Mascot, Rosebery and Eastlakes Floodplain Risk Management Study & Plan

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Foreword

The NSW State Government's Flood Policy provides a framework to support the sustainable use of floodplains. The Policy is specifically structured to define and mitigate existing flooding problems in rural and urban areas. In addition, the Policy provides a means of ensuring that any new development is compatible with the flood hazard and does not create additional flooding problems in other areas.

Under the Policy, the management of flood liable land remains the responsibility of Local Government. The State Government subsidises flood mitigation works to alleviate existing problems and provides specialist technical advice to assist councils with their floodplain management responsibilities.

The Policy provides for technical and financial support by the State Government through the following sequential stages, as outlined in the Floodplain Development Manual (2005) (**Reference 1**):

1. Data Collection

- Compilation of existing data and collection of any additional data. The usability of these data sets are assessed and any existing reports are summarised.

2. Flood Study

- Defines the nature and extent of the flood problem in the study area.

3. Floodplain Risk Management Study

- Determines management options in consideration of social, ecological and economic factors relating to flood risk.

4. Floodplain Risk Management Plan

- Preferred options publically exhibited and subject to revision in light of responses. Formal adoption of the Plan by Council is undertaken.

5. Implementation of the Plan

- Implementation of flood response and property modification measures (including mitigation works, planning controls, flood warnings, flood readiness and response plans, environmental rehabilitation, ongoing data collection and monitoring) by Council. Development controls implemented to ensure that new development is compatible with flood hazard.

1 Introduction and Background

Royal HaskoningDHV (RHDHV) has been commissioned to prepare the Mascot, Rosebery and Eastlakes (MRE) Floodplain Risk Management Study and Plan (FRMS&P) on behalf of Bayside Council (Council) and overseen by the NSW Office of Environment and Heritage (OEH).

Stage 1 (Data Collection) and Stage 2 (Flood Study) of the NSW Floodplain Management Program were completed by WMAwater in 2015 (**Reference 3**). The document herein presents Stages 3 and 4 of the NSW State Government's Floodplain Management Program; the Mascot, Rosebery and Eastlakes Floodplain Risk Management Study and the Mascot Rosebery and Eastlakes Floodplain Risk Management Plan.

A glossary of terms has been provided in **Appendix A**. All levels provided in this report are to Australian Height Datum (AHD).

1.1 Study Objectives

The primary purpose of the FRMS&P is to identify, assess and compare various risk management options whilst considering opportunities for environmental enhancement as part of the mitigation works (**Reference 1**). This study will assess a suite of flood risk management measures and their associated tangible and intangible costs to determine a range of options for inclusion in the Floodplain Risk Management Plan and potential future implementation.

1.1.1 Floodplain Risk Management Study Objectives

The aim of a Floodplain Risk Management Study is to assess a range of flood mitigation strategies to alleviate flood affectation in a Local Government Area (LGA), in accordance with the NSW Government's Flood Policy. The objectives of this study include:

- Reduce the flood hazard and risk to people and property in the existing community and to ensure future development is controlled in a manner consistent with the flood hazard and risk (taking into account the potential impacts of climate change).
- Reduce private and public losses due to flooding.
- Protect and where possible enhance the floodplain environment.
- Be consistent with the objectives of relevant State policies, in particular, the Government's Flood Prone Land and State Rivers and Estuaries Policies and satisfy the objectives and requirements of the Environmental Planning Assessment Act, 1979.

1.1.2 Floodplain Risk Management Plan Objectives

The Floodplain Risk Management Plan aims to present a range of flood mitigation recommendations to address the existing flood liability of an LGA. The objectives of the plan are outlined below:

- Ensure that the floodplain risk management plan is fully integrated with Council's existing corporate, business and strategic plans, existing and proposed planning proposals, meets Council's obligations under the Local Government Act, 1993 and has the support of the local community.
- Ensure actions arising out of the plans are sustainable in social, environmental, ecological and economic terms.
- Ensure that the floodplain risk management plan is fully integrated with the local emergency management plan (flood plan) and other relevant catchment management plans.
- Establish a program for implementation and suggest a mechanism for the funding of the plan, which should include priorities, staging, funding, responsibilities, constraints and monitoring.

1.2 The Study Area

The study area is comprised of two catchment areas; Mascot, Rosebery and Eastlakes (referred to as MRE in this study) and Botany Wetlands and Pagewood. These areas are shown in **Figure 1**. The study area is located within the Bayside Council LGA and has an area of approximately 7.9 km^2.

1.2.1 Mascot, Rosebery and Eastlakes Catchment

The MRE catchment has an area of approximately 4.9 km^2 and is comprised of residential, commercial and industrial developments. This catchment is highly developed and as such largely impervious to rainfall infiltration.

Botany Road separates the Mascot catchment in the west from the Rosebery and Eastlakes catchments to the east. Generally, the Mascot catchment drains in a westerly direction to the Alexandra Canal forming part of the Cooks River catchment. To the east, the Rosebery and Eastlakes catchment drains in a south-westerly direction, into the Ascot Drain which discharges directly to Botany Wetlands.

The Flood Study (**Reference 3**) found that the Metropolitan Goods Railway Line forms a major hydraulic feature of the catchment, obstructing overland flow at Baxter Road. Further, drainage from Baxter Road can only occur via the piped drainage network. As such, this location is subject to frequent ponding of floodwaters resulting in inundation of properties in flood events as frequent as the 0.2 EY (see **Appendix A** for design event probabilities).

Typical urban drainage structures are present in this catchment including kerb and gutter, pits and sub surface pipe networks and some trunk drainage including open channels in the downstream reaches. These structures are owned by Council and Sydney Water Corporation (SWC).

1.2.2 Botany Wetlands and Pagewood Catchments

The Botany Wetlands catchment has an area of approximately 3.0 km^2 and is comprised of golf courses, playing fields and some urbanised areas (Daceyville and Pagewood) on the catchment fringes. This catchment receives inflows from Centennial Park and Kensington to the north (in the Randwick and City of Sydney LGA's).

The Botany Wetlands consists of a series of interconnected constructed ponds forming the largest coastal freshwater wetland system in the Sydney region.

1.3 Overview of Existing Catchment

1.3.1 Land Use and Demographic Overview

To ensure that the correct risk management practices are adopted, it is important to understand the social characteristics of the area. The 2011 Census data provides useful information on factors such as dwelling and tenure type, languages spoken, age of the population and the movement of people into and out of the area. Relevant information from the 2011 Census has been extracted for the study area and is summarised in the following sections.

1.3.1.1 Rosebery

The suburb of Rosebery has a population of 8,479 in 3,353 private dwellings. The population movement in a suburb, such as Rosebery, can provide an indication of the general flood awareness within a catchment.

Typically residents who have lived in an area for a longer period of time would have a better understanding of the flood affectation in their local area than those who have recently moved into the area. In the five years prior to the 2011 Census, approximately 33% of the Rosebery population moved into the area. This indicates that Rosebery is prone to a high population turnover and as such, the community are likely to be less aware of the flood affectation in their area. Furthermore, if a significant flood event were to occur in the Rosebery area, the community are likely to be unprepared to evacuate as necessary.

The tenure of dwellings is also useful to consider since property owners living in the area are more likely to be aware of the flood risks and have measures in place to reduce their flood affectation. Rental properties typically have a high tenant turnover and are therefore less aware of the flood risk at their residence. In Rosebery, approximately 33% of properties are rented.

The provision of flood information to the public is greatly affected by the languages spoken by the population. In Rosebery, 51% of the population speak a language other than English at home. This information should be considered when engaging with the community of Rosebery.

The majority of Rosebery within the study area is comprised of lots zoned as Zone 2(a) Residential and Zone 2(b) Residential dwellings. Along Botany Road and Gardeners Road are several Zone 3(a) General Business lots for commercial and industrial developments. **Figure 2** shows the land use areas in Rosebery.

In terms of sensitive land uses, Gardeners Road Primary School and the Sydney International Film School are located in the Rosebery area. Gardeners Road Primary School is a public school located at the corner of Gardeners Road and Botany Road.

1.3.1.2 Mascot

It was recorded in the 2011 Census that Mascot had a population of 10,179 in 4,075 private dwellings. Approximately 35% of the population moved into the Mascot area in the 5 years prior to the 2011 Census. As previously mentioned (see **Section 1.3.1.1**), it is likely that many members of the Mascot population may not be aware of the flood history or the flood liability of the area.

In Mascot, it was calculated using the 2011 Census data that approximately 33% of properties are rented. As such, it is likely that the tenants are less aware of the flood affectation in their area.

Approximately 47% of the Mascot population speak a language other than English at home. This information is crucial when considering community engagement in Mascot.

The suburb of Mascot has a range of land uses (shown in **Figure 2**). The eastern side of the suburb is predominately zoned as Zone 2(a) and Zone 2(b) Residential with some Zone 3(a) Commercial lots along Botany Road. In the central areas of the suburb (west of Botany Road), the land use is predominately residential with some lots zoned as Zone 6(a) Open Space and Recreation and Zone 4(c2) Industrial Special-Airport Related Restricted. Along O'Riordan Street there are several Zone 4(a) Industrial General A lots. Finally to the east, are a combination of Special Uses (Zone 5), Mixed Uses (Zone 10) and Industrial Uses (Zone 4).

Along Botany Road is a key commercial area for the suburb of Mascot. Redevelopment is currently occurring around the Mascot Railway Station Area. This area will consist of high density commercial and residential developments.

The Police Headquarters for the local Botany Bay Area Command is on Botany Road and Mascot Ambulance Station is situated directly opposite. Mascot Fire Station is located in Coward Street, beside the City of Botany Bay Council Chambers.

Sydney Airport, Sydney's principal airport, is located to the south-west of the suburb.

Mascot Public School is a primary school in King Street and the J. J. Cahill Memorial High School is located in Sutherland Street. St. Therese's School is located adjacent to the St. Therese's Church on Sutherland Street.

Of note, is the proposed WestConnex road infrastructure development along Botany Road which is likely to significantly increase the traffic through the Mascot area in the future.

1.3.1.3 Eastlakes

The suburb of Eastlakes had a population of 6,920 in 2,865 private dwellings, according to the 2011 Census. Approximately 25% of the Eastlakes population moved into the area in the 5 years prior to the census and as such, a significant proportion of the population is likely to be unaware of the flood affectation in the area.

According to the 2011 Census 50% of the properties in Eastlakes are occupied by tenants, compounding the lack of flood awareness in the suburb.

Furthermore, 61% of the population speak a language other than English at home which, as previously mentioned, will be integral to the community engagement in the area.

The suburb of Eastlakes is predominately a mix of Zone 2(a) and Zone 2(b) Residential and Zone 6(c) Open Space Recreation Restricted in the Botany Wetlands area. These land uses are shown in **Figure 2**. The Eastlakes Public School is located on Florence Avenue at the top of the catchment.

1.3.1.4 Botany Wetlands

Historically, Botany Wetlands was used for Sydney's water supply system. The Wetlands are now includes two regionally rare vegetation communities; the Sydney Freshwater Wetlands and Eastern Suburbs Banksia Scrub. These are both listed as *'Endangered Ecological Communities'* under the *Threatened Species Conservation Act 1995* (NSW).

The Botany Wetlands are mapped in the Botany Bay Local Environmental Plan 2013. In terms of Land Use (shown in **Figure 2**), the Wetlands area is predominantly Zone 6(c) Open Space Recreation Restricted.

1.3.1.5 Pagewood

The suburb of Pagewood is located to the south of the Botany Wetlands with a population of 3,643 in 1,362 private dwellings according to the 2011 Census. Approximately 25% of the population moved into the area in the 5 years prior to the census. Similarly, 25% of the properties in the area are occupied by tenants. It was found that 34% of the population speak a language other than English at home.

The majority of Pagewood is zoned as Residential (Zone 2(a) and Zone 2(b)) with some areas zoned as Zone 6(a) Open Space and Recreation and Zone 4(a) Industrial General A. The Pagewood land uses are displayed in **Figure 2**.

2 Available Data

2.1 Previous Studies

2.1.1 Mascot, Rosebery and Eastlakes Flood Study, 2015 (Reference 3)

The Mascot, Rosebery and Eastlakes Flood Study (the Flood Study) was undertaken by WMAwater on behalf of Botany Bay Council (now Bayside Council) in 2015 (**Reference *3***). The Flood Study formed Stage one and Stage two of the NSW flood program, with the current study forming Stage three and Stage four for the same study area.

The Flood Study developed a DRAINS hydrologic model and TUFLOW hydraulic model for the MRE, Botany Wetlands and Pagewood catchments. As is typical in urban areas, there was a lack of gauge data to undertake a thorough calibration of the hydrologic and hydraulic models. Instead, a model verification and detailed sensitivity analysis was conducted.

The Flood Study used the hydraulic model to undertake a critical storm duration analysis for each catchment. In the MRE catchment a critical storm duration of 2 hours was determined. Since the Botany Wetlands conveys flow from the north via Centennial Park and Kensington, a larger critical duration of nine (9) hours was found to govern catchment flows. The Pagewood catchment was found to have a critical storm duration of 25 minutes, which is reasonable considering the small size and largely impervious nature of this catchment.

A detailed analysis of 12 hotspot locations in the catchment was conducted as a part of the Flood Study. Areas which were historically flood prone or were subject to hazardous flows were selected as hotspots for additional analysis. These hotspots formed the basis of the flood modification measures analysed in in the current study (**Section 6.3**).

The current study has reviewed (see **Section 4**) and adopted the TUFLOW hydraulic model developed during the Flood Study.

2.2 Planning Documentation

2.2.1 Botany Bay Local Environment Plan (LEP)

A Local Environment Plan (LEP) is a document prepared by a Council and approved by the NSW State Government. The LEP regulates land use and development within a LGA and guides planning decisions for local governments. The key flood related clause in the Botany Bay LEP (2013) is outlined below:

6.3 Stormwater management

1) *The objective of this clause is to minimise the impacts of urban stormwater on land to which this clause applies and on adjoining properties, native bushland and receiving waters.*
2) *This clause applies to all land in residential, business and industrial zones.*
3) *Development consent must not be granted to development on land to which this clause applies unless the consent authority is satisfied that the development:*
    a. *is designed to maximise the use of water permeable surfaces on the land having regard to the soil characteristics affecting on-site infiltration of water, and*
    b. *includes, if practicable, on-site stormwater retention for use as an alternative supply to mains water, groundwater or river water, and*

c. *avoids any significant adverse impacts of stormwater runoff on adjoining properties, native bushland and receiving waters, or if that impact cannot be reasonably avoided, minimises and mitigates the impact.*

2.2.2 Botany Bay Development Control Plan (DCP)

A Development Control Plan (DCP) provides detailed planning and design guidelines in an LGA to support the planning controls in the LEP. This document is prepared by Council and identifies additional development controls and standards for addressing development issues at a local level. The DCP can be applied more flexibly than the LEP.

Flood related development controls can be found in the Botany Bay DCP (2013) in Section 3G (Stormwater Management) and Section 10 (Stormwater Management Technical Guidelines). Section 10 of the DCP outlines flood related development controls such as on-site detention systems, underground structures, finished flood levels, and the requirements for site specific flood studies and flood impact assessments. It is noted that Botany Bay have adopted a minimum floor level of the 1% AEP flood level plus a freeboard of 0.5 m for habitable structures. For non-habitable structures, a minimum flood level of the 1% AEP flood level plus 0.3 m freeboard has been assigned.

2.3 Survey Data

2.3.1 Floor Level Survey

Floor level survey was performed by Spatial Technologies Pty. Ltd. for properties that experience flood depths of greater than 200 mm in the 0.5 EY. A total of 588 properties were surveyed in these key hotspot areas. The location of surveyed floor levels are shown in **Figure 1**.

The floor levels for the remaining properties within the Probable Maximum Flood (PMF) extent were estimated by use of the DEM to estimate the ground levels at a the front door of a property. The cadastre and the LEP zoning maps were used to determine the land use at each property and as such the ground to floor level. It was assumed that for residential properties the ground to floor height was 0.3 m. Similarly for commercial and industrial properties, it was assumed that the ground to floor height was 0.15 m.

These surveyed and estimated flood levels were combined to form a property database, used to determine the tangible flood damages across the LGA (**Section 5.2**).

3 Community Consultation

Community consultation is a fundamental element of the floodplain risk management process as it facilitates community engagement and ultimately aids the endorsement of the overall project. During the Flood Study, a newsletter and questionnaire was distributed to residents within the catchment to inform residents about the study and seek information regarding flooding experiences and records of historical flooding. Further community consultation has also been undertaken as a part of the FRMS&P in the form of a community information session and an on-site consultation with residents in particularly flood prone areas.
A final community consultation session was held during the public exhibition of the Floodplain Risk Management Study and Plan on 4th of October 2018.

3.1 Community Information Session

A community information session was held on 5th April 2016 at Botany Town Hall. This session was advertised on Council's website and in the local newspaper. The primary objective of this community engagement was to obtain community knowledge of hotspots and ideas of potential flood mitigation options to reduce flood affectation in the study area.

A key outcome of this consultation session was the verification of flooding experienced by residents of properties on Aloha Street and Maloney Street in Mascot and Sparks Street in Eastlakes.

A resident at Maloney Street advised that the stormwater pits on either side of the street's low point effectively convey flow into the drainage network during flood events. This was verified in the hydraulic model. The stormwater pits convey flow until the sub-surface stormwater network has reached capacity and floodwaters flow overland. It is likely that the capacity of the stormwater network is only reached in more rare flood events which have not occurred in recent decades.

Overall, there was minimal attendance at this session in comparison to the catchment size. As such, future consultation meetings as a part of the FRMS&P will undergo more rigorous advertising.

3.2 On-site Consultation

A RHDHV engineer undertook a 'door-knocking' exercise of approximately 30 properties within the MRE catchment. A variety of residential, commercial and industrial properties were visited. These properties were subject to inundation in the 1% AEP design event.

In areas subject to frequent flooding, residents were aware of the flood affectation in their area. These areas included:

- Ricketty Street, Coward Street and Gardeners Road neighbouring Alexandra Canal;
- Robey Street and Baxter Road adjacent to the Sydney Airport domestic terminal entrance; and
- Mascot Public School and adjacent streets of MacIntosh, Forster and Oliver Street.

As anticipated, residents in areas where flooding is less frequent expressed little to no knowledge or awareness of their flood affectation. These areas included:

- Carinya Ave, Hughes Ave and Miles Street west of Mascot Police Station;
- Evans Ave, Mascot Drive and Barber Ave west of Eastlakes Shopping Centre; and
- Hardie Street, Johnson Street and Alfred Street parallel to Botany Road.

A common misconception for residents is that since they have not experienced a significant flood in their living memory, then they often conclude that the area is therefore not flood affected. This misconception was found to be held be many residents interviewed on site, particularly those who had lived in the area for a considerable amount of time.

In terms of flood preparedness, many residents had no flood evacuation plans and believed that they would likely only evacuate once their homes were inundated or after being told to do so by emergency services.

Business owners and managers on Coward Street and Ricketty Street were aware of flooding issues caused by high water levels in the Alexandra Canal. They noted that on a number of occasions during light localised rainfall, the drainage pits were seen to be back flowing from the canal or preventing local drainage of runoff.

3.3 Public Exhibition of the Final Mascot, Rosebery and Eastlakes FRMS&P

Public Exhibition of the Final Mascot, Rosebery and Eastlakes FRMS&P was undertaken between 18th September 2018 and 19th October 2019 to gain the support of the local community. Community consultation report can be found in appendix D.

4 Flood Study Review

4.1 Hydrologic Model Review

The hydrologic DRAINS model developed in the Flood Study (**Reference 3**) has been reviewed in the current study. Three separate DRAINS models were developed to represent the three catchments; MRE, Botany Wetlands and Pagewood.

These DRAINS models were established for input into the hydraulic models, with no catchment routing. A hydrograph for each sub-catchment was output and entered into the hydraulic model at the bottom of each catchment. This hydrologic model lends itself well to the FRMS&P.

Since these hydrologic models were developed prior to the release of the revised Australian Rainfall and Runoff (ARR) guidelines in 2016, design rainfall intensities have been derived from the ARR 1987. These rainfall intensities are considered suitable for the current study.

The adopted DRAINS hydrologic model parameters used are shown in **Table 1**. The adopted values are within the range of typical values for initial and continuing loss rates for a sand soil catchment.

Table 1: Hydrologic Model Parameters (Reference 3)

RAINFALL LOSSES	Value
Paved Area Depression Storage (Initial Loss)	1.0 mm
Grassed Area Depression Storage (Initial Loss)	5.0 mm
SOIL TYPE	**1**
High Infiltration rates. This parameter, in conjunction with the AMC, determines the continuing loss	
ANTECEDENT MOISTURE CONDITIONS (AMC)	
Description	Rather Wet
Total rainfall in 5 days preceding the storm	12.5 to 25 mm

4.2 Hydraulic Model Review

4.2.1 Introduction

Three hydraulic models were developed using TUFLOW software in the Flood Study (**Reference 3**). These models were built separately to utilise a regularly spaced computational grid (2 m) while maintaining low run times. As such the following catchments were modelled separately; Mascot, Rosebery and Eastlakes (MRE), Botany Wetlands and Pagewood. These models were reviewed in the current study to determine their suitability for assessing flood management measures in the hydraulic models.

Hydrodynamic (and hydraulic) modelling was undertaken using TUFLOW, a 1D/2D model which used the St Venant equations to route flow. TUFLOW software has been widely used in Australia and RHDHV has extensive experience with the software package.

The hydraulic TUFLOW models were supplied by Council and run to ensure that identical results were achieved to those supplied. These models use the TUFLOW Build: 2013-12-AB-iDP-w64.

The hydraulic models used topographic LiDAR data collected in 2007 and 2008. Other key hydraulic features that significantly influence flood behaviour such as flow paths, buildings, kerbs and gutters, road embankments, the drainage network, fences and bridges were represented in the hydraulic model.

The pit and pipe data included in the models were collated from Council and Sydney Water Corporation (SWC). The SWC capacity assessment report (SCW, 1998) provided dimensions for the SWC owned underground pipes. Council provided pit locations and pipe dimensions (where available) for Council infrastructure. Finally, Council undertook additional survey in 2013 and 2014 to obtain missing data. Review of the included pit and pipe data indicates that all relevant pit and pipe data has been included in the hydraulic models with some minor changes to the MRE model (see **Section 4.2.2**).

Bridge and weir dimensions were collated from site inspections and incorporated into the model using levels obtained from the LiDAR data.

Buildings can significantly influence the flood behaviour in urban areas. As such, buildings were incorporated into the hydraulic models as impermeable obstructions to floodwaters.

The adopted hydraulic roughness values (shown in **Table 2**) are within the range of typical values for the given land surface category.

Table 2: Roughness Values (Reference 3)

Area	Manning's n
Urban Residential	0.04
Commercial/Industrial	0.03
Light Vegetation/Grass/Field	0.035
Medium Vegetation	0.06
Roads/Pavements	0.022
Concrete-lined Channel	0.015
Railway Corridor - added for Pagewood	0.040

4.2.2 MRE Model

The MRE hydraulic model covers an area of 4.9 km^2 (shown in **Figure 1**). A 2 m by 2 m grid size was utilised and run with a 0.5 second timestep for 2D model elements and a 0.1 second timestep for 1D model elements. These parameters were found to be suitable for the hydraulic model to adequately define features such as kerbs, gutters and open channels.

The Flood Study (**Reference 3**) derived a critical duration of 120 minutes using the hydraulic model. This duration has been adopted in the current study.

The mass balance in the model was reviewed and determined to be relatively stable.

A model file (*"2d_zsh_1225BotanyRd_fences"*) was missing from the supplied hydraulic model files. On inspection of the supplied results and those modelled by RHDHV, it was determined that this missing file did not impact the flood behaviour of the model.

In urban areas subject to overland flow, fences can typically obstruct flow and alter the flood behaviour in an area. As such fences have been represented in the MRE model as layered flow constrictions.

Regular open channels were included in the model as 1D channels. A range of data was collated to aid the modelling of these channels including cross sections from Mascot West SWC 64 Capacity Assessment (SWC, 1998), works-as-executed maps, SWC's drainage database and additional survey undertaken in 2013.

A review of the hydraulic model highlighted some minor inconsistencies with the pit and pipe data. The pipe diameter of Pipe *"pd469"* along Hollingshed Street was changed from 0.375 m to 1.3 m to maintain consistency with the culverts immediately upstream and downstream of the subject pipe. Furthermore, a review found that in some instances, the pipes were not consistently flowing in a downhill direction. As such, minor changes to 41 pit invert levels rectified this issue. These model revisions resulted in only minor changes to the existing 1% AEP results.

4.2.3 Botany Wetlands Model

The Botany Wetlands TUFLOW Model covers an area of 3.0 km^2 (shown in **Figure 1**). A 4 m by 4 m cell size was utilised and run using a 1.0 second timestep in the 2D domain and 0.1 second timestep in the 1D domain. These parameters were found to be suitable for the hydraulic model to adequately define the wetlands.

The Flood Study (**Reference *3***) derived a critical duration of 9 hours (540 minutes) using the hydraulic model. This duration has been adopted in the current study.

The mass balance in the model was reviewed and determined to be relatively stable.

The Botany Wetlands model was determined to be suitable for use in the current study.

4.2.4 Pagewood Model

The Pagewood TUFLOW Model covers an area of 0.2 km^2 (shown in **Figure 1**) and models the overland flow paths through the suburb and draining into Botany Wetlands. A cell size of 2 m by 2 m was adopted and run using a 0.5 second timestep for 2D model elements and a 0.1 second timestep for 1D model elements. These parameters are considered suitable for the hydraulic model.

The Flood Study (**Reference *3***) derived a critical duration of 25 minutes using the hydraulic model. This duration has been adopted in the current study.

All appropriate pit and pipe data has been included in the hydraulic model.

The Pagewood hydraulic model was determined to be suitable for use in the current study

4.3 Summary

The hydrologic and hydraulic models (including the updated MRE TUFLOW model) were determined to be appropriate for assessing flood modification measures (refer to **Section 6.3**).

5 Floodplain Risk Management Study

5.1 Objectives of the Floodplain Risk Management Study

The Floodplain Risk Management Study aims to mitigate flood risk by means of modification measures to address existing, future and continuing flood problems. This study has been conducted in accordance with the NSW Government's Flood Policy, detailed in the Floodplain Development Manual (**Reference 1**).

5.2 Impacts of Flooding

5.2.1 Background

The impacts of flooding are typically divided, into tangible and intangible damages and at a secondary level, as direct and indirect damages. Tangible damages are those for which a monetary value can be easily assigned, while intangible damages are those to which a monetary value cannot easily be attributed. Intangible damages may arise from social and environmental effects caused by flooding, including factors such as loss of life and injury, stress and anxiety.

Tangible damages may be direct or indirect flood damages. Direct damages are directly attributed from the actions of flooding (inundation and flow, on property and structures), while indirect damages arise from the disruptions to physical and economic activities caused by flooding. Examples of indirect damages include losses due to the disruption of business, expenses of alternative accommodation, disruption of public services, emergency relief aid and clean-up costs.

Given the variability of property and contents values, the total likely damages amount in any given flood event is approximate only and while useful to gauge the magnitude of the flood problem, it is of little value for absolute economic evaluation. Given that the primary purpose of the flood damages estimates are to evaluate the economic effectiveness of proposed mitigation options, the methods used are considered appropriate.

The Average Annual Damage (AAD) is the main comparative factor that is derived from this flood damages assessment with which to evaluate the effectiveness of proposed mitigation options. The AAD represents the estimated tangible damages sustained every year on average over a given 'long' period of time and is determined using the full range of design flood events output from the updated hydraulic model (refer to **Section 4.2**).

This flood damages assessment was conducted in accordance with the guidelines specified by the Office of Environment and Heritage (OEH) (formerly the Department of Environment and Climate Change) and the Queensland Department of Natural Resources and Mines (DNRM, 2002), based on the flood damage curves developed by ANUFLOOD (Smith & Greenway 1988).

5.2.2 Residential Properties

A flood damages assessment was undertaken for a total of 4,356 residential properties in the MRE (3,904 properties), Botany Wetlands (317 properties) and Pagewood (135 properties) catchments. All properties within the PMF flood extent were considered in this analysis.

The property database (refer to **Section 2.3.1**) was used to determine the flood affectation at properties within the study area. This database compiled surveyed and estimated floor levels. Floor levels were estimated to be 0.3 m above the ground level of the DEM at the front door of each residential property.

Properties were assumed to be single storey dwellings with a slab on ground construction. This assumption was verified through site visits by RHDHV engineers and a desktop analysis of Google Street View imagery.

It is important that the flood level assigned to each lot is taken proximate to the location where the ground and floor levels were determined. As such, it was established that design flood levels would be taken within a 5 m radius of the front door of each property. Flood damages were calculated for all properties within the design PMF extent.

The ground and floor levels were used to identify the flood event responsible for over floor flooding in the first instance. This data was then used with the flood damages curves to monetarise the potential direct and indirect damages for a range of design flood events.

The residential damages are calculated based on factors such as CPI, regional cost factor, flood awareness, flood warning time, typical cost of contents, typical building footprint and insurance. For high-set houses the curves allow for damages associated with flooding beneath the floor level since these spaces are often used for storage. Further, allowances are made for direct and indirect damages such as clean-up costs and alternative accommodation. **Table 3** presents the parameters adopted to calculate the flood damages.

Table 3: Damages Assessment Parameters

Parameter	Value Adopted
Post November 2001 adjustment factor	**1.71** (average weekly earnings at May 2015)
Regional Cost Variation factor	**1.00** (Rawlinsons 2016)
Post Flood Inflation Factor	**1.40**
Flood Level Awareness	**Low** (refer to **Section 1.3.1**)
Effective Warning Time	**0 hours** (catchment prone to flash flooding & short duration events)

5.2.2.1 Residential Flood Damages

For the analysis of mitigation measures, a flood damages assessment applies a monetary value to property damages allowing comparison of damages estimates for the existing situation with assumed mitigation work. These works can be approximately costed to derive a benefit/cost (B/C) ratio which is readily comparable.

Table 4 to **Table 6** below present the existing residential flood damages for the MRE, Botany Wetlands and Pagewood catchments respectively. These damages calculations form the base scenario against which the preferred mitigation measures will be assessed.

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Table 4: MRE Residential Existing Flood Damages

Event	Properties Affected	Properties Flooded Above Floor Level	Total Damages for Event	Event Contribution to AAD (%)
0.5 EY	1451	242	$ 46,619,000	$ 11,655,000
0.2 EY	1810	292	$ 53,351,000	$ 14,995,000
10.0% AEP	1994	345	$ 58,201,000	$ 5,578,000
5.0% AEP	2200	425	$ 65,472,000	$ 3,092,000
2.0% AEP	2335	525	$ 73,983,000	$ 2,092,000
1.0% AEP	2433	591	$ 81,676,000	$ 778,000
PMF	3250	1858	$ 194,994,000	$ 1,384,000
		Annual Average Damages (AAD)	**$ 39,572,000**	

Table 5: Botany Wetlands Residential Existing Flood Damages

Event	Properties Affected	Properties Flooded Above Floor Level	Total Damages for Event	Event Contribution to AAD (%)
0.5 EY	0	0	$ -	$ -
0.2 EY	0	0	$ -	$ -
10.0% AEP	0	0	$ -	$ -
5.0% AEP	0	0	$ -	$ -
2.0% AEP	0	0	$ -	$ -
1.0% AEP	0	0	$ -	$ -
PMF	115	42	$ 4,819,000	$ 24,000
		Annual Average Damages (AAD)	**$ 24,000**	

Table 6: Pagewood Residential Existing Flood Damages

Event	Properties Affected	Properties Flooded Above Floor Level	Total Damages for Event	Event Contribution to AAD (%)
0.5 EY	41	16	$ 1,810,000	$452,000
0.2 EY	45	17	$ 2,030,000	$576,000
10.0% AEP	47	19	$ 2,180,000	$211,000
5.0% AEP	52	19	$ 2,226,000	$110,000
2.0% AEP	54	19	$ 2,238,000	$ 67,000
1.0% AEP	54	19	$ 2,283,000	$ 23,000
PMF	57	20	$ 2,477,000	$ 24,000
		Annual Average Damages (AAD)	**$ 1,462,000**	

Yard and lot flooding in the MRE and Pagewood catchments occur in events as frequent as the 0.5 EY due to major overland flow flooding. The duration of inundation is likely to be relatively short considering the critical duration of the catchments. Furthermore, flood events during work hours typically go unnoticed by residents unless a property is inundated above floor level.

Of note, in the MRE catchment 292 houses and 16 in the Pagewood catchment are estimated to be inundated above floor level in the 0.5 EY. It is likely, however, that this is an over estimation resulting from an inherent flaw in the prediction of frequent 1987 ARR rainfall IFD depths. Rainfall depths for more frequent events were over-estimated in the 1987 ARR IFD, this issue has been rectified with the recent release of the 2016 ARR guidelines.

5.2.3 Non-Residential – Commercial and Industrial Activities

An existing flood damages assessment was undertaken for the commercial and industrial properties in the MRE and Botany Wetlands catchments. There were no commercial or industrial properties identified in the Pagewood catchment.

The costs of flood damage on non-residential properties vary greatly dependent on the type of business, duration of flooding, the ability to move assets and the ability to transfer the business to a temporary location.

The flood damages calculations for commercial properties used the Queensland DNRM methodology (DNRM, 2002) based upon the stage-damage curves developed by ANUFLOOD (Smith & Greenway 1988). This methodology utilises various stage-damage curves based on both building size and contents value categories. Due to limited information on activities conducted within the commercial properties, it has been assumed that all commercial properties are of medium size (186 to 650m^2) and of medium (Class 3) value.

The industrial flood damages calculations were estimated using the suggested damages for the Rapid Appraisal Method (RAM) for floodplain management. This accords $311/m^2 where flood depth is greater than 0.3 m. A building coverage for industrial properties was assumed to be 90% of the total lot area.

For commercial and industrial properties, floor levels were estimated to be 0.15 m above the ground level inspected from the DEM at the front entrance of each property. As previously mentioned (refer to **Section 5.2.2**), design flood levels were taken within a 5 m radius of the front entrance of each property.

5.2.3.1 Commercial Existing Flood Damages

Table 7 and **Table 8** display the estimated commercial flood damages for the MRE and Botany Wetlands catchments respectively.

Table 7: MRE Commercial Existing Flood Damages

Event	Properties Affected	Properties Flooded Above Floor Level	Total Damages for Event	Event Contribution to AAD (%)
0.5 EY	38	5	$ 848,000	$ 212,000
0.2 EY	69	17	$ 1,650,000	$ 375,000
10.0% AEP	69	17	$ 1,650,000	$ 165,000
5.0% AEP	85	32	$ 2,354,000	$ 100,000
2.0% AEP	96	39	$ 2,553,000	$ 74,000
1.0% AEP	105	45	$ 2,713,000	$ 26,000
PMF	195	125	$ 9,310,000	$ 60,000
		Annual Average Damages (AAD)	**$ 1,012,000**	

Table 8: Botany Wetlands Commercial Existing Flood Damages

Event	Properties Affected	Properties Flooded Above Floor Level	Total Damages for Event	Event Contribution to AAD (%)
0.5 EY	0	0	$ -	$ -
0.2 EY	0	0	$ -	$ -
10.0% AEP	0	0	$ -	$ -
5.0% AEP	0	0	$ -	$ -
2.0% AEP	0	0	$ -	$ -
1.0% AEP	0	0	$ -	$ -
PMF	17	10	$ 204,000	$ 1,000
		Annual Average Damages (AAD)	**$ 1,000**	

These results indicate that the commercial properties in the Botany Wetlands catchment have limited flood liability in design events up to the 1% AEP event. In the MRE catchment, commercial properties are particularly flood liable in events greater than the 10% AEP, where 32 properties are inundated above floor level in the 5% AEP event.

5.2.3.2 *Industrial Existing Flood Damages*

Table ***9*** and Table 10 present the estimated industrial existing flood damages for the MRE and Botany Wetlands catchments respectively***.***

Table 9: MRE Industrial Existing Flood Damages

Event	Properties Affected	Properties Flooded Above Floor Level	Total Damages for Event	Event Contribution to AAD (%)
0.5 EY	46	20	$ 3,128,000	$ 782,000
0.2 EY	59	27	$ 7,799,000	$ 1,639,000
10.0% AEP	64	32	$ 9,388,000	$ 859,000
5.0% AEP	71	37	$ 9,624,000	$ 475,000
2.0% AEP	73	40	$ 10,976,000	$ 309,000
1.0% AEP	74	45	$ 13,868,000	$ 124,000
PMF	111	80	$ 86,791,000	$ 504,000
Annual Average Damages (AAD)			**$ 4,692,000**	

Table 10: Botany Wetlands Industrial Existing Flood Damages

Event	Properties Affected	Properties Flooded Above Floor Level	Total Damages for Event	Event Contribution to AAD (%)
0.5 EY	0	2	$ 10,000	$ 3,000
0.2 EY	0	2	$ 10,000	$ 3,000
10.0% AEP	0	2	$ 10,000	$ 1,000
5.0% AEP	5	4	$ 113,000	$ 3,000
2.0% AEP	5	4	$ 124,000	$ 4,000
1.0% AEP	28	13	$ 361,000	$ 2,000
PMF	71	70	$ 9,758,000	$ 51,000
Annual Average Damages (AAD)			**$ 66,000**	

The industrial flood damages indicate that properties in the MRE catchment are particularly flood liable, with 20 properties inundated above floor level in the 0.5 EY. This result is to be expected since many industrial properties within the MRE catchment are located in the flood hotspot adjacent to Alexandra Canal. This location is subject to frequent flooding due to the insufficient capacity of the drainage outlets into the canal as well as backwatering effects from elevated water levels in the canal.

Industrial properties in the Botany Wetlands catchment are particularly flood liable in events greater than the 2% AEP event.

5.2.4 Public Infrastructure and Other Land Uses

Damage to public infrastructure such as recreational/tourist facilities, utilities (including water, sewerage, gas, telephone, communications and electricity), substations, underground services, rail, roads, bridges and the cost of emergency services and clean up can contribute to a significant proportion of the total costs after a flood. These costs are difficult to quantify or predict.

5.2.4.1 Electricity

The study area was assessed for electricity substations in the area. Four substations were found in the study area. The locations and events when these stations are first flooded are shown in **Table 11**. All of these stations were located in the MRE catchment.

Table 11: Electricity Substations in Study Area

Substation Location	Event First Flooded
No. 40 Robey Street, Mascot	0.2 EY
No. 34 Wentworth Avenue, Mascot	*Not flood affected*
No. 1001 Botany Road, Rosebery	0.5 EY
No. 489 Gardeners Road, Rosebery	0.5 EY

Essential Energy is a NSW Government-owned corporation responsible for building, operating and maintaining Australia’s electricity network. Flooding of a substation could cause loss of power or risk to life. Therefore, in the event of a flood, Essential Energy should be notified to allow an emergency response team to assemble.

5.2.4.2 Schools

Table 12 details the schools in the Study Area and the flood event that they are first inundated above ground level by flood waters. Of note, JJ Cahill Memorial High School on Sutherland Street, Mascot, which is inundated in the 0.5 EY. The impact of a school flooding is reliant on on the time of the day that the flood occurs. Logically, during school hours, flood emergency response is more crucial since there would be many people on site. As such, it is important for schools to have flood evacuation plans in place.

Table 12: Schools in the Study Area

School	Event First Flooded
Mascot Public School	PMF
Mascot Public School Preschool	5% AEP
Eastlakes Public School	*Not flood affected*
JJ Cahill Memorial High School	0.5 EY
St Therese Catholic Primary School	PMF

5.2.4.3 Operations Centres

NSW Randwick-Botany State Emergency Service (SES) is responsible for servicing the study area and is situated approximately 4 km to the east of the study area on Storey Street, Randwick. It is important to note that the SES may have restricted access to the study area during a flood event, particularly if Botany Wetlands is subject to significant flooding and Botany Road and Wentworth Avenue are inundated.

5.3 Hydraulic Categorisation

The Floodplain Development Manual (**Reference 1**) defines three hydraulic categories within the floodplain; the floodway, flood storage and flood fringe. The floodway describes areas where a significant volume of water flows during floods and if only partially blocked would cause a significant increase in flood levels and/or a significant redistribution of flood flow. Floodway's are often areas with deep flows with high velocities. Flood storage describes areas on floodplains that are important for temporary storage of floodwaters during a flood. If the capacity of the flood storage area is substantially reduced by factors, such as development, flood levels in nearby areas may rise and increase the peak discharge downstream. The flood fringe is the remaining area of flood affected land.

The Flood Study (**Reference 3**) determined the hydraulic categories for the 1% AEP and PMF events using the criteria proposed by Howells et. al., 2003. It has been agreed with Council that the Hydraulic Categories determined during the Flood Study will be adopted in the current study.

5.4 True Flood Hazard Classification

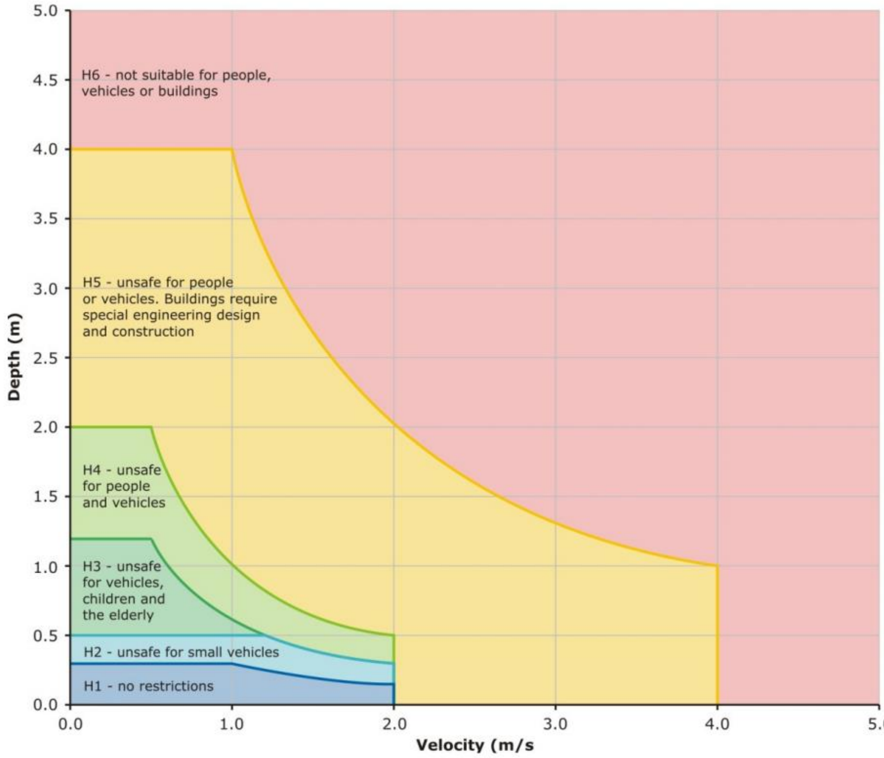
The Flood Study (**Reference 3**) defined the provisional hydraulic hazard based on the methodology outlined in Appendix L of the NSW Floodplain Development Manual (**Reference 1**). This approach used a depth-velocity relationship to define areas as high and low hazard.

The current FRMS&P proposes to use the flood hazard curves proposed by Smith et al. (2014) and recommended by the Australian Emergency Management Institute (AEMI). This approach provides a range of hazard classifications which increase in severity based on the safety threat posed to vehicles, people and buildings. These classifications and the corresponding flood hazard curves are shown in **Table 13** and Image 1 respectively.

Table 13: Hazard Classifications

Hazard Classification	Description
H1	*No vulnerability constraints*
H2	Unsafe for small vehicles
H3	Unsafe for all vehicles, children and the elderly
H4	Unsafe for all people and all vehicles
H5	Unsafe for all people and all vehicles. Buildings require special engineering design and construction
H6	Unconditionally dangerous. Not suitable for any type of development or evacuation access. All building types considered vulnerable to failure.

Image 1 Combined Flood Hazard Curves (Smith et. al. 2014)



In conjunction with considering the hydraulic hazard using the flood depths and velocities from the hydraulic model, it is important to consider other criteria such as the size of the flood, effective warning time, flood readiness, rate of rise of floodwaters, depth and velocity of floodwaters, duration of flooding, evacuation problems, effective flood access and type of land use. These factors are assessed in **Table 14**.

Table 14: Hazard Assessment of Variables

Criteria	Weight	Comment
Size of the flood	Medium	The magnitude of a flood affects the depths and velocities produced in an event. Low flood hazard typically is associated with more frequent flood events while high hazard flows usually are occur during rare (major) flood events. Typically, flood affectation in the study area does not scale greatly in the upper reaches of the catchment for events of varying magnitude (up to 0.2 m level difference between 0.5 EY and PMF event). In downstream areas, such as Baxter Road and Hollingshed Street, flood affectation does scale significantly with the difference between the 0.5 EY and the PMF events of up to 2.3 m depth. These downstream areas would experience high hazard depths and velocities posing a risk to life and a threat to structural stability of buildings.
Depth and velocity of floodwaters	High	As previously mentioned, the flood hazard is related to the product of depths and velocity of flood waters which are influenced by the size of the flood. In the MRE catchment, the streets adjacent to Alexandra Canal and the Baxter Road and Hollingshed street area are all subject to high hazard flooding governed by large flood depths in the 1% AEP event. A number of properties along Baxter Road, Robey Street and Botany Lane are subject to high hazard flooding with flood depths of up to 1.8 m in the 1% AEP event.

Rate of rise of floodwaters	Medium	The rate of rise of floodwaters is influenced by the catchment size, soil type, slope and land use. The spatial and temporal pattern of the rainfall is also related to the rate of rise. The rate of rise in the study area for the MRE and Pagewood catchments can be quite rapid due to the relatively small catchment size and the impervious nature of these catchments. The Botany Wetlands catchment carries flow from a much larger upstream catchment and as such the rate of rise is considerably slower. For the streets adjacent to Alexandra Canal it takes approximately 70 minutes to reach the flood peak from the start of rainfall in the 1% AEP event. In the PMF the peak is reached in 35 minutes. At Robey Street and Baxter Road it takes 120 minutes to reach the flood peak from the start of rainfall in the 1% AEP event. In the PMF the peak is reached in 60 minutes.
Duration of flooding	Low	Typically, the longer the duration of flooding, the more disruption caused to the community and greater the potential flood damages. The duration of flooding in the study area is relatively short with the majoring of flood waters receding to below 0.2 m in the 1% AEP event within 4 hours of a flood event.
Effective warning and evacuation time	Medium	Flood warning and evacuation is subject to the rate of rise, the flood awareness of the community and availably of a flood warning system. Unfortunately there are no flood warning systems for the study area.
Flood awareness and readiness of the community	**High**	As previously discussed, flood awareness in the study area is relatively limited (see **Sections 1.3.1** and **3.2**). Since no events greater than a 0.2 EY have occurred in recent history it is likely that the community are unaware of the flood problem in parts of the study area. This awareness is further complicated by the seemingly frequent turnover of population (see **Section 1.3.1**) and as such the community will be required to be made frequently aware of the areas flood liability.
Effective flood access	Medium	Effective flood access is affected by depths and velocities of floodwaters, evacuation distance, the number of people using the evacuation route and effective communication. In the study area a number of streets could be inundated by floodwaters in larger events and subject to hazardous flows which may result in the residents becoming isolated. Flood access is further discussed in **Section 5.5**.
Evacuation problems	Medium	Some flood prone areas are likely to experience evacuation problems in the catchments due to the rapid rate of rise of a flood event, the limited flood warning time and the relatively low flood awareness in the study area. These problems are exacerbated by the time of day during which flooding occurs and the demographics of the community. Evacuation is further discussed in **Section 5.5**.
Type of development	Medium	The type of development will influence factors such as the level of flood awareness, the mobility of occupants and population density. Long term residents are likely to have a higher level of flood awareness than those visiting the area. Further, mobility and evacuation is more difficult for a school, child care facility or aged care home. Finally, the evacuation of a large residential apartment block will be more complicated than a single dwelling.

An assessment of the variables presented in **Table 14** did not significantly change the flood hazard classifications. True flood hazard maps for the 1% AEP and PMF events are presented in **Figure 3** and **Figure 4** respectively.

Of note is in the 1% AEP event, the Baxter Road and Robey Street areas in Mascot are subject to H4 hazardous floodwaters which are unsafe for people and vehicles. Additionally, there are a number of areas which have been classified as H3 hazard, which can cause significant difficulty with evacuation.

Particularly hazardous flows are experienced during the PMF event in the study area. Large areas experience H4 and H5 flood hazard. The structural stability of buildings within H5 hazard areas is likely to be compromised. These areas include Hollingshed Street, Baxter Road and Robey Street. It is recommended that flood related development controls are implemented in these areas requiring special engineering design for new developments.

5.5 Access and Evacuation Constraints

A key part of emergency planning and effective evacuation is identifying the barriers to flood access and implementing plans to overcome this. The majority of the study area has ease of egress to higher flood free areas, however the access routes to a number of key locations are likely to become inundated rapidly by floodwaters and as such encounter some evacuation difficulties. These key locations are listed below:

- *Area 1:* The streets adjacent to Alexandra Canal including Ricketty Street, Coward Street and Gardeners Road;
- *Area 2:* Robey Street and Baxter Road; and
- *Area 3:* The streets surrounding Hollingshed Street including Botany Lane, Hardie Street, Johnson Street and Alfred Street.

The NSW SES in collaboration with OEH developed the Flood Emergency Response Planning (ERP) classifications (**Reference 5**) to categorize communities according to the ease of evacuation. These guidelines assist the planning and implementation of response strategies. These classifications are determined by analysis of inundation of land, road and overland evacuation routes. Communities are classified as Flood Islands, Rising Road Access, Overland Escape Route, Trapped Perimeter Areas or Indirectly Affected areas.

The Flood ERP Guidelines present these classifications in relation to operational functions such as resupply, rescue and evacuation shown in Table ***15***.

Table 15: Response Required for Difference Flood ERP Classifications (Reference 5)

Classification	Response Required		
	Resupply	Rescue / Medivac	Evacuation
High Flood Island	Yes	Possibly	Possibly
Low Flood Island	No	Yes	Yes
Area with Rising Road Access	No	Possibly	Yes
Areas with Overland Escape Routes	No	Possibly	Yes
Low Trapped Perimeter	No	Yes	Yes
High Trapper Perimeter	Yes	Possibly	Possibly
Indirectly Affected Areas	Possibly	Possibly	Possibly

ERP classifications were determined for areas within the 1% AEP and PMF extents in the Study Area. These classifications are shown in **Figure 7** for the 1% AEP and **Figure 8** for the PMF event.

In the 1% AEP event, egress to flood free land is available for most of the study area. These areas will have flood free access to emergency services and other vital facilities. Of note are the isolated areas classified as Low Flood Islands, High Flood Islands and areas with Overland Refuge on High Flood Islands. These locations are typically located in the eastern Mascot area where several overland flowpaths converge and drain into the Ascot drain. Emergency Services (such as the SES) should be aware of the risk of isolation of these areas and the necessary actions (such as evacuation and/or shelter-in-place) outlined in their Local Flood Plan.

In the PMF event, large areas of the study area are classified as Low Flood Islands. These locations are subject to isolation and, subsequently, inundation from flood waters. This flood mechanism is particularly difficult for evacuation since the access roads are first inundated before the residential areas. As such, this mapping will be particularly useful for the emergency services (such as the SES) when determining the appropriate emergency response actions outlined in their Local Flood Plan.

6 Floodplain Risk Management Measures

6.1 Identifying Floodplain Risk Management Measures

The Floodplain Development Manual (**Reference 1**) states that the purpose of a FRMS&P is to identify, assess and compare various flood risk management options to mitigate flood affectation and as such lower the overall flood damages in an LGA. This process involves assessing the flood impacts of management options for existing, future and continuing flood risk on flood behaviour and hazard and the social, economic, ecological and cultural costs and benefits of options. Assessment of these factors forms the basis for robust decision making in the management plan. The following sections assess a range of flood mitigation options to mitigate and manage flood risk in the LGA.

6.2 Categories for Flood Risk Management Measures

The Floodplain Development Manual (**Reference 1**) categorises the mitigation of flood risk into three groups; Flood Modification Measures, Property Modification Measures and Response Modification Measures.

Flood Modification Measures refer to the implementation of physical changes to the floodplain or drainage structures which alter flood behaviour and as such mitigate flood affectation. Examples of flood modification measures are listed in **Table 16**. Flood modification measures which have been investigated in the current study are discussed in **Section 6.3**.

Property Modification Measures modify the existing land use to minimise the flood hazard and risk to life for properties located in hazardous areas. Additionally, these measures update development controls for future developments to ensure that construction on the floodplain is considered and the appropriate measures are adopted. Examples of property modification measures are listed in **Table 16**. Property modification measures which have been investigated in the current study are discussed in **Section 6.4**.

Response Modification Measures modifies the community's response and awareness of flood hazard. These measures are focused on educating the community to ensure that informed decisions are made during a flood event. Examples of response modification measures are listed in **Table 16**. Response modification measures which have been investigated in the current study are discussed in **Section 6.5**.

Table 16: Typical Floodplain Risk Management Measures

Property Modification Measures	Response Modification Measures	Flood Modification Measures
Zoning	Community Awareness	Retarding Basins
Voluntary Purchase	Community Readiness	Levees
Voluntary House Raising	Flood Prediction & Warning	Channel Construction
Building & Development Controls	Local Flood Plans	Channel Modifications
Flood Proofing Buildings	Evacuation Arrangements	Structure Modifications
Flood Access	Recovery Plans	Drainage Network Modifications

6.3 Flood Modification Measures

Flood Modification Measures refer to physical modifications on the floodplain which alter the flood behaviour and ultimately reduce the flood affectation (flood levels or velocities) in particularly vulnerable areas. **Table 17** presents the modelled flood modification measures investigated in the current study.

Table 17: Flood Modification Measures Investigated

Option	Description	Figure	Report Section
B1	Mascot Public School retarding basin	**Figure B1**	**6.3.1.1**
B2	L'Estrange Park playing fields retarding basin	**Figure B2 - Figure B4**	**6.3.1.2**
B3	JJ Cahill Memorial High School retarding basin	**Figure B5 - Figure B7**	**6.3.1.3**
S1	Levelling Golf Course Embankment, Florence Avenue.	**Figure B8 - Figure B10**	**6.3.4.1**
S2	Lowering Botany Road, Mascot	**Figure B11**	**6.3.4.2**
S3	Lowering Lang Avenue, Pagewood	**Figure B12**	**6.3.4.3**
D1	Increased drainage capacity downstream of Baxter Road	**Figure B13**	**6.3.5.1**
D2	Increased drainage capacity into Alexandra Canal	**Figure B14 - Figure B16**	**6.3.5.2**
D3	Drainage Network Implementation along Hardie Street	**Figure B17**	**6.3.5.3**
D4	Increased Drainage Capacity in the Hollingshed Street & Baxter Road Areas	**Figure B18 - Figure B20**	**6.3.5.4**
D5	Increasing Drainage Capacity on Lang Avenue	**Figure B21**	**6.3.5.5**
S2 / D4	Combined Options S2 and D4	**Figure B22**	**6.3.6.1**

Flood impact maps were produced for the measures listed in **Table 17**, to determine the impact that these options had on flood behaviour. A flood damages assessment and approximate implementation cost was calculated for the mitigation options which were found to effectively reduce the flood affectation. This assessment was undertaken such that a Benefit/Cost (B/C) ratio could be calculated.

Although mitigation measures may not effectively reduce peak flood levels in isolation, it is important to consider these options in combination. As such Section 6.3.6 assesses Combined Mitigation Options.

6.3.1 Retarding Basins

Introduction

A retarding basin is a small dam that provides temporary storage for floodwaters and allows for the controlled release of runoff during and/or after a flood event. Retarding basins can be installed as a preventative measure for future developments to mitigate the effects of increased runoff. Alternatively, retarding basins can be retrospectively implemented to drainage systems to alleviate existing flood problems.

Discussion

Retarding basins are a cost-effective means of reducing peak flows in a catchment, when implemented in a suitable location. Outlet structures such as low flow pipes at the basin floor control the outflow from the basin.

There are inherent limitations to retarding basins such as the area required to store floodwaters, storms of a long duration or multiple peaks and pose a risk of the basin overtopping and the basin may only slightly attenuate the peak if its embankments are overtopped. Therefore, it is crucial that retarding basins are properly designed, constructed and maintained.

For particularly large basins in NSW the Dam Safety Committee (DSC) will maintain continuing oversight of the dam's safety to ensure risks to the community are tolerably low. DSC determines the level of risk of prescribed dams by the likelihood and consequences of dam failure.

Retarding basins require ongoing checks and maintenance which will be conducted by an agreed party such as Council, a developer or land owner.

Three basin options were investigated for the current study at Mascot Public School (Option B1), the Sutherland Street playing fields (Option B2) and JJ Cahill Memorial High School (Option B3). These measures are discussed in the following sections.

6.3.1.1 Option B1 – Mascot Public School Retarding Basin

Overview

Option B1 modelled the implementation of a basin in the playing fields between Macintosh Street and King Street, adjacent to Mascot Public School. This area has been known to experience flooding and floodwaters were reported to have ponded at this location in the June 2016. The potential of formalising this location as an area for flood storage was investigated in Option B1.

A total area of 0.6 ha on the playing fields was lowered by approximately 0.5 m in the hydraulic model to adequately replicate the implementation of a retarding basin or alternatively below ground storage tanks. This measure aimed to provide some flood mitigation in the vicinity of the basin.

Results

Option B1 was modelled for the 1% AEP event and the peak flood impacts are shown in **Figure B1**. Flood levels were reduced by up to 0.05 m in the vicinity of Option B1. Due to a lack of significant flood mitigation provided by Option B1, this option has not been investigated further.

6.3.1.2 Option B2 – L'Estrange Park Playing Fields Retarding Basin

Overview

Option B2 investigated the construction of a retarding basin for flood storage on the Council-owned L'Estrange Park playing fields along Sutherland Street, Mascot. This measure aimed to attenuate flows and reduce flood affectation in downstream areas, particularly along Hollingshed Street.

An area of 2.2 ha was lowered by up to 1.0 m in the hydraulic model to replicate the implementation of a retarding basin in the subject area. It was assumed that a low flow pipe at the basin outlet would connect to the existing drainage network. This mitigation measure was modelled for the 0.2 EY and 1% AEP events.

Results

Peak flood impacts for the 0.2 EY and 1% AEP events are shown in **Figure B2** and **Figure B3**, respectively. In the 0.2 EY event, localised peak flood level decreases were experienced within the basin area however no significant peak flood level reductions occurred outside of this location. In the 1% AEP event, peak flood levels were reduced by up to 0.1 m in the Hollingshed Street and Baxter Road areas. Of note, were the peak flood level decreases on the western side of Botany Road due to the smaller volume of floodwaters spilling over Botany Road from Hollingshed Street.

Similar results could be achieved by the implementation of below-ground storage tanks of the same capacity as the lowered area.

Option B2 was found to be an effective mitigation strategy in the 1% AEP event. **Table 18** displays the benefits provided by the implementation of Option B2 in terms of reduced property flood affectation and the associated damages.

Table 18: Option B2 – Change in Property Affectation and Damages

Event	No. Properties No Longer Flooded	No. Properties No Longer Flooded Over Floor	Reduction in Damages for Event
0.5 EY	4	0	$ 49,000
0.2 EY	12	3	$ 339,000
10% AEP	18	7	$ 411,000
5% AEP	19	19	$ 1,385,000
2% AEP	15	14	$ 1,131,000
1% AEP	16	20	$ 1,974,000
PMF	0	1	$ 857,000
Reduction in Annual Average Damages (AAD)			**$ 220,000**

A damages assessment was undertaken for Option B2 to determine the Benefit/Cost (B/C) ratio for implementing the measure. The cost of implementation was estimated to be approximately $2,000,000. A breakdown of the cost estimation for this measure can be found in **Appendix C**.

To calculate the B/C ratio of a mitigation measure, the Net Present Value (NPV) must be determined for the existing conditions as well as for each mitigation measure. The NPV was calculated using a discount of 7% over a 50 year design life for the mitigation measure. The relative benefit between the NPV for the existing and proposed conditions was then calculated to provide the economic benefit of implementation. This method has been used for all flood modification measures to determine the B/C ratio.

Option B2 was found to provide a relative benefit of approximately $3,258,000 over the lifespan of the measure. As such, a B/C ratio of 1.6 has been calculated.

Since the B/C ratio is greater than one, further investigation into the feasibility of implementation is recommended.

Implications of Climate Change

A climate change analysis was conducted for Option B2 which assessed the flood impacts of increasing the design rainfall by 10%, 20% and 30% for the 1% AEP event. The peak flood impacts of these rainfall increases are shown in **Figure B4**. Generally speaking, each incremental 10% increase in rainfall results in greater peak flood level impacts for the 1% AEP event.

The Option B2 basin retains greater volumes of flood waters with each incremental increase in rainfall. In terms of peak flood level impacts, with each 10% increase in rainfall, peak flood levels along Hollingshed Street are decreased by a further 0.01 m. These flood impacts are the result of the Option B2 basin becoming more efficient.

In the Baxter Road and Robey Street hotspots, peak flood level impacts are decreased with each rainfall increase. This is likely due to the greater volume of floodwaters entering the area from the north, despite floodwaters from the east being retained in the Option B2 basin.

Therefore, with the anticipated increases in rainfall resulting from the effects of climate change, the Option B2 basin is likely to become more efficient at retaining floodwaters however the extent of mitigation provided by this measure will likely be reduced.

Recommendations

Going forward, it is recommended that further investigation be undertaken to determine whether the construction of Option B2 is feasible. Underground storage tanks, of the same capacity of as the lowered park area, would achieve a similar outcome. Option B2 has a B/C ratio greater than one.

6.3.1.3 Option B3 – JJ Cahill Memorial High School Retarding Basin

Overview

Option B3 investigated the peak flood impacts associated with constructing a retarding basin on the playing fields at JJ Cahill Memorial High School, located at the intersection of Coward Street and Horner Avenue, in Mascot. This measure aimed to attenuate peak flows and reduce peak flood levels in the schools vicinity and ultimately in the Hollingshed Street hotspot.

An area of 0.7 ha was lowered by 1.0 m in the hydraulic model to replicate the implementation of a retarding basin in the playing fields of the high school. It was assumed that a low flow pipe at the basin outlet would connect to the existing drainage network. This mitigation measure was modelled for the 0.2 EY and 1% AEP events.

Results

Figure B5 and **Figure B6** display the peak flood impacts of Option B3 for the 0.2 EY and 1% AEP events, respectively. In the 0.2 EY, peak flood level reductions are contained within the grounds of the school with the school no longer affected by flood waters. Peak flood levels in the 1% AEP are reduced by up to 0.05 m along Sutherland Street. Further, on the northern end of the school grounds, peak flood levels are reduced by up to 0.1 m. Conversely, peak flood levels are increased by up to 0.05 m immediately downstream of the basin on the high school grounds.

Similar results could be achieved by the implementation of below-ground storage tanks of the same capacity as the lowered area.

The benefits provided by Option B3 were further assessed and the results are shown in Table ***19*** in terms of reduced property flood affectation and associated damages.

Table 19: Option B3 – Change in Property Affectation and Damages

Event	No. Properties No Longer Flooded	No. Properties No Longer Flooded Over Floor	Reduction in Damages for Event
0.5 EY	5	1	$ 149,000
0.2 EY	11	5	$ 615,000
10% AEP	15	8	$ 503,000
5% AEP	13	9	$ 509,000
2% AEP	9	9	$ 793,000
1% AEP	11	5	$ 1,031,000
PMF	3	3	$ 794,000
		Reduction in Annual Average Damages (AAD)	**$ 271,000**

A damages assessment was undertaken for Option B3 to determine the B/C ratio for implementing the measure. The cost of implementation was estimated to be approximately $1,000,000. A cost breakdown for this measure can be found in **Appendix C**.

Option B3 was found to provide a relative benefit of approximately $4,052,000 over the lifespan of the measure. As such, a B/C ratio of 4.1 has been calculated.

Since the B/C ratio is greater than one, further investigation into the feasibility of implementation is recommended.

Implications of Climate Change

The implication of climate change associated with the implementation of Option B3 was investigated. Design rainfall was increased by 10%, 20% and 30% in the 1% AEP event and the resulting flood impacts are shown in **Figure B7**. In general, the incremental 10% increase in rainfall resulted in negligible difference in flood impacts. This is likely caused from the basin spilling from the south western corner before the flood peak. Therefore, increases in rainfall are unlikely to significantly impact the mitigation provided by Option B3.

Recommendations

It is recommended that further investigation is undertaken to determine the feasibility of Option B3. Underground storage tanks, of the same capacity as the lowered playing fields area, would potentially achieve a similar outcome. Option B3 has a B/C ratio greater than one and the implications of climate change make negligible difference to the mitigation provided by the basin.

6.3.1.4 Summary of Retarding Basins

Options B2 and B3 have been found to provide some localised flood mitigation benefit. Furthermore, B/C ratios greater than one have been calculated for each of these options. Therefore, it is recommended that further investigation is conducted into the feasibility of implementing these strategies for flood mitigation in the Mascot area.

6.3.2 Levees

Introduction

Levees are raised embankments constructed between a flow path and a flood affected area to divert floodwaters up to the levee's design height. Typically levees are earth embankments, however they can also be walls where there is minimal available space. Levees are often preferable options on floodplains since they effectively protect existing development in flood prone areas. Further, the cost of construction and maintenance for a levee is often relatively low. The crest of the levee is determined based on the economics of the situation, the physical limitations of the site, the level that the floodwaters can rise to and the visual impact of the structure. Levee's are typically constructed on large river systems and floodplains.

It is important to consider the implications of a levee overtopping or structurally failing during a flood event. Often this occurrence can be catastrophic and as such appropriate emergency response plans, development controls, maintenance of the levee and ongoing community education must be undertaken to minimise the effects of such an event.

Discussion

Hydraulic modelling is essential for the design and construction of a levee to assess a number of factors. The construction of a levee will result in the displacement of floodwaters from one location on the floodplain to another. Therefore it is essential to determine that properties outside the levee do not experience increased flood affectation as a result of the construction. Furthermore, flooding inside the levee may still occur due to the effect of local rainfall runoff. As such, an assessment of the local flood impacts must be conducted and strategies to drain local runoff must also be implemented.

An appropriate design height of the levee must be determined to provide flood protection for a specified event. This design height must include a freeboard to account for factors such as settlement of the structure, variations in flood levels, the effects of wind waves and waves caused by passing vehicles or boats.

Summary

The implementation of levees has not been considered an option for flood mitigation in the study area due to the density of the urban environment of the catchments. As such, a suitable location for a levee was not found without increasing peak flood levels elsewhere in the study area.

6.3.3 Channel Modifications

Introduction

The efficiency of a watercourse can be increased by widening, deepening and realigning the channel. Clearing the channel banks and bed obstructions can also increase the hydraulic capacity of a channel. Conversely, increasing the vegetation and other obstructions in a channel can decrease peak flood levels downstream of the channel by slowing flow and/or provided flood storage.

Channel modifications are often most effective on relatively small incised streams with overgrown banks and narrow floodplains.

During a large flood event, channel modifications are unlikely to significantly mitigate flood affectation where the channel banks are overtopped or the flooding is governed by elevated tide levels.

Potential disadvantages associated with channel modifications include high maintenance costs, destruction of riverine habitats, impacts of bed and bank stability and potential to increase downstream flood affectation.

Summary

Since the study area is subject to flooding from overland flow and there are very few open channels, channel modifications were not investigated as a part of this study.

6.3.4 Structure Modifications

Introduction

A hydraulic structure is any structure such as a bridge or culvert which, when partially submerged by water, disrupts the natural flow causing backwatering and therefore increased flood levels upstream. Structure modifications can be undertaken to increase the hydraulic conveyance and decrease flood levels. These modifications can include increasing the conveyance of a bridge by lengthening it or raising the deck level, increasing the size of a culvert, or lowering embankments.

Discussion

The hotspot analysis conducted in the Flood Study (**Reference 3**) indicated two locations where hydraulic structures were obstructing overland flow and exacerbating flood affectation in the local area. Options S1 (see **Section 6.3.4.1**) and S2 (see **Section 6.3.4.2**) investigate the mitigating effects of increasing the hydraulic conveyance in these areas.

6.3.4.1 Option S1 – Levelling Golf Course Embankment, Florence Avenue

Overview

Analysis of the existing flood behaviour at the south-western end of Florence Avenue in Eastlakes found that an earth embankment on the golf course boundary was obstructing an overland flow path and exacerbating flooding for properties along Florence Avenue. Therefore, Option S1 investigated the flood impacts of levelling this embankment (reducing its height), allowing overland flow to enter the golf course and lowering peak flood levels for properties on Florence Street.

An area of 0.4 ha was levelled in the hydraulic model (shown in **Figure B8**). Ground levels were lowered by up to 1.4 m and 0.6 m on average. This measure was modelled in the hydraulic model for the 0.2 EY and 1% AEP events.

Results

The peak flood level impacts for the 0.2 EY and 1% AEP events are shown in **Figure B8** and **Figure B9**. In the 0.2 EY, peak flood levels along Florence Avenue are reduced by up to 0.45 m with a number of properties no longer flood affected. On the golf course, peak flood extents and levels are increased by up to 0.4 m. In the 1% AEP event, peak flood levels along Florence Avenue are also reduced by up to 0.45 m. Minor peak flood level increases of up to 0.05 m are experienced on the golf course in the 1% AEP event.

Since Option S1 effectively alleviates flood affectation at properties on Florence Avenue, additional investigation of the flood damages was conducted. These results are presented in Table ***20***.

Table 20: Option S1 – Change in Property Affectation and Damages

Event	No. Properties No Longer Flooded	No. Properties No Longer Flooded Over Floor	Reduction in Damages for Event
0.5 EY	1	0	$ -
0.2 EY	0	0	-$ 1,000
10% AEP	0	0	$ 76,000
5% AEP	1	0	$ 18,000
2% AEP	0	3	$ 210,000
1% AEP	0	4	$ 258,000
PMF	0	0	$ 118,000
Reduction in Annual Average Damages (AAD)			**$ 14,000**

*Note: The negative (-) value indicates that the property no longer flooded in the 0.5 EY is flooded in the 0.2 EY.

While the change in AAD is relatively minor, the cost of implementation was estimated to be $70,000. A cost breakdown for this measure can be found in **Appendix C**.

The relative benefit provided by Option S1 was calculated to be $200,000 over the lifespan of the measure. Therefore a B/C ratio of 2.9 was calculated.

Since the B/C ratio is greater than one, further investigation into the feasibility of implementation is recommended.

Implications of Climate Change

A climate change analysis was conducted for Option S1 which assessed the flood impacts of increasing the design rainfall by 10%, 20% and 30% for the 1% AEP event. The peak flood impacts of these rainfall increases are shown in **Figure B10**. Option S1 was found to be relatively insensitive to increases in rainfall.

Upstream of Option S1, along Florence Avenue, peak flood level impacts are fairly insensitive to increased rainfall with the exception of the flood affectation at the back of some lots along Florence Avenue.

Downstream of Option S1, peak flood levels in the golf course are decreased with the increases in rainfall. The cause of this was determined to be due to the greater flood storage area provided by the lowered embankment area. Therefore, as Option S1 is implemented, flood waters have a greater area to pool and as such peak flood levels are decreased.

Therefore, the implementation of Option S1 is likely to be relatively insensitive to the anticipated increases in rainfall resulting from the effects of climate change.

Recommendations

It is recommended that further investigation is undertaken to determine the feasibility of Option S1. Option S1 has a B/C ratio greater than one and the implications of climate change make only minor differences to the mitigation provided by lowering the embankment.

6.3.4.2 Option S2 – Lowering Botany Road

Overview

Botany Road separates the Hollingshed Street and Baxter Road hotspots in Mascot. In rare flood events, Botany Roads acts as a raised embankment causing overland flow along Hollingshed Street to build up and eventually spill over Botany Road. Once Botany Road is overtopped, flood affectation in the Baxter Road and Robey Street area is exacerbated resulting in high hazard flood conditions.

Option S2 investigated lowering Botany Road (or constructing large culverts beneath the road) to prevent the damming effect of this embankment and to encourage floodwaters to drain across Botany Road earlier during a flood event. While it is understood that this option is unlikely to be implemented, it is important to examine the full extent of works required to provide the greatest decrease in peak flood levels.

In the hydraulic model, a stretch of Botany Road approximately 230 m in length was lowered by 0.2 m on average.

Results

Option S2 was modelled for the 1% AEP event and the peak flood impacts are shown in **Figure B11**. Along Hollingshed Street and the adjacent roads, peak flood levels are lowered by up to 0.05 m. Immediately upstream of Botany Road at Hollingshed Street, peak flood levels are decreased by 0.1 m. On the western side of Botany Road, peak flood levels are increased by up to 0.05 m.

Option S2 has not been considered further since peak flood levels are increased downstream of Botany Road and due to the proposed reconfiguration of Botany Road as part of the WestConnex project.

Option S2 was investigated along with Option D4 (refer to **Section 6.3.5.4**)

6.3.4.3 Option S3 – Lowering Lang Avenue, Pagewood

Overview

The Flood Study (**Reference 3**) noted that a low point in the topography on Bay Street between Lang Avenue and Wentworth Avenue in Pagewood caused water to pond during a storm event once the sub-surface drainage capacity is exceeded. The current study found that Lang Avenue acts as an embankment for overland flow on Bay Street, preventing flood waters from draining into Botany Wetlands and exacerbating the flood affectation in the Bay Street area.

Option S3 examined lowering a 0.12 hectare area of Lang Avenue by 0.8 m on average (1.1 m maximum) to allow flood waters to more easily drain from Bay Street and into Botany Wetlands.

Results

Option S3 was modelled in the hydraulic model for the 1% AEP event and the peak flood level impacts are shown in **Figure B12**. Peak flood levels are decreased by up to 0.17 m on Bay Street in the 1% AEP event with the implementation of Option S3. Along the northern end of Lang Avenue areas are no longer flooded at properties with floodwaters running down the roadway.

Option S3 has not been considered for further investigation due to only minor peak flood level decreases at properties on Bay Street and the feasibility of lowering a roadway.

6.3.4.4 Summary of Structure Modifications

Option S2 and Option S3 are not recommended for further investigation.

Option S1 was found to provide localised flood mitigation along Florence Avenue. In addition, the calculated B/C ratio for this measure was greater than one. Therefore, it is recommended that further investigation is conducted into the feasibility of implementing this strategy for flood mitigation in the Eastlakes area.

6.3.5 Drainage Network Modifications

Introduction

Maintenance and modifications to the existing drainage network ensures that the network is operating efficiently and reduces the risk of blockage. Maintenance involves the removal of unwanted debris and vegetation within the drainage network. Drainage network modifications can include modifying the alignment or increasing the capacity of the network to increase the efficiency of the system.

Discussion

Investigation of the drainage network in the hydraulic model found that the capacity of the network was reached in the 0.5 EY for large areas of the catchment, particularly the Alexandra Canal outlets and the Baxter Road and Hollingshed Street areas. The following sections investigate the peak flood impacts of modifying the drainage network in Mascot.

6.3.5.1 Option D1 – Increased Drainage Capacity Downstream of Baxter Road

Overview

The Flood Study (**Reference 3**) highlighted that the capacity of the drainage network did not consistently increase between Baxter Road and the Ascot Drain, preventing flood waters from efficiently draining from the area. As such, the diameter of the pipe downstream of Baxter Road was increased from 1.2 m to 1.8 m in the hydraulic model to ensure that pipe sizes consistently increased.

Results

Option D1 was modelled for the 1% AEP event and the peak flood impacts are shown in **Figure B13**. Negligible flood impacts (approximately 0.02 m) were found in the vicinity of the mitigation measure since the capacity of the structure was exceeded. As such, Option D1 was not investigated further. Additionally, it was determined that a more significant drainage network update would be required to effectively reduce people flood levels at Baxter Road. This mitigation was investigated in Option D4 (refer to **Section 6.3.5.4**).

6.3.5.2 Option D2 – Increased Drainage Capacity into Alexandra Canal

Overview

Analysis of the Mascot drainage network, which outflows into Alexandra Canal, found that the conveyance capacity was exceeded in the 0.5 EY for a large proportion of this network. The area surrounding Coward Street, Ricketty Street and Gardeners Road is primarily composed of industrial and commercial properties which are subject to backwatering and ponding of flood waters during flood events. Therefore, Option D2 investigated doubling the capacity of the drainage network shown in **Figure B14**.

Results

Option D2 was modelled for the 0.2 EY and 1% AEP events and the peak flood impacts are shown in **Figure B14** and **Figure B15** respectively. In the 0.2 EY, peak flood levels are decreased by up to 0.1 m in the areas where the pipe capacity was doubled. Peak flood level decreases are less significant (up to 0.03 m) in the 1% AEP event due to the substantial volume of water in the overland flow paths and the elevated tailwater in the Alexandra Canal.

Despite the lack of significant flood impacts in the 1% AEP event, a damages assessment was conducted for Option D2 since this measure provides relief to residents in more frequent flood events. The results of this assessment are shown in **Table 21**.

Table 21: Option D2 – Change in Property Affectation and Damages

Event	No. Properties No Longer Flooded	No. Properties No Longer Flooded Over Floor	Reduction in Damages for Event
0.5 EY	4	0	$ 70,000
0.2 EY	2	2	$ 326,000
10% AEP	2	2	$ 97,000
5% AEP	4	3	$ 56,000
2% AEP	4	4	$ 321,000
1% AEP	2	4	$ 2,734,000
PMF	0	2	$ 69,000
Reduction in Annual Average Damages (AAD)			**$ 136,633**

The cost for the implementation of Option D2 was estimated to be $15,000,000. A cost breakdown for this measure can be found in **Appendix C**.

Based on the change in AAD, the relative benefit of Option D2 was calculated to be $2,022,000 over the lifespan of the measure. Therefore a B/C ratio of 0.1 was calculated.

Option D2 has not been recommended for further investigation due to the high cost of construction relative to the minor benefits provided by the measure.

Implications of Climate Change

The implication of climate change was investigated with the implementation of Option D2 by increasing the design rainfall by 10%, 20% and 30% in the 1% AEP event. The peak flood impacts of these rainfall increases are shown in **Figure B16**. Option D2 was found to be insensitive to increases in rainfall in the 1% AEP event. Peak flood impacts for the incremental rainfall increases showed only minor differences in peak flood levels (less than 0.05 m) because the updated pipe system has reached capacity in each of these events. Therefore, it was found that climate change would have a negligible impact on Option D2.

Recommendations

Option D2 is not recommended for further investigation since it has a B/C ratio significantly less than one with very limited flood impacts in comparison to the overall cost of construction. Council may wish to consider this option further in a staged manner when the service life of these structures is reached to improve local drainage over time.

6.3.5.3 Option D3 – Drainage Network Implementation along Hardie Street

Overview

Hollingshed Street is subject to flooding from overland flow, exacerbated by the damming effects of Botany Road. As floodwaters build up against Botany Road, the drainage capacity of the pipe network along Hollingshed Street and Botany Lane is exceeded, causing floodwaters to inundate properties in the vicinity. Option D3 investigates the implementation of an additional drainage network along Hardie Street and Wentworth Avenue in an attempt to alleviate flood affectation in the area. This network modelled a series of pipes, 1.3 m in diameter, along these roads and outflowing through a unidirectional pipe into the Ascot Drain.

Results

Figure B17 presents the peak flood impacts for Option D3 in the 1% AEP event. Negligible flood impacts in the study area were found in the 1% AEP event since the capacity of the Hardie Street drainage network is exceeded prior to the flood peak. As such, Option D3 has not been considered for further investigation.

6.3.5.4 Option D4 – Increased Drainage Capacity in the Hollingshed Street & Baxter Road Areas

Overview

Analysis of the drainage network in the Hollingshed Street and Baxter Road areas found that the capacity of this system was exceeded in events as small as the 0.5 EY. The insufficient capacity of this drainage network relative to the development in the area was identified as a key cause of the flood problem at these locations.

Option D4 investigated duplicating the drainage network shown in **Figure B18**. This measure aimed to allow floodwaters to enter the drainage network more efficiently and therefore lower peak flood levels in the vicinity of Hollingshed Street and Baxter Road.

Results

Figure B18 and **Figure B19** present the peak flood impacts for Option D4 in the 0.2 EY and 1% AEP events. In the 0.2 EY event, peak flood levels are decreased on the eastern side of Botany Road by up to 0.3 m. On the western side of Botany Road, peak flood levels are reduced by up to 0.1 m in the 0.2 EY. The western side of Botany Road is less sensitive to Option D4 in the more frequent events since the volume of water ponding around Baxter Road still greatly exceeds the capacity of the modified drainage network.

In the 1% AEP event, peak flood levels in the Hollingshed Street area (east of Botany Road) are decreased by up to 0.05 m. West of Botany Road, along Baxter Road and Robey Street, peak flood levels are reduced by up to 0.3 m. In the rarer flood events, greater flood impacts are achieved in the Baxter Road area since the volume of floodwaters spilling over Botany Road is less.

Option D4 was found to be an effective flood mitigation measure and as such a damages assessment was conducted to determine the benefit of implementation. These results are presented in Table ***22***.

Table 22: Option D4 – Change in Property Affectation and Damages

Event	No. Properties No Longer Flooded	No. Properties No Longer Flooded Over Floor	Reduction in Damages for Event
0.5 EY	13	9	$ 523,000
0.2 EY	47	30	$ 2,568,000
10% AEP	64	45	$ 3,634,000
5% AEP	57	51	$ 4,214,000
2% AEP	25	60	$ 4,745,000
1% AEP	32	24	$ 3,385,000
PMF	0	3	$ 885,000
Reduction in Annual Average Damages (AAD)			**$ 1,297,000**

The cost for implementation of Option D4 was calculated to be approximately $20,000,000. A cost breakdown for this measure can be found in **Appendix C**.

Based on the change in AAD, the relative benefit of Option D4 was calculated to be $ 19,201,000 over the lifespan of the measure. Therefore a B/C ratio of 1.0 was calculated.

Option D4 has been recommended for further investigation since it has a B/C ratio of 1.0. It is likely, however, that Option D4 will not be feasible for implementation due to the disturbance to the local community and various other factors including cost, environmental and other social factors.

Implications of Climate Change

The effect of climate change on the implementation of Option D4 was investigated by increasing the design rainfall by 10%, 20% and 30% in the 1% AEP event. **Figure B20** shows the peak flood level impacts of these rainfall increases. Generally speaking, each incremental increase in rainfall results in reduced peak flood level impacts for the 1% AEP event since the capacity of the increased pipe network is reached. This is particularly evident in the Baxter Road and Robey Street area. With each rainfall increase, peak flood levels impacts are reduced by 0.05 m on average. Along Hollingshed Street, peak flood level impacts are reduced by approximately 0.03 m per rainfall increase on average. Since the volume of flood water increases with increased rainfall, Option D4 becomes less effective. Therefore, Option D4 was found to be sensitive to climate change.

Recommendations

Option D4 is recommended for further feasibility investigation since it has a B/C ratio of one, however, as previously mentioned; it is likely that this measure is not achievable due to the effect of climate change and other social, financial and environmental factors.

6.3.5.5 Option D5 – Increasing Drainage Capacity on Lang Avenue, Pagewood

Overview

As discussed in **Section 6.3.4.3**, peak flood levels on Bay Street in Pagewood are exacerbated by the damming effect of Lang Road. Increasing the drainage capacity in this area was investigated in Option D5 to mitigate this flood affectation.

Option D5 involved the duplicating the capacity of a 530 m section of the existing 0.3 m diameter drainage network along Lang Avenue and Bay Street.

Results

Figure B21 presents the peak flood impacts of Option D5 in the 1% AEP event. Option D5 had negligible impacts to peak flood levels along Bay Street and Lang Avenue since the capacity of the drainage network was reached prior to the flood peak in the 1% AEP event.

Option D5 has not been recommended for further investigation due to a lack of significant peak flood level decreases.

6.3.5.6 Summary of Drainage Network Modifications

The efficiency of the drainage network was subject to a rigorous investigation in the current study to ensure that the mitigation options examined and presented would effectively address the flood problems in that catchment. Drainage modifications within this study area would provide substantial benefits in terms of flood mitigation however the density of this urban area and the estimated cost of the required drainage updates significantly limit the feasibility of drainage network modification measures.

Nonetheless, Option D4 was calculated to have a B/C ratio of 1.0. Therefore, Option D4 has been recommended for further feasibility investigations.

6.3.6 Combined Mitigation Options

Although mitigation measures may not effectively reduce peak flood levels in isolation, it is important to consider these options in combination. This ensures that the maximum benefit in terms of peak flood level decreases and cost of implementation is investigated.

While Option S2 (see **Section 6.3.4.2**) and Option D4 (see **Section 6.3.5.4**) each provide reductions to peak flood levels in the Hollingshed Street and Baxter Road areas, it was anticipated that together these measures could effectively further mitigate the flood problem. The combination of these measures is investigated in **Section 6.3.6.1**.

6.3.6.1 Combined Option S2 / D4

Overview

Combined Option S2 / D4 aimed to reduce peak flood levels in the Hollingshed Street and Baxter Road areas by allowing floodwaters to spill over Botany Road earlier in a flood event and provide an increased drainage capacity to accommodate for these flows.

Results

The reduction in peak flood level associated with modelling the combined Option S2 / D4 for the 1% AEP event is presented in **Figure B22**. The results indicated that the combination of these options significantly reduces peak flood levels. Peak flood levels are reduced by up to 0.1 m in the vicinity of Hollingshed Street. On the western side of Botany Road around Baxter Road, peak flood levels are reduced by up to 0.2 m.

While the combination of these mitigation measures significantly decreases peak flood levels at the hotspots on either side of Botany Road, it was determined that the implementation of this measure would not be feasible, due to the proposed development of Botany Road as a part of the WestConnex project and the feasibility of lowering a roadway.

6.4 Property Modification Measures

Property Modification Measures have been defined in the Floodplain Development Manual (**Reference 1**) as modifications to existing developments and/or development controls on property and community infrastructure for future development. These measures address the flood problem on an individual property scale rather than the holistic approach adopted when determining Flood Modification Measures (refer to **Section 6.3**).

6.4.1 Voluntary Purchase

Description

Voluntary Purchase (VP) refers to the acquisition and demolition of severely flood affected residential properties which pose a significant risk to life during flood events. Typically, these properties are frequently inundated by high hazard flows. These properties are generally removed from the floodplain and rezoned to a high hazard flood compatible use, such as open public space. The removal of these properties also restores the hydraulic capacity of the floodplain.

Despite measures such as flood proofing (refer to **Section 6.4.3**) and Voluntary House Raising (refer to **Section 6.4.2**), which would effectively reduce the flood damages at these properties, the high hazard flows which these properties are subject to are unsafe for people and would require evacuation prior to the onset of flooding.

Discussion

The VP scheme is an effective mitigation strategy where it is impractical or uneconomic to mitigate high hazard flows to an existing property. Through the Floodplain Management Program, Government funding for VP schemes is available if the property meets the complying criteria.

In the study area, much of the study area is subject to low flood hazard (H1 and H2) in the 1% AEP event (see **Figure 5**). Approximately 30 properties along Robey Street and Baxter Road will hazardous (H4) flows in the 1% AEP event. These flows are unsafe for all vehicles and people. While these properties are likely to be eligible for the Voluntary Purchase Scheme, the total cost of purchasing a significant number of properties is likely to be several million dollars.

Recommendation

It is recommended that the technical committee (OEH & Council) and the Floodplain Management Committee consider the feasibility of the VP of vulnerable developments along Robey Street and Baxter Road. If it is agreed to proceed with the investigation of purchasing these properties, a Voluntary Purchase Feasibility Assessment can be undertaken to assess the flood affectation on a property by property basis.

6.4.2 Voluntary House Raising

Description

Voluntary House Raising (VHR) has been widely used in NSW as a means of mitigation of above floor flood inundation. The application of VHR is limited since it is not suitable for all building types (primarily only for single storey non-brick buildings on piers). VHR is often not cost effective since it is likely to be cheaper or preferable to demolish and rebuild the residence at a higher level. Furthermore, VHR is unlikely to be approved in high hazard areas.

Discussion

A key advantage of VHR is the potential to eliminate above floor inundation and the resulting reductions to flood damages.

An analysis of at-risk properties potentially eligible for VHR in the study area failed to identify any houses suitable for VHR due to the building construction (brick or slab on ground). Furthermore, VHR increases the risk of residents staying in their homes during a flood event which could cause significant evacuation difficulties for residents and emergency services. For these reasons, VHR has not been considered a safe or cost effective option for the study area.

Imposing minimum floor level requirements for new developments will negate the need for raising future properties.

6.4.3 Flood Proofing Buildings

Description
Flood proofing of buildings refers to the design and construction of buildings with appropriate water resistant materials such that flood damage to the buildings itself (structural damage), and damage to the contents, is minimised in the event of inundation from flooding (**Reference 1**).

There are two types of flood proofing; wet proofing and dry proofing. Wet proofing allows water to enter buildings however damage is minimised by having flood compatible materials that resist damage and facilitate drainage and ventilation. This is usually suitable for brick or concrete buildings with concrete/tiled floors and few entry points. Dry proofing aims to completely exclude flood waters from entering a structure up to a certain level.

Temporary flood barriers can also provide flood proofing to structures if they are deployed prior to the onset of flooding. These barriers include sandbagging or private flood barriers over entry ways.

Recent developments in self-triggered flood barriers can be an effective means of limiting floodwater ingress into areas such as pre-existing underground car parking areas or the ground flood level of buildings. Reliance on such temporary measures should not however replace or reduce the requirements for minimum planned habitable floor levels within proposed planning controls for the catchment.

Discussion
Installation of permanent wet and dry flood proofing measures is done best during the construction of a building. Dry flood proofing of existing structures can be affordable relative to the cost of flooding however typically residents are reluctant to implement these measures unless they have previously experienced flooding issues.

Temporary flood barriers such as sandbagging is a cost effective means of flood proofing however adequate warning time is required for implementation. Given the limited warning time in the study area, the implementation of temporary flood barriers should not be relied upon however they should be adequate considering the short time of inundation.

Summary
Flood proofing and use of flood compatible construction materials should be encouraged for all new developments where floor levels will be low or where below floor flooding occurs in the 1% AEP event.

Temporary flood barriers should also be encouraged however due to a lack of warning time; they may be less effective than permanent flood proofing measures.

6.5 Response Modification Measures

Flood response measures encompass various means of modifying the response of the population to the flood threat (**Reference 1**). These measures aim to reduce risk to life and property during a flood event by improving factors such as flood warning and prediction, emergency management planning and community flood education.

6.5.1 Flood Warning Systems

Description

A flood warning system provides information on imminent flood events, allowing residents to take action to minimise the flood impacts. Typically, flood warning systems integrate factors such as rainfall and river flows and weather forecasts to predict the severity and timing of flooding and distribute warning messages to agencies such as the SES and to community members where necessary.

Flood warning systems are most effective on large river systems where there is significant warning time, providing residents and emergency services with ample time to prepare.

Smaller catchments primarily affected by overland flow, such as the study area, are typically subject to flash flooding from short intense bursts of rainfall and tend to be difficult to provide effective warning time because of the rapid onset of flooding. The implementation of a flood warning system in catchments prone to flash flooding would likely be unreliable and require an extremely rapid response to prepare for flooding. Furthermore, rainfall triggers used for flood warning would likely frequently trigger false alarms and therefore would often be ignored.

Discussion

The MRE and Pagewood catchments are subject to flash flooding with warning times of less than 120 minutes in the 1% AEP event (see **Section 5.4**). As such, the implementation of a flood warning system would need to take into account the flashy nature of the system.

The Bureau of Meteorology (BOM) provides some services which can aid emergency services and the community to the threat of flooding. These services include:

- The weather forecasts can provide an indication of the likelihood of heavy rainfall typically with over 24 hours' notice.
- Flood Watch is issued by the NSW Flood Warning Centre to provide 24 to 48 hours' notice that flooding is possible using a combination of forecast rainfall and catchment or other hydrological conditions.
- Severe Weather Warnings are issued for synoptic scale events when torrential rain and/or flash flooding are forecast.
- Severe Thunderstorm Warnings are issued typically provided 0.5 to 2 hours' notice based upon radar and data from field stations, reports from storm spotters where available and the synoptic situation.

Based on these BOM predictions, local flood advices are issued by the NSW SES.

The Botany Wetlands catchment is a larger catchment which receives inflows from Centennial Park and Kensington. As such, this catchment has a greater warning time than the MRE and Pagewood catchments. The implementation of a flood warning system on this catchment would be unnecessary since properties are unaffected by floodwaters in this catchment until events greater than the 1% AEP event.

Summary
Based on the information presented above, the implementation of flood warning systems is not recommended for the catchments in the study area, although, further investigation of more modern flash flood warning techniques (for example a 3Di Model coupled with BOM rainfall prediction modelling), could be further investigated. Since flood affection in the study area does not scale greatly in the upper reaches of the catchment for events of varying magnitude, it would be pertinent that a flood warning system accounts for this and avoids raising frequent false alarms.

It is recommended that Council and the SES consider the implementation of a flood warning alerts to be issued to residents based on BOM forecasts and warnings for example via text message, email or social media updates.

6.5.2 Emergency Management Planning

Description
Effective planning for emergency response helps to reduce risk to life and property damage, particularly for large scale flood events where flood and property modification measures are less effective.

The NSW SES is an emergency and rescue service dedicated to assisting the community during primarily flood and storm emergencies and other incidents such as road accidents, vertical rescue, bush search and rescue and evidence searches. This agency is responsible for the control of flood operations and is guided by flood planning. The SES is in the process of developing Local Flood Plan (LFP) for emergency response for units throughout NSW. A LFP plans for significant flood events by describing various measures to be undertaken before, during and after a flood, including warning, evacuation, resupply and other procedures (**Reference 1**).

Discussion
The study area does not currently have a Local Flood Plan. The findings from the Flood Study (**Reference 3**) and the current study can be incorporated into a LFP when it is developed. The following information would be useful for these plans:

- Flood mapping outputs (such as extents, depths, velocities, hazard classifications and travel times);
- Approximate number of buildings and access roadways inundated by floods up to the PMF such a low flood islands and high flood islands;
- Evacuation constraints such as preferred evacuation routes and timing of inundation of flood evacuation route; and
- Evacuation plans for various areas such as time to evacuate, evacuation route and whether shelter-in-place is appropriate for a location.

Summary
Emergency Management Planning is vital for reducing risk to life and property during a flood event. It is the responsibility of the NSW SES to plan and respond to flooding. This is particularly important in catchments where there is low flood awareness in the community. Therefore it is recommended that a LFP is developed for the study area aided by the outputs of the current study.

6.5.3 Community Flood Education

Description
Communities with high flood awareness are likely to suffer less damage and disruption during the course of a flood event. This is because the community are knowledgeable about flooding in their local area and the actions they are required to take. Flood education programs are effective when they are participatory, involving a range of mediums (such as videos, field trips and forums) and outline methods used in flood risk

management and emergency management measures. It is important that these programs are ongoing, particularly in an area which has such a high turnover of residents (refer to **Section 1.3.1**).

Discussion

At present, the study area has a relatively low awareness of flooding in the area and as such it is important to investigate ways in which flood awareness and preparedness can be enhanced. **Table 23** outlines a number of methods that can be undertaken to increase and sustain flood readiness in the community.

Table 23: Methods to increase Community Flood Education

Method	Comment
S149 Certificate Notifications	Section 149 planning certificates outline whether a lot is subject to planning or development controls based on its flood affectation. More detailed information of a lots flood affectation can be provided under S149(5). This information can be seen by prospective purchasers and is typically only issued on request and payment of a fee.
Letter/Certificate/Pamphlet from Council	This information can be sent with the Council rates notices. Council can specifically target flood liable lots to lower expenses, using the flood information provided in the flood study and the current study. The information in this document can inform residents of their site-specific flood liability and provide advice on actions to take during flooding.
Council Website	Council's website can provide emergency flood information, the floodplain management process and include relevant documentation such as the Flood Study and Floodplain Risk Management Study. The website could also refer to BOM weather warnings.
Floodplain Risk Management Committee	Council could establish (or maintain the existing) Floodplain Risk Management Committee to encourage communication between residents and community members.
Articles in local newspapers	Regular articles in the local newspaper regarding the existing flood problem and of historical flooding can help to remind residents of the flood liability in the area.
Social Media	Council and the SES could use Social Media (such as Facebook or Twitter) as a tool for communicating the existing and future flood risk within the catchment. Posting historical flood photos and issuing flood warnings help to remind residents of the flood liability in the area.
Library Display	The local library could display historical flood photos and the Flood Study and Flood Risk Management Study for residents to view.
NSW SES FloodSafe Guide	A FloodSafe guide for the study area could be prepared describing the flood behaviour of the catchment, listing appropriate actions and any implemented flood mitigation strategies.
Council and SES Community Engagement	Council/the NSW SES could set up a stall at the local shops to inform the community, provide flood maps and NSW SES materials to hand out.
Historical flood markets and flood depth markers	Signs and past flood marks on telegraph poles or trees can indicate the level reached in historical or design floods. Depth indications along flood affected roadways can advise drivers of the potential hazards.

Summary

At present, there is limited community awareness of the flood liability in the study area. Furthermore, during long periods between damaging flooding, it is common for communities to forget about the flood affectation in the area. Therefore, ongoing flood education is recommended to build and maintain flood readiness in the community. It is also important that residents are reminded of the dangers of attempting to cross flood water.

It is recommended that Council develop a program to educate the community of their flood affectation using the methods suggested in Table 23.

7 Floodplain Risk Management Plan

The following section forms the Floodplain Risk Management Plan and provides a framework by which the plan will be implemented. The objective of this Plan is to recommend a range of property, response and flood modification measures to mitigate the existing and future flood affectation in the study area. This plan has been completed in accordance with the Floodplain Development Manual (**Reference 1**).

The following table, **Table 24**, provides an analysis of the preferred Floodplain Risk Management options and priority for each of these options.

Table 24: Measures Recommended for Implementation – Risk Management Options Multi-Criteria Analysis

Measure	Description	Priority	Benefit	Concerns	Responsibility for Implementation, Costs and Funding
FLOOD MODIFICATION MEASURES					
Option B2 (see **Section 6.3.1.2**)	Option B2 investigated the construction of a retarding basin for flood storage on the Council owned playing fields along Sutherland Street, Mascot.	**Medium** *Consider for detailed design and costing*	B/C = 1.6 Option B2 significantly decreases the number of properties flood affected in events up to and including the 1% AEP event.	Option B2 is situated on L'Estrange Park which has various important social and environmental issues that need to be considered during detailed design. The park is a popular venue for residents with a playground and sporting facilities. Flood waters are likely to require pumping out of the basin due required to excavation.	Council would be responsible for costs and implementation of Option B2. Limited funding may be available through the NSW Floodplain Management Program.
Option B3 (see **Section 6.3.1.3**)	Option B3 investigated the construction of a retarding basin on the playing fields of JJ Cahill Memorial High School.	**Medium** *Consider for detailed design and costing*	B/C = 4.1 Option B3 reduces peak flood levels in the vicinity of the basin particularly in events up to and including the 2% AEP event.	Option B3 is located within the grounds of a private high school which may cause in safety concerns. Flood waters are likely to require pumping out of the basin due to required excavation.	Council would be responsible for costs and implementation of Option B3. Limited funding may be available through the NSW Floodplain Management Program.
Option S1 (see **Section 6.3.4.1**)	Option S1 recommended levelling the golf course embankment at the end of Florence Avenue.	**High**	B/C = 2.9 Option S1 is a cost effective measure which reduces flood affectation for properties in the 2% and 1% AEP events.	Option S1 increases peak flood levels on the golf course. Golf course stakeholders will require consultation regarding the works.	Council would be responsible for costs and implementation of Option S1. Limited funding may be available through the NSW Floodplain Management Program.
Option D4 (see **Section 6.3.5.4**)	Option D4 investigated increasing the drainage capacity in the Hollingshed Street and Baxter Road areas.	**Low**	B/C = 1.0 Option D4 significantly reduces peak flood level and property inundation in flood evens up to and including the 1% AEP event.	Option D4 is likely to cause significant economic, environmental and social issues due to the broad scope of works.	Council would be responsible for costs and implementation of Option D4. Limited funding may be available through the NSW Floodplain Management Program.
PROPERTY MODIFICATION MEASURES					
Voluntary Purchase (see **Section 6.4.1**)	Approximately 30 properties along Robey Street and Baxter Road are likely to be eligible for the Voluntary Purchase Scheme.	**Low**	Potential to remove residents from area which are subject to hazardous flood conditions.	The Voluntary Purchase Scheme is a costly measure which often takes decades for all of the approved properties to be removed from the floodplain.	Recommendation for a Voluntary Purchase Feasibility Assessment to be conducted. Limited funding may be

					available through the NSW Floodplain Management Program.
Flood Proofing (see **Section 6.4.3**)	Flood proofing measures (permanent and temporary) can be used. New development within hazardous areas of the floodplain can be required to include flood proofing measures	**Low**	Reducing flood affectation to properties in flood prone locations.	The implementation of permanent flood proofing measures can be expensive. Temporary flood proofing measure can be ineffective if adequate warning time is not provided.	New developments within flood prone areas of the catchment can be required in the DCP to consider flood proofing measures.
			RESPONSE MODIFICATION MEASURES		
Emergency Management Planning (see **Section 6.5.2**)	Effective emergency management planning involves the collaboration of emergency services including the SES and other rescue services to develop a Local Flood Plan.	**High**	A Local Flood Plan will ensure that informed decisions can be made during a flood event and allow for flood preparedness to increase efficiency and reduce risk to residents and emergency services.	Requires effective communication with the community and stakeholders.	The NSW SES are responsible for developing and maintaining a Local Flood Plan for the study area.
Community Flood Education (see **Section 6.5.3**)	A community flood education program would increase flood awareness. This can be undertaken in a variety of ways outlined in **Table 23**.	**Medium**	Increasing flood preparedness and awareness in the community would ensure that communities are informed and ultimately reduce the damages during a flood event.	Community members are likely to ignore flood information if too much is given. Communication needs to be direct and concise.	Council in partnership with the SES are responsible for community education. To reduce costs, this information can be incorporated with other information such as in the local paper or with Council Rates.

8 References

1 NSW State Government (2005). **Floodplain Development Manual**. April 2005

2 Pilgrim DH (Editor in Chief) (ARR1987). **Australian Rainfall and Runoff – A Guide to Flood Estimation**. Institution of Engineers, Australia, 1987

3 Botany Bay Council, **Mascot, Rosebery and Eastlakes Flood Study**, WMAwater 2015

4 NSW Government Department of Planning (2007), **Planning Circular PS 07-003** (New guideline and changes to section 117 direction and EP&A Regulation on flood prone land), Issued 31 January 2007

5 Department of Environment and Climate Change, **Flood Emergency Response Planning Classification of Communities**, NSW State Government, October 2007

PROJECT NO: PA1283 PROJECT TITLE: Mascot, Rosebery & Eastlakes Floodplain Risk Management Study

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Approx. Scale

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FIGURE 01 **Study Area**

CREATED BY: BM REVISION A DATE 31/03/2017

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CO-ORDINATE SYSTEM: Datum: GDA94 Projection: MGA Zone 56

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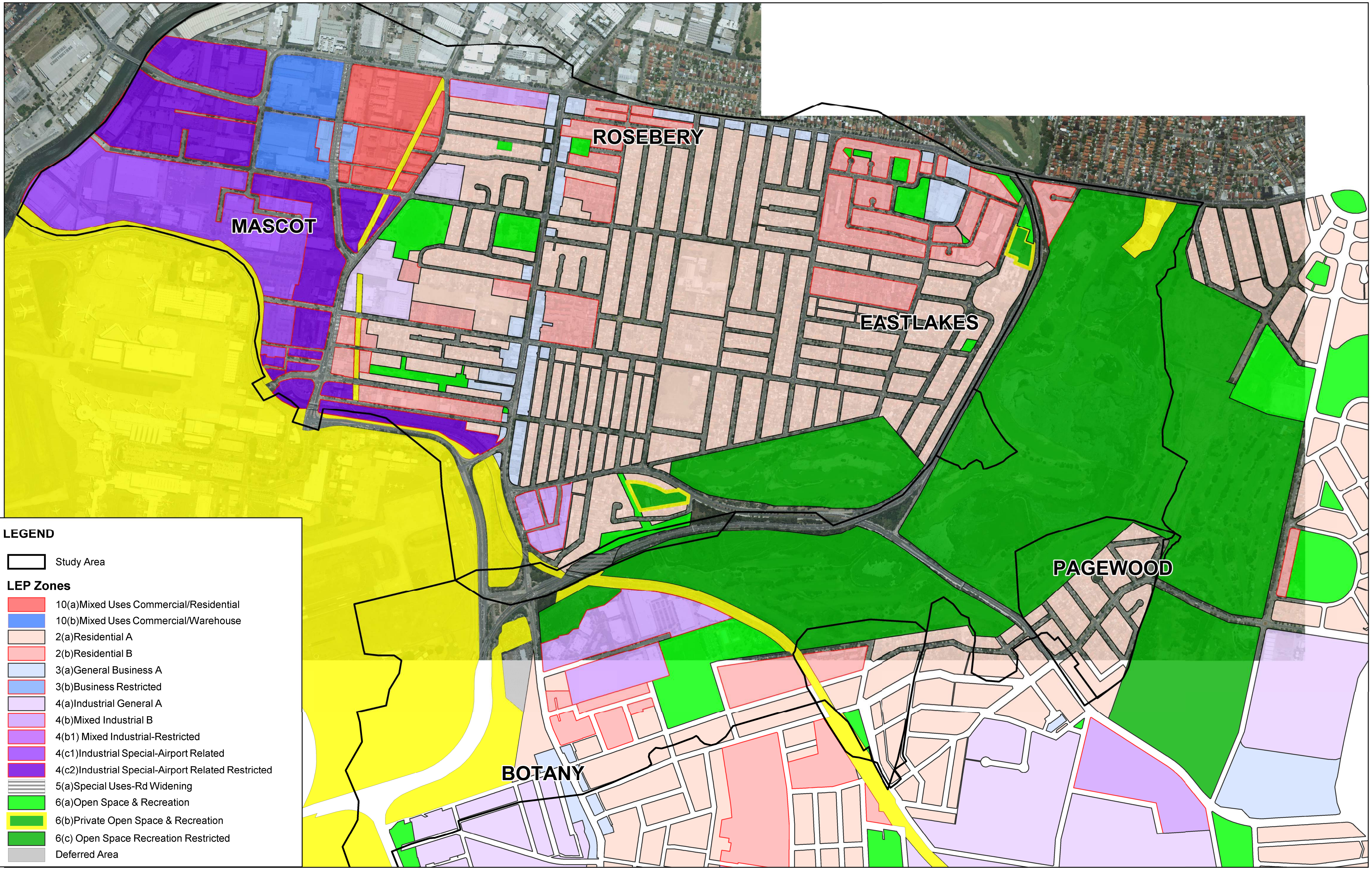

PROJECT NO: PA1283	PROJECT TITLE: Mascot, Rosebery & Eastlakes Floodplain Risk Management Study	0 1.25 2.5km Approx. Scale	SCALE 1:12,500 PAGE SIZE A3 NORTH
FIGURE 02	**Botany Bay LEP 2013 - Land Use**	CREATED BY: BM	REVISION A DATE 31/03/2017
FILEPATH PA1283 MRE FRMS&P\PA1283 MRE FRMS&P\PA1283 Technical Data\E7_GIS\06_Figures\DraftReport\Figure02_LandUse.wor		CO-ORDINATE SYSTEM:	Datum: GDA94 Projection: MGA Zone 56

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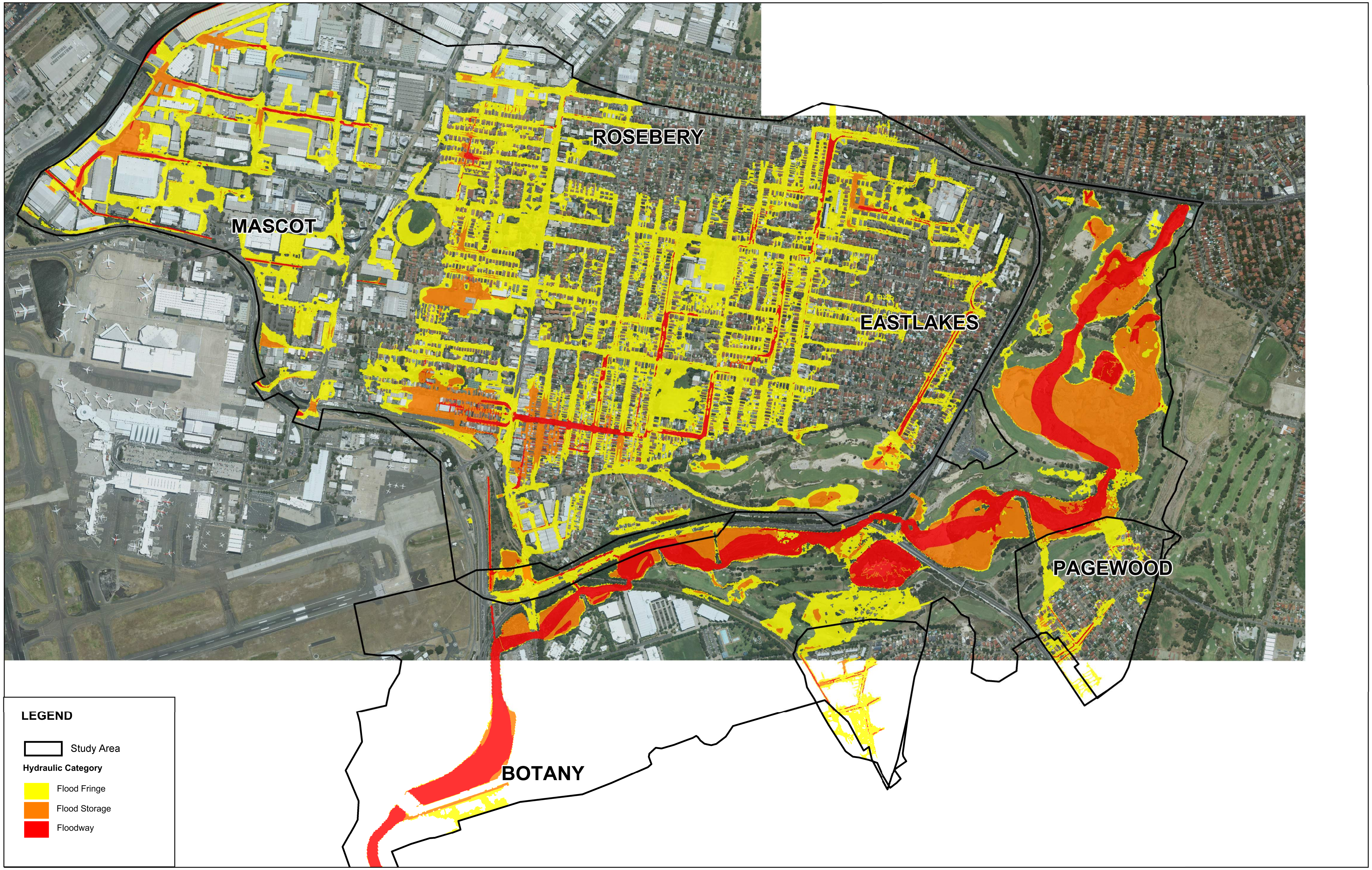

PROJECT NO: PA1283	PROJECT TITLE: Mascot, Rosebery & Eastlakes Floodplain Risk Management Study	
FIGURE 03	Hydraulic Categorisation - 1% AEP Event	

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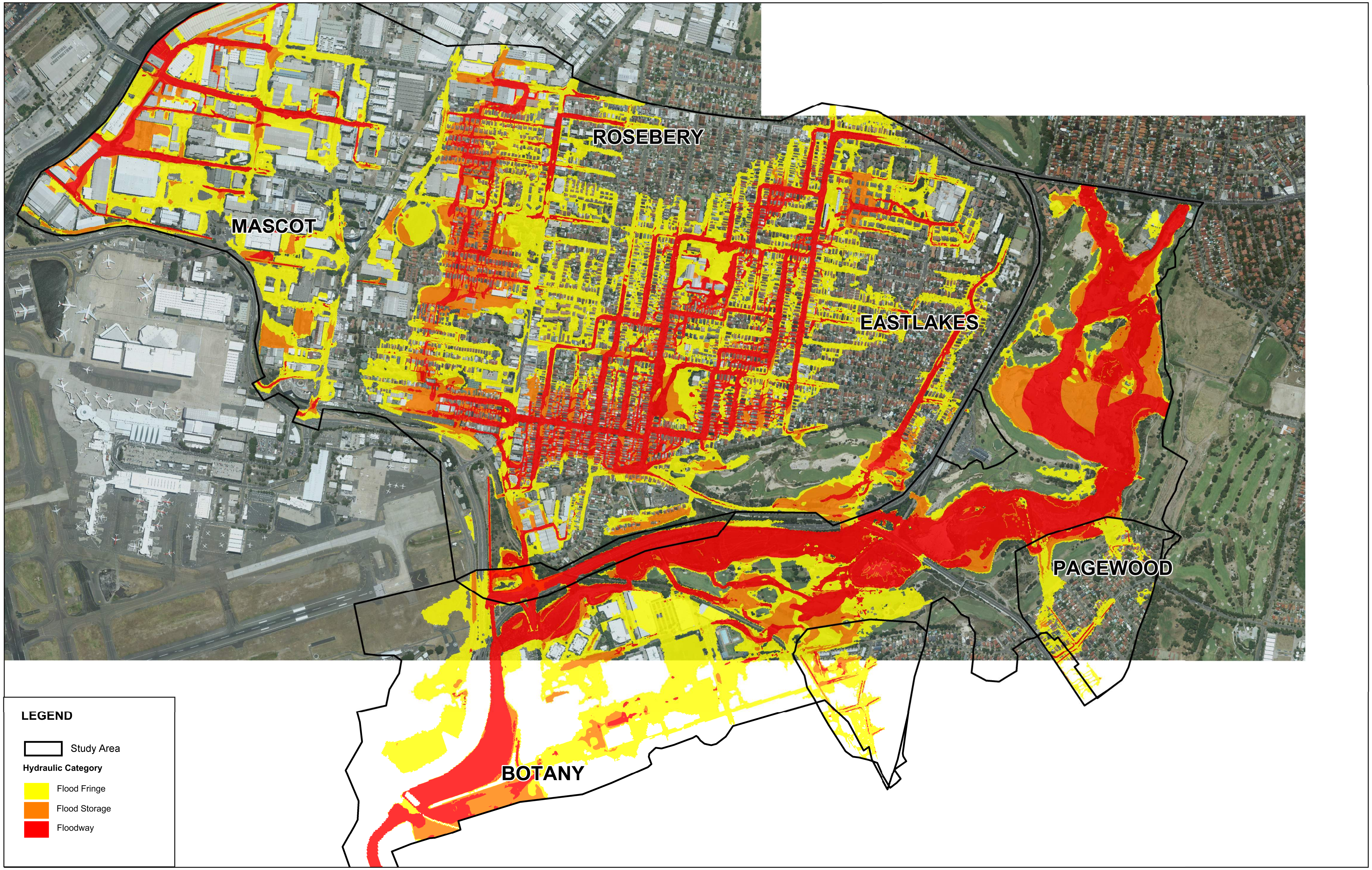

PROJECT NO:	PA1283	PROJECT TITLE:	Mascot, Rosebery & Eastlakes Floodplain Risk Management Study

FIGURE 04 **Hydraulic Categorisation - PMF Event**

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CO-ORDINATE SYSTEM: Datum: GDA94 Projection: MGA Zone 56

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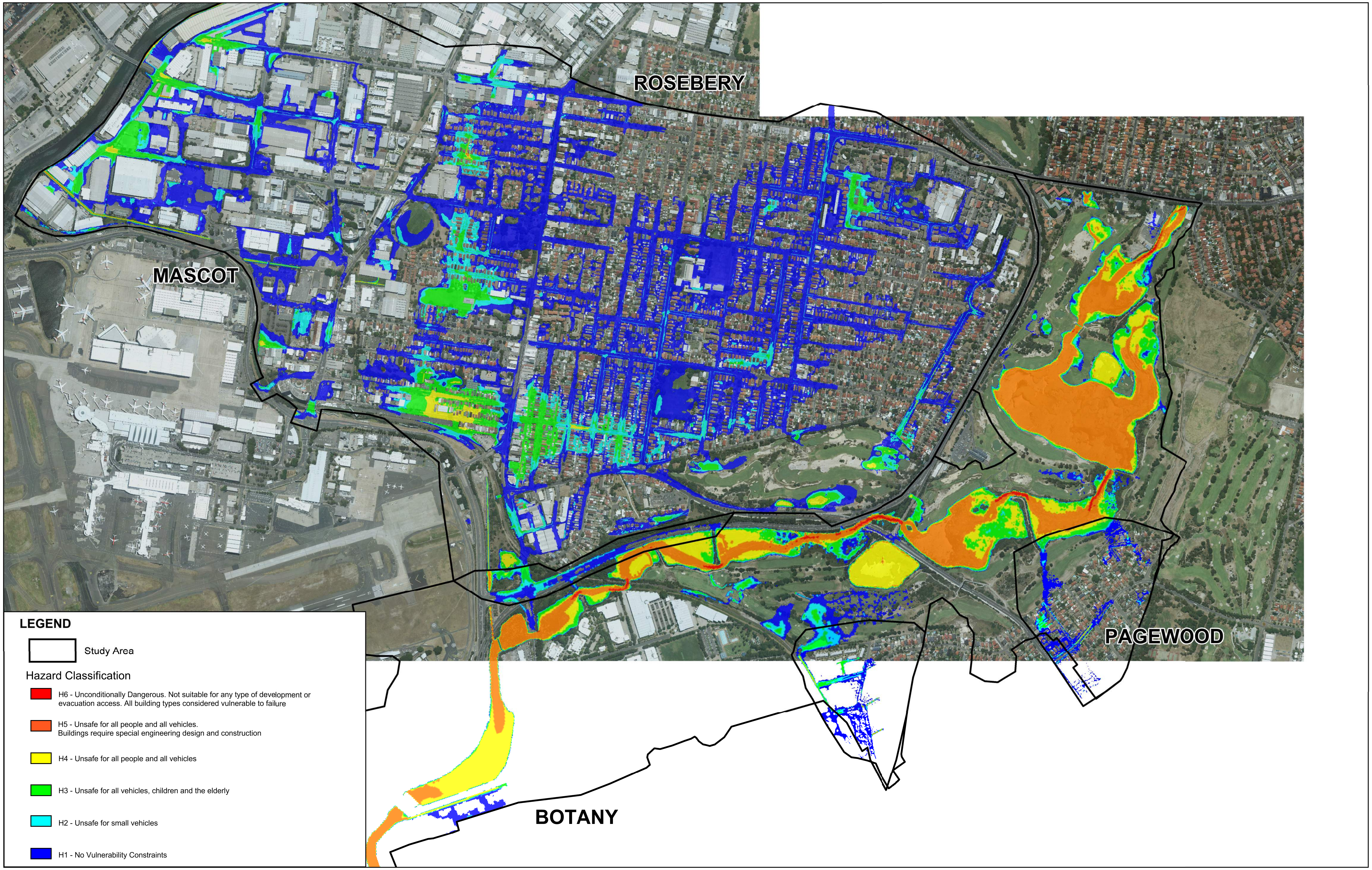

PROJECT NO: PA1283 PROJECT TITLE: Mascot, Rosebery & Eastlakes Floodplain Risk Management Study

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FIGURE 05 **True Hydraulic Hazard - 1% AEP Event**

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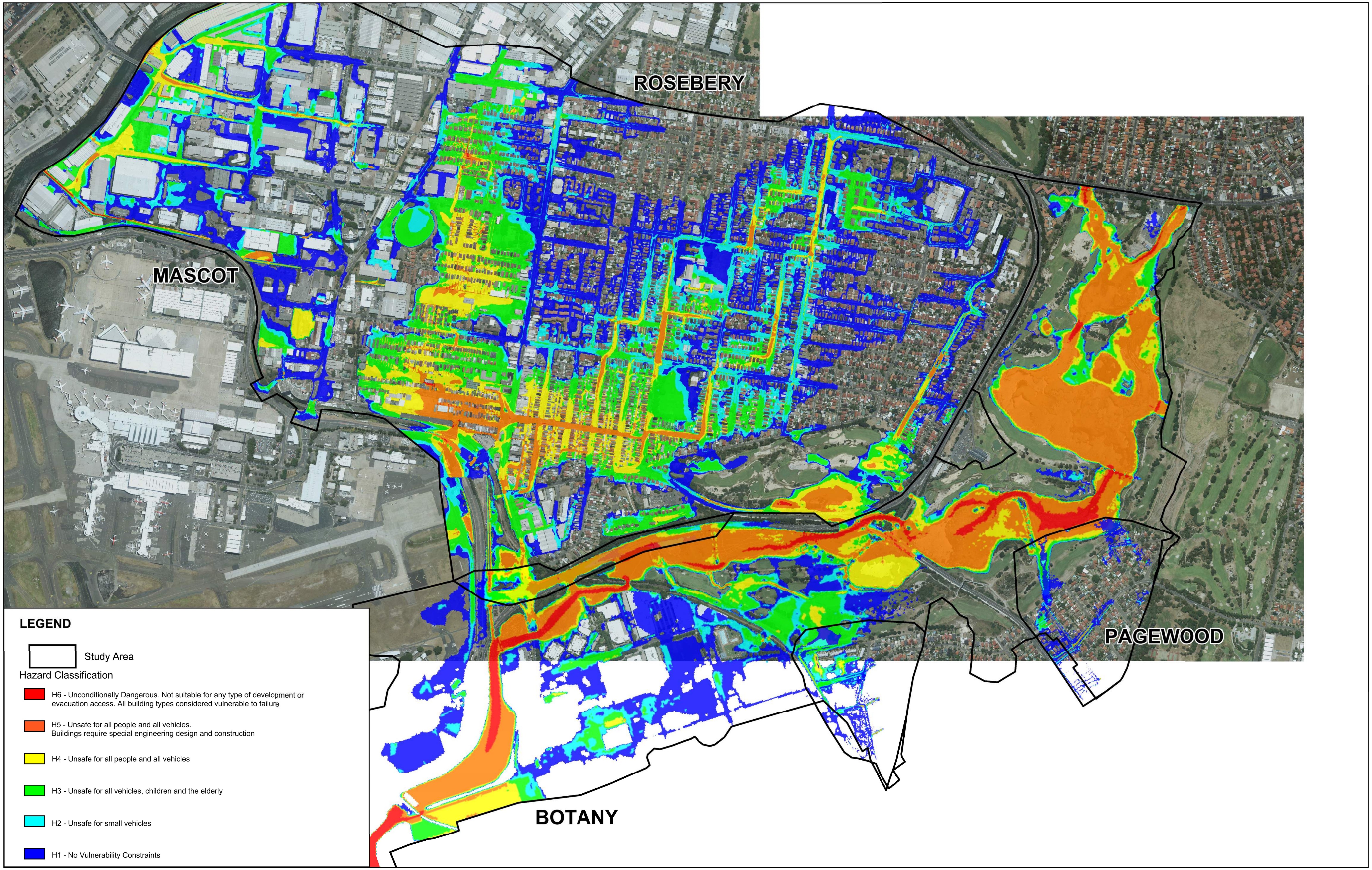

PROJECT NO: PA1283	PROJECT TITLE: Mascot, Rosebery & Eastlakes Floodplain Risk Management Study	0 1.25 2.5km Approx. Scale; SCALE 1:12,500; PAGE SIZE A3; NORTH	NOT FOR CONSTRUCTION
FIGURE 06	True Hydraulic Hazard - PMF Event	CREATED BY: BM; REVISION A; DATE 03/04/2017	
FILEPATH PA1283 MRE FRMS&P\PA1283 Technical Data\E7_GIS\06_Figures\DraftReport\Figure05_HydraulicHazard_1%AEP.wor		CO-ORDINATE SYSTEM: Datum: GDA94 Projection: MGA Zone 56	

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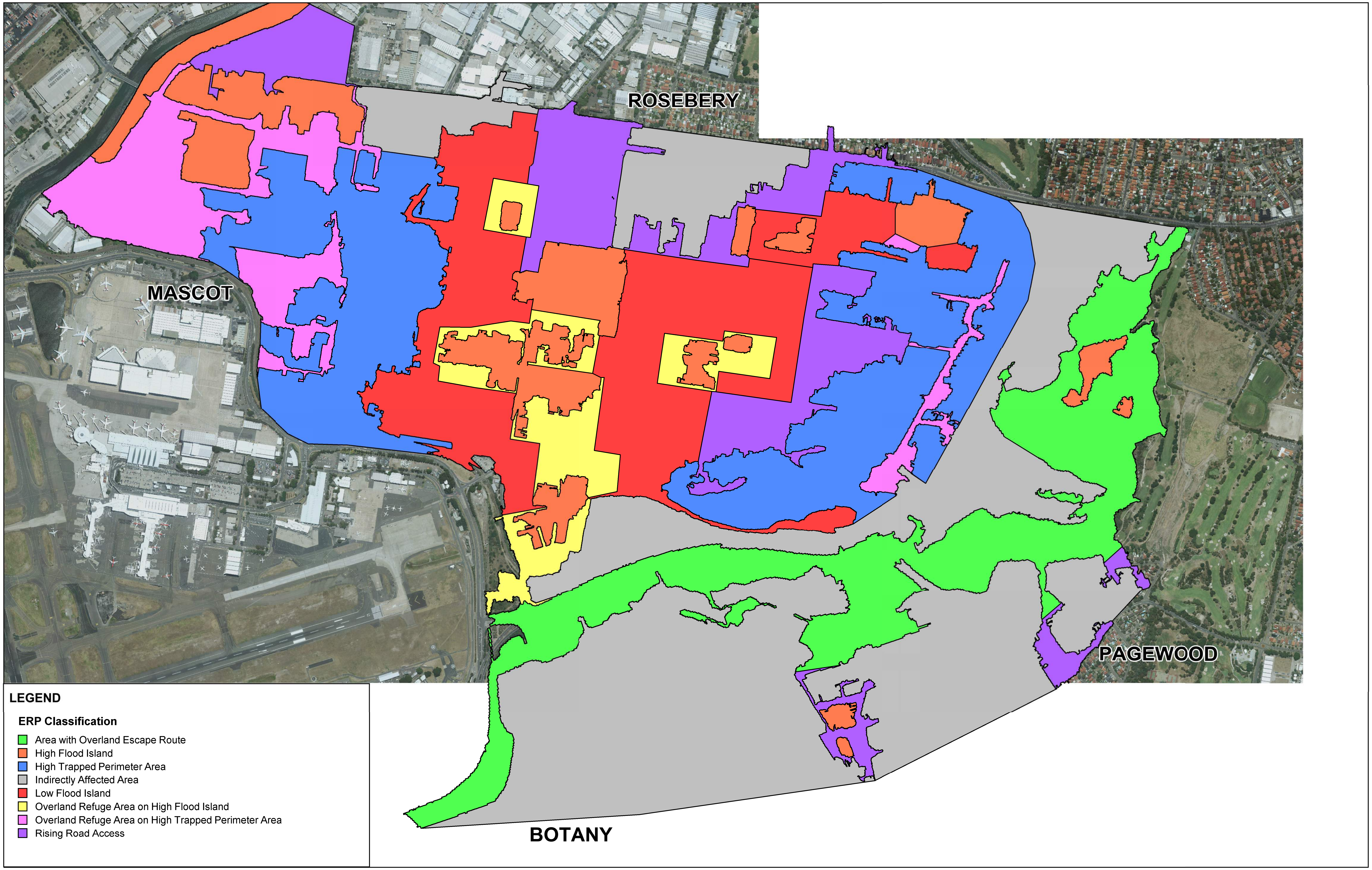

PROJECT NO: PA1283 PROJECT TITLE: Mascot, Rosebery & Eastlakes Floodplain Risk Management Study

FIGURE 07 **Emergency Response Planning Mapping - 1% AEP Event**

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FILEPATH PA1283 MRE FRMS&P\PA1283 Technical Data\E7_GIS\06_Figures\DraftReport\Figure07_EmergencyReponse_1%AEP.wor

CO-ORDINATE SYSTEM: Datum: GDA94 Projection: MGA Zone 56

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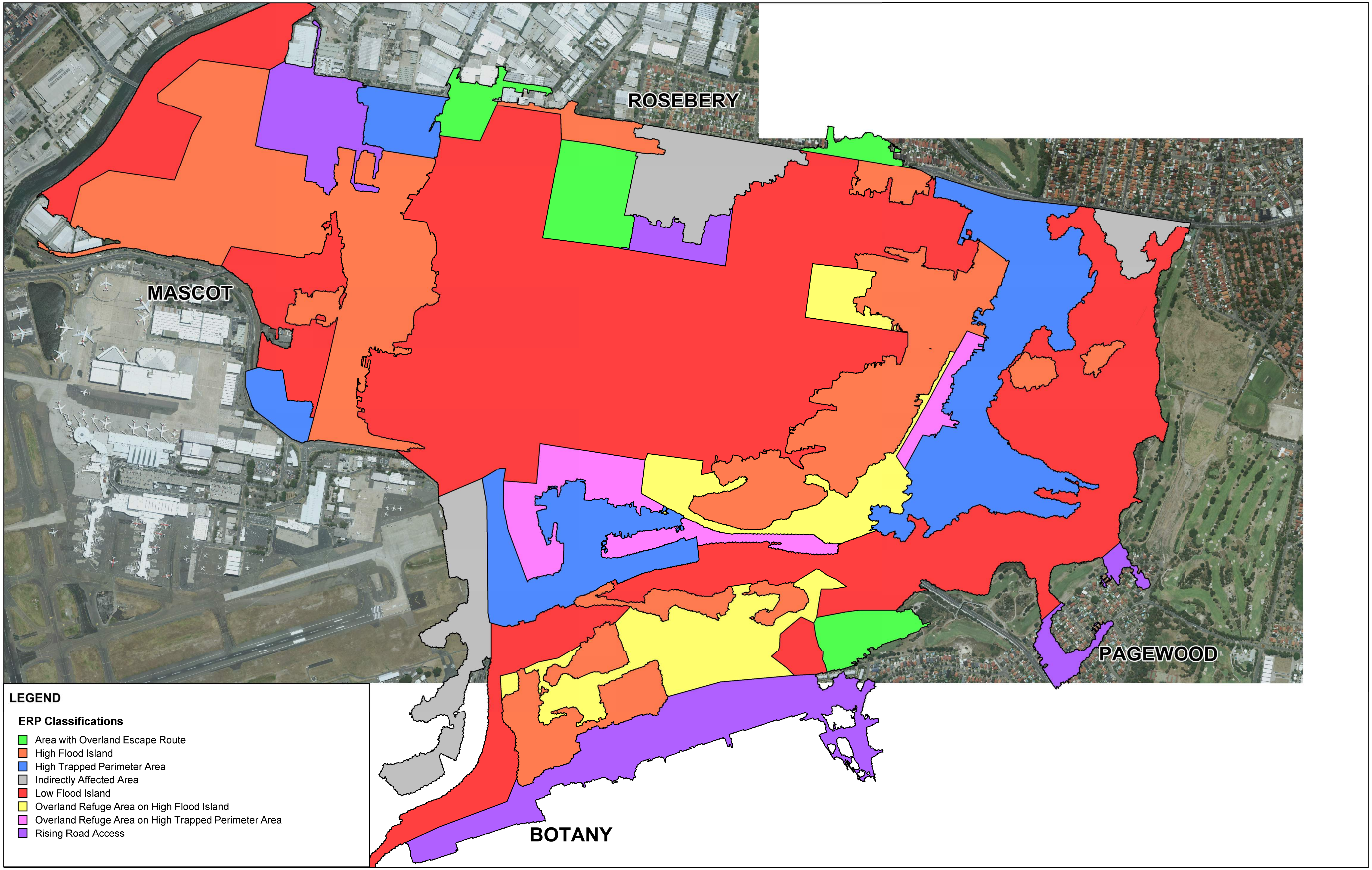

PROJECT NO: PA1283 PROJECT TITLE: Mascot, Rosebery & Eastlakes Floodplain Risk Management Study

FIGURE 08 **Emergency Response Planning Mapping - PMF Event**

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Approx. Scale

SCALE 1:12,500 PAGE SIZE A3 NORTH

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FILEPATH PA1283 MRE FRMS&P\PA1283 Technical Data\E7_GIS\06_Figures\DraftReport\Figure08_EmergencyReponse_PMF.wor

CO-ORDINATE SYSTEM: Datum: GDA94 Projection: MGA Zone 56

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Appendix A – Glossary of Key Terms

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

Image 1: Australian Rainfall and Runoff Preferred Terminology

4. GLOSSARY

acid sulfate soils	are sediments which contain sulfidic mineral pyrite which may become extremely acid following disturbance or drainage as sulfur compounds react when exposed to oxygen to form sulfuric acid. More detailed explanation and definition can be found in the NSW Government Acid Sulfate Soil Manual published by Acid Sulfate Soil Management Advisory Committee.
annual exceedance probability (AEP)	the chance of a flood of a given or larger size occurring in any one year, usually expressed as a percentage. Eg, if a peak flood discharge of 500 m^3/s has an AEP of 5%, it means that there is a 5% chance (that is one-in-20 chance) of a 500 m^3/s or larger events occurring in any one year (see ARI).
Australian Height Datum (AHD)	a common national surface level datum approximately corresponding to mean sea level.
average annual damage (AAD)	depending on its size (or severity), each flood will cause a different amount of flood damage to a flood prone area. AAD is the average damage per year that would occur in a nominated development situation from flooding over a very long period of time. Refer Appendix M.
average recurrence interval (ARI)	the long-term average number of years between the occurrence of a flood as big as or larger than the selected event. For example, floods with a discharge as great as or greater than the 20 year ARI flood event will occur on average once every 20 years. ARI is another way of expressing the likelihood of occurrence of a flood event.
caravan and moveable home parks	caravans and moveable dwellings are being increasingly used for long-term and permanent accommodation purposes. Standards relating to their siting, design, construction and management can be found in the Regulations under the LG Act.
catchment	the land area draining through the main stream, as well as tributary streams, to a particular site. It always relates to an area above a specific location.
consent authority	the council, government agency or person having the function to determine a development application for land use under the EP&A Act. The consent authority is most often the council, however legislation or an EPI may specify a Minister or public authority (other than a council), or the Director General of DIPNR, as having the function to determine an application.
development	is defined in Part 4 of the EP&A Act <u>infill development</u>: refers to the development of vacant blocks of land that are generally surrounded by developed properties and is permissible under the current zoning of the land. Conditions such as minimum floor levels may be imposed on infill development <u>new development:</u> refers to development of a completely different nature to that associated with the former land use. Eg, the urban subdivision of an area previously used

for rural purposes. New developments involve re-zoning and typically require major extensions of existing urban services, such as roads, water supply, sewerage and electric power.

redevelopment: refers to rebuilding in an area. Eg, as urban areas age, it may become necessary to demolish and reconstruct buildings on a relatively large scale. Redevelopment generally does not require either re-zoning or major extensions to urban services.

disaster plan (DISPLAN) a step by step sequence of previously agreed roles, responsibilities, functions, actions and management arrangements for the conduct of a single or series of connected emergency operations, with the object of ensuring the coordinated response by all agencies having responsibilities and functions in emergencies.

discharge the rate of flow of water measured in terms of volume per unit time, for example, cubic metres per second (m^3/s). Discharge is different from the speed or velocity of flow, which is a measure of how fast the water is moving for example, metres per second (m/s).

ESD using, conserving and enhancing natural resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be maintained or increased. A more detailed definition is included in the Local Government Act, 1993. The use of sustainability and sustainable in this manual relate to ESD.

effective warning time the time available after receiving advice of an impending flood and before the floodwaters prevent appropriate flood response actions being undertaken. The effective warning time is typically used to move farm equipment, move stock, raise furniture, evacuate people and transport their possessions.

emergency management a range of measures to manage risks to communities and the environment. In the flood context it may include measures to prevent, prepare for, respond to and recover from flooding.

flash flooding flooding which is sudden and unexpected. It is often caused by sudden local or nearby heavy rainfall. Often defined as flooding which peaks within six hours of the causative rain.

flood relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or local overland flooding associated with major drainage (refer Section C6) before entering a watercourse, and/or coastal inundation resulting from super-elevated sea levels and/or waves overtopping coastline defences excluding tsunami.

flood awareness Awareness is an appreciation of the likely effects of flooding and a knowledge of the relevant flood warning, response and evacuation procedures.

flood education flood education seeks to provide information to raise awareness of the flood problem so as to enable individuals

	to understand how to manage themselves and their property in response to flood warnings and in a flood event. It invokes a state of flood readiness.
flood fringe areas	the remaining area of flood prone land after floodway and flood storage areas have been defined.
flood liable land	is synonymous with flood prone land (ie) land susceptible to flooding by the PMF event. Note that the term flood liable land covers the whole floodplain, not just that part below the FPL (see flood planning area).
flood mitigation standard	the average recurrence interval of the flood, selected as part of the floodplain risk management process that forms the basis for physical works to modify the impacts of flooding.
floodplain	area of land which is subject to inundation by floods up to and including the probable maximum flood event, that is, flood prone land.
floodplain risk management options	the measures that might be feasible for the management of a particular area of the floodplain. Preparation of a floodplain risk management plan requires a detailed evaluation of floodplain risk management options.
floodplain risk management plan	a management plan developed in accordance with the principles and guidelines in this manual. Usually includes both written and diagrammatic information describing how particular areas of flood prone land are to be used and managed to achieve defined objectives.
flood plan (local)	A sub-plan of a disaster plan that deals specifically with flooding. They can exist at state, division and local levels. Local flood plans are prepared under the leadership of the SES.
flood planning area	the area of land below the FPL and thus subject to flood related development controls. The concept of flood planning area generally supersedes the "flood liable land" concept in the 1986 Manual.
flood planning levels (FPLs)	are the combinations of flood levels (derived from significant historical flood events or floods of specific AEPs) and freeboards selected for floodplain risk management purposes, as determined in management studies and incorporated in management plans. FPLs supersede the "standard flood event" in the 1986 manual.
flood proofing	a combination of measures incorporated in the design, construction and alteration of individual buildings or structures subject to flooding, to reduce or eliminate flood damages.
flood prone land	land susceptible to flooding by the PMF event. Flood prone land is synonymous with flood liable land.
flood readiness	Readiness is an ability to react within the effective warning time.
flood risk	potential danger to personal safety and potential damage to property resulting from flooding. The degree of risk varies with circumstances across the full range of floods. Flood risk in this manual is divided into 3 types, existing, future and continuing risks. They are described below.

existing flood risk: the risk a community is exposed to as a result of its location on the floodplain.

future flood risk: the risk a community may be exposed to as a result of new development on the floodplain.

continuing flood risk: the risk a community is exposed to after floodplain risk management measures have been implemented. For a town protected by levees, the continuing flood risk is the consequences of the levees being overtopped. For an area without any floodplain risk management measures, the continuing flood risk is simply the existence of its flood exposure.

flood storage areas

those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood. The extent and behaviour of flood storage areas may change with flood severity, and loss of flood storage can increase the severity of flood impacts by reducing natural flood attenuation. Hence, it is necessary to investigate a range of flood sizes before defining flood storage areas.

floodway areas

those areas of the floodplain where a significant discharge of water occurs during floods. They are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flow, or a significant increase in flood levels.

freeboard

provides reasonable certainty that the risk exposure selected in deciding on a particular flood chosen as the basis for the FPL is actually provided. It is a factor of safety typically used in relation to the setting of floor levels, levee crest levels, etc. (See Section K5). Freeboard is included in the flood planning level.

habitable room

in a residential situation: a living or working area, such as a lounge room, dining room, rumpus room, kitchen, bedroom or workroom.

in an industrial or commercial situation: an area used for offices or to store valuable possessions susceptible to flood damage in the event of a flood.

hazard

a source of potential harm or a situation with a potential to cause loss. In relation to this manual the hazard is flooding which has the potential to cause damage to the community. Definitions of high and low hazard categories are provided in Appendix L.

hydraulics

term given to the study of water flow in waterways; in particular, the evaluation of flow parameters such as water level and velocity.

hydrograph

a graph which shows how the discharge or stage/flood level at any particular location varies with time during a flood.

hydrology

term given to the study of the rainfall and runoff process; in particular, the evaluation of peak flows, flow volumes and the derivation of hydrographs for a range of floods.

local overland flooding

inundation by local runoff rather than overbank discharge from a stream, river, estuary, lake or dam.

local drainage — smaller scale problems in urban areas. They are outside the definition of major drainage in this glossary.

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

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

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

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

merit approach — the merit approach weighs social, economic, ecological and cultural impacts of land use options for different flood prone areas together with flood damage, hazard and behaviour implications, and environmental protection and well being of the State's rivers and floodplains.

The merit approach operates at two levels. At the strategic level it allows for the consideration of social, economic, ecological, cultural and flooding issues to determine strategies for the management of future flood risk which are formulated into council plans, policy, and EPIs. At a site specific level, it involves consideration of the best way of conditioning development allowable under the floodplain risk management plan, local flood risk management policy and EPIs.

minor, moderate and major flooding — both the SES and the BoM use the following definitions in flood warnings to give a general indication of the types of problems expected with a flood:

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

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

major flooding: appreciable urban areas are flooded and/or extensive rural areas are flooded. Properties, villages and towns can be isolated.

modification measures — measures that modify either the flood, the property or the response to flooding. Examples are provided in Table 2.1 with further discussion in Appendix J.

peak discharge — the maximum discharge occurring during a flood event.

probable maximum flood — the PMF is the largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation, and where applicable, snow melt, coupled with the worst flood producing catchment conditions. Generally, it is not physically or economically possible to provide complete protection against this event. The PMF defines the extent of flood prone land, that is, the floodplain. The extent, nature and potential consequences of flooding associated with a range of events rarer than the flood used for designing mitigation works and controlling development, up to and including the PMF event should be addressed in a floodplain risk management study.

probable maximum precipitation — the PMP is the greatest depth of precipitation for a given duration meteorologically possible over a given size storm area at a particular location at a particular time of the year, with no allowance made for long-term climatic trends (World Meteorological Organisation, 1986). It is the primary input to PMF estimation.

probability — a statistical measure of the expected chance of flooding (see AEP).

risk — chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. In the context of the manual it is the likelihood of consequences arising from the interaction of floods, communities and the environment.

runoff — the amount of rainfall which actually ends up as streamflow, also known as rainfall excess.

stage — equivalent to water level (both measured with reference to a specified datum).

stage hydrograph — a graph that shows how the water level at a particular location changes with time during a flood. It must be referenced to a particular datum.

survey plan — a plan prepared by a registered surveyor.

water surface profile — a graph showing the flood stage at any given location along a watercourse at a particular time.

wind fetch — the horizontal distance in the direction of wind over which wind waves are generated.

Appendix B – Flood Mitigation Options – Impact Mapping

PROJECT NO: PA1283 PROJECT TITLE: Mascot, Rosebery & Eastlakes Floodplain Risk Management Study

FIGURE B01 **1% AEP - Peak Flood Impacts (Option B1 - Mascot Public School Basin)**

0 100 200m
Approx. Scale

SCALE 1:10,000 PAGE SIZE A3 NORTH

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FILEPATH PA1283 MRE FRMS&P\PA1283 Technical Data\E7_GIS\06_Figures\DraftReport\FigureB01_FloodImpacts_1%AEP_B1.wor

CO-ORDINATE SYSTEM: Datum: GDA94 Projection: MGA Zone 56

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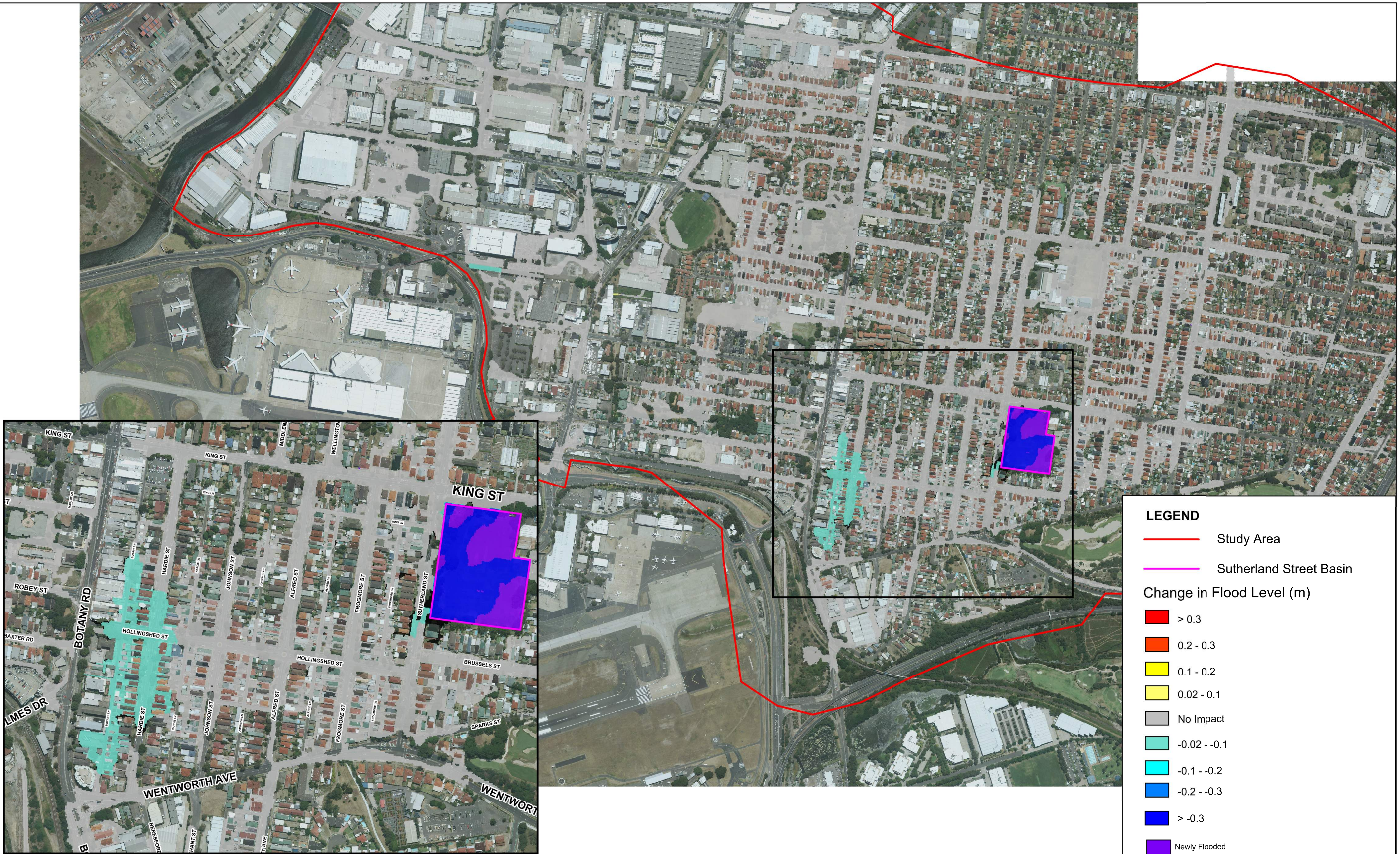

LEGEND

Study Area

Sutherland Street Basin

Change in Flood Level (m)

- > 0.3
- 0.2 - 0.3
- 0.1 - 0.2
- 0.02 - 0.1
- No Impact
- -0.02 - -0.1
- -0.1 - -0.2
- -0.2 - -0.3
- > -0.3
- Newly Flooded
- No Longer Flooded

PROJECT NO: PA1283 PROJECT TITLE: Mascot, Rosebery & Eastlakes Floodplain Risk Management Study

FIGURE B02 **0.2 EY - Peak Flood Impacts (Option B2 - L'Estrange Park Basin)**

0 100 200m
Approx. Scale

SCALE 1:10,000 PAGE SIZE A3 NORTH

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LEGEND

- Study Area
- Sutherland Street Basin

Change in Flood Level (m)

- > 0.3
- 0.2 - 0.3
- 0.1 - 0.2
- 0.02 - 0.1
- No Impact
- -0.02 - -0.1
- -0.1 - -0.2
- -0.2 - -0.3
- > -0.3
- Newly Flooded
- No Longer Flooded

PROJECT NO: PA1283	PROJECT TITLE: Mascot, Rosebery & Eastlakes Floodplain Risk Management Study
FIGURE B03	**1% AEP - Peak Flood Impacts (Option B2 - L'Estrange Park Basin)**
FILEPATH	PA1283 MRE FRMS&P\PA1283 Technical Data\E7_GIS\06_Figures\DraftReport\FigureB03_FloodImpacts_1%AEP_B2.wor

0 100 200m
Approx. Scale

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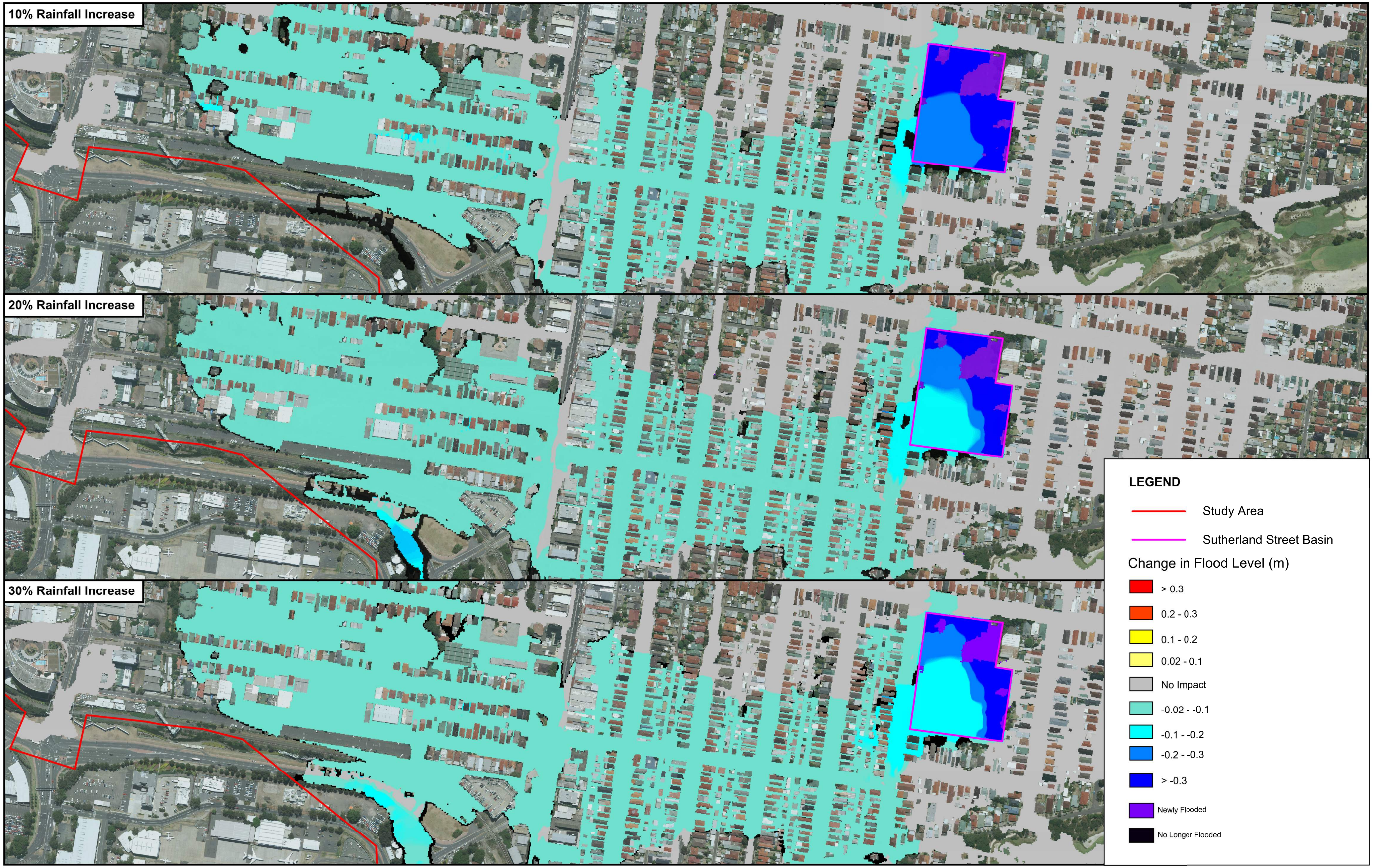

PROJECT NO: PA1283 PROJECT TITLE: Mascot, Rosebery & Eastlakes Floodplain Risk Management Study

FIGURE B04 **1% AEP - Climate Change Peak Flood Impacts (Option B2 - L'Estrange Park Basin)**

0 50 100m
Approx. Scale

SCALE 1:5,000 PAGE SIZE A3 NORTH

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FILEPATH PA1283 MRE FRMS&P\PA1283 Technical Data\E7_GIS\06_Figures\DraftReport\FigureB04_FloodImpacts_1%AEP_B2_ClimateChange.wor

CO-ORDINATE SYSTEM: Datum: GDA94 Projection: MGA Zone 56

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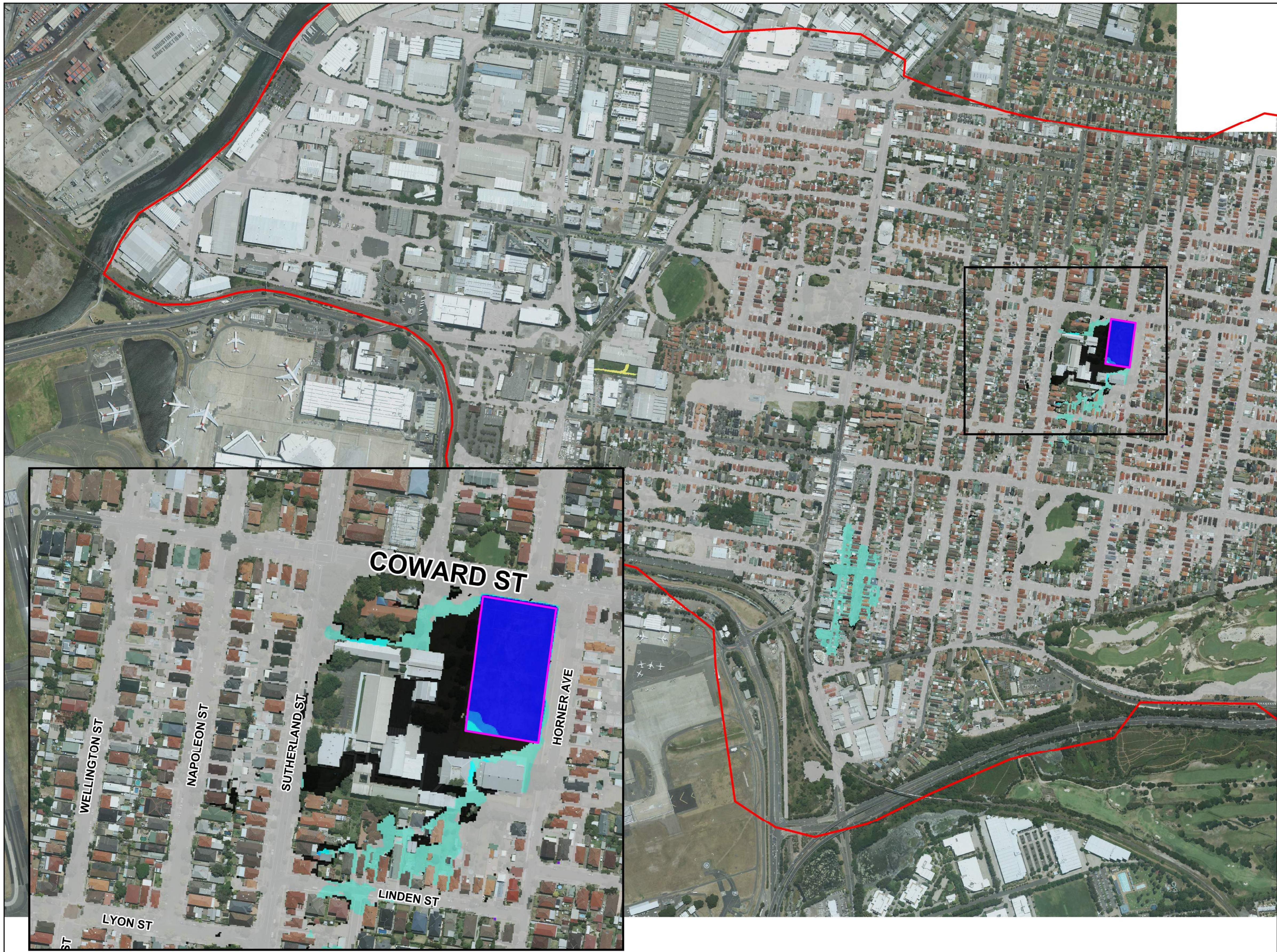

LEGEND

Study Area

Area Lowered

Change in Flood Level (m)

> 0.3

0.2 - 0.3

0.1 - 0.2

0.02 - 0.1

No Impact

-0.02 - -0.1

-0.1 - -0.2

-0.2 - -0.3

> -0.3

Newly Flooded

No Longer Flooded

PROJECT NO:	PA1283	PROJECT TITLE:	Mascot, Rosebery & Eastlakes Floodplain Risk Management Study
FIGURE B05	0.2 EY - Preliminary Flood Impacts (Option B3 - JJ Cahill Memorial High School Basin)		

0 100 200m Approx. Scale

SCALE 1:10,000 PAGE SIZE A3 NORTH

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FILEPATH PA1283 MRE FRMS&P\PA1283 Technical Data\E7_GIS\06_Figures\DraftReport\FigureB05_FloodImpacts_02EY_B3.wor

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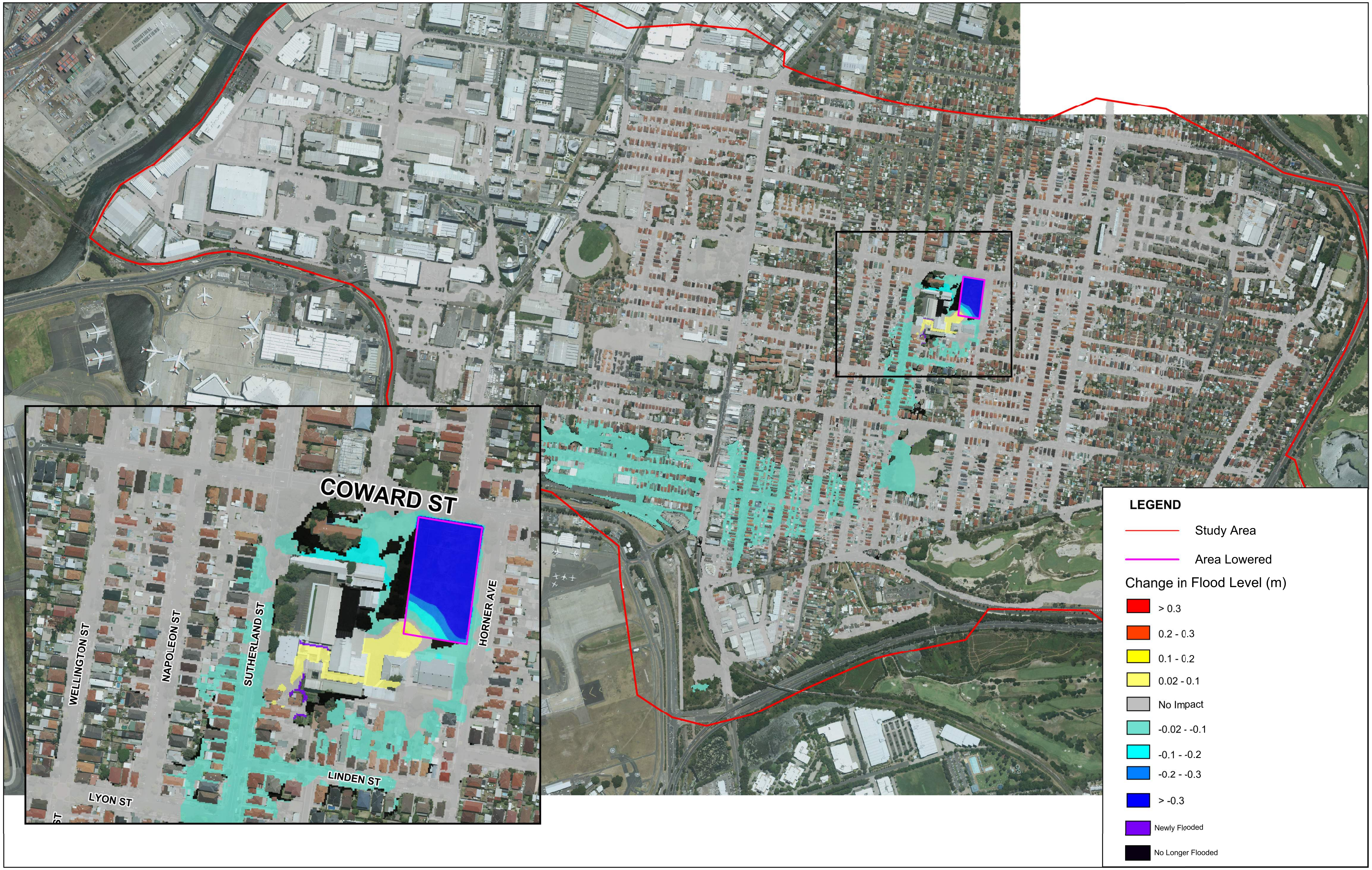

PROJECT NO: PA1283 PROJECT TITLE: Mascot, Rosebery & Eastlakes Floodplain Risk Management Study

FIGURE B06 **1% AEP - Peak Flood Impacts (Option B3 - JJ Cahill Memorial High School Basin)**

0 100 200m
Approx. Scale

SCALE 1:10,000 PAGE SIZE A3 NORTH

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PROJECT NO: PA1283 PROJECT TITLE: Mascot, Rosebery & Eastlakes Floodplain Risk Management Study

FIGURE B07 **1% AEP - Climate Change Peak Flood Impacts (Option B3)**

FILEPATH PA1283 MRE FRMS&P\PA1283 Technical Data\E7_GIS\06_Figures\DraftReport\FigureB07_FloodImpacts_1%AEP_B3_ClimateChange.wor

0 10 20m
Approx. Scale

SCALE 1:10,000 PAGE SIZE A3 NORTH

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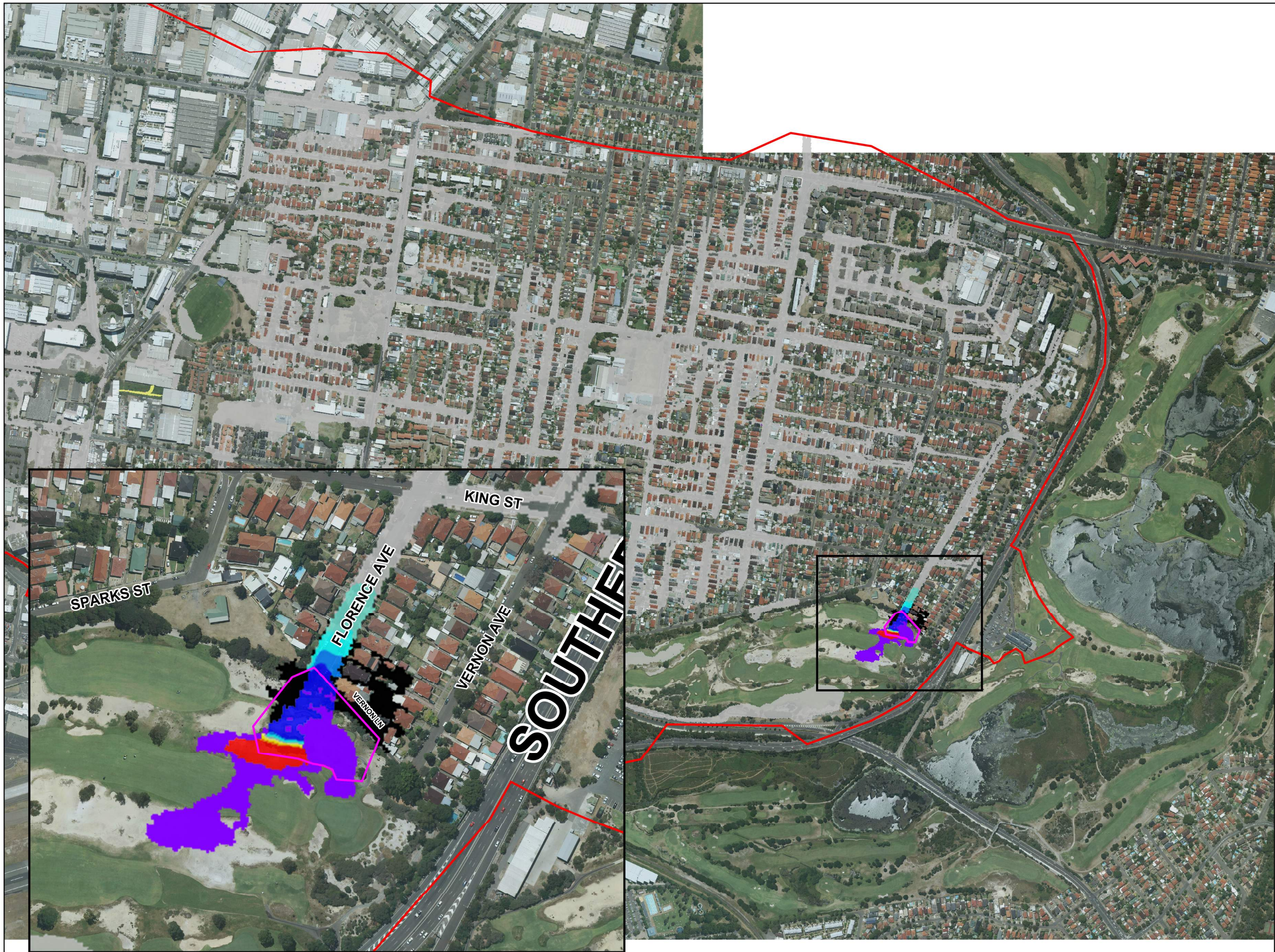

LEGEND

- Study Area
- Area Lowered

Change in Flood Level (m)

- > 0.3
- 0.2 - 0.3
- 0.1 - 0.2
- 0.02 - 0.1
- No Impact
- -0.02 - -0.1
- -0.1 - -0.2
- -0.2 - -0.3
- > -0.3
- Newly Flooded
- No Longer Flooded

PROJECT NO: PA1283 PROJECT TITLE: Mascot, Rosebery & Eastlakes Floodplain Risk Management Study

FIGURE B08 **0.2EY - Peak Flood Impacts (Option S1 - Levelling Golf Course Embankment)**

0 100 200m
Approx. Scale

SCALE 1:10,000 PAGE SIZE A3 NORTH

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FILEPATH PA1283 MRE FRMS&P\PA1283 Technical Data\E7_GIS\06_Figures\DraftReport\FigureB08_FloodImpacts_02EY_S1.wor

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LEGEND

Study Area

Area Lowered

Change in Flood Level (m)

- > 0.3
- 0.2 - 0.3
- 0.1 - 0.2
- 0.02 - 0.1
- No Impact
- -0.02 - -0.1
- -0.1 - -0.2
- -0.2 - -0.3
- > -0.3
- Newly Flooded
- No Longer Flooded

PROJECT NO: PA1283	PROJECT TITLE: Mascot, Rosebery & Eastlakes Floodplain Risk Management Study
FIGURE B09	**1% AEP - Peak Flood Impacts (Option S1 - Levelling Golf Course Embankment)**
FILEPATH	PA1283 MRE FRMS&P\PA1283 Technical Data\E7_GIS\06_Figures\DraftReport\FigureB09_FloodImpacts_1%AEP_S1.wor

0 100 200m
Approx. Scale

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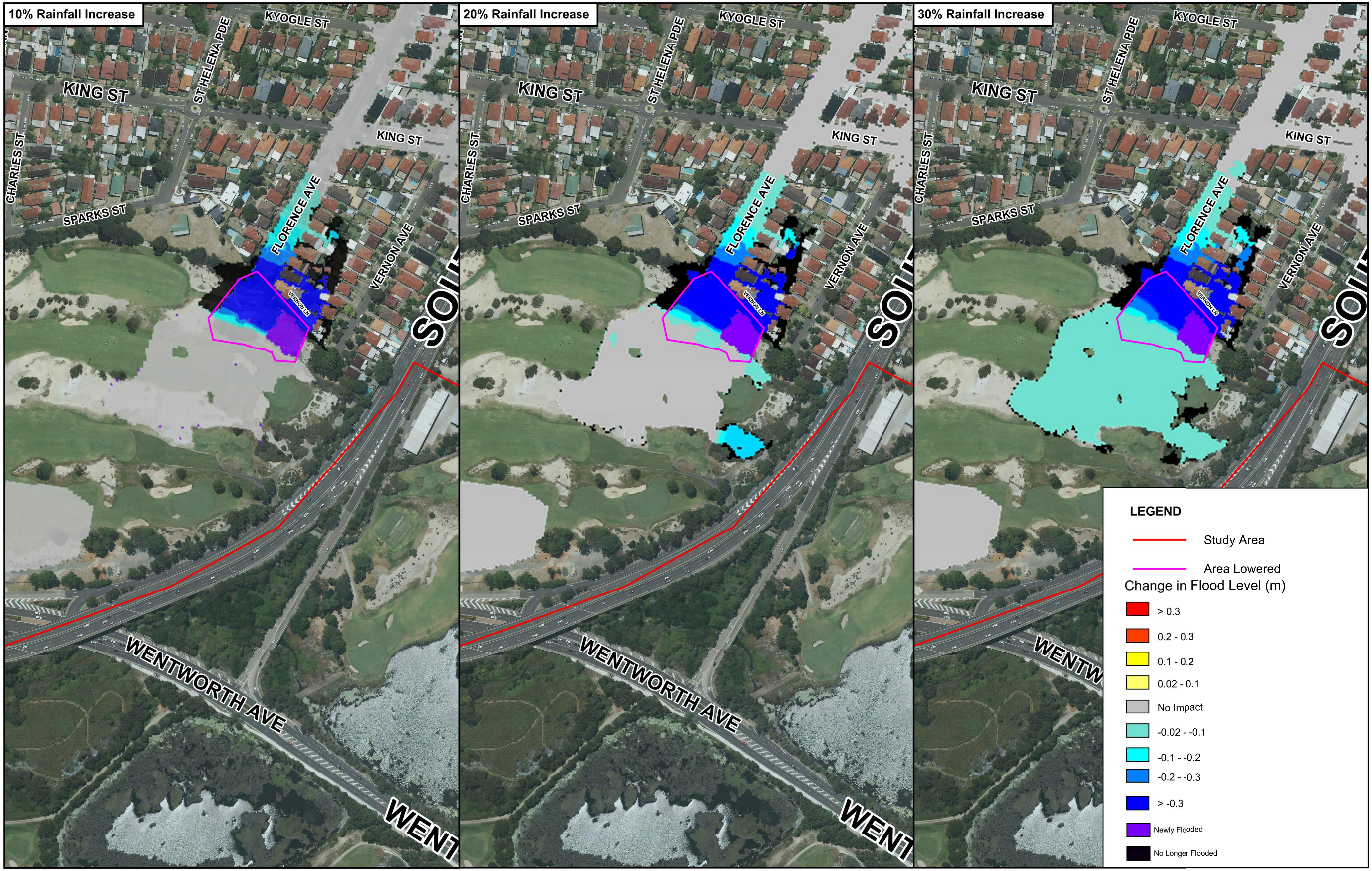

PROJECT NO: PA1283 PROJECT TITLE: Mascot, Rosebery & Eastlakes Floodplain Risk Management Study

FIGURE B10 1% AEP - Climate Change Peak Flood Impacts (Option S1)

FILEPATH PA1283 MRE FRMS&P\PA1283 Technical Data\E7_GIS\06_Figures\DraftReport\FigureB10_FloodImpacts_1%AEP_S1_ClimateChange.wor

0 10 20m
Approx. Scale

SCALE 1:10,000 PAGE SIZE A3 NORTH

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PROJECT NO:	PA1283	PROJECT TITLE:	Mascot, Rosebery & Eastlakes Floodplain Risk Management Study

FIGURE B11 1% AEP - Peak Flood Impacts (Option S2 - Botany Road Lowered)

FILEPATH PA1283 MRE FRMS&P\PA1283 Technical Data\E7_GIS\06_Figures\DraftReport\FigureB11_FloodImpacts_1%AEP_S2.wor

0 100 200m
Approx. Scale

SCALE 1:10,000 PAGE SIZE A3 NORTH

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PROJECT NO: PA1283 PROJECT TITLE: Mascot, Rosebery & Eastlakes Floodplain Risk Management Study

FIGURE B12 **1% AEP - Peak Flood Impacts (Option S3 - Lowering Lang Ave)**

0 10 20m Approx. Scale | SCALE 1:1,000 | PAGE SIZE A3 | NORTH

CREATED BY: BM | REVISION A | DATE 03/04/2017

FILEPATH PA1283 MRE FRMS&P\PA1283 Technical Data\E7_GIS\06_Figures\DraftReport\FigureB12_FloodImpacts_1%AEP_S3.wor

CO-ORDINATE SYSTEM: Datum: GDA94 Projection: MGA Zone 56

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PROJECT NO: PA1283	PROJECT TITLE: Mascot, Rosebery & Eastlakes Floodplain Risk Management Study	0 100 200m Approx. Scale	SCALE 1:10,000 PAGE SIZE A3 NORTH
FIGURE B13	**1% AEP - Peak Flood Impacts (Option D1 - Increased culvert capacity)**	CREATED BY: BM	REVISION A DATE 03/04/2017
FILEPATH	PA1283 MRE FRMS&P\PA1283 Technical Data\E7_GIS\06_Figures\DraftReport\FigureB13_FloodImpacts_1%AEP_D1.wor	CO-ORDINATE SYSTEM:	Datum: GDA94 Projection: MGA Zone 56

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PROJECT NO:	PA1283	PROJECT TITLE:	Mascot, Rosebery & Eastlakes Floodplain Risk Management Study

FIGURE B14 **0.2 EY - Peak Flood Impacts (Option D2 - Increase Drainage Capacity)**

0 100 200m
Approx. Scale

SCALE 1:10,000 PAGE SIZE A3 NORTH

CREATED BY: BM REVISION A DATE 04/04/2017

FILEPATH PA1283 MRE FRMS&P\PA1283 Technical Data\E7_GIS\06_Figures\DraftReport\FigureB14_FloodImpacts_02EY_D2.wor

CO-ORDINATE SYSTEM: Datum: GDA94 Projection: MGA Zone 56

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PROJECT NO: PA1283 PROJECT TITLE: Mascot, Rosebery & Eastlakes Floodplain Risk Management Study

FIGURE B15 **1% AEP - Peak Flood Impacts (Option D2 - Increased Drainage Capacity)**

0 100 200m
Approx. Scale

SCALE 1:10,000 PAGE SIZE A3 NORTH

CREATED BY: BM REVISION A DATE 04/04/2017

FILEPATH PA1283 MRE FRMS&P\PA1283 Technical Data\E7_GIS\06_Figures\DraftReport\FigureB15_FloodImpacts_1%AEP_D2.wor

CO-ORDINATE SYSTEM: Datum: GDA94 Projection: MGA Zone 56

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PROJECT NO: PA1283 PROJECT TITLE: Mascot, Rosebery & Eastlakes Floodplain Risk Management Study

0 25 50m
Approx. Scale

SCALE 1:2,500 PAGE SIZE A3 NORTH

FIGURE B16 **1% AEP - Climate Change Peak Flood Impacts (Option D2)**

CREATED BY: BM REVISION A DATE 04/04/2017

FILEPATH PA1283 MRE FRMS&P\PA1283 Technical Data\E7_GIS\06_Figures\DraftRepor\FigureB16_FloodImpacts_1%AEP_D2_ClimateChange.wor

CO-ORDINATE SYSTEM: Datum: GDA94 Projection: MGA Zone 56

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PROJECT NO: PA1283 PROJECT TITLE: Mascot, Rosebery & Eastlakes Floodplain Risk Management Study

FIGURE B17 **1% AEP - Peak Flood Impacts (Option D3 - Drainage Implementation along Hardie St)**

0 100 200m
Approx. Scale

SCALE 1:10,000 PAGE SIZE A3 NORTH

CREATED BY: BM REVISION A DATE 04/04/2017

FILEPATH PA1283 MRE FRMS&P\PA1283 Technical Data\E7_GIS\06_Figures\DraftReport\FigureB17_FloodImpacts_1%AEP_D3.wor

CO-ORDINATE SYSTEM: Datum: GDA94 Projection: MGA Zone 56

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PROJECT NO: PA1283	PROJECT TITLE: Mascot, Rosebery & Eastlakes Floodplain Risk Management Study	0 100 200m Approx. Scale	SCALE 1:10,000 PAGE SIZE A3 NORTH
FIGURE B18	**0.2 EY - Peak Flood Impacts (Option D4 - Increase Drainage Capacity)**	CREATED BY: BM	REVISION A DATE 04/04/2017
FILEPATH	PA1283 MRE FRMS&P\PA1283 Technical Data\E7_GIS\06_Figures\DraftReport\FigureB18_FloodImpacts_02EY_D4.wor	CO-ORDINATE SYSTEM:	Datum: GDA94 Projection: MGA Zone 56

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Disclaimer: While all reasonable care has been taken to ensure the information contained on this map is up to date and accurate, this map contains information from a number of sources - no warranty is given that the information contained on this map is free from error or omission. Any reliance placed on such information shall be the sole risk of the user. Please verify the accuracy of all information prior to using it. This map is not a design document.

Royal HaskoningDHV
Enhancing Society Together

PROJECT NO: PA1283 PROJECT TITLE: Mascot, Rosebery & Eastlakes Floodplain Risk Management Study

FIGURE B19 **1% AEP - Peak Flood Impacts (Option D4 - Increased Drainage Capacity)**

0 100 200m
Approx. Scale

SCALE 1:10,000 PAGE SIZE A3 NORTH

CREATED BY: BM REVISION A DATE 04/04/2017

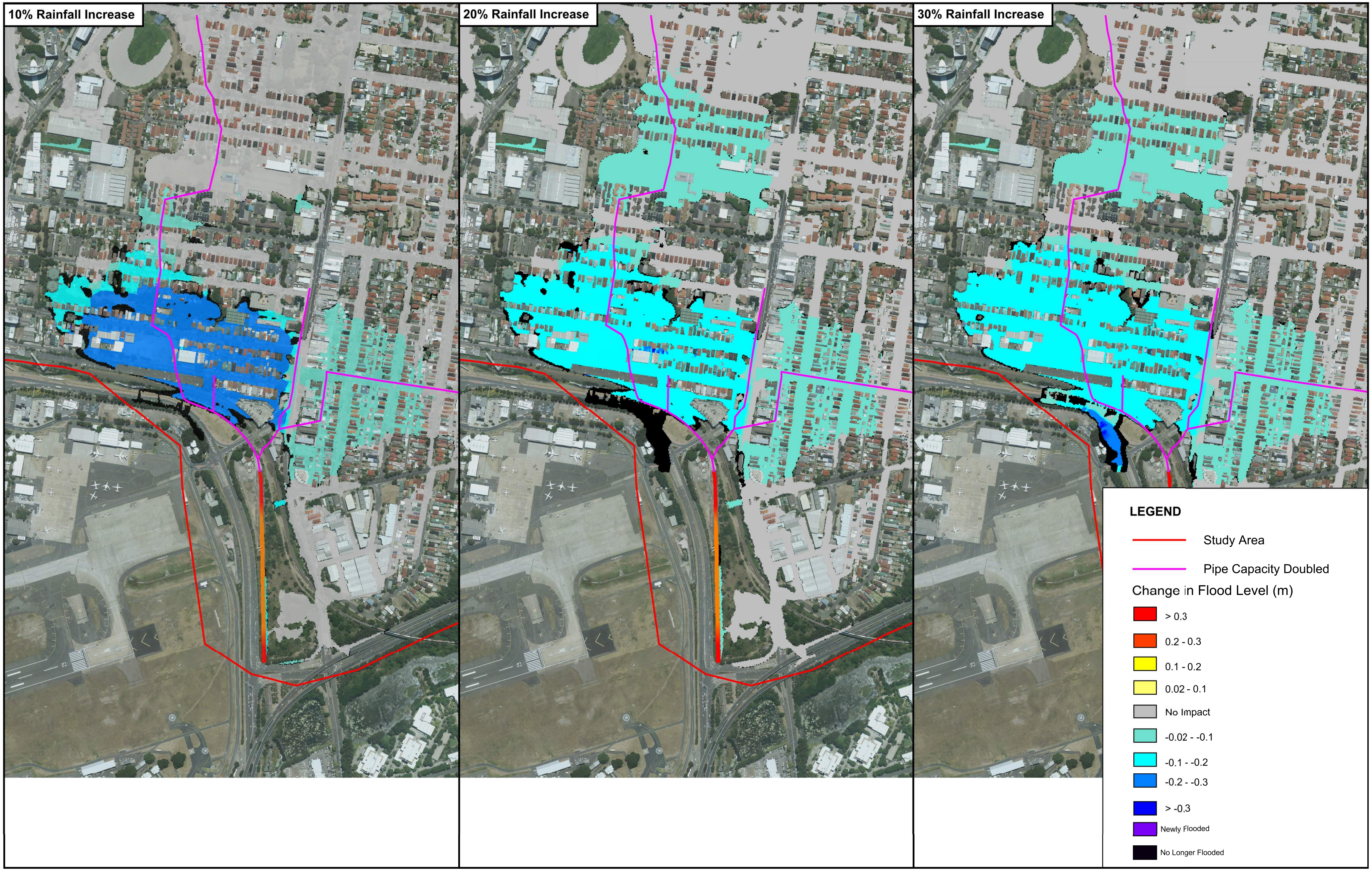
FILEPATH PA1283 MRE FRMS&P\PA1283 Technical Data\E7_GIS\06_Figures\DraftReport\FigureB19_FloodImpacts_1%AEP_D4.wor

CO-ORDINATE SYSTEM: Datum: GDA94 Projection: MGA Zone 56

NOT FOR CONSTRUCTION

Disclaimer: While all reasonable care has been taken to ensure the information contained on this map is up to date and accurate, this map contains information from a number of sources - no warranty is given that the information contained on this map is free from error or omission. Any reliance placed on such information shall be the sole risk of the user. Please verify the accuracy of all information prior to using it. This map is not a design document.

Royal HaskoningDHV
Enhancing Society Together



PROJECT NO:	PA1283	PROJECT TITLE:	Mascot, Rosebery & Eastlakes Floodplain Risk Management Study

FIGURE B20 1% AEP - Climate Change Peak Flood Impacts (Option D4 - Increase Drainage Capacity)

0 25 50m
Approx. Scale

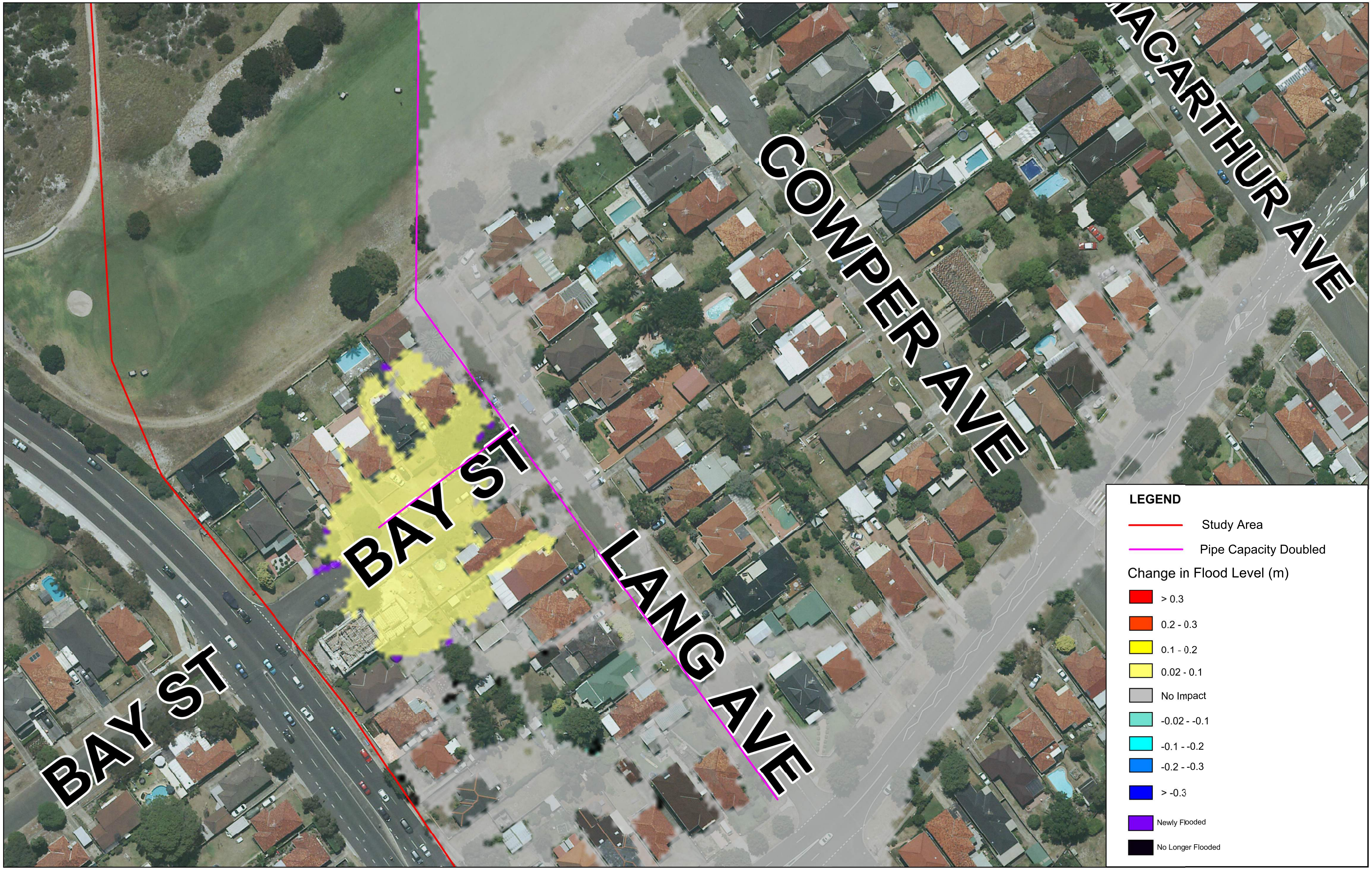
SCALE 1:2,500 PAGE SIZE A3 NORTH

CREATED BY: BM REVISION A DATE 04/04/2017

FILEPATH PA1283 MRE FRMS&P\PA1283 Technical Data\E7_GIS\06_Figures\DraftReport\FigureB20_FloodImpacts_1%AEP_D4_ClimateChange.wor

CO-ORDINATE SYSTEM: Datum: GDA94 Projection: MGA Zone 56

NOT FOR CONSTRUCTION



PROJECT NO: PA1283 PROJECT TITLE: Mascot, Rosebery & Eastlakes Floodplain Risk Management Study

0 10 20m
Approx. Scale

SCALE 1:1,000 PAGE SIZE A3 NORTH

FIGURE B21 1% AEP - Peak Flood Impacts (Option D5 - Increased Drainage Capacity on Lang Ave)

CREATED BY: BM REVISION A DATE 04/04/2017

FILEPATH PA1283 MRE FRMS&P\PA1283 Technical Data\E7_GIS\06_Figures\DraftReport\FigureB21_FloodImpacts_1%AEP_D5.wor

CO-ORDINATE SYSTEM: Datum: GDA94 Projection: MGA Zone 56

NOT FOR CONSTRUCTION

Royal HaskoningDHV
Enhancing Society Together

PROJECT NO: PA1283 PROJECT TITLE: Mascot, Rosebery & Eastlakes Floodplain Risk Management Study

FIGURE B22 1% AEP - Peak Flood Impacts (Combined Options S2 & D4)

0 100 200m
Approx. Scale

SCALE 1:10,000 PAGE SIZE A3 NORTH

CREATED BY: BM REVISION A DATE 04/04/2017

FILEPATH PA1283 MRE FRMS&P\PA1283 Technical Data\E7_GIS\06_Figures\DraftReport\FigureB22_FloodImpacts_1%AEP_S2_D4.wor

CO-ORDINATE SYSTEM: Datum: GDA94 Projection: MGA Zone 56

NOT FOR CONSTRUCTION

Royal HaskoningDHV
Enhancing Society Together

Appendix C – Flood Mitigation Options – Concept Estimate

Royal HaskoningDHV
Enhancing Society Together

Haskoning Australia Pty Ltd Date: 20-Apr-16

Client: Bayside Council
Project Name: Mascot, Rosebery & Eastlakes Floodplain Risk Management Study & Plan

Item #		Rate	Unit	Qty	Total
	B2 - Sutherland Street Playing Fields Retarding Basin				
1	**Preliminaries**				
1.1	Site establishment	$ 5,000.00	item	1	$ 5,000
1.2	Supervision, management, amenities	$ 10,000.00	item	1	$ 10,000
1.3	Survey and setout of works by surveyor	$ 10,000.00	item	1	$ 10,000
1.4	Geotechnical testing and certification	$ 10,000.00	item	1	$ 10,000
1.5	Traffic control	$ 10,000.00	item	1	$ 10,000
1.6	Preparation and implementation of Works EMP	$ 5,000.00	item	1	$ 5,000
2	**Earthworks and demolition**				
2.1	Strip vegetation and 200mm topsoil (Area A)	$ 4.00	cum	4000	$ 16,000
2.2	Earthworks to create profile	$ 10.00	cum	20000	$ 200,000
2.3	Haulage of waste	$ 25.00	T	20000	$ 500,000
2.4	Disposal of waste(General Solid Waste)	$ 50.00	T	20000	$ 1,000,000
3	**Vegetation Management and Planting**				
3.1	turf	$ 6.00	sqm	20000	$ 120,000
3.2	Trees (Area A)	$ 150.00	no.	100	$ 15,000
4	**Construction of Stormwater Line A**				
4.1	Excavate trench for new stormwater pipe	$ 54.90	cum	528	$ 28,987
4.2	Import and place fill for base lining	$ 4.00	sqm	132	$ 528
4.3	Supply and installation of pipe	$ 1,600.00	m	40	$ 64,000
4.4	Precast inlet pit 1	$ 2,640.00	no.	1	$ 2,640
4.5	Inlet pit grating	$ 500.00	no.	2	$ 1,000
4.6	Concrete Headwall foundation	$ 500.00	cum	1	$ 563
4.7	Concrete headwall	$ 440.00	sqm	10	$ 4,400
5	**Spillway 1**				
5.1	Supply rock riprap	$ 40.00	T	95	$ 3,800
5.2	Place rock rip rap	$ 110.00	T	95	$ 10,450
	Subtotal				$ 2,017,368
	Design Contingency 20%				$ 403,474
	Total				$ 2,420,841

Royal HaskoningDHV
Enhancing Society Together

Haskoning Australia Pty Ltd

Date: 20-Apr-16

Client: Bayside Council

Project Name: Mascot, Rosebery & Eastlakes Floodplain Risk Management Study & Plan

Item #		Rate	Unit	Qty	Total
	B3 - JJ Cahill Memorial High School Retarding Basin				
1	**Preliminaries**				
1.1	Site establishment	$ 5,000.00	item	1	$ 5,000
1.2	Supervision, management, amenities	$ 10,000.00	item	1	$ 10,000
1.3	Survey and setout of works by surveyor	$ 10,000.00	item	1	$ 10,000
1.4	Geotechnical testing and certification	$ 10,000.00	item	1	$ 10,000
1.5	Traffic control	$ 10,000.00	item	1	$ 10,000
1.6	Preparation and implementation of Works EMP	$ 5,000.00	item	1	$ 5,000
2	**Earthworks and demolition**				
2.1	Strip vegetation and 200mm topsoil (Area A)	$ 4.00	cum	1680	$ 6,720
2.2	Earthworks to create profile	$ 10.00	cum	8400	$ 84,000
2.3	Haulage of waste	$ 25.00	T	8400	$ 210,000
2.4	Disposal of waste(General Solid Waste)	$ 50.00	T	8400	$ 420,000
3	**Vegetation Management and Planting**				
3.1	turf	$ 6.00	sqm	8400	$ 50,400
3.2	Trees (Area A)	$ 150.00	no.	100	$ 15,000
4	**Construction of Stormwater Line A**				
4.1	Excavate trench for new stormwater pipe	$ 54.90	cum	528	$ 28,987
4.2	Import and place fill for base lining	$ 4.00	sqm	132	$ 528
4.3	Supply and installation of pipe	$ 1,600.00	m	40	$ 64,000
4.4	Precast inlet pit 1	$ 2,640.00	no.	1	$ 2,640
4.5	Inlet pit grating	$ 500.00	no.	2	$ 1,000
4.6	Concrete Headwall foundation	$ 500.00	cum	1	$ 563
4.7	Concrete headwall	$ 440.00	sqm	10	$ 4,400
5	**Spillway 1**				
5.1	Supply rock riprap	$ 40.00	T	95	$ 3,800
5.2	Place rock rip rap	$ 110.00	T	95	$ 10,450
	Subtotal				$ 952,488
	Design Contingency 20%				$ 190,498
	Total				$ 1,142,985

Haskoning Australia Pty Ltd

Date: 20-Apr-16

Client: Bayside Council

Project Name: Mascot, Rosebery & Eastlakes Floodplain Risk Management Study & Plan

Item #		Rate	Unit	Qty	Total
	S1 - Levelling Golf Course Embankment, Florence Ave				
1	**Preliminaries**				
1.1	Site establishment	$ 5,000.00	item	1	$ 5,000
1.2	Geotechnical testing and certification	$ 5,000.00	item	1	$ 5,000
2	**Earthworks and demolition**				
2.1	Excavate material from dams	$ 25.00	cum	400	$ 10,000
2.2	Haulage of waste	$ 25.00	T	400	$ 10,000
2.3	Disposal of waste (general solid waste)	$ 50.00	T	400	$ 20,000
3	**Vegetation Management and Planting**				
3.1	Planting to batter	$ 35.00	sqm	100	$ 3,500
3.2	Trees	$ 150.00	no.	20	$ 3,000
	Subtotal				$ 56,500
	Design Contingency 20%				$ 11,300
	Total				**$ 67,800**

Haskoning Australia Pty Ltd

Date: 20-Apr-16

Client: Bayside Council

Project Name: Mascot, Rosebery & Eastlakes Floodplain Risk Management Study & Plan

Item #		Rate	Unit	Qty	Total
	D2 - Increased drainage capacity into Alexandra Canal				
1	**Preliminaries**				
1.1	Site establishment	$ 20,000.00	item	1	$ 20,000
1.2	Supervision, management, amenities	$ 20,000.00	item	1	$ 20,000
1.3	Services Search, potholing and relocation	$ 200,000.00	item	1	$ 200,000
1.4	Survey and setout of works by surveyor	$ 30,000.00	item	1	$ 30,000
1.5	Geotechnical testing and certification	$ 40,000.00	item	1	$ 40,000
1.6	Traffic control	$ 60,000.00	item	1	$ 60,000
1.7	Preparation and implementation of Works EMP	$ 10,000.00	item	1	$ 10,000
2	**Construction of Stormwater Line (2km)**				
2.1	Excavate trench for new stormwater pipe	$ 100.00	cum	20000	$ 2,000,000
2.2	Shoring	$ 30.00	sqm	10000	$ 300,000
2.3	Haulage of waste	$ 25.00	T	20000	$ 500,000
2.4	Disposal of waste (general solid waste)	$ 100.00	T	20000	$ 2,000,000
2.5	Import and place fill for base lining	$ 4.00	sqm	8000	$ 32,000
2.6	Supply and installation of pipe	$ 1,600.00	m	2000	$ 3,200,000
2.7	Precast inlet pits	$ 2,640.00	no.	67	$ 176,000
2.8	Inlet pit grating	$ 500.00	no.	2	$ 1,000
2.9	Concrete headwall	$ 2,000.00	no.	5	$ 10,000
3	**Making good**				
3.1	Sub base	$ 20.00	sqm	8000	$ 160,000
3.2	Bitumous surface	$ 20.00	sqm	8000	$ 160,000
	Subtotal				$ 8,599,000
	Design Contingency 40%				$ 3,439,600
	Total				$ 12,038,600

Haskoning Australia Pty Ltd

Date: 20-Apr-16

Client: Bayside Council

Project Name: Mascot, Rosebery & Eastlakes Floodplain Risk Management Study & Plan

Item #		Rate	Unit	Qty	Total
	D4 - Increased Drainage Capacity (Hollingshed St & Baxter Rd)				
1	**Preliminaries**				
1.1	Site establishment	$ 20,000.00	item	1	$ 20,000
1.2	Supervision, management, amenities	$ 20,000.00	item	1	$ 20,000
1.3	Services Search, potholing and relocation	$ 200,000.00	item	1	$ 200,000
1.4	Survey and setout of works by surveyor	$ 30,000.00	item	1	$ 30,000
1.5	Geotechnical testing and certification	$ 40,000.00	item	1	$ 40,000
1.6	Traffic control	$ 60,000.00	item	1	$ 60,000
1.7	Preparation and implementation of Works EMP	$ 10,000.00	item	1	$ 10,000
2	**Construction of Stormwater Line (2km)**				
2.1	Excavate trench for new stormwater pipe	$ 100.00	cum	20000	$ 2,000,000
2.2	Shoring	$ 30.00	sqm	10000	$ 300,000
2.3	Haulage of waste	$ 25.00	T	20000	$ 500,000
2.4	Disposal of waste (general solid waste)	$ 100.00	T	20000	$ 2,000,000
2.5	Import and place fill for base lining	$ 4.00	sqm	8000	$ 32,000
2.6	Allownce for thrust boring (500m)	$ 15,000.00	lm	500	$ 7,500,000
2.7	Supply and installation of pipe	$ 1,600.00	m	2000	$ 3,200,000
2.8	Precast inlet pits	$ 2,640.00	no.	67	$ 176,000
2.9	Inlet pit grating	$ 500.00	no.	2	$ 1,000
2.10	Concrete headwall	$ 2,000.00	no.	5	$ 10,000
3	**Making good**				
3.1	Sub base	$ 20.00	sqm	8000	$ 160,000
3.2	Bitumous surface	$ 20.00	sqm	8000	$ 160,000
	Subtotal				$ 16,099,000
	Design Contingency 40%				$ 6,439,600
	Total				$ 22,538,600

Bayside Council
Serving Our Community

Appendix D – Public Exhibition and Community Consultation Report

Prepared By: Bayside Council
Date: 20 Dec 2019

Contents

1. Overview

Community engagement is an important element of the floodplain risk management process and is important in the development of a flood study as it provides an opportunity for the community to 'have their say' and raise awareness of flood prone land. Engagement can also help with acceptance of the overall project.

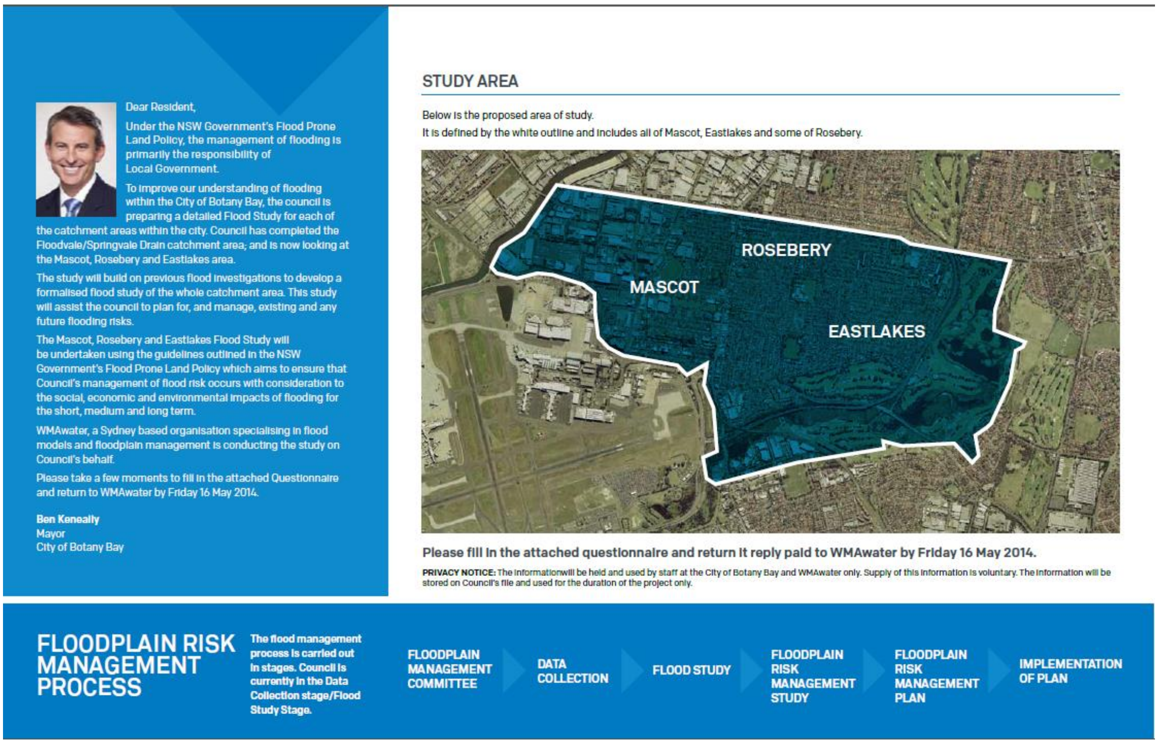
2. Engagement Activities

2.1 Community engagement during preparation of studies

Community Information Session 2014 - Flood Study:

A newsletter and a questionnaire were distributed to residents within the catchment describing the flood study and requesting information on experiences of flooding and to request records of historical flooding. 234 responses were received from the distributed questionnaires. Of those that responded 66 had experienced flooding in their properties with 12 of those experienced flooding above the floor level.

A copy of the newsletter and questionnaire shown below:



Dear Resident,

Under the NSW Government's Flood Prone Land Policy, the management of flooding is primarily the responsibility of Local Government.

To improve our understanding of flooding within the City of Botany Bay, the council is preparing a detailed Flood Study for each of the catchment areas within the city. Council has completed the Floodvale/Springvale Drain catchment area; and is now looking at the Mascot, Rosebery and Eastlakes area.

The study will build on previous flood investigations to develop a formalised flood study of the whole catchment area. This study will assist the council to plan for, and manage, existing and any future flooding risks.

The Mascot, Rosebery and Eastlakes Flood Study will be undertaken using the guidelines outlined in the NSW Government's Flood Prone Land Policy which aims to ensure that Council's management of flood risk occurs with consideration to the social, economic and environmental impacts of flooding for the short, medium and long term.

WMAwater, a Sydney based organisation specialising in flood models and floodplain management is conducting the study on Council's behalf.

Please take a few moments to fill in the attached Questionnaire and return to WMAwater by Friday 16 May 2014.

Ben Keneally
Mayor
City of Botany Bay

STUDY AREA

Below is the proposed area of study.
It is defined by the white outline and includes all of Mascot, Eastlakes and some of Rosebery.

Please fill in the attached questionnaire and return it reply paid to WMAwater by Friday 16 May 2014.

PRIVACY NOTICE: The informationwill be held and used by staff at the City of Botany Bay and WMAwater only. Supply of this information is voluntary. The information will be stored on Council's file and used for the duration of the project only.

FLOODPLAIN RISK MANAGEMENT PROCESS

The flood management process is carried out in stages. Council is currently in the Data Collection stage/Flood Study Stage.

FLOODPLAIN MANAGEMENT COMMITTEE → DATA COLLECTION → FLOOD STUDY → FLOODPLAIN RISK MANAGEMENT STUDY → FLOODPLAIN RISK MANAGEMENT PLAN → IMPLEMENTATION OF PLAN

Figure 2.1.1: Flood Study Newsletter

MASCOT, ROSEBERY & EASTLAKES **FLOOD STUDY** – Please complete and return by Friday 16 2014.

INTRODUCTION

The City of Botany Bay is carrying out a Flood Study for the Mascot, Rosebery and Eastlakes catchments.

Your local knowledge of the catchment and personal experiences of flooding will help us to undertake this flood study.

The extent of the catchment is shown on the enclosed map.

1. The purpose of the Flood Study is to identify the nature of flooding in the catchment area to enable Council to better understand, plan and manage the potential flood risk. We may contact you to discuss some of the information that you provide.

NAME

ADDRESS

EMAIL

PHONE (H/M)

2. How long have you lived or worked in the area?

3. Are you aware of stormwater flooding from streets or channels in your catchment?

4. Have you ever been inconvenienced by uncontrolled floodwater/ stormwater from streets or channels in this area? If **No**, please proceed to question 6.

YES ☐ NO ☐

If you answered **Yes**, please tick the appropriate box below and give details of how uncontrolled floodwater/stormwater has inconvenienced you.

- ☐ Daily routine affected
- ☐ Safety threatened
- ☐ Access to property affected
- ☐ Property and/or contents damaged
- ☐ Business unable to operate during the flooded period
- ☐ Other

Details & Dates

5. Can you remember when you were inconvenienced by uncontrolled floodwater/stormwater from streets or channels in this area?

6. Has your home or other property been flooded because of uncontrolled floodwater/stormwater from streets or channels in this area?

YES ☐ NO ☐

If **Yes**, where was your property flooded and when did it happen? (You may tick more than one box)

- ☐ Front or backyard
- ☐ Garage or shed
- ☐ Residential below floor level
- ☐ Residential above floor level
- ☐ Commercial below floor level
- ☐ Commercial above floor level
- ☐ Industrial eg. factories
- ☐ Other

Details & Dates

7. Did you notice any bridges and/or drains to be blocked during the flooding?

YES ☐ NO ☐

If **Yes**, please provide details, (i.e how blocked would you say they were – 50%, 80%) What was causing the blockage?

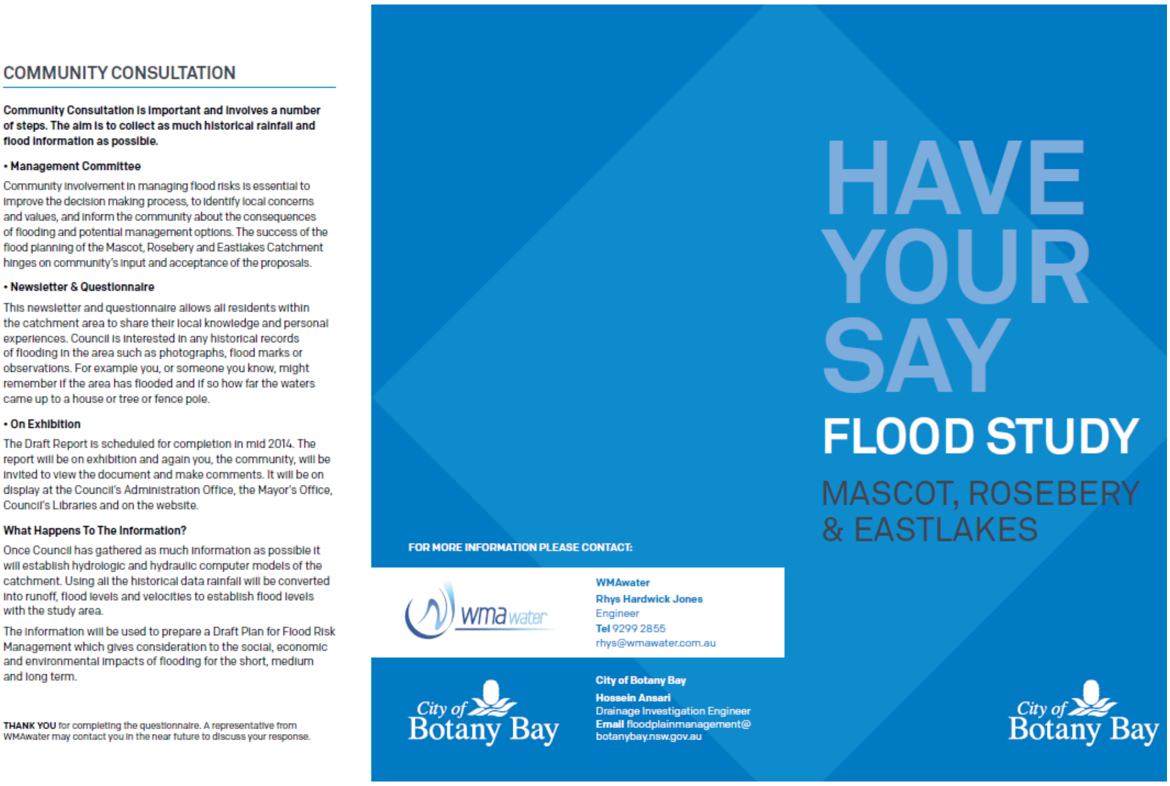
8. Do you have any evidence of past floods (eg. photos, video footage, watermarks on walls or posts)

YES ☐ NO ☐

If **Yes**, please provide as many details as possible:

9. Do you have any more information you think might help the Mascot, Rosebery and Eastlakes Flood Study?

Figure 2.1.2: Mascot, Rosebery and Eastlakes Flood Study Questionnaire



COMMUNITY CONSULTATION

Community Consultation is important and involves a number of steps. The aim is to collect as much historical rainfall and flood information as possible.

• Management Committee

Community involvement in managing flood risks is essential to improve the decision making process, to identify local concerns and values, and inform the community about the consequences of flooding and potential management options. The success of the flood planning of the Mascot, Rosebery and Eastlakes Catchment hinges on community's input and acceptance of the proposals.

• Newsletter & Questionnaire

This newsletter and questionnaire allows all residents within the catchment area to share their local knowledge and personal experiences. Council is interested in any historical records of flooding in the area such as photographs, flood marks or observations. For example you, or someone you know, might remember if the area has flooded and if so how far the waters came up to a house or tree or fence pole.

• On Exhibition

The Draft Report is scheduled for completion in mid 2014. The report will be on exhibition and again you, the community, will be invited to view the document and make comments. It will be on display at the Council's Administration Office, the Mayor's Office, Council's Libraries and on the website.

What Happens To The Information?

Once Council has gathered as much information as possible it will establish hydrologic and hydraulic computer models of the catchment. Using all the historical data rainfall will be converted into runoff, flood levels and velocities to establish flood levels with the study area.

The information will be used to prepare a Draft Plan for Flood Risk Management which gives consideration to the social, economic and environmental impacts of flooding for the short, medium and long term.

THANK YOU for completing the questionnaire. A representative from WMAwater may contact you in the near future to discuss your response.

HAVE YOUR SAY

FLOOD STUDY

MASCOT, ROSEBERY & EASTLAKES

FOR MORE INFORMATION PLEASE CONTACT:

wma water

WMAwater
Rhys Hardwick Jones
Engineer
Tel 9299 2855
rhys@wmawater.com.au

City of Botany Bay

City of Botany Bay
Hossein Ansari
Drainage Investigation Engineer
Email floodplainmanagement@botanybay.nsw.gov.au

City of Botany Bay

Figure 2.1.3: Mascot, Rosebery and Eastlakes Flood Study Newsletter

Community Information Session 2016 – Floodplain Risk Management Study

On 5th April 2016 a community information session was held at Botany Town Hall which was advertised on Council's website and in the local newspaper. The aim of the community engagement session was to obtain community knowledge of flooding hotspots and ideas of potential flood mitigation options to reduce flood affectation in Mascot, Rosebery and Eastlakes catchment.

A consulting engineer from RHDHV undertook door knocking exercise to gather more information from the community in May 2016.

Letters were distributed to all owners and residents affected by 1% AEP flooding on 19th May 2016 to notify residents and owners of the floodplain risk management study and flood level survey inspection.

A copy of the letter is provided below:

City of Botany Bay

Our Ref: S13/118 Trim Doc 16/17674

19 May 2016

TO THE RESIDENT

Dear Resident

RE: PREPARATION OF FLOOD RISK MANAGEMENT STUDY AND PLAN – MASCOT, ROSEBERY, EASTLAKES AND BOTANY WETLANDS – FLOOR LEVEL SURVEY AND INSPECTION

Botany Bay City Council has undertaken a comprehensive Flood Study in the areas of Mascot, Rosebery, Eastlakes and Botany Wetlands, which was completed in May 2015. The Study identified significant flooding issues in this catchment. As part of the NSW Government's Flood Management Plan, Council is now undertaking a Flood Risk Management Study and Plan (FRMSP).

The FRMSP will determine the flood control and mitigation strategy for these areas. Council consultants are working on preparing the strategy and are following the Study Work Plan approved by the NSW Office of Environment and Heritage. As part of that Work Plan, we are required to collect floor level survey data for some properties, which would enable us to prepare the Flood Risk Management Plan.

In the majority of cases our consultant will not need to access your property as some reading can be taken from the street; however there may be occasions where access is required. In this case you will be contacted by an authorised officer to arrange a time for the survey to be undertaken. Your co-operation is highly appreciated.

Should you have any questions please contact Nick Lewis on 0288545104.

Yours faithfully

Steven Poulton

STEVEN POULTON
Manager City Infrastructure

Administration Centre, 141 Coward Street, Mascot NSW 2020. (PO Box 331 Mascot NSW 1460)
Telephone: (02) 9366 3666 Facsimile: (02) 9366 3777
E-mail: council@botanybay.nsw.gov.au Internet: http://www.botanybay.nsw.gov.au

Figure 2.1.4: Initial letter to residents informing the Flood Risk Management Study

2.2 Consultation on Draft Flood Study and Floodplain Risk Management Plan in 2018

The Mascot, Rosebery and Eastlakes Flood Study and Floodplain Risk Management Study consultation period was four weeks from Tuesday 18 September 2018 to Tuesday 16 October 2018 for community feedback.

This was advertised on Council's website (have your say) and in the local newspaper on Tuesday 18th September 2018.

A letter was sent to flood affected residents and landowners as below:

Our Ref: F18/567

17 September 2018

The Owner/Resident
[redacted]
MASCOT NSW 2020

Dear Sir/Madam

Draft Mascot Rosebery and Eastlakes Flood Study and Floodplain Risk Management Study

Under the NSW Government's Flood Prone Land Policy all NSW councils are responsible for identifying and managing flood prone areas within their local government boundary.

In accordance with this policy Council has undertaken a Flood Study of the Mascot, Rosebery and Eastlakes catchment to determine the probability and impact of flooding. This information has identified your property as being affected by flooding in the 1% Annual Exceedance Probability (AEP) flood event.

Council has also completed a draft Floodplain Risk Management Study (FRMS) of the Mascot, Rosebery and Eastlakes catchment. The purpose of the FRMS is to identify, assess and compare various flood risk management options.

We are writing to all the property owners in areas identified as being flood affected to advise them that the Mascot, Rosebery and Eastlakes Flood Study and Floodplain Risk Management Study will be on public exhibition between 18 September 2018 and 19 October 2018. We invite you to view these documents and provide feedback. These documents can be viewed:

- Online at www.haveyoursay.bayside.nsw.gov.au;
- at Mascot library, 2 Hatfield Street, Mascot
- at Rockdale Library, 444-446 Princes Highway, Rockdale

A community drop in session will be held on **Thursday 4 October between 6pm and 8pm** at Mascot Library, 2 Hatfield Street, Mascot. This will be an opportunity for you to speak directly with Council staff and consultants about the studies.

If you would like to speak with a Council Officer about flooding in this catchment, please contact Pulak Saha, Strategic Floodplain Engineer on 9562 1652 or by email at flooding@bayside.nsw.gov.au.

Yours faithfully

Clare Harley
Manager – Strategic Planning

Figure 2.2.1: Letter sent out to Flood affected residents for feedback on Flood Study and Flood Risk Management Study

A drop in session was held at Mascot Library on 04 October 2018. A total of 14 people attended.

Southern Courier Advertisement on 18th September 2018

HAVE YOUR SAY

Bayside Council has completed a Flood Study and Floodplain Risk Management Study (FRMS) of the Mascot, Rosebery and Eastlakes catchment.

These studies will be on public exhibition between Tuesday 18 September and Tuesday 16 October 2018. We invite you to view these documents and Have Your Say. These documents can be viewed;

- Online at **haveyoursay.bayside.nsw.gov.au**
- At Mascot Library, 2 Hatfield Street
- At Rockdale Library, 444-446 Princes Highway

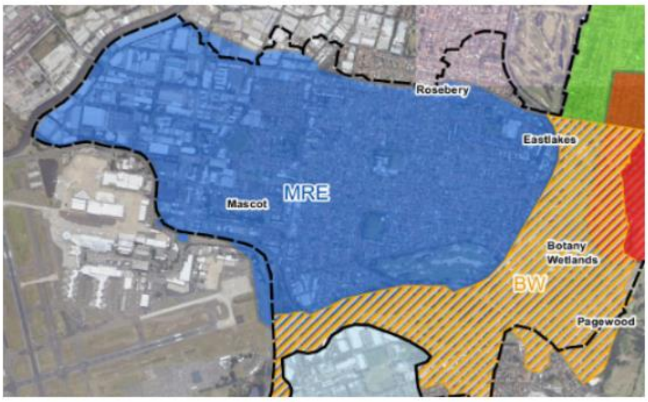
A community drop in session will be held:
Thursday 4 October 2018, 6pm – 8pm
Mascot Library, 2 Hatfield Street

If you would like to speak with a Council Officer about these studies, please contact Council's Strategic Floodplain Engineer on 9562 1652 or via email to flooding@bayside.nsw.gov.au

Figure 2.2.2: The Southern Courier Advertisement 18th September 2018

Public Exhibition: Mascot, Rosebery and Eastlakes Flood Study and Floodplain Risk Management Study

Consultation has concluded



Bayside Council has completed a Flood Study and Floodplain Risk Management Study (FRMS) of the Mascot, Rosebery and Eastlakes catchment.

These studies will be on public exhibition between 18 September 2018 and 19 October 2018. During this period the community is invited to make comments. These documents can be viewed at the following locations:

- Council's website www.haveyoursay.bayside.nsw.gov.au
- Mascot library, 2 Hatfield Street, Mascot
- Rockdale Library, 444-446 Princes Highway, Rockdale

Written comments are due on Friday 19 October 2018 and can be provided in the following ways:

- Online - Click Submission Form below
- Email - flooding@bayside.nsw.gov.au
- In Writing - Attention: Strategic Floodplain Engineer, Bayside Council, PO Box 21, Rockdale NSW 2216.

Please quote reference number F18/567 in your submission.

Bayside Council is holding a **community drop in session** on **Thursday 4 October between 6.00pm and 8.00pm** at Mascot Library, 2 Hatfield Street, Mascot. This is an opportunity for you to speak directly with Council staff and consultants about the studies.

Figure 2.2.3: Advertisement on Council's have your say page on 18th September 2018

3.0 Have your Say website - summary of engagement

Table 3.1.1 - Have your say summary

Number of days open	29 days
Number of visits to Have Your Say website	192
Number of Document downloads	74
Number of survey submissions	13
Number of visitor attended at drop in session	14

Have your say project report / snapshot:

Figure 3.1.2: Bayside have your say- visitors summary

Aware Participants	138
Aware Actions Performed	Participants
Visited a Project or Tool Page	138
Informed Participants	81
Informed Actions Performed	Participants
Viewed a video	0
Viewed a photo	0
Downloaded a document	74
Visited the Key Dates page	4
Visited an FAQ list Page	24
Visited Instagram Page	0
Visited Multiple Project Pages	77
Contributed to a tool (engaged)	3

Widget Type	Engagement Tool Name	Visitors	Views/Downloads
Document	Flood Study Final Draft Volume 1	41	45
Document	MRE 1% AEP Flood extent map	39	48
Document	Overall property tagging map	31	34
Document	Draft Flood Risk Management Study	26	26
Document	MRE property tagging Map 3	20	22
Document	MRE property tagging Map 1	16	17
Document	MRE property tagging Map 4	15	15
Document	Flood Study Final Draft Volume 2 Appendix B	15	16
Document	MRE property tagging Map 2	14	15
Document	Flood Study Final Draft Volume 2 Appendix C	12	13
Faqs	faqs	24	28
Key Dates	Key Date	4	5

Figure 3.1.3: Bayside have your say - document download summary

4.0 Submissions

There were a total of 13 comments received from the community via 4 forums.

Table 4.1.1: Submission summary

Submission source	# Submissions received
Drop in session	4
Email	4
Online submission form (have your say)	3
Phone	2
Total	13

All submissions and responses to the comments are provided below.

Public Exhibition – Community Feedback and Council Staff Responses			
Date	**Communication method**	**Community Feedback**	**Council Staff Response**
4/10/2018	Drop-in	Resident from Forster Street, Mascot: Very thorough study & report but it excludes the airport area! I believe that reclamation of the land & subsequent developments of the airport and surrounding infrastructure has affected runoff & drainage of areas in the study area (Mascot, Rosebery & Eastlakes study area) exacerbating (if not actually causing) some of the flooding around Robey Street, Baxter road & Hardie Street. The airport area needs to be assessed in this regard.	Thank you for your feedback and suggestion. Flood study completed by WMAwater identified the Baxter Road low point as a flooding hotspot. Among the many reasons, it was identified that flooding occurs due to limited capacity of stormwater conduit under the railway embankment. The Flood risk management study then reviewed increasing drainage capacity downstream of Baxter Road and found negligible benefits. Flood planning control, community flood education and emergency management are considered as viable options to reduce flood risk. The Airport area is managed by Commonwealth Government. Council does not have access to the drainage and flooding data to investigate this area, although the topography is reflected in the model.
4/10/2018	Drop-in	Henry Kendall Crescent, Mascot: Thank you Bayside Council for making this study. According to the results Council may be able to prepare (better) for floods in the region. As to the house we have lived in for the last 42 years, we have often experienced heavy rains, but the house has not been affected, as it is raised from the ground sufficiently, i.e. 2 steps. With respect to the yard it is mostly lawn, garden or pavings and the water has always receded promptly. We were told by old neighbours that there used to be a creek running from North to South into Botany Bay and that Botany Road was built parallel to the creek. The waterboard may have used the creek to build the still existing sewerage drain. Therefore we have Burch Lane that runs down from Miles Street to the Knox Church on Botany Road.	The feedback regarding the studies is noted. No response required.
4/10/2018	Drop-in	Resident from Alfred Street Mascot: Insurance duty to report any changes.	In some cases insurance companies use Council's flood model when review the insurance cover and policy while other cases insurance companies conduct their own flood study to identify flood affected properties. It is advised that you review your existing insurance policy to identify your responsibility to provide any known information. There is no change in flood affectation or existing risk of flooding to this site. Through the flood study, Council now have better information regarding flooding in this catchment and you have been informed about the risk of flooding to your property.
4/10/2018	Drop-in	Send link to FRMS and have your say.	Mascot, Rosebery and Eastlakes flood study can be viewed from the link below: https://haveyoursay.bayside.nsw.gov.au/public-exhibition-mascot-rosebery-and-eastlakes-flood-study-and-floodplain-risk-management-study
19/09/2018	Online (have your say)	Resident/owner from Macintosh Street, Mascot: Thank you for your time on the phone just now. As discussed, any adverse effect on land and property values that results from the flood study identifying Macintosh Street as flood prone is without question the responsibility of council because after years of polite and reasonable correspondence on this issue, there is still no firm plan to install stormwater drains in the street. Myself and the other owners pay stormwater fees to Sydney water and rates to the council for services that are simply not delivered. If you see the correspondence below you will not we have been patient and reasonable. Bottom line is that if the stormwater drains are installed, the flood risk goes away.	There are many factors that can affect the value of any property including inflation, a change in interest rates, increased aircraft noise or construction of a new road or shopping centre nearby. The extent to which a property's value is affected once it has been identified as flood affected is impossible to determine. While the notification may affect one potential buyer's decision to purchase a property it may have no impact for another. Ultimately, it is the market that determines the value. Under the NSW Government's Flood Prone Land Policy Council is responsible for identifying and managing flood prone areas within their local government boundary. There is no new change in flood affectation or existing risk of flooding to this site. Through the flood study, Council now have better understanding regarding flooding in this catchment. With regard to stormwater drainage, Council's piped stormwater system is designed to convey frequent minor flood with the aim of reducing day-to-day nuisance flooding. Major storms are conveyed via overland flow paths with the aim of protecting life and property in major events. Hence additional drainage may help in minor rain event flood, however it will not be able to cater for 1% AEP flood event. It is not economically feasible to construct stormwater drainage system that have capacity with 1% AEP flood. The 1% AEP flood means there is a 1% (i.e. a 1 in 100) chance of a flood of this magnitude or greater occurring in any one year. Council is not required to provide this capacity under any legislation or design guidelines. Council's responsibility relates to management of flood risk, which includes planning controls such as restrictions on development in flood prone areas. Unfortunately, the Flood risk management plan has not identified any economically viable option to mitigate

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			flooding in your local area. As next step Council will further investigate options to mitigate minor flooding in this catchment subject to availability of funding.
21/09/2018	Email	Resident from Cleland Street, Mascot: [Name and site address was censored] I have been having problems with flooding under my house in the last 3 years. I had an engineer assess the damage and he advised me to have the house re-pointed - which I did. The damage is still occurring and getting worse every day. So far it has cost me $20000 for re-pointing, $2000 for internal crack repairs and painting (which have already come back - wide cracks in walls skirting boards picture rails. I had to get a carpenter out to adjust my front doors as I couldn't open them from inside and the windows now cannot be locked due to the movement in the foundations. I had a new plumbing system put in with better drainage which cost $4000 and after all this expense (I am on an aged pension) there is no improvement at all. It is actually getting worse day by day. I cannot afford to keep this sort of upkeep and would very much appreciate if you could give me some answers.	I understand your concerns. I have reviewed Mascot, Rosebery and Eastlakes flood report prepared by WMAwater Pty Ltd and identified that in 1% AEP flood event, the risk for your property identified as low hazard. Depth of water and velocity are also considered low. The 1% AEP flood means there is a 1% chance of a flood of this height, or higher occurring in a period of one (1) year. From the information you have provided in the email it is unlikely that this damages occurred due to flood. The damage may be due to original construction issue and site soil condition. I recommend you immediately contact an experienced geotechnical and structural engineer to determine the reason for your house movement and find a solution.
26/09/2018	Email	Resident from Hardie Street: [Name and site address was censored] I was wondering if you could provide us with details of when the Mascot , Roseberry and Eastlakes area has ever flooded? Is there a map of the areas that it has previously affected? What has changed that makes the council believe this area is now flood prone?	We appreciate your feedback in relation to the Mascot, Rosebery and Eastlakes flood study. Floods do not occur in a regular pattern. There may be a period of no floods and a period of several floods. For example, the last time the Brisbane River flooded before the 2011 disaster was in 1974. Residents who moved there in more recent times had not experienced flooding until the floods in January 2011. Following intensive rain larger floods can occur. As part of the flood study Council collected flood information from the properties in this catchment. Please refer to figure 13 and 14 of the flood study report volume 1, for the reported flood affected property locations. The last known large storm events were March 1975 (5% to 2% AEP), February 1993 (10% AEP), 8th November 1984 (20% AEP) and 24th March 2014 (50% AEP). None of these events was as large as the 1% AEP flood that would result from a 1% AEP rainfall event. The 1% AEP flood means there is a 1% (i.e. a 1 in 100) chance of a flood of this height, or higher occurring in any one year. Please find below images from the 2014 rain event (which was estimated to have a 50% chance of occurring in any one year). [images censored] This rainfall event can be expected to occur relatively frequently. A 1% AEP flood event will result in much greater depth of flooding over a much larger area than the very minor 2014 flood event.

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10/10/2018	Email	Resident from Robey Street: [Name and site address was censored] I am writing you in response to your letter vide above reference. My observation is that the road on our house side may be raised by 1 or 2 inches without affecting storm water outlets. This may reduce the sufferings of road users during heavy rains.	Thank you for your valuable feedback and suggestion. Unfortunately, raising the road will potentially increase the flood depth and hazard to the properties on either side of the road. Please refer to the Floodplain Risk Management Study option D4 and figure B19. In this option the consultant reviewed doubling the pipe capacity which may reduce the flooding in this vicinity. However, this option was not considered viable as it would cost approximately $20 million and is likely to cause significant economic, environmental and social issues due to the broad scope of the works. Planning controls are considered the best and most economical approach to reduce flood risk and property damage. The next step is for Council to further investigate the most feasible options to mitigate flooding in this catchment, subject to funding.
16/10/2018	Phone	Resident from Baxter Road, Mascot: I have received three letters for the community consultation. Is my property has higher risk than other neighbouring property?	It was explained that since the owner holds three properties, they have received three letters. Flood risk is similar to the adjacent neighbouring sites.
11/10/2018	Phone	Resident from Coward Street: Why council does the flood study? Are all the other Council is also undertaking similar flood study?	Flooding can cause significant damage to property and risk to life. Council is required by the NSW State Government to undertake studies to determine what land has the potential to be affected by flooding. This is to ensure that new developments are adequately protected from flood hazards and do not make flooding worse.
30/09/2018	Online (have your say)	Resident from Lyon Street, Mascot: I have been living in the Mascot area since 1968. I cannot recall when Mascot was flooded. Would you be able to provide me with any details of when in the past Mascot was flooded, and to what depth. Is this study referring to a 100, 200 etc.year event or what. Certain sections of roads in mascot flood during heavy downpours but this could be due to dirty or even blocked drains. So please advise me of any records that show significant flooding (where waters have actually entered homes) that have occurred in the Mascot area, say in the last 100 years. The report also says that climate change has been taken into consideration, which brings to mind Tim Flannery's predictions that global warming will mean more droughts, therefore less rain and therefore less flooding? I think Council has a responsibility to not cause undue stress by playing up situations that have only a very small chance of occurring in a person's lifetime. The report should state this. Of course natural disasters occur from time to time, but that is the price we pay living on this planet. I think that there is a greater chance of the earth being struck by a meteor large enough to cause global destruction in the next 50 years than substantial flooding occurring in the Mascot area. Looking forward to your reply.	We appreciate your feedback in relation to the Mascot, Rosebery and Eastlakes flood study. Under the NSW Government's Flood Prone Land Policy Council is responsible for identifying and managing flood prone areas within their local government boundary. There is no new change in flood affectation or existing risk of flooding to this site. Through the flood study, Council now have better understanding regarding flooding in this catchment. Floods do not occur in a regular pattern. There may be a period of no floods and a period of several floods. For example, the last time the Brisbane River flooded before the 2011 disaster was in 1974. Residents who moved there in more recent times had not experienced flooding until the floods in January 2011. Following intensive rain larger floods can occur. As part of the flood study Council collected flood information from the properties in this catchment. Please refer to figure 13 and 14 of the flood study report volume 1, for the reported flood affected property locations. The last known large storm events were March 1975 (5% to 2% AEP), February 1993 (10% AEP), 8th November 1984 (20% AEP) and 24th March 2014 (50% AEP). None of these events were as large as the 1% AEP flood that would result from a 1% AEP rainfall event. The 1% AEP flood means there is a 1% (i.e. a 1 in 100) chance of a flood of this height, or higher occurring in any one year. A 1% AEP flood event will result in much greater depth of flooding over a much larger area than the very minor 2014 flood event.

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19/11/2018	Online (have your say)	I have been living at this address since 1985. We NEVER had flooding in our street until a new house was built across the street from me (roughly number XX, I think). When this house was built anew driveway and a new storm water drain was also put in. Clearly it wasn't installed properly because since then we constantly flood. I have had 2 cars rust and destroyed since the installation.	The last known large storm events were March 1975 (5% to 2% AEP), February 1993 (10% AEP), 8th November 1984 (20% AEP) and 24th March 2014 (50% AEP). None of these events was as large as the 1% AEP flood that would result from a 1% AEP rainfall event. The 1% AEP flood means there is a 1% (i.e. a 1 in 100) chance of a flood of this height, or higher occurring in any one year. Regards to the issue of the flooding due to the new development and driveway, you can lodge your concern with customer service on 1300 581 299. Our compliance team will then be able to review approved development plan and determine if new development worsened the existing flood affectation to your property.
24/09/2018	Email	Resident from Aloha Street, Mascot [name and site address censored: I have received your notification of the proposed Community Drop In on 4th October. Unfortunately I cannot attend I was in hospital and missed the Mascot library days when it was going to be on display. I have tried to access the plans online but all I get is a message saying page is not available. Could you please assist me on where I can view the plan? As discussed during the collection phase of this project I am very interested in this study and the plan Bayside has for managing the problem Thank you for your assistance.	Thank you for your email. You can view the report and plans in the link below: https://haveyoursay.bayside.nsw.gov.au/public-exhibition-mascot-rosebery-and-eastlakes-flood-study-and-floodplain-risk-management-study Hard copies of the report are now available in Rockdale and Mascot Library. We will appreciate if you can provide us with your valuable comments regarding the flood study and Floodplain risk management study.