City of Canada Bay

ORDINARY COUNCIL MEETING

ATTACHMENTS BOOKLET

Part 5 - Items 10-11
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CITY OF CANADA BAY COUNCIL

POWELLS CREEK FLOOD STUDY

January 2022

Level 2, 160 Clarence Street
Sydney, NSW, 2000

Tel: 9299 2855
Fax: 9262 6208
Email: wma@wmawater.com.au
Web: www.wmawater.com.au

POWELLS CREEK FLOOD STUDY

JANUARY, 2022

Project Powells Creek Flood Study	**Project Number** 120079
Client City of Canada Bay Council	**Client's Representative** Mark Leong & Khaled Haddad
Authors Fabien Joly Richard Dewar	**Prepared by**
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POWELLS CREEK FLOOD STUDY

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LIST OF ACRONYMS

AEP	Annual Exceedance Probability
AHD	Australian Height Datum
ARI	Average Recurrence Interval
ARR	Australian Rainfall and Runoff (ARR1987 and ARR2019)
ALS	Airborne Laser Scanning sometimes known as LiDAR
BoM	Bureau of Meteorology
CBD	Central Business District
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CFERP	Community Flood Emergency Response Plan
DEM	Digital Elevation Model
DRAINS	Hydrologic computer model developed from ILSAX
ELVIS	Elevation and Depth – Foundation Spatial Data - website
ERP	Emergency Response Planning
EPR	Entire Period of Record of gauge data at Elva Street gauge
EY	Exceedances per Year
FFA	Flood Frequency Analysis
GEV	Generalised Extreme Value probability distribution
GIS	Geographic Information System
GSDM	Generalised Short Duration Method
HEC-RAS	1D hydraulic computer model
HGL	Hydraulic Grade Line
ILSAX	Hydrologic model - a precursor to DRAINS
IFD	Intensity, Frequency and Duration of Rainfall
IPCC	Intergovernmental Panel on Climate Change
LEP	Local Environmental Plan
LGA	Local Government Area
LiDAR	Light Detection and Radar
LP3	Log Pearson III probability distribution
m	metre
MHL	Manly Hydraulics Laboratory
m^3/s	cubic metres per second (flow measurement)
m/s	metres per second (velocity measurement)
NSRUP	North Strathfield Rail Underpass Project
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
SEPP	State Environmental Planning Policy
SMC	Strathfield Municipal Council
SWC	Sydney Water Corporation
TIN	Triangular Irregular Network
TUFLOW	one-dimensional (1D) and two-dimensional (2D) flood and tide simulation software program (hydraulic computer model)
UNSW	University of New South Wales
1D	One dimensional hydraulic computer model
2D	Two dimensional hydraulic computer model

FOREWORD

The NSW State Government's Flood Policy provides a framework to ensure the sustainable use of floodplain environments. The Policy is specifically structured to provide solutions to 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 in the discharge of their floodplain management responsibilities.

The Policy provides for technical and financial support by the Government through four sequential stages:

1. ***Flood Study***
   - Determine the nature and extent of the flood problem.
2. ***Floodplain Risk Management Study***
   - Evaluates management options for the floodplain in respect of both existing and proposed development.
3. ***Floodplain Risk Management Plan***
   - Involves formal adoption by Council of a plan of management for the floodplain.
4. ***Implementation of the Plan***
   - Construction of flood mitigation works to protect existing development, use of Local Environmental Plans to ensure new development is compatible with the flood hazard.

The Powells Creek Flood Study constitutes the first stage of the management process for the City of Canada Bay Council and is based on the prior flood study for the wider Powells Creek and Saleyards Creek catchment undertaken by Strathfield Council, Burwood Council and Sydney Water Corporation.

TERMINOLOGY USED IN REPORT

Australian Rainfall and Runoff (ARR) have produced a set of guidelines for appropriate terminology when referring to the probability of floods. In the past, AEP has generally been used for those events with greater than 10% probability of occurring in any one year, and ARI used for events more frequent than this. However, the ARI terminology is to be replaced with a new term, EY.

Annual Exceedance Probability (AEP) is expressed using percentage probability. It expresses the probability that an event of a certain size or larger will occur in any one year, thus a 1% AEP event has a 1% chance of being equalled or exceeded in any one year. For events smaller than the 10% AEP event however, an annualised exceedance probability can be misleading, especially where strong seasonality is experienced. Consequently, events more frequent than the 10% AEP event are expressed as X Exceedances per Year (EY). Statistically a 0.5 EY event is not the same as a 50% AEP event, and likewise an event with a 20% AEP is not the same as a 0.2 EY event. For example, an event of 0.5 EY is an event which would, on average, occur every two years. A 2 EY event is equivalent to a design event with a 6-month average recurrence interval where there is no seasonality, or an event that is likely to occur twice in one year.

While AEP has long been used for larger events, the use of EY is to replace the use of ARI, which has previously been used in smaller magnitude events. The use of ARI, the Average Recurrence Interval, which indicates the long-term average number of years between events, is now discouraged. It can incorrectly lead people to believe that because a 100-year ARI (1% AEP) event occurred last year it will not happen for another 99 years. For example, there are several instances of 1% AEP events occurring within a short period, for example the 1949 and 1950 events at Kempsey.

Where the % AEP of an event becomes very small, for example in events greater than the 0.02 % AEP, the ARR terminology suggest the use of 1 in X AEP so a 0.02 % AEP event would be the same as a 1 in 5,000 AEP.

The PMF is a term also used in describing floods. This is the Probable Maximum Flood that is likely to occur. It is related to the PMP, the Probable Maximum Precipitation.

This report has adopted the approach of the ARR terminology guidelines and uses % AEP for all events the 50% AEP and greater and EY for all events smaller and more frequent than this. The image below provides the relationship between the various terminologies.

Australian Rainfall and Runoff (ARR) is a technical document which provides guidelines for flood related hydrologic and hydraulic processes. There have been 4 editions of ARR in 1958, 1987, 2016 and 2019. The 2016 and 2019 editions are very similar but provide significant upgrades to the 1987 edition and particularly regarding design rainfall depths and temporal patterns.

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	

The blue shaded areas represent the terminology adopted in this report.

BRIEF OUTLINE OF HOW DESIGN FLOOD LEVELS ARE CALCULATED

There are two broad approaches for calculating design events (floods of a known probability of occurrence such as the old 100-year event now termed the 1% AEP). The first is to undertake statistical analysis (termed flood frequency analysis) of a long record of peak flood levels (such as recorded for over 100 years at Windsor). This approach is rarely used for catchment wide studies as is only applicable at the location of the records. The alternative method (termed rainfall runoff modelling) is to use computer models of the catchment which calculate peak flood levels (based on equations of flow) from design rainfall data provided by the Bureau of Meteorology (BoM). The BoM can calculate design rainfall depths across Australia based on an extensive and long-term record of historical rainfalls. The accuracy of the computer models is increased by "calibrating" them to historical flood height data using the actual rainfall records from that historical event. The models include detailed definition of the topography derived from laser aerial scanning of the ground (this data has a vertical accuracy of around +/- 150mm and is available at approximately 1m spacings).

EXECUTIVE SUMMARY

BACKGROUND

Powells Creek is a small southern tributary of the Parramatta River and Saleyards Creek is the major tributary of Powells Creek (Figure 1). The total catchment area of Powells Creek to Homebush Bay Drive is 8.1km^2 and Saleyards Creek to the confluence with Powells Creek is 3.2km^2.

The Powells Creek catchment is in Sydney's Inner West region, approximately 12 kilometres west of the CBD. The catchment includes the suburbs (or parts) of Burwood, Concord West, Homebush, Homebush West, North Strathfield, Strathfield, and Rookwood (cemetery). Approximately 77% of the catchment is within the Strathfield Municipal Council (SMC) local government area (LGA), 15% is within City of Canada Bay Council LGA, 5% is within Burwood Council LGA and 3% (Rookwood cemetery) within Auburn LGA. Saleyards Creek is predominantly within the SMC LGA, apart from Rookwood cemetery.

The Powells Creek catchment drains to Homebush Bay on the Parramatta River via an open channel. Sydney Water Corporation (SWC) owns the larger "trunk" drainage assets including the open concrete lined channel with the smaller pipe and pit networks owned by the various councils.

The study area of this Flood Study is that part of the City of Canada Bay LGA within the Powells Creek catchment.

OBJECTIVES

The purpose of this Flood Study is to identify mainstream and overland flow flooding (assumed as where there is no defined channel) to define the existing flood liability within the City of Canada Bay part of the catchment. This objective is achieved through the development of a suitable hydrologic and hydraulic modelling platform that can subsequently be used as the basis for a future Floodplain Risk Management Study and Plan for the study area, and to assist Council when undertaking flood-related planning decisions for existing and future developments.

This project involves conducting a flood study:

- Which is a comprehensive investigation of flood behaviour that provides the main technical foundation for the development of a robust floodplain risk management plan.
- It aims to provide a better understanding of the full range of flood behaviour, risks, and consequences in the study area.
- It involves consideration of the local flood history, available collected flood data, and the development of hydrologic and hydraulic models that are calibrated and verified, where possible, against historic flood events and extended, where appropriate, to determine the full range of flood behaviour.

FLOODING HISTORY

From the flooding history it must be noted that the drainage characteristics of this catchment have been significantly altered because of urbanisation and as such older flood extents and depths for a given storm may not apply to present day conditions. There have been many instances of flooding in the past with November 1961, March 1975 and March 1983 having the greatest number of records. Archival records also mention several prior large floods including a particularly severe event in 1860. More recently, reports of minor property inundation from overland flow in 2015 and 2016 in the Burwood LGA have been received as well as in the Canada Bay LGA.

A water level gauge at Elva Street was operated from 1958 to approximately 2010 by the University of New South Wales (UNSW). The records have been digitised up to 1997 and were used for calibration of the modelling system upstream of the gauge as well as flood frequency analysis.

PAST STUDIES

Initially a review of the available reports and data was undertaken. The Powells Creek Flood Study undertaken for SMC in 1998 (Reference 1) was the first study covering the entire catchment and providing detailed flood levels. Subsequently a Flood Study was completed for Sydney Water in 2015. That Flood Study then formed the basis of the Powells Creek Revised Flood Study (Reference 2) for SMC (2016) and Burwood Council (2019). The City of Canada Bay commissioned Jacobs to undertake the 2015 Concord West Precinct Master Plan Flood Study (Reference 3), however this only covered the City of Canada Bay LGA.

All past studies relied upon Australian Rainfall and Runoff 1987 (ARR1987 – Reference 4) which has now been superseded by ARR2019 (Reference 5).

RAINFALL AND FLOOD HEIGHT DATA

There is a limited amount of rainfall data covering the catchment, particularly pluviometer data which is needed to describe the temporal pattern of historical events. A reasonable amount of historical flood height data is available from SWC records as well as the 1998 Powells Creek Flood Study (Reference 1). Water level data is available from the water level gauge at Elva Street from 1958 to 2010. As no significant floods have occurred since the completion of the 1998 Flood Study, no further attempt at obtaining historical flood data from the residents was made as part of the present study.

HYDROLOGIC AND HYDRAULIC MODELLING PROCESS

The hydrologic modelling was undertaken using DRAINS and the hydraulic model was undertaken using TUFLOW. These models were verified by comparison to six historical events (3rd, 7th, 10th and 17th February 1990, 18th March 1990 and 2nd January 1996).

The design rainfall events modelled were the 1EY, 20%, 10%, 5%, 2%, 1%, 0.5% and 0.2% AEP design events and the Probable Maximum Flood (PMF). The temporal patterns for the design events were sourced from ARR2019 (Reference 5) and the rainfall data was obtained from the Bureau of Meteorology's (BoM) internet-based tool. The PMP estimates were derived according to the BoM guidelines.

FLOOD FREQUENCY ANALYSIS

An extensive flood frequency analysis (FFA) was carried out in the 2016 Powells Creek Revised Flood Study (Reference 2) at the Elva Street water level gauge. When compared to FFA design flow estimates, those from TUFLOW overestimate flows for more frequent events and generally accord with the FFA greater events.

SENSITIVITY ANALYSIS, BLOCKAGE AND CLIMATE CHANGE

Sensitivity analysis and blockage assessments were undertaken to assess the effects of varying key model parameters. In addition, assessments of the effects of a sea level rise elevating the adopted design water levels in the Parramatta River and an increase in design rainfall intensities were undertaken. Sea level rise made little difference in the upstream developed areas; however, rainfall increases (potentially due to climate change) will produce a significant increase in flood levels.

OUTCOMES

The results from this study provide design flood data (levels, depths, velocity, hazard, hydraulic classification) which supersede those derived in the 2016 Powells Creek Revised Flood Study (Reference 2) and the 2015 Concord West Precinct Master Plan Flood Study (Reference 3).

Immediately following the next large flood event (10% AEP or greater) water level and rainfall data should be collected and used to verify the hydrologic and hydraulic model calibrations.

1. INTRODUCTION

1.1. Background

The Powells Creek catchment (Figure 1) is located on the southern bank of the Parramatta River at Homebush Bay, approximately 12 kilometres west of the Sydney CBD. The main tributary of Powells Creek is Saleyards Creek which enters immediately upstream of Homebush Bay Drive. Downstream of Homebush Bay Drive, Powells Creek is a natural channel surrounded by dense mangrove vegetation on both sides. Upstream Powells and Saleyards Creeks are concrete lined channels with Powells Creek bounded on the east by the City of Canada Bay LGA; largely comprising of residential development with residential, light industry and open space on the western SMC side. Saleyards Creek is bounded on both sides by open space until reaching Underwood Road where it is largely bordered by commercial developments.

The total catchment area of Powells Creek to Homebush Bay Drive is 8.1km^2 and Saleyards Creek to the confluence with Powells Creek is 3.2km^2. The study area is limited to the City of Canada Bay LGA as shown on Figure 1.

The Powells Creek catchment includes the suburbs (or parts) of Burwood, Concord West, Homebush, Homebush West, North Strathfield, Strathfield and Rookwood (cemetery). Approximately 77% of the catchment is within the SMC LGA, 15% is within City of Canada Bay Council, 5% is within Burwood Council LGA and 3% (Rookwood cemetery) within Auburn LGA (herein termed the Councils). Saleyards Creek is predominantly within the SMC LGA apart from Rookwood cemetery.

Drainage elements in the Powells Creek catchment include kerbs and gutters, pits and pipes, and a network of trunk drainage elements including culverts and open channels. Ownership of the assets is split between SWC and the Councils, with SWC owning the larger "trunk" elements. Amongst the drainage assets is a length of brickwork drain that was one of the first purpose-built stormwater drains in Sydney and constructed in the 1890's. Open channel sections extend from Powells Creek under the railway lines to Elva Street, to just beyond Ismay Avenue on the small tributary, and up Saleyards Creek under Flemington markets to upstream of the railway line.

The primary drivers that highlighted the need for this flood study are

- The City of Canada Bay Council's Concord West Precinct project includes the rezoning and redevelopment of certain industrial zoned sites for medium density residential development (i.e. residential flat/apartment buildings), and associated public domain improvements.
- Implementation of suitable planning controls for the City of Canada Bay to inform and protect the public, residents and property from future flooding impacts and hazards, including flooding of habitable floor levels.
- Several significant changes within the catchment have occurred since the prior flood studies were carried out. There is a requirement to examine the flood effects of these changes within the catchment.
- The revised study area is to include the entire Canada Bay LGA within the Powells Creek catchment and thus includes the overland flow areas not previously modelled in the 2016

Powells Creek Revised Flood Study (Reference 2).

Probable or known drainage "hotspots' include.

- The low-lying area to the north of, and including, the new Canada Bay Public School is situated in a trapped depression, caused mainly by the Homebush Bay Drive embankment and by slightly higher ground levels on Sydney Olympic Park land, between Victoria Avenue and Powells Creek.
- The trapped sag point on George Street to the north of the Rothwell Avenue junction, where an existing industrial building at 176 – 184 George Street prevents floodwaters from flowing overland towards Powells Creek; and
- The separation of the northern floodplain (sub catchment areas in Sydney Olympic Park and Bicentennial Park) from the rest of the catchment by Homebush Bay Drive. This feature has created an effective barrier where cross drainage through the northern catchment is dependent on the capacity of outlet / culvert structures to covey flows.

There have been many instances of flooding in the past with the greatest number of records existing in relation to the November 1961, March 1975, and March 1983 floods events.

The present study has been commissioned by the City of Canada Bay Council to extend upon the previous flood studies of Powells Creek commissioned by SWC, SMC and Burwood Council, and to define mainstream and overland flood behaviour in the catchment. This report covers the part of the catchment lying in the City of Canada Bay LGA. Mainstream is generally defined as flooding occurring from open channels, either lined or natural, whereas overland is mainly flooding where there is no defined open channel and drainage is via the pit and pipe system and overland through private and public properties. However, there are exceptions to these definitions.

1.2. Description of Catchment

The study area's catchment is fully urbanised. Within the Strathfield LGA approximately 79% of the LGA is zoned for residential development, 9% for special purpose, 6% for open space areas (parks and recreation areas) and the remaining 7% for business/commercial and industrial areas. Within the Burwood LGA, approximately 90% is zoned for residential development (mix of low density and general) with remaining areas containing mixed use, public recreation and infrastructure. Within the City of Canada Bay LGA approximately 61% of the LGA is zoned for residential development, 8% for special purpose, 18% for open space areas (parks and recreation areas) and the remaining 13% for business/commercial and industrial areas.

A land use zone map is provided as Figure 2. Upstream of the Parramatta railway the catchment is predominantly occupied by residential development with areas of open space, schools, and active recreation. The residential developments are largely detached dwellings constructed prior to 1960 but there are also several recent higher density developments. Significant commercial development is located near Strathfield railway station at Strathfield Plaza.

Downstream of the railway line the catchments of both Powells and Saleyards creeks are a mixture of residential, commercial (Flemington Markets) and light industrial developments. There are also significant areas of open space surrounding the lower parts of both creeks. The road transport routes (M4 Motorway, Parramatta Road, Homebush Bay Drive) and the railway lines have influenced the flow paths in the lower reaches.

Very little information is available in the City of Canada Bay Council's records regarding the existing site drainage for the catchment in general (i.e., are there rubble pits? If so what size? Is the existing roof drainage connected directly to the street drainage?). On-site detention has been introduced by all Councils since the mid-1990s.

Diagram 1 indicates the significant change in alignment of Powells Creek with construction of the concrete lined SWC channel.

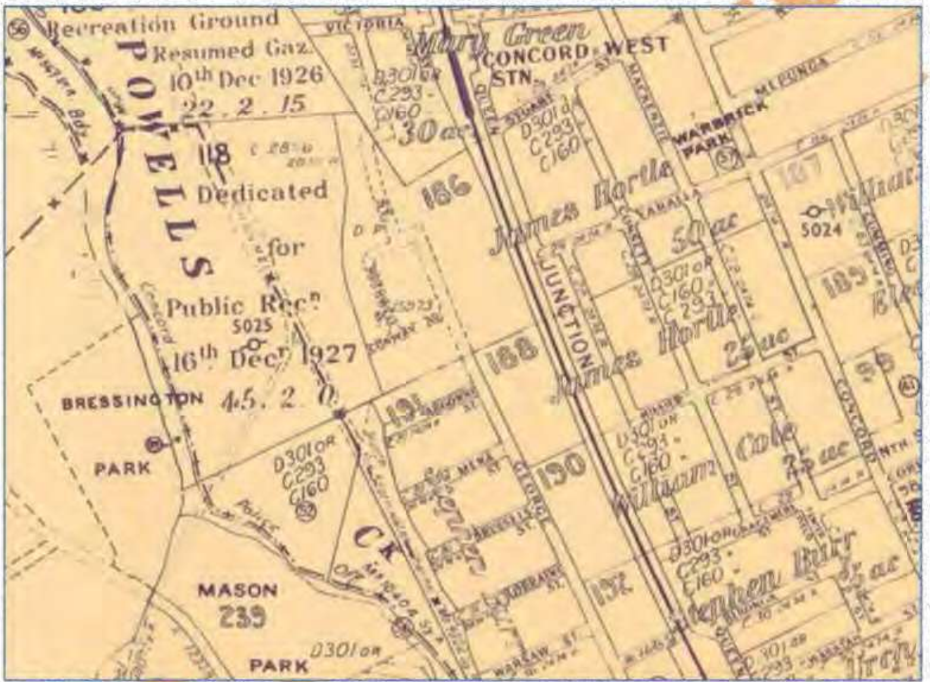


Diagram 1: Cadastral Plan near the time of Construction of the SWC Concrete Channel

Elevations in the upper part of the catchment (Figure 3) reach approximately 55 m AHD near Arthur Street and some reaches are relative steep with 2% to 4% grades. However, the overall catchment slope averages 0.8% along the main flow-path from headwaters to outlet. The main channel is tidal to upstream of Parramatta Road and the lined channel width varies from approximately 2 m in the upper areas to 22 m at Homebush Bay Drive.

Construction of buildings and structures over the open lined channel, as shown on Figure 4, has significantly reduced the capacity of the natural waterways. As a result, flooding has occurred in the past (Figure 5) causing significant tangible and intangible damages.

1.3. Changes to the Study Area

The following major works in the study area have been undertaken since completion of the previous flood studies (Section 2.2),

- North Strathfield Rail Underpass Project.
- Sydney Water Powells Creek Naturalisation.
- Canada Bay Primary School Victoria Avenue Concord West.
- Filling of Powells Creek Reserve North Field; and
- Reconstruction of the west end of Victoria Avenue including drainage upgrade.
- Filling of Powells Creek Reserve Southern Field.
- North Sydney Freight Corridor Project (Stage 2A) and
- West Connex.

1.4. Objectives

The primary objective of the Flood Study was to develop a suitably robust hydrologic and hydraulic modelling system to be used to define flood behaviour, peak flood levels and inundation extents within the study area. This modelling system may subsequently be used within a Floodplain Risk Management Study to assess the effectiveness and suitability of flood mitigation works.

The key stages in the flood study process are.

- undertake a comprehensive review of the available flood related data including previous studies, available survey data and historical rainfall and flood level data.
- establish a hydrologic model for the entire Powells Creek catchment to Homebush Bay Drive.
- develop a suitable hydraulic model of Powells Creek and major tributaries within the study area.
- calibration of the hydrologic and hydraulic models to historic flood data.
- define the flood behaviour and produce information on flood levels, extents, velocities and flows for a full range of design flood events under existing conditions.
- assess the sensitivity of blockage and other assumptions on peak flood flows and levels.
- assess the impacts of sea level rise and increase in rainfall and runoff intensities due to climate change; and,
- prepare hydraulic hazard and category mapping.

This report details the results and findings of the above investigations.

1.5. Floodplain Risk Management Process

As described in the 2005 NSW Government's Floodplain Development Manual (Reference 6), the Floodplain Risk Management Process entails four sequential stages:

Stage 1:	*Flood Study*
Stage 2:	*Floodplain Risk Management Study*
Stage 3:	*Floodplain Risk Management Plan*
Stage 4:	*Implementation of the Plan*

The above first three stages were completed with publication of 2016 Powells Creek Revised

Flood Study (Reference 2) and the 2003 Powells Creek Floodplain Risk Management Study and Plan (Reference 7). However, these studies were primarily focused on the Strathfield LGA. Several other flood studies have also been undertaken and these are reviewed in Section 2.2.

This present document is primarily for the City of Canada Bay LGA, it provides a review of the past flood studies and updates the design flood analysis to current best practice. The most significant change is the adoption of ARR2019 design flood methodology as all prior studies adopted ARR1987 methodology.

A Flood Study is a technical document and is not always easily understood by the public. A glossary of flood related terms is provided in Appendix A to assist. If more explanation of terms or a better understanding of the approach is required, type "*NSW Government Floodplain Development Manual*" into an internet search engine and you will be directed to the NSW Government web site which provides a copy of this manual (Reference 6) and further explanation.

All levels in this report are in metres to Australian Height Datum (AHD). Mean sea level is approximately 0 m AHD and an approximate tidal range in Homebush Bay is +0.6 m AHD to -0.4 m AHD. The highest tide in a year can reach 1.1 m AHD.

1.6. Accuracy of Model Results

The accuracy of all model results provided in this report is dependent on the input data sets and the ability of the modelling approach to replicate recorded historical flood data. As modelling approaches improve over time and additional flood data becomes available from future flood events the accuracy of the results will improve.

A key input data set is the topographic information provided by SWC and the Councils for use in this study. The topographic information was derived from Airborne Laser Scanning (ALS also known as LiDAR) with an estimated accuracy of ± 0.15m in cleared areas, such as car parks or on roads. In locations with more complex terrain, such as vegetated areas, the accuracy of the ALS is likely to be much lower and could vary significantly, by up to ± 1m. It is cost prohibitive to obtain detailed field survey throughout the entire study area and the ALS is assumed to be correct. However due to these potential accuracy limitations, some of the floodway extents, depth estimates, and design flood levels may change if more accurate field survey is obtained. It is estimated that an order of accuracy of the design flood levels is ± 0.3 m where quality historical calibration data are available nearby and up to ± 0.5 m where no such data are available.

The results from the present study incorporate best practice in design flood estimation at this time but it is acknowledged that changes in approach in the future will cause changes to design flood levels. A good example of this is the collection of rainfall data which forms the basis of design flood estimation. ARR2019 (Reference 5) provides an updated version of the 1987 edition of ARR (Reference 4) and introduced new approaches and guidelines which have changed design flood levels.

2. AVAILABLE DATA

2.1. Overview

The first stage in the investigation of flooding matters is to establish the nature, size, and frequency of the problem. On large river systems such as the Hawkesbury or Parramatta Rivers there are generally stream height and historical records dating back to the early 1900's, or in some cases even further. However, in most small urban catchments there are no stream gauges or official historical records available.

The Powells Creek catchment is unique in Sydney because a stream gauge has been operated by the UNSW at Elva Street for a long period (50 years). The records from this gauge have been used for many technical papers and university undergraduate and graduate theses.

An overview of historical of flooding is also available from an examination of the Councils' and SMC records, previous reports, internet search of newspapers, rainfall records and local knowledge.

2.2. Previous Studies

Several previous studies (Table 1) have been undertaken in the Powells Creek catchment as described in Reference 2. Numbers 1 to 6 (Table 1) used ILSAX hydrologic models to assess solutions to drainage problems with the majority distributing a questionnaire to the residents to obtain information about past drainage problems. Only numbers 7 to 11 determined design flood levels. No. 1 provides a summary of the more recent studies.

Table 1: Previous Studies Listed in Reference 2

Title	Consultant	Branches	Date	Comment	No.
Strathfield Local Flooding Issues	Kinhill Engineers	Wentworth Rd, Strathfield Ck, Albyn Rd	March 1997	Expanded upon No's 2 and 3. Undertook HGL.	1
Redmyre Road/Florence Street Catchment Study	Giammarco	Albyn Rd	November 1993	Undertook HGL.	2
Rochester Street Catchment Drainage Investigation	Bewsher Consulting	Strathfield Ck	December 1990	Undertook HGL.	3
Stormwater Drainage Upgrading Programme - Rochester Street Catchment - Feasibility Study and Design Report	Taylor, Thomson, Whitting	Strathfield Ck	1992	Expanded on No. 3. Undertook HGL.	4
Rochester Street Drainage Investigation Report	Rankine and Hill	Strathfield Ck	May 1985	Examined upgrading of pipe system.	5
Arthur Street Catchment Study	Bewsher Consulting	Saleyards Ck	July 1996	Only upstream of the railway line.	6
Saleyards Creek at Park Road, Flemington	Bewsher Consulting	Saleyards Ck	October 1996	Determined design flood levels.	7
12-14 Wentworth Road, Homebush	Bewsher Consulting	Saleyards Ck	February 1995	Determined design flood levels.	8

Title	Consultant	Branches	Date	Comment	No.
32-36 Burlington Road, Homebush	B Lysenko	Strathfield Ck	February 1994	Determined design flood levels.	9
Lower Parramatta River Flood Study	Willing & Partners	Powells Creek to approximately Pomeroy Street	February 1986	Determined design flood levels.	10
Powells Creek at Underwood Street Site Flood Study	Tierney & Partners	Powells Creek at Pomeroy Street	November 1993	Determined design flood levels.	11

The references listed in Table 1 are of little value in the current study as they provide little historical data, and the results cannot be easily compared. The 2016 Powells Creek Revised Flood Study (Reference 2), however, is a comparable study to the current one and extensive use has been made of the data and results which were originally contained in the prior 1998 Powells Creek Flood Study (Reference 1).

The City of Canada Bay commissioned Jacobs to undertake the 2015 Concord West Precinct Master Plan Flood Study (Reference 3), however this only covered the City of Canada Bay LGA.

2.2.1. 1998 Powells Creek Flood Study (Reference 1)

The 1998 Powells Creek Flood Study was undertaken under the NSW Government's Floodplain Management Program and used best practice techniques available at the time. A field survey was undertaken to provide approximately 100 cross sections of the creek channel as well as to collect historical flood height data. Some of the cross-section data have been used in the current study and the historical flood height data is provided in Section 2.10.

A comprehensive data search was undertaken including:

- a review of previous studies.
- interviews with residents.
- discussions with Council Officers.
- contact with SWC, the then Roads & Traffic Authority, the then State Rail Authority, the then Department of Land & Water Conservation and the UNSW.
- review of aerial photographs.
- provision of a questionnaire and review of all previous questionnaires.
- obtaining height and rainfall data from the stream and rainfall gauges operated by the UNSW and SWC.

An ILSAX hydrologic model of the entire Powells and Saleyards Creeks catchment was constructed using ILSAX files from some of the studies listed in Table 1. Inflows from ILSAX were then input into the 1D HEC-RAS hydraulic model which determined flood levels and velocities. Flood extents were not defined; however, this was subsequently undertaken using the peak levels and ALS for the Strathfield LGA.

The ILSAX model was calibrated to the events of 3rd February, 7th February, 10th February, 17th February and 18th March 1990 using rainfall from two pluviometers at St Sabina College and at the Elva Street gauge. Calibration to the Elva Street gauge for the January 1996 event could not be undertaken as the gauge malfunctioned. The results are summarised in the 2016 Powells

Creek Revised Flood Study (Reference 2).

The study concluded that accuracy of the design flood data depended upon several factors including.

- quality of the survey data.
- downstream boundary conditions.
- accuracy of design rainfall data.
- ability of the models to accurately represent the channel hydraulics.
- quantity and quality of available historical data.

The main factors affecting the accuracy of the design data were the ability of the models to simulate the channel hydraulics and the quantity and quality of the historical data. Based upon the above considerations the accuracy of the design flood levels was ±0.4 m. This could be improved if further calibration of the models to future flood events was undertaken.

2.2.2. 2016 Powells Creek Revised Flood Study (Reference 2)

This study provided a significant upgrade to the prior 1998 Powells Creek Flood Study (Reference 1). Its purpose was to define mainstream and overland (where there is no defined channel) flood behaviour under historical and existing floodplain conditions in the study area while addressing possible future variation in flood behaviour due to climate change and provide information for its management. The main features of this study compared to the prior 1998 study were:

- The same historical rainfall and flood data was relied upon as there had been no floods of significance since 1998.
- The modelling approach was similar, adopting flood frequency analysis of the historical flood record at the Elva Street gauge and incorporating a runoff routing approach to define flood levels, extents, and velocities across the entire Powells Creek catchment.
- The flood frequency analysis (based on the same flood record) was re-done using updated approaches which analysed several different distribution procedures.
- The 1998 study relied upon cross section data obtained from field survey to define the topography with the 2016 study relying upon Airborne Laser Scanning (ALS). ALS only became available since approximately the year 2000 and provides ground levels at approximately 1m spacing. It therefore provides a much more detailed and accurate definition of the topography, though cross section data was still used for definition of the lined channels.
- In the 1998 study a HEC-RAS 1 dimensional (1D) computer model based on cross section data was adopted as the hydraulic model to determine design flood levels. In the 2016 study the 2D TUFLOW hydraulic model was adopted which relied upon defining the topography using a 2m-by-2m grid based on the ALS data. This change represents a significant upgrade to the modelling approach as it ensures accurate consideration of both the temporary floodplain storage and conveyance characteristics of the catchment. It also ensures more accurate definition of flow paths, velocities, flood depths and flood extents across the entire floodplain, rather than just at cross sections as in the 1998 study.
- The ILSAX hydrologic model was adopted the 1998 study, and this was converted to a DRAINS hydrologic model for the 2016 study. However, as DRAINS uses the same basic hydrologic approach as ILSAX this change did not result in a significant change to the

inflows but was adopted as it allows more efficient and flexible incorporation of the flow hydrographs into TUFLOW.

- The 2016 study provided significantly improved definition of flood behaviour across the floodplain, including both overland and mainstream flooding. Maps were produced showing information on flood levels, depths, extents, velocities and flows for a range of flood events up to the probable maximum flood (PMF) events and included flood emergency response classification of communities and the sensitivity of flood behaviour to changes in flood producing rainfall events due to climate change (rainfall increase and sea level rise).

A comparison of the results from this study and the present study along the main channel of Powells Creek is provided in Table 31.

2.2.3. 2015 Concord West Precinct Master Plan Flood Study (Reference 3)

This study was initiated by the City of Canada Bay and several landowners, at the time of the proposed naturalisation of the lower parts of Powells Creek by SWC and proposed rezoning of several industrial lots. Jacobs were engaged to undertake a flood study and prepare a concept design for flood mitigation measures for the Master Plan. This study has not been adopted by the City of Canada Bay Council. The study area was defined as:

- Powells Creek from approximately Parramatta Road to Homebush Bay.
- Saleyards Creek from M4 Motorway to Powells Creek; and
- Strathfield Creek from 100m upstream of Ismay Avenue to Powells Creek.

The following were allowed for in the study, based on the design information available at the time, but have since been completed:

- North Strathfield Rail Underpass Project (NSRUP).
- Sydney Water Powells Creek naturalisation.
- Canada Bay Primary School Victoria Avenue Concord West.
- Filling of Powells Creek Reserve North Field; and
- Reconstruction of the west end of Victoria Avenue including drainage upgrade.

Several flood mitigation options were identified and assessed to mitigate flood impacts with the Master Plan. These options have not been discussed in this present report as it is a Flood Study and is therefore only concerned with determining design flood conditions based on the existing conditions at this time (2021). Mitigation options will be considered and investigated in any subsequent Floodplain Risk Management Study and Plan (refer Foreword and Section 1.5).

The study relied upon upstream inflow hydrographs on Powells Creek based on ILSAX from the 1998 Powells Creek Flood Study (Reference 1) and local inflow hydrographs from a DRAINS model incorporating the NSRUP works. It was not possible to undertake an independent calibration of the hydrologic model and the hydraulic model was only calibrated to the one available data point from the 10 February 1990 event (data point taken from Reference 1). The results from comparison of recorded overland peak depths with model depths are shown in Table 2.

Table 2: Comparison of TUFLOW Results to Observed Flood Depths (Reference 3)

Location	Year of Observation	Observed Depth (m)	Modelled Depth (m)	Difference (m)
20 Brussels St	1990	0.5	0.6	0.1
17 Lorraine Ave	2012	0.3	0.18	-0.12
20 Lorraine Ave	2011	0.3	0.34	0.04
30 King St	1985	0.75	0.84	0.09
38 King St	1986?	0.75	0.66	-0.09
40 King St	1988	0.75	0.49	-0.26
End of Victoria Ave	2013	0.3	0.31	0.01

A detailed review of the results from Reference 3 has not been undertaken as the modelling approach along Powells Creek has been superseded by the results from the 2016 Powells Creek Revised Flood Study (Reference 2).

2.3. Data Sources

Data utilised in the present study has been sourced from a variety of organisations. Table 3 lists the type of data and where it has been sourced.

Table 3: Data Sources

Type of Data	Format Provided (Source)	Format Stored
Location, description and invert depths of pits, pipes and trunk drainage network	GIS (Councils)	DRAINS and TUFLOW models
Ground levels from ALS data	GIS (Councils and ELVIS)	GIS and TUFLOW model
Detailed survey data	GIS (Councils)	GIS and TUFLOW model
GIS information (cadastre, drainage pipe layout)	GIS (Councils)	GIS and TUFLOW model
Design rainfall	ARR2019 and Datahub	DRAINS
Recorded flood data	Observation by Councils, Sydney Water, and previous reports	Report

2.4. Topographic Data

ALS or LiDAR survey of the catchment and its immediate surroundings was provided for the study by SWC and SMC but was updated where more recent data was available from ELVIS. These data typically have accuracy in the order of:

- +/- 0.15m (for 70% of points) in the vertical direction on clear, hard ground; and
- +/- 0.75m in the horizontal direction.

The accuracy of the ALS data can be influenced by the presence of open water or vegetation (tree or shrub canopy) at the time of the survey. From this data, a Triangular Irregular Network (TIN) was generated as part of this study. This TIN was sampled at a regular spacing of 1 m by 1 m to create a Digital Elevation Model (DEM), which formed the basis of the two-dimensional hydraulic modelling for the study.

2.5. Structure Survey

All bridges and structures within the open channel extent of the study area were inspected in May 2014 as part of Reference 2. Survey data collected as part of Reference 1 were used to define the structures. Photographs on Figure 4 provide a descriptive overview of the key characteristics of the open channel system.

2.6. Floor Level Survey

Floor level data are used to determine flood damages estimates (see Section 11). Given the large catchment area and number of flood affected properties, theodolite-based survey of all properties was not financially feasible. Details of how building floor levels were estimated are presented below:

- No surveyed floor levels data were available from previous studies.
- Floor level estimation was undertaken by WMAwater for approximately 700 properties for the properties inundated in the 1% AEP event.
- The floor levels were estimated based on the ground level at the front door obtained by ALS plus the height of the floor above the ground (by counting bricks etc.).
- The height of the floor levels above the ground were estimated by visual inspection based on analysis of available digital imagery (Google Street View).

2.7. Rainfall Data

2.7.1. Overview

Rainfall data is recorded either daily (24hr rainfall totals to 9:00 am) or continuously (pluviometers measuring rainfall in small increments – less than 1 mm). Daily rainfall data have been recorded for over 100 years at many locations within the Sydney basin. In general, pluviometers have only been installed since the 1970's. Together these records provide a picture of when and how often large rainfall events have occurred in the past.

However, care must be taken when interpreting historical rainfall measurements. Rainfall records may not provide an accurate representation of past events due to a combination of factors including local site conditions, human error, or limitations inherent to the type of recording instrument used. Examples of limitations that may impact the quality of data used for the present study are:

- Rainfall gauges frequently fail to accurately record the total amount of rainfall. This can occur for a range of reasons including operator error, instrument failure, overtopping and vandalism. Many gauges fail during periods of heavy rainfall and records of large events are often lost or misrepresented.
- Daily read information is usually obtained at 9:00 am in the morning. Thus, if a single storm is experienced both before and after 9:00 am, then the rainfall is "split" between two days of record and a large single day total cannot be identified.
- In the past, rainfall over weekends was often erroneously accumulated and recorded as a combined Monday 9:00 am reading.
- The duration of intense rainfall required to produce overland flooding in the study area is

typically less than 4 hours (though this rainfall may be contained within a longer period of rainfall). This is termed the "critical storm duration". For a larger catchment (such as the Parramatta River) the critical storm duration may be greater (say 12 hours). For the study area a short intense period of rainfall can produce flooding but if the rain stops quickly, the daily rainfall total may not necessarily reflect the magnitude of the intensity and subsequent flooding. Alternatively, the rainfall may be relatively consistent throughout the day, producing a large total but only minor flooding.

- Rainfall records can frequently have "gaps" ranging from a few days to several weeks or even years.
- Pluviometer (continuous) records provide a much greater insight into the intensity (depth vs. time) of rainfall events and have the advantage that the data can generally be analysed electronically. This data has much fewer limitations than daily read data. However, pluviometers can also fail during storm events due to the extreme weather conditions.
- Rainfall events which cause overland flooding (as opposed to mainstream flooding) in the Powells Creek catchment are usually localised and as such are only accurately represented by a nearby gauge. Gauges sited even only a kilometre away can show very different intensities and total rainfall depths.

2.7.2. Rainfall Stations

There are several daily read rainfall stations within the catchment and surrounding area. Data were not collected from these stations as more suitable data were available from six pluviometers (Table 4). The two UNSW pluviometers have operated since approximately 1977 but the dates shown in Table 4 are the periods for which digital data are available. No correction has been made in the digital records for the UNSW gauges to account for errors in the clock speed. Thus, the time of the recorded rainfall can be out by several hours. This has not been corrected for in this report; however, Reference 8 provides an approach that can be used.

Table 4: Pluviometers

Gauge No.	Operator	Operating Period	Location
566005	UNSW	Mar 1981 to Feb 1996 (period when digital records available)	St Sabina College (Russell Street, The Boulevarde)
566004	UNSW	Dec 1980 to June 1993 (period when digital records available)	Stream gauge at Elva Street/Beresford Road
566022	SWC	May 1969 to August 1983, July 1990 to Present	Homebush Bowling Club (Pomeroy Street)
566020	SWC	Oct 1958 to Present	Enfield (Belfield Bowling Club - Margaret Street)
566036	SWC	February 1970 to Present	Potts Hill Reservoir
566064	SWC	June 1988 to Present	Concord (Western Suburbs Club).

2.7.3. Analysis of Pluviometer Data

Rainfall data were collected from some of the available pluviometers for the significant flood events with the peak bursts provided in Table 5 and Figure 9. An estimate of the rainfall frequency for each event can be obtained from comparison with the design rainfalls (Table 6).

Table 5: Historical Rainfall - Maximum Rainfall Depths (mm)

	Duration						
	5 or 6 min	10 min	20 min	30 min	60 min	90 min	120 min
			2nd January 1996:				
Homebush	15	23	36	44	52	54	58
Enfield	17	25	45	57	81	83	88
Potts Hill	11	17	31	42	49	52	54
Concord	7	11	21	30	46	49	52
Elva Street	Instrument Failed						
St Sabina	11	22	37	50	64	n/a	71
			8th February 1992:				
Homebush	Instrument Failed						
Enfield	4	6	10	13	22	28	33
Elva Street	Instrument Failed						
St Sabina	2	5	6	11	16	n/a	n/a
			11th March 1991:				
Homebush	No Significant Rain						
Enfield	13	19	34	37	-	-	-
Potts Hill	11	18	33	35	-	-	-
Concord	10	16	24	24	-	-	-
Elva Street	Instrument Failed						
St Sabina	Instrument Failed						
			18th March 1990:				
Elva Street	20	34	41	44	45	47	50
St Sabina	8	23	26	31	36	43	46
			10th February 1990:				
Homebush	Gauge Not in Operation						
Enfield	11	15	23	26	40	45	50
Potts Hill	12	19	31	36	44	48	52
Concord	7	11	17	25	31	33	38
Elva Street	9	13	22	28	39	n/a	50
St Sabina	6	11	21	31	42	n/a	52
			4-6th August 1986:				
Homebush	Gauge Not in Operation						
Enfield	12	17	27	36	50	59	64
Potts Hill	11	16	27	37	52	60	64
Concord	Gauge Not in Operation						
Elva Street	10	13	17	21			
St Sabina	Very Little Rain						

Note: Data for January 1989 are not shown as the Enfield pluviometer record indicated no significant rainfall events. Data from other pluviometers may be available but were not collected.

2.8. Design Rainfall

Design rainfall intensities for the study area were taken at Pomeroy Street based on procedures in ARR2019 (Reference 5) and are provided in Table 6.

Table 6: ARR2019 Design Rainfall Depths at Pomeroy Street (mm)

	Duration							
Event	15 min	30 min	60 min	90 min	120 min	180 min	360 min	720 min
1 EY	15	22	26	29	34	37	40	46
20% AEP	21	30	35	39	45	49	54	61
10% AEP	27	38	43	49	56	62	68	77
5% AEP	31	43	49	56	64	71	77	88
2% AEP	34	47	54	61	71	78	85	97
1% AEP	40	55	63	71	83	92	100	113
0.5% AEP	52	73	85	97	114	127	138	155
0.2% AEP	69	77	102	120	139	165	186	227
PMP	-	220	326	372	416	-	-	-

Probable Maximum Precipitation (PMP) design rainfall depths were calculated using the 2003 BoM Generalised Short Duration Method (Reference 9) for durations up to 6 hours.

Areal variation of the design rainfalls across the entire Powells Creek catchment was considered but was not adopted as the variation is small (a few percent) and therefore could not be justified.

2.9. Water Level Gauges

2.9.1. UNSW (Elva Street Gauge)

Flood levels have been recorded continuously from September 1958 until 2010 at the Elva Street gauge (Photo 1). Apart from this gauge there are no other long-term flood records for the catchment. SWC operated a gauge on Powells Creek (under the M4), but records are only available from October 1995.

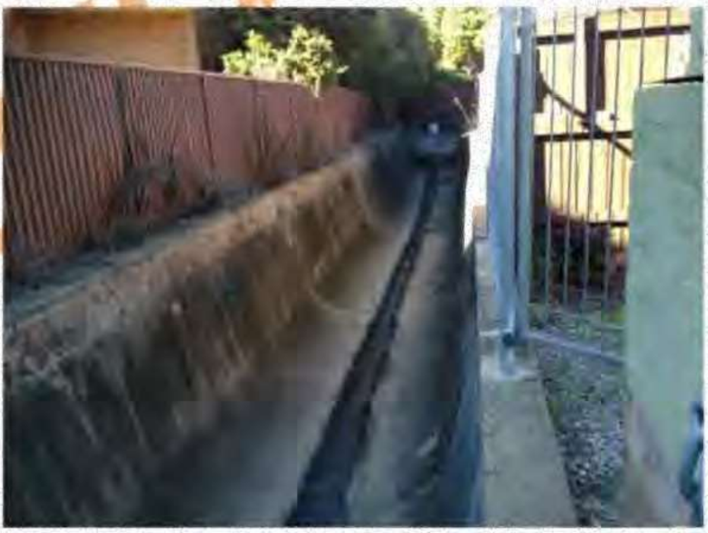


Photo 1: Powells Creek water level gauge at Elva Street

At the time of completion of the 1998 Powells Creek Flood Study (Reference 1) only a limited amount of water level and rainfall data were available from the UNSW as only parts of the historical records were digitised, or quality checked.

Subsequently the entire water level and pluviometer record (both at St Sabina and at Elva Street) have been digitised and a rating table adopted to assign flows to the recorded levels. However, there are many gaps in the digital record, and this means that the record is only complete to November 1997. The digital record has also not been corrected for timing errors and no error correction has been undertaken for this study.

A summary of the water level data is provided on Figure 6 and below indicates the number of days where the water level has exceeded a threshold (1958 to November 1997).

- >3m - 1 day.
- >2.5m - 3 days.
- >2m - 6 days.
- >1.5m - 31 days.
- >1m - 116 days.

The coping of the channel is approximately 3m above the invert and thus only one event (February 1959) has exceeded the capacity of the channel in approximately 62 years of record (1958 to 2020). A review of Figure 6 indicates that since 1974 (46 years) no event has exceeded 2m on the gauge but 5 events did in the period from 1958 to 1974. Unfortunately, this means that calibration can only be undertaken on events smaller than 2m gauge height as the two UNSW pluviometers were not in operation until 1980.

Reference 1 included Table 7 which listed the largest events recorded on the UNSW gauge above 2.0 m. These height data were obtained from inspection of the gauge charts or estimated from debris (Reference 8). The corresponding digital records are shown alongside in Table 7.

Table 7: UNSW Gauge at Elva Street - Major Floods (> 2.0 m) taken from Reference 2

Rank	Year	Date	Gauge Height (m)	Peak Level (m AHD)	Gauge Height (m) from Digital Record
1	1961	18 Nov	4.18 *	9.43	**No Record**
2	1964	10 Jun	3.52 *	8.77	**1.8**
3	1959	18 Feb	3.29 *	8.54	**3.26**
4	1972	29 Oct	3.20	8.45	**0.9**
5	1970	9 Dec	3.09	8.34	**Gauge failed**
6	1963	13 Dec	2.40	7.65	**2.47**
7	1973	9 Apr	2.35	7.60	**0.7**
8	1974	25 May	2.34	7.59	**2.23**

* Estimated from debris.
Gauge zero is RL 5.25 m AHD.

A limited number of gaugings (height v velocity measurements) have been undertaken enabling the construction of a rating curve (height versus flow). Whilst in theory this approach appears very simple it becomes complex for several reasons, including:

- the events occur within a few hours and thus it was very hard for the UNSW staff to get to the gauge whilst a flood was in progress.
- the above means that there are several low flow gaugings but very few high flow gaugings which are more relevant for use in a flood study.
- a gauging was taken by the UNSW at high flows which produced velocities above the rating of the instrument (say above 5 m/s). Thus, even this gauging could not confidently determine the peak flow.

Rating curves from various sources are provided on Figure 7.

2.9.2. Sydney Water Gauge

This gauge, which is located on Powells Creek under the M4, has only recorded one significant flood (January 1996) since it was installed in 1995. The gauge zero is RL 2.15 m AHD and the January 1996 flood peaked at 2.04 m (4.19 m AHD) at 14:05 hours. Three streamflow gaugings have been undertaken. All gaugings are below 0.1 m gauge height (flow <2 m^3/s). Extrapolation of the rating curve based on these data is not appropriate and as a result flow data from this gauge have not been used for calibration of the hydrologic model.

2.10. Flood Levels from Debris or Other Marks

2.10.1. Resident Interviews

As part of the 1998 Powells Creek Flood Study (Reference 1) and earlier studies (refer Table 1) questionnaires were distributed to residents to collect information about past flood events. Prior to the 1998 Powells Creek Flood Study the responses were generally concerned with drainage issues (blocked pits, minor overland flow) and not with identifying historical flood levels. The only exception to this was at Airey Park (Saleyards Creek) for the January 1996 event.

Data obtained from residents should be used with caution for several reasons, including:

- residents may have only been in the study area for a short period.
- residents may have "missed" a flood whilst they were away.
- the more recent events are remembered more clearly than (say) a larger event several years ago.
- some events noted by residents may be because of a blocked drain or other local factors and are more typically referred to as local drainage problems rather than flood related.
- residents can easily forget the date of a flood or become confused about the extent and nature of the problem. Experience has shown that water entering a house may have resulted from a leak in the gutter or a local drainage problem in the yard rather than overbank flow from the main creek.

Table 8 provides the most widely remembered events obtained from the results of the 1998 Powells Creek Flood Study (Reference 1) and previous questionnaire surveys. Note the questionnaire surveys were not provided to Canada Bay residents.

Table 8: Significant Floods Obtained from 1998 Flood Study Questionnaire

Approximate Date	Comment
? 1930's	Infrequently mentioned.
1943	Infrequently mentioned.
18 February 1959	Infrequently mentioned.
? 1960's	Infrequently mentioned.
November 1961	Infrequently mentioned.
? 1964	Infrequently mentioned.
? 1973	Infrequently mentioned.
August 1986	Appears to be the largest event in the last 30 years
March/April and July 1988	Infrequently mentioned.
January 1989	Widely remembered.
February 1990	Widely remembered, larger than 1996 in Saleyards Creek
March 1990	Infrequently mentioned.
April 1990	Infrequently mentioned.
March 1991	Widely remembered.
2 December 1992	Infrequently mentioned.
February 1995	Infrequently mentioned.
October 1995	Infrequently mentioned.
June 1995	Infrequently mentioned.
December 1995	Infrequently mentioned.

Table 8 indicates that 50% of the most widely remembered events are in the 1990's. This could suggest that flooding in the 1990's has been a major issue compared to other periods. This is unlikely to be the case, and merely reflects some of the points noted previously regarding obtaining data from residents. Clearly the gauge record (Figure 6) indicates the period from 1958 to 1974 had more large floods.

As part of the 1998 Powells Creek Flood Study (Reference 1) 125 questionnaires were returned out of approximately 800 hand delivered or mailed (to non-resident owners) with some followed up by telephone or field interview. Table 9 summarises the results from this survey.

Table 9: 1998 Flood Study Questionnaire Results

Total number of questionnaires returned (Note SMC LGA only)	125 (approx.15%)
Number who responded indicating that their property had been inundated by a water depth greater than 100 mm.	60 (49%)
Number not inundated.	65 (52%)
Number who could indicate a historical flood level.	39 (31%)
Number of buildings inundated above floor level*.	6 (5%)

Note: * Previous questionnaire surveys have indicated that other buildings have been inundated above floor level.

A questionnaire was distributed as part of the 2016 Powells Creek Revised Flood Study (Reference 2) with several responses identifying recent occurrences of flooding. The reported flooding was generally less than 0.1 m and would be considered nuisance flooding and has only been for general verification of model results. Further details of prior community consultation are given in Section 2.12.

2.10.2. Surveyed Flood Levels

Several historical flood levels were collected from field interviews as part of the 1998 Powells Creek Flood Study (Reference 1). Many levels were for either the January 1996 or the February 1990 events. These are shown in Table 10 and on Figure 8.

Table 10: Historical Flood Data from Field Interviews in August 1997 as part of Reference 1

Address	Date of Flood	Depth (m)	Description	Flood Level (m AHD)
No. 21 Llandilo Avenue	Approx 1990	0.05-0.08	Garage Floor Level	29.96
	Approx. 1990	0.8	North-West Corner	28.8
No. 8 Agnes Street	Jan-96	0.1	Driveway and Front Boundary	26.71
No. 41 Albyn Road	Jan-96	0.08	Crest of Driveway	22.54
	Jan-96	0.35	Low Point along West. Boundary	21.64
No. 47 Albyn Road	Jan-96	0.25	Garage Floor Level	21.18
No. 35 Redmyre Road	Jan-96	0.05-0.1	Crest of Driveway	13.26
	Jan-96	0.5	Ground Level at Back Fence	12.13
No. 37 Redmyre Road	Jan-96	0.05-0.1	Crest of Driveway	13.27
	Jan-96	0.3	Ground Level at Garage	12.21
No. 45 Churchill Avenue	Jan-96	0.1	Base Steps at Front House	10.74
No. 60 Churchill Avenue	Jan-96	0.2	Ground Level at Path Granny Flat	11.49
No. 66 Churchill Avenue	18th February 1959	0.3	Floor Level	12.06
Upstream Railway crossing near Elva Street	Unknown		Top coping LHS looking Downstream	8.1
			Top coping RHS looking Downstream	7.83
Pharmacy adjoining Plaza Entrance, The Boulevarde	Jan-96		Floor Level - water entered shop	12.29
No. 11 The Boulevarde (Gumbleys Butchery - now gone)	Nov-61	0.3	Estimated Floor Level	12.55
No. 26 Barker Road	Regularly	0.1	Drive at Boundary	25.83
No. 65 Oxford Street	Jan-96	0.45	Carport Slab	24.16
No. 63 Oxford Street	Jan-96	0.3	South-West corner of house	23.75
No. 61 Oxford Street	Jan-96	0.5	Garage Floor Level	23.24
No. 59 Oxford Street	Jan-96	-	Patio Level	23.14
No. 141 Albert Street	Approx. 1990	0.3	Ground level along eastern fence	19.51

Address	Date of Flood	Depth (m)	Description	Flood Level (m AHD)
No. 135 Albert Street	Approx. 1990	0.5	Bottom steps rear of house	18.49
No. 137 Albert Street	Feb-90	-	Crest of driveway	19.24
	Feb-90	-	Water reached floor level	19.01
No. 100 Beresford Road	Feb-90	0.1	Driveway at entrance to house	15.91
No. 102 Beresford Road	Feb-90	0.12	Ground level at back door	16.43
No. 104 Beresford Road	Feb-90	0.55	Ground level rear house	17
No. 110 Beresford Road	Feb-90	0.35	Midway along eastern fence	17.5
No. 53 Beresford Road	Feb-90	0.05	Garage floor level	15.29
No. 108 Beresford Road	Feb-90	0.34	Base steps rear house	17.49
No. 89 Rochester Street	Feb-90	0.1	Floor level shop	12.84
No. 107 Rochester Street	Jan-89	0.45	GL at rear of house	14.12
No. 109 Rochester Street	Feb-90	0.42	Base steps rear house	14.33
	Jan-96	0.24	Base steps rear house	14.15
No. 57 Rochester Street	Jan-96	0.41	Ground level back yard	9.92
No. 28 Broughton Road	Approx. 1992	0.24	North east corner of house	12.88
No. 33-35 Burlington Road	1989	0.3	Garage Floor Level	9.14
No. 38-46 Burlington Road (Hairdresser)	Feb-90	0.48	Ground level at rear shed	9.71
No. 48 Burlington Road	Jan-96	0.1	Ground Floor Level	9.55
No. 29 Burlington Road	Feb-90	-	Stormwater reached this level at rear of factory	9.16
No. 30 The Crescent (Unit No. 2)	Jan-96	0.4	Garage Floor Level	8.7
No. 31 The Crescent	Jan-96	0.2	Garage Floor Level	8.33
No. 79 The Crescent	Feb-90	0.3	Floor level	8.2
	Jan-96	0.28	Base patio at rear	7.75
No. 12 Loftus Crescent	Feb-90	0.15	Ground level backyard	7.87
No. 82 Underwood Road	Feb-90	0.45	Ground level at front house and driveway	4.97
No. 86 Underwood Road	Jan-96	0.3	Base steps front house	4.89
No. 90 Underwood Road	Jan-96	0.16	Base steps front of house	4.74
No. 22 Ismay Avenue	Approx. 1986	0.3	Ground at back fence	2.2
No. 34 Ismay Avenue	Jan-90	0.35	Path at back door	2.57
No. 60 Ismay Avenue	Jan-96	0.1	Ground level at front of house	3.83
No. 55 Ismay Avenue	Feb-90	0.37	Base front steps	4.3
	Jan-96	0.18	Base front steps	4.11
No. 51 Ismay Avenue	Feb-90	0.3	Base front steps	4.19

Address	Date of Flood	Depth (m)	Description	Flood Level (m AHD)
No. 56 Ismay Avenue	Feb-90	0.2	Base front steps	3.83
No. 49 Ismay Avenue	Jan-96	0.22	Base front steps	4.16
No. 48 Ismay Avenue	Jan-96	0.15	Base front steps	3.43
No. 41 Ismay Avenue	Feb-90	0.14	Base front steps	3.71
	Jan-96	0.07	Base front steps	3.64
No. 17 Pemberton Street	1992	0.4	Ground level backyard	16.95
No. 27 Pemberton Street	1992	0.17	Base steps rear house	18.72
No. 10 Mitchell Road	Jan-96	0.28	Ground level low side house	14.75
No. 6 Mitchell Road	Jan-96	0.24	Ground level low side house	14.35
No. 104 Arthur Street	Jan-96	0.27	Ground level front of house	13.87
No.106 Arthur Street	Jan-96	0.34	Ground level at boundary	13.85
No. 105 Arthur Street	Jan-96	0.55	Ground level at house steps side house	13.89
No. 29 Arthur Street	Jan-96	0.16	Base front steps	13.23
	Jan-96	0.4-0.5	Ground level at rear fence	12.98
No. 6 Kessell Avenue	Jan-96	0.44	Ground level at fence	7.76
	Feb-90	-	Water reached floor level	8.42
Airey Park Photos	Jan-96	0.75	Base wall No. 77	7.65

2.10.3. Sydney Water Data

SWC holds records of flooding on Powells Creek and the relevant information is provided in Table 11. These records show no instances of flooding in 1990 and only one record (Feb 1996) since 1988.

Table 11: Sydney Water Records of Flooding in the Powells Creek Catchment

Date Flooded From	Address	Depth (m)	Level Above Floor (m)	Level Above Coping (m)	Property Inundation	Comments
?/07/1952	135 Albert Road, Strathfield				Y	Flooding due to construction activity-water supply. Loss of goods.
6/05/1953	Lot 3, Allen St, Homebush					Flooding occurred where Council's bridge restricts the flow
6/05/1953	4-6 Elva St, Strathfield					Flooding occurred where the channel is deficient in capacity
6/05/1953	36 Minna St, Burwood					Flooding occurred where the channel & Council's subsidiary drainage works are deficient
6/05/1953	Lot 2 Bates St, Homebush (cnr The Crescent)					Flood waters crossed the road where Council's culvert is deficient in capacity
6/05/1953	103 Parramatta Rd, Strathfield					Flooding occurred where the channel is covered at coping level.
9/02/1956	8-10 Elva St, Strathfield			0.45	Y	At the future gauging site

Date Flooded From	Address	Depth (m)	Level Above Floor (m)	Level Above Coping (m)	Property Inundation	Comments
9/03/1958	2A Belgrave St, Burwood	0.37				Flooding of road only?
9/03/1958	4-6 Elva St, Strathfield			0.75		Flooding
9/03/1958	9 Bold St, Burwood (Minna St, Burwood - west of its intersection with Bold St)	0.53			Y	Water banked up to a max. of 0.53m deep against the northern fence of Minna St.
9/03/1958	33 Nicholson St, Burwood	0.1				Flooding of road only?
9/03/1958	20 Woodside Ave, Burwood	0.15				Flooding of road only?
9/03/1958	36A Nicholson St, Burwood	0.05			Y	Water (0.05) deep northern side Nicholson St & sewer surcharge in No. 6A
9/03/1958	24 The Boulevard, Strathfield	0.6			Y	Flood entered the shop and damaged the stock- insufficient inlets
17/02/1959	5 Bold St, Burwood		0.45		Y	Flooding occurred above garage floor level at rear of house, but 0.65m below floor level of house
17/02/1959	7 Bold St, Burwood		0.56		Y	Flooding occurred above garage floor level at rear of house, but .28m below floor level of house
18/02/1959	4-6 Elva St, Strathfield			1.14	Y	1.14m above the coping level of the Stormwater channel at Gauging Station. Floodwater entered the Elva Street and carried some of the timbers away
18/02/1959	2 Elva Street, Strathfield			1.24	Y	
18/02/1959	58 Churchill Avenue		1.5		Y	1.5 m above the kitchen floor. No damage was reported and the kitchen floor is considerably lower than the back yard.
18/02/1959	66 Churchill Avenue		0.3		Y	0.3 m above the floor. Water coming from Redmyre Road has swept through the house and damaged carpets and furniture. Many premises had been flooded.
18/02/1959	27 Minna St, Burwood	0.84			Y	Flooding occurred above the yard level at N/W corner of house but was 0.35m below floor level of house
30/10/1959	7 Bold St, Burwood					Slight flooding only. Flood water rose to 0.30m above footpath level, no houses flooded
17/11/1961	53 Ismay Ave, Homebush				Y	Flooding of homes reported.
19/11/1961	19 Oxford St, Burwood		0.15		Y	Above floor flooding
19/11/1961	21 Morwick St, Strathfield		0.3		Y	Above floor flooding
19/11/1961	26 Morwick St, Strathfield		0.025		Y	New block of home units, water rose to within .025m of floor level & 0.38m above laundry floor.
19/11/1961	41 Woodside Ave, Burwood				Y	Brick fence along the frontage collapsed
19/11/1961	19 Oxford St, Burwood		0.15		Y	Above floor flooding
19/11/1961	62/64 Oxford St, Burwood				Y	Extensive damage to fencing & back gardens

Date Flooded From	Address	Depth (m)	Level Above Floor (m)	Level Above Coping (m)	Property Inundation	Comments
19/11/1961	4-6 Elva St, Strathfield		0.87		Y	Harrisons Timber P/L flooded. Damage to motors & furniture.
19/11/1961	8-10 Elva Street				Y	Flood water was just below the floor level. Garden was ruined. Photos available
19/11/1961	7 Bold St, Burwood.				Y	Severe flooding. Flood water rose to 0.75m above footpath level on North side of Minna St - 19th 4.00 a.m. The water was held back by the side palings of the house No.7 Bold Street but eventually found an outlet through No. 27 Minna Street.
19/11/1961	27 Minna Street				Y	Water rose .1m below the floor level of the rear house
19/11/1961	35 Nicholson Street	0.73			Y	Water level was 0.73 m above ground level and .3 m below the floor level.
19/11/1961	11 The Boulevarde (Gumbleys Butchery), Strathfield.		0.3		Y	Water entered several shops & rose to about 0.30m above floor in Gumbleys Butchery at No. 11
19/11/1961	2 Elva St, Strathfield (U/S main Western Railway Line)					Considerable damage done along route of main channel. S/water unable to reach underground drains flowed over ground surface to low lying areas & followed course of original creek downstream.
7/05/1963	2 Elva Street, Strathfield			0.6	Y	Observed at 8.15am. High tide at 7.15 am= 1.4m?
20/12/1963	12, 13, 14, 15, 16 & 17 Brunswick St, Strathfield				Y	Flooding of roadway & front yards did not enter premises. Date of rain-not clear
20/12/1963	2 Elva St, Strathfield, (Railway viaduct on Main Western Line)			0.75	Y	No apparent damage to properties.
9/06/1964	2 Elva St, Strathfield - Sydney Night Patrol			1.52	Y	Flooding caused by culvert under railway + 2 curves immediately upstream. Property flooding = .9m above ground
11/06/1964	2 Elva St, Strathfield - Sydney Night Patrol			0.46	Y	Flooding caused by culvert under railway + 2 curves immediately upstream.
15/04/1969	177 Parramatta Rd, Homebush				Y	A brick retaining wall collapsed at Saleyards Ck Bch. Poor foundation
29/10/1972	2 Elva St, Strathfield - Sydney Night Patrol				Y	Water rose to 1.22m above brickwork recently added to walls within this property. Vehicles were submerged & a wooden bridge lifted & dumped 9m downstream.
29/10/1972	11 Pilgrim Avenue				Y	Basement of a block of home units was flooded by approximately 1 metre.
29/10/1972	2 Elva St, Strathfield (Railway Culvert under the Main Western Line)					Embankment surcharged - see photo
17/03/1983	167-173 Parramatta Road, Homebush	0.3			Y	Flood level 300 mm above footpath. Above floor flood in one work-shop-150mm
8/11/1984	7-9 Underwood Road, Homebush			0.6	Y	Debris mark on the fence
8/11/1984	Lot 2 Bates St, Strathfield (cnr The Crescent, Railway Culvert upstream)			0.6	Y	Debris on the embankment

Date Flooded From	Address	Depth (m)	Level Above Floor (m)	Level Above Coping (m)	Property Inundation	Comments
29/04/1988	53 Ismay St, Homebush				Y	Surface flooding of 5 houses in Ismay Ave & overland flow at Powell St.
29/04/1988	Flemington Markets, Parramatta Rd, Homebush					Channel overflowed near markets.
29/04/1988	Lot 2 Bates St, Homebush (U/S of The Crescent, Homebush)			0.3	Y	Was contained within the banks. Flood debris 800 mm above the ground at upstream railway line culvert
7/05/1988	32 The Crescent, Homebush				Y	Above floor flooding. Damage $10,000
2/02/1996	Lot C Allen St, Nth Strathfield					Debris on adjacent fences indicated water flowed 500mm above upstream headwall. Flooding confined to adjacent park.
2/02/1996	24 Pomeroy St, Strathfield			0.3	Y	

2.11. Flood Photographs

Several flood photographs taken during floods were provided by SMC and these are shown on Figure 5.

2.12. Community Consultation

Community consultation was undertaken as part of the 2016 Powells Creek Revised Flood Study (Reference 2) to inform the community about the study and gather information on historical flood events. A one-page newsletter detailing the study's purpose was sent to approximately 300 addresses in the study area which excluded Burwood and Canada Bay LGA.

From the questionnaire, twelve responses were received, constituting a response-rate of around 5%. The results from the questionnaires are as follows:

- All responses were from residential properties, with most having lived there for more than 15 years.
- 7 respondents had experienced flooding, with all instances involving water above floor level of the house or other buildings.
- Approximately 9 events in the last 20 years were identified as causing flooding, with flooding reported in 1995, 1996, 1998, 2005, 2010, three times in 2014 and 2015. However, most events had only one reported instance of flooding, and apart from a 0.3 m depth reported for 1995, all depths were 0.2 m or less. No event was consistently mentioned in the responses which suggests that some variation in flood behaviour occurred between similar events, for example due to pit or pipe blockage, location of the rainfall burst or localised effects on flow behaviour.

Figure 8 shows the location of the respondents, alongside the previous consultation and the Sydney Water historical data.

3. APPROACH

The approach adopted in flood studies to determine design flood levels largely depends upon the objectives of the study and the quantity and quality of the data (survey, flood, rainfall, flow etc.). Whilst there is a limited flood record from the Elva Street gauge there is no extensive historical flood record elsewhere on Powells Creek or on Saleyards Creek. A flood frequency approach can be undertaken at the Elva Street gauge. However, reliance must also be made on the use of design rainfalls and establishment of a hydrologic/hydraulic modelling system to determine design flood levels away from the gauge. A diagrammatic representation of the flood study process undertaken in this manner is shown on Diagram 2.

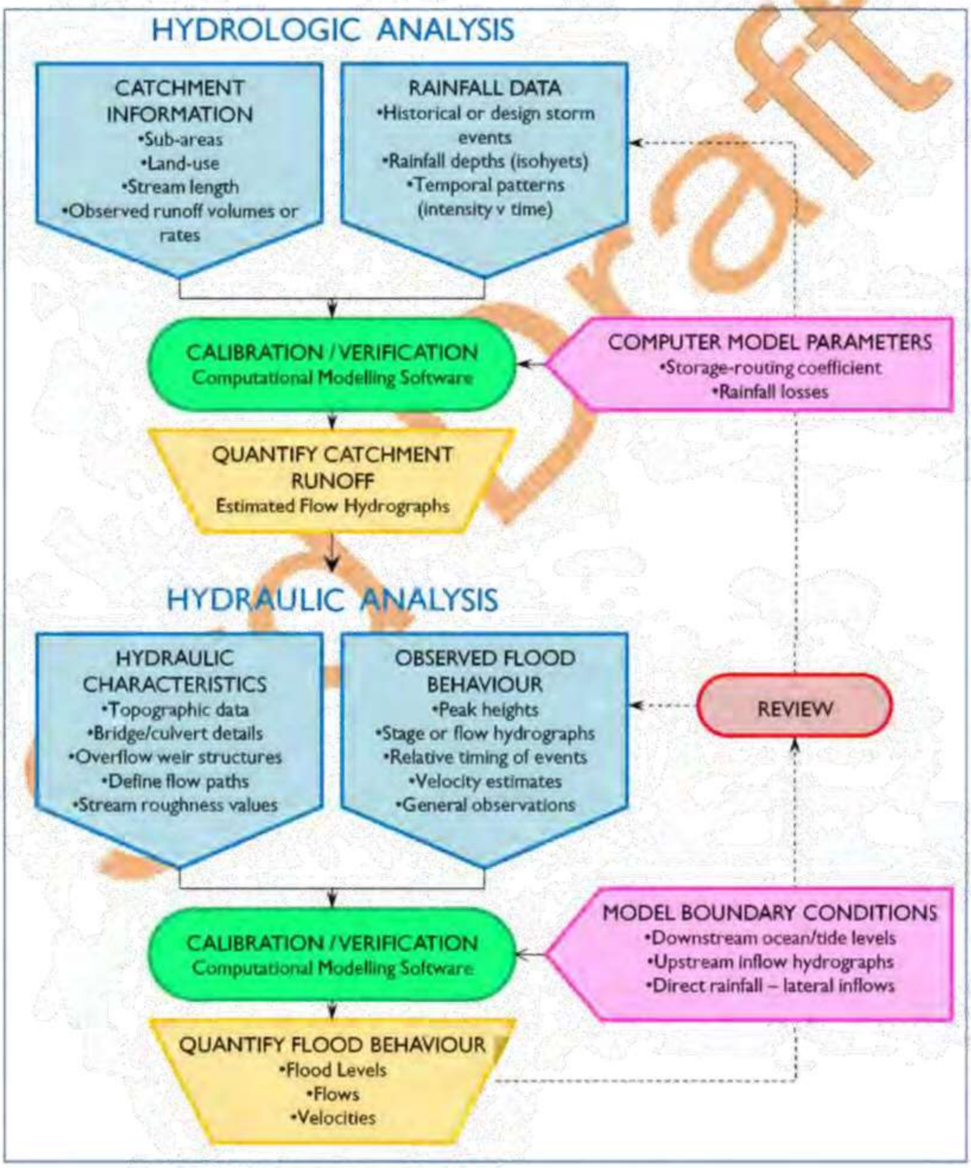


Diagram 2: Flood Study Process

The estimation of flood behaviour in a catchment is undertaken as a two-stage process, consisting of:

1. hydrologic modelling to convert rainfall estimates to overland flow and stream runoff; and
2. hydraulic modelling to estimate overland flow distributions, flood levels and velocities.

As such, the hydrologic model, DRAINS, was built and used to create flow boundary conditions for input into a two-dimensional unsteady flow hydraulic model, TUFLOW.

Good historical flood data facilitates calibration of the models and increases confidence in the estimates. The calibration process involves modifying the initial model parameter values to produce modelled results that concur with observed data. Validation is undertaken to ensure that the calibration model parameter values are acceptable in other storm events with no additional alteration of values. Recorded rainfall and stream-flow data are required for calibration of the hydrologic model, while historic records of flood levels, velocities and inundation extents can be used for the calibration of hydraulic model parameters. In the absence of such data, model verification to peak level data is the only option and a detailed sensitivity analysis of the different model input parameters constitutes current best practice.

The use of a flood frequency approach for the estimation of design floods and/or independent calibration of the hydrologic model is possible for the Powells Creek catchment using the Elva Street water level gauge data.

The broad approach adopted for this study was to use a widely utilised and well-regarded hydrologic model to conceptually model the rainfall concentration phase (including runoff from roof drainage systems, gutters, etc.). The hydrologic model (DRAINS - Reference 5) used design rainfall patterns specified in ARR2019 (Reference 5) and the runoff hydrographs were then used in a hydraulic model (TUFLOW - Reference 10) to estimate flood depths, extents, velocities and hazard in the study area.

The sub-catchments in the hydrologic model were kept small such that the overland flow behaviour for the study area was generally defined by the hydraulic model. This joint modelling approach was then verified against previous studies and historical data where possible.

3.1. Hydrologic Model

Inflow hydrographs are required as inputs at the boundaries of the hydraulic model. Typically, in flood studies a rainfall-runoff hydrologic model (converts rainfall to runoff) is used to provide these inflows. A range of runoff routing hydrologic models is available as described in ARR2019 (Reference 5). These models allow the rainfall depth to vary both spatially and temporarily over the catchment and readily lend themselves to calibration against recorded data.

DRAINS is a hydrologic/hydraulic model that can simulate the full storm hydrograph and can describe the flow behaviour of a catchment and pipe system for real storm events, as well as statistically based design storms. It is designed for analysing urban or partly urban catchments where artificial drainage elements have been installed.

Runoff hydrographs for each sub-catchment area are calculated using the time area method and the conveyance of flow through the drainage system is then modelled using the Hydraulic Grade Line method. DRAINS is limited to development of hydrological inputs into the downstream TUFLOW model and is not used to determine flood levels.

3.2. Hydraulic Model

The availability of high-quality LiDAR/ALS data means that the study area is suitable for two-dimensional (2D) hydraulic modelling. Various 2D software packages are available and the TUFLOW package (Reference 10) was adopted as it is widely used in Australia.

The TUFLOW software is produced by BMT WBM and has been widely used for a range of similar projects. The model is capable of dynamically simulating complex overland flow regimes. It is especially applicable to the hydraulic analysis of flooding in urban areas which is typically characterised by short duration events and a combination of supercritical and subcritical flow behaviour.

The study area consists of a wide range of developments, with residential, commercial, and open space areas. The study area objectives require accurate representation of the overland flow system including kerbs and gutters and defined drainage controls.

For the hydraulic analysis of complex overland flow paths (such as the present study area) where overland flow occurs between and around buildings), an integrated 1D/2D model such as TUFLOW provides several key advantages when compared to a 1D only model. For example, a 2D approach can:

- provide localised detail of any topographic and/or structural features that may influence flood behaviour.
- better facilitate the identification of the potential overland flow paths and flood problem areas.
- dynamically models the interaction between hydraulic structures such as culverts and complex overland flow paths; and
- inherently represent the available floodplain storage within the 2D model geometry.

Importantly, a 2D hydraulic model can better define the spatial variations in flood behaviour across the study area. Information such as flow velocity, flood levels and hydraulic hazard can be readily mapped across the model extent. This information can then be easily integrated into a GIS based environment enabling the outcomes to be readily incorporated into planning activities. The model developed for the present study provides a flexible modelling platform to properly assess the impacts of any overland flow management strategies within the floodplain as part of the ongoing floodplain management process.

In TUFLOW the ground topography is represented as a uniformly spaced grid with a ground elevation and a Manning's "n" roughness value assigned to each grid cell. The grid cell size is determined as a balance between the model result definition required and the computer run time (which is largely determined by the total number of grid cells).

3.3. Australian Rainfall and Runoff 2019

ARR2019 (Reference 5) has introduced many changes to the data and methodology used on flood studies compared to ARR1987 (Reference 4).

3.3.1. Overview

The ARR guidelines were updated in 2019 due to the availability of numerous technological developments, a significantly larger rainfall dataset since the previous edition in 1987 and development of updated methodologies. The rainfall dataset includes a larger number of rainfall gauges which continuously recorded rainfall (pluviometers) and a longer record of storms (events from 1985 to 2015 are included).

This study updates the flood study of the entire Powells Creek catchment in accordance with the ARR2019 methodologies.

3.3.2. ARR2019 – Design Rainfall Update

Three major changes have been made to the approach adopted in ARR1987 (Reference 4) in ARR2019 (References 5).

1. The recommended Intensity, Frequency and Duration (IFD) rainfall data and initial and continuing loss values across Australia have been updated based on analysis of available records (available on the BoM website).
2. ARR2019 recommends the analysis of 10 temporal patterns for each storm duration to determine the critical storm event. The critical storm event for a duration corresponds to the temporal pattern which produces the maximum average peak value from the 10 storms: and
3. The inclusion of Areal Reduction Factors (ARFs) based on Australian data for short (12 hours and less) and long durations (larger than 12 hours). ARFs are an estimate of how design rainfall intensity varies over a catchment, based on the assumption that large catchments will not have a uniform depth of rainfall across their entire area. Based on the size of the Powells Creek catchment an ARF was not used for this study.

3.3.3. IFD Data

Revised IFD curves are available on the BoM website. Diagram 3 indicates the change in rainfall intensities between the ARR1987 and ARR2019 IFD data sets for the study area. The following are noted.

- there is an overall decrease in design intensities for the catchment for all durations greater than 10 minutes.
- the decrease in design intensities is much higher (decreases up to 34%) for durations up to 6 hours.

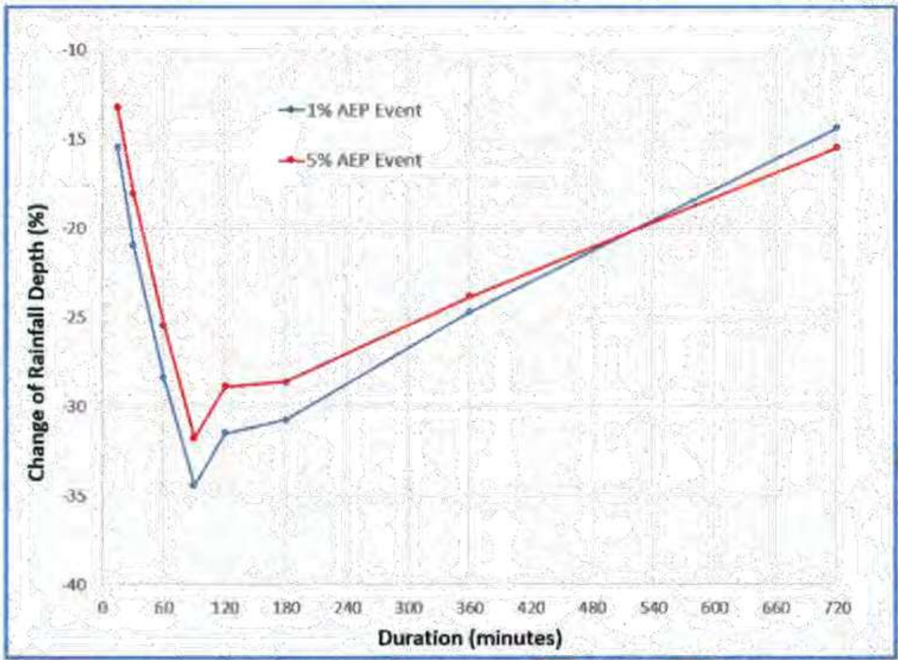


Diagram 3: Change in Rainfall Intensity for 1% AEP and 5 % AEP 2019 v 1987 IFD

It is important to note that the rainfall duration which produces the peak flood levels (termed the critical duration) varies across the catchment. In the upper parts of the Powells Creek catchment, where the catchments are small, the critical duration may be 30 minutes but as the catchment size increases so does the critical duration. In the lower parts of the catchment the critical duration may approach 6 hours. Thus, based on Diagram 3 the volume of rainfall and likely runoff volumes (affected by loss rates) are reduced with the revised ARR2019 IFD data. The change in intensity for longer duration events (12 hours or more) is of little consequence for flooding in this catchment as these events do not produce the highest flood level.

3.3.4. Accuracy of the 2019 IFD Data

The 2019 IFD data can vary significantly from the previous 1987 IFD data (Diagram 3). This issue is addressed by the text below taken from the BoM's web site (May 2019).

> The 2016 IFDs are based on a greatly expanded rainfall database and use contemporary methods for analysis of the rainfall data. In addition, the length of record available for each station has been maximised through quality control processes and Region of Influence methods. The 2016 IFDs provide a better overall fit to the current rainfall database than the old IFDs.
>
> As with all statistical methods, there is a level of uncertainty in the derived results due to the variability inherent in the data sample. In the 2016 IFDs this uncertainty has been reduced through the increased sample size afforded by the additional years of recorded data and inclusion of significant amounts of rainfall data from water agencies around the country.

The process of developing the new IFDs was guided and reviewed by a panel of experts set up by Engineers Australia. The differences in methods between the new IFDs and the ARR1987 IFDs are summarised in the table below:

Method	New IFDs	ARR1987 IFDs
Number of rainfall stations	Daily read - 8074 Continuous - 2280	Daily read - 7500 Continuous - 600
Period of record	All available records up to 2012	All available records to up ~ 1983
Length of record used in analyses	Daily read >= 30 years Continuous > 8 years	Daily read >= 30 years Continuous > 6 years
Source of data	Bureau of Meteorology & other organisations collecting rainfall data	Primarily Bureau of Meteorology
Extreme value series	Annual Maximum Series (AMS)	Annual Maximum Series (AMS)
Frequency analysis	Generalised Extreme Value (GEV) distribution fitted using L-moments	Log-Pearson Type III (LPIII) distribution fitted using method of moments
Extension of sub-daily rainfall statistics to daily read stations	Bayesian Generalised Least Squares Regression (BGLSR)	Principal Component Analysis
Gridding	Regionalised at-site distribution parameters gridded using ANUSPLIN	Maps hand-drawn to at-site distribution parameters, digitised and gridded using an early version of ANUSPLIN

3.3.5. Comparison of At Site Frequency Analysis from a Specific Rain Gauge to the IFD Data on the BoM's Website

A frequent question asked is why does the at site frequency analysis of a specific rain gauge within a catchment not always match up with the IFD data obtained from the BoM web site. This issue is addressed by the text below taken from the BoM's web site (May 2019).

> Although at-site frequency analysis of the Annual Maximum Series (AMS) of observed rainfall was an integral part of the method adopted for the 2016 IFDs, it was only one of many steps used to produce the new gridded, regional IFDs.
>
> A regionalisation method was applied to give more weight to longer record stations within each region. This improved the estimates of rare (less frequent) events. A spline interpolation method was then applied to the regionalised rainfall data from across Australia to estimate gridded values for the whole country. Factors including latitude, longitude, elevation and consistency with neighbouring sites were used, in addition to rainfall characteristics at recording sites, thus allowing more reliable interpolation of rainfall depths in data sparse areas.
>
> Rainfall values from a Generalised Extreme Value (GEV) distribution fitted to the AMS at a specific duration for a particular site will vary from the point values extracted from the grid of IFD values. Although each event in the AMS is a record of the actual rainfall at a site, these measured rainfall values are effectively point samples of the rainfall distribution across Australia. Each point sample has its own uncertainty and does not represent completely the underlying population of rainfall values. The extracted grid values, created from the regionalised rainfall inputs, will generally fall within the 95% confidence limits of the GEV distribution for the specific duration at each location.

The length and period of record at a site makes a significant difference in the level of uncertainty of any at-site comparisons. Regionalisation was applied to the measured rainfall data to effectively smooth out the effects of sampling uncertainty.

3.3.6. Design Loss Data

Design initial and continuing loss values are available from the ARR2019 data hub. The Elva Street gauge has a flow rating curve but it is not considered viable to derive the design rainfall loss values from the limited historical events that are available. For calibration different loss rates can be adopted.

Current guidelines for design recommend using a range of initial losses (Table 12) that depend on the duration and the storm AEP. The data hub suggests a continuing loss of 1.8mm/h but Reference 11 suggests applying a factor of 0.4 to this value. The AEP neutral initial loss in Table 12 were used for the assessment as well as a continuing loss of 0.7 mm/h (0.4*1.8).

Table 12: Design Initial Loss Values from the Data Hub

Duration (min)	Annual Exceedance Probability					
	50%	20%	10%	5%	2%	1%
60	17.1	8.9	8.6	9.5	8.8	6.8
90	15.4	9.1	9.2	10.1	9.8	8.8
120	15.7	9.1	9.3	9.7	8.8	6.9
180	16.6	9.8	10.3	10.1	9.6	6.7
360	16.5	9.7	10.6	9.8	8.9	4.1

In an urban environment such as Powells Creek the effect of the initial loss is minimal due to the impervious nature of the catchment. Moreover, the small size of the Powells Creek catchment results in a short critical duration time (less than 6 hours) and therefore the influence of the continuous loss on the flows is also small.

3.3.7. Storm Temporal Patterns

ARR1987 provided a single temporal pattern for each storm duration for:

- events less than a 30-year ARI; and
- for events greater than a 30-year ARI.

ARR2019 provides several patterns for each storm duration. The temporal patterns were extracted from storms occurring across Australia and are different for each region. The data hub provides a table with all the temporal patterns that could be used at a given location. The temporal patterns are grouped in bins based on the intensity of the recorded storms as shown in Diagram 4.

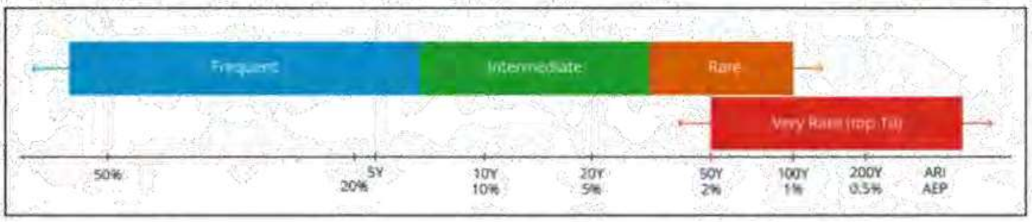


Diagram 4: Rainfall Temporal Pattern Bins

ARR2019 recommends the use of 10 temporal patterns for design storm analysis. The 10 patterns have the same total rainfall depth, but there are differences in rainfall distribution across the storm duration. Some patterns may represent storms with intense bursts at the start, middle or end of the storm duration, others represent storms with multiple bursts, and some may represent storms with constant rainfall. Different patterns can produce different peak flood levels for the same catchment area depending on the catchment topography and response.

The representative temporal pattern (used as part of the critical duration analysis) is the pattern which produces peak flood levels just greater than the average of the 10 temporal patterns (not the temporal pattern which produces the largest peak level) for each storm duration. This can be determined by running each of the 10 temporal patterns through the hydrologic and hydraulic models and obtaining the average flood level or peak flow produced. The critical storm duration for the catchment is the duration whose representative temporal pattern produces the maximum flow or level (i.e., the highest of the average values for all storm durations).

For this study peak flood levels were considered rather than peak flows. For each duration, a grid of the mean peak level at each grid cell was calculated, and from this a maximum grid was calculated taking the highest peak mean level for each grid cell. The adopted critical duration temporal pattern was the pattern which best matched or slightly exceeded this maximum grid at each grid cell.

3.4. Assessment of Data from UNSW Elva Street Gauge

3.4.1. Overview

It is important that the best possible use is made of the available data as this is the only urban catchment in Sydney where there is a long-term record for use in flood frequency analysis and which can be used to calibrate hydrologic (flows) and hydraulic (water level) models. However, there are several issues with the data, and these are discussed below.

3.4.2. Gaugings and Rating Curve

The cross-sectional area of the channel has not changed (lined 'U' shaped channel) since 1958 although the coping has been raised. The gauge zero is at RL 5.25 m AHD and over 29 stream gaugings (velocity measurements using a current meter) have been taken. The channel is well gauged below 1 m (RL 6.25 m AHD); there are 14 gaugings below 0.5 m (RL 5.75 m AHD); 14 gaugings between 0.5 m and 1.0 m; and the highest gauging is at 1.35 m (RL 6.6 m AHD). The gaugings show very little scatter and fit as a smooth line on log-log paper. Above 0.2 m depth the flow tends to be supercritical, and velocities are very high (above 4 m/s). This is the greatest source of uncertainty in the gauging as the velocity is above the normal range of the current meter used to take velocity measurements.

There are four rating curves (Figure 7) namely:

- used in Reference 8 and taken from UNSW records at the time.
- used in the 1998 Powells Creek Flood Study (Reference 1).
- used in the digital records.
- used in the 2016 Powells Creek Revised Flood Study (Reference 2) referred to as the TUFLOW model rating curve.

The 1998 Powells Creek Flood Study (Reference 1) and digital record curves are practically identical and shown as the same on Figure 7. As part of the 2016 Powells Creek Revised Flood Study (Reference 2) a rating curve was produced from the TUFLOW model. All the prior curves, whilst based on various velocity gaugings aimed to extend the rating curve beyond the highest flow gauging height of 1.35 m (RL 6.6 m AHD).

It is interesting to note that the Reference 1 rating curve and the TUFLOW model rating curves are relatively similar in magnitude at a given height. The TUFLOW model rating produces a smaller flow up to approximately 1.8 m before transitioning to produce larger flows than the Reference 1 rating above this level.

Uncertainty between the prior rating curves listed above increases once the flow breaks out of the channel (approximately at 2.5 m or RL 7.75 m AHD). The channel may also choke downstream at very high depths. Since approximately the year 2000 there have been significant changes in the number and size of the bridges across the channel in the immediate reach upstream from the railway line. There is no complete record of the dates when bridges have been removed or installed. The presence of bridges will influence the high flow rating but for most of the historic record the events were not above the coping and thus not influenced by these changes.

3.4.3. For Use in Flood Frequency Analysis

Flood frequency analysis is the fitting of a statistical distribution to either the annual maxima peaks or a partial series (events above a threshold). Partial series analysis is not possible as there are too many gaps in the record. Whilst the gaps in the record also affect the annual maxima series it is expected that this approach will still provide a robust result. Derivation of the annual maxima needs to address whether the record should be based on just the digital record or whether it should be extended to include the data shown in Table 7, and whether the record should be extended from the end of the digital record (1997) to date. It is known that there have been no large events since 1997.

The present study has adopted the flood frequency analysis derived in the 2016 Powells Creek Revised Flood Study (Reference 2). A tabulation of the annual maxima from the various sources is provided on Table 13.

Table 13: Annual Maxima Peaks

Year	Peak Stage (m) from Reference 8	Peak Stage (m) from Digital Records	Difference in Peak Stage (m)	Peak Flows from Reference 8 (m³/s)	Peak Flows from 1998 Flood Study Reference 1 (m³/s)	Peak Flows from Digital Record (m³/s)
1958		1.48			16.0	16.1
1959	3.29	3.26	0.03	29.9	48.2	49.1
1960	1.30	1.12	0.18	11.1	10.8	10.6
1961	4.18	0.79	3.39	38.3	7.0	5.9
1962	1.69	1.74	-0.05	14.8	20.0	20.3
1963	2.40	2.47	-0.07	22.0	33.0	32.1
1964	3.52	1.88	1.64	32.1	25.3	22.5
1965	1.02	0.88	0.14	8.0	8.8	7.2
1966	1.28	1.23	0.05	10.9	12.6	12.3
1967	1.52	1.40	0.12	13.2	17.2	14.9
1968	0.84	0.70	0.14	5.9	5.3	4.7
1969	1.71	1.62	0.09	15.1	18.3	18.4
1970	3.09	1.43	1.66	28.0	17.4	15.4
1971	1.93	1.10	0.83	17.8	12.1	10.3
1972	3.20	2.76	0.44	29.1	38.0	37.3
1973	2.35	2.17	0.18	21.5	33.5	27.1
1974	2.34	2.23	0.11	21.4	28.9	28.0
1975	1.58	1.52	0.06	13.8	17.0	16.7
1976	1.70	1.25	0.45	14.9	14.9	12.6
1977	1.15	1.49	-0.34	9.6	16.5	16.3
1978	1.47	1.38	0.09	12.7	15.1	14.6
1979	1.27	1.22	0.05	10.8	12.6	12.1
1980	1.26	1.27	0.00	10.7	12.7	12.8
1981	1.41	1.38	0.03	12.1	14.6	14.6
1982	1.71	1.67	0.04	15.1	19.3	19.1
1983	1.83	1.80	0.03	16.8	21.3	21.2
1984	1.84	1.81	0.03	16.9	21.3	21.4
1985	1.30	1.21	0.09	11.1	13.1	11.9
1986	1.93	1.73	0.20	17.8	20.2	20.1
1987		1.18			11.8	11.4
1988		1.92			23.1	23.1
1989		1.28			13.9	13.0
1990		1.92			23.3	23.1
1991		1.68			19.2	19.2
1992		1.53			17.1	16.9
1993		1.88				22.4
1994		1.44			6.9	15.4
1995		1.31			13.3	13.4
1996		0.90			7.8	7.4
1997		0.86			7.6	6.9

3.5. Calibration and Verification of the Modelling Process

3.5.1. Approach

As flow data is available from the Elva Street gauge this means that the catchment hydrology (flows) can be calibrated and verified at this location. This is a significant advantage for this catchment as this is possible for only approximately 10 urban catchments in Australia and less than 5 in NSW. TUFLOW model peak levels and the shape of the hydrograph can also be calibrated to water level data from the Elva Street gauge.

In addition, peak levels from TUFLOW can be calibrated to observed water level data provided by

Council and Sydney Water (Section 2.10 and Figure 8).

The stages in the modelling calibration approach were as follows (the same as adopted in Reference 2):

1. collect available historical rainfall and water level data from prior references.
2. select events for calibration and verification based on the quality and quantity of available data (same events as adopted in Reference 2).
3. input historical rainfall data for calibration event to DRAINS.
4. input output of above DRAINS model to TUFLOW.
5. run TUFLOW for historical event.
6. compare output from TUFLOW for calibration event at the Elva Street gauge and other locations where historical flood height data are available.
7. rerun steps 3 to 6 and adjust model parameters until a suitable match is obtained.
8. rerun steps 3 to 6 for verification events without adjustment of model parameters.
9. compare output from TUFLOW from verification events at the Elva Street gauge and other locations where historical flood height data are available.
10. re-run steps 3 to 9 until a satisfactory calibration/verification is achieved.

3.5.2. Calibration Events

The choice of floods used in calibration depends upon several factors including the:

- *time since the flood occurred.* The longer the time since a flood occurred, the greater the likelihood of subsequent changes to the catchment. The major changes in the upper catchment in recent times have been construction/alterations to buildings and fences in the floodplain and to the piped drainage system. The most significant change in recent times at the Elva Street gauge is construction of several bridges across the channel. However, as all the recent events suitable for calibration did not overtop the coping the impact of new bridges is not relevant.
- *quantity and quality of rainfall and streamflow data which are available*. This should have been of lesser importance in this study as data are available from two well placed pluviometers and the Elva Street water level gauge. However, problems with the UNSW rainfall and water level data meant that this became the most important factor in determining the choice of events.
- *quantity, quality, and location of recorded levels along the creeks*. It may be preferable to use a small flood with several levels which define a profile rather than a large flood with only one level. This issue is of little significance as there are few events with suitable recorded levels, apart from at the gauge.
- *magnitude of the flood levels*. The larger the flood the more suitable it is for calibration as it is closer to the larger design flood events.

The following is a summary of the available data considered suitable for calibration in the 2016 Powells Creek Revised Flood Study (Reference 2).

2 January 1996

- the Elva Street water level gauge malfunctioned, and the Elva Street pluviometer had no digital record. The St Sabina pluviometer recorded 62 mm in 45 minutes.

- only record available for Sydney Water gauge under the M4.
- 39 flood levels are available (Table 10).
- at Enfield this event approached a 1% AEP (20 min to 60 min duration) but was approximately only a 5% AEP (or less) at the other gauges.

8 or 9 February 1992

- the Elva Street gauge recorded a peak level of 1.5m and it would appear from the available pluviometer records that this was not a large event. For this reason, it is not suitable for calibration purposes.

11 March 1991

- the Elva Street gauge recorded a peak level of 1.7m and the rainfall intensity approached a 10% AEP (30-minute duration) at Enfield but the lack of other flood height data and failure of both the UNSW pluviometers meant this flood was not suitable for calibration purposes.

18 March 1990

- the flood was approximately a 20% AEP event at the St Sabina pluviometer and a 5% AEP (30-minute duration) at the Elva Street pluviometer. The peak levels and flows at the Elva Street gauge are 1.92 m and approximately 23 m^3/s (based on the UNSW rating curve).
- the availability of water level and pluviometer records from the UNSW gauges meant that this event could be used for calibration at the Elva Street gauge. However, no flood height data were available for calibration of the TUFLOW model elsewhere.

February 1990

- four peaks occurred during February 1990 (3rd, 7th, 10th, and 17th). The water level and pluviometer data (UNSW gauges) are shown on Figure 9. The peak levels and flows (based on the UNSW rating curve) at the Elva Street gauge are:
  - 3rd Feb 1990 - 1.4 m - 14 m^3/s.
  - 7th Feb 1990 - 1.4 m - 15 m^3/s.
  - 10th Feb 1990 - 1.8 m - 21 m^3/s.
  - 17th Feb 1990 - 1.1 m - 11 m^3/s.
- several flood levels (assumed to be for 10th February 1990) are available (Table 10).
- the 10th of February event was approximately a 20% AEP rainfall event (30-minute and 60-minute durations).
- the water level records indicate a peak on the morning of 8th February 1990. This is not compatible with the rainfall record which indicates that the peak was approximately 24 hours earlier. It has been assumed that the timing on the water level gauge malfunctioned.
- the availability of pluviometer and water level data from the UNSW gauges meant that all four events could be used for calibration at the Elva Street gauge. The largest event (10th February) was suitable for calibration of the TUFLOW model as it is presumed the recorded flood levels relate to this event.

4-6 August 1986:

- digital records from the Elva Street gauge show no record for this event. However, Reference 1 indicates a peak of 1.95 m obtained from data collected as part of Reference 8.
- the St Sabina pluviometer malfunctioned, and the Elva Street pluviometer recorded a maximum of 21 mm in 30 minutes which is only modest rainfall. For this reason, this event could not be used for calibration.

Summary

Five events (3rd, 7th, 10th and 17th February 1990 and 18th March 1990) were available for calibration of the Elva Street gauge and two events (10th February 1990 and 2nd January 1996) for calibration of the TUFLOW model in the 2016 Powells Creek Revised Flood Study (Reference 2). These same events were used in the current calibration process.

3.6. Design Flood Modelling

Following model establishment and calibration the following steps were undertaken:

- design tributary inflows were obtained from the DRAINS hydrologic model and included in the TUFLOW model.
- assessment of the design event causing the maximum water levels which is termed the critical storm duration.
- sensitivity analyses to assess the effect of changing model parameters and the assumed water level in the Parramatta River.
- assessment of possible effects of climate change on design flood levels.

4. HYDROLOGIC MODELLING

4.1. Sub-catchment Definition

The total catchment represented by the current DRAINS model is 9.14 km^2. This area has been represented by 781 sub-catchments (Figure 10) giving an average sub-catchment size of approximately 1.17 hectares. The sub-catchment delineation ensures that where hydraulic controls exist that these are accounted for and able to be appropriately incorporated into hydraulic routing. The pit and pipe network is shown on Figure 11. The drainage system defined in the model comprises:

- 1457 pipes.
- 1593 inlet pits.
- 487 junction pits.

4.2. Impervious Surface Area

Runoff from connected impervious surfaces such as roads, gutters, roofs, or concrete surfaces occurs significantly faster than from vegetated surfaces. This results in a faster concentration of flow within the downstream area of the catchment and increased peak flow in some situations. It is therefore necessary to estimate the proportion of the catchment area that is covered by impervious surfaces.

DRAINS categorises these surface areas as either:

- Paved areas (impervious areas directly connected to the drainage system).
- Supplementary areas (impervious areas not directly connected to the drainage system; instead, connected to the drainage system via the pervious areas) and
- Grassed areas (pervious areas).

Within the Powells Creek catchment, the impervious value was determined using the Table 14 and the land types within each sub catchment. The proportion of pervious area and remaining impervious area was defined as:

- For sub catchments with imperviousness below 25% (typically parks), the pervious area is defined as 70% of the non-impervious area and the remaining impervious area is defined as 30% of the non-impervious area.
- For sub catchments with imperviousness above 25% (typically residential properties), the pervious area is defined as 30% of the non-impervious area and the remaining impervious area is define as 70% of the non-impervious area.

Table 14: Impervious Percentage per Land-use

Land-use Category	Impervious Percentage
Residential/Commercial property	60% Impervious
Non-bitumen road reserve	60% Impervious
Vacant non hard surface land	0% Impervious
Green space (such as public parks)	0% Impervious
Roadway/Car parks	100% Impervious
Urbanised land within Canada Bay LGA	70% Impervious
Waterways	0% Impervious

4.3. Rainfall Losses

Methods for modelling the proportion of rainfall that is "lost" to infiltration are outlined in ARR2019 (Reference 5). The methods are of varying degrees of complexity, with the more complex options only suitable if sufficient data are available. The method most typically used for design flood estimation is to apply an initial and continuing loss to the rainfall. The initial loss represents the wetting of the catchment prior to runoff starting to occur and the continuing loss represents the ongoing infiltration of water into the saturated soils while rainfall continues.

Rainfall losses from a paved or impervious area are considered to consist of only an initial loss (an amount sufficient to wet the pavement and fill minor surface depressions). Losses from grassed areas are comprised of an initial loss and a continuing loss as indicated in Section 3.3.6.

4.4. Design Rainfall Data

Rainfall intensities were derived from the BoM website using ARR (Reference 5) data (Table 6). Calculation of the Probable Maximum Precipitation (PMP) was undertaken using the Generalised Short Duration Method (GSDM) according to Reference 9.

For the PMP estimate the following criteria applied:

- as the catchment area is less than 1000 km^2 and located in the coastal transitional area the Generalised Short Duration Method (GSDM) was adopted.
- zero adjustment for elevation was assumed as the catchment topography is less than 1500 m AHD.
- a moisture adjustment factor of 0.7 was adopted.
- the catchment is assumed to be 100% 'smooth'.

5. HYDRAULIC MODELLING

5.1. TUFLOW

The TUFLOW modelling package includes numerical scheme for the solution of the depth averaged shallow water equations in two dimensions. The TUFLOW software has been widely used for a range of similar floodplain projects both internationally and within Australia and is capable of dynamically simulating complex overland flow regimes. The TUFLOW model build used in this study is 2020-10-AA-iSP-w64 and further details regarding TUFLOW software can be found in the User Manual (Reference 10).

The model uses a regularly spaced computational grid, with a cell size of 2 m by 2 m. This resolution was adopted as it provides an appropriate balance between providing sufficient detail for roads and overland flow paths, while still resulting in workable computational run-times. The model grid was established by sampling from a DEM generated from a triangulation of filtered ground points from the ALS dataset, discussed in Section 2.4 and shown in Figure 3.

The TUFLOW hydraulic model includes the Powells Creek catchment to Homebush Bay with the open channel in 1D and the overland areas in 2D. The total area included in the 2D model is approximately 10 km^2. The extents of the TUFLOW model are shown in Figure 12.

5.2. Boundary Locations

Local runoff hydrographs were extracted from the DRAINS model for inclusion within the TUFLOW model domain. These were applied to the downstream end of the sub-catchments within the 2D domain of the hydraulic model. The inflow locations typically corresponded with inlet pits on the roadway as this is where most rainfall is directed.

The downstream boundary was located at the Parramatta River, as shown in Figure 12.

5.3. Roughness Co-efficient

The hydraulic efficiency of the flow paths within the TUFLOW model is represented in part by the hydraulic roughness or friction factor formulated as Manning's "n" values. This factor describes the net influence of bed roughness and incorporates the effects of vegetation and other features which may affect the hydraulic performance of the flow path.

The Manning's "n" values adopted, including flow paths (overland, pipe and in-channel), are shown in Table 15 and were based on site inspection and past experience in similar floodplain environments.

Table 15: Manning's "n" values adopted in TUFLOW

Material	Manning's "n" Value
Bitumen road reserve and some car parks	0.02
Green space - golf course, parks, vacant lots	0.04
Residential/urban area	0.03
Non-bitumen road reserve	0.032
Waterways	0.015
Pipes	0.012

5.4. Hydraulic Structures

5.4.1. Buildings

Buildings and other significant features likely to act as flow obstructions were incorporated into the model network based on building footprints, defined using aerial photography. These types of features were modelled as impermeable obstructions to the floodwaters.

5.4.2. Fencing and Obstructions

Smaller localised obstructions within or bordering private property, such as fences, were not explicitly represented within the hydraulic model, due to the relative impermanence of these features. The cumulative effects of these features on flow behaviour were assumed to be addressed partially by the adopted roughness parameters.

5.4.3. Bridges

Key hydraulic structures were included in the hydraulic model, as shown in Figure 12, bridges were modelled as 1D features within the 1D channels, with the purpose of maintaining continuity within the model.

The modelling parameter values for the culverts and bridges were based on the geometrical properties of the structures, which were obtained from detailed survey, photographs taken during site inspections, and previous experience modelling similar structures.

5.5. Blockage Assumptions

Blockage of hydraulic structures can occur with the transportation of several materials by flood waters. This includes vegetation, garbage bins, building materials and cars, the latter occurred in the Newcastle area in the June 2007 floods. However, the disparity in materials that may be mobilised within a catchment can vary greatly.

Debris availability and mobility can be influenced by factors such as channel shear stress, height of floodwaters, severity of winds, storm duration and seasonal factors relating to vegetation. The channel shear stress and height of floodwaters that influence the initial dislodgment of blockage materials are also related to the AEP of the event. Storm duration is another influencing factor, with the mobilisation of blockage materials generally increasing with increasing storm duration.

The potential effects of blockage include:

- decreased conveyance of flood waters through the blocked hydraulic structure or drainage system.
- variation in peak flood levels.
- variation in flood extent due to flows diverting into adjoining flow paths; and
- overtopping of hydraulic structures.

Existing practices and guidance on the application of blockage can be found in:

- ARR Revision Project 11 Blockage of Hydraulic Structures (Reference 12); and
- the policies of various local authorities and infrastructure agencies.

Current modelling has been undertaken assuming no blockage of pipes, culverts and bridges greater than 225 mm in diameter. Pipes less than or equal to 225 mm in diameter were conservatively assumed to be completely blocked. On grade pits were assumed as 20% blockage and sag pits were assumed as 50% blocked. These blockage values were adopted for all events in this report unless stated otherwise.

Various scenarios have been investigated to assess the catchment's sensitivity to blockage and the results of this are discussed in Section 9. These scenarios included blockage of all pipes, blockage of bridges/culverts over the open channel, and blockage of the drainage infrastructure.

No historical evidence of blocking of structures in the catchment is available; however, it is possible that changed activities on the floodplain may mean that there may be a higher chance of blockage today than in the past. For example, colorbond fencing is much less permeable and less likely to collapse than the more traditional paling fencing. Individual palings becoming mobile in a flood are also less likely to cause blockage than a panel of colorbond fencing. In some council areas garbage bins are known to become mobile during floods and can cause blockage. In summary, it is impossible to accurately determine whether blockage will or will not be an issue in the next flood.

5.6. Ground Truthing

Inspection of the above-ground features along the catchment's overland flow paths was undertaken following calibration of the hydraulic model as part of the 2016 Powells Creek Revised Flood Study (Reference 2). This entailed producing design flood results and mapping the peak flood depth in detail across the catchment. This allowed identification of features (largely buildings) that blocked or partially blocked overland flow. Model schematisation of these features was then compared to the actual features on a site visit and the model was updated where any discrepancy was identified. Changes were minor and only impacted results in the vicinity of the modification.

6. MODEL CALIBRATION AND VERIFICATION

6.1. Introduction

It is important that the performance of the overall modelling system be substantiated prior to defining design flood behaviour. Typically, in urban areas such information is lacking. Issues which may prevent a thorough calibration of hydrologic and hydraulic models are:

- there is only a limited amount of historical flood information available for the study area; and
- rainfall records for past floods are limited and there is a lack of temporal information describing historical rainfall patterns within the catchment.

The adopted rainfall parameters for calibration of the DRAINS model are shown in Table 17. These parameters are different to those in the 2016 Powells Creek Revised Flood Study (Reference 2). They were chosen to eliminate the high storage volume at each drainage pit in TUFLOW adopted in Reference 2 to achieve a calibration.

The rainfall loss values adopted in the 2016 Powells Creek Revised Flood Study (Reference 2) for calibration and design are shown in Table 16.

Table 16: Rainfall Loss Values Adopted in the 2016 Powells Creek Revised Flood Study (Reference 2)

RAINFALL LOSSES	
Paved Area Depression Storage (Initial Loss)	1.0 mm
Grassed Area Depression Storage (Initial Loss)	5.0 mm
SOIL TYPE	3
Slow infiltration rates. This parameter, in conjunction with the AMC, determines the continuing loss	
ANTECEDENT MOISTURE CONDITONS (AMC)	3
Description	Rather wet
Total Rainfall in 5 Days Preceding the Storm	12.5 to 25 mm

The rainfall loss values adopted for calibration in the present study are provided on Table 17.

Table 17: Rainfall Loss Values Adopted in the Present Study

RAINFALL LOSSES	
Paved Area Depression Storage (Initial Loss)	1.0 mm
Grassed Area Depression Storage (Initial Loss)	5.0 mm
SOIL TYPE	1
Low runoff potential, high infiltration rates (consists of sand and gravel)	
ANTECEDENT MOISTURE CONDITONS	3
Description	Rather wet
Total Rainfall in 5 Days Preceding the Storm	12.5 to 25 mm

6.2. Results

The results of the calibration and verification process using the six historical events are shown on Figure 13 (Elva Street Gauge) and Figure 14 (across catchment) and on Table 18 (Elva Street Gauge) and Table 19 (across the catchment).

Table 18: Calibration Results - Elva Street Gauge

Date	Recorded Level (m AHD)	Modelled Level St Sabina Pluviometer (m AHD)	Difference (m)	Modelled Level Elva St Pluviometer (m AHD)	Difference (m)
3-Feb-90	6.58	6.63	0.05	6.63	0.05
7-Feb-90	6.62	6.65	0.03	6.59	-0.03
10-Feb-90	7.00	6.96	-0.14	6.91	-0.09
17-Feb-90	6.38	6.54	0.16	-	-
18-Mar-90	7.14	6.86	-0.28	-	-
2-Jan-96	-	7.91	-	-	-

Table 19: Calibration Results - Peak Heights

Address	Location	Surveyed Level 1990 February 10 (m AHD)	Surveyed Level 1996 January 2 (m AHD)	Modelled Level 1990 February 10 (m AHD)	Modelled Level 1996 January 2 (m AHD)	Difference-1990 February 10 (m AHD)	Difference-1996 January 2 (m AHD)
21 Llandilo Avenue	Garage Floor Level	29.90	-	29.93	-	0.03	-
21 Llandilo Avenue	North-West Corner	28.80	-	28.60	-	-0.20	-
8 Agnes Street	Driveway and Front Boundary	-	26.71	-	26.52	-	-0.19
41 Albyn Road	Crest of Driveway	-	22.54	-	22.48	-	-0.06
41 Albyn Road	Low Point along West. Boundary	-	21.64	-	21.56	-	-0.08
47 Albyn Road	Garage Floor Level	-	21.18	-	21.16	-	-0.02
37 Redmyre Road	Crest of Driveway	-	13.27	-	13.21	-	-0.06
37 Redmyre Road	Ground Level at Garage	-	12.21	-	12.23	-	0.02
35 Redmyre Road	Crest of Driveway	-	13.26	-	13.20	-	-0.06
35 Redmyre Road	Ground Level at Back Fence	-	12.13	-	12.11	-	-0.02
45 Churchill Avenue	Base Steps at Front House	-	10.74	-	11.06	-	0.32
60 Churchill Avenue	Ground Level at Path Granny Flat	-	11.49	-	11.47	-	-0.02
Pharmacy adjoining Plaza Entrance, The Boulevarde		-	12.29	-	12.54	-	0.25
65 Oxford Street	Carport Slab	-	24.16	-	23.95	-	-0.22
63 Oxford Street	South-West corner of house	-	23.75	-	23.61	-	-0.14
61 Oxford Street	Garage Floor Level	-	23.24	-	22.99	-	-0.25
59 Oxford Street	Patio Level	-	23.14	-	23.04	-	-0.10

Address	Location	Surveyed Level 1990 February 10 (m AHD)	Surveyed Level 1996 January 2 (m AHD)	Modelled Level 1990 February 10 (m AHD)	Modelled Level 1996 January 2 (m AHD)	Difference-1990 February 10 (m AHD)	Difference-1996 January 2 (m AHD)
141Albert Street	Ground level along eastern fence	19.51	-	19.28	-	-0.24	-
135 Albert Street	Bottom steps rear of house	18.49	-	Not Flooded	-	Not Flooded	-
137 Albert Street	Crest of driveway	19.24	-	Not Flooded	-	Not Flooded	-
137 Albert Street	Water reached floor level	19.01	-	Not Flooded	-	Not Flooded	-
100 Beresford Road	Driveway at entrance to house	15.91	-	15.77	-	-0.14	-
102 Beresford Road	Ground level at back door	16.43	-	16.23	-	-0.20	-
104 Beresford Road	Ground level rear house	17.00	-	16.59	-	-0.41	-
110 Beresford Road	Midway along eastern fence	17.50	-	17.63	-	0.13	-
108 Beresford Road	Base steps rear house	17.49	-	17.26	-	-0.23	-
53 Beresford Road	Garage floor level	15.29	-	15.05	-	-0.24	-
89 Rochester Street	Floor level shop	12.84	-	12.68	-	-0.16	-
109 Rochester Street	Base steps rear house	14.33	-	14.19	-	-0.14	-
109 Rochester Street	Base steps rear house	-	14.15	-	14.33	-	0.18
57 Rochester Street	Ground level back yard	-	9.92	-	10.10	-	0.18
38-46 Burlington Road	Ground level at rear shed	9.71	-	9.55	-	-0.16	-
48 Burlington Road	Ground Floor Level	-	9.55	-	9.54	-	-0.01
29 Burlington Road	Stormwater reached this level at rear of factory	9.16	-	8.88	-	-0.28	-
30 The Crescent	Garage Floor Level	-	8.70	-	8.75	-	0.05
31 The Crescent	Garage Floor Level	-	8.33	-	8.24	-	-0.09
79 The Crescent	Floor level	8.20	-	7.02	-	-1.18	-
79 The Crescent	Base patio at rear	-	7.75	-	7.78	-	0.03
12 Loftus Crescent	Ground level backyard	7.87	-	Local runoff	-	Local runoff	-
86 Underwood Road	Base steps front house	-	4.89	-	4.65	-	-0.24
82 Underwood Road	Ground level at front house and driveway	4.97	-	4.44	-	-0.53	-
90 Underwood Road	Base steps front of house	-	4.74	-	4.41	-	-0.33

Address	Location	Surveyed Level 1990 February 10 (m AHD)	Surveyed Level 1996 January 2 (m AHD)	Modelled Level 1990 February 10 (m AHD)	Modelled Level 1996 January 2 (m AHD)	Difference-1990 February 10 (m AHD)	Difference-1996 January 2 (m AHD)
60 Ismay Avenue	Ground level at front of house	-	3.83	-	3.80	-	-0.03
55 Ismay Avenue	Base front steps	4.30	4.11	3.32	4.11	-0.98	0.00
51 Ismay Avenue	Base front steps	4.19	Local runoff	-	-	Local runoff	-
56 Ismay Avenue	Base front steps	3.83	-	3.66	-	-0.17	-
49 Ismay Avenue	Base front steps	-	4.16	-	4.00	-	-0.16
48 Ismay Avenue	Base front steps	-	3.43	-	3.36	-	-0.07
41 Ismay Avenue	Base front steps	3.71	Local runoff	-	-	Local runoff	-
10 Mitchell Road	Ground level low side house	-	14.75	-	14.75	-	0.00
6 Mitchell Road	Ground level low side house	-	14.35	-	14.18	-	-0.17
104 Arthur Street	Ground level front of house	-	13.87	-	13.62	-	-0.25
106 Arthur Street	Ground level at boundary	-	13.85	-	13.62	-	-0.23
105 Arthur Street	Ground level at house steps side house	-	13.89	-	13.81	-	-0.08
29 Arthur Street	Base front steps	-	13.23	-	13.22	-	-0.01
29 Arthur Street	Ground level at rear fence	-	12.98	-	12.70	-	-0.28
6 Kessell Avenue	Ground level at fence	8.42	-	8.14	-	-0.28	-
6 Kessell Avenue	Water reached floor level	-	7.76	-	7.79	-	0.03

Note: Local runoff denotes when the flooding is very localised and is therefore not identified in the TUFLOW model.

6.3. Discussion of Results

6.3.1. Elva Street Gauge - Table 18 and Figure 13

Apart from 18th March 1990 and to a lesser extent 10th February 1990, there is a good match to the peak at the Elva Street gauge using the St Sabina pluviometer. The use of the Elva Street pluviometer significantly improves the match for the 10th February 1990 event compared to using the St Sabina pluviometer.

For all events, the relative timings of the water level gauge and the pluviometer are incorrect due to timing errors with the instruments. This was recognised in Reference 8 and an attempt was made to correct this by assuming that the "clocks" decrease or increase in speed linearly (this can be calculated as the on and off times are recorded and the elapsed real time can be compared to the chart time).

In general, the gauge shows a more rapid rise and fall than the model results. Thus, the model assumes a greater volume of runoff than recorded.

Where comparisons can be made, the results from the St Sabina and Elva Street pluviometer show similar shapes of hydrographs. The timing of the two pluviometers is also similar suggesting that the error in timing is the water level gauge. The two pluviometers are only 800 m apart, but timing differences may reflect the passage of a storm across the area.

6.3.2. Across the Catchment Table 19 and Figure 14

For the historical event of 10th February 1990, most of the differences between surveyed and modelled levels were within 0.2 m. However, the modelled flood level at 79 The Crescent was 1.18 m below the level recorded at the floor. The ALS at this location was 7.05 m AHD which was far lower than the recorded flood level of 8.2 m AHD.

The differences were also generally within 0.2 m for the historical event of 2nd January 1996.

In summary the results appear reasonable for these two events, but it should be noted that as both events had shallow overland depths (generally less than 0.5m) a difference of 0.2m is significant. Unfortunately, it is impossible to resurvey the locations or review whether the recorded levels are reliable. However, some confidence in the results is provided in that (certainly for 2nd January 1996) the model produces results above and below the recorded level which suggests that there is no consistent error in the modelling (e.g the peak flows are consistently too low or too high).

7. DESIGN EVENT MODELLING

7.1. Overview

There are two basic approaches to determining design flood levels, namely:

- *flood frequency analysis* – based upon a statistical analysis of the flood events, and
- *rainfall and runoff routing* – design rainfalls are processed by hydrologic and hydraulic computer models to produce estimates of design flood behaviour.

The *flood frequency* approach requires a reasonably complete homogenous record of flood levels and flows over several decades to give satisfactory results. Powells Creek is one of the two catchments in the Sydney basin that has a reasonably reliable water level record over a long period and has had velocity gaugings undertaken (required to derive a rating curve). Thus, flood frequency analysis can be undertaken. However, this approach only provides results at the gauge location and a *rainfall and runoff routing* approach, using DRAINS model results, is also required to derive inflow hydrographs to the TUFLOW hydraulic model, which determines design flood levels, flows and velocities in areas beyond the actual gauge location. This approach reflects current engineering best practice and is consistent with the quality and quantity of available data.

7.2. Critical Duration for Rainfall Runoff Approach

To determine the critical storm duration for various parts of the catchment, modelling of the range of design events was undertaken using temporal patterns from ARR2019 with the approach described in Section 3.3.7. The adopted critical storm durations are provided in Table 20.

Table 20: Adopted Critical Storm Duration Events

Design Rainfall Event	Adopted Critical Storm Duration
0.5EY	45 minutes
20% AEP	45 minutes
10% AEP	60 minutes
5% AEP	60 minutes
2% AEP	60 minutes
1% AEP	60 minutes
0.5% AEP	60 minutes
0.2% AEP	60 minutes
PMF	60 minutes

7.3. Downstream Boundary Conditions

In addition to runoff from the catchment, downstream areas can also be influenced by high water levels at the confluence of the Parramatta River and Powells Creek. Consideration must therefore also be given to accounting for the joint probability of coincident flooding from both catchment runoff and backwater effects.

A full joint probability analysis to consider the interaction of these two mechanisms is beyond the scope of the present study. It is accepted practice to estimate design flood levels in these situations using a 'peak envelope' approach that adopts the highest of the predicted levels from the two mechanisms. However, the 1986 Parramatta River Flood Study (Reference 13) indicates that in this reach of the river the design water level is determined by the tide level and no design flood levels are provided. For the present study, a constant water level of was applied to the downstream boundary for each design rainfall event as shown on Table 21. The typical tidal in Homebush Bay is +0.6 m AHD to -0.4 m AHD and the maximum ocean tide in a year is 1.1 m AHD.

Table 21: Adopted Tailwater Levels for Design Events

Design Rainfall Event (AEP)	Downstream Design Level (AEP)	Downstream Water Level (m AHD)
0.5EY	0.5EY	1.2
20%	20%	1.2
10%	10%	1.2
5%	5%	1.4
2%	5%	1.4
1%	5%	1.4
0.5%	1%	1.43
0.2%	1%	1.43
PMF	1%	1.43

7.4. Design Results

The results from this study are presented on figures as summarised below.

- Peak flood level profiles in Figure 15.
- Peak flood depths and level contours in Figure 16.
- Peak flood velocities in Figure 17.
- Provisional hydraulic hazard in Figure 18 and
- Provisional hydraulic categorisation in Figure 19.

The definition and methodology used to derive these categorisations from the results are discussed below.

7.4.1. Summary of Results

Peak flood levels, depths and velocities at key locations within the catchment are summarised in Table 22, Table 23 and Table 24 for the design events. These key locations coincide with the key locations used for the sensitivity analysis discussed in Section 9 and are shown on Figure 4.

Table 25 provides the peak flows at Homebush Bay Drive for the design events.

Table 22: Peak Flood Levels (m AHD) at Key Locations – Design Events

ID	Location	1.0 EY	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP	0.5% AEP	0.2% AEP	PMF
H01	Pedestrian Bridge 2	1.34	1.42	1.51	1.66	1.70	1.74	1.78	1.82	2.67
H02	Pedestrian Bridge 1	1.30	1.36	1.42	1.59	1.63	1.66	1.70	1.74	2.48
H03	Front of community Centre	1.97	2.00	2.01	2.02	2.03	2.03	2.06	2.15	3.55
H04	Railway underpass 2 East side	7.41	7.44	7.46	7.47	7.49	7.50	7.52	7.53	8.56
H05	Railway underpass east side	6.08	6.23	6.34	6.41	6.55	6.63	6.72	6.84	8.36
H06	Railway underpass west Side	5.88	6.06	6.14	6.20	6.32	6.36	6.43	6.52	6.58
H07	7 Concord Avenue low point	1.55	1.72	1.79	1.88	1.93	2.00	2.06	2.14	3.55
H08	George Street low point near soccer field	2.44	2.89	2.98	3.16	3.29	3.43	3.59	3.89	4.56
H09	Powells Creek @ Argonne Street	1.83	1.84	1.85	2.00	2.09	2.16	2.23	2.32	4.10
H10	Powells Creek @ Pomeroy Bridge		2.40	2.53	2.55	2.60	2.64	2.67	2.71	3.85
H11	Powells Creek @ Allen Street	2.98	3.32	3.44	3.54	3.63	3.70	3.76	3.87	5.28
H12	Powells Creek @ Brussels Street	1.69	1.79	1.87	2.02	2.11	2.19	2.25	2.34	4.12
H13	Powells Creek @ Warsaw Street	1.79	1.85	1.93	2.07	2.17	2.25	2.31	2.40	4.17

Table 23 Peak Flood Depths (m) at Key Locations – Design Events

ID	Location	1.0 EY	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP	0.5% AEP	0.2% AEP	PMF
H01	Pedestrian Bridge 2	0.30	0.38	0.47	0.63	0.67	0.71	0.75	0.79	1.63
H02	Pedestrian Bridge 1	0.74	0.80	0.86	1.04	1.07	1.11	1.15	1.18	1.92
H03	Front of community Centre	0.16	0.18	0.20	0.20	0.21	0.22	0.24	0.33	1.73
H04	Railway underpass 2 East side	0.06	0.10	0.11	0.12	0.14	0.16	0.17	0.18	1.21
H05	Railway underpass east side	0.13	0.29	0.40	0.47	0.60	0.68	0.77	0.89	2.42
H06	Railway underpass west Side	0.24	0.42	0.51	0.57	0.68	0.72	0.79	0.88	0.94
H07	7 Concord Avenue low point	0.16	0.27	0.35	0.44	0.49	0.55	0.61	0.70	2.11
H08	George Street low point near soccer field	0.09	0.54	0.63	0.81	0.93	1.08	1.24	1.54	2.21
H09	Powells Creek @ Argonne Street	0.02	0.03	0.04	0.19	0.28	0.35	0.42	0.50	2.28
H10	Powells Creek @ Pomeroy Bridge		0.05	0.18	0.20	0.25	0.29	0.32	0.37	1.50
H11	Powells Creek @ Allen Street	1.36	1.71	1.83	1.92	2.02	2.09	2.14	2.25	3.66
H12	Powells Creek @ Brussels Street	0.07	0.16	0.25	0.40	0.49	0.56	0.62	0.71	2.49
H13	Powells Creek @ Warsaw Street	0.47	0.53	0.60	0.75	0.85	0.92	0.98	1.07	2.85

Table 24 Peak Flood Velocity (m/s) at Key Locations – Design Events

ID	Location	1.0 EY	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP	0.5% AEP	0.2% AEP	PMF
H01	Pedestrian Bridge 2	0.10	0.09	0.10	0.14	0.18	0.21	0.22	0.25	0.80
H02	Pedestrian Bridge 1	0.57	0.16	0.65	0.93	0.93	0.93	0.96	0.96	0.95
H03	Front of community Centre	0.07	0.11	0.17	0.15	0.16	0.17	0.17	0.19	0.28
H04	Railway underpass 2 East side	1.47	1.93	2.06	2.15	2.28	2.34	2.43	2.49	2.88
H05	Railway underpass east side	0.48	0.44	0.51	0.57	0.74	0.78	0.80	0.82	1.13
H06	Railway underpass west Side	0.24	0.74	0.78	0.80	0.87	0.84	0.97	1.03	1.14
H07	7 Concord Avenue low point	0.10	0.29	0.24	0.21	0.23	0.22	0.21	0.11	0.61
H08	George Street low point near soccer field	0.02	0.39	0.34	0.35	0.33	0.37	0.37	0.40	0.23
H09	Powells Creek @ Argonne Street	0.20	0.26	0.07	0.09	0.11	0.13	0.14	0.15	0.34
H10	Powells Creek @ Pomeroy Bridge		0.24	1.67	1.81	1.88	1.81	1.53	1.64	3.26
H11	Powells Creek @ Allen Street	1.77	1.87	1.90	1.93	1.98	2.01	2.03	2.05	2.32
H12	Powells Creek @ Brussels Street	0.42	0.50	0.48	0.46	0.50	0.50	0.50	0.51	0.60
H13	Powells Creek @ Warsaw Street	0.04	0.05	0.05	0.05	0.10	0.14	0.16	0.19	0.33

Table 25 Peak Flood flow (m^3/s) through Homebush Bay Drive Bridge – Design Events

Location	1.0 EY	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP	0.5% AEP	0.2% AEP	PMF
Homebush Bay Drive Bridge	45	57	69	83	95	107	116	129	503

7.4.2. Provisional Flood Hazard Categorisation

The 2016 Powells Creek Revised Flood Study (Reference 2) defined provisional flood hazard categories in accordance with the NSW Floodplain Development Manual (Reference 6). Provisional hazards only take account of the hydraulic aspects of flood hazard; depth and velocity (Diagram 5), while true hazard takes into account additional factors such as size of flood, effective warning time, flood readiness, rate of rise of floodwaters, duration of flooding, evacuation problems, effective flood access, type of development within the floodplain, complexity of the stream network and the inter-relationship between flows.

Diagram 5: Provisional Hydraulic Hazard Categories

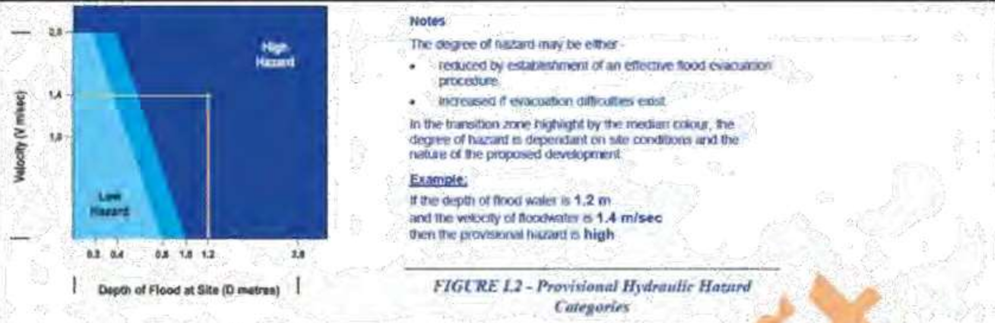


FIGURE L2 - Provisional Hydraulic Hazard Categories

Extracted from The Floodplain Development Manual (Reference 6)

In recent years there has been several developments in the classification of hazard. *Managing the floodplain: a guide to best practice in flood risk management in Australia* (Reference 14) provides revised hazard classifications. These add clarity to the description hazard categories and what they mean in practice. This new methodology for determining hazard has been used in this study.

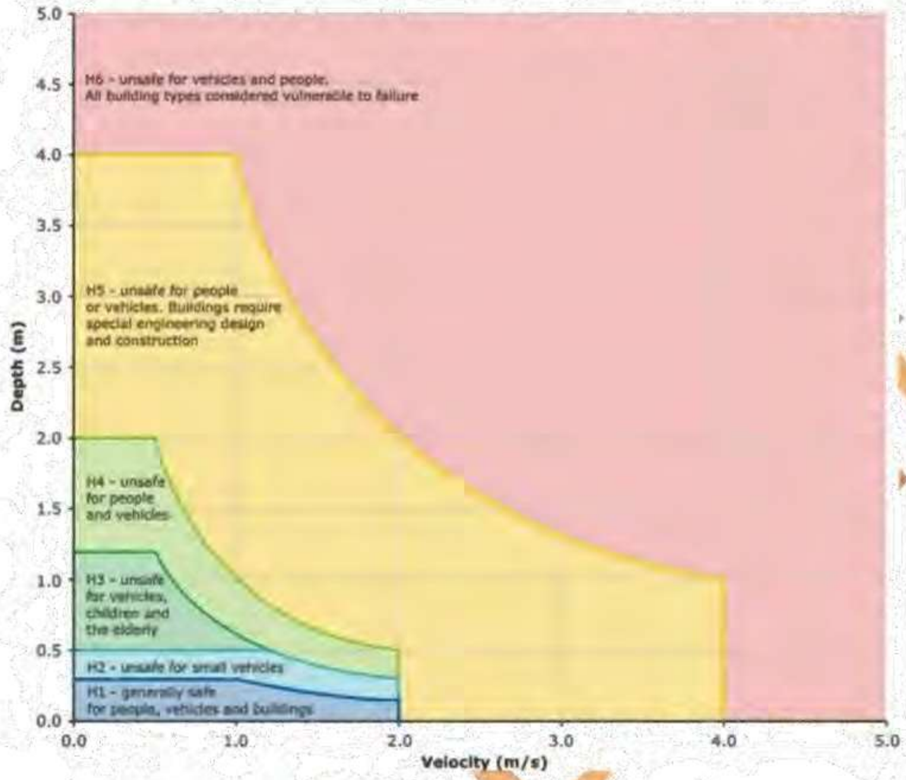
The hazard classifications are divided into six categories (Diagram 6) which indicate the restrictions on people, buildings and vehicles:

- H1 - Generally safe for vehicles, people and buildings.
- H2 - Unsafe for small vehicles.
- H3 - Unsafe for vehicles, children and the elderly.
- H4 - Unsafe for people and vehicles.
- H5 - Unsafe for people or vehicles. Buildings require special engineering design and construction, and
- H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure.

Figure 18 provides the hazard classifications based on the H1 – H6 delineations for the design events. A summary of the 1% AEP (Figure 18F) mapping indicates:

- the H5 and H6 classifications are predominantly within the Powells Creek open channel;
- the majority of the land in the residential areas are H1 (note the land adjacent to the Powells Creek open channel may have a higher classification).

Diagram 6: Hazard Classifications (Reference 14)



7.4.3. Provisional Hydraulic Categorisation

The hydraulic categories, namely floodway, flood storage and flood fringe, are described in the Floodplain Development Manual (Reference 6). However, there is no technical definition of hydraulic categorisation that would be suitable for all catchments, and different approaches are used by different consultants and authorities, based on the specific features of the study catchment in question.

For this study, hydraulic categories were defined by the following criteria (Reference 15) which have been adopted by consultants in many flood studies in NSW:

- Floodway is defined as areas where:
  - the peak value of velocity multiplied by depth (V x D) > 0.25 m^2/s **AND** peak velocity > 0.25 m/s, **OR**
  - peak velocity > 1.0 m/s **AND** peak depth > 0.15 m

The remainder of the floodplain is either Flood Storage or Flood Fringe,

- Flood Storage comprises areas outside the floodway where peak depth > 0.5m; and
- Flood Fringe comprises areas outside the Floodway where peak depth < 0.5m.

7.4.4. Preliminary Flood Emergency Response Classification of Communities

The Floodplain Development Manual, 2005 (Reference 6) requires flood studies to address the management of continuing flood risk to both existing and future development areas. As continuing flood risk varies across the floodplain so does the type and scale of the emergency response problem and therefore the information necessary for effective Emergency Response Planning (ERP). Classification provides an indication of the vulnerability of the community in flood emergency response and identifies the type and scale of information needed by the SES to assist in ERP.

Criteria for determining flood ERP classifications and an indication of the emergency response required for these classifications are provided in the Floodplain Risk Management Guideline, 2007 (Reference 16). Table 26 summarises the response required for areas of different classification. However, these may vary depending on local flood characteristics and resultant flood behaviour, i.e., in flash flooding or overland flood areas.

Table 26: Flood ERP Classifications (taken from Reference 16))

Primary classification	Description	Secondary classification	Description	Tertiary classification	Description
Flooded (F)	The area is flooded in the PMF	Isolated (I)	Areas that are isolated from community evacuation facilities (located on flood-free land) by floodwater and/or impossible terrain as waters rise during a flood event up to and including the PMF. These areas are likely to lose electricity, gas, water, sewerage and telecommunications during a flood.	Submerged (FIS)	Where all the land in the isolated area will be fully submerged in a PMF after becoming isolated.
				Elevated (FIE)	Where there is a substantial amount of land in isolated areas elevated above the PMF.
		Exit Route (E)	Areas that are not isolated in the PMF and have an exit route to community evacuation facilities (located on flood-free land).	Overland Escape (FEO)	Evacuation from the area relies upon overland escape routes that rise out of the floodplain.
				Rising Road (FER)	Evacuation routes from the area follow roads that rise out of the floodplain.
Not Flooded (N)	The area is not flooded in the PMF			Indirect Consequence (NIC)	Areas that are not flooded but may lose electricity, gas, water, sewerage, telecommunications and transport links due to flooding.
				Flood free	Areas that are not flood affected and are not affected by indirect consequences of flooding.

The criteria for classification of floodplain communities are generally more applicable to riverine flooding where significant flood warning time is available and emergency response action can be taken prior to the flood. In urban areas like the Powells Creek catchment, flash flooding from local catchment and overland flow will generally occur as a direct response to intense rainfall without significant warning. For most (if not all) flood affected properties in the catchment, remaining inside the building is likely to present less risk to life than attempting to drive or wade through floodwaters, as flow velocities and depths are likely to be greater in the roadway.

ERP classification for the study area is shown in Figure 20.

8. FLOOD FREQUENCY ANALYSIS

8.1. Overview

Flood frequency analysis (FFA) enables the magnitudes of floods (5%, 1% AEP etc.) to be estimated based on statistical analysis of recorded flows. It can be undertaken graphically or using a mathematical distribution.

The reliability of the flood frequency approach depends largely upon the length and quality of the observed record and accuracy of the rating curve. In addition, flood frequency inherently accounts for many assumptions which are required in rainfall-runoff routing for determining the magnitude of floods for annual exceedance probabilities.

This approach has the following advantages in design flood estimation:

- no assumptions are required regarding the relationship between probabilities of rainfall and runoff.
- all factors affecting flood magnitude are already integrated into the data.
- estimation of rainfall losses is not required.
- confidence limits can be estimated.
- historic rainfall data is not required.

The flood frequency approach does, however, have some limitations. These are:

- there is no "perfect" distribution", thus different distributions will provide different answers.
- as most flood records are relatively short (compared to the design event for which a magnitude is required) there is considerable uncertainty. Whilst rainfall records at a particular location are also short, data can be used by the BoM from other gauges to accurately estimate design intensities much greater than the period of record at a single gauge.
- changes to the local topography such as levee banks, hydraulic controls and the construction of retarding basins or bridges can affect the homogeneity of the data set.
- short to medium term climatic changes may influence the flood record; and
- there are many issues with the accuracy of rating curves, especially at high flows. However, this is less of an issue with the use of hydraulic models based on high quality survey (ALS) to obtain site rating curves.

While some of these factors can affect the quality of the flood frequency analysis, for the purpose of providing confirmation for the runoff routing results they are considered reasonable.

The following is a summary of the flood frequency approach undertaken in the 2016 Powells Creek Revised Flood Study (Reference 2).

8.2. Examined Annual Series

Utilising the data presented in Table 13, various data sets of annual maximum levels are available for converting to flows for the purpose of FFA. These levels can be converted into flows using one of the rating curves described in Section 3.4.2 and presented in Figure 7. Eight potential scenarios were evaluated for FFA.

8.3. Probability Distribution

ARR (Reference 5) recommends that FFA should be applied to peak flows rather than heights. In frequency analysis of flows, the fitting of a particular distribution may be carried out analytically or by fitting a probability distribution. The data may consist of an annual series, where the largest peak in each year is used, or a partial series, where all flows above a selected base value are used. The relative merits of each method are discussed in detail in ARR (Reference 5). In general, an annual series is preferable as there are more methods and experience available.

Many probability distributions have been applied to FFA and this is a very active field of research. However, it is not possible to determine the "correct" form of the distribution as there is no robust evidence that any distribution is more appropriate than another. ARR (Reference 5) provides further discussion on this issue.

Since publication of ARR (Reference 4) in 1987 there have been significant developments in the field of FFA both in Australia and overseas. The approach adopted in the 2016 Powells Creek Revised Flood Study (Reference 2) reflects these developments. Recent research has suggested that the fitting method is as important as the adopted distribution. The Flike flood frequency analysis software developed by Kuczera (Reference 17) uses the Bayesian approach and was utilised in this study.

The rating curve (height-discharge relationship) adopted for the estimation of stream flows from the recorded gauge heights is critical to the success of FFA. The FFA was conducted using the rating curve derived from the calibrated hydraulic model (refer Section 3.4).

Two probability distributions were tested, Log Pearson III (LP3) and Generalised Extreme Value (GEV) distributions and it was found that the LP3 distribution produced a better curve fit to the data.

8.4. Design Flow Results

The results of the FFA are provided on Figure 21 for the LP3 distribution. The choice of distribution was found to have some influence on design flow estimates. It was found that the LP3 distribution fit the annual series data better than the GEV distribution and was therefore selected in preference for determining design flows.

8.5. Reconciling Flood Frequency and Rainfall Runoff Results

An extensive flood frequency analysis (FFA) was carried out in the 2016 Powells Creek Revised Flood Study (Reference 2) at the Elva Street water level gauge. When compared to FFA design flow estimates (Figure 21), those from TUFLOW overestimate flows for more frequent events and generally accord with the FFA greater events.

There are many explanations as to why the flood frequency and rainfall runoff modelling do not reconcile. These are primarily due to data limitations as well as the adequacy of the hydrologic model in representing the runoff routing behaviour of the catchment. Some of the main limitations of the FFA are the limited period of record as well as rating curve errors. Due to the nature of the rating curve, high flow estimates at the Elva Street gauge are very sensitive to small changes in the water level.

In addition to potential uncertainty of the analysis it is important to realise that the flood frequency relationship may not be representative of the greater Powells Creek catchment given that the Elva Street catchment only covers a proportion of the catchment.

As FFA estimates become more uncertain for less frequent flooding such as the 1% AEP which is generally adopted for development control purposes, flow estimates from TUFLOW modelling were adopted for the current study.

9. SENSITIVITY ANALYSIS

9.1. Overview

The following sensitivity analyses were undertaken to establish the variation in design flood levels and flow that may occur if different parameter assumptions were made:

- Manning's "n": The hydraulic roughness values were increased and decreased by 20%.
- Blockage (pipes): Sensitivity to blockage of all pipes was assessed for 20% and 50% blockage.
- Climate change (rainfall increase): Sensitivity to rainfall/runoff estimates were assessed by increasing the rainfall intensities by 10%, 20% and 30% as recommended under current guidelines.
- Climate change (sea level rise): Sea level rise scenarios (elevated levels in the Parramatta River) of 0.4 m and 0.9 m were assessed.
- Comparison of results with the ARR 1987 methodology 2016 Powells Creek Revised Flood Study (Reference 2).

These sensitivity scenarios were undertaken for the 1% AEP rainfall event with a tailwater level of 1.4 m AHD in the Parramatta River.

9.2. Climate Change Background

Intensive scientific investigation is ongoing to estimate the effects that increasing amounts of greenhouse gases (water vapour, carbon dioxide, methane, nitrous oxide, ozone) are having on the average earth surface temperature. Changes to surface and atmospheric temperatures may affect climate and sea levels. The extent of any permanent climatic or sea level change can only be established with certainty through scientific observations over several decades. Nevertheless, it is prudent to consider the possible range of impacts with regard to flooding and the level of flood protection provided by any mitigation works.

Based on the latest research by the United Nations Intergovernmental Panel on Climate Change, evidence is emerging on the likelihood of climate change and sea level rise because of increasing greenhouse gasses. In this regard, the following points can be made:

- greenhouse gas concentrations continue to increase.
- global sea level has risen about 0.1 m to 0.25 m in the past century.
- many uncertainties limit the accuracy to which future climate change and sea level rises can be projected and predicted.

9.2.1. Rainfall Increase

The BoM has indicated that there is no intention at present to revise design rainfalls to take account of the potential climate change, as the implications of temperature changes on extreme rainfall intensities are presently unclear, and there is no certainty that the changes would in fact increase design rainfalls for major flood producing storms. There is some recent literature by CSIRO that suggests extreme rainfalls may increase by up to 30% in parts of NSW (in other places the projected increases are much less or even decrease); however, this information is not of sufficient accuracy for use yet (Reference 18).

Any increase in design flood rainfall intensities will increase the frequency, depth, and extent of inundation across the catchment. It has also been suggested that the cyclone belt may move further southwards. The possible impacts of this on design rainfalls cannot be ascertained at this time as little is known about the mechanisms that determine the movement of cyclones under existing conditions.

Projected increases to evaporation are also an important consideration because increased evaporation would lead to generally dryer catchment conditions, resulting in lower runoff from rainfall. Mean annual rainfall is projected to decrease, which will also result in generally dryer catchment conditions. The influence of dry catchment conditions on river runoff is observable in climate variability using the Indian Pacific Oscillation index. Although mean daily rainfall intensity is not observed to differ significantly between Indian Pacific Oscillation phases, runoff is significantly reduced during periods with fewer rain days.

The combination of uncertainty about projected changes in rainfall and evaporation makes it extremely difficult to predict with confidence the likely changes to peak flows for large flood events within the Powells Creek catchment under warmer climate scenarios.

In light of this uncertainty, the NSW State Government (Reference 18) advice recommends sensitivity analysis on flood modelling should be undertaken to develop an understanding of the effect of various levels of change in the hydrologic regime on the project at hand. Specifically, it is suggested that increases of 10%, 20% and 30% to rainfall intensity be considered.

9.2.2. Sea Level Rise

The *NSW Sea Level Rise Policy Statement* was released by the NSW Government in October 2009 (Reference 19). This Policy Statement was accompanied by the *Derivation of the NSW Government's sea level rise planning benchmarks* (Reference 20) which provided technical details on how the sea level rise assessment was undertaken. Additional guidelines were issued by OEH, including the *Flood Risk Management Guide: Incorporating sea level rise benchmarks in flood risk assessments* (Reference 21).

The Policy Statement says:

> *"Over the period 1870-2001, global sea levels rose by 20 cm, with a current global average rate of increase approximately twice the historical average. Sea levels are expected to continue rising throughout the twenty-first century and there is no scientific evidence to suggest that sea levels will stop rising beyond 2100 or that current trends will be reversed… However, the 4th Intergovernmental Panel on Climate Change in 2007 also acknowledged that higher rates of sea level rise are possible"* (Reference 19).

In light of this uncertainty, the NSW State Government's advice is subject to periodical review. As of October 2012 the NSW State Government withdrew endorsement of sea level rise predictions but still require sea level rise to be considered. This was taken as a 0.4 m rise by the year 2050 and a 0.9 m rise by the year 2100.

9.3. Results

The sensitivity scenario results were compared to the 1% AEP rainfall event and a summary of peak flood level and peak flow differences at various locations are provided in the sections below.

9.3.1. Roughness Variations

Overall peak flood level results were shown to be relatively insensitive to variations in the roughness parameter. Generally, these results were found to be within ± 0.1 m.

Table 27: Results of Roughness Variation – Change in Peak Depth (m)

ID	Location	Peak Flood Depth 5% AEP	Difference with 5% AEP (m)		Peak Flood Depth 1% AEP	Difference with 1% AEP (m)	
			Decrease roughness by 25%	Increase roughness by 25%		Decrease roughness by 25%	Increase roughness by 25%
H01	Pedestrian Bridge 2	0.63	-0.01	0.00	0.71	-0.02	0.01
H02	Pedestrian Bridge 1	1.04	-0.02	0.01	1.11	-0.02	0.01
H03	Front of community Centre	0.20	0.00	0.00	0.22	0.00	0.00
H04	Railway underpass 2 East side	0.12	-0.01	0.01	0.16	-0.01	0.01
H05	Railway underpass east side	0.47	0.00	-0.01	0.68	0.02	-0.02
H06	Railway underpass west Side	0.57	-0.01	0.01	0.72	-0.01	0.01
H07	7 Concord Avenue low point	0.44	0.00	0.00	0.55	0.00	0.00
H08	George Street low point near soccer field	0.81	0.12	-0.01	1.08	0.08	0.03
H09	Powells Creek @ Argonne Street	0.19	0.00	-0.01	0.35	0.00	-0.01
H10	Powells Creek @ Pomeroy Bridge	0.20	0.00	0.00	0.29	-0.02	0.01
H11	Powells Creek @ Allen Street	1.92	0.00	-0.01	2.09	0.00	0.00
H12	Powells Creek @ Brussels Street	0.40	0.00	-0.01	0.56	0.00	0.00
H13	Powells Creek @ Warsaw Street	0.75	0.00	-0.01	0.92	-0.01	0.00

9.3.2. Blockage Variations

Peak flood level results were found to be relatively insensitive to blockage of pipes; although generally peak flood levels increased in the upstream areas and decreased in the downstream areas (due to the retarding effect in the upstream areas).

Table 28: Results of Blockage Variation – Change in Peak Depth (m)

ID	Location	Peak Flood Depth 5% AEP	Difference with 5% AEP (m)		Peak Flood Depth 1% AEP	Difference with 1% AEP (m)	
			Decrease blockage by 25%	Increase blockage by 25%		Decrease blockage by 25%	Increase blockage by 25%
H01	Pedestrian Bridge 2	0.63	0.00	0.00	0.71	-0.01	0.00
H02	Pedestrian Bridge 1	1.04	0.00	0.00	1.11	-0.01	0.00
H03	Front of community Centre	0.20	0.00	0.00	0.22	0.00	0.00
H04	Railway underpass 2 East side	0.12	0.00	0.00	0.16	0.00	0.00
H05	Railway underpass east side	0.47	0.00	0.00	0.68	0.02	0.00
H06	Railway underpass west Side	0.57	0.00	0.00	0.72	0.01	0.00
H07	7 Concord Avenue low point	0.44	0.01	-0.02	0.55	0.02	-0.02
H08	George Street low point near soccer field	0.81	0.10	-0.21	1.08	0.14	-0.18
H09	Powells Creek @ Argonne Street	0.19	0.00	0.00	0.35	-0.01	-0.01
H10	Powells Creek @ Pomeroy Bridge	0.20	0.01	-0.01	0.29	0.00	-0.01
H11	Powells Creek @ Allen Street	1.92	0.01	-0.01	2.09	0.00	-0.01
H12	Powells Creek @ Brussels Street	0.40	0.01	0.00	0.56	-0.01	-0.01
H13	Powells Creek @ Warsaw Street	0.75	0.02	0.00	0.92	-0.02	-0.01

An additional blockage scenario investigated was the effect of 100% blockage of the culverts under Homebush Bay Drive with the results for the 1% AEP event shown on Figure 25. The figure shows that flood levels will rise by up to 0.7m. The two main areas are:

- between Victoria Avenue to the south and Concord Avenue to the north and
- the area termed Village Green surrounded by Settlers Boulevard.

9.3.3. Sea Level Rise Variations

The sea level rise scenarios were found to have an insignificant effect on peak flood levels, except in the most downstream reaches of the catchment. The open channels upstream of Underwood Road and Pomeroy Street have channel inverts of 0.35 m AHD and 0.45 m AHD (respectively) and were therefore tidally affected under current tidal conditions. Under sea level rise conditions, these locations were found to have increased peak flood levels. At Pomeroy Street the increase in peak level reduces to less than 0.1m with a 0.9m increase. The attenuation of sea level rise impacts is because of the retarding effect of the downstream mangroves and the restrictive effect of bridge structures crossing the open channel.

Table 29: Results of Sea Level Rise – Change in Peak Depth (m)

ID	Location	Peak Flood Depth 1% AEP (tailwater level of 1.4 m AHD)	Difference with 1% AEP (m)	
			Tailwater increase to 1.835 m AHD	Tailwater increase to 2.335 m AHD
H01	Pedestrian Bridge 2	0.63	0.18	0.63
H02	Pedestrian Bridge 1	1.04	0.22	0.69
H03	Front of community Centre	0.20	0.06	0.43
H04	Railway underpass 2 East side	0.12	0.00	0.00
H05	Railway underpass east side	0.47	0.00	0.00
H06	Railway underpass west Side	0.57	0.00	0.00
H07	7 Concord Avenue low point	0.44	0.10	0.46
H08	George Street low point near soccer field	0.81	0.09	0.28
H09	Powells Creek @ Argonne Street	0.19	0.13	0.46
H10	Powells Creek @ Pomeroy Bridge	0.20	0.00	0.09
H11	Powells Creek @ Allen Street	1.92	0.00	0.02
H12	Powells Creek @ Brussels Street	0.40	0.13	0.45
H13	Powells Creek @ Warsaw Street	0.75	0.12	0.42

9.3.4. Rainfall Variations

The effects of increasing the design rainfalls by 10%, 20% and 30% have been evaluated for the 1% AEP rainfall event with impacts on peak flood levels observed throughout the study area (shown in Table 30). Each incremental 10% increase in rainfall results in an approximately 0.05m to 0.08m increase in peak flood levels at most of the locations analysed. The 1% AEP event with a rainfall increase of 30% is approximately equivalent to a 0.2% AEP event in present day rainfall conditions and a significant impact on flood levels is not unexpected.

Table 30: Results of Rainfall Increase – Change in Peak Depth – 1% AEP

ID	Location	Peak Flood Depth 1% AEP	Difference with 1% AEP (m)		
			10% Rainfall increase	20% Rainfall increase	30% Rainfall increase
H01	Pedestrian Bridge 2	0.63	0.03	0.06	0.09
H02	Pedestrian Bridge 1	1.04	0.03	0.05	0.08
H03	Front of community Centre	0.2	0.02	0.08	0.14
H04	Railway underpass 2 East side	0.12	0.01	0.02	0.03
H05	Railway underpass east side	0.47	0.08	0.16	0.21
H06	Railway underpass west Side	0.57	0.07	0.11	0.14
H07	7 Concord Avenue low point	0.44	0.06	0.11	0.18
H08	George Street low point near soccer field	0.81	0.22	0.33	0.48
H09	Powells Creek @ Argonne Street	0.19	0.06	0.12	0.18
H10	Powells Creek @ Pomeroy Bridge	0.2	0.03	0.06	0.09
H11	Powells Creek @ Allen Street	1.92	0.05	0.13	0.2
H12	Powells Creek @ Brussels Street	0.4	0.06	0.12	0.18
H13	Powells Creek @ Warsaw Street	0.75	0.05	0.12	0.18

9.3.5. Comparison of 1% AEP Results with the 2016 Powells Creek Revised Flood Study (Reference 2)

A comparison of the 1% AEP peak levels and peak flows are provided in Table 31. The results indicate that along Powells Creek (where levels are available from Reference 2) there is a slight increase in peak level. This has occurred due to slightly different modelling approaches adopted (refer Sections 4 and 5).

Table 31: Comparison of 1% AEP Results with 2016 Powells Creek Revised Flood Study (Reference 2)

ID	Location	Present Study Peak Level (m AHD)	Reference 2 Peak Level (m AHD)	Present Study Peak Flow (m^3/s)	Reference 2 Peak Flow (m^3/s)
H01	Pedestrian Bridge 2	1.74	1.60	-	-
H02	Pedestrian Bridge 1	1.66	1.45	-	-
H03	Front of community Centre	2.03	NF	-	-
H04	Railway underpass 2 East side	7.50	NF	-	-
H05	Railway underpass east side	6.63	NF	-	-
H06	Railway underpass west Side	6.36	NF	-	-
H07	7 Concord Avenue low point	2.00	NF	-	-
H08	George Street low point near soccer field	3.43	NF	-	-
H09	Powells Creek @ Argonne Street	2.16	2.09	36.33	31.16
H10	Powells Creek @ Pomeroy Bridge	2.64	2.47	78.01	78.37
H11	Powells Creek @ Allen Street	3.70	3.55	55.04	60.65
H12	Powells Creek @ Brussels Street	2.19	2.12	47.58	69.95
H13	Powells Creek @ Warsaw Street	2.25	2.22	78.3	82.57

10. FLOOD PLANNING ISSUES

10.1. Preliminary Flood Planning Areas

10.1.1. Background

Land use planning is one of the most effective means of minimising flood risk and damages from flooding. The Flood Planning Area (FPA) identifies land that is subject to flood related development controls via Section 10.7 notifications under the 1979 EP&A Act. The Flood Planning Level (FPL) is the minimum floor level applied to new developments within the FPA.

The process of defining FPA's and FPL's is somewhat complicated by the variability of flow conditions between mainstream and local overland flow, particularly in urban areas. The more traditional approaches typically having been developed for riverine environments and mainstream flow.

Defining the area of flood affectation due to overland flow (which by its nature includes shallow flow) often involves determining at which point it becomes significant enough to classify as "flooding". The difference in peak flood level between events of varying magnitude may be minor in areas of overland flow, such that applying the typical freeboard can result in an FPL greater than the PMF level.

The FPA should include properties where future development would result in impacts on flood behaviour in the surrounding area and areas of high hazard that pose a risk to safety or life. Further to this, the FPL is determined with the purpose to decrease the likelihood of over-floor flooding of buildings and the associated damages.

The Floodplain Development Manual (Reference 6) suggests that the FPL generally be based on the 1% AEP event plus an appropriate freeboard. The typical freeboard cited in the manual is that of 0.5 m; however, it also recognises that different freeboards may be deemed more appropriate due to local conditions. In these circumstances, some justification is called for where a lower value is adopted.

The FPA is classified as 'provisional' as it is based on results from the current study and may be re-assessed as part of a floodplain risk management study for the catchment. Such a study would review the area's existing planning policies with respect to floodplain management, and then make recommendations (including adoption of a FPA and FPL) via a floodplain risk management plan. It may also be that the same assessment for other catchments in the LGA be undertaken so that a single LGA-wide FPA/FPL can be adopted.

10.1.2. Methodology and Criteria

The methodology used in this report is consistent with that adopted in several previous studies. It divides flooding between Mainstream flooding and Overland flooding using the following criteria.

- **Mainstream flooding:** Any property within the open channel section of Powells Creek that has land below the peak 1% AEP flood level plus a 0.5 m freeboard, with the level extended perpendicular to the flow direction.

- **Overland flooding:** Greater than or equal to 10% of the lot is affected by the 1% AEP peak flood depth of greater than 0.15 m.

In situations where a cadastral lot is subject to both mainstream flooding and overland flooding, the mechanism that produces the highest FPL should be taken.

10.1.3. Results

The provisional FPA is shown in Figure 22. The mainstream and overland flood affectation was limited to the Canada Bay LGA portion of the Powells Creek catchment. A total of 217 properties were identified for flood related development controls in Canada Bay as follows:

- Mainstream only 20
- Overland only 136
- Mainstream & overland 61

Properties that are not identified as part of this process may not be excluded from flood affectation. It is advisable that new developments (regardless of whether they are identified as flood liable or not) have habitable floor levels a minimum of 300 mm above the surrounding ground level to minimise affectation due to local overland flow.

It should be noted that the above approach does not include any sea level rise component. This information can be obtained from Table 29.

10.2. Cumulative Impact Assessment

Cumulative impact assessment was introduced to determine and address the small increases in flood level resulting from catchment wide development. Each development will cause an increase in flood level and whilst this is small, when the entire catchment is developed, the cumulative impacts may result in significant increases in flood level, thus adversely affect floodplain users.

However, the value of cumulative impact assessment has been significantly reduced as Councils now can ensure all private and public developments undertake a rigorous flood impact assessment. The threshold that is adopted is generally taken as no increase in the 1% AEP flood level by greater than 0.01m. This threshold means that the cumulative impact of all developments will still be very small.

10.3. Flood Risk Precincts

Figure 24 provides the flood risk precincts which are defined as follows:

High Flood Risk Precinct = Land within the 1% AEP Hazard categories H4, H5 and H6.
Medium Flood Risk Precinct = Remaining land within the 1% AEP extent and not in the High Flood Risk precinct.
Low Flood Risk Precinct = All land outside the 1% AEP and within the PMF extent.

11. ECONOMIC IMPACTS OF FLOODING

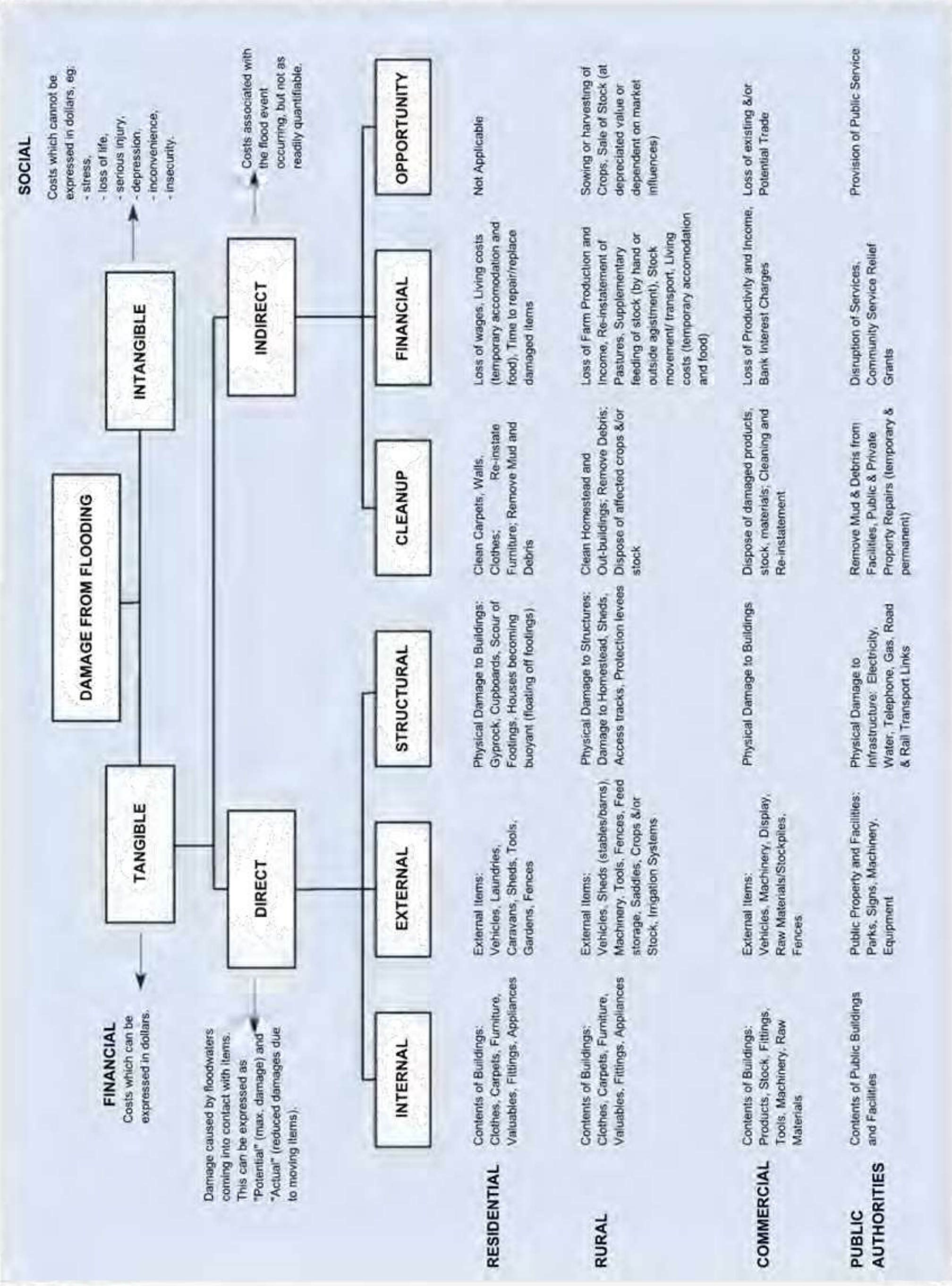
11.1. Overview

The impact of flooding can be quantified through the calculation of flood damages. Flood damage calculations do not include all impacts associated with flooding (for example it does not include worry, risk to life or injury). They do, however, provide a basis for assessing the economic loss of flooding and a non-subjective means of assessing the merit of flood mitigation works such as retarding basins, levees, drainage enhancement etc. The quantification of flood damages is an important part of the floodplain risk management process. By quantifying flood damages for a range of design events, appropriate cost-effective management measures can be analysed in terms of their benefits (reduction in damages) versus the cost of implementation. The cost of damage and the degree of disruption to the community caused by flooding depends upon many factors including:

- The magnitude (depth, velocity, and duration) of the flood.
- Land use and susceptibility to damages.
- Awareness of the community to flooding.
- Effective warning time.
- The availability of an evacuation plan or damage minimisation program.
- Physical factors such as failure of services (sewerage), flood borne debris, sedimentation, and
- The types of assets and infrastructure affected.

The estimation of flood damages tends to focus on the physical impact of damages on the human environment but there is also a need to consider the ecological cost and benefits associated with flooding. Flood damages can be defined as being tangible or intangible. 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. Types of flood damages are shown in Table 32.

Table 32: Categories of Flood Damages



11.2. Tangible Flood Damages

Tangible flood damages are comprised of two basic categories; direct and indirect damages (refer Table 32). Direct damages are caused by floodwaters wetting goods, structures and possessions thereby damaging them and resulting in either costs to replace or repair or in a reduction to their value. Direct damages are further classified as either internal (damage to the contents of a building including carpets, furniture), structural (referring to the structural fabric of a building such as foundations, walls, floors, windows) or external (damage to all items outside the building such as cars, garages). Indirect damages are the additional financial losses caused by the flood for example the cost of temporary accommodation, loss of wages by employees, etc.

Given the variability of flooding and property and content values, the total likely damages figure in any given flood event is useful to get a feel for the magnitude of the flood problem, however it is of limited value for absolute economic evaluation. Flood damage estimates are also useful when studying the economic effectiveness of proposed mitigation options, however difficulties arise when trying to assess intangible damages such as loss of life or inconvenience. Understanding the total damages prevented over the life of the option in relation to current damages, or to an alternative option, can assist in the decision-making process.

The standard way of expressing flood damages is in terms of average annual damages (AAD). AAD represents the equivalent average damages that would be experienced by the community on an annual basis, by considering the probability of a flood occurrence. This means the smaller floods, which occur more frequently, are given a greater weighting than the rare catastrophic floods.

To quantify the damages caused by inundation for existing development a floor level survey was undertaken (see Section 2.6). This was used in conjunction with modelled flood level information from the updated flood information (Section 7.4) to calculate damages. Damage calculations were carried out for all properties within the PMF extent.

The damages were calculated using height-damage curves which relate the depth of water above the floor with tangible damages. Each component of tangible damages is allocated a maximum value and a maximum depth at which this value occurs. Any flood depths greater than this allocated value do not incur additional damages as it is assumed that, by this level, all potential damages have already occurred.

Damages were calculated for residential and commercial/industrial properties, discussed separately below. This flood damages estimate does not include the cost of restoring or maintaining public services and infrastructure. It should be noted that damages calculations do not consider flood damages to any basements or cellars, hence where properties have basements, damages can be underestimated.

11.2.1. Residential Properties

Residential properties suffer damages from flooding in several ways. Direct damages include loss of property contents and/or damage to the structure of the property. Indirect damage costs can be incurred when property occupiers live elsewhere while repairs are being made. A flood damages assessment for residential properties was undertaken for the floor level data obtained by the methods outlined in Section 2.6. A summary of the flood damages assessment is provided in Table 33 with the properties shown on Figure 23.

Table 33: Flood Damages (Residential)

Event	No. Properties Affected	No. Flooded Above Floor Level	Total Damages for Event	% Contribution to AAD	Ave. Damage Per Flood Affected Property
20% AEP	60	8	$ 622,000	31	$ 10,000
10% AEP	69	10	$ 820,000	24	$ 12,000
5% AEP	81	13	$ 1,107,000	16	$ 14,000
2% AEP	94	18	$ 1,507,000	13	$ 16,000
1% AEP	100	20	$ 1,821,000	6	$ 18,000
0.5% AEP	117	22	$ 2,026,000	3	$ 17,000
0.2% AEP	132	25	$ 2,261,000	2	$ 17,000
PMF	366	133	$ 13,212,000	5	$ 36,000
Average Annual Damages (AAD)			$ 301,000		$ 1,000

Table 33 indicates a moderate degree of flood liability for more frequent events with 20 residential properties flooded above floor level in the 1% AEP event with the properties shown on Figure 23. In the PMF there are an estimated 133 residential properties flooded above floor level indicating a significant degree of flood risk and associated flood damages. On average, flooding to residential properties in the study area catchment costs Council and the community approximately $300,000 per annum.

11.2.2. Non-Residential – Commercial and Industrial

Non-residential land uses in the study area are predominantly situated on land above the extent of inundation from mainstream flooding from Powells Creek. As overland flow is general shallow depth the extent of damages is relatively small.

Non-residential properties are affected either directly by flood damage or indirectly by loss of business due to restricted customer and/or employee access. Costs vary significantly depending on the type of activity.

- Type of business – stock based or not, costs of damages to goods.
- Duration of flooding – affects how long a business may be closed for not just whether the business itself is closed, but when access to it is restored.
- Ability to move stock or assets before onset of flooding. Some large machinery will not be able to be moved and in other instances there may be insufficient warning time to move stock to dry locations; and
- Ability to transfer business to a temporary location.

Table 34: Flood Damages (Commercial and Industrial)

Event	No. Properties Affected	No. Flooded Above Floor Level	Total Damages for Event	% Contribution to AAD	Ave. Damage Per Flood Affected Property
20% AEP	10	2	$ 163,000	27	$ 16,000
10% AEP	13	4	$ 270,000	24	$ 21,000
5% AEP	17	5	$ 407,000	19	$ 24,000
2% AEP	23	6	$ 477,000	15	$ 21,000
1% AEP	24	7	$ 588,000	6	$ 25,000
0.5% AEP	25	8	$ 626,000	3	$ 25,000
0.2% AEP	25	9	$ 721,000	2	$ 29,000
PMF	36	21	$ 2,103,000	3	$ 58,000
Average Annual Damages (AAD)			$ 89,000		$ 2,000

A summary of the flood damages assessment for commercial and industrial properties is provided in Table 34 with the properties shown on Figure 23. Table 34 indicates relatively limited flood liability for non-residential properties.

11.2.3. Critical Infrastructure and Vulnerable Facilities

Public sector (non-building) damages include recreational/tourist facilities; water and sewerage supply; gas supply; telephone supply; electricity supply including transmission poles/lines, sub-stations, and underground cables; rail; roads and bridges including traffic lights/signs; and costs to employ emergency services and assist in cleaning up. Public sector damages can contribute a significant proportion to total flood costs but are difficult to accurately calculate or predict.

Costs to Councils from flooding typically comprise;

- Clean-up costs.
- Erosion and siltation.
- Drain cleanout and maintenance.
- Removing fallen trees.
- Inundation of Council buildings.
- Direct damage to roads, bridges and culverts.
- Removing vehicles washed away.
- Assistance to ratepayers.
- Increases in insurance premiums.
- Closures of streets.
- Loss of working life of road pavements; and
- Operational costs following and during flood events.

There are three vulnerable properties in the catchment which are described below the 1% AEP flood extent and another three properties are within the PMF extent as shown Table 35.

Table 35: Vulnerable Properties within the Floodplain

Type	Address	Flood- Affectation	PMF-Hazard	1% AEP-Hazard
Aged Care	124/23 George Street	No		
Child Care	31B George Street	Yes	1	0
Child Care	27/29 George Street	No		
Child Care	13 George Street	Yes	1	0
Church	3-5 Carrington Street	No		
Church	15 George Street	No		
Church	2A Napier Street	No		
College	17 George Street	No		
Community Centre	64-66 Victoria Street	Yes	5	2
Medical Practice	27/29 George Street	No		
Medical Practice	117 Queen Street	No		
School	345-347 Queen Street	No		
School	1/23 George Street	No		
School	1A Hamilton Street East	Yes	1	1
School	3 Bakehouse Lane	Yes	3	0
School	64-66 Victoria Street	Yes	5	1

Note: The Hazard shown is the highest / peak hazard on the whole property (lot) and it may be only a small part of the land affected. Individual lot information can be obtained from Council.

Flooding to schools, and to similar institutions, would have different impacts depending on the time of day and obviously during school hours response would be more critical due to the number of persons on the site. It is important that the affected schools have effective flood plans implemented.

11.2.4. Basement Car Parks

In the last 10+ years there has been an increasing construction of basement car parks for residential (unit and detached housing) and to a lesser extent for commercial buildings. No assessment of the damages to underground car parks has been undertaken.

11.3. Intangible Flood Damages

The intangible damages associated with flooding, by their nature, are inherently more difficult to estimate in monetary terms. In addition to the tangible damages discussed previously, additional costs/damages are incurred by residents affected by flooding, such as stress, risk/loss to life, injury, loss of sentimental items, etc. It is not possible to put a monetary value on the intangible damages as they are likely to vary dramatically between each flood (from a negligible amount to several hundred times greater than the tangible damages) and depend on a range of factors such as the size of flood, the individuals affected, and community preparedness. However, it is still important that the consideration of intangible damages is included when considering the impacts of flooding on a community.

Post-flood damages surveys in mainly rural areas (the effect in urban areas such as Woolcoware Bay is likely to be much less) have linked flooding to stress, ill-health, and trauma for the residents. For example, the loss of memorabilia, pets, insurance papers and other items without fixed costs and of sentimental value may cause stress and subsequent ill-health. In addition, flooding may affect personal relationships and lead to stress in domestic and work situations. As well as the stress caused during an event (from concern over property damage, risk to life for the individuals or their family, clean up, etc.) many residents in rural areas who have experienced a major flood are fearful of the occurrence of another flood event and the associated damage (this impact is less so in urban areas). The extent of the stress depends on the individual and although most flood victims recover, these effects can lead to a reduction in quality of life for the flood victims.

Flood affectation to many of the critical infrastructure and vulnerable facilities may also result in significant intangible damages. For example, damage to service supply (water, sewage) will affect households as will the temporary closure of schools or childcare facilities as repairs are carried out. The flood affectation to these facilities will not necessarily occur at the site of the facility. Thus, just because the facility is not directly affected by flooding does not mean that flooding will not have a bearing on the facilities activities and the resulting community. For example, with schools, childcare and aged care the main issue is with access to the facility, and this may be some distance from the building.

With service infrastructure (sewer, water, electricity) the main facility will likely not be directly affected by floodwaters, but the supply will be affected by say fallen trees hitting power lines or closure of the sewer system as floodwaters are entering the system in the flooded area. Many of these affectations to the critical infrastructure and vulnerable facilities are variable and will not necessarily occur in all floods or at the same locations. It is only through review of past floods that the true affectation to critical infrastructure and vulnerable facilities can be addressed.

12. HOTSPOT DISCUSSION

Hotspots are defined as those locations where there is a known flood issue. They are identified by considering accounts of previous floods and by examining the flood behaviour. The latter involves identifying areas of high hazard flow where flooding of property occurs frequently, where inundation of main roads occurs and through consideration of subsurface drainage capacity. The identification of hotspots is largely based upon the results from this study as there is only limited historical data. As floods occur a review of these hotspot areas should be undertaken.

It should be noted that this report is a Flood Study and merely describes the issues which should be investigated in detail in the subsequent Floodplain Risk Management Study and Plan.

A. **Victoria Avenue underpass** (Photo 2). The issue at this area is that runoff from the east flows west down Victoria Avenue, reaching the underpass but high ground on the west side of Homebush Bay Drive prevents adequate drainage to escape into Homebush Bay. Runoff ponds in the relatively low-lying land to the north of the road and east of Homebush Bay Drive. Additional culverts under Homebush Bay Drive are likely to be cost prohibitive and whilst the west side of Homebush Bay Drive is predominantly open space, it would be expensive to create an open swale to discharge floodwaters to the Powells Creek channel due to the heavy vegetation and road network.

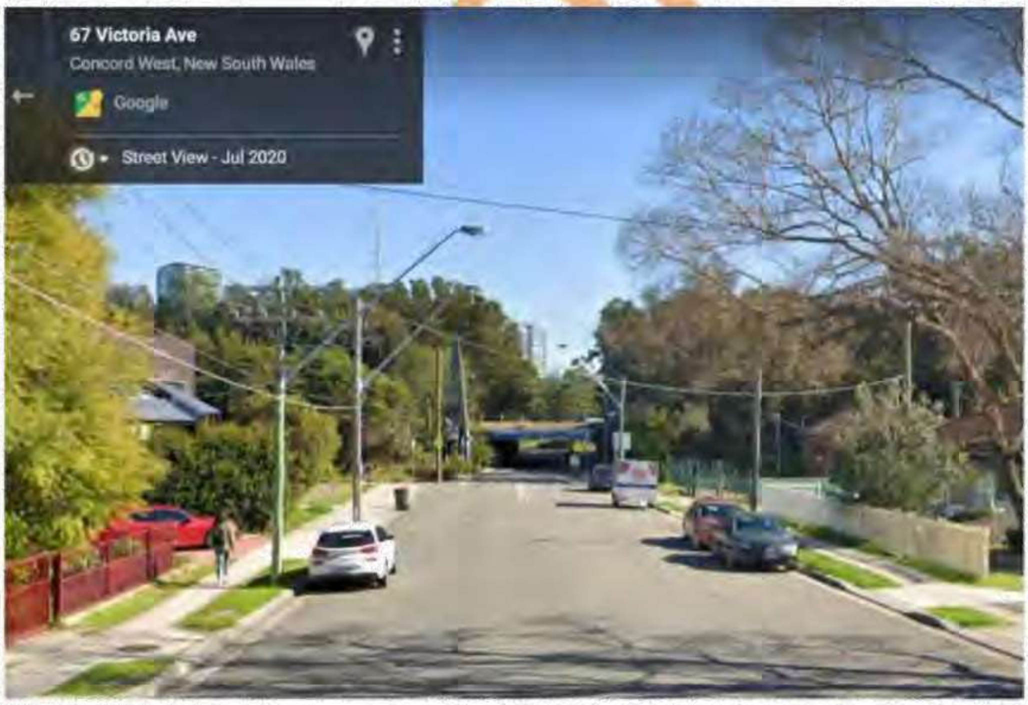


Photo 2: Victoria Avenue underpass

B. **George Street sag point** (Photo 3). This sag point is a known hot spot created by construction of the building on the east side leaving no exit path for overland flow collecting at the low point. There is no simple solution to this problem until redevelopment of the building is undertaken. Fortunately, the impact of flooding is confined to the road and the building itself. The simplest mitigation strategy is to flood proof inlets to the building.

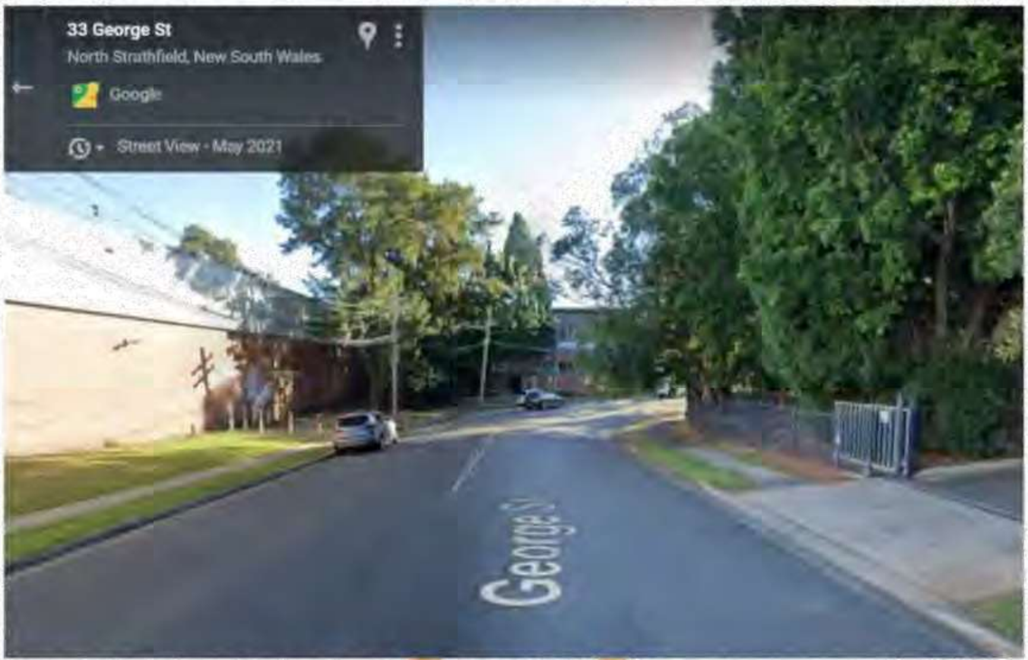


Photo 3: George Street sag point

C. **Adjacent to Powells Creek Channel** (Brussels Street to Allen Street - Photo 4). In a large flood, greater than the 1% AEP, all properties adjacent to the Powells Creek channel within Canada Bay LGA will be subject to inundation with some above floor inundation. There is relatively easy access to high ground by moving to the east but there will be yard and building damages as well as risk to life issues. Whilst Sydney Water has relined the channel in the last 5 years this has not resulted in increased flow capacity. There is also no proposal to increase the capacity as this would require purchase of private properties.

Re-development is the only practical solution as this would ensure that the buildings are constructed with floors levels at the required flood planning levels.

Photo 4: Adjacent to Powells Creek Channel (Brussels Street to Allen Street)

D. **Raw Square Rail Underpass** (Photo 5): This location is on the boundary with Strathfield Municipal Council. Typically, all road and rail underpasses are sag points which collect runoff and thus are inundated in floods causing significant traffic disruption though no or very little damage to property. There is no simple solution to this issue as the road level is below the surrounding ground level and thus runoff cannot drain effectively by gravity. Constructing additional pipes will provide some benefit but will be technically difficult and expensive.

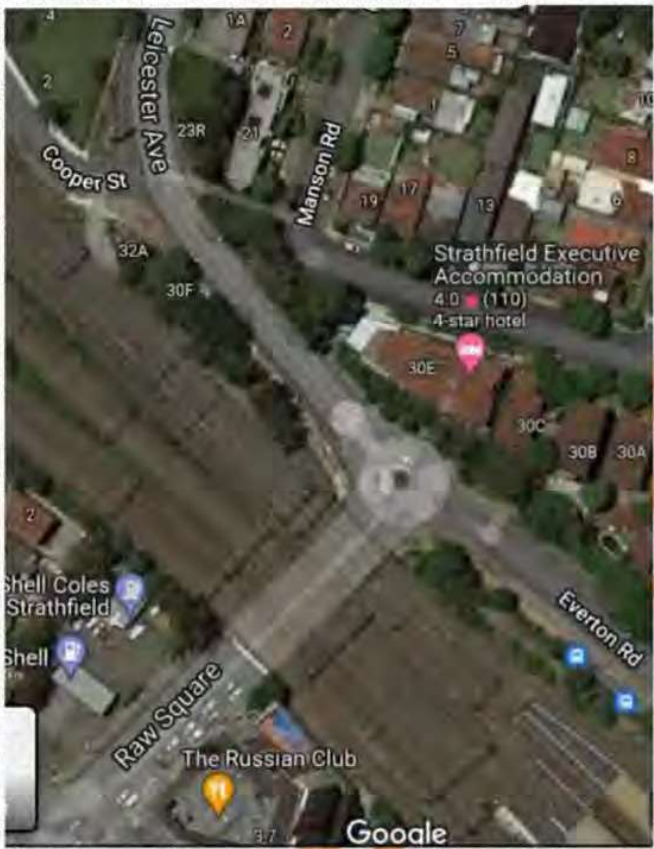


Photo 5: Raw Square Rail Underpass

13. ACKNOWLEDGEMENTS

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- City of Canada Bay Council.
- Strathfield Municipal Council.
- Burwood Council.
- Sydney Water.
- Bureau of Meteorology.
- Residents of the Powells Creek catchment.

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Figures

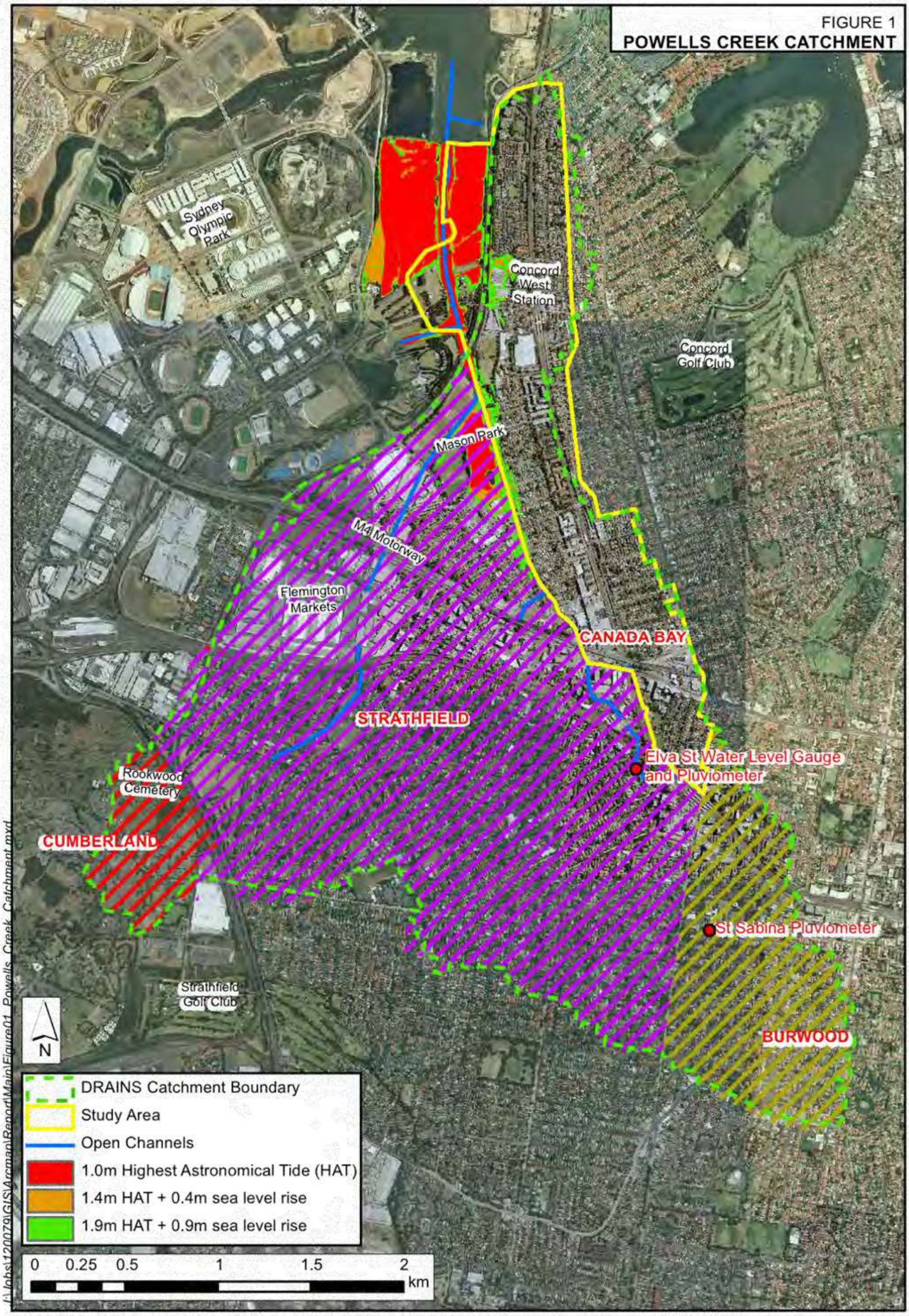


FIGURE 1
POWELLS CREEK CATCHMENT
Sydney Olympic Park
Concord West Station
Concord Golf Club
Mason Park
M4 Motorway
Flemington Markets
CANADA BAY
STRATHFIELD
Elva St Water Level Gauge and Pluviometer
Rookwood Cemetery
CUMBERLAND
St Sabina Pluviometer
Strathfield Golf Club
BURWOOD
N
DRAINS Catchment Boundary
Study Area
Open Channels
1.0m Highest Astronomical Tide (HAT)
1.4m HAT + 0.4m sea level rise
1.9m HAT + 0.9m sea level rise
0 0.25 0.5 1 1.5 2
km

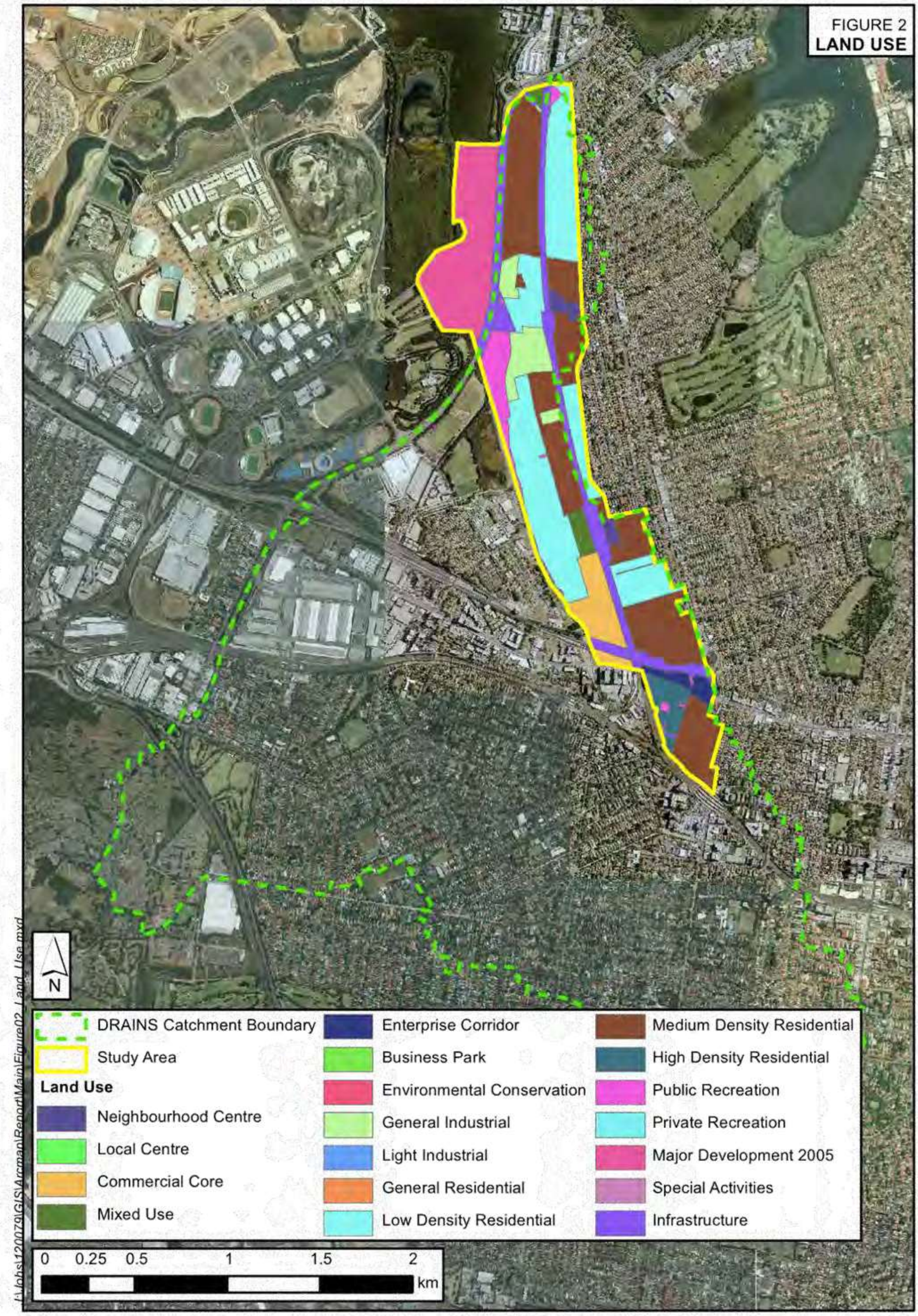


FIGURE 2
LAND USE
N
DRAINS Catchment Boundary
Study Area
Land Use
Neighbourhood Centre
Local Centre
Commercial Core
Mixed Use
Enterprise Corridor
Business Park
Environmental Conservation
General Industrial
Light Industrial
General Residential
Low Density Residential
Medium Density Residential
High Density Residential
Public Recreation
Private Recreation
Major Development 2005
Special Activities
Infrastructure
0 0.25 0.5 1 1.5 2
km

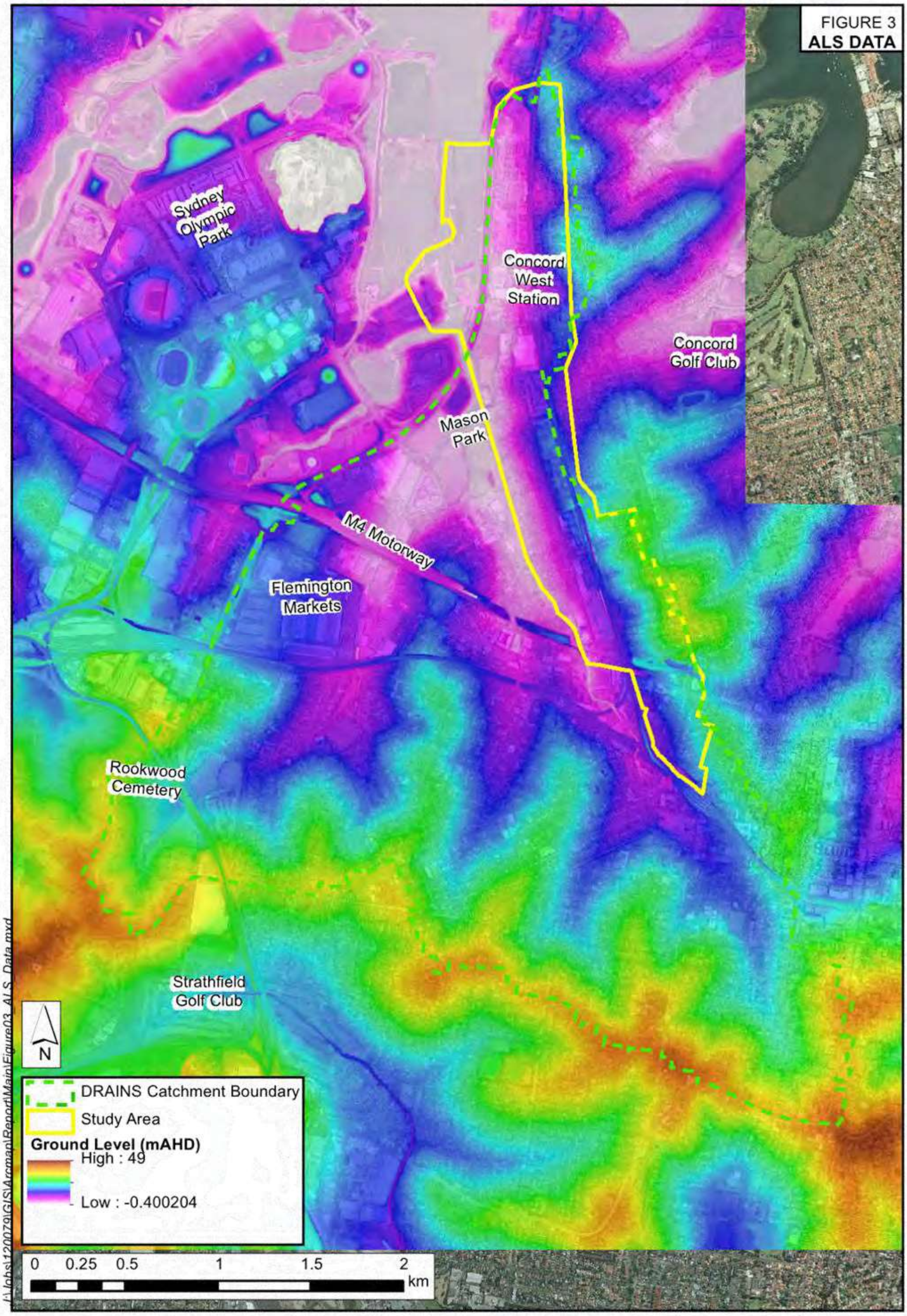


FIGURE 3
ALS DATA
Sydney Olympic Park
Concord West Station
Concord Golf Club
Mason Park
M4 Motorway
Flemington Markets
Rookwood Cemetery
Strathfield Golf Club
N
DRAINS Catchment Boundary
Study Area
Ground Level (mAHD)
High : 49
Low : -0.400204
0 0.25 0.5 1 1.5 2 km

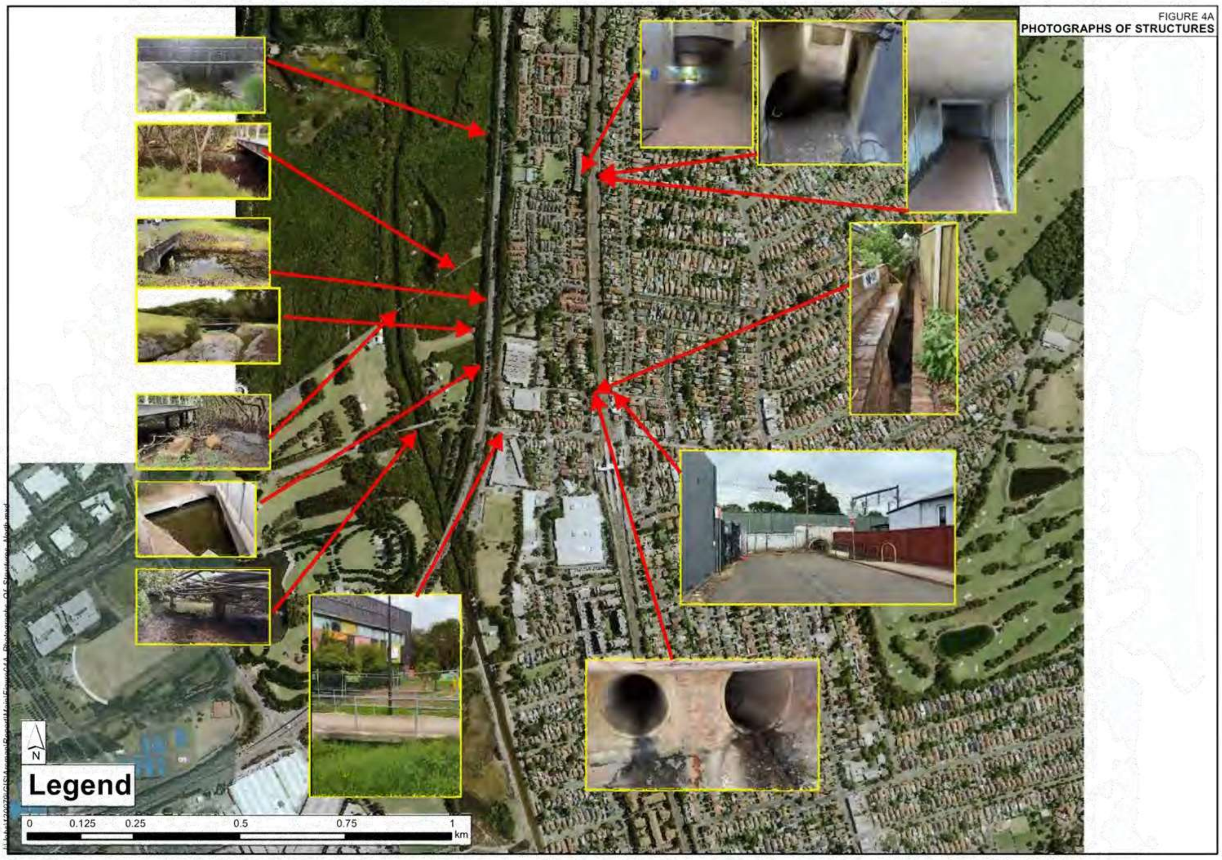


FIGURE 4A
PHOTOGRAPHS OF STRUCTURES
Legend
N
0 0.125 0.25 0.5 0.75 1 km

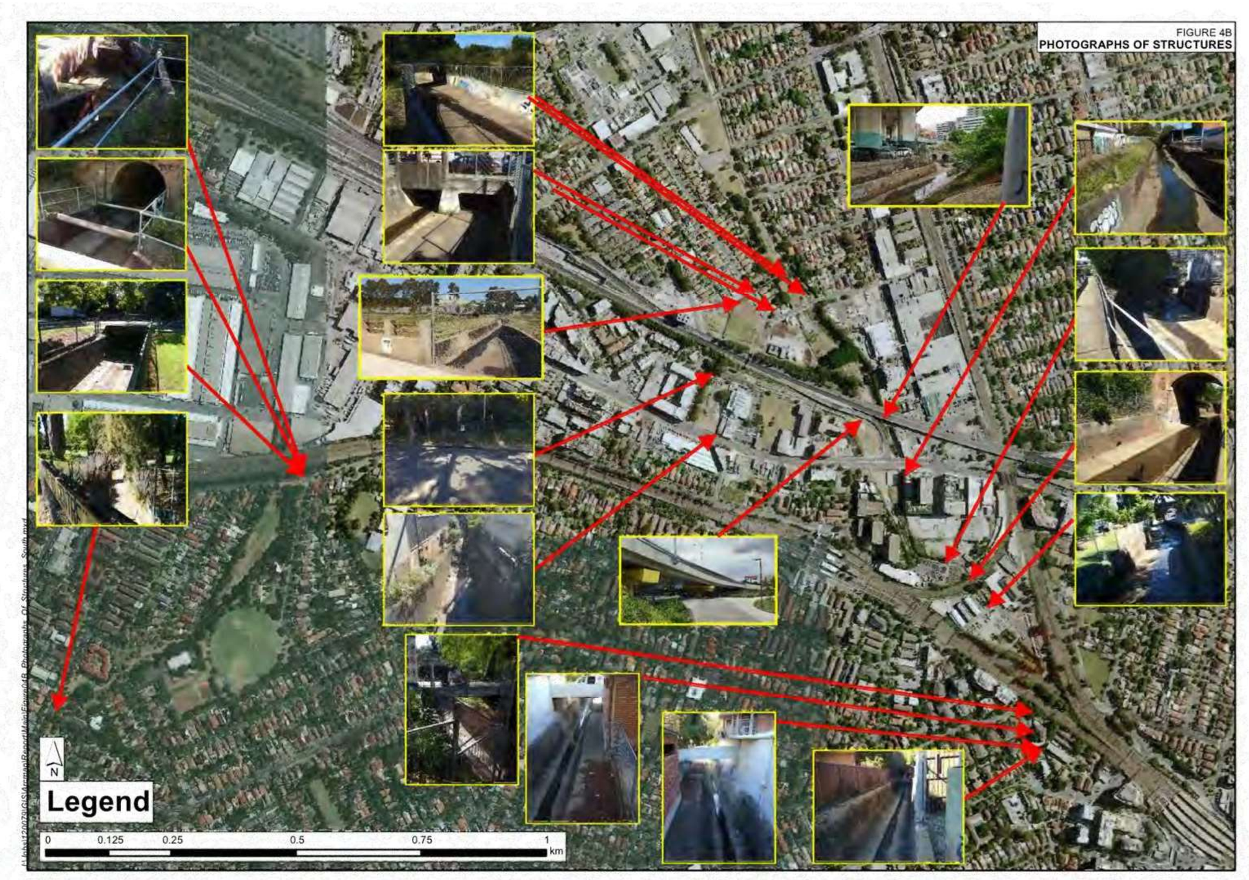


FIGURE 4B
PHOTOGRAPHS OF STRUCTURES
N
Legend
0
0.125
0.25
0.5
0.75
1
km

FIGURE 5A
HISTORICAL FLOOD PHOTOGRAPHS
SHEET 1


Airey Park 2/01/96


Airey Park 2/01/96


The Crescent opposite Airey Park 2/01/96


19 Shortland Ave 10/02/1990


Airey Park The Crescent 2/01/96


Oxford Road 2/01/96


1 Heyde Ave 2/01/96


Rochester Street eastern side, Mirabooka Ave & Broughton Rd


Redmyre Road 2/01/96


62 Beresford Road 10/02/1990


19 Shortland Ave 10/02/1990


Corner of Todman Ave; and Oxford Rd: eastern side

FIGURE 5B
HISTORICAL FLOOD PHOTOGRAPHS
SHEET 2


Barker Road, Southern side


Todman Ave; at Barker Road

Corner of Badgery Ave; and Bates Street


29 Badgery Avenue


Outside 29 Badgery Avenue


139 Albert Road 10.2.90


139 Albert Road 10.2.90


139 Albert Road 10.2.90

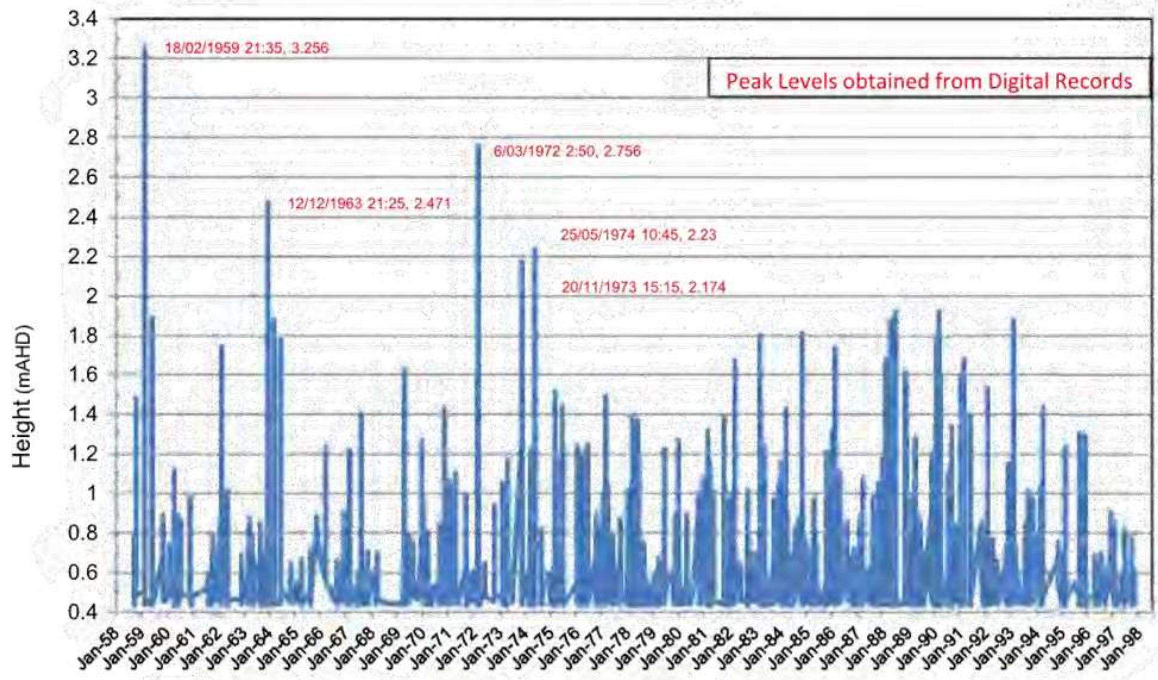

139 Albert Road 10.2.90


139 Albert Road 10.2.90


Underwood Road 18/03/1990


Underwood Road 18/03/1990

FIGURE 6
WATER LEVEL GAUGE RECORDS



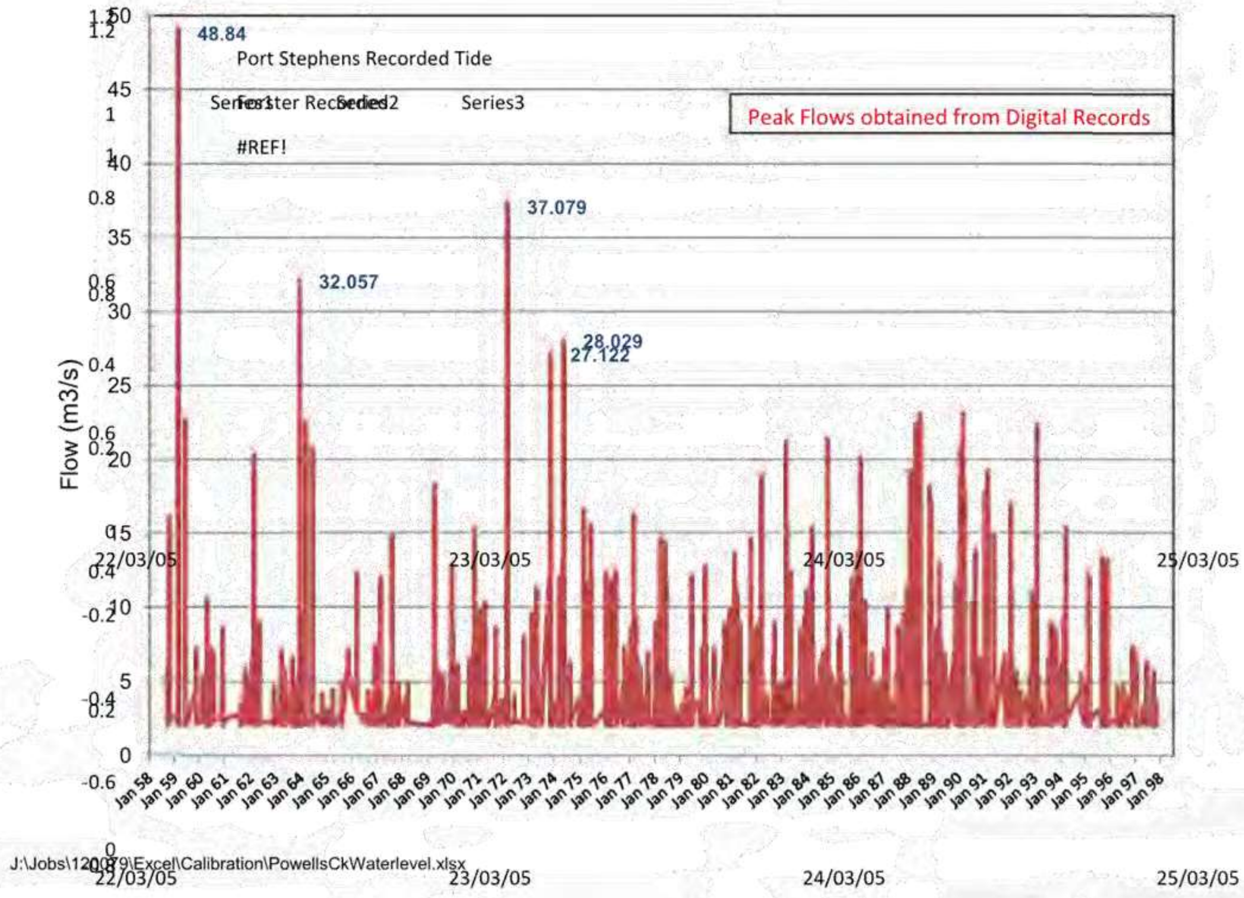
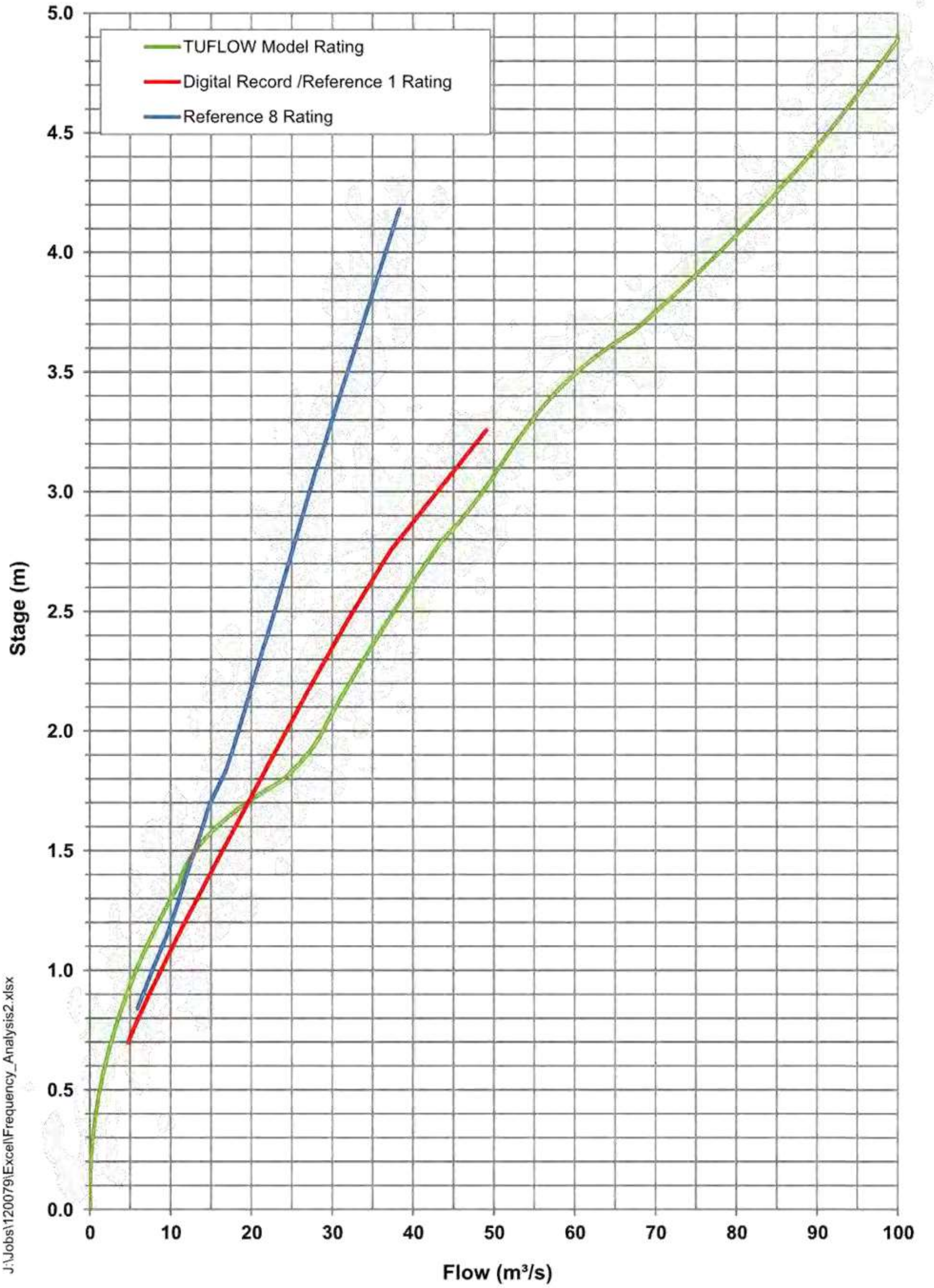


FIGURE 7
RATING CURVES AT ELVA STREET GAUGE



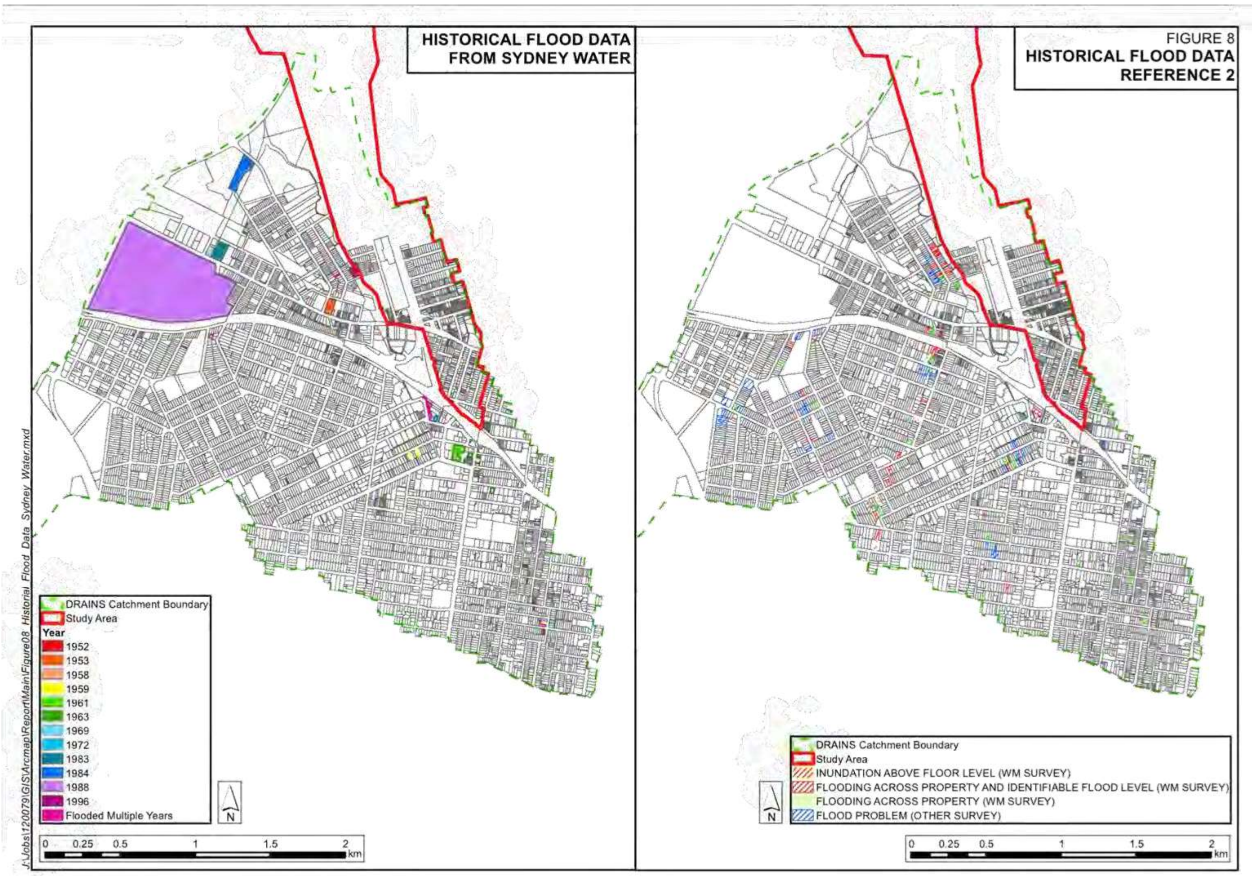
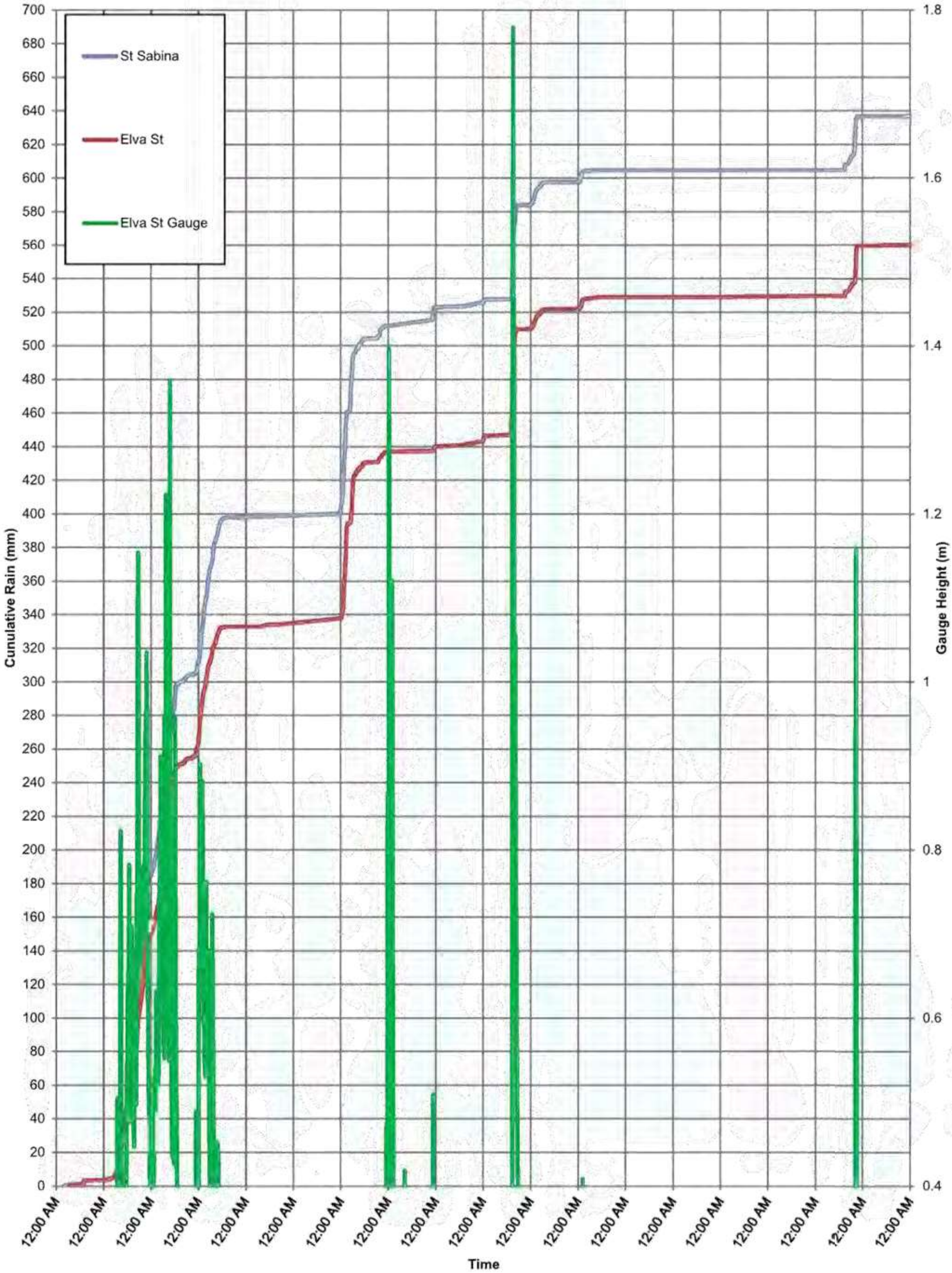
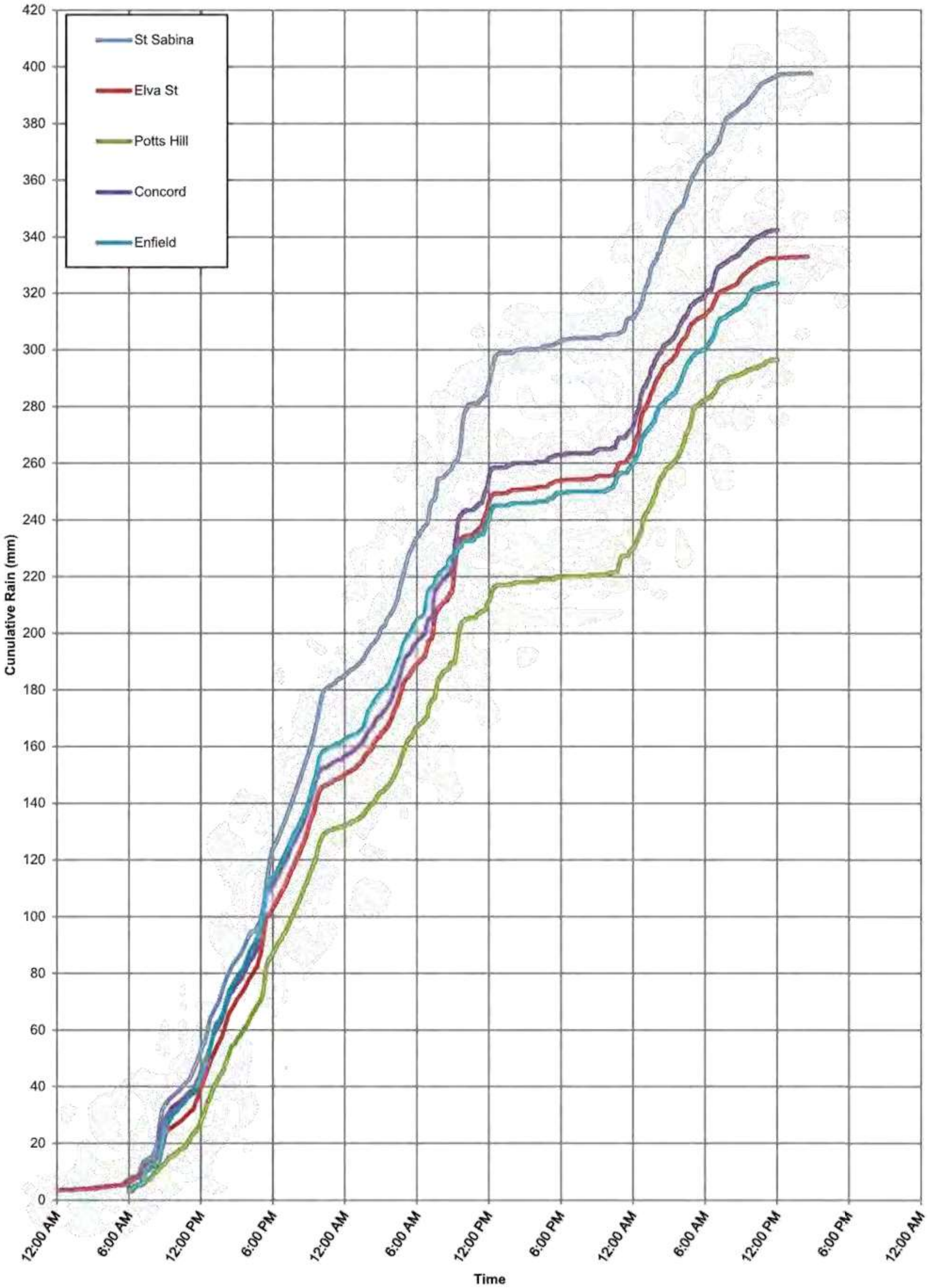

HISTORICAL FLOOD DATA
FROM SYDNEY WATER
DRAINS Catchment Boundary
Study Area
Year
1952
1953
1958
1959
1961
1963
1969
1972
1983
1984
1988
1996
Flooded Multiple Years
N
0
0.25
0.5
1
1.5
2
km
J:\Jobs\120079\GIS\Arcmap\Report\Main\Figure08_Historial_Flood_Data_Sydney_Water.mxd
FIGURE 8
HISTORICAL FLOOD DATA
REFERENCE 2
DRAINS Catchment Boundary
Study Area
INUNDATION ABOVE FLOOR LEVEL (WM SURVEY)
FLOODING ACROSS PROPERTY AND IDENTIFIABLE FLOOD LEVEL (WM SURVEY)
FLOODING ACROSS PROPERTY (WM SURVEY)
FLOOD PROBLEM (OTHER SURVEY)
N
0
0.25
0.5
1
1.5
2
km

FIGURE 9A
EVENTS OF FEBRUARY 1990



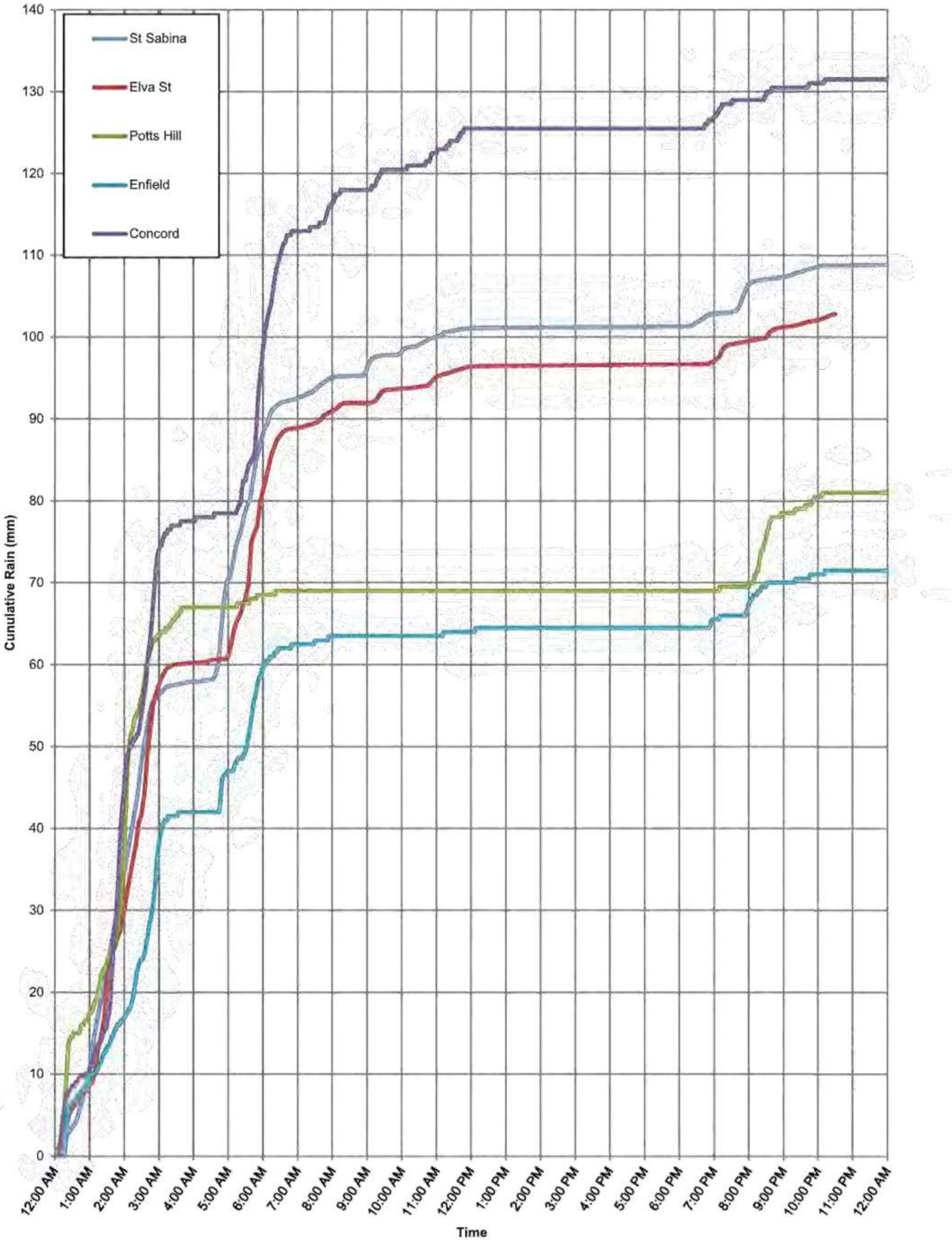
J:\Jobs\120079\Excel\Calibration\PowellsCkWaterlevel.xlsx

FIGURE 9B
PLUVIOMETER DATA
2-4 FEBRUARY 1990



J:\Jobs\120079\Excel\Calibration\PowellsCkWaterlevel.xlsx

FIGURE 9C
PLUVIOMETER DATA
7 FEBRUARY 1990



J:\Jobs\120079\Excel\Calibration\PowellsCkWaterlevel.xlsx

FIGURE 9D
PLUVIOMETER DATA
17 FEBRUARY 1990

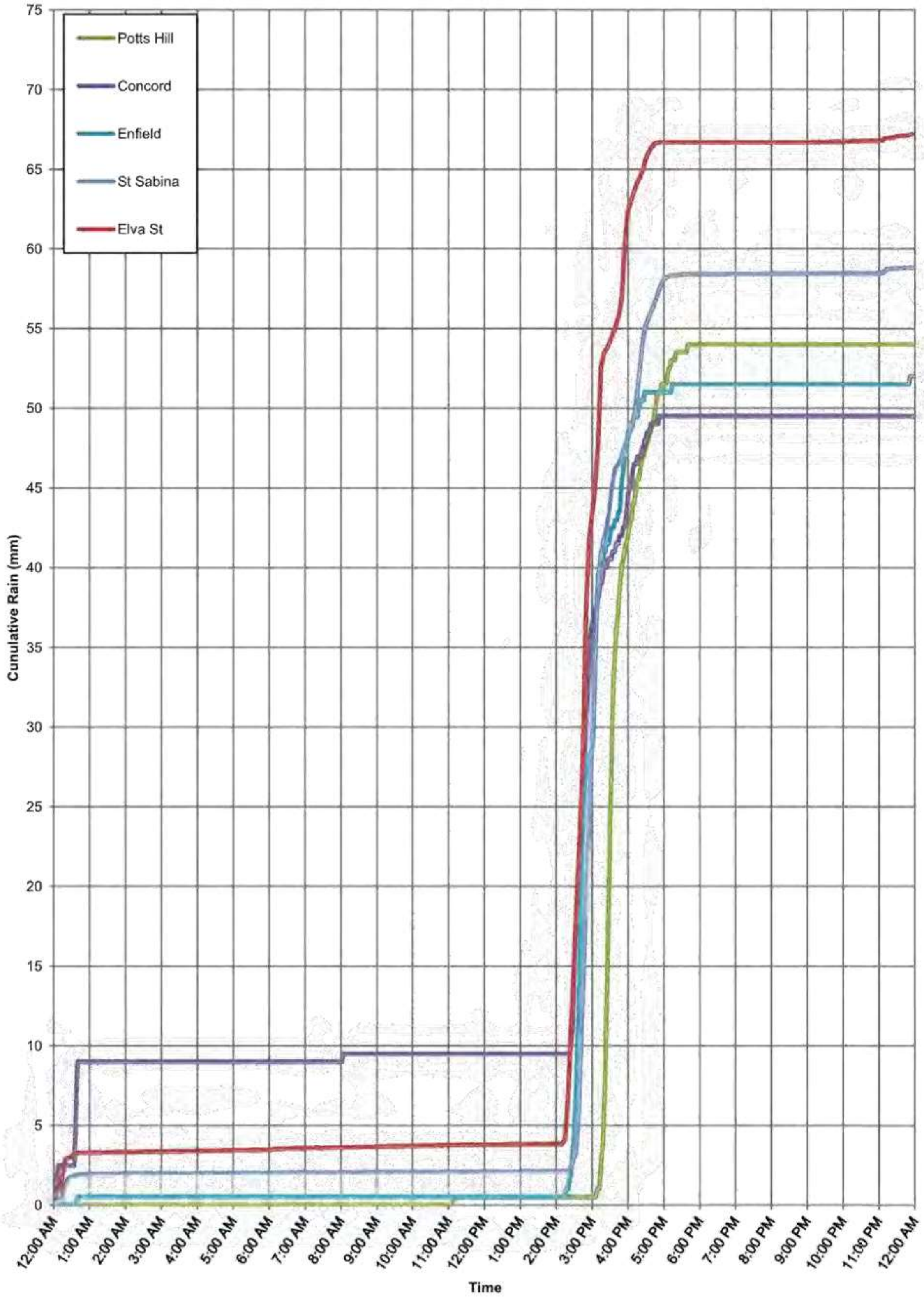


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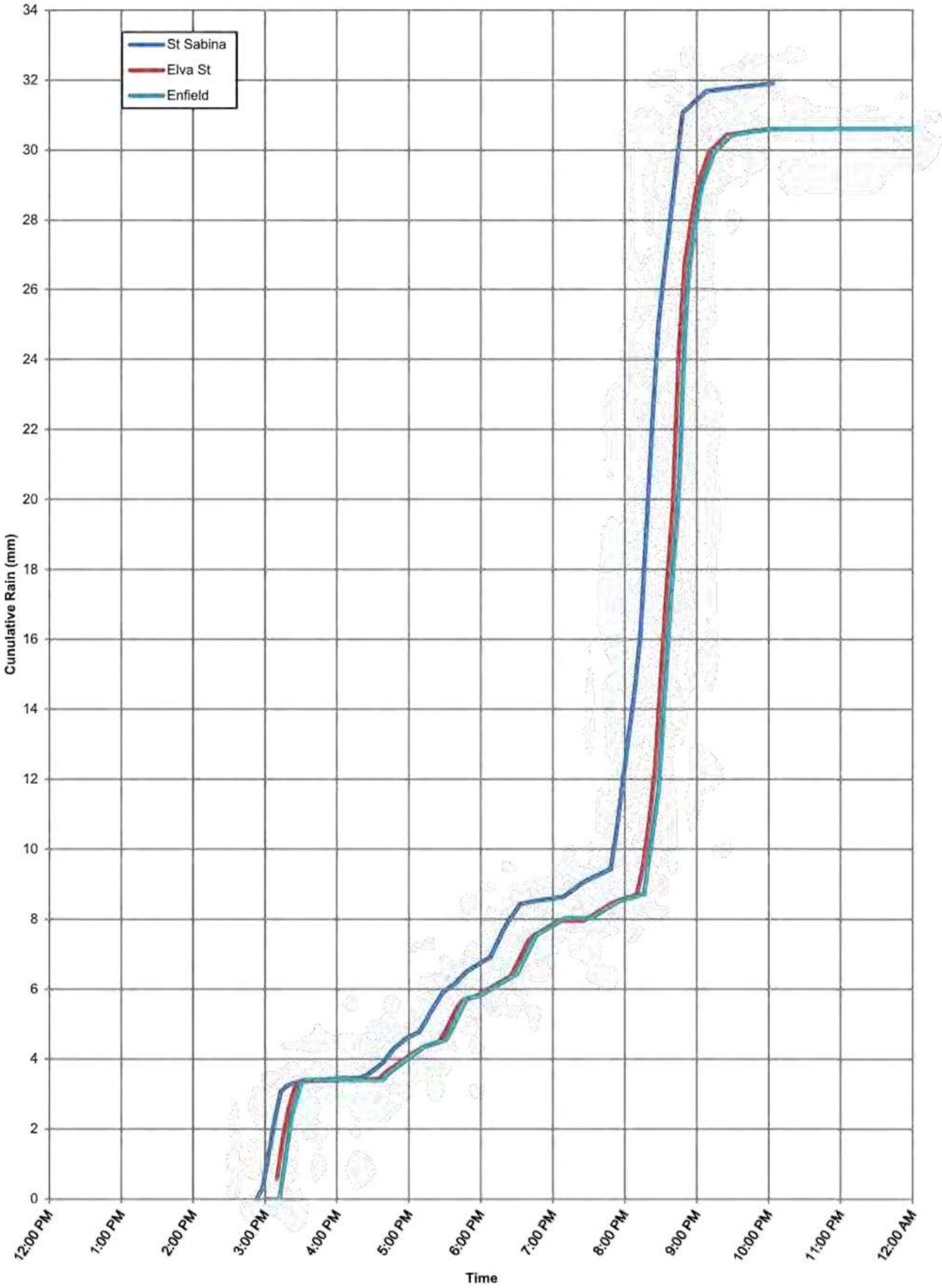
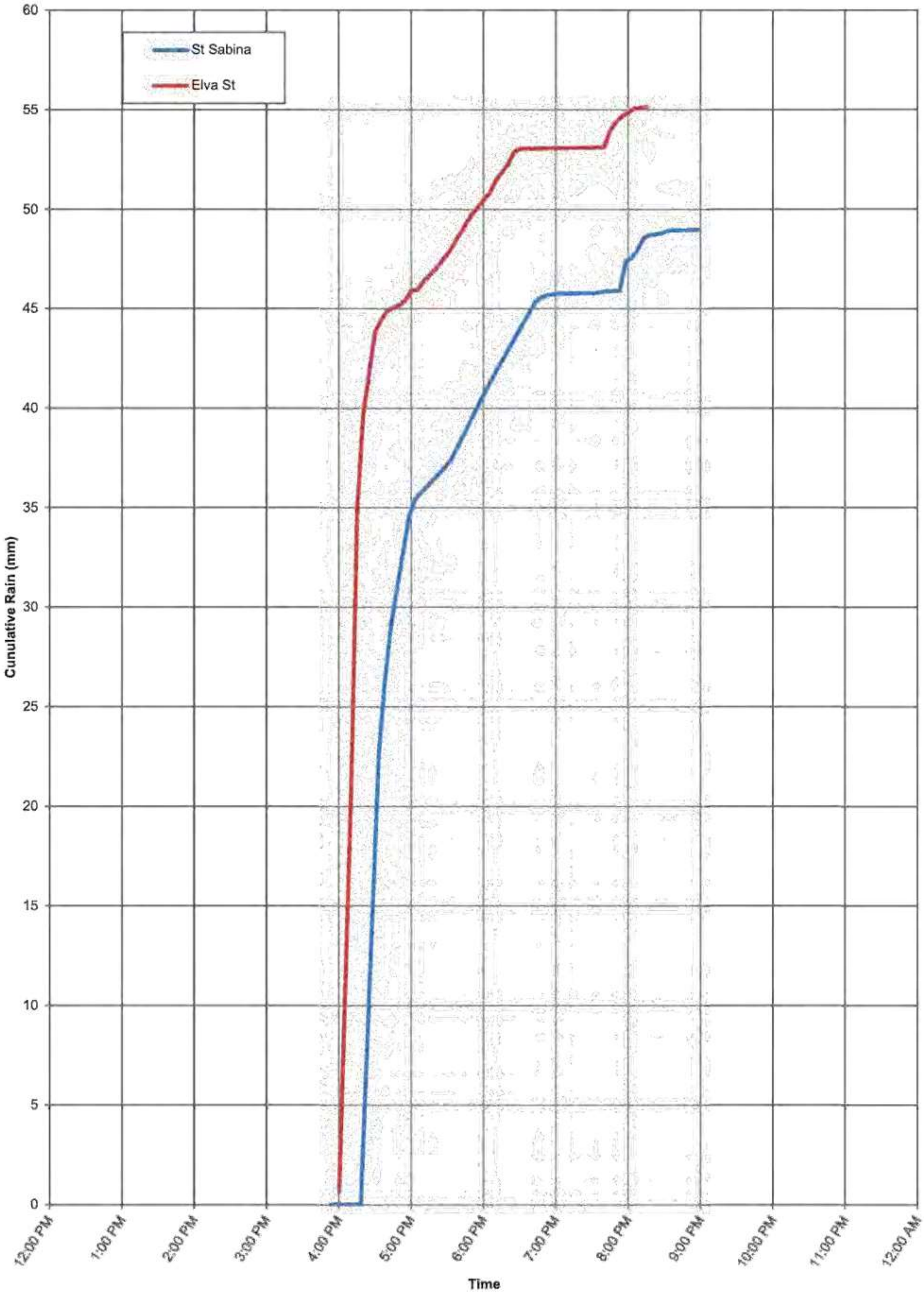
FIGURE 9E
PLUVIOMETER DATA
17 FEBRUARY 1990



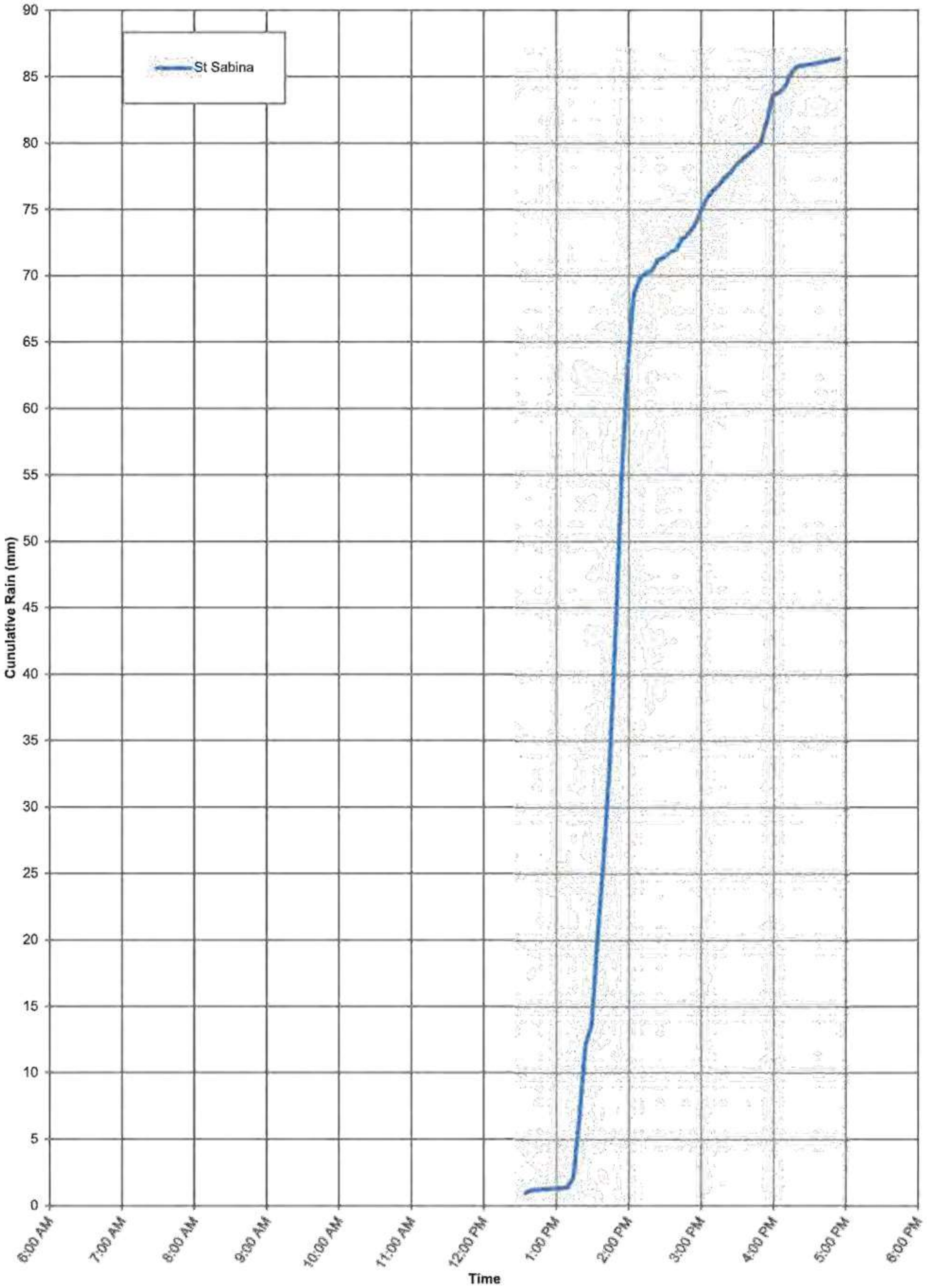
J:\Jobs\120079\Excel\Calibration\PowellsCkWaterlevel.xlsx

FIGURE 9F
PLUVIOMETER DATA
18 MARCH 1990



J:\Jobs\120079\Excel\Calibration\PowellsCkWaterlevel.xlsx

FIGURE 9G
PLUVIOMETER DATA
2 JANUARY 1996



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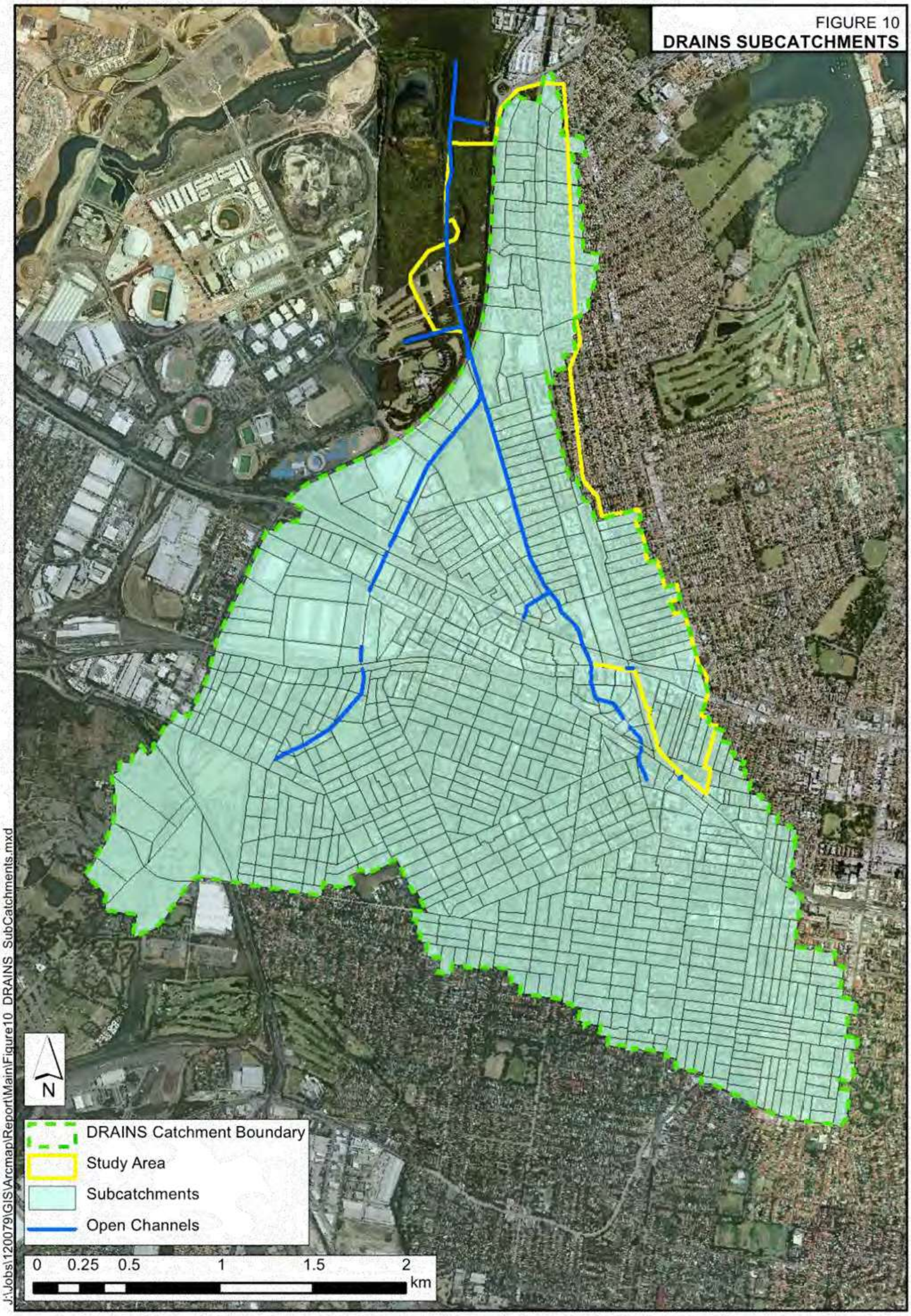


FIGURE 10
DRAINS SUBCATCHMENTS
DRAINS Catchment Boundary
Study Area
Subcatchments
Open Channels
N
0
0.25
0.5
1
1.5
2
km
J:\Jobs\120079\GIS\Arcmap\Report\Main\Figure10_DRAINS_SubCatchments.mxd

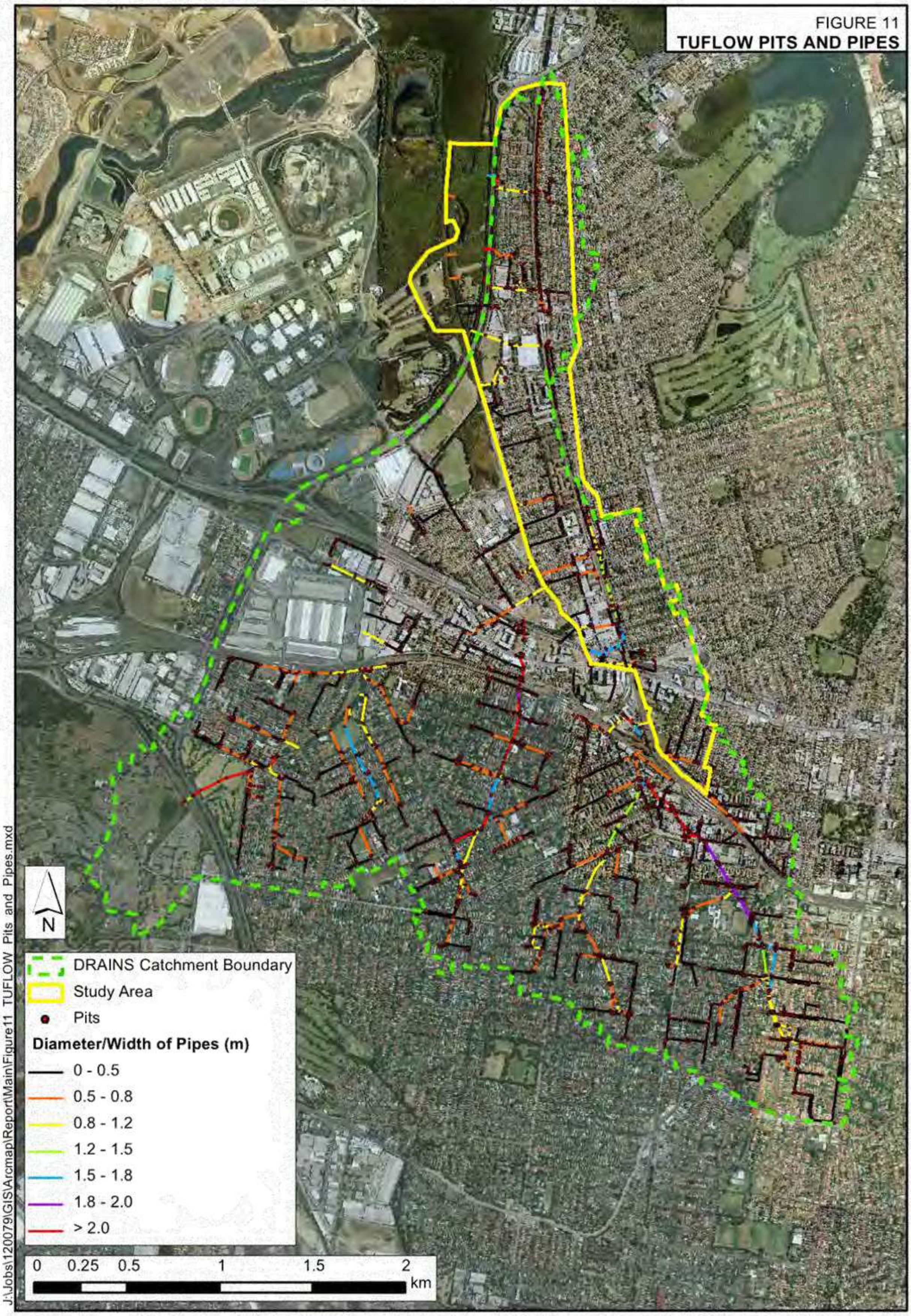


FIGURE 11
TUFLOW PITS AND PIPES
N
DRAINS Catchment Boundary
Study Area
Pits
Diameter/Width of Pipes (m)
0 - 0.5
0.5 - 0.8
0.8 - 1.2
1.2 - 1.5
1.5 - 1.8
1.8 - 2.0
> 2.0
0 0.25 0.5 1 1.5 2
km
J:\Jobs\120079\GIS\Arcmap\Report\Main\Figure11_TUFLOW_Pits_and_Pipes.mxd

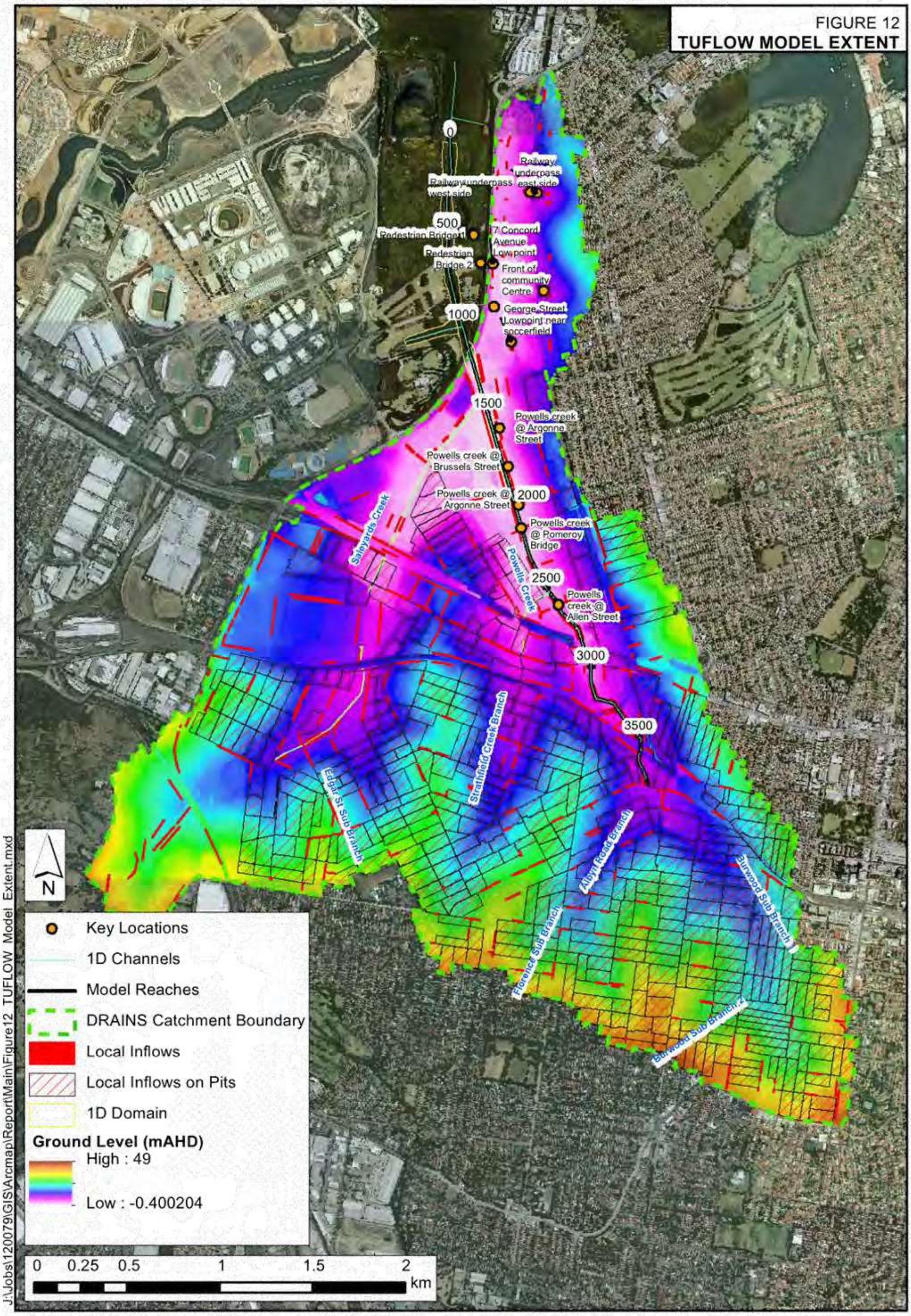


FIGURE 12
TUFLOW MODEL EXTENT
0
500
1000
1500
2000
2500
3000
3500
Railway underpass west side
Railway underpass east side
Pedestrian Bridge 1
Pedestrian Bridge 2
7 Concord Avenue Lowpoint
Front of community Centre
George Street Lowpoint near soccerfield
Powells creek @ Argonne Street
Powells creek @ Brussels Street
Powells creek @ Argonne Street
Powells creek @ Pomeroy Bridge
Powells creek @ Allen Street
Saleyards Creek
Powells Creek
Strathfield Creek Branch
Edgar St Sub Branch
Albyn Road Branch
Burwood Sub Branch
Florence St Sub Branch
Burwood Sub Branch 2
N
Key Locations
1D Channels
Model Reaches
DRAINS Catchment Boundary
Local Inflows
Local Inflows on Pits
1D Domain
Ground Level (mAHD)
High : 49
Low : -0.400204
0 0.25 0.5 1 1.5 2
km
J:\Jobs\120079\GIS\Arcmap\Report\Main\Figure12_TUFLOW_Model_Extent.mxd

FIGURE 13A
CALIBRATION RESULTS--ELVA STREET GAUGE
3 FEBRUARY 1990

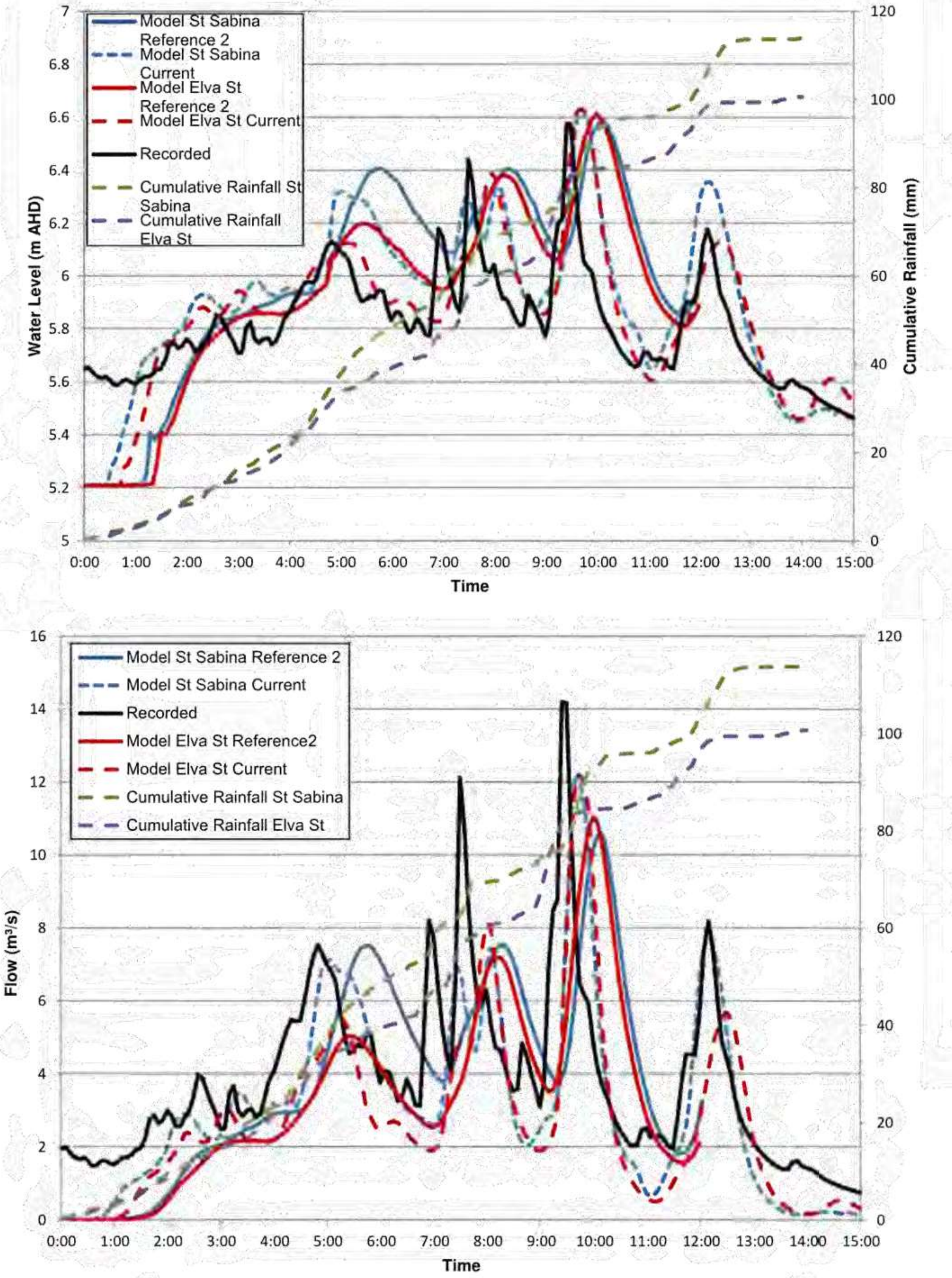


FIGURE 13B
CALIBRATION RESULTS--ELVA STREET GAUGE
7 FEBRUARY 1990

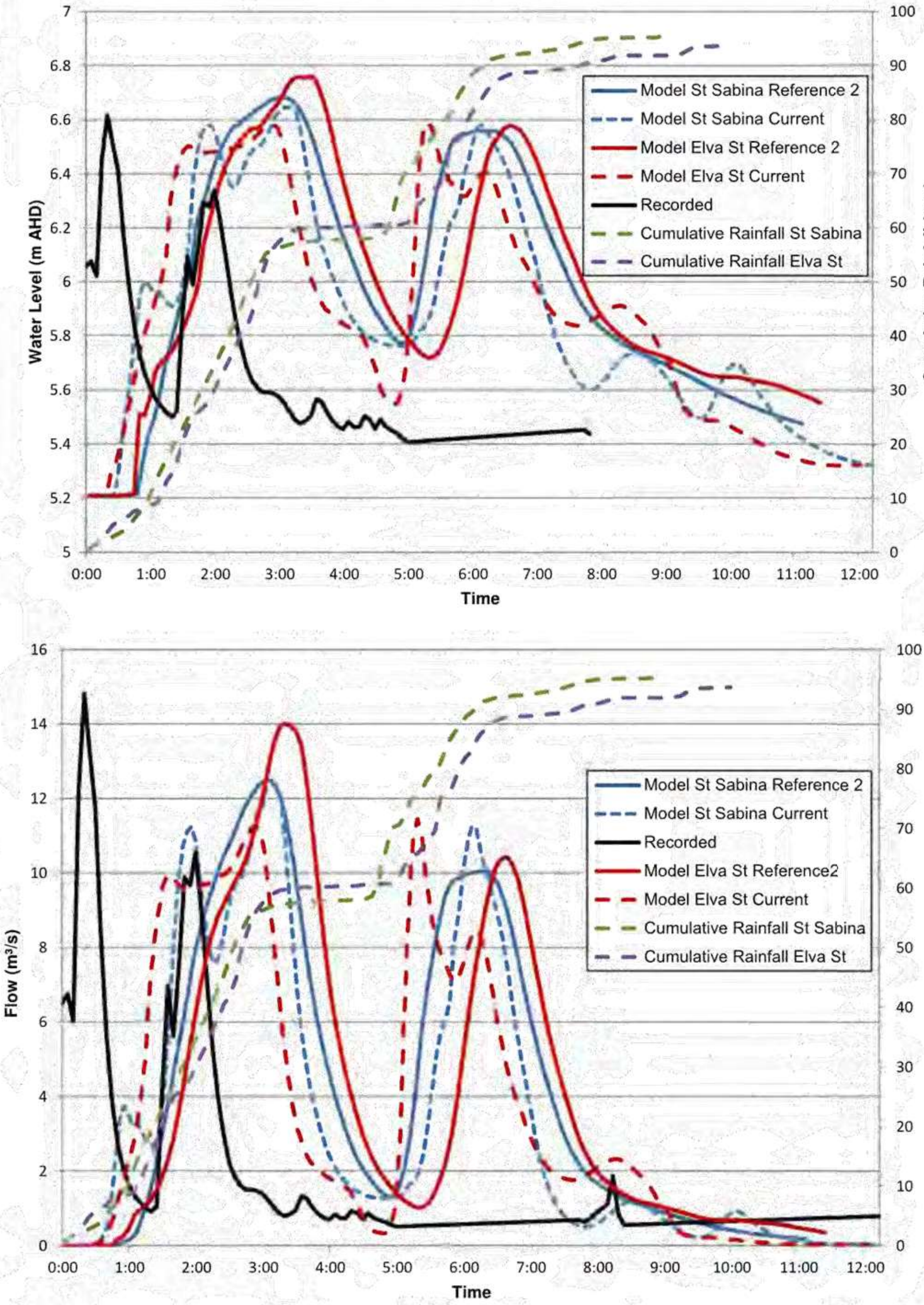
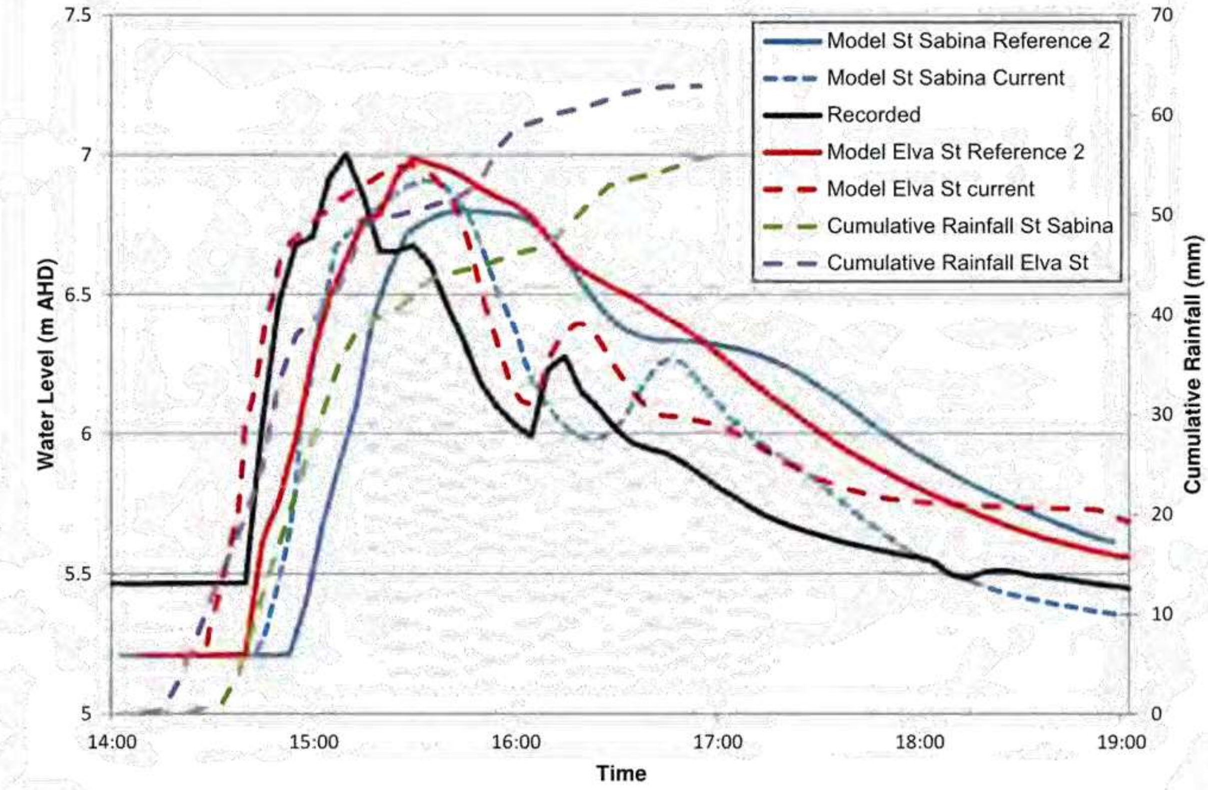


FIGURE 13C
CALIBRATION RESULTS--ELVA STREET GAUGE
10 FEBRUARY 1990



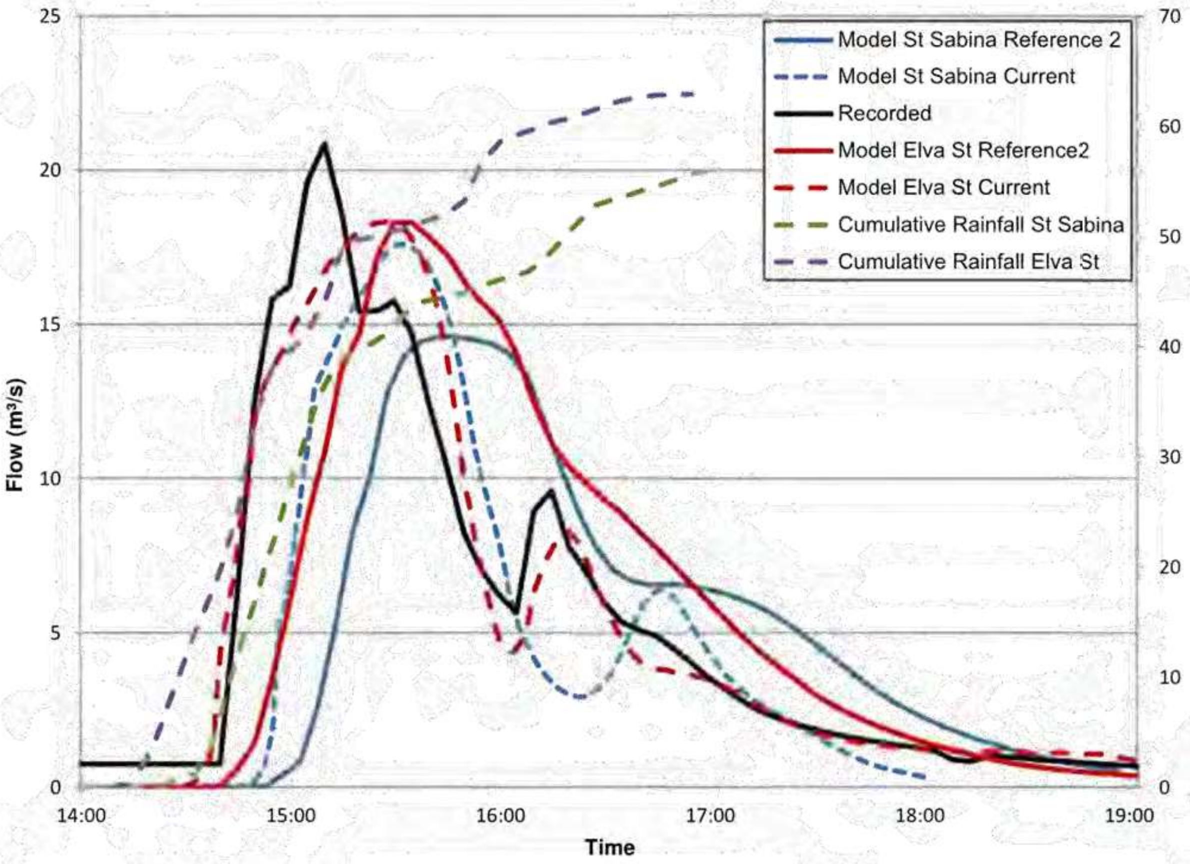
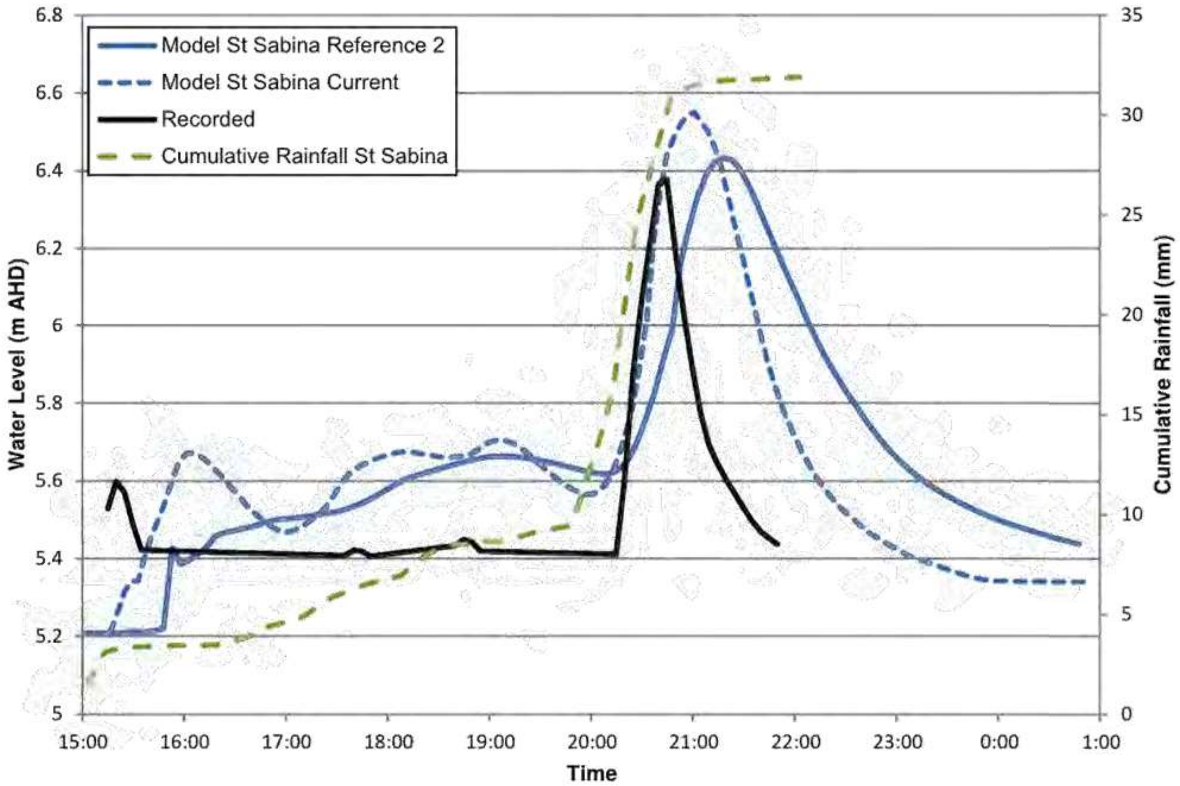


FIGURE 13D
CALIBRATION RESULTS--ELVA STREET GAUGE
17 FEBRUARY 1990



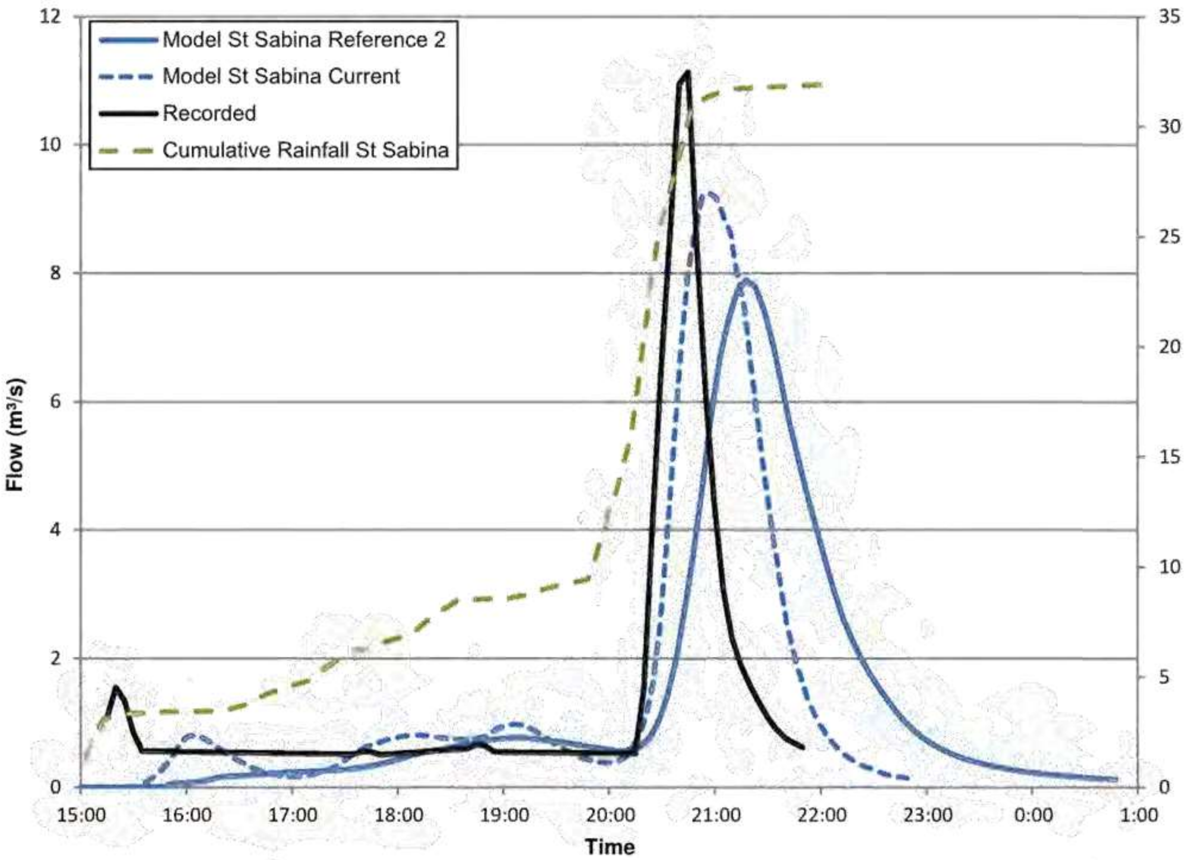
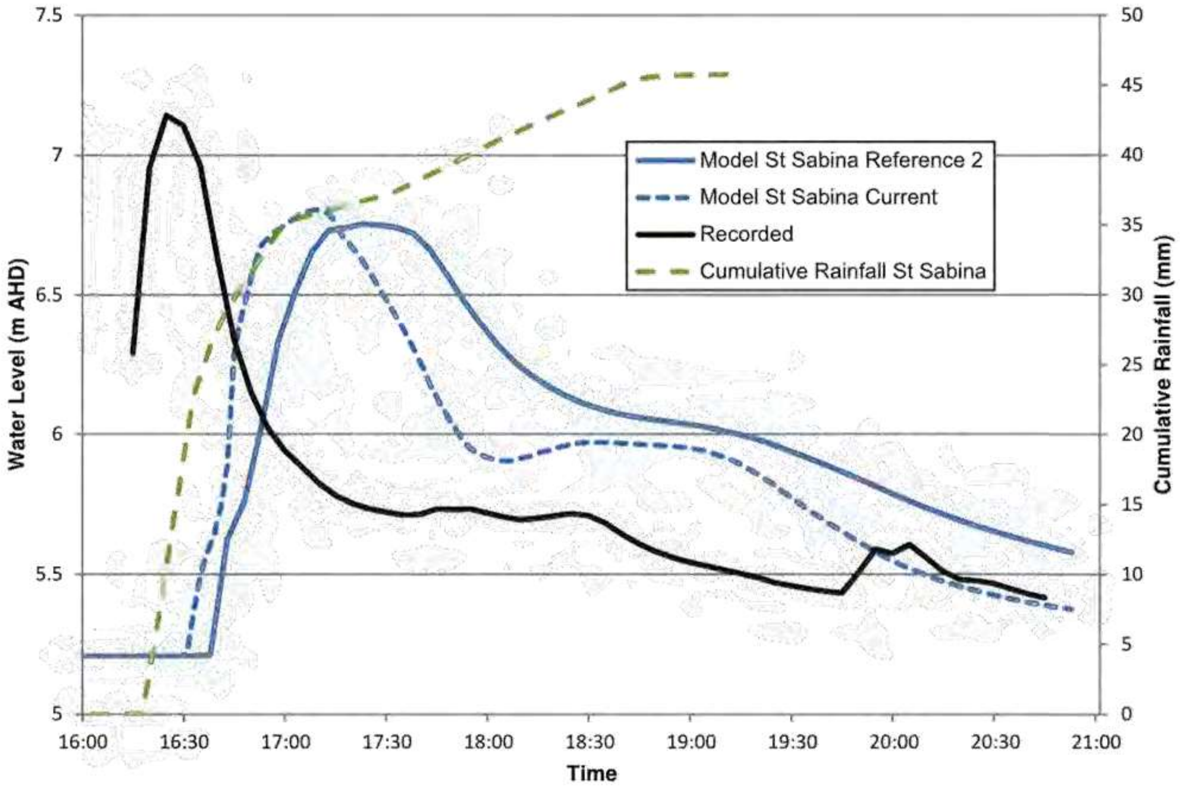


FIGURE 13E
CALIBRATION RESULTS--ELVA STREET GAUGE
18 MARCH 1990



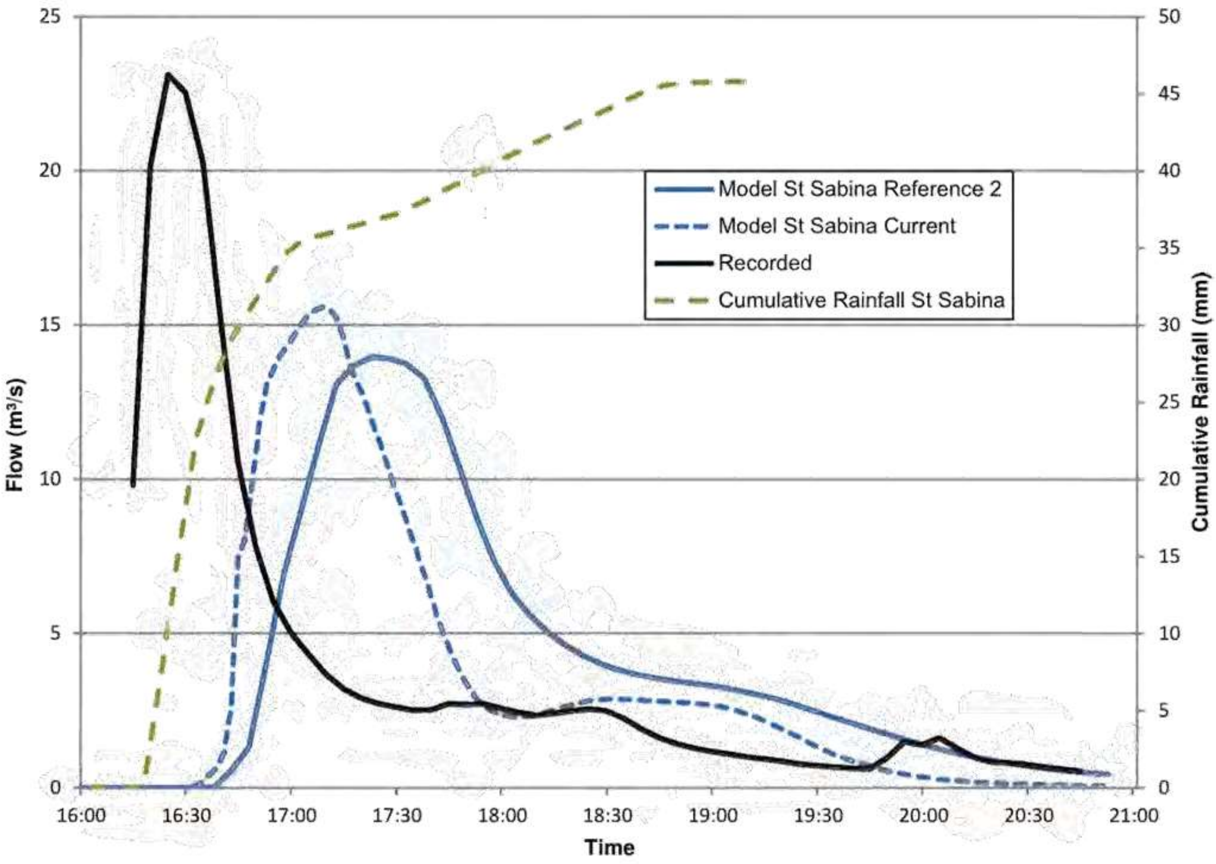
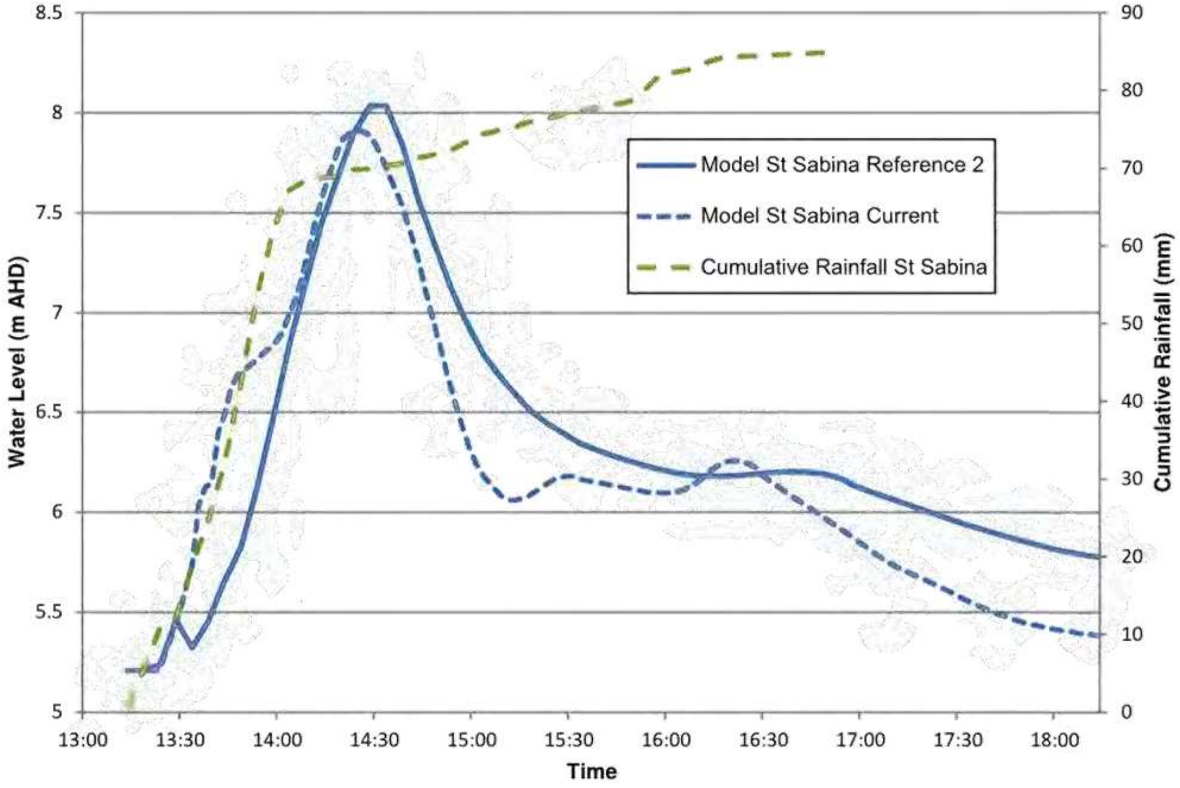
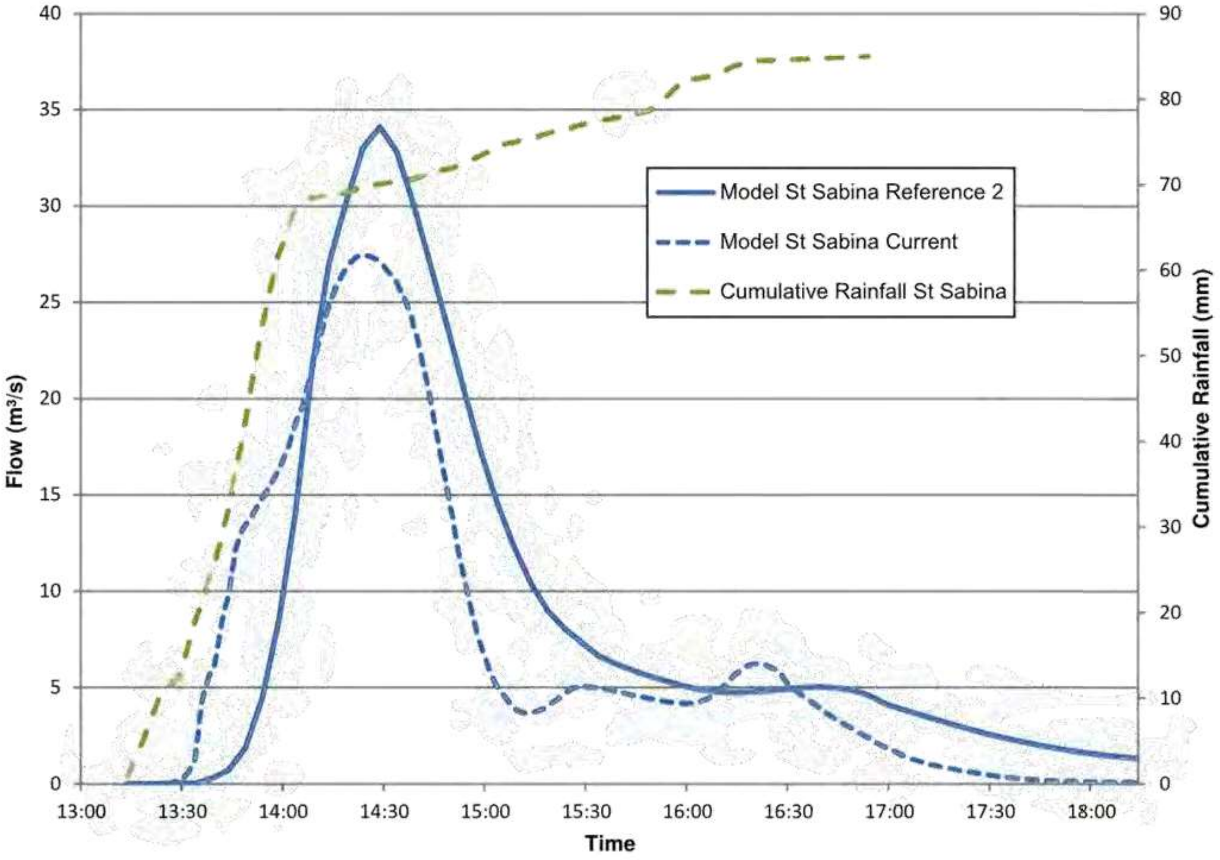


FIGURE 13F
CALIBRATION RESULTS--ELVA STREET GAUGE
2 JANUARY 1996





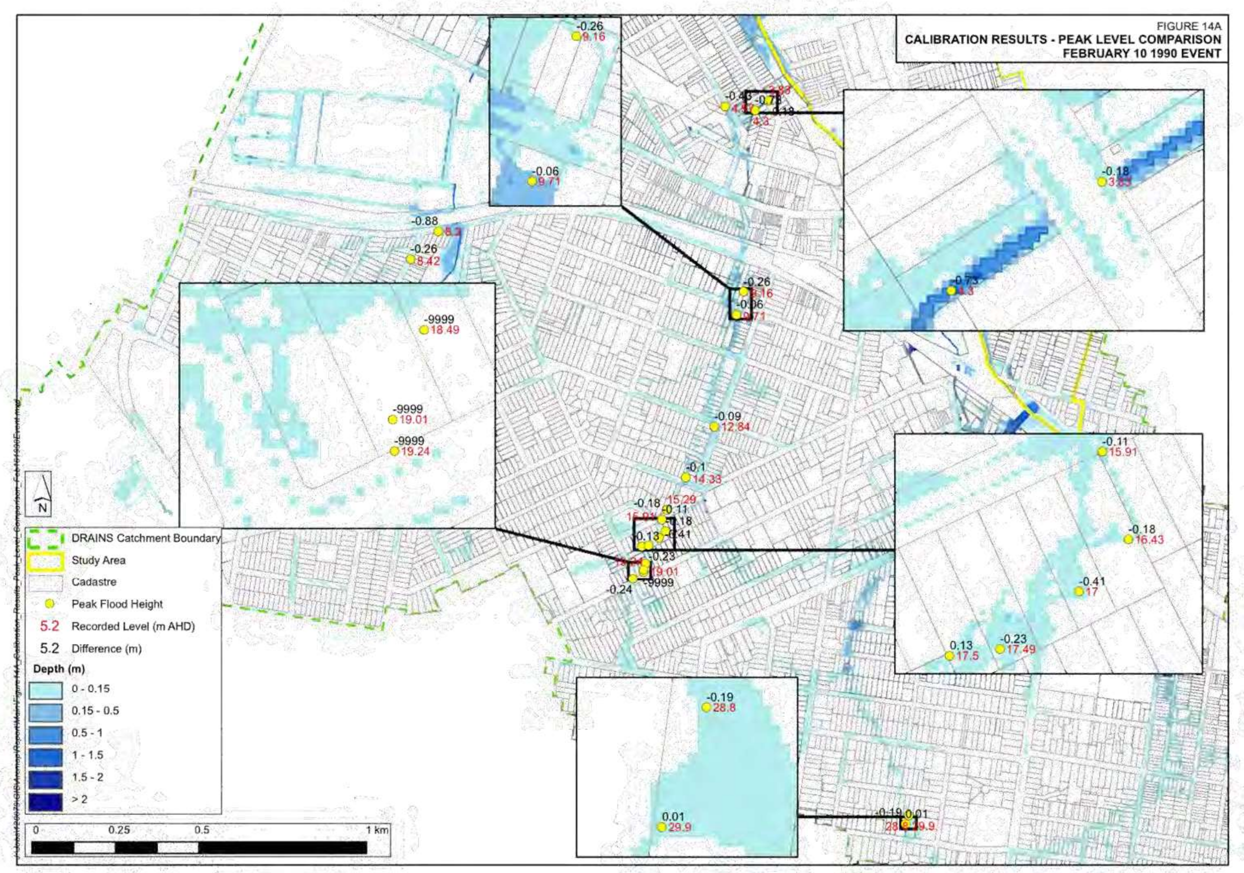


FIGURE 14A
CALIBRATION RESULTS - PEAK LEVEL COMPARISON
FEBRUARY 10 1990 EVENT
DRAINS Catchment Boundary
Study Area
Cadastre
Peak Flood Height
5.2 Recorded Level (m AHD)
5.2 Difference (m)
Depth (m)
0 - 0.15
0.15 - 0.5
0.5 - 1
1 - 1.5
1.5 - 2
> 2
0
0.25
0.5
1 km
N
-0.26
9.16
-0.06
9.71
-0.88
-0.26
8.42
-9999
18.49
-9999
19.01
-9999
19.24
-0.09
12.84
-0.1
14.33
-0.18
3.83
-0.11
15.91
-0.18
16.43
-0.41
17
0.13
17.5
-0.23
17.49
-0.19
28.8
0.01
29.9

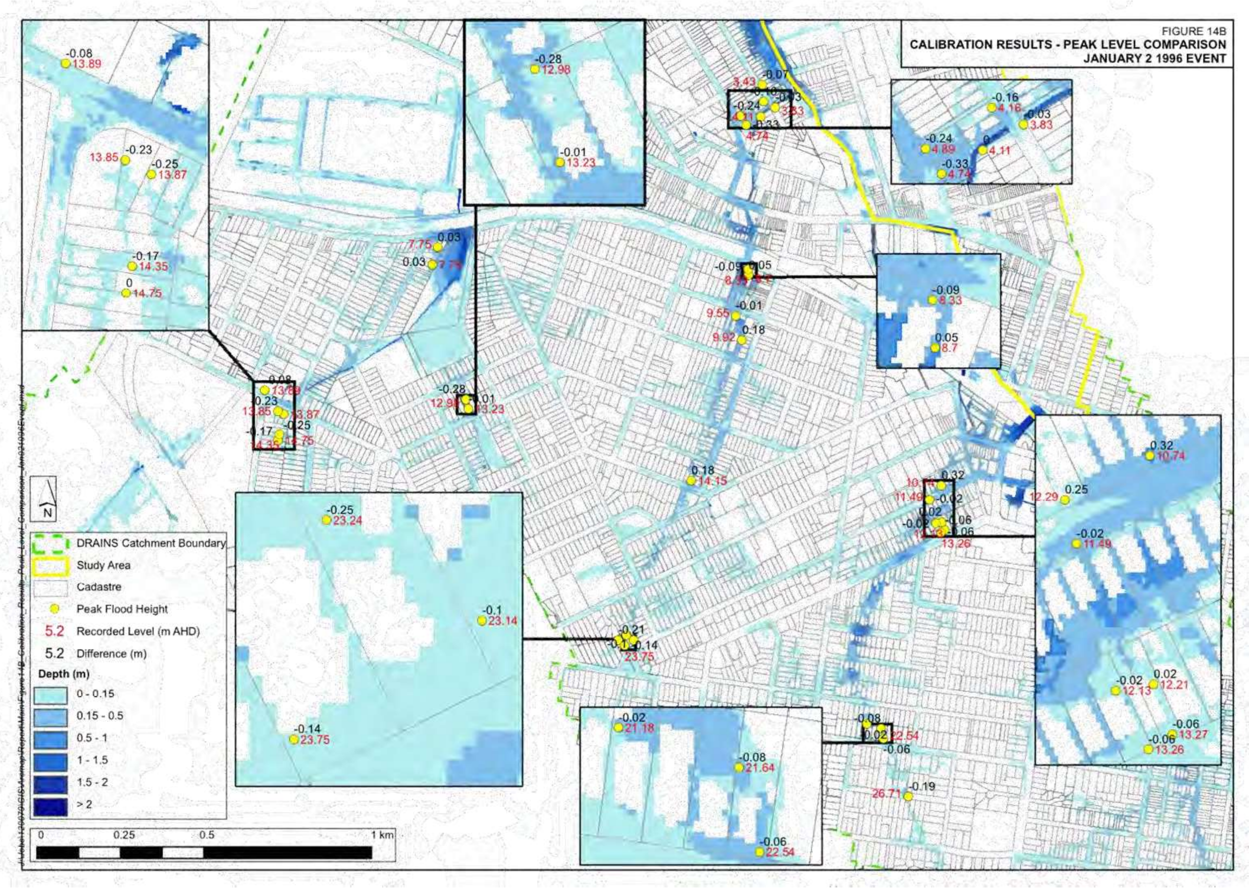


FIGURE 14B
CALIBRATION RESULTS - PEAK LEVEL COMPARISON
JANUARY 2 1996 EVENT
N
DRAINS Catchment Boundary
Study Area
Cadastre
Peak Flood Height
5.2 Recorded Level (m AHD)
5.2 Difference (m)
Depth (m)
0 - 0.15
0.15 - 0.5
0.5 - 1
1 - 1.5
1.5 - 2
> 2
0
0.25
0.5
1 km

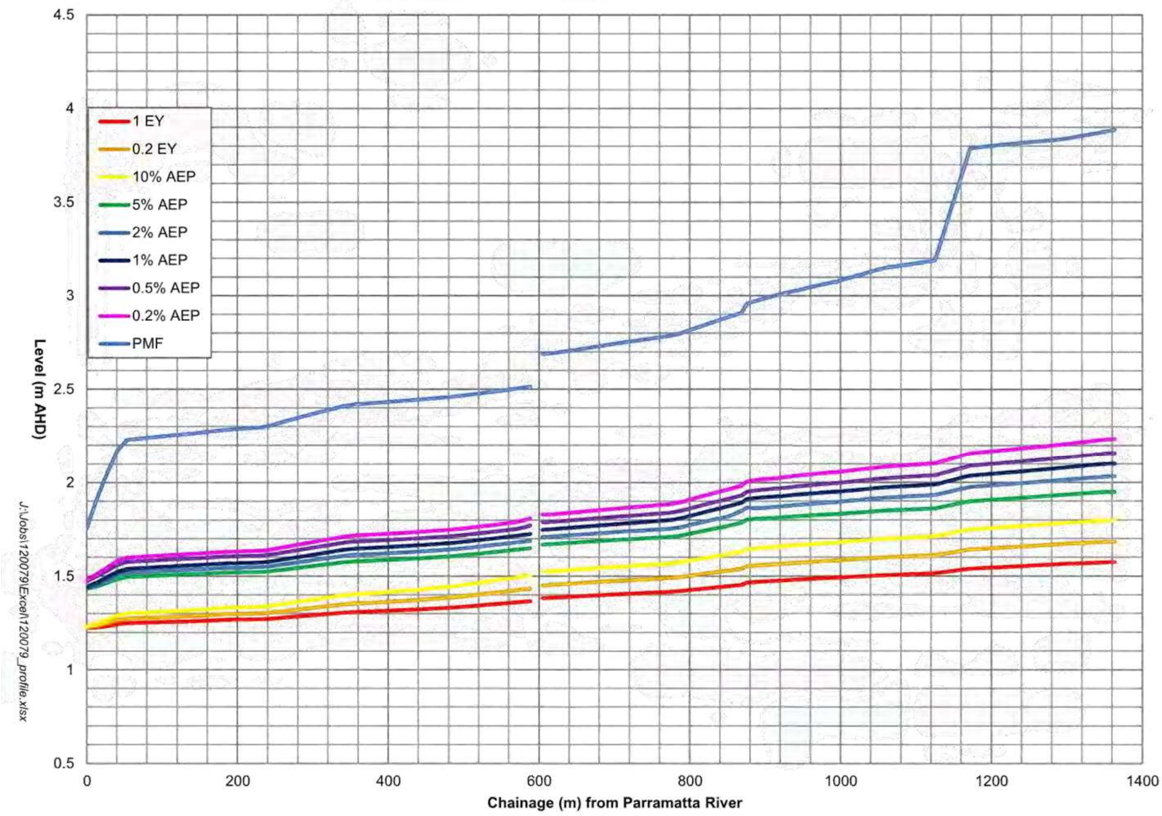
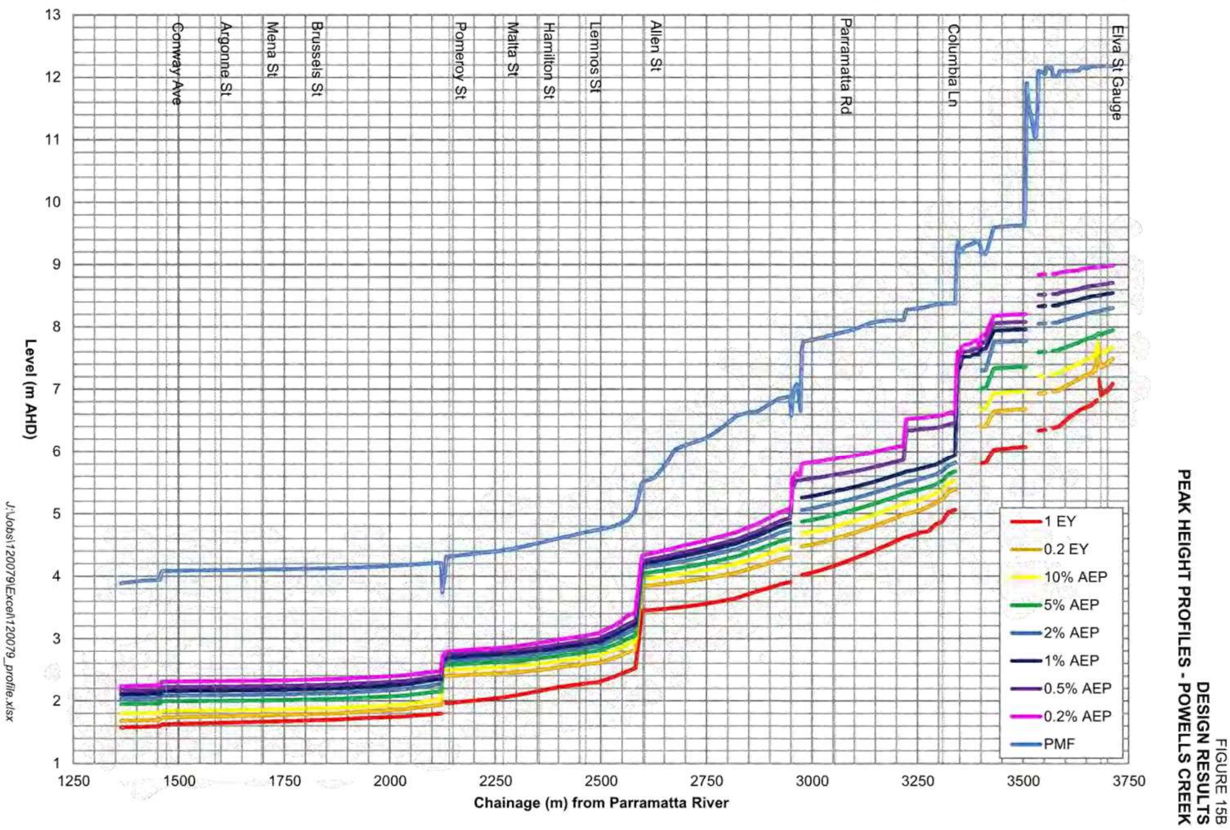


FIGURE 15A
DESIGN RESULTS
PEAK HEIGHT PROFILES - POWELLS CREEK


Conway Ave
Argonne St
Mena St
Brussels St
Pomeroy St
Malta St
Hamilton St
Lemnos St
Allen St
Parramatta Rd
Columbia Ln
Elva St Gauge
Level (m AHD)
Chainage (m) from Parramatta River
1 EY
0.2 EY
10% AEP
5% AEP
2% AEP
1% AEP
0.5% AEP
0.2% AEP
PMF
J:\Jobs\120079\Excel\120079_profile.xlsx
FIGURE 15B
DESIGN RESULTS
PEAK HEIGHT PROFILES - POWELLS CREEK

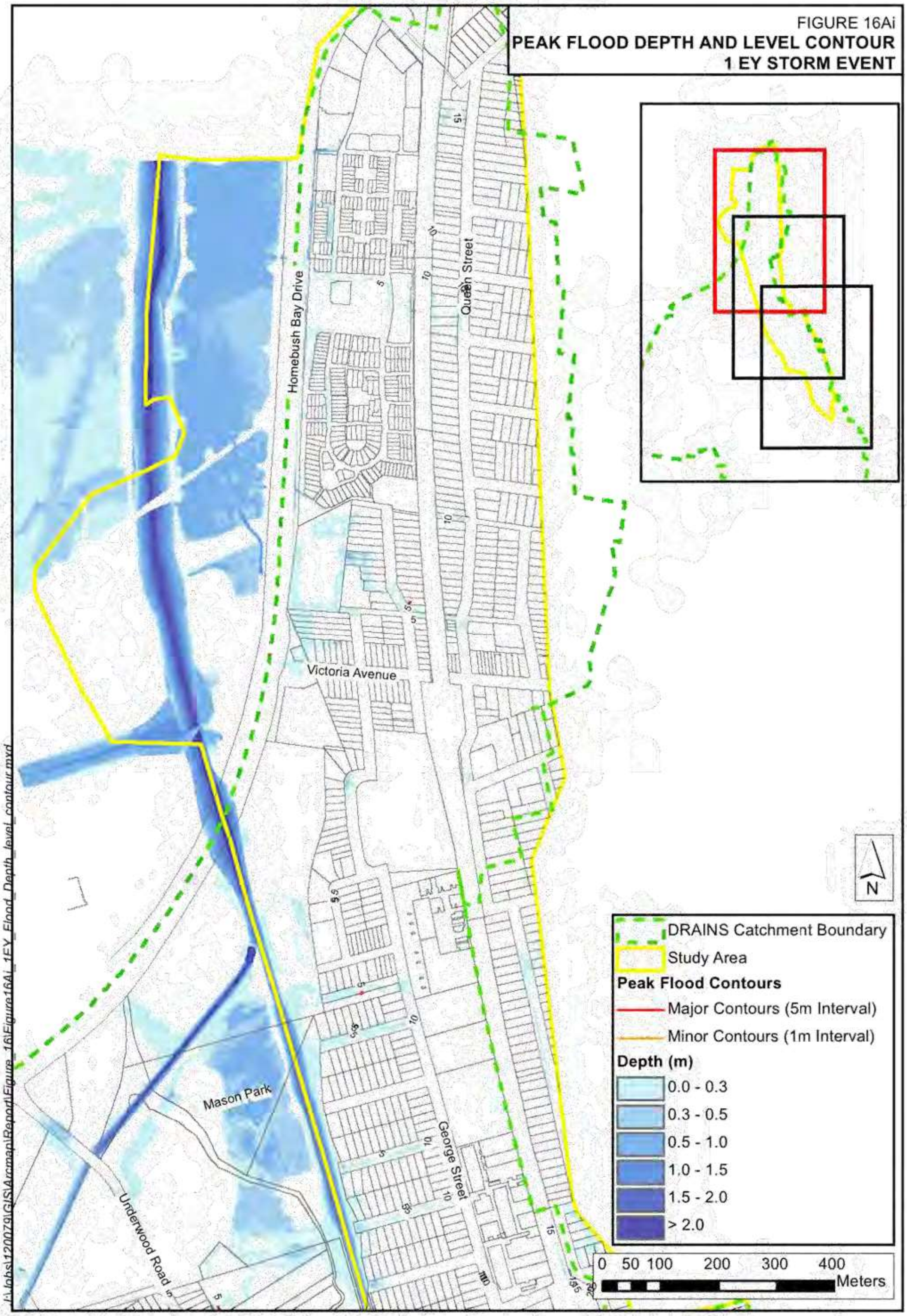


FIGURE 16Ai
PEAK FLOOD DEPTH AND LEVEL CONTOUR
1 EY STORM EVENT
Homebush Bay Drive
Queen Street
Victoria Avenue
Mason Park
Underwood Road
George Street
DRAINS Catchment Boundary
Study Area
Peak Flood Contours
Major Contours (5m Interval)
Minor Contours (1m Interval)
Depth (m)
0.0 - 0.3
0.3 - 0.5
0.5 - 1.0
1.0 - 1.5
1.5 - 2.0
> 2.0
0 50 100 200 300 400
Meters
N

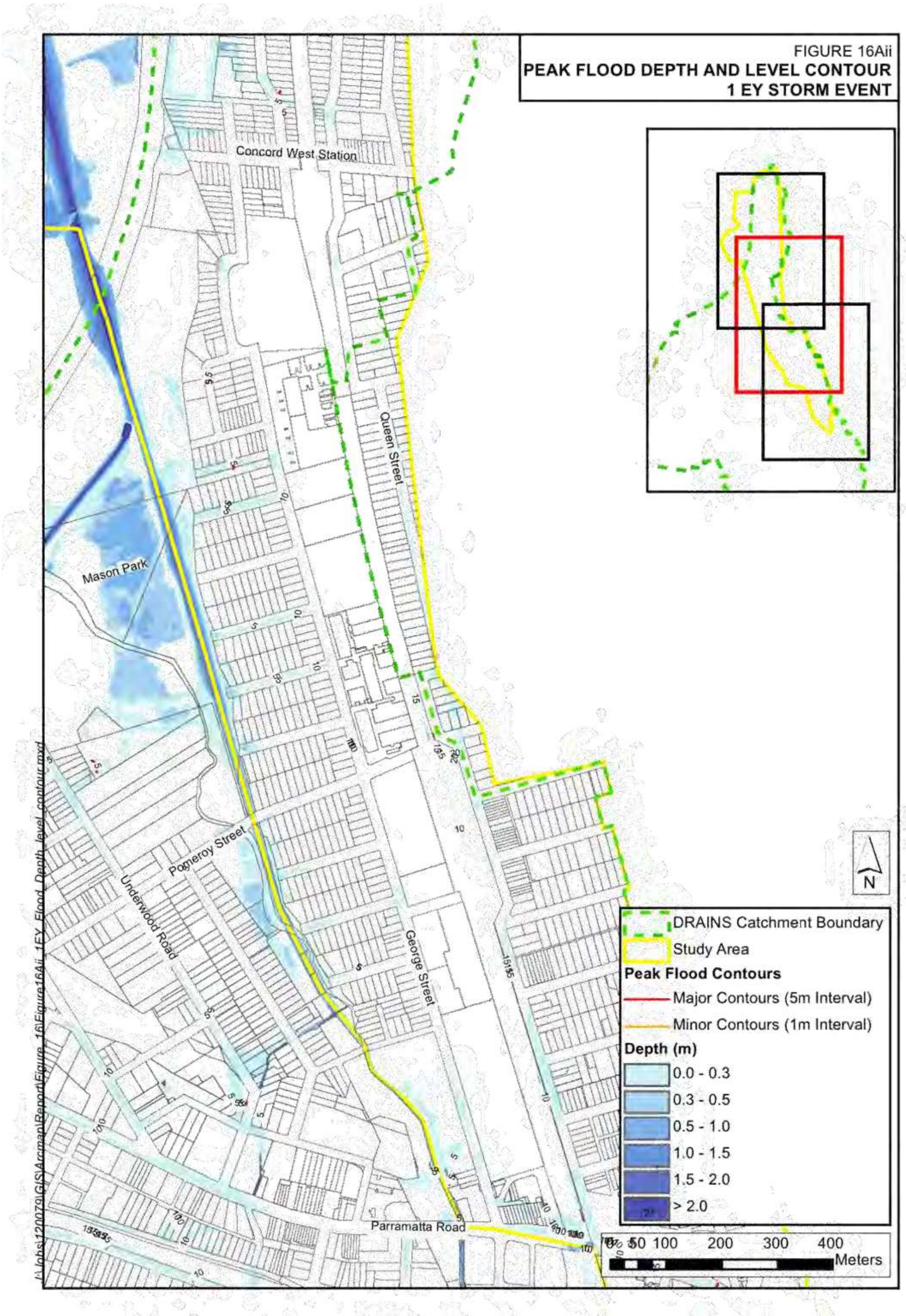


FIGURE 16Aii
PEAK FLOOD DEPTH AND LEVEL CONTOUR
1 EY STORM EVENT
Concord West Station
Queen Street
Mason Park
Pomeroy Street
Underwood Road
George Street
Parramatta Road
DRAINS Catchment Boundary
Study Area
Peak Flood Contours
Major Contours (5m Interval)
Minor Contours (1m Interval)
Depth (m)
0.0 - 0.3
0.3 - 0.5
0.5 - 1.0
1.0 - 1.5
1.5 - 2.0
> 2.0
50 100 200 300 400
Meters
N

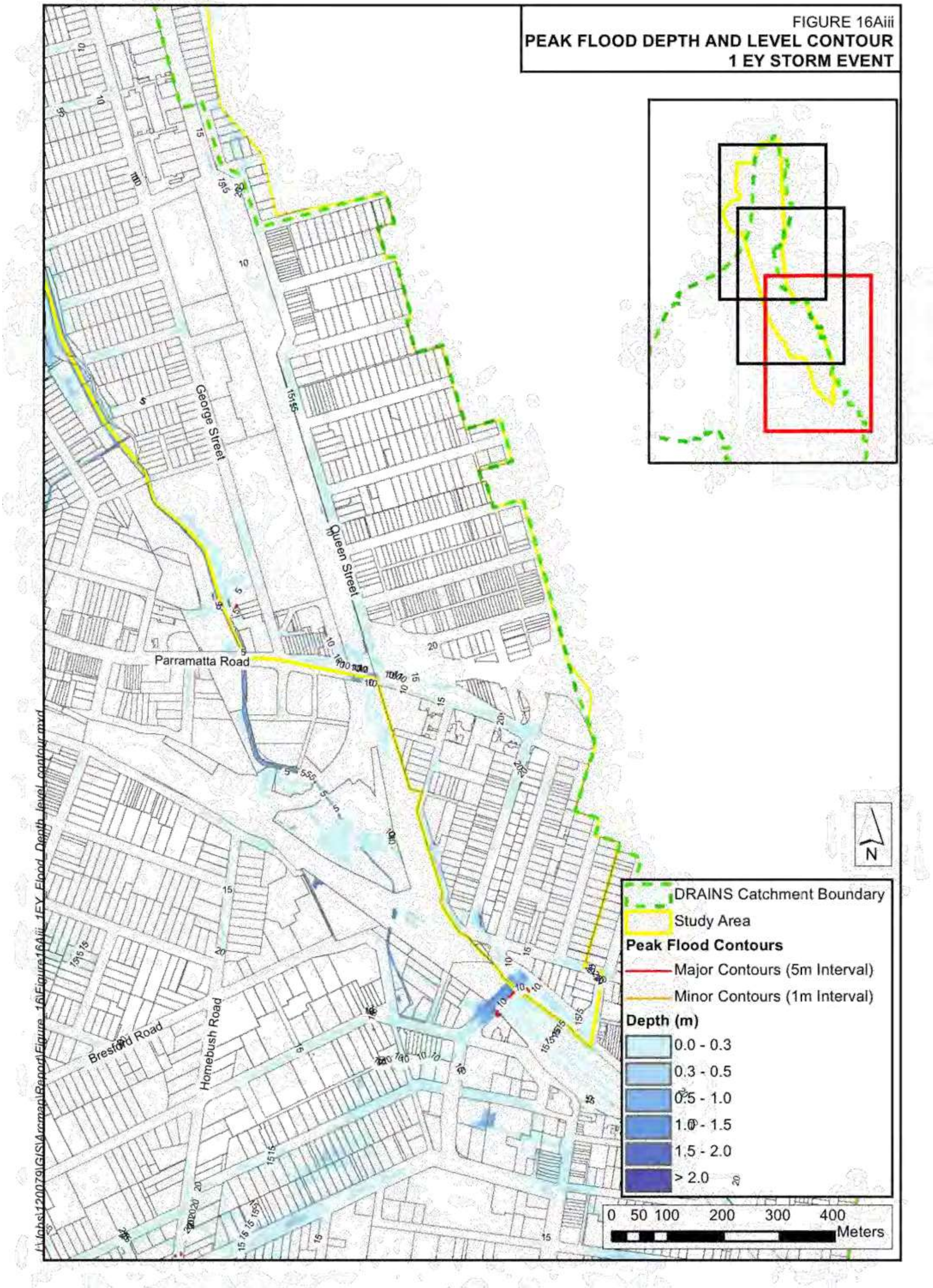


FIGURE 16Aiii
PEAK FLOOD DEPTH AND LEVEL CONTOUR
1 EY STORM EVENT
George Street
Queen Street
Parramatta Road
Bresford Road
Homebush Road
DRAINS Catchment Boundary
Study Area
Peak Flood Contours
Major Contours (5m Interval)
Minor Contours (1m Interval)
Depth (m)
0.0 - 0.3
0.3 - 0.5
0.5 - 1.0
1.0 - 1.5
1.5 - 2.0
> 2.0
0 50 100 200 300 400
Meters
N

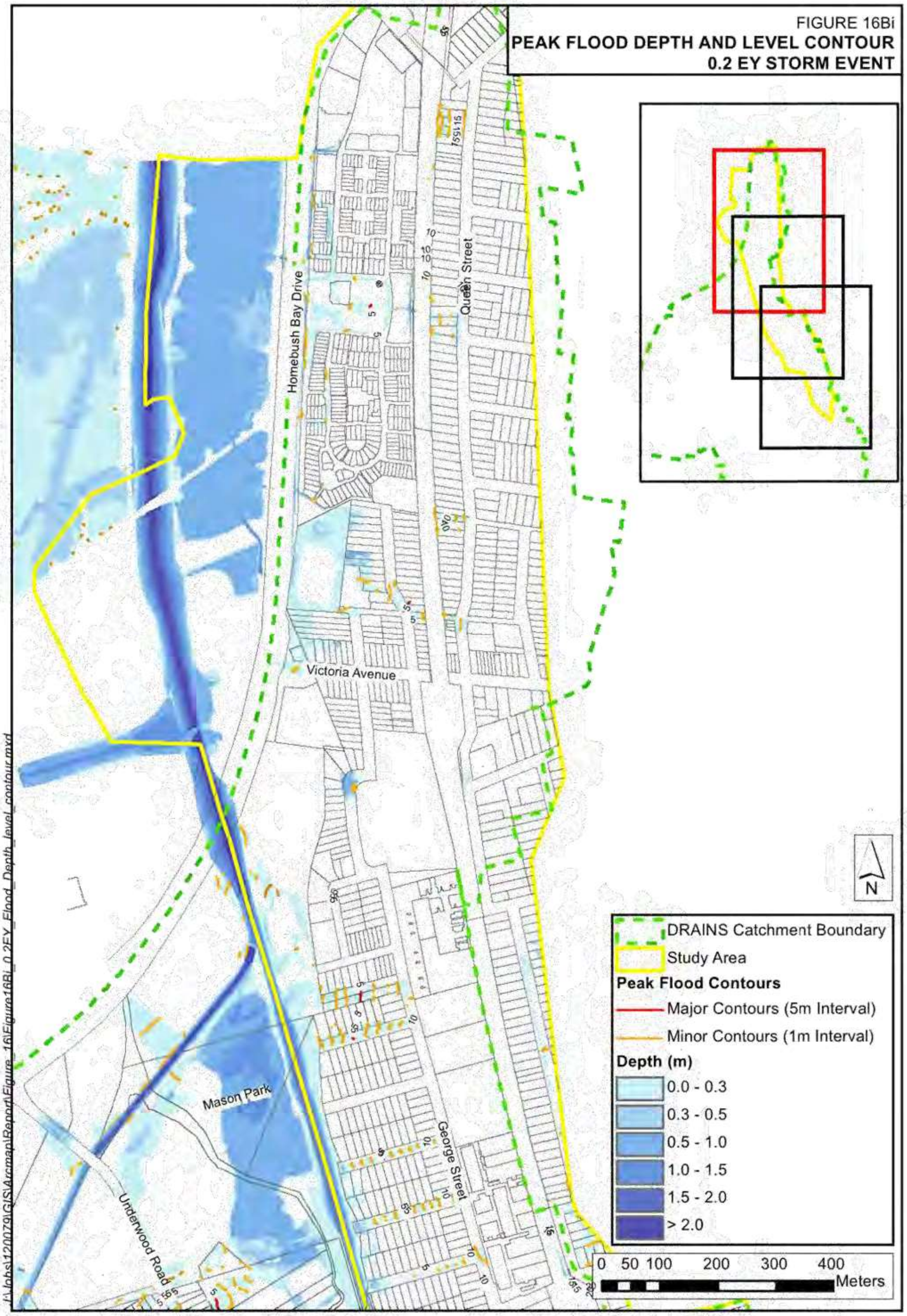


FIGURE 16Bi
PEAK FLOOD DEPTH AND LEVEL CONTOUR
0.2 EY STORM EVENT
Homebush Bay Drive
Queen Street
Victoria Avenue
Mason Park
George Street
Underwood Road
DRAINS Catchment Boundary
Study Area
Peak Flood Contours
Major Contours (5m Interval)
Minor Contours (1m Interval)
Depth (m)
0.0 - 0.3
0.3 - 0.5
0.5 - 1.0
1.0 - 1.5
1.5 - 2.0
> 2.0
0 50 100 200 300 400
Meters
N

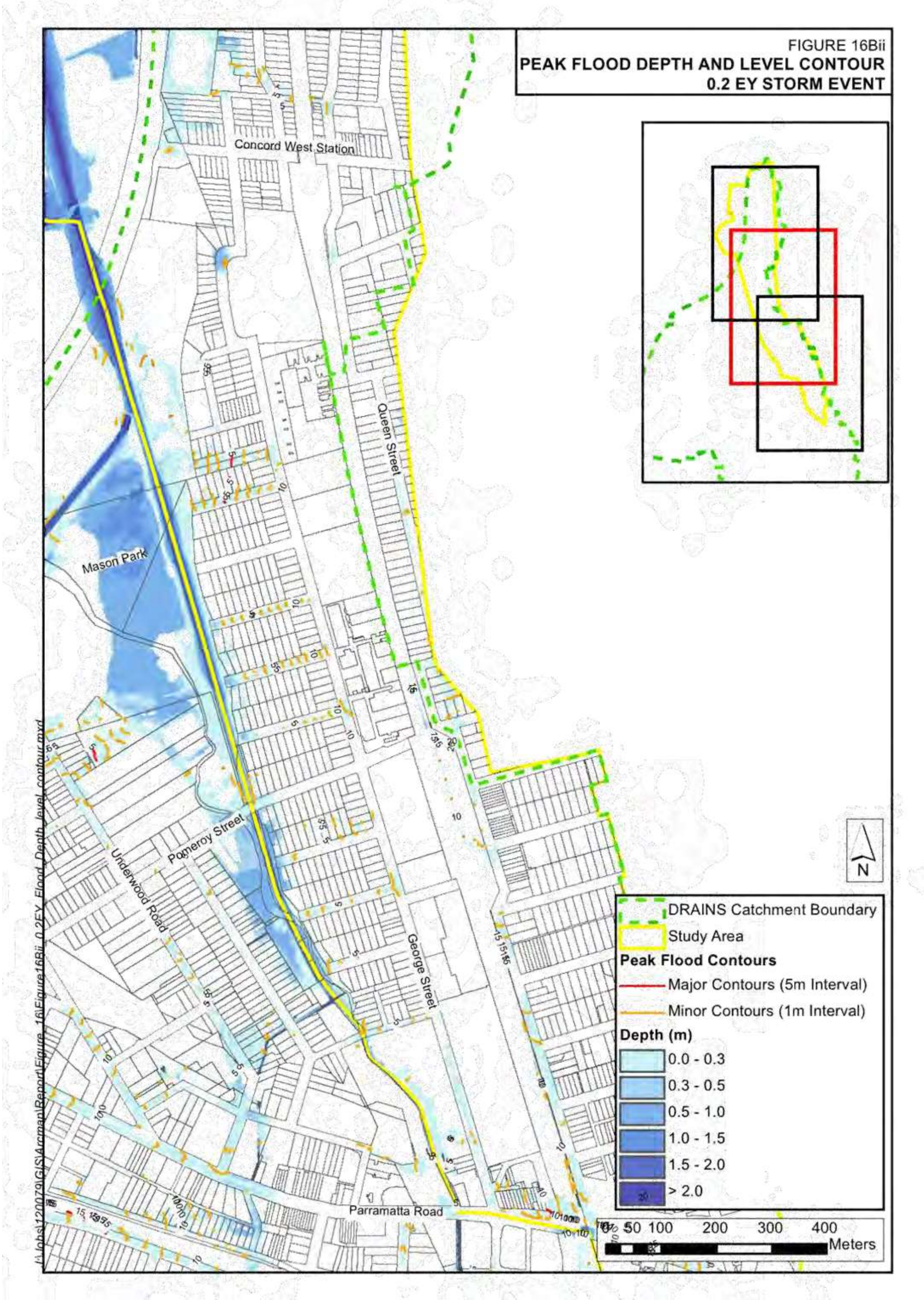


FIGURE 16Bii
PEAK FLOOD DEPTH AND LEVEL CONTOUR
0.2 EY STORM EVENT
Concord West Station
Queen Street
Mason Park
Pomeroy Street
Underwood Road
George Street
Parramatta Road
DRAINS Catchment Boundary
Study Area
Peak Flood Contours
Major Contours (5m Interval)
Minor Contours (1m Interval)
Depth (m)
0.0 - 0.3
0.3 - 0.5
0.5 - 1.0
1.0 - 1.5
1.5 - 2.0
> 2.0
N
0 50 100 200 300 400
Meters

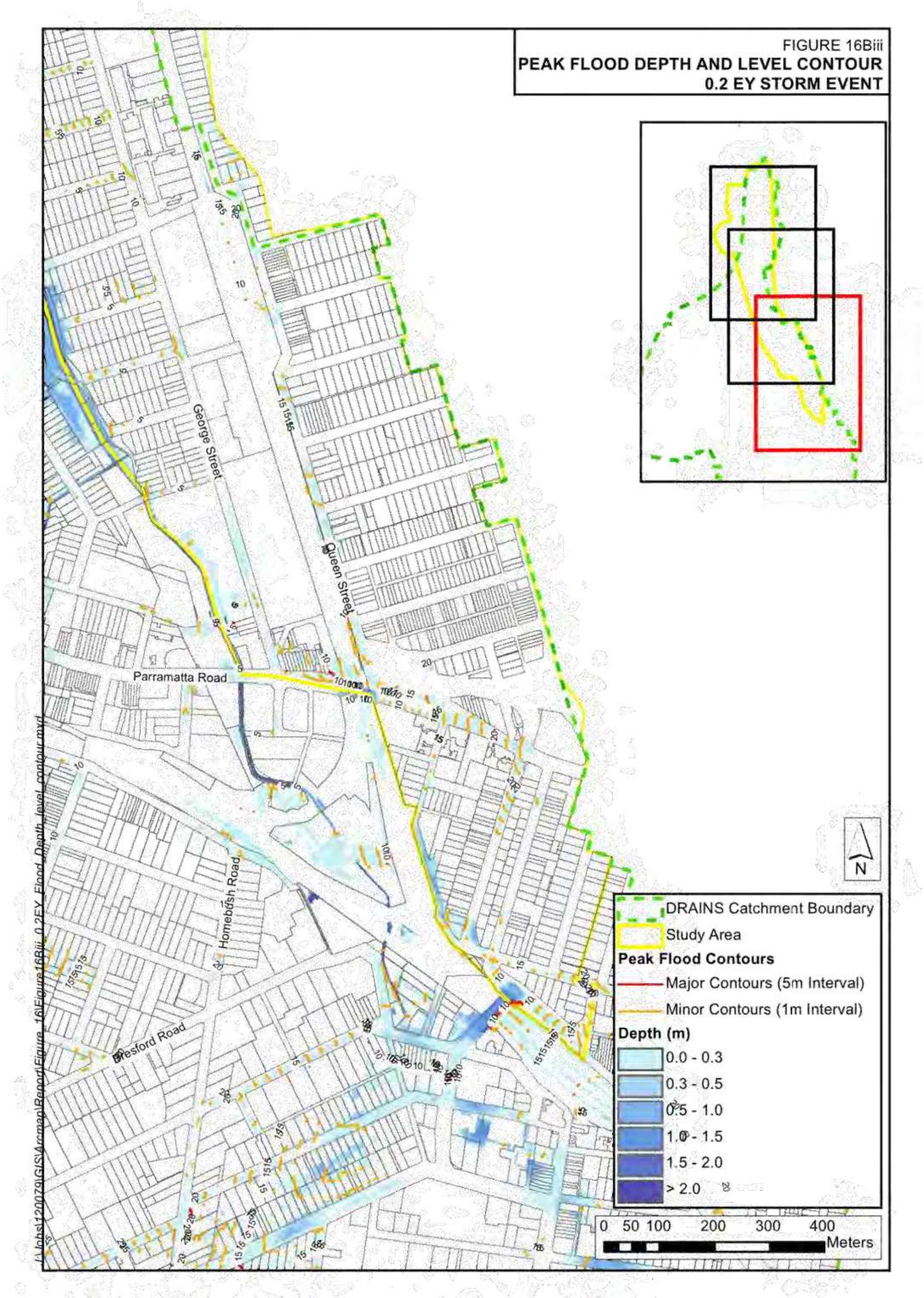


FIGURE 16Biii
PEAK FLOOD DEPTH AND LEVEL CONTOUR
0.2 EY STORM EVENT
George Street
Queen Street
Parramatta Road
Homebush Road
Bresford Road
DRAINS Catchment Boundary
Study Area
Peak Flood Contours
Major Contours (5m Interval)
Minor Contours (1m Interval)
Depth (m)
0.0 - 0.3
0.3 - 0.5
0.5 - 1.0
1.0 - 1.5
1.5 - 2.0
> 2.0
0 50 100 200 300 400
Meters
N

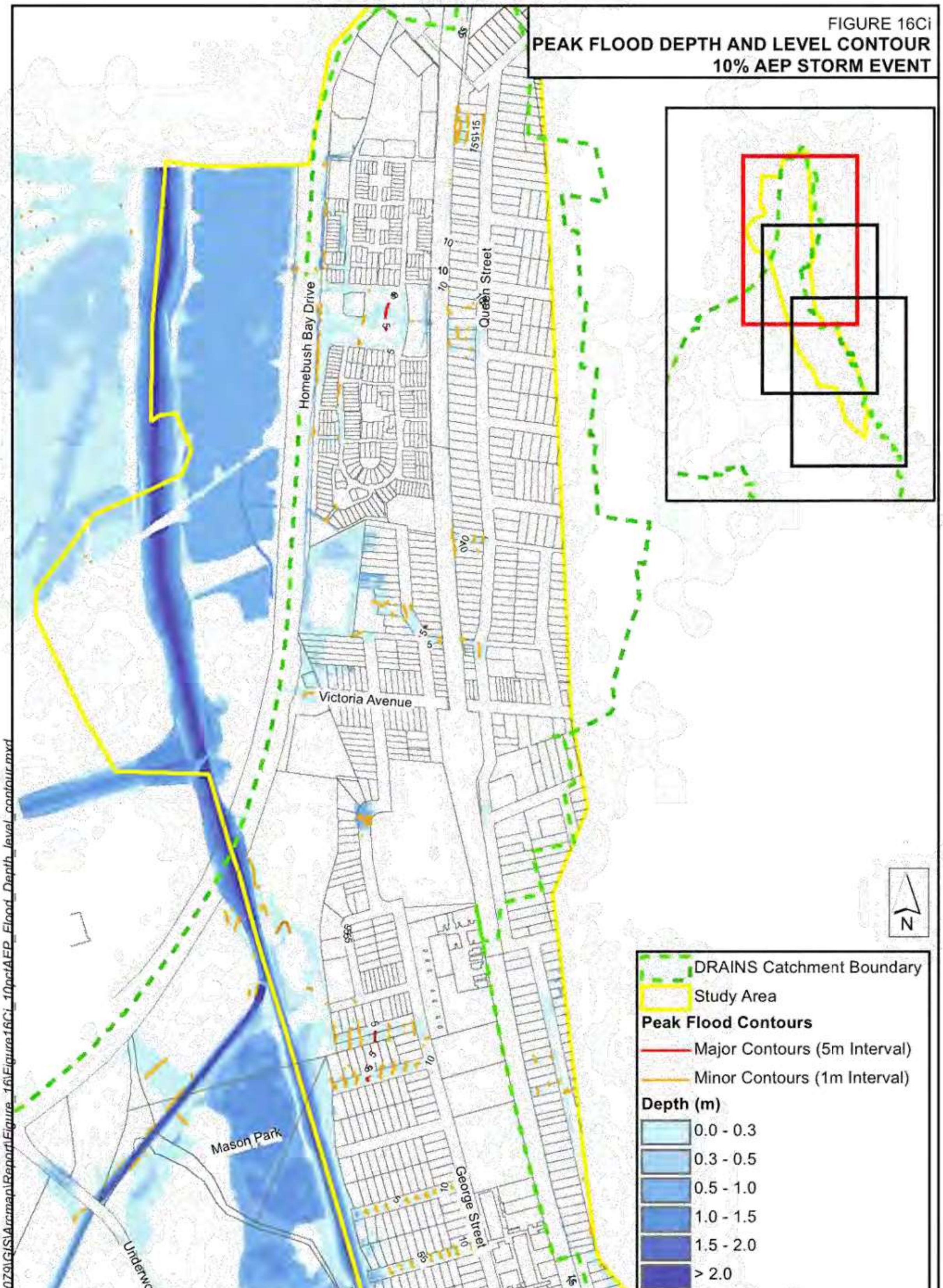


FIGURE 16Ci
PEAK FLOOD DEPTH AND LEVEL CONTOUR
10% AEP STORM EVENT
Homebush Bay Drive
Queen Street
Victoria Avenue
Mason Park
George Street
Underwood Road
N
DRAINS Catchment Boundary
Study Area
Peak Flood Contours
Major Contours (5m Interval)
Minor Contours (1m Interval)
Depth (m)
0.0 - 0.3
0.3 - 0.5
0.5 - 1.0
1.0 - 1.5
1.5 - 2.0
> 2.0
0 50 100 200 300 400
Meters

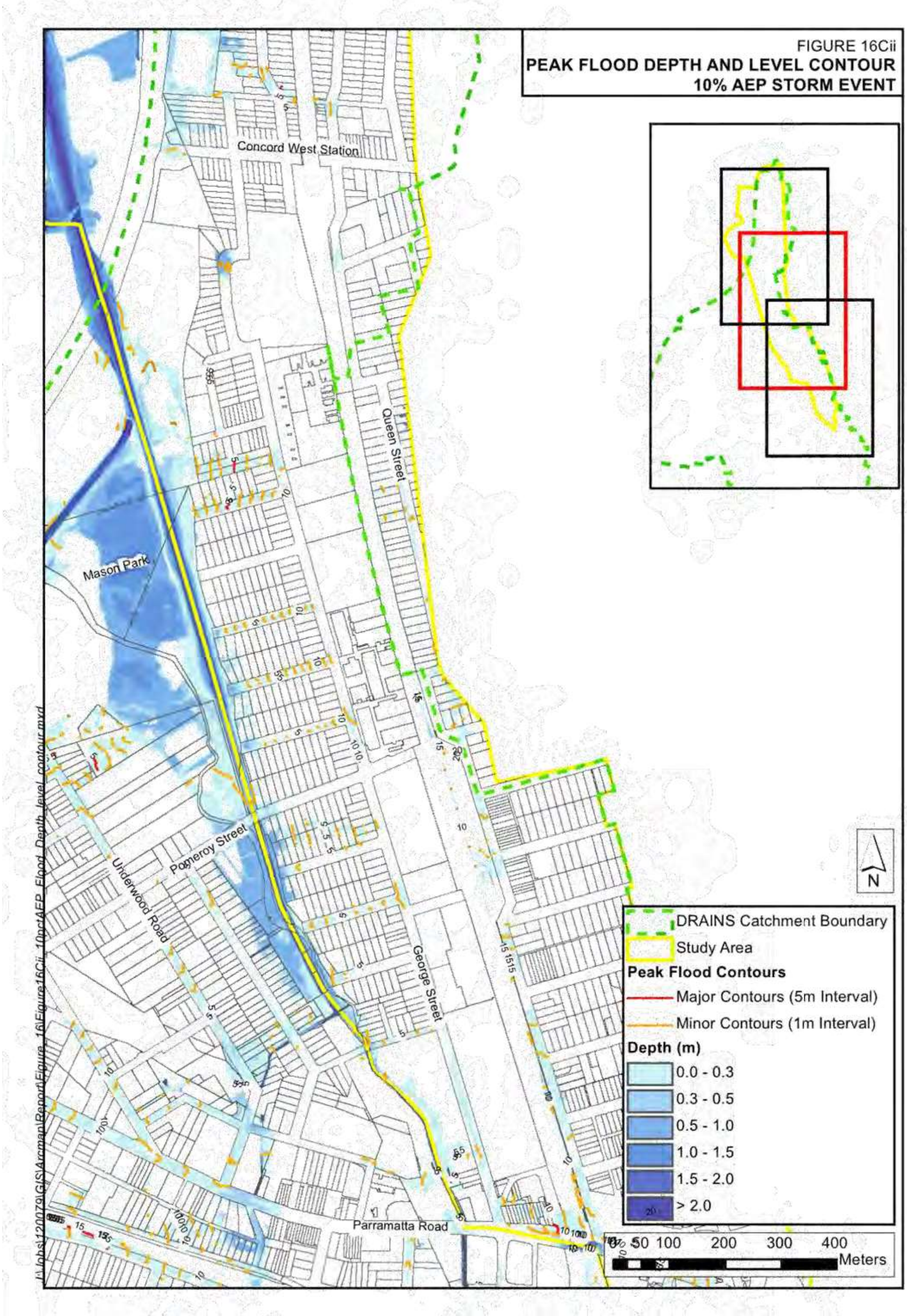


FIGURE 16Cii
PEAK FLOOD DEPTH AND LEVEL CONTOUR
10% AEP STORM EVENT
Concord West Station
Queen Street
Mason Park
Pomeroy Street
Underwood Road
George Street
Parramatta Road
N
DRAINS Catchment Boundary
Study Area
Peak Flood Contours
Major Contours (5m Interval)
Minor Contours (1m Interval)
Depth (m)
0.0 - 0.3
0.3 - 0.5
0.5 - 1.0
1.0 - 1.5
1.5 - 2.0
> 2.0
0 50 100 200 300 400
Meters

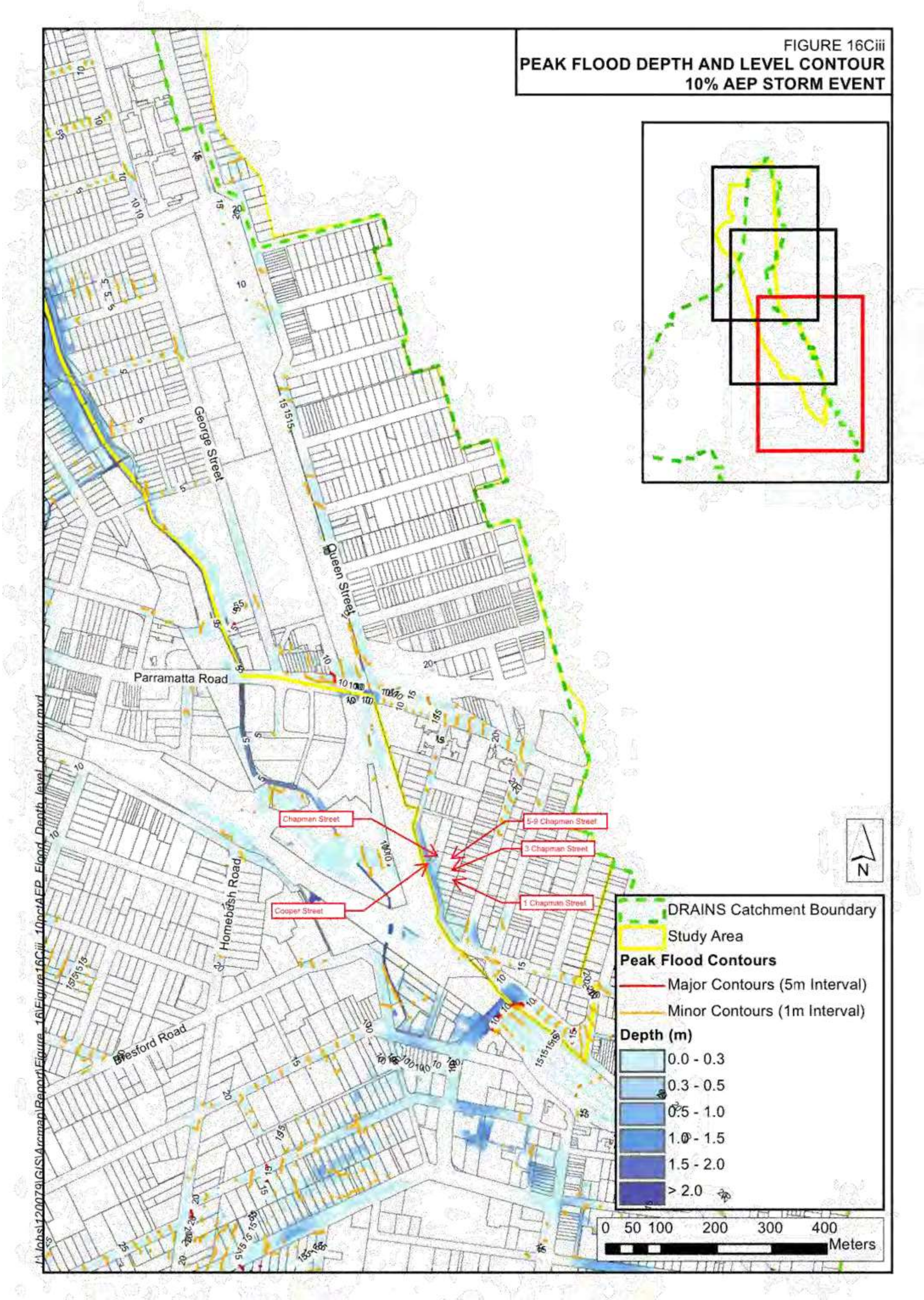


FIGURE 16Ciii
PEAK FLOOD DEPTH AND LEVEL CONTOUR
10% AEP STORM EVENT
George Street
Queen Street
Parramatta Road
Homebush Road
Bresford Road
Chapman Street
Cooper Street
5-9 Chapman Street
3 Chapman Street
1 Chapman Street
N
DRAINS Catchment Boundary
Study Area
Peak Flood Contours
Major Contours (5m Interval)
Minor Contours (1m Interval)
Depth (m)
0.0 - 0.3
0.3 - 0.5
0.5 - 1.0
1.0 - 1.5
1.5 - 2.0
> 2.0
0 50 100 200 300 400
Meters

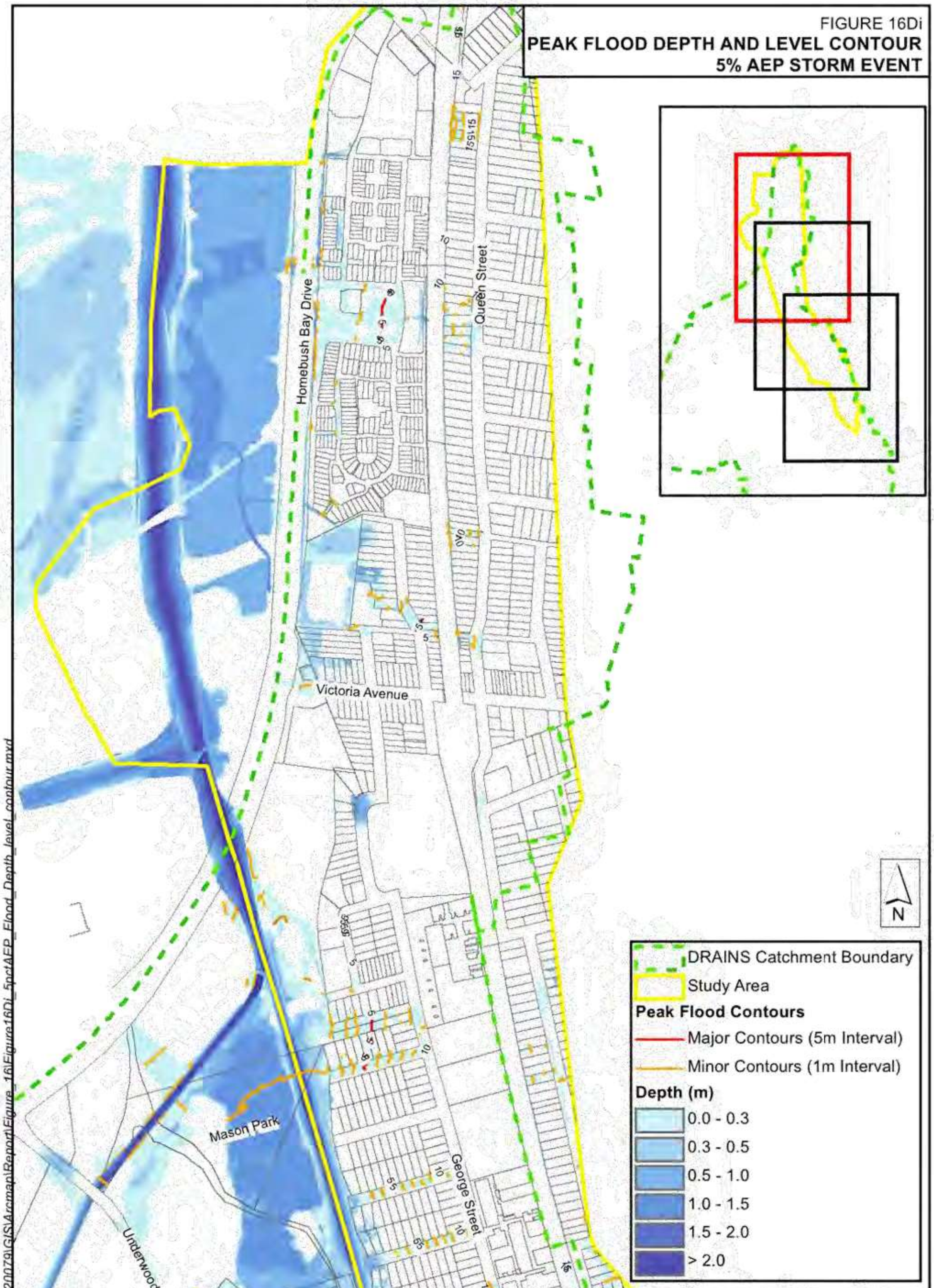


FIGURE 16Di
PEAK FLOOD DEPTH AND LEVEL CONTOUR
5% AEP STORM EVENT
Homebush Bay Drive
Queen Street
Victoria Avenue
Mason Park
Underwood Road
George Street
DRAINS Catchment Boundary
Study Area
Peak Flood Contours
Major Contours (5m Interval)
Minor Contours (1m Interval)
Depth (m)
0.0 - 0.3
0.3 - 0.5
0.5 - 1.0
1.0 - 1.5
1.5 - 2.0
> 2.0
0 50 100 200 300 400
Meters
N

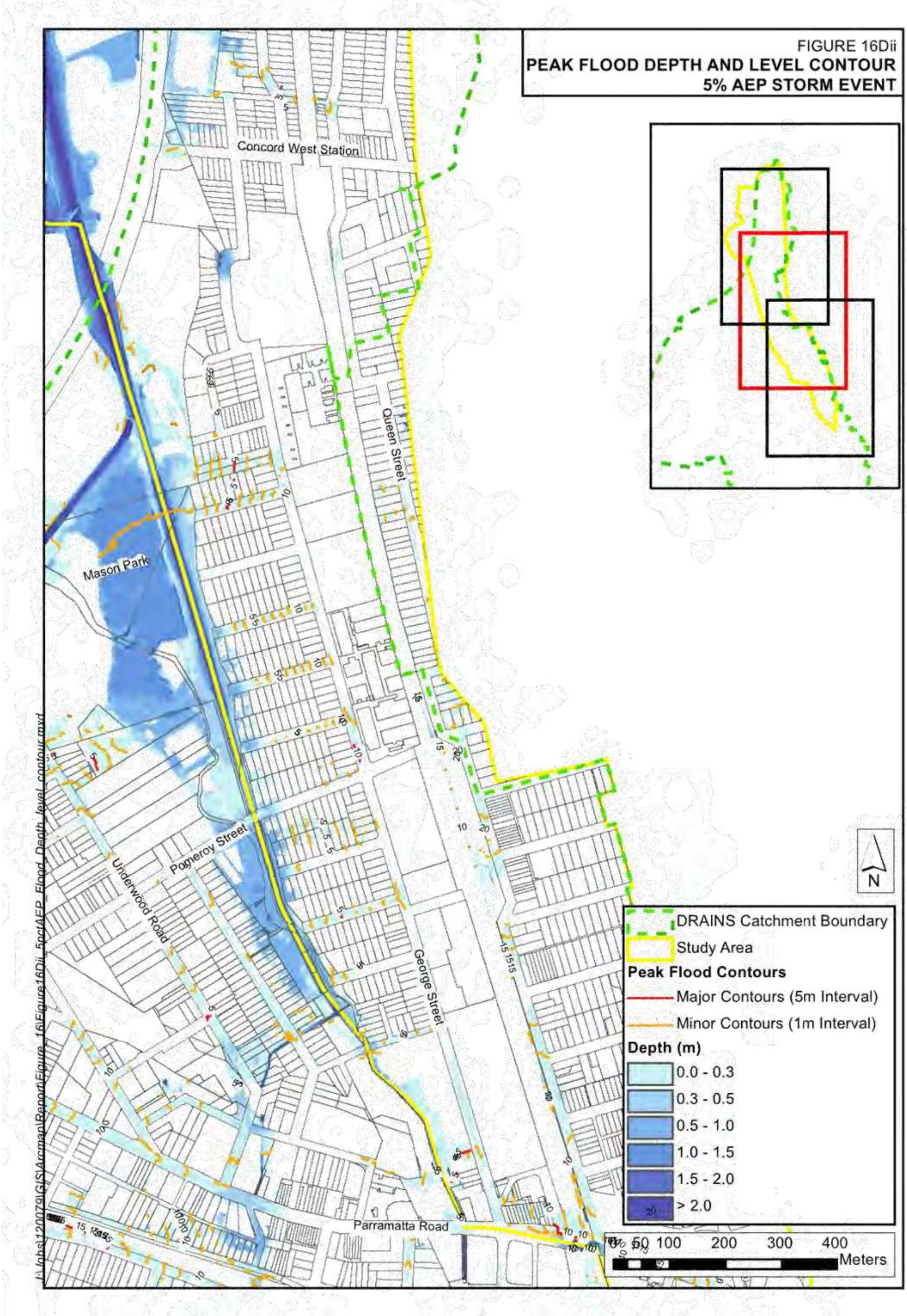


FIGURE 16Dii
PEAK FLOOD DEPTH AND LEVEL CONTOUR
5% AEP STORM EVENT
Concord West Station
Queen Street
Mason Park
Pomeroy Street
Underwood Road
George Street
Parramatta Road
DRAINS Catchment Boundary
Study Area
Peak Flood Contours
Major Contours (5m Interval)
Minor Contours (1m Interval)
Depth (m)
0.0 - 0.3
0.3 - 0.5
0.5 - 1.0
1.0 - 1.5
1.5 - 2.0
> 2.0
0 50 100 200 300 400
Meters
N

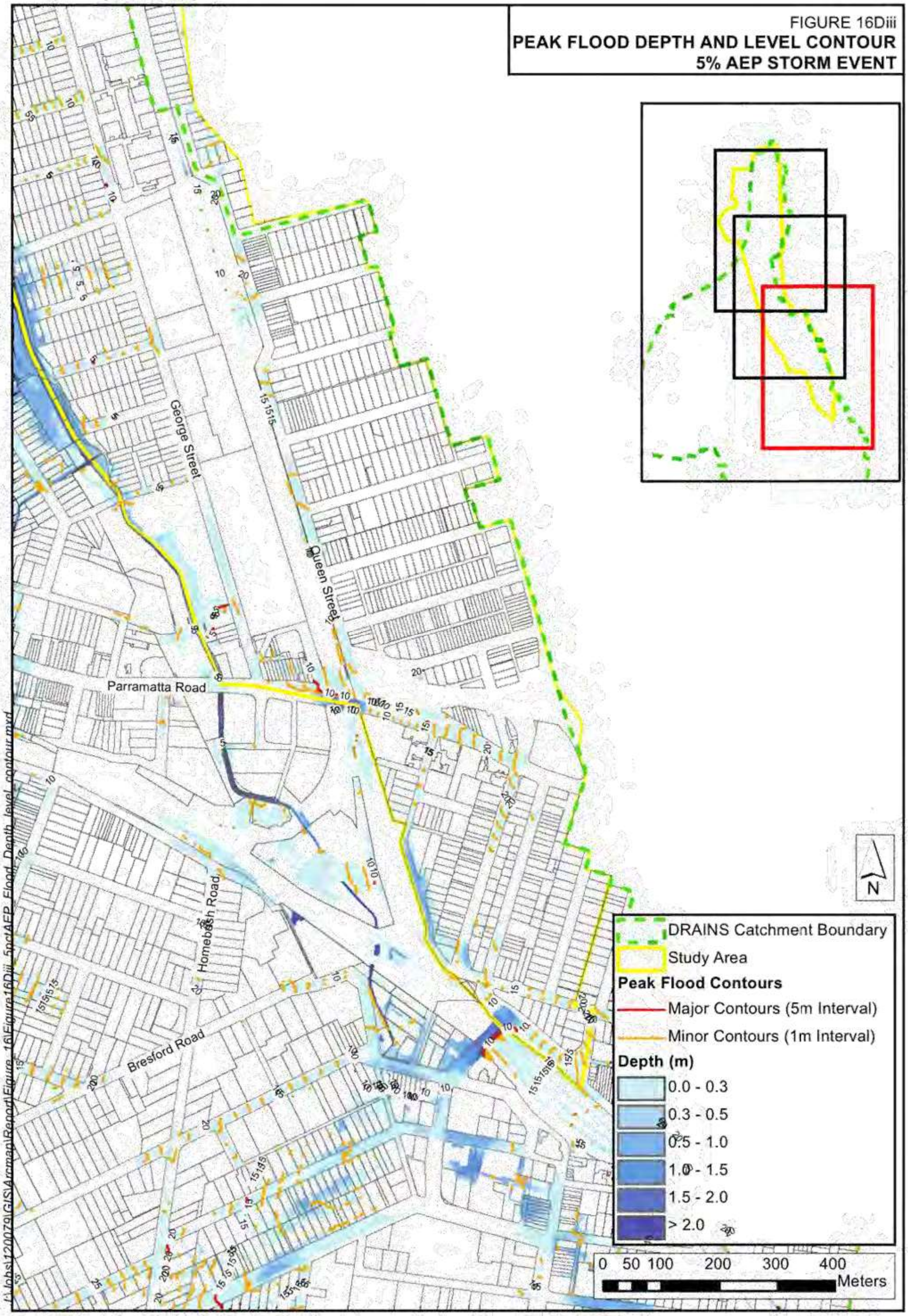


FIGURE 16Diii
PEAK FLOOD DEPTH AND LEVEL CONTOUR
5% AEP STORM EVENT
George Street
Queen Street
Parramatta Road
Homebush Road
Bresford Road
DRAINS Catchment Boundary
Study Area
Peak Flood Contours
Major Contours (5m Interval)
Minor Contours (1m Interval)
Depth (m)
0.0 - 0.3
0.3 - 0.5
0.5 - 1.0
1.0 - 1.5
1.5 - 2.0
> 2.0
0 50 100 200 300 400
Meters
N

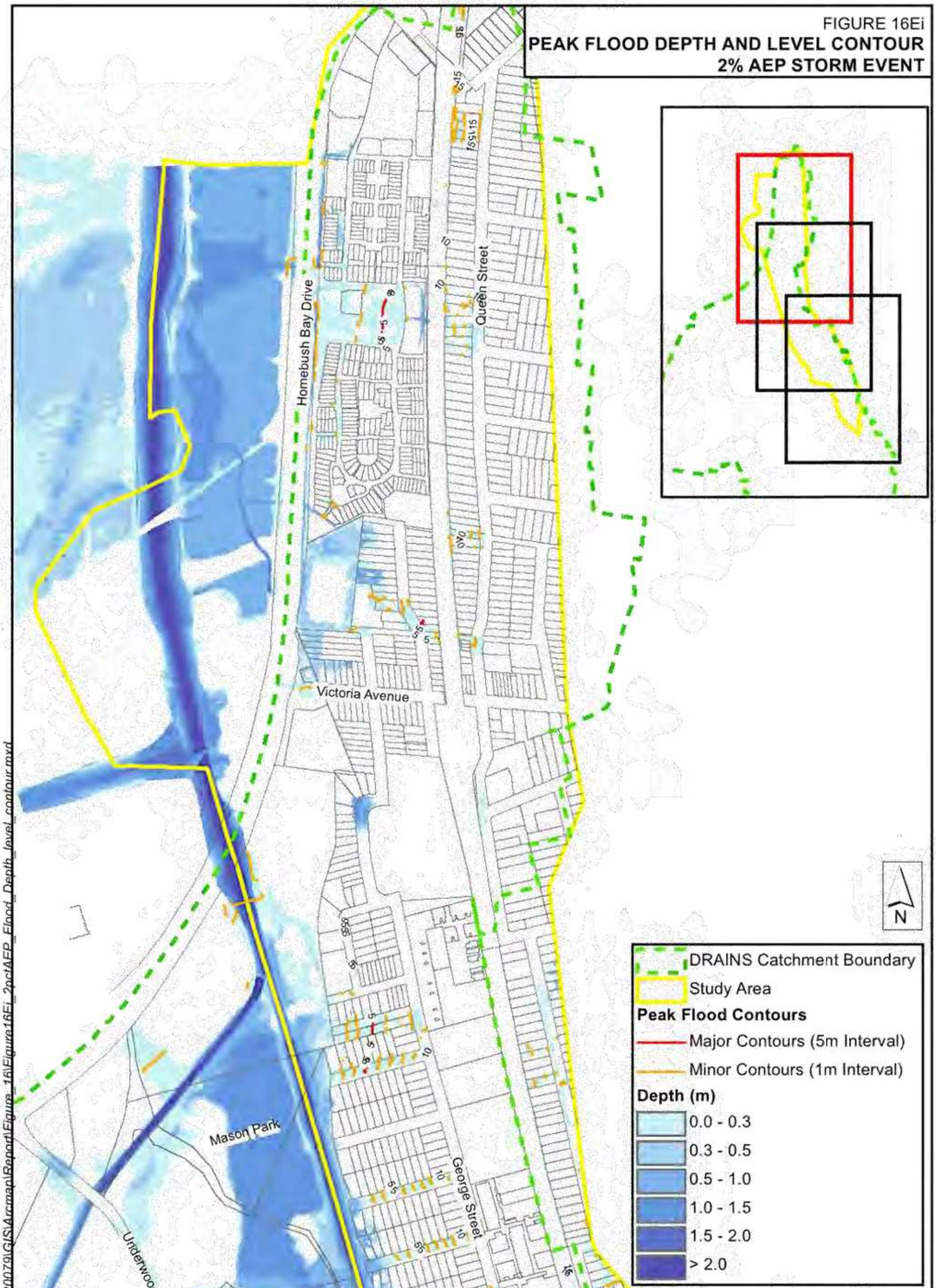


FIGURE 16Ei
PEAK FLOOD DEPTH AND LEVEL CONTOUR
2% AEP STORM EVENT
Homebush Bay Drive
Queen Street
Victoria Avenue
George Street
Mason Park
Underwood Road
DRAINS Catchment Boundary
Study Area
Peak Flood Contours
Major Contours (5m Interval)
Minor Contours (1m Interval)
Depth (m)
0.0 - 0.3
0.3 - 0.5
0.5 - 1.0
1.0 - 1.5
1.5 - 2.0
> 2.0
0 50 100 200 300 400
Meters
N

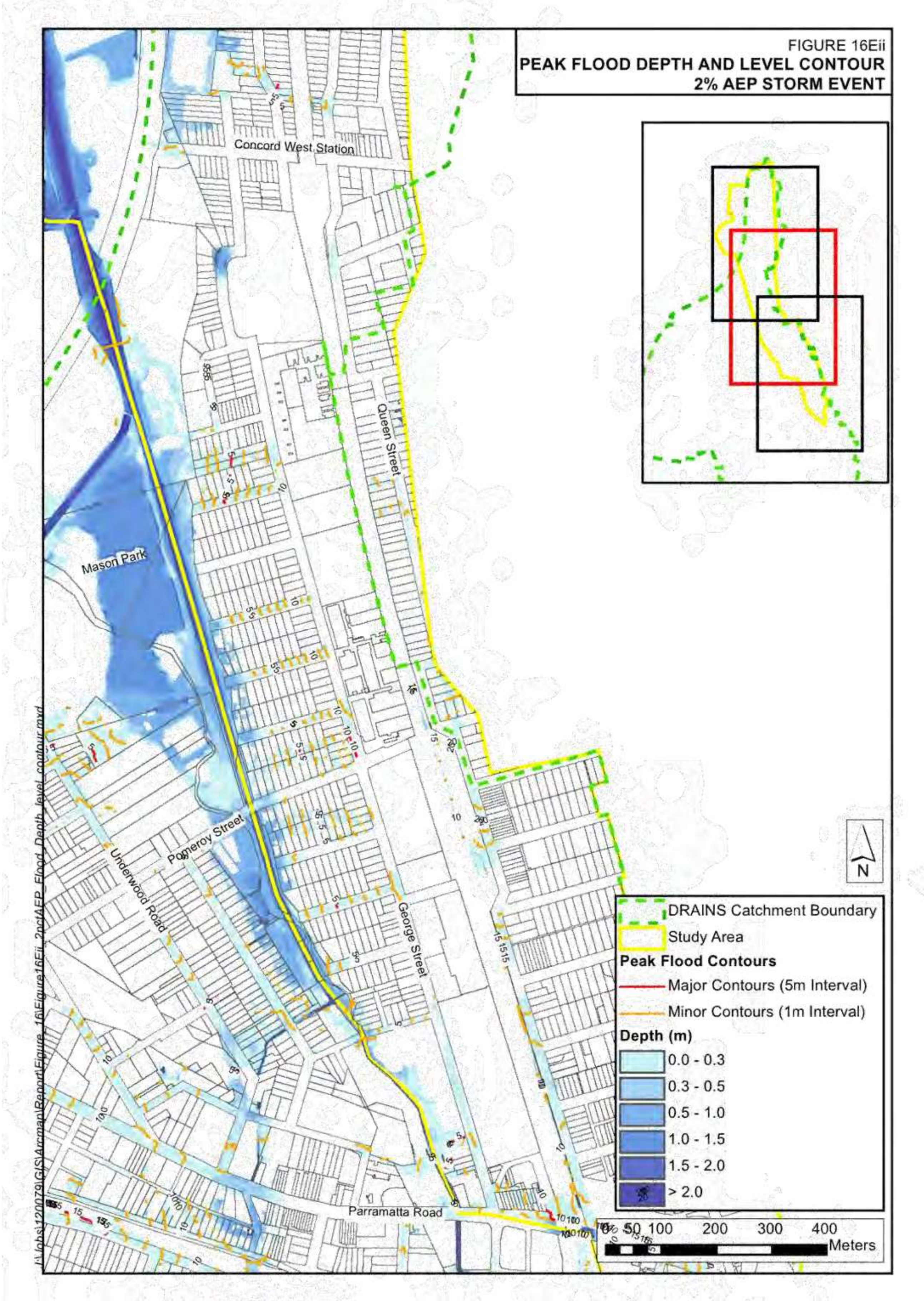


FIGURE 16Eii
PEAK FLOOD DEPTH AND LEVEL CONTOUR
2% AEP STORM EVENT
Concord West Station
Queen Street
Mason Park
Pomeroy Street
Underwood Road
George Street
Parramatta Road
DRAINS Catchment Boundary
Study Area
Peak Flood Contours
Major Contours (5m Interval)
Minor Contours (1m Interval)
Depth (m)
0.0 - 0.3
0.3 - 0.5
0.5 - 1.0
1.0 - 1.5
1.5 - 2.0
> 2.0
0 50 100 200 300 400
Meters
N

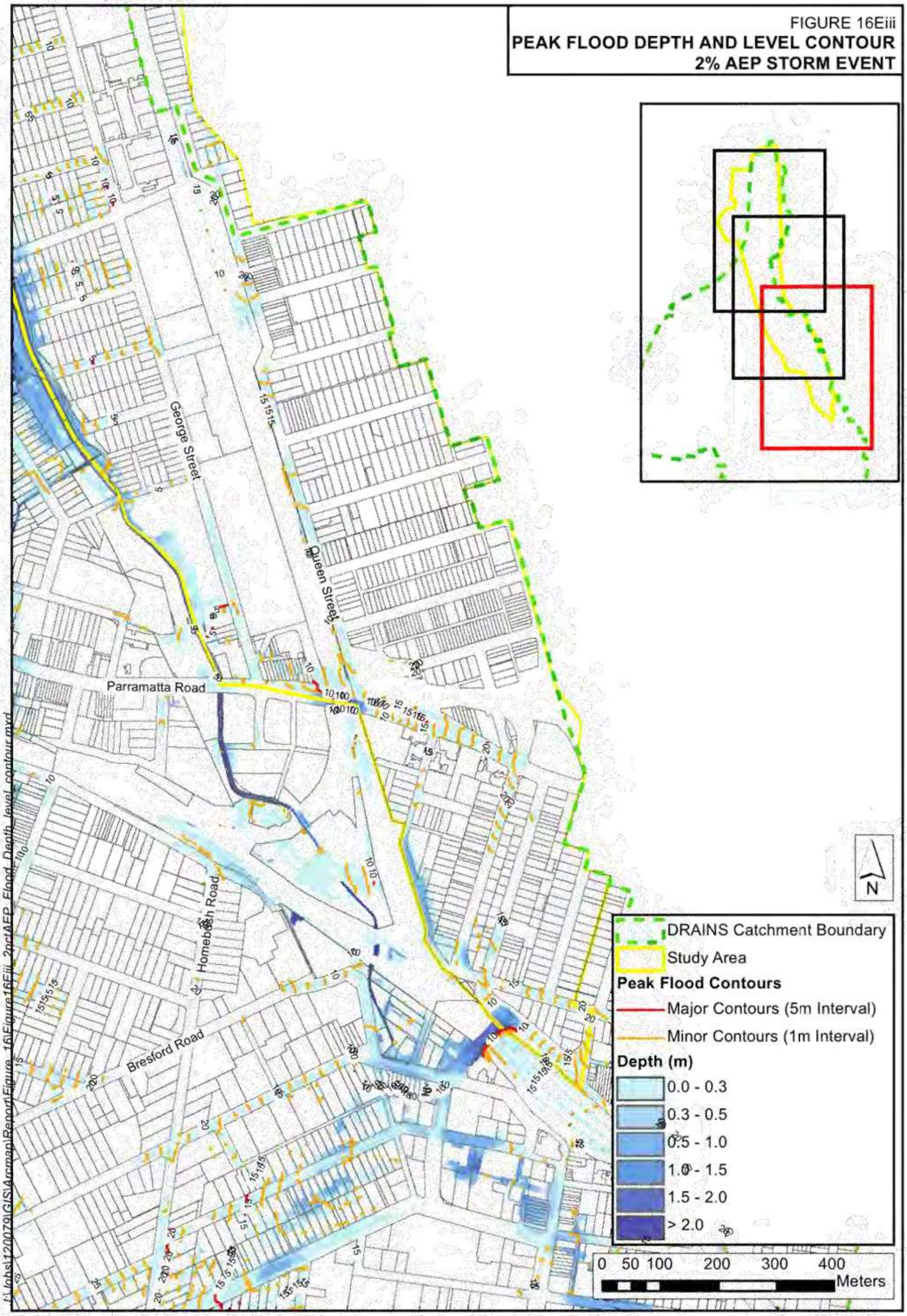


FIGURE 16Eiii
PEAK FLOOD DEPTH AND LEVEL CONTOUR
2% AEP STORM EVENT
George Street
Queen Street
Parramatta Road
Homebush Road
Bresford Road
DRAINS Catchment Boundary
Study Area
Peak Flood Contours
Major Contours (5m Interval)
Minor Contours (1m Interval)
Depth (m)
0.0 - 0.3
0.3 - 0.5
0.5 - 1.0
1.0 - 1.5
1.5 - 2.0
> 2.0
0 50 100 200 300 400
Meters
N

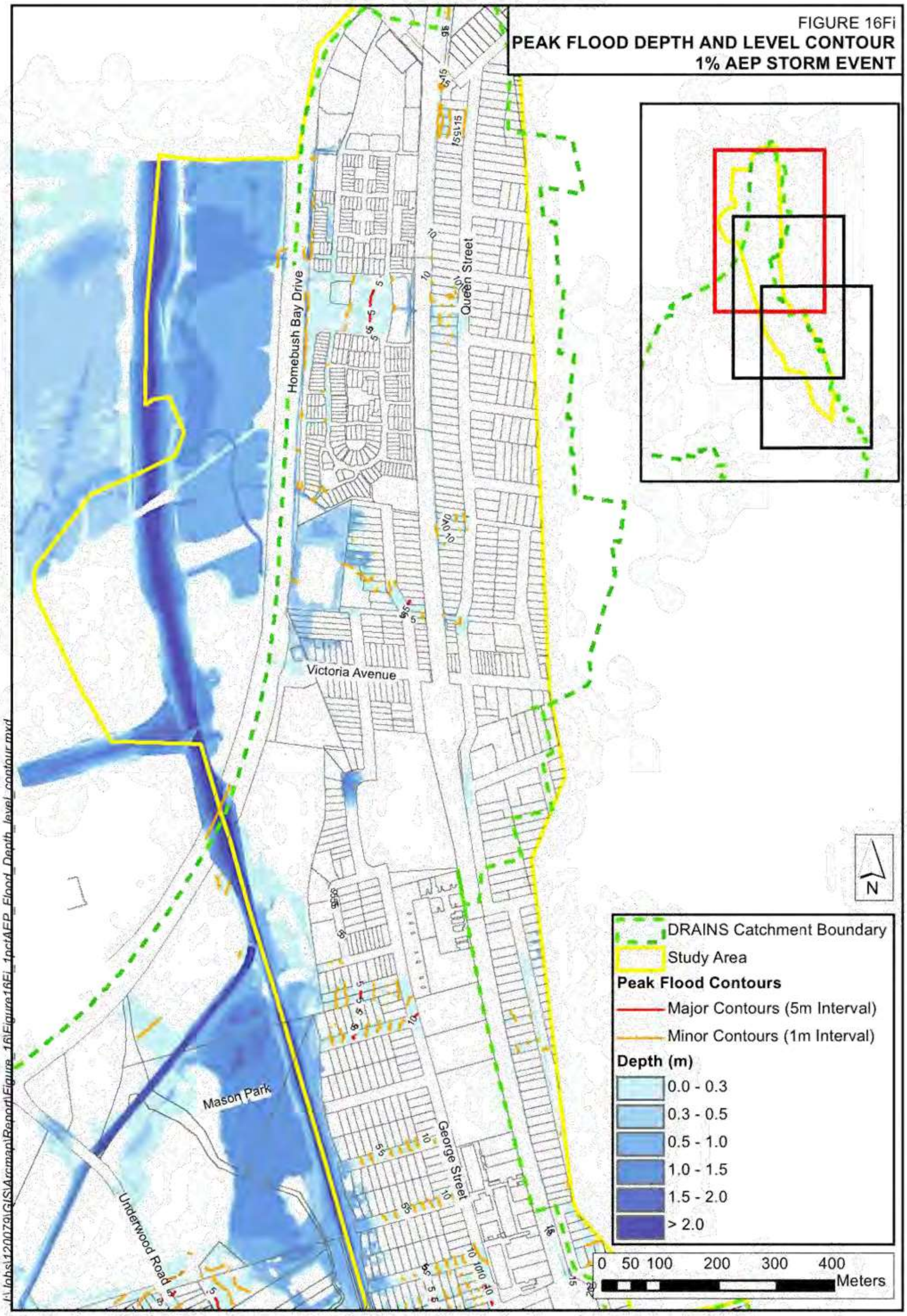


FIGURE 16Fi
PEAK FLOOD DEPTH AND LEVEL CONTOUR
1% AEP STORM EVENT
Homebush Bay Drive
Queen Street
Victoria Avenue
Mason Park
George Street
Underwood Road
DRAINS Catchment Boundary
Study Area
Peak Flood Contours
Major Contours (5m Interval)
Minor Contours (1m Interval)
Depth (m)
0.0 - 0.3
0.3 - 0.5
0.5 - 1.0
1.0 - 1.5
1.5 - 2.0
> 2.0
0 50 100 200 300 400
Meters
N

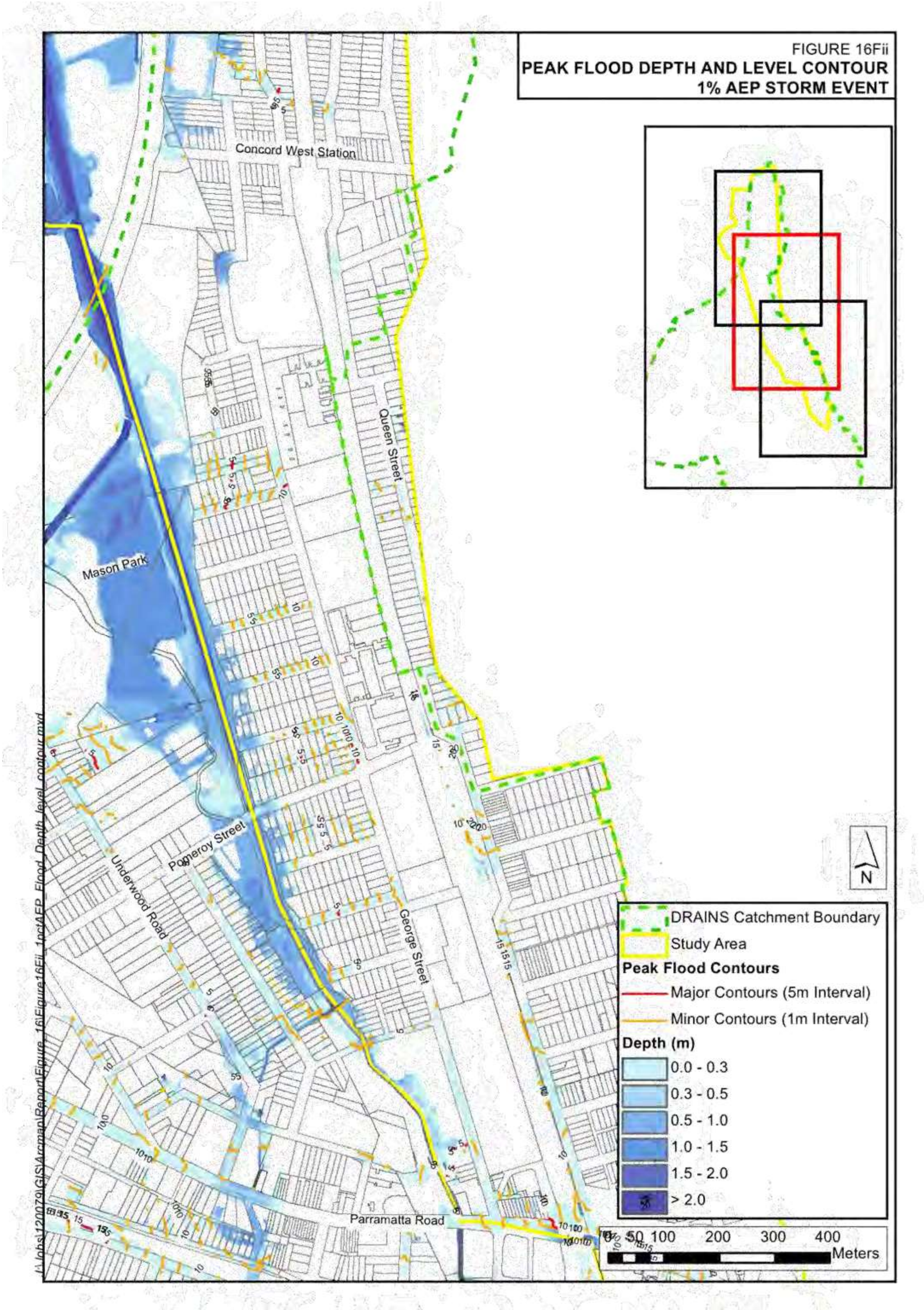


FIGURE 16Fii
PEAK FLOOD DEPTH AND LEVEL CONTOUR
1% AEP STORM EVENT
Concord West Station
Queen Street
Mason Park
Pomeroy Street
Underwood Road
George Street
Parramatta Road
DRAINS Catchment Boundary
Study Area
Peak Flood Contours
Major Contours (5m Interval)
Minor Contours (1m Interval)
Depth (m)
0.0 - 0.3
0.3 - 0.5
0.5 - 1.0
1.0 - 1.5
1.5 - 2.0
> 2.0
0 50 100 200 300 400
Meters
N

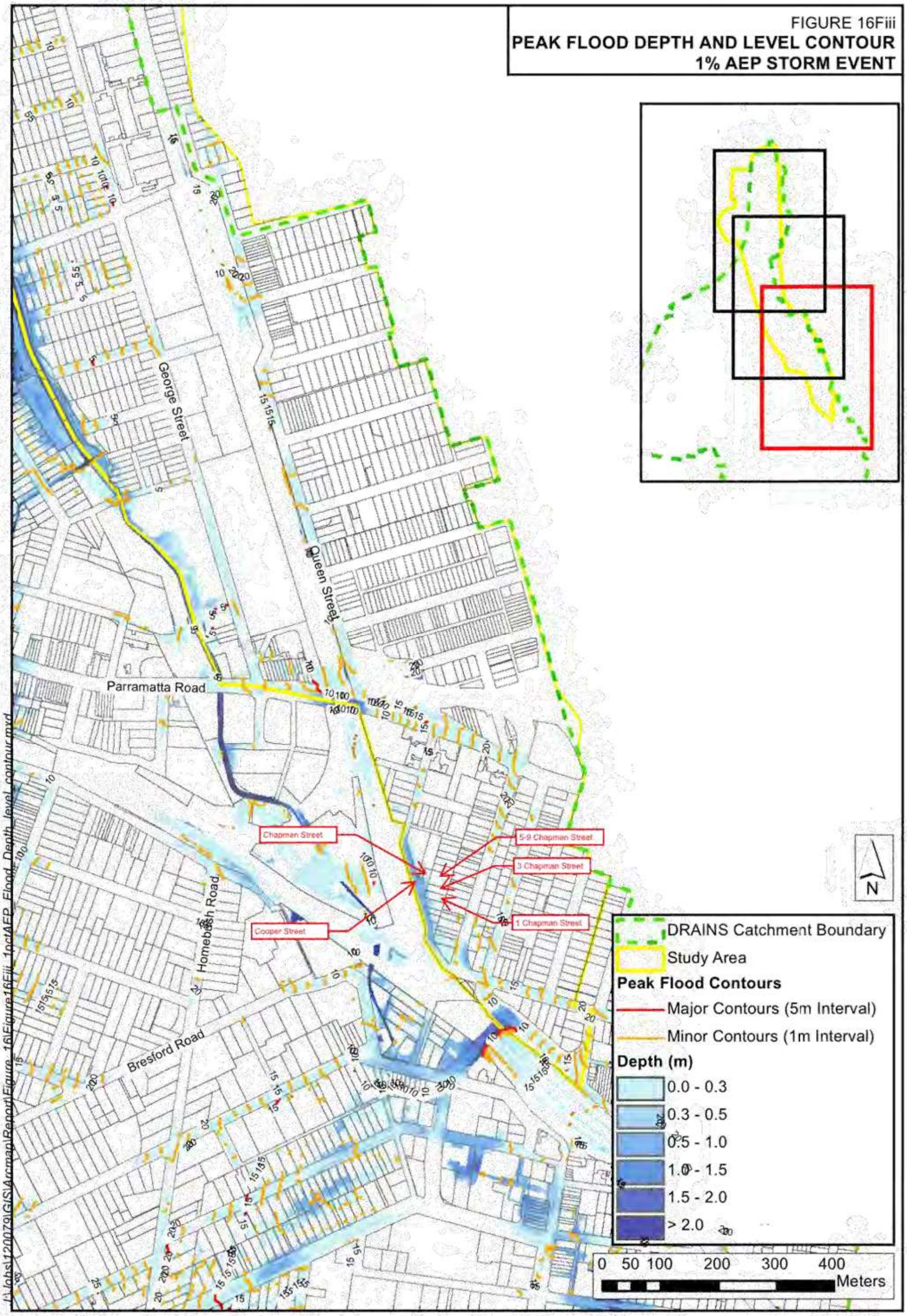


FIGURE 16Fiii
PEAK FLOOD DEPTH AND LEVEL CONTOUR
1% AEP STORM EVENT
George Street
Queen Street
Parramatta Road
Homebush Road
Bresford Road
Chapman Street
Cooper Street
5-9 Chapman Street
3 Chapman Street
1 Chapman Street
N
DRAINS Catchment Boundary
Study Area
Peak Flood Contours
Major Contours (5m Interval)
Minor Contours (1m Interval)
Depth (m)
0.0 - 0.3
0.3 - 0.5
0.5 - 1.0
1.0 - 1.5
1.5 - 2.0
> 2.0
0 50 100 200 300 400
Meters

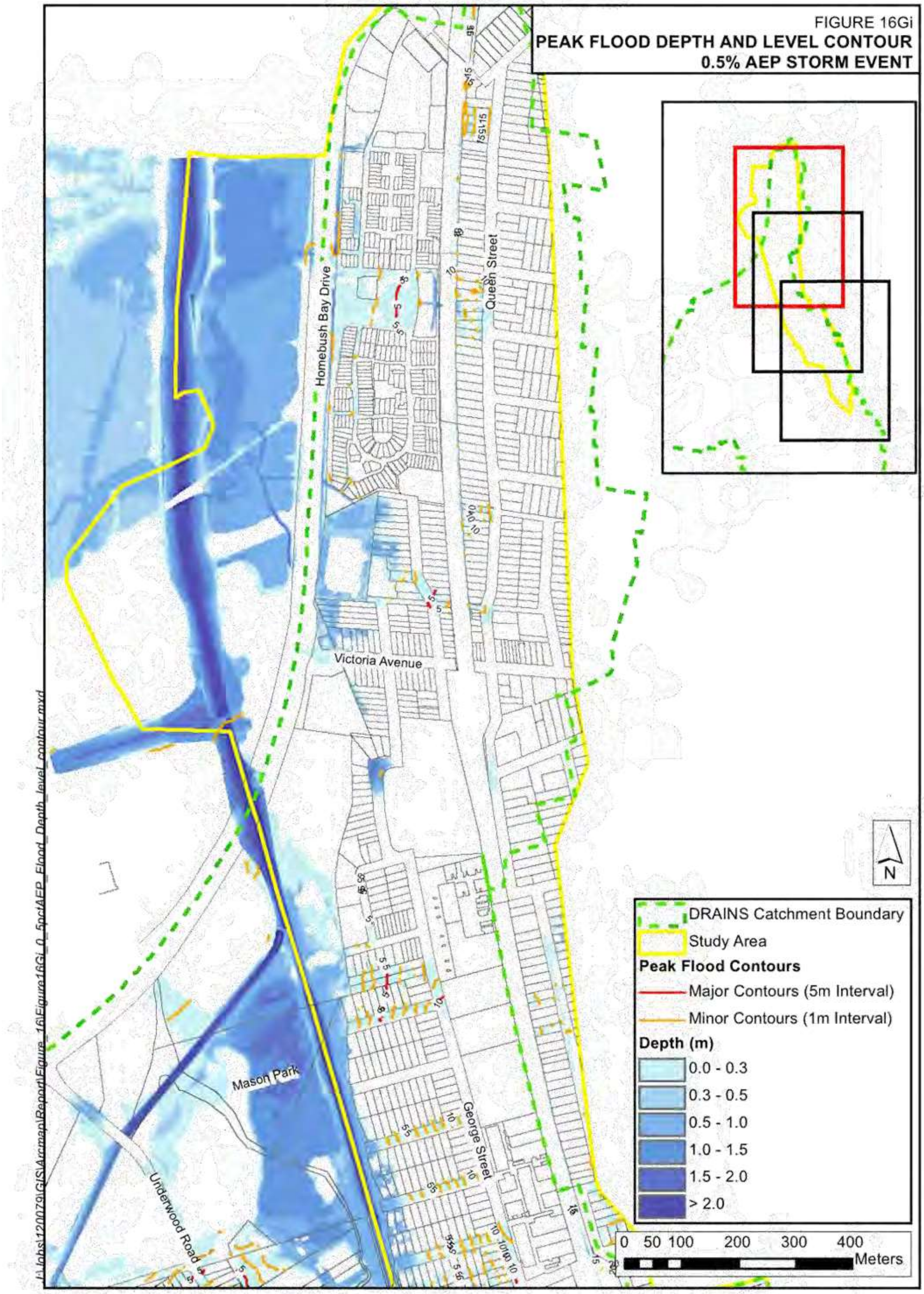


FIGURE 16Gi
PEAK FLOOD DEPTH AND LEVEL CONTOUR
0.5% AEP STORM EVENT
Homebush Bay Drive
Queen Street
Victoria Avenue
Mason Park
Underwood Road
George Street
DRAINS Catchment Boundary
Study Area
Peak Flood Contours
Major Contours (5m Interval)
Minor Contours (1m Interval)
Depth (m)
0.0 - 0.3
0.3 - 0.5
0.5 - 1.0
1.0 - 1.5
1.5 - 2.0
> 2.0
0 50 100 200 300 400
Meters
N

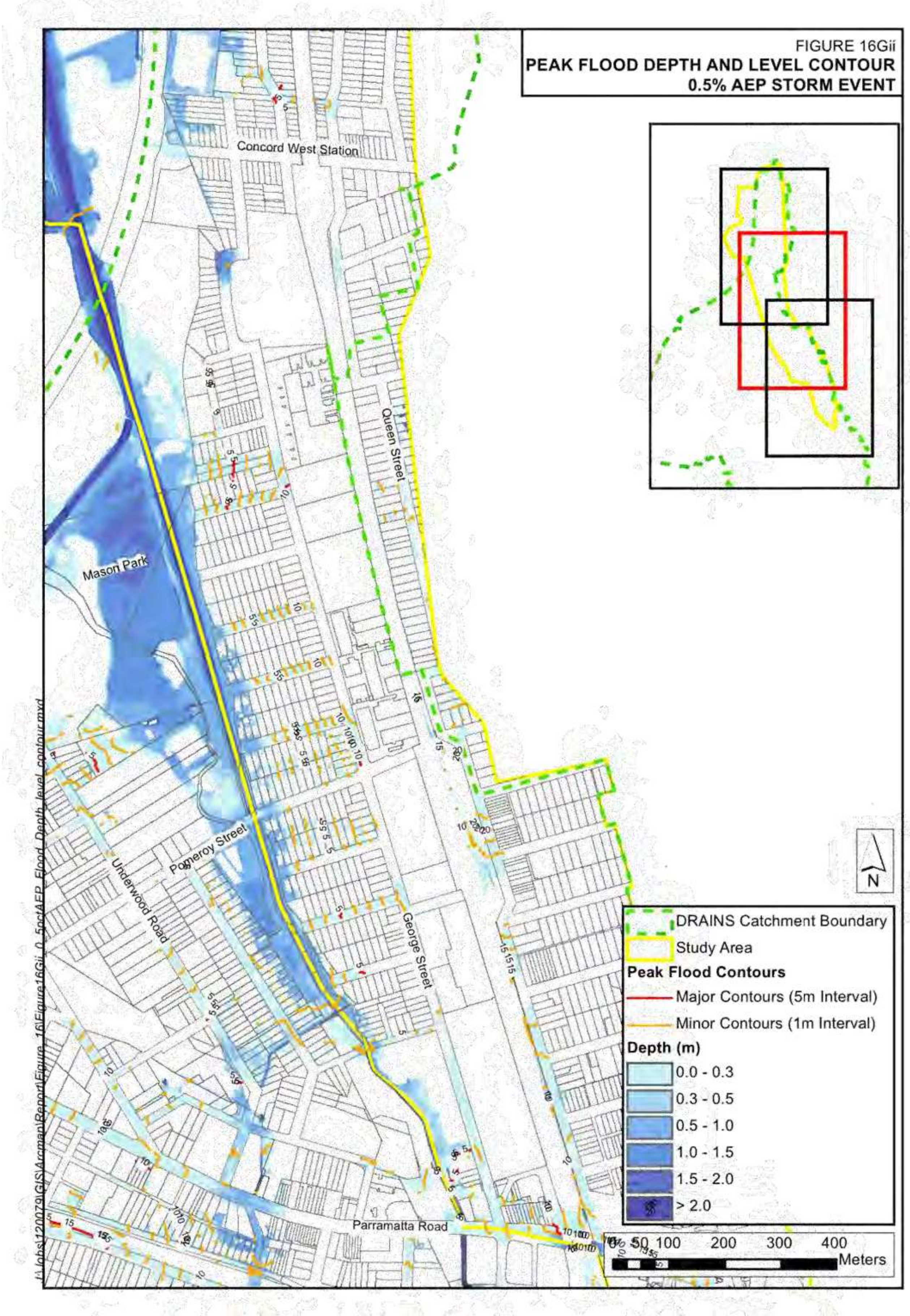


FIGURE 16Gii
PEAK FLOOD DEPTH AND LEVEL CONTOUR
0.5% AEP STORM EVENT
Concord West Station
Queen Street
Mason Park
Pomeroy Street
Underwood Road
George Street
Parramatta Road
N
DRAINS Catchment Boundary
Study Area
Peak Flood Contours
Major Contours (5m Interval)
Minor Contours (1m Interval)
Depth (m)
0.0 - 0.3
0.3 - 0.5
0.5 - 1.0
1.0 - 1.5
1.5 - 2.0
> 2.0
0 50 100 200 300 400
Meters

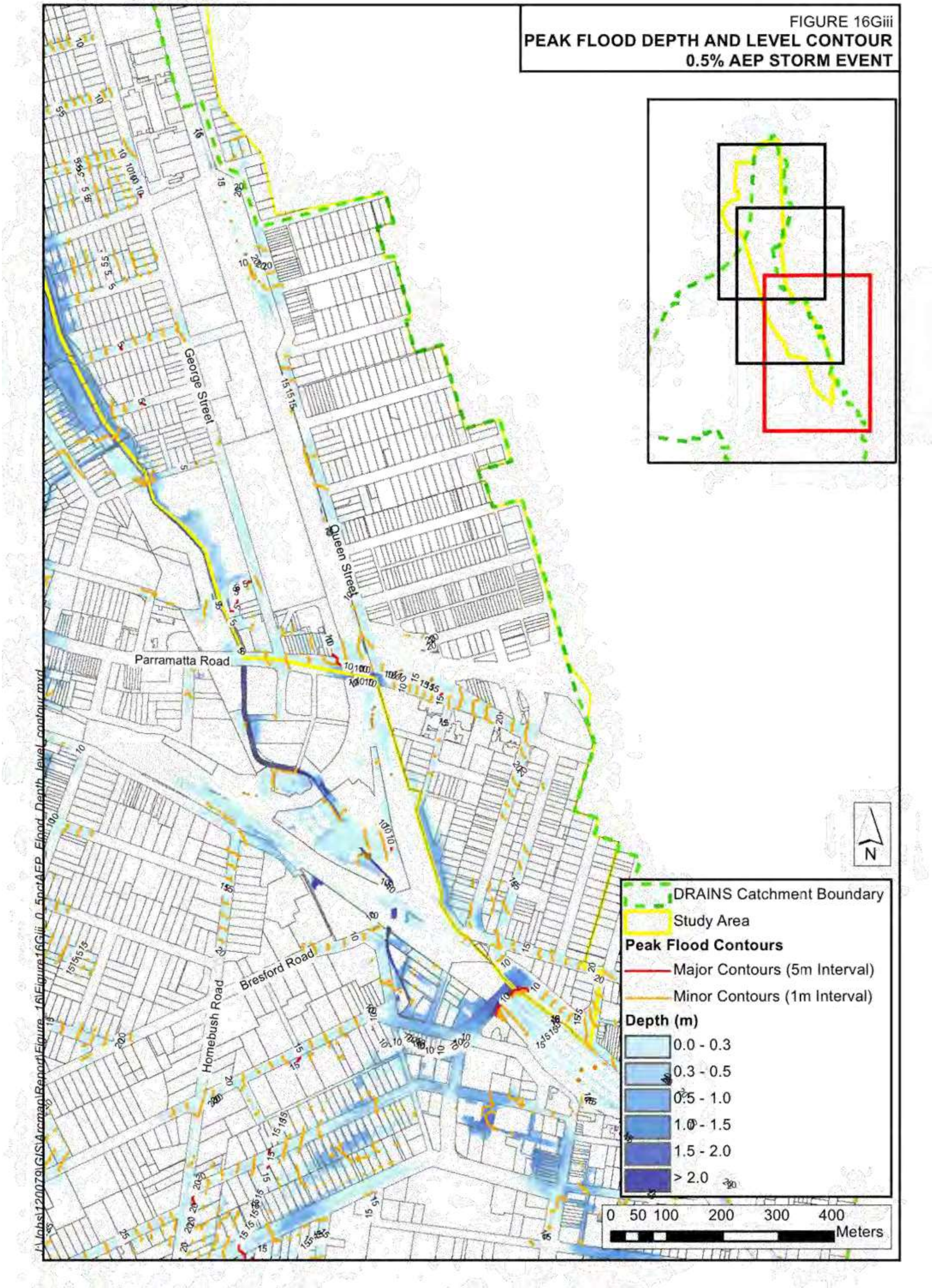


FIGURE 16Giii
PEAK FLOOD DEPTH AND LEVEL CONTOUR
0.5% AEP STORM EVENT
George Street
Queen Street
Parramatta Road
Bresford Road
Homebush Road
DRAINS Catchment Boundary
Study Area
Peak Flood Contours
Major Contours (5m Interval)
Minor Contours (1m Interval)
Depth (m)
0.0 - 0.3
0.3 - 0.5
0.5 - 1.0
1.0 - 1.5
1.5 - 2.0
> 2.0
0 50 100 200 300 400
Meters
N

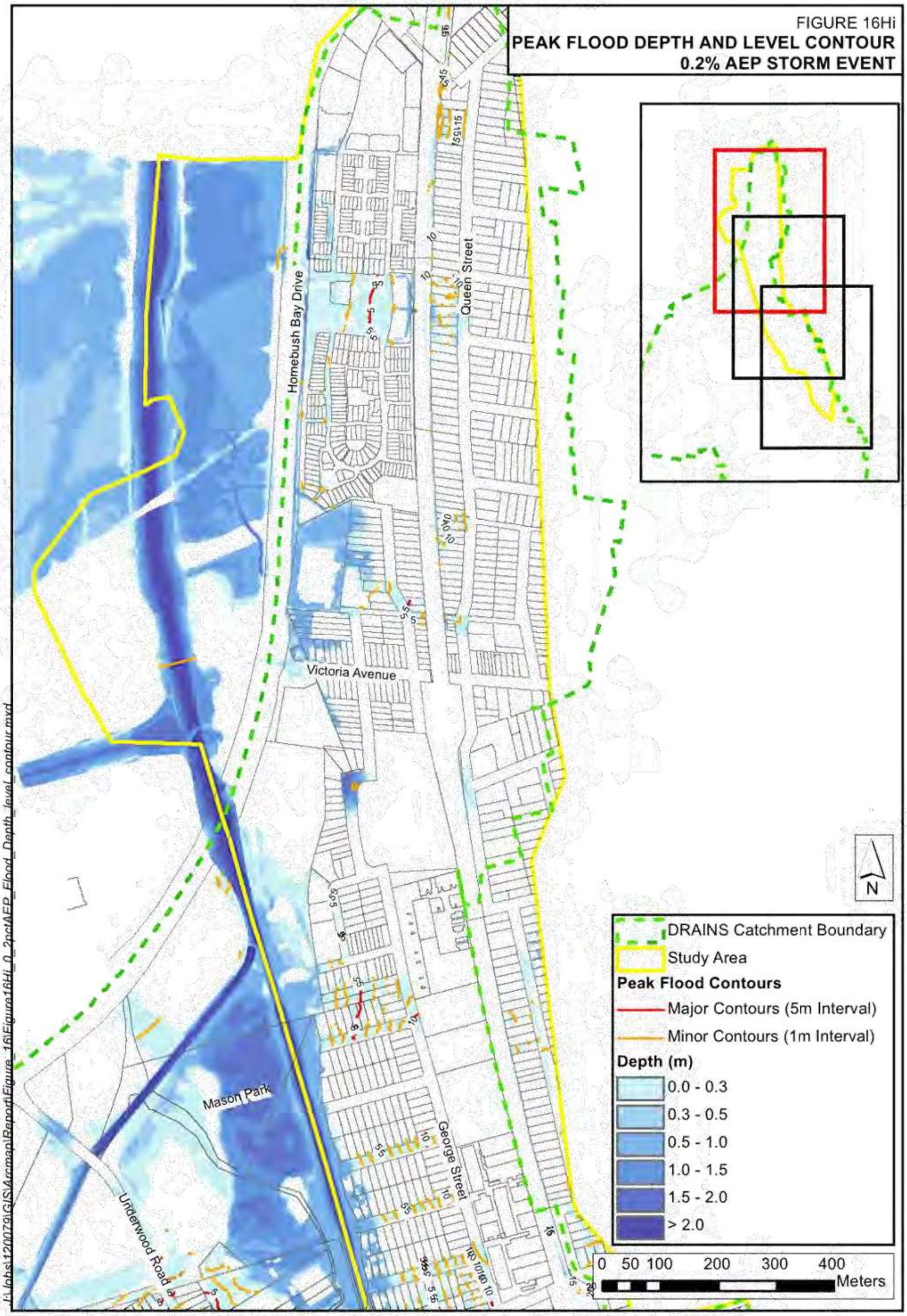


FIGURE 16Hi
PEAK FLOOD DEPTH AND LEVEL CONTOUR
0.2% AEP STORM EVENT
Homebush Bay Drive
Queen Street
Victoria Avenue
Mason Park
Underwood Road
George Street
N
DRAINS Catchment Boundary
Study Area
Peak Flood Contours
Major Contours (5m Interval)
Minor Contours (1m Interval)
Depth (m)
0.0 - 0.3
0.3 - 0.5
0.5 - 1.0
1.0 - 1.5
1.5 - 2.0
> 2.0
0 50 100 200 300 400
Meters

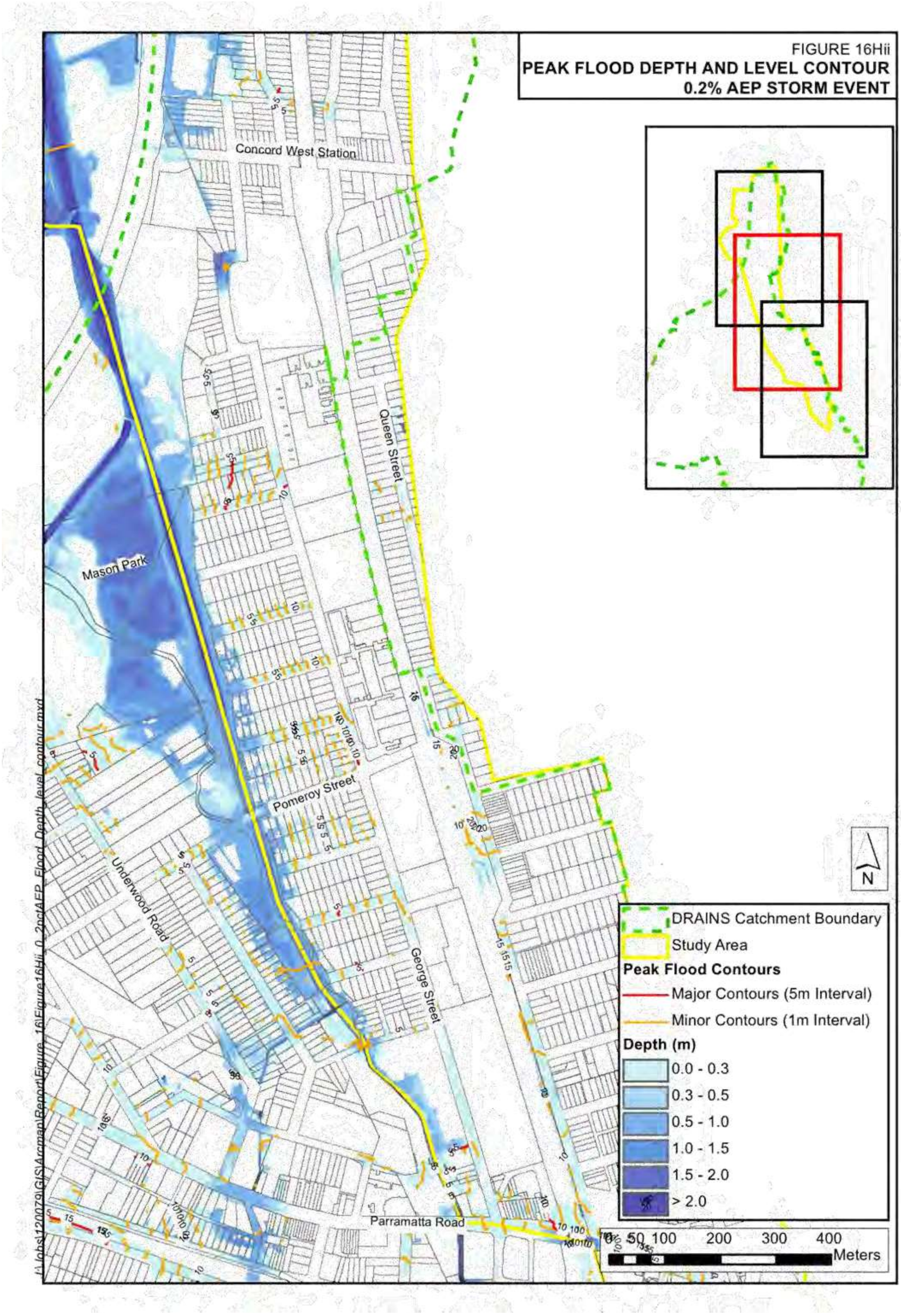


FIGURE 16Hii
PEAK FLOOD DEPTH AND LEVEL CONTOUR
0.2% AEP STORM EVENT
Concord West Station
Queen Street
Mason Park
Pomeroy Street
Underwood Road
George Street
Parramatta Road
DRAINS Catchment Boundary
Study Area
Peak Flood Contours
Major Contours (5m Interval)
Minor Contours (1m Interval)
Depth (m)
0.0 - 0.3
0.3 - 0.5
0.5 - 1.0
1.0 - 1.5
1.5 - 2.0
> 2.0
N
0 50 100 200 300 400
Meters

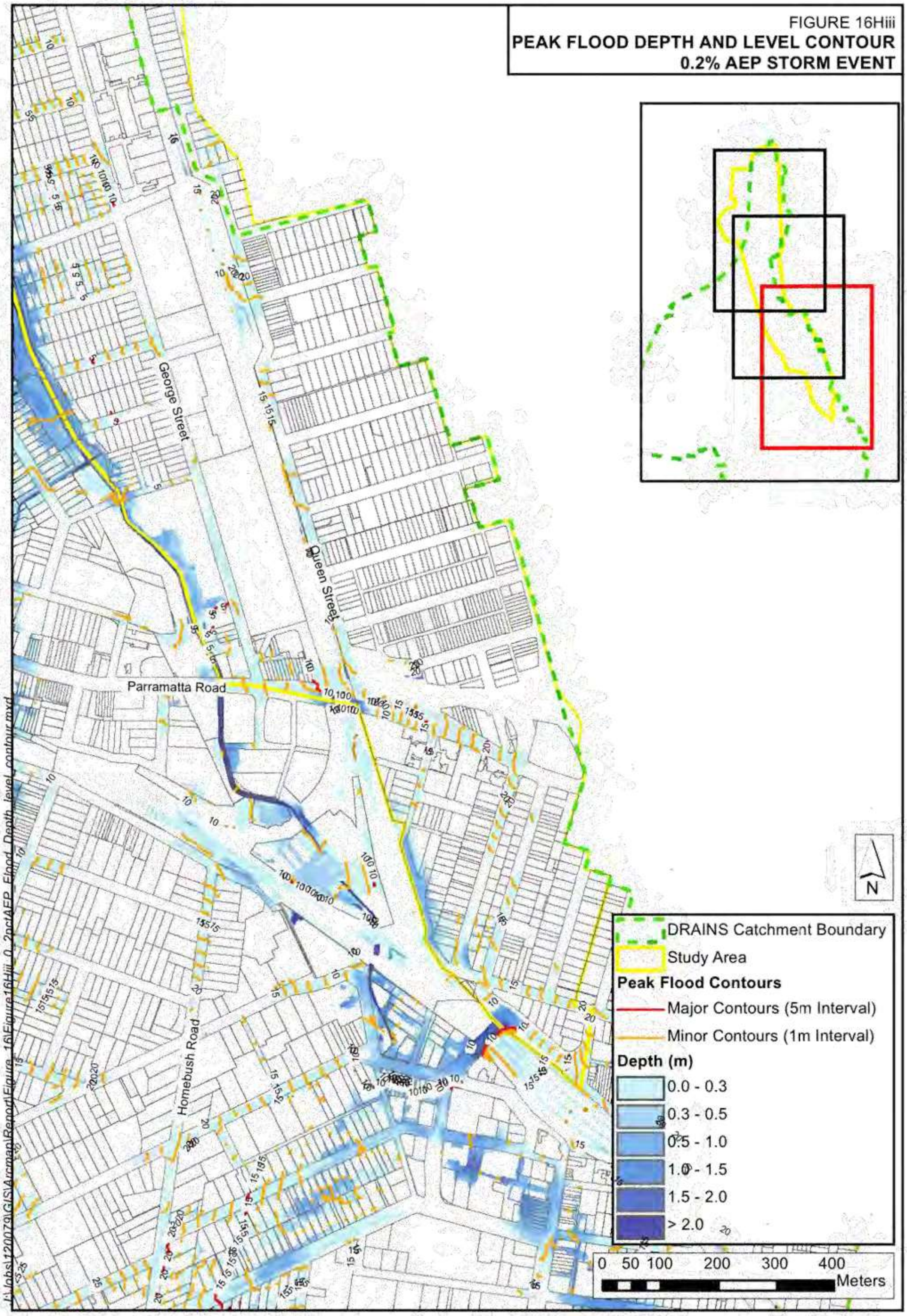


FIGURE 16Hiii
PEAK FLOOD DEPTH AND LEVEL CONTOUR
0.2% AEP STORM EVENT
George Street
Queen Street
Parramatta Road
Homebush Road
DRAINS Catchment Boundary
Study Area
Peak Flood Contours
Major Contours (5m Interval)
Minor Contours (1m Interval)
Depth (m)
0.0 - 0.3
0.3 - 0.5
0.5 - 1.0
1.0 - 1.5
1.5 - 2.0
> 2.0
N
0 50 100 200 300 400
Meters

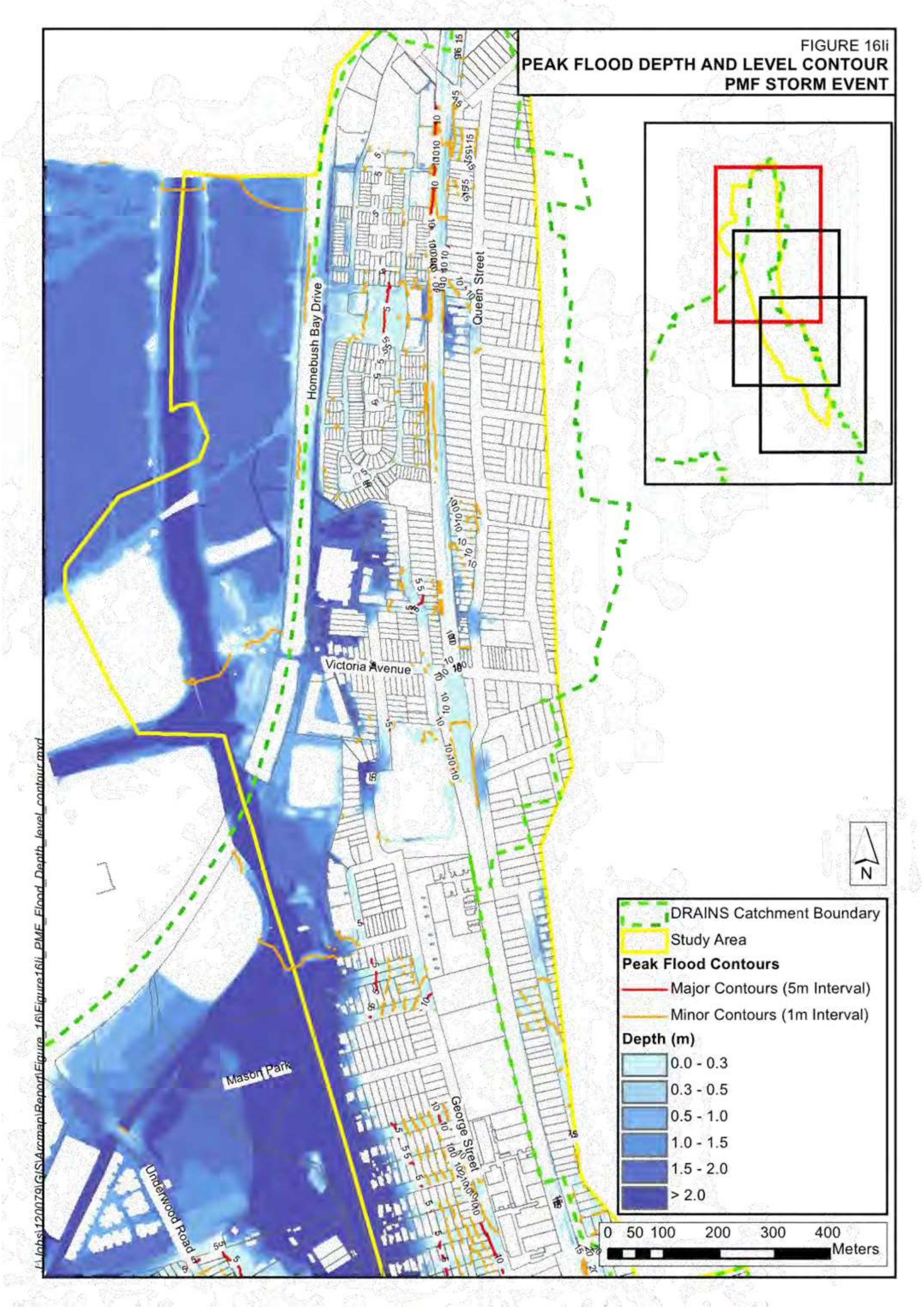


FIGURE 16li
PEAK FLOOD DEPTH AND LEVEL CONTOUR
PMF STORM EVENT
Homebush Bay Drive
Queen Street
Victoria Avenue
Mason Park
George Street
Underwood Road
N
DRAINS Catchment Boundary
Study Area
Peak Flood Contours
Major Contours (5m Interval)
Minor Contours (1m Interval)
Depth (m)
0.0 - 0.3
0.3 - 0.5
0.5 - 1.0
1.0 - 1.5
1.5 - 2.0
> 2.0
0 50 100 200 300 400
Meters

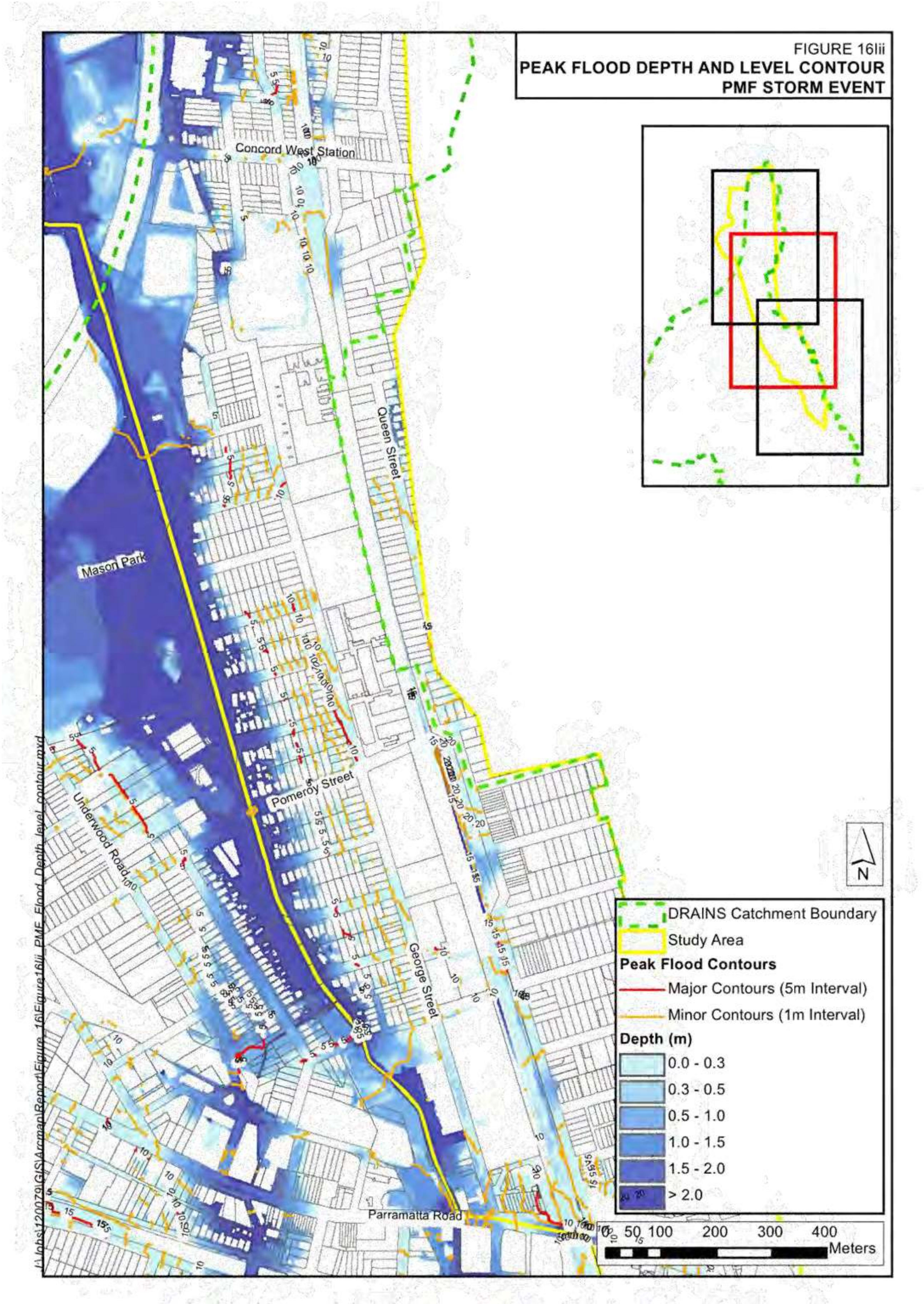


FIGURE 16lii
PEAK FLOOD DEPTH AND LEVEL CONTOUR
PMF STORM EVENT
Concord West Station
Queen Street
Mason Park
Pomeroy Street
Underwood Road
George Street
Parramatta Road
DRAINS Catchment Boundary
Study Area
Peak Flood Contours
Major Contours (5m Interval)
Minor Contours (1m Interval)
Depth (m)
0.0 - 0.3
0.3 - 0.5
0.5 - 1.0
1.0 - 1.5
1.5 - 2.0
> 2.0
0 50 100 200 300 400
Meters
N

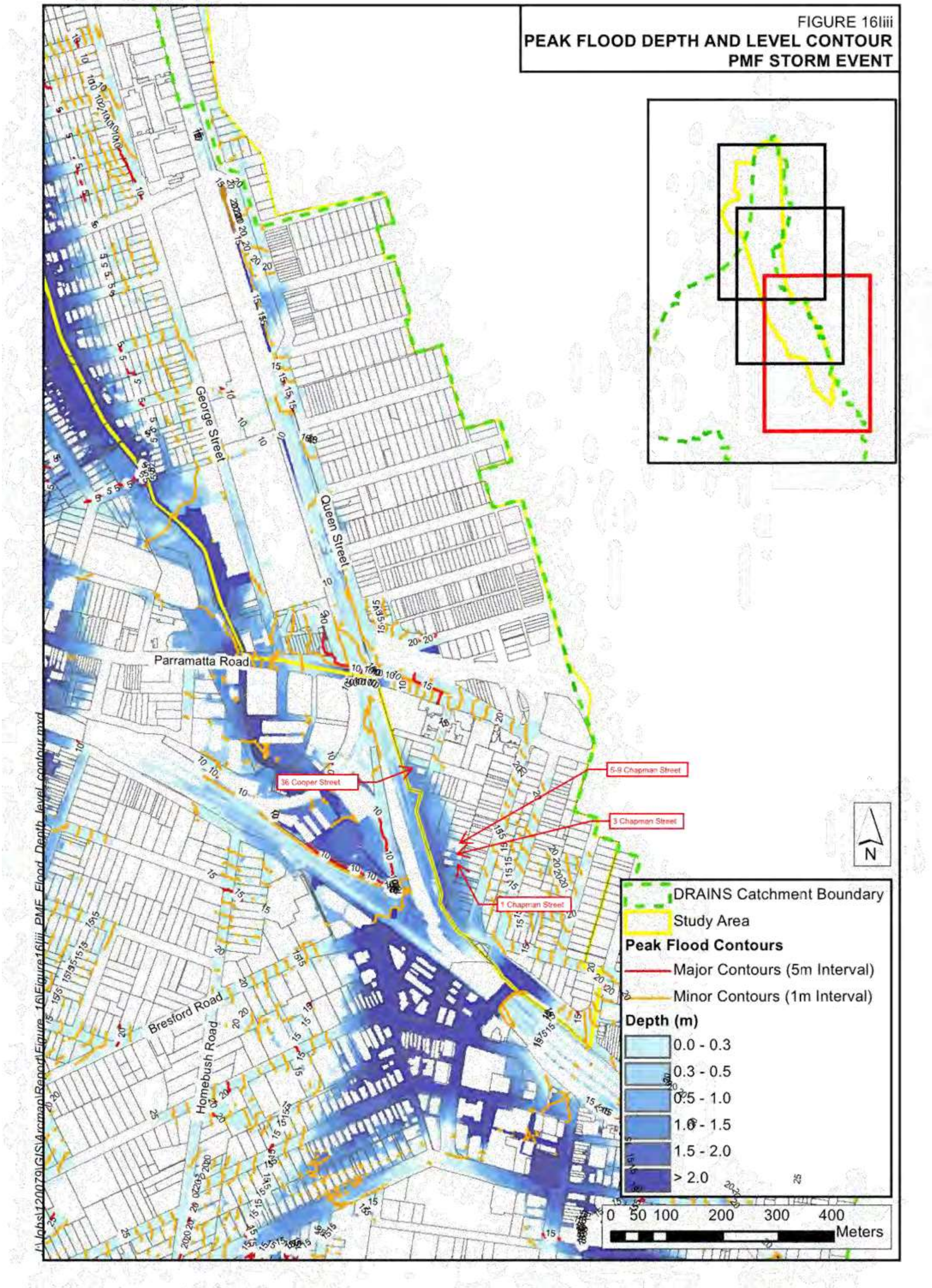


FIGURE 16liii
PEAK FLOOD DEPTH AND LEVEL CONTOUR
PMF STORM EVENT
George Street
Queen Street
Parramatta Road
Bresford Road
Homebush Road
36 Cooper Street
5-9 Chapman Street
3 Chapman Street
1 Chapman Street
N
DRAINS Catchment Boundary
Study Area
Peak Flood Contours
Major Contours (5m Interval)
Minor Contours (1m Interval)
Depth (m)
0.0 - 0.3
0.3 - 0.5
0.5 - 1.0
1.0 - 1.5
1.5 - 2.0
> 2.0
0 50 100 200 300 400
Meters

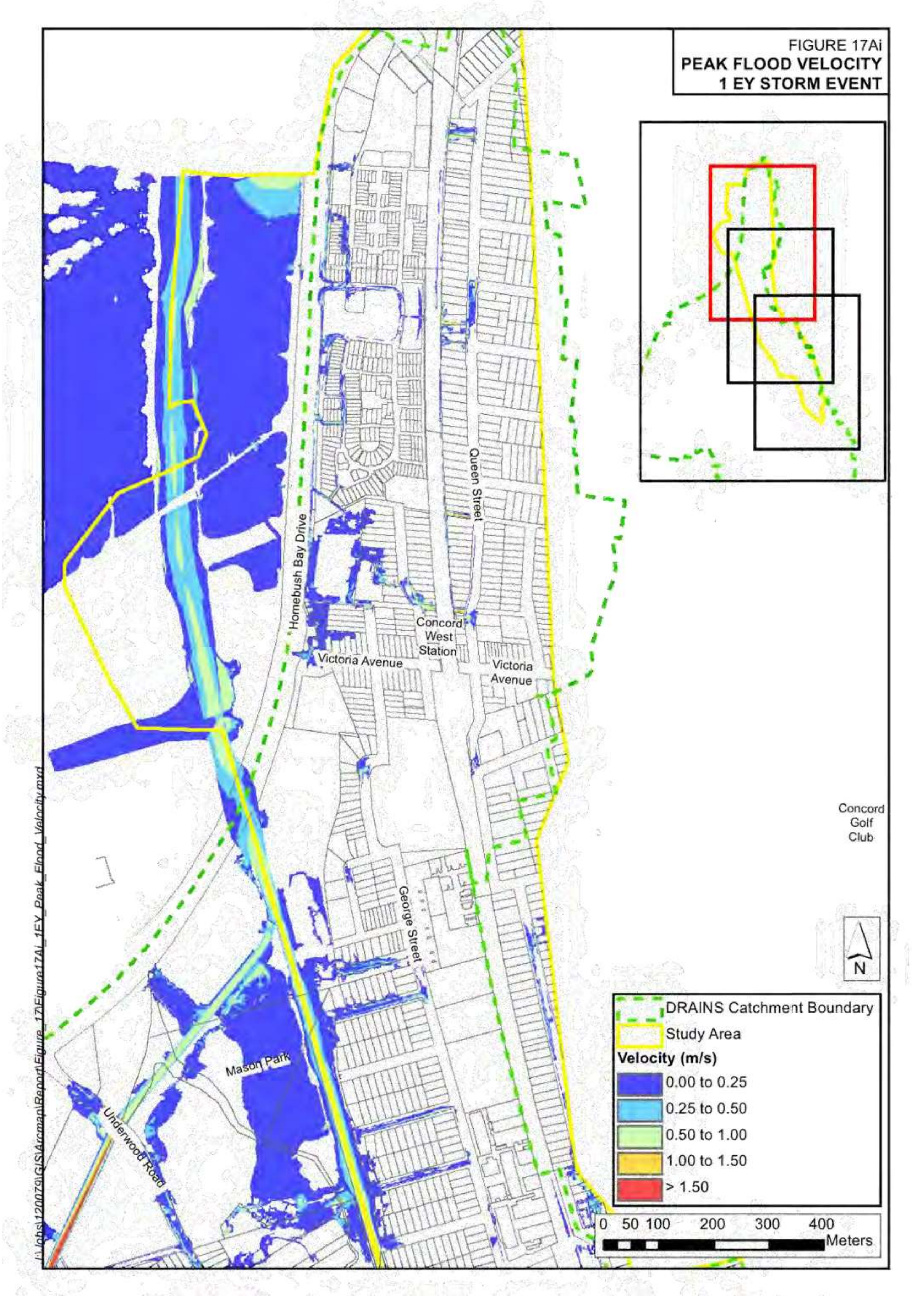


FIGURE 17Ai
PEAK FLOOD VELOCITY
1 EY STORM EVENT
Homebush Bay Drive
Queen Street
Concord West Station
Victoria Avenue
Victoria Avenue
George Street
Mason Park
Underwood Road
Concord Golf Club
N
DRAINS Catchment Boundary
Study Area
Velocity (m/s)
0.00 to 0.25
0.25 to 0.50
0.50 to 1.00
1.00 to 1.50
> 1.50
0 50 100 200 300 400
Meters

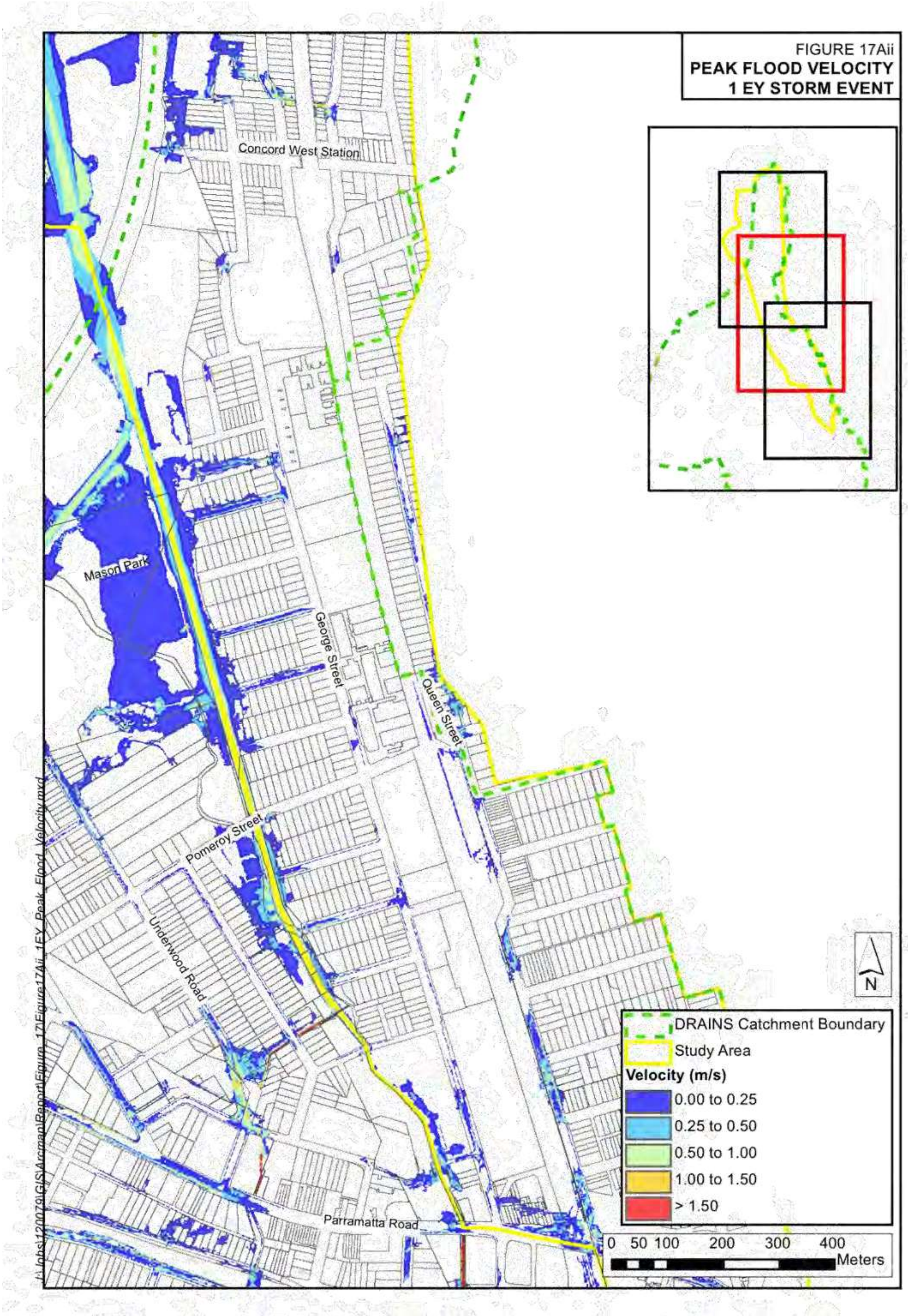


FIGURE 17Aii
PEAK FLOOD VELOCITY
1 EY STORM EVENT
Concord West Station
Mason Park
George Street
Queen Street
Pomeroy Street
Underwood Road
Parramatta Road
DRAINS Catchment Boundary
Study Area
Velocity (m/s)
0.00 to 0.25
0.25 to 0.50
0.50 to 1.00
1.00 to 1.50
> 1.50
N
0 50 100 200 300 400
Meters

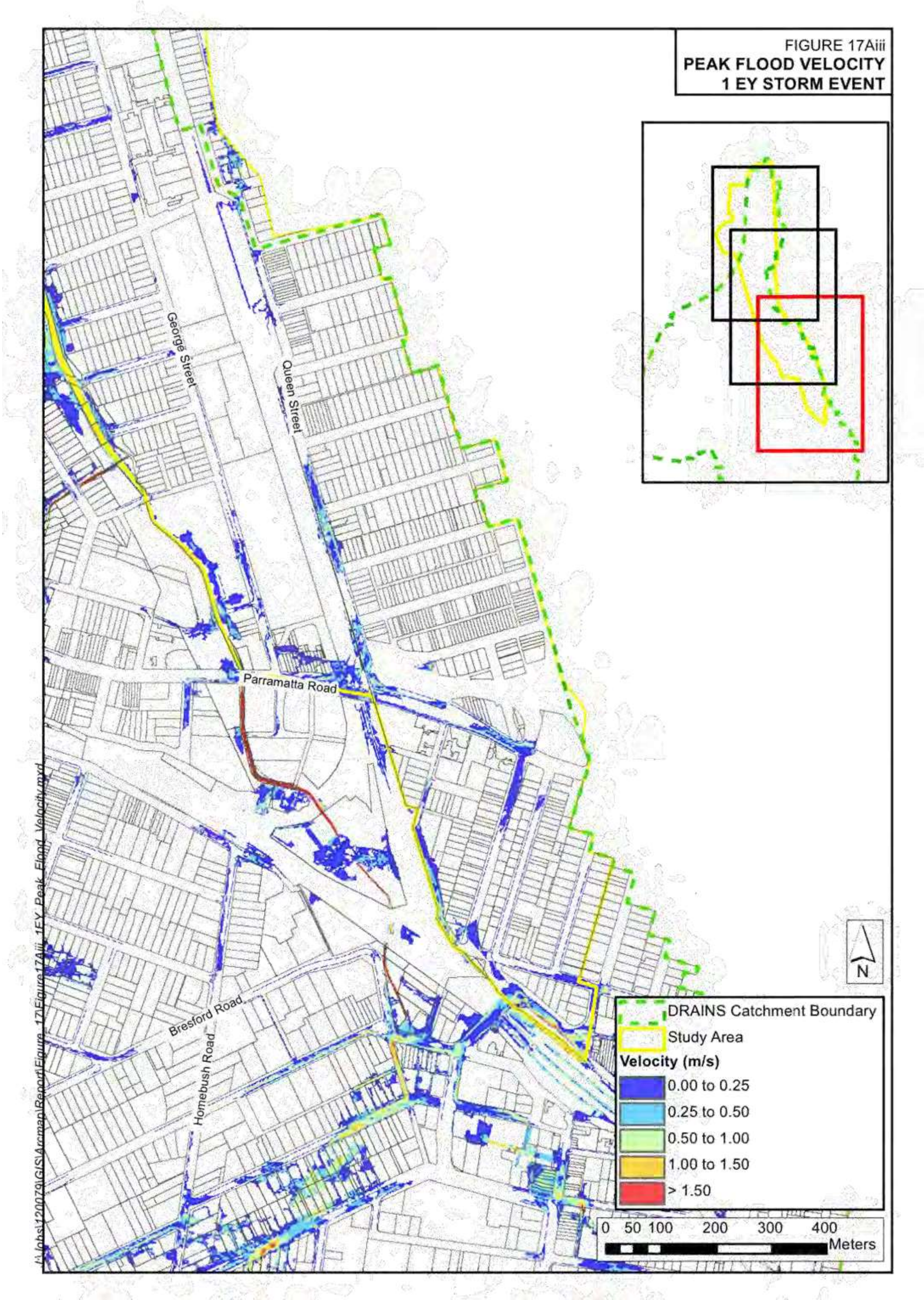


FIGURE 17Aiii
PEAK FLOOD VELOCITY
1 EY STORM EVENT
George Street
Queen Street
Parramatta Road
Bresford Road
Homebush Road
N
DRAINS Catchment Boundary
Study Area
Velocity (m/s)
0.00 to 0.25
0.25 to 0.50
0.50 to 1.00
1.00 to 1.50
> 1.50
0 50 100 200 300 400
Meters

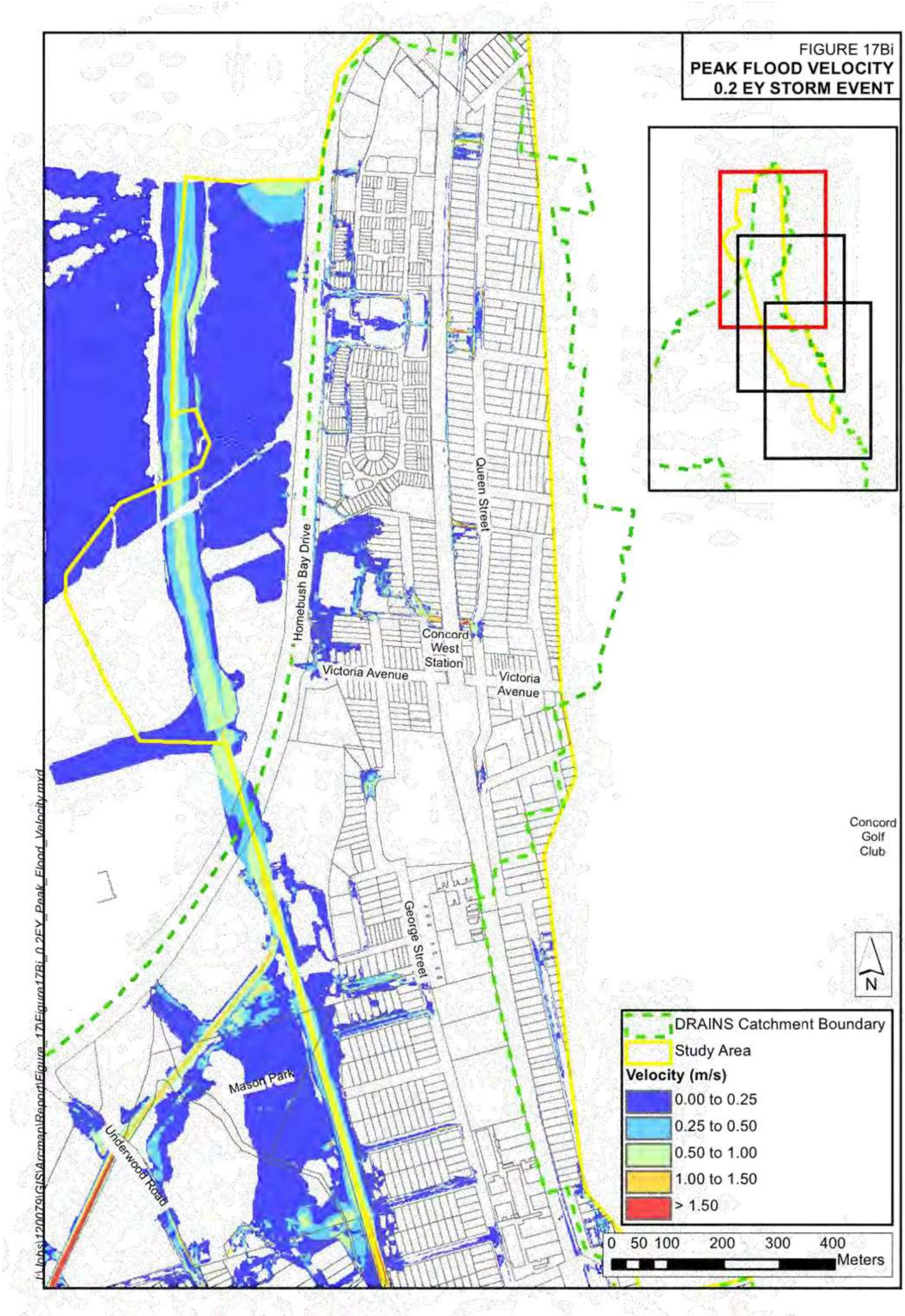


FIGURE 17Bi
PEAK FLOOD VELOCITY
0.2 EY STORM EVENT
Homebush Bay Drive
Queen Street
Concord West Station
Victoria Avenue
Victoria Avenue
George Street
Mason Park
Underwood Road
Concord Golf Club
N
DRAINS Catchment Boundary
Study Area
Velocity (m/s)
0.00 to 0.25
0.25 to 0.50
0.50 to 1.00
1.00 to 1.50
> 1.50
0 50 100 200 300 400
Meters

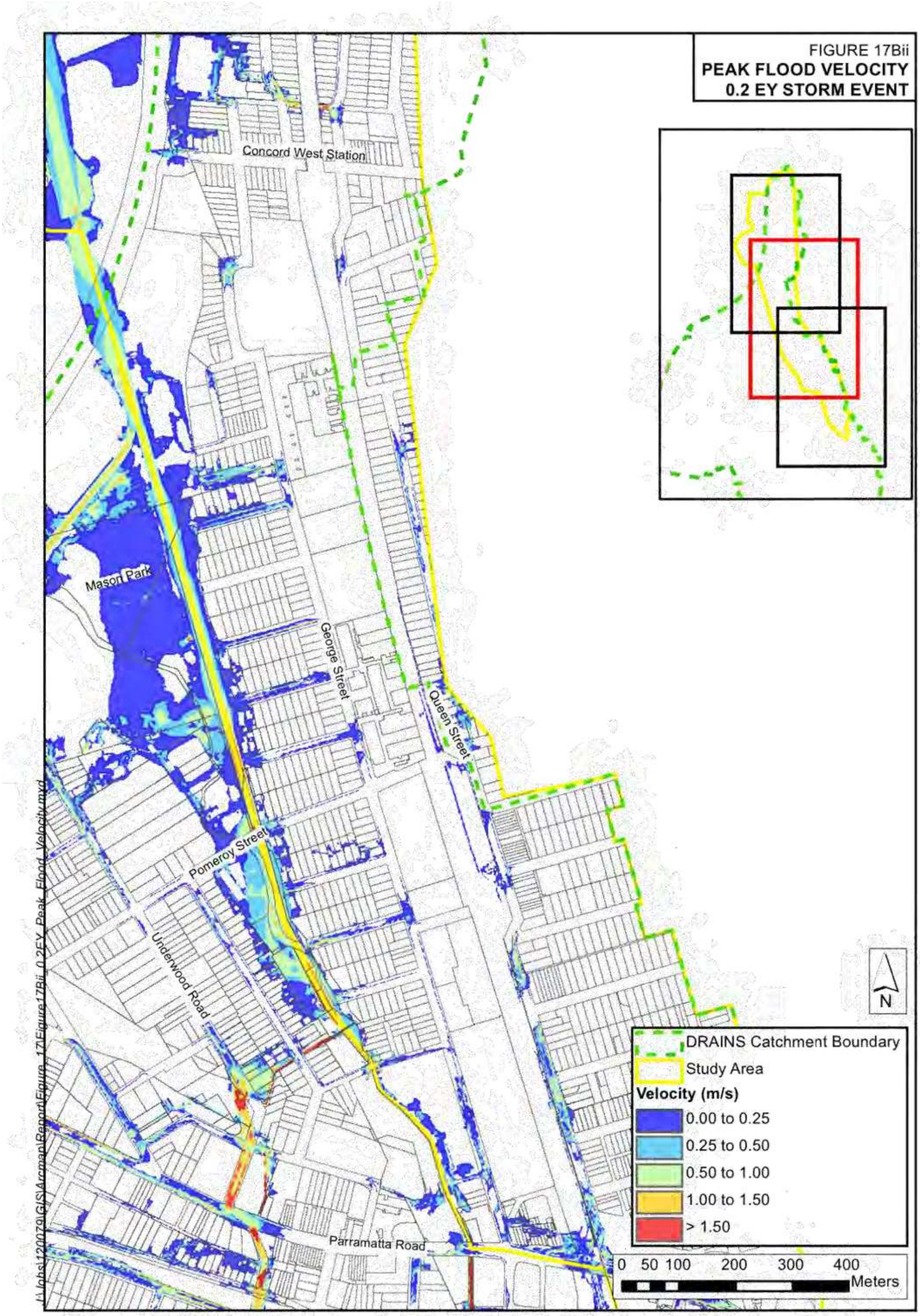


FIGURE 17Bii
PEAK FLOOD VELOCITY
0.2 EY STORM EVENT
Concord West Station
Mason Park
George Street
Queen Street
Pomeroy Street
Underwood Road
Parramatta Road
N
DRAINS Catchment Boundary
Study Area
Velocity (m/s)
0.00 to 0.25
0.25 to 0.50
0.50 to 1.00
1.00 to 1.50
> 1.50
0 50 100 200 300 400
Meters

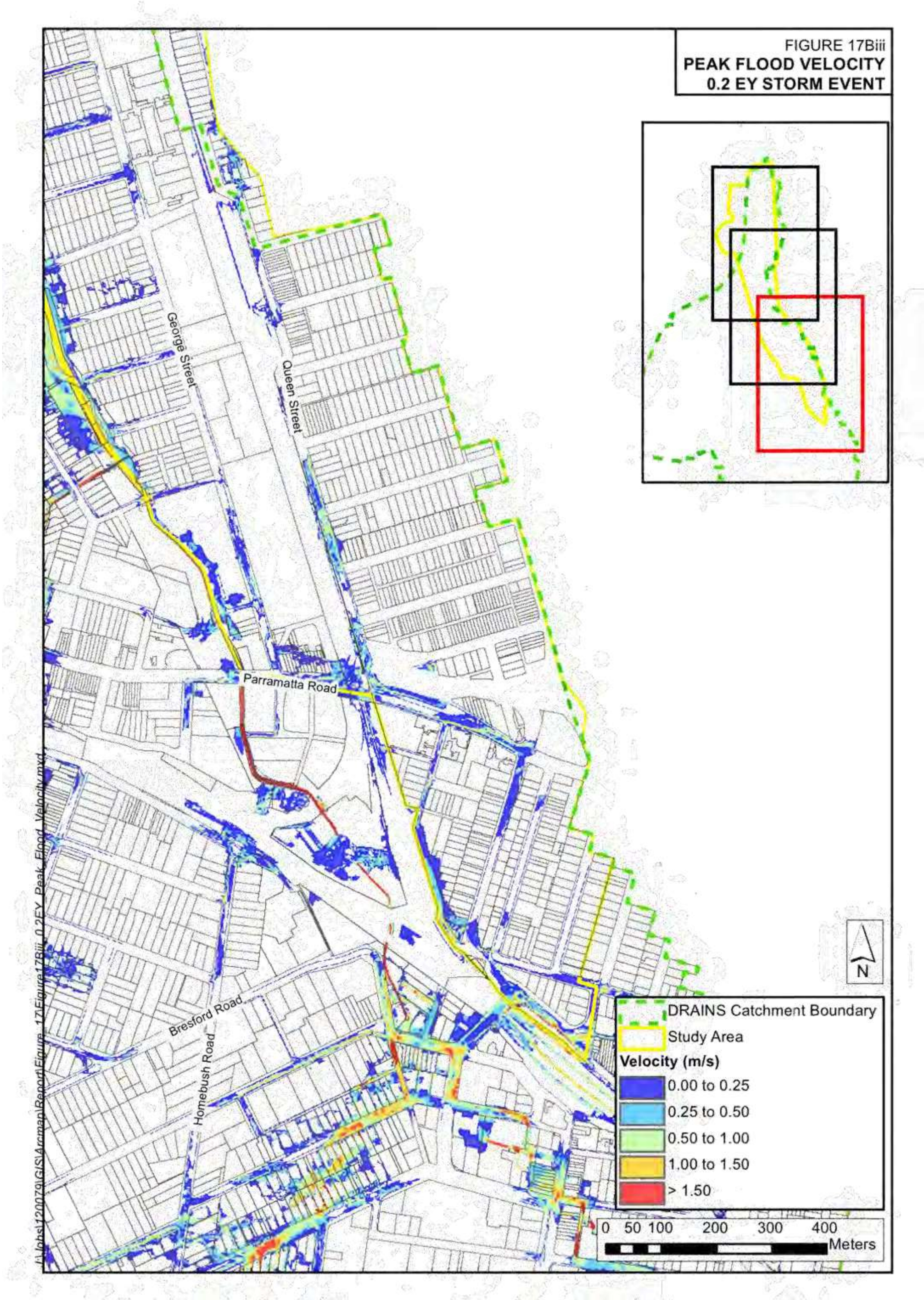


FIGURE 17Biii
PEAK FLOOD VELOCITY
0.2 EY STORM EVENT
George Street
Queen Street
Parramatta Road
Bresford Road
Homebush Road
N
DRAINS Catchment Boundary
Study Area
Velocity (m/s)
0.00 to 0.25
0.25 to 0.50
0.50 to 1.00
1.00 to 1.50
> 1.50
0 50 100 200 300 400
Meters

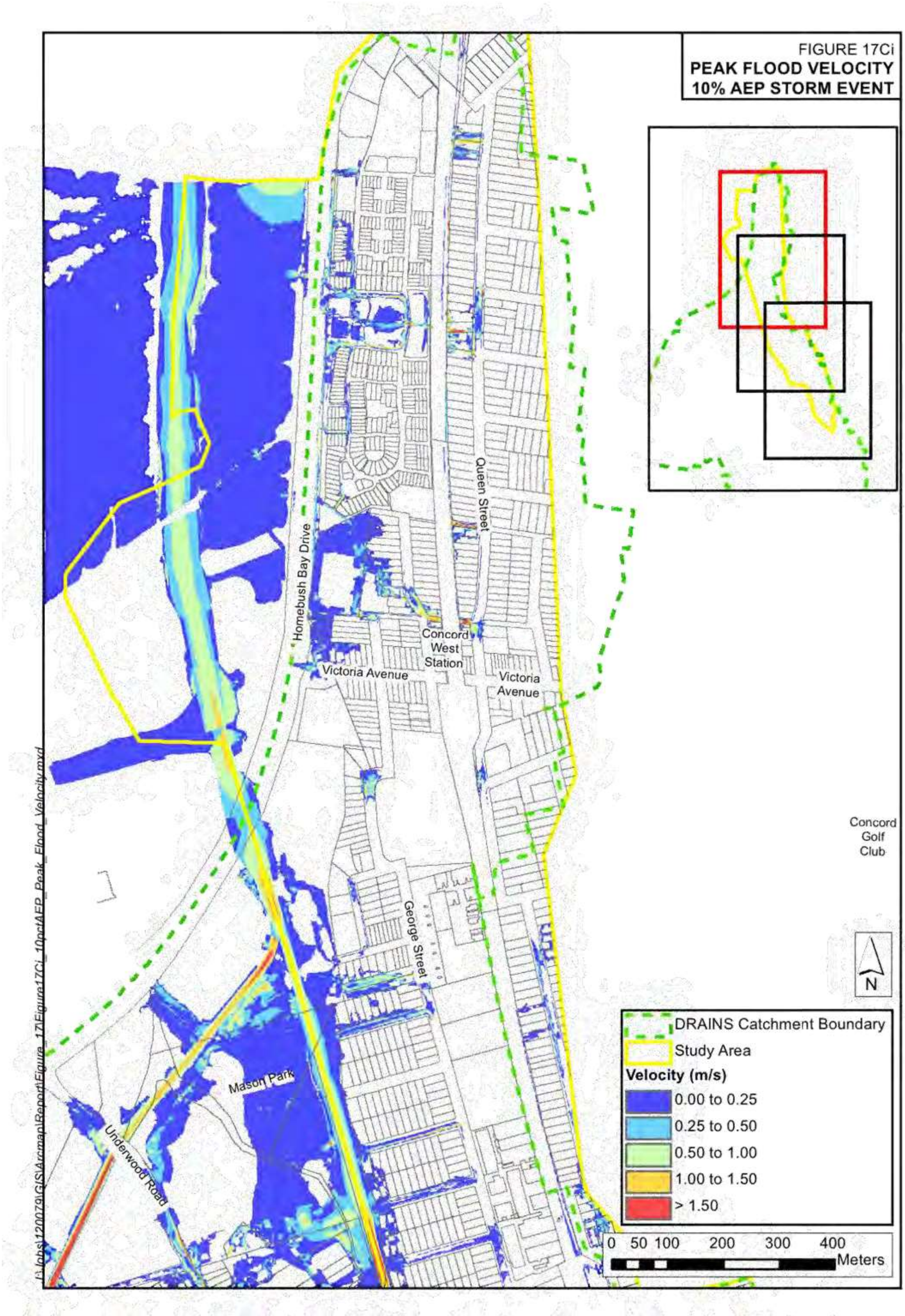


FIGURE 17Ci
PEAK FLOOD VELOCITY
10% AEP STORM EVENT
Homebush Bay Drive
Queen Street
Concord West Station
Victoria Avenue
Victoria Avenue
George Street
Mason Park
Underwood Road
Concord Golf Club
N
DRAINS Catchment Boundary
Study Area
Velocity (m/s)
0.00 to 0.25
0.25 to 0.50
0.50 to 1.00
1.00 to 1.50
> 1.50
0 50 100 200 300 400
Meters

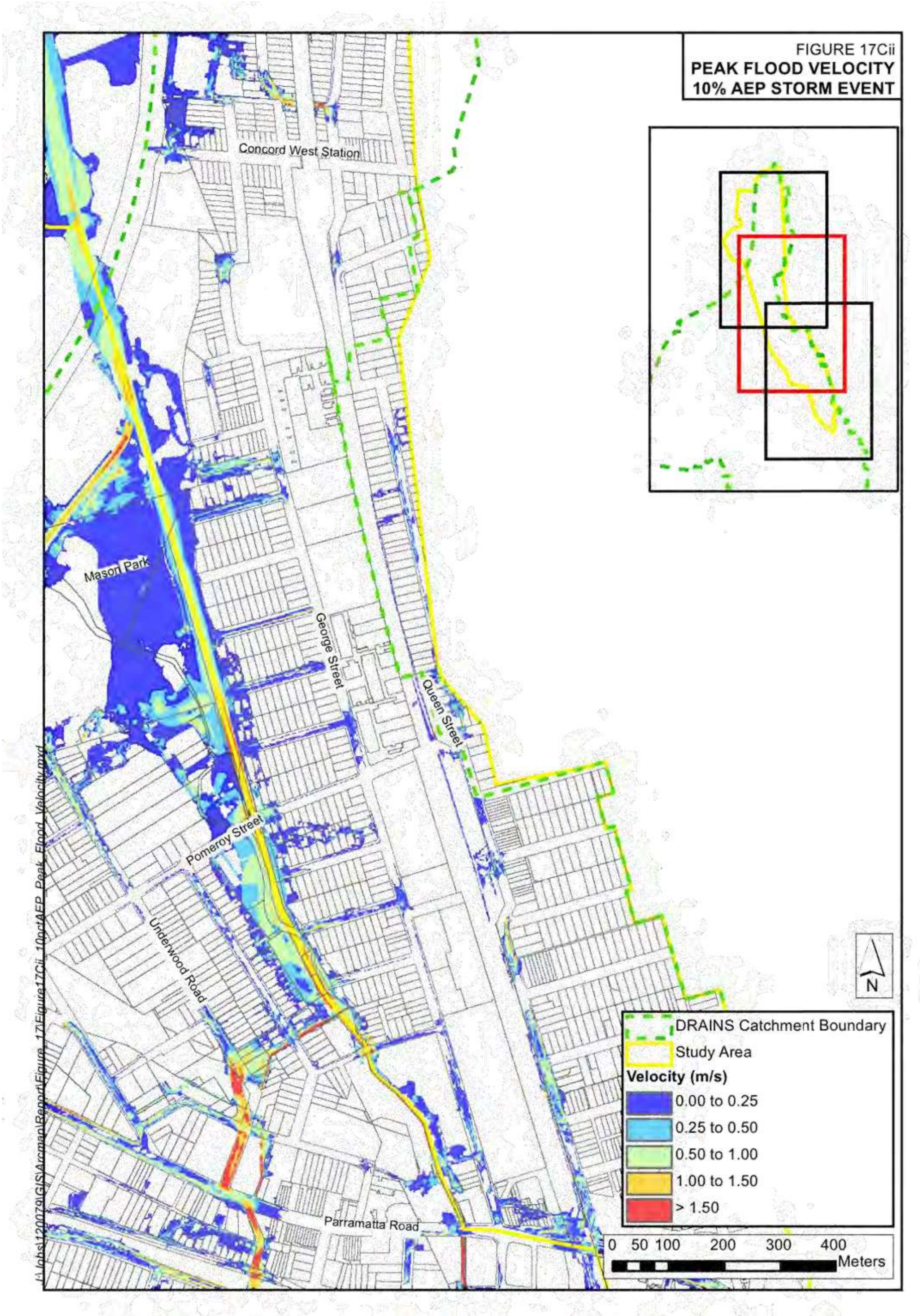


FIGURE 17Cii
PEAK FLOOD VELOCITY
10% AEP STORM EVENT
Concord West Station
Mason Park
George Street
Queen Street
Pomeroy Street
Underwood Road
Parramatta Road
DRAINS Catchment Boundary
Study Area
Velocity (m/s)
0.00 to 0.25
0.25 to 0.50
0.50 to 1.00
1.00 to 1.50
> 1.50
0 50 100 200 300 400
Meters
N

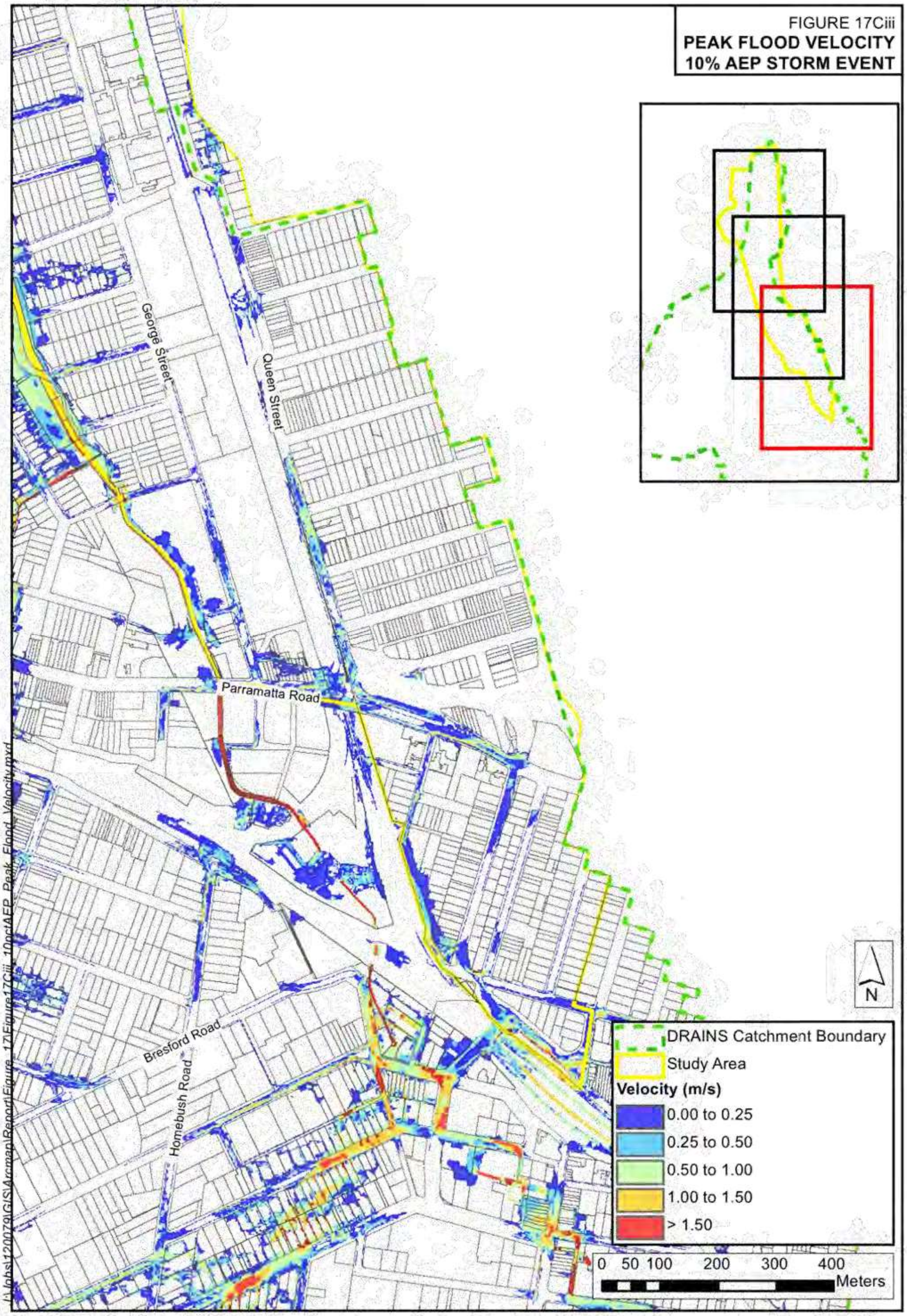


FIGURE 17Ciii
PEAK FLOOD VELOCITY
10% AEP STORM EVENT
George Street
Queen Street
Parramatta Road
Bresford Road
Homebush Road
N
DRAINS Catchment Boundary
Study Area
Velocity (m/s)
0.00 to 0.25
0.25 to 0.50
0.50 to 1.00
1.00 to 1.50
> 1.50
0 50 100 200 300 400
Meters

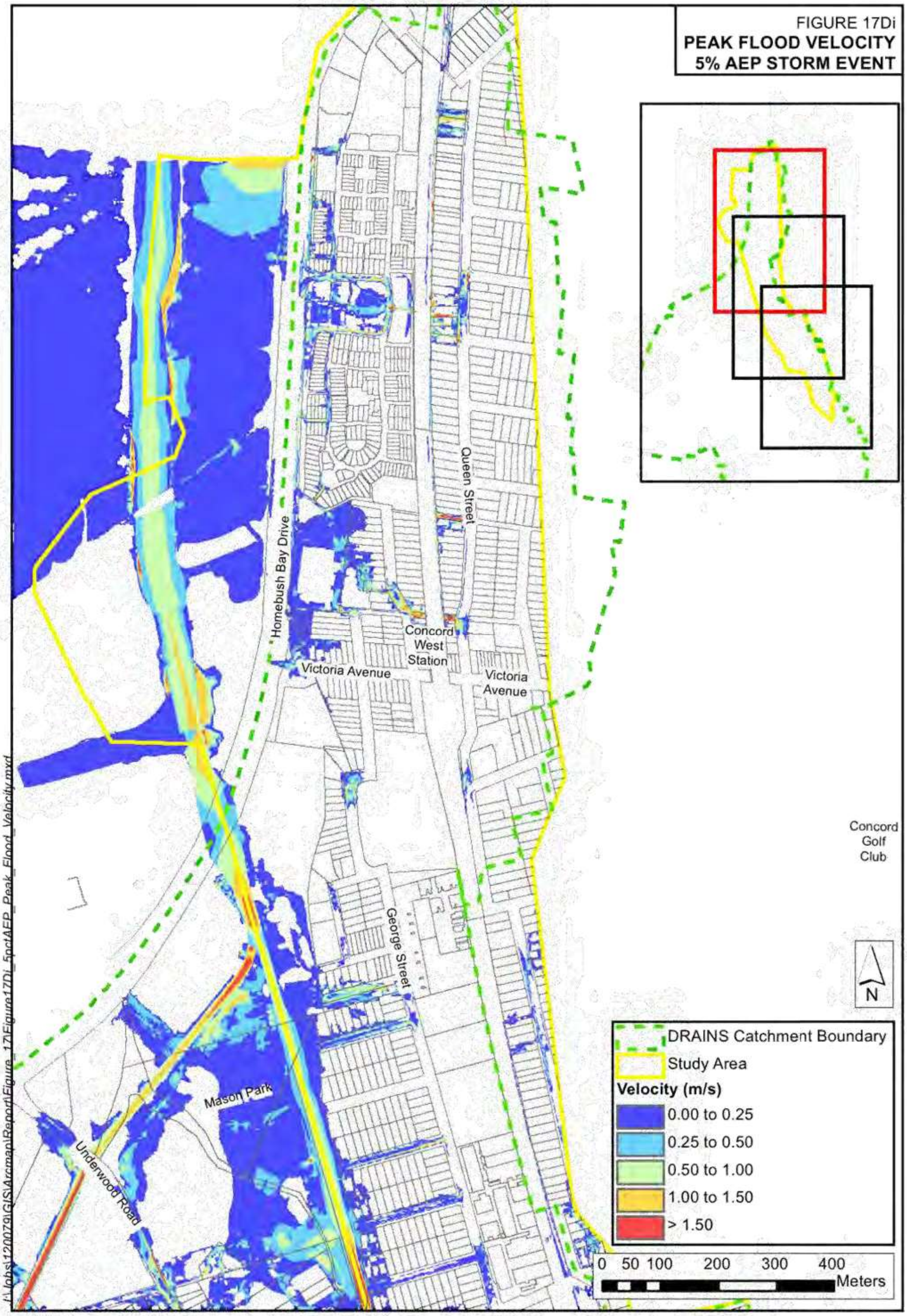


FIGURE 17Di
PEAK FLOOD VELOCITY
5% AEP STORM EVENT
Homebush Bay Drive
Queen Street
Concord West Station
Victoria Avenue
Victoria Avenue
George Street
Mason Park
Underwood Road
Concord Golf Club
N
DRAINS Catchment Boundary
Study Area
Velocity (m/s)
0.00 to 0.25
0.25 to 0.50
0.50 to 1.00
1.00 to 1.50
> 1.50
0 50 100 200 300 400
Meters

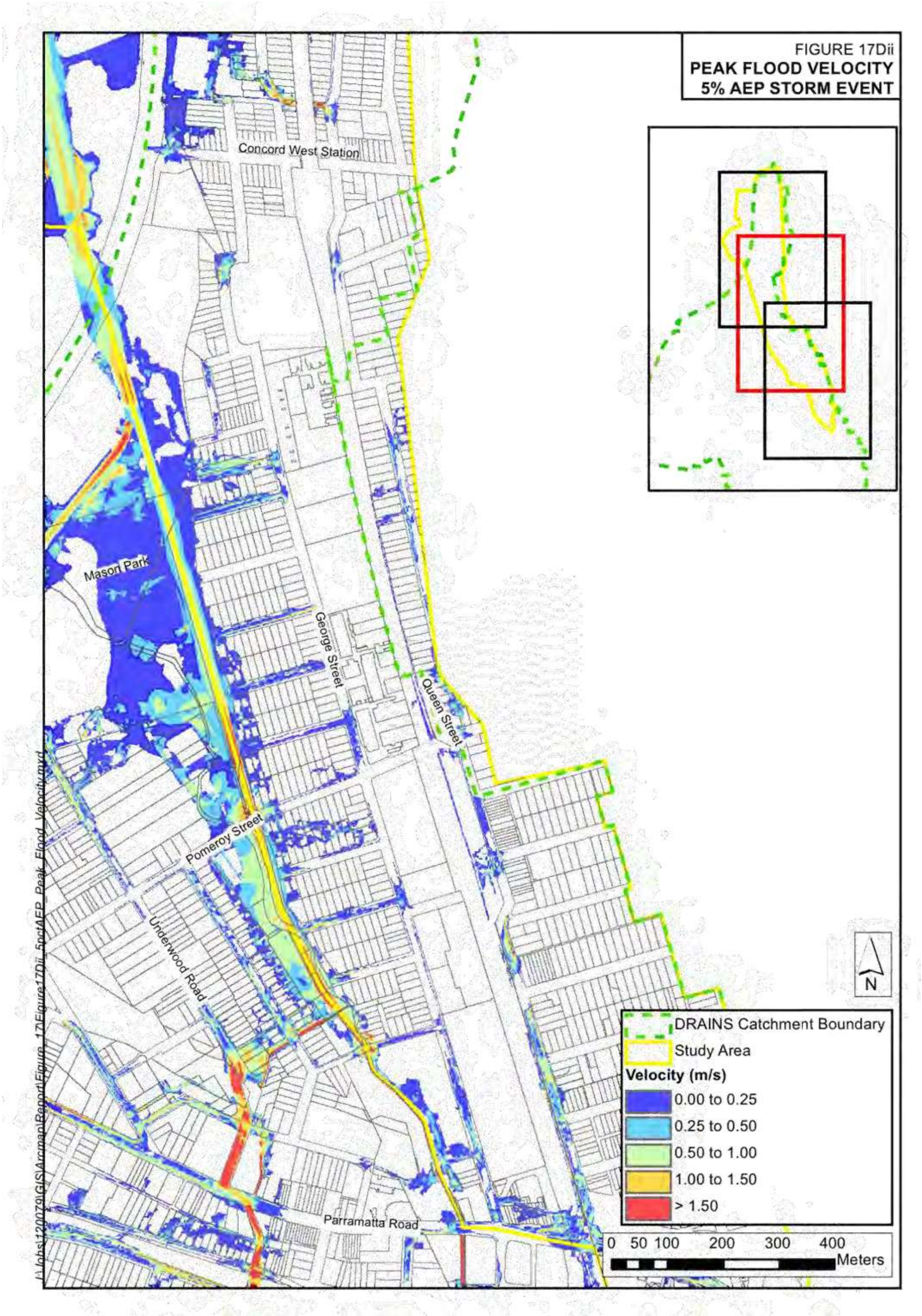


FIGURE 17Dii
PEAK FLOOD VELOCITY
5% AEP STORM EVENT
Concord West Station
Mason Park
George Street
Queen Street
Pomeroy Street
Underwood Road
Parramatta Road
DRAINS Catchment Boundary
Study Area
Velocity (m/s)
0.00 to 0.25
0.25 to 0.50
0.50 to 1.00
1.00 to 1.50
> 1.50
0 50 100 200 300 400
Meters
N

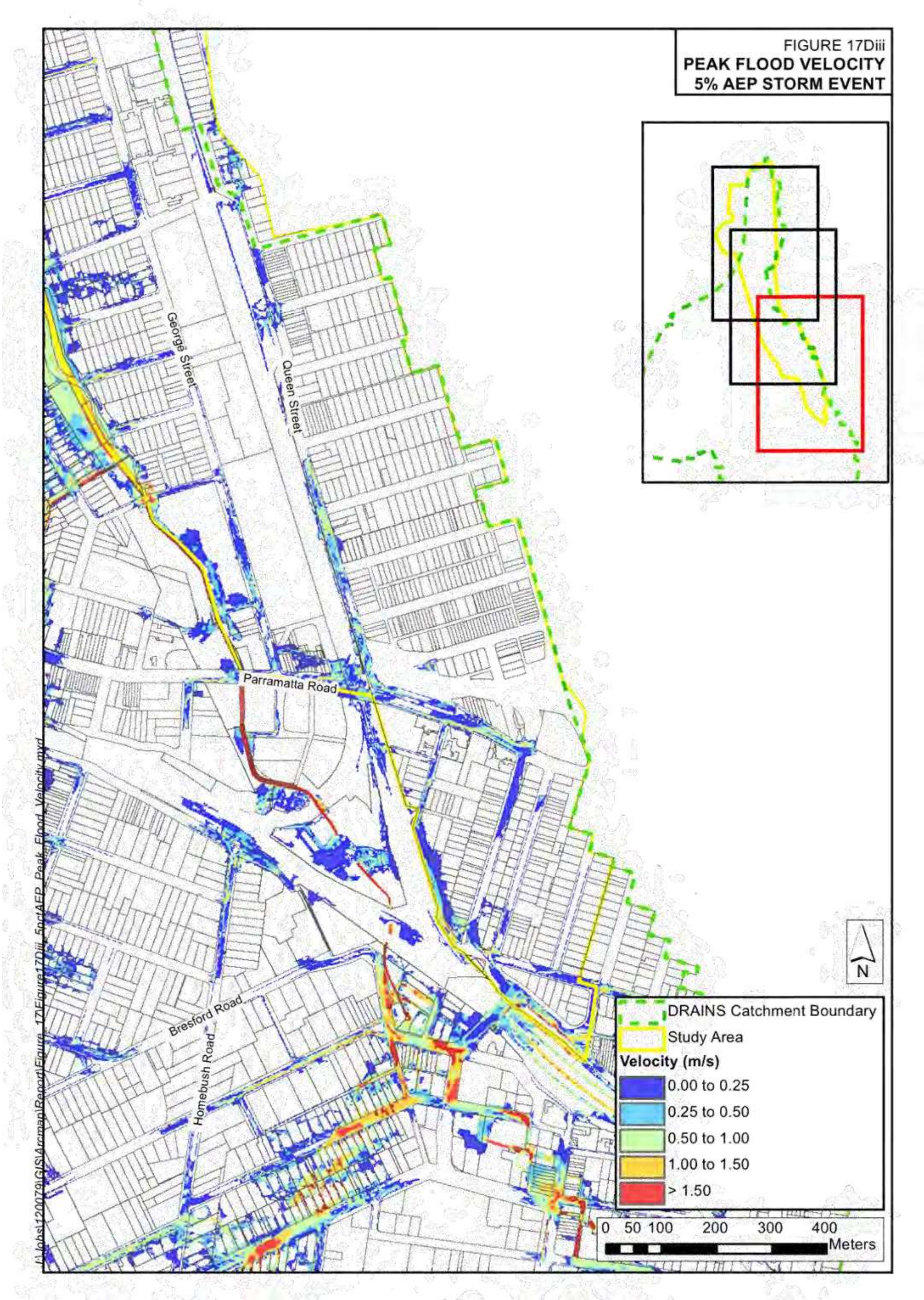


FIGURE 17Diii
PEAK FLOOD VELOCITY
5% AEP STORM EVENT
George Street
Queen Street
Parramatta Road
Bresford Road
Homebush Road
N
DRAINS Catchment Boundary
Study Area
Velocity (m/s)
0.00 to 0.25
0.25 to 0.50
0.50 to 1.00
1.00 to 1.50
> 1.50
0 50 100 200 300 400
Meters

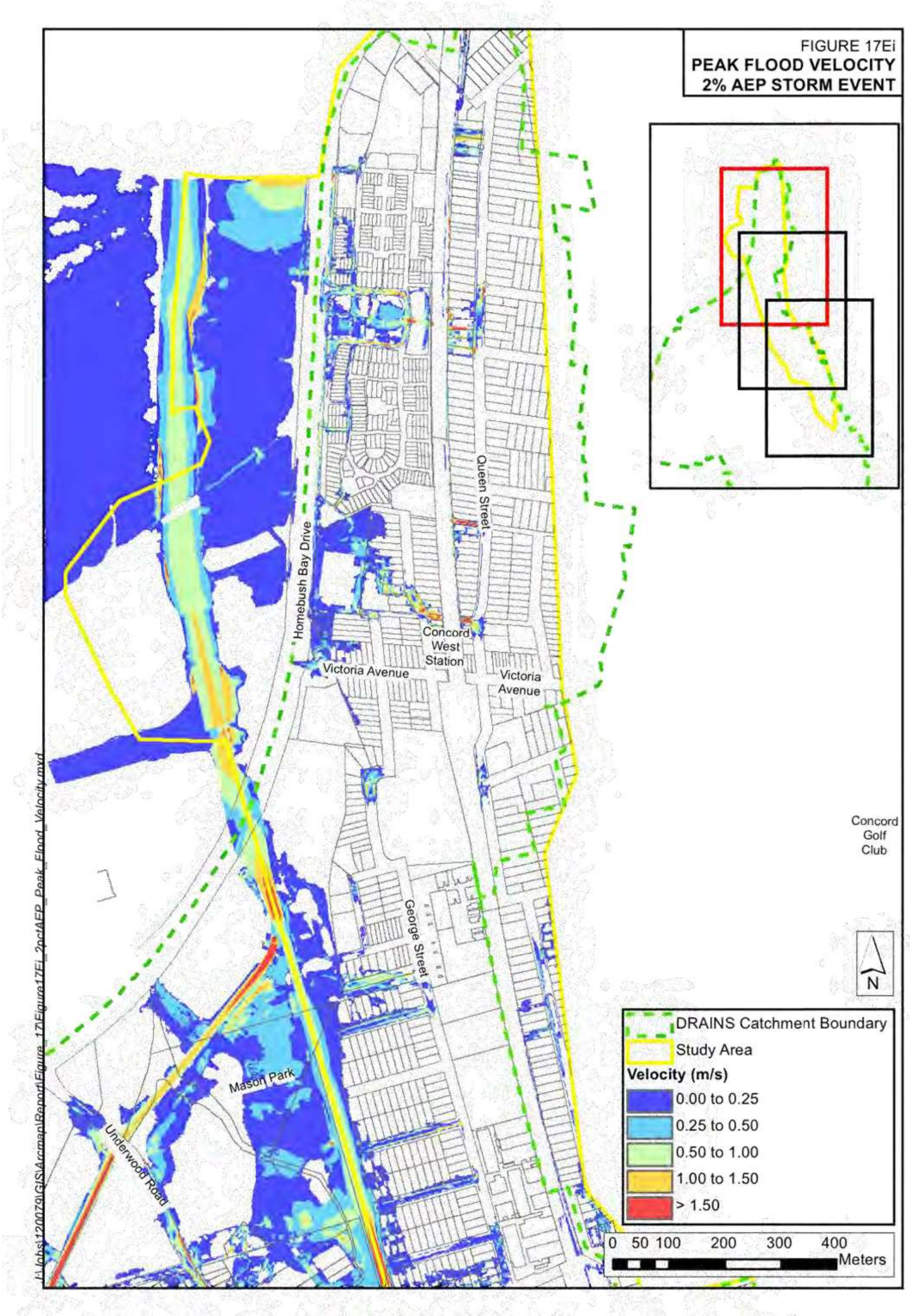


FIGURE 17Ei
PEAK FLOOD VELOCITY
2% AEP STORM EVENT
Homebush Bay Drive
Queen Street
Concord West Station
Victoria Avenue
Victoria Avenue
George Street
Mason Park
Underwood Road
Concord Golf Club
N
DRAINS Catchment Boundary
Study Area
Velocity (m/s)
0.00 to 0.25
0.25 to 0.50
0.50 to 1.00
1.00 to 1.50
> 1.50
0 50 100 200 300 400
Meters

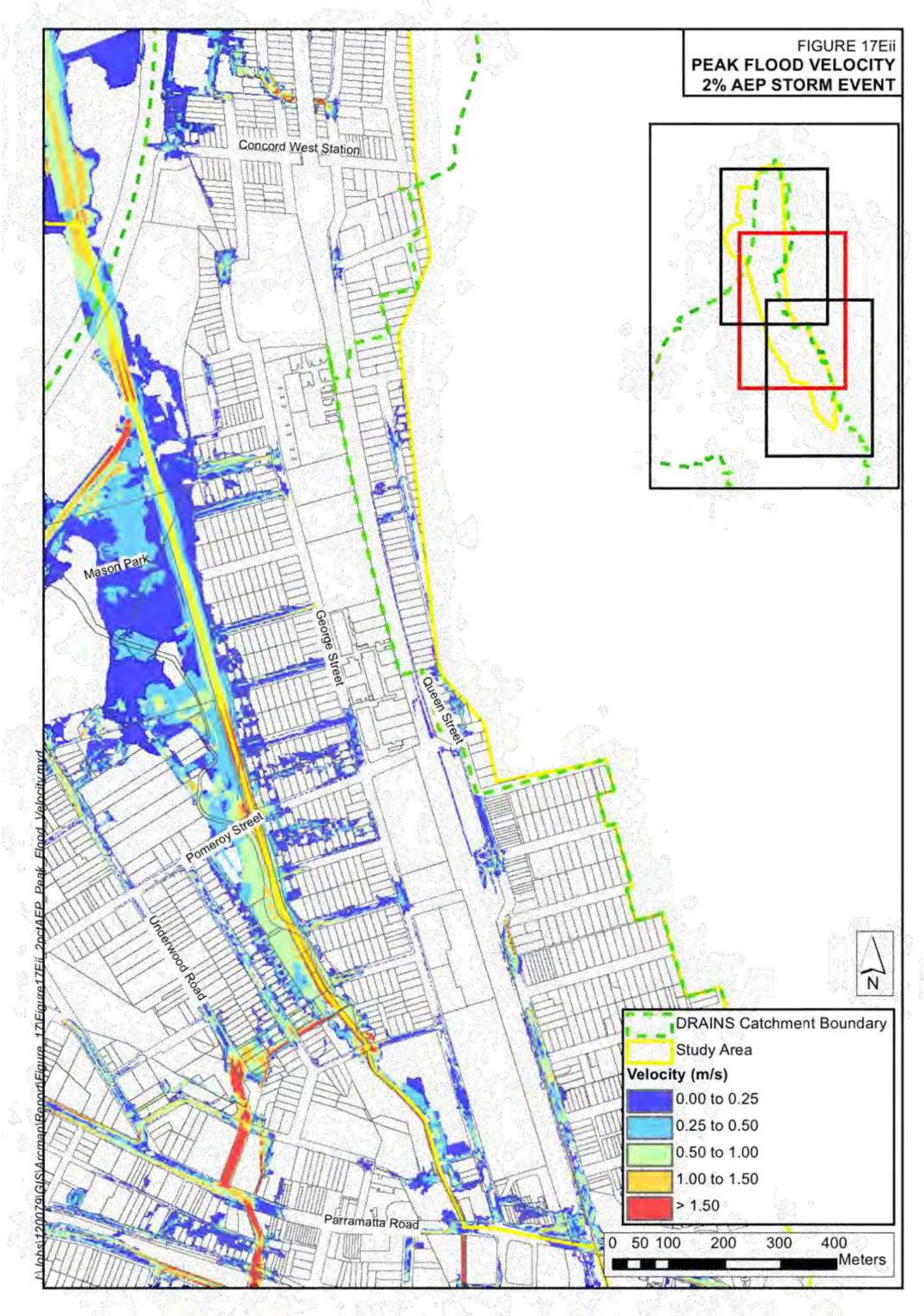


FIGURE 17Eii
PEAK FLOOD VELOCITY
2% AEP STORM EVENT
Concord West Station
Mason Park
George Street
Queen Street
Pomeroy Street
Underwood Road
Parramatta Road
N
DRAINS Catchment Boundary
Study Area
Velocity (m/s)
0.00 to 0.25
0.25 to 0.50
0.50 to 1.00
1.00 to 1.50
> 1.50
0 50 100 200 300 400
Meters

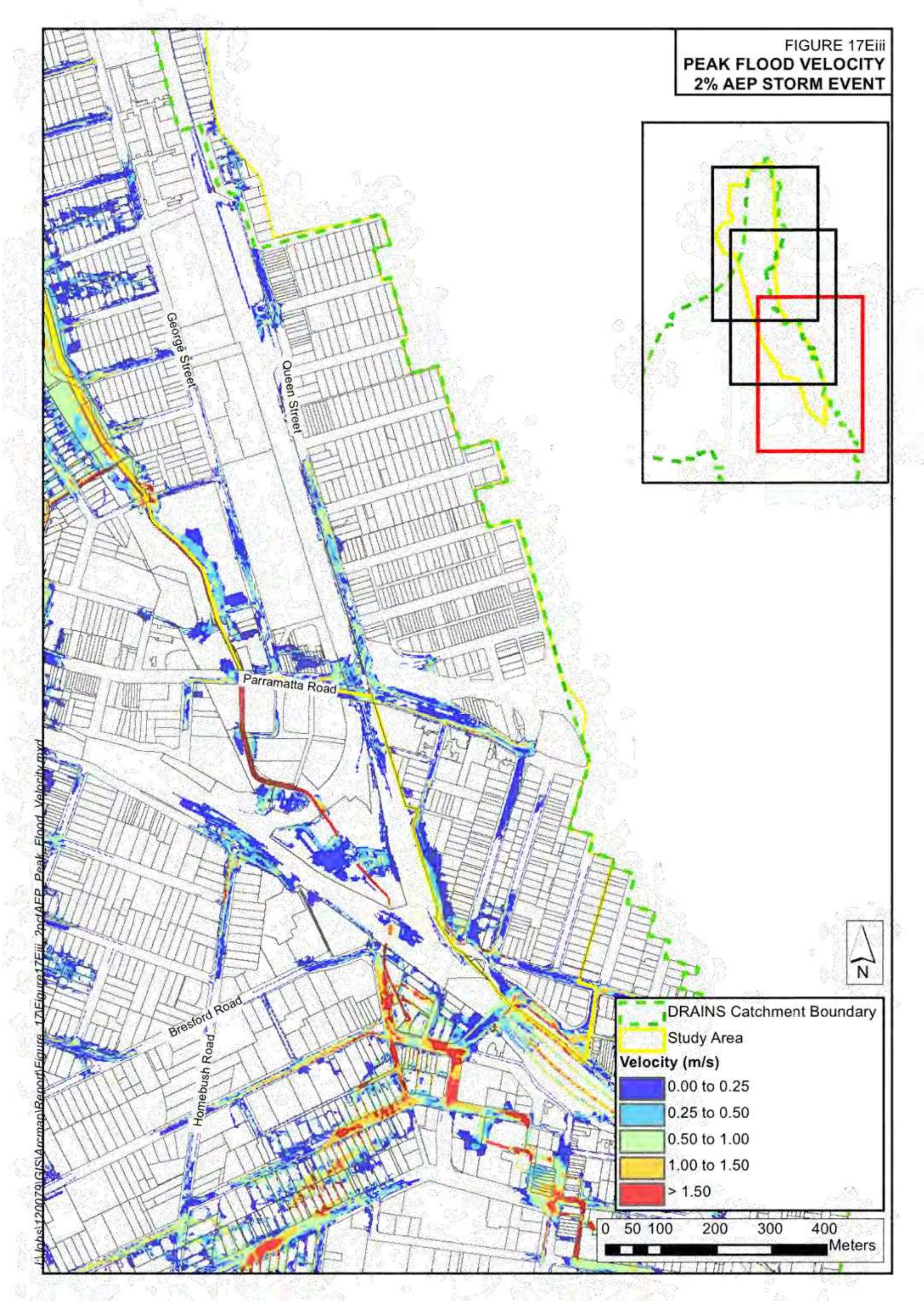


FIGURE 17Eiii
PEAK FLOOD VELOCITY
2% AEP STORM EVENT
George Street
Queen Street
Parramatta Road
Bresford Road
Homebush Road
N
DRAINS Catchment Boundary
Study Area
Velocity (m/s)
0.00 to 0.25
0.25 to 0.50
0.50 to 1.00
1.00 to 1.50
> 1.50
0 50 100 200 300 400
Meters

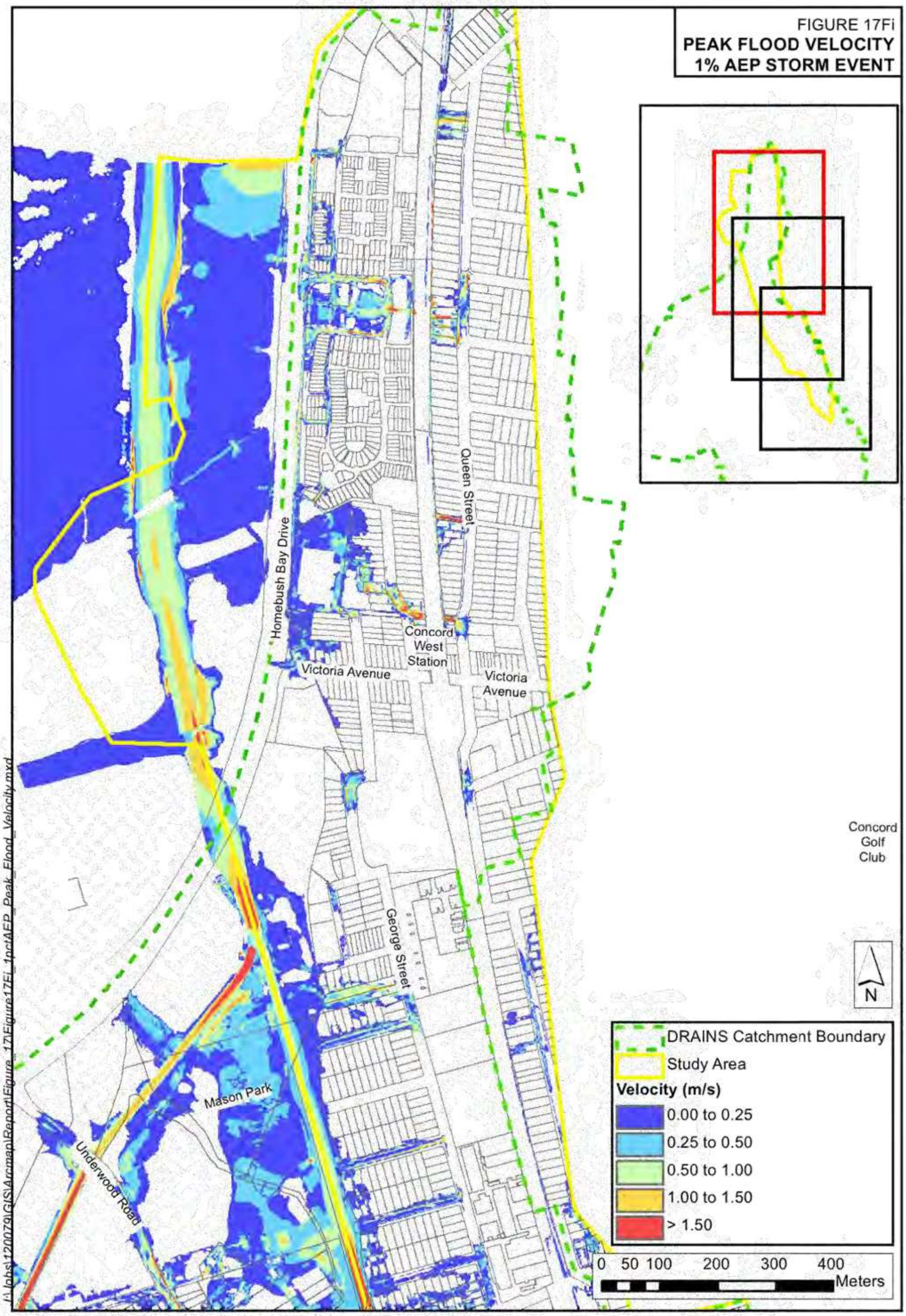


FIGURE 17Fi
PEAK FLOOD VELOCITY
1% AEP STORM EVENT
Homebush Bay Drive
Queen Street
Concord West Station
Victoria Avenue
Victoria Avenue
George Street
Mason Park
Underwood Road
Concord Golf Club
N
DRAINS Catchment Boundary
Study Area
Velocity (m/s)
0.00 to 0.25
0.25 to 0.50
0.50 to 1.00
1.00 to 1.50
> 1.50
0 50 100 200 300 400
Meters

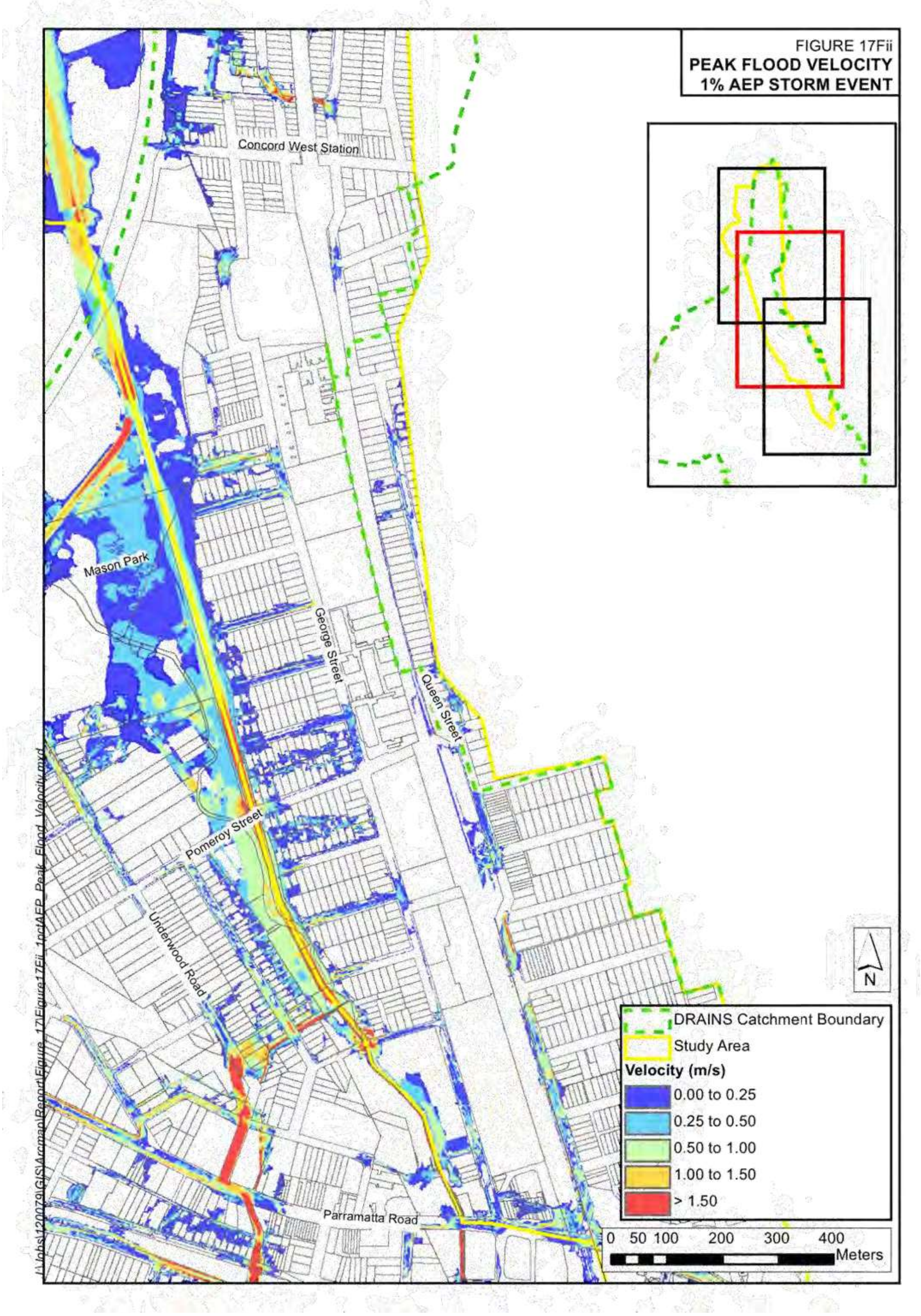


FIGURE 17Fii
PEAK FLOOD VELOCITY
1% AEP STORM EVENT
Concord West Station
Mason Park
George Street
Queen Street
Pomeroy Street
Underwood Road
Parramatta Road
DRAINS Catchment Boundary
Study Area
Velocity (m/s)
0.00 to 0.25
0.25 to 0.50
0.50 to 1.00
1.00 to 1.50
> 1.50
0 50 100 200 300 400
Meters
N

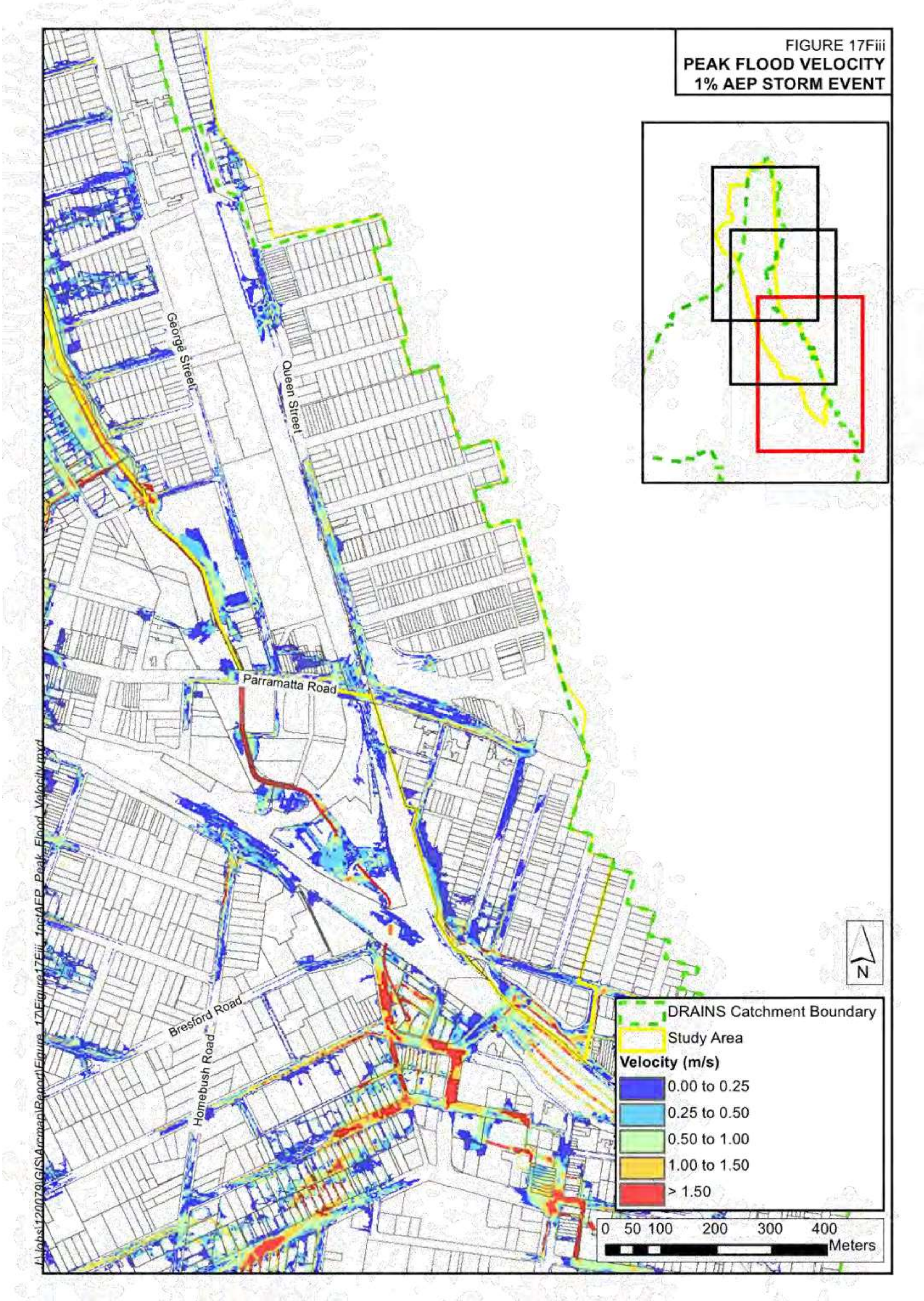


FIGURE 17Fiii
PEAK FLOOD VELOCITY
1% AEP STORM EVENT
George Street
Queen Street
Parramatta Road
Bresford Road
Homebush Road
DRAINS Catchment Boundary
Study Area
Velocity (m/s)
0.00 to 0.25
0.25 to 0.50
0.50 to 1.00
1.00 to 1.50
> 1.50
0 50 100 200 300 400
Meters
N

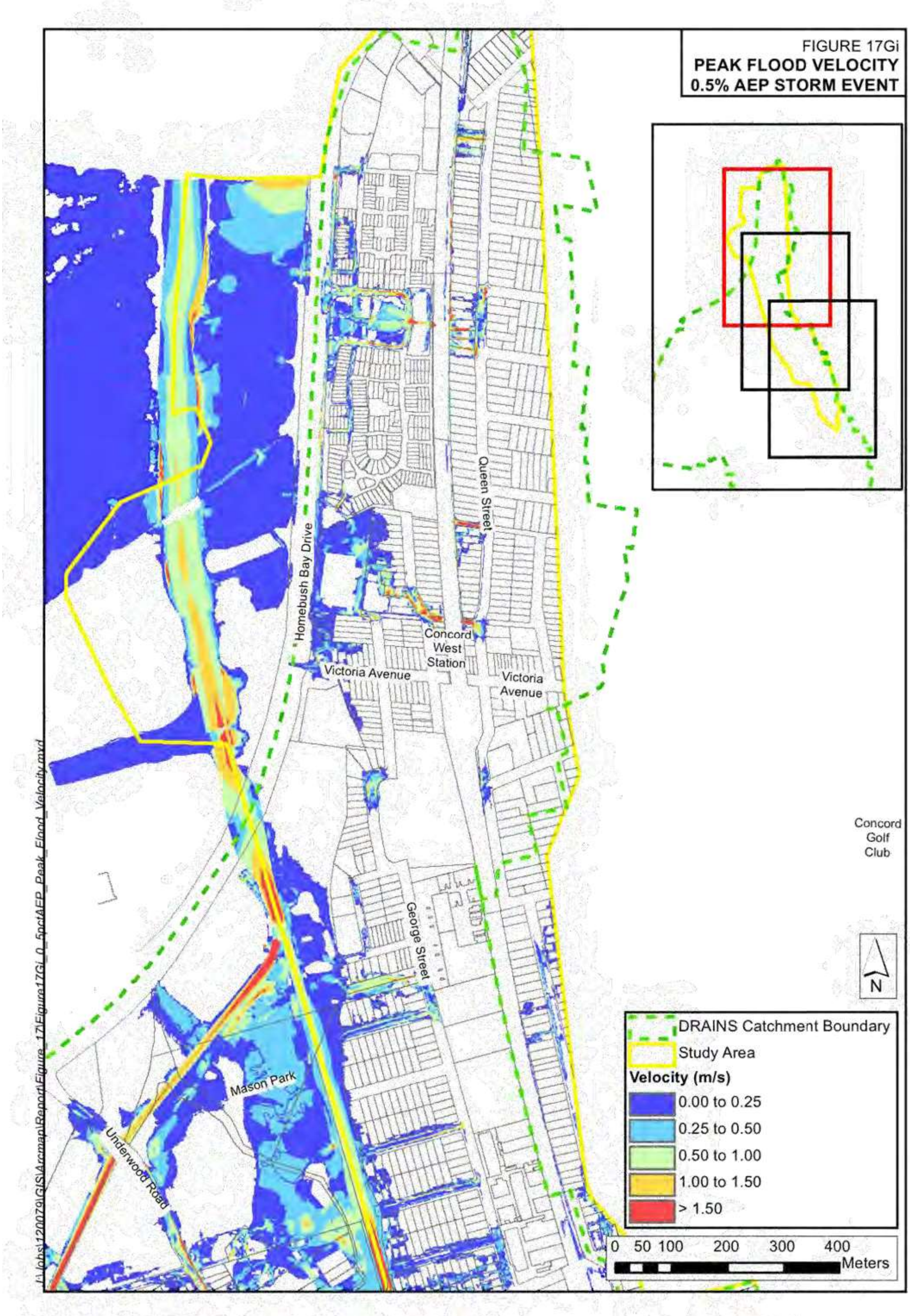


FIGURE 17Gi
PEAK FLOOD VELOCITY
0.5% AEP STORM EVENT
Queen Street
Homebush Bay Drive
Concord West Station
Victoria Avenue
Victoria Avenue
Concord Golf Club
George Street
Mason Park
Underwood Road
N
DRAINS Catchment Boundary
Study Area
Velocity (m/s)
0.00 to 0.25
0.25 to 0.50
0.50 to 1.00
1.00 to 1.50
> 1.50
0 50 100 200 300 400
Meters

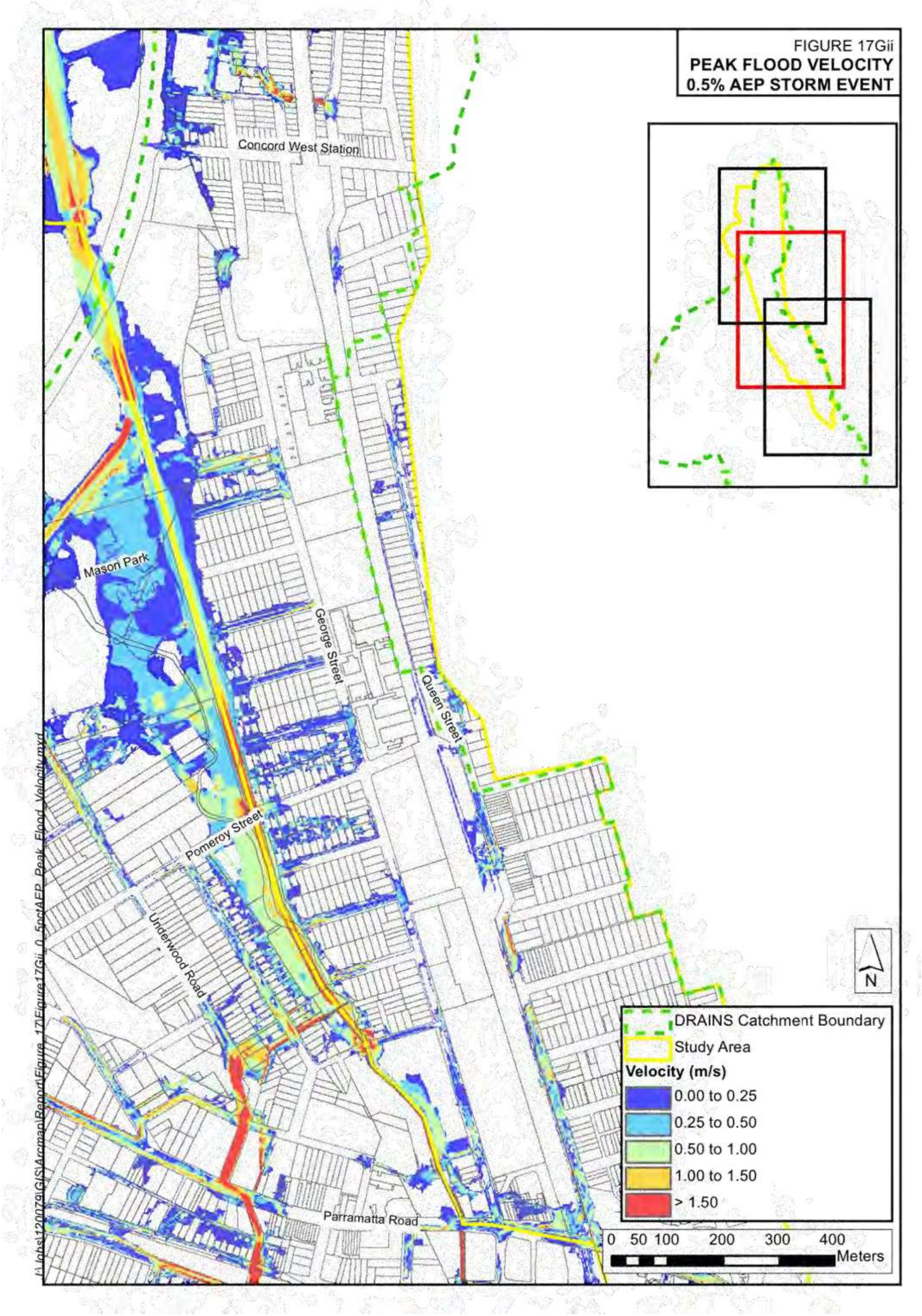


FIGURE 17Gii
PEAK FLOOD VELOCITY
0.5% AEP STORM EVENT
Concord West Station
Mason Park
George Street
Queen Street
Pomeroy Street
Underwood Road
Parramatta Road
DRAINS Catchment Boundary
Study Area
Velocity (m/s)
0.00 to 0.25
0.25 to 0.50
0.50 to 1.00
1.00 to 1.50
> 1.50
0 50 100 200 300 400
Meters
N

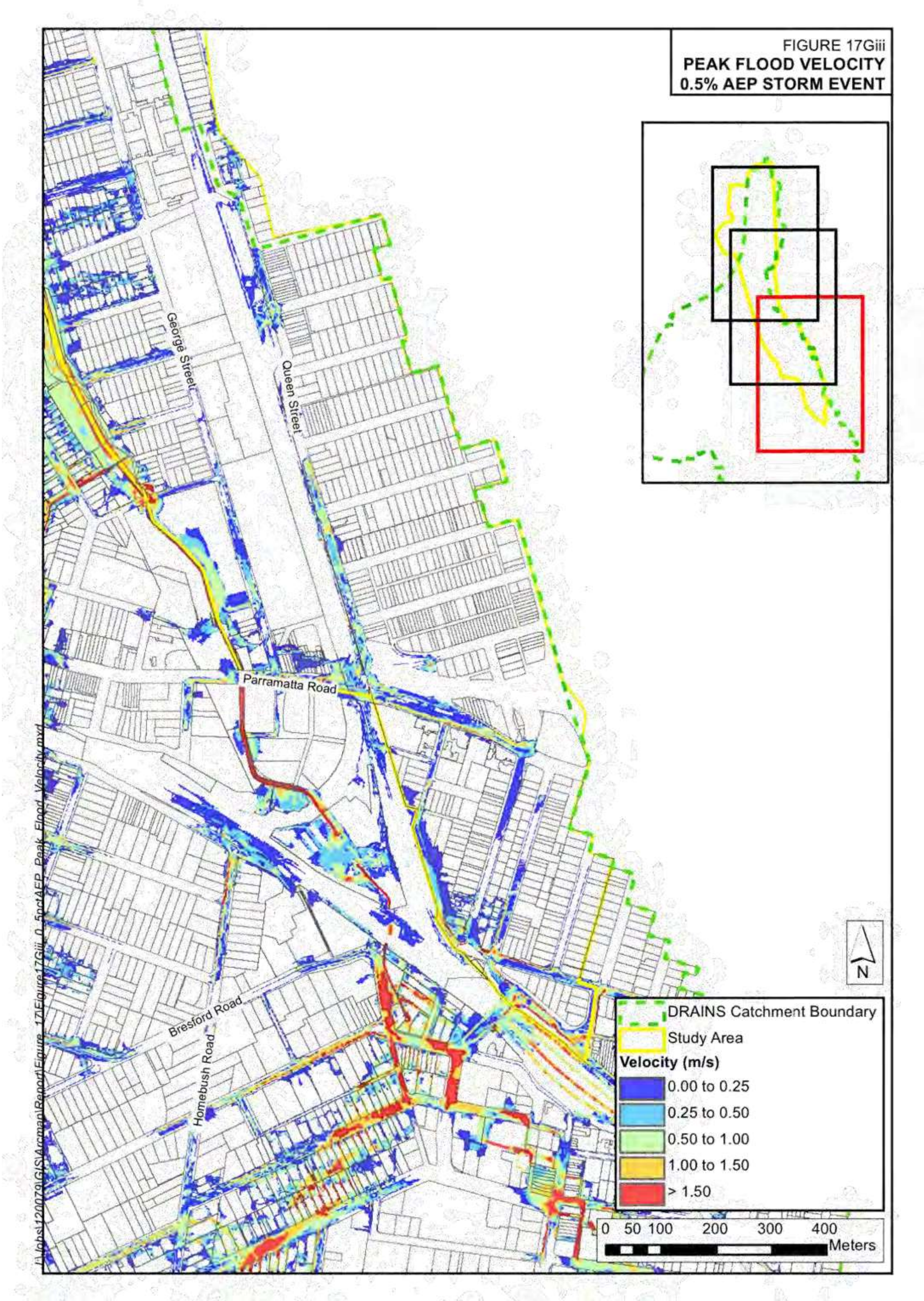


FIGURE 17Giii
PEAK FLOOD VELOCITY
0.5% AEP STORM EVENT
George Street
Queen Street
Parramatta Road
Bresford Road
Homebush Road
DRAINS Catchment Boundary
Study Area
Velocity (m/s)
0.00 to 0.25
0.25 to 0.50
0.50 to 1.00
1.00 to 1.50
> 1.50
N
0 50 100 200 300 400
Meters

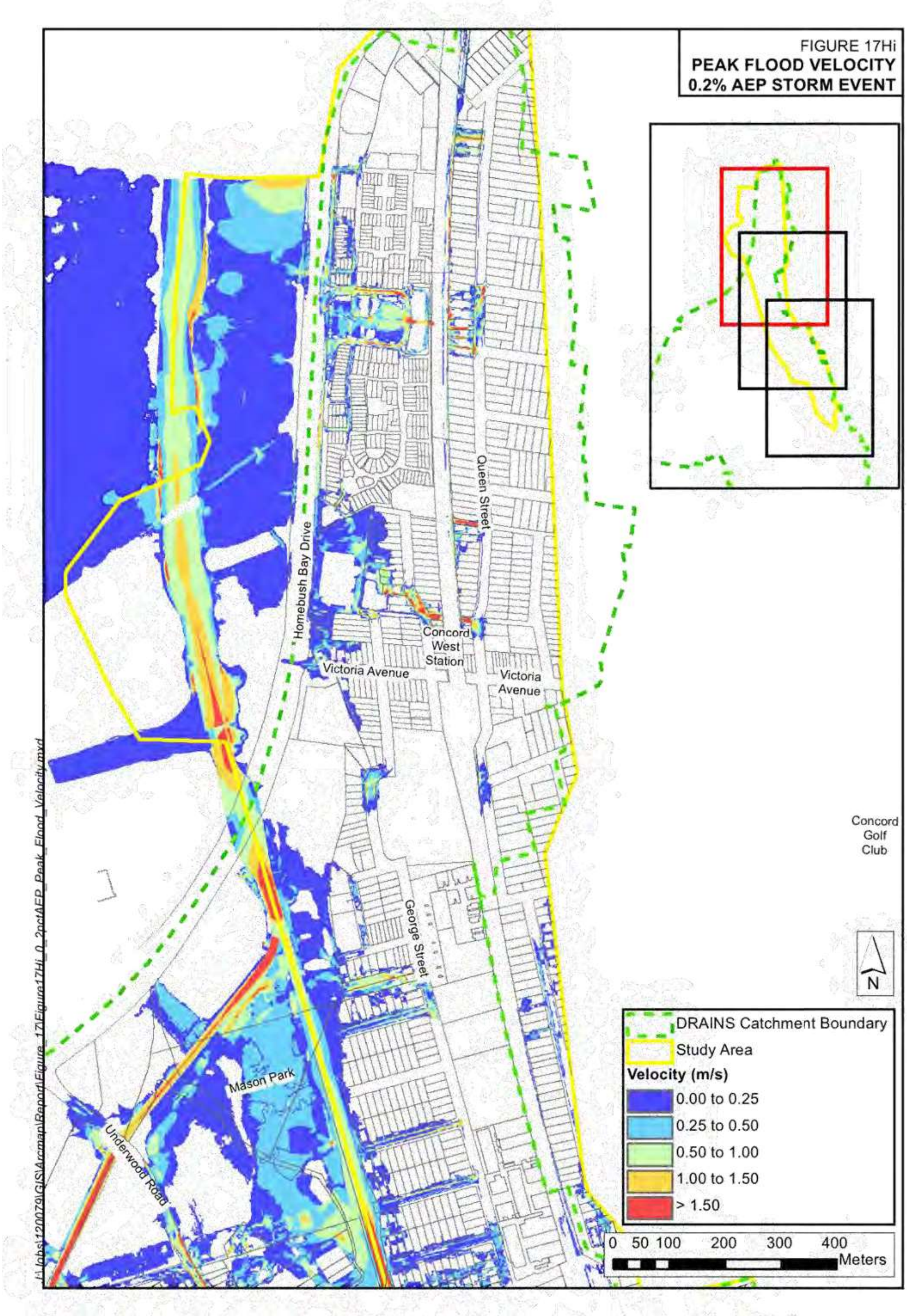


FIGURE 17Hi
PEAK FLOOD VELOCITY
0.2% AEP STORM EVENT
Homebush Bay Drive
Queen Street
Concord West Station
Victoria Avenue
Victoria Avenue
George Street
Mason Park
Underwood Road
Concord Golf Club
N
DRAINS Catchment Boundary
Study Area
Velocity (m/s)
0.00 to 0.25
0.25 to 0.50
0.50 to 1.00
1.00 to 1.50
> 1.50
0 50 100 200 300 400
Meters

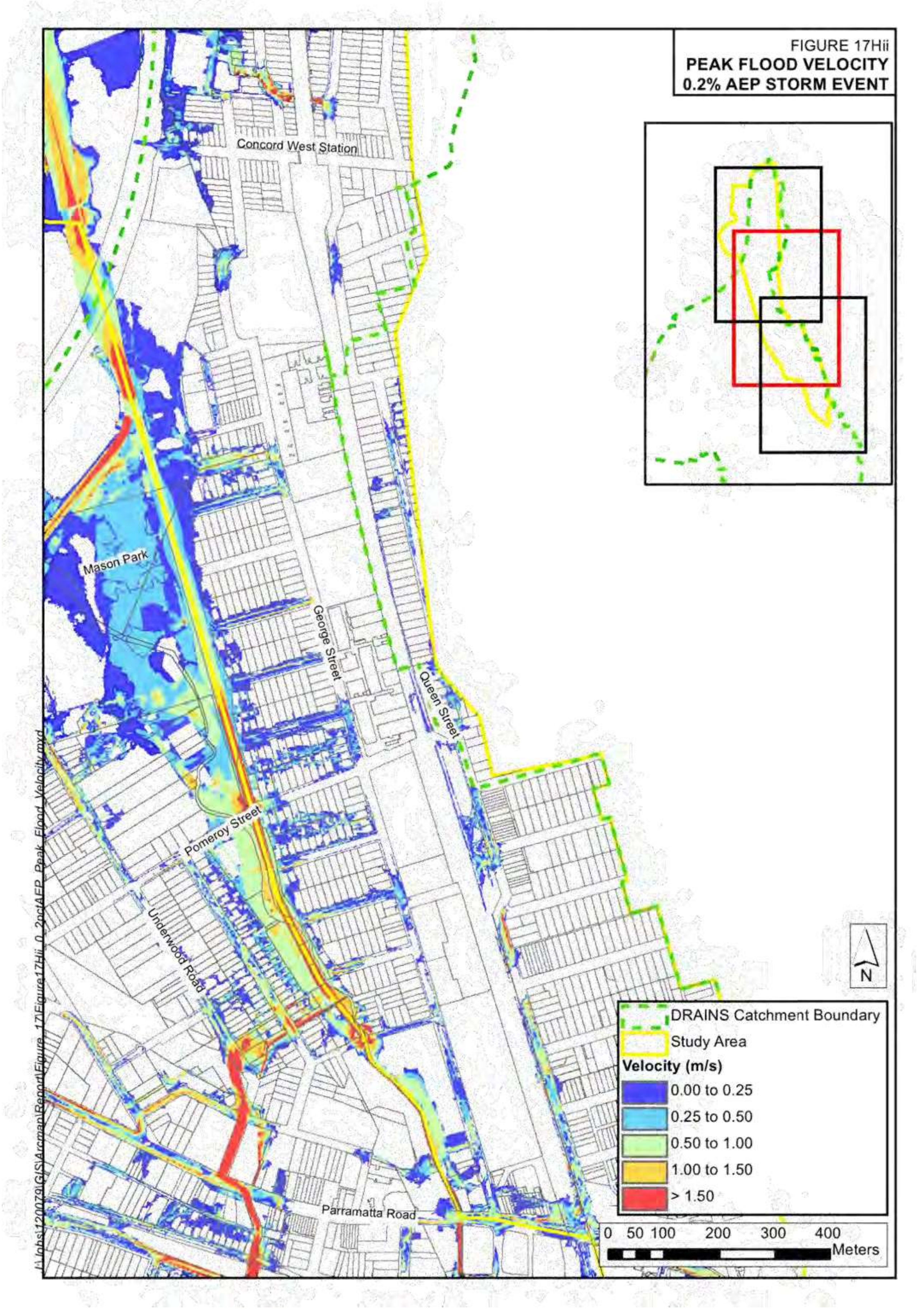


FIGURE 17Hii
PEAK FLOOD VELOCITY
0.2% AEP STORM EVENT
Concord West Station
Mason Park
George Street
Queen Street
Pomeroy Street
Underwood Road
Parramatta Road
N
DRAINS Catchment Boundary
Study Area
Velocity (m/s)
0.00 to 0.25
0.25 to 0.50
0.50 to 1.00
1.00 to 1.50
> 1.50
0 50 100 200 300 400
Meters

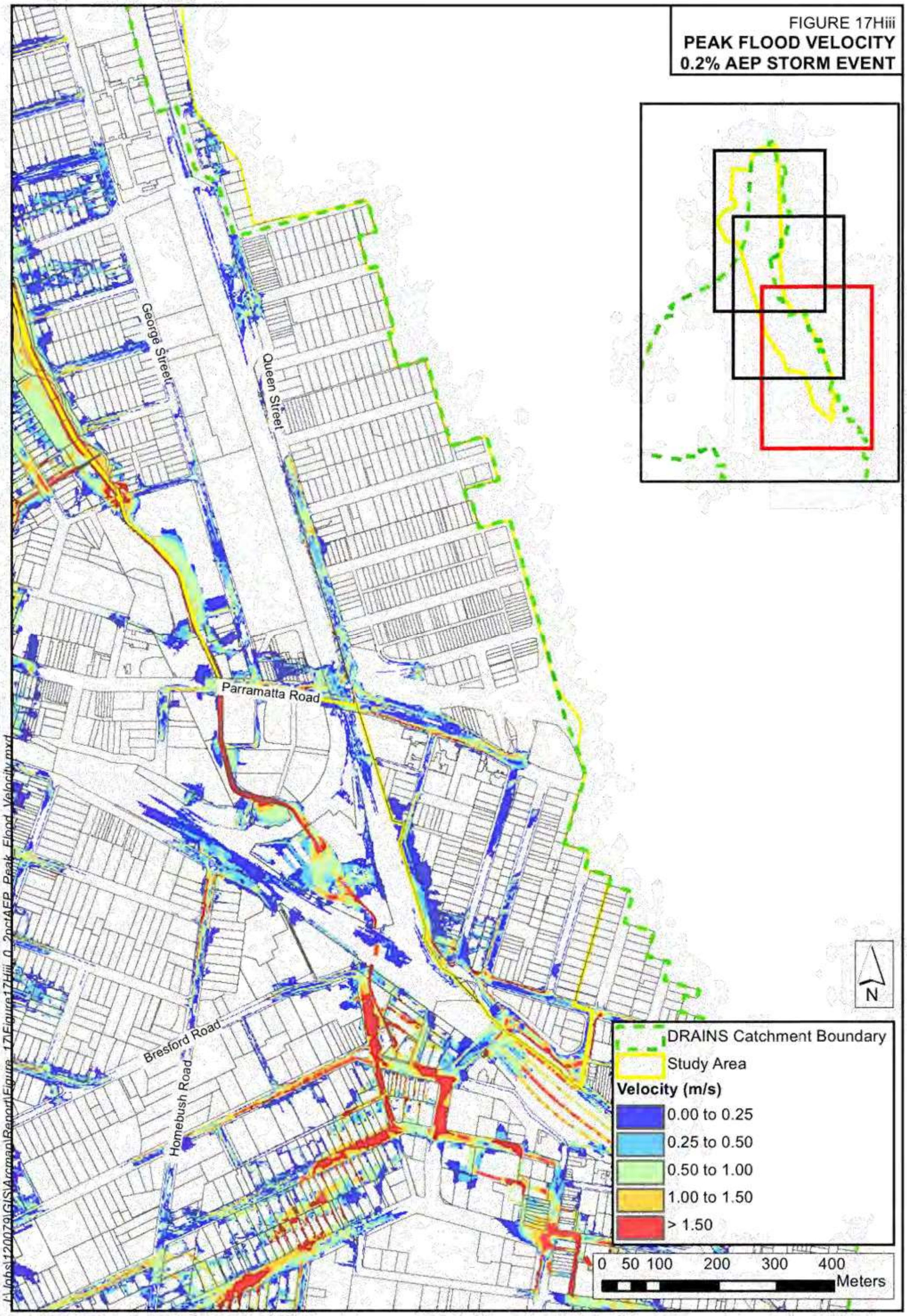


FIGURE 17Hiii
PEAK FLOOD VELOCITY
0.2% AEP STORM EVENT
George Street
Queen Street
Parramatta Road
Bresford Road
Homebush Road
N
DRAINS Catchment Boundary
Study Area
Velocity (m/s)
0.00 to 0.25
0.25 to 0.50
0.50 to 1.00
1.00 to 1.50
> 1.50
0 50 100 200 300 400
Meters

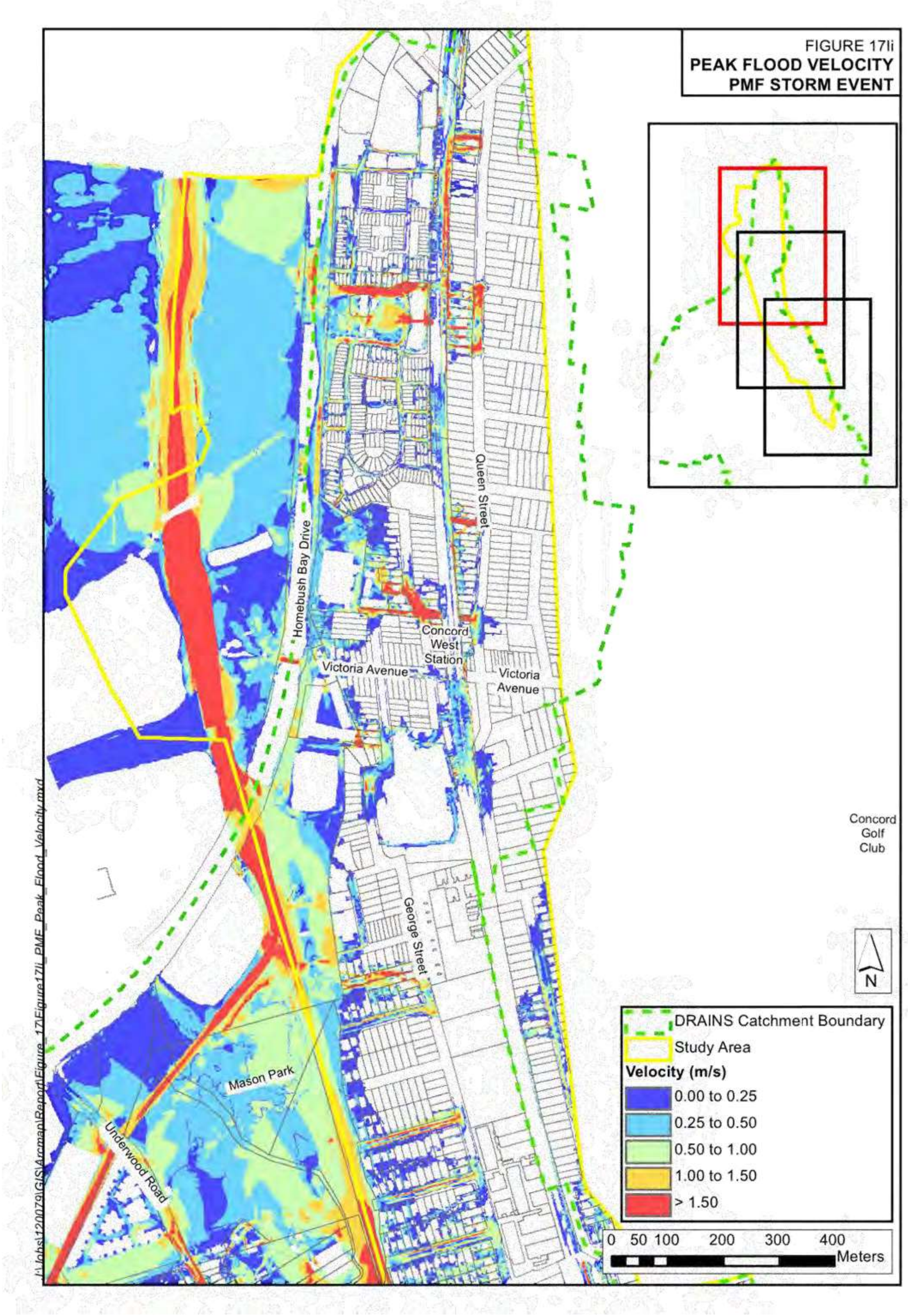


FIGURE 17Ii
PEAK FLOOD VELOCITY
PMF STORM EVENT
Homebush Bay Drive
Queen Street
Concord West Station
Victoria Avenue
Victoria Avenue
George Street
Mason Park
Underwood Road
Concord Golf Club
N
DRAINS Catchment Boundary
Study Area
Velocity (m/s)
0.00 to 0.25
0.25 to 0.50
0.50 to 1.00
1.00 to 1.50
> 1.50
0 50 100 200 300 400
Meters

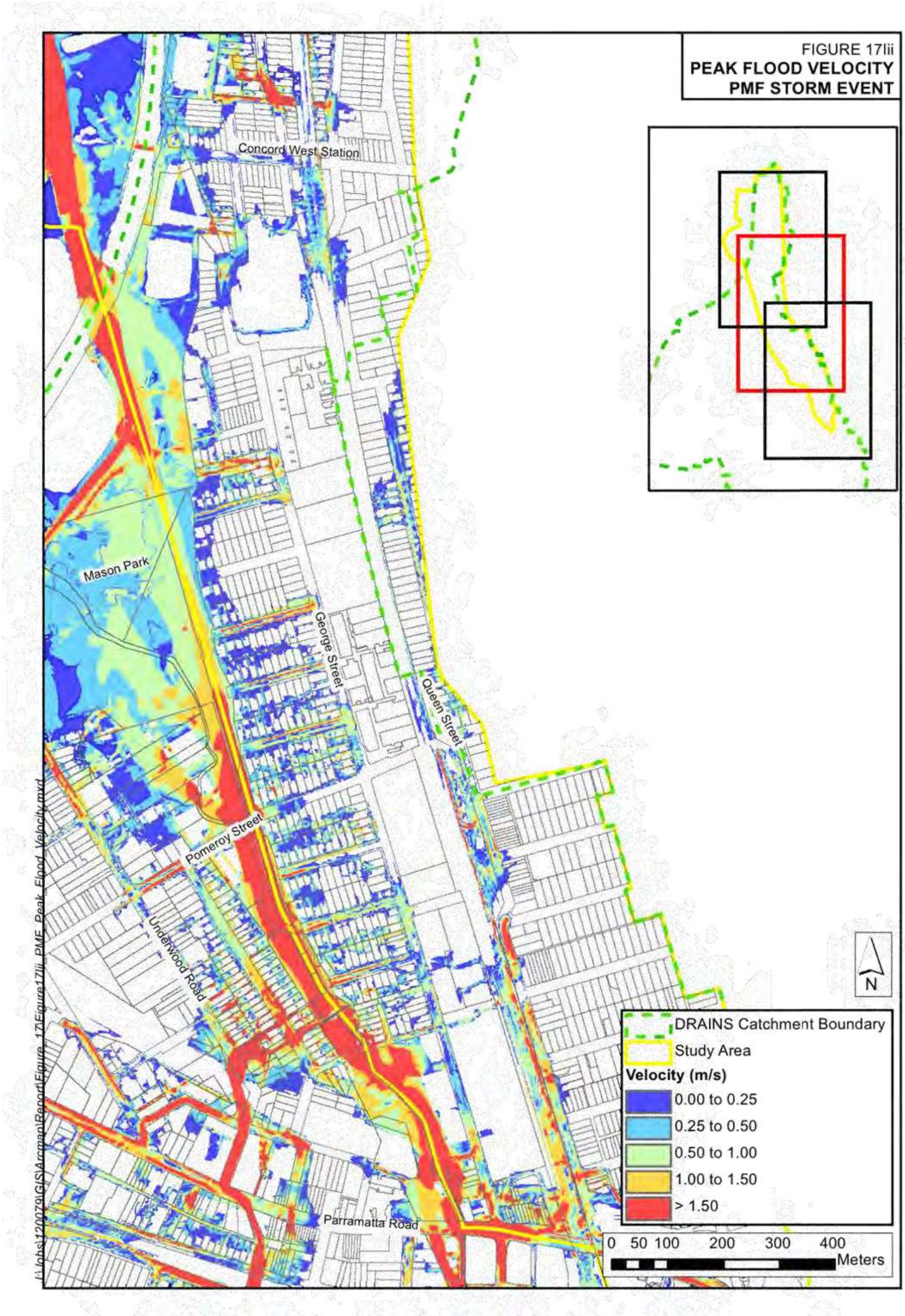


FIGURE 17lii
PEAK FLOOD VELOCITY
PMF STORM EVENT
Concord West Station
Mason Park
George Street
Queen Street
Pomeroy Street
Underwood Road
Parramatta Road
DRAINS Catchment Boundary
Study Area
Velocity (m/s)
0.00 to 0.25
0.25 to 0.50
0.50 to 1.00
1.00 to 1.50
> 1.50
N
0 50 100 200 300 400
Meters

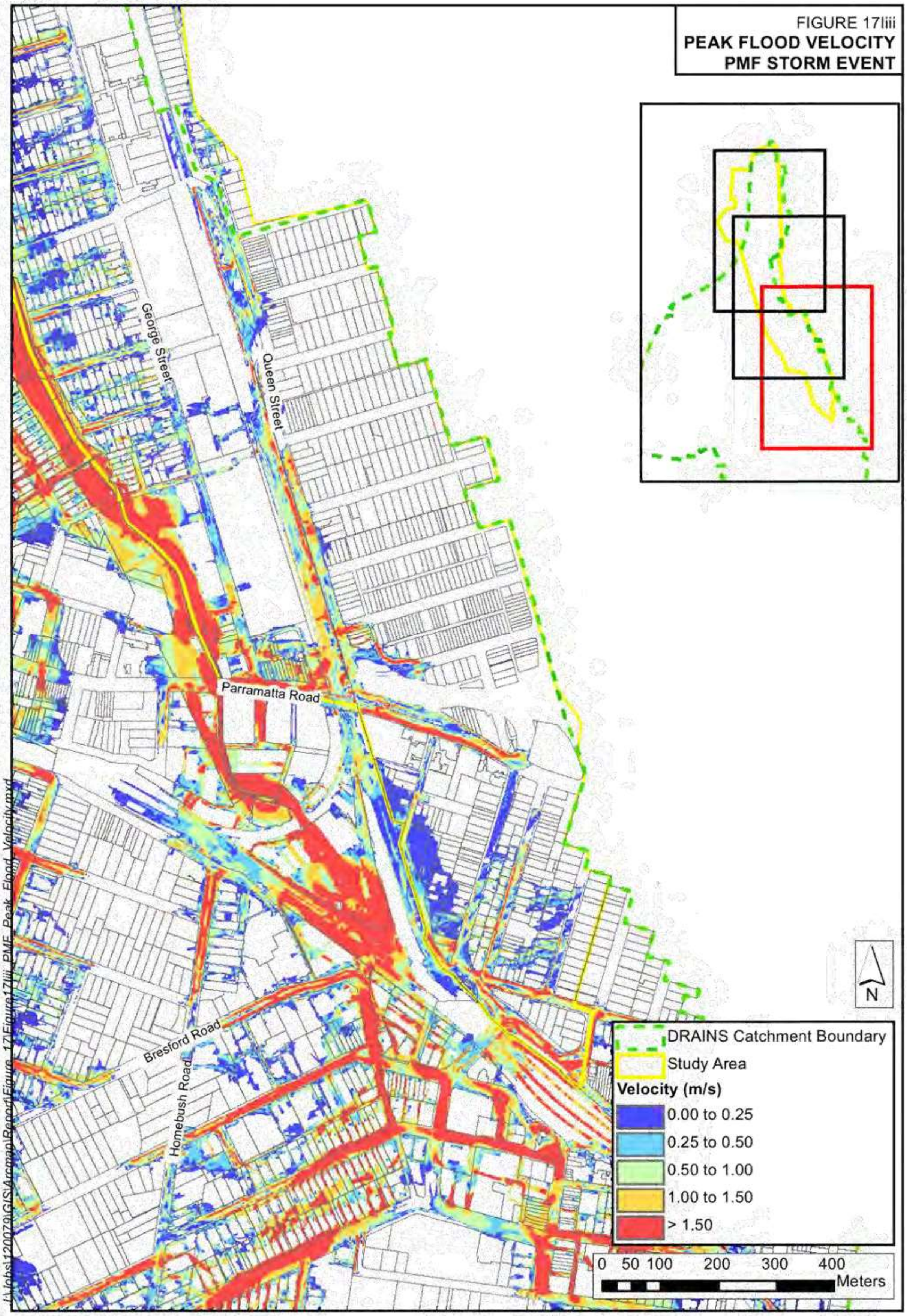


FIGURE 17liii
PEAK FLOOD VELOCITY
PMF STORM EVENT
George Street
Queen Street
Parramatta Road
Bresford Road
Homebush Road
DRAINS Catchment Boundary
Study Area
Velocity (m/s)
0.00 to 0.25
0.25 to 0.50
0.50 to 1.00
1.00 to 1.50
> 1.50
0 50 100 200 300 400
Meters
N

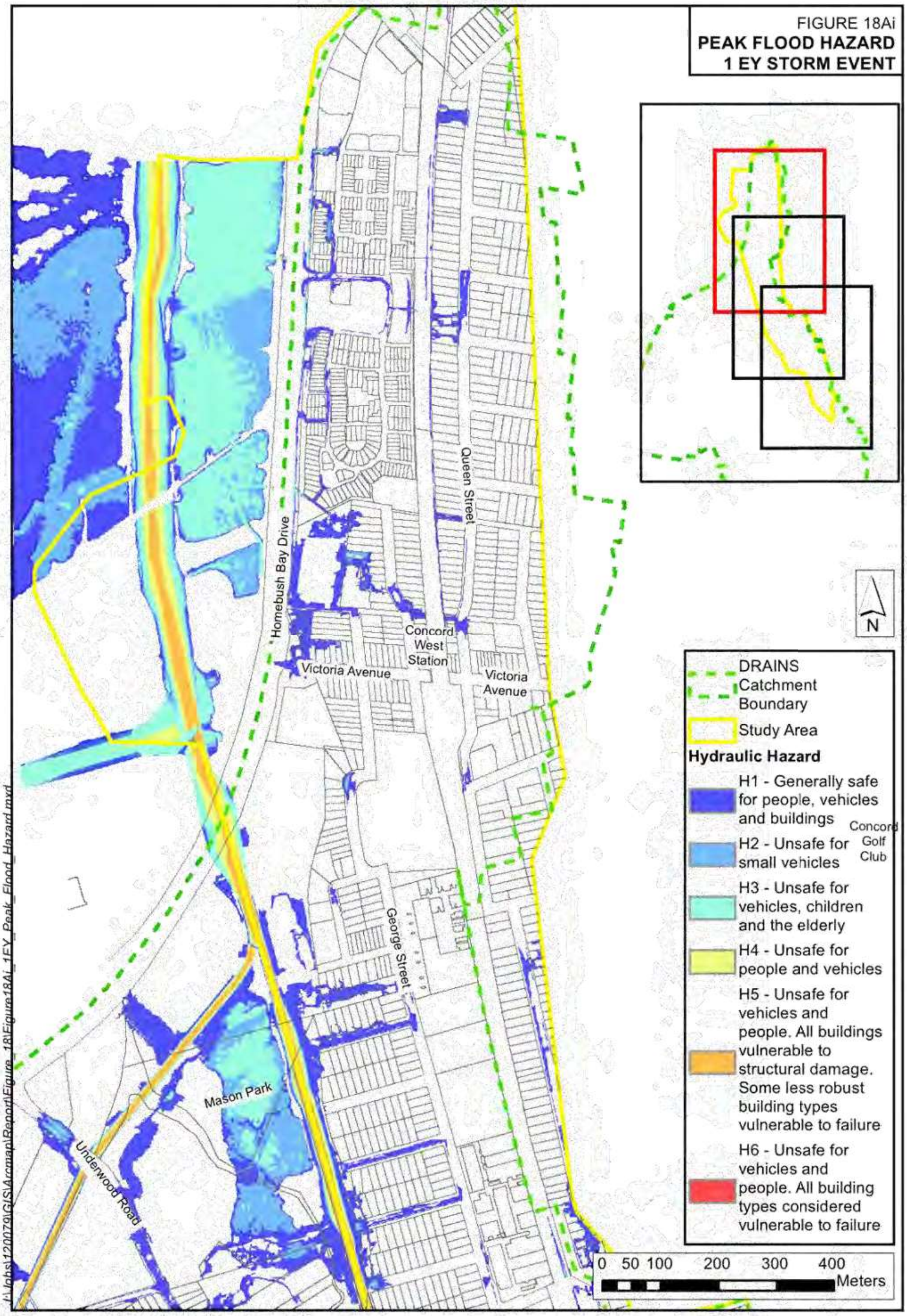


FIGURE 18Ai
PEAK FLOOD HAZARD
1 EY STORM EVENT
Homebush Bay Drive
Queen Street
Concord West Station
Victoria Avenue
Victoria Avenue
George Street
Mason Park
Underwood Road
Concord Golf Club
N
DRAINS Catchment Boundary
Study Area
Hydraulic Hazard
H1 - Generally safe for people, vehicles and buildings
H2 - Unsafe for small vehicles
H3 - Unsafe for vehicles, children and the elderly
H4 - Unsafe for people and vehicles
H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure
H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure
0 50 100 200 300 400
Meters

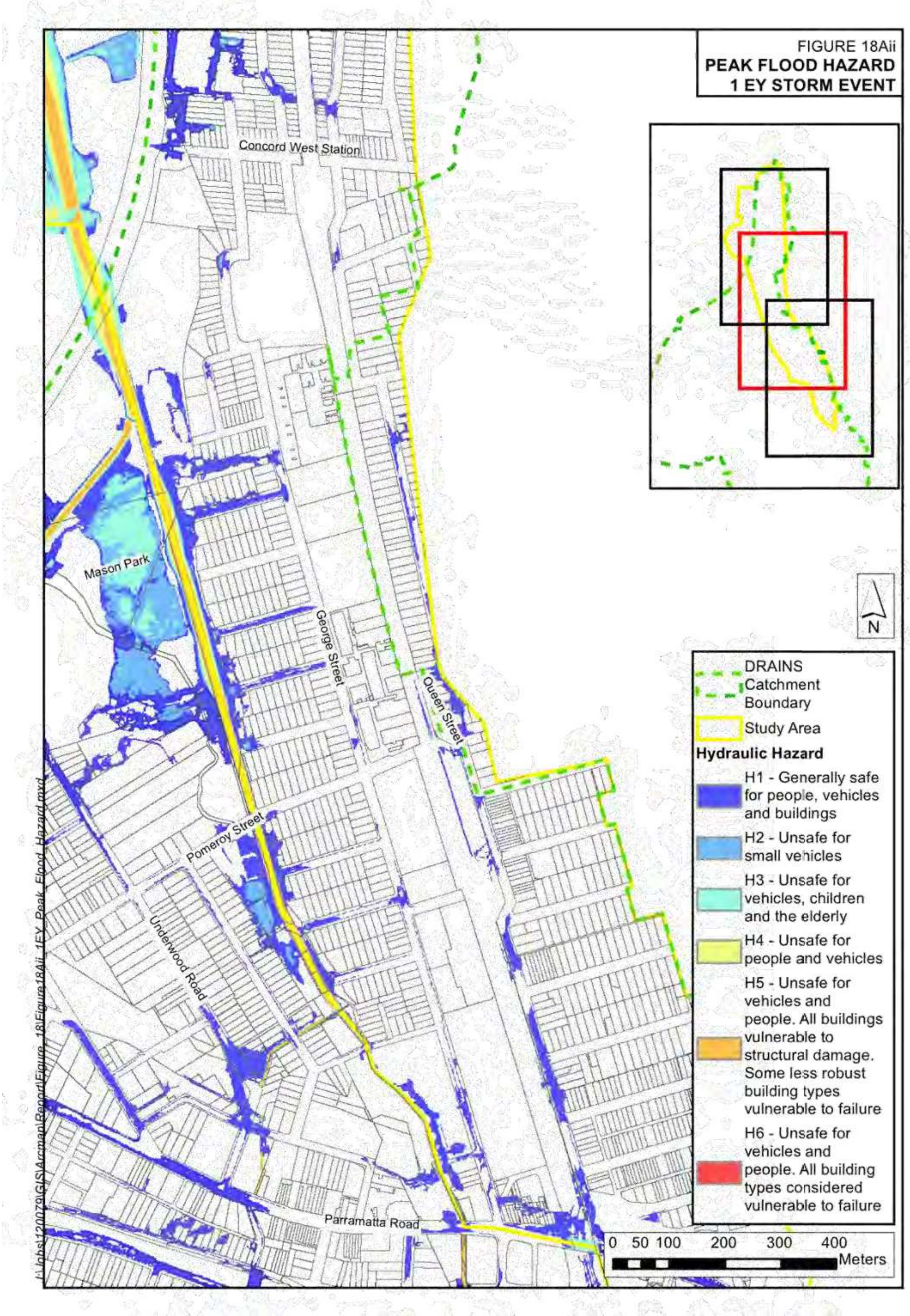


FIGURE 18Aii
PEAK FLOOD HAZARD
1 EY STORM EVENT
Concord West Station
Mason Park
George Street
Queen Street
Pomeroy Street
Underwood Road
Parramatta Road
N
DRAINS Catchment Boundary
Study Area
Hydraulic Hazard
H1 - Generally safe for people, vehicles and buildings
H2 - Unsafe for small vehicles
H3 - Unsafe for vehicles, children and the elderly
H4 - Unsafe for people and vehicles
H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure
H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure
0 50 100 200 300 400
Meters

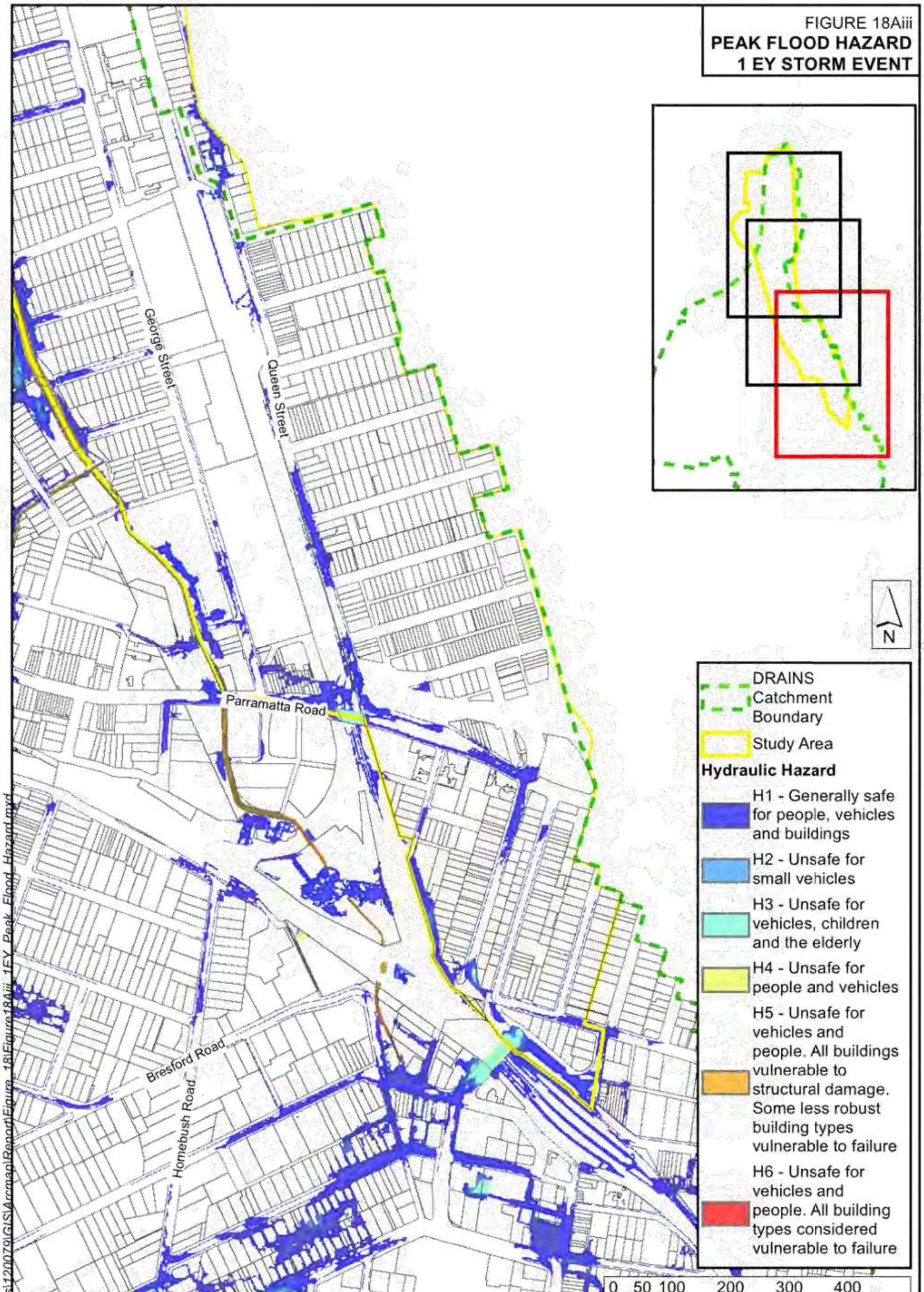


FIGURE 18Aiii
PEAK FLOOD HAZARD
1 EY STORM EVENT
George Street
Queen Street
Parramatta Road
Bresford Road
Homebush Road
N
DRAINS Catchment Boundary
Study Area
Hydraulic Hazard
H1 - Generally safe for people, vehicles and buildings
H2 - Unsafe for small vehicles
H3 - Unsafe for vehicles, children and the elderly
H4 - Unsafe for people and vehicles
H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure
H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure
0 50 100 200 300 400
Meters

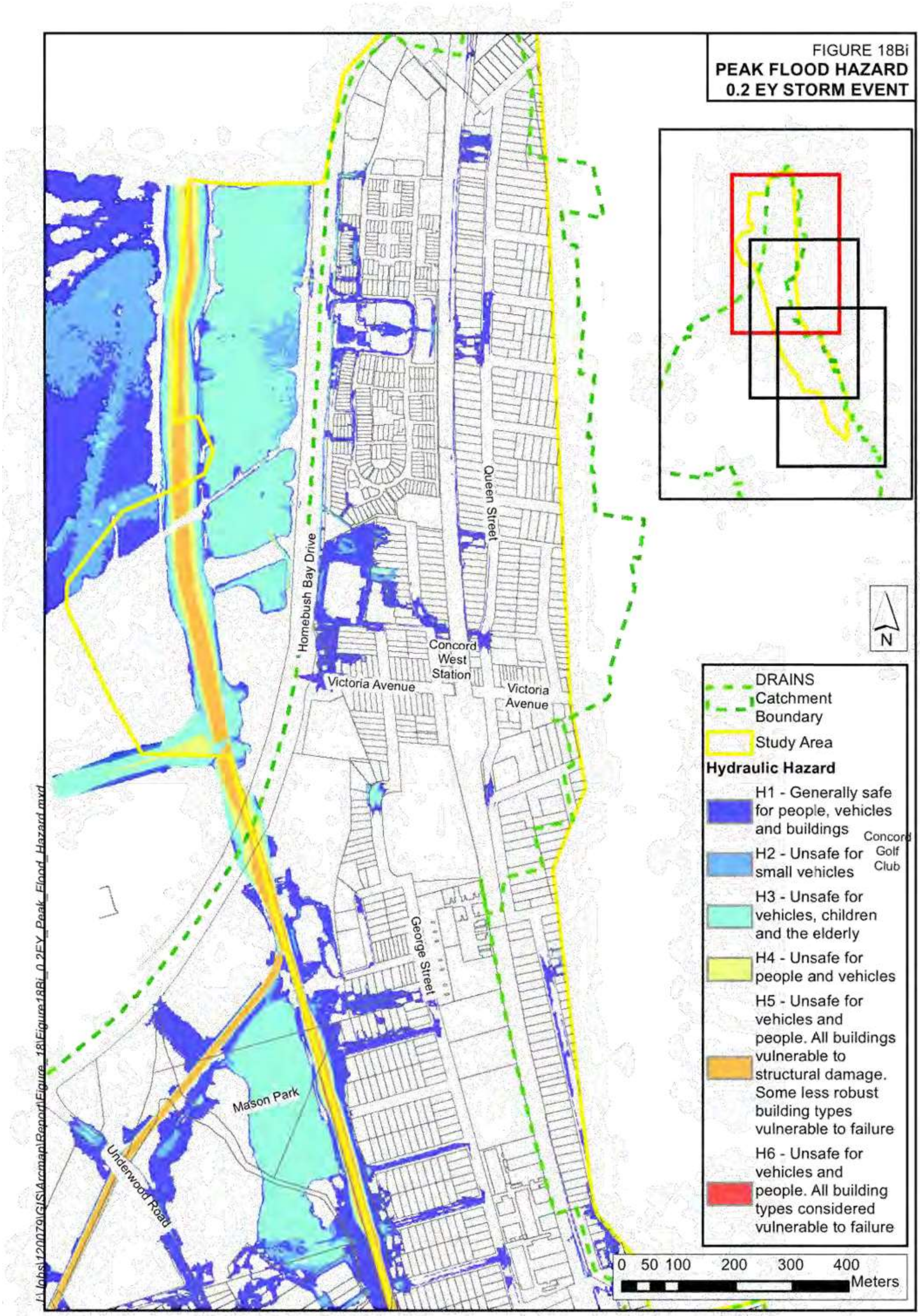


FIGURE 18Bi
PEAK FLOOD HAZARD
0.2 EY STORM EVENT
Queen Street
Homebush Bay Drive
Concord West Station
Victoria Avenue
Victoria Avenue
George Street
Mason Park
Underwood Road
Concord Golf Club
DRAINS Catchment Boundary
Study Area
Hydraulic Hazard
H1 - Generally safe for people, vehicles and buildings
H2 - Unsafe for small vehicles
H3 - Unsafe for vehicles, children and the elderly
H4 - Unsafe for people and vehicles
H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure
H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure
0 50 100 200 300 400
Meters
N

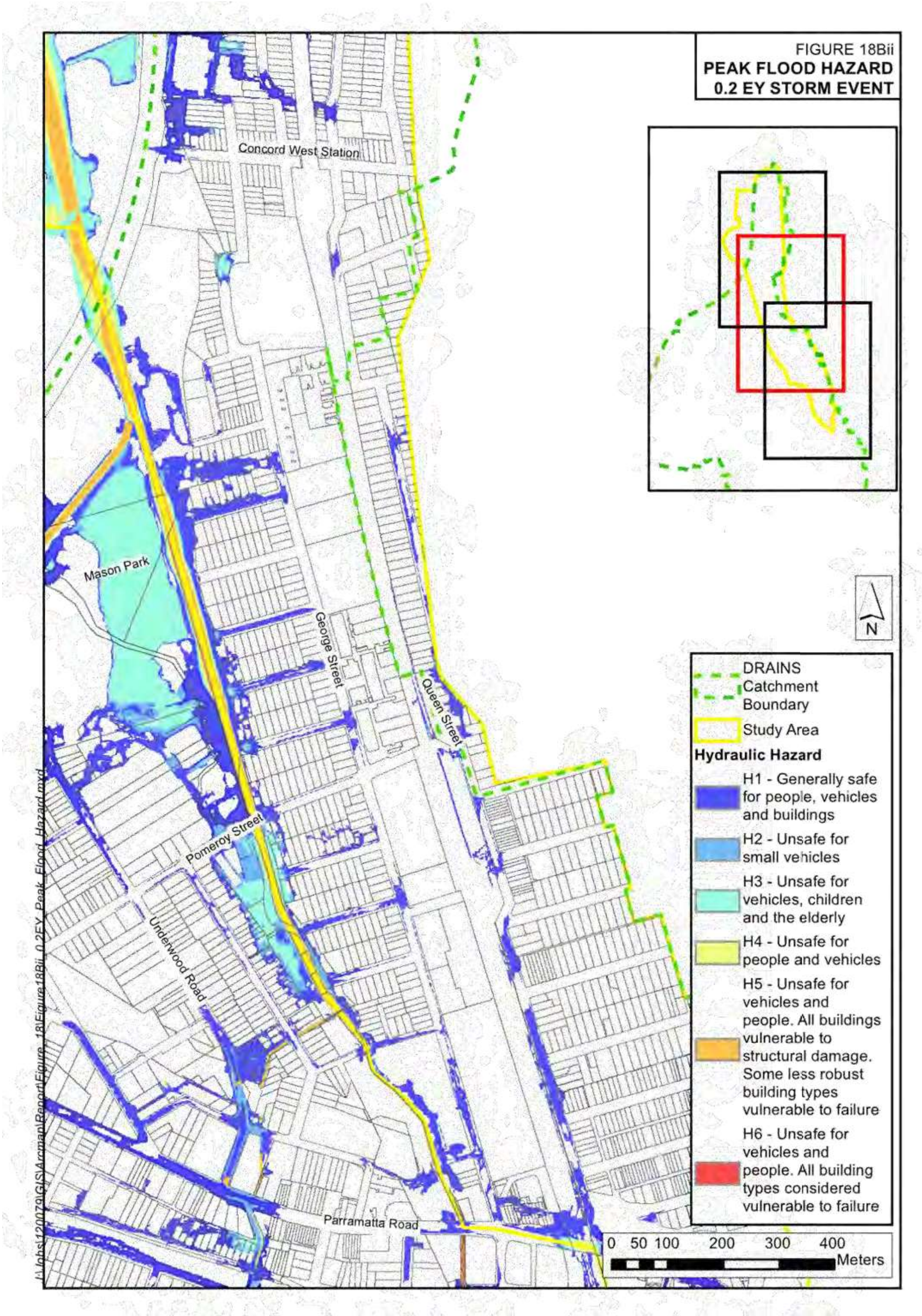


FIGURE 18Bii
PEAK FLOOD HAZARD
0.2 EY STORM EVENT
Concord West Station
Mason Park
George Street
Queen Street
Pomeroy Street
Underwood Road
Parramatta Road
N
DRAINS Catchment Boundary
Study Area
Hydraulic Hazard
H1 - Generally safe for people, vehicles and buildings
H2 - Unsafe for small vehicles
H3 - Unsafe for vehicles, children and the elderly
H4 - Unsafe for people and vehicles
H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure
H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure
0 50 100 200 300 400
Meters

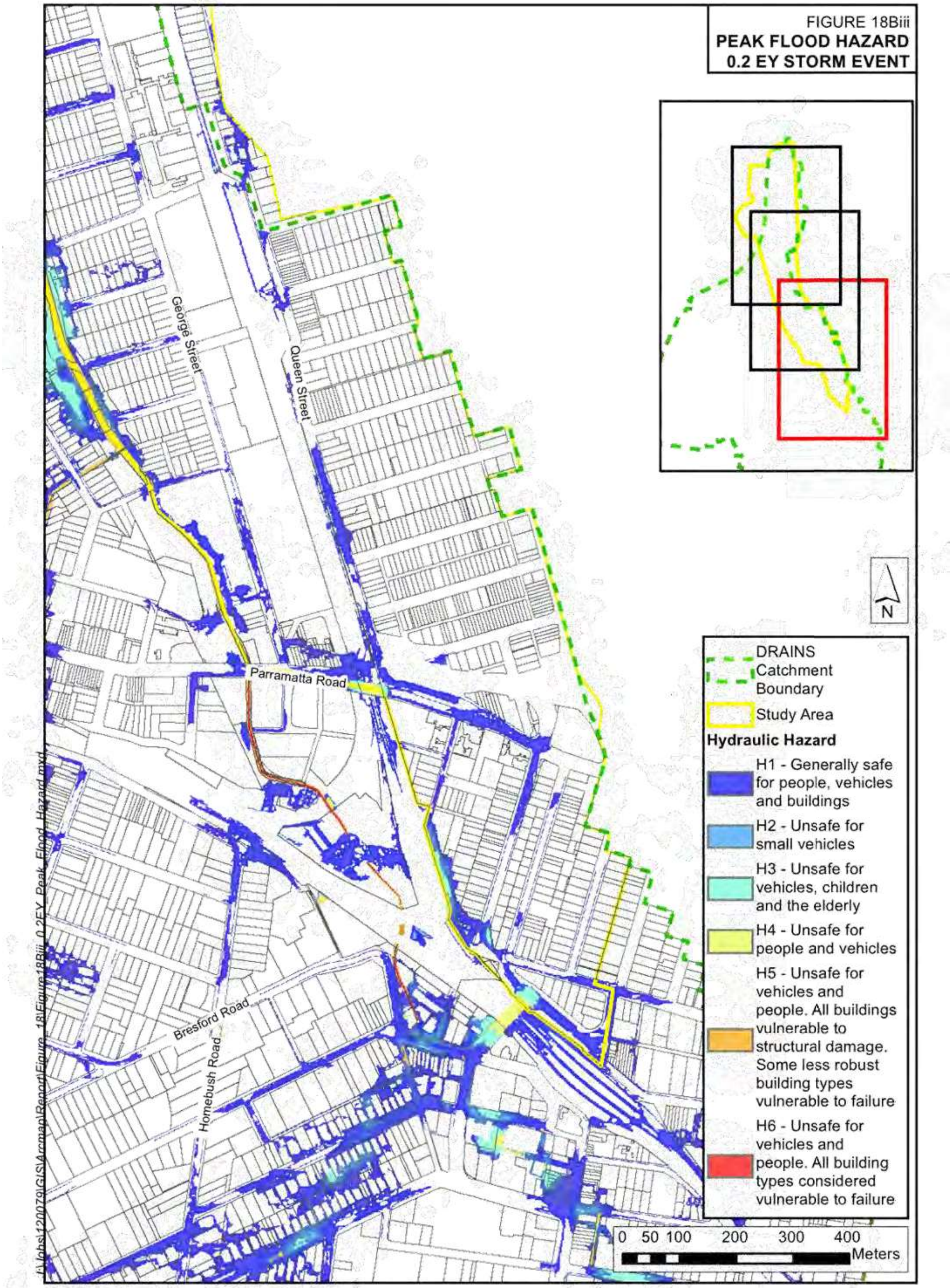


FIGURE 18Biii
PEAK FLOOD HAZARD
0.2 EY STORM EVENT
George Street
Queen Street
Parramatta Road
Bresford Road
Homebush Road
N
DRAINS Catchment Boundary
Study Area
Hydraulic Hazard
H1 - Generally safe for people, vehicles and buildings
H2 - Unsafe for small vehicles
H3 - Unsafe for vehicles, children and the elderly
H4 - Unsafe for people and vehicles
H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure
H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure
0 50 100 200 300 400
Meters

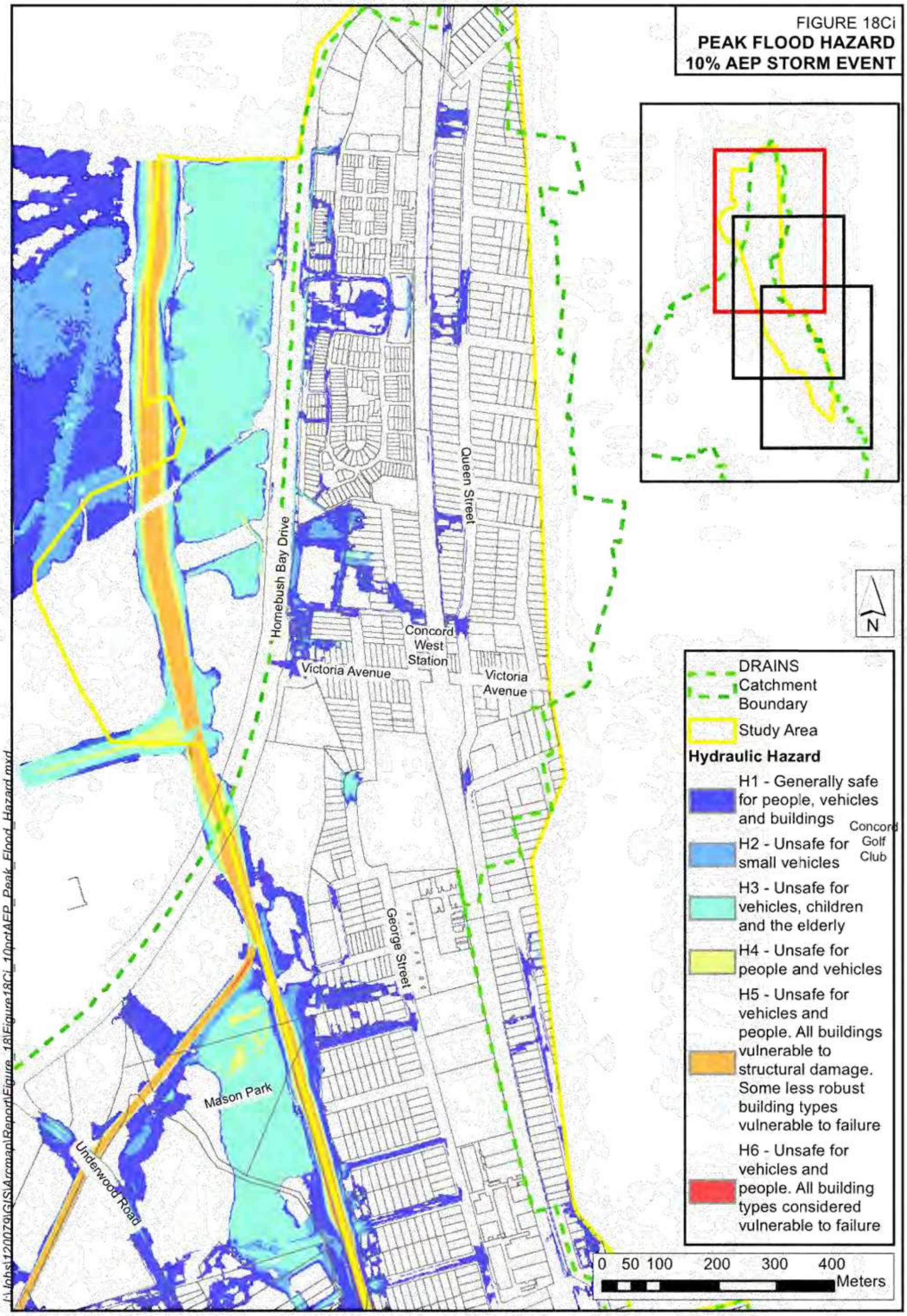


FIGURE 18Ci
PEAK FLOOD HAZARD
10% AEP STORM EVENT
Homebush Bay Drive
Queen Street
Concord West Station
Victoria Avenue
Victoria Avenue
George Street
Mason Park
Underwood Road
Concord Golf Club
N
DRAINS Catchment Boundary
Study Area
Hydraulic Hazard
H1 - Generally safe for people, vehicles and buildings
H2 - Unsafe for small vehicles
H3 - Unsafe for vehicles, children and the elderly
H4 - Unsafe for people and vehicles
H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure
H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure
0 50 100 200 300 400
Meters

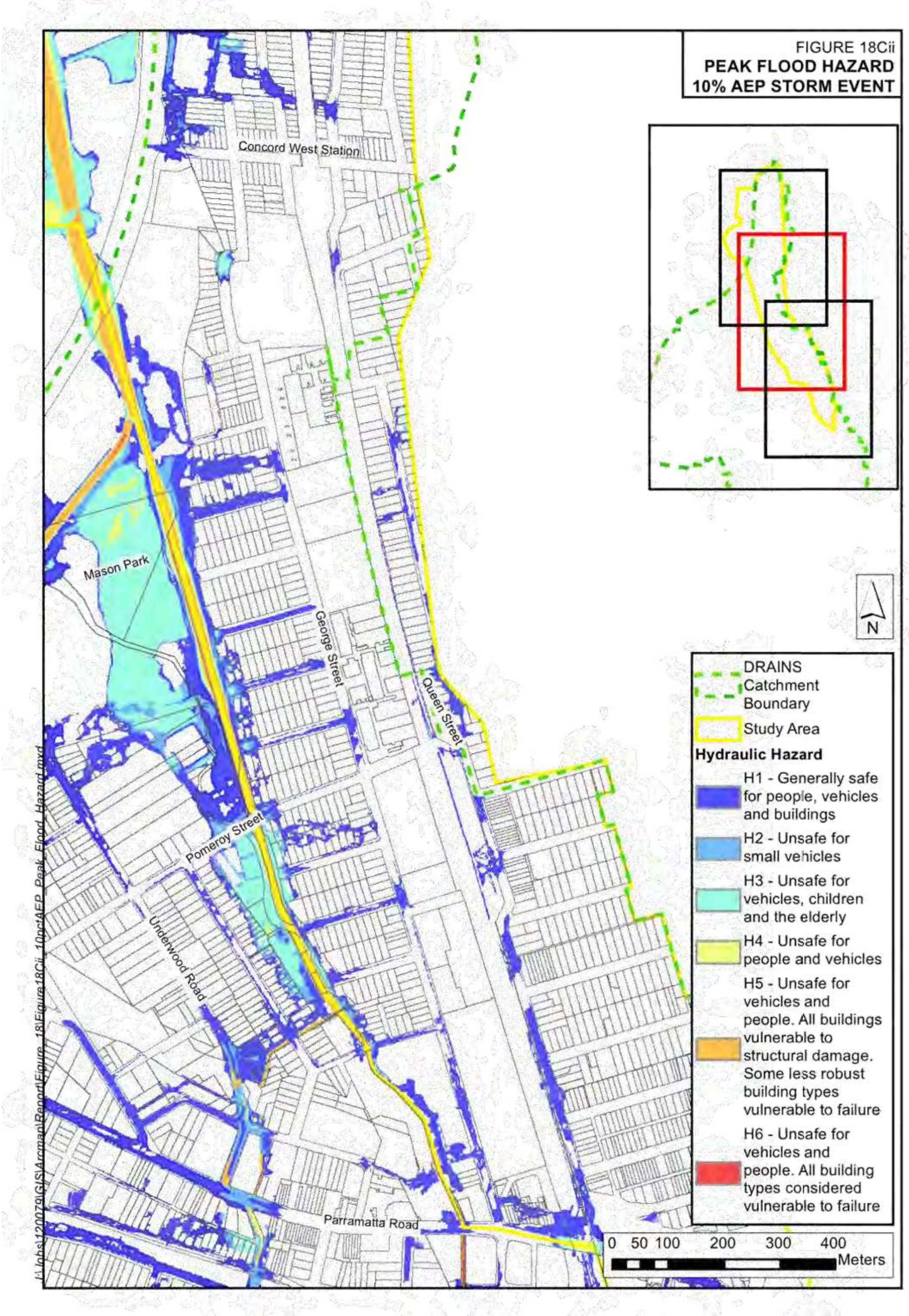


FIGURE 18Cii
PEAK FLOOD HAZARD
10% AEP STORM EVENT
Concord West Station
Mason Park
George Street
Queen Street
Pomeroy Street
Underwood Road
Parramatta Road
N
DRAINS Catchment Boundary
Study Area
Hydraulic Hazard
H1 - Generally safe for people, vehicles and buildings
H2 - Unsafe for small vehicles
H3 - Unsafe for vehicles, children and the elderly
H4 - Unsafe for people and vehicles
H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure
H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure
0 50 100 200 300 400
Meters

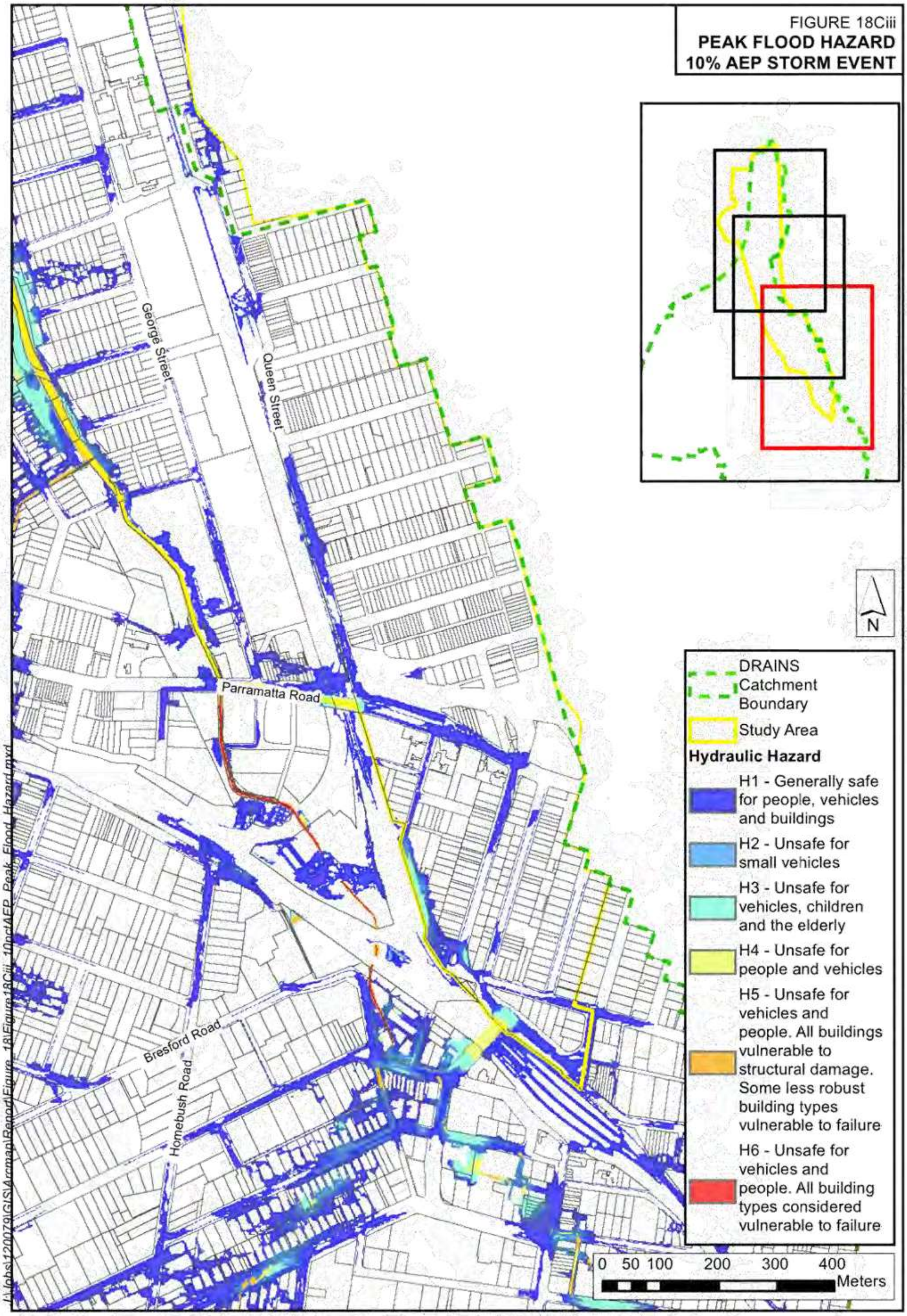


FIGURE 18Ciii
PEAK FLOOD HAZARD
10% AEP STORM EVENT
George Street
Queen Street
Parramatta Road
Bresford Road
Homebush Road
N
DRAINS Catchment Boundary
Study Area
Hydraulic Hazard
H1 - Generally safe for people, vehicles and buildings
H2 - Unsafe for small vehicles
H3 - Unsafe for vehicles, children and the elderly
H4 - Unsafe for people and vehicles
H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure
H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure
0 50 100 200 300 400
Meters

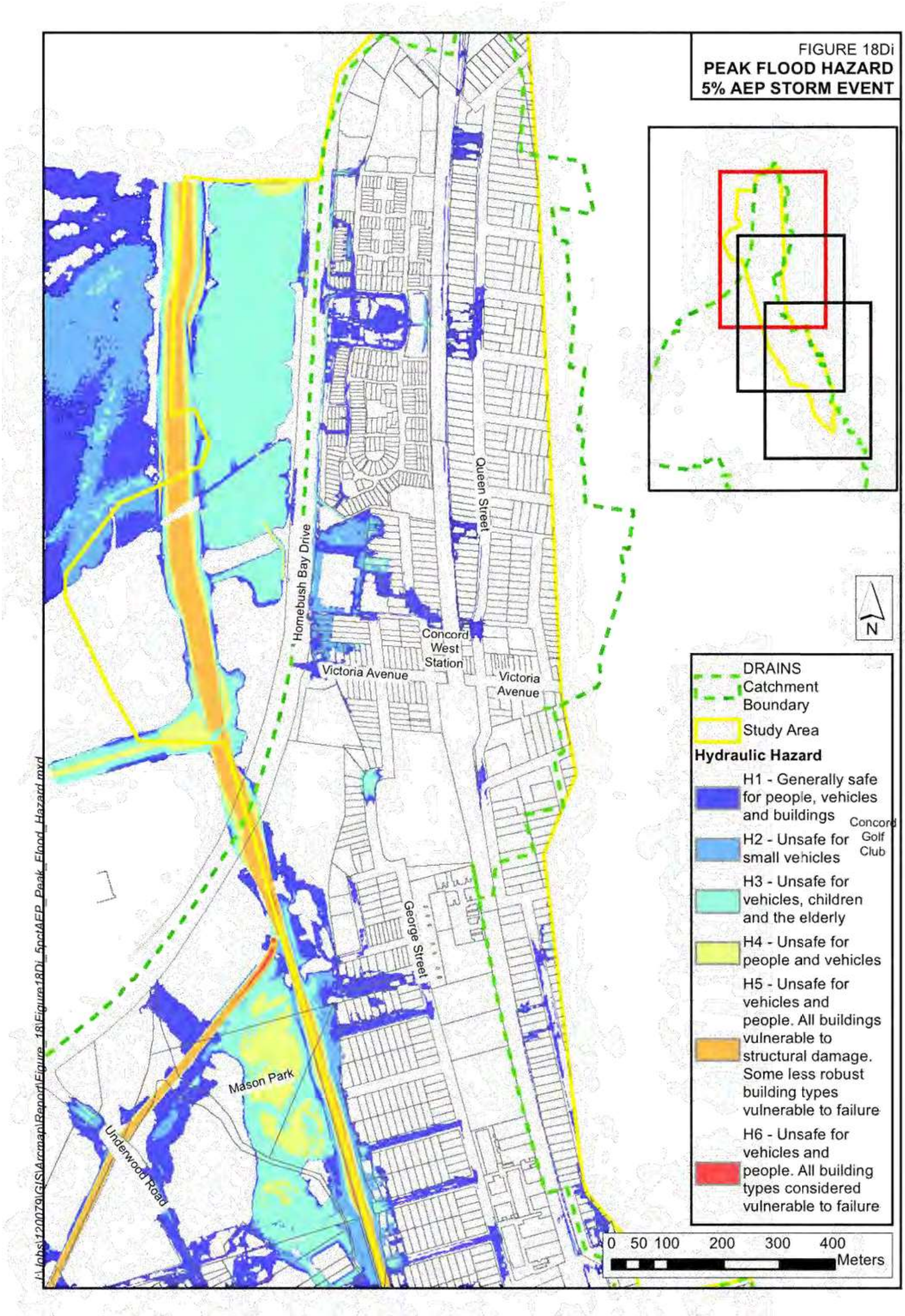


FIGURE 18Di
PEAK FLOOD HAZARD
5% AEP STORM EVENT
Homebush Bay Drive
Queen Street
Concord West Station
Victoria Avenue
Victoria Avenue
George Street
Mason Park
Underwood Road
Concord Golf Club
DRAINS Catchment Boundary
Study Area
Hydraulic Hazard
H1 - Generally safe for people, vehicles and buildings
H2 - Unsafe for small vehicles
H3 - Unsafe for vehicles, children and the elderly
H4 - Unsafe for people and vehicles
H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure
H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure
0 50 100 200 300 400
Meters
N

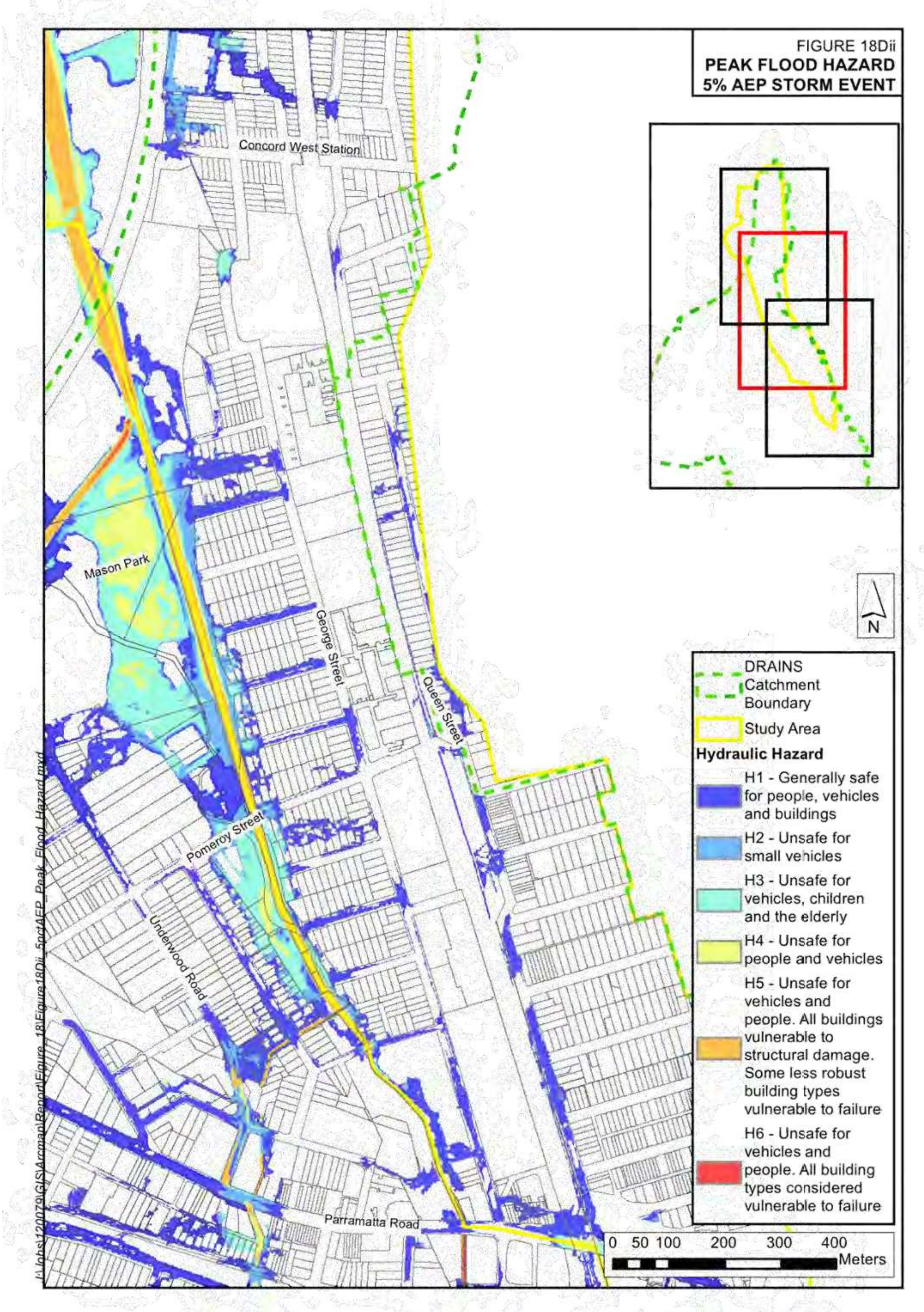


FIGURE 18Dii
PEAK FLOOD HAZARD
5% AEP STORM EVENT
Concord West Station
Mason Park
George Street
Queen Street
Pomeroy Street
Underwood Road
Parramatta Road
N
DRAINS Catchment Boundary
Study Area
Hydraulic Hazard
H1 - Generally safe for people, vehicles and buildings
H2 - Unsafe for small vehicles
H3 - Unsafe for vehicles, children and the elderly
H4 - Unsafe for people and vehicles
H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure
H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure
0 50 100 200 300 400
Meters

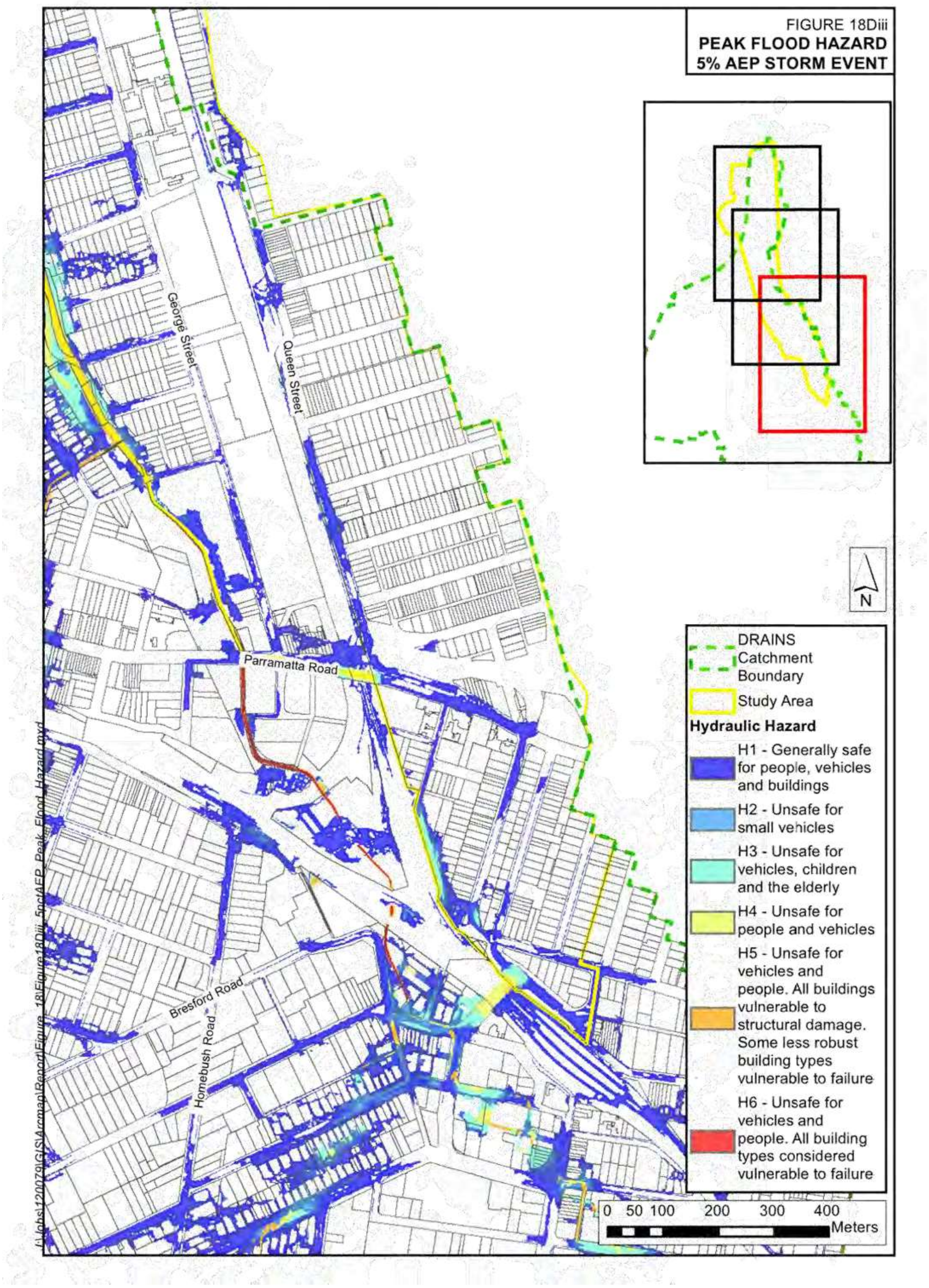


FIGURE 18Diii
PEAK FLOOD HAZARD
5% AEP STORM EVENT
George Street
Queen Street
Parramatta Road
Bresford Road
Homebush Road
N
DRAINS Catchment Boundary
Study Area
Hydraulic Hazard
H1 - Generally safe for people, vehicles and buildings
H2 - Unsafe for small vehicles
H3 - Unsafe for vehicles, children and the elderly
H4 - Unsafe for people and vehicles
H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure
H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure
0 50 100 200 300 400
Meters

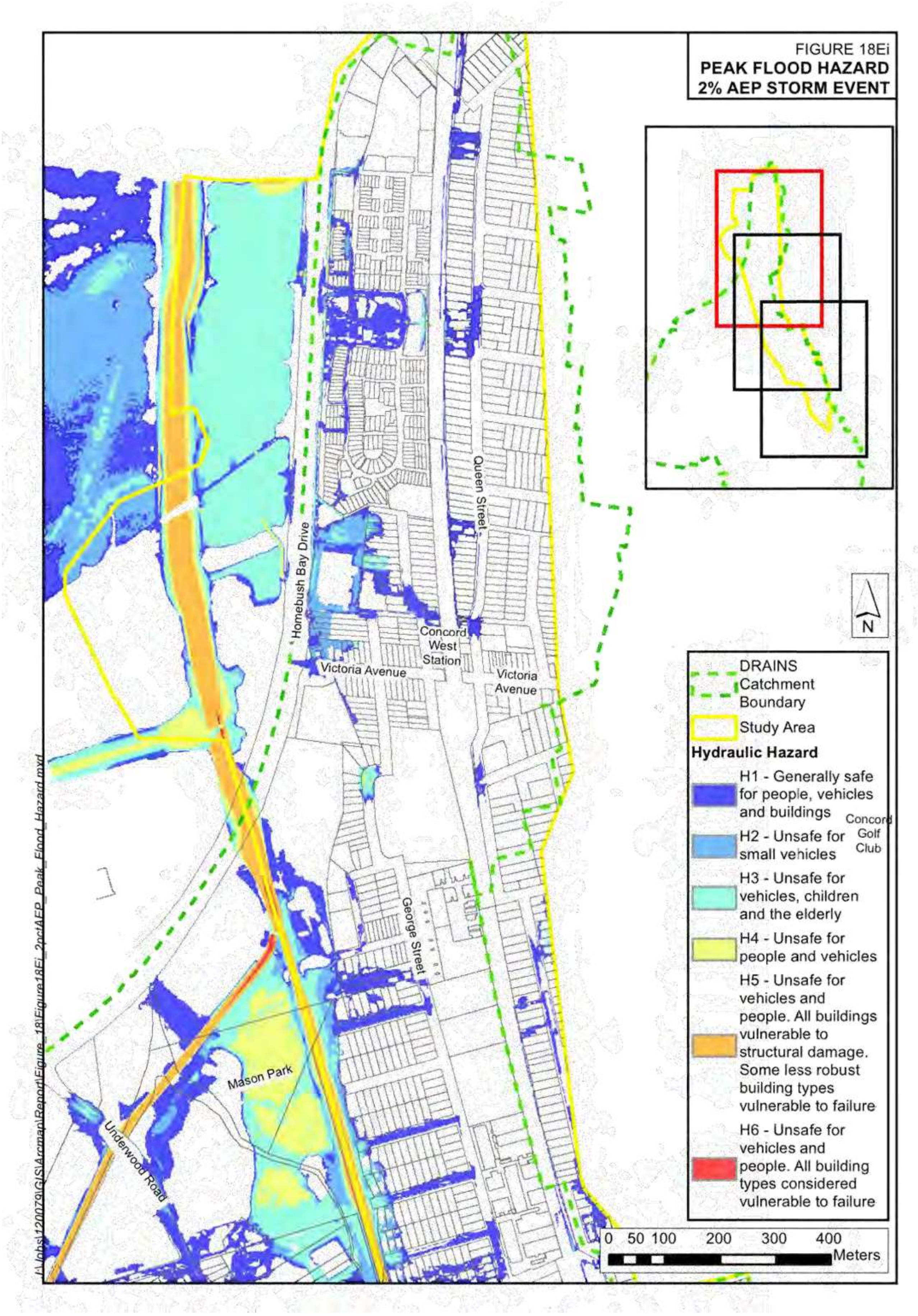


FIGURE 18Ei
PEAK FLOOD HAZARD
2% AEP STORM EVENT
Homebush Bay Drive
Queen Street
Concord West Station
Victoria Avenue
Victoria Avenue
George Street
Mason Park
Underwood Road
Concord Golf Club
N
DRAINS Catchment Boundary
Study Area
Hydraulic Hazard
H1 - Generally safe for people, vehicles and buildings
H2 - Unsafe for small vehicles
H3 - Unsafe for vehicles, children and the elderly
H4 - Unsafe for people and vehicles
H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure
H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure
0 50 100 200 300 400
Meters

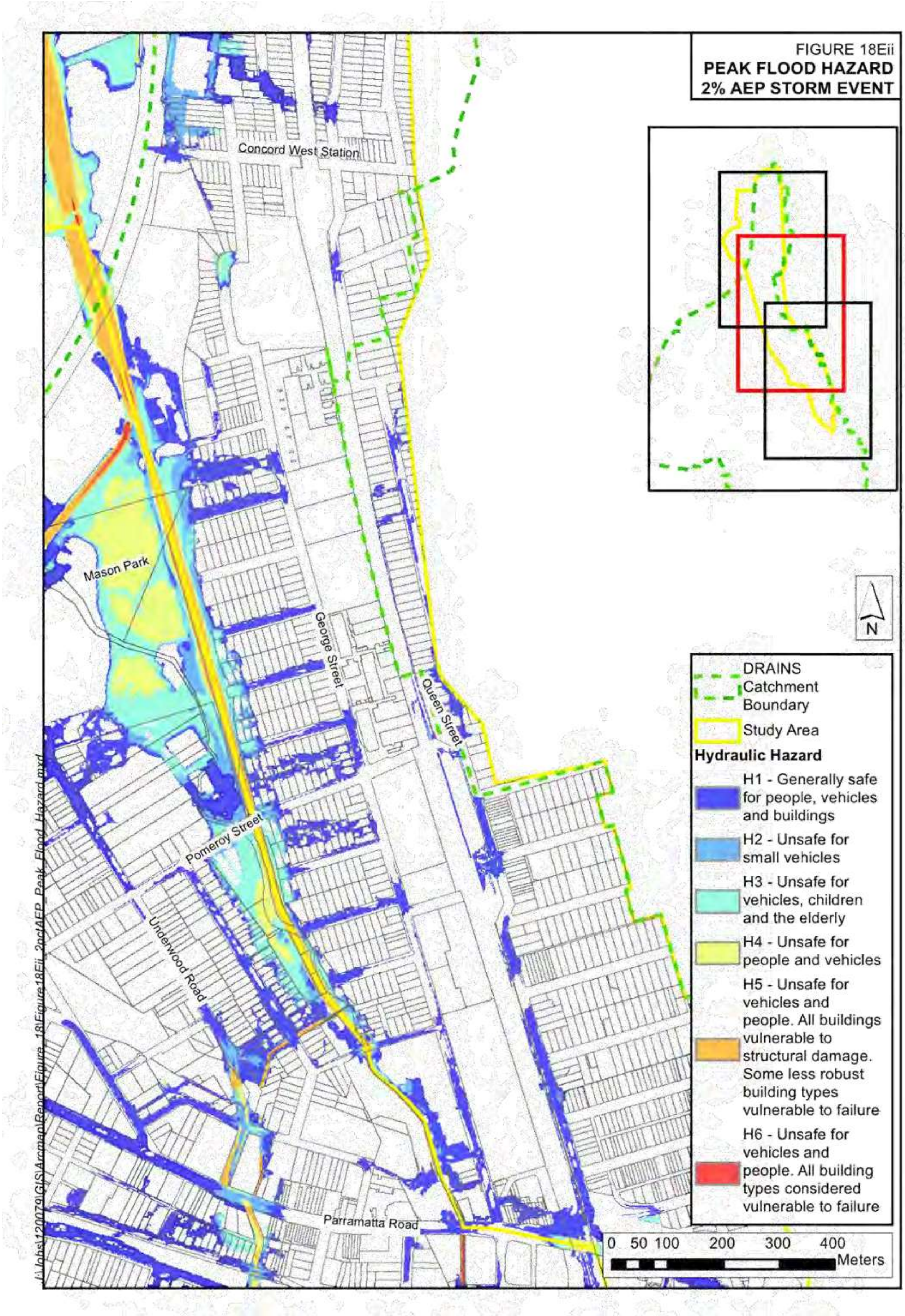


FIGURE 18Eii
PEAK FLOOD HAZARD
2% AEP STORM EVENT
Concord West Station
Mason Park
George Street
Queen Street
Pomeroy Street
Underwood Road
Parramatta Road
N
DRAINS Catchment Boundary
Study Area
Hydraulic Hazard
H1 - Generally safe for people, vehicles and buildings
H2 - Unsafe for small vehicles
H3 - Unsafe for vehicles, children and the elderly
H4 - Unsafe for people and vehicles
H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure
H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure
0 50 100 200 300 400
Meters

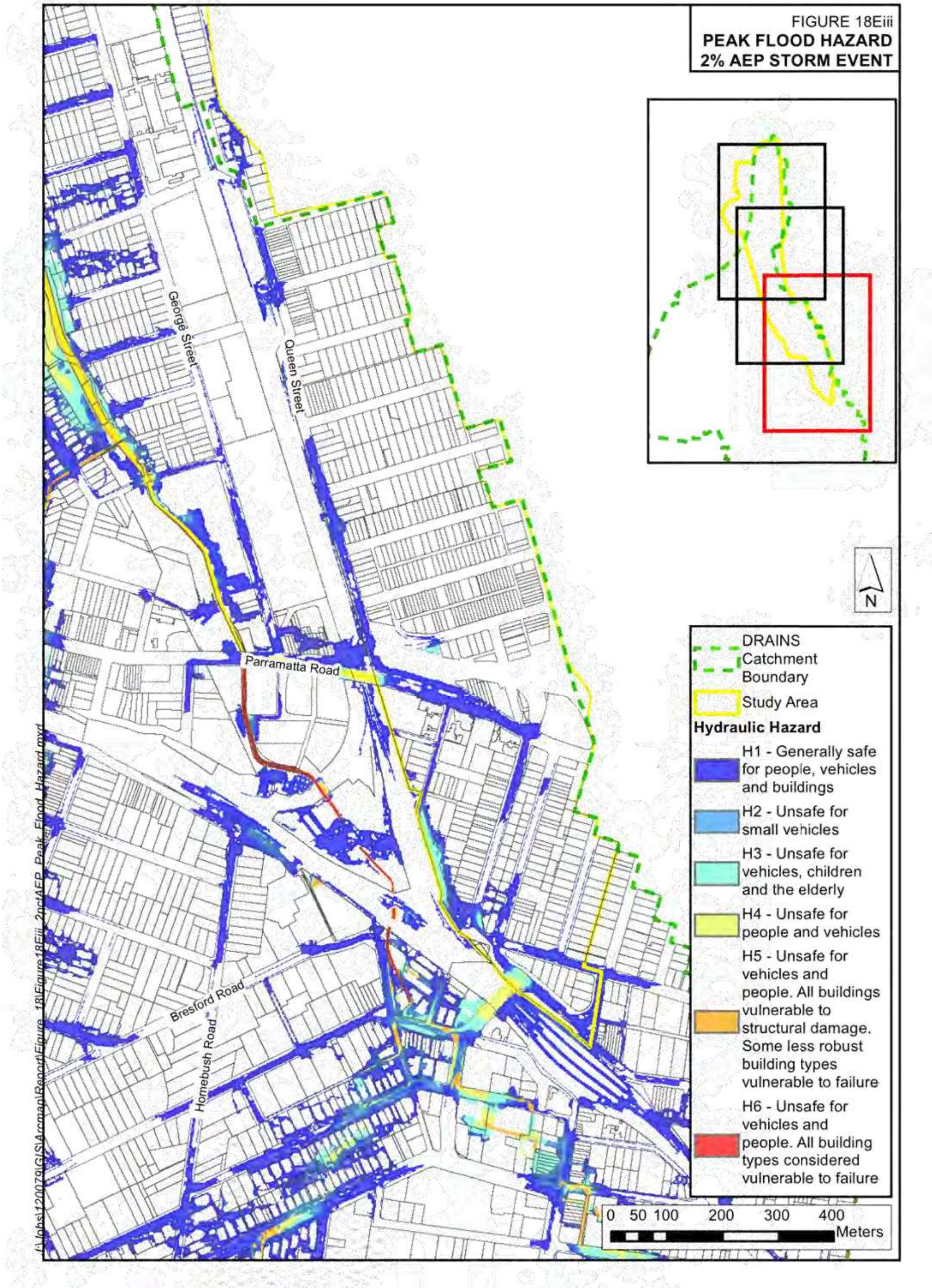


FIGURE 18Eiii
PEAK FLOOD HAZARD
2% AEP STORM EVENT
George Street
Queen Street
Parramatta Road
Bresford Road
Homebush Road
N
DRAINS Catchment Boundary
Study Area
Hydraulic Hazard
H1 - Generally safe for people, vehicles and buildings
H2 - Unsafe for small vehicles
H3 - Unsafe for vehicles, children and the elderly
H4 - Unsafe for people and vehicles
H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure
H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure
0 50 100 200 300 400
Meters

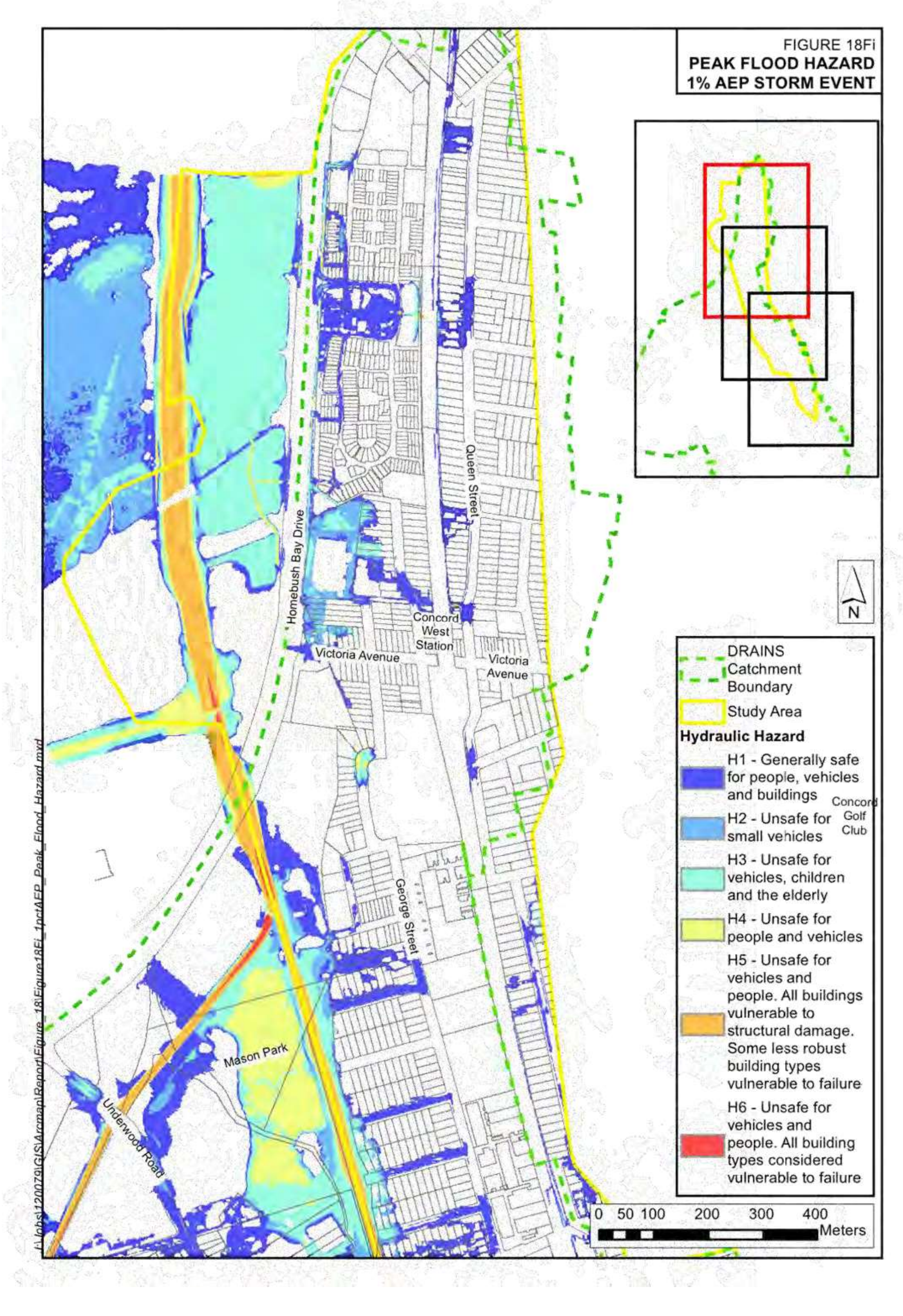


FIGURE 18Fi
PEAK FLOOD HAZARD
1% AEP STORM EVENT
Homebush Bay Drive
Queen Street
Concord West Station
Victoria Avenue
Victoria Avenue
George Street
Mason Park
Underwood Road
Concord Golf Club
N
DRAINS Catchment Boundary
Study Area
Hydraulic Hazard
H1 - Generally safe for people, vehicles and buildings
H2 - Unsafe for small vehicles
H3 - Unsafe for vehicles, children and the elderly
H4 - Unsafe for people and vehicles
H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure
H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure
0 50 100 200 300 400
Meters

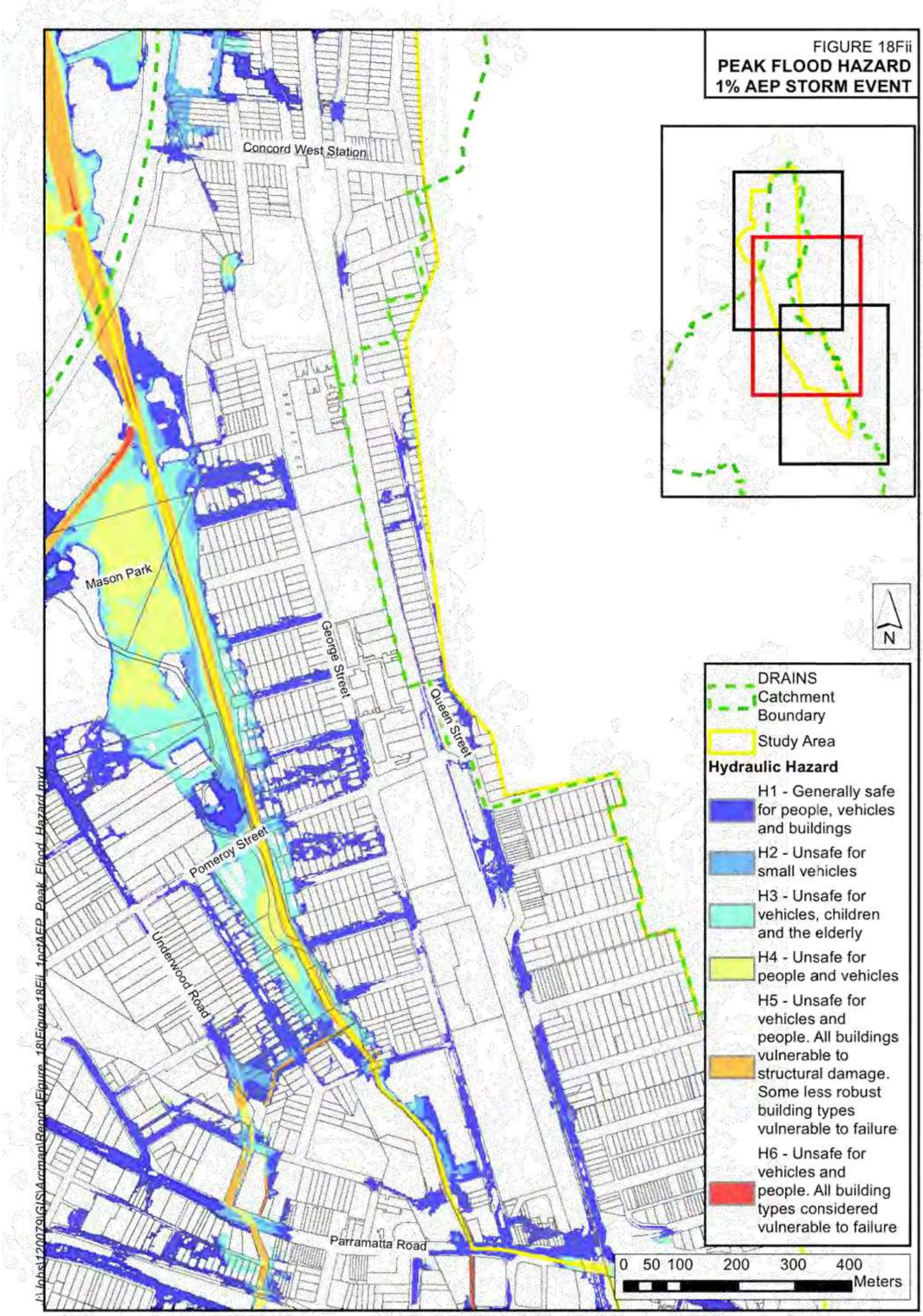


FIGURE 18Fii
PEAK FLOOD HAZARD
1% AEP STORM EVENT
Concord West Station
Mason Park
George Street
Queen Street
Pomeroy Street
Underwood Road
Parramatta Road
N
DRAINS Catchment Boundary
Study Area
Hydraulic Hazard
H1 - Generally safe for people, vehicles and buildings
H2 - Unsafe for small vehicles
H3 - Unsafe for vehicles, children and the elderly
H4 - Unsafe for people and vehicles
H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure
H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure
0 50 100 200 300 400
Meters

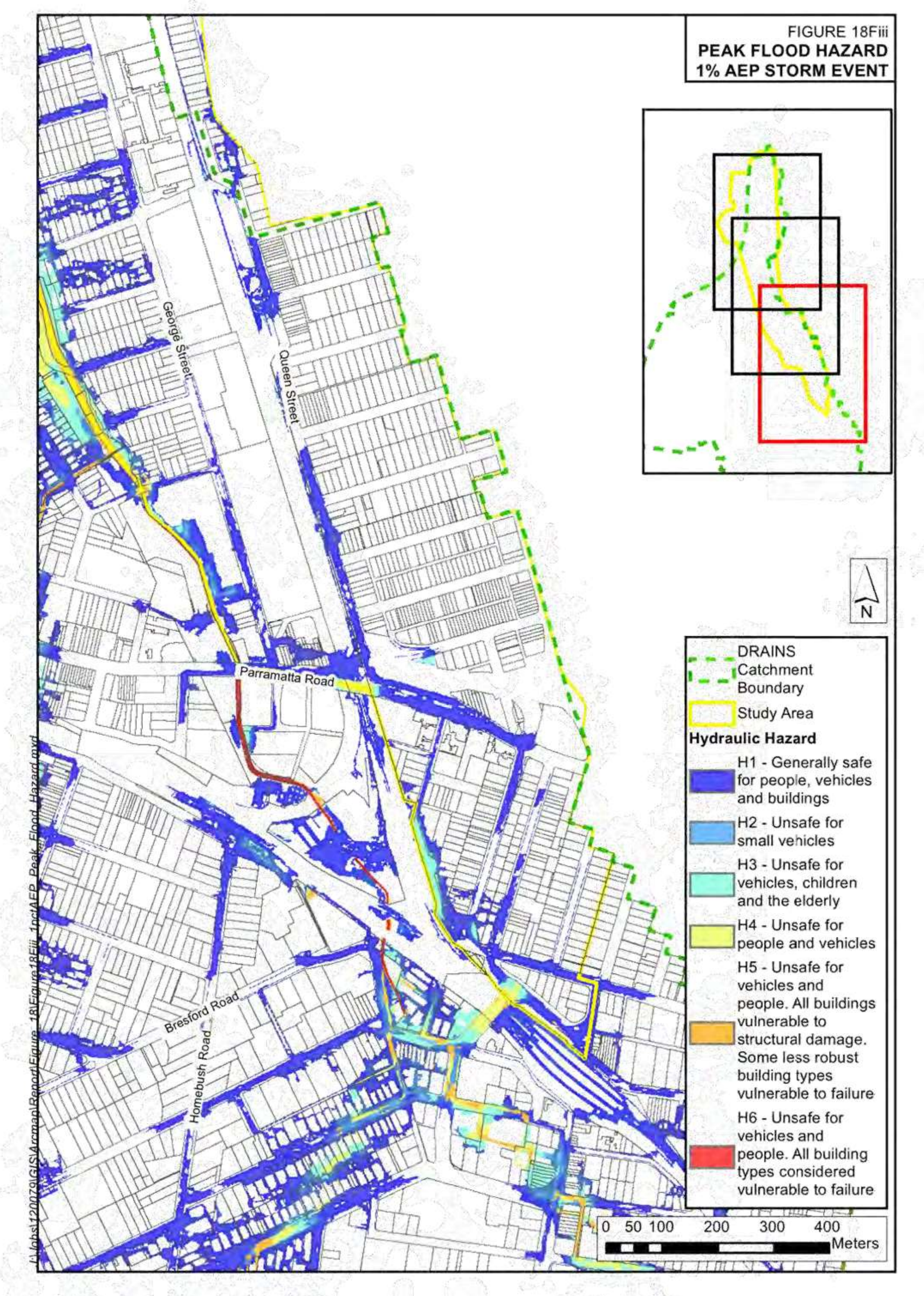


FIGURE 18Fiii
PEAK FLOOD HAZARD
1% AEP STORM EVENT
George Street
Queen Street
Parramatta Road
Bresford Road
Homebush Road
N
DRAINS Catchment Boundary
Study Area
Hydraulic Hazard
H1 - Generally safe for people, vehicles and buildings
H2 - Unsafe for small vehicles
H3 - Unsafe for vehicles, children and the elderly
H4 - Unsafe for people and vehicles
H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure
H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure
0 50 100 200 300 400
Meters

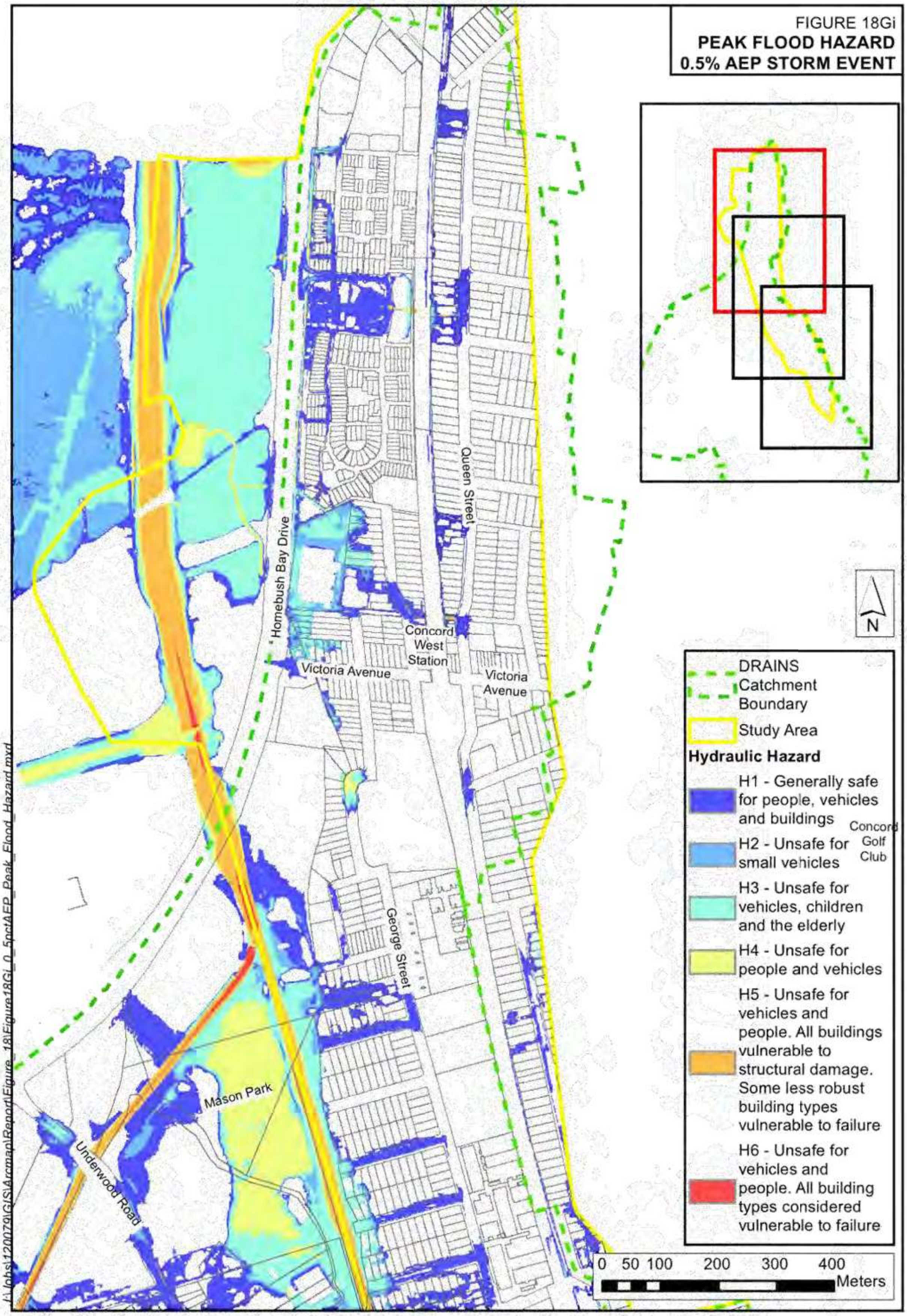


FIGURE 18Gi
PEAK FLOOD HAZARD
0.5% AEP STORM EVENT
Homebush Bay Drive
Queen Street
Concord West Station
Victoria Avenue
Victoria Avenue
George Street
Mason Park
Underwood Road
Concord Golf Club
N
DRAINS Catchment Boundary
Study Area
Hydraulic Hazard
H1 - Generally safe for people, vehicles and buildings
H2 - Unsafe for small vehicles
H3 - Unsafe for vehicles, children and the elderly
H4 - Unsafe for people and vehicles
H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure
H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure
0 50 100 200 300 400
Meters

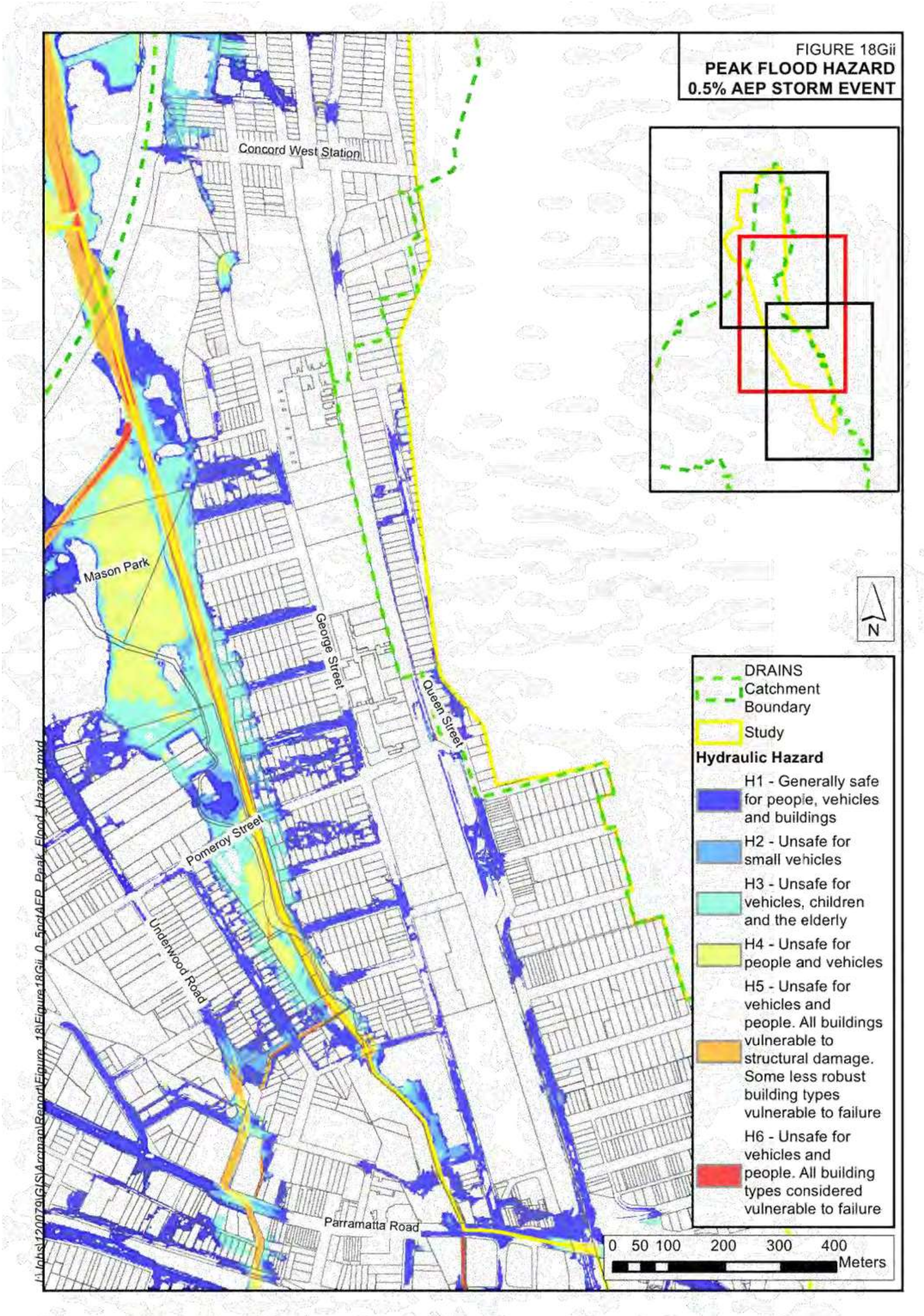


FIGURE 18Gii
PEAK FLOOD HAZARD
0.5% AEP STORM EVENT
Concord West Station
Mason Park
George Street
Queen Street
Pomeroy Street
Underwood Road
Parramatta Road
DRAINS Catchment Boundary
Study
Hydraulic Hazard
H1 - Generally safe for people, vehicles and buildings
H2 - Unsafe for small vehicles
H3 - Unsafe for vehicles, children and the elderly
H4 - Unsafe for people and vehicles
H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure
H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure
0 50 100 200 300 400
Meters
N

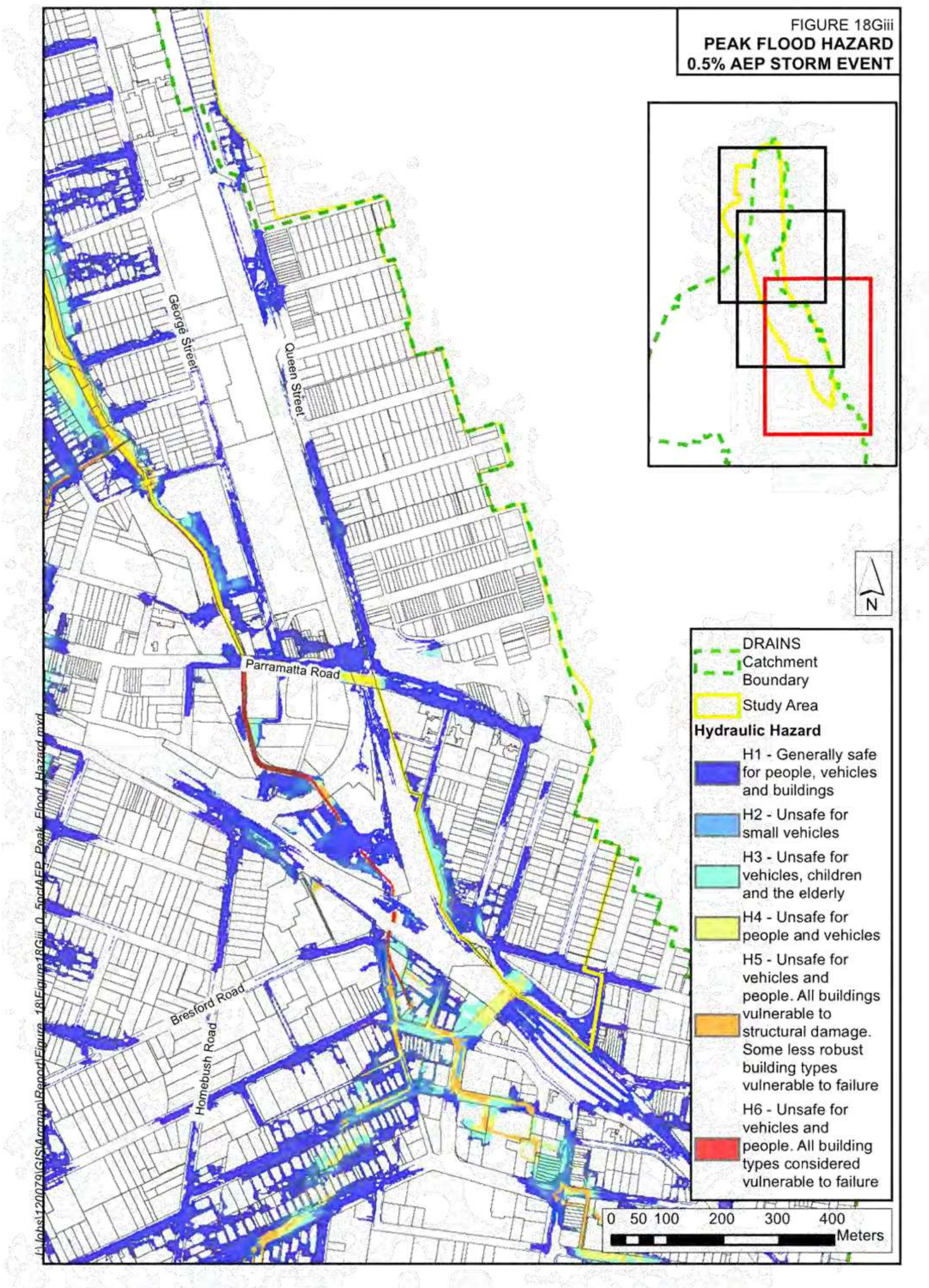


FIGURE 18Giii
PEAK FLOOD HAZARD
0.5% AEP STORM EVENT
George Street
Queen Street
Parramatta Road
Bresford Road
Homebush Road
N
DRAINS Catchment Boundary
Study Area
Hydraulic Hazard
H1 - Generally safe for people, vehicles and buildings
H2 - Unsafe for small vehicles
H3 - Unsafe for vehicles, children and the elderly
H4 - Unsafe for people and vehicles
H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure
H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure
0 50 100 200 300 400
Meters

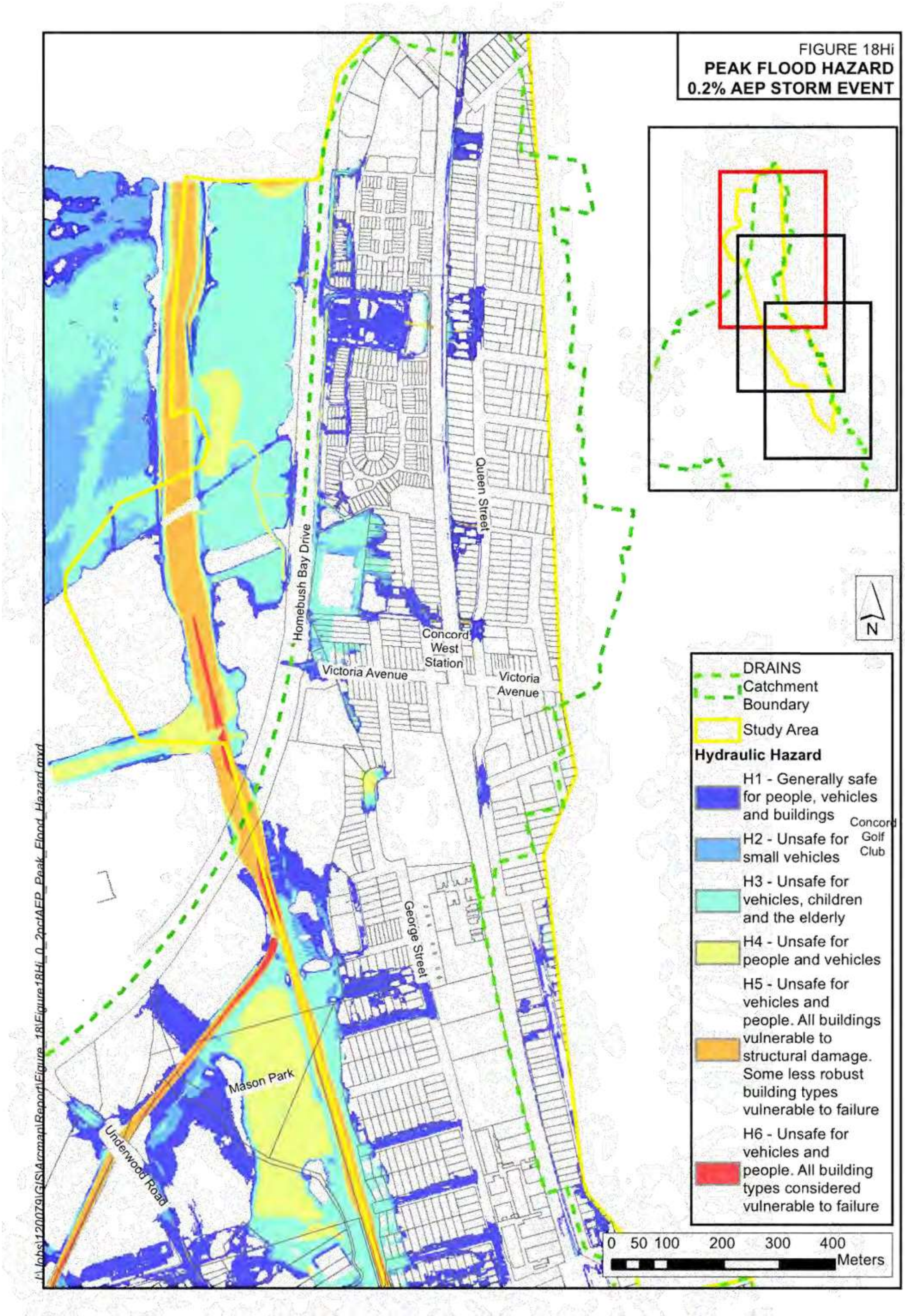


FIGURE 18Hi
PEAK FLOOD HAZARD
0.2% AEP STORM EVENT
Homebush Bay Drive
Queen Street
Concord West Station
Victoria Avenue
Victoria Avenue
George Street
Mason Park
Underwood Road
Concord Golf Club
DRAINS Catchment Boundary
Study Area
Hydraulic Hazard
H1 - Generally safe for people, vehicles and buildings
H2 - Unsafe for small vehicles
H3 - Unsafe for vehicles, children and the elderly
H4 - Unsafe for people and vehicles
H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure
H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure
0 50 100 200 300 400
Meters
N

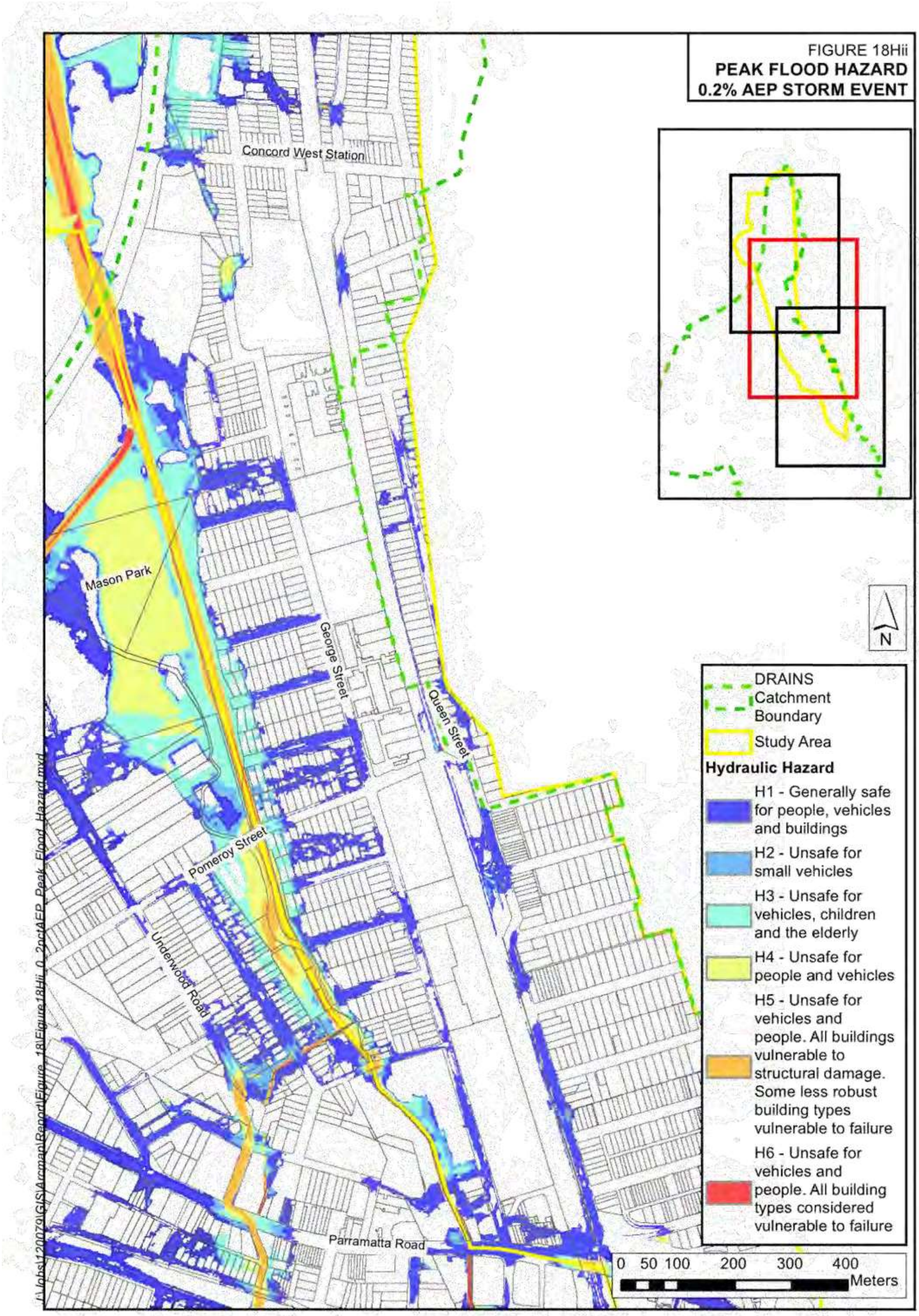


FIGURE 18Hii
PEAK FLOOD HAZARD
0.2% AEP STORM EVENT
Concord West Station
Mason Park
George Street
Queen Street
Pomeroy Street
Underwood Road
Parramatta Road
N
DRAINS Catchment Boundary
Study Area
Hydraulic Hazard
H1 - Generally safe for people, vehicles and buildings
H2 - Unsafe for small vehicles
H3 - Unsafe for vehicles, children and the elderly
H4 - Unsafe for people and vehicles
H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure
H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure
0 50 100 200 300 400
Meters

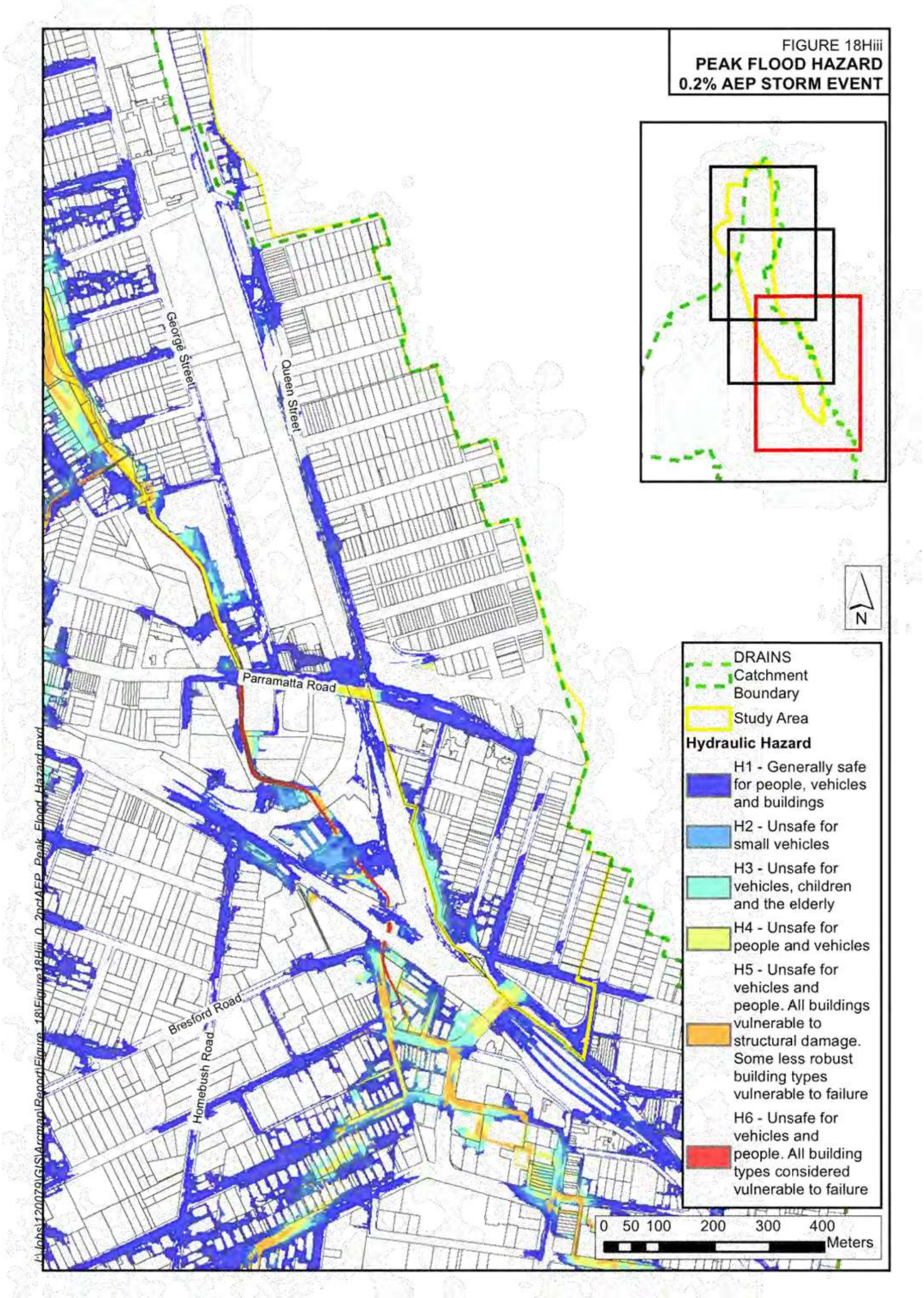


FIGURE 18Hiii
PEAK FLOOD HAZARD
0.2% AEP STORM EVENT
George Street
Queen Street
Parramatta Road
Bresford Road
Homebush Road
N
DRAINS Catchment Boundary
Study Area
Hydraulic Hazard
H1 - Generally safe for people, vehicles and buildings
H2 - Unsafe for small vehicles
H3 - Unsafe for vehicles, children and the elderly
H4 - Unsafe for people and vehicles
H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure
H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure
0 50 100 200 300 400
Meters

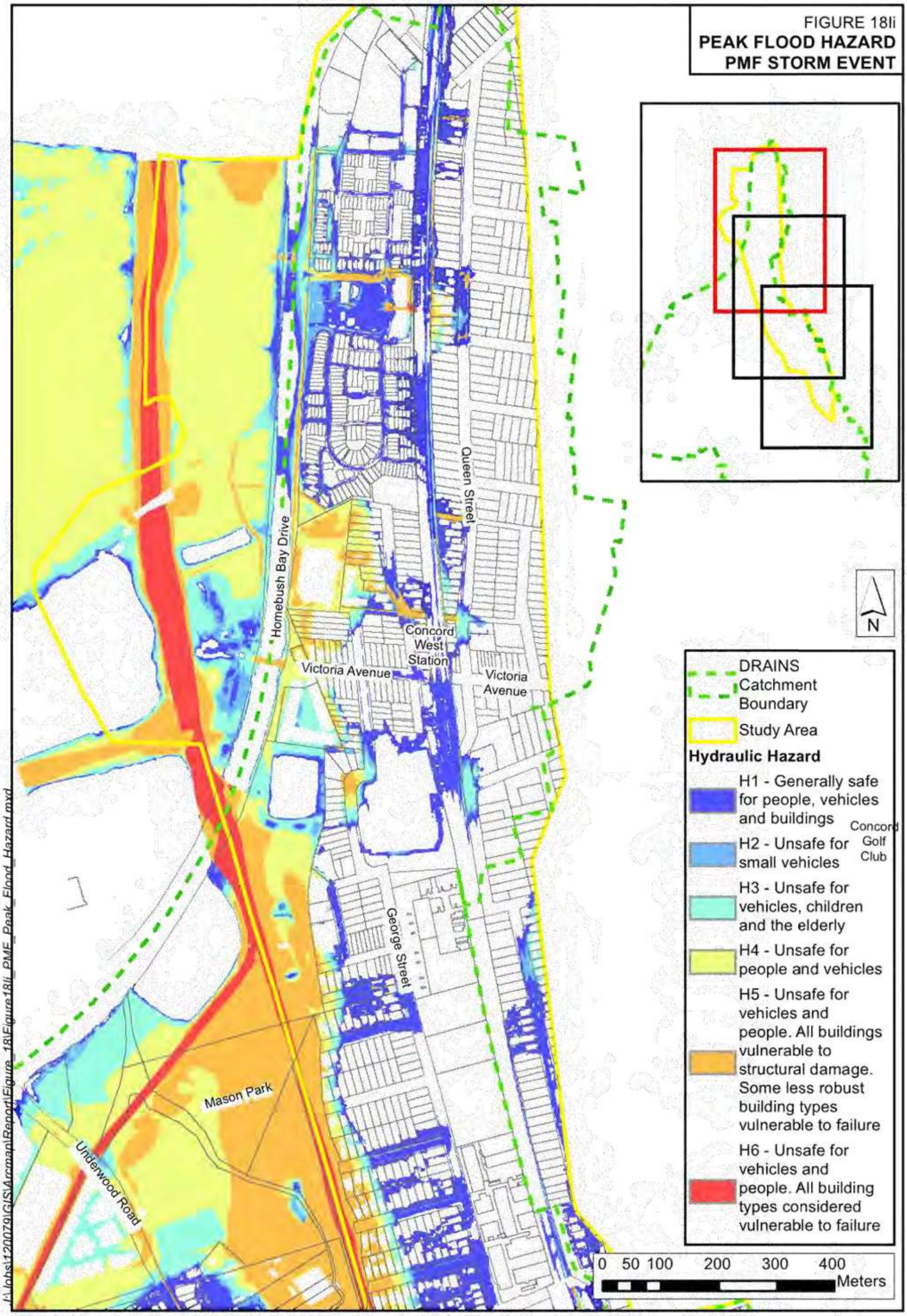


FIGURE 18Ii
PEAK FLOOD HAZARD
PMF STORM EVENT
Queen Street
Homebush Bay Drive
Concord
West
Station
Victoria Avenue
Victoria
Avenue
George Street
Mason Park
Underwood Road
Concord
Golf
Club
N
DRAINS
Catchment
Boundary
Study Area
Hydraulic Hazard
H1 - Generally safe for people, vehicles and buildings
H2 - Unsafe for small vehicles
H3 - Unsafe for vehicles, children and the elderly
H4 - Unsafe for people and vehicles
H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure
H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure
0 50 100 200 300 400
Meters

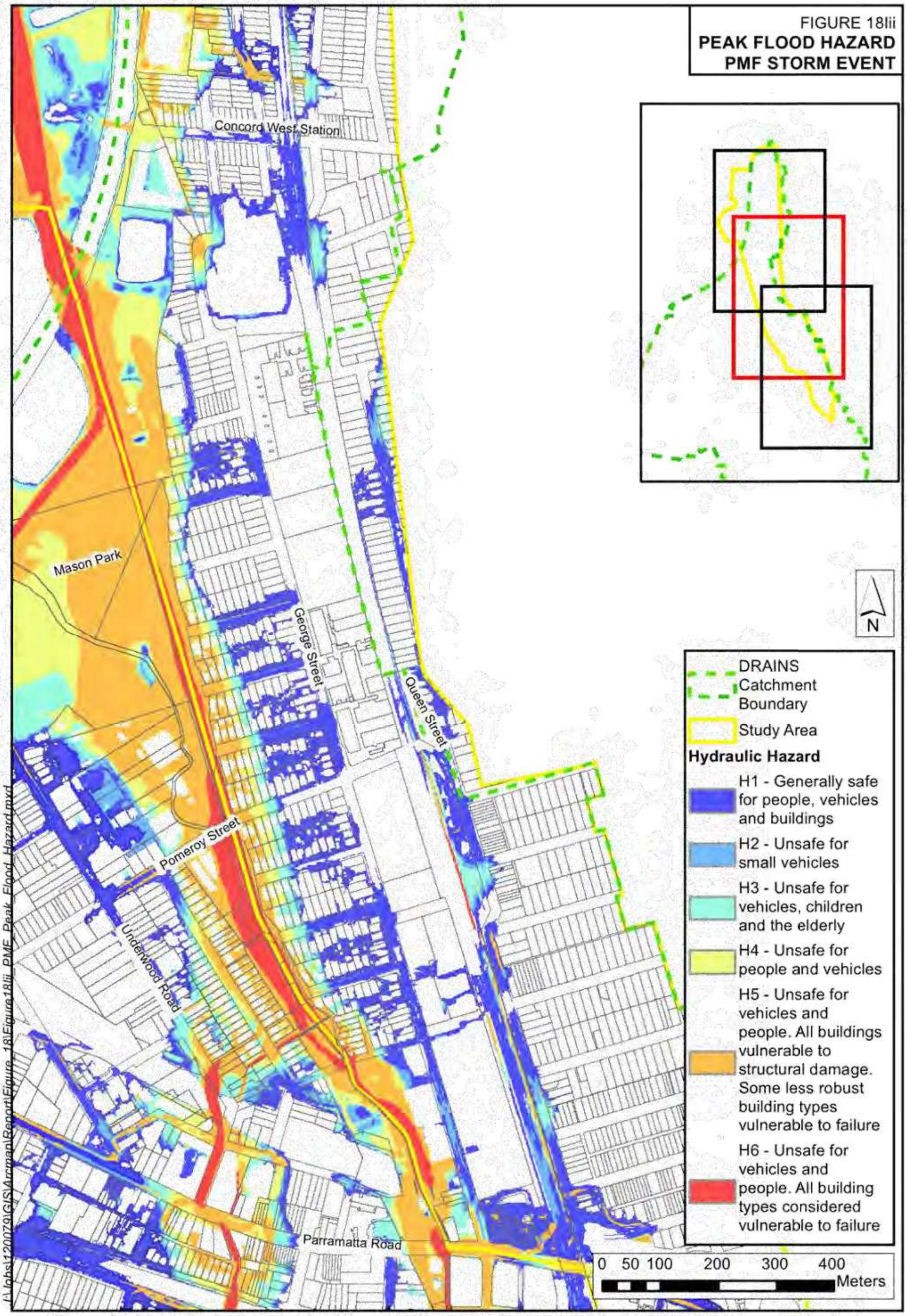


FIGURE 18lii
PEAK FLOOD HAZARD
PMF STORM EVENT
Concord West Station
Mason Park
George Street
Queen Street
Pomeroy Street
Underwood Road
Parramatta Road
DRAINS Catchment Boundary
Study Area
Hydraulic Hazard
H1 - Generally safe for people, vehicles and buildings
H2 - Unsafe for small vehicles
H3 - Unsafe for vehicles, children and the elderly
H4 - Unsafe for people and vehicles
H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure
H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure
0 50 100 200 300 400
Meters
N

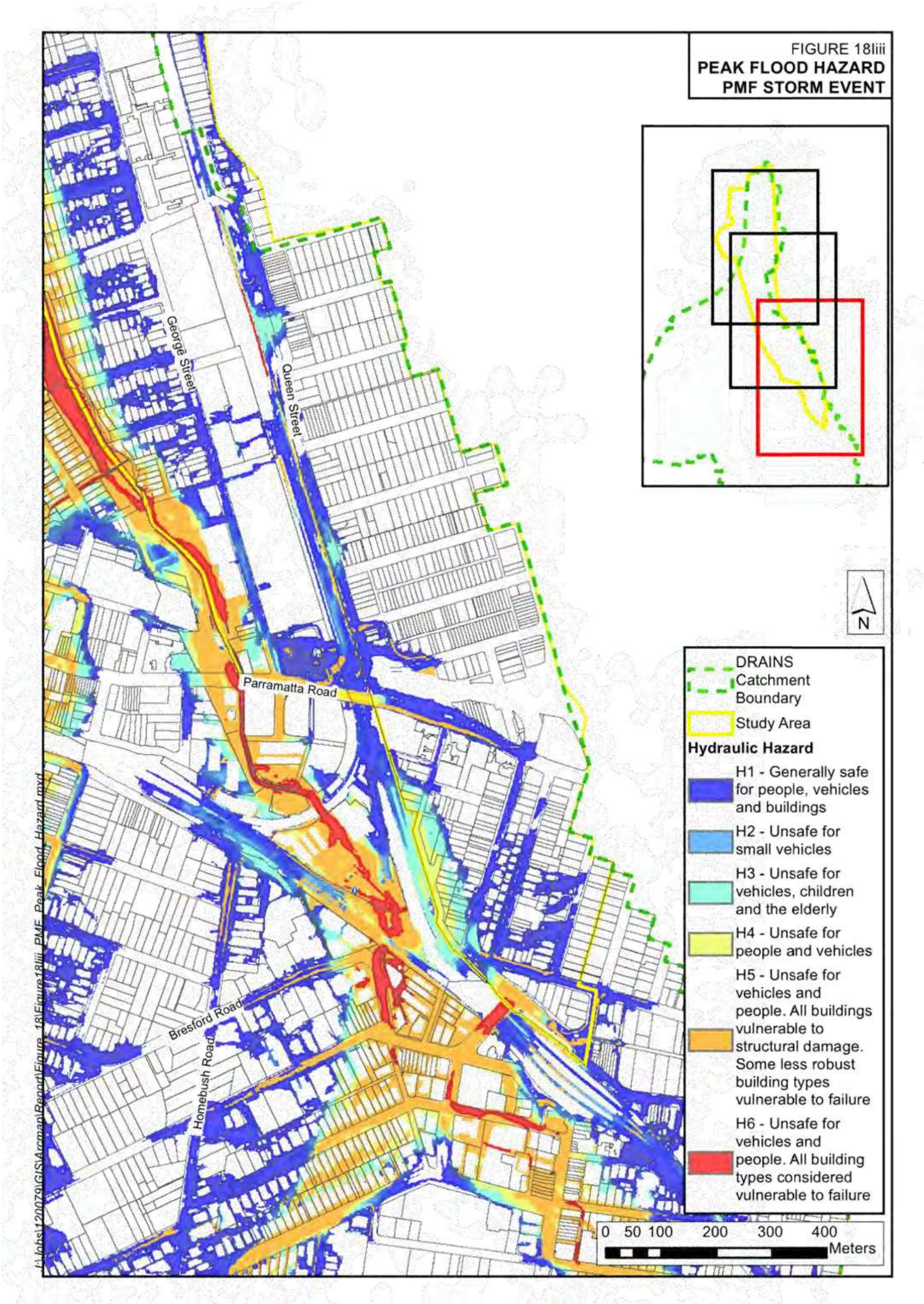


FIGURE 18liii
PEAK FLOOD HAZARD
PMF STORM EVENT
George Street
Queen Street
Parramatta Road
Bresford Road
Homebush Road
N
DRAINS Catchment Boundary
Study Area
Hydraulic Hazard
H1 - Generally safe for people, vehicles and buildings
H2 - Unsafe for small vehicles
H3 - Unsafe for vehicles, children and the elderly
H4 - Unsafe for people and vehicles
H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure
H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure
0 50 100 200 300 400
Meters

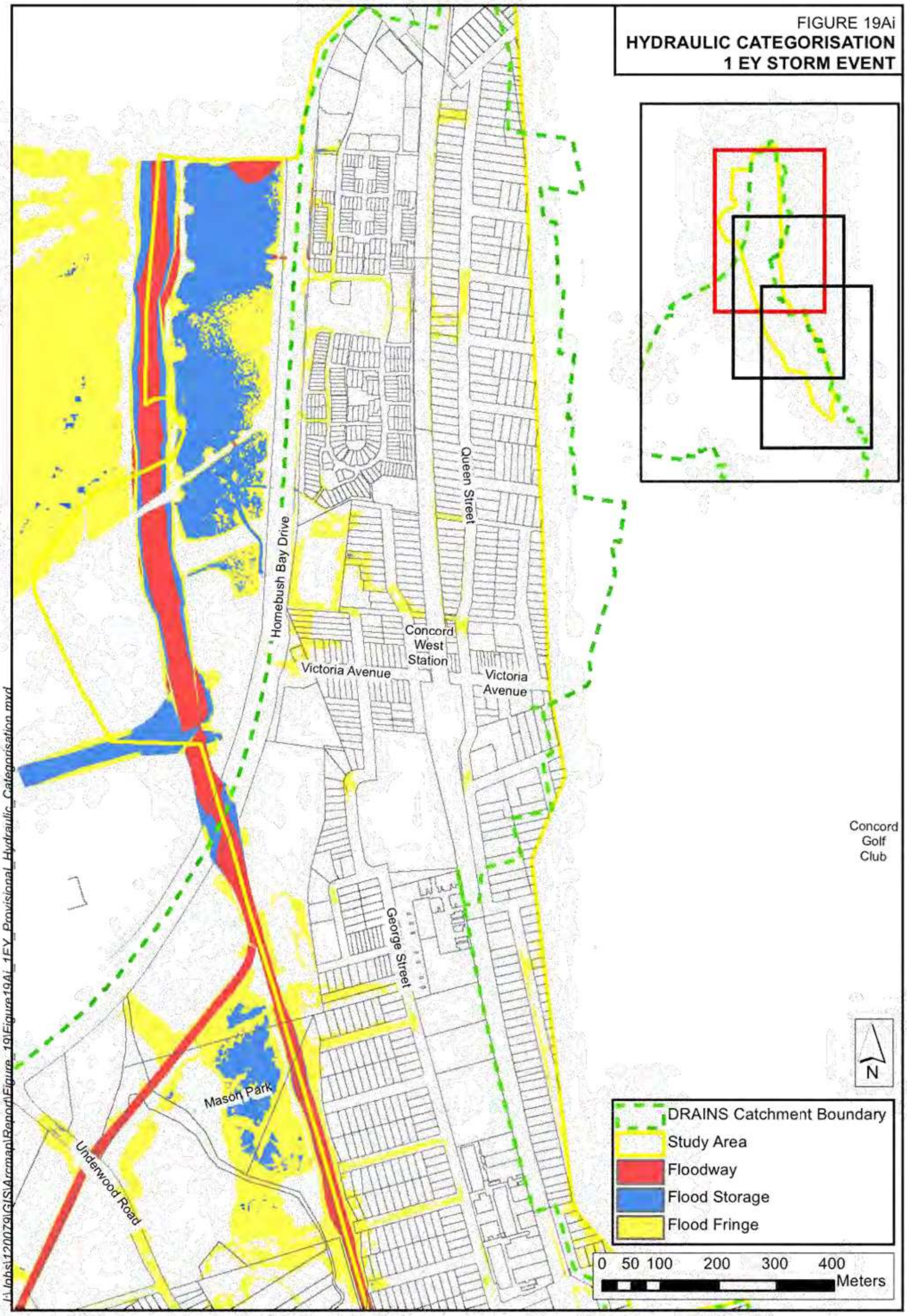


FIGURE 19Ai
HYDRAULIC CATEGORISATION
1 EY STORM EVENT
Homebush Bay Drive
Queen Street
Concord West Station
Victoria Avenue
Victoria Avenue
George Street
Mason Park
Underwood Road
Concord Golf Club
N
DRAINS Catchment Boundary
Study Area
Floodway
Flood Storage
Flood Fringe
0 50 100 200 300 400
Meters

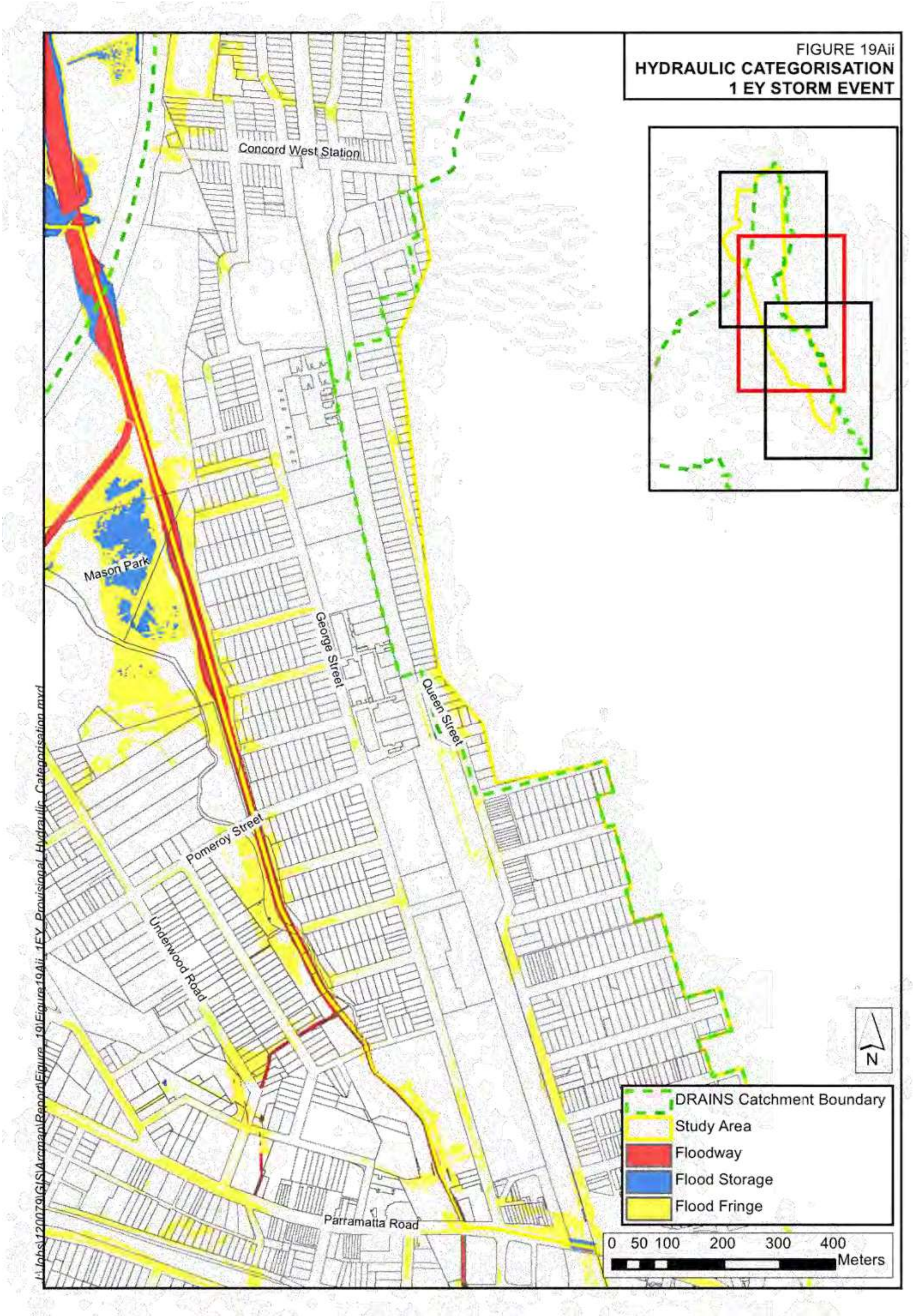


FIGURE 19Aii
HYDRAULIC CATEGORISATION
1 EY STORM EVENT
Concord West Station
Mason Park
George Street
Queen Street
Pomeroy Street
Underwood Road
Parramatta Road
DRAINS Catchment Boundary
Study Area
Floodway
Flood Storage
Flood Fringe
0 50 100 200 300 400
Meters
N

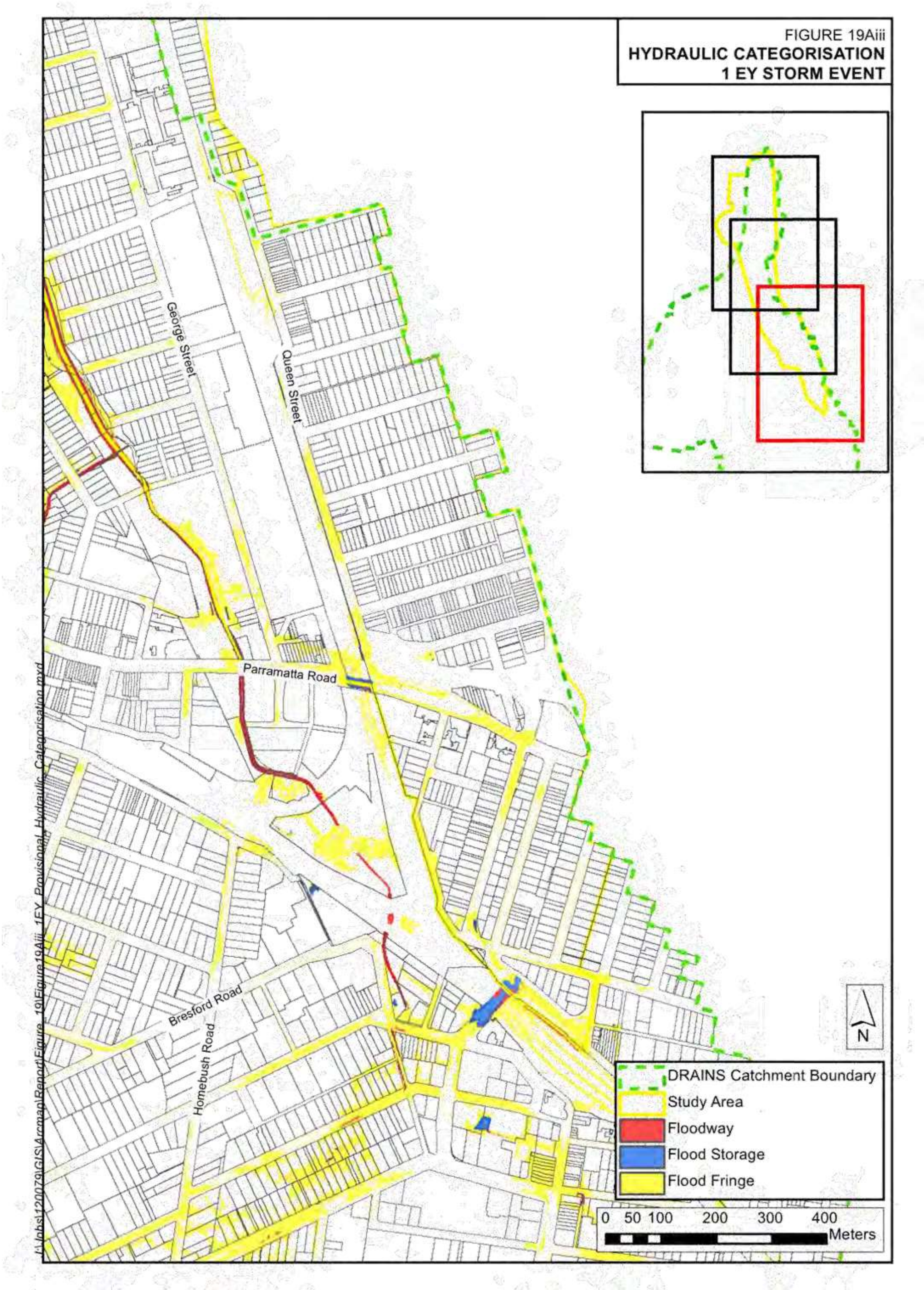


FIGURE 19Aiii
HYDRAULIC CATEGORISATION
1 EY STORM EVENT
George Street
Queen Street
Parramatta Road
Bresford Road
Homebush Road
DRAINS Catchment Boundary
Study Area
Floodway
Flood Storage
Flood Fringe
0 50 100 200 300 400
Meters
N

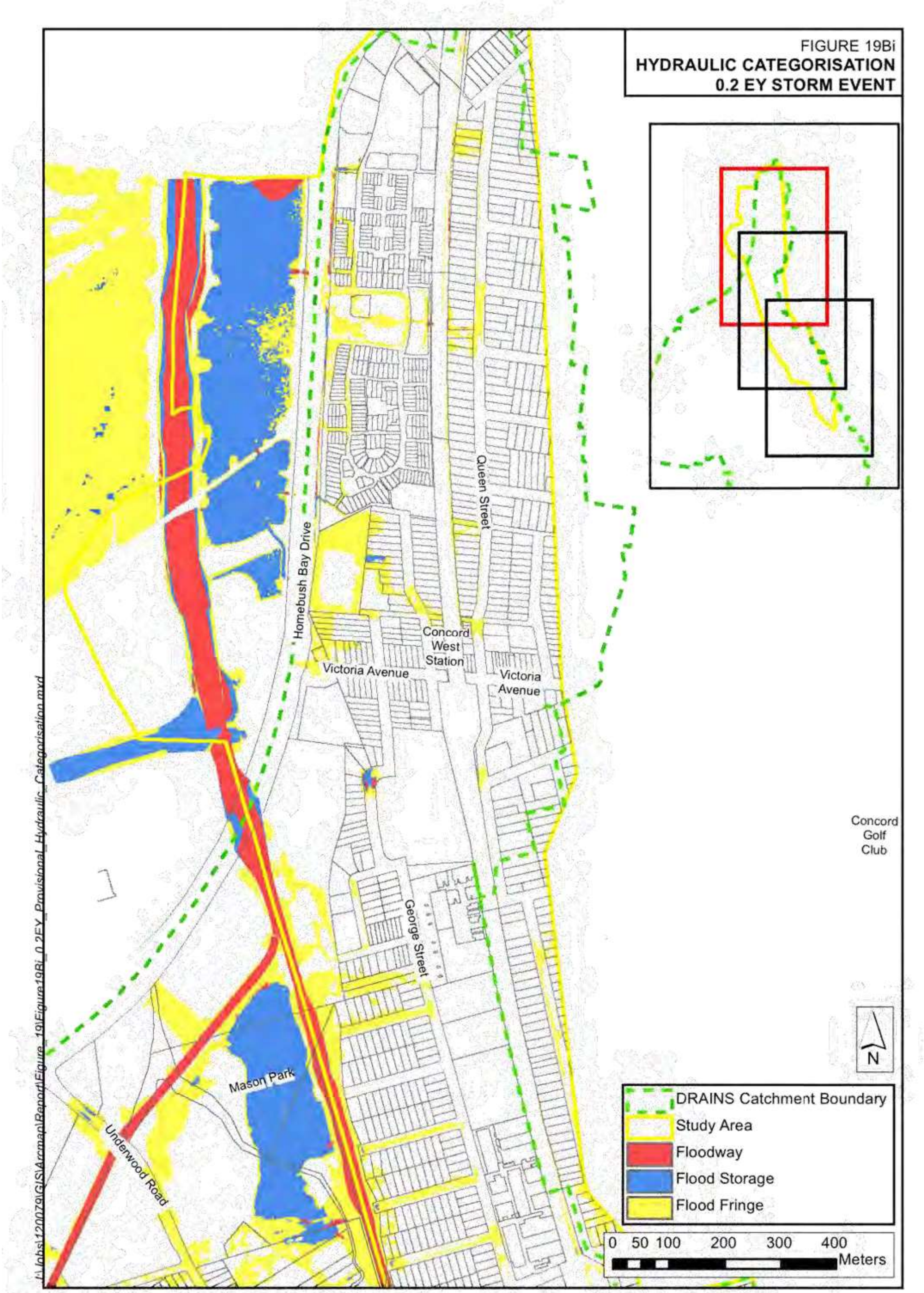


FIGURE 19Bi
HYDRAULIC CATEGORISATION
0.2 EY STORM EVENT
Queen Street
Homebush Bay Drive
Concord West Station
Victoria Avenue
Victoria Avenue
George Street
Concord Golf Club
Mason Park
Underwood Road
N
DRAINS Catchment Boundary
Study Area
Floodway
Flood Storage
Flood Fringe
0 50 100 200 300 400
Meters

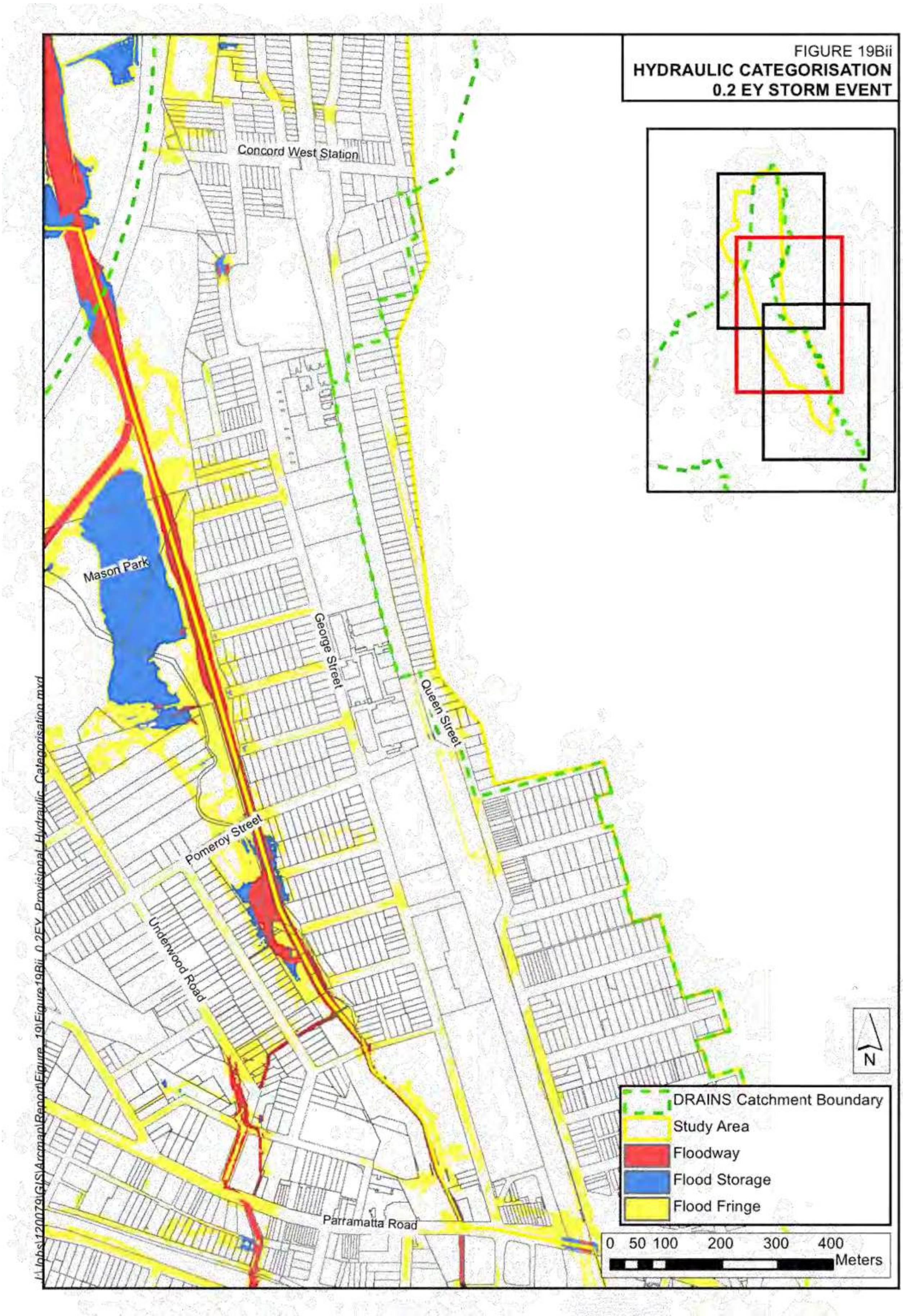


FIGURE 19Bii
HYDRAULIC CATEGORISATION
0.2 EY STORM EVENT
Concord West Station
Mason Park
George Street
Queen Street
Pomeroy Street
Underwood Road
Parramatta Road
DRAINS Catchment Boundary
Study Area
Floodway
Flood Storage
Flood Fringe
0 50 100 200 300 400
Meters
N

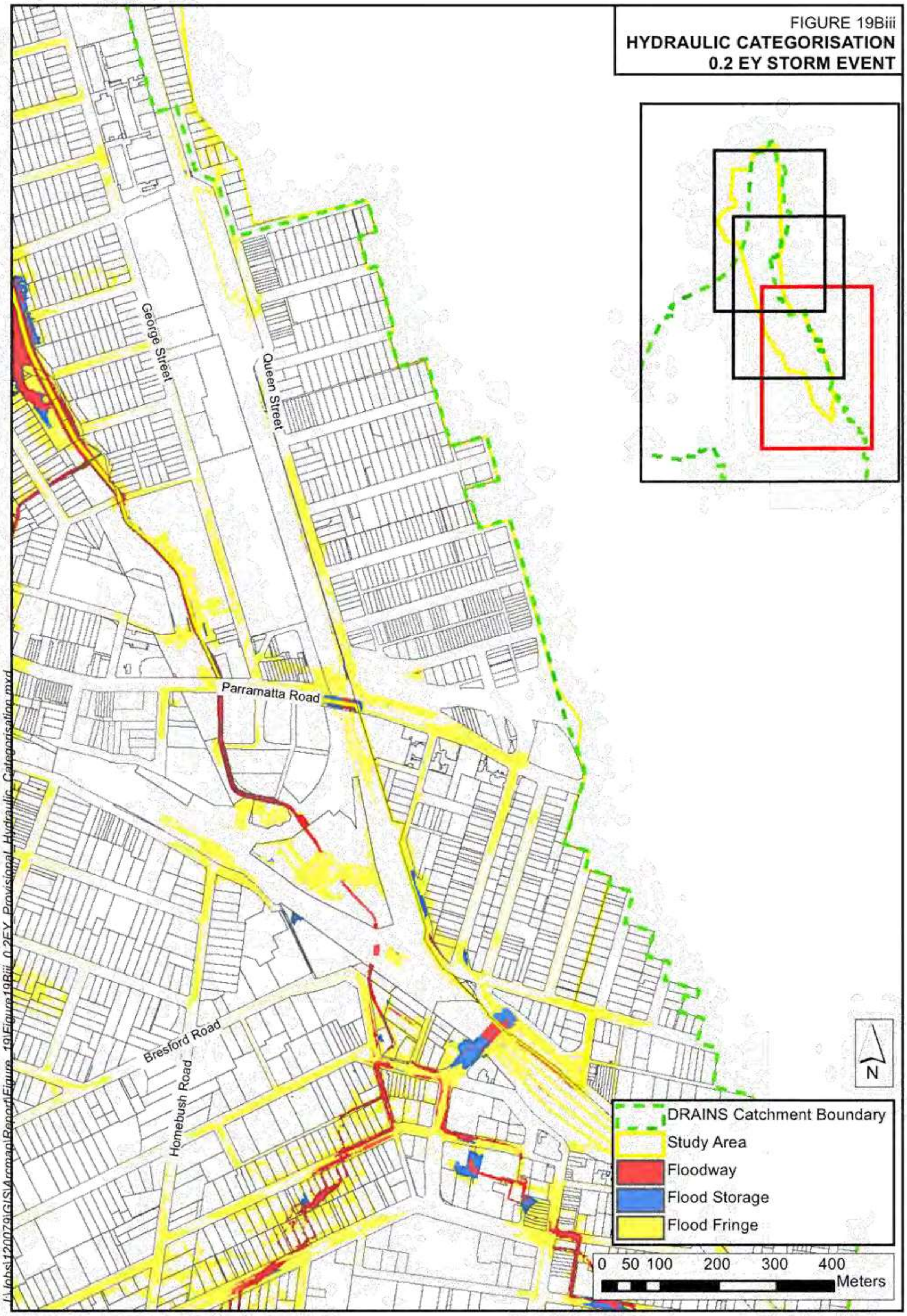


FIGURE 19Biii
HYDRAULIC CATEGORISATION
0.2 EY STORM EVENT
George Street
Queen Street
Parramatta Road
Bresford Road
Homebush Road
N
DRAINS Catchment Boundary
Study Area
Floodway
Flood Storage
Flood Fringe
0 50 100 200 300 400
Meters

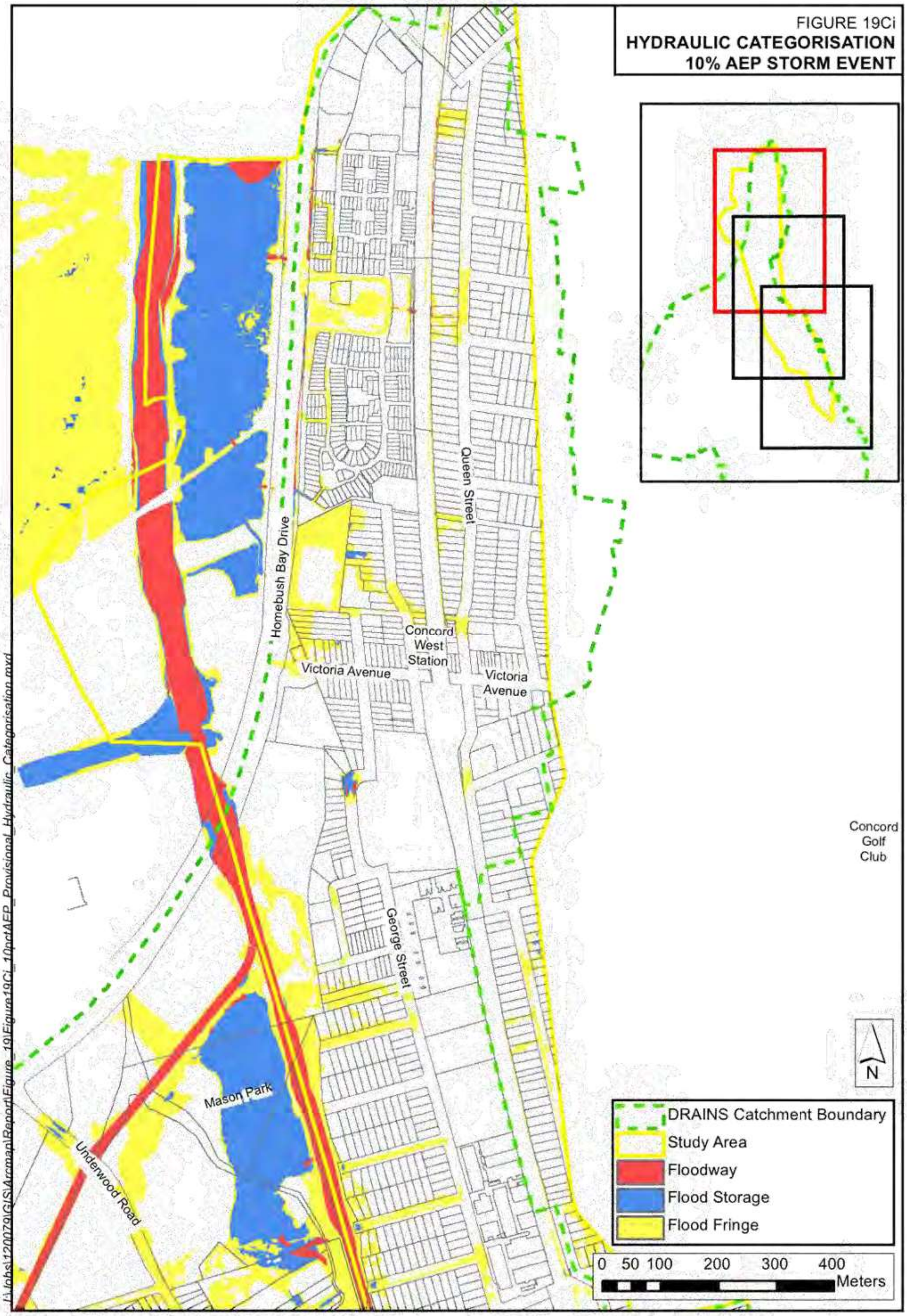


FIGURE 19Ci
HYDRAULIC CATEGORISATION
10% AEP STORM EVENT
Homebush Bay Drive
Queen Street
Concord West Station
Victoria Avenue
Victoria Avenue
George Street
Concord Golf Club
Mason Park
Underwood Road
N
DRAINS Catchment Boundary
Study Area
Floodway
Flood Storage
Flood Fringe
0 50 100 200 300 400
Meters

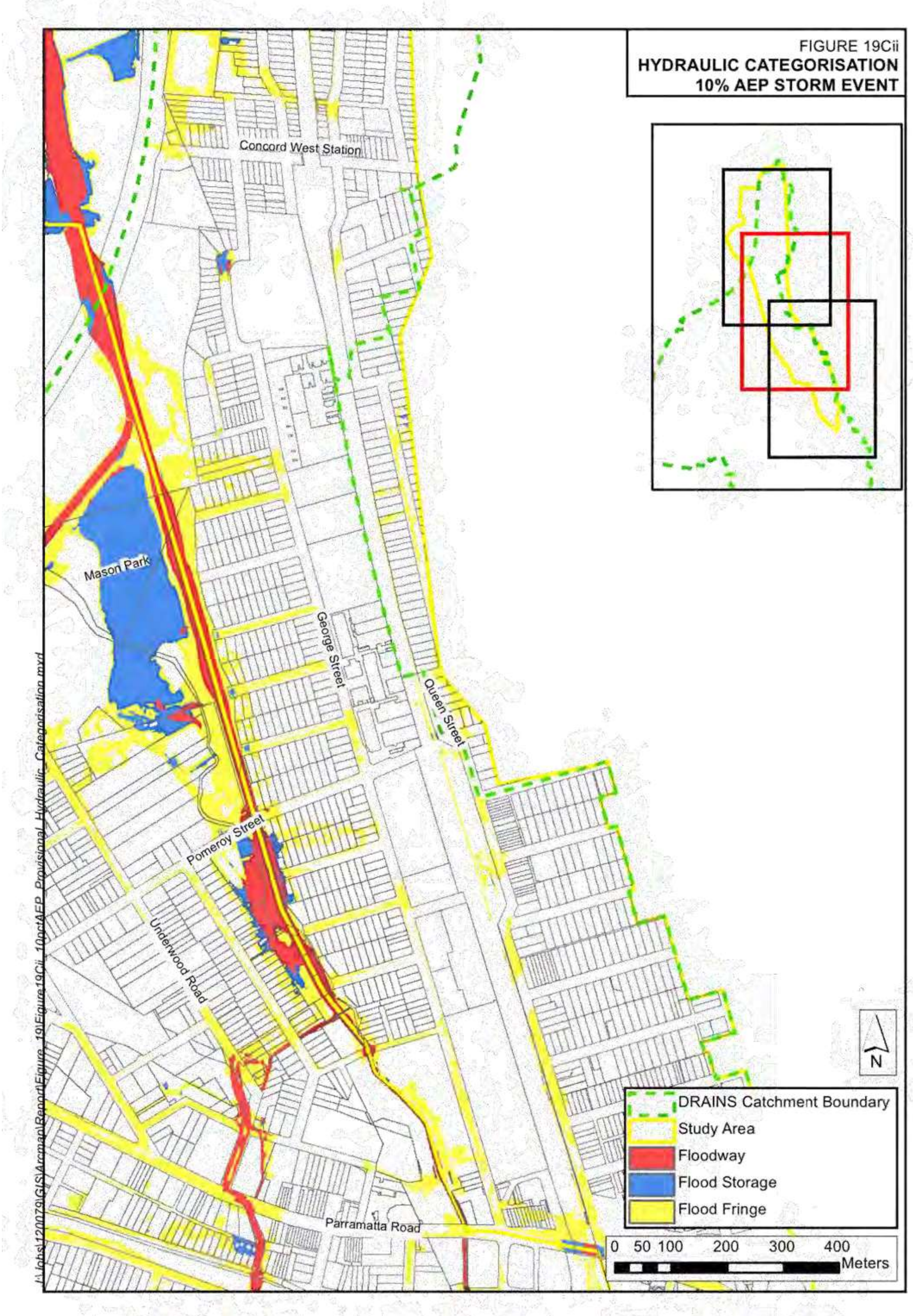


FIGURE 19Cii
HYDRAULIC CATEGORISATION
10% AEP STORM EVENT
Concord West Station
Mason Park
George Street
Queen Street
Pomeroy Street
Underwood Road
Parramatta Road
N
DRAINS Catchment Boundary
Study Area
Floodway
Flood Storage
Flood Fringe
0 50 100 200 300 400
Meters

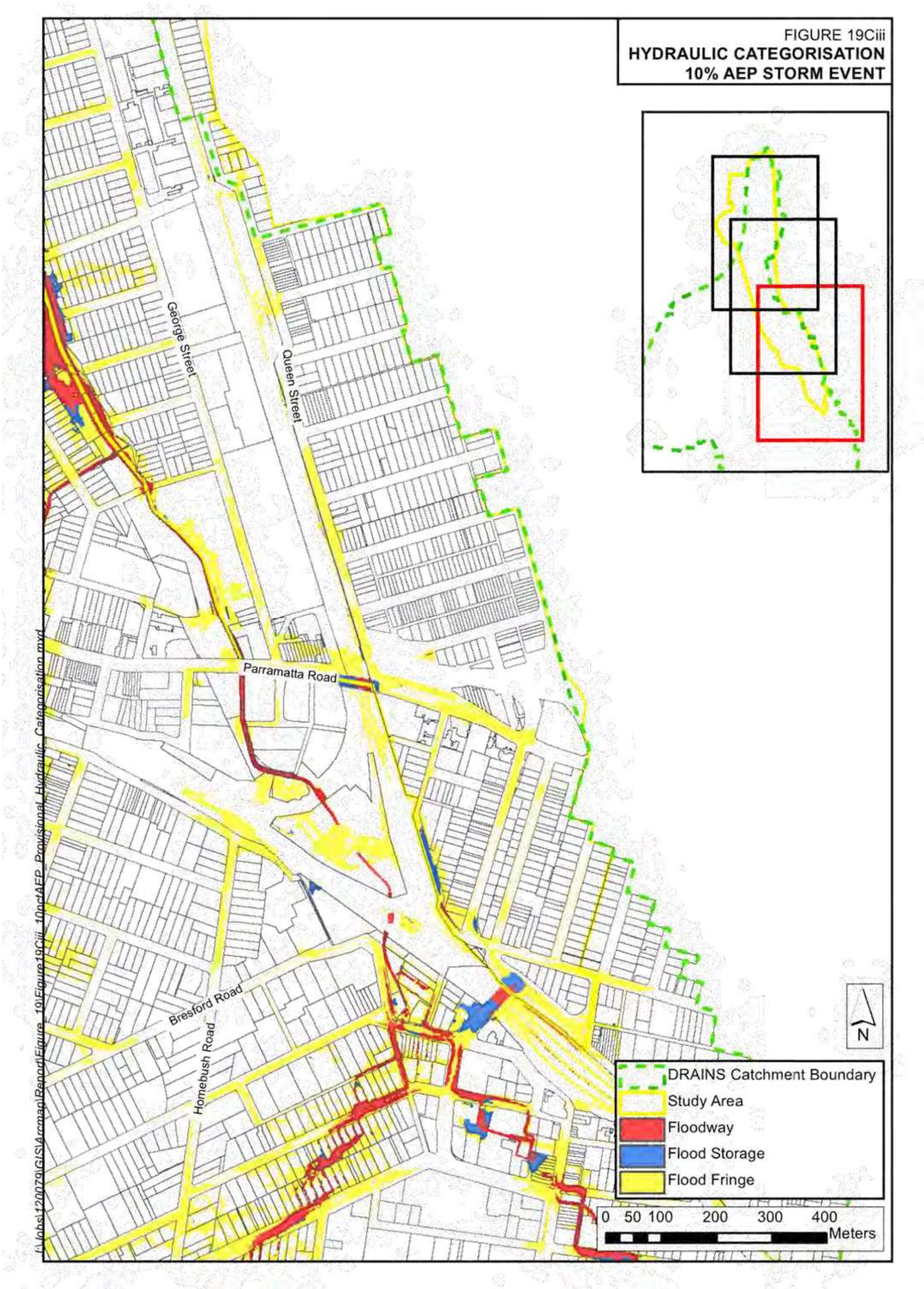


FIGURE 19Ciii
HYDRAULIC CATEGORISATION
10% AEP STORM EVENT
George Street
Queen Street
Parramatta Road
Bresford Road
Homebush Road
N
DRAINS Catchment Boundary
Study Area
Floodway
Flood Storage
Flood Fringe
0 50 100 200 300 400
Meters

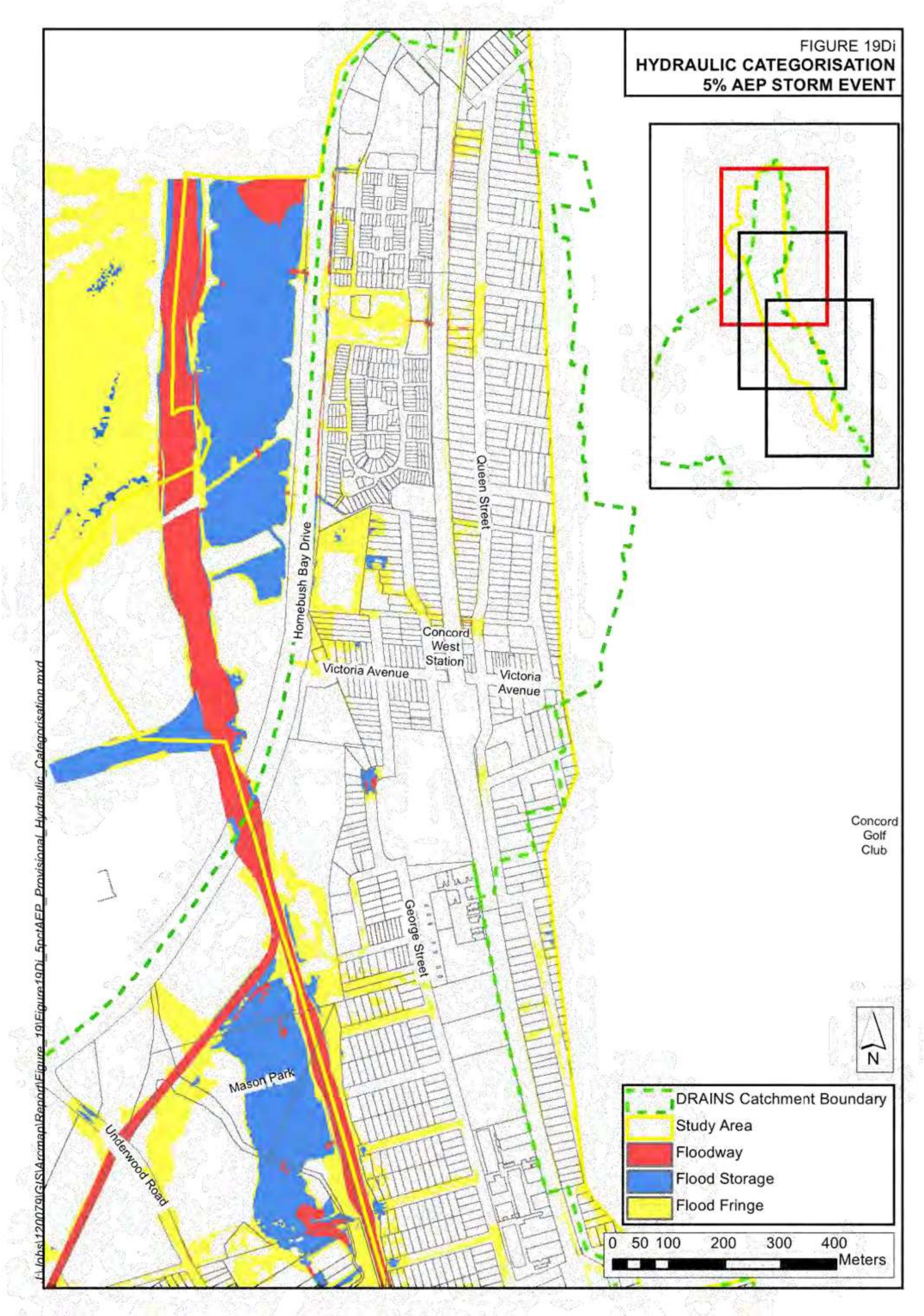


FIGURE 19Di
HYDRAULIC CATEGORISATION
5% AEP STORM EVENT
Queen Street
Homebush Bay Drive
Concord West Station
Victoria Avenue
Victoria Avenue
George Street
Concord Golf Club
Mason Park
Underwood Road
N
DRAINS Catchment Boundary
Study Area
Floodway
Flood Storage
Flood Fringe
0 50 100 200 300 400
Meters

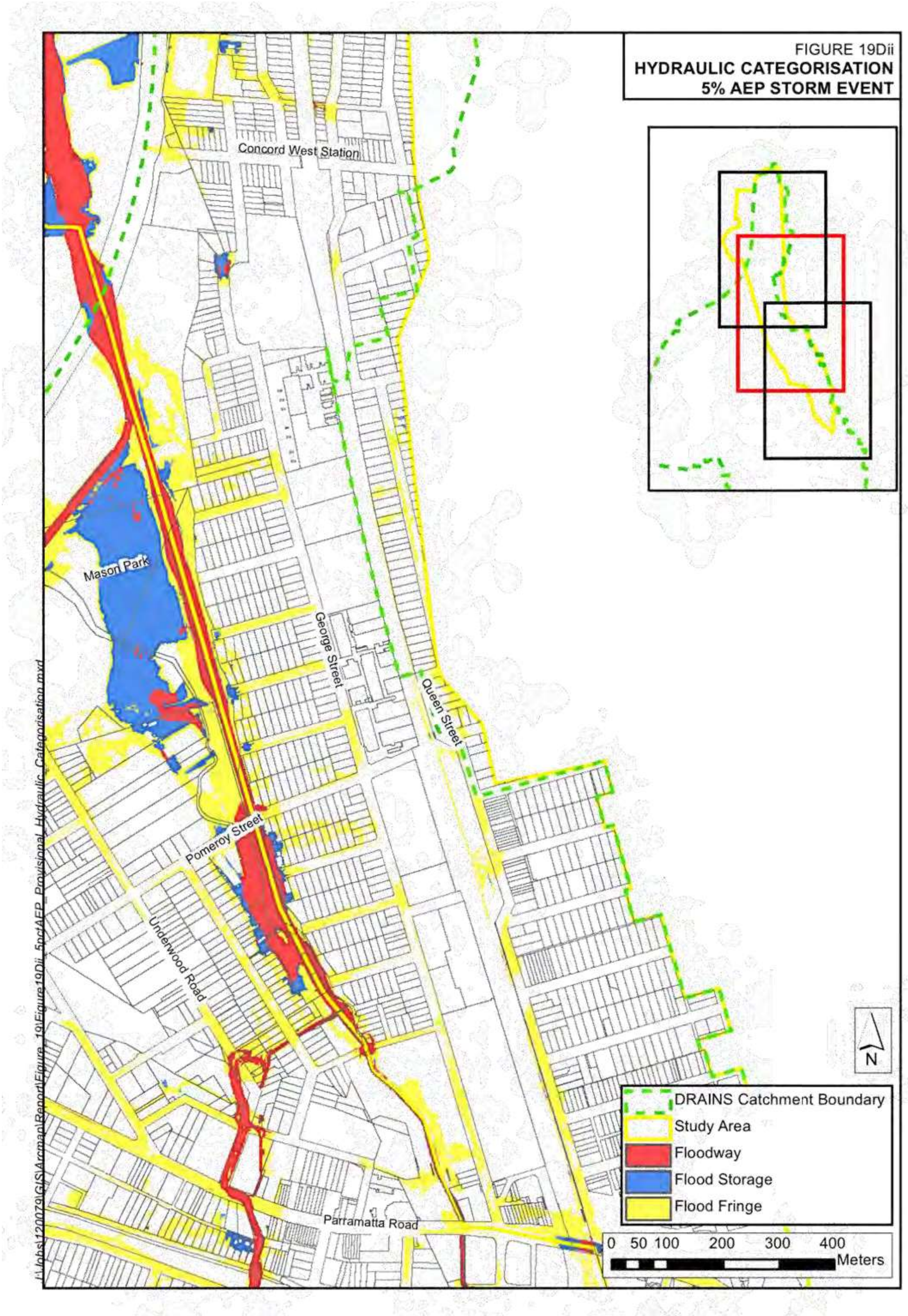


FIGURE 19Dii
HYDRAULIC CATEGORISATION
5% AEP STORM EVENT
Concord West Station
Mason Park
George Street
Queen Street
Pomeroy Street
Underwood Road
Parramatta Road
DRAINS Catchment Boundary
Study Area
Floodway
Flood Storage
Flood Fringe
0 50 100 200 300 400
Meters
N

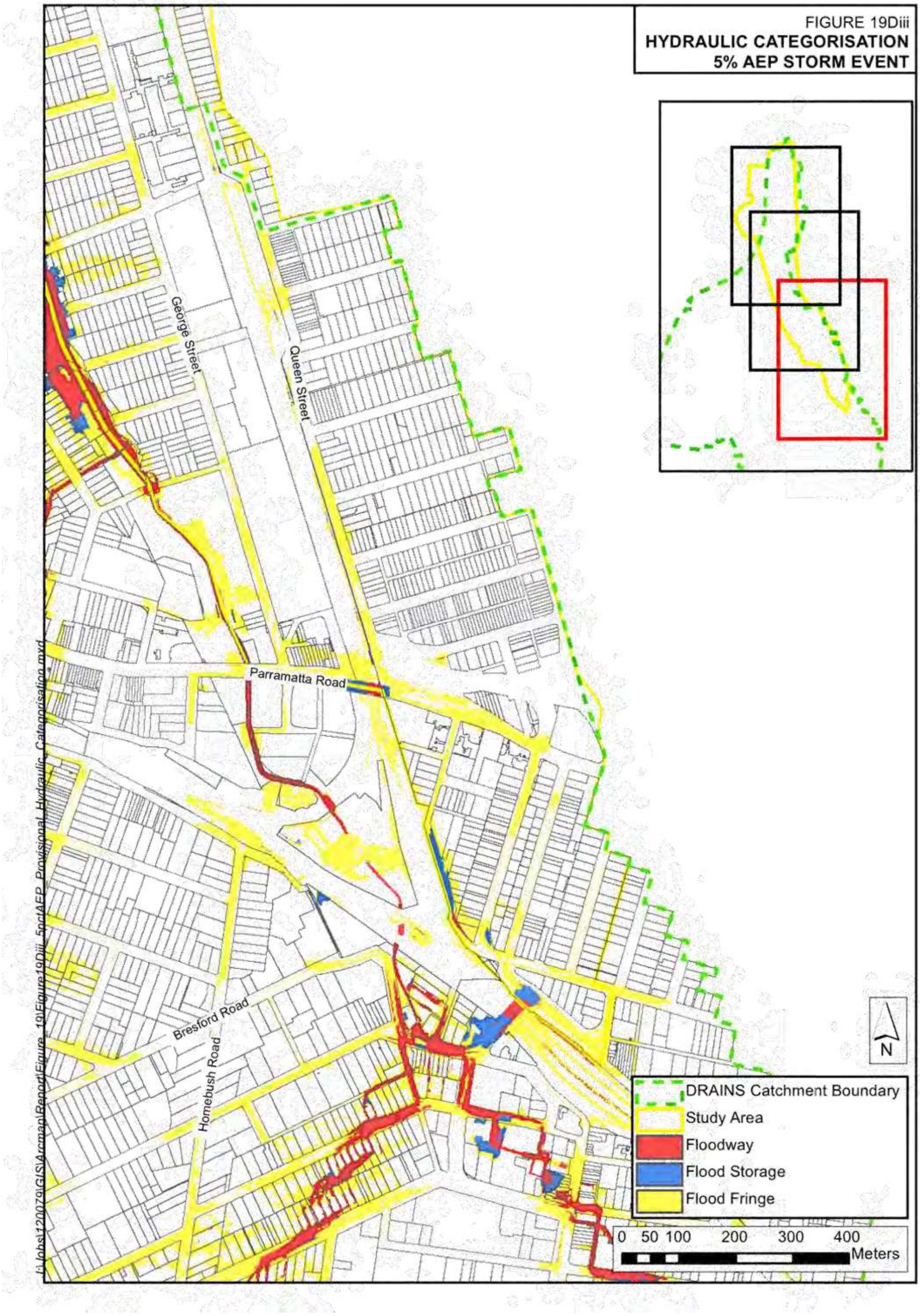


FIGURE 19Diii
HYDRAULIC CATEGORISATION
5% AEP STORM EVENT
George Street
Queen Street
Parramatta Road
Bresford Road
Homebush Road
DRAINS Catchment Boundary
Study Area
Floodway
Flood Storage
Flood Fringe
N
0 50 100 200 300 400
Meters

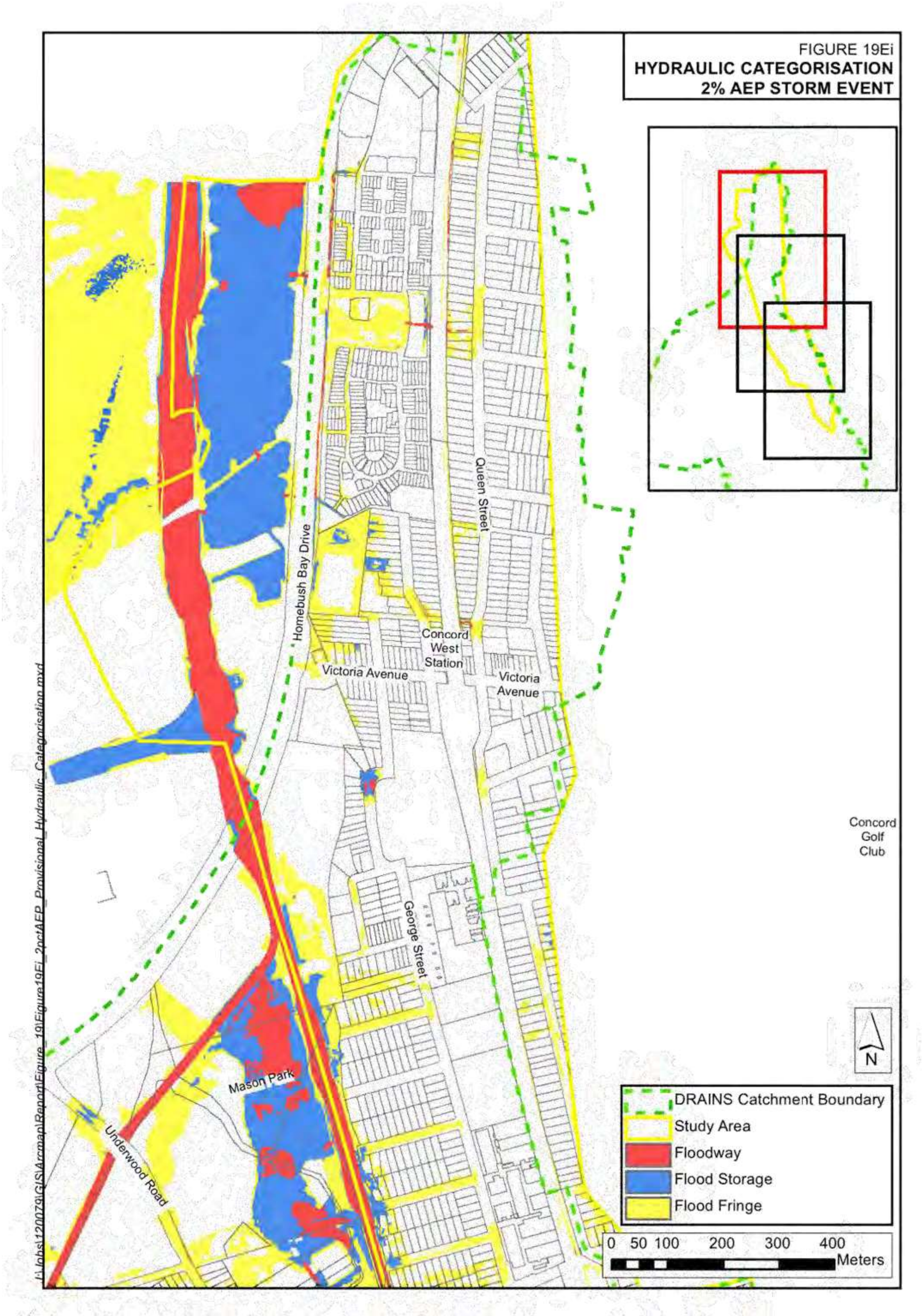


FIGURE 19Ei
HYDRAULIC CATEGORISATION
2% AEP STORM EVENT
Homebush Bay Drive
Queen Street
Concord West Station
Victoria Avenue
Victoria Avenue
George Street
Mason Park
Underwood Road
Concord Golf Club
N
DRAINS Catchment Boundary
Study Area
Floodway
Flood Storage
Flood Fringe
0 50 100 200 300 400
Meters

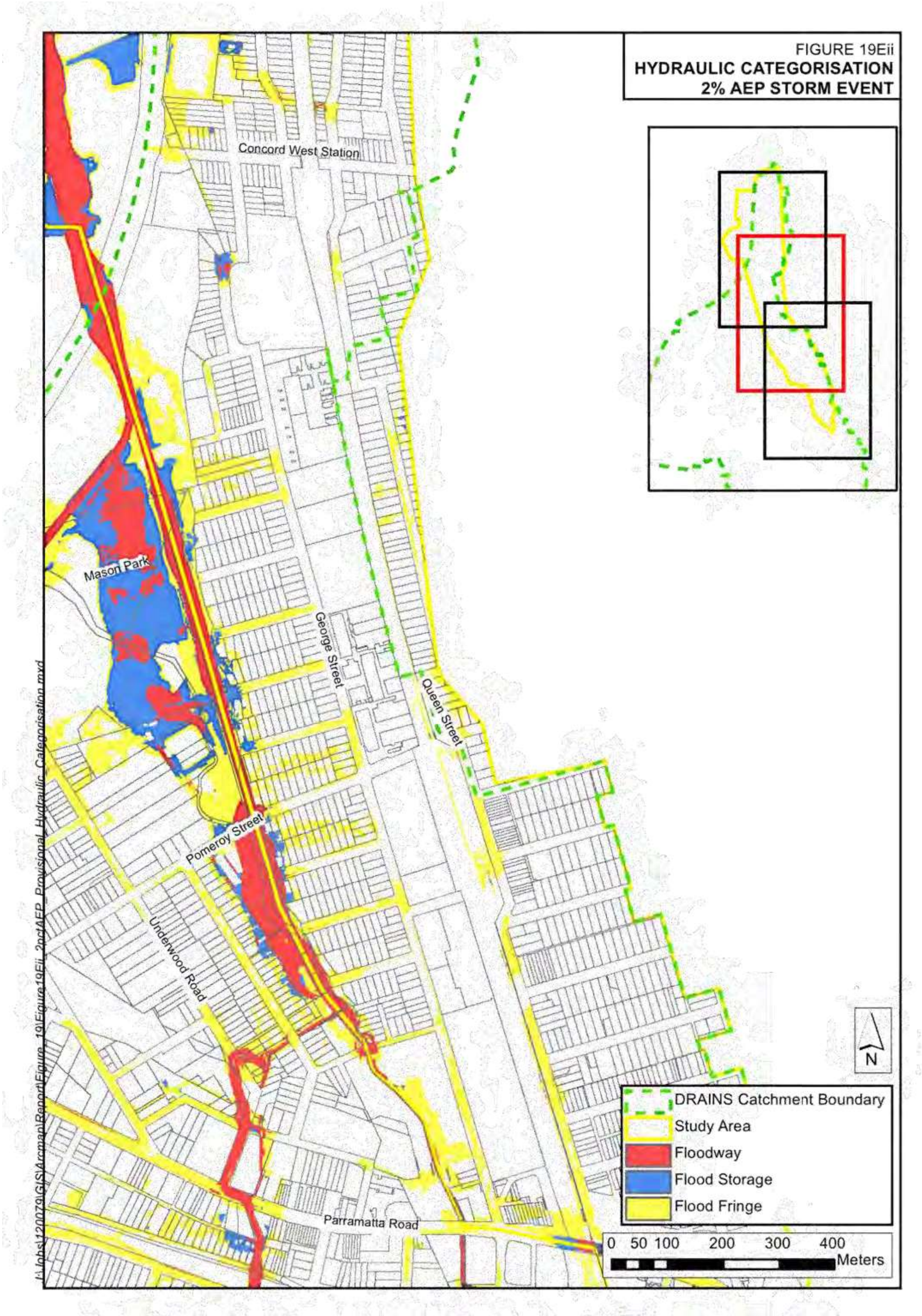


FIGURE 19Eii
HYDRAULIC CATEGORISATION
2% AEP STORM EVENT
Concord West Station
Mason Park
George Street
Queen Street
Pomeroy Street
Underwood Road
Parramatta Road
N
DRAINS Catchment Boundary
Study Area
Floodway
Flood Storage
Flood Fringe
0 50 100 200 300 400
Meters

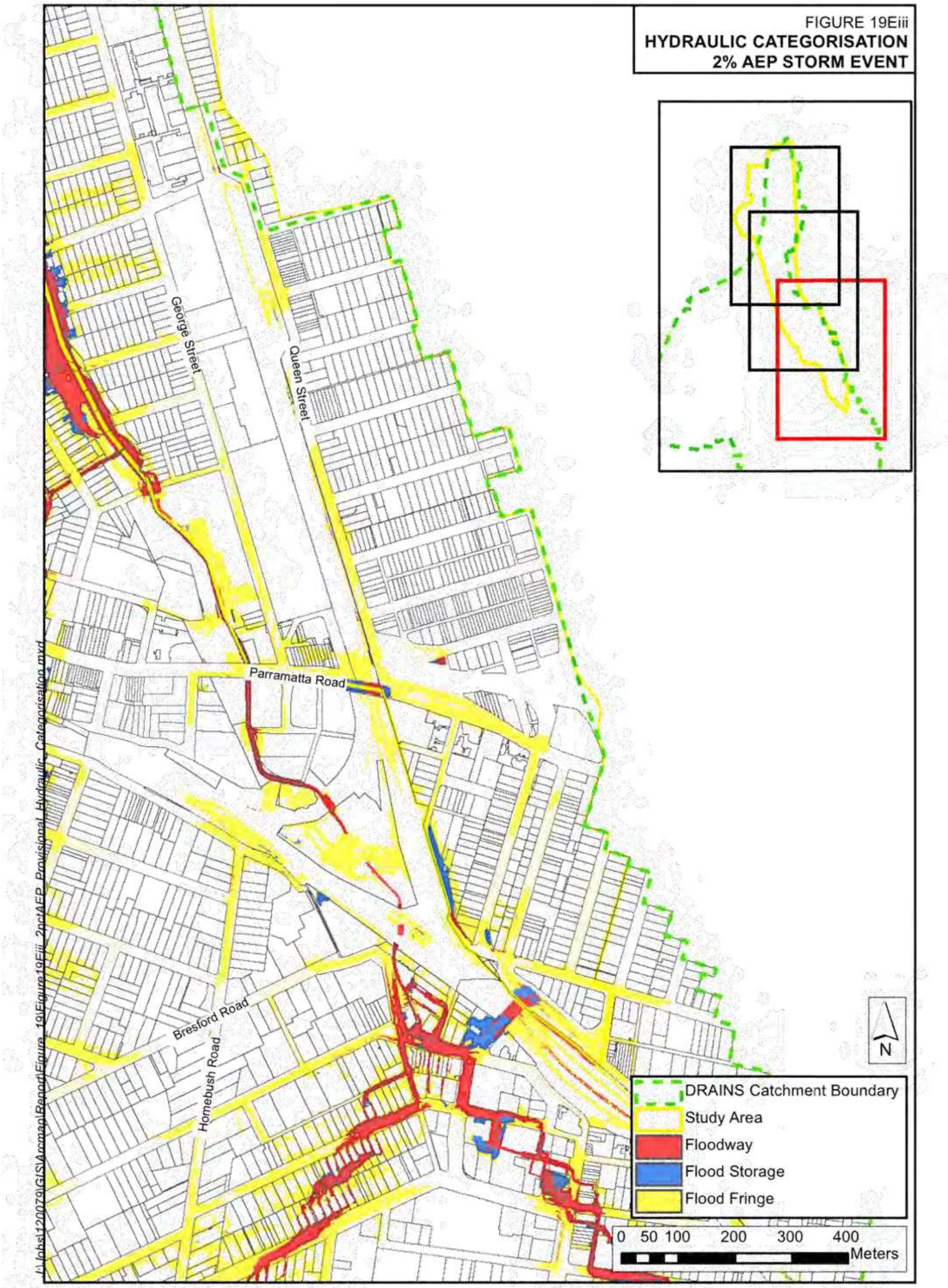


FIGURE 19Eiii
HYDRAULIC CATEGORISATION
2% AEP STORM EVENT
George Street
Queen Street
Parramatta Road
Bresford Road
Homebush Road
N
DRAINS Catchment Boundary
Study Area
Floodway
Flood Storage
Flood Fringe
0 50 100 200 300 400
Meters

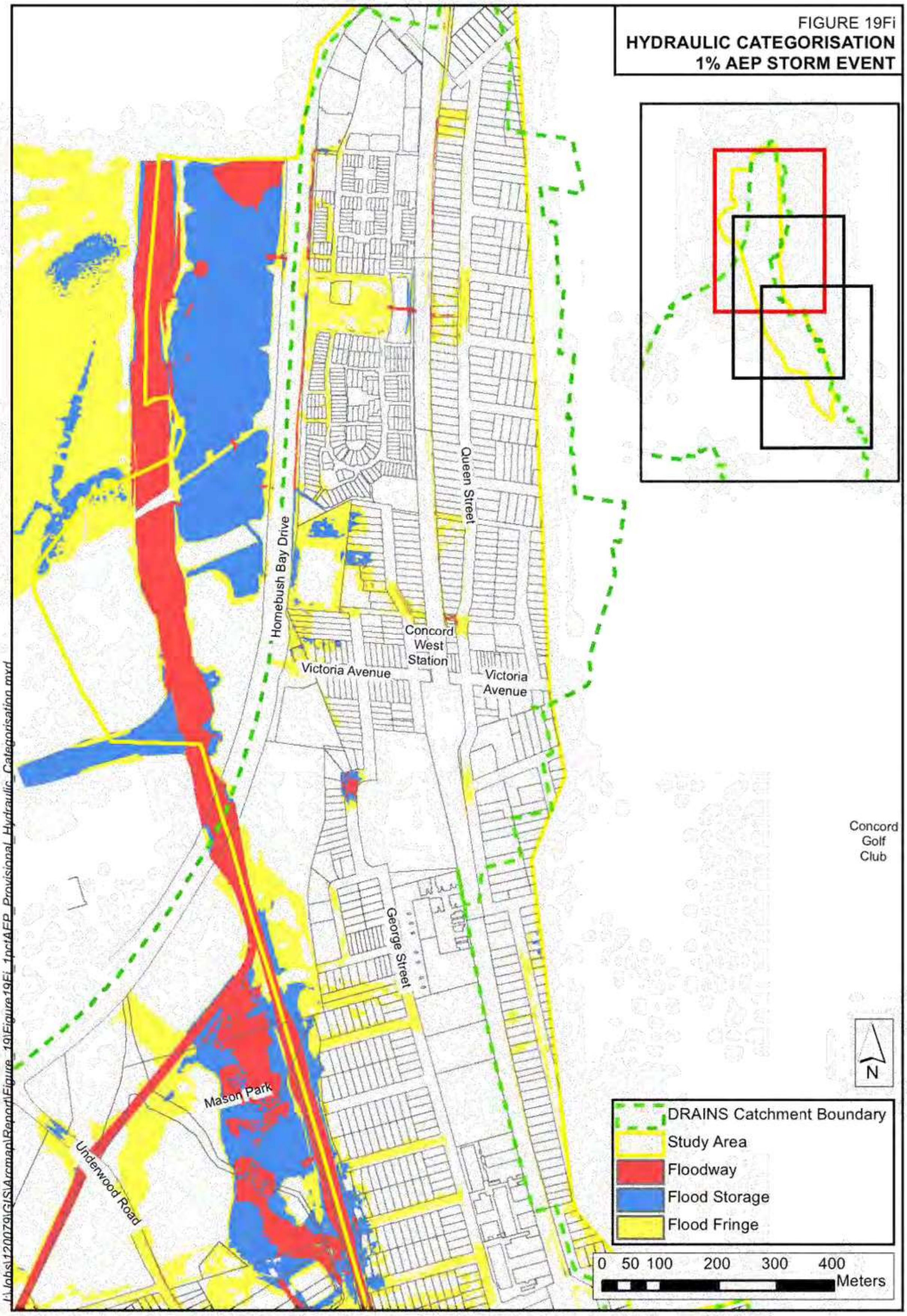


FIGURE 19Fi
HYDRAULIC CATEGORISATION
1% AEP STORM EVENT
Homebush Bay Drive
Queen Street
Concord West Station
Victoria Avenue
Victoria Avenue
George Street
Mason Park
Underwood Road
Concord Golf Club
N
DRAINS Catchment Boundary
Study Area
Floodway
Flood Storage
Flood Fringe
0 50 100 200 300 400
Meters

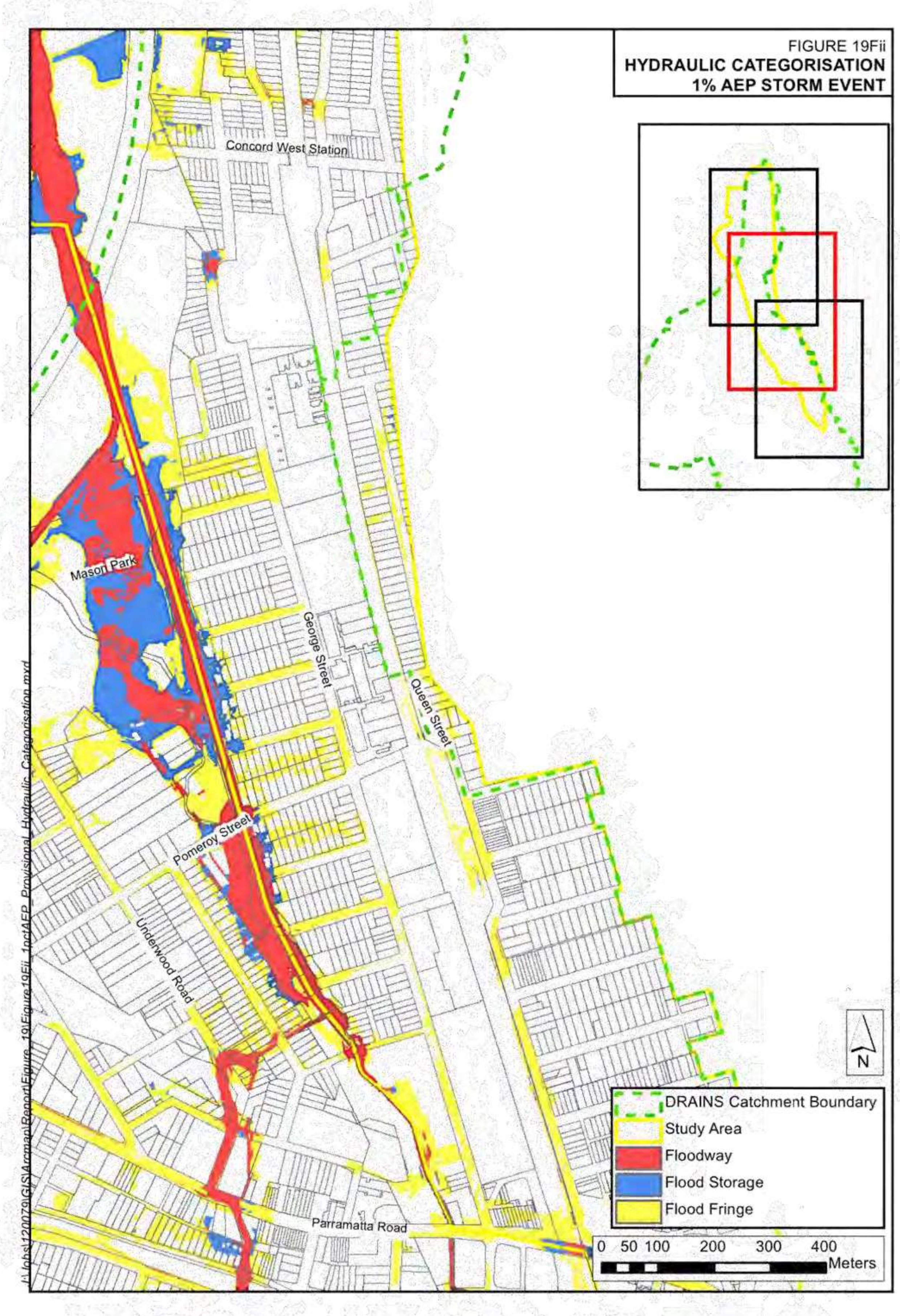


FIGURE 19Fii
HYDRAULIC CATEGORISATION
1% AEP STORM EVENT
Concord West Station
Mason Park
George Street
Queen Street
Pomeroy Street
Underwood Road
Parramatta Road
N
DRAINS Catchment Boundary
Study Area
Floodway
Flood Storage
Flood Fringe
0 50 100 200 300 400
Meters

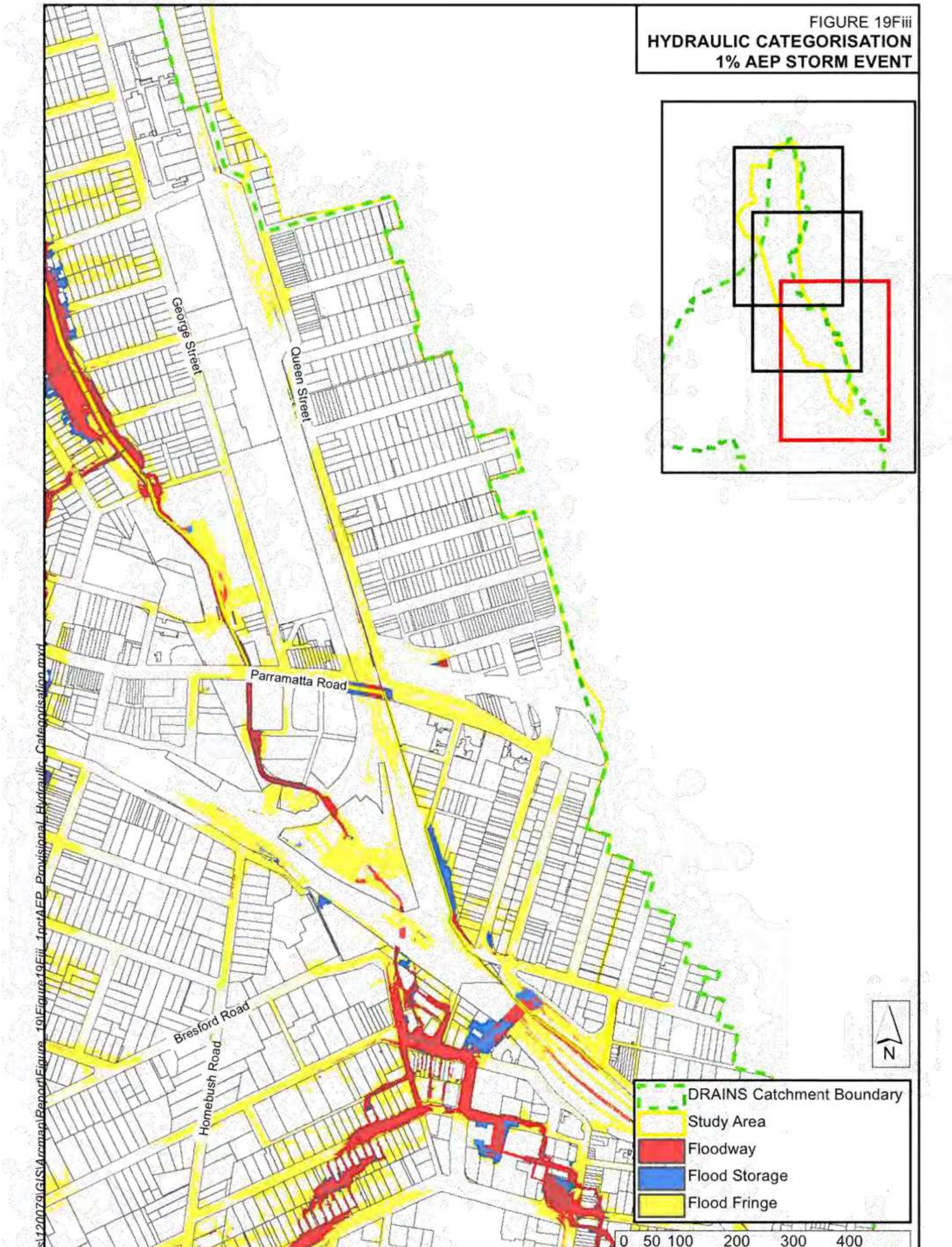


FIGURE 19Fiii
HYDRAULIC CATEGORISATION
1% AEP STORM EVENT
George Street
Queen Street
Parramatta Road
Bresford Road
Homebush Road
N
DRAINS Catchment Boundary
Study Area
Floodway
Flood Storage
Flood Fringe
0 50 100 200 300 400
Meters

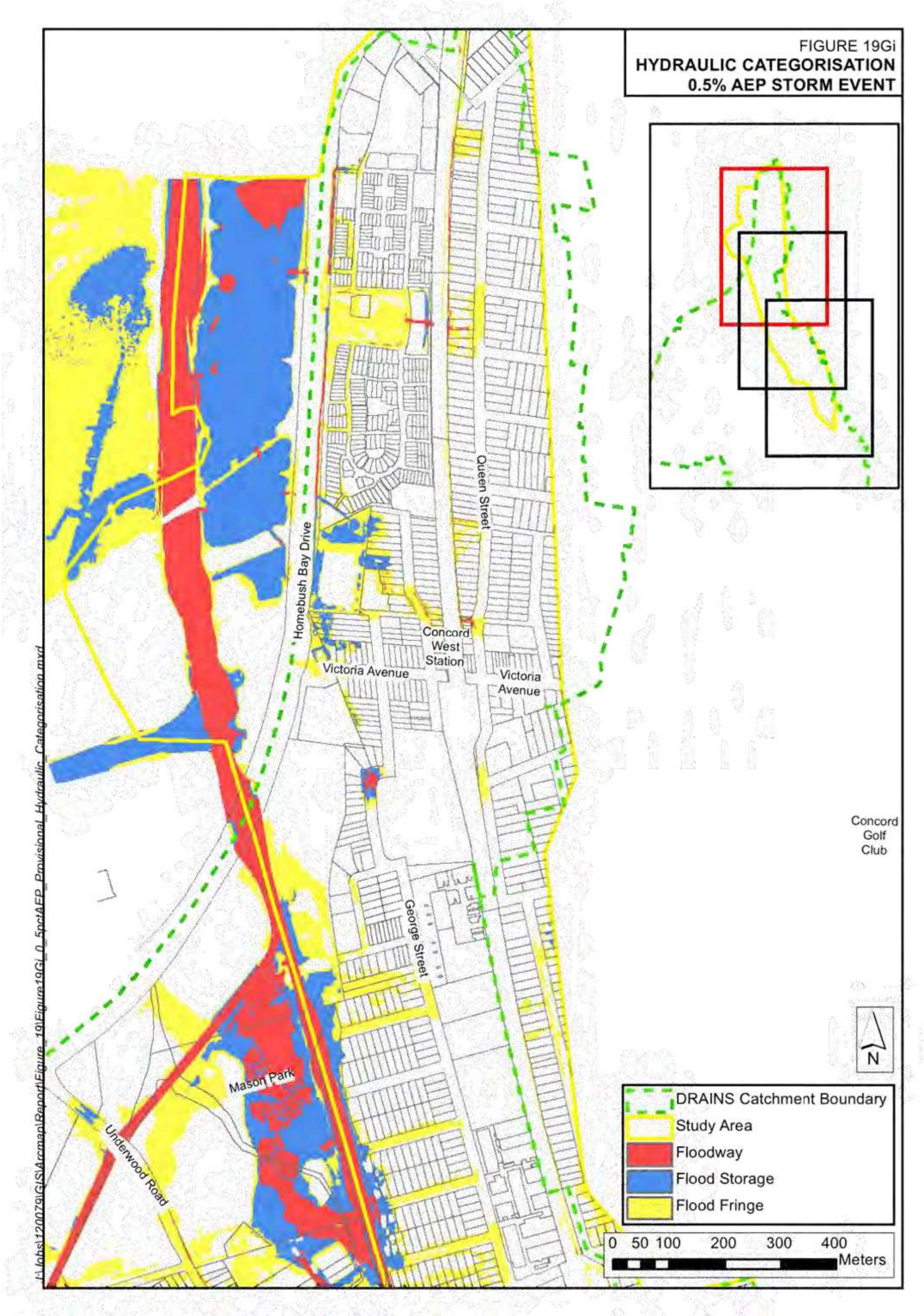


FIGURE 19Gi
HYDRAULIC CATEGORISATION
0.5% AEP STORM EVENT
Homebush Bay Drive
Queen Street
Concord West Station
Victoria Avenue
Victoria Avenue
George Street
Mason Park
Underwood Road
Concord Golf Club
N
DRAINS Catchment Boundary
Study Area
Floodway
Flood Storage
Flood Fringe
0 50 100 200 300 400
Meters

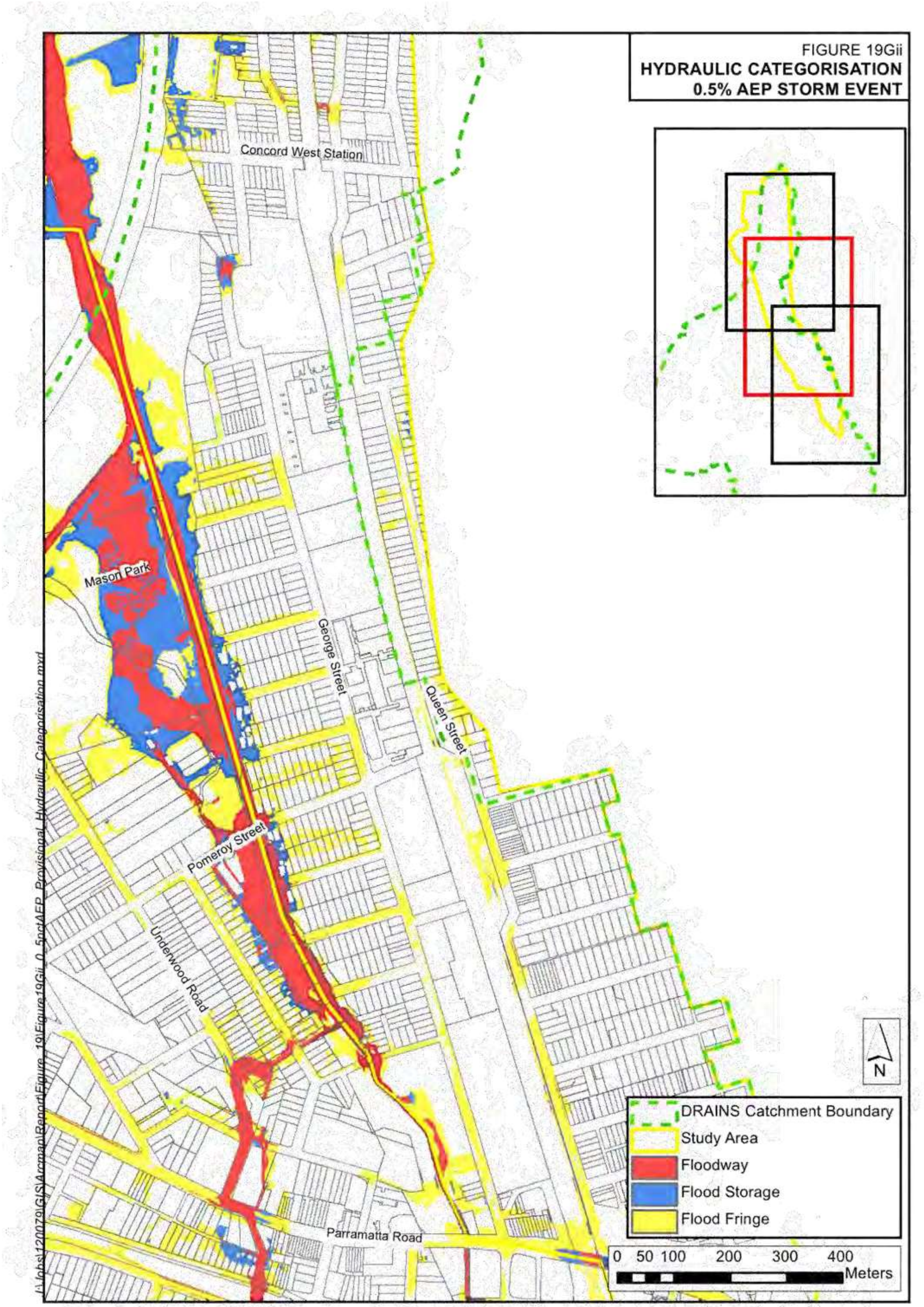


FIGURE 19Gii
HYDRAULIC CATEGORISATION
0.5% AEP STORM EVENT
Concord West Station
Mason Park
George Street
Queen Street
Pomeroy Street
Underwood Road
Parramatta Road
DRAINS Catchment Boundary
Study Area
Floodway
Flood Storage
Flood Fringe
0 50 100 200 300 400
Meters
N

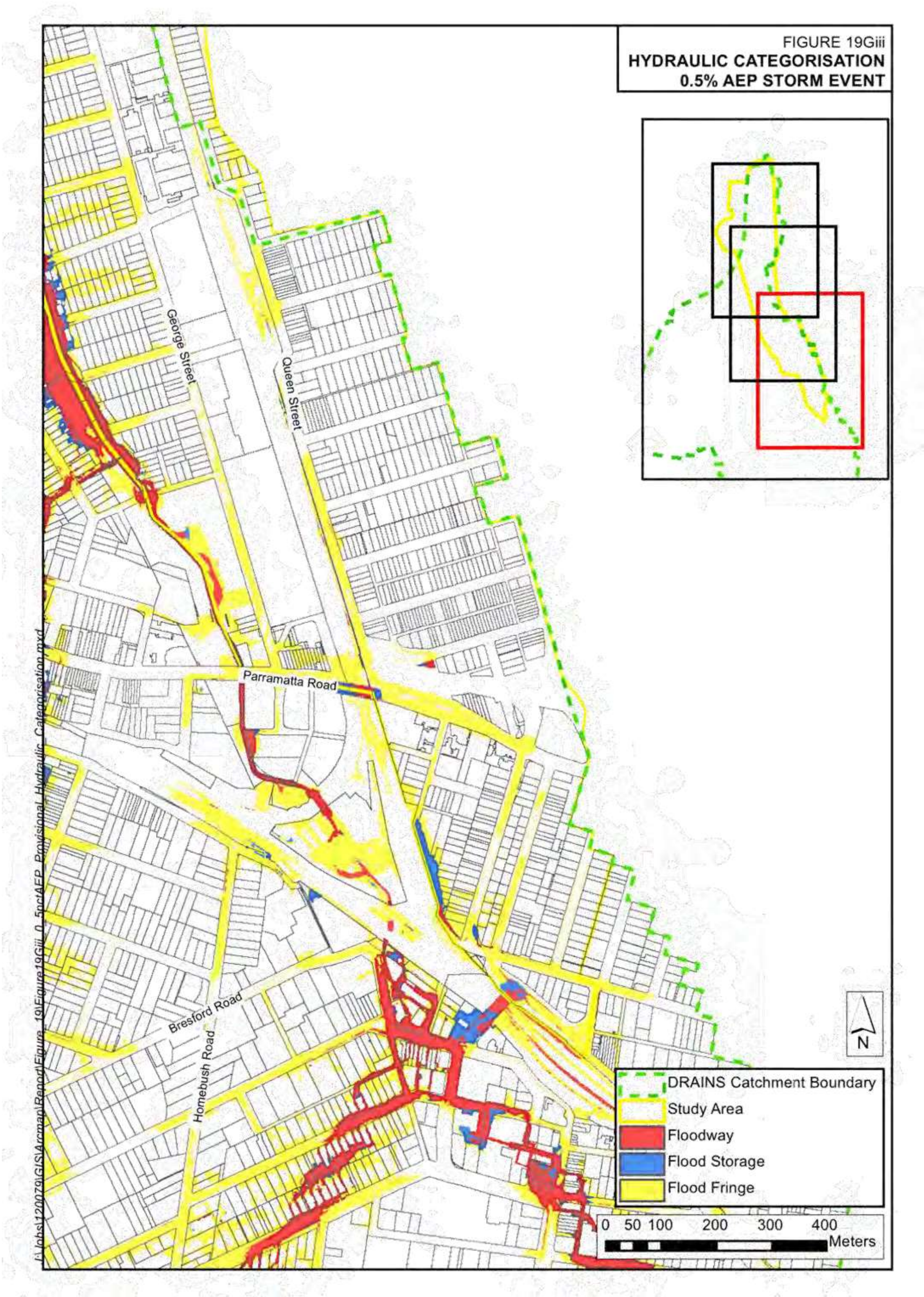


FIGURE 19Giii
HYDRAULIC CATEGORISATION
0.5% AEP STORM EVENT
George Street
Queen Street
Parramatta Road
Bresford Road
Homebush Road
DRAINS Catchment Boundary
Study Area
Floodway
Flood Storage
Flood Fringe
0 50 100 200 300 400
Meters
N

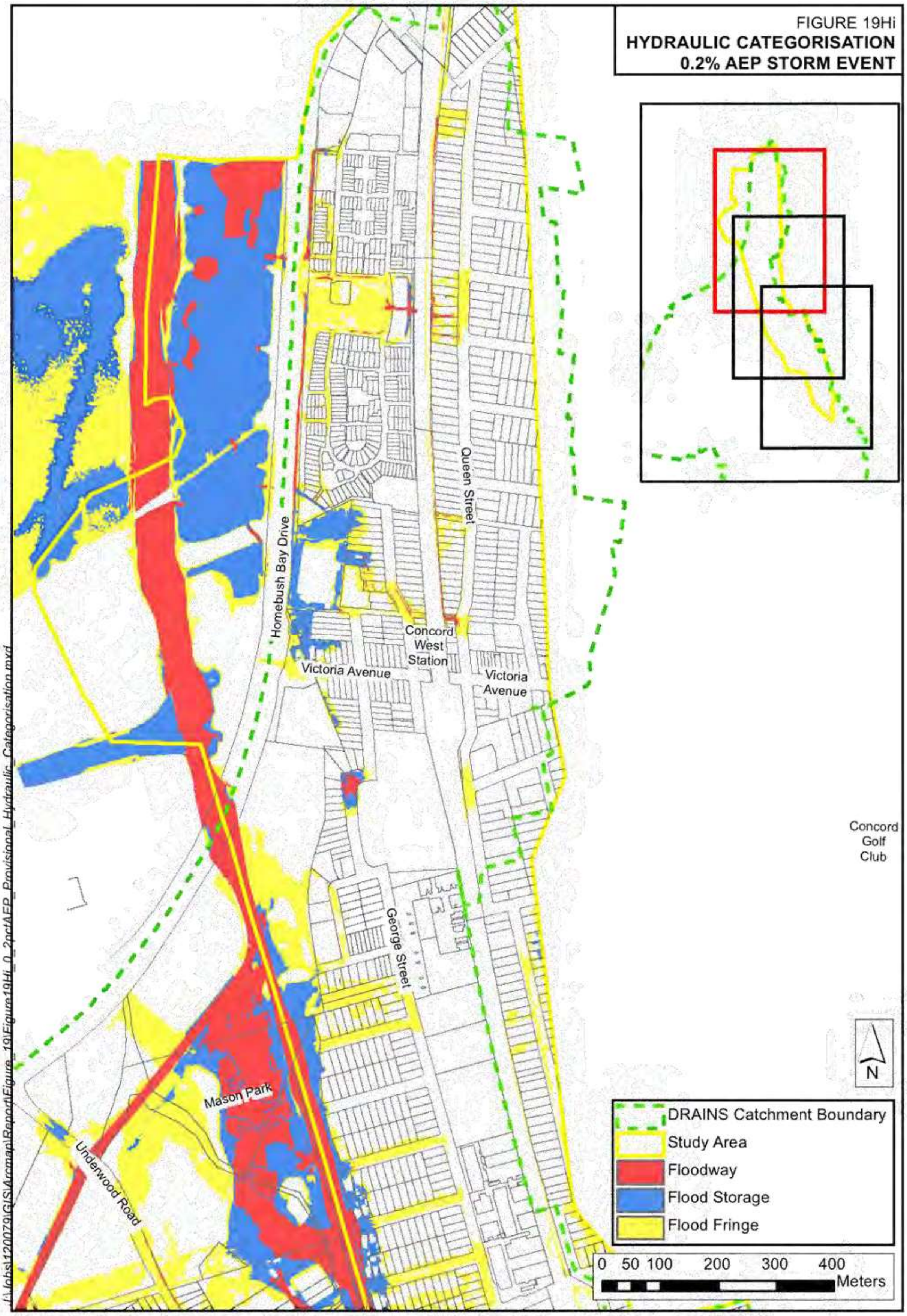


FIGURE 19Hi
HYDRAULIC CATEGORISATION
0.2% AEP STORM EVENT
Homebush Bay Drive
Queen Street
Concord West Station
Victoria Avenue
Victoria Avenue
George Street
Mason Park
Underwood Road
Concord Golf Club
N
DRAINS Catchment Boundary
Study Area
Floodway
Flood Storage
Flood Fringe
0 50 100 200 300 400
Meters
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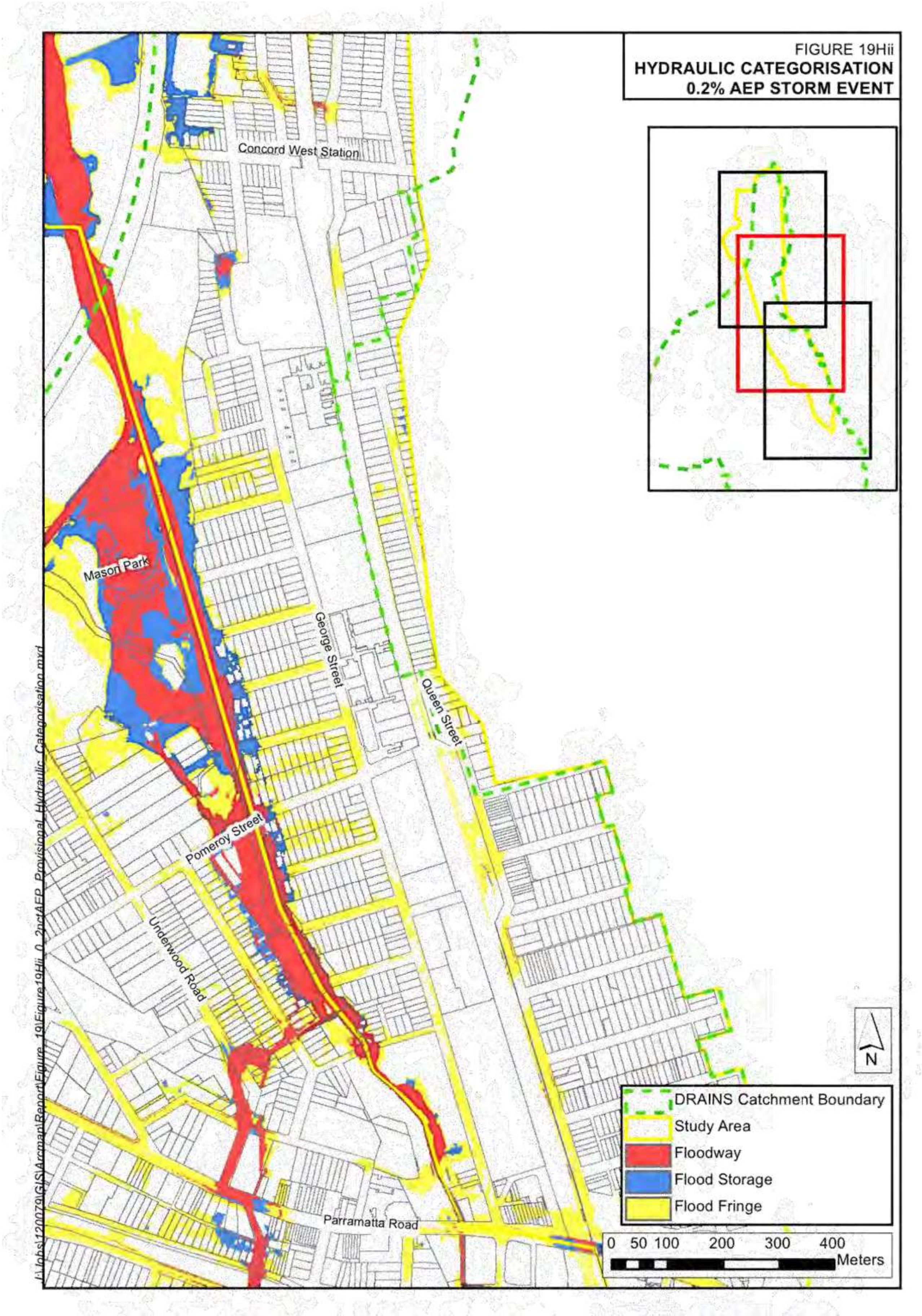
FIGURE 19Hii
HYDRAULIC CATEGORISATION
0.2% AEP STORM EVENT
Concord West Station
Mason Park
George Street
Queen Street
Pomeroy Street
Underwood Road
Parramatta Road
N
DRAINS Catchment Boundary
Study Area
Floodway
Flood Storage
Flood Fringe
0 50 100 200 300 400
Meters

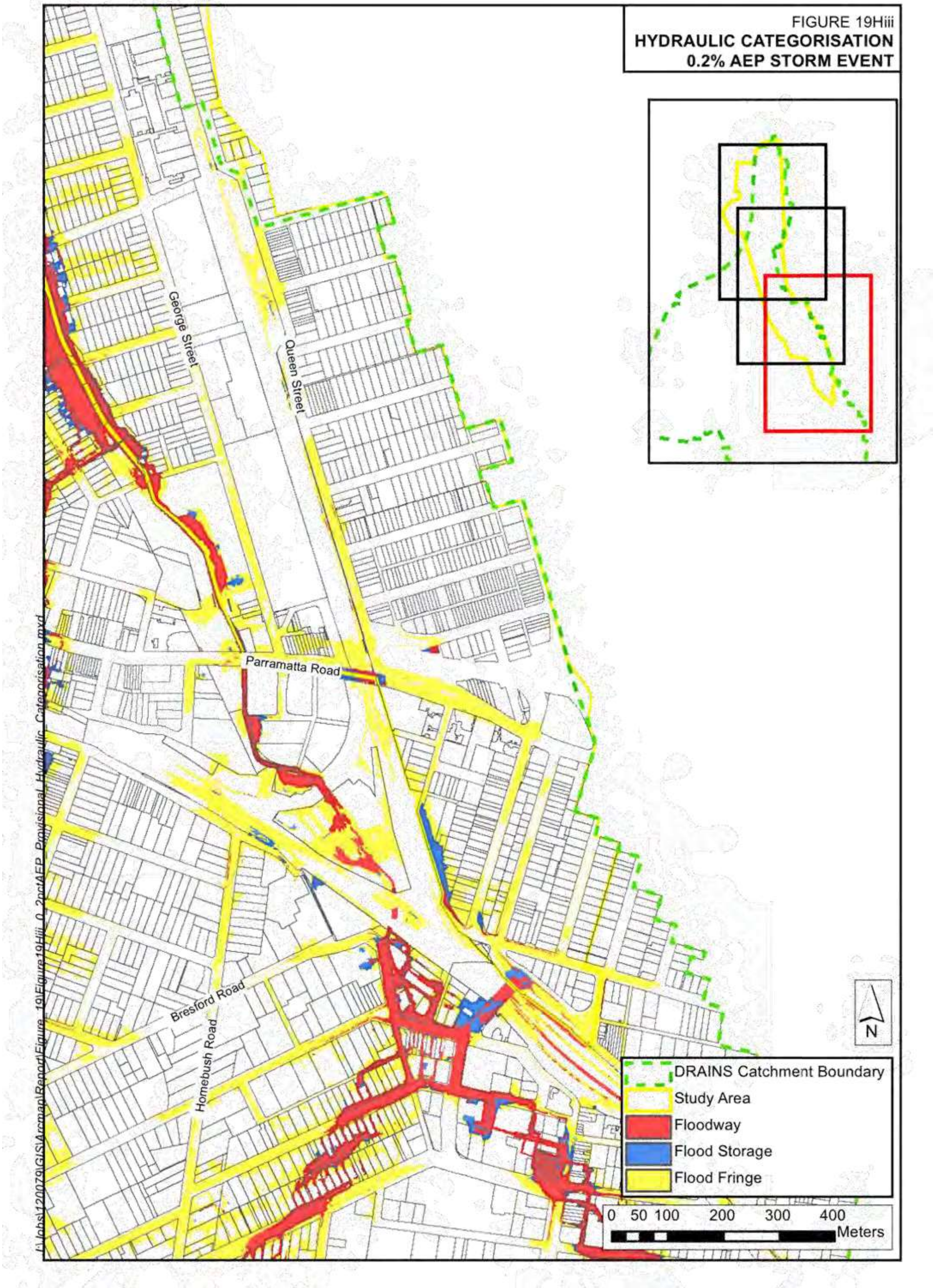
FIGURE 19Hiii
HYDRAULIC CATEGORISATION
0.2% AEP STORM EVENT
George Street
Queen Street
Parramatta Road
Bresford Road
Homebush Road
DRAINS Catchment Boundary
Study Area
Floodway
Flood Storage
Flood Fringe
N
0 50 100 200 300 400
Meters

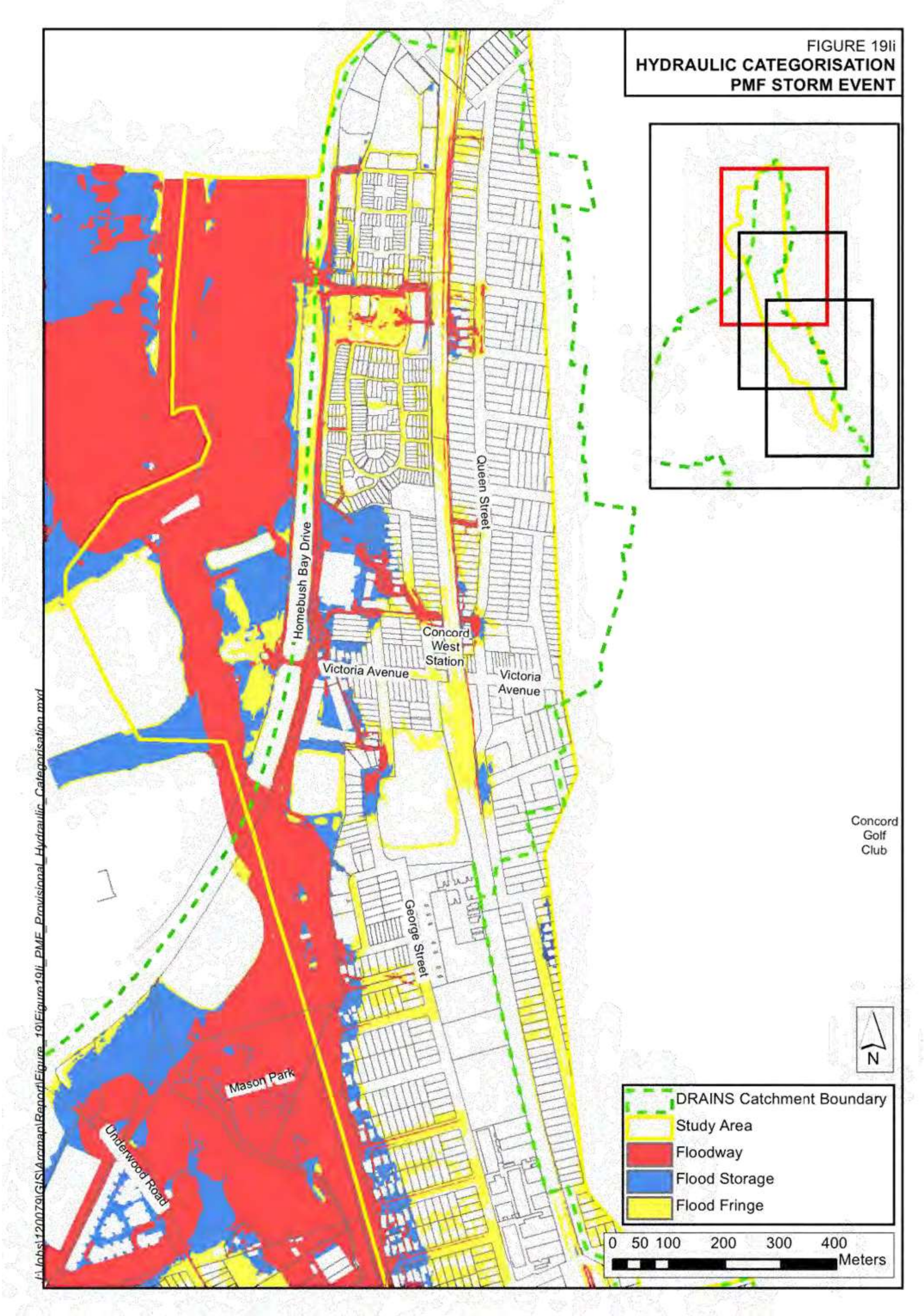
FIGURE 19Ii
HYDRAULIC CATEGORISATION
PMF STORM EVENT
Queen Street
Homebush Bay Drive
Concord West Station
Victoria Avenue
Victoria Avenue
George Street
Concord Golf Club
Mason Park
Underwood Road
N
DRAINS Catchment Boundary
Study Area
Floodway
Flood Storage
Flood Fringe
0 50 100 200 300 400
Meters

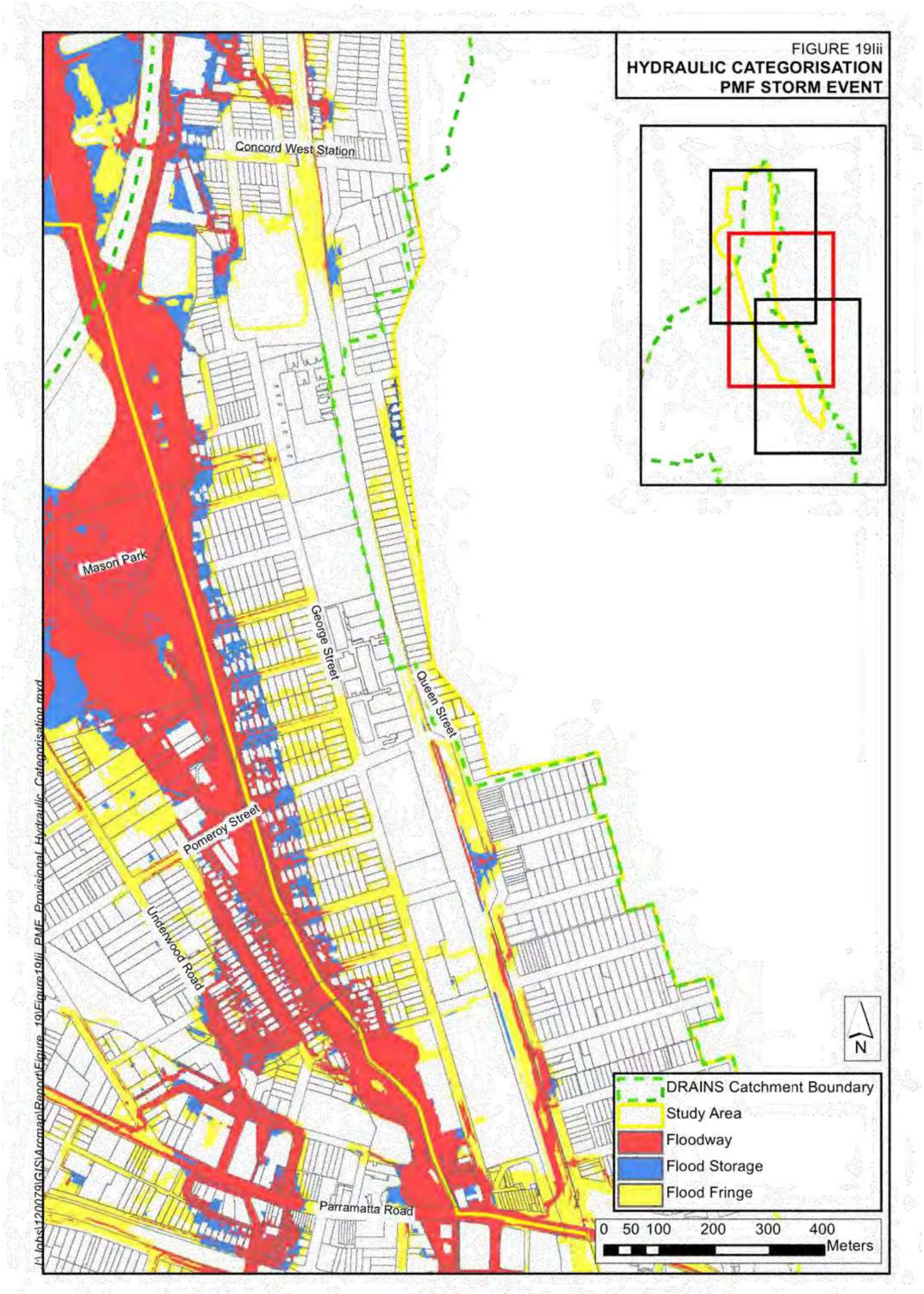
FIGURE 19Iii
HYDRAULIC CATEGORISATION
PMF STORM EVENT
Concord West Station
Mason Park
George Street
Queen Street
Pomeroy Street
Underwood Road
Parramatta Road
DRAINS Catchment Boundary
Study Area
Floodway
Flood Storage
Flood Fringe
0 50 100 200 300 400
Meters
N

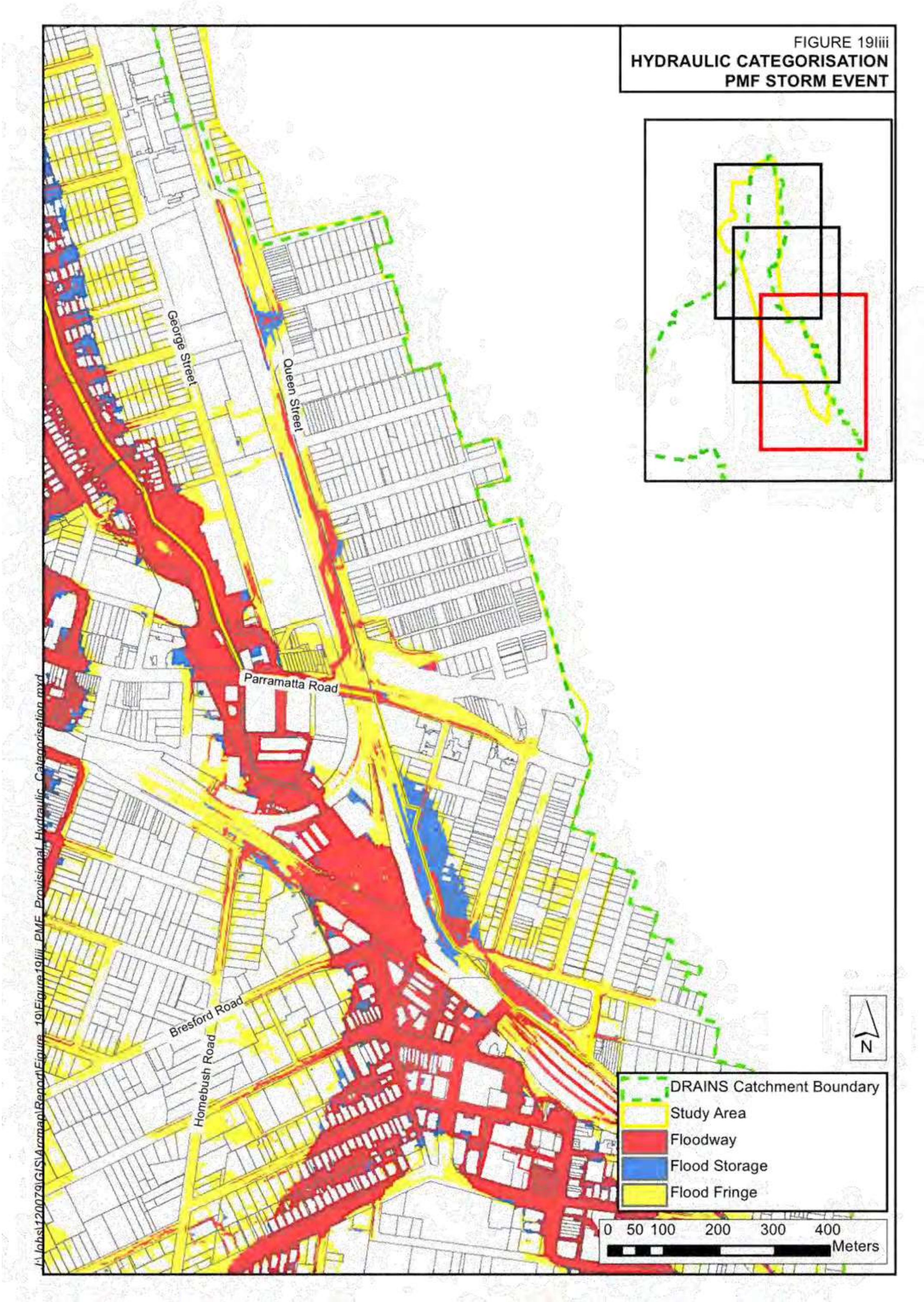
FIGURE 19liii
HYDRAULIC CATEGORISATION
PMF STORM EVENT
George Street
Queen Street
Parramatta Road
Bresford Road
Homebush Road
DRAINS Catchment Boundary
Study Area
Floodway
Flood Storage
Flood Fringe
0 50 100 200 300 400
Meters
N


FIGURE 20A
PRELIMINARY FLOOD EMERGENCY RESPONSE
CLASSIFICATION OF COMMUNITIES
Concord West Station
Mason Park
Concord Golf Club
N
Study Area
DRAINS Catchment Boundary
Not Flooded
Flooded Exit Route
Flooded Isolated Elevated
Flooded Isolated Submerged
0 50 100 200 300 400
Meters
J:\Jobs\120079\GIS\Arcmap\Report\Main\Figure20A Preliminary Flood Emergency Response Classification of Communities.mxd

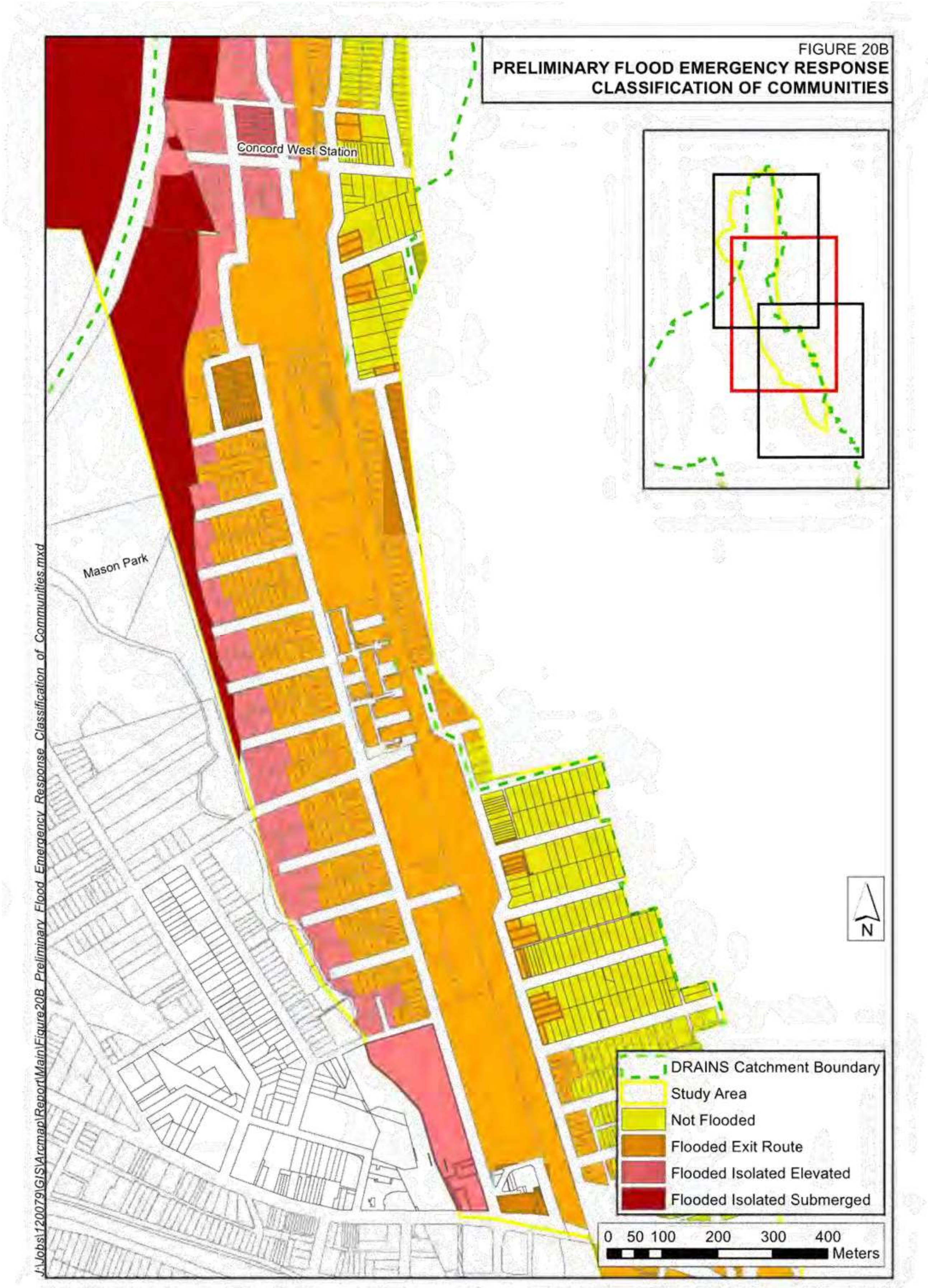
FIGURE 20B
PRELIMINARY FLOOD EMERGENCY RESPONSE
CLASSIFICATION OF COMMUNITIES
Concord West Station
Mason Park
J:\Jobs\120079\GIS\Arcmap\Report\Main\Figure20B_Preliminary_Flood_Emergency_Response_Classification_of_Communities.mxd
DRAINS Catchment Boundary
Study Area
Not Flooded
Flooded Exit Route
Flooded Isolated Elevated
Flooded Isolated Submerged
0 50 100 200 300 400
Meters
N

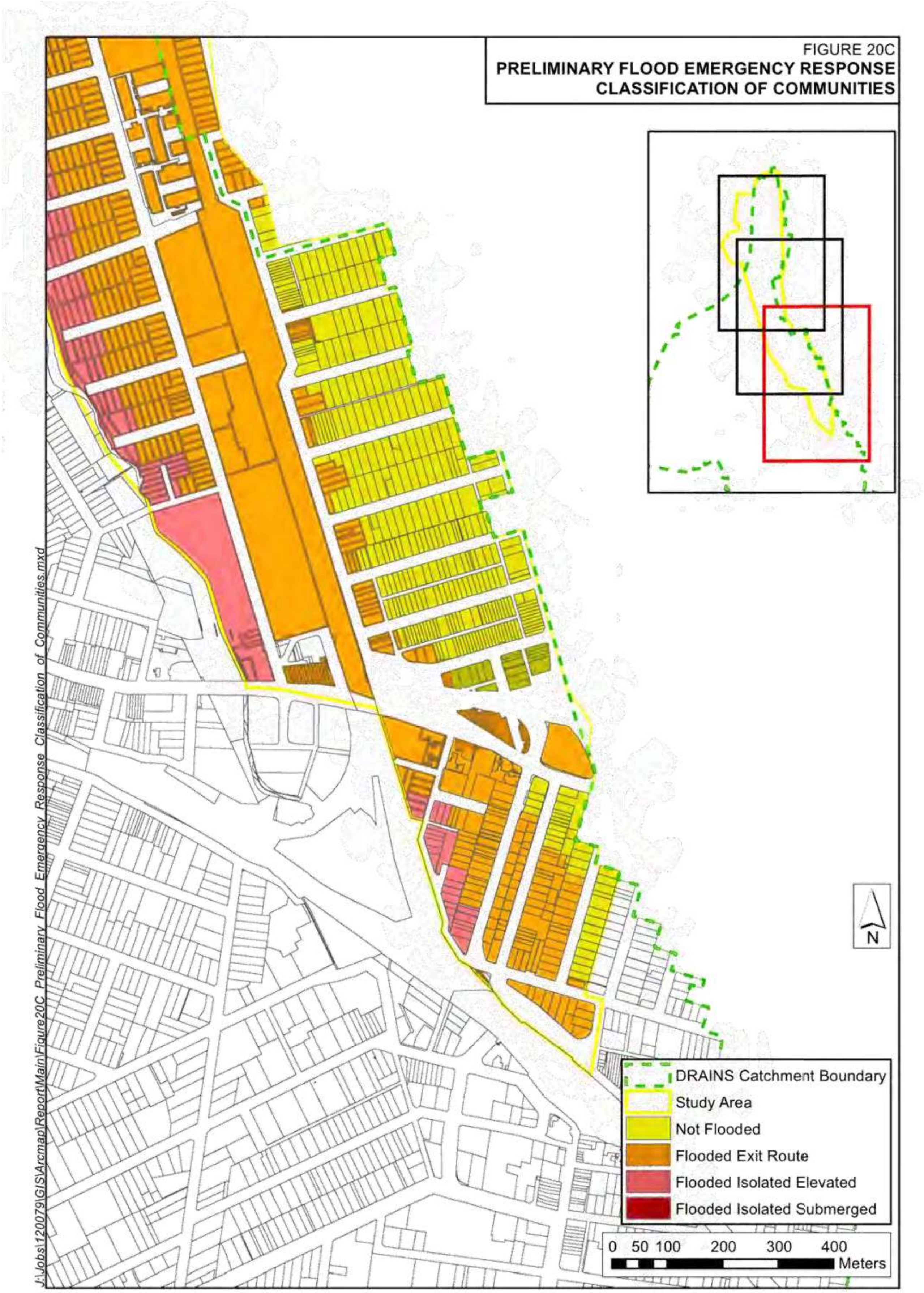
FIGURE 20C
PRELIMINARY FLOOD EMERGENCY RESPONSE
CLASSIFICATION OF COMMUNITIES
DRAINS Catchment Boundary
Study Area
Not Flooded
Flooded Exit Route
Flooded Isolated Elevated
Flooded Isolated Submerged
0 50 100 200 300 400
Meters
N
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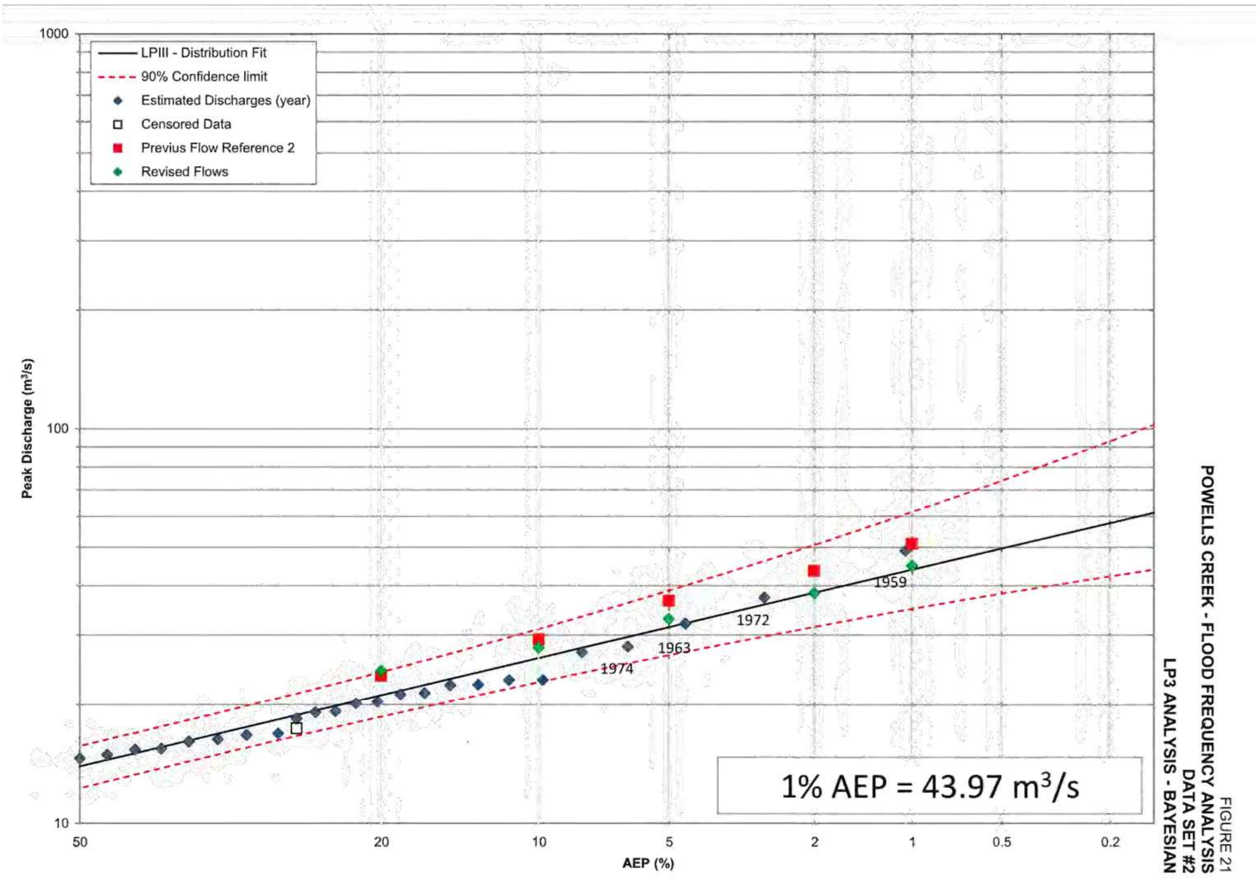

FIGURE 21
POWELLS CREEK - FLOOD FREQUENCY ANALYSIS
DATA SET #2
LP3 ANALYSIS - BAYESIAN

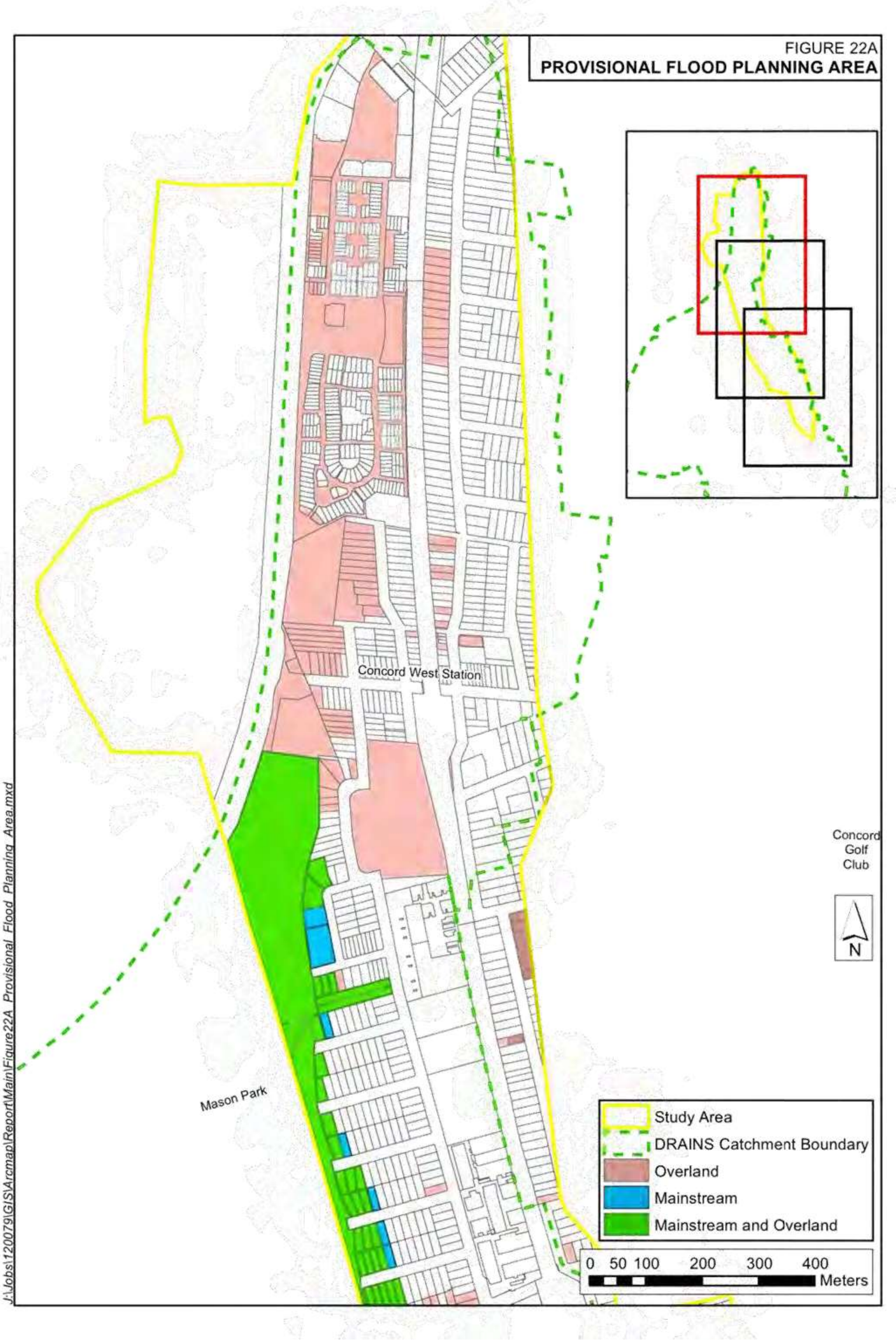
FIGURE 22A
PROVISIONAL FLOOD PLANNING AREA
Concord West Station
Concord Golf Club
N
Mason Park
Study Area
DRAINS Catchment Boundary
Overland
Mainstream
Mainstream and Overland
0 50 100 200 300 400
Meters
J:\Jobs\120079\GIS\Arcmap\Report\Main\Figure22A_Provisional_Flood_Planning_Area.mxd

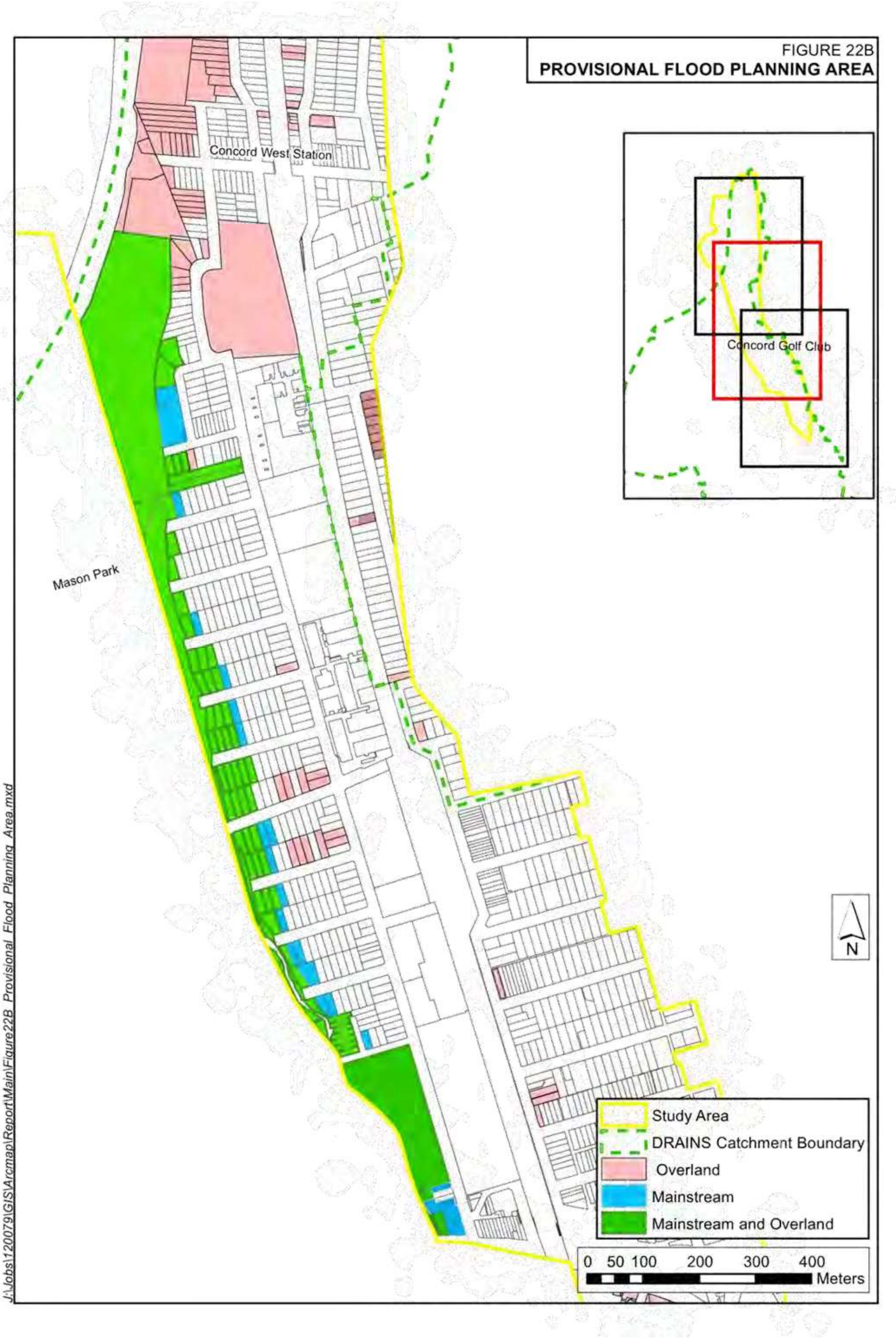
FIGURE 22B
PROVISIONAL FLOOD PLANNING AREA
Concord West Station
Mason Park
Concord Golf Club
N
Study Area
DRAINS Catchment Boundary
Overland
Mainstream
Mainstream and Overland
0 50 100 200 300 400
Meters
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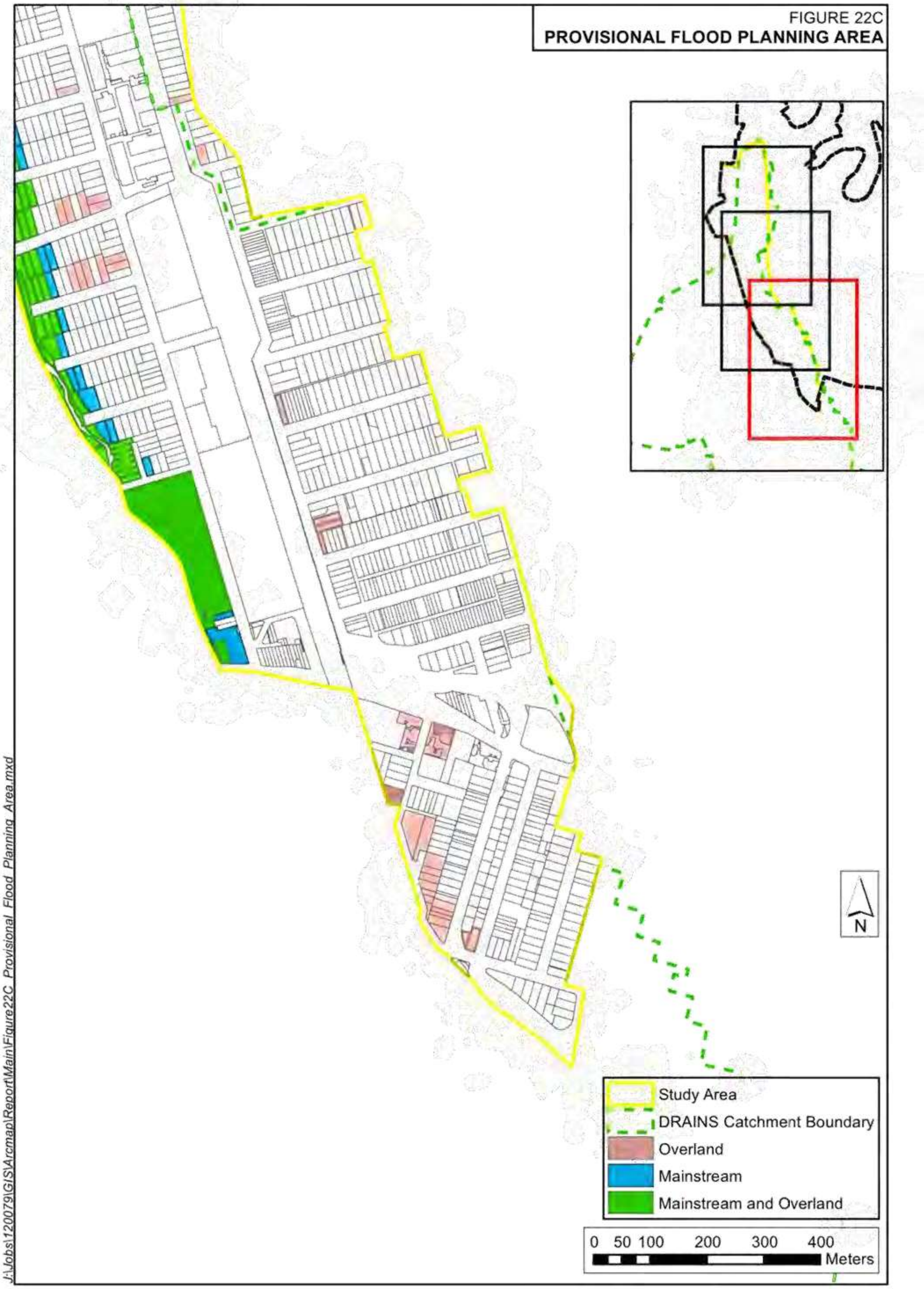
FIGURE 22C
PROVISIONAL FLOOD PLANNING AREA
Study Area
DRAINS Catchment Boundary
Overland
Mainstream
Mainstream and Overland
0 50 100 200 300 400
Meters
N
J:\Jobs\120079\GIS\Arcmap\Report\Main\Figure22C_Provisional_Flood_Planning_Area.mxd

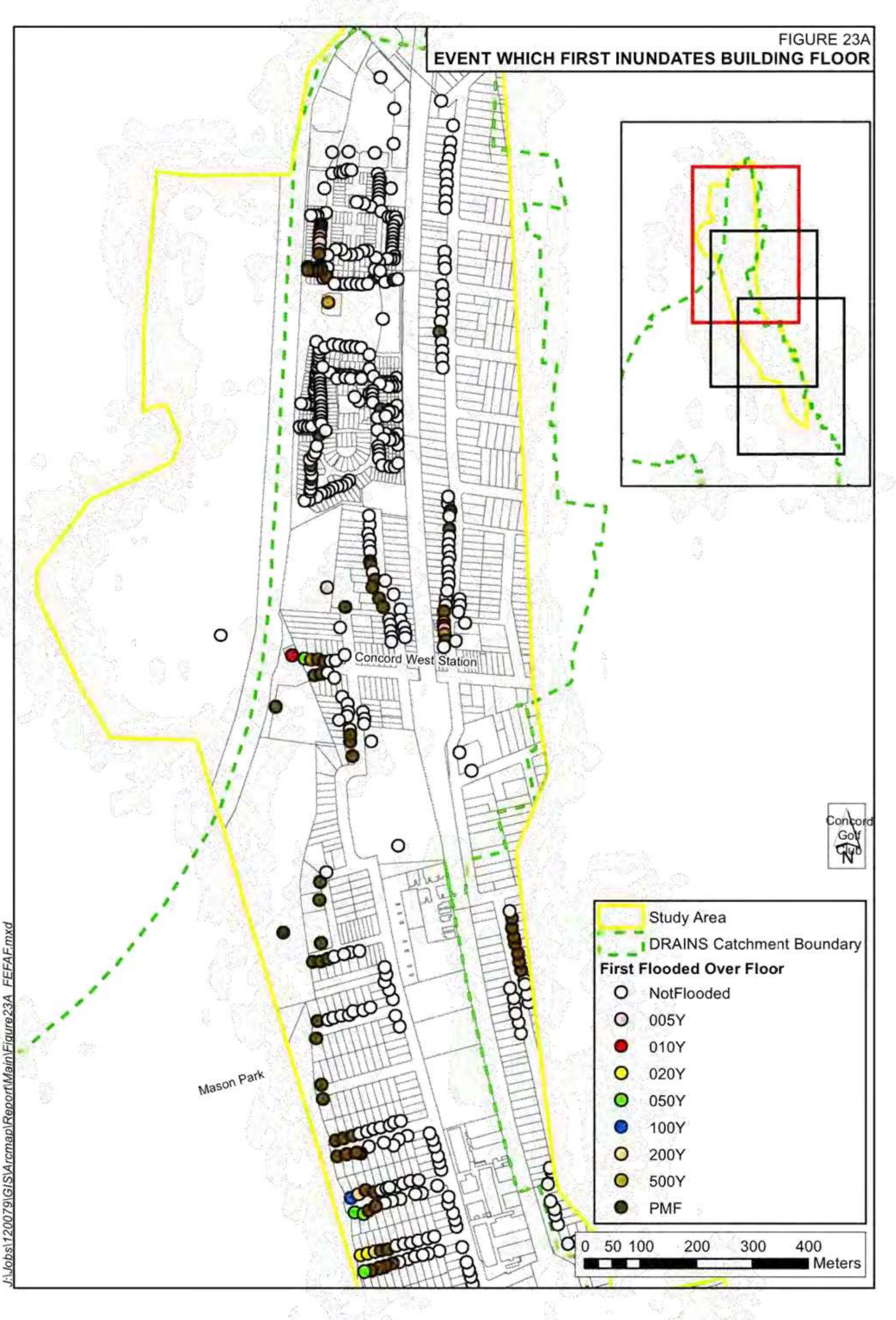
FIGURE 23A
EVENT WHICH FIRST INUNDATES BUILDING FLOOR
Concord West Station
Mason Park
Concord Golf Club
N
Study Area
DRAINS Catchment Boundary
First Flooded Over Floor
NotFlooded
005Y
010Y
020Y
050Y
100Y
200Y
500Y
PMF
0 50 100 200 300 400
Meters
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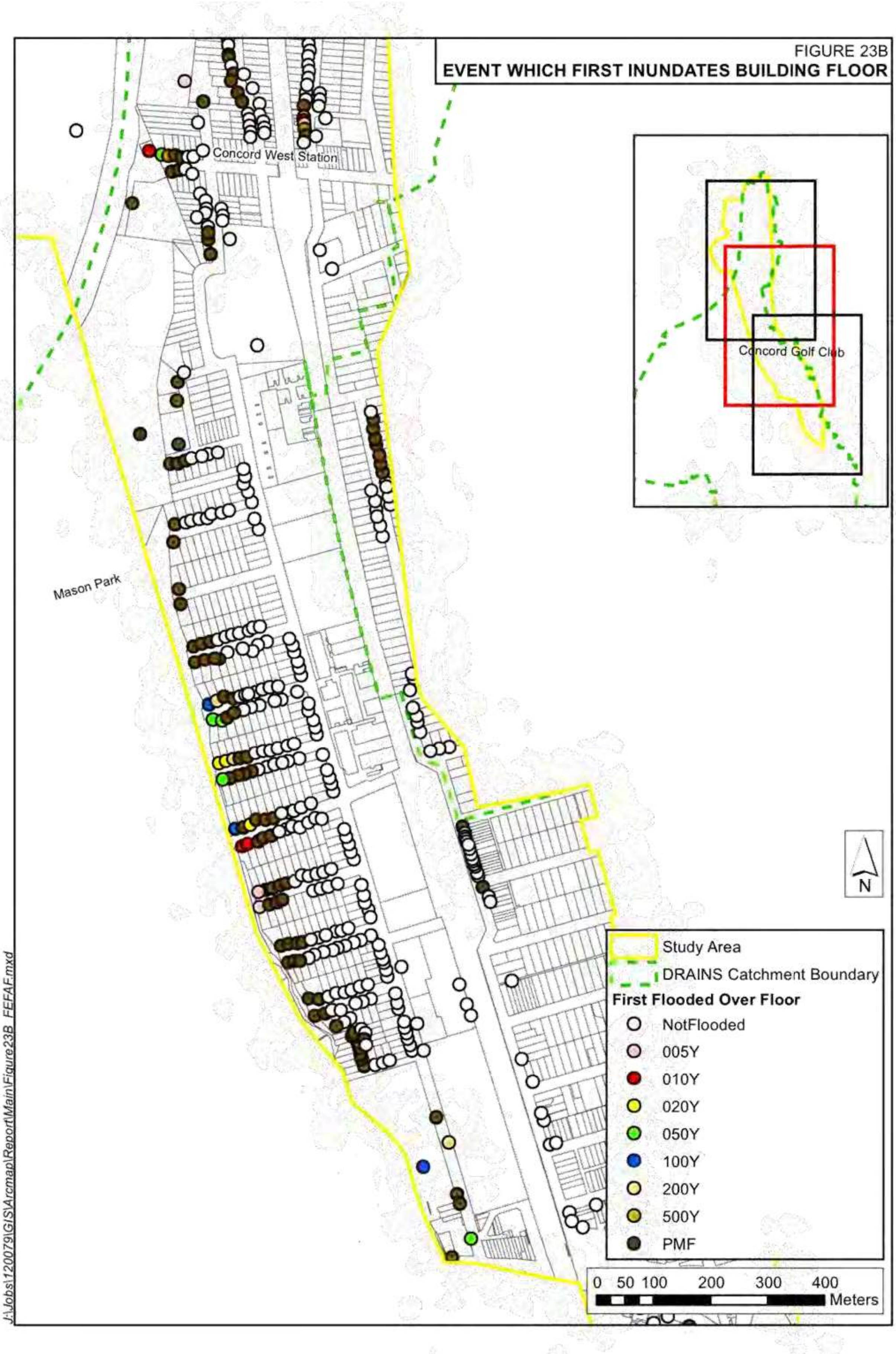
FIGURE 23B
EVENT WHICH FIRST INUNDATES BUILDING FLOOR
Concord West Station
Mason Park
Concord Golf Club
N
Study Area
DRAINS Catchment Boundary
First Flooded Over Floor
NotFlooded
005Y
010Y
020Y
050Y
100Y
200Y
500Y
PMF
0 50 100 200 300 400
Meters
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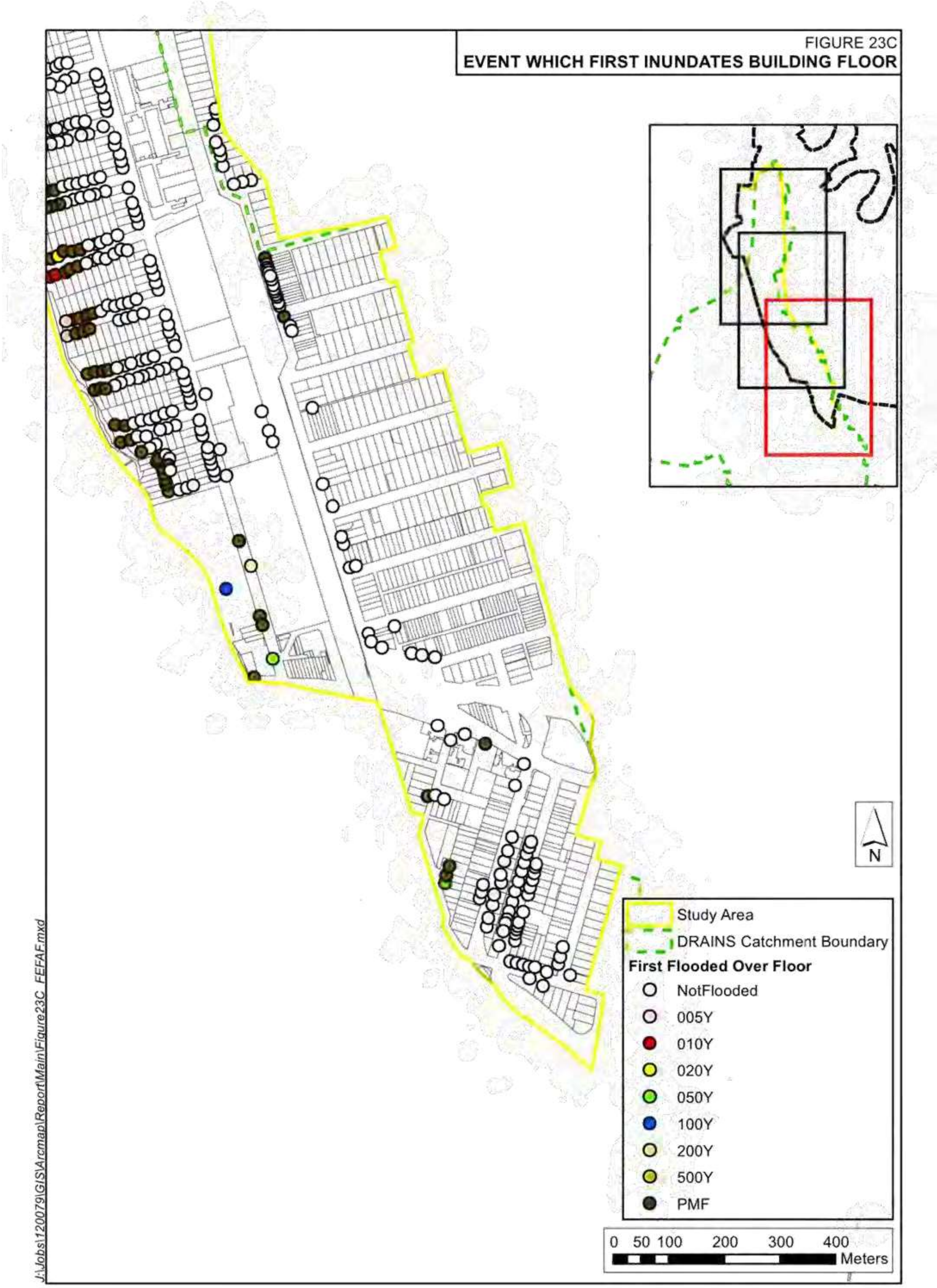
FIGURE 23C
EVENT WHICH FIRST INUNDATES BUILDING FLOOR
Study Area
DRAINS Catchment Boundary
First Flooded Over Floor
NotFlooded
005Y
010Y
020Y
050Y
100Y
200Y
500Y
PMF
0 50 100 200 300 400
Meters
N
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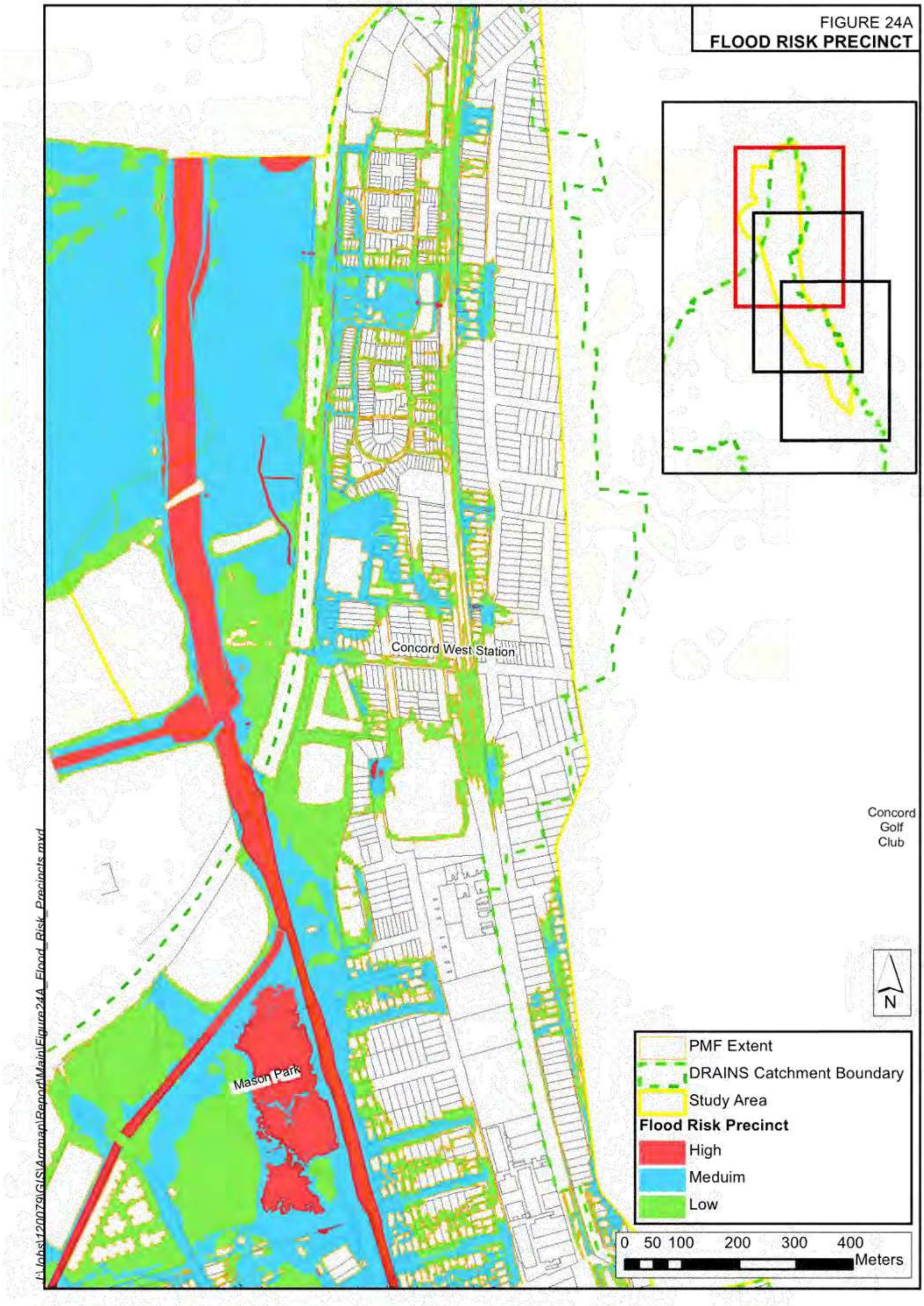
FIGURE 24A
FLOOD RISK PRECINCT
Concord West Station
Mason Park
Concord Golf Club
N
PMF Extent
DRAINS Catchment Boundary
Study Area
Flood Risk Precinct
High
Meduim
Low
0 50 100 200 300 400
Meters

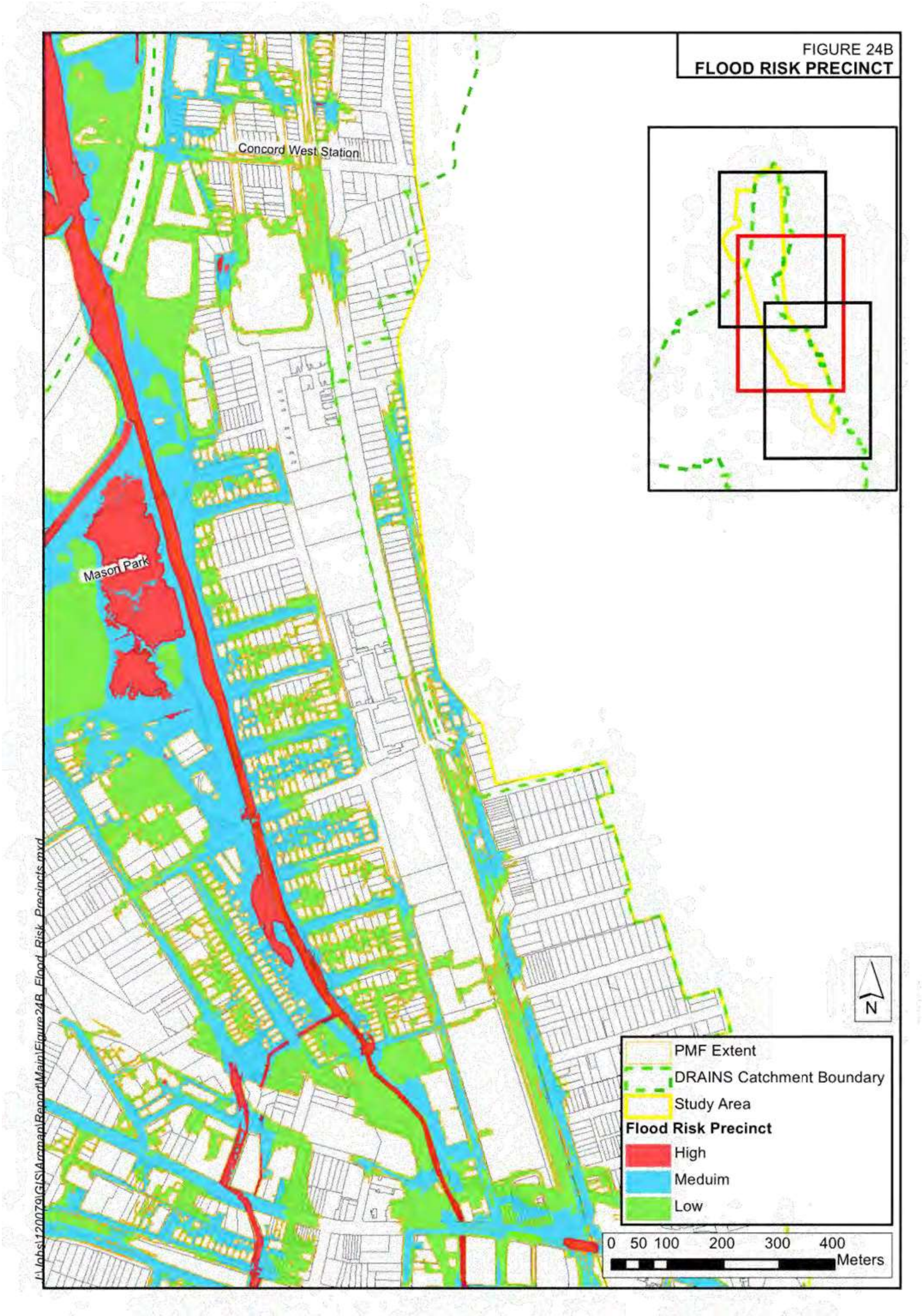
FIGURE 24B
FLOOD RISK PRECINCT
Concord West Station
Mason Park
PMF Extent
DRAINS Catchment Boundary
Study Area
Flood Risk Precinct
High
Meduim
Low
0 50 100 200 300 400
Meters
N
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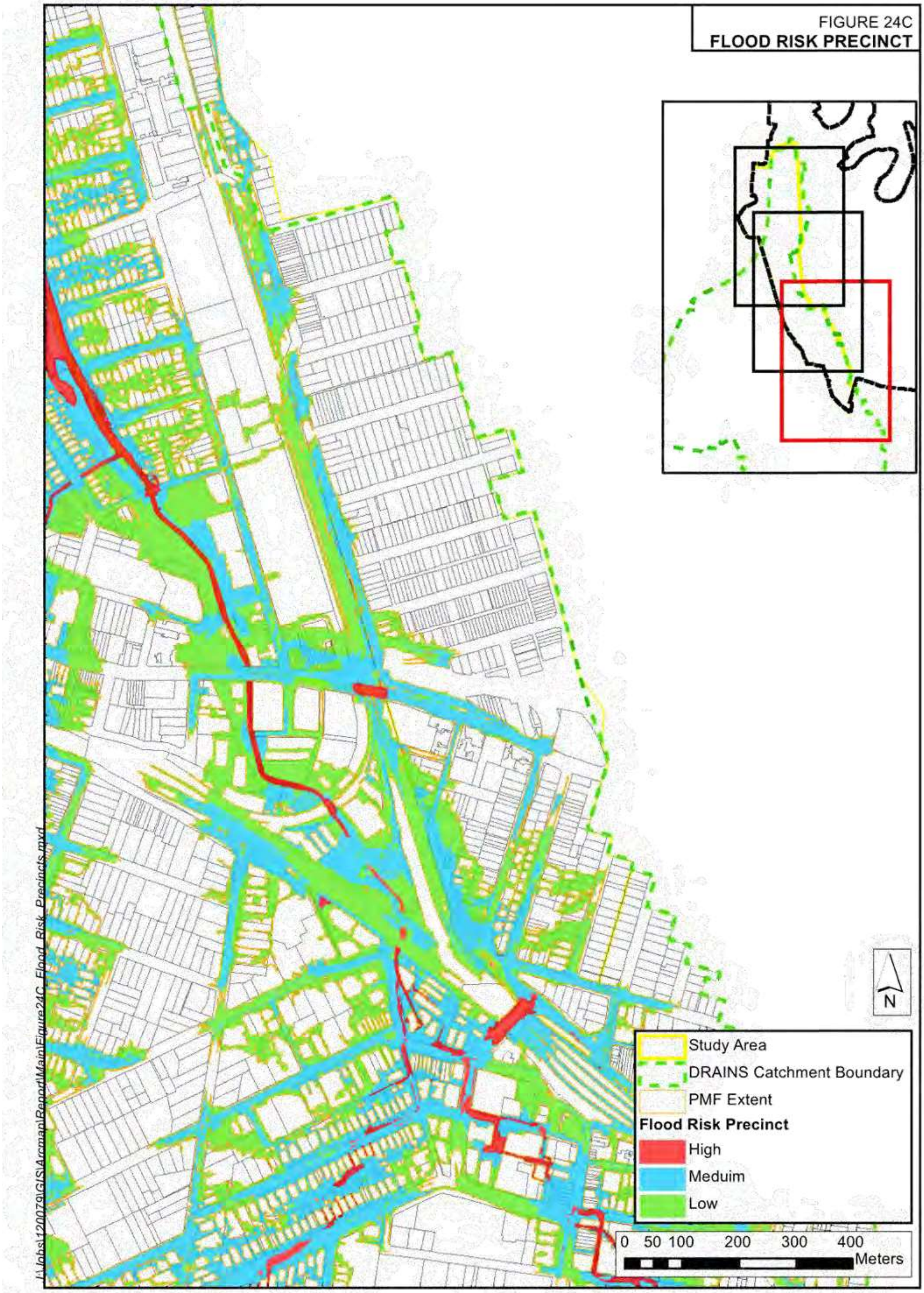
FIGURE 24C
FLOOD RISK PRECINCT
Study Area
DRAINS Catchment Boundary
PMF Extent
Flood Risk Precinct
High
Meduim
Low
0 50 100 200 300 400
Meters
N
J:\Jobs\120079\GIS\Arcmap\Report\Main\Figure24C_Flood_Risk_Precincts.mxd

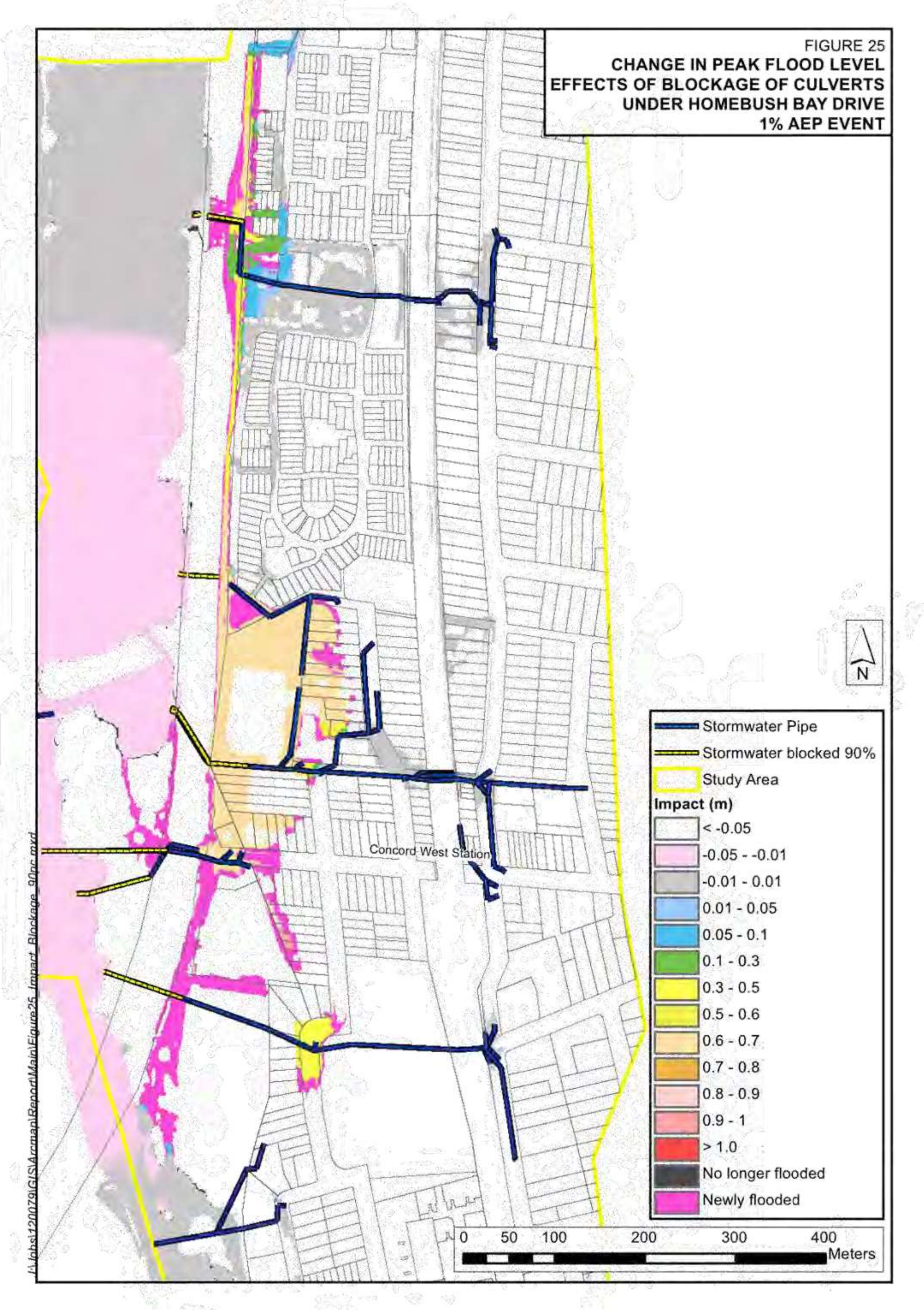
FIGURE 25
CHANGE IN PEAK FLOOD LEVEL
EFFECTS OF BLOCKAGE OF CULVERTS
UNDER HOMEBUSH BAY DRIVE
1% AEP EVENT
Concord West Station
N
Stormwater Pipe
Stormwater blocked 90%
Study Area
Impact (m)
< -0.05
-0.05 - -0.01
-0.01 - 0.01
0.01 - 0.05
0.05 - 0.1
0.1 - 0.3
0.3 - 0.5
0.5 - 0.6
0.6 - 0.7
0.7 - 0.8
0.8 - 0.9
0.9 - 1
> 1.0
No longer flooded
Newly flooded
0 50 100 200 300 400
Meters

Appendix A

APPENDIX A: GLOSSARY of TERMS

Taken from the Floodplain Development Manual (April 2005 edition)

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. For example, if a peak flood discharge of 500 m^3/s has an AEP of 5%, it means that there is a 5% chance (that is one-in-20 chance) of a 500 m^3/s or larger event occurring in any one year (see ARI).
Australian Height Datum (AHD)	A common national surface level datum approximately corresponding to mean sea level.
Average Annual Damage (AAD)	Depending on its size (or severity), each flood will cause a different amount of flood damage to a flood prone area. AAD is the average damage per year that would occur in a nominated development situation from flooding over a very long period of time.
Average Recurrence Interval (ARI)	The long term average number of years between the occurrence of a flood as big as, or larger than, the selected event. For example, floods with a discharge as great as, or greater than, the 20 year ARI flood event will occur on average once every 20 years. ARI is another way of expressing the likelihood of occurrence of a flood event.
caravan and moveable home parks	Caravans and moveable dwellings are being increasingly used for long-term and permanent accommodation purposes. Standards relating to their siting, design, construction and management can be found in the Regulations under the LG Act.
catchment	The land area draining through the main stream, as well as tributary streams, to a particular site. It always relates to an area above a specific location.
consent authority	The Council, Government agency or person having the function to determine a development application for land use under the EP&A Act. The consent authority is most often the Council, however legislation or an EPI may specify a Minister or public authority (other than a Council), or the Director General of DIPNR, as having the function to determine an application.
development	Is defined in Part 4 of the Environmental Planning and Assessment Act (EP&A Act). **infill development:** refers to the development of vacant blocks of land that are generally surrounded by developed properties and is permissible under the current zoning of the land. Conditions such as minimum floor levels may be imposed on infill development. **new development:** refers to development of a completely different nature to that associated with the former land use. For example, the urban subdivision of an area previously used for rural purposes. New developments involve rezoning and typically require major extensions of existing urban services, such as roads, water supply, sewerage and electric power. **redevelopment:** refers to rebuilding in an area. For example, as urban areas age, it may become necessary to demolish and reconstruct buildings on a relatively large scale. Redevelopment generally does not require either rezoning or major extensions to urban services.
disaster plan (DISPLAN)	A step by step sequence of previously agreed roles, responsibilities, functions, actions and management arrangements for the conduct of a single or series of

	connected emergency operations, with the object of ensuring the coordinated response by all agencies having responsibilities and functions in emergencies.
discharge	The rate of flow of water measured in terms of volume per unit time, for example, cubic metres per second (m^3/s). Discharge is different from the speed or velocity of flow, which is a measure of how fast the water is moving for example, metres per second (m/s).
ecologically sustainable development (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 before entering a watercourse, and/or coastal inundation resulting from super-elevated sea levels and/or waves overtopping coastline defences excluding tsunami.
flood awareness	Flood awareness is an appreciation of the likely effects of flooding and a knowledge of the relevant flood warning, response and evacuation procedures.
flood education	Flood education seeks to provide information to raise awareness of the flood problem so as to enable individuals to understand how to manage themselves an their property in response to flood warnings and in a flood event. It invokes a state of flood readiness.
flood fringe areas	The remaining area of flood prone land after floodway and flood storage areas have been defined.
flood liable land	Is synonymous with flood prone land (i.e. land susceptible to flooding by the probable maximum flood (PMF) event). Note that the term flood liable land covers the whole of the floodplain, not just that part below the flood planning level (see flood planning area).
flood mitigation standard	The average recurrence interval of the flood, selected as part of the floodplain risk management process that forms the basis for physical works to modify the impacts of flooding.
floodplain	Area of land which is subject to inundation by floods up to and including the probable maximum flood event, that is, flood prone land.
floodplain risk management options	The measures that might be feasible for the management of a particular area of the floodplain. Preparation of a floodplain risk management plan requires a detailed evaluation of floodplain risk management options.
floodplain risk management plan	A management plan developed in accordance with the principles and guidelines in this manual. Usually includes both written and 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 State Emergency Service.
flood planning area	The area of land below the flood planning level and thus subject to flood related development controls. The concept of flood planning area generally supersedes the "flood liable land" concept in the 1986 Manual.
Flood Planning Levels (FPLs)	FPL's are the combinations of flood levels (derived from significant historical flood events or floods of specific AEPs) and freeboards selected for floodplain risk management purposes, as determined in management studies and incorporated in management plans. FPLs supersede the "standard flood event" in the 1986 manual.
flood proofing	A combination of measures incorporated in the design, construction and alteration of individual buildings or structures subject to flooding, to reduce or eliminate flood damages.
flood prone land	Is land susceptible to flooding by the Probable Maximum Flood (PMF) event. Flood prone land is synonymous with flood liable land.
flood readiness	Flood readiness is an ability to react within the effective warning time.
flood risk	Potential danger to personal safety and potential damage to property resulting from flooding. The degree of risk varies with circumstances across the full range of floods. Flood risk in this manual is divided into 3 types, existing, future and continuing risks. They are described below. **existing flood risk:** the risk a community is exposed to as a result of its location on the floodplain. **future flood risk:** the risk a community may be exposed to as a result of new development on the floodplain. **continuing flood risk:** the risk a community is exposed to after floodplain risk management measures have been implemented. For a town protected by levees, the continuing flood risk is the consequences of the levees being overtopped. For an area without any floodplain risk management measures, the continuing flood risk is simply the existence of its flood exposure.
flood storage areas	Those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood. The extent and behaviour of flood storage areas may change with flood severity, and loss of flood storage can increase the severity of flood impacts by reducing natural flood attenuation. Hence, it is necessary to investigate a range of flood sizes before defining flood storage areas.
floodway areas	Those areas of the floodplain where a significant discharge of water occurs during floods. They are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flows, or a significant increase in flood levels.
freeboard	Freeboard provides reasonable certainty that the risk exposure selected in deciding on a particular flood chosen as the basis for the FPL is actually provided. It is a factor of safety typically used in relation to the setting of floor levels, levee crest levels, etc. Freeboard is included in the flood planning level.
habitable room	**in a residential situation:** a living or working area, such as a lounge room, dining room, rumpus room, kitchen, bedroom or workroom. **in an industrial or commercial situation:** an area used for offices or to store valuable possessions susceptible to flood damage in the event of a flood.
hazard	A source of potential harm or a situation with a potential to cause loss. In relation to this manual the hazard is flooding which has the potential to cause damage to

	the community. Definitions of high and low hazard categories are provided in the Manual.
hydraulics	Term given to the study of water flow in waterways; in particular, the evaluation of flow parameters such as water level and velocity.
hydrograph	A graph which shows how the discharge or stage/flood level at any particular location varies with time during a flood.
hydrology	Term given to the study of the rainfall and runoff process; in particular, the evaluation of peak flows, flow volumes and the derivation of hydrographs for a range of floods.
local overland flooding	Inundation by local runoff rather than overbank discharge from a stream, river, estuary, lake or dam.
local drainage	Are smaller scale problems in urban areas. They are outside the definition of major drainage in this glossary.
mainstream flooding	Inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam.
major drainage	Councils have discretion in determining whether urban drainage problems are associated with major or local drainage. For the purpose of this manual major drainage involves: • the floodplains of original watercourses (which may now be piped, channelised or diverted), or sloping areas where overland flows develop along alternative paths once system capacity is exceeded; and/or • water depths generally in excess of 0.3 m (in the major system design storm as defined in the current version of Australian Rainfall and Runoff). These conditions may result in danger to personal safety and property damage to both premises and vehicles; and/or • major overland flow paths through developed areas outside of defined drainage reserves; and/or • the potential to affect a number of buildings along the major flow path.
mathematical/computer models	The mathematical representation of the physical processes involved in runoff generation and stream flow. These models are often run on computers due to the complexity of the mathematical relationships between runoff, stream flow and the distribution of flows across the floodplain.
merit approach	The merit approach weighs social, economic, ecological and cultural impacts of land use options for different flood prone areas together with flood damage, hazard and behaviour implications, and environmental protection and well being of the State's rivers and floodplains. The merit approach operates at two levels. At the strategic level it allows for the consideration of social, economic, ecological, cultural and flooding issues to determine strategies for the management of future flood risk which are formulated into Council plans, policy and EPIs. At a site specific level, it involves consideration of the best way of conditioning development allowable under the floodplain risk management plan, local floodplain risk management policy and EPIs.
minor, moderate and major flooding	Both the State Emergency Service and the Bureau of Meteorology use the following definitions in flood warnings to give a general indication of the types of problems expected with a flood: **minor flooding:** causes inconvenience such as closing of minor roads and the submergence of low level bridges. The lower limit of this class of flooding on the reference gauge is the initial flood level at which landholders and townspeople begin to be flooded.

	moderate flooding: low-lying areas are inundated requiring removal of stock and/or evacuation of some houses. Main traffic routes may be covered. **major flooding:** appreciable urban areas are flooded and/or extensive rural areas are flooded. Properties, villages and towns can be isolated.
modification measures	Measures that modify either the flood, the property or the response to flooding. Examples are indicated in Table 2.1 with further discussion in the Manual.
peak discharge	The maximum discharge occurring during a flood event.
Probable Maximum Flood (PMF)	The PMF is the largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation, and where applicable, snow melt, coupled with the worst flood producing catchment conditions. Generally, it is not physically or economically possible to provide complete protection against this event. The PMF defines the extent of flood prone land, that is, the floodplain. The extent, nature and potential consequences of flooding associated with a range of events rarer than the flood used for designing mitigation works and controlling development, up to and including the PMF event should be addressed in a floodplain risk management study.
Probable Maximum Precipitation (PMP)	The PMP is the greatest depth of precipitation for a given duration meteorologically possible over a given size storm area at a particular location at a particular time of the year, with no allowance made for long-term climatic trends (World Meteorological Organisation, 1986). It is the primary input to PMF estimation.
probability	A statistical measure of the expected chance of flooding (see AEP).
risk	Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. In the context of the manual it is the likelihood of consequences arising from the interaction of floods, communities and the environment.
runoff	The amount of rainfall which actually ends up as streamflow, also known as rainfall excess.
stage	Equivalent to "water level". Both are measured with reference to a specified datum.
stage hydrograph	A graph that shows how the water level at a particular location changes with time during a flood. It must be referenced to a particular datum.
survey plan	A plan prepared by a registered surveyor.
water surface profile	A graph showing the flood stage at any given location along a watercourse at a particular time.
wind fetch	The horizontal distance in the direction of wind over which wind waves are generated.

Draft
CHARTER
2022

FLOODPLAIN RISK MANAGEMENT COMMITTEE

City of
Canada Bay

Background

The City of Canada Bay Council is implementing the NSW Government Flood Prone Policy to better manage the community's risk and loss associated with flooding and provide Emergency Management Planning. In doing so Council is managing its liability in accordance with Section 733 of the Local Government Act 1993.

Council is following the Floodplain Risk Management (FRM) Process described in the Floodplain Development Manual. As part of the FRM process, a FRM Committee is to be established in accordance with the Floodplain Development Manual and be guided by the Flood Risk Management Committee Handbook, attached.

Core Objectives

The principal objective of the committee is to provide advice to Council on floodplain risk management issues within the City of Canada Bay Local Government Area, including the development of FRM Plans by contributing ideas, professional expertise, experience and local knowledge, in accordance with the NSW Government's *Floodplain Development Manual: The Management of Flood Liable Land.*

The roles of the committee may include:

- To assist Council by providing direction through the process of preparation and implementation of Floodplain Risk Management Planning
- The discussion of technical, social, economic and ecological issues and for the distillation of possibly differing viewpoints on these issues.
- To foster partnerships and collaboration between the local community and Council

Under Section of 733 of the Local Government Act (1993) Council does not incur liability for any advice furnished in good faith, relating to the likelihood of any land being flooded or the nature or extent of any such flooding.

The Committee is purely advisory and does not have a role in the operational function of Council. Equally, where Council has adopted a Strategic Policy or Strategic Planning document, the Committee must observe the Council position as set out in that policy, plan or document.

Membership

Flood Risk Management Committee will consist of both voting and non voting members.

Relevant Council and industry experts will contribute their professional expertise and opinions, whilst community members will contribute their knowledge of historical information, local problems, and possible solutions. They also channel input from the wider community. The Committee should represent the views of the Committee in a wholistic manner, not only those of consultants, State Government Representatives or Council.

Members are encouraged to contribute widely to the Committee's deliberations to produce the best possible outcomes for managing the flood problem. This involves seeking solutions to the existing, future and continuing flood risk issues, not solely on addressing the past.

Voting Members

- 2 Councillors including the Mayor (or their delegate) nominated by Council
- Up to five (5) community representatives

Non-Voting Members

- Council Staff representative(s) (from engineering, panning and environmental disciplines)
- Parramatta River Catchment Group representative
- NSW State Emergency Service representative (from Metro Zone)
- NSW Department of Planning, Industry and Environment representative
- Sydney Water representative
- Transport for NSW representative
- Additional Agency Representatives may be invited if deemed appropriate to address particular items.

Membership Selection and Tenure

The Committee shall comprise of members who are committed to, and actively involved in the preparation of the management plan which may take an extended period of time.

If a community representative member resigns or is terminated, the position may be left vacant (provided one community representative member is maintained on the Committee) or filled through a review of earlier Expressions of Interest or a call for new Expressions of Interest.

Designated Council officer(s) will attend the committee. The role of these officer/s include coordinating the Committee and to fulfil secretarial duties.

Councillors are appointed by Council Resolution, Community Representatives are appointed by Council Resolution, Council Staff are appointed by the General Manager and State Government / Agency Representatives are appointed by the respective agency.

The Flood Risk Management Committee will dissolve at or prior to the General Election of a new Council, with new Committee members being called following the Election of a new Council (at each term.) The Council (by resolution) may dissolve the Committee at any time.

A person shall cease to be a member of the Committee if:

- The member resigns in writing to the Committee
- The member is absent for more than 3 meetings without leave granted from the Committee
- Breaches of relevant policies as related to the Committee including the Code of Conduct
- Prior to the General Election of a new Council.

Chairperson

The chairperson shall be a Councillor member to act as Chairperson and is required to achieve a quorum.

Meetings

Quorum

50% of voting members plus 1 (which shall include 1 Councillor representative, noting that whilst not a voting member, the committee cannot go ahead unless at least 1 Council Staff representative is in attendance for governance/ minute taking purposes.

Minutes, Agendas and Reporting Requirements

The Committee shall meet at least 4 times per year, (generally) quarterly. Additional meetings may be held by agreement if urgent matters require consideration prior to the next scheduled meeting.

Meeting date schedules for the coming year are to be placed in Council's corporate calendar and on Council's website.

Advice of upcoming meetings will be distributed to members and Councillors and posted on Council's webpage 10 days prior to the date of the next scheduled meeting (this advice will include an agenda and the previous meeting's minutes).

Council officers are responsible for providing administrative support for the meetings. This includes preparation and distribution of agenda's, minutes and other relevant information. Minutes are to be uploaded onto Council's website within 14 days of the meeting date.

Council officers will furnish an annual report to Council outlining the activities of the Committee during the previous 12 month period and advise of proposed activities in the upcoming 12-month period.

Decision Making

The Committee is not a decision making body of Council.

The main objective of the Committee is to provide advice and recommendations for the consideration of Council.

Standing Agenda Items

Standing agenda items for the Committee will be as follows (inclusive of any working groups):

- Acknowledgement of Country
- Apologies
- Disclosure of Pecuniary and Non Pecuniary Interests
- Confirmation of iMnutes
- Reports
- General Business

Code of Conduct

All members of the Committee are required to act in accordance with the City of Canada Bay Council's Code of Conduct and any other policy or requirement applicable to the proper functioning of the Committee.

Committee members should act in a professional and responsible manner with the information they obtain as a Member as Committees require openness and honesty to function well.

Committee members should feel free to express their opinions and views without fear of recrimination. It is therefore important that Committee members respect each other (despite differences) and work together to create an open and trusting committee atmosphere.

It is essential for committee members to accept collective responsibility, and remain loyal to decisions of the Committee, even where they may not have agreed with the final decision.

A breach of the Code of Conduct may lead to the member being expelled from the Committee and/or other appropriate action.

Conflicts of Interest and Pecuniary Interest

Committee members must declare any conflicts of interest or pecuniary interest at the start of each meeting or before discussion of a relevant agenda item or topic. Details of any conflicts of interest and pecuniary interest are to be appropriately documented within the minutes of the meeting.

Where members or invitees at Committee meetings have a conflict of interest or significant pecuniary interest, the member should not participate in discussion or deliberation on the issue.

Financial

The operational costs of convening Committee will be met by Council's budget.

No sitting fees or out of pocket expenses, including travel and parking arrangements will be paid to members of the Committees.

Confidentiality and Privacy

Members may have contact with confidential or personal information retained by Council. If so, members are required to maintain the security of any confidential or personal information and not access, use or remove any information unless the member is authorised to do so.

Privacy legislation governs the collection, holding, use, correction, disclosure and transfer of personal information. More information about the legislation, can be obtained by contacting the Council's Public Officer.

Should a member become aware of any breach of the security, or misuse of Council's confidential and personal information they should contact the Public Officer.

Media Protocol

Members of the Committee may not speak to the media in their capacity as Committee members. The Mayor or the Chairperson of the Committee is the only person/s permitted to speak to the media on behalf of the Committee.

Relevant Documents

Flood Risk Management Committee Handbook - State of NSW and Department of Planning Industry and Environment (2019)

Variation of the Charter

This Charter may be added to, repealed, or amended by approval of the General Manager in consultation with or upon the recommendation of the Flood Risk Management Committee.

The following procedure will apply where a Committee member seeks to amend the Charter:

i) The Committee must consider and vote on any proposed changes to the Charter

ii) Any proposed change is to be approved by the General Manager.

iii) Any changes will be advised to Committee members.

Any requests from Council Executive to amend the Charter are to be made through the General Manager for submission to the Council.

Flood Risk Management Committee Handbook

A guide for committee members

Published by:

Department of Planning Industry and Environment
59 Goulburn Street, Sydney NSW 2000
PO Box A290, Sydney South NSW 1232
Phone: +61 2 9995 5000 (switchboard)
Phone: 1300 361 967 (DPIE and national parks enquiries)
TTY users: phone 133 677, then ask for 1300 361 967
Speak and listen users: phone 1300 555 727, then ask for 1300 361 967
Email: info@environment.nsw.gov.au
Website: www.environment.nsw.gov.au

Report pollution and environmental incidents
Environment Line: 131 555 (NSW only) or info@environment.nsw.gov.au
See also www.environment.nsw.gov.au

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Find out more about your environment at:

www.environment.nsw.gov.au

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1. WELCOME

Enjoy being part of your flood risk management committee. Your input into the flood risk management process is valuable, and it is hoped that it will also be a rewarding personal experience.

This handbook has been prepared by the NSW Department of Planning, Industry and Environment (DPIE)[1] to provide committee members with a basic understanding of flood risk management in NSW.

The handbook explains some of the key areas of flood risk management, such as:

- what is flood risk and what is involved in managing flood risk (Section 2)
- the flood risk management framework, principles, aims and the various responsibilities (Section 3)
- some of the technical procedures (Section 4), and
- some of the key options in managing flood risk and how they are evaluated (Section 5).

The handbook can be used as a quick reference guide to the issues that may arise during committee meetings.

Should you have any questions about flood risk management, do not hesitate to ask the relevant Council staff, DPIE or other State Government representatives.

The NSW Government's Floodplain Development Manual and supporting publications provide advice to local councils on how to most effectively understand and manage their flood risk. These can be viewed and/or downloaded from https://www.environment.nsw.gov.au/topics/water/floodplains/floodplain-manual and https://www.environment.nsw.gov.au/topics/water/floodplains/floodplain-guidelines.

Definitions and abbreviations used in this guide have the same meaning as those in the NSW Government's Floodplain Development Manual.

Note

[1] The Department of Planning Industry and Environment (DPIE) was formerly the Office of Environment and Heritage (OEH) up until 30 June 2019. References to DPIE documents may relate to documents labelled OEH.

2. MANAGING FLOOD RISK IN NSW

2.1 What is flooding and what causes it?

Flooding is a natural phenomenon that occurs when water covers land which would normally be dry. Floods generally come from catchment flooding due to prolonged or heavy rainfall (severe thunderstorms, tropical cyclones, monsoonal rains in the tropics and east coast lows) or coastal inundation or a combination of these. Catchment flooding may result in flooding from water leaving waterways (riverine flooding) or from water on the way to waterways (overland flooding). In coastal areas, flooding may also be influenced by water levels in the oceans, tides as well as the same rainfall events that result in flooding.

Floods vary greatly in size and frequency. Small floods may cause local nuisance flooding in an area each year, or more regularly. Larger floods causing significant community impacts may occur at the same location a few times in an average lifetime, or in some cases, not at all.

Studies under the Program generally look at larger floods. They will look at what happened in historical floods but also consider what may happen when floods larger than historical floods and outside the experience of the community occur. It is important to understand the potential impacts so that ways to manage these can be considered. Studies will also consider extreme floods to help understand the upper limit of potential impacts as this is important to understand in emergency management.

2.2 What is Flood Risk?

A flood event can create dangerous or damaging conditions on the floodplain. These hazardous conditions can exist whether or not there are people, infrastructure or assets in the floodplain.

It is the human interaction with a flood that results in a flood risk to the community. Flooding can affect the health and safety of individuals and communities living in the floodplain. It can also affect the built environment and other interests that support them.

Floods can be fatal, cause significant damage to public and private infrastructure and utilities, and have devastating impacts on communities that can require extended recovery time. They can cause considerable stress and concern in the community and on average, floods in New South Wales cause damage well in excess of $150 million a year.

Flood risk involves a combination of both the likelihood that a flood event causes a consequence to the community and the scale of the consequences of that event when it occurs. This risk will vary with the frequency of exposure to this hazard, the severity of the hazard, and the vulnerability of the community and its supporting infrastructure to the hazard (Figure 1). For example, a frequent storm likely to flood an area but only results in minor consequences is of low risk, whereas a frequent storm likely to flood an area that results in significant consequences would be a high risk.

Figure 1 Risk Triangle

There are generally three types of risk to be managed in flooding. These are:

- Existing flood risk – risk associated with the existing development in the floodplain. This can be limited by mitigation actions
- Future flood risk – risk associated with the future development of the floodplain. This can be limited by considering flooding when deciding where and how to develop within the floodplain
- Continuing flood risk – the risk remaining in both existing and future development areas, after all practical and justifiable management measures such as works, land-use planning, and development controls are implemented.

2.3 What is Flood Risk Management?

Flood risk management (FRM) is the management of flood risk to both existing and future people and property in the floodplain.

Effective consideration of flood risk requires both an understanding of the impacts of floods and the ways that it can practically be managed at a local level.

Flood risk is managed in NSW through the development of a FRM framework and undertaking studies through the FRM process. These are discussed in Section 3.

For more information on the general benefits of undertaking FRM refer to videos developed by Gosford City Council, Part A (before FRM) and Part C (after FRM).

3. FLOOD RISK MANAGEMENT FRAMEWORK

3.1 Background

To address the community's concerns with flooding, the State Government released the Flood Prone Land Policy (the Policy) in 1984 with the primary objective of reducing the impact of flooding and flood liability on individual owners and occupiers, and to reduce private and public losses resulting from flooding. The Policy has since been updated but its primary objective remains the same.

To support delivery of the Policy, the State Government released the first NSW Government Floodplain Development Manual in 1986 which provides councils with advice on a recommended framework and approach to better understand and manage their flood risk.

The 1986 Manual and Policy have since been updated with the gazetted 2005 Floodplain Development Manual (the Manual) and incorporates the Policy. A suite of guidelines also support the implementation of the Policy and Manual.

Councils can apply for subsidised funding under the State Floodplain Management Program (the Program) managed by DPIE to develop and implement FRM plans to manage their flood risk in accordance with the Policy and Manual.

The Manual is currently being reviewed and updates are available from DPIE's representative on the committee. When complete, the updated Manual will be available on the relevant government website. Supporting publications are regularly reviewed and updated and made available through the relevant government web page. During the update of the Manual some of the information or diagrams provided in this document may be slightly different than in the Manual.

3.2 Responsibilities in Flood Risk Management

Managing flood risk to the community requires cooperation across all levels of government, and between the government and non-government sector. The National Strategy for Disaster Resilience outlines that flood resilience is a shared responsibility between government and the community.

FRM is complex, and therefore requires access to a range of different skills and disciplines, which reside in a variety of agencies and across government levels.

3.2.1 Government

In NSW, FRM is a partnership between all levels of government with local councils primarily responsible in their local government area (Table 1). Additional details on key local, state and federal government roles are provided below.

All councils are strongly encouraged to call on the local community and state government agencies to assist them with this responsibility. This is best achieved by the establishment of a management committee and technical working group (Section 3.3).

Table 1 Government Roles and Responsibilities

Local Government	State Government	Federal Government
Flood risk management, land-use planning, development and infrastructure provision and maintenance	Leading, monitoring and maintaining legislative, policy and administrative framework for flood risk management.	
	Supporting management of flood risk by councils.	
	Supporting effective land-use planning, and development and building controls.	
	Technical and financial support to councils for studies and infrastructure under the management process	Financial support to councils under the management process (via the state government)
Supporting flood emergency management	Lead flood emergency management planning	
Local flood recovery	Leadership of regional and statewide disaster recovery and support for local disaster recovery	Support for disaster recovery
Providing information on flood risk to the community and to support local decision making	Information systems to support state government decision making	
Considering flood risk in decision making	Considering flood risk in decision making	Considering flood risk in decision making
		Conservation of natural resources and environmental values of national significance.
Roles and Responsibilities Shared across all Government levels		
Flood prediction and warning		
Managing gauges and supporting infrastructure to inform flood warning		
Funding coordination and management		
Recovery after a flood		
Research and training		
National coordination and cooperation in best practice		

Local Government

The Policy outlines that the management of flood prone land is primarily the responsibility of local government. Managing flood risk at a local level involves understanding flood risk and supporting practical management options across the local government service area (LGA).

Local responsibilities include:

- FRM – establishing a local FRM framework and developing and implementing FRM plans to understand and manage flood risk
- providing information on flood risk to the community and government
- considering flood risk in land use planning decisions
- developing, operating, maintaining and asset management for FRM infrastructure
- leading the local emergency management committee and support for flood emergency management planning

- local flood recovery

Many decisions are made at a local government level. These may involve prioritising efforts to understand and manage flood risk across different catchments within the LGA, including catchments shared with other LGAs. These decisions may be informed by flood studies, management studies and management plans in different catchments within the LGA, including those derived from studies undertaken in partnership with other LGAs in the same catchment.

State Government

The State Government provides local councils with technical and financial assistance to undertake studies to understand their flood risk, examine options to manage this risk, and to decide on and implement plans to manage this risk through the Program managed by DPIE. Under the Program funding may be available for the preparation of the various studies, and the implementation of FRM plans including the construction of mitigation works.

Funding under the Program (State and sometimes Federal Government funding) is provided on a priority basis considering annual applications from local councils across NSW for all stages of the FRM process. The priorities are determined by the relevant Minister considering the advice of the State Floodplain Management Assessment Committee led by DPIE.

Local government usually contribute its share (generally 1/3rd) of funding through its budgetary processes. However, low financial capacity councils can access better funding ratios requiring lower local contribution for some projects. In some cases, a council may seek to raise a specific levy to support implementation of major works.

DPIE technical staff assist councils with managing their flood risk and developing and implementing FRM plans.

The NSW State Emergency Service (SES) also has a key role in emergency management of flooding including:

- establishing, maintaining local flood plans and activating these plans in response to a flood threat.
- educating the community on response to flood threats and advising them of how to respond to an imminent flood threat.

3.3 The Flood Risk Management Committee

The formation of a FRM Committee is a key step in the management process to develop and implement management plans.

3.3.1 The Role of the Committee

The Committee assists Council in developing and implementing a FRM plan by contributing ideas, professional expertise, experience, and local knowledge.

Community members contribute their knowledge of historical information, local problems, and possible solutions. They also channel input from the wider community.

While it is important that key aspects of the FRM process are addressed, members are encouraged to contribute widely to the Committee's deliberations to produce the best possible outcomes for managing the flood problem. This involves seeking solutions to the existing, future and continuing flood risk issues, not solely on addressing the past.

The Committee should operate as a team with the community's interests being foremost.

Committee members may be required to vote to determine the majority opinion on different issues. Because the FRM plan should be a local based process, State Government representatives abstain from voting.

It is crucial that the Committee actively directs the course of the studies to ensures studies represent the views of the Committee, not only those of the consultant and Council.

3.3.2 Membership of the Committee

The FRM committee may be stand alone or the role of the committee may be given to a broader council committee which may already exist.

If flood risk is to be considered as part of a broader committee, both a technical working group (to facilitate agency input) and a community reference group (to support community input) should be established to ensure the community is included in the FRM process. FRM issues should also be a clear part of meeting agendas.

Committee (including technical working and community reference group) members are generally a mix of elected, community, and professional members, whose collective skills and interests are suited to addressing the flooding problem of a particular catchment. Typically, membership is:

- elected members of council;
- council staff from engineering, planning and environmental disciplines;
- an appropriate number of representatives of the local community (for example, local flood affected landholders (residential and business), relevant industry bodies (e.g. the chamber of commerce), and environmental groups);
- officers from the DPIE; and
- representative(s) from the State Emergency Service (SES).

Depending on the nature of the flooding problem at hand, the Committee may choose to co-opt other individuals or agencies as required.

3.3.3 What is expected of Committee Members

The FRM process is neither short nor simple, nor is it the singular responsibility of council officers, consultants or government officers to have input to the process.

The FRM Committee must comprise members who are committed to and actively involved in the preparation and implementation of the FRM plan. It may take 2 to 5 years from the start of a flood study to the development of the FRM plan and the implementation of all recommendations may take much longer (typical lengths of time are shown in Table 2). Local community members who are enthusiastic and energetic are more likely to 'see the distance' to complete the FRM plan.

Committee members are expected to attend meetings at critical points in the project stages, on average this is every 3 months. Meetings are generally held at a convenient time for all committee members, most likely at night to accommodate work schedules. Committee members are expected to read and review the documents provided prior to meetings. This guide can be referred to in order to get an overview of the relevant stage in the project and a background on what may be discussed in the meetings.

In view of the length of time involved, the turnover of committee members, including both council staff and elected representatives, can be a problem. Whilst little can be done with respect to the potential turnover of council and government officers, the structure of the committee should be decided with consideration of its long-term viability and relationship with other committees in operation in the local area.

Table 2 Flood Risk Management Process Time Frames

Stage	Typical timeframe	Typical steps
Flood Study	1-1½ yrs.	Data collection. Engage consultant/s. Study very complex.
Flood Risk Management Study	1-2 yrs.	Committee/consultant examines management options. Involves widespread community consultation.
Flood Risk Management Plan	½ - 1 yrs.	Finalise options. Committee plans implementation.
Plan Implementation	1-15 yrs.	Flood warning systems, development controls, rezoning, levee construction, voluntary purchase etc.

3.3.4 The Role of the Consultant

In most cases, consultants will be engaged to prepare the necessary studies and reports in accordance with Council's study briefs. The Committee should contribute to the development of these briefs.

Consultants will undertake a range of investigations to enable Council to make management decisions with the Committee's assistance. The consultant will often be required to make presentations to the Committee to help with their deliberations.

Whilst it is expected the consultant will contribute initiative to the study, it is important that the Committee direct the consultant so that local issues are considered.

3.3.5 Community Involvement

If FRM is to be successful, it is important that the local community accepts the need for effective management practices, recognises that the finalised FRM plan has considered all factors of concern to the community, and that flood prone members of the community accept their individual responsibilities to reduce flood risk.

This requires the support of the community covered by the plan. Community involvement is a key component of the development of the plan through both membership of the Committee and through consultation at key points during studies. The Committee should represent the wider community and ensure that it acts in the interests of the whole community.

An important role of the management committee will be to assist in the presentation and resolution of conflicting desires and requirements on the part of various community groups and individuals. Public meetings, often spirited, are an important part of this process.

The community can be actively involved in the process by engaging in the community consultation activities and providing information on their local experiences with flooding.

The FRM plan will be a compromise involving trade-offs. Certain individuals may be disadvantaged, others advantaged, but the community will be better off.

3.4 The Flood Risk Management Framework

The FRM framework in NSW is outlined in Figure 2. It sets out a series of logical steps that if followed are likely to produce the best possible FRM outcomes for the community, allowing for variation in flood behaviour and impacts. Councils can provide local advice on the way in which they manage flood risk within their organisation. The keys steps in flood studies and FRM study and plan projects are described in Section 3.4.1 to 3.4.5.

FRM plans comprehensively consider flood risk and outline practical measures that can address the flood problems in the area covered by the plan. The area covered by a plan may be a town or locality or specific river catchment. The development of the FRM plan involves the application of a merit-based approach to management options that considers the variation in flood behaviour and impacts on the community rather than the application of a blanket rule.

For FRM to be successful, it is important that the local community accepts the need for effective FRM practices, recognises that the effective management plan has taken into account all factors of concern to the community, and that flood prone members of the community accept their individual responsibilities to reduce hazard. Community consultation and input is a major component of the development of the plan.

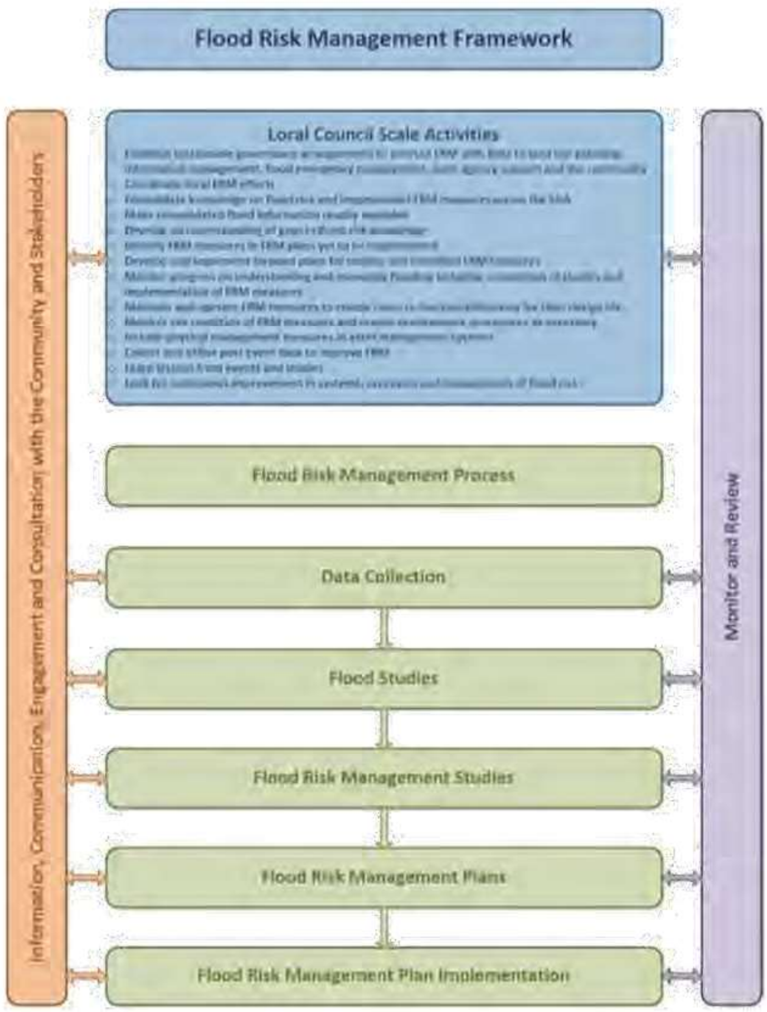

Figure 2 **Flood Risk Management Framework**

3.4.1 Flood Study

The flood study is generally the first stage of the FRM process as it involves defining flood behaviour and provides the main foundation of a robust management plan. It aims to improve the current understanding of the full range of flood behaviour and consequences.

Typically, a flood study considers the local flood history and available collected data, to develop flood models that are calibrated and verified, where possible, against significant historic flood events. These models are then used to determine the full range of potential flood behaviour and impacts. The community is to be consulted at key milestones throughout the development of the flood study.

Study outputs can include:

- a description of the historic floods,
- a description of existing flood mitigation measures,
- hydrologic and hydraulic models that are calibrated and validated considering historic flood events where possible,
- a description of the existing flood situation, and flood extent and level, depth, velocity information,
- the scale and variation in flood impacts, which can include the number of properties affected and the potential flood damages,
- breakdown of the floodplain considering:
    - variations in flood functions of flow conveyance and flood storage in the floodplain
    - variation in flood hazard (based on velocity and depth) across the floodplain
    - emergency response management limitations, including a breakdown of the floodplain to identify areas with different types and severities of response limitations
    - development of mapping to identify how flood related constraints on land vary across the floodplain for consideration in land use planning
- updated and consolidated information on flooding and its management, including the report, updated flood mapping, emergency management and land-use planning information, and community flood awareness information,
- an explanation of the degree of uncertainty in flood estimates.

The study, developed with Committee input, is provided to Council for consideration and adoption. Information in the study should be considered in FRM, land use planning activities and emergency management planning and associated decisions.

3.4.2 Flood Risk Management Study

The FRM study extends the flood study to increase understanding of the flood risk to the existing and future community and test management options. It provides a basis for developing the FRM plan.

Community engagement is vital to the successful development of the management study. The community should be consulted to allow their concerns, suggestions and comments about management options to be considered. Study outputs include:

- a description of existing flood mitigation measures
- the scale and variation in flood impacts, including the number and types of properties affected, and the potential flood damages
- An understanding of future development directions and consideration of the cumulative impacts of future development on flooding
- An assessment of FRM options to address risks to the existing and future community

- the outcomes of community consultation
- recommendations on options
- updated information and consolidated information on flooding and its management – this should include the report, flood mapping, information to assist with emergency management planning, land-use planning, and understanding the climate change impacts and the degree of uncertainty in flood estimates
- sufficient information on options to provide an understanding of their capabilities, limitations, interdependencies, costs and practical feasibility to inform implementation or further investigation.

Information in the study should be considered in FRM, land use planning activities and emergency management planning and associated decisions.

3.4.3 Flood Risk Management Plan

The FRM plan forms the basis of FRM in the study area into the future and details the final management options that have been agreed upon. It should be developed in consultation with the community and in consideration of relevant legislation, policies and guidance that may influence its implementation and the viability of the various management measures.

The plan generally involves a range of measures to manage existing, future and continuing risk, which will vary between different locations in the floodplain. It needs a prioritised implementation strategy, which outlines the commitment to implement, its staging and provides sufficient detail to facilitate implementation.

Management plans need to consider the cumulative impact of changes in the catchment on flooding behaviour due to both incremental development of the floodplain and a changing climate.

The plan developed by the committee is provided to the Council for consideration and adoption. Once a plan has been finalised and adopted by the council, it should be used to update and consolidate information on flooding and its management and communicate to relevant agencies and the community to update them on the flood risk.

3.4.4 Flood Risk Management Plan Implementation

The plan needs to be implemented to manage risk, and this implementation monitored. This requires commitment, coordination and communication within government and with the community.

The recommendations from the FRM plan would generally feed into the broader consideration and prioritisation of recommendation from FRM management plans from across the whole LGA. It should be reviewed every 5 years, if possible, or after a significant event has occurred.

Implementation of major mitigation works that significantly changes flood behaviour or the response of the community to a flood event can lead to a need to review the management study and plan to ensure that information is up to date and available to the community. It can also involve education of the community of how flood impacts or community response has changed.

Implementation is generally led by council and overseen by the Technical Working Group, led by the Council and involving relevant agencies.

3.4.5 Key Steps in Projects under the Process

Although there may be some variations, typically the major steps involved in producing these reports and who is involved in these steps are outlined in Table 3.

Table 3 Flood Study Key Steps Example

Step	Council	DPIE	Consultant	FRM Committee	Council decision making Committee
All projects					
Application for funding	x	x			
Scoping	x	x		x	
Prepare Brief	x	x			
Call for Proposals	x				
Review Proposals	x	x			
Engage Consultant	x				
Inception Meeting	x	x	x		
Data collection and review	x		x	x	
Model setup or review, calibration and validations	x		x	x	
Design results and mapping	x		x	x	
Draft flood study report	x		x	x	
Final flood study report			x		
Adoption of flood study					x
Update and consolidate information on flooding and its management	x				x
Updated information available to the community	x				x
Incorporation into decisions (FRM and land use planning)	x				
Incorporation into Emergency Management planning	x				x

4. UNDERSTANDING FLOOD BEHAVIOUR

4.1 Introduction

Councils may use in-house or consultancy hydrology and hydraulics skills to provide information on flood behaviour. This information is used to:

- understand the impacts of floods on the community
- analyse mitigation and management options
- investigate, design, construct and maintain mitigation works
- facilitate informed decisions on treating flood risk
- consider constraints on land use planning to facilitate informed decisions for floodplain development
- improve flood predictions and warnings
- support updated emergency management planning
- provide information to the community on flood risk and emergency response.

4.2 Flood Modelling

Flood modelling allows the computation of complex mathematical equations and procedures to provide simulations of river and flood behaviour and are most commonly performed by computers. Computer models can be developed to represent the whole or part of the catchment. There are two main types of computer models used in flood studies; hydrologic models convert rainfall to flows and hydraulic models route flows across the catchment. More recently, direct rainfall models allow for rainfall to be directly input onto the hydraulic model (i.e. bypassing the hydrologic model). There are various benefits and limitations to these models, some of which are discussed in the following sections.

4.2.1 Hydrological Models

Hydrological models convert rainfall over catchments into flow(s), see Figure 3.

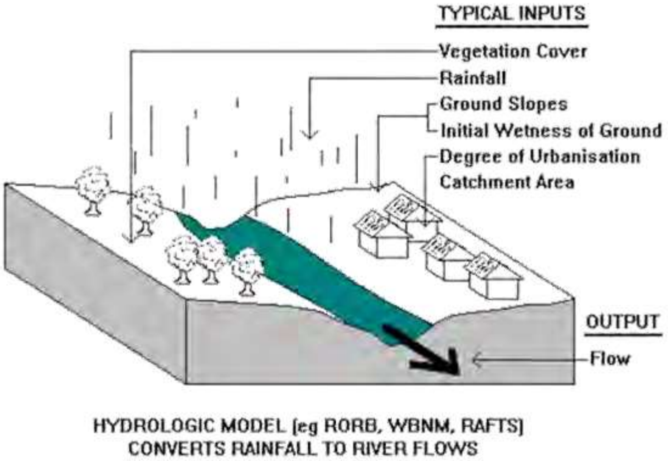

Figure 3 Hydrologic Computer Model

Typical examples of hydrologic model setups are shown in Figure 4.

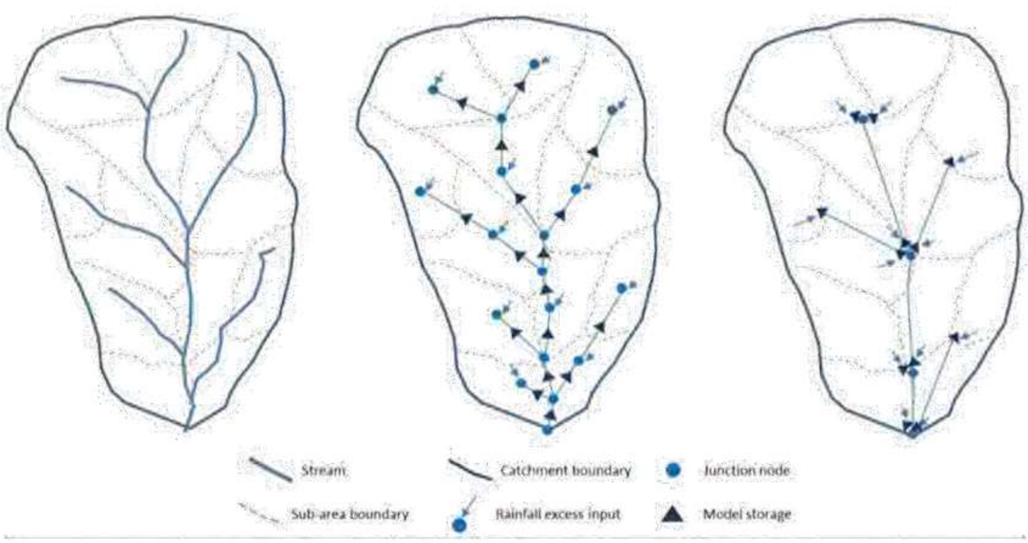

Figure 4 Examples of hydrologic runoff-routing models (ARR 2019)

The output from hydrologic models is normally in the form of flow hydrographs. As storm duration and patterns vary, hydrologic computer models run a range of different storm patterns for the same storm duration (see Figure 5) and compare representative patterns for different storm durations in selecting a design hydrograph(s) (see Figure 6) that are used in hydraulic modelling.

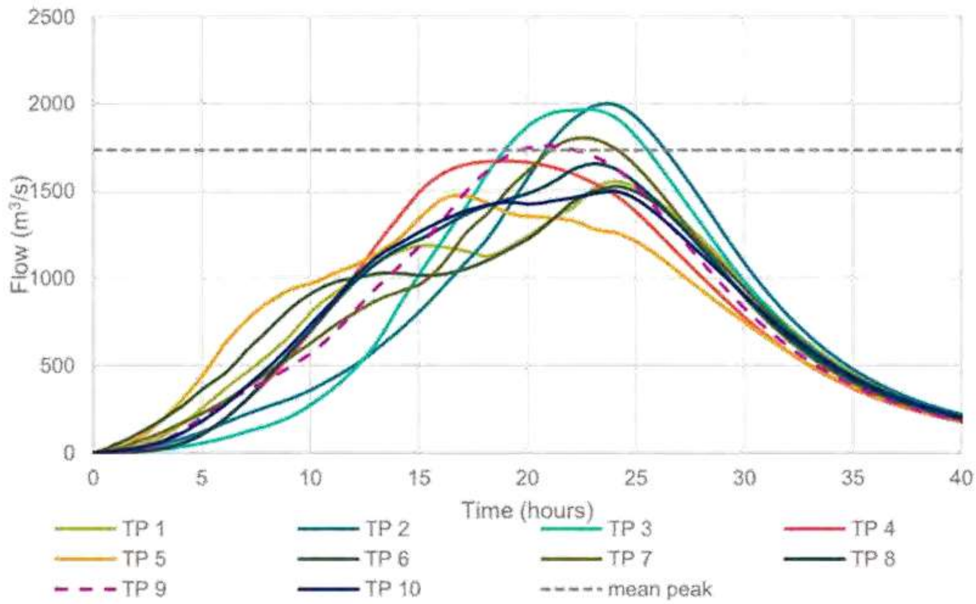

Figure 5 Sample of variations in Flow Hydrograph for different storm patterns (DPIE 2019)

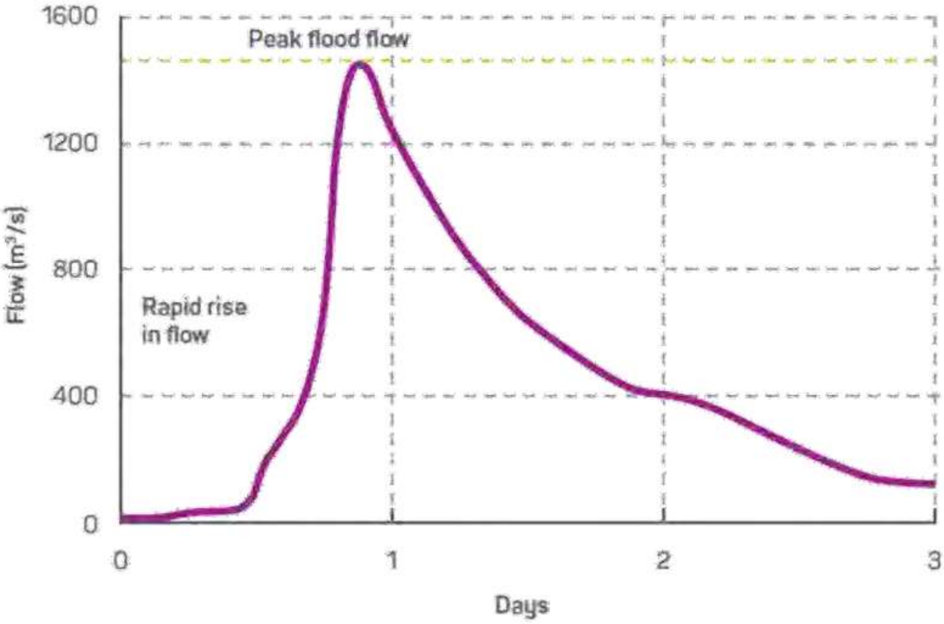

Figure 6 Sample Selected Design Flow Hydrograph (AIDR 2017a)

4.2.2 Hydraulic Models

Hydraulic models take the flow produced from hydrologic models and produce outputs such as flood levels, depths and velocities (see Figure 7).

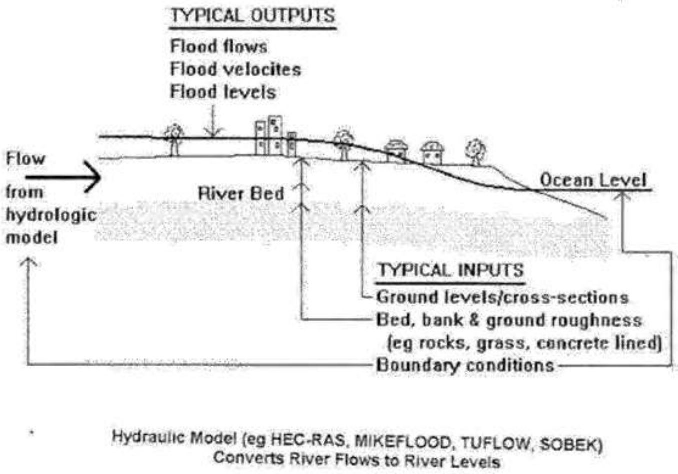

Figure 7 Hydraulic Computer Model

1D Hydraulic Model Examples

Hydraulic models can be 1D (see Figure 8 and Figure 9) to allow analysis of flooding in a channel, for example a river.

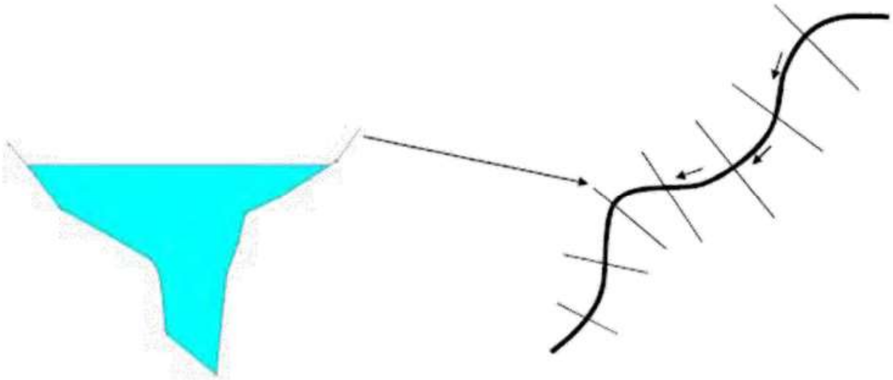

Figure 8 1D hydraulic model typical cross-section

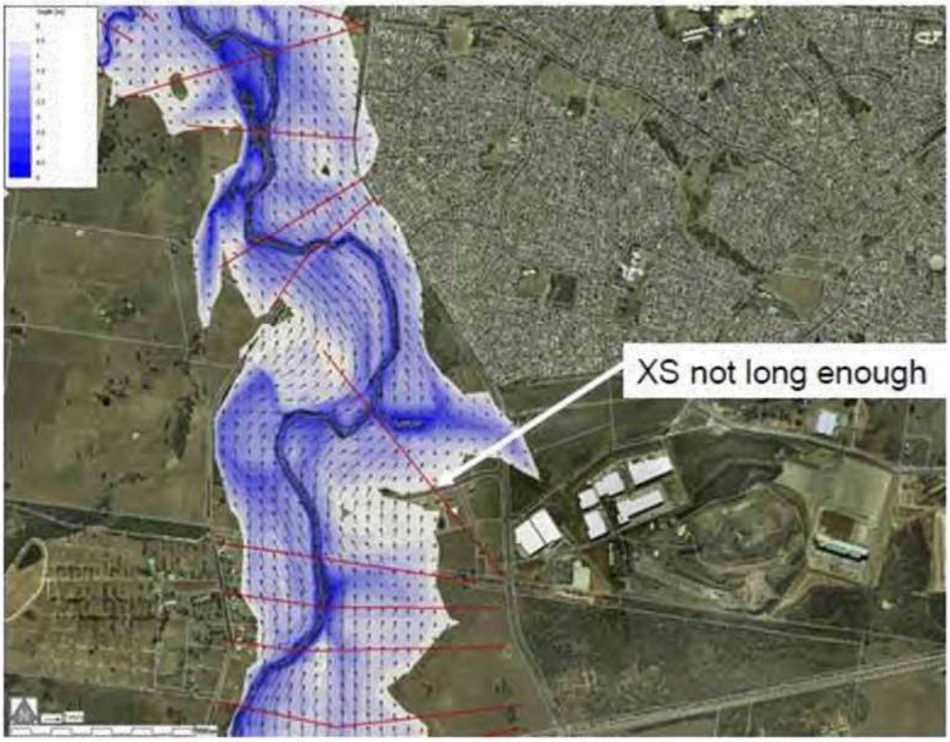

Figure 9 Example 1D hydraulic model results

2D Hydraulic Model Examples

Hydraulic models can be a 2D grid or mesh (see Figure 10) to analyse flooding from channels that extends into the floodplain and overland flows from catchment flooding.

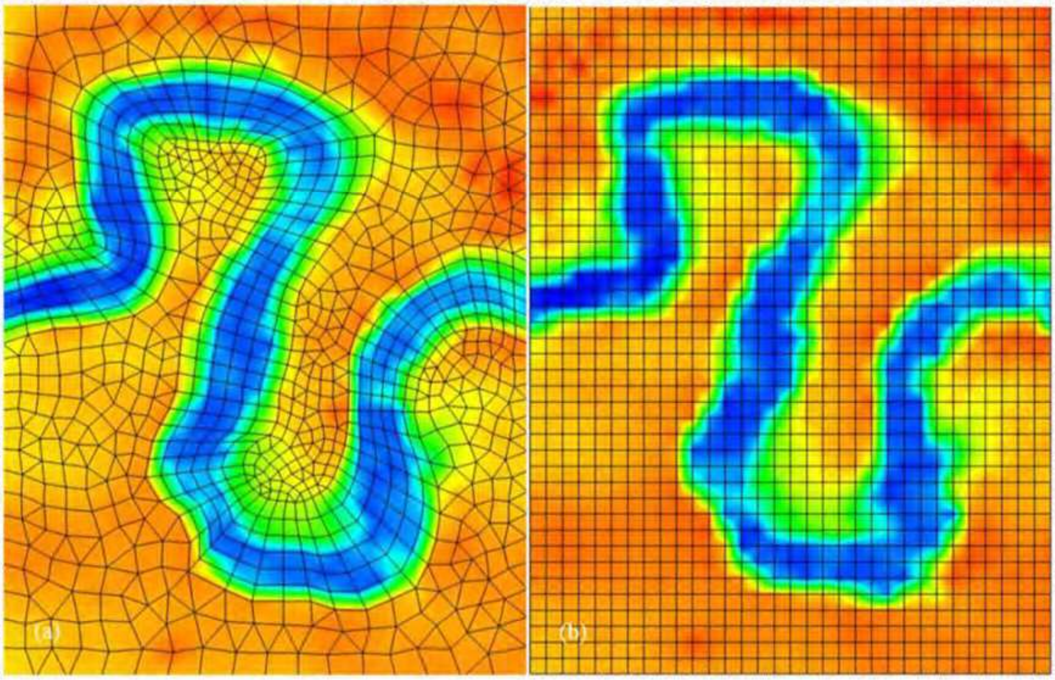

Figure 10 2D hydraulic model examples (a) is a flexible mesh (b) is a grid (ARR 2019)

1D/2D Hydraulic Model Examples

Hydraulic models can be a combination of 1D and 2D to allow the combination of riverine and overland flows to be modelled at the same time (Figure 11 and Figure 12).

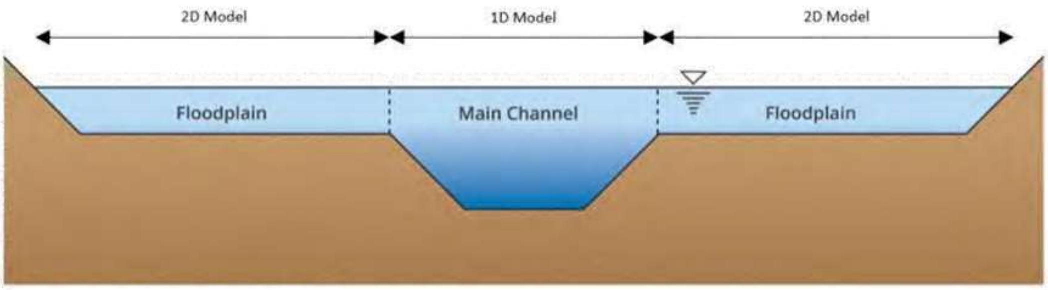

Figure 11 Cross-section of 1D/2D interface

Figure 12 1D/2D Hydraulic Model results showing flow patterns

The output from hydraulic models comes in a number of forms e.g. stage hydrographs, flood profiles, flood contours (Figure 13).

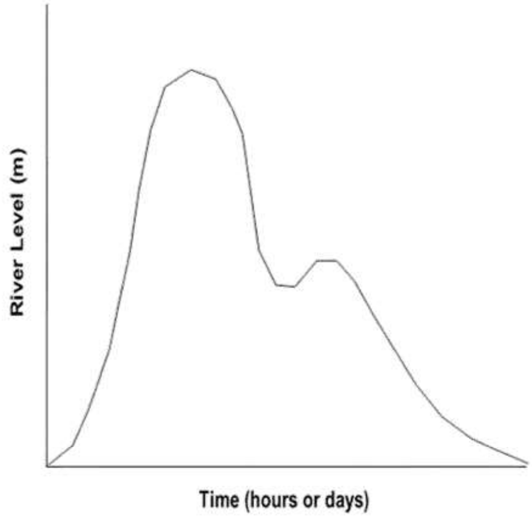

Figure 13 Sample Stage Hydrograph at a Particular Site

The output at different locations can then be used to produce flood profiles or contours along the river showing the maximum water level, depth and velocity at each location for either an actual or design flood (Figure 14 and Figure 15).

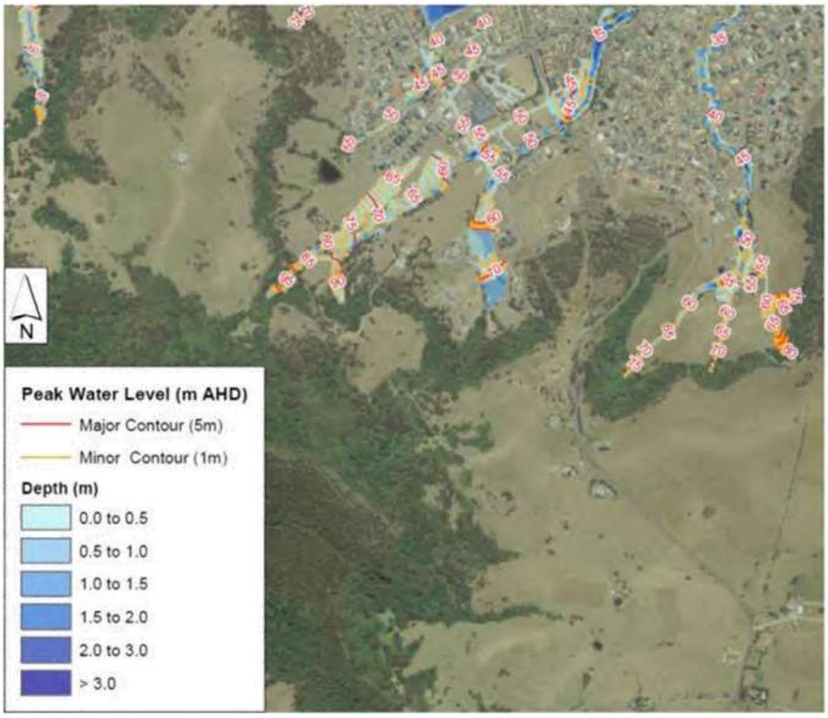

Figure 14 Flood Depths and Flood Level Contours (WMAwater 2017)

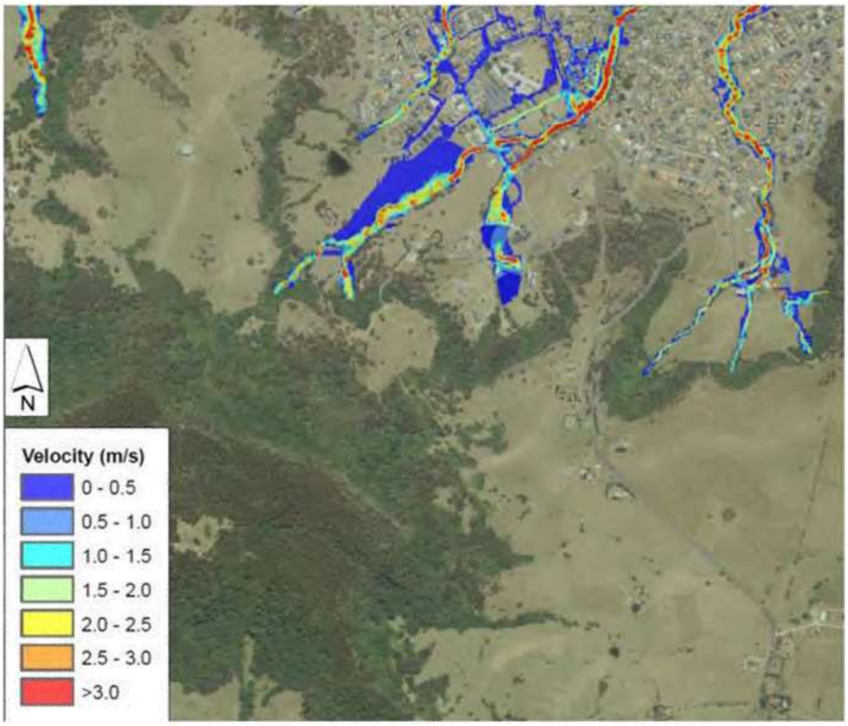

Figure 15 Flood Velocities (WMAwater 2017)

4.2.3 Direct Rainfall Models

Direct rainfall models, known as "rainfall on the grid" take rainfall directly onto the hydraulic model (Figure 16) to generate flow and produce outputs such as flood levels, depths (Figure 14) and velocities (Figure 15).

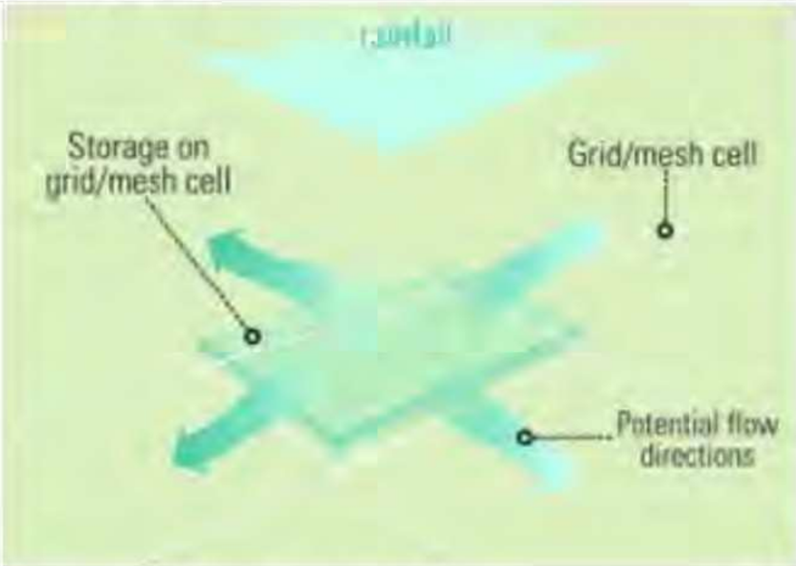

Figure 16 Conceptualisation of Direct Rainfall

4.2.4 Modelling Process

Modelling usually follows the process below, including:

- Calibration – Local historical data recorded during an actual flood event is used in the models to calculate river flows and levels and compare these to recorded levels. These are then compared with the recorded river flows, levels and extents for that flood event. It is normal to have to adjust some of the catchment characteristics to get a match between actual and modelled flows and levels.
- Validation – After calibration of the model is achieved, a check of the ability of the model to predict flood behaviour is carried out. Here the models are run for perhaps 2 or 3 other known flood events to ensure that the model results compare with the recorded flood levels from those events within an acceptable degree of accuracy.
- Design Modelling – After the models demonstrate they can satisfactorily represent actual flood events via calibration and validation, design rainfall data are used to enable the models to produce design flood flows and levels, depths and velocities along the river or floodplain. This is used as a baseline for looking at management options in the management study phase.
- Models are then used to develop the information required from design floods which can vary between studies. This information is then used to derive information to assist in future flood risk management, emergency management and land use planning.

In the FRM study phase, the model is run to assess:

- Development impacts – the effect that development has on flood behaviour and impacts can be assessed.
- Management options – to examine the effect flood mitigation works can have flood behaviour and impacts.

4.2.5 Accuracy of Computer Modelling

Even with powerful computers and programs, flood modelling still needs to be based on a number of assumptions. Accordingly, it would be unrealistic to believe that modelling can exactly replicate the river behaviour at every location.

However, with experienced operators, using proven modelling software to develop the models, reliable estimation of flood behaviour can be provided. This reliability is improved by the calibration and validation of model results (discussed above) with the information available in historical floods and the communities experience of these floods.

It is important to remember that the calibration and validation process demonstrates that the models can satisfactorily predict flood levels within acceptable limits of accuracy. Models can also predict the impact of floodplain changes such as development or mitigation works.

4.3 Design Floods

4.3.1 What Are Design Floods?

To fully appreciate the flood hazard, it is desirable to have a consistent procedure to assess how often floods will reach different levels. The concept of design flood levels achieves this. For example, a 1% AEP (annual exceedance probability) design flood level has a 1% (or 1 in 100) chance of being reached or exceeded in any one year. Historically, this flood was referred to as the 100 year ARI (Average Recurrence Interval) flood as it can be expected to occur, on average, once every 100 years over a very long period, say 10,000 years. Common design floods used in flood risk management shown in Table 4.

Table 4 Common design floods used in flood risk management

PMF	PMF
0.2% AEP	500 year ARI
0.5% AEP	200 year ARI
1% AEP	100 year ARI
2% AEP	50 year ARI
5% AEP	20 year ARI
10% AEP	10 year ARI
20% AEP	5 year ARI

Although a 10% AEP flood is likely to occur once every 10 years on average, it is important to note that there is nothing preventing two 10% floods (or even 1% floods) from occurring only weeks or months apart. This is similar to a lottery where the odds suggest you have a chance of winning a prize say once every 50 tickets you buy, but there is nothing stopping you winning a prize twice in a row or purchasing 200 tickets without a win. Figure 17 shows how likely you are to experience a given size flood at a location in an average person's life time.

Annual exceedance probability (%)	Approximate Average recurrence interval (years)	Probability of experiencing a given-sized flood in an 80-year period	
		At least once (%)	At least twice (%)
20	5	100	100
10	10	99.9	99.8
5	20	98.4	91.4
2	50	80.1	47.7
1	100	55.3	19.1
0.5	200	33.0	6.11
0.2	500	14.8	1.14
0.1	1,000	7.69	0.30
0.01	10,000	0.80	0.003

Figure 17 Probability of experiencing a given-sized flood one or more times in 80 years (AIDR 2017a)

4.3.2 Estimating Design Flood Levels

There are three accepted methods of estimating design flood levels:

- Physical Modelling: A scale model of the catchment is built, flooded, and water levels measured. Whilst they have some benefits, physical models are expensive and, as they occupy large amounts of space, are normally dismantled after use making unplanned subsequent studies costly. These are rarely undertaken today.
- Computer Modelling: This is the most common method (see Section 4.2 for explanation). It is used in conjunction with other techniques, such as flood frequency analysis, to determine design flood levels.
- Flood Frequency Analysis (FFA): This method involves performing a statistical analysis on known historic flood flows to draw a graph of flood flows against probability of occurrence, see Figure 18. Generally, creek and river flows are not measured directly. They are estimated from water levels using rating curves that relate water level to estimated flow based upon gauge measurements and hydraulic analysis, see Figure 19. FFA is often used as a check of the computer modelling results at sites where a sufficient length of record exists. FFA is site specific and can only be applied at the gauge location.

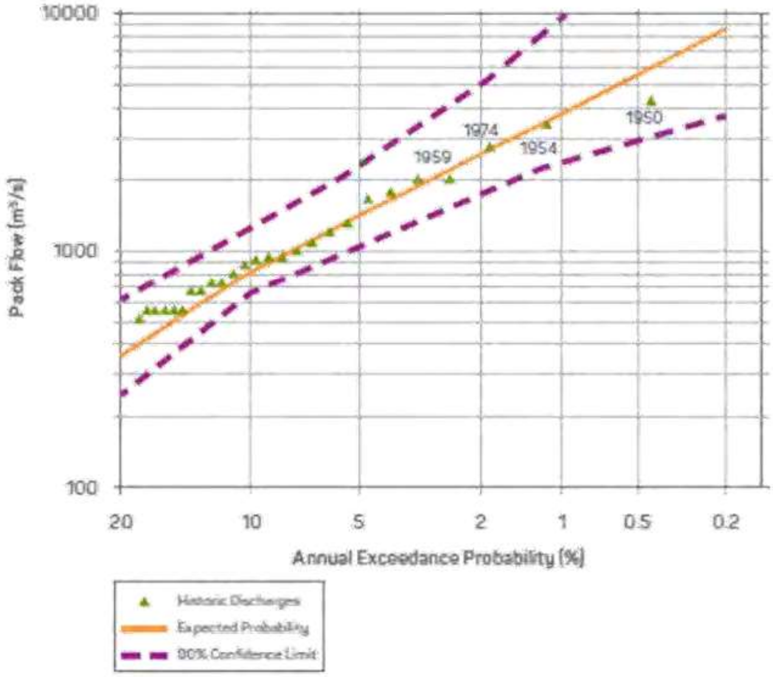

Figure 18 Sample frequency distribution for a stream gauging station (AIDR 2017a)

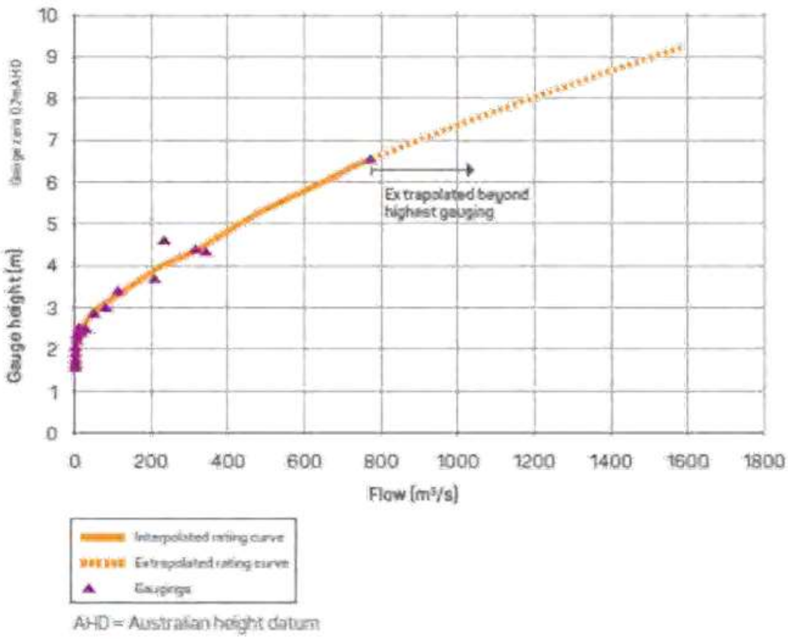

Figure 19 Example rating curve for a stream gauging station (AIDR 2017a)

4.3.3 Defined flood event or planning flood

The defined flood event (DFE) or planning flood is a large flood that is selected and used to determine where to apply minimum development standards, see Figure 20.

Selection of a DFE should consider the full range of flood events and take into account standards and guidance from government and industry. It can reflect what government and the local community may accept as a general standard that allows for a reasonable compromise between living on the floodplain and accepting the consequences of this choice. DFEs are the key floods used to derive information to inform management and land-use planning.

In NSW the 1% AEP flood is often used to define the DFE, a freeboard is then added to the DFE to determine the Flood Planning Level (FPL) (see Section 4.4.2) in which general development controls are applied to new standard residential and commercial development to limit growth in risk.

DFEs are initially determined in flood studies and may be refined in management studies, they are then incorporated in management plans.

Figure 20 Defined flood event and other key terms (AIDR 2017a)

4.3.4 Probable Maximum Flood

The probable maximum flood (PMF) as defined in the Floodplain Development Manual provides the upper limit of flooding to inform flood risk management for communities. Estimation of the PMF provides a basis for understanding the extent of the floodplain and the upper scale of the flood problem faced by communities.

Depending on a number of factors, the PMF or an equivalent extreme flood can range from less than 1 metre to more than 10 metres higher than the 1% AEP flood levels (Figure 21). The PMF is likely to be higher than levels considered for minimum floor levels or for the crest of a levee.

It is a key event to consider in emergency management and should be considered with regard to the location of resources critical during floods such as evacuation centres and, hospitals with an emergency response function, disaster management centres and those whose occupants may be placed at more risk in evacuation (i.e. critical care patients in hospitals).

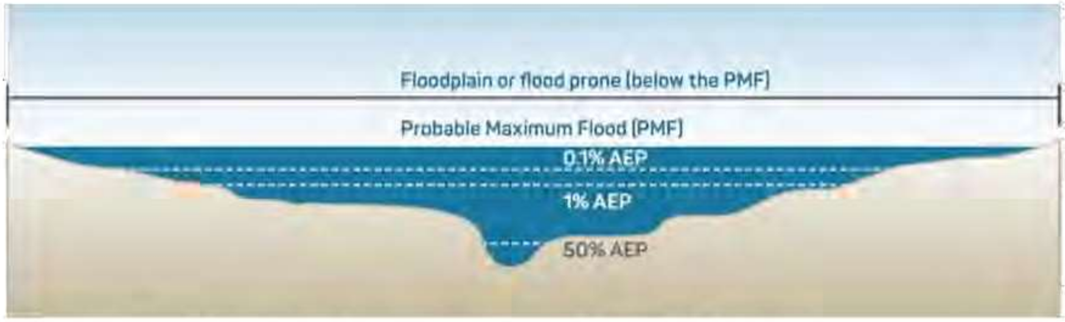

Figure 21 Floodplain and probable maximum flood (PMF) (AIDR 2017a)

4.3.5 Consideration of Climate Change

Consideration of climate change in flood studies is important as it can lead to altered flood behaviour and increased community exposure to flood risks and impacts. Climate change is expected to have adverse impacts upon sea levels (relevant in the lower portion of coastal waterways) and flood producing rainfall events (relevant across NSW).

Depending on the local flood situation both can have significant impacts on flood behaviour that is assessed as part of the studies.

Guidance on how to assess climate change impacts on flood behaviour and its impacts on the community is available within NSW Government FRM Guidance.

4.4 Categorisation of the Floodplain

The area flooded during a flood event (or events) can be further categorised based on different criteria depending on what information is required. These include the flood planning area, flood function (also call hydraulic categorisation), flood hazard, flood emergency response classifications and flood planning constraint categorisation. The categorisation of the flood behaviour in these ways can better inform processes such as land use planning and emergency planning, discussed in the sections below.

4.4.1 The Floodplain or Flood Prone Land

The floodplain or flood prone land is the area that is inundated by the PMF. Land above the PMF level may sometimes be referred to as flood-free although it should be remembered that some land above the PMF level could still experience local drainage problems or water flow across the ground or may be indirectly affected by flooding due to loss of services or power from facilities that are inundated.

4.4.2 Flood Planning Areas (FPAs) and the Flood Planning Levels (FPLs)

Flood planning areas are a type of flood planning constraint category. They are areas where councils apply flood planning controls for all types of development. The FPA is generally determined based on the areas inundated by the DFE or planning flood and includes a freeboard and therefore below the flood planning level (FPL) (Figure 20). Freeboards can vary depending on the type of flooding and the certainty of the modelling process, typical freeboards for riverine flooding are generally 0.5m and for overland flow flooding are generally 0.3m.

FPAs should be based on an understanding of flood behaviour and the associated hazards and risks. Choosing an FPL is a matter of assessing and balancing the social, environmental and economic consequences of adopting that FPL.

4.4.3 Flood Function (Hydraulic Categorisation)

The determination of flood function (hydraulic categorisation) of flood prone land is an essential element of flood studies and management studies as it assists in determining appropriate flood risk management strategies for both existing and future development.

To identify areas that perform an essential flood function it is necessary to divide the floodplain into areas that reflect different flood functions or hydraulic categories. These are:

- Floodway - areas where a significant volume of water flows during flood and are often aligned with obvious natural channels. They are areas which, if only partially blocked, would cause a significant increase in flood levels and/or a significant redistribution of flood flow.
- Flood Storage - areas are those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood.
- Flood Fringe - is the remaining area of land affected by flooding, after the floodway and flood storage have been derived.

The extent of flooding and floodways and flood storage areas will generally increase as the scale of flood increases. They are usually mapped for a minimum of the DFE (see Figure 20 and Figure 22), plus a smaller and larger event, and the PMF. This enables an understanding of how the flood function varies to be considered in management decisions.

Floodways and flood storage areas would have additional development controls that aim to support the flood function of the floodplain.

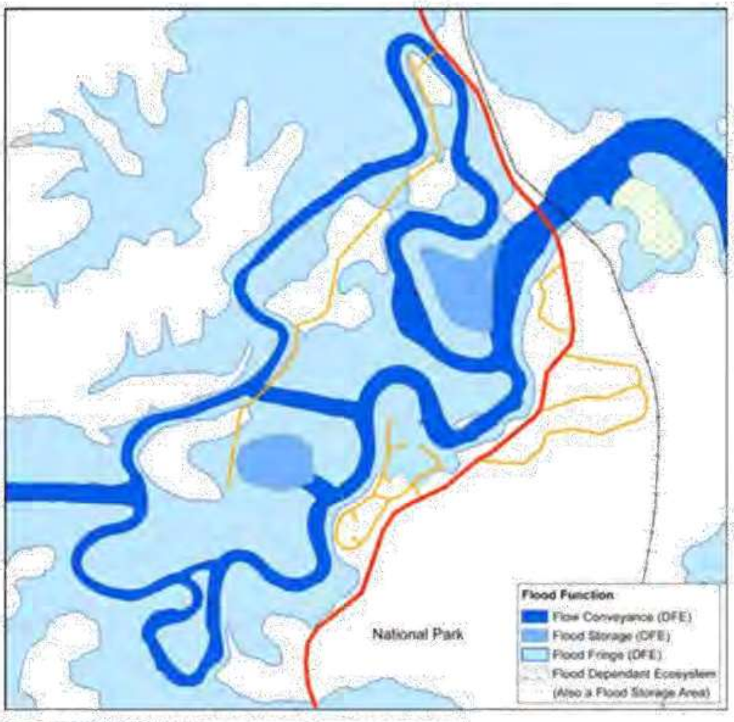

Figure 22 Breakdown of the DFE flood into flood functions (AIDR 2017a)

4.4.4 Flood Hazard

The extent of flooding in an event can be categorised based on the varying degree of hazard that flood poses to the land.

Hazard vulnerability curves (Figure 23) classify hazard based on the consequences of the flood hazard on people, vehicles and buildings. This information can be used to highlight where the flood is hazardous to these different elements (Figure 24).

This provides important information for FRM, emergency management planning and land use planning

Hazard Categories

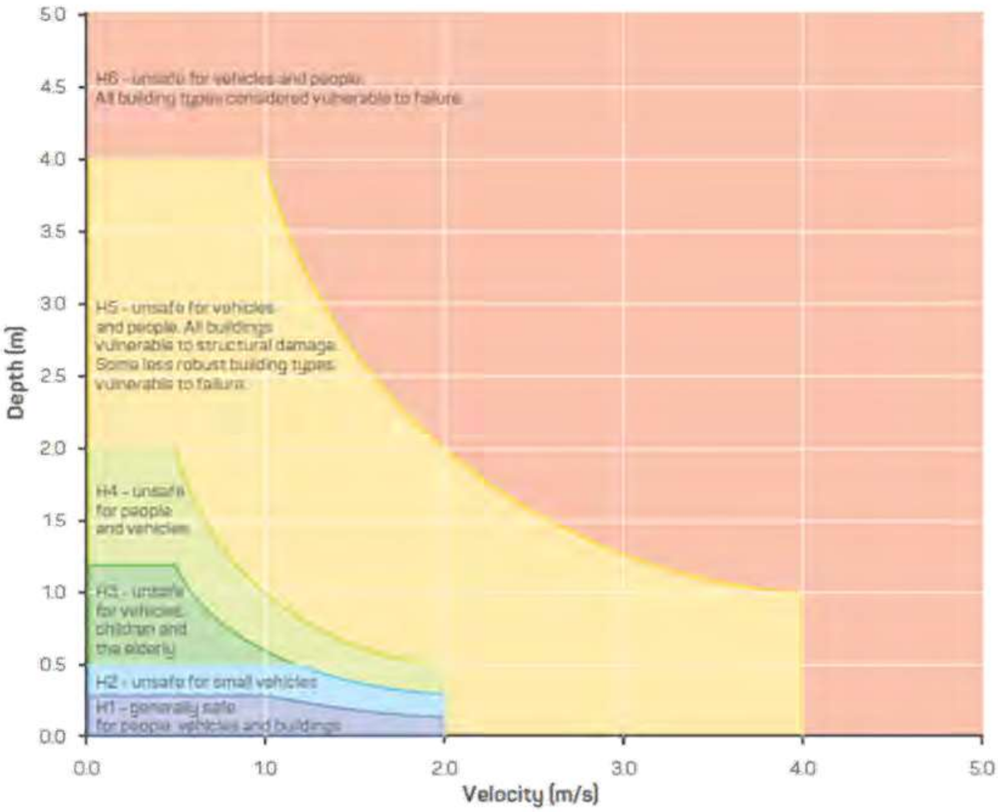

Figure 23 General flood hazard vulnerability curves

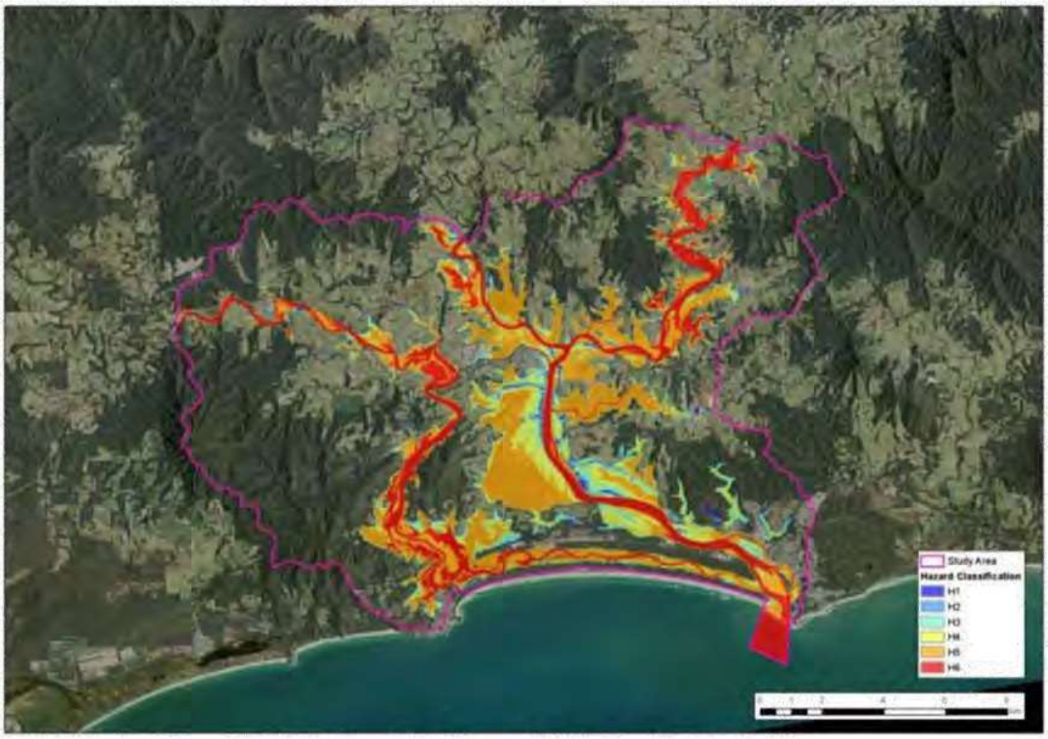

Figure 24 Example breakdown of the floodplain into hazard categories (AIDR 2017b)

4.4.5 Flood Emergency Response Classification

Flooding can isolate parts of the landscape and cut-off evacuation routes to flood-free land or locations where community facilities are available to support evacuated residents in a flood event. This can result in a dangerous situation, because people may see the need to cross floodwaters to access services, employment or family members. Any situation that increases people's need to cross floodwaters increases the likelihood of an injury or fatality.

The floodplain can be classified in relation to isolation and access considerations in a way that informs emergency response management (Figure 25). This classification provides the basis for understanding the nature, seriousness and scale of isolation problems.

It provides important information for emergency management planning, FRM and land use planning

Further information can be found in the Guide on Flood Emergency Response Planning Classification of Communities.

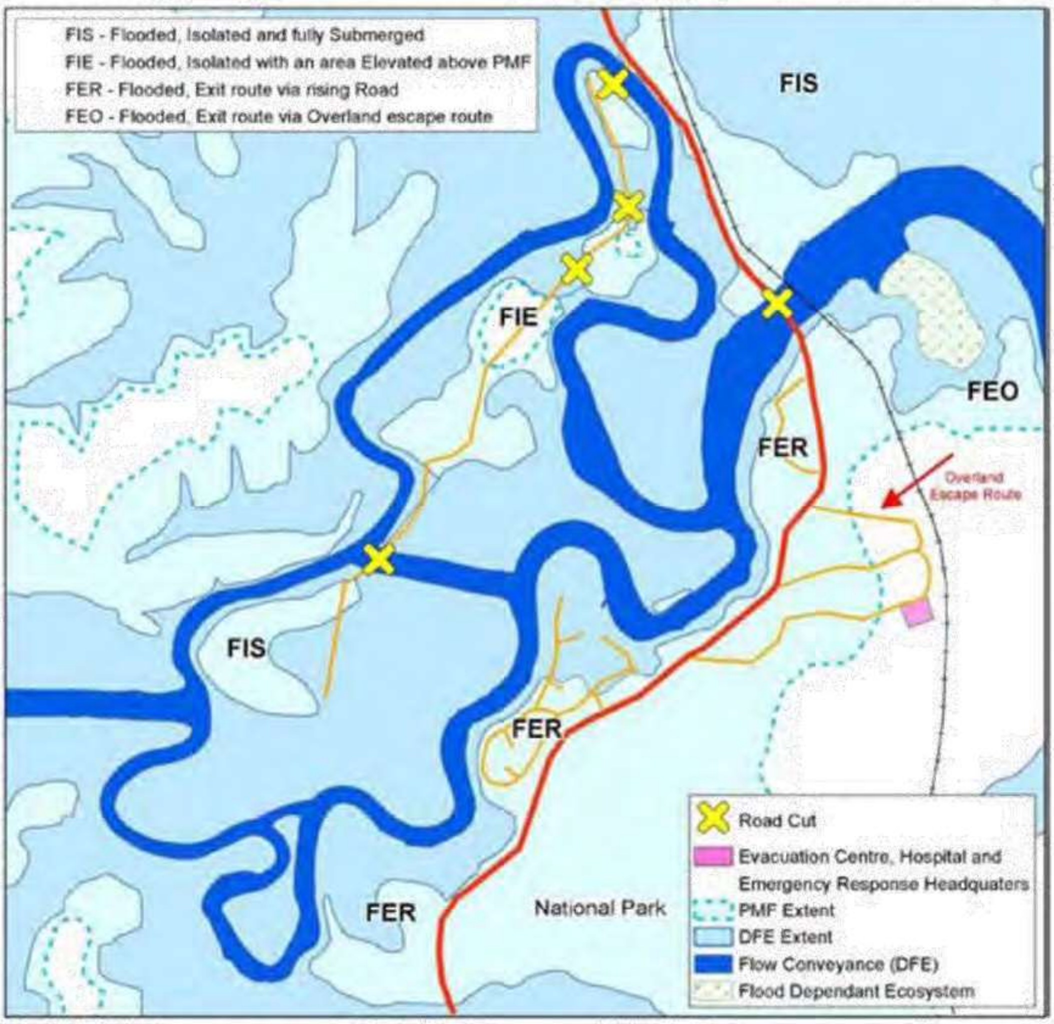

Figure 25 Example of flood emergency response classification of the floodplain (AIDR 2017c)

4.4.6 Flood Planning Constraint Categories

Flood studies typically produce many maps, each focusing on a particular design event and element of flood behaviour. Collectively, they provide a very detailed description of flood behaviour and the issues that are important in different areas of the floodplain.

Combining all elements of flood behaviour can produce a succinct set of information that breaks the floodplain down into areas with similar degrees of constraint – Flood Planning Constraint Categories (FPCC). FPCCs can better inform and support land-use planning activities by identifying where flood-related constraints can be treated similarly.

Deriving flood planning constraint categories involves using information derived from modelling including varied flood function (see section 4.4.3), flood hazard (section 4.4.4), flood emergency response classification (section 4.4.5) and considering the range of flood events. An example of FPCCs is shown in Figure 26, for further detail of the mapping components used to develop this example refer to Australian Disaster Resilience Guideline 7-5 Flood Information to Support Land-use Planning (AIDR 2017), Appendix A.

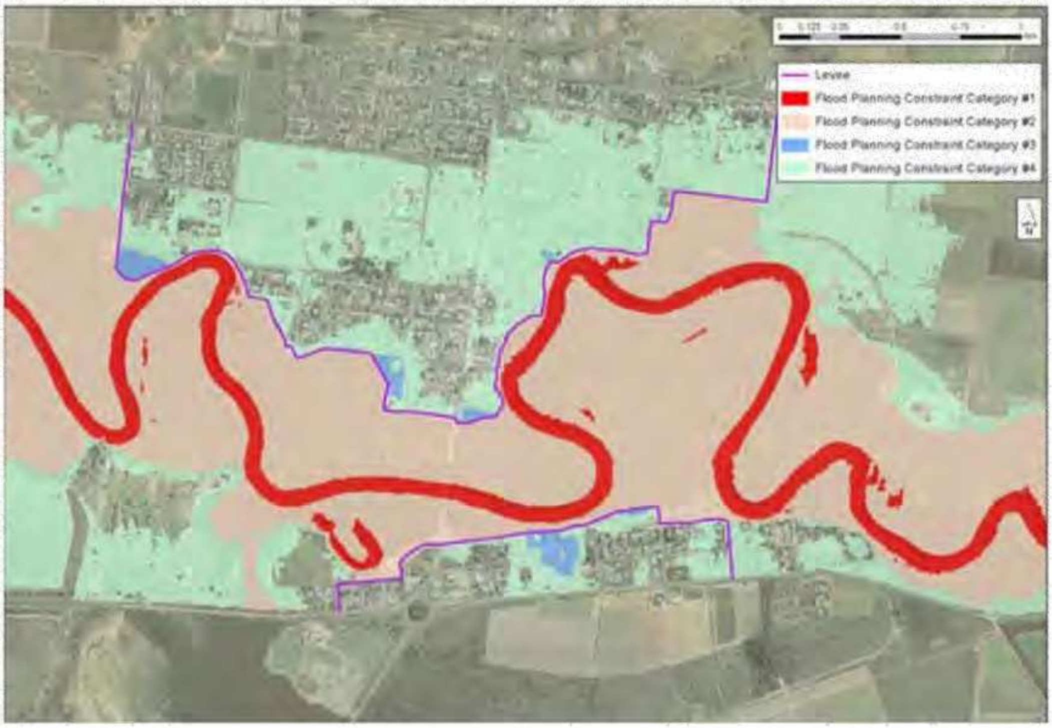

Figure 26 Example flood planning constraint categories (AIDR 2017c)

FPCCs can come in different forms. For example, Table 5 shows four FPCCs that have been developed to separate areas of the floodplain from the most constrained and least suitable for intensification of land use or development (FPCC1) to the least constrained and more suitable for intensification of land use or development (FPCC4). Other examples of FPCCs include flood risk precincts where the floodplain is broken down into areas of low, medium and high risk and the breakdown of the floodplain into floodway areas, the flood planning area and the flood risk management area.

Table 5 Flood Planning Constraint Categories – Implications and Key Considerations

FPCC	Level of constraints
1	Severe limitations on usage due to impacts on flood behaviour and hazard
2	Significant controls on development due to emergency response limitations, flood behaviour in rare events and the level of flood hazard
3	Standard land-use and development controls aimed at reducing damage and the exposure of the development to flooding in the DFE are likely to be suitable. Consider the need for additional conditions for emergency response facilities, key community infrastructure and vulnerable users.
4	Consider the need for conditions for emergency response facilities, key community infrastructure and land uses with vulnerable users.

5. MANAGEMENT MEASURES

5.1 Types of Measures

There are various ways of managing floodplains to reduce flood losses which include:

- modifying the response of the population at risk
- imposing controls on property and infrastructure development
- modifying the behaviour of the flood itself

The first two measures can be referred to as non-structural options or measures (Table 6). The third measure is often referred to as a structural option (those measures which modify flood behaviour by reducing flood levels or excluding floodwaters from areas at risk).

Table 6 Types of Modification Measures

Property Modification Measures	Response Modification Measures	Flood Modification Measures
Zoning	Community Awareness	Flood Control Dams
Voluntary Purchase	Community Readiness	Retarding Basins
Voluntary House Raising	Flood Prediction and Warning	Levees
Building and Development Controls	Local Flood Plans	Bypass Floodways
Flood Proofing Buildings	Evacuation Arrangements	Channel Improvements
Flood Access	Recovery Plans	Flood Gates

A FRM study will examine a wide range of management options for selection in the management plan and may include measures which:

- change the community's response to the next flood event;
- change the impact of floodwaters on development;
- change where the floodwaters go; and
- change the way we currently plan for future development and apply controls to current development.

5.2 Evaluation of Measures

The implementation of management measures is likely to have economic, social and environmental implications. The benefits of each measure need to be weighed up against their costs to justify their implementation.

When examining management options, the focus of looking at benefits and costs should be on aspects that will change due to the management option and effort should not be wasted on aspects that do not change.

Management option, especially structural options, need to consider whether the option impacts on the environment. For example, the construction of levees and floodgates may impact on wetlands which require tidal flows for efficient operation. Whilst such as examination should be sufficiently thorough to determine whether the option is environmentally viable, it does not extend to undertaking an environmental impact assessment. These more detailed assessments which will if needed be undertaken as part of detailed investigation and design before construction commencing. Where possible, opportunities for enhancement of the environment via the implementation of FRM measures should also be investigated and promoted.

While it is possible to identify tangible costs e.g. the financial costs of implementing structural works or development controls, it is not practical to ascribe a monetary value to intangible costs e.g. social dislocation caused by flooding. This does not mean, however, that intangible costs are any less important in considering whether management options are justifiable. They are generally examined in a qualitative way so that this can inform decisions.

When examining management measures and development proposals, it is very important that consideration be given to the impact of the development or measure on flood behaviour as well as the impact of flooding on the measure or development.

5.3 Flood Damage

The assessment of damages can help focus FRM efforts by providing important information on the severity and location of impacts. Any reduction in impacts resulting from the implementation of mitigation measures provides advice on their relative cost-efficiency through cost-benefit analyses including qualitative assessments of benefits and costs where relevant.

The severity of consequences of flooding on the community can be assessed based upon the frequency and scale of tangible and intangible impacts.

5.3.1 Types of Damage

Flood damages are traditionally divided into tangible and intangible damages. Tangible damages are also sub-divided into direct and indirect damages (Figure 27).

Figure 27 Types of Damage

5.3.2 Stage – Damage Curves

Direct damages are normally calculated using stage-damage curves. These curves show the damages that can be expected to occur for a range of depth of water over the floor. A sample stage-damage curve is shown in Figure 28.

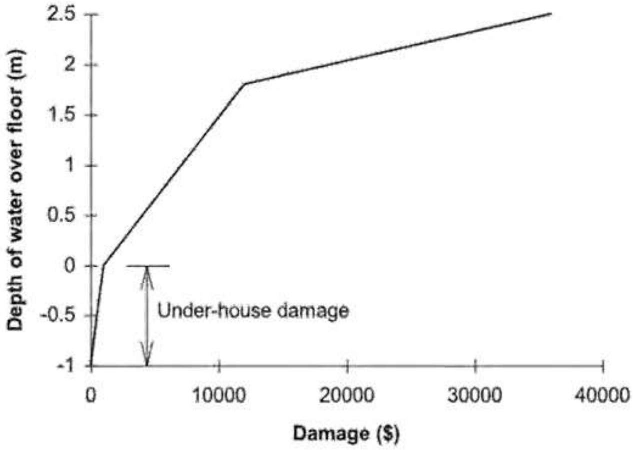

Figure 28 Sample Stage-Damage Curve

5.3.3 Average Annual Damage

The average annual damage (AAD) is the total damage caused by all floods over a long period of time divided by the number of years in that period. It represents the amount of damage that can be expected to occur every year on average. A sample curve relating damages to various design floods is shown in Figure 29. Such curves can be used to calculate the area under the curve to give AAD.

Examining the change in AAD is a convenient way to compare the economic benefits of various proposed mitigation measures.

Figure 29 A Sample of a flood damage curve for a range of AEP events (ARR 2019)

5.3.4 Benefit/Cost Ratio

A convenient method of assessing the economic viability of proposed mitigation measures is the benefit/cost ratio. Here the net present worth of the benefits associated with the measure (e.g. the reduced AAD) (Figure 30) is divided by the cost of the measure (e.g. construction cost, on-going maintenance costs and financing costs). If the B/C ratio is greater than 1 this implies the works have more tangible benefits than cost, and vice versa for a B/C ratio less than 1. However, works with a lower B/C ratio may still be viable when social, environmental and similar benefits and costs considerations are also considered.

The level of economic appraisal of an option varies with cost, impacts etc. Economic appraisal can be an iterative approach with cursory analysis needed in the initial phases of a study to detailed analysis for final decisions.

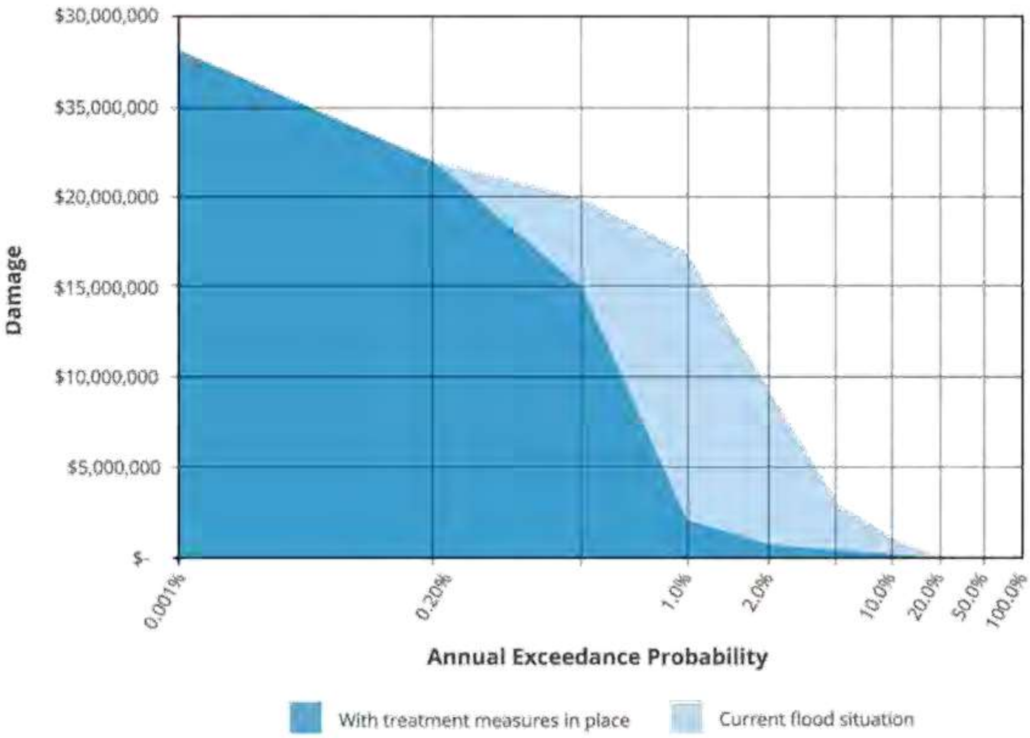

Figure 30 Sample Damage Curve with and without treatment options (ARR 2019)

6. REFERENCES

This handbook only provides basic information on flood risk management issues. The following publications and videos can assist in obtaining more comprehensive information.

AIDR 2017a, Australian Disaster Resilience Handbook 7 Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia, https://knowledge.aidr.org.au/media/3521/adr-handbook-7.pdf

AIDR 2017b, Australian Disaster Resilience Guideline 7-3 Flood Hazard, https://knowledge.aidr.org.au/media/3518/adr-guideline-7-3.pdf

AIDR 2017c, Australian Disaster Resilience Guideline 7-5 Flood Information to Support Land-use Planning, https://knowledge.aidr.org.au/media/3519/adr-guideline-7-5.pdf

ARR 2019, Australian Rainfall and Runoff: A Guide to Flood Estimation, Geoscience Australia, http://arr.ga.gov.au/arr-guideline

Managing Flood Risk (Video Series) Gosford City Council (2013), https://www.youtube.com/playlist?list=PLjDIzhwADz3YsX_Wb-B9JUsEI9PEiX0-Y

NSW Government (2005), *Floodplain Development Manual*, Department of Infrastructure Planning and Natural Resources, DIPNR 05_020, https://www.environment.nsw.gov.au/research-and-publications/publications-search/floodplain-development-manual

NSW Department of Planning Industry and Environment (DPIE), Floodplain Risk Management Guidelines, https://www.environment.nsw.gov.au/topics/water/floodplains/floodplain-guidelines

NSW Department of Planning Industry and Environment (DPIE), Floodplain Risk Management Guidelines, *Incorporating 2016 Australian Rainfall and Runoff in studies*, 2019, https://www.environment.nsw.gov.au/topics/water/floodplains/floodplain-guidelines

Shellharbour City Council, *Macquarie Rivulet Flood Study*, WMAwater, 2017

Note

[1] The Department of Planning Industry and Environment (DPIE) was formerly the Office of Environment and Heritage (OEH) up until 30 June 2019. References to DPIE documents may relate to documents labelled OEH.

City of Canada Bay

Plan of Management

Barnwell Golf Course

place design group.

WILLOWTREE PLANNING

Contents

KEY INFORMATION

Plan of Management for Barnwell Park Golf Course
City of Canada Bay Council
X date of adoption.

Issue	Date
Draft POM for Review	10/11/2022
Draft POM	29/11/2022
Draft POM	30/11/2022

In the spirit of reconciliation Place Design Group and Willowtree Planning acknowledge the Traditional Custodians of this area, the Wangal clan of the Eora nation and their connections to land, sea and community. We pay our respect to their elders past and present and extend that respect to all Aboriginal and Torres Strait Islander peoples today.

This plan of management (PoM) has been prepared by City of Canada Bay Council and provides direction as to the use and management of council-owned community land and council-managed Crown reserves classified as 'community land' in the City of Canada Bay Council area. The PoM is required in accordance with Section 3.23 of the *Crown Land Management Act 2016* and Section 36 of the *Local Government Act 1993*.

This PoM specifically addresses the management of Barnwell Park Golf Course. The PoM outlines the way the land will be used and provides the framework for Council to follow in relation to the express authorisation of leases and licence on the land.

INTRODUCTION

Background

The Local Government Act, 1993, requires Councils to produce plans of management for all areas of community land (i.e. Council owned land) by July 1996. Although there is no legal requirement, plans of management are also being prepared for areas of Crown land under Council's control. Barnwell Park Golf Course is a mixture of Crown land and community land.

The plan of management provides guidelines for the short and long term management of all land owned by Council or under Council control and also provides for consistency in how all parks are managed.

Community consultation has shown that residents of the Canada Bay Council area value highly the provision of parks, sporting fields, foreshore walks, and the close proximity to water. Indeed, these were often seen as major benefits of living in the area. The plan of management for Barnwell Park is prepared with this in mind. The document sets clear objectives for the improvement and management of this significant area of open space taking into consideration the needs of park users and residents.

The plan of management provides a basis for determining priorities in work programming and budgeting. An annual review will assess implementation and performance of the plan, and a review after 5 years will allow policy and planning issues to be updated.

Our Future 2036

OUR future 2036 is the Community Strategic Plan (CSP) for the future of the City of Canada Bay. The plan reflects the aspirations and priorities of the community that were identified following extensive engagement.

The plan includes a community vision statement, and key directions and goals that will provide direction for the delivery of outcomes from 2022 to 2036. In effect, this document outlines where we were in 2021, where we want to be in 2036, how we will get there, and how we will know when we have arrived.

The five key directions in Our Future 2036 are:

- Connected community
- Sustainable and thriving environment
- Vibrant urban living
- Infrastructure and transport
- Civic leadership.

No one entity can deliver all of the outcomes we need for our future. All levels of government, businesses, community groups, and residents have a level of responsibility to work together and contribute to the goals of Our Future 2036. Council's four-year Delivery Program and annual Operational Plan outline how Council will deliver on the Community Strategic Plan goals.

Purpose of the plan of management

The *Crown Land Management Act 2016* (the CLM Act) authorises local councils (council managers) appointed to manage dedicated or reserved Crown land to manage that land as if it were public land under the *Local Government Act 1993* (LG Act). A PoM is required for all council-managed Crown reserves on community land.

The purpose of this PoM is to:

- contribute to the council's broader strategic goals and vision as set out in Our Future 2036
- ensure compliance with the *Local Government Act 1993* and the *Crown Land Management Act 2016*
- provide clarity in the future development, use and management of the community land
- ensure consistent management that supports a unified approach to meeting the varied needs of the community.

Further information about the legislative context of Crown Reserve PoMs can be found in Appendix [A2] of this document.

Process of preparing this plan of management

Figure 1 illustrates the process undertaken by Council in preparing this PoM.

Step 1 **Drafting the plan of management**

- The PoM should meet all the minimum requirements outlined in section 36(3) of the LG Act and identify the owner of the land (templates provided).
- Any activities (including tenure or development) to be undertaken on the reserve must be expressly authorised in the PoM to be lawfully authorised.
- Councils must obtain written advice from a qualified native title manager that the PoM and the activities under the PoM comply with the NT Act.

⇩

Step 2 **Notifying the landowner and seek Minister's consent to adopt**

- The department as the landowner is to be notified of the draft PoM prior to public exhibition of the plan under s39 of the LG Act.
- Councils are also required to seek the department's written consent to adopt the draft PoM (under clause 70B of CLM Regulation). The department's consent can be sought at the same time as notifying the landowner of the draft plan.

⇩

Step 3 **Community consultation**

Councils are required to publicly notify and exhibit PoM under section 38 of the LG Act

- Councils are not required to hold a public hearing under section 40A of the LG Act (exemption under clause70A of the CLM Regulation).

⇩

Step 4 **Adopting a plan of management**

- If there are any changes to the plan following public exhibition of the draft PoM, councils must seek the department's consent to adopt the PoM.
- Council resolution of a PoM that covers Crown land should note that the PoM is adopted pursuant to section 40 of the LG Act in accordance with 3.23(6) of the CLM Act.
- Once a council has adopted the PoM, a copy of the adopted PoM should be forwarded to the department (council.clm@crownland.nsw.gov.au) for record purposes.

Change and review of plan of management

This PoM will require regular review in order to align with community values and changing community needs, and to reflect changes in council priorities. Council has determined that a major review and update of this PoM should be considered ten years from the date of adoption of the Plan, if not carried out prior..

However, the implementation of this PoM and its ongoing relevant will be reviewed on a yearly basis to ensure that the Reserve is being managed in accordance with the PoM, is well maintained and provides a safe environment for public enjoyment.

The community will have an opportunity to participate in reviews of this PoM.

Community consultation

In accordance with section 39 of the *Local Government Act 1993*, prior to being placed on public exhibition, the draft PoM was referred to the Department of Planning and Environment – Crown Lands, as representative of the state of NSW, which is the owner of the Reserve. Council has included in the plan any provisions that have been required by the Department of Planning and Environment – Crown Lands.

Cycleway Project Community Consultation

Along the northern side of Lyons Road West between Crane Street and Friend Avenue, Council is planning to construct an East-West Regional Cycleway. This Cycleway will partially encroach into Barnwell Park as further detailed later in this plan with respect to Management of land by category.

There have been several stages of consultation to inform the East-West Regional Cycleway project, of which Lyons Road West forms part. Early community engagement to inform planning for Council's broader cycling network was undertaken in June/July 2019 via Councill's engagement platform, Collaborate. Feedback on issues, facilities needed, and ideas was received right across the Council area.

As part of this process, a Bike Steering Group was also formed comprising community members such as the Canada Bay Bicycle User Group, commuters & recreational cyclists and anyone who has an interest in cycling and willing to provide input. Feedback received via Collaborate and the Bike Steering Group was used to identify which route the East-West Regional Cycleway should take, and from there detailed concept plans were prepared.

In July/August 2020 the broader community was consulted regarding the proposed East-West Regional Cycleway. There was generally community support for the proposed separated cycleway and footpath along the north side of Lyons Road West, along with suggestions of how to make it even better. Community feedback is being incorporated into the detailed design for the Cycleway.

Barnwell Golf Club Consultation

Barnwell Golf Club was consulted on the 01 November 2022 regarding the proposed separated cycleway and footpath along the northern side of Lyons Road West. The following were outcomes from the discussion:

1. Road crossing adjacent to 10th tee – concerns were raised from the Club about golfers gathering to tee off on the pedestrian / cycleway. Council confirmed that they were mindful of this in the draft design with golfers provided with space to gather on the golf course area and not outside. The club confirmed that a space for gathering on the golf course already exists and would mean that the golfers would only have to walk a short distance to cross the road at the proposed new crossing
2. The Club emphasised their view that the pedestrian / cycleway be accompanied by a golf ball screen. Council confirmed this was the intent and that the detailed design process would confirm the dimensions in term of required height to provide adequate protection.
3. Future Works – priorities have been identified across the site for further protection from golf balls.
4. The Club's position was confirmed that they did not consider the encroachment onto the course along the boundary with Lyons Road West to be significant and unduly impact golfers.
5. Concerns were raised regarding the removal of parking along the northern side of Lyons Road West between Regatta Road and Friend Avenue. It was noted that this will impact upon the Barnwell Park golfers particularly on weekends and affect patrons for Carmen's on the Park. Council staff noted that this was outside of the scope of the PoM and that community consultation had previously been undertaken regarding this and other impacts of the East-West Regional Cycleway.

LAND DESCRIPTION

This plan of management covers Barnwell Park Golf Course. The reserve information is detailed in Table 1. The land is owned by the Crown and is managed by Council as Crown land manager under the Crown Land Management Act 2016. Barnwell Park is a 14.3 hectare Golf Course established at Lyons Road West, within the suburb of Five Dock, and within the local government area (LGA) of Canada Bay. The reserve is located approximately 9.6km west of Sydney's central business district (CBD).

The Reserve is a low-lying area which sits adjacent Canada and Kings Bay, both inlets of the Parramatta River. The reserve has a comfortable open grassed character, with scattered stands of native trees, including eucalypts, casuarinas and melaleucas.

There are significant water views that can be obtained along the foreshore track and along Lyons Road West. There are limited views north to Canada Bay with significant native screening along the waters edge.

At present, Barnwell Park is a Golf Course which offers both social and competitive golf events for its members and visitors.

The surrounding land-use of site to the south-west of the reserve is residential, consisting of predominantly single-storey detached dwellings. Five Dock Leisure Centre adjoins Barnwell Park to the south. St Luke's Park and Cintra Park are located southwest of the site and include a childcare centre, a sportsground, netball courts, tennis and sports centre and Hockey complex.

Table 1**: information about reserve covered by this plan of management.**

<table>
<tr><td>Reserve Numbers</td><td>70289 – 88132 - 91037</td></tr>
<tr><td>Reserve purpose</td><td>Public Recreation</td></tr>
<tr><td>Land parcel/s</td><td>Crown Land
<table>
<tr><td>Res No</td><td>Lot</td><td>DP</td><td>Area m2</td></tr>
<tr><td>88132</td><td>7050</td><td>1124789</td><td>51996</td></tr>
<tr><td rowspan="2">91037</td><td>477</td><td>752023</td><td rowspan="2">46957</td></tr>
<tr><td>103</td><td>909059</td></tr>
<tr><td>70289</td><td>7331</td><td>1160809</td><td>2247</td></tr>
</table>
Community Land</td></tr>
</table>

	Lot / DP / Area m2: 91 / 1278356 / 23362 96 / 127358 / 3633 20 / 237206 / 10629 44 / 242652 / 3784 7330 / 1160809 / 1176 3 / 237206 / 2846
Area (Ha)	146,630
LEP zoning	RE1 Public Recreation
Assigned category/categories	Currently Sportsground. Proposed categorisation is Sportsground and Park

Lot	DP	Area m2
91	1278356	23362
96	127358	3633
20	237206	10629
44	242652	3784
7330	1160809	1176
3	237206	2846

This PoM is specific to the land mentioned in Table 1.

Land containing significant natural features

As Barnwell Park is a reclamation site, existing vegetation was introduced post construction in the 1960's. Grey Mangroves (Avicennia marina var. australasica), grow along the Western edge of Kings Bay at Lyons Road West. The two Barnwell Park Golf Club precincts have stands of vegetation throughout its course, occurring in rows.

Planting along the perimeter of the park is sporadic, varying between rows of planting and single standing trees. These vegetation clumps consist of Bottlebrush (Callistemon sp.), She-oak (Casuarina sp.), Coast Banksia (Banksia integrifolia), Ficus (Ficus sp.) and Stringybark (Eucalyptus sp.).

Other significant tree planting within the Reserve:

- Row of Bottlebrush (Callistemon sp.), She-oak (Casuarina sp.), Coast Banksia (Banksia integrifolia) and a Stringybark (Eucalyptus sp.) along the edge of William Street and Barnwell Park Golf Club.
- Row of Stringybark (Eucalyptus sp.) on the verge of Lyons Road West between Carmen's on the Park Five dock and Barnwell Park Pro Shop.

The dominant ground cover over the parks is turf grass -being Kikuyu and Couch species.

Culturally significant land

Prior to European settlement, the area now known as the City of Canada Bay was occupied by the Wangal clan. The term 'Wangal' is derived from the word for their Country. They form part of the Darug (Dharug) language group. The Wangal clan were living in the Sydney area for at least 10,000 years. The Wangal clan's territory is thought to have originally extended from Darling Harbour, around the Balmain Peninsula almost to Parramatta in the west, the Parramatta River formed the northern boundary although it is uncertain how far south their land extended. Goat Island (which they called Me-mel or Memill) opposite Balmain was also part of their land.

The Parramatta River is viewed as a living entity. The river has always been a key transport route, from First Nations into colonial trading. There is a strong cultural and spiritual connection between First Nations peoples and water/marine resources. Fishing is a cultural practice and is informed by traditional knowledges. Camps and rest areas were often established adjacent to waterways for the functional and aesthetic features of the Parramatta River.

During the summer months, food was gathered along the banks of the Parramatta River including fish and shellfish (creating middens within the Canada Bay area).Prominent fish species caught in this area include baludarri (leather-jacket) or garuma (bream) and other small fish.

Few traces of Aboriginal occupation survive in the Canada Bay area. The Wangal today are remembered by the Wangal Reserve (Mortlake) and Wangal Place (Five Dock).

BASIS OF MANAGEMENT

The site is currently categorised as a Sportsground. As part of this POM, Council is proposing an additional categorisation of Park – specifically for the strip of land within the Reserve that is proposed to become a separated cycleway and footpath.

Council intends to manage its community land to meet:

- assigned categorisation of community land
- the LG Act guidelines and core objectives for community land
- restrictions on management of Crown land community land.
- the Council's strategic objectives and priorities
- development and use of the land outlined in Section 6 of the LG Act.

Categorisation of the land

All community land is required to be categorised as one or more of the following categories. Where the land is owned by the Crown, the category assigned should align with the purpose for which the land is dedicated or reserved.

The LG Act defines five categories of community land:

- **Park** – for areas primarily used for passive / informal recreation.
- **Sportsground** – for areas where the primary use is for active recreation involving organised sports or the playing of outdoor games.
- **General community use** – for all areas where the primary purpose relates to public recreation and the physical, cultural, social, and intellectual welfare or development of members of the public. This includes venues such as community halls, scout and guide halls, and libraries.
- **Cultural significance** – for areas with Aboriginal, aesthetic, archaeological, historical, technical, research or social significance.
- **Natural area** – for all areas that play an important role in the area's ecology. This category is further subdivided into bushland, escarpment, foreshore, watercourse and wetland categories.

The categorisation of the land is identified in Appendix A1- Plan 2: Land Categorisation Map.

Guidelines and core objectives for management of community land

The management of community land is governed by the categorisation of the land, its purpose, and the core objectives of the relevant category of community land (see Categorisation of the land). Council may then apply more specific management objectives to community land, though these must be compatible with the core objectives for the land.

The guidelines for categorisation of community land are set out in the Local Government (General) Regulation 2005. The core objectives for each category are set out in the LG Act. The guidelines and core objectives for the Park and Sportsground categories for Barnwell Park are set out in the relevant category sections of this plan of management.

Community land is valued for its important role in the social, intellectual, spiritual and physical enrichment of residents, workers, and visitors to the City of Canada Bay area.

The intrinsic value of community land is also recognised, as is the important role this land plays in biodiversity conservation and ecosystem function.

City of Canada Bay encourages a wide range of uses of community land and intends to facilitate uses which increase the activation of its land, where appropriate. Within buildings, swimming pools, and recreational and sporting facilities in particular, City of Canada Bay intends to permit and encourage a broad range of appropriate activities.

Restrictions on management of Crown land

Council is the Crown land manager of the Crown reserves described in this plan of management in accordance with the legislation and conditions imposed by the Minister administering the *Crown Land Management Act 2016*. The use of the land described in this plan of management must:

- be consistent with the purpose for which the land was dedicated or reserved
- consider native title rights and interests and be consistent with the provisions of the Commonwealth *Native Title Act 1993*
- consider the inchoate interests of Aboriginal people where an undetermined Aboriginal Land Claim exists
- consider and not be in conflict with any interests and rights granted under the *Crown Land Management Act 2016*
- consider any interests held on title.

Council's strategic objectives and priorities

Council, in consultation with the community, has developed the following strategies and plans to identify the priorities and aspirations of the community and the delivery of a vision for the future. They have a direct influence on the objectives, uses and management approach covered by PoMs.

Development and use

The site's primary use as a Golf Course is intended to remain. The management model is to outsource the management and operation of the facility and for Council to retain the greenkeeping and maintenance responsibilities.

The recent Covid-19 pandemic has resulted in increased participation in golf and with the constraints of the Barnwell Park site Council is also mindful of managing ongoing issues related to safety from golf balls inadvertently leaving the course.

Current use of the land

Each relevant category section of this plan of management contains information about the existing use of the land, including:

- condition of the land and structures,
- use of the land and structures, and
- current leases and licences on the land.

Permissible uses / future uses

The site is currently utilised as a Golf Course and includes the Course Pro Shop and maintenance building. A portion of the land is proposed to become part of an East West Regional Cycleway in the future.

It is noted that development for the following purposes is permitted with consent on land zoned RE1:

Aquaculture; Biosolids treatment facilities; Boat sheds; Business identification signs; Car parks; Centre-based child care facilities; Community facilities; Environmental facilities; Information and education facilities; Jetties; Kiosks; Marinas; Markets; Mooring pens; Recreation areas; Recreation facilities (indoor); Recreation facilities (outdoor); Respite day care centres; Restaurants or cafes; Roads; Take away food and drink premises; Water recycling facilities

List of Category sections

- Park (specifically for the land proposed to become a Regional Cycleway)
- Sportsground

Express authorisation of leases and licences and other estates

Under section 46(1)(b) of the LG Act, leases, licences and other estates formalise the use of community land. A lease, licence or other estate may be granted to organisations and persons, community groups, sports clubs and associations, non-government organisations, charities, community welfare services, non-profit organisations and government authorities.

The lease or licence must be for uses consistent with the reserve purpose(s), the assigned categorisation and zoning of the land, be in the best interests of the community as a whole, and enable, wherever possible, shared use of community land.

Any lease or licence proposal will be individually assessed and considered, including the community benefit, compatibility with this PoM and the capacity of the community land itself and the local area to support the activity.

A lease is normally issued where exclusive control of all or part of an area by a user is proposed. In all other instances a licence or short-term licence or hire agreement will be issued.

Leases and licences authorised by the plan of management

Current Leases and Licences include:

Lease – Barnwell Park Golf Course Pro Shop – 3 years + 2 x 1-year options

Licence – Access to and use of Barnwell Park Golf Course (Crown Land managed by Council) – 3 years + 2 x 1-year options

Licence – Access to and use of Barnwell Park Golf Course (Council owned Community Land) – 3 years + 2 x 1-year options

This plan of management **expressly authorises** the issue of leases, licences and other estates over the land covered by the plan of management, provided that:

- the purpose is consistent with the purpose for which it was dedicated or reserved
- the purpose is consistent with the core objectives for the category of the land
- the lease, licence or other estate is for a permitted purpose listed in the *Local Government Act 1993* or the Local Government (General) Regulation 2005
- the issue of the lease, licence or other estate and the provisions of the lease, licence or other estate can be validated by the provisions of the *Native Title Act 1993* (Cth)
- where the land is subject to a claim under the *Aboriginal Land Rights Act 1983* the issue of any lease, licence or other estate will not prevent the land from being transferred in the event the claim is granted

- the lease, licence or other estate is granted and notified in accordance with the provisions of the *Local Government Act 1993* or the Local Government (General) Regulation 2005
- the issue of the lease, licence or other estate will not materially harm the use of the land for any of the purposes for which it was dedicated or reserved.

Tables in the relevant category sections of this plan of management further identify the purposes for which leases and licences may be issued over the reserves identified in this plan of management.

Short-term licences and bookings may be used to allow the council to program different uses of community land at different times, allowing the best overall use.

Short-term licences are authorised for the purpose of:

(b) engaging in a trade or business

(c) the playing of a lawful game or sport

(d) the delivery of a public address

(e) commercial photographic sessions

(g) filming sessions

Fees for short-term casual use will be charged in accordance with the Council's adopted Fees and Charges at the time.

Native title and Aboriginal land rights considerations in relation to leases, licences and other estates

When planning to grant a lease or licence on Crown reserves, Council must comply with the requirements of the Commonwealth *Native Title Act 1993* (NT Act) and have regard for any existing claims made on the land under the NSW *Aboriginal Land Rights Act 1983*.

It is the role of the Council's engaged or employed native title manager to provide written advice in certain circumstances to advise if the proposed activities and dealings are valid under the NT Act (see Appendix A3 for more information).

Management of land by category

A. Park

This is the proposed categorisation for the strip of land within the reserve that is proposed to be used for the Regional Cycleway (refer to Appendix A1 – Plan 2: Land Categorisation Map). The strip of land is 1m wide along Lyons Road West between the western edge of the park and Regatta Road. Opposite Regatta Road through to the eastern edge of the northern part of Barnwell Park, the strip is 3m wide.

The existing fence line along the north side of Lyons Road West is setback generally between 0.5m and 1m from the true boundary of Barnwell Park. The misalignment of the true boundary and the existing fence line increases significantly to just under 3m in the area opposite and just east of Regatta Road.

The entirety of the indicated strip of lane is not required for the Regional Cycleway. The exact extents of the partial encroachment of the Cycleway into Barnwell Park will be determined in the final detailed design and will be variable along the length of Lyons Road West. This is noting the existing variable alignment of Lyons Road West within the road reserve and various constraints such as existing infrastructure.

It is anticipated that the existing alignment of the fence line along the northern side of Lyons Road West will be largely unchanged, with some sections of the fence setback up to approximately 0.5m further into Barnwell Park. This is not anticipated to have any notable impact on the operation of Barnwell Park Golf Club.

Guidelines and core objectives

Parks are defined in clause 104 of the LG (General) Regulation as land which is improved by landscaping, gardens or the provision of non-sporting equipment and facilities, and for uses which are mainly passive or active recreational, social, educational and cultural pursuits that do not intrude on the peaceful enjoyment of the land by others.

The core objectives for parks, as outlined in Section 36G of the LG Act, are to:

- encourage, promote and facilitate recreational, cultural, social and educational pastimes and activities
- provide for passive recreational activities or pastimes and for the casual playing of games
- improve the land in such a way as to promote and facilitate its use to achieve the other core objectives for its management.

Key issues

Visitor Experience

Management

Provision of a new dedicated cycle path for recreation and commuter use.

This path will form part of a broader Regional Cycleway connecting east-west cycling movements across the Council area, as well as provide local connections to schools, parks, recreation facilities, commercial areas, etc.

By connecting along Lyons Road West, the Regional Cycleway project will also capture cycling movements to/from the north-west of the Council area such as Rhodes.

Health and Safety Risk Management

Provide a safe facility for users which promotes a healthy lifestyle and sustainable mode of transport and recreation along Parramatta River and the adjacent golf course. A lack of cycling facilities and high traffic volumes on Lyons Road West is currently a significant barrier to cycling. Whilst confident cyclists currently ride along Lyons Road West in spite of this, these movements don't reflect routes and infrastructure needs required to suit the significantly larger portion of cyclists who are less confident.

Accessibility

Provides a facility that accommodates people with a range of disabilities and restricted mobility. This facility also allows for all skill levels or cyclists and micro-mobility users.

Increases foreshore access for visitors and locals and reduces congestion between cyclists and vehicles.

Currently there is no footpath along much of the north side of Lyons Road West between Crane Street and Friend Avenue. As a result, there is a poor level of connectivity for mobility impaired people.

Management framework for reserves categorised as Park

Council will undertake regular maintenance of the separated cycleway and footpath, including street sweeping and condition assessment. This will be funded through Council's annual Operational budget.

Development and use

Infrastructure and Facilities

Council proposes the installation of safety fencing along the golf course frontage (Lyons Road West) to provide safety for pedestrians, cyclists and adjacent properties. The proposed fencing should be designed to minimise impact on the surrounding environment and views / sight lines for pedestrians and cyclists.

Easements

Council reserves the right to grant easements as required for utilities and access.

Signs

Council uses signs to regulate the activities carried out on community land and to provide educational and safety information. All Council signs erected under Part 9 of the CLM Act, plus course name signs, traffic and safety signs, are permissible. Council must approve all other signs, including design before erection. All signs must be sympathetic to their environments in their design, construction and location.

Current use of the land

Condition of the land and structures

Refer to Appendix A5 for details on assets. The site is generally in good condition and functions well for its use as a Golf Course and pedestrian footpath / verge.

Use of the land and structures

Whilst the land is currently technically part of the golf course, the existing fence does not align with the true boundary. Whilst there is generally no footpath along the north side of Lyons Road West between Crane Street and Friend Avenue, the land is currently utilised informally by pedestrians. The land to be classified as 'Park' includes the existing fence.

Current leases and licences

Licences include the Barnwell Park Golf Course (Crown Land managed by Council) and Barnwell Park Golf Course (Council owned Community Land).

Permissible uses / future uses

The general types of uses which may occur on community land categorised as Park and the forms of development generally associated with those uses, are set out in detail in Table 2. The facilities on community land may change over time, reflecting the needs of the community.

Table 2. Permissible use and development of community land categorised as Park by council or the community

Purpose/Use, such as…	Development to facilitate uses, such as…
• Active and passive recreation such as walking and cycling • Connection for users between the northern and southern halves of Barnwell Park • Community events such as forming part of a walking and/or cycling route	• Development for the purposes of improving access, amenity and the visual character of the park, for example paths, public art • Development for the purposes of active recreation such as walking and cycling paths • Amenities to facilitate the safe use and enjoyment of the park, for example picnic • Lighting, seating, paved areas • Hard and soft landscaped areas

Purpose/Use, such as…	Development to facilitate uses, such as…

	• Heritage and cultural interpretation, for example signs
	• Advertising structures and signage (such as A-frames and banners) that:
	  ○ relate to approved uses/activities
	  ○ are discreet and temporary
	  ○ are approved by the council
	• Energy-saving initiatives such as solar lights and solar panels
	• Locational, directional and regulatory signage

Express authorisation of leases, licences and other estates - Park

This plan of management **expressly authorises** the issue of leases, licences and other estates over the land categorised as Park, listed in Table 3.

Table 3. Leases, licences and other estates and purposes for which they may be granted for community land categorised as Park.

Type of tenure arrangement	Maximum term	Purpose for which tenure may be granted
Other estates		This PoM allows the council to grant 'an estate' over community land for the provision of public utilities and works associated with or ancillary to public utilities and provision of services, or connections for premises adjoining the community land to a facility of the council or public utility provider on the community land in accordance with the LG Act.

Action plan

Section 36 of the LG Act requires that a PoM for community land details:

- objectives and performance targets for the land
- the means by which the council proposes to achieve these objectives and performance targets
- the manner in which the council proposes to assess its performance in achieving the objectives and performance targets.

Table 4 sets out these requirements for community land categorised as Park.

Table 4. Objectives and performance targets, means of achieving them and assessing achievement for community land categorised as Park

Management Issues	s.36(3)(b) **Objectives and Performance Targets**	s.36(3)(c) **Means of achievement of objectives**	s.36(3)(d) **Manner of assessment of performance**
Management	Provision of a new separated cycleway for recreation and commuter use.	This path will form part of a broader Regional Cycleway connecting east-west cycling movements across the Council area, as well as provide local connections to schools, parks, recreation facilities, commercial areas, etc. The NSW Government is funding this $7 million Regional Cycleway project as part of the Parramatta Road Urban Amenity Improvement Program (PRUAIP).	Separated cycleway constructed along Lyons Road West
Health and Safety Risk Management	Provide a safe facility for users which promotes a healthy lifestyle and sustainable mode of transport and recreation along Parramatta River and the adjacent golf course. A lack of cycling facilities and high traffic volumes on Lyons Road West is currently a significant barrier to cycling.	Whilst confident cyclists currently ride along Lyons Road West in spite of this, these movements don't reflect routes and infrastructure needs required to suit the significantly larger portion of cyclists who are less confident.	Separated cycleway constructed along Lyons Road West

Management Issues	s.36(3)(b) **Objectives and Performance Targets**	s.36(3)(c) **Means of achievement of objectives**	s.36(3)(d) **Manner of assessment of performance**
Accessibility Currently there is no footpath along much of the north side of Lyons Road West between Crane Street and Friend Avenue. As a result, there is a poor level of connectivity for mobility impaired people.	Provide a facility that accommodates people with a range of disabilities and restricted mobility. This facility also allows for all skill levels or cyclists and mirco-mobility users.	Increased foreshore access for visitors and locals and reduces congestion between cyclists and vehicles.	Separated cycleway and footpath constructed along Lyons Road West

B. Sportsground

Barnwell Park Golf Course is currently categorised as sportsfield. Barnwell Park is a 14.3 hectare Golf Course established at Lyons Road West, within the suburb of Five Dock, and within the local government area (LGA) of Canada Bay. The reserve is located approximately 9.6km west of Sydney's central business district (CBD).

The Reserve is a low-lying area which sits adjacent Canada and Kings Bay, both inlets of the Parramatta River. The reserve has a comfortable open grassed character, with scattered stands of native trees, including eucalypts, casuarinas and melaleucas.

There are significant water views that can be obtained along the foreshore track and along Lyons Road West. There are limited views north to Canada Bay with significant native screening along the waters edge.

At present, Barnwell Park is a Golf Course which offers both social and competitive golf events for its members and visitors.

Guidelines and core objectives

Sportsgrounds are defined in clause 103 of the LG (General) Regulation as land used primarily for active recreation involving organised sports or playing outdoor games.

The core objectives for sportsgrounds, as outlined in Section 36F of the LG Act, are to:

- encourage, promote and facilitate recreational pursuits in the community involving organised and informal sporting activities and games
- ensure that such activities are managed having regard to any adverse impact on nearby residences.

Key issues

The below are factors that impact the affected reserve:

- Risk of Damage to property or injury to persons from golf balls
- Future conflict of pedestrian, cyclists and golfers when Regional Cycleway is built
- Future loss of parking due to introduction of cycleway along Lyons Road West
- Current use of land categorised as Sportsground for future regional cycleway

Management framework for reserves categorised as Sportsground

Councils approach to managing sportsground reserves include:

- Management and Operations of the golf course is contracted out to an external service provider
- Greenkeeping and course maintenance is carried out by Council

- The service provider is required to levy Council's adopted fees and charges (annual basis)

Development and use

Infrastructure and Facilities

Council proposes the installation of safety fencing along the golf course frontage (Lyons Road West) to provide safety for pedestrians, cyclists and adjacent properties. The proposed fencing should be designed to minimise impact on the surrounding environment and views / sight line for pedestrians and cyclists.

Easements

Council reserves the right to grant easements as required for utilities and access.

Signs

Council uses signs to regulate the activities carried out on community land and to provide educational and safety information. All Council signs erected under Part 9 of the CLM Act, plus course name signs, traffic and safety signs, are permissible. Council must approve all other signs, including design before erection. All signs must be sympathetic to their environments in their design, construction and location.

Parking

Council provides off road parking accessible from Lyons Road West. Two separate carparks exist, one adjacent the Barnwell Golf Course Club house and the other next to the Barnwell Park Golf Course Pro Shop. On road parking currently exists along Lyons Road West and on adjacent streets.

Current use of the land

Condition of the land and structures

Refer to Appendix A6 for details on assets. The site is generally in good condition and functions well for its use as a Golf Course. There are two structures onsite which include the Golf Pro Shop and maintenance building.

Use of the land and structures

The land is currently used as a golf course. The strip of land along Lyons Road West (see Appendix A1 – Plan 2: Land Categoration Map is proposed to facilitate a Regional Cycleway (subject to recategorisation as *park*).

Current leases and licences

Leases onsite currently include the Barnwell Park Golf Course Pro Shop.

Licences include the Barnwell Park Golf Course (Crown Land managed by Council) and Barnwell Park Golf Course (Council owned Community Land).

Permissible uses / future uses

The general types of uses which may occur on community land categorised as Sportsground and the forms of development generally associated with those uses, are set out in detail in Table 5. The facilities on community land may change over time, reflecting the needs of the community.

Table 5. Permissible use and development of community land categorised as Sportsground, by council or the community

Purpose/Use, such as…	Development to facilitate uses, such as…

• Active and passive recreational and sporting activities compatible with the nature of the particular land and any relevant facilities
• Organised and unstructured recreation activities
• Community events and gatherings
• Commercial uses ancillary to the use of sports facilities
	Development for the purpose of conducting and facilitating organised sport Facilities ancillary to the use for organised sport i.e. change room/locker areas, Shower/toilet facilities
	• Kiosk/café uses
	• Car parking and loading areas
	• Ancillary areas (staff rooms, meeting rooms, recording rooms, equipment storage areas)
	• Storage ancillary to recreational uses, community events or gatherings, and public meetings
	• Facilities for sports training,
	• Equipment sales/hire areas
	• Meeting rooms/staff areas
	• Compatible, small scale commercial uses, e.g. sports tuition
	• Advertising structures and signage (such as A-frames and banners) that:
	  ○ relate to approved uses/activities
	  ○ are discreet and temporary
	  ○ are approved by the council
	• Water-saving initiatives such as stormwater harvesting, rain gardens and swales
	• Energy-saving initiatives such as solar lights and solar panels
	• Locational, directional and regulatory signage

Express authorisation of leases, licences and other estates - Sportsground

This plan of management **expressly authorises** the issue of leases, licences and other estates over the land categorised as Sportsground, listed in Table 6.

Table 6. Leases, licences and other estates and purposes for which they may be granted for community land categorised as Sportsground

Type of tenure arrangement	Maximum term	Purpose for which tenure may be granted
Lease	• 3 years + 2 x 1-year options	• hire or sale of recreational equipment • commercial uses ancillary to sports use – i.e. sports coaching.
Licence	• 3 years + 2 x 1-year options	• outdoor café/kiosk seating and tables • management of court or similar facilities

Action plan

Section 36 of the LG Act requires that a PoM for community land details:

- objectives and performance targets for the land
- the means by which the council proposes to achieve these objectives and performance targets
- the manner in which the council proposes to assess its performance in achieving the objectives and performance targets.

Table 7 sets out these requirements for community land categorised as Sportsground.

Table 7. Objectives and performance targets, means of achieving them and assessing achievement for community land categorised as Sportsground.

Management Issues	s.36(3)(b) Objectives and Performance Targets	s.36(3)(c) Means of achievement of objectives	s.36(3)(d) Manner of assessment of performance
To minimise real and perceived adverse impacts on neighbouring properties caused by the use of Barnwell Park and changes to course facilities.	To preserve the amenity of the surrounding neighbourhood	Identify potential impacts arising from any proposed changes to the course or course facilities (such as measures to reduce golf ball damage to property and cars).	List of potential impacts completed.
		Determine means of mitigating adverse impacts and implement appropriate measures.	Implementation of mitigation measures.
		Ensure that residents are informed of any proposed developments e.g. major landscape initiatives, fencing, and that public input is facilitated.	Residents are informed of proposed developments.

Management Issues	s.36(3)(b) **Objectives and Performance Targets**	s.36(3)(c) **Means of achievement of objectives**	s.36(3)(d) **Manner of assessment of performance**
To improve the visual and aesthetic qualities of Barnwell Park through appropriate landscaping	To enhance the appeal of the golf course for golfers and residents.	Prepare a **Master Plan** for the course, which would include details of landscape proposals, and invite comments from residents and golfers.	Master Plan completed.
To progressively upgrade the playing surface of the fairways and tees	To provide landscape variety throughout the park.	Undertake landscape initiatives as per landscape plan	Planting program implemented
		Ensure that 'view corridors' of the bay are retained	View corridors established to satisfaction of adjoining residents and course users
		Involve the local community in tree planting initiatives where appropriate	Resident participation in planting programs. Program implemented. Positive feedback from residents.
To improve signage that is clear and informative		Identify signage which needs upgrading. Identify areas where additional signage is required.	Areas requiring signage identified and listed.
		Replace existing signage and install new signage as required, consistent with Council's predominant style.	New signage installed. Positive feedback from park users.
To provide a range of facilities which	To improve/maintain the amenity of the park for park users.	Update inventory of existing facilities in Barnwell Park.	Inventory Complete

Management Issues	s.36(3)(b) Objectives and Performance Targets	s.36(3)(c) Means of achievement of objectives	s.36(3)(d) Manner of assessment of performance
meet the needs of park users.		Determine whether current facilities meet user needs via user surveys and site observations.	User survey complete Meet regularly with course operator and Barnwell Park Golf Club
To provide facilities which are well sited, functional, and visually attractive.		Upgrade or build new facilities as required and within budget constraints.	Facilities which meet user needs are upgraded or installed.
		Consult with residents and golfers on proposals for any significant works.	Community satisfied with consultation process and outcomes.
To provide facilities which provide equal access	The golf course is accessible for all users	Consult with the course operator on user needs, at times when facility improvements or park developments are planned, and at all stages during their development.	Increased access of the course by all members of the community.
To implement effective and efficient management practices so that Barnwell Park is maintained to a satisfactory and safe standard.	So that users enjoy a course which is well maintained and aesthetically pleasing. So that risks to park users and potential for claims against Council are minimised	Review current maintenance strategy for parks and facilities.	Review complete
		Prepare comprehensive maintenance programs for all components requiring maintenance work.	Maintenance program complete.
		Carry out regular maintenance inspections.	Regular inspections carried out.
		Undertake maintenance on a regular cycle and complete emergency repairs as required.	Maintenance implemented to agreed schedule and within budget.

Management Issues	s.36(3)(b) **Objectives and Performance Targets**	s.36(3)(c) **Means of achievement of objectives**	s.36(3)(d) **Manner of assessment of performance**
To provide safety for nearby residents and motorists and to reduce damage to property caused by misguided golf balls.		To identify risk area and develop measures (not restricted to fencing) to manage problem.	Risk identification and prioritisation completed
		To consult with residents/golfers as part of the process	Engage with Barnwell Park Golf Club
		To implement appropriate strategies to reduce golf ball damage and improve safety.	Reduced golf ball damage/increased safety.

APPENDICES

Appendix A1 – Maps

The Local Government (General) Regulation 2005 (Clause 113) requires that a draft plan of management that categorises an area of community land, or parts of an area of community land, in more than one category must clearly identify the land or parts of the land and the separate categories (by a map or otherwise).

In addition, a map of the reserve allows the reader to clearly understand the land use and context of the land in the surrounding area.

The maps should clearly identify:

- *The owner of the land, where the PoM covers both land owned by council and Crown land*
- *The community land categories applied to the land, whether one category is assigned or multiple categories*
- *Any areas of the reserve which are to be managed as operational land (if applicable)*
- *Key features of the land*
- *Zoning of the land under the LEP (optional)*

Plan 1: Crown and Community Land covering Barnwell Park Golf Course

Plan 2: Land Categorisation Plans

Appendix A2 – Plan of Management Legislative Framework

The primary legislation that impacts on how community land is managed or used is briefly described below. You can find further information regarding these acts at www.legislation.nsw.gov.au.

Local Government Act 1993

Section 35 of the *Local Government Act 1993* (LG Act) provides that community land can only be **used** in accordance with:

- the plan of management applying to that area of community land, and
- any law permitting the use of the land for a specified purpose or otherwise regulating the use of the land, and
- the provisions of Division 2 of Chapter 6 of the Act.

Section 36 of the Act provides that a plan of management for community land must identify the following:

a) the category of the land,
b) the objectives and performance **targets** of the plan with respect to the land,
c) the means by which the council proposes to **achieve** the plan's objectives and performance targets,
d) the manner in which the council proposes **to assess its performance** with respect to the plan's objectives and performance targets,

and may require the prior approval of the council to the carrying out of any specified activity on the land.

A plan of management that applies to just one area of community land:

a) must include a description of:
   (i) the condition of the land, and of any buildings or other improvements on the land, as at the date of adoption of the plan of management, and
   (ii) the use of the land and any such buildings or improvements as at that date, and
b) must:
   (i) specify the purposes for which the land, and any such buildings or improvements, will be permitted to be used, and
   (ii) specify the purposes for which any further development of the land will be permitted, whether under lease or licence or otherwise, and
   (iii) describe the scale and intensity of any such permitted use or development.

Land is to be categorised as one or more of the following:

a) a natural area
b) a sportsground
c) a park
d) an area of cultural significance
e) general community use.

Land that is categorised as a natural area is to be further categorised as one or more of the following:

a) bushland
b) wetland
c) escarpment
d) watercourse
e) foreshore
f) a category prescribed by the regulations.

Additionally, under section 36 of the LG Act, a site-specific PoM must be made for land declared:

- as critical habitat, or directly affected by a threat abatement plan or a recovery plan under threatened species laws (sections 36A(2) and 36B(3))
- by council to contain significant natural features (section 36C(2))
- by council to be of cultural significance (section 36D(2)).

Classification of public land

The LG Act requires classification of public land into either 'community' or 'operational' land (Section 26). The classification is generally made for council-owned public land by the council's Local Environmental Plan (LEP) or in some circumstances by a resolution of the council (Section 27).

Crown reserves managed by council as Crown land manager have been classified as community land upon commencement of the *Crown Land Management Act 2016* (CLM Act). Councils may manage these Crown reserves as operational land if written consent is obtained from the Minister administering the CLM Act.

Classification of land has a direct effect on the council's ability to dispose of or alienate land by sale, leasing, licensing or some other means. Under the LG Act, community land must not be sold (except for scheduled purposes), exchanged or otherwise disposed of by the council, and the land must be used and managed in accordance with an adopted PoM. In addition, community land is subject to strict controls relating to leases and licences (sections 45 and 46) of the LG Act.

By comparison, no such restrictions apply to operational land that is owned by councils. For example, operational land can be sold, disposed, exchanged or leased including exclusive use over the land, unencumbered by the requirements which control the use and management of community land. Crown reserves managed by council as operational land may generally be dealt with as other operational land but may not be sold or otherwise disposed of without the written consent of the Minister administering the CLM Act.

Operational land would usually include land held as a temporary asset or an investment, land which facilitates the council carrying out its functions or land which may not be open to the general public (for example, a works depot).

The classification or reclassification of council-owned public land will generally be achieved by a Local Environmental Plan (LEP) or by a resolution of council in accordance with sections 31, 32 and 33 of the LG Act. If land is not classified by resolution within a three-month period from acquisition it automatically becomes community land, regardless of whether it satisfies the objectives for community land as outlined in the LG Act.

For Crown land, Council cannot reclassify community land as operational land without consent of the Minister administering the CLM Act.

Crown Land Management Act 2016

Crown reserves are land set aside on behalf of the community for a wide range of public purposes, including environmental and heritage protection, recreation and sport, open space, community halls, special events and government services.

Crown land is governed by the CLM Act, which provides a framework for the state government, local councils and members of the community to work together to provide care, control and management of Crown reserves.

Under the CLM Act, as Council Crown land managers, councils manage Crown land as if it were public land under the LG Act. However, it must still be managed in accordance with the purpose of the land and cannot be used for an activity incompatible with its purpose – for example, Crown land assigned the purpose of 'environmental protection' cannot be used in a way that compromises its environmental integrity.

Councils must also manage Crown land in accordance with the objects and principles of Crown land management outlined in the CLM Act. The objects and principles are the key values that guide Crown land management to benefit the community and to ensure that Crown land is managed for sustainable, multiple uses.

Principles of Crown land management

- Environmental protection principles are to be observed in the management and administration of Crown land.
- The natural resources of Crown land (including water, soil, flora, fauna and scenic quality) will be conserved wherever possible.
- Public use and enjoyment of appropriate Crown land are to be encouraged.
- Where appropriate, multiple uses of Crown land should be encouraged.
- Where appropriate, Crown land should be used and managed in such a way that both the land and its resources are sustained.
- Crown land is to be occupied, used, sold, leased, licensed or otherwise dealt with in the best interests of the state of NSW, consistent with the above principles.

Crown land management compliance

In addition to management and use of Crown reserves that is aligned with the reserve purpose(s), there are other influences over council management of Crown reserves. For example, Crown land managers may have conditions attached to any appointment instruments, or councils may have to comply with specific or general Crown land management rules that may be published in the NSW Government Gazette. Councils must also comply with any Crown land regulations that may be made.

Native Title Act 1993

The Commonwealth *Native Title Act 1993* (NT Act) recognises and protects native title rights and interests. The objects of the NT Act are to:

- provide for the recognition and protection of native title
- establish ways in which future dealings affecting native title may proceed and to set standards for those dealings
- establish a mechanism for determining claims to native title
- provide for, or permit, the validation of past acts invalidated because of the existence of native title.

The NT Act may affect use of Crown land, particularly development and granting of tenure.

Specifically, the CLM Act makes it mandatory for council to engage or employ a native title manager. This role provides advice to council as to how the council's dealings and activities on Crown land can be valid or not valid in accordance with the NT Act.

Council must obtain the written advice from an accredited native title manager that Council complies with any applicable provisions of the native title legislation when:

a) granting leases, licences, permits, forestry rights, easements or rights of way over the land
b) mortgaging the land or allowing it to be mortgaged
c) imposing, requiring or agreeing to covenants, conditions or other restrictions on use (or removing or releasing, or agreeing to remove or release, covenants, conditions or other restrictions on use) in connection with dealings involving the land

d) approving (or submitting for approval) a plan of management for the land that authorises or permits any of the kinds of dealings referred to in (a), (b) or (c).

Council plans and policies relating to this plan of management

Council has developed plans and policies that are concerned to some extent with the management of community land. These documents have been considered when preparing this PoM.

The following is a list of documents that have a direct association with this PoM:

- *Local Movement Strategy* adopted by Council on 20 August 2019;
- *Foreshore Access Strategy* adopted by Council on 20 October 2020
- *Social Infrastructure (Open Space and Recreation) Strategy* adopted by Council on 26 September 2019

Local Planning Controls

City of Canada Bay Local Environmental Plan (LEP) 2013

Zoning for Barnwell Park Golf Course – RE1 - City of Canada Bay LEP 2013

A plan of management's provisions must be consistent with the land uses and developments permissible for an area under a local environmental plan and other planning regulations.

The *City of Canada Bay Local Environmental Plan (LEP) 2013* is Council's key local land use planning document. It describes land use objectives as well as permitted and prohibited developments and uses for all parts of the local government area according to land use zones. The 2013 LEP covers Barwell Park Golf Course, with the area zoned RE1 Public Recreation.

The objectives of the RE1 Public Recreation zone are to:

- enable land to be used for public open space or recreational purposes.
- provide a range of recreational settings and activities and compatible land uses.
- protect and enhance the natural environment for recreational purposes.
- facilitate public access to and along the foreshore.
- conserve public open space that enhances the scenic and environmental quality of Canada Bay.

Land uses within this zone is required to be consistent with the permitted and prohibited uses identified in Council's current Local Environmental Plan 2013 and any succeeding planning control, which are as follows:

Aquaculture; Biosolids treatment facilities; Boat sheds; Business identification signs; Car parks; Centre-based child care facilities; Community facilities; Environmental facilities; Information and education facilities; Jetties; Kiosks; Marinas; Markets; Mooring pens; Recreation areas; Recreation facilities (indoor); Recreation facilities (outdoor); Respite day care centres; Restaurants or cafes; Roads; Take away food and drink premises; Water recycling facilities

City of Canada Bay Development Control Plan (DCP):

The Park is subject to the *City of Canada Bay Development Control Plan (DCP)*. This more detailed planning document sets out standards and controls in relation to both development generally (for individual buildings to master-planned sites and subdivisions) as well as for specific types of building or development.

Other state and Commonwealth legislation

NSW state legislation

Environmental Planning and Assessment Act 1979

The *Environmental Planning and Assessment Act 1979* (EP&A Act) provides the framework for planning and development across NSW and guides environmental planning instruments which provide a basis for development control.

The EP&A Act ensures that effects on the natural environment, along with social and economic factors, are considered by the council when granting approval for or undertaking works, developments or activities.

This Act is also the enabling legislation for planning policies which may have a direct influence on open space management. On a state-wide level there are State Environmental Planning Policies (SEPPs). On a regional level there are Regional Environmental Plans (REPs). On a local level there are Local Environmental Plans (LEPs) as well as Development Control Plans (DCPs).

Aboriginal Land Rights Act 1983

The *Aboriginal Land Rights Act 1983* (ALR Act) is important legislation that recognises the rights of Aboriginal peoples in NSW. It recognises the need of Aboriginal peoples for land and acknowledges that land for Aboriginal people in the past was progressively reduced without compensation. Crown land meeting certain criteria may be granted to an Aboriginal Land Council. This Act may affect dealings with Crown land that is potentially claimable.

National Parks and Wildlife Act 1974

Statutory responsibilities on the council arising from this Act specifically relate to the protection of sites of pre- and post-European contact archaeological significance. This Act may affect community land categorised as cultural significance, natural area or park.

Biodiversity Conservation Act 2016

> **Note:** This Act repealed several pieces of legislation including the *Native Vegetation Act 2003*, *Threatened Species Conservation Act 1995*, the *Nature Conservation Trust Act 2001*, and the animal and plant provisions of the *National Parks and Wildlife Act 1974*.

This Act covers conservation of threatened species, populations and ecological communities, the protection of native flora and fauna. This Act primarily relates to community land categorised as natural area. However, other categories may also be affected.

The *Threatened Species Conservation Act 1995* has been repealed and superseded by the *Biodiversity Conservation Act 2016*. However, references to the former legislation remain in the LG Act and are therefore retained in this guideline.

DPE's Energy, Environment and Science division advises that recovery plans and threat abatement plans made under the *Threatened Species Conservation Act 1995* were repealed on the commencement of the *Biodiversity Conservation Act* in 2017. These plans have not been preserved by any savings and transitional arrangement under the Biodiversity Conservation Act or LG Act, meaning pre-existing plans have no legal effect.

For this reason, requirements relating to recovery plans and threat abatement plans for local councils preparing plans of management under section 36B of the LG Act are now redundant. Councils will be advised if future amendments are made to the LG Act to enable these mechanisms.

Certain weeds are also declared noxious under this Act, which prescribes categories to which the weeds are assigned, and these control categories identify the course of action which needs to be carried out on the weeds. A weed may be declared noxious in part or all of the state.

Water Management Act 2000

This Act is based on the concept of ecologically sustainable development, and its objective is to provide for the sustainable and integrated management of the water sources of the state for the benefit of both present and future generations. The Act recognises:

- the fundamental health of our rivers and groundwater systems and associated wetlands, floodplains, estuaries has to be protected
- the management of water must be integrated with other natural resources such as vegetation, native fauna, soils and land
- to be properly effective, water management must be a shared responsibility between the government and the community
- water management decisions must involve consideration of environmental, social, economic, cultural and heritage aspects
- social and economic benefits to the state will result from the sustainable and efficient use of water.

Commonwealth legislation

Environmental Protection and Biodiversity Conservation Management Act 1999

This Act enables the Australian Government to join with the states and territories in providing a national scheme of environment and heritage protection and biodiversity conservation. It incorporates threatened species on a national level and with relevance to Matters of National Environmental Significance.

Telecommunications Act 1997

This Act provides for telecommunication facilities being permitted on community land without authorisation in a PoM.

State Environmental Planning Policies

State Environmental Planning Policy (Infrastructure) 2007

This planning policy lists development allowed with consent or without consent on community land.

State Environmental Planning Policy (Sydney Drinking Water Catchment) 2011

This aims to protect quality of surface water and the ecosystems that depend on it and requires that any development would have a neutral or beneficial effect on water quality.

State Environmental Planning Policy (Vegetation in Non-Rural Areas) 2017

This policy deals with clearing of native vegetation in urban areas and land zoned for environmental protection.

Other relevant legislation, policies and plans

Aboriginal Land Rights Act 1983

Biodiversity Conservation Act 2016

Biosecurity Act 2015

Catchment Management Authorities Act 2003

Companion Animals Act 1998

Disability Discrimination Act 1992

Environmental Planning and Assessment Act 1979

Environmental Protection and Biodiversity Conservation Management Act 1999 (Cth)

Fisheries Management Act 1994

Heritage Act 1977

Local Land Services Act 2013

Operations Act 1997

Pesticides Act 1999

Protection of the Environment Operations Act 1997

Retail Leases Act 1994

Rural Fires Act 1997

Soil Conservation Act 1938

Telecommunications Act 1997 (Cth)

Water Management Act 2000

NSW Invasive Species Plan 2008-2015

National Local Government Biodiversity Strategy

NSW Biodiversity Strategy

A Vegetation Management Plan for the Sydney Region (Green Web Sydney)

Australian Natural Heritage Charter

Appendix A3 – Aboriginal interests in Crown land

Crown land has significant spiritual, social, cultural and economic importance to the Aboriginal peoples of NSW. The CLM Act recognises and supports Aboriginal rights, interests and involvement in Crown land.

The management of Crown land can be impacted by the *Native Title Act 1993* (Cth) and the *Aboriginal Land Rights Act 1983* (NSW).

Native Title

Native title describes the rights and interests that Aboriginal and Torres Strait Islander people have in land and waters according to their traditional law and customs. Native title is governed by the Commonwealth *Native Title Act 1993* (NT Act).

Native title does not transfer the land to the native title holder, but recognises the right to land and water, by providing access to the land and if applicable, compensation for any loss, diminution, impairment or other effect of the act on their native title rights and interests.

All Crown land in NSW can be subject to a native title claim under the NT Act. A native title claim does not generally affect Crown land where native title has been extinguished or it is considered excluded land.

When preparing a PoM, Council is required to employ or engage a qualified native title manager to provide advice and validate acts (developments and tenures) over the reserve, in line with the NT Act. The most effective way to validate acts under the NT Act is to ensure all activities align with the reserve purpose.

If native title rights are found to exist on Crown land, council Crown land managers may be liable to pay compensation for acts that impact on native title rights and interests. This compensation liability arises for local councils whether or not the act was validated under the NT Act.

For further information about native title and the future acts framework see the Crown lands website.

Aboriginal Land Rights

The *Aboriginal Land Rights Act 1983* (ALR Act) seeks to compensate Aboriginal peoples for past dispossession, dislocation and removal of land in NSW (who may or may not also be native title holders).

Aboriginal land claims may be placed on any Crown land in NSW. The Department of Planning, Industry and Environment is responsible for investigating claims as defined in the ALR Act. If a claim is established, the land is transferred to the Aboriginal Land Council as freehold land.

At the time of preparing this plan of management, there are [insert number] reserves which are affected by an undetermined Aboriginal land claim. Council has considered the claim(s) in development of this plan of management.

Appendix A4 – Action Plan

In accordance with the Local Government Act, the action plan below provides performance objectives and targets for the following categories of community land at Barnwell Golf Course:
• Parks (P);
• Sportsground (S);

Objectives and targets are derived from Council's following strategic objectives and priorities:
• LMS = *Local Movement Strategy* adopted by Council on 20 August 2019;
• FAS = *Foreshore Access Strategy* adopted by Council on 20 October 2020
• SIS = *Social Infrastructure (Open Space and Recreation) Strategy* adopted by Council on 26 September 2019

REF	CATEGORY	S36(3)(b) OBJECTIVES and PERFORMANCE TARGETS	S36(3)(c) HOW TO ACHIEVE OBJECTIVES AND PERFORMANCE TARGETS	S36(3)(d) PERFORMANCE MEASURE	MASTERPLAN ITEM
Management Issue: FUNCTION, PROVISION AND DESIGN					
1.1	P	LMS PP66: Review previous cycle route options, investigate new options and identify a preferred cycle route through the LGA	Investigate safe cycling routes within one kilometre of schools through new or improved facilities	Improved safety and increased use	N/A
1.2	P	FAS PP37 Deliver new foreshore paths through Council owned parks and open space.	Create a shared, publicly accessible foreshore path along the Barnwell Park Golf Course, re-orient the fairways or consider redeveloping the site as a 9-hole course to also create a new public foreshore park	Increased use of the foreshore by the public	N/A

1.3	S	FAS PP37 Deliver new foreshore paths through Council owned parks and open space.	Create a new council owned pedestrian bridge over St Luke's Canal when access is available through Barnwell Park Golf Course	Improved access to foreshore	N/A
1.4	P	FAS PP39 Upgrade the quality of existing pedestrian / cycle paths and parks in priority locations.	Deliver a new footpath on Lyons Road West to the foreshore side, with landscaping to improve the pedestrian amenity	Improved access to foreshore and increased use by the public	N/A
1.5	S	SIS PP117 Priority open space and recreation facility and program needs are summarised below	Green Grid recreation trails from Goddard Park to Massey Park Golf Course, and Concord Oval to Barnwell Park Golf Course in Concord	Improved access to open spaces	N/A
1.6	P	SIS PP29 Deliver new cycle links	Deliver these along William Street and through Barnwell Park Golf Course and Walker Street	Increased use of cycleways by all members of the community	N/A
1.7	S	SIS PP116 Investigate opportunities to utilise golf courses for increased access to public open space and recreation facilities and deliver identified needs	Create a shared, publicly space within Barnwell Park Golf Course	Improved access to open spaces and increased use by the community	N/A

Appendix A5 – Condition of assets table

Inspection Report Template - Barnwell Park

Ref #	Item/ Facility	Condition	Image
1	Building Type 1 – Barnwell Park Pro Shop	Shop to serve Barnwell Park Pro club Condition - Poor – moderate. Structure sound. Rust to post plates and cracks to concrete.	 
2	Building Type 2 – Carmen's on the Park Five Dock	Restaurant Condition - Good	
3	Building Type 2 – Carmen's on the Park Five Dock	Service Condition - Good	
4	Bin Type 1 – Free standing Wheelie Bins	Rubbish/Disposal Condition - Moderate, Unlocked	

5	Concrete Drain Type 1	Manage surface runoff Condition - Moderate	
6	Concrete Drain Type 2	Manage Stormwater runoff Condition - Moderate. Good standing covered with debris and	
7	Grate Type - metal	Drainage Clear debris, along Lyon Road West, build-up of water along kerb edges	
8	Fence Type 1 – Steel chain wire (x)	Golf Course Perimeter Condition - Poor, Poor standing, very rusty and misshaped by tree roots	
9	Fence Type 2 -	Fence to prevent golf balls from damaging vehicles Condition - Good	

10	Fencing Type 3 -	Perimeter fence of golf course Condition - Good	
11	Fencing Type 4 – High Fencing	Fence to prevent golf balls from flying out Condition - Good	 
12	Fencing Type - 5	Perimeter fence of golf course Condition - Good	
13	Fence Type 7	1000mm black fence Condition - Good	
14	Fence Type 8 – Practice Nets	1000mm black net fencing used for practice Condition - Good	

15	Fence Type 9 – Chain fence	Barrier fence along canal to Parramatta River Condition - Good	
16	Fence Type 10 – Golf Nets	Nets suspended to prevent golf balls from leaving the golf course Condition - Good, Poor location (no protection of nearby residential areas, only roads)	 
17	Fence Type 11	Perimeter fence of golf course Condition - Good	
18	Fence Type 12	Fence to canal edge Condition - Poor, rusted fence	
19	Wall Type 1	Element to perimeter fence of golf course Condition - Good	
20	Gate Type 1 – Swing Gate (x1)	Manage Vehicle entry Condition - Moderate. Some rusting	

21	Light Post Type 1 – Street Lyons Road West (x8)	Provides lighting to street Condition - Good	
22	Light Post Type 2 – William St	Street light (x3 lamps) along William St Condition - Good	
23	Light Post Type 3 – Utility Post Street Light	Street light (x3 lamps) at William St Condition - Good	
24	Furniture Type 1 - Bench	Seating bench in golf course Condition - Good	
25	Amenity Type 1 – Golf Ball cleaner	Golf ball cleaner on golf course perimeter Condition - Moderate, staining to exterior	
26	Utility Type 1 – Water Pump (x1)	Service point	

27	Utility Type 2 -	Service point	
28	Utility Type 3 -	Service point	
29	Utility Type 4 – Electric Box	Service Point	
30	Utility Type 5 - Network	Service Point	
31	Utility Type 6 -	Service point	
32	Utility Type 7 - Stormwater	Stormwater	

33	Utility Type 8 - Stormwater	Stormwater	
34	Utility Type 8 – Gas Line	Below ground gas line. Do not dig.	N/A
35	Pavement Type 1 - Carpark	Parking Condition - poor. Pavement deteriorating, debris and low branch to be clear from tree	
36	Pavement Type 2 – Gravel	Vehicle / pedestrian access. Condition - poor. Gravel washed away, numerous potholes.	
37	Pavement Type 3 – 3000mm (w) Concrete Footpath	Pedestrian path Condition -moderate. Debris to be cleared and pavement lifted in some areas	
38	Pavement Type 4 – 1500mm (w) Concrete Path	Connecting Concord Foreshore Walk to Deakin Street Condition - Good	

39	Pavement Type 5 2000mm - varies (w) Concrete Path	Path along Lyons Road West. Condition - Good. New	
40	Pavement Type 6 2000mm - varies (w) Concrete Path	Path Condition - moderate, various material types and uneven level	
41	Pavement Type 6 – Asphalt Footpath 3000mm (w)	Connecting path between two concrete pavements Condition - poor misshaped by tree roots, uneven ground	
42	Pavement Type 7 – Aggregated Concrete	Driveway Condition - Moderate, some signs of cracking	
43	Pavement type 8 – Aggregated Concrete	Driveway Condition - Poor. Gravel washed away	

44	Pavement Type 9 – Asphalt Pram Kerb	Road Condition - Poor, hazard, pothole, pieces of asphalt to be cleared	
45	Pavement type 10 – Aggregated Concrete	Car Park Condition - Good	
46	Pavement type 11 – Verge to Carpark	Verge Condition - poor, broken away asphalt, debris to be cleared	
47	Pavement Type 12 – Asphalt Footpath 3000mm (w)	Path Condition – Good	 
48	Plaque Type 1- 'Burnwell Park Golf Club'	Commemorating donation of practice nets by NSW Government's Community Building Partnership Program Condition – Good	
49	Signage Type 1 – Rotary Club Sign	A sign of the Rotary International club meeting sign Condition – Good	

50	Signage Type 2 – Golf Ball Zone Sign	A sign to warn people that golf balls may enter this area Condition – Good	
51	Signage Type 3 – Speed camera sign	A mobile speed camera sign Condition – Good	
52	Signage Type 4 – Welcome sign	A welcome sign for members and visitors Condition – Good, tied to poor conditioned fence	 
53	Signage Type 5 – Notice signs	Signed tied to chain link fence Condition – moderate, minor damage and fading	

54	Signage Type 6 – Street Sign and Pedestrian/ cyclist shared zone sign	Signage Condition – Good	
55	Signage Type 7 – Refuge Island	Road signage Condition – Good	
56	Signage Type 8 – Barnwell Park Golf Course rule sign	A sign for rules to access golf course Condition – Good	

57	Signage Type 9 – Danger sign	Danger sign Condition – Good	 
58	Signage Type 10 – Council sign	Council sign Hard to read text, Condition – Good	
59	Signage Type 11 – Danger Sign	Danger sign for gas Condition – Good	
60	Signage Type 12 – Golf Course Map	Map for visitors to golf course Condition – Good	

61	Signage Type 13 – Danger Sign	Danger sign for gas Condition – Good	
62	Signage Type 14 – Council sign	Information sign regarding golf course usage Condition – Good	
63	Signage Type 15 – Council sign	Danger sign for gas	
64	Signage Type 16 – Sydney Water Temporary Sign	Warning sign of sewerage overflow Condition – Good	
65	Signage Type 17 – Council sign	Information regarding access to golf course Condition – moderate, some corrosion to signs including rust and fading of writing	
66	Signage Type 18 – Shared Parking / Cycle sign	Notice for shared cycle and parking lane Condition – poor, graffiti and fading to sign	
67	Canal	N/A	

INSPECTION REPORT PLANS

BARNWELL PARK - PLAN OF MANAGEMENT

DATE	PROJECT NO.	REVISION	PAGE NO.
14/11/2022	2522099	01	1

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INSPECTION REPORT PLANS

BARNWELL PARK - PLAN OF MANAGEMENT

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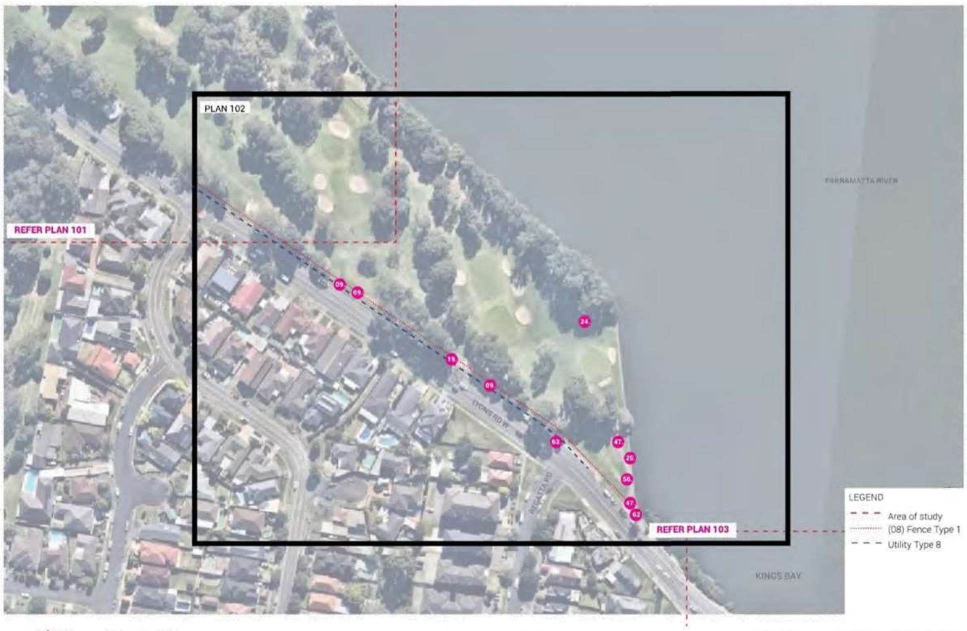

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INSPECTION REPORT PLANS
BARNWELL PARK - PLAN OF MANAGEMENT

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PLAN 103
REFER PLAN 102
REFER PLAN 104
KINGS BAY
LEGEND
Area of study
(08) Fence Type 1
Utility Type 8
(45) Pavement type 10
(16) Fence Type 10
(09) Fence Type 2
(39) Pavement Type 39
(18) Fence Type 12
(15) Fence Type 9
place design group.
INSPECTION REPORT PLANS
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INSPECTION REPORT PLANS

BARNWELL PARK - PLAN OF MANAGEMENT

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TRAFFIC COMMITTEE

17 November 2022

(VIA EMAIL)

MINUTES

Committee Members:		
	Cr Michael Megna	Chair
	Sergeant S Tohme	NSW Police
	Kathryn Hawkins	Transport for NSW
	Mr J Sidoti	Local Member of Parliament
Advisory Members:		
	Mr B MacGillicuddy	CCB Council
	Mr L Huang	CCB Council
	Mr S Lindsay	CCB Council
	Mr S Pandey	CCB Council
	Mr P Whitney	State Transit Authority, Sydney Buses
	TBA	Access Committee
	Mr G Purves	Bay Bug – Canada Bay Bicycle Users Group
Minute Taker:	Ms Christine Di Natale	CCB Council

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Traffic Committee Meeting
17 November 2022

APOLOGIES

Mr P Whitney	State Transit Authority, Sydney Buses
TBA	Access Committee
Mr G Purves	Bay Bug – Canada Bay Bicycle Users Group

DECLARATIONS OF PECUNIARY INTEREST

Nil

CONFIRMATION OF MINUTES

Traffic Committee Meeting – 20 October 2022

COMMITTEE RECOMMENDATION

THAT the minutes of the Traffic Committee Meeting of 20 October 2022 be confirmed.

ITEM 1 IANDRA STREET, CONCORD WEST – CHANGE IN PARKING RESTRICTIONS

Department City Services and Assets

Author Initials: LH

REPORT

Council has been requested to consider changes to the parking restrictions in Iandra Street, Concord West.

At present, there is a mix of unrestricted and timed parking restrictions within Iandra Street, taking the form of '3P, 6am – 6pm Mon-Fri, Permit Holders Exempted'. This was implemented as part of the expansion of the Area 4 Permit Parking Scheme that occurred in 2019. The current arrangement is a result of feedback from the residents received during the initial consultation process.

Over time, residents parking needs have change and as a result Council has been requested to consider changing a small section of '3P' in Iandra Street back to unrestricted parking.

Council staff undertook consultation with the immediate surrounding properties and no objections were received.

STAFF RECOMMENDATION

THAT the 3P restrictions in the subject section of Iandra Street, Concord West be removed as per the attachment.

DISCUSSION

Item is in order.

COMMITTEE RECOMMENDATION

THAT the 3P restrictions in the subject section of Iandra Street, Concord West be removed as per the attachment.

Attachments:

1. Iandra Street Removal of Timed Parking.

ITEM 2 CABARITA PARK, CABARITA – NEW YEARS EVE

Department City Services and Assets

Author Initials: SP

REPORT

Whilst there is no organised event in the Cabarita Park on New Year's Eve, large volumes of people typically visit the park. The Police raised concerns about safety issues that occurred during New Year's Eve 2016. In particular illegal parking issues and significant traffic volumes attempting to circulate through Cabarita Park. This resulted in potential issues for emergency services in getting access should incidents occur.

As a result, Council has organised traffic control to be undertaken from 4pm to 1am on New Year's Eve in recent years (where attendance was not significantly impacted by Covid-19 related restrictions). The proposed Traffic Management measures for this year are consistent with those successfully implemented in past years.

This 'event' at Cabarita Park is considered as Class 3 special event as specified under Guide to Traffic and Transport Management of Special Events.

STAFF RECOMMENDATION

THAT the Traffic Management Plan for New Year's Eve 2022 at Cabarita Park, be approved.

DISCUSSION

The TfNSW representative noted that as this is a Class 3 event, no formal concurrence of the TMP is required from TFNSW.

COMMITTEE RECOMMENDATION

THAT the Traffic Management Plan for New Year's Eve 2022 at Cabarita Park, be approved.

Attachments:
1. Traffic Management Plan

ITEM 3 STUART STREET, CONCORD WEST – PEDESTRIAN REFUGE

Department City Services and Assets

Author Initials: SL

REPORT

In July 2021, Council resolved to adopt our Pedestrian Access & Mobility Plan (PAMP). The PAMP outlines an infrastructure strategy to improve pedestrian accessibility, connectivity, and safety within the local area.

The intersection of Queen Street and Stuart Street was identified for potential pedestrian infrastructure improvements, noting the proximity to St Ambrose Catholic Primary School and Concord West Train Station.

At present, the location of the existing pram ramps and splitter island associated with the roundabout means that pedestrians walk in the circulation lane of the roundabout.

To assist pedestrians in crossing the road at this location, as well as enhancing overall safety, it is proposed that a new pedestrian refuge and kerb buildout be installed. As outlined in the attached plans, the proposal requires the removal of one on-street parking space on the northern side of Stuart Street and two on-street parking spaces on the southern side of Stuart Street.

Community Consultation
Consultation has been undertaken with the surrounding properties, as well as with St Ambrose Catholic Primary School. Feedback was sought via an online survey, email and phone calls.

An on-site meeting between Council staff and St Ambrose Catholic Primary School was conducted on 26 October 2022. The school Principal expressed their support for the proposal.
In addition to this, Council received four responses in various formats, three of which were in support of the proposed refuge.

One response was not in support of the proposed refuge, stating that the proposal does not improve safety and the funding would be better spent in alternative locations. Given that the item was highlighted in the PAMP as a priority and the existing safety risk posed with pedestrians walking in the circulation lane of the roundabout, the proposed works are considered appropriate.

STAFF RECOMMENDATION

THAT a pedestrian refuge be installed on Stuart Street at its intersection with Queen Street as detailed in the attached plan.

DISCUSSION

The TfNSW representative requested that the detailed design of the refuge is as per relevant Technical Direction (TDT 2011-01a), including the island detail with holding rails, 'Keep Left' Signage, refuge island signage (W6-1 / W6-3), and unidirectional hazard marker (D4-1-2) on the kerb extension.

Council staff agreed that the detailed design of the refuge and subsequent construction would be with respect to TDT 2011-01a.

COMMITTEE RECOMMENDATION

THAT a pedestrian refuge be installed on Stuart Street at its intersection with Queen Street as detailed in the attached plan and with respect to TfNSW TDT 2011-01a.

Attachments:
1. Stuart Street – proposed pedestrian refuge

ITEM 4 FAIRLIGHT STREET, FIVE DOCK – WORKS ZONE

Department City Services and Assets

Author Initials: LH

REPORT

Council has received an application for a 'Works Zone' outside 53 Fairlight Street, Five Dock, to facilitate the construction of a two storey dwelling.

In its current arrangement, there is approximately 5m between the wing of the driveway and a power pole where a 'No Parking' sign is installed. Noting that there is only approx. 4.5m between this power pole and the driveway to the rear of 38 Ramsay Road, it is proposed to temporarily relocate the existing 'No Parking' sign approx. 2.5m to the west.

This minor change is not anticipated to have any notable traffic flow impact and will allow for a 7.5m long Work Zone, which is the minimum length generally accepted by Council to facilitate small delivery trucks. Where larger deliveries are required, the builder will need to apply for additional day by day approvals.

The proposed Works Zone would operate '7am-5pm Mon-Sat'. The applicant has requested that it be installed as soon as possible with an initial operating period of 5 months, however it is likely to be required for longer. It is intended to return the 'No Parking' sign to its original position when the 'Works Zone' is no longer required.

STAFF RECOMMENDATION

THAT the existing 'No Parking' sign outside 53 Fairlight Street be relocated and a 7.5m long 'Work Zone 7am-5pm Mon-Sat' be installed as outlined in the attached plan.

DISCUSSION

Items are in order.

COMMITTEE RECOMMENDATION

THAT the existing 'No Parking' sign outside 53 Fairlight Street be relocated and a 7.5m long 'Work Zone 7am-5pm Mon-Sat' be installed as outlined in the attached plan.

Attachments:
1. Fairlight Street Works Zone.

ITEM 5 PARK AVENUE, CONCORD – NEW MOBILITY PARKING SPACE

Department City Services and Assets

Author Initials: BM

REPORT

Council is currently upgrading the amenities building at Goddard Park, Concord. In conjunction with these works, it is proposed to install a new mobility parking space in Park Avenue.

Park Avenue adjoins the south side of the park and provides the closest parking to the amenities building. At present there is no mobility parking spaces provided around the park.

The new mobility parking space is proposed to be installed as outlined in the attached plan. There is an existing pram ramp that does not currently provide any connectivity which will be removed and replaced approximately 1.2m further west with a new pram ramp to meet current standards and service the mobility parking space.

As per relevant Australian Standards, a mobility parking space needs to be a minimum 3.2m wide. As Park Avenue is approximately 12.8m in width, a 3.2m clear width will still be available for through traffic without needing to indent the new mobility parking space.

STAFF RECOMMENDATION

THAT a new mobility parking space be installed in Park Avenue as outlined in the attached plan.

DISCUSSION

Items are in order.

COMMITTEE RECOMMENDATION

THAT a new mobility parking space be installed in Park Avenue as outlined in the attached plan.

Attachments:
1. Park Ave

ITEM 6 VILLAGE DRIVE, BREAKFAST POINT – TRAFFIC CALMING

Department City Services and Assets

Author Initials: BM

REPORT

The Breakfast Point Community Association (CA) has proposed the installation of speed cushions and rumble bars in the Village Drive, Breakfast Point. The streets within Breakfast Point are privately owned and maintained. As they are publicly accessible, Councils is however still the roads authority from which approval is required for changes to the management of traffic and parking.

The proposed speed cushions and rumble bars are intended to assist in managing vehicle speeds and reduce corner cutting at the subject location. Rumble bars have previously been approved and installed in Magnolia Drive, Breakfast Point, and have been successful in addressing a similar issue at that location. Similarly there are already a number of speed cushions installed throughout Breakfast Point.

The Community Association is responsible for consulting with their community and it is understood that this has been successfully completed. All the proposed works are to be at a cost to, and managed by, the Breakfast Point Community Association.

STAFF RECOMMENDATION

THAT speed cushions and rumble bars be installed in Village Drive as outlined in the attached plan.

DISCUSSION

The TfNSW representative requested clarification of the treatment to ensure that there will be sufficient room for vehicles to travel between the parked vehicles on the bend in the road and the new linemarking.

Council staff noted that the total width of the proposed treatment is 0.3m. Village Drive is approximately 12.8m wide from kerb to kerb. Where allowing for a 2.1m wide parallel parking area and the proposed 0.3m wide treatment, there will still be 4.15m clear width for each lane of traffic. Whilst the subject location is on a bend, this is still considered more than adequate.

COMMITTEE RECOMMENDATION

THAT speed cushions and rumble bars be installed in Village Drive as outlined in the attached plan.

Attachments:
1. Village Dr

ITEM 7 QUEEN STREET, NORTH STRATHFIELD – METRO WEST WORKS

Department City Services and Assets

Author Initials: BM

REPORT

As part of the Metro West project, a new underground station is to be constructed adjoining the existing North Strathfield Railway Station. For simplification, in the context of this report references to Metro West should be taken as including other parties under that project umbrella. This includes the primary contractor AFJV who are delivering the current stage of the project.

To facilitate construction of the new station, various traffic and parking management changes are proposed to be implemented as detailed in this report.

Background
The new Metro station will be located within the rail corridor on the west side of Queen Street. The construction site generally extends from Beronga Street to Wellbank Street. Council staff have been regularly liaising with Metro West with regard to construction management. Council remains the road authority from which approval is required for changes to the Local and Regional Roads surrounding the subject site.

The proposed changes outlined in this report are relatively permanent, noting that major Metro West construction works are underway with the project not set to be complete until 2030. There may however be further changes during this construction period and there is separate planning underway regarding the ultimate configuration following the opening of Metro West.

New traffic signals at the intersection of Wellbank Street and Queen Street
As part of the Stage 1 approval of Metro West, it was identified that the intersection of Queen Street and Wellbank Street would need to be modified to accommodate heavy vehicles movements and provide safe pedestrian access. At the time it was noted that this may include signalisation and/or changes to zebra crossings.

Following further investigations by Metro West, they have proposed that traffic signals be installed at this intersection. The exact details of the traffic signal infrastructure and associated signage/linemarking are subject to TfNSW requirements and their final approvals. On-going planning for the end state design of the station indicates that the traffic signals will be permanent.

The signal design includes a 'No Left Turn, Vehicles under 11m Excepted' restriction on movements from Wellbank Street westbound into Queen Street southbound. Whilst not currently restricted, this is an improvement compared to what the intersection can currently physically accommodate. Other turning movements through the intersection would also be improved as a result of the traffic signal works.

New raised pedestrian crossing on Queen Street just south of Beronga Street
To facilitate construction, the footpath along the western side of Queen Street between Beronga Street and Wellbank Street needs to be closed for an extended period. As a result, pedestrians will need to cross Queen Street near Beronga Street.

As present, there are no facilities to assist pedestrians in crossing the road at this location. Noting this, a new raised pedestrian crossing is proposed to assist pedestrian in safely crossing Queen Street. The pedestrian crossing is proposed to be constructed at a height of 75mm, noting that Queen Street is used as a school bus route.

Queen Street/Beronga Street/Pomeroy Street roundabout modifications
Minor modifications are proposed to facilitate truck turning movements through the roundabout. In the longer term, the roundabout has been identified by Metro West as requiring further review as part of the end state design.

Parking restriction changes
A large number of parking restriction changes are required in the subject area. These changes are summarised as follows.

Bus Zones
At present there are bus stops located on either side of Queen Street just north of Wellbank Street. The bus stops are used for school bus services. The bus stop on the west side of Queen Street needs to be relocated to facilitate construction and is proposed to be relocated to the south side of Wellbank Street.

The bus stop on the east side of Queen Street is proposed to be relocated slightly further north to accommodate the new traffic signals and the length of the associated 'Bus Zone' is proposed to be extended to meet current standards.

Mail Zone
To accommodate the new traffic signals, the existing 'Mail Zone' on the east side of Queen Street near Wellbank Street, and associated mail box, is proposed to be relocated further north.

No Stopping
Parking along the west side of Queen Street between Beronga Street and Wellbank Street has already been removed, with the exception of a 'Bus Zone'. Additional areas are required to be restricted to 'No Stopping' to meet relevant standards and vehicle turning manoeuvre requirements.

No Parking - Kiss and Ride
Historically a section of 'No Parking was provided on the west side of Queen Street, midway between Wellbank Street and Waratah Street, to facilitate 'Kiss and Ride'.

It is proposed that these 'Kiss and Ride' movements be relocated to the south side of Wellbank Street just east of Queen Street.

In conjunction with the traffic signals, this will provide a convenient location for these types of movements. The end state design of the station will further review the location of the 'Kiss and Ride' area.

Time restricted parking
Time restricted parking along the western side of Queen Street between Waratah Street and Beronga Street is already occupied by Metro West construction activities. There will be a further reduction of time restricted parking as a result of the proposed changes.

Without extending time restricted parking onto residential frontages, there is limited opportunity to offset this loss of parking. Parking demand and feedback from businesses will be monitored and further consideration given to if and what additional changes to parking restrictions may be required in the area.

Consultation
Over the past eighteen months AFJV has continued the work of Sydney Metro to build and establish relationships to deliver a personal approach to consultation and communication of all upcoming pedestrian, traffic and parking changes.

A dedicated Place Manager has kept local businesses, stakeholders and residents abreast of upcoming changes around the station site. This involves community forums and drop-in sessions around the station site and at Concord Library, site walks and presentations to larger stakeholders such as The McDonald College and Our Lady of the Assumption primary school, meetings with local businesses and regular doorknocking of residents on Queen, Beronga, Pomeroy, Waratah and Wellbank streets.

These stakeholders, as well as the wider community, are also provided regular information through quarterly newsletters, monthly notifications and specific weekly email updates.

To date, Sydney Metro have advised that they have not received any complaints regarding the new traffic arrangements on Queen Street and associated parking removal already implemented, or proposed changes outlined above.

STAFF RECOMMENDATION

THAT Metro West implement the traffic, parking and pedestrian changes outlined in the attached plans.

DISCUSSION

Items are in order.

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COMMITTEE RECOMMENDATION

THAT Metro West implement the traffic, parking and pedestrian changes outlined in the attached plans.

Attachments:
1. Metro West

ITEM 8 BAYVIEW PARK, CONCORD – PARKING RECONFIGURATION

Department City Services and Assets

Author Initials: BM

REPORT

As part of the NSW Government's Places to Swim Program grant, Council has allocated $350,000 to upgrade facilities at Bayview Park to improve access to and enjoyment of a recently re-established swim site.

In part of the existing carpark, it is currently unclear at what angle drivers should be parking their vehicles due to the angle of the kerbs and absence of linemarking/signage. As a result, some drivers are parking at 90 degrees and some are parking at 45 degrees.

As outlined in the attached plan, it is proposed to formalise a 90 degree angled parking arrangement. This will provide 5 additional parking spaces compared to a 45 degree angled parking arrangement. These spaces would be restricted to 'vehicles under 6m only'.

The proposed improvements also include providing two additional mobility parking spaces. This will mean a total of four mobility parking spaces will be provided within Bayview Park.

STAFF RECOMMENDATION

THAT the parking along the eastern edge of the Bayview Park carpark be linemarking and signposted as '90 degree angled parking, vehicles under 6m only' as outlined in the attached plan.

THAT two additional mobility parking spaces be provided in Bayview Park as outlined in the attached plan.

DISCUSSION

Items are in order.

COMMITTEE RECOMMENDATION

THAT the parking along the eastern edge of the Bayview Park carpark be linemarking and signposted as '90 degree angled parking, vehicles under 6m only' as outlined in the attached plan.

THAT two additional mobility parking spaces be provided in Bayview Park as outlined in the attached plan.

Attachments:
1. Bayview Park

ITEM 9 PENINSULA DRIVE, BREAKFAST POINT – PARKING RECONFIGURATION & TRAFFIC MANAGEMENT

Department City Services and Assets

Author Initials: BM

REPORT

The Breakfast Point Community Association (CA) has proposed a revised location for previously approved speed cushions, reconfiguration of existing parking spaces and the installation of rumble bars in Peninsula Drive.

The streets within Breakfast Point are privately owned and maintained. As they are publicly accessible, Councils is however still the roads authority from which approval is required for changes to the management of traffic and parking.

It the Traffic Committee meeting on 24 February 2022, a report was considered proposing the installation of a number of traffic management devices at various locations within Breakfast Point. This included speed cushions on Peninsula Drive just east of the driveway to number 2-4. These proposals were supported by the Traffic Committee and adopted at the following Council meeting.

Since then, the Community Association has further reviewed the proposed works on Peninsula Drive in consultation with stakeholders. The approved speed cushions in Peninsula Drive have not yet been installed and are instead now proposed to be installed slightly further west as outlined in the attached plan. This would result in a more even spacing between existing speed cushions.

Rumble bars are also now proposed on Peninsula Drive, either side of its intersection with Vineyard Way, to address corner cutting issues and promote additional caution when navigating the intersection. Rumble bars have previously been approved and installed in Magnolia Drive, Breakfast Point, and have been successful in addressing a similar issue at that location.

It is also proposed to reconfigure parking to improve sight lines at driveways in the subject section of Peninsula Drive. This includes removing one existing parking space from the north side of Peninsula Drive adjoining a driveway, as well as relocating an existing mobility parking space from the south side of the road to the north side. One mobility parking space will still be retained on the south side of the road.

The width of the existing mobility parking spaces does not comply with current standards. The relocated space would similarly not comply however the Community Association has advised that this is anticipated to still meet the needs of their community.

On the south side of the road various shuffling of parking space is proposed to enhance sightlines at driveways as detailed in the attached plan. One additional parking space is proposed to be provided near the intersection of Vineyard Way, however this would still be outside of the 10m 'No Stopping' zone typically provided at intersections. As a result of the changes, there will be a net loss of one on-street parking space.

Council staff have previously provided feedback to the Community Association on the proposed changes. In this feedback it was noted that the driveway on the south side of Peninsula Drive where parking is proposed to be set back from already has greater sight distances than a typical driveway on a straight road, as the bend is beneficial in that case.

In feedback provided to the association by Council staff it was also noted that the removal of one parking space on the north side of Peninsula Drive, to the east of the driveway, may be more beneficial with respect to enhancing sightlines. Notwithstanding this feedback, the proposed changes detailed in the attached plan remain the Communities Association's preferred outcome. It is noted that these changes do not exacerbate or create new non-compliances with relevant standards.

The Community Association is responsible for consulting with their community and it is understood that this has been successfully completed. All the proposed works are to be at a cost to, and managed by, the Breakfast Point Community Association.

STAFF RECOMMENDATION

THAT rumble bars be installed in Peninsula Drive either side of its intersection with Vineyard Way as outlined in the attached plan.

THAT speed cushions be installed in Peninsula Drive as outlined in the attached plan.

THAT parking in Peninsula Drive be reconfigured as outlined in the attached plan.

DISCUSSION

Items are in order.

COMMITTEE RECOMMENDATION

THAT rumble bars be installed in Peninsula Drive either side of its intersection with Vineyard Way as outlined in the attached plan.

THAT speed cushions be installed in Peninsula Drive as outlined in the attached plan.

THAT parking in Peninsula Drive be reconfigured as outlined in the attached plan.

Attachments:
1. Peninsula Dr

ITEM 10 NORMAN STREET, CONCORD – PARKING RECONFIGURATION AND EXPANSION

Department City Services and Assets

Author Initials: BM

REPORT

At its meeting on 20 September 2022, Council adopted a new Master Plan for Majors Bay Reserve. This Plan includes providing a new off-street parking area within the southern edge of the Reserve, accessed off Norman Street.

Norman Street is a Regional Road and at present features two traffic lanes, one-way cycle lanes on either side of the road, and a parallel parking lane along the northern side.

As outlined in the attached plan, it is proposed to create a new off-street parking area, with 90 degree angled parking on one side and parallel parking along the other side. Along the adjoining section of Norman Street, the parallel parking between the existing kerb lines of Norman Street would be removed.

A central median island is proposed in Norman Street across the entry to the proposed off-street carpark. This will prevent right turn movements into the carpark which may otherwise delay through traffic movements and/or result in through vehicles movements passing waiting vehicles via the cycle lane.

To access the carpark, westbound drivers will need to perform a U-turn at the roundabout approximately 90m further west at the intersection of Norman Street and Nullawarra Avenue. To discourage U-turn manoeuvres and passing manoeuvres on Norman Street itself, some sections of existing broken centreline marking are proposed to be changed to an unbroken double centreline.

Four mobility parking spaces are proposed within the new carpark as outlined in the attached plan. The location of the spaces has been selected to align with a new path that will provide north-south connectivity across the Reserve. It is proposed that the carpark be signposted and enforced under Section 650 of the Local Government Act.

The final design of the carpark itself may vary as a result of the detailed design and investigation process. For example, the amount of additional parking may need to be reduced to minimise impacts on significant trees within the Reserve.

Consultation

Consultation on the proposed parking arrangement was undertaken in May 2022 as part of the broader consultation of the draft Plan of Management. This was advertised via Council's online community engagement platform Collaborate, a letterbox drop to over 4,000 residents in surrounding streets, direct emails to identified stakeholders, social media, Council's enewsletter and on-site signage.

The Norman Street angled parking concept was welcomed by some participants, while other participants believed it would be dangerous to cyclists. In particular, there were concerns regarding the safety of vehicles reversing onto the cycle lane. It should be noted that the Masterplan which was put out for consultation did not correctly show that the parking area would be physically separated from the existing cycle lane.

By physically separating the parking from the existing cycle lane along the north side of Norman Street, there will be no reversing movements across it. Whilst the proposal will result in an overall increase in the number of vehicle movements across the cycle lane, these movements will be concentrated at the entry and exits to the parking area. This will enhance safety compared to the existing arrangement where vehicles are arriving/leaving the existing parallel parking sporadically. It will also avoid potential issues associated with car door opening, which was raised as a concern by the community with the existing configuration.

There were some suggestions from the community that a physically separated cycling facility be provided along Norman Street. Whilst no significant changes to the existing cycle lanes are planned within the current package of works, in the future Norman Street may be suitable for a separated bidirectional cycleway along the south side of the road. This would avoid interaction with the carpark entry/exits and the parallel parking which is being retained on other parts of Norman Street.

The width that is proposed to be maintained between the kerb lines in Norman Street has been designed to accommodate a separated bidirectional cycleway should this occur in the future.

STAFF RECOMMENDATION

THAT Norman Street be reconfigured as outlined in the attached plan, with the final design of the carpark to be determined through the detailed design and investigation process.

THAT four mobility parking spaces be signposted within the new carpark

THAT the new carpark be signposted under Section 650 of the Local Government Act 1993.

DISCUSSION

The TfNSW representative recommended that yellow 'No Stopping' linemarking be installed along the kerb. This would remind drivers to not stop along the bike lane where the existing parallel parking is being removed.

The Police representative suggested that signage be erected at the carpark entry advising drivers to give way to cyclists who are in the cycle lane going the same direction as the cars turning.

Council staff agreed that the suggested yellow 'No Stopping' linemarking and additional signage such as w8-200n (or other appropriate signage) can be incorporated into the detailed design.

COMMITTEE RECOMMENDATION

THAT Norman Street be reconfigured as outlined in the attached plan, along with yellow 'No Stopping' linemarking where the existing parallel parking is being removed and appropriate cyclist warning signage at the carpark entry/exit, with the final design of the carpark to be determined through the detailed design and investigation process.

THAT four mobility parking spaces be signposted within the new carpark

THAT the new carpark be signposted under Section 650 of the Local Government Act 1993.

THAT the legislated No Stopping line marking is installed along the kerb to remind drivers to not stop along the bike lane.

THAT the entry of the new carpark to include further signage for vehicles to give way to cyclists on the cycle path.

Attachments:
1. Norman Street

LATE ITEM CABARITA PARK AND BAYVIEW PARK – PARKING RESTRICTION SIGNAGE REVIEW

Department City Services and Assets

Author Initials: BM

REPORT

The signposting of parking restrictions in Cabarita Park and Bayview Park have been largely of the same configuration for many years, with minor changes occurring time to time for specific areas within these parks. Following consideration by the Traffic Committee, park wide changes to restrictions were last approved by Council back in late 2004 for Cabarita Park, followed by Bayview Park in late 2006.

Council staff have recently conducted a park wide review of the signposting of parking restrictions in these parks. The proposed changes outlined in this report incorporate the changes outlined in the separate report in the current agenda 'Item 8 Bayview Park, Concord – Parking Reconfiguration'

The parking restrictions in the parks currently generally comprise of 'Restricted Parking Area, Ticket Parking Only' signage and 'Ticket Parking Area' signs. Some areas are restricted to 'Vehicles with Trailers Only' to accommodate users of the boat ramps in the two parks. There are also other restrictions signposted in the parks such as 'No Stopping', 'No Parking' and 'Disabled Only'.

A number of changes are proposed to bring the parking restriction signage in line with latest TfNSW guidelines and assist in ensuring parking restrictions are clear to park users. In practice, how people are currently parking within the parks would generally be unchanged.

The existing 'Restricted Parking Area' signs are proposed to be removed and instead the 'Area' parking restrictions are proposed to be reinforced and updated. The signage would indicate '24P Ticket, All Days, Permit Holders Excepted Parks/Marina' and 'Park in Bays Only'. The approximate location of the area parking signs is outlined on the attached plan and will be refined as appropriate to ensure signage is appropriately visible when installed.

Whilst the parks are not signposted as having a maximum period for which metered parking can be paid for, in practice the parking meters are limited to a maximum 24-hour period. This is desirable to manage long term parking and over the years Council has not received a notable number of complaints regarding this restriction.

Noting this, it is proposed to reflect this limitation by including '24P' on the signage. Vehicles displaying valid parking permits will remain exempt from this maximum metered parking time limit.

There are some areas within the parks that are currently restricted to 'Vehicles with Trailers Only', however not all these spaces are physically configured in a manner to accommodate such use. For example the design of the gate at the entry to Bayview Park limits the length of vehicles that can be parked in the adjoining parking spaces. Where spaces are physically constrained, they are proposed to be made regular parking spaces with the resulting arrangement detailed in the attached plans.

The 'No Stopping', 'No Parking', 'Bus Zone', 'Motor Bikes Only' and 'Disabled Only' parking restrictions are generally already signposted. Some additional areas are proposed to be signposted to assist drivers in parking legally and existing signage will be reviewed and updated as appropriate.

STAFF RECOMMENDATION

THAT parking restrictions be signposted in Bayview Park and Cabarita Park as outlined in the attached plans

DISCUSSION

The TfNSW representative requested that other than that 'Area' parking restriction signage, the signage such 'No Stopping' and 'No Parking' include appropriate arrows to clearly indicate the area they apply to.

Council staff agreed that arrows would be incorporated on the signs as appropriate.

COMMITTEE RECOMMENDATION

THAT parking restrictions be signposted in Bayview Park and Cabarita Park as outlined in the attached plans

Attachments:
1. Parks Parking Area signage design
2. Bayview Park signage arrangement
3. Cabarita Park signage arrangement


Barunga Street
Iandra Street
Proposed unrestricted parking
CONCORD WEST

TRANSPORT MANAGEMENT PLAN

NEW YEAR'S EVE CABARITA PARK

Saturday 31st December 2022

PREPARED ON BEHALF OF
City of Canada Bay Council

Version 1.1
7th November 2022

TRAFFIC PLANNERS
SAFETY CONSULTANTS

WHO DARES PTY LTD
SHED 8 / 1 CANAL ROAD
LEICHHARDT 2040
PO BOX 187 FIVE DOCK 2046

Ph: 02 9569 9922
Fax: 02 9569 9933

Event Organiser: **City of Canada Bay Council**

Document Author: **Tim Emslie**

Document Author: **Tim Emslie**
Who Dares Pty Ltd
Prepare a Work Zone Traffic Management Plan
Safework Card Number: TCT0073149
Phone: 02 9569 9922

Version Control

Version	Date	Status	Comments
Version 1.0	4 November, 2022	DRAFT	1st Draft
Version 1.1	7 November, 2022	DRAFT	Police Contacts Amended & PLI Added

1. INTRODUCTION

1.1. Introduction

This plan has been prepared for the **City of Canada Bay Council.**

It has been prepared after discussions with The City of Canada Bay Council and Who Dares.

The plan relates to road closures for the New Year's Eve event held on Saturday 31st December 2022.

1.2. Objective

It is the objective of this report to set out the means and measures by which roads may be closed to through traffic so that the event described above may take place.

The plan will include a description and detailed plan of the proposed measures, will identify and assess the impact of the proposed measures, will discuss the impact of re-assigned traffic, the proposal's effect on public transport services and what provisions are to be made for Emergency Services vehicles, heavy vehicles, cyclists and pedestrians. Furthermore, the plan will assess the effect of the proposal on existing and future developments within the vicinity, the possible flow on effects for traffic in adjoining Council Areas and finally will include a discussion about the requirement for a public consultation process with respect to the proposal.

1.3. Authority of the TMP

This Transport Management Plan (TMP) when approved by the relevant authorities becomes the prime document detailing the traffic, transport and pedestrian arrangements under which the New Year's Eve event, will operate.

In case of emergencies, or for the management of incidents, the NSW Police are not subject to the conditions of this TMP but should endeavour to inform other agencies of the nature of the incident and the Police response.

2. EVENT DETAILS

2.1. Event summary

Event Name	**New Year's Eve**
Event Location	**Cabarita Park, Cabarita**
Event Date:	**Saturday 31st December 2022**
Event Start Time:	**16:00 hours**
Event Finish Time:	**01:00 hours**
Estimated Spectators:	**Approximately 10,000 spectators**

2.2. Contact Names

City of Canada Bay Council

Brendan MacGillicuddy	**Phone**	02 9911 6396
Coordinator, Traffic & Transport	**Mobile**	0449 953 990
	E-mail	Brendan.MacGillicuddy@canadabay.nsw.gov.au
Shankar Pandey	**Phone**	02 9911 6448
Traffic Engineer	**Mobile**	0481 919 019
	E-mail	Shankar.Pandey@canadabay.nsw.gov.au
Steve Deamer	**Phone**	02 9911 6472
Recreation Bookings Coordinator	**Mobile**	0449 951 002
	E-mail	steve.deamer@canadabay.nsw.gov.au

NSW POLICE – Burwood Police Area Command

Snr Constable Germaine Grant	**Phone**	02 9745 8463
Burwood Traffic Services	**Mobile**	
	E-mail	gran1ger@police.nsw.gov.au

Traffic Contractor – Who Dares Pty Ltd

Tim Emslie	**Phone**	02 9569 9922
Senior Events Manager	**Fax**	02 9569 9933
	Mobile	0417 467 814
	E-mail	tim@whodares.com.au

2.3. Description of the event

Cabarita Park is a very popular vantage point for New Years Eve revellers to watch the fireworks and to see in the new year. New Years Eve celebrations at Cabarita Park in past years has attracted large crowds of people, predominately families, which Police estimate to be up to 10000 people.

3. TRAFFIC AND TRANSPORT MANAGEMENT

3.1. Traffic Management Requirements Unique to This Event

From 16:00 hours on Saturday 31st December 2022 until 01:00 hours on Sunday 1st January 2023, Traffic Controllers will be onsite at Cabarita Park to assist in managing the traffic within the park.

At all times there will be a traffic controller stationed at the main internal roundabout within Cabarita Park. Initially there will also be a traffic controller stationed down at the wharf carpark to monitor traffic. **Refer TGS 01A**

Once the wharf carpark reaches capacity the north-western arm of the park will be closed to all vehicles. The only exception to this will be the 466 buses that are utilising the bus stop at the Cabarita Ferry Wharf. The traffic controller stationed down at the wharf will then relocate up to the entrance to the park. The traffic team leader will continue to monitor both the north-western and south-western arms of the park and these will be closed once they reach capacity.
Refer TGS 01B

Once all car spaces within Cabarita Park have reached capacity Cabarita Road will be closed at the Edgewood Crescent roundabout. From that point forward there will be no vehicle access to Cabarita Park with the only exception being the 466 & 502 buses that are utilising the bus stop at the Cabarita Ferry Wharf.
Refer TGS 01C

Any vehicles that are parked within Cabarita Park prior to the closures being implemented will not be restricted from leaving and are expected to do so progressively over the course of the evening.

3.2. Spectator Parking

Parking within Cabarita Park is limited given the volume of spectators that are anticipated. There are approximately 220 car spaces within the park. These will be monitored by traffic controllers throughout the evening and the various arms of the park will be closed to traffic as they reach capacity.

In addition to parking with Cabarita Park there is large amounts of street parking available in the surrounding suburbs.

3.3. Public Transport

Spectators will be encouraged to get public transport to the Cabarita Park. Across Greater Sydney there are additional train, bus and ferry services available.

For public transport timetables and planning visit:
http://www.transportnsw.info/

3.4. Transit Systems Buses

Cabarita Park is serviced by the 466 & 502 bus services. Access for buses will be maintained at all times. Transit Systems to advise if the 466 & 502 bus services will run to a normal timetable.

3.5. Sydney Ferries

Cabarita Wharf is serviced by the F3 Parramatta River ferry service. Sydney Ferries to advise if the F3 Parramatta River ferry service will run to a normal timetable.

3.6. Traffic Control

NSW Police or an accredited Who Dares Traffic Manager will oversee implementation of the Traffic Control Plans, including road closures.

Temporary traffic control signage, barricades and equipment as per the supplied Traffic Control Plans must be installed by TfNSW or SafeWork accredited traffic controllers with a current "Implement Traffic Control Plan" certificate. Any person operating a Stop/Slow bat onsite must hold a current "Traffic Controller" certificate.

3.7. Construction, traffic calming and traffic generating developments

At present, there is no construction works that will impact the event.

3.8. Trusts, authorities or Government enterprises

The event is held at Cabarita Park which is maintained by the City of Canada Bay Council.

3.9. Heavy Vehicle impacts

There should be no delay to heavy vehicle movements although there may be increased traffic.

3.10. Special Event Clearways

No special event clearways are required for this event.

4. RISK MANAGEMENT - TRAFFIC

4.1. Occupational Health & Safety – Traffic Control

*"Temporary traffic management (TTM) is one of the highest risk activities on a roadwork site."**

City of Canada Bay are the Risk Managers for their event operations. It is City of Canada Bay's policy to identify and treat hazards by endeavouring to prevent or eliminate health and safety risk as far as is reasonably practicable (SFAIRP).

Who Dares as the contracted Traffic Control Company engaged by City of Canada Bay is the Delivery Partner and will fulfill all its legal duty to advise during consultation to deliver traffic plans that reflect the joint efforts of Who Dares, City of Canada Bay and all agencies assigned to the process of devising a plan that creates traffic and other arrangements appropriate to the safe delivery of the event.

The appropriateness of the arrangements is directly linked to the desirability of the event to the community compared with what is reasonably practicable to ameliorate inconvenience and safety risks.

Any risk treatment measure implemented by Who Dares through the Traffic Guidance Systems (TGS)s that are addended to this TMP will be consistent with their obligations in accordance with the Work Health and Safety Act 2011 (NSW), Work Health and Safety Regulations 2017 (NSW) and AS/NZS ISO 31000:2018 Risk Management- guidelines.

The risk methods in this TMP will adhere to a feasibility hierarchy firstly endeavouring to eliminate risk by detouring traffic around effected areas completely separating traffic from the event. Secondly if traffic is unable to be detoured around traffic will be planned to pass the event using engineering methods to isolate risk. Some through methods will be considered under very controlled methods such as limited crossover points or emergency access.

City of Canada Bay must develop with the help of Who Dares a plan that is appropriately resourced through accumulating sufficient data to evaluate options to produce a draft TMP for consultation and development that will create the best achievable outcome for all stakeholders.

Who Dares in its capacity as the traffic management specialist and will do all that is reasonably practicable to give advice for options to ameliorate risks that are identified.

* Transport for NSW Traffic Control at work sites, Technical Manual issue 6.1, 2022, 31.

4.2. Public Liability Insurance

Refer Annex 1

4.3. Hostile Vehicle Mitigation

Hostile Vehicle mitigation strategies may be undertaken within the road closure in accordance with the event's Vulnerability Report and NSW Police direction. This information is to remain confidential.

4.4. Police

Burwood Police Area Command will be notified in writing of the event by the event organiser.

4.5. Fire and Rescue NSW, and NSW Ambulance

Fire and Rescue NSW and NSW Ambulance will be notified in writing of the event by the event organiser.

4.6. Risk & Contingency Plans

City of Canada Bay Council has compiled Risk Assessments and Site-Specific Safety Plans for the events that are not included in this Transport Management Plan

Item	Verified	Action Taken
All one-way streets are as described	☒ Yes ☐ No ☐ N/A	*Road closures, barricade and signage installed. Point duty by NSW Police and or authorised Traffic Controllers.*
Block access to local businesses	☐ Yes ☒ No ☐ N/A	*Confirm list of letters to residents, businesses, and car parks. Advertisement of event to general public.*
Block Police vehicle access	☐ Yes ☒ No ☐ N/A	*Confirm access and consultation of routes to and within areas affected by closures with Emergency Services.*
Block Ambulance access	☐ Yes ☒ No ☐ N/A	*Confirm access and consultation of routes to and within areas affected by closures with Emergency Services.*
Block fire station access	☐ Yes ☒ No ☐ N/A	*Normal access to fire station facilities are maintained Confirm access and consultation of routes to and within areas affected by closures with Emergency Services.*
Block heavy vehicle access	☐ Yes ☐ No ☒ N/A	*All heavy vehicles are diverted before the closure.*
Restricted movements – banned turns, heavy/high vehicles	☐ Yes ☐ No ☒ N/A	*All vehicles are diverted before the closure.*
Block Public facility (football oval, car park etc.)	☒ Yes ☐ No ☐ N/A	*Confirm list of letters to residents, businesses, and car parks. Advertisement of event to general public.*
Block public transport access	☐ Yes ☒ No ☐ N/A	*Managed access for the various hotels and businesses*
Can route use alternatives such as bicycle tracks, paths, parks, bush tracks etc.?	☐ Yes ☐ No ☒ N/A	None required
Construction – existing, proposed that may conflict	☐ Yes ☒ No ☐ N/A	None required

Item	Verified	Action Taken
Numbers of lanes and their width are as described	[x] Yes [ ] No [ ] N/A	None required
Road signage – existing/temporary	[x] Yes [ ] No [ ] N/A	*Temporary signage Installed and removed by Who Dares Traffic Management.*
Route impeded by traffic calming devices?	[ ] Yes [ ] No [x] N/A	
Signalised intersections (flashing yellow? Point duty?	[ ] Yes [x] No [ ] N/A	As required by NSW Police
Tidal flows	[ ] Yes [ ] No [x] N/A	
Traffic generators – shopping centres, schools, churches, industrial area, hospitals	[ ] Yes [x] No [ ] N/A	*Advertisement of event to general public.*
Traffic movement contrary to any Notice	[ ] Yes [x] No [ ] N/A	*Under the direction of Police or traffic controllers*
Traffic signals are as described	[x] Yes [ ] No [ ] N/A	*Controlled by TMC*
Turning lanes are as described	[x] Yes [ ] No [ ] N/A	
Letter Drop Zone Maps to indicate precincts mailed	[x] Yes [ ] No [ ] N/A	*Attached in annexes (TBC)*

This section of the Transport Management Plan describes the contingency plans for the event. The contingency plan checklist identifies all possible issues/risks that may interfere with the event and the action to be taken to minimise the disturbance of the event.

Issues/Risks	**Applicable**	**Action Taken**
Heavy Weather	☒ Yes ☐ No	If heavy weather may cause crowds to depart early
Flood hazard on the route	☒ Yes ☐ No	TMC / TfNSW and Police provide diversions around flooded area.
Flood hazard at the parking area	☐ Yes ☒ No	Event organiser to close parking area and direct to hardstand parking.
Parking during Wet weather	☒ Yes ☐ No	Local Car parks only.
Bush fire hazard	☐ Yes ☒ No	For major local/regional bushfire hazard affecting general public health or transport to greater Sydney, take direction from NSW Police
Accident on the route	☒ Yes ☐ No	If CCTV monitored by TMC. Facilitate emergency response to area.
Breakdown	☒ Yes ☐ No	If CCTV monitored by TMC. Facilitate response to area.
Absence of marshals and volunteers	☐ Yes ☒ No	Re-deploy existing staff as required.
Block public transport access	☒ Yes ☐ No	Managed access for taxis and buses to various hotels and businesses.
Slow participants	☐ Yes ☒ No	
Delayed Event	☐ Yes ☒ No	
Cancellation of Event	☒ Yes ☐ No	Cancellation of any aspect of the event will be communicated by the event organiser.
Security of participants/general public	☒ Yes ☐ No	Provided by event organiser.
Security of very important persons (VIP's)	☒ Yes ☐ No	As Required.

It shall be noted that Transport Management Plan (TMP) and particularly Traffic Guidance Schemes (TGS) are seen as risk control measures, but alone they cannot substitute for a compliant and detailed event Risk Assessment.

Contingency form part of the risk assessment and management plan and will be addressed in the Overall Event Risk Assessment.

4.7. Regulatory Framework

This Transport Management Plan has been written in accordance with the following Act, Regulation, Australian Standards and Road Design Technical Direction

- NSW WHS Act 2011
- NSW WHS Regulation 2017
- AS/NZS ISO 31000:2018 Risk Management - Guidelines
- ISO/IEC 31010:2019 - Risk Management - Risk Assessment Techniques
- ISO Guide 73:2009 - Risk Management – Vocabulary
- Traffic Control at Work Sites – (TfNSW) V6.1 Feb 2022
- AS 1742.2:2009 Manual of uniform traffic control devices - Traffic control devices for general use
- AS 1743:2018 Road signs - Specifications
- AS/NZS 1906.4:2010 Retro-reflective materials and devices for road traffic control purposes - High-visibility materials for safety garments
- AS 3996-2019 Access covers and grates
- AS 1742.10-2009 Manual of uniform traffic control devices - Pedestrian control and protection
- AS 1742.13-2009 Manual of uniform traffic control devices - Local area traffic management
- AS 1742.3-2009 Manual of uniform traffic control devices - Traffic control for works on roads
- RMS Guide to Traffic & Transport Management for Special Event Version 3.5 – June 2018

5. MINIMISING IMPACT ON THE NON-EVENT COMMUNITY AND EMERGENCY SERVICES

5.1. Access for local residents, businesses, hospitals and emergency vehicles

Access will be maintained for local residents & businesses although there may be delays due to increased traffic.

5.2. Advertise the traffic management arrangements

All local residents & businesses will be notified of the event through:

- Letterbox drop to all local residents & businesses

5.3. Portable Variable message signs (VMS)

Variable Message Signs will not be required for this event.

5.4. Permanent Variable message signs

City of Canada Bay Council have installed a LED sign at the entrance to Cabarita Park. This will be used to inform spectators that the carpark is full once the park reaches capacity.

6. PRIVACY NOTICE

The "Personal Information" contained in the completed Transport Management Plan may be collected and held by the NSW Police, the Transport for NSW (TfNSW), or Local Government.

I declare that the details in this application are true and complete. I understand that:

The "personal information" is being collected for submission of the Transport Management Plan for the event described in Section 1 of this document;

I must supply the information under the Road Transport Legislation (as defined in the Road Transport (General) Act 1999) and the Roads Act 1993;

Failure to supply full details and to sign or confirm this declaration can result in the event not proceeding;

The "personal information" being supplied is either my own or I have the approval of the person concerned to provide his/her "personal information";

The "personal information" held by the Police, TfNSW or Local Government may be disclosed inside and outside of NSW to event managers or any other person or organisation required to manage or provide resources required to conduct the event or to any business, road user or resident who may be impacted by the event;

The person to whom the "personal information" relates has a right to access or correct it in accordance with the provisions of the relevant privacy legislation.

7. APPROVAL

TMP Approved by: .... Date: ....

City of Canada Bay Council

8. ATTACHMENTS

Annex 1 – Public Liability Insurance

9. TRAFFIC GUIDANCE SCHEMES

TGS 01A Cabarita Park CABARITA
TGS 01B Cabarita Park CABARITA
TGS 01C Cabarita Park CABARITA

ANNEX 1

PUBLIC LIABILITY INSURANCE

statewide mutual.

ABN 69 009 098 864
One International Towers,
100 Barangaroo Ave,
Sydney, NSW, 2000
Tel: (02) 9320 2700
Direct: (02) 9320 2726
Naamon.Eurell@jlta.com.au
www.statewidemutual.com.au

26 April 2022

Attention: Julia Kalouche

The General Manager
Locked Bag 1470
DRUMMOYNE NSW 1470

Dear Julia Kalouche

Certificate of Currency

This is to certify that membership is current, as at the date stated above. This certificate provides a summary of the cover and is not intended to amend, extend, replace or override the terms and conditions provided by the Statewide Mutual Liability Scheme.

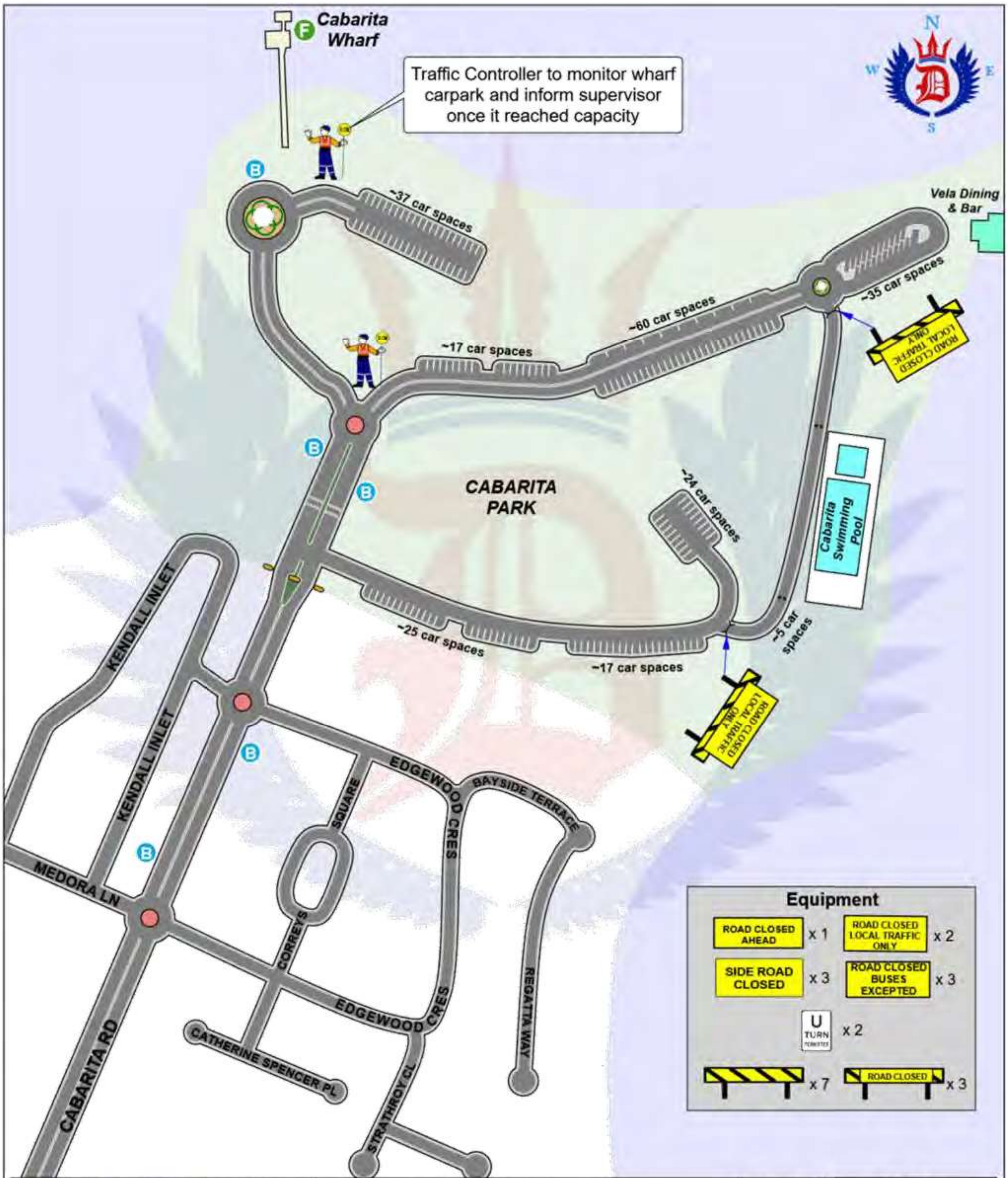
CLASS	Public Liability/Professional Indemnity
MEMBER	City of Canada Bay Council
BUSINESS OF MEMBER:	Local Government Authority, as defined in wording
EXPIRY DATE	30 June 2023
GEOGRAPHICAL SCOPE	Anywhere in the World, excluding the Dominion of Canada and the United States of America.
LIMITS OF PROTECTION	Public Liability $20,000,000 any one occurrence Products Liability $20,000,000 any one occurrence and in the aggregate any one Period of Protection Professional Indemnity $20,000,000 any one claim and in the aggregate any one Period of Protection
STATEWIDE CERTIFICATE NUMBER	000763

This certificate of currency is issued as a matter of information only and confers no rights upon the certificate holder.

Yours sincerely,

N. E

Naamon Eurell
Executive Officer

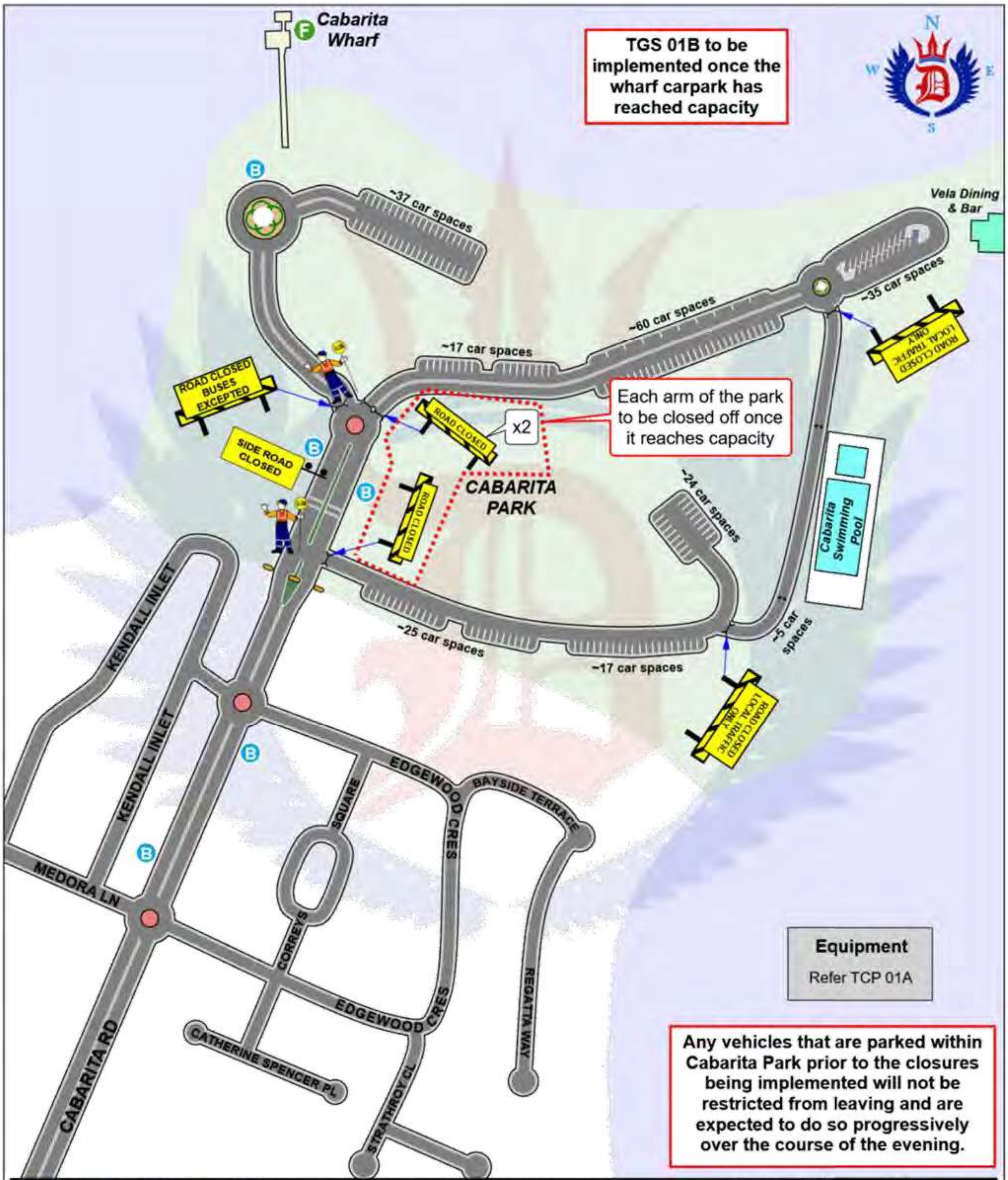


CABARITA PARK - NYE | Cabarita Road CABARITA | TGS **01A** | DATE **Sat 31st Dec 2022**

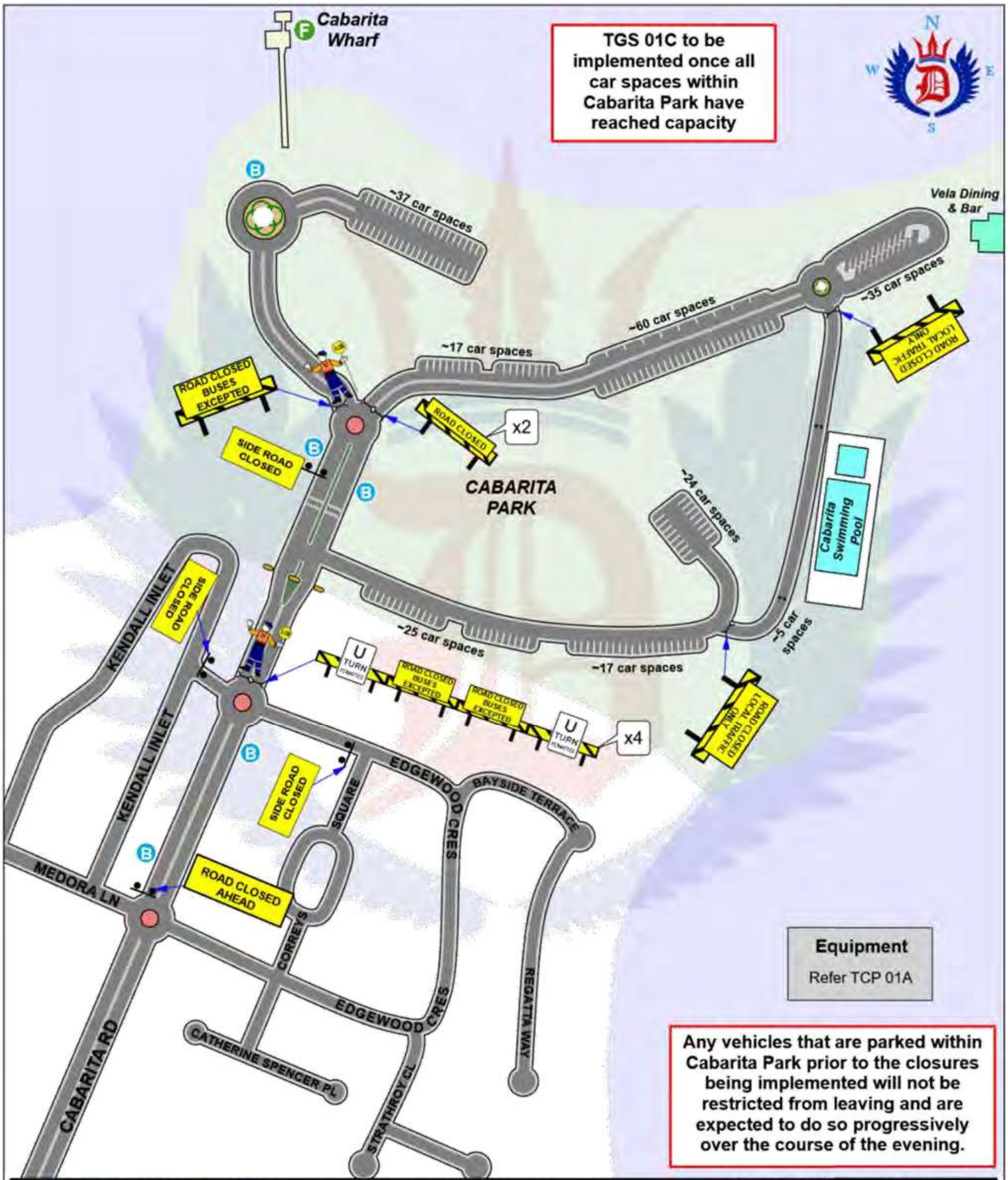
AGENCY	PRIMARY TASK	SECONDARY TASK	STAFF ON-SITE	TIME
CANADA BAY COUNCIL				
POLICE				
WHO DARES	Deliver & Install Signage		3	16:00 - 01:00
MARSHAL				

Drawn by: Tim Emslie
SafeWork PWZ Card No. TCT0073149
for Who Dares Pty Ltd
Signature:

Revised 04 Nov 22

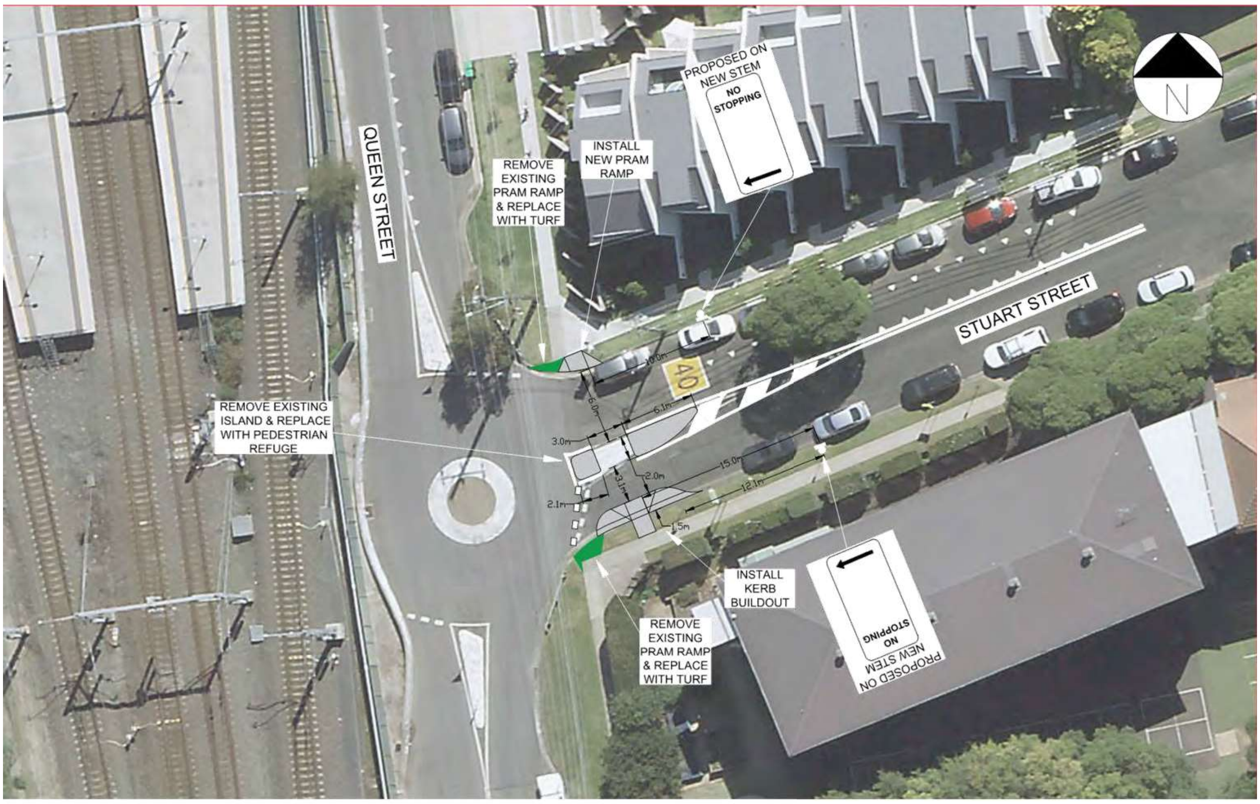


CABARITA PARK - NYE	Cabarita Road CABARITA				TGS	01B
AGENCY	PRIMARY TASK	SECONDARY TASK	STAFF ON-SITE	TIME	DATE	Sat 31st Dec 2022
CANADA BAY COUNCIL					Drawn by: Tim Emslie SafeWork PWZ Card No. TCT0073149 for Who Dares Pty Ltd Signature:	
POLICE						
WHO DARES	Deliver & Install Signage		3	16:00 - 01:00		
MARSHAL					Revised 04 Nov 22	

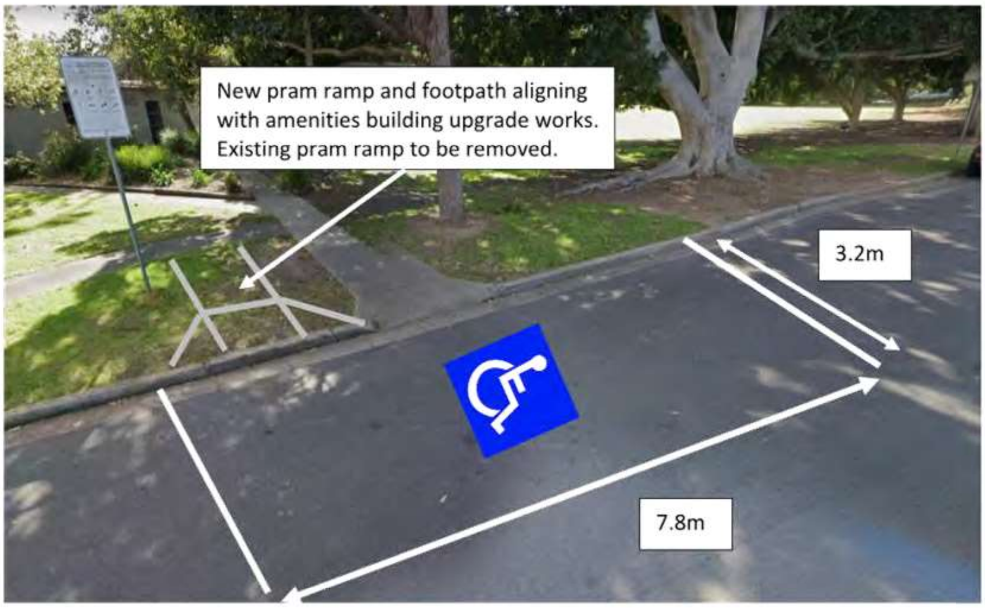


CABARITA PARK - NYE		Cabarita Road CABARITA			TGS	01C
AGENCY	PRIMARY TASK	SECONDARY TASK	STAFF ON-SITE	TIME	DATE	Sat 31st Dec 2022
CANADA BAY COUNCIL					Drawn by: Tim Emslie SafeWork PWZ Card No. TCT0073149 for Who Dares Pty Ltd	
POLICE					Signature:	
WHO DARES	Deliver & Install Signage		3	16:00 - 01:00		
MARSHAL					Revised 04 Nov 22	

Who Dares Pty Ltd accepts no liability for the implementation or execution of this TGS unless undertaken by authorised Who Dares personnel.


QUEEN STREET
STUART STREET
PROPOSED ON NEW STEM
NO STOPPING
INSTALL NEW PRAM RAMP
REMOVE EXISTING PRAM RAMP & REPLACE WITH TURF
REMOVE EXISTING ISLAND & REPLACE WITH PEDESTRIAN REFUGE
INSTALL KERB BUILDOUT
REMOVE EXISTING PRAM RAMP & REPLACE WITH TURF
PROPOSED ON NEW STEM
NO STOPPING
40
N


N
W
E
S
Relocation of 'No Parking'
from power pole to stem
Fairlight Street
Proposed Work Zone
53 Fairlight Street
Ramsay Road



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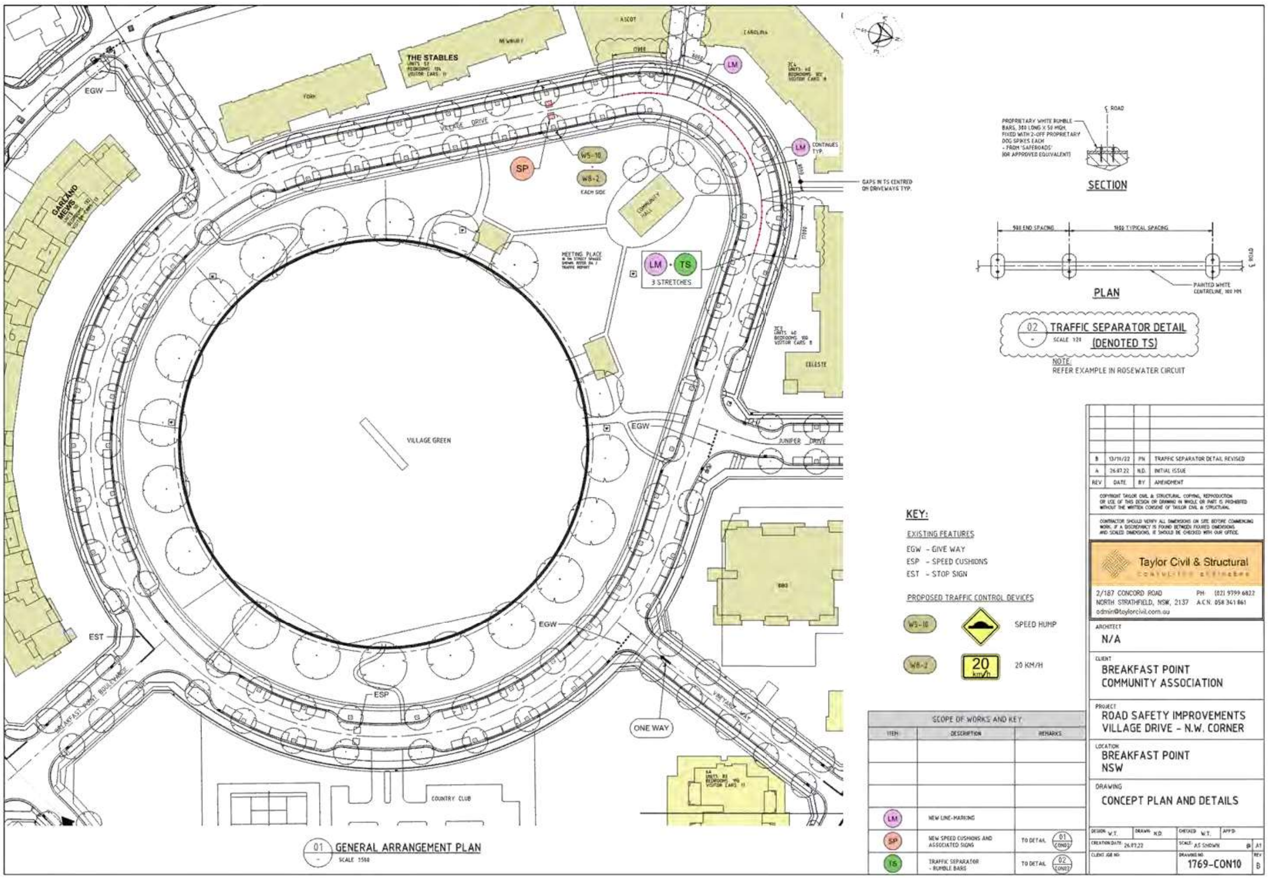

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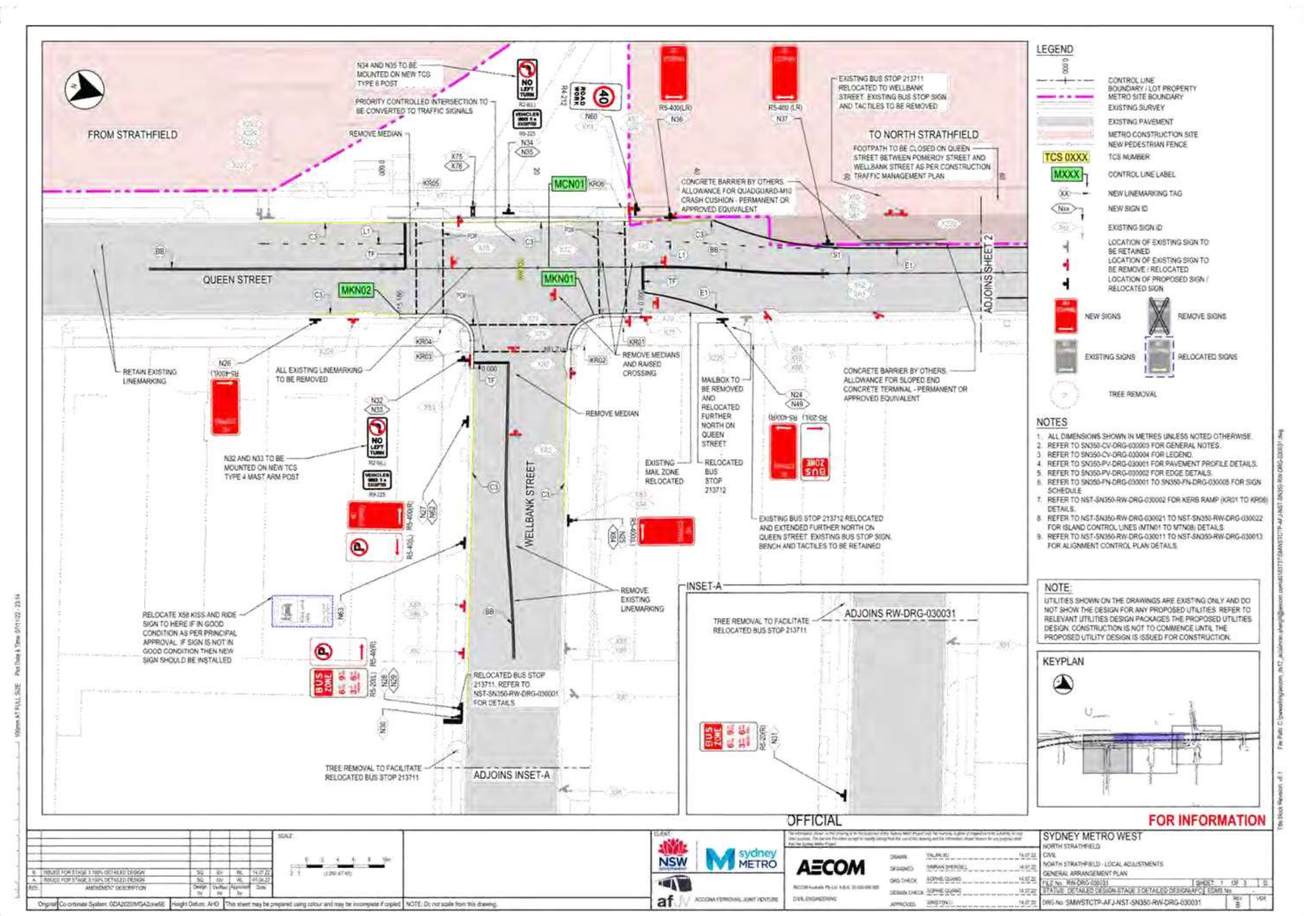
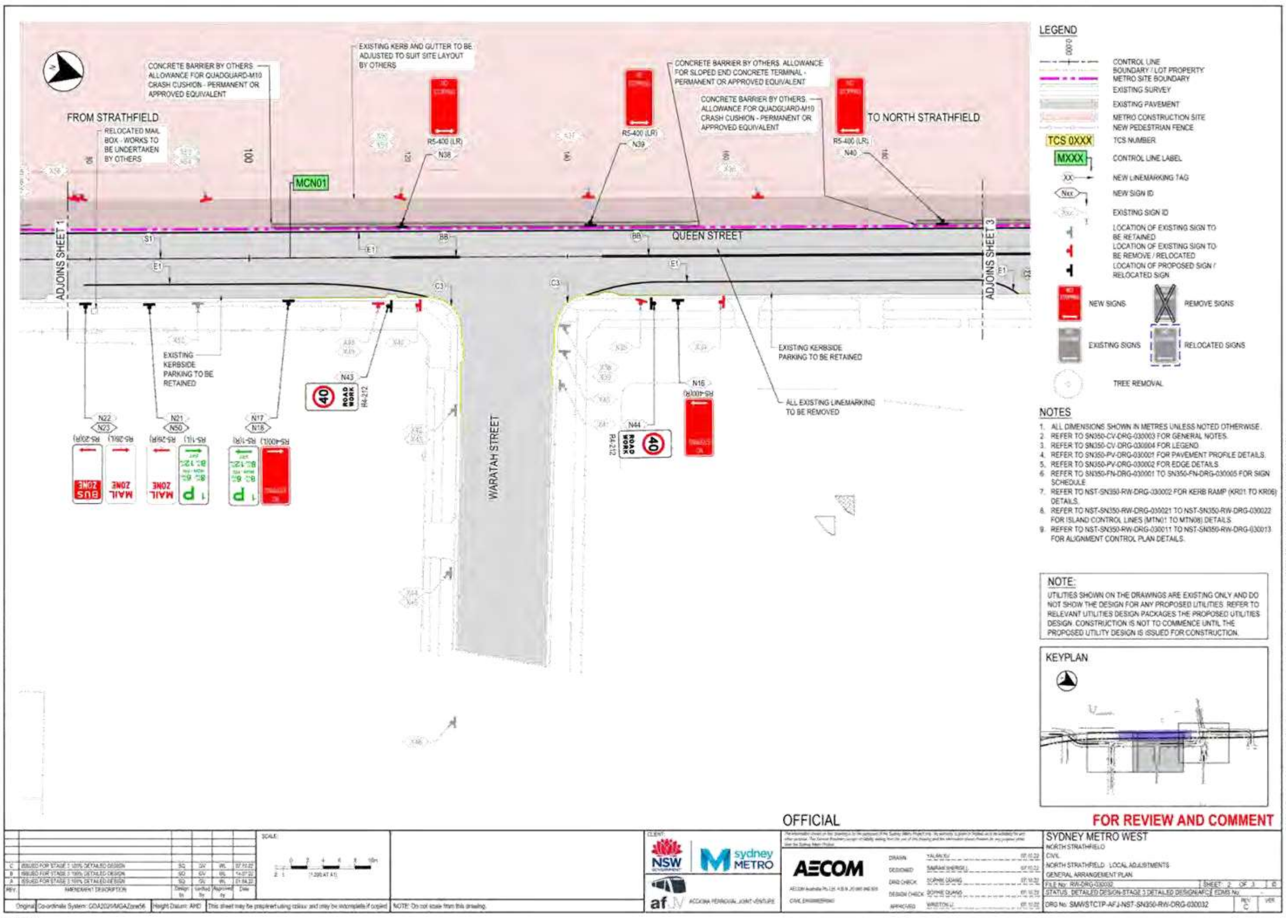
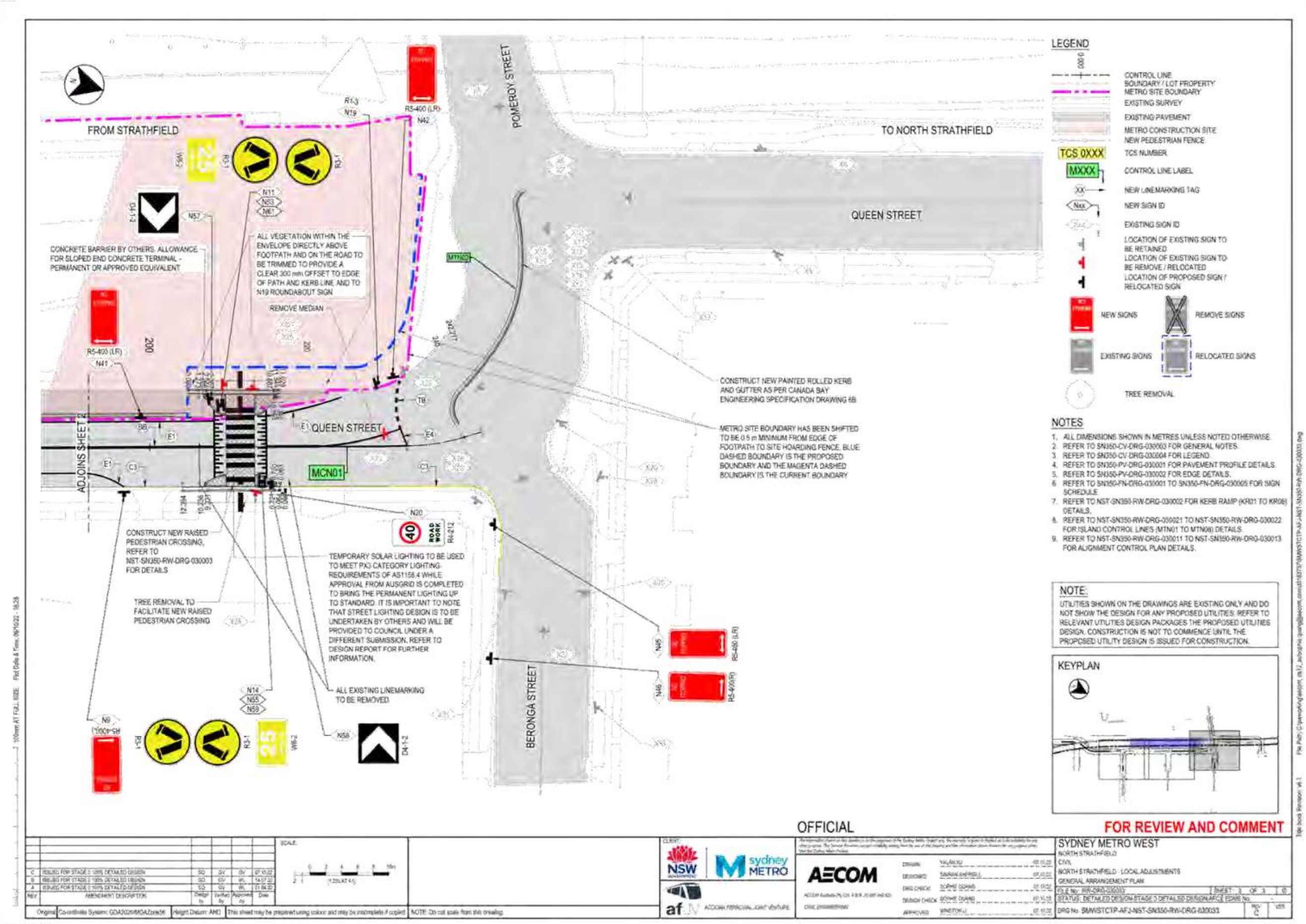
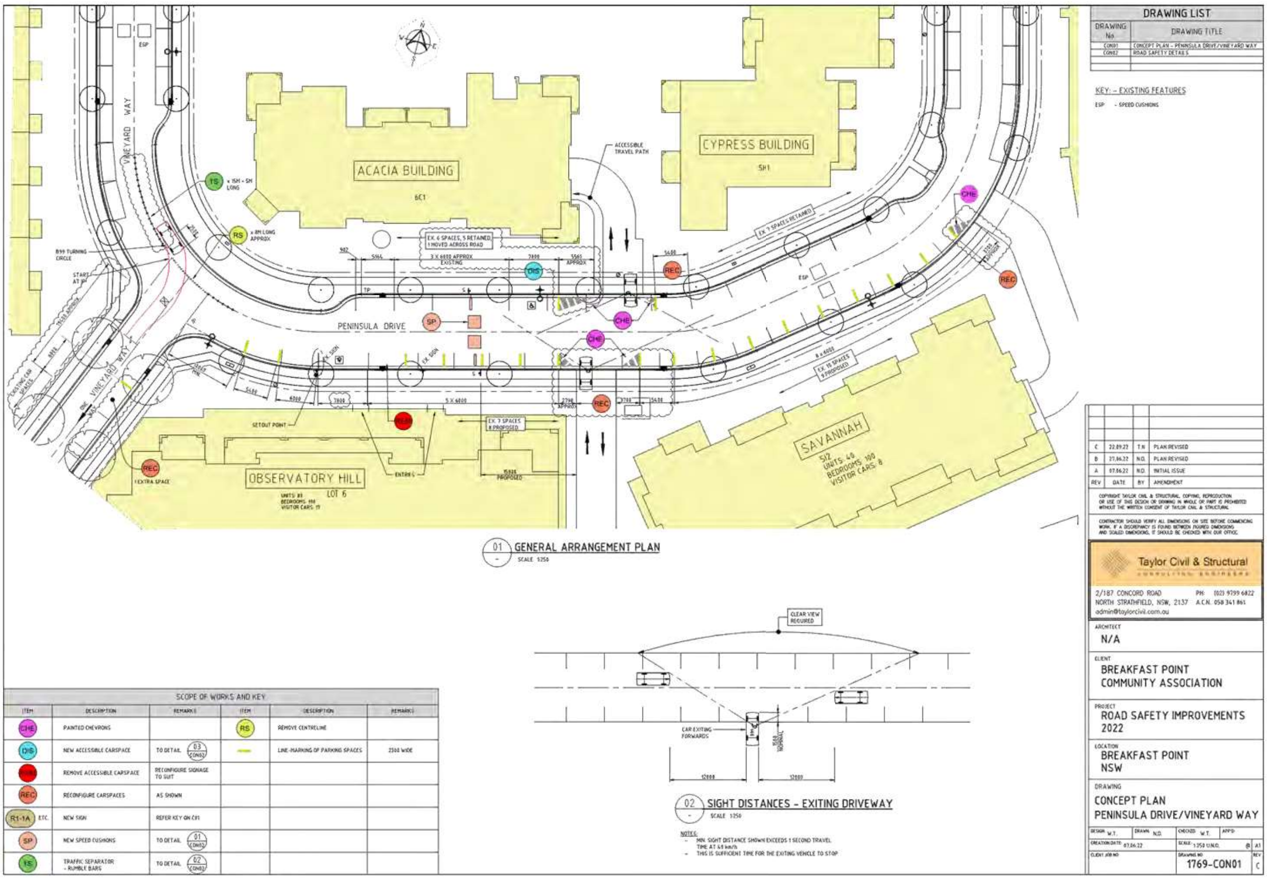
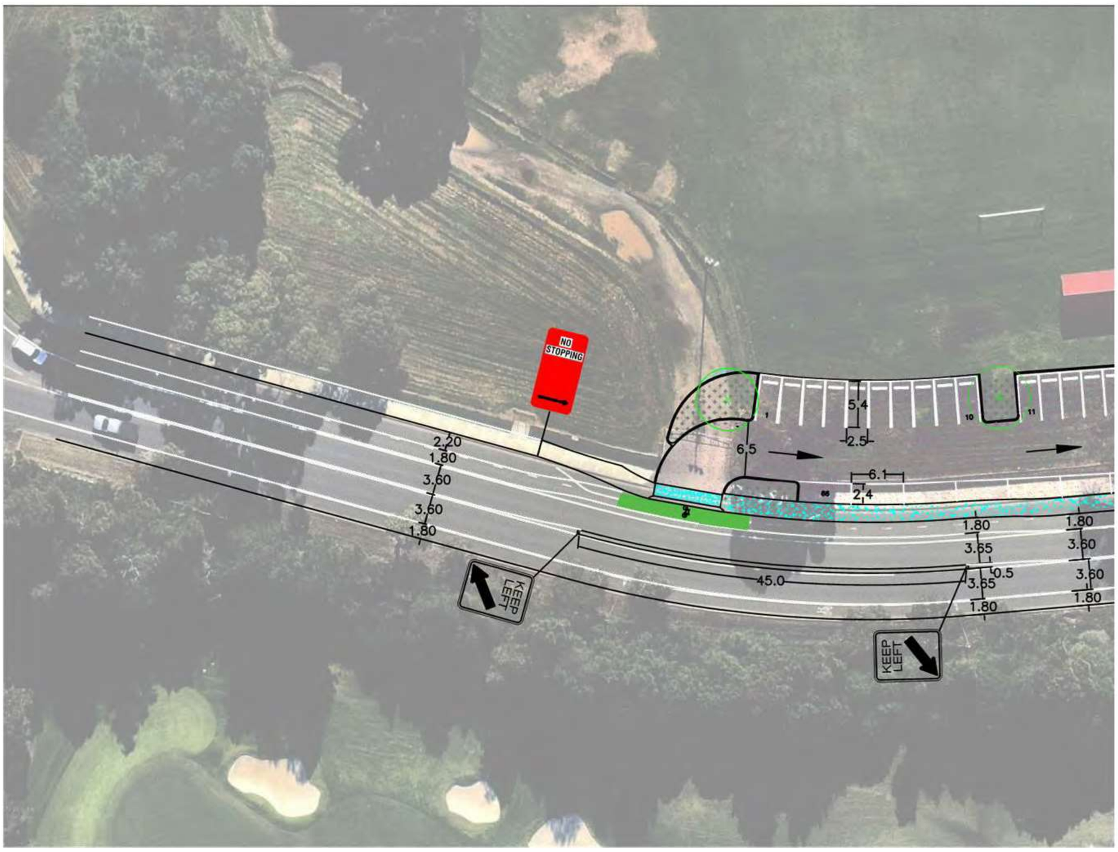

FROM STRATHFIELD
TO NORTH STRATHFIELD
QUEEN STREET
WELLBANK STREET
ADJOINS SHEET 2
ADJOINS INSET-A
INSET-A
ADJOINS RW-DRG-030031
LEGEND
NOTES
KEYPLAN
OFFICIAL
FOR INFORMATION
SYDNEY METRO WEST
AECOM

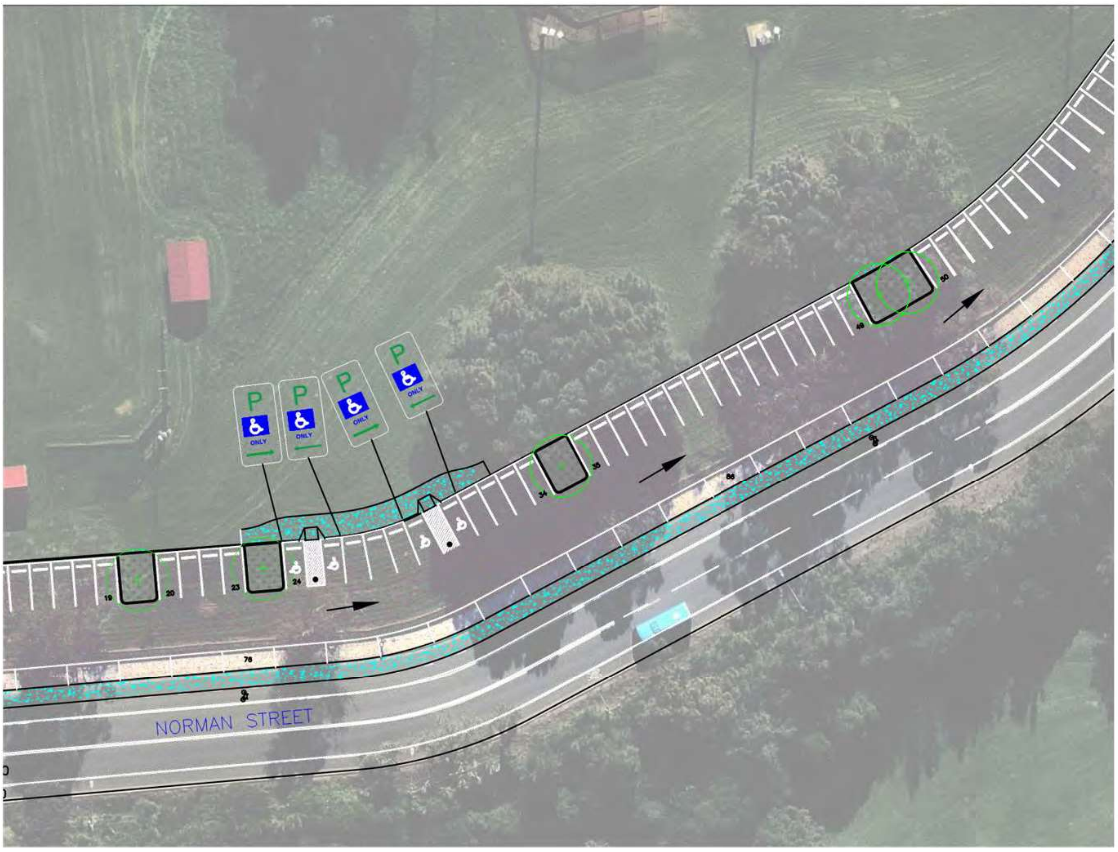

FROM STRATHFIELD
TO NORTH STRATHFIELD
QUEEN STREET
WARATAH STREET
ADJOINS SHEET 1
ADJOINS SHEET 3
CONCRETE BARRIER BY OTHERS ALLOWANCE FOR QUADGUARD-M10 CRASH CUSHION - PERMANENT OR APPROVED EQUIVALENT
EXISTING KERB AND GUTTER TO BE ADJUSTED TO SUIT SITE LAYOUT BY OTHERS
CONCRETE BARRIER BY OTHERS. ALLOWANCE FOR SLOPED END CONCRETE TERMINAL - PERMANENT OR APPROVED EQUIVALENT
RELOCATED MAIL BOX - WORKS TO BE UNDERTAKEN BY OTHERS
EXISTING KERBSIDE PARKING TO BE RETAINED
ALL EXISTING LINEMARKING TO BE REMOVED
MCN01
LEGEND
CONTROL LINE
BOUNDARY / LOT PROPERTY
METRO SITE BOUNDARY
EXISTING SURVEY
EXISTING PAVEMENT
METRO CONSTRUCTION SITE
NEW PEDESTRIAN FENCE
TCS NUMBER
CONTROL LINE LABEL
NEW LINEMARKING TAG
NEW SIGN ID
EXISTING SIGN ID
LOCATION OF EXISTING SIGN TO BE RETAINED
LOCATION OF EXISTING SIGN TO BE REMOVE / RELOCATED
LOCATION OF PROPOSED SIGN / RELOCATED SIGN
NEW SIGNS
REMOVE SIGNS
EXISTING SIGNS
RELOCATED SIGNS
TREE REMOVAL
NOTES
1. ALL DIMENSIONS SHOWN IN METRES UNLESS NOTED OTHERWISE.
2. REFER TO SN350-CV-DRG-030003 FOR GENERAL NOTES.
3. REFER TO SN350-CV-DRG-030004 FOR LEGEND.
4. REFER TO SN350-PV-DRG-030001 FOR PAVEMENT PROFILE DETAILS.
5. REFER TO SN350-PV-DRG-030002 FOR EDGE DETAILS.
6. REFER TO SN350-FN-DRG-030001 TO SN350-FN-DRG-030005 FOR SIGN SCHEDULE.
7. REFER TO NST-SN350-RW-DRG-030002 FOR KERB RAMP (KR01 TO KR06) DETAILS.
8. REFER TO NST-SN350-RW-DRG-030021 TO NST-SN350-RW-DRG-030022 FOR ISLAND CONTROL LINES (MTN01 TO MTN08) DETAILS.
9. REFER TO NST-SN350-RW-DRG-030011 TO NST-SN350-RW-DRG-030013 FOR ALIGNMENT CONTROL PLAN DETAILS.
NOTE:
UTILITIES SHOWN ON THE DRAWINGS ARE EXISTING ONLY AND DO NOT SHOW THE DESIGN FOR ANY PROPOSED UTILITIES. REFER TO RELEVANT UTILITIES DESIGN PACKAGES THE PROPOSED UTILITIES DESIGN. CONSTRUCTION IS NOT TO COMMENCE UNTIL THE PROPOSED UTILITY DESIGN IS ISSUED FOR CONSTRUCTION.
KEYPLAN
OFFICIAL
FOR REVIEW AND COMMENT
SYDNEY METRO WEST
NORTH STRATHFIELD
CIVIL
NORTH STRATHFIELD - LOCAL ADJUSTMENTS
GENERAL ARRANGEMENT PLAN
AECOM


LEGEND
CONTROL LINE
BOUNDARY / LOT PROPERTY
METRO SITE BOUNDARY
EXISTING SURVEY
EXISTING PAVEMENT
METRO CONSTRUCTION SITE
NEW PEDESTRIAN FENCE
TCS 0XXX
TCS NUMBER
MXXX
CONTROL LINE LABEL
NEW LINEMARKING TAG
NEW SIGN ID
EXISTING SIGN ID
LOCATION OF EXISTING SIGN TO BE RETAINED
LOCATION OF EXISTING SIGN TO BE REMOVE / RELOCATED
LOCATION OF PROPOSED SIGN / RELOCATED SIGN
NEW SIGNS
REMOVE SIGNS
EXISTING SIGNS
RELOCATED SIGNS
TREE REMOVAL
NOTES
1. ALL DIMENSIONS SHOWN IN METRES UNLESS NOTED OTHERWISE.
2. REFER TO SN350-CV-DRG-030003 FOR GENERAL NOTES.
3. REFER TO SN350-CV-DRG-030004 FOR LEGEND.
4. REFER TO SN350-PV-DRG-030001 FOR PAVEMENT PROFILE DETAILS.
5. REFER TO SN350-PV-DRG-030002 FOR EDGE DETAILS.
6. REFER TO SN350-FN-DRG-030001 TO SN350-FN-DRG-030005 FOR SIGN SCHEDULE.
7. REFER TO NST-SN350-RW-DRG-030002 FOR KERB RAMP (KR01 TO KR08) DETAILS.
8. REFER TO NST-SN350-RW-DRG-030021 TO NST-SN350-RW-DRG-030022 FOR ISLAND CONTROL LINES (MTN01 TO MTN08) DETAILS.
9. REFER TO NST-SN350-RW-DRG-030011 TO NST-SN350-RW-DRG-030013 FOR ALIGNMENT CONTROL PLAN DETAILS.
NOTE:
UTILITIES SHOWN ON THE DRAWINGS ARE EXISTING ONLY AND DO NOT SHOW THE DESIGN FOR ANY PROPOSED UTILITIES. REFER TO RELEVANT UTILITIES DESIGN PACKAGES THE PROPOSED UTILITIES DESIGN. CONSTRUCTION IS NOT TO COMMENCE UNTIL THE PROPOSED UTILITY DESIGN IS ISSUED FOR CONSTRUCTION.
KEYPLAN
FROM STRATHFIELD
TO NORTH STRATHFIELD
POMEROY STREET
QUEEN STREET
BERONGA STREET
ADJOINS SHEET 2
MCN01
MTN02
CONCRETE BARRIER BY OTHERS. ALLOWANCE FOR SLOPED END CONCRETE TERMINAL - PERMANENT OR APPROVED EQUIVALENT
ALL VEGETATION WITHIN THE ENVELOPE DIRECTLY ABOVE FOOTPATH AND ON THE ROAD TO BE TRIMMED TO PROVIDE A CLEAR 300 mm OFFSET TO EDGE OF PATH AND KERB LINE, AND TO N19 ROUNDABOUT SIGN
REMOVE MEDIAN
CONSTRUCT NEW PAINTED ROLLED KERB AND GUTTER AS PER CANADA BAY ENGINEERING SPECIFICATION DRAWING 6B
METRO SITE BOUNDARY HAS BEEN SHIFTED TO BE 0.5 m MINIMUM FROM EDGE OF FOOTPATH TO SITE HOARDING FENCE. BLUE DASHED BOUNDARY IS THE PROPOSED BOUNDARY AND THE MAGENTA DASHED BOUNDARY IS THE CURRENT BOUNDARY
CONSTRUCT NEW RAISED PEDESTRIAN CROSSING, REFER TO NST-SN350-RW-DRG-030003 FOR DETAILS
TREE REMOVAL TO FACILITATE NEW RAISED PEDESTRIAN CROSSING
TEMPORARY SOLAR LIGHTING TO BE USED TO MEET PX3 CATEGORY LIGHTING REQUIREMENTS OF AS1158.4 WHILE APPROVAL FROM AUSGRID IS COMPLETED TO BRING THE PERMANENT LIGHTING UP TO STANDARD. IT IS IMPORTANT TO NOTE THAT STREET LIGHTING DESIGN IS TO BE UNDERTAKEN BY OTHERS AND WILL BE PROVIDED TO COUNCIL UNDER A DIFFERENT SUBMISSION. REFER TO DESIGN REPORT FOR FURTHER INFORMATION.
ALL EXISTING LINEMARKING TO BE REMOVED
R5-400 (LR)
R1-3
N19
N42
N41
N11
N57
N20
N14
N55
N59
N58
N9
N45
N46
R3-1
W6-2
D4-1-2
R5-400 (LR)
R5-400 (R)
25
40
OFFICIAL
FOR REVIEW AND COMMENT
AECOM
SYDNEY METRO WEST
NORTH STRATHFIELD
CIVIL
NORTH STRATHFIELD - LOCAL ADJUSTMENTS
GENERAL ARRANGEMENT PLAN
DRG No SMWSTCTP-AFJ-NST-SN350-RW-DRG-030033


New footpath and pram ramp
Existing timber barrier removed and replaced with sandstone blocks setback 600mm from face of kerb to allow for vehicle overhang
Minor expansion of parking area


DRAWING LIST
CON01 CONCEPT PLAN - PENINSULA DRIVE/VINEYARD WAY
CON02 ROAD SAFETY DETAILS
KEY: - EXISTING FEATURES
ESP - SPEED CUSHIONS
ACACIA BUILDING
CYPRESS BUILDING
PENINSULA DRIVE
VINEYARD WAY
OBSERVATORY HILL
LOT 6
SAVANNAH
ACCESSIBLE TRAVEL PATH
01 GENERAL ARRANGEMENT PLAN
CLEAR VIEW REQUIRED
CAR EXITING FORWARDS
02 SIGHT DISTANCES - EXITING DRIVEWAY
SCOPE OF WORKS AND KEY
ITEM | DESCRIPTION | REMARKS | ITEM | DESCRIPTION | REMARKS
CHE PAINTED CHEVRONS
RS REMOVE CENTRELINE
DIS NEW ACCESSIBLE CARSPACE TO DETAIL 03 CON02
LINE-MARKING OF PARKING SPACES 2300 WIDE
REMOVE ACCESSIBLE CARSPACE RECONFIGURE SIGNAGE TO SUIT
REC RECONFIGURE CARSPACES AS SHOWN
R1-1A ETC. NEW SIGN REFER KEY ON C01
SP NEW SPEED CUSHIONS TO DETAIL 01 CON02
TS TRAFFIC SEPARATOR - RUMBLE BARS TO DETAIL 02 CON02
C 22.09.22 T.N. PLAN REVISED
B 27.06.22 N.O. PLAN REVISED
A 07.06.22 N.O. INITIAL ISSUE
REV DATE BY AMENDMENT
Taylor Civil & Structural
CONSULTING ENGINEERS
2/187 CONCORD ROAD
NORTH STRATHFIELD, NSW, 2137
PH: (02) 9799 6822
A.C.N. 058 341 861
admin@taylorcivil.com.au
ARCHITECT
N/A
CLIENT
BREAKFAST POINT
COMMUNITY ASSOCIATION
PROJECT
ROAD SAFETY IMPROVEMENTS
2022
LOCATION
BREAKFAST POINT
NSW
DRAWING
CONCEPT PLAN
PENINSULA DRIVE/VINEYARD WAY
DESIGN W.T.
DRAWN N.O.
CHECKED W.T.
CREATION DATE 07.06.22
SCALE 1:250 U.N.O. @ A1
DRAWING NO
1769-CON01
REV C


NO STOPPING
KEEP LEFT
KEEP LEFT
2.20
1.80
3.60
3.60
1.80
6.5
5.4
2.5
6.1
2.4
45.0
1.80
3.65
0.5
3.65
1.80
1.80
3.60
3.60
1.80


NORMAN STREET
ONLY
ONLY
ONLY
ONLY

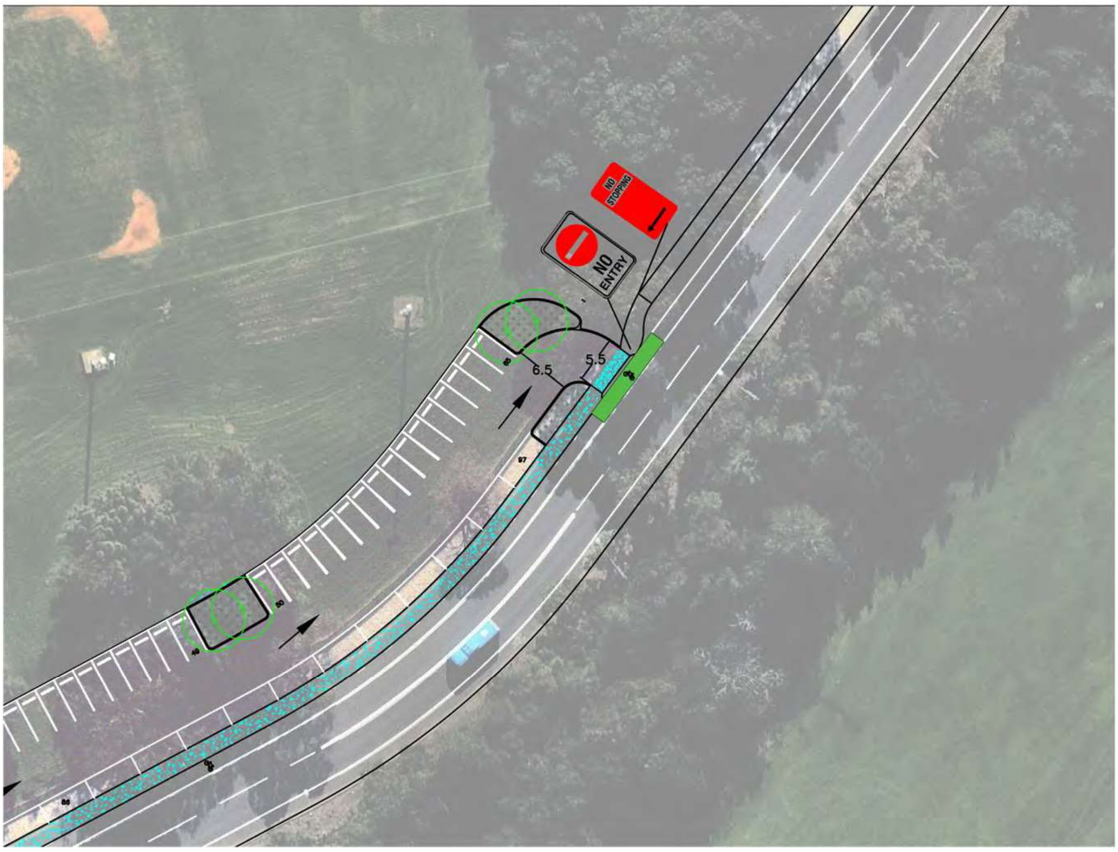
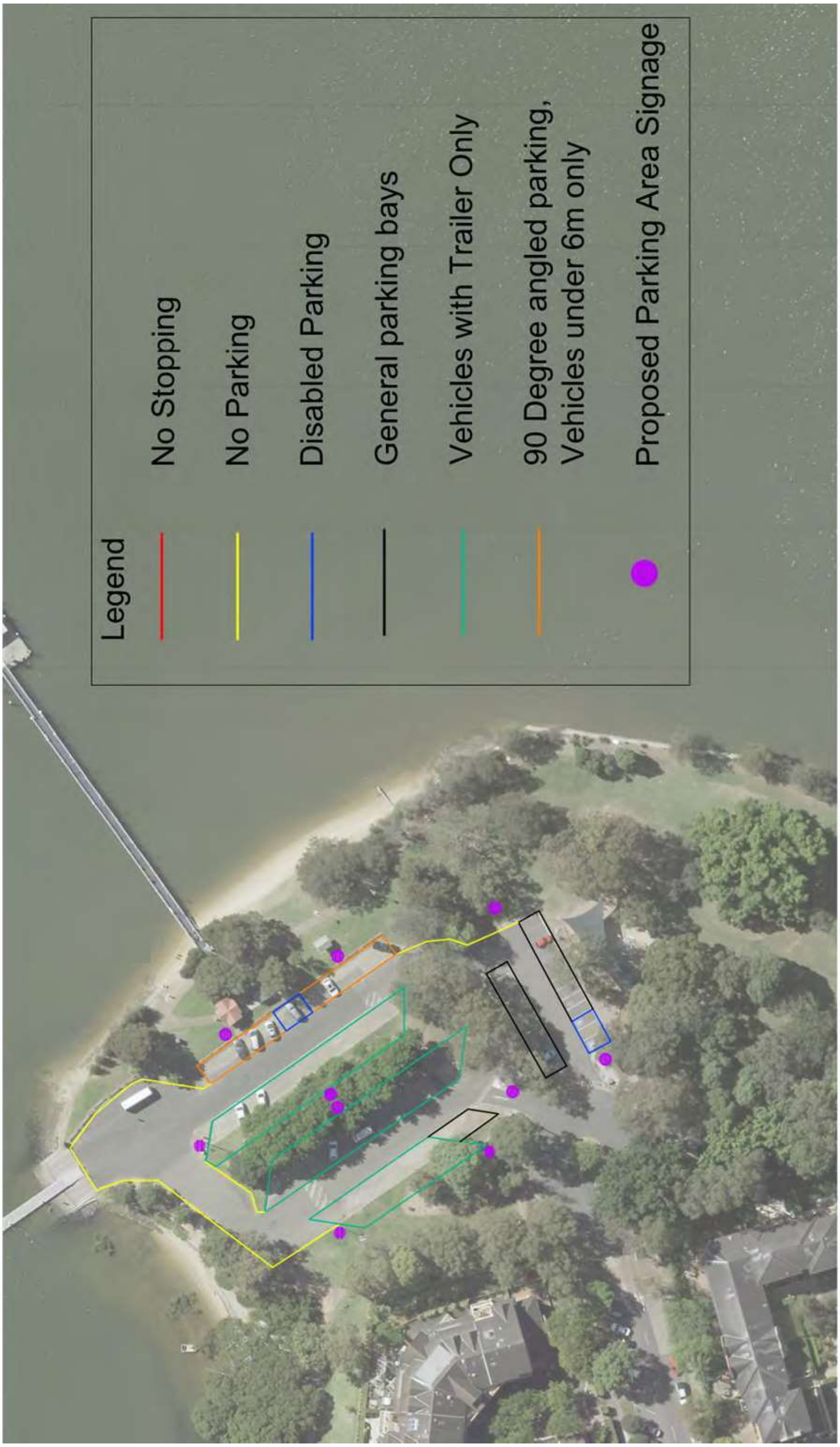

NO STOPPING
NO ENTRY
6.5
5.5

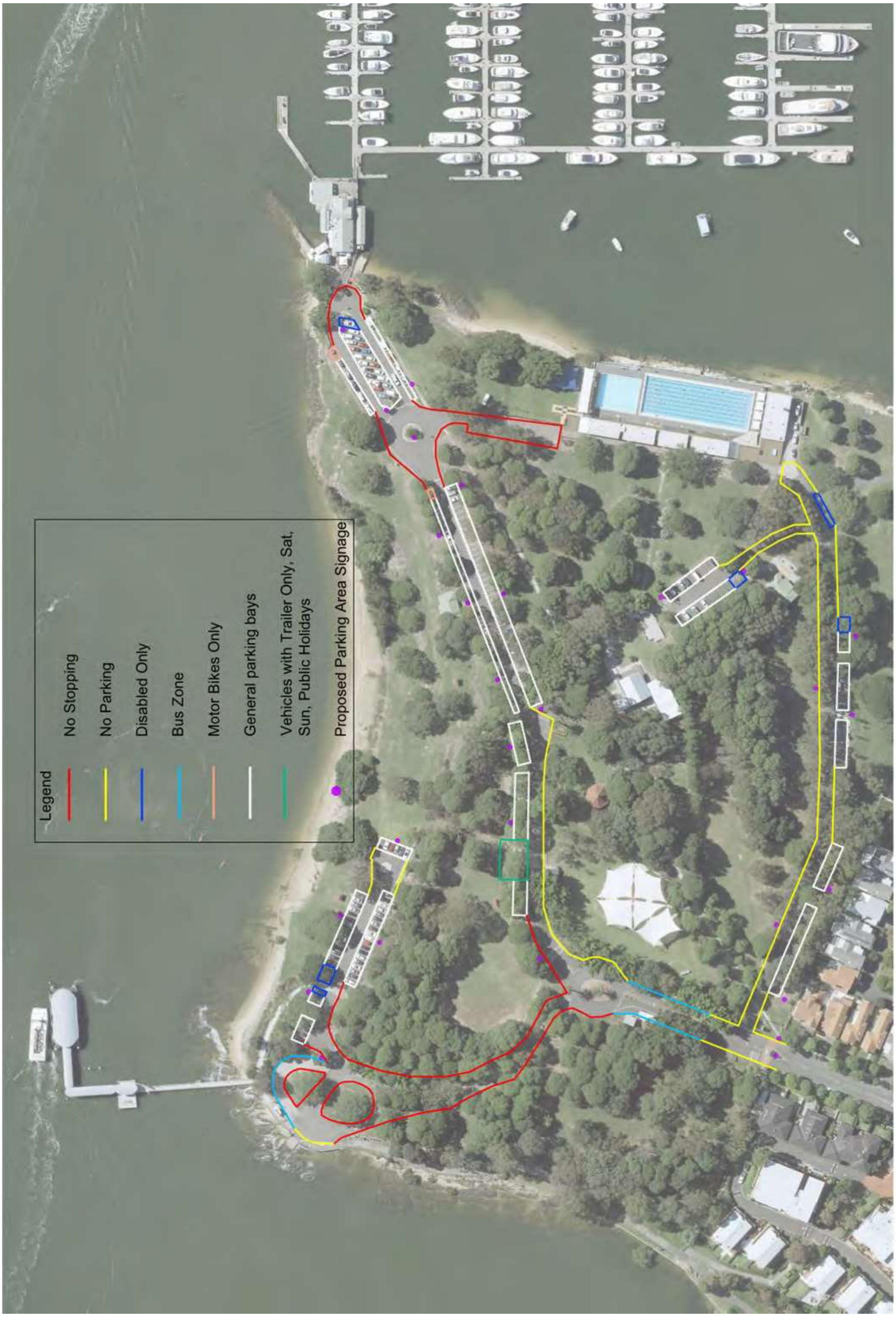
Figure 1: Entrance Sign
Cabarita Park

Figure 2: Entrance Sign
Bayview Park

Figure 3: Repeater Signs
Both Parks

Figure 4: Exit Signs
Both Parks


Legend
No Stopping
No Parking
Disabled Parking
General parking bays
Vehicles with Trailer Only
90 Degree angled parking, Vehicles under 6m only
Proposed Parking Area Signage


Legend
No Stopping
No Parking
Disabled Only
Bus Zone
Motor Bikes Only
General parking bays
Vehicles with Trailer Only, Sat, Sun, Public Holidays
Proposed Parking Area Signage

Attachment 1 – Investment Report November 2022

INVESTMENT
REPORT
NOVEMBER 2022

INVESTMENT REPORT NOVEMBER 2022

Contents

Investment Report NOVEMBER 2022

November 2022 Investment Report

Statement of Cash Investments as of 25 November 2022

STATEMENT OF CASH INVESTMENTS							
Maturity Date	Bank/Issuer	Long Term Rating	Fair Value	Term	Interest	Issue Date	Investment Type
30/11/22	National Australia Bank	AA-	$2,000,000.00	89	3.00%	02/09/22	Term Deposits
08/12/22	Commonwealth Bank of Australia	AA-	$3,000,000.00	216	2.43%	06/05/22	Term Deposits
23/12/22	Commonwealth Bank of Australia	AA-	$3,000,000.00	88	3.50%	26/09/22	Term Deposits
05/01/23	Commonwealth Bank of Australia	AA-	$3,000,000.00	244	2.62%	06/05/22	Term Deposits
12/01/23	Commonwealth Bank of Australia	AA-	$2,000,000.00	216	3.06%	10/06/22	Term Deposits
20/01/23	Commonwealth Bank of Australia	AA-	$3,000,000.00	133	3.31%	09/09/22	Term Deposits
27/01/23	National Australia Bank	AA-	$3,000,000.00	108	3.55%	11/10/22	Term Deposits
17/02/23	National Australia Bank	AA-	$1,500,000.00	126	3.56%	14/10/22	Term Deposits
02/03/23	Bank of Queensland	BBB+	$2,000,000.00	216	3.50%	29/07/22	Term Deposits
09/03/23	Commonwealth Bank of Australia	AA-	$3,000,000.00	223	3.45%	29/07/22	Term Deposits
10/03/23	National Australia Bank	AA-	$2,000,000.00	120	3.80%	10/11/22	Term Deposits
16/03/23	Macquarie Bank	A+	$2,000,000.00	365	1.20%	16/03/22	Term Deposits
21/03/23	AMP Bank	BBB	$1,000,000.00	210	3.70%	23/08/22	Term Deposits
23/03/23	Commonwealth Bank of Australia	AA-	$2,000,000.00	139	3.83%	04/11/22	Term Deposits
30/03/23	MyState Ltd	Baa2	$2,000,000.00	181	4.10%	30/09/22	Term Deposits
06/04/23	Commonwealth Bank of Australia	AA-	$3,000,000.00	169	3.83%	19/10/22	Term Deposits
20/04/23	Commonwealth Bank of Australia	AA-	$2,000,000.00	182	3.94%	20/10/22	Term Deposits
26/04/23	Westpac Bank	AA-	$2,000,000.00	180	4.00%	28/10/22	Term Deposits
27/04/23	National Australia Bank	AA-	$1,000,000.00	181	4.00%	28/10/22	Term Deposits
02/05/23	AMP Bank	BBB	$2,000,000.00	180	1.00%	03/11/22	Term Deposits
04/05/23	MyState Ltd	Baa2	$2,000,000.00	365	2.93%	04/05/22	Term Deposits
04/05/23	Commonwealth Bank of Australia	AA-	$2,000,000.00	363	3.18%	06/05/22	Term Deposits
11/05/23	MyState Ltd	Baa2	$2,000,000.00	188	4.30%	04/11/22	Term Deposits
08/06/23	Commonwealth Bank of Australia	AA-	$2,500,000.00	307	3.69%	05/08/22	Term Deposits
23/06/23	National Australia Bank	AA-	$3,000,000.00	365	0.60%	23/06/22	Term Deposits
06/07/23	Commonwealth Bank of Australia	AA-	$2,500,000.00	335	3.74%	05/08/22	Term Deposits
17/07/23	Commonwealth Bank of Australia	AA-	$3,000,000.00	381	0.60%	01/07/22	Term Deposits
28/07/23	National Australia Bank	AA-	$3,000,000.00	364	0.65%	29/07/22	Term Deposits
03/08/23	National Australia Bank	AA-	$2,000,000.00	367	0.65%	01/08/22	Term Deposits
16/02/26	National Australia Bank	AA-	$2,000,000.00	1461	1.04%	16/02/22	Term Deposits
02/12/22	Westpac Bank	AA-	$2,000,000.00	364	0.58%	03/12/21	ESG TD
13/04/23	Westpac Bank	AA-	$3,000,000.00	364	1.89%	14/04/22	Tailored Deposits
20/10/23	Westpac Bank	AA-	$1,500,000.00	365	4.53%	20/10/22	Tailored Deposits
30/10/23	Westpac Bank	AA-	$1,000,000.00	367	1.11%	28/10/22	ESG TD
19/02/24	Westpac Bank	AA-	$1,000,000.00	458	4.05%	18/11/22	ESG TD
04/03/24	Westpac Bank	AA-	$2,000,000.00	546	1.68%	05/09/22	ESG TD
14/11/24	Westpac Bank	AA-	$1,500,000.00	731	1.62%	14/11/22	ESG TD
02/12/24	Westpac Bank	AA-	$1,500,000.00	819	1.62%	05/09/22	ESG TD
17/02/25	Westpac Bank	AA-	$2,000,000.00	822	2.02%	18/11/22	ESG TD
24/02/25	Westpac Bank	AA-	$2,500,000.00	822	2.10%	25/11/22	ESG TD
20/11/25	Westpac Bank	AA-	$1,500,000.00	1095	1.87%	21/11/22	ESG TD
17/02/26	Westpac Bank	AA-	$2,500,000.00	1187	2.24%	18/11/22	ESG TD
24/02/26	Westpac Bank	AA-	$2,000,000.00	1187	2.31%	25/11/22	ESG TD
03/03/26	Westpac Bank	AA-	$2,000,000.00	1275	2.22%	05/09/22	ESG TD
03/02/23	Bank of Queensland	BBB+	$2,000,000.00	1635	4.10%	13/08/18	Floating Rate Notes
06/02/23	Newcastle Permanent Building Society	BBB	$2,000,000.00	1707	4.46%	05/06/18	Floating Rate Notes
24/02/23	RACQ Bank	BBB+	$1,500,000.00	1096	4.07%	24/02/20	Floating Rate Notes
16/08/23	Commonwealth Bank of Australia	AA-	$1,500,000.00	1826	3.98%	16/08/18	Floating Rate Notes
08/02/24	ANZ Bank	AA-	$1,500,000.00	1826	4.16%	08/02/19	Floating Rate Notes
29/08/24	ANZ Bank	AA-	$1,500,000.00	1827	3.20%	29/08/19	Floating Rate Notes
14/11/24	Citibank	A+	$1,000,000.00	1827	3.91%	14/11/19	Floating Rate Notes
12/02/25	Macquarie Bank	A+	$2,000,000.00	1827	3.87%	12/02/20	Floating Rate Notes
06/05/25	Royal Bank of Canada	AA-	$1,000,000.00	1096	3.76%	06/05/22	Floating Rate Notes
09/12/25	Macquarie Bank	A+	$2,000,000.00	1651	3.09%	02/06/21	Floating Rate Notes
15/06/26	Teachers Mutual Bank	BBB	$850,000.00	1825	3.48%	16/06/21	Floating Rate Notes
19/08/26	ING Bank	A+	$500,000.00	1826	3.47%	19/08/21	Floating Rate Notes
18/08/27	Commonwealth Bank of Australia	AA-	$1,100,000.00	1826	4.07%	18/08/22	Floating Rate Notes
17/10/25	Suncorp Metway	A+	$1,000,000.00	1096	3.82%	17/10/22	Floating Rate Notes
23/12/26	Commonwealth Bank of Australia	AA-	$2,000,000.00	1917	3.32%	23/09/21	ESG FRN
15/12/22	NTTC	Aa3	$2,000,000.00	808	0.90%	28/09/20	Fixed Rate Bond
15/12/23	NTTC	Aa3	$2,000,000.00	1186	1.00%	15/09/20	Fixed Rate Bond
15/12/24	NTTC	Aa3	$2,000,000.00	1206	1.00%	27/08/21	Fixed Rate Bond
15/06/25	NTTC	Aa3	$2,000,000.00	1496	1.10%	11/05/21	Fixed Rate Bond
18/08/25	Commonwealth Bank of Australia	AA-	$1,500,000.00	1096	4.20%	18/08/22	Fixed Rate Bond
24/08/26	Suncorp Metway	A+	$2,000,000.00	1587	3.25%	20/04/22	Fixed Rate Bond
	AMP Bank	BBB	$1,009,176.87		3.30%		AMP 31Day Notice
	AMP Bank	BBB	$3,786.49		0.50%		AMP Business Saver
	Macquarie Bank	A+	$1,999,999.99		3.05%		Macquarie CMA
	Macquarie Bank	A+	$3,448,481.68		2.85%		Macquarie CMA
	30/11/22		$133,911,445.03				
	TOTAL INVESTMENTS at 31/10/2022		$139,758,583.00				
	Net Increase/(Decrease) in Investments		($5,847,137.97)				

Certificate of the Responsible Accounting Officer

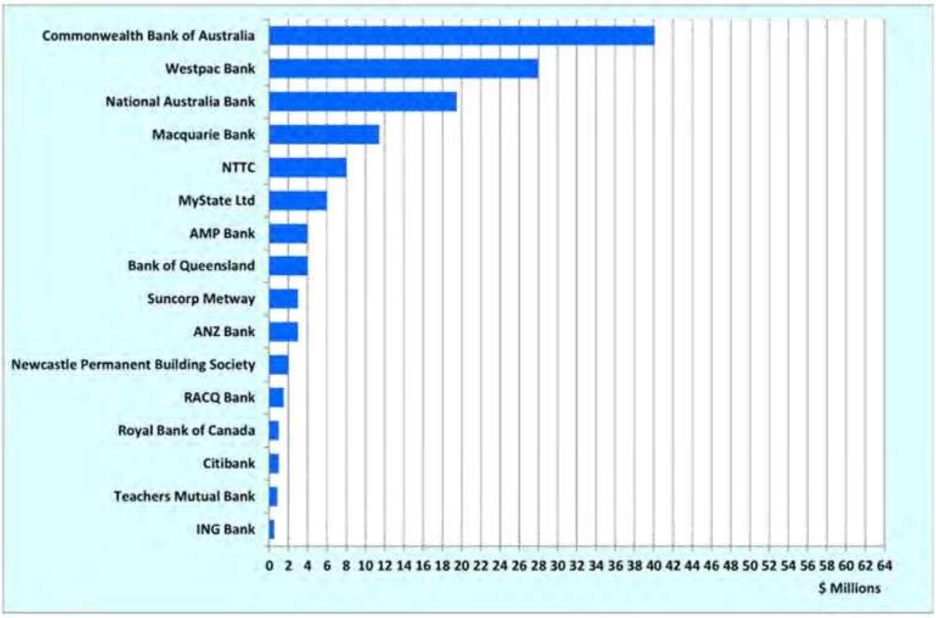
I certify that as at the date of this report, the investments listed have been made and are held in compliance with Council's Investment Policy and applicable legislation.

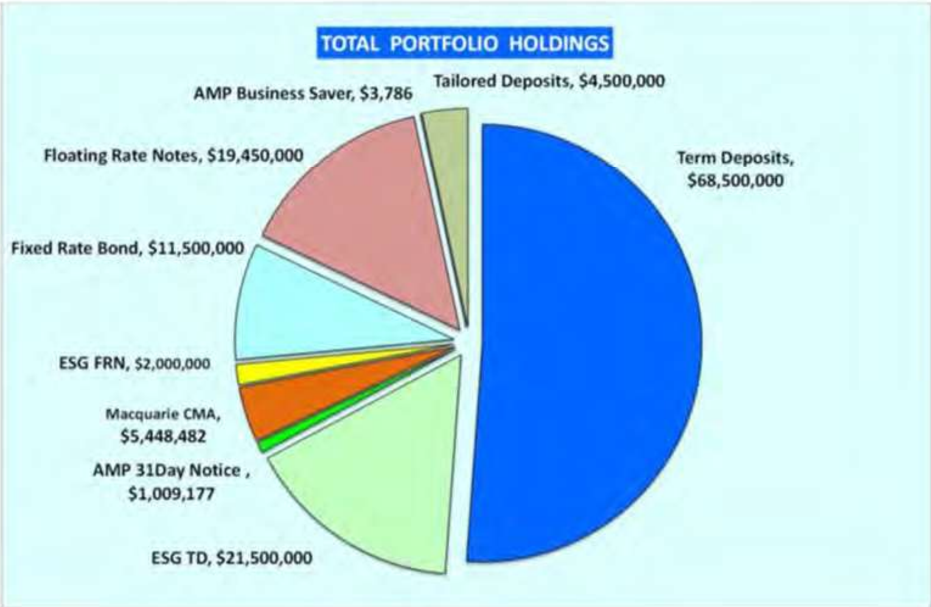
Evan Hutchings

Date: 25 November 2022

Investment Report NOVEMBER 2022

Total Investment Deposits by Institution as of 25 November 2022





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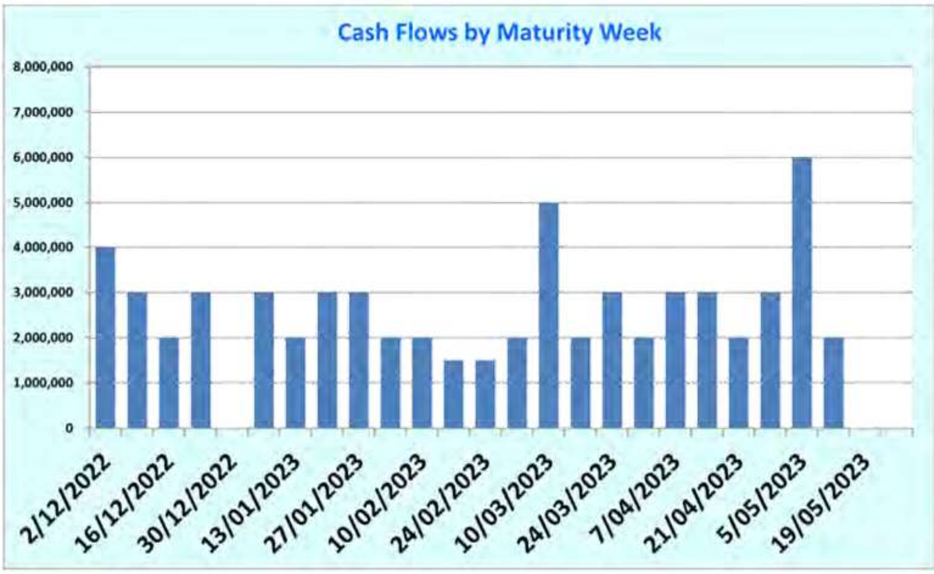
Weekly cash flow forecast for 6 months as of 25 November 2022



Investment Report NOVEMBER 2022

Individual Counterparty Limits for Term Deposits, Fixed Rate Notes, Floating Rate TDs, and FRNs as per Council Investment Policy

LT Ratings	ADI	Policy Limit	% of Portfolio
AA-	ANZ Bank	45%	2.24%
	Commonwealth Bank of Australia	45%	29.95%
	National Australia Bank	45%	14.56%
	Westpac Bank	45%	20.91%
	Royal Bank of Canada	45%	0.75%
Aa3	NTTC	45%	5.97%
A+	Macquarie Bank	30%	8.55%
	ING Bank	30%	0.37%
	Suncorp Metway	30%	2.24%
	Citibank	30%	0.75%
BBB+	RACQ Bank	10%	1.12%
	Bank of Queensland	10%	2.99%
Baa2	MyState Ltd	10%	4.48%
BBB	Teachers Mutual Bank	5%	0.63%
	AMP Bank	5%	3.00%
	Newcastle Permanent Building Society	5%	1.49%
	Total Portfolio		**100.00%**

Counter Party Class Limits for Term Deposits, Fixed Rate Notes, Floating Rate TDs, and FRNs as per Council's Investment Policy (excluding At Call Deposits)

Type Long Term	Holdings	Policy Limit	% Portfolio
AA-	$93,600,000.00	45%	69.90%
Aa3	$8,000,000.00	45%	5.97%
A+	$13,948,481.67	30%	10.42%
A	$0.00	30%	0.00%
BAA2	$6,000,000.00	10%	4.48%
BBB+	$5,500,000.00	10%	4.11%
BBB	$6,862,963.36	5%	5.13%
BBB-	$0.00	5%	0.00%
NR	$0.00	0%	0.00%
Total	**$133,911,445.03**		**100.00%**

Investment Report NOVEMBER 2022

Investment Transactions during November 2022

Date	Transaction	Bank/Issuer	Type	Term	Int Rate	Amount	Interest Paid
31/10/2022	Balance	Investment Balance Fair Value				$139,758,583.00	
3/11/2022	Maturity	Commonwealth Bank of Australia	Term Deposit	64	2.54%	($2,000,000.00)	$8,907.40
3/11/2022	Reset	AMP Bank	Term Deposit	180	1.00%	$2,000,000.00	
3/11/2022	Reset	AMP Bank	Term Deposit	180	1.00%	($2,000,000.00)	$20,000.00
3/11/2022	Reset	Bank of Queensland	Floating Rate Notes	1635	4.10%	$2,000,000.00	
3/11/2022	Reset	Bank of Queensland	Floating Rate Notes	1635	3.23%	($2,000,000.00)	$16,273.16
4/11/2022	Purchase	Commonwealth Bank of Australia	Term Deposit	139	3.83%	$2,000,000.00	
4/11/2022	Purchase	MyState Ltd	Term Deposit	188	4.30%	$2,000,000.00	
7/11/2022	Reset	Newcastle Permanent Building Society	Floating Rate Notes	1707	4.46%	$2,000,000.00	
7/11/2022	Reset	Newcastle Permanent Building Society	Floating Rate Notes	1707	3.66%	($2,000,000.00)	$18,224.93
7/11/2022	Reset	Royal Bank of Canada	Floating Rate Notes	1096	3.76%	$1,000,000.00	
7/11/2022	Reset	Royal Bank of Canada	Floating Rate Notes	1096	2.96%	($1,000,000.00)	$7,367.26
8/11/2022	Maturity	National Australia Bank	Term Deposit	270	0.70%	($2,000,000.00)	$10,356.17
8/11/2022	Reset	ANZ Bank	Floating Rate Notes	1826	4.16%	$1,500,000.00	
8/11/2022	Reset	ANZ Bank	Floating Rate Notes	1826	3.38%	($1,500,000.00)	$12,684.66
10/11/2022	Maturity	Bank of Queensland	Term Deposit	210	1.50%	($3,000,000.00)	$25,890.41
10/11/2022	Purchase	National Australia Bank	Term Deposit	120	3.80%	$2,000,000.00	
14/11/2022	Reset	Citibank	Floating Rate Notes	1827	3.91%	$1,000,000.00	
14/11/2022	Reset	Citibank	Floating Rate Notes	1827	3.20%	($1,000,000.00)	$7,965.87
14/11/2022	Reset	Macquarie Bank	Floating Rate Notes	1827	3.87%	$2,000,000.00	
14/11/2022	Reset	Macquarie Bank	Floating Rate Notes	1827	3.14%	($2,000,000.00)	$16,152.55
14/11/2022	Reset	Westpac Bank	ESG TD	731	1.62%	$1,500,000.00	
14/11/2022	Reset	Westpac Bank	ESG TD	731	1.62%	($1,500,000.00)	$6,258.08
16/11/2022	Reset	Commonwealth Bank of Australia	Floating Rate Notes	1826	3.98%	$1,500,000.00	
16/11/2022	Reset	Commonwealth Bank of Australia	Floating Rate Notes	1826	3.23%	($1,500,000.00)	$12,225.00
18/11/2022	Maturity	Westpac Bank	ESG TD	364	0.54%	($2,000,000.00)	$10,770.41
18/11/2022	Reset	Commonwealth Bank of Australia	Floating Rate Notes	1826	4.07%	$1,100,000.00	
18/11/2022	Reset	Commonwealth Bank of Australia	Floating Rate Notes	1826	3.30%	($1,100,000.00)	$9,251.34
18/11/2022	Reset	Westpac Bank	ESG TD	458	4.05%	$1,000,000.00	
18/11/2022	Reset	Westpac Bank	ESG TD	822	2.02%	$2,000,000.00	
18/11/2022	Reset	Westpac Bank	ESG TD	1187	2.24%	$2,500,000.00	
18/11/2022	Reset	Westpac Bank	ESG TD	458	3.32%	($1,000,000.00)	$8,359.90
18/11/2022	Reset	Westpac Bank	ESG TD	822	2.02%	($2,000,000.00)	$10,183.01
18/11/2022	Reset	Westpac Bank	ESG TD	1187	2.24%	($2,500,000.00)	$14,115.07
21/11/2022	Reset	ING Bank	Floating Rate Notes	1826	3.47%	$500,000.00	
21/11/2022	Reset	ING Bank	Floating Rate Notes	1826	2.73%	($500,000.00)	$3,513.50
21/11/2022	Reset	Westpac Bank	ESG TD	1095	1.87%	$1,500,000.00	
21/11/2022	Reset	Westpac Bank	ESG TD	1095	1.87%	($1,500,000.00)	$7,223.84
24/11/2022	Reset	RACQ Bank	Floating Rate Notes	1096	4.07%	$1,500,000.00	
24/11/2022	Reset	RACQ Bank	Floating Rate Notes	1096	3.32%	($1,500,000.00)	$12,559.80
25/11/2022	Maturity	Commonwealth Bank of Australia	Term Deposit	78	2.87%	($2,000,000.00)	$12,266.30
25/11/2022	Reset	Westpac Bank	ESG TD	822	2.10%	$2,500,000.00	
25/11/2022	Reset	Westpac Bank	ESG TD	1187	2.31%	$2,000,000.00	
25/11/2022	Reset	Westpac Bank	ESG TD	822	2.10%	($2,500,000.00)	$11,644.93
25/11/2022	Reset	Westpac Bank	ESG TD	1187	2.31%	($2,000,000.00)	$13,232.88
	Activity	AMP Bank 31Day Notice	At Call (AMP)		3.05%	$2,545.54	$2,545.54
	Activity	AMP Business Saver	At Call (AMP)		0.50%	($849,683.51)	$316.49
25/11/2022		EOM Balance			Total	$133,911,445.03	$278,288.50

Total Interest Received during November 2022

Ledger Account	Type	November
102623-1465-40068	Investments	$275,426.47
102623-1465-40067	At Call Accounts	$2,862.03
	Sub-Total	**$278,288.50**
102623-1465-40066	General Bank Account	$4,023.63
	Total	**$282,312.13**

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Statement of Consolidated Cash and Investments as of 25 November 2022

Consolidated Cash & Investments		
Cash & Investments		
Cash At Bank as at 24 Nov 2022	$4,581,544.45	
Investments at Fair Value as at 25 Nov 2022	$133,911,445.03	
Total Cash & Investments		**$138,492,989.48**
The above cash and investments are comprised of:		
Externally Restricted Reserves		
Externally restricted reserves refer to funds received that are restricted by externally imposed requirements for expenditure on specific purposes. Externally restricted reserves include unexpended developer contributions under Sections 7.11 and 7.12.		
Total External Restrictions		**$91,378,913.48**
Internally Restricted Reserves		
Internally restricted reserves are funds restricted in the use by resolution or policy of Council		
Total Internal Restrictions		**$44,505,827.53**
Unrestricted Cash & Investments		
Total Unrestricted Cash & Investments		**$2,608,248.47**
Total Cash & Investments		**$138,492,989.48**

Note: At the time of this report, developer contributions have yet to be finalised for Nov 2022

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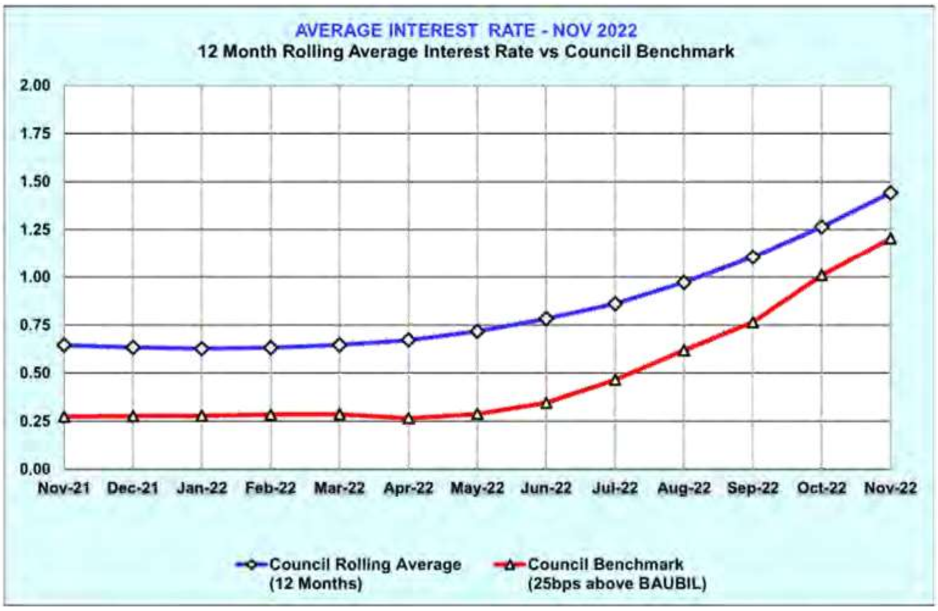
Comparative Graphs



The BAUBIL (Bloomberg Ausbond Bank Bill) Index is engineered to measure the Australian money market by representing a passively-managed short term money market portfolio. This index is comprised of 13 synthetic instruments defined by rates interpolated from the RBA 24-hour cash rate, 1M BBSW, and 3M BBSW.

The Annual Average BAUBIL plus 25bps (a quarter of 1 percent) forms Council's benchmark rate against which Council's actual investment returns are compared.

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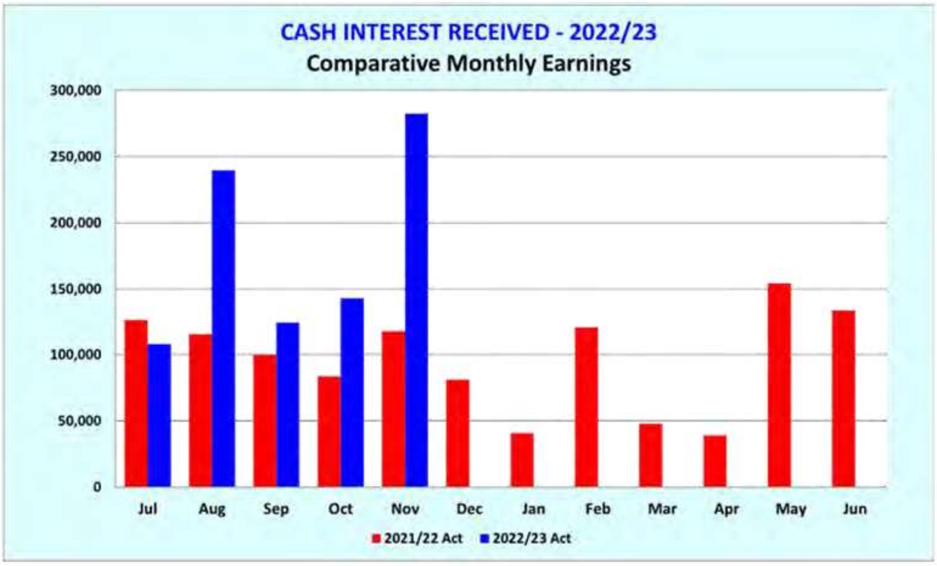

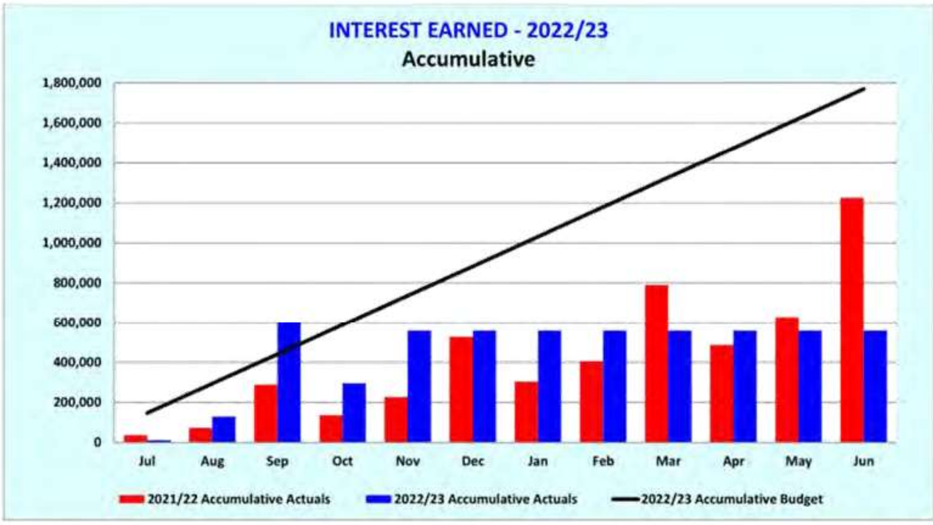

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1a Marlborough Street, Drummoyne NSW 2047
Tel 9911 6555 Fax 9911 6550 **www.canadabay.nsw.gov.au**