rainfall location. This analysis has also focused on a single demographic profile and a sole objective of reducing 5 year ARI peak stormwater discharges to a given rate as defined by a weighted runoff coefficient.

A summary of the study results in shown in **Table 3.3.**

Table 3.3: Roof Area and Rainwater Tank Size for Compliance with Knox City Council's OSD Policy (Coombes, 2009)

	% of Site Area = Roof Area	Tank Size to Achieve Compliance with Council's OSD Policy
Duplex	11 %	No Compliance
	21 %	> 3 kL
	42 %	10 kL
Triplex	8.8 %	No Compliance
	17.5 %	> 2 kL
	35 %	> 4 kL
Townhouse	8.5 %	No Compliance
	16.9 %	> 3 kL
	33.9 %	10 kL
Units	10 %	No Compliance
	20 %	> 30 kL
	40 %	> 30 kL
Warehouse	13 %	No Compliance
	26 %	> 50 kL
	51 %	No Compliance

Rainwater Tank Options for Stormwater Management in the Upper Parramatta River Catchment (Coombes, P., Frost, A., Kuczera, G., O'Loughlin, G. and Lees, S., 2004)

This study investigated the extent to which rainwater tanks reduce the amount of on-site stormwater detention (OSD) storage required to satisfy the Upper Parramatta River Catchment Trust's (UPRCT's) OSD policy. In view of the limitations of the design storm approach, a continuous simulation approach was adopted. The DRIP stochastic rainfall model was linked with an allotment water balance model to evaluate different allotment scenarios using a 1000-year synthetic pluviograph record. The DRIP model was calibrated to a 53-year pluviograph located at Ryde. Comparison with statistics not used in calibration showed that DRIP performed satisfactorily. In particular, good agreement with observed intensity-frequency duration (IFD) curves was obtained, whereas AR&R IFD curves consistently underestimated the observed IFDs. Scenarios involving combinations of OSD, using 10kL rainwater tanks with 0 and 5 kL of detention storage were examined. For allotments with single dwellings between 50 to 70% of the tank volume can be counted towards the allotment's OSD volume. For a townhouse development, this percentage varied between 36% and 53%. Rainwater tanks used in the single dwelling and townhouse scenarios are expected to reduce mains water consumption by 39% - 30% and 32% - 27% respectively. The variation depends on the number of occupants and the amount of tank airspace reserved for detention storage and the fraction of allotment drained by the rainwater tank(s).

UPRCT On-site Detention Handbook (Fourth Addition)

In addition to the assessments outlined above which were undertaken on behalf of the UPRCT, The Handbook (Fourth Edition) also outlined the results of various rainwater tank simulations to identify the airspace at the start of a storm within a rainwater tank.

The following procedure was identified to calculate the rainwater tank dynamic airspace at the start of a storm:

$$\textit{Dynamic airspace (kL)} = 8.7 \times \textit{Nett Tank Volume (kL)}^{1.05} \times \textit{Roof Area } (m^2)^{-0.5} \times \textit{Demand (kL/d)}^{0.35}$$

Where the Nett Tank Volume = Total Tank Volume – Dedicated Airspace – Top Up Volume.

4 Catchment Analysis

4.1 RAFTS Development

An XP-RAFTS hydrological model was established for the Whites Creek Catchment. The Whites Creek catchment is approximately 187 ha. The catchment rises to the south of Parramatta Road (external to the study area) to an elevation of approximately 46m AHD and includes portions of Leichhardt and Annandale. The southern portion of the Creek is a box culvert and Whites Creek Lane follows the majority of the length of this culvert. The culvert discharges into an open channel between Booth Street and Piper Street, and eventually discharges into Rozelle Bay to the east of The Crescent at an elevation of approximately 0m AHD. The land use within the catchment is highly urbanised and is predominantly residential.

Whites Creek Catchment has been selected as a representative catchment for the entire study area of the Leichhardt Flood Risk Management Study. Catchment analysis of various on-site detention (OSD) scenarios within this catchment will be used to inform the recommendations regarding OSD policy in the study area.

4.1.1 Model Set Up

Sub-Catchment Delineation

The catchment was divided into 160 sub-catchments based on the topographic and structural features. Contour data (0.5m contours), pipe network data and the cadastre was utilized to perform the subcatchment delineation. The average area of each sub-catchment is 1.2 hectares. The sub-catchment layout of the Whites creek catchment is presented in **Figure 4-1** and the RAFTS nodes are shown in **Figure 4-2**.

Land Use

Each sub-catchment was categorised according to the land uses contained within and appropriate impervious percentages were applied to each land use category. **Table 4-1** shows the impervious/pervious percentages used for each category.

Table 4-1: Impervious/Pervious Percentages

Land Use Category	Impervious (%)	Pervious (%)
Residential	60	40
Commercial	80	20
Open Space	5	95

Residential land use roughly occupied 137 hectares which represents 73% of the Whites Creek Catchment.

Figure 4-1 - Whites Creek Sub-Catchments

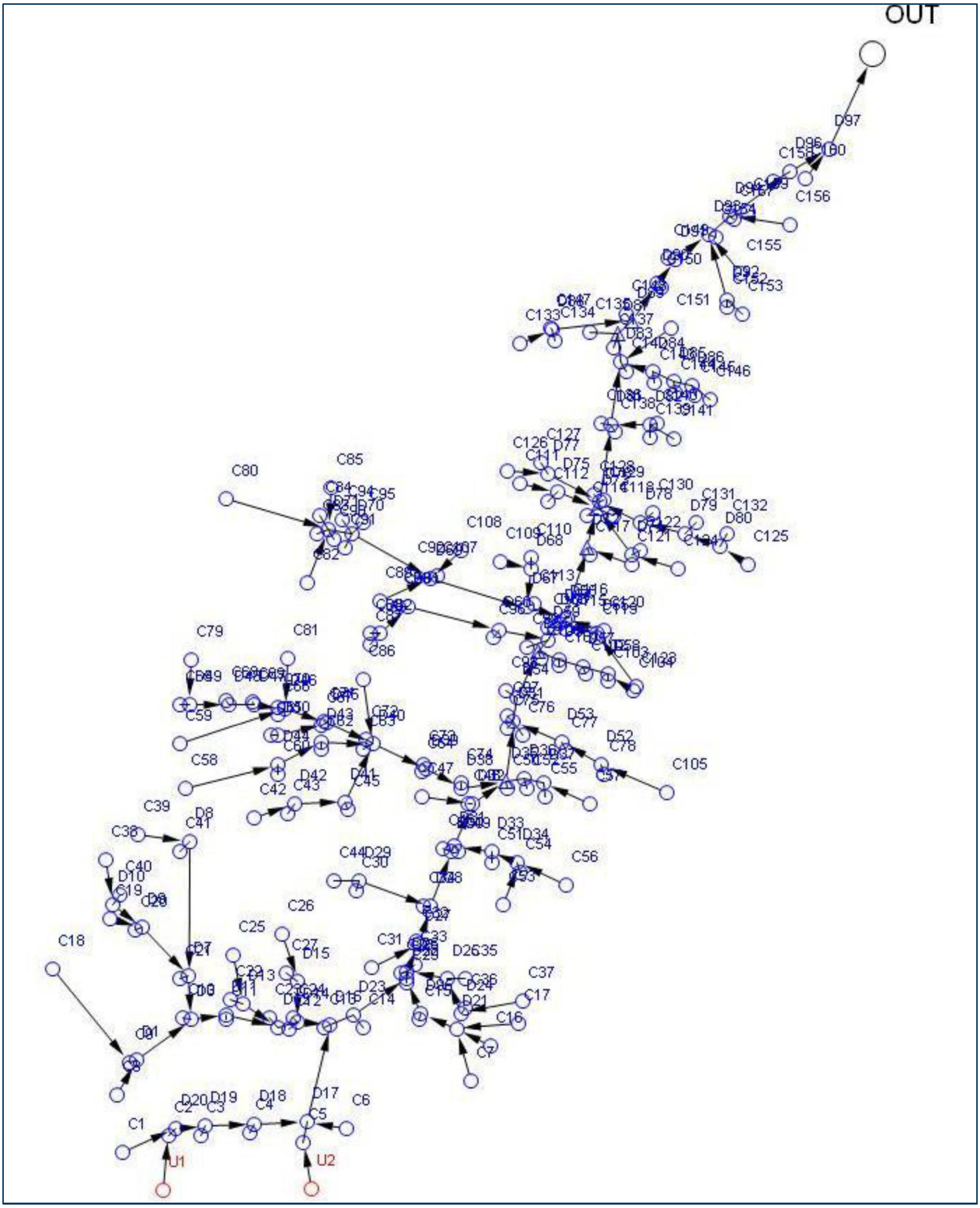


Figure 4-2 - RAFTS Model (160 node catchment model)

Rainfall Losses

The initial and continuing rainfall loss rates for impervious/pervious areas are presented in **Table 4-2**, which are based on Leichhardt LGA Flood Study (Cardno, 2014).

Table 4-2: Rainfall Loss Rate

Rainfall Loss Rate	Impervious Area	Pervious Area
Initial loss (mm)	1.5	10
Continuing loss (mm/hr)	0	2.5

Catchment Roughness

The values of catchment roughness were also based on Leichhardt LGA Flood Study (Cardno, 2014). The adopted values were 0.015 for impervious area, and 0.10 for pervious area.

Design Rainfall

The design rainfall was based on Leichhardt LGA Flood Study (Cardno, 2014). The rainfall intensities for the 5 year, 20 year and 100 year ARI events are provided in **Table 4-3**. The 1-2 hour duration event was critical for the majority of the Whites Creek Catchment.

Table 4-3: Key Rainfall Intensities

Rainfall Event	Intensity (mm/hr)		
	5yr ARI	20yr ARI	100yr ARI
45 minute	62	83	110
1 hour	53	71	95
90 minute	41	55	73
2 hour	34	45	60

4.1.2 Model Verification

The verification of the RAFTS model was undertaken by comparing the results of the 100 year ARI event extracted from the hydraulic model (SOBEK) with that of the hydrological model (XP- RAFTS). The SOBEK model was run using “rainfall on the grid” to simulate flows. It is not always expected that the results of the hydraulic and hydrologic models will exactly match (in fact, even two separate traditional hydrological models with similar parameters can produce significantly different results). However, where there are differences some interpretation of the results can be made, and the models can be checked as to why this is the case.

The comparison was undertaken along the major flow paths. It must be noted that the significant hydraulic controls, such as culverts and localised depression storages, would not be accounted in the hydrological model. The primary aim of this comparison was to ensure that the timing and peak flows from the direct rainfall hydraulic model (SOBEK) were reasonable, with a focus on the runoff areas rather than the mainstream flooding areas.

The locations where the models are compared are shown in **Figure 4-3**. Peak flow and volume estimated by the XP-RAFTS and SOBEK models at the comparison points for the 100 year ARI 60 minute event from the two sub-catchments are listed in **Table 4-5**.

Table 4-5: Sub-catchment Results for SOBEK and XP-RAFTS Models

Category	Catchment Area (ha)	Peak Flow (m^3/s)			Volume (m^3)		
		XP-RAFTS	SOBEK	% Change	XP-RAFTS	SOBEK	% Change
Node D14	24.17	10.15	8.15	19.85%	21771	19585	10.00%
Node D26	51.29	27.05	25.45	5.80%	64021	58743	8.25%
Node D40	22.32	8.60	8.65	-0.90%	19658	16225	17.45%
Node D54	104.42	42.50	40.80	3.98%	112046	98998	11.65%
Node D69	19.94	7.80	6.95	11.1%	17383	13175	24.20%

These results indicate a very reasonable agreement between the Direct Rainfall (SOBEK) and the XPRAFTS models. The overall volume of runoff is higher in the XP-RAFTS model than in the SOBEK model due to storage effects. The SOBEK model has an elevation grid that details localised depression storages, such as at roads, properties, and buildings, that are not represented in the XP-RAFTS model.

Peak flows are also reduced in the SOBEK model compared to the XP-RAFTS model due to the storage effects and due to the elevation and roughness grids in SOBEK that result in more detailed assessment of the conveyance and concentration of flows. Time-series hydrographs extracted at these locations are shown in **Chart 1** to **Chart 5** which show a similar rise and fall timing between the two models. The RAFTS hydrographs generally show an earlier start to flow than the SOBEK model due the lack of detailed storage and conveyance calculations.

Figure 4-3 - Comparison Nodes

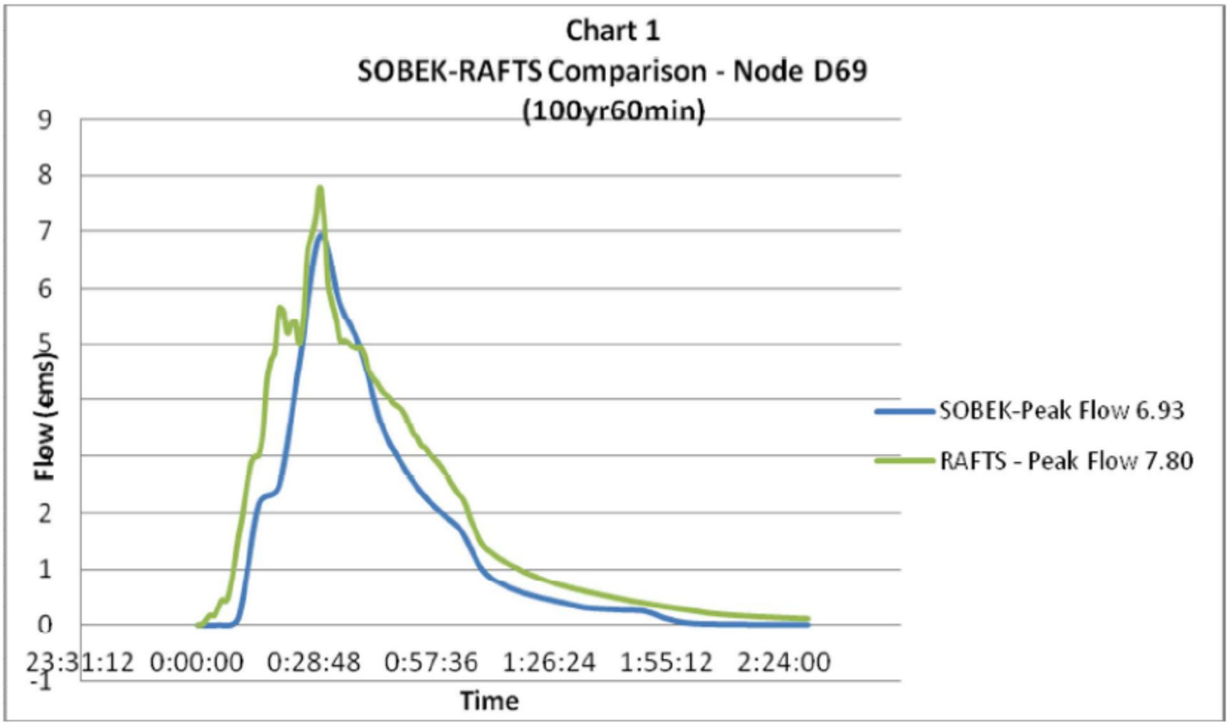


Chart 1
SOBEK-RAFTS Comparison - Node D69
(100yr60min)
Flow (cms)
9
8
7
6
5
4
3
2
1
0
-1
23:31:12 0:00:00 0:28:48 0:57:36 1:26:24 1:55:12 2:24:00
Time
SOBEK-Peak Flow 6.93
RAFTS - Peak Flow 7.80

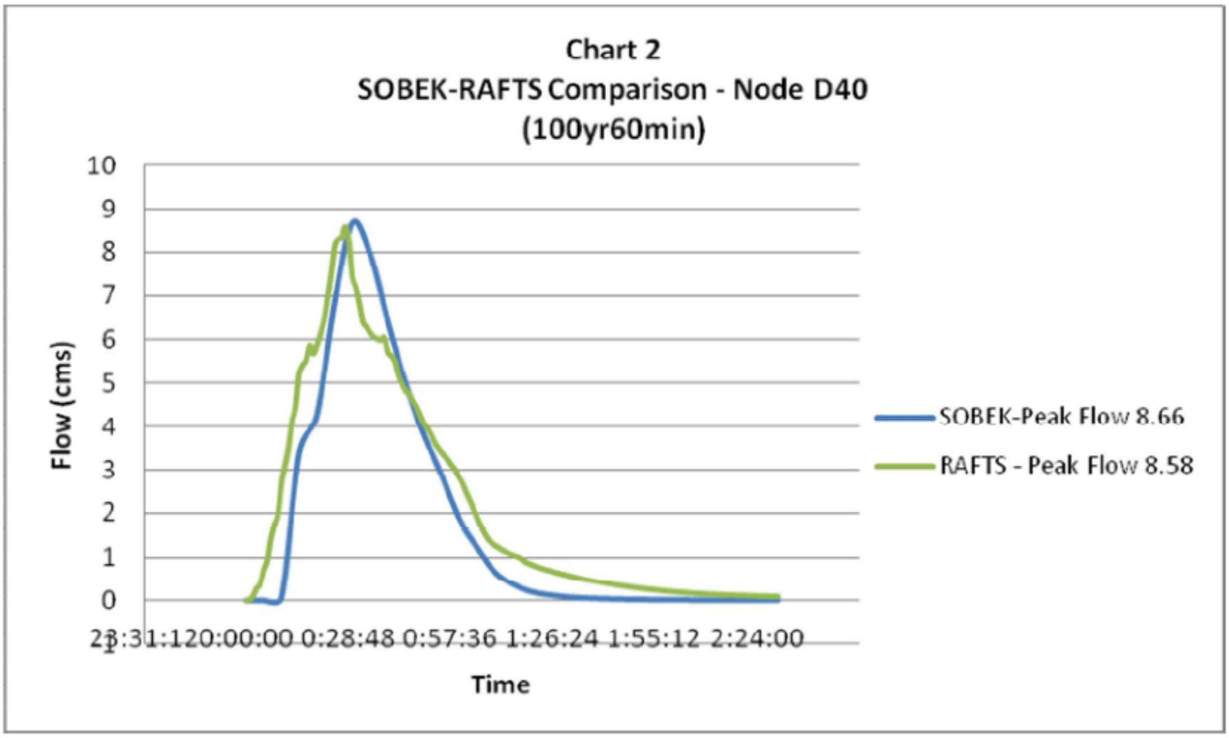


Chart 2
SOBEK-RAFTS Comparison - Node D40
(100yr60min)
Flow (cms)
10
9
8
7
6
5
4
3
2
1
0
-1
23:31:12 0:00:00 0:28:48 0:57:36 1:26:24 1:55:12 2:24:00
Time
SOBEK-Peak Flow 8.66
RAFTS - Peak Flow 8.58

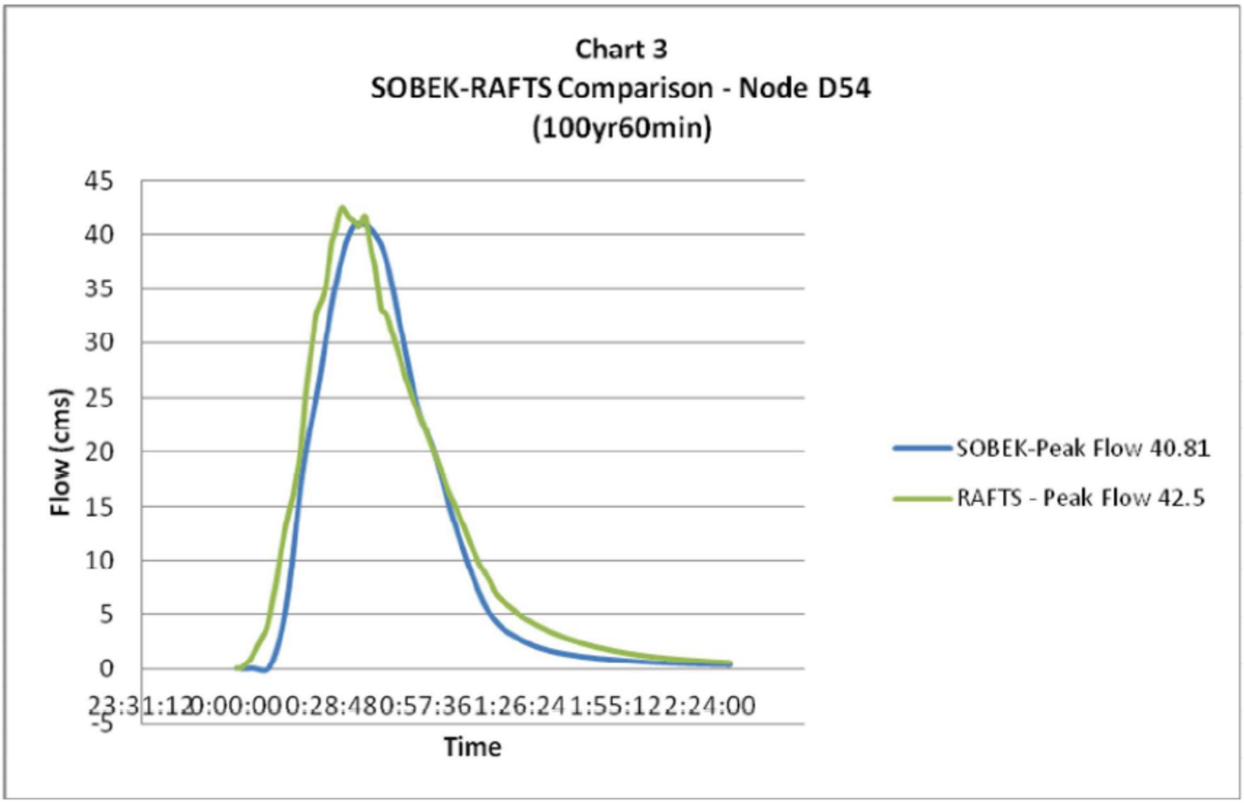


Chart 3
SOBEK-RAFTS Comparison - Node D54
(100yr60min)
Flow (cms)
45
40
35
30
25
20
15
10
5
0
-5
23:31:12
0:00:00
0:28:48
0:57:36
1:26:24
1:55:12
2:24:00
Time
SOBEK-Peak Flow 40.81
RAFTS - Peak Flow 42.5

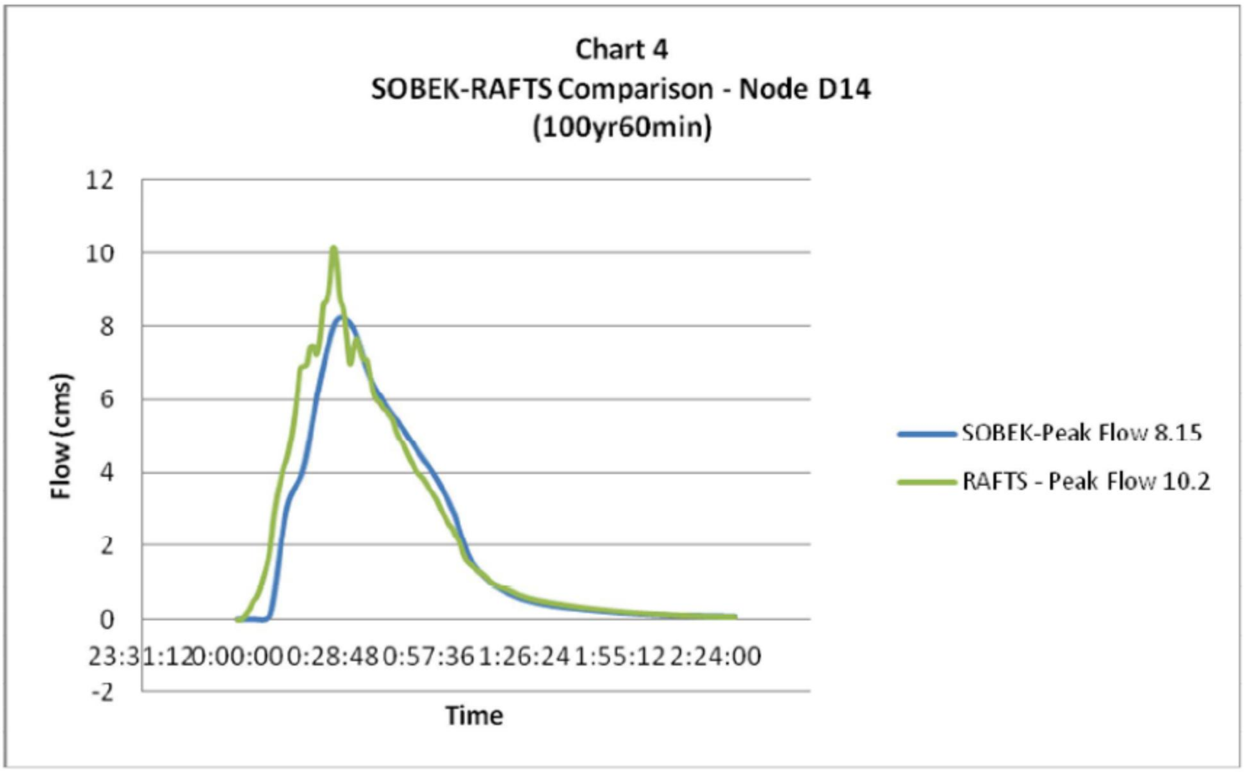
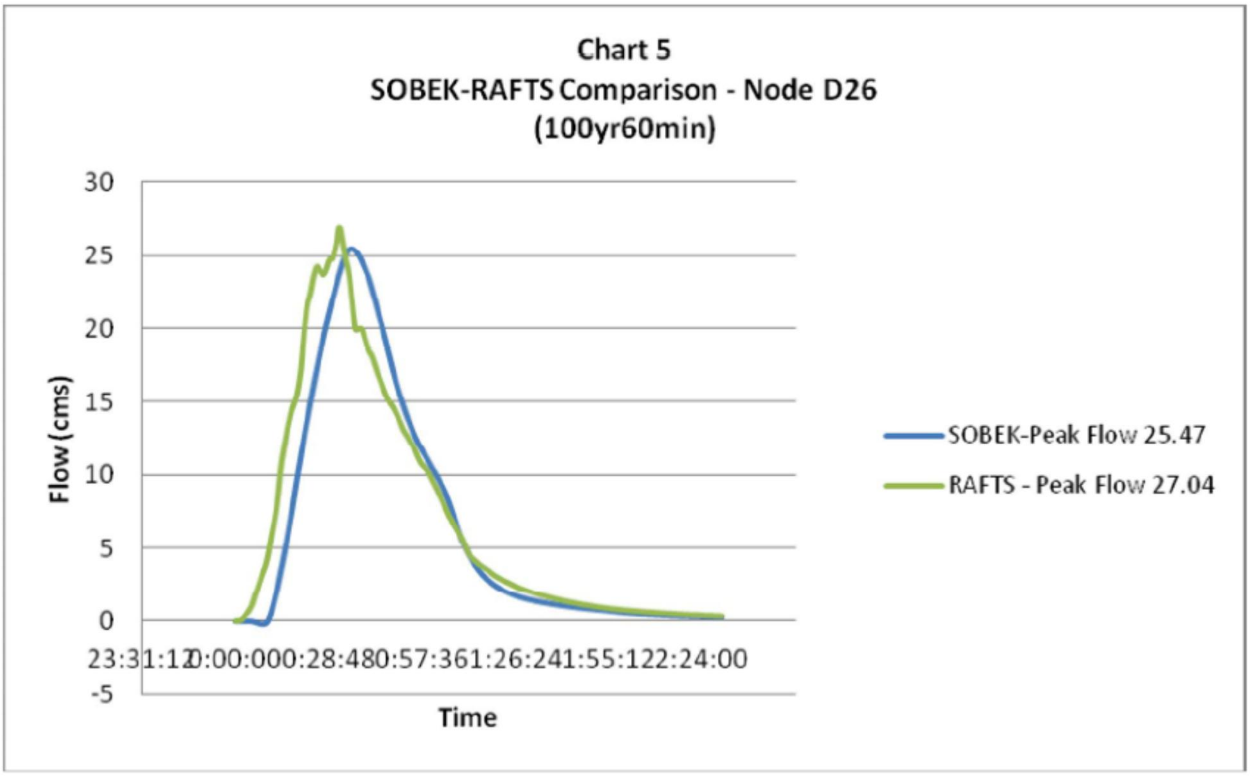


Chart 4
SOBEK-RAFTS Comparison - Node D14
(100yr60min)
Flow (cms)
12
10
8
6
4
2
0
-2
23:31:12
0:00:00
0:28:48
0:57:36
1:26:24
1:55:12
2:24:00
Time
SOBEK-Peak Flow 8.15
RAFTS - Peak Flow 10.2



4.1.3 Incorporating OSD into the Model

On-site detention was initially incorporated into the model for a test sub-catchment only. This allowed the model results to be verified on a small scale to ensure the OSD module was performing appropriately and also allowed a comparison of local effects of OSD compared to regional impacts.

The test sub-catchment is shown in **Figure 4-4**. The test sub-catchment was selected to ensure an appropriate combination of commercial / industrial, residential and road areas. The test sub-catchment has a total area of 13.6 ha which consists of 48% combined commercial and industrial, 35% residential, and 17% road.

As discussed in **Section 2.1.3**, a portion of properties may not feasibly be able to drain to OSD either partially or completely due to site topography. It was determined that those properties with greater than 1.5m fall from the street level would face difficulties draining to OSD. The test catchment was identified to contain approximately 5 percent of the property area within these “downhill” properties. For the purposes of the hydrological assessment, it was assumed that these properties would not contain OSD.

4.1.3.1 High Early Discharge

High early discharge (HED) systems work by routing stormwater runoff into a smaller secondary pit, located inside the OSD system at the location of the control outlet, allowing overflow to spill stormwater runoff to the main OSD storage. The stormwater runoff reaches its peak discharge rate faster as the water in the secondary pit fills up quicker due to the smaller area of the secondary pit. By allowing a greater rate of runoff at the commencement of the storm event the OSD volume to be provided to restrict post development flows back to pre-development levels may be reduced.

All hydrologic modelling was undertaken for scenarios with High Early Discharge (HED) turned on and off. The use of OSD without HED reduces the peak local drainage discharges when compared to OSD with HED.

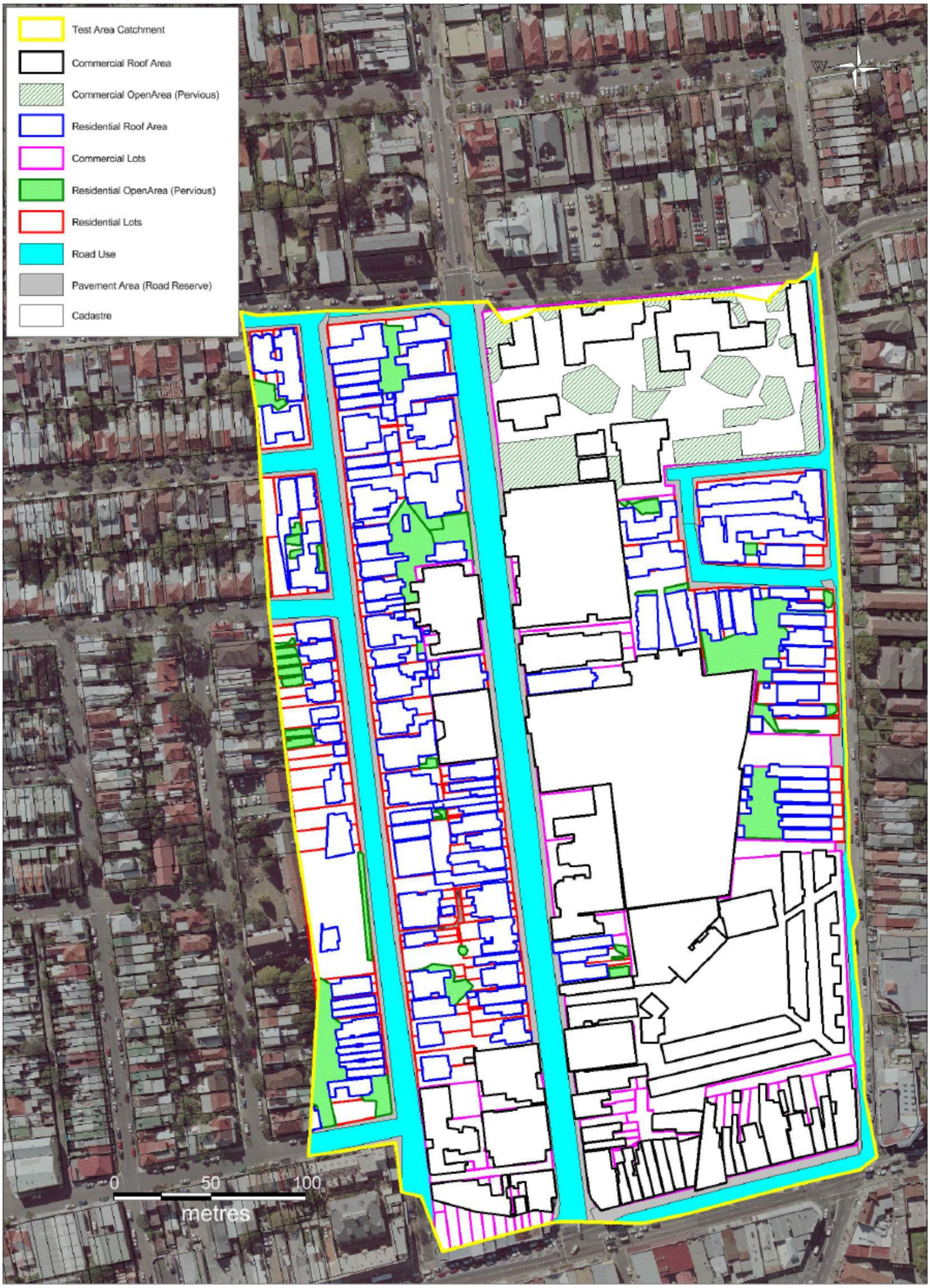


Figure 4-4 Land Use for Test Sub-Catchment

4.2 On-site Detention Scenario Analysis

The hydrological model was utilised to review Council's existing approach to OSD and to assess serval alternative approaches.

The modelling of Council's existing OSD approach involved:

- **Review of Council's current policy with regards to catchment wide flood impacts:** Council's current policy requires the discharge from the site in a 100 Year ARI event (post development) to be equal to the 5 Year ARI pre-development flows from the site. The RAFTS model was utilised to assess the SSR required to achieve this objective for the catchment as a whole.
- **Review of the existing calculation methods in Council's policy:** Council's existing OSD Policy is fairly flexible with regards to the calculation methods employed. This generally results in calculations only accounting for the immediate catchment and therefore assessing a critical duration of likely less than 30 minutes. On average, the existing calculation methods result in an SSR of approximately 2,000 L per lot. The benefits of this storage volume were assessed for the catchment as a whole.

Additional scenarios were then modelled as follows:

- **No OSD in Downstream Portion of Catchment:** Hydrological modelling was undertaken to assess the impacts of not applying OSD to the downstream portions of the Whites Creek Catchment.
- **No OSD on Low Density Residential Development:** While OSD can often more readily be included in commercial, industrial and high density developments, low density (i.e. single lot) residential development can be restricted by lot size and other site constraints such as the ability to excavate for OSD. As such, the impacts of not applying OSD to low density residential development was assessed.
- **Rainwater Tank Offsets for Low Density Residential Development:** The use of rainwater tanks instead of OSD was modelled for all low density residential development across the catchment.

4.3 Results

4.3.1 Review Council's Existing OSD Policy

Council's existing OSD Policy requires post development 100 Year ARI flows to be reduced to 5 Year ARI flows using OSD. The SSR and PSD values required to meet this objective were calculated using the test sub-catchment. The results were then extrapolated across the Whites Creek Catchment to see if the local catchment calculations resulted in the same reductions in flows across the wider catchment.

The test sub-catchment was modelled in RAFTS with no OSD for the 5 year, 20 year, 50 year and 100 year ARI events and each for the 45 minute, 1 hour, 90 minute and 2 hour duration storms. The resulting hydrographs were used to calculate the volume difference between the 100 year and 5 year ARI for the four durations. The results are shown in **Table 4-6**.

Table 4-6 – SSR required for 100 year ARI flows to be reduced to 5 year ARI flows

	45 min	1 hour	90 min	2 hour
SSR (m^3/ha)	256.1	300.4	248.0	229.4

The PSD was calculated using the 5 year ARI peak flow for the four durations since the objective of the OSD was to achieve a 5 year ARI flow from a 100 year ARI flow. The peak flows were then divided by the area of the representative sub-catchment. The results are presented in **Table 4-7**.

Table 4-7 – PSD required for 100 year ARI to fall to a 5 year ARI

	45 min	1 hour	90 min	2 hour
5yr Peak Flow (m^3/s)	3.7	4.1	4.3	4.0
PSD (L/s/ha)	353.4	384.2	409.1	374.0

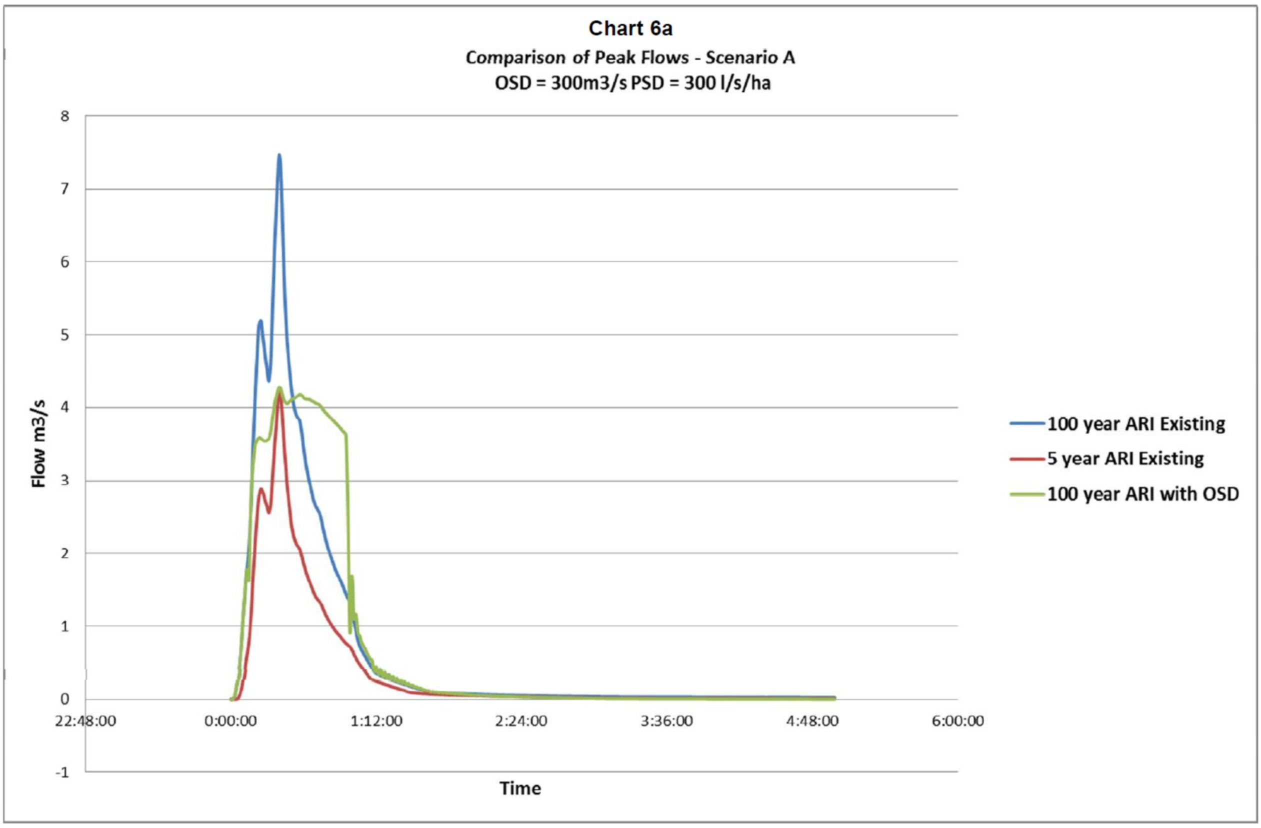
The critical duration for the test sub-catchment is 1 hour. Therefore, the following 1 hour SSR and PSD values were used as initial estimates for the OSD modelling in RAFTS:

- SSR = 300 m^3/ha
- PSD = 384 l/s/ha

The above values were then refined and verified for the local test sub-catchment using RAFTS. The updated SSR and PSD requirements are:

- SSR = 300 m^3/ha
- PSD = 300 l/s/ha

The updated estimates reduced the 100 year ARI flow for the 1 hour duration to the 5 year ARI flow in the representative catchment modelled in RAFTS. The hydrograph for Scenario A is depicted in **Chart 6a**.



The OSD parameters were then applied to the Whites creek catchment. Charts 6b to 10 depict the comparison of the flows with and without OSD for the nodes in **Table 4-5**.

It was found that while the OSD parameters calculated for the test sub-catchment were effective for the local catchment, the larger the contributing catchment became, the less effective the same OSD parameters were. At the catchment outlet (i.e. the most downstream point), there is almost no resulting difference in the peak flows as a result of OSD.

Some testing was also undertaken for large SSR requirements. However, very little difference in the results was observed.

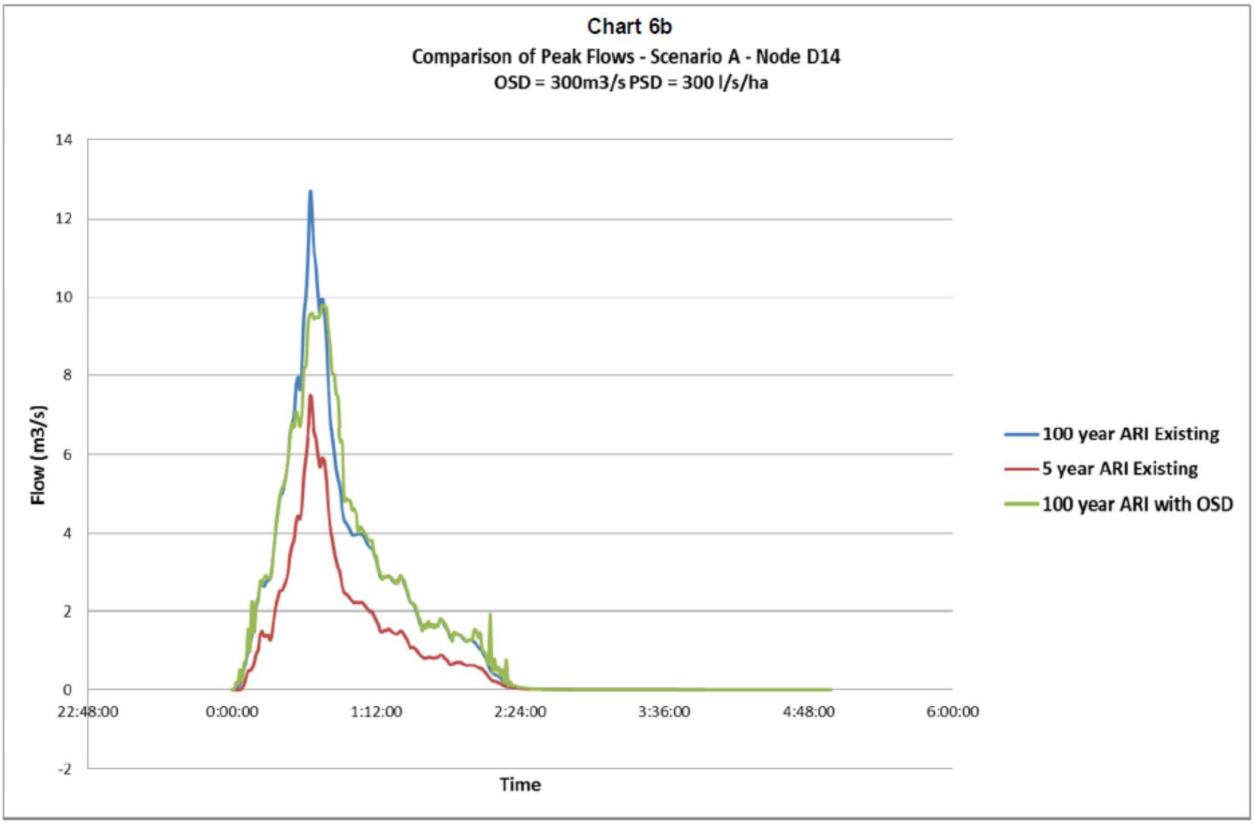


Chart 6b
Comparison of Peak Flows - Scenario A - Node D14
OSD = 300m3/s PSD = 300 l/s/ha
Flow (m3/s)
14
12
10
8
6
4
2
0
-2
22:48:00
0:00:00
1:12:00
2:24:00
3:36:00
4:48:00
6:00:00
Time
100 year ARI Existing
5 year ARI Existing
100 year ARI with OSD

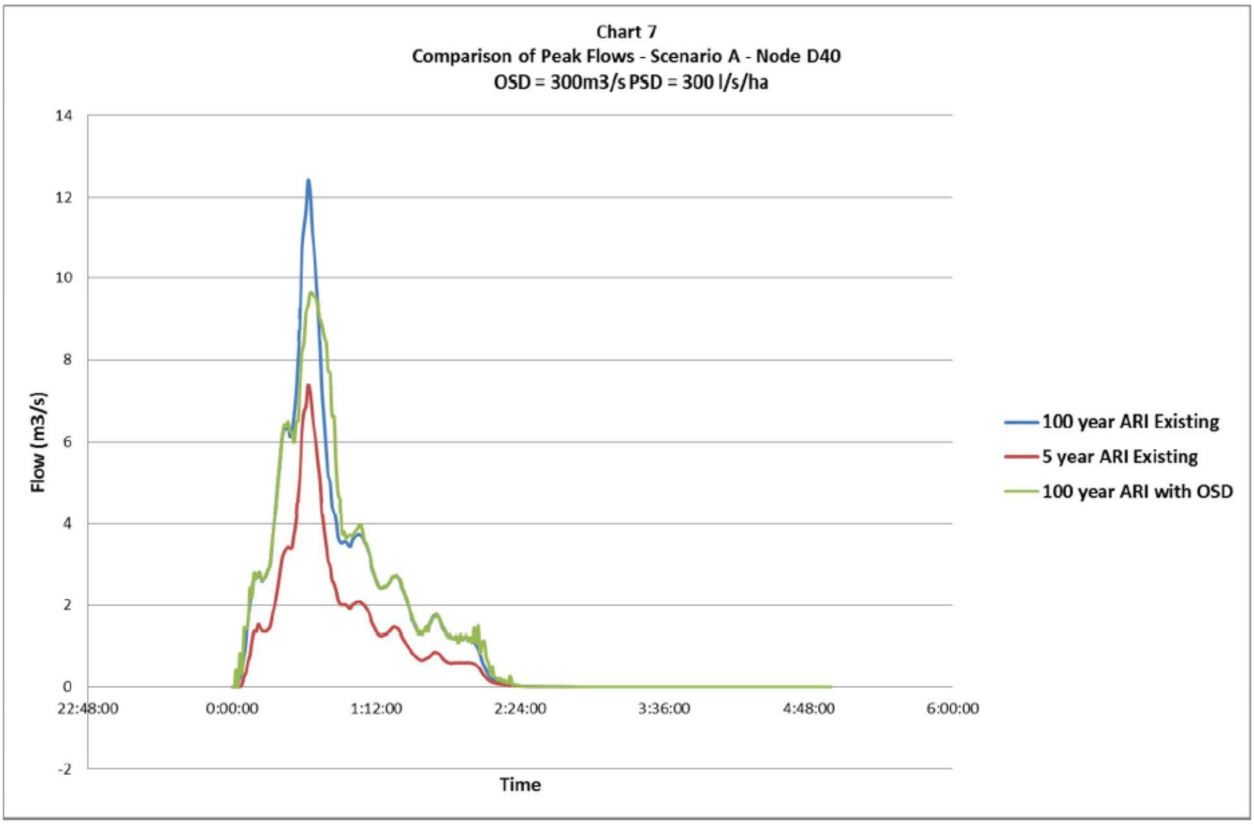


Chart 7
Comparison of Peak Flows - Scenario A - Node D40
OSD = 300m3/s PSD = 300 l/s/ha
Flow (m3/s)
14
12
10
8
6
4
2
0
-2
22:48:00
0:00:00
1:12:00
2:24:00
3:36:00
4:48:00
6:00:00
Time
100 year ARI Existing
5 year ARI Existing
100 year ARI with OSD

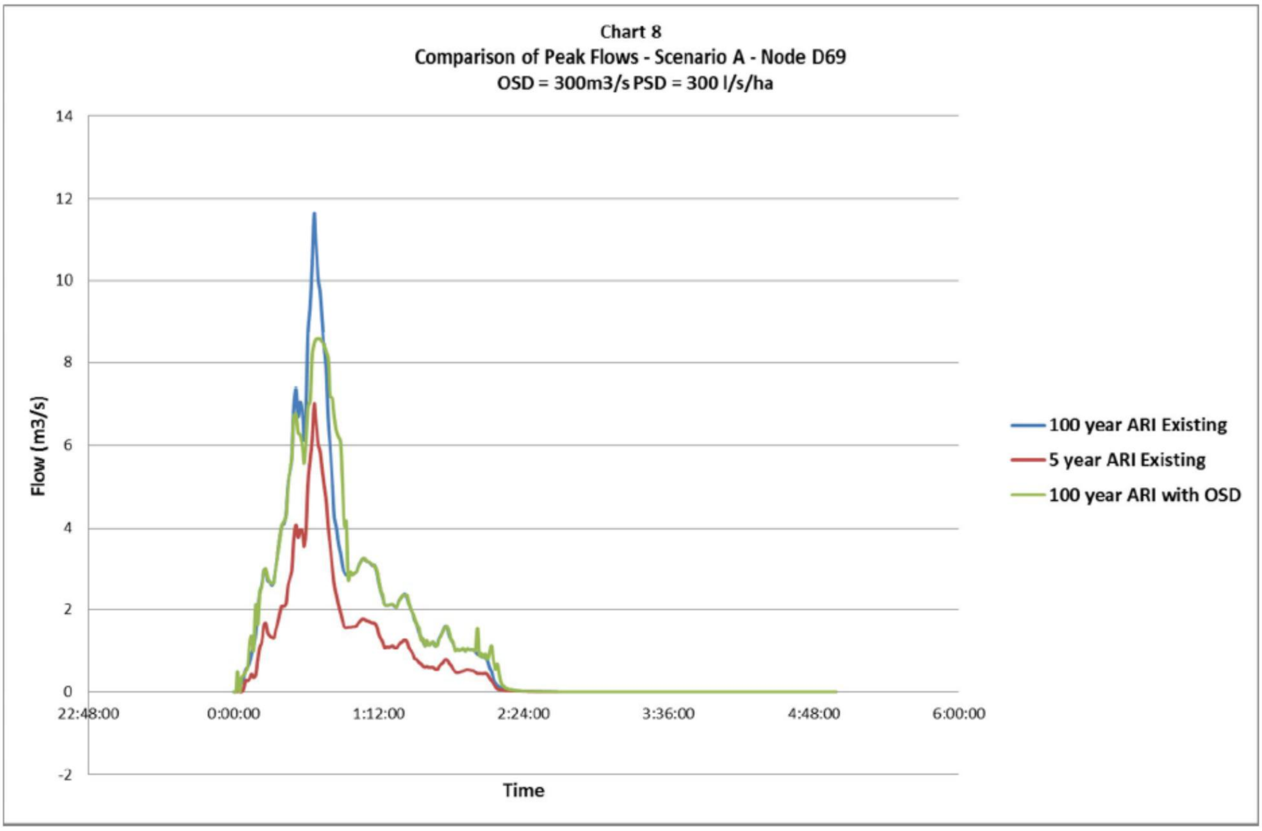


Chart 8
Comparison of Peak Flows - Scenario A - Node D69
OSD = 300m3/s PSD = 300 l/s/ha
Flow (m3/s)
Time
100 year ARI Existing
5 year ARI Existing
100 year ARI with OSD
14
12
10
8
6
4
2
0
-2
22:48:00
0:00:00
1:12:00
2:24:00
3:36:00
4:48:00
6:00:00

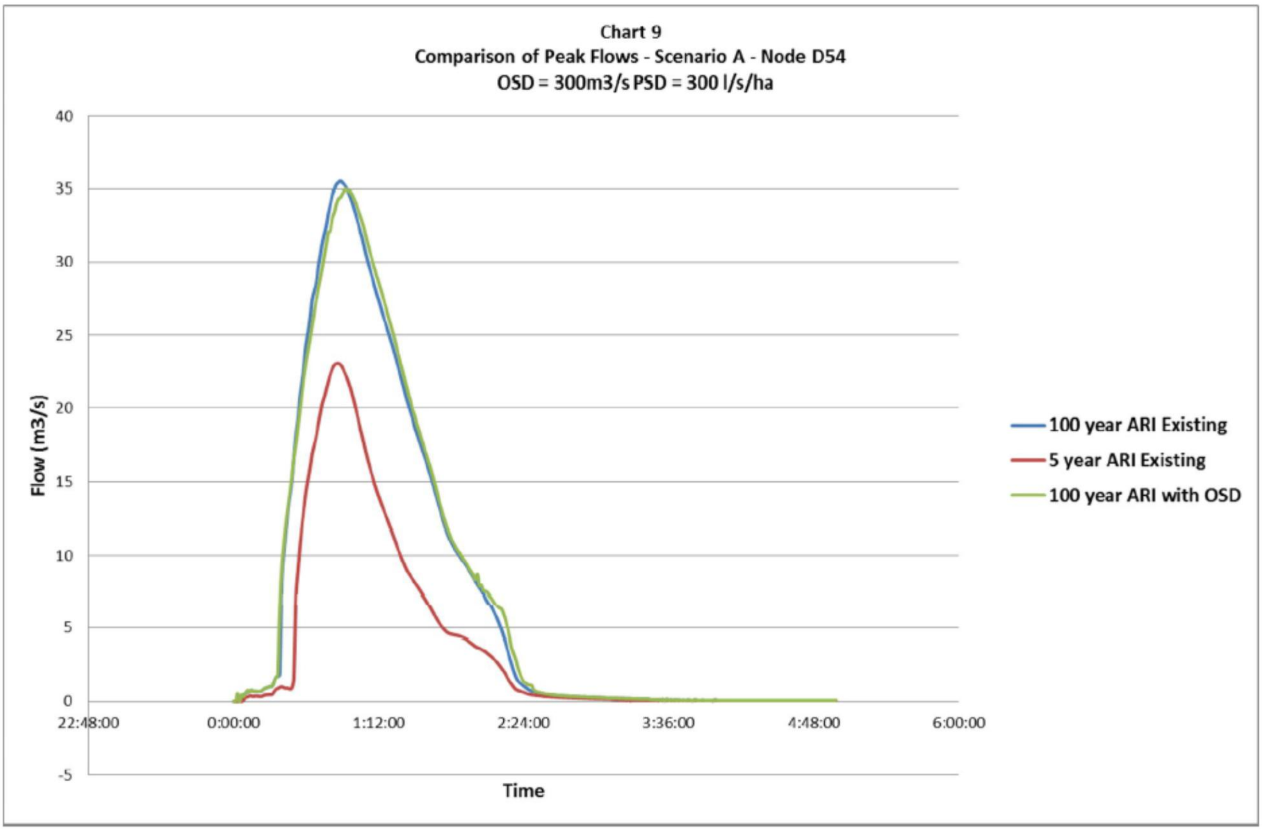
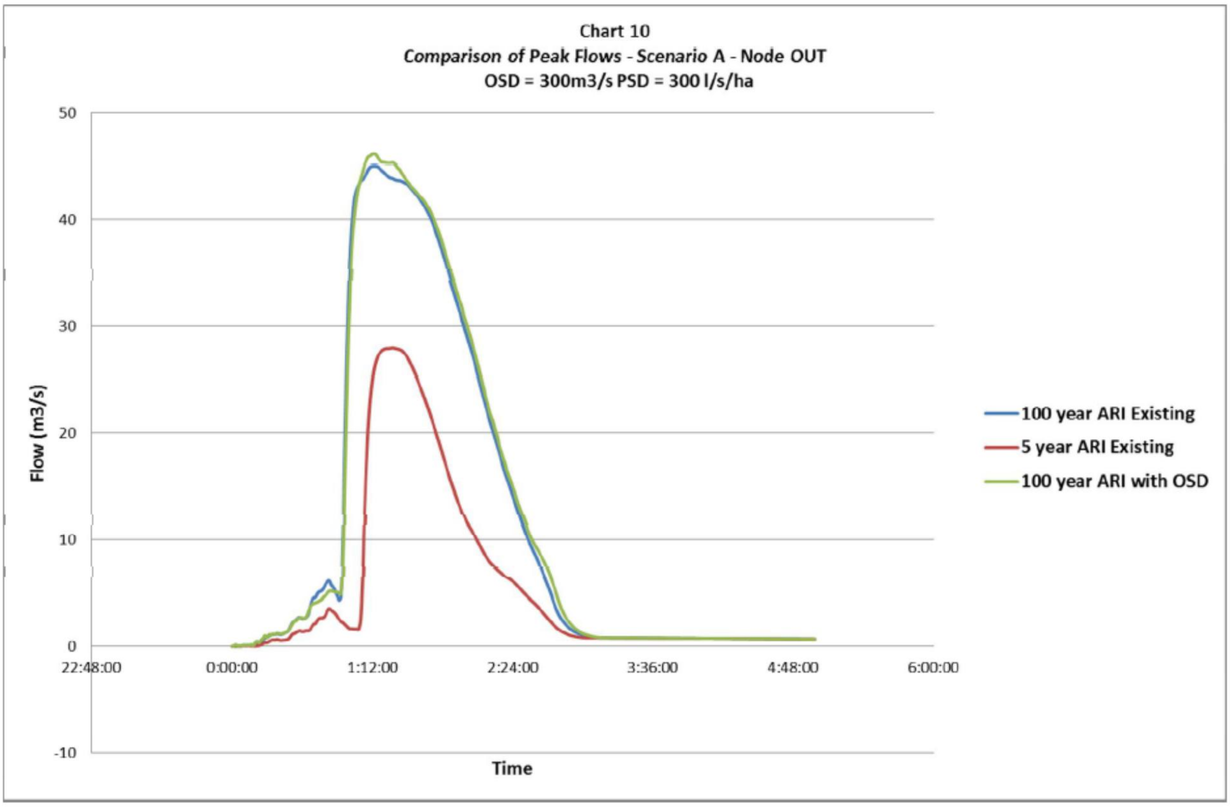


Chart 9
Comparison of Peak Flows - Scenario A - Node D54
OSD = 300m3/s PSD = 300 l/s/ha
Flow (m3/s)
Time
100 year ARI Existing
5 year ARI Existing
100 year ARI with OSD
40
35
30
25
20
15
10
5
0
-5
22:48:00
0:00:00
1:12:00
2:24:00
3:36:00
4:48:00
6:00:00



4.3.2 Review of the existing calculation methods in Council's policy

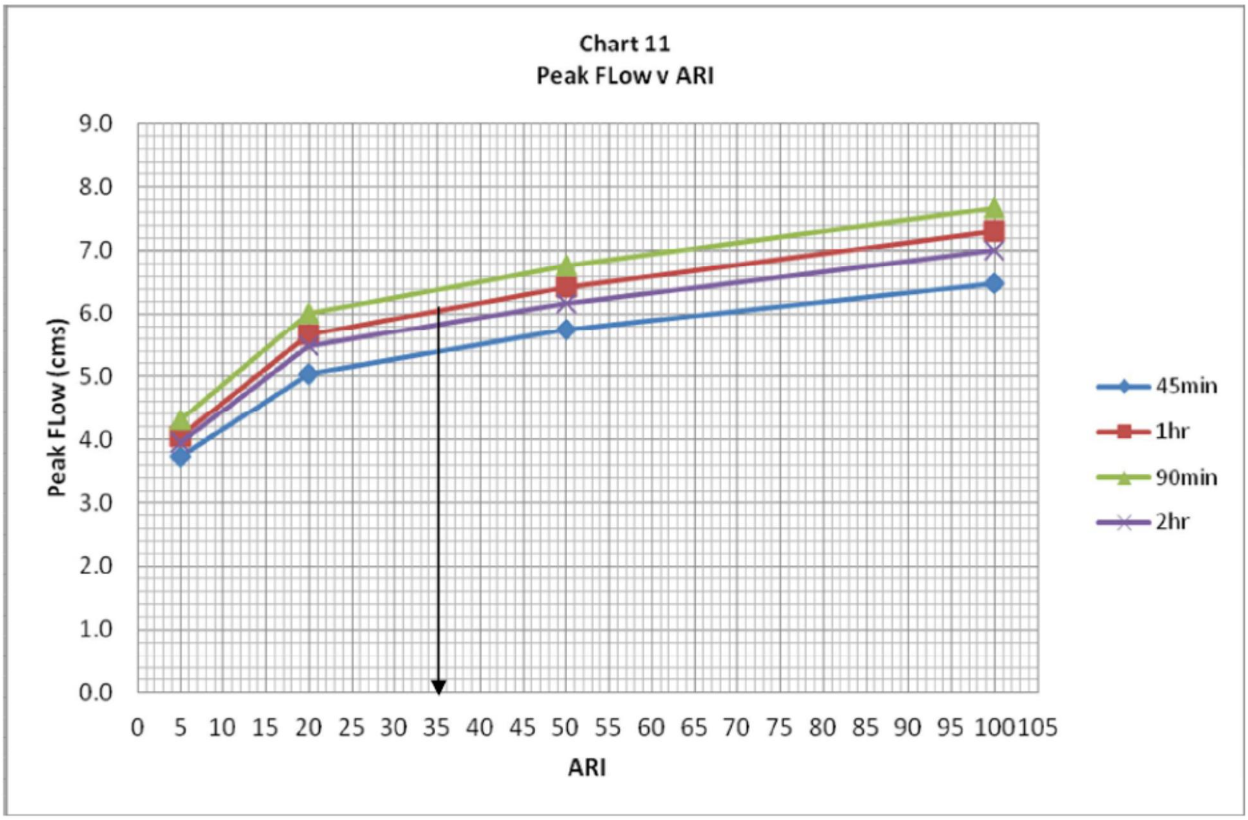
Council has advised that the existing calculation methods generally result in an approximately SSR of 2,000 L/lot. This equates to approximately 68 m^3/ha. This is significantly less than the SSR calculated above. This is likely to be due to the fact that in the absence of any specifications, calculations have generally been done for the immediate catchment only resulting in the application of a short critical duration (likely to be less than 30 minutes). The critical duration for the catchment is generally greater than 1 hour. This would result in a significantly smaller volume of rainfall being assessed for OSD application.

The existing policy was tested for the test sub-catchment within a spreadsheet and RAFTS. The policy was then also applied across the Whites Creek Catchment.

The test sub-catchment has a peak flow of 7.5 m^3/s for the 100 year ARI, 1 hour duration under existing conditions. The peak flow with a SSR of 68 m^3/s was 6.01 m^3/s for the same hydrograph. The reduction in peak flow shows that the OSD has some effect on the 100 year ARI. In order to determine the effectiveness of the OSD (SSR = 68 m^3/s a Peak Flow v ARI chart (Chart 11) was utilised. Chart 11 was plotted by extracting the peak flow data of the representative catchment (Table 4-8).

Table 4-8 Peak Flows

ARI	45min Peak Flow (m^3/s)	1hr Peak Flow (m^3/s)	90min Peak Flow (m^3/s)	2hr Peak Flow (m^3/s)
5	3.7	4.1	4.3	4.0
20	5.0	5.7	6.0	5.5
50	5.7	6.4	6.8	6.2
100	6.5	7.3	7.7	7.0



The equivalent ARI for the peak flow of 6.01 m^3/s was 35 Year ARI for the one hour duration. This identifies that the SSR of 68 m^3/s was not able to reduce the 100 year ARI flow to a 5 year ARI flow for the test subcatchment. Instead, the SSR only achieved a 35 year ARI flow.

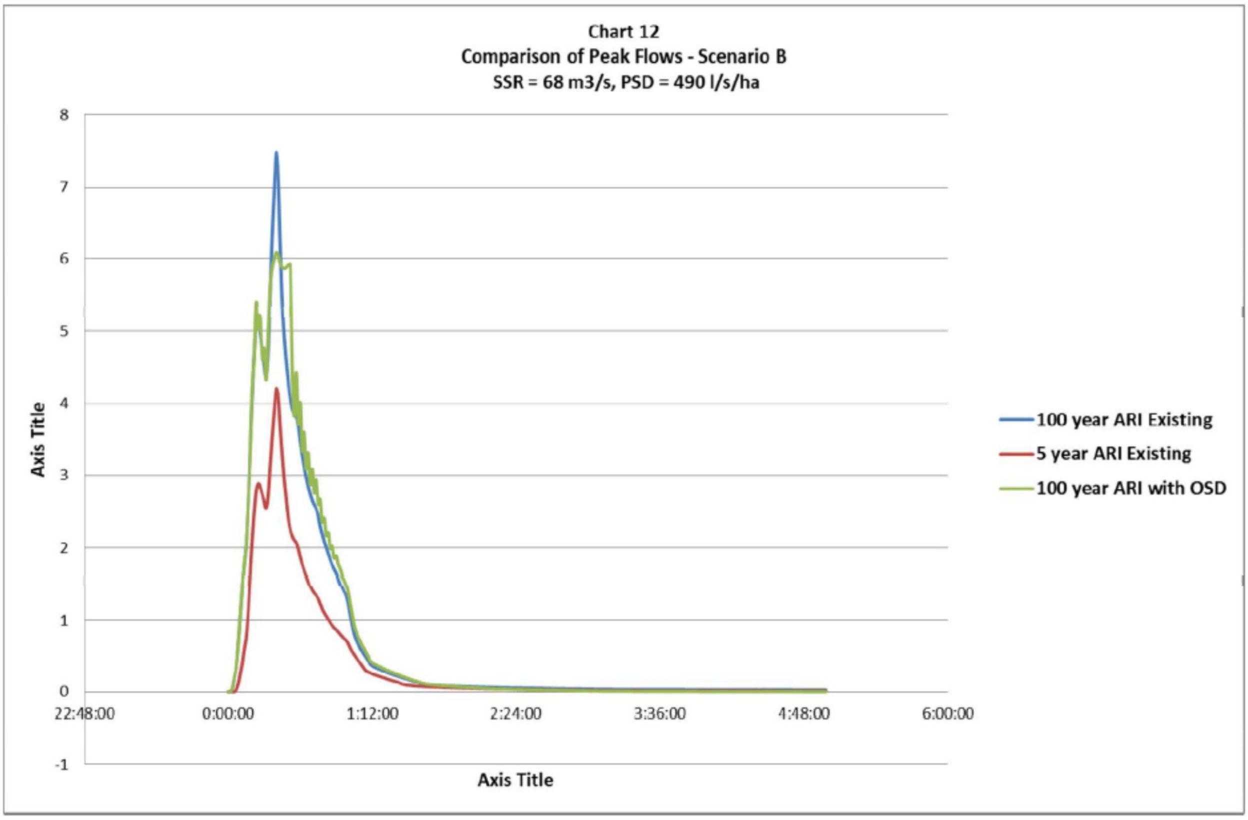
Based on a peak flow of 6.01 m^3/s and the area of the test sub-catchment and the SSR estimated by Council, the following initial SSR and PSD values were identified:

- SSR = 68 m^3/ha
- PSD = 569 l/s/ha

The above values were then refined and verified for the local test sub-catchment using the RAFTS model to achieve the 35 Year ARI flows. The updated SSR and PSD requirements are:

- SSR = 68 m^3/ha
- PSD = 490 l/s/ha

Chart 12 shows the comparison of peak flows (extracted from RAFTS) for the representative catchment area for the 100 Year Ari flows without OSD, the 100 Year ARI flows when an SSR of 68 m^3/ha is applied (i.e. approximately 2,000L per lot) and the 5 Year ARI flows without OSD (Council's Policy Objective).



The OSD parameters were then applied to the Whites Creek Catchment. It was found that OSD was effective for the local catchment but ineffective in the global catchment. **Charts 14 to 18 depict** the existing to OSD comparison for the nodes in **Table 4-5** excluding node 26. The charts depict that the existing OSD policy is inadequate for the local and global catchments.

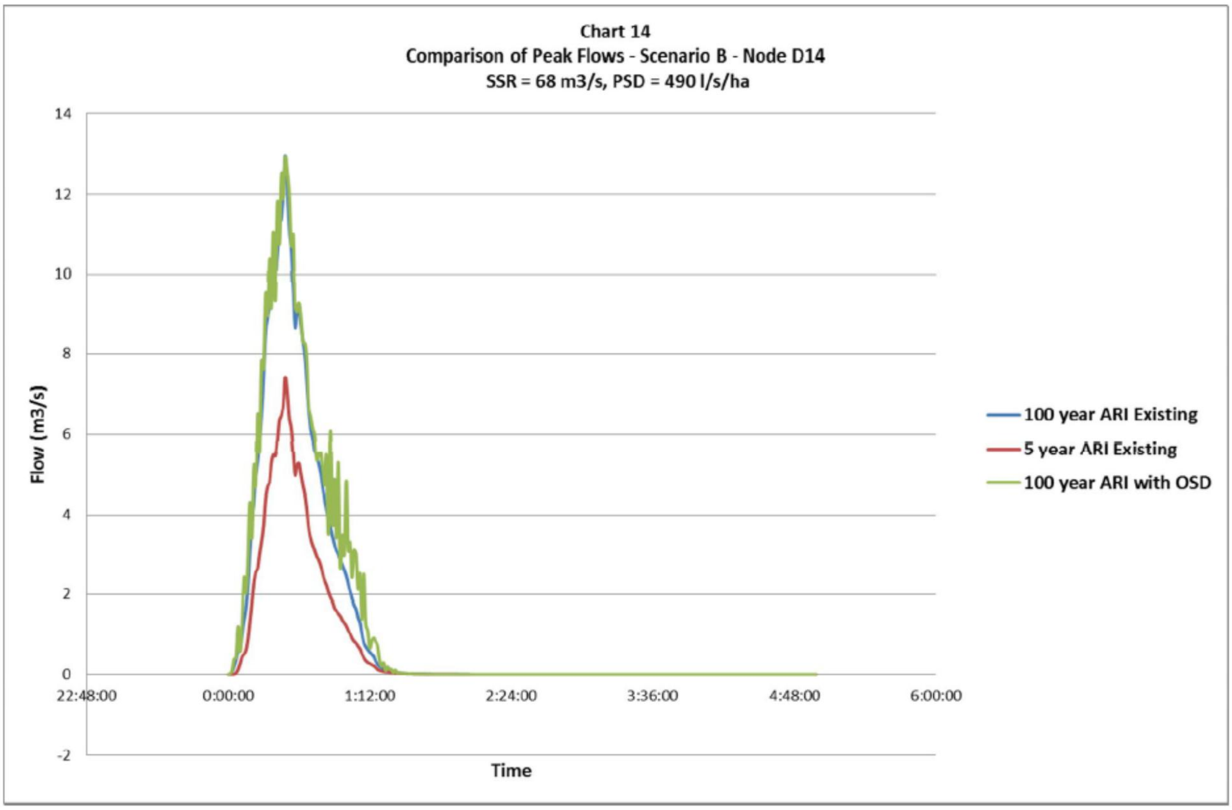


Chart 14
Comparison of Peak Flows - Scenario B - Node D14
SSR = 68 m3/s, PSD = 490 l/s/ha
Flow (m3/s)
14
12
10
8
6
4
2
0
-2
22:48:00
0:00:00
1:12:00
2:24:00
3:36:00
4:48:00
6:00:00
Time
100 year ARI Existing
5 year ARI Existing
100 year ARI with OSD

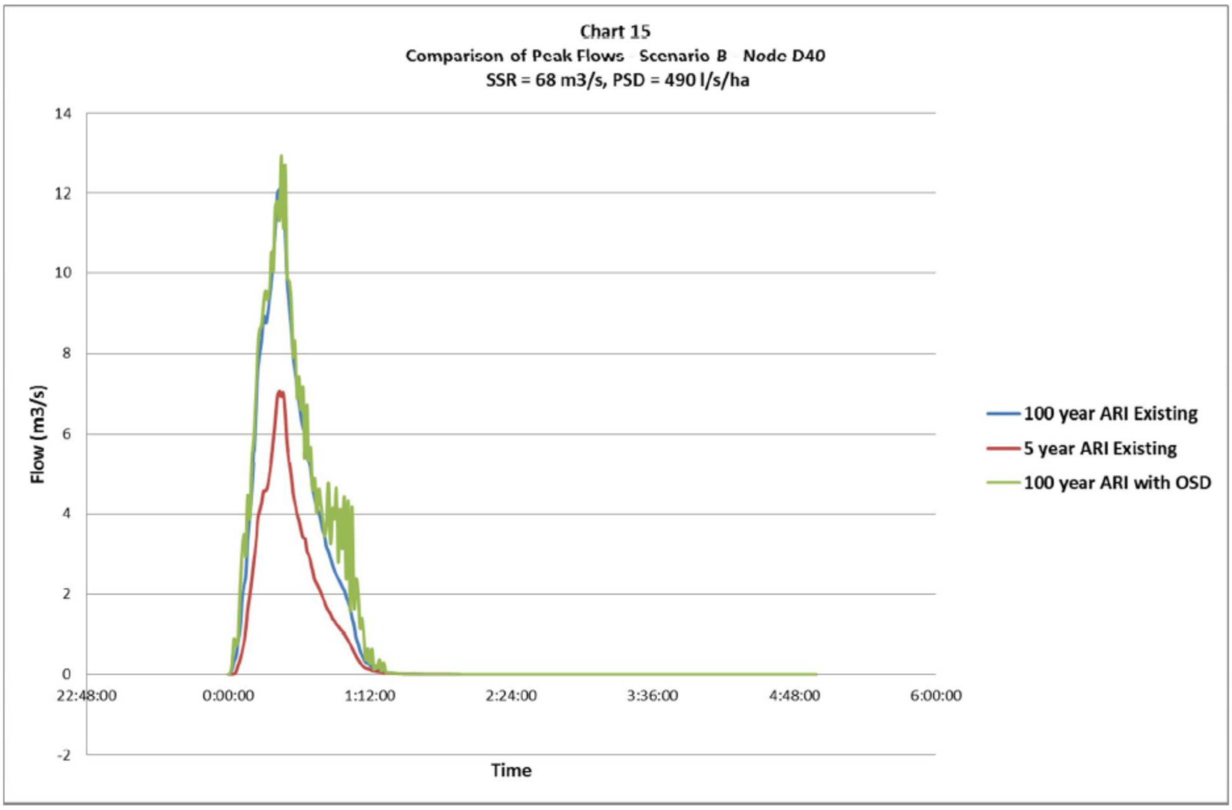


Chart 15
Comparison of Peak Flows Scenario B Node D40
SSR = 68 m3/s, PSD = 490 l/s/ha
Flow (m3/s)
14
12
10
8
6
4
2
0
-2
22:48:00
0:00:00
1:12:00
2:24:00
3:36:00
4:48:00
6:00:00
Time
100 year ARI Existing
5 year ARI Existing
100 year ARI with OSD

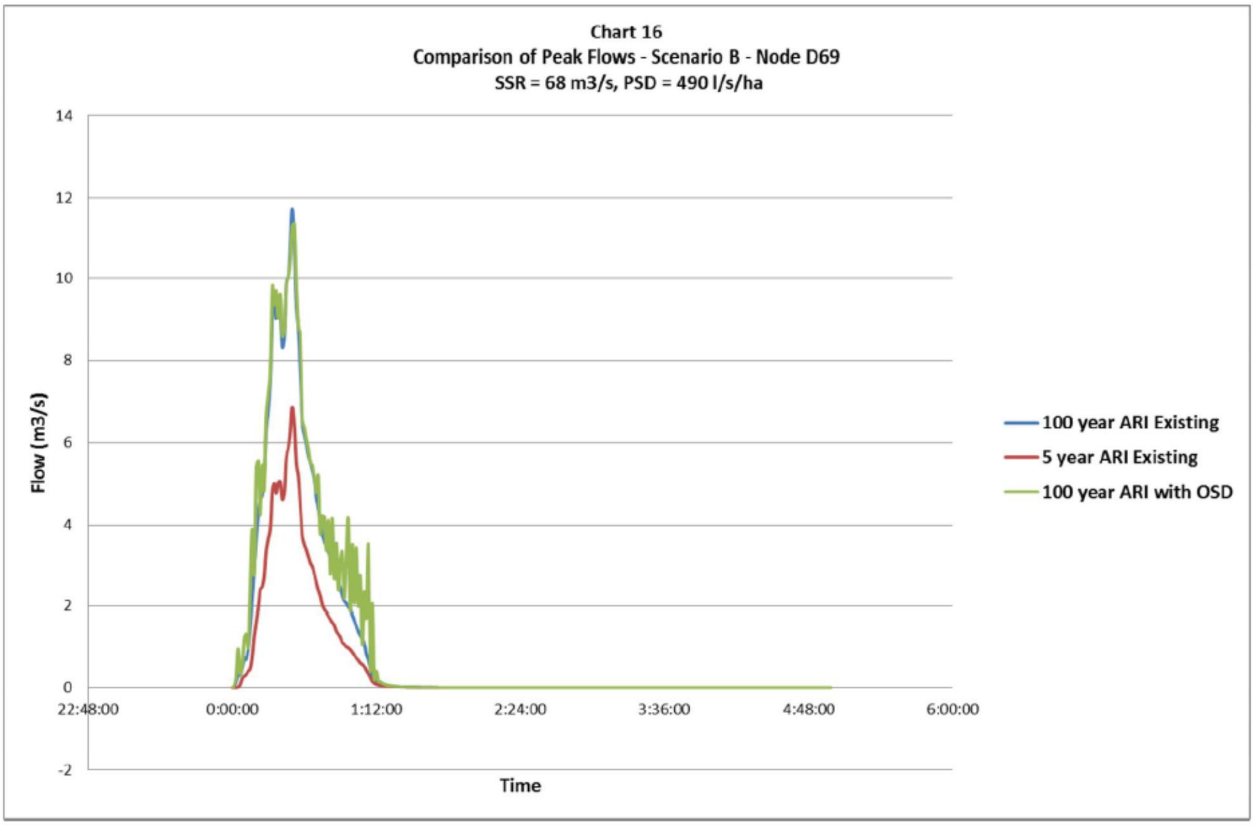


Chart 16
Comparison of Peak Flows - Scenario B - Node D69
SSR = 68 m3/s, PSD = 490 l/s/ha
Flow (m3/s)
14
12
10
8
6
4
2
0
-2
22:48:00
0:00:00
1:12:00
2:24:00
3:36:00
4:48:00
6:00:00
Time
100 year ARI Existing
5 year ARI Existing
100 year ARI with OSD

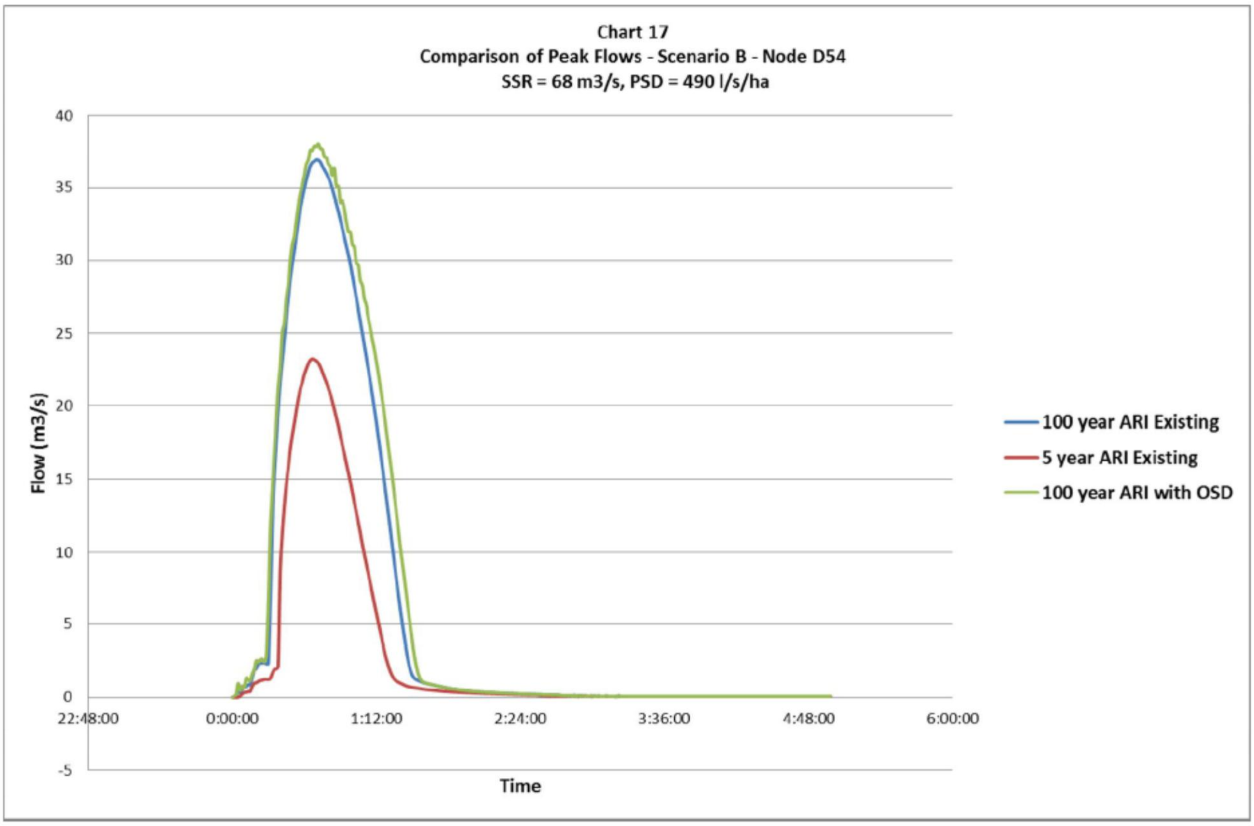


Chart 17
Comparison of Peak Flows - Scenario B - Node D54
SSR = 68 m3/s, PSD = 490 l/s/ha
Flow (m3/s)
40
35
30
25
20
15
10
5
0
-5
22:48:00
0:00:00
1:12:00
2:24:00
3:36:00
4:48:00
6:00:00
Time
100 year ARI Existing
5 year ARI Existing
100 year ARI with OSD

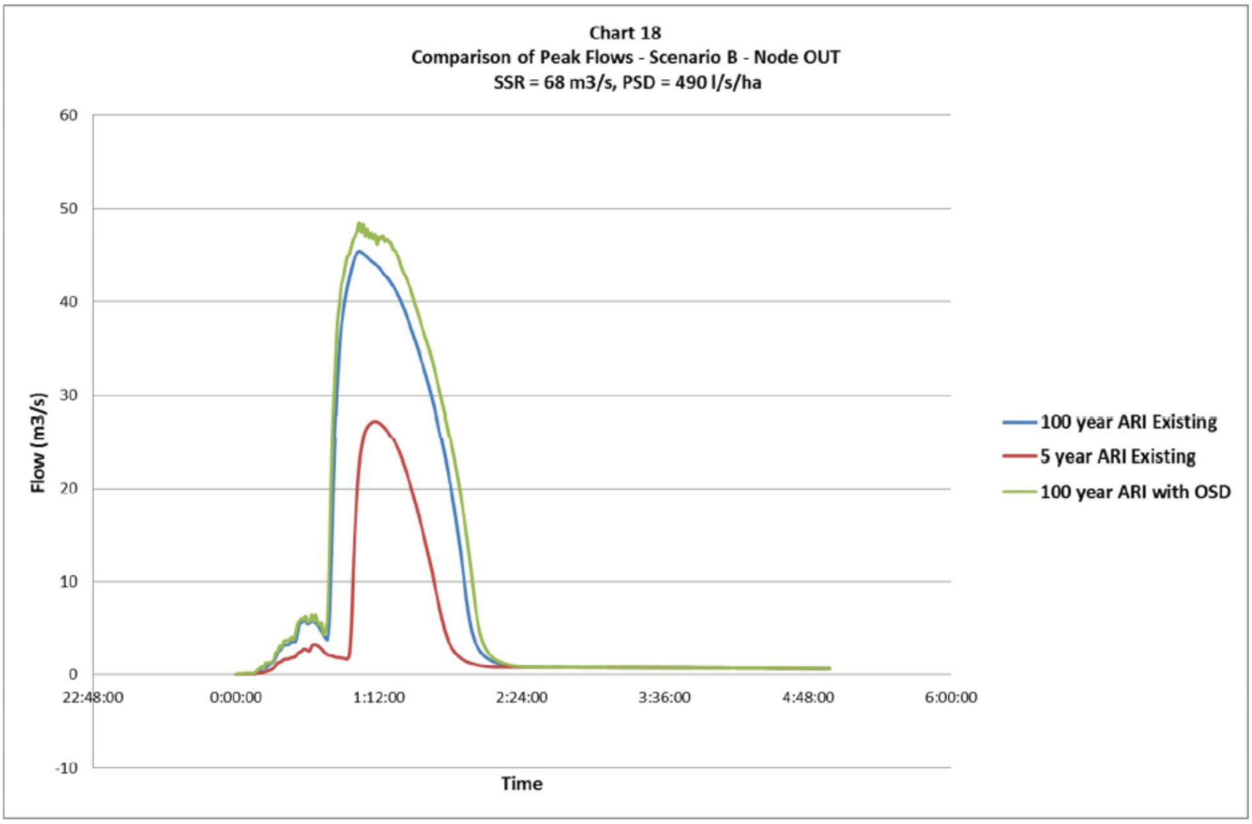


Table 4-9 gives a summary of the peak flows for the different scenarios for the representative catchment.

Table 4-9 – Summary of the Peak flow for the Different scenarios for the representative Catchment (RAFTS)

	Existing – 100year Peak Flow	Existing – 5year Peak	Scenario A Peak Flow	Scenario B Peak Flow
Flow (m3/s)	7.4 7	4.21	6.09	4.20

4.3.3 Downstream OSD Exclusion Zones

The modelling identified that applying OSD had benefits at a small scale but there were limited benefits at the downstream end of the catchment. Exclusion zones for OSD can be applied where the implementation of OSD has negligible benefits or in some cases, actually worsens flooding. For example, it may be beneficial to allow the flows in the downstream portions of the catchment to be discharged prior to the flows from the upstream areas “coming through”. By detaining the local flows in the downstream areas, the flood peaks may actually end up coinciding with other catchment flows, thereby resulting in increased flood levels or durations of flooding.

Hydrological modelling was undertaken to assess the impacts of not applying OSD to the downstream portions of the Whites Creek Catchment. OSD was not applied downstream of Node C73 (see **Figure 4-1)**.

The following OSD parameters were modelled in the upstream areas:

- SSR = 300 m3/ha
- PSD = 300 l/s/ha

The results for both the OSD applied across the whole catchment and OSD removed from the exclusion zones are shown in **Figures 4-5 and 4-6**.

The results indicate that there is very little difference in flood behaviour within the 100 Year ARI flood extent when comparing the application of OSD in the exclusion zones and without OSD in these zones. The small difference that is shown should be interpreted within the context of the limitations of the hydrological modelling. As such, the difference is not considered to be of likely significance.

Although the flood behaviour is not impacted within the 100 Year ARI flood extent, there are local benefits to applying OSD within the exclusion zone. This may include management of property flows to the street, reduced ponding depths on roads and public areas and general reduced likelihood of drainage issues.

4.3.4 No OSD on Low Density Residential Development

While OSD can often more readily be included in commercial, industrial and high density developments, low density (i.e. single lot) residential development can be restricted by lot size and other site constraints such as the ability to excavate for OSD. As such, the impacts of not applying OSD to low density residential development was assessed.

The following OSD parameters were applied:

- Low density (i.e. single lot) residential development: no OSD or OSR
- All other development type: SSR = 300 m^3/ha and PSD = 300 L/s/ha

The results are shown in **Figure 4-7**, this should be compared against **Figure 4-5** to interpret the impact of this scenario on drainage and flood flows. The model results showed that due to the fact that the majority of land use in the catchment is low density residential development, the lack of OSD on these properties resulted in almost no reduction in flood flows across the catchment.

4.3.5 Hydrological Testing of Rainwater Tank Offsets

The research currently available regarding the use of rainwater tanks for OSD suggests that there are considerable opportunities for providing OSD offsets in traditional rainwater tanks.

Council has in the past allowed a rainwater tank offset of 2.5 OSR : 1 OSD. The effectiveness of this approach was tested by reducing the OSD for all lots by 1m^3 and applying a rainwater tank volume of 2,500 L (2.5m^3). The results are shown in **Figure 4-8**. This should be compared against **Figure 4-5** to interpret the impact of this offset scenario has on drainage flows and flood flows. It was found that this significantly reduced the effectiveness of OSD, with the 100 Year ARI Flows in the upstream reaches being reduced to approximately 50 Year ARI flows.

An alternative approach was then assessed as follows:

- OSD was applied to all development except low density (i.e. single lot) residential development at the following rate:
  - SSR = 300m^3/ha and PSD = 300 L/s.
- OSR was applied to all low density (i.e. single lot) residential development, using 5,000 L/lot.

In both of the scenarios above, it has been assumed that the same rainwater tank policy has been applied upstream of the study boundary (i.e. upstream of Parramatta Road).

The results are shown in **Figure 4-9**. This should be compared against **Figure 4-5** to interpret the impact of this offset scenario has on drainage flows and flood flows. The results identified that while the flood management outcomes are not as beneficial as applying OSD to all development types, there is still a flood benefit from this approach (reductions of the 100 Year ARI flows to approximately 20 Year ARI flows in the upstream reaches of the floodplain).

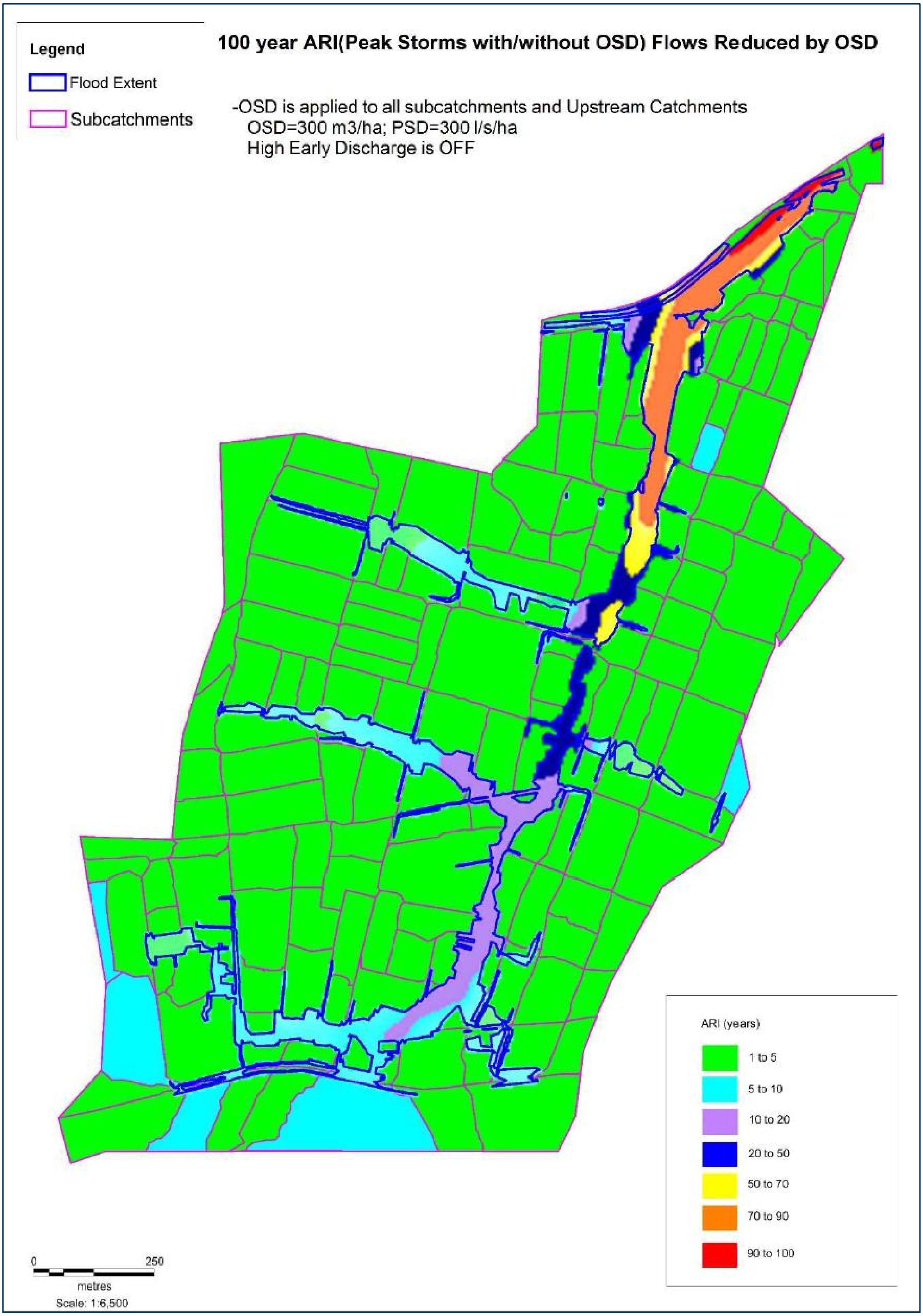


Figure 4-5 OSD Applied to Entire Catchment

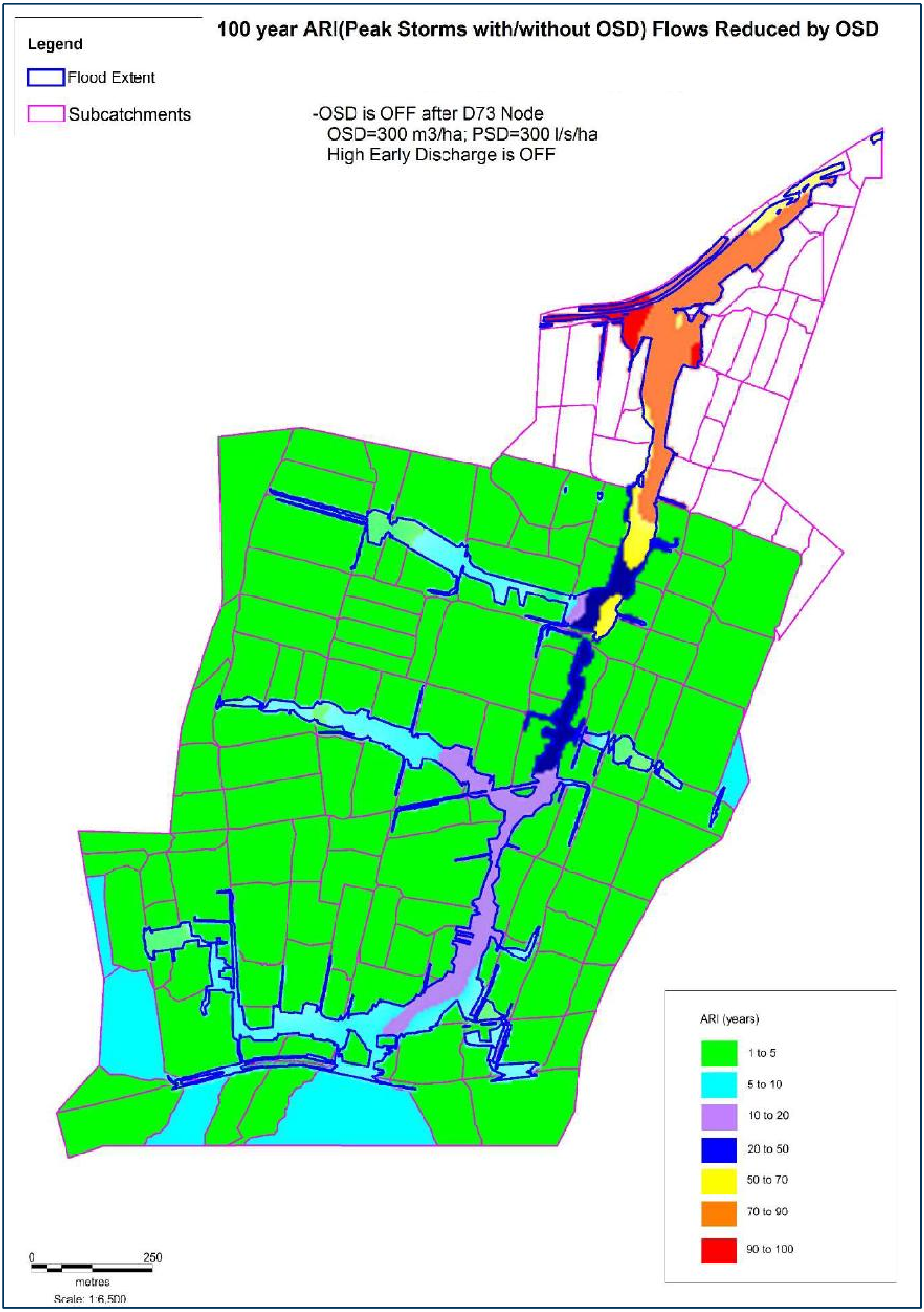


Figure 4-6 OSD not Applied in Exclusion Zones

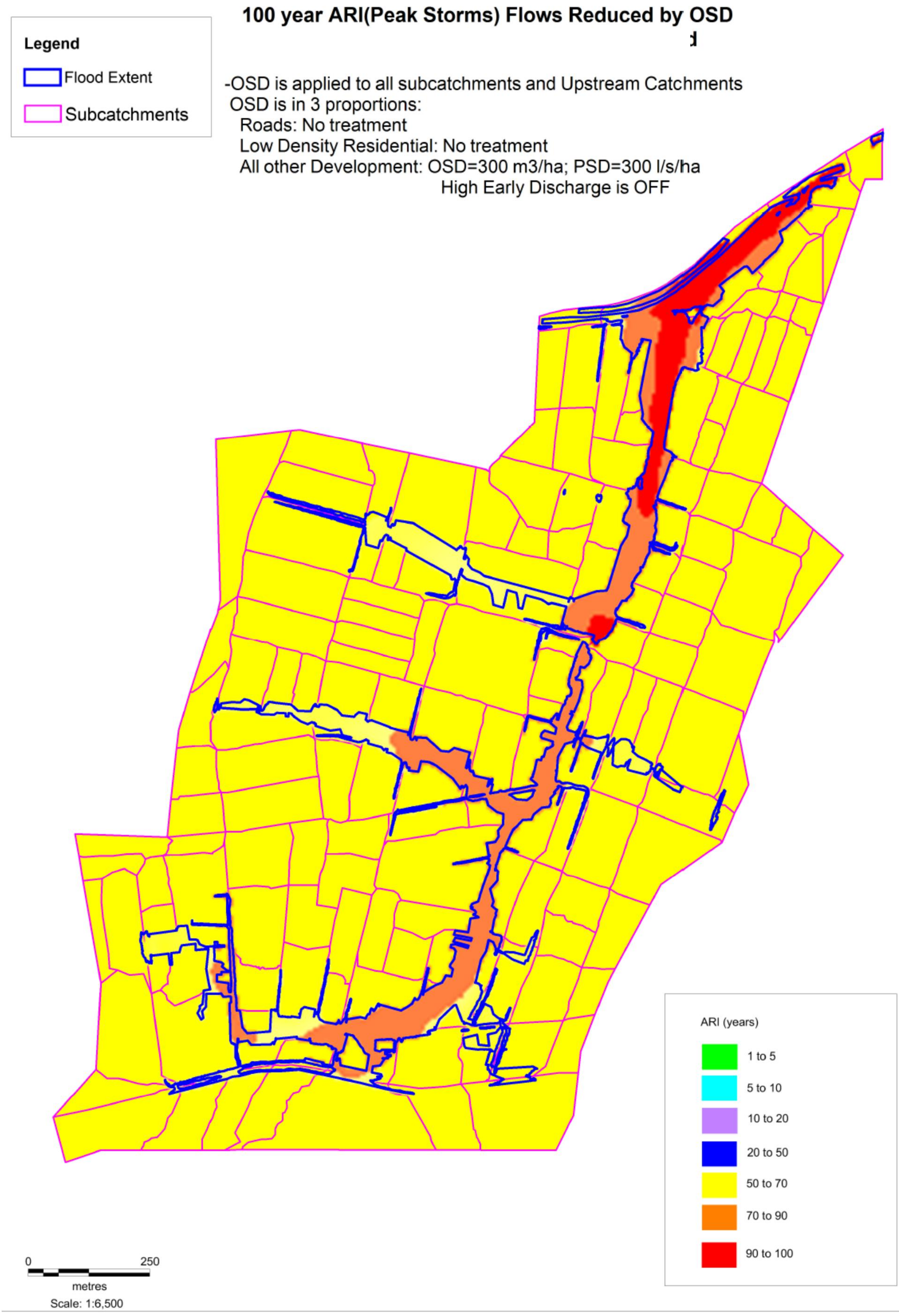


Figure 4-7 No OSD on Low Density Residential Development

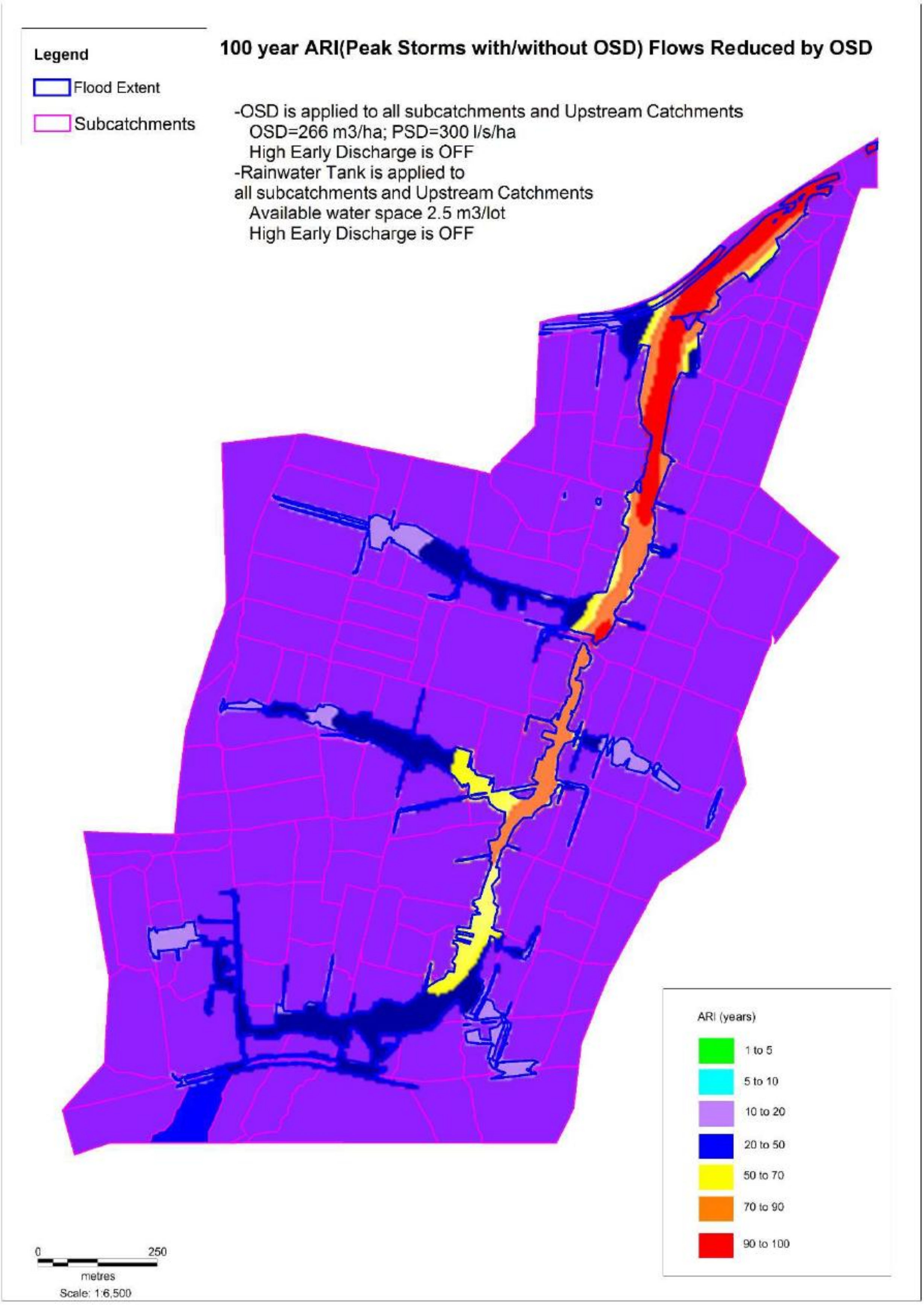


Figure 4-8 Testing 2,500L Rainwater Tank Offset for OSD

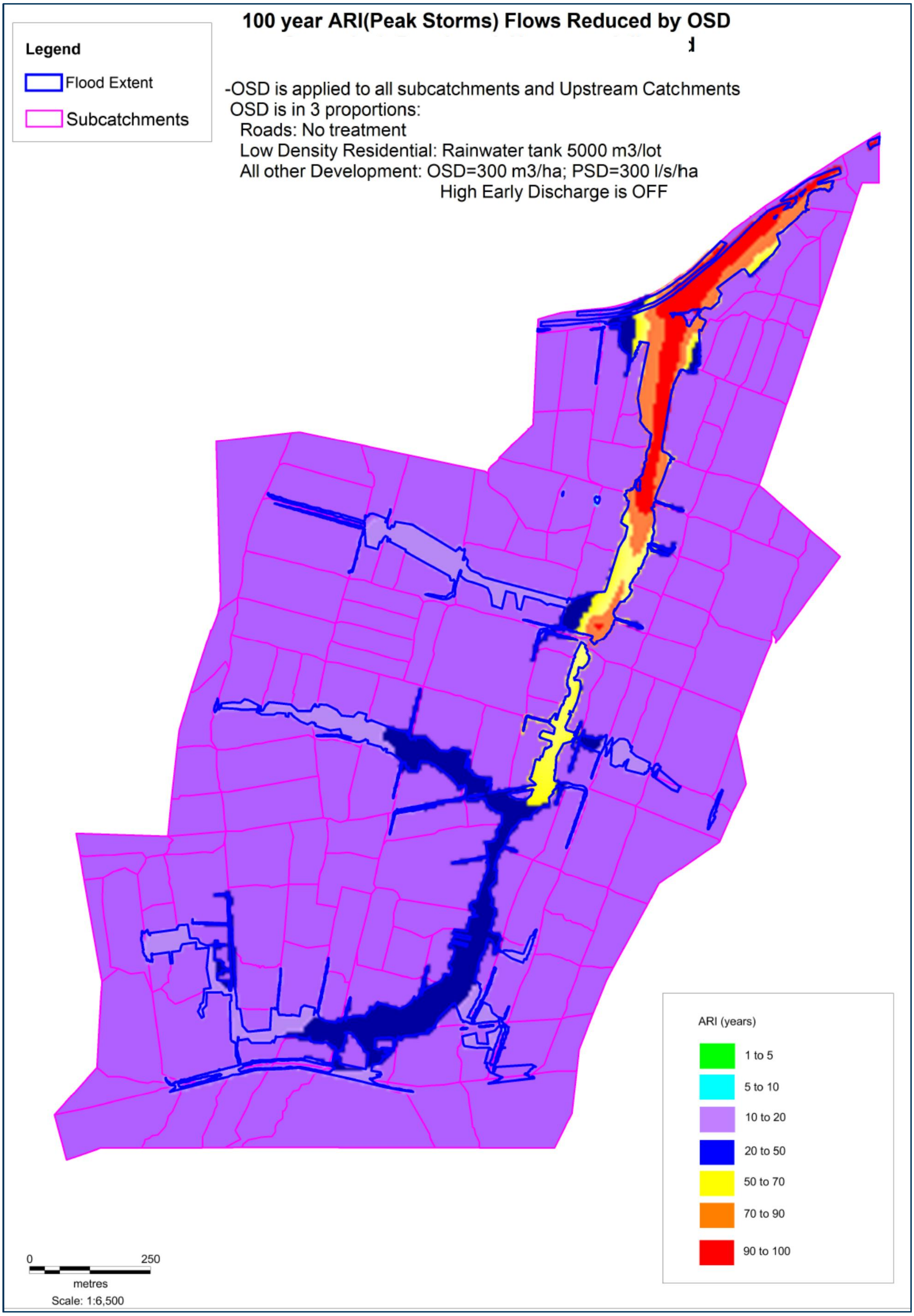


Figure 4-9 Testing 5,000L Rainwater Tank for Low Desnrity Residential

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Leichhardt Floodplain Risk Management Study and Plan

APPENDIX D

MITIGATION OPTION ASSESSMENTS SUB-CATCHMENT REPORTS

Cardno
Shaping the Future

Area 1 - Hawthorne Canal Options Assessment

Leichhardt Flood Risk Management Study and Plan

NA49913094

Prepared for
Inner West Council

Cardno
Shaping the Future

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Tables

Figures

1 Hawthorne Canal Catchment Description

The catchment for Hawthorne Canal is in the order of 670 hectares in size, and is the single largest catchment in the study area. A large portion of the catchment, greater than 400 hectares, is located outside of the study area.

The majority of the flooding issues within the Hawthorne Canal catchment occur upstream of the rail line that runs generally parallel to the canal. In this area, there are no formalised creeks or channels, and when the capacity of the existing pipe system is exceeded overland flow proceeds down streets and through properties.

There are a number of tributaries of the Canal in this area, the largest of which originates from upstream of Parramatta Road (outside of the study area).

The rail line itself forms a major hydraulic control in the study area, and significant ponding occurs upstream of this location. The ponding is largely influenced by the capacity of the culverts under the rail line connecting to Hawthorne Canal. The high hazard classification in this area is depth governed.

Flooding from the main Canal itself is limited to the west of the rail line, and does not affect a significant number of properties within the Study Area. However, flood levels within the Canal can affect the conveyance of flows from the culverts originating on the eastern side of the rail line.

The options proposed for assessment in the report are located within the study area portion of the Hawthorne Canal Catchment.

The location of the Hawthorne Canal Catchment within the Study Area is shown in Figure 1-1.

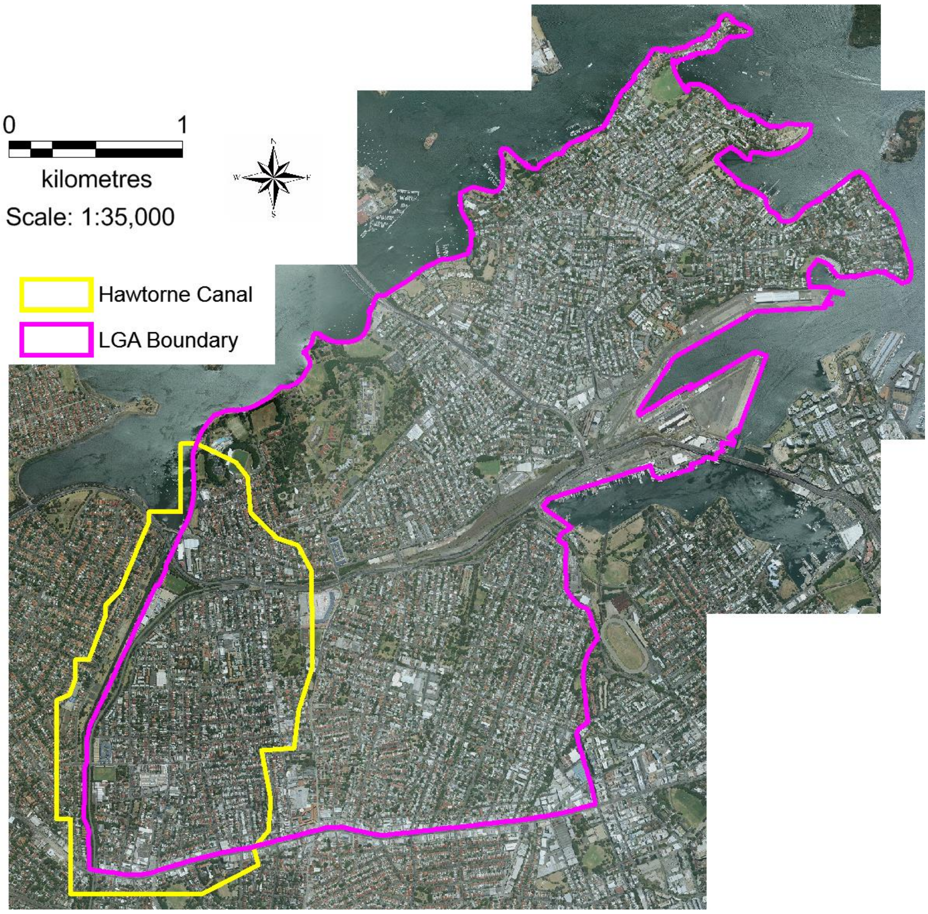


Figure 1-1 Hawthorne Canal Catchment Location

2 Flood Mitigation Options Identification

2.1 Flood Modification Measures for Hawthorne Canal

The existing flood behaviour within the Hawthorne Canal is detailed in the Leichhardt Flood Study (Cardno 2014). Based on the flood model results, historical information and engineering judgement, possible flood modification measures (i.e. structural measures) for the study area were identified.

The various management options were identified taking into consideration the:

- flood behaviour and flow in the 20 year ARI event;
- grade of pipe (upstream and downstream); and
- preliminary availability and location of easements.

It should also be noted that Sydney Water and RMS may also play a major role in regards to fund allocation for the options recommended. Sydney Water's approach to flood-related improvement works on its assets is that Sydney Water will work with Councils to deliver the works (typically on a 50:50 cost-sharing basis) and provided Sydney Water has funding available within its Flood Risk Program. It is assumed that RMS will provide all the funding for the transverse pipe sections across State roads. Currently no allocation of RMS funding has been assigned for infrastructure travelling longitudinally along State Roads. It is likely that some contribution would be required from RMS for these upgrades in State Road easements. The total cost for HC-FM5 was allocated to RMS.

Flood modification measures for the Hawthorne Canal Catchment have been identified based on opportunities to connect with future upgrades and improvements.

2.2 Hawthorne Canal Flood Mitigation Options

Within the Hawthorne Canal catchment five (5) sets of options were modelled. These are shown in **Table 2-1** and **Figure 2-1**. The 100yr, 20yr and 5yr ARI peak water level difference plots for each mitigation option are attached at the end of this appendix report.

Table 2-1 Hawthorne Canal Mitigation Options

Option Description	Option Name	ID
Beeson Street Flow Path - Additional pipes /culverts from Parramatta Road to Hawthorne Canal via Beeson Street.	Beeson Street Flow Path HC-FM1	HC-FM1
Marion Street Flow Path – Additional pipes or duplication of existing network from Reuss Street to Hawthorne Canal via Elswick Street, Flood Street and Marion Street.	Marion Street Branch HC-FM2	HC-FM2
Regent Street Flow Path – Additional pipes/culverts from Elswick Street to Hawthorne Canal (via Regent Street and Darley Road). Also extra pipes at Darley Road to reduce flood depths on the Road.	Regent Street Branch HC-FM3	HC-FM3
Hubert Street Flow Path - Additional pipes/ culverts from William Street to Hawthorne Canal via Hubert Street and Darley Road.	Hubert Street Branch HC-FM4	HC-FM4
Darley Road - Proposed culverts through the rail embankment to drain flood waters from Darley Road to Hawthorne Canal.	Darley Road Branch HC-FM5	HC-FM5

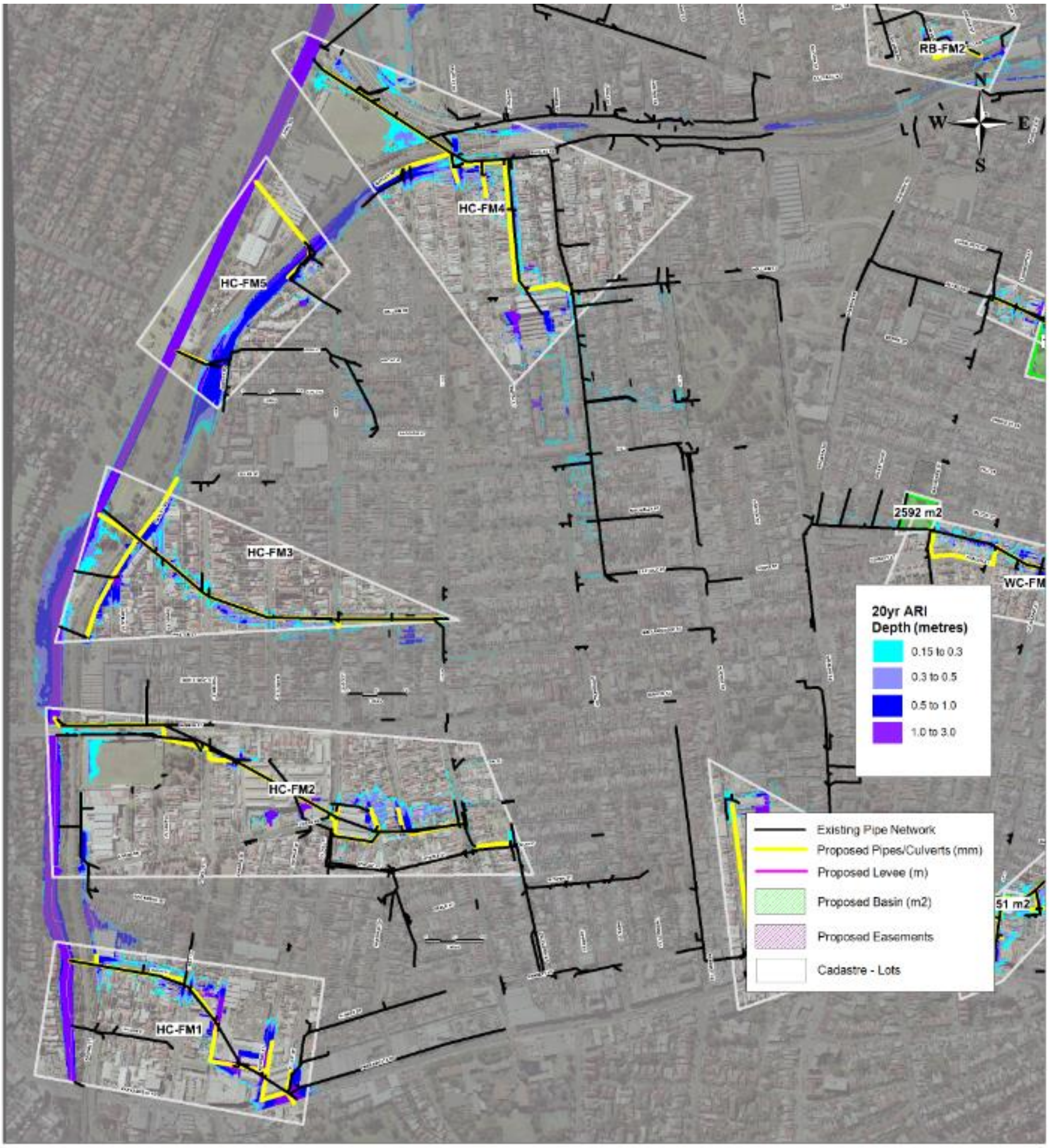


Figure 2-1 Hawthorne Canal Mitigation Options Locations

2.2.1 Beeson Street Flow Path HC-FM1

HC-FM1 consists of additional pipes and culverts from Parramatta Road to Hawthorne Canal via Beeson Street. This option aims to mitigate flood inundation due to the 20 year ARI flood event. The option is expected to mitigate the inundation experienced along the sections of Flood Street, George Street, Upward Street and Tebbutt Street that are located between Parramatta Road and Kegworth Street. Flooding on Beeson Street is also expected to reduce.

Under existing conditions, the worst flooding due to the 20 year ARI event takes place on Flood Street, George Street, Upward Street and Parramatta Road with depths up to 1.9m.

The main branch of the option comprises of a box culvert (2.4m x 2.1m) that is 625m in length. There are also 1800mm diameter pipes connecting to the culverts at Parramatta Road, Flood Street and George Street as well as a pipe at the western end of Beeson Street.

There is a new development currently underway at 22 George Street, Leichhardt. This development has incorporated re-routing and upgrading if the existing trunk drainage pipeline passing through the property, consistent with the recommendations of this mitigation option. The development is also required to make provision for a future overland flow path between McAleer and Upward Streets to cater for larger storm events, consistent with the objectives of this mitigation option.

Construction of the culvert from Flood Street to George Street along Parramatta Road will be difficult, as there are challenges with the grade and there are likely to be significant services in this area. If any re-development is scheduled to occur in the industrial block between Flood Street and George Street, the proposed culvert could be incorporated into the development which would simplify the design. It should be noted that this option would also rely on drainage upgrade on the Southern side of Parramatta Road, within Petersham.

Potential constraints for this measure also include construction of a pipeline under the rail corridor and pipe crossings of major roads, especially Parramatta Road, with associated costs due to construction, services and traffic management requirements. Any pipeline upgrade between Upward Street and Tebbutt Street will most likely be reliant upon future development of these properties and being able to incorporate the upgraded pipeline and overland flow path into the development.

In regards to cost allocation between the primary asset owners, both RMS and Sydney Water could potentially share a majority of the cost alongside Council. The transverse drainage across Tebbutt Street and Parramatta Road would ideally be allocated to RMS while the remaining major trunk drainage upgrades will potentially be the responsibility of Sydney Water.

2.2.2 Marion Street Branch HC-FM2

HC-FM2 on Marion Street contains new pipes and modifications to the existing network. The option begins from Reuss Street and ends at Hawthorne Canal via Elswick Street, Flood Street and Marion Street. The aim of the option is to mitigate flood inundation due to the 20 year ARI event which produces flooding at the car park adjacent to Lord Street.

The main branch of the option comprises of a 1500mm diameter pipe that is 900m in length. Pipes, 900mm in diameter, connect to the main branch on Edith Lane, Ivory Lane and Flood Street and a 600mm diameter pipe is used on Reuss Street.

The final alignment of the upgrades would be subject to ongoing liaison with Sydney Water to look at potential opportunities to upgrade Sydney Water pipelines located nearby in lieu of additional pipelines through 1A Lords Road.

There will be costs associated due to construction, services and traffic management requirements. There is potential for RMS (Foster Road transverse crossing) and Sydney Water (Main trunk drainage) to share some of the cost.

2.2.3 Regent Street Branch HC-FM3

This option consists of two major branches. One branch is along Darley Road between Walter Street and Allen Street. The Darley Road branch consists of a Culvert (1.5mx0.9m) that is 350m in length. This culvert targets the ponding which occurs behind the rail line on Darley Road.

The other branch starts from Elswick Street and ends at Hawthorne Canal and consists of 900mm and 1200mm diameter pipes with a combined length of 650m plus a box culvert (1.8m x 1.5m) with a length of 80m. This branch travels through Regent Street and crosses Edith Street, Flood Street, Burfitt Street, Foster Street and Daniel Street and finally Darley Road and then beneath the railway track and into Hawthorne Canal. Heavy flooding as a result of the 20 year ARI storm event is expected at the intersection of Darley Road and Loftus Street with depths in this location of around 1.1m.

A major constraint for this measure consists of the tunnelling under the railway line plus other construction costs that maybe required for pipe crossings beneath the railways line. To reduce these costs and construction constraints the viability of construction of a new pipeline from Darley Road via the existing pedestrian subway between Darley Road and Hawthorne Canal instead of tunnelling beneath the railway line could also be investigated.

In addition to the tunnelling constraint the pipeline has to be upgraded through substantial lengths of private property, which may require the buyback of 4 properties. It is likely to be more feasible to continue the pipeline through the four properties, because an alternative alignment to reduce the property buy-backs will require pits at a depth of 3m below the current road level.

In regards to the primary asset owners in the area (RMS, Sydney Water and Council), RMS could possibly be apportioned part of the upgrade cost. The cost applicable to RMS would involve the transverse drainage in Foster Street.

It is noted that an alternative is to split this option into two components, being those works upstream and downstream of Darley Road . Construction of the Darley Road culvert and crossing under the rail line would assist in alleviating the flooding in this area, without construction of the longer pipe up to Elswick Street which has a number of constraints.

2.2.4 Hubert Street Branch HC-FM4

HC-FM4 consists of pipes and culverts from William Street to Hawthorne Canal via Hubert Street and Darley Road. There are two types of culverts. One is a 2.4mx2.1m culvert 300m in length that begins from the Charles Street/Darley Road Intersection and drains onto Hawthorne Canal after crossing Canal Road. The other culvert (2.1mx1.8m) is 90m in length and travels along Darley Road between Hubert Street and Charles Street. The proposed pipes consist of a 1800mm diameter line and a separate 1200mm diameter line. The 1800mm diameter pipe is 320m in length and starts on Francis Street, travels along William Street and then onto Hubert Street, finally ending at Darley Road. The 1200mm diameter pipes are located on an Un-Named Lane between Hubert Street and Charles Street, Charles Street and Darley Road.

The worst of the flooding is predominantly on Darley Road with depths approaching the 1m level during the 20 year ARI storm event. Potential constraints include costs due to construction, services and traffic management requirements on Darley Road.

An alternative is split this option into two components, being initially the construction of the works at Darley Road , with a long term aim to construct the other upstream sections. This would assist in addressing the flooding issues on Darley Road.

RMS funding could be investigated for works that involve transverse drainage in Darley Road.

2.2.5 Darley Road Branch HC-FM5

The Darley Road branch consists two sections of proposed culverts that cross through the rail embankment to drain flood waters from Darley Road to Hawthorne Canal. One section consists of a culvert (1.8m x 1.2m) with a length of 60m and is on Darley Road between Athol Street and Lyall Street. The other section consists of a 1200mm diameter pipe starting from the William Street/ Darley Road intersection then connecting to a 1.8m x 1.2m culvert on Darley road that crosses beneath the rail embankment.

Major flooding due to the 20 year ARI storm event is on Darley Road with depths to around 1.25m. A major constraint for this measure consist of the tunnelling plus other construction costs that maybe required for pipe crossing at the railways line.

RMS funding could be investigated to contribute for most of the costs related with this option. This includes the sections that are upgraded on Darley Road.

3 Mitigation Option Modelling Outcomes

The Hawthorne Canal flood mitigation options were assed for the 5, 10, 20, 50 and 100 Year ARI design flood events, along with the PMF event.

The outcomes of the modelling are shown in the 5, 20, and 100 Year ARI water level difference plots attached at the end of this catchment report.

A summary of the impacts on flood behaviour for each option is provided below.

3.1 Beeson Street Flow Path HC-FM1

The proposed increase in drainage capacity of mitigation option HC-FM1 is shown to reduce overland flows along the Beeson Street flow path. The mitigation strategy shows water level decreases of 0.2m – 0.5m along sections of Parramatta Road, Flood Street, George Street, Upward Street and McAleer Street, and Beeson Street leading into Hawthorne Canal.

Significant reductions are apparent at properties located on Upward Street, Tebbutt Street, Beeson Street and Kegworth Street. Modelling of this mitigation strategy indicates that 63 properties would have a decrease in water level of more than 0.15m in the 20 Year ARI event.

3.2 Marion Street Branch HC-FM2

The increase in drainage capacity at the Marion Street Branch proposed in HC-FM2 is shown to decrease flood levels by 0.2m – 0.5m in the vicinity of Ivory Street, Edith Street and Edith Lane in the 20 Year ARI event. Significant water level decreases of more than 0.5m are also apparent at the car park adjacent to Lord Street in this event. A 0.2m – 0.5m water level decrease is also visible in properties between Edith Street and Flood Street in the 20 Year ARI event. Results indicate that 21 properties would experience a decrease in water level of more than 0.15m in the 20 Year ARI event due to this mitigation strategy.

3.3 Regent Street Branch HC-FM3

Mitigation option FM3 shows significant water level decreases of more than 0.5m in some areas of Darley Road between Walter Street and Allen Street in the 20 Year ARI event. Decreases are also observable upstream, along Regent Street at Elswick Street, Edith Street and Flood Street, as well as Burfitt Street, Forster Street and Daniel Street towards Hawthorne Canal. The increased conveyance under the railway to Hawthorne Canal reduces flood levels on a number of residential properties, with 22 properties showing a water level decrease of more than 0.15m in the 20 Year ARI event.

3.4 Hubert Street Branch HC-FM4

Mitigation option HC-FM4 shows significant decrease in water levels either side of the railway at Darley Road and Charles Street. The most significant reductions are seen at the intersections of Darley Road and Falls Street, Elswick Street and Charles Street. These reductions are between 0.2m and 0.5m in the 20 Year ARI event. Water level decreases of 0.01m to 0.2m are also observable at Blackmore Park and along Canal Road in the 20 Year ARI event. Results indicate that 26 properties would experience a decrease in water level of more than 0.15m in the 20 Year ARI event due to this mitigation strategy.

3.5 Darley Road Branch HC-FM5

Mitigation option HC-FM5 shows a decrease in ponding along Darley Road between Walter Street and Falls Street due to an increase in conveyance beneath the railway embankment to Hawthorne Canal. The majority of this water level decrease in the 20 Year ARI is between 0.2m and 0.5m. Results indicate that 9 properties would experience a decrease in water level of more than 0.15m in the 20 Year ARI event due to this mitigation strategy.

4 Economic Assessment of Flood Damages in the Hawthorne Canal Catchment

4.1 Hawthorne Canal Mitigation Options Damages Assessment

An assessment of damages for the existing condition in the Hawthorne Canal Catchment is presented in the Floodplain Risk Management Study. The approach adopted for calculating the existing damages has been repeated for the modelling results from the mitigation options proposed for the Hawthorne Canal catchment.

The economic flood damage results for each of the options and the existing scenarios are presented in **Table 4-1** to **Table 4-6**. The reductions in properties affected by overground and overfloor flooding, total damages and AAD are provided.

The total reduction in damaged properties and the associated reduction in damage costs for each mitigation strategy is summarised in **Table 4-6**. This table represents a summary of differences between existing and Mitigation scenarios presented in **Table 4-1** to **Table 4-5**.

The flood damages assessment is a useful tool for comparing the merits of various options, it is not a precise flood risk analysis tool and the limitation associated with the assessment should be considered when interpreting the results.

The following information should be considered when interpreting the damages data:

- Negative property or dollar values represent increases from the existing scenario.
- Where an option results in a reduction in flood depths there may not be any reduction in the flood damages where:
  - The reduction in flood depths or extent occur in open space or roadways; or
  - The reduction in flood depths occurs on properties that were not impacted by over floor flooding (i.e. the flooding on the property grounds is shallower but still exists).
- The flood damages are calculated at a discrete location on each property. This location is where the floor level and ground level survey was obtained from. As such, if the flooding occurs at another location on the property other than the survey point, this property will not register any damages with regards to this damages assessment.
- Commercial and industrial damages are only incurred when over floor flooding exists.
- The reduction in the number of properties impacted as a result of an option may vary between different flood events due to the performance of the proposed work under the different flow behaviour of each flood event.

Table 4-1 HC_FM1 Flood Damage Assessment Summary

Event / Property type	Properties with Overfloor Flooding		Properties with Overground Flooding		Estimated Total Damage ($ June 2016)	
	Existing Case	*Mitigation Case*	*Existing Case*	*Mitigation Case*	*Existing Case*	*Mitigation Case*
PMF Event						
Residential	91	82	109	109	$ 7,774,777	$ 6,821,243
Commercial	3	3	4	4	$ 1,302,890	$ 1,290,785
Industrial	38	32	38	36	$ 7,811,077	$ 6,991,709
PMF Total	**132**	**117**	**151**	**149**	**$ 16,888,744**	**$ 15,103,737**
100yr ARI						
Residential	18	6	40	37	$ 1,009,407	$ 290,063
Commercial	2	0	2	2	$ 110,694	$ -
Industrial	24	13	26	22	$ 3,648,873	$ 1,224,851
100yr ARI Total	**44**	**19**	**68**	**61**	**$ 4,768,973**	**$ 1,514,914**
50yr ARI						
Residential	18	7	39	35	$ 960,444	$ 315,935
Commercial	2	0	2	2	$ 104,434	$ -
Industrial	24	9	25	21	$ 3,310,125	$ 1,284,383
50yr ARI Total	**44**	**16**	**66**	**58**	**$ 4,375,003**	**$ 1,600,318**
20yr ARI						
Residential	13	4	32	28	$ 704,390	$ 246,953
Commercial	1	0	2	2	$ 84,980	$ -
Industrial	20	8	22	20	$ 2,604,302	$ 1,039,801
20yr ARI Total	**34**	**12**	**56**	**50**	**$ 3,393,671**	**$ 1,286,754**
10yr ARI						
Residential	11	4	23	19	$ 569,359	$ 231,269
Commercial	1	0	2	2	$ 79,321	$ -
Industrial	20	6	20	18	$ 2,224,903	$ 865,964
10yr ARI Total	**32**	**10**	**45**	**39**	**$ 2,873,583**	**$ 1,097,233**
5yr ARI						
Residential	4	2	11	8	$ 237,109	$ 95,268
Commercial	1	0	2	2	$ 70,209	$ -
Industrial	18	4	19	16	$ 1,667,896	$ 480,795
5yr ARI Total	**23**	**6**	**32**	**26**	**$ 1,975,215**	**$ 576,063**
Total Annual Average Damage					**$ 965,931**	**$ 376,372**

Table 4-2 HC_FM2 Flood Damage Assessment Summary

Event / Property type	Properties with Overfloor Flooding		Properties with Overground Flooding		Estimated Total Damage ($ June 2016)	
	Existing Case	*Mitigation Case*	*Existing Case*	*Mitigation Case*	*Existing Case*	*Mitigation Case*
PMF Event						
Residential	131	116	223	222	$ 8,039,935	$ 7,185,828
Commercial	6	6	6	6	$ 695,940	$ 680,626
Industrial	2	2	2	2	$ 2,628,273	$ 2,442,588
PMF Total	**139**	**124**	**231**	**230**	**$ 11,364,148**	**$ 10,309,043**
100yr ARI						
Residential	26	16	55	53	$ 1,956,331	$ 1,123,743
Commercial	5	4	5	4	$ 361,630	$ 146,889
Industrial	0	0	1	1	$ -	$ -
100yr ARI Total	**31**	**20**	**61**	**58**	**$ 2,317,961**	**$ 1,270,632**
50yr ARI						
Residential	19	16	49	48	$ 1,601,238	$ 1,119,109
Commercial	5	4	5	4	$ 282,991	$ 142,482
Industrial	0	0	1	1	$ -	$ -
50yr ARI Total	**24**	**20**	**55**	**53**	**$ 1,884,229**	**$ 1,261,591**
20yr ARI						
Residential	18	15	43	42	$ 1,498,207	$ 985,487
Commercial	4	3	4	4	$ 109,477	$ 106,782
Industrial	0	0	0	0	$ -	$ -
20yr ARI Total	**22**	**18**	**47**	**46**	**$ 1,607,684**	**$ 1,092,270**
10yr ARI						
Residential	17	11	39	39	$ 1,344,886	$ 859,912
Commercial	3	2	4	4	$ 104,526	$ 100,790
Industrial	0	0	0	0	$ -	$ -
10yr ARI Total	**20**	**13**	**43**	**43**	**$ 1,449,412**	**$ 960,702**
5yr ARI						
Residential	13	10	32	31	$ 1,023,686	$ 798,536
Commercial	2	2	4	4	$ 99,131	$ 99,082
Industrial	0	0	0	0	$ -	$ -
5yr ARI Total	**15**	**12**	**36**	**35**	**$ 1,122,817**	**$ 897,618**
Total Annual Average Damage					**$ 515,255**	**$ 384,745**

Table 4-3 HC_FM3 Flood Damage Assessment Summary

Event / Property type	Properties with Overfloor Flooding		Properties with Overground Flooding		Estimated Total Damage ($ June 2016)	
	Existing Case	*Mitigation Case*	*Existing Case*	*Mitigation Case*	*Existing Case*	*Mitigation Case*
PMF Event						
Residential	113	111	180	178	$ 6,977,319	$ 6,663,452
Commercial	0	0	0	0	$ -	$ -
Industrial	1	1	1	1	$ 203,585	$ 204,891
PMF Total	**114**	**112**	**181**	**179**	**$ 7,180,904**	**$ 6,868,343**
100yr ARI						
Residential	42	24	78	75	$ 2,204,349	$ 1,297,488
Commercial	0	0	0	0	$ -	$ -
Industrial	1	1	1	1	$ 92,138	$ 484
100yr ARI Total	**43**	**25**	**79**	**76**	**$ 2,296,487**	**$ 1,297,972**
50yr ARI						
Residential	36	18	75	70	$ 1,884,444	$ 1,003,401
Commercial	0	0	0	0	$ -	$ -
Industrial	1	0	1	1	$ 83,715	$ -
50yr ARI Total	**37**	**18**	**76**	**71**	**$ 1,968,159**	**$ 1,003,401**
20yr ARI						
Residential	28	13	64	56	$ 1,395,539	$ 729,808
Commercial	0	0	0	0	$ -	$ -
Industrial	1	0	1	1	$ 80,480	$ -
20yr ARI Total	**29**	**13**	**65**	**57**	**$ 1,476,018**	**$ 729,808**
10yr ARI						
Residential	18	11	52	46	$ 1,062,192	$ 639,099
Commercial	0	0	0	0	$ -	$ -
Industrial	1	0	1	1	$ 74,296	$ -
10yr ARI Total	**19**	**11**	**53**	**47**	**$ 1,136,488**	**$ 639,099**
5yr ARI						
Residential	14	10	42	39	$ 854,526	$ 600,027
Commercial	0	0	0	0	$ -	$ -
Industrial	1	0	1	1	$ 66,071	$ -
5yr ARI Total	**15**	**10**	**43**	**40**	**$ 920,598**	**$ 600,027**
Total Annual Average Damage					**$ 426,625**	**$ 264,516**

Table 4-4 HC_FM4 Flood Damage Assessment Summary

Event / Property type	Properties with Overfloor Flooding		Properties with Overground Flooding		Estimated Total Damage ($ June 2016)	
	Existing Case	*Mitigation Case*	*Existing Case*	*Mitigation Case*	*Existing Case*	*Mitigation Case*
PMF Event						
Residential	216	221	372	373	$ 15,099,829	$ 15,406,768
Commercial	23	23	24	24	$ 749,167	$ 760,372
Industrial	0	0	0	0	$ -	$ -
PMF Total	**239**	**244**	**396**	**397**	**$ 15,848,996**	**$ 16,167,140**
100yr ARI						
Residential	82	71	178	177	$ 5,885,739	$ 5,516,880
Commercial	7	7	11	11	$ 127,183	$ 127,194
Industrial	0	0	0	0	$ -	$ -
100yr ARI Total	**89**	**78**	**189**	**188**	**$ 6,012,923**	**$ 5,644,074**
50yr ARI						
Residential	74	63	169	169	$ 5,395,138	$ 4,962,925
Commercial	7	7	10	10	$ 126,664	$ 126,654
Industrial	0	0	0	0	$ -	$ -
50yr ARI Total	**81**	**70**	**179**	**179**	**$ 5,521,802**	**$ 5,089,578**
20yr ARI						
Residential	62	55	155	152	$ 4,744,297	$ 4,342,642
Commercial	7	5	10	10	$ 126,245	$ 85,826
Industrial	0	0	0	0	$ -	$ -
20yr ARI Total	**69**	**60**	**165**	**162**	**$ 4,870,542**	**$ 4,428,468**
10yr ARI						
Residential	57	49	146	141	$ 4,218,891	$ 3,893,819
Commercial	7	5	10	10	$ 125,738	$ 85,315
Industrial	0	0	0	0	$ -	$ -
10yr ARI Total	**64**	**54**	**156**	**151**	**$ 4,344,629**	**$ 3,979,134**
5yr ARI						
Residential	46	42	112	108	$ 3,445,695	$ 3,258,243
Commercial	7	5	9	9	$ 124,934	$ 84,519
Industrial	0	0	0	0	$ -	$ -
5yr ARI Total	**53**	**47**	**121**	**117**	**$ 3,570,629**	**$ 3,342,762**
Total Annual Average Damage					**$ 1,484,594**	**$ 1,383,183**

Table 4-5 HC_FM5 Flood Damage Assessment Summary

Event / Property type	Properties with Overfloor Flooding		Properties with Overground Flooding		Estimated Total Damage ($ June 2016)	
	Existing Case	*Mitigation Case*	*Existing Case*	*Mitigation Case*	*Existing Case*	*Mitigation Case*
PMF Event						
Residential	64	63	83	83	$ 4,001,594	$ 4,002,015
Commercial	0	0	0	0	$ -	$ -
Industrial	3	3	3	3	$ 267,663	$ 265,222
PMF Total	**67**	**66**	**86**	**86**	**$ 4,269,257**	**$ 4,267,238**
100yr ARI						
Residential	24	15	47	47	$ 1,164,144	$ 732,444
Commercial	0	0	0	0	$ -	$ -
Industrial	1	1	1	1	$ 92,138	$ 84,869
100yr ARI Total	**25**	**16**	**48**	**48**	**$ 1,256,281**	**$ 817,312**
50yr ARI						
Residential	17	12	47	47	$ 893,077	$ 612,722
Commercial	0	0	0	0	$ -	$ -
Industrial	1	1	1	1	$ 83,715	$ 82,774
50yr ARI Total	**18**	**13**	**48**	**48**	**$ 976,792**	**$ 695,496**
20yr ARI						
Residential	12	10	40	39	$ 578,480	$ 426,423
Commercial	0	0	0	0	$ -	$ -
Industrial	1	1	1	1	$ 80,480	$ 80,527
20yr ARI Total	**13**	**11**	**41**	**40**	**$ 658,959**	**$ 506,949**
10yr ARI						
Residential	8	6	34	33	$ 413,894	$ 295,650
Commercial	0	0	0	0	$ -	$ -
Industrial	1	1	1	1	$ 74,296	$ 74,316
10yr ARI Total	**9**	**7**	**35**	**34**	**$ 488,189**	**$ 369,966**
5yr ARI						
Residential	2	2	21	20	$ 175,441	$ 129,619
Commercial	0	0	0	0	$ -	$ -
Industrial	1	1	1	1	$ 66,071	$ 66,091
5yr ARI Total	**3**	**3**	**22**	**21**	**$ 241,513**	**$ 195,711**
Total Annual Average Damage					**$ 164,717**	**$ 130,584**

Table 4-6 Reduction in Damages Associated with Each Option

	Overfloor flooding properties reduction	Overground flooding properties reduction	Total Damage Reduction ($)	AAD Reduction ($)
	HC-FM1			
PMF event	15	2	$ 1,785,006	$25,193
100yr ARI event	25	7	$ 3,254,059	$30,144
50yr ARI event	28	8	$ 2,774,685	$73,224
20yr ARI event	22	6	$ 2,106,918	$97,082
10yr ARI event	22	6	$ 1,776,349	$158,775
5yr ARI event	17	6	$ 1,399,152	$209,873
Total				**$594,290**
	HC-FM2			
PMF event	15	1	$ 1,055,105	$10,511
100yr ARI event	11	3	$ 1,047,329	$8,350
50yr ARI event	4	2	$ 622,639	$17,071
20yr ARI event	4	1	$ 515,414	$25,103
10yr ARI event	7	0	$ 488,710	$35,695
5yr ARI event	3	1	$ 225,199	$33,780
Total				**$130,510**
	HC-FM3			
PMF event	2	2	$ 312,561	$6,555
100yr ARI event	18	3	$ 998,515	$9,816
50yr ARI event	19	5	$ 964,759	$25,665
20yr ARI event	16	8	$ 746,211	$31,090
10yr ARI event	8	6	$ 497,388	$40,898
5yr ARI event	5	3	$ 320,570	$48,086
Total				**$162,109**
	HC-FM4			
PMF event	Assumed to be equal to the existing case damages1			
100yr ARI event	11	1	$ 368,849	$4,005
50yr ARI event	11	0	$ 432,224	$13,114
20yr ARI event	9	3	$ 442,074	$20,189
10yr ARI event	10	5	$ 365,494	$29,668
5yr ARI event	6	4	$ 227,867	$34,180
Total				**$101,157**
	HC-FM5			
PMF event	1	0	$ 2,020	$2,205
100yr ARI event	9	0	$ 438,969	$3,601
50yr ARI event	5	0	$ 281,297	$6,500
20yr ARI event	2	1	$ 152,010	$6,756
10yr ARI event	2	1	$ 118,223	$8,201
5yr ARI event	0	1	$ 45,802	$6,870
Total				**$34,133**

[1] A modelling instability produced unreliable results for the PMF design event for FM4. The results available, would suggest the flow behaviour would not be impacted significantly in the PMF as a result of this option.

4.2 Benefit to Cost Ratio of Options

The economic evaluation of each modelled measure was assessed by considering the reduction in the amount of flood damages incurred for the design events and by then comparing this value with the cost of implementing the measure.

Table 4-7 summarises the results of the economic assessment of each of the flood management options. The indicator adopted to rank these measures on economic merit is the benefit-cost ratio (B/C), which is based on the net present worth (NPW) of the benefits (reduction in AAD) and the costs (capital and ongoing), adopting a 7% discount rate and an implementation period of 50 years.

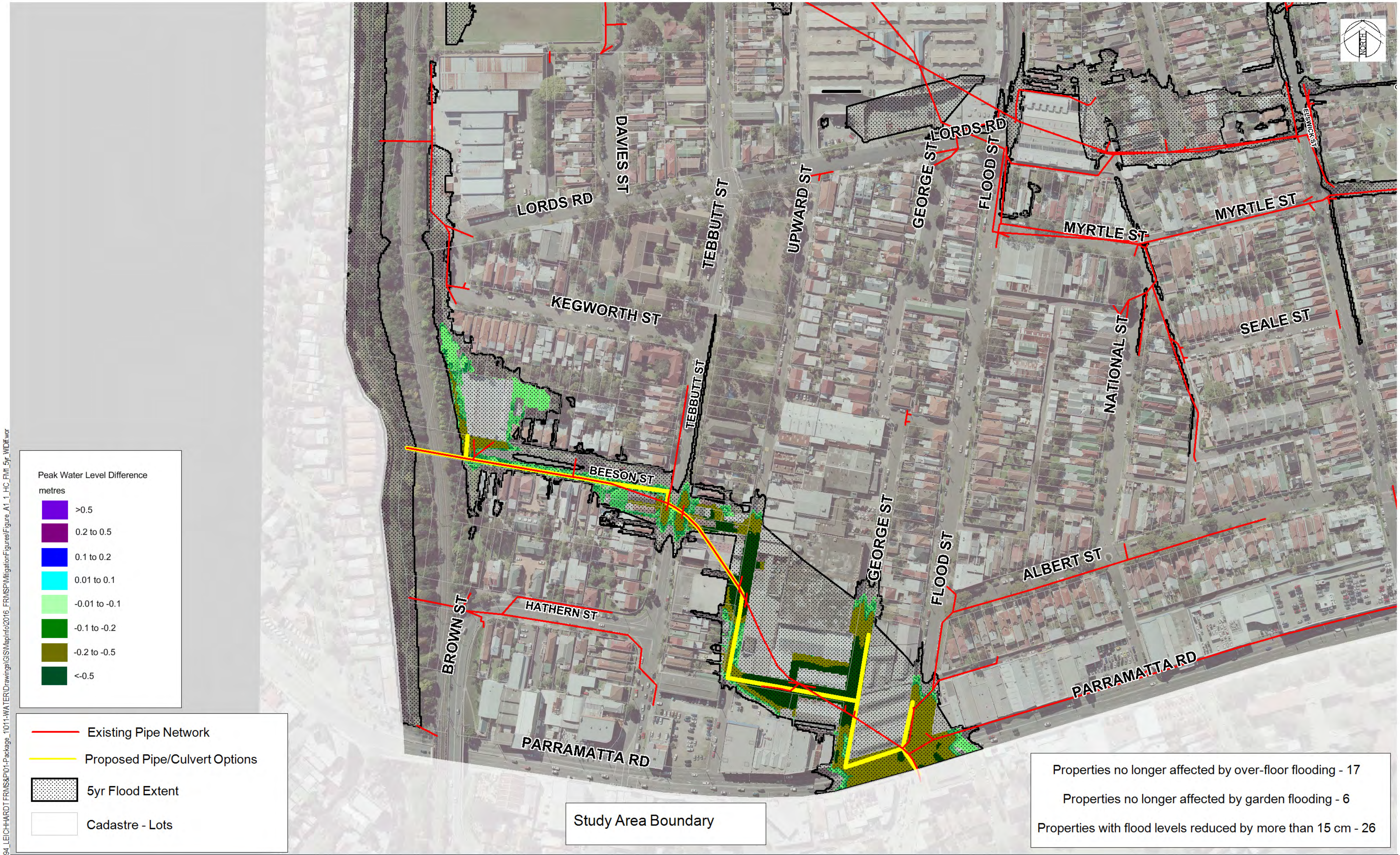
The benefit-cost ratio provides an insight into how the damage savings from a measure, relate to its cost of construction and maintenance:

- Where the benefit-cost is greater than 1 the economic benefits are greater than the cost of implementing the measure;
- Where the benefit-cost is less than 1 but greater than 0, there is still an economic benefit from implementing the measure but the cost of implementing the measure is greater than the economic benefit;
- Where the benefit-cost is equal to zero, there is no economic benefit from implementing the measure; and
- Where the benefit-cost is less than zero, there is a negative economic impact of implementing the measure.

Table 4-7 Summary of Economic Assessment of Flood Management Options

Option ID	Option Description	NPW of Reduction in AAD	NPW of Cost of Implementation	B/C Ratio	Economic Ranking
HC_FM1	Additional pipes /culverts from Parramatta Road to Hawthorne Canal via Beeson Street.	$8,202,000	$11,588,000	0.71	1
HC_FM2	Additional pipes or duplication of existing network from Reuss Street to Hawthorne Canal via Elswick Street, Flood Street and Marion Street.	$1,801,000	$10,634,000	0.17	3
HC_FM3	Additional pipes/culverts from Elswick Street to Hawthorne Canal (via Regent Street and Darley Road). Also extra pipes at Darley Road to reduce flood depths on the Road.	$2,237,000	$17,194,000	0.13	5
HC_FM4	Additional pipes/ culverts from William Street to Hawthorne Canal via Hubert Street and Darley Road.	$1,400,000	$8,398,000	0.17	4
HC_FM5	Proposed culverts through the rail embankment to drain flood waters from Darley Road to Hawthorne Canal.	$471,000	$2,729,000	0.17	2

Hawthorne Canal Mitigation Option Figures



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INNER WEST COUNCIL
LEICHHARDT FRMS&P

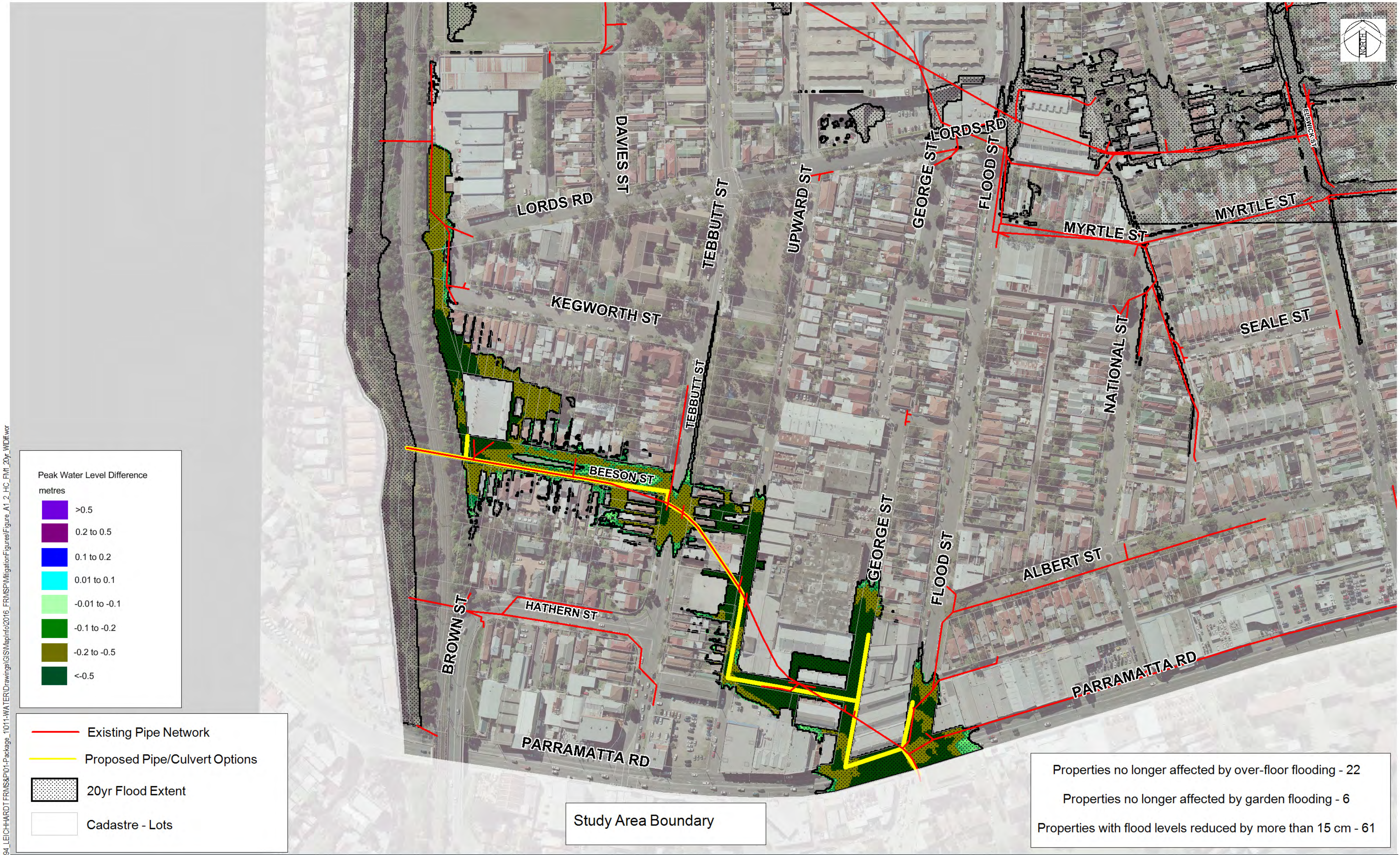
HC_FM1 5YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A1_1

Date
03/2017

Size
A3

HC_FM1_5yr_WlDiff
Drawing Number

03
Revision



INNER WEST COUNCIL

LEICHHARDT FRMS&P

HC_FM1 20YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A1_2

Date
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Size
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HC_FM1_20yr_WlDiff
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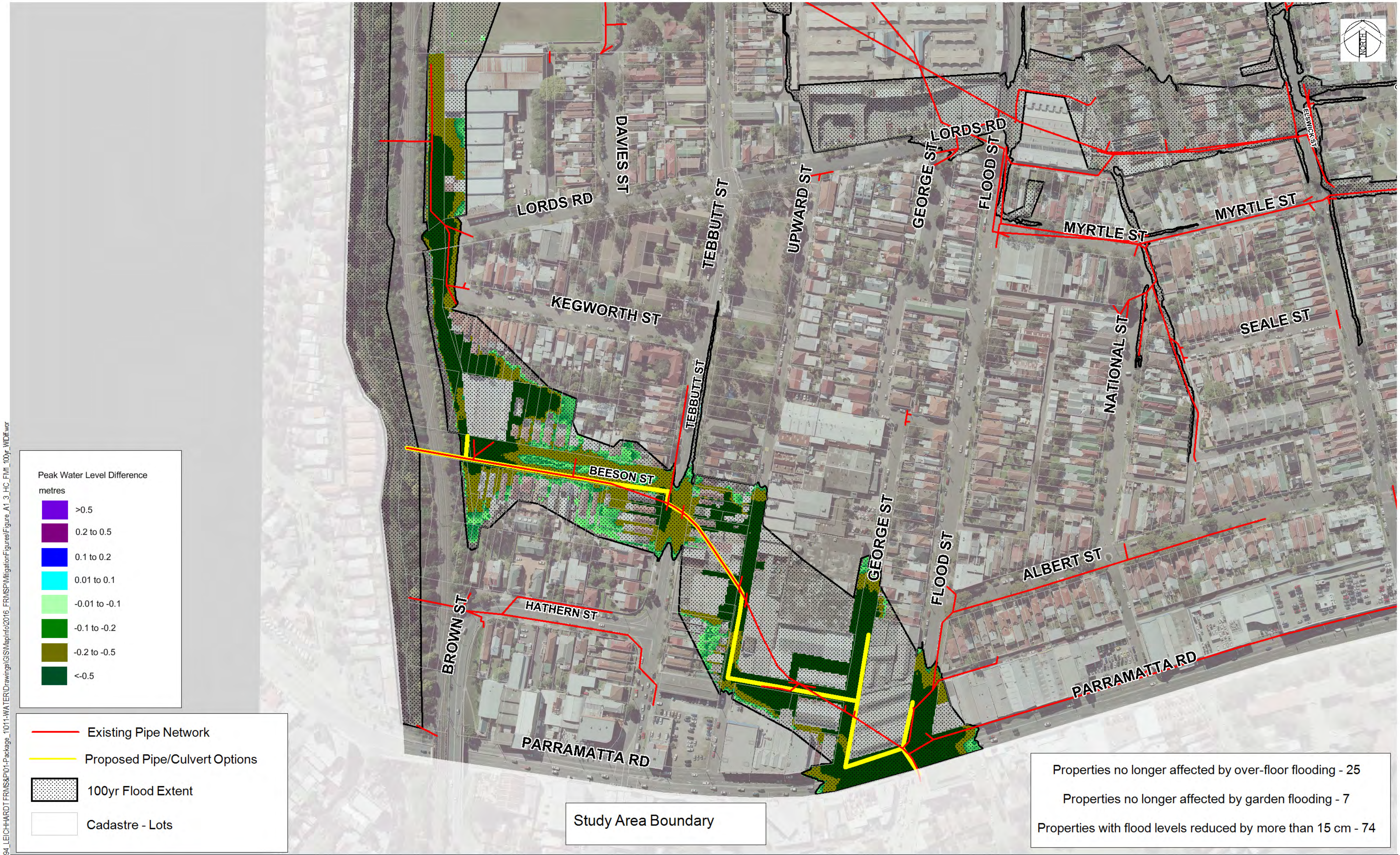

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INNER WEST COUNCIL
LEICHHARDT FRMS&P

HC_FM1 100YR ARI WL DIFF
MITIGATION LESS EXISTING
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Date
03/2017

Size
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HC_FM1_100yr_WlDiff
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03
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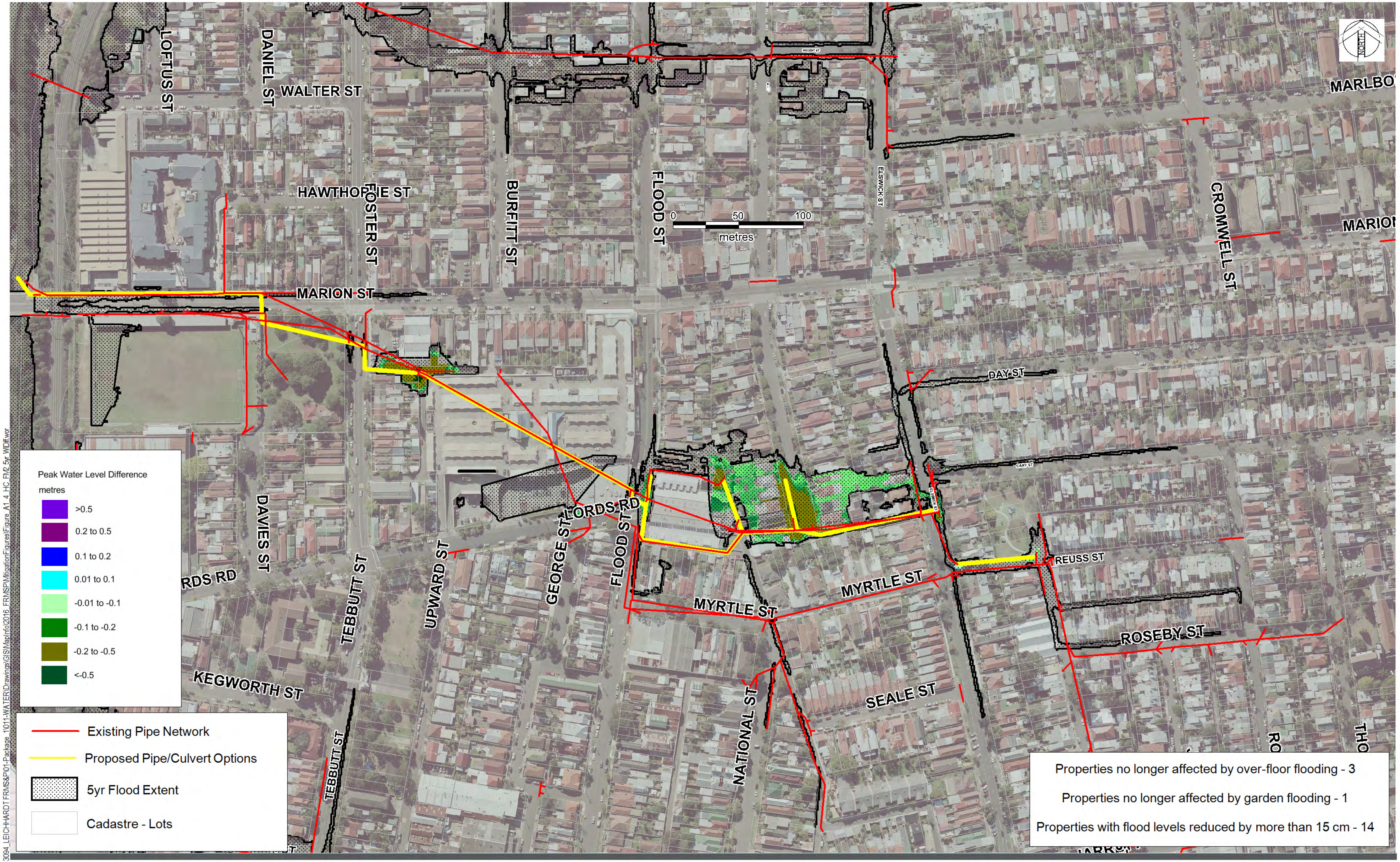

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INNER WEST COUNCIL
LEICHHARDT FRMS&P
HC_FM2 5YR ARI WL DIFF
MITIGATION LESS EXISTING
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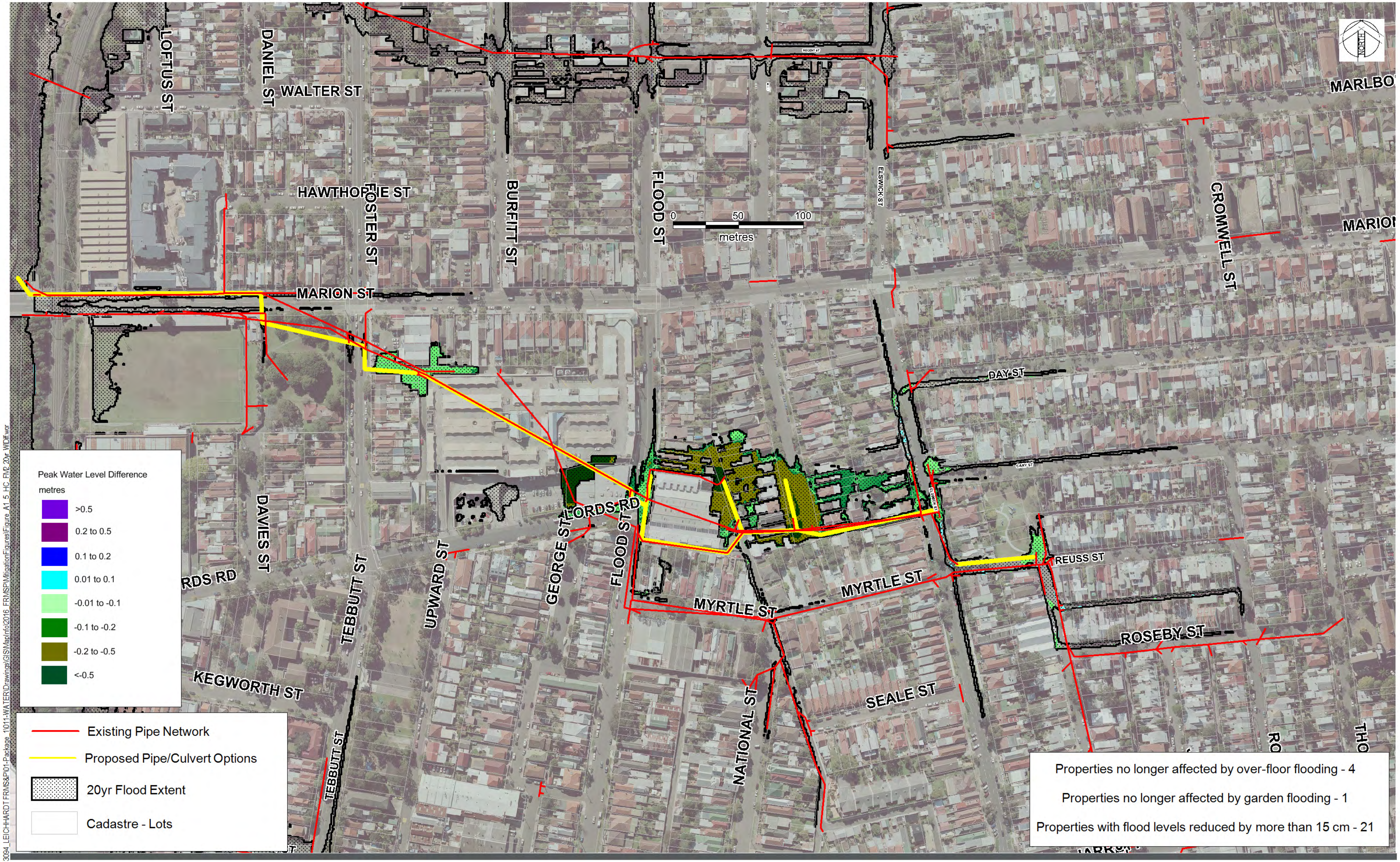

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INNER WEST COUNCIL
LEICHHARDT FRMS&P
HC_FM2 20YR ARI WL DIFF
MITIGATION LESS EXISTING
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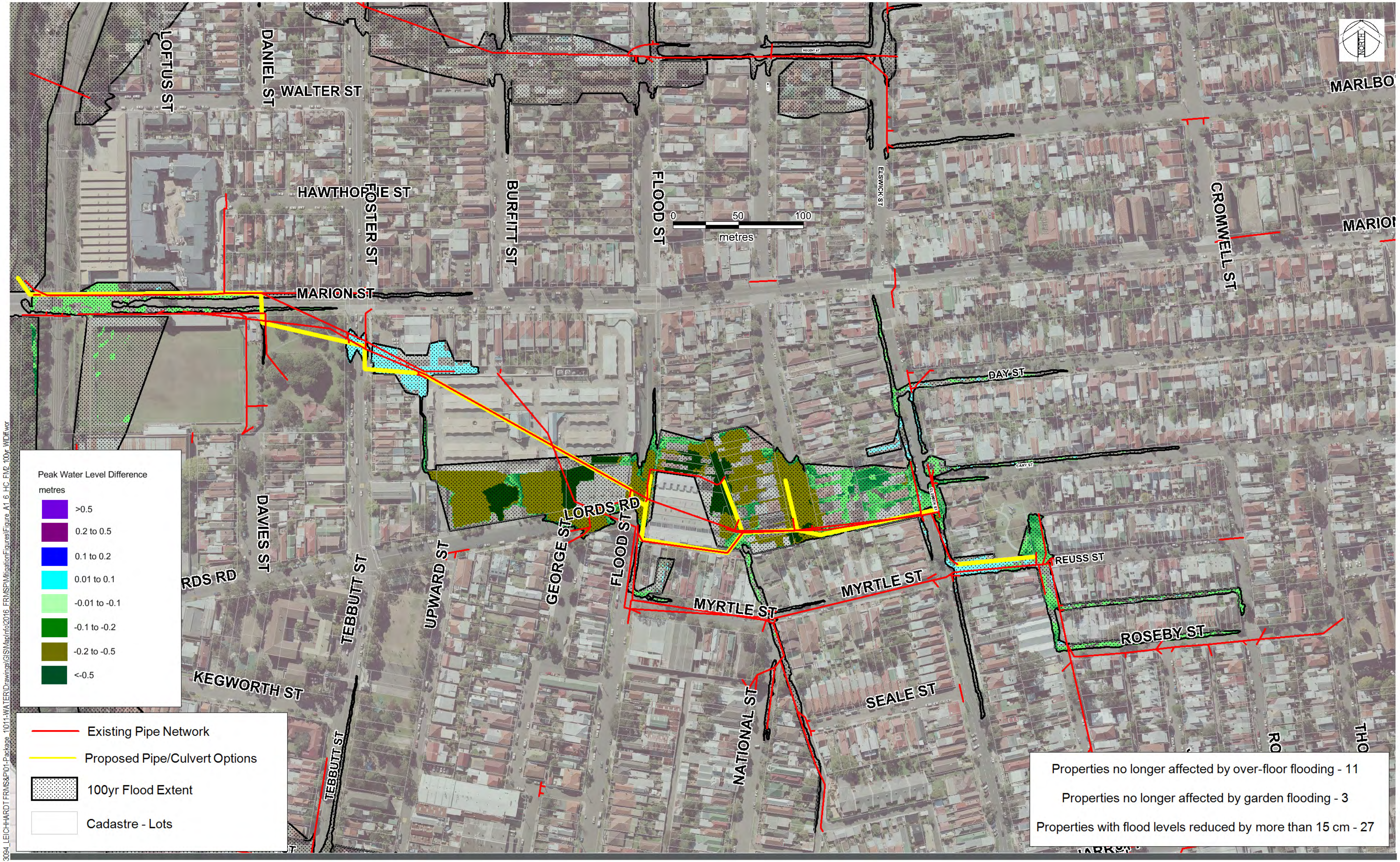
Revision



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LEICHHARDT FRMS&P
HC_FM2 100YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A1_6

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03/2017	A3
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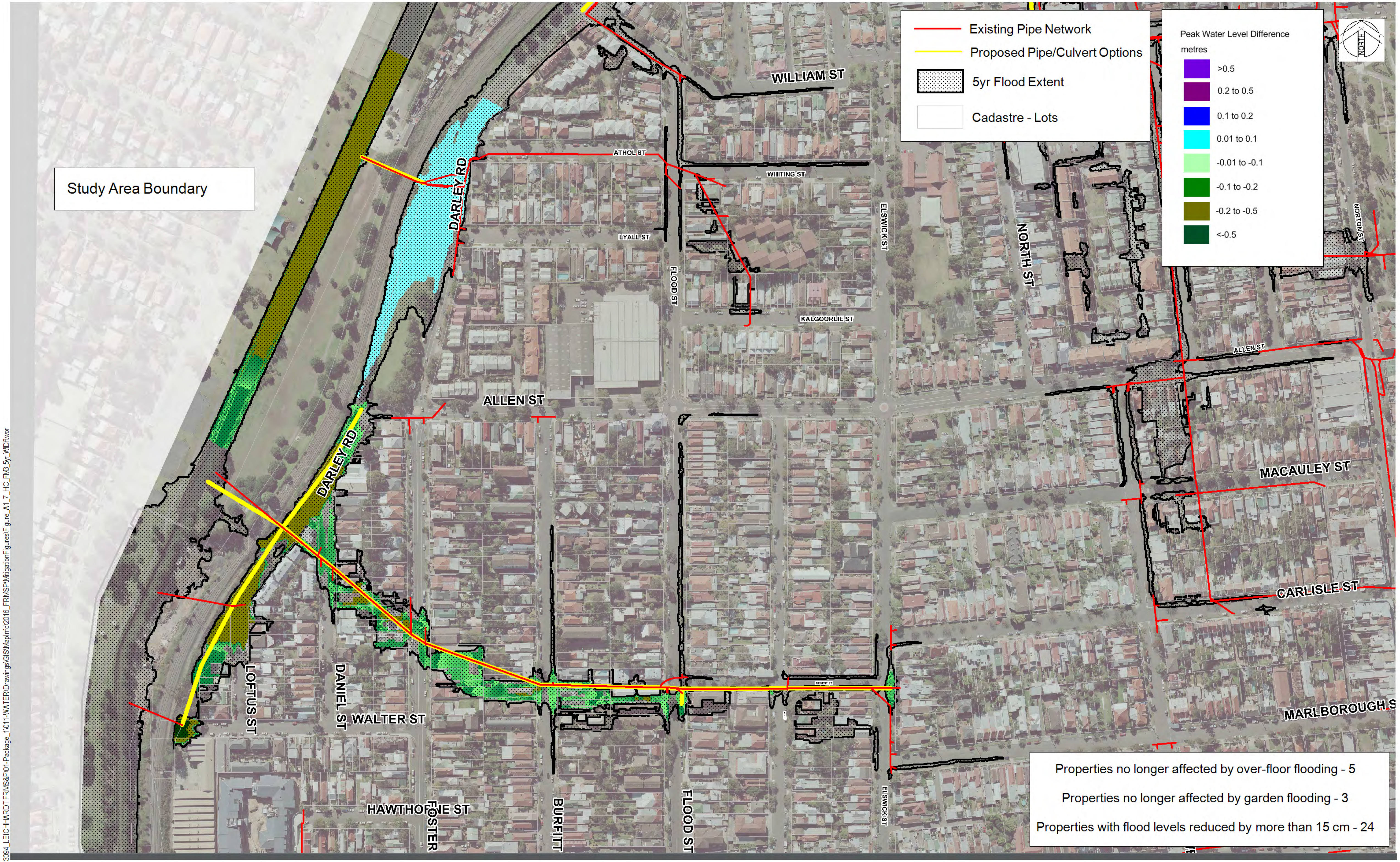

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LEICHHARDT FRMS&P
HC_FM3 5YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A1_7

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HC_FM3_5yr_WlDiff		03
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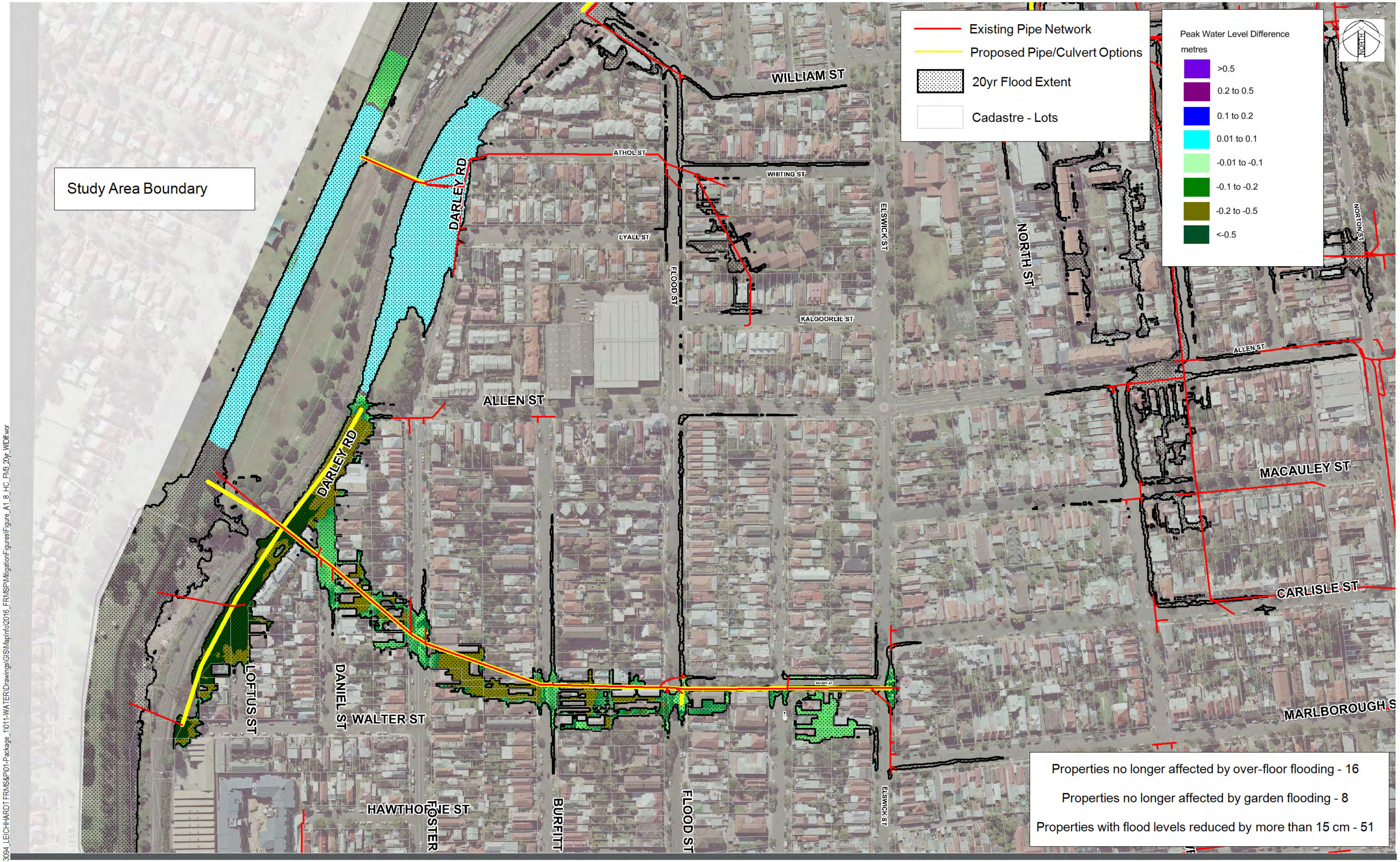

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LEICHHARDT FRMS&P
HC_FM3 20YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A1_8

Date
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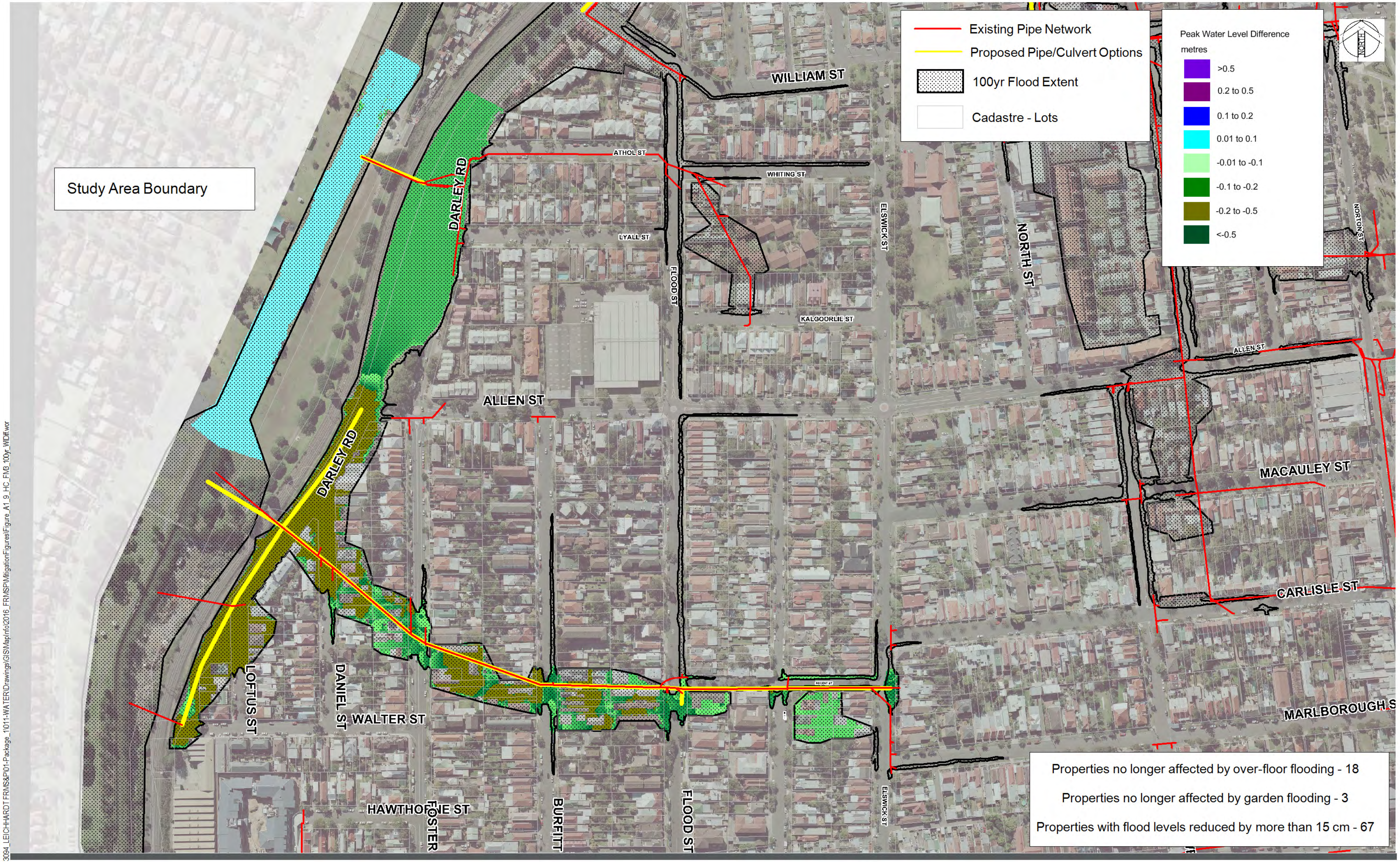

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INNER WEST COUNCIL
LEICHHARDT FRMS&P
HC_FM3 100YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A1_9

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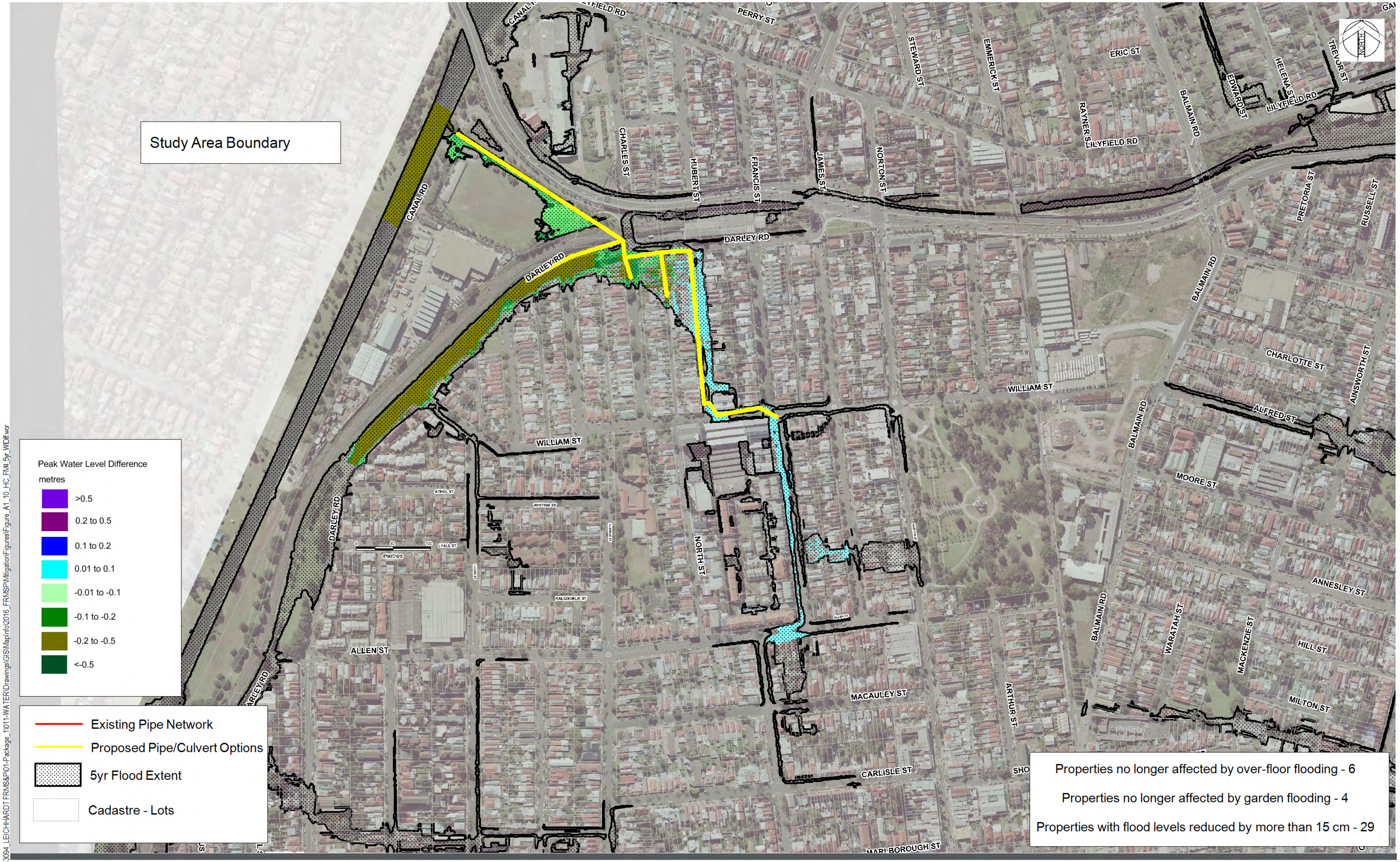

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LEICHHARDT FRMS&P
HC_FM4 5YR ARI WL DIFF
MITIGATION LESS EXISTING
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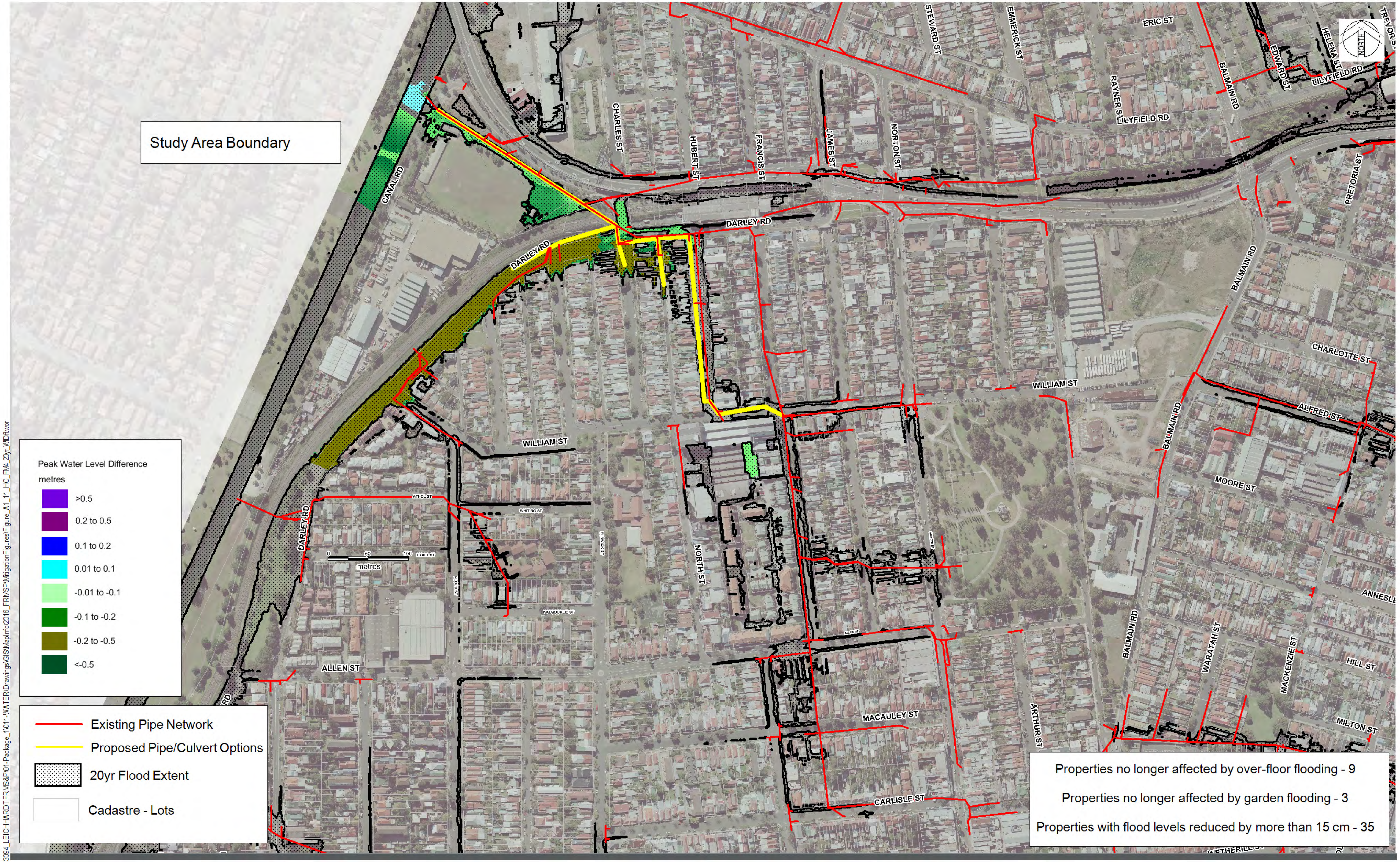

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LEICHHARDT FRMS&P
HC_FM4 20YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A1_11

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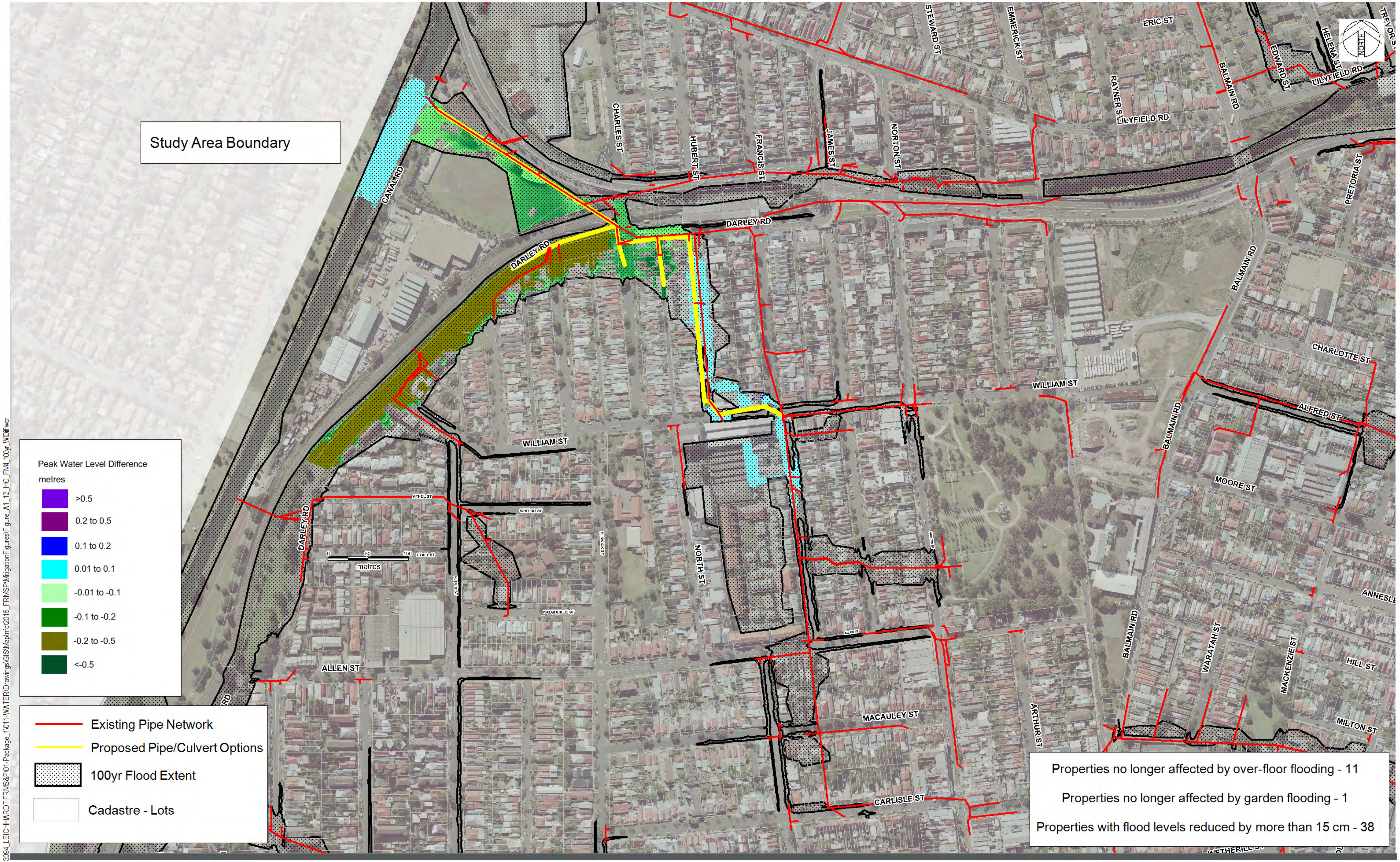

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HC_FM4 100YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A1_12

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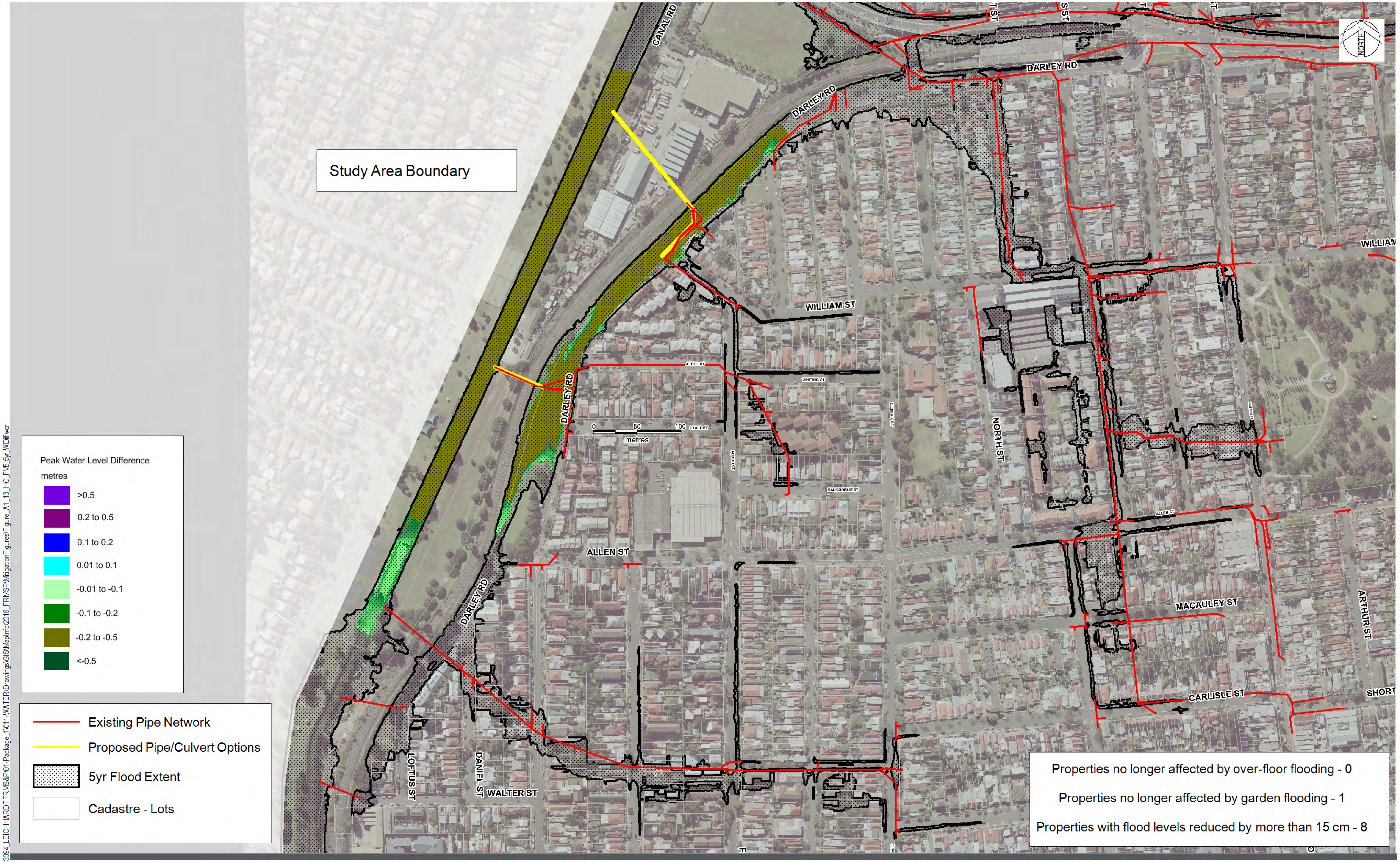

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LEICHHARDT FRMS&P
HC_FM5 5YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A1_13

Date
03/2017

HC_FM5_5yr_WlDiff
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Size
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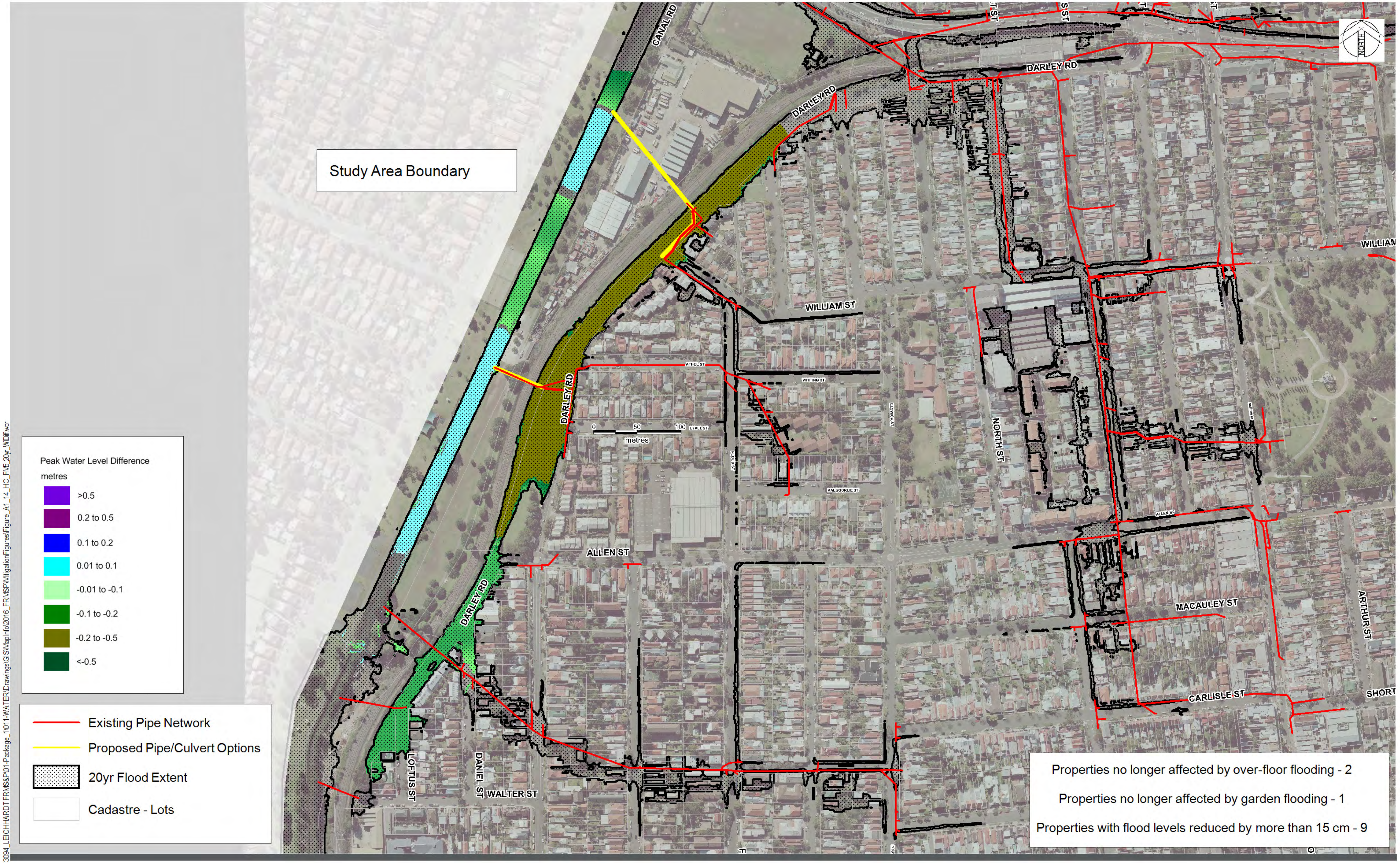
Revision



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LEICHHARDT FRMS&P
HC_FM5 20YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A1_14

Date
03/2017

HC_FM5_20yr_WlDiff
Drawing Number

Size
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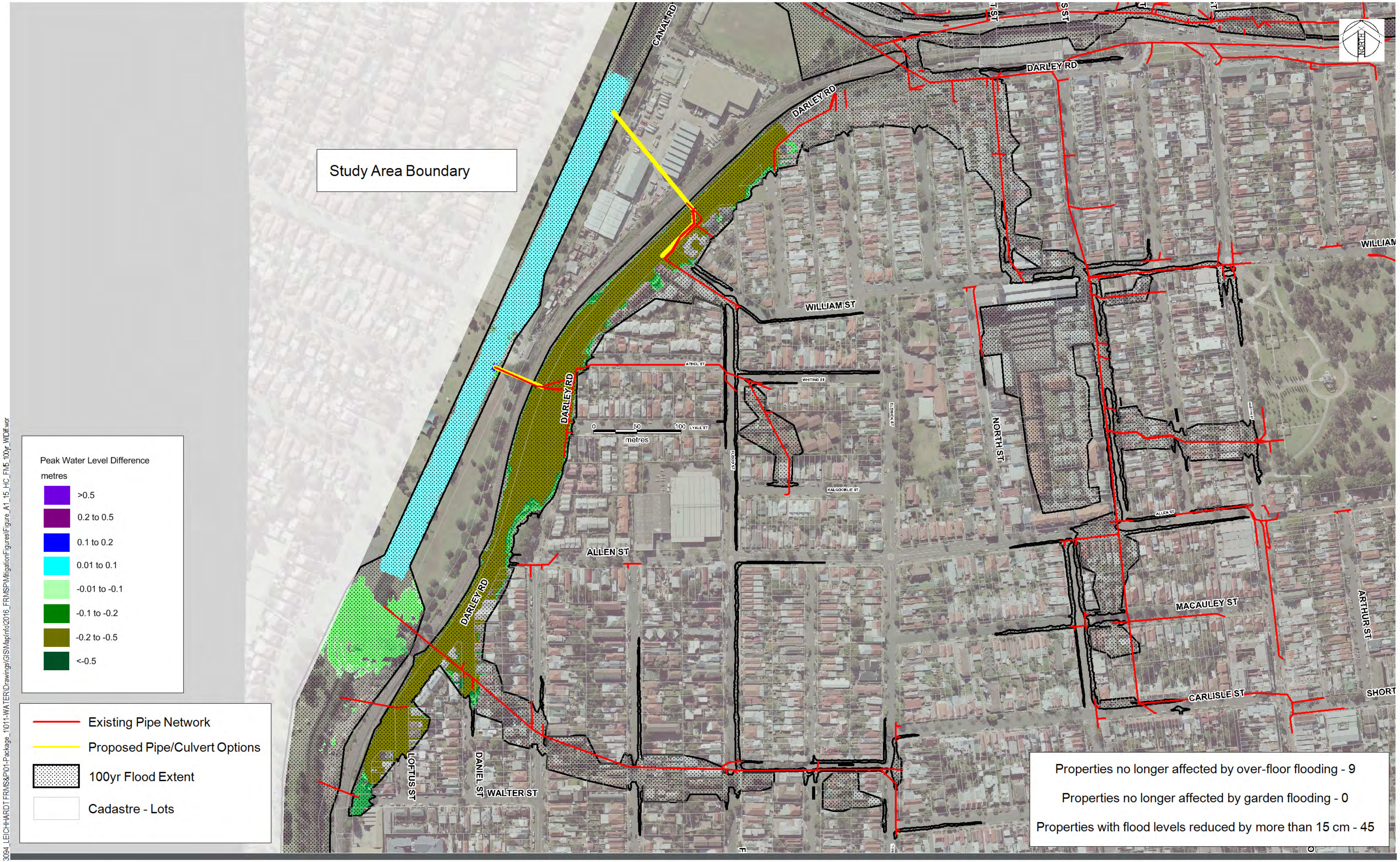
Revision



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LEICHHARDT FRMS&P
HC_FM5 100YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A1_15

Date	Size
03/2017	A3
HC_FM5_100yr_WlDiff	03
Drawing Number	Revision

Area 2 - Johnstons Creek Options Assessment

Leichhardt Flood Risk Management Study and Plan

NA49913094

Prepared for
Inner West Council

Table of Contents

Figures

1 Johnstons Creek Catchment Description

Johnstons Creek originates from the south of the study area. The catchment within study area is in the order of approx.100 hectares in size. A large portion of Johnstons Creek is also located within the City of Sydney LGA, including all areas north of The Crescent. A short section of the creek within the study area, from Parramatta Road to approximately Water Street, is a covered channel. The remainder is an open concrete lined channel.

The majority of the length of the main creek is followed by parkland, which limits flood impacts on adjacent properties. However, a number of tributaries to the main creek result in overland flooding of properties in these areas.

The options proposed for assessment in the report are only located within the study area portion of the Johnstons Creek Catchment.

The location of the Johnstons Creek Catchment within the study area is shown in **Figure 1-1.**

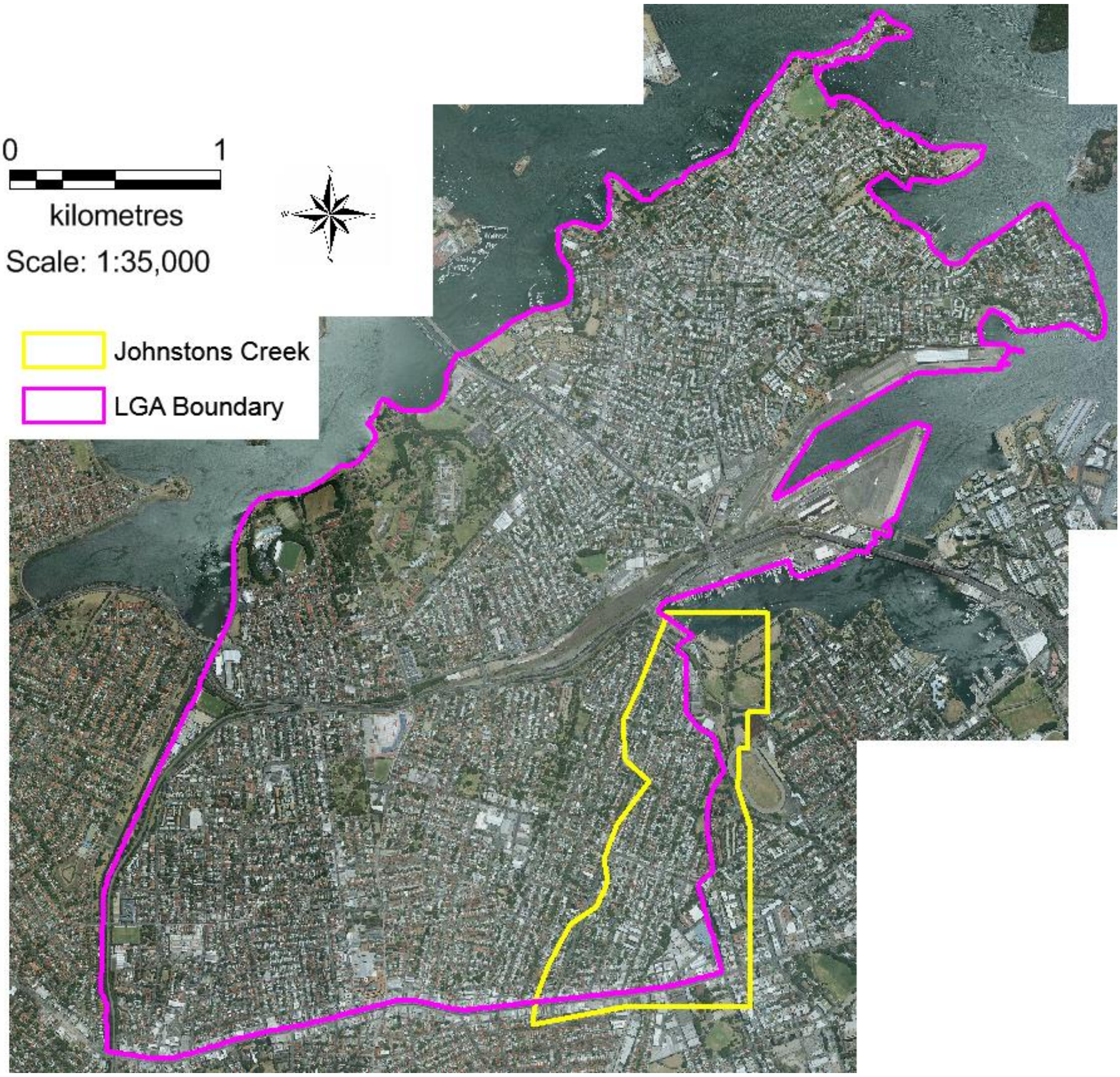


Figure 1-1 Johnstons Creek Catchment Location

2 Flood Mitigation Options Identification

2.1 Flood Modification Measures for Johnstons Creek

The existing flood behaviour within Johnstons Creek is detailed in the Leichhardt Flood Study (Cardno 2014). Based on the flood model results, historical information and engineering judgement, possible flood modification measures (i.e. structural measures) for the study area were identified.

The various management options were identified taking into consideration the:

- flood behaviour and flow in the 20 year ARI event;
- grade of pipe (upstream and downstream); and
- preliminary availability and location of easements.

It should also be noted that Sydney Water and RMS may also play a major role in regards to fund allocation for the options recommended. Sydney Water's approach to flood-related improvement works on its assets is that Sydney Water will work with Councils to deliver the works (typically on a 50:50 cost-sharing basis) and provided Sydney Water has funding available within its Flood Risk Program. It is assumed that RMS will provide all the funding for the transverse pipe sections across State roads. Currently no allocation of RMS funding has been assigned for infrastructure travelling longitudinally along State Roads. It is likely that some contribution would be required from RMS for these upgrades in State Road easements.

Options have been proposed within the Inner West Council portion of the Johnstons Creek catchment. It is noted that City of Sydney Council has also undertaken a Floodplain Risk Management Study for portions of the Johnstons Creek catchment. Options identified by City of Sydney Council have not been duplicated in the Leichhardt FRMS.

Flood modification measures for the Johnstons Creek Catchment have been identified based on opportunities to connect with future upgrades and improvements.

2.2 Johnstons Creek Flood Mitigation Options

Within the Johnstons Creek catchment six (6) sets of options were modelled. These are shown in **Table 2-1** and **Figure 2-1**. The 100yr, 20yr and 5yr ARI peak water level difference plots for each mitigation option are attached at the end of this appendix report.

Table 2-1 Johnstons Creek Mitigation Options

Option Description	Option Name	ID
Johnston Street Flow Path – Proposing additional pipes/ culverts and duplication of existing pipe network from Johnston St to Johnstons Creek open channel. Additional pipes on Parramatta Rd, Trafalgar St, Albion St and Nelson St.	Johnston Street Branch JC-FM1	JC-FM1
Pyrmont Bridge Road Flow Path – Additional pipes or duplication of existing network from Parramatta Rd to Johnstons Creek via Pyrmont Bridge Rd.	Pyrmont Bridge Road Branch JC-FM2	JC-FM2
View Street Flow Path – Duplication of existing pipe network or additional pipes from View St to Johnston Creek (via Trafalgar St, Nelson St and Taylor St).	View Street Branch JC-FM3	JC-FM3
Rose Street Flow Path - Additional pipes from Rose St/Johnston St to Federal Park via View St and Trafalgar St. Proposed Easement downstream of The Crescent to drain flood waters from the low point of the Rd.	Rose Street Branch JC-FM4	JC-FM4
Additional pipes within Johnstons Creek Catchment – At Bayview Crescent, Piper St and at Wigram Rd.	Wigram Road Branch JC-FM5	JC-FM5

Levee option	Piper Street Branch JC-FM5	JC-FM6

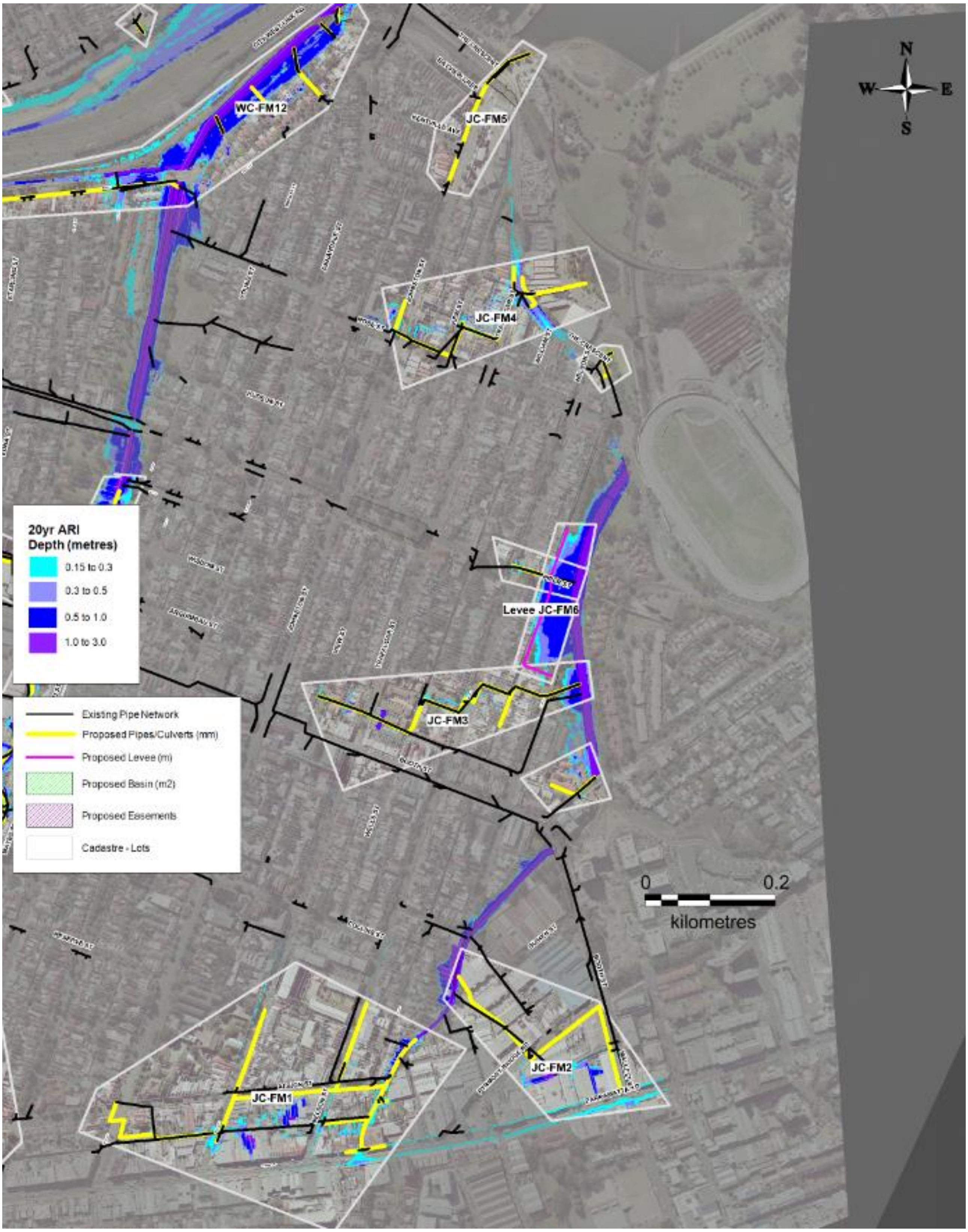


Figure 2-1 Johnstons Creek Mitigation Options Locations

2.2.1 Johnston Street Branch JC-FM1

JC-FM1 proposes additional pipes, a culvert and duplication of the existing pipe network from Johnston Street to Johnstons Creek open channel. The option starts from Johnston Street with a 750mm diameter pipe that connects to a 600mm diameter pipe on Trafalgar Street. Next, a 1050mm diameter pipe takes over and travels through Albion Street eventually connecting to a 1.8m x 1.6m culvert (200m) that follows the alignment of Johnstons Creek. Additional pipes are located at Nelson Street (600mm diameter), McCarthy Lane (1200mm diameter), Parramatta Road (1200mm diameter) and Cahill Street (1200mm diameter).

Major flooding due the 20 year ARI storm event is present within the block between Trafalgar Street and Nelson Street, with flood depths in this location up to 1.3m. Flooding is also present under existing conditions at the northern end of the proposed culverts with depths in this location up to 2.2m.

Potential constraints for this measure include the pipe crossings of major roads, with associated costs due to construction, services and traffic management requirements.

RMS may potentially provide funding for the transverse section across Johnston Street while Sydney Water may provide funding for upgrading Johnston Creek Channel.

2.2.2 Pyrmont Bridge Road Branch JC-FM2

This option proposes additional pipes and/or duplication of the existing network from Parramatta Road to Johnstons Creek via Mallet Street and Pyrmont Bridge Rd. The option consists of a 1650mm diameter pipe with a length of 440m. The majority of the flooding under existing conditions is present on Parramatta Road close to Mallet Street with a flood depth of 0.2m in the 20 Year ARI event.

Potential constraints for this measure include interaction with private property and pipe crossings of major roads, especially Parramatta Road, with associated costs due to construction, services and traffic management requirements. Further, this option would rely on drainage upgrades on the southern side of Parramatta Road, which is external to the study area.

Funding from Sydney Water and RMS could potentially be allocated for the majority of the works.

2.2.3 View Street Branch JC-FM3

JC-FM3 consists of proposed pipes from View Street to Johnston Creek via Trafalgar Street, Trafalgar Lane, Nelson Street, Nelson Lane and Taylor Street. The major proposed drainage branch is composed of a 900mm diameter pipe with a length of 500m. Additionally, a 600mm diameter pipe is proposed to connect to the major branch on Nelson Lane. Trafalgar Street is exposed to the worst of the flooding under existing conditions, with the 20 year ARI storm event resulting in flood depths of up to 1.9m.

Potential constraints for this measure include pipe crossings of roads with associated costs due to construction, services and traffic management requirements.

Funding from Sydney Water may be available for upgrades to the main trunk drainage.

2.2.4 Rose Street Branch JC-FM4

The Rose Street Branch option consists of proposed pipes and a culvert from the Rose St/Johnston St intersection to Federal Park via View Street and Trafalgar Street. It also includes a proposed easement (not included in capital cost estimate) downstream of The Crescent to drain flood waters from the low point of the road. The option consists of a proposed 900mm diameter pipe section with 900mm diameter branches. The 900mm diameter pipe eventually connects to a box culvert (1.2m x 1.2m) that is located along The Crescent that drains onto Federal Park. The option also proposed three 1050mm diameter pipes to connect into the culvert.

There is a new development currently underway at 233A Johnston Street. Annandale. This development has incorporated upgrade of the drainage system and re-routing of the existing overland flow path through the site to Rose Street.

The City of Sydney may be involved in this option as this option crosses into their LGA. Additionally, the easement is required to access the existing open channel. The majority of the flooding under existing conditions takes place on The Crescent with the 20 year ARI storm event resulting in flood depths up to 0.7m.

Funding from Sydney Water (for the main trunk drainage at the Crescent) and RMS funding may be available for a majority of the cost. The RMS funding would be allocated towards the transverse pipe upgrades on Johnston Street and The Crescent.

2.2.5 Additional pipes within Johnstons Creek Catchment JC-FM5

This option proposes additional pipes in four separate locations in order to minimise the flooding due to the 20 year ARI storm event. The first sets of pipes (900mm diameter) are proposed to be located along Johnston Street and then cross at Bayview Crescent and The Crescent. The rest of the pipes (900mm diameter) are proposed to be located on The Crescent (close to The Crescent/Nelson Street intersection), on Piper Street (Between Nelson Street and Nelson Lane) and on Wigram Road (Start point on Booth Lane).

The majority of the flooding under existing conditions takes place along Johnstons Creek due to the 20 year ARI storm event. Where options have been proposed, flood depths reach up to 2m.

A majority of the capital cost of the option will potentially be the responsibility of RMS, especially for the works carried out on Johnston Street and the Crescent. Sydney Water will also be responsible for the works on Piper Street.

The City of Sydney may be involved in discussions for this option as it is partially located within the City of Sydney LGA.

2.2.6 Levee Option JC-FM6

A levee or embankment is proposed on Nelson Lane, starting from the northern end of Taylor Street in order to minimise flooding adjacent to Johnstons Creek. The Levee is proposed to be 270m in length and 1m high.

Significant constraints may include the level of excavation and or fill that will be required to place the levee and ensuring that there are no adverse flooding impacts on the eastern side of Johnston’s Creek.

3 Mitigation Option Modelling Outcomes

The Johnstons Creek flood mitigation options were assessed for the 5, 10, 20, 50 and 100 Year ARI design flood events, along with the PMF event.

The outcomes of the modelling are shown in the 5, 20, and 100 Year ARI water level difference plots attached at the end of this catchment report.

A summary of the impacts on flood behaviour for each option is provided below.

3.1 Johnston Street Branch JC-FM1

The proposed increase in drainage capacity of mitigation option JC-FM1 is shown to reduce overland flows along the Johnston Street flow path. The water level difference results show a decrease of 0.10m – 0.50m along the flow path in the 100 Year ARI event. The proposed mitigation strategy shows water level decreases along sections of Parramatta Road, Johnston Street, Trafalgar Street, Nelson Street, Albion Street and Mccarthy Lane, and along the closed section of Johnston's Creek.

Increases in water levels are also seen along the open channel downstream of Water Street in an order of 0.01m to 0.10m. These increases are largely confined to the creek reserves, however, some impacts are seen on industrial properties.

3.2 Pyrmont Bridge Road Branch JC-FM2

Mitigation option JC-FM2 shows significant flood level decreases of more than 1.00m on Bignell Lane and 0.60m on Pyrmont Bridge Road in a 100 Year ARI event. A 0.01m – 0.10m water level decrease results along parts of Parramatta Road and along the Pyrmont Bridge Road flowpath.

Increases in water levels are also seen along the open channel in an order of 0.01m to 0.06m in all events. These increases downstream are largely confined to the creek reserves. However, there are some increases in flooding within residential properties.

3.3 View Street Branch JC-FM3

The proposed increase in drainage capacity of mitigation option JC-FM3 shows decrease in water levels along the View Street Branch flowpath. The mitigation strategy shows water level decreases in an order of 0.10m to 0.45m for all the modelled design events on View Street, Trafalgar Street, Trafalgar Lane, Nelson Street and Nelson Lane.

Minor increases in flood levels are observed in the downstream reaches within the open space areas.

3.4 Rose Street Branch JC-FM4

Mitigation option JC-FM4 shows significant decrease in water levels on The Crescent up to 0.30m in a 20 Year ARI event. The proposed increase in drainage capacity results in decreases in water levels along the Rose Street Branch flowpath in the order of 0.01m to 0.30m in a 20 Year ARI event. The most significant reductions are seen on Johnstons Street, View Street, parts of Rose Street and The Crescent.

3.5 Additional pipes within Johnstons Creek Catchment JC-FM5

The proposed increase in drainage capacity in Johnston Street shows decreases in water levels in an order of 0.01m to 0.10m along Johnston Street and The Crescent.

Proposed mitigation works on Piper Street reduces flood levels between Nelson Street and Nelson Lane up to 0.45m in a 20 Year ARI.

The proposed mitigation option on Wigram Road (near Booth Lane) reduces water levels up to 0.10m in all the modelled design events.

3.6 Levee Option JC-FM6

The proposed Levee or Embankment mitigation option on Nelson Lane will have an adverse impact. Significant increases of flood levels up to 0.50m are seen in all the modelled design events on Nelson Lane upstream of the Levee. This option is not recommended as a preferred option due to the adverse impacts.

4 Economic Assessment of Flood Damages in the Johnstons Creek Catchment

4.1 Johnstons Creek Mitigation Options Damages Assessment

An assessment of damages for the existing condition in the Johnstons Creek Catchment is presented in the Floodplain Risk Management Study. The approach adopted for calculating the existing damages has been repeated for the modelling results from the mitigation options proposed for the Johnstons Creek catchment.

The economic flood damage results for each of the options and the existing scenarios are presented in **Table 4-1 to Table 4-6**. The reductions in properties affected by overground and overfloor flooding, total damages and AAD are provided. Negative values represent increases from the existing scenario.

The total reduction in damaged properties and the associated reduction in damage costs for each mitigation strategy is summarised in **Table 4-7**. This table represents a summary of differences between existing and Mitigation scenarios presented in **Table 4-1** to **Table 4-6.**

The flood damages assessment is a useful tool for comparing the merits of various options, it is not a precise flood risk analysis tool and the limitation associated with the assessment should be considered when interpreting the results.

The following information should be considered when interpreting the damages data:

- Negative property or dollar values represent increases from the existing scenario.
- Where an option results in a reduction in flood depths there may not be any reduction in the flood damages where:
  - The reduction in flood depths or extent occur in open space or roadways; or
  - The reduction in flood depths occurs on properties that were not impacted by over floor flooding (i.e. the flooding on the property grounds is shallower but still exists).
- The flood damages are calculated at a discrete location on each property. This location is where the floor level and ground level survey was obtained from. As such, if the flooding occurs at another location on the property other than the survey point, this property will not register any damages with regards to this damages assessment.
- Commercial and industrial damages are only incurred when over floor flooding exists.
- The reduction in the number of properties impacted as a result of an option may vary between different flood events due to the performance of the proposed work under the different flow behaviour of each flood event.

Table 4-1 JC_FM1 Flood Damage Assessment Summary

Event / Property type	Properties with Overfloor Flooding		Properties with Overground Flooding		Estimated Total Damage ($ June 2016)	
	Existing Case	*Mitigation Case*	*Existing Case*	*Mitigation Case*	*Existing Case*	*Mitigation Case*
PMF Event						
Residential	112	108	170	168	$ 6,905,349	$ 6,455,078
Commercial	40	37	49	47	$ 1,943,047	$ 1,725,697
Industrial	27	27	30	30	$ 4,692,758	$ 4,606,772
PMF Total	**179**	**172**	**249**	**245**	**$ 13,541,155**	**$ 12,787,547**
100yr ARI						
Residential	37	34	62	59	$ 1,644,421	$ 1,519,454
Commercial	17	11	31	29	$ 753,831	$ 488,308
Industrial	12	13	13	13	$ 949,341	$ 1,099,228
100yr ARI Total	**66**	**58**	**106**	**101**	**$ 3,347,593**	**$ 3,106,989**
50yr ARI						
Residential	36	31	58	55	$ 1,559,031	$ 1,394,390
Commercial	15	9	29	28	$ 700,125	$ 381,108
Industrial	12	12	13	13	$ 884,929	$ 930,406
50yr ARI Total	**63**	**52**	**100**	**96**	**$ 3,144,085**	**$ 2,705,904**
20yr ARI						
Residential	34	26	52	49	$ 1,447,881	$ 1,116,214
Commercial	14	8	22	21	$ 562,005	$ 296,458
Industrial	12	12	13	13	$ 891,189	$ 830,262
20yr ARI Total	**60**	**46**	**87**	**83**	**$ 2,901,074**	**$ 2,242,934**
10yr ARI						
Residential	30	21	51	49	$ 1,307,856	$ 930,701
Commercial	13	8	22	21	$ 499,235	$ 279,004
Industrial	12	12	13	13	$ 842,284	$ 763,863
10yr ARI Total	**55**	**41**	**86**	**83**	**$ 2,649,375**	**$ 1,973,568**
5yr ARI						
Residential	21	19	44	41	$ 974,485	$ 878,861
Commercial	13	8	20	19	$ 456,919	$ 269,869
Industrial	12	12	12	13	$ 747,004	$ 769,549
5yr ARI Total	**46**	**39**	**76**	**73**	**$ 2,178,409**	**$ 1,918,280**
Total Annual Average Damage					**$ 914,483**	**$ 770,509**

Table 4-2 JC_FM2 Flood Damage Assessment Summary

Event / Property type	Properties with Overfloor Flooding		Properties with Overground Flooding		Estimated Total Damage ($ June 2016)	
	Existing Case	*Mitigation Case*	*Existing Case*	*Mitigation Case*	*Existing Case*	*Mitigation Case*
PMF Event						
Residential	89	91	108	108	$ 5,401,038	$ 5,470,598
Commercial	16	16	19	19	$ 1,146,777	$ 1,144,707
Industrial	51	44	61	60	$ 7,890,238	$ 6,277,209
PMF Total	**156**	**151**	**188**	**187**	**$ 14,438,053**	**$ 12,892,515**
100yr ARI						
Residential	29	30	43	43	$ 1,239,326	$ 1,278,776
Commercial	8	8	11	11	$ 335,511	$ 336,078
Industrial	23	18	29	29	$ 2,363,025	$ 1,296,158
100yr ARI Total	**60**	**56**	**83**	**83**	**$ 3,937,862**	**$ 2,911,012**
50yr ARI						
Residential	28	29	40	40	$ 1,166,060	$ 1,209,098
Commercial	7	7	11	11	$ 307,551	$ 308,174
Industrial	22	17	26	25	$ 1,997,649	$ 1,188,249
50yr ARI Total	**57**	**53**	**77**	**76**	**$ 3,471,260**	**$ 2,705,521**
20yr ARI						
Residential	26	27	37	37	$ 1,063,721	$ 1,110,604
Commercial	6	6	9	9	$ 237,490	$ 237,517
Industrial	20	17	22	22	$ 1,790,969	$ 1,124,498
20yr ARI Total	**52**	**50**	**68**	**68**	**$ 3,092,181**	**$ 2,472,618**
10yr ARI						
Residential	23	22	36	36	$ 961,578	$ 941,382
Commercial	6	6	9	9	$ 225,808	$ 223,965
Industrial	19	17	20	20	$ 1,431,804	$ 1,027,135
10yr ARI Total	**48**	**45**	**65**	**65**	**$ 2,619,190**	**$ 2,192,482**
5yr ARI						
Residential	15	15	32	33	$ 660,168	$ 682,756
Commercial	6	6	7	7	$ 222,620	$ 233,743
Industrial	18	17	18	18	$ 1,155,131	$ 865,923
5yr ARI Total	**39**	**38**	**57**	**58**	**$ 2,037,919**	**$ 1,782,422**
Total Annual Average Damage					**$ 908,695**	**$ 767,500**

Table 4-3 JC_FM3 Flood Damage Assessment Summary

Event / Property type	Properties with Overfloor Flooding		Properties with Overground Flooding		Estimated Total Damage ($ June 2016)	
	Existing Case	*Mitigation Case*	*Existing Case*	*Mitigation Case*	*Existing Case*	*Mitigation Case*
PMF Event						
Residential	79	68	106	105	$ 4,963,436	$ 4,536,044
Commercial	8	7	16	16	$ 149,216	$ 128,920
Industrial	0	0	0	0	$ -	$ -
PMF Total	**87**	**75**	**122**	**121**	**$ 5,112,653**	**$ 4,664,964**
100yr ARI						
Residential	11	10	22	22	$ 667,145	$ 585,978
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
100yr ARI Total	**11**	**10**	**22**	**22**	**$ 667,145**	**$ 585,978**
50yr ARI						
Residential	11	10	23	23	$ 647,491	$ 572,370
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
50yr ARI Total	**11**	**10**	**23**	**23**	**$ 647,491**	**$ 572,370**
20yr ARI						
Residential	11	10	20	20	$ 613,983	$ 551,606
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
20yr ARI Total	**11**	**10**	**20**	**20**	**$ 613,983**	**$ 551,606**
10yr ARI						
Residential	10	9	18	18	$ 498,757	$ 449,900
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
10yr ARI Total	**10**	**9**	**18**	**18**	**$ 498,757**	**$ 449,900**
5yr ARI						
Residential	7	6	13	13	$ 352,684	$ 291,045
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
5yr ARI Total	**7**	**6**	**13**	**13**	**$ 352,684**	**$ 291,045**
Total Annual Average Damage					**$ 177,684**	**$ 154,645**

Table 4-4 JC_FM4 Flood Damage Assessment Summary

Event / Property type	Properties with Overfloor Flooding		Properties with Overground Flooding		Estimated Total Damage ($ June 2016)	
	Existing Case	*Mitigation Case*	*Existing Case*	*Mitigation Case*	*Existing Case*	*Mitigation Case*
PMF Event						
Residential	69	65	108	108	$ 3,979,076	$ 3,803,742
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
PMF Total	**69**	**65**	**108**	**108**	**$ 3,979,076**	**$ 3,803,742**
100yr ARI						
Residential	21	18	40	38	$ 1,339,891	$ 1,104,829
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
100yr ARI Total	**21**	**18**	**40**	**38**	**$ 1,339,891**	**$ 1,104,829**
50yr ARI						
Residential	19	17	35	35	$ 1,239,310	$ 1,039,956
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
50yr ARI Total	**19**	**17**	**35**	**35**	**$ 1,239,310**	**$ 1,039,956**
20yr ARI						
Residential	18	16	33	32	$ 1,157,013	$ 992,966
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
20yr ARI Total	**18**	**16**	**33**	**32**	**$ 1,157,013**	**$ 992,966**
10yr ARI						
Residential	18	15	28	27	$ 1,090,293	$ 925,472
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
10yr ARI Total	**18**	**15**	**28**	**27**	**$ 1,090,293**	**$ 925,472**
5yr ARI						
Residential	15	11	20	19	$ 936,480	$ 798,922
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
5yr ARI Total	**15**	**11**	**20**	**19**	**$ 936,480**	**$ 798,922**
Total Annual Average Damage					**$ 373,426**	**$ 319,777**

Table 4-5 JC_FM5 Flood Damage Assessment Summary

Event / Property type	Properties with Overfloor Flooding		Properties with Overground Flooding		Estimated Total Damage ($ June 2016)	
	Existing Case	*Mitigation Case*	*Existing Case*	*Mitigation Case*	*Existing Case*	*Mitigation Case*
PMF Event						
Residential	8	8	8	8	$ 1,501,106	$ 1,520,227
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
PMF Total	**8**	**8**	**8**	**8**	**$ 1,501,106**	**$ 1,520,227**
100yr ARI						
Residential	0	0	3	3	$ 8,999	$ 3,000
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
100yr ARI Total	**0**	**0**	**3**	**3**	**$ 8,999**	**$ 3,000**
50yr ARI						
Residential	0	0	3	3	$ -	$ 3,000
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
50yr ARI Total	**0**	**0**	**3**	**3**	**$ -**	**$ 3,000**
20yr ARI						
Residential	0	0	0	0	$ -	$ -
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
20yr ARI Total	**0**	**0**	**0**	**0**	**$ -**	**$ -**
10yr ARI						
Residential	0	0	0	0	$ -	$ -
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
10yr ARI Total	**0**	**0**	**0**	**0**	**$ -**	**$ -**
5yr ARI						
Residential	0	0	0	0	$ -	$ -
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
5yr ARI Total	**0**	**0**	**0**	**0**	**$ -**	**$ -**
Total Annual Average Damage					**$ 7,595**	**$ 7,690**

Table 4-6 JC_FM6 Flood Damage Assessment Summary

Event / Property type	Properties with Overfloor Flooding		Properties with Overground Flooding		Estimated Total Damage ($ June 2016)	
	Existing Case	*Mitigation Case*	*Existing Case*	*Mitigation Case*	*Existing Case*	*Mitigation Case*
PMF Event						
Residential	70	70	71	71	$ 3,947,417	$ 4,023,200
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
PMF Total	**70**	**70**	**71**	**71**	**$ 3,947,417**	**$ 4,023,200**
100yr ARI						
Residential	4	19	24	24	$ 180,231	$ 691,205
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
100yr ARI Total	**4**	**19**	**24**	**24**	**$ 180,231**	**$ 691,205**
50yr ARI						
Residential	4	16	21	21	$ 153,024	$ 637,614
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
50yr ARI Total	**4**	**16**	**21**	**21**	**$ 153,024**	**$ 637,614**
20yr ARI						
Residential	1	16	20	20	$ 82,224	$ 605,635
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
20yr ARI Total	**1**	**16**	**20**	**20**	**$ 82,224**	**$ 605,635**
10yr ARI						
Residential	1	13	16	16	$ 57,211	$ 468,568
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
10yr ARI Total	**1**	**13**	**16**	**16**	**$ 57,211**	**$ 468,568**
5yr ARI						
Residential	0	8	10	10	$ 22,828	$ 322,596
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
5yr ARI Total	**0**	**8**	**10**	**10**	**$ 22,828**	**$ 322,596**
Total Annual Average Damage					**$ 36,743**	**$ 163,665**

Table 4-7 Reduction in Damages Associated with Each Option

	Overfloor flooding properties reduction	Overground flooding properties reduction	Total Damage Reduction ($)	AAD Reduction ($)
JC-FM1				
PMF event	7	4	$ 753,607	$4,971
100yr ARI event	8	5	$ 240,603	$3,394
50yr ARI event	11	4	$ 438,181	$16,445
20yr ARI event	14	4	$ 658,141	$33,349
10yr ARI event	14	3	$ 675,807	$46,797
5yr ARI event	7	3	$ 260,129	$39,019
Total				**$143,974**
JC-FM2				
PMF event	5	1	$1,545,538	$12,861
100yr ARI event	4	0	$1,026,850	$8,963
50yr ARI event	4	1	$ 765,739	$20,780
20yr ARI event	2	0	$ 619,563	$26,157
10yr ARI event	3	0	$ 426,708	$34,110
5yr ARI event	1	-1	$ 255,498	$38,325
Total				**$141,195**
JC-FM3				
PMF event	12	1	$ 447,689	$2,644
100yr ARI event	1	0	$ 81,166	$781
50yr ARI event	1	0	$ 75,121	$2,062
20yr ARI event	1	0	$ 62,377	$2,781
10yr ARI event	1	0	$ 48,857	$5,525
5yr ARI event	1	0	$ 61,639	$9,246
Total				**$23,039**
JC-FM4				
PMF event	4	0	$ 175,333	$2,052
100yr ARI event	3	2	$ 235,062	$2,172
50yr ARI event	2	0	$ 199,353	$5,451
20yr ARI event	2	1	$ 164,047	$8,222
10yr ARI event	3	1	$ 164,821	$15,119
5yr ARI event	4	1	$ 137,558	$20,634
Total				**$53,649**
JC-FM5				
PMF event	0	0	-$ 19,121	-$66
100yr ARI event	0	0	$ 5,999	$15
50yr ARI event	0	0	-$ 3,000	-$45
20yr ARI event	0	0	$ -	$0
10yr ARI event	0	0	$ -	$0
5yr ARI event	0	0	$ -	$0
Total				**-$96**
JC-FM6				
PMF event	0	0	-$ 75,782	-$2,933
100yr ARI event	-15	0	-$ 510,974	-$4,978
50yr ARI event	-12	0	-$ 484,590	-$15,120
20yr ARI event	-15	0	-$ 523,411	-$23,369
10yr ARI event	-12	0	-$ 411,356	-$35,556
5yr ARI event	-8	0	-$ 299,768	-$44,965
Total				**-$126,922**

4.2 Benefit to Cost Ratio of Options

The economic evaluation of each modelled measure was assessed by considering the reduction in the amount of flood damages incurred for the design events and by then comparing this value with the cost of implementing the measure.

Table 4-8 summarises the results of the economic assessment of each of the flood management options. The indicator adopted to rank these measures on economic merit is the benefit-cost ratio (B/C), which is based on the net present worth (NPW) of the benefits (reduction in AAD) and the costs (capital and ongoing), adopting a 7% discount rate and an implementation period of 50 years.

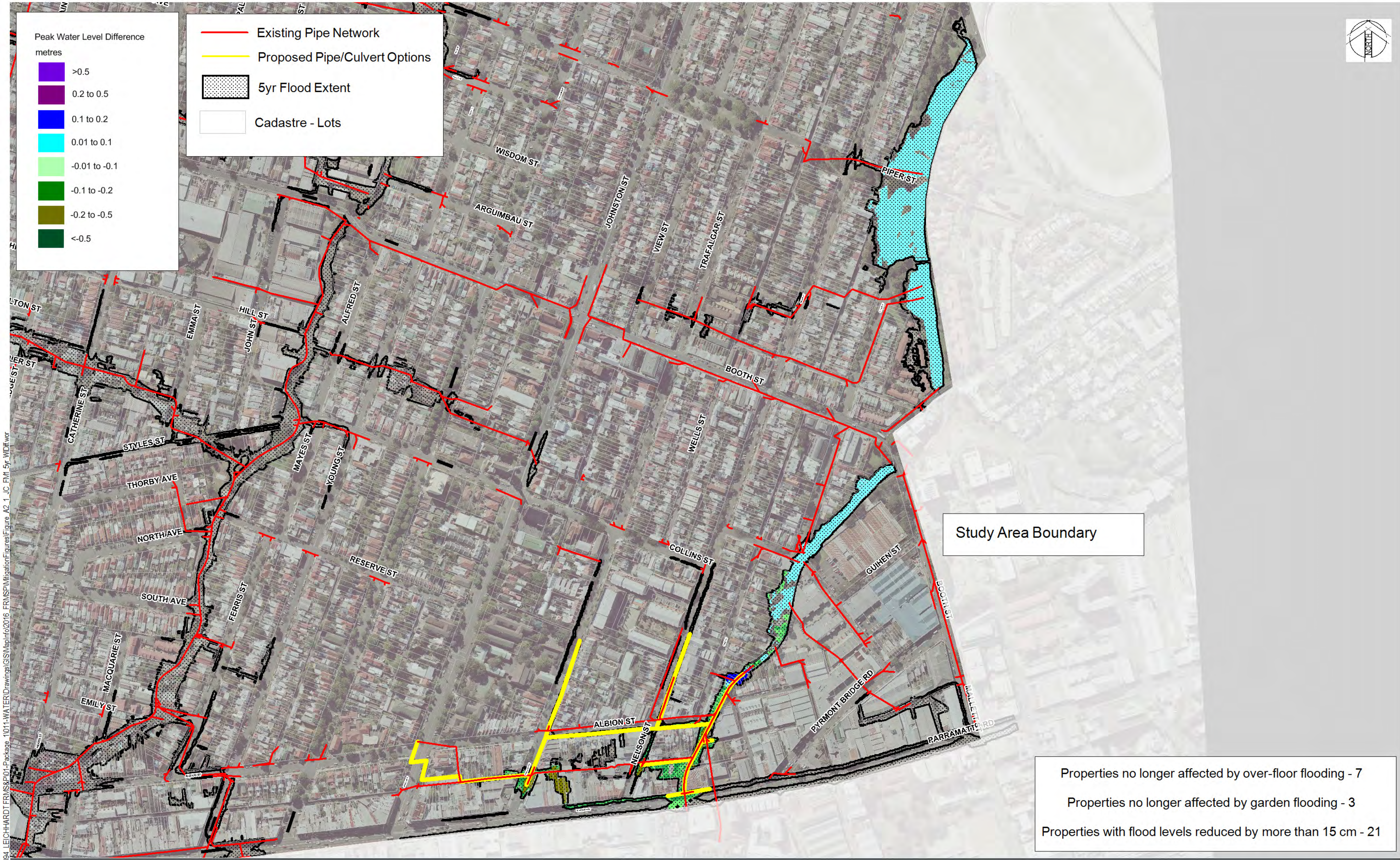
The benefit-cost ratio provides an insight into how the damage savings from a measure, relate to its cost of construction and maintenance:

- Where the benefit-cost is greater than 1 the economic benefits are greater than the cost of implementing the measure;
- Where the benefit-cost is less than 1 but greater than 0, there is still an economic benefit from implementing the measure but the cost of implementing the measure is greater than the economic benefit;
- Where the benefit-cost is equal to zero, there is no economic benefit from implementing the measure; and
- Where the benefit-cost is less than zero, there is a negative economic impact of implementing the measure.

Table 4-8 Summary of Economic Assessment of Flood Management Options

Option ID	Option Description	NPW of Reduction in AAD	NPW of Cost of Implementation	B/C Ratio	Economic Ranking
JC-FM1	Johnston Street Flow Path – Proposing additional pipes/ culverts and duplication of existing pipe network from Johnston St to Johnstons Creek open channel. Additional pipes on Parramatta Rd, Trafalgar St, Albion St and Nelson St.	$1,987,000	$8,109,000	0.25	2
JC-FM2	Pyrmont Bridge Road Flow Path – Additional pipes or duplication of existing network from Parramatta Rd to Johnstons Creek via Pyrmont Bridge Rd.	$1,949,000	$6,182,000	0.32	1
JC-FM3	View Street Flow Path – Duplication of existing pipe network or additional pipes from View St to Johnston Creek (via Trafalgar St, Nelson St and Taylor St).	$318,000	$3,039,000	0.10	4
JC-FM4	Rose Street Flow Path - Additional pipes from Rose St/Johnston St to Federal Park via View St and Trafalgar St. Proposed Easement downstream of The Crescent to drain flood waters from the low point of the Rd.	$740,000	$3,491,000	0.21	3
JC-FM5	Additional pipes within Johnstons Creek Catchment – At Bayview Crescent, Piper St and at Wigram Rd.	-$1,000	$2,447,000	0.00	5
JC-FM6	Levee option	-$1,752,000	$633,000	-2.77	6

Johnstons Creek Mitigation Option Figures



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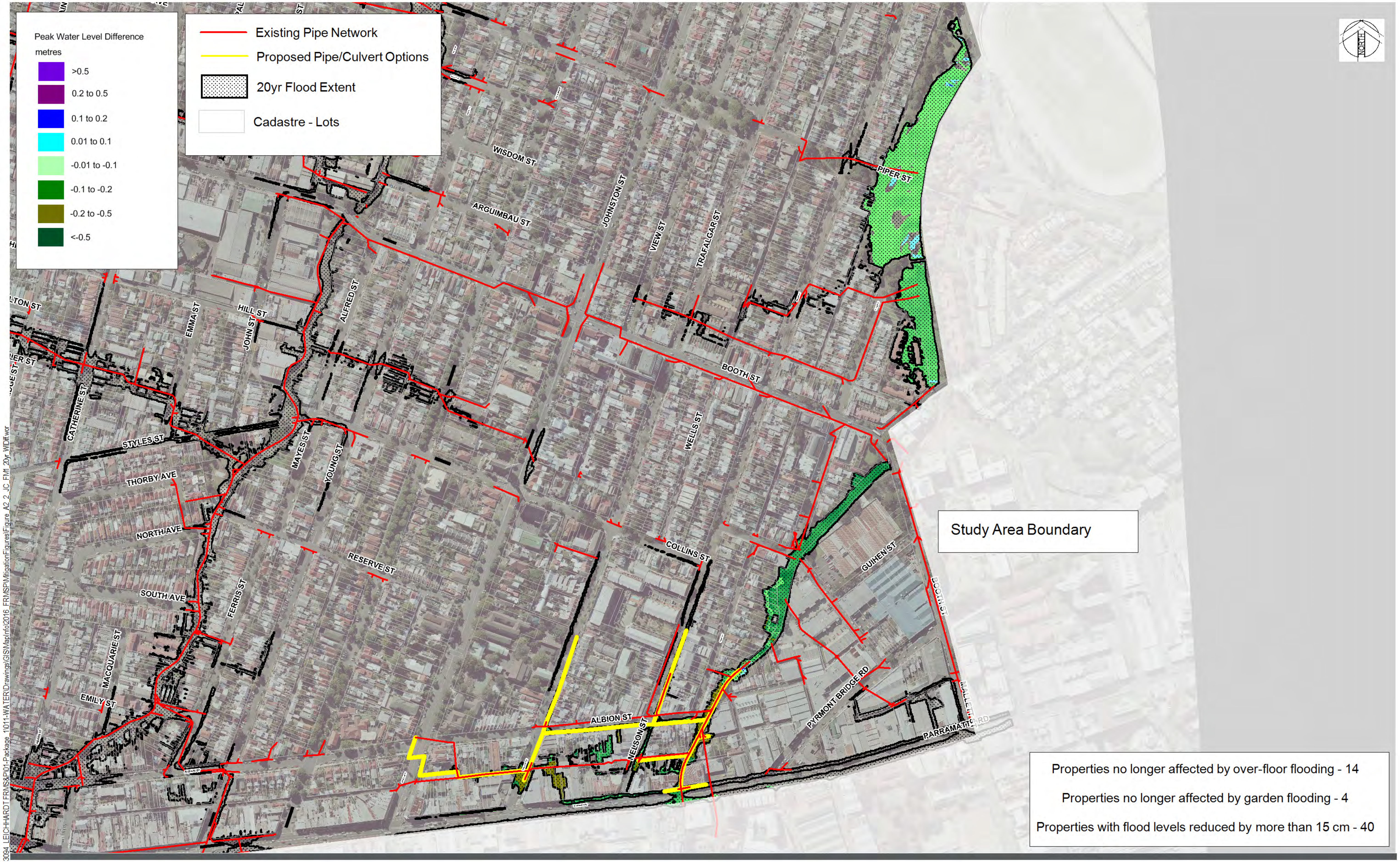
JC_FM1 5YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A2_1

Date	Size
03/2017	A3
JC_FM1_5yr_WlDiff	03
Drawing Number	Revision



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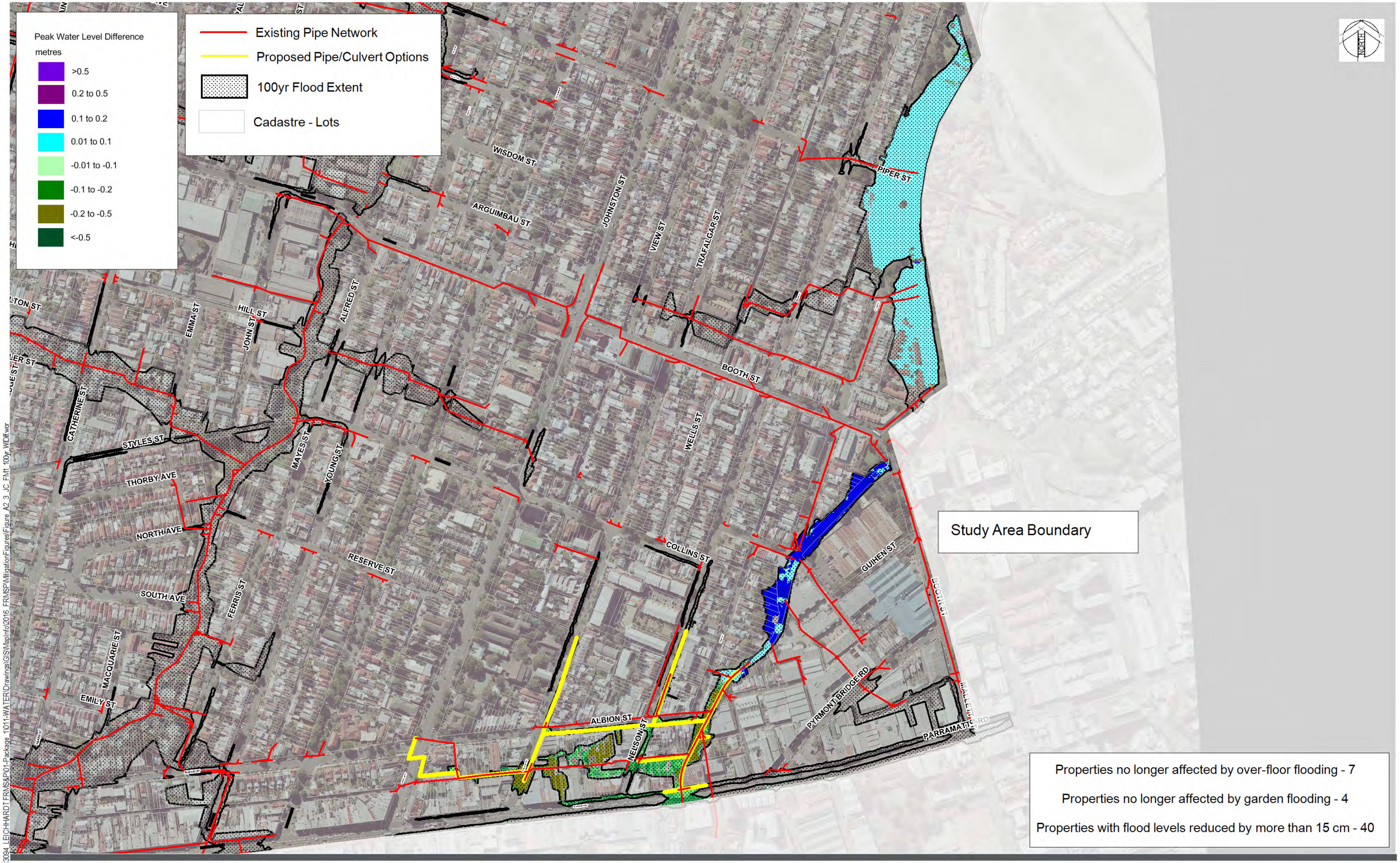
JC_FM1 20YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A2_2

Date	Size
03/2017	A3

JC_FM1_20yr_WlDiff
Drawing Number

03
Revision



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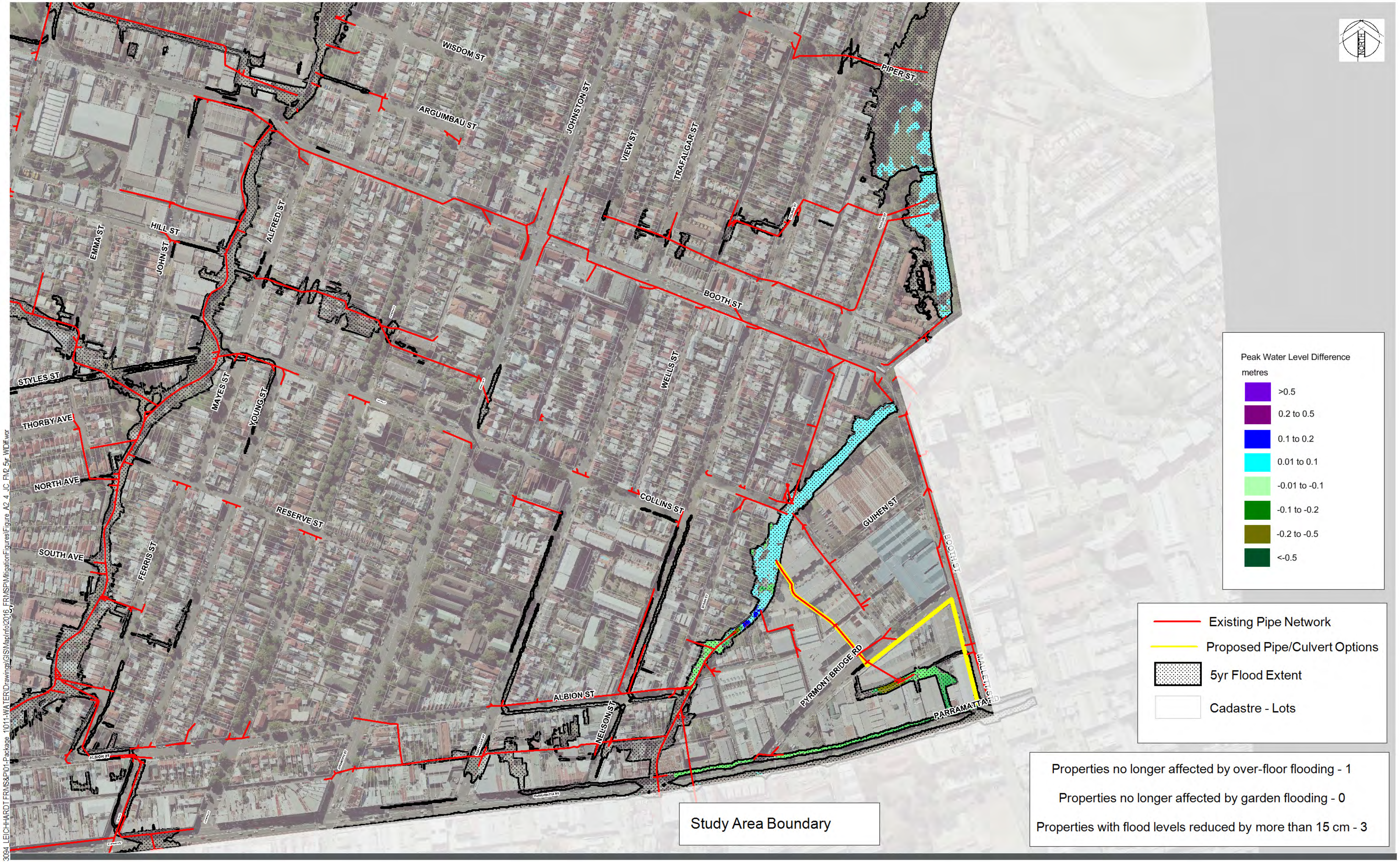
JC_FM1 100YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A2_3

Date
03/2017

JC_FM1_100yr_WlDiff
Drawing Number

Size
A3

03
Revision



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JC_FM2 5YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A2_4

Date
03/2017

JC_FM2_5yr_WlDiff
Drawing Number

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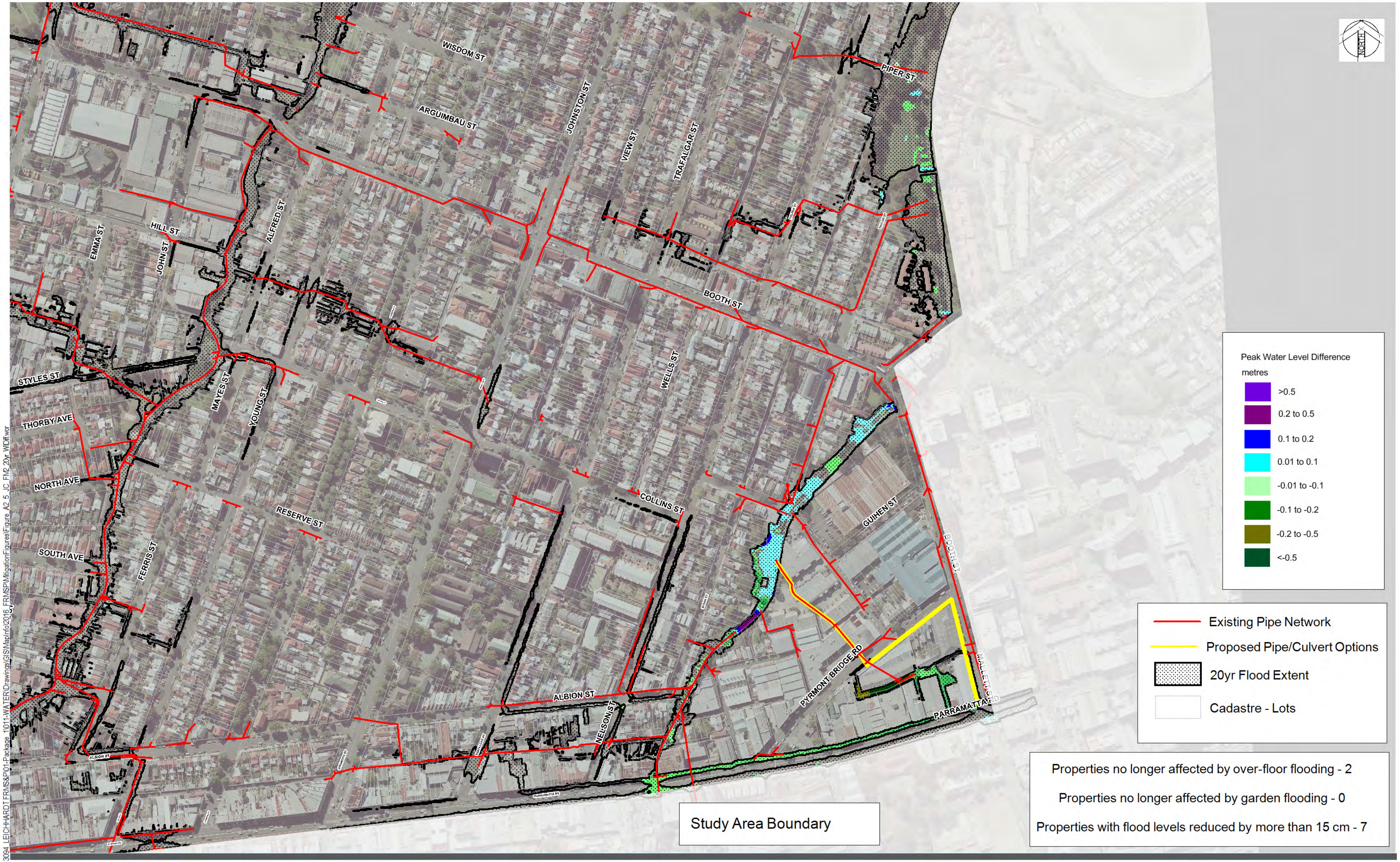
A3

03
Revision



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JC_FM2 20YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A2_5

Date		Size
03/2017		A3
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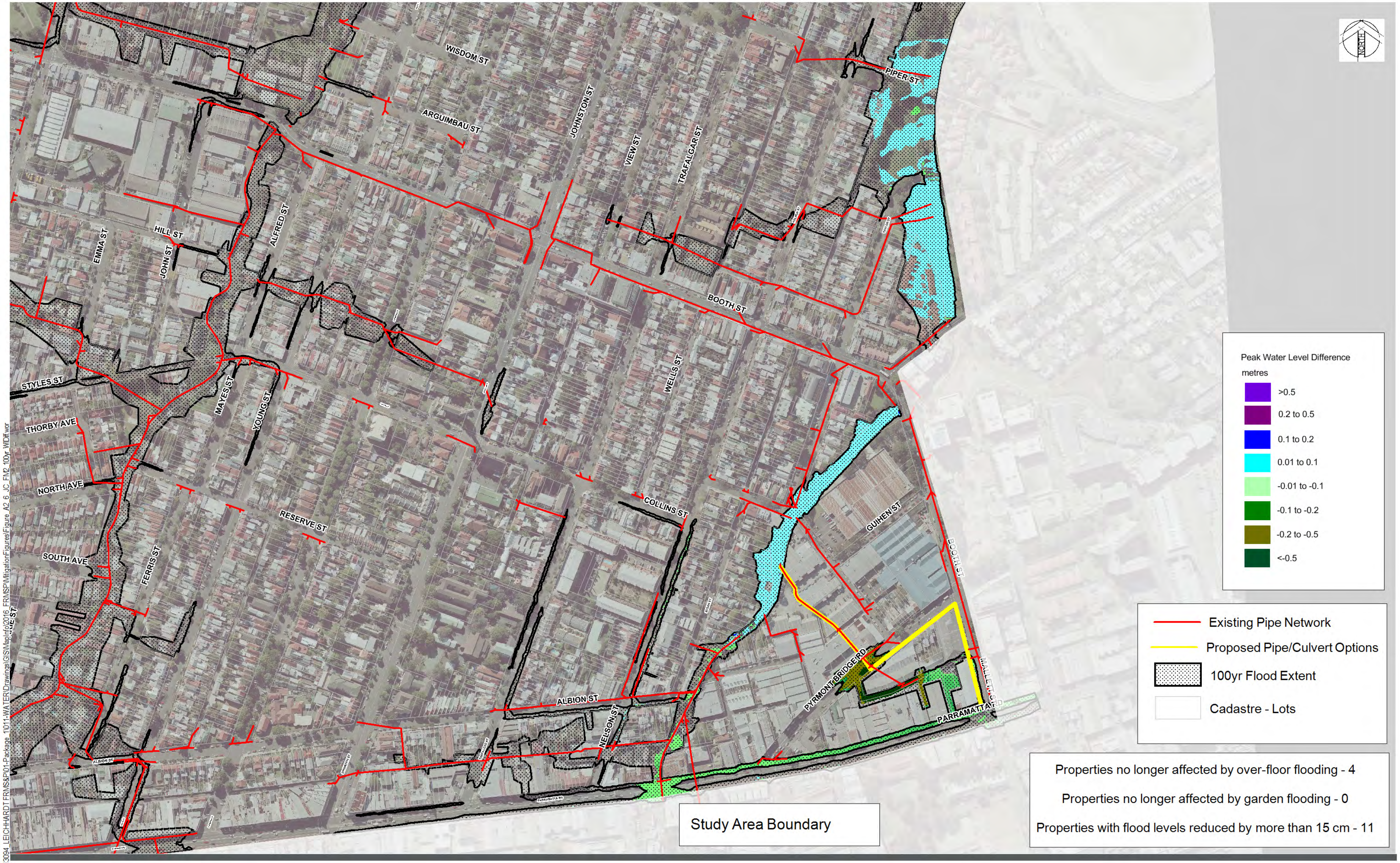
Drawing Number		Revision



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JC_FM2 100YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A2_6

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03/2017		A3
	JC_FM2_100yr_WIDiff	03
	Drawing Number	Revision

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JC_FM3 5YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A2_7

Date	03/2017
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Drawing Number	JC_FM3_5yr_WlDiff
Revision	03

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LEICHHARDT FRMS&P
JC_FM3 20YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A2_8

Date
03/2017

JC_FM3_20yr_WlDiff
Drawing Number

Size
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Revision

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JC_FM3 100YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A2_9

Date
03/2017

Size
A3

JC_FM3_100yr_WlDiff
Drawing Number

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Revision

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JC_FM4 5YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A2_10

Date	Size
03/2017	A3
JC_FM4_5yr_WlDiff	03
Drawing Number	Revision

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LEICHHARDT FRMS&P
JC_FM4 20YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A2_11

Date
03/2017

JC_FM4_20yr_WlDiff
Drawing Number

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Revision

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JC_FM4 100YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A2_12

Date	Size
03/2017	A3
JC_FM4_100yr_WlDiff	03
Drawing Number	Revision

Properties no longer affected by over-floor flooding - 0

Properties no longer affected by garden flooding - 0

Properties with flood levels reduced by more than 15 cm - 2

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JC_FM5 5YR ARI WL DIFF
MITIGATION LESS EXISTING

FIG_A2_13

Date
03/2017

JC_FM5_5yr_WlDiff
Drawing Number

Size
A3

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Revision

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Properties no longer affected by over-floor flooding - 0

Properties no longer affected by garden flooding - 0

Properties with flood levels reduced by more than 15 cm - 5

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JC_FM5 20YR ARI WL DIFF
MITIGATION LESS EXISTING

FIG_A2_14

Date
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JC_FM5_20yr_WlDiff
Drawing Number

Size
A3

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Revision

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JC_FM5 100YR ARI WL DIFF
MITIGATION LESS EXISTING

FIG_A2_15

Date
03/2017

JC_FM5_100yr_WlDiff
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Size
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LEICHHARDT FRMS&P
JC_FM6 5YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A2_16

Date		Size
03/2017		A3
JC_FM6_5yr_WlDiff		03
Drawing Number		Revision

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LEICHHARDT FRMS&P

JC_FM6 20YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A2_17

Date
03/2017

JC_FM6_20yr_WlDiff
Drawing Number

Size
A3

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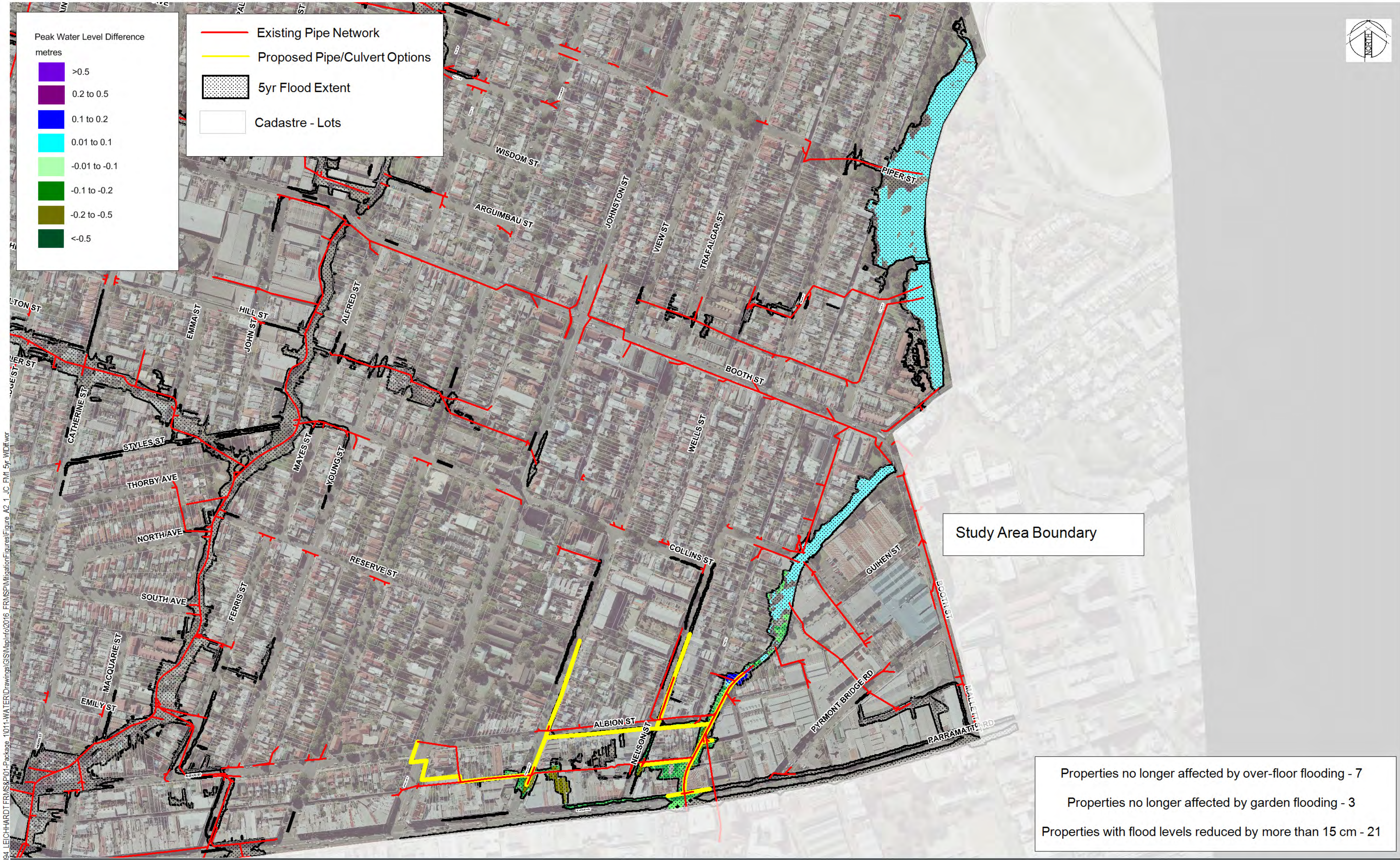
LEICHHARDT FRMS&P

JC_FM6 100YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A2_18

Date	Size
03/2017	A3

JC_FM6_100yr_WlDiff
Drawing Number

03
Revision



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LEICHHARDT FRMS&P
JC_FM1 5YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A2_1

Date
03/2017

JC_FM1_5yr_WlDiff
Drawing Number

Size
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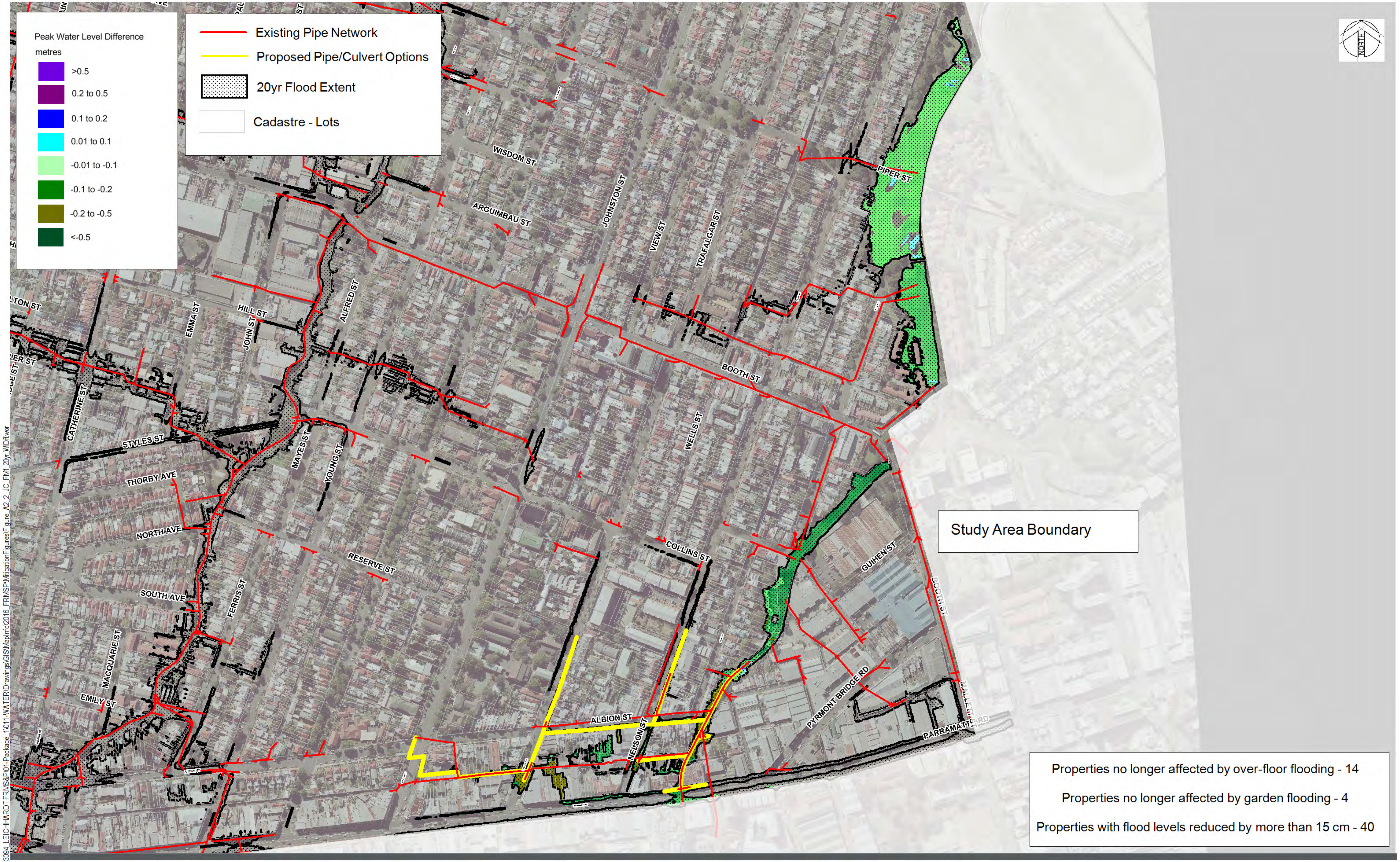
Revision



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LEICHHARDT FRMS&P
JC_FM1 20YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A2_2

Date
03/2017

JC_FM1_20yr_WlDiff
Drawing Number

Size
A3

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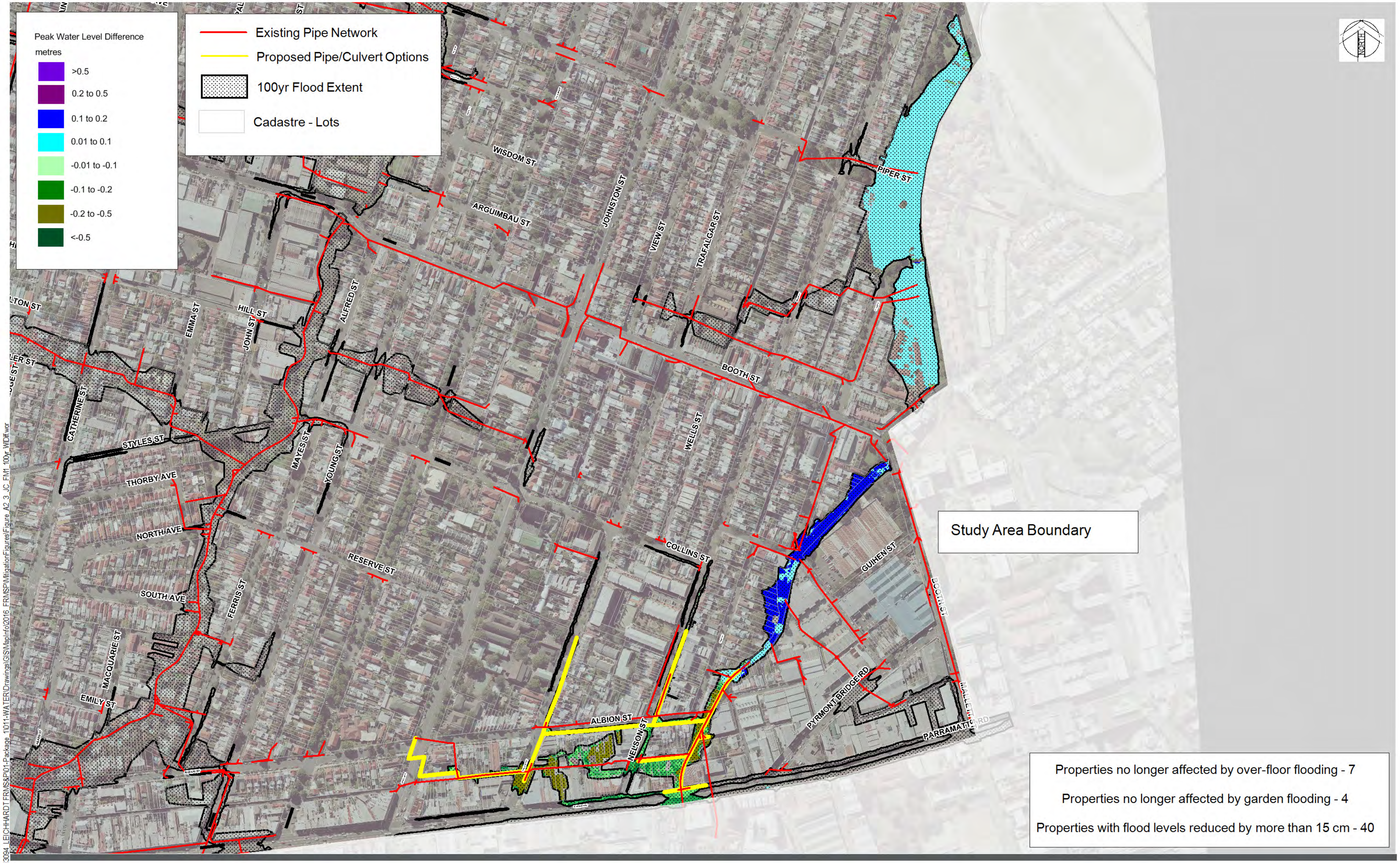
Revision



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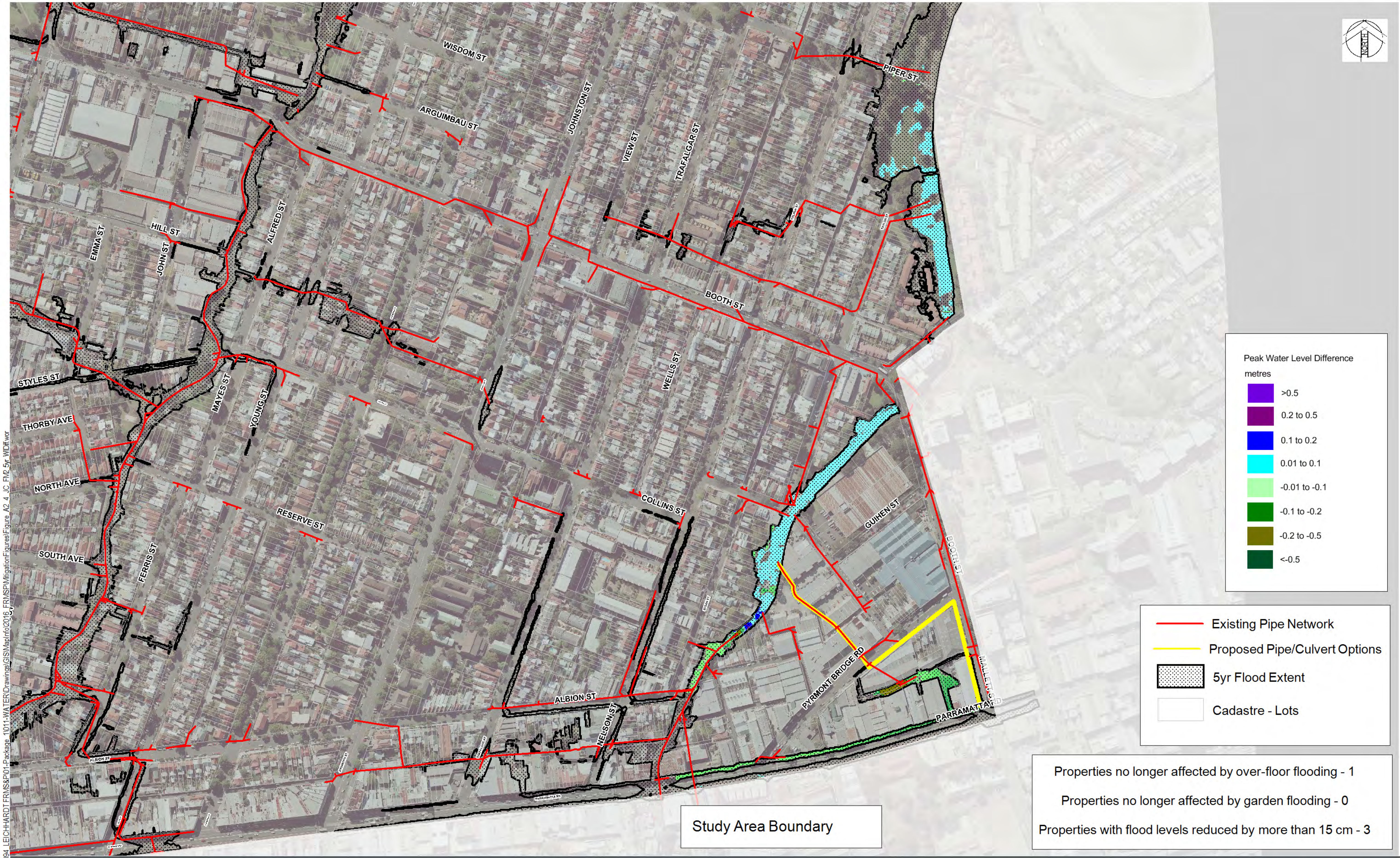
LEICHHARDT FRMS&P
JC_FM1 100YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A2_3

Date	Size
03/2017	A3

JC_FM1_100yr_WlDiff	03
Drawing Number	Revision



INNER WEST COUNCIL
LEICHHARDT FRMS&P
JC_FM2 5YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A2_4

Date
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Size
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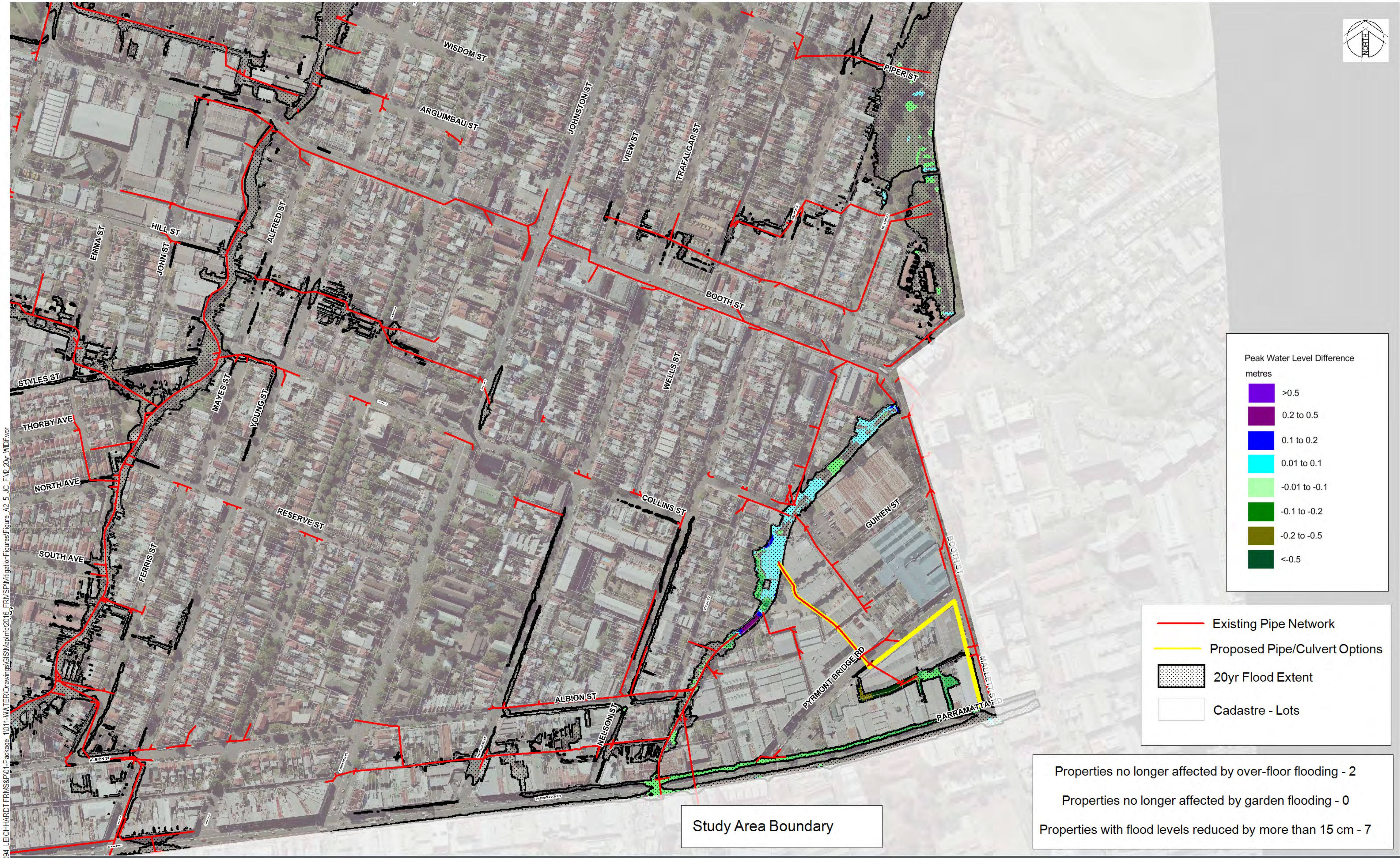

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LEICHHARDT FRMS&P
JC_FM2 20YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A2_5

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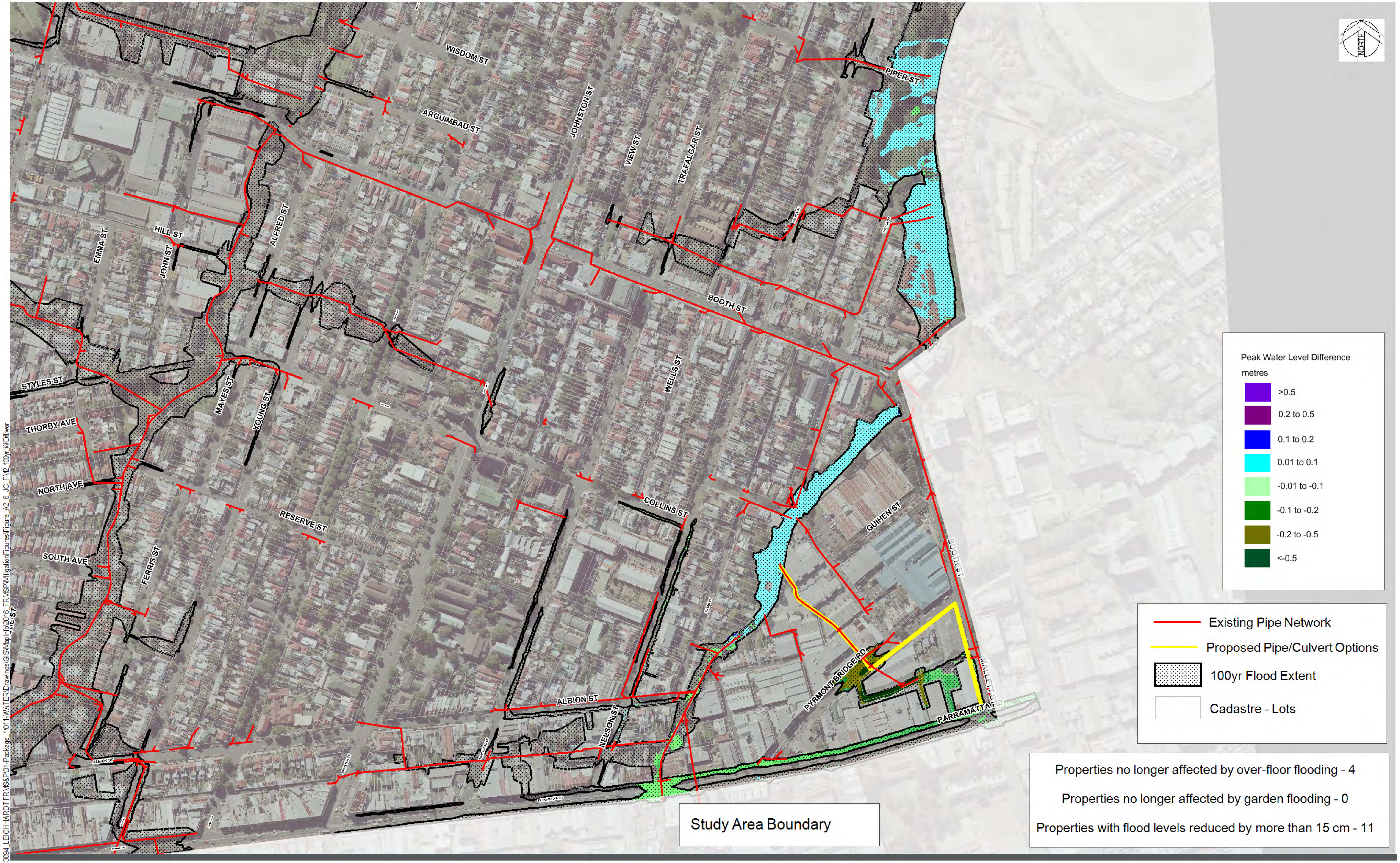
JC_FM2_20yr_WlDiff	03
Drawing Number	Revision



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LEICHHARDT FRMS&P
JC_FM2 100YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A2_6

Date
03/2017

JC_FM2_100yr_WlDiff
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JC_FM3 5YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A2_7

Date
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LEICHHARDT FRMS&P
JC_FM3 20YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A2_8

Date
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JC_FM3_20yr_WlDiff
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JC_FM3 100YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A2_9

Date
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JC_FM4 5YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A2_10

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JC_FM4 20YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A2_11

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LEICHHARDT FRMS&P

JC_FM4 100YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A2_12

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Properties no longer affected by over-floor flooding - 0

Properties no longer affected by garden flooding - 0

Properties with flood levels reduced by more than 15 cm - 2

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LEICHHARDT FRMS&P

JC_FM5 5YR ARI WL DIFF
MITIGATION LESS EXISTING

FIG_A2_13

Date
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JC_FM5_5yr_WlDiff
Drawing Number

Size
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JC_FM5 20YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A2_14

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JC_FM5 100YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A2_15

Date
03/2017

JC_FM5_100yr_WlDiff
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JC_FM6 5YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A2_16

Date
03/2017

JC_FM6_5yr_WlDiff
Drawing Number

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JC_FM6 20YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A2_17

Date
03/2017

JC_FM6_20yr_WlDiff
Drawing Number

Size
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JC_FM6 100YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A2_18

Date
03/2017

JC_FM6_100yr_WlDiff
Drawing Number

Size
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Area 3 - Whites Creek Options Assessment

Leichhardt Flood Risk Management Study and Plan

NA49913094

Prepared for
Inner West Council

Table of Contents

Tables

Figures

1 Whites Creek Catchment Description

The Whites Creek catchment includes areas to the south of Parramatta Road (outside of the study area)., The catchment area within the study area includes portions of Leichhardt and Annandale. The southern portion of Whites Creek is a box culvert and Whites Creek Lane follows the majority of the length of this culvert. The culvert becomes an open channel between Booth Street and Piper Street, and eventually discharges into Rozelle Bay to the east of The Crescent.

Flooding in the area occurs along both the creek itself and a number of overland flow tributaries that connect with the creek. The major flowpath tends to follow Whites Creek Lane. Downstream of the culvert section of Whites Creek, the creek is bounded by parkland on both sides for the majority of the length. Flooding downstream of the culvert is primarily limited to the parkland, although a number of adjacent properties are affected. A number of properties are also impacted by overland flooding from tributaries to the main Whites Creek flowpath.

The options proposed for assessment in the report are located within the study area portion of the Whites Creek Catchment.

The location of the Whites Creek Catchment within the study area is shown in **Figure 1-1**.

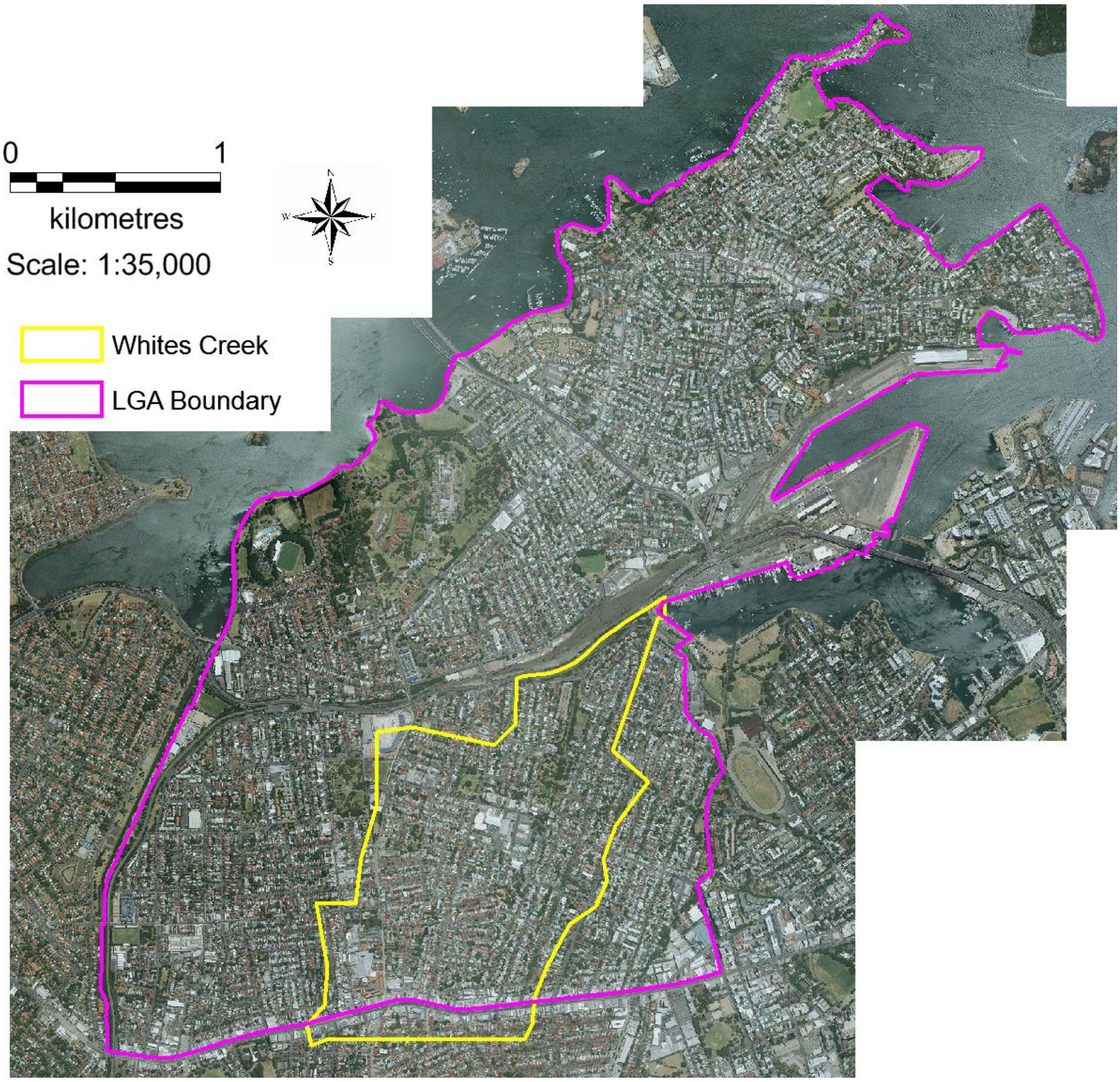

Figure 1-1 Whites Creek Catchment Location

2 Flood Mitigation Options Identification

2.1 Flood Modification Measures for Whites Creek

The existing flood behaviour within the Whites Creek Catchment is detailed in the Leichhardt Flood Study (Cardno 2014). Based on the flood model results, historical information and engineering judgement, possible flood modification measures (i.e. structural measures) for the study area were identified.

The various management options were identified taking into consideration the:

- flood behaviour and flow in the 20 year ARI event;
- grade of pipe (upstream and downstream); and
- preliminary availability and location of easements.

It should also be noted that Sydney Water and RMS may also play a major role in regards to fund allocation for the options recommended. Sydney Water's approach to flood-related improvement works on its assets is that Sydney Water will work with Councils to deliver the works (typically on a 50:50 cost-sharing basis) and provided Sydney Water has funding available within its Flood Risk Program.

Flood modification measures for the Whites Creek Catchment have been identified based on opportunities to connect with future upgrades and improvements.

2.2 Whites Creek Flood Mitigation Options

Within the Whites Creek catchment thirteen (13) sets of options were modelled. These are shown in **Table 2-1** and **Figure 2-1-1**. The 100yr, 20yr and 5yr ARI peak water level difference plots for each mitigation option are attached at the end of this appendix report.

Table 2-1 Whites Creek Mitigation Options

Option Description	Option Name	ID
Whites Creek Culvert – Proposing additional culvert or duplication of existing Whites Creek culvert from Parramatta Rd to the open channel downstream of Moore St (at Wisdom Street). Also combining WC-FM2 along with this option.	Whites Creek Culvert WC-FM1	WC-FM1
Young Street Flow Path – Proposing new pipe network from Young Street/Parramatta Road to Whites Creek culvert via Young St, Albion St, Ferris St and Clarke St. Additional pipe network from Young St to Albion Street.	Young Street Branch WC-FM2	WC-FM2
Balmain Road Flow Path – Additional pipe from the low point on Norton St to the existing pipe network (towards Parramatta Rd). Duplication of existing pipe network or extra pipes from Balmain Rd to Whites Creek Culvert at Hearn St.	Balmain Road Branch WC-FM3	WC-FM3
Hearn Street – Detention Basin or Large Inlet Pits at Hearn St to collect flood waters and convey into the proposed Whites Creek Culvert. Additional pipes from Albion St to Whites Creek culvert.	Hearn Street Proposed Basin WC-FM4	WC-FM4
Detention Basin at Mackenzie Street (upstream at the intersection of Mackenzie and Milton St)	Mackenzie Street Proposed Basin WC-FM5	WC-FM5
Styles Street Flow Path – Additional pipes from Mackenzie St to Whites Creek Culvert.	Styles Street Branch WC-FM6	WC-FM6

Option Description	Option Name	ID
Detention Basin at Evan Jones Park	Evan Jones Park Proposed Basin WC-FM7	WC-FM7
Annandale Street Flow Path – Duplication of existing pipe network or additional pipes from Annandale St to Whites Creek culvert.	Annandale Street Branch WC-FM8	WC-FM8
Detention Basin at Catherine Street (War Memorial Park)	Moore Street Proposed Basin WC-FM10	WC-FM10
Moore Street Flow Path – Additional Pipes from Catherine St to Whites Creek along Moore Lane.	Moore Street Branch WC-FM11	WC-FM11
Additional pipes at Brenan St and Railway PDE to reduce flooding on the roads.	Brenan Street Branch WC-FM12	WC-FM12
Whites Creek Culvert/Open Channel – Proposing additional culvert or duplication of existing Whites Creek culvert from Parramatta Rd to the open channel downstream of Moore St (WC-FM1). Widening of the open channel to convey additional flows. Upgrade Bridges at Piper Street and Brenan Street (WC-FM14)	Whites Creek Culvert WC-FM13	WC-FM13
Whites Creek Bridge Upgrades–Upgrade Bridges at Piper Street and Brenan Street.	Whites Creek Culvert WC-FM14	WC-FM14

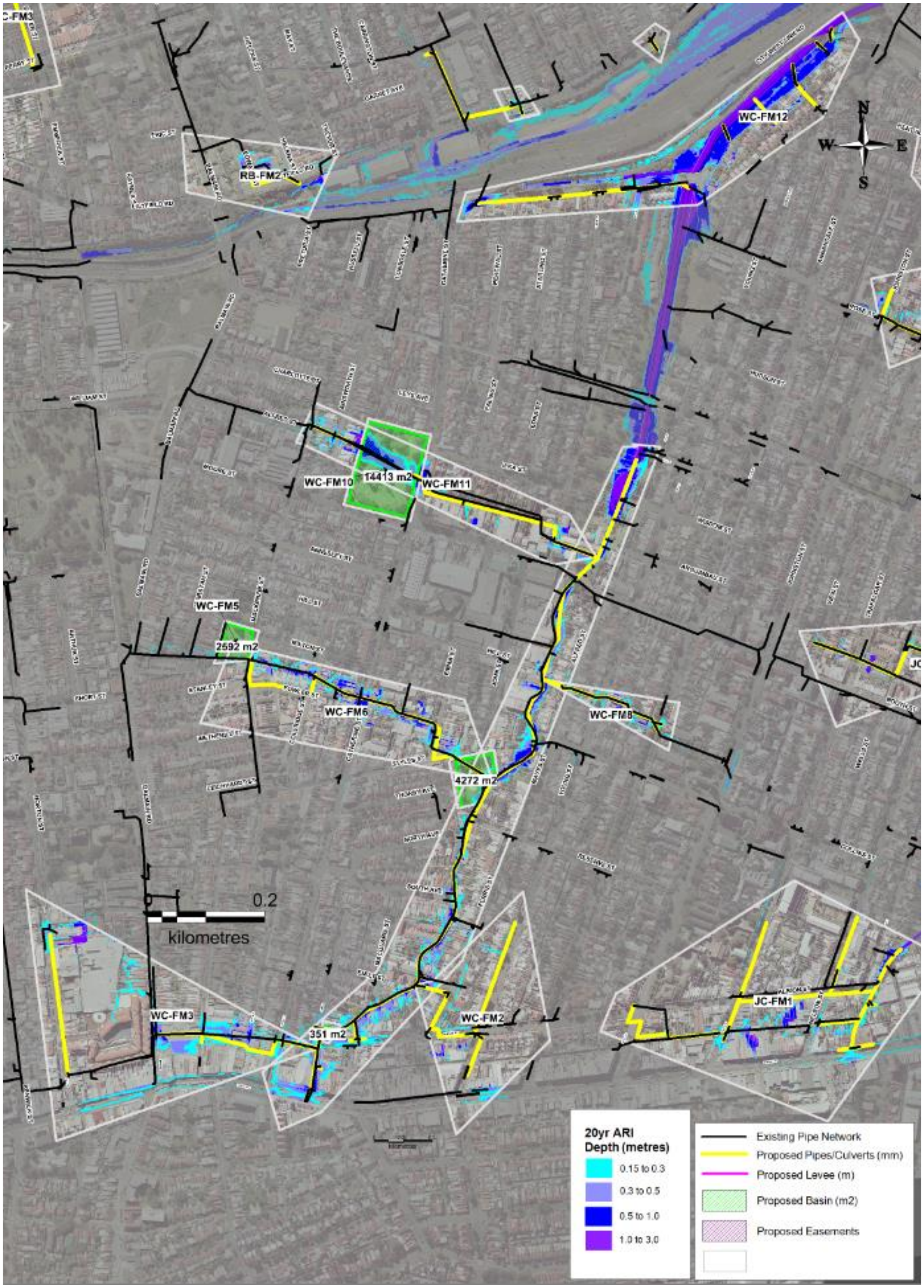

Figure 2-1 Whites Creek Mitigation Options Locations

2.2.1 Whites Creek Culvert WC-FM1

Whites Creek Culvert consists of various box culverts with a combined length of 1,395m that start from Parramatta Road, traveling along Whites Creek Lane and then coming to an end at Whites Creek Valley Park. The culvert has several pipes (1650mm diameter and 1200mm diameter) feeding into it upstream of the catchment. The box culvert sizes are 1.8m x 1.2m (100m), 2.1m x 1.8m (210m), 2.4m x 1.8m (400m), 2.7m x 2.1m (470m) and 3.1m x 2.1m (215m). This option (WC-FM1) proposes to duplicate these existing culverts.

A potential issue in regards to this option are road closures and traffic disruption during construction of the system and potential impacts to Whites Creek Valley Park, depending on the configuration of the adopted works.

Funding from Sydney Water (for the main trunk drainage) and RMS funding is potentially available for a majority of the cost. The RMS funding has been allocated towards the transverse pipe upgrades on Parramatta Road, Styles Street and Moore Street.

2.2.2 Young Street Branch WC-FM2

WC-FM2 consists of a pipe and a culvert. The culvert (1.5m x 0.9m) starts from Young Street/ Parramatta Road conveying runoff into Whites Creek culvert via Young Street, Albion Street, Ferris Street and Clarke Street. The 750mm diameter pipe network runs from Young St (north of Albion St) to the Young Street/Albion Street junction, then connects to the proposed culvert in Albion Street.

Potential constraints for this measure include road closures and traffic disruption during construction.

Funding from Sydney Water may be available for the works that include the Sydney Water main trunk drainage.

2.2.3 Balmain Road Branch WC-FM3

This option proposes additional pipes in two sections. One section is from the low point on Norton Street to the existing pipe network (towards Parramatta Road) with a 450mm diameter pipe (250m in length). The other section includes duplication of the existing pipe network or additional pipes from Balmain Road to Whites Creek Culvert at Hearn Street. Pipes in the second section comprise of 1650mm, 1350mm and 1200mm diameters.

Within the first section of proposed pipe there are existing flood depths in the 20 Year ARI up to 2m. Within the second section the 20 Year ARI flood depths reach approximately 0.7m.

Constraints for this measure include interaction with private property, road closures and traffic disruption during construction of the option.

2.2.4 Hearn Street Proposed Basin WC-FM4

This option proposes the use of either a detention basin and large inlet pits at Hearn Street to collect and convey flood waters into the proposed Whites Creek Culvert. Additional pipes from Albion Street to Whites Creek culvert have also been proposed. During the development of this option it was identified that there is insufficient space for a retarding basin in this location.

2.2.5 Mackenzie Street Proposed Basin WC-FM5

WC-FM5 is a detention basin that has been proposed to be located at the 36th Battalion Park (upstream from the intersection of Mackenzie and Milton St). The basin has an area of 2,592 square meters and is required to hold a volume of around 1,505 cubic meters. The aim of the basin is to mitigate flood inundation downstream of Mackenzie Street. Flood depths in this area under existing conditions reach around 0.6m in the 20 year ARI storm event.

Potential constraints for this measure includes vegetation removal in 36th Battalion Park and changes to recreational use of 36th Battalion Park, depending on the configuration of the basin and if underground storage is adopted.

2.2.6 Styles Street Branch WC-FM6

This option proposes additional pipes from Mackenzie Street to Whites Creek Culvert. The proposed pipes include a 1500mm diameter pipe from Mackenzie Street (the pipe crosses Coleridge and Catherine Streets) that then drains into a proposed 1650mm diameter pipe that travels from Catherine Street through to Styles Street, eventually draining into the Whites Creek Culvert. Additionally, there is a proposed 900mm diameter branch on Coleridge Street that drain onto the proposed 1500mm diameter branch.

The area currently experiences flood depths of around 1.4m in the 20 year ARI storm event.

Potential constraints for this measure includes interaction with private property and pipe crossings of roads with associated costs due to construction, services and traffic management requirements.

A majority of the cost could potentially be sourced from Sydney Water.

2.2.7 Evan Jones Park Proposed Basin WC-FM7

WC-FM7 is a proposed detention Basin at Evan Jones Park. Potential constraints for this measure include the slope and grades of flow paths and pipes connecting into and from the proposed basin. This is discussed in more detail in **Section 3.7**.

2.2.8 Annandale Street Branch WC-FM8

WC-FM8 consists of the duplication of the existing pipe network from Annandale Street (between Booth Street and Collins Street) to Whites Creek culvert. Two pipes, 900mm diameter each, start from Annandale Street and connect to a 1050mm diameter pipe that eventually connects to Whites Creek Culvert. The area experiences flood depths of around 1.3m due the 20 ARI storm event.

Potential constraints for this measure include the interaction with private property and constructing pipes along narrow easements.

2.2.9 Moore Street Proposed Basin WC-FM10

WC-FM10 proposes a detention basin located at the War Memorial Park which is in the block between Moore Street and Leys Avenue. The basin has an area of 14,400 square metres and conceptually holds a volume of around 2,400 cubic metres. It has been assumed that this basin would be an above ground retarding basin utilising the natural shape of the park.

The aim of the basin is to mitigate flood inundation around that specific block and on Ainsworth Street due to the 20 year ARI storm event. Depths in this area reach around 1.4m in this event.

Potential constraints for this measure includes vegetation removal in War Memorial Park and changes to recreational use of War Memorial Park, depending on the configuration of the basin.

Sydney Water may potentially fund part of the cost. However, it was assumed that all retarding basin maintenance costs will be Council's responsibility.

2.2.10 Moore Street Branch WC-FM11

The Moore Street branch option consists of two sections of proposed additional Pipes from the west end of Alfred Street to Whites Creek along Moore Lane. The second section of the option consists of a 1500mm diameter pipe, which eventually drains into the Whites Creek Culvert.

The major flooding is similar to that experienced by WC-FM10 with a depth of around 1.4m in the vicinity due to the 20 year ARI storm event.

It should be noted that Sydney Water will potentially fund some of the cost associated with this option.

2.2.11 Brenan Street Branch WC-FM12

Additional pipes are proposed in six areas/sections to combine to make up option WC-FM12. The longest section is along Brenan Street and the rest of the sections lie across Railway Parade. All sections have pipes with a 900mm diameter. The peak existing flood depth in the area due to the 20 year ARI storm event is 1.5m.

2.2.12 Whites Creek Culvert & Open Channel WC-FM13

The results of the WC-FM1 modelling indicate that there are likely to be significant flood benefits associated with duplicating the existing culverts and pipes along the Whites Creek main drainage line. However, this option also results in increases in flood levels downstream of the culvert.

This proposed mitigation option includes option WC-FM1 (duplicating of the existing culvert and Young Street works) and widening of the open channel (6m x 1m) from Wisdom Street to Rozelle Bay. The intent of this options is to accommodate the increases resulting from the culvert duplication within the improved open channel. This option also includes upgrading of Piper Street and Brenan Street Bridges (WC-FM14). Funding from Sydney Water (for the main trunk drainage) and RMS funding is potentially available for a majority of the cost.

2.2.13 Whites Creek Bridge Upgrades WC-FM14

This mitigation option includes duplicating of the openings under the existing Piper Street and Brenan Street Bridges.

3 Mitigation Option Modelling Outcomes

The Whites Creek flood mitigation options were assessed for the 5, 10, 20, 50 and 100 Year ARI design flood events, along with the PMF event.

The outcomes of the modelling are shown in the 5, 20, and 100 Year ARI water level difference plots attached at the end of this catchment report.

A summary of the impacts on flood behaviour for each option is provided below.

3.1 Whites Creek Culvert WC-FM1

The proposed mitigation option WC-FM1 shows a significant decrease in water level along the Whites Creek Lane. The water level difference shows a decrease in water levels up to 1.30m in the 100 Year ARI event. In general, the reductions in a 20 Year ARI are in the order of 0.10m to 0.70m. Notable reductions are seen in all the modelled design events along parts of Parramatta Road, Albion Street, Clarke Street and Styles Street. Results indicate that many properties would experience a decrease in water level in a 100 Year ARI due to this mitigation strategy.

However, due to the proposed works (duplicating of the existing culvert), flood level increases are expected to occur downstream of the culvert in an order of 0.01m to 0.25m.

3.2 Young Street Branch WC-FM2

Mitigation option WC-FM2 shows a decrease in water level of up to 0.20m in a 20Year ARI. The reductions of water levels are observed along parts of Young Street, Albion Street, Ferris Street, Clarke Street and downstream of Whites Creek Lane. These reductions in flood levels are primarily contained to roadways and do not result in a significant decrease in the number of properties with over floor flooding.

Slight increases in flood levels are observed in all events, in an order of 0.01m to 0.15m along the open channel. However, these increases are confined to the creek reserve. Results indicate properties along Young Street, Ferris Street and Albion Street would experience a decrease in water level in a 20 Year ARI due to this mitigation strategy.

3.3 Balmain Road Branch WC-FM3

Mitigation option WC-FM3 shows a decrease in water levels of up to 0.40m in a 20 Year ARI. The decreases in levels are observed along the Balmain Road Branch flowpath and along the Whites Creek Lane. The most significant reductions are seen at Balmain Road, Hay Street, Reymond Street, Catherine Street, Albion Street, Hearn Street, Macquarie Street and parts of Whites Creek Lane.

Due to the proposed drainage works slight increases in flood levels in an order of 0.01m to 0.03m are observed in a 100 Year ARI along Whites Creek Lane downstream of South Avenue. Isolated increases in water levels up to 0.15m are seen upstream and downstream of Moore Street bridge in a 100 Year ARI.

3.4 Hearn Street Proposed Basin WC-FM4

The option of proposing a large inlet structures and detention basin at Hearn Street was identified in the preliminary list of options. During the development of this option it was identified that there is insufficient space for a retarding basin in this location. Preliminary modelling only identified minor reductions in flood levels and it was concluded that due to the land space restrictions and lack of flood benefits that this option would not be pursued further.

3.5 Mackenzie Street Proposed Basin WC-FM5

Proposing a detention basin at Mackenzie Street results in reduction of water levels downstream of the basin along the flowpath in an order of 0.01m to 0.25m in a 100 Year ARI event. Notable reductions are seen in all the modelled design events on Mackenzie Street, Coleridge Street, Catherine Street and Styles Street. Results indicate properties downstream of the basin along the flowpath would experience a decrease in water levels up to 0.25m in the 100 Year ARI event due to the proposed basin at Mackenzie Street.

3.6 Styles Street Branch WC-FM6

The proposed drainage works WC-FM6 show significant reductions of water levels along the flow path. The reductions in flood levels are in an order of 0.01m to 0.60m in a 100 Year ARI. The maximum reductions are seen on Catherine Street up to 0.60m. Noticeable reductions are seen in all the modelled design events on Mackenzie Street, Coleridge Street, Catherine Street, Emma Street and parts of Styles Street.

Minor increases in flood levels are observed along parts of Whites Creek Lane in an order of 0.01m to 0.05m upstream and downstream of Styles Street. Isolated increases in water levels up to 0.10m are seen in Vicinity of Reserve Street in a 100 Year ARI.

3.7 Evan Jones Park Proposed Basin WC-FM7

This option of proposing a detention basin at Evan Jones Park was assessed, the results show minor reduction of flood levels downstream of the basin and along the Styles Street flowpath. The reductions are in an order of 0.01m to 0.05m.

It should be noted that although a theoretical allowance of detention storage has been assessed at this location, the technical feasibility of this option may inhibit it from being constructed. The street grades of the pipes entering the basin and shallow grades of the pipes connecting the basin to Whites Creek will likely limit its feasibility. As such, the hydraulic results have been provided for Council, if further consideration of works at this location become viable in the future. However, this option has not been included in the benefit cost analysis or multi-criteria analysis as it is not recommended for implementation based on technical merits.

3.8 Annandale Street Branch WC-FM8

The proposed additional pipe drainage along Annandale Street flow path WC-FM8 shows reduction in water levels along the flowpath in an order of 0.01m to 0.30m in a 100 Year ARI. The reduction in flood levels are seen on Annandale Street, Collins Lane, Young Street, Alfred Street and parts for Whites Creek Lane. Minor increases in flood levels up to 0.05m are seen downstream of Booth Street.

3.9 Moore Street Proposed Basin WC-FM10

The proposed basin at Moore Street WC-FM10 show reduction in flood levels downstream of the proposed basin up to 0.35m in a 100 Year ARI. Significant reductions in water levels are seen on Catherine Street, along Moore Lane and White Street. The regrading of the park also assists in reducing flood levels upstream of the basin. Decreases in levels up to 0.10m are observed on Ainsworth Street.

3.10 Moore Street Branch WC-FM11

Mitigation option WC-FM11 shows a decrease in water level of up to 0.40m in a 100 Year ARI event. The results show decreases in flood depths along the flowpath on Ainsworth Street up to 0.10m, Catherine Street up to 0.20m, along Moore Lane in an order of 0.01m to 0.25m and White Street up to 0.40m in a 100 Year ARI event. Minor increases in a range of 0.01m to 0.05m are observed downstream of Moore Street along Whites Creek Lane.

3.11 Brenan Street Branch WC-FM12

Proposed pipe drainage WC-FM12 shows a reduction of flood levels up to 0.18m on Brenan Street and 0.14m on Railway Parade in the 20 Year ARI event. No notable differences were identified in the 100 Year ARI event. However, the model results were unstable and the model was unable to be verifiably run for this event, as such no flood impact figure is shown for the 100 Year ARI event and the damages are assumed to be unchanged from the existing conditions.

3.12 Whites Creek Culvert & Open Channel WC-FM13

Mitigation option WC-FM13 shows significant decreases in flood levels along the Whites Creek. The reduction of flood depths along the closed section of the culvert along Whites Creek Lane is up to 1.20m in a 100 Year ARI. The reduction along the open channel section is approx. 0.30m. Reductions in an order of 0.01m to 0.10m are also seen along the Young Street flowpath and Styles Street flowpath because of the additional conveyance downstream.

Notable reductions are seen along parts of Parramatta Road, Albion Street, Clarke Street, Styles Street, Brenan Street and Railway Parade. No increase in flood levels are observed as an outcome of this option.

3.13 Whites Creek Bridge Upgrades WC-FM14

Mitigation option WC-FM14 results show reduction in flood levels upstream of Brenan Street and Piper Street. The reductions are due to more conveyance through the proposed upgraded bridges. The reduction in water levels are in an order of 0.15m to 0.20m in a 20 Year ARI. The reduction of flood depths on Brenan Street are up to 0.07m. Slight increase up to 0.03m are seen downstream of Brenan Street in a 20 Year ARI because of increased flow downstream in Whites Creek.

4 Economic Assessment of Flood Damages in the Whites Creek Catchment

4.1 Whites Creek Mitigation Options Damages Assessment

An assessment of damages for the existing condition in the Whites Creek Catchment is presented in the Floodplain Risk Management Study. The approach adopted for calculating the existing damages has been repeated for the modelling results from the mitigation options proposed for the Whites Creek catchment.

The economic flood damage results for each of the options and the existing scenarios are presented in **Table 4-1** to **Table 4-13**. The reductions in properties affected by overground and overfloor flooding, total damages and AAD are provided. Negative values represent increases from the existing scenario.

The total reduction in damaged properties and the associated reduction in damage costs for each mitigation strategy is summarised in **Table 4-14** This table represents a summary of differences between existing and Mitigation scenarios presented in **Table 4-1** to **Table 4-13**.

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Table 4-1 WC_FM1 Flood Damage Assessment Summary

Event / Property type	Properties with Overfloor Flooding		Properties with Overground Flooding		Estimated Total Damage ($ June 2016)	
	Existing Case	*Mitigation Case*	*Existing Case*	*Mitigation Case*	*Existing Case*	*Mitigation Case*
PMF Event						
Residential	758	742	1332	1324	$ 46,298,929	$ 44,384,607
Commercial	157	155	193	193	$ 10,366,324	$ 10,231,242
Industrial	83	82	89	89	$ 10,580,722	$ 10,098,639
PMF Total	**998**	**979**	**1614**	**1606**	**$ 67,245,974**	**$ 64,714,488**
100yr ARI						
Residential	209	159	396	389	$ 11,288,568	$ 9,098,393
Commercial	46	45	65	64	$ 4,494,647	$ 4,293,657
Industrial	19	17	23	23	$ 1,432,247	$ 914,707
100yr ARI Total	**274**	**221**	**484**	**476**	**$ 17,215,462**	**$ 14,306,757**
50yr ARI						
Residential	171	140	379	373	$ 9,734,166	$ 8,123,884
Commercial	43	43	62	61	$ 4,241,808	$ 4,138,522
Industrial	18	16	22	22	$ 1,207,955	$ 763,732
50yr ARI Total	**232**	**199**	**463**	**456**	**$ 15,183,929**	**$ 13,026,138**
20yr ARI						
Residential	123	107	333	325	$ 7,489,429	$ 6,548,266
Commercial	35	33	55	55	$ 3,904,476	$ 3,805,459
Industrial	10	9	19	19	$ 865,386	$ 598,029
20yr ARI Total	**168**	**149**	**407**	**399**	**$ 12,259,290**	**$ 10,951,753**
10yr ARI						
Residential	94	86	286	280	$ 5,999,116	$ 5,405,309
Commercial	30	28	50	50	$ 3,623,175	$ 3,547,977
Industrial	9	8	15	15	$ 666,535	$ 502,459
10yr ARI Total	**133**	**122**	**351**	**345**	**$ 10,288,826**	**$ 9,455,744**
5yr ARI						
Residential	64	57	210	208	$ 4,488,210	$ 4,106,680
Commercial	29	27	47	47	$ 3,331,915	$ 3,249,711
Industrial	8	6	14	14	$ 510,281	$ 390,208
5yr ARI Total	**101**	**90**	**271**	**269**	**$ 8,330,406**	**$ 7,746,600**
Total Annual Average Damage					**$ 3,740,136**	**$ 3,423,694**

Table 4-2 WC_FM2 Flood Damage Assessment Summary

Event / Property type	Properties with Overfloor Flooding		Properties with Overground Flooding		Estimated Total Damage ($ June 2016)	
	Existing Case	*Mitigation Case*	*Existing Case*	*Mitigation Case*	*Existing Case*	*Mitigation Case*
PMF Event						
Residential	473	473	781	779	$ 28,560,012	$ 28,032,685
Commercial	43	43	55	55	$ 1,637,045	$ 1,619,822
Industrial	63	63	65	65	$ 7,583,825	$ 7,233,871
PMF Total	**579**	**579**	**901**	**899**	**$ 37,780,883**	**$ 36,886,378**
100yr ARI						
Residential	142	139	266	266	$ 8,017,928	$ 7,896,553
Commercial	20	20	25	25	$ 479,971	$ 507,578
Industrial	15	15	16	16	$ 1,333,275	$ 1,298,411
100yr ARI Total	**177**	**174**	**307**	**307**	**$ 9,831,175**	**$ 9,702,543**
50yr ARI						
Residential	115	107	255	254	$ 6,960,315	$ 6,698,338
Commercial	19	19	23	23	$ 447,918	$ 445,021
Industrial	14	14	15	15	$ 1,130,432	$ 1,117,404
50yr ARI Total	**148**	**140**	**293**	**292**	**$ 8,538,666**	**$ 8,260,763**
20yr ARI						
Residential	87	81	223	222	$ 5,568,600	$ 5,382,700
Commercial	15	15	20	20	$ 362,895	$ 362,016
Industrial	9	9	14	14	$ 853,463	$ 850,950
20yr ARI Total	**111**	**105**	**257**	**256**	**$ 6,784,959**	**$ 6,595,666**
10yr ARI						
Residential	72	69	189	188	$ 4,733,374	$ 4,604,973
Commercial	11	11	19	19	$ 268,908	$ 268,607
Industrial	8	8	11	11	$ 656,802	$ 652,115
10yr ARI Total	**91**	**88**	**219**	**218**	**$ 5,659,084**	**$ 5,525,695**
5yr ARI						
Residential	52	52	146	146	$ 3,641,341	$ 3,591,527
Commercial	11	11	18	18	$ 269,999	$ 270,111
Industrial	7	8	11	11	$ 502,629	$ 497,724
5yr ARI Total	**70**	**71**	**175**	**175**	**$ 4,413,969**	**$ 4,359,362**
Total Annual Average Damage					**$ 2,036,589**	**$ 1,996,775**

Table 4-3 WC_FM3 Flood Damage Assessment Summary

Event / Property type	Properties with Overfloor Flooding		Properties with Overground Flooding		Estimated Total Damage ($ June 2016)	
	Existing Case	*Mitigation Case*	*Existing Case*	*Mitigation Case*	*Existing Case*	*Mitigation Case*
PMF Event						
Residential	595	588	1073	1073	$ 35,465,015	$ 34,876,039
Commercial	144	140	178	178	$ 10,209,337	$ 9,810,909
Industrial	75	74	81	81	$ 9,053,927	$ 8,950,717
PMF Total	**814**	**802**	**1332**	**1332**	**$ 54,728,278**	**$ 53,637,664**
100yr ARI						
Residential	172	157	342	344	$ 9,364,092	$ 8,751,559
Commercial	46	36	64	64	$ 4,494,647	$ 3,841,745
Industrial	18	18	19	19	$ 1,414,603	$ 1,410,334
100yr ARI Total	**236**	**211**	**425**	**427**	**$ 15,273,342**	**$ 14,003,638**
50yr ARI						
Residential	137	128	327	327	$ 8,006,158	$ 7,541,842
Commercial	43	33	61	61	$ 4,241,808	$ 3,612,334
Industrial	17	17	18	18	$ 1,193,133	$ 1,242,882
50yr ARI Total	**197**	**178**	**406**	**406**	**$ 13,441,100**	**$ 12,397,059**
20yr ARI						
Residential	104	94	287	287	$ 6,359,028	$ 5,919,056
Commercial	35	28	54	54	$ 3,904,476	$ 2,167,206
Industrial	9	10	16	16	$ 853,463	$ 908,404
20yr ARI Total	**148**	**132**	**357**	**357**	**$ 11,116,967**	**$ 8,994,665**
10yr ARI						
Residential	85	76	244	241	$ 5,284,652	$ 4,767,447
Commercial	30	25	50	50	$ 3,623,175	$ 1,399,564
Industrial	8	9	12	12	$ 656,802	$ 700,483
10yr ARI Total	**123**	**110**	**306**	**303**	**$ 9,564,628**	**$ 6,867,495**
5yr ARI						
Residential	59	55	187	184	$ 4,000,804	$ 3,654,949
Commercial	29	22	47	47	$ 3,331,915	$ 1,153,130
Industrial	7	9	11	11	$ 502,629	$ 544,507
5yr ARI Total	**95**	**86**	**245**	**242**	**$ 7,835,348**	**$ 5,352,585**
Total Annual Average Damage					**$ 3,424,257**	**$ 2,601,498**

Table 4-4 WC_FM4 Flood Damage Assessment Summary

Event / Property type	Properties with Overfloor Flooding		Properties with Overground Flooding		Estimated Total Damage ($ June 2016)	
	Existing Case	*Mitigation Case*	*Existing Case*	*Mitigation Case*	*Existing Case*	*Mitigation Case*
PMF Event						
Residential	270	270	450	449	$ 15,403,960	$ 15,176,396
Commercial	132	128	161	161	$ 9,877,658	$ 9,788,653
Industrial	0	0	0	0	$ -	$ -
PMF Total	**402**	**398**	**611**	**610**	**$ 25,281,618**	**$ 24,965,049**
100yr ARI						
Residential	76	44	163	162	$ 3,737,977	$ 2,467,169
Commercial	46	41	63	63	$ 4,494,647	$ 4,294,602
Industrial	0	0	0	0	$ -	$ -
100yr ARI Total	**122**	**85**	**226**	**225**	**$ 8,232,624**	**$ 6,761,770**
50yr ARI						
Residential	58	59	160	160	$ 3,140,633	$ 3,098,792
Commercial	43	43	60	61	$ 4,241,808	$ 4,252,541
Industrial	0	0	0	0	$ -	$ -
50yr ARI Total	**101**	**102**	**220**	**221**	**$ 7,382,442**	**$ 7,351,333**
20yr ARI						
Residential	43	43	143	143	$ 2,326,527	$ 2,317,737
Commercial	35	35	53	53	$ 3,904,476	$ 3,902,580
Industrial	0	0	0	0	$ -	$ -
20yr ARI Total	**78**	**78**	**196**	**196**	**$ 6,231,002**	**$ 6,220,316**
10yr ARI						
Residential	33	33	128	127	$ 1,866,810	$ 1,786,925
Commercial	30	31	50	50	$ 3,623,175	$ 3,635,536
Industrial	0	0	0	0	$ -	$ -
10yr ARI Total	**63**	**64**	**178**	**177**	**$ 5,489,985**	**$ 5,422,461**
5yr ARI						
Residential	24	24	100	100	$ 1,322,908	$ 1,260,293
Commercial	29	27	47	47	$ 3,331,915	$ 3,295,607
Industrial	0	0	0	0	$ -	$ -
5yr ARI Total	**53**	**51**	**147**	**147**	**$ 4,654,823**	**$ 4,555,900**
Total Annual Average Damage					**$ 1,948,320**	**$ 1,906,131**

Table 4-5 WC_FM5 Flood Damage Assessment Summary

Event / Property type	Properties with Overfloor Flooding		Properties with Overground Flooding		Estimated Total Damage ($ June 2016)	
	Existing Case	*Mitigation Case*	*Existing Case*	*Mitigation Case*	*Existing Case*	*Mitigation Case*
PMF Event						
Residential	114	97	222	219	$ 6,877,748	$ 5,881,107
Commercial	1	1	2	2	$ 82,822	$ 80,761
Industrial	0	0	0	0	$ -	$ -
PMF Total	**115**	**98**	**224**	**221**	**$ 6,960,571**	**$ 5,961,869**
100yr ARI						
Residential	45	24	72	66	$ 2,814,421	$ 1,942,722
Commercial	0	0	1	1	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
100yr ARI Total	**45**	**24**	**73**	**67**	**$ 2,814,421**	**$ 1,942,722**
50yr ARI						
Residential	37	19	69	61	$ 2,486,852	$ 1,586,994
Commercial	0	0	1	1	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
50yr ARI Total	**37**	**19**	**70**	**62**	**$ 2,486,852**	**$ 1,586,994**
20yr ARI						
Residential	27	19	60	57	$ 2,063,269	$ 1,674,762
Commercial	0	0	1	1	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
20yr ARI Total	**27**	**19**	**61**	**58**	**$ 2,063,269**	**$ 1,674,762**
10yr ARI						
Residential	24	19	55	54	$ 1,801,852	$ 1,579,099
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
10yr ARI Total	**24**	**19**	**55**	**54**	**$ 1,801,852**	**$ 1,579,099**
5yr ARI						
Residential	17	9	46	42	$ 1,540,111	$ 1,188,537
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
5yr ARI Total	**17**	**9**	**46**	**42**	**$ 1,540,111**	**$ 1,188,537**
Total Annual Average Damage					**$ 638,371**	**$ 504,103**

Table 4-6 WC_FM6 Flood Damage Assessment Summary

Event / Property type	Properties with Overfloor Flooding		Properties with Overground Flooding		Estimated Total Damage ($ June 2016)	
	Existing Case	*Mitigation Case*	*Existing Case*	*Mitigation Case*	*Existing Case*	*Mitigation Case*
PMF Event						
Residential	206	193	357	353	$ 12,359,434	$ 11,252,476
Commercial	1	1	2	2	$ 82,822	$ 83,346
Industrial	20	20	21	21	$ 2,196,132	$ 2,074,153
PMF Total	**227**	**214**	**380**	**376**	**$ 14,638,389**	**$ 13,409,975**
100yr ARI						
Residential	67	35	109	97	$ 3,685,523	$ 2,281,641
Commercial	0	0	1	1	$ -	$ -
Industrial	5	5	5	5	$ 731,197	$ 713,504
100yr ARI Total	**72**	**40**	**115**	**103**	**$ 4,416,720**	**$ 2,995,145**
50yr ARI						
Residential	52	25	103	92	$ 3,057,293	$ 1,917,899
Commercial	0	0	1	1	$ -	$ -
Industrial	5	5	5	5	$ 617,342	$ 587,326
50yr ARI Total	**57**	**30**	**109**	**98**	**$ 3,674,635**	**$ 2,505,224**
20yr ARI						
Residential	33	17	90	83	$ 2,362,296	$ 1,563,075
Commercial	0	0	1	1	$ -	$ -
Industrial	3	3	4	4	$ 406,674	$ 395,256
20yr ARI Total	**36**	**20**	**95**	**88**	**$ 2,768,970**	**$ 1,958,331**
10yr ARI						
Residential	26	10	81	76	$ 1,944,399	$ 1,378,005
Commercial	0	0	0	0	$ -	$ -
Industrial	2	3	3	3	$ 305,484	$ 306,279
10yr ARI Total	**28**	**13**	**84**	**79**	**$ 2,249,883**	**$ 1,684,284**
5yr ARI						
Residential	19	10	63	59	$ 1,638,707	$ 1,260,337
Commercial	0	0	0	0	$ -	$ -
Industrial	2	2	4	4	$ 247,083	$ 243,647
5yr ARI Total	**21**	**12**	**67**	**63**	**$ 1,885,790**	**$ 1,503,983**
Total Annual Average Damage					**$ 847,500**	**$ 652,549**

Table 4-7 WC_FM7 Flood Damage Assessment Summary

Event / Property type	Properties with Overfloor Flooding		Properties with Overground Flooding		Estimated Total Damage ($ June 2016)	
	Existing Case	*Mitigation Case*	*Existing Case*	*Mitigation Case*	*Existing Case*	*Mitigation Case*
PMF Event						
Residential	97	82	130	129	$ 5,504,663	$ 4,379,051
Commercial	0	0	0	0	$ -	$ -
Industrial	30	27	31	31	$ 2,928,380	$ 2,188,136
PMF Total	**127**	**109**	**161**	**160**	**$ 8,433,043**	**$ 6,567,188**
100yr ARI						
Residential	20	17	41	41	$ 780,336	$ 737,628
Commercial	0	0	0	0	$ -	$ -
Industrial	6	6	6	6	$ 746,560	$ 739,197
100yr ARI Total	**26**	**23**	**47**	**47**	**$ 1,526,895**	**$ 1,476,825**
50yr ARI						
Residential	13	13	35	35	$ 480,325	$ 516,218
Commercial	0	0	0	0	$ -	$ -
Industrial	6	6	6	6	$ 630,621	$ 617,975
50yr ARI Total	**19**	**19**	**41**	**41**	**$ 1,110,946**	**$ 1,134,193**
20yr ARI						
Residential	5	5	30	30	$ 254,769	$ 260,464
Commercial	0	0	0	0	$ -	$ -
Industrial	4	4	5	5	$ 417,537	$ 404,873
20yr ARI Total	**9**	**9**	**35**	**35**	**$ 672,306**	**$ 665,337**
10yr ARI						
Residential	2	2	21	21	$ 100,683	$ 97,465
Commercial	0	0	0	0	$ -	$ -
Industrial	3	3	4	4	$ 311,637	$ 302,085
10yr ARI Total	**5**	**5**	**25**	**25**	**$ 412,320**	**$ 399,550**
5yr ARI						
Residential	2	2	13	13	$ 77,427	$ 70,541
Commercial	0	0	0	0	$ -	$ -
Industrial	3	2	5	5	$ 249,677	$ 189,174
5yr ARI Total	**5**	**4**	**18**	**18**	**$ 327,105**	**$ 259,715**
Total Annual Average Damage					**$ 202,885**	**$ 178,807**

Table 4-8 WC_FM8 Flood Damage Assessment Summary

Event / Property type	Properties with Overfloor Flooding		Properties with Overground Flooding		Estimated Total Damage ($ June 2016)	
	Existing Case	*Mitigation Case*	*Existing Case*	*Mitigation Case*	*Existing Case*	*Mitigation Case*
PMF Event						
Residential	105	102	156	155	$ 6,774,335	$ 6,544,519
Commercial	1	1	1	1	$ 38,276	$ 36,190
Industrial	37	37	38	38	$ 3,933,298	$ 3,710,476
PMF Total	**143**	**140**	**195**	**194**	**$ 10,745,910**	**$ 10,291,185**
100yr ARI						
Residential	35	30	58	56	$ 1,996,739	$ 1,784,282
Commercial	0	0	0	0	$ -	$ -
Industrial	11	11	11	11	$ 1,294,779	$ 1,240,750
100yr ARI Total	**46**	**41**	**69**	**67**	**$ 3,291,518**	**$ 3,025,033**
50yr ARI						
Residential	30	29	53	52	$ 1,741,156	$ 1,614,894
Commercial	0	0	0	0	$ -	$ -
Industrial	11	11	11	11	$ 1,095,928	$ 1,108,127
50yr ARI Total	**41**	**40**	**64**	**63**	**$ 2,837,085**	**$ 2,723,021**
20yr ARI						
Residential	25	22	48	47	$ 1,446,881	$ 1,308,518
Commercial	0	0	0	0	$ -	$ -
Industrial	8	8	10	10	$ 824,133	$ 825,029
20yr ARI Total	**33**	**30**	**58**	**57**	**$ 2,271,015**	**$ 2,133,547**
10yr ARI						
Residential	21	17	40	38	$ 1,254,514	$ 1,117,084
Commercial	0	0	0	0	$ -	$ -
Industrial	7	7	9	9	$ 630,045	$ 633,474
10yr ARI Total	**28**	**24**	**49**	**47**	**$ 1,884,559**	**$ 1,750,558**
5yr ARI						
Residential	12	10	24	23	$ 838,178	$ 747,506
Commercial	0	0	0	0	$ -	$ -
Industrial	6	7	10	10	$ 477,571	$ 478,087
5yr ARI Total	**18**	**17**	**34**	**33**	**$ 1,315,749**	**$ 1,225,593**
Total Annual Average Damage					**$ 638,712**	**$ 597,912**

Table 4-9 WC_FM10 Flood Damage Assessment Summary

Event / Property type	Properties with Overfloor Flooding		Properties with Overground Flooding		Estimated Total Damage ($ June 2016)	
	Existing Case	*Mitigation Case*	*Existing Case*	*Mitigation Case*	*Existing Case*	*Mitigation Case*
PMF Event						
Residential	51	39	90	89	$ 2,921,353	$ 2,296,102
Commercial	0	0	0	0	$ -	$ -
Industrial	27	22	28	28	$ 2,229,886	$ 1,928,293
PMF Total	**78**	**61**	**118**	**117**	**$ 5,151,239**	**$ 4,224,395**
100yr ARI						
Residential	8	6	35	34	$ 468,429	$ 323,175
Commercial	0	0	0	0	$ -	$ -
Industrial	9	3	10	10	$ 188,626	$ 86,915
100yr ARI Total	**17**	**9**	**45**	**44**	**$ 657,055**	**$ 410,089**
50yr ARI						
Residential	6	6	32	31	$ 386,234	$ 288,509
Commercial	0	0	0	0	$ -	$ -
Industrial	8	3	9	9	$ 147,917	$ 82,349
50yr ARI Total	**14**	**9**	**41**	**40**	**$ 534,151**	**$ 370,858**
20yr ARI						
Residential	6	6	25	25	$ 341,113	$ 277,359
Commercial	0	0	0	0	$ -	$ -
Industrial	2	2	8	8	$ 58,225	$ 42,617
20yr ARI Total	**8**	**8**	**33**	**33**	**$ 399,338**	**$ 319,976**
10yr ARI						
Residential	5	4	12	12	$ 254,581	$ 191,118
Commercial	0	0	0	0	$ -	$ -
Industrial	2	2	5	5	$ 43,128	$ 37,640
10yr ARI Total	**7**	**6**	**17**	**17**	**$ 297,709**	**$ 228,758**
5yr ARI						
Residential	4	3	10	10	$ 204,153	$ 127,816
Commercial	0	0	0	0	$ -	$ -
Industrial	2	1	3	3	$ 25,058	$ 24,102
5yr ARI Total	**6**	**4**	**13**	**13**	**$ 229,211**	**$ 151,918**
Total Annual Average Damage					**$ 127,151**	**$ 92,977**

Table 4-10 WC_FM11 Flood Damage Assessment Summary

Event / Property type	Properties with Overfloor Flooding		Properties with Overground Flooding		Estimated Total Damage ($ June 2016)	
	Existing Case	*Mitigation Case*	*Existing Case*	*Mitigation Case*	*Existing Case*	*Mitigation Case*
PMF Event						
Residential	66	64	132	132	$ 4,430,637	$ 4,221,984
Commercial	1	1	1	1	$ 38,276	$ 35,241
Industrial	30	28	31	31	$ 2,851,231	$ 2,706,696
PMF Total	**97**	**93**	**164**	**164**	**$ 7,320,144**	**$ 6,963,921**
100yr ARI						
Residential	15	13	43	43	$ 1,260,966	$ 1,114,960
Commercial	0	0	0	0	$ -	$ -
Industrial	12	5	13	13	$ 668,043	$ 422,590
100yr ARI Total	**27**	**18**	**56**	**56**	**$ 1,929,009**	**$ 1,537,550**
50yr ARI						
Residential	13	13	40	39	$ 1,158,300	$ 1,066,223
Commercial	0	0	0	0	$ -	$ -
Industrial	11	5	12	12	$ 562,512	$ 408,585
50yr ARI Total	**24**	**18**	**52**	**51**	**$ 1,720,812**	**$ 1,474,807**
20yr ARI						
Residential	13	13	32	32	$ 1,081,999	$ 1,034,145
Commercial	0	0	0	0	$ -	$ -
Industrial	5	3	11	11	$ 435,927	$ 270,197
20yr ARI Total	**18**	**16**	**43**	**43**	**$ 1,517,926**	**$ 1,304,342**
10yr ARI						
Residential	12	12	19	19	$ 929,650	$ 943,369
Commercial	0	0	0	0	$ -	$ -
Industrial	5	3	8	8	$ 345,165	$ 217,858
10yr ARI Total	**17**	**15**	**27**	**27**	**$ 1,274,815**	**$ 1,161,227**
5yr ARI						
Residential	10	10	17	17	$ 837,592	$ 839,900
Commercial	0	0	0	0	$ -	$ -
Industrial	4	3	6	5	$ 252,952	$ 220,527
5yr ARI Total	**14**	**13**	**23**	**22**	**$ 1,090,543**	**$ 1,060,427**
Total Annual Average Damage					**$ 464,739**	**$ 431,038**

Table 4-11 WC_FM12 Flood Damage Assessment Summary

Event / Property type	Properties with Overfloor Flooding		Properties with Overground Flooding		Estimated Total Damage ($ June 2016)	
	Existing Case	*Mitigation Case*	*Existing Case*	*Mitigation Case*	*Existing Case*	*Mitigation Case*
PMF Event						
Residential	27	27	28	28	$ 1,946,798	$ 1,946,798
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
PMF Total	**27**	**27**	**28**	**28**	**$ 1,946,798**	**$ 1,946,798**
100yr ARI						
Residential	19	19	25	25	$ 818,980	$ 818,980
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
100yr ARI Total	**19**	**19**	**25**	**25**	**$ 818,980**	**$ 818,980**
50yr ARI						
Residential	16	8	24	24	$ 677,012	$ 335,386
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
50yr ARI Total	**16**	**8**	**24**	**24**	**$ 677,012**	**$ 335,386**
20yr ARI						
Residential	6	-4	22	22	$ 268,486	-$ 99,577
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
20yr ARI Total	**6**	**-4**	**22**	**22**	**$ 268,486**	**-$ 99,577**
10yr ARI						
Residential	0	0	20	20	$ 35,938	-$ 11,941
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
10yr ARI Total	**0**	**0**	**20**	**20**	**$ 35,938**	**-$ 11,941**
5yr ARI						
Residential	0	0	11	11	$ 5,999	$ -
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
5yr ARI Total	**0**	**0**	**11**	**11**	**$ 5,999**	$ -
Total Annual Average Damage					**$ 46,097**	**$ 19,751**

Table 4-12 WC_FM13 Flood Damage Assessment Summary

Event / Property type	Properties with Overfloor Flooding		Properties with Overground Flooding		Estimated Total Damage ($ June 2016)	
	Existing Case	*Mitigation Case*	*Existing Case*	*Mitigation Case*	*Existing Case*	*Mitigation Case*
PMF Event						
Residential	595	558	997	986	$ 35,598,770	$ 31,641,961
Commercial	135	134	165	165	$ 10,011,863	$ 9,944,936
Industrial	75	71	81	81	$ 9,053,927	$ 7,797,374
PMF Total	**805**	**763**	**1243**	**1232**	**$ 54,664,560**	**$ 49,384,271**
100yr ARI						
Residential	185	101	364	352	$ 9,884,855	$ 6,314,795
Commercial	46	45	64	63	$ 4,494,647	$ 4,376,377
Industrial	18	16	19	19	$ 1,414,603	$ 856,841
100yr ARI Total	**249**	**162**	**447**	**434**	**$ 15,794,106**	**$ 11,548,013**
50yr ARI						
Residential	147	86	346	340	$ 8,364,273	$ 5,375,188
Commercial	43	43	61	60	$ 4,241,808	$ 4,134,528
Industrial	17	15	18	18	$ 1,193,133	$ 750,816
50yr ARI Total	**207**	**144**	**425**	**418**	**$ 13,799,214**	**$ 10,260,532**
20yr ARI						
Residential	99	62	302	293	$ 6,247,307	$ 4,371,725
Commercial	35	33	54	54	$ 3,904,476	$ 3,812,438
Industrial	9	8	16	16	$ 853,463	$ 579,698
20yr ARI Total	**143**	**103**	**372**	**363**	**$ 11,005,246**	**$ 8,763,861**
10yr ARI						
Residential	74	59	256	250	$ 4,881,454	$ 3,940,039
Commercial	30	28	50	50	$ 3,623,175	$ 3,547,496
Industrial	8	7	12	12	$ 656,802	$ 453,736
10yr ARI Total	**112**	**94**	**318**	**312**	**$ 9,161,431**	**$ 7,941,271**
5yr ARI						
Residential	53	43	194	192	$ 3,801,472	$ 3,260,299
Commercial	29	27	47	47	$ 3,331,915	$ 3,250,218
Industrial	7	5	11	11	$ 502,629	$ 361,845
5yr ARI Total	**89**	**75**	**252**	**250**	**$ 7,636,016**	**$ 6,872,363**
Total Annual Average Damage					**$ 3,361,733**	**$ 2,888,204**

Table 4-13 WC_FM14 Flood Damage Assessment Summary

Event / Property type	Properties with Overfloor Flooding		Properties with Overground Flooding		Estimated Total Damage ($ June 2016)	
	Existing Case	*Mitigation Case*	*Existing Case*	*Mitigation Case*	*Existing Case*	*Mitigation Case*
PMF Event						
Residential	64	62	96	92	$ 4,431,593	$ 4,222,109
Commercial	2	2	2	2	$ 51,383	$ 48,738
Industrial	0	0	0	0	$ -	$ -
PMF Total	**66**	**64**	**98**	**94**	**$ 4,482,976**	**$ 4,270,848**
100yr ARI						
Residential	35	33	49	47	$ 1,669,281	$ 1,552,234
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
100yr ARI Total	**35**	**33**	**49**	**47**	**$ 1,669,281**	**$ 1,552,234**
50yr ARI						
Residential	32	27	47	47	$ 1,474,196	$ 1,220,057
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
50yr ARI Total	**32**	**27**	**47**	**47**	**$ 1,474,196**	**$ 1,220,057**
20yr ARI						
Residential	16	12	43	41	$ 858,709	$ 726,592
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
20yr ARI Total	**16**	**12**	**43**	**41**	**$ 858,709**	**$ 726,592**
10yr ARI						
Residential	7	7	39	39	$ 475,851	$ 464,366
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
10yr ARI Total	**7**	**7**	**39**	**39**	**$ 475,851**	**$ 464,366**
5yr ARI						
Residential	4	4	21	21	$ 286,855	$ 276,989
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
5yr ARI Total	**4**	**4**	**21**	**21**	**$ 286,855**	**$ 276,989**
Total Annual Average Damage					**$ 195,997**	**$ 180,564**

Table 4-14 Reduction in Damages Associated with Each Option

	Overfloor flooding properties reduction	Overground flooding properties reduction	Total Damage Reduction ($)	AAD Reduction ($)
		WC-FM1		
PMF event	19	8	$ 2,531,486	$27,198
100yr ARI event	53	8	$ 2,908,705	$25,332
50yr ARI event	33	7	$ 2,157,791	$51,980
20yr ARI event	19	8	$ 1,307,537	$53,515
10yr ARI event	11	6	$ 833,081	$70,844
5yr ARI event	11	2	$ 583,806	$87,571
Total				**$316,441**
		WC-FM2		
PMF event	0	2	$ 894,505	$5,115
100yr ARI event	3	0	$ 128,632	$2,033
50yr ARI event	8	1	$ 277,903	$7,008
20yr ARI event	6	1	$ 189,293	$8,067
10yr ARI event	3	1	$ 133,388	$9,400
5yr ARI event	-1	0	$ 54,607	$8,191
Total				**$39,814**
		WC-FM3		
PMF event	12	0	$ 1,090,614	$11,800
100yr ARI event	25	-2	$ 1,269,704	$11,569
50yr ARI event	19	0	$ 1,044,041	$47,495
20yr ARI event	16	0	$ 2,122,301	$120,486
10yr ARI event	13	3	$ 2,697,134	$258,995
5yr ARI event	9	3	$ 2,482,762	$372,414
Total				**$822,759**
		WC-FM4		
PMF event	4	1	$ 316,569	$8,936
100yr ARI event	37	1	$ 1,470,854	$7,510
50yr ARI event	-1	-1	$ 31,109	$627
20yr ARI event	0	0	$ 10,686	$1,955
10yr ARI event	-1	1	$ 67,524	$8,322
5yr ARI event	2	0	$ 98,923	$14,838
Total				**$42,189**
		WC-FM5		
PMF event	17	3	$ 998,702	$9,351
100yr ARI event	21	6	$ 871,699	$8,858
50yr ARI event	18	8	$ 899,858	$19,325
20yr ARI event	8	3	$ 388,507	$15,281
10yr ARI event	5	1	$ 222,753	$28,716
5yr ARI event	8	4	$ 351,574	$52,736
Total				**$134,268**
		WC-FM6		
PMF event	13	4	$ 1,228,414	$13,249
100yr ARI event	32	0	$ 1,421,575	$12,955
50yr ARI event	27	11	$ 1,169,411	$29,701

	Overfloor flooding properties reduction	Overground flooding properties reduction	Total Damage Reduction ($)	AAD Reduction ($)
20yr ARI event	16	7	$ 810,639	$34,406
10yr ARI event	15	5	$ 565,599	$47,370
5yr ARI event	9	4	$ 381,806	$57,271
Total				**$194,951**
		WC-FM7		
PMF event	18	1	$ 1,865,856	$9,579
100yr ARI event	3	0	$ 50,070	$134
50yr ARI event	0	0	-$ 23,247	-$244
20yr ARI event	0	0	$ 6,969	$493
10yr ARI event	0	0	$ 12,769	$4,008
5yr ARI event	1	0	$ 67,389	$10,108
Total				**$24,078**
		WC-FM8		
PMF event	3	1	$ 454,725	$3,606
100yr ARI event	5	0	$ 266,486	$1,903
50yr ARI event	1	1	$ 114,064	$3,773
20yr ARI event	3	1	$ 137,468	$6,787
10yr ARI event	4	2	$ 134,001	$11,208
5yr ARI event	1	1	$ 90,156	$13,523
Total				**$40,799**
		WC-FM10		
PMF event	17	1	$ 926,845	$5,868
100yr ARI event	8	0	$ 246,966	$2,051
50yr ARI event	5	1	$ 163,293	$3,640
20yr ARI event	0	0	$ 79,362	$3,708
10yr ARI event	1	0	$ 68,951	$7,312
5yr ARI event	2	0	$ 77,293	$11,594
Total				**$34,174**
		WC-FM11		
PMF event	4	0	$ 356,223	$3,738
100yr ARI event	9	0	$ 391,459	$3,187
50yr ARI event	6	1	$ 246,005	$6,894
20yr ARI event	2	0	$ 213,584	$8,179
10yr ARI event	2	0	$ 113,588	$7,185
5yr ARI event	1	1	$ 30,117	$4,518
Total				**$33,701**
		WC-FM12		
PMF event	0	0	$ -	$0
100yr ARI event	0	0	$ -	$1,708
50yr ARI event	8	0	$ 341,625	$10,645

	Overfloor flooding properties reduction	Overground flooding properties reduction	Total Damage Reduction ($)	AAD Reduction ($)
20yr ARI event	10	0	$ 368,064	$10,399
10yr ARI event	0	0	$ 47,879	$2,694
5yr ARI event	0	0	$ 5,999	$900
Total				**$26,346**
		WC-FM13		
PMF event	42	11	$ 5,280,289	$47,627
100yr ARI event	87	0	$ 4,246,093	$38,924
50yr ARI event	63	7	$ 3,538,682	$86,701
20yr ARI event	40	9	$ 2,241,385	$86,539
10yr ARI event	18	6	$ 1,220,160	$99,191
5yr ARI event	14	2	$ 763,652	$114,548
Total				**$473,529**
		WC-FM14		
PMF event	2	4	$ 212,128	$1,646
100yr ARI event	2	0	$ 117,047	$1,856
50yr ARI event	5	0	$ 254,139	$5,794
20yr ARI event	4	2	$ 132,116	$3,590
10yr ARI event	0	0	$ 11,485	$1,068
5yr ARI event	0	0	$ 9,866	$1,480
Total				**$15,433**

4.2 Benefit to Cost Ratio of Options

The economic evaluation of each modelled measure was assessed by considering the reduction in the amount of flood damages incurred for the design events and by then comparing this value with the cost of implementing the measure.

0 summarises the results of the economic assessment of each of the flood management options. The indicator adopted to rank these measures on economic merit is the benefit-cost ratio (B/C), which is based on the net present worth (NPW) of the benefits (reduction in AAD) and the costs (capital and ongoing), adopting a 7% discount rate and an implementation period of 50 years.

The benefit-cost ratio provides an insight into how the damage savings from a measure, relate to its cost of construction and maintenance:

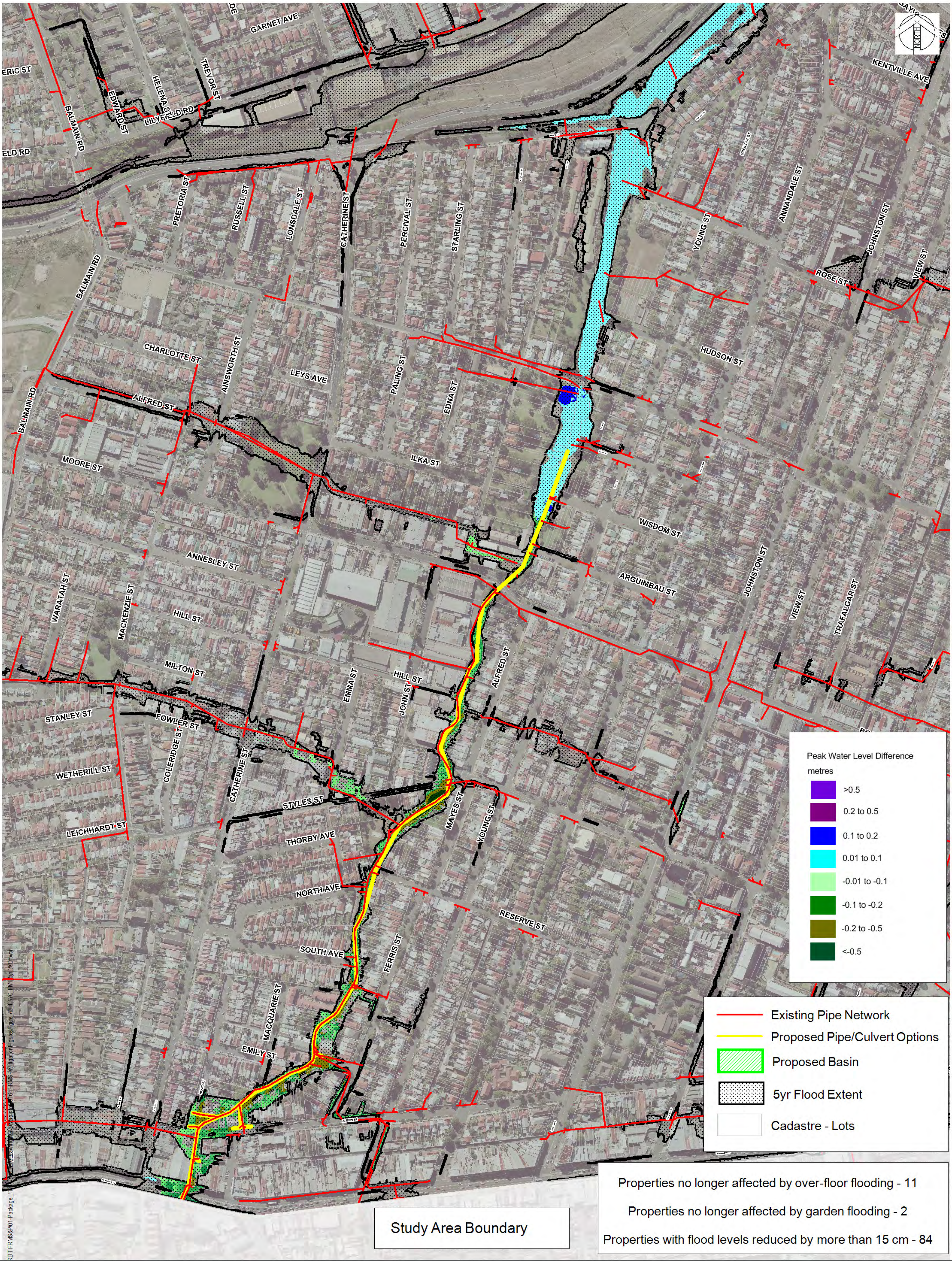
- Where the benefit-cost is greater than 1 the economic benefits are greater than the cost of implementing the measure;
- Where the benefit-cost is less than 1 but greater than 0, there is still an economic benefit from implementing the measure but the cost of implementing the measure is greater than the economic benefit;
- Where the benefit-cost is equal to zero, there is no economic benefit from implementing the measure; and
- Where the benefit-cost is less than zero, there is a negative economic impact of implementing the measure.

Table 4-15 Summary of Economic Assessment of Flood Management Options

Option ID	Option Description	NPW of Reduction in AAD	NPW of Cost of Implementation	B/C Ratio	Economic Ranking
WC-FM1	Whites Creek Culvert – Proposing additional culvert or duplication of existing Whites Creek culvert from Parramatta Rd to the open channel downstream of Moore St (at Wisdom Street). Also combining WC-FM2 along with this option.	$4,367,000	$20,673,000	0.21	6
WC-FM2	Young Street Flow Path – Proposing new pipe network from Young Street/Parramatta Road to Whites Creek culvert via Young St, Albion St, Ferris St and Clarke St. Additional pipe network from Young St to Albion Street.	$549,000	$4,293,000	0.13	9
WC-FM3	Balmain Road Flow Path – Additional pipe from the low point on Norton St to the existing pipe network (towards Parramatta Rd). Duplication of existing pipe network or extra pipes from Balmain Rd to Whites Creek Culvert at Hearn St.	$11,355,000	$7,148,000	1.59	2
WC-FM4	Hearn Street – Detention Basin or Large Inlet Pits at Hearn St to collect flood waters and convey into the proposed Whites Creek Culvert. Additional pipes from Albion St to Whites Creek culvert.	*Not Feasible*			
WC-FM5	Detention Basin at Mackenzie Street (upstream at the intersection of Mackenzie and Milton St)	$1,853,000	$1,003,000	1.85	1
WC-FM6	Styles Street Flow Path – Additional pipes from Mackenzie St to Whites Creek Culvert.	$2,690,000	$9,483,000	0.28	3
WC-FM7	Detention Basin at Evan Jones Park	*Not Feasible*			
WC-FM8	Annandale Street Flow Path – Duplication of existing pipe network or additional pipes from Annandale St to Whites Creek culvert.	$563,000	$3,969,000	0.14	7
WC-FM10	Detention Basin at Catherine Street (War Memorial Park)	$472,000	$2,221,000	0.21	5
WC-FM11	Moore Street Flow Path – Additional Pipes from Catherine St to Whites Creek along Moore Lane.	$465,000	$3,719,000	0.13	10
WC-FM12	Additional pipes at Brenan St and Railway PDE to reduce flooding on the roads.	$364,000	$2,788,000	0.13	8

Option ID	Option Description	NPW of Reduction in AAD	NPW of Cost of Implementation	B/C Ratio	Economic Ranking
WC-FM13	Whites Creek Culvert/Open Channel – Proposing additional culvert or duplication of existing Whites Creek culvert from Parramatta Rd to the open channel downstream of Moore St (WC-FM1). Widening of the open channel to convey additional flows. Upgrade Bridges at Piper Street and Brenan Street (WC-FM14)	$6,535,000	$28,738,000	0.23	4
WC-FM14	Whites Creek Bridge Upgrades – Upgrade Bridges at Piper Street and Brenan Street.	$213,000	$6,620,000	0.03	11

Whites Creek Mitigation Options Figures



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INNER WEST COUNCIL
LEICHHARDT FRMS&P
WC_FM1 5YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A3_1

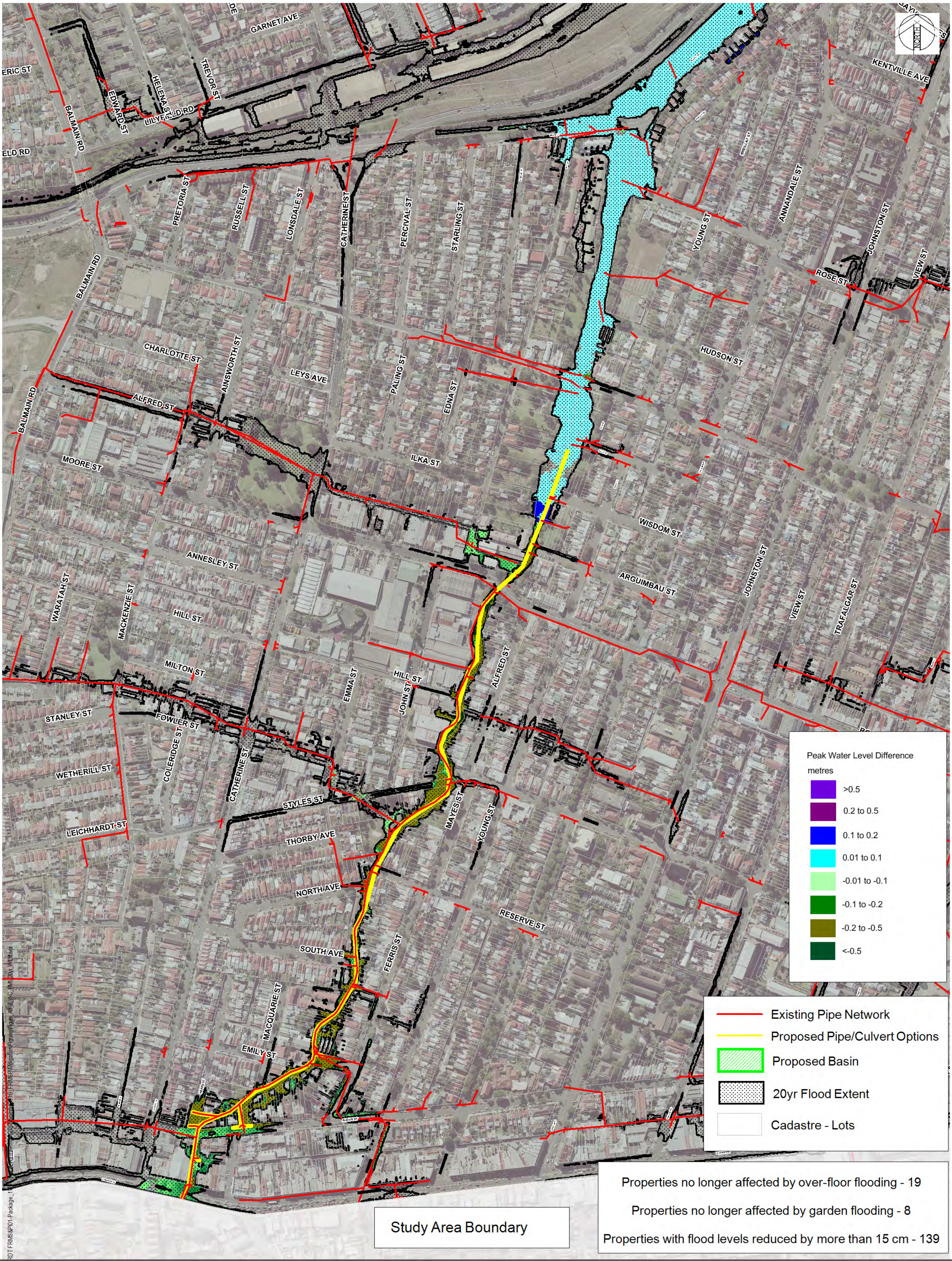
Date
03/2017

Size
A3

WC_FM1_5yr_WlDiff
Drawing Number

03
Revision

DATE PLOTTED: 04-Nov-2016 BY: Matthew Pearl



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LEICHHARDT FRMS&P
WC_FM1 20YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A3_2

Date: 03/2017

Size: A3

WC_FM1_20yr_WlDiff
Drawing Number

03
Revision

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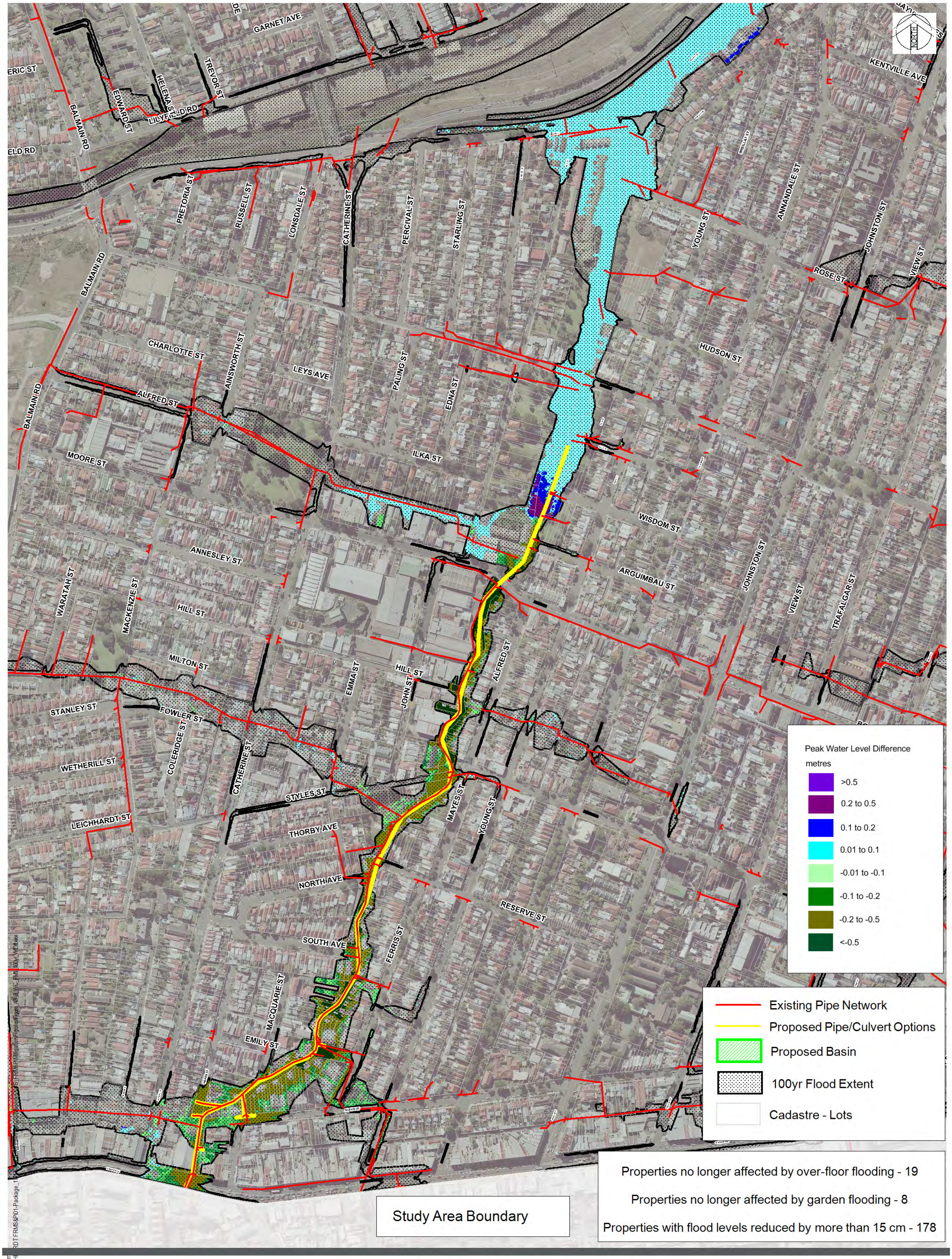

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INNER WEST COUNCIL
LEICHHARDT FRMS&P
WC_FM1 100YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A3_3

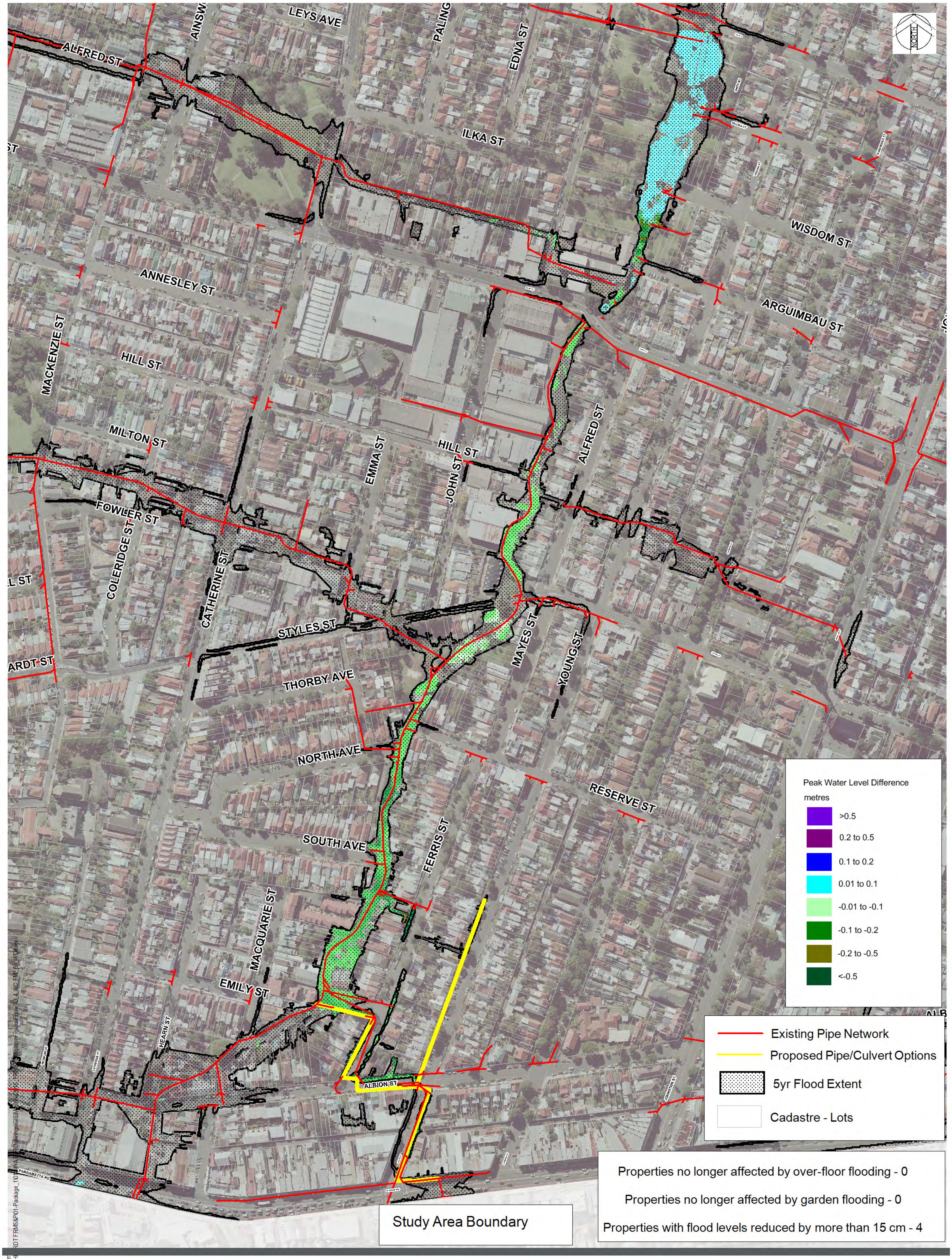
Date
03/2017

WC_FM1_100yr_WlDiff
Drawing Number

Size
A3

03
Revision

DATE PLOTTED: 04-Nov-2016 BY: MatthewPum



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INNER WEST COUNCIL
LEICHHARDT FRMS&P
WC_FM2 5YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A3_4

Date
03/2017

Size
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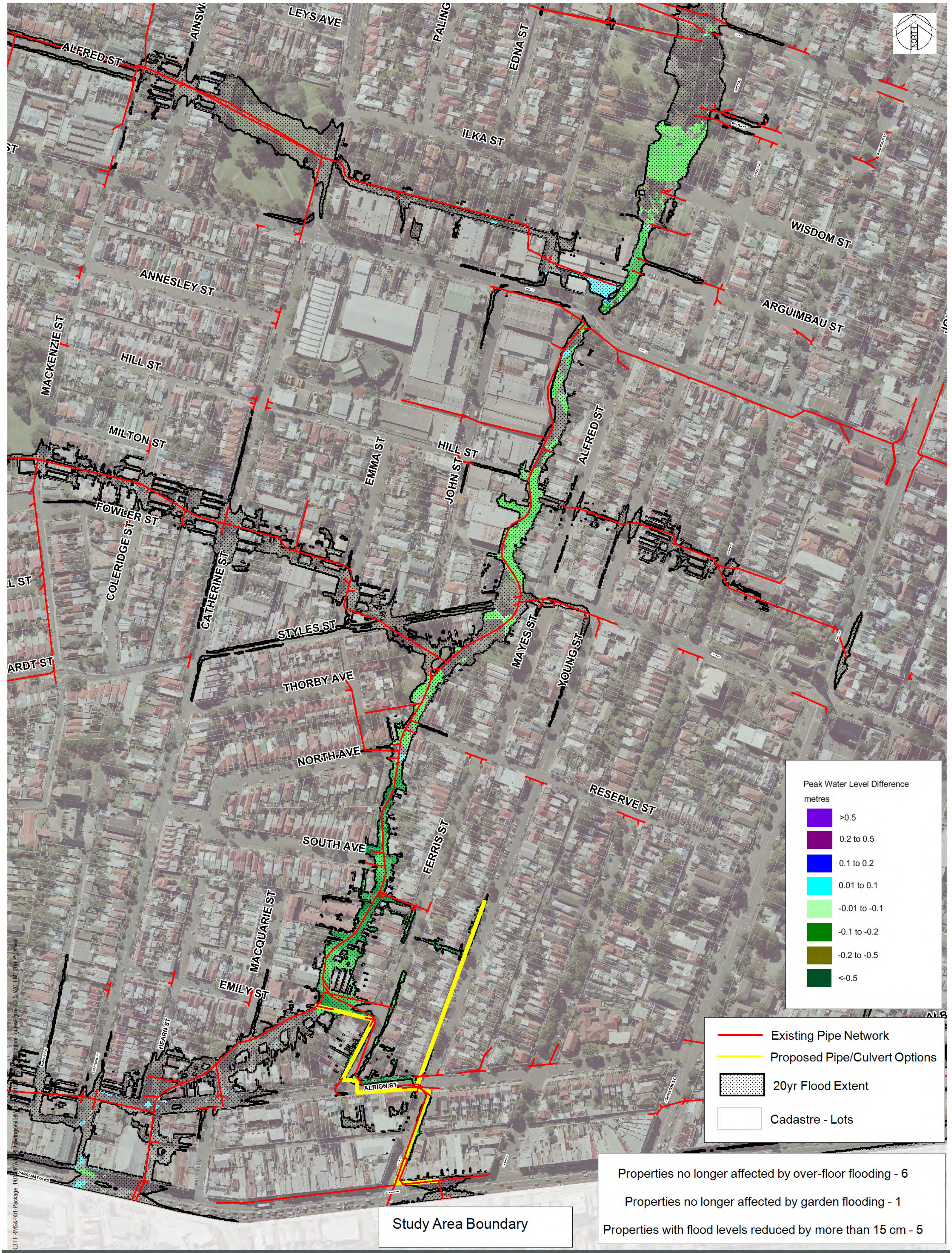
WC_FM2_5yr_WlDiff
Drawing Number

03
Revision



DATE PLOTTED: 04-Nov-2016 BY: MatthewPhan

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INNER WEST COUNCIL
LEICHHARDT FRMS&P

WC_FM2 20YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A3_5

Date
03/2017

Size
A3

WC_FM2_20yr_WlDiff
Drawing Number

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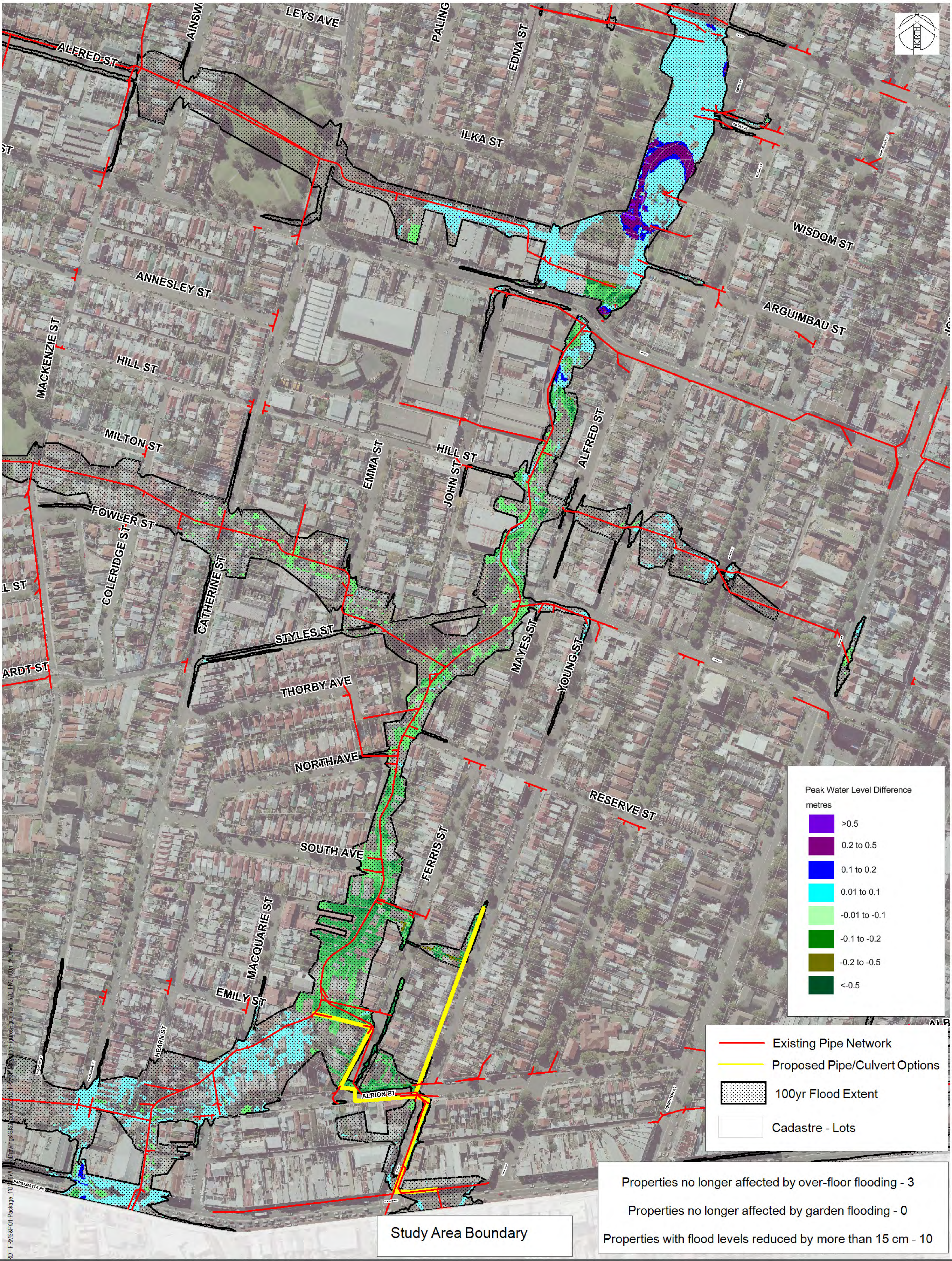

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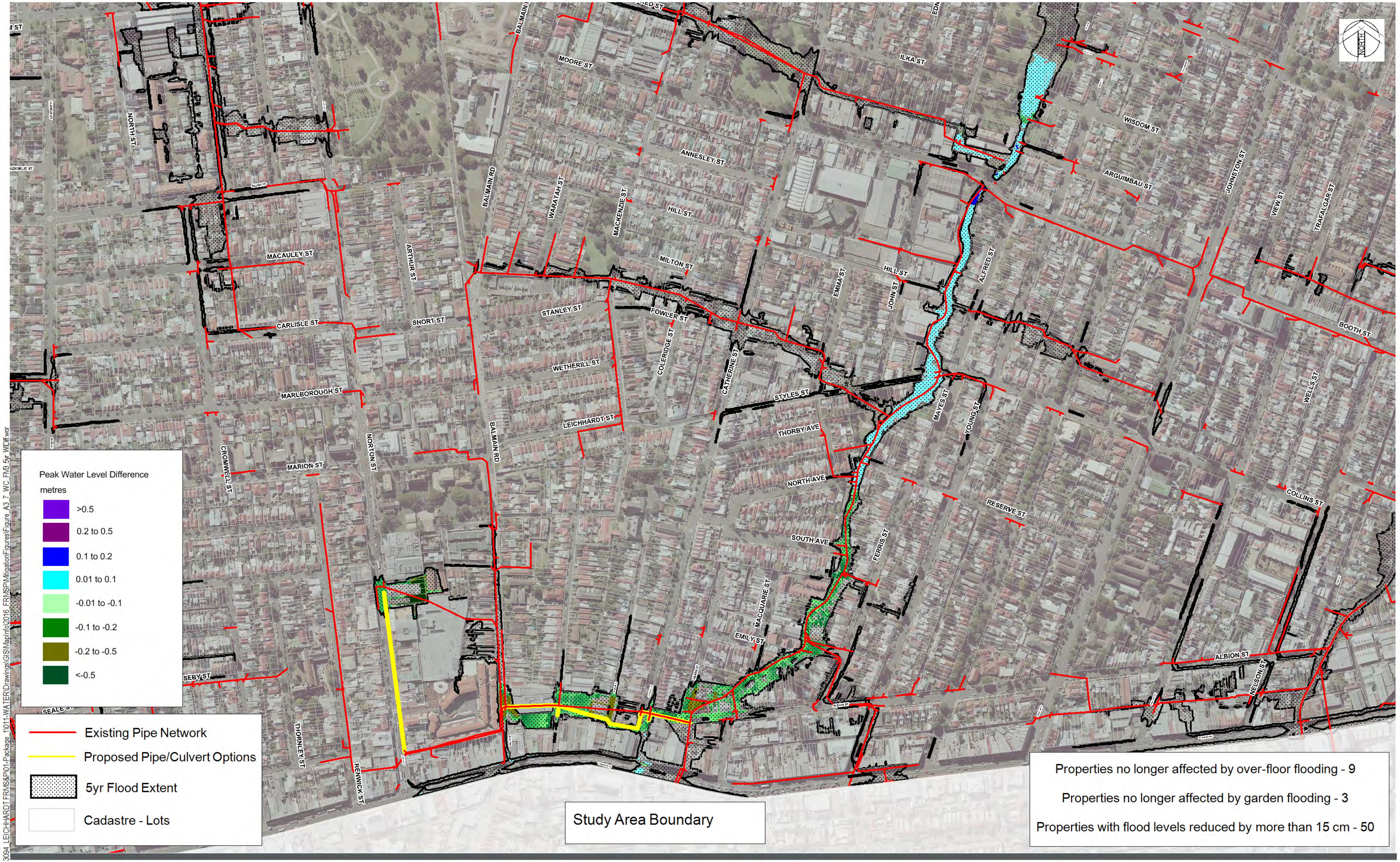

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WC_FM3 5YR ARI WL DIFF
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FIG_A3_7

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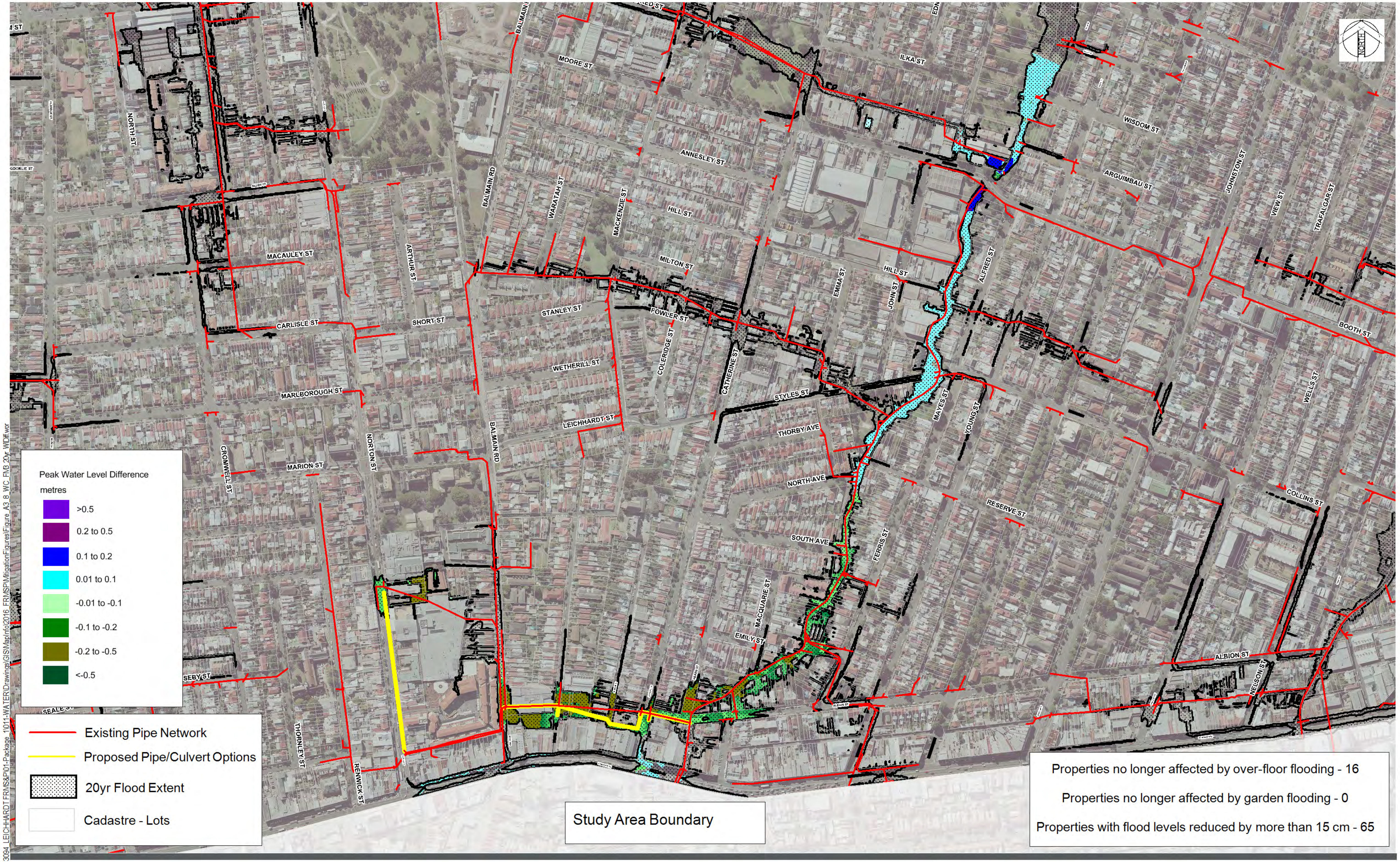

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WC_FM3 20YR ARI WL DIFF
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FIG_A3_8

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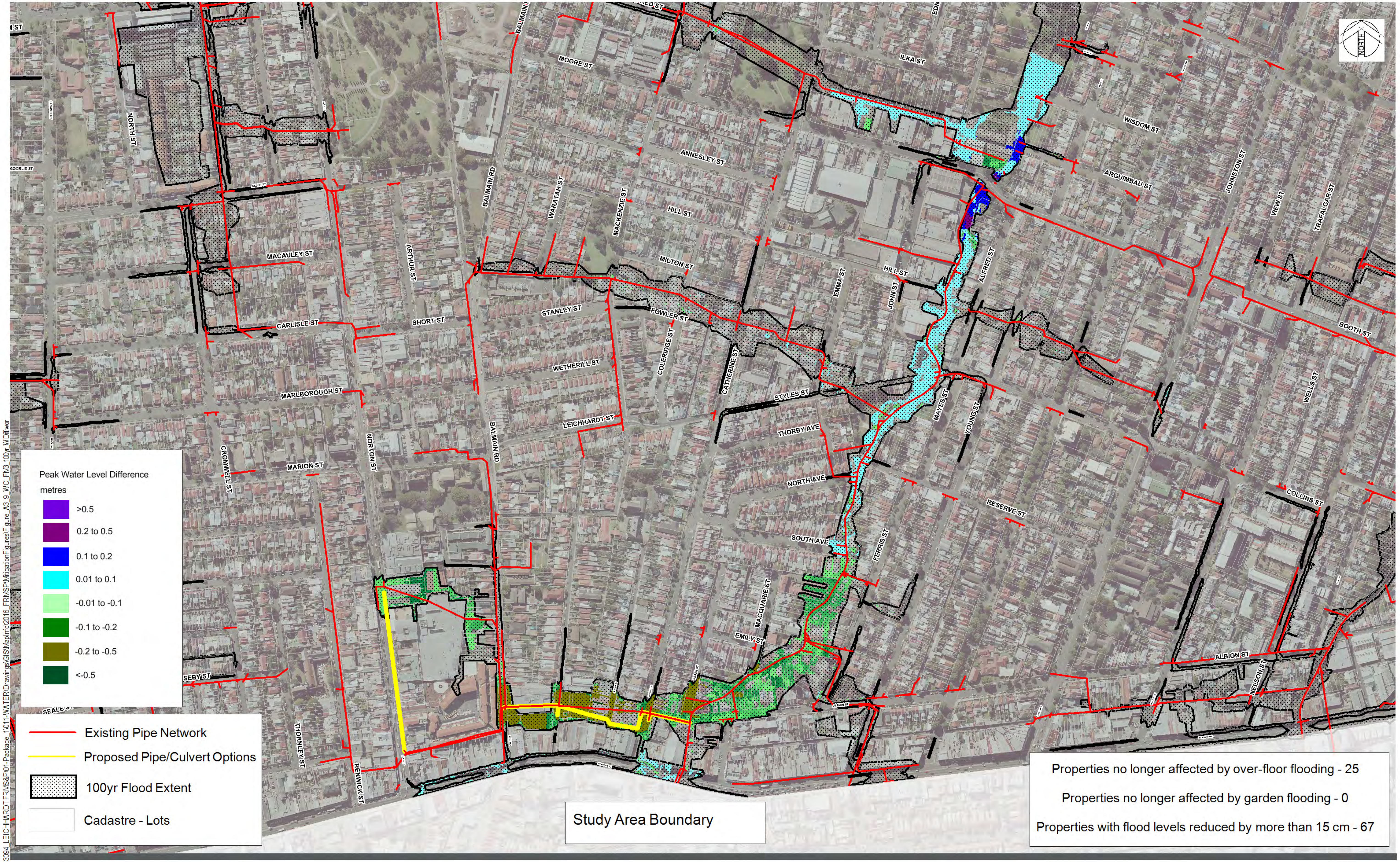

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WC_FM3 100YR ARI WL DIFF
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FIG_A3_9

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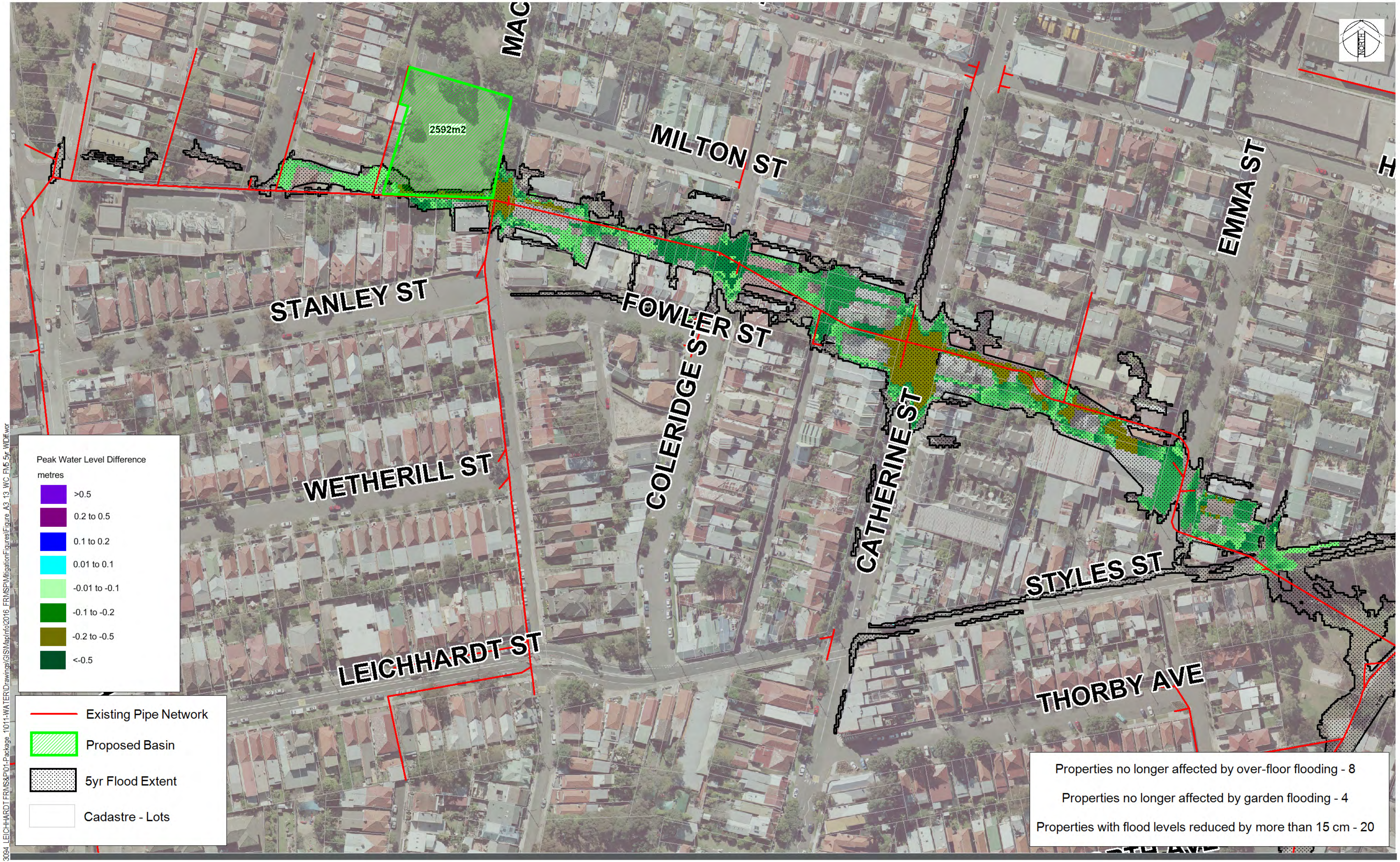

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WC_FM5 5YR ARI WL DIFF
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FIG_A3_13

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WC_FM5 20YR ARI WL DIFF
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FIG_A3_14

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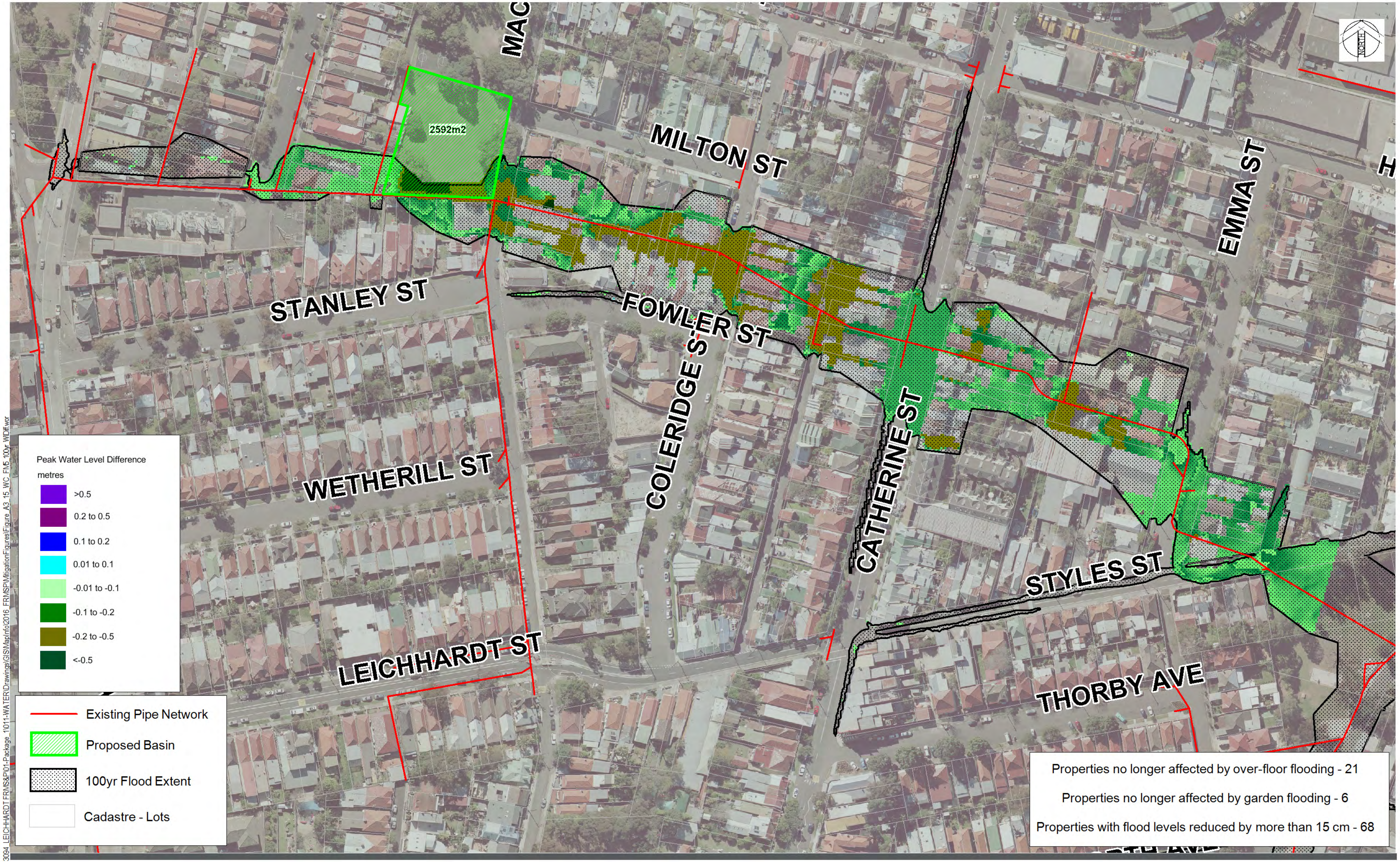

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FIG_A3_15

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FIG_A3_17

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FIG_A3_18

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FIG_A3_19

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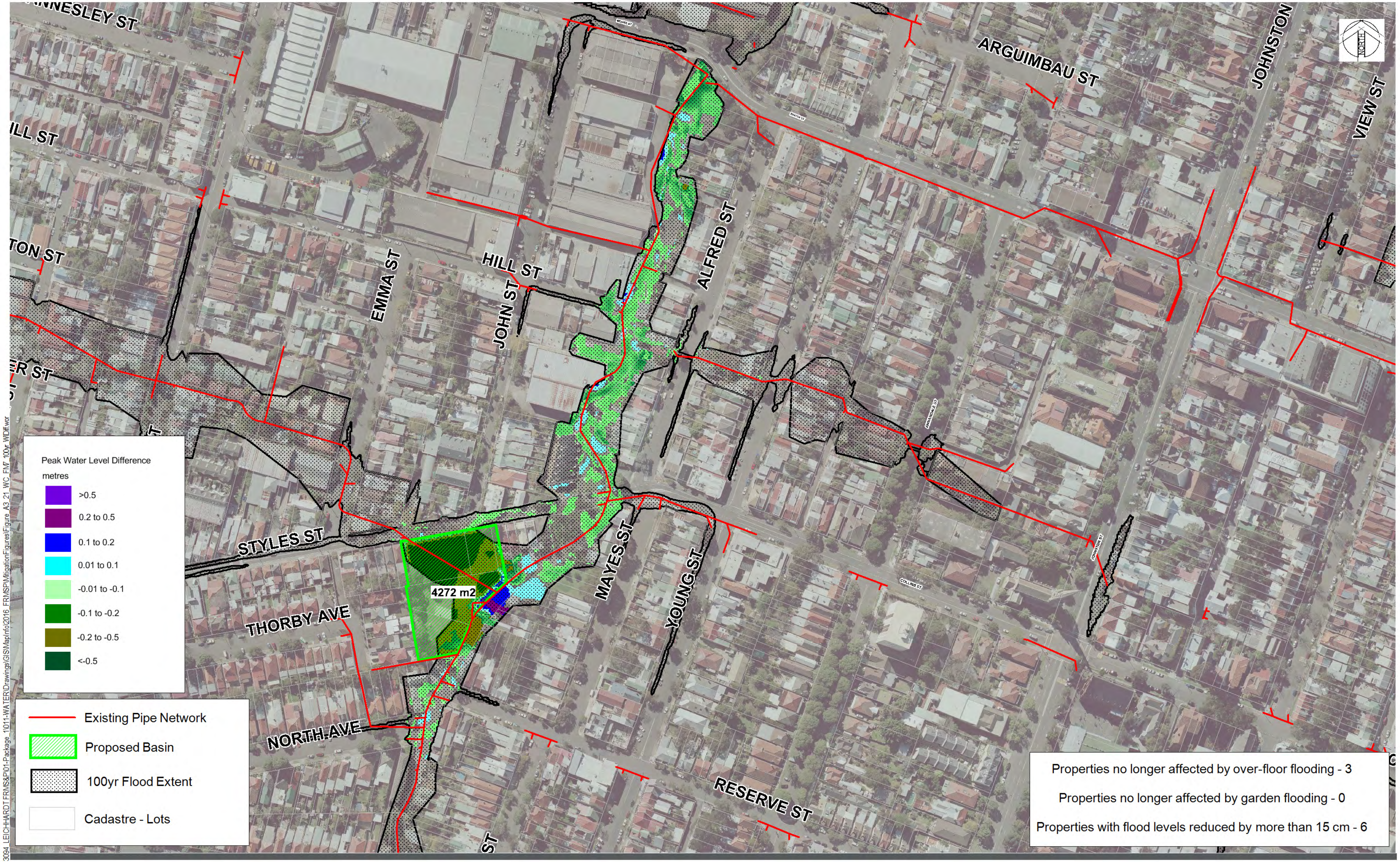

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WC_FM7 100YR ARI WL DIFF
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FIG_A3_21

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MITIGATION LESS EXISTING
FIG_A3_22

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WC_FM8 20YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A3_23

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WC_FM8 100YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A3_24

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FIG_A3_28

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MITIGATION LESS EXISTING
FIG_A3_29

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LEICHHARDT FRMS&P
WC_FM10 100YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A3_30

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MITIGATION LESS EXISTING
FIG_A3_31

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WC_FM11 20YR ARI WL DIFF
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FIG_A3_32

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WC_FM11 100YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A3_33

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WC_FM12 5YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A3_34

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WC_FM12 20YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A3_35

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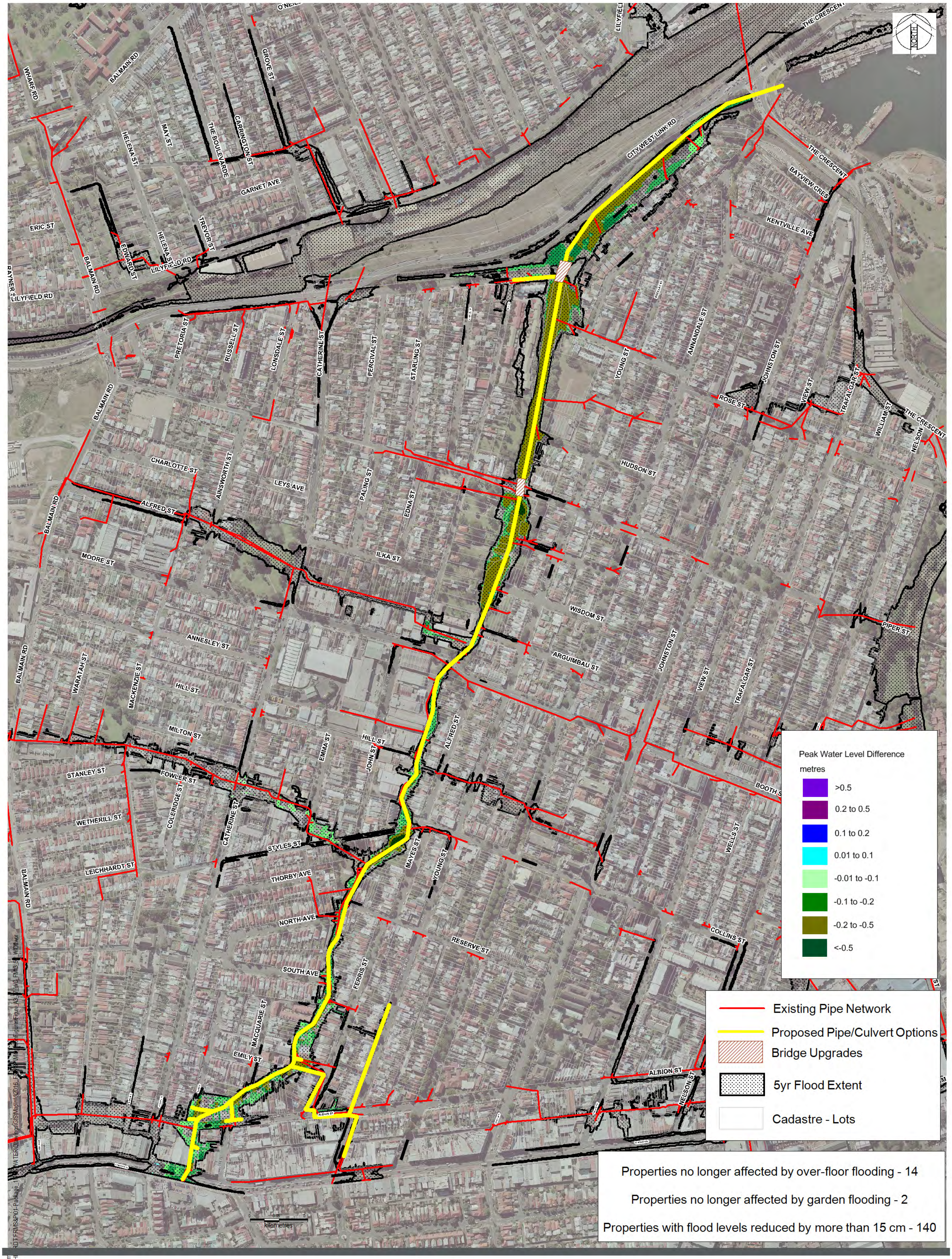

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FIG_A3_37

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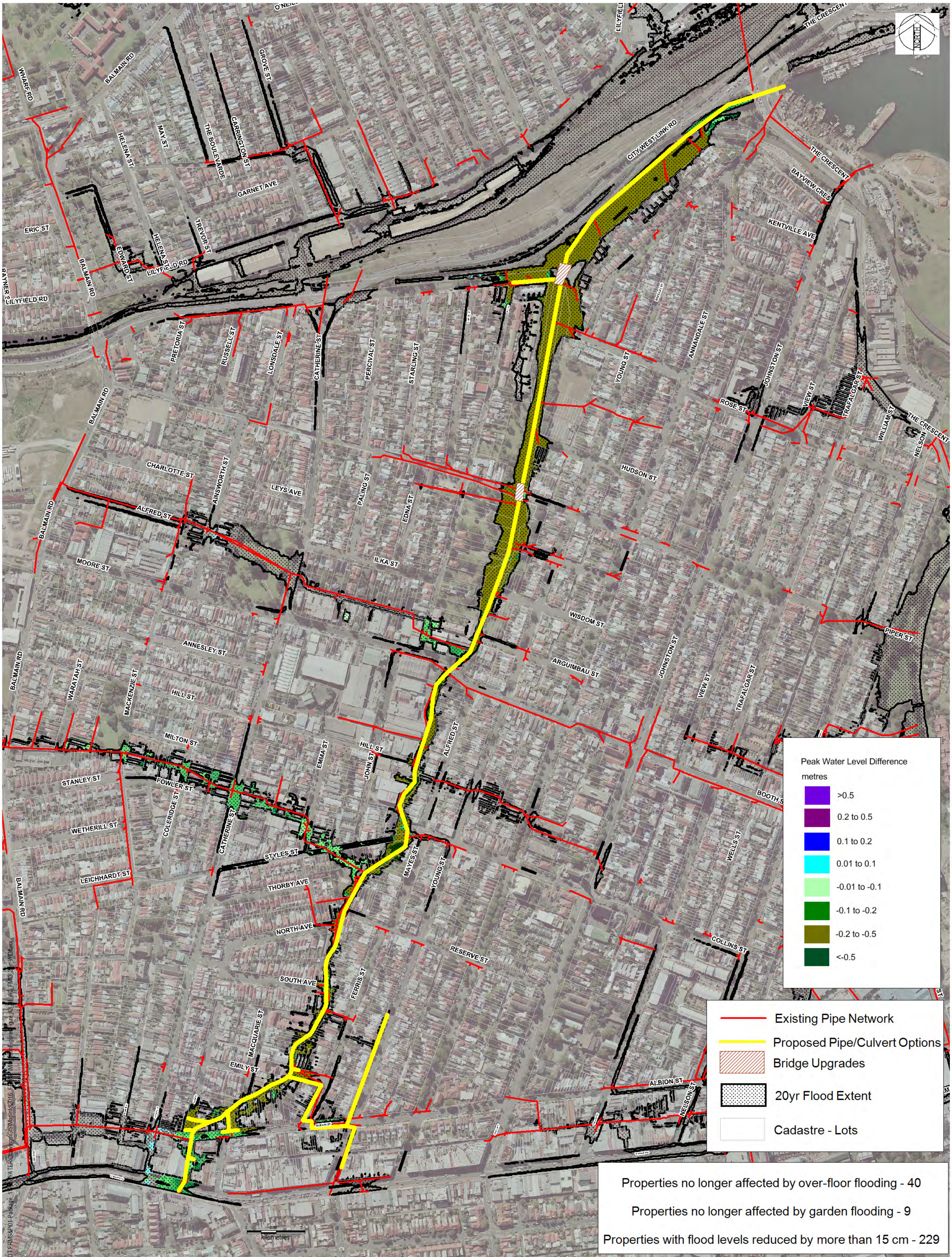

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WC_FM13 20YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A3_38

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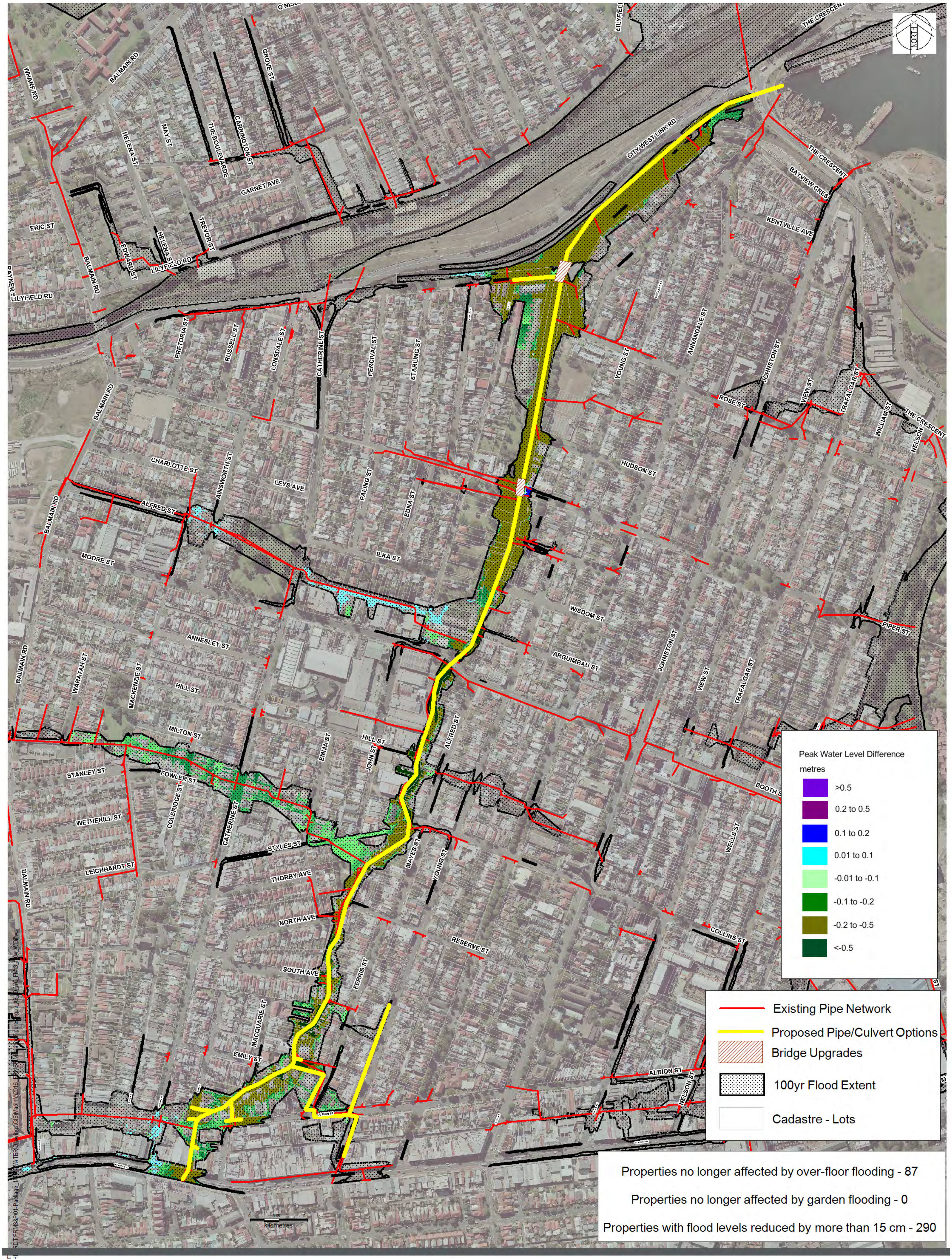

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WC_FM13 100YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A3_39

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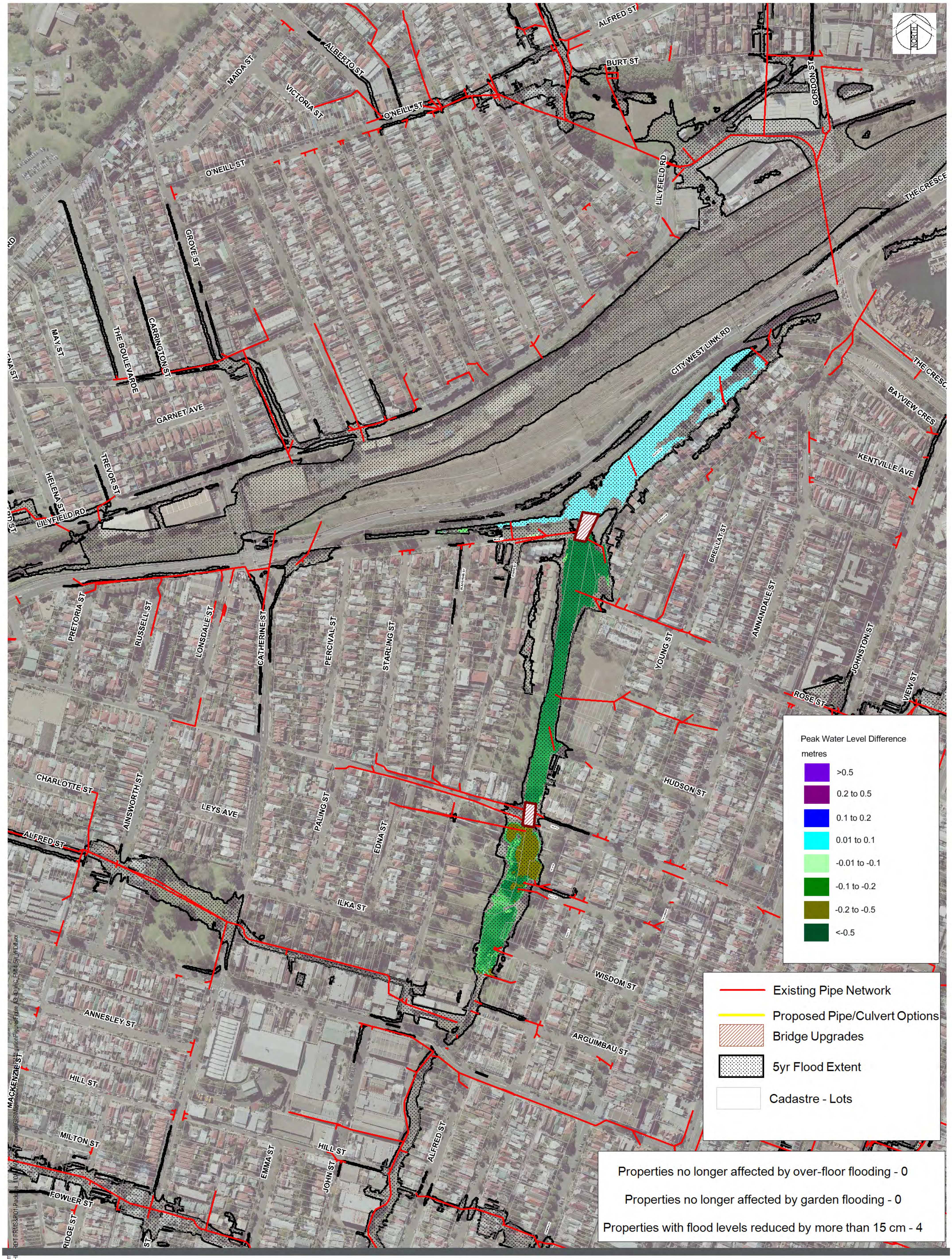

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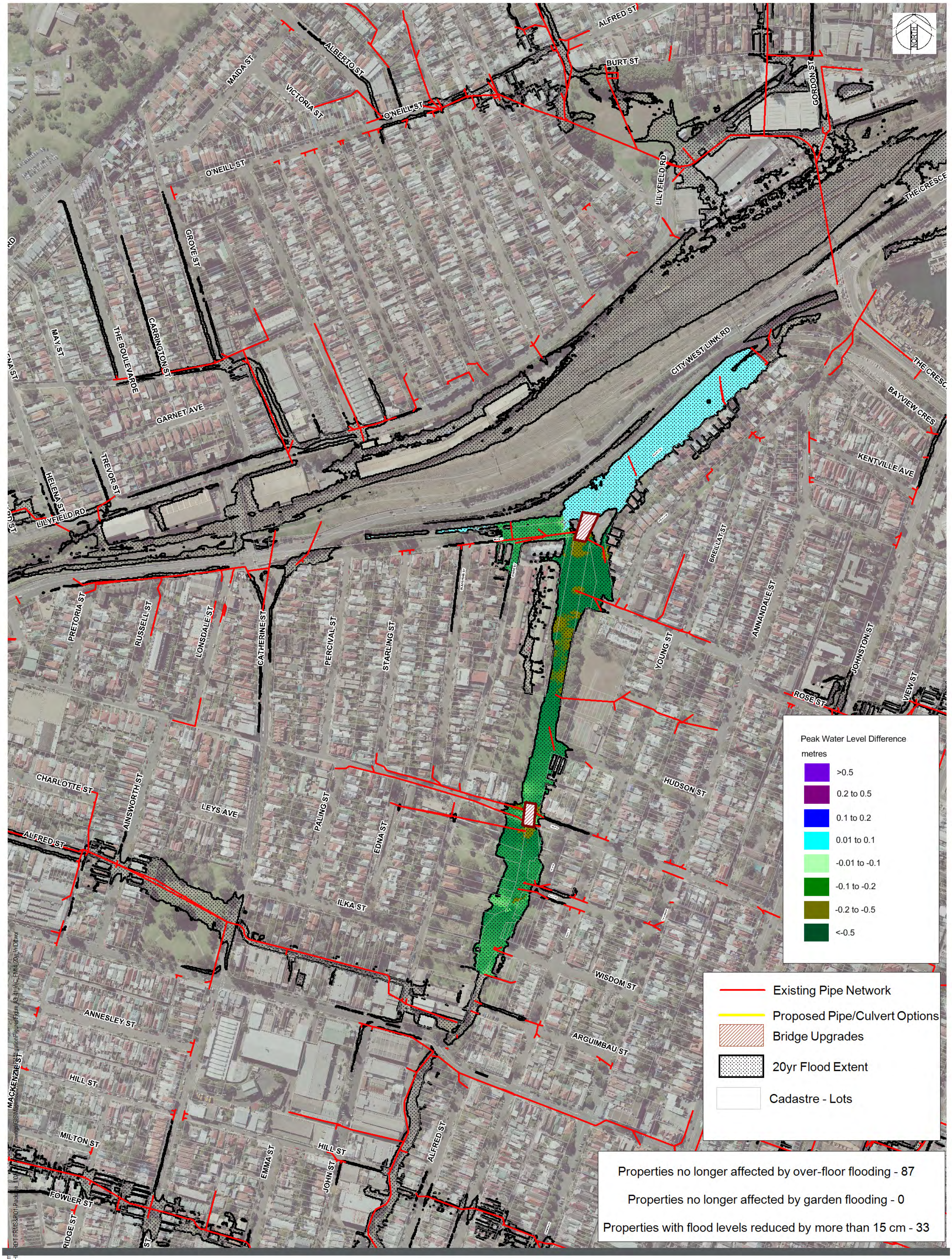

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FIG_A3_41

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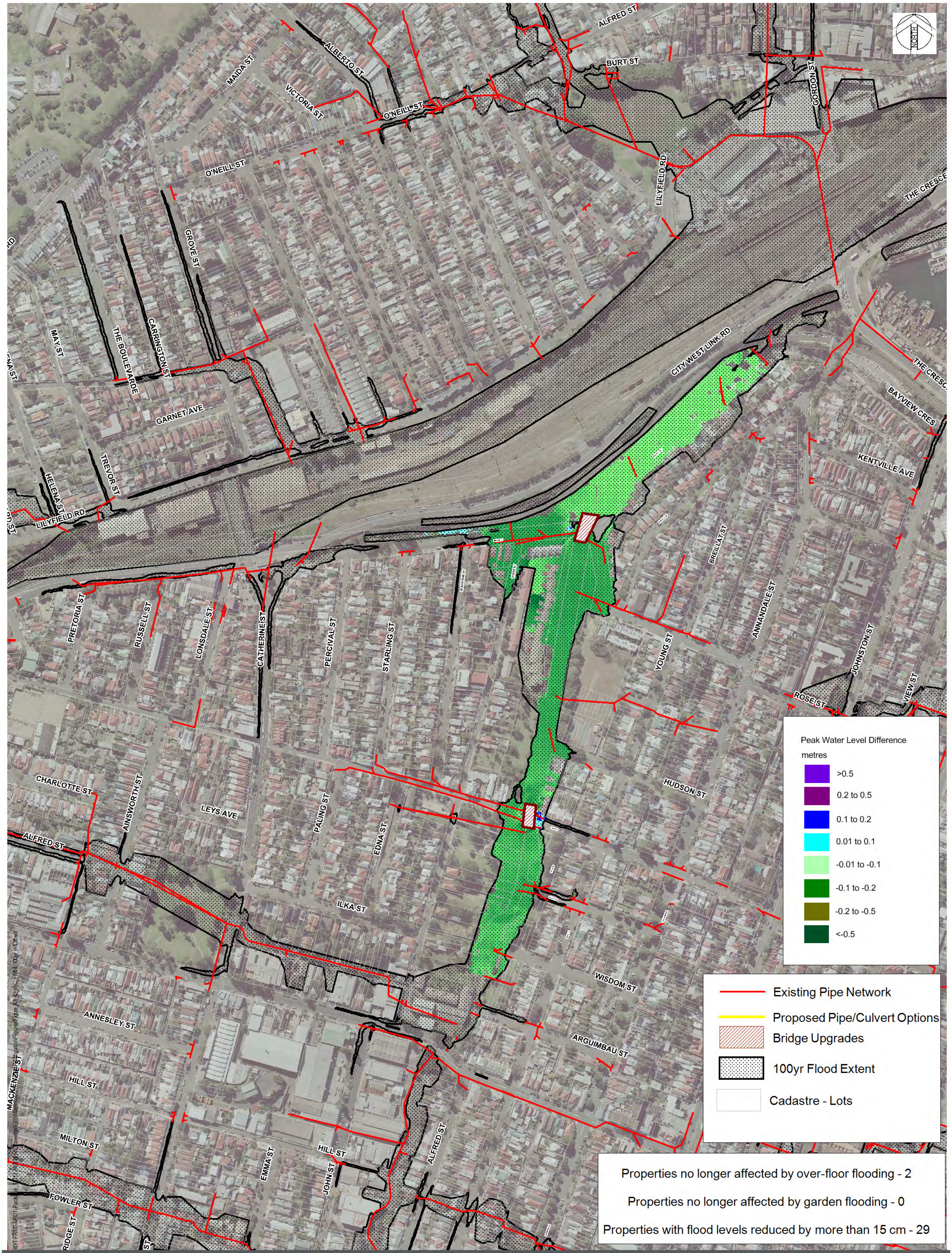

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MITIGATION LESS EXISTING
FIG_A3_42

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Area 4 - Iron Cove Options Assessment

Leichhardt Flood Risk Management Study and Plan

NA49913094

Prepared for
Inner West Council

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Table of Contents

Tables

Figures

1 Iron Cove Catchment Description

The majority of the Iron Cove catchment is located within the suburb of Rozelle. Overland flowpaths to the north of Balmain Road and Perry Street are primarily contained within Leichhardt Park, Rozelle Hospital and King George Park.

The overland flow in these areas impacts on existing infrastructure, such as the buildings within the Rozelle Hospital grounds. Significant ponding occurs around the electrical substation to the south east of King George Park, and this may have implications on the operation of this substation during a significant flood event. A small section of the King George Park tributary also affects properties south of Victoria Road.

The location of the Iron Cove Catchment within the study area is shown in **Figure 1-1**

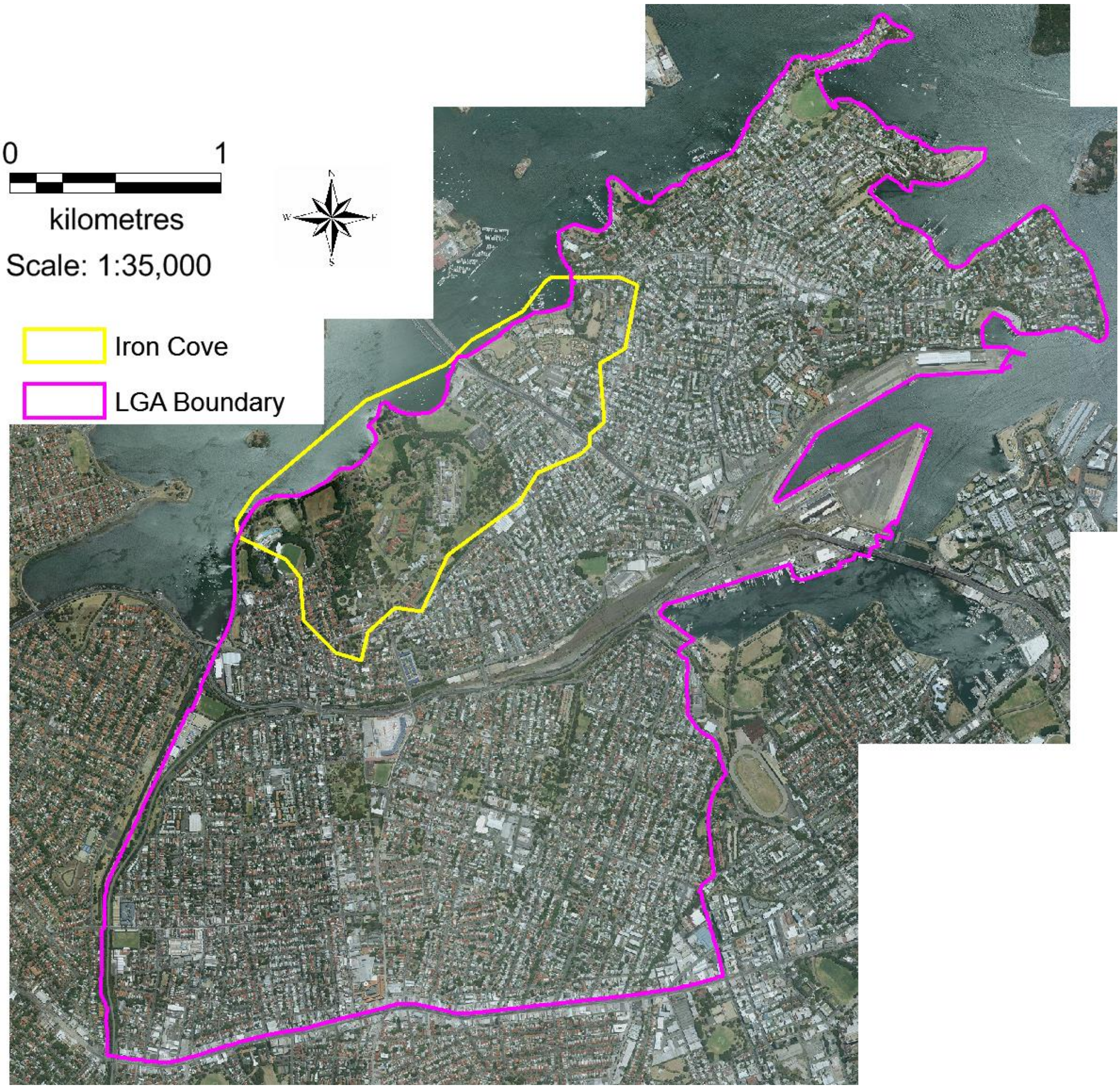

Figure 1-1 Iron Cove Catchment Location

2 Flood Mitigation Options Identification

2.1 Flood Modification Measures for Iron Cove

The existing flood behaviour within the Iron Cove catchment is detailed in the Leichhardt Flood Study (Cardno 2014). Based on the flood model results, historical information and engineering judgement, possible flood modification measures (i.e. structural measures) for the study area were identified.

The various management options were identified taking into consideration the:

- flood behaviour and flow in the 20 year ARI event;
- grade of pipe (upstream and downstream); and
- preliminary availability and location of easements.

Flood modification measures for the Iron Cove Catchment have been identified based on opportunities to connect with future upgrades and improvements.

2.2 Iron Cove Flood Mitigation Options

Within the Iron Cove catchment four sets of options were modelled. These are shown in **Table 2-1** and **Figure 2-1**. The 100yr, 20yr and 5yr ARI peak water level difference plots for each mitigation option are attached at the end of this appendix report.

Table 2-1 Iron Cove Mitigation Options

Option Description	Option Name	ID
Victoria Road Branch – Additional pipes from the Victoria Rd/Terry St intersection that drains into Iron Cove	Victoria Road Branch IC-FM1	IC-FM1
Manning Street Branch – Additional pipes that crosses Mannings St at three locations onto other street. Toelle St, Callan St and Springside St.	Manning Street Branch IC-FM2	IC-FM2
Glover Street Branch – Additional pipe along Glover St between Perry St and Church St.	Glover Street Branch IC-FM3	IC-FM3
Longview Street Branch – Additional pipes to drain flooding from the low point on Longview Street.	Longview Street Branch IC-FM4	IC-FM4

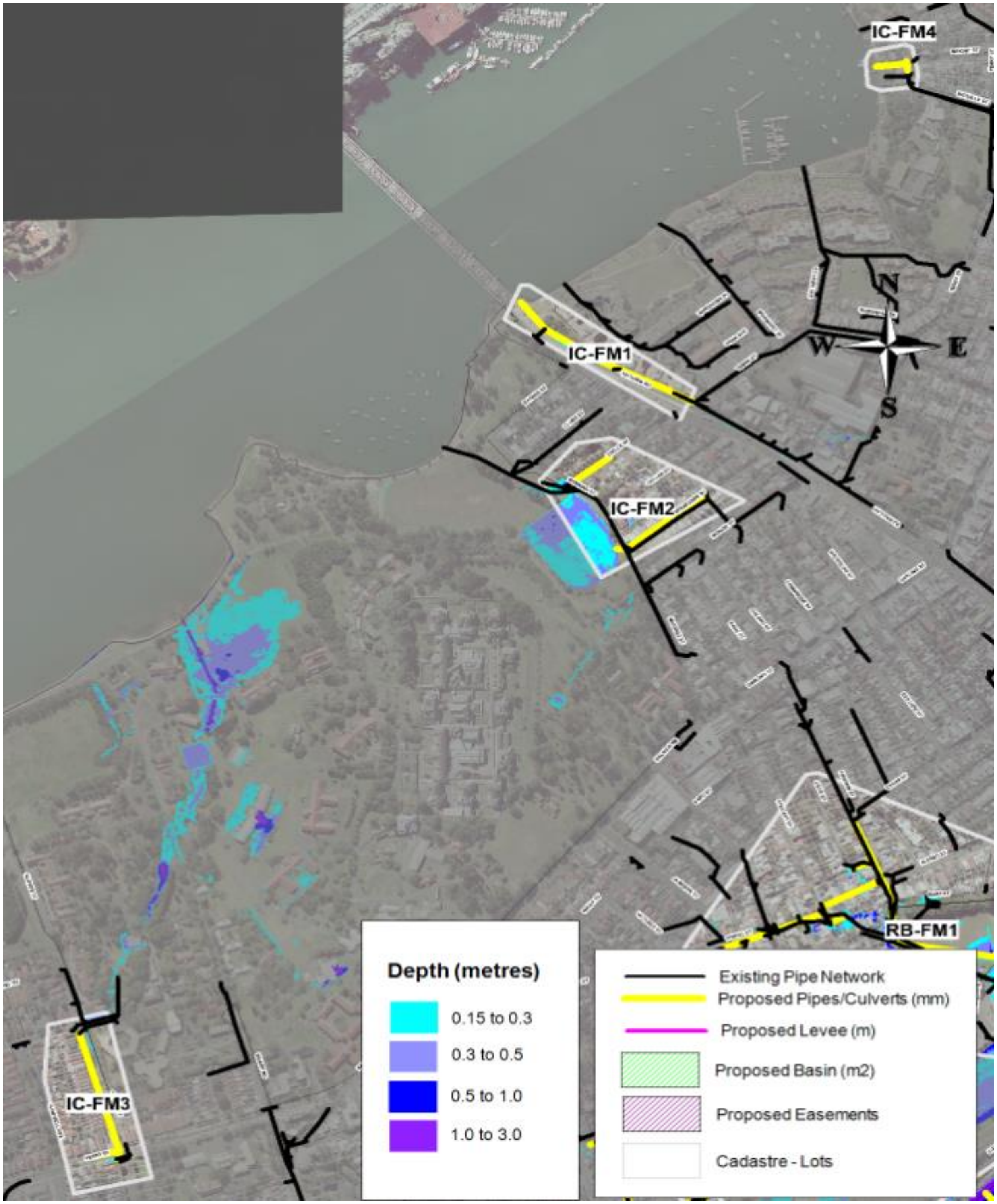

Figure 2-1 Iron Cove Mitigation Options Locations

2.2.1 Victoria Road Branch IC-FM1

IC-FM1 proposed an additional pipe along Victoria Road. The pipe starts from the Victoria Rd / Terry St intersection then drains into Iron Cove. The 750mm diameter pipe is 290m in length and is proposed to minimise the flooding on Victoria Road in a 20 year ARI storm event. Victoria Road is subjected to depths of around 0.25m due the 20 year ARI event.

A potential constraint for this measure includes the pipe construction along Victoria Road due to construction, services and traffic management requirements and costs.

RMS could potentially be responsible for funding all the works involved in this mitigation option.

2.2.2 Manning Street Branch IC-FM2

The Manning Street option proposes two sections of pipes. The pipes are proposed to be located along Toelle Street (450mm diameter) and Springside Street (600mm diameter). IC-FM2 aims to mitigate the flooding under existing conditions at Callan Street, Springside Street and potentially King George Park. An additional pipe (375mm diameter) from Balmain road to the electrical substation has also been proposed. The area impacted by the option is inundated with flood depths under existing conditions of around 1.6m in a 20 year ARI storm event.

2.2.3 Glover Street Branch IC-FM3

Two types of pipes (600mm diameter and 1050mm diameter) are proposed as part of the Glover Street Option. The pipes are proposed to run along Glover Street between Perry Street and Church Street.

Glover Street experiences flood depths in existing conditions of around 0.25m due to the 20 year ARI storm event.

Funding from RMS may be available for the transverse drainage works on Perry Street.

2.2.4 Longview Street Branch IC-FM4

This option proposes additional pipes (600mm diameter and 7500mm diameter) at Longview Street to mitigate flooding at the low point on Longview Street. The existing 600mm pipeline and the inlet system of pits have been identified to be undersized based on the modelled flows arriving at this location.

3 Mitigation Option Modelling Outcomes

The Iron Cove flood mitigation options were assed for the 5, 10, 20, 50 and 100 Year ARI design flood events, along with the PMF event.

The outcomes of the modelling are shown in the 5, 20, and 100 Year ARI water level difference plots attached at the end of this catchment report.

A summary of the impacts on flood behaviour for each option is provided below.

3.1 Victoria Road Branch IC-FM1

The mitigation option IC-FM1 has no discernible reduction in flood depths on Victoria Road in all the modelled design events. As such, no flood level impact mapping has been provided for this option.

3.2 Manning Street Branch IC-FM2

Duplicating the existing pipe downstream of Darling Street results in reductions of flood levels of up to 0.07m along Springside Street, Manning Street, at the electrical substation and King George Park.

The results indicate that properties along Springside Street would experience only minor decreases in water levels in the more frequent flood events.

3.3 Glover Street Branch IC-FM3

Mitigation option IC-FM3 shows a decreases in water levels along parts of Perry Street, Glover Street and Church Street in an order of 0.01m to 0.08m in all the modelled design events. Results indicate properties along Glover Street would experience decrease in water levels in frequent storms. However, these properties do not experience overfloor flooding under existing conditions, and flooding will not be removed from their properties completely. As such, there is no reduction in the flood damages for these events.

3.4 Longview Street Branch IC-FM4

Mitigation option IC-FM4 shows significant decrease in water levels on Longview Street. The water level decreases are up to 0.25m in a 100 Year ARI event at the low point on the street. Results indicate the benefits of this option are largely confined to the road with only limited benefits to private property.

There is a reduction of flood levels on one property of 0.16m. However, as this property does not experience overfloor flooding, the flood damages remain unchanged.

4 Economic Assessment of Flood Damages in the Iron Cove Catchment

4.1 Iron Cove Mitigation Options Damages Assessment

An assessment of damages for the existing condition in the Iron Cove Catchment is presented in the Floodplain Risk Management Study. The approach adopted for calculating the existing damages has been repeated for the modelling results from the mitigation options proposed for the Iron Cove catchment.

The economic flood damage results for each of the options and the existing scenarios are presented in **Table 4-1** to **Table 4-4**. The reductions in properties affected by overground and overfloor flooding, total damages and AAD are provided. Negative values represent increases from the existing scenario.

The total reduction in damaged properties and the associated reduction in damage costs for each mitigation strategy is summarised in **Table 4-5**. This table represents a summary of differences between existing and Mitigation scenarios presented in **Table 4-1** to **Table 4-4**.

The flood damages assessment is a useful tool for comparing the merits of various options, it is not a precise flood risk analysis tool and the limitation associated with the assessment should be considered when interpreting the results.

The following information should be considered when interpreting the damages data:

- Negative property or dollar values represent increases from the existing scenario.
- Where an option results in a reduction in flood depths there may not be any reduction in the flood damages where:
    - The reduction in flood depths or extent occur in open space or roadways; or
    - The reduction in flood depths occurs on properties that were not impacted by over floor flooding (i.e. the flooding on the property grounds is shallower but still exists).
- The flood damages are calculated at a discrete location on each property. This location is where the floor level and ground level survey was obtained from. As such, if the flooding occurs at another location on the property other than the survey point, this property will not register any damages with regards to this damages assessment.

Table 4-1 IC_FM1 Flood Damage Assessment Summary

Event / Property type	Properties with Overfloor Flooding		Properties with Overground Flooding		Estimated Total Damage ($ June 2016)	
	Existing Case	*Mitigation Case*	*Existing Case*	*Mitigation Case*	*Existing Case*	*Mitigation Case*
PMF Event						
Residential	3	3	5	5	$ 717,024	$ 712,085
Commercial	0	0	0	0	$ -	$ -
Industrial	1	1	1	1	$ 3,829	$ 3,829
PMF Total	**4**	**4**	**6**	**6**	**$ 720,852**	**$ 715,913**
100yr ARI						
Residential	0	0	0	0	$ -	$ -
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ 3,829	$ 3,829
100yr ARI Total	**0**	**0**	**0**	**0**	**$ 3,829**	**$ 3,829**
50yr ARI						
Residential	0	0	0	0	$ -	$ -
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ 3,829	$ 3,829
50yr ARI Total	**0**	**0**	**0**	**0**	**$ 3,829**	**$ 3,829**
20yr ARI						
Residential	0	0	0	0	$ -	$ -
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ 3,829	$ 3,829
20yr ARI Total	**0**	**0**	**0**	**0**	**$ 3,829**	**$ 3,829**
10yr ARI						
Residential	0	0	0	0	$ -	$ -
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ 3,829	$ 3,829
10yr ARI Total	**0**	**0**	**0**	**0**	**$ 3,829**	**$ 3,829**
5yr ARI						
Residential	0	0	0	0	$ -	$ -
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ 3,829	$ 3,829
5yr ARI Total	**0**	**0**	**0**	**0**	**$ 3,829**	**$ 3,829**
Total Annual Average Damage					**$ 4,925**	**$ 4,900**

Table 4-2 IC_FM2 Flood Damage Assessment Summary

Event / Property type	Properties with Overfloor Flooding		Properties with Overground Flooding		Estimated Total Damage ($ June 2016)	
	Existing Case	*Mitigation Case*	*Existing Case*	*Mitigation Case*	*Existing Case*	*Mitigation Case*
PMF Event						
Residential	39	39	48	48	$ 2,588,325	$ 2,573,259
Commercial	0	0	0	0	$ -	$ -
Industrial	2	2	2	2	$ 824,277	$ 822,573
PMF Total	**41**	**41**	**50**	**50**	**$ 3,412,602**	**$ 3,395,832**
100yr ARI						
Residential	7	7	7	7	$ 526,334	$ 524,750
Commercial	0	0	0	0	$ -	$ -
Industrial	1	1	1	1	$ 6,455	$ 4,237
100yr ARI Total	**8**	**8**	**8**	**8**	**$ 532,789**	**$ 528,988**
50yr ARI						
Residential	7	7	7	7	$ 507,283	$ 504,747
Commercial	0	0	0	0	$ -	$ -
Industrial	1	1	1	1	$ 5,693	$ 3,065
50yr ARI Total	**8**	**8**	**8**	**8**	**$ 512,975**	**$ 507,813**
20yr ARI						
Residential	7	7	7	7	$ 482,203	$ 479,334
Commercial	0	0	0	0	$ -	$ -
Industrial	1	1	1	1	$ 4,946	$ 2,602
20yr ARI Total	**8**	**8**	**8**	**8**	**$ 487,148**	**$ 481,935**
10yr ARI						
Residential	6	6	7	7	$ 429,189	$ 426,419
Commercial	0	0	0	0	$ -	$ -
Industrial	1	1	1	1	$ 4,190	$ 2,321
10yr ARI Total	**7**	**7**	**8**	**8**	**$ 433,380**	**$ 428,739**
5yr ARI						
Residential	4	4	5	5	$ 222,480	$ 219,957
Commercial	0	0	0	0	$ -	$ -
Industrial	1	1	1	1	$ 3,609	$ 3,609
5yr ARI Total	**5**	**5**	**6**	**6**	**$ 226,090**	**$ 223,566**
Total Annual Average Damage					**$ 129,856**	**$ 128,569**

Table 4-3 IC_FM3 Flood Damage Assessment Summary

Event / Property type	Properties with Overfloor Flooding		Properties with Overground Flooding		Estimated Total Damage ($ June 2016)	
	Existing Case	*Mitigation Case*	*Existing Case*	*Mitigation Case*	*Existing Case*	*Mitigation Case*
PMF Event						
Residential	32	32	43	43	$ 2,063,827	$ 2,048,696
Commercial	3	3	3	3	$ 1,243,585	$ 1,243,585
Industrial	0	0	0	0	$ -	$ -
PMF Total	**35**	**35**	**46**	**46**	**$ 3,307,412**	**$ 3,292,282**
100yr ARI						
Residential	0	0	0	0	$ -	$ -
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
100yr ARI Total	**0**	**0**	**0**	**0**	**$ -**	**$ -**
50yr ARI						
Residential	0	0	0	0	$ -	$ -
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
50yr ARI Total	**0**	**0**	**0**	**0**	**$ -**	**$ -**
20yr ARI						
Residential	0	0	0	0	$ -	$ -
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
20yr ARI Total	**0**	**0**	**0**	**0**	**$ -**	**$ -**
10yr ARI						
Residential	0	0	0	0	$ -	$ -
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
10yr ARI Total	**0**	**0**	**0**	**0**	**$ -**	**$ -**
5yr ARI						
Residential	0	0	0	0	$ -	$ -
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
5yr ARI Total	**0**	**0**	**0**	**0**	**$ -**	**$ -**
Total Annual Average Damage					**$ 16,535**	**$ 16,460**

Table 4-4 IC_FM4 Flood Damage Assessment Summary

Event / Property type	Properties with Overfloor Flooding		Properties with Overground Flooding		Estimated Total Damage ($ June 2016)	
	Existing Case	*Mitigation Case*	*Existing Case*	*Mitigation Case*	*Existing Case*	*Mitigation Case*
PMF Event						
Residential	3	3	5	5	$ 717,024	$ 714,154
Commercial	0	0	0	0	$ -	$ -
Industrial	1	1	1	1	$ 3,829	$ 3,843
PMF Total	**4**	**4**	**6**	**6**	**$ 720,852**	**$ 717,998**
100yr ARI						
Residential	0	0	0	0	$ -	$ 15
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ 3,829	$ 3,858
100yr ARI Total	**0**	**0**	**0**	**0**	**$ 3,829**	**$ 3,873**
50yr ARI						
Residential	0	0	0	0	$ -	$ 29
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ 3,829	$ 3,876
50yr ARI Total	**0**	**0**	**0**	**0**	**$ 3,829**	**$ 3,906**
20yr ARI						
Residential	0	0	0	0	$ -	$ 47
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ 3,829	$ 3,827
20yr ARI Total	**0**	**0**	**0**	**0**	**$ 3,829**	**$ 3,875**
10yr ARI						
Residential	0	0	0	0	$ -	$ -
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ 3,829	$ 3,829
10yr ARI Total	**0**	**0**	**0**	**0**	**$ 3,829**	**$ 3,829**
5yr ARI						
Residential	0	0	0	0	$ -	$ -
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ 3,829	$ 3,829
5yr ARI Total	**0**	**0**	**0**	**0**	**$ 3,829**	**$ 3,829**
Total Annual Average Damage					**$ 4,925**	**$ 4,914**

Table 4-5 Reduction in Damages Associated with Each Option

	Overfloor flooding properties reduction	Overground flooding properties reduction	Total Damage Reduction ($)	AAD Reduction ($)
IC-FM1				
PMF event	0	0	$ 4,939	$25
100yr ARI event	0	0	$ -	$0
50yr ARI event	0	0	$ -	$0
20yr ARI event	0	0	$ -	$0
10yr ARI event	0	0	$ -	$0
5yr ARI event	0	0	$ -	$0
Total				**$25**
IC-FM2				
PMF event	0	0	$ 16,770	$103
100yr ARI event	0	0	$ 3,801	$45
50yr ARI event	0	0	$ 5,163	$156
20yr ARI event	0	0	$ 5,213	$246
10yr ARI event	0	0	$ 4,640	$358
5yr ARI event	0	0	$ 2,524	$379
Total				**$1,286**
IC-FM3				
PMF event	0	0	$ 15,131	$76
100yr ARI event	0	0	$ -	$0
50yr ARI event	0	0	$ -	$0
20yr ARI event	0	0	$ -	$0
10yr ARI event	0	0	$ -	$0
5yr ARI event	0	0	$ -	$0
Total				**$76**
IC-FM4				
PMF event	0	0	$ 2,855	$14
100yr ARI event	0	0	-$ 44	-$1
50yr ARI event	0	0	-$ 77	-$2
20yr ARI event	0	0	-$ 46	-$1
10yr ARI event	0	0	$ -	$0
5yr ARI event	0	0	$ -	$0
Total				**$10**

4.2 Benefit to Cost Ratio of Options

The economic evaluation of each modelled measure was assessed by considering the reduction in the amount of flood damages incurred for the design events and by then comparing this value with the cost of implementing the measure.

Table 4-6 summarises the results of the economic assessment of each of the flood management options. The indicator adopted to rank these measures on economic merit is the benefit-cost ratio (B/C), which is based on the net present worth (NPW) of the benefits (reduction in AAD) and the costs (capital and ongoing), adopting a 7% discount rate and an implementation period of 50 years.

The benefit-cost ratio provides an insight into how the damage savings from a measure, relate to its cost of construction and maintenance:

- Where the benefit-cost is greater than 1 the economic benefits are greater than the cost of implementing the measure;

- Where the benefit-cost is less than 1 but greater than 0, there is still an economic benefit from implementing the measure but the cost of implementing the measure is greater than the economic benefit;
- Where the benefit-cost is equal to zero, there is no economic benefit from implementing the measure; and
- Where the benefit-cost is less than zero, there is a negative economic impact of implementing the measure.

Table 4-6 Summary of Economic Assessment of Flood Management Options

Option ID	Option Description	NPW of Reduction in AAD	NPW of Cost of Implementation	B/C Ratio	Economic Ranking
IC_FM1	Victoria Road Branch – Additional pipes from the Victoria Rd/Terry St intersection that drains into Iron Cove	$0	$1,580,000	0.00	4
IC_FM2	Manning Street Branch – Additional pipes that crosses Mannings St at three locations onto other street. Toelle St, Callan St and Springside St.	$18,000	$2,285,000	0.01	1
IC_FM3	Glover Street Branch – Additional pipe along Glover St between Perry St and Church St.	$1,000	$1,507,000	0.00	2
IC_FM4	Longview Street Branch – Additional pipes to drain flooding from the low point on Longview Street.	$0	$316,000	0.00	3

Iron Cove Mitigation Option Figures

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IC_FM2 5YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A4_4

Date
03/2017

IC_FM2_5yr_WlDiff
Drawing Number

Size
A3

03
Revision

DATE PLOTTED: 04-Nov-2016 BY: Matthew.Prumm
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LEICHHARDT FRMS&P
IC_FM2 20YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A4_5

Date	Drawing Number	Size	Revision
03/2017	IC_FM2_20yr_WlDiff	A3	03

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LEICHHARDT FRMS&P
IC_FM2 100YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A4_6

Date
03/2017

Size
A3

IC_FM2_100yr_WlDiff
Drawing Number

03
Revision

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IC_FM3 5YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A4_7

Date	Size
03/2017	A3

IC_FM3_5yr_WlDiff
Drawing Number

03
Revision

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LEICHHARDT FRMS&P
IC_FM3 20YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A4_8

Date
03/2017

IC_FM3_20yr_WlDiff
Drawing Number

Size
A3

03
Revision

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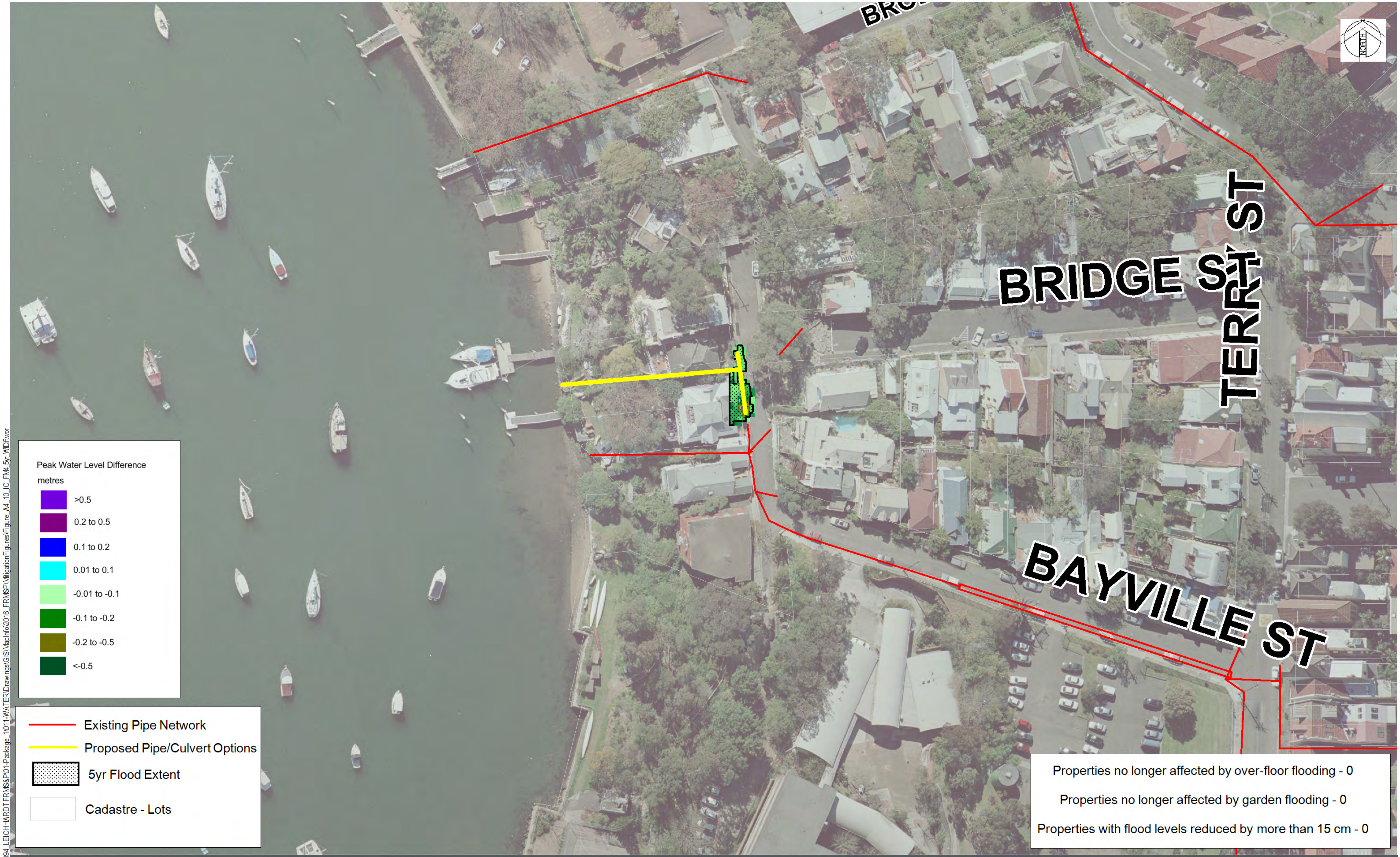
IC_FM3 100YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A4_9

Date
03/2017

IC_FM3_100yr_WlDiff
Drawing Number

Size
A3

03
Revision



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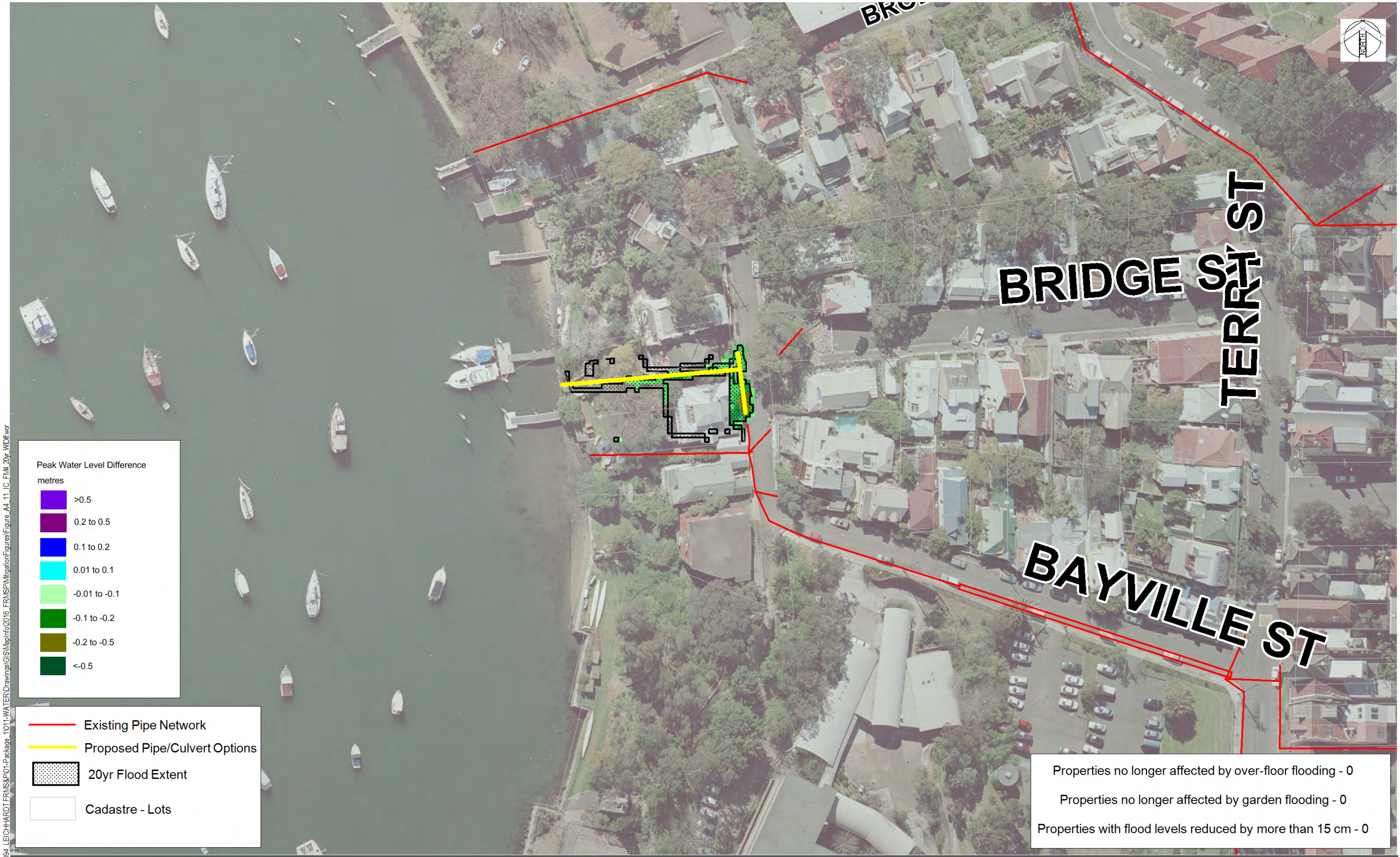
IC_FM4 5YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A4_10

Date
03/2017

IC_FM4_5yr_WlDiff
Drawing Number

Size
A3

03
Revision



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LEICHHARDT FRMS&P
IC_FM4 20YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A4_11

Date	Size
03/2017	A3
IC_FM4_20yr_WlDiff	03
Drawing Number	Revision

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IC_FM4 100YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A4_12

Date
03/2017

Size
A3

IC_FM4_100yr_WlDiff
Drawing Number

03
Revision

Area 5 - Mort Bay Options Assessment

Leichhardt Flood Risk Management Study and Plan

NA49913094

Prepared for
Inner West Council

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Tables

Figures

1 Mort Bay Catchment

Mort Bay Catchment is located in Birchgrove, Balmain and Balmain East. Overland flowpaths are located to the north of Darling Street and discharges into Mort Bay. In a number of cases, the streets in this area are aligned such that the majority of the overland flow proceeds along them, rather than directly through the houses. Significant ponding occurs at the low point on Cameron Street.

The location of the Mort Bay Catchment within the study area is shown in **Figure 1-1.**

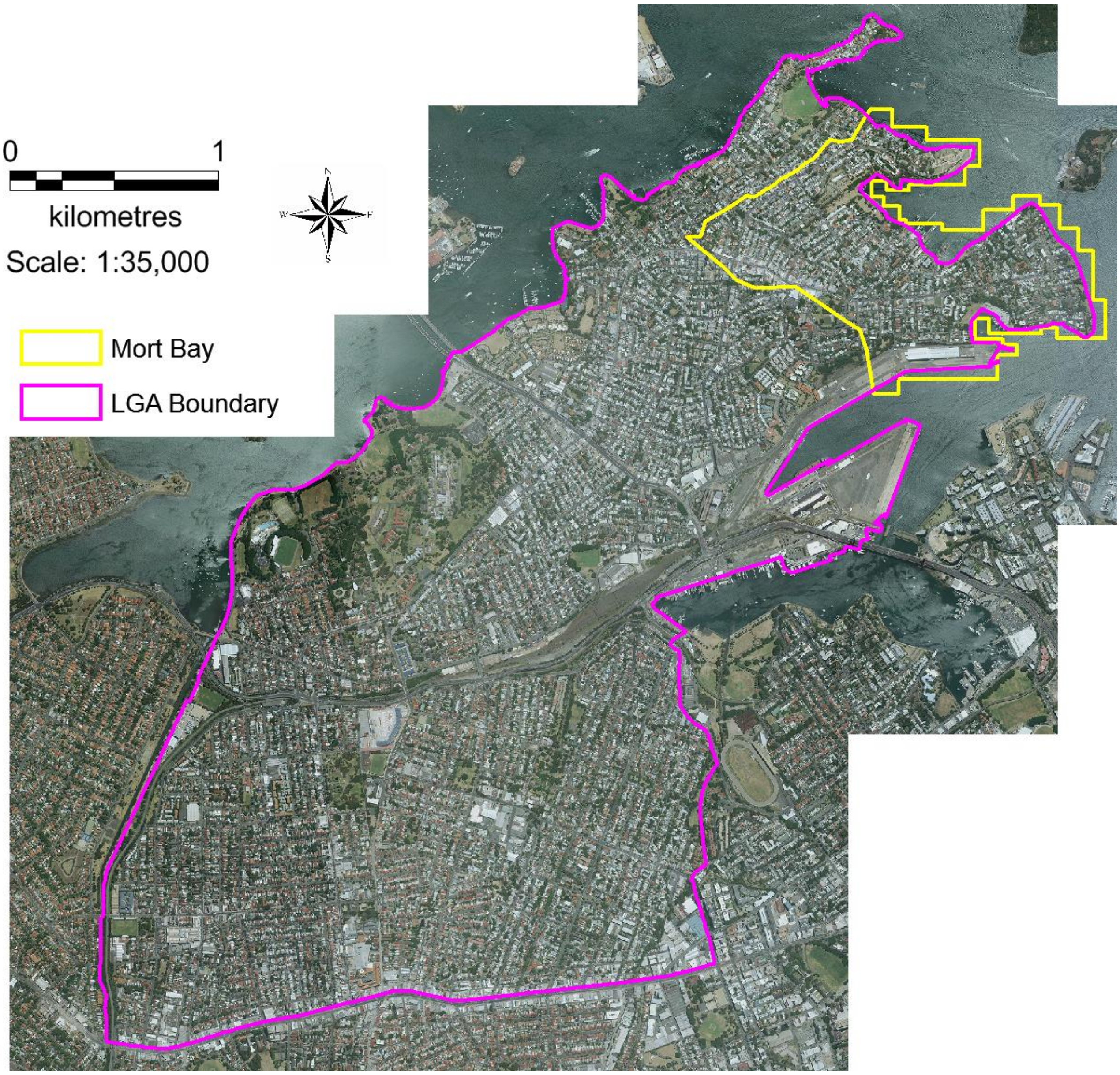


Figure 1-1 Mort Bay Catchment Location

2 Flood Mitigation Options Identification

2.1 Flood Modification Measures for Mort Bay

The existing flood behaviour within the Mort Bay Catchment is detailed in the Leichhardt Flood Study (Cardno 2014). Based on the flood model results, historical information and engineering judgement, possible flood modification measures (i.e. structural measures) for the study area were identified.

The various management options were identified taking into consideration the:

- flood behaviour and flow in the 20 year ARI event;
- grade of pipe (upstream and downstream); and
- preliminary availability and location of easements.

2.2 Mort Bay Flood Mitigation Options

Within the Mort Bay catchment four (4) sets of options were modelled. These are shown in **Table 2-1** and **Figure 2-1**. The 100yr, 20yr and 5yr ARI peak water level difference plots for each mitigation option are attached at the end of this appendix report.

Table 2-1 Mitigation Options

Option Description	Option Name	ID
Colgate Street Branch – Proposing additional pipes to be incorporated into the existing network. Starting from Darling St/Queens Pl intersection, passes along Colgate Av and drains into Mort Bay. There are also additional pipes on St Andrews St and Cooper St.	Colgate Street Branch MB-FM1	MB-FM1
Curtis Rd Branch – Propose additional pipes along Mort St and Clayton St and connecting to an additional proposed pipe on Cameron St (MB-FM4) which drains into Mort Bay.	Curtis Rd Branch MB-FM3	MB-FM3
College Street Branch – Additional pipe network starting from the Cardwell/North St intersection, travelling along (SE) Macquarie St and the Curtis Rd. The pipe branches off into Phillip St, Church St and College St and finally connects into the existing Sydney Water pipe and to the proposed pipe on Cameron St which drains into Mort Bay.	College Street Branch MB-FM4	MB-FM4
McKell Street Branch – Additional pipe from Short St that crosses McKell St and drain into Mort Bay	McKell Street Branch MB-FM5	MB-FM5

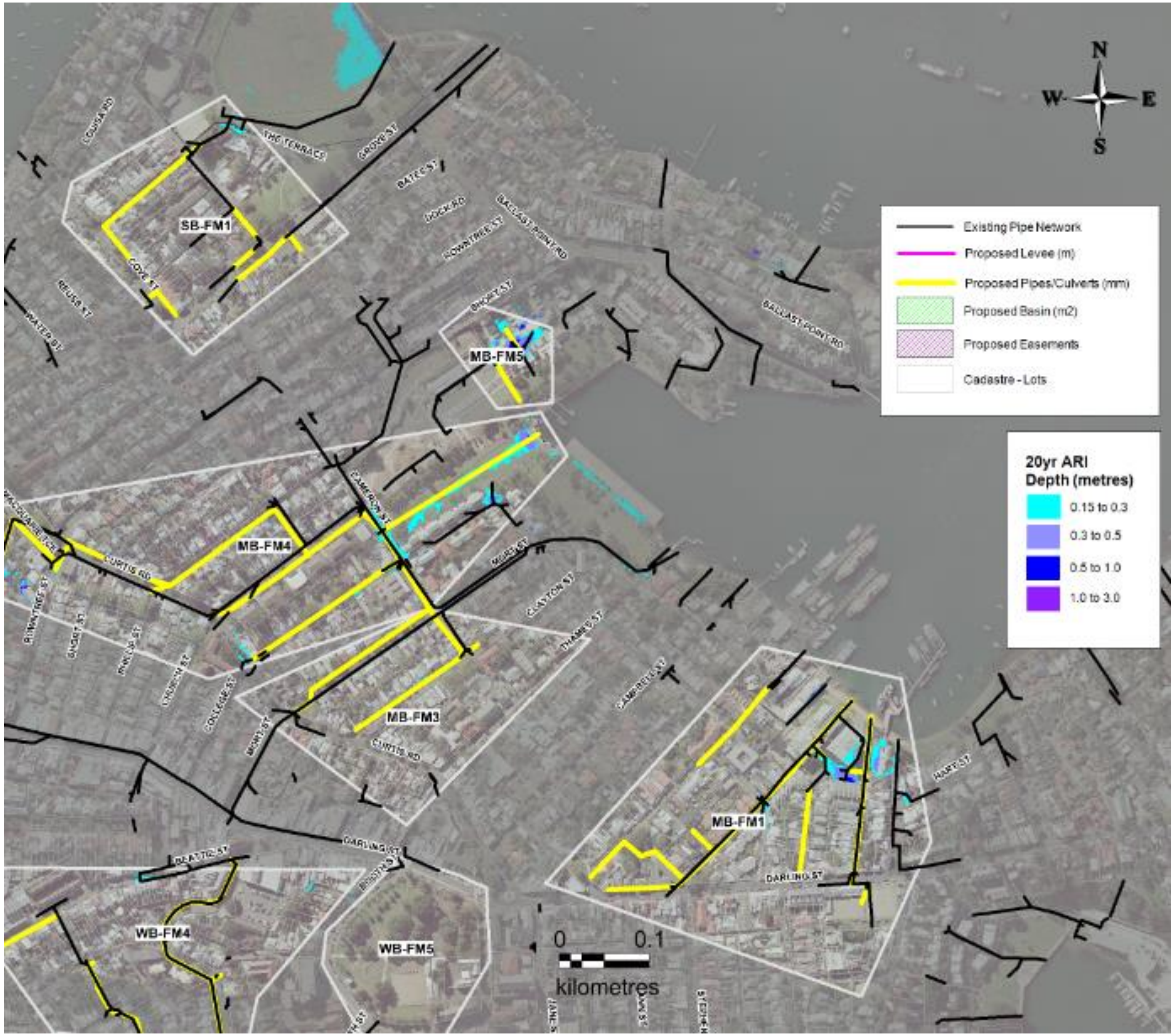


Figure 2-1 Mort Bay Mitigation Options Locations

2.2.1 Colgate Avenue Branch MB-FM1

MB-FM1 proposes additional pipes to be incorporated into the existing network. A 450mm diameter pipe is proposed from Darling Street / Queens Place intersection, pipes with diameters of 600mm, 900mm and 1050mm are then proposed along Colgate Avenue, which then drain into Mort Bay. There are also additional pipes proposed on St. Andrews Street (375mm diameter) and Cooper Street (750mm and 1200mm diameter) that drain into Mort Bay.

The Colgate Avenue main branch has four proposed side branches attached to it consisting of pipe diameters of 350mm and 450mm. Additionally, the St Andrews Branch has one side branch proposed with a pipe diameter of 1200mm.

In 20 Year ARI storm event under existing conditions, flooding in this area occurs between Colgate Avenue and Cooper Street. Flood depths ranging from 0.30m to 0.50m are observed on Walumil Street.

A potential constraint to the implementation of this option may include the unforeseen costs associated with construction, services and traffic management requirements on Darling Street.

2.2.2 Curtis Rd Branch MB-FM3

This option proposes additional pipes from the recently completed drainage works in Curtis Road to Cameron Street. A proposed 600mm diameter pipe is proposed from the intersection of Clayton Street and Curtis Road, along Curtis Road and then connecting to a proposed 1200mm pipe at the Cameron Street / Mort Street intersection.

The other proposed branch is located along Mort Street (1050mm diameter pipe) which then connects to a proposed 1200mm diameter pipe at the Cameron Street / Mort Street intersection before draining into Mort Bay. Additionally, there is a short branch (450mm diameter pipe) proposed at Clayton Street.

Flood depths up to 0.15m on Clayton Street and Mort Street occur in an existing 20 Year ARI event.

A potential constraint to the implementation of this option may include the unforeseen costs associated with construction, services and traffic management requirements.

2.2.3 College Street Branch MB-FM4

This option proposes an additional pipe network starting from the Cardwell Street / North Street intersection, travelling along Macquarie Terrace (in a south east direction) and then on Curtis Rd (consisting of 600mm and 900mm diameter pipes). A 1000mm diameter pipe is proposed along Phillip Street and Spring Street, a 1200mm diameter pipe is proposed along Church Street, which is proposed to connect to a proposed 1500mm diameter pipe on Cameron Street, which will then drain into Mort Bay through a proposed 1800mm diameter pipe. Additional pipes are proposed along Church Street (1000mm diameter) and along College Street (900mm diameter). It should be noted that the proposed Church Street branch connects to the existing Sydney Water pipe on Cameron Street.

Flooding under existing conditions due to the 20 year ARI storm results in flood depths up to 0.30m on Cameron Street.

A potential constraint to the implementation of this option may include the unforeseen costs associated with construction, services and traffic management requirements.

2.2.4 McKell Street Branch MB-FM5

This option proposes pipes along McKell Street that drain into Mort Bay. This option comprises of 900mm and 1050mm diameter pipes. Existing infrastructure exists in this area and is proposed to be increased in capacity. The proposed pipes will aim to drain the low point on McKell Street around the buildings to Mort Bay. The impacted buildings experience flood depths under existing conditions of around 0.5m in the 20 Year ARI storm event.

3 Mitigation Option Modelling Outcomes

The Mort Bay Catchment flood mitigation options were assed for the 5, 10, 20, 50 and 100 Year ARI design flood events, along with the PMF event.

The outcomes of the modelling are shown in the 5, 20, and 100 Year ARI water level difference plots attached at the end of this catchment report.

A summary of the impacts on flood behaviour for each option is provided below.

3.1 Colgate Avenue Branch MB-FM1

The increase in drainage capacity at the College Street Branch proposed in MB-FM1 is shown to decrease flood levels by 0.01m – 0.1m in all the design storms in the vicinity of Colgate Avenue, Cooper Street and Walumil Street. Results indicate that the properties at the low point on Malumil Street only would experience a decrease in water level of up to 0.10m in the all the design storms due to this mitigation strategy.

The decrease in flood levels results in a minor reduction in flood damages (due to reduced depth of flooding). However, no reduction in the actual number of properties being flooded is achieved.

3.2 Curtis Rd Branch MB-FM3

The proposed increase in drainage capacity of mitigation option MB-FM3 is shown to reduce overland flows along the flow path. The water level difference results show a decrease of 0.01m – 0.10m along the flow path in all the design storms on Clayton Street and Mort Street. The results show that the large extent of reduction of flood levels occurs in the open space area downstream of Cameron Street.

The decrease in flood levels results in a minor reduction in flood damages (due to reduced depth of flooding). However, no reduction in the actual number of properties being flooded is achieved.

3.3 College Street Branch MB-FM4

Mitigation option MB-FM4 shows reduction in water levels along the flow paths where the drainage network is proposed. The reductions of flood depths are in an order of 0.01m to 0.10m in all the design storms along the flow paths in Curtis Road, Church Street, College Street and Cameron Street. The increased conveyance of flow through the proposed drainage works indicate that the properties at the low point on Cameron Street would experience a decrease in water level of more than 0.10m in all flood events.

3.4 McKell Street Branch MB-FM5

Mitigation option MB-FM5 shows a decrease in flood levels along McKell Street due to the proposed drainage works. The water level decreases in both the 20 Year ARI and a 100 Year ARI are approximately 0.25m and 0.30m respectively. Results indicate that the properties at the low point on McKell Street would experience a decrease in water level of more than 0.25m in the 20 Year ARI event due to this mitigation strategy.

4 Economic Assessment of Flood Damages in the Mort Bay Catchment

4.1 Mort Bay Mitigation Options Damages Assessment

An assessment of damages for the existing condition in the Mort Bay Catchment is presented in the Floodplain Risk Management Study. The approach adopted for calculating the existing damages has been repeated for the modelling results from the mitigation options proposed for the Mort Bay catchment.

The economic flood damage results for each of the options and the existing scenarios are presented in **Table 4-1** to **Table 4-4**. The reductions in properties affected by overground and overfloor flooding, total damages and AAD are provided. Negative values represent increases from the existing scenario.

The total reduction in damaged properties and the associated reduction in damage costs for each mitigation strategy is summarised in **Table 4-5.** This table represents a summary of differences between existing and Mitigation scenarios presented in **Table 4-1** to **Table 4-4**.

The flood damages assessment is a useful tool for comparing the merits of various options, it is not a precise flood risk analysis tool and the limitation associated with the assessment should be considered when interpreting the results.

The following information should be considered when interpreting the damages data:

- Negative property or dollar values represent increases from the existing scenario.
- Where an option results in a reduction in flood depths there may not be any reduction in the flood damages where:
    - The reduction in flood depths or extent occur in open space or roadways; or
    - The reduction in flood depths occurs on properties that were not impacted by over floor flooding (i.e. the flooding on the property grounds is shallower but still exists).
- The flood damages are calculated at a discrete location on each property. This location is where the floor level and ground level survey was obtained from. As such, if the flooding occurs at another location on the property other than the survey point, this property will not register any damages with regards to this damages assessment.
- Commercial and industrial damages are only incurred when over floor flooding exists.
- The reduction in the number of properties impacted as a result of an option may vary between different flood events due to the performance of the proposed work under the different flow behaviour of each flood event.

Table 4-1 MB_FM1 Flood Damage Assessment Summary

Event / Property type	Properties with Overfloor Flooding		Properties with Overground Flooding		Estimated Total Damage ($ June 2016)	
	Existing Case	*Mitigation Case*	*Existing Case*	*Mitigation Case*	*Existing Case*	*Mitigation Case*
PMF Event						
Residential	21	21	53	53	$ 1,250,174	$ 1,058,464
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
PMF Total	**21**	**21**	**53**	**53**	**$ 1,250,174**	**$ 1,058,464**
100yr ARI						
Residential	1	1	9	8	$ 37,963	$ 34,737
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
100yr ARI Total	**1**	**1**	**9**	**8**	**$ 37,963**	**$ 34,737**
50yr ARI						
Residential	1	1	7	7	$ 34,827	$ 34,505
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
50yr ARI Total	**1**	**1**	**7**	**7**	**$ 34,827**	**$ 34,505**
20yr ARI						
Residential	1	1	6	6	$ 34,531	$ 31,019
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
20yr ARI Total	**1**	**1**	**6**	**6**	**$ 34,531**	**$ 31,019**
10yr ARI						
Residential	1	1	6	6	$ 31,232	$ 27,309
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
10yr ARI Total	**1**	**1**	**6**	**6**	**$ 31,232**	**$ 27,309**
5yr ARI						
Residential	1	1	5	5	$ 30,900	$ 26,265
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
5yr ARI Total	**1**	**1**	**5**	**5**	**$ 30,900**	**$ 26,265**
Total Annual Average Damage					**$ 17,230**	**$ 14,871**

Table 4-2 MB_FM3 Flood Damage Assessment Summary

Event / Property type	Properties with Overfloor Flooding		Properties with Overground Flooding		Estimated Total Damage ($ June 2016)	
	Existing Case	*Mitigation Case*	*Existing Case*	*Mitigation Case*	*Existing Case*	*Mitigation Case*
PMF Event						
Residential	83	79	120	118	$ 6,369,742	$ 6,250,964
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
PMF Total	**83**	**79**	**120**	**118**	**$ 6,369,742**	**$ 6,250,964**
100yr ARI						
Residential	2	2	5	5	$ 75,386	$ 73,878
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
100yr ARI Total	**2**	**2**	**5**	**5**	**$ 75,386**	**$ 73,878**
50yr ARI						
Residential	2	2	5	5	$ 74,972	$ 73,510
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
50yr ARI Total	**2**	**2**	**5**	**5**	**$ 74,972**	**$ 73,510**
20yr ARI						
Residential	2	2	5	5	$ 74,681	$ 73,228
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
20yr ARI Total	**2**	**2**	**5**	**5**	**$ 74,681**	**$ 73,228**
10yr ARI						
Residential	2	2	5	5	$ 74,280	$ 72,843
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
10yr ARI Total	**2**	**2**	**5**	**5**	**$ 74,280**	**$ 72,843**
5yr ARI						
Residential	2	2	3	3	$ 74,142	$ 72,714
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
5yr ARI Total	**2**	**2**	**3**	**3**	**$ 74,142**	**$ 72,714**
Total Annual Average Damage					**$ 57,485**	**$ 56,396**

Table 4-3 MB_FM4 Flood Damage Assessment Summary

Event / Property type	Properties with Overfloor Flooding		Properties with Overground Flooding		Estimated Total Damage ($ June 2016)	
	Existing Case	*Mitigation Case*	*Existing Case*	*Mitigation Case*	*Existing Case*	*Mitigation Case*
PMF Event						
Residential	94	92	146	146	$ 7,317,898	$ 7,209,644
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
PMF Total	**94**	**92**	**146**	**146**	**$ 7,317,898**	**$ 7,209,644**
100yr ARI						
Residential	1	1	4	4	$ 46,505	$ 46,663
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
100yr ARI Total	**1**	**1**	**4**	**4**	**$ 46,505**	**$ 46,663**
50yr ARI						
Residential	1	1	3	3	$ 45,565	$ 42,593
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
50yr ARI Total	**1**	**1**	**3**	**3**	**$ 45,565**	**$ 42,593**
20yr ARI						
Residential	1	1	3	3	$ 44,682	$ 41,684
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
20yr ARI Total	**1**	**1**	**3**	**3**	**$ 44,682**	**$ 41,684**
10yr ARI						
Residential	1	1	3	3	$ 43,405	$ 40,462
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
10yr ARI Total	**1**	**1**	**3**	**3**	**$ 43,405**	**$ 40,462**
5yr ARI						
Residential	1	1	2	2	$ 43,397	$ 40,353
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
5yr ARI Total	**1**	**1**	**2**	**2**	**$ 43,397**	**$ 40,353**
Total Annual Average Damage					**$ 51,684**	**$ 50,136**

Table 4-4 HC_FM5 Flood Damage Assessment Summary

Event / Property type	Properties with Overfloor Flooding		Properties with Overground Flooding		Estimated Total Damage ($ June 2016)	
	Existing Case	*Mitigation Case*	*Existing Case*	*Mitigation Case*	*Existing Case*	*Mitigation Case*
PMF Event						
Residential	7	7	7	7	$ 641,836	$ 625,715
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
PMF Total	**7**	**7**	**7**	**7**	**$ 641,836**	**$ 625,715**
100yr ARI						
Residential	1	0	2	1	$ 61,140	$ 3,000
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
100yr ARI Total	**1**	**0**	**2**	**1**	**$ 61,140**	**$ 3,000**
50yr ARI						
Residential	1	0	2	1	$ 48,544	$ 3,000
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
50yr ARI Total	**1**	**0**	**2**	**1**	**$ 48,544**	**$ 3,000**
20yr ARI						
Residential	0	0	2	1	$ 25,993	$ -
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
20yr ARI Total	**0**	**0**	**2**	**1**	**$ 25,993**	**$ -**
10yr ARI						
Residential	0	0	2	0	$ 5,999	$ -
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
10yr ARI Total	**0**	**0**	**2**	**0**	**$ 5,999**	**$ -**
5yr ARI						
Residential	0	0	1	0	$ 3,000	$ -
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
5yr ARI Total	**0**	**0**	**1**	**0**	**$ 3,000**	**$ -**
Total Annual Average Damage					**$ 6,881**	**$ 3,218**

Table 4-5 Reduction in Damages Associated with Each Option

	Overfloor flooding properties reduction	Overground flooding properties reduction	Total Damage Reduction ($)	AAD Reduction ($)
		MB-FM1		
PMF event	0	0	$ 191,709	$975
100yr ARI event	0	1	$ 3,226	$18
50yr ARI event	0	0	$ 322	$58
20yr ARI event	0	0	$ 3,513	$186
10yr ARI event	0	0	$ 3,923	$428
5yr ARI event	0	0	$ 4,635	$695
Total				**$2,359**
		MB-FM3		
PMF event	4	2	$ 118,778	$601
100yr ARI event	0	0	$ 1,508	$15
50yr ARI event	0	0	$ 1,462	$44
20yr ARI event	0	0	$ 1,453	$72
10yr ARI event	0	0	$ 1,437	$143
5yr ARI event	0	0	$ 1,427	$214
Total				**$1,089**
		MB-FM4		
PMF event	2	0	$ 108,254	$540
100yr ARI event	0	0	-$ 157	$14
50yr ARI event	0	0	$ 2,972	$90
20yr ARI event	0	0	$ 2,998	$149
10yr ARI event	0	0	$ 2,943	$299
5yr ARI event	0	0	$ 3,045	$457
Total				**$1,549**
		MB-FM5		
PMF event	0	0	$ 16,120	$371
100yr ARI event	1	1	$ 58,140	$518
50yr ARI event	1	1	$ 45,544	$1,073
20yr ARI event	0	1	$ 25,993	$800
10yr ARI event	0	2	$ 5,999	$450
5yr ARI event	0	1	$ 3,000	$450
Total				**$3,662**

4.2 Benefit to Cost Ratio of Options

The economic evaluation of each modelled measure was assessed by considering the reduction in the amount of flood damages incurred for the design events and by then comparing this value with the cost of implementing the measure.

Table 4-6 summarises the results of the economic assessment of each of the flood management options. The indicator adopted to rank these measures on economic merit is the benefit-cost ratio (B/C), which is based on the net present worth (NPW) of the benefits (reduction in AAD) and the costs (capital and ongoing), adopting a 7% discount rate and an implementation period of 50 years.

The benefit-cost ratio provides an insight into how the damage savings from a measure, relate to its cost of construction and maintenance:

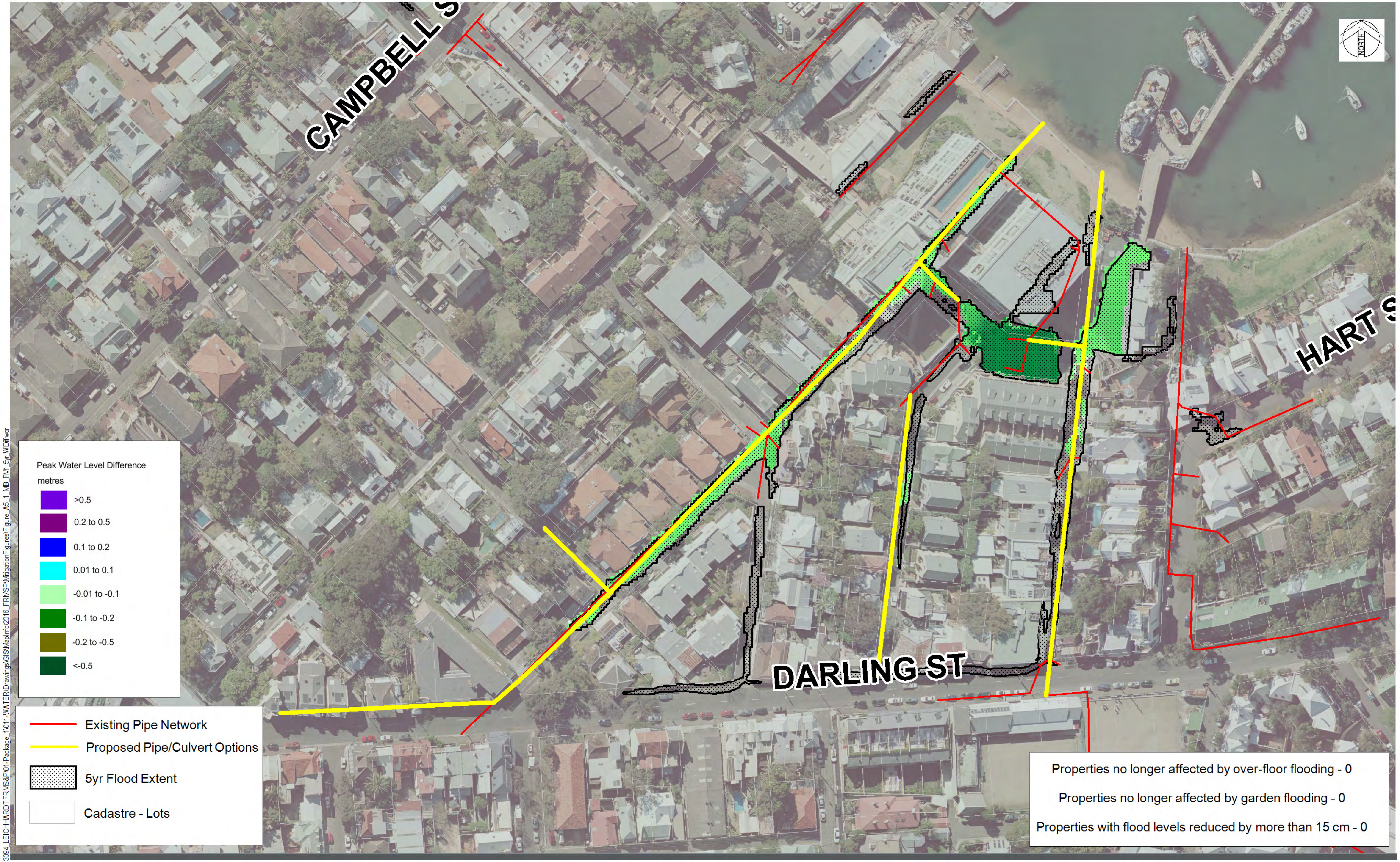
- Where the benefit-cost is greater than 1 the economic benefits are greater than the cost of implementing the measure;
- Where the benefit-cost is less than 1 but greater than 0, there is still an economic benefit from implementing the measure but the cost of implementing the measure is greater than the economic benefit;

- Where the benefit-cost is equal to zero, there is no economic benefit from implementing the measure; and
- Where the benefit-cost is less than zero, there is a negative economic impact of implementing the measure.

Table 4-6 Summary of Economic Assessment of Flood Management Options

Option ID	Option Description	NPW of Reduction in AAD	NPW of Cost of Implementation	B/C Ratio	Economic Ranking
MB_FM1	Colgate Street Branch – Proposing additional pipes to be incorporated into the existing network. Starting from Darling St/Queens Pl intersection, passes along Colgate Av and drains into Mort Bay. There are also additional pipes on St Andrews St and Cooper St.	$33,000	$4,924,000	0.01	2
MB_FM3	Curtis Rd Branch – Propose additional pipes along Mort St and Clayton St and connecting to an additional proposed pipe on Cameron St (MB-FM4) which drains into Mort Bay.	$15,000	$4,820,000	0.00	3
MB_FM4	College Street Branch – Additional pipe network starting from the Cardwell/North St intersection, travelling along (SE) Macquarie St and the Curtis Rd. The pipe branches off into Phillip St, Church St and College St and finally connects into the existing Sydney Water pipe and to the proposed pipe on Cameron St which drains into Mort Bay.	$21,000	$8,860,000	0.00	4
MB_FM5	McKell Street Branch – Additional pipe from Short St that crosses McKell St and drain into Mort Bay	$51,000	$646,000	0.08	1

Mort Bay Mitigation Option Figures



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LEICHHARDT FRMS&P
MB_FM1 5YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A5_1

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MB_FM1_5yr_WlDiff
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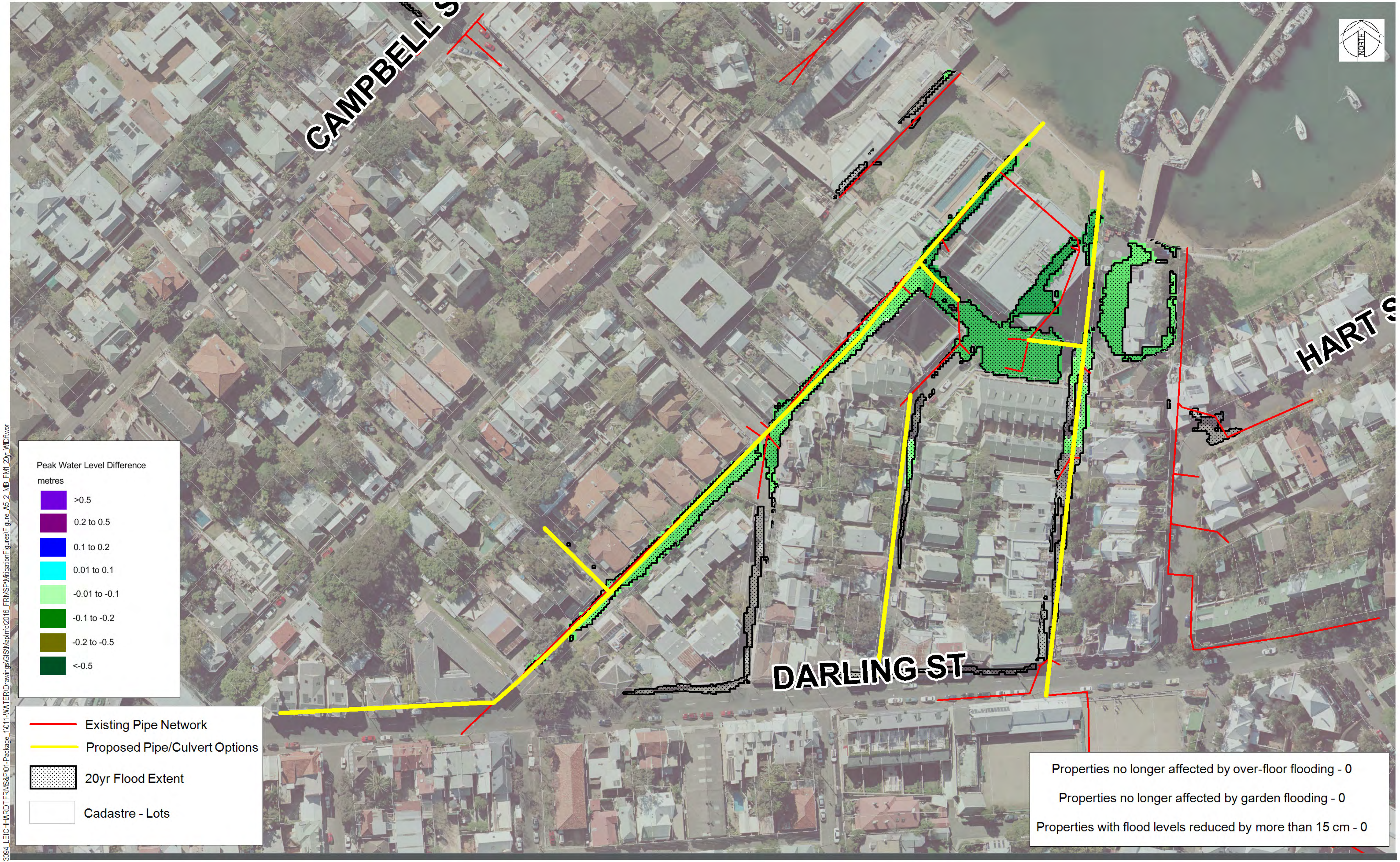

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LEICHHARDT FRMS&P
MB_FM1 20YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A5_2

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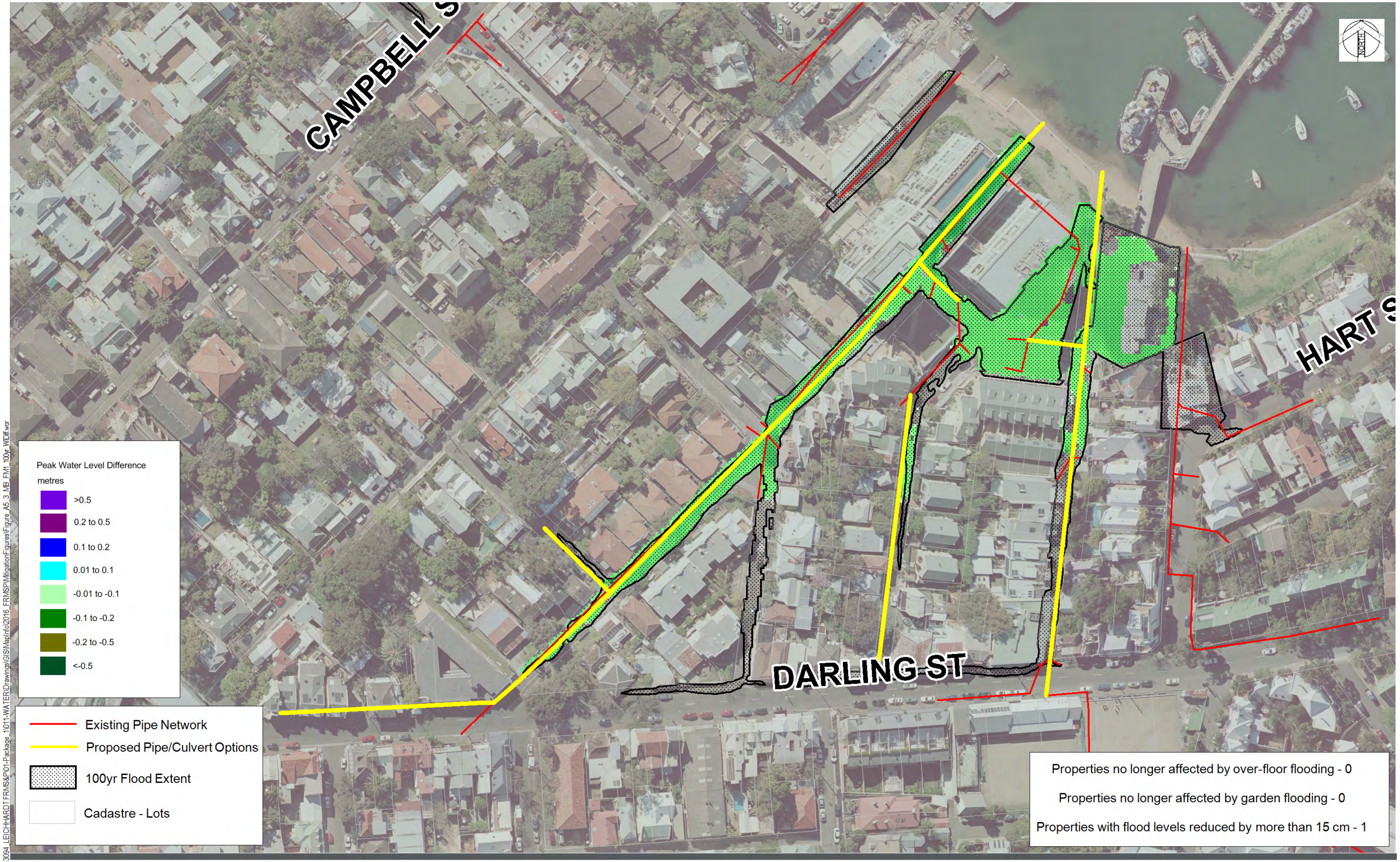

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LEICHHARDT FRMS&P
MB_FM1 100YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A5_3

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LEICHHARDT FRMS&P
MB_FM3 5YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A5_7

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MB_FM3_5yr_WlDiff	03
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MB_FM3 20YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A5_8

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MB_FM3_20yr_WlDiff
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LEICHHARDT FRMS&P
MB_FM3 100YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A5_9

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MB_FM4 5YR ARI WL DIFF
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MB_FM4 20YR ARI WL DIFF
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LEICHHARDT FRMS&P
MB_FM4 100YR ARI WL DIFF
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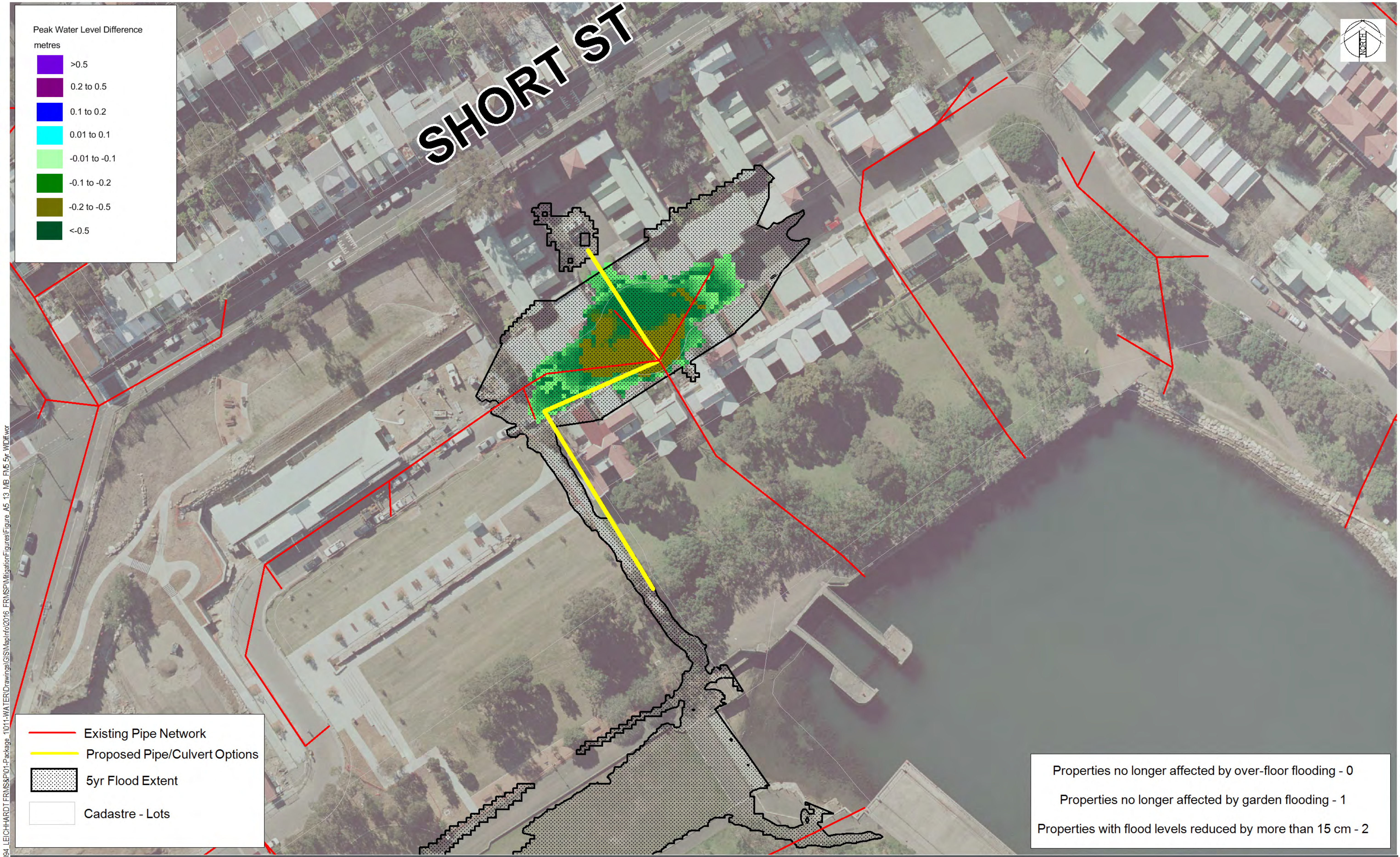

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LEICHHARDT FRMS&P
MB_FM5 5YR ARI WL DIFF
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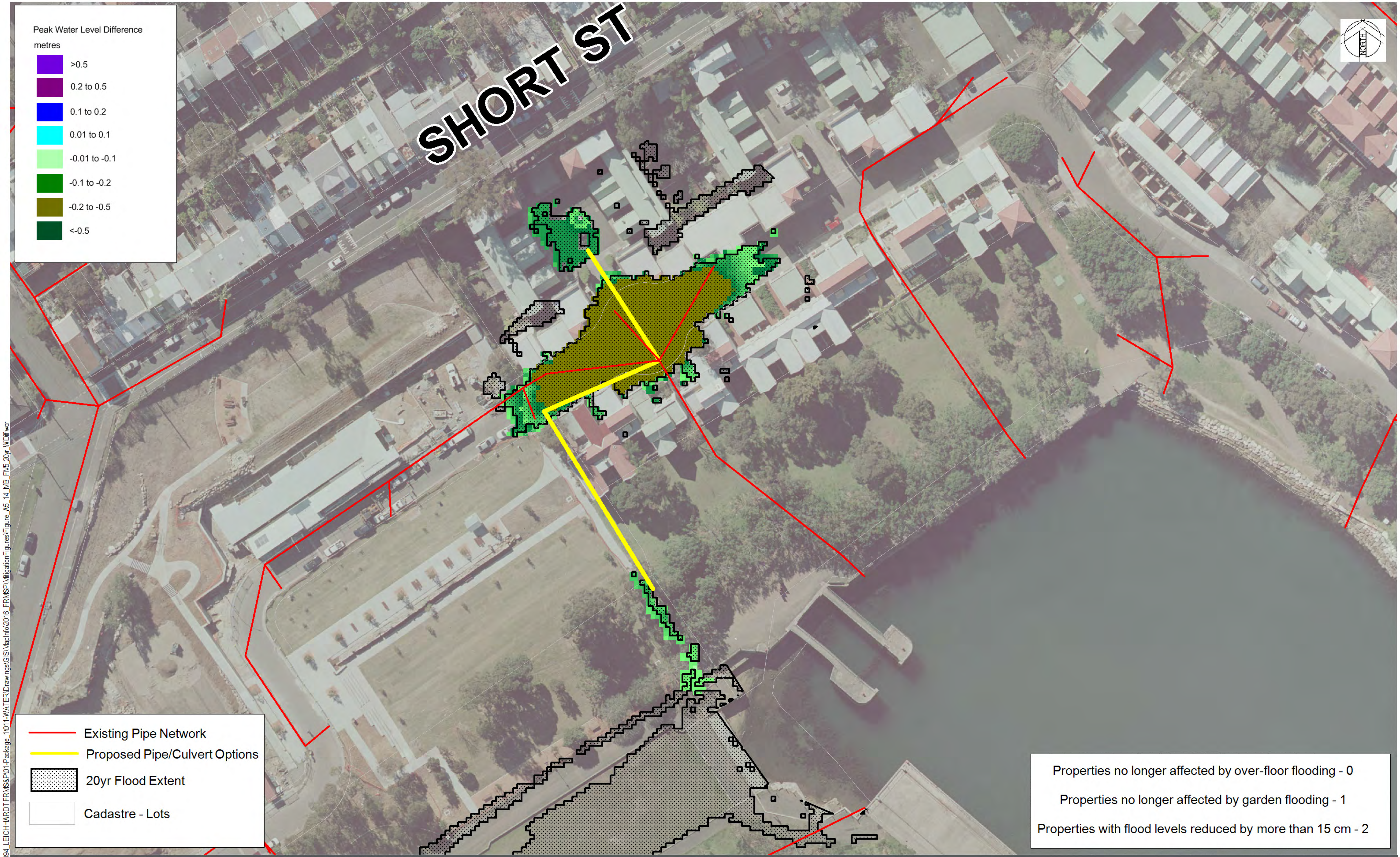

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LEICHHARDT FRMS&P
MB_FM5 20YR ARI WL DIFF
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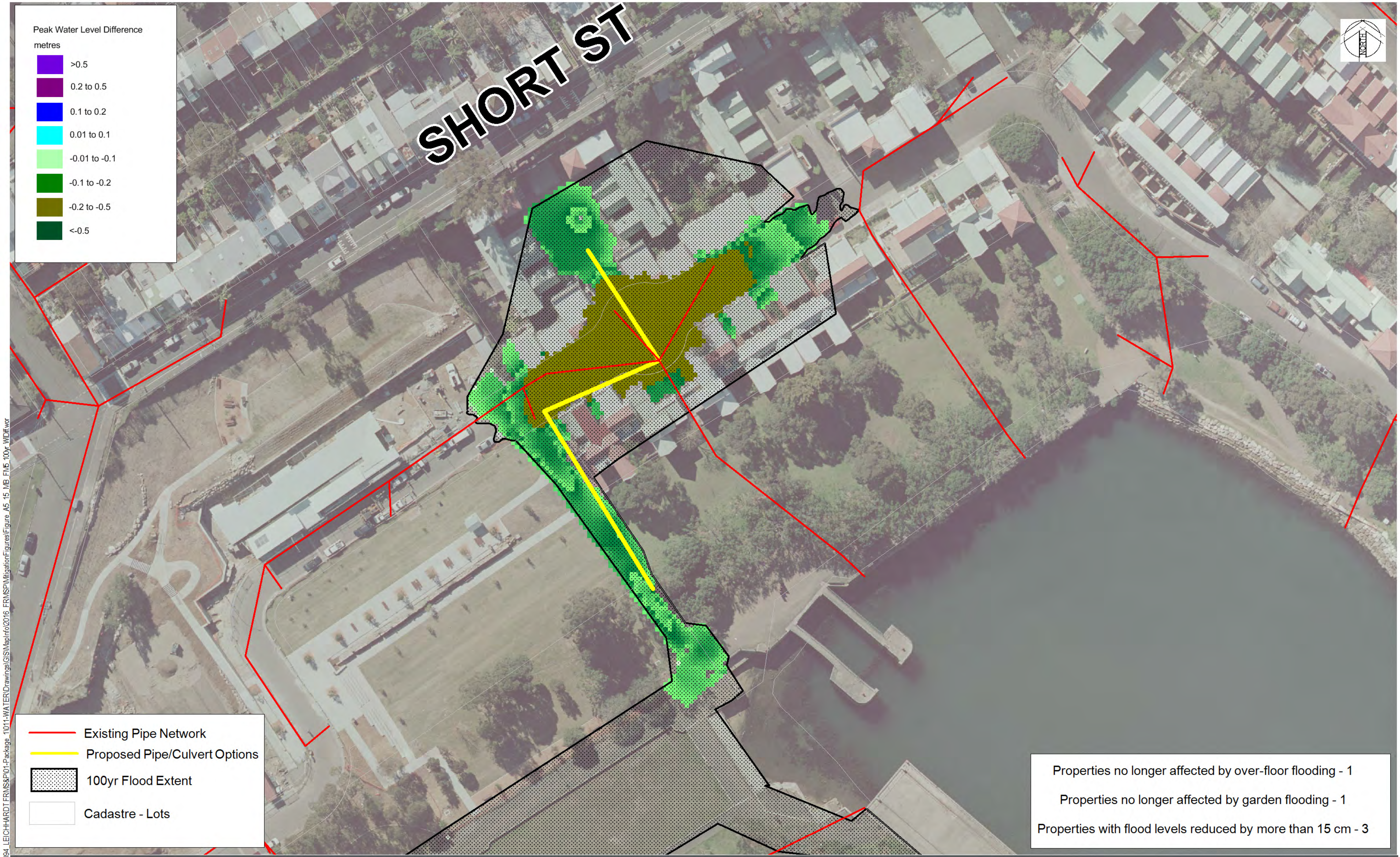
Revision



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LEICHHARDT FRMS&P

MB_FM5 100YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A5_15

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MB_FM5_100yr_WlDiff
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Area 6 - Parramatta River and Snails Bay Options Assessment

Leichhardt Flood Risk Management Study and Plan

NA49913094

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1 Parramatta River and Snails Bay Catchments Description

Both Parramatta River and Snails Bay Catchments are within Balmain and Birchgrove suburbs. Smaller overland flowpaths are located in these catchments and the overland flows discharge to the Parramatta River and Snails Bay. In a number of cases, the streets in this area are aligned such that the majority of the overland flow proceeds along them, rather than directly through the houses. Significant ponding does occur on Birchgrove Oval, due to the low grades in this area.

The options proposed for assessment in the report are located within the study area portion of the Parramatta River and Snails Bay Catchment.

The location of the Parramatta River and Snails Bay Catchment within the study area is shown in **Figure 1-1**

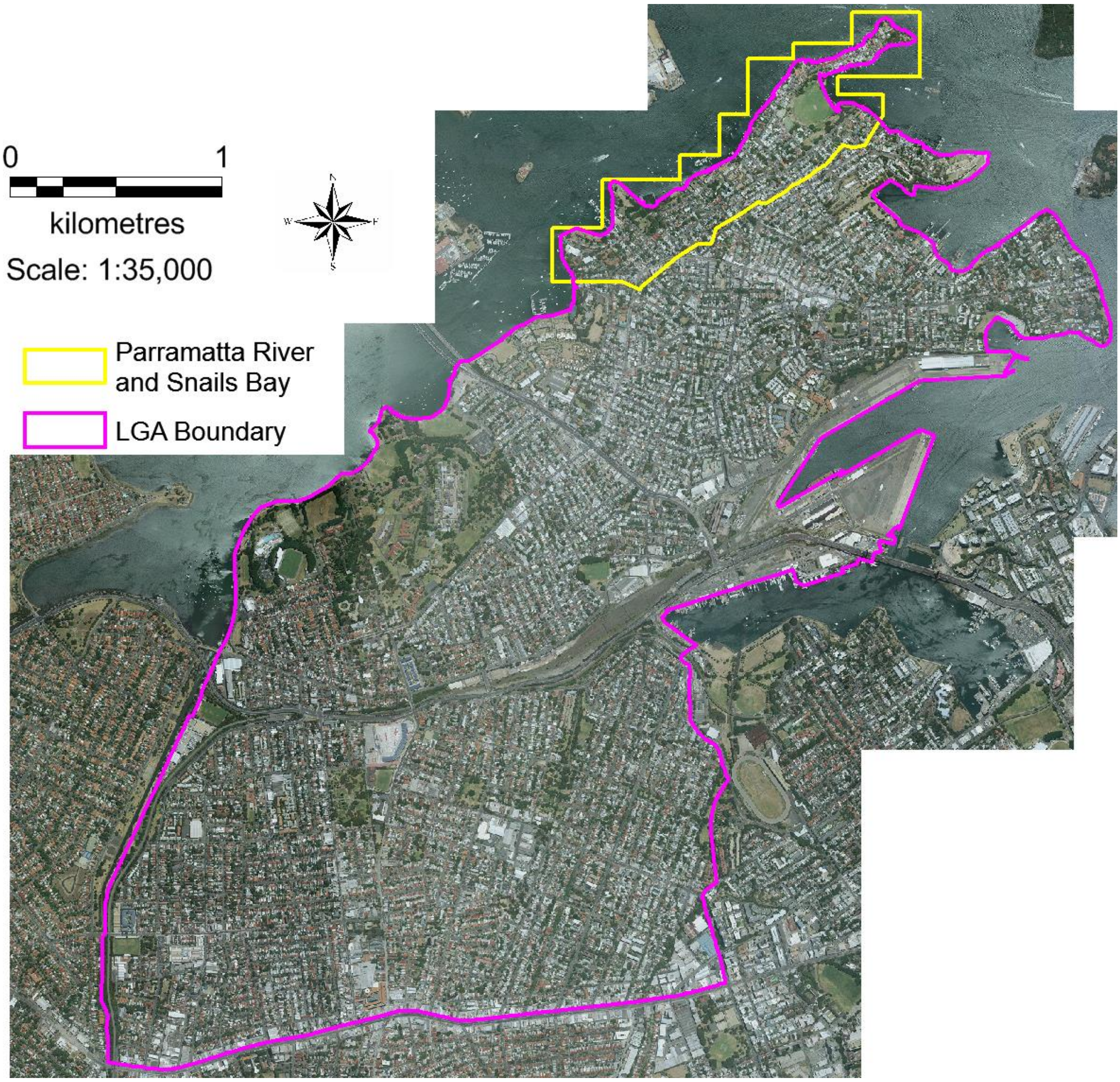

Figure 1-1 Parramatta River and Snails Bay Catchment Location

2 Flood Mitigation Options Identification

2.1 Flood Modification Measures for the Parramatta River and Snails Bay Catchments

The existing flood behaviour within the Parramatta River and Snails Bay Catchments are detailed in the Leichhardt Flood Study (Cardno 2014). Based on the flood model results, historical information and engineering judgement, possible flood modification measures (i.e. structural measures) for the study area were identified.

The various management options were identified taking into consideration the:

- flood behaviour and flow in the 20 year ARI event;
- grade of pipe (upstream and downstream); and
- preliminary availability and location of easements.

2.2 Parramatta River and Snails Bay Catchments Flood Mitigation Options

While several preliminary options were identified as part of the preliminary options report within these catchments, subsequent revision of flood modelling and mapping identified reduced and in some cases no flood risk in those location previously identified for potential options. As a result only one option was identified for further assessment, this option is located in the Snails Bay Catchment. This option is shown in Table 2-1 and Figure 2-1. The 100yr, 20yr and 5yr ARI peak water level difference plots for each mitigation option are attached at the end of this appendix report.

Table 2-1 Parramatta River and Snails Bay Mitigation Options

Option Description	Option Name	ID
Cove Street Branch – The proposed pipe starts from the Cove/Birchgrove St Intersection and then goes along Ferdinand St and connects to the existing pipe network in The Terrace. Additional pipes along Grove St, Rose St and Bay St.	Cove St Branch and Additional Pipes SB-FM1	SB-FM1

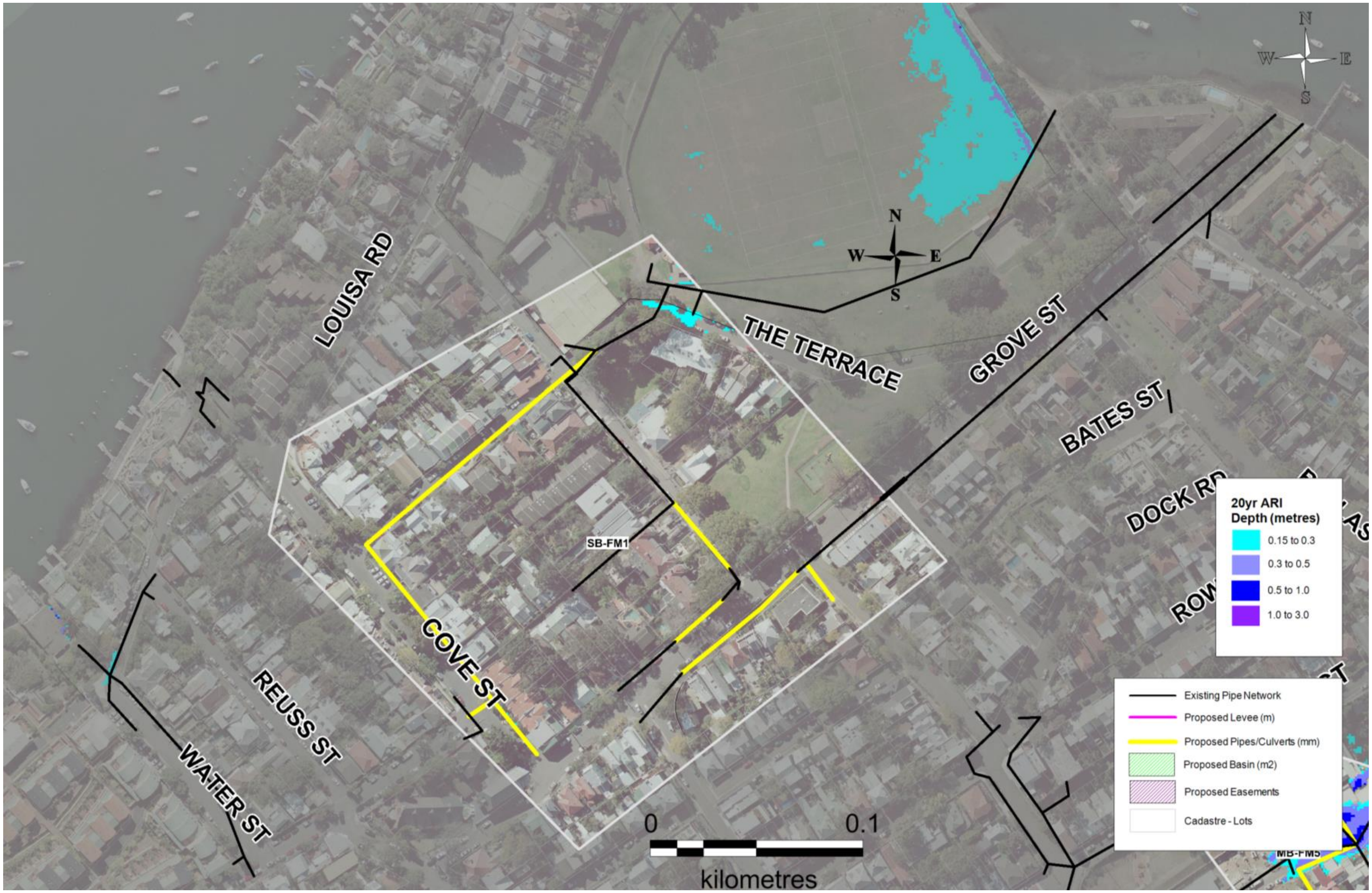

Figure 2-1 Snails Bay Mitigation Options Locations

2.2.1 Cove St Branch and Additional Pipes SB-FM1

Following extensive review of the flooding conditions and impacts in the Snails Bay catchment, it was identified that SB-FM1 is the only potentially effective option to justify further assessment. The option consists of a proposed pipe starting from the Cove Street / Birchgrove Street Intersection (600mm diameter), which then goes along Ferdinand Street and connects to the existing pipe network in The Terrace. Additional pipes (450mm diameter) are also proposed along Grove Street, Rose Street and Bay Street.

Flood depths along this flow path under existing conditions reach 0.2m in the 20 Year ARI event.

3 Mitigation Option Modelling Outcomes

The Snails Bay flood mitigation option was assessed for the 5, 10, 20, 50 and 100 Year ARI design flood events, along with the PMF event.

The outcomes of the modelling are shown in the 5, 20, and 100 Year ARI water level difference plots attached at the end of this catchment report.

A summary of the impacts on flood behaviour for the option is provided below.

3.1 Cove St Branch and Additional Pipes SB-FM1

Mitigation option SB-FM1 shows decreases in water levels along parts of Cove Street, Ferdinand Street, Sardinia Place and Grove Street in an order of 0.01m to 0.05m. The maximum flood depth prior to implementation of the option is 0.2m in a 20 Year ARI event.

There is very little decrease in flood level on private properties. As a result there is no change in the flood damages for all events except the PMF.

4 Economic Assessment of Flood Damages in the Snails Bay Catchment

4.1 Snails Bay Mitigation Options Damages Assessment

An assessment of damages for the existing condition in the Parramatta River and Snails Bay Catchment is presented in the Floodplain Risk Management Study. The approach adopted for calculating the existing damages has been repeated for the modelling results from the mitigation options proposed for the Snails Bay catchment.

The economic flood damage results for the option and the existing scenario are presented in Table 4-1. The reductions in properties affected by overground and overfloor flooding, total damages and AAD are provided in Table 4-2. Negative values represent increases from the existing scenario.

The total reduction in damaged properties and the associated reduction in damage costs for SB-FM1 is also provided in Table 4-2.

The flood damages assessment is a useful tool for comparing the merits of various options, it is not a precise flood risk analysis tool and the limitation associated with the assessment should be considered when interpreting the results.

The following information should be considered when interpreting the damages data:

- Negative property or dollar values represent increases from the existing scenario.
- Where an option results in a reduction in flood depths there may not be any reduction in the flood damages where:
  - The reduction in flood depths or extent occur in open space or roadways; or
  - The reduction in flood depths occurs on properties that were not impacted by over floor flooding (i.e. the flooding on the property grounds is shallower but still exists).
- The flood damages are calculated at a discrete location on each property. This location is where the floor level and ground level survey was obtained from. As such, if the flooding occurs at another location on the property other than the survey point, this property will not register any damages with regards to this damages assessment.
- Commercial and industrial damages are only incurred when over floor flooding exists.
- The reduction in the number of properties impacted as a result of an option may vary between different flood events due to the performance of the proposed work under the different flow behaviour of each flood event.

Table 4-1 SB-FM1 Flood Damage Assessment Summary

Event / Property type	Properties with Overfloor Flooding		Properties with Overground Flooding		Estimated Total Damage ($ June 2016)	
	Existing Case	*Mitigation Case*	*Existing Case*	*Mitigation Case*	*Existing Case*	*Mitigation Case*
PMF Event						
Residential	28	28	57	57	$ 1,604,314	$ 1,531,771
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
PMF Total	**28**	**28**	**57**	**57**	**$ 1,604,314**	**$ 1,531,771**
100yr ARI						
Residential	0	0	0	0	$ -	$ -
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
100yr ARI Total	**0**	**0**	**0**	**0**	**$ -**	**$ -**
50yr ARI						
Residential	0	0	0	0	$ -	$ -
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
50yr ARI Total	**0**	**0**	**0**	**0**	**$ -**	**$ -**
20yr ARI						
Residential	0	0	0	0	$ -	$ -
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
20yr ARI Total	**0**	**0**	**0**	**0**	**$ -**	**$ -**
10yr ARI						
Residential	0	0	0	0	$ -	$ -
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
10yr ARI Total	**0**	**0**	**0**	**0**	**$ -**	**$ -**
5yr ARI						
Residential	0	0	0	0	$ -	$ -
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
5yr ARI Total	**0**	**0**	**0**	**0**	**$ -**	**$ -**
Total Annual Average Damage					**$ 8,021**	**$ 7,658**

Table 4-2 Reduction in Damages Associated with Option SB-FM1

	Overfloor flooding properties reduction	Overground flooding properties reduction	Total Damage Reduction ($)	AAD Reduction ($)
SB-FM1				
PMF event	0	0	$ 72,544	$363
100yr ARI event	0	0	$ -	$0
50yr ARI event	0	0	$ -	$0
20yr ARI event	0	0	$ -	$0
10yr ARI event	0	0	$ -	$0
5yr ARI event	0	0	$ -	$0
Total				**$363**

4.2 Benefit to Cost Ratio of Options

The economic evaluation of each modelled measure was assessed by considering the reduction in the amount of flood damages incurred for the design events and by then comparing this value with the cost of implementing the measure.

Table 4-3 summarises the results of the economic assessment of each of the flood management options. The indicator adopted to rank these measures on economic merit is the benefit-cost ratio (B/C), which is based on the net present worth (NPW) of the benefits (reduction in AAD) and the costs (capital and ongoing), adopting a 7% discount rate and an implementation period of 50 years.

The benefit-cost ratio provides an insight into how the damage savings from a measure, relate to its cost of construction and maintenance:

- Where the benefit-cost is greater than 1 the economic benefits are greater than the cost of implementing the measure;
- Where the benefit-cost is less than 1 but greater than 0, there is still an economic benefit from implementing the measure but the cost of implementing the measure is greater than the economic benefit;
- Where the benefit-cost is equal to zero, there is no economic benefit from implementing the measure; and
- Where the benefit-cost is less than zero, there is a negative economic impact of implementing the measure.

Table 4-3 Summary of Economic Assessment of Flood Management Options

Option ID	Option Description	NPW of Reduction in AAD	NPW of Cost of Implementation	B/C Ratio	Economic Ranking
SB_FM1	Cove Street Branch – The proposed pipe starts from the Cove/Birchgrove St Intersection and then goes along Ferdinand St and connects to the existing pipe network in The Terrace. Additional pipes along Grove St, Rose St and Bay St.	$5,000	$3,004,000	0.00	1

Parramatta River and Snails Bay Mitigation Option Figures

Figure SB_FM1_5yr_WlDiff
Figure SB_FM1_20yr_WlDiff
Figure SB_FM1_100yr_WlDiff

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LEICHHARDT FRMS&P
SB_FM1 5YR ARI WL DIFF
MITIGATION LESS EXISTING
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SB_FM1_5yr_WlDiff
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LEICHHARDT FRMS&P
SB_FM1 20YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A6_8

Date
03/2017

SB_FM1_20yr_WlDiff
Drawing Number

Size
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03
Revision

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LEICHHARDT FRMS&P

SB_FM1 100YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A6_9

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Revision	03

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Area 7- Rozelle Bay Options Assessment

Leichhardt Flood Risk Management Study and Plan

NA49913094

Prepared for
Inner West Council

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Tables

Figures

1 Rozelle Bay Catchment Description

A large portion of the Rozelle Bay Catchment is located within the suburb of Lilyfield. The majority of the catchment drains towards the Rozelle old rail yards and then into Rozelle Bay. Significant ponding occurs in the rail yards, with the flood levels controlled by the centreline of the City West Link.

The location of the Rozelle Bay Catchment within the study area is shown in **Figure 1-1.**

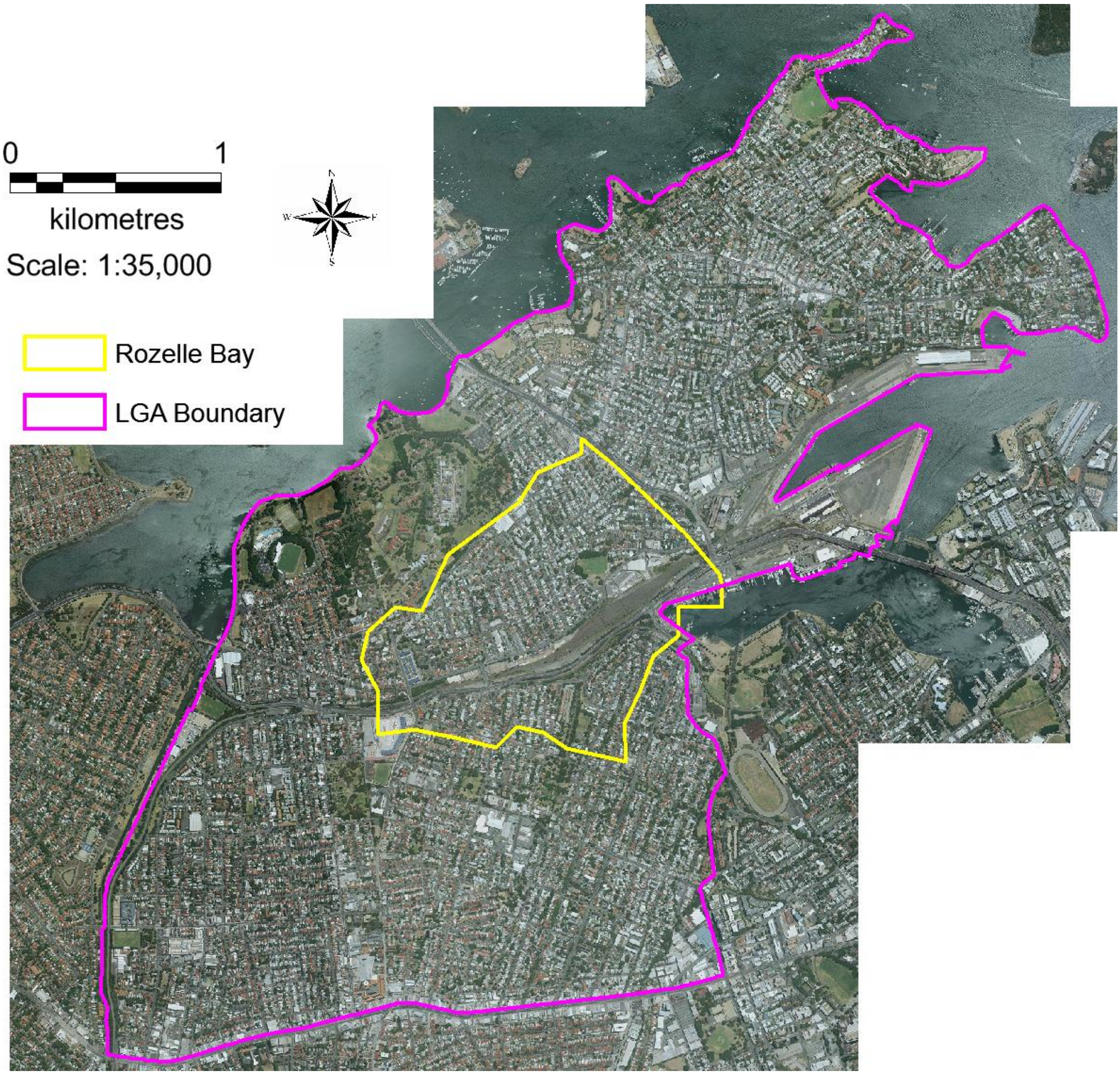


Figure 1-1 Rozelle Bay Catchment Location

2 Flood Mitigation Options Identification

2.1 Flood Modification Measures for Rozelle Bay

The existing flood behaviour within the Rozelle Bay Catchment is detailed in the Leichhardt Flood Study (Cardno 2014). Based on the flood model results, historical information and engineering judgement, possible flood modification measures (i.e. structural measures) for the study area were identified.

The various management options were identified taking into consideration the:

- flood behaviour and flow in the 20 Year ARI event;
- grade of pipe (upstream and downstream); and
- preliminary availability and location of easements.

2.2 Rozelle Bay Flood Mitigation Options

Within the Rozelle Bay catchment two (2) sets of options were modelled. These are shown in Table 2-1 and Figure 2-1.

The 100yr, 20yr and 5yr ARI peak water level difference plots for each mitigation option are attached at the end of this appendix report.

Table 2-1 Rozelle Bay Mitigation Options

Option Description	Option Name	ID
Lilyfield Road Flow Path – Proposing additional pipes or duplication of existing pipe network. Proposed pipes connecting into the existing network at O' Neill St. Additional pipes from the low point on Denison St to the outlet at Rozelle Bay. Additional pipe network in Quirk Street, Gordon Street and Lilyfield Road with a branch along Alfred Street.	Lilyfield Street Branch RB-FM1	RB-FM1
Additional Culverts/Pipes across Lilyfield Road at four locations. From Joseph Street along Halloran Street to Lilyfield Road, Edward St, Justin St, Cecily St and Brenan Street South of the railyards.	Additional Culverts at Lilyfield Rd RB-FM2	RB-FM2

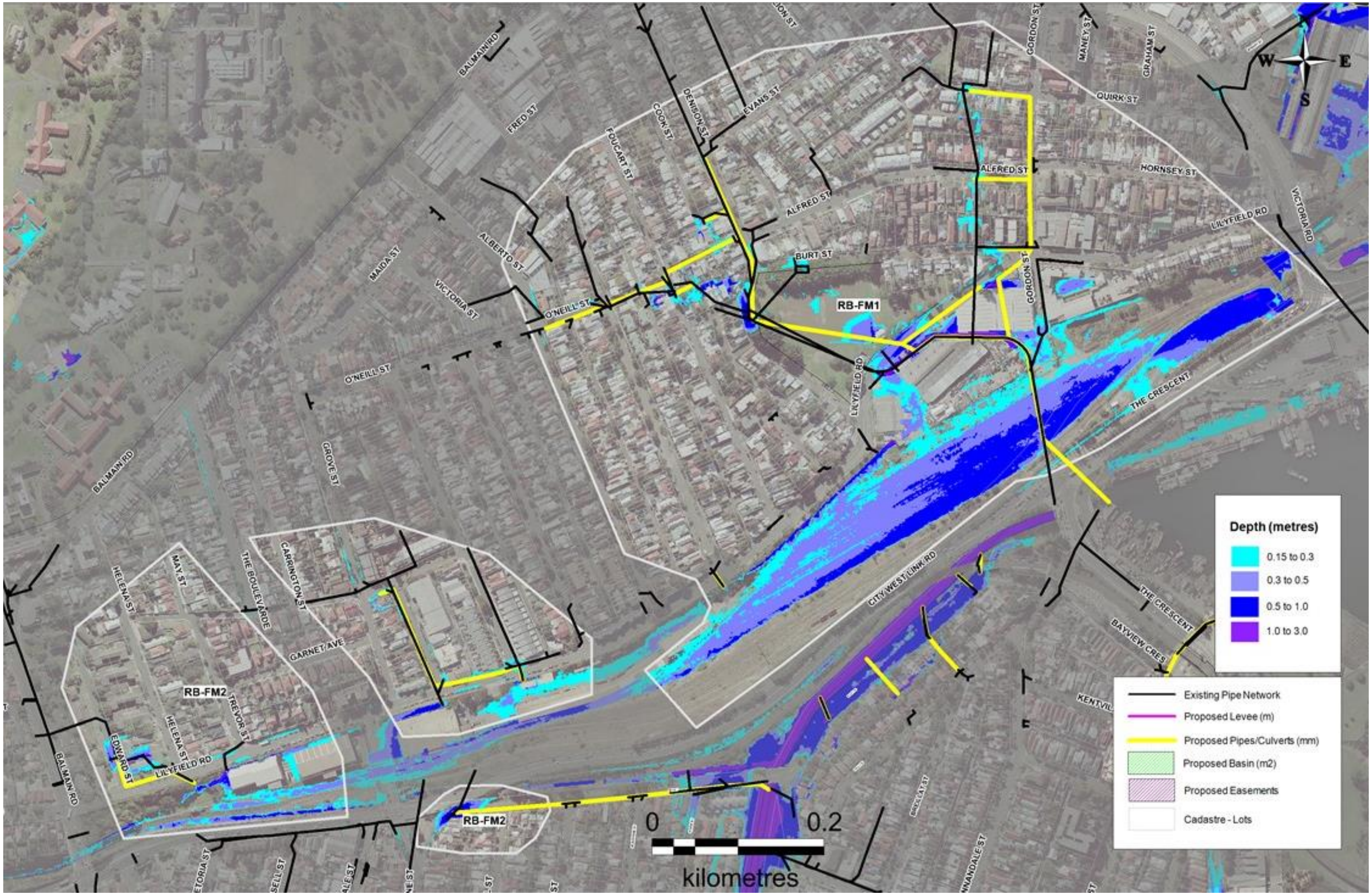


Figure 2-1 Rozelle Bay Mitigation Options Locations

2.2.2 Lilyfield Street Branch RB-FM1

The Lilyfield Road Flow Path proposes additional pipes and duplication of the existing pipe network. The option starts on O'Neill Street where a proposed pipe (900mm diameter) connects into the existing network at O' Neill Street. The proposed pipe continues onto Denison Street and connects to the proposed Dennison Street pipe at a junction point between a 1050mm diameter and a 1400mm diameter pipe. The 1400mm diameter pipe then connects to a box culvert (1.8m x 1.2m) which crosses Easton Park. At the southern end of the park, the culvert branches out into a 3.6m x 2.1m culvert and 1500mm diameter pipe. The final culvert eventually drains into Rozelle Bay.

The option also includes a proposed additional pipe network consisting of 750mm, 900mm and 1050mm diameter pipes in Quirk Street, Gordon Street and Lilyfield Road with a branch along Alfred Street.

The worst flooding under existing conditions occurs between Easton Park and Rozelle Bay with flood depths reaching around 2.8m in the 20 Year ARI event.

Potential constraints for this measure includes vegetation removal in Easton Park and changes to recreational use of Easton Park depending on the configuration of the adopted works.

This option will require communication with the rail stakeholders.

2.2.3 Additional Culverts / Pipes Lilyfield Rd RB-FM2

RB-FM2 proposes three pipes that cross Lilyfield Road towards north of the railyards and a proposed 900mm diameter pipe on Brenan Street South of the railyards.

The three pipes crossing Lilyfield Road start from Edward Street (900mm and 1200mm diameter pipes), Joseph Street along Halloran Street, Justin Street (900mm and 1200mm diameter pipes) and Cecily Street (900mm diameter pipe). Significant flood depths, due to the 20 Year ARI storm event, occur in the vicinity of Edward Street with depths up to 0.7m.

Funding from RMS may be available for the transverse pipe crossing works on Lilyfield Road.

3 Mitigation Option Modelling Outcomes

The Lilyfield Catchment flood mitigation options were assed for the 5, 10, 20, 50 and 100 Year ARI design flood events, along with the PMF event.

The outcomes of the modelling are shown in the 5, 20, and 100 Year ARI water level difference plots attached at the end of this catchment report.

A summary of the impacts on flood behaviour for each option is provided below.

3.1 Lilyfield Street Branch RB-FM1

The proposed mitigation option RB-FM1 shows reduction in flood levels along both O'Neill and Alfred Street flow path. The proposed increase in drainage capacity of mitigation option RB-FM1 is shown to decrease flood levels in an order of 0.01m – 0.30m in a 100 Year ARI. The mitigation strategy shows water level decreases along sections of O'Neil Street, Foucart Street, Brockley Street, Cheltenham Street, Denison Street and along Easton Park.

Along the Alfred Street flowpath, the reduction in water levels are in an order of 0.01m – 0.20m. Significant reductions in flood levels up to 0.50m are seen on Lilyfield Road and 0.10m on the railyards in a 100 Year ARI due to this proposed additional drainage. Results indicate many properties would experience a decrease in water level in a 100 Year ARI event due to this mitigation strategy.

3.2 Additional Culverts/Pipes Lilyfield Rd RB-FM2

The increase in drainage capacity at Edward Street, Halloran Street and Cecily Street flowpaths resulted in lower flood levels by 0.01m to 0.10m in a 100 Year ARI event. Significant reductions in flood levels up to 0.70m are seen on corner of Catherine Street and Brenan Street due to the proposed 900mm diameter additional pipe.

4 Economic Assessment of Flood Damages in the Rozelle Bay Catchment

4.1 Rozelle Bay Mitigation Options Damages Assessment

An assessment of damages for the existing condition in the Rozelle Bay Catchment is presented in the Floodplain Risk Management Study. The approach adopted for calculating the existing damages has been repeated for the modelling results from the mitigation options proposed for the Rozelle Bay catchment.

The economic flood damage results for each of the options and the existing scenarios are presented in **Table 4-1** and **Table 4-2**. The reductions in properties affected by overground and overfloor flooding, total damages and AAD are provided. Negative values represent increases from the existing scenario.

The total reduction in damaged properties and the associated reduction in damage costs for each mitigation strategy is summarised in **Table 4-3**. This table represents a summary of differences between existing and Mitigation scenarios presented in **Table 4-1** and **Table 4-2**.

The flood damages assessment is a useful tool for comparing the merits of various options, it is not a precise flood risk analysis tool and the limitation associated with the assessment should be considered when interpreting the results.

The following information should be considered when interpreting the damages data:

- Negative property or dollar values represent increases from the existing scenario.
- Where an option results in a reduction in flood depths there may not be any reduction in the flood damages where:
  - The reduction in flood depths or extent occur in open space or roadways; or
  - The reduction in flood depths occurs on properties that were not impacted by over floor flooding (i.e. the flooding on the property grounds is shallower but still exists).
- The flood damages are calculated at a discrete location on each property. This location is where the floor level and ground level survey was obtained from. As such, if the flooding occurs at another location on the property other than the survey point, this property will not register any damages with regards to this damages assessment.
- Commercial and industrial damages are only incurred when over floor flooding exists.
- The reduction in the number of properties impacted as a result of an option may vary between different flood events due to the performance of the proposed work under the different flow behaviour of each flood event.

Table 4-1 RB_FM1 Flood Damage Assessment Summary

Event / Property type	Properties with Overfloor Flooding		Properties with Overground Flooding		Estimated Total Damage ($ May 2015)	
	Existing Case	*Mitigation Case*	*Existing Case*	*Mitigation Case*	*Existing Case*	*Mitigation Case*
PMF Event						
Residential	141	123	228	223	$ 9,598,169	$ 8,508,429
Commercial	0	0	0	0	$ -	$ -
Industrial	4	4	4	4	$ 2,051,997	$ 1,714,311
PMF Total	**145**	**127**	**232**	**227**	**$ 11,650,166**	**$ 10,222,739**
100yr ARI						
Residential	30	23	48	47	$ 2,540,987	$ 1,944,581
Commercial	0	0	0	0	$ -	$ -
Industrial	2	1	2	2	$ 996,564	$ 340,243
100yr ARI Total	**32**	**24**	**50**	**49**	**$ 3,537,550**	**$ 2,284,824**
50yr ARI						
Residential	30	22	44	44	$ 2,410,925	$ 1,843,621
Commercial	0	0	0	0	$ -	$ -
Industrial	2	1	2	2	$ 899,702	$ 269,153
50yr ARI Total	**32**	**23**	**46**	**46**	**$ 3,310,627**	**$ 2,112,774**
20yr ARI						
Residential	25	20	40	40	$ 2,171,712	$ 1,240,251
Commercial	0	0	0	0	$ -	$ -
Industrial	2	1	2	2	$ 765,193	$ 234,546
20yr ARI Total	**27**	**21**	**42**	**42**	**$ 2,936,905**	**$ 1,474,797**
10yr ARI						
Residential	23	17	36	35	$ 1,959,699	$ 808,069
Commercial	0	0	0	0	$ -	$ -
Industrial	2	1	2	2	$ 657,015	$ 225,902
10yr ARI Total	**25**	**18**	**38**	**37**	**$ 2,616,713**	**$ 1,033,972**
5yr ARI						
Residential	17	13	29	28	$ 1,629,893	$ 551,422
Commercial	0	0	0	0	$ -	$ -
Industrial	1	1	1	1	$ 499,187	$ 218,493
5yr ARI Total	**18**	**14**	**30**	**29**	**$ 2,129,080**	**$ 769,914**
Total Annual Average Damage					**$ 899,377**	**$ 406,734**

Table 4-2 RB_FM2 Flood Damage Assessment Summary

Event / Property type	Properties with Overfloor Flooding		Properties with Overground Flooding		Estimated Total Damage ($ May 2015)	
	Existing Case	*Mitigation Case*	*Existing Case*	*Mitigation Case*	*Existing Case*	*Mitigation Case*
PMF Event						
Residential	44	45	83	83	$ 3,069,550	$ 3,056,221
Commercial	8	8	11	11	$ 491,606	$ 491,988
Industrial	9	9	10	10	$ 1,633,151	$ 1,633,157
PMF Total	**61**	**62**	**104**	**104**	**$ 5,194,306**	**$ 5,181,365**
100yr ARI						
Residential	8	7	19	19	$ 342,009	$ 296,432
Commercial	0	0	0	0	$ -	$ -
Industrial	1	1	3	3	$ 17,644	$ 19,343
100yr ARI Total	**9**	**8**	**22**	**22**	**$ 359,653**	**$ 315,775**
50yr ARI						
Residential	8	7	17	17	$ 305,513	$ 274,085
Commercial	0	0	0	0	$ -	$ -
Industrial	1	1	3	3	$ 14,822	$ 15,370
50yr ARI Total	**9**	**8**	**20**	**20**	**$ 320,335**	**$ 289,455**
20yr ARI						
Residential	7	6	15	15	$ 276,499	$ 253,173
Commercial	0	0	0	0	$ -	$ -
Industrial	1	1	2	2	$ 11,922	$ 12,687
20yr ARI Total	**8**	**7**	**17**	**17**	**$ 288,421**	**$ 265,860**
10yr ARI						
Residential	6	5	14	14	$ 230,276	$ 202,147
Commercial	0	0	0	0	$ -	$ -
Industrial	1	1	2	2	$ 9,733	$ 10,464
10yr ARI Total	**7**	**6**	**16**	**16**	**$ 240,009**	**$ 212,611**
5yr ARI						
Residential	3	3	12	11	$ 128,046	$ 102,204
Commercial	0	0	0	0	$ -	$ -
Industrial	1	1	2	2	$ 7,652	$ 8,330
5yr ARI Total	**4**	**4**	**14**	**13**	**$ 135,698**	**$ 110,534**
Total Annual Average Damage					**$ 92,649**	**$ 83,538**

Table 4-3 Reduction in Damages Associated with Each Option

	Overfloor flooding properties reduction	Overground flooding properties reduction	Total Damage Reduction ($)	AAD Reduction ($)
	RB-FM1			
PMF event	18	5	$1,427,426	$13,399
100yr ARI event	8	1	$1,252,726	$12,253
50yr ARI event	9	0	$1,197,853	$39,899
20yr ARI event	6	0	$1,462,108	$76,121
10yr ARI event	7	1	$1,582,742	$147,095
5yr ARI event	4	1	$1,359,165	$203,875
Total				**$492,643**
	RB-FM2			
PMF event	0	0	$ 12,941	$284
100yr ARI event	1	0	$ 43,878	$374
50yr ARI event	1	0	$ 30,880	$802
20yr ARI event	1	0	$ 22,561	$1,249
10yr ARI event	1	0	$ 27,399	$2,628
5yr ARI event	0	1	$ 25,164	$3,775
Total				**$9,111**

4.2 Benefit to Cost Ratio of Options

The economic evaluation of each modelled measure was assessed by considering the reduction in the amount of flood damages incurred for the design events and by then comparing this value with the cost of implementing the measure.

Table 4-12 summarises the results of the economic assessment of each of the flood management options. The indicator adopted to rank these measures on economic merit is the benefit-cost ratio (B/C), which is based on the net present worth (NPW) of the benefits (reduction in AAD) and the costs (capital and ongoing), adopting a 7% discount rate and an implementation period of 50 Years.

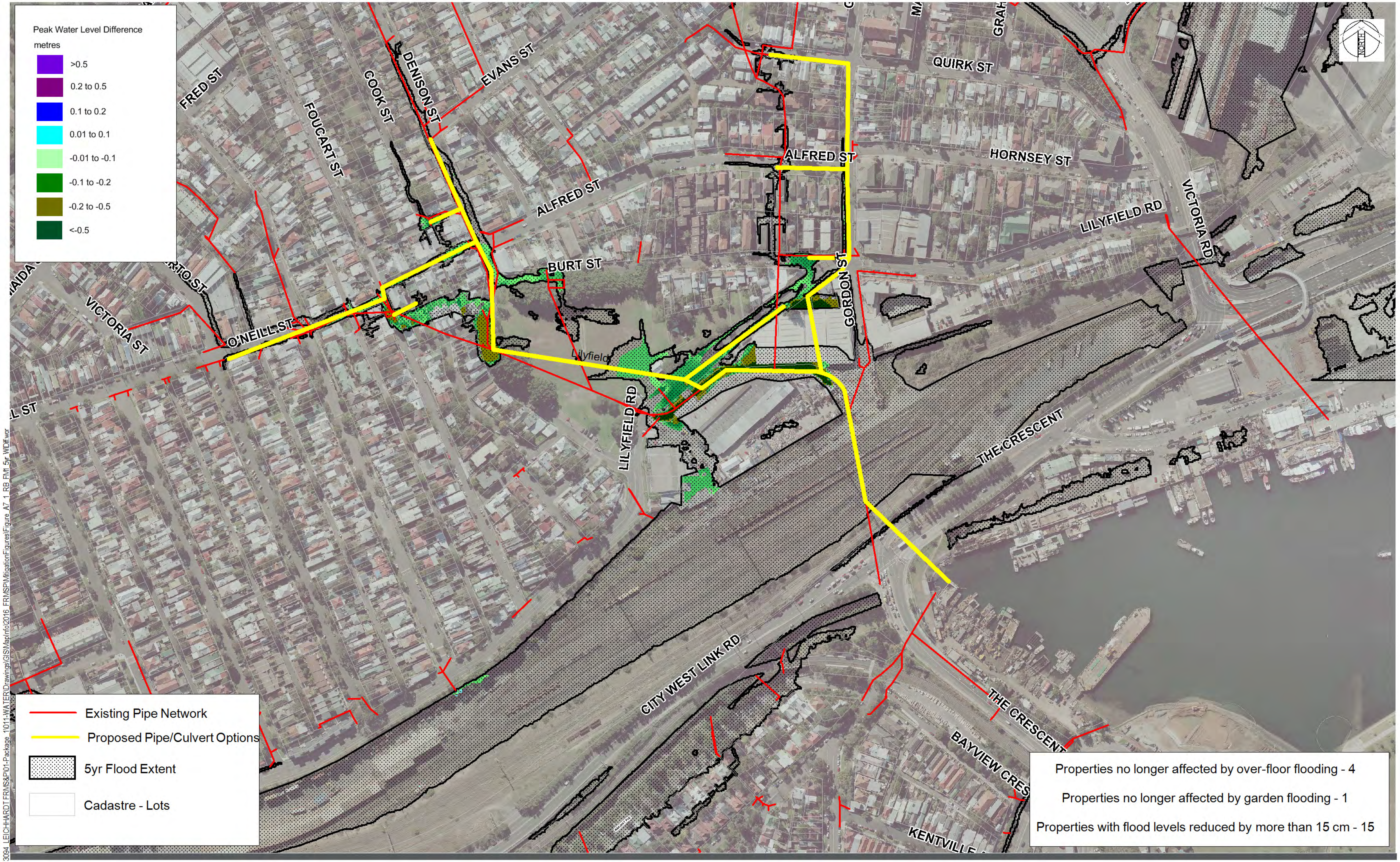
The benefit-cost ratio provides an insight into how the damage savings from a measure, relate to its cost of construction and maintenance:

- Where the benefit-cost is greater than 1 the economic benefits are greater than the cost of implementing the measure;
- Where the benefit-cost is less than 1 but greater than 0, there is still an economic benefit from implementing the measure but the cost of implementing the measure is greater than the economic benefit;
- Where the benefit-cost is equal to zero, there is no economic benefit from implementing the measure; and
- Where the benefit-cost is less than zero, there is a negative economic impact of implementing the measure.

Table 4-4 Summary of Economic Assessment of Flood Management Options

Option ID	Option Description	NPW of Reduction in AAD	NPW of Cost of Implementation	B/C Ratio	Economic Ranking
RB-FM1	**Lilyfield Road Flow Path** – Proposing additional pipes or duplication of existing pipe network. Proposed pipes connecting into the existing network at O' Neill St. Additional pipes from the low point on Denison St to the outlet at Rozelle Bay. Additional pipe network in Quirk Street, Gordon Street and Lilyfield Road with a branch along Alfred Street.	$6,799,000	$ 18,517,000	0.37	1
RB-FM2	**Additional Culverts/Pipes across Lilyfield Road** at four locations. From Joseph Street along Halloran Street to Lilyfield Road, Edward St, Justin St, Cecily St and Brenan Street South of the railyards.	$126,000	$ 3,108,000	0.04	2

Rozelle Bay Mitigation Option Figures



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RB_FM1 5YR ARI WL DIFF
MITIGATION LESS EXISTING
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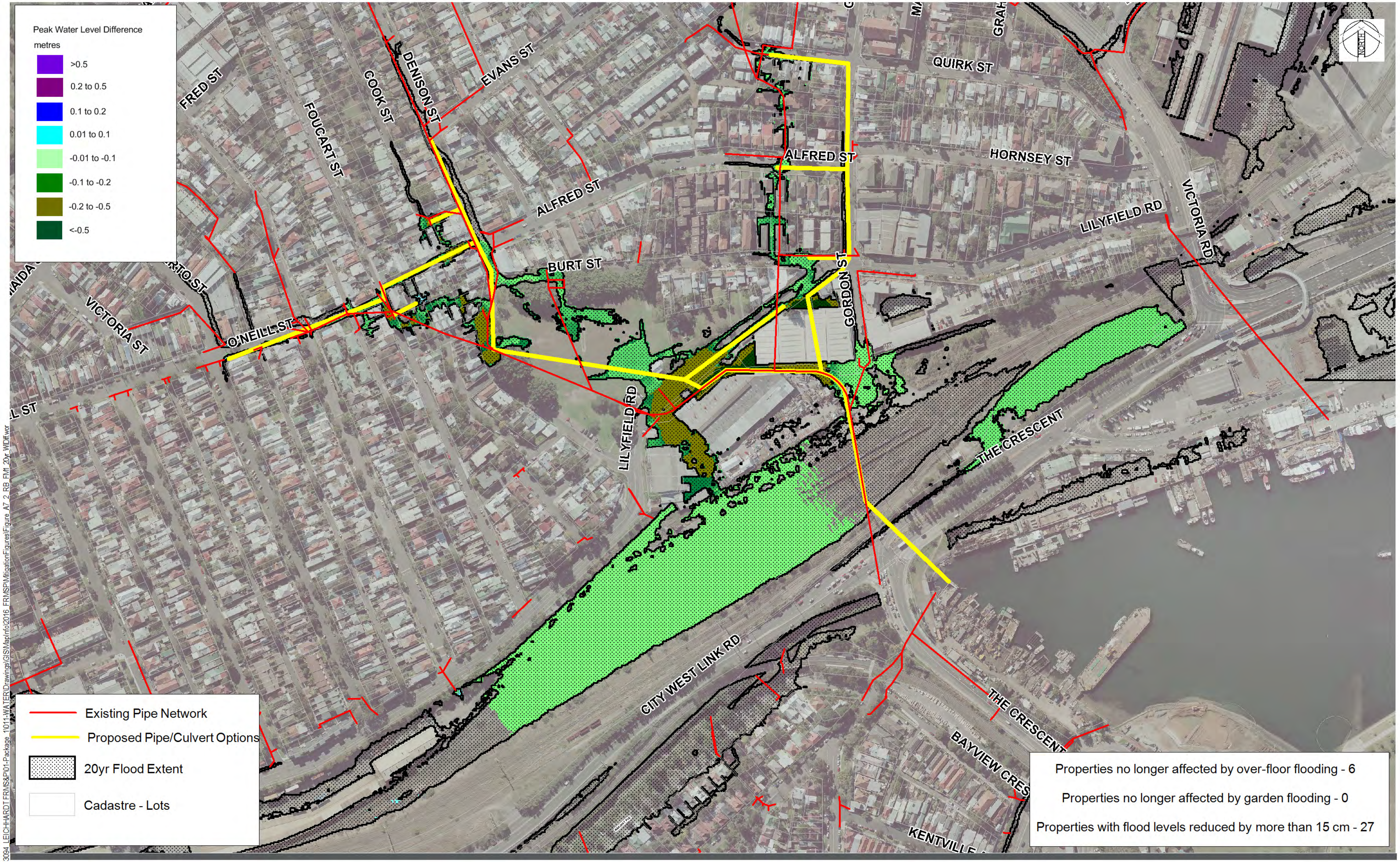

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RB_FM1 20YR ARI WL DIFF
MITIGATION LESS EXISTING
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Size
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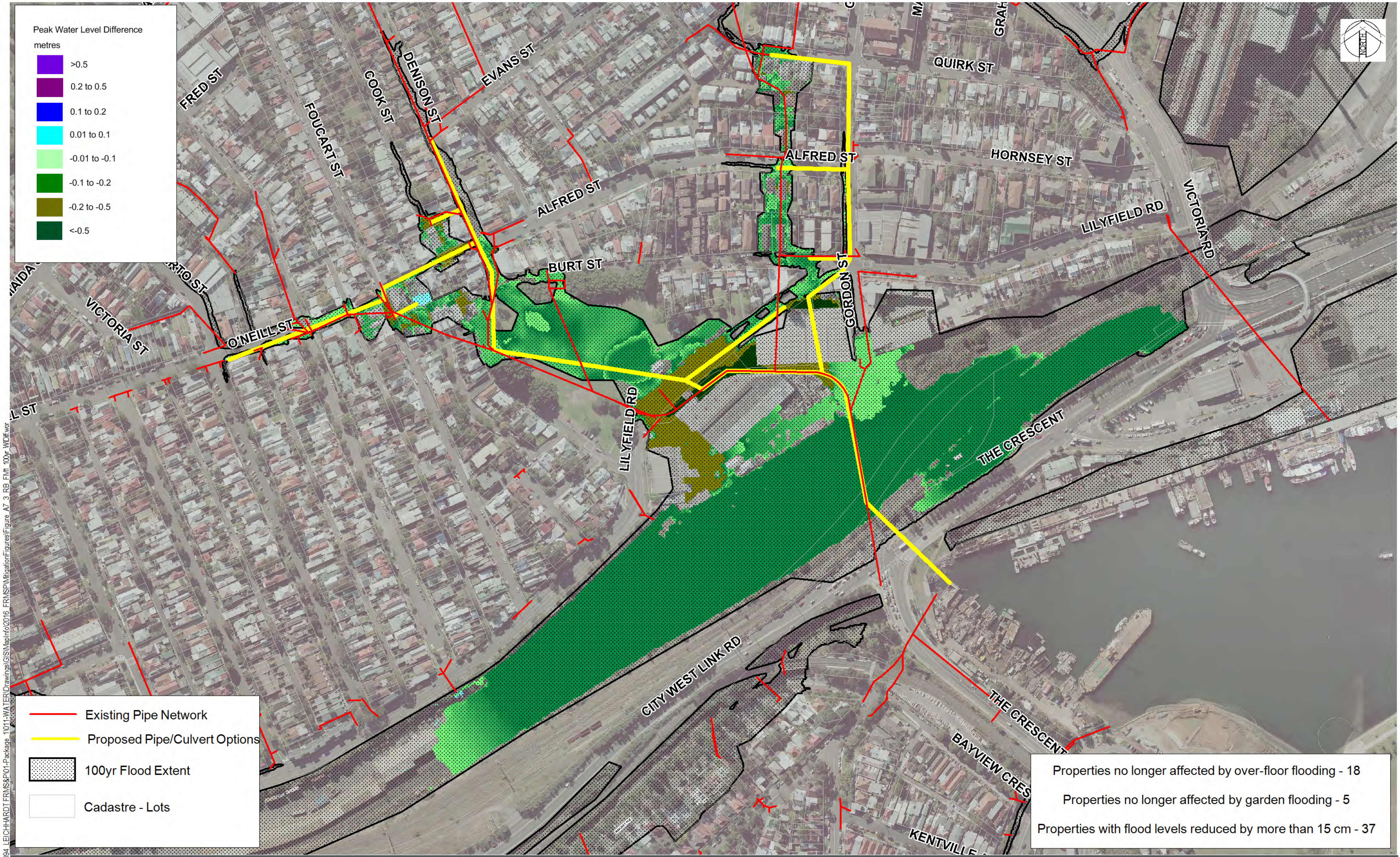

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INNER WEST COUNCIL
LEICHHARDT FRMS&P
RB_FM1 100YR ARI WL DIFF
MITIGATION LESS EXISTING
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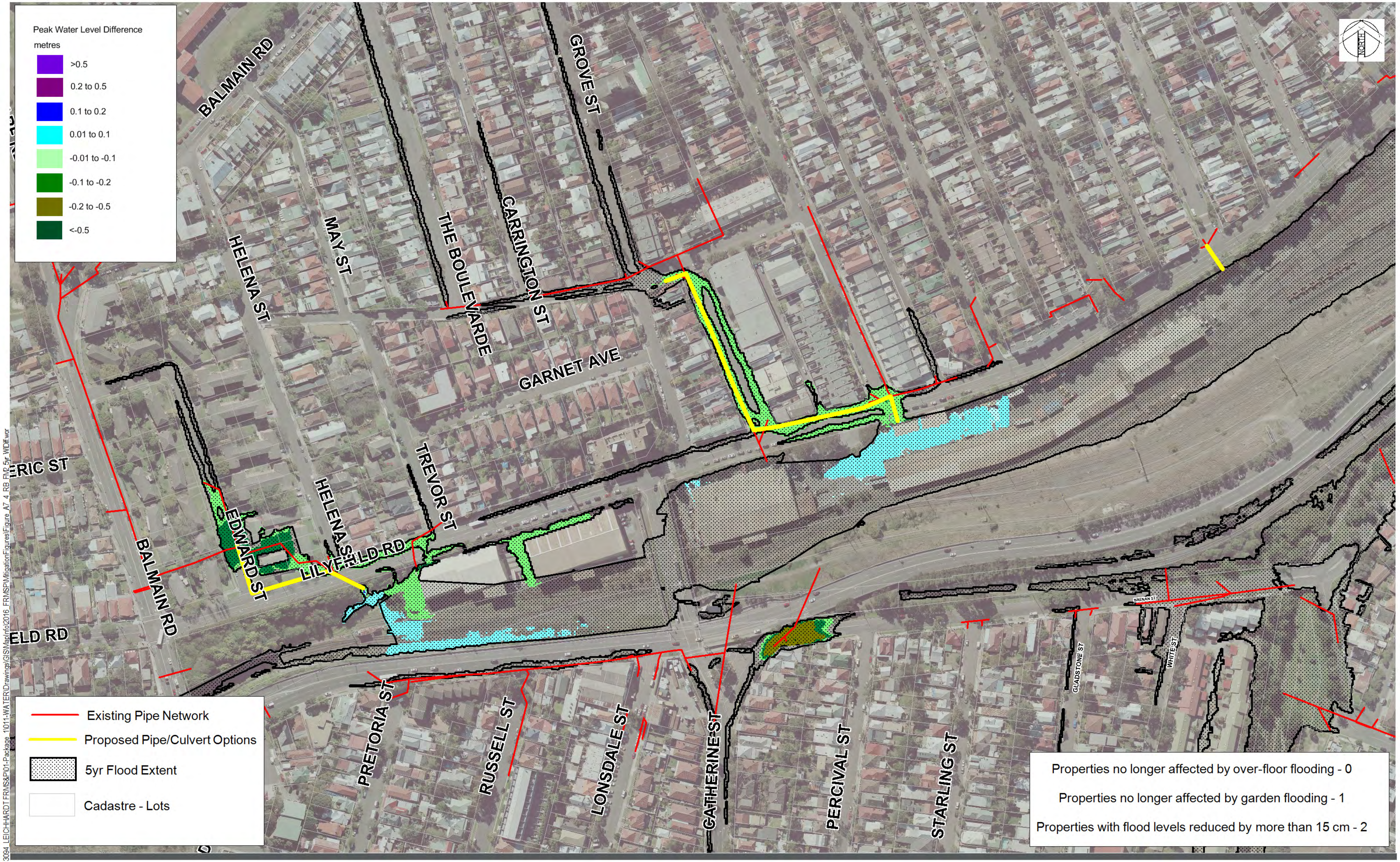

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LEICHHARDT FRMS&P
RB_FM2 5YR ARI WL DIFF
MITIGATION LESS EXISTING
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Date
03/2017

RB_FM2_5yr_WlDiff
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Size
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INNER WEST COUNCIL
LEICHHARDT FRMS&P
RB_FM2 20YR ARI WL DIFF
MITIGATION LESS EXISTING
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INNER WEST COUNCIL
LEICHHARDT FRMS&P
RB_FM2 100YR ARI WL DIFF
MITIGATION LESS EXISTING
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RB_FM2_100yr_WlDiff
Drawing Number

Size
A3

03
Revision

Area 8 - White Bay Options Assessment

Leichhardt Flood Risk Management Study and Plan

NA49913094

Prepared for
Inner West Council

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Tables

Figures

1 White Bay Catchment Description

The Whites Bay Catchment is approximately 120 hectares in size. The majority of the catchment is within Balmain. The two main flowpaths in this catchment discharge into Whites Bay. In both cases, properties have historically been constructed across the flowpaths resulting in significant obstruction to overland flows and associated ponding of water in streets and properties. In some cases, this obstruction to flow also results in an effective detention basin with a flood benefit to the properties downstream (as the obstruction from the properties slows and holds back the water, reducing the potential flooding downstream).

In the downstream portion of both of these flowpaths, flood levels are controlled by the culverts under Robert Street and the port at White Bay and the ability for flows to overtop the port area. In addition, a long section of the port is obstructed by a high level fence. The combination of these factors results in significant ponding of water in this location along Robert Street.

The location of the White Bay Catchment within the study area is shown in **Figure 1-1.**

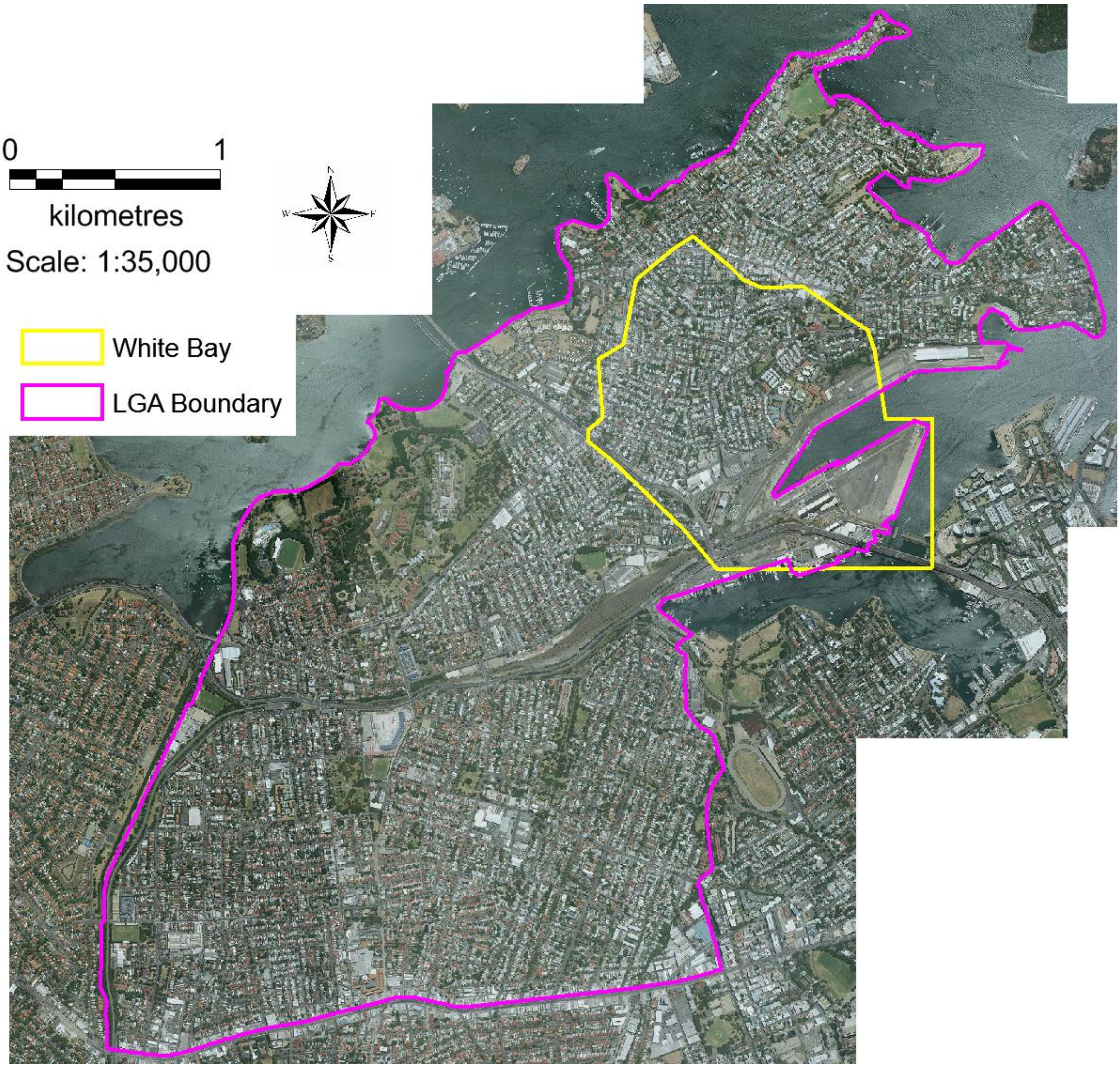


Figure 1-1 White Bay Catchment Location

2 Flood Mitigation Options Identification

2.1 Flood Modification Measures for White Bay

The existing flood behaviour within the Whites Bay is detailed in the Leichhardt Flood Study (Cardno 2014). Based on the flood model results, historical information and engineering judgement, possible flood modification measures (i.e. structural measures) for the study area were identified.

The various management options were identified taking into consideration the:

- flood behaviour and flow in the 20 year ARI event;
- grade of pipe (upstream and downstream); and
- preliminary availability and location of easements.

It should also be noted that Sydney Water and RMS may also play a major role in regards to fund allocation for the options recommended. Sydney Water's approach to flood-related improvement works on its assets is that Sydney Water will work with Councils to deliver the works (typically on a 50:50 cost-sharing basis) and provided Sydney Water has funding available within its Flood Risk Program. It is assumed that RMS will provide all the funding for the transverse pipe sections across State roads. Currently no allocation of RMS funding has been assigned for infrastructure travelling longitudinally along State Roads.

2.2 White Bay Flood Mitigation Options

Within the White Bay catchment six (6) sets of options were modelled, these are shown in **Table 2-1** and **Figure 2-1.** The 100yr, 20yr and 5yr ARI peak water level difference plots for each mitigation option are attached at the end of this appendix report.

Table 2-1 White Bay Mitigation Options

Option Description	Option Name	ID
Beattie Street Branch – Proposing a new pipe network or duplication of existing pipe network. Starting from Llewellyn St to the outlet at White Bay. The trunk drainage starts from Roseberry St at the start and Robert St to the end. Then travelling East, parallel to Robert St and eventually draining into White Bay.	Beattie Street Branch WB-FM1	WB-FM1
Wortley Street Branch – Proposing additional pipes to be incorporated into the existing pipe network. Additions at Creek St, Wortley St, Foy St, Hyam St, Roseberry Place and eventually crossing Robert St to drain into White bay.	Wortley Street Branch WB-FM2	WB-FM2
Reynolds Street/(Wortley Street) Proposed Basin – Proposed basin in Punch park, situated next to Reynolds St.	Reynolds Street Proposed Basin WB-FM3	WB-FM3
Montague Street Branch and additional pipes – Proposing additional pipes from Montague St that connect into the existing network.	Montague Street Branch WB-FM4	WB-FM4
Booth Street Proposed Basin – at Gladstone park (Balmain Public School) next to Booth St.	Booth Street Proposed Basin WB-FM5	WB-FM5
Elliot Street Basin	Elliot Street Basin WB-FM6	WB-FM6

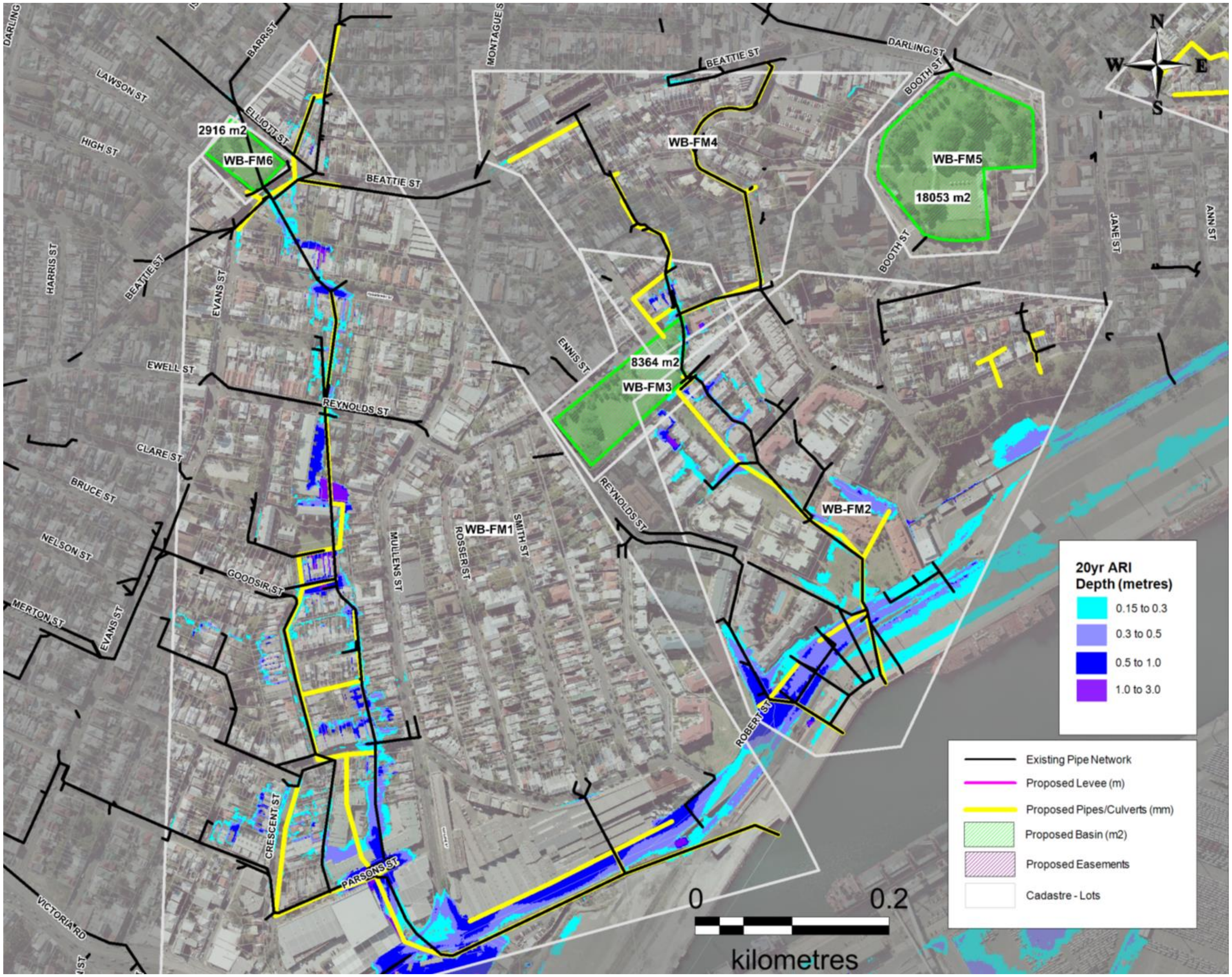


Figure 2-1 White Bay Mitigation Options Locations

2.2.1 Beattie Street Branch WB-FM1

The Beattie Street Branch proposes new pipes and duplication of the existing pipe network. WB-FM1 starts with a proposed 600mm diameter pipe north of the Beattie Street / Elliot Street intersection, with the proposed works culminating in a proposed 2.8m x 1.8m culvert draining to White Bay. The proposed branch which starts at Llewellyn Street includes proposed 600mm and 900mm diameter pipes, which join the existing Sydney Water 900mm diameter pipe in Evans Street. The main pipe branch of this option crosses Roseberry Street (1200mm diameter pipe), Reynolds Street (1500mm diameter pipe), Goodsir Street (1650mm diameter pipe), Perrett Street (1650mm diameter pipe), Mullens Street (1650mm diameter pipe), Mansfield Street (1650mm diameter pipe) and ending on Parsons Street (1650mm diameter pipe). Side branches (900mm, 1200mm, 1000mm diameter pipes) drain into the main branch at various locations between Beattie Street and Parson Street. On Parson Street the pipe drains onto a 2.8m x 1.8m box culvert located along Robert Street before eventually draining into White Bay.

Further additional drainage works are proposed from Hanover Street (450mm, 600mm and 900mm diameter pipes) to the existing main trunk drainage at Parsons Street.

Flooding is present under existing conditions in the area with depths reaching up to 2m as result of the 20 year ARI storm event.

Potential constraints for this measure include the buyback of two properties and costs due to construction, services and traffic management requirements on Robert Street.

Funding from Sydney Water (for the main trunk drainage) and RMS funding may be available for a majority of the cost. The RMS funding has been allocated towards the transverse pipe upgrade on Robert Street.

2.2.2 Wortley Street Branch WB-FM2

This option proposes additional pipes from Pashley Street to Roberts Street. The proposed drainage passes through Creek Street, Wortley Street, Foy Street, Hyam Street, Roseberry Place and eventually crossing Robert Street to drain into White Bay.

2.2.3 Reynolds Street Proposed Basin WB-FM3

WB-FM3 consists of a proposed basin with an area of 8,400 square meters. The basin is proposed in Punch Park, next to Reynolds Street. The basin is required to hold a volume of 2,300 cubic meters. The aim of the basin is to mitigate flood inundation around the area due to the 20 year ARI storm event. Depths under existing conditions can reach around 1.6m in the 20 year ARI storm event.

Potential constraints for this measure includes vegetation removal in Punch Park and changes to recreational use of Punch Park, depending on the configuration of the basin and if underground storage is adopted.

2.2.4 Palmer Street Branch WB-FM4

Additional 750mm pipes are proposed from Beattie Street, connecting at the downstream end to the existing pipe network at Wortley Street.

2.2.5 Booth Street Proposed Basin WB-FM5

The preliminary options modelling reviewed the potential for a basin located at Gladstone Park (Balmain Public School), near to Booth Street. However, preliminary results indicated that there were very little, if any reductions in flood levels as a result of the proposed basin. As such, this option has not been assessed further.

2.2.6 Elliot Street Basin WB-FM6

WB-FM6 is a detention basin that has been proposed to be located at Ann Cashman Reserve north-west of the Elliot Street/Beattie Street intersection. The basin has an area of 2916 square meters and is proposed to hold a volume of around 2500 cubic meters. The aim of the basin is to mitigate flood inundation around that specific block. Under existing conditions flood depths reach up to 1m due to the 20 year ARI storm event.

Potential constraints for this measure includes vegetation removal from the grounds and changes to recreational use of the grounds. The specific design of the basin configuration and / or the use of underground storage may mitigate some of these impacts.

3 Mitigation Option Modelling Outcomes

The Whites Bay flood mitigation options were assed for the 5, 10, 20, 50 and 100 Year ARI design flood events, along with the PMF event.

The outcomes of the modelling are shown in the 5, 20, and 100 Year ARI water level difference plots in **Appendix D**.

A summary of the impacts on flood behaviour for each option is provided below.

3.1 Beattie Street Branch WB-FM1

The proposed increase in drainage capacity of mitigation option WB-FM1 is shown to reduce overland flows for the majority of the Beattie Street flow path. The water level difference results show a decrease of 0.1m – 0.85m along the flow path in the 20 Year ARI event. The mitigation strategy particularly shows significant water level decreases on Beattie Street, Roseberry Street, Reynolds Street, Goodsir Street, Moore Street, Perrett Street, Pine Street, Mansfield Street, Parsons Street and Robert Street. Decreases in water levels up to 0.10m are also observed on Hanover Street, Murdoch Street, Collins Street and Crescent Street.

Modelling of this mitigation strategy indicates that many properties in this catchment would have a reduction in water levels in all events, with a number of properties no longer experiencing over floor flooding in both frequent and rare events.

3.2 Wortley Street Branch WB-FM2

Mitigation option WB-FM2 shows significant water level decreases along the Wortley Street Branch flowpath. The increase in drainage capacity at Roberts Street has significant reductions in flood levels (up to 0.70m in a 100 Year ARI event). Decreases in flood levels are also seen on Wortley Street, Foy Street, Hyam Street, Rosebery Place and Buchanan Street. The reductions in flood levels along the flowpath are in an order of 0.10m and 0.30m for all the modelled design flood events.

Over floor flooding is removed for up to 10 properties in most events assessed.

3.3 Reynolds Street Proposed Basin WB-FM3

The proposed detention basin option at Reynolds Street (WB-FM3) shows slight reductions in flood levels downstream of the basin. The reductions are in an order of 0.01m to 0.10m in a 5 Year ARI event.

3.4 Palmer Street Branch WB-FM4

Mitigation option WB-FM4 shows decreases in flood levels along the Palmer Street flowpath and the Little Street flowpath in all the modelled flood events. The reductions are in an order of 0.01m to 0.10m vicinity of the proposed option.

The option does not remove flooding entirely from the grounds of any properties, but may result in two properties no longer being affected by overfloor flooding in all events up to and including the 100 year ARI event.

3.5 Elliot Street Basin WB-FM6

The basin proposed at Elliot Street results in only minor decreases in flood levels and results in flood level increases of approximately 0.2m immediately downstream of the basin.

The minor flood level reductions are relatively widespread and so result in an overall flood damages reduction in the more frequent events, despite the increased damages locally to the basin. However, in the rarer events (50 Year ARI and greater) the increase in flood levels immediately downstream of the basin exceed the benefits further downstream and result in an overall increase in flood damages. Due to these increases in flood damages, this option has not been assessed with regards to its benefit costs ratio.

4 Economic Assessment of Flood Damages in the Whites Bay Catchment

4.1 Whites Bay Mitigation Options Damages Assessment

An assessment of damages for the existing condition in the White Bay Catchment is presented in the Floodplain Risk Management Study. The approach adopted for calculating the existing damages has been repeated for the modelling results from the mitigation options proposed for the White Bay catchment.

The economic flood damage results for each of the options and the existing scenarios are presented in **Table** 4-1 to **Table 4-5**. The reductions in properties affected by overground and overfloor flooding, total damages and AAD are provided. Negative values represent increases from the existing scenario.

The total reduction in damaged properties and the associated reduction in damage costs for each mitigation strategy is summarised in **Table 4-6**. This table represents a summary of differences between existing and Mitigation scenarios presented in **Table 4-1** to **Table 4-5.**

The flood damages assessment is a useful tool for comparing the merits of various options, it is not a precise flood risk analysis tool and the limitation associated with the assessment should be considered when interpreting the results.

The following information should be considered when interpreting the damages data:

- Negative property or dollar values represent increases from the existing scenario.
- Where an option results in a reduction in flood depths there may not be any reduction in the flood damages where:
  - The reduction in flood depths or extent occur in open space or roadways; or
  - The reduction in flood depths occurs on properties that were not impacted by over floor flooding (i.e. the flooding on the property grounds is shallower but still exists).
- The flood damages are calculated at a discrete location on each property. This location is where the floor level and ground level survey was obtained from. As such, if the flooding occurs at another location on the property other than the survey point, this property will not register any damages with regards to this damages assessment.
- Commercial and industrial damages are only incurred when over floor flooding exists.
- The reduction in the number of properties impacted as a result of an option may vary between different flood events due to the performance of the proposed work under the different flow behaviour of each flood event.

Table 4-1 WB_FM1 Flood Damage Assessment Summary

Event / Property type	Properties with Overfloor Flooding		Properties with Overground Flooding		Estimated Total Damage ($ June 2016)	
	Existing Case	*Mitigation Case*	*Existing Case*	*Mitigation Case*	*Existing Case*	*Mitigation Case*
PMF Event						
Residential	357	316	531	525	$ 22,742,301	$ 20,166,820
Commercial	2	2	7	7	$ 79,707	$ 79,733
Industrial	39	37	43	43	$ 9,367,993	$ 8,775,617
PMF Total	**398**	**355**	**581**	**575**	**$ 32,190,001**	**$ 29,022,170**
100yr ARI						
Residential	104	83	154	145	$ 5,595,125	$ 4,289,188
Commercial	0	0	0	0	$ -	$ -
Industrial	26	12	26	26	$ 5,076,109	$ 4,413,319
100yr ARI Total	**130**	**95**	**180**	**171**	**$ 10,671,235**	**$ 8,702,507**
50yr ARI						
Residential	96	80	150	142	$ 5,019,880	$ 4,095,138
Commercial	0	0	0	0	$ -	$ -
Industrial	24	9	26	26	$ 4,681,605	$ 4,077,309
50yr ARI Total	**120**	**89**	**176**	**168**	**$ 9,701,484**	**$ 8,172,447**
20yr ARI						
Residential	85	72	138	135	$ 4,396,833	$ 3,762,711
Commercial	0	0	0	0	$ -	$ -
Industrial	21	9	24	23	$ 4,429,241	$ 3,907,988
20yr ARI Total	**106**	**81**	**162**	**158**	**$ 8,826,073**	**$ 7,670,699**
10yr ARI						
Residential	77	65	123	121	$ 3,991,635	$ 3,241,294
Commercial	0	0	0	0	$ -	$ -
Industrial	18	9	23	10	$ 4,106,883	$ 3,714,501
10yr ARI Total	**95**	**74**	**146**	**131**	**$ 8,098,518**	**$ 6,955,795**
5yr ARI						
Residential	50	42	89	86	$ 2,826,076	$ 2,202,891
Commercial	0	0	0	0	$ -	$ -
Industrial	15	6	15	14	$ 2,650,756	$ 2,340,196
5yr ARI Total	**65**	**48**	**104**	**100**	**$ 5,476,832**	**$ 4,543,087**
Total Annual Average Damage					**$ 2,517,469**	**$ 2,132,696**

Table 4-2 WB_FM2 Flood Damage Assessment Summary

Event / Property type	Properties with Overfloor Flooding		Properties with Overground Flooding		Estimated Total Damage ($ June 2016)	
	Existing Case	*Mitigation Case*	*Existing Case*	*Mitigation Case*	*Existing Case*	*Mitigation Case*
PMF Event						
Residential	96	96	143	143	$ 10,160,824	$ 10,160,824
Commercial	1	1	3	3	$ 289,104	$ 289,104
Industrial	16	16	16	16	$ 7,461,065	$ 7,461,065
PMF Total	**113**	**113**	**162**	**162**	**$ 17,910,993**	**$ 17,910,993**
100yr ARI						
Residential	28	24	40	39	$ 2,233,888	$ 1,469,113
Commercial	0	0	0	0	$ -	$ -
Industrial	12	6	12	12	$ 3,244,299	$ 2,844,632
100yr ARI Total	**40**	**30**	**52**	**51**	**$ 5,478,187**	**$ 4,313,745**
50yr ARI						
Residential	26	22	40	39	$ 2,146,353	$ 1,397,231
Commercial	0	0	0	0	$ -	$ -
Industrial	11	4	12	12	$ 2,888,702	$ 2,505,333
50yr ARI Total	**37**	**26**	**52**	**51**	**$ 5,035,055**	**$ 3,902,564**
20yr ARI						
Residential	24	22	38	37	$ 1,920,098	$ 1,391,384
Commercial	0	0	0	0	$ -	$ -
Industrial	9	2	11	11	$ 2,470,792	$ 2,133,331
20yr ARI Total	**33**	**24**	**49**	**48**	**$ 4,390,890**	**$ 3,524,715**
10yr ARI						
Residential	21	19	34	33	$ 1,670,693	$ 1,144,833
Commercial	0	0	0	0	$ -	$ -
Industrial	9	2	10	9	$ 2,085,534	$ 1,797,925
10yr ARI Total	**30**	**21**	**44**	**42**	**$ 3,756,227**	**$ 2,942,758**
5yr ARI						
Residential	18	16	29	28	$ 1,445,713	$ 993,860
Commercial	0	0	0	0	$ -	$ -
Industrial	8	1	8	8	$ 272,794	$ 76,702
5yr ARI Total	**26**	**17**	**37**	**36**	**$ 1,718,507**	**$ 1,070,563**
Total Annual Average Damage					**$ 502,048**	**$ 500,033**

Table 4-3 WB_FM3 Flood Damage Assessment Summary

Event / Property type	Properties with Overfloor Flooding		Properties with Overground Flooding		Estimated Total Damage ($ June 2016)	
	Existing Case	*Mitigation Case*	*Existing Case*	*Mitigation Case*	*Existing Case*	*Mitigation Case*
PMF Event						
Residential	35	35	36	36	$ 5,395,415	$ 5,335,719
Commercial	1	1	1	1	$ 289,104	$ 289,131
Industrial	0	0	0	0	$ -	$ -
PMF Total	**36**	**36**	**37**	**37**	**$ 5,684,519**	**$ 5,624,849**
100yr ARI						
Residential	20	18	22	22	$ 1,464,784	$ 1,304,625
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
100yr ARI Total	**20**	**18**	**22**	**22**	**$ 1,464,784**	**$ 1,304,625**
50yr ARI						
Residential	19	17	21	21	$ 1,415,370	$ 1,249,483
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
50yr ARI Total	**19**	**17**	**21**	**21**	**$ 1,415,370**	**$ 1,249,483**
20yr ARI						
Residential	19	16	21	21	$ 1,261,857	$ 1,114,281
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
20yr ARI Total	**19**	**16**	**21**	**21**	**$ 1,261,857**	**$ 1,114,281**
10yr ARI						
Residential	16	14	19	19	$ 1,054,304	$ 899,479
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
10yr ARI Total	**16**	**14**	**19**	**19**	**$ 1,054,304**	**$ 899,479**
5yr ARI						
Residential	14	12	15	15	$ 882,709	$ 749,194
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
5yr ARI Total	**14**	**12**	**15**	**15**	**$ 882,709**	**$ 749,194**
Total Annual Average Damage					**$ 377,463**	**$ 328,028**

Table 4-4 WB_FM4 Flood Damage Assessment Summary

Event / Property type	Properties with Overfloor Flooding		Properties with Overground Flooding		Estimated Total Damage ($ June 2016)	
	Existing Case	*Mitigation Case*	*Existing Case*	*Mitigation Case*	*Existing Case*	*Mitigation Case*
PMF Event						
Residential	86	83	132	131	$ 6,177,358	$ 6,019,987
Commercial	1	1	4	4	$ 289,104	$ 288,353
Industrial	0	0	0	0	$ -	$ -
PMF Total	**87**	**84**	**136**	**135**	**$ 6,466,462**	**$ 6,308,340**
100yr ARI						
Residential	24	22	35	35	$ 1,569,261	$ 1,499,172
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
100yr ARI Total	**24**	**22**	**35**	**35**	**$ 1,569,261**	**$ 1,499,172**
50yr ARI						
Residential	23	22	36	36	$ 1,492,568	$ 1,435,410
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
50yr ARI Total	**23**	**22**	**36**	**36**	**$ 1,492,568**	**$ 1,435,410**
20yr ARI						
Residential	22	21	34	34	$ 1,423,753	$ 1,364,256
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
20yr ARI Total	**22**	**21**	**34**	**34**	**$ 1,423,753**	**$ 1,364,256**
10yr ARI						
Residential	20	19	30	30	$ 1,201,420	$ 1,147,428
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
10yr ARI Total	**20**	**19**	**30**	**30**	**$ 1,201,420**	**$ 1,147,428**
5yr ARI						
Residential	17	16	27	27	$ 1,021,235	$ 950,024
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
5yr ARI Total	**17**	**16**	**27**	**27**	**$ 1,021,235**	**$ 950,024**
Total Annual Average Damage					**$ 429,176**	**$ 405,870**

Table 4-5 WB_FM6 Flood Damage Assessment Summary

Event / Property type	Properties with Overfloor Flooding		Properties with Overground Flooding		Estimated Total Damage ($ June 2016)			
	Existing Case	*Mitigation Case*	*Existing Case*	*Mitigation Case*	*Existing Case*		*Mitigation Case*	
PMF Event								
Residential	296	298	402	402	$	17,585,743	$	17,780,398
Commercial	0	0	0	0	$	-	$	-
Industrial	34	34	38	38	$	3,347,421	$	3,339,273
PMF Total	**330**	**332**	**440**	**440**	**$**	**20,933,164**	**$**	**21,119,672**
100yr ARI								
Residential	100	100	150	150	$	4,983,405	$	4,975,314
Commercial	0	0	0	0	$	-	$	-
Industrial	22	22	22	22	$	2,439,372	$	2,450,042
100yr ARI Total	**122**	**122**	**172**	**172**	**$**	**7,422,777**	**$**	**7,425,356**
50yr ARI								
Residential	92	93	146	146	$	4,415,728	$	4,436,709
Commercial	0	0	0	0	$	-	$	-
Industrial	20	19	22	22	$	2,394,427	$	2,385,119
50yr ARI Total	**112**	**112**	**168**	**168**	**$**	**6,810,156**	**$**	**6,821,827**
20yr ARI								
Residential	82	83	134	134	$	3,839,152	$	3,835,032
Commercial	0	0	0	0	$	-	$	-
Industrial	17	17	20	20	$	2,323,403	$	2,322,578
20yr ARI Total	**99**	**100**	**154**	**154**	**$**	**6,162,555**	**$**	**6,157,610**
10yr ARI								
Residential	74	74	119	119	$	3,449,964	$	3,445,416
Commercial	0	0	0	0	$	-	$	-
Industrial	14	14	19	19	$	2,242,490	$	2,239,377
10yr ARI Total	**88**	**88**	**138**	**138**	**$**	**5,692,454**	**$**	**5,684,793**
5yr ARI								
Residential	48	48	86	86	$	2,348,242	$	2,337,902
Commercial	0	0	0	0	$	-	$	-
Industrial	11	11	11	11	$	983,743	$	981,414
5yr ARI Total	**59**	**59**	**97**	**97**	**$**	**3,331,985**	**$**	**3,319,316**
Total Annual Average Damage					**$**	**1,654,916**	**$**	**1,652,801**

Table 4-6 Reduction in Damages Associated with Each Option

	Overfloor flooding properties reduction	Overground flooding properties reduction	Total Damage Reduction ($)	AAD Reduction ($)
WB-FM1				
PMF event	43	6	$3,167,831	$25,680
100yr ARI event	35	9	$1,968,728	$17,489
50yr ARI event	31	8	$1,529,038	$40,266
20yr ARI event	25	4	$1,155,375	$57,452
10yr ARI event	21	15	$1,142,723	$103,823
5yr ARI event	17	4	$ 933,745	$140,062
Total				**$384,773**
WB-FM2				
PMF event	0	0	$ -	$5,822
100yr ARI event	10	1	$1,164,442	$11,485
50yr ARI event	11	1	$1,132,491	$29,980
20yr ARI event	9	1	$ 866,175	$41,991
10yr ARI event	9	2	$ 813,469	$73,071
5yr ARI event	9	1	$ 647,944	$97,192
Total				**$259,540**
WB-FM3				
PMF event	0	0	$ 59,669	$1,099
100yr ARI event	2	0	$ 160,158	$1,630
50yr ARI event	2	0	$ 165,887	$4,702
20yr ARI event	3	0	$ 147,576	$7,560
10yr ARI event	2	0	$ 154,825	$14,417
5yr ARI event	2	0	$ 133,515	$20,027
Total				**$49,436**
WB-FM4				
PMF event	3	1	$ 158,122	$1,141
100yr ARI event	2	0	$ 70,088	$636
50yr ARI event	1	0	$ 57,158	$1,750
20yr ARI event	1	0	$ 59,497	$2,837
10yr ARI event	1	0	$ 53,992	$6,260
5yr ARI event	1	0	$ 71,211	$10,682
Total				**$23,306**
WB-FM6				
PMF event	-2	0	-$ 186,508	-$945
100yr ARI event	0	0	-$ 2,579	-$71
50yr ARI event	0	0	-$ 11,672	-$101
20yr ARI event	-1	0	$ 4,944	$315
10yr ARI event	0	0	$ 7,661	$1,016
5yr ARI event	0	0	$ 12,669	$1,900
Total				**$2,114**

[1] A modelling instability produced unreliable results for the PMF design event for FM2. The results available, would suggest the flow behaviour would not be impacted significantly in the PMF as a result of this option.

4.2 Benefit to Cost Ratio of Options

The economic evaluation of each modelled measure was assessed by considering the reduction in the amount of flood damages incurred for the design events and by then comparing this value with the cost of implementing the measure.

Table 4-7 summarises the results of the economic assessment of each of the flood management options. The indicator adopted to rank these measures on economic merit is the benefit-cost ratio (B/C), which is based on the net present worth (NPW) of the benefits (reduction in AAD) and the costs (capital and ongoing), adopting a 7% discount rate and an implementation period of 50 years.

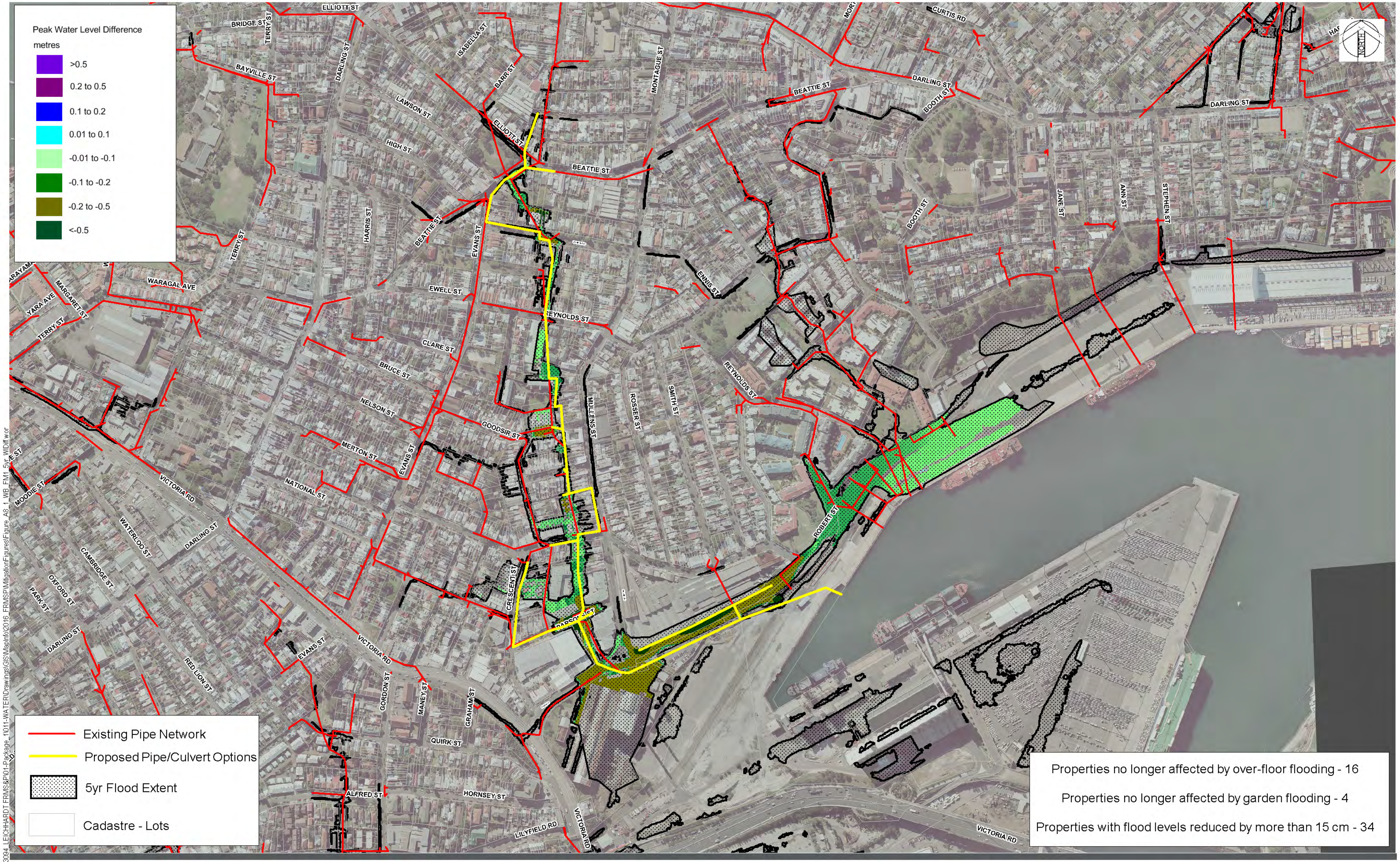
The benefit-cost ratio provides an insight into how the damage savings from a measure, relate to its cost of construction and maintenance:

- Where the benefit-cost is greater than 1 the economic benefits are greater than the cost of implementing the measure;
- Where the benefit-cost is less than 1 but greater than 0, there is still an economic benefit from implementing the measure but the cost of implementing the measure is greater than the economic benefit;
- Where the benefit-cost is equal to zero, there is no economic benefit from implementing the measure; and
- Where the benefit-cost is less than zero, there is a negative economic impact of implementing the measure.

Table 4-7 Summary of Economic Assessment of Flood Management Options

Option ID	Option Description	NPW of Reduction in AAD	NPW of Cost of Implementation	B/C Ratio	Economic Ranking
WB-FM1	**Beattie Street Branch** – Proposing a new pipe network or duplication of existing pipe network. Starting from Llewellyn St to the outlet at White Bay. The trunk drainage starts from Roseberry St at the start and Robert St to the end. Then travelling East, parallel to Robert St and eventually draining into White Bay.	$5,310,000	$ 26,063,000	0.20	3
WB-FM2	**Wortley Street Branch** – Proposing additional pipes to be incorporated into the existing pipe network. Additions at Creek St, Wortley St, Foy St, Hyam St, Roseberry Place and eventually crossing Robert St to drain into White bay.	$3,582,000	$ 8,675,000	0.41	1
WB-FM3	**Reynolds Street (Wortley Street) Proposed Basin** – Proposed basin in Punch park, situated next to Reynolds St.	$682,000	$ 1,728,000	0.39	2
WB-FM4	**Montague Street Branch and additional pipes** – Proposing additional pipes from Montague St that connect into the existing network.	$322,000	$ 2,190,000	0.15	4
WB-FM5	**Booth Street Proposed Basin** – at Gladstone park (Balmain Public School) next to Booth St.	*Not Feasible*			
WB-FM6	**Elliot Street Basin**	*Not Feasible*			

White Bay Mitigation Option Figures



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WB_FM1 5YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A8_1

Date
10/2016

WB_FM1_5yr_WlDiff
Drawing Number

Size
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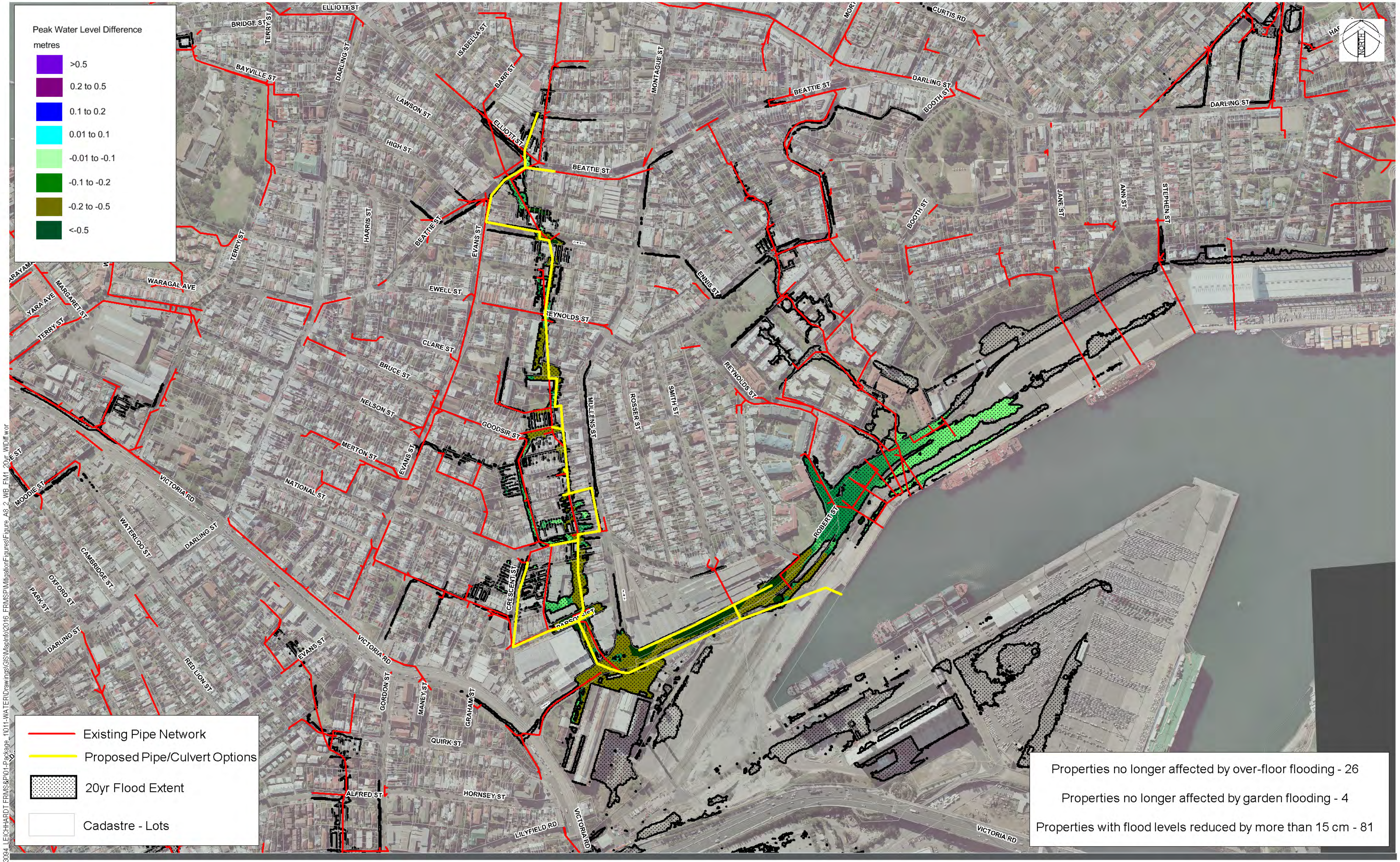
Revision



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WB_FM1 20YR ARI WL DIFF
MITIGATION LESS EXISTING
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Date
10/2016

WB_FM1_20yr_WlDiff
Drawing Number

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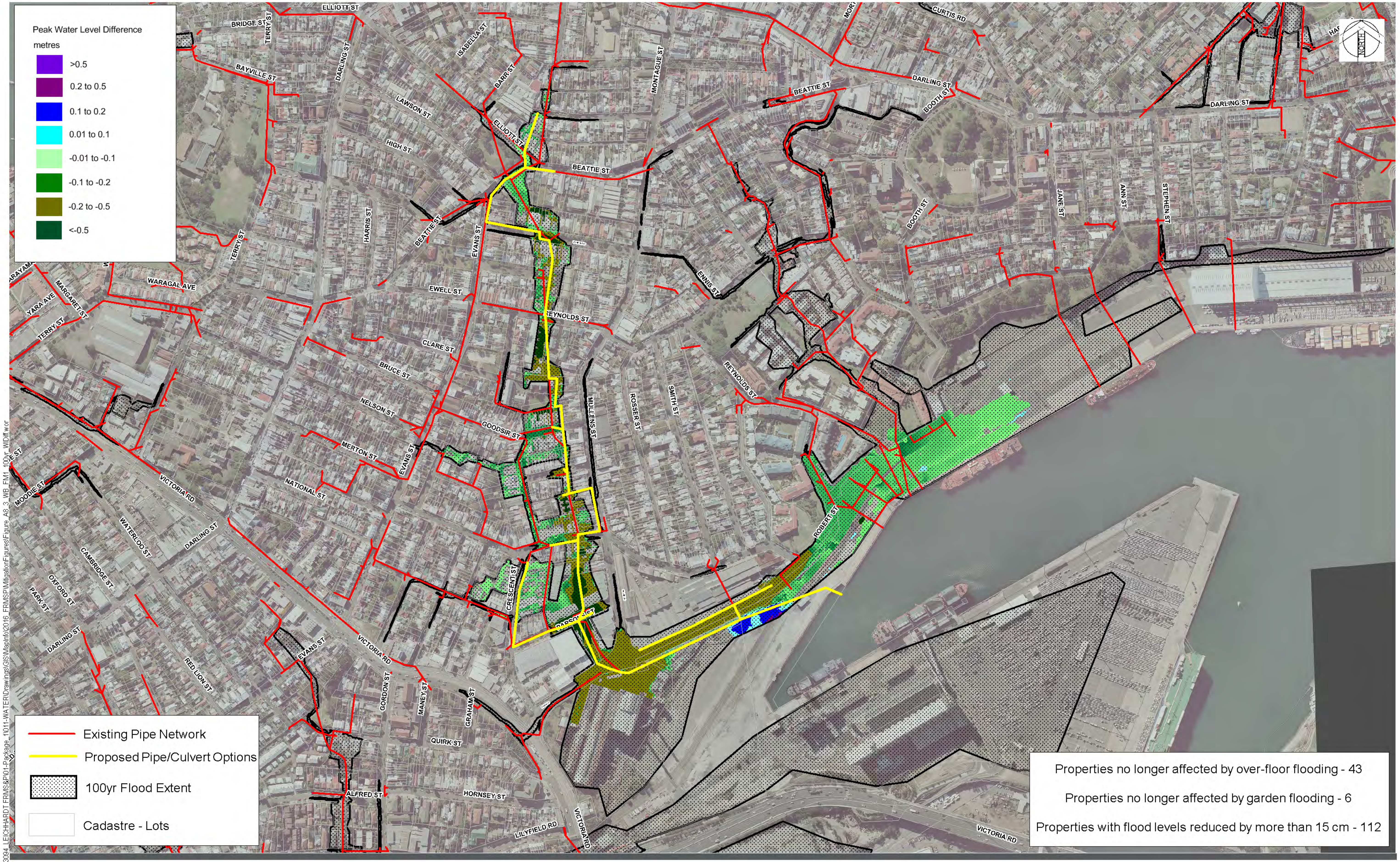

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LEICHHARDT FRMS&P
WB_FM1 100YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A8_3

Date
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WB_FM1_100yr_WlDiff
Drawing Number

Size
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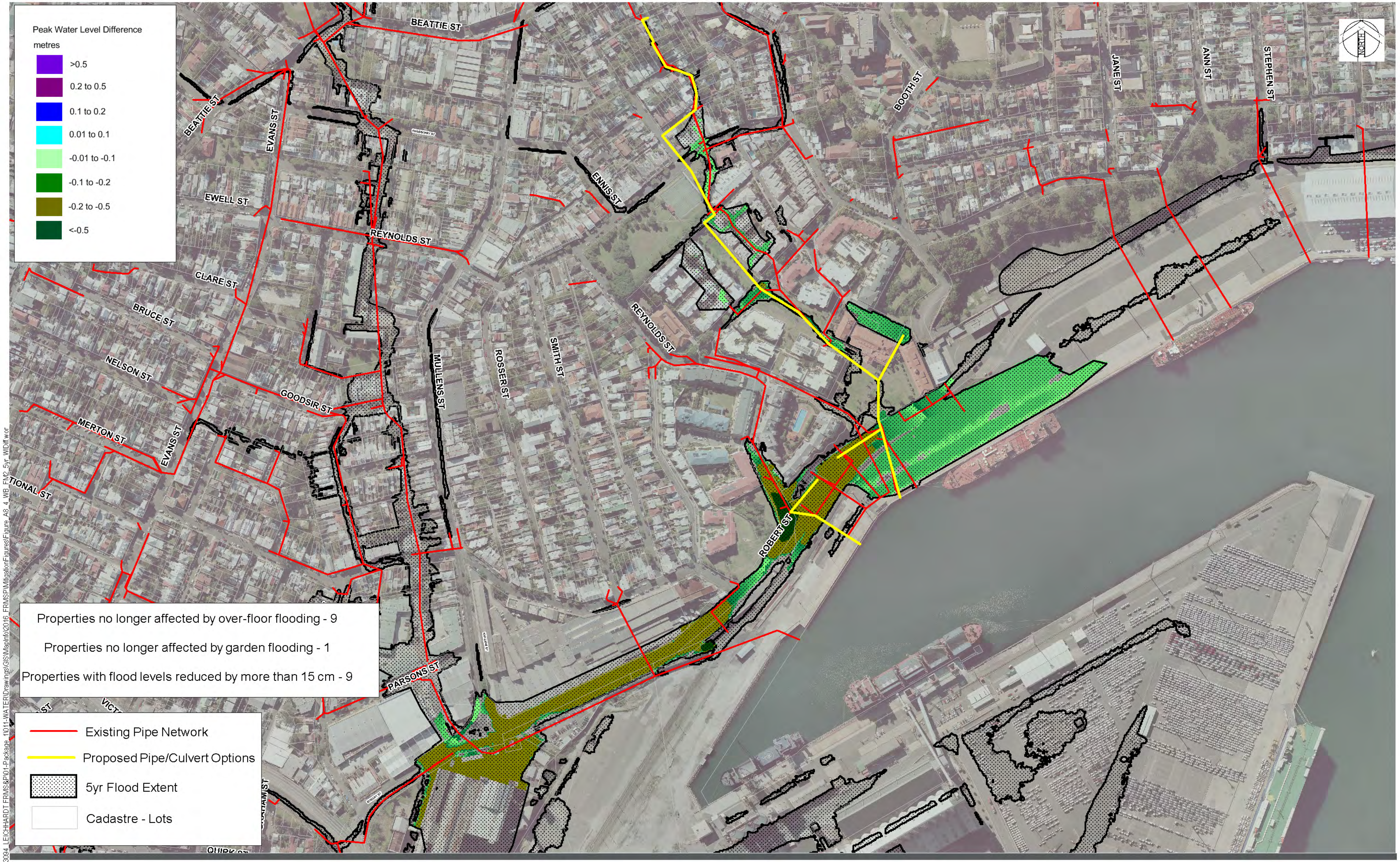
Revision



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WB_FM2 5YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A8_4

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WB_FM2_5yr_WlDiff
Drawing Number

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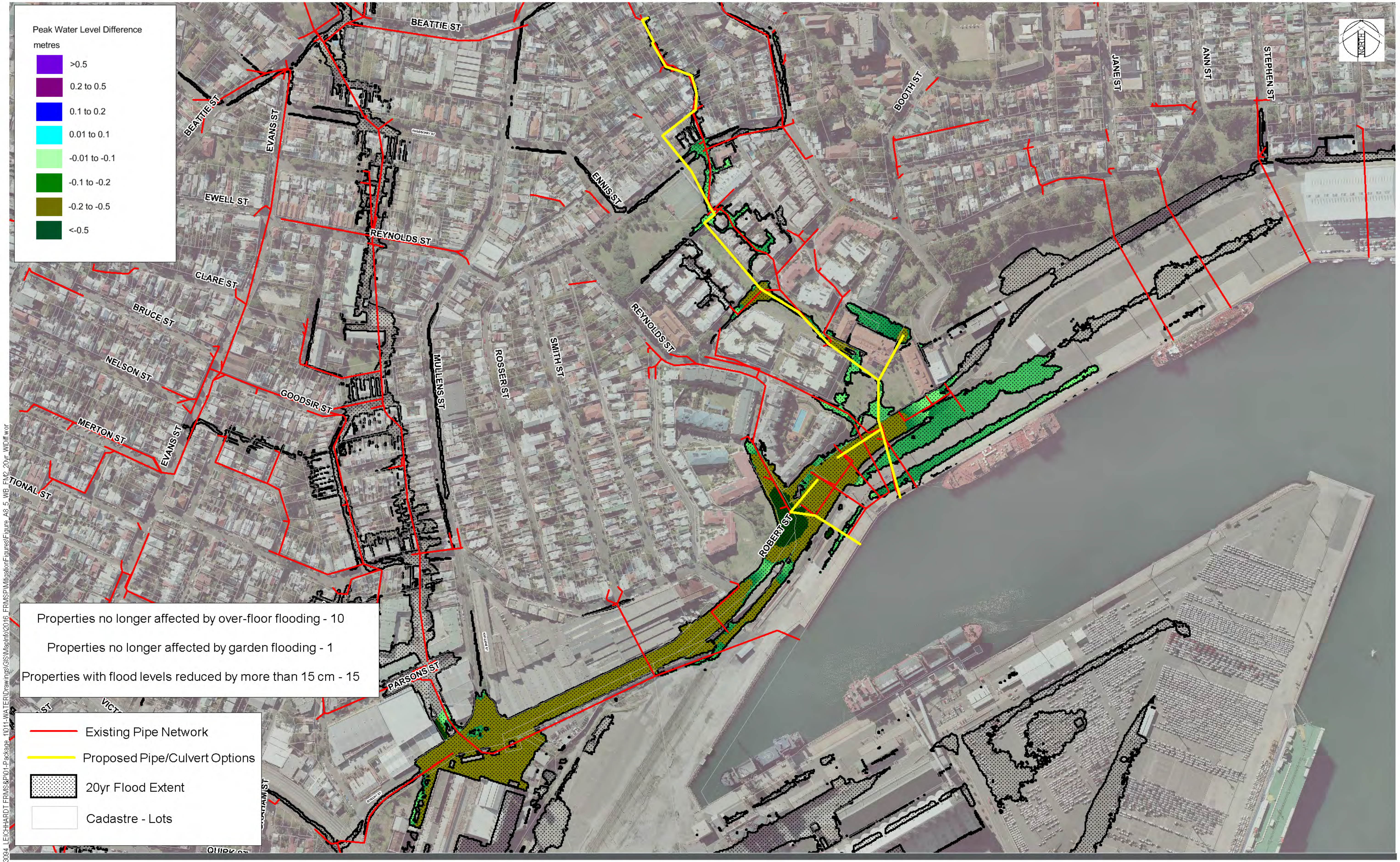
Revision



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WB_FM2 20YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A8_5

Date
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WB_FM2_20yr_WlDiff
Drawing Number

Size
A3

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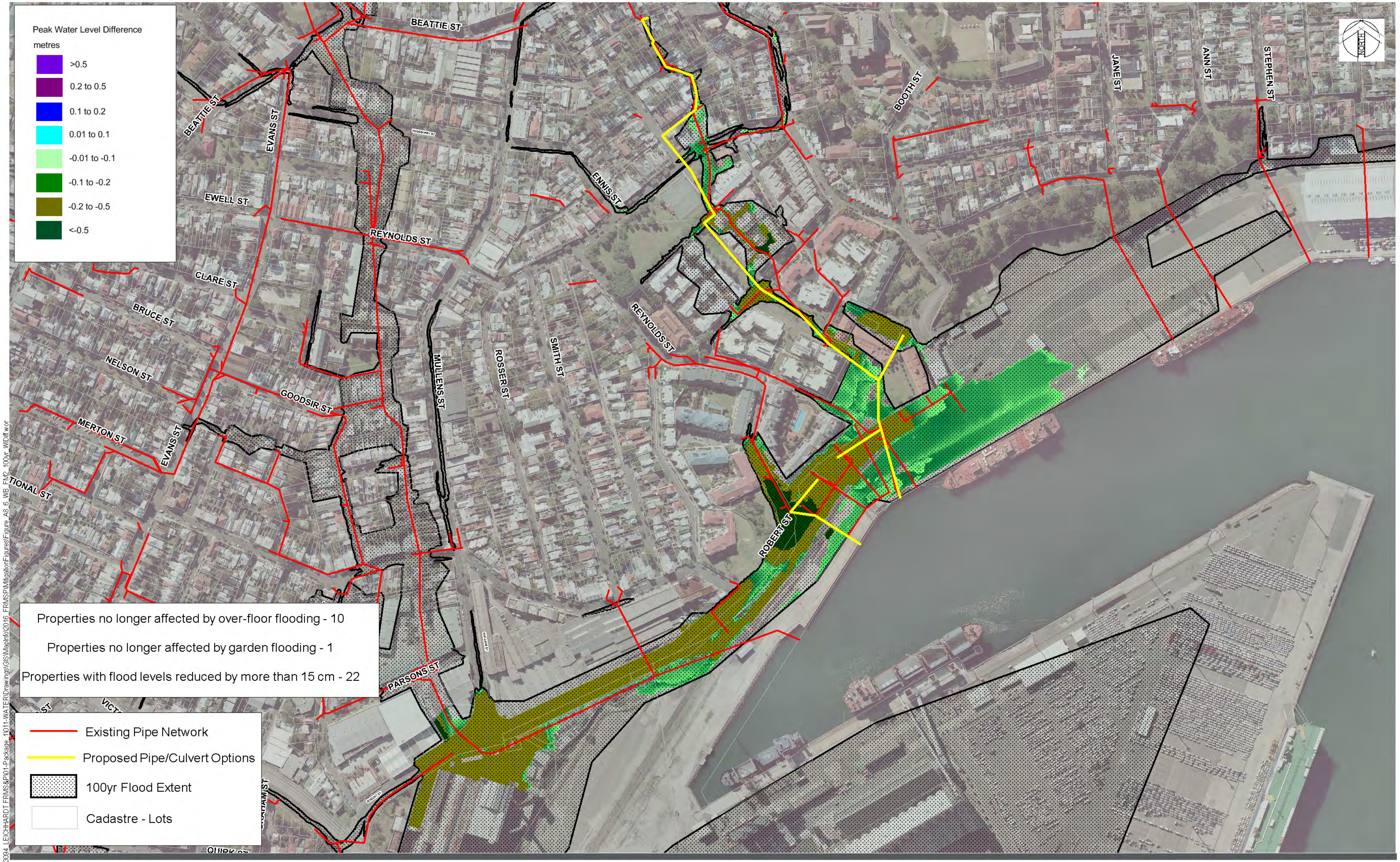
Revision



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WB_FM2 100YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A8_6

Date
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WB_FM3 5YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A8_7

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Drawing Number

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Revision

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WB_FM3 20YR ARI WL DIFF
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FIG_A8_8

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Drawing Number	Revision

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WB_FM3 100YR ARI WL DIFF
MITIGATION LESS EXISTING
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MITIGATION LESS EXISTING
FIG_A8_10

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WB_FM4 20YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A8_11

Date	Size
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WB_FM4_20yr_WlDiff	01
Drawing Number	Revision

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WB_FM4 100YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A8_12

Date
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WB_FM4_100yr_WlDiff
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Revision

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WB_FM5 5YR ARI WL DIFF
MITIGATION LESS EXISTING
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WB_FM5 20YR ARI WL DIFF
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FIG_A8_14

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WB_FM5 100YR ARI WL DIFF
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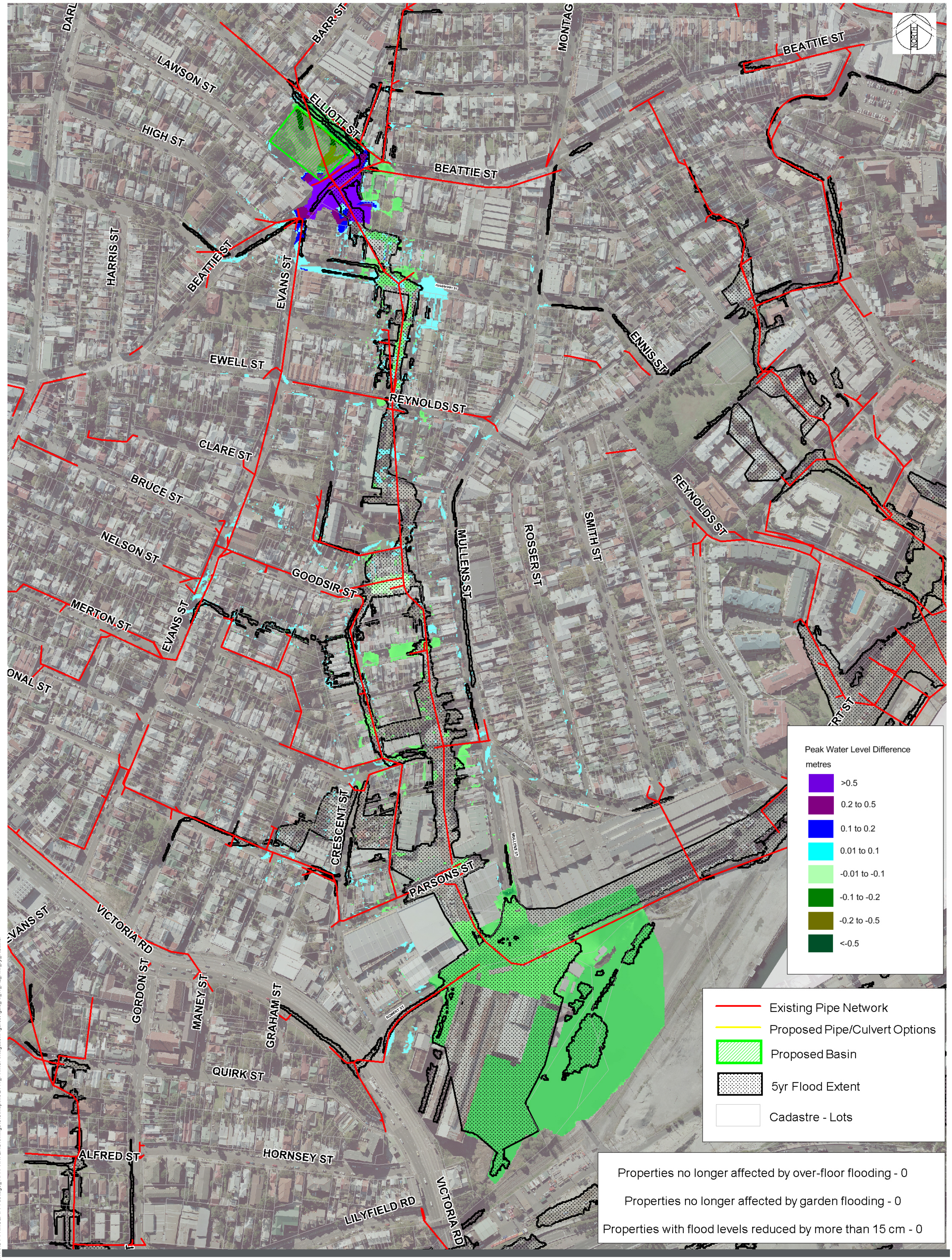

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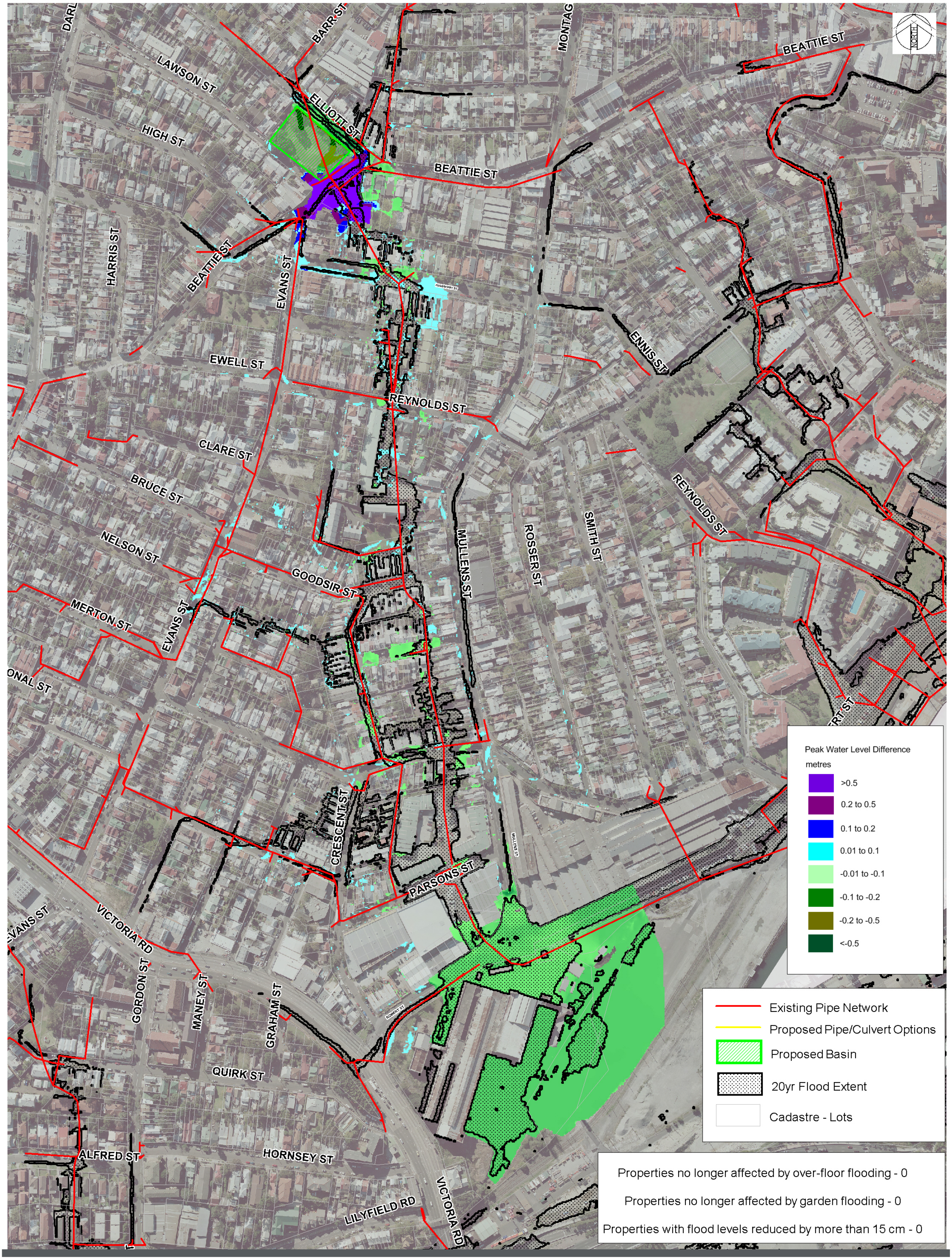

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WB_FM6 20YR ARI WL DIFF
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03/2017

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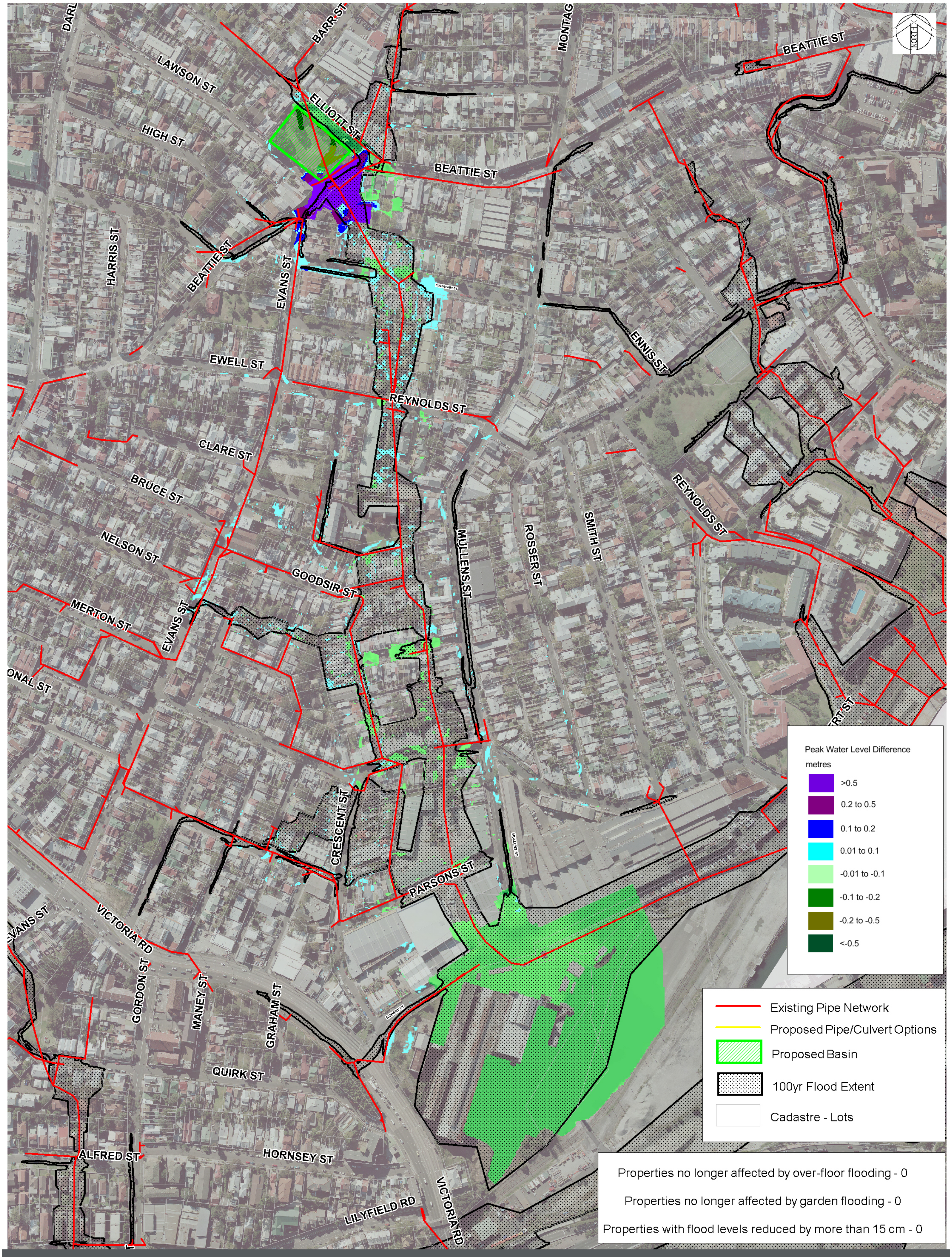

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WB_FM6 100YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A8_18

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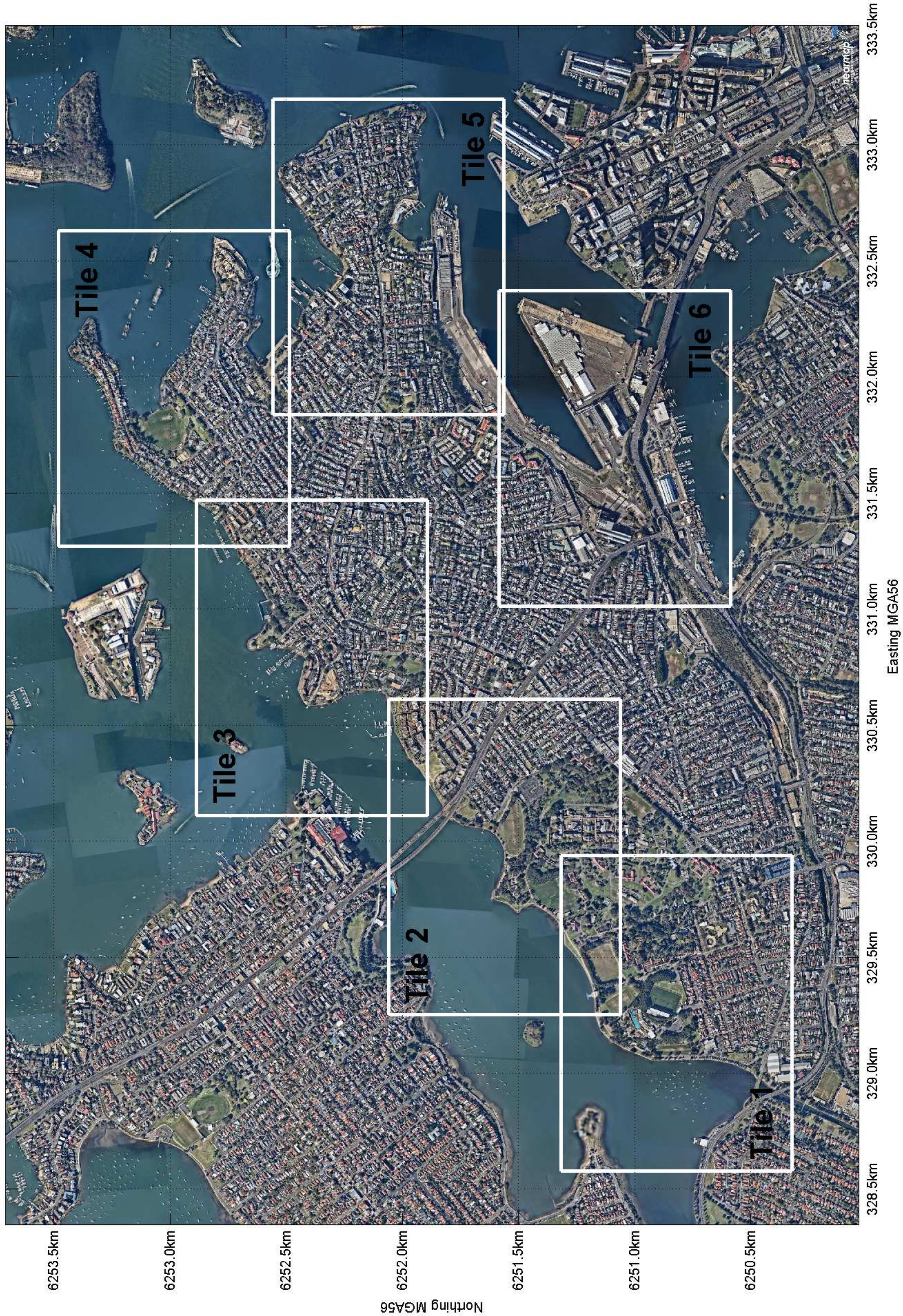
Drawing Number		Revision

APPENDIX E
FORESHORE MANAGEMENT

Shaping the Future



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Leichhardt Foreshore Options Assessment

Inundation Extents
Figure Overview

Appendix E.1

Cardno

Leichhardt Foreshore Options Assessment

Inundation Extents
Present Day − Tile 1

Appendix E.2

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Leichhardt Foreshore Options Assessment

Inundation Extents

2050 (+0.4m) − Tile 1 − Estuary Planning Level

Appendix E.3

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Leichhardt Foreshore Options Assessment

Inundation Extents

2100 (+0.9m) − Tile 1 − Estuary Planning Level

Appendix E.4

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Leichhardt Foreshore Options Assessment

Inundation Extents

2100 (+1.1m) − Tile 1 − Estuary Planning Level

Appendix E.5

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Leichhardt Foreshore Options Assessment

Inundation Extents
Present Day − Tile 2

Appendix E.6

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Leichhardt Foreshore Options Assessment

Inundation Extents

2050 (+0.4m) − Tile 2 − Estuary Planning Level

Appendix E.7

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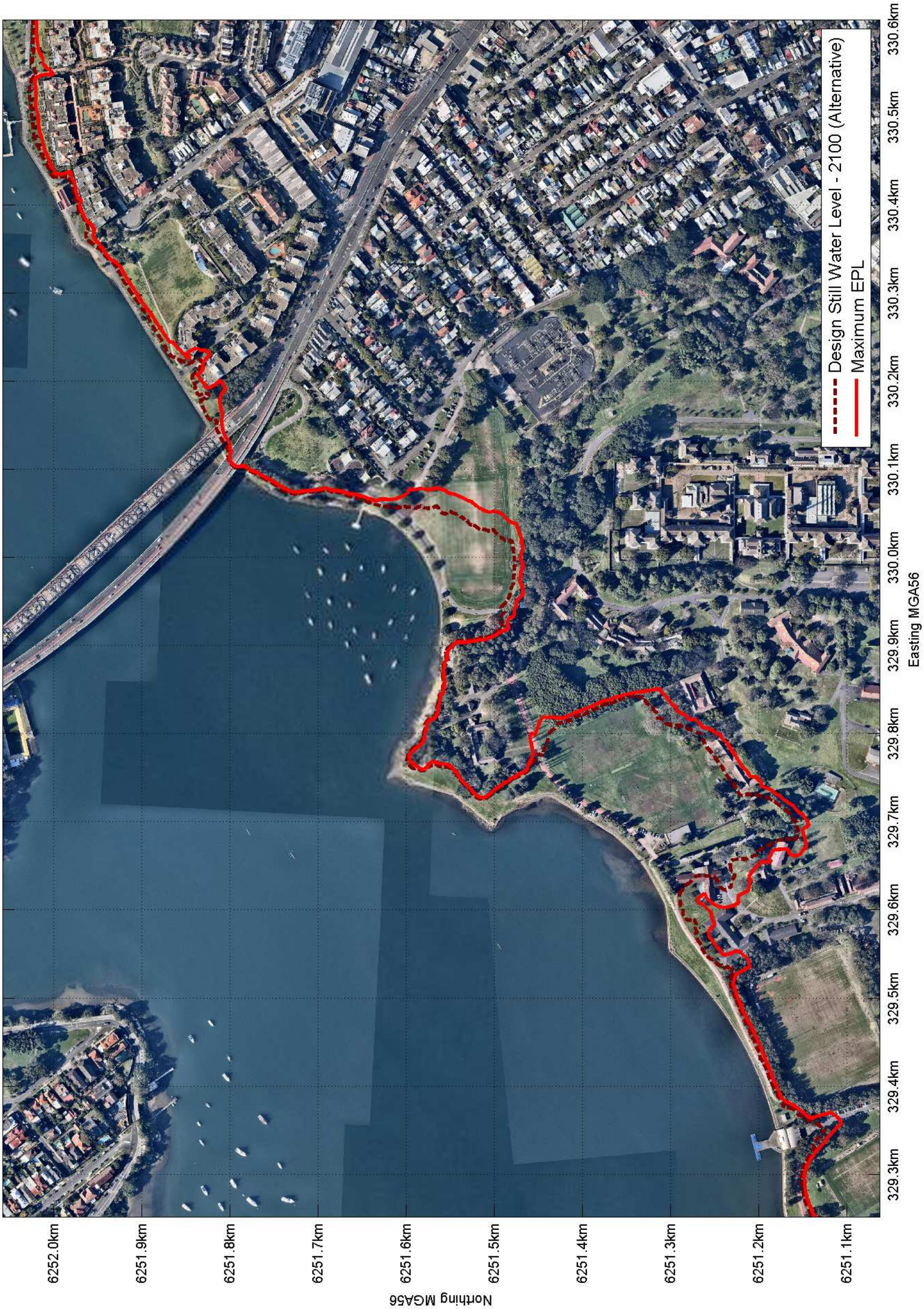
Leichhardt Foreshore Options Assessment

Inundation Extents

2100 (+0.9m) − Tile 2 − Estuary Planning Level

Appendix E.8



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Leichhardt Foreshore Options Assessment

Inundation Extents

2100 (+1.1m) − Tile 2 − Estuary Planning Level

Appendix E.9

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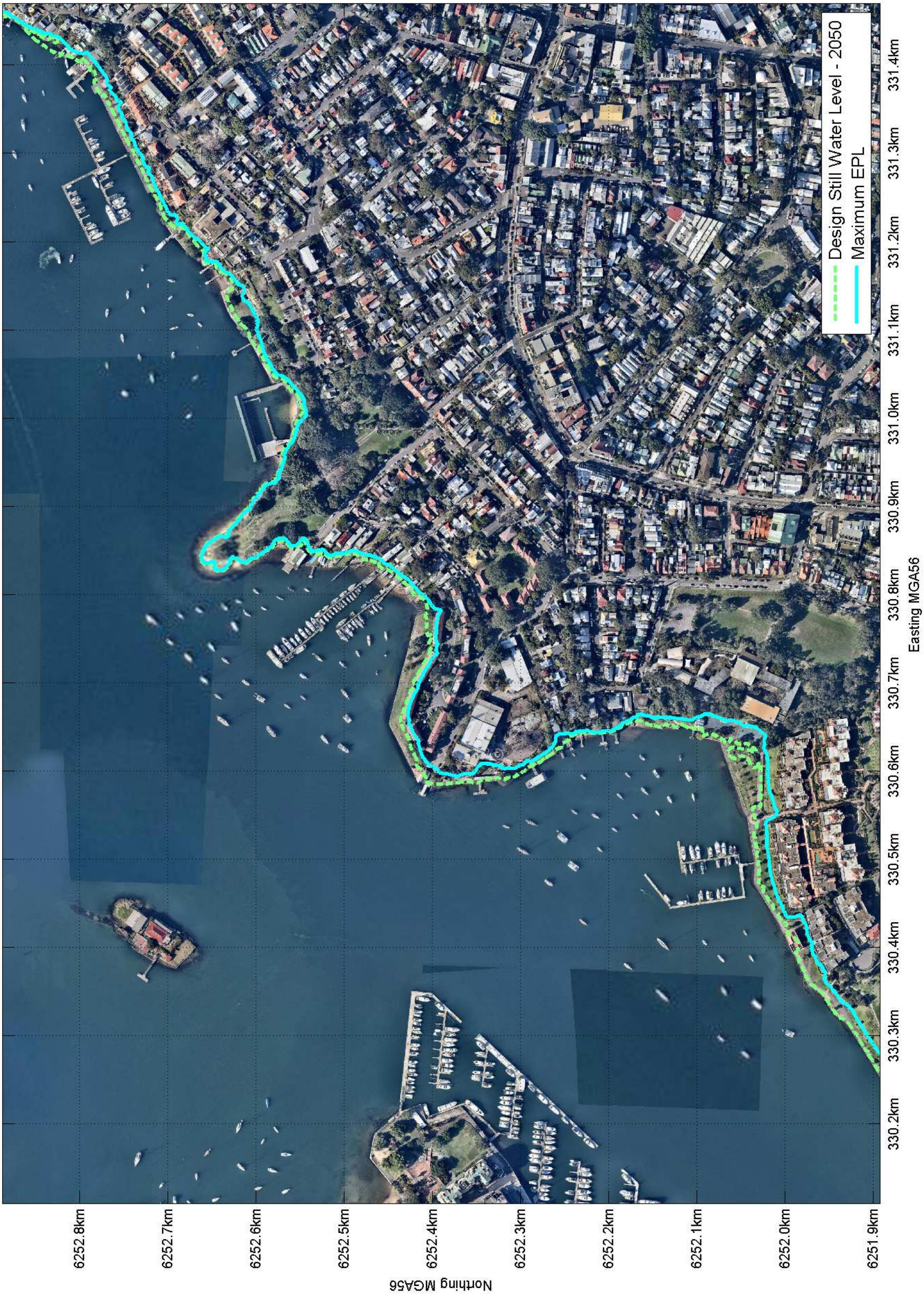
Leichhardt Foreshore Options Assessment

Inundation Extents
Present Day – Tile 3

Appendix E.10



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Leichhardt Foreshore Options Assessment

Inundation Extents

2050 (+0.4m) − Tile 3 − Estuary Planning Level

Appendix E.11

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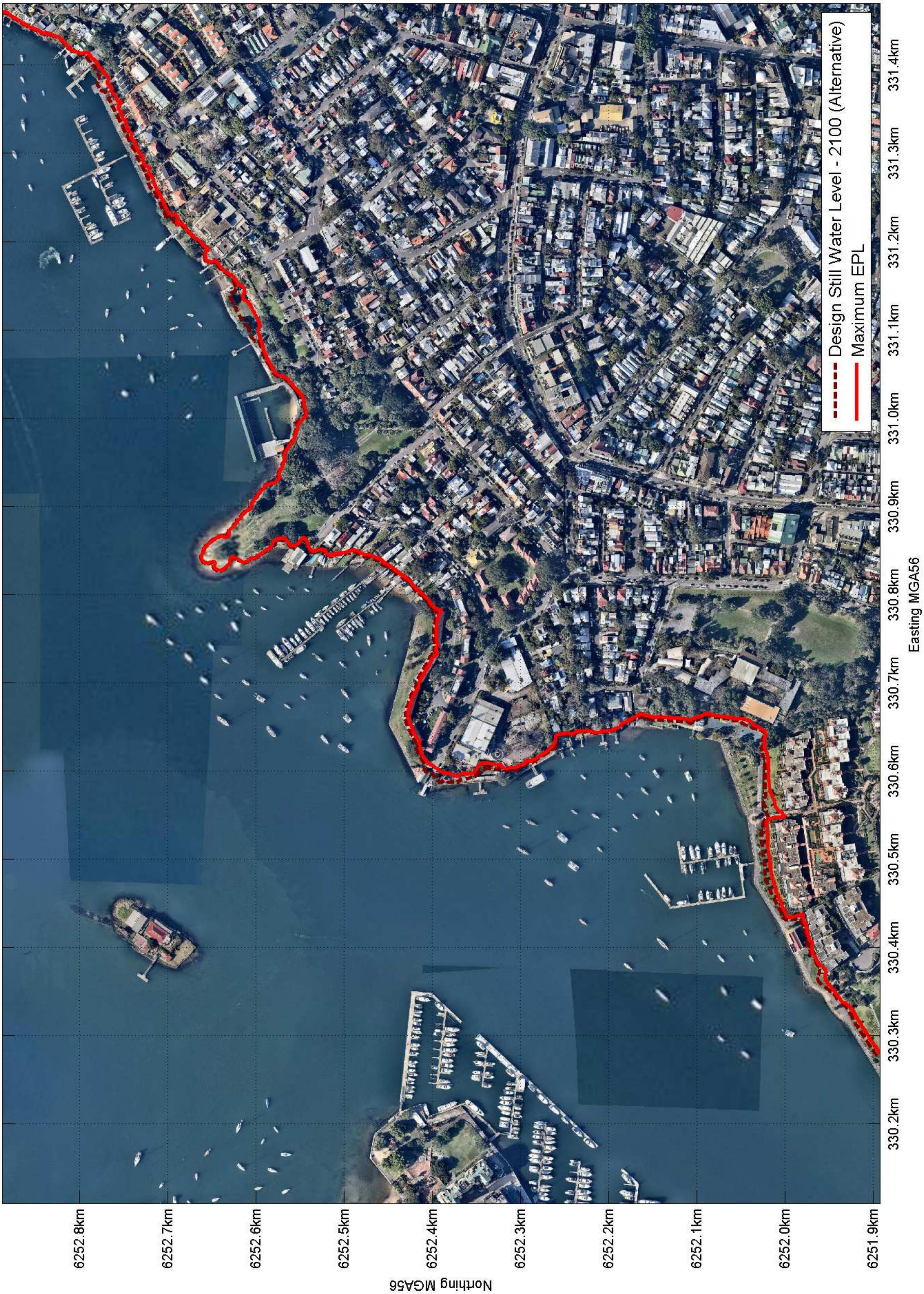
Leichhardt Foreshore Options Assessment

Inundation Extents

2100 (+0.9m) − Tile 3 − Estuary Planning Level

Appendix E.12



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Leichhardt Foreshore Options Assessment

Inundation Extents

2100 (+1.1m) − Tile 3 − Estuary Planning Level

Appendix E.13

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Leichhardt Foreshore Options Assessment

Inundation Extents

Present Day − Tile 4

Appendix E.14

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Leichhardt Foreshore Options Assessment

Inundation Extents

2050 (+0.4m) − Tile 4 − Estuary Planning Level

Appendix E.15

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Leichhardt Foreshore Options Assessment

Inundation Extents

2100 (+0.9m) − Tile 4 − Estuary Planning Level

Appendix E.16

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Leichhardt Foreshore Options Assessment

Inundation Extents

2100 (+1.1m) − Tile 4 − Estuary Planning Level

Appendix E.17

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Leichhardt Foreshore Options Assessment

Inundation Extents
Present Day – Tile 5

Appendix E.18

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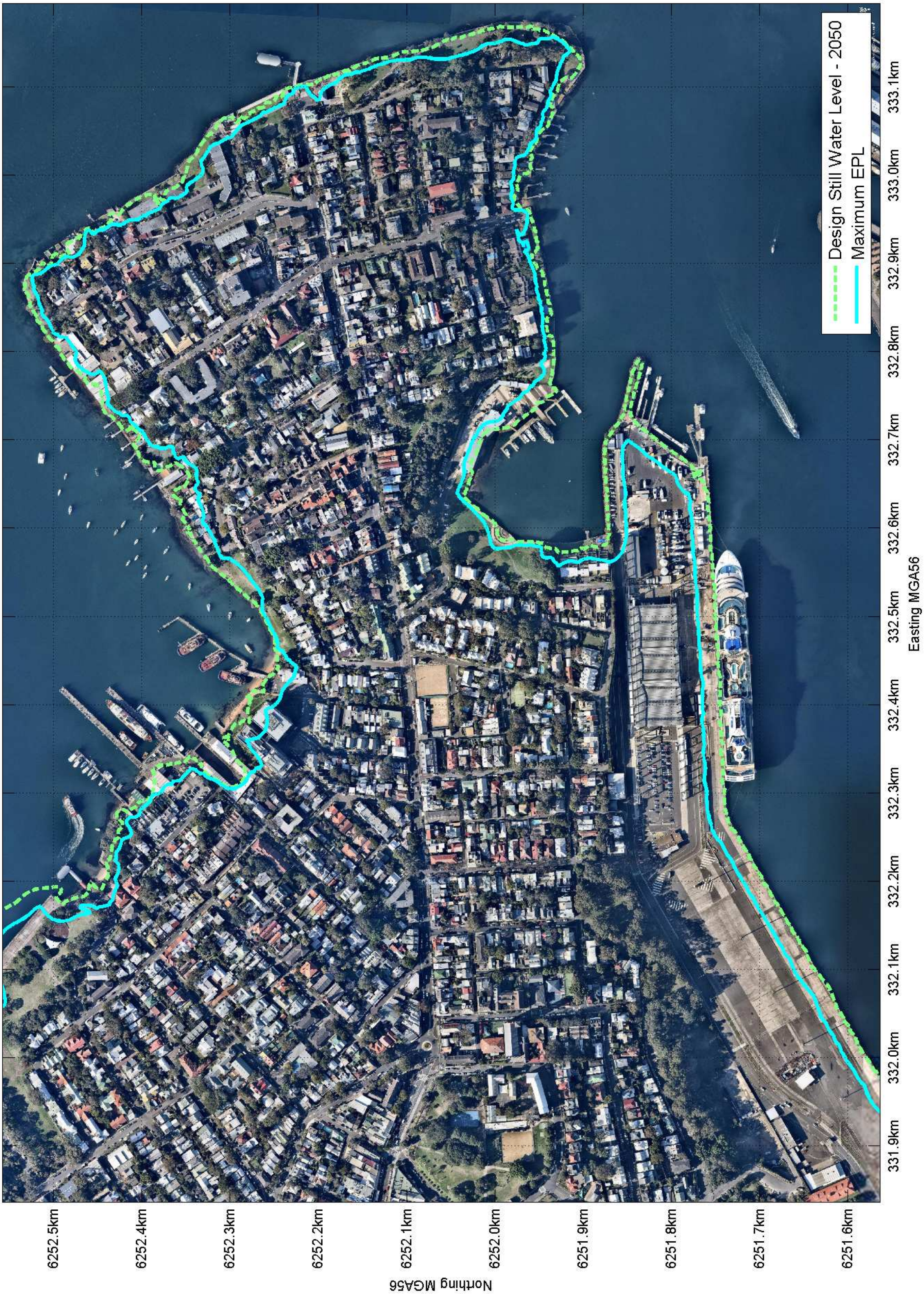

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Leichhardt Foreshore Options Assessment

Inundation Extents

2050 (+0.4m) − Tile 5 − Estuary Planning Level

Appendix E.19

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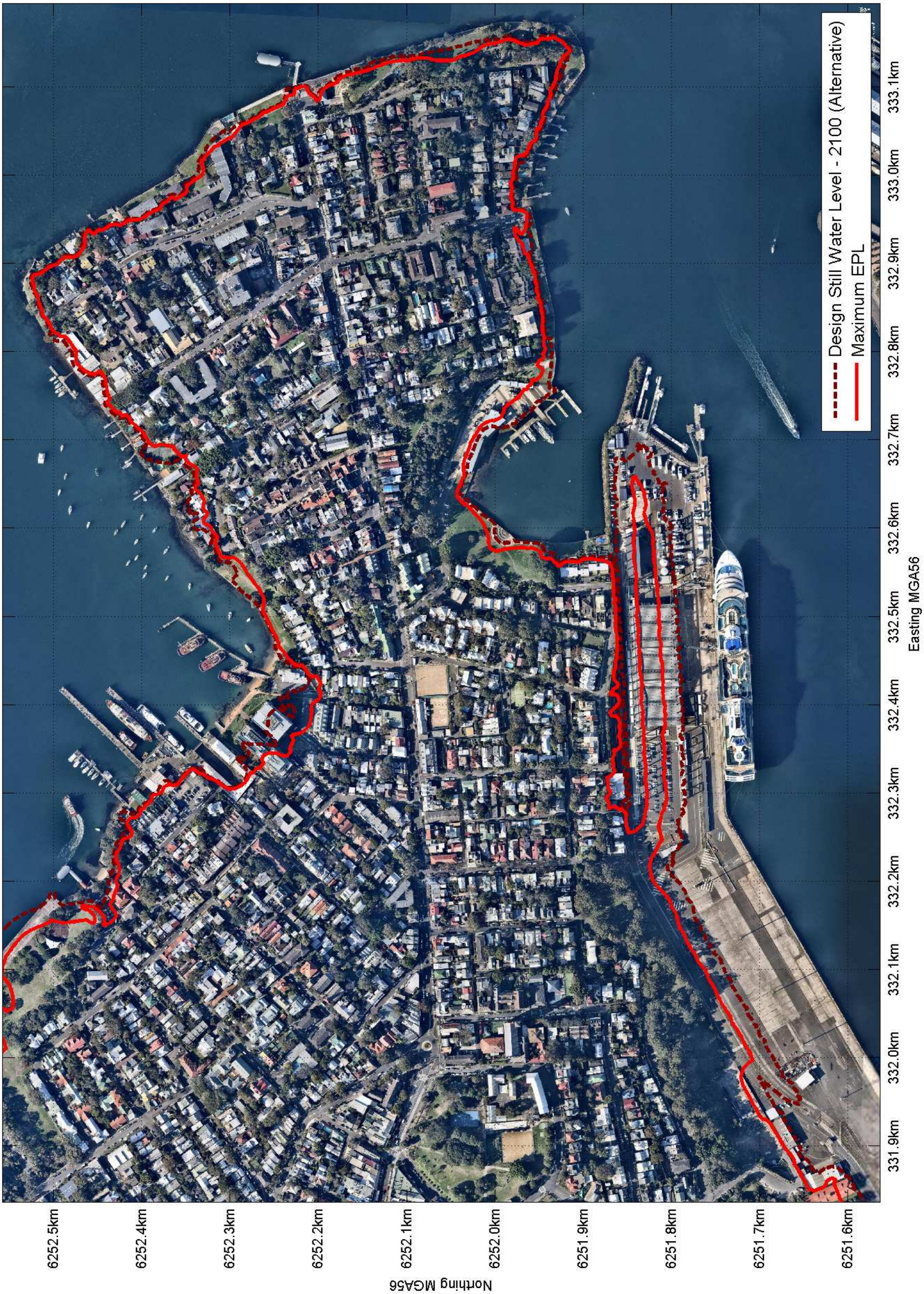
Leichhardt Foreshore Options Assessment

Inundation Extents

2100 (+0.9m) − Tile 5 − Estuary Planning Level

Appendix E.20



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Leichhardt Foreshore Options Assessment

Inundation Extents

2100 (+1.1m) − Tile 5 − Estuary Planning Level

Appendix E.21

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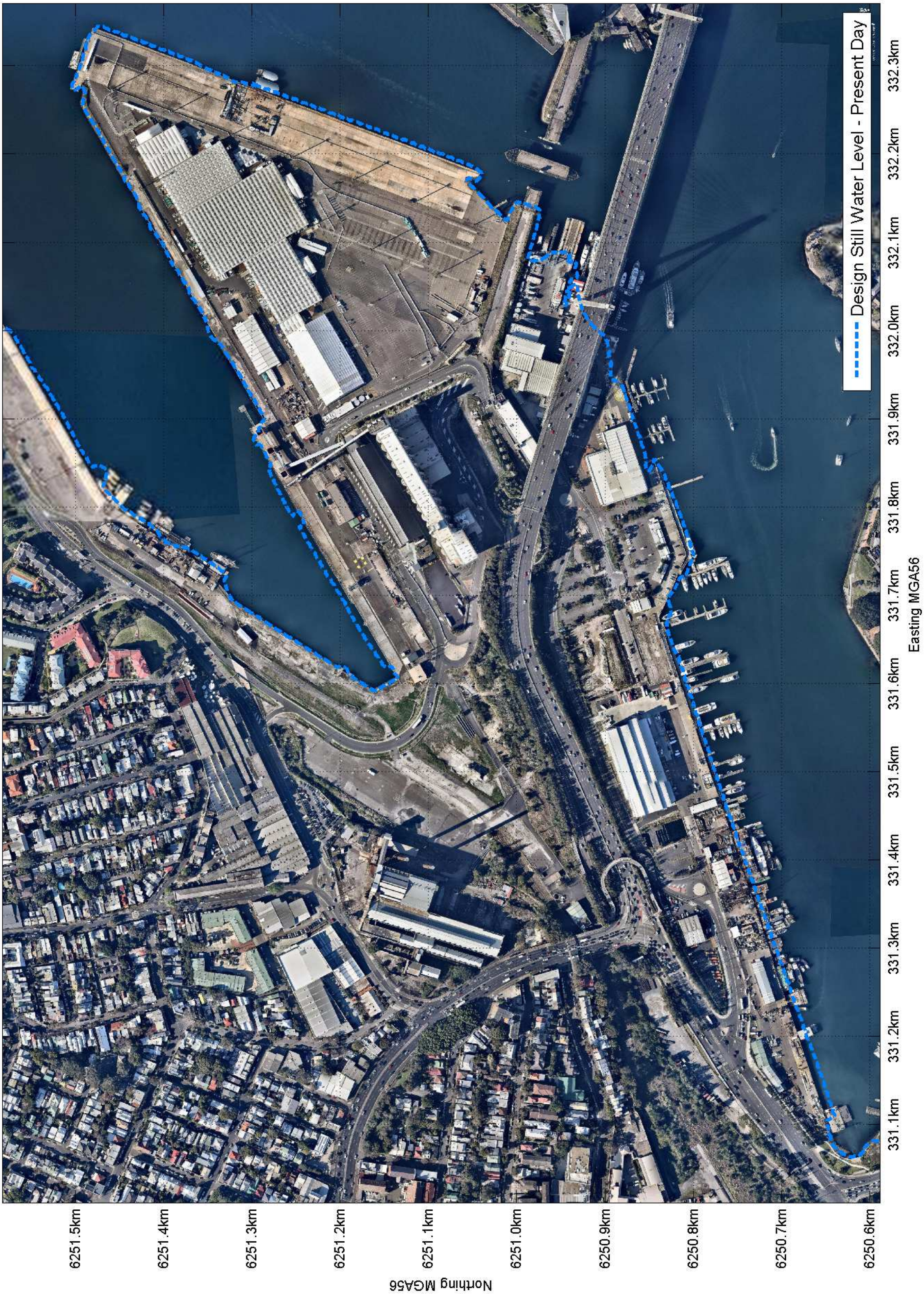

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Leichhardt Foreshore Options Assessment

Inundation Extents
Present Day – Tile 6

Appendix E.22

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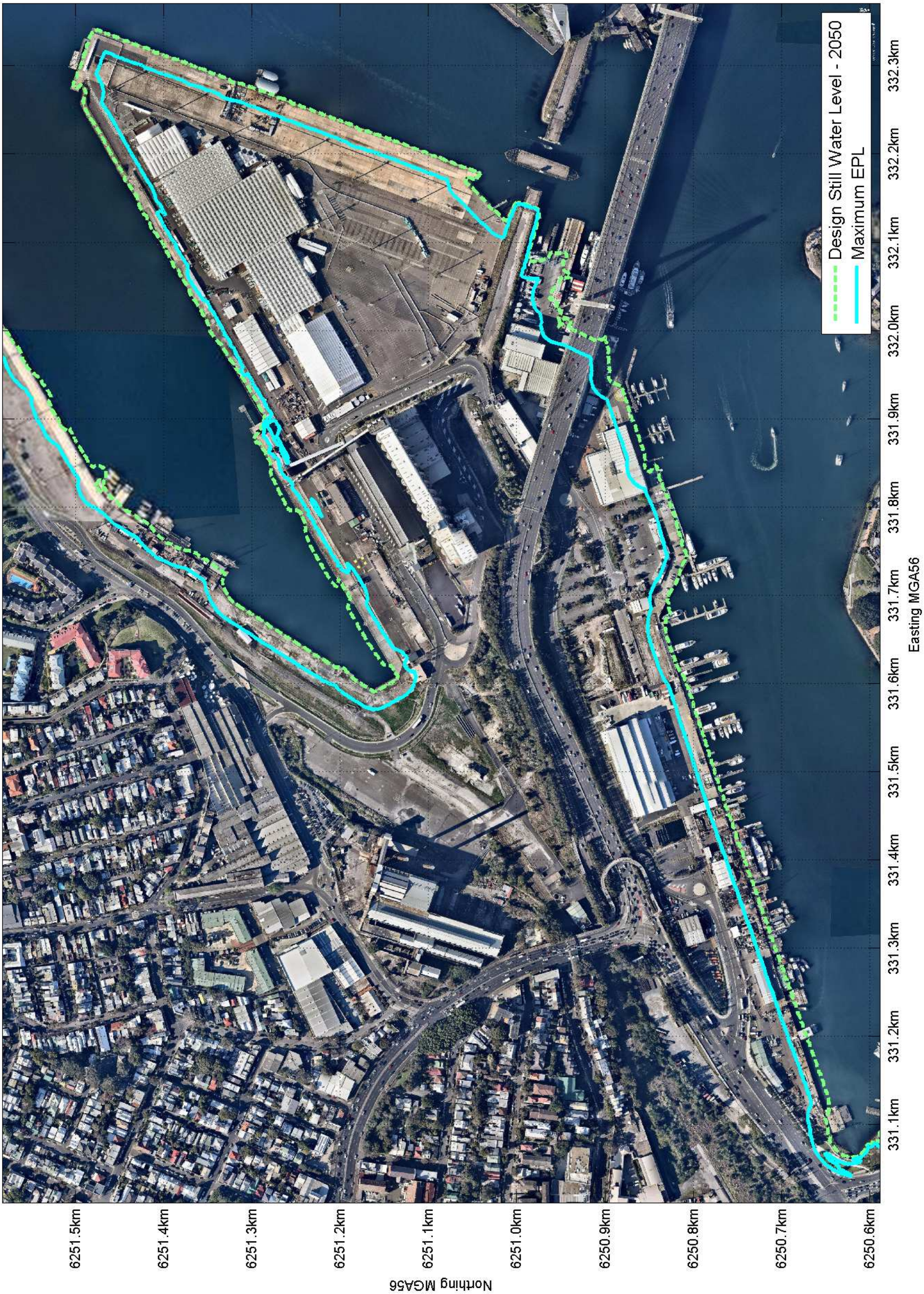

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Leichhardt Foreshore Options Assessment

Inundation Extents

2050 (+0.4m) − Tile 6 − Estuary Planning Level

Appendix E.23

Cardno

Leichhardt Foreshore Options Assessment

Inundation Extents

2100 (+0.9m) − Tile 6 − Estuary Planning Level

Appendix E.24

NA49913094 Jun 2016

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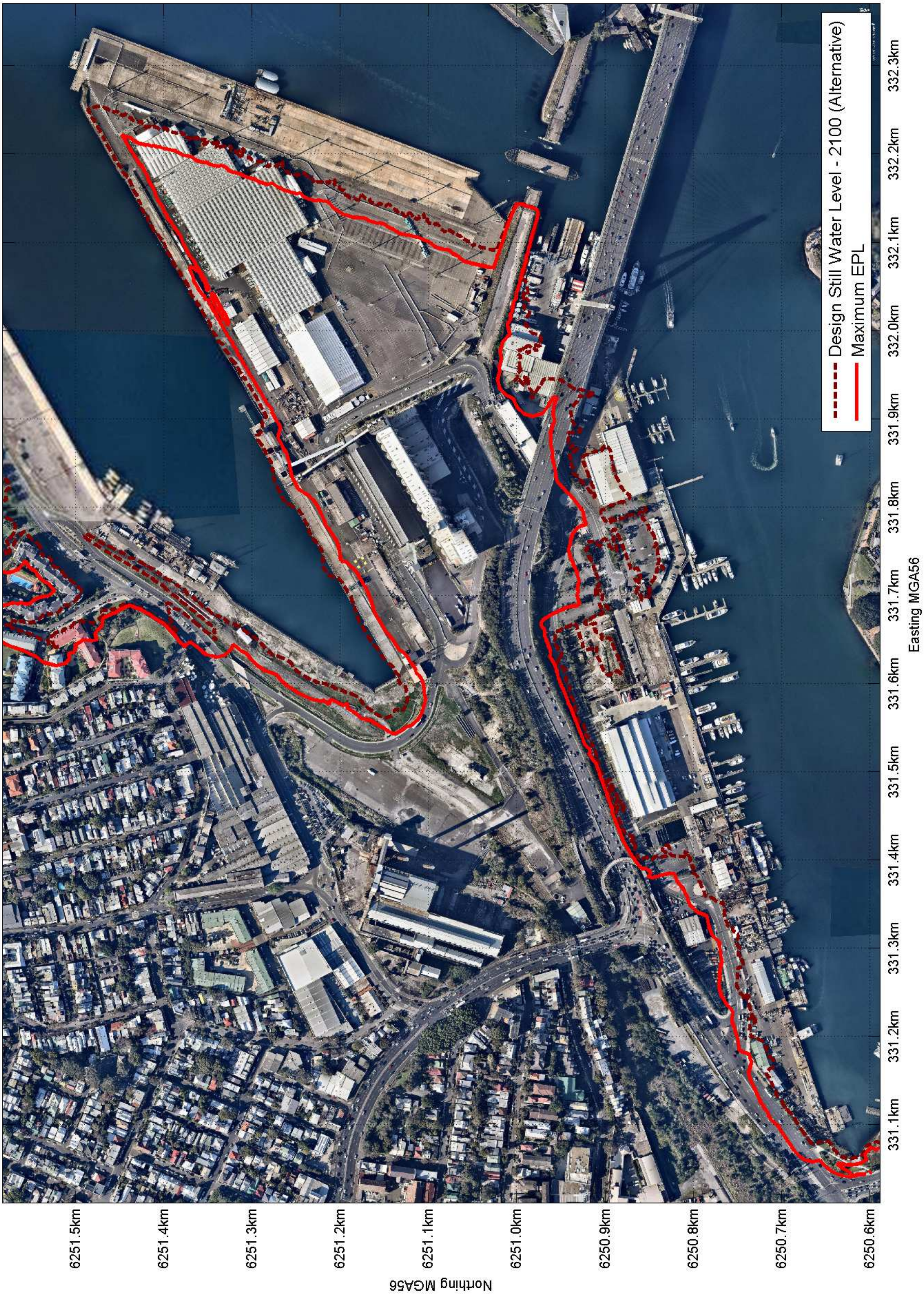

Cardno

Leichhardt Foreshore Options Assessment

Inundation Extents

2100 (+1.1m) − Tile 6 − Estuary Planning Level

Appendix E.25

NA49913094 Jun 2016

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Option ID	Location	Details	Existing Seawall Condition	Reasoning	Scenario where damage occurs	Constraints
F1	Outlet of Hawthorne Canal (north and south of Lilyfield Road)	Raise sea wall	Good - Very Good (seawall was remediated in 2014, though not raised)	- Protection of foreshore access and safety of pedestrians. - Protection of commercial and residential buildings.	- Foreshore open space area impacted by 2050 (+0.4m) SWL. - Buildings impacted by 2050 (+0.4m) EPL and 2100 (+0.9m) SWL.	- Potential impacts on visual amenity. - Development controls on future development of impacted buildings may negate the need for seawall raising for building protection.
F2a	Leichhardt Park Bay Run and Leichhardt Rowing Club	Raise sea wall	Good - Very Good (seawall was remediated in 2014, though not raised)	Iconic portion of the Bay Run and recreational areas impacted by inundation.	- Waves only at 2050 (+0.4m). - SWL at 2100 (+0.9m).	- Depending on height increase required, may impact on visual amenity.
F2b		Wave dissipation along existing seawall.		Wave dissipation might be able to be designed into seawall design without any increase in the seawall height. This area is only impacted by wave run-up and over topping in 2050 (+0.4m) so SWL protection is not required until sea levels increase beyond 0.4m.		- Depending on nature of design and visibility during low tide, may impact on visual amenity.
F3	Callan Park	Fill and raise Callan Park grounds	Medium	Significant amount of land affected by rising sea level. Crown Land. Very high amenity. Some sections of the existing seawall appear to require maintenance.	- Inundated by Still Water Level at 2050 (+0.4m).	- Fill would require drainage in order to preserve storm water conveyance. There may be funding considerations as the land is Crown Land.
F4	King Georges Park	Fill western area of King George Park	Fair	Much of King George park is significantly inundated in various scenarios. Fill may be required to preserve iconic bay run and recreational area.	- Approximately 50% of park inundated by Still Water Level at 2100 (+0.9m). - Park completely inundated by EPL at 2050 (+0.4m).	- A large area of fill is required, with potential issues arising from funding and overland flow considerations. Drainage systems would be required in order to preserve storm water conveyance.
F5	Iron cove Bridge to Balmain Campus	Raise Seawall	Good	Residential lots are affected by EPL cases, while council land is affected by both SWL and EPL. Raising the Seawall by a minor amount may reduce overtopping while retaining visual amenity of the recreational areas.	- Several buildings affected by EPL at 2100 (+0.9m). -	- Potential impacts on visual amenity.
F6	Sydney Secondary College - Balmain Campus	Raise Seawall or Fill	Good	Filling area around tennis courts and/or raising seawall in vicinity of school will reduce amount of property inundated in future scenarios.	- Tennis courts completely inundated by Still Water Level at 2100 (+0.9m).	- Potential impacts on overland flow and visual amenity.
F7	Broderick / Elliott Street	Raise seawall or Extend seaward to reduce overtopping	Good	Raise Seawall level or extend seaward to prevent overtopping and inundation of commercial properties in future scenarios.	- Approximately 5m of foreshore inundated by Still Water Level at 2100 (+0.9m).	- Development controls may be a more effective method of foreshore protection at this location.
F8	Carieville Street	Raise seawall or Extend seaward to reduce overtopping	Unknown	Properties are significantly affected by SWL in future scenarios. Most buildings are generally set back to approximately the future SWL extent, though they will be affected by overtopping.	- Some buildings near the foreshore significantly inundated by Still Water Level at 2050 (+0.4m) - Buildings which are set back will be affected by overtopping in future scenarios.	- Funding considerations, private land, Sydney Water easement.

Option ID	Location	Details	Existing Seawall Condition	Reasoning	Scenario where damage occurs	Constraints
F9	Dawn Fraser Pool	Increase structural stability of pool.	NA	Increase structural stability of pool to withstand increased inundation and wave impacts under future sea level rise scenarios.	- All events.	- Heritage value of asset.
F10	Gow Street to Cove Street	Raise seawall or Extend seaward to reduce overtopping	Fair	Some residential lots in the lee of Balmain Wharf may be affected by overtopping, raising of seawall between Gow street and Cove Street would protect significant amount of land (residential and recreational).	- Several lots affected by SWL and EPL cases in all scenarios (including existing).	- Potential impacts on visual amenity.
F11	Birchgrove Park	Fill	Very Good	Fill park in order for it to withstand sea level rise. Park is completely inundated in several future scenarios.	- Birchgrove Park approximately 70% inundated by Still Water level at 2100 (+0.9m) and 90% inundated at 2100 (+1.1m). - Birchgrove Park completely inundated by EPL in 2100 (+1.1m).	- Very large fill area which will be costly for likely low economic benefit. Overland flow needs to be considered so upstream levels do not increase as a result of the fill.
F12	Mort Bay Park	Raise Seawall to protect areas of Mort bay Park	Varying	Localised area of Mort Bay Park inundated by still water level in several scenarios. Raising seawall will protect park and foreshore.	- Park foreshore significantly inundated by Still Water level at 2100 (+1.1m). - Park partially inundated by EPL at 2100 (+0.9m).	- Major overland flow path between McKell Street and College Street needs to be considered / preserved.
F13	Waterview Street	Raise Sea Wall	Medium	Raising seawall in this vicinity would protect several infrastructure lots.	- Infrastructure lots approximately 50% inundated by Still Water level at 2050 (+0.4m).	- Overland flow in the east of the SP2 area.
F14	Propeller Park	Fill, Raise recreational Land	Good	Raising seawall will be insufficient as still water levels are so high, hence, fill is required to reduce SWL affectation.	- Recreational land significantly inundated by Still Water level at 2100 (+0.9m). - Residential land affected by Still Water level at 2100 (+1.1m)	- Major Overland Flow around Colgate Ave, costly to fill, visual amenity.
F15	Private properties on Gilchrist and Duke Place	Raise seawalls	Unknown	Low lying portions of private properties inundated. Some structures and buildings appear to be impacted.	- Existing SWL.	- Private property.
F16	Duke Street to Simmons Point Reserve	Raise seawall	Fair	Raise seawall to protect lots including B2 (Local Centre) area in future scenarios.	- Buildings partially inundated by Still Water level at 2100 (+0.9m). - Buildings significantly inundated by EPL in future scenarios.	- Minor overland flow path to be considered. Localised lack of data regarding seawall height and condition.
F17	Simmons Reserve to Lookes Ave	Raise or extend seawall	Fair	Buildings are set back from seawall, affected by EPL and mostly free from SWL inundation. Increasing seawall height would reduce overtopping at these locations.	- Foreshore area and foreshore buildings of several properties are affected by Still Water Level at 2050 (+0.4m). - Several buildings affected by EPL in future scenarios.	- Localised overland flow, funding (private property).
F18	NSW Police maritime Area Command, Jubilee Place	Raise Seawall	Fair	Raise seawall to protect police building from SWL, Overtopping is not a critical concern here as the location is low wave climate.	- Building partially inundated by Still Water Level at 2011 (+0.9m). - Building and Jubilee Park significantly affected by EPL in future scenarios.	- Minor Overland Flow.

Leichardt Floodplain Risk Management Study and Plan

APPENDIX F
MULTI-CRIERIA ASSESSMENT

Cardno
Shaping the Future

			Economic				Social				Environmental									
			1.3				*1*				*0.5*									
		BCR	Benefit Cost Ratio	Implementation Complexity	Staging of Works	Change in OF 100yr	Reduction in risk to life and social impacts	Emergency Access and Social Disruption	Compatibility of proposed works / option with Council Plans & Policies	Community and Stakeholder Support	Heritage Conservation Areas and Heritage Items	Flora / Fauna Impacts – including Street Trees	Acid Sulfate Soils	Contaminated Land	Visual Impact	Recreation Space	Score	Sub-Catchment Rank	Overall Rank	Overall Rank BCR
			5	*3*	*3*		*5*	*4*	*3*	*3*	*3*	*3*	*3*	*3*	*3*	*3*				
HC_FM1	Additional pipes /culverts from Parramatta Road to Hawthorne Canal via Beeson Street.	0.71	2	1	2	-25	4	3	1	0	-1	0	0	0	0	0	58.8	1	2	3
HC_FM2	Additional pipes or duplication of existing network from Reuss Street to Hawthorne Canal via Elswick Street, Flood Street and Marion Street.	0.17	1	1	2	-11	3	2	1	0	-2	0	0	0	0	0	41.7	4	9	15
HC_FM3	Additional pipes/culverts from Elswick Street to Hawthorne Canal (via Regent Street and Darley Road). Also extra pipes at Darley Road to reduce flood depths on the Road.	0.13	1	1	2	-18	4	3	1	0	0	0	-1	0	0	0	52.2	2	4	20
HC_FM4	Additional pipes/ culverts from William Street to Hawthorne Canal via Hubert Street and Darley Road.	0.17	1	1	2	-11	3	2	1	0	0	0	0	0	0	-1	43.2	3	7	15
HC_FM5	Proposed culverts through the rail embankment to drain flood waters from Darley Road to Hawthorne Canal.	0.17	1	2	1	-9	2	2	1	0	0	0	-1	-3	0	0	33.7	5	13	15
JC-FM1	Johnston Street Flow Path – Proposing additional pipes/ culverts and duplication of existing pipe network from Johnston St to Johnstons Creek open channel. Additional pipes on Parramatta Rd, Trafalgar St, Albion St and Nelson St.	0.25	1	1	2	-8	2	1	1	0	-1	0	0	0	0	0	34.2	1	12	9
JC-FM2	Pyrmont Bridge Road Flow Path – Additional pipes or duplication of existing network from Parramatta Rd to Johnstons Creek via Pyrmont Bridge Rd.	0.32	1	2	1	-4	1	1	1	0	0	0	0	0	0	0	30.7	2	16	7
JC-FM3	View Street Flow Path – Duplication of existing pipe network or additional pipes from View St to Johnston Creek (via Trafalgar St, Nelson St and Taylor St).	0.10	1	1	2	-1	1	1	1	0	0	0	0	0	0	0	30.7	2	16	24
JC-FM4	Rose Street Flow Path - Additional pipes from Rose St/Johnston St to Federal Park via View St and Trafalgar St. Proposed Easement downstream of The Crescent to drain flood waters from the low point of the Rd.	0.21	1	1	2	-3	1	1	1	0	-3	0	0	0	0	0	26.2	4	23	11
JC-FM5	Additional pipes within Johnstons Creek Catchment – At Bayview Crescent, Piper St and at Wigram Rd.	0.00	0	2	1	0	0	1	1	0	-4	0	0	0	0	0	13.0	5	34	30
JC-FM6	A levee or embankment is proposed on Nelson Lane, starting from the northern end of Taylor Street in order to minimise flooding adjacent to Johnstons Creek.	-2.77	-4	3	0	15	-4	-3	0	0	0	-1	0	0	-2	-2	-54.2	6	37	37
WC-FM1	Whites Creek Culvert – Proposing additional culvert or duplication of existing Whites Creek culvert from Parramatta Rd to the open channel downstream of Moore St (at Wisdom Street). Also combining WCFM2 along with this option.	0.21	1	1	2	-53	4	3	1	0	-1	0	0	0	0	-1	50.7	3	5	11
WC-FM2	Young Street Flow Path – Proposing new pipe network from Young Street/Parramatta Road to Whites Creek culvert via Young St, Albion St, Ferris St and Clarke St. Additional pipe network from Young St to Albion Street.	0.13	1	2	0	-3	1	1	1	0	0	0	0	0	0	0	26.7	9	22	20
WC-FM3	Balmain Road Flow Path – Additional pipe from the low point on Norton St to the existing pipe network (towards Parramatta Rd). Duplication of existing pipe network or extra pipes from Balmain Rd to Whites Creek Culvert at Hearn St.	1.59	3	1	2	-25	4	3	1	0	-1	0	0	-1	0	0	64.0	1	1	2
WC-FM5	Detention Basin at Mackenzie Street (upstream at the intersection of Mackenzie and Milton St)	1.85	3	2	0	-21	4	3	0	0	0	-1	0	0	0	0	58.5	2	3	1
WC-FM6	Styles Street Flow Path – Additional pipes from Mackenzie St to Whites Creek Culvert.	0.28	1	1	2	-32	4	3	1	0	-3	0	0	0	0	0	49.2	4	6	8
WC-FM8	Annandale Street Flow Path – Duplication of existing pipe network or additional pipes from Annandale St to Whites Creek culvert.	0.14	1	2	2	-5	1	1	1	0	-3	0	0	0	0	0	30.2	8	19	19
WC-FM10	Detention Basin at Catherine Street (War Memorial Park)	0.21	1	2	0	-8	2	2	0	0	0	-1	0	0	0	0	31.2	7	15	11
WC-FM11	Moore Street Flow Path – Additional Pipes from Catherine St to Whites Creek along Moore Lane.	0.13	1	2	1	-9	2	1	1	0	0	0	0	0	0	0	35.7	6	11	20
WC-FM12	Additional pipes at Brenan St and Railway PDE to reduce flooding on the roads.	0.13	1	2	2	0	0	0	1	0	-3	0	0	0	0	0	21.2	11	27	20
WC-FM13	Whites Creek Culvert/Open Channel – Proposing additional culvert or duplication of existing Whites Creek culvert from Parramatta Rd to the open channel downstream of Moore St (WC-FM1). Widening of the open channel to convey additional flows. Upgrade Bridges at Piper Street and Brenan Street (WC-FM14)	0.23	1	-1	2	-87	4	3	1	0	0	-2	0	0	0	0	42.7	5	8	10
WC-FM14	Whites Creek Bridge Upgrades –Upgrade Bridges at Piper Street and Brenan Street.	0.03	1	2	1	-2	1	1	2	0	-4	-1	0	0	0	0	26.2	10	23	27
IC_FM1	Victoria Road Branch – Additional pipes from the Victoria Rd/Terry St intersection that drains into Iron Cove	0.00	0	2	0	0	0	0	1	0	0	0	0	0	0	0	11.0	4	36	30
IC_FM2	Manning Street Branch – Additional pipes that crosses Mannings St at three locations onto other street. Toelle St, Callan St and Springside St.	0.01	1	2	1	0	0	1	1	0	-4	0	0	0	0	-1	18.2	2	31	28

			Economic				Social				Environmental									
			1.3				*1*				*0.5*									
		BCR	Benefit Cost Ratio	Implementation Complexity	Staging of Works	Change in OF 100yr	Reduction in risk to life and social impacts	Emergency Access and Social Disruption	Compatibility of proposed works / option with Council Plans & Policies	Community and Stakeholder Support	Heritage Conservation Areas and Heritage Items	Flora / Fauna Impacts – including Street Trees	Acid Sulfate Soils	Contaminated Land	Visual Impact	Recreation Space	Score	Sub-Catchment Rank	Overall Rank	Overall Rank BCR
			5	*3*	*3*		*5*	*4*	*3*	*3*	*3*	*3*	*3*	*3*	*3*	*3*				
IC_FM3	Glover Street Branch – Additional pipe along Glover St between Perry St and Church St.	0.00	0	2	1	0	0	1	1	0	0	0	0	0	0	0	19.0	1	29	30
IC_FM4	Longview Street Branch – Additional pipes to drain flooding from the low point on Longview Street.	0.00	0	2	0	0	0	1	1	0	0	0	0	0	0	0	15.0	3	33	30
MB_FM1	Colgate Street Branch – Proposing additional pipes to be incorporated into the existing network. Starting from Darling St/Queens Pl intersection, passes along Colgate Av and drains into Mort Bay. There are also additional pipes on St Andrews St and Cooper St.	0.01	1	2	2	0	0	1	1	0	-3	0	-1	0	0	0	23.7	2	26	28
MB_FM3	Curtis Rd Branch – Propose additional pipes along Mort St and Clayton St and connecting to an additional proposed pipe on Cameron St (MB-FM4) which drains into Mort Bay.	0.00	0	2	2	0	0	1	1	0	-1	0	0	0	0	-1	20.0	3	28	30
MB_FM4	College Street Branch – Additional pipe network starting from the Cardwell/North St intersection, travelling along (SE) Macquarie St and the Curtis Rd. The pipe branches off into Phillip St, Church St and College St and finally connects into the existing Sydney Water pipe and to the proposed pipe on Cameron St which drains into Mort Bay.	0.00	0	2	2	0	0	1	1	0	-2	0	0	0	0	-1	18.5	4	30	30
MB_FM5	McKell Street Branch – Additional pipe from Short St that crosses McKell St and drain into Mort Bay	0.08	1	2	1	-1	1	1	1	0	0	0	0	0	0	-1	29.2	1	20	25
SB_FM1	Cove Street Branch – The proposed pipe starts from the Cove/Birchgrove St Intersection and then goes along Ferdinand St and connects to the existing pipe network in The Terrace. Additional pipes along Grove St, Rose St and Bay St.	0.00	0	2	1	0	0	1	1	0	-2	0	0	0	0	0	16.0	1	32	30
RB-FM1	Lilyfield Road Flow Path – Proposing additional pipes or duplication of existing pipe network. Proposed pipes connecting into the existing network at O' Neill St. Additional pipes from the low point on Denison St to the outlet at Rozelle Bay. Additional pipe network in Quirk Street, Gordon Street and Lilyfield Road with a branch along Alfred Street.	0.37	1	1	2	-8	2	2	1	0	-3	0	-2	0	0	-1	30.7	1	16	6
RB-FM2	Additional Culverts/Pipes across Lilyfield Road at four locations. From Joseph Street along Halloran Street to Lilyfield Road, Edward St, Justin St, Cecily St and Brenan Street South of the railyards.	0.04	1	2	1	-1	1	1	1	0	0	0	0	0	-2	0	27.7	2	21	26
WB-FM1	Beattie Street Branch – Proposing a new pipe network or duplication of existing pipe network. Starting from Llewellyn St to the outlet at White Bay. The trunk drainage starts from Roseberry St at the start and Robert St to the end. Then travelling East, parallel to Robert St and eventually draining into White Bay.	0.20	1	1	2	-35	4	3	1	0	-4	0	-1	-3	0	0	41.7	1	9	14
WB-FM2	Wortley Street Branch – Proposing additional pipes to be incorporated into the existing pipe network. Additions at Creek St, Wortley St, Foy St, Hyam St, Roseberry Place and eventually crossing Robert St to drain into White bay.	0.41	1	1	2	-10	2	2	1	0	-3	0	0	0	0	-1	33.7	2	13	4
WB-FM3	Reynolds Street (Wortley Street) Proposed Basin – Proposed basin in Punch park, situated next to Reynolds St.	0.39	1	1	0	-2	1	1	0	0	-3	-1	-1	0	0	0	12.2	4	35	5
WB-FM4	Montague Street Branch and additional pipes – Proposing additional pipes from Montague St that connect into the existing network.	0.15	1	2	0	-2	1	1	1	0	-1	0	0	0	0	0	25.2	3	25	18

	Economic							Social						Environmental							
	1.3							1						0.5							
	Likely Reduction in Flood Damages		Capital Cost		Operating and Maintenance Cost	Implementation Complexity	Staging of Works	Increased Awareness	Improved Response	Emergency Access	Reduction in risk to life	Compatibility of proposed works / option with Council Plans & Policies	Community and Stakeholder Support	Heritage Conservation Areas and Heritage Items	Flora / Fauna Impacts – including Street Trees	Acid Sulfate Soils	Contaminated Land	Visual Impact	Recreation Space	Score	Rank
	5		4		4	4	3	5	5	4	5	3	3	3	3	3	3	3	3		
PM1 – Review of LEP Wording	1	$ -	0	$ -	0	4	0	0	0	0	1	2	0	0	0	0	0	0	0	38.3	4
PM2 – DCP Review for Effective Flood Access	0	$ -	0	$ -	0	4	0	0	0	1	3	1	0	0	0	0	0	0	0	42.8	2
PM3 – DCP 2013 Review for Car Parking Controls	0	$ -	0	$ -	0	4	0	0	0	0	3	2	0	0	0	0	0	0	0	41.8	3
PM4 – Onsite Detention Requirements	1	$ -	0	$ -	0	4	0	0	0	1	1	0	0	0	0	0	0	0	0	36.3	5
PM5 – Flood Planning Level	0	$ -	0	$ -	0	4	0	1	0	0	1	1	0	0	0	0	0	0	0	33.8	6
PM6 – Voluntary House Purchase	4	$ 800,000	-3	$ 126,000	-2	-2	2	0	0	0	2	0	0	0	0	0	0	1	2	11.9	9
PM7 – Voluntary House Raising	4	$ 320,000	-2	$ -	0	-3	2	0	0	0	1	0	0	0	0	0	0	0	0	12.8	8
PM8 – Incentives for Flood Compatible Redevelopment	4	$ 40,000	-1	$ 40,000	-2	-2	2	3	0	0	1	0	0	0	0	0	0	0	0	27.8	7
PM9 – Strategic Planning	3	$ -	0	$ -	0	3	0	0	0	1	3	3	0	0	0	0	0	0	1	64.6	1
EM1 – Information Transfer to SES	0	$ -	0	$ -	0	4	0	0	3	0	1	0	0	0	0	0	0	0	0	40.8	3
EM2 – Prepare a Local Flood Plan	0	$ -	0	$ -	0	4	0	4	4	0	1	0	0	0	0	0	0	0	0	65.8	1
EM3 – Public Awareness and Education	0	$ 30,000	-1	$ 5,000	-2	4	1	4	3	0	1	0	0	0	0	0	0	0	0	49.1	2
EM4 – Early Warning Alert System	0	$ 60,000	-2	$ 10,000	-2	-2	1	3	4	0	3	0	0	0	0	0	0	0	0	22.7	4
EM5 – Flood Warning Signs at Critical Locations	0	$ 165,000	-2	$ 33,000	-2	-2	2	3	3	0	3	0	0	0	0	0	0	-1	0	20.1	5
EM6 – Establish Evacuation Centres	0	$ 100,000	-2	$ 20,000	-2	-1	2	0	3	0	3	0	0	0	0	0	0	0	0	11.8	6
EM7 – Improved Flood Access	0	$ 3,000,000	-4	$ 50,000	-2	-3	2	0	0	4	4	0	0	0	0	0	0	0	0	-3	7

Leichhardt Floodplain Risk Management Study and Plan

APPENDIX G

PUBLIC EXHIBITION RESPONSES

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Leichhardt Flood Risk Management Plan and Study feedback form Public Exhibition

Date of contribution	Survey Response				Responses post exhibtion period	
	Do you have any comments on the Emergency Management Options?	Do you have any comments on the Property Modification Options?	Do you have any comments on the Structural Flood Modification Options?	Do you have any other comments?	Response - Council	Acknowledgement letter
Aug 15 17 08:49:54 pm	NA	NA	can the plan be detailed by sub-catchment? I am not clear what is proposed for Iron Cove, especially the foreshore - the map shows my property on a PMF area (next to the Balmain high school in Rozelle)	Is the plan taking into account likely rising of water level with global warming? the whole bay is at risk (and the waterfront properties). it's probably for the whole city rather than just the council, but would be good to investigate some type of levee / dam to control the water level...	Thank you for your submission in relation to the recent public exhibition of the draft Leichhardt Flood Risk Management Study and Plan. All feedback received during the exhibition period will be considered by Council's Consultants (Cardno) in consultation with Council. A report on the feedback received during the exhibition period will be prepared for Council's Flood Management Advisory Committee prior Council's consideration of the same at a Council meeting during early 2018. Council will notify all persons who made a submission during the exhibition period in writing of the meeting date.	8-Nov-17
Sep 18 17 10:31:34 am			1) You have shown the possible impact of many discrete modification options to the culvert / pipe network. Is there a flood simulation map that shows the overall effect of all of these proposals being implemented together? 2) You are proposing a large amount of additional flow into Whites Creek. Each of these proposals indicates the expected size of the new pipe / culvert to Whites Creek to provide added capacity. Does this size reflect the required pipework for that particular proposal, or the the size it will need to be if all of the proposals are implemented? 3) Figure 4.2 in the LFRMP lists the modification options, presumably in the order that they are recommended to be implemented. The first option listed is WC-FM3, which, if implemented in isolation, is actually detrimental to my immediate area. If it has a negative effect on the 20yARI flooding beside my house, as per the map, it will also worsen the consequences of the 100yARI and PMF event. I would object to any such modification if it is not done in conjunction with another modification option that will at least neutralise, if not improve the overall effect. 4) I own a house adjacent to Whites Creek (on Arguimbau St). The flood study proposes a new 3100 x 2100 culvert - will this be simply built alongside the existing? 5) In increasing the catchment of Whites Creek, is there going to be work undertaken along Whites Creek itself to minimise the effects of flooding on adjacent / nearby residences? Will there be improved drainage to the streets that are immediately surrounding this main culvert?	Thanks for your work in flood management. I hope that through these works you can rescue my house from being at risk in a PMF.	Thank you for your submission in relation to the recent public exhibition of the draft Leichhardt Flood Risk Management Study and Plan. All feedback received during the exhibition period will be considered by Council's Consultants (Cardno) in consultation with Council. A report on the feedback received during the exhibition period will be prepared for Council's Flood Management Advisory Committee prior Council's consideration of the same at a Council meeting during early 2018. Council will notify all persons who made a submission during the exhibition period in writing of the meeting date. In response to the particular matter you raised, the Leichhardt Flood Risk Management Study and Plan is a high level planning document that identifies the outcomes or reduction in flooding that could be achieved should a given structural flood modification (FM) option be implemented in the general vicinity shown in the Study and Plan. Notwithstanding this, it is a fundamental criteria that any works undertaken should not adversely impact properties upstream or downstream of the works. In this regard, Council would not implement structural flood modification option WC-FM3 in isolation if doing so would be detrimental to downstream properties.	8-Nov-17
Aug 27 17 04:33:32 pm	no	no	yes Thank you for your letter containing information on the draft flood control mapping. I have grave concerns that my property at Young Street, Annandale has been identified as a 'flood control lot'. Assuming the issue the authors of the 1 in 100 Year Flood report have with this area is the speed with which storm water drains from the centre of this part of Young Street. I feel there are three relevant points to make: • The older houses in the street date from around 1900 (was built in 1902). Since this time more of the surface area has been sealed causing a change in run off patterns. Development and change is still occurring in this area and there is no reason to suppose the run off patterns will not change again as a result of this. Identification of a flood control lot based on a totally static urban environment (the 2009 'snap short') would appear short sighted. • If council perceives storm water drainage parallel to this part of Young Street to be a problem, one option would be to install storm water drains to assist this run off. I see this has been proposed on p76 of the report and I strongly support its actioning. • Currently there is 'rear to kerb' parking on the lower (west) side of Young Street and 'parallel to kerb' parking on the upper side. Council may recognise that car tyres against the kerb can restrict the flow of water parallel to the street, at times exacerbated by build up of leaves trapped by the tyres. This can lead to build up of water in the mid-section of this part of Young Street. This can be solved (cheaply) by one of two methods: 1) Install concrete 'stops' a short distance from the kerb to prevent parking of vehicles directly on the kerb, or 2) (suggested by a neighbour) make rear to kerb parking on the upper side of Young Street and parallel parking on the lower side. I have one question: if the drainage proposed on p76 of the report goes ahead, does this mean that the houses in the middle of this block of Young St will NOT be classified as flood lots?		Thank you for your submission in relation to the recent public exhibition of the draft Leichhardt Flood Risk Management Study and Plan. All feedback received during the exhibition period will be considered by Council's Consultants (Cardno) in consultation with Council. A report on the feedback received during the exhibition period will be prepared for Council's Flood Management Advisory Committee prior Council's consideration of the same at a Council meeting during early 2018. Council will notify all persons who made a submission during the exhibition period in writing of the meeting date. In response to the particular matter you raised, following completion of any of the structural flood modification (FM) options in the future, flood modelling would be again undertaken to identify any changes required to the Flood Control Lot mapping. At that time any properties no longer considered flood affected will be notified and removed from being classified as a Flood Control Lot.	8-Nov-17
Aug 15 17 05:39:41 pm	no	something needs to be done with future planning proper easements for upgrading of pipes and more stormwater drains in suburban streets..	not enough detail visible on pdf	I have not managed to read the whole study but I did go to the maps at the back. We live on Louisa road, in a house that sits proximate at street level to the two main stormwater drain entry points for the street. We have had flooding into the house because of the stormwater drains not being sufficient to drain rain in heavy storms. Despite this , Lousia Road is not flagged as having any flooding hazards. This is an oversight. The street does not have adequate storm water drainage as too many people have been allowed to build over potential access points to the pipe. The pipe into the harbour is also very old and narrow. Most of our house is not visible from street level as it drops down to the the harbour; this has meant that water has come from the street under the door and down into the lower levels. I think the consultants should have come to talk to owners of properties such as ours. We have made several submissions to council in the past to get the problem rectified but no action that we have been advised of. Thank you	Thank you for your submission in relation to the recent public exhibition of the draft Leichhardt Flood Risk Management Study and Plan. All feedback received during the exhibition period will be considered by Council's Consultants (Cardno) in consultation with Council. A report on the feedback received during the exhibition period will be prepared for Council's Flood Management Advisory Committee prior Council's consideration of the same at a Council meeting during early 2018. Council will notify all persons who made a submission during the exhibition period in writing of the meeting date.	8-Nov-17
Aug 19 17 09:49:57 am				Is Carlisle Street a flood control lot? I could not tell from the maps attached to the report. Carlisle Street should not be a flood control lot.	Thank you for your submission in relation to the recent public exhibition of the draft Leichhardt Flood Risk Management Study and Plan. All feedback received during the exhibition period will be considered by Council's Consultants (Cardno) in consultation with Council. A report on the feedback received during the exhibition period will be prepared for Council's Flood Management Advisory Committee prior Council's consideration of the same at a Council meeting during early 2018. Council will notify all persons who made a submission during the exhibition period in writing of the meeting date. In response to the particular matter you raised, your property is no longer classified as a Flood Control Lot in Leichhardt DCP 2013.	8-Nov-17

Date of contribution	Survey Response				Responses post exhibtion period	
	Do you have any comments on the Emergency Management Options?	Do you have any comments on the Property Modification Options?	Do you have any comments on the Structural Flood Modification Options?	Do you have any other comments?	Response - Council	Acknowledgement letter
Aug 15 17 05:04:34 pm	no	no	there is less infrastructure or street planting of trees which soak up a lot of water how about that massive parramatta road a lot of concrete surface area i dont know if the council can do it or is it the states responsibility but after the west connex is built which is supposed to take 60 000 cars off parramatta rd they could green or plant trees plus parking and or retention pits on the kirb lanes reducing surface run off which im sure it generates enormous amounts of water flow	only for parramatta rd needs landscaping I know the great god car has the first priority but if property owners have to modify, then the roads have to they contribute equally to the problem of flooding	Thank you for your submission in relation to the recent public exhibition of the draft Leichhardt Flood Risk Management Study and Plan. All feedback received during the exhibition period will be considered by Council's Consultants (Cardno) in consultation with Council. A report on the feedback received during the exhibition period will be prepared for Council's Flood Management Advisory Committee prior Council's consideration of the same at a Council meeting during early 2018. Council will notify all persons who made a submission during the exhibition period in writing of the meeting date.	8-Nov-17
Sep 08 17 01:17:26 am	run to higher ground			well you could stop planting stupid gum trees in the streets for a start, Fix the canals and the existing drainage system so it will cope. also I've been here for 30 years I never seen any Flooding up Marion street coming into people homes and nor have you. please don't waste my tax money on flood level meters ridiculous!' this is not QLD. and thanks for helping put my insurance premiums up well done! glade to see your on top of the job predicting the Future	Thank you for your submission in relation to the recent public exhibition of the draft Leichhardt Flood Risk Management Study and Plan. All feedback received during the exhibition period will be considered by Council's Consultants (Cardno) in consultation with Council. A report on the feedback received during the exhibition period will be prepared for Council's Flood Management Advisory Committee prior Council's consideration of the same at a Council meeting during early 2018. Council will notify all persons who made a submission during the exhibition period in writing of the meeting date.	8-Nov-17
Aug 16 17 11:18:38 am	N/A	N/A	N/A	This consultation is being managed very poorly. 1. The correspondence landed at out house on 15 August at 3.15pm and I rang to speak to someone at 3.30pm only to be told no one was available. Surely you guys would have someone manning the phones on the day the info landed... I spoke to someone in customer service who told me not to worry that the correspondence included mention of property acquisition as it "wouldn't happen tomorrow". I then spoke to a supervisor who assured me that someone would ring me first thing the next morning (16 August). Late morning and nobody has bothered to call me. 2. The draft plan and study are very technical documents that are hard to understand and it is almost impossible to interpret what it means for me specifically. I'm not sure how I can comment on any of the above points without being a flood expert or knowing what it means specifically for my property. It would have been really useful to have a summary of what the plan means in practical terms for landowners, and particularly for landowners in different catchments. 3. The FAQ's really don't provide a clear explanation of what any of this means for me, only a vague reference to the possibility of increased insurance premiums. We need a clear understanding of the potential implications and impacts of the plan on owners of flood control lots. 4. Filling out this form requires me to comment on the above points (the form states they can't be blank) but I don't have the expertise to understand your 79 page technical document and they are necessarily the pints I want to comment on. Frankly it's a bit like push polling...	Thank you for your submission in relation to the recent public exhibition of the draft Leichhardt Flood Risk Management Study and Plan. All feedback received during the exhibition period will be considered by Council's Consultants (Cardno) in consultation with Council. A report on the feedback received during the exhibition period will be prepared for Council's Flood Management Advisory Committee prior Council's consideration of the same at a Council meeting during early 2018. Council will notify all persons who made a submission during the exhibition period in writing of the meeting date.	8-Nov-17
Aug 16 17 12:02:21 pm	More civil servants	more costs	no	As my front door is 47 meters above high tide approximately I do not consider even a 1 in a 100 event will cause much of a problem. The generic nature of the boundaries on the map are ridiculous, but not at all unusual from a council. Be more specific.	Thank you for your submission in relation to the recent public exhibition of the draft Leichhardt Flood Risk Management Study and Plan. All feedback received during the exhibition period will be considered by Council's Consultants (Cardno) in consultation with Council. A report on the feedback received during the exhibition period will be prepared for Council's Flood Management Advisory Committee prior Council's consideration of the same at a Council meeting during early 2018. Council will notify all persons who made a submission during the exhibition period in writing of the meeting date.	8-Nov-17
Sep 13 17 12:01:31 pm	Early warning Alert system sounds great, everything else is a waste of money: - People don't read signs	- Making onsite detention mandatory if its isn't already on new developments	Not sure how your MCA works but structural measures should be assessed based on cost vs effect on flood level and how what area it effects. This will ensure structural measures implemented first have greatest effect onr educing flood hazard to teh most people.		Thank you for your submission in relation to the recent public exhibition of the draft Leichhardt Flood Risk Management Study and Plan. All feedback received during the exhibition period will be considered by Council's Consultants (Cardno) in consultation with Council. A report on the feedback received during the exhibition period will be prepared for Council's Flood Management Advisory Committee prior Council's consideration of the same at a Council meeting during early 2018. Council will notify all persons who made a submission during the exhibition period in writing of the meeting date.	8-Nov-17
Sep 28 17 07:29:43 am		I have been communicating with the council about this issue and have had officers out to look at my property. The property modifications provided by council are extremely expensive and I have concerns that the development application for this property (submitted by previous owners) didn't require drainage in the front and council approved this knowing it was a flood risk area.	We strongly need option WC-FM1 or WC- FM13 to go ahead for our neighbourhood. We have significant flooding on the street not only when there is heavy rain, but also when we have moderate rain fall. As we live on Ferris st, all of the water comes down from Parramatta rd and down Albion st from Johnston, Annandale, Young and the drainage is not sufficient to manage the volume. My property and my neighbours property have been flooded on numerous occasions. I have emailed videos to the council illustrating the problem in our street. We urgently need a solution.	Ferris St	Thank you for your submission in relation to the recent public exhibition of the draft Leichhardt Flood Risk Management Study and Plan. All feedback received during the exhibition period will be considered by Council's Consultants (Cardno) in consultation with Council. A report on the feedback received during the exhibition period will be prepared for Council's Flood Management Advisory Committee prior Council's consideration of the same at a Council meeting during early 2018. Council will notify all persons who made a submission during the exhibition period in writing of the meeting date.	8-Nov-17
Sep 28 17 07:31:31 am		I have been communicating with the council about this issue and have had officers out to look at my property. The property modifications provided by council are extremely expensive and I have concerns that the development application for this property (submitted by previous owners) didn't require drainage in the front and council approved this knowing it was a flood risk area. We need a more wholistic resolution for the whole street.	We strongly need option WC-FM1 or WC- FM13 to go ahead for our neighbourhood. We have significant flooding on the street not only when there is heavy rain, but also when we have moderate rain fall. As we live on Ferris st, all of the water comes down from Parramatta rd and down Albion st from Johnston, Annandale, Young and the drainage is not sufficient to manage the volume. My property and my neighbours property have been flooded on numerous occasions. I have emailed videos to the council illustrating the problem in our street. We urgently need a solution.		Thank you for your submission in relation to the recent public exhibition of the draft Leichhardt Flood Risk Management Study and Plan. All feedback received during the exhibition period will be considered by Council's Consultants (Cardno) in consultation with Council. A report on the feedback received during the exhibition period will be prepared for Council's Flood Management Advisory Committee prior Council's consideration of the same at a Council meeting during early 2018. Council will notify all persons who made a submission during the exhibition period in writing of the meeting date.	8-Nov-17
Aug 20 17 10:34:22 am	Yes - how will these be impacted by digging the west connex tunnel under whites creek lane?	Does the west connex tunnel need to conform to these property modification options?	Yes - how will these be impacted by digging the west connex tunnel under whites creek lane?	Reserve St	Thank you for your submission in relation to the recent public exhibition of the draft Leichhardt Flood Risk Management Study and Plan. All feedback received during the exhibition period will be considered by Council's Consultants (Cardno) in consultation with Council. A report on the feedback received during the exhibition period will be prepared for Council's Flood Management Advisory Committee prior Council's consideration of the same at a Council meeting during early 2018. Council will notify all persons who made a submission during the exhibition period in writing of the meeting date.	8-Nov-17

Date of contribution	Survey Response				Responses post exhibtion period	
	Do you have any comments on the Emergency Management Options?	Do you have any comments on the Property Modification Options?	Do you have any comments on the Structural Flood Modification Options?	Do you have any other comments?	Response - Council	Acknowledgement letter
Aug 23 17 01:36:52 pm			I live in Wortley Street very close to a drain in front of 13-15 Wortley Street. The drain receives water from Wortley St (Reynolds Street side), Wortley Street (Palmer Street side) and Davidson Street. Unfortunately when it rains it tends to become overwhelmed and bank up - so much so that I don't park my car on that side of the road when it is raining so as to avoid water coming into the car through the bottom of the side door. Given that its capacity to drain is limited even when it rains, I would consider this places the area at higher risk for any potential floods. I would ask that you prioritise fixing up the problem by widening the pipes or any other way you see most appropriate. Thank you		Thank you for your submission in relation to the recent public exhibition of the draft Leichhardt Flood Risk Management Study and Plan. All feedback received during the exhibition period will be considered by Council's Consultants (Cardno) in consultation with Council. A report on the feedback received during the exhibition period will be prepared for Council's Flood Management Advisory Committee prior Council's consideration of the same at a Council meeting during early 2018. Council will notify all persons who made a submission during the exhibition period in writing of the meeting date.	8-Nov-17
Aug 24 17 03:40:15 pm	No	No	No	It'd be really good if council could sweep roads/lanes. This would avoid blocked drains, reduce blockages and avoid flooding (thinking Whites Creek lane near Styles St)	Comment noted	No
Aug 25 17 10:35:34 am				Our property sits on the Corner of Nelson St and The Crescent and whist capital works have been undertaken to control flooding, the reality is that flooding still occurs - road and footpath are completely immersed in water when it rains. This is of particular concern to both drivers and pedestrians so I have to question how effective those works have been.	Thank you for your submission in relation to the recent public exhibition of the draft Leichhardt Flood Risk Management Study and Plan. All feedback received during the exhibition period will be considered by Council's Consultants (Cardno) in consultation with Council. A report on the feedback received during the exhibition period will be prepared for Council's Flood Management Advisory Committee prior Council's consideration of the same at a Council meeting during early 2018. Council will notify all persons who made a submission during the exhibition period in writing of the meeting date.	8-Nov-17
Aug 29 17 09:55:02 am	The measures seem sound except that it is hard to make any real assessment without an implementation plan.	No real comments except that purchase and demolition of properties should be very carefully considered and not without substantial community consultation. Should this be necessary a true value of the property should be obtained in consultation and agreement with the property owner.		I live on Cromwell street between Carlisle and McAuley Streets. This area which is on a slope is subject to large volumes of water flooding down the street, particularly on the odd number side of the street during heavy rain events. On these occasions the current drains do not cope with the water volume and there is significant flooding along this section of the street. During these periods the intersection of Macauley and Cromwell becomes completely inundated and water comes up over the curb and floods onto the footpath. This large volume of water can persist for hours after the rain has passed. In very heavy events it can flood into garages. An additional drain outlet is needed on Cromwell street between Carlisle and Macauley streets on the odd numbered side of the street.	Thank you for your submission in relation to the recent public exhibition of the draft Leichhardt Flood Risk Management Study and Plan. All feedback received during the exhibition period will be considered by Council's Consultants (Cardno) in consultation with Council. A report on the feedback received during the exhibition period will be prepared for Council's Flood Management Advisory Committee prior Council's consideration of the same at a Council meeting during early 2018. Council will notify all persons who made a submission during the exhibition period in writing of the meeting date.	8-Nov-17
Aug 30 17 12:01:31 pm			The section of road along Arguimbau St from Whites Creek to Young St is at the lower end of a very heavy section of stormwater. As a result extremely strong flows wash down the area fronting the Arguimbau Park raising serious safety concerns. As requested on numerous occasions previously we request this section be reviewed for pipes to be installed!	Council has wasted thousands of dollars providing a water treatment pond in this area and missed previous opportunities to incorporate pipe upgrades for safety. Very disappointing lack of priorities!	Thank you for your submission in relation to the recent public exhibition of the draft Leichhardt Flood Risk Management Study and Plan. All feedback received during the exhibition period will be considered by Council's Consultants (Cardno) in consultation with Council. A report on the feedback received during the exhibition period will be prepared for Council's Flood Management Advisory Committee prior Council's consideration of the same at a Council meeting during early 2018. Council will notify all persons who made a submission during the exhibition period in writing of the meeting date.	8-Nov-17
Sep 06 17 08:57:19 am	No	No	No	I am concerned that this plan draws a line across the centre of Hawthorne Canal as it was undertaken prior to the Inner West Council being formed. It also recommends increasing culverts flowing into Hawthorne Parade. We need a comprehensive plan for the Hawthorne Canal area, particularly along the lower reaches that spans both sides to ensure a thorough and strong mitigation plan. Already when there is heavy rain, particularly combined with a high tide, the harbour end of Hawthorne Parade often floods - and it is becoming difficult to get insurance for houses in the street due to a lack of flood mitigation action.	Thank you for your submission in relation to the recent public exhibition of the draft Leichhardt Flood Risk Management Study and Plan. All feedback received during the exhibition period will be considered by Council's Consultants (Cardno) in consultation with Council. A report on the feedback received during the exhibition period will be prepared for Council's Flood Management Advisory Committee prior Council's consideration of the same at a Council meeting during early 2018. Council will notify all persons who made a submission during the exhibition period in writing of the meeting date.	8-Nov-17
Sep 06 17 11:52:28 am		Yes I do have a comment on property modification some time ago in hubert st leichhardt was excuvated so they could have underground parking in doing so they hit a underground creek which needs to be bilged pumped morning and night !		I have lived in hubert st for 35 yrs about 15 yrs ago hubert street was excuvated to make underground parking they hit a underground creek which needs to be pumped out morning and night the water runs down the street causing flooding hubert st needs to put in a storm drain near their property to catch the water . The photo above is charles st hubert st is next to charles st .	Thank you for your submission in relation to the recent public exhibition of the draft Leichhardt Flood Risk Management Study and Plan. All feedback received during the exhibition period will be considered by Council's Consultants (Cardno) in consultation with Council. A report on the feedback received during the exhibition period will be prepared for Council's Flood Management Advisory Committee prior Council's consideration of the same at a Council meeting during early 2018. Council will notify all persons who made a submission during the exhibition period in writing of the meeting date.	8-Nov-17
Sep 07 17 08:43:09 pm			I would be very supportive of implementation of the structural options in RB-FM1. Flooding on Denison St outside our property on Denison St rises very quickly and very often and drainage is completely reliant on one pipe out beneath Easton Park to drain the entire catchment area upwards of the park. I shudder to think what would happen if that pipe blocked with debris from a storm.	The plan was informative but doesn't actually commit to implementing anything which makes it pretty meaningless. My take is here are some options and only 1-2 of them have a B/C above 1 so what is council actually planning on doing with it??	Thank you for your submission in relation to the recent public exhibition of the draft Leichhardt Flood Risk Management Study and Plan. All feedback received during the exhibition period will be considered by Council's Consultants (Cardno) in consultation with Council. A report on the feedback received during the exhibition period will be prepared for Council's Flood Management Advisory Committee prior Council's consideration of the same at a Council meeting during early 2018. Council will notify all persons who made a submission during the exhibition period in writing of the meeting date.	8-Nov-17
Sep 29 17 02:19:47 pm		See other comments below	See other comments below	A letter raising concern of the potential impact of proposed mitigation option WC-FM3 on the property at 1-23 Balmain Rd Leichhardt, including points for consideration, was submitted to Ms Christine Phillips on 26 September 2017.	Thank you for your submission in relation to the recent public exhibition of the draft Leichhardt Flood Risk Management Study and Plan. All feedback received during the exhibition period will be considered by Council's Consultants (Cardno) in consultation with Council. A report on the feedback received during the exhibition period will be prepared for Council's Flood Management Advisory Committee prior Council's consideration of the same at a Council meeting during early 2018. Council will notify all persons who made a submission during the exhibition period in writing of the meeting date. In response to the particular matters you raised, the Leichhardt Flood Risk Management Study and Plan is a high level planning document that identifies the outcomes or reduction in flooding that could be achieved should a given structural flood modification (FM) option be implemented in the general vicinity shown in the Study and Plan. Detailed investigation and consultation with relevant stakeholders, including property owners, will be undertaken as part of the design phase. At that time the key points raised in your letter dated 26 September 2017 will be addressed. Please note that that implementation of many of the structural modification options, including the Balmain Road Branch Option WC-FM3 that passes beneath your property, are also dependent upon funding availability and coordinated actions by the other asset owners, for example Sydney Water and Roads and Maritime Services (RMS).	8-Nov-17

Date of contribution	Survey Response				Responses post exhibtion period	
	Do you have any comments on the Emergency Management Options?	Do you have any comments on the Property Modification Options?	Do you have any comments on the Structural Flood Modification Options?	Do you have any other comments?	Response - Council	Acknowledgement letter
Sep 15 17 01:57:37 pm	I note that my property at Gilchrist Place is impacted by the study, given earlier correspondence and the invitation to participate. However, I don't see any properties in Gilchrist Place impacted according to the mapping. I'm concerned that such properties will have a negative stigma assigned, when there is little or zero flood risk. The justification for these comments are obvious. ie the properties front the Mort Bay sea wall where flooding is impossible, at least for the foreseeable future.				Thank you for your submission in relation to the recent public exhibition of the draft Leichhardt Flood Risk Management Study and Plan. All feedback received during the exhibition period will be considered by Council's Consultants (Cardno) in consultation with Council. A report on the feedback received during the exhibition period will be prepared for Council's Flood Management Advisory Committee prior Council's consideration of the same at a Council meeting during early 2018. Council will notify all persons who made a submission during the exhibition period in writing of the meeting date.	8-Nov-17
Sep 17 17 01:43:38 pm	My property has only one entrance (in Clarke St) and no rear entrance. If a once in a century flood were to occur that involved water flooding to a significant depth and/or, moving at high velocity at the front of my property, I have no options to escape such a situation. Therefore, an appropriate Emergency Management Options are extremely limiting and may result in risk to personal safety/life. Many properties in my area also have only a single front entrance	Considering that all houses within Clarke St were, in February, 2017, placed under Heritage Listing by our Local Council, modifying/renovating my house in such a way that would allow me to raise it above the current level and the suggested flood height (in the region of 1.5 metres) would contravene this Listing and therefore this option appears to be a very unlikely consideration. Also, it appears that if I attempt to divert water from my property (eg, by raising and waterproofing my front fence), it only creates a flooding issue for my neighbours	This appears to be the most appropriate option. Not only would it benefit myself, but would appear to be the case to most properties within the region of flooding. There are a number of points to support this option: (a) how the classification of a one in a 100 years flood may significantly affect my house and contents insurance: in fact, obtaining any insurance covering flooding may not be possible; (b) WCFM 1 and WCFM 13 will significantly reduce the flooding issues and considering the unlikelihood of the two previous boxes above being feasible, improving the drainage of flood water in White's Ck Lane is the ideal solution (c) as population and demands for improved infrastructure continues within this area, improving water drainage under White's Ck Lane is the appropriate option (d) work on WCL is already classified as a priority by Sydney Water (e) SW and Local Council should feel obliged that once they have alerted property owners of dangers that can affect their property, to make appropriate responses (f) the affect the current flooding possibility will have on property prices	I am very concerned about the problem associated with the possibility of a one in a 100 yr flood. Considering the large number of properties that would be affected by flooding and the significant limitations that exist whereby residents may not be able to reduce the problems, protext themselves or insure themselves adequately, the combination of Leichhardt Council and Sydney Water that make this an urgent priority.	Thank you for your submission in relation to the recent public exhibition of the draft Leichhardt Flood Risk Management Study and Plan. All feedback received during the exhibition period will be considered by Council's Consultants (Cardno) in consultation with Council. A report on the feedback received during the exhibition period will be prepared for Council's Flood Management Advisory Committee prior Council's consideration of the same at a Council meeting during early 2018. Council will notify all persons who made a submission during the exhibition period in writing of the meeting date.	8-Nov-17
Sep 19 17 11:56:13 am	As I understand it, my property is currently modeled in a high hazard 1 in 100 ARI event. It would appear from the modeling and diagrams there is NO safe passage from the property to higher ground. Any structural solution or property modification that improved this situation is our only real option.	As I understand it, many properties along Whites creek are now included in a draft conservation area. Previously these properties where not in a conservation area. Given this, my understanding is that council would not support changes to the external appearance of properties. As far as I can see, unless structural solutions are undertaken, the only option I would have would be to raise the floor level of the property (by 800mm). This would require changing the external appearance. We need clearer guidance from council how these two competing guidelines (flood vs conservation) are going to be managed. Given some of the planning decisions I have seen made, it would seem conservation criteria takes precedence over flood risk.	At the intersection of Whites Creek and Clarke Street, there are 7 properties which would, under the current model, have over floor flooding. It would also be assumed that many of the NSW Housing townhouses further down whites creek would also suffer over floor flooding. I am concerned that WC-FM3 which currently has a MCA Rank of 1 would deliver flood waters to whites creek faster than it would currently. I would therefore encourage the council, with Sydney Water to seriously consider implementing WC-FM1 (or better still WC-FM13) as soon as possible	It would be helpful if council would clearly state if conservation or flood safety takes precedence in planning. DCP 2014 Part E Section C2.C happily suggests "if raising floors levels are impractical due to conservation area constraints then you can be below the FPL". Is the flood risk taken seriously in planning or not? Given it seems conservation does take precedence I would encourage council to expedite the implementation of WC-FM13 now that the risk to life and property have been made clear in the 2014 flood study and the implication of those models in the 2017 Flood Management Study.	Thank you for your submission in relation to the recent public exhibition of the draft Leichhardt Flood Risk Management Study and Plan. All feedback received during the exhibition period will be considered by Council's Consultants (Cardno) in consultation with Council. A report on the feedback received during the exhibition period will be prepared for Council's Flood Management Advisory Committee prior Council's consideration of the same at a Council meeting during early 2018. Council will notify all persons who made a submission during the exhibition period in writing of the meeting date.	8-Nov-17
Sep 19 17 10:59:09 am		Not sure if I could save my house from flooding. Possibly raise the house on piers, but I believe we are now in a Draft Conservation area so there are limits on what DA would be approve?	I strongly support WC-FM1 or WC-FM13 which includes upgrading all the way from Parramatta Road to Rozelle Bay.	I have lived in this house for the past 20 years and have seen many down pours and strongly believe my neighbourhood is at risk of severe flooding that could endanger life and believe the Whites Creek upgraded should be a priority. Thank you.	Thank you for your submission in relation to the recent public exhibition of the draft Leichhardt Flood Risk Management Study and Plan. All feedback received during the exhibition period will be considered by Council's Consultants (Cardno) in consultation with Council. A report on the feedback received during the exhibition period will be prepared for Council's Flood Management Advisory Committee prior Council's consideration of the same at a Council meeting during early 2018. Council will notify all persons who made a submission during the exhibition period in writing of the meeting date.	8-Nov-17
Sep 29 17 05:50:57 pm		I have had trouble finding detail regarding changes to Whites Creek and Arguimbau St area.	Generally not in favour of the culvert duplication options that cause an increase in flood levels at residential areas and busy cycle routes such as end of Arguimbau St Annandale. Given the obvious storm water issues raised in the report and the poor cross falls (making it difficult to park) in the lower end of Arguimbau St we would like to see under road drainage and curb and gutter improvements for safety and functional improvements.	Further to our comments in the Annandale North Area plan we would like to see the above improvements assessed in conjunction with upgrades to the end of Arguimbau St to improve cycleway access and landscaping improvements for privacy and safety.	Thank you for your submission in relation to the recent public exhibition of the draft Leichhardt Flood Risk Management Study and Plan. All feedback received during the exhibition period will be considered by Council's Consultants (Cardno) in consultation with Council. A report on the feedback received during the exhibition period will be prepared for Council's Flood Management Advisory Committee prior Council's consideration of the same at a Council meeting during early 2018. Council will notify all persons who made a submission during the exhibition period in writing of the meeting date.	8-Nov-17
Sep 22 17 02:04:19 pm				I would be happy and relieved if Inner West Council cleaned out kerbside drains regularly (or even once!) in municipality ie a PREVENTATIVE MEASURE Every drain in my neighbourhood is clogged with litter including leaf litter I don't know how stormwater runs off when drains are blocked with litter The occasional council blower effort just moves litter from gutters not drains	Thank you for your submission in relation to the recent public exhibition of the draft Leichhardt Flood Risk Management Study and Plan. All feedback received during the exhibition period will be considered by Council's Consultants (Cardno) in consultation with Council. A report on the feedback received during the exhibition period will be prepared for Council's Flood Management Advisory Committee prior Council's consideration of the same at a Council meeting during early 2018. Council will notify all persons who made a submission during the exhibition period in writing of the meeting date.	8-Nov-17
Sep 29 17 07:11:01 am	We live in Ferris st Annandale where there is significant water overflow into our property in storms and heavy rainfall. The whole street floods at our end of the street turning into a river as water flows down off parramatta rd and young st. We strongly feel option wc-fm1 and wc-fm13 are needed to go ahead. A solution is urgently needed for our street, the current situation is unacceptable				Thank you for your submission in relation to the recent public exhibition of the draft Leichhardt Flood Risk Management Study and Plan. All feedback received during the exhibition period will be considered by Council's Consultants (Cardno) in consultation with Council. A report on the feedback received during the exhibition period will be prepared for Council's Flood Management Advisory Committee prior Council's consideration of the same at a Council meeting during early 2018. Council will notify all persons who made a submission during the exhibition period in writing of the meeting date.	8-Nov-17

Date of contribution	Survey Response				Responses post exhibtion period	
	Do you have any comments on the Emergency Management Options?	Do you have any comments on the Property Modification Options?	Do you have any comments on the Structural Flood Modification Options?	Do you have any other comments?	Response - Council	Acknowledgement letter
Sep 29 17 10:55:56 am				I have glanced over some and looked closely at many documents & flooding modelled map links you have provided. I also attended the information session on the 29th August to comprehend what this is all about. I will not pretend to understand all the documents, and there are not enough hours in a day to do so as I work part time, and also having been full time caring for my ill mother for whom it is likely will require me to call an ambulance again today for a return to RPA Hospital. IN RESPONSE I would briefly like to say - I do not wish for my property to be included in this controversial flood study/modelling. I do not hold much faith in such modelling, which I understand was conceived by a mob called Cardno. (I note as an example, the recent farce or should I say Business of "Climate Change" Modelling - they used to call it "Global Warming", but that the facts did not add up so it was renamed). I have personally lived at this property 40 years, and Sydney has experienced very large rain & flooding events in that time and never has this property ever come close to flooding. All that I can agree with in the recent Flood Certificate I received for this property , is where it states that "This report provides flooding information for the area IN THE VICINITY" of my property. And I do agree there is flooding in the vicinity, which I believe results because the Stormwater drains, not only become blocked quite often but probably need upgrading also to handle the load when it rains. But I AM NOT about blaming Council for the flooding that occurs in the vicinity. If you wish to propose this flood study & plan for adoption that is fine, but I do not want my property to be part of this guessing game. If at a future time flooding does occur at this property I will contact Council to inform that they can now classify my property as a " Flood Control Lot " . Please confirm you have received my request and have removed this classification "FLOOD CONTROL LOT " for my property.	Thank you for your submission in relation to the recent public exhibition of the draft Leichhardt Flood Risk Management Study and Plan. All feedback received during the exhibition period will be considered by Council's Consultants (Cardno) in consultation with Council. A report on the feedback received during the exhibition period will be prepared for Council's Flood Management Advisory Committee prior Council's consideration of the same at a Council meeting during early 2018. Council will notify all persons who made a submission during the exhibition period in writing of the meeting date. In response to the particular matters you raised, the tagging of your property as a Flood Control Lot was identified during the Flood Study process in 2010-2014 and is not a part of this Flood Risk Management Study and Plan process. The purpose of the Flood Risk Management Study and Plan is identify and prioritise measures to reduce the impact of flooding and protect people and property through better planning, emergency management and infrastructure works, including upgrading of the piped drainage system where doing so has been shown to be beneficial. One of the measures considered as part of the Leichhardt Flood Risk Management Study and Plan is upgrade of the existing piped drainage system between William Street and Hawthorne Canal via Hubert Street, referred to as HC-FM4 in the Study and Plan.	8-Nov-17
Sep 29 17 10:11:07 am				Whites Creek Lane (between North Ave and Styles St, adjacent to Evan Jones Park) - The drains to Whites Creek between the park and Styles St are inadequate. I realise that this is considered a retention basin however for every flood event in the last 7 years (maximum 450mm at the rear of Styles St properties) the Storm water channel was not even half full (as evidence by inspection of the grates adjacent to Evan Jones reserve), whilst there was flood water above ground. An upgrade to these three drains could be made to allow the basin to drain more quickly without overly affecting the carriage of water further down stream. -Compounding the problem is the soft fall material in the Evan Jones Playground. In heavy rain events, large quantities of this material is washed from the park into the lane and quickly blocks these drains. As a group of neighbours we have photos of a time when multiple tonnes of the soft material has been washed into the lane. Council consistently puts too much of this soft fall material in the park, as is evidenced by the fact that swings must be dug out below to allow their use and that the finished level of the soft material is approx 10-20mm above the level of the surrounding path. - The storm water drain which runs south on Styles St and cuts diagonally through Evan Jones Reserve to the GPT before entering White's Creek Lane is inadequate in heavy rains. The large concrete access lid pops up in every heavy rain event and often it can take days for it to be returned to it's normal housing. When the access lid has popped out it posses an unacceptable risk to the public particularly given it's proximity to the playground.	Thank you for your submission in relation to the recent public exhibition of the draft Leichhardt Flood Risk Management Study and Plan. All feedback received during the exhibition period will be considered by Council's Consultants (Cardno) in consultation with Council. A report on the feedback received during the exhibition period will be prepared for Council's Flood Management Advisory Committee prior Council's consideration of the same at a Council meeting during early 2018. Council will notify all persons who made a submission during the exhibition period in writing of the meeting date. In response to the particular matters you raised at Evan Jones Playground, your suggestions will be referred to Council's Parks Asset Team for investigation and consideration.	8-Nov-17
Sep 29 17 06:04:22 pm				We strongly need option WC-FM1 or WC- FM13 to go ahead for our neighbourhood. We have significant flooding on the street not only when there is heavy rain, but also when we have moderate rain fall. As we live on Ferris st, all of the water comes down from Parramatta rd and down Albion st from Johnston, Annandale, Young and the drainage is not sufficient to manage the significant volume of water. properties have been flooded on numerous occasions. Property owners have emailed videos and outlined the issues to the council illustrating the significant and immediate problem in our street over the last few years. We urgently need a solution.	Thank you for your submission in relation to the recent public exhibition of the draft Leichhardt Flood Risk Management Study and Plan. All feedback received during the exhibition period will be considered by Council's Consultants (Cardno) in consultation with Council. A report on the feedback received during the exhibition period will be prepared for Council's Flood Management Advisory Committee prior Council's consideration of the same at a Council meeting during early 2018. Council will notify all persons who made a submission during the exhibition period in writing of the meeting date.	8-Nov-17
Sep 30 17 07:48:41 am			Not in favour of the duplication options that cause an increase in flood levels at residential areas and busy cycle routes such as end of Arguimbau St Annandale. would like to see the above improvements assessed in conjunction with upgrades to the end of Arguimbau St to improve cycleway access and landscaping improvements for privacy and safety. Given the obvious storm water issues raised in the report and the poor cross fallls (making it difficult to park) in the lower end of Arguimbau St we would like to see under road drainage and curb and gutter improvements for safety and functional improvements. The Whites Creek end of Arguimbau St is well over due for upgrade of formal kerb and gutter and landscaping in line with adjacent streets recently upgraded at Gillies and Wisdom Streets.		Thank you for your submission in relation to the recent public exhibition of the draft Leichhardt Flood Risk Management Study and Plan. All feedback received during the exhibition period will be considered by Council's Consultants (Cardno) in consultation with Council. A report on the feedback received during the exhibition period will be prepared for Council's Flood Management Advisory Committee prior Council's consideration of the same at a Council meeting during early 2018. Council will notify all persons who made a submission during the exhibition period in writing of the meeting date.	8-Nov-17

Date of contribution	Survey Response				Responses post exhibtion period	
	Do you have any comments on the Emergency Management Options?	Do you have any comments on the Property Modification Options?	Do you have any comments on the Structural Flood Modification Options?	Do you have any other comments?	Response - Council	Acknowledgement letter
via submission box				Very in depth, well presented study. So much information for a simple home owner. After spending at least an hour perusing Flood Management Plan I feel more anxious about how it will affect my property, where I have happily lived since 1979. Where can I get specific details about what this Plan will mean for me?	Thank you for your submission in relation to the recent public exhibition of the draft Leichhardt Flood Risk Management Study and Plan. All feedback received during the exhibition period will be considered by Council's Consultants (Cardno) in consultation with Council. A report on the feedback received during the exhibition period will be prepared for Council's Flood Management Advisory Committee prior Council's consideration of the same at a Council meeting during early 2018. Council will notify all persons who made a submission during the exhibition period in writing of the meeting date.In response to your particular question, the draft Leichhardt Flood Risk Management Study and Plan is a high level planning and working document that identifies a series of structural flood modification measures (this generally being an upgrade of the existing piped drainage system) and property modification measures (this generally being related to development controls) that could be implemented to mitigate and manage flooding in a particular area. The outcomes and benefits to the community that could be achieved through the measures are also identified. The Leichhardt Flood Risk Management Study and Plan does not recommend a specific program for implementation of any of the structural measures, nor does it prescribe the exact location and route any of the structural measures would take. The exact location and route for any given option will be determined as part of the detailed design phase, which all stakeholders, including affected residents, will be invited to be a part of. Please note that that implementation of many of the structural measures, including the Styles Street Branch Option WC-FM6 that passes beneath the rear of your property, are also dependent upon funding availability and coordinated actions by the other asset owners, for example Sydney Water and Roads and Maritime Services (RMS).	8-Nov-17
15-Aug-17				It was fortuitous that I was at home today when I received council's letter regarding the above topic, as it enabled me to call and speak about a matter that has caused me concern. In your absence, I spoke with Mr James Ogg, who assisted with my enquiry generally. I firstly called to register to attend the information session to be held at Balmain Town Hall on the evening of Wednesday, 30 August 2017. If I could be added to the register, that would be appreciated. BY WAY FEEDBACK AND CONCERNS Having read the "Frequently Asked Questions" paper, in particular question 7, I then enquired if it could be ascertained whether my property was affected by any proposed new pipeline before attending the information session. It currently appears the plan only indicates the existing pipe, which runs from the lane at the rear of my property, along the boundary line and to the front of my property. Although completed several years ago now, I explained to Mr James Ogg that as part of DA - D/2006/274, endorsed 26/07/12 Certificate No: CC/176/12 (DA for a garage/studio), I had to obtain a flood risk management report for a one in 1000 year flood and implement the requisite infrastructure to accommodate for such a flood. Part of this necessitated the installation of two very large pipes, which also run the length of the boundary above the existing pipe, which should obviate the need for any further modifications to the existing pipe. In addition, there is a double-pit drain at the rear of the property which addresses significant rain events and prevents my garage flooding, when it is not blocked by debris. Finally, the telephone call also enabled me to make mention of two emails I sent in 2015 to the person responsible at the time for storm water at Leichhardt Council, Mr M Sikzen. These concerned flooding, the result of the drain at the rear of my property being blocked by debris. A site meeting was held and suggestions addressing the issue were thereafter put in writing by me and sent. These emails are located below and may provide some insight into the issues that concern Glassop Street, Balmain regarding managing flood risk. Unfortunately, neither email has been responded to. I have further photographs following this event, if required. By way of feedback, the original email sent to Mr M Sikzen dated 29/08/15, points 1 to 3 (see below), still set out what I believe are the best options to manage flooding in this immediate vicinity, in particular, the installation of a single pit being installed two properties east of the double-pit to assist in facilitating the removal of storm water from the street, should the double-pit at the rear of my property be disabled by debris blockage. I would also still be appreciative if those matters raised in the emails below could be addressed and responded to. I thank you for this opportunity of being able to raise my concerns and provide my views by way of feedback. If I can be of any further assistance, my details are provided below.	Thank you for your submission in relation to the recent public exhibition of the draft Leichhardt Flood Risk Management Study and Plan. All feedback received during the exhibition period will be considered by Council's Consultants (Cardno) in consultation with Council. A report on the feedback received during the exhibition period will be prepared for Council's Flood Management Advisory Committee prior Council's consideration of the same at a Council meeting during early 2018. Council will notify all persons who made a submission during the exhibition period in writing of the meeting date.In response to the particular matters you raised, as discussed with Council's engineer Mrs Christine Phillips, the draft Leichhardt Flood Risk Management Study and Plan does not propose any works to Council's existing stormwater drainage pipeline between Roseville Lane and Glassop Street that is located beneath your property. With regard to your report of the frequent blockage of the existing drainage pits in Roseville Lane by rubbish and debris, please be advised that Council undertakes regular cleaning of the pits and drainage pipes in Roseville Lane, particularly during periods of heavy rain. Your request for construction of an additional pit and pipeline in Roseville Lane east of your property will be investigated and, if considered feasible, will be included in future works programs.	8-Nov-17
29-Sep-17				unfortunately i didn't get to the information sessions but have gone through documents avail on the website. I am keen to support all recommended flood modifications especially option 1D - RB - FM1. I couldn't find address details of the properties marked for possible purchase, is there a list? Does the council need any further written support from me to help with these plans please?	Thank you for your submission in relation to the recent public exhibition of the draft Leichhardt Flood Risk Management Study and Plan. All feedback received during the exhibition period will be considered by Council's Consultants (Cardno) in consultation with Council. A report on the feedback received during the exhibition period will be prepared for Council's Flood Management Advisory Committee prior Council's consideration of the same at a Council meeting during early 2018. Council will notify all persons who made a submission during the exhibition period in writing of the meeting date.	8-Nov-17
24-Aug-17				I have been reviewing the Draft Leichhardt Flood Risk Management Plan following the letter I received that said my property is/has been classified as a flood control lot. I am in the White Bay sub catchment. I can see that it and the study are very detailed, technically based and lengthy - this makes it difficult for people to generally understand. I suggest making a simplified version for community consultation. At this stage have two major queries: 1. Why are all of the structural options based primarily on drainage pipelines, culverts or embankments? These are general engineering based approaches. I can't see any specific mention or review of the Inner West Council water sensitive urban design practices (for example a modification of a park to include a rain garden to provide on-site detention and sustainable habitat) 2. Very specifically to my property at Murdcoh Street Rozelle 2039. This will be impacted by the preferred option Beattie Street Branch WB-FM1 including a new pipe network or duplication of existing pipe network. The figures and text do not make it clear on what the work would actually involve. Can you please provide me with more detailed information such as: a) a more detailed pipeline figure showing location b) likely construction methodology c) the likely timing if this option is chosen? This would enable me to provide further feedback. I also see that this has a very substantial capital cost of almost $26 million. I will also raise the proposed options and plan with my neighbours so they are encouraged to provide feedback. Another general comment is how the construction of Westconnex Stage 3 (potential, but likely) will impact on the option by use of Robert Street in the development.	Thank you for your submission in relation to the recent public exhibition of the draft Leichhardt Flood Risk Management Study and Plan. All feedback received during the exhibition period will be considered by Council's Consultants (Cardno) in consultation with Council. A report on the feedback received during the exhibition period will be prepared for Council's Flood Management Advisory Committee prior Council's consideration of the same at a Council meeting during early 2018. Council will notify all persons who made a submission during the exhibition period in writing of the meeting date. In response to the particular matters you raised, the Leichhardt Flood Risk Management Study and Plan is a high level planning document that identifies the outcomes or reduction in flooding that could be achieved should a given structural flood modification (FM) option be implemented in the general vicinity shown in the Study and Plan. The exact location and construction methodology for any given FM option will be determined as part of the detailed design phase, which all stakeholders, including affected residents, will be invited to be a part of. The Leichhardt Flood Risk Management Study and Plan does not recommend a specific works plan for implementation of the structural options. Instead the Plan identifies a series of measures that have merit for implementation when the opportunity arises and funding becomes available. Of importance to note is that many of the structural measures, including the Beattie Street Branch Option WB-FM1, are dependent upon coordinated actions by the other asset owners, for example Sydney Water.	8-Nov-17

Date of contribution	Survey Response				Responses post exhibtion period	
	Do you have any comments on the Emergency Management Options?	Do you have any comments on the Property Modification Options?	Do you have any comments on the Structural Flood Modification Options?	Do you have any other comments?	Response - Council	Acknowledgement letter
28-Sep-17				Comments: 1. Wished to raise a complaint with regard to inconsistency in the application of Council's flood controls on developments. He is currently pursuing a proposed development on his property, which includes parking at the rear. Council has advised that the parking would not be supported on the basis of flood risk. He compares this to Charles Street, which got a parking space approved, despite being a new dwelling on a vacant lot; and the Dan Murphy's development, which required a roundabout to be constructed which resulted in flooding of between 300-400mm at the intersection when it rained during construction. Why does Council let one thing happen for big companies and developers, but not for individual home owners. 2. Unclear where the proposed property acquisitions were and asked for further detail.	Thank you for your submission in relation to the recent public exhibition of the draft Leichhardt Flood Risk Management Study and Plan. All feedback received during the exhibition period will be considered by Council's Consultants (Cardno) in consultation with Council. A report on the feedback received during the exhibition period will be prepared for Council's Flood Management Advisory Committee prior Council's consideration of the same at a Council meeting during early 2018. Council will notify all persons who made a submission during the exhibition period in writing of the meeting date.	8-Nov-17
28-Sep-17				The Whites Creek Catchment drains a large area that is even greater than the representation shown in the mapping as when drain, grates , pits and gutters block closer to Parramatta Road water flows from the blocked infrastructure into the Whites Creek collection water collection points near Chapman Street causing more overload on the drains and pipes. It is respectfully requested that the proposal to duplicate the pipes in the above collection point be moved up the works priority list as an urgent matter. If the works are completed sooner rather than delayed the benefits will "flow" down the catchment to all property holders as the effects of flooding will be ameliorated for all.	Comments and support for the Plan noted.	No
21-Aug-17				I note that drawing WB_FM2_20yr_WIDiff shows a proposed new pipe/culvert option below my property whereas WB_FM4_20yr_WIDiff shows a different plan. Can you please advise what the difference is between these two proposals/drawings and which is the plan being recommended?	Thank you for your submission in relation to the recent public exhibition of the draft Leichhardt Flood Risk Management Study and Plan. All feedback received during the exhibition period will be considered by Council's Consultants (Cardno) in consultation with Council. A report on the feedback received during the exhibition period will be prepared for Council's Flood Management Advisory Committee prior Council's consideration of the same at a Council meeting during early 2018. Council will notify all persons who made a submission during the exhibition period in writing of the meeting date. In response to the particular matters you raised, as discussed with Council's engineer Mrs Christine Phillips, structural options WB-FM2 and WB-FM4 have been considered as independent options, not reliant upon the other or as an alternative to the other. WB-FM2 considers the potential benefits of upgrading the existing drainage system between Beattie Street and White Bay via Punch Park. WB-FM4 considers the potential benefits of upgrading the existing drainage system in Palmer Street and Wortley Street. The Leichhardt Flood Risk Management Study and Plan does not recommend a specific works programme for implementation of any of the structural options. Instead the Plan is a working document identifies a series of structural flood modification measures such, as WB-FM2 and WB-FM4, that have merit for implementation when the opportunity arises and funding becomes available.	8-Nov-17
26-Sep-17		A proposed solution should not infringe on our rights under the current easement lodged. The evaluation of compensation for any impacts on the property if changes to, or enforcement of the easement are required, including an assessment of the land value before and after any poetnetial change will need a detailed evaluation. Further Investigation of the impact of any potential works on the foundations (footings, piering etc.) of the exisiting building, which will require more detailed site-specific assessment by a structural engineer.	Further investigation of the proposed solutio WC-FM3, including verification of the draft Plan's 100 year ARI hydraulic modelling with consideration of the capacity of the exisiting stormwater box culvert under the site, which will require more detailed site-specific hydraulic assessment	Futher and more detailed cost/benefit analysis of any mitigation proposals affecting the site. This should include comparison with other strategic implementation options as identified in the draft Plan and Study, and a more detailed flood damage assessment. This analysis would also need to include an assessment of the llong-term impact on the valuable future re-development potential of the site, which has a significant place in the Balmain Road / Parramatta Road precent.	Thank you for your submission in relation to the recent public exhibition of the draft Leichhardt Flood Risk Management Study and Plan. All feedback received during the exhibition period will be considered by Council's Consultants (Cardno) in consultation with Council. A report on the feedback received during the exhibition period will be prepared for Council's Flood Management Advisory Committee prior Council's consideration of the same at a Council meeting during early 2018. Council will notify all persons who made a submission during the exhibition period in writing of the meeting date. In response to the particular matters you raised, the Leichhardt Flood Risk Management Study and Plan is a high level planning document that identifies the outcomes or reduction in flooding that could be achieved should a given structural flood modification (FM) option be implemented in the general vicinity shown in the Study and Plan. Detailed investigation and consultation with relevant stakeholders, including property owners, will be undertaken as part of the design phase. At that time the key points raised in your letter dated 26 September 2017 will be addressed. Please note that that implementation of many of the structural modification options, including the Balmain Road Branch Option WC-FM3 that passes beneath your property, are also dependent upon funding availability and coordinated actions by the other asset owners, for example Sydney Water and Roads and Maritime Services (RMS).	8-Nov-17
28-Aug-17				Telephone conversation regarding flooding conerns at Carey street and options to mitigate.	I hope I was able to answer your questions on the telephone today. As we discussed, the draft Leichhardt Flood Risk Management Study and Plan looks at ways flooding can be managed or mitigated throughout the former Leichhardt Local Government Area. The management and mitigation methods are generally classified as Emergency Management measures, Property Modification measures (how the land is used) and Structural Flood Modification measures (pits and pipes). You can find information about these methods in Section 4 of the Plan or Section 121 of the Study. As we discussed, the draft Leichhardt Flood Risk Management Study and Plan looks at ways flooding can be managed or mitigated throughout the former Leichhardt Local Government Area. The management and mitigation methods are generally classified as Emergency Management measures, Property Modification measures (how the land is used) and Structural Flood Modification measures (pits and pipes). You can find information about these methods in Section 4 of the Plan or Section 121 of the Study. The option relevant to your property is called HC-FM2. Figure 4-11 of the Plan shows the additional pipes proposed by HC-FM2. Details and the benefit of HC-FM2 can be found in the booklet Appendix D – Area 1 – Hawthorne Canal (this is a separate document to the Plan). This booklet is Document 6 of 15 in the set available at the Leichhardt Administration Centre and at Leichhardt Library.	No
24-Aug-17				Having looked over the materials online I wasn't able to understand if the flooding risk was due to stormwater pipes being unable to cope or if it was due to rainwater run off. Please could you clarify?	Generally heavy rainfall causes flooding where the capacity of the natural overland flow paths (and piped drainage system if there is one) is insufficient to convey the amount of water that falls. Within the area covered by the draft Leichhardt Flood Risk Management Study and Plan development over time has restricted (or in some places completely blocked) the natural overland flow paths as well as increased the amount of hard surfaces, which in turn increases the amount of runoff than there otherwise would have been if the ground was permeable (ie gardens and grass). The existing pipe network in many places is now too small to convey the water and flooding occurs. The draft Leichhardt Flood Risk Management Study and Plan looks at ways to manage flooding in the study area. One of those methods investigated is to increase the size of the pipes in some places.	8-Nov-17

Date of contribution	Survey Response				Responses post exhibtion period	
	Do you have any comments on the Emergency Management Options?	Do you have any comments on the Property Modification Options?	Do you have any comments on the Structural Flood Modification Options?	Do you have any other comments?	Response - Council	Acknowledgement letter
13-Sep-17				1. In the FRMP Table 2-4 it mentions 302 properties in the Whites Creek Catchment that would have overfloor Flooding in 100 Year ARI a. Is there a list of these 302 properties? b. If not, are you able to advise if 4 Clarke Street is one of these 302 properties? 2. Section 4.4.7-4.4.9 of the FRMP list between 8 to 400 properties affected a. Is there a list of these properties? b. If not, are you able to advise if 4 Clarke Street is one of these properties? 3. Are the WC-FM1 differencing models available in higher resolution, or ideally online in the Flood Management tool? a. If not, is it possible to get details on modelled flood levels for the corner of Clarke and Whites Creek lane from this model? 4. In the Whites Creek Options Assessment Appendix (WCOA), table 4-1 to 4-13, many of the Commercial and Industrial Property Types have no figure in the Estimated total Damage Mitigation Case, even though the Properties with Over Floor Flooding was lower. Does this lack of figure indicate a. With Mitigation there is no Benefit? b. With Mitigation all risk have been eliminated and therefore there is no costs for the event? c. The Mitigation case could not be calculated? 5. Similarly to above WCOA Table 4-14 , WC-FM1 shows a reduction of 19+8 properties for the PMF event, with a total Damage reduction of 12mil. But WC-FM3 shows a reduction of 12 properties for the PMF event, with a total Damage reduction of 19mil. How was this figure arrived at? 6. In the WCOA, Table 4-15 shows a "Reduction in AAD" for option WC-FM3 of $11,355,000. This is considerably more than any other WC-FM option, even though this seems to be a smaller area and impact less properties that some of the other options. Can you clarify how this figure was arrived at?	Thank you for your submission in relation to the recent public exhibition of the draft Leichhardt Flood Risk Management Study and Plan. All feedback received during the exhibition period will be considered by Council's Consultants (Cardno) in consultation with Council. A report on the feedback received during the exhibition period will be prepared for Council's Flood Management Advisory Committee prior Council's consideration of the same at a Council meeting during early 2018. Council will notify all persons who made a submission during the exhibition period in writing of the meeting date.	8-Nov-17
				Water from the top of Ewell St, Part of Slade Street, half of Harris Street collects and runs down Ewell Street. Due to the camber of the road the water falls to a low point at the kerb just above Ewell Street. The surface stormwater mounts the kerb and enters the property of Ewell St. The stormwater is pumped via a make shift pump (installed by the owner)from under the ground floor structure into the back yard of Ewell St. A normal rain fall would generate approximately 240 L per hour that needs to be pumped from under the house.If the pump in not in action the water floods the lower ground level of the house. The health implications of the current situation are critical. Mould, flooding , lower ground level flooring surface is lifting. The structural implications are urgent. The foundations of the house have been undermined and the ground floor structure is sinking. No satisfactory course of action can be taken by the owner temporarily because the water can not be stopped from entering the property. If a 150-200mm mm kerb was built in front of the house it would simply move the issue 5m down the road and give Ewell Street the problem. The kerb is eroding in places due to the volume of water.Stormwater from the roof of Ewell St are unable to flow into the street normally due to the pressure of water flowing down the street and over the kerb.	Refer to Stormwater engineer to investigate	Pending investigation
29-Aug-17				Grove street Birchgrove. No gutter on one side, dirt ditch. Water goes under the building. Clean out / put in a gutter	Thank you for your submission in relation to the recent public exhibition of the draft Leichhardt Flood Risk Management Study and Plan. All feedback received during the exhibition period will be considered by Council's Consultants (Cardno) in consultation with Council. A report on the feedback received during the exhibition period will be prepared for Council's Flood Management Advisory Committee prior Council's consideration of the same at a Council meeting during early 2018. Council will notify all persons who made a submission during the exhibition period in writing of the meeting date. In response to the particular matters you raised within Grove Street, your suggestions will be referred to Council's Infrastructure Planning team for investigation and consideration.	8-Nov-17
29-Aug-17				Remember that water came into backyard and then into house since 2000	Thank you for your submission in relation to the recent public exhibition of the draft Leichhardt Flood Risk Management Study and Plan. All feedback received during the exhibition period will be considered by Council's Consultants (Cardno) in consultation with Council. A report on the feedback received during the exhibition period will be prepared for Council's Flood Management Advisory Committee prior Council's consideration of the same at a Council meeting during early 2018. Council will notify all persons who made a submission during the exhibition period in writing of the meeting date.	8-Nov-17
29-Aug-17				Can you advise if Hubert Street will have reduced flood expousre if the Hawthorne Canal improvements (the new pipe along Hubert Street) is carried out.	Thank you for your submission in relation to the recent public exhibition of the draft Leichhardt Flood Risk Management Study and Plan. All feedback received during the exhibition period will be considered by Council's Consultants (Cardno) in consultation with Council. A report on the feedback received during the exhibition period will be prepared for Council's Flood Management Advisory Committee prior Council's consideration of the same at a Council meeting during early 2018. Council will notify all persons who made a submission during the exhibition period in writing of the meeting date.	8-Nov-17
29-Aug-17				There is a dirt (unsealed) lane way at the rear of the crescent Annandale. Debris from the laneway travels down the crescent towards Trafalgar Street during any rain event. This contributes to blockage in the drains at the intersection of the crescent and Trafalgar streets. Replacing the drain is good but will quickly block again once it rains unless the laneway is appropriately sealed or drained.	Thank you for your submission in relation to the recent public exhibition of the draft Leichhardt Flood Risk Management Study and Plan. All feedback received during the exhibition period will be considered by Council's Consultants (Cardno) in consultation with Council. A report on the feedback received during the exhibition period will be prepared for Council's Flood Management Advisory Committee prior Council's consideration of the same at a Council meeting during early 2018. Council will notify all persons who made a submission during the exhibition period in writing of the meeting date. In response to the particular matters you raised within the laneway at the rear of your property, your suggestions will be referred to Council's Infrastructure Planning team for investigation and consideration.	8-Nov-17
21-Sep-17			1. The Park was constructed by landfill over 5O years ago and landscaped towards the homes on Ainsworth Street - especially where the backyards are lower than the Park as a result. 2. Council allowing roof water from the units in Leys Avenue to flow into the Park contrary to Regulations. 3. Council not clearing drains in the Park for over 25 years causing to two(2) major floods to homes- namely to a depth of 14.5meters. Drains are now clear . 4. The new bus depot has increased the water flow in the stormwater drain with all the additional hard surfaces it has built.	1. The Council check the drains on a regular basis to ensure they are clear of debris. 2. Corrective landscaping to take place so that water does not flow towards the designated properties. 3. The units on Leys Avenue put in place drainage such that it does not flow into the Park. 4. Approach Sydney Water to come up with a PLAN to resolve the problem of under capacity of the drains. 5. Contact home owners directly and inform them of what action is being taken.	Thank you for your submission in relation to the recent public exhibition of the draft Leichhardt Flood Risk Management Study and Plan. All feedback received during the exhibition period will be considered by Council's Consultants (Cardno) in consultation with Council. A report on the feedback received during the exhibition period will be prepared for Council's Flood Management Advisory Committee prior Council's consideration of the same at a Council meeting during early 2018. Council will notify all persons who made a submission during the exhibition period in writing of the meeting date.	8-Nov-17

Feedback from Council's Development Advisory Service			
Reference	**Areas of Concern**	**Comments**	**Responses**
4.4.5.4 Areas not Directed to Onsite Detention	Above ground OSD tanks should be installed where this will allow for free drainage to the Council's drainage system.	Concerns are raised regarding the streetscape/heritage implications of this recommendation. Protection of heritage fabric and the built environment needs to be given a higher priority.	Comments Noted. Protection of heritage fabric and the built environment needs to be given a higher priority.
	Where the proposed habitable ground floor area of an addition to an existing dwelling exceeds 60% of the total existing retained habitable ground floor area, the existing ground floor must be raised to the FPL. Where the habitable floor area of above ground floor additions is equal to or exceeds the existing total habitable floor area, the existing ground floor area must also be raised to the FPL. It is also recommended that Council include clear provisions for the limit of these exceptions, particularly where exception may be requested several times for the same property over multiple development applications.	Concerns are raised regarding the streetscape/heritage implications of this recommendation. There is also concern as to how to address the potential tension between these recommendations, and the likely impact on neighbouring properties – for example overshadowing and overlooking or view loss. Protection of heritage fabric and the built environment needs to be given a higher priority.	Comments Noted. Protection of heritage fabric and the built environment needs to be given a higher priority.
4.4.7 PM6 – Voluntary House Purchase	The outcomes of the 2013 social assessment (Floodplain Risk Management Study) have been used in this assessment, assuming an average property purchase price of $800,000 (2013).	Concerns are raised that the recommendations of this study have been based on unrealistic purchase price expectations.	Comments Noted. The price was considered at the time of this assessment (2013).
4.4.8 PM7 – Voluntary House Raising		Concerns are raised regarding the streetscape/heritage implications of this recommendation, and potential impacts on neighbouring properties. There are major planning and economic implications for rezoning land using flood risk as the determinative factor.	Comments Noted. A new para has been included in Section 9.2 to state "It is noted that the there are no flood related provisions in the DCP for development in heritage conservation areas. Given that some of the heritage conservation areas within the study area are flood affected, it is recommended that Council consider provisions of flood related controls in the DCP for development in heritage conservation areas."
9.5.1 Leichhardt Local Environment Plan 2013	There are significantly more properties impacted by PMF when compared to the 100 Year ARI. Therefore, if the PMF was used for planning purposes this would likely put much more onerous requirements on a large number of properties		
10.8 Consequences of Adopting the PMF as a Flood Planning Level	However, the economic and planning consequences of the adoption of the PMF for these purposes often outweigh the potential benefits.	Any such proposed change needs to be pursued only after there has been a comprehensive assessment and public consultation with regard to the implications of this.	Comments Noted.
Page 67		Concern is raised that the above indicates that demolition of existing buildings is the solution for providing additional pipes but does not take into the suite of considerations in particular heritage and vegetation constraints and appropriateness of pedestrian/cycle access in terms of location and impact.	Comments Noted. Protection of heritage fabric and the built environment needs to be given a higher priority.

INNER WEST COUNCIL

8 November 2017

[redacted]
[redacted] Ferris Street
Annandale NSW 2038

Dear [redacted]

Re: [redacted] Ferris Street, Leichhardt

Have your say Managing flood risk in your neighbourhood

Public Exhibition of the draft Leichhardt Flood Risk Management Study and Plan

Thank you for your submission in relation to the recent public exhibition of the draft Leichhardt Flood Risk Management Study and Plan. All feedback received during the exhibition period will be considered by Council's Consultants (Cardno) in consultation with Council. A report on the feedback received during the exhibition period will be prepared for Council's Flood Management Advisory Committee prior Council's consideration of the same at a Council meeting during early 2018.

Council will notify all persons who made a submission during the exhibition period in writing of the meeting date.

If you require further information please call Council's Stormwater and Development Engineer, Mrs Christine Phillips, on 9392 5644 or email christine.phillips@innerwest.nsw.gov.au.

Yours sincerely

A. Giunta

Tony Giunta
Infrastructure Planning (Transport & Stormwater) Manager
Inner West Council

INNER WEST COUNCIL

8 November 2017

[redacted]
[redacted] Young Street
Annandale NSW 2038

Dear [redacted]

Re: [redacted] Young Street, Annandale

Have your say Managing flood risk in your neighbourhood

Public Exhibition of the draft Leichhardt Flood Risk Management Study and Plan

Thank you for your submission in relation to the recent public exhibition of the draft Leichhardt Flood Risk Management Study and Plan. All feedback received during the exhibition period will be considered by Council's Consultants (Cardno) in consultation with Council. A report on the feedback received during the exhibition period will be prepared for Council's Flood Management Advisory Committee prior Council's consideration of the same at a Council meeting during early 2018.

Council will notify all persons who made a submission during the exhibition period in writing of the meeting date.

In response to the particular matter you raised, following completion of any of the structural flood modification (FM) options in the future, flood modelling would be again undertaken to identify any changes required to the Flood Control Lot mapping. At that time any properties no longer considered flood affected will be notified and removed from being classified as a Flood Control Lot.

If you require further information please call Council's Stormwater and Development Engineer, Mrs Christine Phillips, on 9392 5644 or email christine.phillips@innerwest.nsw.gov.au.

Yours sincerely

A. Giunta

Tony Giunta
Infrastructure Planning (Transport & Stormwater) Manager
Inner West Council

8 November 2017

[redacted]
[redacted] Emma Street
Leichhardt NSW 2040

Dear [redacted]

Re: [redacted] Emma Street, Leichhardt

Have your say Managing flood risk in your neighbourhood

Public Exhibition of the draft Leichhardt Flood Risk Management Study and Plan

Thank you for your submission in relation to the recent public exhibition of the draft Leichhardt Flood Risk Management Study and Plan. All feedback received during the exhibition period will be considered by Council's Consultants (Cardno) in consultation with Council. A report on the feedback received during the exhibition period will be prepared for Council's Flood Management Advisory Committee prior Council's consideration of the same at a Council meeting during early 2018.

Council will notify all persons who made a submission during the exhibition period in writing of the meeting date.

In response to your particular question, the draft Leichhardt Flood Risk Management Study and Plan is a high level planning and working document that identifies a series of structural flood modification measures (this generally being an upgrade of the existing piped drainage system) and property modification measures (this generally being related to development controls) that could be implemented to mitigate and manage flooding in a particular area. The outcomes and benefits to the community that could be achieved through the measures are also identified.

The Leichhardt Flood Risk Management Study and Plan does not recommend a specific program for implementation of any of the structural measures, nor does it prescribe the exact location and route any of the structural measures would take. The exact location and route for any given option will be determined as part of the detailed design phase, which all stakeholders, including affected residents, will be invited to be a part of.

Please note that that implementation of many of the structural measures, including the Styles Street Branch Option WC-FM6 that passes beneath the rear of your property, are also dependent upon funding availability and coordinated actions by the other asset owners, for example Sydney Water and Roads and Maritime Services (RMS).

If you require further information please call Council's Stormwater and Development Engineer, Mrs Christine Phillips, on 9392 5644 or email christine.phillips@innerwest.nsw.gov.au.

Yours sincerely

A. Giunta.

Tony Giunta
Infrastructure Planning (Transport & Stormwater) Manager
Inner West Council

INNER WEST COUNCIL

8 November 2017

[redacted]
[redacted] Hawthorne Parade
Haberfield NSW 2045

Dear [redacted]

Re: [redacted] Hawthorne Parade, Haberfield

Have your say Managing flood risk in your neighbourhood

Public Exhibition of the draft Leichhardt Flood Risk Management Study and Plan

Thank you for your submission in relation to the recent public exhibition of the draft Leichhardt Flood Risk Management Study and Plan. All feedback received during the exhibition period will be considered by Council's Consultants (Cardno) in consultation with Council. A report on the feedback received during the exhibition period will be prepared for Council's Flood Management Advisory Committee prior Council's consideration of the same at a Council meeting during early 2018.

Council will notify all persons who made a submission during the exhibition period in writing of the meeting date.

If you require further information please call Council's Stormwater and Development Engineer, Mrs Christine Phillips, on 9392 5644 or email christine.phillips@innerwest.nsw.gov.au.

Yours sincerely

Tony Giunta
Infrastructure Planning (Transport & Stormwater) Manager
Inner West Council

INNER WEST COUNCIL

8 November 2017

[redacted]
[redacted] Glassop Street
Balmain NSW 2041

Dear [redacted]

Re: [redacted] Glassop Street, Balmain

Have your say Managing flood risk in your neighbourhood

Public Exhibition of the draft Leichhardt Flood Risk Management Study and Plan

Thank you for your submission in relation to the recent public exhibition of the draft Leichhardt Flood Risk Management Study and Plan. All feedback received during the exhibition period will be considered by Council's Consultants (Cardno) in consultation with Council. A report on the feedback received during the exhibition period will be prepared for Council's Flood Management Advisory Committee prior Council's consideration of the same at a Council meeting during early 2018.

Council will notify all persons who made a submission during the exhibition period in writing of the meeting date.

In response to the particular matters you raised, as discussed with Council's engineer Mrs Christine Phillips, the draft Leichhardt Flood Risk Management Study and Plan does not propose any works to Council's existing stormwater drainage pipeline between Roseville Lane and Glassop Street that is located beneath your property.

With regard to your report of the frequent blockage of the existing drainage pits in Roseville Lane by rubbish and debris, please be advised that Council undertakes regular cleaning of the pits and drainage pipes in Roseville Lane, particularly during periods of heavy rain. Your request for construction of an additional pit and pipeline in Roseville Lane east of your property will be investigated and, if considered feasible, will be included in future works programs.

If you require further information please call Council's Stormwater and Development Engineer, Mrs Christine Phillips, on 9392 5644 or email christine.phillips@innerwest.nsw.gov.au.

Yours sincerely

Tony Giunta
Infrastructure Planning (Transport & Stormwater) Manager
Inner West Council

8 November 2017

[redacted]
[redacted] Pashley Street
Balmain NSW 2041

Dear [redacted]

Re: [redacted] Pashley Street Balmain

Have your say Managing flood risk in your neighbourhood

Public Exhibition of the draft Leichhardt Flood Risk Management Study and Plan

Thank you for your submission in relation to the recent public exhibition of the draft Leichhardt Flood Risk Management Study and Plan. All feedback received during the exhibition period will be considered by Council's Consultants (Cardno) in consultation with Council. A report on the feedback received during the exhibition period will be prepared for Council's Flood Management Advisory Committee prior Council's consideration of the same at a Council meeting during early 2018.

Council will notify all persons who made a submission during the exhibition period in writing of the meeting date.

In response to the particular matters you raised, as discussed with Council's engineer Mrs Christine Phillips, structural options WB-FM2 and WB-FM4 have been considered as independent options, not reliant upon the other or as an alternative to the other. WB-FM2 considers the potential benefits of upgrading the existing drainage system between Beattie Street and White Bay via Punch Park. WB-FM4 considers the potential benefits of upgrading the existing drainage system in Palmer Street and Wortley Street.

The Leichhardt Flood Risk Management Study and Plan does not recommend a specific works programme for implementation of any of the structural options. Instead the Plan is a working document identifies a series of structural flood modification measures such, as WB-FM2 and WB-FM4, that have merit for implementation when the opportunity arises and funding becomes available.

If you require further information please call Council's Stormwater and Development Engineer, Mrs Christine Phillips, on 9392 5644 or email christine.phillips@innerwest.nsw.gov.au.

Yours sincerely

Tony Giunta
Infrastructure Planning (Transport & Stormwater) Manager
Inner West Council

INNER WEST COUNCIL

8 November 2017

[redacted]
[redacted] Styles Street
Leichhardt NSW 2040

Dear [redacted]

Re: [redacted] Styles Street, Leichhardt

Have your say Managing flood risk in your neighbourhood

Public Exhibition of the draft Leichhardt Flood Risk Management Study and Plan

Thank you for your submission in relation to the recent public exhibition of the draft Leichhardt Flood Risk Management Study and Plan. All feedback received during the exhibition period will be considered by Council's Consultants (Cardno) in consultation with Council. A report on the feedback received during the exhibition period will be prepared for Council's Flood Management Advisory Committee prior Council's consideration of the same at a Council meeting during early 2018.

Council will notify all persons who made a submission during the exhibition period in writing of the meeting date.

In response to the particular matters you raised at Evan Jones Playground, your suggestions will be referred to Council's Parks Asset Team for investigation and consideration.

If you require further information please call Council's Stormwater and Development Engineer, Mrs Christine Phillips, on 9392 5644 or email christine.phillips@innerwest.nsw.gov.au.

Yours sincerely

A. Giunta

Tony Giunta
Infrastructure Planning (Transport & Stormwater) Manager
Inner West Council

8 November 2017

[redacted]
[redacted] Ferris Street
Annandale NSW 2038

Dear [redacted]

Re: [redacted] Ferris Street, Annandale

Have your say Managing flood risk in your neighbourhood

Public Exhibition of the draft Leichhardt Flood Risk Management Study and Plan

Thank you for your submission in relation to the recent public exhibition of the draft Leichhardt Flood Risk Management Study and Plan. All feedback received during the exhibition period will be considered by Council's Consultants (Cardno) in consultation with Council. A report on the feedback received during the exhibition period will be prepared for Council's Flood Management Advisory Committee prior Council's consideration of the same at a Council meeting during early 2018.

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If you require further information please call Council's Stormwater and Development Engineer, Mrs Christine Phillips, on 9392 5644 or email christine.phillips@innerwest.nsw.gov.au.

Yours sincerely

A. Giunta

Tony Giunta
Infrastructure Planning (Transport & Stormwater) Manager
Inner West Council

INNER WEST COUNCIL

8 November 2017

[redacted]
[redacted] Ferris Street
Annandale NSW 2038

Dear [redacted]

Re: [redacted] Ferris Street, Annandale

Have your say Managing flood risk in your neighbourhood

Public Exhibition of the draft Leichhardt Flood Risk Management Study and Plan

Thank you for your submission in relation to the recent public exhibition of the draft Leichhardt Flood Risk Management Study and Plan. All feedback received during the exhibition period will be considered by Council's Consultants (Cardno) in consultation with Council. A report on the feedback received during the exhibition period will be prepared for Council's Flood Management Advisory Committee prior Council's consideration of the same at a Council meeting during early 2018.

Council will notify all persons who made a submission during the exhibition period in writing of the meeting date.

If you require further information please call Council's Stormwater and Development Engineer, Mrs Christine Phillips, on 9392 5644 or email christine.phillips@innerwest.nsw.gov.au.

Yours sincerely

A. Giunta

Tony Giunta
Infrastructure Planning (Transport & Stormwater) Manager
Inner West Council

INNER WEST COUNCIL

8 November 2017

[redacted]
[redacted] Annandale Street
Annandale NSW 2038

Dear [redacted]

Re: [redacted] Annandale Street, Annandale

Have your say Managing flood risk in your neighbourhood

Public Exhibition of the draft Leichhardt Flood Risk Management Study and Plan

Thank you for your submission in relation to the recent public exhibition of the draft Leichhardt Flood Risk Management Study and Plan. All feedback received during the exhibition period will be considered by Council's Consultants (Cardno) in consultation with Council. A report on the feedback received during the exhibition period will be prepared for Council's Flood Management Advisory Committee prior Council's consideration of the same at a Council meeting during early 2018.

Council will notify all persons who made a submission during the exhibition period in writing of the meeting date.

If you require further information please call Council's Stormwater and Development Engineer, Mrs Christine Phillips, on 9392 5644 or email christine.phillips@innerwest.nsw.gov.au.

Yours sincerely

A. Giunta

Tony Giunta
Infrastructure Planning (Transport & Stormwater) Manager
Inner West Council

8 November 2017

[redacted]
[redacted] Hubert Street
Leichhardt NSW 2040

Dear [redacted]

Re: [redacted] Hubert Street, Leichhardt

Have your say Managing flood risk in your neighbourhood

Public Exhibition of the draft Leichhardt Flood Risk Management Study and Plan

Thank you for your submission in relation to the recent public exhibition of the draft Leichhardt Flood Risk Management Study and Plan. All feedback received during the exhibition period will be considered by Council's Consultants (Cardno) in consultation with Council. A report on the feedback received during the exhibition period will be prepared for Council's Flood Management Advisory Committee prior Council's consideration of the same at a Council meeting during early 2018.

Council will notify all persons who made a submission during the exhibition period in writing of the meeting date.

In response to the particular matters you raised, the tagging of your property as a Flood Control Lot was identified during the Flood Study process in 2010-2014 and is not a part of this Flood Risk Management Study and Plan process.

The purpose of the Flood Risk Management Study and Plan is identify and prioritise measures to reduce the impact of flooding and protect people and property through better planning, emergency management and infrastructure works, including upgrading of the piped drainage system where doing so has been shown to be beneficial. One of the measures considered as part of the Leichhardt Flood Risk Management Study and Plan is upgrade of the existing piped drainage system between William Street and Hawthorne Canal via Hubert Street, referred to as HC-FM4 in the Study and Plan.

If you require further information please call Council's Stormwater and Development Engineer, Mrs Christine Phillips, on 9392 5644 or email christine.phillips@innerwest.nsw.gov.au.

Yours sincerely

A. Giunta

Tony Giunta
Infrastructure Planning (Transport & Stormwater) Manager
Inner West Council

INNER WEST COUNCIL

8 November 2017

[redacted]
[redacted] Bay Street
Double Bay NSW 2028

Dear [redacted]

Re: [redacted] Balmain Road, Leichhardt

Have your say Managing flood risk in your neighbourhood

Public Exhibition of the draft Leichhardt Flood Risk Management Study and Plan

Thank you for your submission in relation to the recent public exhibition of the draft Leichhardt Flood Risk Management Study and Plan. All feedback received during the exhibition period will be considered by Council's Consultants (Cardno) in consultation with Council. A report on the feedback received during the exhibition period will be prepared for Council's Flood Management Advisory Committee prior Council's consideration of the same at a Council meeting during early 2018.

Council will notify all persons who made a submission during the exhibition period in writing of the meeting date.

In response to the particular matters you raised, the Leichhardt Flood Risk Management Study and Plan is a high level planning document that identifies the outcomes or reduction in flooding that could be achieved should a given structural flood modification (FM) option be implemented in the general vicinity shown in the Study and Plan. Detailed investigation and consultation with relevant stakeholders, including property owners, will be undertaken as part of the design phase. At that time the key points raised in your letter dated 26 September 2017 will be addressed.

Please note that that implementation of many of the structural modification options, including the Balmain Road Branch Option WC-FM3 that passes beneath your property, are also dependent upon funding availability and coordinated actions by the other asset owners, for example Sydney Water and Roads and Maritime Services (RMS).

If you require further information please call Council's Stormwater and Development Engineer, Mrs Christine Phillips, on 9392 5644 or email christine.phillips@innerwest.nsw.gov.au.

Yours sincerely

Tony Giunta
Infrastructure Planning (Transport & Stormwater) Manager
Inner West Council

8 November 2017

[redacted]
[redacted] Clarke Street
Annandale NSW 2038

Dear [redacted]

Re: [redacted] Clarke Street, Annandale

Have your say Managing flood risk in your neighbourhood

Public Exhibition of the draft Leichhardt Flood Risk Management Study and Plan

Thank you for your submission in relation to the recent public exhibition of the draft Leichhardt Flood Risk Management Study and Plan. All feedback received during the exhibition period will be considered by Council's Consultants (Cardno) in consultation with Council. A report on the feedback received during the exhibition period will be prepared for Council's Flood Management Advisory Committee prior Council's consideration of the same at a Council meeting during early 2018.

Council will notify all persons who made a submission during the exhibition period in writing of the meeting date.

If you require further information please call Council's Stormwater and Development Engineer, Mrs Christine Phillips, on 9392 5644 or email christine.phillips@innerwest.nsw.gov.au.

Yours sincerely

Tony Giunta
Infrastructure Planning (Transport & Stormwater) Manager
Inner West Council

INNER WEST COUNCIL

8 November 2017

[redacted]
[redacted] Charles Street
Leichhardt NSW 2040

Dear [redacted]

Re: [redacted] Charles Street, Leichhardt

Have your say Managing flood risk in your neighbourhood

Public Exhibition of the draft Leichhardt Flood Risk Management Study and Plan

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Council will notify all persons who made a submission during the exhibition period in writing of the meeting date.

If you require further information please call Council's Stormwater and Development Engineer, Mrs Christine Phillips, on 9392 5644 or email christine.phillips@innerwest.nsw.gov.au.

Yours sincerely

A. Giunta.

Tony Giunta
Infrastructure Planning (Transport & Stormwater) Manager
Inner West Council

INNER WEST COUNCIL

8 November 2017

[redacted]
[redacted] Foucart Street
Rozelle NSW 2039

Dear [redacted]

Re: [redacted] Foucart Street, Rozelle

Have your say Managing flood risk in your neighbourhood

Public Exhibition of the draft Leichhardt Flood Risk Management Study and Plan

Thank you for your submission in relation to the recent public exhibition of the draft Leichhardt Flood Risk Management Study and Plan. All feedback received during the exhibition period will be considered by Council's Consultants (Cardno) in consultation with Council. A report on the feedback received during the exhibition period will be prepared for Council's Flood Management Advisory Committee prior Council's consideration of the same at a Council meeting during early 2018.

Council will notify all persons who made a submission during the exhibition period in writing of the meeting date.

If you require further information please call Council's Stormwater and Development Engineer, Mrs Christine Phillips, on 9392 5644 or email christine.phillips@innerwest.nsw.gov.au.

Yours sincerely

A. Giunta

Tony Giunta
Infrastructure Planning (Transport & Stormwater) Manager
Inner West Council

INNER WEST COUNCIL

8 November 2017

[redacted]
[redacted] Louisa Road
Birchgrove NSW 2041

Dear [redacted]

Re: [redacted] Louisa Road, Birchgrove

Have your say Managing flood risk in your neighbourhood

Public Exhibition of the draft Leichhardt Flood Risk Management Study and Plan

Thank you for your submission in relation to the recent public exhibition of the draft Leichhardt Flood Risk Management Study and Plan. All feedback received during the exhibition period will be considered by Council's Consultants (Cardno) in consultation with Council. A report on the feedback received during the exhibition period will be prepared for Council's Flood Management Advisory Committee prior Council's consideration of the same at a Council meeting during early 2018.

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If you require further information please call Council's Stormwater and Development Engineer, Mrs Christine Phillips, on 9392 5644 or email christine.phillips@innerwest.nsw.gov.au.

Yours sincerely

A. Giunta.

Tony Giunta
Infrastructure Planning (Transport & Stormwater) Manager
Inner West Council

8 November 2017

[redacted]
[redacted] Arguimbau Street
Annandale NSW 2038

Dear [redacted]

Re: [redacted] Arguimbau Street, Annandale

Have your say Managing flood risk in your neighbourhood

Public Exhibition of the draft Leichhardt Flood Risk Management Study and Plan

Thank you for your submission in relation to the recent public exhibition of the draft Leichhardt Flood Risk Management Study and Plan. All feedback received during the exhibition period will be considered by Council's Consultants (Cardno) in consultation with Council. A report on the feedback received during the exhibition period will be prepared for Council's Flood Management Advisory Committee prior Council's consideration of the same at a Council meeting during early 2018.

Council will notify all persons who made a submission during the exhibition period in writing of the meeting date.

In response to the particular matter you raised, the Leichhardt Flood Risk Management Study and Plan is a high level planning document that identifies the outcomes or reduction in flooding that could be achieved should a given structural flood modification (FM) option be implemented in the general vicinity shown in the Study and Plan. Notwithstanding this, it is a fundamental criteria that any works undertaken should not adversely impact properties upstream or downstream of the works. In this regard, Council would not implement structural flood modification option WC-FM3 in isolation if doing so would be detrimental to downstream properties.

If you require further information please call Council's Stormwater and Development Engineer, Mrs Christine Phillips, on 9392 5644 or email christine.phillips@innerwest.nsw.gov.au.

Yours sincerely

Tony Giunta
Infrastructure Planning (Transport & Stormwater) Manager
Inner West Council

INNER WEST COUNCIL

8 November 2017

[redacted]
[redacted] Reserve Street
Annandale NSW 2038

Dear [redacted]

Re: [redacted] Reserve Street, Annandale

Have your say Managing flood risk in your neighbourhood

Public Exhibition of the draft Leichhardt Flood Risk Management Study and Plan

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Yours sincerely

A. Giunta.

Tony Giunta
Infrastructure Planning (Transport & Stormwater) Manager
Inner West Council

8 November 2017

[redacted]
[redacted] Ferris Street
Annandale NSW 2038

Dear [redacted]

Re: [redacted] Ferris Street, Annandale

Have your say Managing flood risk in your neighbourhood

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Yours sincerely

A. Giunta

Tony Giunta
Infrastructure Planning (Transport & Stormwater) Manager
Inner West Council

INNER WEST COUNCIL

8 November 2017

[redacted]
[redacted] Gilchrist Place
Balmain East NSW 2041

Dear [redacted]

Re: [redacted] Gilchrist Place, Balmain East

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Yours sincerely

Tony Giunta
Infrastructure Planning (Transport & Stormwater) Manager
Inner West Council

INNER WEST COUNCIL

8 November 2017

[redacted]
[redacted] Ferris Street
Annandale NSW 2038

Dear [redacted]

Re: [redacted] Ferris Street, Annandale

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Yours sincerely

Tony Giunta
Infrastructure Planning (Transport & Stormwater) Manager
Inner West Council

8 November 2017

[redacted]
[redacted] Marion Street
Leichhardt NSW 2040

Dear [redacted]

Re: [redacted] Marion Street, Leichhardt

Have your say Managing flood risk in your neighbourhood

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Yours sincerely

A. Giunta

Tony Giunta
Infrastructure Planning (Transport & Stormwater) Manager
Inner West Council

INNER WEST COUNCIL

8 November 2017

[redacted]
[redacted] Wortley Street
Balmain NSW 2041

Dear [redacted]

Re: [redacted] Wortley Street Balmain

Have your say Managing flood risk in your neighbourhood

Public Exhibition of the draft Leichhardt Flood Risk Management Study and Plan

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Yours sincerely

Tony Giunta
Infrastructure Planning (Transport & Stormwater) Manager
Inner West Council

P.O. Box 14 Petersham 2049 | P (02) 9392 5000 | E council@innerwest.nsw.gov.au
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INNER WEST COUNCIL

8 November 2017

[redacted]
[redacted] Cromwell Street
Leichhardt NSW 2040

Dear [redacted]

Re: [redacted] Cromwell Street, Leichhardt

Have your say Managing flood risk in your neighbourhood

Public Exhibition of the draft Leichhardt Flood Risk Management Study and Plan

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Yours sincerely

A. Giunta

Tony Giunta
Infrastructure Planning (Transport & Stormwater) Manager
Inner West Council

INNER WEST COUNCIL

8 November 2017

[redacted]
[redacted] Parramatta Road
Annandale NSW 2038

Dear [redacted]

Re: [redacted] Parramatta Road, Annandale

Have your say Managing flood risk in your neighbourhood

Public Exhibition of the draft Leichhardt Flood Risk Management Study and Plan

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Yours sincerely

Tony Giunta
Infrastructure Planning (Transport & Stormwater) Manager
Inner West Council

INNER WEST COUNCIL

8 November 2017

[redacted]
[redacted] Daniel Street
Leichhardt NSW 2040

Dear [redacted]

Re: [redacted] Daniel Street, Leichhardt

Have your say Managing flood risk in your neighbourhood

Public Exhibition of the draft Leichhardt Flood Risk Management Study and Plan

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Yours sincerely

Tony Giunta
Infrastructure Planning (Transport & Stormwater) Manager
Inner West Council

INNER WEST COUNCIL

8 November 2017

[redacted]
[redacted] Murdoch Street
Rozelle NSW 2039

Dear [redacted]

Re: [redacted] Murdoch Street, Rozelle

Have your say Managing flood risk in your neighbourhood

Public Exhibition of the draft Leichhardt Flood Risk Management Study and Plan

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Council will notify all persons who made a submission during the exhibition period in writing of the meeting date.

In response to the particular matters you raised, the Leichhardt Flood Risk Management Study and Plan is a high level planning document that identifies the outcomes or reduction in flooding that could be achieved should a given structural flood modification (FM) option be implemented in the general vicinity shown in the Study and Plan. The exact location and construction methodology for any given FM option will be determined as part of the detailed design phase, which all stakeholders, including affected residents, will be invited to be a part of.

The Leichhardt Flood Risk Management Study and Plan does not recommend a specific works plan for implementation of the structural options. Instead the Plan identifies a series of measures that have merit for implementation when the opportunity arises and funding becomes available. Of importance to note is that many of the structural measures, including the Beattie Street Branch Option WB-FM1, are dependent upon coordinated actions by the other asset owners, for example Sydney Water.

If you require further information please call Council's Stormwater and Development Engineer, Mrs Christine Phillips, on 9392 5644 or email christine.phillips@innerwest.nsw.gov.au.

Yours sincerely

A. Giunta

Tony Giunta
Infrastructure Planning (Transport & Stormwater) Manager
Inner West Council

INNER WEST COUNCIL

8 November 2017

[redacted]
[redacted] Wulumay Close
Rozelle NSW 2039

Dear [redacted]

Re: [redacted] Wulumay Close, Rozelle

Have your say Managing flood risk in your neighbourhood

Public Exhibition of the draft Leichhardt Flood Risk Management Study and Plan

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If you require further information please call Council's Stormwater and Development Engineer, Mrs Christine Phillips, on 9392 5644 or email christine.phillips@innerwest.nsw.gov.au.

Yours sincerely

A. Giunta

Tony Giunta
Infrastructure Planning (Transport & Stormwater) Manager
Inner West Council

INNER WEST COUNCIL

8 November 2017

[redacted]
[redacted] Hyam Street
Balmain NSW 2041

Dear [redacted]

Re: [redacted] Hyam Street, Balmain

Have your say Managing flood risk in your neighbourhood

Public Exhibition of the draft Leichhardt Flood Risk Management Study and Plan

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Yours sincerely

Tony Giunta
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Inner West Council

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INNER WEST COUNCIL

8 November 2017

[redacted]
[redacted] Callan Street
Rozelle NSW 2039

Dear [redacted]

Re: [redacted] Callan Street, Rozelle

Have your say Managing flood risk in your neighbourhood

Public Exhibition of the draft Leichhardt Flood Risk Management Study and Plan

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Yours sincerely

A. Giunta

Tony Giunta
Infrastructure Planning (Transport & Stormwater) Manager
Inner West Council

INNER WEST COUNCIL

8 November 2017

[redacted]
[redacted] Carlisle Street
Leichhardt NSW 2040

Dear [redacted]

Re: [redacted] Carlisle Street, Annandale

Have your say Managing flood risk in your neighbourhood

Public Exhibition of the draft Leichhardt Flood Risk Management Study and Plan

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Council will notify all persons who made a submission during the exhibition period in writing of the meeting date.

In response to the particular matter you raised, your property is no longer classified as a Flood Control Lot in Leichhardt DCP 2013.

If you require further information please call Council's Stormwater and Development Engineer, Mrs Christine Phillips, on 9392 5644 or email christine.phillips@innerwest.nsw.gov.au.

Yours sincerely

Tony Giunta
Infrastructure Planning (Transport & Stormwater) Manager
Inner West Council

INNER WEST COUNCIL

8 November 2017

[redacted]
[redacted] Young Street
Annandale NSW 2038

Dear [redacted]

Re: [redacted] Young Street, Annandale

Have your say Managing flood risk in your neighbourhood

Public Exhibition of the draft Leichhardt Flood Risk Management Study and Plan

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Yours sincerely

A. Giunta

Tony Giunta
Infrastructure Planning (Transport & Stormwater) Manager
Inner West Council

INNER WEST COUNCIL

8 November 2017

[redacted]
[redacted] Denison Street
Rozelle NSW 2039

Dear [redacted]

Re: [redacted] Denison Street, Rozelle

Have your say Managing flood risk in your neighbourhood

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Yours sincerely

A. Giunta

Tony Giunta
Infrastructure Planning (Transport & Stormwater) Manager
Inner West Council

INNER WEST COUNCIL

8 November 2017

[redacted]
[redacted] Hubert Street
Leichhardt NSW 2040

Dear [redacted]

Re: [redacted] Hubert Street, Leichhardt

Have your say Managing flood risk in your neighbourhood

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Yours sincerely

A. Giunta

Tony Giunta
Infrastructure Planning (Transport & Stormwater) Manager
Inner West Council

8 November 2017

[redacted]
[redacted] Waragal Ave
Rozelle NSW 2039

Dear [redacted]

Re: [redacted] Waragal Ave, Rozelle

Have your say Managing flood risk in your neighbourhood

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Yours sincerely

Tony Giunta
Infrastructure Planning (Transport & Stormwater) Manager
Inner West Council

INNER WEST COUNCIL

8 November 2017

[redacted]
[redacted] Arguimbau Street
Annandale NSW 2038

Dear [redacted]

[redacted]: [redacted] Arguimbau Street, Annandale

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Yours sincerely

Tony Giunta
Infrastructure Planning (Transport & Stormwater) Manager
Inner West Council

INNER WEST COUNCIL

8 November 2017

[redacted]
[redacted] Clarke Street
Annandale NSW 2038

Dear [redacted]

Re: [redacted] Clarke Street, Annandale

Have your say Managing flood risk in your neighbourhood

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Yours sincerely

A. Giunta

Tony Giunta
Infrastructure Planning (Transport & Stormwater) Manager
Inner West Council

8 November 2017

[redacted]
[redacted] Crescent Street
Rozelle NSW 2039

Dear [redacted]

Re: [redacted] Crescent Street, Rozelle

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Yours sincerely

A. Giunta

Tony Giunta
Infrastructure Planning (Transport & Stormwater) Manager
Inner West Council

INNER WEST COUNCIL

8 November 2017

[redacted]
[redacted] Nelson Street
Annandale NSW 2038

Dear [redacted]

Re: [redacted] Nelson Street, Annandale

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