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St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study – Final Report

W4735

Prepared for Penrith City Council

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GLOSSARY

* Many terms in this Glossary have been derived or adapted from the NSW Government *Floodplain Development Manual*, 2005.

Australian Height Datum (AHD)	A common national surface level datum approximately corresponding to mean sea level.
Average recurrence interval (ARI)	The long-term average number of years between the occurrences 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.
Cadastre, cadastral base	Information in map or digital form showing the extent and usage of land, including streets, lot boundaries, water courses etc.
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.
Creek Rehabilitation	Rehabilitating the natural 'biophysical' (i.e. geomorphic and ecological) functions of the creek.
Creek Modification	Widening or altering the creek channel in an environmentally compatible manner (i.e. including weed removal and stabilisation with suitable native endemic vegetation) to allow for additional conveyance.
Design flood	A significant event to be considered in the design process; various works within the floodplain may have different design events, e.g. some roads may be designed to be overtopped in the 1 year ARI flood event.

Development	Is defined in Part 4 of the 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 landuse. Eg, the urban subdivision of an area previously used for rural purposes. New developments involve re-zoning and typically require major extensions of existing urban services, such as roads, water supply, sewerage and electric power. Redevelopment: refers to rebuilding in an area. Eg, as urban areas age, it may become necessary to demolish and reconstruct buildings on a relatively large scale. Redevelopment generally does not require either re-zoning or major extensions to urban services.
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).
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 fringe	The remaining area of flood-prone land after floodway and flood storage areas have been defined.
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 provisional hazard categories are provided in Appendix L of the Floodplain Development Manual (NSW Government, 2005).

Flood-prone land	Land susceptible to inundation by the probable maximum flood (PMF) event, i.e. the maximum extent of flood liable land.
Floodplain	Area of land which is subject to inundation by floods up to the probable maximum flood event, i.e. 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.
Flood planning area	The area of land below the FPL and thus subject to flood related development controls.
Flood planning levels	Are the combinations of flood levels (derived from significant historical flood events or floods of specific ARIs) and freeboards selected for floodplain risk management purposes, as determined in management studies and incorporated in management plans.
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 are important for the temporary storage of floodwaters during the passage of a flood. The extent and behaviour of flood storage areas may change with flood severity, and loss of flood storage can increase the severity of flood impacts by reducing natural flood attenuation. Hence, it is necessary to investigate a range of flood sizes before defining flood storage areas.

Floodway areas	Those areas of the floodplain where a significant discharge of water occurs during floods. They are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flow, or a significant increase in flood levels.
Freeboard	Provides reasonable certainty that the risk exposure selected in deciding on a particular flood chosen as the basis for the FPL is actually provided. It is a factor of safety typically used in relation to the setting of floor levels, levee crest levels, etc. (See Section K5). Freeboard is included in the flood planning level.
Geographical information systems (GIS)	A system of software and procedures designed to support the management, manipulation, analysis and display of spatially referenced data.
High hazard	Flood conditions that pose a possible danger to personal safety; evacuation by trucks difficult; able-bodied adults would have difficulty wading to safety; potential for significant structural damage to buildings.
Hydraulics	The term given to the study of water flow in a river, channel or pipe, in particular, the evaluation of flow parameters such as stage and velocity.
Hydrograph	A graph that shows how the discharge changes with time at any particular location.
Hydrology	The term given to the study of the rainfall and runoff process as it relates to the derivation of hydrographs for given floods.
Local overland flooding	Inundation by local runoff rather than overbank discharge from a stream, river, estuary, lake or dam.
Low hazard	Flood conditions such that should it be necessary, people and their possessions could be evacuated by trucks; able-bodied adults would have little difficulty wading to safety.
Mainstream flooding	Inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam.

Management plan	A document including, as appropriate, both written and diagrammatic information describing how a particular area of land is to be used and managed to achieve defined objectives. With regard to flooding, the objective of the management plan is to minimise and mitigate the risk of flooding to the community. It may also include description and discussion of various issues, special features and values of the area, the specific management measures which are to apply and the means and timing by which the plan will be implemented.
Mathematical/computer models	The mathematical representation of the physical processes involved in runoff and stream flow. These models are often run on computers due to the complexity of the mathematical relationships. In this report, the models referred to are mainly involved with rainfall, runoff, pipe and overland stream flow.
Peak discharge	The maximum discharge occurring during a flood event.
Probable maximum flood	The PMF is the largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation, and where applicable, snow melt, coupled with the worst flood producing catchment conditions. Generally, it is not physically or economically possible to provide complete protection against this event. The PMF defines the extent of flood prone land, that is, the floodplain. The extent, nature and potential consequences of flooding associated with a range of events rarer than the flood used for designing mitigation works and controlling development, up to and including the PMF event should be addressed in a floodplain risk management study.
Probable maximum precipitation	The PMP is the greatest depth of precipitation for a given duration meteorologically possible over a given size storm area at a particular location at a particular time of the year, with no allowance made for long-term climatic trends (World Meteorological Organisation, 1986). It is the primary input to PMF estimation.
Probability	A statistical measure of the expected frequency or occurrence of flooding.
Risk	Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. For this study, it is the likelihood of consequences arising from the interaction of floods, communities and the environment.

Runoff	The amount of rainfall that actually ends up as stream or pipe flow, 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 changes with time. It must be referenced to a particular location and datum.
Stormwater flooding	Inundation by local runoff. Stormwater flooding can be caused by local runoff exceeding the capacity of an urban stormwater drainage system or by the backwater effects of mainstream flooding causing the urban stormwater drainage system to overflow.
Topography	A surface which defines the ground level of an area.

List of Abbreviations

1D	One Dimensional
2D	Two Dimensional
AHD	Australian Height Datum
ARI	Average Recurrence Interval
BoM	Bureau of Meteorology
DECCW	Department of Environment, Climate Change & Water (now OEH)
FPL	Flood Planning Level
FRMP	Floodplain Risk Management Plan
FRMS	Floodplain Risk Management Study
km	kilometres
km^2	Square kilometres
LGA	Local Government Area
m	metre
m^2	Square metres
m^3	Cubic metres
mAHD	Metres to Australian Height Datum
mm	millimetres
m/s	metres per second
NSW	New South Wales
OSD	On-site Detention
OEH	Office of Environment and Heritage
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
SES	State Emergency Service
SWC	Sydney Water Corporation

Foreword

The NSW Government's Flood Prone Land Policy is directed towards providing solutions to existing flood problems in developed areas utilising ecologically positive methods wherever possible and ensuring that 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 prone land is the responsibility of Local Government. To achieve its primary objective, the policy provides for State Government financial assistance to Councils for actions to alleviate existing flooding problems. The policy also provides for State Government technical assistance to Councils to ensure that the management of flood prone land is consistent with the flood hazard and that future development does not create or increase flooding problems in flood prone areas.

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

1. Data Collection	Collect all data required for flood studies, including ground survey, historical rainfall and flood levels data.
2. Flood Study	Determines the nature and extent of the flood problem.
3. Floodplain Risk Management Study	Evaluates management options for the floodplain in respect of both existing and proposed development.
4. Floodplain Risk Management Plan	Involves formal adoption by Council of a plan of management for the floodplain.
5. Implementation of the Plan	Implementation of actions to manage flood risks for existing and new development.

The St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study is the first and the second stages of the management for St Marys and surrounding suburbs and has been prepared for Penrith Council by Cardno to define flood behaviour under existing catchment conditions.

EXECUTIVE SUMMARY

Cardno was commissioned by Penrith Council to undertake Penrith Detailed Overland Flow Flood Study, which consists of the Penrith CBD study and St Marys study. This final report provides the model results of St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study.

The study area lies in the Byrnes Creek catchment, which is approximately 45 kilometres west of Sydney CBD. The study area has an area of approximately 310 hectares, which is bounded by the M4 Motorway in the south, and South Creek in the west.

An extensive data compilation and review was undertaken in the study. This included an extensive survey exercise which required the collection of data for approximately 840 pits and 840 pipes within the study area, together with cross sections of stormwater channels and details of hydraulic structures such as culverts.

The data compilation also included a resident survey of approximately 2080 properties. This survey targeted local residents' experience with flooding in the study area to collect the historical flooding information for the model calibration and validation. All survey data has been complied into a GIS database for Council.

A fully dynamic 1D/2D hydraulic TUFLOW model was established. The TUFLOW model incorporates a detailed one dimensional (1D) network (drainage system, including channels in the study area) with a fine 1 metre terrain grid for the entire study area in 100 year, 20 year and 5 year ARIs. For other design events, a 1 metre grid was adopted in the west of the study area, whilst 1.5 metre grid was adopted in the east of the study area. Hydrological modelling was undertaken utilising a combination of Direct Rainfall within the study area and traditional hydrological modelling for catchments external to the study area.

Calibration and validation are two important processes to ensure the feasibility of the hydraulic model. However, it is difficult to directly calibrate the hydraulic model in this study due to scarce calibration data, such as historical flood levels, representative rainfall and localised storm events. Therefore, the robustness and reliability of the hydraulic model was tested by an indirect validation. The validation results suggest that the hydraulic model is capable of reasonably simulating the hydrological and hydraulic processes of the catchment.

The primary objective of the study is to define flood behaviour for the study area under existing conditions that represent the features of overland flowpaths and the drainage system. The study provides information on flood extents, flood levels, depths, and flood velocities for a full range of design storm events, including 1 year, 2 year, 5 year, 10 year, 20 year, 50 year, 100 year, and 200 year ARI storm events together with the Probable Maximum Flood (PMF) event. This study defines provisional hazards and hydraulic categories for the study area. A flood damage assessment has also been undertaken as a part of this study.

Preliminary options to manage the flooding within the study area have also been identified. These options will provide a starting point for the next stage of the Floodplain Risk Management process.

1 INTRODUCTION

1.1 Background

Penrith City Council completed a broad-scale overland flow flood study ("Overview Study") in October 2006 (Cardno Lawson Treloar, 2006) in order to prioritise future detailed overland flow flood studies for all catchments within the Penrith Local Government Area (LGA) in accordance with the NSW Government's Floodplain Development Manual, 2005.

St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study is an outcome of that process. Compared with previous "Overview Study", the key features associated with St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study are:

- A fine 1m to 1.5m grid was applied within the study area in order to identify the overland flow paths in detail; and
- Detailed 1D components were incorporated within the 2D grid, including pits, pipes, channels, and other hydraulic control structures.

The primary objective of the study is to define the flood behaviour, the flood hazard and to quantify flood damages under existing conditions. The outcome of this study could be utilised in a Floodplain Risk Management Study.

1.2 Study Area

The study area lies in the Byrnes Creek catchment, which is approximately 7 kilometres east of Penrith CBD (**Figure 1.1**). The study area has an area of approximately 310 hectares, which is bounded by M4 Motorway in the south and South Creek in the west, as shown in **Figure 1.2**.

The eastern parts of the study area are relatively steep and have generally more confined overland flooding, whilst the western parts of the study area are relatively flat where overland flow can pond and spread out over a larger area.

An important feature of the study area is the levee along the western boundary of the study area, which separates South Creek from the study area. This levee minimises flooding from South Creek affecting the majority of the study area.

There are two large parks in and near the study area, which will assist with the storage of flood waters. Cook Park near Wilson Street provides some storage in major flood events whereas Monfarville Reserve is a formal detention basin, which lies just upstream of the Mamre Road. While Monfarville Reserve is upstream of the study area, it has been incorporated within the hydraulic model to ensure that the hydraulic behaviour is adequately represented.

The catchment itself extends beyond the study area, with a large portion to the south of the M4 Motorway. The area to the south extends approximately 2.3 kilometres, representing an area of approximately 206 hectares upstream of the M4 Motorway.

1.3 Study Objectives

The primary objective of the study is to define flood behaviour for the study area under existing conditions that represent the features of overland flowpaths and the drainage system. The study provides information on flood extents, flood levels, flows, depths, and flood velocities for a full range of design storm events, including 1 year, 2 year, 5 year, 10 year, 20 year, 50 year, 100 year, and 200 year ARI storm events together with the Probable Maximum Flood (PMF) event. This study also defines provisional hazards, hydraulic categories and quantifies the flood damages for the study area. The results of the study may form the basis for subsequent Floodplain Risk Management and Plan for the study area.

In order to achieve these objectives, the following tasks have been undertaken:

- Compile and review all relevant information to enhance Council's existing drainage infrastructure database (**Section 2**);
- Investigate the likely extent and nature of flooding under the existing conditions and identify potential hydraulic control structures through a detailed site inspection (**Section 2**);
- Develop a hydrological model to obtain upstream input hydrographs into the 1D/2D hydraulic model for the study area (**Section 5**);
- Establish a 1D/2D hydraulic model to investigate the flood behaviour for the full range of design storm events (**Section 6**);
- Undertake a validation process to test the robustness and reliability of the 1D/2D hydraulic model (**Section 7**);
- Define the flood extents, flood levels, velocities and depths for the study area (**Section 8**);
- Define Provisional Flood Hazard for flood-affected areas (**Section 9**);
- Define the Hydraulic Categories for flood-affected areas (**Section 10**);
- Estimate flood damage costs (**Section 11**);
- Undertake sensitivity analysis on key model parameters (**Section 12**), and
- Identify preliminary flood mitigation options (**Section 13**).

2 DATA COMPILATION

Quality data is one of the essential factors for undertaking an overland flow flood study. In general, data includes information required for inputs to the hydrological and hydraulic models, such as existing drainage system, hydraulic control structures and terrain (ALS) data. Data also includes information required for calibration and validation of models, such as historical rainfall and flood levels data.

Data for this study was obtained from the following sources:

- Previous flood study reports relevant to the current study area (**Section 2.1**);
- Ground and property survey and aerial survey information (**Section 2.2**);
- Pit and Pipe Survey (**Section 2.2**);
- Aerial photography taken in 2008 from Penrith Council;
- General GIS information (such as cadastre, street names, and etc.) from Penrith Council; and
- Rainfall data from Sydney Water (**Section 2.5**).

2.1 Previous Studies and Reports

2.1.1 Penrith Overland Flow Study –"Overview Study"

Penrith Overland Flow Flood Study –"Overview Study" was undertaken by Cardno Lawson Treloar in 2006. This study developed a two-dimensional (2D) hydraulic model to determine the overland flow behaviour for the entire LGA excluding areas defined by South Creek or Nepean River flood extents. Due to the computer limitations at the time, a course/fine grid combination was applied in the study, where a coarse 45m grid was established for the entire LGA and finer 3m grids or 9m grids were then nested within the coarse grid. Only significant culverts/bridges in the study area were included as one-dimensional (1D) components within the fine grid, e.g. the large culverts under Great Western Highway.

This study investigated the overland flow behaviour throughout the LGA by defining the flood extents, flood velocities, flood levels and flow rates only for the 20 year and 100 year ARIs along with the PMF design flood events. The results of this study were used as a guide for Council to identify and prioritise areas for future detailed overland flow flood studies.

2.1.2 South Creek Flood Study

Penrith City Council are currently undertaking the South Creek Flood Study, which describes mainstream flooding behaviour. Draft peak flood levels at a number of locations along South Creek were provided by Council on 28 March 2011. These were utilised to establish upstream and downstream boundary conditions for the modelling (**Section 6.6**).

2.2 Survey Information

Penrith City Council provided a substantial amount of the data required for the study. An additional survey was undertaken by Cardno's own in-house team of surveyors to obtain detailed information regarding pits, pipes, channel cross sections and hydraulic control structures within the study area. In addition, a property survey was also conducted by Penrith City Council to collect property floor level data and other relevant data for estimating property damage costs.

2.2.1 Topographic Survey

Airborne Laser Scanning (ALS) based on a survey undertaken on 7-9 November 2002 was supplied by Penrith City Council. Generally, the accuracy of ALS data is +/- 0.15m to one standard deviation on hard surfaces. The ALS data defines the topographic features in the study area. It is noted that features such as channels and culverts are generally not well defined in the ALS data. These features were picked up through ground survey, discussed in **Section 2.2.2**.

2.2.2 Ground Survey

A detailed field survey undertaken by Cardno's in-house surveyors was completed in October 2008. The survey provided information that is sufficient to set up 1D/2D hydraulic models for the study area, including pits, pipes, hydraulic control structures and the creek cross sections. The layout of surveyed drainage system for the study area is displayed in **Figure 2.1**.

The following survey details were obtained within the study areas:

- Pit and Pipe Field Survey – Approximately 840 pits and 840 pipes were surveyed for the study area. This generates a 'pit and pipe GIS database' which identifies the dimensions and locations of all surveyed pits and pipes. The surface levels and invert levels of pits in the 'database' were directly measured by the surveyors. A small portion of pits and pipes have incomplete information due to inaccessibility of some of these structures.

- Cross Sections and Culvert Dimensions – cross sections of the open channels and culvert dimensions within the study area were obtained (see **Figure 2.1**). These details are generally not adequately defined in the aerial survey described in **Section 2.2.1** and were therefore obtained as supplementary information.

2.2.3 Property Survey

A property survey was arranged by Penrith City Council and supplied to Cardno in August 2011. The data includes floor levels and representative ground levels, along with other details of the property such as building type, number of storeys etc. Information obtained by property survey was used to assess the flood damage for various design flood events.

2.3 Site Inspections

The site inspections were undertaken by Cardno's experienced hydraulic engineers. The site visits provided the opportunity to fine tune the modelling approach to capture various street drainage features, and to visually identify potential flooding hotspots in the study area which are shown in **Figure 2.2**. A summary of these hot spots is presented in **Table 2.1**. **Appendix A** includes site inspection photos showing these flooding hotspots.

Table 2.1 Flooding Hotspots Identified by Site Inspections

Hotspot	Description	Photo ID
Hotspot 1	Putland St between Neale St and Pages Rd	1
Hotspot 2	Channel near Saddington St between Pages Rd and Garner St	2,3
Hotspot 3	School at Saddington Rd between Garner St and Mamre Rd	4
Hotspot 4	Lowest Spot between Ryan St and Monfarville St	5
Hotspot 5	Monfarville St between Mitchell St and Lonsdale St	6
Hotspot 6	At the end point of Monfarville St and Thomas St near retarding basin	7
Hotspot 7	Retarding basin at end point of Monfarville St and Thomas St	8
Hotspot 8	Northern entrance of Macleay Crescent	9

2.4 General Data

The following Geographic Information System (GIS) data was provided by Council for this study:

- The study area catchment plans with minor and major contours (0.5m and 5m interval respectively);
- Existing pit and pipe layout plans;
- Cadastre for the study area;
- Flood extents from Penrith Overland Flood Flow Study (Cardno Lawson Treloar, 2006);
- Landuse map, and
- Digital ortho-rectified aerial images of the study area recorded in 2008

2.5 Historical Rainfall Information

Figure 2.3 shows the rain gauges in the surrounding areas. The details of these rain gauges are listed in **Table 2.2**.

It is noted that due to the short critical duration for the study area, only the Pluviometer rainfall data is appropriate for the study. Therefore, rainfall data was obtained for historical events from the Sydney Water gauge at the St Marys ST (567087), which is approximately 4.3 kilometres away from the centre of the study area.

Table 2.2 Rain Gauge Information

Station No.	Station Name	Source	Longitude (0E)	Latitude (0S)	Type
567087	St Marys ST	Sydney Water	150.77	-33.7357	Pluviometer (6min interval)
67024	St Marys Bowling Club	BOM	150.767	-33.7667	Hourly Interval
67003	Colyton (Ball Street)	BOM	150.789	-33.7742	Hourly Interval

According to Bureau of Meteorology (*http://www.bom.gov.au*), the rain gauge (67024) closed in December 1984, whilst the rain gauge (67003) closed in March 2008. The event in 11 February 2007 is the largest recorded historical event in the study area. **Section 5.4** provides detailed information regarding historical rainfall analysis. Therefore, no sufficient rainfall data (required at least three rain gauge data) can be used to undertake rainfall isohyets analysis in this study.

2.6 Historical Flood Levels

Information regarding historical flood levels is usually used to calibrate or validate the hydraulic model. In this study, only limited information on historical flood levels was reported by the Community Survey, which is further described in **Section 3**.

3 COMMUNITY CONSULTATION

3.1 Overview

A residential survey has been undertaken to gain a better understanding of the community experience with flooding in the catchment. A questionnaire was prepared in consultation with Council to seek information regarding whether residents have experienced flooding, the nature and depth of flooding and the timing of such floods.

The questionnaires were sent in the post to all residents in the study area in March 2008 by Council. Approximately 2080 properties were contacted. It is noted that the number of questionnaires delivered would be larger than this as the properties include units and multi-dwelling developments.

The questionnaire featured eight questions, which were directed at understanding of community awareness of flooding as well as historical flood information which would be used for the model calibration and validation (**Section 7**). A copy of the questionnaire and associated figures are attached in **Appendix B**. The data received are summarised in this report, with a complete detailed list of responses provided to Council separately.

A summary of the responses to each question can be found in **Sections 3.3 – 3.7**.

3.2 Response Rate

A total of 194 respondents were received, indicating a response rate of approximately 9%. This represents a mid-range response rate in comparison to similar studies undertaken by Cardno (as a guide a low return rate is 5% or less and a high return rate is around 15%). It is also noted that the survey was delivered to the entire study area, with many residents likely outside of the floodplain extent.

3.3 Duration of Residence

The duration of residency reported by the respondents is shown in **Table 3.1** and **Figure 3.1**.

Table 3.1 Duration of Residence of Respondents

Period of Residence	Number of Respondents	Percentage (%)
Less than 1 year	3	1.6
1 to 2 years	13	6.9
2 to 5 years	22	11.6
5 to 10 years	31	16.4
10 to 20 years	23	12.2
20 to 30 years	27	14.3
30 to 40 Years	26	13.8
More than 40 Years	44	23.3
Total	189	

Note: 5 respondents did not mention the duration of residency.

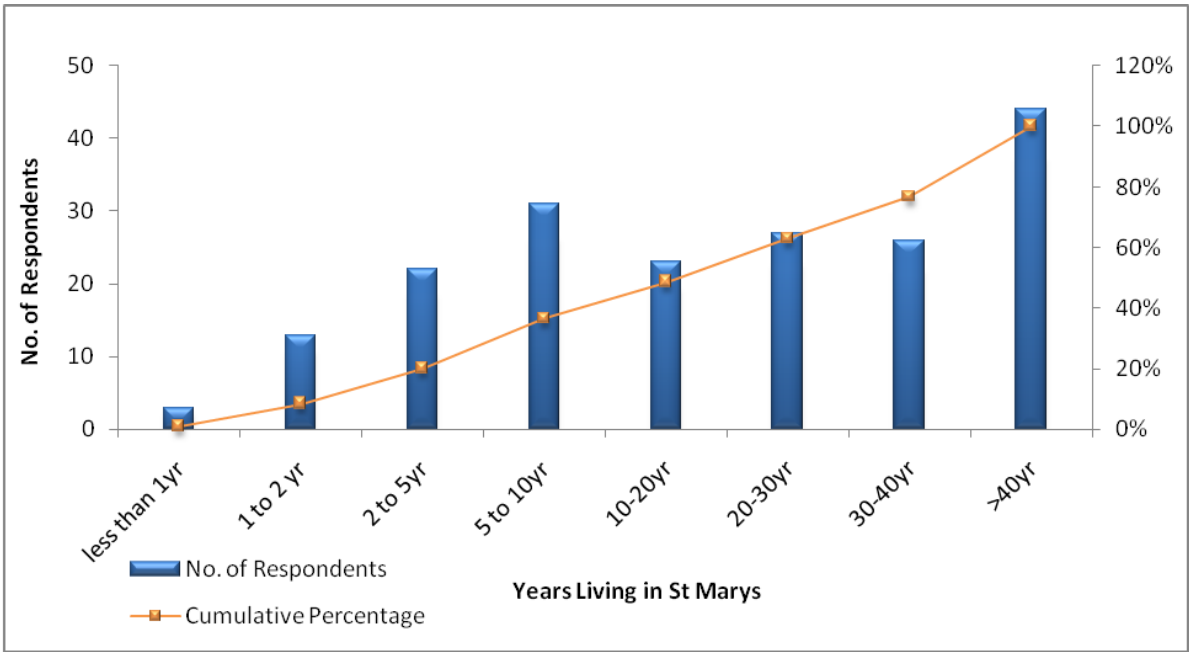


Figure 3.1 Duration of Residence of Respondents

Approximately 37 % of the respondents have lived in the study area for less than 10 years, while approximately 51% respondents have lived here for more than 20 years. Generally, there is a fairly even spread in regards to the duration of residence.

3.4 Flood Awareness

There was considerable awareness of flooding amongst the respondents. A total of 88 out of the 194 (approximately 45%) respondents indicated awareness or some knowledge of flooding in the study area.

3.5 Flood Impacts

The respondents provided information as to where their properties were flooded, and which areas they have seen flooded. Around 30 respondents reported to have driveway flooding, whilst two respondents experienced over floor flooding. However, one of these respondents referred to a property outside of the study area, so only 1 property with over floor flooding has been recorded for this study. The response results are summarised in **Table 3.2**.

Table 3.2 Summary of Responses on Flood Impact

Location	No. Responses	Location	No. Response
Driveway	30	Garage	19
Backyard	34	Building (below floor level)	13
Front yard	20	Building (above floor level)	1
Shed	13		

3.6 Events Experienced

A number of flooding events have been experienced by respondents in the study area in the past. It is expected that residents will be unlikely to recall the specific timing of all of these events, particularly the more distant events. More respondents may experience recent events whereas only longer term residents may recall events which occurred further in the past. In general, the responses were skewed towards more recent events.

Only 20 respondents provided information when the historical flooding events occurred. According to the survey respondents, a number of historical flooding events may have occurred in 2008, 2007/2006, 1990, 1989, 1988, 1987/1986, 1976, and 1972**. Table 3.3** shows the possible historical flooding events and the number of respondents who remember these events. **Table 3.3** indicates that the survey results only provided scarce timing information about the historical flood events.

2007/2006 reported the greater number of responses, and this also correlates to the largest event in recent times, as discussed in **Section 5.4**. It is also noted that it can commonly be difficult to recall exact dates of events. For example, the respondent who reported on event in 2007 may in fact be referring to 2006.

Table 3.3 Inferred Flood Experience of Respondents Based on Time of Residency

Storm Events	Respondents that may have been present	
	Percentage	Number
2008	2.1%	4
2007/2006	2.6%	5
1990	0.5%	1
1989	0.5%	1
1988	2.6%	5
1987/1986	1.0%	2
1976	0.5%	1
1972	0.5%	1

(Note: 2007/2006 indicates that some respondent reported that the event may occur in 2007 or 2006.)

3.7 Verification Data

Few respondents provided information about historical flood levels in detail. Therefore, the primary information was through which property had over ground flooding or over floor flooding. A property which occurred flooding either in Driveway, Backyard, Frontyard, or Garage is classified as over ground flooding. The properties that experienced flooding based on the survey information are shown in **Figure 3.2**.

4 METHODOLOGY

Two numerical modelling tools were utilised to assess flood behaviour in the study area:

- Hydrological model (XP-RAFTS)
- Hydraulic model (TUFLOW)

Both models are described in general below, and in detail in **Sections 5** and **6** respectively.

4.1 Hydrological Model

A hydrological model simulates the complicated hydrological processes of the catchment by converting rainfall into runoff. A traditional hydrological XP-RAFTS model was developed through the entire catchment, including the area upstream of the 2D domain. The primary purpose of this traditional hydrological model is to generate input hydrographs to the 1D/2D hydraulic model at the boundaries of the study area.

The 'Direct Rainfall' method (also known as 'rainfall on the grid') was used for areas within the 2D domain. Refer to **Section 6** for more detailed information.

4.2 Hydraulic Model

A hydraulic model produces water levels and velocities by converting runoff (traditionally from a hydrological model) throughout the major drainage/creek systems in the study area. The model simulates the hydraulic behaviour of the water within the study area by accounting for flow in the major channels as well as potential flow paths, which develop when the capacity of the channels is exceeded. It relies on boundary conditions, which include the runoff hydrographs produced by the hydrological model and the appropriate downstream boundary.

A dynamic hydraulic modelling system TUFLOW was applied in this study. As a widely used hydraulic modelling system in Australia, TUFLOW has been shown to provide reliable, robust simulation of flood behaviour in urban and rural areas through a vast number of applications. TUFLOW incorporates a one dimensional (1D) network (drainage system, including channels in the study area) with a two dimensional (2D) domain (representing the study area topography) to fully simulate the catchment hydrological and hydraulic responses to rainfall.

Stormwater drainage pits, pipes and channels are represented in the model as one-dimensional elements which are dynamically linked to the water conveyed across the elevation grids. An important feature of the model is the ability to model the hydraulic structures in the 1D component rather than in the 2D domain. The benefit of this approach is that structure hydraulics are modelled more precisely than the approximate representation possible in a 2D domain.

5 HYDROLOGICAL MODELLING

Hydrological modelling was undertaken using two methods:

- Traditional hydrological modelling using XP-RAFTS - The hydrological modelling was undertaken to develop catchment runoff hydrographs through the entire catchment, including the upstream area of the 2D model domain. These hydrographs generated from the upstream area of the 2D model domain were used as inflow boundaries for the 1D/2D hydraulic modelling.
- Direct Rainfall Method, where rainfall is applied directly to the 2D hydraulic model grid and routing occurs within the hydraulic model.

5.1 Traditional Hydrological Modelling (XP-RAFTS)

An XP-RAFTS hydrological model was established for the entire catchment, including the catchment area upstream of the study area. The landuse within the catchment is highly urbanised with predominantly residential areas and some business/commercial areas. The following attributes were considered in the hydrological analysis of the catchment:

- Rainfall intensity-frequency-duration (IFD) relationships;
- Sub-catchment divisions;
- Slopes and overland flowpath lengths; and
- Landuse (pervious and impervious areas).

5.1.1 Sub-Catchment Delineation

Sub-catchment delineation is a preparation step for establishing the hydrological model. The total area for the XP-RAFTS model is 6.30 km^2, with elevation varied from 74m AHD in the upper reaches of the catchment to 24m AHD at the catchment outlet.

The catchment was divided into 39 sub-catchments based on the topographic features (using the 5 metre contour data supplied by Council), the likely flowpaths, and the input requirements of the hydraulic model. The sub-catchment layout is presented in **Figure 5.1** and the details of these sub-catchments are provided in **Table 5.1**.

Pervious and impervious fractions for each sub-catchment were estimated based on aerial photography and site inspections. For each sub-catchment, the major landuses were identified and the area of each landuse was estimated using GIS. The following impervious fractions were used for different types of landuse.

- Highly urbanised residential: 60%
- Industrial/Commercial: 90%
- Open Space: 5%

The study catchment has an estimated 52.5% of impervious area, which represents approximately 330 hectares.

Table 5.1 Sub-catchment details

Sub-catchment ID	Area (ha)	Catchment Slope (%)	(%) Impervious
C1	7.0	0.8	60.0
C11	14.2	1.0	54.8
C12	30.4	1.2	47.0
C13	13.4	1.1	52.1
C14	8.0	0.4	41.8
C15	6.6	1.9	59.9
C16	13.0	0.9	80.0
C17	7.0	0.6	58.2
C18	12.0	1.7	60.0
C19	19.7	2.0	60.0
C20	11.5	1.8	37.9
C21	16.3	1.9	60.0
C22	24.8	1.7	60.0
C23	32.5	2.0	60.0
C24	18.2	0.6	21.0
C25	25.9	2.9	47.6
C26	15.4	2.8	60.0
C27	10.4	0.5	60.3
C28	47.5	1.9	36.5
C29	31.6	2.4	60.0
C3	8.4	3.2	60.0
C30	10.3	0.3	28.7
C31	21.7	2.4	49.9
C32	25.2	2.1	52.1
C33	41.6	1.2	50.2
C34	19.4	3.2	66.2
C35	17.8	1.5	69.2
C5	12.7	2.9	60.0
C7	12.6	2.9	60.0
C8	17.2	1.9	61.6
C9	18.6	2.8	60.0
C9a	7.5	3.1	60.0
Basin1	4.9	2.6	39.5
Basin2	3.2	2.4	35.7
Basin3	2.3	2.2	35.9
Basin4	11.3	2.5	53.8
Basin5	11.1	1.6	53.8
Basin6	13.5	1.3	28.1
Basin7	4.0	0.6	5.0
Total Area	628.5		52.5

**See Figure 5.1 for the location of each sub-catchment*

5.1.2 Detention Basins

There are 7 detention basins identified in the study area based on the terrain data. The stage-storage relationship for each basin was generated by 12D modelling using the terrain data. The details of stage-storage relationship for these basins are provided in **Appendix C**.

5.1.3 Hydrological Model Parameters

A number of parameters are required in the development of the RAFTS model. The important parameters include initial and continuing rainfall loss rate, and Manning roughness.

A split sub-catchment approach was applied to develop the RAFTS model. Catchment roughness values for impervious and pervious area were set as 0.015 and 0.04 respectively.

The initial and continuing rainfall lost rates for impervious/pervious areas are presented in **Table 5.2**.

Table 5.2 Rainfall Loss Rate

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

5.2 Direct Rainfall

Direct Rainfall Method was applied directly within the 2D domain in this study. In the application of Direct Rainfall Method, the hydrology and the hydraulics are undertaken in the same modelling package TUFLOW.

In the 2D model, rainfall is applied directly to the 2D terrain, and the hydraulic model automatically routes the flow using the same computation process that controls the routing of all other flows through the model. This means that catchment outlets do not have to be predefined, and flowpaths are identified by the model, rather than being assumed.

There are a number of advantages of the modelling approach, particularly given the nature of the study area. In flat areas, such as the west parts of the study area, overland flow paths are not obvious. Furthermore, additional and unexpected ‘cross-catchment’ flows may activate in larger events. The rainfall on grid approach overcomes these issues, as the model will automatically divert flood waters along different flowpaths (based on the terrain and the roughness) during high flow events.

For a flood study dealing with a large number of stormwater pits and pipes, it can be difficult to determine the catchment that applies to a particular pit in using a traditional hydrological modelling approach. With the Direct Rainfall method, flows are automatically routed to the pit. This can provide a significant saving in time, as well as reduce potential errors in the application of flow.

5.3 Design Rainfall

5.3.1 Standard Design Rainfall Information

A uniform rainfall distribution was assumed for the study area due to its relatively small size. The rainfall intensities provided by the Council were applied in this study.

Table 5.3 lists the rainfall intensities for a full range of design events. The design rainfall for the 9 hour event was developed using standard techniques provided in *Australian Rainfall and Runoff* (AR&R) (Engineers Australia, 1999).

Table 5.3 Design Rainfall Intensities (mm/hr)*

Time	Return Period (Years)							
hr min	**1**	**2**	**5**	**10**	**20**	**50**	**100**	**200+**
0 15	47.5	61.5	80.2	91.2	105.8	125.0	139.7	153.0
0 30	33.5	43.4	56.5	64.3	74.6	88.0	98.4	107.3
0 45	26.8	34.7	45.2	51.5	59.7	70.5	78.8	85.5
1 00	22.7	29.4	38.4	43.7	50.6	59.8	66.8	72.3
1 30	17.9	23.2	30.2	34.4	39.9	47.1	52.6	56.5
2 00	15.1	19.6	25.4	28.9	33.5	39.6	44.2	47.3
3 00	11.9	15.3	19.9	22.6	26.2	30.9	34.5	36.7
4 30	9.3	12.0	15.6	17.7	20.4	24.1	26.9	28.4
6 00	7.8	10.1	13.1	14.8	17.2	20.2	22.5	23.7
9 00+	6.4	8.2	10.3	11.5	13.2	16.3	16.9	18.4
12 00	5.1	6.6	8.5	9.5	11.0	12.8	14.2	15.3

* Data supplied by Penrith City Council
\+ Values derived from AR&R IFD calculations

5.3.2 Probable Maximum Precipitation

The Probable Maximum Precipitation (PMP) was estimated according to the publication *The Estimation of Probable Maximum Precipitation in Australia: Generalised Short - Duration Method (Bureau of Meteorology, 2003)*. The PMP ellipses to generate PMP spatial distribution for this study area are shown in **Appendix D**.

The values of the key parameters for generating PMP are shown in **Table 5.4**. The PMP rainfall intensities for a range of critical durations are shown in **Table 5.5**.

Table 5.4 Values of the Key Parameters for Estimating PMP

Study Area	PMP Ellipse	Area Enclosed (km^2)	Area Between (km^2)	Moisture Adjustment Factor	Elevation Adjustment Factor	Percentage Rough
St Marys	A	2.06	2.06	0.72	1	0
	B	4.3	2.24	0.72	1	0

Table 5.5 Rainfall Intensities of PMP Events (mm/hr)

Study Area	Duration						
	15mins	30mins	45mins	60mins	90mins	120mins	180mins
St Marys	640	480	400	350	267	220	167

5.4 Historical Rainfall Analysis

Six historical events were reported through the community consultation (**Section 3**), including January 2008, February 2007, February 2006, February 1990, November 1988 and August 1986. An analysis has been undertaken on these events based on the St Marys STP gauge (refer **Section 2.5**). It is noted that this gauge is over 4 kilometres away, and therefore may not be representative of the rainfall that fell within the catchment. However, the following analysis should provide an indication of the severity of the different historical storm events.

The daily rainfall depth for the historical storm events identified from the community consultation are summarised in **Table 5.6**. The daily rainfall data at St Marys STP was sourced from Sydney Water.

Table 5.6 Daily Rainfall for Historical Storm Events

Events	Total Daily Rainfall (mm)
13 Jan. 2008	45.0
11 Feb. 2007	122.5
26 Feb. 2006	89.0
7 Feb.1990	76.5
26 Nov. 1988	46.0
5 Aug.1986	211.5

Sources: St Marys STP Rain Gauge (567087).

The intensities for these historical storm events and their approximate ARIs are summarised in **Table 5.7**.

Table 5.7 Approximate ARI of Historical Rainfall Events

Event	Details	Duration (mins)								
		15	30	45	60	90	120	180	360	540
Jan.2008	Intensity	52.0	40.0	30.7	29.0	22.7	18.0	12.0	6.3	*
	Approx.ARI	1-2yr	1-2yr	1-2yr	1-2yr	1-2yr	1-2yr	~1yr	<1yr	*

Event	Details	Duration (mins)								
		15	30	45	60	90	120	180	360	540
Feb.2007	Intensity	96.0	92.0	88.0	77.0	60.7	47.0	31.7	17.7	12.1
	Approx.ARI	10-20yr	50-100yr	>100yr	>100yr	>100yr	>100yr	50-100yr	20-50yr	10-20yr
Feb.2006	Intensity	80.0	76.0	65.3	52.0	42.7	35.5	25.7	13.5	9.0
	Approx.ARI	~5yr	20-50yr	20-50yr	20-50yr	20-50yr	20-50yr	10-20yr	5-10yr	~2yr
Feb.1990	Intensity	88.0	72.0	42.7	55.0	38.7	29.0	19.3	9.8	6.6
	Approx.ARI	5-10yr	10-20yr	2-5yr	20-50yr	~20yr	10	~5yr	~2yr	1-2yr
Nov.1988	Intensity	68.0	76.0	52.0	39.0	26.0	19.5	14.3	9.2	8.3
	Approx.ARI	2-5yr	20-50yr	~10yr	~5yr	2-5yr	~2yr	1-2yr	1-2yr	~2yr
Aug.1986	Intensity	*	*	30.7	27.0	23.3	19.5	17.0	13.5	11.8
	Approx.ARI	*	*	1-2yr	1-2yr	1-2yr	~2yr	2-5yr	5-10yr	~10yr

Note: * indicates that the storm intensity (mm/hr) is less than the intensity of 1 year ARI design storm.

From **Table 5.7**, it can be seen that the storm event on February 2007 was the largest historical event recalled by residents, which is larger than 100 year ARI based on the rainfall intensity. The second largest event occurred on February 2006, which is between 20 year ARI and 50 year ARI event.

The temporal patterns of 2007 event and the 100 year design event (90 minute duration) are overlaid in **Figure 5.2**.

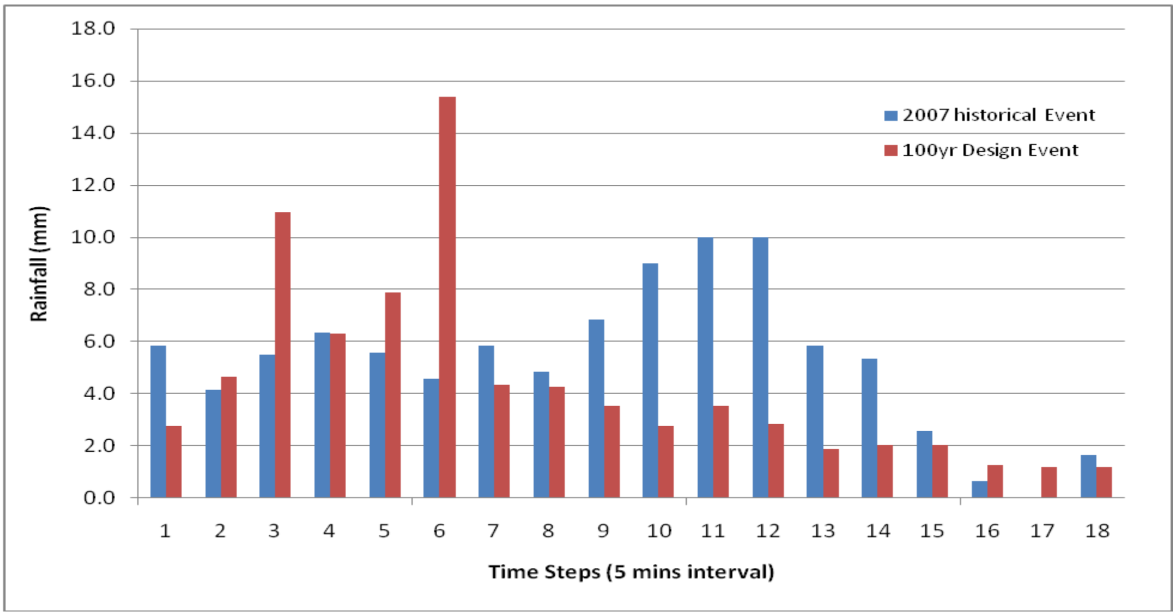


Figure 5.2 Temporal Patterns of February 2007 Event and 100 Year ARI Design Event

Figure 5.2 indicates that 2007 historical event spreads more evenly than the design event. The peak rainfall (5 minute interval) of 2007 is smaller than those in 100 year ARI design event.

There are two important points to note in regard to this analysis. Firstly, a rainfall analysis such as this is not always indicative of the ARI of the flood event, due to such effects as preceding rainfall. Furthermore, the storm patterns affecting the study area may be localised and may not be registered at St Marys ST gauge which is 4.3 kilometres away. Therefore, this analysis should be considered indicative.

5.5 Hydrological Model Validation

As is common for most urban areas, there are no flow gauges in the study area (i.e. gauges that measure actual water flows, commonly in a channel) and hence the hydrological model could not be calibrated directly. Instead, the hydrological model was validated by comparing the XP-Rafts results with the Rational Method, and the Direct Rainfall methods from alternative modelling software SOBEK.

5.5.1 Validation using the Rational Method

In order to validate the hydrological model, the Rational Method was used to estimate the peak flows at the outlet for a number of design events. The detailed procedures of the Rational Method are defined in Australian Rainfall and Runoff (AR&R) (Pilgrim (ed), 1999).

The peak flows based on the Rational Method were calculated as following steps:

i. Determine the critical duration as the time of concentration $t_c = 0.76A^{0.38} = 0.76*6.3^{0.38} \approx 1.5hr$

ii. Calculate the runoff coefficient C_{10} for urban areas (AR&R, Book VIII)

The runoff coefficient for the pervious area: $C^1_{10} = 0.1+(0.7-0.1)\times({}^{10}I_1-25)/(70-25) = 0.35$

10 year ARI runoff coefficient $C_{10} = 0.9\times f + C^1_{10}\times(1-f) = 0.64$

The fraction of impervious areas f was estimated as 53% (**Section 5.1.1**).

iii. Determine the frequency factor $FF_{100} = 2.57-0.588\times I_{12,50}/ I_{12,2} = 1.43$

$FF_{50} = 1.99-0.366\times I_{12,50}/ I_{12,2} = 1.28$

$FF_{20} = 1.12$

iv. Estimate the peak flows: $Q_y = 0.278\times C_y\times I_{tc,Y}\times A$

$Q_{100} = 84.75\ m^3/s$

$Q_{50} = 67.64\ m^3/s$

$Q_{20} = 50.10\ m^3/s$

The peak flow values at the outlet based on the RAFTS model and the Rational Method for 100 year, 50 year and 20 year ARI events are presented in **Table 5.8**.

Table 5.8 Comparison of RAFTS model and Rational Method (Peak Flow, m³/s)

Storm (ARI)	Rational Method	RAFTS	Difference (%)
100 Year	84.75	74.88	-11.6
50 Year	67.64	63.41	-6.3
20 Year	50.10	53.64	7.1

For the 100 year ARI event, the peak flow at the outlet based on the RAFTS model is approximately 12% lower than one calculated by the Rational Method. Note that the Rational Method provides a relatively coarse estimate of flows, and therefore the differences noted above are considered acceptable.

5.5.2 Validation using the SOBEK Model

An additional validation was conducted by establishing a 2D hydraulic model of the catchment and applying the Direct Rainfall methodology. The SOBEK modelling system developed by Deltares was adopted for the validation and has been used in a number of studies, including the "Overview Study" (Cardno Lawson Treloar, 2006).

In the validation process, the SOBEK 2D model was developed for the entire catchment. A terrain grid with 5m×5m grid cell was used to develop the SOBEK 2D model.

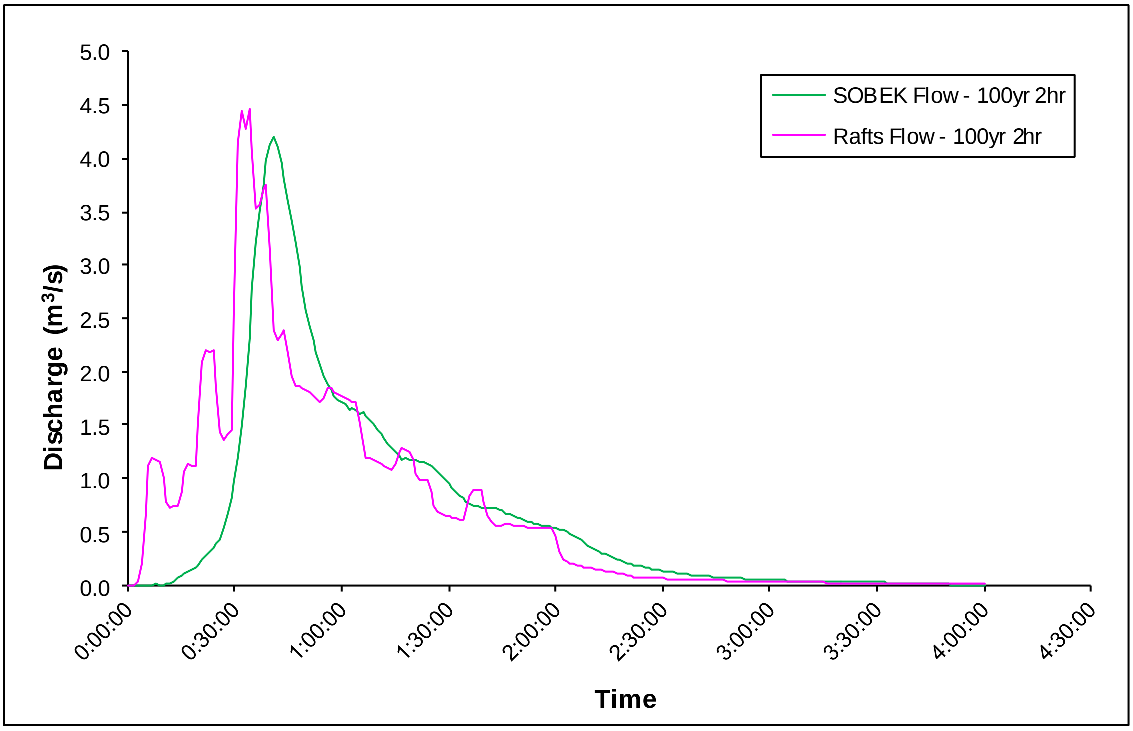
The 2D model was simulated using two design storm events, the 100 year ARI 2 hour duration and 100 year ARI 9 hour duration. The locations for comparing hydrographs based on XP-RAFTS and SOBEK model are shown in **Figure 5.1**.

The hydrograph comparisons at node C5 and C9 are shown in **Figure 5.3** and **5.4** respectively. Modelled results for the two storm events at these locations are listed in **Table 5.9**.

Table 5.9 Results Comparison for RAFTS and SOBEK

Location ID	Storm Event	Peak Flow (m3/s)		Peak Flow Difference (%)	Total Volume (m3)		Volume Difference (%)
		SOBEK	RAFTS		SOBEK	RAFTS	
C5	100yr, 2hr	4.21	4.46	5.94	9,667	10,331	6.87
	100yr, 9hr	1.89	1.78	-5.82	16,918	17,570	3.85
C9	100yr, 2hr	6.01	6.19	3.00	15,670	14,781	-5.68
	100yr, 9hr	3.07	2.51	-18.24	28,314	25,175	-11.09

It is not always expected that the two models will fully match. In fact two separate traditional hydrological models with similar parameters may result in significantly different results. The peak flow differences at C5 generated by the RAFTS and SOBEK model for two design events are within ±6%, whilst the total volume differences for these two design events are within 7%. The largest flow difference (approximately 18%) occurs at C9 for the storm event of 100 year ARI with 9 hour duration. The results indicate that the RAFTS model is capable of simulating the hydrological process of the catchment.



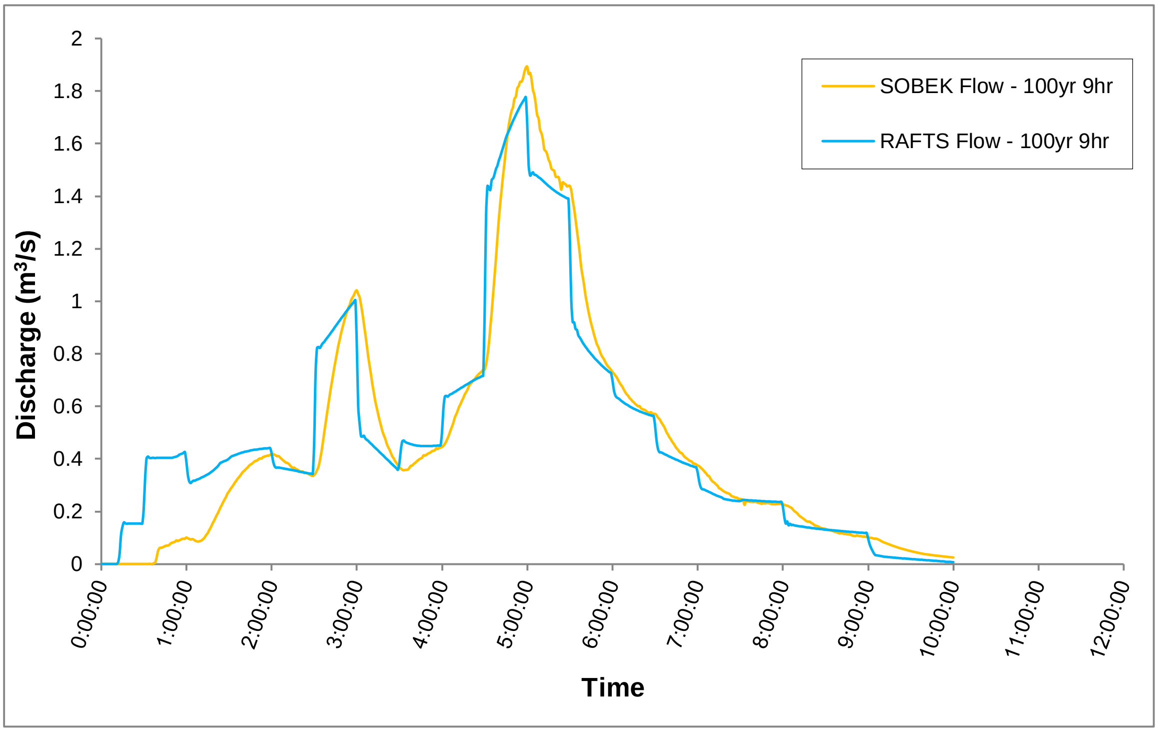
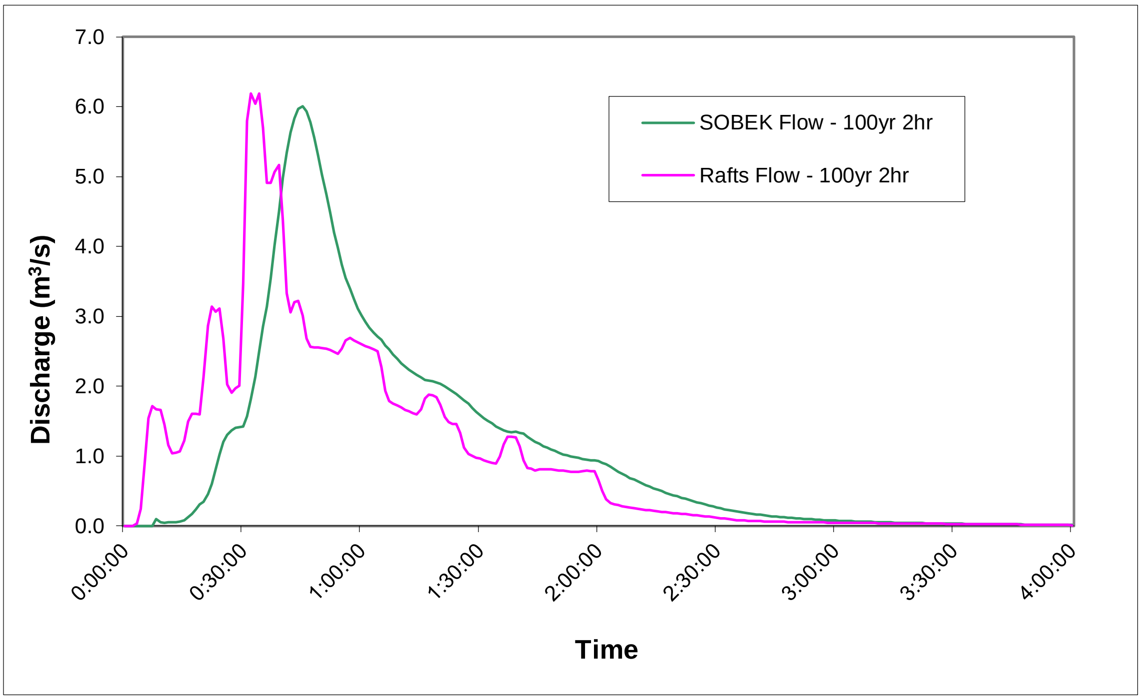


Figure 5.3 Hydrograph Comparison for RAFTS and SOBEK model at Node C5



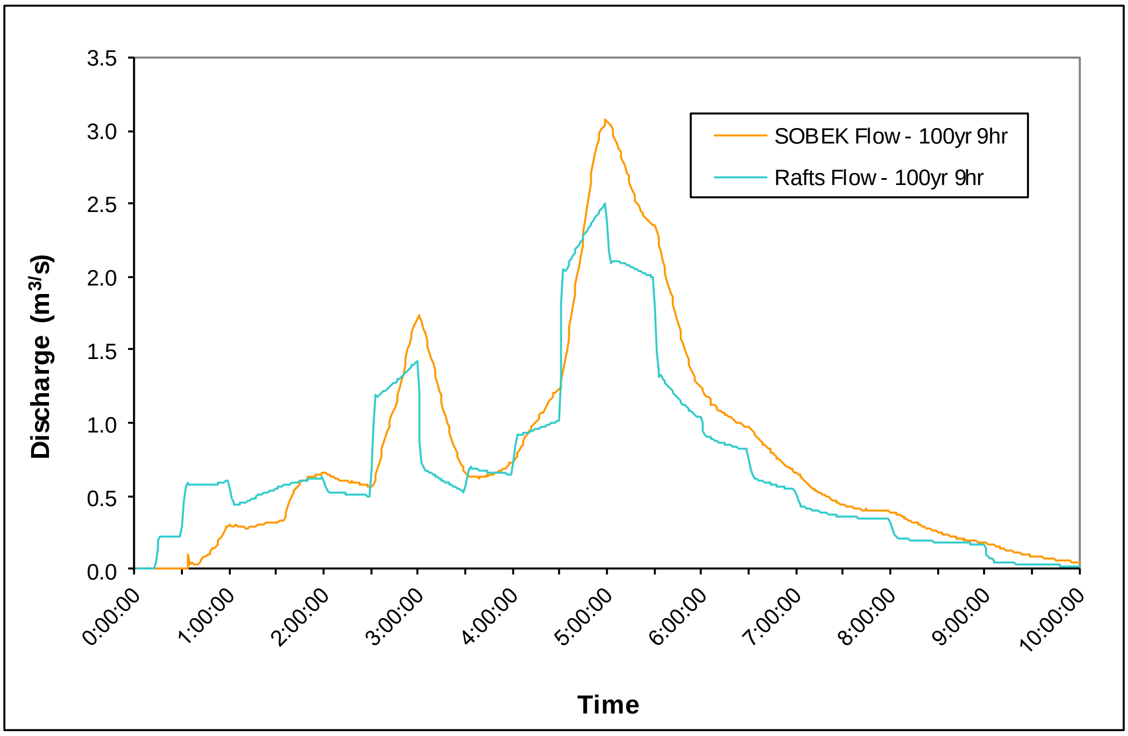


Figure 5.4 Hydrograph Comparison for RAFTS and SOBEK model at Node C9

5.6 Runoff Hydrographs

The RAFTS model was used to produce the runoff hydrographs for inputs to the 1D/2D hydraulic model. The model runs were carried out for a full range of design storms.

Design storm rainfall intensities for the full range of storm frequencies and duration were discussed in **Section 4**. The peak flows from the RAFTS model at the input nodes to the 1D/2D hydraulic model for the design events are presented in **Table 5.10**. The locations of input nodes to the 2D domain are referred to **Figure 5.1**.

Table 5.10 Peak Flows of Input Nodes to 1D/2D Hydraulic Model

ARI	Duration (mins)	Peak Flow (m^3/s)			
		C17	C15	C12	C13
1 year	15	0.2	0.5	3.0	2.2
	30	0.2	0.4	2.8	2.8
	45	0.2	0.4	2.5	2.3
	60	0.2	0.4	2.7	2.8
	90	0.2	0.4	2.9	2.9
	120	0.2	0.4	2.8	3.3
	180	0.1	0.2	1.6	3.6
	360	0.1	0.2	1.2	4.0
	540	0.1	0.2	1.3	5.3
2 year	15	0.3	0.6	3.9	3.0
	30	0.3	0.6	3.7	3.6
	45	0.2	0.5	3.2	3.0
	60	0.3	0.5	3.5	3.6
	90	0.3	0.6	3.9	4.4
	120	0.3	0.6	3.7	4.9
	180	0.2	0.3	2.1	5.1
	360	0.2	0.3	1.6	5.7
	540	0.2	0.3	1.8	6.6
5 year	15	0.4	0.8	5.1	4.1
	30	0.4	0.7	4.8	4.5
	45	0.3	0.6	4.3	5.1
	60	0.4	0.7	4.7	6.5
	90	0.5	0.8	5.2	7.5
	120	0.4	0.7	4.9	8.3
	180	0.3	0.5	2.9	8.2
	360	0.3	0.4	2.3	8.9

ARI	Duration (mins)	Peak Flow (m^3/s)			
		C17	C15	C12	C13
	540	0.2	0.3	2.3	8.9
10 year	15	0.4	0.9	5.8	4.7
	30	0.5	0.8	5.5	5.1
	45	0.4	0.7	4.9	7.1
	60	0.5	0.8	5.4	8.7
	90	0.6	0.9	6.0	9.4
	120	0.5	0.9	5.6	10.2
	180	0.4	0.6	3.4	9.9
	360	0.3	0.4	2.7	10.6
	540	0.3	0.4	2.6	10.2
20 year	15	0.5	1.0	6.8	5.4
	30	0.6	1.0	6.5	6.8
	45	0.4	0.9	5.7	9.8
	60	0.6	1.0	6.4	11.4
	90	0.7	1.1	7.0	12.2
	120	0.6	1.0	6.6	12.9
	180	0.5	0.7	4.0	12.0
	360	0.4	0.5	3.3	13.0
	540	0.3	0.4	3.0	12.1
50 year	15	0.6	1.2	7.6	6.3
	30	0.6	1.1	7.1	10.2
	45	0.5	1.0	6.4	13.3
	60	0.7	1.1	7.2	15.1
	90	0.8	1.2	7.8	15.8
	120	0.7	1.2	7.4	16.8
	180	0.5	0.8	4.6	15.3
	360	0.4	0.6	3.8	15.1
	540	0.4	0.5	3.6	16.2
100 year	15	0.7	1.3	8.5	7.1
	30	0.7	1.2	8.0	12.7
	45	0.6	1.1	7.2	16.1
	60	0.8	1.3	8.1	18.6
	90	0.9	1.4	8.9	19.3
	120	0.8	1.3	8.3	19.9
	180	0.6	0.9	5.2	18.1

ARI	Duration (mins)	Peak Flow (m^3/s)			
		C17	C15	C12	C13
	360	0.4	0.6	4.3	18.0
	540	0.4	0.5	3.7	17.0
200 year	15	0.8	1.5	9.4	7.8
	30	0.8	1.4	8.8	14.9
	45	0.7	1.2	7.8	18.9
	60	0.9	1.4	8.8	21.7
	90	1.0	1.5	9.5	22.0
	120	0.9	1.4	8.9	22.5
	180	0.7	0.9	5.6	19.6
	360	0.5	0.7	4.6	19.5
	540	0.4	0.6	4.1	19.0
PMF	15	4.1	5.9	36.4	114.8
	30	4.2	5.7	33.4	158.7
	45	4.0	5.6	32.8	166.7
	60	3.5	5.0	33.0	163.9
	90	2.7	3.8	29.3	137.4
	120	2.3	3.2	26.0	119.1
	180	1.8	2.4	20.2	93.9

6 HYDRAULIC MODELLING

It is a complex task to define overland flows in an urban environment. A number of features associated with urban development have a significant impact on flood behaviour, including:

- In many developed areas, the natural creek systems have been replaced with underground pipe drainage, which has a limited capacity; and
- The complexity of overland flowpaths is increased as a result of the development of the area.

A reasonably accurate assessment of flooding in urban areas requires a two-dimensional approach in modelling the flood behaviour.

6.1 Model Schematisation

A fully dynamic one and two dimensional (1D/2D) hydraulic model was developed for the study area using the TUFLOW modelling system. The drainage system layout is shown in **Figure 6.1**.

Channels have been modelled as one-dimensional (1D) elements, where the cross-sections were surveyed to define the channel geometry. Once the channel capacity is exceeded, flow is able to spill into the two-dimensional (2D) grid and simulated as overland flow.

Stormwater drainage pits and pipes, shown in **Figure 6.1** have also been incorporated into the model as 1D elements. Once the pipe capacity is exceeded, excess flow spills into the 2D domain via the pits. Similarly, overland flow is able to enter the pipe network through the relevant pit when the drainage system at that location is not at capacity.

6.2 1D Model Set-up

1D components of the hydraulic model consists of pipes, pits, open channels and other hydraulic structures.

6.2.1 Piped Drainage Systems

Piped drainage systems are incorporated into the TUFLOW model as distinct 1D elements connected to the terrain grid. Approximately 18 kilometres of pipes and 2 kilometres of channels are modelled in this study. The TUFLOW model includes 895 pipes and 597 inlet pits. Detailed field survey by Cardno's surveyors (**Section 2.2**) was primarily utilised for the modelling.

The detailed information of pits and pipes in the TUFLOW model is provided in **Appendix E**.

Some of the surveyed pits and pipes have incomplete information, thus assumptions are made for compiling the pit and pipe data to the TUFLOW model. The main assumptions are:

- Missing data for some pits and pipes, such as inlet size and pipe diameter, were determined by reviewing the pit and pipe dimensions in the vicinity;

- Inconsistencies between pit inverts and their respective pipe inverts were corrected. For example, pit inverts were lowered to match pipe inverts;
- Ground survey was not able to provide detailed information on junction pits, thus the invert of junction pits is interpolated between known upstream and downstream pits;
- Pit inverts were corrected where the downstream pit invert is higher than the upstream pit invert;
- Pit surface levels were estimated using the terrain grid in locations where a detailed survey level was not available; and
- Pit surface levels (in 1D) were adjusted in the model to match the terrain grid level (2D) to allow efficient inflow of surface runoff into the piped drainage system.

6.2.2 Open Channels and other Hydraulic Structures

There are three main open channels in the study area (see **Figure 6.1**). Channel 1 starts from culverts at M4 Motorway, crosses Monfarville Reserve, and ends at Mamre Road. Channel 2 has a length of approximate 1.1 kilometres, which conveys water from downstream of Monfarville Reserve to Saddington Street. It is noted that the section of channel 2 between John Street and Saddington Street was modelled as 2D in the TUFLOW model as this provided a better representation. Channel 3 is located between the western end of Putland Street and five culverts under Great Western Highway.

The channel features were determined by the representative cross sections. In this study, 41 cross sections were surveyed. These cross sections were located such that all flow controls were captured, and so that the cross sections adequately represented variations in the channel definition. Details of structures within the study area (including 44 culverts) were also gathered, and included in the model. The modelled culverts are also provided in **Appendix E**.

6.2.3 Inlet Capacity

Inlet capacity is one of key factors that may constrain flows into the drainage system in urban hydraulic modelling. The capacity of inlets depends on the depth and velocity of approaching run-off and the configuration of the inlets.

The pit types and inlet openings were surveyed by Cardno's surveyors. The inlets were modelled in TUFLOW by using inlet capacity curves in accordance with inlet pit types. Inlet pits were classified into 18 categories, which are shown in Table 6.1, whist the details of the inlet curves are provided in **Appendix F**. Inlet curves were developed for the 18 types of inlet pits according to pit inlet rating curves as identified in DRAINS.

Table 6.1 Inlet Types Applied in the TUFLOW Model

Inlet Type	Grate		Inlet
	Length (m)	Width (m)	Length (m)
1	≤0.7		-
2	0.7<x≤1.1		-
3	1.1<x≤1.6		-
4	1.95	0.9	-
5	4.0	2.0	-
6	5.0	5.0	-
7	-	-	≤1.5
8	-	-	1.5<x≤2.1
9	-	-	2.1<x≤2.7
10	-	-	2.7<x≤3.3
11	-	-	3.3<x≤3.9
12	0.9	0.45	≤1.5
13	0.9	0.45	1.5<x≤2.1
14	0.9	0.45	2.1<x≤2.7
15	0.9	0.45	2.7<x≤3.3
16	0.9	0.45	3.3<x≤3.9
17	0.9	0.45	3.9<x≤4.5
18	0.9	0.45	>4.5

6.2.4 Blockage

The capacity of a drainage system is directly impacted by blockages to the pits and pipes. This study adopted 50% blockage to all inlet pits and no blockage in pipes for design events in accordance with Council's blockage policies. A sensitivity assessment simulation with 0% pit blockage was undertaken to investigate the impact to flood behaviour in the study area if all pits are at capacity, and this is detailed in **Section 12**.

6.3 2D Model Set-up

Two-dimensional (2D) hydraulic modelling was developed to define the flood behaviour for the study area. The 'Direct Rainfall' method (also known as 'rainfall on grid') was used for areas within the 2D Domain. The inflow hydrographs at the four locations to the 1D/2D hydraulic model in the study area were generated by the traditional hydrological model XP-RAFTS (see **Figure 5.1**).

The TUFLOW model incorporates all 1D components with a two dimensional (2D) domain (representing the study area topography) to simulate the flood behaviour in the study area. These models take approximately 4-12 weeks to run using 1m grid (on an Inlet(R), CPU3.2GHz, 64 bits with 96 GB Ram). A typical 9 hours design event takes about 3 months to complete, whilst a typical 2 hours design event takes about 1 month to complete.

Following some initial challenges with simulations and model run times, the model was split into two separate models for all of other ARIs:

- Model A –1 metre grid for 100 year, 20 year and 5 year ARI, and a 1.5 metre grid for the other ARIs, used to define the overland flow generally upstream of Mamre Road; and
- Model B – 1 metre grid covering the downstream part of the study area, with a 4 metre grid providing inflows from the upstream parts of the study area.

Figure 6.2 shows the general layout of the models. **Table 6.2** lists the detailed information about the TUFLOW models applied in this study.

Table 6.2 A Summary of TUFLOW Model Results Adopted in This Study

Design Events (ARI)	Model A Zone		Model B Zone	
	Grid Size	Duration (mins)	Grid Size (4m/1m model)	Duration (mins)
100yr and 5yr	1m	15, 30, 45, 60, 90, 120, 180, 360, 540	1m	540
20yr	1m	30, 60, 90, 120, 180, 540	1m	540
200yr, 50yr, 10yr, 2yr, 1yr	1.5m	120	1m	540
PMF	1.5m	30	1m	30

6.3.1 Model Terrain

A terrain grid (also referred to as a 'topographic' grid) was developed to represent ground elevations based on aerial laser scanning data provided by Council (**Section 2**). A terrain grid incorporated the ground surface information in the current development on Putland Street and Neale Street, based on drawings which were provided by Council.

The model terrain is shown in **Figure 6.3**. The terrain grid of the model A for the TUFLOW model was developed at 1.5mx1.5m comprising about 5 million grid points, and for model B is approximately 1.7 million grid points.

6.3.2 Buildings

Buildings within the floodplain in the study area were conservatively assumed to completely block overland flow, and were modelled as raised blocks in the topographic grids. The floodplain covers the area affected by the flood extent in a PMF event defined in the "Overview Study" (Cardno Lawson Treloar, 2006).

The building outlines used in the "Overview Study" (Cardno Lawson Treloar, 2006) were modified (based on 2008 Aerial photographs provided by the Council) to include buildings recently developed in the downstream of the study area. The buildings layout is shown in **Figure 6.4**. There are 2570 buildings raised within the TUFLOW model boundary in this study.

Buildings outside of the floodplain were modelled using a high roughness value of 0.1. Syme (2008) undertook analysis on different methodologies for incorporating buildings in 2D models, including blocking of the buildings and modelling them with high roughness. The testing indicated that both approaches resulted in similar upstream water levels, although local velocity behaviour could potentially differ. This suggests that the approach of modelling buildings as high roughness provides sufficient detail, particularly outside of the floodplain.

6.4 Adjustment of DTM and Inclusion of Specific Features

Following review of the modelling by Council and Cardno, the TUFLOW model was revised to include the following key features based on additional information supplied by Penrith City Council. The main features and revisions are as follows:

- Building outlines were modified based on the 2008 aerial photographs provided by Council.
- In accordance with Council's advice and information received in December 2011, it is noted that areas between Putland Street and Great Western Highway, east of Neale Street have been developed. A local DTM of the as-built ground levels was developed, and incorporated in the 2D model. The constructed stormwater trunk drain previously a 7.1m wide drainage easement was modelled as a 3.8mW and 1.8mH box culvert in the model. This culvert is connected to the twin 1.65m diameter pipe in Neale Street, and discharges into the open formalised channel immediately downstream of the development. However, pit and pipe drains on driveways and car parks within the development (i.e. local site drainage) were not included in the model.
- The discrepancy of the compacted earth levee levels from ALS data along the east bank of South Creek west of St. Marys was filled by survey information. The revised levee levels were modelled in the 2D model.
- Sound barriers along the existing developed areas north and south of the M4 Western Motorway which would potentially block flood flows in the upper part of the model were modelled as walls in the model.
- The stormwater drain beneath Monfarville Reserve east of Mamre Road and north of the M4 Western Motorway was modelled using a 1.2m diameter pipe according to survey data. On the south side of Monfarville Reserve, another reserve drain in the form of an open grass swale was also modelled in the model.

6.5 Hydraulic Roughness

A hydraulic roughness map is required for 2D modelling to classify the surface roughness for various landuses. The roughness map was determined using both aerial photography supplied by Council (**Section 2.2**) and site inspections carried out during the study (**Section 2.3**).

There is no standard reference that provides guidelines on estimating the hydraulic roughness for overland flow in 2D models in urban areas. Previous experience gained from calibrating the catchments with similar landuse and topography usually provides a better guide to determine the roughness values.

The hydraulic roughness map used in the "Overview Study" (Cardno Lawson Treloar, 2006) has been used as a 'base' roughness map in this study, with modifications reflecting the current land development. Fences were modelled in the TUFLOW model using a very high roughness value. **Figure 6.5** shows the hydraulic roughness layout applied in the 2D model.

The roughness values adopted for the 2D and 1D elements are listed in **Table 6.3**.

Table 6.3 Roughness Values for 2D and 1D Elements

Classification	Adopted Roughness Value
2D Roughness Values	
Grass	0.030
Roads	0.015
Residential/Urban Areas	0.100
Forest/Bushland	0.100
Creeks/Waterways	0.030
Open Bushland/Shrubs	0.050
Fences (highly impermeable)	1.00
1D Roughness Values	
Pipe	0.015
Culvert	0.015
Natural Open Channel	0.035
Concrete Open Channel	0.020

6.6 Boundary Conditions

6.6.1 Model Inflows

As discussed in **Section 4**, the 'Direct Rainfall' method was applied for areas within the 2D domain. Thus rainfall-runoff routing for the modelled area was directly carried out in the hydraulic model.

However, a large volume of runoff was generated by the upstream areas of 2D domain. The hydrographs generated by the traditional hydrological model XP-RAFTS were used as inflows to the 1D/2D model at four locations (see **Figure 5.1**).

6.6.2 Boundary Conditions

The upstream and downstream boundary conditions in the model were adopted from the South Creek Flood Study. Council provided the boundary levels for South Creek at the locations shown in **Figure 6.2**. The levels provided are summarised in **Table 6.4**.

Table 6.4 Boundary Levels for Range of Design Events

Boundary Node	Boundary Levels (m AHD)				
	PMF,200yr, 100yr, 50yr and 20yr	10yr	5yr	2yr	1yr
Us_Node1	27.25	27.18	27.15	27.13	27.12
Us_Node2	26.85	26.76	26.72	26.69	26.68
Ds_Node	23.67	23.6	23.57	23.55	23.54

For the purposes of this study, the 20 year ARI South Creek flood level was adopted as boundary conditions for 20 year ARI and larger events. The boundary levels for 10 year, 5 year, 2 year and 1 year ARI were obtained by linearly extrapolating the South Creek flood levels for the corresponding design event. The boundary levels for the range of design events are summarised in **Table 6.5**.

These boundary levels were applied as a constant water level near the M4 and at the downstream end of the model. This was undertaken in the absence of discharge information for South Creek as well as detailed terrain data in this area. By creating upstream and downstream water levels on South Creek, this results in a forcing of flow along the creek to create a 20 year flow. It is noted that this only provides an approximate representation of the 20 year ARI flood levels in South Creek between the upstream and downstream ends.

It is important to note that the results provided in this report in areas in the vicinity of South Creek should be cross checked against flood levels from the South Creek Flood Study, once completed. In many locations, flood levels from South Creek may be higher than those identified from the local catchment runoff.

Table 6.5 Adopted Boundary Conditions

Local Catchment Flood Event	Adopted South Creek Boundary Event
PMF, 200 year, 100 year, 50 year, 20 year	20 year ARI
10 year ARI	10 year ARI
5 year ARI	5 year ARI
2 year ARI	2 year ARI
1 year ARI	1 year ARI

7 MODEL CALIBRATION AND VALIDATION

Calibration and validation are two important processes to ensure that the hydraulic model is capable of simulating the catchment natural responses to the rainfall effectively. Calibration is usually conducted by adjusting the model parameters within acceptable ranges so that the modelled flood levels reasonably match the recorded flood levels at calibration locations. As discussed in **Section 3**, the information regarding the historical flood levels is scarce and the rainfall data may not be representative, making it difficult to calibrate the hydraulic model in this study. Therefore, the robustness and reliability of the hydraulic model was tested by an indirect verification.

The results of community survey (**Section 3**) indicate that 43 properties experienced over ground flooding, including one property experienced over floor flooding (see **Figure 3.2**) within the study area.

The validation was undertaken according to the following steps:

- Determine whether properties that experienced flooding are within the flood extents; and
- Examine whether the hydraulic model is capable of identifying those properties that experienced over floor flooding.

7.1 Validation Based on the Flood Extents

The historical rainfall analysis in **Section 2.5** suggests that the event in February 2007 was the largest historical storm event reported by the community survey, which is larger than 100 year design storm based on the rainfall intensity. However, the storm patterns affecting St Marys study area may be localised and may not be registered at St Marys ST (567087), which is approximately 4.3 kilometres away from the centre of the study area. Therefore, the validation was undertaken using 20 year, 50 year, 100 year, and 200 year ARI design events. The validation results are shown in **Figure 7.1**. A summary of the validation results is presented in **Table 7.1**.

Table 7.1 Validation Results Based on Flood Extents

Property ID	Flood Flag	200yr Extent	100yr Extent	50yr Extent	20yr Extent
Impacted by 20 year ARI Extent					
A1	2	1	1	1	1
A2	1	1	1	1	1
A3	2	1	1	1	1
A4	2	1	1	1	1
A5	2	1	1	1	1
A6	2	1	1	1	1
A7	2	1	1	1	1
A8	2	1	1	1	1
A9	2	1	1	1	1
A10	2	1	1	1	1
A11	2	1	1	1	1
A12	2	1	1	1	1

Property ID	Flood Flag	200yr Extent	100yr Extent	50yr Extent	20yr Extent
A13	2	1	1	1	1
A14	2	1	1	1	1
A15	2	1	1	1	1
A16	2	1	1	1	1
A17	2	1	1	1	1
A18	2	1	1	1	1
A19	2	1	1	1	1
A20	2	1	1	1	1
Impacted by 200 year ARI Extent					
A21	2	1	0	0	0
Not Impacted by 200 Year ARI Extent					
A22	2	0	0	0	0
A23	2	0	0	0	0
A24	2	0	0	0	0
A25	2	0	0	0	0
A26	2	0	0	0	0
A27	2	0	0	0	0
A28	2	0	0	0	0
A29	2	0	0	0	0
A31	2	0	0	0	0
A32	2	0	0	0	0
A33	2	0	0	0	0
A34	2	0	0	0	0
A35	2	0	0	0	0
A36	2	0	0	0	0
A37	2	0	0	0	0
A38	2	0	0	0	0
A39	2	0	0	0	0
A40	2	0	0	0	0
A41	2	0	0	0	0
A42	2	0	0	0	0
A43	2	0	0	0	0

Note: flood flag column: 1 – over floor flooding in February 2007 event, 2 – over ground flooding in February 2007 event. For flood extent column, 1 indicates that it was impacted by flood extent.

The community survey (**Section 3**) indicates that 43 properties experienced over ground flooding, including one property which experienced over floor flooding. From **Table 7.1**, it was found that 20 out of 43 properties are within the flood extent in a 20 year ARI event. One property is affected by 200 year ARI flood event. However, 22 properties are not directly affected by 200 year ARI flood extent.

7.1.1 Properties in the East of the Study Area

The hydraulic model results indicate that 17 properties that experienced historical over ground flooding are not affected by modelled 100 year ARI flood extent in the east of the study area.

Property A25, A27, A34, A39 and A42 are located at the upper portions of the floodplain. These properties are unlikely to have a significant overland flow flooding risk. However, they are located near stormwater pipelines, therefore, they may be affected by local water ponding due to a localised pit blockage. The respondent at A34, for example, clearly mentioned that the flooding was caused by inefficiency of the drainage system.

Property A28, A30, A33 and A41 are far away from major overland flowpaths and pipelines. These properties reported to have a flooding in driveway, frontyard or backyard. This may be caused by water ponding due to blockage along the local overland flowpaths.

Property A22, A24, A32, A40 and A43 are located in the vicinity of major overland flowpaths and pipelines. The flooding in these sites may occur due to an extreme flood event (larger than 100 year ARI) or localised drainage or blockage issues.

Property A29 is not affected by 100 year ARI event. However, this site is approximately 0.35 meters lower than the surrounding area, and may therefore be affected by localised flows.

7.1.2 Properties in the West of the Study Area

Six properties experienced over ground flooding in the west of the study area, but the hydraulic model does not show that these properties are affected by 100 year ARI flood extent. However, property A21 is affected by 200 year ARI flood extent.

The western parts of the study area are located at the lower and flat portion of the study area. The model results identify two main overland flowpaths in the west of the study area. One overland flowpath is along the creek which starts from the southern end of Collins Street towards Putland Street. Another overland flowpath is along the levee. The peak depth results indicate local water ponding occurs at most of the properties in the west of the study area. In order to distinguish the overland flow flooding from local water ponding, the flood extents were obtained by a depth filter of 0.15m and excluded all water ponding areas which are smaller than 100m^2. The hydraulic model results indicate that the five properties are affected by local water ponding, but not directly impacted by 100 year ARI flood extent.

7.2 Validation Based on Over Floor Flooding

This validation was undertaken by testing whether the hydraulic model is capable of defining the properties being affected by over floor flooding.

The community survey clearly reported property A2 experienced over floor flooding. Therefore, the validation on over floor flooding is tested at A2 only. **Table 7.2** shows the validation results based on testing over floor flooding.

Table 7.2 Validation Results Based on Testing Over Floor Flooding

Property ID	Floor Levels Surveyed (mAHD)	Flood Levels Modelled (mAHD)			Difference (m)		
		20yr	50yr	100yr	20yr	50yr	100yr
A2	37.61	37.68	37.70	37.72	0.07	0.09	0.11

The flood levels in **Table 7.2** were obtained based on flood damage estimation in **Section 11**. It is referred to **Section 11** for details.

Table 7.2 indicates that the hydraulic model identifies over floor flooding occurred at Property A2 for 20 year, 50 year and 100 year ARI events. This suggests that the model is providing similar behaviour as was observed in the 2007 event.

8 DESIGN FLOOD MODELLING RESULTS

8.1 Flood Extents

As discussed in **Section 4**, rainfall was applied directly to the 2D domain, using the 'Direct Rainfall' approach. This approach results in every 2D cell being inundated with some flood depth. In order to create model extents and provide reasonable results, a filter is applied to separate what is normal catchment runoff and what is flooding. The flood extents were drawn only for depths greater than and equal to 0.15m, consistent with Cardno Lawson Treloar (2006). In addition, flood extents do not include isolated water ponding areas outside of major overland flowpaths which are smaller than 100 m^2. Flood extents for PMF, 200 year, 100 year, 50 year, 20 year, 10 year, 5 year, 2 year and 1 year ARI are shown in **Figure 8.1-8.9**.

8.2 Critical Duration

Critical durations for 100 year ARI and 5 year ARI events are shown in **Figures 8.10-8.11**. These were derived from a SOBEK model that was used for the study area. The SOBEK covered the entire catchment using a 5m grid. The critical durations based on the SOBEK model are generally consistent with those expected from the TUFLOW model.

In general, the 2 hour storm is the critical duration for a 100 year and 5 year ARIs in the eastern part of the study area. There are some small areas with longer critical durations, but these are generally associated with isolated ponding locations. The 9 hour storm is the critical duration for a 100 year and 5 year ARIs in the western part of the study area.

The rainfall temporal patterns of 100 year ARI and 5 year ARI represent the temporal patterns of all of the design events, except for PMP (AR&R, 1999). It was assumed that other design events, excluding PMP, have the similar critical durations as 100 year and 5 year ARIs in this study.

8.3 Peak Flood Levels, Depths, and Velocities

Model results for the flood peak depth and velocity were processed within the flood extents. Peak flood depths for a full range of design events are shown in **Figure 8.12-8.20**, whilst the peak water levels are shown in **Figure 8.21-8.29**. The peak velocities for these design events are shown in **Figure 8.30-8.38**.

Water levels, depths and velocities for design storms at a number of reference points are provided in **Appendix G**, and the locations of these reference points are shown in **Figure 8.39**.

8.4 Peak Flows of Pipes and Open Channels

The peak flows for pipes which are greater than 600mm diameter are provided in **Appendix H**. The results of pipe capacity analysis are also shown in **Appendix H** (**Section 8.8** for details). The peak flows for open channel are provided in **Appendix I**, whereas the channel locations are shown in **Figure 8.40**.

8.5 2D Peak Flows

2D peak flows at reference locations for a full range of design events are provided in **Appendix J**, whilst these reference locations are shown in **Figure 8.41**.

8.6 Discussion of Results

The following discussion is based primarily on the results of 100 year ARI events, unless otherwise stated.

8.6.1 Flood Behaviour in the East of the Study Area

The eastern parts of the study area are relatively steep with elevations in the range of 30 and 65 mAHD. Runoff in the eastern parts of the study area is generated by the local catchment. Residential properties are the primary land-use in these areas.

The modelling (**Figure 8.3**) indicates four major overland flowpaths in the east of the study area as follows:

- Flowpath 1 drains from Carpenter Street to the corner of Chilaw Avenue and Monfarville Street.
- Flowpath 2 starts from Carpenter Street, and drains down to Mamre Road via Monfarville Street.
- Flowpath 3 drains from Morris Street towards Mamre Road.
- Flowpath 4 stars from the corner of Phillips Street and Lethbridge Street, and drains down to the corner of Kungala Street and Carinya Avenue.

The flowpaths in the east of the study area are primarily overland flow, and proceed between the houses and across the roads in these areas. There are eight significant ponding locations (these locations were identified where they have peak water depths exceed 0.5m in a 20 year ARI) in the east of the study area (shown in **Figure 8.42**). A summary of the model results at these ponding areas is presented in **Table 8.1**.

Table 8.1 Summary of the Model Results at the Ponding Areas

Ponding Area	Location	Peak Water Depth (m)		
		PMF	100yr ARI	20 year ARI
Area 1	Near Macleay Crescent	2.2	1.0	0.9
Area 2	Corner of Collins St and Mamre Lane	2.4	1.1	0.9
Area 3	Downstream end of Ryan St	1.6	1.0	0.9
Area 4	Corner of Stapleton Parade and King St	1.3	0.7	0.6
Area 5	Corner of East Lane and Chapel St	2.4	0.9	0.6
Area 6	Corner of Mitchell St and Monfarville St	1.8	0.9	0.8
Area 7	Corner of Carpenter St and Monfarville St	1.7	1.2	1.1
Area 8	Corner of Carpenter St and Mark St	1.6	1.0	0.9

8.6.2 Flood Behaviour in the West of the Study Area

The western parts of the study area are located at the lower and flat portion of the study area. The area incorporates a mix of residential and industrial properties.

Flooding in this area consists of three sources, including local runoff, the upstream runoff from a large catchment area to the south of M4 Motorway, and runoff from the east of the study area. The upstream runoff is the dominant portion, which is generated based on a catchment area of approximate 187 hectares.

There are two main overland flowpaths in the west of the study area. One overland flowpath is along the creek which starts from the southern end of Collins Street towards Putland Street. Another overland flowpath is along the eastern side of levee. In particular, the peak water depths exceed 0.65m in a 100 year ARI event at a trapped low point in the corner of Putland Street and Neale Street due to the obstruction of the commercial buildings and the limited capacity of the drainage system.

The water depths in a 100 year ARI exceeds 1.5m in Monfarville Reserve. There is a significant ponding area located at the south end of Mamre Road, in which the water depths exceed 2.0m in a 100 year ARI. The site inspection photos in this location are presented in picture 7 and 8 in **Appendix A**.

Two overland flowpaths exist in the south and north of St Marys Village Shopping Centre. The peak water depths exceed 0.7m in the southern overland flowpath and 0.4m in the northern overland flowpath in a 100 year ARI.

From **Section 6.2**, the downstream boundary level of 23.67m AHD was adopted for 20 year ARI to PMF. **Figure 8.3** shows the maximum area potentially affected by South Creek backwater.

8.7 Major Access Road Flooding

There are a number of major roads in the study area, including Great Western Highway, Saddington Street, Putland Street, and Mamre Road. Road flooding not only directly impacts on local traffic, but also hinders the access of emergency vehicles using the road network in the study area.

A summary of major access road flooding is provided in **Table 8.2,** with the locations shown in **Figure 8.43**. This table provides indicative flood depths at a number of locations. The actual depth may vary depending on the location on the road. It should be noted that, in general, the critical duration for flooding in the study area ranges from 2 to 9 hours, therefore, road inundation may occur over a relatively long timeframe, particular, in the western portions of the catchment. Only depths greater than 0.15m are shown in the table.

Table 8.2 Major Access Road Flooding - Indicative Depths (metres)

Location ID	Street Name	PMF	200yr	100yr	50yr	20yr	10yr	5yr	2yr	1yr
R1	Arnold St	1.01	0.49	0.38	0.37	0.34	0.3	0.24	0.19	0.16
R2	Maranie Ave	0.76	0.31	0.25	0.25	0.22	0.21	0.18	-	-
R3	Desborough St	0.72	0.43	0.38	0.37	0.37	0.35	0.35	0.32	0.3
R4	Macleay Cres	1.74	0.87	0.85	0.84	0.8	0.75	0.67	0.53	0.42

Location ID	Street Name	PMF	200yr	100yr	50yr	20yr	10yr	5yr	2yr	1yr
R5	Macleay Cres	2.12	0.74	0.59	0.58	0.47	0.34	0.24	-	-
R6	Carrington St	1.06	0.4	0.32	0.31	0.28	0.25	0.23	-	-
R7	Monfarville St	0.73	0.33	0.31	0.29	0.29	0.27	0.27	0.24	0.2
R8	Monfarville St	0.82	0.29	0.26	0.24	0.24	0.21	0.2	0.17	-
R9	Collins St	1.61	0.21	-	-	-	-	-	-	-
R10	Mamre Rd	0.47	0.27	0.21	0.21	0.18	-	-	-	-
R11	Wilson St	1.61	0.66	0.36	-	-	-	-	-	-
R12	Atchison St	1.86	0.6	0.6	0.37	0.37	0.35	0.33	0.28	0.24
R13	Barker St	0.74	-	-	-	-	-	-	-	-
R14	Ryan St	1.64	0.98	0.92	0.91	0.84	0.74	0.58	0.24	-
R15	Mamre Rd	0.59	0.32	0.28	0.26	0.26	0.23	0.23	0.2	-
R16	Edgar St	2.17	1.36	1.15	1.14	1.09	1.01	0.93	0.78	0.63
R17	John St	1.17	0.17	-	-	-	-	-	-	-
R18	Vincent St	1.19	0.37	0.29	0.28	0.26	0.17	-	-	-
R19	Pages Rd	1.25	0.26	-	-	-	-	-	-	-
R20	Saddington St	1.4	0.63	0.44	0.43	0.38	0.3	0.23	-	-
R21	Saddington St	1.24	0.3	0.16	0.16	-	-	-	-	-
R22	Saddington St	1.24	0.29	0.19	0.19	0.17	-	-	-	-
R23	Saddington St	1.93	1.08	1	1	0.97	0.88	0.86	0.84	0.82
R24	Pages Rd	1.69	0.9	0.67	0.65	0.51	0.29	-	-	-
R25	George St	1.3	0.51	0.43	0.42	0.39	0.31	0.28	0.26	0.24
R26	Putland St	1.25	0.55	0.44	0.43	0.39	0.28	0.26	0.23	0.21
R27	Putland St	1.83	1.04	0.96	0.95	0.93	0.84	0.82	0.8	0.77
R28	Pages Rd	1.25	0.94	0.86	0.86	0.84	0.83	0.78	0.76	0.74
R29	GWH	0.61	0.3	0.27	0.27	0.26	0.24	0.22	0.21	0.2
R30	Stapleton Parade	1.19	0.75	0.62	0.62	0.53	0.42	0.36	0.29	0.23
R31	Gidley St	0.78	0.45	0.4	0.38	0.38	0.34	0.27	-	-
R32	Gidley St	1.12	0.62	0.59	0.57	0.56	0.51	0.5	0.43	0.36

8.8 Pipe Capacity Assessment

A pipe capacity assessment was undertaken for the trunk drainage system for the study area, for pipes generally greater than 600mm in diameter. Pipe attributes (upper invert, lower invert, pipe length, slope, pipe diameter) were extracted from the TUFLOW hydraulic model.

This assessment was undertaken by comparing the nominal pipe capacity based on a Mannings equation against the modelled pipe capacity. The nominal pipe capacity and the modelled peak flows for design events are provided in **Appendix H**. The ARI rating of the pipes (nominal return period) were calculated by determining the design event in which the pipe was running full.

The nominal return period for these pipes are shown in **Figure 8.44**, which clearly identify which pipe sizes are not sufficient to convey flows in the study area. The flow capacity for 408 pipes was analysed. The nominal capacity of 321 pipes is greater than a 100 year ARI. The nominal capacity of 50 pipes (in **Figure 8.44**) is not greater than a 5 year ARI.

9 PROVISIONAL FLOOD HAZARD

9.1 General

Flood hazard can be defined as the risk to life and limb caused by a flood. The hazard caused by a flood varies both in time and place across the floodplain.

The *Floodplain Development Manual* (NSW Government, 2005) describes various factors to be considered in determining the degree of hazard. These factors are:

- Size of the flood
- Depth and velocity of floodwaters
- Effective warning time
- Flood awareness
- Rate of rise of floodwaters
- Duration of flooding
- Evacuation problems
- Access.

Hazard categorisation based on all the above factors is often referred to as 'true hazard'. The scope of the present study is to determine 'provisional' flood hazards only. The provisional flood hazard is generally considered in conjunction with the above listed factors as part of the Floodplain Risk Management Study (the next stage of the Floodplain Risk Management process after the Flood Study) to provide a comprehensive analysis of the overall flood hazard.

9.2 Provisional Flood Hazard

Provisional flood hazard is determined through a relationship developed between the depth and velocity of floodwaters (NSW Government, 2005). The two categories for provisional hazard are defined as High and Low shown in **Figure 9.1**.

The hazard results were directly generated by the TUFLOW model, which utilises the model results of flood depth and velocity to determine hazard. In this study, high hazard includes the high and medium hazard zones shown in **Figure 9.1**.

Provisional flood hazard for PMF, 200 year,100 year, 50 year, 20 year, 10 year, 5 year, 2 year and 1 year ARI design events is shown in **Figures 9.2-9.10**.

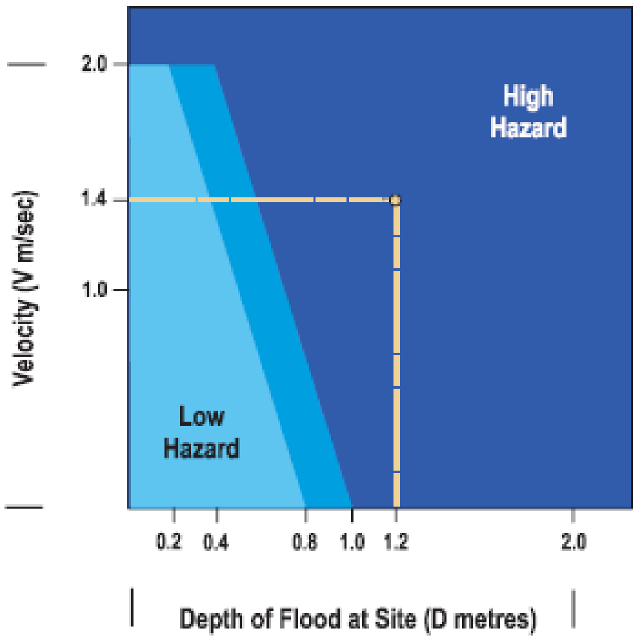


Figure 9.1 Provisional Hazard Classifications (NSW Government, 2005)

9.3 Discussion

Generally high hazard is limited to the channels and the downstream ponding areas in the west of the study area, in particular, the area adjacent to the channel between Wilson Oval and Saddington Street.

In the east of the study area, high hazard only occurs in a number of small ponding areas. In general, the east of the study area is affected by isolated areas of high hazard for storm events up to 200 year ARI.

In term of PMF, high hazard dominates the majority of the west of the study area, as well as along the main overland flowpaths in the east of the study area.

10 HYDRAULIC CATEGORIES

10.1 General

The damages and disruption caused by floodwaters depend on the extent and duration of flood inundation, and on the depth and the velocity of flow. The hydraulic categories (floodway, flood storage and flood fringe) are typically defined in accordance with the NSW Government's *Floodplain Development Manual (April 2005)* as follows:

- Floodways tend to be aligned with natural channels and carry the main volumes of water during floods, often at substantial flow velocities;
- Flood storage areas become filled with water for temporary storage during floods;
- Flood fringe areas are those remaining after floodways and storage areas have been defined.

Hydraulic Categories for the study area have been provided for a full range of design storms. The method of mapping the hydraulic categories is as follows (Howells et al, 2003):

- Floodways include creek and channels. Floodways are also defined following depth and velocity criteria:
    - Velocity-depth product must be greater than 0.25m^2/s and velocity must be greater than 0.25 m/s or
    - Velocity is greater than 1m/s.
- Flood storage is the remaining area where flood depth is greater than 0.2 m; and
- Flood fringe is the remaining area within the flood extent which is not either Floodway or Flood Fringe.

The hydraulic categories for the full range of design events are shown in **Figure 10.1 to 10.9**.

10.2 Discussion

There are three major overland flowpaths in the east of the study area. The overland flowpath which starts from Bega Street towards the intersection of Monfarville Street and Carrington Street is dominated by floodway in a 100 year ARI event. Portions of other two overland flowpaths in the downstream areas are floodway. For storm events smaller than a 20 year ARI, the flowpaths in the east of the study area are dominated by flood storage and flood fringe.

In the west of the study area, floodway is limited to the channels and South Creek Park on the corner of Great Western Highway and Charles Hackett Drive.

11 ECONOMIC DAMAGES

11.1 Background

Flooding is likely to cause significant social and economic damages to the communities. The flood damages are classified into different categories, which are summarised in **Table 11.1**.

Table 11.1 Types of Flood Damages

Type of Flood Damage	Description
Direct	Building contents (internal) Structure (building repair and clean) External items (vehicles, contents of sheds etc)
Indirect	Clean-up (immediate removal of debris) Financial (loss of revenue, extra expenditure) Opportunity (non-provision of public services)
Intangible	Social – increased levels of insecurity, depression, stress General inconvenience in post-flood stage

The direct damage costs, as indicated in the above table, are just one component of the entire cost of a flood event. There are also indirect costs. Both direct and indirect costs are referred to as 'tangible' costs. In addition to this there are also 'intangible' costs such as social distress. The flood damage values discussed in this report are the tangible damages and do not include an assessment of the intangible costs which are difficult to calculate in economic terms.

Flood damages can be assessed by a number of methods including the use of computer programs such as FLDAMAGE or ANUFLOOD or via more generic methods using spreadsheets. For the purposes of this project, generic spreadsheets have been used with assistance from DECCW Damage Curves on the adoption of appropriate damage curves.

11.2 Floor Level and Property Survey

A detailed floor level and property survey spreadsheet and GIS data were provided by Council in August, 2011. The floor survey data includes details of a property including the type of a property (residential, commercial, Industrial, car parks, or vacant), the ground and floor levels, the floor area of commercial/industrial buildings etc.

The floor level and property survey GIS data provided survey information about 971 properties, including 2 duplicated cadastre lots. It results in 969 properties for flood damage estimation. Some properties have incomplete survey data, including:

- 54 properties did not have information regarding the type of property (residential, commercial, industrial, car parks, or vacant);
- 137 properties do not have floor levels; and

- 21 commercial/industrial properties do not have information regarding the floor area.

11.3 Assumptions

The following assumptions were applied for flood damage estimation since the floor level and property survey data provided incomplete information. These assumptions are:

i. The flood level for each property was estimated as the sum of the surveyed ground level and the average flood depth.

ii. For 137 properties without surveyed floor levels (based on the survey spreadsheet data), the floor levels for these properties were assumed to be 0.3m higher than the surveyed ground levels.

iii. For 21 commercial/industrial properties without floor area, the floor areas were estimated from aerial photographs.

iv. For 54 properties without information regarding the type of property, the type of this property was identified (Residential, Commercial/Industrial, Car parks or Vacant) from aerial photographs.

v. For 75 properties, the surveyed floor level is significantly lower than the surveyed ground level. It results in unrealistic estimates of damage, e.g., up to 2m of flood depth for 1 year ARI event at some properties. It was assumed that the floor levels for these properties were 0.3m higher than the surveyed ground levels.

vi. In damage calculation spreadsheet, the damage costs caused by flooding were only estimated for properties which building outline (1m buffer) was affected by flood extents.

11.4 Damage Analysis

A flood damage assessment for the existing catchment and floodplain conditions has been undertaken as part of the current study. The assessment is based on damage curves that relate the depth of flooding on a property, to the potential damage within the property.

Ideally, the damage curves should be prepared for the particular catchment for which the study is being carried out. However, damage data in most catchments is not available and recourse is generally made to damage curves from other catchments. OEH has carried out research and prepared a methodology (draft) to develop damage curves based on state-wide historical data. This methodology is only for residential properties and does not cover industrial or commercial properties.

The OEH methodology is only a recommendation and there are currently no strict guidelines regarding the use of damage curves in NSW. However, correspondence at the outset of this project with OEH confirmed that the use of OEH curves was appropriate.

The following sections set out the methodology for the determination of damages within the St Marys floodplain.

11.4.1 Residential Damage Curves

The draft DNR (now OEH) Floodplain Management Guideline No. 4 Residential Flood Damage Calculation (2004) was used in the creation of the residential damage curves. These guidelines include a template spreadsheet program that determines damage curves for three types of residential buildings:

- Single storey, slab-on-ground
- Two storey, slab-on-ground
- Single storey, high-set (i.e. on piers).

Two types of these properties were adopted for this study, including the single storey slab-on-ground and the two storey slab-on-ground. No single storey high-set houses, apartment buildings and townhouses were identified in the survey therefore no additional costs were apportioned based on these landuses.

Damages are generally incurred on a property prior to any over-floor flooding. The OEH curves allow for a damage of $10,452 (May 2012 dollars) to be incurred when the water level reaches the base of the house (the base of the house is determined by 0.3m below the floor level for slab on ground). Damages of this type are generally direct external damages (sheds, gardens), direct structural damages (foundational damage) or indirect damages (garden amenity and debris clean-up). According to the damage curves this amount of damage remains constant from the base of the house to the floor level of the house.

There are a number of input parameters required for the OEH curves, such as floor area and level of flood awareness. The following parameters were adopted:

- Based on interrogation of the aerial photos a value of 200m^2 was adopted as a conservative estimate of the floor area for residential dwellings for the floodplain. With a floor area of 200m^2, the default contents value is $50,000 (November 2001 dollars).
- The effective warning time has been assumed to be zero due to the absence of any flood warning systems in the catchment. A long effective warning time allows residents to prepare for flooding by moving valuable household contents (e.g. the placement of valuables on top of tables and benches).
- The St Marys catchment is within a large metropolitan area, and as such is not likely to cause any post-flood inflation. These inflation costs are generally experienced in remote areas, where re-construction resources are limited and large floods can cause a strain on these resources.

It is noted that a number of cadastre lots include more than one residential properties in the study area. The flood damages for these cadastre lots were estimated by multiplying the number of properties.

Average Weekly Earnings

The OEH curves are derived for late 2001, and were updated to represent May 2012 dollars. General recommendations by OEH are to adjust values in residential damage curves by Average Weekly Earnings (AWE), rather than by the inflation rate as measured by the Consumer Price Index (CPI). OEH proposes that AWE is a better representation of societal wealth, and hence an indirect measure of the building and contents value of a home. The most recent data for AWE from the Australian Bureau of Statistics at the time of the assessment was for May 2012. Therefore all ordinates in the residential flood damage curves were updated to May 2012 dollars.

While not specified, it has been assumed that the curves provided by OEH were derived in November 2001, which allows the use of November 2001 AWE statistics (issued quarterly) for comparison purposes. November 2001 AWE and May 2012 AWE were taken from the Australian Bureau of Statistics website (www.abs.gov.au).

Table 11.2 AWE Statistics (Source: the Australian Bureau of Statistics)

Month	Year	AWE
November	2001	$676.40
May	2012	$1057.30
Change	56.31%	

Consequently, all ordinates on the damage curves were increased by 56.31%.

11.4.2 Commercial Damage Curves

Commercial damage curves have been adopted from the FLDamage Manual, Water Studies Pty Ltd (1992). FLDamage allows for three types of commercial properties:

- Low value commercial;
- Medium value commercial; and
- High value commercial.

In determining these damage curves, it has been assumed that the effective warning time is approximately zero, and the loss of trading days as a result of the flooding has been taken as 10 days.

These curves are determined based on the floor area of the property. The floor level survey provides an estimate of the floor area of the individual properties. For some commercial properties without the surveyed floor area, the floor area was estimated from aerial photographs.

The Consumer Price Index (CPI) was used to bring the 1990 data to March 2012 dollars (this data was obtained from the Australian Bureau of Statistics website (www.abs.gov.au). The CPI data is shown in **Table 11.3**.

Table 11.3 CPI Statistics for Commercial Property Damage Estimation

Month	Year	CPI
June	1990	102.50
March	2012	178.80
Change	74.44%	

Consequently, damages have been increased by 74.44%.

11.4.3 Industrial Damage Curves

Cardno, as a part of the Allans Creek Floodplain Management Study, conducted a survey of industrial properties in 1998 for Wollongong City Council (Cardno Lawson Treloar, 2006). The damage curves derived from this survey are more recent than those presented in FLDamage and have been used in a number of previous studies. Therefore Cardno feels these damage curves are adequate for use in this study.

The curves were prepared for three categories:

- Low value industrial (e.g. small factories and workshops)
- Medium value industrial (e.g. large industrial properties in the corner of Castlereagh Road and Railway)
- High value industrial (e.g. BHP steelworks in Wollongong).

Within the catchment, there are no properties considered to be representative of high value industrial properties, and hence these curves were not used.

The survey conducted only accounts for structural and contents damage to the property. Clean up costs and indirect financial costs were estimated based on FLDamage Manual. Actual internal damage could be estimated, along with potential internal damage, using various factors within FLDamage. Using both the actual and potential internal damages, estimation of both the cleanup costs and indirect financial costs could be made. The values were adjusted to March 2012 dollars using the CPI statistics shown in **Table 11.4**.

Table 11.4 CPI Statistics for Industrial Property Damage Estimation

Month	Year	CPI
June	1998	121.00
March	2012	178.80
Change	47.77%	

Consequently, damages have been increased by 47.77%.

11.4.4 Car Park Damage Curves

The floor level and property survey data indicate that there are a number of car parks in the study area. Flooding may cause significant car damage costs, including clean-up, repairs, and disposal costs.

There are no standard damage curves for car parks in the current application in New South Wales. Damage curves for car park were derived by Cardno for this study following the assumptions as below:

- Approximately 70% of the total area is used for carspace lots;
- The area of a carspace lot is approximately 15m^2 (5.5m*2.6m);
- Approximately 80% of carspace lots are occupied;

- Proportional damage costs between $3,000 and $10,000 per car are estimated when the flood depths are in a range of 0.3-1.0m; and
- The assumed average disposal cost is $10,000 per car when the flood depths are higher than 1.0m.

11.4.5 Adopted Damage Curves

The adopted damage curves are shown in **Figure 11.1**. The commercial and industrial damage curves are for a property with a floor area of 100m². The car park damage curves are estimated per car.

To normalise the damages for property size, the curves have been factored to account for floor area. The floor level survey provided an estimate of the floor area of commercial\ industrial properties. For some commercial\industrial properties without the surveyed floor area, the floor area was estimated from aerial photographs.

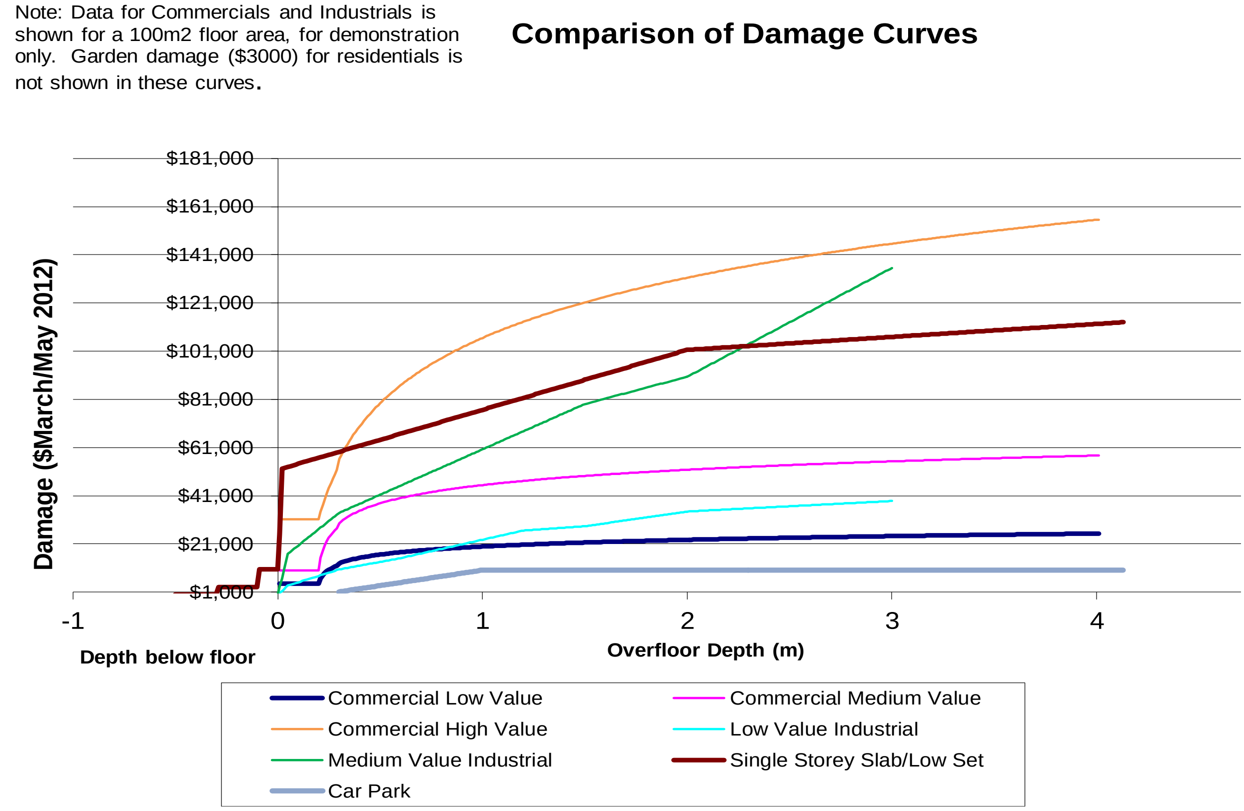


Figure 11.1 Adopted Damage Curves

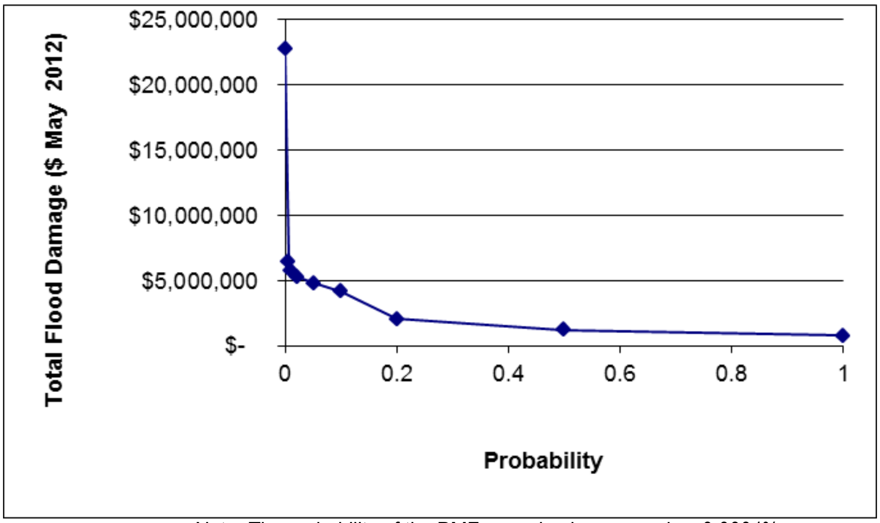
11.5 Average Annual Damage

Average Annual Damage (AAD) is calculated on a probability approach, using the flood damages calculated for each design event.

Flood damages (for a design event) are calculated by using the 'damage curves' described in the sections above. These damage curves define the damage experienced on a property for varying depths of flooding. The total damage for a design event is determined by adding all the individual property damages for that event.

AAD attempts to quantify the flood damage that a floodplain would receive on average during a single year. It does this using a probability approach. A probability curve is drawn, based on the flood damages calculated for each design event (**Figure 11.2**). For example, the 100 year ARI design event has a probability of occurring of 1% in any given year, and as such the 100 year ARI flood damage is plotted at this point on the AAD curve (**Figure 11.2**). AAD is then calculated by determining the area under this curve.

Further information on the calculation of AAD is provided in Appendix M of the Floodplain Development Manual (NSW Government, 2005).



Note: The probability of the PMF occurring is assumed as 0.0001%

Figure 11.2 Flood Damage Variation with AEP for St Marys

11.6 Results

Table 11.5 shows the results of the flood damage assessments. Based on the analysis described in **Section 11.4**, the average annual damage estimated for the St Marys floodplain under existing conditions is approximately $1.6 million.

The average annual damage reflects of the likelihood of each design flood event in one year and the damages likely to occur as a result of that event. Whilst this is a useful tool for evaluating the benefit of flood management options and assessing the flood damage to an area over a long period of time, it is also important to note the actual damages estimated to occur as a result of each design flood event. The cost to the community of flood damage is not incurred as an average annual amount. The costs will be borne at one time by the damage incurred by a specific flood event.

Financial and community attitude surveys and analysis undertaken in other areas of Sydney (e.g. the Hawkesbury Nepean Valley) (Gillespie et al, 2002) suggests that many people would have real difficulties dealing with the cost of recovering from severe flooding.

Table 11.5 Damage Calculation Summary

Property Type	Properties with Overfloor Flooding	Average Overfloor Flooding Depth (m)	Maximum Overfloor Flooding Depth (m)	Properties with Overground Flooding	Total Damage ($May 2012)
PMF					
Residential	216	0.45	1.66	639	$14,993,697
Commercial	76	0.66	2.74	95	$8,382,983
Industry	-	-	-	-	-
Car Park				1	$87,333
PMF Total	292			735	$23,464,013
200 Year ARI					
Residential	52	0.25	1.10	315	$3,442,402
Commercial	27	0.36	0.95	52	$2,077,118
Industry	-	-	-	-	-
Car Park				-	-
200 Year ARI Total	79			367	$5,519,520
100 Year ARI					
Residential	48	0.25	1.07	285	$3,190,223
Commercial	26	0.33	0.76	48	$1,857,184
Industrial	-	-	-	-	-
Car Park				-	-
100 Year ARI Total	74			333	$5,047,407
50 Year ARI					
Residential	41	0.26	0.98	272	$2,797,432
Commercial	25	0.26	0.71	44	$1,701,871
Industrial	-	-	-	-	-
Car Park				-	-
50 Year ARI Total	66			316	$4,499,303
20 Year ARI					
Residential	36	0.25	0.95	264	$2,438,386
Commercial	24	0.24	0.60	43	$1,549,861
Industrial	-	-	-	-	-
Car Park				-	-
20 Year ARI Total	60			307	$3,988,247
10 Year ARI					
Residential	32	0.24	0.91	249	$2,066,987
Commercial	21	0.19	0.43	40	$1,313,311
Industry	-	-	-	-	-
Car Park				-	-
10 Year ARI Total	53			289	$3,380,298
5 Year ARI					
Residential	25	0.26	0.89	244	$1,750,295
Commercial	-	-	-	16	-
Industry	-	-	-	-	-
Car Park				-	-
5 Year ARI Total	25			260	$1,750,295
2 Year ARI					
Residential	14	0.23	0.51	115	$1,009,644
Commercial	-	-	-	7	-

Property Type	Properties with Overfloor Flooding	Average Overfloor Flooding Depth (m)	Maximum Overfloor Flooding Depth (m)	Properties with Overground Flooding	Total Damage ($May 2012)
Industry	-	-		-	-
Car Park				-	
2 Year ARI Total	14			122	$1,009,644
1 Year ARI					
Residential	10	0.23	0.49	91	$728,611
Commercial	-	-	-	7	-
Industry	-	-		-	
Car Park				-	-
1 Year ARI Total	10			98	$728,611

Note: damage costs exclude GST. It did not consider garden damages for commercial and industrial properties.

12 SENSITIVITY ANALYSIS

A sensitivity analysis was undertaken to investigate the flood impact of the key model parameters, including:

- Rainfall – increase and decrease by 20%;
- Hydraulic roughness – increase and decrease by 20%;
- Pits and pipes blocked;
- Major culverts blockage;
- Incorporation of missing buildings;
- Modifications of roughness values of car parks and paved ground;
- Inclusion of an easement, and
- Roof roughness

The sensitivity analysis was undertaken using 3m grid model. The existing case was also modelled using a 3m grid. The critical event of 100 year and 20 year ARI with 2 hour duration was used for the sensitivity tests.

12.1 Rainfall

An analysis of the sensitivity of the model to rainfall is an indication of the sensitivity of the study area to potential impacts for climate change. The 20% increase in rainfall assessed here is in the middle of the recommended DECCW climate change guidelines of 10 – 30% rainfall increases.

The flood level impact of an increase\decrease of rainfall by 20% of 100 year ARI is shown in **Figure 12.1-12.2** respectively. The upstream inflows were obtained by applying a 20% increase in rainfall intensity in the XP-RAFTS model.

The model results indicate that the flood level differences are within ±0.1m due to an increase/decrease of rainfall by 20%. However, the sensitivity analysis results in a more significant change in flood levels along the open channel downstream of Monfarville Reserve. In general, the flood levels along this open channel increase in a range of 0.2m-0.6m due to a 20% rainfall increase, whilst the flood levels along this open channel decrease by approximately 0.15m due to a 20% rainfall decrease.

The flood level impact of an increase\decrease of rainfall by 20% of 20 year ARI is shown in **Figure 12.3**-**12.4**. In general, the flood level differences are within ±0.1m. The flood levels along the open channel between Mamre Road and Wilson Street increase in a range of 0.08m-0.12m due to a 20% rainfall increase. The flood levels along this open channel decrease in a range of 0.1m-0.2m due to a 20% rainfall decrease. A 20% increase/decrease in rainfall results in the flood levels varying in a range of +/-0.1m-0.25m in Monfarville Reserve generally.

12.2 Hydraulic Roughness

The flood level impact of 100 year ARI due to a 20% increase\decrease of hydraulic roughness is shown in **Figure 12.5-12.6** respectively. Varying in hydraulic roughness has a relatively minor impact on the predicted flood levels in the 100 year ARI event. The flood level differences are typically within +/-0.05 metres by varying +/-20% in hydraulic roughness. However, a significant flood level impact (+/-0.18 metres) occurs in the area near the levee.

The flood level impact of 20 year ARI due to a 20% increase\decrease of hydraulic roughness is shown in **Figure 12.7-12.8** respectively. The flood level differences are typically within +/-0.05 metres. However, a flood level impact (+/-0.15 metres) occurs in the area near the levee.

12.3 Pit and Pipe Blockage

As discussed in **Section 6.2.4**, this study adopted 50% blockage to all inlet pits and no blockage in pipes for design events in accordance with Council's blockage policies. A sensitivity analysis with 0% pit blockage was undertaken to investigate the impact to flood behaviour in the study area if all pits are at capacity.

The flood level impact of 0% pit blockage for 100 year ARI is shown in **Figure 12.9**. It results in reductions in peak flood levels generally within 0m to 0.1m in the eastern part of the study area. However, the peak flood levels increase up to 0.25m in the western part of the study area (excluding open channels). The flood levels increase in a range of 0.5m and 1m along the open channel between Monfarville Reserve and Wilson Street, and by up to 0.35m in Monfarville Reserve due to 0% pit blockage.

12.4 Major Culvert Blockage

A sensitivity test of the flood impact of major culverts becoming blocked was undertaken. Major culverts were identified on main flowpaths in conjunction with Council as shown on **Figure 12.10**. The locations of these major culverts that were blocked in the model are listed in **Table 12.1**.

Table 12.1 A Summary of Locations of the Major Culverts Blocked

Location ID	Location ID	%Blocked
L1	1099 1100 1101 1102 1103 1104	50%
L2	1315	50%
L3	1135 1136	50%
L4	1187 1196	50%
L5	1670 1752 1753 1754 1755	50%

The level of blockage assumed was based on Penrith CBD Stormwater Design Standards Review (Cardno, 2012), which assigns a certain amount of blockage based on the size of the culvert. The recommendations from this report were applied as follows:

- Culverts with a diagonal opening less than 6m, 50% blocked; and
- Culverts with a diagonal opening greater or equal to 6m, 25% blocked.

The water level impacts of these major culverts blocked for 100 year and 20 year ARI are shown in **Figure 12.11** and **Figure 12.12** respectively.

The results indicate that the potential blockage of culverts has a large flood impact in the immediate vicinity of each of the culverts. The flood levels increase by 0.15m and 0.38m approximately in Monfarville Reserve for the 100 year and 20 year ARI events respectively. The flood levels increase by up to 0.15m in the vicinity of culvert location L4 for 100 year and 20 year ARI.

The culvert blockage at location L3 results in an increase in flood levels in a range of 0.15m-0.32m, and 0.22m-0.35m along the open channel between Mamre Road and Wilson Street for the 100 year and 20 year ARI respectively.

The results indicate that the flood levels increase by up to 0.65m and 0.53m along the open channel between Monfarville Reserve and Mamre Road for the 100 year and 20 year ARI respectively due to culvert blockage at location L2.

Model results are particularly sensitive to the large culverts under the Great Western Highway (at location L5) as these are the key outlet from the study area. The flood levels increase by up to 0.4m and 0.35m at location L5 for 100 year and 20 year ARI respectively when these culverts are blocked.

12.5 Incorporation of Missing Buildings

In this study, buildings within the floodplain in the study area were conservatively assumed to completely block overland flow, and were modelled as raised blocks in the topographic grids.

However, a number of buildings in the east side of the levee were not included in the building outlines utilised in the current study. A sensitivity test run was undertaken to investigate the flood impacts by raising these additional buildings. The water level impacts of this sensitivity run and the location of these missing buildings are shown in **Figure 12.13**. The results indicate that raising these buildings do not have an adverse flood impact in the surrounding areas.

12.6 Modification of Roughness Values in Car Parks and Paved Ground

This study adopted a uniform hydraulic roughness value (0.1) for all residential, commercial and industrial blocks, which were generally based on the Penrith Overland Flow Flood "Overview Study" (Cardno Lawson Treloar, 2006).

A refinement of roughness map for car parks and concrete ground in the study area was undertaken to assess the flood impacts by the modified roughness map. The refined roughness map for car parks and concrete ground is presented in **Figure 12.4**. The modified roughness value 0.02 was adopted for car parks and concrete ground showing in **Figure 12.14**.

The flood impacts of the revised roughness value for car parks and paved ground are shown in **Figure 12.15**. The results indicate that the water levels decreased by less than 0.03m for the majority of refined roughness areas. A slight increase in water levels (less than 0.03m) occurred to the immediate east side of the levee. The flood levels decrease in a range of 0.02m-0.08m in the St Marys Village car park. In general, the refinement of roughness does not have significant flood impacts on any property in the study area.

12.7 Inclusion of Easements

There are a number of easements within the study area, some of which may not have been adequately accounted for by the TUFLOW model due to raised building outlines on the terrain grid. The locations of these easements were provided by the Council, which are shown in **Figure 12.16**.

A sensitivity test was undertaken by incorporating these easements into the TUFLOW model. The flood level impacts of these easements are shown in **Figure 12.17**. The results indicate that a decrease in water levels in the areas near easements is in a range of 0.02m-0.2m in general.

12.8 Roof Roughness

As discussed in **Section 6.5**, a uniform high roughness value of 0.1 was applied in residential/urban areas in this study, indicating a high roughness value of 0.1 applied for raised buildings in this study.

A sensitivity analysis has been undertaken to evaluate the potential flood impact by using roughness value of 0.02 for all raised buildings within the TUFLOW model boundary. The flood impact of using roughness value of 0.02 for raised buildings is shown in **Figure 12.18**.

The results indicate that the water levels have a slight increase (approximately 0.02m in the vicinity of Mamre Rd and Hall Street. A slight decrease (less than 0.02m) in water levels occurred in the ponding area in the northern end of East Lane.

It concludes that a uniform high roughness value of 0.1 applied in residential/urban areas in this study does not cause a significant flood impact in the study area.

13 PRELIMINARY FLOOD MITIGATION OPTIONS

The model results indicate that flooding may cause significant economic damage costs in the St Marys study area. This study provides some preliminary flood mitigation options to Council based on the hydraulic modelling results. It is recommended to undertake a flood risk management study and plan to investigate the effectiveness of flood mitigation options in detail.

13.1 Areas for Flood Mitigation Options

The assessment of flood behaviour under existing conditions for the St Marys catchment indicates that the following areas exposure to a higher level of flood risk (**Figure 13.1**):

- Area 1 – properties along the overland flowpath between Saddington Street and Putland Street;
- Area 2 – industrial buildings in the corner of Pages Road and Sainsbury Street;
- Area 3 – residential buildings along Schleicher Street between Vincent Street and Saddington Street;
- Area 4 – properties affected by overland flowpath in Macleay Crescent; and
- Area 5 – properties affected by overland flowpath in the corner of Moira Crescent and Monfarville Street.

It is noted that the ponding areas 4 and 5 are located near Council's drainage easements. The sensitivity test indicates that the flood levels decrease by approximately 0.2m and 0.1m in the ponding area 4 and 5 respectively by incorporating the drainage easements into the model. However, the water depths exceed 1m in these ponding areas. Therefore, there is still a flood risk in this area which is targeted by some of these options.

13.2 Storage and Detention Basin Modification

There is a potential to incorporate detention at Cook Park, Wilson Oval, Mary Mackillop Park and Victoria Park. A list of basin-related flood mitigation options is provided in **Table 13.1**. The locations of these options are shown in **Figure 13.2**. It may be possible to incorporate storage in one or two of these parks to alleviate the flooding.

Table 13.1 A List of Flood Mitigation Options Regarding Potential Basins

Option	Location	Comments
Option 1	Mary Mackillop Park	Potential benefit to Area 1
Option 2	Riparian Corridor between John St and Saddington St	May decrease flooding impact downstream areas.
Option 3	Cook Park and Wilson Oval	May decrease flood levels in flood affected areas downstream due to a decrease of flows into Creek.
Option 4	Victoria Park	May decrease flood levels in Area 2.

13.3 Pipes and Culverts Upgrades

The study area is highly urbanised. Upgrading pipes and culverts would assist in alleviating flooding in the area. The results of pipe capacity assessment (**Figure 8.44**) indicate that 56 pipes have flow capacity which is less than a 5 year ARI. Upgrading pipes and culverts requires consideration of pipe network rather than individual pipes.

13.3.1 Flood Mitigation Option 5

Flood mitigation option 5 (**Figure 13.3**) constructs a new pipeline which conveys flows from creek near Saddington St to conduit near the Great Western Highway. The aim of this option is to decrease a flooding risk for properties in Area 1 (**in Figure 13.1**).

13.3.2 Flood Mitigation Option 6

Flood mitigation option 6 considers providing an improved overland flowpath or constructing a new drainage line, which is shown in **Figure 13.4**. Option 6 proposes to decrease a flooding risk in Area 3 (see **Figure 13.1**).

13.3.3 Flood Mitigation Option 7

Flood mitigation option 7 is shown in **Figure 13.5**. A number of properties in Macleay Crescent are exposed to flooding, with a peak depth in a range of 0.5m-1.0m in this area in a 100 year ARI event. Flood mitigation option 7 proposes a construction of a new pipeline in this area. There are constraints with construction through private properties; therefore, two possible alignments are shown in **Figure 13.5**.

13.3.4 Flood Mitigation Option 8

Flood mitigation option 8 considers construction of a new pipeline at the corner of Moira Crescent and Monfarville Street, shown in **Figure 13.6**. The model results indicate that seven properties are exposed to flooding in this area. The peak water depths may reach up to 1.0m in a 100 year ARI event for some properties. Option 8 is aimed to decrease a flooding risk in this area.

It is noted that the flood mitigation options identified in this report are preliminary. It is recommended to undertake detailed studies to investigate the effectiveness of these flood mitigation options.

13.4 Maintenance

Effective drainage maintenance is an essential factor to ensure the performance of drainage system. A number of residents noted that blockage of the stormwater system from debris results in adverse flooding. Therefore, maintenance of the drainage system may be an effective flood risk management tool.

As a part of an overall risk management study, a review could be undertaken on Council's maintenance programme. This might include, for example, prioritising areas where higher flood risks exist or critical stormwater infrastructure is located.

14 CONCLUSIONS

This report has been prepared for Penrith City Council to define the nature and extent of flooding for St Marys study area. Flood modelling was completed to define flood behaviour under existing conditions for a full range of design events. Information provided in this report includes flood extents, flood levels, depths, and flood velocities for these design events. This study also defines provisional hazards and hydraulic categories for the study area.

This study defined the existing flood behaviour in the study area, and identified areas exposed to a higher level of flood risk. Preliminary options to manage the flooding within the study area have also been identified. These options will provide a starting point for the next stage of the Floodplain Risk Management process.

A sensitivity analysis was undertaken to investigate the flood impact of the key model parameters, including the model inflows, hydraulic roughness and pit and pipe blockage. This sensitivity analysis suggests that the model is most sensitive to changes in inflows and rainfalls applied to the model.

The investigation and modelling procedures adopted for this study follow current best practice and considerable care has been applied to the preparation of the results. It is known that uncertainty is always associated with the model results due to the input data quality and other systematic errors. In particular, the hydraulic model was not fully calibrated due to scarce calibration data. Instead, the robustness and reliability of the hydraulic model was tested by an indirect validation. This should be considered in the future application of the model results.

15 ACKNOWLEDGEMENT

The St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study was prepared by Cardno (NSW/ACT) Pty Ltd on behalf of Penrith City Council and NSW Office of Environment and Heritage (OEH). The study has been prepared with the technical guidance and financial assistance from the New South Wales Government through its Floodplain Management Program.

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Figures

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FIGURE 1.1
LOCALITY OF THE STUDY AREA

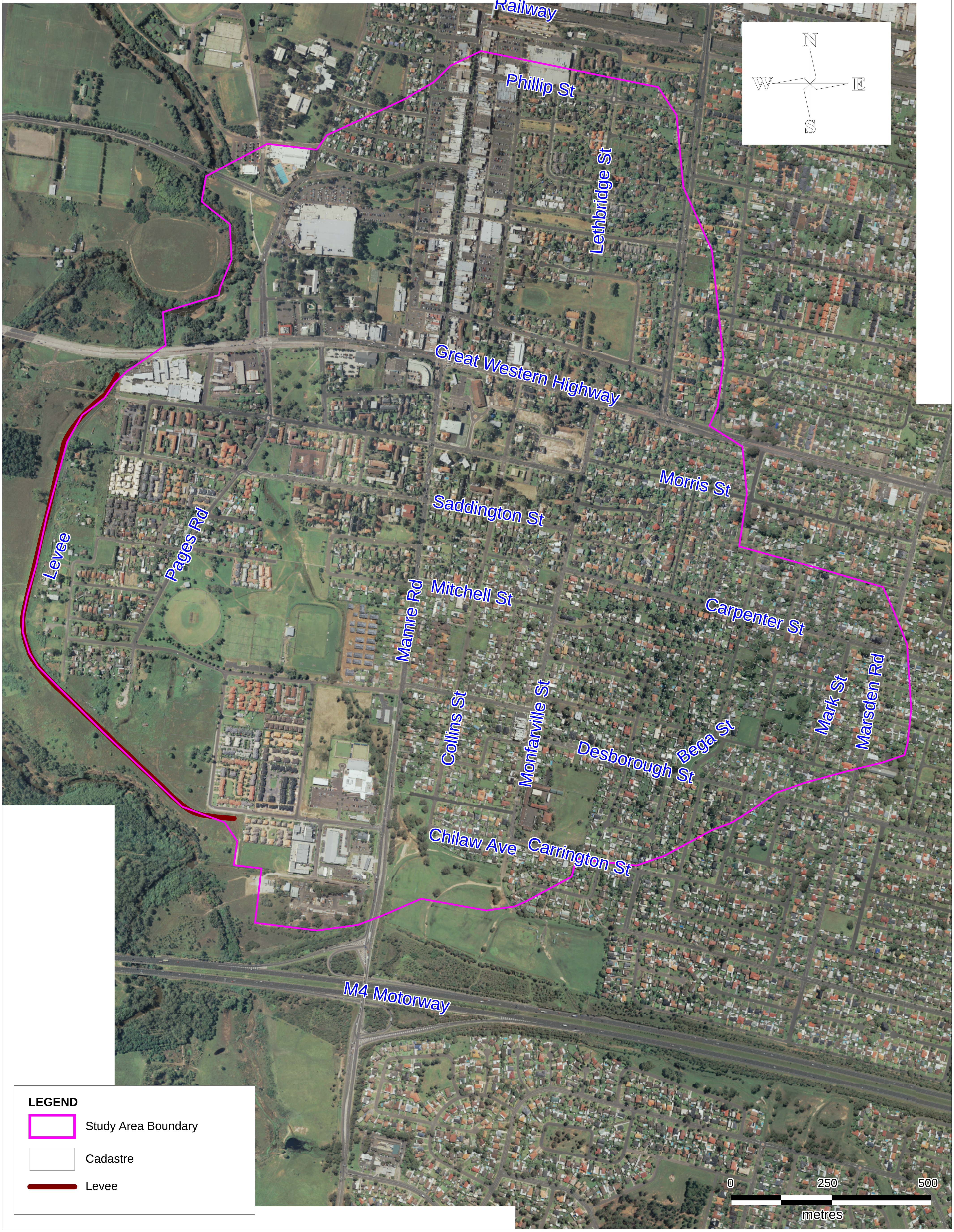

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FIGURE 1.2
STUDY AREA BOUNDARY

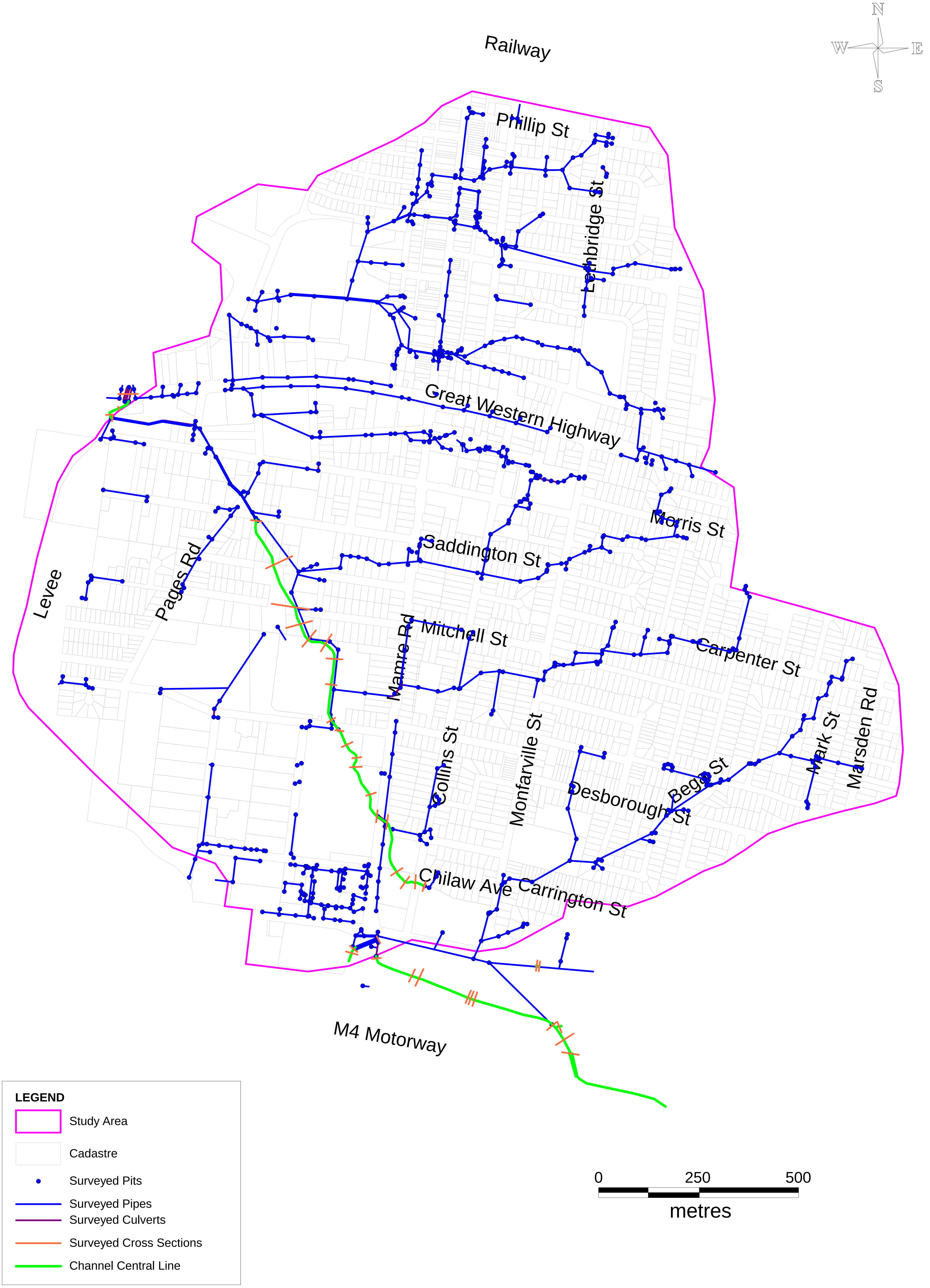

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FIGURE 2.1
SURVEYED DRAINAGE SYSTEM LAYOUT

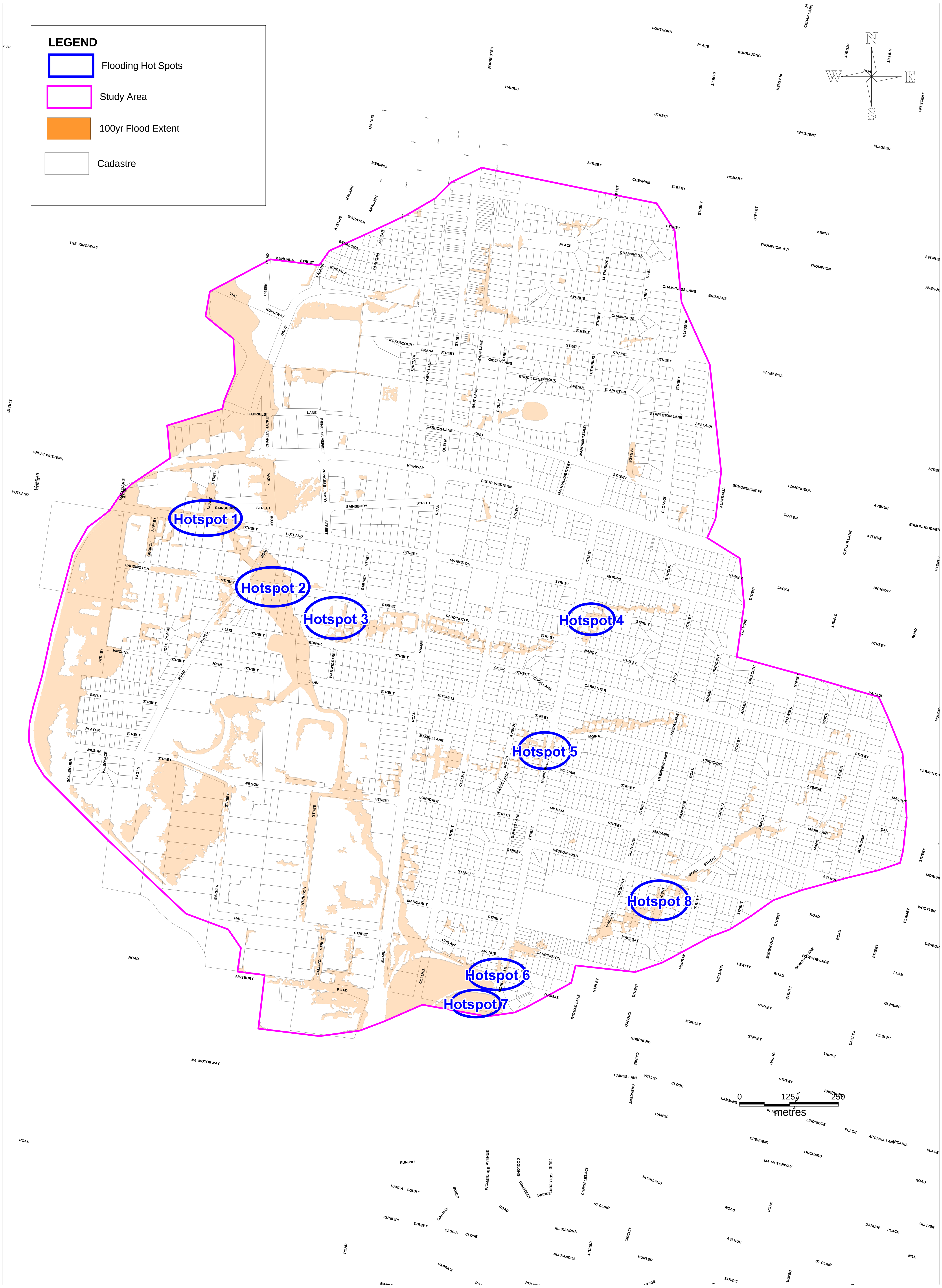

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FIGURE 2.2
FLOODING HOTSPOTS
SITE INSPECTIONS

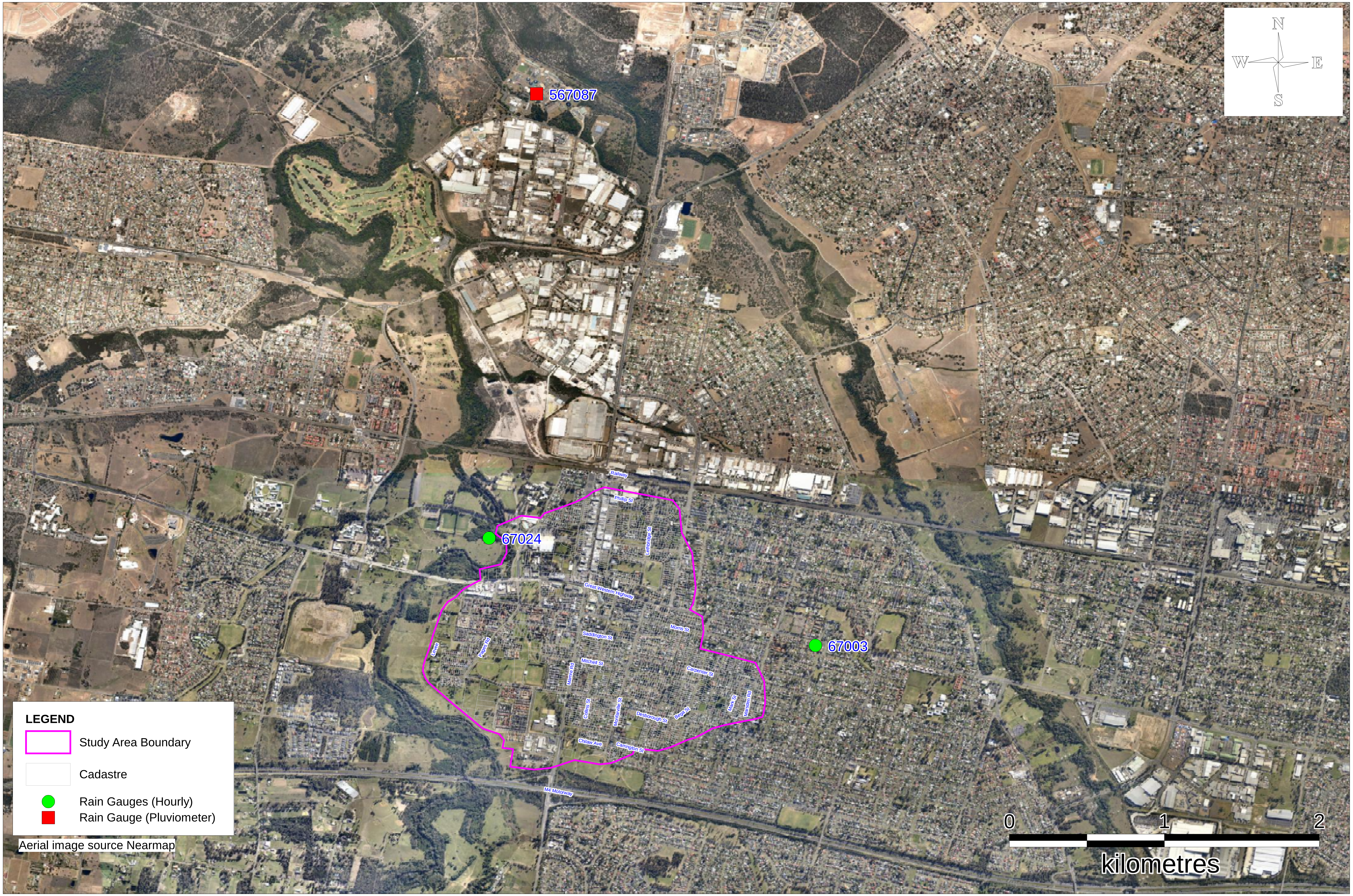

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FIGURE 2.3
RAIN GAUGES

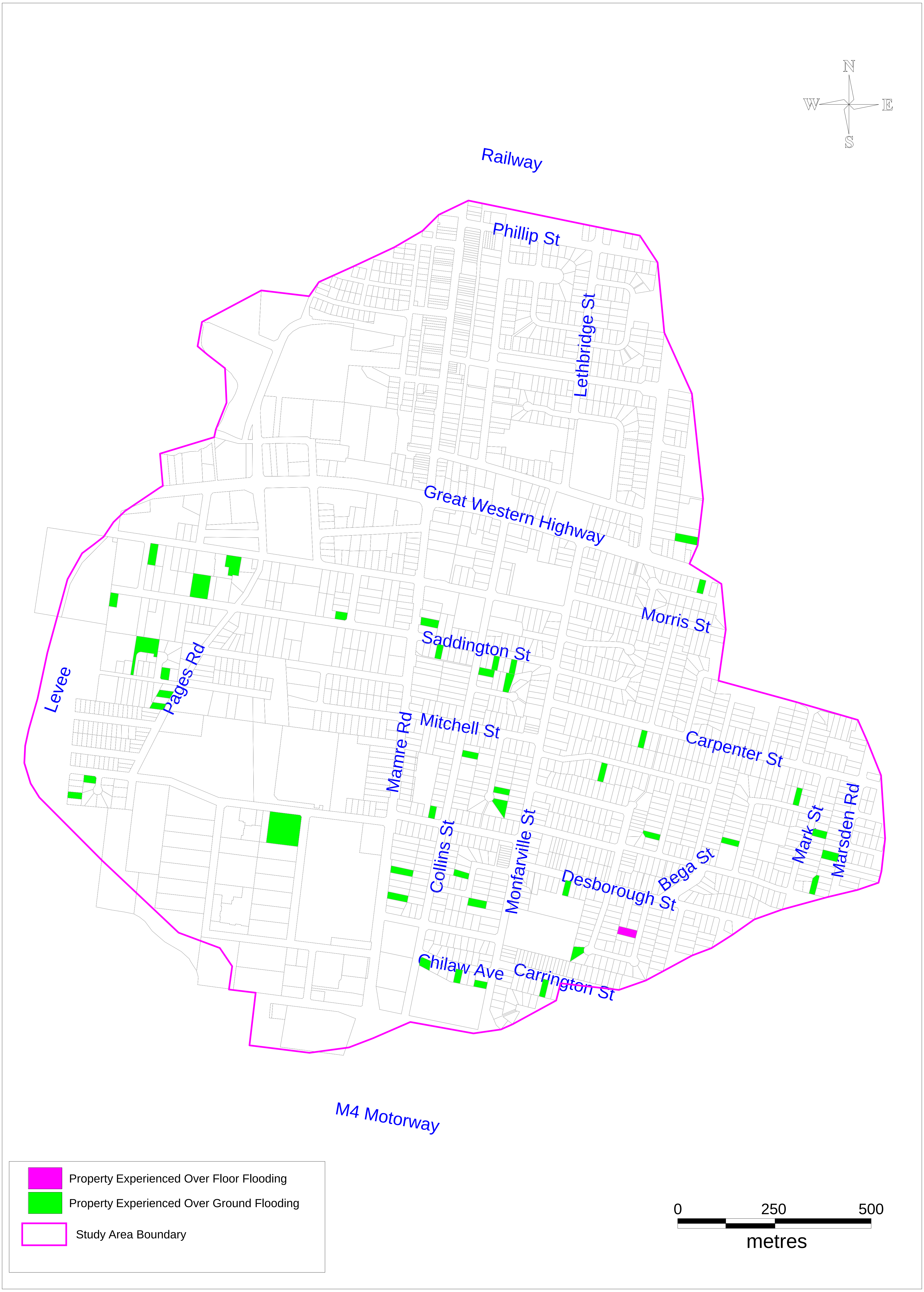
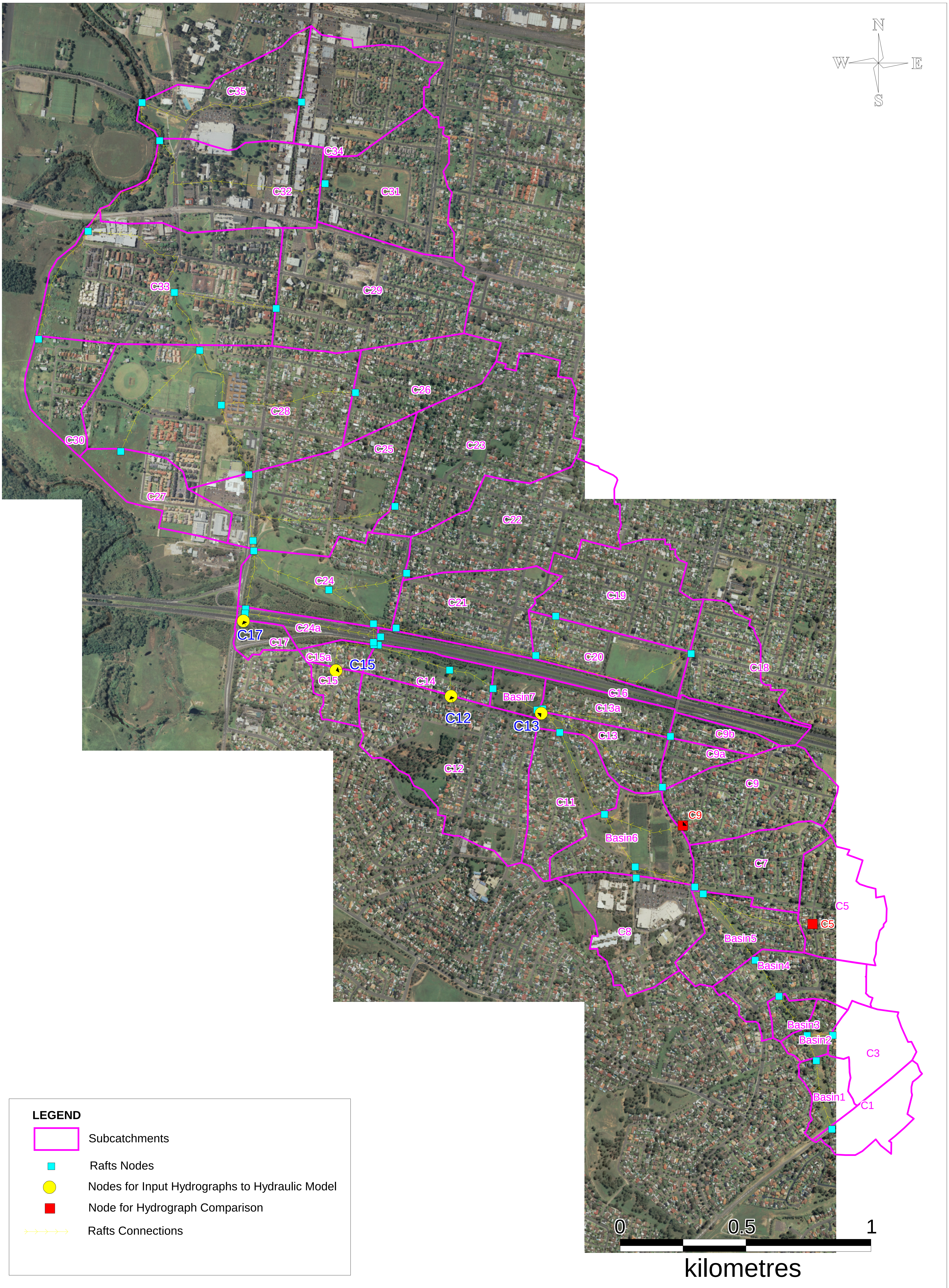


FIGURE 3.2
PROPERTIES EXPERIENCED FLOODING
FROM COMMUNITY SURVEY



LEGEND

Subcatchments

Rafts Nodes

Nodes for Input Hydrographs to Hydraulic Model

Node for Hydrograph Comparison

Rafts Connections

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FIGURE 5.1
ST MARYS RAFTS SUBCATCHMENT LAYOUT

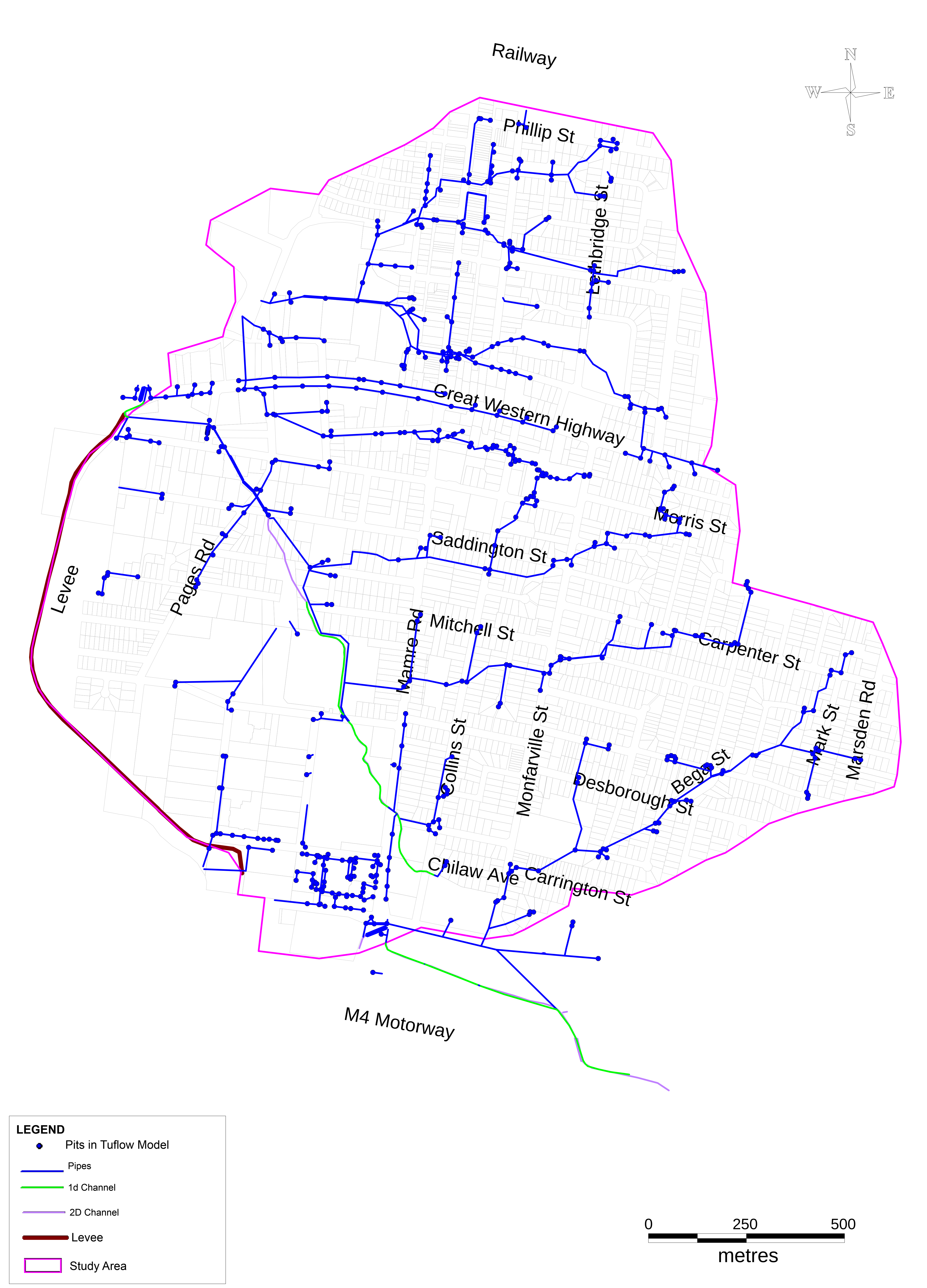
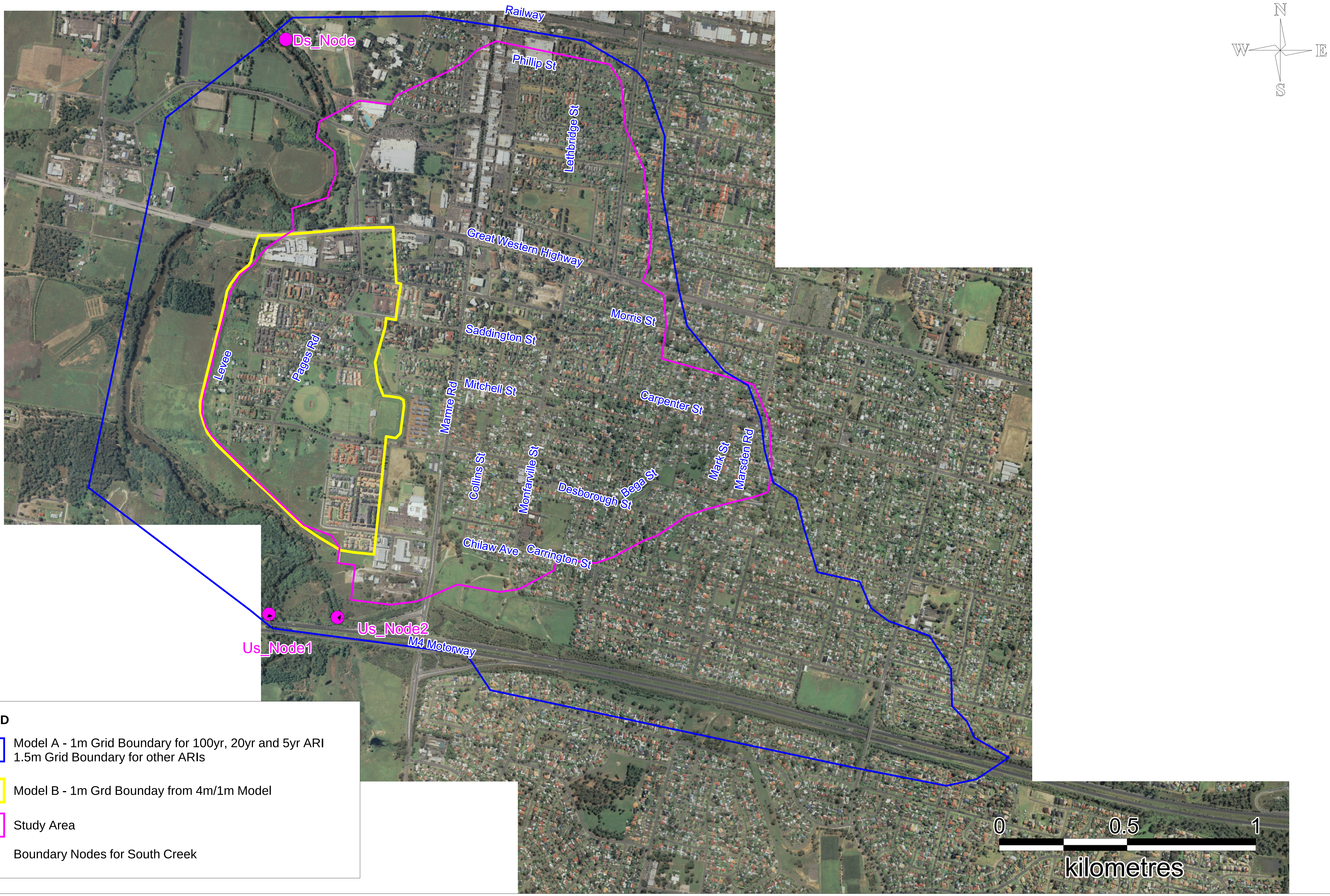


FIGURE 6.1
1D COMPONENTS OF HYDRAULIC MODEL



LEGEND

- Model A - 1m Grid Boundary for 100yr, 20yr and 5yr ARI 1.5m Grid Boundary for other ARIs
- Model B - 1m Grd Bounday from 4m/1m Model
- Study Area
- Boundary Nodes for South Creek

FIGURE 6.2
TUFLOW MODEL LAYOUT

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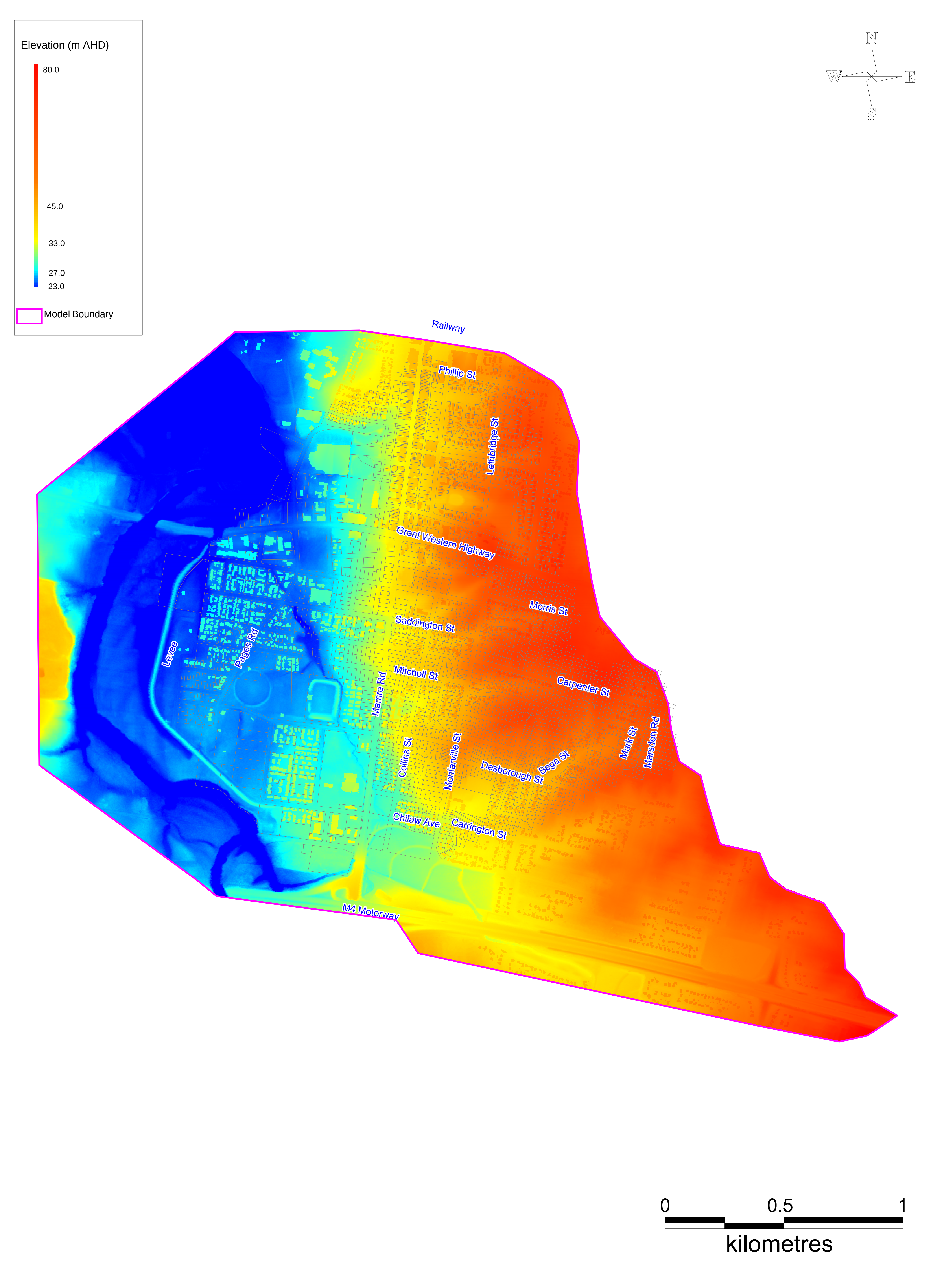

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FIGURE 6.3
MODEL TERRAIN

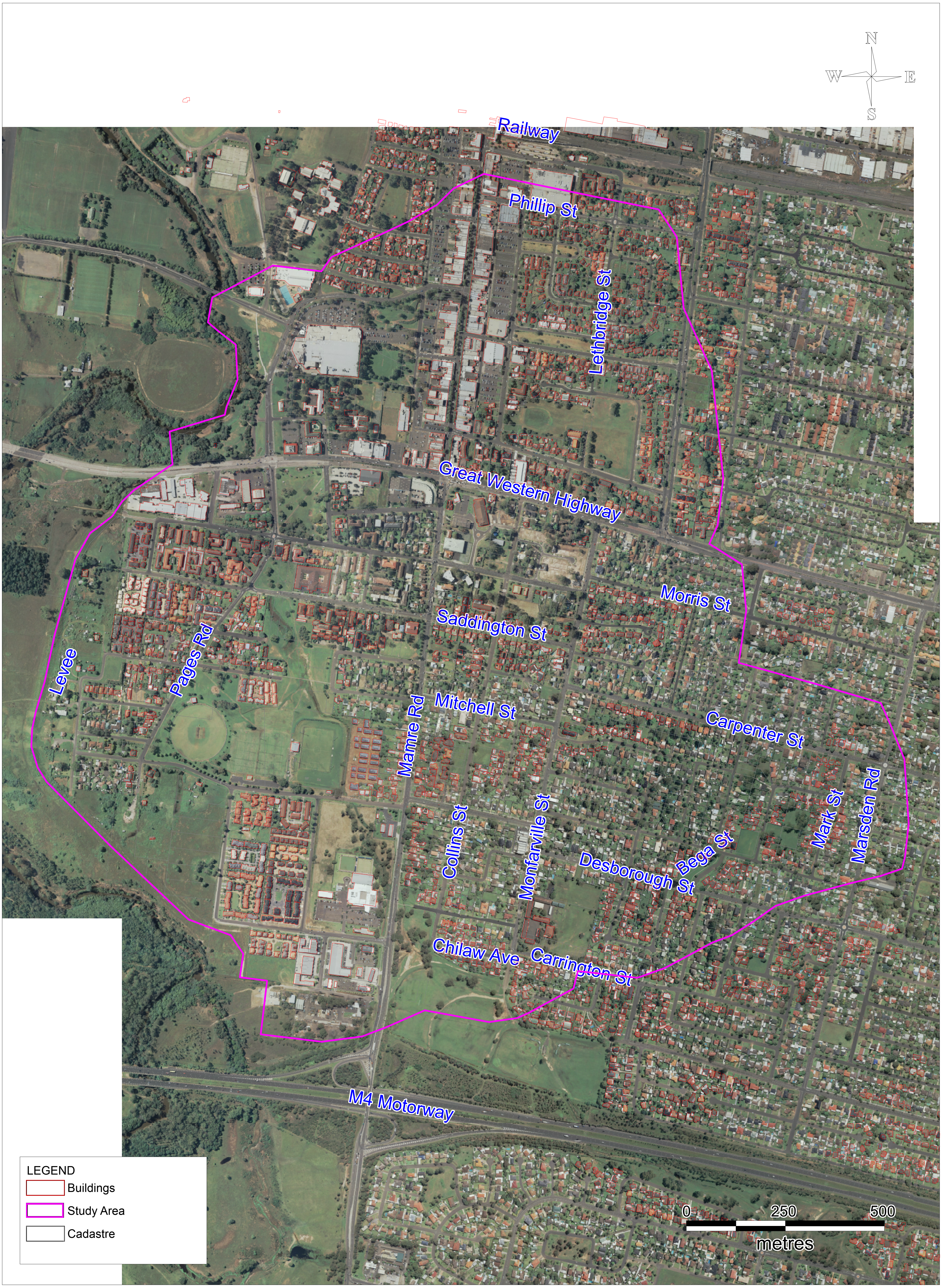

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FIGURE 6.4
BUILDINGS LAYOUT

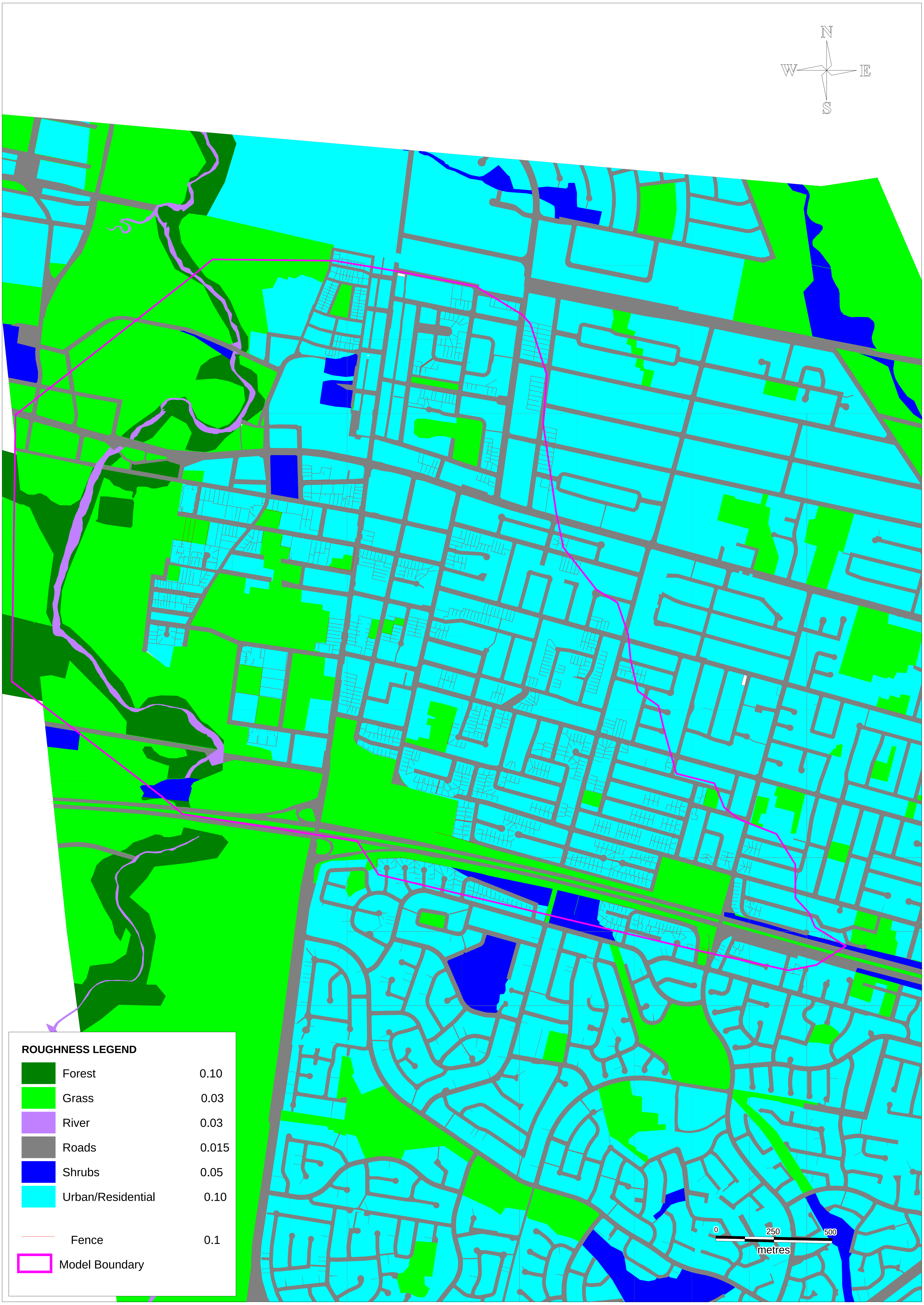

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FIGURE 6.5
2D ROUGHNESS MAPPING

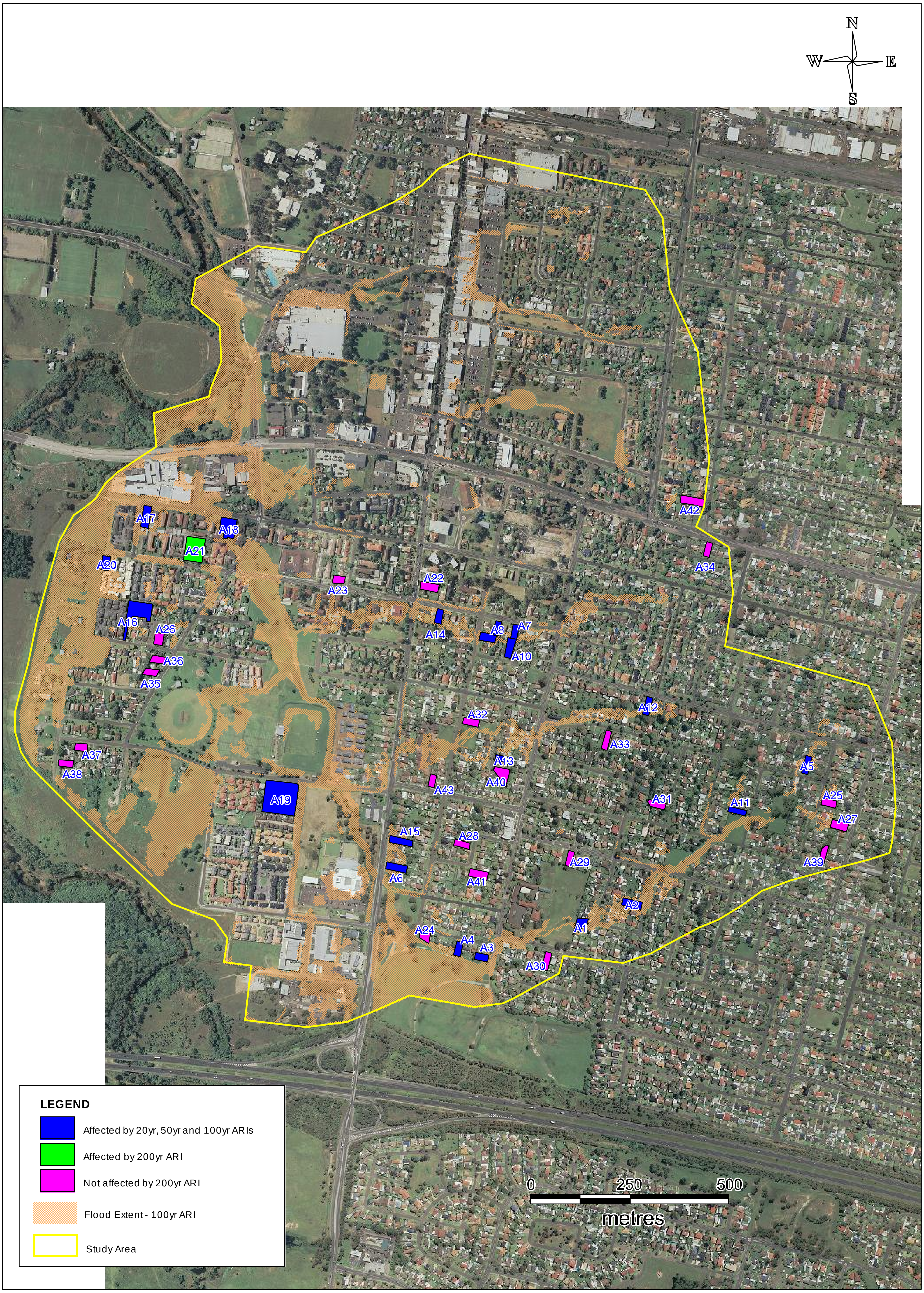

FIGURE 7.1
VALIDATION RESULTS

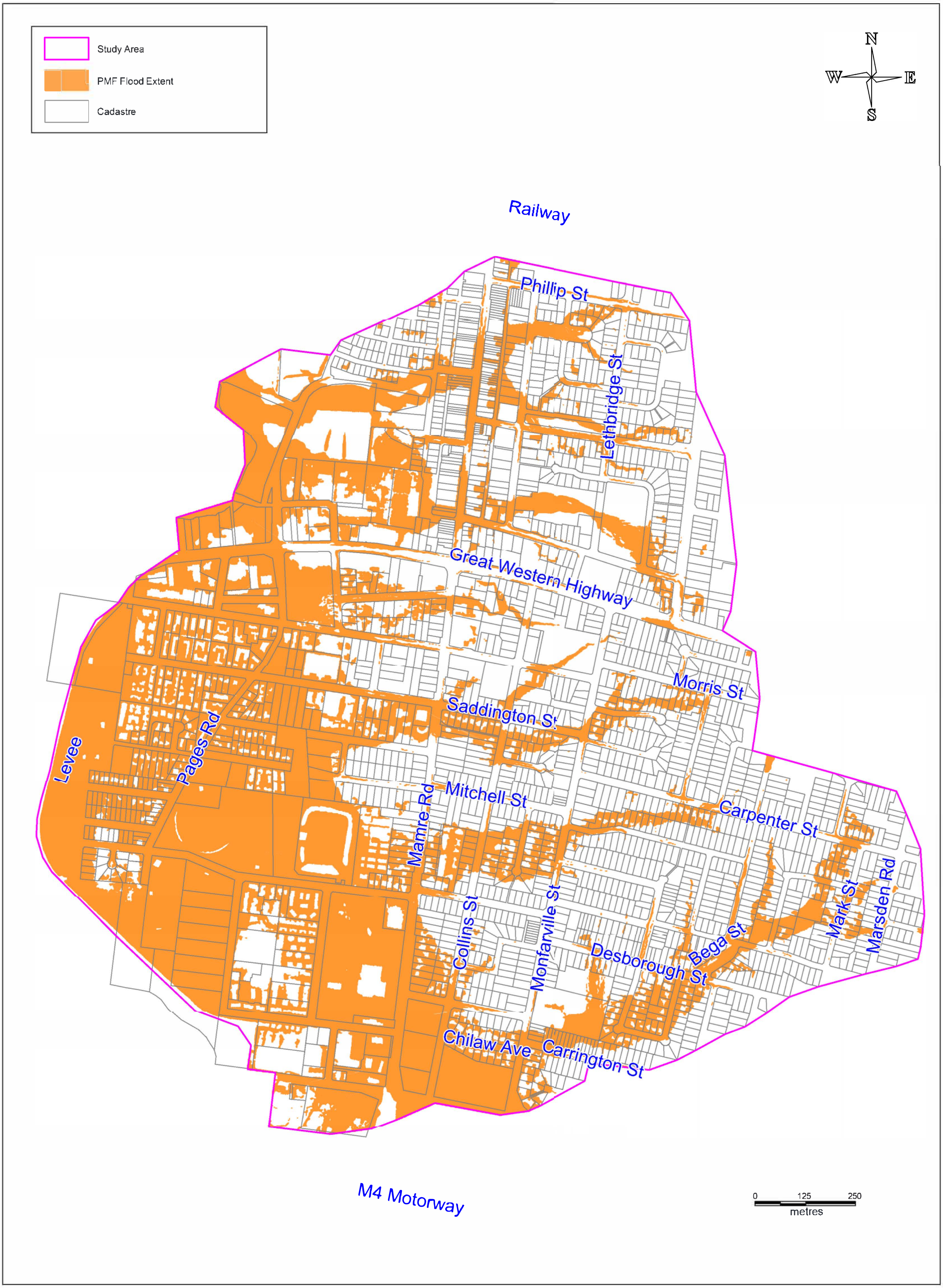

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FIGURE 8.1
PMF - FLOOD EXTENT

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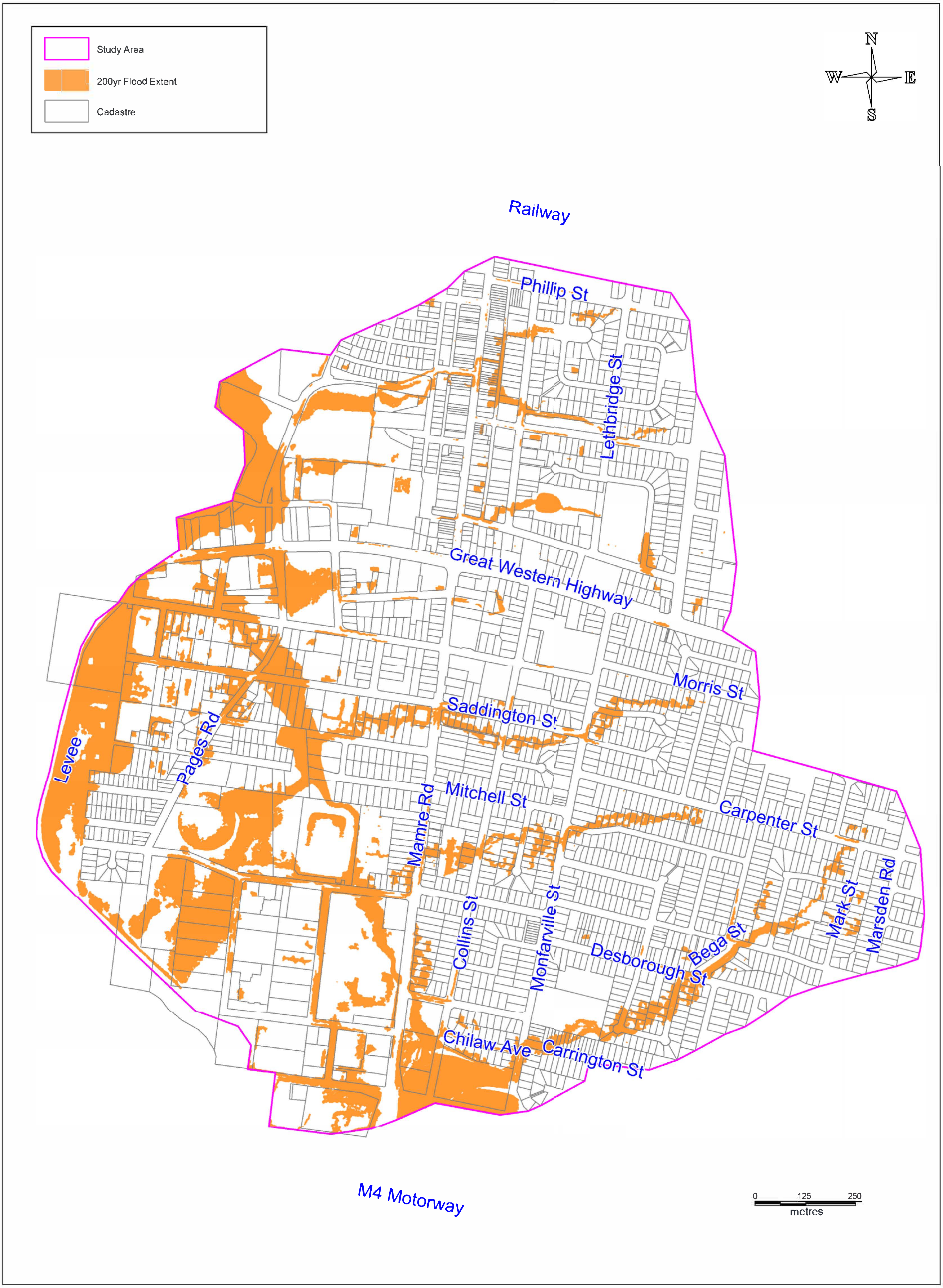

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FIGURE 8.2
200 YEAR ARI - FLOOD EXTENT

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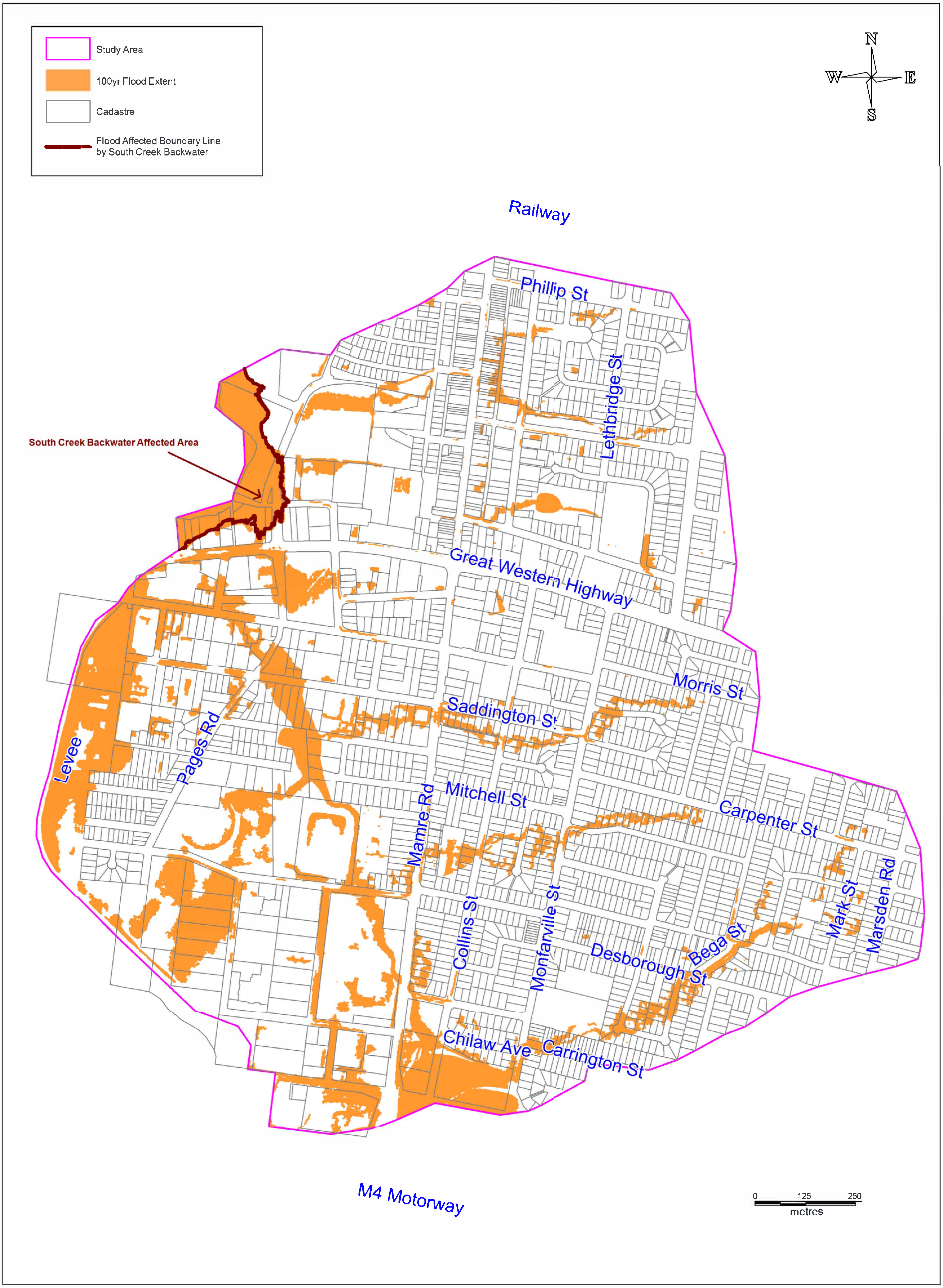

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FIGURE 8.3
100 YEAR ARI - FLOOD EXTENT

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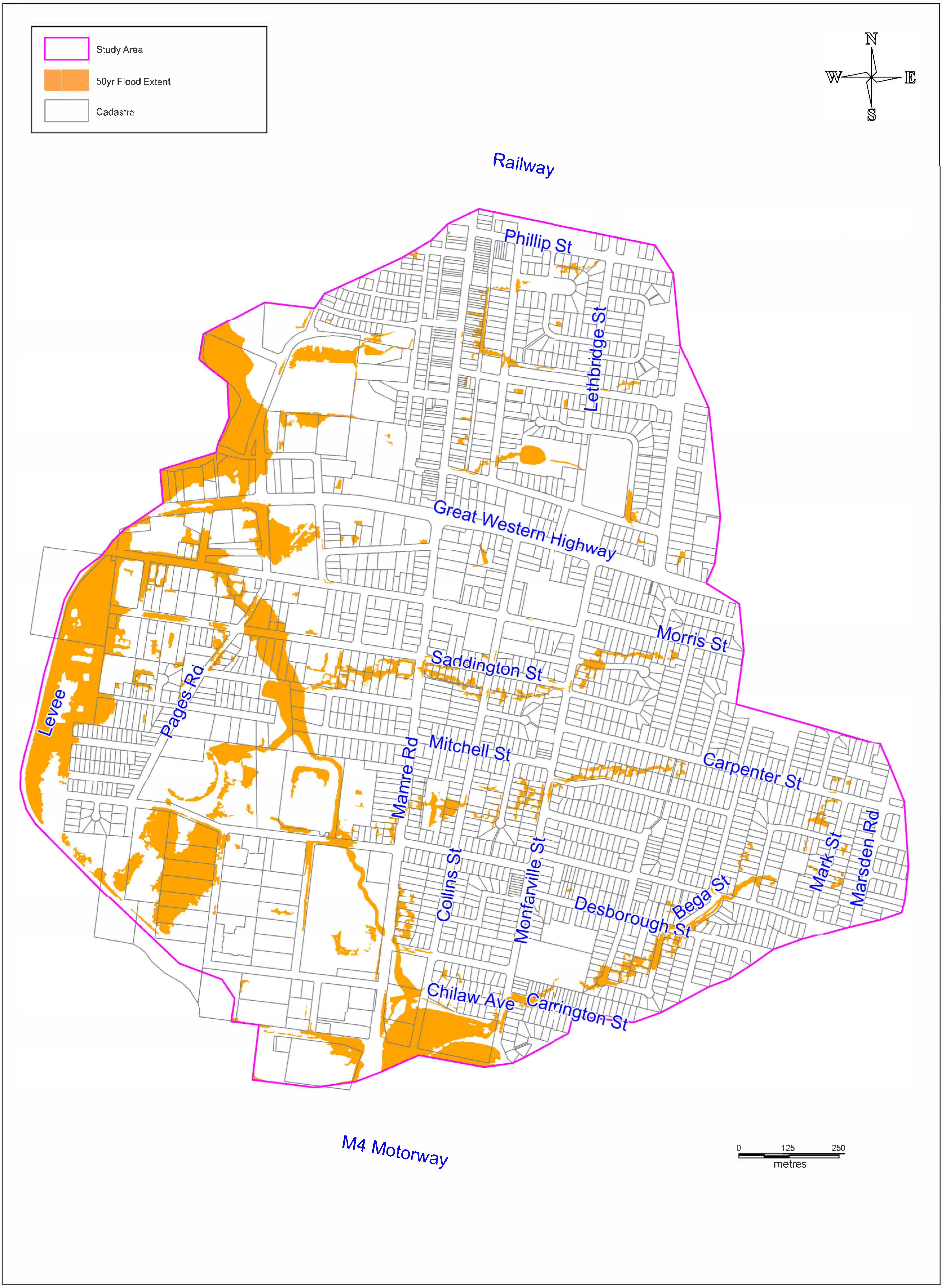

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FIGURE 8.4
50 YEAR ARI - FLOOD EXTENT

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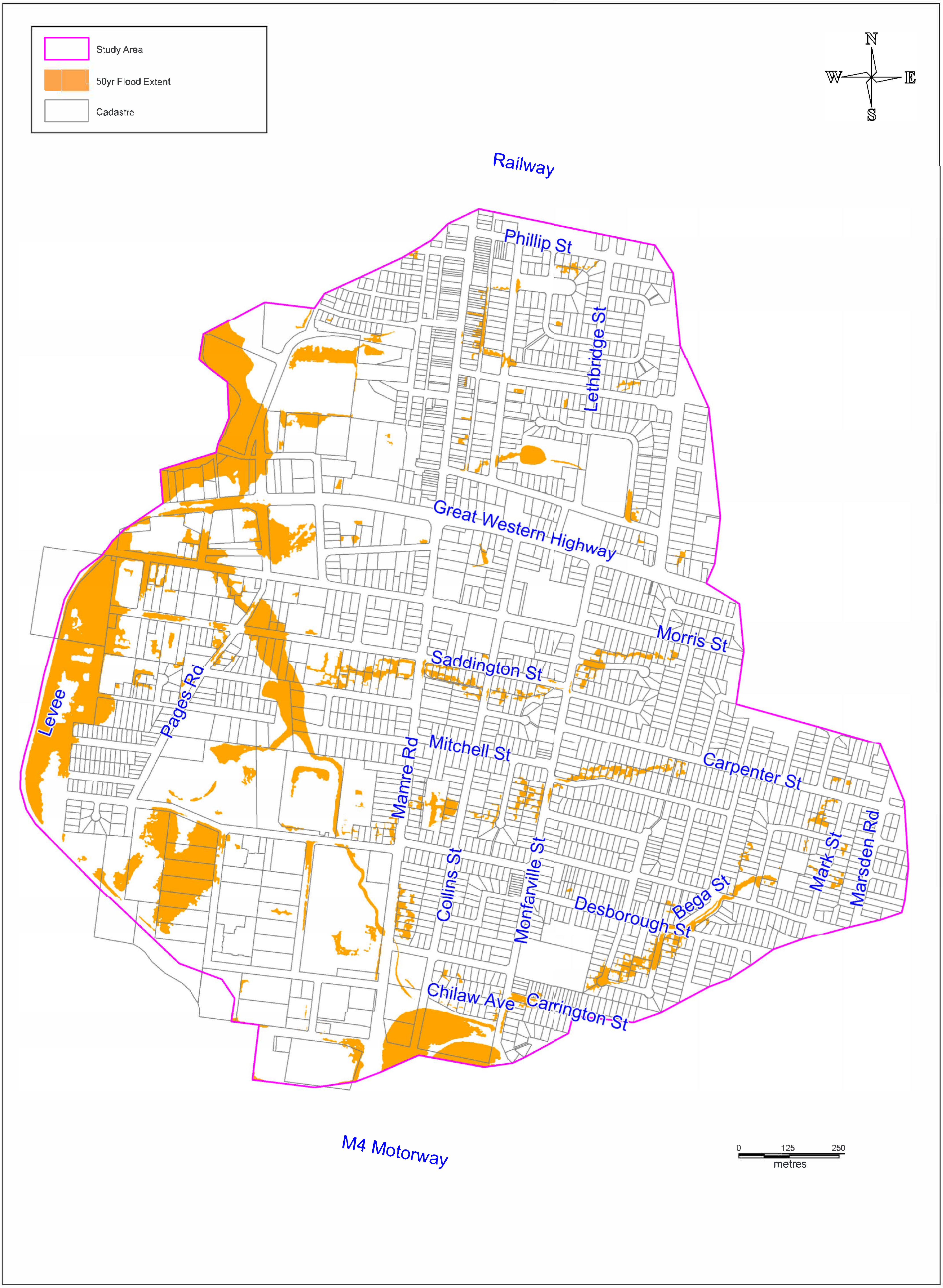

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FIGURE 8.5
20 YEAR ARI - FLOOD EXTENT

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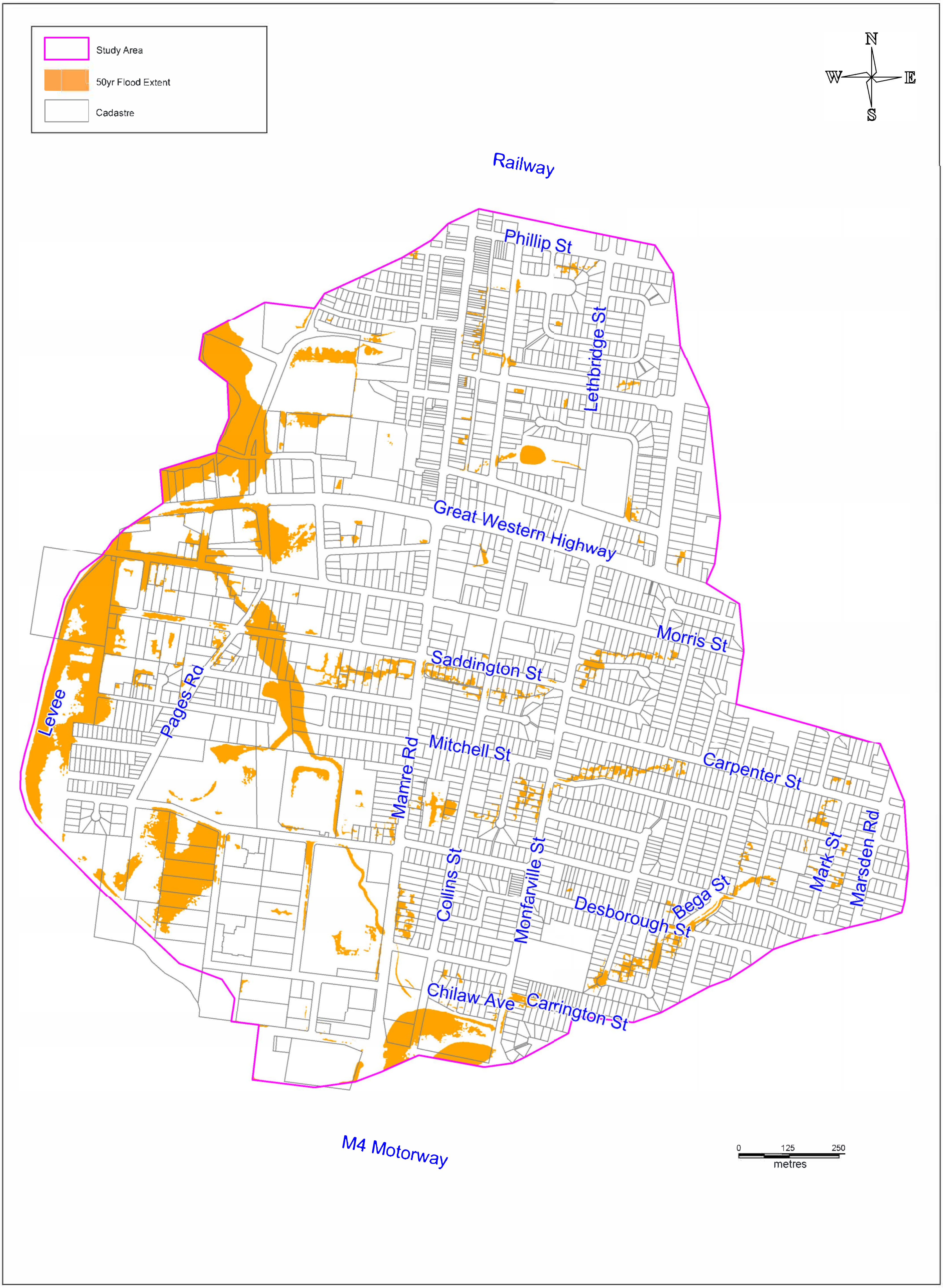

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FIGURE 8.6
10 YEAR ARI - FLOOD EXTENT

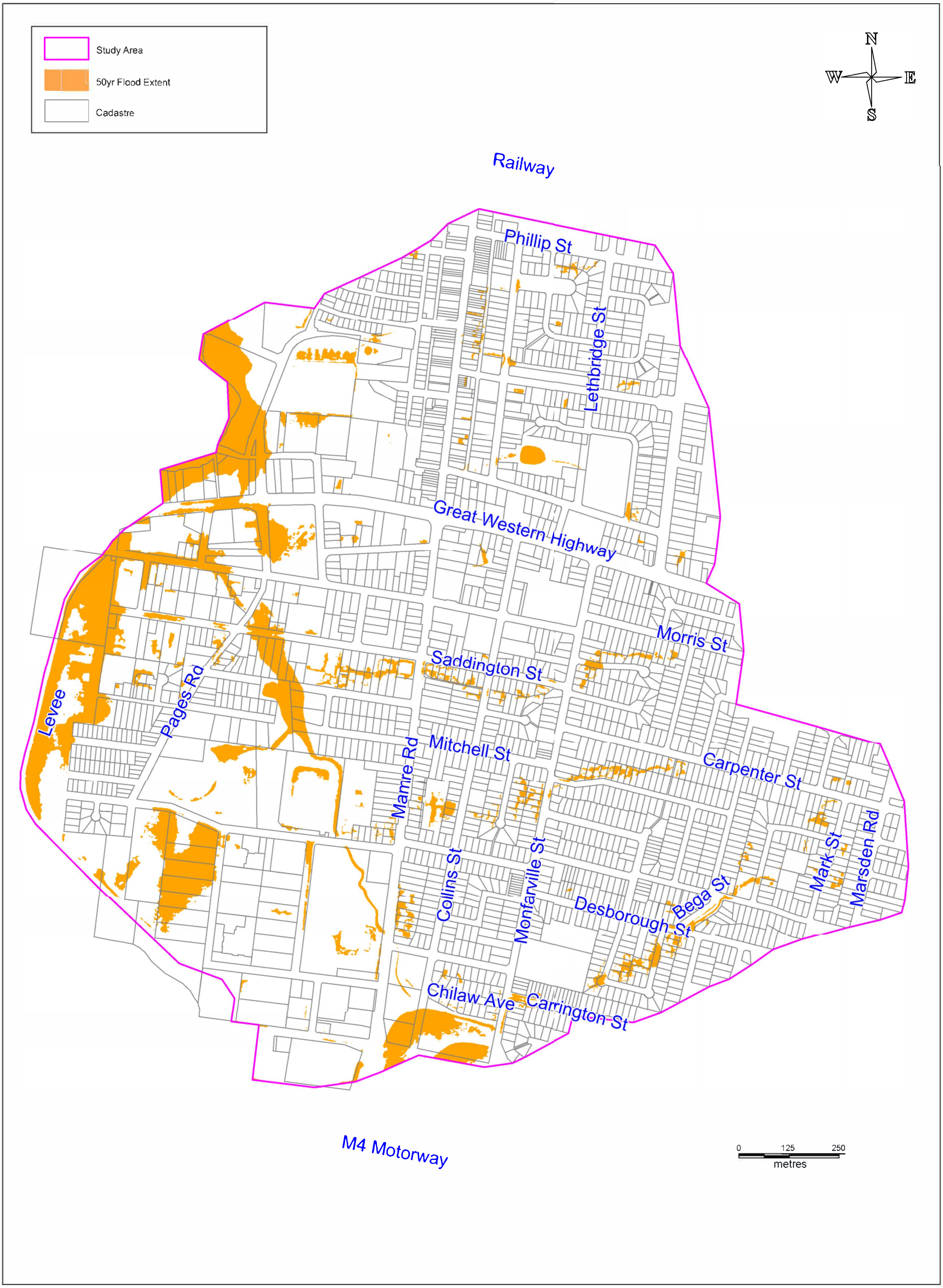

FIGURE 8.7
5 YEAR ARI - FLOOD EXTENT

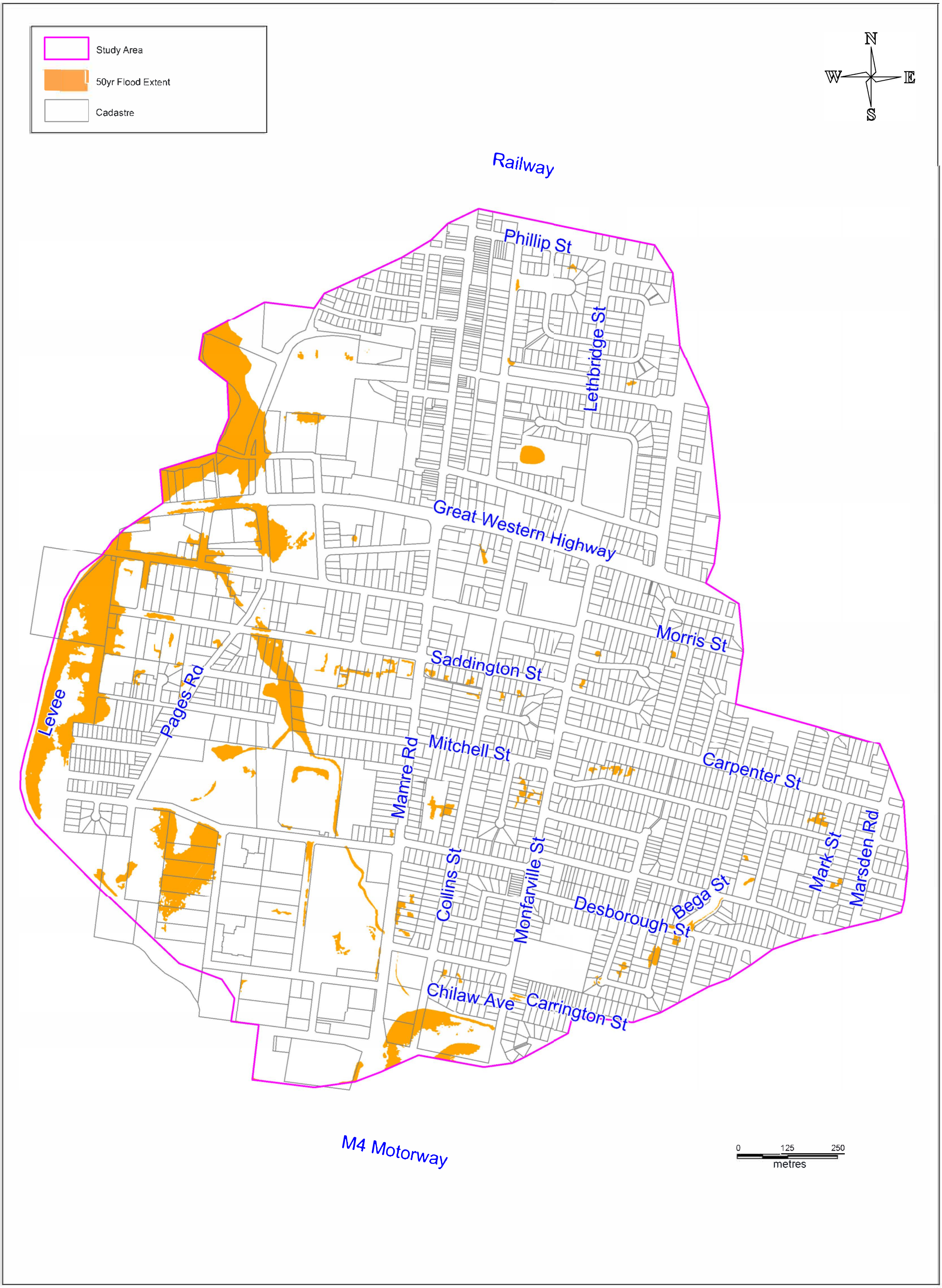

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FIGURE 8.8
2 YEAR ARI - FLOOD EXTENT

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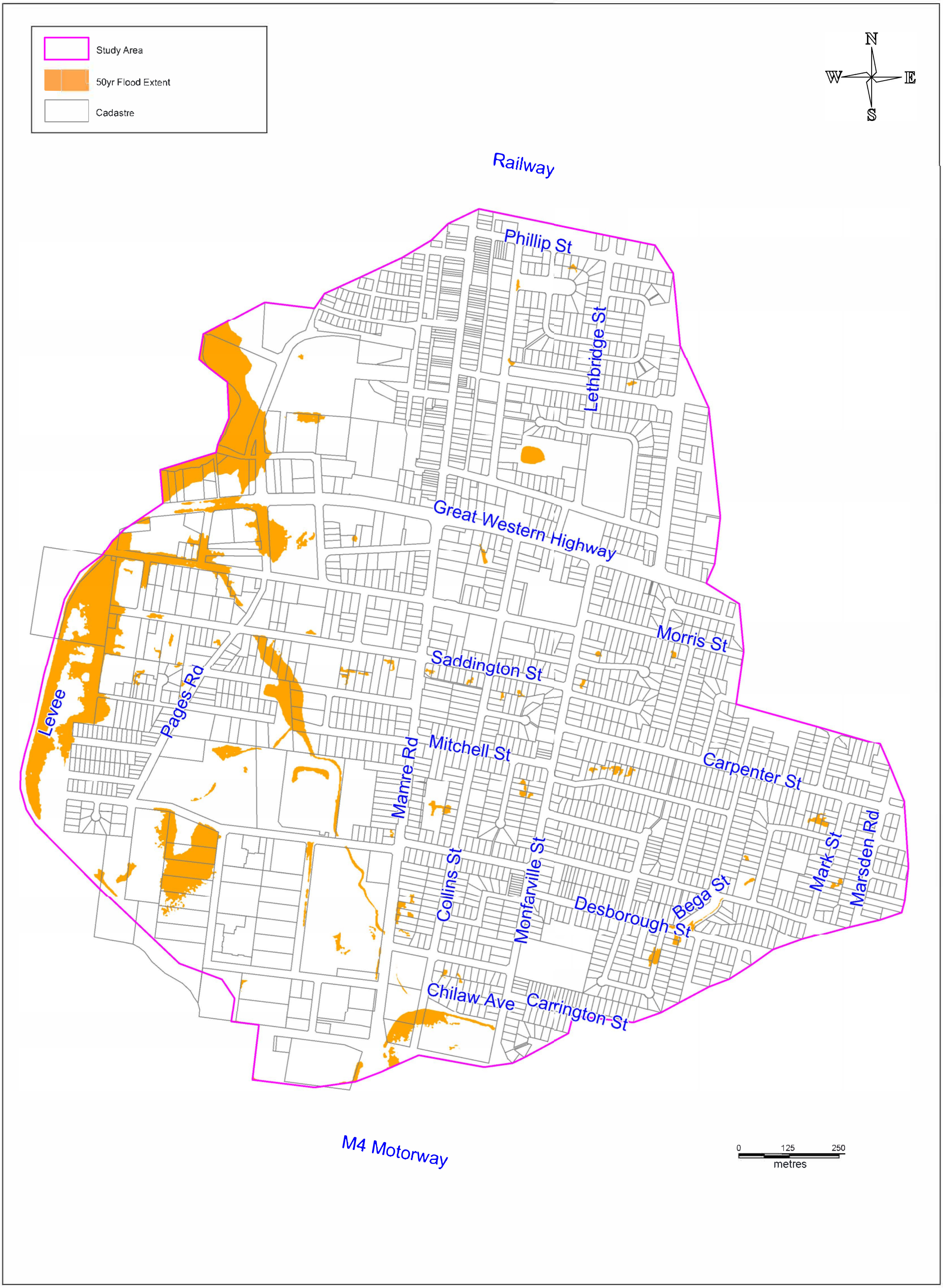

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FIGURE 8.9
1 YEAR ARI - FLOOD EXTENT

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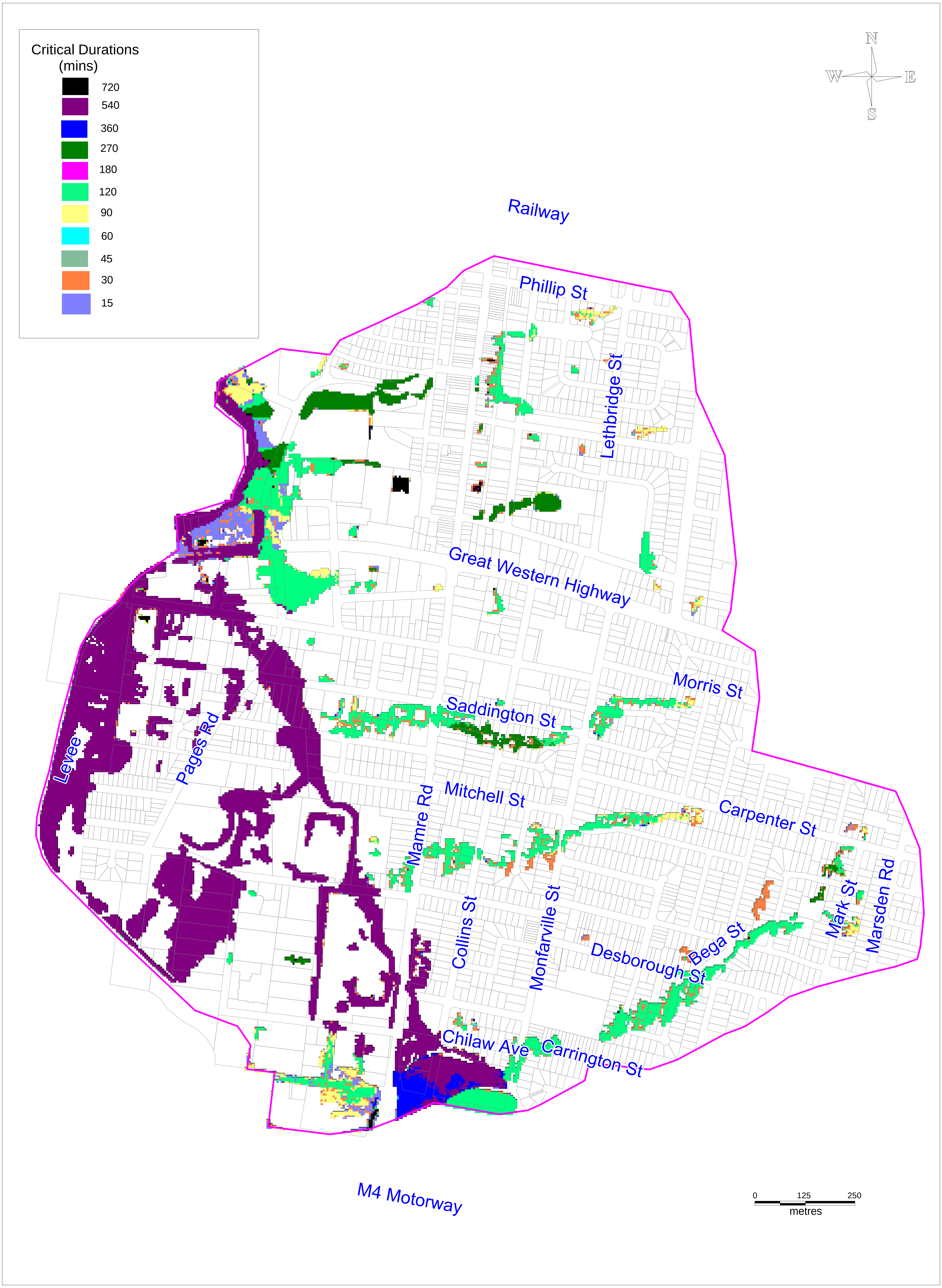

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FIGURE 8.10
CRITICAL DURATIONS - 100 YEAR ARI

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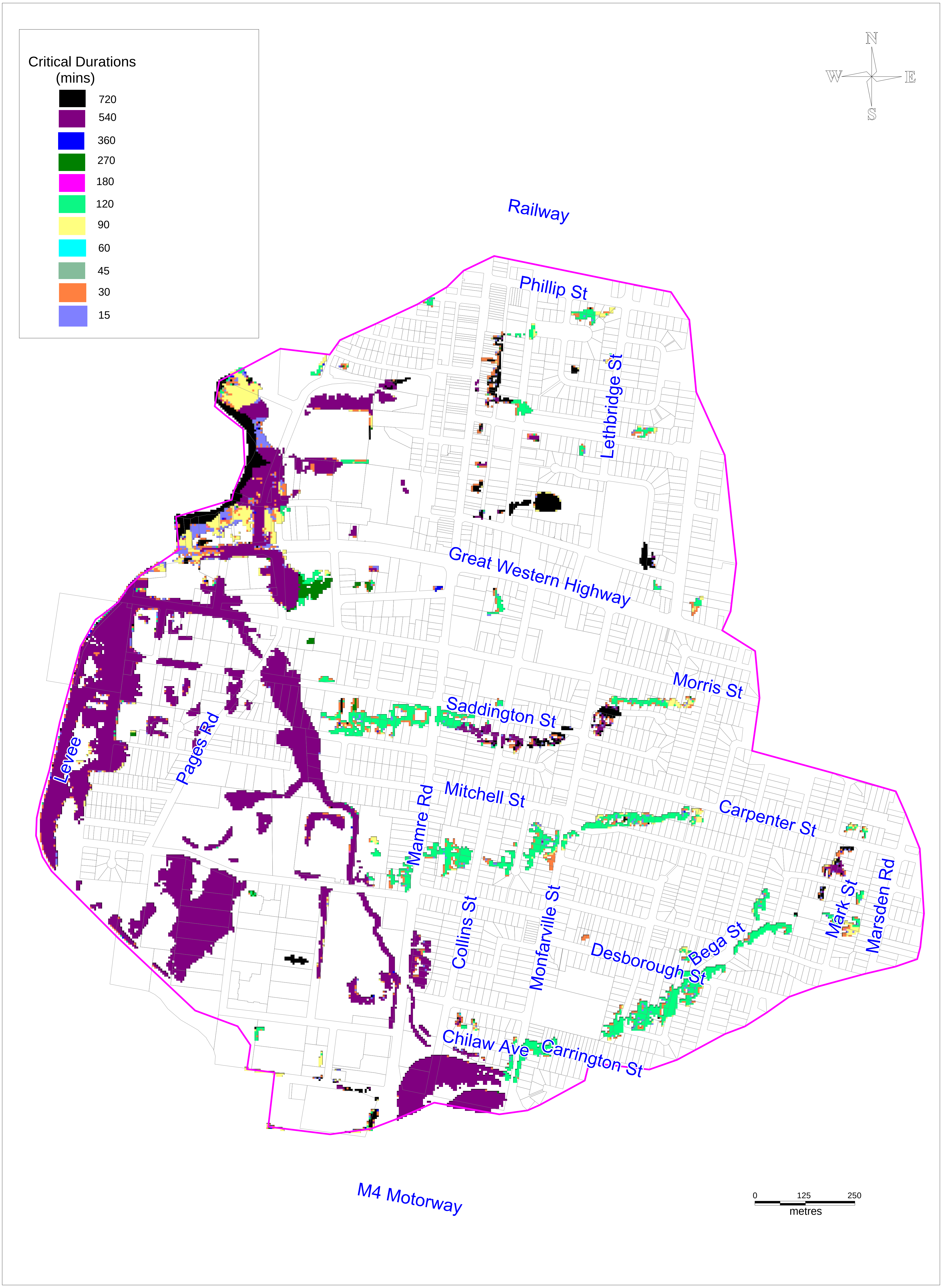

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FIGURE 8.11
CRITICAL DURATIONS - 5 YEAR ARI

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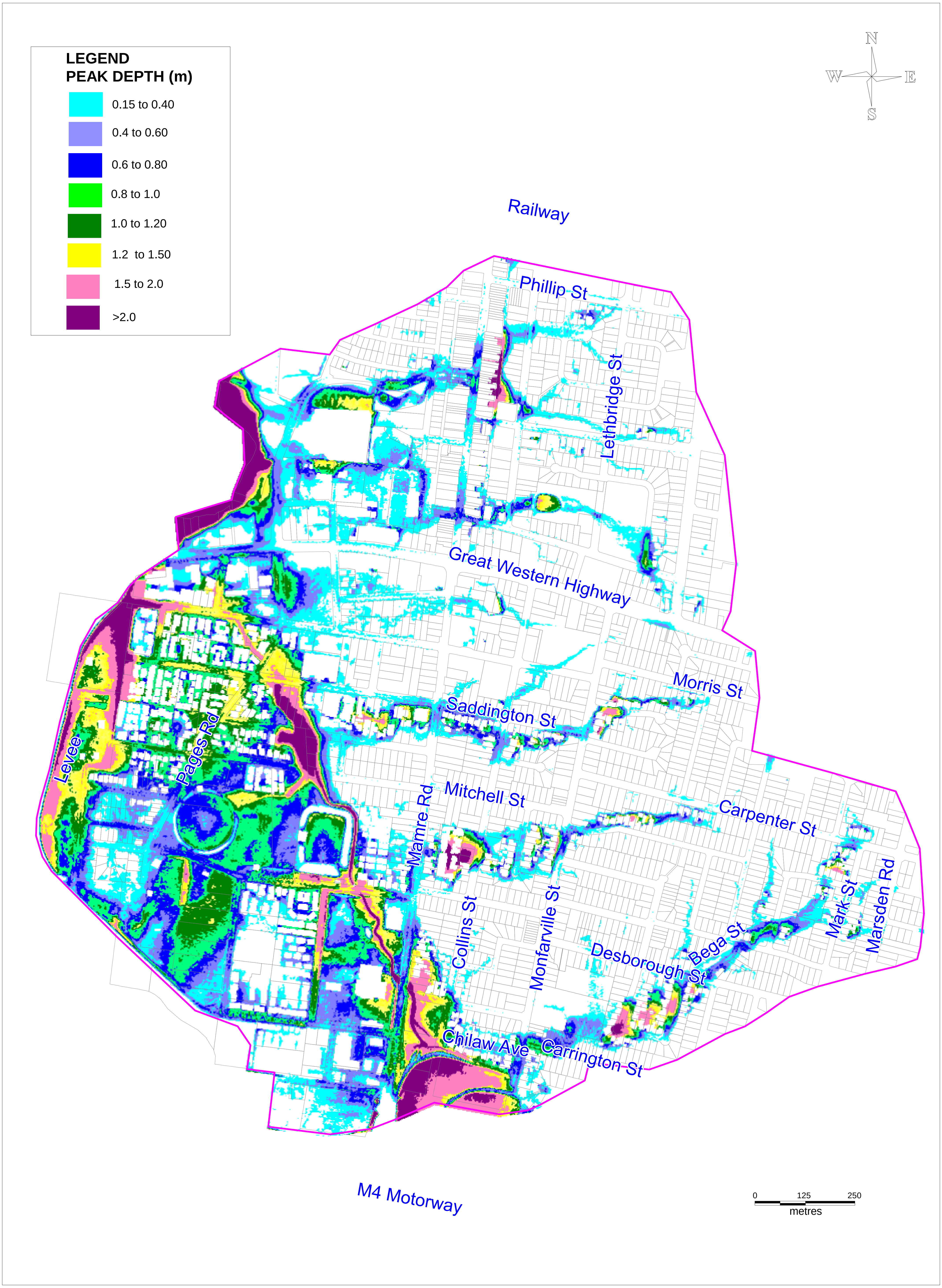

FIGURE 8.12
PMF - FLOOD DEPTHS

St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study

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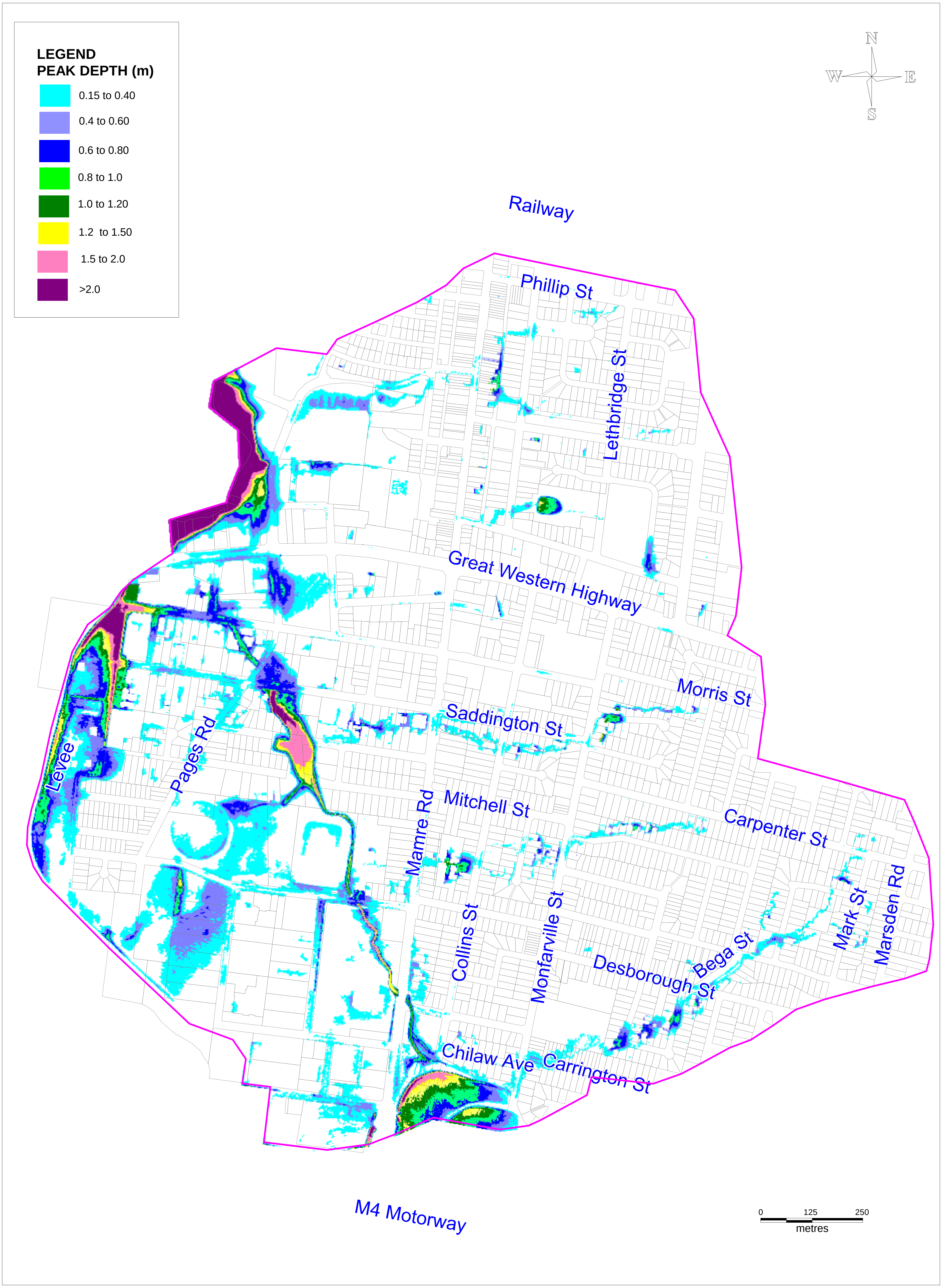
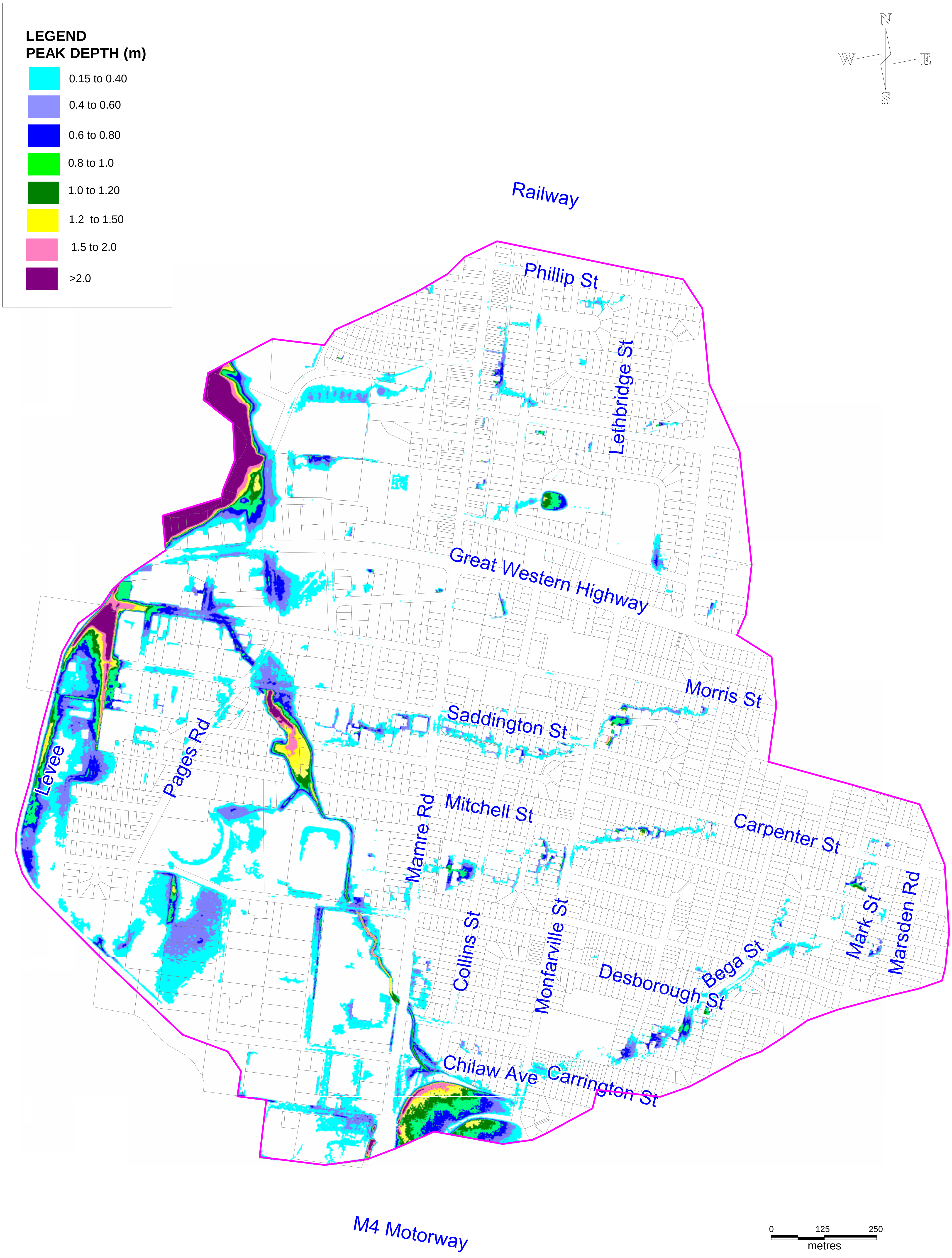


FIGURE 8.13
200 YEAR ARI - PEAK FLOOD DEPTHS



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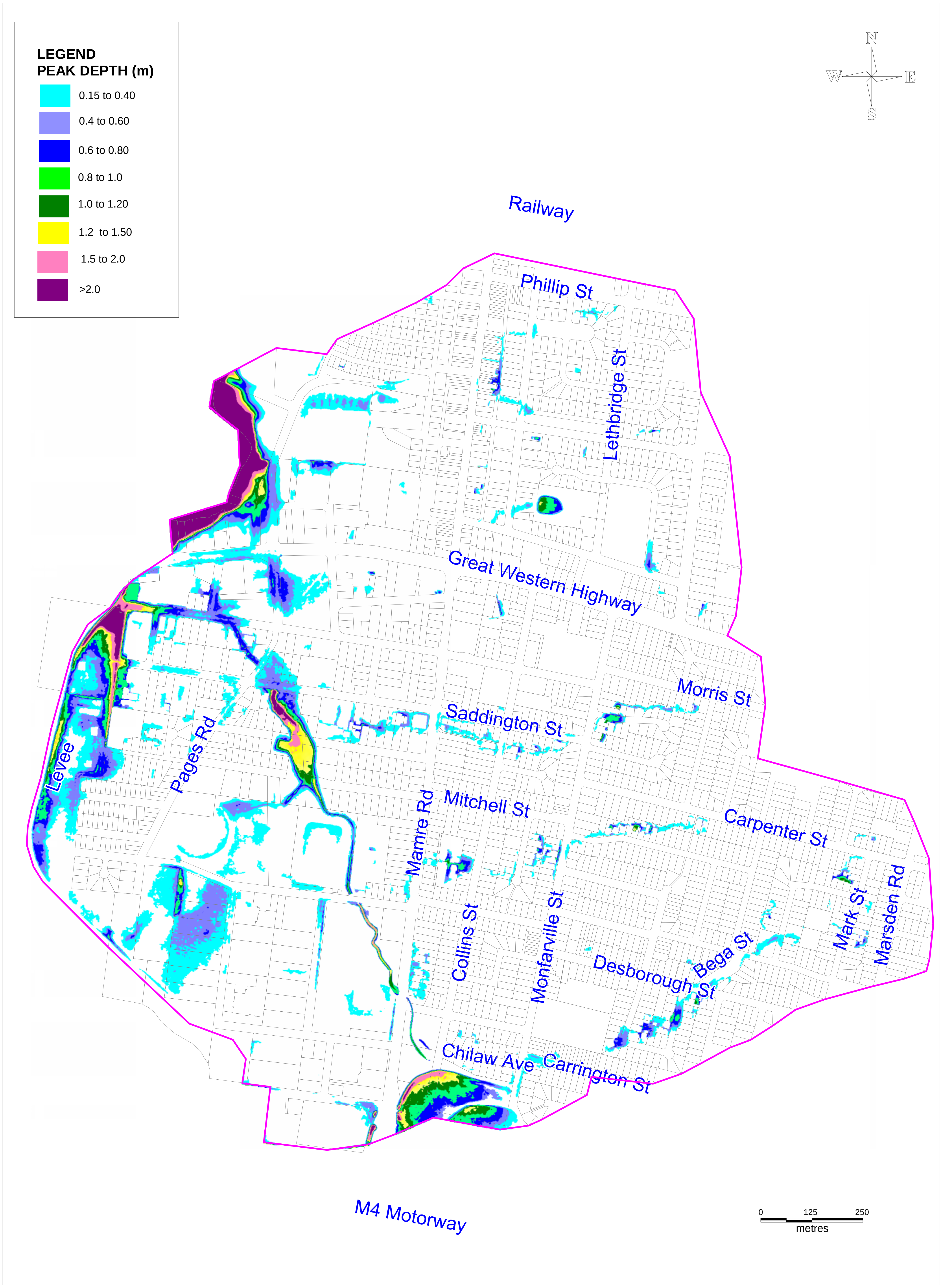
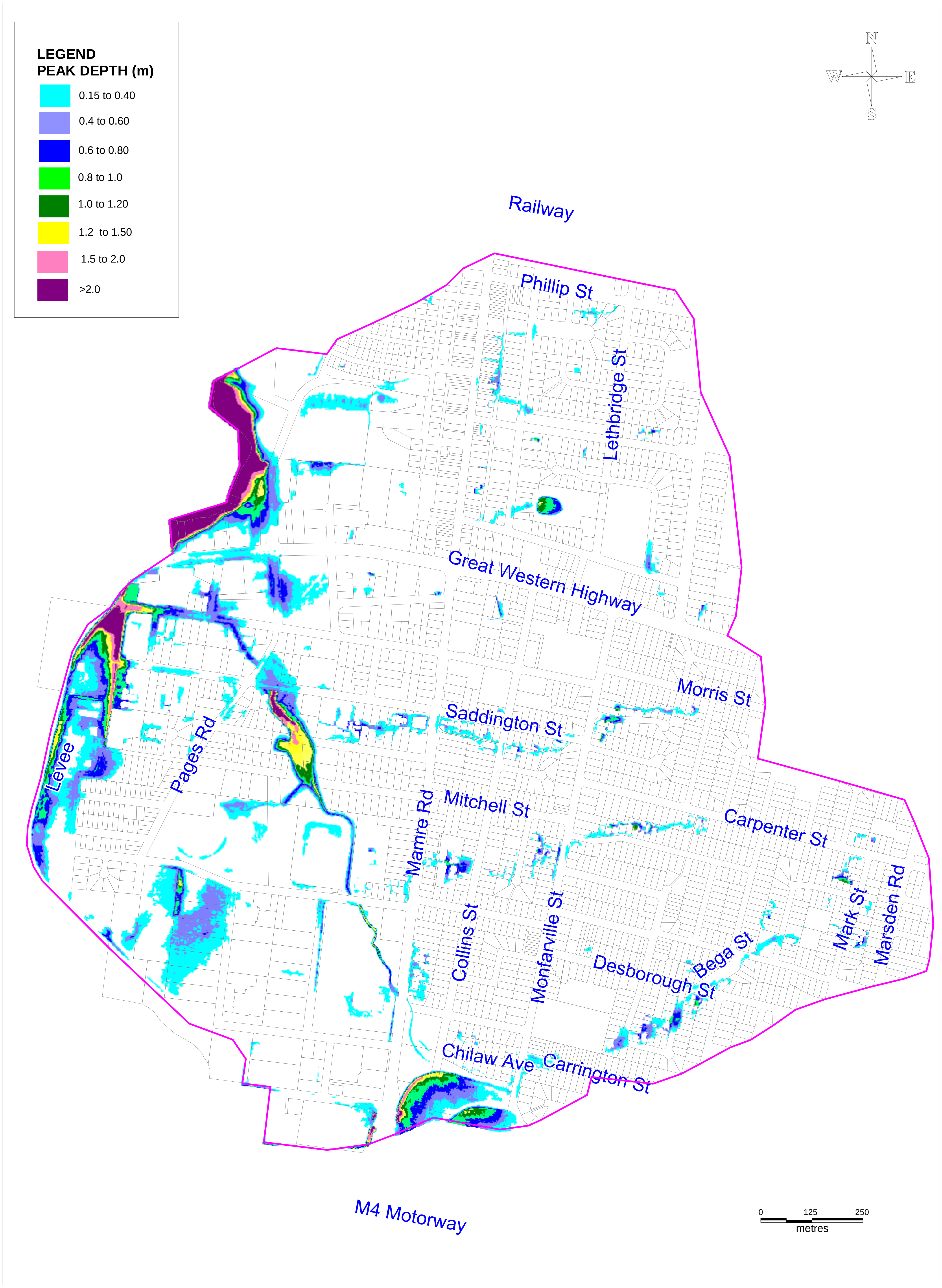
St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study

FIGURE 8.14
100 YEAR ARI - PEAK FLOOD DEPTHS



LEGEND
PEAK DEPTH (m)
0.15 to 0.40
0.4 to 0.60
0.6 to 0.80
0.8 to 1.0
1.0 to 1.20
1.2 to 1.50
1.5 to 2.0
>2.0
N
W
E
S
Railway
Phillip St
Lethbridge St
Great Western Highway
Morris St
Saddington St
Levee
Pages Rd
Mamre Rd
Mitchell St
Carpenter St
Collins St
Monfarville St
Mark St
Marsden Rd
Bega St
Desborough St
Chilaw Ave
Carrington St
M4 Motorway
0
125
250
metres



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St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study

FIGURE 8.16
20 YEAR ARI - PEAK FLOOD DEPTHS

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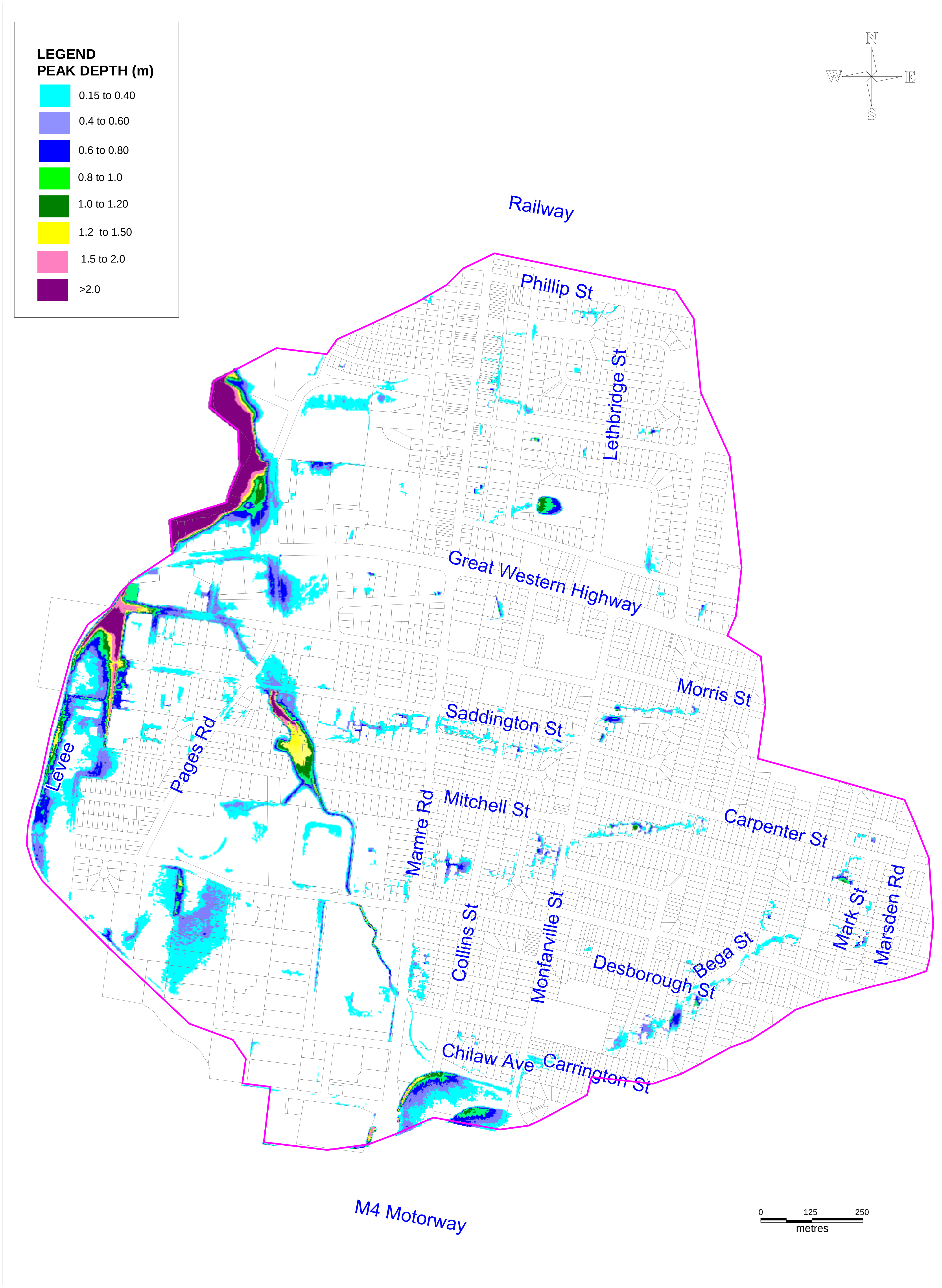

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St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study

FIGURE 8.17
10 YEAR ARI - PEAK FLOOD DEPTHS

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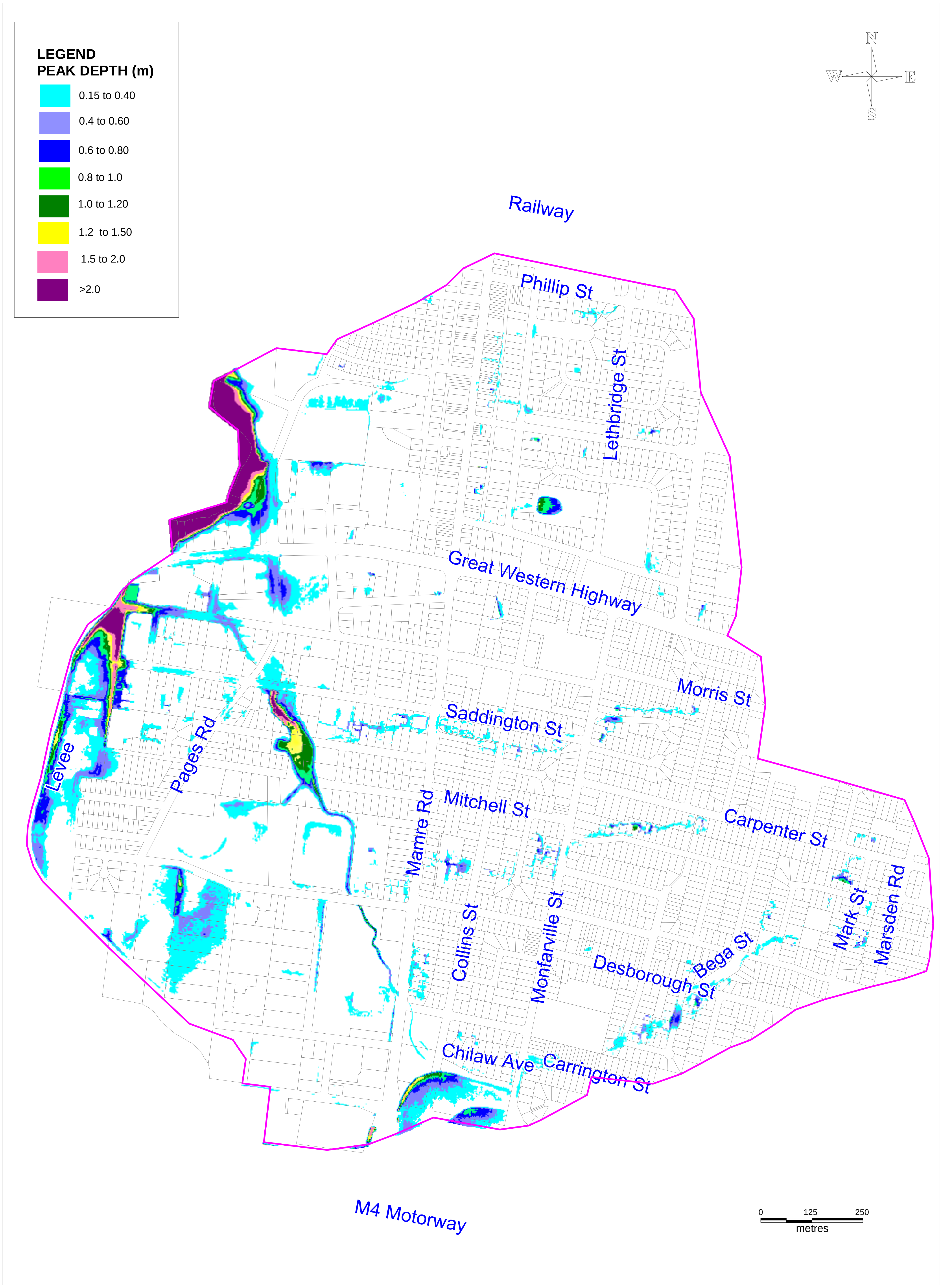

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FIGURE 8.18
5 YEAR ARI - PEAK FLOOD DEPTHS

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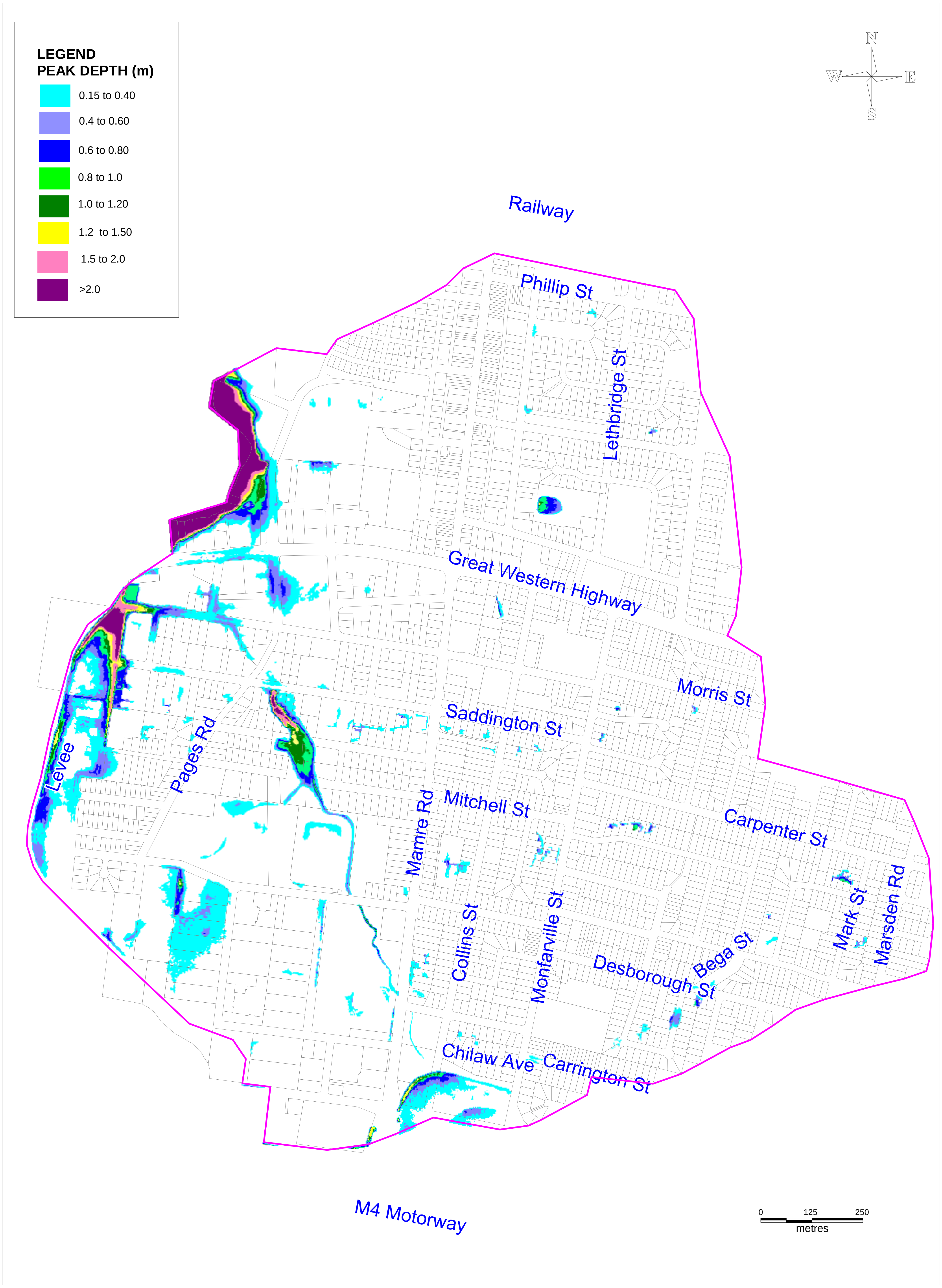

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FIGURE 8.19
2 YEAR ARI - PEAK FLOOD DEPTHS

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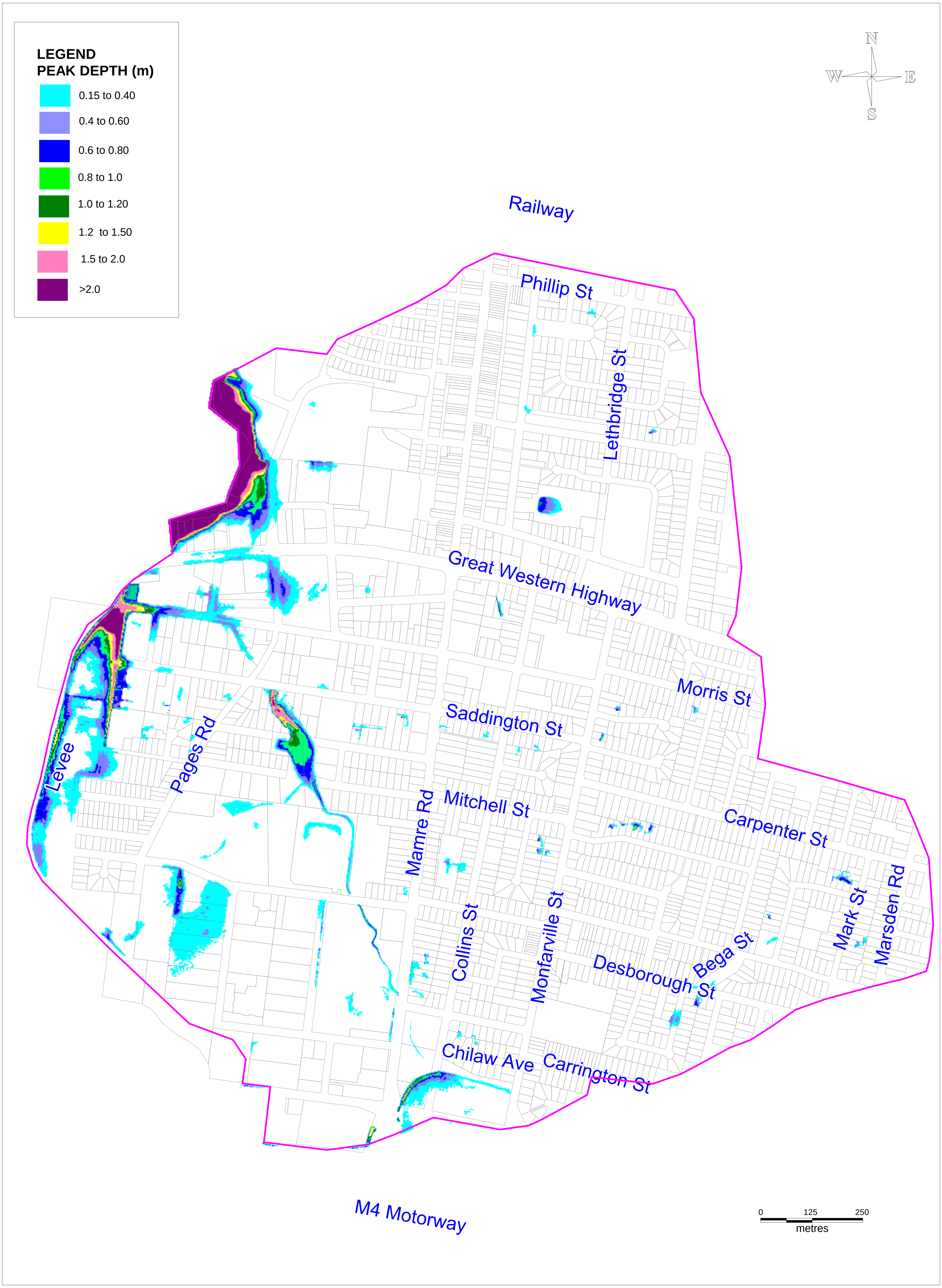

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FIGURE 8.20
1 YEAR ARI - PEAK FLOOD DEPTHS

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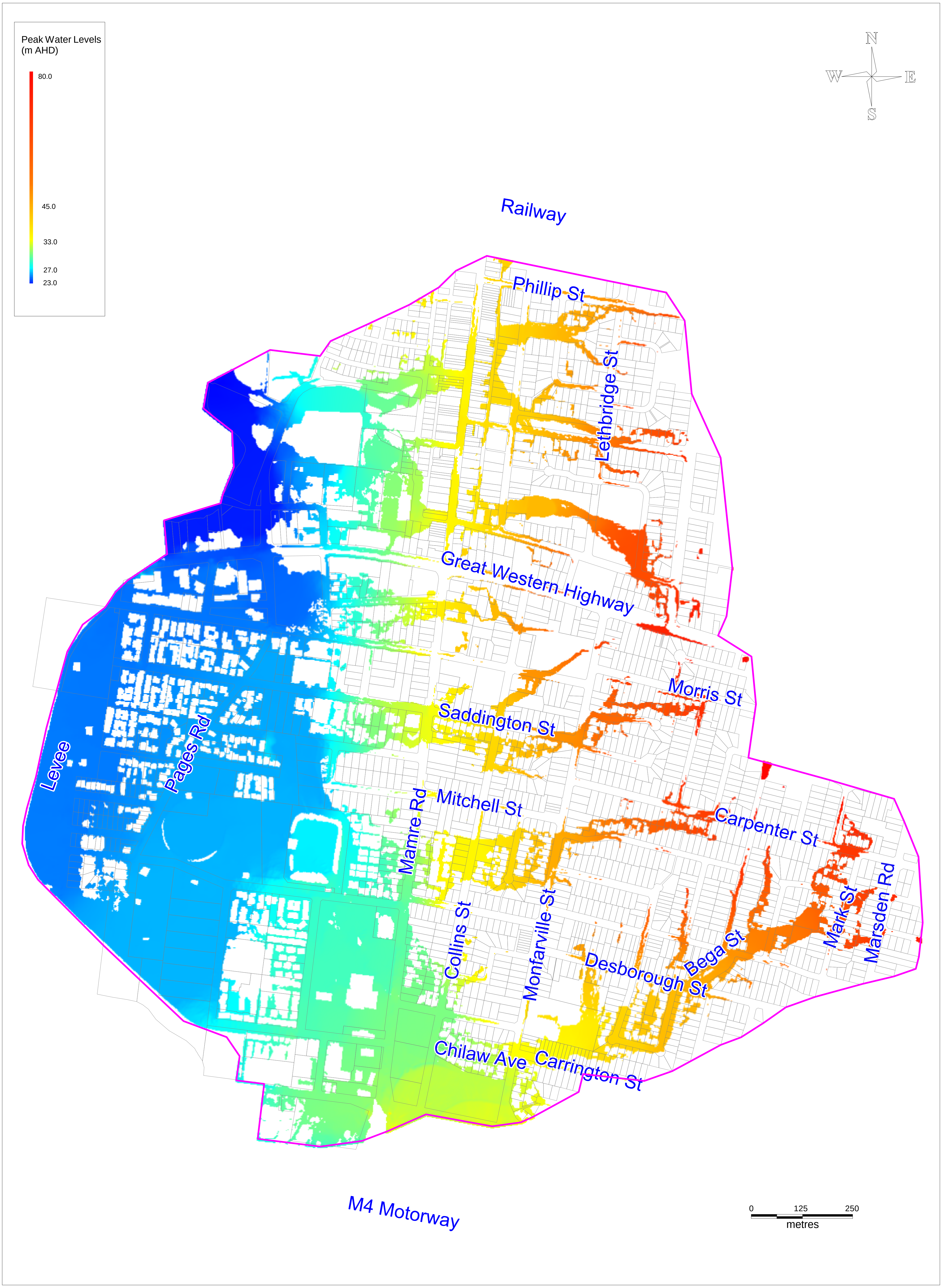

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St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study

FIGURE 8.21
PMF - PEAK FLOOD WATER LEVELS

W4735
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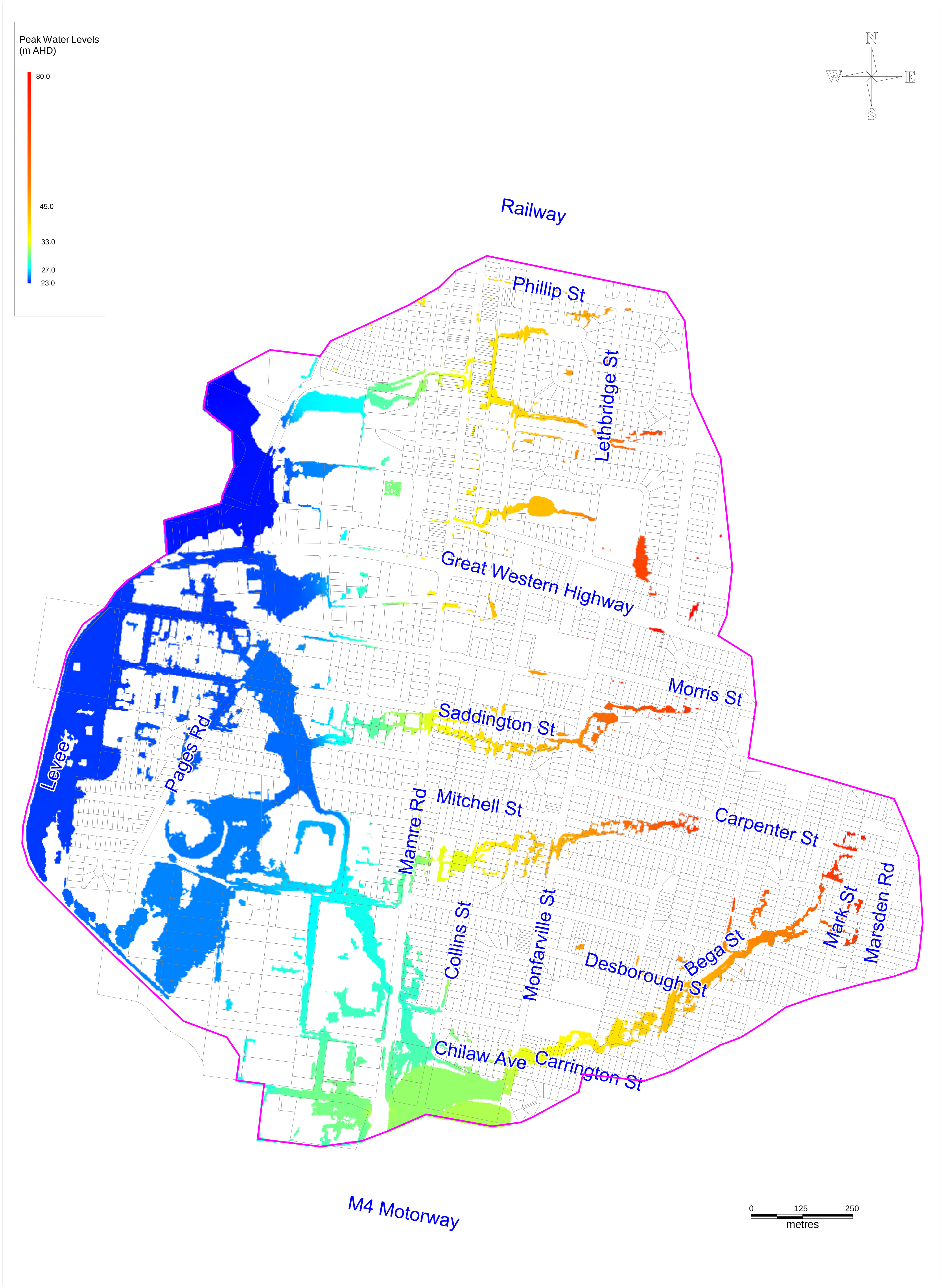

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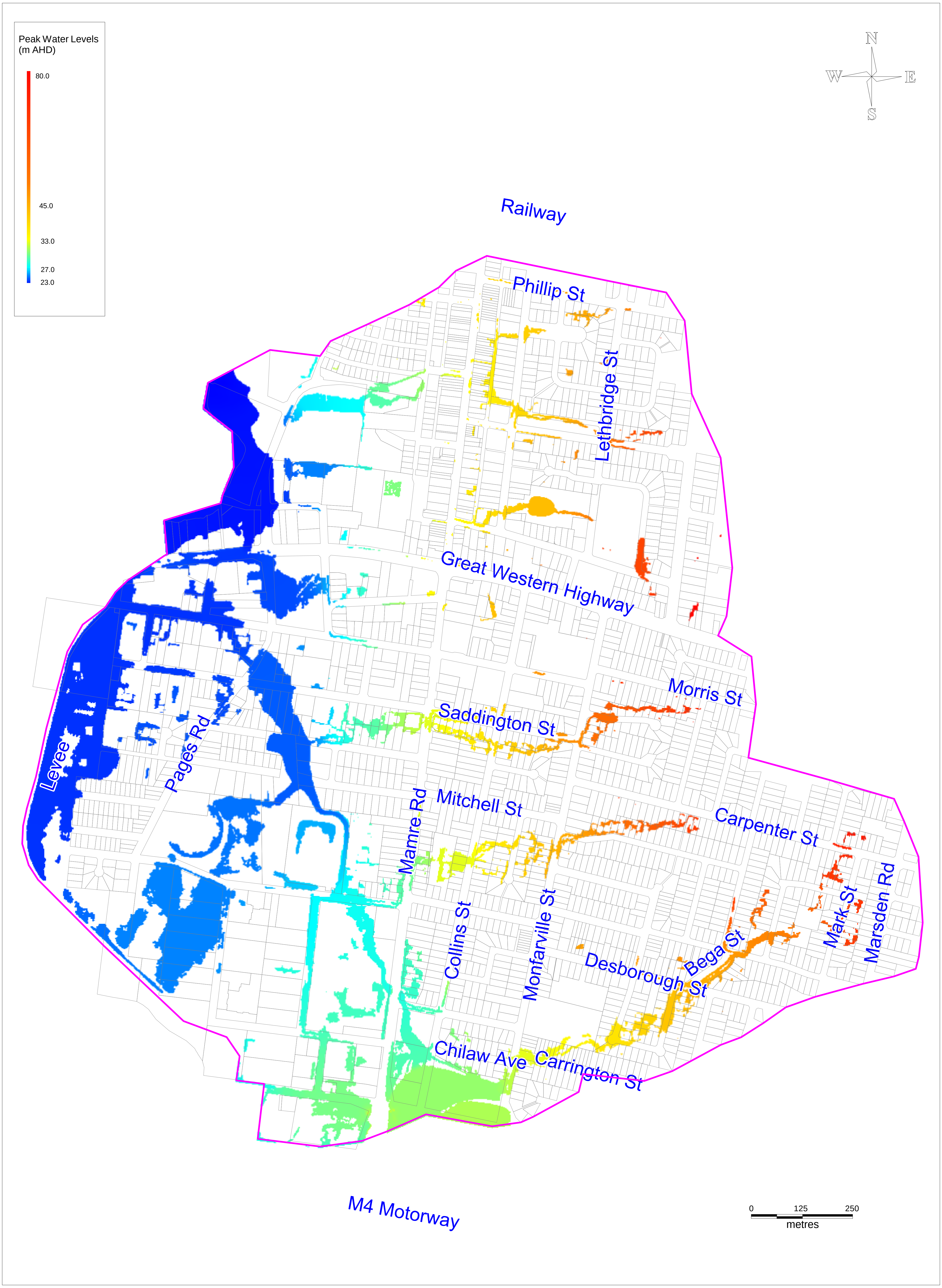
St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study

FIGURE 8.22
200 YEAR ARI - PEAK FLOOD WATER LEVELS

W4735
November 2015



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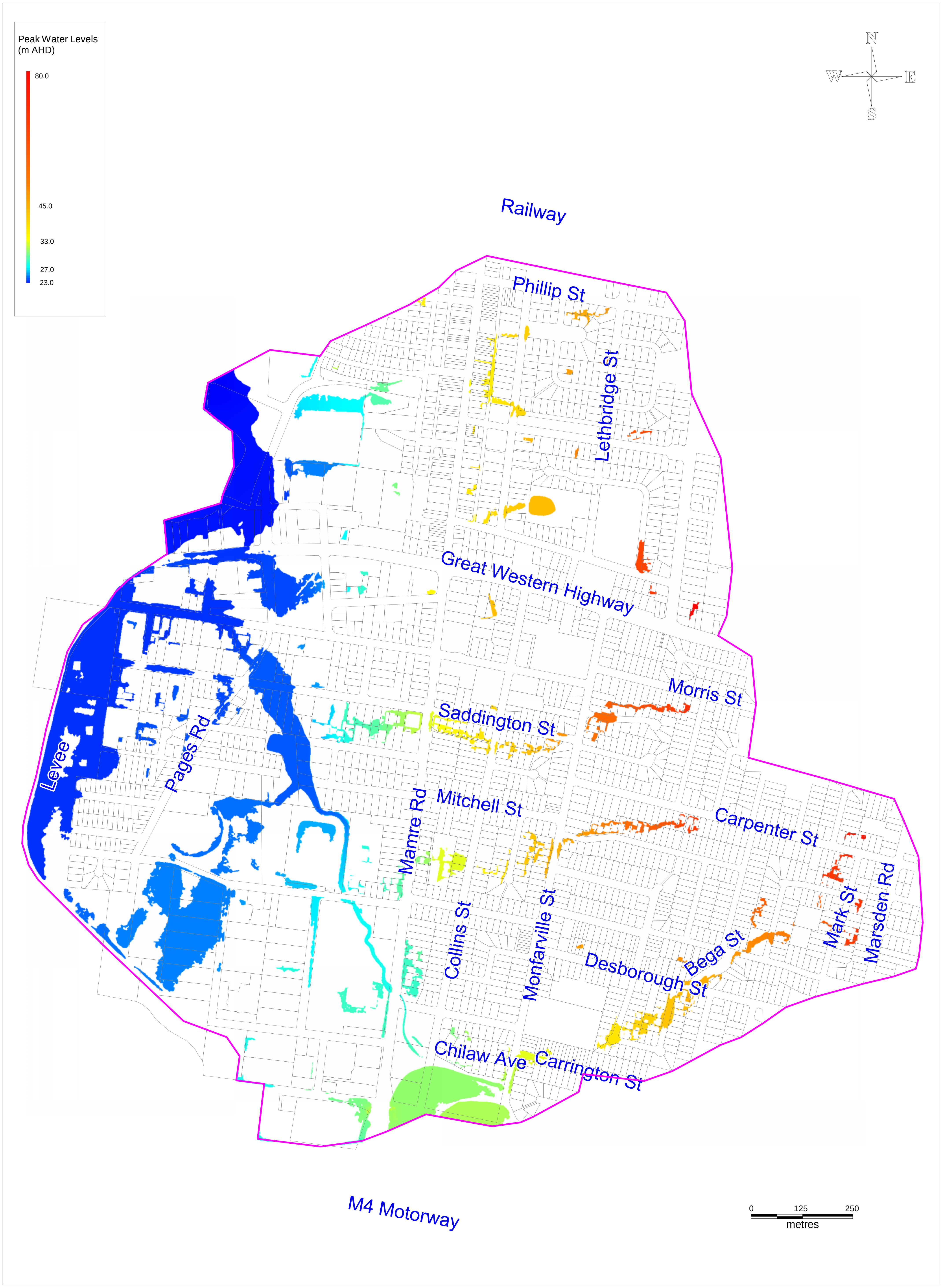
St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study

FIGURE 8.23
100 YEAR ARI - PEAK FLOOD WATER LEVELS

W4735
November 2015



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St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study

FIGURE 8.24
50 YEAR ARI - PEAK FLOOD WATER LEVELS

W4735
November 2015

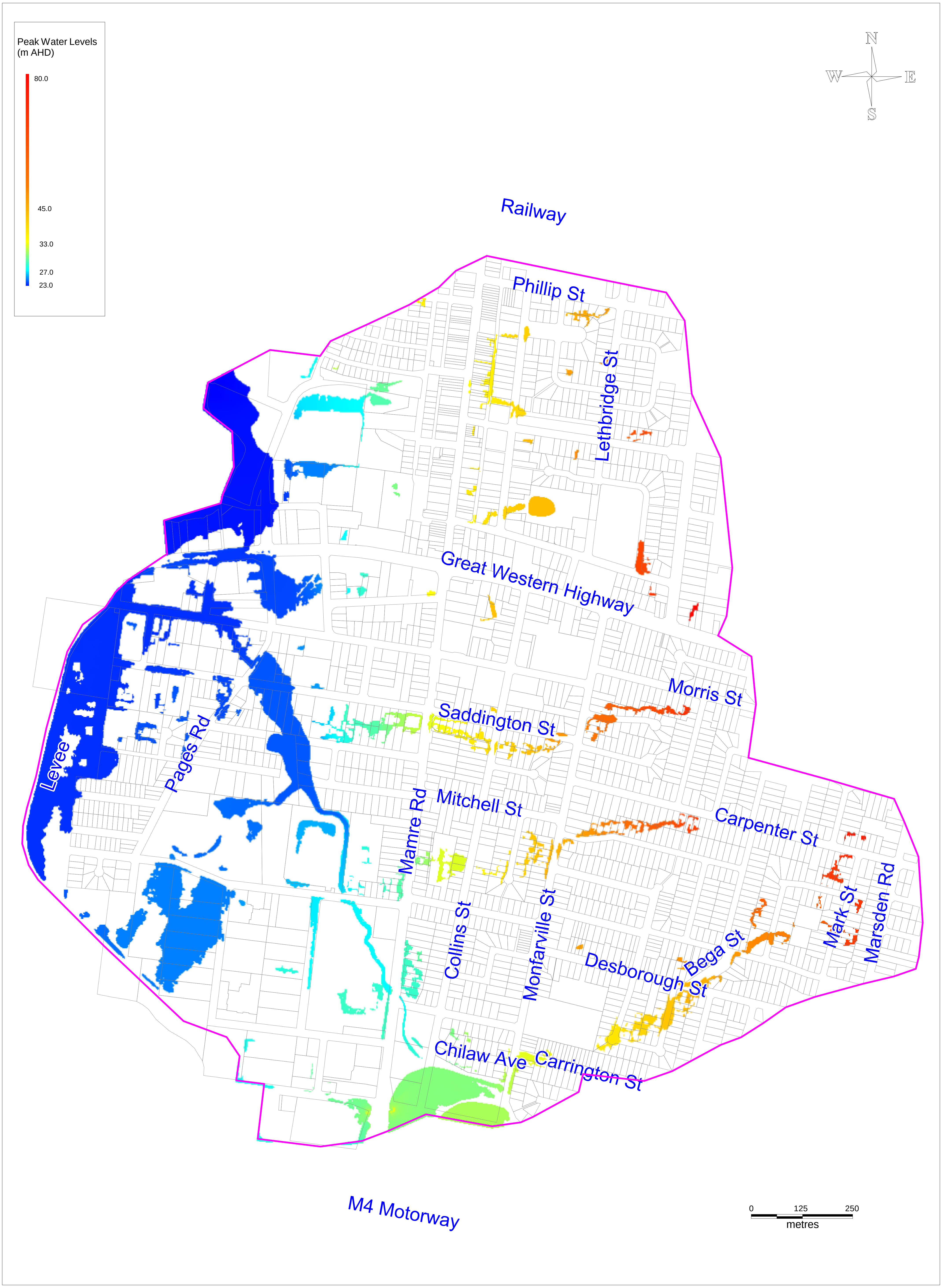
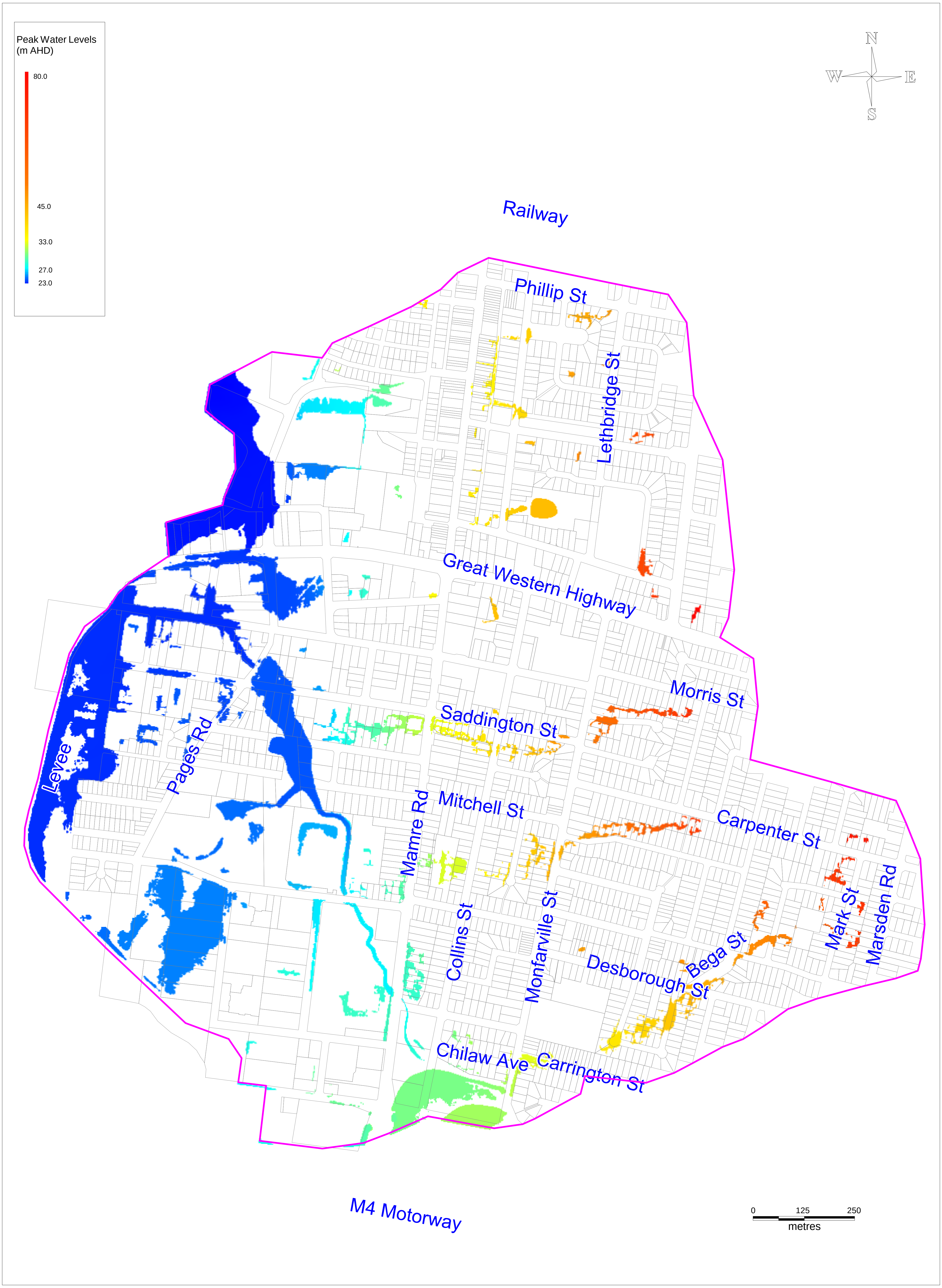


FIGURE 8.25
20 YEAR ARI - PEAK FLOOD WATER LEVELS



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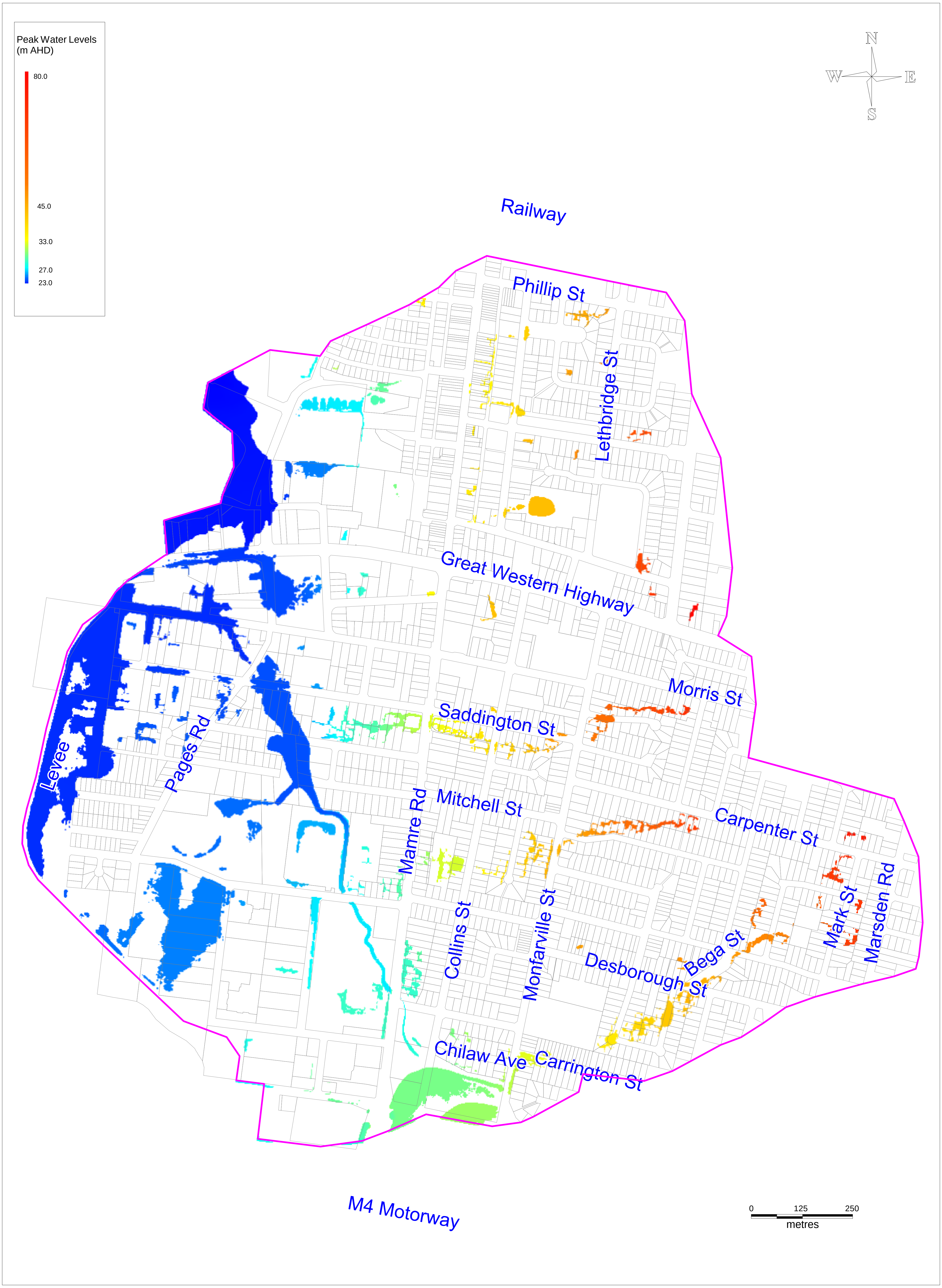
St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study

FIGURE 8.26
10 YEAR ARI - PEAK FLOOD WATER LEVELS

W4735
November 2015



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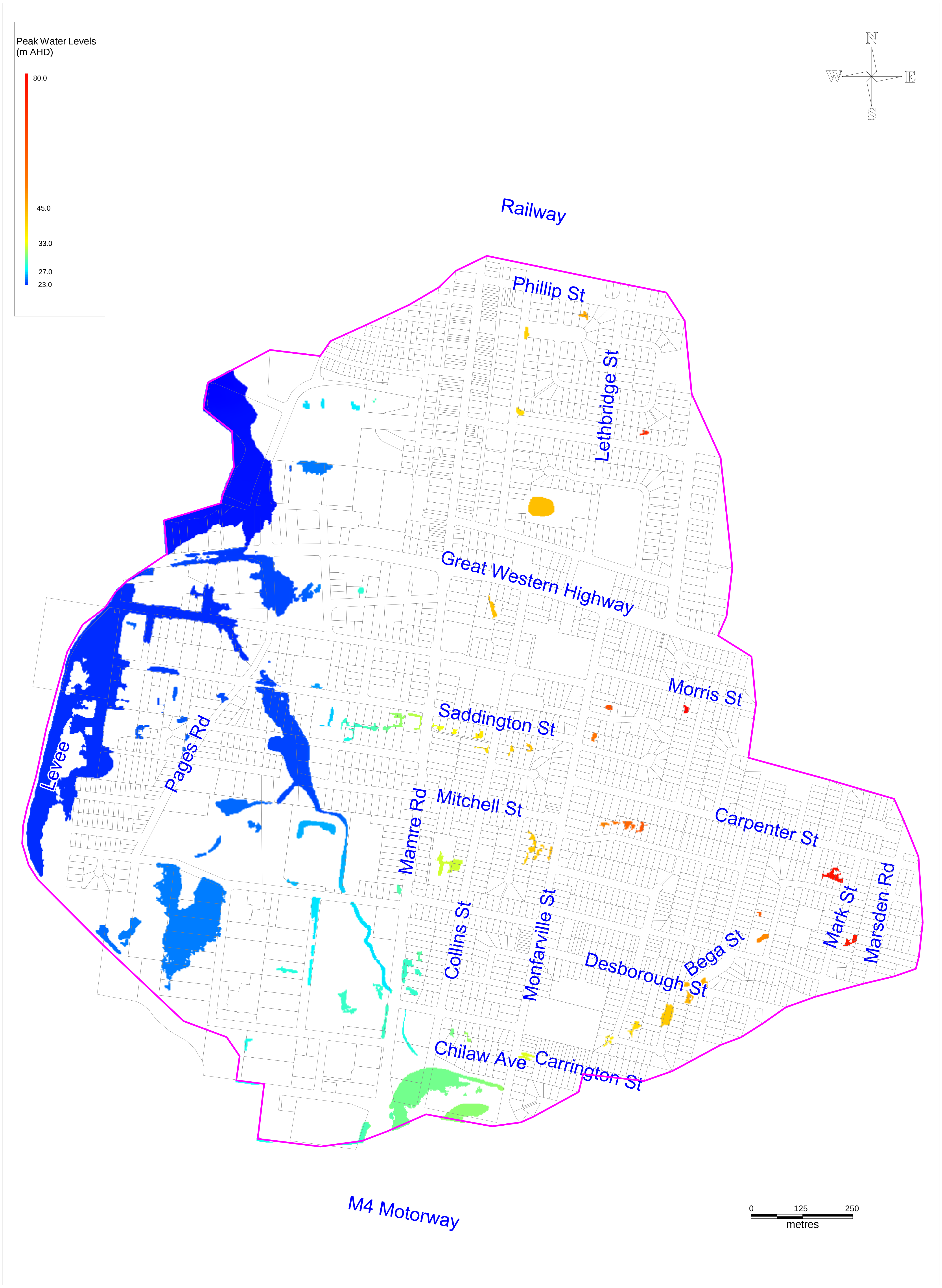
St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study

FIGURE 8.27
5 YEAR ARI - PEAK FLOOD WATER LEVELS

W4735
November 2015



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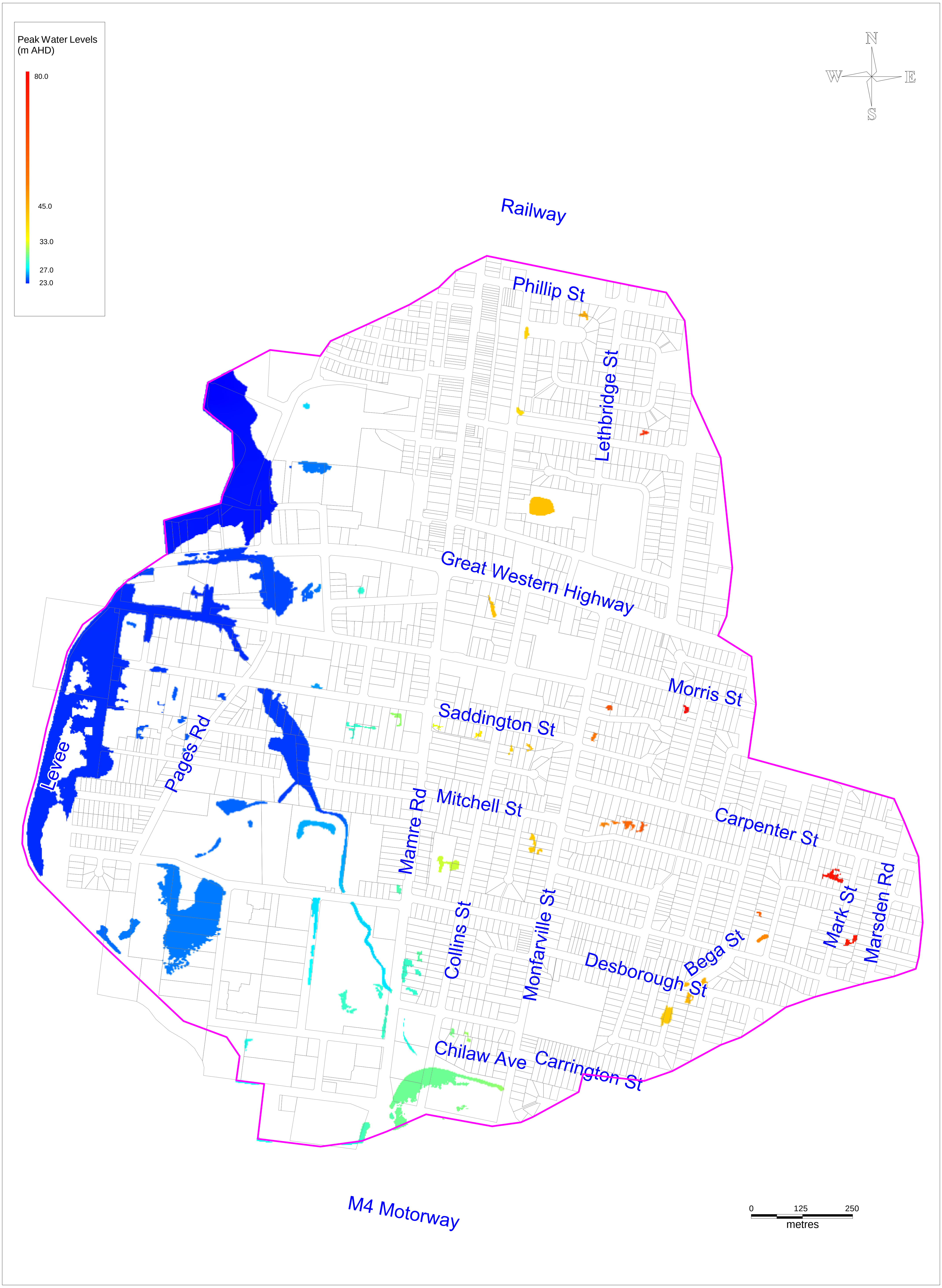
W4735
November 2015

St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study

FIGURE 8.28
2 YEAR ARI - PEAK FLOOD WATER LEVELS



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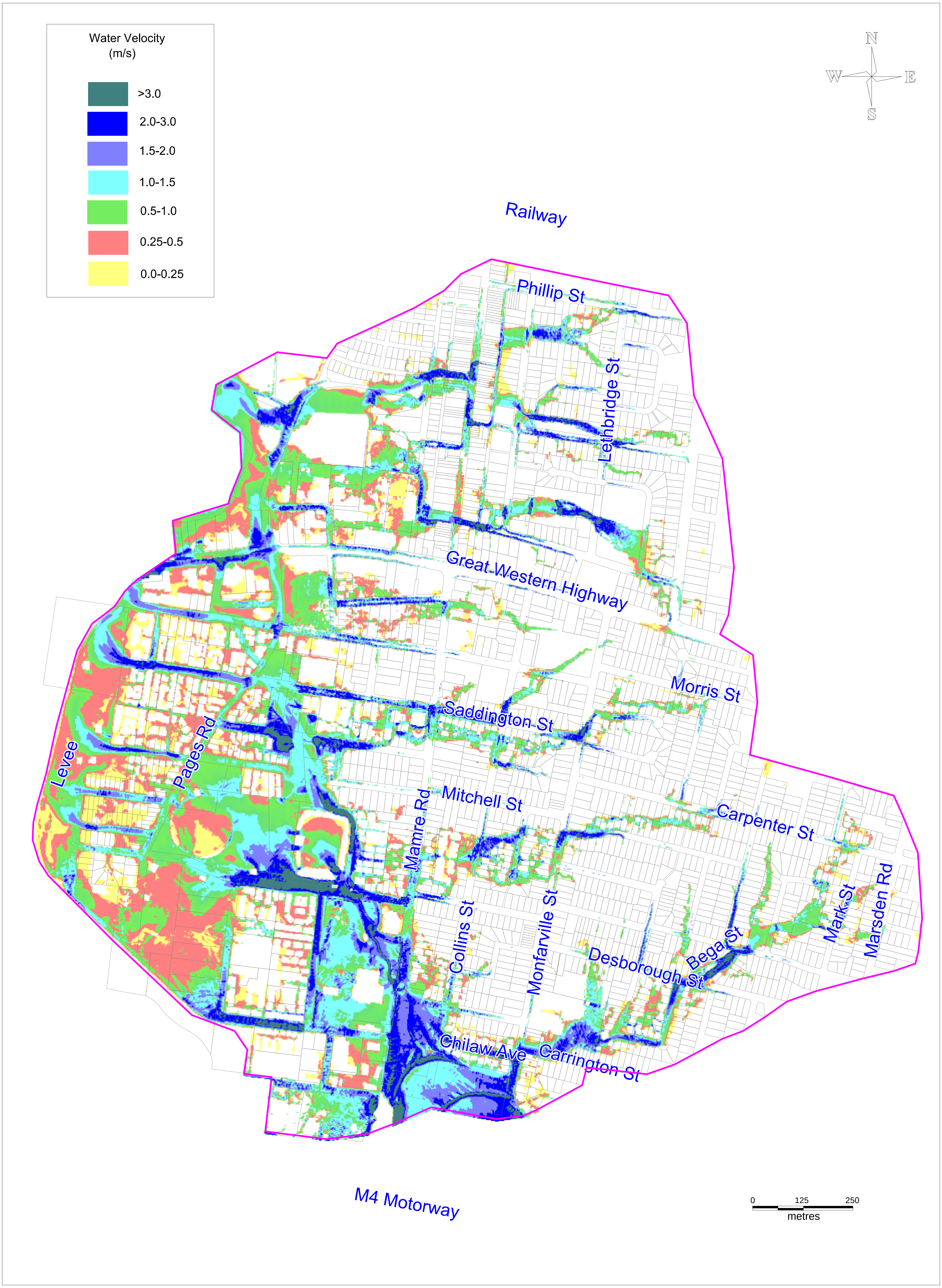
St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study

FIGURE 8.29
1 YEAR ARI - PEAK FLOOD WATER LEVELS

W4735
November 2015



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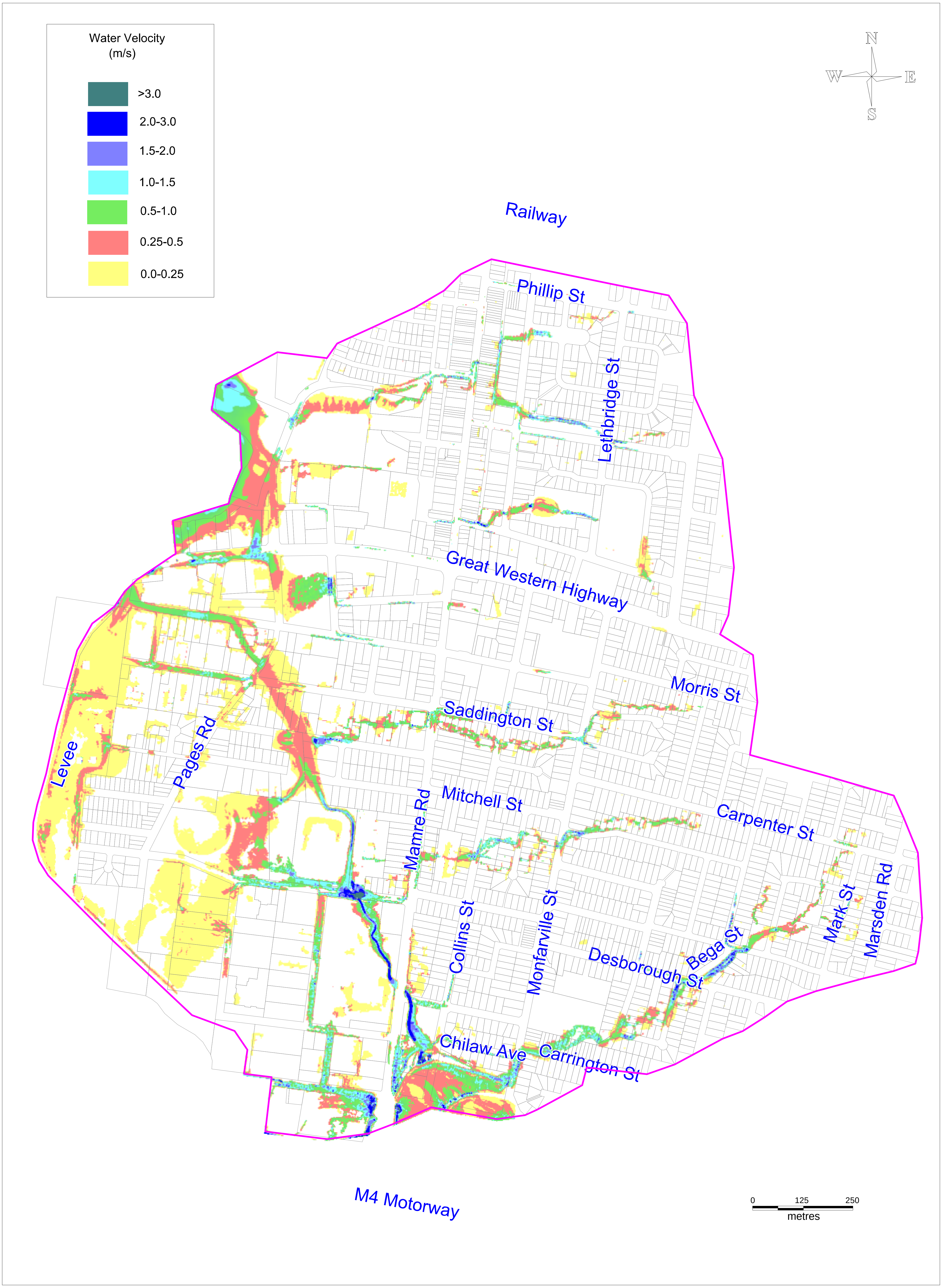
St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study

FIGURE 8.30
PMF - PEAK FLOOD VELOCITY

W4735
November 2015



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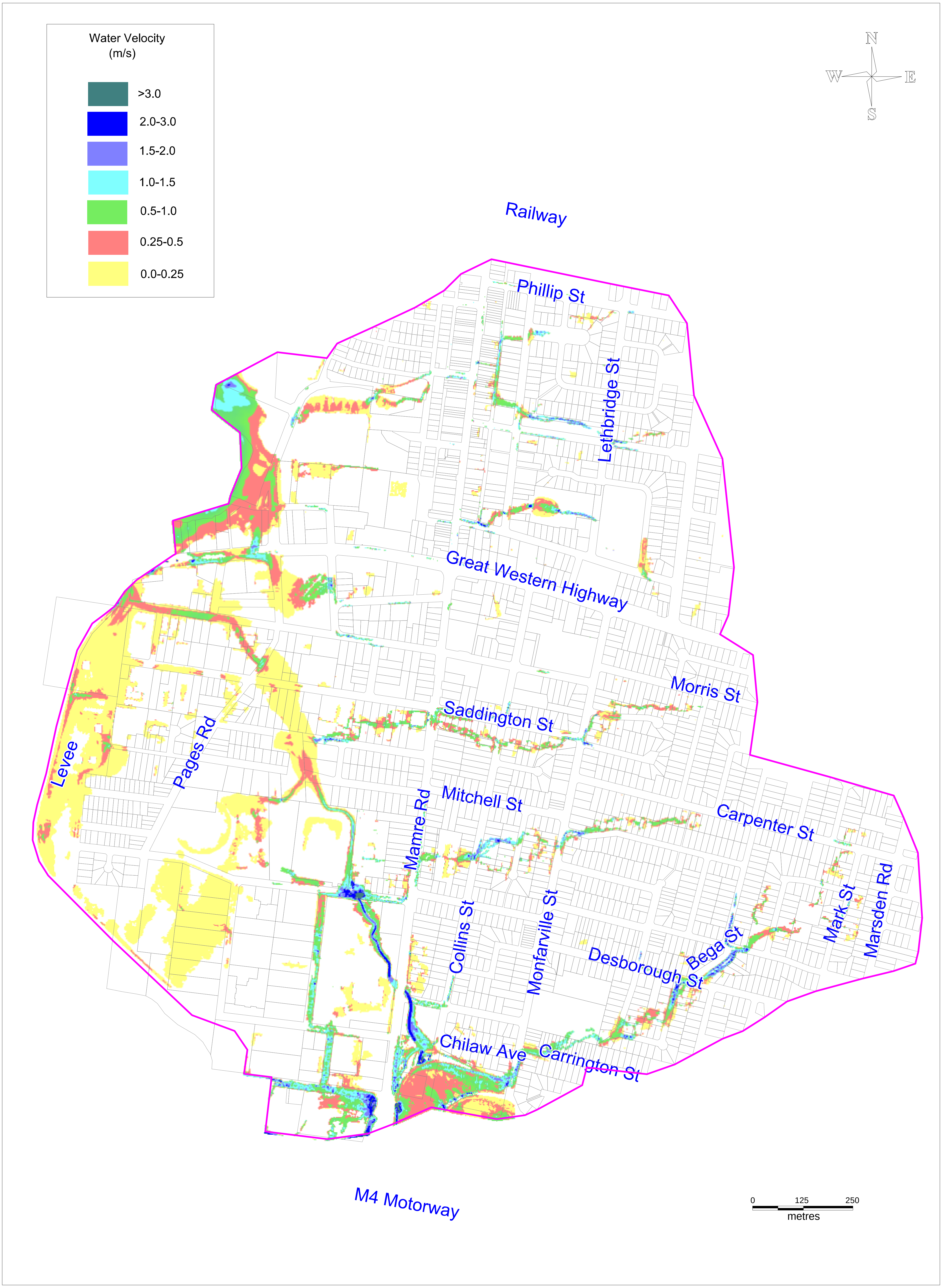
St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study

FIGURE 8.31
200 YEAR ARI - PEAK FLOOD VELOCITY

W4735
November 2015



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St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study

FIGURE 8.32
100 YEAR ARI - PEAK FLOOD VELOCITY

W4735
November 2015

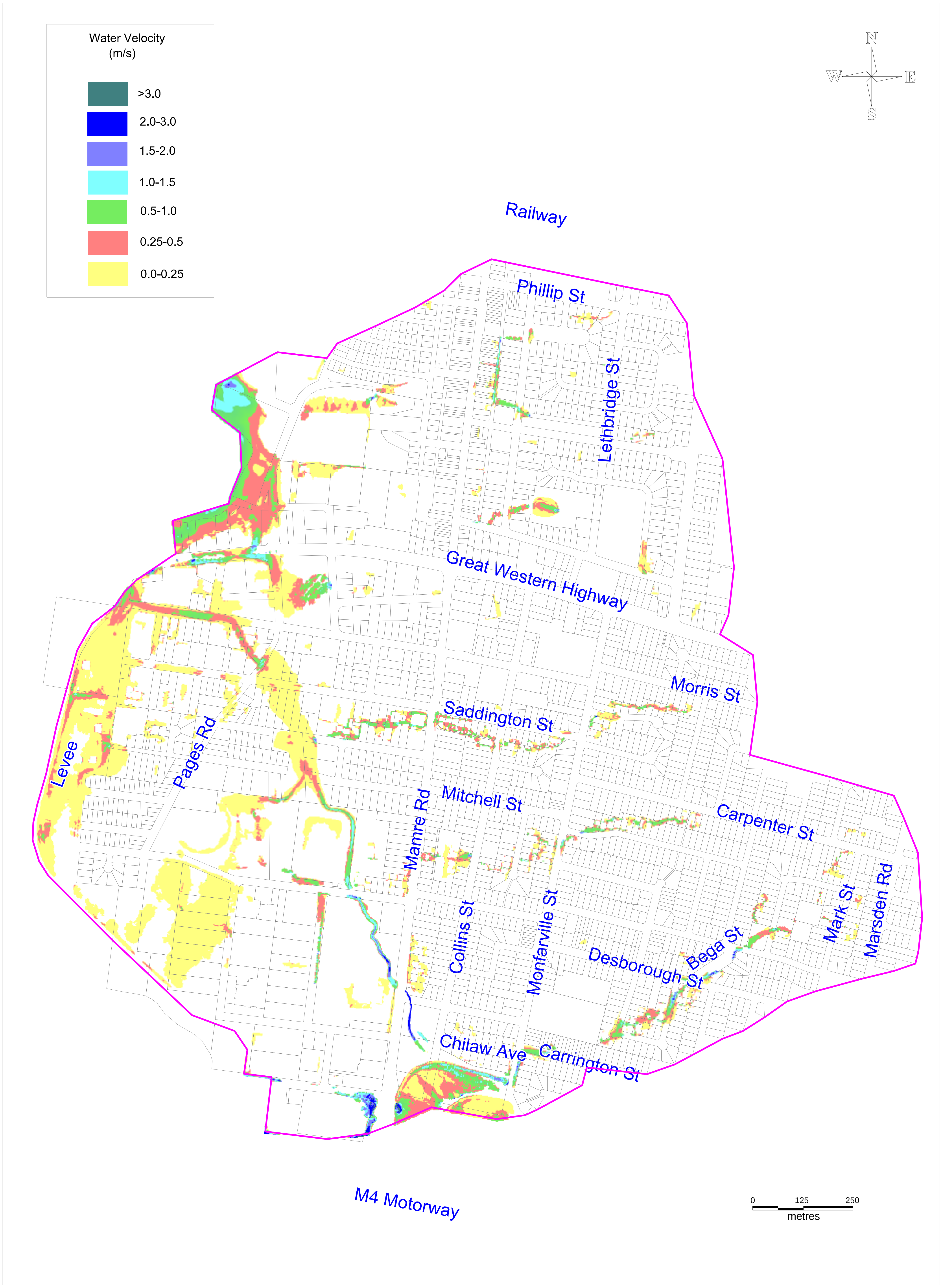
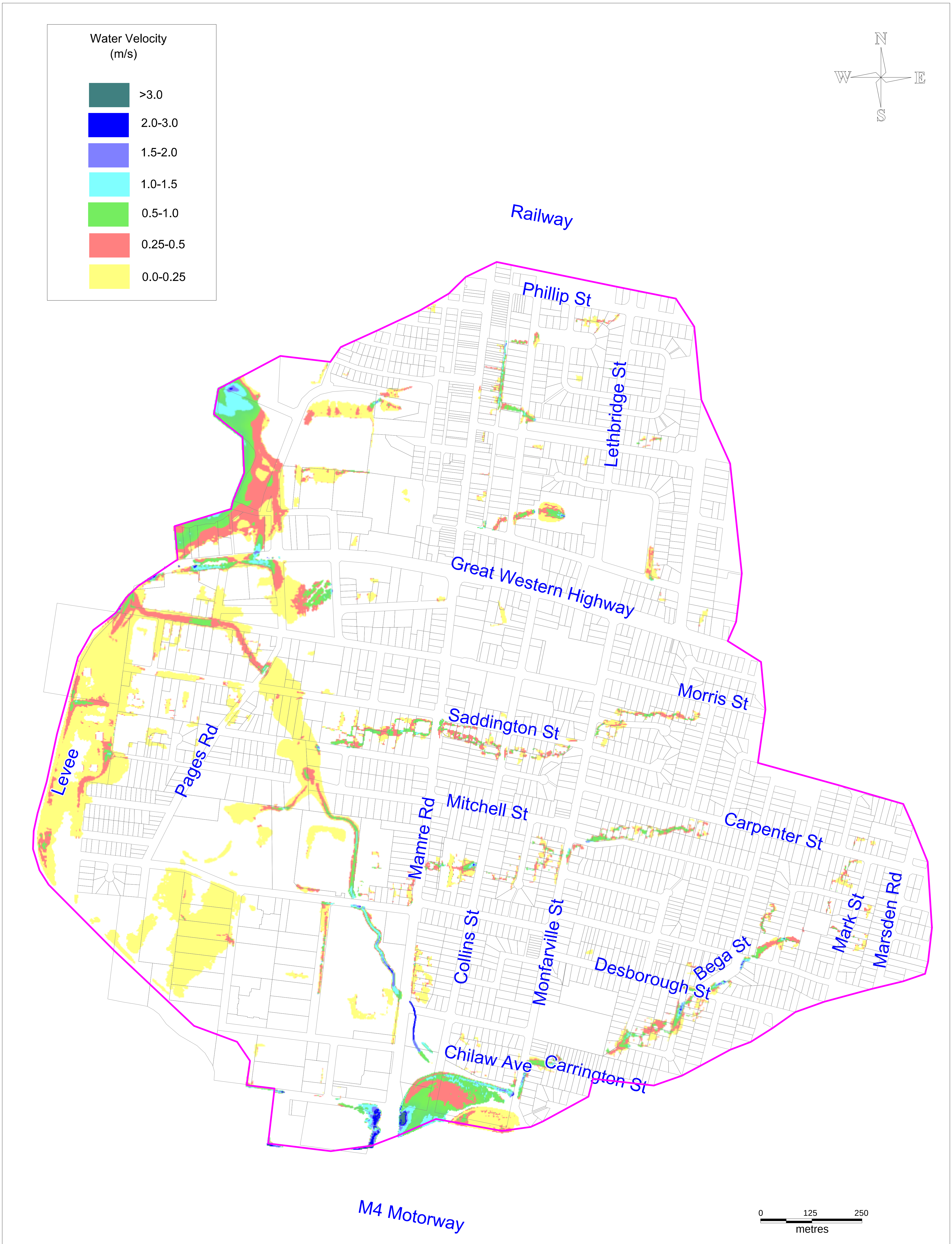


FIGURE 8.33
50 YEAR ARI - PEAK FLOOD VELOCITY



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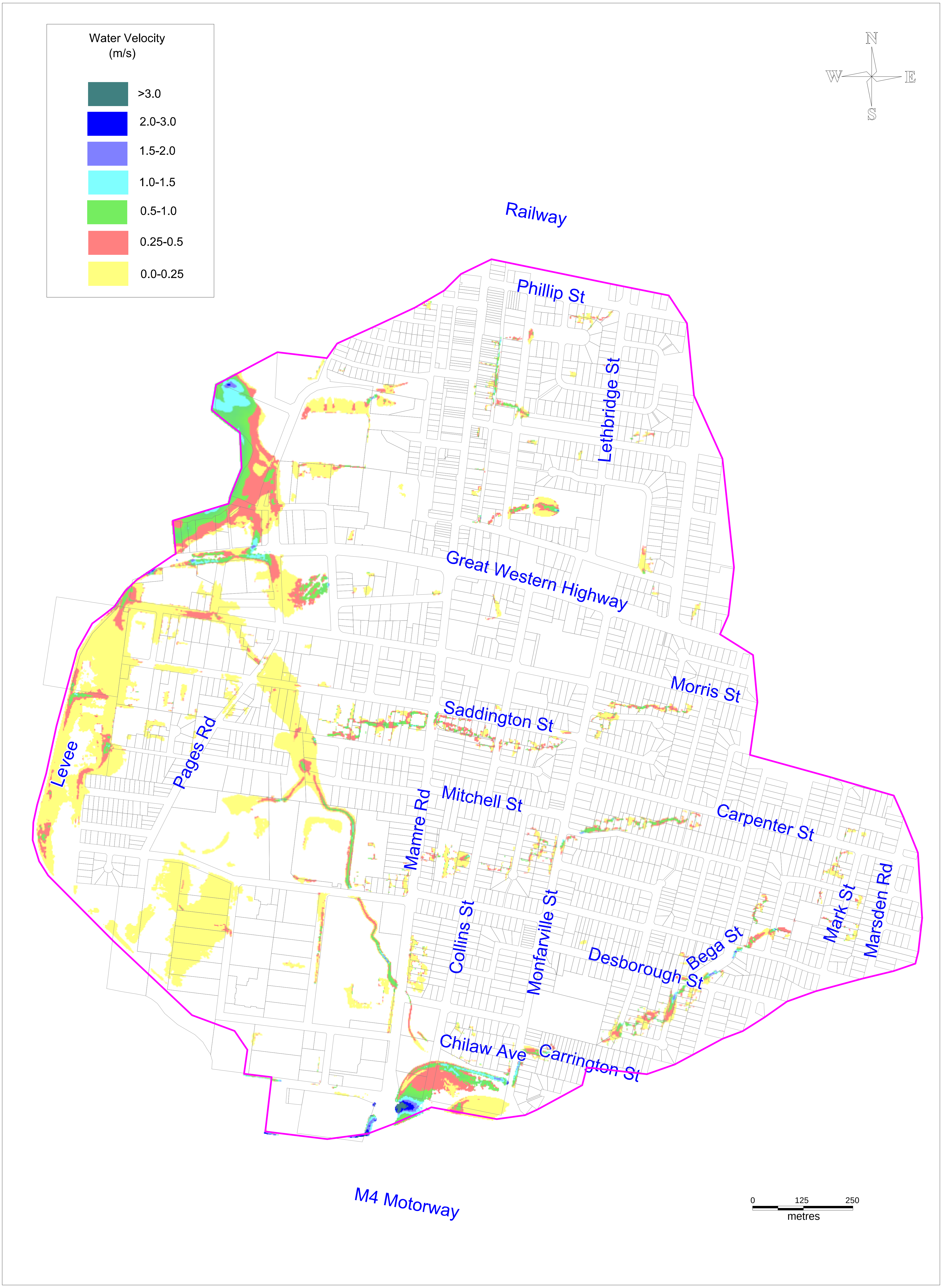
St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study

FIGURE 8.34
20 YEAR ARI - PEAK FLOOD VELOCITY

W4735
November 2015



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St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study

FIGURE 8.35
10 YEAR ARI - PEAK FLOOD VELOCITY

W4735
November 2015

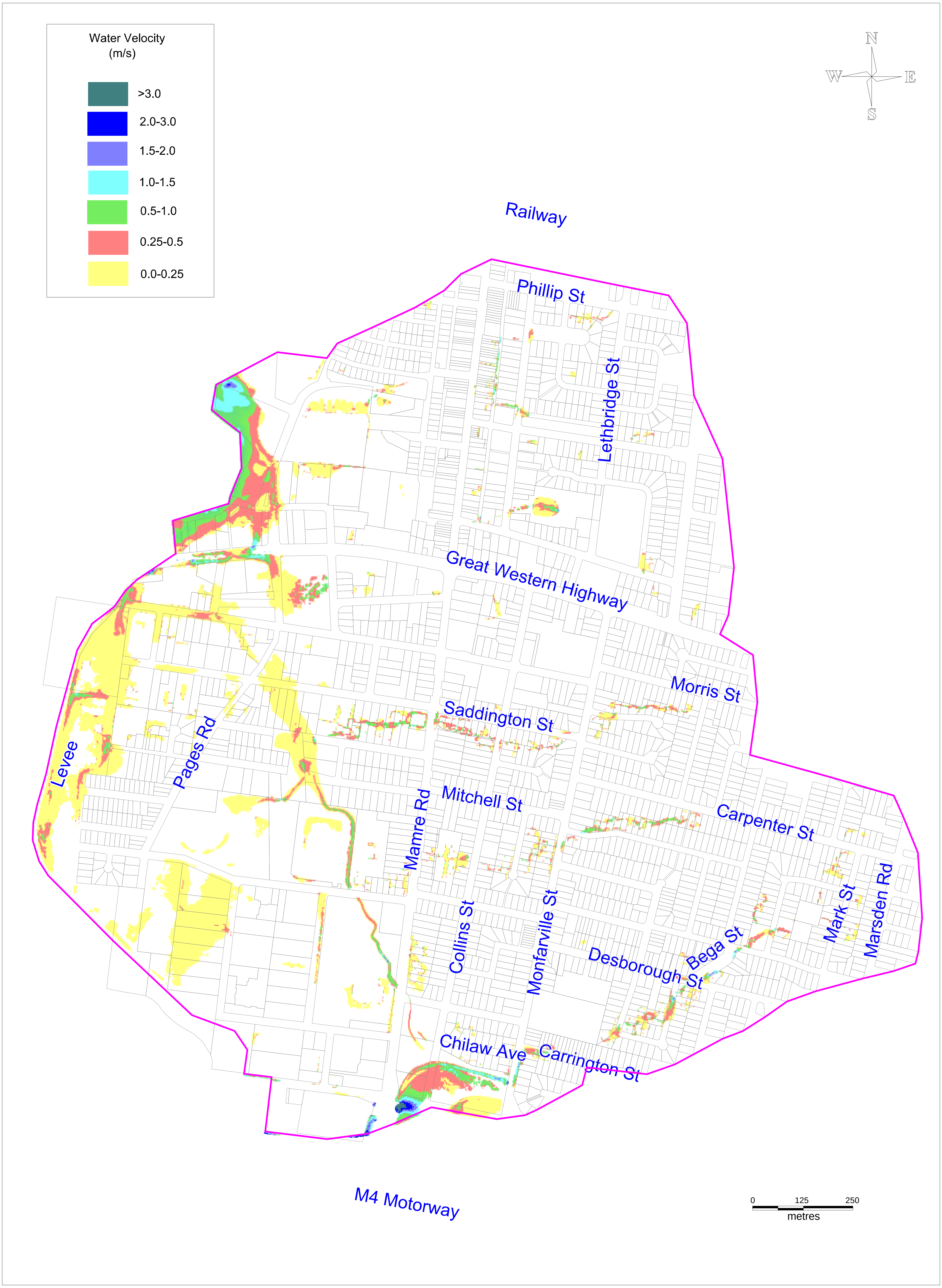
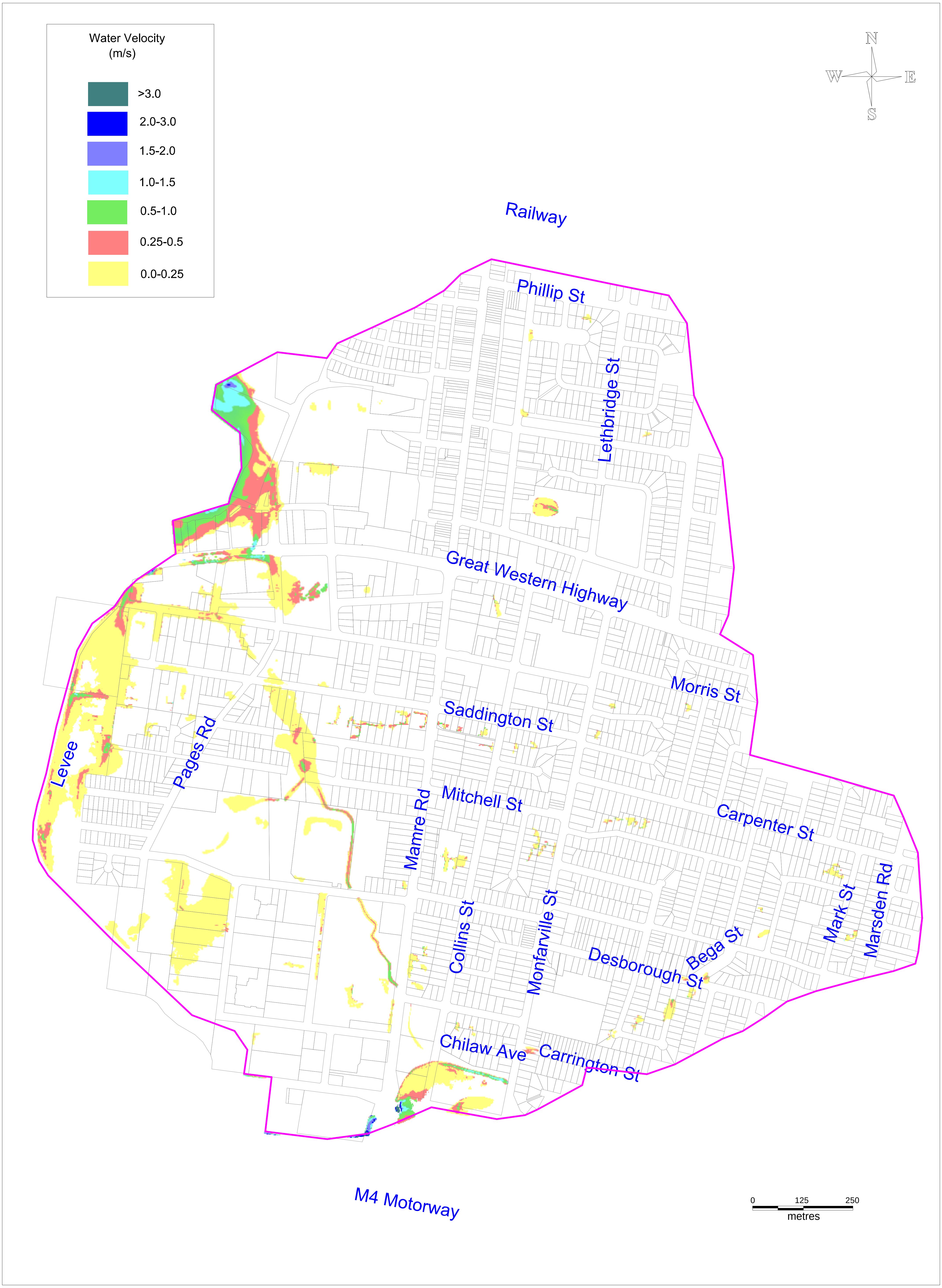


FIGURE 8.36
5 YEAR ARI - PEAK FLOOD VELOCITY



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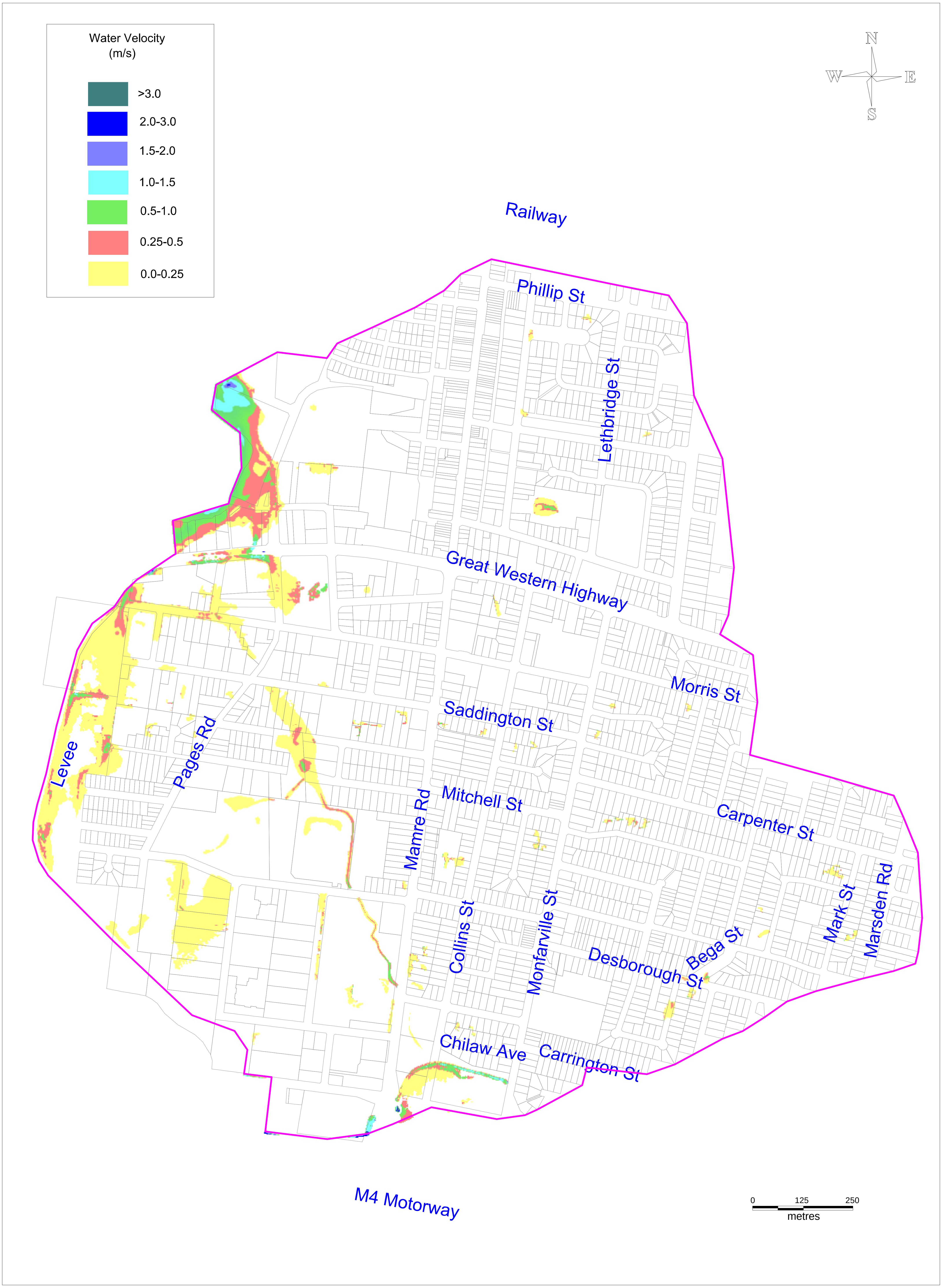
St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study

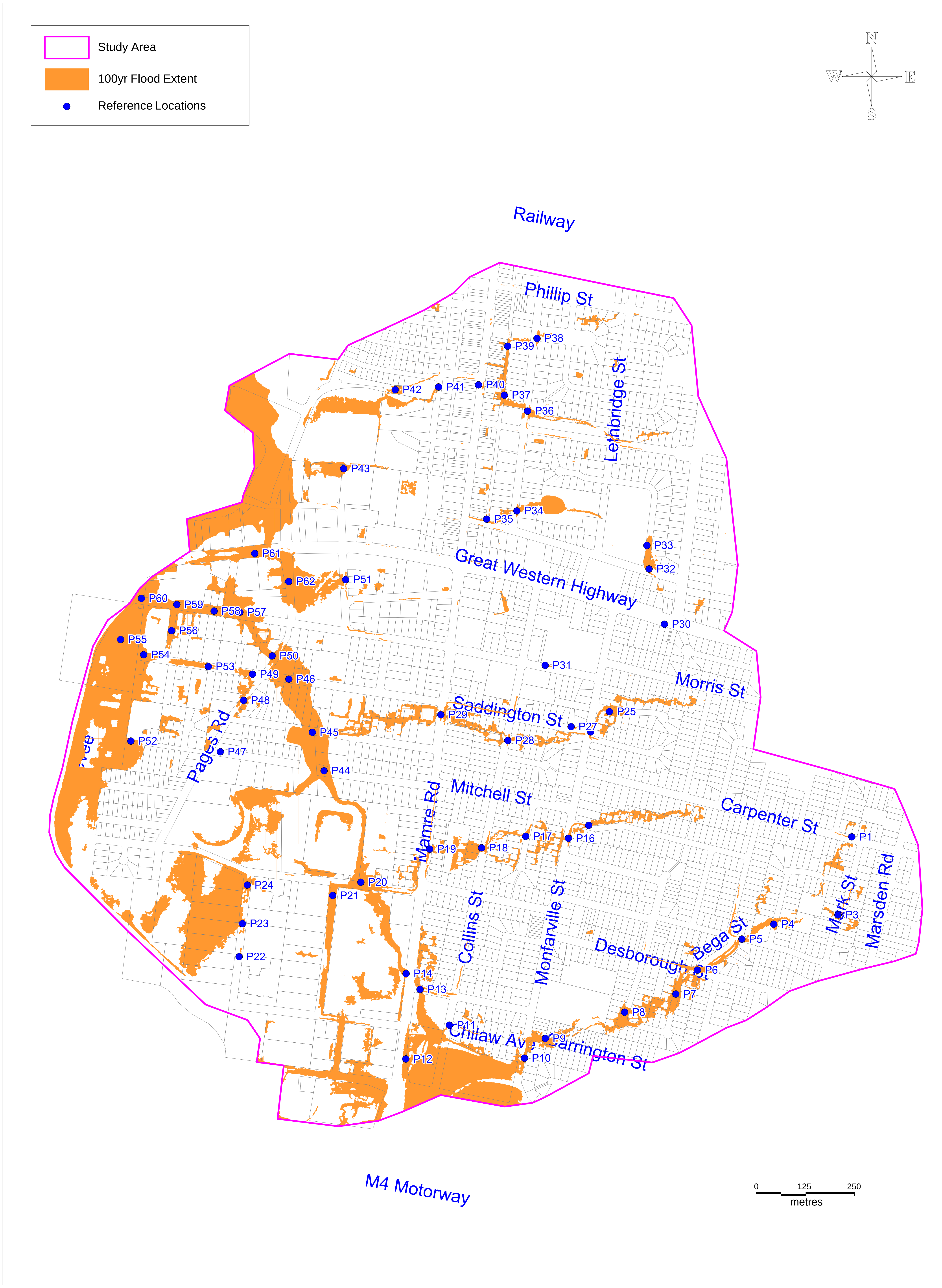
FIGURE 8.37
2 YEAR ARI - PEAK FLOOD VELOCITY

W4735
November 2015



St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study

FIGURE 8.38
1 YEAR ARI - PEAK FLOOD VELOCITY



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St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study

FIGURE 8.39
REFERENCE LOCATIONS FOR PEAK WATER LEVELS
DEPTHS AND VELOCITIES

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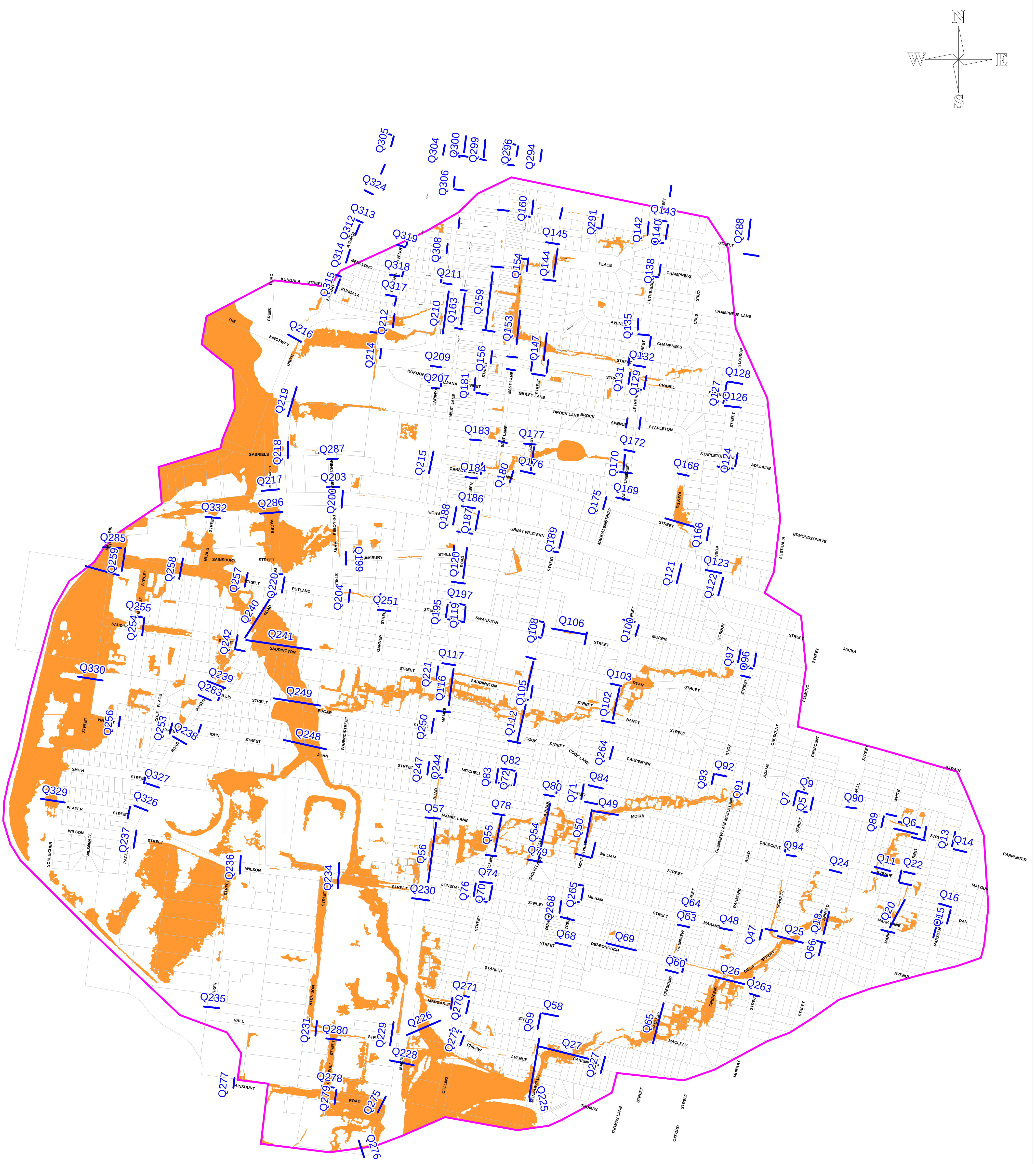
St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study

FIGURE 8.40
CHANNEL LOCATIONS FOR APPENDIX I



LEGEND

- Study Area
- 100yr Flood Extent
- Cadastre
- Reference Locations for 2D Flows

0 250 500
metres

FIGURE 8.41
REFERENCE LOCATIONS FOR 2D PEAK FLOW

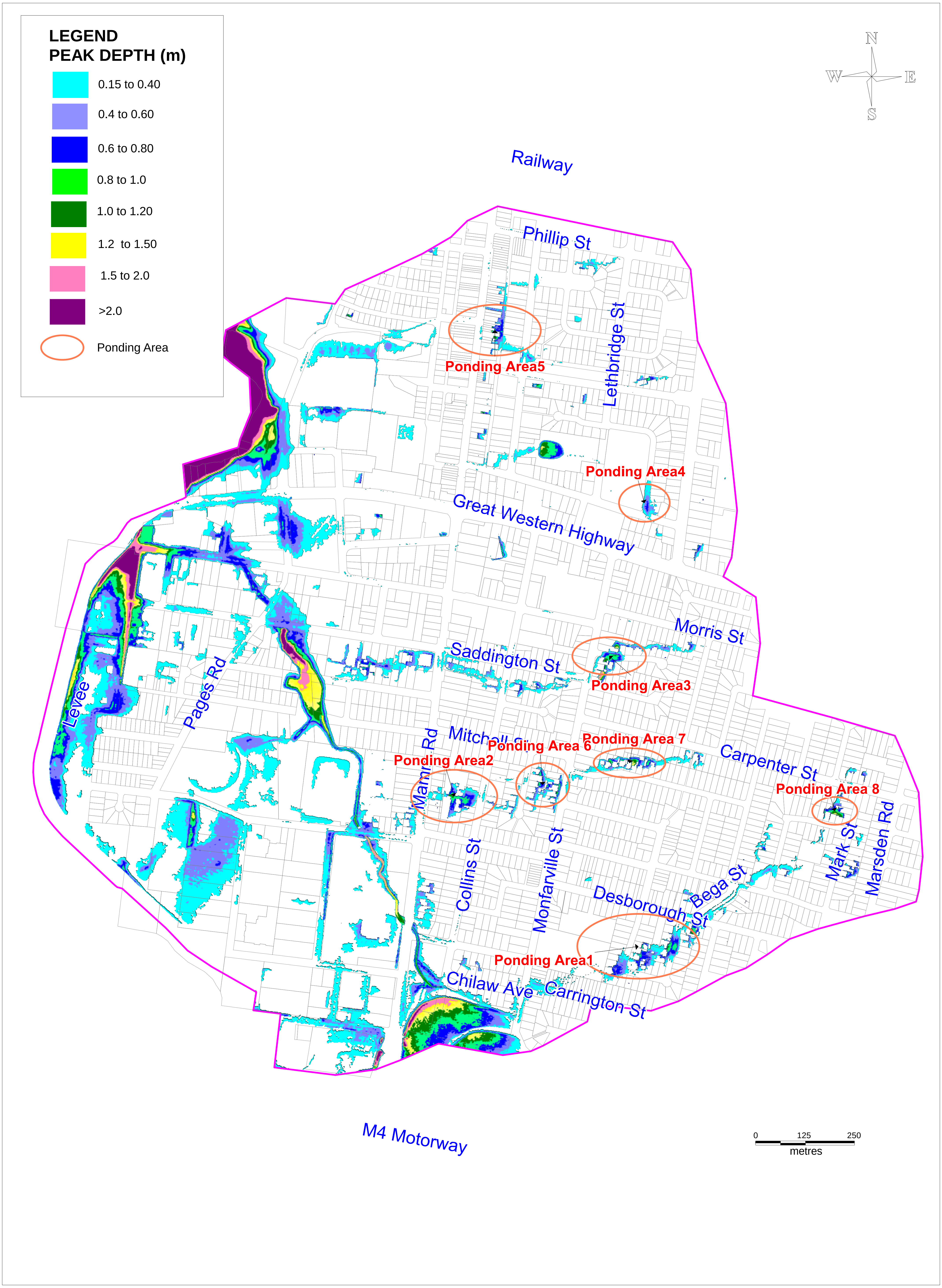


FIGURE 8.42
PONDING AREAS
100 YEAR ARI - PEAK FLOOD DEPTHS

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St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study

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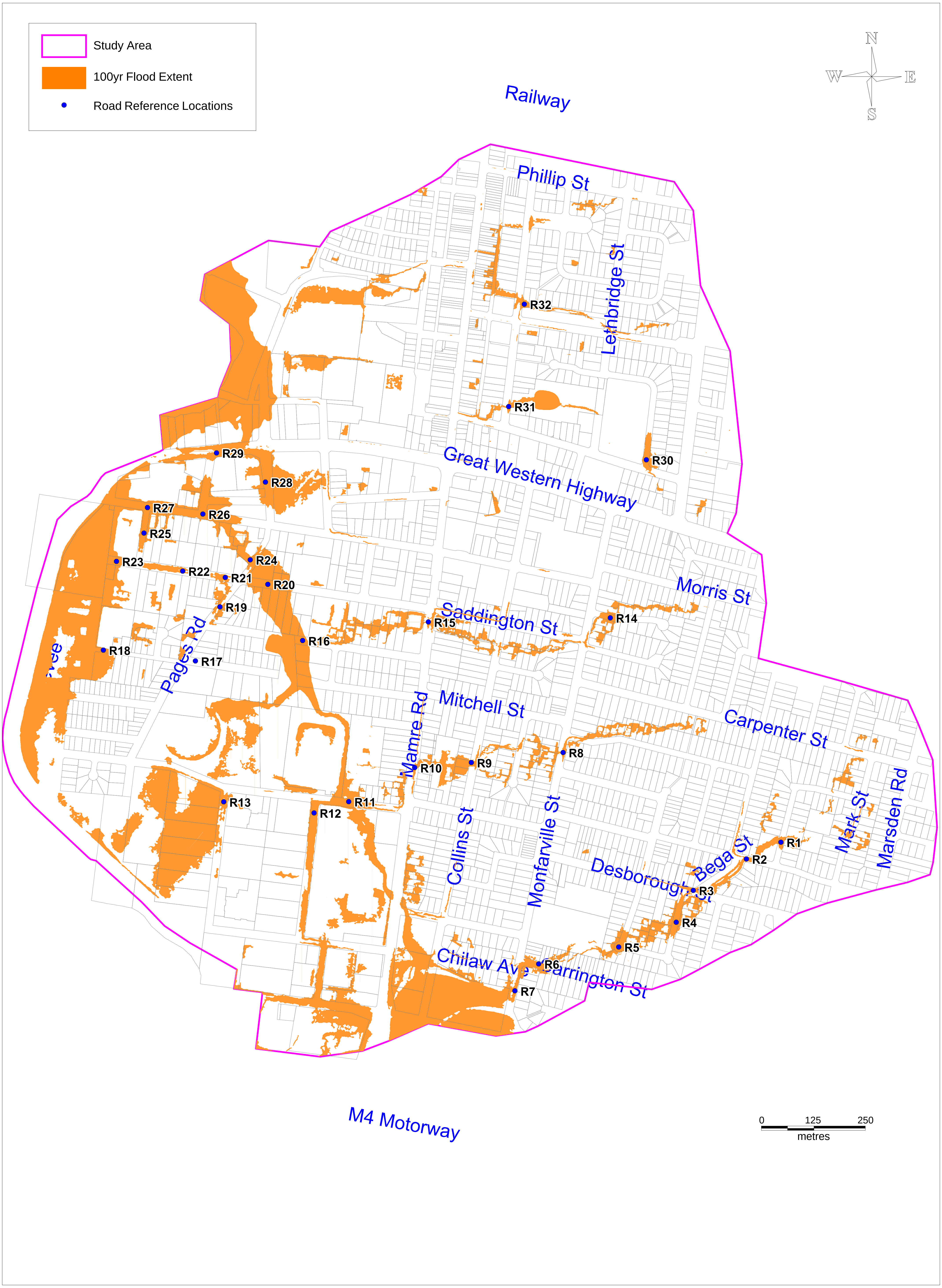
November 2015



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St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study

FIGURE 8.43
MAJOR ACCESS ROAD FLOODING LOCATIONS

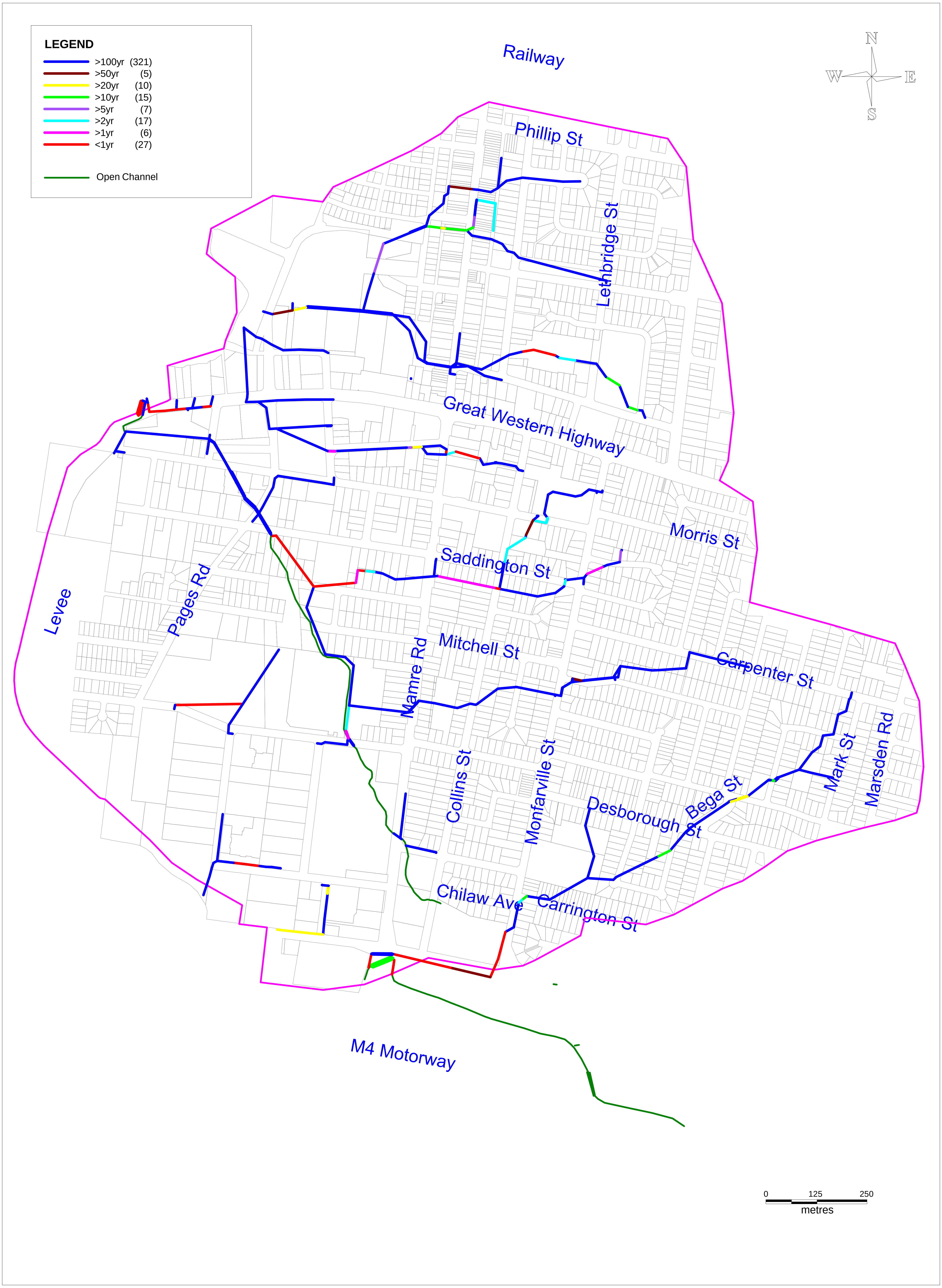

FIGURE 8.44
PIPE CAPACITY

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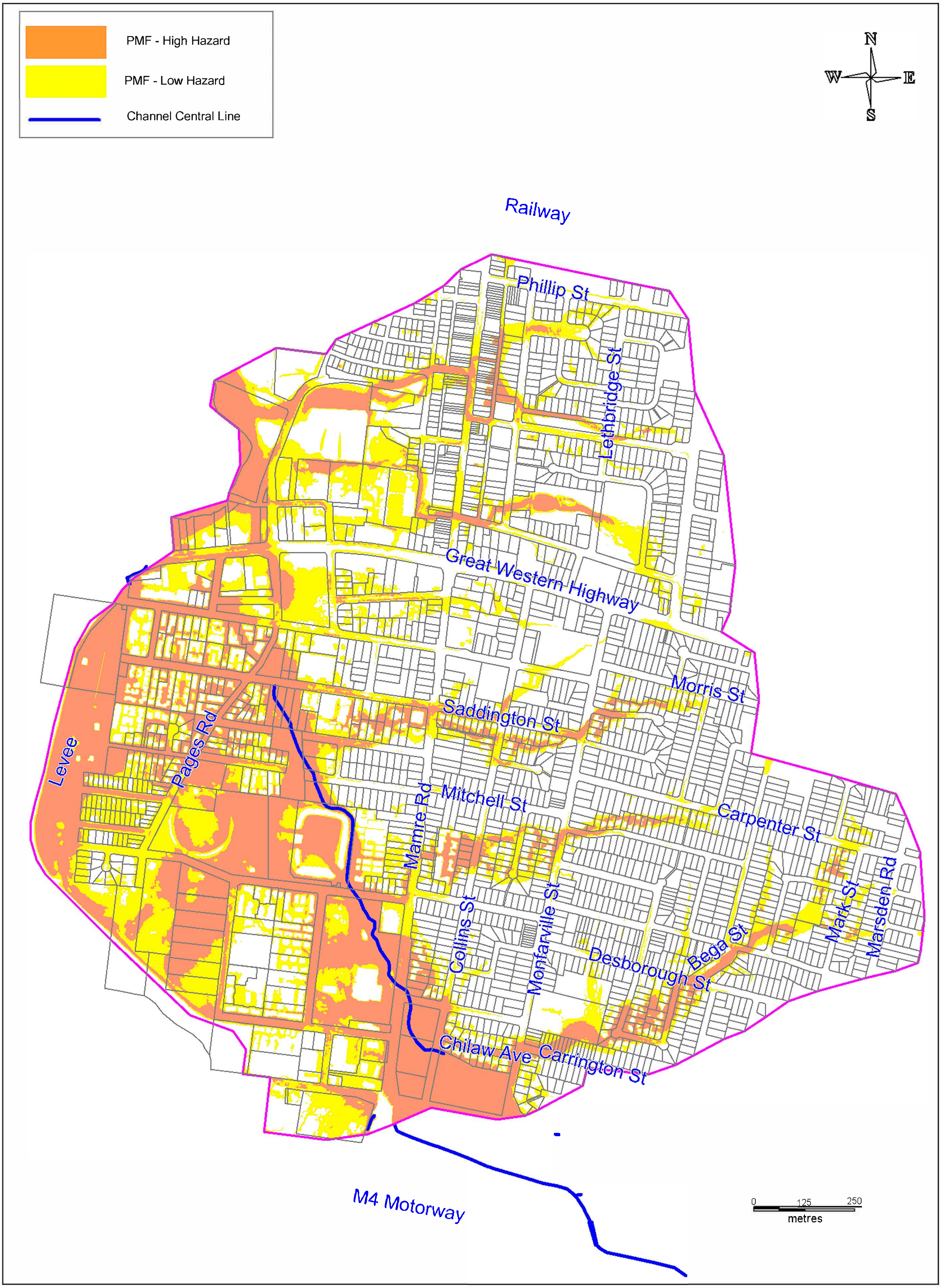
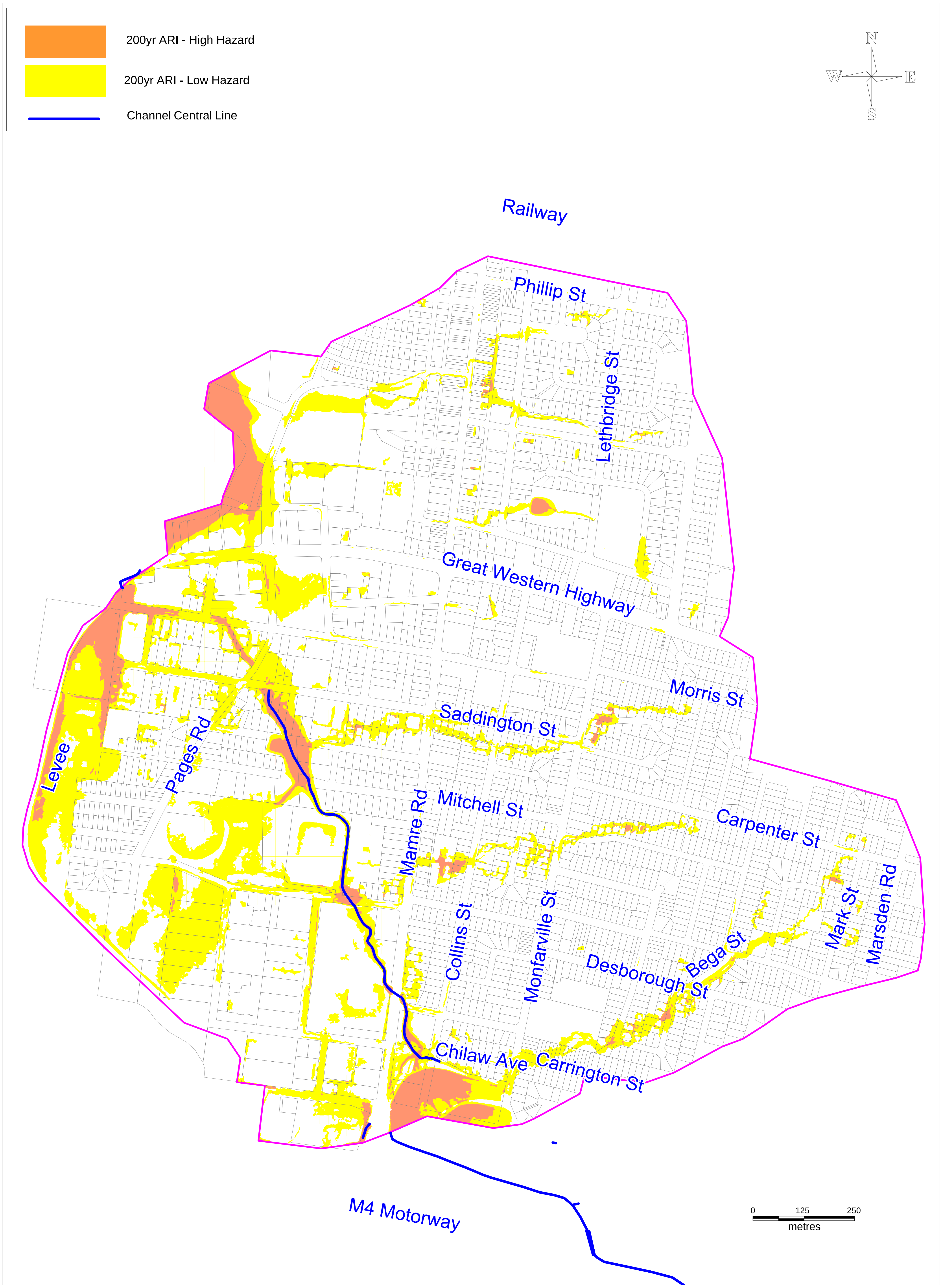


FIGURE 9.2
PMF - PROVISIONAL HAZARD

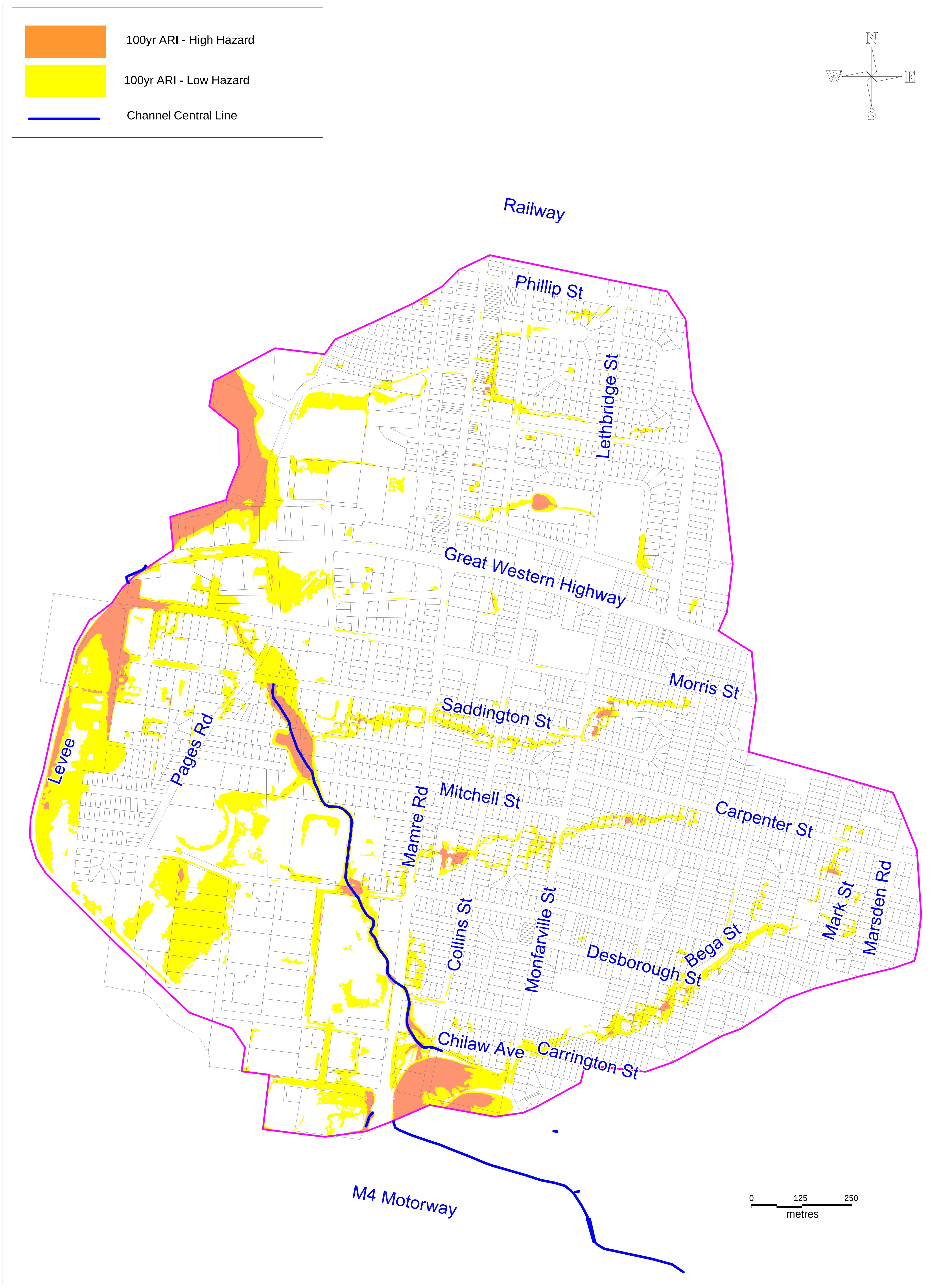


Cardno

W4735
November 2015

St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study

FIGURE 9.3
200 YEAR ARI - PROVISIONAL HAZARD



Cardno

St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study

FIGURE 9.4
100 YEAR ARI - PROVISIONAL HAZARD

W4735
November 2015

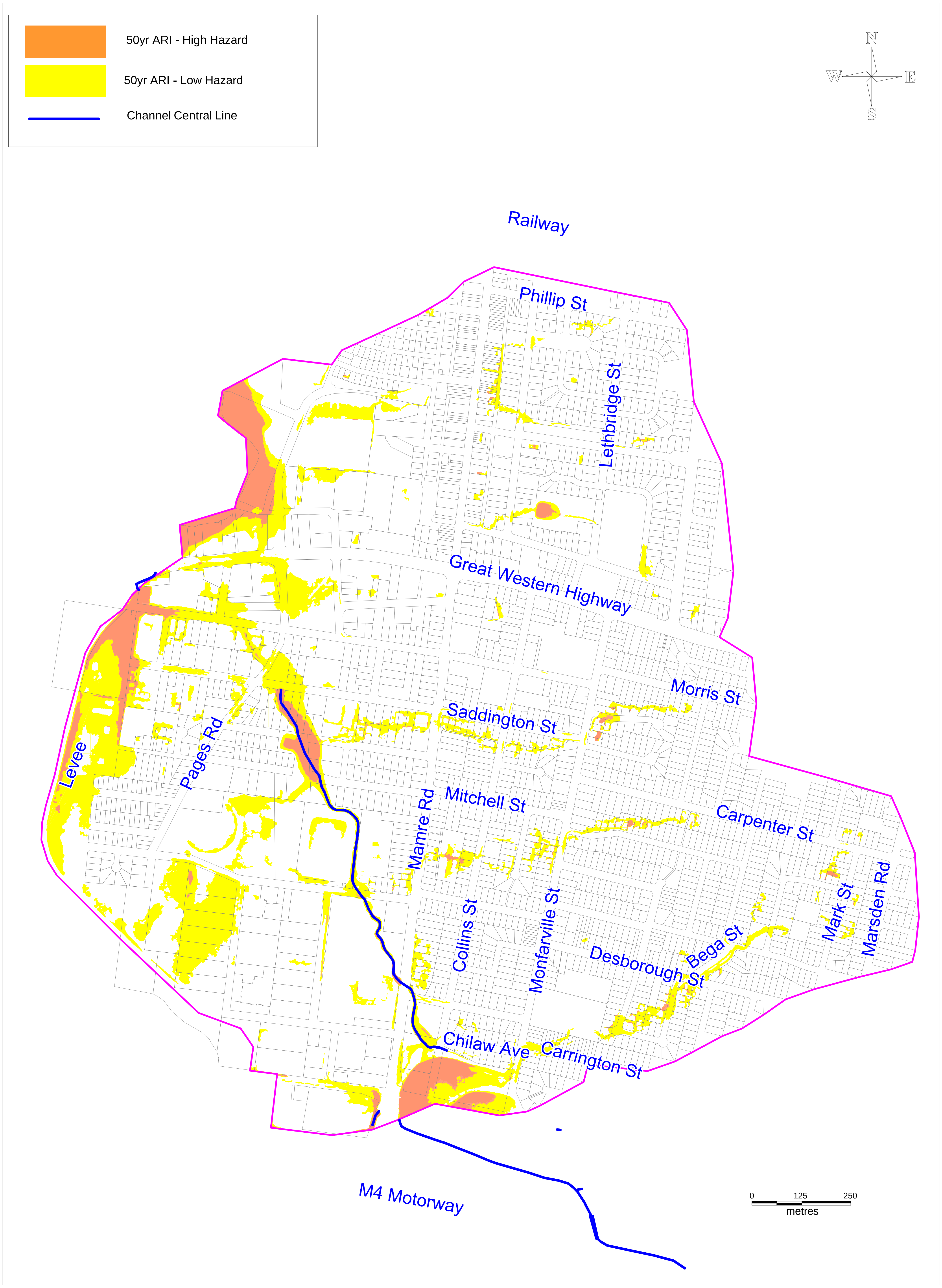
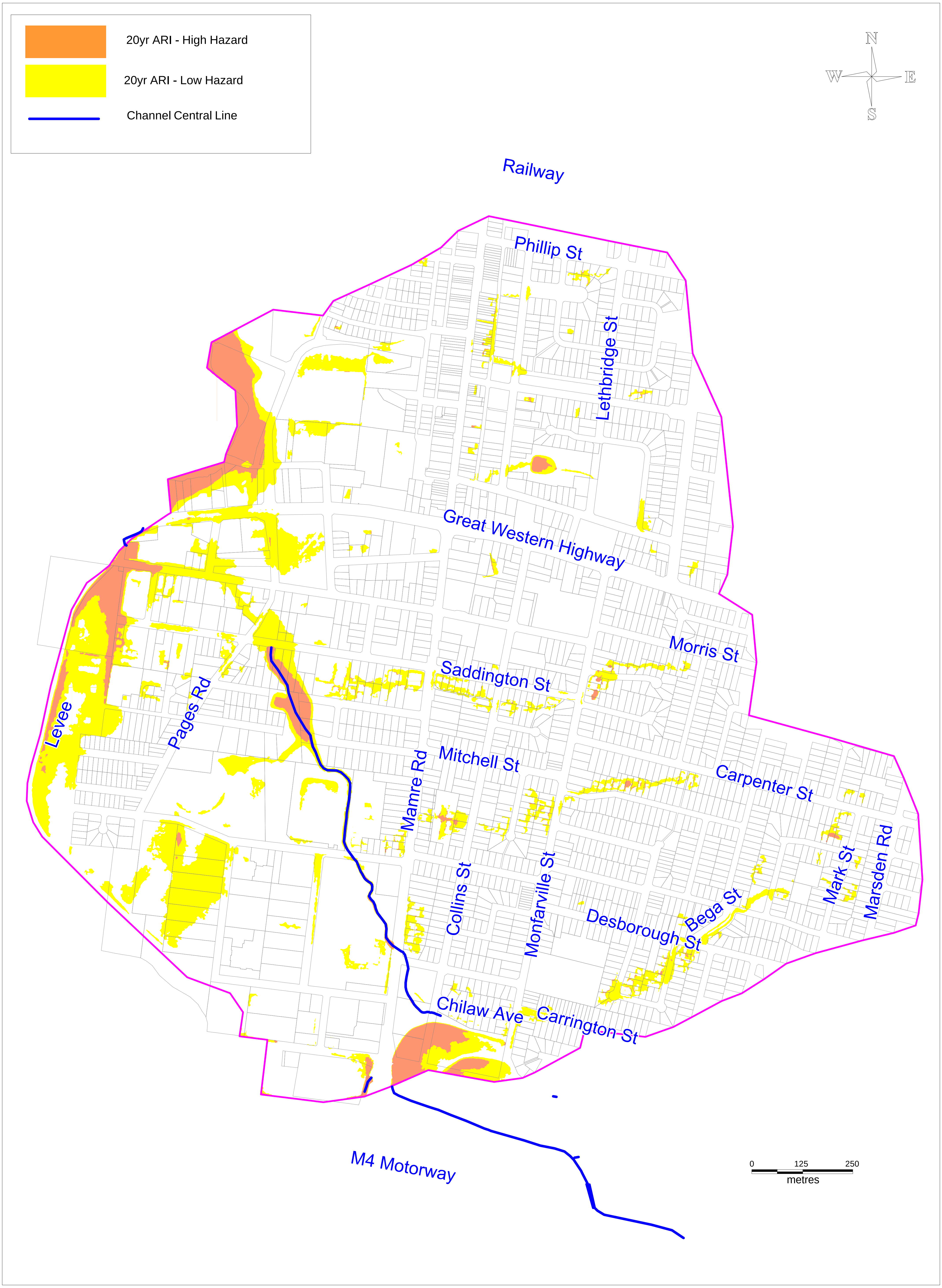


FIGURE 9.5
50 YEAR ARI - PROVISIONAL HAZARD

St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study

Cardno

W4735
November 2015



Cardno

St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study

FIGURE 9.6
20 YEAR ARI - PROVISIONAL HAZARD

W4735
November 2015

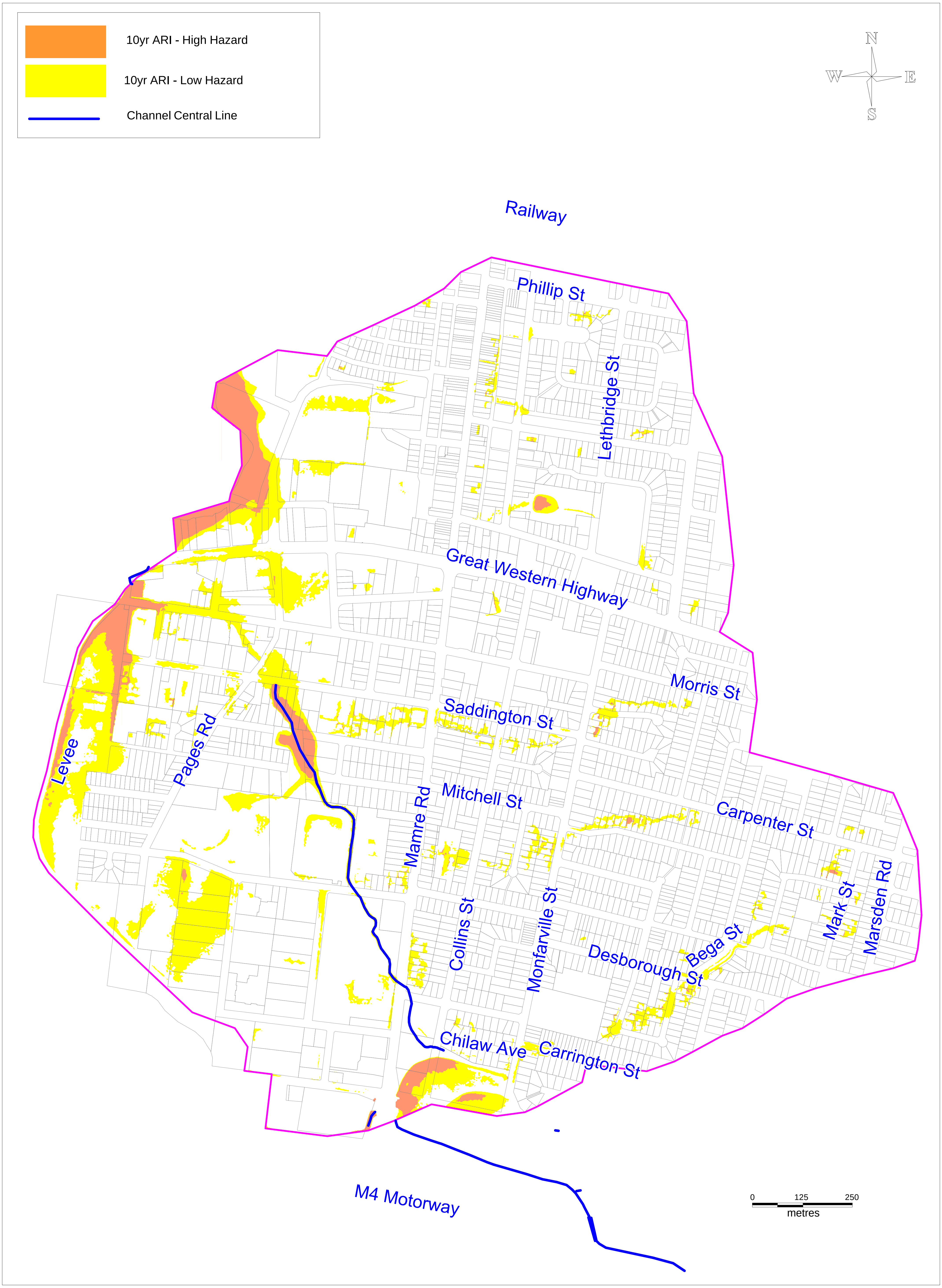
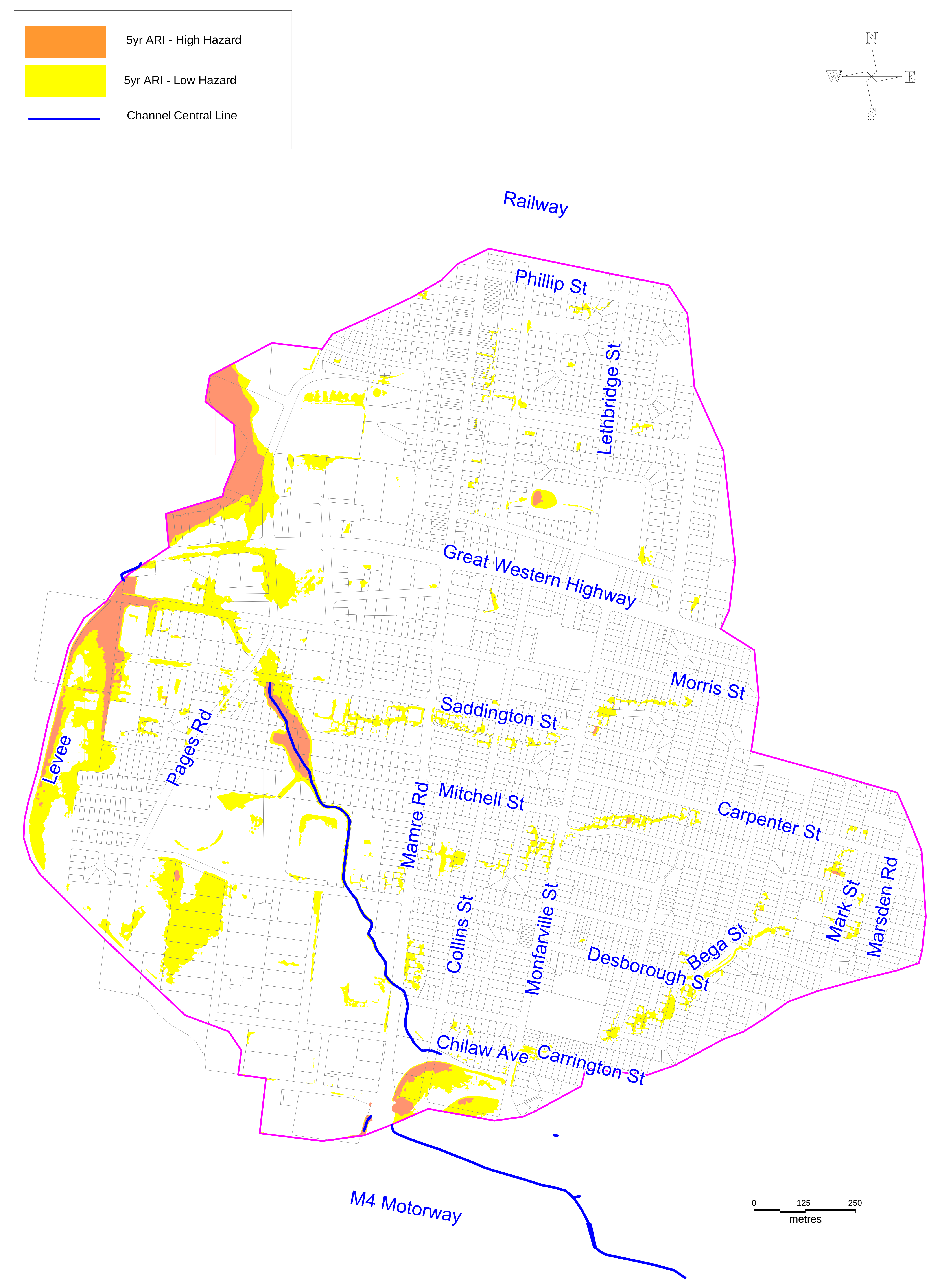


FIGURE 9.7
10 YEAR ARI - PROVISIONAL HAZARD

St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study

Cardno

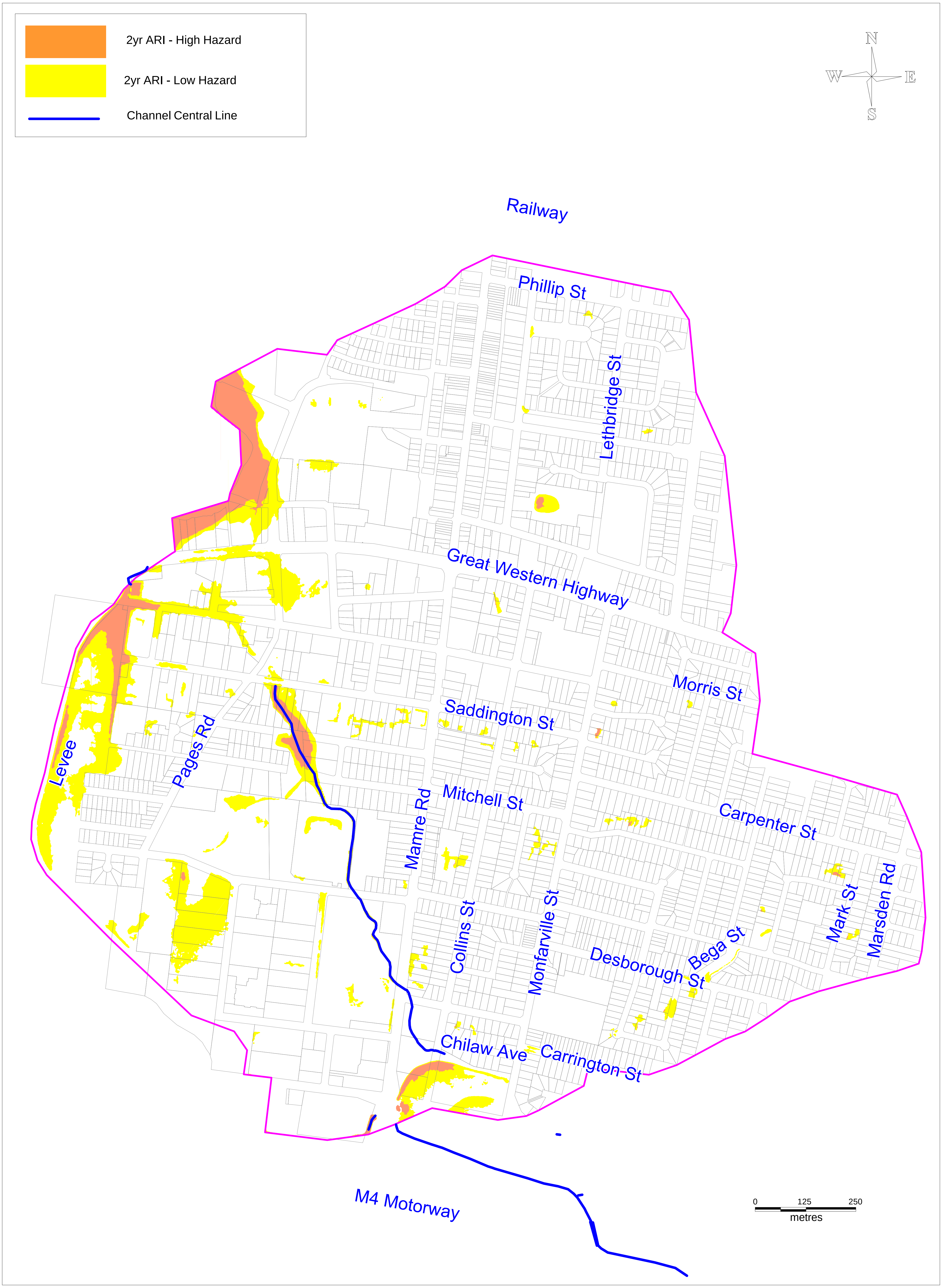
W4735
November 2015



St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study

FIGURE 9.8
5 YEAR ARI - PROVISIONAL HAZARD

W4735
November 2015



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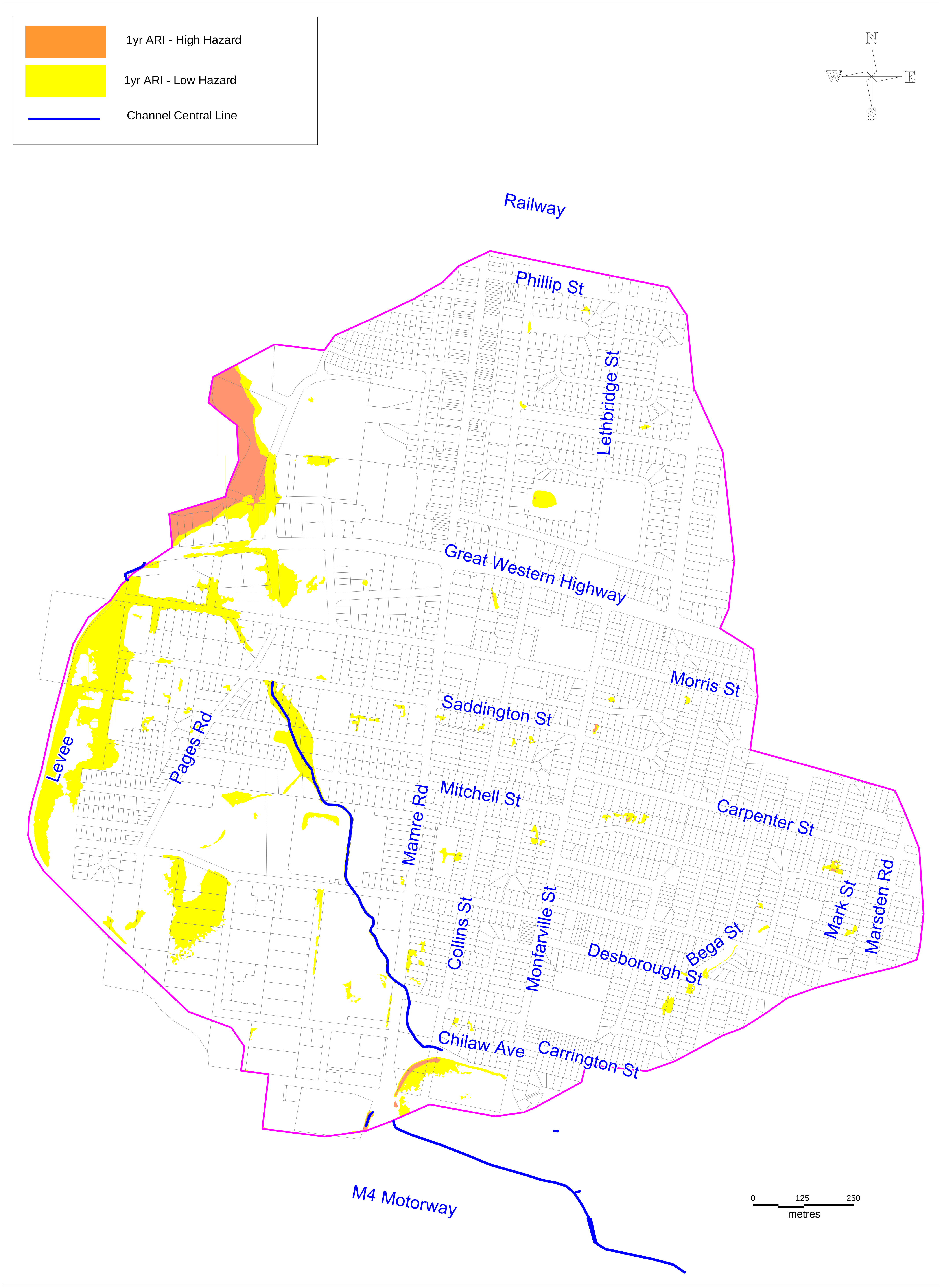
St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study

FIGURE 9.9
2 YEAR ARI - PROVISIONAL HAZARD

W4735
November 2015



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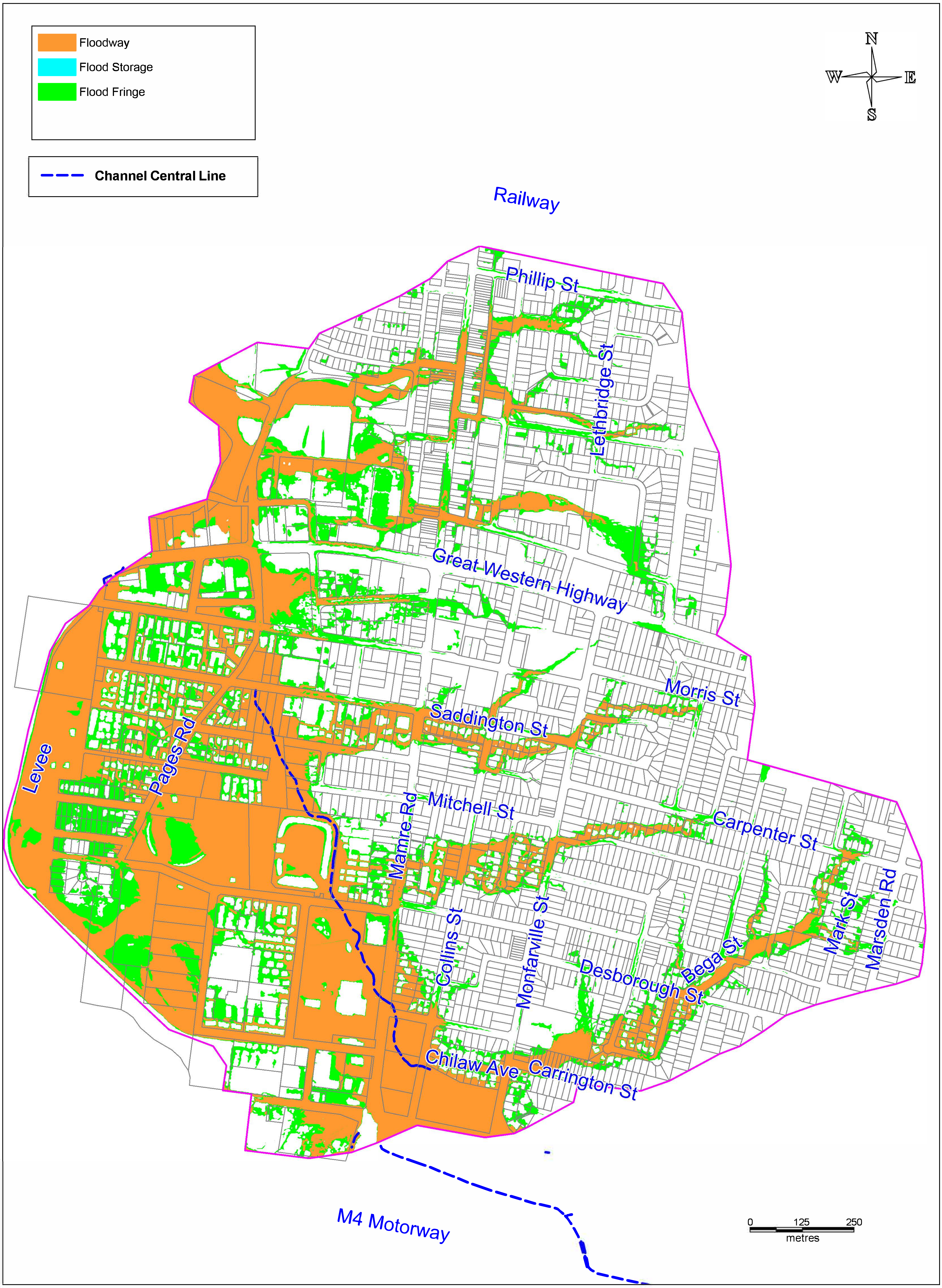
St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study

FIGURE 9.10
1 YEAR ARI - PROVISIONAL HAZARD

W4735
November 2015



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St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study

FIGURE 10.1
PMF - HYDRAULIC CATEGORIES

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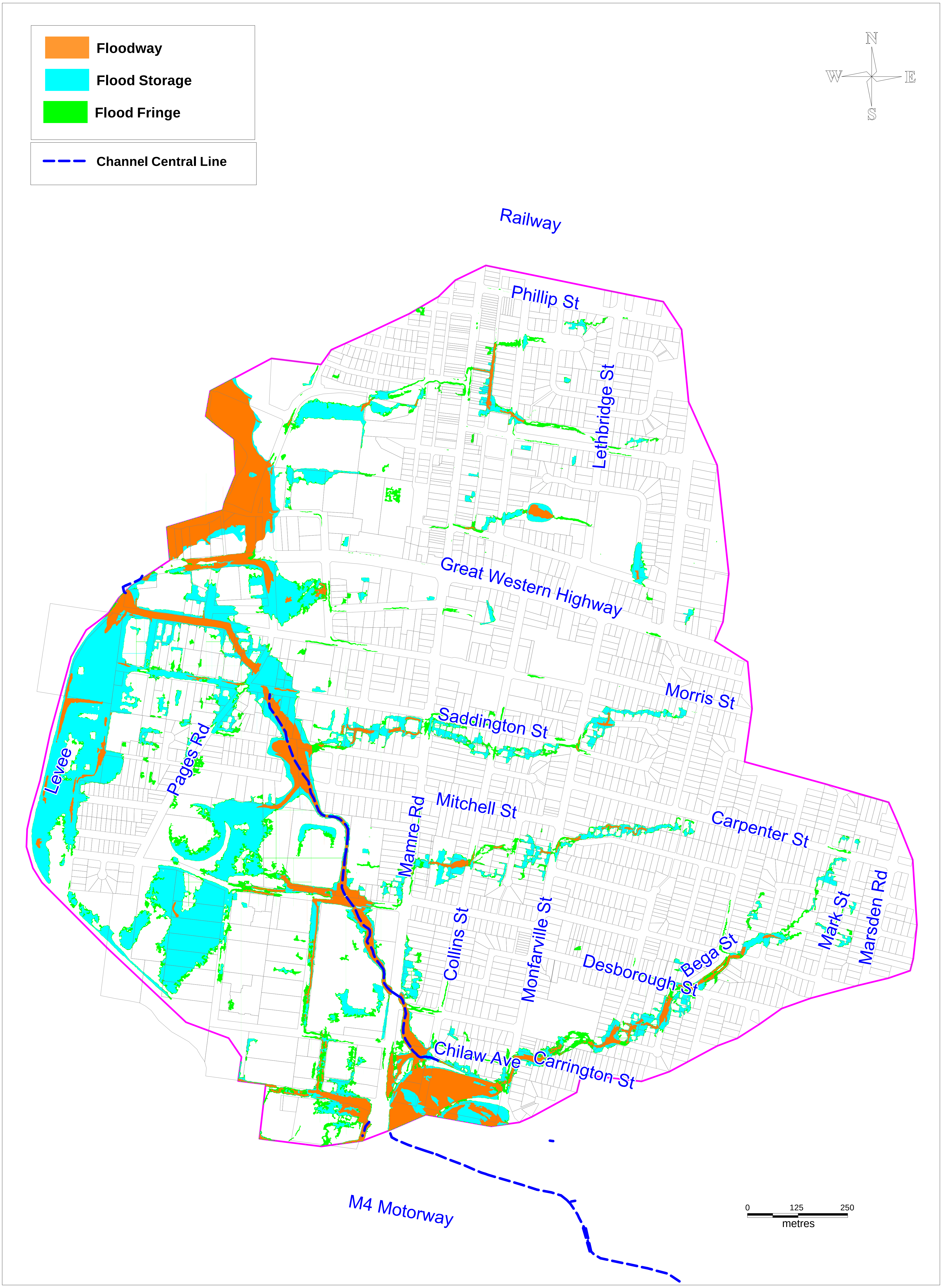
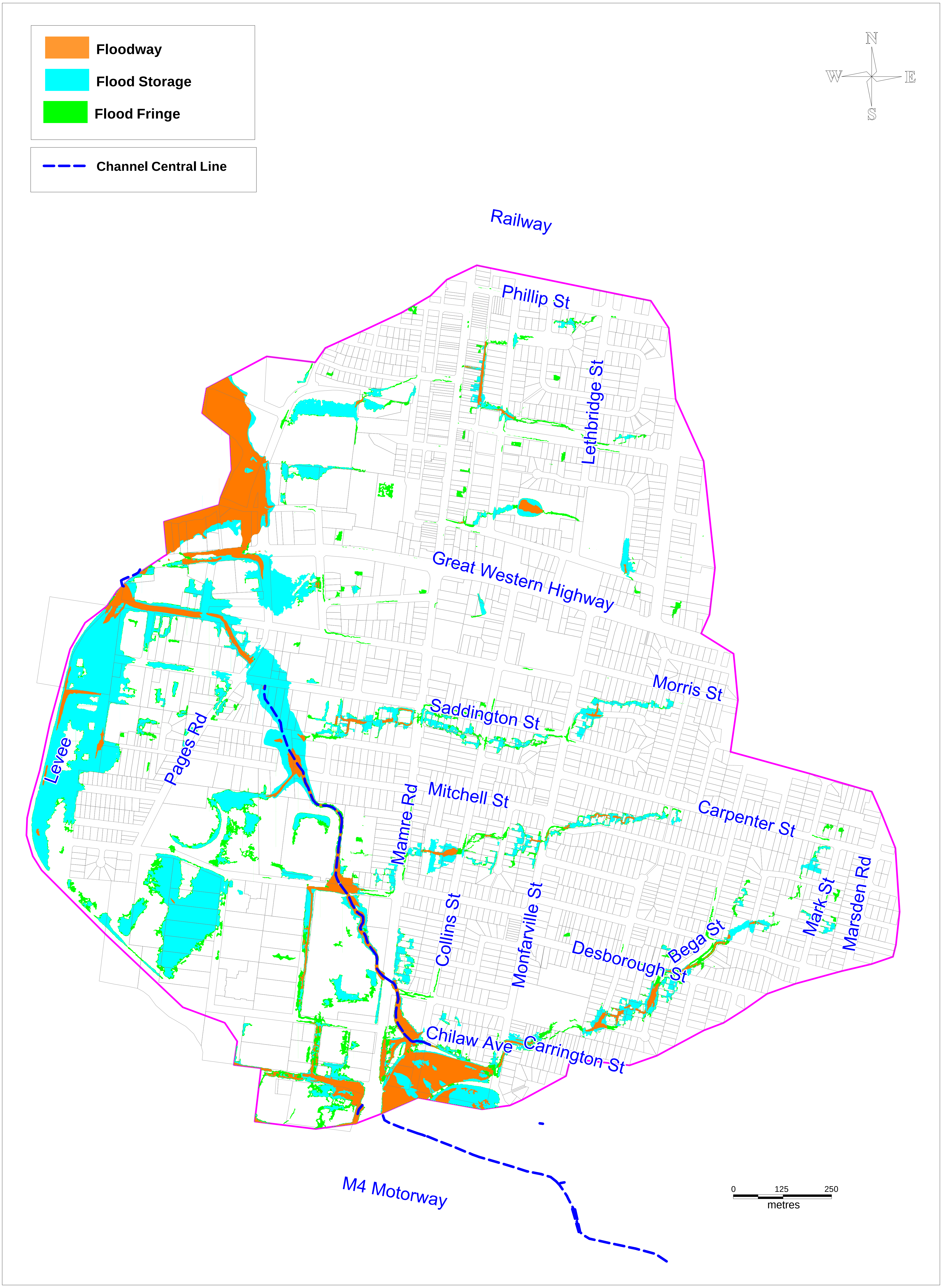


FIGURE 10.2

St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study

200 YEAR ARI - HYDRAULIC CATEGORIES

W4735
November 2015



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St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study

FIGURE 10.3
100 YEAR ARI - HYDRAULIC CATEGORIES

W4735
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St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study

FIGURE 10.4
50 YEAR ARI - HYDRAULIC CATEGORIES

W4735
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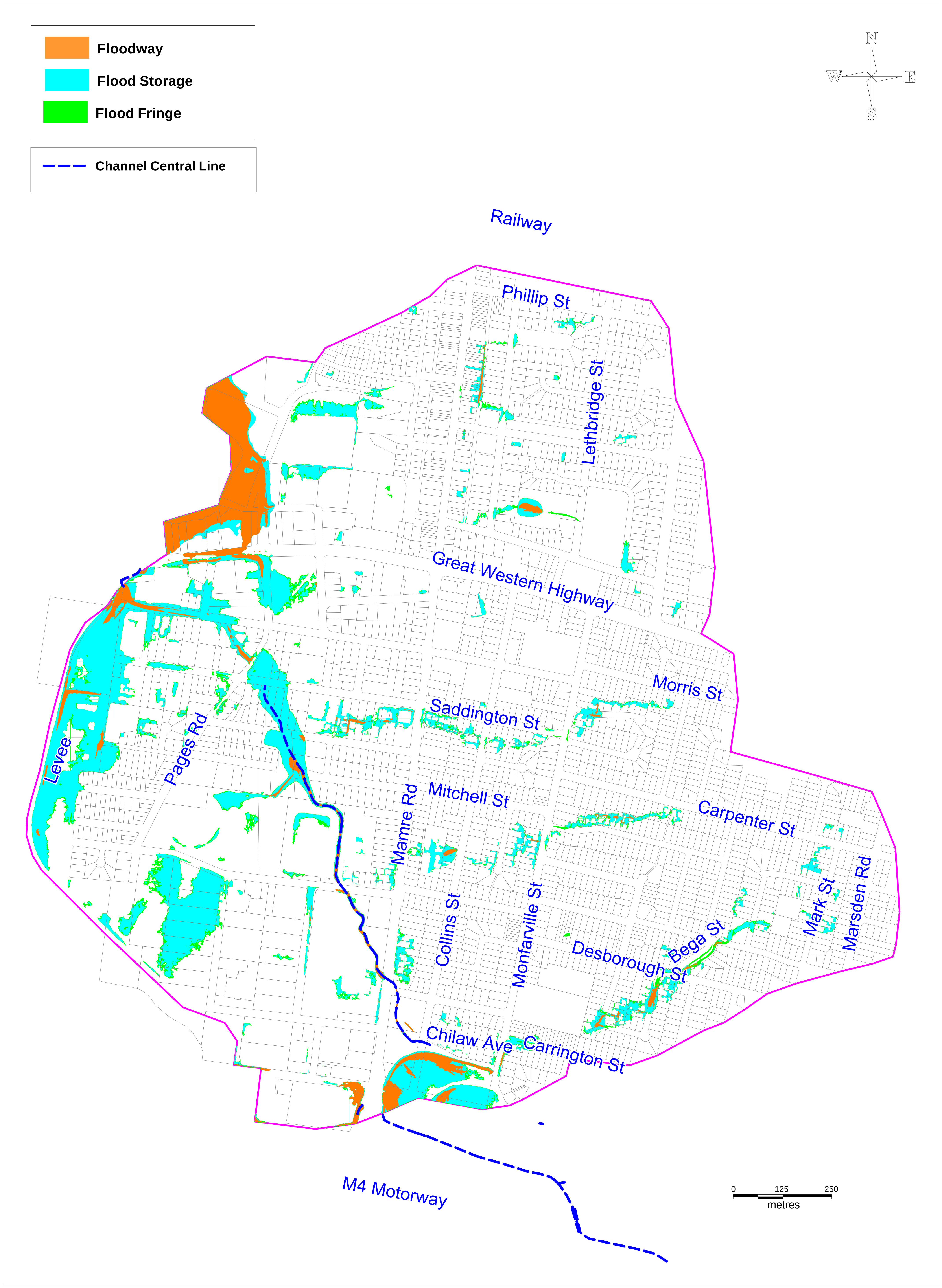

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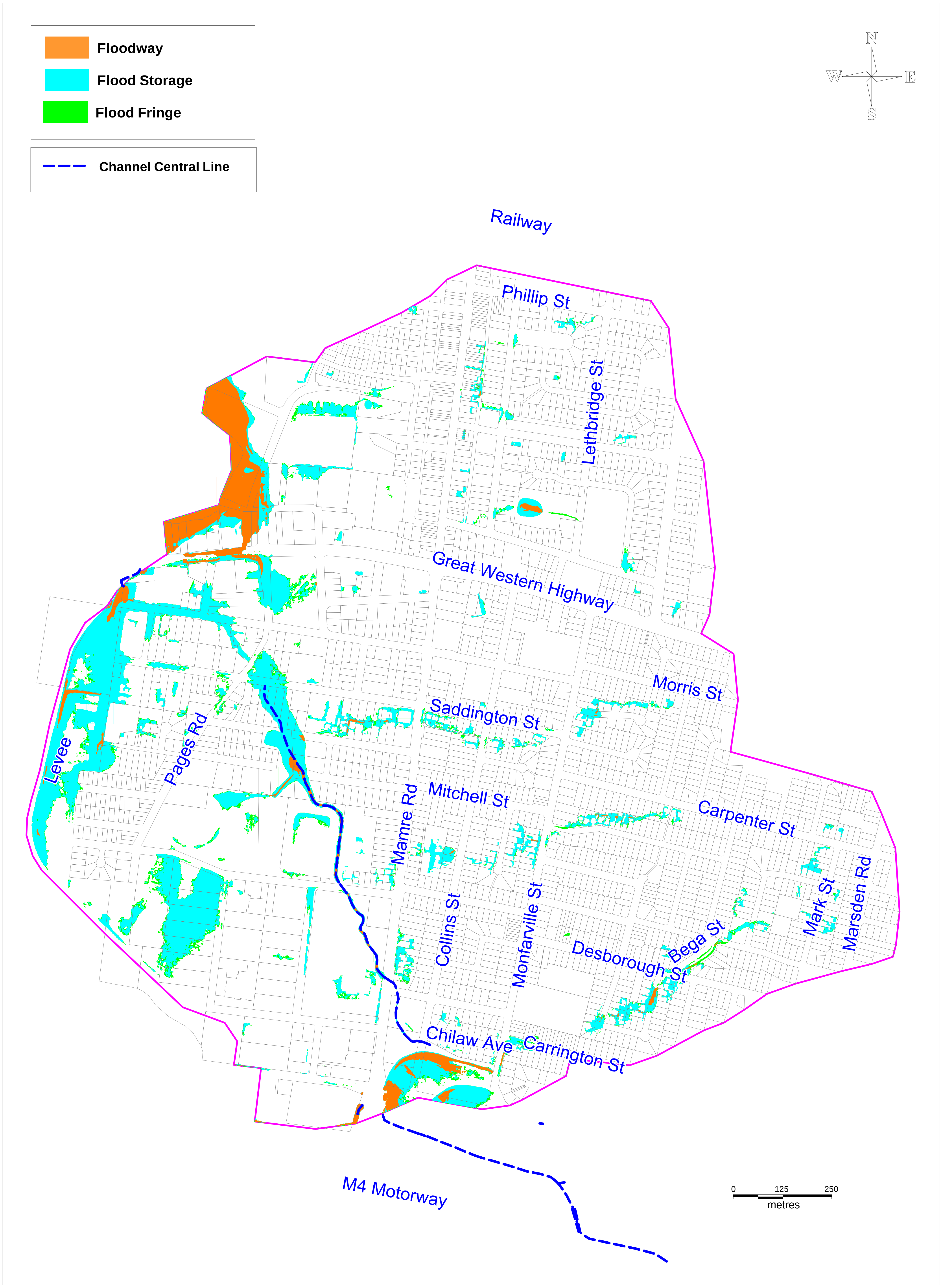
St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study

FIGURE 10.5
20 YEAR ARI - HYDRAULIC CATEGORIES

W4735
November 2015



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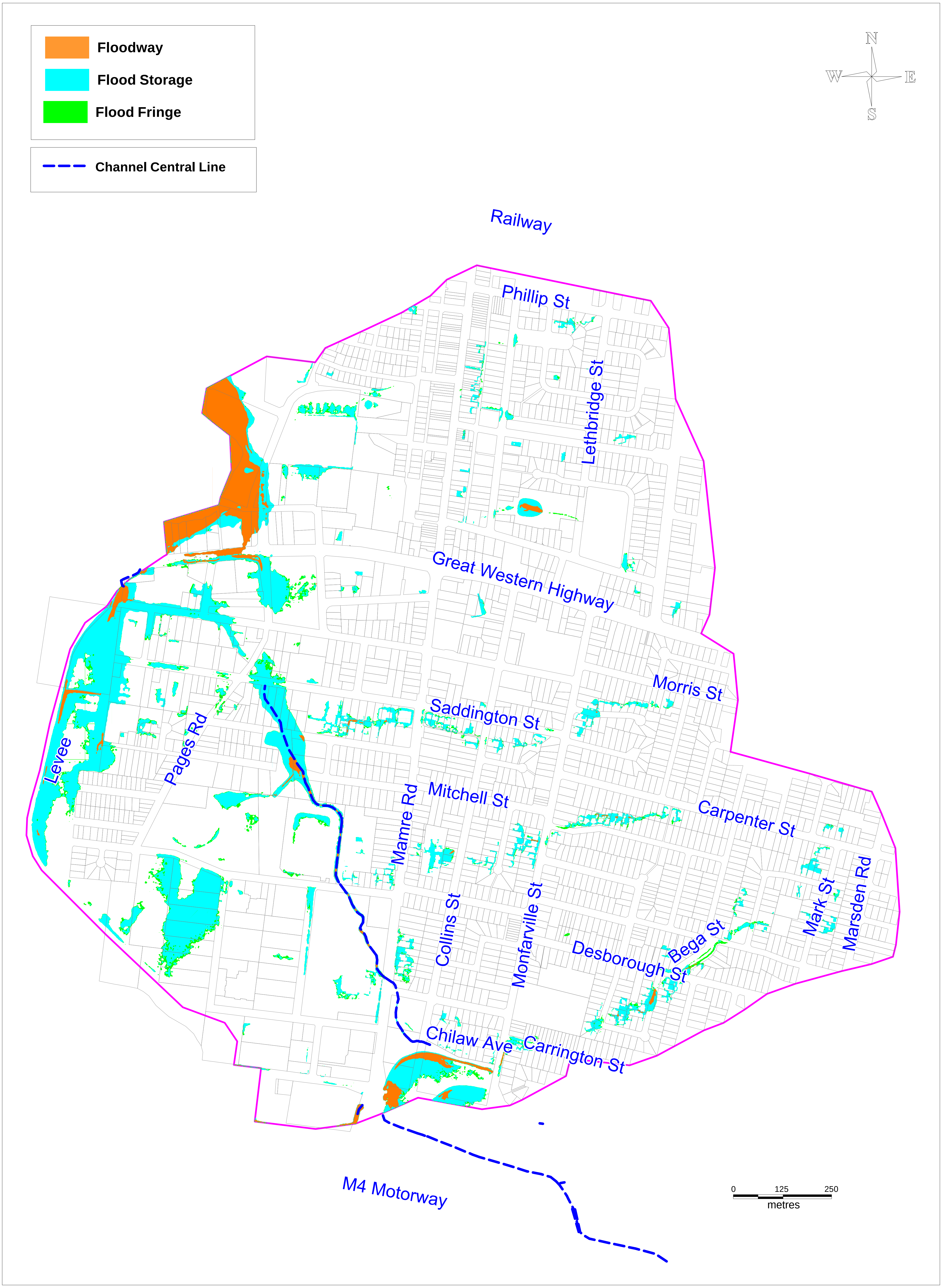
St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study

FIGURE 10.6
10 YEAR ARI - HYDRAULIC CATEGORIES

W4735
November 2015



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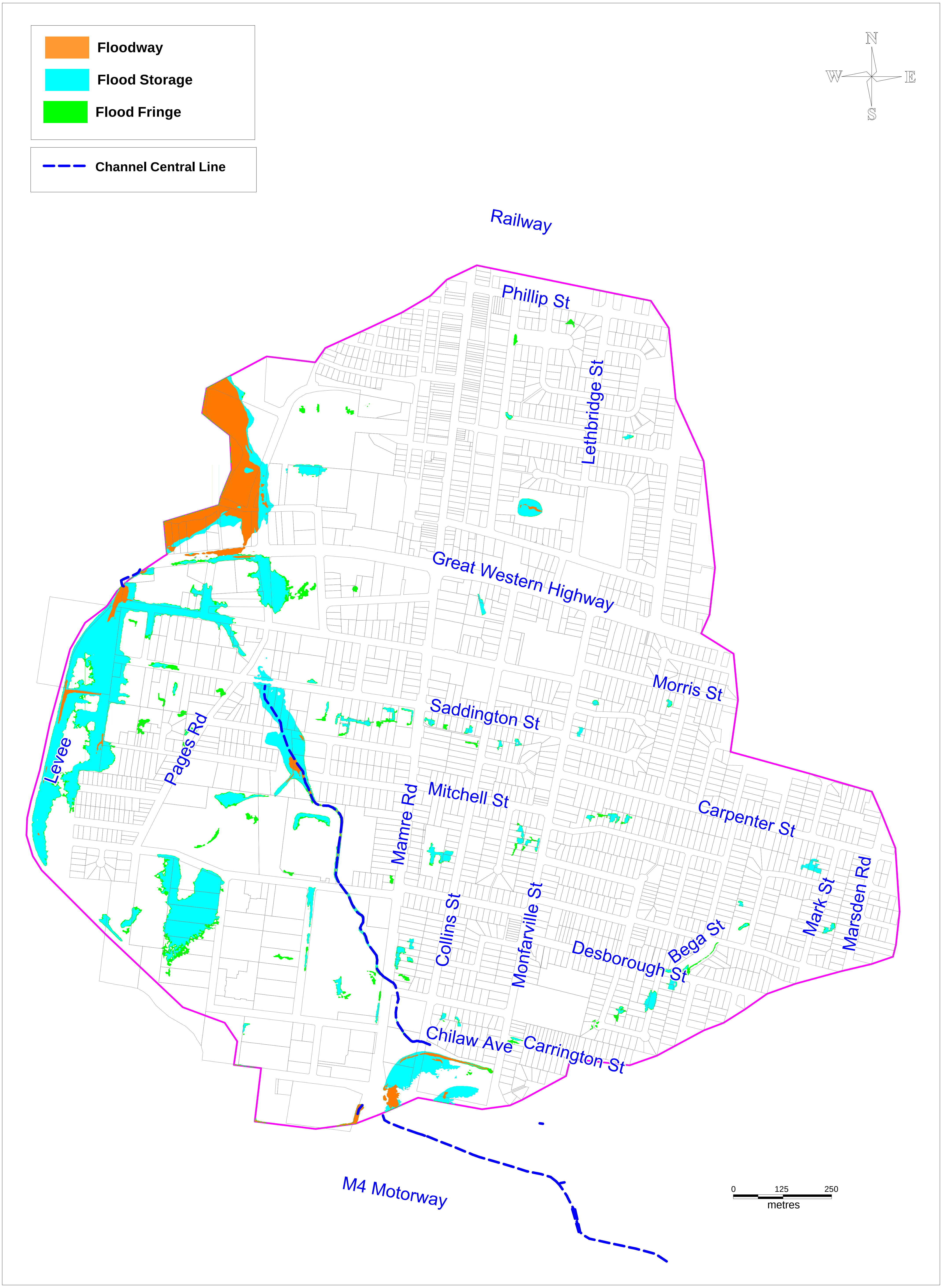
St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study

FIGURE 10.7
5 YEAR ARI - HYDRAULIC CATEGORIES

W4735
November 2015



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St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study

FIGURE 10.8
2 YEAR ARI - HYDRAULIC CATEGORIES

W4735
November 2015

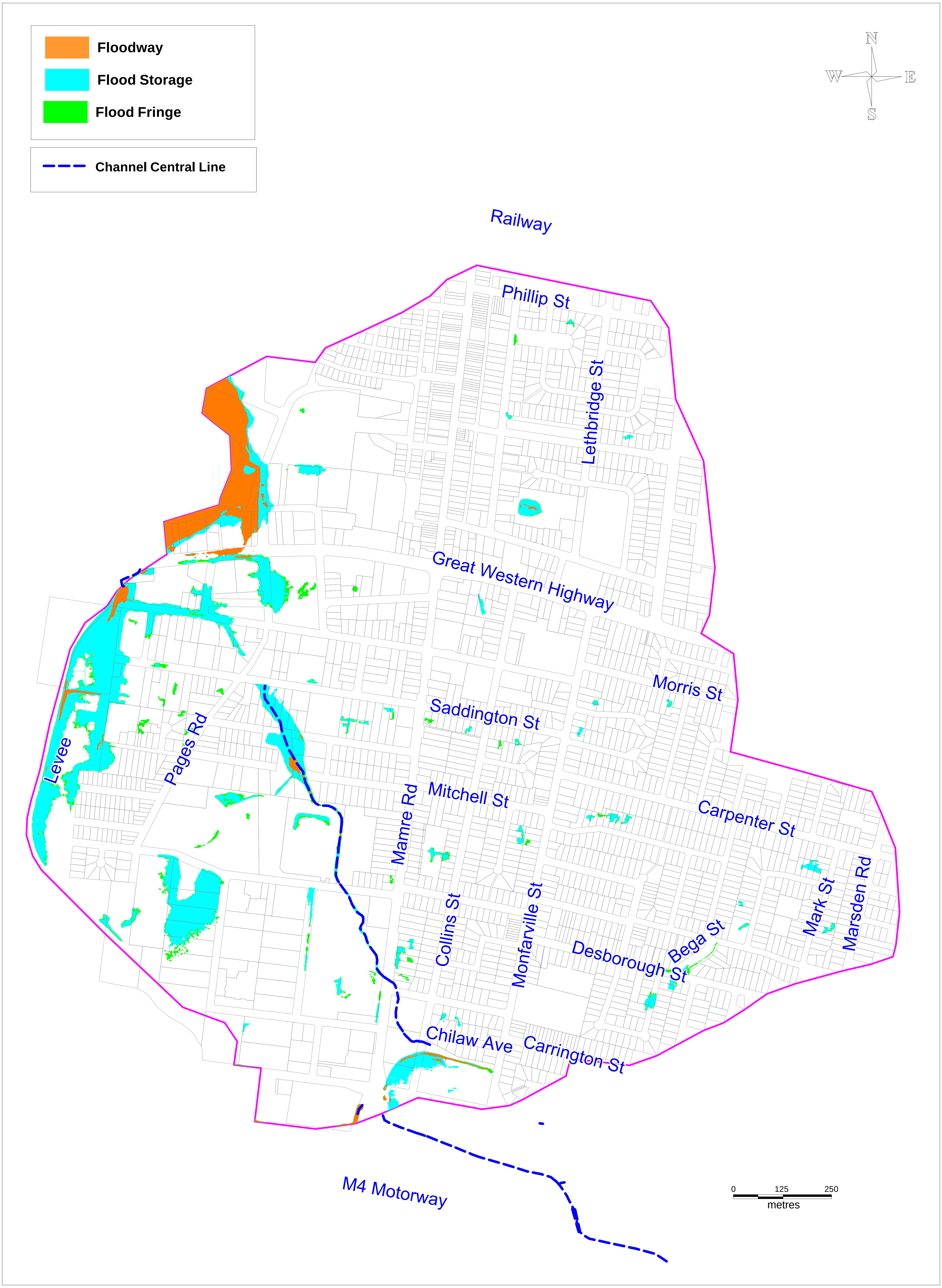

FIGURE 10.9
1 YEAR ARI - HYDRAULIC CATEGORIES

St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study

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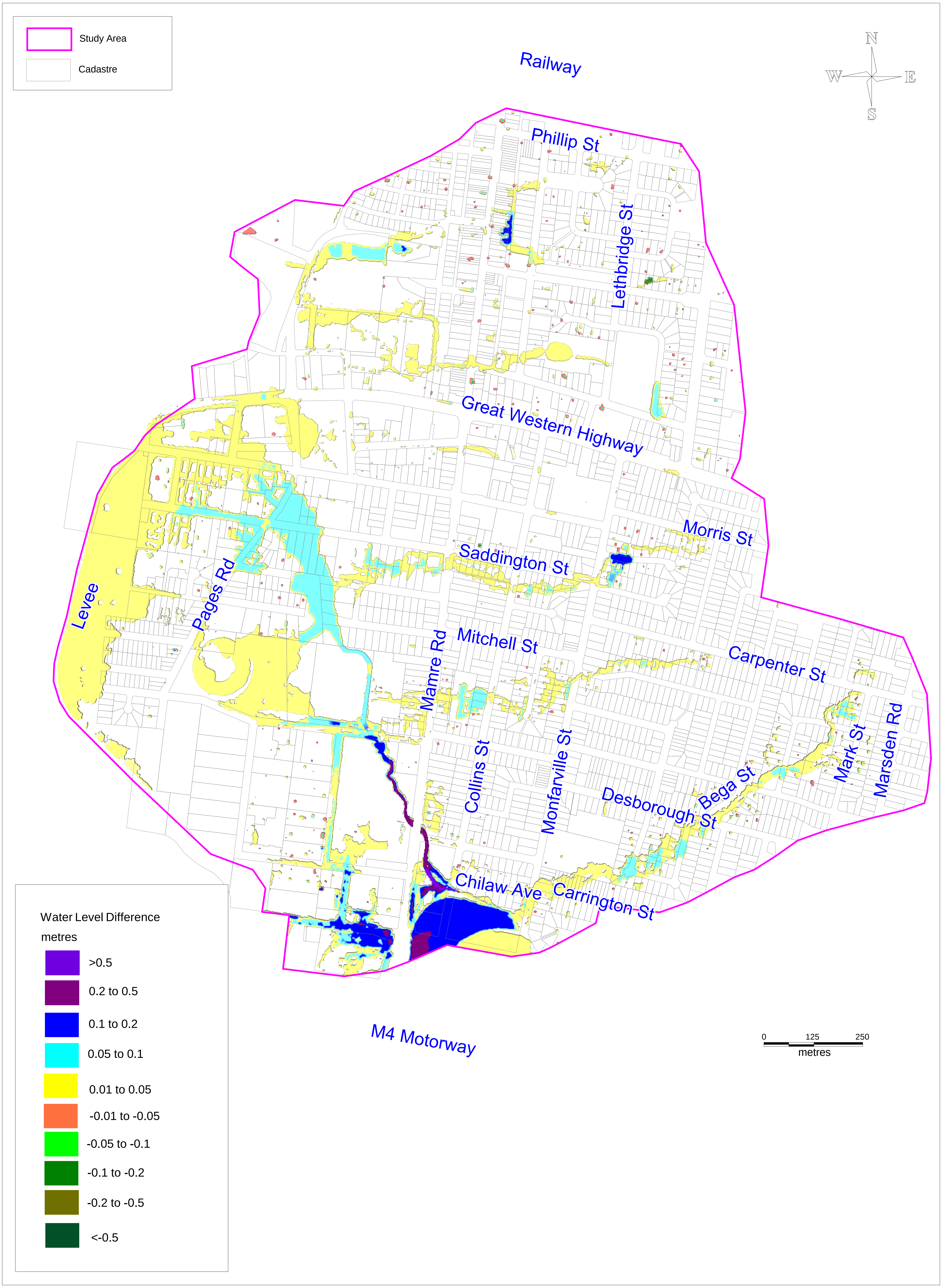
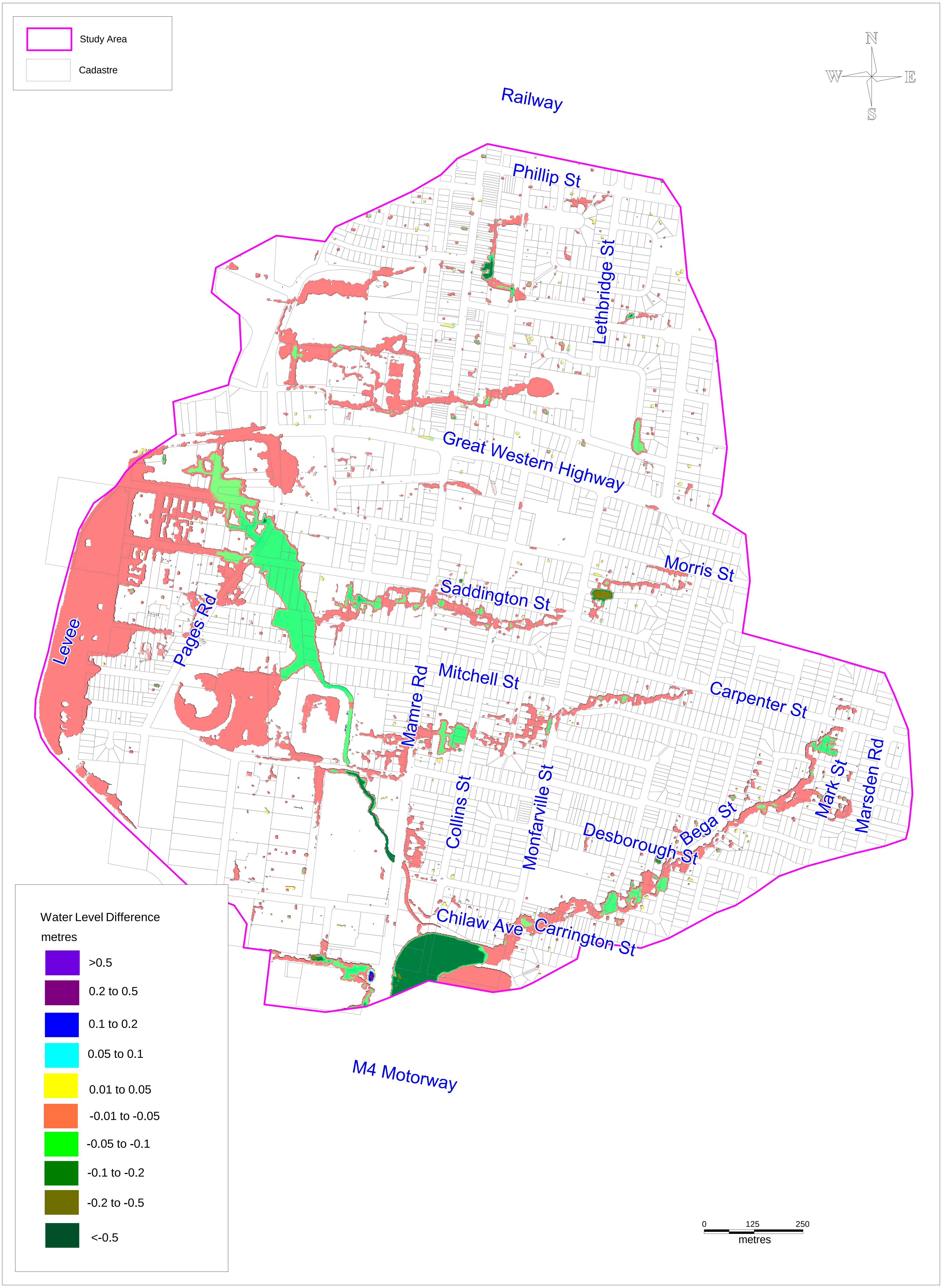


FIGURE 12.1
100 YEAR ARI WATER LEVEL DIFFERENCES
RAINFALL+20% LESS EXISTING



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St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study

FIGURE 12.2
100 YEAR ARI WATER LEVEL DIFFERENCES
RAINFALL-20% LESS EXISTING

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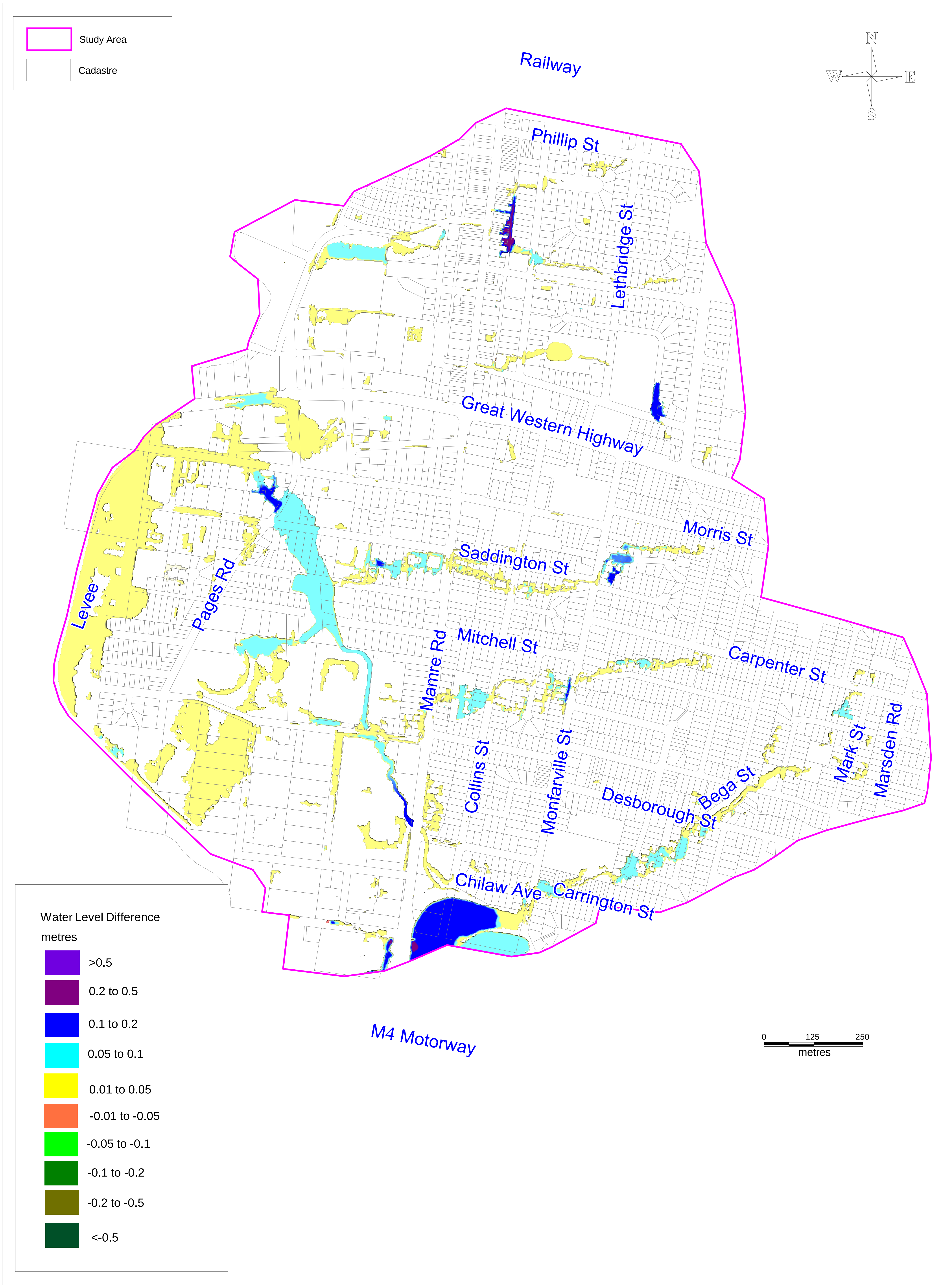
November 2015



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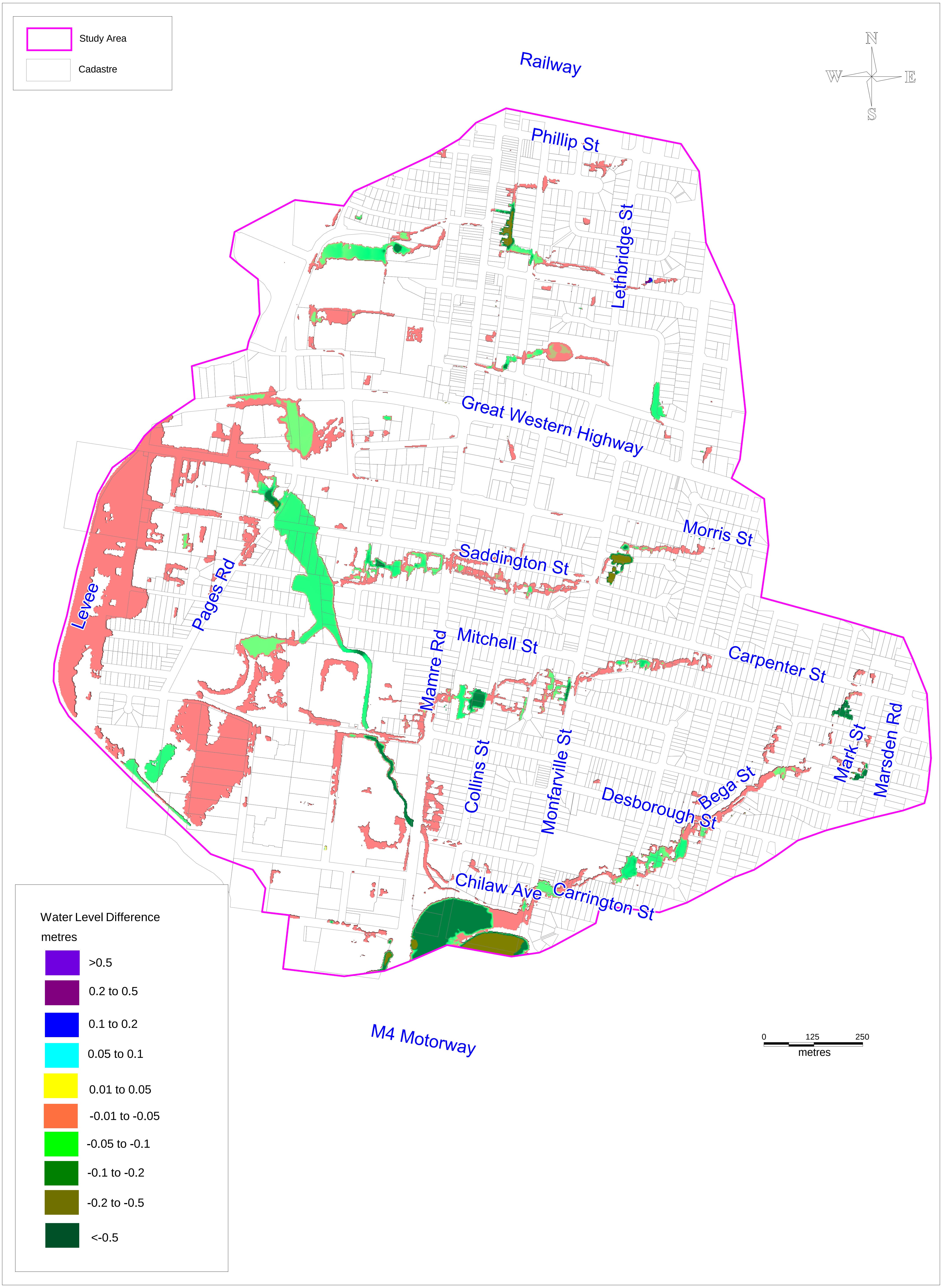
St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study

FIGURE 12.3
20 YEAR ARI WATER LEVEL DIFFERENCES
RAINFALL+20% LESS EXISTING



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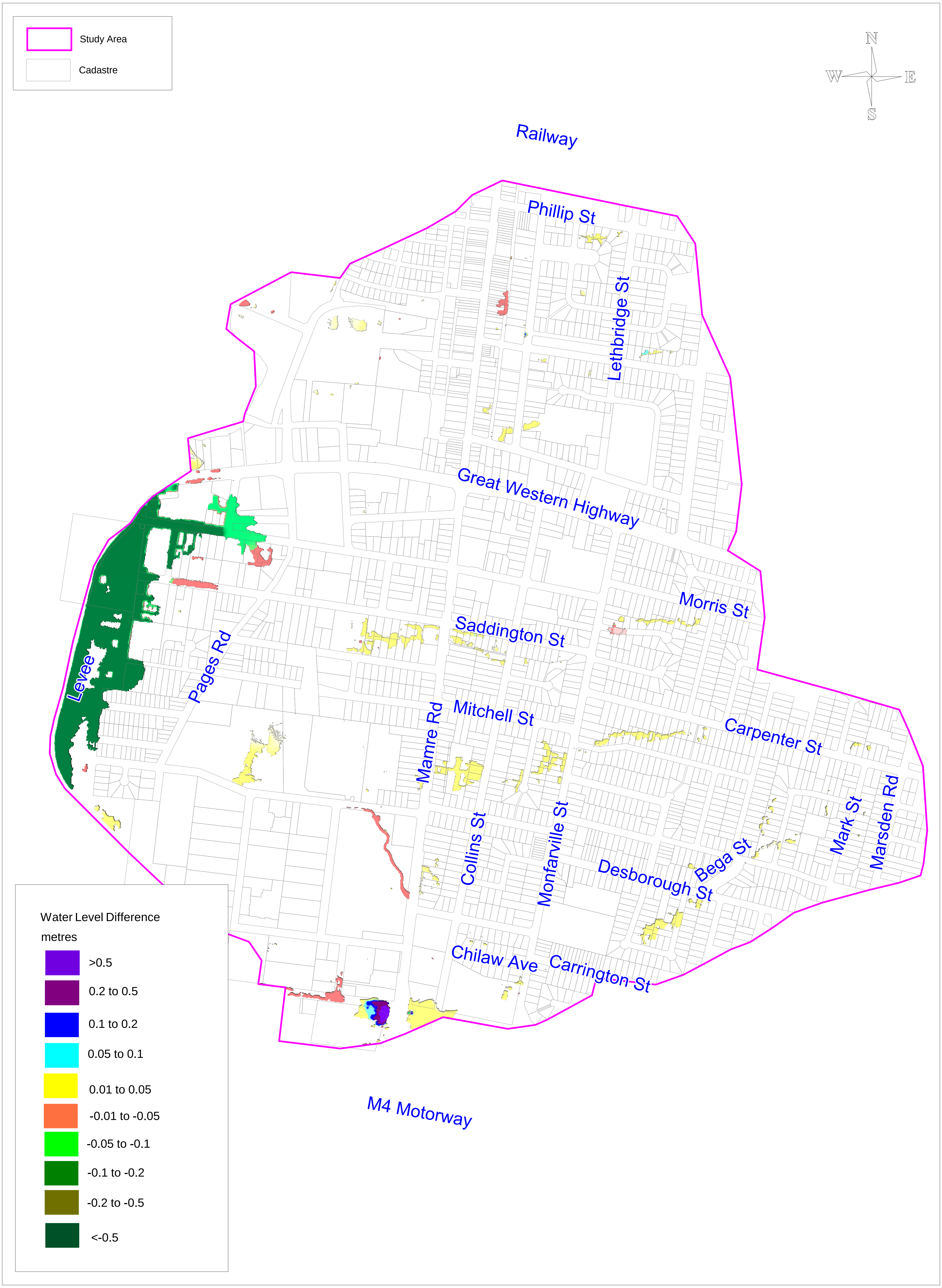
St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study

FIGURE 12.4
20 YEAR ARI WATER LEVEL DIFFERENCES
RAINFALL-20% LESS EXISTING



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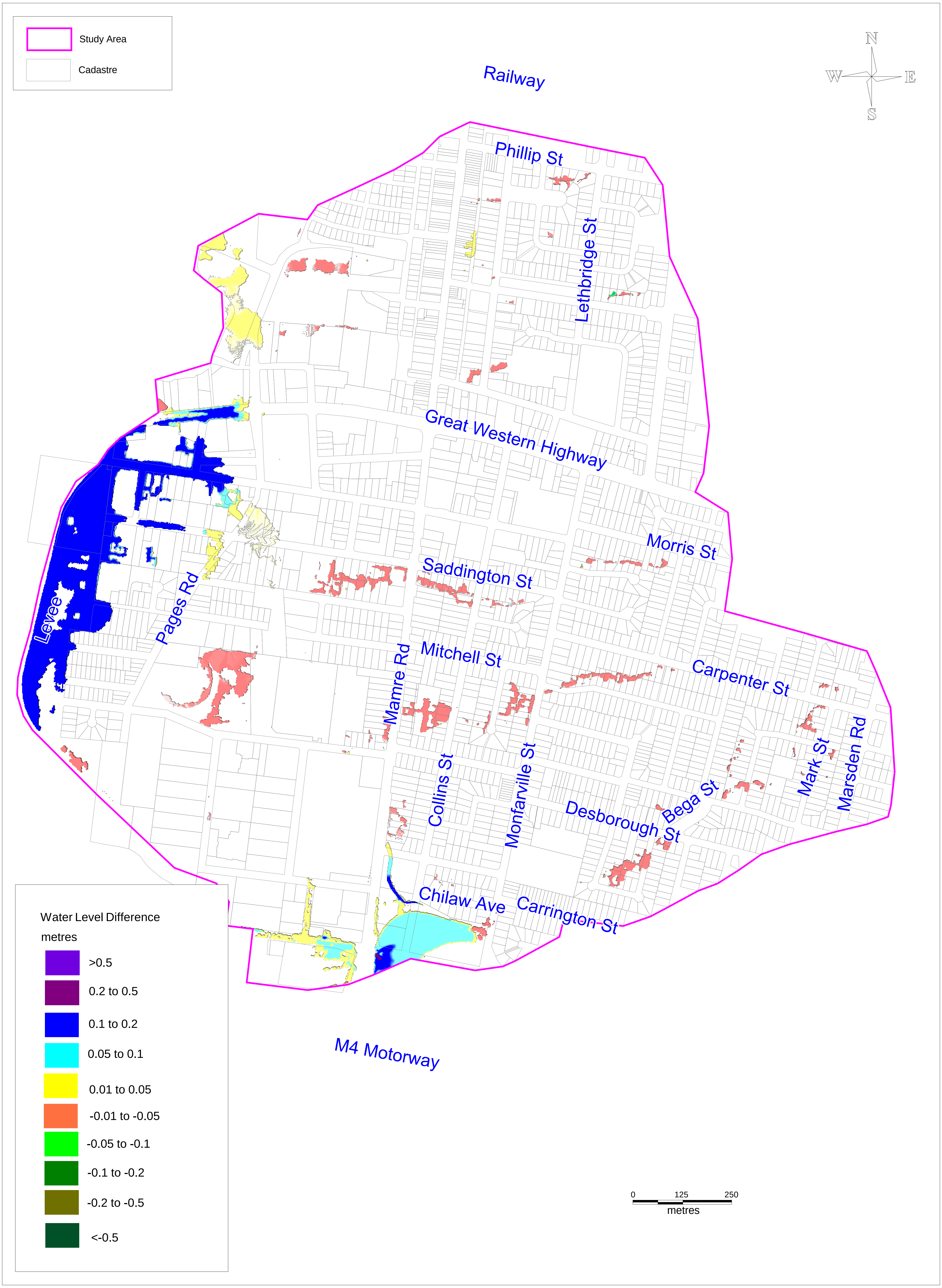
St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study

FIGURE 12.5
100 YEAR ARI WATER LEVEL DIFFERENCES
ROURHNESS+20% LESS EXISTING

W4735
November 2015



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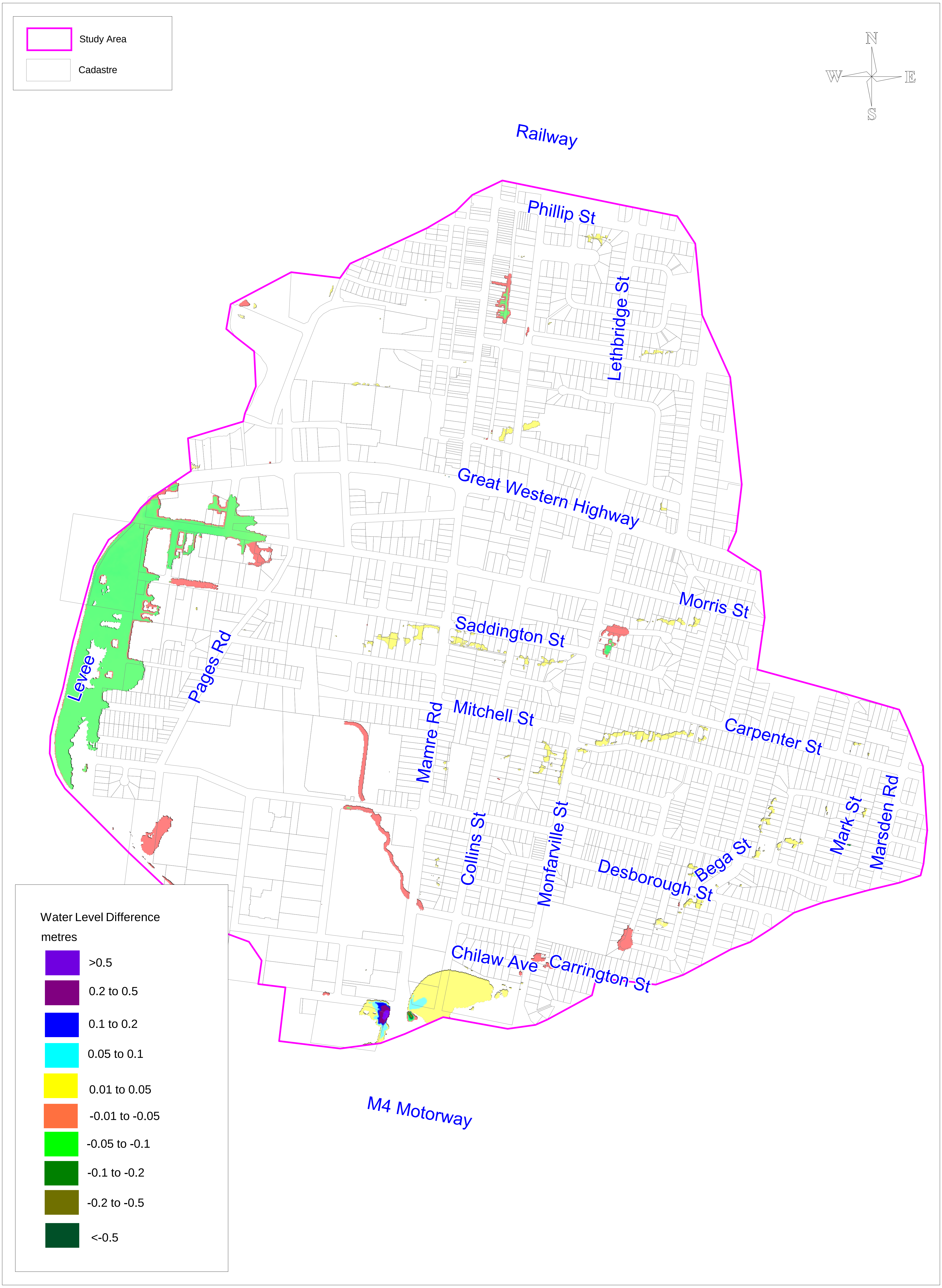
St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study

W4735
November 2015

FIGURE 12.6
100 YEAR ARI WATER LEVEL DIFFERENCES
ROURHNESS-20% LESS EXISTING



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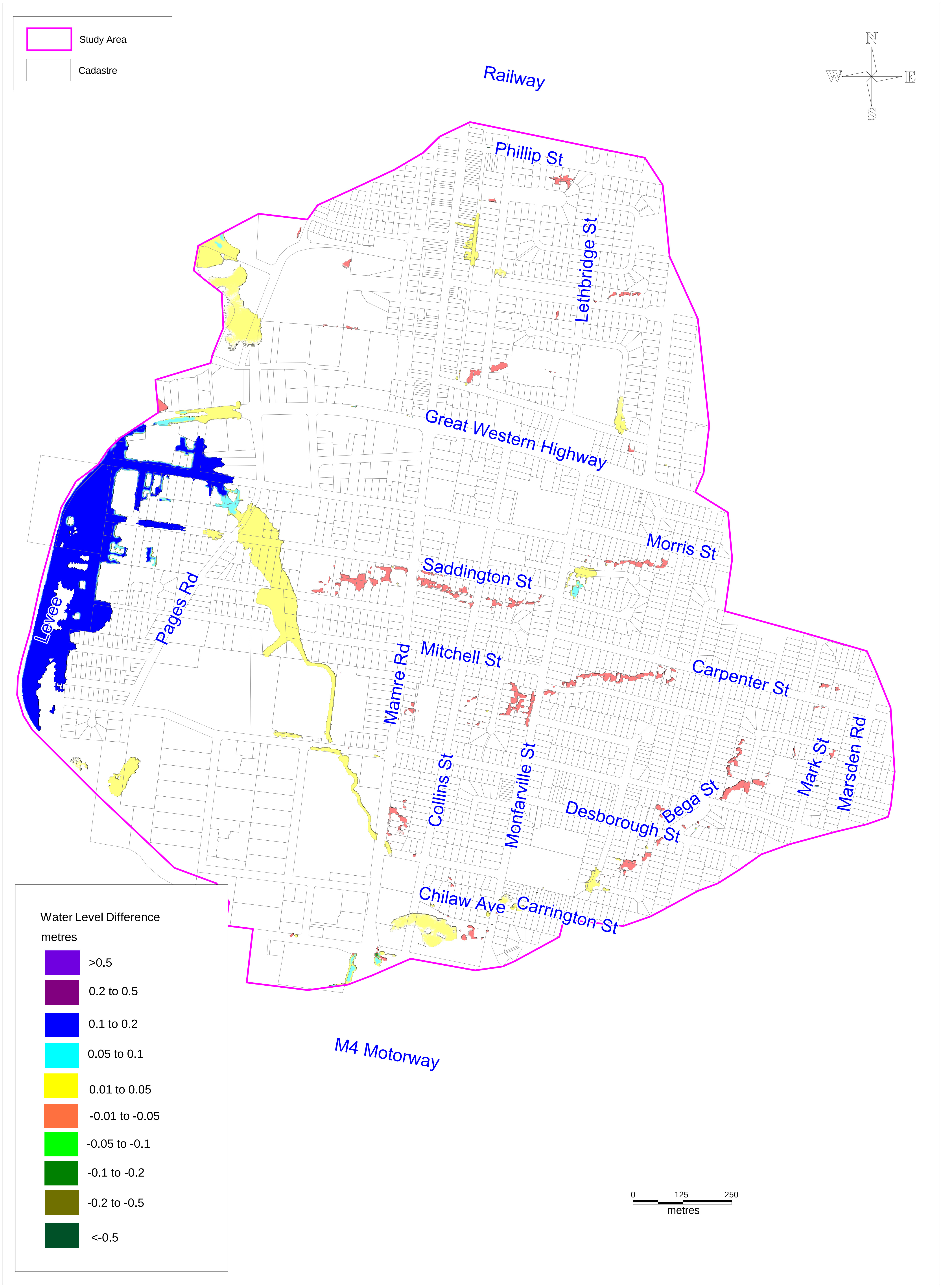
St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study

FIGURE 12.7
20 YEAR ARI WATER LEVEL DIFFERENCES
ROURHNESS+20% LESS EXISTING

W4735
November 2015



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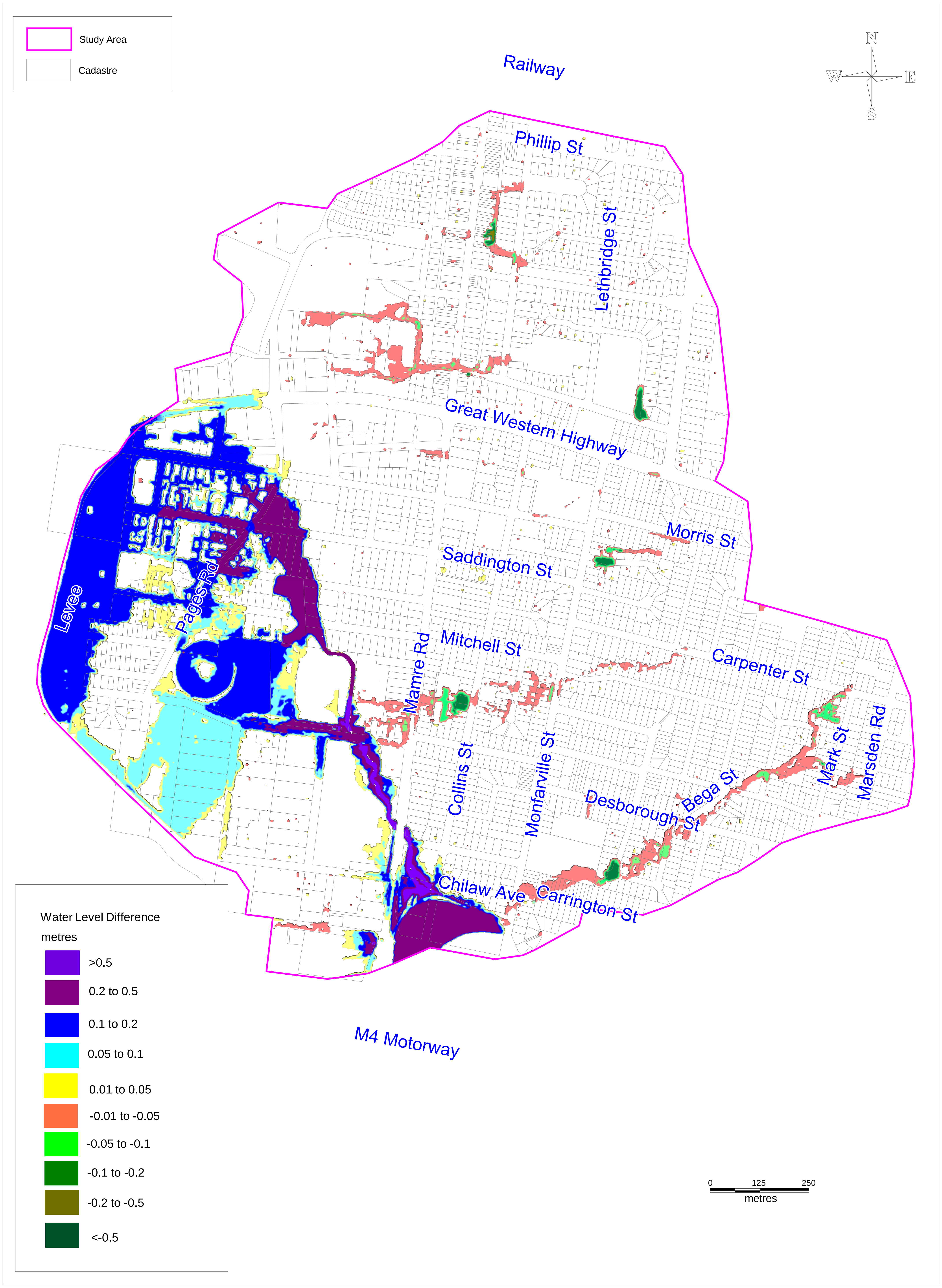
St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study

FIGURE 12.8
20 YEAR ARI WATER LEVEL DIFFERENCES
ROURHNESS-20% LESS EXISTING

W4735
November 2015



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St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study

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FIGURE 12.9
100 YEAR ARI WATER LEVEL DIFFERENCES
0% PITS BLOCKED LESS EXISTING WITH 50% PITS BLOCKED

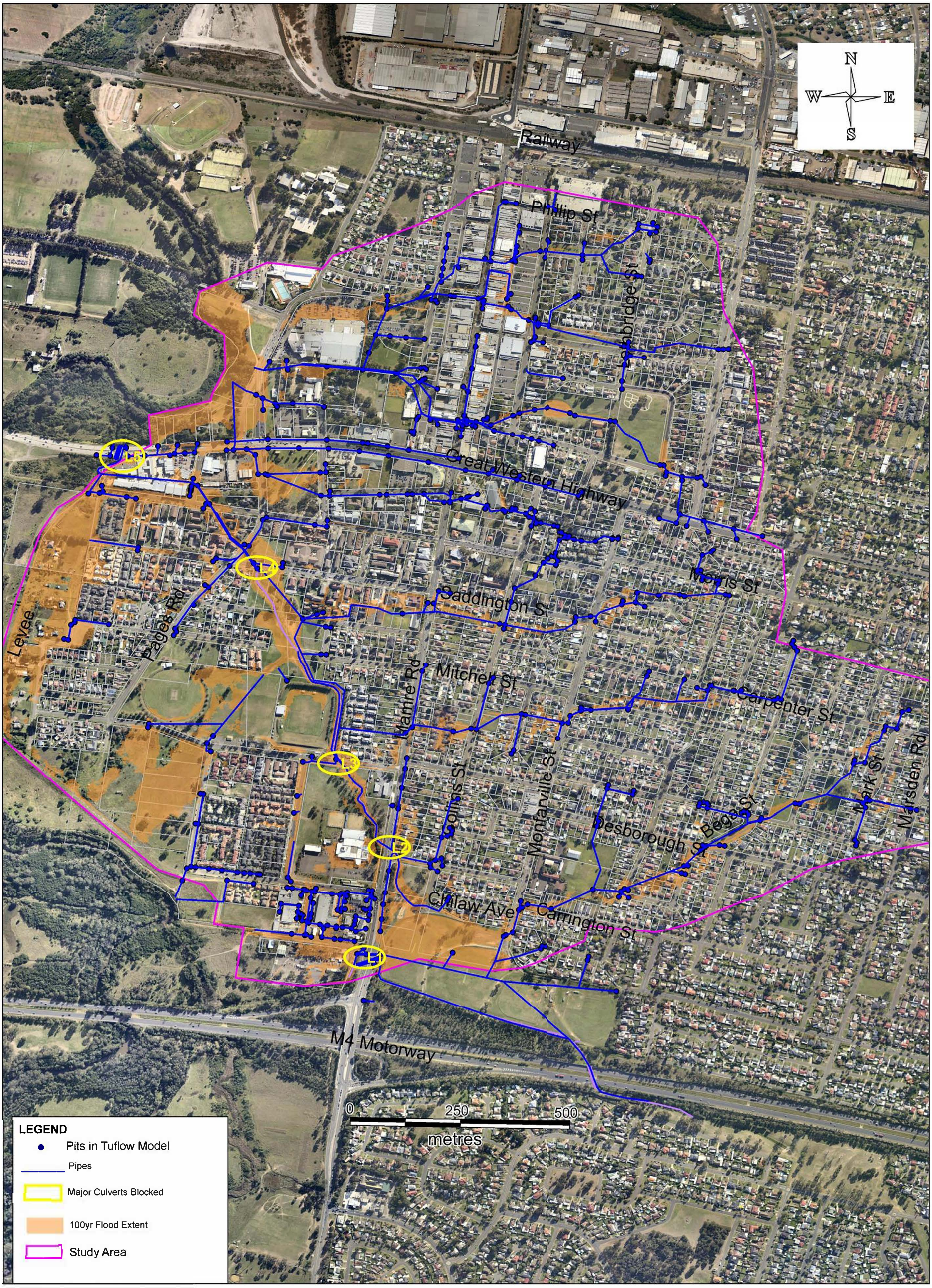
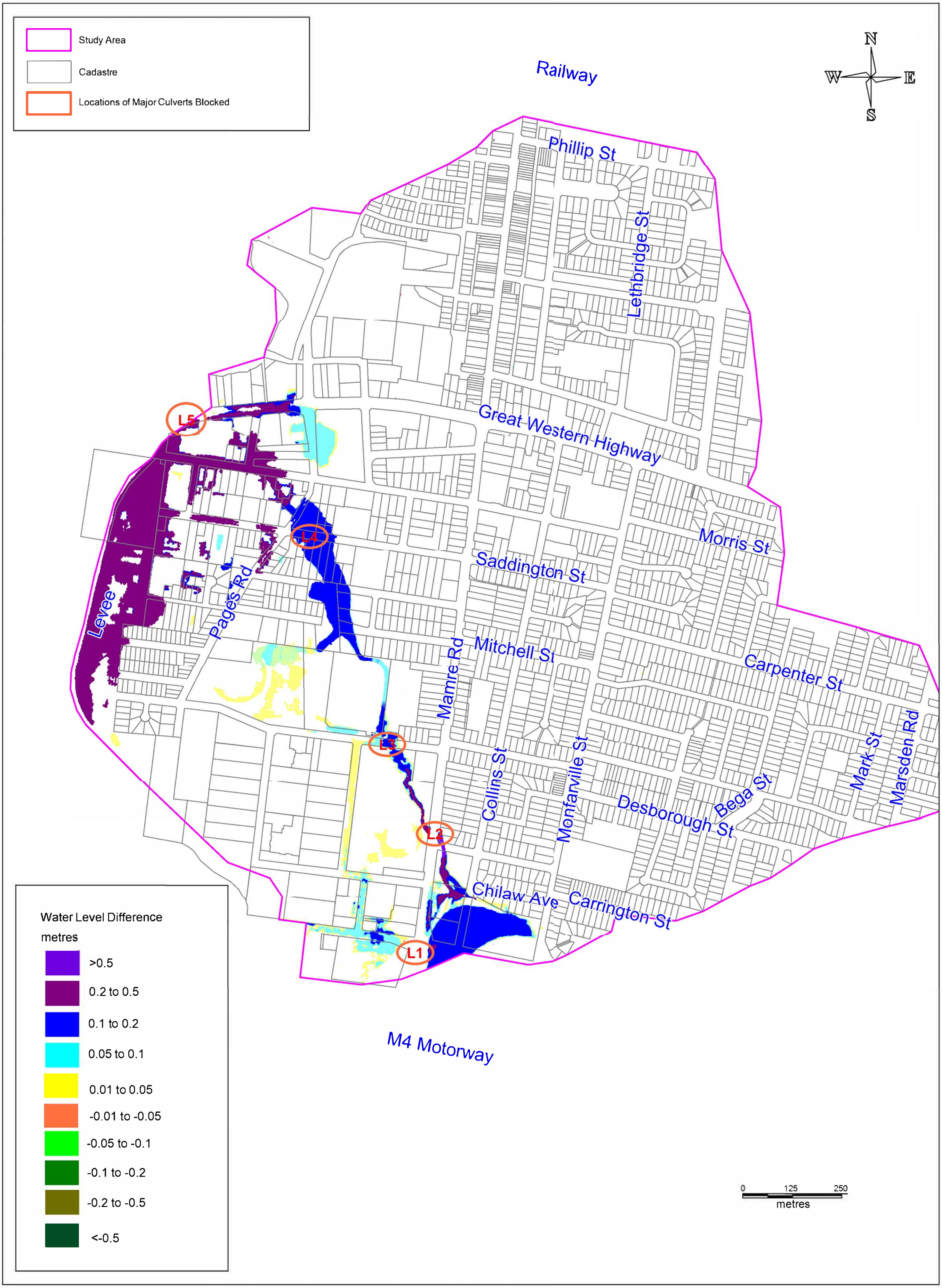


FIGURE 12.10
LOCATIONS OF MAJOR CULVERTS BLOCKED



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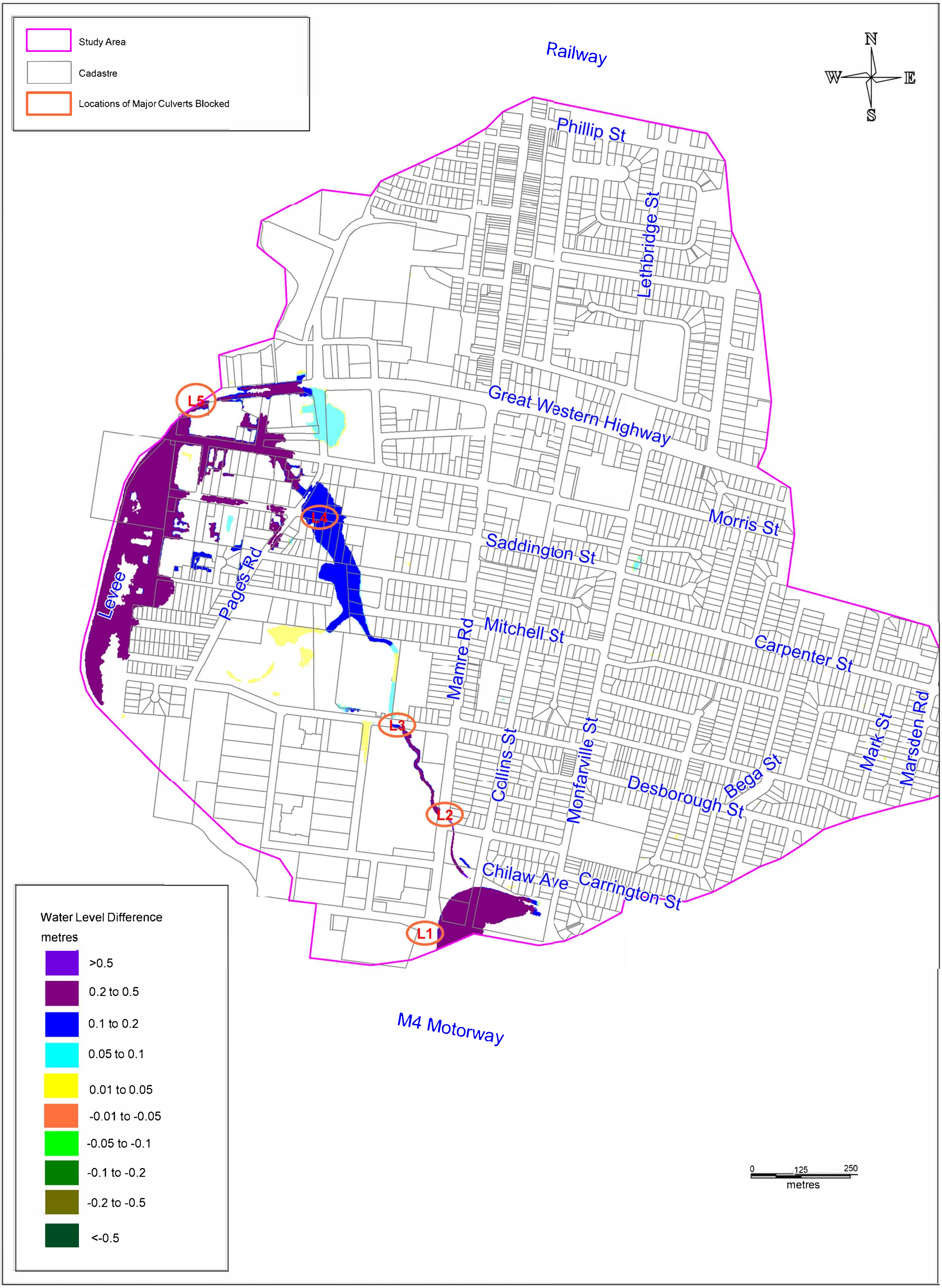
St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study

FIGURE 12.11
100 YEAR ARI WATER LEVEL DIFFERENCES
MAJOR CULVERTS BLOCKED LESS EXISTING

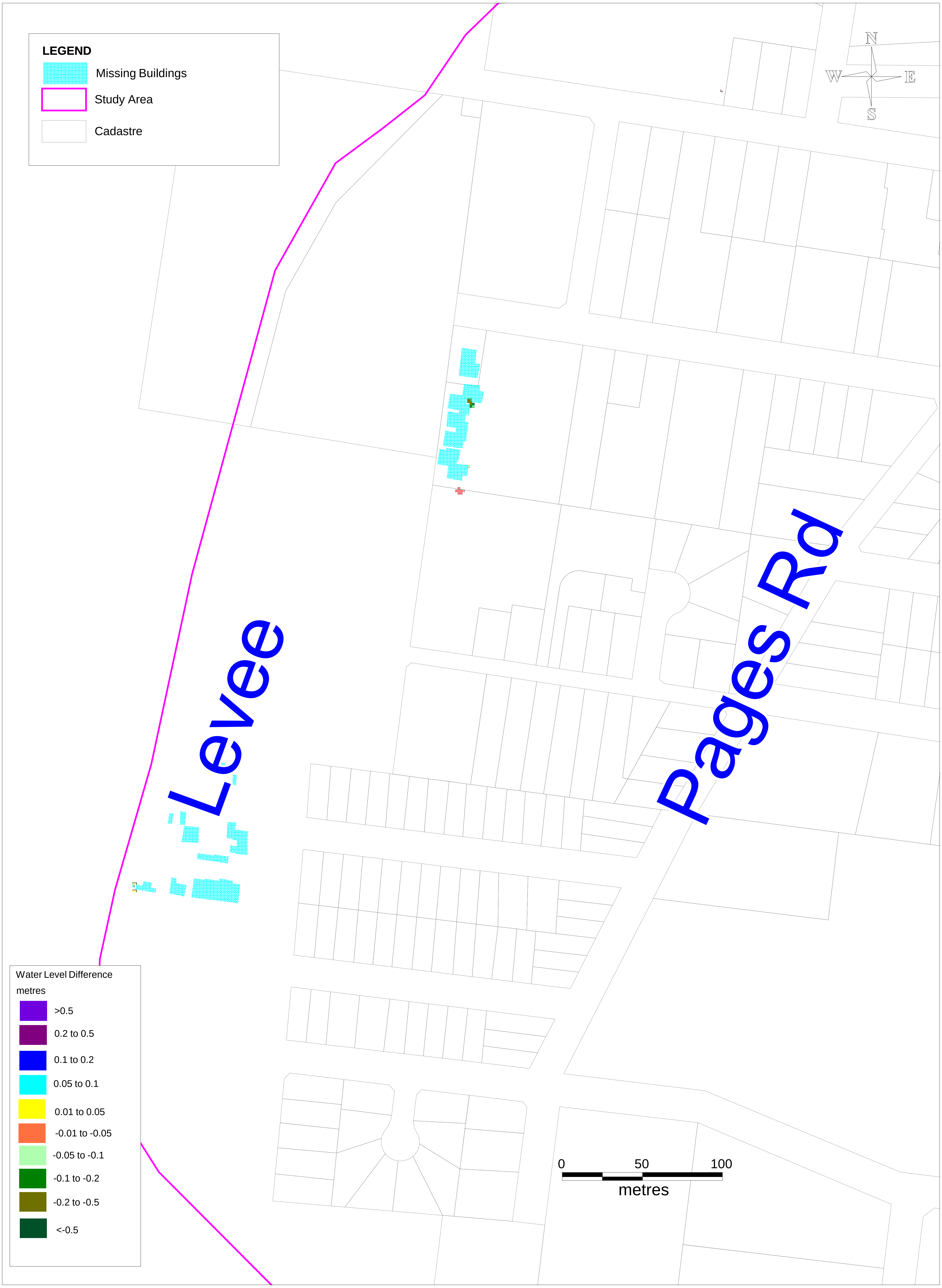


Cardno

St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study

FIGURE 12.12
20 YEAR ARI WATER LEVEL DIFFERENCES
MAJOR CULVERTS BLOCKED LESS EXISTING

W4735
November 2015



Cardno

St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study

FIGURE 12.13
100 YEAR ARI WATER LEVEL DIFFERENCES
MISSING BUILDINGS LESS EXISTING

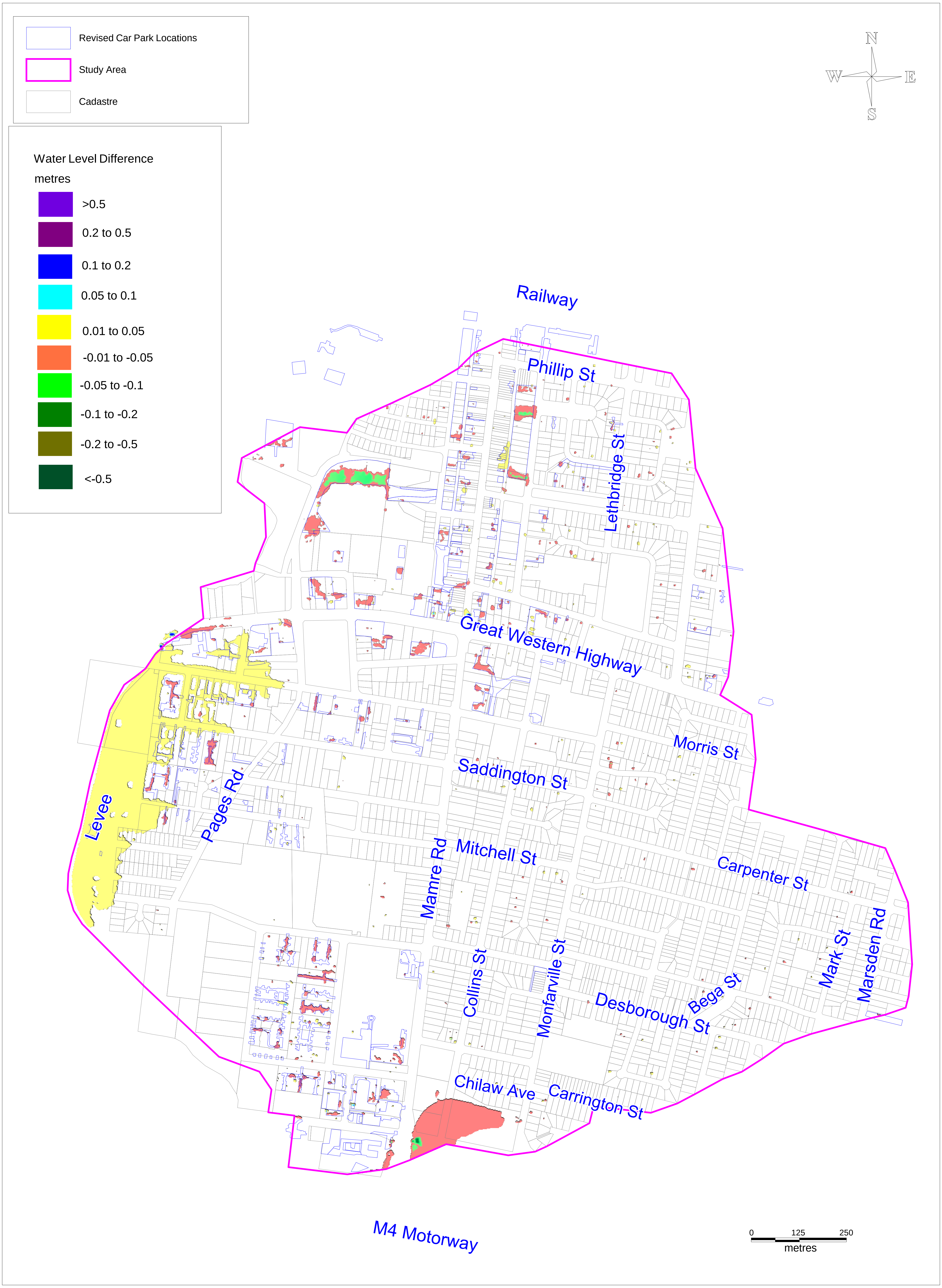
W4735
November 2015

Cardno

St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study

FIGURE 12.14
REVISED CAR PARK LOCATIONS

W4735
November 2015

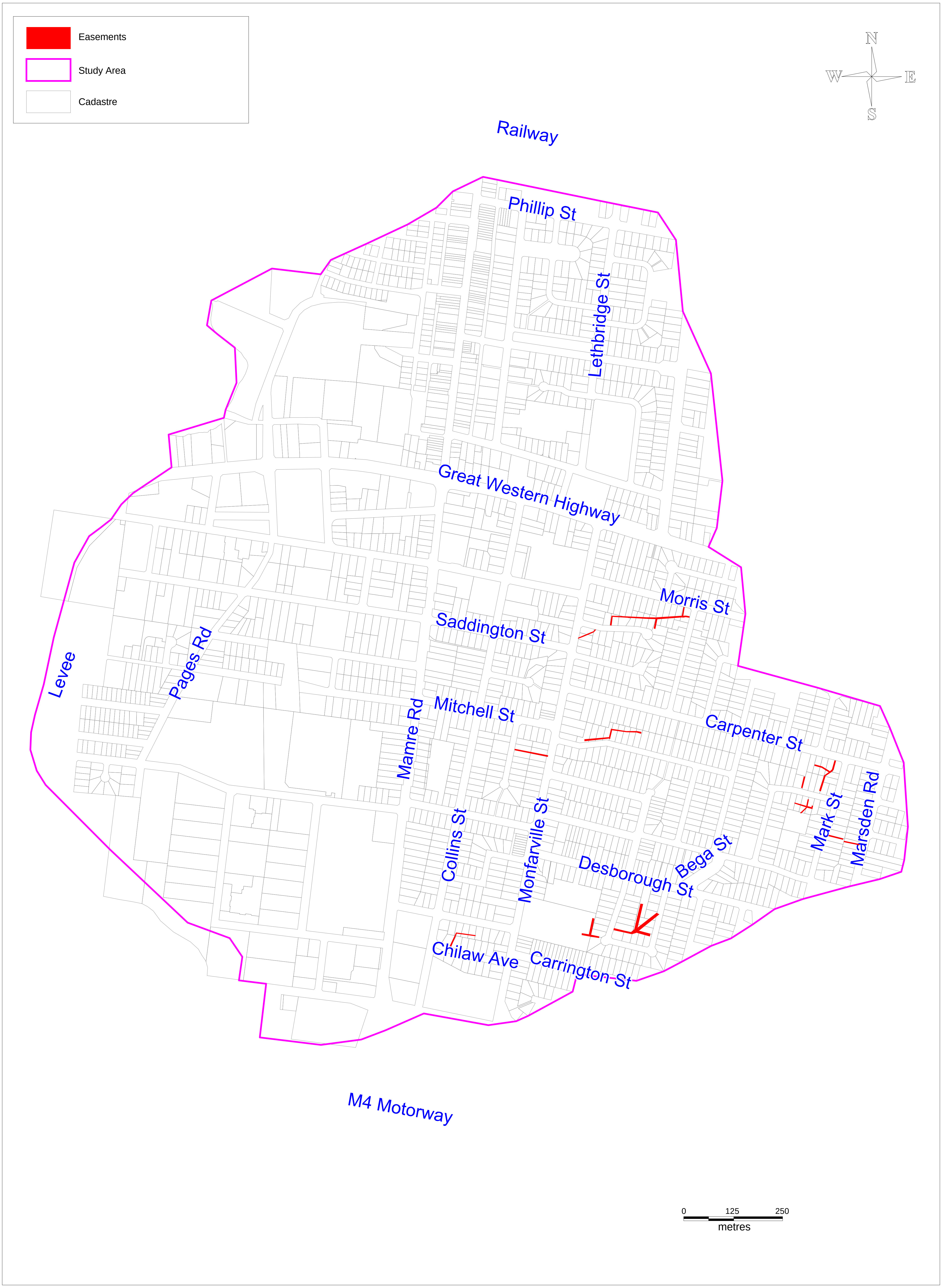


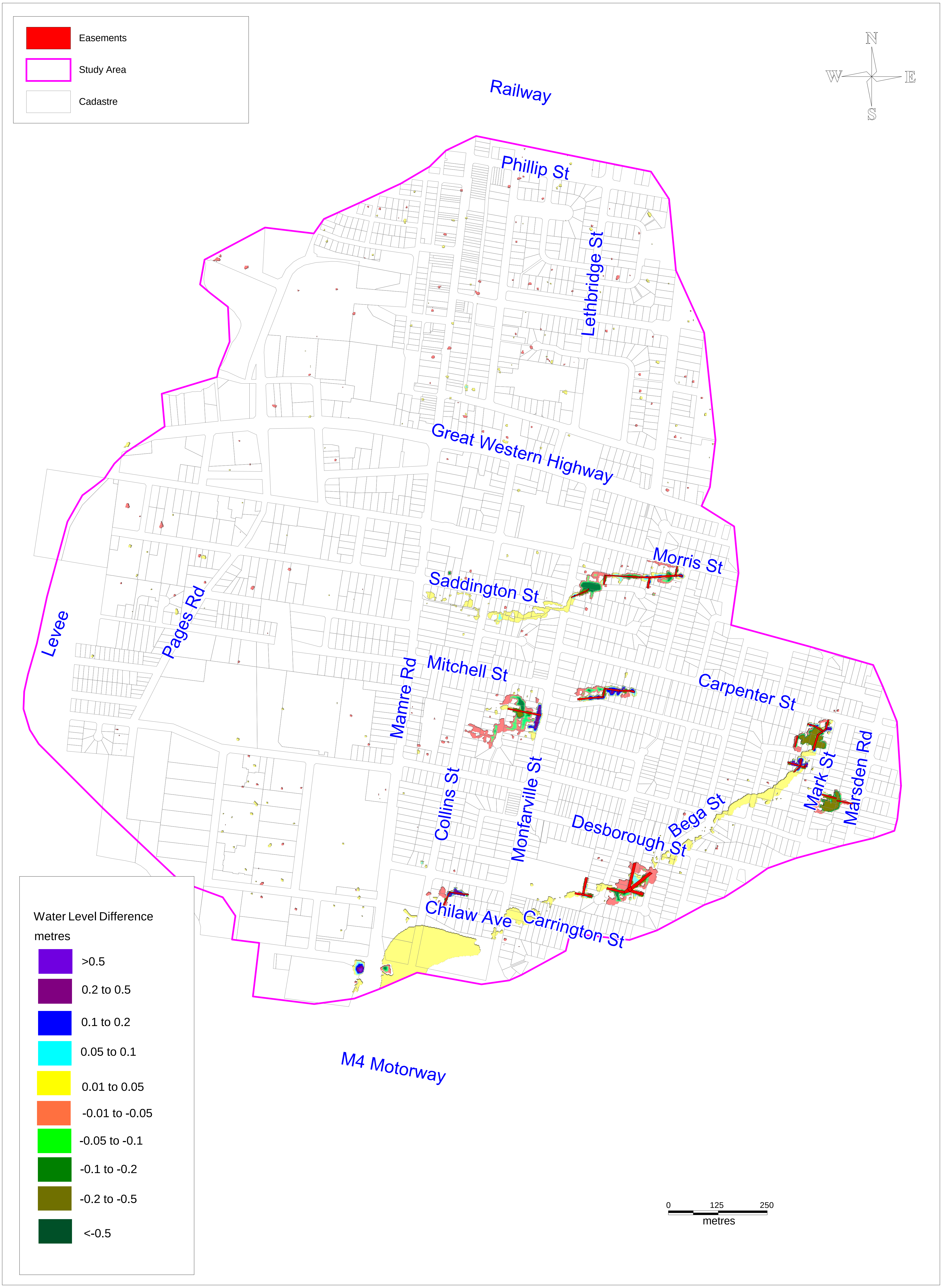
Cardno

St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study

W4735
November 2015

FIGURE 12.15
100 YEAR ARI WATER LEVEL DIFFERENCES
REVISED CAR PARK ROUGHNESS LESS EXISTING


Easements
Study Area
Cadastre
N
W
E
S
Railway
Phillip St
Lethbridge St
Great Western Highway
Morris St
Saddington St
Levee
Pages Rd
Mitchell St
Mamre Rd
Carpenter St
Mark St
Marsden Rd
Collins St
Monfarville St
Desborough St
Bega St
Chilaw Ave
Carrington St
M4 Motorway
0
125
250
metres

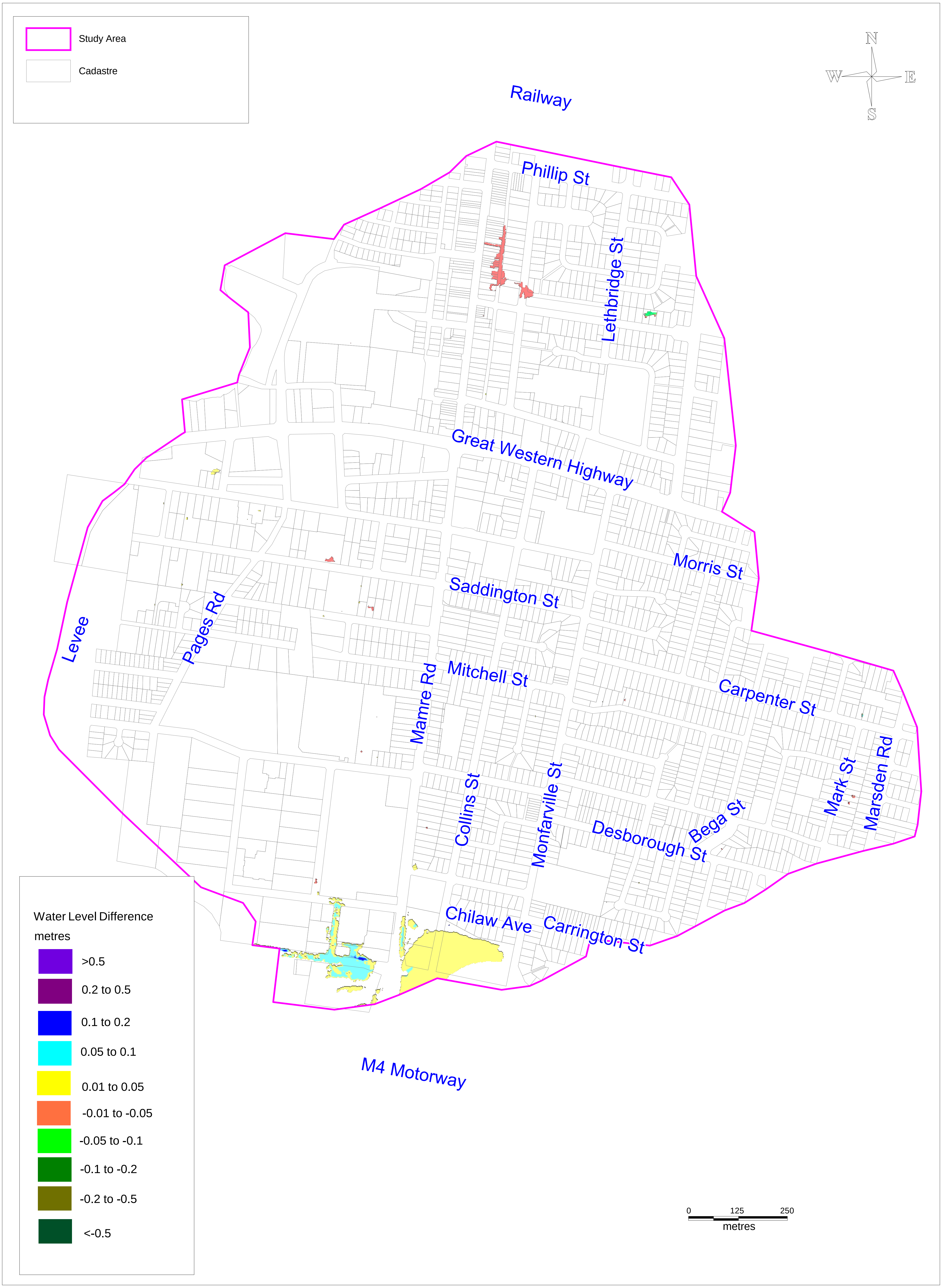


Cardno

St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study

FIGURE 12.17
100 YEAR ARI WATER LEVEL DIFFERENCES
EASEMENT LESS EXISTING

W4735
November 2015



Cardno

W4735
November 2015

St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study

FIGURE 12.18
100 YEAR ARI WATER LEVEL DIFFERENCES
ROOF ROUGHNESS (0.02) LESS EXISTING

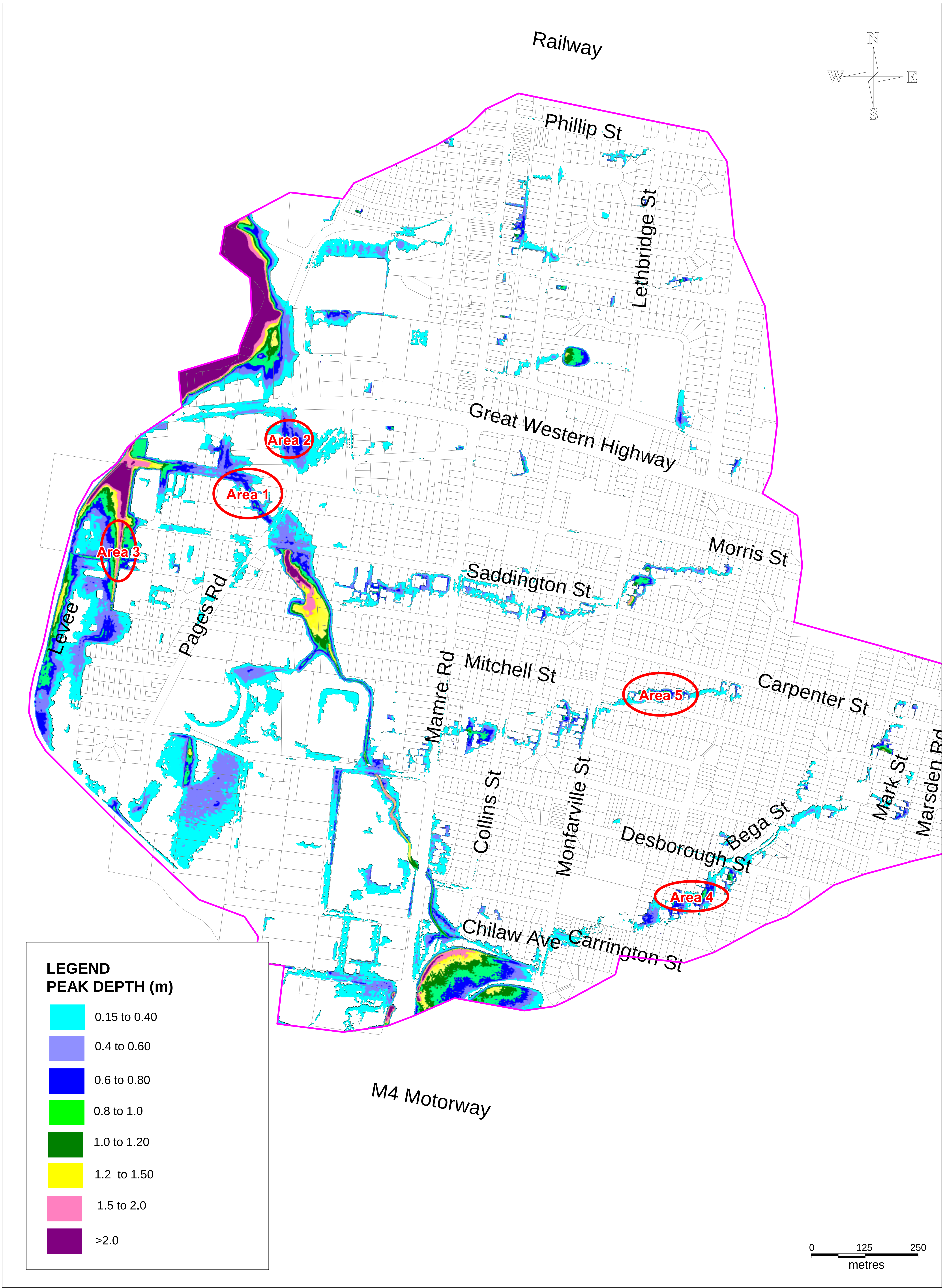


FIGURE 13.1
AREAS FOR FLOOD MITIGATION OPTIONS

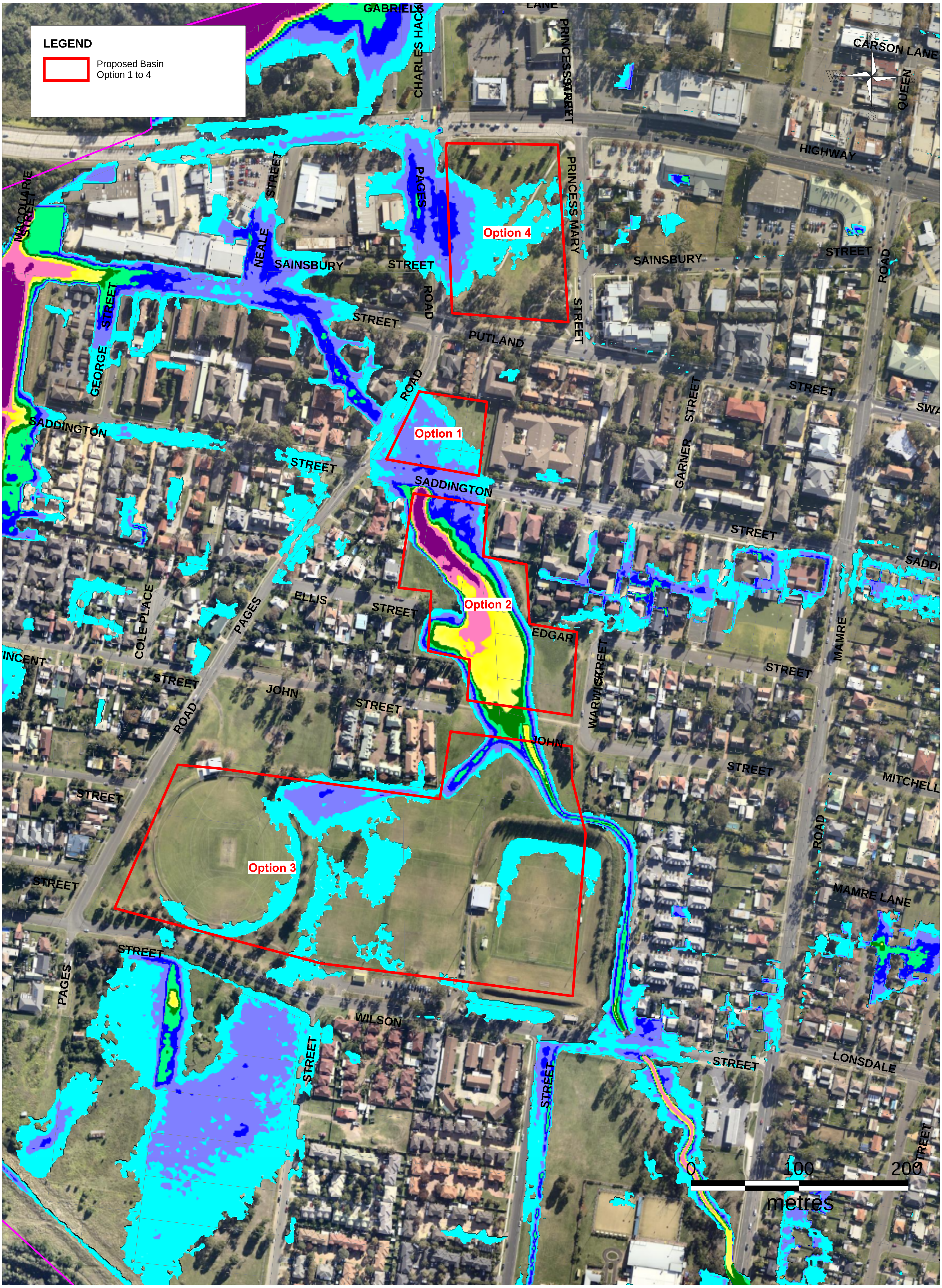


FIGURE 13.2
FLOOD MITIGATION OPTION 1 TO OPTION 4

St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study

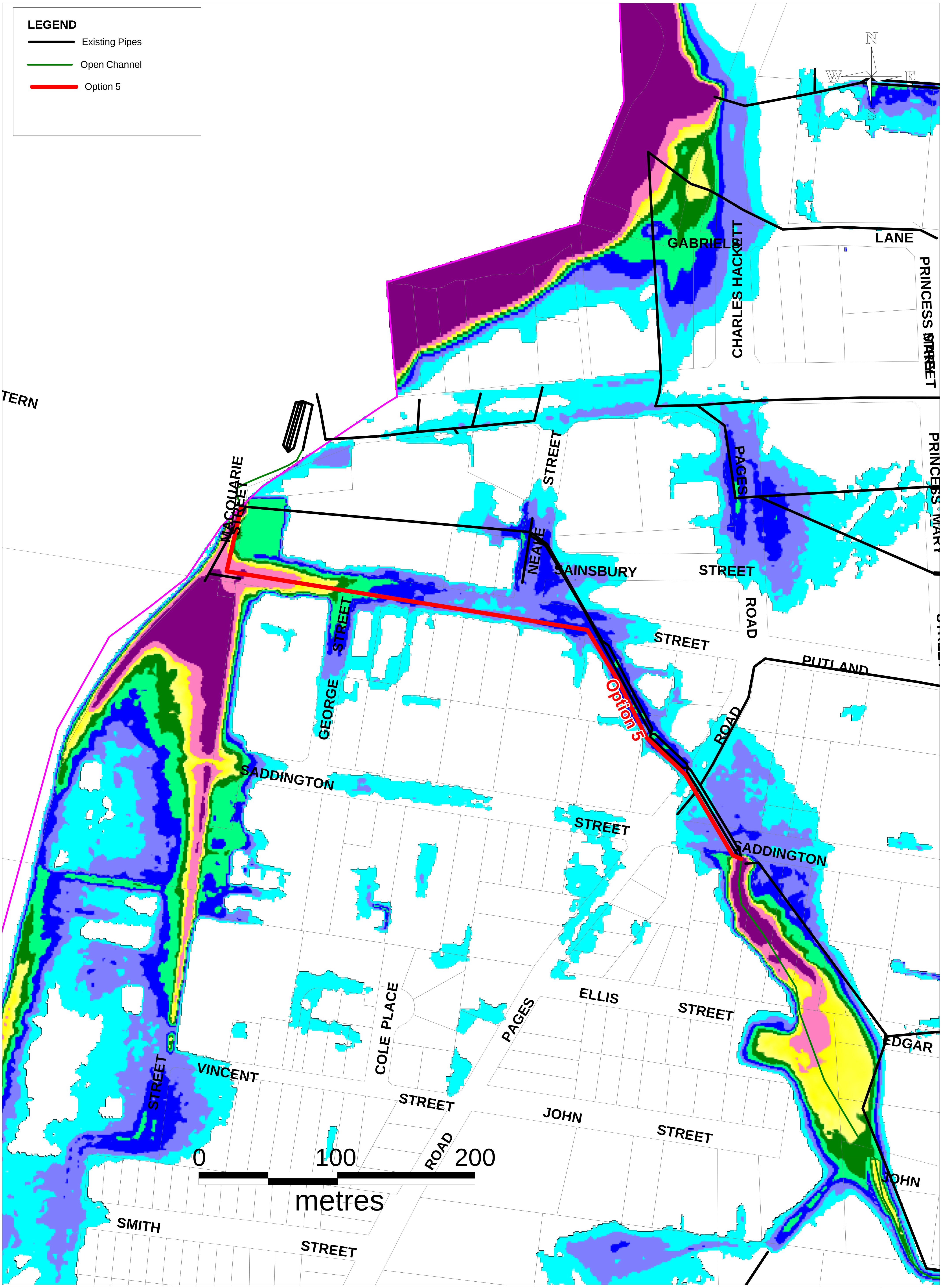
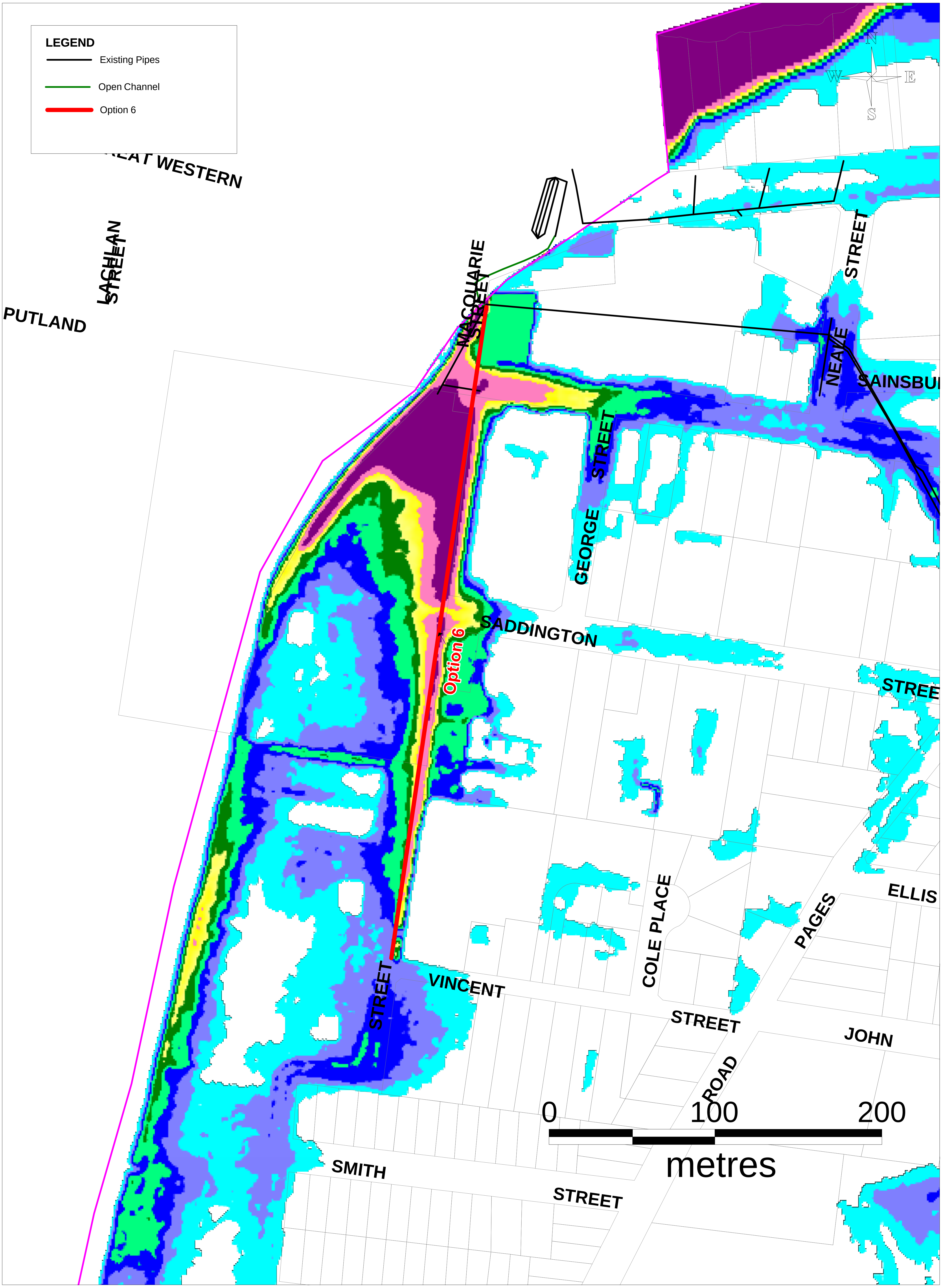


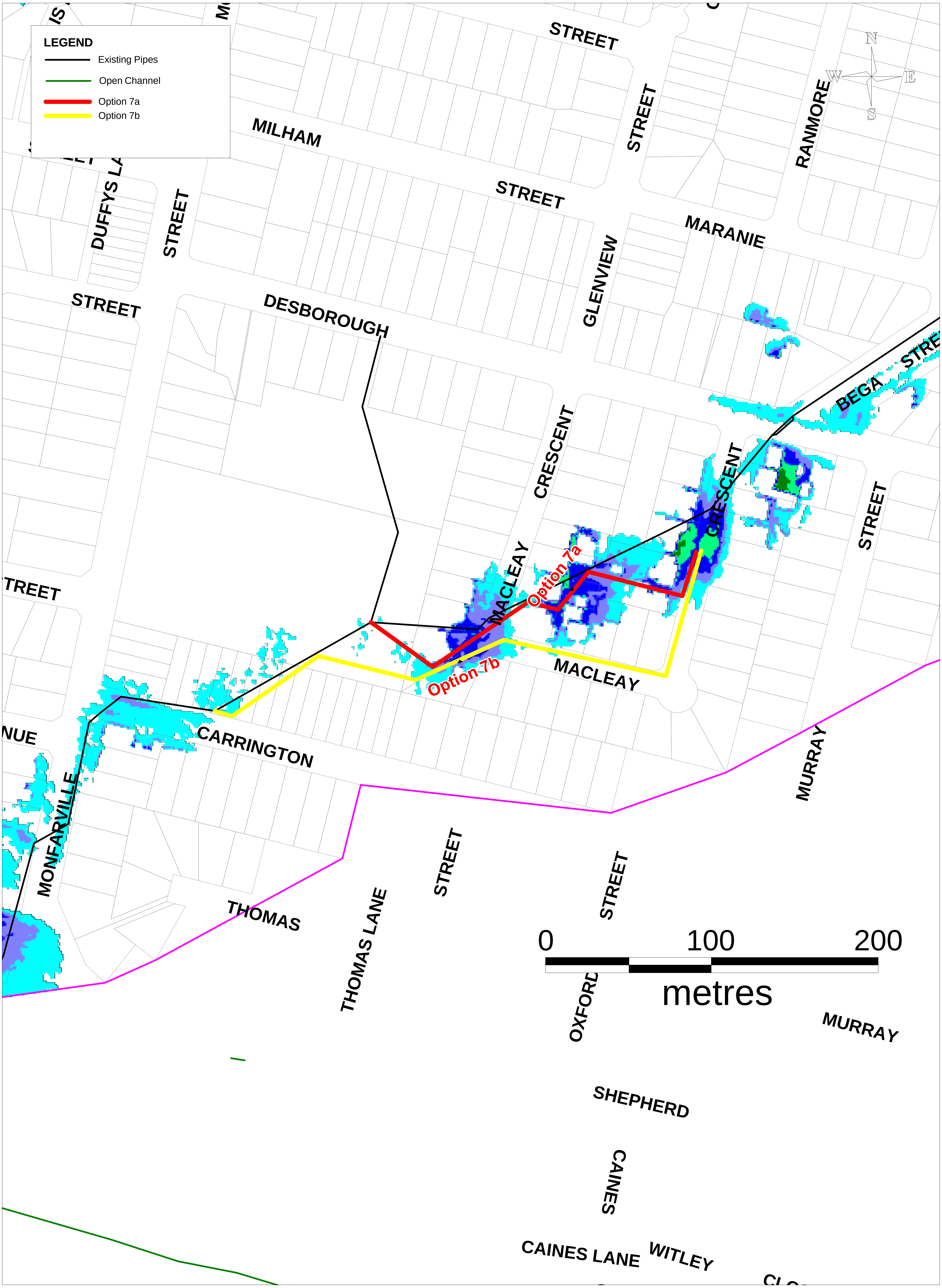
FIGURE 13.3
FLOOD MITIGATION OPTION 5

Cardno

St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study

W4735
November 2015


LEGEND
Existing Pipes
Open Channel
Option 6
GREAT WESTERN
LACHLAN STREET
PUTLAND
MACQUARIE STREET
STREET
NEALE
SAINSBU
GEORGE STREET
SADDINGTON
Option 6
STREE
ELLIS
PAGES
COLE PLACE
VINCENT
STREET
JOHN
ROAD
SMITH
STREET
0
100
200
metres
N
E
W
S



Cardno

W4735
November 2015

St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study

FIGURE 13.5
FLOOD MITIGATION OPTION 7

LEGEND
Existing Pipes
Open Channel
Option 8
N
W
E
S
STREET
CARPENTER
KNOX
MOIRA LANE
Option 8
MOIRA
GLENVIEW LANE
ROAD
STREET
0
50
100
metres

Appendix A

Site Inspection Photos Showing Hotspots

Picture 1: Units with Flood Level Marking at Putland St between Neale St and Pages Rd

Picture 2: Channel at Saddington Rd between Pages Rd and Garner St

Picture 3: other side of Channel at Saddington Rd between Pages Rd and Garner St

Picture 4: School at Saddington Rd between Garner St and Mamre Rd

Picture 5: Metal fence in Lowest Point between Ryan St and Monfarville St

Picture 6: Raised House at Monfarville St between Mitchell St and Lonsdale St

Picture 7: High Metal Fence at End Point of Monfarville St and Thomas St Near Retarding Basin

Picture 8 : Retarding Basin at end point of Monfarville St and Thomas St

Picture 9: High Metal Fence at Northern Entrance of Macleay Cres

Appendix B

Consultation Documents

PENRITH OVERLAND FLOW FLOOD STUDY: COMMUNITY QUESTIONNAIRE

Penrith City Council has engaged Consultants Cardno Lawson Treloar to undertake a Detailed Overland Flow Flood Study to identify areas that are at risk of flooding during heavy rainfall. You have received this questionnaire because you live within the study area that may have experienced flooding.

By understanding the extent of the flooding risks, Council can develop strategies to reduce the future occurrence of flooding and minimise the costs and damages incurred by the community.

The study involves sophisticated computer modelling, which is fine tuned by correlating it with historical flood records. Although Council has access to some such records, the recollections of members of the community who have seen or experienced flooding can be valuable for this purpose.

Please consider setting aside around ten minutes to complete the questionnaire below, either on this form and return in the enclosed "reply paid" envelope, or by entering Council's website **http://www.penrithcity.nsw.gov.au/index.asp?id=4916**

YOUR PERSONAL INFORMATION WILL REMAIN COMPLETELY CONFIDENTIAL AND WILL ONLY BE USED IF WE NEED TO CONTACT YOU TO FURTHER CLARIFY THE DETAILS YOU HAVE PROVIDED.

If you have any queries related to this questionnaire, please contact:

Ratnam Thilliyar – PENRITH CITY COUNCIL Ph: **4732 7777**,

Question 1
Can you please provide us with the following details? We may wish to contact you to discuss some of the information that you provide in this questionnaire.

Name: ……………………………………………………………… Daytime Ph: ……………………………………………………

Address: …………………………………………………………… Email: ……………………………………………………………
……………………………………………………………………

Question 2
How long have you lived, worked, or shopped in this locality?

…………Months …………Years

Question 3
How aware are you of stormwater flooding from streets or channels in the catchment? (*Please tick one*)

…………… Aware
…………… Some knowledge
…………… Not aware

Question 4
Has your property been flooded because of floodwater/stormwater from streets or channels in this locality?

YES ………… NO …………

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

	Location	Dates/ Times/ Description
☐	Driveway	……………………………………………………………………
☐	Backyard	……………………………………………………………………
☐	Front yard	……………………………………………………………………
☐	Shed	……………………………………………………………………
☐	Garage	……………………………………………………………………
☐	Building (below floor level)	……………………………………………………………………
☐	Building (above floor level)	……………………………………………………………………
☐	Other (please specify) ………………………………………………………………………………… ……	

PENRITH CITY COUNCIL Serving Our Community · SES STATE EMERGENCY SERVICE · Department of Environment & Climate Change NSW · Cardno Lawson Treloar

Question 5

If you have experienced flooding, what other areas have you seen flooded? (*You may tick more than one)*

	Location	Location/Address	Description (incl. Date/Time if known)
☐	Residential	……………………………………………… ……………………………………………… ………………………………………………	……………………………………………………… ……………………………………………………… ………………………………………………………
☐	Commercial	……………………………………………… ……………………………………………… ………………………………………………	……………………………………………………… ……………………………………………………… ………………………………………………………
☐	Parks	……………………………………………… ……………………………………………… ………………………………………………	……………………………………………………… ……………………………………………………… ………………………………………………………
☐	Roads and paths	……………………………………………… ……………………………………………… ………………………………………………	……………………………………………………… ……………………………………………………… ………………………………………………………
☐	Other (*please specify*)	……………………………………………… ……………………………………………… ………………………………………………	……………………………………………………… ……………………………………………………… ………………………………………………………

Question 6

Do you have any evidence of past flood events (eg photos, video footage, watermarks on walls or posts)?

YES ………… NO …………

If YES, please give as much detail as possible:

……
……
……
……
……
……
……
……
……
……
……
……

Question 7

If you have any other information that would help facilitate the Penrith Overland Flow Flood Study including any ideas on potential solutions to the flooding problem, please provide it in the space below:

……
……
……
……
……
……
……

Thankyou for providing this information. Please remember to place all pages in the reply paid envelope and send to Council by Monday 21st April 2008. A representative from Council or the Consultant Cardno Lawson Treloar may contact you in the near future to discuss your response.

Council will keep any persons who respond to the questionnaire included in future mail outs that are related to the project.

Appendix C

Detention Basin Details

APPENDIX C

Stage - Storage Relationship for the Detention Basins

Basin 1	
Reference Level (m AHD)	**Volume (m3)**
57.2	0
57.3	0
57.4	0
57.5	3
57.6	18
57.7	53
57.8	118
57.9	219
58.0	359
58.1	548
58.2	789
58.3	1085
58.4	1442
58.5	1854
58.6	2301
58.7	2761
58.8	3226
58.9	3696
59.0	4168
59.1	4641
59.2	5115
59.3	5589
59.4	6064
59.5	6538
59.6	7012

Basin 2	
Reference Level (m AHD)	**Volume (m3)**
55.3	0
55.4	0
55.5	2
55.6	17
55.7	76
55.8	198
55.9	403
56.0	710
56.1	1118
56.2	1625
56.3	2223
56.4	2888
56.5	3589
56.6	4298
56.7	5009
56.8	5719
56.9	6430
57.0	7140
57.1	7851
57.2	8562
57.3	9272
57.4	9983
57.5	10693
57.6	11404
57.7	12114
57.8	12825
57.9	13535

Basin 3	
Reference Level (m AHD)	**Volume (m3)**
52.4	0
52.5	0
52.6	0
52.7	5
52.8	27
52.9	74
53.0	141
53.1	221
53.2	311
53.3	409
53.4	515
53.5	631
53.6	766
53.7	927
53.8	1116
53.9	1335
54.0	1587
54.1	1871
54.2	2182
54.3	2513
54.4	2850
54.5	3189
54.6	3529
54.7	3868
54.8	4207
54.9	4547
55.0	4886

Basin 4	
Reference Level (m AHD)	**Volume (m3)**
50.0	0
50.1	0
50.2	1
50.3	6
50.4	25
50.5	72
50.6	151
50.7	277
50.8	453
50.9	674
51.0	935
51.1	1235
51.2	1564
51.3	1909
51.4	2262
51.5	2616
51.6	2969
51.7	3323
51.8	3676
51.9	4030
52.0	4384
52.1	4737
52.2	5091
52.3	5445
52.4	5798
52.5	6152
52.6	6506

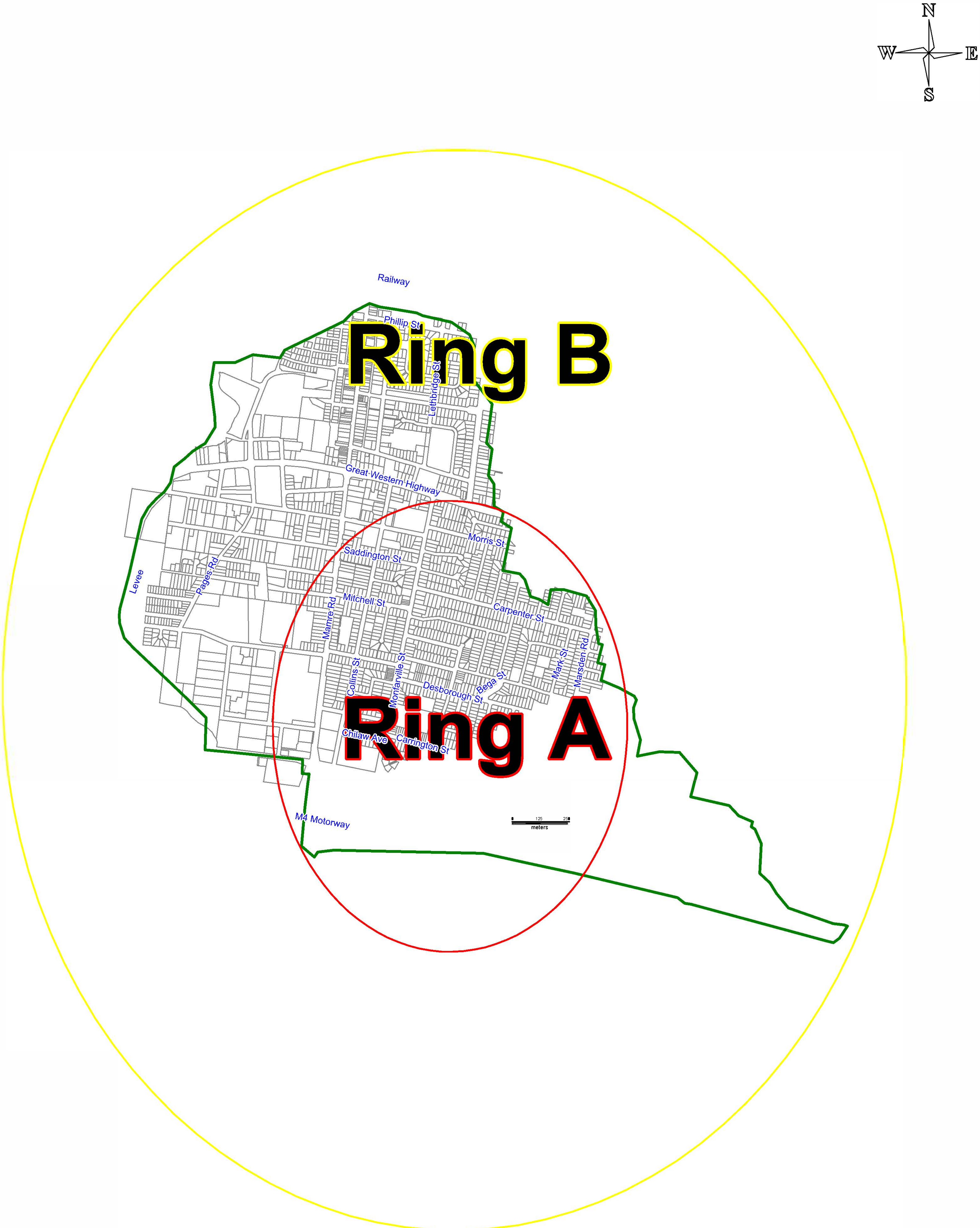
Basin 5	
Reference Level (m AHD)	**Volume (m3)**
46.1	0
46.2	0
46.3	0
46.4	2
46.5	16
46.6	68
46.7	170
46.8	344
46.9	615
47.0	980
47.1	1430
47.2	1954
47.3	2527
47.4	3117
47.5	3710
47.6	4304
47.7	4899
47.8	5494
47.9	6089
48.0	6683
48.1	7278
48.2	7873
48.3	8468
48.4	9062
48.5	9657

Basin 6	
Reference Level (m AHD)	Volume (m3)
39.8	0
39.9	0
40.0	1
40.1	4
40.2	18
40.3	62
41.4	184
41.5	446
41.6	918
41.7	1673
41.8	2763
41.9	4227
42.0	6110
42.1	8455
42.2	11251
42.3	14366
42.4	17645
42.5	21000
42.6	24397
42.7	27818
42.8	31255
42.9	34704
43.0	38156
43.1	41607
43.2	45059
43.3	48511
43.4	51962
43.5	55414

Basin 7	
Reference Level (m AHD)	Volume (m3)
36.0	0
36.1	0
36.2	10
36.3	78
36.4	337
36.5	874
36.6	1741
36.7	2928
36.8	4431
36.9	6192
37.0	8105
37.1	10094
37.2	12126
37.3	14179
37.4	16239
37.5	18303
37.6	20368
37.7	22434
37.8	24499
37.9	26565
38.0	28630
38.1	30696

Appendix D

PMP Ellipses



LEGEND

Area Generating PMP

APPENDIX D

PMP Temporal Pattern (Bureau of Meteorology)

% of Time	% of PMP
5	4
10	6
15	8
20	7
25	7
30	7
35	7
40	6
45	7
50	5
55	6
60	5
65	5
70	5
75	4
80	3
85	3
90	2
95	2
100	1

Appendix E

Pit and Pipe Information in Model

APPENDIX E

Detailed Information of Pipes/Culverts in the Tuflow Model

Conduit ID	Type	Length	Manning's n	US_Invert	DS_Invert	Width_or_Dia	Height_or_WF	Number_of Conduit	Entry_Loss	Exis_Loss
C1150	C	8.22	0.015	28.35	27.95	0.375		1	0.3	0.2
C1058	C	45.05	0.015	27.17	27.05	0.375		1	0.3	0.2
C1000	C	8.38	0.015	53.21	52.94	0.45		1	0.3	0.2
C1001	C	15.51	0.015	52.94	52.21	0.45		1	0.3	0.2
C1328	C	16.86	0.015	38.59	38.24	0.75		1	0.3	0.2
C1330	C	57.68	0.015	36.62	36.02	1.2		1	0.3	0.2
C1384	C	8.60	0.015	36.28	36.14	0.45		1	0.3	0.2
C1385	C	24.02	0.015	36.14	35.78	0.525		1	0.3	0.2
C1292	C	23.53	0.015	29.05	28.88	1.35		1	0.3	0.2
C1090	C	7.19	0.015	31.25	31.15	0.375		1	0.3	0.2
C1089	C	39.56	0.015	31.15	30.71	0.375		1	0.3	0.2
C1087	C	25.45	0.015	30.71	30.44	0.375		1	0.3	0.2
C1086	C	44.71	0.015	30.44	28.48	0.375		1	0.3	0.2
C1091	C	8.87	0.015	31.43	31.25	0.375		1	0.3	0.2
C1366	C	29.67	0.015	51.86	50.78	0.525		1	0.3	0.2
C1365	C	21.52	0.015	50.78	50.05	0.525		1	0.3	0.2
C1364	C	50.25	0.015	50.05	48.50	0.6		1	0.3	0.2
C1363	C	25.82	0.015	48.50	47.71	0.6		1	0.3	0.2
C1361	C	27.39	0.015	47.71	46.91	0.675		1	0.3	0.2
C1360	C	25.99	0.015	46.91	46.12	0.675		1	0.3	0.2
C1172	C	56.99	0.015	30.60	29.82	1.35		1	0.3	0.2
C1171	C	15.57	0.015	29.82	29.71	1.35		1	0.3	0.2
C1173	C	62.40	0.015	29.67	29.10	1.35		1	0.3	0.2
C1367	C	12.80	0.015	52.19	52.06	0.6		1	0.3	0.2
C1348	C	65.37	0.015	42.42	41.22	0.9		1	0.3	0.2
C1347	C	24.37	0.015	40.96	40.32	0.675		1	0.3	0.2
C1331	C	111.39	0.015	40.26	38.59	1.05		1	0.3	0.2
C1036	C	2.93	0.015	38.27	38.03	0.525		1	0.3	0.2
C1025	C	103.66	0.015	43.19	39.39	0.525		1	0.3	0.2
C1281	C	10.47	0.015	44.91	44.22	0.375		1	0.3	0.2
C1282	C	86.93	0.015	44.22	39.09	0.375		1	0.3	0.2
C1286	C	6.15	0.015	38.54	38.15	0.375		1	0.3	0.2
C1285	C	13.38	0.015	38.15	37.74	0.525		1	0.3	0.2
C1398	C	7.93	0.015	39.23	37.80	0.6		1	0.3	0.2
C1397	C	52.30	0.015	37.80	36.69	0.6		1	0.3	0.2
C1396	C	37.86	0.015	36.69	35.95	0.6		1	0.3	0.2
C1391	C	62.87	0.015	35.95	34.98	0.6		1	0.3	0.2
C1392	C	12.44	0.015	33.79	33.79	0.75		1	0.3	0.2
C1769	C	12.78	0.015	43.20	42.56	0.75		1	0.3	0.2
C1018	C	13.93	0.015	51.91	51.44	0.3		1	0.3	0.2
C1017	C	19.37	0.015	51.57	50.76	0.375		1	0.3	0.2
C1016	C	1.85	0.015	51.41	51.07	0.375		1	0.3	0.2
C1545	C	9.97	0.015	50.77	50.56	0.45		1	0.3	0.2
C1542	C	2.28	0.015	49.35	49.30	0.45		1	0.3	0.2
C1635	C	32.25	0.015	55.77	55.32	0.375		1	0.3	0.2
C1528	C	16.13	0.015	33.73	33.32	0.9		1	0.3	0.2
C1529	C	21.88	0.015	33.32	32.75	0.9		1	0.3	0.2
C1587	C	13.50	0.015	32.75	32.41	0.9		1	0.3	0.2
C1588	C	10.69	0.015	32.41	32.17	0.9		1	0.3	0.2

Conduit ID	Type	Length	Manning's n	US_Invert	DS_Invert	Width_or_Dia	Height_or_WF	Number_of Conduit	Entry_Loss	Exis_Loss
C1574	C	17.07	0.015	35.24	34.76	0.375		1	0.3	0.2
C1575	C	17.77	0.015	34.76	33.76	0.375		1	0.3	0.2
C7560	C	8.70	0.015	45.79	45.72	0.45		1	0.3	0.2
C7561	C	3.24	0.015	45.22	44.95	0.375		1	0.3	0.2
C7562	C	63.42	0.015	44.95	41.51	0.375		1	0.3	0.2
C1786	C	48.83	0.015	41.51	38.82	0.375		1	0.3	0.2
C1564	C	13.29	0.015	38.34	38.15	0.375		1	0.3	0.2
C1569	C	16.66	0.015	36.32	36.08	0.375		1	0.3	0.2
C1543	C	7.38	0.015	47.13	46.79	0.3		1	0.3	0.2
C7564	R	18.77	0.015	46.79	46.46	0.75	0.1	1	0.3	0.2
C1520	C	11.90	0.015	35.36	34.17	0.375		1	0.3	0.2
C1526	C	3.98	0.015	35.00	34.93	0.3		1	0.3	0.2
C1533	C	22.82	0.015	37.09	36.64	0.375		1	0.3	0.2
C1511	C	5.92	0.015	43.27	43.22	0.75		1	0.3	0.2
C1487	C	44.15	0.015	46.33	45.32	0.375		1	0.3	0.2
C1505	C	19.24	0.015	45.28	44.77	0.375		1	0.3	0.2
C1504	C	26.96	0.015	44.45	43.40	0.45		1	0.3	0.2
C1721	C	6.69	0.015	29.61	29.24	0.375		1	0.3	0.2
C1723	C	16.71	0.015	28.86	28.64	0.45		1	0.3	0.2
C1631	C	27.63	0.015	29.31	28.84	1.05		1	0.3	0.2
C1580	C	14.42	0.015	32.32	32.30	0.3		1	0.3	0.2
C1714	C	47.84	0.015	24.91	24.15	1.5		1	0.3	0.2
C1694	C	43.73	0.015	30.05	29.21	0.45		1	0.3	0.2
C1695	C	25.87	0.015	29.21	26.91	0.45		1	0.3	0.2
C1692	C	5.44	0.015	29.93	29.59	0.375		1	0.3	0.2
C1693	C	7.09	0.015	29.43	29.32	0.375		1	0.3	0.2
C1703	C	6.96	0.015	30.14	30.12	0.375		1	0.3	0.2
C1704	C	34.33	0.015	30.11	29.78	0.375		1	0.3	0.2
C1706	C	8.14	0.015	29.78	29.77	0.375		1	0.3	0.2
C1536	C	9.55	0.015	31.18	31.09	0.6		1	0.3	0.2
C1459	C	12.79	0.015	32.37	32.20	0.75		1	0.3	0.2
C1460	C	15.57	0.015	32.20	31.75	0.45		1	0.3	0.2
C1469	C	7.39	0.015	32.68	31.95	0.3		1	0.3	0.2
C1477	C	47.22	0.015	33.48	31.62	0.9		1	0.3	0.2
C1623	C	35.98	0.015	33.70	33.10	0.375		1	0.3	0.2
C1624	C	36.00	0.015	33.10	31.69	0.375		1	0.3	0.2
C1626	C	19.21	0.015	30.99	30.56	0.375		1	0.3	0.2
C1628	C	1.42	0.015	30.10	29.43	0.375		1	0.3	0.2
C1607	C	9.81	0.015	38.35	37.88	0.375		1	0.3	0.2
C1609	C	35.41	0.015	37.51	37.28	0.45		1	0.3	0.2
C7566	C	13.79	0.015	43.21	42.66	0.375		1	0.3	0.2
C1550	C	28.77	0.015	42.66	41.71	0.45		1	0.3	0.2
C7569	C	8.31	0.015	43.17	42.96	0.3		1	0.3	0.2
C7565	C	7.94	0.015	42.89	42.66	0.375		1	0.3	0.2
C1133	C	11.95	0.015	25.67	25.52	0.375		1	0.3	0.2
C1044	C	2.97	0.015	30.92	30.86	0.9		1	0.3	0.2
C1302	C	24.76	0.015	21.81	21.54	1.05		1	0.3	0.2
C1659	C	15.54	0.015	22.12	21.34	0.375		1	0.3	0.2
C1676	C	18.28	0.015	22.83	21.62	0.375		1	0.3	0.2
C1295	C	13.39	0.015	24.39	24.22	0.6		1	0.3	0.2
C1297	C	124.06	0.015	24.22	22.97	0.6		1	0.3	0.2
C7572	C	3.45	0.015	33.48	33.45	0.45		1	0.3	0.2
C1183	C	17.08	0.015	22.82	22.07	0.675		1	0.3	0.2
C1179	C	11.23	0.015	23.60	23.42	0.375		1	0.3	0.2

Conduit ID	Type	Length	Manning's n	US_Invert	DS_Invert	Width_or_Dia	Height_or_WF	Number_of Conduit	Entry_Loss	Exis_Loss
C1175	C	9.75	0.015	23.61	23.37	0.375		1	0.3	0.2
C1688	C	4.27	0.015	31.45	30.76	0.375		1	0.3	0.2
C1047	C	18.62	0.015	35.60	35.33	0.375		1	0.3	0.2
C1736	C	9.61	0.015	22.84	22.66	0.45		1	0.3	0.2
C1142	C	7.10	0.015	27.84	27.73	0.375		1	0.3	0.2
C1147	C	13.20	0.015	28.14	27.83	0.3		1	0.3	0.2
C1127	C	12.25	0.015	27.10	26.70	0.375		1	0.3	0.2
C1128	C	97.88	0.015	26.70	26.21	0.375		1	0.3	0.2
C1159	C	81.56	0.015	24.21	23.91	0.525		1	0.3	0.2
C1158	C	116.30	0.015	23.77	23.39	0.75		1	0.3	0.2
C1160	C	6.09	0.015	24.55	24.26	0.375		1	0.3	0.2
C1161	C	6.68	0.015	24.54	24.26	0.375		1	0.3	0.2
C1121	C	12.25	0.015	27.66	27.53	0.375		1	0.3	0.2
C1119	C	20.24	0.015	27.53	27.42	0.45		1	0.3	0.2
C1113	C	63.37	0.015	27.42	27.12	0.75		1	0.3	0.2
C1107	C	37.90	0.015	27.12	26.94	0.9		1	0.3	0.2
C1108	C	30.15	0.015	26.94	26.80	0.9		1	0.3	0.2
C1105	C	15.57	0.015	28.37	27.18	0.375		1	0.3	0.2
C1110	C	4.69	0.015	27.23	27.12	0.375		1	0.3	0.2
C1117	C	10.44	0.015	27.77	27.42	0.3		1	0.3	0.2
C1125	C	3.06	0.015	27.73	27.71	0.375		1	0.3	0.2
C1070	C	9.23	0.015	30.62	30.51	0.375		1	0.3	0.2
C1069	C	9.47	0.015	30.51	29.89	0.375		1	0.3	0.2
C1071	C	10.31	0.015	29.89	29.56	0.45		1	0.3	0.2
C1072	C	13.71	0.015	29.56	29.41	0.45		1	0.3	0.2
C1081	C	19.22	0.015	27.92	27.76	0.375		1	0.3	0.2
C1080	C	10.92	0.015	27.76	27.63	0.375		1	0.3	0.2
C1570	C	6.49	0.015	36.98	36.47	0.3		1	0.3	0.2
C1611	C	0.83	0.015	35.69	35.65	0.225		1	0.3	0.2
C7571	C	1.31	0.015	33.47	31.77	0.3		1	0.3	0.2
C1705	C	5.83	0.015	30.31	30.12	0.3		1	0.3	0.2
C1625	C	19.66	0.015	31.57	30.99	0.375		1	0.3	0.2
C1467	C	7.30	0.015	31.45	31.35	0.9		1	0.3	0.2
C1590	C	68.08	0.015	32.45	32.34	0.75		1	0.3	0.2
C1591	C	5.31	0.015	32.45	32.44	0.75		1	0.3	0.2
C1593	C	47.72	0.015	32.34	32.21	0.75		1	0.3	0.2
C1760	C	3.12	0.015	33.68	32.87	0.375		1	0.3	0.2
C1020	C	1.89	0.015	51.99	51.87	0.375		1	0.3	0.2
C1034	C	20.88	0.015	38.93	38.62	0.675		1	0.3	0.2
C1784	C	5.53	0.015	31.53	31.14	0.6		1	0.3	0.2
C1783	C	14.24	0.015	31.63	31.57	0.45		1	0.3	0.2
C1395	C	144.58	0.015	33.79	30.52	0.75		1	0.3	0.2
C1141	C	23.79	0.015	24.41	24.26	0.6		1	0.3	0.2
C1138	C	5.22	0.015	25.08	25.07	0.375		1	0.3	0.2
C1123	R	5.51	0.015	27.67	27.65	0.75	0.3	1	0.3	0.2
C1118	C	20.53	0.015	27.53	27.42	0.45		1	0.3	0.2
C1007	C	1.88	0.015	55.76	55.40	0.3		1	0.3	0.2
C1012	C	8.63	0.015	58.76	58.64	0.3		1	0.3	0.2
C1011	C	10.79	0.015	58.64	58.54	0.375		1	0.3	0.2
C1010	C	11.65	0.015	58.54	58.44	0.375		1	0.3	0.2
C1022	C	8.15	0.015	39.78	39.53	0.525		1	0.3	0.2
C1027	C	26.75	0.015	39.53	38.93	0.525		1	0.3	0.2
C1039	C	10.10	0.015	35.28	35.10	0.525		1	0.3	0.2
C1040	C	99.35	0.015	35.10	34.26	0.525		1	0.3	0.2

Conduit ID	Type	Length	Manning's n	US_Invert	DS_Invert	Width_or_Dia	Height_or_WF	Number_of Conduit	Entry_Loss	Exis_Loss
C1051	C	28.48	0.015	28.21	28.00	0.525		1	0.3	0.2
C1052	C	42.34	0.015	30.63	29.85	1.05		1	0.3	0.2
C1054	C	54.33	0.015	28.00	27.65	0.525		1	0.3	0.2
C1055	C	57.02	0.015	27.65	27.36	0.525		1	0.3	0.2
C1057	C	7.94	0.015	27.60	27.52	0.375		1	0.3	0.2
C1059	C	2.25	0.015	27.05	27.03	0.375		1	0.3	0.2
C1066	C	38.92	0.015	28.97	28.29	1.05		1	0.3	0.2
C1065	R	9.32	0.015	27.82	27.51	0.9	0.6	1	0.3	0.2
C1050	R	30.80	0.015	28.12	27.51	0.9	0.6	1	0.3	0.2
C1068	C	67.02	0.015	27.51	26.29	1.2		1	0.3	0.2
C1078	R	1.01	0.015	27.63	27.58	0.6	0.6	1	0.3	0.2
C1082	C	20.44	0.015	28.09	28.05	0.3		1	0.3	0.2
C1083	C	10.47	0.015	28.35	28.33	0.45		1	0.3	0.2
C1084	C	33.75	0.015	28.33	27.96	0.45		1	0.3	0.2
C1088	C	47.33	0.015	28.48	27.85	0.45		1	0.3	0.2
C1092	C	10.24	0.015	32.82	32.62	0.375		1	0.3	0.2
C1093	C	59.57	0.015	32.55	31.63	0.375		1	0.3	0.2
C1096	C	15.21	0.015	30.39	29.33	0.375		1	0.3	0.2
C1103	C	55.79	0.015	27.42	27.09	1.5		1	0.3	0.2
C1104	C	58.13	0.015	27.42	27.09	1.5		1	0.3	0.2
C1114	C	14.73	0.015	27.35	27.27	0.375		1	0.3	0.2
C1129	C	11.77	0.015	26.15	26.06	0.375		1	0.3	0.2
C1130	C	11.70	0.015	25.93	25.85	0.375		1	0.3	0.2
C1139	R	10.71	0.015	24.60	24.55	0.9	0.3	1	0.3	0.2
C1140	R	20.37	0.015	24.55	24.41	0.9	0.3	1	0.3	0.2
C1220	C	160.83	0.015	24.12	23.70	0.6		1	0.3	0.2
C1151	C	61.19	0.015	27.40	26.21	0.375		1	0.3	0.2
C1152	C	60.37	0.015	26.28	25.68	0.375		1	0.3	0.2
C1155	C	10.25	0.015	24.44	23.73	0.45		1	0.3	0.2
C1163	C	40.97	0.015	22.95	22.85	0.375		1	0.3	0.2
C1165	C	7.30	0.015	22.67	22.67	0.55		1	0.3	0.2
C1166	C	3.63	0.015	22.67	22.65	0.6		1	0.3	0.2
C1170	C	9.26	0.015	29.71	29.67	1.35		1	0.3	0.2
C1174	C	6.59	0.015	23.90	23.50	0.375		1	0.3	0.2
C1178	C	27.79	0.015	22.92	22.49	0.45		1	0.3	0.2
C1182	C	8.64	0.015	23.32	23.02	0.375		1	0.3	0.2
C1193	R	17.35	0.015	25.24	25.17	0.6	0.3	1	0.3	0.2
C1194	C	11.93	0.015	23.27	23.07	0.45		1	0.3	0.2
C1195	C	65.23	0.015	23.02	22.15	0.45		1	0.3	0.2
C1201	C	8.53	0.015	21.76	21.39	0.375		1	0.3	0.2
C1202	C	22.83	0.015	21.20	20.48	0.675		1	0.3	0.2
C1205	C	52.95	0.015	20.48	20.30	1.05		1	0.3	0.2
C1210	C	99.67	0.015	21.81	21.50	1.65		1	0.3	0.2
C1208	C	14.59	0.015	22.74	22.32	0.375		1	0.3	0.2
C1209	C	7.89	0.015	22.32	21.42	0.375		1	0.3	0.2
C1214	C	81.04	0.015	21.51	21.34	1.65		1	0.3	0.2
C1211	C	12.86	0.015	22.27	22.13	0.7		1	0.3	0.2
C1213	R	8.85	0.015	21.55	21.52	1.2	1.5	1	0.3	0.2
C1216	C	15.94	0.015	21.34	21.26	1.65		1	0.3	0.2
C1215	C	62.41	0.015	21.42	21.26	1.65		1	0.3	0.2
C1219	C	167.62	0.015	24.57	24.12	0.375		1	0.3	0.2
C1243	C	18.28	0.015	28.31	27.97	0.15		1	0.3	0.2
C1233	C	1.23	0.015	28.60	28.59	0.225		1	0.3	0.2
C1236	C	4.24	0.015	28.56	28.19	0.3		1	0.3	0.2

Conduit ID	Type	Length	Manning's n	US_Invert	DS_Invert	Width_or_Dia	Height_or_WF	Number_of Conduit	Entry_Loss	Exis_Loss
C1229	C	13.29	0.015	28.47	28.37	0.225		1	0.3	0.2
C1228	C	28.70	0.015	28.37	28.17	0.225		1	0.3	0.2
C1227	C	23.28	0.015	28.17	28.07	0.3		1	0.3	0.2
C1226	C	13.60	0.015	27.98	27.85	0.3		1	0.3	0.2
C1238	C	10.84	0.015	28.53	28.41	0.225		1	0.3	0.2
C1237	C	12.19	0.015	28.43	28.36	0.225		1	0.3	0.2
C1259	C	17.39	0.015	27.93	27.72	0.3		1	0.3	0.2
C1260	C	30.87	0.015	27.64	27.46	0.375		1	0.3	0.2
C1249	C	30.06	0.015	28.23	28.07	0.15		1	0.3	0.2
C1248	C	11.31	0.015	27.93	27.58	0.225		1	0.3	0.2
C1315	R	19.54	0.015	26.72	26.53	2.6	1.5	5	0.3	0.2
C1263	C	78.91	0.015	26.29	25.17	1.2		1	0.3	0.2
C1270	C	12.39	0.015	25.72	25.44	0.375		1	0.3	0.2
C1287	C	43.78	0.015	37.74	37.06	0.675		1	0.3	0.2
C1288	C	78.68	0.015	37.00	34.25	0.675		1	0.3	0.2
C1289	C	56.39	0.015	34.25	32.64	0.675		1	0.3	0.2
C1621	C	8.09	0.015	31.03	30.27	0.375		1	0.3	0.2
C1617	C	5.89	0.015	33.24	33.12	0.375		1	0.3	0.2
C1707	C	15.63	0.015	30.78	29.63	0.375		1	0.3	0.2
C1633	C	28.71	0.015	57.52	57.11	0.3		1	0.3	0.2
C1682	C	11.99	0.015	27.22	26.93	0.375		1	0.3	0.2
C1653	C	69.96	0.015	26.46	25.22	0.525		1	0.3	0.2
C1294	C	22.17	0.015	24.54	24.39	0.45		1	0.3	0.2
C1751	R	37.06	0.015	19.76	19.75	3.5	3.7	1	0.3	0.2
C1241	C	23.93	0.015	28.56	28.53	0.225		1	0.3	0.2
C1242	C	30.01	0.015	28.65	28.53	0.225		1	0.3	0.2
C1247	C	10.33	0.015	27.58	27.23	0.225		1	0.3	0.2
C1254	C	7.70	0.015	28.04	28.03	0.225		1	0.3	0.2
C1255	C	4.58	0.015	28.13	27.84	0.225		1	0.3	0.2
C1256	C	9.17	0.015	28.02	27.75	0.225		1	0.3	0.2
C1257	C	5.37	0.015	28.28	28.24	0.225		1	0.3	0.2
C1258	C	10.28	0.015	28.24	28.08	0.225		1	0.3	0.2
C1261	C	6.86	0.015	28.05	27.39	0.375		1	0.3	0.2
C7556	C	18.77	0.015	28.05	28.05	0.225		1	0.3	0.2
C1262	C	16.52	0.015	27.94	27.77	0.225		1	0.3	0.2
C1271	C	43.45	0.015	25.44	23.14	0.375		1	0.3	0.2
C1274	C	55.79	0.015	25.73	22.79	0.375		1	0.3	0.2
C1280	C	15.51	0.015	24.20	23.95	0.375		1	0.3	0.2
C7557	C	4.46	0.015	29.97	29.84	0.375		1	0.3	0.2
C1296	C	14.75	0.015	24.39	24.22	0.6		1	0.3	0.2
C1299	C	5.54	0.015	22.72	22.69	0.75		1	0.3	0.2
C1314	C	106.16	0.015	25.66	23.89	0.375		1	0.3	0.2
C1324	C	48.49	0.015	28.48	28.21	0.675		1	0.3	0.2
C1327	C	18.50	0.015	31.63	30.85	0.375		1	0.3	0.2
C1329	C	18.33	0.015	38.59	38.24	0.75		1	0.3	0.2
C1337	C	8.55	0.015	44.99	44.86	0.375		1	0.3	0.2
C1336	C	20.40	0.015	44.86	44.74	0.375		1	0.3	0.2
C1338	C	8.56	0.015	45.06	45.00	0.375		1	0.3	0.2
C1339	C	5.86	0.015	45.00	44.82	0.375		1	0.3	0.2
C1340	C	8.67	0.015	44.82	44.74	0.375		1	0.3	0.2
C1341	C	94.64	0.015	44.74	41.37	0.45		1	0.3	0.2
C1342	C	5.83	0.015	42.71	42.59	0.375		1	0.3	0.2
C1343	C	8.66	0.015	42.55	42.36	0.375		1	0.3	0.2
C1344	C	5.94	0.015	42.36	42.11	0.375		1	0.3	0.2

Conduit ID	Type	Length	Manning's n	US_Invert	DS_Invert	Width_or_Dia	Height_or_WF	Number_of Conduit	Entry_Loss	Exis_Loss
C1345	C	9.12	0.015	42.06	41.37	0.45		1	0.3	0.2
C1349	C	25.67	0.015	40.96	40.65	0.675		1	0.3	0.2
C1354	C	14.79	0.015	43.10	42.76	0.6		1	0.3	0.2
C1369	C	25.75	0.015	52.64	52.31	0.375		1	0.3	0.2
C1372	C	16.51	0.015	55.25	54.50	0.3		1	0.3	0.2
C1376	C	2.50	0.015	48.60	48.43	0.3		1	0.3	0.2
C1387	C	116.44	0.015	36.02	32.99	1.2		1	0.3	0.2
C1388	C	10.08	0.015	32.99	32.78	1.2		1	0.3	0.2
C1386	C	8.69	0.015	33.89	32.90	0.375		1	0.3	0.2
C1389	C	12.17	0.015	33.87	33.02	0.375		1	0.3	0.2
C1390	C	17.41	0.015	34.16	33.02	0.375		1	0.3	0.2
C1393	C	11.57	0.015	35.25	34.93	0.375		1	0.3	0.2
C1399	C	18.08	0.015	41.66	41.22	0.375		1	0.3	0.2
C1402	C	10.90	0.015	40.89	40.73	0.6		1	0.3	0.2
C1403	C	11.40	0.015	40.73	40.52	0.6		1	0.3	0.2
C1404	C	17.26	0.015	42.59	40.94	0.375		1	0.3	0.2
C1405	C	35.36	0.015	40.52	37.97	0.6		1	0.3	0.2
C1406	C	8.31	0.015	39.05	38.65	0.45		1	0.3	0.2
C1407	C	7.05	0.015	38.59	38.23	0.45		1	0.3	0.2
C1408	C	13.23	0.015	37.94	37.01	0.75		1	0.3	0.2
C1409	C	6.95	0.015	37.22	36.96	0.375		1	0.3	0.2
C1412	C	28.78	0.015	36.86	36.39	0.75		1	0.3	0.2
C1413	C	17.60	0.015	36.39	36.08	0.75		1	0.3	0.2
C1414	C	2.29	0.015	36.08	35.51	0.375		1	0.3	0.2
C1424	C	15.08	0.015	45.74	45.65	0.825		1	0.3	0.2
C1426	R	17.32	0.015	45.03	44.92	2.7	1.5	1	0.3	0.2
C1427	R	17.27	0.015	44.92	44.80	2.7	1.5	1	0.3	0.2
C1428	R	17.28	0.015	44.80	44.72	2.7	1.5	1	0.3	0.2
C1429	R	4.28	0.015	44.72	44.63	2.7	1.5	1	0.3	0.2
C1430	C	0.92	0.015	44.63	42.89	1.05		1	0.3	0.2
C1431	C	9.15	0.015	46.10	45.91	0.45		1	0.3	0.2
C1432	C	6.37	0.015	45.13	44.96	0.525		1	0.3	0.2
C1434	C	4.30	0.015	45.46	45.38	0.375		1	0.3	0.2
C1433	C	11.91	0.015	45.38	45.28	0.375		1	0.3	0.2
C1435	C	13.65	0.015	42.89	42.67	1.05		1	0.3	0.2
C1436	C	37.25	0.015	42.67	41.70	1.05		1	0.3	0.2
C1437	R	10.74	0.015	41.70	41.50	1.2	0.45	1	0.3	0.2
C1438	C	7.01	0.015	41.56	41.50	0.375		1	0.3	0.2
C1439	R	13.42	0.015	41.50	41.01	1.2	0.45	1	0.3	0.2
C1440	C	12.89	0.015	40.71	40.62	0.45		1	0.3	0.2
C1441	C	14.25	0.015	40.71	40.62	0.45		1	0.3	0.2
C1442	C	32.32	0.015	40.62	40.50	0.6		1	0.3	0.2
C1444	C	3.32	0.015	41.58	41.45	0.6		1	0.3	0.2
C1446	C	3.60	0.015	50.53	50.40	0.75		1	0.3	0.2
C1449	C	7.73	0.015	56.93	56.93	0.3		1	0.3	0.2
C1450	C	22.17	0.015	56.93	56.71	0.375		1	0.3	0.2
C1451	C	43.13	0.015	56.66	53.93	0.375		1	0.3	0.2
C1452	C	3.98	0.015	53.93	53.58	0.375		1	0.3	0.2
C1454	C	19.75	0.015	53.58	53.34	0.375		1	0.3	0.2
C1457	C	9.67	0.015	53.10	53.05	0.375		1	0.3	0.2
C1458	C	27.26	0.015	53.05	51.79	0.375		1	0.3	0.2
C1456	C	37.51	0.015	53.22	53.10	0.375		1	0.3	0.2
C1773	C	10.48	0.015	45.12	44.98	0.375		1	0.3	0.2
C1775	C	23.40	0.015	47.27	45.66	0.375		1	0.3	0.2

Conduit ID	Type	Length	Manning's n	US_Invert	DS_Invert	Width_or_Dia	Height_or_WF	Number_of Conduit	Entry_Loss	Exis_Loss
C1462	C	14.81	0.015	32.17	32.05	0.375		1	0.3	0.2
C1471	C	5.24	0.015	33.24	33.06	0.3		1	0.3	0.2
C1488	C	29.20	0.015	33.09	32.84	0.375		1	0.3	0.2
C1489	C	60.07	0.015	32.21	31.91	0.375		1	0.3	0.2
C1578	C	62.43	0.015	31.91	31.62	0.45		1	0.3	0.2
C1577	C	17.53	0.015	32.62	32.47	0.375		1	0.3	0.2
C1524	C	12.77	0.015	35.41	34.17	0.375		1	0.3	0.2
C1535	C	16.89	0.015	31.18	30.83	1.05		1	0.3	0.2
C1552	C	5.75	0.015	41.70	41.59	0.45		1	0.3	0.2
C1604	C	74.64	0.015	35.18	33.07	0.6		1	0.3	0.2
C1639	C	25.63	0.015	54.82	54.51	0.45		1	0.3	0.2
C1658	C	2.08	0.015	21.34	21.24	0.375		1	0.3	0.2
C1666	C	4.28	0.015	23.23	23.06	0.375		1	0.3	0.2
C1667	C	26.26	0.015	22.93	22.90	0.45		1	0.3	0.2
C1671	C	23.02	0.015	22.63	22.57	0.6		1	0.3	0.2
C1674	C	9.91	0.015	23.04	22.84	0.375		1	0.3	0.2
C1675	C	10.04	0.015	22.54	22.05	0.6		1	0.3	0.2
C1709	C	11.56	0.015	29.77	28.81	0.375		1	0.3	0.2
C1716	C	142.91	0.015	24.15	22.18	1.5		1	0.3	0.2
C1733	C	26.62	0.015	23.11	22.73	0.375		1	0.3	0.2
C1350	C	5.84	0.015	42.65	42.42	0.6		1	0.3	0.2
C1352	C	9.36	0.015	42.76	42.65	0.6		1	0.3	0.2
C1538	C	60.02	0.015	30.83	29.94	0.9		1	0.3	0.2
C1711	C	170.21	0.015	29.41	25.88	1.2		1	0.3	0.2
C1747	C	15.09	0.015	41.37	40.26	0.45		1	0.3	0.2
C1746	C	7.92	0.015	41.57	40.96	0.375		1	0.3	0.2
C1752	R	38.81	0.015	19.76	19.75	3.5	3.7	1	0.3	0.2
C1753	R	42.82	0.015	19.76	19.75	3.5	3.7	1	0.3	0.2
C1754	R	39.55	0.015	19.76	19.75	3.5	3.7	1	0.3	0.2
C1755	R	48.38	0.015	19.92	19.75	3.5	3.7	1	0.3	0.2
C1761	C	26.93	0.015	31.90	31.63	0.45		1	0.3	0.2
C1763	C	2.20	0.015	41.89	41.52	0.45		1	0.3	0.2
C1765	C	4.40	0.015	41.30	41.05	0.675		1	0.3	0.2
C1770	R	15.45	0.015	42.80	42.56	0.75	0.3	1	0.3	0.2
C1793	C	35.69	0.015	28.64	28.00	1.2		1	0.3	0.2
C7503	C	5.65	0.015	33.02	32.63	0.375		1	0.3	0.2
C7504	C	145.83	0.015	27.85	27.44	1.2		1	0.3	0.2
C7505	R	14.91	0.015	27.50	27.43	1.5	0.87	1	0.3	0.2
C7511	C	5.12	0.015	49.30	49.11	0.6		1	0.3	0.2
C7513	C	45.53	0.015	23.14	22.97	0.9		1	0.3	0.2
C7514	C	47.17	0.015	22.97	22.79	0.9		1	0.3	0.2
C7518	C	21.94	0.015	30.76	30.35	0.6		1	0.3	0.2
C7523	C	19.97	0.015	27.84	27.73	0.375		1	0.3	0.2
C7525	C	2.54	0.015	33.07	33.01	0.75		1	0.3	0.2
C7526	C	20.96	0.015	31.77	31.21	0.525		1	0.3	0.2
C7527	C	2.14	0.015	31.25	31.21	0.9		1	0.3	0.2
C7528	C	5.85	0.015	30.27	30.19	0.9		1	0.3	0.2
C7529	C	8.85	0.015	29.43	29.32	1.05		1	0.3	0.2
C7530	C	2.82	0.015	36.29	36.19	0.45		1	0.3	0.2
C7531	C	5.08	0.015	32.17	32.05	0.9		1	0.3	0.2
C7532	C	62.52	0.015	32.44	32.34	0.75		1	0.3	0.2
C7533	C	9.01	0.015	28.00	27.84	1.2		1	0.3	0.2
C7537	C	9.03	0.015	29.63	29.41	1.05		1	0.3	0.2
C7538	C	1.10	0.015	30.12	30.11	0.375		1	0.3	0.2

Conduit ID	Type	Length	Manning's n	US_Invert	DS_Invert	Width_or_Dia	Height_or_WF	Number_of Conduit	Entry_Loss	Exis_Loss
C7541	C	15.69	0.015	22.07	22.01	1.65		1	0.3	0.2
C7544	C	18.11	0.015	22.07	22.01	1.65		1	0.3	0.2
C7545	C	23.44	0.015	22.49	22.07	0.6		1	0.3	0.2
CGWHculv	S	58.00	-	31.52	31.46					
CX30a2	S	125.00	-	31.65	31.52					
CX30	S	37.00	-	31.46	31.16					
CX31	S	46.00	-	31.16	30.78					
CX31_BOX	R	4.00	0.025	31.38	31.21	2.4	1.2	1	0.3	0.2
CX35Bculv	R	6.00	0.030	29.78	29.72	4.5	1.2	1	0.3	0.2
CX36culv	R	6.50	0.030	29.14	28.58	4.5	1.2	1	0.3	0.2
CX33	S	212.00	-	30.78	29.78					
CX35A	S	142.00	-	29.72	29.14					
CX36A	S	113.00	-	28.58	27.50					
CX27	S	9.63	-	20.40	20.13					
CX10	S	25.00	-	27.92	27.68					
CX11	S	25.50	-	27.68	27.63					
CX12	S	33.70	-	27.63	27.45					
CX13	S	134.00	-	27.45	26.76					
CX14	S	64.00	-	26.53	26.16					
CX15	S	83.00	-	26.16	25.49					
CX16	S	26.00	-	25.49	25.45					
CX17	S	41.00	-	25.45	25.37					
CX18	S	44.20	-	25.37	25.32					
CX19	S	97.00	-	25.85	25.20					
CX20	S	66.00	-	25.20	25.00					
CX21	S	55.00	-	25.00	24.04					
CX22	S	46.00	-	24.04	23.97					
CX23	S	43.00	-	23.97	23.47					
CX24	S	44.30	-	23.47	23.35					
CX28	S	9.71	0.024	20.13	20.09					
CX28_1	S	11.62	0.024	20.09	20.04					
CX28_2	S	11.11	0.024	20.04	20.00					
CX29	S	8.16	0.024	20.00	19.98					
CX29_1	S	7.15	0.024	19.98	19.96					
CX29_2	S	8.12	0.024	19.96	19.94					
CX29_3	S	7.40	0.024	19.94	19.92					
C7567	C	11.61	0.015	43.54	42.96	0.375		1	0.3	0.2
C1551	C	31.49	0.015	42.96	42.00	0.375		1	0.3	0.2
C7570	C	13.43	0.015	42.00	41.70	0.375		1	0.3	0.2
C1789	C	45.52	0.015	41.59	40.29	0.45		1	0.3	0.2
C1788	C	21.36	0.015	40.29	39.70	0.45		1	0.3	0.2
C1787	C	40.08	0.015	39.69	39.49	0.45		1	0.3	0.2
C1566	C	42.53	0.015	38.82	37.95	0.6		1	0.3	0.2
C1565	C	32.58	0.015	38.70	38.10	0.375		1	0.3	0.2
C1608	C	13.38	0.015	38.02	37.63	0.375		1	0.3	0.2
C1567	C	85.36	0.015	37.95	36.08	0.6		1	0.3	0.2
C1571	C	27.28	0.015	36.47	36.08	0.3		1	0.3	0.2
C1568	C	3.32	0.015	36.36	36.08	0.3		1	0.3	0.2
C1572	C	14.45	0.015	36.08	35.50	0.6		1	0.3	0.2
C1573	C	40.53	0.015	35.50	34.18	0.75		1	0.3	0.2
C1603	C	22.07	0.015	34.18	33.18	0.75		1	0.3	0.2
C1576	C	8.51	0.015	34.39	33.72	0.375		1	0.3	0.2
C1601	C	5.56	0.015	33.18	33.07	0.75		1	0.3	0.2
C1602	C	17.81	0.015	33.01	32.39	0.75		1	0.3	0.2

Conduit ID	Type	Length	Manning's n	US_Invert	DS_Invert	Width_or_Dia	Height_or_WF	Number_of Conduit	Entry_Loss	Exis_Loss
C1616	C	33.46	0.015	32.39	31.70	0.75		1	0.3	0.2
C1612	C	28.48	0.015	36.08	35.69	0.225		1	0.3	0.2
C1610	C	4.23	0.015	35.92	35.75	0.375		1	0.3	0.2
C1613	C	17.87	0.015	35.60	35.27	0.525		1	0.3	0.2
C1614	C	129.73	0.015	35.27	31.77	0.525		1	0.3	0.2
C1615	C	12.18	0.015	31.21	30.96	0.9		1	0.3	0.2
C1618	C	56.98	0.015	30.96	30.55	0.9		1	0.3	0.2
C1619	C	18.13	0.015	30.55	30.33	0.9		1	0.3	0.2
C1620	C	4.28	0.015	30.33	30.27	0.9		1	0.3	0.2
C1622	C	19.07	0.015	30.19	29.93	0.9		1	0.3	0.2
C1629	C	36.91	0.015	29.93	29.43	1.05		1	0.3	0.2
C1606	C	19.10	0.015	35.68	35.18	0.525		1	0.3	0.2
C1605	C	4.62	0.015	35.23	35.18	0.3		1	0.3	0.2
C1627	C	17.33	0.015	30.56	29.43	0.45		1	0.3	0.2
C1513	C	11.82	0.015	53.59	53.33	0.3		1	0.3	0.2
C1514	C	1.63	0.015	53.33	53.26	0.3		1	0.3	0.2
C1515	C	8.86	0.015	53.26	53.15	0.3		1	0.3	0.2
C1516	C	90.87	0.015	53.15	49.47	0.3		1	0.3	0.2
C1517	C	18.94	0.015	49.47	48.79	0.3		1	0.3	0.2
C1508	C	36.89	0.015	48.79	47.53	0.3		1	0.3	0.2
C1507	C	13.10	0.015	47.53	47.20	0.375		1	0.3	0.2
C1506	C	61.48	0.015	47.20	44.04	0.375		1	0.3	0.2
C1485	C	22.33	0.015	47.52	46.33	0.375		1	0.3	0.2
C1502	C	31.78	0.015	46.51	45.12	0.375		1	0.3	0.2
C1503	C	12.59	0.015	45.12	44.85	0.375		1	0.3	0.2
C1510	C	13.13	0.015	44.00	43.63	0.375		1	0.3	0.2
C1509	C	8.42	0.015	43.22	43.02	0.75		1	0.3	0.2
C1512	C	216.05	0.015	43.02	34.17	0.75		1	0.3	0.2
C1523	C	8.49	0.015	39.64	39.52	0.3		1	0.3	0.2
C1522	C	67.02	0.015	39.52	37.31	0.3		1	0.3	0.2
C1521	C	37.82	0.015	37.31	36.42	0.3		1	0.3	0.2
C1518	C	26.40	0.015	36.37	35.23	0.375		1	0.3	0.2
C1519	C	10.09	0.015	35.07	34.17	0.375		1	0.3	0.2
C1486	C	83.35	0.015	41.90	39.32	0.375		1	0.3	0.2
C1532	C	6.86	0.015	36.74	36.50	0.3		1	0.3	0.2
C1531	C	9.82	0.015	36.50	36.29	0.45		1	0.3	0.2
C1530	C	2.32	0.015	36.55	36.29	0.375		1	0.3	0.2
C1534	C	34.61	0.015	36.19	35.37	0.45		1	0.3	0.2
C1525	C	5.89	0.015	35.61	35.51	0.3		1	0.3	0.2
C1527	C	16.50	0.015	34.17	33.73	0.9		1	0.3	0.2
C1586	C	4.98	0.015	33.15	32.17	0.375		1	0.3	0.2
C1581	C	49.04	0.015	32.05	30.93	0.9		1	0.3	0.2
C1600	C	10.46	0.015	34.70	32.54	0.375		1	0.3	0.2
C1589	C	3.26	0.015	33.09	33.03	0.375		1	0.3	0.2
C1592	C	47.79	0.015	32.34	32.21	0.75		1	0.3	0.2
C1594	C	13.09	0.015	32.21	31.95	0.75		1	0.3	0.2
C1595	C	13.12	0.015	32.21	31.95	0.75		1	0.3	0.2
C1597	C	30.30	0.015	31.95	31.07	0.75		1	0.3	0.2
C1596	C	30.33	0.015	31.95	31.07	0.75		1	0.3	0.2
C1599	C	26.12	0.015	31.07	30.96	0.75		1	0.3	0.2
C1598	C	26.07	0.015	31.07	30.96	0.75		1	0.3	0.2
C1584	C	17.79	0.015	30.96	30.86	0.75		1	0.3	0.2
C1585	C	17.84	0.015	30.96	30.86	0.75		1	0.3	0.2
C1579	C	7.74	0.015	32.89	31.93	0.375		1	0.3	0.2

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C1582	C	18.09	0.015	30.87	30.33	1.05		1	0.3	0.2
C1583	C	54.82	0.015	30.33	29.47	1.05		1	0.3	0.2
C1630	C	7.91	0.015	29.47	29.31	1.05		1	0.3	0.2
C1724	C	11.05	0.015	28.84	28.64	1.05		1	0.3	0.2
C1725	C	27.96	0.015	29.32	28.70	1.05		1	0.3	0.2
C1722	C	10.38	0.015	29.05	28.86	0.45		1	0.3	0.2
C1790	C	35.75	0.015	29.03	28.68	0.45		1	0.3	0.2
C1726	C	42.83	0.015	28.64	27.84	1.2		1	0.3	0.2
C1792	C	70.75	0.015	27.84	26.78	1.35		1	0.3	0.2
C1727	C	14.78	0.015	28.33	28.02	0.375		1	0.3	0.2
C1728	C	21.07	0.015	28.02	26.78	0.375		1	0.3	0.2
C1718	C	41.98	0.015	30.08	28.59	0.375		1	0.3	0.2
C1719	C	36.44	0.015	28.47	27.59	0.375		1	0.3	0.2
C1720	C	32.59	0.015	27.50	27.03	0.45		1	0.3	0.2
C1743	C	77.58	0.015	26.78	26.05	1.35		1	0.3	0.2
C1717	C	49.96	0.015	26.05	24.91	1.35		1	0.3	0.2
C1632	C	68.18	0.015	58.18	57.11	0.3		1	0.3	0.2
C1634	C	71.59	0.015	57.06	55.32	0.3		1	0.3	0.2
C1637	C	40.58	0.015	55.31	54.82	0.375		1	0.3	0.2
C1638	C	25.75	0.015	55.06	54.80	0.375		1	0.3	0.2
C1636	C	56.70	0.015	55.32	54.51	0.375		1	0.3	0.2
C7568	C	95.68	0.015	54.41	50.77	0.45		1	0.3	0.2
C1548	C	22.77	0.015	53.28	52.33	0.45		1	0.3	0.2
C7534	C	2.16	0.015	52.30	52.22	0.525		1	0.3	0.2
C1547	C	8.02	0.015	52.22	51.96	0.525		1	0.3	0.2
C1549	C	2.13	0.015	53.12	52.22	0.375		1	0.3	0.2
C1546	C	34.00	0.015	51.96	50.56	0.525		1	0.3	0.2
C7563	C	9.40	0.015	49.56	49.35	0.45		1	0.3	0.2
C1544	C	37.22	0.015	50.56	49.30	0.525		1	0.3	0.2
C1541	C	19.19	0.015	48.95	48.30	0.75		1	0.3	0.2
C1540	C	8.53	0.015	48.25	48.13	0.75		1	0.3	0.2
C1539	C	2.89	0.015	48.13	47.76	0.75		1	0.3	0.2
C1495	C	25.45	0.015	47.76	47.20	0.75		1	0.3	0.2
C1494	C	57.14	0.015	47.20	45.29	0.75		1	0.3	0.2
C1493	C	39.57	0.015	45.29	44.34	0.75		1	0.3	0.2
C1492	C	39.76	0.015	44.34	43.24	0.75		1	0.3	0.2
C1491	C	10.41	0.015	43.24	43.01	0.75		1	0.3	0.2
C1490	C	42.83	0.015	43.01	41.40	0.75		1	0.3	0.2
C1496	C	38.80	0.015	41.40	39.85	0.6		1	0.3	0.2
C1497	C	13.02	0.015	39.05	37.52	0.6		1	0.3	0.2
C1498	C	54.77	0.015	37.40	36.77	0.375		1	0.3	0.2
C1499	C	30.60	0.015	36.69	36.03	0.375		1	0.3	0.2
C1500	C	30.89	0.015	36.03	35.32	0.6		1	0.3	0.2
C1479	C	4.56	0.015	35.32	34.95	0.9		1	0.3	0.2
C1478	C	16.26	0.015	34.95	34.41	0.9		1	0.3	0.2
C1476	C	56.84	0.015	34.41	32.81	0.9		1	0.3	0.2
C1484	C	38.55	0.015	42.22	40.28	0.375		1	0.3	0.2
C1483	C	17.42	0.015	39.66	38.82	0.45		1	0.3	0.2
C1482	C	21.06	0.015	38.82	37.98	0.45		1	0.3	0.2
C1481	C	23.85	0.015	37.38	36.21	0.45		1	0.3	0.2
C1480	C	43.51	0.015	36.08	34.03	0.6		1	0.3	0.2
C1472	C	7.33	0.015	32.89	32.69	0.45		1	0.3	0.2
C7535	C	17.94	0.015	32.81	32.19	0.9		1	0.3	0.2
C1473	C	10.42	0.015	32.69	32.19	0.45		1	0.3	0.2

Conduit ID	Type	Length	Manning's n	US_Invert	DS_Invert	Width_or_Dia	Height_or_WF	Number_of Conduit	Entry_Loss	Exis_Loss
C1474	C	16.45	0.015	32.19	31.57	0.9		1	0.3	0.2
C1461	C	22.05	0.015	33.27	32.45	0.375		1	0.3	0.2
C1468	C	22.93	0.015	31.57	31.45	0.9		1	0.3	0.2
C7536	C	8.72	0.015	31.57	31.41	1.05		1	0.3	0.2
C1470	C	14.39	0.015	32.55	31.41	0.375		1	0.3	0.2
C1464	C	14.14	0.015	32.36	32.15	0.525		1	0.3	0.2
C1475	C	22.22	0.015	31.41	31.09	1.05		1	0.3	0.2
C1463	C	10.72	0.015	32.06	31.98	0.525		1	0.3	0.2
C1466	C	65.49	0.015	31.62	31.37	0.6		1	0.3	0.2
C7559	C	8.92	0.015	31.32	31.18	0.6		1	0.3	0.2
C1465	C	12.07	0.015	31.09	30.83	1.05		1	0.3	0.2
C1537	C	50.21	0.015	30.93	29.63	1.05		1	0.3	0.2
C1708	C	4.02	0.015	30.94	30.79	0.3		1	0.3	0.2
C1710	C	26.36	0.015	29.94	28.81	1.05		1	0.3	0.2
C1698	C	69.97	0.015	28.81	27.20	1.05		1	0.3	0.2
C1699	C	5.92	0.015	29.93	29.65	0.375		1	0.3	0.2
C1700	C	6.74	0.015	29.63	29.47	0.375		1	0.3	0.2
C1701	C	31.55	0.015	29.47	27.68	0.375		1	0.3	0.2
C1696	C	12.48	0.015	27.20	26.91	1.05		1	0.3	0.2
C1697	C	44.01	0.015	26.91	26.47	1.05		1	0.3	0.2
C1702	C	28.99	0.015	27.68	27.17	0.375		1	0.3	0.2
C1713	C	77.70	0.015	25.88	24.15	1.05		1	0.3	0.2
C1712	C	75.95	0.015	26.32	24.15	1.05		1	0.3	0.2
C1715	C	81.78	0.015	24.15	22.50	1.5		1	0.3	0.2
C1731	C	59.14	0.015	22.50	22.18	1.5		1	0.3	0.2
C1730	C	33.73	0.015	22.10	21.58	1.5		1	0.3	0.2
C1732	C	17.18	0.015	22.26	22.18	0.825		1	0.3	0.2
C7573	C	7.83	0.015	22.53	22.48	0.375		1	0.3	0.2
C7574	C	51.27	0.015	21.58	20.67	1.5		1	0.3	0.2
C1640	C	12.86	0.015	52.51	51.88	0.375		1	0.3	0.2
C1641	C	80.81	0.015	51.83	46.37	0.375		1	0.3	0.2
C1642	C	15.27	0.015	47.09	46.37	0.375		1	0.3	0.2
C1643	C	67.29	0.015	46.35	41.70	0.375		1	0.3	0.2
C1644	C	12.73	0.015	42.20	41.70	0.375		1	0.3	0.2
C1645	C	66.18	0.015	41.55	37.96	0.45		1	0.3	0.2
C1646	C	14.66	0.015	38.73	38.23	0.375		1	0.3	0.2
C1647	C	53.05	0.015	37.44	35.49	0.45		1	0.3	0.2
C1650	C	86.93	0.015	35.44	31.64	0.45		1	0.3	0.2
C1651	C	91.96	0.015	31.09	28.15	0.525		1	0.3	0.2
C1652	C	67.43	0.015	28.15	26.46	0.525		1	0.3	0.2
C1654	C	67.25	0.015	25.22	24.03	0.6		1	0.3	0.2
C1655	C	69.74	0.015	23.89	23.02	0.6		1	0.3	0.2
C1656	C	48.83	0.015	22.98	21.54	0.6		1	0.3	0.2
C1657	C	30.10	0.015	21.54	21.24	1.05		1	0.3	0.2
C1648	C	116.13	0.015	34.98	29.93	0.3		1	0.3	0.2
C1684	C	48.50	0.015	29.93	28.52	0.3		1	0.3	0.2
C1683	C	45.77	0.015	28.49	27.30	0.375		1	0.3	0.2
C1681	C	81.10	0.015	26.90	24.93	0.375		1	0.3	0.2
C1680	C	71.05	0.015	24.93	24.34	0.45		1	0.3	0.2
C1679	C	62.74	0.015	24.34	23.74	0.525		1	0.3	0.2
C1678	C	74.17	0.015	23.74	21.04	0.525		1	0.3	0.2
C1744	C	13.40	0.015	24.99	24.61	0.6		1	0.3	0.2
C1745	C	59.62	0.015	24.61	22.99	0.75		1	0.3	0.2
C1735	C	39.90	0.015	22.99	22.36	0.75		1	0.3	0.2

Conduit ID	Type	Length	Manning's n	US_Invert	DS_Invert	Width_or_Dia	Height_or_WF	Number_of Conduit	Entry_Loss	Exis_Loss
C1734	C	32.10	0.015	22.66	21.95	0.375		1	0.3	0.2
C1737	C	31.74	0.015	22.36	21.75	0.75		1	0.3	0.2
C1738	C	17.70	0.015	21.75	21.51	0.75		1	0.3	0.2
C1739	C	11.18	0.015	21.51	21.15	0.75		1	0.3	0.2
C1740	C	13.63	0.015	21.15	20.96	0.75		1	0.3	0.2
C1741	C	38.46	0.015	20.96	20.57	0.825		1	0.3	0.2
C1453	C	7.44	0.015	54.24	54.13	0.375		1	0.3	0.2
C1455	C	9.82	0.015	53.37	53.34	0.375		1	0.3	0.2
C7515	C	8.80	0.015	52.21	51.79	0.525		1	0.3	0.2
C1422	C	8.29	0.015	45.32	45.07	0.375		1	0.3	0.2
C1421	C	33.87	0.015	45.07	41.70	0.375		1	0.3	0.2
C1400	C	23.00	0.015	41.69	41.40	0.375		1	0.3	0.2
C1420	C	10.39	0.015	41.70	41.53	0.375		1	0.3	0.2
C1419	C	4.67	0.015	41.61	41.53	0.375		1	0.3	0.2
C1401	C	12.52	0.015	41.53	41.40	0.375		1	0.3	0.2
C1410	C	4.38	0.015	36.96	36.86	0.525		1	0.3	0.2
C1411	C	5.84	0.015	36.96	36.86	0.525		1	0.3	0.2
C1690	C	9.58	0.015	37.22	35.93	0.375		1	0.3	0.2
C1691	C	59.28	0.015	35.40	34.07	0.375		1	0.3	0.2
C1415	C	20.77	0.015	35.22	34.56	0.45		1	0.3	0.2
C1416	C	3.80	0.015	34.56	34.46	0.45		1	0.3	0.2
C1417	C	15.01	0.015	34.46	34.07	0.45		1	0.3	0.2
C1418	C	25.97	0.015	34.07	33.45	0.45		1	0.3	0.2
C1649	C	10.89	0.015	33.74	33.50	0.375		1	0.3	0.2
C1685	C	13.22	0.015	33.45	33.42	0.45		1	0.3	0.2
C1687	C	18.28	0.015	33.42	32.62	0.45		1	0.3	0.2
C1311	C	45.70	0.015	32.62	30.75	0.45		1	0.3	0.2
C1686	C	13.62	0.015	33.61	32.87	0.45		1	0.3	0.2
C7539	C	32.89	0.015	32.87	31.56	0.45		1	0.3	0.2
C1312	C	22.04	0.015	31.56	30.95	0.45		1	0.3	0.2
C1310	C	25.49	0.015	30.65	30.26	0.6		1	0.3	0.2
C1309	C	11.63	0.015	30.26	30.06	0.6		1	0.3	0.2
C1308	C	47.08	0.015	30.06	28.62	0.6		1	0.3	0.2
C1307	C	15.46	0.015	28.62	28.15	0.6		1	0.3	0.2
C1306	C	113.87	0.015	28.15	24.88	0.6		1	0.3	0.2
C1305	C	12.86	0.015	25.18	25.03	0.375		1	0.3	0.2
C1304	C	20.05	0.015	24.86	24.73	0.525		1	0.3	0.2
C1303	C	20.68	0.015	24.86	24.73	0.525		1	0.3	0.2
C1298	C	133.06	0.015	24.52	22.72	0.75		1	0.3	0.2
C1300	C	16.50	0.015	22.29	22.26	1.05		1	0.3	0.2
C1301	C	52.92	0.015	22.26	21.81	1.05		1	0.3	0.2
C1660	C	10.18	0.015	21.24	21.14	1.05		1	0.3	0.2
C1677	C	10.98	0.015	21.14	21.04	1.05		1	0.3	0.2
C1742	C	163.36	0.015	21.04	19.22	1.05		1	0.3	0.2
C1448	C	4.29	0.015	50.64	50.51	0.75		1	0.3	0.2
C1447	C	12.73	0.015	50.51	50.40	0.75		1	0.3	0.2
C1425	C	20.40	0.015	50.35	48.99	0.825		1	0.3	0.2
C1423	C	23.25	0.015	47.19	46.99	0.825		1	0.3	0.2
C1443	C	16.62	0.015	41.45	40.77	0.6		1	0.3	0.2
C1445	C	39.50	0.015	40.50	39.23	0.6		1	0.3	0.2
C1791	C	70.03	0.015	51.79	48.64	0.525		1	0.3	0.2
C1781	C	11.37	0.015	48.37	48.13	0.525		1	0.3	0.2
C1780	C	34.97	0.015	48.13	47.36	0.525		1	0.3	0.2
C1779	C	14.96	0.015	47.36	47.07	0.525		1	0.3	0.2

Conduit ID	Type	Length	Manning's n	US_Invert	DS_Invert	Width_or_Dia	Height_or_WF	Number_of Conduit	Entry_Loss	Exis_Loss
C1778	C	47.23	0.015	47.03	45.93	0.525		1	0.3	0.2
C1777	C	4.33	0.015	45.93	45.81	0.6		1	0.3	0.2
C1776	C	26.18	0.015	45.81	45.39	0.6		1	0.3	0.2
C1774	C	32.02	0.015	45.33	44.56	0.675		1	0.3	0.2
C1772	C	12.53	0.015	44.56	44.11	0.675		1	0.3	0.2
C1771	C	41.13	0.015	44.11	43.31	0.6		1	0.3	0.2
C1768	C	12.50	0.015	42.56	42.12	0.75		1	0.3	0.2
C1767	C	33.20	0.015	42.12	41.52	0.75		1	0.3	0.2
C1764	C	11.76	0.015	41.52	41.30	0.675		1	0.3	0.2
C1766	C	26.65	0.015	41.05	39.72	0.675		1	0.3	0.2
C1762	C	45.18	0.015	39.72	37.80	0.675		1	0.3	0.2
C1394	C	96.26	0.015	37.80	34.81	0.75		1	0.3	0.2
C1782	C	14.25	0.015	31.63	31.57	0.45		1	0.3	0.2
C1785	C	15.91	0.015	31.14	31.03	0.6		1	0.3	0.2
C7516	C	7.56	0.015	30.52	30.35	0.9		1	0.3	0.2
C7517	C	25.43	0.015	30.35	29.79	0.9		1	0.3	0.2
C1689	C	28.48	0.015	31.22	29.79	0.375		1	0.3	0.2
C1749	C	46.88	0.015	30.19	28.71	0.9		1	0.3	0.2
C1748	C	24.00	0.015	28.71	28.08	0.9		1	0.3	0.2
C1750	C	34.23	0.015	28.08	26.36	0.9		1	0.3	0.2
C1759	C	20.85	0.015	26.36	25.91	0.9		1	0.3	0.2
C1756	C	20.27	0.015	25.91	25.59	0.9		1	0.3	0.2
C1757	C	20.92	0.015	25.59	25.39	0.9		1	0.3	0.2
C1758	C	31.43	0.015	24.83	24.49	0.9		1	0.3	0.2
C1279	C	104.21	0.015	24.49	23.76	0.9		1	0.3	0.2
C1273	C	12.17	0.015	25.92	25.73	0.375		1	0.3	0.2
C1277	C	20.12	0.015	23.95	23.63	0.375		1	0.3	0.2
C1276	C	13.64	0.015	23.59	23.29	0.375		1	0.3	0.2
C1278	C	169.12	0.015	22.75	22.24	0.9		1	0.3	0.2
C1192	C	27.88	0.015	25.17	24.62	0.525		1	0.3	0.2
C1190	C	110.92	0.015	24.62	23.39	0.6		1	0.3	0.2
C1189	C	10.04	0.015	23.39	23.26	0.6		1	0.3	0.2
C1188	C	22.47	0.015	23.26	23.11	0.675		1	0.3	0.2
C1191	C	55.36	0.015	23.11	22.82	0.675		1	0.3	0.2
C1196	C	4.12	0.015	22.25	22.21	1.65		1	0.3	0.2
C1197	C	16.48	0.015	22.21	22.15	1.65		1	0.3	0.2
C1186	C	39.81	0.015	22.15	22.07	1.65		1	0.3	0.2
C1187	C	58.85	0.015	22.25	22.07	1.65		1	0.3	0.2
C7554	C	11.39	0.015	24.02	23.92	0.375		1	0.3	0.2
C1168	C	9.63	0.015	23.92	23.77	0.375		1	0.3	0.2
C1169	C	79.93	0.015	23.77	23.50	0.375		1	0.3	0.2
C1176	C	54.76	0.015	23.50	23.37	0.375		1	0.3	0.2
C1177	C	74.71	0.015	23.37	22.92	0.45		1	0.3	0.2
C1180	C	28.74	0.015	23.42	23.07	0.375		1	0.3	0.2
C1181	C	20.83	0.015	23.07	22.49	0.375		1	0.3	0.2
C7542	C	3.01	0.015	22.01	21.99	1.65		1	0.3	0.2
C1184	C	34.37	0.015	21.99	21.81	1.65		1	0.3	0.2
C1185	C	38.60	0.015	22.01	21.81	1.65		1	0.3	0.2
C1207	C	76.86	0.015	21.81	21.51	1.65		1	0.3	0.2
C7543	C	9.91	0.015	21.50	21.42	1.65		1	0.3	0.2
C1212	C	10.01	0.015	22.26	21.82	0.75		1	0.3	0.2
C1217	R	205.50	0.015	21.34	20.46	3.8	1.8	1	0.3	0.2
C1204	C	16.13	0.015	21.97	21.76	0.3		1	0.3	0.2
C1206	C	21.57	0.015	22.79	22.38	0.375		1	0.3	0.2

Conduit ID	Type	Length	Manning's n	US_Invert	DS_Invert	Width_or_Dia	Height_or_WF	Number_of Conduit	Entry_Loss	Exis_Loss
C1203	C	62.27	0.015	22.38	21.20	0.45		1	0.3	0.2
C7546	C	6.13	0.015	20.50	20.48	1.05		1	0.3	0.2
C1662	C	24.81	0.015	23.34	23.10	0.375		1	0.3	0.2
C1661	C	22.16	0.015	23.10	23.07	0.375		1	0.3	0.2
C1663	C	23.01	0.015	23.07	23.00	0.45		1	0.3	0.2
C1664	C	24.68	0.015	23.35	23.24	0.375		1	0.3	0.2
C1665	C	13.31	0.015	22.97	22.93	0.45		1	0.3	0.2
C1669	C	23.25	0.015	23.55	23.44	0.375		1	0.3	0.2
C1668	C	28.37	0.015	22.82	22.81	0.525		1	0.3	0.2
C1670	C	38.39	0.015	22.77	22.66	0.525		1	0.3	0.2
C1672	C	30.82	0.015	23.90	23.48	0.375		1	0.3	0.2
C1673	C	23.03	0.015	23.48	23.04	0.375		1	0.3	0.2
C1199	C	10.38	0.015	23.41	23.32	0.375		1	0.3	0.2
C1200	C	110.99	0.015	23.32	21.99	0.375		1	0.3	0.2
C7553	C	10.20	0.015	22.85	22.67	0.375		1	0.3	0.2
C1167	C	77.04	0.015	23.21	22.67	0.375		1	0.3	0.2
C1164	R	9.55	0.015	23.11	22.95	0.9	0.3	1	0.3	0.2
C1009	C	106.23	0.015	58.44	57.71	0.375		1	0.3	0.2
C1005	C	30.27	0.015	57.71	56.19	0.375		1	0.3	0.2
C1004	C	11.72	0.015	56.21	55.76	0.3		1	0.3	0.2
C1006	C	17.30	0.015	56.05	55.40	0.375		1	0.3	0.2
C1008	C	93.54	0.015	55.40	51.87	0.6		1	0.3	0.2
C1003	C	17.31	0.015	52.40	51.87	0.375		1	0.3	0.2
C7508	C	2.18	0.015	51.87	51.79	0.6		1	0.3	0.2
C1021	C	1.86	0.015	51.92	51.79	0.375		1	0.3	0.2
C7509	C	50.98	0.015	51.79	49.89	0.6		1	0.3	0.2
C7510	C	3.75	0.015	49.89	49.75	0.6		1	0.3	0.2
C1015	C	1.80	0.015	51.58	49.75	0.45		1	0.3	0.2
C1014	C	24.90	0.015	51.25	51.06	0.375		1	0.3	0.2
C1013	C	2.39	0.015	51.06	50.65	0.375		1	0.3	0.2
C1796	C	12.50	0.015	49.75	49.30	0.6		1	0.3	0.2
C1795	C	23.10	0.015	50.61	49.63	0.6		1	0.3	0.2
C1798	C	66.75	0.015	49.60	47.64	0.525		1	0.3	0.2
C1797	C	43.76	0.015	50.10	47.76	0.375		1	0.3	0.2
C1799	C	16.85	0.015	47.61	47.09	0.525		1	0.3	0.2
C1800	C	79.04	0.015	47.10	44.44	0.525		1	0.3	0.2
C1019	C	3.24	0.015	51.44	51.21	0.3		1	0.3	0.2
C1801	C	45.71	0.015	50.60	46.88	0.3		1	0.3	0.2
C1804	C	18.45	0.015	46.58	44.44	0.375		1	0.3	0.2
C1031	C	6.05	0.015	43.66	43.22	0.375		1	0.3	0.2
C1802	C	8.06	0.015	44.44	44.29	0.525		1	0.3	0.2
C1032	C	19.93	0.015	44.29	43.59	0.525		1	0.3	0.2
C1030	C	10.01	0.015	43.59	43.22	0.525		1	0.3	0.2
C1029	C	89.78	0.015	44.44	40.97	0.525		1	0.3	0.2
C1028	C	22.91	0.015	40.97	40.16	0.45		1	0.3	0.2
C1023	C	22.70	0.015	40.16	39.78	0.525		1	0.3	0.2
C1024	C	7.34	0.015	39.87	39.39	0.375		1	0.3	0.2
C1026	C	28.21	0.015	39.39	38.93	0.525		1	0.3	0.2
C1035	C	21.18	0.015	38.93	38.62	0.675		1	0.3	0.2
C7524	C	14.04	0.015	38.59	38.03	0.9		1	0.3	0.2
C1038	C	44.14	0.015	39.49	38.27	0.525		1	0.3	0.2
C1037	C	88.91	0.015	38.14	34.45	0.9		1	0.3	0.2
C1041	C	9.07	0.015	34.45	34.26	0.9		1	0.3	0.2
C1042	C	46.12	0.015	34.26	33.37	0.9		1	0.3	0.2

Conduit ID	Type	Length	Manning's n	US_Invert	DS_Invert	Width_or_Dia	Height_or_WF	Number_of Conduit	Entry_Loss	Exis_Loss
C1043	C	64.90	0.015	33.19	30.92	0.9		1	0.3	0.2
C1046	C	127.78	0.015	35.33	31.64	0.375		1	0.3	0.2
C1045	C	12.26	0.015	30.83	30.63	1.05		1	0.3	0.2
C1053	C	49.73	0.015	29.85	28.97	1.05		1	0.3	0.2
C1048	C	18.22	0.015	31.79	31.67	0.375		1	0.3	0.2
C1067	R	9.49	0.015	28.29	28.12	0.9	0.6	1	0.3	0.2
C7540	R	8.52	0.015	28.29	28.13	0.9	0.6	1	0.3	0.2
C1049	C	152.64	0.015	31.67	29.02	0.45		1	0.3	0.2
C1371	C	42.66	0.015	54.50	53.15	0.3		1	0.3	0.2
C1370	C	4.32	0.015	52.89	52.69	0.3		1	0.3	0.2
C1368	C	5.50	0.015	52.06	51.94	0.6		1	0.3	0.2
C1362	C	9.78	0.015	48.16	47.71	0.45		1	0.3	0.2
C1373	C	14.26	0.015	52.79	52.44	0.375		1	0.3	0.2
C1374	C	46.73	0.015	50.44	50.36	0.375		1	0.3	0.2
C1375	C	47.46	0.015	50.36	48.43	0.375		1	0.3	0.2
C1377	C	14.37	0.015	48.19	47.80	0.375		1	0.3	0.2
C1379	C	17.83	0.015	48.43	47.80	0.375		1	0.3	0.2
C1382	C	8.55	0.015	53.32	53.19	0.375		1	0.3	0.2
C1381	C	8.43	0.015	53.12	53.00	0.375		1	0.3	0.2
C1380	C	89.81	0.015	52.84	48.91	0.375		1	0.3	0.2
C7558	C	12.42	0.015	48.91	48.54	0.45		1	0.3	0.2
C1378	C	3.01	0.015	48.54	48.20	0.45		1	0.3	0.2
C1359	C	56.62	0.015	47.80	45.74	0.75		1	0.3	0.2
C1357	C	29.14	0.015	45.74	44.77	0.75		1	0.3	0.2
C1358	C	52.42	0.015	46.12	44.77	0.825		1	0.3	0.2
C1356	C	54.88	0.015	44.77	43.10	0.9		1	0.3	0.2
C1355	C	14.01	0.015	43.10	42.76	0.6		1	0.3	0.2
C1353	C	9.46	0.015	42.76	42.65	0.6		1	0.3	0.2
C1351	C	6.05	0.015	42.65	42.42	0.6		1	0.3	0.2
C7501	C	24.57	0.015	41.22	40.96	0.675		1	0.3	0.2
C1346	C	22.73	0.015	41.22	40.96	0.675		1	0.3	0.2
C7522	C	3.88	0.015	40.32	40.26	1.05		1	0.3	0.2
C1335	C	11.64	0.015	39.04	38.84	0.375		1	0.3	0.2
C1334	C	30.50	0.015	38.84	38.59	0.375		1	0.3	0.2
C1332	C	8.21	0.015	39.05	38.93	0.375		1	0.3	0.2
C1383	C	9.18	0.015	37.03	36.71	0.375		1	0.3	0.2
C7549	C	31.74	0.015	36.02	35.78	1.2		1	0.3	0.2
C1284	C	10.48	0.015	46.02	45.71	0.375		1	0.3	0.2
C1283	C	60.31	0.015	45.67	44.71	0.375		1	0.3	0.2
C1291	C	64.23	0.015	32.63	31.88	1.35		1	0.3	0.2
C1290	C	107.88	0.015	31.87	30.60	1.35		1	0.3	0.2
C1094	C	24.43	0.015	30.69	29.67	0.375		1	0.3	0.2
C1293	C	69.78	0.015	28.88	28.48	0.6		1	0.3	0.2
C7500	C	85.81	0.015	32.24	30.85	0.6		1	0.3	0.2
C1326	C	174.77	0.015	30.85	28.91	0.6		1	0.3	0.2
C1323	C	219.40	0.015	30.90	28.71	0.9		1	0.3	0.2
C1325	C	39.93	0.015	28.34	28.21	1.05		1	0.3	0.2
C1320	C	101.24	0.015	28.21	27.85	1.2		1	0.3	0.2
C1075	C	18.16	0.015	33.06	32.46	0.375		1	0.3	0.2
C1074	C	97.84	0.015	32.46	29.91	0.375		1	0.3	0.2
C1077	C	14.83	0.015	28.05	27.96	0.375		1	0.3	0.2
C1073	C	63.35	0.015	29.33	27.88	0.45		1	0.3	0.2
C1076	C	14.82	0.015	27.88	27.79	0.525		1	0.3	0.2
C1079	C	69.01	0.015	27.58	27.06	0.6		1	0.3	0.2

Conduit ID	Type	Length	Manning's n	US_Invert	DS_Invert	Width_or_Dia	Height_or_WF	Number_of Conduit	Entry_Loss	Exis_Loss
C1322	R	23.66	0.015	27.60	27.50	1.5	0.87	1	0.3	0.2
C1063	C	15.31	0.015	30.75	27.50	0.375		1	0.3	0.2
C1064	C	23.71	0.015	34.38	28.50	0.375		1	0.3	0.2
C1102	C	57.66	0.015	27.42	27.09	1.5		1	0.3	0.2
C1101	C	62.43	0.015	27.42	27.09	1.5		1	0.3	0.2
C1321	C	9.86	0.015	28.04	27.96	0.375		1	0.3	0.2
C1099	C	53.79	0.015	27.44	27.39	1.5		1	0.3	0.2
C1100	C	54.67	0.015	27.44	27.39	1.5		1	0.3	0.2
C1095	C	3.36	0.015	29.53	29.33	0.375		1	0.3	0.2
C1097	C	18.68	0.015	29.33	28.52	0.375		1	0.3	0.2
C1098	C	28.08	0.015	27.39	27.31	1.2		1	0.3	0.2
C1062	C	32.89	0.015	28.17	27.83	0.375		1	0.3	0.2
C1061	C	40.90	0.015	27.83	27.52	0.375		1	0.3	0.2
C1060	C	32.82	0.015	27.52	27.38	0.375		1	0.3	0.2
C7551	C	59.98	0.015	27.29	27.17	0.375		1	0.3	0.2
C1056	C	110.92	0.015	27.26	26.76	0.6		1	0.3	0.2
C1230	C	32.83	0.015	29.09	28.50	0.225		1	0.3	0.2
C1239	C	10.90	0.015	28.53	28.46	0.225		1	0.3	0.2
C1240	C	12.69	0.015	28.52	28.17	0.225		1	0.3	0.2
C7555	C	20.98	0.015	27.98	27.84	0.3		1	0.3	0.2
C1235	C	14.04	0.015	27.84	27.76	0.3		1	0.3	0.2
C1234	C	20.57	0.015	27.76	27.62	0.375		1	0.3	0.2
C1232	C	16.99	0.015	27.62	27.55	0.375		1	0.3	0.2
C1231	C	26.24	0.015	27.55	27.27	0.375		1	0.3	0.2
C1111	C	6.09	0.015	27.24	27.12	0.45		1	0.3	0.2
C1109	C	83.39	0.015	26.80	26.28	0.9		1	0.3	0.2
C1116	C	3.07	0.015	27.47	27.39	0.375		1	0.3	0.2
C1246	C	21.88	0.015	28.45	28.15	0.3		1	0.3	0.2
C1245	C	41.11	0.015	28.15	27.84	0.3		1	0.3	0.2
C7548	C	11.68	0.015	28.05	27.92	0.375		1	0.3	0.2
C1126	C	25.61	0.015	28.46	27.73	0.375		1	0.3	0.2
C1124	C	2.99	0.015	27.71	27.67	0.375		1	0.3	0.2
C1122	R	10.91	0.015	27.65	27.53	0.75	0.3	1	0.3	0.2
C1253	C	41.69	0.015	28.47	28.13	0.225		1	0.3	0.2
C1143	C	21.77	0.015	27.95	27.84	0.375		1	0.3	0.2
C1144	C	8.10	0.015	27.73	27.71	0.375		1	0.3	0.2
C1145	C	54.69	0.015	27.68	27.43	0.375		1	0.3	0.2
C1148	C	8.28	0.015	27.43	27.34	0.45		1	0.3	0.2
C1225	C	5.16	0.015	27.25	27.23	0.24		1	0.3	0.2
C1224	C	17.53	0.015	27.23	27.06	0.24		1	0.3	0.2
C1223	C	13.87	0.015	27.06	26.84	0.24		1	0.3	0.2
C1222	C	15.50	0.015	26.84	26.10	0.24		1	0.3	0.2
C1162	C	35.03	0.015	25.62	25.23	0.3		1	0.3	0.2
C1153	C	30.17	0.015	25.23	24.93	0.3		1	0.3	0.2
C1154	C	30.58	0.015	24.93	24.48	0.3		1	0.3	0.2
C1156	C	10.55	0.015	23.39	23.31	1.05		1	0.3	0.2
C7507	C	12.38	0.015	23.31	23.27	1.05		1	0.3	0.2
C1157	C	22.57	0.015	23.27	23.20	1.05		1	0.3	0.2
C1313	C	48.00	0.015	23.20	23.03	1.05		1	0.3	0.2
C1131	R	10.83	0.015	25.60	25.56	0.6	0.3	1	0.3	0.2
C1132	C	9.75	0.015	25.56	25.52	0.45		1	0.3	0.2
C1134	C	54.78	0.015	25.52	25.14	0.45		1	0.3	0.2
C1137	C	11.75	0.015	25.14	25.08	0.375		1	0.3	0.2
C1135	C	24.81	0.015	25.32	25.07	0.9		1	0.3	0.2

Conduit ID	Type	Length	Manning's n	US_Invert	DS_Invert	Width_or_Dia	Height_or_WF	Number_of Conduit	Entry_Loss	Exis_Loss
C1136	C	24.58	0.015	25.32	25.07	0.9		1	0.3	0.2
C1268	C	19.45	0.015	25.07	25.00	0.6		1	0.3	0.2
C1269	C	18.71	0.015	25.07	25.00	0.6		1	0.3	0.2
C1221	C	37.40	0.015	24.49	24.27	0.3		1	0.3	0.2
C1272	C	79.11	0.015	23.44	23.14	0.9		1	0.3	0.2
C1264	C	63.50	0.015	25.00	24.80	0.9		1	0.3	0.2
C1265	C	99.82	0.015	24.80	24.49	0.9		1	0.3	0.2
C1266	C	29.09	0.015	24.49	24.32	0.9		1	0.3	0.2
C1267	C	49.66	0.015	24.43	24.14	0.9		1	0.3	0.2
C1501	R	9.10	0.015	39.32	38.50	0.3	0.15	1	0.3	0.2
C1729	C	22.80	0.015	20.59	19.69	1.5		1	0.3	0.2
C1275	C	7.81	0.015	22.79	22.75	0.9		1	0.3	0.2
C1106	C	3.71	0.015	27.00	26.98	0.375		1	0.3	0.2
C7552	R	22.28	0.015	28.29	27.82	0.9	0.6	1	0.3	0.2
C1218	R	10.14	0.015	24.69	24.67	0.36	0.3	1	0.3	0.2
C7506	R	3.97	0.015	26.76	26.72	2.6	1.5	5	0.3	0.2
C7512	C	38.76	0.015	24.26	24.12	0.6		1	0.3	0.2
C1244	C	16.74	0.015	27.84	27.77	0.3		1	0.3	0.2
C1115	C	5.00	0.015	27.39	27.35	0.375		1	0.3	0.2
C1112	C	10.92	0.015	27.27	27.12	0.375		1	0.3	0.2
C1252	C	18.51	0.015	28.11	28.07	0.3		1	0.3	0.2
C1251	C	38.96	0.015	28.05	27.83	0.3		1	0.3	0.2
C1250	C	2.77	0.015	27.80	27.71	0.3		0	0.3	0.2
C1120	C	5.05	0.015	27.58	27.53	0.45		1	0.3	0.2
C1146	C	12.83	0.015	27.39	27.20	0.525		1	0.3	0.2
C1149	C	5.49	0.015	27.20	27.11	0.525		1	0.3	0.2
C1085	C	11.69	0.015	27.96	27.92	0.45		1	0.3	0.2
NealTrans	S	2.80	0.024	20.46	20.40	0		0	0	0
C7547_1	R	2.62	0.015	21.70	21.67	1.2	1.5	1	0.3	0.2
C7547_2	R	1.30	0.015	21.67	21.66	1.2	1.5	1	0.3	0.2
C7547_3	R	2.85	0.015	21.66	21.63	1.2	1.5	1	0.3	0.2
C7547_4	R	1.54	0.015	21.63	21.62	1.2	1.5	1	0.3	0.2
C7547_5	R	2.85	0.015	21.62	21.59	1.2	1.5	1	0.3	0.2
C7547_6	R	1.50	0.015	21.59	21.58	1.2	1.5	1	0.3	0.2
C7547_7	R	2.90	0.015	21.58	21.55	1.2	1.5	1	0.3	0.2

Detailed Information of Pits in the Tuflow Model

Pit ID	Surface_level	Inlet_Type
P1303	24.08	Type_13
P1639	24.20	Type_13
P1640	24.05	Type_13
P1642	23.98	Type_16
P1660	23.96	Type_16
P1638	23.67	Type_13
P1637	25.66	Type_13
P1636	26.64	Type_13
P1663	24.66	Type_13
P1665	26.68	Type_13
P1666	28.10	Type_12
P1634	29.38	Type_13
P1668	29.51	Type_12
P1669	30.44	Type_13
P1633	33.02	Type_13
P1630	36.67	Type_13
P1632	35.96	Type_13
P1629	39.41	Type_13
P1628	40.05	Type_7
P1302	23.85	Type_14
P1300	23.94	Type_14
P1299	25.53	Type_14
P1298	25.55	Type_9
P1305	26.24	Type_12
P1304	25.96	Type_14
P1306	26.12	Type_13
P1311	32.20	Type_12
P1788	34.41	Type_14
P1313	34.71	Type_13
P1631	34.43	Type_14
P1406	35.39	Type_8
P1401	39.72	Type_15
P1195	24.07	Type_8
P1196	24.21	Type_8
P1179	24.57	Type_8
P1180	24.57	Type_10
P1183	24.98	Type_13
P1185	24.91	Type_12
P1186	25.82	Type_7
P1187	26.25	Type_9
P1176	24.36	Type_13
P1175	24.38	Type_8
P1172	24.46	Type_8
P1166	24.70	Type_8

Pit ID	Surface_level	Inlet_Type
P1173	24.55	Type_12
P1276	24.92	Type_4
P1672	31.87	Type_14
P1671	32.08	Type_13
P1740	32.45	Type_7
P1045	33.06	Type_10
P1046	32.80	Type_10
P1044	37.19	Type_8
P1043	36.61	Type_8
P1715	24.15	Type_13
P1714	23.94	Type_9
P1718	23.56	Type_15
P1717	23.43	Type_15
P1719	23.33	Type_15
P1716	24.63	Type_9
P1643	24.16	Type_12
P1644	24.10	Type_13
P1645	24.33	Type_13
P1646	24.28	Type_13
P1651	24.52	Type_13
P1650	24.12	Type_13
P1659	24.26	Type_13
P1214	23.64	Type_9
P1206	23.64	Type_9
P1591	36.58	Type_13
P1592	37.79	Type_8
P1587	38.77	Type_13
P1586	39.81	Type_16
P1559	44.07	Type_9
P1558	44.49	Type_11
P1557	44.43	Type_11
P1556	43.93	Type_9
P1561	41.94	Type_13
P1560	42.65	Type_8
P1753	46.92	Type_2
P1755	47.57	Type_2
P1757	49.20	Type_2
P1759	50.30	Type_2
P1760	49.86	Type_2
P1751	46.03	Type_9
P8562	29.14	Type_2
P1145	28.81	Type_13
P1056	28.75	Type_13
P1001	54.27	Type_7
P1000	54.27	Type_7
P1325	39.84	Type_9
P1377	37.49	Type_9

Pit ID	Surface_level	Inlet_Type
P1378	37.42	Type_8
P1375	37.85	Type_8
P1376	37.74	Type_8
P1292	31.19	Type_11
P1293	30.91	Type_9
P8565	31.98	Type_7
P1086	32.06	Type_2
P1087	32.34	Type_8
P1357	53.22	Type_14
P1354	50.01	Type_8
P1352	49.29	Type_10
P1353	49.20	Type_9
P1349	49.72	Type_8
P1369	49.37	Type_13
P1365	53.46	Type_10
P1364	53.56	Type_8
P1345	43.99	Type_9
P1343	43.83	Type_8
P1291	32.58	Type_3
P1170	32.00	Type_10
P1169	31.93	Type_8
P1090	32.36	Type_12
P1358	53.17	Type_13
P1326	39.95	Type_11
P1038	35.96	Type_10
P1037	35.90	Type_9
P1034	39.78	Type_8
P1032	39.77	Type_8
P1024	40.82	Type_12
P1023	40.90	Type_12
P1026	41.40	Type_8
P1033	40.20	Type_8
P1003	53.40	Type_10
P1282	46.34	Type_8
P1281	46.56	Type_8
P1286	40.23	Type_16
P1285	40.10	Type_10
P1398	40.39	Type_2
P1393	42.72	Type_14
P1388	37.85	Type_8
P1387	37.13	Type_8
P1384	36.23	Type_8
P1386	36.06	Type_8
P1787	43.43	Type_8
P1743	42.72	Type_8
P1020	52.78	Type_7
P1021	52.82	Type_7

Pit ID	Surface_level	Inlet_Type
P1018	52.54	Type_7
P1015	52.13	Type_11
P1014	52.24	Type_11
P1016	52.36	Type_9
P1004	52.99	Type_8
P1008	56.74	Type_8
P1007	57.00	Type_8
P1006	57.06	Type_10
P1468	37.04	Type_7
P1469	36.92	Type_10
P1493	37.62	Type_2
P1492	37.25	Type_2
P1491	37.97	Type_2
P1490	41.22	Type_2
P1483	45.09	Type_7
P1484	45.38	Type_7
P1530	49.93	Type_8
P1529	49.99	Type_8
P1533	50.44	Type_7
P1536	53.50	Type_8
P1539	54.18	Type_14
P1534	51.70	Type_2
P1535	51.95	Type_7
P1470	37.58	Type_16
P1471	38.94	Type_16
P1473	41.20	Type_16
P1474	43.36	Type_16
P1627	42.78	Type_13
P1626	43.61	Type_7
P1625	47.32	Type_13
P1624	48.13	Type_7
P1622	53.51	Type_7
P1623	53.05	Type_13
P1621	55.81	Type_16
P1617	56.29	Type_13
P1614	58.32	Type_13
P1613	59.23	Type_13
P1616	56.28	Type_13
P1615	58.61	Type_13
P1618	55.92	Type_2
P1619	55.85	Type_13
P1594	34.13	Type_8
P1580	35.12	Type_16
P1572	34.65	Type_8
P1520	38.92	Type_11
P1581	34.55	Type_13
P1566	34.93	Type_13

Pit ID	Surface_level	Inlet_Type
P1564	35.66	Type_7
P1783	36.17	Type_7
P1565	35.12	Type_16
P1545	37.21	Type_7
P1547	37.49	Type_8
P1544	36.96	Type_8
P1549	37.04	Type_8
P1553	39.28	Type_8
P1555	39.43	Type_8
P1543	39.56	Type_8
P1552	46.48	Type_1
P1551	46.90	Type_7
P1550	47.04	Type_8
P1540	47.92	Type_13
P1541	47.85	Type_13
P1515	37.09	Type_11
P1521	37.67	Type_11
P1518	36.20	Type_11
P1519	36.40	Type_11
P1516	40.52	Type_11
P1517	40.63	Type_11
P1513	36.13	Type_10
P1524	37.48	Type_11
P1525	37.48	Type_14
P1527	37.91	Type_11
P1526	37.45	Type_14
P1506	44.45	Type_11
P1505	44.62	Type_11
P1507	44.91	Type_11
P1511	54.06	Type_8
P1508	54.33	Type_13
P1509	54.36	Type_7
P1498	45.61	Type_11
P1497	45.80	Type_11
P1499	47.33	Type_11
P1500	45.99	Type_11
P1477	47.67	Type_8
P1475	48.65	Type_8
P1476	42.81	Type_13
P1704	29.01	Type_10
P1705	29.04	Type_8
P1724	28.59	Type_4
P1698	30.71	Type_7
P1699	30.45	Type_2
P1569	33.02	Type_17
P1567	33.18	Type_11
P1784	33.07	Type_16

Pit ID	Surface_level	Inlet_Type
P1568	33.33	Type_13
P1694	28.70	Type_2
P1692	27.30	Type_1
P1691	29.18	Type_2
P1681	30.42	Type_2
P1680	30.63	Type_2
P1679	30.87	Type_2
P1693	25.17	Type_1
P1675	30.29	Type_8
P1673	30.58	Type_2
P1674	30.35	Type_13
P1678	31.25	Type_12
P1687	31.07	Type_8
P1686	30.96	Type_8
P1683	31.19	Type_13
P1684	31.12	Type_8
P1689	31.79	Type_7
P1460	33.20	Type_14
P1452	33.51	Type_14
P1450	33.81	Type_14
P1457	33.42	Type_16
P1454	33.58	Type_14
P1456	33.53	Type_16
P1461	33.57	Type_2
P1462	33.74	Type_16
P1465	34.73	Type_13
P1464	34.08	Type_2
P1466	34.84	Type_14
P1467	35.37	Type_16
P1604	34.92	Type_13
P1605	34.16	Type_8
P1607	31.87	Type_7
P1608	31.47	Type_7
P1610	30.50	Type_8
P1058	28.79	Type_14
P1059	28.95	Type_13
P1144	28.94	Type_13
P1142	28.79	Type_13
P1143	28.88	Type_13
P1140	28.90	Type_12
P1139	28.89	Type_13
P1138	28.94	Type_13
P1141	29.10	Type_12
P1120	28.19	Type_13
P1121	27.86	Type_13
P1127	26.36	Type_13
P1130	26.52	Type_9

Pit ID	Surface_level	Inlet_Type
P1134	25.19	Type_12
P1136	25.45	Type_9
P1156	25.24	Type_14
P1155	25.42	Type_14
P1151	26.16	Type_2
P1153	25.89	Type_2
P1150	26.38	Type_2
P1148	26.86	Type_1
P1149	26.62	Type_2
P1154	26.33	Type_2
P1115	28.52	Type_13
P1113	28.50	Type_13
P1117	29.08	Type_2
P1118	28.94	Type_2
P1119	29.21	Type_1
P1780	28.81	Type_2
P1112	28.75	Type_13
P1101	29.30	Type_1
P1100	29.36	Type_13
P1104	29.16	Type_13
P1108	29.08	Type_13
P1109	29.13	Type_2
P1110	29.12	Type_2
P1111	29.03	Type_2
P1105	29.37	Type_2
P1106	29.37	Type_12
P1099	29.38	Type_2
P1068	30.58	Type_10
P1067	30.87	Type_8
P1066	31.36	Type_8
P1065	31.37	Type_10
P1064	31.37	Type_8
P1071	28.92	Type_8
P1073	29.34	Type_8
P1075	28.61	Type_10
P1076	28.79	Type_10
P1054	28.57	Type_9
P1047	29.95	Type_14
P1050	31.51	Type_1
P1042	32.24	Type_8
P1041	32.30	Type_8
P1048	29.68	Type_12
P1094	29.45	Type_6
P1514	36.00	Type_11
P1571	34.38	Type_15
P1575	33.80	Type_17
P1546	37.74	Type_8

Pit ID	Surface_level	Inlet_Type
P1589	36.36	Type_13
P1595	34.42	Type_13
P1685	30.98	Type_7
P1723	28.22	Type_13
P1695	30.99	Type_13
P1696	29.65	Type_13
P1697	28.62	Type_13
P1700	30.27	Type_13
P1611	31.55	Type_13
P1612	31.74	Type_10
P1606	32.72	Type_13
P1609	31.21	Type_8
P1532	50.30	Type_13
P1459	33.30	Type_13
P1688	32.00	Type_8
P1583	36.86	Type_13
P1584	36.77	Type_12
P1747	43.52	Type_9
P1738	34.17	Type_9
P1731	31.23	Type_2
P1167	24.73	Type_10
P1005	53.00	Type_8
P1030	45.33	Type_12
P1338	43.47	Type_8
P1328	40.02	Type_8
P1133	26.73	Type_9
P1114	28.63	Type_2
P1116	28.60	Type_13
P1010	59.46	Type_8
P1011	59.35	Type_8
P1012	59.39	Type_8
P1013	59.69	Type_8
P1017	52.17	Type_11
P1025	40.89	Type_7
P1022	40.86	Type_7
P1036	36.37	Type_2
P1035	36.23	Type_12
P1049	29.15	Type_15
P1052	28.98	Type_10
P1053	28.71	Type_9
P1055	28.38	Type_2
P1060	29.08	Type_13
P1061	29.27	Type_13
P1062	32.13	Type_13
P1063	36.08	Type_13
P1074	28.50	Type_10
P1077	28.93	Type_8

Pit ID	Surface_level	Inlet_Type
P1080	29.42	Type_8
P1079	29.34	Type_8
P1084	29.82	Type_8
P1088	33.80	Type_11
P1089	33.74	Type_9
P1168	32.05	Type_8
P1093	31.33	Type_13
P1098	29.72	Type_6
P1102	28.93	Type_2
P1107	29.15	Type_13
P1123	27.04	Type_13
P1125	26.75	Type_13
P1137	24.99	Type_2
P1147	27.96	Type_1
P1152	26.08	Type_14
P1157	26.51	Type_2
P1159	23.56	Type_16
P1161	23.74	Type_2
P1162	23.85	Type_16
P1163	23.89	Type_16
P1781	24.53	Type_10
P1165	24.74	Type_9
P1597	34.11	Type_13
P1451	33.56	Type_14
P1463	34.20	Type_8
P1472	40.20	Type_12
P1620	55.79	Type_12
P1602	32.35	Type_1
P1478	34.50	Type_13
P1479	34.34	Type_14
P1480	34.04	Type_14
P1481	33.70	Type_13
P1482	33.76	Type_14
P1726	26.00	Type_8
P1301	23.90	Type_1
P1647	24.51	Type_13
P1653	24.50	Type_13
P1655	25.20	Type_13
P1654	25.15	Type_13
P1652	24.73	Type_13
P1199	22.27	Type_14
P1198	22.56	Type_13
P1203	23.03	Type_14
P1204	23.44	Type_8
P1213	23.83	Type_16
P1210	23.72	Type_18
P1209	23.80	Type_18

Pit ID	Surface_level	Inlet_Type
P1208	23.84	Type_16
P1207	23.79	Type_9
P1174	24.77	Type_12
P1171	24.64	Type_8
P1216	25.23	Type_9
P1273	26.82	Type_8
P1274	26.98	Type_10
P1272	26.69	Type_10
P1271	26.58	Type_10
P1220	27.51	Type_1
P1221	27.68	Type_1
P1222	27.86	Type_1
P1223	28.06	Type_1
P1739	32.85	Type_7
P1191	24.28	Type_15
P1193	24.17	Type_7
P1189	25.21	Type_1
P1190	24.58	Type_13
P1280	26.79	Type_1
P1279	26.11	Type_1
P1390	40.04	Type_1
P1385	36.12	Type_8
P1290	34.10	Type_3
P1283	47.02	Type_8
P1379	35.11	Type_9
P1295	30.71	Type_11
P1744	42.64	Type_13
P1752	45.91	Type_11
P1754	47.99	Type_11
P1448	54.38	Type_12
P1449	54.37	Type_13
P1447	54.11	Type_15
P1446	54.26	Type_15
P1444	54.88	Type_12
P1443	54.96	Type_15
P1445	55.26	Type_15
P1442	57.49	Type_12
P1441	58.11	Type_13
P1440	58.08	Type_12
P1667	28.39	Type_13
P1635	28.04	Type_13
P1297	25.50	Type_13
P1188	26.11	Type_7
P1307	29.41	Type_12
P1308	29.77	Type_13
P1309	30.93	Type_13
P1310	31.35	Type_13

Pit ID	Surface_level	Inlet_Type
P1408	35.41	Type_8
P1409	35.14	Type_8
P1404	37.51	Type_12
P1402	38.93	Type_15
P1399	40.60	Type_13
P1397	40.56	Type_14
P1396	42.49	Type_13
P1392	43.35	Type_13
P1391	42.64	Type_13
P1411	43.17	Type_13
P1410	43.14	Type_13
P1412	43.62	Type_13
P1395	43.11	Type_13
P1413	47.03	Type_13
P1414	48.11	Type_13
P1426	49.80	Type_13
P1425	50.14	Type_13
P1421	50.16	Type_2
P1427	48.78	Type_13
P1420	50.33	Type_2
P1424	50.57	Type_13
P1423	50.83	Type_13
P1419	50.70	Type_2
P1418	50.02	Type_2
P1415	48.78	Type_2
P1437	51.86	Type_15
P1436	51.96	Type_15
P1439	52.06	Type_15
P1438	52.10	Type_15
P1428	44.16	Type_13
P1429	43.13	Type_13
P1430	43.02	Type_13
P1435	42.56	Type_14
P1434	42.52	Type_12
P1431	42.88	Type_13
P1432	42.88	Type_13
P1433	42.58	Type_14
P1249	28.86	Type_2
P1250	29.04	Type_2
P1251	28.88	Type_2
P1255	29.23	Type_13
P1260	28.91	Type_1
P1261	29.19	Type_13
P1259	29.07	Type_1
P1256	29.02	Type_2
P1258	29.13	Type_1
P1238	29.49	Type_1

Pit ID	Surface_level	Inlet_Type
P1237	29.52	Type_1
P1240	29.63	Type_1
P1239	29.58	Type_1
P1235	29.39	Type_2
P1236	29.44	Type_1
P1234	29.59	Type_2
P1232	29.52	Type_1
P1233	29.61	Type_1
P1231	29.45	Type_1
P1224	29.43	Type_2
P1229	29.43	Type_2
P1242	29.11	Type_1
P1246	29.35	Type_2
P1247	29.34	Type_2
P1248	29.31	Type_2
P1243	29.20	Type_2
P1244	28.54	Type_1
P1245	29.20	Type_1
P1262	28.99	Type_2
P1225	29.37	Type_2
P1226	29.51	Type_1
P1227	29.53	Type_1
P1228	29.94	Type_1
P1254	29.16	Type_13
P1253	29.13	Type_13
P1252	28.99	Type_2
P1197	23.60	Type_1
P1205	23.72	Type_9
P1241	29.69	Type_1
P1257	29.21	Type_1
P1284	46.91	Type_8
P1327	39.79	Type_11
P1329	40.00	Type_8
P1335	45.84	Type_7
P1333	45.97	Type_8
P1334	46.06	Type_8
P1330	45.79	Type_8
P1332	45.89	Type_8
P1331	45.73	Type_8
P1336	43.79	Type_7
P1337	43.59	Type_8
P1339	42.99	Type_8
P1340	42.44	Type_9
P1360	53.72	Type_2
P1362	55.48	Type_2
P1363	56.05	Type_1
P1374	54.04	Type_8

Pit ID	Surface_level	Inlet_Type
P1373	53.95	Type_8
P1372	53.73	Type_7
P1371	50.02	Type_8
P1368	49.37	Type_8
P1380	35.01	Type_8
P1383	35.34	Type_8
P1381	34.84	Type_8
P1382	34.80	Type_9
P1394	43.68	Type_13
P1407	36.37	Type_7
P1422	50.22	Type_2
P1537	53.63	Type_13
P1707	24.58	Type_13
P1712	24.02	Type_2
P1711	24.86	Type_1
P1728	42.40	Type_7
P8500	33.04	Type_11
P8511	25.24	Type_14
P8512	25.45	Type_14
P8517	40.29	Type_8
P8520	25.29	Type_11
P8548	34.07	Type_14
P8551	38.02	Type_14
P8560	24.97	Type_13
P1091	30.64	Type_13
P1069	33.86	Type_8
P8563	28.69	Type_13
P1201	21.23	Type_1
P1160	23.53	Type_16
P1217	24.98	Type_9
P1209_1	23.76	Type_18
P1209_2	23.78	Type_18
P1209_3	23.79	Type_18
P1209_4	23.79	Type_18
P1209_5	23.73	Type_18
P1209_6	23.77	Type_18

Note: Pit surface levels were modified based on the terrain grid

Appendix F

TUFLOW Inlet Curve Relationships

APPENDIX F

Inlet Curves

Depth (m)	Inlet Flows (m^3/s)																	
	Type_1	Type_2	Type_3	Type_4	Type_5	Type_6	Type_7	Type_8	Type_9	Type_10	Type_11	Type_12	Type_13	Type_14	Type_15	Type_16	Type_17	Type_18
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.025	0.034	0.068	0.102	0.136	1.088	3.400	0.004	0.008	0.011	0.014	0.016	0.072	0.076	0.079	0.082	0.084	0.087	0.100
0.050	0.048	0.096	0.144	0.192	1.536	4.800	0.012	0.023	0.031	0.039	0.047	0.108	0.119	0.127	0.135	0.143	0.150	0.190
0.075	0.059	0.118	0.177	0.236	1.888	5.900	0.021	0.043	0.057	0.071	0.086	0.139	0.161	0.175	0.189	0.204	0.218	0.290
0.100	0.068	0.136	0.204	0.272	2.176	6.800	0.033	0.066	0.088	0.110	0.132	0.169	0.202	0.224	0.246	0.268	0.290	0.400
0.125	0.076	0.152	0.228	0.304	2.432	7.600	0.046	0.092	0.123	0.154	0.184	0.198	0.244	0.275	0.306	0.336	0.367	0.520
0.150	0.083	0.167	0.249	0.334	2.672	8.350	0.061	0.121	0.162	0.202	0.242	0.228	0.288	0.329	0.369	0.409	0.450	0.651
0.175	0.090	0.180	0.270	0.360	2.880	9.000	0.076	0.153	0.204	0.255	0.306	0.256	0.333	0.384	0.435	0.486	0.536	0.792
0.200	0.096	0.193	0.288	0.386	3.088	9.650	0.093	0.187	0.249	0.311	0.373	0.286	0.380	0.442	0.504	0.566	0.628	0.939
0.225	0.102	0.204	0.306	0.408	3.264	10.200	0.111	0.223	0.297	0.371	0.445	0.315	0.427	0.501	0.575	0.649	0.724	1.094
0.250	0.108	0.215	0.324	0.430	3.440	10.750	0.130	0.261	0.348	0.435	0.522	0.345	0.476	0.563	0.650	0.737	0.824	1.259
0.275	0.113	0.226	0.339	0.452	3.616	11.300	0.150	0.301	0.401	0.502	0.602	0.376	0.527	0.627	0.728	0.828	0.928	1.430
0.300	0.118	0.236	0.354	0.472	3.776	11.800	0.171	0.343	0.457	0.571	0.686	0.407	0.579	0.693	0.807	0.922	1.036	1.608
0.325	0.123	0.245	0.369	0.490	3.920	12.250	0.193	0.387	0.515	0.644	0.773	0.438	0.632	0.760	0.889	1.018	1.147	1.791
0.350	0.127	0.255	0.381	0.510	4.080	12.750	0.216	0.432	0.576	0.720	0.864	0.471	0.687	0.831	0.975	1.119	1.263	1.983
0.375	0.132	0.264	0.396	0.528	4.224	13.200	0.240	0.479	0.639	0.799	0.958	0.504	0.743	0.903	1.063	1.222	1.382	2.180
0.400	0.136	0.272	0.408	0.544	4.352	13.600	0.264	0.528	0.704	0.880	1.056	0.536	0.800	0.976	1.152	1.328	1.504	2.384
0.425	0.140	0.281	0.420	0.562	4.496	14.050	0.289	0.578	0.771	0.964	1.156	0.570	0.859	1.052	1.245	1.437	1.630	2.593
0.450	0.144	0.289	0.432	0.578	4.624	14.450	0.315	0.630	0.840	1.050	1.260	0.604	0.919	1.129	1.339	1.549	1.759	2.809
0.475	0.148	0.297	0.444	0.594	4.752	14.850	0.342	0.683	0.911	1.138	1.366	0.639	0.980	1.208	1.435	1.663	1.891	3.029
0.500	0.152	0.304	0.456	0.608	4.864	15.200	0.369	0.738	0.984	1.230	1.475	0.673	1.042	1.288	1.534	1.779	2.025	3.254
0.525	0.156	0.312	0.468	0.624	4.992	15.600	0.397	0.794	1.058	1.323	1.587	0.709	1.106	1.370	1.635	1.899	2.164	3.486
0.550	0.160	0.319	0.480	0.638	5.104	15.950	0.426	0.851	1.135	1.418	1.702	0.745	1.170	1.454	1.737	2.021	2.305	3.723
0.575	0.163	0.326	0.489	0.652	5.216	16.300	0.455	0.910	1.213	1.516	1.820	0.781	1.236	1.539	1.842	2.146	2.449	3.966
0.600	0.167	0.333	0.501	0.666	5.328	16.650	0.485	0.970	1.293	1.616	1.939	0.818	1.303	1.626	1.949	2.272	2.596	4.211
0.625	0.170	0.340	0.510	0.680	5.440	17.000	0.515	1.031	1.375	1.718	2.062	0.855	1.371	1.715	2.058	2.402	2.746	4.464
0.650	0.174	0.347	0.522	0.694	5.552	17.350	0.547	1.093	1.458	1.822	2.187	0.894	1.440	1.805	2.169	2.534	2.898	4.721
0.675	0.177	0.354	0.531	0.708	5.664	17.700	0.579	1.157	1.543	1.929	2.314	0.933	1.511	1.897	2.283	2.668	3.054	4.982
0.700	0.180	0.360	0.540	0.720	5.760	18.000	0.611	1.222	1.629	2.037	2.444	0.971	1.582	1.989	2.397	2.804	3.211	5.248
0.725	0.183	0.367	0.549	0.734	5.872	18.350	0.644	1.288	1.717	2.174	2.576	1.011	1.655	2.084	2.541	2.943	3.372	5.519
0.750	0.186	0.373	0.558	0.746	5.968	18.650	0.678	1.355	1.807	2.259	2.711	1.051	1.728	2.180	2.632	3.084	3.535	5.795
0.775	0.190	0.379	0.570	0.758	6.064	18.950	0.712	1.424	1.898	2.373	2.847	1.091	1.803	2.277	2.752	3.226	3.701	6.073
0.800	0.193	0.385	0.579	0.770	6.160	19.250	0.747	1.493	1.991	2.488	2.986	1.132	1.878	2.376	2.873	3.371	3.869	6.357
0.825	0.196	0.391	0.588	0.782	6.256	19.550	0.782	1.564	2.085	2.606	3.127	1.173	1.955	2.476	2.997	3.518	4.039	6.645
0.850	0.198	0.397	0.594	0.794	6.352	19.850	0.818	1.635	2.180	2.725	3.270	1.215	2.032	2.577	3.122	3.667	4.212	6.937
0.875	0.201	0.403	0.603	0.806	6.448	20.150	0.854	1.708	2.277	2.846	3.416	1.257	2.111	2.680	3.249	3.819	4.388	7.235
0.900	0.204	0.408	0.612	0.816	6.528	20.400	0.891	1.782	2.375	2.969	3.563	1.299	2.190	2.783	3.377	3.971	4.565	7.534
0.925	0.207	0.414	0.621	0.828	6.624	20.700	0.928	1.856	2.475	3.094	3.713	1.342	2.270	2.889	3.508	4.127	4.745	7.840
0.950	0.210	0.420	0.630	0.840	6.720	21.000	0.966	1.932	2.576	3.220	3.864	1.386	2.352	2.996	3.640	4.284	4.928	8.148
0.975	0.213	0.425	0.639	0.850	6.800	21.250	1.004	2.009	2.678	3.348	4.018	1.429	2.434	3.103	3.773	4.443	5.112	8.461
1.000	0.216	0.431	0.648	0.862	6.896	21.550	1.043	2.087	2.782	3.478	4.173	1.474	2.518	3.213	3.909	4.604	5.300	8.777

Appendix G

Peak Water Levels at Reference Points

APPENDIX G

Peak Water Depths for Design Events at Reference Points

Reference ID	Peak Water Depths (m)								
	PMF	200yr ARI	100yr ARI	50yr ARI	20yr ARI	10yr ARI	5yr ARI	2yr ARI	1yr ARI
P1	0.65	0.39	-	-	-	-	-	-	-
P3	0.49	0.30	0.25	0.23	0.23	0.21	0.20	-	-
P4	1.03	0.51	0.39	0.38	0.36	0.30	0.26	-	-
P5	0.76	0.31	0.25	0.25	0.22	0.21	0.18	-	-
P6	0.41	0.18	0.17	0.16	0.16	0.15	-	-	-
P7	1.64	0.78	0.75	0.75	0.70	0.64	0.57	0.43	0.32
P8	1.98	0.61	0.46	0.45	0.34	0.21	-	-	-
P9	1.06	0.40	0.32	0.31	0.28	0.25	0.23	0.16	-
P10	0.78	0.27	0.27	0.25	0.25	0.23	0.23	-	-
P11	1.34	0.19	-	-	-	-	-	-	-
P12	1.32	0.47	0.43	0.36	-	-	-	-	-
P13	2.81	1.12	0.94	0.82	0.23	0.19	0.17	-	-
P14	2.40	1.25	1.11	0.98	0.44	0.32	0.25	0.23	0.22
P15	0.53	0.22	0.18	0.18	0.17	-	-	-	-
P16	0.82	0.29	0.26	0.24	0.24	0.21	0.20	-	-
P17	0.46	0.23	-	-	-	-	-	-	-
P18	1.61	0.21	-	-	-	-	-	-	-
P19	0.43	0.18	-	-	-	-	-	-	-
P20	1.36	0.42	0.30	0.21	-	-	-	-	-
P21	1.86	0.60	0.60	0.42	0.37	0.35	0.33	0.28	0.24
P22	0.63	0.24	0.18	0.17	-	-	-	-	-
P23	0.75	-	-	-	-	-	-	-	-
P24	0.74	-	-	-	-	-	-	-	-
P25	1.69	1.01	0.95	0.94	0.88	0.76	0.62	-	-
P26	0.55	0.31	-	-	-	-	-	-	-
P27	0.50	0.21	0.19	0.19	0.18	0.17	0.16	-	-
P28	0.55	0.24	0.22	0.20	0.20	0.19	0.18	-	-
P29	0.59	0.32	0.28	0.26	-	-	-	-	-
P30	0.51	0.24	-	-	-	-	-	-	-
P31	0.38	0.24	-	-	-	-	-	-	-
P32	1.00	0.56	0.43	0.41	0.34	0.23	0.17	-	-
P33	0.82	0.40	0.27	0.26	0.18	-	-	-	-
P34	0.78	0.45	0.40	0.39	0.38	0.34	0.27	-	-
P35	0.82	0.25	0.15	0.15	-	-	-	-	-
P36	0.74	0.23	0.21	0.21	0.17	0.15	-	-	-
P37	2.18	0.65	0.45	0.43	0.25	-	-	-	-
P38	0.46	0.29	0.27	0.27	0.26	0.26	0.23	0.21	0.19
P39	1.83	0.31	0.25	0.22	0.22	0.19	0.17	-	-
P40	0.92	0.22	-	-	-	-	-	-	-
P41	0.63	0.20	-	-	-	-	-	-	-
P42	0.87	0.23	0.19	0.19	0.16	0.15	-	-	-
P43	1.20	0.49	0.46	0.46	0.43	0.41	0.37	0.29	0.26
P44	1.88	1.09	0.91	0.90	0.85	0.77	0.69	0.54	0.39
P45	2.53	1.71	1.51	1.50	1.45	1.37	1.29	1.14	0.99
P46	1.40	0.63	0.44	0.43	0.38	0.30	0.23	-	-
P47	1.17	0.17	-	-	-	-	-	-	-
P48	1.25	0.26	-	-	-	-	-	-	-
P49	1.26	0.30	0.15	0.15	-	-	-	-	-
P50	1.69	0.90	0.67	0.65	0.51	0.29	-	-	-
P51	0.32	0.21	0.21	0.17	-	-	-	-	-

Reference ID	Peak Water Depths (m)								
	PMF	200yr ARI	100yr ARI	50yr ARI	20yr ARI	10yr ARI	5yr ARI	2yr ARI	1yr ARI
P52	1.25	0.43	0.36	0.35	0.33	0.23	0.21	0.19	0.18
P53	1.24	0.29	0.19	0.19	0.17	0.15	-	-	-
P54	2.17	1.35	1.26	1.25	1.23	1.14	1.12	1.10	1.08
P55	1.82	1.02	0.94	0.93	0.91	0.82	0.80	0.78	0.76
P56	1.30	0.51	0.43	0.42	0.39	0.31	0.28	0.26	0.24
P57	1.58	0.88	0.75	0.74	0.68	0.58	0.56	0.53	0.51
P58	1.19	0.42	0.34	0.33	0.30	0.21	0.19	0.17	0.15
P59	1.88	1.09	1.01	1.00	0.98	0.89	0.87	0.84	0.83
P60	2.60	1.85	1.77	1.76	1.73	1.64	1.62	1.60	1.58
P61	0.79	0.45	0.41	0.41	0.40	0.39	0.37	0.35	0.33
P62	1.02	0.71	0.64	0.64	0.62	0.60	0.56	0.54	0.52

smaller than 0.15m were not included.

APPENDIX G

Peak Water Levels for Design Events at Reference Points

Reference ID	Peak Water Levels (m AHD)								
	PMF	200yr ARI	100yr ARI	50yr ARI	20yr ARI	10yr ARI	5yr ARI	2yr ARI	1yr ARI
P1	53.77	53.50	53.47	53.47	53.45	53.43	53.39	53.34	53.30
P3	49.87	49.68	49.62	49.61	49.61	49.59	49.58	49.52	49.47
P4	44.87	44.35	44.24	44.23	44.21	44.15	44.10	44.06	44.03
P5	43.12	42.66	42.60	42.60	42.58	42.55	42.53	42.51	42.49
P6	40.44	40.22	40.21	40.20	40.20	40.19	40.18	40.16	40.14
P7	39.25	38.38	38.36	38.36	38.31	38.24	38.18	38.04	37.93
P8	37.05	35.68	35.53	35.51	35.41	35.28	35.20	35.14	35.13
P9	33.17	32.51	32.43	32.42	32.39	32.37	32.34	32.26	32.21
P10	32.00	31.50	31.49	31.47	31.47	31.46	31.45	31.41	31.35
P11	30.02	28.87	28.80	28.80	28.78	28.75	28.74	28.73	28.72
P12	30.38	29.53	29.49	29.43	29.11	29.10	29.10	29.09	29.09
P13	29.80	28.11	27.93	27.81	27.22	27.19	27.16	27.11	27.08
P14	28.93	27.78	27.64	27.50	26.97	26.86	26.77	26.76	26.74
P15	41.91	41.61	41.57	41.57	41.55	41.53	41.52	41.48	41.46
P16	40.70	40.16	40.13	40.11	40.11	40.09	40.08	40.04	40.00
P17	36.34	36.11	36.08	36.06	36.06	36.05	36.03	36.00	35.99
P18	33.87	32.47	32.37	32.37	32.34	32.33	32.31	32.30	32.28
P19	30.35	30.10	30.02	30.02	29.99	29.97	29.95	29.94	29.93
P20	28.15	27.21	27.09	26.99	26.78	26.77	26.77	26.77	26.77
P21	28.24	26.99	26.98	26.80	26.75	26.73	26.71	26.66	26.62
P22	26.06	25.68	25.62	25.62	25.61	25.60	25.59	25.58	25.57
P23	26.05	25.44	25.42	25.41	25.39	25.37	25.34	25.32	25.31
P24	26.06	25.44	25.42	25.41	25.39	25.37	25.34	25.32	25.31
P25	47.61	46.94	46.87	46.86	46.80	46.70	46.54	46.20	46.07
P26	43.93	43.69	43.65	43.63	43.62	43.59	43.59	43.57	43.56
P27	43.31	43.01	43.00	42.99	42.99	42.98	42.97	42.95	42.87
P28	36.70	36.39	36.37	36.35	36.35	36.34	36.33	36.32	36.30
P29	32.63	32.35	32.31	32.30	32.30	32.28	32.27	32.23	32.20
P30	56.30	56.03	55.96	55.95	55.94	55.93	55.92	55.90	55.89
P31	42.97	42.83	42.79	42.78	42.69	42.60	42.57	42.57	42.57
P32	51.15	50.72	50.58	50.56	50.49	50.39	50.33	50.27	50.25
P33	51.14	50.72	50.59	50.58	50.50	50.39	50.34	50.32	50.32
P34	37.72	37.39	37.34	37.32	37.32	37.30	37.21	37.05	37.04
P35	34.95	34.37	34.27	34.27	34.22	34.16	34.14	34.13	34.13
P36	37.06	36.54	36.52	36.52	36.49	36.45	36.42	36.36	36.32
P37	36.40	34.86	34.66	34.64	34.47	34.26	34.26	34.25	34.25
P38	37.62	37.44	37.42	37.42	37.41	37.40	37.38	37.36	37.35
P39	36.42	34.90	34.83	34.80	34.80	34.77	34.75	34.70	34.66
P40	33.94	33.24	33.19	33.18	33.16	33.09	33.08	33.07	33.06
P41	31.03	30.59	30.53	30.53	30.49	30.45	30.41	30.40	30.40
P42	30.11	29.47	29.43	29.43	29.41	29.38	29.36	29.29	29.23
P43	26.14	25.43	25.40	25.40	25.38	25.35	25.31	25.24	25.20
P44	25.92	25.12	24.91	24.90	24.85	24.77	24.70	24.55	24.40
P45	25.93	25.12	24.91	24.90	24.85	24.77	24.70	24.54	24.39
P46	25.87	25.11	24.91	24.90	24.85	24.77	24.69	24.54	24.48
P47	25.91	24.91	24.86	24.86	24.85	24.85	24.84	24.83	24.82
P48	25.83	24.83	24.71	24.70	24.69	24.67	24.66	24.63	24.61
P49	25.78	24.82	24.66	24.66	24.64	24.62	24.61	24.58	24.53
P50	25.84	25.06	24.84	24.82	24.68	24.45	24.26	24.23	24.21
P51	25.94	25.83	25.82	25.81	25.80	25.78	25.77	25.74	25.72

Reference ID	Peak Water Levels (m AHD)								
	PMF	200yr ARI	100yr ARI	50yr ARI	20yr ARI	10yr ARI	5yr ARI	2yr ARI	1yr ARI
P52	25.29	24.46	24.38	24.38	24.36	24.26	24.24	24.22	24.20
P53	25.54	24.60	24.49	24.48	24.47	24.45	24.43	24.41	24.37
P54	25.29	24.46	24.38	24.38	24.35	24.26	24.24	24.22	24.20
P55	25.26	24.46	24.38	24.38	24.35	24.26	24.24	24.22	24.20
P56	25.26	24.46	24.38	24.37	24.35	24.27	24.24	24.22	24.20
P57	25.26	24.55	24.43	24.42	24.38	24.27	24.24	24.22	24.20
P58	25.25	24.48	24.39	24.38	24.36	24.27	24.24	24.22	24.20
P59	25.25	24.46	24.38	24.37	24.35	24.26	24.24	24.22	24.20
P60	25.22	24.47	24.38	24.38	24.35	24.26	24.24	24.22	24.20
P61	24.82	24.48	24.45	24.44	24.44	24.42	24.40	24.38	24.36
P62	25.06	24.75	24.68	24.67	24.66	24.64	24.60	24.58	24.56

APPENDIX G

Peak Water Velocity for Design Events at Reference Points

Reference ID	Peak Water Velocity (m/s)								
	PMF	200yr ARI	100yr ARI	50yr ARI	20yr ARI	10yr ARI	5yr ARI	2yr ARI	1yr ARI
P1	0.52	0.39	0.41	0.39	0.41	0.22	0.21	0.12	0.19
P3	0.88	0.40	0.38	0.36	0.33	0.33	0.31	0.15	0.20
P4	0.34	0.16	0.22	0.16	0.22	0.30	0.28	0.12	0.13
P5	1.49	1.13	1.14	1.10	1.02	0.85	0.81	0.57	0.60
P6	2.62	1.61	1.58	1.52	1.45	1.22	1.16	0.90	0.92
P7	1.76	1.03	1.19	1.08	1.09	0.73	0.69	0.33	0.34
P8	0.76	0.66	0.71	0.66	0.65	0.52	0.50	0.16	0.21
P9	1.83	0.63	0.69	0.64	0.64	0.53	0.50	0.34	0.44
P10	2.17	2.02	1.93	1.79	1.66	1.40	1.33	0.94	0.60
P11	1.81	0.54	0.52	0.46	0.32	0.34	0.32	0.16	0.17
P12	2.50	1.61	1.48	1.24	1.26	0.11	0.10	0.05	0.07
P13	2.73	2.92	2.93	2.77	2.73	0.54	0.51	0.29	0.32
P14	2.76	1.39	1.26	1.03	0.97	0.80	0.76	0.62	0.52
P15	2.45	1.79	1.74	1.64	1.56	1.61	1.53	1.07	1.16
P16	1.38	1.00	0.97	0.91	0.85	0.74	0.70	0.33	0.23
P17	0.81	0.32	0.72	0.29	0.70	0.23	0.21	0.15	0.09
P18	2.03	1.36	1.47	1.02	1.15	1.18	1.12	0.81	0.69
P19	1.46	0.79	0.75	0.59	0.57	0.13	0.12	0.04	0.03
P20	3.92	2.65	2.34	1.80	1.74	0.01	0.00	0.00	0.00
P21	2.16	0.34	0.40	0.35	0.24	0.20	0.19	0.07	0.16
P22	1.46	0.29	0.15	0.15	0.13	0.12	0.11	0.09	0.07
P23	1.03	0.14	0.15	0.14	0.11	0.09	0.07	0.08	0.03
P24	0.79	0.16	0.06	0.03	0.01	0.01	0.01	0.00	0.00
P25	0.80	0.26	0.26	0.20	0.20	0.09	0.09	0.07	0.05
P26	1.17	0.93	0.89	0.78	0.56	0.15	0.14	0.26	0.17
P27	1.55	0.29	0.28	0.23	0.23	0.19	0.18	0.14	0.08
P28	0.66	0.39	0.40	0.37	0.34	0.24	0.23	0.14	0.20
P29	1.05	0.68	0.73	0.66	0.71	0.47	0.44	0.28	0.21
P30	0.35	0.19	0.23	0.19	0.19	0.16	0.15	0.07	0.11
P31	0.68	0.47	0.50	0.40	0.30	0.14	0.13	0.00	0.00
P32	1.06	0.66	0.85	0.65	0.77	0.75	0.72	0.34	0.51
P33	0.45	0.16	0.16	0.14	0.13	0.11	0.11	0.00	0.05
P34	1.12	0.32	0.31	0.31	0.30	0.19	0.18	0.04	0.11
P35	1.89	1.34	1.32	1.10	1.15	0.37	0.35	0.12	0.26
P36	1.67	1.06	1.07	1.02	0.97	0.67	0.64	0.00	0.00
P37	1.20	0.21	0.24	0.15	0.17	0.27	0.26	0.00	0.01
P38	1.19	0.53	0.51	0.48	0.42	0.38	0.36	0.18	0.22
P39	1.97	1.41	1.37	1.32	1.26	1.06	1.01	0.55	0.64
P40	0.79	0.46	0.42	0.30	0.22	0.30	0.29	0.17	0.22
P41	0.81	0.70	0.69	0.51	0.19	0.11	0.11	0.00	0.01
P42	1.25	0.35	0.32	0.29	0.27	0.24	0.23	0.00	0.00
P43	0.78	0.17	0.25	0.16	0.21	0.15	0.14	0.03	0.09
P44	1.84	0.58	0.37	0.31	0.23	0.21	0.19	0.14	0.09
P45	1.41	0.40	0.22	0.19	0.18	0.19	0.20	0.20	0.20
P46	1.12	0.34	0.21	0.20	0.19	0.11	0.09	0.02	0.00
P47	0.63	0.11	0.04	0.04	0.03	0.03	0.03	0.02	0.02
P48	0.94	0.12	0.10	0.10	0.09	0.07	0.06	0.04	0.01
P49	1.86	0.66	0.06	0.06	0.05	0.04	0.04	0.04	0.00
P50	0.97	0.64	0.57	0.56	0.46	0.31	0.05	0.01	0.00
P51	0.54	0.55	0.55	0.52	0.49	0.39	0.37	0.23	0.23

Reference ID	Peak Water Velocity (m/s)								
	PMF	200yr ARI	100yr ARI	50yr ARI	20yr ARI	10yr ARI	5yr ARI	2yr ARI	1yr ARI
P52	1.40	0.19	0.14	0.14	0.13	0.11	0.13	0.06	0.08
P53	1.91	0.69	0.26	0.25	0.21	0.16	0.12	0.05	0.01
P54	2.23	0.13	0.08	0.07	0.08	0.06	0.06	0.06	0.06
P55	1.52	0.11	0.12	0.12	0.11	0.08	0.08	0.07	0.07
P56	1.16	0.22	0.13	0.12	0.12	0.09	0.08	0.04	0.06
P57	1.20	0.67	0.44	0.42	0.30	0.12	0.06	0.06	0.06
P58	1.93	1.17	0.84	0.79	0.65	0.41	0.31	0.19	0.24
P59	1.52	0.71	0.46	0.43	0.33	0.18	0.13	0.12	0.12
P60	0.90	0.31	0.33	0.33	0.32	0.34	0.36	0.36	0.36
P61	3.57	0.95	0.64	0.66	0.66	0.66	0.64	0.60	0.58
P62	1.03	0.29	0.28	0.27	0.24	0.24	0.23	0.25	0.25

Appendix H

Pipe Peak Flows

APPENDIX H

Pipe Capacity Analysis

Pipe/Culvert ID	Type	US INVERT	DS INVERT	Diameter/ Width	Height	SLOPE	Mannings (n)	Nominal Capacity*	Max Modelled Flow	Nominal Return Period^	Modelled Flows (m^3/s) PMF	200yr ARI	100yr ARI	50yr ARI	20yr ARI	10yr ARI	5yrARI	2yr ARI	1yrARI
		m AHD	m AHD	m	m	m/m		(m^3/s)	m3/s	ARI									
C1008	Pipe	55.40	51.87	0.6		0.038	0.015	1.03	0.32	>100yr	0.3	0.3	0.2	0.2	0.2	0.2	0.1	0.1	0.1
C1022	pipe	39.78	39.53	0.525		0.031	0.015	0.65	0.60	>100yr	0.6	0.6	0.5	0.5	0.4	0.4	0.4	0.3	0.2
C1023	pipe	40.16	39.78	0.525		0.017	0.015	0.48	0.60	>50yr	0.6	0.6	0.5	0.4	0.4	0.4	0.3	0.3	0.2
C1024	pipe	39.87	39.39	0.375		0.065	0.015	0.39	0.20	>100yr	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1
C1025	pipe	43.19	39.39	0.525		0.037	0.015	0.71	0.50	>100yr	0.5	0.5	0.3	0.3	0.3	0.2	0.2	0.2	0.1
C1026	pipe	39.39	38.93	0.525		0.016	0.015	0.48	0.63	>2yr	0.6	0.6	0.6	0.6	0.5	0.5	0.5	0.4	0.3
C1027	pipe	39.53	38.93	0.525		0.022	0.015	0.56	0.60	>100yr	0.6	0.6	0.5	0.5	0.5	0.4	0.4	0.3	0.2
C1028	pipe	40.97	40.16	0.45		0.035	0.015	0.46	0.40	>100yr	0.4	0.4	0.3	0.3	0.3	0.2	0.2	0.2	0.1
C1029	pipe	44.44	40.97	0.525		0.039	0.015	0.73	0.40	>100yr	0.4	0.4	0.3	0.3	0.3	0.2	0.2	0.2	0.1
C1030	pipe	43.59	43.22	0.525		0.037	0.015	0.72	0.40	>100yr	0.4	0.4	0.3	0.3	0.3	0.2	0.2	0.2	0.1
C1031	pipe	43.66	43.22	0.375		0.073	0.015	0.41	0.10	>100yr	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C1032	pipe	44.29	43.59	0.525		0.035	0.015	0.70	0.40	>100yr	0.4	0.4	0.3	0.3	0.3	0.2	0.2	0.2	0.1
C1034	pipe	38.93	38.62	0.675		0.015	0.015	0.89	0.70	>100yr	0.7	0.7	0.6	0.6	0.5	0.5	0.4	0.3	0.3
C1035	pipe	38.93	38.62	0.675		0.015	0.015	0.88	0.70	>100yr	0.7	0.7	0.6	0.6	0.5	0.5	0.4	0.3	0.3
C1036	pipe	38.27	38.03	0.525		0.082	0.015	1.07	0.69	>100yr	0.7	0.6	0.6	0.6	0.5	0.4	0.3	0.2	0.1
C1037	pipe	38.14	34.45	0.9		0.042	0.015	3.20	2.44	>100yr	2.4	1.4	1.3	1.3	1.2	1.2	1.1	0.9	0.7
C1041	pipe	34.45	34.26	0.9		0.021	0.015	2.27	2.26	>100yr	2.3	1.4	1.3	1.3	1.2	1.2	1.1	0.9	0.7
C1042	pipe	34.26	33.37	0.9		0.019	0.015	2.18	2.37	>100yr	2.4	1.4	1.3	1.3	1.3	1.2	1.2	1.0	0.7
C1043	pipe	33.19	30.92	0.9		0.035	0.015	2.93	2.37	>100yr	2.4	1.4	1.3	1.3	1.3	1.2	1.2	1.0	0.7
C1044	pipe	30.92	30.86	0.9		0.020	0.015	2.23	1.47	>100yr	1.5	1.4	1.3	1.3	1.3	1.2	1.2	1.0	0.7
C1045	pipe	30.83	30.63	1.05		0.016	0.015	3.02	2.57	>100yr	2.6	1.5	1.3	1.3	1.3	1.3	1.3	1.1	0.8
C1052	pipe	30.63	29.85	1.05		0.018	0.015	3.21	3.14	>100yr	3.1	1.5	1.4	1.3	1.3	1.3	1.2	1.2	0.9
C1053	pipe	29.85	28.97	1.05		0.018	0.015	3.15	3.28	>100yr	3.3	1.6	1.4	1.3	1.3	1.3	1.2	1.1	0.9
C1056	pipe	27.26	26.76	0.6		0.005	0.015	0.36	0.37	>100yr	0.4	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.0
C1066	pipe	28.97	28.29	1.05		0.017	0.015	3.13	3.28	>100yr	3.3	1.6	1.4	1.3	1.3	1.3	1.3	1.2	0.9
C1068	pipe	27.51	26.29	1.2		0.018	0.015	4.56	3.00	>100yr	3.0	3.0	1.5	1.4	1.4	1.3	1.3	1.3	1.0
C1079	pipe	27.58	27.06	0.6		0.008	0.015	0.46	0.10	>100yr	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
C1098	pipe	27.39	27.31	1.2		0.003	0.015	1.80	5.36	<1yr	5.4	2.9	2.8	2.7	2.5	2.4	2.3	2.1	2.0
C1099	pipe	27.44	27.39	1.5		0.001	0.015	1.87	2.94	>100yr	2.9	1.8	1.6	1.5	1.4	1.3	1.3	1.1	1.0
C1100	pipe	27.44	27.39	1.5		0.001	0.015	1.85	2.92	>100yr	2.9	1.8	1.5	1.4	1.3	1.3	1.3	1.1	1.0
C1101	pipe	27.42	27.09	1.5		0.005	0.015	4.45	6.80	>10yr	6.8	6.1	5.8	5.4	5.1	3.5	3.1	2.0	1.4
C1102	pipe	27.42	27.09	1.5		0.006	0.015	4.63	6.98	>10yr	7.0	6.3	5.9	5.6	5.2	3.6	3.1	2.1	1.4
C1103	pipe	27.42	27.09	1.5		0.006	0.015	4.71	7.06	>10yr	7.1	6.4	6.0	5.6	5.3	3.7	3.2	2.1	1.4
C1104	pipe	27.42	27.09	1.5		0.006	0.015	4.62	6.96	>10yr	7.0	6.3	5.9	5.6	5.2	3.6	3.1	2.0	1.4
C1107	pipe	27.12	26.94	0.9		0.005	0.015	1.08	1.00	>100yr	1.0	1.0	1.0	1.0	0.6	0.4	0.4	0.3	0.2
C1108	pipe	26.94	26.80	0.9		0.005	0.015	1.07	1.13	>20yr	1.1	1.1	1.1	1.1	0.6	0.4	0.4	0.3	0.2
C1109	pipe	26.80	26.28	0.9		0.006	0.015	1.24	1.50	>20yr	1.5	1.5	1.4	1.3	0.7	0.5	0.4	0.3	0.2
C1113	pipe	27.42	27.12	0.75		0.005	0.015	0.66	0.50	>100yr	0.5	0.5	0.4	0.4	0.3	0.2	0.2	0.1	0.1
C1118	pipe	27.53	27.42	0.45		0.005	0.015	0.18	0.20	>20yr	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1
C1119	pipe	27.53	27.42	0.45		0.005	0.015	0.18	0.20	>20yr	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1
C1132	pipe	25.56	25.52	0.45		0.004	0.015	0.16	0.12	>100yr	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
C1134	pipe	25.52	25.14	0.45		0.007	0.015	0.21	0.11	>100yr	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
C1135	pipe	25.32	25.07	0.9		0.010	0.015	1.57	1.84	>100yr	1.8	1.6	1.5	1.5	1.4	1.2	1.1	0.6	0.4
C1136	pipe	25.32	25.07	0.9		0.010	0.015	1.58	1.84	>100yr	1.8	1.6	1.5	1.5	1.4	1.2	1.1	0.6	0.4
C1137	pipe	25.14	25.08	0.375		0.005	0.015	0.11	0.11	>100yr	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
C1138	pipe	25.08	25.07	0.375		0.002	0.015	0.07	0.19	<1yr	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
C1141	pipe	24.41	24.26	0.6		0.006	0.015	0.42	0.11	>100yr	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
C1153	pipe	25.23	24.93	0.3		0.010	0.015	0.08	0.10	<1yr	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

Pipe/Culvert ID	Type	US INVERT	DS INVERT	Diameter/ Width	Height	SLOPE	Mannings (n)	Nominal Capacity*	Max Modelled Flow	Nominal Return Period^	Modelled Flows (m^3/s) PMF	200yr ARI	100yr ARI	50yr ARI	20yr ARI	10yr ARI	5yrARI	2yr ARI	1yrARI
		m AHD	m AHD	m	m	m/m		(m^3/s)	m3/s	ARI									
C1154	pipe	24.93	24.48	0.3		0.015	0.015	0.10	0.16	>100yr	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
C1155	pipe	24.44	23.73	0.45		0.069	0.015	0.65	0.23	>100yr	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
C1156	pipe	23.39	23.31	1.05		0.008	0.015	2.06	0.20	>100yr	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1
C1157	pipe	23.27	23.20	1.05		0.003	0.015	1.32	0.20	>100yr	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1
C1158	pipe	23.77	23.39	0.75		0.003	0.015	0.55	0.30	>100yr	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2
C1162	pipe	25.62	25.23	0.3		0.011	0.015	0.09	0.10	<1yr	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
C1170	pipe	29.71	29.67	1.35		0.004	0.015	3.04	4.72	>2yr	4.7	4.3	4.0	3.9	3.8	3.5	3.2	2.6	2.0
C1171	pipe	29.82	29.71	1.35		0.007	0.015	3.89	4.91	>10yr	4.9	4.3	4.1	4.0	3.9	3.5	3.2	2.5	1.9
C1172	pipe	30.60	29.82	1.35		0.014	0.015	5.41	5.21	>100yr	5.2	4.5	4.4	4.3	4.2	3.6	3.2	2.4	1.9
C1173	pipe	29.67	29.10	1.35		0.009	0.015	4.42	4.10	>100yr	4.1	4.1	3.7	3.6	3.5	3.3	3.1	2.6	2.0
C1183	pipe	22.82	22.07	0.675		0.044	0.015	1.53	0.49	>100yr	0.5	0.3	0.2	0.2	0.2	0.2	0.2	0.1	0.1
C1184	pipe	21.99	21.81	1.65		0.005	0.015	5.72	4.42	>100yr	4.4	3.5	3.1	3.1	3.0	3.0	2.9	2.4	1.9
C1185	pipe	22.01	21.81	1.65		0.005	0.015	5.69	4.37	>100yr	4.4	3.5	3.1	3.1	3.0	3.0	2.9	2.4	2.0
C1186	pipe	22.15	22.07	1.65		0.002	0.015	3.54	4.10	>100yr	4.1	3.2	2.9	2.9	2.8	2.8	2.7	2.2	1.7
C1187	pipe	22.25	22.07	1.65		0.003	0.015	4.37	4.40	>100yr	4.4	3.5	3.1	3.1	3.0	3.0	2.9	2.4	1.9
C1188	pipe	23.26	23.11	0.675		0.007	0.015	0.60	0.48	>100yr	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1
C1189	pipe	23.39	23.26	0.6		0.013	0.015	0.61	0.39	>100yr	0.4	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1
C1190	pipe	24.62	23.39	0.6		0.011	0.015	0.56	0.26	>100yr	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
C1191	pipe	23.11	22.82	0.675		0.005	0.015	0.53	0.48	>100yr	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1
C1192	pipe	25.17	24.62	0.525		0.020	0.015	0.52	0.21	>100yr	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
C1196	pipe	22.25	22.21	1.65		0.010	0.015	7.78	3.91	>100yr	3.9	3.1	2.8	2.8	2.7	2.7	2.6	2.1	1.7
C1197	pipe	22.21	22.15	1.65		0.004	0.015	4.77	3.92	>100yr	3.9	3.1	2.8	2.8	2.7	2.7	2.6	2.1	1.7
C1202	pipe	21.20	20.48	0.675		0.032	0.015	1.29	0.10	>100yr	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
C1205	pipe	20.48	20.30	1.05		0.003	0.015	1.38	0.71	>100yr	0.7	0.5	0.5	0.5	0.5	0.5	0.4	0.4	0.4
C1207	pipe	21.81	21.51	1.65		0.004	0.015	4.94	4.48	>100yr	4.5	3.5	3.1	3.1	3.1	3.1	2.9	2.4	2.0
C1210	pipe	21.81	21.50	1.65		0.003	0.015	4.41	4.31	>100yr	4.3	3.5	3.1	3.1	3.0	3.0	2.9	2.4	1.9
C1211	pipe	22.27	22.13	0.7		0.011	0.015	0.84	0.20	>100yr	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1
C1212	pipe	22.26	21.82	0.75		0.044	0.015	2.02	0.20	>100yr	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
C1214	pipe	21.51	21.34	1.65		0.002	0.015	3.62	4.48	>100yr	4.5	3.5	3.1	3.1	3.1	3.1	2.9	2.4	2.0
C1215	pipe	21.42	21.26	1.65		0.003	0.015	4.00	4.22	>100yr	4.2	3.5	3.1	3.1	3.0	3.0	2.9	2.4	1.9
C1216	pipe	21.34	21.26	1.65		0.005	0.015	5.60	4.52	>100yr	4.5	3.5	3.1	3.1	3.1	3.0	2.9	2.4	2.0
C1219	pipe	24.57	24.12	0.375		0.003	0.015	0.08	0.10	<1yr	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
C1220	pipe	24.12	23.70	0.6		0.003	0.015	0.27	0.20	>100yr	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1
C1222	pipe	26.84	26.10	0.24		0.048	0.015	0.10	0.07	>100yr	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C1223	pipe	27.06	26.84	0.24		0.016	0.015	0.06	0.03	>100yr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C1224	pipe	27.23	27.06	0.24		0.010	0.015	0.05	0.02	>100yr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C1225	pipe	27.25	27.23	0.24		0.004	0.015	0.03	0.01	>100yr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C1263	pipe	26.29	25.17	1.2		0.014	0.015	4.03	3.00	>100yr	3.0	3.0	1.4	1.4	1.4	1.4	1.4	1.3	1.0
C1264	pipe	25.00	24.80	0.9		0.003	0.015	0.88	1.10	>2yr	1.1	1.1	1.0	0.9	0.9	0.9	0.9	0.8	0.4
C1265	pipe	24.80	24.49	0.9		0.003	0.015	0.87	1.05	>100yr	1.0	0.9	0.8	0.8	0.8	0.8	0.8	0.8	0.8
C1266	pipe	24.49	24.32	0.9		0.006	0.015	1.20	1.05	>100yr	1.0	0.9	0.8	0.8	0.8	0.8	0.8	0.8	0.8
C1267	pipe	24.43	24.14	0.9		0.006	0.015	1.20	1.05	>100yr	1.0	0.9	0.8	0.8	0.8	0.8	0.8	0.8	0.8
C1268	pipe	25.07	25.00	0.6		0.004	0.015	0.32	0.52	>1yr	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.4	0.2
C1269	pipe	25.07	25.00	0.6		0.004	0.015	0.33	0.53	>1yr	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.4	0.2
C1272	pipe	23.44	23.14	0.9		0.004	0.015	0.97	1.05	>100yr	1.0	0.9	0.8	0.8	0.8	0.8	0.8	0.8	0.8
C1275	pipe	22.79	22.75	0.9		0.005	0.015	1.12	0.90	>100yr	0.9	0.9	0.8	0.8	0.8	0.8	0.8	0.8	0.8
C1278	pipe	22.75	22.24	0.9		0.003	0.015	0.86	1.82	<1yr	1.8	1.6	1.6	1.6	1.6	1.6	1.6	1.5	1.4
C1279	pipe	24.49	23.76	0.9		0.007	0.015	1.31	2.06	<1yr	2.1	2.0	2.0	2.0	2.0	2.0	2.0	1.9	1.6
C1287	pipe	37.74	37.06	0.675		0.016	0.015	0.91	0.67	>100yr	0.7	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.2
C1288	pipe	37.00	34.25	0.675		0.035	0.015	1.36	0.67	>100yr	0.7	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.2
C1289	pipe	34.25	32.64	0.675		0.029	0.015	1.23	0.67	>100yr	0.7	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.2
C1290	pipe	31.87	30.60	1.35		0.012	0.015	5.02	5.53	>100yr	5.5	5.0	4.6	4.6	4.4	3.8	3.3	2.4	1.8
C1291	pipe	32.63	31.88	1.35		0.012	0.015	5.00	5.31	>100yr	5.3	4.8	4.5	4.4	4.1	3.5	3.0	2.2	1.7

Pipe/Culvert ID	Type	US INVERT	DS INVERT	Diameter/ Width	Height	SLOPE	Mannings (n)	Nominal Capacity*	Max Modelled Flow	Nominal Return Period^	Modelled Flows (m^3/s) PMF	200yr ARI	100yr ARI	50yr ARI	20yr ARI	10yr ARI	5yrARI	2yr ARI	1yrARI
		m AHD	m AHD	m	m	m/m		(m^3/s)	m3/s	ARI									
C1292	pipe	29.05	28.88	1.35		0.007	0.015	3.93	3.10	>100yr	3.1	3.1	2.5	2.5	2.5	2.4	2.3	2.0	1.7
C1293	pipe	28.88	28.48	0.6		0.006	0.015	0.40	0.86	<1yr	0.9	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
C1295	pipe	24.39	24.22	0.6		0.013	0.015	0.60	0.20	>100yr	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.0	0.0
C1296	pipe	24.39	24.22	0.6		0.012	0.015	0.57	0.20	>100yr	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.0	0.0
C1297	pipe	24.22	22.97	0.6		0.010	0.015	0.53	0.50	>100yr	0.5	0.5	0.4	0.4	0.4	0.3	0.3	0.2	0.1
C1298	pipe	24.52	22.72	0.75		0.014	0.015	1.12	0.96	>100yr	1.0	0.9	0.9	0.9	0.8	0.8	0.7	0.6	0.5
C1299	pipe	22.72	22.69	0.75		0.005	0.015	0.71	0.90	>5yr	0.9	0.9	0.9	0.8	0.8	0.8	0.7	0.6	0.5
C1300	pipe	22.29	22.26	1.05		0.002	0.015	1.01	1.16	>100yr	1.2	1.0	1.0	1.0	1.0	0.9	0.8	0.7	0.6
C1301	pipe	22.26	21.81	1.05		0.009	0.015	2.18	1.07	>100yr	1.1	1.0	1.0	1.0	0.9	0.8	0.8	0.7	0.6
C1302	pipe	21.81	21.54	1.05		0.011	0.015	2.47	1.08	>100yr	1.1	1.0	1.0	1.0	0.9	0.9	0.9	0.7	0.7
C1303	pipe	24.86	24.73	0.525		0.006	0.015	0.30	0.50	>1yr	0.5	0.5	0.4	0.4	0.4	0.4	0.3	0.3	0.2
C1304	pipe	24.86	24.73	0.525		0.006	0.015	0.30	0.50	>5yr	0.5	0.5	0.4	0.4	0.4	0.4	0.3	0.3	0.2
C1306	pipe	28.15	24.88	0.6		0.029	0.015	0.90	0.90	>100yr	0.9	0.9	0.8	0.8	0.7	0.7	0.6	0.5	0.5
C1307	pipe	28.62	28.15	0.6		0.030	0.015	0.93	0.85	>100yr	0.9	0.8	0.8	0.8	0.7	0.7	0.6	0.5	0.5
C1308	pipe	30.06	28.62	0.6		0.031	0.015	0.93	0.82	>100yr	0.8	0.8	0.8	0.8	0.7	0.7	0.6	0.5	0.5
C1309	pipe	30.26	30.06	0.6		0.017	0.015	0.70	0.86	>5yr	0.9	0.8	0.8	0.8	0.7	0.7	0.6	0.5	0.4
C1310	pipe	30.65	30.26	0.6		0.015	0.015	0.66	0.91	>20yr	0.9	0.8	0.7	0.7	0.6	0.6	0.6	0.5	0.4
C1311	pipe	32.62	30.75	0.45		0.041	0.015	0.50	0.41	>100yr	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.2	0.2
C1312	pipe	31.56	30.95	0.45		0.028	0.015	0.41	0.50	>100yr	0.5	0.5	0.3	0.3	0.3	0.3	0.3	0.2	0.2
C1313	pipe	23.20	23.03	1.05		0.004	0.015	1.41	0.14	>100yr	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C1320	pipe	28.21	27.85	1.2		0.004	0.015	2.01	2.68	>50yr	2.7	2.2	2.1	2.0	2.0	1.9	1.9	1.7	1.6
C1324	pipe	28.48	28.21	0.675		0.006	0.015	0.54	1.05	<1yr	1.1	1.0	1.0	1.0	1.0	0.9	0.9	0.9	0.8
C1328	pipe	38.59	38.24	0.75		0.021	0.015	1.39	1.59	>100yr	1.6	1.5	1.3	1.2	1.1	1.0	0.9	0.8	0.6
C1329	pipe	38.59	38.24	0.75		0.019	0.015	1.33	1.59	>100yr	1.6	1.5	1.3	1.2	1.1	1.0	0.9	0.8	0.6
C1330	pipe	36.62	36.02	1.2		0.010	0.015	3.45	3.71	>100yr	3.7	3.0	2.7	2.6	2.4	2.2	1.9	1.6	1.4
C1331	pipe	40.26	38.59	1.05		0.015	0.015	2.90	2.80	>100yr	2.8	2.5	2.0	1.9	1.7	1.4	1.3	0.9	0.7
C1346	pipe	41.22	40.96	0.675		0.011	0.015	0.78	1.02	>20yr	1.0	1.0	0.9	0.8	0.7	0.6	0.6	0.4	0.3
C1347	pipe	40.96	40.32	0.675		0.026	0.015	1.18	1.15	>100yr	1.2	1.1	0.9	0.9	0.8	0.7	0.6	0.5	0.4
C1348	pipe	42.42	41.22	0.9		0.018	0.015	2.13	2.07	>100yr	2.1	1.9	1.7	1.6	1.5	1.3	1.1	0.8	0.7
C1349	pipe	40.96	40.65	0.675		0.012	0.015	0.80	1.26	>20yr	1.3	1.1	1.0	0.9	0.8	0.7	0.6	0.4	0.3
C1350	pipe	42.65	42.42	0.6		0.039	0.015	1.06	1.04	>100yr	1.0	0.9	0.8	0.8	0.7	0.6	0.6	0.4	0.3
C1351	pipe	42.65	42.42	0.6		0.038	0.015	1.04	1.03	>100yr	1.0	0.9	0.8	0.8	0.7	0.6	0.6	0.4	0.3
C1352	pipe	42.76	42.65	0.6		0.012	0.015	0.58	0.98	>10yr	1.0	0.9	0.7	0.7	0.6	0.5	0.5	0.3	0.3
C1353	pipe	42.76	42.65	0.6		0.012	0.015	0.57	0.97	>10yr	1.0	0.9	0.7	0.7	0.6	0.5	0.5	0.3	0.3
C1354	pipe	43.10	42.76	0.6		0.023	0.015	0.81	0.98	>100yr	1.0	0.9	0.6	0.5	0.5	0.4	0.4	0.3	0.3
C1355	pipe	43.10	42.76	0.6		0.024	0.015	0.83	1.00	>100yr	1.0	0.9	0.6	0.6	0.5	0.4	0.4	0.3	0.3
C1356	pipe	44.77	43.10	0.9		0.030	0.015	2.74	1.99	>100yr	2.0	1.9	1.2	1.1	1.0	0.9	0.8	0.6	0.5
C1357	pipe	45.74	44.77	0.75		0.033	0.015	1.76	0.73	>100yr	0.7	0.7	0.4	0.4	0.4	0.3	0.3	0.2	0.2
C1358	pipe	46.12	44.77	0.825		0.026	0.015	2.00	1.28	>100yr	1.3	1.1	0.7	0.7	0.6	0.6	0.5	0.4	0.4
C1359	pipe	47.80	45.74	0.75		0.036	0.015	1.84	0.73	>100yr	0.7	0.7	0.4	0.4	0.4	0.3	0.3	0.2	0.2
C1360	pipe	46.91	46.12	0.675		0.030	0.015	1.27	1.28	>100yr	1.3	1.1	0.7	0.7	0.6	0.6	0.5	0.4	0.4
C1361	pipe	47.71	46.91	0.675		0.029	0.015	1.25	1.28	>100yr	1.3	1.1	0.7	0.7	0.6	0.6	0.5	0.4	0.4
C1363	pipe	48.50	47.71	0.6		0.031	0.015	0.93	0.74	>100yr	0.7	0.7	0.5	0.5	0.5	0.4	0.4	0.3	0.3
C1364	pipe	50.05	48.50	0.6		0.031	0.015	0.93	0.74	>100yr	0.7	0.7	0.5	0.5	0.4	0.4	0.4	0.3	0.3
C1365	pipe	50.78	50.05	0.525		0.034	0.015	0.69	0.74	>100yr	0.7	0.7	0.5	0.5	0.4	0.4	0.4	0.3	0.3
C1366	pipe	51.86	50.78	0.525		0.036	0.015	0.71	0.74	>100yr	0.7	0.7	0.5	0.5	0.4	0.4	0.4	0.3	0.3
C1367	pipe	52.19	52.06	0.6		0.010	0.015	0.54	0.50	>100yr	0.5	0.5	0.4	0.4	0.4	0.3	0.3	0.3	0.3
C1368	pipe	52.06	51.94	0.6		0.022	0.015	0.79	0.74	>100yr	0.7	0.7	0.5	0.5	0.4	0.4	0.4	0.3	0.3
C1387	pipe	36.02	32.99	1.2		0.026	0.015	5.45	4.33	>100yr	4.3	3.5	3.3	3.2	3.0	2.8	2.5	1.8	1.4
C1388	pipe	32.99	32.78	1.2		0.021	0.015	4.88	4.41	>100yr	4.4	3.9	3.8	3.6	3.4	2.9	2.5	1.9	1.4
C1391	pipe	35.95	34.98	0.6		0.015	0.015	0.66	0.79	>100yr	0.8	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.4
C1392	pipe	33.79	33.79	0.75		0.000	0.015	0.00	1.61	<1yr	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.5	1.2
C1394	pipe	37.80	34.81	0.75		0.031	0.015	1.70	1.25	>100yr	1.3	1.2	1.1	1.1	1.1	1.1	1.1	1.0	0.7

Pipe/Culvert ID	Type	US INVERT	DS INVERT	Diameter/ Width	Height	SLOPE	Mannings (n)	Nominal Capacity*	Max Modelled Flow	Nominal Return Period^	Modelled Flows (m^3/s) PMF	200yr ARI	100yr ARI	50yr ARI	20yr ARI	10yr ARI	5yrARI	2yr ARI	1yrARI
		m AHD	m AHD	m	m	m/m		(m^3/s)	m3/s	ARI									
C1395	pipe	33.79	30.52	0.75		0.023	0.015	1.45	1.61	>1yr	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.2
C1396	pipe	36.69	35.95	0.6		0.020	0.015	0.74	0.84	>2yr	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.6	0.4
C1397	pipe	37.80	36.69	0.6		0.021	0.015	0.78	1.02	>2yr	1.0	0.9	0.9	0.9	0.9	0.9	0.8	0.5	0.4
C1398	pipe	39.23	37.80	0.6		0.180	0.015	2.26	1.02	>100yr	1.0	0.9	0.9	0.9	0.9	0.9	0.8	0.5	0.4
C1402	pipe	40.89	40.73	0.6		0.015	0.015	0.64	0.63	>100yr	0.6	0.6	0.4	0.4	0.4	0.4	0.4	0.3	0.2
C1403	pipe	40.73	40.52	0.6		0.018	0.015	0.72	0.88	>100yr	0.9	0.7	0.5	0.5	0.5	0.4	0.4	0.3	0.3
C1405	pipe	40.52	37.97	0.6		0.072	0.015	1.43	0.99	>100yr	1.0	0.7	0.5	0.5	0.5	0.5	0.4	0.3	0.3
C1408	pipe	37.94	37.01	0.75		0.070	0.015	2.56	1.16	>100yr	1.2	0.8	0.6	0.6	0.5	0.5	0.4	0.3	0.3
C1410	pipe	36.96	36.86	0.525		0.023	0.015	0.56	0.61	>100yr	0.6	0.4	0.3	0.3	0.3	0.3	0.2	0.2	0.1
C1411	pipe	36.96	36.86	0.525		0.017	0.015	0.49	0.55	>100yr	0.6	0.4	0.3	0.3	0.3	0.2	0.2	0.2	0.1
C1412	pipe	36.86	36.39	0.75		0.016	0.015	1.23	1.19	>100yr	1.2	0.8	0.6	0.6	0.5	0.5	0.4	0.3	0.3
C1413	pipe	36.39	36.08	0.75		0.018	0.015	1.28	1.19	>100yr	1.2	0.8	0.7	0.6	0.5	0.5	0.4	0.3	0.3
C1414	pipe	36.08	35.51	0.375		0.249	0.015	0.76	0.50	>100yr	0.5	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
C1418	pipe	34.07	33.45	0.45		0.024	0.015	0.38	0.48	>2yr	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.3
C1423	pipe	47.19	46.99	0.825		0.009	0.015	1.15	0.84	>100yr	0.8	0.5	0.4	0.4	0.4	0.4	0.4	0.1	0.1
C1424	pipe	45.74	45.65	0.825		0.006	0.015	0.96	0.93	>100yr	0.9	0.6	0.5	0.5	0.5	0.5	0.4	0.2	0.1
C1425	pipe	50.35	48.99	0.825		0.067	0.015	3.21	0.84	>100yr	0.8	0.5	0.4	0.4	0.4	0.4	0.4	0.1	0.1
C1430	pipe	44.63	42.89	1.05		1.891	0.015	32.55	1.00	>100yr	1.0	0.6	0.5	0.4	0.4	0.4	0.4	0.2	0.1
C1435	pipe	42.89	42.67	1.05		0.016	0.015	3.00	1.00	>100yr	1.0	0.6	0.5	0.4	0.4	0.4	0.4	0.2	0.1
C1436	pipe	42.67	41.70	1.05		0.026	0.015	3.82	1.02	>100yr	1.0	0.6	0.5	0.4	0.4	0.4	0.4	0.2	0.1
C1440	pipe	40.71	40.62	0.45		0.007	0.015	0.21	0.32	>2yr	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.1	0.1
C1441	pipe	40.71	40.62	0.45		0.006	0.015	0.20	0.31	>2yr	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.1	0.1
C1442	pipe	40.62	40.50	0.6		0.004	0.015	0.32	0.60	>2yr	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.2	0.2
C1443	pipe	41.45	40.77	0.6		0.041	0.015	1.08	0.50	>100yr	0.5	0.5	0.4	0.4	0.4	0.3	0.3	0.2	0.2
C1444	pipe	41.58	41.45	0.6		0.039	0.015	1.05	0.30	>100yr	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.1	0.1
C1445	pipe	40.50	39.23	0.6		0.032	0.015	0.95	1.08	>50yr	1.1	1.0	1.0	0.9	0.9	0.9	0.8	0.5	0.4
C1446	pipe	50.53	50.40	0.75		0.036	0.015	1.83	0.16	>100yr	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0
C1447	pipe	50.51	50.40	0.75		0.009	0.015	0.90	0.41	>100yr	0.4	0.3	0.2	0.2	0.2	0.2	0.1	0.1	0.1
C1448	pipe	50.64	50.51	0.75		0.030	0.015	1.68	0.23	>100yr	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.0
C1459	pipe	32.37	32.20	0.75		0.013	0.015	1.11	0.18	>100yr	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C1460	pipe	32.20	31.75	0.45		0.029	0.015	0.42	0.37	>100yr	0.4	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1
C1465	pipe	31.09	30.83	1.05		0.022	0.015	3.47	3.04	>100yr	3.0	2.2	1.4	1.3	1.1	0.9	0.8	0.6	0.5
C1466	pipe	31.62	31.37	0.6		0.004	0.015	0.33	0.31	>100yr	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0
C1467	pipe	31.45	31.35	0.9		0.014	0.015	1.84	1.96	>100yr	2.0	1.6	1.0	0.9	0.9	0.7	0.6	0.5	0.4
C1468	pipe	31.57	31.45	0.9		0.005	0.015	1.14	1.74	>100yr	1.7	1.2	0.7	0.7	0.7	0.6	0.5	0.4	0.3
C1474	pipe	32.19	31.57	0.9		0.038	0.015	3.05	2.50	>100yr	2.5	2.3	1.5	1.4	1.3	1.1	1.0	0.7	0.6
C1475	pipe	31.41	31.09	1.05		0.014	0.015	2.84	2.37	>100yr	2.4	2.0	1.1	1.0	0.9	0.7	0.6	0.5	0.4
C1476	pipe	34.41	32.81	0.9		0.028	0.015	2.63	1.88	>100yr	1.9	1.8	1.1	1.1	1.0	0.9	0.8	0.6	0.5
C1477	pipe	33.48	31.62	0.9		0.039	0.015	3.11	1.10	>100yr	1.1	0.5	0.1	0.1	0.1	0.1	0.1	0.1	0.1
C1478	pipe	34.95	34.41	0.9		0.033	0.015	2.86	1.80	>100yr	1.8	1.8	1.1	1.1	1.0	0.9	0.8	0.6	0.5
C1479	pipe	35.32	34.95	0.9		0.081	0.015	4.47	0.70	>100yr	0.7	0.7	0.5	0.5	0.5	0.5	0.5	0.4	0.4
C1480	pipe	36.08	34.03	0.6		0.047	0.015	1.16	0.73	>100yr	0.7	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1
C1490	pipe	43.01	41.40	0.75		0.038	0.015	1.87	1.22	>100yr	1.2	1.2	1.2	1.2	1.2	1.2	1.2	0.8	0.7
C1491	pipe	43.24	43.01	0.75		0.022	0.015	1.43	1.60	>100yr	1.6	1.6	1.4	1.4	1.4	1.3	1.2	0.8	0.7
C1492	pipe	44.34	43.24	0.75		0.028	0.015	1.60	1.60	>100yr	1.6	1.6	1.5	1.5	1.5	1.4	1.2	0.8	0.7
C1493	pipe	45.29	44.34	0.75		0.024	0.015	1.49	1.60	>10yr	1.6	1.6	1.5	1.5	1.5	1.4	1.2	0.8	0.7
C1494	pipe	47.20	45.29	0.75		0.033	0.015	1.76	1.60	>100yr	1.6	1.6	1.5	1.5	1.5	1.4	1.2	0.8	0.7
C1495	pipe	47.76	47.20	0.75		0.022	0.015	1.43	1.60	>10yr	1.6	1.6	1.5	1.5	1.5	1.4	1.2	0.8	0.7
C1496	pipe	41.40	39.85	0.6		0.040	0.015	1.06	1.40	>2yr	1.4	1.4	1.2	1.2	1.2	1.2	1.2	0.8	0.7
C1497	pipe	39.05	37.52	0.6		0.118	0.015	1.82	1.10	>100yr	1.1	1.1	0.9	0.9	0.9	0.9	0.9	0.8	0.7
C1498	pipe	37.40	36.77	0.375		0.012	0.015	0.16	0.40	<1yr	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.3
C1499	pipe	36.69	36.03	0.375		0.022	0.015	0.22	0.43	<1yr	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
C1500	pipe	36.03	35.32	0.6		0.023	0.015	0.81	0.70	>100yr	0.7	0.7	0.5	0.5	0.5	0.5	0.5	0.4	0.4

Pipe/Culvert ID	Type	US INVERT	DS INVERT	Diameter/ Width	Height	SLOPE	Mannings (n)	Nominal Capacity*	Max Modelled Flow	Nominal Return Period^	Modelled Flows (m^3/s) PMF	200yr ARI	100yr ARI	50yr ARI	20yr ARI	10yr ARI	5yrARI	2yr ARI	1yrARI
		m AHD	m AHD	m	m	m/m		(m^3/s)	m3/s	ARI									
C1509	pipe	43.22	43.02	0.75		0.024	0.015	1.49	0.50	>100yr	0.5	0.5	0.3	0.3	0.3	0.2	0.2	0.2	0.2
C1511	pipe	43.27	43.22	0.75		0.008	0.015	0.89	0.40	>100yr	0.4	0.4	0.2	0.2	0.2	0.1	0.1	0.1	0.1
C1512	pipe	43.02	34.17	0.75		0.041	0.015	1.95	0.70	>100yr	0.7	0.7	0.4	0.4	0.3	0.2	0.2	0.2	0.2
C1527	pipe	34.17	33.73	0.9		0.027	0.015	2.56	2.00	>100yr	2.0	2.0	1.4	1.3	1.2	1.1	1.0	0.9	0.8
C1528	pipe	33.73	33.32	0.9		0.025	0.015	2.50	2.00	>100yr	2.0	2.0	1.4	1.3	1.2	1.1	1.0	0.9	0.8
C1529	pipe	33.32	32.75	0.9		0.026	0.015	2.53	2.00	>100yr	2.0	2.0	1.4	1.3	1.2	1.1	1.0	0.9	0.7
C1535	pipe	31.18	30.83	1.05		0.021	0.015	3.41	2.29	>100yr	2.3	1.8	1.2	1.1	0.9	0.7	0.6	0.5	0.4
C1536	pipe	31.18	31.09	0.6		0.009	0.015	0.52	0.10	>100yr	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
C1537	pipe	30.93	29.63	1.05		0.026	0.015	3.81	3.51	>100yr	3.5	2.2	1.5	1.3	1.1	0.9	0.7	0.5	0.4
C1538	pipe	30.83	29.94	0.9		0.015	0.015	1.91	2.52	>100yr	2.5	2.1	1.4	1.3	1.1	0.9	0.8	0.7	0.5
C1539	pipe	48.13	47.76	0.75		0.128	0.015	3.45	1.60	>100yr	1.6	1.6	1.5	1.5	1.5	1.4	1.2	0.8	0.7
C1540	pipe	48.25	48.13	0.75		0.014	0.015	1.14	1.13	>100yr	1.1	1.1	1.1	1.1	1.1	1.0	0.8	0.6	0.5
C1541	pipe	48.95	48.30	0.75		0.034	0.015	1.78	0.86	>100yr	0.9	0.8	0.8	0.8	0.7	0.6	0.4	0.3	0.2
C1566	pipe	38.82	37.95	0.6		0.020	0.015	0.76	0.40	>100yr	0.4	0.4	0.3	0.3	0.3	0.2	0.2	0.2	0.1
C1567	pipe	37.95	36.08	0.6		0.022	0.015	0.79	0.66	>100yr	0.7	0.6	0.4	0.4	0.4	0.3	0.3	0.2	0.2
C1572	pipe	36.08	35.50	0.6		0.040	0.015	1.07	0.86	>100yr	0.9	0.8	0.6	0.6	0.6	0.5	0.5	0.4	0.3
C1573	pipe	35.50	34.18	0.75		0.033	0.015	1.74	1.17	>100yr	1.2	1.0	0.7	0.7	0.7	0.6	0.5	0.4	0.4
C1581	pipe	32.05	30.93	0.9		0.023	0.015	2.37	2.63	>100yr	2.6	2.2	1.8	1.7	1.4	1.2	1.1	0.9	0.7
C1582	pipe	30.87	30.33	1.05		0.030	0.015	4.09	2.28	>100yr	2.3	2.1	1.9	1.8	1.5	1.3	1.2	1.0	0.8
C1583	pipe	30.33	29.47	1.05		0.016	0.015	2.96	3.81	>10yr	3.8	3.5	3.4	3.4	3.2	2.8	2.3	1.7	1.2
C1584	pipe	30.96	30.86	0.75		0.006	0.015	0.72	0.93	>10yr	0.9	0.8	0.8	0.8	0.8	0.7	0.6	0.3	0.2
C1585	pipe	30.96	30.86	0.75		0.006	0.015	0.72	0.93	>10yr	0.9	0.8	0.8	0.8	0.8	0.7	0.6	0.3	0.2
C1587	pipe	32.75	32.41	0.9		0.025	0.015	2.49	2.00	>100yr	2.0	2.0	1.4	1.3	1.2	1.1	1.0	0.9	0.7
C1588	pipe	32.41	32.17	0.9		0.022	0.015	2.35	2.21	>100yr	2.2	2.1	1.5	1.3	1.2	1.1	1.0	0.9	0.7
C1590	pipe	32.45	32.34	0.75		0.002	0.015	0.39	0.92	>2yr	0.9	0.8	0.8	0.8	0.8	0.7	0.6	0.3	0.2
C1591	pipe	32.45	32.44	0.75		0.002	0.015	0.42	0.80	>2yr	0.8	0.8	0.8	0.8	0.8	0.7	0.6	0.3	0.2
C1592	pipe	32.34	32.21	0.75		0.003	0.015	0.50	0.93	>2yr	0.9	0.8	0.8	0.8	0.8	0.7	0.6	0.3	0.2
C1593	pipe	32.34	32.21	0.75		0.003	0.015	0.50	0.93	>2yr	0.9	0.8	0.8	0.8	0.8	0.7	0.6	0.3	0.2
C1594	pipe	32.21	31.95	0.75		0.020	0.015	1.36	0.93	>100yr	0.9	0.8	0.8	0.8	0.8	0.7	0.6	0.3	0.2
C1595	pipe	32.21	31.95	0.75		0.020	0.015	1.36	0.93	>100yr	0.9	0.8	0.8	0.8	0.8	0.7	0.6	0.3	0.2
C1596	pipe	31.95	31.07	0.75		0.029	0.015	1.64	0.93	>100yr	0.9	0.8	0.8	0.8	0.8	0.7	0.6	0.3	0.2
C1597	pipe	31.95	31.07	0.75		0.029	0.015	1.64	0.93	>100yr	0.9	0.8	0.8	0.8	0.8	0.7	0.6	0.3	0.2
C1598	pipe	31.07	30.96	0.75		0.004	0.015	0.63	0.93	>5yr	0.9	0.8	0.8	0.8	0.8	0.7	0.6	0.3	0.2
C1599	pipe	31.07	30.96	0.75		0.004	0.015	0.63	0.93	>5yr	0.9	0.8	0.8	0.8	0.8	0.7	0.6	0.3	0.2
C1601	pipe	33.18	33.07	0.75		0.020	0.015	1.36	1.22	>100yr	1.2	1.1	0.9	0.9	0.8	0.7	0.6	0.5	0.4
C1602	pipe	33.01	32.39	0.75		0.035	0.015	1.80	1.77	>100yr	1.8	1.5	1.2	1.1	1.0	0.9	0.7	0.6	0.4
C1603	pipe	34.18	33.18	0.75		0.045	0.015	2.05	1.16	>100yr	1.2	1.0	0.7	0.7	0.7	0.6	0.5	0.4	0.4
C1604	pipe	35.18	33.07	0.6		0.028	0.015	0.89	0.27	>100yr	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
C1615	pipe	31.21	30.96	0.9		0.021	0.015	2.25	2.10	>100yr	2.1	1.9	1.4	1.2	1.1	1.0	0.8	0.6	0.5
C1616	pipe	32.39	31.70	0.75		0.021	0.015	1.39	1.77	>100yr	1.8	1.5	1.2	1.1	1.0	0.9	0.7	0.6	0.4
C1618	pipe	30.96	30.55	0.9		0.007	0.015	1.33	2.17	>50yr	2.2	2.0	1.4	1.2	1.1	1.0	0.8	0.6	0.5
C1619	pipe	30.55	30.33	0.9		0.012	0.015	1.73	2.17	>100yr	2.2	2.0	1.4	1.2	1.1	1.0	0.8	0.6	0.5
C1620	pipe	30.33	30.27	0.9		0.014	0.015	1.86	2.17	>100yr	2.2	2.0	1.4	1.3	1.1	1.0	0.8	0.6	0.5
C1622	pipe	30.19	29.93	0.9		0.014	0.015	1.83	2.12	>100yr	2.1	2.0	1.4	1.3	1.1	1.0	0.8	0.6	0.5
C1629	pipe	29.93	29.43	1.05		0.014	0.015	2.75	2.12	>100yr	2.1	2.0	1.4	1.3	1.1	1.0	0.8	0.6	0.5
C1630	pipe	29.47	29.31	1.05		0.020	0.015	3.37	3.55	>20yr	3.6	3.5	3.4	3.4	3.2	2.8	2.3	1.7	1.2
C1631	pipe	29.31	28.84	1.05		0.017	0.015	3.09	3.57	>10yr	3.6	3.5	3.5	3.4	3.3	2.9	2.5	1.7	1.2
C1654	pipe	25.22	24.03	0.6		0.018	0.015	0.71	0.64	>100yr	0.6	0.5	0.3	0.3	0.3	0.3	0.2	0.2	0.1
C1655	pipe	23.89	23.02	0.6		0.012	0.015	0.59	0.62	>100yr	0.6	0.5	0.3	0.3	0.3	0.3	0.2	0.2	0.1
C1656	pipe	22.98	21.54	0.6		0.029	0.015	0.91	0.50	>100yr	0.5	0.5	0.3	0.3	0.3	0.3	0.1	0.1	0.1
C1657	pipe	21.54	21.24	1.05		0.010	0.015	2.36	1.38	>100yr	1.4	1.0	1.0	1.0	1.0	1.0	0.9	0.9	0.8
C1660	pipe	21.24	21.14	1.05		0.010	0.015	2.35	1.29	>100yr	1.3	1.2	1.0	1.0	1.0	1.0	0.9	0.8	0.8
C1661	pipe	23.10	23.07	0.375		0.001	0.015	0.06	0.10	<1yr	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

Pipe/Culvert ID	Type	US INVERT	DS INVERT	Diameter/ Width	Height	SLOPE	Mannings (n)	Nominal Capacity*	Max Modelled Flow	Nominal Return Period^	Modelled Flows (m^3/s) PMF	200yr ARI	100yr ARI	50yr ARI	20yr ARI	10yr ARI	5yrARI	2yr ARI	1yrARI
		m AHD	m AHD	m	m	m/m		(m^3/s)	m3/s	ARI									
C1662	pipe	23.34	23.10	0.375		0.010	0.015	0.15	0.04	>100yr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C1663	pipe	23.07	23.00	0.45		0.003	0.015	0.14	0.10	>100yr	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
C1664	pipe	23.35	23.24	0.375		0.004	0.015	0.10	0.06	>100yr	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C1665	pipe	22.97	22.93	0.45		0.003	0.015	0.14	0.16	>100yr	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
C1666	pipe	23.23	23.06	0.375		0.040	0.015	0.30	0.10	>100yr	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
C1667	pipe	22.93	22.90	0.45		0.001	0.015	0.08	0.19	<1yr	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
C1668	pipe	22.82	22.81	0.525		0.000	0.015	0.07	0.24	<1yr	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
C1669	pipe	23.55	23.44	0.375		0.005	0.015	0.10	0.06	>100yr	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C1670	pipe	22.77	22.66	0.525		0.003	0.015	0.20	0.33	<1yr	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
C1671	pipe	22.63	22.57	0.6		0.003	0.015	0.27	0.49	<1yr	0.5	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
C1675	pipe	22.54	22.05	0.6		0.049	0.015	1.18	0.58	>100yr	0.6	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4
C1677	pipe	21.14	21.04	1.05		0.009	0.015	2.26	1.29	>100yr	1.3	1.2	1.0	1.0	1.0	1.0	0.9	0.8	0.8
C1685	pipe	33.45	33.42	0.45		0.002	0.015	0.12	0.30	<1yr	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2
C1686	pipe	33.61	32.87	0.45		0.054	0.015	0.58	0.41	>100yr	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.2	0.2
C1687	pipe	33.42	32.62	0.45		0.044	0.015	0.52	0.41	>100yr	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.2	0.2
C1691	pipe	35.40	34.07	0.375		0.022	0.015	0.23	0.34	<1yr	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
C1696	pipe	27.20	26.91	1.05		0.023	0.015	3.61	2.49	>100yr	2.5	1.6	1.0	0.8	0.6	0.4	0.4	0.2	0.1
C1697	pipe	26.91	26.47	1.05		0.010	0.015	2.37	2.74	>100yr	2.7	1.9	1.2	0.9	0.7	0.5	0.5	0.3	0.3
C1698	pipe	28.81	27.20	1.05		0.023	0.015	3.59	2.50	>100yr	2.5	1.6	1.0	0.8	0.6	0.4	0.4	0.2	0.1
C1710	pipe	29.94	28.81	1.05		0.043	0.015	4.90	2.48	>100yr	2.5	1.4	0.7	0.6	0.5	0.3	0.2	0.1	0.1
C1711	pipe	29.41	25.88	1.2		0.021	0.015	4.87	3.59	>100yr	3.6	3.0	2.2	2.0	1.8	1.5	1.3	1.1	0.9
C1712	pipe	26.32	24.15	1.05		0.029	0.015	4.00	3.20	>100yr	3.2	2.5	1.7	1.0	0.8	0.6	0.5	0.3	0.2
C1713	pipe	25.88	24.15	1.05		0.022	0.015	3.53	3.17	>100yr	3.2	2.5	2.0	2.0	1.7	1.5	1.4	1.2	0.9
C1714	pipe	24.91	24.15	1.5		0.016	0.015	7.72	5.43	>100yr	5.4	5.4	5.3	5.1	5.0	4.6	4.0	2.9	2.2
C1715	pipe	24.15	22.50	1.5		0.020	0.015	8.70	5.34	>100yr	5.3	4.9	4.4	4.1	3.7	3.4	2.9	2.2	1.7
C1716	pipe	24.15	22.18	1.5		0.014	0.015	7.19	5.24	>100yr	5.2	4.7	4.3	4.0	3.7	3.4	2.9	2.2	1.7
C1717	pipe	26.05	24.91	1.35		0.023	0.015	6.99	5.40	>100yr	5.4	5.4	5.3	5.1	5.0	4.6	4.0	2.9	2.2
C1724	pipe	28.84	28.64	1.05		0.018	0.015	3.18	3.57	>10yr	3.6	3.5	3.5	3.4	3.3	2.9	2.4	1.7	1.2
C1725	pipe	29.32	28.70	1.05		0.022	0.015	3.52	2.10	>100yr	2.1	2.1	1.4	1.3	1.2	1.0	0.8	0.6	0.5
C1726	pipe	28.64	27.84	1.2		0.019	0.015	4.62	2.72	>100yr	2.7	2.7	2.6	2.5	2.4	2.0	1.7	1.2	1.0
C1729	pipe	20.59	19.69	1.5		0.039	0.015	12.17	9.85	>100yr	9.8	8.8	8.3	7.7	7.1	6.6	5.9	4.5	3.3
C1730	pipe	22.10	21.58	1.5		0.015	0.015	7.61	10.41	>20yr	10.4	8.8	8.3	7.7	7.3	6.6	5.9	4.5	3.3
C1731	pipe	22.50	22.18	1.5		0.005	0.015	4.51	5.18	>100yr	5.2	4.6	4.3	3.9	3.7	3.3	2.9	2.2	1.7
C1732	pipe	22.26	22.18	0.825		0.005	0.015	0.85	0.20	>100yr	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1
C1735	pipe	22.99	22.36	0.75		0.016	0.015	1.21	0.35	>100yr	0.4	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1
C1737	pipe	22.36	21.75	0.75		0.019	0.015	1.34	0.59	>100yr	0.6	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1
C1738	pipe	21.75	21.51	0.75		0.014	0.015	1.12	0.44	>100yr	0.4	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1
C1739	pipe	21.51	21.15	0.75		0.032	0.015	1.73	0.36	>100yr	0.4	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1
C1740	pipe	21.15	20.96	0.75		0.014	0.015	1.14	0.36	>100yr	0.4	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1
C1741	pipe	20.96	20.57	0.825		0.010	0.015	1.25	0.36	>100yr	0.4	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1
C1742	pipe	21.04	19.22	1.05		0.011	0.015	2.50	1.59	>100yr	1.6	1.3	1.2	1.1	1.1	1.1	1.0	1.0	0.9
C1743	pipe	26.78	26.05	1.35		0.009	0.015	4.49	5.36	>5yr	5.4	5.3	5.1	5.0	4.8	4.5	3.9	2.9	2.1
C1744	pipe	24.99	24.61	0.6		0.028	0.015	0.90	0.14	>100yr	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C1745	pipe	24.61	22.99	0.75		0.027	0.015	1.59	0.14	>100yr	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C1748	pipe	28.71	28.08	0.9		0.026	0.015	2.54	2.10	>100yr	2.1	2.0	2.0	2.0	2.0	2.0	2.0	1.9	1.6
C1749	pipe	30.19	28.71	0.9		0.032	0.015	2.79	2.08	>100yr	2.1	2.0	2.0	2.0	2.0	2.0	2.0	1.9	1.6
C1750	pipe	28.08	26.36	0.9		0.050	0.015	3.52	2.10	>100yr	2.1	2.1	2.0	2.0	2.0	2.0	2.0	1.9	1.6
C1756	pipe	25.91	25.59	0.9		0.016	0.015	1.97	2.09	>2yr	2.1	2.0	2.0	2.0	2.0	2.0	2.0	1.9	1.6
C1757	pipe	25.59	25.39	0.9		0.010	0.015	1.53	2.09	<1yr	2.1	2.0	2.0	2.0	2.0	2.0	2.0	1.9	1.6
C1758	pipe	24.83	24.49	0.9		0.011	0.015	1.63	2.17	>1yr	2.2	2.0	2.0	2.0	2.0	2.0	2.0	1.9	1.6
C1759	pipe	26.36	25.91	0.9		0.022	0.015	2.30	2.09	>100yr	2.1	2.0	2.0	2.0	2.0	2.0	2.0	1.9	1.6
C1762	pipe	39.72	37.80	0.675		0.042	0.015	1.50	1.25	>100yr	1.3	1.2	1.1	1.1	1.1	1.1	1.1	1.0	0.7
C1763	pipe	41.89	41.52	0.45		0.168	0.015	1.01	0.14	>100yr	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

Pipe/Culvert ID	Type	US INVERT	DS INVERT	Diameter/ Width	Height	SLOPE	Mannings (n)	Nominal Capacity*	Max Modelled Flow	Nominal Return Period^	Modelled Flows (m^3/s) PMF	200yr ARI	100yr ARI	50yr ARI	20yr ARI	10yr ARI	5yrARI	2yr ARI	1yrARI
		m AHD	m AHD	m	m	m/m		(m^3/s)	m3/s	ARI									
C1764	pipe	41.52	41.30	0.675		0.019	0.015	1.00	1.10	>2yr	1.1	1.1	1.1	1.1	1.1	1.0	1.0	0.9	0.7
C1765	pipe	41.30	41.05	0.675		0.057	0.015	1.74	1.25	>100yr	1.3	1.2	1.1	1.1	1.1	1.1	1.1	1.0	0.7
C1766	pipe	41.05	39.72	0.675		0.050	0.015	1.63	1.25	>100yr	1.3	1.2	1.1	1.1	1.1	1.1	1.1	1.0	0.7
C1767	pipe	42.12	41.52	0.75		0.018	0.015	1.30	1.13	>100yr	1.1	1.1	1.1	1.1	1.1	1.0	1.0	0.8	0.6
C1768	pipe	42.56	42.12	0.75		0.035	0.015	1.81	1.23	>100yr	1.2	1.1	1.1	1.1	1.0	1.0	0.9	0.8	0.6
C1769	pipe	43.20	42.56	0.75		0.050	0.015	2.16	1.27	>100yr	1.3	1.1	1.1	1.1	1.0	1.0	0.9	0.8	0.6
C1771	pipe	44.11	43.31	0.6		0.019	0.015	0.74	1.27	>1yr	1.3	1.1	1.1	1.1	1.0	1.0	0.9	0.8	0.6
C1772	pipe	44.56	44.11	0.675		0.036	0.015	1.38	1.27	>100yr	1.3	1.1	1.1	1.1	1.0	1.0	0.9	0.8	0.6
C1774	pipe	45.33	44.56	0.675		0.024	0.015	1.13	0.90	>100yr	0.9	0.9	0.9	0.8	0.8	0.7	0.7	0.6	0.4
C1776	pipe	45.81	45.39	0.6		0.016	0.015	0.67	0.90	>5yr	0.9	0.9	0.8	0.8	0.7	0.7	0.6	0.6	0.4
C1777	pipe	45.93	45.81	0.6		0.028	0.015	0.89	0.68	>100yr	0.7	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.3
C1784	pipe	31.53	31.14	0.6		0.071	0.015	1.41	0.20	>100yr	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0
C1785	pipe	31.14	31.03	0.6		0.007	0.015	0.44	0.20	>100yr	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0
C1792	pipe	27.84	26.78	1.35		0.015	0.015	5.66	5.45	>100yr	5.5	5.3	5.1	5.0	4.7	4.1	3.5	2.5	1.9
C1793	pipe	28.64	28.00	1.2		0.018	0.015	4.52	2.70	>100yr	2.7	2.7	2.5	2.4	2.3	2.0	1.7	1.2	0.9
C1795	pipe	50.61	49.63	0.6		0.042	0.015	1.10	0.70	>100yr	0.7	0.7	0.5	0.4	0.4	0.4	0.3	0.3	0.2
C1796	pipe	49.75	49.30	0.6		0.036	0.015	1.01	0.70	>100yr	0.7	0.7	0.4	0.3	0.3	0.3	0.2	0.2	0.1
C1798	pipe	49.60	47.64	0.525		0.029	0.015	0.64	0.70	>100yr	0.7	0.7	0.5	0.4	0.4	0.4	0.3	0.3	0.2
C1799	pipe	47.61	47.09	0.525		0.031	0.015	0.65	0.73	>100yr	0.7	0.7	0.5	0.4	0.4	0.4	0.3	0.3	0.2
C1800	pipe	47.10	44.44	0.525		0.034	0.015	0.68	0.73	>100yr	0.7	0.7	0.5	0.4	0.4	0.4	0.3	0.3	0.2
C1802	pipe	44.44	44.29	0.525		0.019	0.015	0.51	0.40	>100yr	0.4	0.4	0.3	0.3	0.3	0.2	0.2	0.2	0.1
C7501	pipe	41.22	40.96	0.675		0.011	0.015	0.75	1.05	>20yr	1.1	0.9	0.8	0.8	0.7	0.6	0.6	0.4	0.3
C7504	pipe	27.85	27.44	1.2		0.003	0.015	1.79	2.85	<1yr	2.9	2.6	2.5	2.3	2.3	2.2	2.2	2.1	2.0
C7507	pipe	23.31	23.27	1.05		0.003	0.015	1.35	0.20	>100yr	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1
C7508	pipe	51.87	51.79	0.6		0.037	0.015	1.02	0.51	>100yr	0.5	0.4	0.3	0.3	0.3	0.2	0.2	0.1	0.1
C7509	pipe	51.79	49.89	0.6		0.037	0.015	1.03	0.56	>100yr	0.6	0.5	0.3	0.3	0.3	0.2	0.2	0.1	0.1
C7510	pipe	49.89	49.75	0.6		0.037	0.015	1.03	0.58	>100yr	0.6	0.5	0.3	0.3	0.3	0.3	0.2	0.1	0.1
C7511	pipe	49.30	49.11	0.6		0.037	0.015	1.03	0.70	>100yr	0.7	0.7	0.5	0.4	0.4	0.4	0.3	0.3	0.2
C7512	pipe	24.26	24.12	0.6		0.004	0.015	0.32	0.21	>100yr	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1
C7513	pipe	23.14	22.97	0.9		0.004	0.015	0.96	0.90	>100yr	0.9	0.9	0.8	0.8	0.8	0.8	0.8	0.8	0.8
C7514	pipe	22.97	22.79	0.9		0.004	0.015	0.97	0.90	>100yr	0.9	0.9	0.8	0.8	0.8	0.8	0.8	0.8	0.8
C7516	pipe	30.52	30.35	0.9		0.022	0.015	2.35	1.61	>100yr	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.2
C7517	pipe	30.35	29.79	0.9		0.022	0.015	2.33	1.88	>100yr	1.9	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.4
C7518	pipe	30.76	30.35	0.6		0.019	0.015	0.73	0.30	>100yr	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2
C7522	pipe	40.32	40.26	1.05		0.015	0.015	2.94	2.41	>100yr	2.4	2.2	1.9	1.8	1.6	1.4	1.2	0.9	0.7
C7524	pipe	38.59	38.03	0.9		0.040	0.015	3.13	1.75	>100yr	1.8	1.4	1.3	1.3	1.2	1.2	1.1	0.9	0.7
C7525	pipe	33.07	33.01	0.75		0.024	0.015	1.48	1.41	>100yr	1.4	1.1	1.0	0.9	0.8	0.7	0.6	0.5	0.4
C7527	pipe	31.25	31.21	0.9		0.019	0.015	2.15	1.74	>100yr	1.7	1.5	1.2	1.1	1.0	0.9	0.8	0.6	0.4
C7528	pipe	30.27	30.19	0.9		0.014	0.015	1.83	2.13	>100yr	2.1	2.0	1.4	1.3	1.2	1.0	0.8	0.6	0.5
C7529	pipe	29.43	29.32	1.05		0.012	0.015	2.64	2.10	>100yr	2.1	2.1	1.4	1.3	1.2	1.0	0.8	0.6	0.5
C7531	pipe	32.17	32.05	0.9		0.024	0.015	2.41	2.63	>100yr	2.6	2.2	1.8	1.7	1.4	1.2	1.1	0.9	0.7
C7532	pipe	32.44	32.34	0.75		0.002	0.015	0.39	0.95	>2yr	0.9	0.8	0.8	0.8	0.8	0.7	0.6	0.3	0.2
C7533	pipe	28.00	27.84	1.2		0.018	0.015	4.50	2.80	>100yr	2.8	2.8	2.5	2.5	2.4	2.1	1.8	1.3	0.9
C7535	pipe	32.81	32.19	0.9		0.035	0.015	2.92	2.19	>100yr	2.2	2.1	1.2	1.2	1.1	1.0	0.9	0.6	0.5
C7536	pipe	31.57	31.41	1.05		0.018	0.015	3.21	2.22	>100yr	2.2	1.8	1.0	0.9	0.8	0.7	0.5	0.4	0.3
C7537	pipe	29.63	29.41	1.05		0.024	0.015	3.69	3.48	>100yr	3.5	2.2	1.5	1.3	1.1	0.9	0.8	0.6	0.4
C7538	pipe	30.12	30.11	0.375		0.009	0.015	0.14	0.10	>100yr	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0
C7539	pipe	32.87	31.56	0.45		0.040	0.015	0.49	0.50	>100yr	0.5	0.5	0.3	0.3	0.3	0.3	0.3	0.2	0.2
C7541	pipe	22.07	22.01	1.65		0.004	0.015	4.88	4.37	>100yr	4.4	3.5	3.1	3.1	3.0	3.0	2.9	2.3	1.8
C7542	pipe	22.01	21.99	1.65		0.007	0.015	6.44	4.30	>100yr	4.3	3.4	3.0	3.0	3.0	3.0	2.9	2.4	1.9
C7543	pipe	21.50	21.42	1.65		0.008	0.015	7.10	4.27	>100yr	4.3	3.5	3.1	3.1	3.0	3.0	2.9	2.4	1.9
C7544	pipe	22.07	22.01	1.65		0.003	0.015	4.55	4.46	>100yr	4.5	3.4	3.0	3.0	3.0	3.0	3.0	2.5	2.0
C7545	pipe	22.49	22.07	0.6		0.018	0.015	0.71	0.35	>100yr	0.4	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Pipe/Culvert ID	Type	US INVERT	DS INVERT	Diameter/ Width	Height	SLOPE	Mannings (n)	Nominal Capacity*	Max Modelled Flow	Nominal Return Period^	Modelled Flows (m^3/s) PMF	200yr ARI	100yr ARI	50yr ARI	20yr ARI	10yr ARI	5yrARI	2yr ARI	1yrARI
		m AHD	m AHD	m	m	m/m		(m^3/s)	m3/s	ARI									
C7546	pipe	20.50	20.48	1.05		0.003	0.015	1.35	0.63	>100yr	0.6	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3
C7549	pipe	36.02	35.78	1.2		0.008	0.015	2.94	4.33	>10yr	4.3	3.5	3.3	3.2	3.0	2.8	2.5	1.8	1.4
C7559	pipe	31.32	31.18	0.6		0.016	0.015	0.67	0.86	>100yr	0.9	0.3	0.2	0.2	0.1	0.1	0.1	0.1	0.0
C7574	pipe	21.58	20.67	1.5		0.018	0.015	8.16	9.98	>50yr	10.0	8.8	8.3	7.7	7.2	6.6	5.9	4.5	3.3
C1050	Culvert	28.12	27.51	0.9	0.6	0.020	0.015	1.62	1.50	>100yr	1.5	1.5	0.8	0.8	0.8	0.8	0.7	0.7	0.5
C1065	Culvert	27.82	27.51	0.9	0.6	0.033	0.015	2.09	1.50	>100yr	1.5	1.5	0.8	0.7	0.7	0.7	0.6	0.6	0.5
C1067	Culvert	28.29	28.12	0.9	0.6	0.018	0.015	1.54	1.76	>100yr	1.8	1.5	0.7	0.7	0.7	0.7	0.6	0.6	0.5
C1078	Culvert	27.63	27.58	0.6	0.6	0.050	0.015	1.51	0.21	>100yr	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1
C1122	Culvert	27.65	27.53	0.75	0.3	0.011	0.015	0.35	0.20	>100yr	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1
C1123	Culvert	27.67	27.65	0.75	0.3	0.004	0.015	0.20	0.10	>100yr	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
C1131	Culvert	25.60	25.56	0.6	0.3	0.004	0.015	0.16	0.13	>100yr	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
C1139	Culvert	24.60	24.55	0.9	0.3	0.005	0.015	0.29	0.10	>100yr	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
C1140	Culvert	24.55	24.41	0.9	0.3	0.007	0.015	0.35	0.10	>100yr	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
C1193	Culvert	25.24	25.17	0.6	0.3	0.004	0.015	0.16	0.08	>100yr	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C1213	Culvert	21.55	21.52	1.2	1.5	0.003	0.015	3.36	2.13	>100yr	2.1	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.5
C1217	Culvert	21.34	20.46	3.8	1.8	0.004	0.015	21.48	11.06	>100yr	11.1	7.2	6.1	6.0	5.8	5.5	5.3	4.3	3.6
C1218	Culvert	24.69	24.67	0.36	0.3	0.002	0.015	0.06	0.03	>100yr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C1315	Culvert	26.72	26.53	2.6	1.5	0.010	0.015	78.10	72.47	>100yr	72.5	15.7	7.6	6.2	1.5	1.3	1.1	0.8	0.6
C1322	Culvert	27.60	27.50	1.5	0.87	0.004	0.015	2.39	3.90	<1yr	3.9	3.8	3.6	3.6	3.6	3.6	3.6	3.6	3.6
C1426	Culvert	45.03	44.92	2.7	1.5	0.006	0.015	13.23	0.93	>100yr	0.9	0.6	0.5	0.5	0.5	0.5	0.4	0.2	0.1
C1427	Culvert	44.92	44.80	2.7	1.5	0.007	0.015	13.84	0.94	>100yr	0.9	0.6	0.5	0.5	0.5	0.5	0.4	0.2	0.1
C1428	Culvert	44.80	44.72	2.7	1.5	0.005	0.015	11.30	0.96	>100yr	1.0	0.5	0.5	0.4	0.4	0.4	0.4	0.2	0.1
C1429	Culvert	44.72	44.63	2.7	1.5	0.021	0.015	24.07	0.97	>100yr	1.0	0.6	0.5	0.4	0.4	0.4	0.3	0.2	0.1
C1437	Culvert	41.70	41.50	1.2	0.45	0.019	0.015	1.47	1.03	>100yr	1.0	0.6	0.5	0.5	0.5	0.5	0.5	0.2	0.1
C1439	Culvert	41.50	41.01	1.2	0.45	0.037	0.015	2.06	0.75	>100yr	0.7	0.5	0.5	0.5	0.5	0.5	0.5	0.2	0.1
C1751	Culvert	19.76	19.75	3.5	3.7	0.000	0.015	13.21	44.90	<1yr	44.9	44.3	44.3	44.3	44.3	43.8	43	42.9	40.4
C1752	Culvert	19.76	19.75	3.5	3.7	0.000	0.015	12.91	38.60	<1yr	38.6	38.5	38.5	38.5	38.4	38.4	38.4	38.2	38.2
C1753	Culvert	19.76	19.75	3.5	3.7	0.000	0.015	12.29	38.30	<1yr	38.3	38	38	37.9	37.9	37.9	37.7	37.7	37.5
C1754	Culvert	19.76	19.75	3.5	3.7	0.000	0.015	12.79	43.90	<1yr	43.9	43.9	43.9	43.9	43.9	43.4	43.1	42.8	42.8
C1755	Culvert	19.92	19.75	3.5	3.7	0.004	0.015	47.68	29.90	>100yr	29.9	22.3	22.3	22.3	20.3	16.4	15	14	13.4
C1770	Culvert	42.80	42.56	0.75	0.3	0.016	0.015	0.42	0.10	>100yr	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0
C7505	Culvert	27.50	27.43	1.5	0.87	0.005	0.015	2.52	3.84	<1yr	3.8	3.8	3.6	3.6	3.6	3.6	3.6	3.6	3.6
C7506	Culvert	26.76	26.72	2.6	1.5	0.010	0.015	79.50	72.72	>100yr	72.7	15.7	7.6	6.2	1.5	1.3	1.1	0.8	0.6
C7540	Culvert	28.29	28.13	0.9	0.6	0.019	0.015	1.57	1.52	>100yr	1.5	1.4	0.6	0.6	0.6	0.6	0.6	0.6	0.5
C7547_1	Culvert	21.70	21.67	1.2	1.5	0.011	0.015	6.17	0.34	>100yr	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2
C7547_2	Culvert	21.67	21.66	1.2	1.5	0.008	0.015	5.06	0.55	>100yr	0.6	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2
C7547_3	Culvert	21.66	21.63	1.2	1.5	0.011	0.015	5.92	0.78	>100yr	0.8	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2
C7547_4	Culvert	21.63	21.62	1.2	1.5	0.006	0.015	4.65	1.02	>100yr	1.0	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
C7547_5	Culvert	21.62	21.59	1.2	1.5	0.011	0.015	5.92	1.27	>100yr	1.3	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3
C7547_6	Culvert	21.59	21.58	1.2	1.5	0.007	0.015	4.71	1.54	>100yr	1.5	0.5	0.5	0.5	0.5	0.4	0.4	0.4	0.4
C7547_7	Culvert	21.58	21.55	1.2	1.5	0.010	0.015	5.87	1.83	>100yr	1.8	0.6	0.6	0.6	0.6	0.5	0.5	0.5	0.4
C7552	Culvert	28.29	27.82	0.9	0.6	0.021	0.015	1.67	1.59	>100yr	1.6	1.5	0.7	0.7	0.7	0.7	0.7	0.6	0.5

Notes
* Nominal Capacity calculated based on Mannings Equation.
# calculated by comparing the max flow from the model with the nominal capacity. Where the maximum flow from the model is less than the nominal capacity, the pipe is potential limited by the inlet pits upstream
^ Determined through comparison of the modelled flow in each ARI event with the nominal capacity
Note that the nominal capacity calculation does not account for restrictions downstream. For example, where a pipe downstream is under capacity and therefore limits the capacity of a pipe upstream
In general, pipes greater than 600mm in diameter have been included in the analysis.

Appendix I

Channel Peak Flows

APPENDIX I

Channel Flows

		Modelled Flows (m^3/s)								
Channel ID	**Type**	**PMF**	**200yr ARI**	**100yr ARI**	**50yr ARI**	**20yr ARI**	**10yr ARI**	**5yrARI**	**2yr ARI**	**1yrARI**
CX12	Open Channel	12.8	4.8	4.3	2.1	0.2	0.2	0.2	0.1	0.1
CX13	Open Channel	55.6	13.5	11.9	2.7	0.8	0.7	0.5	0.3	0.2
CX14	Open Channel	105.6	15.9	13.3	3.6	3.0	2.4	1.9	1.3	1.0
CX15	Open Channel	52.9	15.2	13.1	5.2	5.1	4.7	4.1	1.2	1.1
CX16	Open Channel	58.0	13.9	12.0	3.4	3.3	3.0	2.6	1.2	0.8
CX17	Open Channel	34.8	13.3	11.5	3.4	3.2	3.0	2.6	1.2	0.8
CX18	Open Channel	32.1	13.3	11.3	3.2	3.0	2.7	2.4	1.2	0.8
CX19	Open Channel	39.8	11.0	9.6	4.6	3.8	3.1	2.8	2.2	1.5
CX20	Open Channel	51.7	12.2	10.4	5.5	4.5	3.4	3.0	2.4	1.6
CX21	Open Channel	67.4	12.5	10.5	5.6	4.6	3.5	3.1	2.4	1.6
CX22	Open Channel	60.9	12.6	10.6	5.8	4.7	3.7	3.3	2.5	1.6
CX23	Open Channel	43.7	12.5	10.6	8.7	7.7	6.5	5.5	4.8	4.2
CX24	Open Channel	31.2	10.3	8.6	5.1	4.5	3.6	3.2	2.5	2.4

Appendix J

2D Peak Flows at Reference Locations

APPENDIX J

2D Peak Flows at Reference Locations

Reference ID	Peak Flows (m^3/s)								
	PMF	200yr ARI	100yr ARI	50yr ARI	20yr ARI	10yr ARI	5yr ARI	2yr ARI	1yr ARI
Q5	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q6	5.1	0.9	0.8	0.6	0.5	0.4	0.3	0.1	0.1
Q7	0.9	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1
Q8	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q9	0.8	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1
Q10	2.3	0.7	0.7	0.6	0.5	0.4	0.3	0.2	0.2
Q11	2.7	1.1	1.0	0.8	0.7	0.5	0.4	0.2	0.2
Q12	5.3	1.1	1.0	0.8	0.7	0.5	0.4	0.2	0.1
Q13	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q14	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q15	0.5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0
Q16	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q17	2.1	0.5	0.4	0.4	0.3	0.3	0.2	0.2	0.1
Q18	15.8	3.3	3.0	2.5	2.0	1.5	1.2	0.7	0.4
Q19	15.7	2.9	2.5	2.0	1.6	1.2	0.9	0.5	0.3
Q20	3.0	0.9	0.8	0.7	0.6	0.5	0.4	0.2	0.1
Q21	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q22	0.5	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0
Q23	2.1	0.4	0.3	0.3	0.2	0.2	0.1	0.1	0.1
Q24	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q25	20.9	4.0	3.6	2.9	2.4	1.8	1.4	0.9	0.6
Q26	28.0	5.5	4.8	3.9	3.2	2.4	1.9	1.0	0.4
Q27	38.2	5.2	4.4	3.3	2.3	1.6	1.1	0.6	0.4
Q28	1.3	0.3	0.3	0.2	0.2	0.2	0.2	0.1	0.1
Q46	3.0	0.6	0.5	0.5	0.4	0.3	0.3	0.2	0.2
Q47	0.4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0
Q48	3.0	0.7	0.6	0.5	0.5	0.4	0.3	0.3	0.2
Q49	12.4	2.8	2.6	2.3	1.9	1.6	1.4	0.9	0.6
Q50	16.5	2.4	2.1	1.8	1.6	1.3	1.1	0.7	0.4
Q51	0.9	0.4	0.3	0.3	0.2	0.2	0.2	0.1	0.1
Q52	1.1	0.3	0.3	0.3	0.2	0.2	0.2	0.1	0.1
Q53	0.7	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1
Q54	14.3	1.9	1.7	1.5	1.2	0.9	0.7	0.1	0.1
Q55	22.3	4.4	4.0	3.6	2.9	2.3	1.8	0.5	0.3
Q56	21.5	3.6	3.3	2.7	2.1	1.6	1.1	0.1	0.1
Q57	1.9	0.6	0.5	0.5	0.4	0.4	0.3	0.2	0.2
Q58	1.0	0.3	0.3	0.3	0.2	0.2	0.2	0.1	0.1
Q59	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q60	0.7	0.2	0.2	0.1	0.1	0.1	0.1	0.0	0.0
Q61	0.5	0.5	0.5	0.4	0.4	0.3	0.1	0.1	0.1
Q62	2.1	0.5	0.5	0.4	0.4	0.3	0.3	0.2	0.2
Q63	1.4	0.4	0.3	0.3	0.3	0.2	0.2	0.1	0.1
Q64	1.2	0.3	0.3	0.3	0.2	0.2	0.2	0.1	0.1
Q65	34.1	4.9	4.2	3.4	2.5	1.8	1.3	0.7	0.3
Q66	0.8	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1
Q67	0.4	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0
Q68	0.5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0
Q69	2.5	0.5	0.4	0.4	0.3	0.3	0.2	0.2	0.1
Q70	0.8	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1
Q71	0.3	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0

Reference ID	Peak Flows (m³/s)								
	PMF	200yr ARI	100yr ARI	50yr ARI	20yr ARI	10yr ARI	5yr ARI	2yr ARI	1yr ARI
Q72	0.9	0.3	0.3	0.2	0.2	0.2	0.2	0.1	0.1
Q73	0.6	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1
Q74	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q75	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q76	0.9	0.3	0.3	0.2	0.2	0.2	0.1	0.1	0.1
Q77	2.6	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.0
Q78	1.2	0.3	0.3	0.3	0.2	0.2	0.2	0.1	0.1
Q79	0.8	0.3	0.3	0.2	0.2	0.1	0.1	0.1	0.0
Q80	1.0	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1
Q81	0.5	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1
Q82	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Q83	0.6	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1
Q84	0.5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0
Q85	0.7	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.0
Q86	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0
Q87	1.5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0
Q88	0.7	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1
Q89	0.7	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.0
Q90	0.3	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0
Q91	2.7	0.4	0.4	0.4	0.3	0.3	0.2	0.2	0.1
Q92	1.0	0.3	0.2	0.2	0.2	0.2	0.1	0.1	0.1
Q93	0.9	0.3	0.3	0.2	0.2	0.2	0.1	0.1	0.1
Q94	1.1	0.3	0.2	0.2	0.2	0.2	0.1	0.1	0.1
Q95	0.4	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0
Q96	1.4	0.3	0.3	0.3	0.2	0.2	0.2	0.1	0.1
Q97	1.0	0.3	0.3	0.3	0.2	0.2	0.2	0.1	0.1
Q98	0.8	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.0
Q99	1.9	0.3	0.3	0.3	0.2	0.2	0.2	0.1	0.1
Q100	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q101	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q102	14.1	1.7	1.5	1.1	0.6	0.2	0.2	0.1	0.1
Q103	1.5	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0
Q104	0.8	0.3	0.2	0.2	0.2	0.2	0.1	0.1	0.1
Q105	1.8	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1
Q106	4.3	0.8	0.8	0.7	0.5	0.4	0.3	0.2	0.2
Q107	0.9	0.3	0.3	0.2	0.2	0.2	0.2	0.1	0.1
Q108	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q109	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q110	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q111	7.3	1.1	0.9	0.7	0.6	0.6	0.4	0.2	0.1
Q112	18.3	2.2	1.9	1.4	1.1	0.9	0.8	0.4	0.2
Q113	0.8	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0
Q114	0.6	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0
Q115	0.4	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0
Q116	29.8	4.3	3.9	3.2	2.7	2.2	1.8	0.8	0.5
Q117	0.7	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.0
Q118	0.5	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0
Q119	1.0	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.0
Q120	6.6	0.7	0.6	0.6	0.5	0.5	0.4	0.2	0.2
Q121	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q122	1.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.0
Q123	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q124	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q125	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0

Reference ID	Peak Flows (m^3/s)								
	PMF	200yr ARI	100yr ARI	50yr ARI	20yr ARI	10yr ARI	5yr ARI	2yr ARI	1yr ARI
Q126	1.0	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1
Q127	1.1	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1
Q128	0.4	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0
Q129	6.3	1.3	1.2	0.9	0.6	0.4	0.2	0.2	0.1
Q130	2.2	0.5	0.5	0.4	0.4	0.3	0.2	0.1	0.1
Q131	3.2	0.7	0.6	0.4	0.4	0.3	0.2	0.2	0.1
Q132	0.3	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0
Q133	0.9	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0
Q134	0.3	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0
Q135	0.7	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.0
Q136	0.7	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.0
Q137	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q138	0.8	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Q139	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Q140	2.7	0.6	0.6	0.5	0.4	0.3	0.3	0.2	0.2
Q141	0.5	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.0
Q142	2.4	0.5	0.5	0.4	0.3	0.3	0.2	0.2	0.1
Q143	0.2	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0
Q144	11.5	2.2	1.9	1.6	1.3	1.0	0.8	0.5	0.3
Q145	0.5	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0
Q146	0.4	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0
Q147	16.3	2.4	2.0	1.4	1.2	0.8	0.6	0.3	0.1
Q148	1.7	0.4	0.4	0.3	0.3	0.2	0.2	0.1	0.1
Q149	1.3	0.3	0.2	0.2	0.2	0.2	0.1	0.1	0.1
Q150	1.2	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0
Q151	0.4	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0
Q152	3.6	0.4	0.4	0.3	0.3	0.2	0.2	0.1	0.1
Q153	16.1	2.6	2.3	1.8	1.6	1.2	0.9	0.9	0.9
Q154	8.8	1.9	1.8	1.5	1.2	0.9	0.6	0.3	0.1
Q155	0.4	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0
Q156	13.4	0.5	0.5	0.5	0.5	0.1	0.1	0.1	0.1
Q157	9.8	0.3	0.3	0.2	0.2	0.2	0.1	0.1	0.1
Q158	2.8	0.4	0.4	0.4	0.4	0.3	0.3	0.2	0.1
Q159	27.0	1.5	1.1	0.7	0.4	0.4	0.3	0.2	0.1
Q160	1.4	0.4	0.3	0.3	0.3	0.2	0.2	0.2	0.1
Q161	2.0	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0
Q162	2.5	0.4	0.3	0.3	0.2	0.1	0.1	0.1	0.0
Q163	29.4	1.6	1.2	0.7	0.6	0.4	0.4	0.4	0.4
Q164	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q165	0.5	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0
Q166	2.3	0.4	0.4	0.3	0.3	0.3	0.3	0.2	0.1
Q167	7.7	0.9	0.8	0.8	0.7	0.6	0.5	0.4	0.3
Q168	1.0	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.0
Q169	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q170	14.4	1.1	1.0	0.9	0.8	0.5	0.4	0.3	0.2
Q171	1.9	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1
Q172	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q173	0.8	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1
Q174	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q175	0.8	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1
Q176	0.6	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.0
Q177	0.3	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0
Q178	18.9	2.4	2.1	1.8	1.4	0.8	0.4	0.0	0.0
Q179	1.6	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.1

Reference ID	Peak Flows (m³/s)								
	PMF	200yr ARI	100yr ARI	50yr ARI	20yr ARI	10yr ARI	5yr ARI	2yr ARI	1yr ARI
Q180	5.5	0.7	0.6	0.6	0.5	0.4	0.3	0.2	0.2
Q181	3.4	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0
Q182	0.8	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0
Q183	1.5	0.2	0.2	0.2	0.2	0.1	0.1	0.0	0.0
Q184	1.5	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.0
Q185	23.3	2.2	1.9	1.4	1.0	0.5	0.3	0.2	0.1
Q186	1.1	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1
Q187	1.7	0.4	0.4	0.3	0.3	0.2	0.2	0.1	0.1
Q188	0.6	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.0
Q189	1.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1
Q190	1.4	0.3	0.3	0.2	0.2	0.2	0.2	0.1	0.1
Q191	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q192	0.4	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0
Q193	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q194	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q195	1.1	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1
Q196	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q197	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q198	2.1	0.2	0.2	0.1	0.1	0.1	0.0	0.0	0.0
Q199	7.9	1.0	0.9	0.7	0.5	0.4	0.3	0.2	0.1
Q200	4.1	0.4	0.4	0.3	0.3	0.2	0.2	0.1	0.1
Q203	2.5	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.0
Q204	5.1	1.1	1.0	0.9	0.8	0.7	0.5	0.4	0.3
Q206	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q207	0.6	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1
Q208	3.7	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1
Q209	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q210	31.3	1.7	1.3	0.9	0.7	0.6	0.5	0.3	0.2
Q211	1.6	0.3	0.3	0.3	0.2	0.2	0.1	0.1	0.1
Q212	22.9	1.4	1.1	0.9	0.7	0.5	0.3	0.1	0.0
Q213	24.5	2.4	2.0	1.7	1.3	0.7	0.4	0.1	0.0
Q214	1.8	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q215	18.2	1.8	1.5	1.0	0.6	0.4	0.2	0.1	0.1
Q216	28.2	0.9	0.7	0.5	0.3	0.2	0.2	0.1	0.1
Q217	4.3	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0
Q218	10.2	0.9	0.8	0.6	0.5	0.4	0.3	0.2	0.1
Q219	18.9	2.0	1.8	1.4	1.1	0.6	0.3	0.1	0.0
Q220	1.1	0.4	0.4	0.4	0.3	0.3	0.2	0.2	0.1
Q221	13.3	0.4	0.4	0.2	0.2	0.1	0.1	0.1	0.0
Q225	48.1	7.9	7.0	5.9	4.6	3.8	3.0	2.0	1.3
Q226	132.6	11.2	8.2	0.7	0.4	0.4	0.3	0.3	0.2
Q227	1.3	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1
Q228	81.6	4.8	3.4	0.6	0.2	0.1	0.1	0.1	0.1
Q229	23.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q230	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q231	11.3	0.5	0.5	0.2	0.0	0.0	0.0	0.0	0.0
Q235	7.8	1.2	1.1	1.1	1.0	0.8	0.7	0.6	0.6
Q236	51.4	3.4	2.1	0.5	0.5	0.5	0.2	0.1	0.1
Q237	7.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q238	8.8	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0
Q239	16.9	0.4	0.3	0.3	0.2	0.2	0.2	0.1	0.1
Q240	48.5	10.5	7.5	5.9	4.3	0.3	0.0	0.0	0.0
Q241	69.6	12.1	8.2	6.2	4.4	0.7	0.2	0.0	0.0
Q242	25.4	2.6	0.7	0.2	0.0	0.0	0.0	0.0	0.0

Reference ID	Peak Flows (m^3/s)								
	PMF	200yr ARI	100yr ARI	50yr ARI	20yr ARI	10yr ARI	5yr ARI	2yr ARI	1yr ARI
Q243	3.5	0.7	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Q244	1.8	0.5	0.5	0.4	0.4	0.3	0.3	0.2	0.1
Q245	1.5	0.5	0.5	0.4	0.4	0.3	0.3	0.2	0.1
Q246	2.0	0.3	0.3	0.2	0.2	0.2	0.1	0.1	0.1
Q247	0.6	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0
Q248	98.3	18.4	12.9	8.6	7.0	4.0	3.2	3.2	3.2
Q249	96.0	19.7	13.5	10.0	8.2	4.4	3.6	3.4	3.3
Q250	0.2	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0
Q251	0.7	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0
Q252	3.5	0.8	0.7	0.6	0.6	0.5	0.4	0.3	0.2
Q253	19.1	0.5	0.5	0.4	0.3	0.2	0.2	0.2	0.2
Q254	44.9	3.2	1.1	0.7	0.5	0.2	0.1	0.0	0.0
Q255	12.3	1.6	0.5	0.4	0.3	0.1	0.0	0.0	0.0
Q256	25.4	0.7	0.7	0.5	0.4	0.3	0.2	0.1	0.1
Q257	10.5	1.0	0.4	0.2	0.1	0.1	0.1	0.0	0.0
Q258	22.7	9.1	7.5	6.0	4.6	1.0	0.8	0.6	0.5
Q259	30.1	10.6	8.0	6.4	4.9	1.3	1.1	0.8	0.8
Q261	8.8	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Q262	1.3	0.3	0.3	0.3	0.2	0.2	0.2	0.1	0.1
Q263	0.3	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0
Q264	0.6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0
Q265	0.4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0
Q266	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q267	0.8	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1
Q268	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q269	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q270	3.0	0.6	0.6	0.5	0.5	0.4	0.3	0.2	0.2
Q271	3.1	0.8	0.8	0.7	0.6	0.6	0.5	0.4	0.3
Q272	16.8	1.1	0.8	0.5	0.4	0.3	0.2	0.2	0.1
Q273	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0
Q274	8.3	1.7	1.6	1.4	1.3	1.1	0.9	0.7	0.5
Q275	6.4	5.9	5.9	5.3	0.1	0.0	0.0	0.0	0.0
Q276	38.3	31.7	31.7	30.4	27.2	16.9	14.9	10.2	10.1
Q277	4.3	4.3	4.3	3.1	0.9	0.7	0.6	0.4	0.2
Q278	3.3	2.3	2.3	1.3	0.0	0.0	0.0	0.0	0.0
Q279	6.0	4.7	4.7	3.0	0.5	0.1	0.1	0.0	0.0
Q280	3.4	1.7	1.7	0.7	0.0	0.0	0.0	0.0	0.0
Q282	14.2	0.3	0.3	0.3	0.2	0.2	0.1	0.1	0.1
Q283	10.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Q284	12.3	0.3	0.3	0.2	0.2	0.1	0.1	0.1	0.1
Q285	53.1	15.4	15.4	14.7	12.3	7.1	7.1	6.2	6.2
Q286	19.4	2.5	2.1	1.6	1.2	0.7	0.4	0.1	0.1
Q287	5.5	0.6	0.6	0.5	0.4	0.3	0.2	0.1	0.1
Q288	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q289	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q290	1.1	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1
Q291	0.8	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1
Q292	0.9	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1
Q293	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q295	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0
Q301	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q302	0.3	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0
Q303	5.5	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.1
Q304	7.4	1.0	1.0	1.0	0.5	0.4	0.1	0.1	0.1

Reference ID	Peak Flows (m^3/s)								
	PMF	200yr ARI	100yr ARI	50yr ARI	20yr ARI	10yr ARI	5yr ARI	2yr ARI	1yr ARI
Q305	8.0	0.4	0.4	0.3	0.3	0.2	0.2	0.1	0.1
Q306	1.6	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.0
Q307	6.8	1.3	1.2	1.0	0.9	0.7	0.6	0.4	0.3
Q308	0.5	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0
Q309	0.9	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0
Q310	0.8	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q311	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q312	0.7	0.6	0.6	0.6	0.1	0.1	0.1	0.1	0.0
Q313	0.6	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0
Q314	1.2	1.2	1.1	0.7	0.7	0.1	0.1	0.1	0.1
Q315	0.4	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0
Q316	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q317	0.5	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0
Q318	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q319	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q320	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0
Q321	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q322	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q324	0.2	0.2	0.2	0.2	0.1	0.0	0.0	0.0	0.0
Q325	13.4	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Q326	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q327	6.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q328	15.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q329	16.4	1.3	1.2	1.1	1.0	0.7	0.5	0.5	0.4
Q330	7.3	2.8	1.8	1.7	1.7	1.3	1.2	1.0	1.0
Q331	45.2	7.3	5.4	5.3	4.9	3.6	3.5	3.2	3.1
Q332	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0