MOLINO STEWART

ENVIRONMENT & NATURAL HAZARDS

**Parramatta City Council**
**Auburn City Council**
**Bankstown City Council**

# Duck River Catchment Floodplain Risk Management Study

*Final Report*

MOLINO STEWART
ENVIRONMENT & NATURAL HAZARDS

# Duck River Catchment
# Floodplain Risk Management Study

FINAL REPORT

for

Parramatta City Council

Auburn City Council

Bankstown City Council

by

Molino Stewart Pty Ltd

ACN 067 774 332

NOVEMBER 2012

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# DOCUMENT CONTROL

| | |
|---|---|
| ***Document Reference*** | 0351 Duck River Floodplain Risk Management Study Final |
| ***Project*** | Duck River Catchment Floodplain Risk Management Study |
| ***Document Type*** | Final Report |
| ***Author*** | Neil Benning |

## REVISION HISTORY

| ***Date*** | **Version** | **Name** | **Comments** |
|---|---|---|---|
| *9/11/2011* | 1 | Neil Benning | First draft for review |
| *16/8/2012* | 2 | Neil Benning | Final Draft for Exhibition |
| *6/11/2012* | 3 | Neil Benning | Final |

## DOCUMENT APPROVAL

| | |
|---|---|
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# GLOSSARY AND ABBREVIATIONS

This Floodplain Risk Management Study utilises the terminology used in the NSW Floodplain Development Manual (2005). The following Glossary is drawn from that Manual.

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| *Acid sulfate soils* | These are sediments which contain sulfidic mineral pyrite which may become extremely acid following disturbance or drainage as sulfur compounds react when exposed to oxygen to form sulfuric acid. |
| *Annual exceedance probability (AEP)* | The chance of a flood of a given or larger size occurring in any one year, usually expressed as a percentage. For example, if a peak flood discharge of 500 $m^3/s$ has an AEP of 5%, it means that there is a 5% chance (i.e., a one-in-20 chance) of a 500 $m^3/s$ or larger events occurring in any one year (see ARI). |
| *Australian Height Datum (AHD)* | A common national surface level datum approximately corresponding to mean sea level. |
| *Average annual damage (AAD)* | Depending on its size (or severity), each flood will cause a different amount of flood damage to a flood prone area. AAD is the average damage per year that would occur in a nominated development situation from flooding over a very long period of time. |
| *Average recurrence interval (ARI)* | The long-term average number of years between the occurrence of a flood as big as or larger than the selected event. For example, floods with a discharge as great as or greater than the 20 year ARI flood event will occur on average once every 20 years. ARI is another way of expressing the likelihood of occurrence of a flood event. |
| *BoM* | Bureau of Meteorology |
| *Catchment* | The land area draining through the main stream, as well as tributary streams, to a particular site. It always relates to an area above a specific location. |
| *Consent authority* | The council, government agency or person having the function to determine a development application for land use under the EP&A Act. The consent authority is most often the council, however legislation or an EPI may specify a Minister or public authority (other than a council), or the Director General of DPI, as having the function to determine an application. |

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| *Development* | Defined in Part 4 of the EP&A Act:<br><br>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<br><br>New development: refers to development of a completely different nature to that associated with the former land use. For example, the urban subdivision of an area previously used for rural purposes. New developments involve re-zoning and typically require major extensions of existing urban services, such as roads, water supply, sewerage and electric power.<br><br>Redevelopment: refers to rebuilding in an area. For example, as urban areas age, it may become necessary to demolish and reconstruct buildings on a relatively large scale. Redevelopment generally does not require either re-zoning or major extensions to urban services. |
| *Disaster plan (DISPLAN)* | A step by step sequence of previously agreed roles, responsibilities, functions, actions and management arrangements for the conduct of a single or series of connected emergency operations, with the object of ensuring the coordinated response by all agencies having responsibilities and functions in emergencies. |
| *Discharge* | The rate of flow of water measured in terms of volume per unit time, for example, cubic metres per second ($m^3/s$). Discharge is different from the speed or velocity of flow, which is a measure of how fast the water is moving for example, metres per second (m/s). |
| *EP&A Act* | The Environmental Planning & Assessment Act, the principal planning legislation in NSW. |
| *EPI* | Environmental Planning Instrument – a generic term for the suite of planning documents specified under the Environmental Planning & Assessment ACT and includes State Environmental Planning Policies (SEPP), Local Environmental Plans (LEP) and Development Control Plans (DCP). |
| *Ecologically Sustainable Development (ESD)* | Using, conserving and enhancing natural resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be maintained or increased. A more detailed definition is included in the Local Government Act, 1993. |

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| *Effective warning time* | The time available after receiving advice of an impending flood and before the floodwaters prevent appropriate flood response actions being undertaken. The effective warning time is typically used to raise furniture, evacuate people and their possessions. |
| *Emergency management* | A range of measures to manage risks to communities and the environment. In the flood context it may include measures to prevent, prepare for, respond to and recover from flooding. |
| *Flash flooding* | Flooding which is sudden and unexpected. It is often caused by sudden local or nearby heavy rainfall. Often defined as flooding which peaks within six hours of the causative rain. |
| *Flood* | Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or local overland flooding associated with major drainage before entering a watercourse, and/or coastal inundation resulting from super-elevated sea levels and/or waves overtopping coastline defences excluding tsunami. |
| *Flood awareness* | Flood awareness is an appreciation of the likely effects of flooding and a knowledge of the relevant flood warning, response and evacuation procedures. |
| *Flood education* | Flood education seeks to provide information to raise awareness of the flood problem so as to enable individuals to understand how to manage themselves and their property in response to flood warnings and in a flood event. It invokes a state of flood readiness. |
| *Flood fringe areas* | The remaining area of flood prone land after floodway and flood storage areas have been defined. |
| *Flood liable land* | Is synonymous with flood prone land, i.e., land susceptible to flooding by the PMF event. Note that the term flood liable land covers the whole floodplain, not just that part below the FPL (see flood planning area). |
| *Flood mitigation standard* | The average recurrence interval of the flood, selected as part of the floodplain risk management process that forms the basis for physical works to modify the impacts of flooding. |
| *Floodplain* | Area of land which is subject to inundation by floods up to and including the probable maximum flood event, that is, flood prone land. |

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| *Floodplain risk management options* | The measures that might be feasible for the management of a particular area of the floodplain. Preparation of a floodplain risk management plan requires a detailed evaluation of floodplain risk management options. |
| *Floodplain risk management plan* | A management plan developed in accordance with the principles and guidelines in this manual. Usually includes both written and diagrammatic information describing how particular areas of flood prone land are to be used and managed to achieve defined objectives. |
| *Flood plan (local)* | A sub-plan of a disaster plan that deals specifically with flooding. They can exist at state, division and local levels. Local flood plans are prepared by the SES. |
| *Flood planning area (FPA)* | The area of land below the FPL and thus subject to flood related development controls. |
| *Flood planning levels (FPLs)* | Are the combinations of flood levels and freeboards selected for floodplain risk management purposes, as determined in management studies and incorporated in management plans. |
| *Flood proofing* | A combination of measures incorporated in the design, construction and alteration of individual buildings or structures subject to flooding, to reduce or eliminate flood damages. |
| *Flood prone land* | Land susceptible to flooding by the PMF event. Flood prone land is synonymous with flood liable land. |
| *Flood readiness* | Readiness is an ability to react within the effective warning time. (see flood awareness) |
| *Flood Refuge* | In an industrial or commercial situation: an area used for offices or to store valuable possessions susceptible to flood damage in the event of a flood. |
| *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 can be divided into 3 types, existing, future and continuing:<br>• Existing flood risk: the risk a community is exposed to as a result of its location on the floodplain.<br>• Future flood risk: the risk a community may be exposed to as a result of new development on the floodplain.<br>• Continuing flood risk: the risk a community is exposed to after floodplain risk management measures have been implemented. |

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| *Flood storage areas* | Those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood. |
| *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* | It is a factor of safety typically used in relation to the setting of floor levels, levee crest levels, etc. |
| *Habitable room* | In a residential situation: a living or working area, such as a lounge room, dining room, rumpus room, kitchen, bedroom or workroom. |
| *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. Two levels of hazard are usually adopted in floodplain risk management planning:<br>High hazard: possible danger to personal safety; evacuation by trucks difficult; able-bodied adults would have difficulty in wading to safety; potential for significant structural damage to buildings.<br>Low hazard: should it be necessary, truck could evacuate people and their possessions; able-bodied adults would have little difficulty in wading to safety. |
| *Hydraulics* | The study of water flow in waterways; in particular, the evaluation of flow parameters such as water level and velocity. |
| *Hydrograph* | A graph which shows how the discharge or stage/flood level at any particular location varies with time during a flood. |
| *Hydrology* | The study of the rainfall and runoff process; in particular, the evaluation of peak flows, flow volumes and the derivation of hydrographs for a range of floods. |
| *Local overland flooding* | Inundation by local runoff rather than overbank discharge from a stream, river, estuary, lake or dam. |
| *Local drainage* | Smaller scale problems in urban areas. They are outside the definition of major drainage in this glossary. |
| *Mainstream flooding* | Inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam. |

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| *Major drainage* | Councils have discretion in determining whether urban drainage problems are associated with major or local drainage. For the purposes of this study, major drainage involves:<br><br>the floodplains of original watercourses (which may now be piped, channelised or diverted), or sloping areas where overland flows develop along alternative paths once system capacity is exceeded; and/or<br><br>water depths generally in excess of 0.3m (in the major system design storm as defined in the current version of Australian Rainfall and Runoff). These conditions may result in danger to personal safety and property damage to both premises and vehicles; and/or<br><br>major overland flowpaths through developed areas outside of defined drainage reserves; and/or<br><br>the potential to affect a number of buildings along the major flow path. |
| *Minor, moderate and major flooding* | Both the SES and the BoM use the following definitions in flood warnings to give a general indication of the types of problems expected with a flood:<br><br>Minor flooding: causes inconvenience such as closing of minor roads and the submergence of low level bridges. The lower limit of this class of flooding on the reference gauge is the initial flood level at which landholders and townspeople begin to be flooded.<br><br>Moderate flooding: low-lying areas are inundated requiring removal of stock and/or evacuation of some houses. Main traffic routes may be covered.<br><br>Major flooding: appreciable urban areas are flooded and/or extensive rural areas are flooded. Properties, villages and towns can be isolated. |
| *Modification measures* | Measures that modify either the flood or the property or the response to flooding.<br><br>There are three generally recognised ways of managing floodplains to minimise the risk to life and to reduce flood losses:<br><br>By modifying the response of the population at risk to better cope with a flood event (Response Modification);<br><br>by modifying the behaviour of the flood itself (Flood Modification); and<br><br>by modifying or removing existing properties and/or by imposing controls on property and infrastructure development (Property Modification). |

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| *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 viable to provide complete protection against this event.<br><br>The PMF defines the extent of flood prone land, that is, the floodplain. The extent, nature and potential consequences of flooding associated with a range of events rarer than the flood used for designing mitigation works and controlling development, up to and including the PMF event should be addressed in a floodplain risk management study. |
| *Probable maximum precipitation* | The PMP is the greatest depth of precipitation for a given duration meteorologically possible over a given size storm area at a particular location at a particular time of the year, with no allowance made for long-term climatic trends (World Meteorological Organisation, 1986). It is the primary input to PMF estimation. |
| *Probability* | A statistical measure of the expected chance of flooding (see AEP). |
| *Risk* | Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. In this context, it is the likelihood of consequences arising from the interaction of floods, communities and the environment. |
| *Runoff* | The amount of rainfall which actually ends up as streamflow, also known as rainfall excess. |
| *SES* | State Emergency Service |
| *stage* | Equivalent to water level (both measured with reference to a specified datum). |
| *stage hydrograph* | A graph that shows how the water level at a particular location changes with time during a flood. It must be referenced to a particular datum. |
| *survey plan* | A plan prepared by a registered surveyor. |
| *water surface profile* | A graph showing the flood stage along a watercourse at a particular time. |

# 1 INTRODUCTION

## 1.1 CONTEXT OF STUDY

The continuing occurrence of flooding across NSW (and other States, e.g. 2011 floods in Brisbane) has highlighted the importance of managing the risks associated with flooding. In NSW, the Government's Flood Policy is directed at providing solutions to existing flooding problems in developed areas, and ensuring that new developments are compatible with the flood hazard and do not exacerbate existing flooding or create additional flooding problems in other areas. Under the Policy, the management of flood prone land is the responsibility of local government. To facilitate this, the NSW Government published in 2005, the "Floodplain Development Manual: the management of flood liable land" (the Manual) to provide guidance to Councils in the implementation of the Policy. The NSW Government also provides funding in support of floodplain management programs.

The Manual describes a floodplain risk management process comprising the following sequential stages:

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| *Flood Study* | Determines the nature and extent of the flood problem for the full range of flood events |
| *Floodplain Risk Management Study*<br>*(This report)* | Evaluates management options for the floodplain with respect to both existing and future development. |
| *Floodplain Risk Management Plan* | Involves formal adoption by Council of a plan of management for the floodplain. |
| *Implementation of the Plan* | Involves implementation of flood risk management measures, where viable, to protect existing development. Uses planning controls to ensure that future development is compatible with flood hazards. |
| *Review of Plan* | Review of plan to ensure it remains current and appropriate. A review is normally carried out after 5 - 10 years, subject to the implementation of the Plan or the occurrence of flooding. |

This report pertains to Stage 2 of the Flood Risk Management Process.

Parramatta, Auburn and Bankstown City Councils have prepared this report with financial assistance from the NSW Government through its Floodplain Management Program. The preparation of this report has been overseen by the Office of Environment and Heritage, however this report does not necessarily represent the opinions of the NSW Government or the Office of Environment and Heritage.

## 1.2 DUCK RIVER FLOOD RISK MANAGEMENT STUDY

In early 2009, Parramatta City Council (PCC), Bankstown City Council (BCC) and Auburn City Council (ACC) developed a partnership to manage flooding across the Duck River catchment as each Council had areas of land within the catchment. It was agreed that PCC would be the lead Council, and be responsible for administering contractual arrangements for the project.

In April 2009, PCC put out a request for quotation for the Duck River catchment Floodplain Risk Management Study and Plan (hereafter "The Study" and "The Plan" or FRMS&P). In May 2009, PCC engaged Molino Stewart to prepare the FRMS&P. This Study would bring together the relevant data from previous studies into a comprehensive set of management measures for the three Councils participating in the project.

This Report pertains to the second stage of the floodplain management process outlined above. It should be read in conjunction with the following reports:

- Duck River and Duck Creek Flood Study Review (WMAWater, 2010).
- Duck River Stormwater Catchment Study including the 2009 Addendum (Bewsher Consulting and BMT WMB, 2009).
- Wolumba Stormwater Catchment Study (BMT WMB, 2010).

The overall objective of this Study is to develop sufficient and reliable information to assist in the development of a Floodplain Risk Management Plan for the study area that addresses the existing and future flood risks in accordance with the Manual. This will ensure that the following broad needs are met:

- Reduce the flood hazard and risk to people and property, now and in the future;
- Protect, maintain and where possible enhance the river and floodplain environment; and
- Ensure floodplain risk management decisions integrate the social, economic and environmental considerations.

# 2 STUDY AREA

## 2.1 THE STUDY AREA

The Duck River catchment covers an area of approximately 42 square kilometres and incorporates parts of the Auburn, Bankstown, Holroyd and Parramatta local government areas (LGAs). Apart from its own catchment, Duck River also receives flows from Duck Creek, Little Duck Creek and A'Becketts Creek. The study area for this consultancy covers only the PCC, BCC and ACC LGAs (see Figure 1). Holroyd City Council (HCC) elected not to participate in the study because they are presently undertaking flood studies across their LGA.

The Duck River catchment generally flows north/south with the eastern and western sides being moderately sloping; it becomes flatter towards the downstream reach from Parramatta Road to its confluence with Parramatta River near Silverwater Bridge. The Duck River catchment is heavily urbanised.

The tributaries of Duck River within PCC include:

- Duck Creek;
- Little Duck Creek; and
- A'Becketts Creek, the lower section of which, downstream of Pitt Street, Parramatta, is within the study area.

The catchment areas of the major sections of Duck River are:

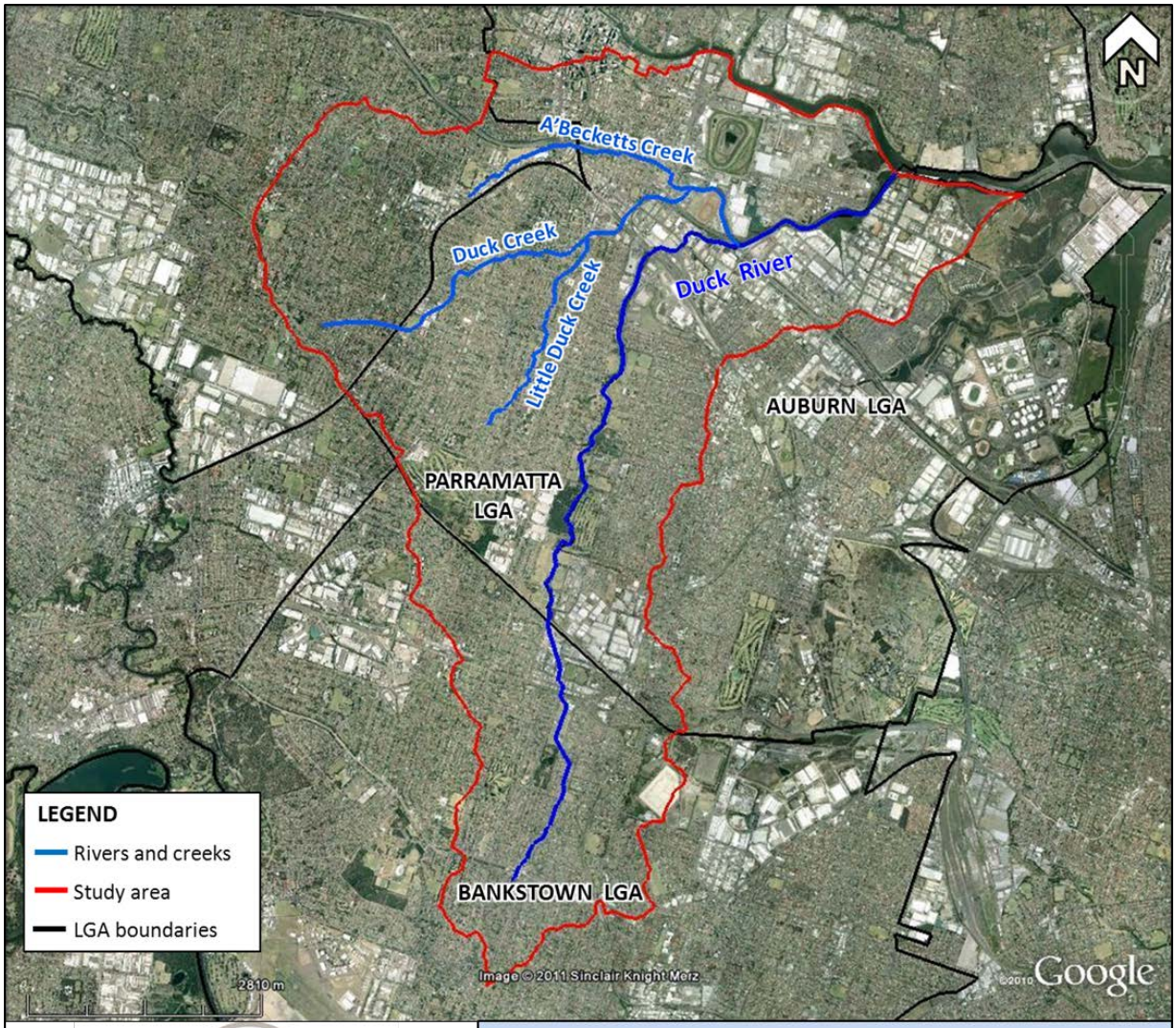
- The upper Duck River catchment (approximately 8 $km^2$) within BCC ;
- The lower Duck River catchment (approximately 17 $km^2$) within PCC and ACC;
- The Duck Creek and Little Duck Creek catchments (approximately 9 $km^2$) within PCC and HCC; and
- The A'Becketts Creek catchment (approximately 7 $km^2$) within PCC and HCC LGAs.

The headwaters of the Duck River are in Bankstown. Within the headwaters area, two sub-catchments have been defined - that of Duck River and the smaller sub-catchment of Wolumba. The Duck River commences in the suburb of Yagoona West and the drainage path travels in a northerly direction through the suburbs of Birrong and Sefton before crossing under the Sydney Water pipeline (SWP) which forms the boundary between BCC and PCC/ACC LGAs.

Within BCC, the open channel is almost entirely concrete lined with the upper parts draining by overland flow and a pit and pipe network. There are approximately five kilometres of open channel system (trapezoidal or rectangular section) with wider sections as the upstream catchment increases. There are closed channels under roads and railways.

Downstream of the SWP, the channel is in a semi natural state (unlined) and it is crossed by several bridges and pipelines. PCC is on the western side and ACC on the east. In places the channel is deeply incised and anecdotal evidence suggests that, in places, the floodplain has been filled or landscaped for sporting fields or areas of open space. The main channel is vegetated to varying extents and in places extensive bank revegetation has occurred. In the lower parts the channel is lined by mangroves.

In this reach, the Duck River corridor contains regionally significant areas of natural bushland and wildlife habitat, interspersed amongst sports fields and open space used for passive recreation (Norford, Hislop, Everley, Progress, Oriole and Mona Parks, Marshall Reserve, Rosnay Golf Course and the Auburn Botanic Gardens).

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Molino Stewart endeavours to ensure that the information provided in this map is correct at the time of publication. Molino Stewart does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

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*Figure 1: Duck River Floodplain Risk Management Study - Study Area*

In the lower reaches, the River corridor is a more urbanised landscape and has significant commercial and industrial areas including Camellia and South Granville. The residential areas encroach on the fringes of the floodplain with industrial developments fronting the channel from upstream of the Main Western Railway to its junction with the Parramatta River upstream of Silverwater Road.

The Duck River catchment within ACC is divided into smaller (unnamed) sub catchments. The catchment has mixed industrial and residential area. The main industrial areas that contribute to the catchments are Regents Park industrial park, Clyde marshalling yard and Silverwater.

Development within the catchment is predominately detached residential developments with higher density villa and unit developments in parts. There is considerable industrial development in the lower parts and scattered commercial development throughout.

### 2.1.1 Duck Creek and Little Duck Creek

West of the main Southern Railway the catchment is within HCC. Duck Creek and Little Duck Creek have similar sized catchments to their confluence upstream of the main Southern Railway. Both catchments are largely occupied by medium to high density residential areas (Reference 2) and drained by lined open channels. The channel only becomes non concrete lined downstream of the M4 Western Motorway.

### 2.1.2 A'Becketts Creek

A'Becketts Creek is within the PCC LGA downstream of the western rail line as it passes under the M4 Western Motorway. The land to the north of the creek is largely medium to high density residential with the land to the south medium density residential with commercial developments along Parramatta Road. The creek is lined upstream of the Carlingford railway line. The creek is crossed by several bridges between the two rail tracks. Downstream of the Carlingford railway, A'Becketts Creek joins with Duck Creek and further downstream with Duck River.

## 2.2 LITERATURE REVIEW

| *Title* | Date | LGA | Authors |
|---|---|---|---|
| *Duck River Stormwater Management Plan* | July 1999 | PCC, ACC, HCC, BCC | Sinclair Knight Merz |
| *Duck River Flood Study* | 1986 | PCC | Willing and Partners for PWD |
| *Duck River Flood Study* | 1994 | PCC | Brian O'Mara |
| *Duck River Flood Study - Lots 15,16 and 17 Berry St and Great Western Highway, Granville* | 1994 | PCC | Brian O'Mara |
| *Duck River Flood Study* | September 2006 | PCC | Cardno Willing |
| *A'Becketts Creek and Duck Creek Flood Study* | November 1987 | PCC | Sinclair Knight and Partners for Water Board and Department of Main Roads |
| *Duck Creek (SWP No. 35) Catchment Management Study* | 1991 | PCC | Sinclair Knight and Partners for Water Board |
| *Duck Creek Railway Culvert Analysis* | February 2007 | PCC | Cardno for Railcorp |

| *Title* | Date | LGA | Authors |
|---|---|---|---|
| *Duck Creek Sub-catchment Management Plan - Final Report With Flood Level Update* | September 2004 | PCC | Cardno Willing |
| *Lower Parramatta River - Flood Study Review* | May 2005 | PCC | SKM |
| *Lower Parramatta River - Flood FPRMS & Plan* | August 2005 | PCC | SKM & Don Fox Planning |
| *The August 1986 Flood Study - A'Becketts Creek* | 1987 | PCC | Sinclair Knight and Partners for PCC |
| *A'Becketts Creek (SWP No. 46) Catchment Management Study* | 1990 | PCC | Bewsher Consulting for Water Board |
| *Granville Flood Study* | 1990 | PCC | Sinclair Knight and Partners |
| *Parramatta Drainage Study* | 1990 | PCC | Sinclair Knight and Partners |
| *Duck Creek Flood Study GIS and Data* | | PCC | |
| *Duck River Flood Study GIS and Data* | | PCC | |
| *Lower Parramatta River - FRMS Data Disks 1 / 2* | | PCC | |
| *A'Becketts Creek - Revision of flood levels from Stormwater Channel No. 35 Catchment Management Plan* | 1993, 2008 | BCC, PCC | |
| *Lower Parramatta River Flood Study* | 1986 | PCC | Willing and Partners for PWD |
| *Parramatta City Council Local Floodplain Risk Management Policy* | 2006 | PCC | PCC |
| *Duck River Floodplain Risk Management Study and Plan (Proposal)* | 2009 | PCC | Cardno Lawson Treloar |

| *Title* | Date | LGA | Authors |
|---|---|---|---|
| *Guildford Park detention basin feasibility study* | 2004 | PCC | Cardno Willing |
| *Granville Park basin feasibility study* | 2008 | PCC | Cardno Willing |
| *Stormwater Management Plan* | 2008 | BCC | |
| *Duck River Stormwater Catchment Study including 2009 addendum* | 2009 | BCC | Bewsher/BMT WBM |
| *Bankstown City Council DCP - Part E3 Flood Risk Management* | 2005 | BCC | |
| *BCC Flood Level Surveys* | | BCC | |
| *Wolumba Stormwater Catchment Flood Study* | 2010 | BCC | BMTWBM |

# 3 LAND USE PLANNING AND REVIEW

## 3.1 SYDNEY REGIONAL ENVIRONMENTAL PLANS

Sydney Regional Environmental Plans (SREPs) are prepared by the Minister for Planning and cover issues across the Sydney Region. SREPs which are now deemed State Environmental Planning Policies (SEPPs) provide the framework for detailed local planning by councils and are made by the Minister for Planning under the Environmental Planning and Assessment Act 1979. SREPs may be exhibited in draft form for public comment and all submissions are considered before a final plan is gazetted and becomes legal.

The two SREPs which apply to the Duck River catchment area are:

- Sydney Regional Environmental Plan (Sydney Harbour Catchment) 2005 - The Plan covers the area of Sydney Harbour, including Parramatta River and its tributaries and the Lane Cove River. The plan aims to establish a balance between promoting a prosperous working harbour, maintaining a healthy and sustainable waterway environment and promoting recreational access to the foreshore and waterways. It establishes planning principles and controls for the catchment as a whole. The plan consolidates and replaces the following instruments: - Sydney Regional Environmental Plan No. 22 - Parramatta River (SREP 22); - Sydney Regional Environmental Plan No. 23 - Sydney and Middle Harbours (SREP 23); and amends State Environmental Planning Policy No. 56 Sydney Harbour Foreshores and Tributaries (SEPP 56).
- REP No. 24 - Homebush Bay Area - Applies to land generally bounded by Parramatta River, Homebush Bay Drive, M4 and Silverwater industrial area. Provides a planning framework to guide and coordinate the continued renewal of the Homebush Bay area, including the facilities planned for the Olympics. The plan acknowledges the principles of ecologically sustainable development. It identifies and protects environmental conservation areas, as well as heritage items, heritage conservation areas and potential archaeological sites.

## 3.2 STATE ENVIRONMENTAL PLANNING POLICIES

State Environmental Planning Policies (SEPPs), also prepared by the Minister for Planning, deal with issues that are significant to the State and have been gazetted as a legal document.

Some of the SEPPs that may affect the Duck River catchment are listed below:

- SEPP (Affordable Rental Housing) 2009 - Establishes a consistent planning regime for the provision of affordable rental housing. The policy provides incentives for new affordable rental housing, facilitates the retention of existing affordable rentals, and expands the role of not-for-profit providers. It also aims to support local centres by providing housing for workers close to places of work, and facilitate development of housing for the homeless and other disadvantaged people.
- SEPP (Exempt and Complying Development Codes) 2008 - Streamlines assessment processes for development that complies with specified development standards. The policy provides exempt and complying development codes that have State-wide application, identifying, in the General Exempt Development Code, types of development that are of minimal environmental impact that may be carried out without the need for development consent; and, in the General Housing Code, types of complying development that may be carried out in accordance with a complying development certificate as defined in the Environmental Planning and Assessment Act 1979. This SEPP also introduces the concept of the Flood Control Lot, defined as a lot to which flood related development controls apply in respect of development for the purposes of dwelling houses, dual occupancies, multi dwelling housing or residential flat buildings. This concept is subject to on-going review within the relevant Departments.
- SEPP (Infrastructure) 2007 - Provides a consistent planning regime for infrastructure and the provision of services across NSW, along with providing for consultation with relevant public

authorities during the assessment process. The SEPP supports greater flexibility in the location of infrastructure and service facilities along with improved regulatory certainty and efficiency. This may only apply should there be major infrastructure proposals for the catchment.

## 3.3 LOCAL ENVIRONMENTAL PLANS

### 3.3.1 Auburn City

#### a) Local Environmental Plan

Council's principal local environmental plan - Auburn Local Environmental Plan (LEP) 2010 - was made on 29th October 2010. It applies to the entire LGA but excludes land in Sydney Olympic Park and land at Wentworth Point which are covered by specific Planning Instruments however these are outside the Duck River catchment.

Auburn LEP 2010 was prepared in accordance with State Government planning reforms which include the Standard Instrument (LEPs) Order 2006 - a State-wide LEP template which all Councils must use to prepare new principal LEPs.

Auburn LEP 2010 is the starting point for all zoning, land use and development enquiries. Through the land use tables, land use matrix and zoning map, the range of land uses that are allowed in each zone can be established, be it residential, commercial, open space or industrial. Other parts of the Auburn LEP 2010 contain specific controls that apply to certain precincts or affect certain development types such as controls relating to heritage items or may relate to environmental issues such as flood prone land.

The Auburn LEP 2010 is subject to regular amendments, so the zones may change. Council strongly recommends that the zoning be confirmed in writing, by requesting a Section 149 Planning Certificate from Council.

A Land Use Matrix accompanies the Auburn Local Environmental Plan 2010 instrument. Whilst it is not part of the instrument, it helps clarify the land uses which are permissible or prohibited in each zone. This is because the land use table does not explicitly list all permissible or prohibited land uses.

In relation to floodplain risk management, the relevant clause in LEP 2010 is:

> 6.3 Flood planning
>
> (1) The objectives of this clause are as follows:
>
> (a) to minimise the flood risk to life and property associated with the use of land,
>
> (b) to allow development on land that is compatible with the land's flood hazard, taking into account projected changes as a result of climate change,
>
> (c) to avoid significant adverse impacts on flood behaviour and the environment.
>
> (2) This clause applies to:
>
> (a) land that is shown as "Flood planning area" on the Flood Planning Map, and
>
> (b) other land at or below the flood planning level.
>
> (3) Development consent must not be granted for development on land to which this clause applies unless the consent authority is satisfied that the development:
>
> (a) is compatible with the flood hazard of the land, and
>
> (b) is not likely to significantly adversely affect flood behaviour resulting in detrimental increases in the potential flood affectation of other development or properties, and

(c) incorporates appropriate measures to manage risk to life from flood, and

(d) is not likely to significantly adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses, and

(e) is not likely to result in unsustainable social and economic costs to the community as a consequence of flooding.

(4) A word or expression used in this clause has the same meaning as it has in the NSW Government's Floodplain Development Manual published in 2005, unless it is otherwise defined in this clause.

(5) In this clause:

Flood Planning Level means the level of a 1:100 ARI (average recurrent interval) flood event plus 0.5 metre freeboard.

Flood Planning Map means the Auburn Local Environmental Plan 2010 Flood Planning Map.

#### b) Development Control Plan

Auburn Development Control Plan (DCP) 2010 has been prepared in accordance with the Environmental Planning and Assessment Act 1979 (the Act) and the Environmental Planning and Assessment Regulation 2000. The DCP applies to the same area to which the Auburn LEP 2010 applies. The DCP provides additional objectives and controls to enhance the function, appearance, and amenity of development in the Auburn local government area. The development controls include setbacks, urban design, stormwater drainage, amenity, landscaping, parking and access. The DCP covers various development types including residential, commercial and industrial development.

Under Section 79C of the Act, the consent authority is required to take into consideration the relevant provisions of this DCP in determining an application for development in the Auburn LGA.

The DCP for Stormwater Drainage covers Flood management in Section 6 of the DCP. It does note however that as the FRMP is yet to be finalised for the Duck River catchment, the Development Controls for that area are to be reviewed upon preparation of an FRMP. In the interim, the controls applicable to the Haslams Creek floodplain will be applied to Duck River. No Flood Risk Precinct (FRP) maps apply and appropriate FRPs must be determined on an individual site basis.

### 3.3.2 Bankstown City

#### a) Current

The Bankstown LGA is currently managed by the Bankstown Local Environmental Plan (LEP) 2001. The objectives of this Plan are:

(a) to regulate development in accordance with the following principles:

(i) new buildings should be designed to achieve:

(A) good urban design, and

(B) public and private safety, and

(C) energy and resource efficiency, and

(ii) remnant bushland, natural watercourses and threatened species should be protected, and

(iii) intensive trip generating activities should be concentrated in locations most accessible to rail transport, and

(iv) new development should not diminish the role of the Bankstown central business district (CBD) as a sub-regional centre, and

(v) new development in or affecting residential areas should be compatible with the prevailing suburban character and amenity of the locality of the development site, and

(b) to provide a framework within which the Council may prepare development control plans to make more detailed provisions.

The relevant clauses of LEP to floodplain management are:

- Clause 13 - 2) Flood liable land development may be carried out on flood liable land only with consent;
- Clause 26 Flood liable land "Before determining an application for consent to carry out development on flood liable land, the consent authority must consider the provisions of any relevant development control plan and the requirements of any floodplain development manual published by a public authority that the Council considers relevant to the assessment of the development;" and
- Clause 58 Floodway:

  (1) This clause applies to land within Zone 6 (a) that has the annotation "floodway" on the map.

  (2) A building must not be erected or an existing building extended on the land to which this clause applies.

The LEP is supported by the Bankstown Development Control Plan 2005. The objectives of this DCP are:

(a) to have a single, dynamic document that supports Bankstown Local Environmental Plan 2001;

(b) to have objectives and development controls that establish clear guidelines for development in the City of Bankstown;

(c) to develop a high quality urban environment and built form character in the City of Bankstown;

(d) to ensure development contributes to the prosperity of the City of Bankstown;

(e) to ensure development protects and enhances the natural environment in the City of Bankstown;

(f) to ensure development incorporates the principles of ecologically sustainable development; and

(g) to promote a safe and secure environment in the City of Bankstown.

Part E3 of the DCP supports the LEP by providing additional objectives and development controls to control development of flood liable land in the City of Bankstown. Council adopted the amendments to Part E3 on 23 May 2006 and the amendments came into effect on 1 July 2006.

Part E3 applies to all flood liable land in the City of Bankstown. It states that flood liable land identified by the Georges River Flood Risk Management Plan is depicted in a map. Flood Studies for the Duck River catchment and the Wolumba catchment have been adopted by Council and the resulting maps can be viewed in either the Council offices or on Council's web-site.

The objectives of Part E3 of this DCP are:

(a) to reduce the risk to human life and damage to property caused by flooding through controlling development on land affected by potential floods;

(b) to apply a "merit-based approach" to all development decisions which takes account of social, economic and environmental as well as flooding considerations in accordance with the principles contained in the NSW Floodplain Development Manual (FDM);

(c) to control development and other activity within each of the individual floodplains within the LGA having regard to the characteristics and level of information available for each of the floodplains; and

(d) to assess applications for development on land that could be flood affected in accordance with the principles included in the FDM, issued by the State Government.

Schedule 5 - Catchments Affected by Stormwater Flooding contains a development matrix applied to land affected by flooding setting out what types of development are permissible in different flood zones and what development controls apply. This matrix and accompanying notes and directions is based on the principles applied to the Georges River and currently under review by Council. It considers what development controls should apply to the full range of potential developments on land defined as being within the medium or high flood risk precincts.

#### b) Proposed

Bankstown City Council has prepared a Draft Standard Instrument Principal LEP in accordance with State Government planning reforms which include the Standard Instrument (LEPs) Order 2006 - a State-wide LEP template which all Councils must use to prepare new principal LEPs.

This LEP, when adopted, will be the starting point for all zoning, land use and development enquiries. Through land use tables, land use matrix and zoning map, the range of land uses that are allowed in each zone will be established, be it residential, commercial, open space or industrial. Other parts of the LEP will contain specific controls that apply to certain precincts or affect certain development types such as controls relating to heritage items or may relate to environmental issues such as flood prone land.

The LEP has yet to be reported to Council or placed on public exhibition. Council has advised that there are no proposed zoning changes at this point in time, however there will be a change to the flood clauses to reflect the Standard Instrument.

### 3.3.3 Parramatta City

#### a) Local Environmental Plan

Parramatta City Council has prepared a revised Standard Instrument Principal LEP in accordance with State Government planning reforms which include the Standard Instrument (LEPs) Order 2006 - a State-wide LEP template which all Councils must use to prepare new principal LEPs. The Parramatta LEP 2011 was published on 7 October 2011 and replaces Parramatta LEP 2001 and SREP No 28.

This LEP is the starting point for all zoning, land use and development enquiries. Through land use tables, and the zoning map, the range of land uses that are allowed in each zone will be established, be it residential, commercial, open space or industrial. Other parts of the LEP will contain specific controls that apply to certain precincts or affect certain development types such as controls relating to heritage items or may relate to environmental issues such as flood prone land.

In relation to floodplain risk management, the relevant clause in LEP 2010 is:

6.3 Flood planning

(1) The objectives of this clause are as follows:

(a) to minimise the flood risk to life and property associated with the use of land,

(b) to allow development on land that is compatible with the land's flood hazard, taking into account projected changes as a result of climate change,

(c) to avoid significant adverse impacts on flood behaviour and the environment.

(2) This clause applies to land at or below the flood planning level.

(3) Development consent must not be granted to development on land to which this clause applies unless the consent authority is satisfied that the development:

(a) is compatible with the flood hazard of the land, and

(b) is not likely to significantly adversely affect flood behaviour resulting in detrimental increases in the potential flood affectation of other development or properties, and

(c) incorporates appropriate measures to manage risk to life from flood, and

(d) is not likely to significantly adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses, and

(e) is not likely to result in unsustainable social and economic costs to the community as a consequence of flooding.

(4) A word or expression used in this clause has the same meaning as it has in the Floodplain Development Manual (ISBN 0 7347 5476 0), published in 2005 by the NSW Government, unless it is otherwise defined in this clause.

(5) In this clause:

Flood Planning Level means the level of a 1:100 ARI (average recurrent interval) flood event plus 0.5 metre freeboard.

### b) Development Control Plan

Parramatta Development Control Plan (DCP) 2011 has been prepared in accordance with the Environmental Planning and Assessment Act 1979 (the Act) and the Environmental Planning and Assessment Regulation 2000. The DCP applies to the same area to which the Parramatta Local Environmental Plan 2011 applies. The DCP provides additional objectives and controls to enhance the function, appearance, and amenity of development in the Parramatta local government area. The development controls that apply to flooding are to be found in Section 2.4.2 and are listed below. Tables relating to "Land Use Category Definitions" and "Flood Risk Precincts" are not reproduced in this Study and can be inspected on Council's web-site.

**Flooding**

Flooding is a significant issue that affects existing and future development in the Parramatta Local Government Area (LGA). This Section establishes Council's approach to floodplain planning and the general flood prone land requirements relating to development control for the whole LGA. The development of Council's approach to flooding has regard to and complies with the New South Wales Government's Floodplain Development Manual (FDM 2005).

The criteria for determining applications for proposals potentially affected by flooding are structured to recognise that different controls are applicable to different land uses and levels of potential flood inundation and hazard. As a first step in the development consent process, proponents are strongly advised to consult with Council officers, particularly for proposals located in the medium and high flood risk categories.

**Objectives**

O.1 To ensure the proponents of development and the community in general are aware of the potential flood hazard and consequent risk and liability associated with the use and

development of flood liable land.

O.2 To manage flood liable land in an economically, environmentally and socially sustainable manner.

O.3 To ensure that developments with high sensitivity to flood risk (e.g. critical public utilities) are sited and designed to provide reliable access and minimise risk from flooding.

O.4 To allow development with a lower sensitivity to the flood hazard to be located within the floodplain, subject to appropriate design and siting controls and provided that the potential consequences that could still arise from flooding remain acceptable.

O.5 To prevent any intensification of the development and use of High Flood Risk Precinct or floodways, and wherever appropriate and feasible, allow for their conversion to natural waterway corridors.

O.6 To ensure that the proposed development does not expose existing development to increased risks associated with flooding.

O.7 To ensure building design and location address flood hazard and do not result in adverse flood impact and unreasonable impacts upon the amenity or ecology of an area.

O.8 To minimise the risk to life by ensuring the provision of appropriate access from areas affected by flooding up to extreme events.

O.9 To minimise the damage to property, including motor vehicles, arising from flooding.

O.10 To incorporate the principles of Ecologically Sustainable Development (ESD).

**Design Principles**

P.1 New development should not result in any increased risk to human life.

P.2 The additional economic and social costs which may arise from damage to property from flooding should not be greater than that which can reasonably be managed by the property owner, property occupants and general community.

P.3 New development should only be permitted where effective warning time and reliable access is available for the evacuation of an area potentially affected by floods to an area free of risk from flooding. Evacuation should be consistent with any relevant flood evacuation strategy where in existence.

P.4 Development should not adversely increase the potential flood affectation on other development or properties, either individually or in combination with similar developments(s) that are likely to occur within the same catchment.

P.5 New developments must make allowances for motor vehicles to be relocated to an area with substantially less risk from flooding, within an effective warning time.

P.6 New developments must provide an evacuation plan detailing procedures that would be in place for an emergency (such as warning systems, signage or evacuation drills).

P.7 Flood mitigation measures associated with new developments should not result in significant impacts upon the amenity of an area by way of unacceptable overshadowing of adjoining properties, privacy impacts (e.g. by unsympathetic house raising) or by being incompatible with the streetscape or character of the locality (including heritage).

P.8 Proposals for raising structures must provide a report from a suitably qualified engineer demonstrating that the raised structure will not be at risk of failure from the forces of floodwaters.

P.9 Development is to be compatible with any relevant Floodplain Risk Management Plan, Flood Studies, or Sub-Catchment Management Plan.

P.10 Development must not divert flood waters, nor interfere with floodwater storage or the natural function of waterways.

P.11 Filling of land up to 1:100 Average Recurrence Interval (ARI) (or flood storage area if determined) is not permitted. Filling of and above 1:100 ARI up to the Probable Maximum Flood (PMF) (or in flood fringe) must not adversely impact upon flood behaviour.

P.12 New development must consider the impact of flooding resulting from local overland flooding whether it is a result of Local Drainage or Major Drainage.

P.13 Where hydraulic flood modelling is required, flow hazard categories should be identified and adequately addressed in the design of the development.

P.14 Council strongly discourages basement car parks on properties within the floodplain. Where site conditions require a basement car park on a property within the floodplain, development applications must provide a detailed hydraulic flood study and design demonstrating that the proposed basement car park has been protected from all flooding up to and including the PMF event. An adequate emergency response and evacuation plan must also be provided where basement car parks are proposed in the floodplain.

**Design Controls**

All proposals are to have regard to the planning matrix at Figure 2.7 (not included). The procedure to determine which design standards apply to proposed development involves:

Step 1: identify the land use category of the development from Table 2.6;

Step 2: determine which flood risk category applies to the land (refer to Catchment Management Unit of Council for the Flood Risk Precincts and relevant flood risk mapping); and

Step 3: apply the objectives and design principles as outlined in this section and then the design standards in the planning matrix at Figure 2.7 as applicable to the floodplain and land use category.

NOTE: An evacuation plan is not enough to negate compliance with all building regulations.

Additional guidelines relating to flood risk management and flood prone land are contained in Council's Local Floodplain Risk Management Policy.

## 3.4 LAND USE - ZONINGS

### 3.4.1 Auburn

Zonings for the Auburn LGA are shown on the zoning map from the Auburn LEP 2010 (not included in this Report). On that map, the land in areas potentially affected by flooding from Duck River predominately fall into the following zonings:

- Public Recreation;
- General Industrial;
- Infrastructure; and
- Enterprise Corridor.

However, it should be noted that residential areas in the localities surrounded by Manchester Road, Chisholm Road and Mona Street and Mary Street, Chisholm Road and Tavistock Street are increasingly affected by floods between the 100 year ARI and the PMF.

### 3.4.2 Bankstown

Current zonings for the areas of the Bankstown LGA, potentially affected by Duck River flooding, are shown on Zoning Maps 7, 8, 15, 16, 22, 23, 29 and 30 of the LEP. On these maps, the land in potentially flood affected areas covers a wide range of zonings but predominately falls into the following zonings:

- Open Space;
- Residential A;
- General Industrial;
- Light Industrial; and
- Special Uses.

### 3.4.3 Parramatta

Current zonings for the areas of the Parramatta LGA potentially affected by Duck River flooding, are shown on Zoning Maps 6, 10, 11, 12 and 15 in the Parramatta Local Environmental Plan (LEP) 2011 (not included in this Report). On these maps, the land in areas potentially affected by flooding from Duck River covers a wide range of zonings but predominately falls into the following zonings:

- Heavy Industrial / General Industrial;
- Private Recreation;
- Low Density Residential;
- High Density Residential;
- Public Recreation;
- Infrastructure;
- Environmental Conservation;
- Enterprise Corridor.

# 4 FLOOD BEHAVIOUR AND IMPACTS

## 4.1 FLOOD BEHAVIOUR

### 4.1.1 General

There have been a number of previous Flood Studies within the Duck River catchment and while these earlier studies provided significant input to the work recorded in this Report, the principal source of flood data and mapping was based on Duck River and Duck Creek Flood Study Review (WMAWater 2010), Duck River Stormwater Catchment Study and addendum (Bewsher/BMT WBM, June 2007 and BMT WBM addendum of 2009) and Wolumba Stormwater Catchment Flood Study (BMT WBM 2010). The following Sections provide a short summary based on that document.

### 4.1.2 Flood Studies

#### a) Parramatta / Auburn

As part of the Duck River Floodplain Risk Management Study, a review of the previous Flood Studies was undertaken. The principal reasons for this review were to ensure:

- Consistency in the approach within the PCC and ACC LGA; and
- Results compatible with the approach adopted within the upstream BCC LGA.

The Flood Study Review revealed some inconsistencies within the existing studies and models because they had been carried out by different organisations for different purposes over more than 20 years. Modelling techniques and technologies have changed over that time. Following detailed analysis and resolution of the identified issues, WMAwater established a TUFLOW hydraulic model for the main channel of Duck River and Duck Creek within PCC and ACC LGAs which is consistent with the model and assumptions used for the recently completed flood study for the Duck River and Wolumba catchments in Bankstown LGA.

#### b) Bankstown

BMT WBM was commissioned by Bankstown City Council through Bewsher Consulting to undertake a stormwater runoff study of the Duck River catchment within BCC. The study included the development of relevant computer models within the catchment, which will assist Council in managing floods within the catchments.

The first stage of the study focused on the MIKESTORM model development – to determine the flow rates and water levels in the pits and pipes stormwater runoff system as well as providing approximations of overland flood flows. The second stage of the study focused on the TUFLOW hydraulic model development. TUFLOW includes the computing capabilities of the MIKESTORM model with the additional capability of two-dimensional mapping of the flood results. The model outputs and scale as well as the computing intensity of the TUFLOW model make it a suitable tool for floodplain management purposes.

The Duck River catchment model included all the stormwater pits and pipes in the catchment, the creeks and open drains, and the floodplain topography and characteristics. It determined the flood extents, water levels, velocities and provisional hazards for the 1 year, 2 year, 5 year, 10 year, 20 year, 50 year and 100 year ARI flood events and the PMF for the entire study area.

The Wolumba study looked at the 20, 50, 100, 200, 500 1000 year ARI flood events and the PMF. Provisional flood hazards were defined for the 100 year flood event.

#### c) Overall

The Bankstown models by BMT WMB and the Parramatta / Auburn model by WMAWater have been deemed suitable for application to the Floodplain Risk Management process. These effectively constitute the first stage of the floodplain risk management process, superseding the previous flood studies for Parramatta and provide the basis for the future management of the floodplain.

The lower catchment model considers inundation from overtopping of the main channels only (i.e., mainstream flooding) and does not consider inundation within the local catchments (overland flooding) which contribute to the main channel system. The modelling in the Bankstown LGA considers both flooding mechanisms.

### 4.1.3 Flood Mechanisms

Based on the available information, site observations and experience in similar catchments, flooding within the study area occurs as a result of three main mechanisms:

- Flow in excess of the pit and pipe networks being conveyed along roads and overland flowpaths to natural low points, ultimately reaching the open channels (termed overland flooding in this report). Flooding may be exacerbated by inadequate or blocked local drainage systems and restrictions in overland flow paths such as buildings or fences;
- Overtopping of the main channels and spreading into the overbank areas (termed mainstream flooding in this report), this may be exacerbated by blockage of bridges and culverts along the main channel; and
- Elevated water levels in the Parramatta River.

### 4.1.4 Historical Flood Information

There is extensive documentation of past flooding within the catchment, mainly within the Parramatta LGA contained within previous studies of the Duck River catchment. The key sources of information include the 1986 Lower Parramatta River Study and the 1991 Duck Creek SWP No. 35 Catchment Management Study. While there are many measured levels throughout the catchment, they only relate to three floods: April 1969; April 1974 and August 1986.

## 4.2 EXISTING FLOODPLAIN RISK MANAGEMENT MEASURES

### 4.2.1 Property Modification

Within all three LGAs, the predominant existing floodplain risk management measure is an application of property modification through various planning controls and conditions.

### 4.2.2 Flood Behaviour Modification

There is very limited application of measures in the catchment which modify flood behaviour. Within the Parramatta LGA, a section of Granville Park was recently modified to act as a retarding basin and this benefits the properties immediately downstream. Within Bankstown LGA a levee bank was constructed behind properties backing onto Rose Park in response to flooding in the late 1980's/early 1990's.

Historically, there has been significant channelisation of the creeks/river and while this has had some benefit for the more common floods, it has been accompanied by development close to the channels

resulting in inundation of development in larger floods, and it limits scope to enhance channel capacity.

### 4.2.3 Flood Preparedness

With regard to managing human responses to flooding as a means of mitigating their impacts, there is no specific SES Local Flood Plan that covers the Duck River catchment, there is no flood warning system in place and no systematic community education has been implemented. This is discussed further in Section 6.

It should be noted that there is a Blacktown Local Flood Plan which addresses mainly the Georges River flooding. This will be further discussed in Section 9.1 below.

## 4.3 FLOOD DAMAGES

The costs of flood damages and the extent of the disruption to the community depend upon many factors including:

- The characteristics (depth, velocity, rate of rise and duration) of the flood;
- Land usage and susceptibility to damages e.g. whether floor levels are inundated;
- Awareness of the community to flooding;
- Effective warning time; and
- The availability of an evacuation plan or damage minimisation program.

The following sections describe how the damages estimates were prepared, the data used and the various calculations and parameters used in the estimations.

### 4.3.1 Floor Level Database

In order to estimate the damages associated with property inundation of existing development in the Duck River catchment a floor level database was established. It should be noted that the floor level estimates are based on a range of methods, as described below. Due to the varied levels or accuracy associated with each method of capturing floor levels, the floor levels themselves should be treated with some caution, as they were captured for the purposes of a flood damages assessment, and should not be used to provide advice on an individual property basis, such as for insurance purposes or information included on Section 149 Certificates.

#### a) Bankstown City Council LGA

In Bankstown City Council LGA, a floor level survey for the upper Duck River catchment was undertaken by Council in 2008 using a GPS and laser gun system. A subsequent survey was undertaken in 2010 within the upper Duck River catchment as a result of updated flood extent mapping and to resolve inconsistencies with the previous survey; the Wolumba catchment was also surveyed at this time. Surveys undertaken in 2010 also include a digital photo of buildings which has been linked to the database. The database comprising of 1760 floor levels for the upper Duck River and the Wolumba catchments within the Bankstown City Council LGA was provided in GIS and spreadsheet format by Council in December 2010. Both residential and non-residential properties are included in the database for this portion of the study area.

Of the approximately 1,760 buildings contained in the database, flood modelling showed that only approximately 549 were inundated above floor level in the PMF; these were included in the floor level flood damages assessment. Other properties that had only property inundation were also included in

the flood damages assessment, for although the flood damages assessment is heavily influenced by above-floor inundation, damage to assets in yards make a small but significant contribution to total damages.

#### b) Parramatta City Council LGA

As a result of the current study, WMAwater surveyed the floor levels of over 600 residential properties within the Parramatta City Council LGA. These properties were identified as being within the 100 year ARI flood extent. Floor levels were obtained by estimating the height of the building floor above ground level and obtaining the ground level from the aerial laser survey (ALS) data provided by council. This approach was adopted as opposed to a field survey by a Registered Surveyor for economic considerations. Within the lower parts of Duck Creek and Duck River catchments there is a considerable amount of non-residential (mainly industrial and large commercial premises) properties. A detailed flood damages assessment for these properties was outside the scope of the present study as the prime focus of the NSW Government's Floodplain Management Process is to reduce flood damages for residential properties. For this reason and the complexity in obtaining the relevant data necessary to evaluate flood damages for non-residential properties a floor height of 0.5 m was assumed for all non-residential properties in this part of the study area.

#### c) Auburn City Council LGA

No residential floor level survey was undertaken within the Auburn LGA as an initial review of the flood extents indicated that no residential properties would be affected by floods up to the 100 year ARI flood. However, there are large sections of residential land that are affected by the PMF and those lots are shown on Figure 2 as described below.

### 4.3.2 Flooding of Properties

To assist in the development of the Flood Damages Estimates a series of maps was developed that show which flood initially inundated the floor of each property (see Figure 2, Figure 3 and Figure 4). It must be stressed that these maps are indicative only and should be used as a guide to localities where flood damages reduction may be achieved. The results are summarised in Table 1 below.

*Table 1: Number of Properties with Water Inside a Building During Flooding*

| LGA | Subarea | Code | PMF | 100y | 50y | 20y | 5y |
|---|---|---|---|---|---|---|---|
| *Auburn* | Commercial/Industrial | AI | 160 | 47 | 37 | 22 | 9 |
| *Bankstown* | Wolumba | B1 | 9 | 4 | 3 | 3 | 2 |
| *Bankstown* | Duck River U/S Hume Highway | B2 | 26 | 11 | 8 | 8 | 6 |
| *Bankstown* | Duck River U/S Carlingford Road | B3 | 320 | 81 | 65 | 53 | 34 |
| *Bankstown* | Duck River U/S SW Pipeline | B4 | 96 | 49 | 25 | 16 | 8 |
| *Bankstown* | Commercial/Industrial | BI | 98 | 47 | 30 | 27 | 19 |
| *Auburn* | Duck River | DA | 163 | 0 | 0 | 0 | 0 |
| *Parramatta* | Duck Creek | DC | 906 | 93 | 63 | 35 | 6 |
| *Parramatta* | Duck River | DP | 217 | 0 | 0 | 0 | 0 |
| *Parramatta* | Little Duck Creek | LDC | 377 | 78 | 54 | 38 | 8 |
| *Parramatta* | Commercial/Industrial | PI | 220 | 39 | 28 | 17 | 7 |
| | *Parramatta* | | 1720 | 210 | 145 | 90 | 21 |
| | *Bankstown* | | 549 | 192 | 131 | 107 | 69 |
| | *Auburn* | | 323 | 47 | 37 | 22 | 9 |
| | | **TOTAL** | 2592 | 449 | 313 | 219 | 99 |

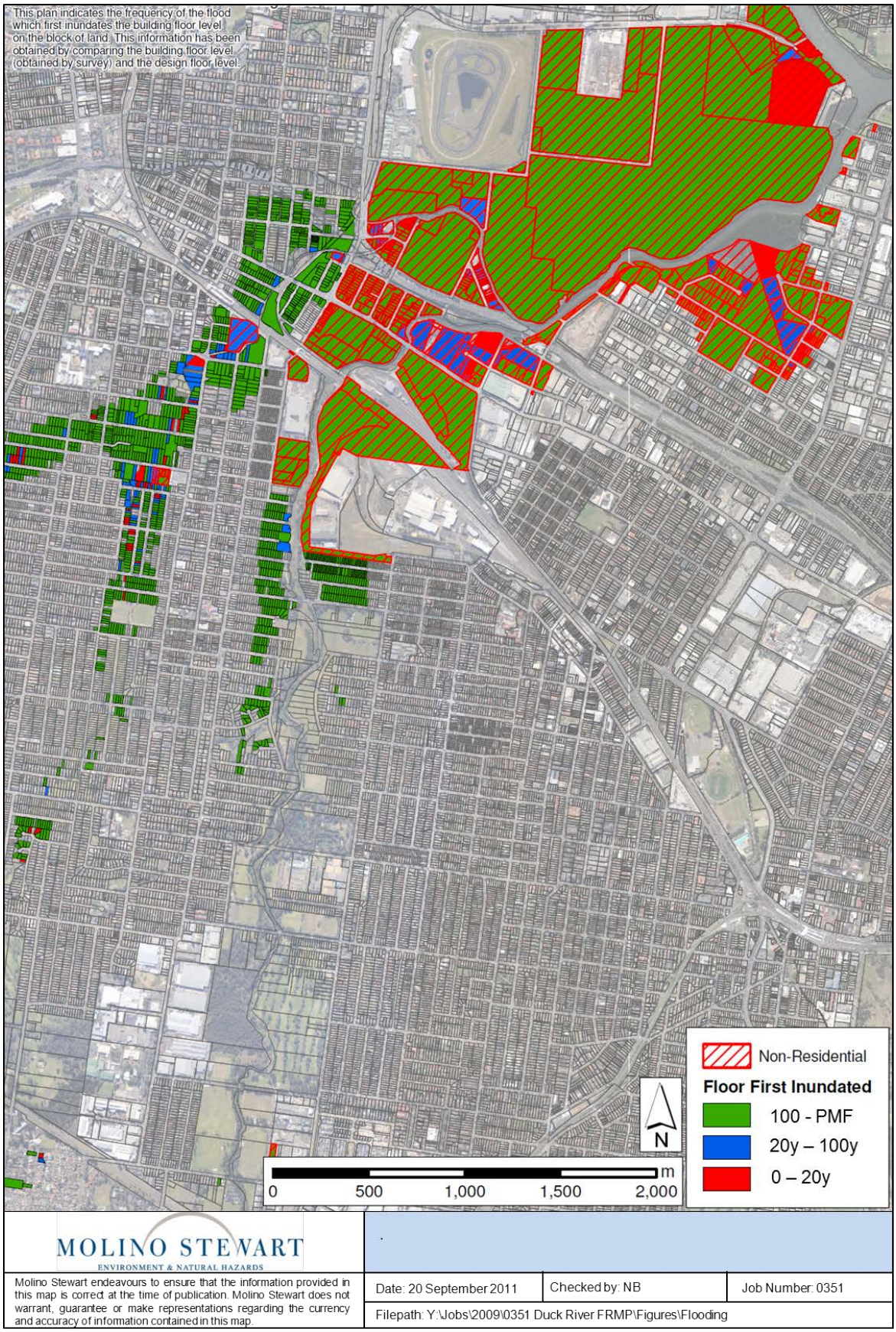


*Figure 2 - Flood affected properties in Auburn/Parramatta- shows first flood to affect*

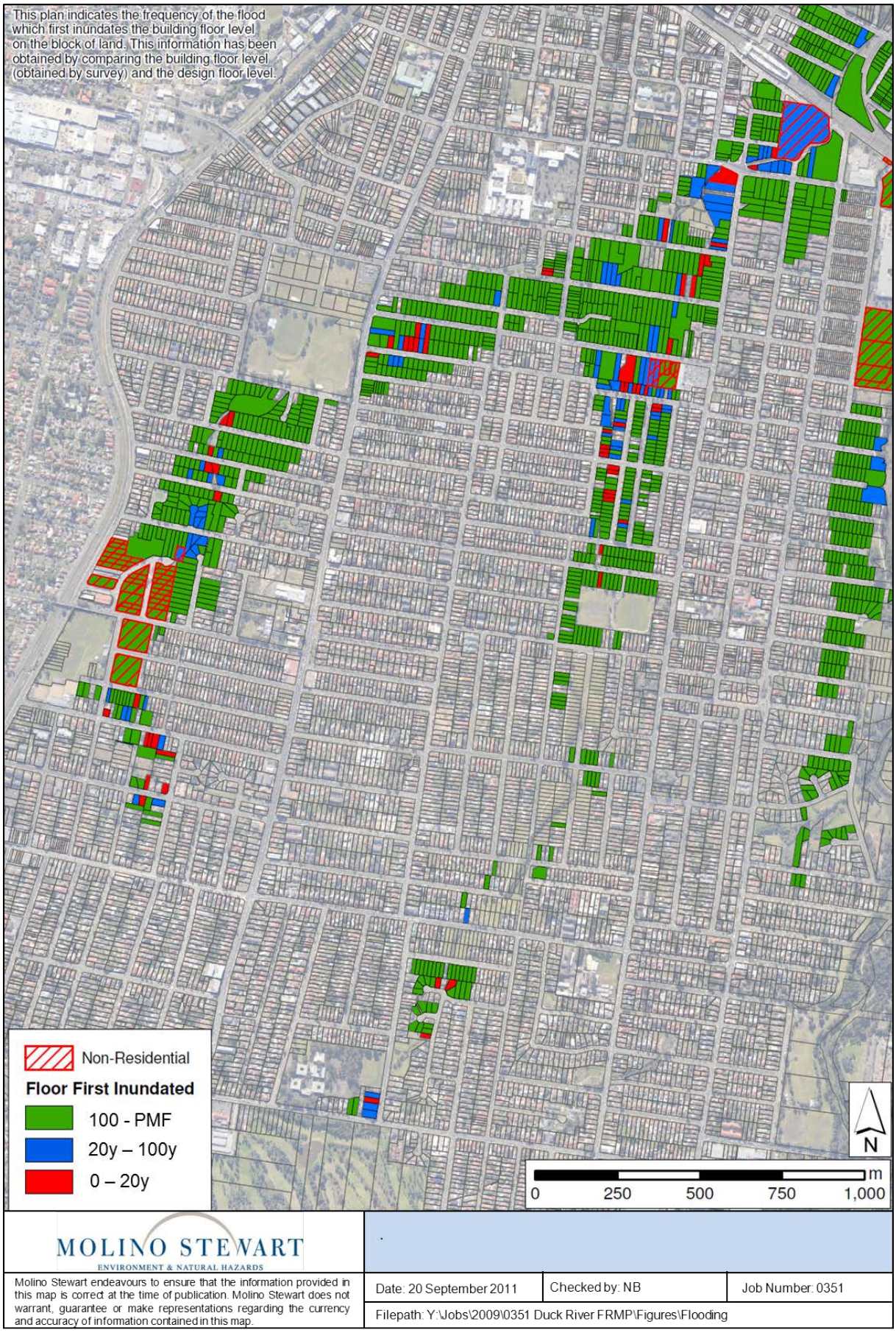


*Figure 3 - Flood affected properties in Auburn/Parramatta- shows first flood to affect*

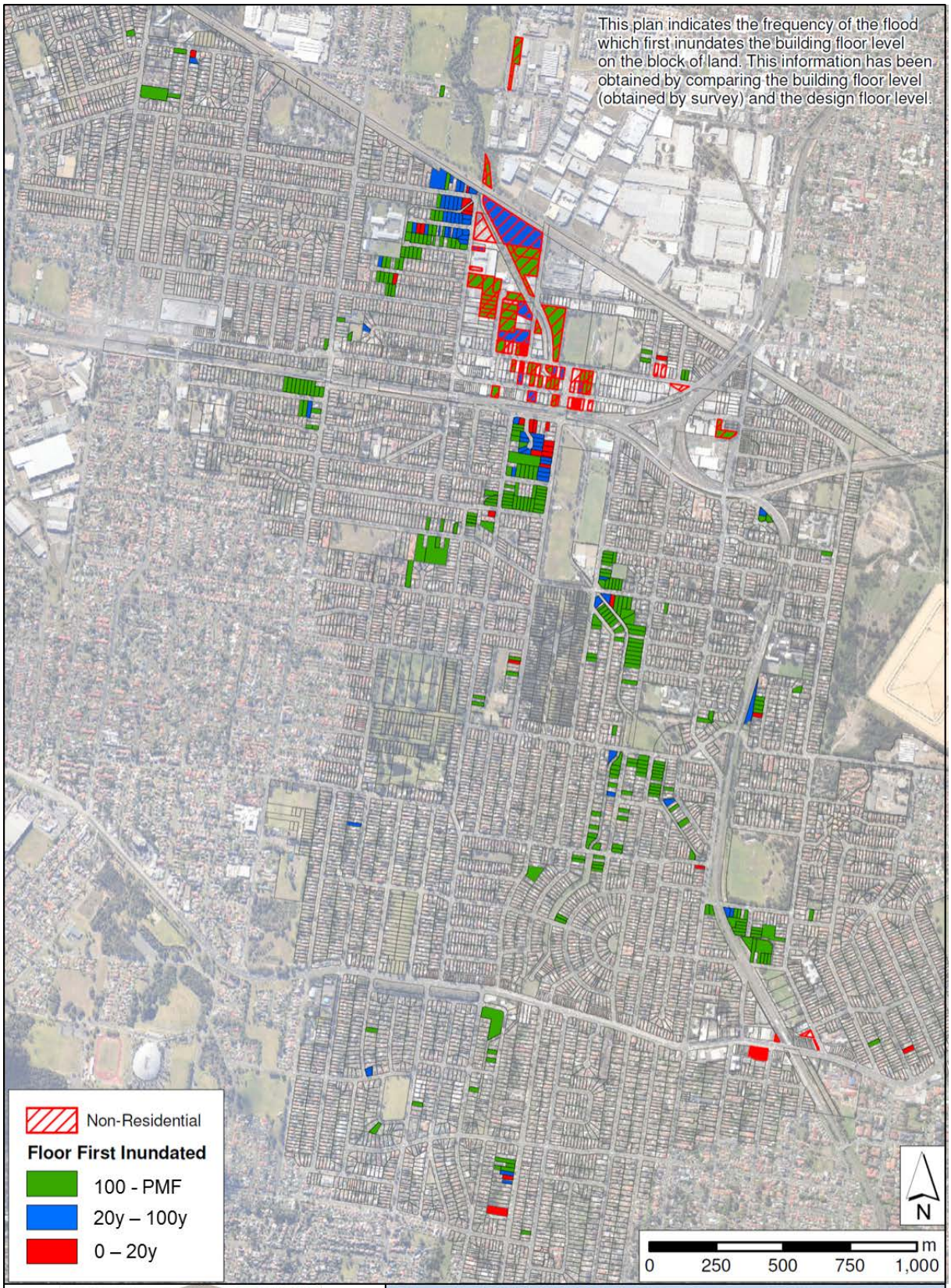


*Figure 4 - Flood affected properties in Auburn/Parramatta- shows first flood to affect*

### 4.3.3 Description of Flood Damages

Flood damages can be defined as being “tangible” or intangible”, both of which may be further divided into direct and indirect damages. Tangible damages are those damages for which a monetary value can be assigned, in contrast to intangible damages, which cannot easily be attributed a monetary value. A summary of the types of damages is provided in Figure 5.

While the total likely damages in a given flood are useful to get a “feel” for the magnitude of the flood problem, it is of little value for absolute economic evaluation. When considering the economic effectiveness of a proposed mitigation option, the key question is what are the total damages prevented over the life of the option? This is a function not only of the high damages which occur in large floods but also of the lesser but more frequent damages which occur in small floods.

The standard way of expressing flood damages is in terms of average annual damages (AAD). AAD represents the equivalent average damages that would be experienced by the community on an annual basis by a series of floods over a very long time, by taking into account the probability of each flood’s occurrence. This means the smaller floods, which occur more frequently, are given a greater weighting than the rare catastrophic floods. For the calculation of AAD in this study it was assumed that there are no flood damages in the flood which has an ARI of one year. A flood damages assessment was undertaken for existing development in the Duck River catchment and is summarised in Table 2 and Table 3.

It should be noted that the damages quoted are “potential” damages and do not describe actual damages from an historical flood. Usually, there is an allowance to take potential damages to actual damages, taking into account any measures taken to reduce the damages, e.g., raising furniture and valuables above flood levels, evacuating material from the property, etc. In the case of the Duck River catchment, the reduction is likely to be small as the effective warning time is very short and the community is not all flood aware.

**Tangible Damages**
**Financial - Costs which can be expressed in dollars.**

**Intangible Damages**

**Costs which cannot be expressed in dollars, e.g.:**
**stress and anxiety, loss of life, serious illness / injury, depression, inconvenience, environmental degradation, insecurity. loss of personal memorabilia, loss of cultural heritage items**

Damage caused by floodwaters coming into contact with items. This can be expressed as "Potential" (max. damage) and "Actual" (reduced damages due to moving items).

**Direct**

**Indirect**

Costs associated with the flood event occurring, but not as readily quantifiable.

| | **Internal** | **Structural** | **External** | **Clean-up** | **Financial** | **Opportunity** |
|---|---|---|---|---|---|---|
| ***RESIDENTIAL*** | Contents of Buildings: Clothes, Carpets, Furniture, Valuables, Fittings, Appliances | External Items: Vehicles, Laundries, Caravans, Sheds, Tools, Gardens, Fences | Physical Damage to Buildings: Gyprock, Cupboards, Scour of Footings, Houses becoming buoyant (floating off footings) | Clean Carpets, Walls, Clothes; Re-instate Furniture; Remove Mud and Debris | Loss of wages, Living costs (temporary accommodation and food), Time to repair/replace damaged items | Not Applicable |
| ***COMMERCIAL*** | Contents of Buildings: Products, Stock, Fittings, Tools, Machinery, Raw Materials | External Items: Vehicles, Machinery, Display, Raw Materials/Stockpiles, Fences | Physical Damage to Buildings | Dispose of damaged products, stock, materials; Cleaning and Re-instatement | Loss of Productivity and Income, Bank Interest Charges | Loss of existing &/or Potential Trade |
| ***PUBLIC AUTHORITIES*** | Contents of Public Buildings and Facilities | Public Property and Facilities: Parks, Signs, Machinery, Equipment | Physical Damage to Infrastructure: Electricity, Water, Telephone, Gas, Road & Rail Transport Links | Remove Mud & Debris from Facilities, Public & Private Property Repairs (temporary & permanent) | Disruption of Services, Community Service Relief Grants | Provision of Public Service |

*Figure 5 - Flood Damages Categories*

*Table 2 - Summary of Direct Flood Damages*

| Council | Subarea | Code | PMF | 100y | 50y | 20y | 5y |
|---|---|---|---|---|---|---|---|
| Auburn | Industrial | AI | $16,033,000 | $4,167,840 | $3,303,680 | $2,285,250 | $1,340,400 |
| Auburn | Duck River | DA | $13,782,310 | $0 | $0- | $0- | $0- |
| Bankstown | Wolumba | B1 | $571,150 | $349,080 | $284,780 | $282,680 | $236,980 |
| Bankstown | Duck River U/S Hume Highway | B2 | $1,662,890.00 | $944,900.00 | $872,390.00 | $827,330 | $712,680 |
| Bankstown | Duck River U/S Carlingford Road | B3 | $24,747,330 | $8,871,250 | $7,787,590 | $6,929,210 | $5,508,800 |
| Bankstown | Duck River U/S SW Pipeline | B4 | $7,392,810 | $3,622,130 | $2,657,190 | $2,082,710 | $1,663,740 |
| Bankstown | Industrial | BI | $7,381,370 | $3,730,150 | $3,088,530 | $2,702,280 | $2,267,900 |
| Parramatta | Duck Creek | DC | $76,379,280 | $9,744,170 | $7,164,350 | $5,122,280 | $3,031,320 |
| Parramatta | Duck River | DP | $17,813,700 | $198,230 | $148,740 | $79,330 | $39,660 |
| Parramatta | Little Duck Creek | LDC | $28,860,990 | $7,593,560 | $6,287,940 | $4,829,300 | $2,735,300 |
| Parramatta | Industrial | PI | $20,831,750 | $3,480,810 | $2,668,530 | $1,967,460 | $1,104,540 |
| | | Parramatta | $143,885,720 | $21,016,770 | $16,269,560 | $11,998,370 | $6,910,820 |
| | | Bankstown | $41,755,550 | $17,517,510 | $14,690,480 | $12,824,210 | $10,390,100 |
| | | Auburn | $29,815,310 | $4,167,840 | $3,303,680 | $2,285,250 | $1,340,400 |
| | | TOTAL | $215,456,580 | $42,702,120 | $34,263,720 | $27,107,830 | $18,641,320 |

*Table 3 - Summary of Total Flood Damages (Direct + Indirect + Infrastructure + Motor Vehicles + Social)*

| Council | Subarea | Code | PMF | 100y | 50y | 20y | 5y |
|---|---|---|---|---|---|---|---|
| Auburn | Industrial | AI | $25,652,800 | $6,668,540 | $5,285,880 | $3,656,400 | $2,144,650 |
| Auburn | Duck River | DA | $24,591,590 | $0- | $0- | $0- | $0- |
| Bankstown | Wolumba | B1 | $969,320 | $558,530 | $455,650 | $452,280 | $379,170 |
| Bankstown | Duck River U/S Hume Highway | B2 | $ 2,892,410 | $1,511,840 | $1,395,820 | $1,323,720 | $1,140,280 |
| Bankstown | Duck River U/S Carlingford Road | B3 | $43,489,250 | $14,194,000 | $12,460,150 | $11,086,740 | $8,814,080 |
| Bankstown | Duck River U/S SW Pipeline | B4 | $13,062,680 | $5,795,400 | $4,251,500 | $3,332,340 | $2,661,980 |
| Bankstown | Industrial | BI | $11,810,190 | $5,968,240 | $4,941,640 | $4,323,650 | $3,628,640 |
| Parramatta | Duck Creek | DC | $134,380,280 | $15,590,670 | $11,462,960 | $8,195,650 | $4,850,110 |
| Parramatta | Duck River | DP | $30,839,050 | $317,170 | $237,980 | $126,920 | $63,460 |
| Parramatta | Little Duck Creek | LDC | $51,070,590 | $12,149,700 | $10,060,700 | $7,726,890 | $4,376,470 |
| Parramatta | Industrial | PI | $33,330,800 | $5,569,300 | $4,269,640 | $3,147,940 | $1,767,260 |
| | | Parramatta | $249,620,720 | $33,626,840 | $26,031,280 | $19,197,400 | $11,057,300 |
| | | Bankstown | $72,223,850 | $28,028,010 | $23,504,760 | $20,518,730 | $16,624,150 |
| | | Auburn | $50,244,390 | $6,668,540 | $5,285,880 | $3,656,400 | $2,144,650 |
| | | TOTAL | $372,088,960 | $68,323,390 | $54,821,920 | $43,372,530 | $29,826,100 |

### 4.3.4 Tangible Flood Damages

#### a) Direct Flood Damages

Tangible flood damages are comprised of two basic categories, direct and indirect damages. Direct damages are caused by floodwaters wetting goods and possessions thereby damaging them and resulting in either costs to replace or repair or a reduction in their value. Direct damages are further classified as either internal (damage to the contents of a building including carpets, furniture), structural (referring to the structural fabric of a building such as foundations, walls, floors, windows) or external (damage to all items outside the building such as cars, garages). Indirect damages are the additional financial losses caused by the flood including the cost of temporary accommodation, loss of wages by employees etc. Tangible damages include external damages which may occur with or without house floor inundation.

#### b) Indirect Flood Damages

Indirect damages can take many forms and can be quantified with a monetary value, some examples including occupation of alternative accommodation and reduced industrial output. The magnitude of indirect damages will be dependent upon the degree of alteration to the normal levels and paths of societal economic activity and the spatial boundary in which the economy is analysed. For the purposes of this study, indirect damages were estimated as a fixed proportion of direct Average Annual Damages (AAD) at the local-scale.

There have been a number of investigations both in Australia and overseas which have estimated indirect damages from actual floods and reported these as a percentage of direct residential damages (Table 4). From this information, the percentages to be adopted to calculate indirect residential damages (including clean-up costs) in this study were five (5) per cent of direct damages for events more frequent than a 100 year ARI. For the 100 year ARI flood and larger floods, 25 per cent of the direct damages were assumed as a reasonable estimation of indirect damage.

*Table 4 - Indirect residential damages from past studies (adapted from Smith et. al., 1990).*

| *Study* | Percentage | Comments |
|---|---|---|
| *USA - (Kates, 1965)* | 15% | Surveyed. Excludes clean up costs. |
| *Brisbane - (SMEC, 1975)* | 15% | Assumed. |
| *Lismore - (Smith et al, 1979)* | 39% | Surveyed. Includes clean up costs. |
| *Sydney - (Joy, 1986)* | 5% | Surveyed. Excludes clean up costs. |
| *Sydney - (Smith et al, 1990)* | 15% | Assumed. Includes clean up costs. |
| *Nyngan - (Water Studies, 1990)* | 41% | Surveyed. Includes clean up costs. |

#### c) Commercial and Industrial Damages

Industrial and commercial flood damages were not included in the current estimate as floor area survey would be required. Approximately 20 ~ 30% of all properties inundated were industrial or commercial, the majority of which are located near the Parramatta River.

The commercial damages were not estimated as they are not subject to government assisted flood mitigation measures and can bias damages estimates to make a measure more economically viable than it actually is. Indeed, the percentage of commercial / industrial damages to residential damages is relatively low but more influential as flood levels rise.

In addition, whether a property / residence / commercial operation is large or small is not a sound guide to the level of likely damages – it is the contents and their location that govern the damages that are caused by flooding. For example, if there are two identically sized and shaped buildings where one is a high tech warehouse and the other stores heavy mechanical equipment, the resultant damage from flooding will be very different and thus broad averages are used to produce estimates.

When considering indirect damages for commercial and industrial enterprises, it is important to distinguish between financial losses and economic losses. Indirect commercial and industrial damages are usually estimated in a similar way to residential damages. That is, they are calculated as a fixed percentage of direct damages. Table 5 lists the percentages estimated from a number of post flood surveys. It also includes a description of what costs were included in deriving the figures where this is clear from the literature.

The wide variation in ratios reflects the range of commercial and industrial enterprises considered in each of the studies and the effects of flooding on the rest of the economy. To represent a "worst-case scenario", the case of Nyngan flooding (Table 5) provides an estimate of indirect damages associated with the complete shut-down of a community for an extended period of time due to flooding – this is appropriate for indirect damages for commercial, industrial and public buildings for large-scale events (greater than or equal to the 100 year ARI). For more frequent events it was assumed tangible indirect damages would be 50 per cent of direct tangible damages. This value was derived from the previous studies where flooding did not result in complete community shut-down, as outlined in Table 5.

*Table 5 - Indirect commercial and industrial damages (Sydney Water, 1995)*

| ***Study*** | **Percentage of Direct Damages** | | **What was included** |
|---|---|---|---|
| | **Commercial** | **Industrial** | |
| USA - Kates (1965) | 37% | 45% | Loss of sales only |
| Brisbane - SMEC (1975) | | | |
| All survey returns | 35% | 65% | Not Stated |
| Survey by others | 45% | 51% | Not Stated |
| Values adopted by SMEC | 37% | 45% | Not Stated |
| Lismore - Smith *et al* (1979) | 27% | 52% | Loss of sales, removal and storage, clean up, loss of business confidence |
| Adelaide - SMEC(1980) | 45% | 72% | Not Stated |
| Sydney - Smith *et al* (1990) | 55% | 55% | Loss of sales, clean up |
| Nyngan - Water Studies (1990) | 145% | 145% | Loss of sales only |
| Surveyed | 148% | 148% | Loss of sales, clean up |
| Swalecliffe UK - Parker *et al* (1985) return periods between 3 and 250 years | 5% | 19.5% | Not Stated |

### d) Damages Calculations

The flood damages were calculated with use of a number of stage damage curves (relationship between flood depth of inundation and magnitude of tangible damages) which were developed based on guidelines provided by the State Government.

Each component of tangible damages is allocated a maximum value and a maximum depth of inundation at which this value occurs. Flood depths greater than this maximum value do not incur additional damages as it is assumed that, by this level, all potential damages have already occurred.

Internal damages were allocated a maximum value of $60,000 occurring at a depth of 2 m above the building floor level. Structural and indirect damages were combined and a maximum value of $17,000 assumed to occur at 0.5 m depth above building floor level. External damages were allocated a maximum of $3,000 occurring at 0.5 m above the property ground level and linearly proportioned for depths below this.

Indirect damages for residential properties are taken as 20% of the direct damages. Infrastructure is taken as 15% of total direct damages, motor vehicles are considered damaged from 0.3m to 0.6m with a write-off cost of $12,000.

We assume 1.3 vehicles present per property at any particular time and ground level from which depths are taken is the average ground level on the property. Social damages are taken as 25% of total direct damages.

Annual average damage (AAD) is, as indicated above, a method of summarising the flood damage given the probabilities for certain events to occur. The AAD is essentially the average cost per year of flooding over a long period of time. AAD also reveals which sized floods are likely to make the largest contribution to total flood damages over a long period of time.

The AAD is equal to the area under the probability – damage curve which accounts for a continuum of flood probabilities from the most common up to the PMF. The contribution to AAD listed in the table for each flood represents the area under the curve for a band of floods centred on that event and is not the product of the probability multiplied by the damage for each event. It is indicative of which range of events make the greatest contribution to AAD.

Standard practice in flood damage economic analyses is to determine the Net Present Value (NPV) of the AAD to determine a present day value of flood damages which can be compared to a present day cost of mitigation options. This study uses a period of 20 years and real discount rates of 7, 8 and 10 per cent be considered.

While many of the costs and benefits have been explicitly escalated at CPI to calculate present day values, the economic analysis, which is done in real terms, keeps AAD constant into the future.

For this assessment we have applied the 7 per cent discount rate for a 50 year period and used the 4 and 11 per cent discount rates in sensitivity analyses.

A summary of the average annual damages for each LGA is provided in Table 6.

*Table 6 - Average Annual Damages*

| ***LGA*** | **Average Annual Damages** | **Net Present Value of Damages (20 years)** | | |
|---|---|---|---|---|
| | | 7% | 8% | 10% |
| Auburn | $121,720 | $31,450 | $26,110 | $18,090 |
| Bankstown | $925,870 | $239,250 | $198,600 | $137,580 |
| Parramatta | $3,926,240 | $1,014,540 | $842,180 | $583,440 |
| TOTAL | $4,973,830 | $1,285,240 | $1,066,890 | $739,110 |

### e) Intangible Flood Damages

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

While it is not possible to put a precise monetary value on these matters, it is generally conceded that the higher the number of buildings that experience above flood flooding, the greater intangible losses are likely to be. The number of buildings experiencing above floor flooding is therefore a useful way to quantify the degree of intangible damages.

Even though it is generally considered that the value of the tangible damages can be doubled to account for the intangible damages, in the strictest economic assessment, placing a value on "intangible" damages renders those damages "tangible". Placing a value on the range of potential "intangibles" requires far more "blue sky" estimating than is warranted. Nobody knows what such trauma costs – that's why they are "intangible".

If a value must be ascribed to intangible losses, the proportion of properties affected by above floor flooding against the number within the catchment may give a better picture of intangible damages than any generalised percentage of some other value.

An overview of the types of intangible damages likely to occur in the Duck River catchment is discussed below.

#### *i) Risk to Life and Injury*

During any flood event there is the potential for injury as well as loss of life. In the Duck Creek catchment there is overland flow down roads and through properties. Several streets including Bursill Street, Stuart Street, Gregory Street and Ruby Street (all within the Parramatta City Council LGA) experience velocities greater than 2 m/s with depths up to 0.5m. In addition, the main lined drainage channels of Duck Creek and Little Duck Creek often flow through properties with velocities greater than 4 m/s and there is a risk of people falling in and drowning or vehicles entering them during a flood.

#### *ii) Stress*

In addition to the stress caused during an event (from concern over property damage, risk to life for the individuals or their family, clean up etc.) many residents who have experienced a major flood are fearful of the occurrence of another flood event and its associated damage. The extent of the stress depends on the individual.

#### *iii) Loss of Pets, Photographs, Memorabilia*

In the aftermath of all floods the residents become aware of the loss of goods and pets that cannot be replaced, whatever the cost. With foresight these items should have been protected from harm but prior to the flood the effect of their loss was not readily apparent. In many cases the loss of these items represents a greater loss than the tangible damages which can be relatively easily replaced.

## 4.4 DAMAGES ASSESSMENT

### 4.4.1 Bankstown City Council LGA

Based on the damages estimates prepared for this study, flood damages in the Bankstown City Council LGA may occur in floods that may be more common than the 1 in 5 year ARI event with an accelerating total damages estimate to the PMF. The estimated indirect, infrastructure and other damages are 37.5% to 43% of the estimated direct damages.

The majority of the flood damages occur in the stream reaches between Carlingford Street and the Hume Highway and where 320 of the 451 residential properties affected by flooding up to the PMF in Bankstown LGA are located. The breakdown of affected properties is in Table 7 below.

Of the total 451 residential properties, 306 residential properties are between the 1 in 100 year ARI flood and the PMF, leaving 145 residential properties affected up to the 1 in 100 year ARI flood. As shown in Figure 2, Figure 3 and Figure 4, the majority of affected properties are scattered about the catchment without a specific concentration of a "hot spot" of damages. Thus management measures must look at both broad scale approaches to reduce damages, usually property modification measures, and apply flood modification measures only where a relatively large number of properties may benefit.

*Table 7: Affected Residential Properties - Bankstown*

| | **Residential Properties Affected in each flood** | | | | |
|---|---|---|---|---|---|
| *Subarea* | PMF | 100y | 50y | 20y | 5y |
| *Wolumba* | 9 | 4 | 3 | 3 | 2 |
| *Duck River U/S Hume Highway* | 26 | 11 | 8 | 8 | 6 |
| *Duck River U/S Carlingford Road* | 320 | 81 | 65 | 53 | 34 |
| *Duck River U/S SW Pipeline* | 96 | 49 | 25 | 16 | 8 |

There are 98 commercial / industrial properties affected by the PMF – the vast majority of these are centred on the Sefton commercial centre.

The management measures and their assessment are in Sections 7 and 8.

### 4.4.2 Parramatta City Council LGA

Based on the damages estimates prepared for this study, flood damages in the Parramatta City Council LGA may occur in floods that may be more common than the 1 in 5 year ARI event with an accelerating total damages estimate to the PMF. This is particularly so in the Duck Creek and Little Duck Creek reaches however it should be noted that in the Duck River reach, damages only occur in floods that are greater than the 1 in 100 year ARI event. The estimated indirect, infrastructure and other damages are 37.5% to 43% of the estimated direct damages.

The majority of the flood damages occur in the Duck Creek reach and the vast majority of that occurs in floods between the 1 in 100 year event and the PMF when affected property numbers go from 93 in the 1 in 100 year ARI to 906 in the PMF. The breakdown of affected properties is in Table 8 below.

*Table 8: Affected Residential Properties - Parramatta*

| *Subarea* | PMF | 100y | 50y | 20y | 5y |
|---|---|---|---|---|---|
| *Duck Creek* | 906 | 93 | 63 | 35 | 6 |
| *Duck River* | 217 | 0 | 0 | 0 | 0 |
| *Little Duck Creek* | 377 | 78 | 54 | 38 | 8 |

Of the total 1500 residential properties affected in this LGA, , 306 residential properties are between the 1 in 100 year ARI flood and the PMF, leaving 145 residential properties affected up to the 1 in 100 year ARI flood.

As shown in Figure 2, Figure 3 and Figure 4, the majority of affected properties are scattered about the catchment without a specific concentration of a “hot spot” of damages. Thus management measures must look at both broad scale approaches to reduce damages, usually property modification measures, and apply flood modification measures only where a relatively large number of properties may benefit.

There are 220 commercial / industrial properties affected by the PMF – the vast majority of these are centred on the Granville / Rosehill Industrial area.

The management measures and their assessment are in Sections 7 and 8.

### 4.4.3 Auburn City Council LGA

Based on the damages estimates prepared for this study, Residential damages in Auburn City Council LGA occur in floods that are greater than the 1 in 100 year ARI event. The estimated indirect, infrastructure and other damages are nearly equal to the estimated direct damages, indicating the need for a community education program to address such damages and allow the community to contribute to the reduction in flood damages.

# 5 HERITAGE AND ENVIRONMENTAL ISSUES

The Duck River catchment includes sites of heritage and environmental significance, not only for the immediate catchment area but also for the wider Sydney basin and, given the history of Sydney's development, the nation. Accordingly, these issues must be addressed and considered in the development and implementation of a Floodplain Risk Management Plan, both in terms of how flooding can impact on them but also what opportunities and constraints they create for mitigation options.

## 5.1 HERITAGE ISSUES

Heritage consists of those places and objects the community has inherited from the past and have indicated a desire to hand on to future generations. Our heritage gives us a sense of living history and provides a physical link to the work and way of life of earlier generations. It enriches our lives and helps us to understand who we are today.

NSW's heritage is diverse and includes buildings, objects, monuments, Aboriginal places, gardens, bridges, landscapes, archaeological sites, shipwrecks, relics, bridges, streets, industrial structures and conservation precincts. Flooding can cause direct damage to heritage items through the forces of water and debris or soiling from pollutants in the water. More indirect damage can occur through prolonged dampness following the flood and the moulds and fungi which that promotes.

The Heritage sites within the flood affected areas of study area are listed in Table 9, Table 10 and Table 11 below. These sites have been extracted from the Australian Heritage Places Inventory, items listed under the NSW Heritage Act, items listed by State Agencies and items/locations listed in the LEPs of each Council. These sites are also shown on Figure 6, Figure 7 and Figure 8.

*Table 9: Heritage items/locations - Auburn*

| No. | Item Name | Address | Suburb |
|---|---|---|---|
| 1 | Auburn Botanic Gardens | Chisholm Road | Auburn |
| 2 | Clyde Marshalling Yards | Parramatta Road | Auburn |
| 3 | Earnest Fleming Pty Ltd Machinery Merchants | 79 Derby Street | Silverwater |
| 4 | Lower Duck River Wetlands | Shirley Street, | Rosehill/Silverwater |
| 5 | Parramatta Road Milestones | Parramatta Road between Rawson Street and Duck River | Auburn |
| 6 | Silverwater Prison Complex Conservation Area | Holker Street | Silverwater |
| 7 | Sydney Water Pipelines | Near Rose Crescent | Auburn |

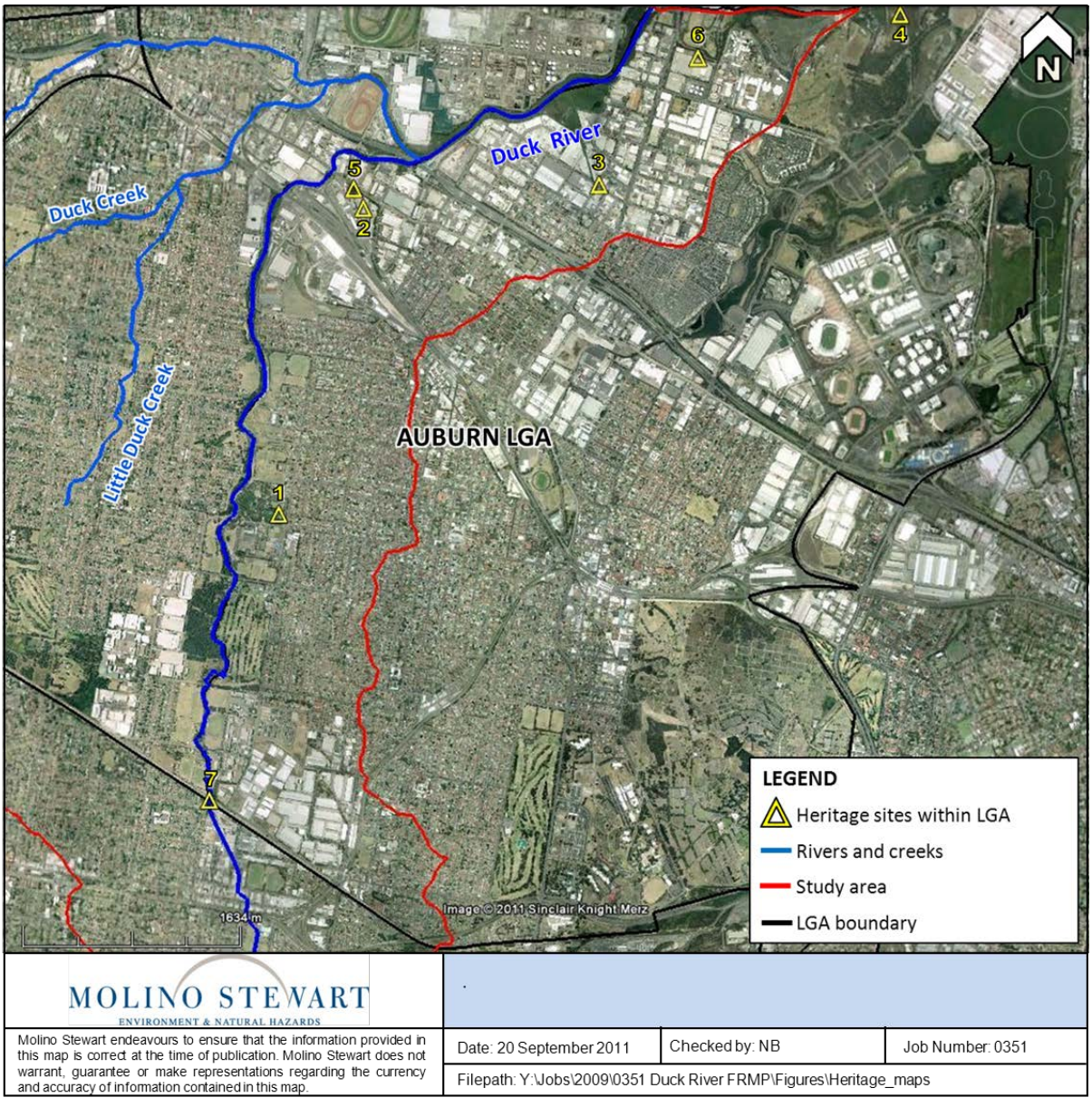


*Figure 6: Heritage locations in Auburn LGA*

*Table 10: Location of Heritage Items - Bankstown*

| No. | Item Name | Address | Suburb |
|---|---|---|---|
| *1* | Potts Hill Reservoir | 146 Rookwood Road | Yagoona |
| *2* | Allder Park (Site of Tower's "Ranah/The Ranch") | 201 Rodd Street | Sefton |
| *3* | Site of Pugh's "Crooked Billet Inn" | 724–734 Hume Highway | Yagoona |
| *4* | Site of the "Globe Inn" | 656 Hume Highway, Yagoona | |
| *5* | "Allder's Farmhouse" | 49 Hill Road | Birrong |
| *6* | Regents Park Public School | Bagdad Road | Regents Park |
| *7* | Sefton Railway Station Group | Wellington Road | Sefton |
| 8 | Chester Hill Railway Station Group | Waldron Road / Chester Hill Road | Chester Hill |

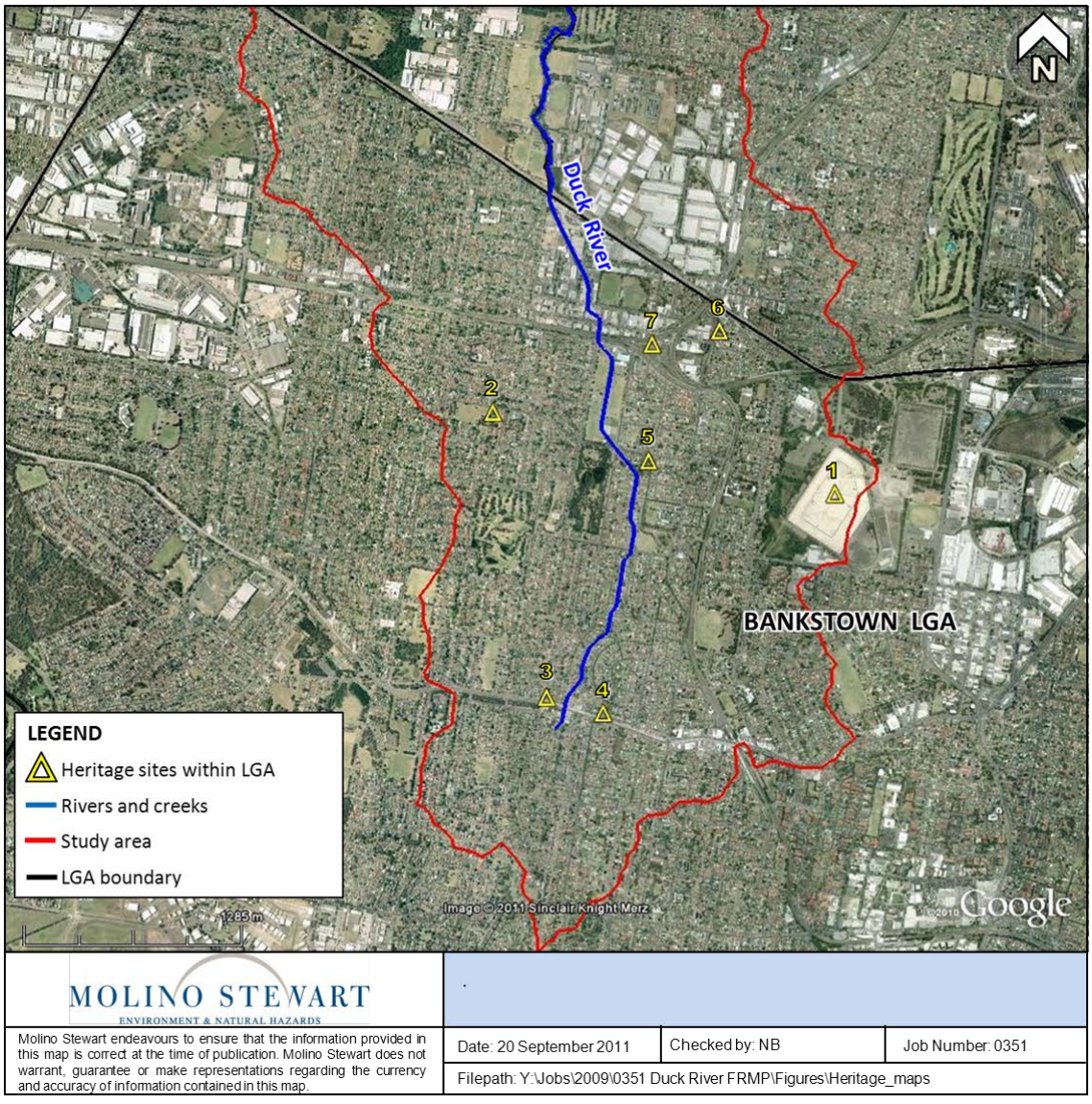


*Figure 7 – Location of Heritage Items in the Duck River catchment in Bankstown LGA*

*Table 11: Heritage items/locations Parramatta*

| No. | Item Name | Address | Suburb |
|---|---|---|---|
| 1 | Crest Theatre | 157 Blaxcell Street | Granville |
| 2 | Cottage (1) | 1 Salisbury Road | Guildford |
| 3 | Uniting Church | 104 South Street | Granville |
| 4 | Cottage (2) | 54 Stuart Street | Granville |
| 5 | Monuments | 29 William Street | Granville |
| 6 | Homes for the unemployed cottage | 46 Bertha Street | Merrylands |
| 7 | Wunderlich | 10 Grand Avenue | Rosehill |
| 8 | RTA Depot | 4a James Ruse Drive | Rosehill |
| 9 | Capral Aluminium | Unwin Street | Rosehill |
| 10 | Former shop and dwelling | 15 Abbott Street | Granville |
| 11 | Terraces | 5 – 23 Arthur Street | Granville |
| 12 | Cottage (4) | 29 Bertha Street | Merrylands |
| 13 | Colquhuon  park and monument | 196 Blaxcell Street | Granville |
| 14 | Electrical substation | 417 Blaxcell Street | Granville |
| 15 | Electrical substation | 2 Bright Street | Granville |
| 16 | Cottage (5) | 10 Bury Street | Guildford |
| 17 | East St residences | 21-23 East Street | Parramatta |
| 18 | Granville pool | 1a Enid Avenue | Granville |
| 19 | Scout Hall | 1A Glen Street | Granville |
| 20 | Pumping station | 41 Grand Avenue | Camellia |
| 21 | Electrical substation | 133 Guildford Road | Guildford |
| 22 | Cottage (7) | 2 Lisgar Street | Granville |

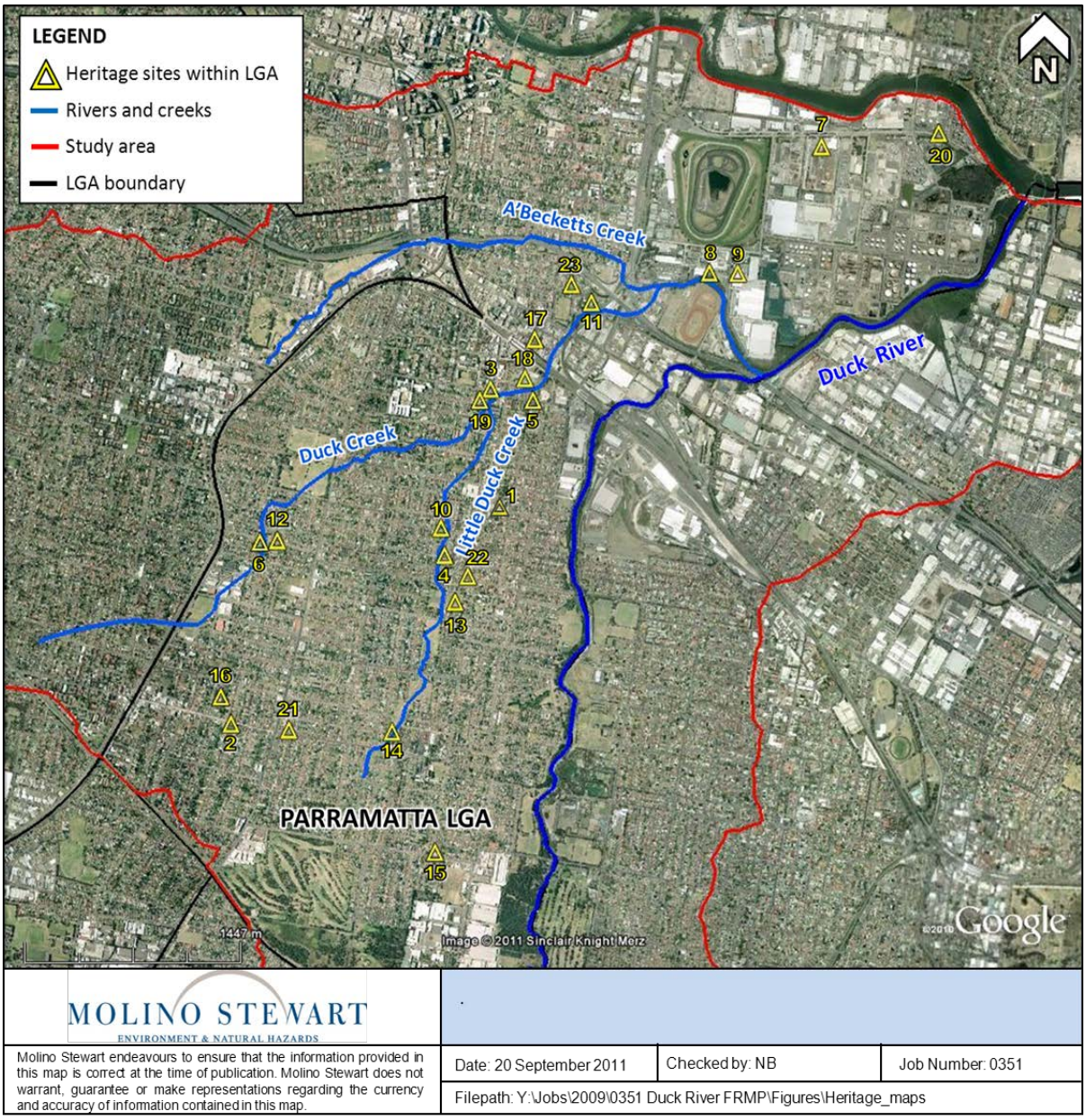


*Figure 8: Heritage locations in Parramatta LGA*

The vast majority of the heritage listed sites shown in Figures 6, 7 and 8 are above the 1 in 100 year ARI flood level however they are affected, to varying degrees, by the PMF.

The heritage aspects of any areas or buildings within that area should be considered in the development of any future floodplain risk management measures.

## 5.2 ENVIRONMENTAL ISSUES

The Duck River catchment covers the transition zone from the rolling low hills of the Wianamatta Shales of the Cumberland Plain in the south to the shallow soils on Hawkesbury Sandstone on the Hornsby Plateau in the north with Quaternary Alluvium following the river and creek lines.

Comprehensive clearing of the catchment for residential and industrial development has resulted in a dramatic reduction in natural areas and these are now primarily concentrated within 10 kilometres either side of the Duck River channel, this is referred to for the purposes of this broad assessment as the Duck River riparian corridor. A riparian corridor definition has been provided by the NSW Office of Water (2010):

"A riparian corridor forms a transition zone between the land, also known as the terrestrial environment, and the river or watercourse or aquatic environment" (NSW Office of Water 2010).

When determining the appropriate width of a riparian corridor the NSW Office of Water recommends consideration of three riparian zones: the core riparian zone (CRZ) which is the land contained within and adjacent to the channel; the vegetated buffer (VB) that protects the environmental integrity of the CRZ; and the asset protection zone (APZ) a requirement of the NSW Rural Fire Service designed to protect adjacent assets from bushfire damage. Duck River would be considered a third order watercourse by the NSW Office of Water (2010) as there is a defined channel and water flows intermittently or permanently. As a result the recommended width of a core riparian zone would be between 20 and 40 metres measured from the highest bank and on both sides of the watercourse (NSW Office of Water 2010). In the case of Duck River the width of the riparian corridor is highly variable and depends on the level of modification of the river channel and the proximity of adjacent urban and recreational development. Now that the extent of flooding has been determined, it is important that each Council develop a definition for the preferred Duck River riparian corridor).

Many of the remaining remnants represent examples of endangered ecological communities listed on the NSW Threatened Species (TSC) Act 1995 and the Environment Protection and Biodiversity Conservation (EPBC) Act 1999. The remnants are often small, linear and isolated and their long term viability will be dependent on ongoing management, maximising their size and re-establishing ecological connections with habitat corridors. The Sydney Metropolitan Catchment Management Authority (SMCMA) has undertaken draft mapping of native and exotic vegetation through modelling within the Sydney Metropolitan Catchment. This mapping provides an indication of areas of natural vegetation but is based on a draft data set that is subject to further refinement and field validation by the Office of Environment and Heritage (OEH).

The distribution of natural vegetation and exotic vegetation along the riparian corridor based on the draft SMCMA mapping (DECCW 2009) is shown in Figure 9.

This environmental assessment does not address the issues relating to the large numbers of industrial activities in the Rosehill / Silverwater area. These areas may be affected by the PMF event however depths and velocities are quite low. The area is far more affected by flooding from the Parramatta River, which is outside the brief for this study.

Parramatta and Auburn Councils do need to develop a long-term land use plan for these industrial areas that takes account of flooding, as well as the issues relating to current and past activities.

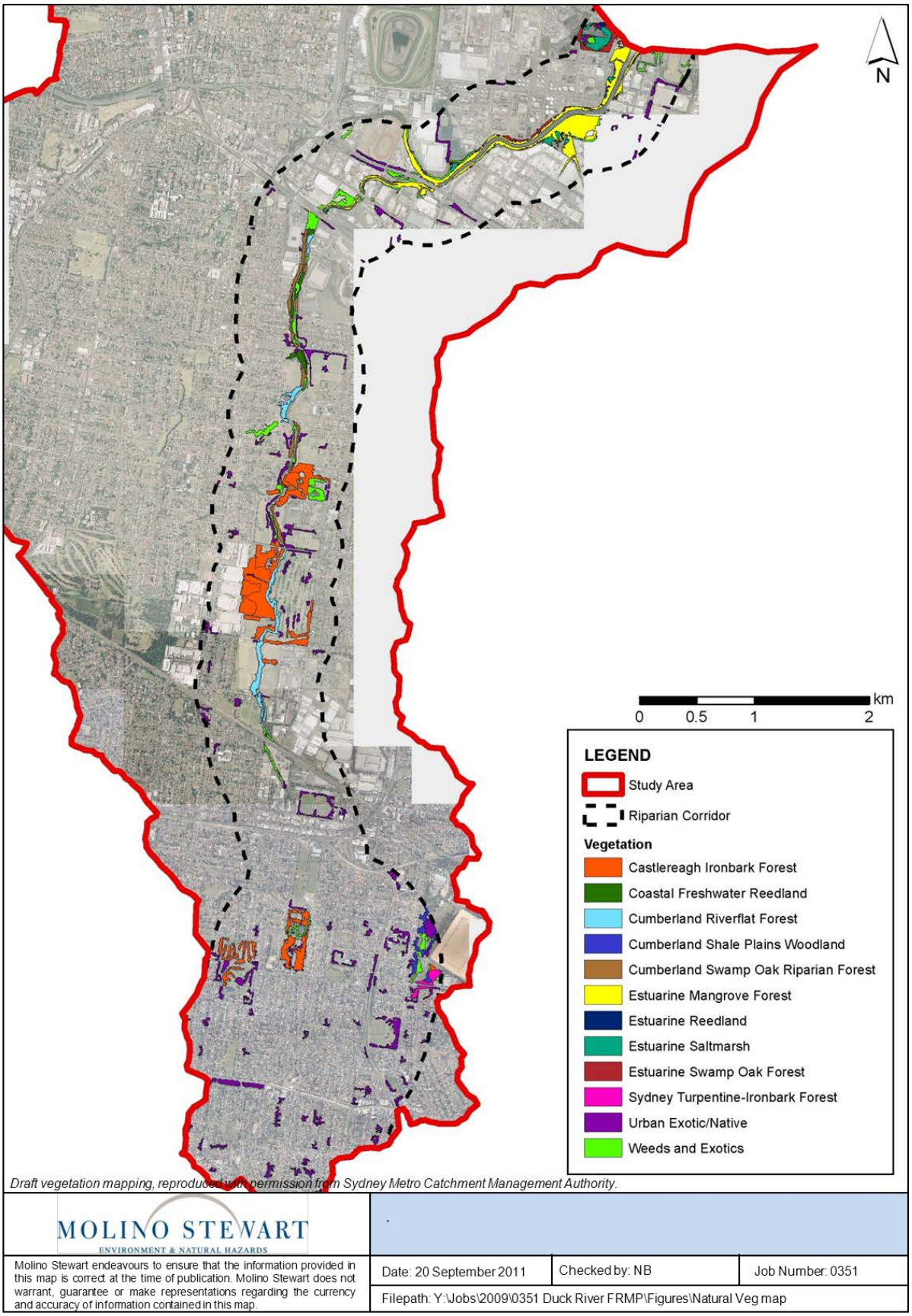


*Figure 9: Natural and Exotic Vegetation within the Duck River Riparian Corridor (adapted from SMCMA, 2009)*

### 5.2.1 Biodiversity Overview

Key biodiversity assets in the Duck River catchment include:

- the riparian corridor;
- two key populations of the Green and Golden Bell Frog;
- six endangered ecological communities within the riparian corridor;
- three threatened flora species;
- an endangered plant population;
- the lower Duck River wetlands; and
- remnant native vegetation.

Significant areas of parkland and remnant native vegetation remain in the Duck River riparian corridor. In the upper reaches of the catchment, native vegetation occurs as remnant alluvial and terrestrial forest and often constitutes endangered ecological communities. In the lower reaches, vegetation includes alluvial forest and areas of mangrove and salt marsh. The Duck River riparian corridor contains a mix of largely cleared open parks used for passive or active recreation and pockets of remnant native vegetation. Nature reserves, golf courses and botanic gardens occur along the corridor and mangroves adjoin the channel in the lower reaches. The lower Duck River Wetlands are listed on the register of the National Estate and support the oldest known stand of mangroves remaining on the river (Australian Department of Sustainability, Environment, Water, Population and Communities 2011).

Riparian areas in urban environments are often subject to weed invasion due to the high levels of nutrients in alluvial soils that result from run off from urbanised environments. Flooding could exacerbate weed infestation in riparian zones in a number of ways including:

- erosion of riparian zones and floodplains can create suitable situations for subsequent weed invasion by a variety of weed species;
- promoting dispersal of weed seeds and propagules across the broader area impacted by flooding.

Flooding can also increase erosion and siltation of natural waterways and destroy suitable habitat for native fauna. Given the adverse biodiversity effects of serious flooding, it would be advisable to temporarily divert extra resources to manage these effects after future floods in the Duck River

The Green and Golden Bell Frog (GGBF) Litoria aurea is listed as ‘endangered’ under Schedule 1 of the NSW TSC Act 1995 and ‘vulnerable’ under Schedule 1 Part 2 of the Commonwealth EPBC Act 1999. Two of the three key populations of the GGBF in Parramatta are present in the Duck River catchment. The key populations are defined in the recovery plan (DECC 2008) as the:

- Clyde/Rosehill key population – taking in the Camellia peninsula; and
- Merrylands key population – taking in the Holroyd Gardens and Walpole Street Park along A’Becketts Creek at Holroyd.

### 5.2.2 Opportunities for Improving Biodiversity

The natural and parkland areas along the Duck River riparian corridor offer opportunities to improve biodiversity across the catchment. Potential improvements centre on the conservation and management of the Duck River riparian corridor. The potential of riparian areas to contribute to

positive biodiversity outcomes has been recognised at the local government level through umbrella environment, biodiversity or sustainability policies and specific plans of management.

There is also recognition that along the corridor and particularly in the upper reaches of the Duck River catchment there is potential to link the Duck River riparian corridor with Salt Pan Creek riparian corridor, ultimately creating a wildlife corridor that links the Parramatta and the Georges River. This would require rehabilitation of existing bushland areas and revegetation of some areas with locally endemic native species.

There are also some opportunities in the upper reaches of the Duck River riparian corridor, south of the Sydney Water pipeline to undertake naturalisation of the channel and river bank. In this area the river is confined to open and piped concrete channels which provide limited habitat for native plants and animals. This opportunity would require further investigation to consider in detail the opportunities and constraints around channel naturalisation at specific sites and, in particular in the context of this study, the implications of such changes on flood behaviour.

Enhancement of the Duck River riparian corridor is recognised as contributing to the achievement of policy goals in:

- Bankstown City Council's Biodiversity Strategy (Bankstown City Council and Ecologica Australia 2002);
- Bankstown Environmental Action Plan 2010 – 2014; and
- The Duck River Biodiversity Corridor Master Plan (Mather & Associates Pty Ltd 2003).

Parramatta City Council has also recognised the value of natural and riparian corridors in:

- Parramatta Natural Areas Plan of Management (2006);
- Parramatta City Biodiversity Plan (2003).

The Duck River Bushland Reserve is recognised as one of Parramatta's larger bushland remnants.

Auburn Council has recognised the significance of the Duck River riparian corridor in:

- Auburn Council's Sustainability Strategy (2008).

Specific recommendations for management of the riparian corridor have been documented in a variety of plans of management that cover the key reserves along Duck River including:

- Plan of management for Duck River Foreshore (Auburn Council 2001);
- Plan of Management for Natural Areas/Bushland within the Auburn Golf Course (Auburn Council 2001a);
- Plan of Management for Natural Areas/Bushland within Peter Hislop Park (Auburn Council 2001b);
- Plan of Management for Auburn Botanic Gardens Precinct (Auburn Council 2001c).

Community interest in the Duck River riparian corridor is high with five dedicated bush care groups occurring in Parramatta, Auburn and Bankstown LGAs.

### 5.2.3 Biodiversity Assets

In each LGA the key biodiversity assets are recognised within the Duck River catchment including:

- Wildlife corridors.
- Threatened flora and fauna species;

- Endangered ecological communities; and
- Remnant native vegetation;

These features are summarised for the LGAs as follows.

### a) Bankstown LGA

*i) Wildlife Corridors*

Within their Biodiversity Strategy and Duck River Biodiversity Corridor Masterplan Report, BCC has indicated the maintenance and expansion of biodiversity corridors is a priority. A network of biodiversity corridors are proposed linking habitats throughout the Bankstown LGA and to link important corridors in neighbouring local government areas. The Duck River corridor is shown as a core biodiversity corridor in the Bankstown Biodiversity Policy. The majority of this corridor is riparian and lies within flood affected areas. Parcels of land within the corridor identified as having ecological significance include:

- Jensen Park;
- Jim Ring Reserve;
- Maluga Passive Park;
- Rose Park;
- Sefton Golf Course;
- Walshaw Park;
- Band Hall Reserve; and
- O'Neill Park.

These are shown on Figure 10.

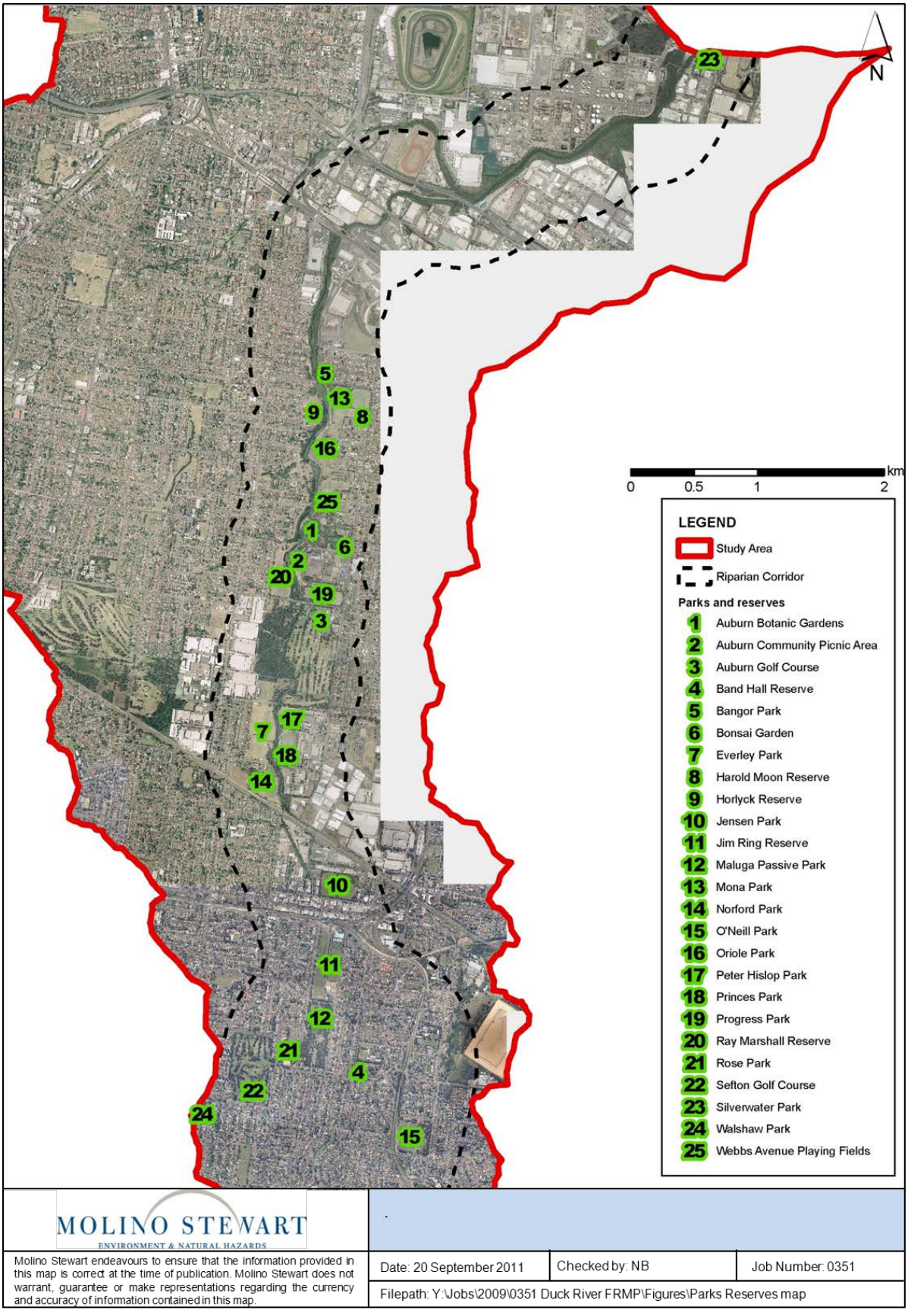


*Figure 10: Location of selected parks and reserves within the Duck River Riparian Corridor*

*ii) Threatened Species and Migratory Birds*

Map 3 from the BCC Biodiversity Strategy indicates that one species of threatened flora Acacia pubescens (Downy Wattle), listed as vulnerable at the State and national level, has been reported in several locations potentially affected by flooding. This species is known to occur in open woodland and forest, in a variety of plant communities, including the Cooks River/ Castlereagh Ironbark Forest, Shale/ Gravel Transition Forest and the Cumberland Plain Woodland (NSW NPWS 2003) (NSW NPWS 2003a). Both of these Endangered Ecological Communities (EECs) are known to occur in the Duck River riparian corridor (BCC 2002).

Map 4 from the BCC Biodiversity Strategy indicates that no species of threatened fauna have been reported in potentially flood affected locations. BCC acknowledges that a variety of common fauna species including the ring tail possum along with more than 68 native bird species utilise habitats in the Duck River corridor.

The grey headed flying fox (Pteropus poliocephalus) is listed as a vulnerable species on the Environmental Protection Biodiversity Conservation Act 1999 (EPBC Act). A permanent camp site is located to the north west at Parramatta Park (Ecological 2008) and has been sighted in the Duck River corridor in Bankstown LGA and is likely to forage in the area (Bankstown City Council, undated).

Map 5 from the BCC Biodiversity Strategy indicates that one migratory bird, the Long-toed Stint (Calidris subminuta), listed under the Japan-Australia Migratory Bird Agreement (JAMBA) and China-Australia Migratory Bird Agreement (CAMBA) agreements, has been reported in one location potentially affected by flooding.

*iii) Endangered Ecological Communities (EECs)*

The BCC Biodiversity Strategy indicates that a number of EECs exist in a number of potentially flood affected locations. The EECs are listed in Table 12.

*Table 12: EECs in flood affected areas in Bankstown LGA*

| ***EEC*** | **Conservation Status** |
|---|---|
| *Cumberland Plain Woodland* | critically endangered NSW Level[1]<br>critically endangered National Level[2] |
| *Cooks River Castlereagh Ironbark Forest* | EEC NSW Level[1] |
| *Sydney Turpentine Ironbark Forest* | EEC NSW Level[1]<br>critically endangered National level[2] |
| *Shale Sandstone Transition Forest* | EEC NSW Level[1]<br>endangered National Level[2] |
| *Shale Gravel Transition Forest* | EEC NSW Level [1]<br>critically endangered National Level[2] |
| *Sydney Coastal Riverflat Forest* | EEC NSW Level[1] |

[1] NSW listed under the Threatened Species Conservation Act (TSC Act)

[2] National level listed under the EPBC Act

The distribution of EECs in the Duck River catchment is shown in Figure 11.

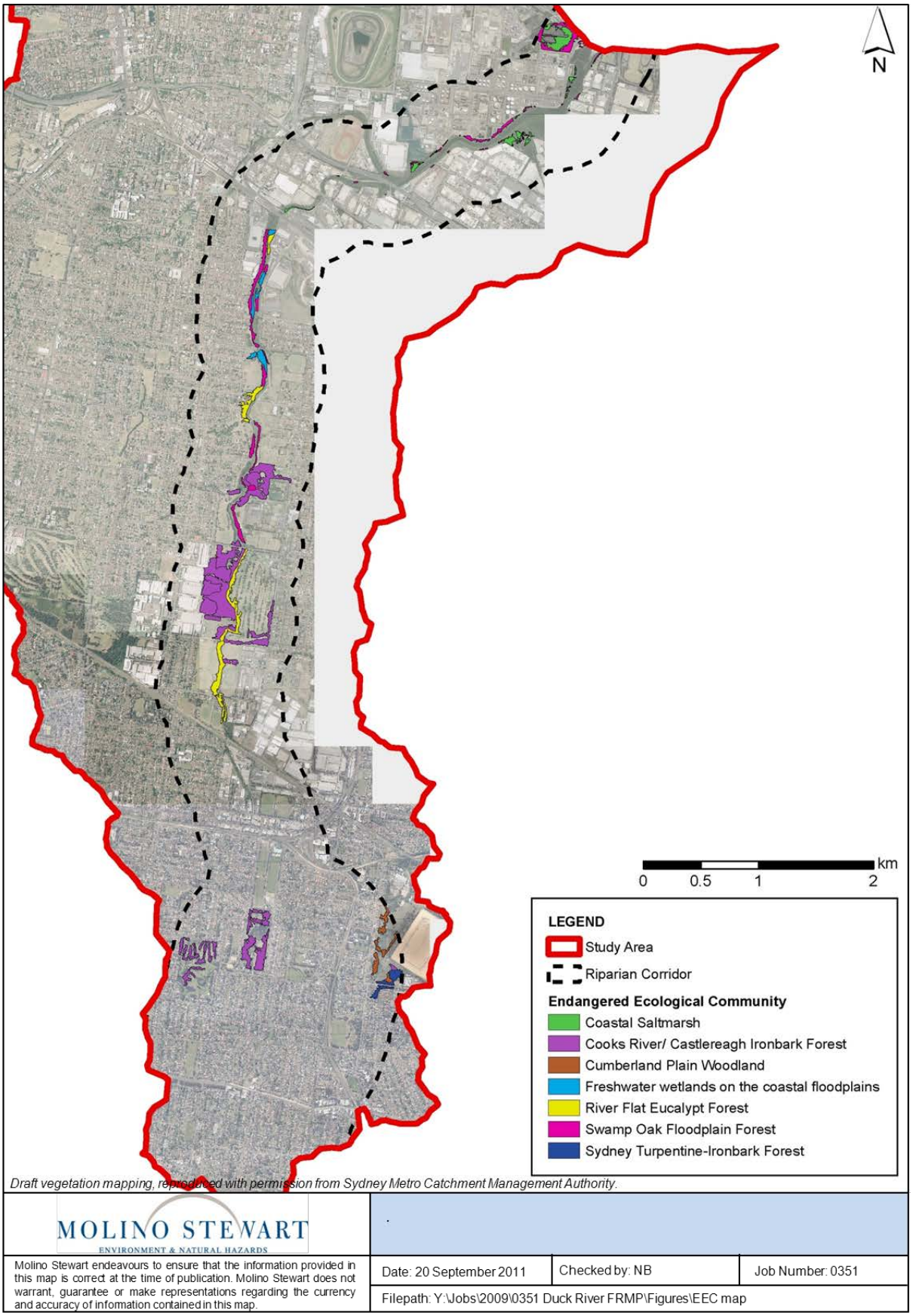


*Figure 11: Distribution of EECs in the Duck River catchment (adapted from SMCMA, 2009)*

*iv) Other Conservation Priorities*

Map 12 from the BCC Biodiversity Strategy indicates areas of ecological significance in the Bankstown LGA in addition to EECs. A number of these areas exist in potentially flood affected locations within the upper reaches of the Duck River riparian corridor. They include the reserves identified as being areas of ecological significance that form part of the Duck River riparian wildlife corridor, including:

- Jensen Park;
- Jim Ring Reserve;
- Maluga Passive Park;
- Sefton Golf Course;
- Walshaw Park; and
- Herbert Crabtree Reserve.

These areas represent potential biodiversity gains as their condition and biodiversity value could be increased with bush regeneration and revegetation.

### b) Parramatta and Auburn LGAs

*i) Wildlife Corridors*

Parramatta City Council has identified the contribution of creek lines and riparian areas to biodiversity corridors. The council has identified the significance of biodiversity corridors in their Biodiversity Plan and Natural Areas Plan of Management and has identified the Duck River Reserve as one of Parramatta's larger bushland remnants.

Reserves identified as corridors by Parramatta City Council (2006) in the Duck River riparian corridor include:

- Horlyck Reserve (Boronia St South Granville);
- Everley Park (Boundary Road Chester Hill);
- Norford Park (Hector Street Chester Hill);

Reserves not identified as corridors by Parramatta City Council (2006) in the Duck River riparian corridor include:

- Bangor Park (Seventh St Granville);
- Ray Marshall Reserve (Erie St South Granville).

Auburn Council has recognised a range of reserves as part of the Plan of management for Duck River Foreshore that contribute to the riparian corridor, these include:

- Lower Duck River Reserve (Rhyl Street Auburn);
- Bangor park (Bangor Street Auburn);
- Mona Park (Chisholm Road Auburn);
- Harold Moon Reserve (Mary Street and Chisholm Street Auburn);
- Oriole Park (western side of Mary Street along Duck river to Arthur Street, Auburn);
- Webbs Avenue Playing Fields (Webbs Avenue Auburn);
- Auburn Botanic Gardens precinct (Chisholm Road Auburn);
- 1 and 4 West Street Auburn;

- Auburn RSL Bowling Club (Chisholm Road Auburn);
- The Auburn Aviary (Chiswick Road Auburn);
- Bonsai Garden (Chiswick Road Auburn);
- Council Works Depot (Chiswick Road Auburn);
- Fernery (Chiswick Road Auburn);
- Floral Clock (Chiswick Road Auburn);
- Nursery (Chiswick Road Auburn);
- Quarantine Shed (Chiswick Road Auburn);
- Auburn Community picnic Area and Killen Street car park (Killen Street Auburn);
- Progress Park (Chisholm Road Auburn, Killen Street Auburn);
- Auburn Golf Course (Chisholm Road, Wellington Road and Everley Road Auburn);
- Peter Hislop Park (Everley Road Auburn);
- Princes park (Princes Road Auburn);
- Upper Duck River Reserve (Princes Street Regent Park).

Other reserves located in the Duck River riparian corridor not identified by Auburn Council include:

- Silverwater Park (Clyde Street Silverwater at the confluence of Duck and Parramatta Rivers).

*ii) Green and Golden Bell Frog Parramatta Key Populations*

The Management Plan (DECC 2008) for the Green and Golden Bell Frog (GGBF) Parramatta Key Population; reveals two of the three key populations of the GGBF exist in potentially flood affected areas within the Duck River catchment. These are:

- Clyde/Rosehill key population- taking in the Camellia peninsula; and
- Merrylands key population taking in the Holroyd Gardens and Walpole Street Park along A'Becketts Creek at Holroyd.

The locations are shown in Figure 12.

Recommendations for the ongoing management of the GGBF detailed in the Management Plan (DECC 2008) include:

- Further development of GGBF breeding and other habitat components on public and private lands;
- Improvement of habitat within the GGBF key populations (including improving the connectivity between habitats);
- Education and communication to develop awareness of the GGBFs and encourage further on-ground actions;
- Reduction of external threats to GGBFs (habitat loss and degradation; monitoring for and removal of carp and Gambusia; implement Hygiene Protocol for the Control of Disease in Frogs to reduce the spread of Chytrid fungus);
- Monitoring and research to better understand the Parramatta GGBF population;
- Coordination and communication between the various stakeholders, land managers and community.

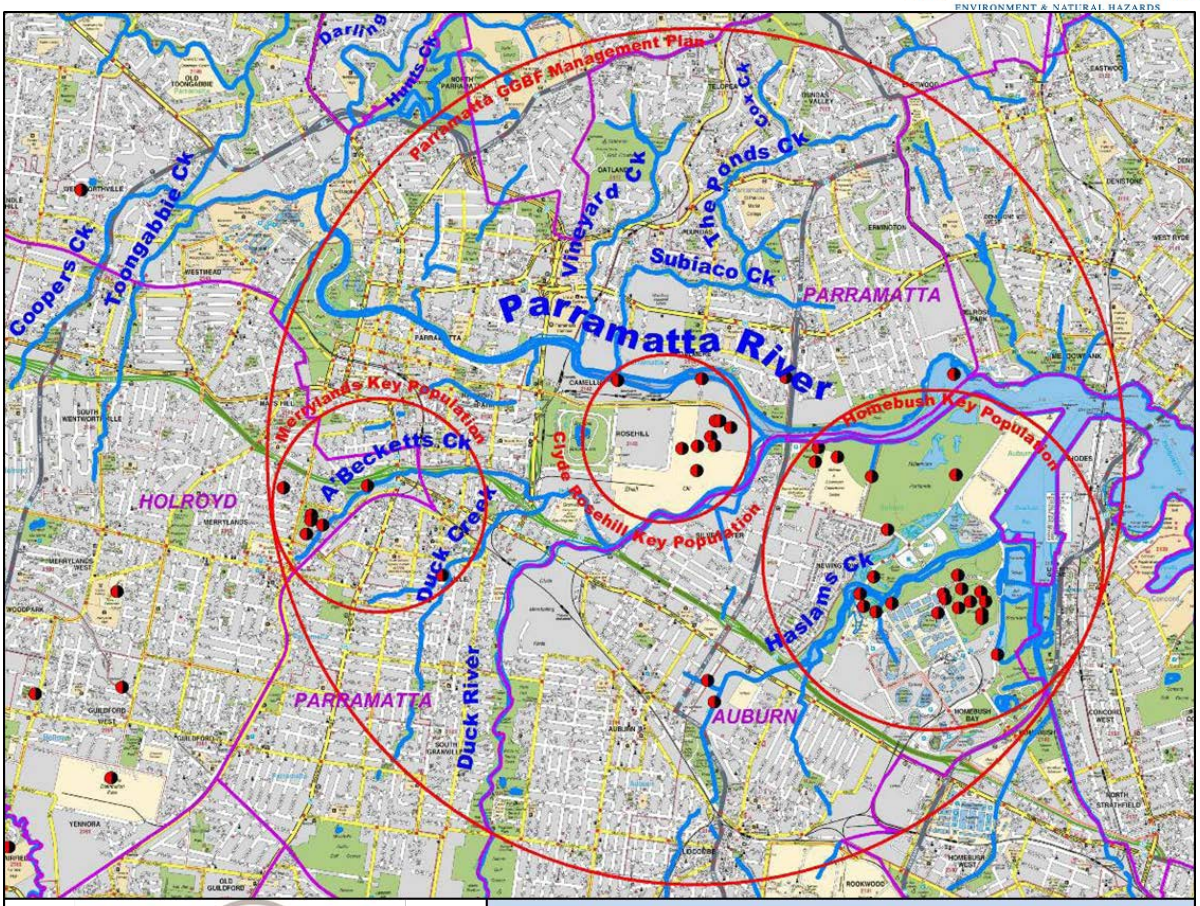


*Figure 12: GGBF Key Population Locations in the Parramatta LGA (Source: DECC, 2008)*

### *iii) Threatened Species and Migratory Birds*

The Parramatta Biodiversity Plan (Parramatta City Council 2003) reveals three threatened flora species occur in the Duck River Reserve, they include:

- *Acacia pubescens* (Downy Wattle) listed as vulnerable on the NSW TSC Act 1995 and the EPBC Act 1999;
- *Callistemon linearifolius* (Needle Bottle Brush) listed as vulnerable on the NSW TSC 1995;
- *Deyeuxia appressa* perennial grass listed as endangered on the NSW TSC Act 1995 and the EPBC Act 1999.

The first two species are also known to occur in the Auburn LGA (Duck River Sydney undated).

The lower Duck River wetlands also support extensive patches of the vulnerable saltmarsh plant:

- *Wilsonia backhousei* (Narrow-leafed Wilsonia) listed as vulnerable on the NSW TSC Act

One endangered population is also known from the Duck River riparian corridor:

- *Wahlenbergia multicaulis* (Tadgell's Bluebell) endangered population is known to occur in remnants of Cooks River/ Castlereagh Ironbark Forest (DEC 2005) in the Parramatta and Auburn LGAs.

The grey headed flying fox (*Pteropus poliocephalus*) is listed as a vulnerable species on the EPBC Act. A permanent camp site is located to the north of the Duck River riparian corridor at Parramatta

Park on the bank of the Parramatta River (Ecological 2008). The camp (roost) site is located in vegetation that represents River-flat Eucalypt Forest on Coastal Floodplain in the Sydney basin, an EEC listed under the TSC Act, also present in the Duck River riparian corridor. The grey headed flying fox is known to occur in the Duck River riparian corridor (Bankstown City Council undated) and is likely to forage in vegetation present in the riparian corridor.

The DEC (2005a) species profile lists the following measures for the recovery of this species:

Protection of roost sites particularly avoid disturbance September through November;

- Identify and protect key foraging areas;
- Manage and enforce licensed shooting;
- Investigate and promote alternative non-lethal crop protection mechanisms; and
- Identify power-line black spots and implement measures to reduce deaths.

Further guidelines for bushland managers and regenerators are presented in Best Practice Guidelines for grey headed flying fox (DECC 2008a).

*iv) Endangered Ecological Communities (EECs)*

A variety of endangered ecological communities occurs within the Duck River riparian corridor and is potentially flood affected. These are listed in Table 13.

A variety of information on the conservation and management of EECs is provided in the DEC profiles for these communities. Guidelines for the recovery of EECs on the Cumberland Plain are provided in Recovering bushland on the Cumberland Plain: best practice guidelines for the management and restoration of bushland (DEC 2005b).

*Table 13: EECs in flood affected areas in Parramatta and Auburn LGAs*

| ***EEC*** | **Conservation Status** |
|---|---|
| *Shale Sandstone Transition Forest* | EEC State level - endangered National level |
| *Cooks River Castlereagh Ironbark Forest.* | EEC State level |
| *Cumberland Plain Woodland* | critically endangered State level - critically endangered National level |
| *Sydney Coastal Riverflat Forest* | EEC State level |

*v) Other Significant Ecological Communities*

The following ecological community while not listed as endanger under the TSC Act is protected under the Fisheries Management Act 1994 and occurs within the Duck River riparian corridor:

- Mangrove/Saltmarsh Complex.

The following area is listed on the Register of the National Estate:

- Lower Duck River Wetlands, Shirley St Rosehill NSW.

The Register of the National Estate is a list of natural, Indigenous and historic heritage places throughout Australia. It was originally established under the Australian Heritage Commission Act 1975. In 2004, responsibility for maintaining the Register shifted to the Australian Heritage Council, under the Australian Heritage Council Act 2003 (AHC Act). Following amendments to the Australian Heritage Council Act 2003, the Register of the National Estate (RNE) was frozen on 19 February 2007, which means that no new places can be added, or removed. The Register will continue as a

statutory register until February 2012. During this period the Minister for the Environment, Heritage and the Arts (the Minister) is required to continue considering the Register when making some decisions under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) (Australian Department of Sustainability, Environment, Water, Population and Communities 2008).

The Lower Duck River wetlands are one of eight significant remnant wetlands listed on the Register of the National Estate (Ermington Bay/Mud Flats, Meadowbank Park Foreshore, Yarralla Bay, Majors Bay, Mason Park, Homebush Bay and Haslams Creek). These wetlands were once part of an extensive wetland system bordering the Parramatta River. Mangroves of the Parramatta River area represent a significant proportion of the mangroves remaining in the Sydney Region. Lower Duck River supports the oldest known stand of mangroves remaining on the river. The uncommon species, small pig face (*Lampranthus tegens*), is present in the Lower Duck River wetlands (Australian Department of Sustainability, Environment, Water, Population and Communities 2011).

The lower Duck River wetlands also include important areas of saltmarsh which are extensive and in fair condition, and are not represented in conservation reserves (Kelleway *et al* 2007). These saltmarshes are in the Duck River channel and are species rich, due possibly to the influence of clay-rich Wianamatta shale substrate and the low gradient of the intertidal lands (Kelleway *et al* 2007). The saltmarshes include some of the most extensive stands of:

- *Wilsonia backhousei* listed as vulnerable on the TSC Act.

Saltmarshes on the western Duck River are also home to the only occurrences in Sydney Harbour Parramatta area of:

- *Selliera radicans* (sensitive saltmarsh species).

The eastern shore of the Duck River includes the Silverwater Wetland (managed by NSW Maritime), which is one of the most extensive in the estuary and contains stands of:

- *Wilsonia backhousei*; and
- *Halosarcia pergranulata* subspecies *pergranulata* (sensitive saltmarsh species).

The lower Duck River wetlands are part of a once extensive system of mangrove and saltmarsh communities that are in good health, with a species composition uncommon in the Sydney area (Australian Department of Sustainability, Environment, Water, Population and Communities 2011). The wetlands as a group support 75 bird species, of which 37 species occur regularly, and the area provides breeding habitat for 17 species. The wetlands have been ranked sixth in importance for waders in NSW and provide habitat for 20 bird species listed under JAMBA and 19 bird species listed under the CAMBA migratory bird treaty (Australian Department of Sustainability, Environment, Water, Population and Communities 2011).

# 6 EMERGENCY MANAGEMENT

## 6.1 STATE EMERGENCY SERVICE

Under the State Emergency Service Act, 1989, the State Emergency Service (SES) is the designated Combat Agency for dealing with floods, and to coordinate the rescue, evacuation and welfare of affected communities[1].

The SES is to protect persons from dangers to their safety and health, and to protect property from destruction or damage, arising from floods (SES Act, 1989).

Details of the roles and responsibilities of the SES (and other emergency services and affected parties) can be found in the State Flood Sub Plan, a Sub Plan of the New South Wales Disaster Plan (Displan).

For floods generally, the role of the SES covers prevention, preparedness, response and recovery.

### a) Prevention

- Provide emergency management advice to councils in relation to the management of land which is subject to flooding;
- Contribute to the deliberations of Floodplain Risk Management Committees established by councils;

### b) Preparedness

- Contribute to the identification of flood problems, specifically in relation to emergency management matters including warning, evacuation, rescue and resupply functions;
- Develop and maintain flood intelligence systems for the full range of flood types and severities;
- Lead in the preparation, maintenance and exercising of Flood Sub Plans at State, Region and Local levels;
- Ensure that SES Controllers, operations centre staff and field staff are appropriately trained and equipped for flood-related tasks;
- Ensure that appropriate agencies, organisations and officers are aware of and ready for tasks related to their agreed flood responsibilities;
- Prepare, coordinate and deliver awareness and educational materials and programs regarding flooding;
- Prepare prewritten Flood Bulletins for key gauges, flash flood environments and for areas downstream of deficient dams;
- Prepare systems for the communication of warnings and public information regarding flooding; and
- Define and continually review the state's flood warning requirements in conjunction with the Flood Warning Consultative Committee, councils, the owners of dams classified as deficient and flood-affected communities;

### c) Response

- Control flood operations;
- Coordinate the responses of agencies supporting flood operations;

[1] State Emergency Service Act 1989 - Section 8 - Functions of Service

- Ensure that relevant Emergency Operations Controllers and supporting agencies are briefed on flood operations, including relevant flood and dam failure warnings;
- Respond to indications of potential dam failure when Dam Failure Warning Systems are activated;
- Assist in the development of official flood warnings by providing data to the BoM from the SES network of river height gauges and those private gauges to which it has access;
- Coordinate the development and communication of SES Flood Bulletins to at risk communities, including:
- Augmentation of official BoM flood warnings by assessing the likely consequences of flooding at the predicted heights and suggesting appropriate actions for people in areas expected to be affected and disseminating this information;
- Livestock and Equipment Warnings when there is evidence of rises in levels below minor flood heights, and disseminate these within Region Flood Bulletins;
- Local Flood Advices for communities for which the BoM does not issue official flood warnings, and disseminate these within Region Flood Bulletins;
- Coordinate reconnaissance of areas likely to be affected by floods;
- Coordinate the resupply of isolated communities and properties;
- Coordinate the evacuation and immediate welfare of people at risk;
- Coordinate flood rescue operations;
- Coordinate operations to protect property;
- Provide an information service to the community regarding flooding;
- Assist councils to organise temporary repairs or improvements to levees;
- Assist the NSW Police Force, RTA and councils with road closure and traffic control operations;
- Assist the Agriculture and Animals Services Functional area with fodder supply operations;
- Depending upon the scale of the event establish a Joint Media Information Centre as near as is practicable to the areas affected by flooding;
- Coordinate the collection of flood intelligence and post impact data and make it available to recovery agencies;
- Establish a spatial information group if required to coordinate the collection; analysis; mapping and distribution of spatial information regarding flooding;
- Provide Situation Reports incorporating the activities of supporting agencies to all agencies listed under this Plan and to all state level supporting operations centres and relevant members of parliament;
- Provide information to Treasury on damage to public infrastructure for the purpose of Natural Disaster Relief and Recovery Arrangements;
- Provide immediate welfare support to evacuees;

### d) Recovery

- Ensure that initial recovery operations are commenced;
- Coordinate the conduct of after action reviews / debriefs following flood operations;
- Ensure any recovery coordinating committee is briefed regarding the flood response phase and that appropriate information is provided to appropriate recovery agencies; and
- Participate in recovery committees as required.

## 6.2 BUREAU OF METEOROLOGY

Under the State Flood Sub Plan, the Bureau of Meteorology is responsible to:

- Assist the SES in the exercising of Flood Sub Plans;
- Act as the flood prediction agency;
- Develop warning systems in conjunction with the SES and other state and local agencies;
- Collect, collate and analyse rain and river data;
- Provide near real time rainfall and river level data on the internet;
- Contribute to flood education programs;
- Formulate and issue official forecasts and warnings for:
    - River basins (Flood Watches);
    - Key locations on rivers and creeks (Preliminary Flood Warnings and Flood Warnings);
- Weather Forecast Districts (Regional Severe Thunderstorm Warnings and Severe Weather Warnings) and the Newcastle/Sydney/Wollongong area (Severe Thunderstorm Warnings); and
    - Coastal areas (large waves and storm surges).

The Bureau of Meteorology will work closely with the Regional and Local SES to ensure the quality and accuracy of weather and flood warnings.

## 6.3 DUCK RIVER CATCHMENT OPERATIONAL ISSUES

The Duck River catchment falls within the boundaries of two SES operational regions, City Western and Sydney Southern Regions. This is not a cause for concern as both regions will have received the same training and can operate as a larger unit if required.

The major issues for the SES in the Duck River catchment are that the catchment essentially generates a flash-flood scenario i.e. the flood peaks less than 6 hours after commencement of rain, with its critical storm being approximately a 2 hour duration event. This scenario does not provide any sound basis for the Bureau of Meteorology to issue flood warnings, though there is some warning function for the Parramatta River. The Bureau of Meteorology will be able to release Severe Thunderstorm Warnings and Severe Weather Warnings and these should be noted by the community.

As such, there is very little time for the SES to provide complex response activities in the highly built up catchment. Thus, the SES role in the catchment will very much concentrate on the prevention, preparedness and recovery functions as outlined above.

The various measures available in the Duck River catchment are discussed in greater detail in Sections 7 and 8.

# 7 COMMUNITY CONSULTATION

## 7.1 FLOODPLAIN RISK MANAGEMENT COMMITTEE

This study has been directed by a Floodplain Risk Management Committee (FRMC), established by Parramatta City Council with assistance from Auburn and Bankstown City Councils at the commencement of the project. The Committee Membership consisted of:

- Parramatta City Council: Councillor Glenn Elmore, Councillor Scott Lloyd, Paul Hackney, Jennifer Concato, Peter Sirianni and Jim Tsom;
- Bankstown Council: Cherie Blackburn;
- Auburn Council: Siva Sivakumar, Councillor Malikeh Michels
- Business Representatives: Bernard Walker or Amanda Basten (Merck Sharp and Dohme (Aust) Pty Ltd)
- Community Representatives: Ms Raema Walker (Regents Park), Mr Alf Grisauskas (Birrong) Mrs Kathleen Mealing (Chester Hill) and Mr Michael Robinson (Sefton).
- Stakeholders: Office of Environment and Heritage - Urban and Coastal Water Programs, State Emergency Service - City Western and Sydney Southern Regions, Sydney Metropolitan Catchment Management Authority and Sydney Water.

Nancy Hermoso from Parramatta City Council provided administrative support to the Committee.

The Committee met five times to receive progress reports, discuss findings and to provide directions for future work, culminating in this report.

In addition one catchment tour was undertaken prior to flood modelling commencing, consisting of consultants, council staff and interested members of the FRMC.

## 7.2 COMMUNITY CONSULTATION METHODS

Effective Community Consultation is critical towards ensuring the community is engaged in a rational debate about the issues and options presented in this Study. Initial contact for community consultation was invited by:

- Writing to owners of all properties potentially affected by flooding in a 1 in 100 year ARI flood event (Parramatta, Bankstown Councils); and
- Placing a public notice in local papers advertising the proposed consultations.

The letters included Councils' standard notification of the availability of interpreter services to explain the contents of the letter. Subsequent rounds of consultation was generally restricted to those people who responded to the first round of consultation and/or registered their interest in being kept informed throughout the process or responded to subsequent public notices. In the second round at BCC we also sent letters to properties in the high risk precinct, regardless of whether they registered or not.

The following methods were used to engage the community on a number of levels to provide the required information to the largest number of people possible across the three LGAs.

### 7.2.1 Owner Letter and Survey

In consultation with the FRMC, a letter was posted to all property owners whose properties were mapped as being affected in whole or in part by the 1 in 100 ARI flood event. The letter was an invitation to attend one of the public forums which were aimed at making the flood prone residents aware of the study and afford them the opportunity to feedback on flood related questions. It was

accompanied by a one page survey which they could complete and return. The questions used in the survey were based on other social research (e.g. by NSW SES) carried out regarding flooding in NSW.

Along with the forum invitation and survey, a non-technical fact sheet was distributed, summarising the project and how to become involved.

Within the Parramatta LGA, 760 letters were sent and 67 survey responses were received. In Bankstown LGA, 2084 letters were sent and 386 responses were received. No letters were sent to property owners in Auburn LGA where only a few commercial and industrial properties lie below the 1 in 100 AEP flood level.

### 7.2.2 Community Forums

Community forums were held in April and May 2011 to brief the community and obtain their feedback. The first round of forums was held to review the flood study and damages assessment and to identify potential floodplain management options. A second was held to review the draft floodplain risk management study and the evaluation of management options.

In the first round of consultation, one community forum was held in Parramatta, where 24 people attended as well as three Council staff and one Councillor. Seven forums were held in Bankstown, where 105 property owners plus Councillors, Council officers and Committee members attended over the course of the forums. There were no forums held in Auburn at Council's request.

Written feedback forms were presented and filled out at the end of the forum sessions and the results collated. A set of Frequently Asked Questions and responses was also created to hand out at the forums. This document, along with a fact sheet and resident survey were also made available on Council's websites. A copy of all these documents can be found in Appendix A. The fact sheets were translated into Chinese, Vietnamese and Arabic and were available at the forums and from the relevant websites.

### 7.2.3 Displays

Large size, laminated displays were created for use during the community forums and to be able to be displayed in community locations such as libraries for the duration of the project. The displays included information on which areas can flood, the floodplain risk management study and plan process, general information and details on how to be involved in the process. These were placed on display in Council Offices and libraries at Parramatta. In Bankstown the relevant Flood Studies were made available for viewing in Council Offices and local libraries for a period of approximately 2 months.

## 7.3 CONSULTATION FINDINGS – STAGE ONE

### 7.3.1 Community Forums

#### a) Parramatta

*i) During the forums*

During the community meetings, there were four kinds of input from those attending; questions that were asked of the presenters and council, personal observations of residents, opinions put forward by those attending and suggestions for improvements to the flooding issue.

The kinds of questions that were asked were based around specific modelling questions relating to the flood maps, including the definition of AHD and the contour representations. Other questions related to the movement of water through the catchment, the timing of flood peaks and possible flooded areas.

Some participants put forward the opinion that they had never seen a flood and therefore they did not believe the modelling. Attendees also pointed out that members of the public who received the letters about flooding in Duck River would have ignored them because they don't realise that the concrete drainage channel at the back of their homes is actually part of the river system.

A number of suggestions were put forward regarding what can be done about flooding in Duck River:

- Increase the frequency of inspection, maintenance and clearing of stormwater channels, pipes, drains and the creek, including rubbish and tree roots
- Develop controls on types of fencing in flood prone areas, i.e. not colourbond or concrete walls
- Review options to increase the amount of water travelling along Duck River at the Railway Bridge near Granville Pool when this location is renewed in 2013-14
- Remove the chain mesh from the Railway Bridge as it catches vegetation and causes build up during flooding
- Council to conduct personal visits to affected homes to advise residents of the information and discuss the issues with them if required

*ii) Written feedback*

Results from the forum feedback indicate that it was very well received by participants. About 70% of people indicated that they understood the information very well, with no participants stating that they did not understand the information presented. Around 70% stated that they would be involved in future meetings. About 82% of people believed the information to be relevant or very relevant to them and/or their property and a further 12% believed the information to be somewhat relevant.

Specific comments that were provided as part of the feedback process included suggestions regarding information on the process of providing flooding information. Residents want to be provided with up to date information on flooding when it becomes available and to feel like their suggestions and feedback would be listened to and considered. Community education on how to be prepared was also requested, along with information on fencing options and their effects on flooding and the definition of flooding for insurance purposes. The suggestion was also made that smaller information meetings could be held according to the areas of risk, for example by street block.

Other comments were in regards to the physical infrastructure within the council area with suggestions of improvements, upgrades and expansion of the canals and creek systems to try to contain the flood. Reducing over-development in flood-prone land and the buyback of properties in flood prone areas for parks and open space was also suggested.

### b) Bankstown

*i) During the forums*

During the community meetings there were four kinds of input from those attending; questions that were asked of the presenters and council, personal observations of residents, opinions put forward by those attending and suggestions for improvements to the flooding issue.

The types of questions asked reflect on the kinds of issues that are currently unclear to residents and that they need more information or clarity on. They also show the areas or topics of interest or relevance to those who attended the forums.

A summary of the types of questions asked include:

- Information about the extent and severity of recent and past flood events;

- The impacts of increasing development and how it will affect flooding;
- What other factors make flooding worse, i.e. cutting down trees, fencing, changing the channels and canals;
- The ability of the national Emergency Alert system to dispatch warning messages to residents in a flash flood;
- How home insurance is likely to be impacted and how flood insurance is currently determined;
- Who will have access to the results of the flood studies i.e. insurance companies, developers;
- What individuals can do to protect themselves from flooding, i.e. sand bags;
- Why flood risks haven't been communicated to residents sooner and how long has council known about it;
- How high risk flood zones are determined and why they change;
- How the models work and if they could be wrong;
- How much effort is put in by Councils and Sydney Water into pipe and channel maintenance;
- Council's level of consultation with other agencies, e.g. RailCorp;
- What the Council intends to do about flooding and the results of the study;
- Options to have levees and voluntary purchase schemes; and
- The notification of residents following implementation of projects that reduce the flooding risk.

A number of those attending also provided personal observations of flooding in the past, where the water has reached and how deep it was. A common source of flooding from these comments was the Sydney Water pipeline acting as a choke point and causing the water to back up. Another common complaint was that stormwater running off neighbouring properties had caused flooding because some properties are missing down pipes and correct guttering systems. One attendee said that they had been flooded in the past from water released from Potts Hill reservoir.

Overall, the opinions presented in the forums were mainly positive with many attendees expressing gratitude that Council is trying to do something about flooding. An example of some critical opinions that came to light from the forums included the impacts of climate change, whether it has been considered in the modelling and whether it actually exists. Some attendees made statements that the large developments constructed in the area seemed to make flooding issues worse, the re-development of air-force land in Regents Park being one example. Some residents also expressed concerns regarding their property values, particularly with the installation of "Flood Zone" signage on Sydney Water channels.

The majority of the forums also resulted in a number of suggestions on how to manage and reduce the risk of flooding in the Bankstown LGA. Some common suggestions included:

- Increasing the diameter of stormwater pipes and the widths of canals;
- •Amending culverts to allow them to open and close depending on the flood situation;
- Constructing retention basins in strategic areas to hold the water back;
- Increasing maintenance, e.g. regular cleaning and checking of stormwater drains, creeks and canals (Council and Sydney Water.);
- Conducting education programs on flooding and not dumping rubbish in the creeks or drains, including within the sporting fields;
- Reconfiguring the Sydney Water pipeline to prevent water backing up in the area (Munro Street);
- Providing on-going communication of the flood risk to all residents;
- Considering disabled and elderly people when Council plan their flood response;
- Planting of trees along the channels;

- Installing levees to flood the parks rather than properties; and
- Information on building material options, i.e. concrete floor rather than timber.

*ii) Written feedback suggestions*

Results from the forum feedback indicate that they were well received by participants. Nearly 60% of people understood the information very well with a further 32% stating that they understood it fairly well. No participants stated that they did not understand the information presented and 60% stated that they would definitely be involved in future meetings. However, only 31% of people believed the information to be very relevant to themselves and their property. 36% of people stated that it was fairly relevant, 27% answered somewhat relevant and 6% said it was not relevant at all.

The written feedback responses from the forums included suggestions around three key areas: communications and education, council services and planning and infrastructure. In terms of communications and education the following suggestions were put forward:

- Keep the community informed on future development from council and other relevant authorities
- Provide a contact number for when the stormwater drain is blocked with rubbish
- If a flood is likely, make sure that awareness of the risk is communicated over the radio on "popular" stations, such as 2GB and 2UE, as well as the ABC and local radio stations.
- Provide flood education in schools within the LGA.
- Provide information and education at council festivals, pamphlets in the mail and other methods about what individuals can do on their properties to aid themselves and others in reducing the flood risk and for emergency planning – this is particularly important for people who have never experienced a flood
- Use Council's website along with the local paper to provide updates on the flood management plan and actions and to give information on risks to property and how it may affect property values.
- Local newspapers publish a list of suggestions for people to consider and act upon in the event of a natural disaster – not just for floods but for fire, storm, earthquake etc. This should include advice as to safe storage of important documents, what to turn off or take with you and what insurance is available for re-building and recovery.

A suggestion that was strongly re-iterated across the forums was the clearing and cleaning of creeks, canals and drains of rubbish and blockages. This includes tree roots that have infiltrated pipe systems.

In terms of physical infrastructure, ideas were also put forward to increase drain sizes, extend underground pipework and increase the number of holding areas (i.e. parks) adjacent to the canals.

### 7.3.2 Community Surveys

#### a) Parramatta

*i) Demographics and property details*

The results of the survey show that 84% of the surveys were received from residential properties, with 17% from business premises. About 96% of respondents were the occupier of the property.

The amount of time they have been at the property ranged from 2 months to 60 years. The greatest number of respondents (59%) had lived/worked at the property for more than 20 years, with the second largest percentage (18%) having lived/worked there between 11 and 20 years. Only 9% of respondents had been at the property less than a year.

The majority of survey respondents (78%) had access to the internet, while 22% did not.

*ii) Flood Experience*

Of the survey respondents, 28% had experienced a flood at the property while 72% had not. When asked if they thought a flood could occur at the property, the survey answers were split at 50%, indicating that approximately 30% of people who had not experienced a flood before, did believe that one could occur.

When asked to explain why they thought they could flood, a number of responses were provided and the most common were:

- There is a canal/creek running next to my property
- I have seen flooding on my property and/or surrounding areas
- My friends/family/neighbours have told me about flooding
- Flood control lot or flood information when the property was purchased
- The drains and creeks are not clear enough to prevent a flood
- Council has informed us of flooding

Reasons for believing that a flood could not affect their property:

- Have never seen a flood on the property or the road before
- The property is too high – ground levels and/or building levels
- The stormwater systems are adequate
- Sydney rarely has bad storms
- Nowhere near the creek
- Flooding only caused by blockages
- The slope of my block – only a small portion could be flooded

Nearly 70% of survey respondents said that they had not previously seen or heard any information on flooding for the local creek or river. While the remaining 30% stated that they had advice from friends/family/neighbours, received a letter from the Council, obtained information when the property was purchased, seen articles in the local paper or been advised through correspondence with Sydney Water.

*iii) Flood responsibilities*

When asked if they would know how to protect themselves and their property in the event of a flood, the answers were fairly evenly split with 43% answering yes and 57% answering no. The questions prompted respondents to write down what they would do in a flood and a summary of the answers provided include:

- Raise all stock/belongings onto high shelves or upstairs, i.e. get as much off the ground as possible
- Evacuate to neighbours/friends or relatives
- Move to higher ground
- Turn power off
- Ring 000
- Ring the SES
- Sandbag the property
- Pull the fence down or remove palings to allow the water to escape
- Help others and access advice and current information
- Remove potential obstacles and debris that may clog the canals

A large number of respondents simply replied that they would “get out” or “leave”.

Respondents were asked who in the community is responsible for reducing flood risks and were allowed to select more than one answer. An overwhelming 99% of respondents stated that it was Council’s responsibility to reduce flood risks, followed by the State Government (76%), the landowner/resident (34%), the SES (27%) and someone else (21%). The majority of people who selected someone else stated that the Water Board (Sydney Water) should also be responsible. Other answers included neighbours, developers, planners, the Federal Government, the CMA and State Rail (RailCorp).

When asked about their level of involvement in the floodplain risk management process following the survey, 91% of people stated that they would be interested in receiving further information. Table 14 shows a list of expected reactions and which the respondent intended to undertake.

*Table 14 - Community responses - Parramatta*

| ***Action*** | **No. (%)** | **Possibly (%)** | **Definitely (%)** |
|---|---|---|---|
| *Seek information on the flood risk to their property* | 18 | 30 | 52 |
| *Seek information on what to do to prepare for a flood* | 11 | 28 | 61 |
| *Seek to be involved in this flood risk management process* | 30 | 35 | 35 |

*iv) Suggestions*

The survey also provided respondents with the opportunity to provide suggestions about what they would like Council to do about future flooding in their area. A summary of the suggestions follows:

- Regular removal of rubbish and debris from stormwater channels, canals, drains and creeks
- The construction of more stormwater detention basins
- More tree planting
- Changes and controls to development, i.e. less medium density housing, no building in flood prone areas
- Work in conjunction with Sydney Water as to development, maintenance and resources
- Give more information to the owners so they are aware of what Council is doing to manage floods and ensure all information is easily available
- Build the channels higher and wider, excavate the creek and increase the size of pipes
- Council to follow up on complaints by residents of neighbours increasing flood risk, i.e. incorrect guttering/drainage, illegal levee banks
- Prepare for the possibility of flooding and assist those who are in the direct line of floods to protect their property
- Educate residents and business owners about their flood risk and how to prepare for a flood and keep them up to date
- Don’t alter the natural water courses and allow concrete and buildings to cover all of the ground

A large number of respondents simply said that Council should just prevent flooding.

### b) Bankstown

*i) Demographics and property details*

The results of the survey show that 93% of the surveys were received from residential properties, with 7% from business premises. About 92% of respondents were the occupier of the property.

The amount of time they have been at the property ranged from 5 months to 66 years. The greatest number of respondents (53%) had lived/worked at the property for more than 20 years, with the second largest percentage (30%) having lived/worked there between 11 and 20 years. Only 2% of respondents had been at the property less than a year.

The majority of survey respondents (63%) had access to the internet, while 37% did not.

*ii) Flood Experience*

Of the survey respondents, 18% had experienced a flood at the property before while 82% had not. When asked if they thought a flood could occur at the property, 31% of respondents answered that they thought it could flood, while 69% believed their property could not flood. This indicates that approximately 12% of people who had not experienced a flood before, did believe that one could occur.

When asked to explain why they thought they could flood, a number of responses were provided and the most common were:

- There is a canal/creek running next to my property.
- The property is in a low point in the landscape.
- The property is located within the flood zone.
- I have seen flooding on my property and/or surrounding areas.
- My friends/family/neighbours have told me about flooding.
- Impacts from climate change.
- Flood control lot or flood information when the property was purchased.
- From flood maps.
- The gutters and grates are blocked with rubbish and drainage is inadequate.
- Council has informed us of flooding and the levels.

Reasons for believing that a flood could not affect their property included:

- Have never seen a flood on the property or the road before, even when we have experienced heavy rainfall.
- The property is too high – ground levels and/or building levels.
- The stormwater systems are adequate especially with recent updates and new pipes installed.
- The property has good drainage.
- The property is nowhere near the creek.
- Flooding only caused by blockages.
- It was never indicated when we purchased the property.
- Council would not approve residential development on flood prone land.
- The slope of my block – only a small portion could be flooded.

Nearly 90% of survey respondents said that they had not previously seen or heard any information on flooding for the local creek or river. About 10% stated that they had, including advice from friends/family/neighbours, posted information from the Council, information when the property was

purchased, articles in the local paper, on the television news, and through correspondence with Sydney Water.

*iii) Flood responsibilities*

When asked if they would know how to protect themselves and their property in the event of a flood, the answers were split with 40% answering yes and 60% answering no. The questions prompted respondents to write down what they would do in a flood and a summary of the answers provided included:

- Raise all stock/belongings onto high shelves or upstairs, i.e. get as much off the ground as possible.
- Place documents in waterproof bags.
- Collect valuables and get to higher ground/evacuate to friends or family.
- Turn off the power.
- Assess whether you would need to leave or not.
- Phone relatives, 000 or the SES for advice.
- Sandbag the property.
- Stay on high point of the property.
- Insure the property and its contents.
- Clear the drainage area, make sure nothing is blocking the flow of water.
- Move vehicles to higher ground.
- Turn on the pump.
- Stay indoors.
- Open garage doors to allow water to flow through.
- Listen to radio for updates.
- Have emergency kit ready.
- Keep in touch with neighbours.
- Remove fence palings.

A large number of respondents simply replied that they would “get out” or “leave”. Another common response that was written was that respondents would just “panic”.

Respondents were asked who in the community is responsible for reducing flood risks and were allowed to select more than one answer. An overwhelming 94% of respondents stated that it was Council’s responsibility to reduce flood risks, followed by the State Government (34%), the SES (27%) the landowner/resident (24%), and someone else (6%). The majority of people who selected someone else stated that Sydney Water should also be responsible. Other answers included neighbours, developers, planners, the Federal Government, the CMA and State Rail (RailCorp).

When asked about their level of involvement in the floodplain risk management process following the survey 84% of people stated that they would be interested in receiving further information. Table 15 shows a list of expected reactions and which the respondent intended to undertake.

*Table 15 - Community responses - Bankstown*

| Action | No. (%) | Possibly (%) | Definitely (%) |
|---|---|---|---|
| *Seek information on the flood risk to their property* | 21 | 33 | 46 |
| *Seek information on what to do to prepare for a flood* | 21 | 31 | 49 |
| *Seek to be involved in this flood risk management process* | 33 | 40 | 27 |

*iv) Suggestions*

The survey also provided respondents with the opportunity to provide suggestions about what they would like Council to do about future flooding in their area. A summary of the suggestions included:

- Make sure the region prepares strategies to ensure protection of life and property
- Keep the channels, drains and creeks free from rubbish and large items, including trees, with regular maintenance
- Provide residents with up to date information, including pamphlets and brochures on the local area, the risk and what to do in a flood. Consider having a flood website with all the information on it, including what council is doing/has done.
- Educate the elderly or vulnerable on risks and how to respond and prepare.
- House visits from council to address specific stormwater/drainage problems and provide advice on solutions.
- Increase and improve drainage infrastructure, more sewers and pipes, remove bottlenecks.
- Community project and education to keep drains and creeks clean.
- Maintain the creek banks to make sure they are secure.
- Give residents some warning, maybe on TV or radio, or via text messages.
- Prevent building and development in areas most at risk and very dense development.
- Issue flood kits to possibly affected houses.
- Widen, deepen and concrete the creek.
- Ensure all services and interested parties have a co-ordinated approach to minimise the risk.
- Ensure residents have adequate roof guttering and downpipes attached to the stormwater system.
- Identify low-lying areas of open parkland and direct flows there away from housing.
- Consider flooding impacts in sports field maintenance, i.e. when top dressing and contouring the playing fields.
- Ensure insurance companies define what a flood is and whether such flooding would be covered by insurance, don't let them inflate premiums.
- Make sure new developments have correct drainage requirements, don't block overland flows and fencing requirements.
- Do further studies and keep residents informed on progress.
- Increase the amount of grassed areas on properties.
- Inform people before buying or renting.

- Develop evacuation centres and procedures and provide the information to residents.
- Install underground water tanks in the parks on the overland flow paths.

## 7.4 CONSULTATION FINDINGS - STAGE TWO

Following acceptance by the Councils, the draft Study and draft Plan were placed on exhibition and community meetings were held in Parramatta (Granville Community Centre) and Bankstown (Chester Hill Community Centre).

### 7.4.1 Parramatta City Council

A community meeting was held on 11 July 2012 at the Granville Community Centre. It was attended by 16 residents and interested parties. A short presentation was made regarding the principal aspects, finding sand recommendations of the study and plan.

The presentation was well received and the subsequent comments and questions covered the majority of the issues raised at the previous community events, reported in Section 7.3 above.

Two issues raised warranted inclusion in the overall management plan:

- The placing of flood height markers at the various creek crossings to warn drivers and pedestrians how deep water is during flooding; and
- The education program be expanded to advise residents where areas that will not be affected by floodwaters are located so that they can seek refuge there during floods, and also allow SES or others to establish emergency shelters in flood free areas.

Other matters raised were very site specific and are being addressed individually by Council.

### 7.4.2 Bankstown City Council

Two community meetings were held in Bankstown City on 9 August 2012 at the Chester Hill Community Centre. The afternoon meeting was attended by 15 residents and interested parties, and the evening meeting was attended by 26 residents and interested parties. A short presentation was made regarding the principal aspects, findings and recommendations of the study and plan.

The presentation was well received and the subsequent comments and questions covered the majority of the issues raised at the previous community events, reported in Section 7.3 above.

Two issues raised warranted inclusion in the overall management plan:

- The concept of placing bollards at selected locations required greater explanation; and
- The education program be expanded to include the concept of risk management and the meaning of Council's risk categories.

It is noted that BCC sent letters to residents in the high risk zone, whether or not they had previously registered to attend meetings or receive feedback. Other matters raised were very site specific and are being addressed individually by Council.

# 8 FLOODPLAIN RISK MANAGEMENT OPTIONS

## 8.1 GENERAL

The following discussion and descriptions are based on the NSW Floodplain Development Manual, 2005. Greater detail on these matters can be found in the Manual and its Appendices. At the time of writing of this report the Floodplain Development Manual could be found online at http://www.environment.nsw.gov.au/floodplains/manual.htm.

There are three generally recognised ways of managing floodplains to minimise the risk to life and to reduce flood losses:

- By modifying the response of the population at risk to better cope with a flood event (Response Modification);
- By modifying the behaviour of the flood itself (Flood Modification); and
- By modifying or removing existing properties and/or by imposing controls on property and infrastructure development (Property Modification).

Flood Modification and Property Modification may also be referred to as "Structural Measures" and Response modification as "Non-structural Measures" respectively. Including flood preparedness and response measures in an overall Floodplain Risk Management Plan is an effective method of minimising the impact of floods not addressed by other measures.

A fundamental principle of floodplain risk management is that management measures should not be considered in isolation. Rather, they must be considered collectively on a risk management basis that allows their interactions, their suitability and effectiveness, and their social, ecological and economic impacts to be assessed.

The various methods are listed in Table 16 below.

*Table 16: Floodplain Management Measures*

| ***Response Modification*** | **Flood Modification** | **Property Modification** |
|---|---|---|
| *Community awareness* | Flood control dams | Land use zoning |
| *Community preparedness* | Retarding basins | Voluntary purchase |
| *Flood prediction and warning* | Channel improvements | Voluntary house raising |
| *Flood Emergency Plans* | Levees | Building and development controls |
| *Evacuation arrangements* | Bypass floodways | Flood access |
| *Recovery plans* | Flood gates | Flood proofing buildings |

## 8.2 RESPONSE MODIFICATION MEASURES

Flood response measures encompass various means of modifying the response of the population to the flood threat. Planning for these measures should be incorporated in the local flood plan for the area, which is prepared by the NSW SES. The local flood plan is complementary to the floodplain management plan.

The development and implementation of effective flood response within the community is a means of reducing the damage associated with this risk. Response modification measures, such as flood warning and evacuation procedures, can be of substantial benefit in their own right. Flood warning and

evacuation plans can be very cost effective. In fact, they may, in some cases, be the only economically justifiable risk management measures.

### 8.2.1 Local Flood Plans

The SES, in association with the Councils and other relevant agencies and the community, through the Local Emergency Management Organisation, leads in the development of detailed local flood plans for areas with significant flood problems. These plans describe the various measures to be undertaken before, during and after a flood, including warning, evacuation, resupply and other procedures.

Floodplain management measures adopted in the floodplain management plan should be compatible with the local flood plan.

### 8.2.2 Flood Prediction and Warning

The Bureau of Meteorology (BoM) has a system of weather data collection that allows flood levels to be predicted in non-flash flooding catchments. However, In the case of catchments affected by flash flooding such as the Duck River catchment, it is not possible for the BoM to provide any prediction and warning, other than a general severe weather warning, because the flood events occur so quickly after the onset of rainfall – the time of concentration in this catchment being approximately 2 hours and anything less than 6 hours is considered flash flooding.

SES has responsibility to issue flood warnings and adds local information to the broad scale advice prepared by BoM, and turns the predictions of flood levels at specified gauges into warnings about the consequences of predicted flooding, such as, closing of roads or water entering properties or otherwise affecting human interests and activities. The SES may not be able to undertake its usual role in flash flooding circumstances.

### 8.2.3 Flood Education

Community education helps to build resilience to flooding through learning. There are four ways that community education can help communities, including residents and businesses, to improve their flood resilience:

- Learning to prepare for a flood;
- Learning how to respond to a flood;
- Learning how to recover from a flood; and
- Learning how to improve after a flood.

Research shows that there are several psychological factors that must be addressed to increase flood preparedness through learning. These factors include perception of the flood risk, perception of the importance of the risk, whether people believe that they have control over circumstances, their assessment of their resources to enable an action ('self-efficacy') and their capacity for problem solving and to confront challenges. Even with these factors advanced it has been shown that people will only prepare appropriately if they trust the emergency authority (e.g. SES). A recent flood experience is another factor that may increase people's preparedness activities.

Preparedness covers learning how to prepare for, respond to and recover from a flood. In practice, preparation may involve a range of activities including residents and businesses flood proofing properties and having an emergency kit. Response learning can include how to respond to flood

warnings and when and how to evacuate. Recovery learning can include the ways to clean up, resume functions and safety and health precautions.

A method to cover and integrate these preparedness activities is through the development of emergency plans for the different users e.g. residents, businesses, caravan parks, retirement homes, schools. These emergency plans should link to local flood plans.

There are other aspects of resilience-building that can also be assisted through learning. The ability of a community to adapt to a flood event is also dependent on how its capabilities (e.g. leadership, networks) and all its systems (e.g. flood warning systems, recovery systems) operate. Learning can be conducted to further improve capabilities (e.g. training for emergency management volunteers, briefings for community leaders such as councillors) and systems (e.g. evacuation drills, review of flood warning and communications).

It is important to learn immediately after a flood event to further build resilience to future flood events including by improving preparedness, capabilities and systems. Ways to conduct this learning include through community de-briefs, ongoing discourse (e.g. through the media) and reviews (e.g. by the SES).

Community flood education programs should consider all of the above in their design. As a flood can occur at any time, they should be ongoing as learning can be lost rapidly if they are not maintained.

Research has shown that flood education programs are most effective when they:

- Are participatory i.e. not totally consisting of top-down provision of information but where the community has input to the development, implementation and evaluation of education activities;
- Involve a range of learning styles e.g. experiential learning (e.g. field trips, flood commemorations), information provision (e.g. via pamphlets, DVDs, the media), collaborative group learning (e.g. scenario role plays with community groups) and community discourse (e.g. forums, de-briefs).
- Use volunteers to lead informal discussions in the community about flooding
- Are linked with structural and other non-structural floodplain management options (e.g. by encouraging the community having a say in structural infrastructure options, commenting on planning options).
- Are part of local flood plans.

### 8.2.4 Recovery Planning

The floodplain management plan needs to recognise that after the flood:

- Council and other authorities will need to restore or clean up their assets;
- Individuals will be engaged in some clean-up activities;
- Council will be expected to provide some assistance, even if only in disposing of waste materials and debris;
- Authorities such as Community Services may provide some welfare services;
- Meetings to share flood experiences and subsequent problems could include trauma counselling to help people realise they are not alone in the floodplain; and
- The period after the flood is an opportunity to collect data that will help agencies and communities to better deal with the next flood event. This information should include:
    - Water information (levels, rates of rise and fall, velocities, areas inundated);
    - Details of damage;
    - Information which did or did not become available when needed during the flood; and

- Actions which were taken during the flood.

## 8.3 FLOOD MODIFICATION MEASURES

The purpose of flood modification measures is to modify the behaviour of the flood itself by reducing flood levels or velocities or by excluding floodwaters from areas under threat. It is essential that these measures are assessed, first, on an overall catchment basis, and second, from within the strategic framework of an overall floodplain management plan. If assessed individually or in isolation, there is the possibility that future land-use developments may reduce, if not eliminate, present mitigating effects. For example, retarding basins must be assessed on a systems basis that incorporates the impact of future development and a range of flooding scenarios.

### 8.3.1 Flood Mitigation Dams

Flood mitigation dams are designed to reduce downstream flood discharges and are most effective in very large catchment situations. As the flood wave passes through the dam storage area, the dam is progressively filled to the point of overflow, trapping a portion of the floodwaters. The full dam then provides temporary storage for floodwaters subsequently passing through it.

Such structures are extremely expensive and their design usually incorporates irrigation supply or power generation, as well as the flood mitigation aspect.

These structures are not relevant to this catchment and flood mitigation dams are not discussed further.

### 8.3.2 Retarding Basins

A retarding basin is a small dam that provides temporary storage for floodwaters. Retarding basins are used as a means of controlling the peak discharge from urbanised areas. Some of these basins are becoming quite large, and in fact, they are more properly regarded as small dams and have to be designed as such. A retarding basin behaves in the same way as a flood mitigation dam, but on a much smaller scale. In urban areas, retarding basins are most suitable for small streams that respond quickly to rapidly rising flooding. Retarding basins have a number of inherent disadvantages that should be carefully evaluated for each particular situation, for example:

- They require a substantial area to achieve the necessary storage;
- Where they involve multi-purpose uses, safety aspects during flooding need to be addressed;
- Long duration or multi-peak storms (when the basin is filled in the first peak) can increase the likelihood of overtopping (when no alternative is available), or embankment breaching or failure (‘dam break’), and the resulting personal danger and damage; and
- They provide little attenuating effect when overtopping occurs.

Consequently, it is important that retarding basins are properly designed (including consideration of alternative storm patterns and flood recurrence intervals), constructed and maintained. Risk is reduced by complementary works (bypass spillways) or specific land use planning measures (downstream flowpaths). It is noted that with appropriately designed outlet works, retarding basins may act as sediment traps thereby improving urban water quality by reducing the concentration of solids.

### 8.3.3 Bypass Floodways

Bypass floodways redirect a portion of the floodwaters away from areas under threat from flooding, and so reduce flood levels along the channel downstream of the diversion. Opportunities for the construction of bypass floodways may be limited by existing development, the topography of the area, environmental considerations and the availability of land. Bypass floodways may exacerbate flood problems further downstream and, as they direct flows away from natural paths, may impact on channel form both upstream and downstream of the site of the works. Despite these shortcomings, bypass floodways can, on occasions, provide a useful management option.

Given the highly built up nature of the catchment, bypass floodways are considered unviable and will not be discussed further.

### 8.3.4 Levees

Levees are frequently the most economically attractive measure to protect existing development in flood prone areas. The height or crest level of a levee is determined by a variety of factors that include:

- The economics of the situation (including the nature of development requiring protection);
- The physical limitations of the site;
- The level to which floods can rise relative to the ground levels in the area (important in safety considerations); and
- The visual impact of the levee.

A levee may rarely be called upon to achieve its design requirements. If it fails at this time because of poor design, improper construction or poor maintenance, the money spent on its construction has largely been wasted. Even if design, construction and maintenance are exemplary, all levees will ultimately be overtopped by an 'overwhelming' flood (unless designed for the PMF event). It is not a question of if overtopping will occur, but of when and what the consequences will be. Hence, the importance of plans that address the defence and evacuation of areas protected by levees cannot be overstated (i.e. residual flood risk).

In using levees for flood risk management, in either urban or rural situations, the following precautions need to be noted:

- The likelihood and consequences of catastrophic damage and unacceptable personal danger levels when the levee is overtopped, (when the levees at Nyngan, NSW, were breached in 1990, the cost of the resulting damage and disruption was some $150 million in 2010 terms);
- Appropriate design of the levee and provision of spillways to avoid uncontrolled high velocity flows or even failure when the levee is overtopped;
- Proper maintenance of the levee crest level, grass cover and spillways and the avoidance of damage from traffic or animals;
- Provision is necessary for local overland flooding/local rainfall within the levee into the main stream. This may require a pumping system and storage basin within the levee, the provision of flap gates on piped systems that pass through the levee or other site specific measures;
- Emergency response plans for levee overtopping and evacuation. The need for such plans is particularly important where escape routes can be severed;
- Analysis of flow conditions that may develop when overtopping occurs and the flood continues to rise. In some situations high hazard conditions can develop in protected areas and unless appropriate restrictions are applied, development and personal safety could be at risk. Such development control measures or restrictions may include buffer zones where development is limited or even prohibited;

- The need for infrastructure management plans to reduce damage to essential services and facilitate rapid recommissioning following flooding is essential;
- On-going community education to ensure that the population is aware of the risk of overtopping, is informed about emergency response plans and does not lapse into the common belief that levees 'provide protection against all floods'; and
- Levees may prevent the flow of water to valuable environmental areas, such as wetlands, and the consequences of this need to be considered especially for threatened species and the ecological community as a whole.

Permanent, carefully designed, constructed and maintained levees are a common and important management measure for existing flood risks. Depending on likely height of levee and population/development being protected, the levee may best be designed as a small dam. However, they are a partial solution and should be supplemented by comprehensive flood planning and readiness measures.

### 8.3.5 Channel Modifications

The hydraulic capacity of a river channel to discharge floodwater can be increased by widening, deepening or re-aligning the channel and by clearing the channel banks and bed of obstructions to flow.

The effectiveness of channel modifications depends upon the characteristics of the river channel and the river valley. In urban situations, channel modifications can provide the community with other positive benefits. In the main, these involve enhanced visual aesthetics by landscaping and the provision of recreation facilities, such as linear parks.

Channel modifications are likely to be most effective (including reducing the need for other structural works) on steeper smaller streams with overgrown banks and narrow floodplains. Channel modifications are unlikely to have a significant effect in flooding situations where there are extensive areas of overbank flooding or where flooding effects are dominated by increased tide levels.

As a management measure, channel modifications have a number of potential disadvantages. For instance:

- Like bypass floodways, they facilitate the transfer of floodwaters downstream and can accentuate downstream flooding problems;
- The potential impacts of such works on channel bed and bank stability, both upstream and downstream of the site;
- The high cost of maintenance;
- The destruction of riverine habitat; and
- The visual impact of replacing naturally varying channel sections with a section of more uniform geometry.

The use of concrete lined channels to replace natural streams is particularly undesirable from an environmental stand point and should be avoided where possible. Where modifications to natural streams are proposed these should be designed considering guidelines for the rehabilitation and restoration of streams as available through organisations such as the Co-operative Research Centre for Catchment Hydrology.

### 8.3.6 Floodgates

Floodgates may be used to control flow down a bypass floodway, or to prevent flow along a small creek or drain or other waterway. When used to control flow down a bypass floodway the opening of

the floodgates is generally designed to keep the flow in the mainstream until bank full conditions are about to be reached. The gate is then opened to reduce the problems that would occur if there were somewhat uncontrolled overbank flow from the mainstream.

There are many locations where floodgates are used to keep flood waters from backing up a drain or creek. These gates may be designed to be normally open and closed when there is a flood. They are often used to prevent oceanic inundation. Alternatively, in some situations they may be normally closed and open only when the water level behind the gate is higher than the water level in the stream or estuary.

Floodgates may be designed to open or close automatically, or may require someone to open or close the gate at flood time. The protection of some low-lying urban areas, such as the lower reaches of the Duck River in PCC LGA, is usually the key function of floodgates. This benefit must be compared with a range of other adverse environmental impacts of floodgates such as:

- Changes in aquatic ecology;
- Exposure of acid sulfate soils;
- Changes in water quality;
- Drying out of wetlands and change in functionality;
- Potentially altered hydrological regime resulting in changed vegetation species composition; and
- Restriction of fish passage and loss of nursery habitat.

Changes in operation of flood gates, particularly those whose principal purpose was to exclude tidal inundation and backwater flooding, can assist in reducing or rehabilitating these problems. In areas of known acid sulfate soil problems allowing for controlled tidal flushing during non-flood periods can decrease the level of acidity released into an estuary to a more acceptable level. In addition, controlled opening of floodgates can direct additional water to wetlands. This can be accomplished by maintaining some or all gates in an open position during non-flood times and having procedures to have gates closed during flood periods. Closure of gates can be automatic with maintenance ensuring closure has occurred during flood periods.

Maintenance of floodgates is important to ensure that they do close or open satisfactorily when the flood comes and remain closed or open as required during non-flood times.

## 8.4 PROPERTY MODIFICATION MEASURES

Property Modification measures incorporate modifying or removing existing properties from flood affected areas and/or by imposing controls on future property and infrastructure development. These are aimed at steering inappropriate development away from areas with a high potential for damage and ensuring that potential damage to developments likely to be affected by flooding is limited to acceptable levels by means of minimum floor levels, flood proofing requirements, etc.

In this catchment, it is convenient to divide these measures into Works and Planning, as each sub-category has differing impacts and applications.

### 8.4.1 Property Modification - Works

Property Modification – Works includes any measure that changes the character of the property or residence, including:

- Voluntary purchase;
- House raising;

- Flood proofing buildings; and
- Flood access.

### a) Voluntary Purchase

In certain high hazard areas of the floodplain it may be impractical or uneconomic to mitigate flooding risk to existing properties. In such circumstances, it may be appropriate to cease occupation of such properties in order to free both residents and potential rescuers from the danger and cost of future floods.

This is achieved by the purchase of the properties and their removal or demolition as part of an adopted floodplain management plan. Under such circumstances, property should be purchased at an equitable price and only where voluntarily offered. Such areas should ultimately be rezoned to a flood compatible use such as public open space.

### b) Voluntary House Raising

Voluntary house raising has long been a traditional response to flooding. Home owners generally have very strong sentimental and emotional attachments to their dwellings, which often also represent a large capital investment. Avoidance of flood damage by house raising achieves the following three important objectives:

- A reduction in personal loss;
- A reduction in danger to personal safety and in the costs of servicing isolated people who remain in their homes to protect possessions; and
- A reduction in stress and post-flood trauma.

In general, voluntary house raising is a suitable management measure only for low hazard areas of the floodplain. In high hazard areas, either physical means of protection, for example, levees, or voluntary purchase measures are required.

While raising a house may achieve the objectives described previously, care must be exercised in implementing this measure by considering the implications of a slightly higher than design flood. The new construction may be isolated for long periods during floods, necessitating an increased load on emergency services, should they be required. The isolated house would also need to be capable of “self support” during flooding. This requires, for example, adequate food, water and possibly power supplies.

Thus it is essential that both the benefits of and problems associated with voluntary house raising are considered in the floodplain management planning process.

### c) Flood Proofing of Buildings

Flood proofing refers to the design and construction of buildings with appropriate water resistant materials and configuration such that flood damage to the building itself (structural damage), and possibly its contents, is minimised should the building be inundated.

At best, flood proofing is an adjunct to other management measures. Because of this, the recommendation to adopt flood proofing as a formal management measure can only be made on an objective basis from within the strategic framework of a floodplain management plan. Whilst flood proofing can minimise structural and possibly content damages to flood-affected buildings, the occupiers of flood affected buildings still suffer the social and economic disruption of flooding. Thus, councils cannot simply allow development of flood prone land as long as buildings are “flood proofed”.

Rather, the social and economic consequence of flooding needs to be assessed for both the “non-flood proofed” and “flood proofed” situations. If the consequences of flooding with flood proofing in

place are still unacceptable, other management measures need to be sought such as levees (for existing development) or alternative locations or development controls (for new development).

#### d) Flood Access

Flood access can be partly dealt with as a development control. However, it also needs to be addressed on a broader scale than the layout of new sub-divisions. In the Duck River area, where floods rise and fall in hours (rather than the days or weeks which may be characteristic of very large catchments), complete isolation during a flood may be acceptable. It needs to be remembered, however, that this only applies to smaller floods as larger floods which involve over floor flooding may require evacuation.

In the more usual situation, in which complete isolation during a flood is not acceptable, an access route which is closed in small or large floods may be acceptable, if there is an alternative route available. The alternative route may have significantly lower traffic capacity, but should allow large vehicles through. Hence it should not have extremely steep gradients, tight bends or bridges with load limits.

#### e) Insurance

Insurance is not strictly a property modification measure but is a means of mitigating the cost of the residual risk to property after all other mitigation measures have been implemented. Insurance can be taken out on private property as well as public infrastructure and buildings. It is available for residential, commercial and industrial property. However, the cost of insurance may be considered unaffordable by those who have to pay for it.

### 8.4.2 Property Modification - Planning

Property Modification – Planning includes any measure that governs what can be built and any requirements to minimise or negate the impacts of flooding. These measures usually constitute land use planning and development controls.

Land use planning limits and controls are an essential element in managing flood risk and the most effective way of ensuring future flood risk is managed appropriately. Effective consideration of future development involves a strategic assessment of flood risk to future development areas to guide councils, in wisely and rationally controlling development to reduce the risk exposure of new development to an acceptable level.

Strategic assessment of flood risk can steer inappropriate development away from areas with a high hazard and/or with the potential to have significant impacts upon flood behaviour in other areas. It can also reduce potential damage to developments likely to be affected by flooding to acceptable levels by means of minimum fill and floor levels and flood proofing requirements, etc.

Specific land use planning measures and controls include:

- Zoning - Appropriate land use control measures are strongly recommended if the rate of growth of future flood damage is to be limited. The most effective way to protect the floodway and prevent development occurring within an area of high hydraulic hazard is by zoning the land appropriately. However, the use of zoning to unjustifiably restrict development simply because land is flood prone is not supported.
- Development Controls are the appropriate means of implementing detailed aspects of council's floodplain management plan, particularly when addressing future flood risk. The suitability and effectiveness of development controls in managing risk needs to be considered within a strategic management framework as part of the management study. The aspects of land use planning and development controls that need to be addressed in detail in the management study with associated recommendations in the management plan should include:

- Access to the Site before, during and after Flood Events;
- Fill or Excavation in the Floodplain;
- Freeboard;
- Floor levels;
- Differences between Land Uses;
- Services;
- Impact on Flood Behaviour;
- Structural Soundness When Flooded;
- Building Materials; and
- Fencing.

### 8.4.3 Flood Planning Level

A key decision in the Floodplain Risk Management Study is the determination of the Flood Planning Level (FPL) and the subsequent Flood Planning Area. These concepts are defined in the Floodplain Development Manual as below:

- Flood planning levels (FPLs) - FPLs 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 risk management studies and incorporated in risk management plans.
- Flood planning area - The area of land below the FPL and thus subject to flood related development controls.

The decision on the adopted FPL should be a merit based decision, taking into account the full range of flood sizes, up to and including the probable maximum flood (PMF) and the corresponding risks associated with each flood. However, the Manual notes that while there may be a few exceptions, it is neither feasible nor socially or economically justifiable to adopt the PMF as the basis for FPLs.

### 8.4.4 Hydraulic & Hazard Categories

Prior to determining the FPL and FPA, the Hydraulic and Hazard Categories need to be determined. An explanation of the determination of these categories is given below:

#### a) Hydraulic Categories

It is not feasible to provide explicitly quantitative criteria for defining floodways, flood storage areas and flood fringe areas, as the significance of such areas is site specific. Generally, the following definitions are applied:

- Floodways are areas conveying a significant proportion of the flood flow and where partial blocking will adversely affect flood behaviour to a significant and unacceptable extent.
- Flood storage areas - those areas outside floodways which, if completely filled with solid material, would cause peak flood levels to increase anywhere by more than 0.1 m and/or would cause the peak discharge anywhere downstream to increase by more than 10%.
- Flood fringe - the remaining area of land affected by flooding, after floodway and flood storage areas have been defined. Development in flood fringe areas would not have any significant effect on the pattern of flood flows and/or flood levels.

Using velocity and depth data from the hydraulic models, the high and low hazard floodway and flood fringe have been determined across the whole range of flood conditions. There are very few areas that would fall within the flood storage criteria and this hydraulic category can be ignored for the majority of flood events. Extreme floods may create localised floodways; however as their likelihood is so small, basing any planning decision on these floods, other than for emergency planning, is not justified.

### b) Provisional Hazard Categories

Hazard categories are broken down into high and low hazard for each hydraulic category. These can be defined as:

- High hazard: possible danger to personal safety; evacuation by trucks difficult; able-bodied adults would have difficulty in wading to safety; potential for significant structural damage to buildings.
- Low hazard: should it be necessary, truck could evacuate people and their possessions; able-bodied adults would have little difficulty in wading to safety.

Provisional flood hazard categorisation based around initial hydraulic evaluations does not consider a range of other factors that influence flood hazard. Therefore provisional hazard categorisation should be used with the following factors to determine true hazard categories:

- Size of flood;
- Effective warning time;
- Flood readiness;
- Rate of rise of floodwaters;
- Depth and velocity of floodwaters;
- Duration of flooding;
- Evacuation problems;
- Effective flood access; and
- Type of development.

### c) Applying the Categories

*i) Parramatta*

Provisional hazard and hydraulic categorisation has been prepared and is mapped in the Flood Study Review. As could be expected, the high hazard areas for the 100 year ARI follow the main channels and watercourses and only where there is an overflow into adjoining roads is there any property directly affected.

In the PMF, a number of the roads become significant floodways, particularly where the road is parallel to the main stream channel. Should there be consideration of a major and extensive redevelopment of the area, or in the commercial / industrial area a major change of use, a more rigorous assessment for extreme floods may be warranted.

There is a need to incorporate the hazard and hydraulic category mapping into PCC's planning instruments, particularly the DCP, to ensure that these issues are considered in the development process.

*ii) Bankstown*

BCC have mapped the provisional flood risk precincts for the 100 year event and the PMF event; these were derived from the provisional hazard categories. These can be interpreted as follows:

- High flood risk precinct: high provisional hazard;
- Medium and low flood risk precincts: low provisional hazard.

It will be essential to ensure that these risk precincts are incorporated into the revised LEP and DCP currently in preparation.

*iii) Auburn*

ACC has defined risk precincts for its Haslams Creek floodplain, utilising provisional hazard and hydraulic categories prepared by others. This approach and the supporting definitions could be used by ACC for this area and it is essential to ensure that these risk precincts are incorporated into the LEP 2010 and DCP 2010.

### d) Refining the Risk Categories

While all Councils have adopted a "risk precinct" approach to floodplain management, the risk precincts are based on the provisional hazards rather than a comprehensive assessment of risk. The most recent discussion on this issue is provided in *A Framework for Holistic Risk Based Floodplain Planning*, presented by Steven Molino and Steven Roso to the Planning Institute of Australia 2012. This Paper is attached as Appendix C.

Undertaking this "conversion" to the full range of risks is a lengthy and complex process and has not been undertaken in this Study. It is recommended that the risk assessment process be applied to the various sections of the study area once all data is available and in the next review of the floodplain management process.

# 9 OPTIONS SHORTLIST

This section discusses in greater detail the options available for floodplain risk management, and identifies those options that have a higher viability and thus a higher likelihood of achieving the overall objectives when implemented in a Floodplain Risk Management Plan.

## 9.1 RESPONSE MODIFICATION

This option involves people taking actions before, during and after a flood to reduce the risk to life and the risk to property.

The critical storm – the storm likely to cause the highest runoff, and therefore flooding - for the Duck River catchment is approximately 2 hours and typical warning times available in Duck River and its tributaries is significantly less, in the order of 30 minutes. The Bureau of Meteorology considers this scenario as “Flash Flooding” and it does not issue specific flood warnings for this catchment. There are, however, severe weather warnings issued for areas such as Greater Sydney and this should be a trigger for residents to be alert for flooding conditions.

Within these timeframes, comprehensive evacuation of affected properties is not a realistic option. Therefore, response modification measures in the catchment would be better described as behaviour modification. i.e., what people can do in preparation at any time and what the response should be when they hear a generalised warning for flash flooding or they see evidence of floodwaters rising.

Community education therefore has to underpin this and is essentially the only practical response modification option which can be undertaken by Government and Councils within the Duck River catchment. Individual property owners would then be responsible for implementing a personalised flood plan.

Accordingly, a community education program, prepared with the aim of behaviour modification, is a recommended option as part of the Duck River Floodplain Risk Management Plan:

In the past few years, a new approach to community education has emerged and been successfully used by emergency managers and local councils around Australia and elsewhere in the world. It deviates markedly from the ‘traditional’ education approach of only distributing information to communities in the hope that they will prepare for and respond appropriately to a flood as a result of possibly reading it. Extensive research has shown that although this may lead to increased awareness, it will not by itself change preparedness and response behaviours.

For the new approach, Dufty (2008) defines community flood education as ‘any learning process or activity that builds community resilience to flooding’. Resilience is the ability of a community to ‘bounce back’ after a flood and continue its normal functioning (and even improve as a result of the flood). It is viewed by the Australian Government as a critical factor in adapting to the possible future impacts of climate change.

The term ‘education’ in the new approach is viewed in its broadest sense and includes learning both in formal (e.g. schools) and non-formal (e.g. community events) settings. Community flood education can include:

- Public communications, information products and services e.g. publications, Internet sites, displays, promotional products, media liaison, advertising/marketing, public education campaigns.
- Training, development and industry-specific programs e.g. skills development courses, professional training, workplace induction programs, field days.
- Community development programs e.g. public participation programs, awareness-raising programs, discussion groups, developing education networks.

- Use of social media for learning e.g. Facebook, Twitter, YouTube
- Comprehensive personal education programs e.g. school curriculum, university curriculum, personal development courses, action research programs, community education courses.

In the new approach, learning is tailored for community sectors including:

Residents

- Businesses and Industry
- Schools, universities and other places of learning
- Vulnerable people e.g. aged, CALD communities, caravan park residents
- Government agencies e.g. SES and their volunteers
- Local councils

The features of the new approach to community flood education include:

- Learning for understanding flood risks and ways flood risks are managed, how to prepare for a flood, how to respond to a flood (including to warnings) and how to recover from a flood
- Participation of communities with councils and emergency agencies in the design, implementation and evaluation of community flood education programs
- Variety in the learning processes
- Ongoing and planned learning – a local community flood education plan is a useful mechanism to achieve this
- Household and business emergency plans as key outputs of the learning
- Community flood education linked to other strategies in flood management.
- Using a cross-hazard approach where possible e.g. learning related to fires as well as floods
- Post-flood learning to evaluate the impact of community education programs and improve general community resilience to future floods

This community education approach does not negate the activities of the SES as the flood response agency. The SES will need to base its local flood plan and areas of concern on the mapping and property identifications in this Report and to use that data to concentrate their limited resources where they will have the greatest benefit, e.g. between Lackey and Elizabeth Streets on Little Duck Creek.

It is recommended that the Response Modification Measures outlined above should form part of the preferred options and will be investigated further.

## 9.2 FLOOD MODIFICATION

As indicated in Section 8, there are limited opportunities to implement Flood Modification Measures in the Duck River catchment. The following sections describe potential options for detention basins, channel improvement/flow enhancement and levees/flow diversion, the most viable Flood Modification measures.

### 9.2.1 Detention (Retarding) Basins

#### a) Basins

Using the mapping described above, locations for potential detention/retarding basins which may be large enough to provide flood detention storage capable of mitigating downstream flooding have been identified and are discussed below.

Two locations, Sefton Golf Course (BCC) and Woodville Golf Course (PCC), have been identified as being of a sufficient size to make a significant difference downstream when compared to the flow which they can detain. Both of these Golf Courses are in public ownership, simplifying any actions taken at these sites.

The detention may be achieved by the construction of berms between fairways where they cross the flow paths and/or the addition of mitigation capacity to existing or proposed water supply dams. This work would have to be carefully designed so that there is no adverse impact to the golf course and its ability to provide enjoyable recreation and earn its keep within its budgetary requirements.

Although neither area offers huge detention capacity, it is large compared to flows at the upper ends of the catchment and so could potentially make a difference to houses immediately downstream. At Sefton, there is also the potential to divert the outflows flows from going through private properties. It is noted however that no above floor flooding has been identified adjacent to Sefton golf course.

Although there are a number of other open spaces/parks along the drainage lines, both major and minor, the initial assessment is that there is just not enough open space to make a significant difference to downstream flood levels when the cost of construction, etc., is taken into account. In addition, there is a common problem with Parks in that the fill material may be of questionable quality (because of past practice) and could have material in it such as contaminated soils, asbestos (in varying forms) or building rubble which would make disposal alone expensive. If a detention system is to be employed, it would be more appropriate to build walls up rather than dig down unless there is absolute confidence in the quality of the material to be extracted.

Examples of open space which are not large enough where this situation arises are:

- O'Neill Park, Birrong – Would require removal of substantial quantities of fill for water to be detained which would not benefit properties upstream which experience above ground flooding in 1 in 5 year ARI event. The very low properties at the Cooper Road/Daley Road corner may be better addressed through Voluntary House Raising. This approach may also be appropriate for the low lying properties in Talbot Road and Brodie Street downstream of the Park.
- Band Hall Reserve, Birrong – This Reserve has the junction of three waterways at its north-western extremity with a waterway downstream that has only limited expansion to accommodate the multiple inflows. It would require the removal of substantial quantities of fill for water to be detained however this is already overwhelmed in 1 in 100 year ARI due to a flow constriction downstream. The drainage line from the south does have scattered properties where above floor flooding commences in quite small floods and these are scattered throughout the sub-catchment. Again, Voluntary House Raising may be the most appropriate course of action for these properties.
- Jim Ring Reserve, Birrong and Maluga Passive Park, Birrong – As the largest open space other than Sefton Golf Course (the outflow from which enters Maluga Passive Park), these Parks are treated as a single unit. Again, substantial fill would need to be removed to create any significant detention and because it is further downstream than previous mentioned parks, even more fill has to be removed to lower flood levels if there is no work upstream. Several houses on the western side of Woods Road have above floor flooding in 1 in 5 year, 1 in 20 year or 1 in 50 year ARI so there may be an opportunity for some benefits here however the constriction where the channel passes under the rail embankment would appear to be a major contributor to the flooding. Any work for a retarding basin would need supplementary work on the railway, which may have adverse impacts by increasing flows downstream.
- Jensen Park Sefton – Most of the properties adjacent to the park get above floor flooding in a PMF and significant excavation would be needed to deliver benefits.
- Parklands, open space and Auburn Public Golf Course (Rosnay) – these properties line Duck River for a considerable distance and the adjoining properties generally do not have above floor flooding until a PMF occurs. The Parks, etc. are built up high above the creek line so for them to make any difference, a massive amount of fill would have to be removed.

In the Duck Creek and Little Duck Creek sub-catchments, there are numerous properties which have frequent above floor flooding but there is very little open space big enough to provide sufficient storage to make a difference. Examples of this include:

- A small park downstream of Elizabeth Street that may have some benefit for William Street/Blaxcell Street and William Street/The Trongate;
- Colquhoun Park/Harry Gapes Reserve/Wolseley Street Reserve/Bright Park, which, if treated as a series of basins, may have some benefit for properties as far downstream as Louis Street;
- Upgrading previous work in Granville Park may have some benefit for Meadows Street/Louis Street though the main above floor flooding problem in this area appears to be generated by an old watercourse rather than existing mainstream flows; and
- Guildford Park may have some benefit for Harold Street, Vairys Crescent and Lansdowne Street.

It is considered that only Sefton Golf Course and Woodville Golf Course are suitable for use as detention storages. The other open space within the catchment does not provide the volume of storage or the general benefits of the two major sites and it would be hard to justify the likely cost of any works for the few properties which might benefit by reduced above floor flooding. Accordingly, the sites other than Sefton Golf Course and Woodville Golf Course were not investigated further.

### b) On Site Detention

An alternative to providing one or more large detention basins is to provide hundreds or thousands of smaller ones. This can be done through the construction of on-site detention structures on private properties throughout the catchment. This is common practice in many local government areas around Australia. All Councils in the catchment apply On Site Detention (OSD) to developments within their areas of operation although there are some exceptions that accept its inapplicability in certain areas. The OSD policies are summarised below:

- Auburn City – Policy is located within the Auburn Development Control Plan 2010 and contains the objective of “To ensure that through the on-site detention (OSD) of stormwater, discharge is controlled thereby ensuring the development does not increase the risk of downstream flooding of roads and properties, or erosion of unstable waterways.” A Performance Criteria that “Sufficient storage is provided to ensure peak flow rates at any point within the downstream drainage system do not increase as a result of the development during all storm events up to the 100 year ARI” is also stated as are the Permissible Site Discharge (PSD) and the Site Storage Requirements (SSR).
- Bankstown City – Policy is located within the Engineering and Drainage Standards Version June 2009 and contains the objective of “OSD must be designed and constructed to control stormwater runoff from development sites such that, for 5 to 100 year ARI events, peak stormwater discharges from the site do not exceed pre-development stormwater discharges.” A specific Performance Criteria is not stated however there are a range of engineering standards to be met. There are no specific Permissible Site Discharge (PSD) and the Site Storage Requirements (SSR) – these are to be determined by the designer.
- Parramatta City - Policy is located within the draft Design and Development Guidelines and contains the objective “to reduce the peak runoff rate from a development to existing conditions.” A specific Performance Criteria is not stated however there are a range of engineering standards to be met as well as satisfying the specified the Permissible Site Discharge (PSD) and the Site Storage Requirements (SSR) for all catchments within the area of Council’s responsibility. There is also a cross-reference to Upper Parramatta River Catchment Trust OSD handbook for general OSD requirements.

The most important issue to note here is that all OSD policies and design parameters are set so that “the development does not increase the risk of downstream flooding”. As such, the continued application of OSD to new and infill developments is encouraged however it is essential that the community is aware that the OSD policies applied in the catchment are not a process that makes flooding better, as can be achieved by major structural works, it prevents flooding from getting worse.

For OSD to prevent development from increasing runoff in a 1 in 100 chance of occurrence per year event, the Site Storage Requirement design parameter is a minimum of 430$m^3$ / hectare in Parramatta and 530$m^3$/hectare in Auburn – as noted above, there is no specific SSR in Bankstown and the SSR is assumed to be of a similar order for this Study only. An average 20 square house would require 9 - 10$m^3$ of storage which would be a space 3m by 3m and 1 – 1.5m deep. If a substantial reduction was to be made to flooding a storage volume many times larger than this would be necessary. It should also be noted that this storage volume needs to be empty at the beginning of the rainfall event for it to mitigate flooding therefore rainwater tanks or other water supply storages cannot fulfil a flood mitigation function.

A policy to reduce flooding in larger events using on site detention policies would not be practical and was not investigated further. However, it is recommended that the existing OSD policies be continued to ensure that flooding does not become worse in frequent floods.

### 9.2.2 Channel Improvement/Flow Enhancement

#### a) Existing Flow Constrictions

Using the mapping described above, locations where constrictions to flow are causing flooding upstream have been identified and whether these constrictions can be removed has been reviewed in general terms.

Locations which were looked at included:

- O'Neill Park, Birrong/Rail embankment – a "solution" here would be very costly as it would involve the construction of a larger waterway through the railway embankment and, as there are already flooded houses downstream, it is likely that flooding would be made worse for these houses by any works here;
- Band Hall Reserve, Birrong – a solution here can only be achieved by widening the downstream channel however this would require removal/acquisition of substantial sections of backyards and some buildings from at least 50 houses which back onto the channel. This is a very costly exercise and would involve the removal of private property which the option is setting out to protect. However, this Reserve offers an opportunity to enhance the environmental qualities of the channel – this is discussed in Section 8.1.4.
- Sefton Rail Embankment/Jones St - a "solution" here would be very costly as it would involve the construction of a larger waterway through the railway embankment and under the commercial/industrial area of Sefton between Carlingford Street and Clapham Road. Although this work may offer the potential to streamline the flows (removing the two bends in the waterway), there are flooded buildings downstream and it is likely that flooding would be made worse by any works here;
- SWP at Munro St/Duck River – there are a significant number of properties affected upstream of this location; downstream there is little other than open space. Accordingly, on paper, this appears a worthwhile measure. However, preliminary investigation (see Appendix B) indicates that removal of the 50% blockage in the existing culvert will not make a significant difference to flood levels. To achieve a greater impact, the measures here would require either an additional, unblocked culvert, raising the pipeline (with all the issues that may involve) or prevention of blockage through mechanical means, or a combination of measures. It may be viable to investigate this option further to establish both upstream and downstream impacts and whether there is any economic benefit to the option. BCC has received a report from its consultants BMT WBM on this matter and the report is at Appendix B. A detailed description of the report and its results is given in Section 10.2 under Channel Enhancement.
- SWP Wolumba St/Wolumba Creek – The school oval seems to be slowing water flow to the pipeline however the pipeline itself is also a constriction. A solution here would require a significant expense, probably more than the value of the house that is affected by above floor flooding in 1 in 20 year ARI event.

- Rail Embankment at Granville –Downstream properties get affected in 1 in 50 year ARI so opening up to benefit upstream is likely to make it worse downstream.

### b) Blockages

Structures across the channels (natural or concrete-lined) may trap materials entrained by flood flows such as shopping trolleys, branches, wheelie bins, fence panels, general litter and even cars. When these materials are bigger than the structure opening they help stop even smaller objects. Material accumulation in front of an opening causes the hydraulic structure to perform inefficiently. The way blockages were assessed by each Council is given below:

#### PCC

In undertaking the Duck River and Duck Creek Flood Study Review, all structures having a waterway opening less than 6.1m (as measured in the diagonal and based on a review of the blockage in the August 1998 flood at North Wollongong by Wollongong City Council) were assumed to be 50% blocked for the base case design event modelling. The impact of different blockage assumptions at these structures was examined as part of the sensitivity analyses (i.e., for no blockage and 100% blockage scenarios).

The channel structures underneath Wellington Road, Mona Street and all other structures along Duck River have a diagonal opening width of greater than 6.1m and as such are not considered for blockage. The impact of changing blockage assumptions is therefore minimal along Duck River.

For the 100% blockage scenario, flood levels in Duck Creek are decreased due to attenuation of flow and this has an impact of as much as -0.07m in Duck River downstream of the railway, for the 0% blockage case the impact is up to -0.05m.

For Duck Creek, the 100% blockage scenario resulted in increased flood levels in the upper reaches and the no blockage scenario results in lower flood levels, as could be expected due to increased efficiency of hydraulic structures.

For the lower reaches, altering the blockage parameters has the effect of increasing flood levels for the no blockage case due to increased flow. The 100% blockage case decreases flood levels in the lower reaches due to the attenuation of flow from storage in the upper reaches.

Little Duck Creek has similar trends with flood levels increasing upstream of Elizabeth Street due to storage and decreasing downstream of Elizabeth Street, Granville. The greatest impact is seen upstream of Thomas Street with levels varying by +/- 0.6m. For the 1% AEP design scenario a large proportion of flow is overland and hence subject to higher losses and low hydraulic efficiency. Assuming blockage to be 100% forces the majority of flow to travel overland, hence increasing storage and flood levels significantly.

#### BCC

In modelling undertaken for BCC, sensitivity tests were required to ascertain the impact on flooding due to blockages according to recommendations in Australian Rainfall and Runoff and “Bankstown Engineering and Drainage Standards Policy”. In application, this meant:

- For an open channel drain or creek, no blockage was applied
- Where there was a bridge or culvert across an open drain or creek, a 50% blockage factor was applied laterally to the waterway area of all bridges, box culverts, or pipe culverts where the clear opening is less than 6m, otherwise no blockage factor was applied.

This sensitivity was tested in detail and individual properties have been identified by Council as being vulnerable to blockage impacts. No further investigation is warranted for blockages.

Bankstown Council has also investigated a blockage prevention device to prevent large items blocking the culvert for incorporation into the existing concrete channel at the Sydney Water Pipeline. At the

time there were some concerns from Sydney Water so it was not constructed. If a particular drainage path is regularly subject to blockage or debris build-up, it may be worth investigating gross pollution traps for that area.

### c) Drainage Maintenance

Community members certainly raised the issue of keeping drainage lines clear as a means of reducing flooding. In the majority of cases, the community was referring to local street drainage which surcharges during more frequent events (up to say 1 in 5 year ARI) and is overwhelmed in the larger regional flood events that are the subject of this study.

Even for the clearest of drainage lines at the onset of rain, debris gets washed in during a flood and can cause blockages. In addition, the removal of vegetation from waterways may benefit flow but can also be detrimental and lead to erosion/sedimentation if not undertaken in careful, pre-planned operations. Certainly, if the vegetation is weeds, then it needs to be removed; what is most undesirable is the removal of native species. In fact, the use of native species to stabilise any "natural" channel is strongly encouraged.

Sydney Water and each of the Councils have regular maintenance programs for the sections of channel for which they are responsible and Councils also maintain and clean the smaller drainage networks on a regular basis. All of these organisations also respond to community notifications of blockages or other maintenance issues.

It is recommended that these programs continue and that the community education program include strategies to encourage community members to refrain from dumping waste, garden clippings and shopping trolleys in the drainage system and to report any incidences so that the matter can be dealt with promptly.

### d) Channel Widening or Deepening

Many of the Community Sessions raised the idea of widening or deepening the existing drainage lines, particularly those in close proximity to residential properties.

For this potential measure to have an effective impact on flooding, a detailed and comprehensive modelling and planning process would have to be undertaken with consideration given to a range of options. However, to provide a sense of scale of the works that would be required, it is noted that in many locations the width of the flow path in a 1% AEP event is of the order of 100m and is about 1m deep. The channel in these areas is currently less than 10m wide and 2m deep. For all of the flow from outside of the channel to be confined within the channel the channel would need to be widened to almost 60m which is approximately the length of two average residential blocks.

As has been indicated, there are a number of locations where any change to the existing channel would involve the acquisition of private land, the disruption to existing infrastructure and a cost far in excess of any viable economic return.

The infrastructure changes would include, as an example, widening or potentially total reconstruction of bridges and other crossings of the channels. For example, widening the reach of Duck River from Farnell Road Yagoona (near O'Neill Park) to the Sydney Water pipeline would involve altering:

- 4 Road Crossings;
- 2 Road and Rail Crossings, including a 180m long culvert at Sefton;
- 1 Footbridge;
- 3 Confluence structures; and
- Disruption to 92 residential properties.

The channel widening measure, while technically feasible, would require significant funding from a range of sources and it is considered that other, less costly measures can achieve a similar level of flood mitigation. Accordingly, it is not considered further in this Study.

### 9.2.3 Levees / Flow Diversion

The use of levees, embankments and higher channel walls can be considered to keep water from public land. Given the nature and level of development in the Duck River catchment, the use of flow diversion measures to protect one locality is likely to make flooding worse on adjoining or downstream properties. This is particularly so in Duck Creek and Little Duck Creek as well as the upper reaches of Duck River where urban development is very close to the channel.

For example, while an embankment along the Woods Road edge of Jim Ring Reserve would keep water from Duck River away from houses on the other side of the road, there is a flow path towards Duck River through the back of these houses which makes a substantial contribution to flooding and such an embankment would simply make flooding from this direction worse. In other words it would reduce the amount of floodwater which arrives at these houses from their front yards but would increase the ponding of water that comes to them through their back yards.

Another form of flow diversion not usually considered is the type of fencing used in new development or re-development. It is noted that many of the community-raised issues concerned the impact of colourbond, brick or concrete fences. These fences have the capacity to divert flows into neighbouring properties or to contain localised flows, not allowing the free passage of flood waters/overland flows. This is well illustrated by considering the fences along the back of the properties that back onto Sefton Golf Course. These fences contain, to a large degree, the overland flows on Sefton Golf Course and redirect flows to the flow passage across Rose Street to Rose Park and beyond. It is to be noted that in this case the redirection of flows has a positive impact, but in most other cases, it is accompanied by an undesirable impact elsewhere.

The type of fencing to be used in flood affected areas needs to be addressed in the DCP for flood affected areas and strict controls enforced on “hard” fencing such as brick fences. In Bankstown’s DCP for flood risk management, a separate section provides details of fencing controls.

## 9.3 PROPERTY MODIFICATION

As discussed in Section 7, Property Modification can be broken down further to Works and Planning sub-categories. For the existing situation, a “Works” approach is most appropriate with the application of Voluntary Purchase or Voluntary House Raising. For future developments, including in-fill developments, re-developments or changes brought about by residential strategies, the most appropriate approach is to cover these situations with Planning and Development Controls.

### 9.3.1 Property Modification Measures - Works

#### a) Voluntary Purchase (VP) - Existing buildings

The most radical Property Modification Measure is to remove buildings from the flooding situation. In certain high hazard areas of the floodplain it may be impractical or uneconomic to mitigate flooding risk to existing properties. In such circumstances, it may be appropriate to cease occupation of such properties in order to free both residents and potential rescuers from the danger and cost of future floods. This is achieved by the purchase of the properties and their removal or demolition as part of an adopted floodplain management plan. Under such circumstances, property should be purchased at an equitable price and only where voluntarily offered. Such areas should ultimately be rezoned to a flood compatible use such as public open space.

The Federal and State government make funds available to local government to establish voluntary purchase schemes to acquire houses around the country with significant risk from natural hazards. The funds are limited and are made available on a priority basis. Even if only the houses with above floor flooding in the 1 in 5 AEP flooding were purchased at $500,000 each, it would cost in the order of $40 million.

Given the potential number of properties that may fall under a VP scheme, it is recommended that the following criteria be considered for selection of potential candidates for VP:

- House is placed on sale voluntarily and owner agrees that Council may have "first refusal";
- Property is affected (over floor flooding) by the 1 in 20 year ARI flood event;
- The house is located in a high hazard zone for a 1 in 100 year ARI flood event;
- The house is located in a high hazard zone for a 1 in 20 year ARI flood event; and
- The house is located in a high hazard zone for a 1 in 5 year ARI flood event.

If the house meets the adopted criteria, then it is possible that it could be a candidate for VP. Further detailed investigations e.g. surveying, valuations, localised flood modelling etc., would need to be conducted to identify if a house were a definite VP candidate. Note that the age of the property is not important in this consideration; the principal consideration is the safety and life preservation of the residents.

However, given the issues relating to floor levels highlighted in the Flood Damages discussion (Section 4.3), it is recommended that an extension study is undertaken across all three Councils to accurately determine the floor levels of properties, especially those in the high hazard areas.

### b) Voluntary Purchase – "Open Space" exchange

An alternative to using these government funds is to look at purchasing some of these properties using S94 contributions for local and regional open space which will be required as part of higher density redevelopment in some of these areas under existing or proposed future zoning.

The amount and location of required open space will be dependent on other town planning considerations however residences with frequent above floor flooding which exist next to current open space areas and/or constitute a cluster of properties which could provide significant open space are at:

- Woods Road, Wellington Street and Rose Street Sefton opposite Jim Ring Reserve, well within a 500m radius of the Sefton "town centre";
- Helen, Roosevelt and Munro Streets Sefton, which are also contiguous with a drainage reserve and high school playing fields;
- Louis, Thomas and Farnell Streets, as a cluster in South Granville around the existing large supermarket, however there are townhouses in this area which may make consolidation / redevelopment expensive;
- Guildford Road, Mountford Street, Bury Road and West Street Guildford, all within 500 metres of the Guildford "town centre"; and
- William St, Enid Ave and Diamond Ave Granville – note that there are home units showing up as frequently flooded in Blaxcell Street in this area and these need a closer analysis.

### c) Voluntary House Raising (VHR)

A potentially less costly option is voluntary house raising. This currently costs about $80,000 per house but not all houses are suitable. Clad, timber-framed houses built on piers are most suitable to house raising which involves lifting the entire house up to a higher level at its current location. This gets floor level above 1 in 100 year ARI event but does not stop property flooding. If applied to all 329 properties that have an above floor flooding of 1 in 100 year ARI then the cost would be about $26m.

If those properties where the building type is not suitable for raising are excluded and it is assumed that some of the Voluntary Purchase goes ahead, then the cost may be less than $20m all up.

A further option may be a combination of VP and VHR. This may involve:

- The purchase of the property by Council and its resale for development with strictly enforced development controls regarding floor level, habitable rooms, etc.;
- The purchase of the house on the property and its demolition, and then the house is rebuilt by the existing owner to the required standard. The full cost of the house may be met by Council or there may be a payment equivalent to the house raising cost.

The combination approach may be suitable for isolated locations where the above floor flooding is low and there will be no alternative management measure.

### d) Property Modification - Planning Development and Controls

All Local Government Areas have prepared revised LEPs in accordance with the Department of Planning's "Standard Instrument Principal LEP". The flood related clauses from each are detailed in Section 3.

The function of the LEP is to set the overall objectives, standards and requirements for developments generally. More specific matters, such as development controls that set minimum floor levels and other requirements to ensure compatibility with floods risk are to be found in the Development Control Plans (DCPs) established by each Council. It should be noted that the community raised the issues of fencing, retaining walls and backfilling of properties and these will need to be addressed in the DCPs.

It will be essential for each Council to assess the approach in its DCP and how it reflects the flood hazard and hydraulic category identified in the various flood studies. This should not be a general, broad-brush approach; it should also consider the cumulative impact of development, such as confining flows between solid, flood-proofed structures, the "accidental" storage of water behind fences and backfilling to allow a development to achieve a floor level at the adopted FPL.

As noted in Section 8.4.4, all Councils have adopted a "risk precinct" approach to floodplain management, however the risk precincts are based on the provisional hazards rather than a comprehensive assessment of risk. Undertaking a "conversion" to the full range of risks is a lengthy and complex process and has not been undertaken in this Study. It is recommended that the risk assessment process be applied to the various sections of the study area once all data is available and in the next review of the floodplain management process.

### e) Recommendation

It is recommended that the Property Modification Measures detailed above be examined in detail as part of a comprehensive review of using land use planning to minimise future flooding damages.

## 9.4 BIODIVERSITY ENHANCEMENT

In addition to managing flooding, part of the brief was to consider whether there were opportunities to incorporate biodiversity enhancement along the creeks.

Regionally, if vegetation is able to be provided along the full length of Duck River then there is the potential to link the Parramatta, Georges and Cooks river ecosystems and create wildlife corridors. However, while a vegetation corridor might be possible in the Parramatta/Auburn section of Duck River, the upper reaches of Duck River (BCC) or into the Duck Creek and Little Duck Creek (PCC) catchments would require vegetating along drainage lines and private property boundaries. Unless suitable species are selected, this might increase flooding of properties when a flood exceeds channel capacity because of increased obstruction to flows.

Pockets and strips in current and future open space areas provide better opportunities without impacting flooding. Such pocket enhancements can also consider the creation of rain gardens and artificial wetlands.

Two particular spots within BCC have been identified as potentially suitable:

- Band Hall Reserve
- Northern end of Jim Ring Reserve

If other pocket parks or existing parks are extended as part of voluntary purchase/Open space creation, then they may also be suitable and they may be able to incorporate some flood detention in the more frequent events but could not be relied upon for substantial reductions in above floor flooding costs.

These would need detailed design and costing and community engagement before proceeding. The FPRMP could only go to the point of saying these are places worth investigating for these as part of a separate study.

We should note that the community sessions raised the issue of stream clearing though this was more in terms of removal of rubbish, maintenance and, as the area has been subject to extensive “Bush Regeneration”, the removal of weed species.

This approach will be expanded further after consultation with Councils.

# 10 OPTIONS ASSESSMENT

## 10.1 ASSESSMENT OF SHORTLISTED OPTIONS

Based on the preceding discussions, the preliminary list of Floodplain Risk Management Options has been subjected to an assessment process. It is neither beneficial nor affordable to examine all options to the same level of detail. Many options are likely to be ineffective, impractical, unaffordable or have unacceptable impacts. At the same time, it is important to give serious consideration to all nominated options and only eliminate options from further consideration because of demonstrable shortcomings.

The assessment stage includes qualitative and semi quantitative evaluation criteria worked out in close consultation with officers from the three councils. The criteria are grouped into the following six categories:

- Effectiveness – using simple calculations (i.e. not necessarily running the flood models) what order of magnitude difference would it make to flood levels and impacts. Any option which would not reduce flood levels significantly should not be considered further.
- Practicality – some options will not be practical to implement and therefore can be eliminated
- Acceptability – if it will have unacceptable environmental or social impacts including transferring flood problems from one group of properties to another group then the option should not be shortlisted
- Affordability – using order of magnitude costings, is it within the realms of affordability, if not it should not be considered further
- Longevity – some options may have an immediate but not a lasting benefit while others will have their effectiveness eroded by future changes in climate. High cost options which deliver only short term benefits are unlikely to be carried through.
- Comparative Performance – some options will clearly have similar benefits but one may have much greater costs and impacts. There is no value in carrying such options through for detailed investigation.

These overall criteria are divided into further sub-criteria to allow for a slightly more rigorous assessment:

- Reduction in Flood Level – if implemented, would flood levels be reduced and if so, would it be significant or otherwise;
- Reduction in Property Damage - if implemented, would flood damages be reduced and if so, would it be significant or otherwise;
- Technical Feasibility – generally, all measures can be constructed given the design, the budget and the willingness of the proponent. Whether the measure should be constructed is very much determined by other criteria. All “non-structural” measures are scored as feasible.
- Financial Feasibility - recorded under the Practicality criteria, is based on preliminary estimates of the likely cost of a measure and the benefits likely to arise if it is implemented. For example, the construction of a retarding basin will have a capital cost of approximately $1.5 million and on-going maintenance of up to $50,000 per annum for the life of the structure. If the basin only provides a reduction in flood damages for 6 – 10 houses, reducing AAD by $5,000, then the financial return / feasibility is low and is scored accordingly.
- Social Impact - this is a qualitative assessment of a measure which, if implemented, would have impacts on the social life and fabric of the community, significant or otherwise.
- Community Acceptance – this is a qualitative assessment, based on Council and the consultant’s experience and reflects the community’s likely attitude to the measure proposed.
- Environmental Impact – There is a considerable interest in the creek/river environments within the catchment. Therefore, any measure that has a positive impact – stream naturalisation,

removal of weeds, management of erosion – scores high, as does a measure that does not require any major works, though these can incorporate environmentally beneficial measures.

- Capital Cost – the estimated up-front cost of the measure, high for major "structural works", relatively lower for Response Modification measures.
- On-going Cost (Maintenance) – a standard requirement for any works constructed with public monies. It also includes the regular costs associated with Response Modification measures.
- Long-term performance - if implemented, would the measure be a long term solution with minimal call on Council to monitor – it is assumed, particularly for "structural" works that an operations and maintenance plan would be established and adhered to for the life of the work.

The assessment is shown in Table 17. In order to develop a comparison of options, a scoring system was developed which is generally based on 3 points for high, positive or significant impact, 2 points for medium, neutral or some impact and 1 point for low, negative or no impact. However, when applying a score under the affordability criteria, 1 point is applied for high capital or high maintenance cost, 2 points for medium costs and 3 point for low costs. A cut off score of 18 was adopted for the assessment – any option with 19 points or more was deemed worthy of further investigation, any score of 18 or less was not investigated further. There is no binding guide to this assessment; it was based on professional judgement and experience in the implementation of floodplain management measures across the State.

*Table 17: Preliminary Assessment – Floodplain risk management measures*

| ***Floodplain Risk Management Option*** | **Council Area** | **Assessment Criteria** | | | | | | | | | | | **Further Investigation Recommended / Comment** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Effectiveness** | | **Practicality** | | **Acceptability** | | | **Affordability** | | **Longevity** | **Comparative Performance** | |
| | | **Reduction in Flood Level** | **Reduction In Property Damage** | **Technical Feasibility** | **Financial Feasibility** | **Social Impact** | **Community Acceptance** | **Environmental Impact** | **Capital Cost** | **On-going Cost (Maintenance)** | **Long-term performance** | **[sum of scores]** | |
| ***Response Modification Measures*** | | | | | | | | | | | | | |
| *Community education including Education Materials and specialized packages* | All | 1 | 3* | 3 | 3 | 3 | 3* | 2 | 3 | 3 | 3 | 27 | YES<br>All activities should be coordinated with local SES |
| *Personalised flood emergency plans.* | All | 1 | 3* | 2 | 3 | 3 | 3* | 2 | 3 | 3 | 3 | 26 | YES<br>All activities should be coordinated with local SES |
| ***Flood Modification Measures*** | | | | | | | | | | | | | |
| ***Detention (Retarding) Basins*** | | | | | | | | | | | | | |
| *Sefton Golf Course* | BCC | 3 | 3 | 3** | 2 | 2 | 2 | 2 | 1 | 2 | 2*** | 22 | YES – further detailed investigations required |
| *Woodville Golf Course* | PCC | 3 | 3 | 3** | 2 | 2 | 2 | 2 | 1 | 2 | 2*** | 22 | YES – further detailed investigations required |
| ***On Site Detention*** | All | 2 | 2 | 3** | 2 | 3 | 2 | 2 | 1 | 2 | 2*** | 21 | YES – maintain existing policies for individual developments however not a suitable measure for large scale flood mitigation |
| ***Channel Enhancement*** | | | | | | | | | | | | | |
| *O'Neill Park, Birrong/Rail embankment* | BCC | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 1 | 1 | 2*** | 14 | No |
| *Band Hall Reserve, Birrong* | BCC | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 1 | 1 | 2*** | 14 | No (see below for larger scheme) |
| *Sefton Rail Embankment/Jones St* | BCC | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 1 | 1 | 2*** | 14 | No |
| *SWP at Munro St/Duck River* | BCC | 3 | 2 | 2 | 1 | 2 | 3 | 2 | 1 | 1 | 2*** | 19 | Potential Measure involves increasing waterway under pipeline – further technical investigation required |
| *SWP Wolumba St/Wolumba creek* | BCC | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 1 | 1 | 2*** | 14 | No |
| *Rail Embankment at Granville* | PCC | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 1 | 1 | 2*** | 14 | No |
| *Blockage / Debris Management* | All | 2 | 2 | 3 | 2 | 3 | 3 | 3 | 2 | 2 | 2*** | 24 | YES – continue existing maintenance activities especially Little Duck Creek (PCC) and SWP area |

| *Floodplain Risk Management Option* | Council Area | Assessment Criteria | | | | | | | | | | | Further Investigation Recommended / Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Effectiveness | | Practicality | | Acceptability | | | Affordability | | Longevity | Comparative Performance | |
| | | Reduction in Flood Level | Reduction In Property Damage | Technical Feasibility | Financial Feasibility | Social Impact | Community Acceptance | Environmental Impact | Capital Cost | On-going Cost (Maintenance) | Long-term performance | [sum of scores] | |
| ***Stream Clearing / Naturalisation*** | | | | | | | | | | | | | |
| *Upstream of SWP at Munro St, Sefton* | BCC | 1 | 1 | 2** | 2 | 2 | 3 | 3 | 2 | 2 | 2*** | 20 | YES<br>Subject to resolution of ownership details and responsibilities |
| *Blockage prevention Structure / Debris Trap Upstream of SWP at Munro St, Sefton* | BCC | 1 | 2 | 3 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 19 | YES<br>Needs consideration and design refinement – on-going maintenance an absolute priority |
| *Band Hall Reserve, Birrong* | BCC | 1 | 1 | 2** | 2 | 2 | 3 | 3 | 2 | 2 | 2*** | 20 | YES<br>Potential as demonstration site for biodiversity enhancement |
| *Biodiversity Enhancement* | All | 1 | 1 | 3** | 3 | 3 | 3 | 3 | 2 | 2 | 2*** | 23 | YES<br>Selected areas |
| ***Levees*** | | | | | | | | | | | | | |
| *Embankment - Woods Rd edge of Jim Ring Reserve.* | BCC | 3 | 3 | 3 | 1 | 2 | 1 | 1 | 1 | 1 | 2 | 18 | No<br>Only effective for mainstream flows - local overland flows continue to affect properties |
| *Levee end of Neilson, Mimosa and Myrtle Streets* | PCC | 3 | 3 | 3 | 1 | 2 | 1 | 1 | 1 | 1 | 2 | 18 | No<br>Only effective for mainstream flows - local overland flows continue to affect properties |
| ***Property Modification Measures*** | | | | | | | | | | | | | |
| *Voluntary Purchase* | All | 1 | 3 | 3 | 1 | 1 | 1 | 2 | 1 | 3 | 3 | 19 | YES (Selective)<br>May offer opportunities to enhance open space requirements in redevelopments |
| *Voluntary House Raising* | All | 1 | 3 | 3 | 1 | 2 | 2 | 2 | 1 | 3 | 3 | 21 | YES (Selective)<br>Monitoring needed to ensure no habitable rooms established with passage of time |
| *Zoning & Development Controls* | All | 1 | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 3 | 3 | 26 | YES |

Notes:

Scoring is based on 3 for high, positive or significant impact, 2 for medium, neutral or some impact, 1 for low, negative or no impact. Opposite scoring will apply for affordability with 1 for high cost, high maintenance, 2 for medium and 1 for low costs.

*- Result scored subject to actions by residents

** - Feasibility may be subject to underlying conditions, e.g. soils, adverse fill materials, presence of groundwater, etc.

*** - Monitoring and Maintenance required for these measures to ensure original objectives retained.

## 10.2 PREFERRED OPTIONS

Following the preliminary assessment of Floodplain Risk Management Options, the preferred options are detailed below:

### 10.2.1 Response Modification Measures

The main activities under this overall measure are proposed to be:

- Participation of communities with councils and emergency agencies in the design, implementation and evaluation of community flood education programs;
- Ongoing and planned learning through a local community flood education plan to plan for, understand and respond to flooding. This includes SES actions such as "FloodSafe" brochures and more detailed information packages;
- Household and business emergency plans as key outputs of the learning;
- Community flood education linked to other strategies in flood management; and
- Post-flood learning to evaluate the impact of community education programs and improve general community resilience to future floods.

In addition to the planning and response to flooding, the education program should also advise residents where areas that will not be affected by floodwaters are located so that they can seek refuge there during floods, and also allow SES or others to establish emergency shelters in flood free areas. It should also include the concept of risk management and the meaning of Council's risk categories.

There has been considerable investigation into the benefits of Community Education and Awareness programs, all of which has revealed a clear economic advantage in undertaking such programs in flood affected areas, together with whatever flood warning measures may be viable[1].

Flood education and awareness can be defined as "any learning process or activity that builds community resilience to floods." It includes a number of processes and activities, such as awareness raising, community engagement, training, evaluation, communications, preparedness and community capacity building. These processes and activities are designed to draw the community's attention to the potential threats of flooding and the appropriate response when floods do occur. As such, a formal flood education and awareness program reduces both existing and future flood damages.

The approach for the awareness programs would consist of a qualified staff member from each Council (preferably with suitable experience in such programs) taking the time to develop the material, and to liaise with the SES so that overlap is avoided or, at least, targeted to achieve the correct emphasis.

An initial budget for such a program would be in the order of $150,000 for the first year, across all Councils. Once the program is in place, the annual budget could be reduced to $75,000, reflecting the need to continue the message, update forms and brochures and maintain the liaison with the SES.

It is recommended that this measure be adopted as part of the Floodplain Risk Management Plan.

[1] See "Final Report - Flood Risk Reduction - Assessment of Costs and Benefits", prepared for the Victorian Department of Sustainability and Environment by Halcrow Pacific Pty Ltd, with assistance from SJB Planning, Molino Stewart and Risk Frontiers for the most recent analysis.

## 10.2.2 Flood Modification Measures

### a) Detention (Retarding) Basins

Two sites have been identified as being viable for the construction of a detention basin:

- Woodville Golf Course - A preliminary assessment of physical benefits of constructing a retarding basin in the Woodville Golf Course has indicated that if storage of some 60,000 $m^3$ could be achieved, the peak flow rate from the course would be reduced by more than 50%. This would be of significant benefit to the residences in Rawson Road, Excelsior Street and Brazier Street, i.e., immediately downstream. Approximately 15 fewer houses would experience overfloor flooding in a 1% AEP event if this retarding basin were built, however the benefits do reduce significantly the further downstream the flow progresses.
- Sefton Golf Course - A preliminary assessment of physical benefits of constructing a retarding basin in the Sefton Golf Course has indicated that flood levels could be reduced by 0.15m to 0.20m in the immediate vicinity of the Golf Course. This would be of significant benefit to the residences in Rose Street, Karraba Street and Woods Road, i.e., immediately downstream. Approximately 18 - 20 fewer houses would experience overfloor flooding in a 1% AEP event if this retarding basin were built, however the reductions in flood level do reduce significantly the further downstream the flow progresses. Appendix B provides greater detail on this assessment.

### b) Channel Enhancement

- Sydney Water pipeline at Sefton – this option has been modelled and reported by BMT WBM (see Appendix B). The model results indicate:
  - The maximum decrease in peak flood levels upstream of the Pipeline is approximately 0.35m.
  - Decreases in flood levels of 0.2m to 0.3m extend approximately 150m to 200m upstream of the Pipeline.
  - The 100 year ARI flood extent in the vicinity of the Pipeline has been reduced by between 10m and 20m.
  - The flood level difference immediately downstream of the Pipeline is below 0.05m.
  - The peak flood levels are increased to slightly above 0.05m (but to less than 0.1m) from about 500m downstream of the Pipeline and extend to the Mona Street Bridge.
  - Model results have shown that the largest increase in flood levels (of about 0.09m) is in the vicinity of the Wellington Road Bridge.

These results indicate minimal benefit for a significant output in costs however the final decision on modifications of the Sydney Water Pipeline rests with Sydney Water, as the asset owner. Reduced impacts in BCC would also need to be considered carefully in light of increased flood levels and extents in ACC / PCC during certain flood events.

- Blockage / debris management - Sydney Water and each of the Councils have regular maintenance programs for the sections of channel for which they are responsible and Councils also maintain and clean the smaller drainage networks on a regular basis. All of these organisations also respond to community notifications of blockages or other maintenance issues. It is recommended that these programs continue and that the community education program include strategies to encourage community members to refrain from dumping waste, garden clippings and shopping trolleys in the drainage system and to report any incidences so that the matter can be dealt with promptly.
- As well as the smaller debris, there is a risk that large pieces may be washed in to the high velocity flows from streets or crossings. The most likely entry points are on bridges or where the channel is close to the roadway. It is considered that the appropriate measure here is the installation of secure bollards along the bridge or road kerb with the risk, and thus priority, determined by the velocity depth data available from the Flood Studies. The bollards could be

either single-post style or inverted U-shapes and in a variety of materials and finishes. The final choice will be a matter for individual Council Assets Managers.

- The placing of flood height markers at the various creek crossings to warn drivers and pedestrians how deep water is during flooding.

#### c) Stream Clearing / Naturalisation

- SWP at Munro St/Duck River - this option has been modelled and reported by BMT WBM (see Appendix B). The model results indicated that flood levels may vary by up to 0.15m depending on the extent of blockage. The blockage / debris management approach raised above should apply.
- Band Hall Reserve, Birrong - this option has been modelled and reported by BMT WBM (see Appendix B). The model results indicate no exacerbation of existing flooding, with the channel widening and revegetation expected to benefit biodiversity and water quality in the Duck River catchment.

### 10.2.3 Property Modification Measures

#### a) Voluntary Purchase and Voluntary House Raising

For the purposes of assessing the options in greater detail, it is assumed that the Voluntary Purchase option is applied to all residential properties with an above floor flooding of 1 in 5 year ARI, that all properties with an above floor flooding of 1 in 20 year ARI will be either purchased or raised and that other residences up to the above floor flooding of 1 in 100 years will be purchased or raised as agreed between Council, owners and OE&H.

This assessment is illustrated in Table 18. Based on the data presented in that table, the following Benefit Cost Ratios (BCR) are established and illustrated in Table 19.

To remove all residences in the Parramatta LGA that have an above floor flooding at or below the 1 in 5 year ARI is the option with the best BCR but even here it only just exceeds 0.5. Any option with a BCR less than 1 would not normally be supported through the various government floodplain management programs. The BCR rapidly reduces once there is a movement towards Voluntary House Raising combined with Voluntary Purchase and addressing the above floor flooding of 1 in 100 year ARI.

However, the decision on whether to adopt Voluntary Purchase or Voluntary House Raising or both is not solely an economic decision, it can also be a decision based on social factors. This is particularly the case with residential properties that are affected by an above floor flooding of the 1 in 5 year ARI flood level.

Although extensive flooding is not a common occurrence across the Duck River catchment, floods of this nature can occur as flash floods, causing significant shock and anxiety to the residents. These costs cannot be prescribed a specific dollar-value however experience in other areas of Sydney, and State-wide, has indicated the efficacy of this measure in relieving the strains on and concerns of the residents affected.

#### b) Development option

The option of linking Voluntary Purchase of flood affected properties with future consolidation / redevelopment of areas within a footprint of a town centre has been considered in cooperation with Council Planning staff.

In the Bankstown LGA, the principal area for consideration is the Sefton “Town Centre”, an area within a radius of 400 – 500 m from the Sefton Railway Station. This radius includes the cluster of significantly affected houses in the Woods Road, Wellington Street, Rose Street precinct. At present,

it is understood that there is sufficient open space in the area however there may be the opportunity, under long term planning, of adding to open space into the area through the purchase of these affected properties.

The other area with a significant concentration of low above floor flooding properties, the Munro Street / Helen Street precinct does not offer as favourable a prospect for large scale Voluntary Purchase / Open Space conversion. There are potential social issues regarding open space near industrial developments and these would probably rule out any action here.

In the Parramatta LGA, it is understood that a recent review of open space ratios has indicated that, within the Duck River catchment covered by this Study, that the area around the Guildford "town centre" is the area most in need of additional open space.

It is understood that the current land use plans identify a group of blocks reserved for conversion to open space, however these are a considerable distance from the "town centre". Consideration could be given to changing that reservation to the significantly affected properties in the Guildford Road, Mountford Street, Bury Road and West Street Guildford precinct, all within 500 metres of the Guildford "town centre". This may offer the solution of both mitigating flood impacts and providing open space for future beneficiaries.

### c) Flood proofing

As noted previously, flood proofing refers to the design and construction of buildings with appropriate water resistant materials and configuration such that flood damage to the building itself (structural damage), and possibly its contents, is minimised should the building be inundated. It can also refer to the actions of a resident to prevent water entering or, more particularly, inundating the space between the floor and the ground (where applicable).

At best, flood proofing is an adjunct to other management measures. Because of this, the recommendation to adopt flood proofing as a formal management measure can only be made on an objective basis from within the strategic framework of a floodplain management plan. Whilst flood proofing can minimise structural and possibly content damages to flood-affected buildings, the occupiers of flood affected buildings still suffer the social and economic disruption of flooding. Thus, councils cannot simply allow development of flood prone land as long as buildings are "flood proofed".

In addition, the short warning time for flooding in this catchment means that traditional "flood proofing" measures, sealing underfloor air vents, sand-bagging of entries, may not be able to be implemented before flooding actually occurs.

Therefore, it is recommended that flood related DCPs for all areas include guidance on flood compatible construction methods, building materials and building layouts that will assist in minimising flood damages across the full range of floods.

### d) Zoning & Development Controls

As noted in Section 8.1.3 (c), the Councils managing the Duck Creek catchment have the Standard Instrument Principal LEP in place or prepared as a draft for consideration by the Department of Planning and Infrastructure. Generally, with the exception of the erroneous terminology "1:100 ARI (average recurrent interval) flood event" – it should read "1 in 100 year ARI (average recurrence interval) flood event" – the LEPs provide a sound basis for managing development on flood prone land.

The key to the long-term management of the floodplain lies in the relevant DCPs and, for all three Councils, their application of the "Flood Risk Precinct" approach. This approach is a fully integrated feature of the development control process across the catchment, developed either from other studies, such as the Parramatta River FRMS&P, or more directly as with the Bankstown Stormwater Flooding guidelines.

The detailed review of these Tables and controls is outside the ambit of this Study. However, it is considered that the following points should be addressed along with those currently raised:

Although the Floodplain Development Manual limits consideration to the 1 in 100 year ARI flood event, there are many risks associated with floods of a greater impact if lesser frequency. This is particularly the case in:

- The Manchester Road, Chisholm Road and Mona Street precinct within the Auburn LGA – the roadways and adjoining lands become high hazard floodways or flood storages in a PMF event, a situation that is not present for the 1 in 100 year ARI or lesser floods.
- The Sixth Street, Clyde Street and Boronia Street precinct in the Parramatta LGA - the roadways and properties become high hazard floodways or flood storages in a PMF event, a situation that is not present for the 1 in 100 year ARI or lesser floods.
- Both Duck Creek and Little Duck Creek, areas that are affected by the 1 in 100 year ARI or lesser floods as low hazard flood fringe are rendered as high hazard floodways or flood storages in a PMF event and on a significantly increased scale.
- The Woods Road, Wellington Street, Rose Street precinct where Climate Change Impact modelling and mapping show affluxes of 0.1 – 0.2m upstream of the Sefton railway culvert over the 1 in 100 year ARI flood levels.

Accordingly, it is essential that the questions of flood hazard and hydraulic categorisation be examined across the full range of floods and not be limited to the 1 in 100 year ARI flood.

It is essential that the potential for flow diversions from development site to adjacent sites be considered when establishing the minimum floor levels for developments. For example, although the desire to have car parks above some minimum level, these obstructions to flow may have a localised impact that is detrimental to the adjoining property. Some consideration may need to be given to placing car parks, especially large areas, at grade and applying emergency management measures, such as evacuation, as a more appropriate measure.

It is also recommended that Councils take the opportunity to convert their current risk precincts" to the full range of risks once all data is available and in the next review of the floodplain management process.

### 10.2.4 Table Explanations

The terms used in the following Tables are:

- LGA – the relevant Local Government Area
- Total AAD – the total Average Annual Damage incurred in the LGA in 2012 $ terms
- No. Residences – based on the floor levels used in the flood damages estimates, the number of residences affected by that flood. When applied to the larger floods, these are the additional properties between the nominated flood and the previous flood, e.g. in Parramatta, there are 30 residences affected by the 5 year ARI event, and an additional 57 in the 20 year ARI event, etc.
- Cost (100% Purchase) – based on a price of $500,000 per residence
- Reduction in AAD – the AAD reduced by undertaking the voluntary purchase of all affected properties.
- Benefit (NPV of Reduced AAD over 50 years as detailed in Section 4.4.

*Table 18: Reduction in AAD for Voluntary Purchase of properties in the floodplain*

| | No Mitigation | Remove all under 5 yr ARI | | | Remove all under 20 yr ARI | | | Remove all under 50 yr ARI | | | Remove all under 100 yr ARI | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *LGA* | Total AAD $ | No. Residences | Cost (100% Purchase) $ | Reduction in AAD $ | No. Residences | Cost (50% Purchase, 50% Raise) $ | Reduction in AAD $ | No. Residences | Cost (100% Raise) $ | Reduction in AAD $ | No. Residences | Cost (100% Raise) $ | Reduction in AAD $ |
| *Auburn* | 44,000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bankstown* | 588,000 | 50 | 25M | 364,000 | 30 | 8.7M | 72,000 | 21 | 1.68M | 25,000 | 44 | 3.52M | 30,000 |
| *Parramatta* | 1,105,000 | 30 | 15M | 590,000 | 57 | 16.32M | 133,000 | 42 | 3.36M | 41,000 | 55 | 4.4M | 24,000 |

Note: Costs are based on an average purchase price of $500,000 and average house raising cost of $80,000.

*Table 19: Estimated BCR for Voluntary Purchase of properties in the floodplain*

| | No Mitigation | Remove all under 5 yr ARI | | | Remove all under 20 yr ARI | | | Remove all under 50 yr ARI | | | Remove all under 100 yr ARI | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *LGA* | Total AAD $ | Cost $ | Benefit (NPV of Reduced AAD over 50 years $ | BCR | Cost $ | Benefit (NPV of Reduced AAD over 50 years $ | BCR | Cost $ | Benefit (NPV of Reduced AAD over 50 years $ | BCR | Cost $ | Benefit (NPV of Reduced AAD over 50 years $ | BCR |
| *Auburn* | 44,000 | 0 | 0 | - | 0 | 0 | - | 0 | 0 | - | 0 | 0 | - |
| *Bankstown* | 588,000 | 25M | 5.023M | 0.20 | 33.7M | 6.02M | 0.18 | 35.38M | 6.36M | 0.18 | 38.9M | 6.78M | 0.17 |
| *Parramatta* | 1,105,000 | 15M | 8.14M | 0.54 | 31.32M | 9.98M | 0.32 | 34.68M | 10.54M | 0.30 | 39.08M | 10.87M | 0.28 |

## 10.3 BIODIVERSITY ENHANCEMENT

Biodiversity enhancement and flood mitigation can be achieved concurrently in the Duck River riparian corridor.

Biodiversity enhancement can be considered in three ways:

- Safeguarding existing biodiversity assets;
- Rehabilitation, revegetation and extension of the riparian corridor;
- Naturalisation of the channel and riverbank.

Flood mitigation constraints to the enhancement of biodiversity centre around the risks of revegetation and channel naturalisation impeding the flow of flood water. The following section summarises these risks and identifies areas that are suitable for further investigation to achieve biodiversity gains along the Duck River riparian corridor.

### 10.3.1 Risks and Further Studies

There are risks associated with biodiversity gains in the upper reaches of the Duck River riparian corridor in the Bankstown LGA through:

- Rehabilitation, revegetation and extension of the riparian corridor;
- Naturalisation of the channel and riverbank.

Rehabilitation, revegetation and extension of the riparian corridor in the upper reaches of Duck River or into the Duck Creek and Little Duck Creek catchments would require vegetating along the top of the canal between canal and adjacent property boundaries. This might increase flooding of properties when flood flows exceed canal capacity as the vegetation would slow any flows, leading to increased flood levels. This could be mitigated by revegetation of the canal edge with canopy species and native grasses rather than a complex under storey that would increase roughness. Consideration could also be given to encouraging property owners to plant endemic plants in the yards of properties which abut the canal easement where fence lines are already interfering with flows and additional vegetation is not likely to exacerbate flooding.

Pockets and strips in current and future open space areas such as the northern and southern ends of Jim Ring Reserve and Band Hall Reserve provide opportunities for biodiversity gains without increasing the extent of flooding. The use of constructed wetlands in these areas may also be viable.

A number of the areas identified for revegetation may be able to incorporate some flood detention in the more frequent events but could not be relied upon for substantial reductions in above floor flooding costs.

The areas identified here would need detailed design and costing and community engagement before proceeding. A similar process has been undertaken by Sydney Water in identifying areas suitable for naturalisation along the Cooks River.

#### a) Safeguard Existing Biodiversity Assets

Existing biodiversity assets have been presented in Chapter 2. The assets reflect the highly developed nature of the Duck River catchment and the high levels of past clearing of native vegetation and fauna habitat. Natural areas that remain are often examples of endangered ecological communities with significantly reduced distribution in the Duck River catchment. Existing biodiversity assets include:

- The riparian corridor;
- Two key populations of the Green and Golden Bell Frog;
- Six endangered ecological communities within the riparian corridor;
- 3 threatened flora species;
- 1 endangered plant population;
- The lower Duck River wetlands; and
- Remnant native vegetation.

Habitat for these significant species and communities is generally located in small, linear and isolated reserves that range from pockets of natural vegetation to lines of canopy trees adjacent to the Duck River channel. Significant reserves of natural vegetation and habitat are present in the Parramatta and Auburn LGAs, in particular in areas recognised as having wildlife corridor values listed in Section 4.4.6.

Biodiversity assets also occur outside the Duck River riparian corridor reserve system, in particular the two key populations of Green and Golden Bell Frogs at Clyde/Rosehill and A'Becketts Creek. However management measures documented for these populations promote the development of linkages between habitat areas (DECC 2008).

The lower Duck River wetlands are part of a once extensive system of wetlands and are listed on the Register of the National Estate. Management actions taken in the Duck River riparian corridor upstream of the wetlands to enhance biodiversity will have a positive impact on this sensitive downstream biodiversity asset.

The long term viability of biodiversity assets in the Duck River riparian corridor will be dependent on:

- Recognition of each riparian reach and or reserve as part of a larger riparian corridor;
- A coordinated approach to management of the riparian corridor that includes key local and state government stakeholders and takes into account all the biodiversity assets in the corridor;
- Ongoing bushland management (including weed control, rehabilitation and revegetation);
- Maximising the size of natural areas within the riparian corridor; and
- Re-establishing and consolidating linkages of habitat areas along the riparian corridor.

### b) Rehabilitation, revegetation and extension of the riparian corridor

Natural riparian corridors are diverse, dynamic and complex biophysical habitats that possess a wide range of species and environmental processes (Naiman *et al* 1993). Riparian corridors provide important habitat links for wildlife in urban environments and are recognised as significant in maintaining regional biodiversity (Savard *et al* 2000). Corridors of riparian vegetation in good condition can significantly increase levels of urban biodiversity (Savard *et al* 2000) while even degraded urban habitats when restored can also contribute to local biodiversity (Savard *et al* 2000).

In general, wider corridors allow for greater species diversity and exhibit less impacts from adjoining land uses and associated edge effects (DEC 2004). Management of wildlife corridors should aim to:

- Maintain and increase vegetation cover and habitat quality;
- Provide specific habitat resources and ecological needs, particularly for threatened species;
- Maximise corridor width and function through revegetation and control of weeds and feral pests;
- Maximise the protection and linkage of landforms (for example from the lower Duck River wetlands at the confluence with the Parramatta River to the rolling hills of the Cumberland Plain in Bankstown and beyond to the Georges River).

The Duck River riparian corridor represents an important regional biodiversity corridor (BCC 2002). A number of management measures could be taken to promote protection, rehabilitation, revegetation and expansion of the Duck River riparian corridor including:

- Recognition of the entire Duck River riparian corridor from its origins in Bankstown at O'Neill Park and Walshaw Park through the Parramatta and Auburn LGAs to its confluence with the Parramatta River;
- The development of an holistic management framework for the Duck River riparian corridor that encompasses its entire extent and considers all biodiversity assets in the corridor;
- The development of a management structure for the entire Duck River riparian corridor that includes all key stakeholders including representatives from Bankstown, Parramatta, Holroyd and Auburn Councils and the Sydney Metropolitan Catchment Management Authority (SMCMA);
- The development of a live GIS map that crosses local government boundaries and allows for the keeping of records of biodiversity assets and management actions.

From the Sydney Water supply pipeline downstream to the confluence with the Parramatta River, the Duck River channel remains in a more natural state and a variety of opportunities exist to rehabilitate, revegetate and extend the riparian corridor. Riparian vegetation is important because it shades the river, stabilises its banks, and improves water quality (OPIRG 2009). Elevated water temperatures associated with removal of riparian vegetation have a negative impact on stream health and are a key problem for urban waterways. High water temperatures contribute directly to poor water quality by stimulating the growth of algae and bacteria, and by lowering concentrations of dissolved oxygen (OPIRG 2009).

The SMCMA water rehabilitation project adjacent to the Webb Avenue Playing fields, Auburn and Mackay Road, South Granville is a good example of the improvements that can be achieved through rehabilitation of riparian vegetation.

Specific areas suitable for further investigation for rehabilitation, revegetation and expansion of the Duck River riparian corridor can be divided into those suitable for ongoing management for biodiversity and those areas suitable for revegetation and expansion. In a number of situations the gains for the riparian corridor appear small however when consider as part of the larger corridor would contribute to consolidating linkages between areas of natural habitat. Suitable areas for investigation include:

**Auburn and Parramatta LGAs**

*Ongoing management*

- The park at the confluence of Duck Creek and Duck River on the northern bank of Duck River adjacent to the M4 motorway;
- Northern bank of Duck River between the river and the Shell Oil site;
- The wetland on the southern bank of Duck River at the end of Millennium Circuit , Silverwater;
- The eastern bank of Duck River between Parramatta Road and the railway line;
- The eastern and western side of Duck River between the rail line and Duck River Reserve (adjacent to Manchester Road Auburn);
- Bangor Park;
- Duck River Reserve;
- Horlyck Reserve (rehabilitation of riparian vegetation adjacent to Mona Street);
- Ray Marshall Reserve (riparian edge);
- Everley Park (from Wellington Road to Everley Road ongoing management for biodiversity values);

- Peter Hislop Park (ongoing maintenance riparian edge);
- Princes Park (ongoing maintenance).

*Revegetation and Expansion*

- The riparian corridor adjacent to the channel in Silverwater Park;
- The narrow riparian strip between Holker Street and Giffard Street Silverwater;
- The narrow riparian strip west of the factory north of the intersection of the M4 motorway and Junction Street Silverwater;
- The triangle park within the Shell site on the northern bank of Duck River, opposite the end of Carnarvon Street, Silverwater;
- The northern bank of Duck River at the confluence with Duck Creek, adjacent to a factory on Shirley Street;
- Bangor Park (revegetation between Manchester Road and Mona Street);
- Duck River Reserve (additional revegetation west of existing vegetation toward pathway);
- Auburn Community Picnic Area (widen riparian vegetation);
- Ray Marshall Reserve (small area suitable for revegetation at the end of Chiswick Road);
- Auburn Public Golf Course (revegetation of riparian edge);
- Norford Park (triangle area at the southern end suitable for revegetation);
- End of Melissa Street Regents Park (area suitable for further investigation).

A number of reserves along the Duck River riparian corridor in the Parramatta and Auburn LGAs are utilised for active recreation and support playing fields. Areas adjacent to Duck River require management measures sympathetic to the maintenance of biodiversity values and riparian vegetation. These riparian areas require specific management approaches that may be set out in site specific management plans that apply to Duck River riparian vegetation.

**Bankstown LGA**

A number of reserves occur along the upper reaches of the Duck River riparian corridor in the Bankstown LGA. Linking of these reserves through revegetation with reserves along the Salt Pan Creek Corridor (also identified by BCC) could create a series of habitat stepping stones linking the Parramatta River via Duck River to the Georges River and ultimately Heathcote National Park to the south.

Significant revegetation works (with locally endemic native species) would be required to achieve these links, a number of specific reserves have been identified as suitable for further investigation and are listed below.

- Jensen Park (additional canopy cover on reserve edges);
- Duck River canal edges (weed removal, rehabilitation and revegetation of canal edges between Munro Street and Clapham Road Sefton)
- Jim Ring Reserve (additional canopy cover adjacent to the Duck River Channel and along Woods Road and Gascoigne Road on the edge of the reserve);
- Jim Ring Reserve (revegetation of small triangle reserve at the northern end of Jim Ring Reserve adjacent to Wellington Road;
- Jim Ring Reserve (revegetation of triangle behind Birrong Bowling and Sports Club between Duck River and Rodd Street Birrong);
- Maluga Passive Park (ongoing management for biodiversity values and passive recreation);

- Duck River canal edges between Rodd Street and Band Hall Reserve (introduction of native canopy cover);
- Band Hall Reserve (comprehensive revegetation of the Duck River riparian corridor to the full extent of the reserve);
- Duck River canal between Ferrier Road and Hume Highway (introduction of native canopy cover adjacent to canal);
- Duck River canal edges between Ferrier Road and Auburn Road (introduction of native canopy cover);
- O'Neill Park (introduction of native canopy cover adjacent to Duck River channel, rehabilitation and revegetation of native vegetation on reserve edges);
- End of Martha Street Yagoona (revegetation with native vegetation on small triangle reserve adjacent to Scout Hall);
- Gazzard Park Yagoona (revegetation of reserve edges with native canopy cover);
- Rose Park Sefton (rehabilitation/revegetation of Duck River open and piped channel diagonally across the park from Woods Road to Rose Street;
- Sefton Golf Course (use of native species in landscaping);
- Walshaw Park Bass Hill (revegetation of north east corner of park with native species, introduction of native canopy species around edge of the reserve;
- Herbert Crabtree Reserve (expansion of native revegetation ongoing management for biodiversity values, introduction of native canopy along the boundary of the reserve to link with Walshaw Park.

**Note:** Sites highlighted above identified as high ecological significance in Biodiversity Strategy 2002.

There may also be opportunities in the more confined reaches of the Duck River to encourage private land owners to plant endemic species in their gardens to create vegetated links between the above listed locations.

### c) Naturalisation of the Duck River channel and riverbank

Naturalisation of the Duck River channel and riverbank would create the opportunity for significant biodiversity enhancement in the Duck River in the Bankstown LGA. Within Bankstown much of the Duck River is contained in open or piped concrete channels. Riverbank naturalisation has been successfully undertaken in the Cooks River by Sydney Water by removing areas of concrete channel and replacing them with river banks that are more natural to improve the river's health and natural character (Sydney Water undated).

River bank naturalisation can take different forms, but generally involves the removal of some, or all of the concrete channel and creating a more gently sloping bank (Sydney Water undated). This is stabilised with native plants, trees and rocks. Naturalisation creates a softer landscape and can greatly improve the river bank habitat for native birds and animals and plant species (Sydney Water undated). Wetlands can also be established as part of the naturalisation process. Wetlands have a positive role in improving the river's ecology and health by treating stormwater runoff from streets and industrial areas, before it enters the river (Sydney Water undated).

In the Bankstown LGA, the Duck River channel has been confined in an open concrete canal, essentially from Woods Road, between Clapham Road and Carlingford Street to the upper reaches near the Hume Highway. The riparian corridor is very confined except where the canal passes through open space such as Jim Ring Reserve, Band Hall Reserve and O'Neill Park on the eastern arm and Maluga Passive Reserve, Rose Park and . Sefton Golf Course on the western arm.

The opportunities for biodiversity gains by channel and riverbank naturalisation in these areas need to be balanced against the requirements for flood mitigation that are available from a concrete channel.

However a combination of a series of off stream water storages including naturalised detention basins or constructed wetlands and increased water storage on Sefton Golf Course, along with increased maintenance of gross pollutant traps provide the opportunity to achieve biodiversity gains through naturalisation in some areas. A number of sites have been identified as suitable for further investigation for naturalisation and include:

- Jim Ring Reserve (small triangle reserve at the northern end of Jim Ring Reserve adjacent to Wellington Road and an area of the public swimming pool car park on the north eastern side of the channel (area may be suitable for creation of a constructed wetland or where some stormwater could be diverted or stored and harvested to water the playing fields, the area also may be suitable for channel naturalisation;
- Jim Ring Reserve (triangle behind Birrong Bowling and Sports Club between Duck River and Rodd Street Birrong may be suitable for channel naturalisation or constructed wetland);
- Band Hall Reserve, both arms of the concrete channel in the reserve may be suitable for naturalisation and/or constructed wetlands.

# 11 RECOMMENDATIONS

Council engaged Molino Stewart in May 2009 to undertake the Floodplain Risk Management Study and the development of a Duck River Floodplain Risk Management Study & Plan. This Study would bring together the relevant data from previous studies into a comprehensive set of management measures for all LGAs interested in this catchment.

Based on detailed assessment of Floodplain Risk management Options, it is recommended that the following be adopted by the relevant Councils:

## 11.1 ALL COUNCILS

Response Modification Measures – in co-operation with Sydney Water, work with SES to establish a community education program containing some or all of the following actions:

- Participation of communities with councils and emergency agencies in the design, implementation and evaluation of community flood education programs
- Ongoing and planned learning through a local community flood education plan to plan for, understand and respond to flooding. This includes SES actions such as “FloodSafe” brochures and more detailed information packages.
- Household and business emergency plans as key outputs of the learning
- Community flood education linked to other strategies in flood management.
- Post-flood learning to evaluate the impact of community education programs and improve general community resilience to future floods.

In addition to the planning and response to flooding, the education program should also advise residents where areas that will not be affected by floodwaters are located so that they can seek refuge there during floods, and also allow SES or others to establish emergency shelters in flood free areas. It should also include the concept of risk management and the meaning of Council’s risk categories.

Sydney Water and each of the Councils have regular maintenance programs for the sections of channel for which they are responsible and Councils also maintain and clean the smaller drainage networks on a regular basis. All of these organisations also respond to community notifications of blockages or other maintenance issues. It is recommended that these programs continue and that the community education program include strategies to encourage community members to refrain from dumping waste, garden clippings and shopping trolleys in the drainage system and to report any incidences so that the matter can be dealt with promptly.

## 11.2 AUBURN

### 11.2.1 Flood Modification

No specific measures proposed. Consideration be given to the installation of bollards at bridges/culverts and the installation of flood height indicators at creek crossings.

### 11.2.2 Property Modification:

- Incorporate the findings of the Flood Study review into the Planning documents to advise residents accordingly.
- Convert current risk precincts to true risk precincts.

### 11.2.3 Environmental Measures:

These measures apply to a combined Parramatta City/Auburn City Councils approach and are shown in Figure 13 and Figure 14.

#### a) Ongoing Management:

- The wetland on the southern bank of Duck River at the end of Millennium Circuit , Silverwater;
- The eastern bank of Duck River between Parramatta Road and the railway line;
- The eastern and western side of Duck River between the rail line and Duck River Reserve (adjacent to Manchester Road Auburn);
- Bangor Park;
- Peter Hislop Park (ongoing maintenance riparian edge);
- Princes Park (ongoing maintenance).

#### b) Revegetation and Expansion:

- The riparian corridor adjacent to the channel in Silverwater Park;
- The narrow riparian strip between Holker Street and Giffard Street Silverwater;
- The narrow riparian strip west of the factory north of the intersection of the M4 motorway and Junction Street Silverwater;
- Bangor Park (revegetation between Manchester Road and Mona Street);
- Duck River Reserve (additional revegetation west of existing vegetation toward pathway);
- Auburn Community Picnic Area (widen riparian vegetation);
- Auburn Public Golf Course (revegetation of riparian edge);
- End of Melissa Street Regents Park (area suitable for further investigation).

## 11.3 PARRAMATTA

#### a) Flood Modification:

Investigate in detail the use of Woodville Golf Course as a retarding basin.

Consideration be given to the installation of bollards at bridges/culverts and the installation of flood height indicators at creek crossings.

#### b) Property Modification:

- Consider a Voluntary Purchase and Voluntary House raising scheme for some of the properties most affected by the 1 in 5 year and 1 in 20 year ARI flood events;

- Consider an amendment to current open space plans to allow the purchase of extremely flood liable properties in the Guildford Road, Mountford Street, Bury Road and West Street Guildford precinct for use as open space;
- Incorporate the findings of the Flood Study review into the Planning documents to advise residents accordingly.
- Convert current risk precincts to true risk precincts.

### c) Environmental Measures:

These measures apply to a combined Parramatta City/Auburn City Councils approach and are shown in Figure 13 and Figure 14.

### d) Ongoing Management:

- The park at the confluence of Duck Creek and Duck River on the northern bank of Duck River adjacent to the M4 motorway;
- Northern bank of Duck River between the river and the Shell Oil site;
- The eastern and western side of Duck River between the rail line and Duck River Reserve (adjacent to Manchester Road Auburn);
- Duck River Reserve;
- Horlyck Reserve (rehabilitation of riparian vegetation adjacent to Mona Street);
- Ray Marshall Reserve (riparian edge);
- Everley Park (from Wellington Road to Everley Road ongoing management for biodiversity values);

### e) Revegetation and Expansion:

- The triangle park within the Shell site on the northern bank of Duck River, opposite the end of Carnarvon Street, Silverwater;
- The northern bank of Duck River at the confluence with Duck Creek, adjacent to a factory on Shirley Street;
- Duck River Reserve (additional revegetation west of existing vegetation toward pathway);
- Ray Marshall Reserve (small area suitable for revegetation at the end of Chiswick Road);
- Norford Park (triangle area at the southern end suitable for revegetation);

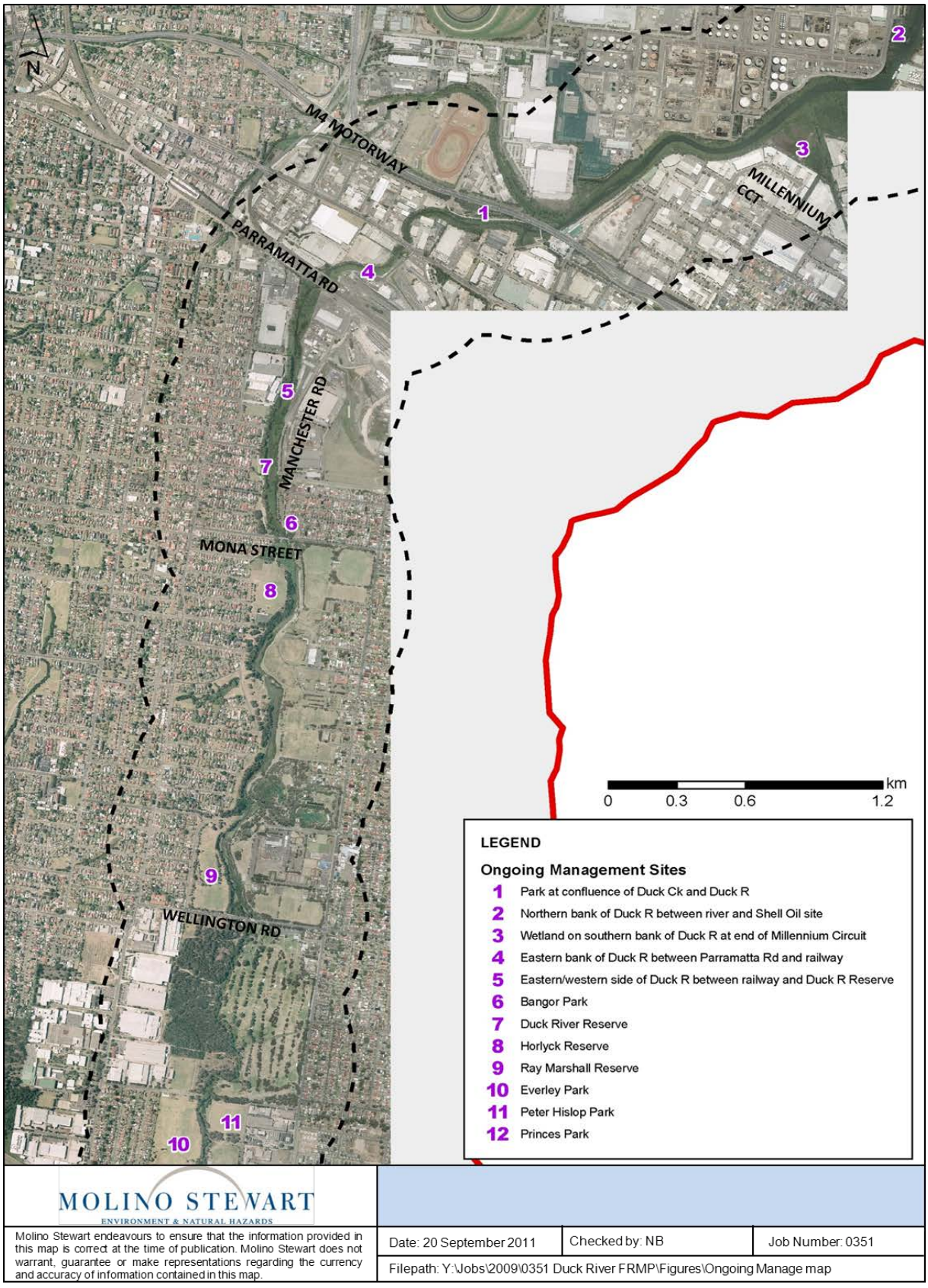


*Figure 13 - Sites for On-going Maintenance within the Parramatta and Auburn LGAs*

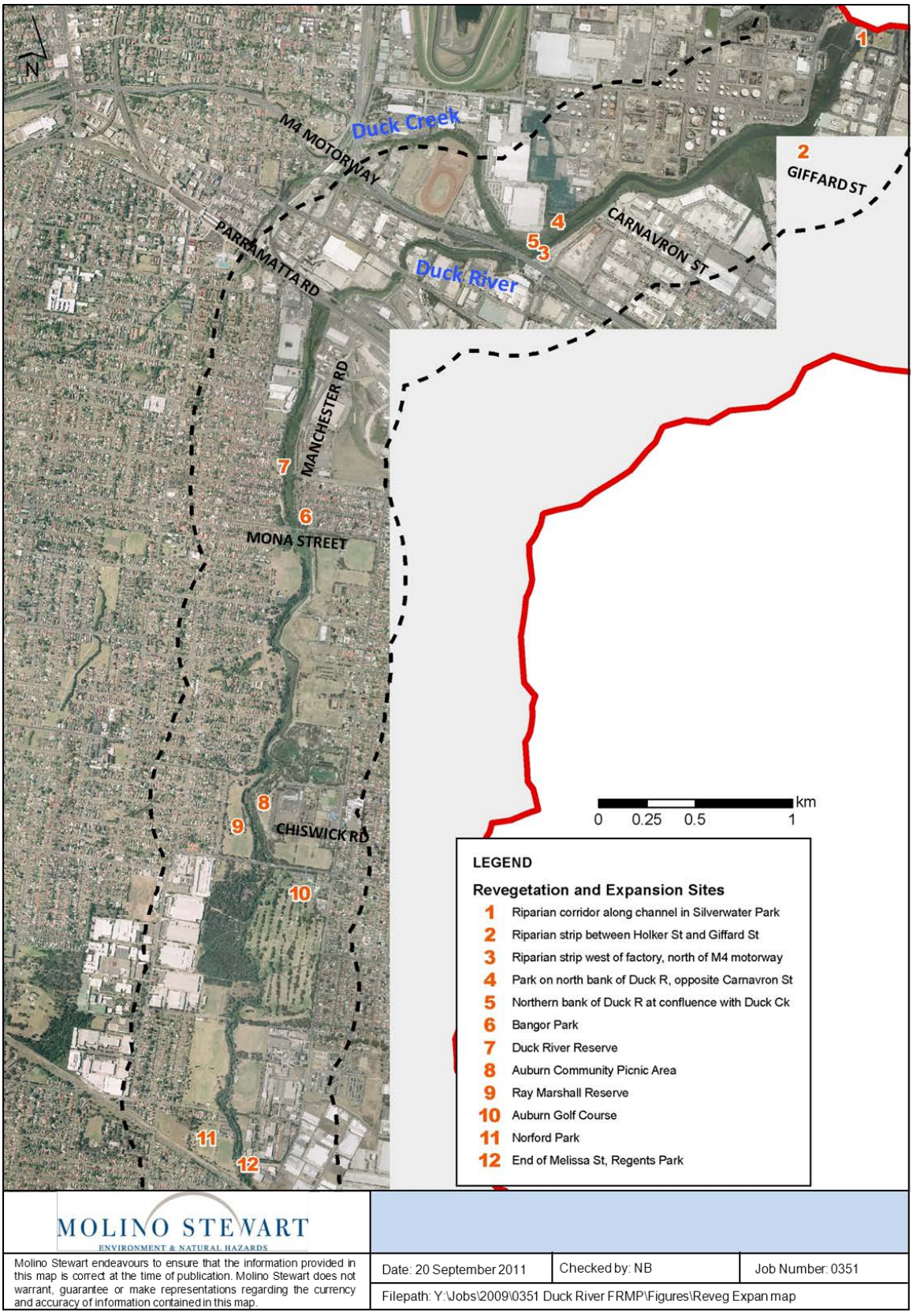


*Figure 14: Sites for Revegetation and Expansion within the Parramatta and Auburn LGAs*

## 11.4 BANKSTOWN

### a) Flood Modification Measures:

- Investigate in detail the use of Sefton Golf Course as a retarding basin. This has the secondary benefit of potentially allowing an increase in on-site storage for watering the course.
- Work with Sydney Water to investigate the structural integrity of the water supply pipeline at Munro and Helen Streets and to share results from this work in longer –term planning for the locality; and
- Investigate the potential to convert Band Hall Reserve into a "wet basin" in conjunction with environmental enhancement measures. It should be noted that Sydney Water owns the open channel asset through the reserve and liaison with Sydney Water would be necessary in any investigations.
- Consideration be given to the installation of bollards at bridges/culverts and the installation of flood height indicators at creek crossings.

In investigating or implementing these measures, it is essential to ensure that appropriate environmental impact assessments are undertaken at the scoping stage of all recommended measures in order to identify and protect environmental values present on each site.

### b) Property Modification Measures:

- Confirm floor levels or properties potentially affected by above floor flooding in flood events less than the 20 year flood event.
- Consider a Voluntary Purchase and Voluntary House raising scheme for properties that have floor levels affected by up to the 20 year ARI flood event;
- Convert current risk precincts to true risk precincts.

### c) Environmental Measures:

Significant revegetation works (with locally endemic native species) would be required to achieve these links, a number of specific reserves have been identified as suitable for further investigation. These are listed below and shown in Figure 15.

- Jensen Park (additional canopy cover on reserve edges);
- Duck River canal edges (weed removal, rehabilitation and revegetation of canal edges between Munro Street and Clapham Road Sefton)
- Jim Ring Reserve (additional canopy cover adjacent to the Duck River Channel and along Woods Road and Gascoigne Road on the edge of the reserve);
- Jim Ring Reserve (revegetation of small triangle reserve at the northern end of Jim Ring Reserve adjacent to Wellington Road;
- Jim Ring Reserve (revegetation of triangle behind Birrong Bowling and Sports Club between Duck River and Rodd Street Birrong);
- Maluga Passive Park (ongoing management for biodiversity values and passive recreation);
- Duck River canal edges between Rodd Street and Band Hall Reserve (introduction of native canopy cover);
- Band Hall Reserve (comprehensive revegetation of the Duck River riparian corridor to the full extent of the reserve);

- Duck River canal between Ferrier Road and Hume Highway (introduction of native canopy cover adjacent to canal);
- Duck River canal edges between Ferrier Road and Auburn Road (introduction of native canopy cover);
- O'Neill Park (introduction of native canopy cover adjacent to Duck River channel, rehabilitation and revegetation of native vegetation on reserve edges);
- End of Martha Street Yagoona (revegetation with native vegetation on small triangle reserve adjacent to Scout Hall);
- Gazzard Park Yagoona (revegetation of reserve edges with native canopy cover);
- Rose Park Sefton (rehabilitation/revegetation of Duck River open and piped channel diagonally across the park from Woods Road to Rose Street;
- Sefton Golf Course (use of native species in landscaping);
- Walshaw Park Bass Hill (revegetation of north east corner of park with native species, introduction of native canopy species around edge of the reserve;
- Herbert Crabtree Reserve (expansion of native revegetation ongoing management for biodiversity values, introduction of native canopy along the boundary of the reserve to link with Walshaw Park.
- Naturalisation of the Duck River channel and riverbank in selected areas of Jim Ring Reserve and Band Hall Reserve.

Also investigate means by which private land owners might be encouraged to plant endemic species in their gardens to create vegetated links between the above listed locations in the more confined reaches of the Duck River.

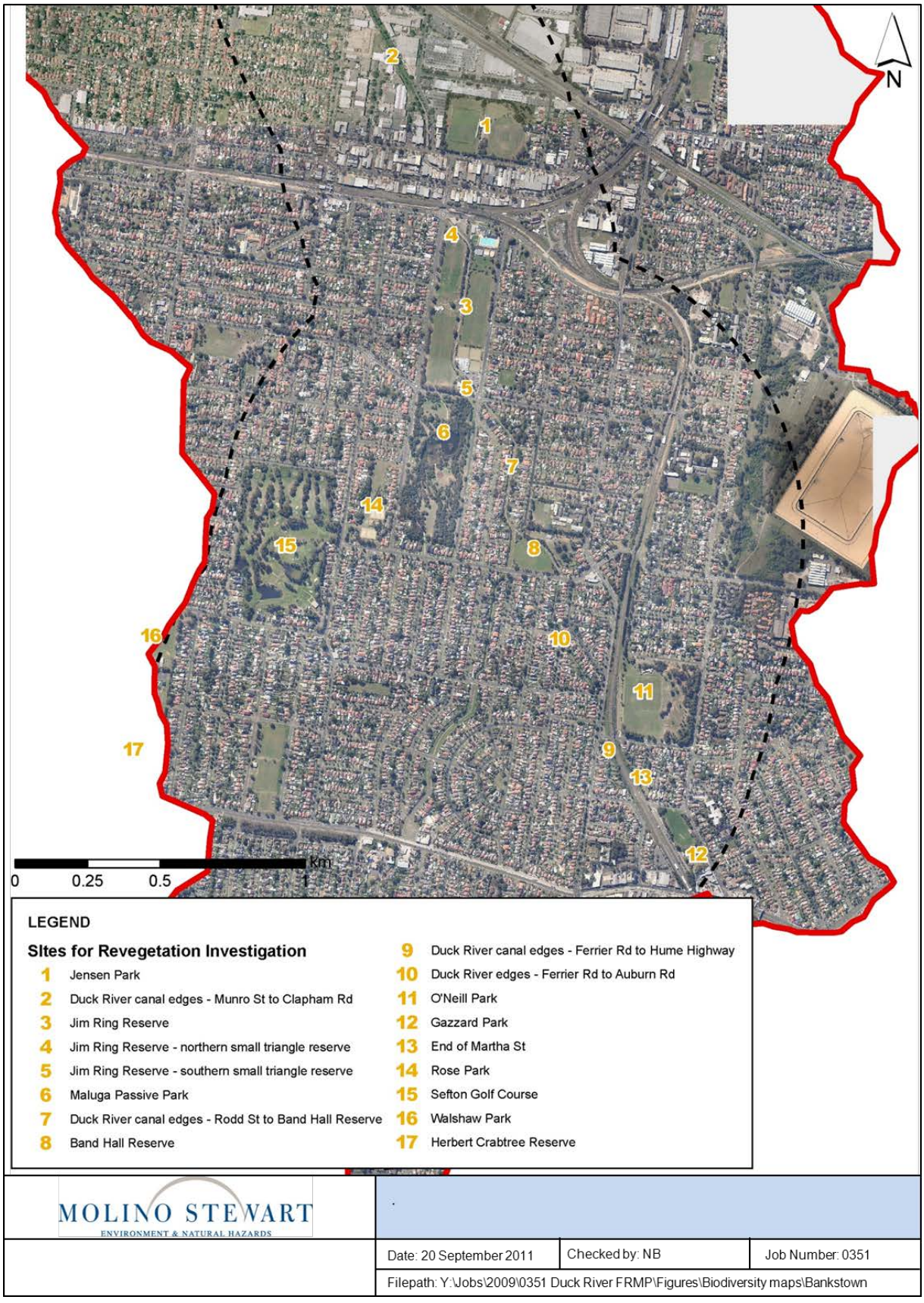


*Figure 15: Sites Identified for Revegetation Investigation within the Bankstown LGA*

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# APPENDIX A – COMMUNITY CONSULTATION DOCUMENTS

31 March 2011

«NAME»
«CARE_OF»
«RATEPAYER_ADD2»
«RATEPAYER_ADD3»

Dear Sir/Madam,

**Duck River Catchment Flooding - Flood Survey & Community Information Sessions**
**Premises at «PROPERTY_ADD1», Chester Hill**

Parramatta City, Auburn and Bankstown City Councils have been conducting a joint study of flooding in areas near the Duck River, Duck Creek and Little Duck Creek. The relevant flood studies for the Bankstown area can be viewed at the Bankstown Customer Service Centre and the libraries at Bankstown, Chester Hill and Greenacre from 4 April 2011 to 15 May 2011.

The flood studies have found that there is a chance your property may be affected by flooding during exceptionally large storms. I have included with this letter a fact sheet on flooding in your area and a map showing where flooding may occur; these may answer any questions you have.

Council will also be holding six Community Information Sessions so property owners can find out more about flooding in the Duck River and the Floodplain Risk Management Study and Plan. The dates, locations and times of these sessions are given below.

| | | |
|---|---|---|
| When: | Thursday 28 April 2011 | Thursday 5 May 2011 |
| Where: | Chester Hill Community Centre<br>25 Chester Hill Road (Yellow Hall) | Chester Hill Community Centre<br>25 Chester Hill Road (Yellow Hall) |
| Times: | 10am or 2pm or 6pm | 10am or 2pm or 6pm |

If you are interested in attending one of these sessions or would like to remain informed of the progress of the Duck River Catchment Flood Study, please indicate this on the attached flood survey. You can also call Ph 9707 9920 to register your interest or ask any questions. Note that only those registering their interest in the study will receive further correspondence from Council on the Study.

It would be appreciated if you could return the survey in the prepaid addressed envelope enclosed with this letter by **Friday 21 April 2011.**

Yours faithfully

Cherie Blackburn
**Catchment Management Planner**
Encl.

Note: The stormwater inundation maps can also be viewed online at http://www.bankstown.nsw.gov.au/Planning-Maps/default.aspx (accept the "conditions of use" click on "view planning maps" then click on "change map" & select "stormwater flood risk precincts")

# DUCK RIVER FLOODING FACT SHEET

## For communities in the Bankstown Council area

The Duck River extends from Bankstown to the Parramatta River, with several tributaries such as Little Duck River, Duck Creek and A'Becketts Creek draining into Duck River. The area of land which drains into the Duck River is known as the "Duck River Catchment". Four Councils operate in the Duck River catchment – Parramatta, Auburn, Bankstown and Holroyd, although only Parramatta, Auburn and Bankstown are participating in the Duck River Flood Risk Management Study and Plan.

A large part of the Duck River catchment has residential and commercial areas that have many hard surfaces such as roofs, roads and paths. Nearly all of the rain that falls onto these hard surfaces runs off straight into gutters, pipes and drains. In a less developed area, some of this rainfall would slowly soak into the ground.

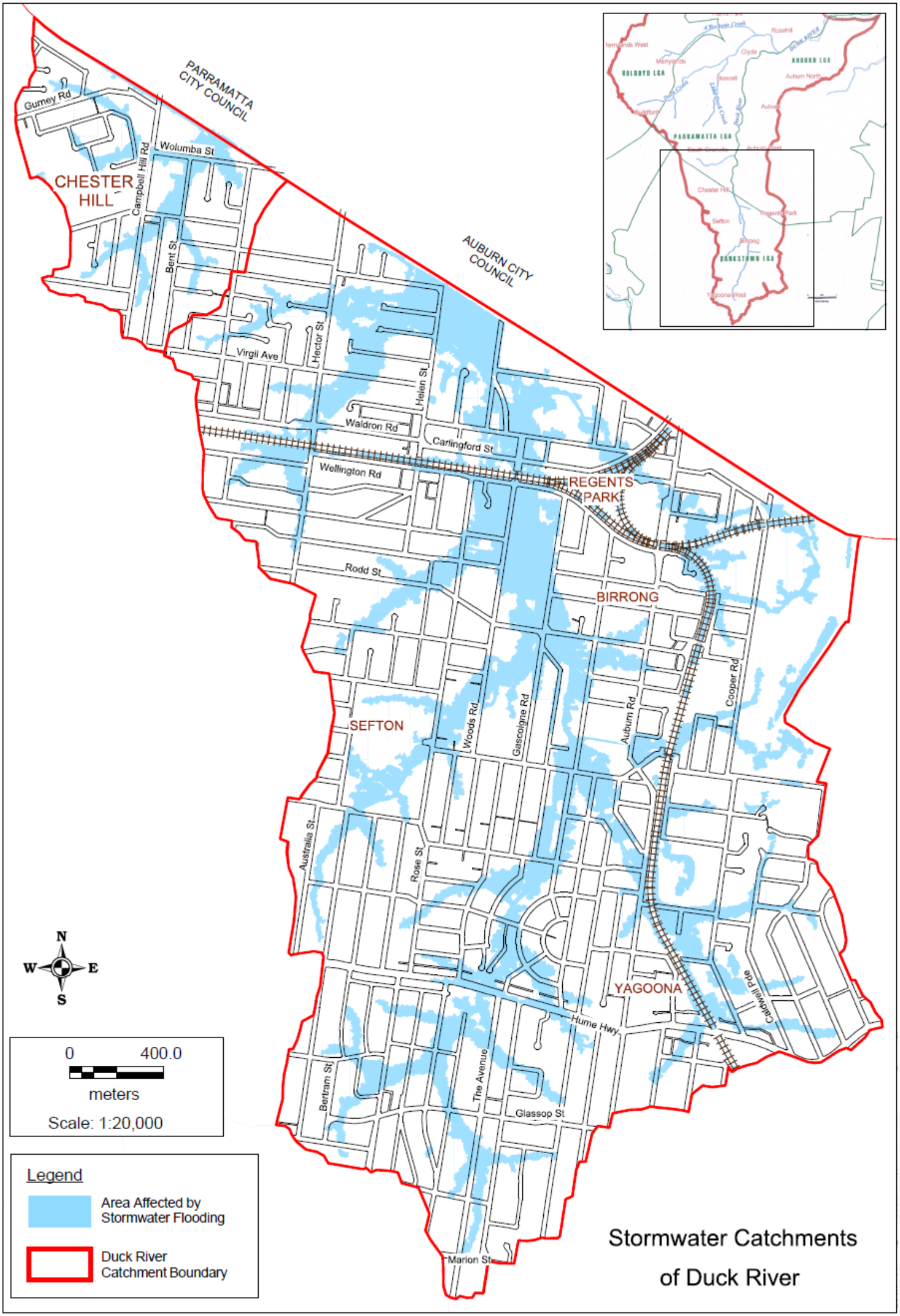
Just like in any urban area, these pipes and drains are not large enough to contain all the rain when there is a very large storm. The water that flows over the ground, instead of through pipes and drains, is called overland flow and the route it flows along is called an overland flow path. All of this water flows towards Duck River. In large storms local canals and creeks, and even the Duck River, are not big enough to take the flow that runs into them. They overflow their banks causing flooding of nearby properties. In very large storms flooding can affect properties a long way from local waterways.

Recent studies, based on historic information and using advanced computer models, have identified significant overland flow paths and overbank flooding in the Duck River catchment. The studies have indicated that in very large storms your property may be affected by floodwater. Figure 1 shows the estimated 1 in 100 year flood in your area. A 1 in 100 year flood does not mean that a flood of that particular size occurs once every 100 years. It means that in any given year, there is a 1 in 100 chance of it occurring. If you live to be 70, there is about a 50 per cent chance that you will experience a 1 in 100 flood in your lifetime. This is the same chance as tossing a coin and it showing heads.

Places in Australia have experienced more than one of these floods in a single decade or even within the same year. Other areas have experienced floods bigger than the 1 in 100 year flood.

The NSW State Government has said that the area potentially flooded by this 1 in a 100 year storm is the area that Councils must take into account when considering residential, commercial and industrial property development activities. The State Government has also said that Councils and the State Emergency Service must also consider how floods even larger than the 1 in a 100 year storm might be managed.

If you would like to discuss the results of the recent flood study in your area, please contact the person listed on the letter accompanying this fact sheet, or attend one of the planned community information sessions.


PARRAMATTA CITY COUNCIL
AUBURN CITY COUNCIL
Gurney Rd
Wolumba St
CHESTER HILL
Campbell Hill Rd
Bent St
Virgil Ave
Hector St
Helen St
Waldron Rd
Carlingford St
Wellington Rd
REGENTS PARK
Rodd St
BIRRONG
SEFTON
Woods Rd
Gascoigne Rd
Auburn Rd
Cooper Rd
Australia St
Rose St
YAGOONA
Hume Hwy
Cadwell Pde
Bertram St
The Avenue
Glassop St
Marion St
N
W
E
S
0
400.0
meters
Scale: 1:20,000
Legend
Area Affected by Stormwater Flooding
Duck River Catchment Boundary
Stormwater Catchments of Duck River

# DUCK RIVER COMMUNITY FLOOD SURVEY

Address of property:-

1. Is this a residential or business address? Residential Business

2. Are you the occupier of this property? YES NO

3. How long have you lived/worked at this property? Years…….. Months……..

4. Have you ever experienced a flood at this property? YES NO
   Do you have any photo's we could borrow? YES NO
   (Please attach any photo's and we will copy them and return them to you).

5. Did you think this property could flood? YES NO
   Why / Why Not?

6. Have you ever seen / heard any flood information for your local creek or river? YES NO
   If yes, where did this information come from?

7. If a flood did occur, would you know what to do to protect yourself and your property?
   YES NO

   What would you do?

8. Who in the community is responsible for reducing flood risks? (more than one answer allowed)

   ☐ Council ☐ State Emergency Service ☐ Landowner/Resident
   ☐ State Government ☐ Someone else (please tell us who) _____

9. Following this survey, do you intend to: (circle one in each row)

| | | | |
|---|---|---|---|
| Seek information on flood risk to your property | NO | Possibly | Definitely |
| Seek information about what to do to prepare for a flood | NO | Possibly | Definitely |
| Seek to be involved in this flood risk management process | NO | Possibly | Definitely |

10. Do you have access to the internet? YES NO

11. What would you like Council to do about future flooding in your area?

The information from this survey will remain confidential, and will only be used to assist Council in its planning for how to best minimise the effects of flooding in the Duck River catchment. Completion of this survey is voluntary. No names or addresses will be included in any published material.

# DUCK RIVER COMMUNITY FLOOD SURVEY

12. Would you be interested in receiving further information about flooding in your area? YES NO

13. Are you interested in attending a Community Information Session? YES NO

Please nominate preferred session:

10 am to 12pm, Thursday 28 April, Bankstown SES Headquarters, 2 Johnston Rd, Bass Hill ☐

2 pm to 4pm, Thursday 28 April, Bankstown SES Headquarters, 2 Johnston Rd, Bass Hill ☐

6 pm to 8 pm, Thursday 28 April, Bankstown SES Headquarters, 2 Johnston Rd, Bass Hill ☐

10 am to 12pm, Thursday 5 May, Chester Hill Community Centre, 25 Chester Hill Road ☐

2 pm to 4 pm, Thursday 5 May, Chester Hill Community Centre, 25 Chester Hill Road ☐

6 pm to 8 pm, Thursday 5 May, Chester Hill Community Centre, 25 Chester Hill Road ☐

As the number of participants in each session is limited to 20, if your preferred session is full, in some cases it will be necessary for Council to contact you and organise an alternate session for you to attend.

14. Your contact details (in case we need to ask you anything further or organise an alternate Community Information Session for you to attend)

Name:

Email:

Phone:

Thank-you for your participation

The information from this survey will remain confidential, and will only be used to assist Council in its planning for how to best minimise the effects of flooding in the Duck River catchment. Completion of this survey is voluntary. No names or addresses will be included in any published material.

[Name]
[Address]

[Date]

Dear [Name]

**Duck River Catchment Flooding - Community Information Session and Survey for local residents**

Parramatta City, Auburn and Bankstown City Councils have recently been conducting a joint study of flooding in areas near the Duck River, Duck Creek and Little Duck Creek. This work has found that there is a chance your property may be affected by flooding during exceptionally large storms. I have included with this letter a fact sheet and other documents on the issue of flooding in your area which may answer any questions you have.

Alternatively, to find out more about this issue you are invited to attend a Community Information Session on the Floodplain Risk Management Study and Plan for the Duck River Catchment.

Details of the information session are below.

When: [INSERT DETAILS]
Where: [INSERT DETAILS]
Time: [INSERT DETAILS]
RSVP: If you would like to attend the information session please contact [INSERT NAME] by telephone on [INSERT NUMBER] or email [INSERT EMAIL] by [INSERT DATE]

Finally, you may wish to discuss this issue directly with a Council officer, if so then please ring [INSERT NAME] on [INSERT NUMBER].

If you are a property owner with tenants at your property please let them know about the information in this letter and other included documents.

Residents and business owners are also encouraged to fill out a short flood survey, particularly if they are unable to attend the Community Information Session. This can be done by:

- Returning the hard copy with the pre-paid and addressed envelope enclosed in this letter

- Filling in a survey at the Community Information Session.

Dated flood photos showing any past flooding are particularly valuable to enable better estimation of the extent of future flooding.

Please return the survey by April 15th 2011.

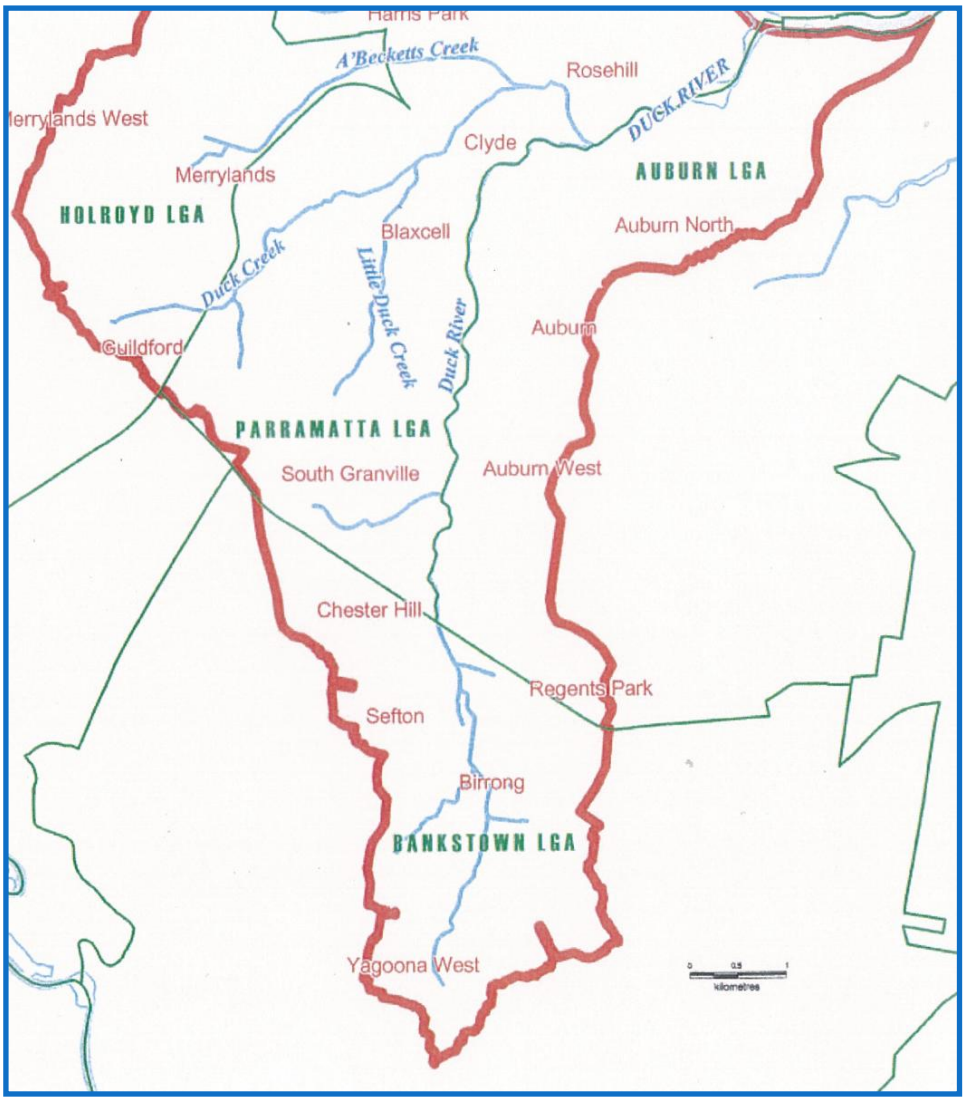
Yours sincerely

[Insert Name]
**[Insert position]**

# DUCK RIVER FLOODING FACT SHEET

## For communities in the [INSERT COUNCIL NAME] Council area

The Duck River extends from Bankstown to the Parramatta River, with several tributaries such as Little Duck River, Duck Creek and A'Becketts Creek draining into Duck River. The area of land which drains into the Duck River is known as the "Duck River Catchment". Four Councils operate in the Duck River catchment – Parramatta, Auburn, Bankstown and Holroyd, although only Parramatta, Auburn and Bankstown are participating in the Duck River Flood Risk Management Study and Plan.




**Map of the Duck River Catchment**

A large part of the Duck River catchment has residential and commercial areas that have many hard surfaces such as roofs, roads and paths. Nearly all of the rain that falls onto these hard surfaces runs off straight into gutters, pipes and drains. In a less developed area, some of this rainfall would slowly soak into the ground.

Just like in any urban area, these pipes and drains are not large enough to contain all the rain when there is a very large storm. The water that flows over the ground, instead of through pipes and drains, is called overland flow and the route it flows along is called an overland flow path. All of this water flows towards Duck River. In large storms local canals and creeks, and even the Duck River, are not big enough to take the flow that runs into them. They overflow their banks causing flooding of nearby properties. In very large storms flooding can affect properties a long way from local waterways.

A recent study, based on historic information and using advanced computer models, has identified significant overland flow paths and overbank flooding in the Duck River catchment. The study has indicated that in very large storms the property your property may be affected by floodwater. A separate A3 map sheet, included with this letter, shows the estimated 1 in 100 year flood in your area. A 1 in 100 year flood does not mean that a flood of that particular size occurs once every 100 years. It means that in any given year, there is a 1 in 100 chance of it occurring. If you live to be 70, there is about a 50 per cent chance that you will experience a 1 in 100 flood in your lifetime. This is the same chance as tossing a coin and it showing heads.

Places in Australia have experienced more than one of these floods in a single decade or even within the same year. Other areas have experienced floods bigger than the 1 in 100 year flood.

The NSW State Government has said that the area potentially flooded by this "1 in a 100 year" storm is the area that Councils must take into account when considering residential, commercial and industrial property development activities. The State Government has also said that Councils and the State Emergency Service must also consider how floods even larger than the "1 in a 100 year" storm might be managed.

If you would like to discuss the results of the recent flood study in your area, please contact the person listed on the letter accompanying this fact sheet, or attend one of the planned community information sessions.

# DUCK RIVER COMMUNITY FLOOD SURVEY

Address of property:-

1. **Is this a residential or business address?** Residential Business

2. **Are you the occupier of this property?** YES NO

3. **How long have you lived/worked at this property? Years..... Months.....**

4. **Have you ever experienced a flood at this property?** YES NO

5. **Did you think this property could flood?** YES NO

   **Why/Why Not?**

6. **Have you ever seen/heard any flood information for your local creek or river?** YES NO

   **If yes, where did this information come from?**

7. **If a flood did occur, would you know what to do to protect yourself and your property?** YES NO

   **What would you do?**

8. **Who in the community is responsible for reducing flood risks? (more than one answer allowed)**

   ☐ Council ☐ State Emergency Service ☐ Landowner/Resident
   ☐ State Government ☐ Someone else (please tell us who) _____

9. **Following this survey, do you intend to: (circle one in each row)**

| | | | |
|---|---|---|---|
| Seek information on flood risk to your property | NO | Possibly | Definitely |
| Seek information about what to do to prepare for a flood | NO | Possibly | Definitely |
| Seek to be involved in this flood risk management process | NO | Possibly | Definitely |

10. **Do you have access to the internet?** YES NO

11. **What would you like Council to do about future flooding in your area?**

12. **Would you be interested in receiving further information about flooding in your area?** YES NO

13. **Your name and contact details (optional)**

**Please note the information in this survey will remain confidential, and will only be used to assist Council in its planning for how to best minimise the effects of flooding in the Duck River catchment.**

MR = 14A

# Duck River Floodplain Risk Management Plan

## Frequently Asked Questions

Council is undertaking continuing flood studies in the Duck River area and planning to ensure flood prone land is appropriately developed and managed. The following answers some frequently asked questions about Council's work in this area.

**What kind of flooding is council concerned with?**

Council is investigating and managing the natural flooding that occurs in all parts of Australia. This kind of flooding occurs where runoff after rain exceeds the capacity of the drainage system including the creeks, rivers, built pipes and channels. It can be dangerous and result in property damage and even loss of life.

Local overland flows after heavy rains which take the 'path of least resistance' on the way to drains or water courses can also cause localised flooding.

Urbanisation and an increasing number of hard surfaces have impacted flows because they stop ground absorption of rainfall and allow run-off to reach catchments faster than before areas were developed.

**Have we flooded before?**

The earliest recorded flood in the Parramatta River occurred in 1795, although floods would have occurred previous to this. It is likely that Duck River and its tributaries flooded at this time but no one recorded this information. Significant flooding of Duck River has previously occurred in April 1969 and April 1974. Similar significant floods occurred in nearby catchments in 1986, 1988 and 1990 but did not affect Duck River as badly.

Few notable floods have occurred in the Duck River catchment in recent decades.

**What is a "Floodplain Risk Management Plan"?**

A document outlining a range of actions aimed at improving floodplain management. The plan is the principal means of managing the risks associated with the use of the floodplain. The plan will usually contain both written information and diagrams describing how particular areas of the floodplain are to be used and managed to reduce the risks from floods.

**Why is Council conducting this study?**

Flooding costs local government and property owners and occupiers a lot of money and imposes substantial intangible costs on the community, such as social and emotional costs. The main objectives of Floodplain Management are:

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

Key aims of the Floodplain Risk Management Plan are to:

- minimise the risk to life, health and safety;

- minimise damage to property;
- preserve the natural function of the floodplain;
- ensure development on the floodplain is compatible to flood risk.

**Who is responsible for Floodplain Management?**
In NSW, the primary responsibility for Floodplain Risk Management rests with local Councils:

*Parramatta, Auburn and Bankstown City Councils*
- Prepare and implement floodplain management plans;
- Commission, maintain and enhance flood information;
- Construct and maintain flood management infrastructure
- Input to statutory planning schemes, community education and involvement;
- Provide flood advice and controls on developments.

Additional technical support and financial assistance is provided by both the Commonwealth and State governments. In particular:

*NSW Department of Environment, Climate Change and Water*
- Defines broad policy objectives;
- Provides technical advice and financial assistance;
- Provides emergency management advice.

*State Emergency Service*
- Act as the lead agency for coordinating evacuation and welfare during flood events

*Sydney Water*
- Prepare and implement floodplain management plans;
- Commission, maintain and enhance flood information;
- Construct flood related infrastructure.

**How have the flood risk maps been prepared?**
Because large and rare floods have often not been experienced since European settlement commenced, computer models are used to simulate the depths and velocities of major floods. These computer models are established and operated by flooding experts. Because of the critical importance of the flood level estimates produced by the models, such modelling is subjected to very close scrutiny before flood information is formally adopted by a council.

Maps of flood risks are prepared after consideration of such issues as:
- flood levels and velocities for a range of possible floods;
- ground levels;
- flood warning time and duration of flooding;
- suitability of evacuation and access routes; and
- emergency management during floods.

**Why were houses built in areas where it floods?**
The Duck River area was developed for urban usage mainly in the 1950's and the design of the suburbs is typical of most Sydney suburbs designed at that time. Flood problems often occur in many other places around Sydney.

While parks and canals were built where most of the water naturally flowed, and the lowest lying land was kept clear of development, it was not understood back then just how much water could flow through the catchment in the rarer storms. It is only in the last decade that this has been properly appreciated and the rainfall data and computer technology has been available to better understand and calculate it.

**What is flash flooding?**
Flooding that is sudden and unexpected is referred to as flash flooding. It is usually caused by slow-moving thunderstorms that deposit an extraordinary amount of water in a relatively short period of time.

**What is the 100 year flood?**
A 100 year flood is the flood that will occur or be exceeded on average once every 100 years. It has a probability of 1% of occurring in any given year. If your area has had a 100 year flood, it is wrong to think you will need to wait another 99 years before the next flood arrives. Floods do not happen like that. Some parts of Australia have received a couple of 100 year floods in one decade or even a year apart. On average, if you live to be 70 years old, you have about a 50/50 chance of experiencing a 100 year flood.

**There is no recorded history of flooding in my area, could I still be at risk?**
Lack of evidence of historical flooding does not necessarily mean the area is not prone to flooding. If you live close to a creek, river, stormwater drain or in a low-lying area, you may be at risk from flooding even if you have not experienced it personally. Flooding can also occur on the sides of hills if the shape of the landscape concentrates overland flows on their way to the drainage network.

**What are the consequences of flooding?**
Flooding causes severe economic damage and emotional distress. Flooding in urban and rural NSW is estimated to cost our economy about $250 million each year, and the human impact is even greater.

Flooding can be dangerous to people and animals and cause damage to buildings, infrastructure and utilities.
It may also cause the loss of valuable belongings and the disruption of essential services. Some examples of the risks associated with flooding:

- Fast moving waters may knock down a person
- A moving water height of about 600mm is all that is needed to float and wash away an average vehicle
- About 50% of deaths are caused by driving, walking or swimming in floodwaters

**What solutions are available?**
In theory there are many different ways in which flood risks can be managed. Which ones are the most effective, practical or acceptable to the community will depend on the nature of flooding, the local topography, existing development and future aspirations for a locality. This is why we are consulting with you, the local community.

Broadly the approaches to dealing with flooding are:

1. Simply live with it – accept that the damage and disruption caused by flooding is part of the experience of living or doing business in flood prone areas.
2. Take actions to protect people and possessions when flooding occurs – move goods to higher levels and evacuate at-risk properties.
3. Install new drainage works to convey the floodwaters away – deepen or widen creeks, channels or drains.
4. Install new detention works to temporarily store water further up in the catchment – this could involve many small structures on individual properties or a few large structures in parks or open space.
5. Raise existing buildings so that they are less likely to flood – clad, timber-framed houses can be jacked up and supported on piers.
6. Erect barriers around properties to keep floodwaters out – these could be permanent measures such as levees or temporary measures such as sandbags.
7. Place restrictions on new development – by specifying the type and design of new buildings (floor levels, building materials) in the floodplain it is possible to reduce the damage and disruption caused by flooding in the long term.
8. Negotiating with the owners of particularly vulnerable properties to voluntarily purchase their property, demolish it and convert the area to public open space.
9. Fill in part of the floodplain and build houses on top of the fill

The appropriateness of each of these approaches will vary for each area within the catchment and a detailed assessment would be required before identifying and implementing the best approach for any specific site or area. Councils may not permit some of these approaches in their area, for example, filling in the floodplain may help an individual householder, but it makes everyone else's flooding worse.

**What can I do to minimise flooding?**
Flooding is a significant issue, which affects the entire community, and actions by individuals may have serious consequences on others within the catchment. To play your part:

- be aware if your property is affected by flooding or contains a potential overflow path;
- be aware of what drainage easement affects your property;
- be conscious of flow paths around your dwelling and keep them clear - be careful not to dispose of grass clippings and other garden cuttings in or near the watercourse and remove any obstructions that may cause blockages.;
- do not fence over known flow paths;

- do not construct raised gardens or plant significant trees or vegetation within flow paths - Certain species such as Jacaranda, Poplar, Willow, Fig, Camphor Laurel, rubber Trees and other types with aggressive root systems can cause pipelines to become blocked or cracked;
- do not perform any significant work (earthworks, creek bank protection, bridges, piping etc) to the watercourse through your property without first consulting Council;
- do not lay any pipes, construct a bridge or divert a watercourse without first consulting Council. Unapproved work can increase flooding for both you and your neighbours;
- do not fill in low lying areas of your yard without seeking Council approval may cause water to pond and increase flooding potential on both your property and your neighbour's.

With your help, we can help to minimise flood risks and damages.

**How does Council maintain drainage infrastructure?**
Council carries out regular maintenance of its entire drainage infrastructure. Council's drainage infrastructure was checked after recent storms in May 2010 and found to be open and clear. As the majority of the drainage infrastructure is underground, blockages inside pipes are not evident till a rain event occurs.

Illegal dumping of waste (grass clippings, soil, concrete slurry etc) in the drainage system can cause blockages and contribute to flooding. The 'first flush' of a rain event can also cause blockages by dislodging debris from a variety of places. Larger rain events can also move large objects (fences, cars etc) and block culverts and open drains making flooding worse.

**Will Council upgrade existing drainage infrastructure?**
The floodplain management process allows Council to identify deficiencies in its drainage system and investigate potential upgrades of this system. If upgrades are recommended as part of the floodplain process, Council will prioritise these projects and plan for them to be undertaken as soon as funds are available.

**What if I want to sell my property?**
The approach taken by each Council in providing flood information is often different. However, generally when you sell your property you are required to attach a "Section 149 (2)" certificate from Council to the contract of sale. This will inform the purchaser if there are any Council policies (including policies relating to flooding) applying to the property which restricts the use or development of the land or places obligations on the owner. A Section 149 (5) certificate provides additional information to that given above.

Advice on flood risk on the Section 149 certificate may change in accordance with the notification policy adopted in the Floodplain Risk Management Plan.

**What will this do to my property value?**

Research in Australia[1] indicates that these certificates do not have a noticeable effect on property values, particularly in high value markets such as Sydney. However, any change in a Council's classification of properties can have an impact on property values. If your property is now classified as being in a Flood Planning Area, the real flood risks on your property have not changed, only its classification has been assigned. A prospective purchaser of your property could have previously discovered this risk if they had made enquiries themselves.

Ultimately, however, the market determines the value of any residential property. Individual owners should seek their own valuation advice if they are concerned that the Flood Planning Area categorisation may influence their property value.

**Will Council make me change my property?**
If you prefer, you can choose to do nothing about any potential risks associated with flooding.

**What if I want to carry our building works on my property?**
When you make major modifications to your building you will have to make the property comply with any new requirements for building or development that may now apply to your property as a result of the Flood Planning Area assigned and the Floodplain Risk Management Plan which Council adopts at the end of this process. Generally this means that rebuilt houses and house extensions take into account the flood risk in their design and thus reduce the risk of damage to the property as a result of flooding.

**My property was never classified as 'flood prone' or 'flood liable' before. Now it is. Why?**

There are three main reasons why this could have occurred:

1.) Council had not previously undertaken a study to the level that has now been undertaken
2.) The State Government changed the meaning of the terms 'flood prone', 'flood liable' and 'floodplain' in 2001. Prior to this time, these terms generally related to land below the 100 year flood level. Now it is different. These terms now relate to all land that could possibly be inundated, up to an extreme flood known as the probable maximum flood (PMF). This is a very rare flood. The reason the Government changed the definition of these terms was because there was always some land above the 100 year flood level that was at risk of being inundated in rarer and more extreme flood events. History has shown that these rarer flood events can and do happen (e.g. the 1990 flood in Nyngan, the November 1996 flood in Coffs Harbour, the August 1998 flood in Wollongong, the 1998 flood in Katherine, the 2007 Gippsland floods, and the widespread flooding along Queensland's Central Coast in June 2008.
3.) Better computer models and information become available over time which has shown there is a risk of flooding in your area

**What is the probable maximum flood (PMF)?**

[1] Dr Stephen Yeo, "Are Residential Property Values Adversely Affected by Disclosure of Flood Risk?" Proceedings of the 44th Annual Floodplain Management Authorities Conference, Coffs Harbour May 2004

The PMF is the largest flood that could possibly occur in your area. It is a very rare and improbable flood. Despite this, a number of historical floods in Australia have approached the magnitude of a PMF. Every property potentially inundated by a PMF will have some flood risk, even if it is very small. Under the State Government changes implemented during 2001, councils must now consider floods of all possible sizes, even these very unlikely ones, when managing floodplains. As part of the State Government changes, the definitions of the terms 'flood liable', flood prone' and 'floodplain' have been changed to refer to land inundated by the PMF. Although the PMF is much rarer than a 100 year event, there is a surprisingly high chance of occurrence of extreme events over an average lifetime. For example, a 500 year event has about a 1 in 6 chance (or a roll of a die) in a 70 year life time. In February 2007 a 500 year flood occurred in Campbelltown and in January 2007, a 1,000 year flood occurred in Hawker, South Australia.

**Will I be able to get house and contents insurance if my house might be affected by flooding?**

Until recently it was difficult to get flood insurance for your property. Recently some larger insurers have extended their policies to cover flooding.

In some policies the additional coverage is automatically included while in others it is an optional extra. In either case, if you have flood insurance coverage you will most likely pay a higher premium for it, either directly or indirectly. Insurance companies do use Council flood studies to calculate property flood risks but where such information is not readily available they use their own methods of identifying which properties are likely to flood.

This project will not change your flood risk nor change your eligibility for flood insurance. It might change your premium (up or down) if the Council's more accurate modeling of your flood risk differs from your insurer's estimate.

You should contact your insurer to find out your level of coverage and what options are available for flood insurance. More information is available from the Insurance Council of Australia, www.insurancecouncil.com.au

**Will I be able to get a home loan if my land might be affected by flooding?**

Most banks and lending institutions do not account for flood risks when assessing home loan applications unless there is a very significant risk of flooding at your property. The "Flood Planning Area" includes properties that might be affected by a 100 year flood. The system of Flood Planning Area classification will make it clear to all concerned the nature of the flood risks. Under the previous system, if a prospective lending authority made appropriate enquiries, they would have identified the nature of the flood risk and considered it during assessment of home loan applications. As a result, it is not likely that the classification of your property within a Flood Planning Area will alter your ability to obtain a home loan. Nevertheless, property owners who are concerned about their ability to obtain a loan should clarify the situation with their own lending authority.

**What will climate change do?**

No one knows exactly. Certainly the areas which currently flood will still flood. It is expected that new areas at the bottom end of Duck River will be affected by any sea

level rises. If the rainfall intensity increases, as is predicted by the CSIRO, some new properties at the outer limits of the existing flood extent may be slightly more affected by flooding where they were before. Increased rainfall intensity may also cause localised ponding in natural depressions and behind major flow constrictions such as elevated railways and roadways where the culvert capacity is insufficient.

Modelling of the Sydney Region by the CSIRO suggests that flooding may happen more often. The Duck River Floodplain Risk Management Study and Plan will look at the possible effects of sea level rise and increased rainfall intensity.

**How can I get involved and have my say?**

There are multiple opportunities for property owners and occupiers to be involved in the floodplain risk management process. Community members are encouraged to attend forums which will be held at two stages of the project:

- Review of the Draft Flood Study Review Report
- Review of the Flood Damages and Floodplain Management Options Report

Community displays will be set up for three phases of consultation:

- Inception and purpose of the study
- Draft Floodplain Risk Management Study
- Draft Floodplain Risk Management Plan

The displays will be shown at appropriate community forums, at municipal libraries and at Council offices in each LGA.

A property owner survey is also available to be filled out either in hard copy or on the project website. A fact sheet of flood information is also included in a pack to property owners.

The community is also allowed to review the final draft report and plan at a public exhibition and make recommendations or suggestions before it is adopted by Council.

For more information on any of the above consultation steps contact:
[INSERT NAME] from Parramatta City Council on [INSERT NUMBER] if you live in this Council's area, or
[INSERT NAME] from Bankstown City Council on [INSERT NUMBER] if you live in this Council's area, or
[INSERT NAME] from Auburn Council on [INSERT NUMBER] if you live in this Council's area

# APPENDIX B – BMT WBM FINAL LETTER REPORT FOR THE DUCK RIVER FLOOD MITIGATION MODELLING TO BANKSTOWN CITY COUNCIL

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Our Ref: AK: L.B18608.003.Final Report.doc

8 November 2011

Bankstown City Council
Upper Ground Floor, Civic Tower
66-72 Rickard Road
BANKSTOWN NSW 2200

Attention: Cherie Blackburn

**RE: FINAL LETTER REPORT FOR THE DUCK RIVER FLOOD MITIGATION MODELLING**

This letter report outlines the flood mitigation modelling and associated flood impact assessment of three options investigated in the Duck River catchment.

## 1 Introduction and Background

BMT WBM developed the Duck River model for Bankstown City Council (BCC) in 2007 and it was subsequently updated in 2009. This Duck River model extends to the Sydney Water Main (SWM) within the Bankstown Local Government Area (LGA). Flood modelling has indicated that properties immediately upstream of the Sydney Water Main are flood affected due to the flow constriction at the Sydney Water Main culverts and properties downstream of the Sefton Links Golf Course are flood affected.

The neighbouring Councils, Auburn and Parramatta City Councils (ACC and PCC), to the north (downstream) of BCC, have also undertaken flood studies of Duck River in their LGAs. In 2009, the three Councils jointly commissioned the Duck River Floodplain Risk Management Study. As part of this study, flood damages from various storm events have been calculated and extensive community consultation has been undertaken which has highlighted public interest in the existing flood risk upstream of the Sydney Water Main flow constriction and also in other areas of the catchment.

To address these issues and inform the Duck River Floodplain Risk Management Study, BCC commissioned BMT WBM to undertake hydraulic impact assessments of two potential options for managing flood risk and another potential option for improving water quality in the Duck River.

## 2 Methodology

The following three options have been assessed:

1 Widening of the culverts and channel underneath the SWM;

2 Construction of a detention basin on the grounds of the Sefton Golf Course; and

3 Widening and revegetating the existing channels traversing Band Hall Reserve.

The primary objective of the first two options is flood mitigation, while the third is improvement in water quality and other associated environmental benefits. This letter report focuses solely on the hydraulic assessment of all three options; other benefits or impacts are outside the scope of this project.

Option 1, the SWM culvert widening, utilised the following three hydraulic models:

- BMT WBM 2009 Duck River model, developed for BCC upstream of the SWM;
- WMA 2010 Duck River model, developed for PCC downstream of the SWM; and

- A combined model consisting of the two models joined together covering the entire BMT WBM model area and extending approximately 5.5km downstream of the SWM to the M4 Western Motorway in PCC.

The BMT WBM and WMA models form the main part of the assessment, and the combined model has been utilised to verify results of the assessment. This approach was undertaken to assess the potential affect of the adopted downstream boundary applied in the BMT WBM 2009 Duck River model. The downstream boundary was a stage-time hydrograph with different peak flood levels for various storm events. For more details on the selection of the downstream boundary refer to the *Duck River Stormwater Catchment Study 2007 Report including 2009 Addendum* (BMT WBM, 2010).

Options 2 and 3 were simulated utilising the 2009 Duck River model developed for BCC.

All three options have been assessed using the 100 Year Average Recurrence Interval (ARI) event. All model simulations utilised both the blocked and unblocked scenarios, as per BCC adopted blockage specifications (see Duck River Stormwater Catchment Study, 2007 Report including 2009 Addendum, prepared by BMT WBM for BCC, May 2010).

Details on the locality are outlined below; the results are presented in Section 3.

***Widening of the Sydney Water Main Culverts (Option 1)***

This flood mitigation option involved the widening of the culverts and channel from approximately 11.0m to 20.0m (an increase of approximately 9 metres) underneath the Sydney Water Main over a length of approximately 40m. Image 1 illustrates the locality with the existing channel and culvert under the SWM in the aerial photograph, and the widening of the culverts and channels to the east (indicated by the yellow polygons).

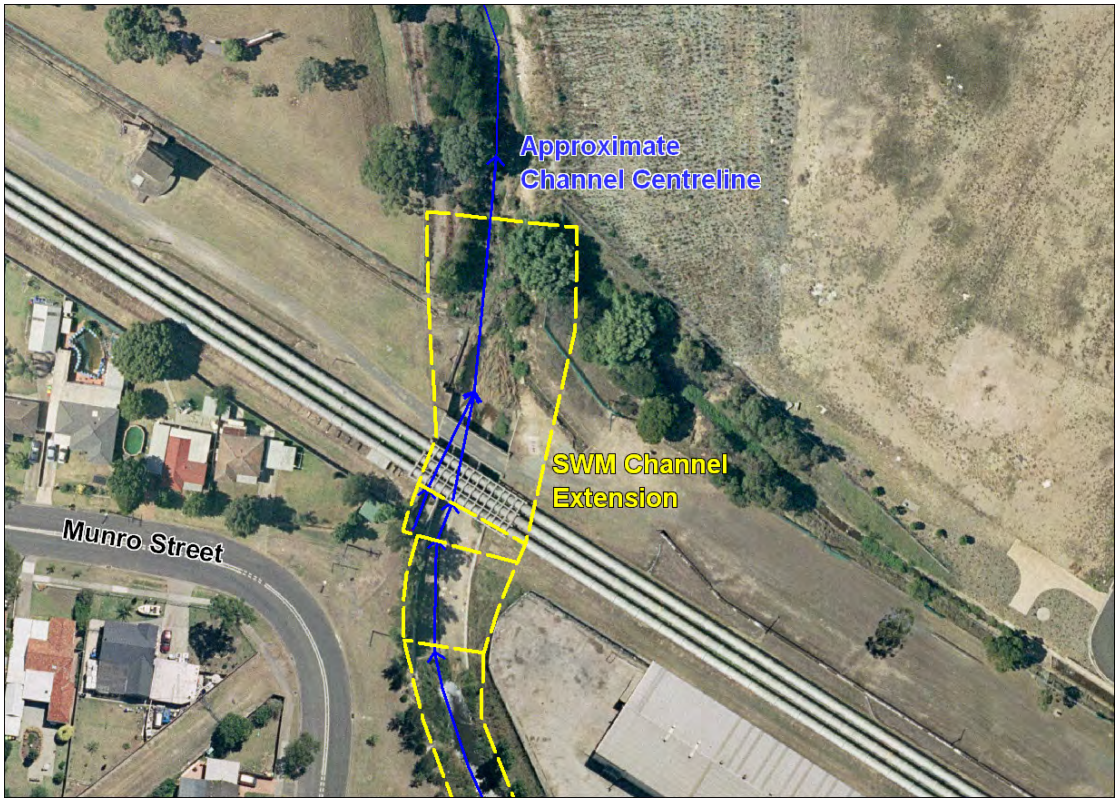



**Image 1: Widening of the Sydney Water Main Culverts (Option 1)**

***Blockage Scenarios at Sydney Water Main Culverts***

In addition to the modelling of the channel widening outlined above, an additional simulation was undertaken in May and June 2011 using the BMT WBM 2009 Duck River model. This additional simulation assessed the effects of blockage at the SWM (no widening of the culvert undertaken). To understand this additional simulation it is important to be aware of Council's blockage policy, in combination with the dimensions of the culvert structure underneath the SWM at the downstream end of the Duck River model; also outlined in Section 4 of the *Duck River 2009 Addendum Report* (BMT WBM, 2010).

Council's blockage policy includes a lateral blockage factor of 50% of structure openings with a diagonal span of less than 6 metres. Photos of the culvert structure underneath the SWM are provided in Image 2. With regards to the openings under the Sydney Water Main, Council have adopted the following blockage policy looking downstream for the Duck River Model:

- **Left hand opening unblocked:** Diagonal span less than 6 metres, however left unblocked as the potential for debris blockage was considered low due to the immediately adjacent fence, and the culvert is at the downstream end of a pipe and box culvert system.
- **Middle opening unblocked:** Diagonal span greater than 6 metres.
- **Right hand opening 50% blocked:** Diagonal span less than 6 metres.

TUFLOW modelling undertaken for Bankstown City Council catchments includes the modelling of the following two scenarios:

1 **'Blocked' scenario:** Council's blockage policy applied to all inlets and structures; and

2 **'Unblocked' scenario:** No blockage applied apart from at downstream boundary structure (i.e. for the Duck River TUFLOW model, at the Sydney Water Main crossing).

In 2009, a third fully unblocked scenario was also modelled to provide additional information on peak flood flows and levels at the Sydney Water Main crossing:

3 **'Fully unblocked' scenario:** No blockage applied at the Sydney Water Main crossing.

In May and June 2011 an additional fourth scenario was modelled to further assess the effects of blockage at the culverts underneath the SWM:

4 **'Blocked scenario, but with the right culvert underneath the SWM 0% blocked':** Council's blockage policy applied to all inlets and structures, but reduction of 50% blockage to 0% blockage to the right culvert underneath the SWM.

This fourth scenario provides additional information to evaluate a blockage prevention structure, which could be constructed at the SWM. Results for this additional modelling are also provided in Section 3.

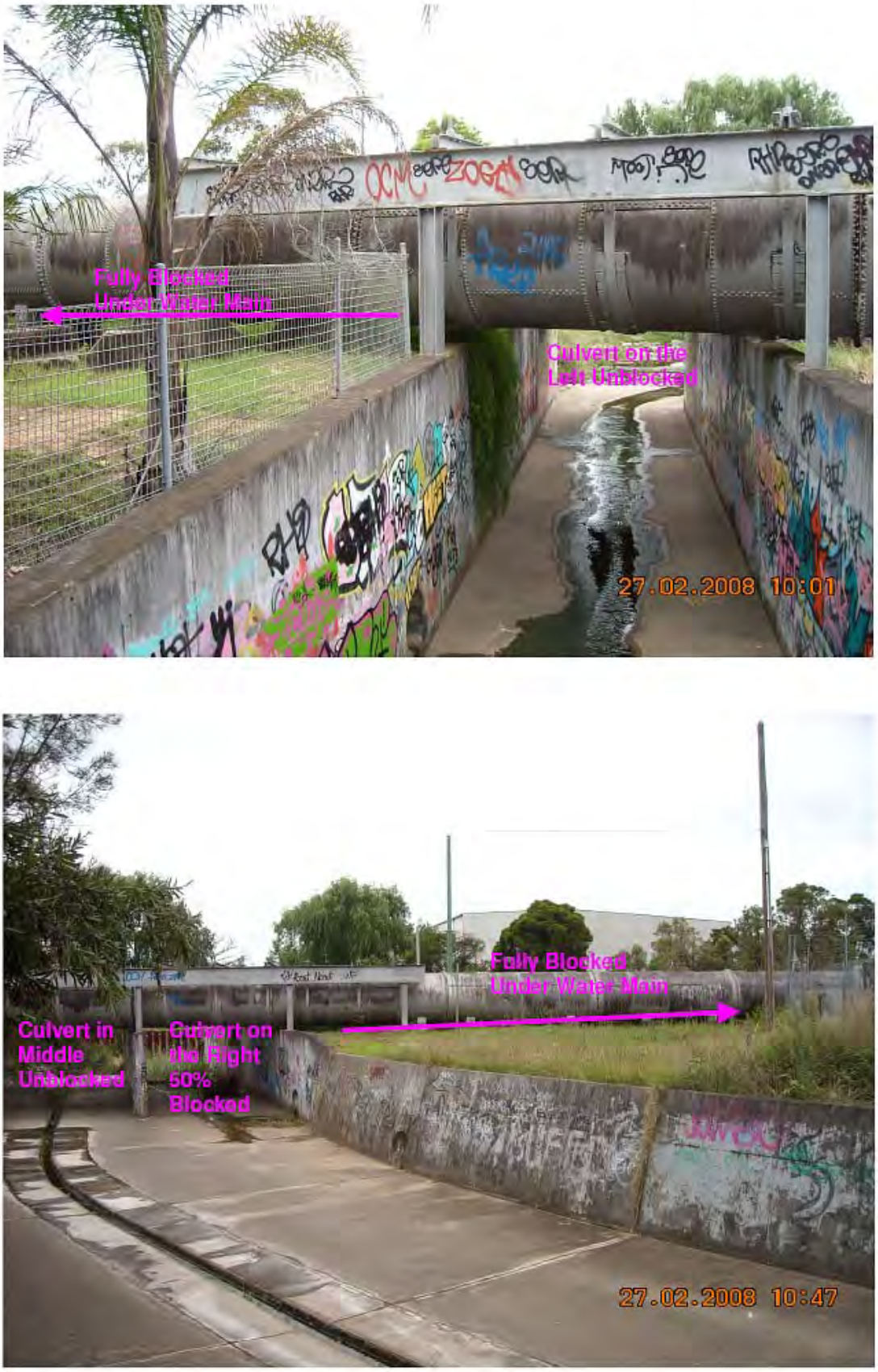



**Image 2: Duck River at Sydney Water Main (Looking Downstream) Blockage Scenario**

***Sefton Golf Course Detention Levee (Option 2)***

Image 3 shows the location of the proposed detention basin wall (illustrated as a bright green line) on the Sefton Golf Course. The proposed wall runs directly behind the row of houses on Rose Street, which back onto the course. For this assessment, the basin wall height has been set so that no overtopping of the basin wall will occur in the 100 year ARI event. A 5m x 2m inlet structure and 1200mm outlet pipe have been used to drain the detention area into the current trunk drainage network.


**Image 3: Sefton Golf Course Detention Levee (Option 2)**

***Band Hall Reserve Channel Works (Option 3)***

Option 3 involved the widening of the existing channel running along the western, eastern and northern side of the Band Hall Reserve. Image 4 illustrates the locality of the existing channel in the aerial photograph and the proposed widening of the channel along Band Hall Reserve, highlighted with the yellow polygons. Channel widths were increased from approximately 4.0m to approximately 9.0m at the top of the channel; a channel widening of approximately 5m. The base of the channel remained the same.

The increase in Manning's 'n' roughness within the northern, eastern and western channel was increased from 0.016 to 0.04 to reflect the proposed revegetation. Image 4 shows the labels of the modelled roughness values; the labels in black present the existing case, the green labels present the option 3 mitigation case.

This option has been identified by Council for the purposes of improving water quality and has been assessed to determine the impact of the channel widening and revegetation on flood risk.


**Image 4: Band Hall Reserve Channel Widening (Option 3)**

## 3 Results

For each option modelled, the flood levels from the existing scenario were compared to flood levels of the option modelled. Floor level inundation information provided by Council was also analysed (DR_W_Cadastre_region.TAB).

***Widening of the Sydney Water Main Culverts (Option 1)***

The model results are presented in Table 1 and indicate the following:

- The maximum decrease in peak flood levels upstream of the SWM is approximately 0.35m.
- Decreases in flood levels of 0.2m to 0.3m extend approximately 150m to 200m upstream of the SWM.
- The 100 year ARI flood extent in the vicinity of the SWM has been reduced by between 10m and 20m.
- The flood level difference immediately downstream of the SWM is below 0.05m.
- The peak flood levels are increased to slightly above 0.05m (but to less than 0.1m) from about 500m downstream of the SWM and extend to the Mona Street Bridge.
- Model results have shown that the largest increase in flood levels (of about 0.09m) is in the vicinity of the Wellington Road Bridge.

Table 1 shows the peak flood level impact (difference in peak flood levels) of Option 1 at key locations. The decreases in peak flood levels upstream of the SWM and increases in peak flow levels downstream of the SWM are illustrated in Figures 1, 2 and 3 respectively.

**Table 1: Selected Results from the WMA Model**

| Location | Change in Peak Flood Level (m) |
|---|---|
| Upstream of Sydney Water Main | -0.05 to -0.35 |
| Downstream of Sydney Water Main | 0.04 |
| Wellington Road | 0.09 |
| Upstream of Mona Street Bridge | 0.06 |
| Downstream of Mona Street Bridge | <0.02 |

It is noted that the increases in flood levels between Wellington Road and Mona Street Bridge are likely to have negligible affect on residents, as this part of the creek is located within park and open space reserves.

The Wellington Road Bridge was modelled with a road level of 9.45m. The WMA model results (WMA, 2010) indicate that upstream of Wellington Road the 100 year ARI event flood level is 9.6 mAHD. Therefore under existing conditions Wellington Road is already inundated in the 100 year ARI event. Under this option, it is estimated that the flood depth at Wellington Road would increase by approximately 0.1m in the 100 year ARI event.

The Mona Street Bridge was modelled with a road level of 6.9mAHD. Under both existing conditions and Option 1, modelling indicates this road will remain flood free in the 100 year ARI event.

Upstream of the SWM, it is estimated that under current conditions:

- Between 40 and 50 properties are affected by flooding in a 100 Year ARI event;
- Four of these properties are potentially inundated above floor level in a 20 year ARI event;
- Approximately 10 of these properties are potentially inundated above floor level in a 50 year ARI event; and
- Approximately 20 of these properties are potentially inundated above floor level in a 100 year ARI event.

It is expected that these properties would benefit under this option, with reduced levels of 0.1 to 0.3m, for the 100 Year ARI event. A cost-benefit analysis for this mitigation option, using flood damages estimates and constructions cost may be useful for further appraisal of this option.

As outlined in the methodology (Section 2), the separate BMT WBM and WMA models form the main part of the assessment, and the combined model was utilised to verify results of the assessment. The model results from the combined model also show downstream impacts of up to approximately 0.09m (same result as for the separate models), verifying the assessment based on the two separate models. This indicates that although the fixed water level boundary at the downstream of the Duck River model does influence flood levels in the area, similar downstream impacts are predicted under different boundary assumptions.

***Blockage Scenarios at Sydney Water Main Culverts***

The simulation of the blocked scenario with 0% blockage at right culvert of SWM resulted in a reduction of flood levels of 0.1m to 0.2m, upstream of the SMW.

The modelled peak flood levels and flows for the 100 year ARI event at the Sydney Water Main for the four blockage scenarios and for the Option 1 scenarios are summarised in Table 2 and the flow hydrographs are provided in Image 5.

**Table 2: Peak Flood Levels and Flows at Sydney Water Main**

| Blockage Scenario | Details of Blockage Scenario | 100 Year ARI Peak Flood Levels Upstream of SWM | 100 Year ARI Peak Flow Downstream of SWM |
|---|---|---|---|
| Blocked | BCC's blockage policy applied to all inlets and structures | 19.75 mAHD | 121 m3/s |
| Unblocked | No blockage applied apart from at SWM | 19.85 mAHD | 128 m3/s |
| Fully unblocked | Unblocked scenario + no blockage applied at SWM | 19.70 mAHD | 129 m3/s |
| Blocked with 0% blockage at right culvert of SWM | BCC's blockage policy applied to all inlets and structures + blockage of right culvert underneath the SWM changed from 50% to 0% | 19.75 mAHD | 122 m3/s |
| Blocked and widening of culverts at SWM (Option 1) | BCC's blockage policy applied to all inlets and structures (including the SWM) | 19.75 mAHD | 121 m3/s |
| Unblocked and widening of culverts at SWM (Option 1) | No blockage applied apart from at SWM | 19.85 mAHD | 126 m3/s |

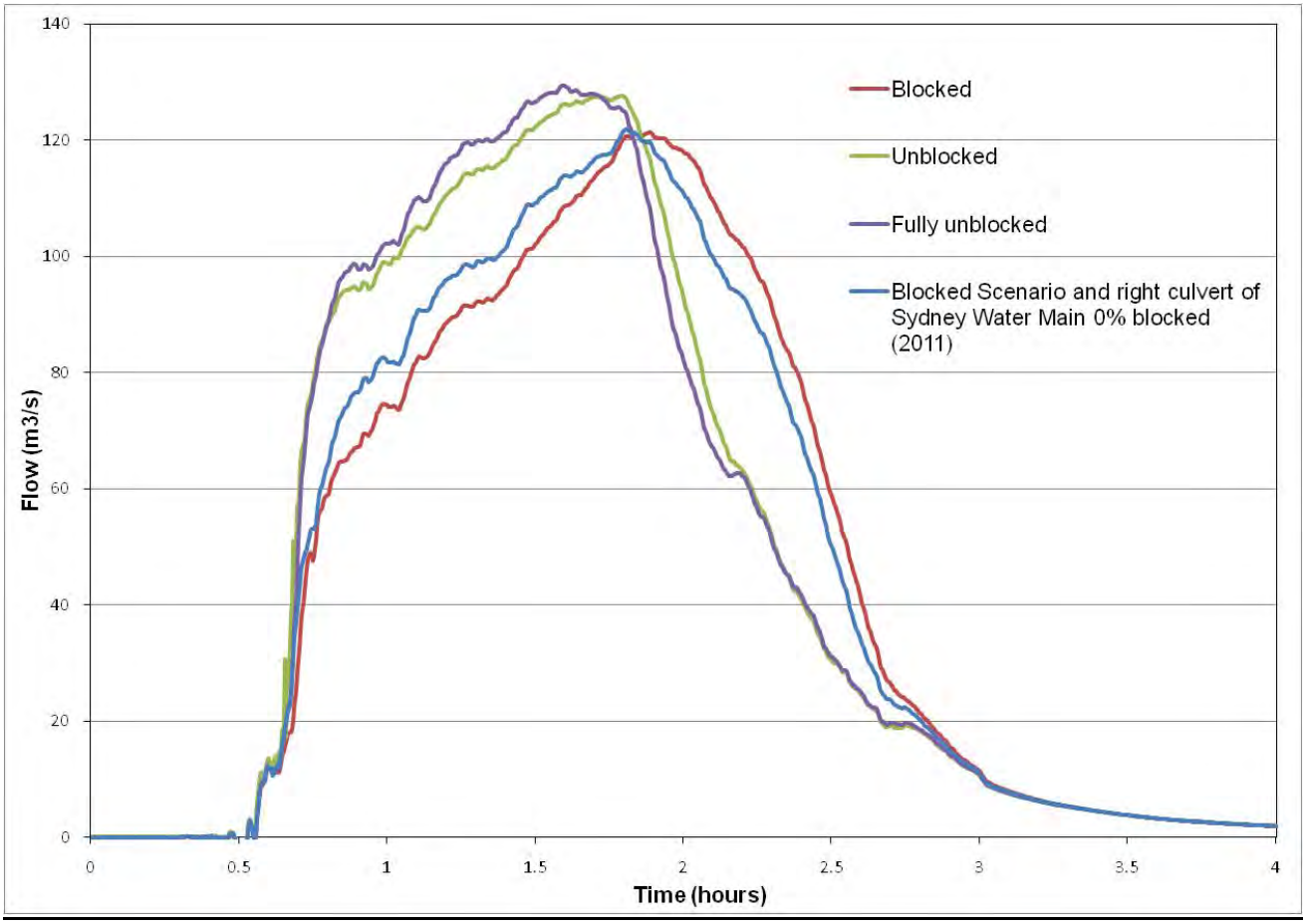



**Image 5: Flow Hydrographs Downstream of the SWM for Four Blockage Scenarios**

***Sefton Golf Course Detention Levee (Option 2)***

Under Option 2, the Sefton Golf Course detention basin, modelling indicates peak flood levels are reduced by between 0.05m and 0.20m between the retention basin and Maluga Passive Park, and by about 0.06m from Maluga Passive Park to Gascoigne Street. Downstream of these areas, flood levels are within 0.05m of those previously modelled. The flood level impact for Option 2 is presented in Figure 4 and Figure 5.

The reduction in peak flood level between the levee and Maluga Passive Park would benefit approximately 18 to 20 properties along Rose Street, Woods Road and Karraba Street. All of these properties currently experience flooding in the 100 Year ARI event. In addition, some of these are potentially affected by flooding above the floor level under current conditions. One house is first potentially affected by above floor level flooding in a 20 Year ARI event; another house potentially affected in a 50 Year ARI event and three potentially affected in a Probable Maximum Flood (PMF).

Flood level increases of up to 1m would occur within the Sefton Park golf course only, and would not affect any residential or industrial properties.

To contain the 100 year flood event, the detention basin wall would need to be between 0.7m and 2m high. Image 6 shows the detention basin wall, with selected locations being labelled with the wall height (and illustrated by yellow triangles).

A wall height of 1m to 2m behind the properties along Rose Street may be unacceptable by the residents. A lower wall height may provide reduced flood levels for events smaller than the 100 Year ARI event. If Council would like to investigate this option further it is recommended to simulate additional smaller storm events (i.e. the 5 and 20 year ARI events).


**Image 6: Retention Basin Wall Heights Required To Contain The 100 Year ARI Flood**

***Band Hall Reserve Channel Works (Option 3)***

Under Option 3, widening and revegetating the channels at Band Hall Reserve, modelling indicates increases of up to 0.4m in peak flood levels within the channel only. Residential and industrial properties in the vicinity will not be affected by increases in peak flood levels.

Decreases in flood levels ranging between 0.05m to 0.1m occur upstream of Ferrier Road. The modelling shows that two properties to the north of Ferrier Road, will benefit from peak flood level reductions of up to 0.2m. Currently, these two properties are affected by flooding above floor level in the PMF event. The flood level impact for Option 3 is presented in Figure 6 and Figure 7.

## 4 Conclusions

Hydraulic impact assessments of three options for providing flood mitigation or improving water quality have been investigated in the Duck River catchment:

1 Widening of the culverts and channel underneath the SWM;

2 Construction of a detention basin at Sefton Golf Course (utilised as a detention basin); and

3 Widening and revegetating the existing concrete lined channels around Band Hall Reserve to improve water quality.

Option 1 resulted in flood level reduction for a number of flood prone residential properties upstream of the SWM by up to 0.3m, but also resulted in flood level increases (with maximums of 0.1m) between Wellington Road and Mona Street. It is likely that residential properties in this area will not be affected by the increase in flood levels.

Option 2 resulted in beneficial outcomes with no exacerbation of existing flooding and with flood level reductions for a number of flood prone residential properties between the levee and Maluga Passive Park (west of Gascoigne Street).

A cost-benefit analysis of mitigation options 1 and 2, using flood damages estimates and construction costs may be useful for further appraisal of these options.

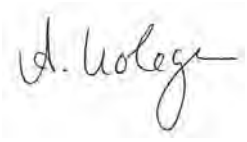
Options 3 resulted in no exacerbation of existing flooding, with the channel widening and revegetation expected to benefit water quality in the Duck River catchment.

The modelling of the different blockage scenarios applied in the Duck River model (BMT WBM, 2010) at the culverts underneath the SWM show that the resulting flood levels upstream of the SWM vary by up to 0.15m between the different blockage scenarios.

Please do not hesitate to contact either Anne Kolega or Sharon Wallace on (07) 3831 6744, should you have any questions.

Yours faithfully

**BMT WBM Pty Ltd**



**Anne Kolega**

Senior Flood Engineer

Enclosed:

- Figure 1: Peak Flood Level Impact, 100 Year ARI Event Widening of the Sydney Water Main Culvert in Bankstown.
- Figure 2 (Inset): Peak Flood Level Impact, 100 Year ARI Event Widening of the Sydney Water Main Culvert in Bankstown.
- Figure 3: Peak Flood Level Impact, 100 Year ARI Event Widening of the Sydney Water Main, Downstream of SWM
- Figure 4: Peak Flood Level Impact, 100 Year ARI Event Sefton Golf Course Detention Basin
- Figure 5 (Inset): Peak Flood Level Impact, 100 Year ARI Event Sefton Golf Course Detention Basin
- Figure 6: Peak Flood Level Impact, 100 Year ARI Event Band Hall Reserve Channel Widening and Revegetation
- Figure 7 (Inset): Peak Flood Level Impact, 100 Year ARI Event Band Hall Reserve Channel Widening and Revegetation


Title:

# Peak Flood Level Impact, 100 Year ARI Event
# Widening of Sydney Water Main Culvert in Bankstown

Figure: 1

Rev: A



N

0 400 800m

Approx. Scale

BMT WBM
www.bmtwbm.com.au

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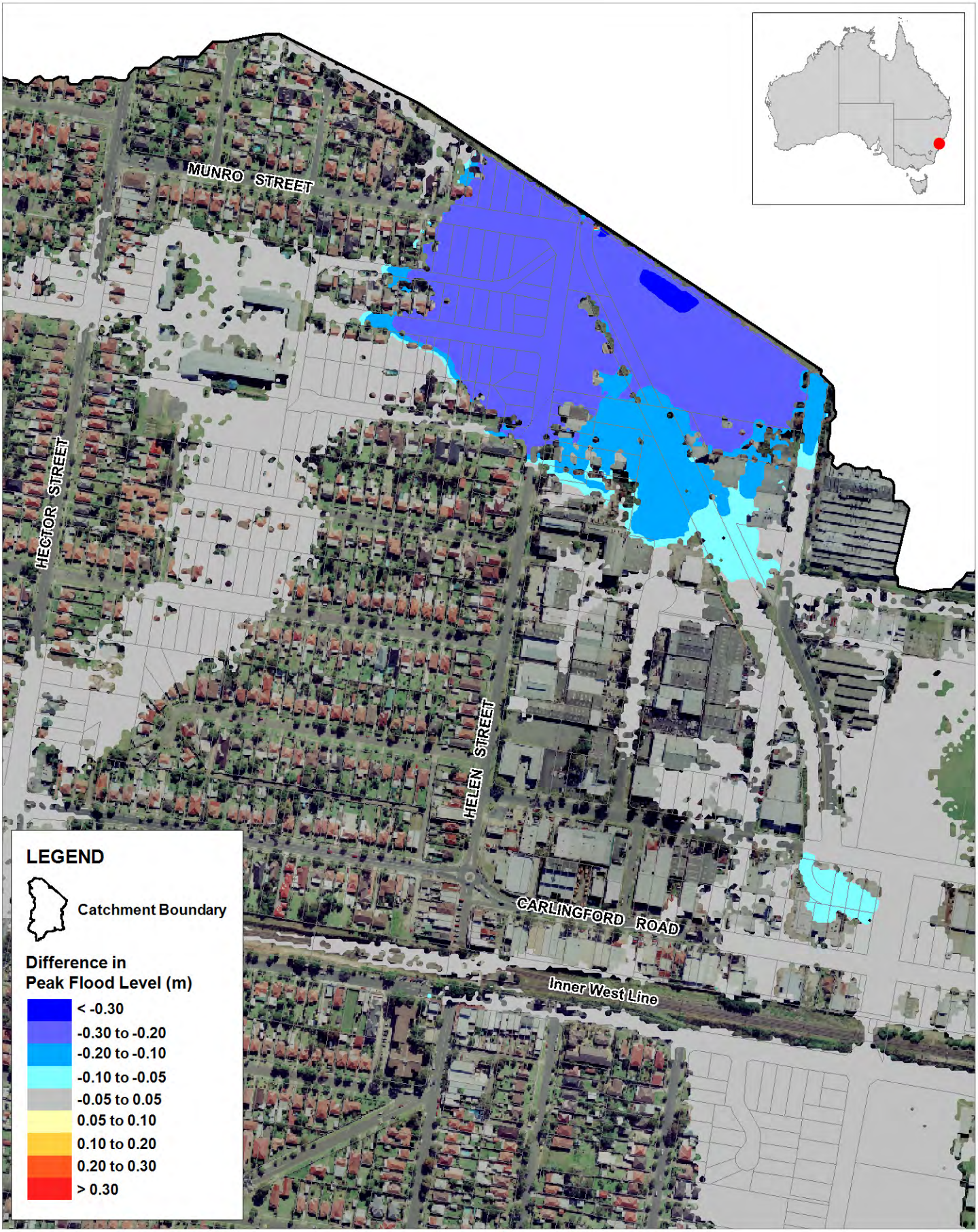



Title:

# Peak Flood Level Impact, 100 Year ARI Event
# Widening of Sydney Water Main Culvert in Bankstown

Figure: 2

Rev: A



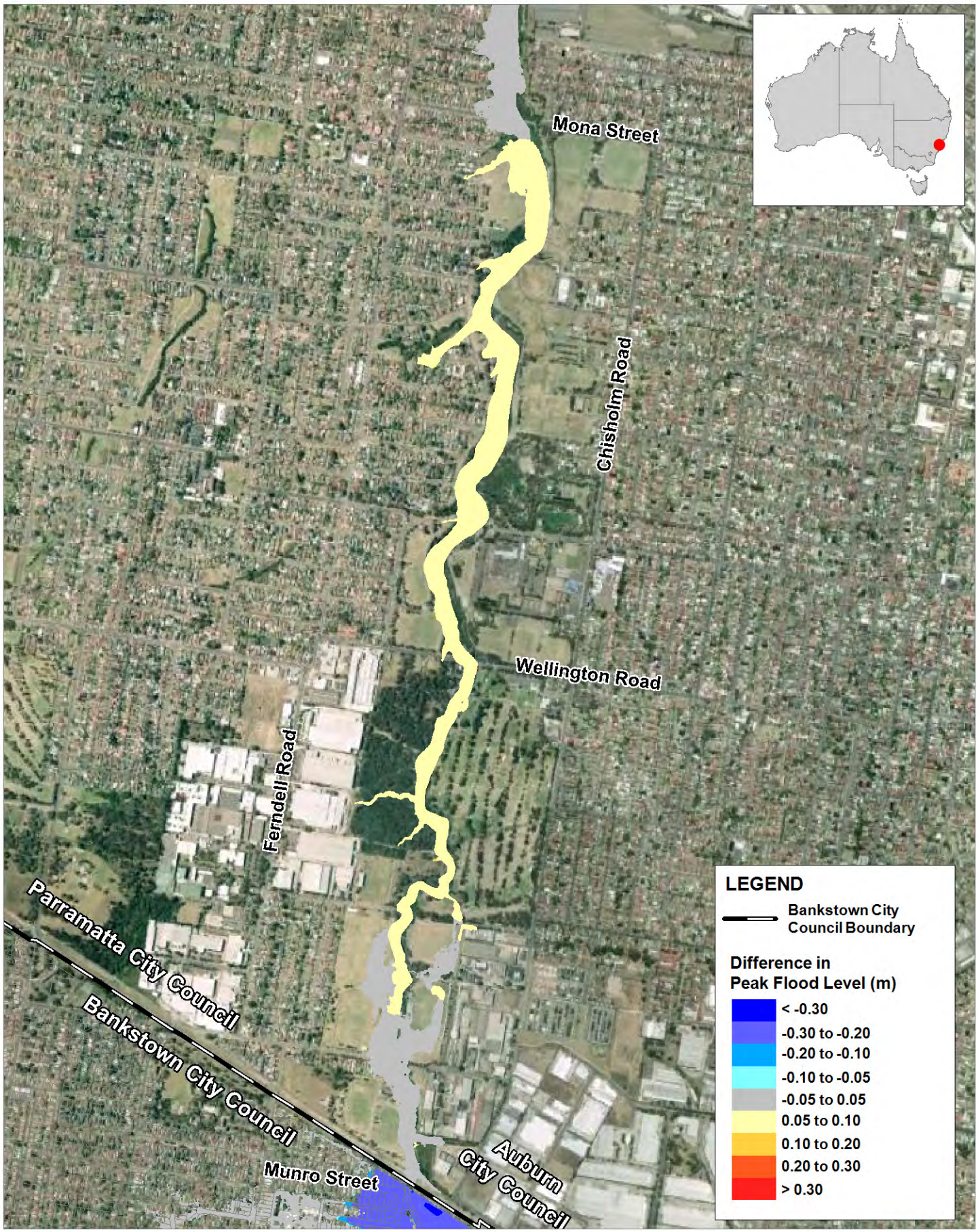
N

0 100 200m

Approx. Scale

BMT WBM
www.bmtwbm.com.au

Filepath : I:\B14677.i.gjr\DRG\additional mapping b18608\FLD_005_20102011_DR_Q100_Impact_SWP_Inset.wor




Title:

# Peak Flood Level Impact, 100 Year ARI Event
# Widening of Sydney Water Main, Downstream of SWM

Figure: 3

Rev: B



N

0 300 600m

Approx. Scale

BMT WBM
www.bmtwbm.com.au

Filepath : I:\B14677.i.gjr\DRG\additional mapping b18608\FLD_004_27102011_DR_Q100_Impact_SWP.wor


Title:

# Peak Flood Level Impact, 100 Year ARI Event
# Sefton Golf Course Detention Basin

Figure: 4

Rev: A



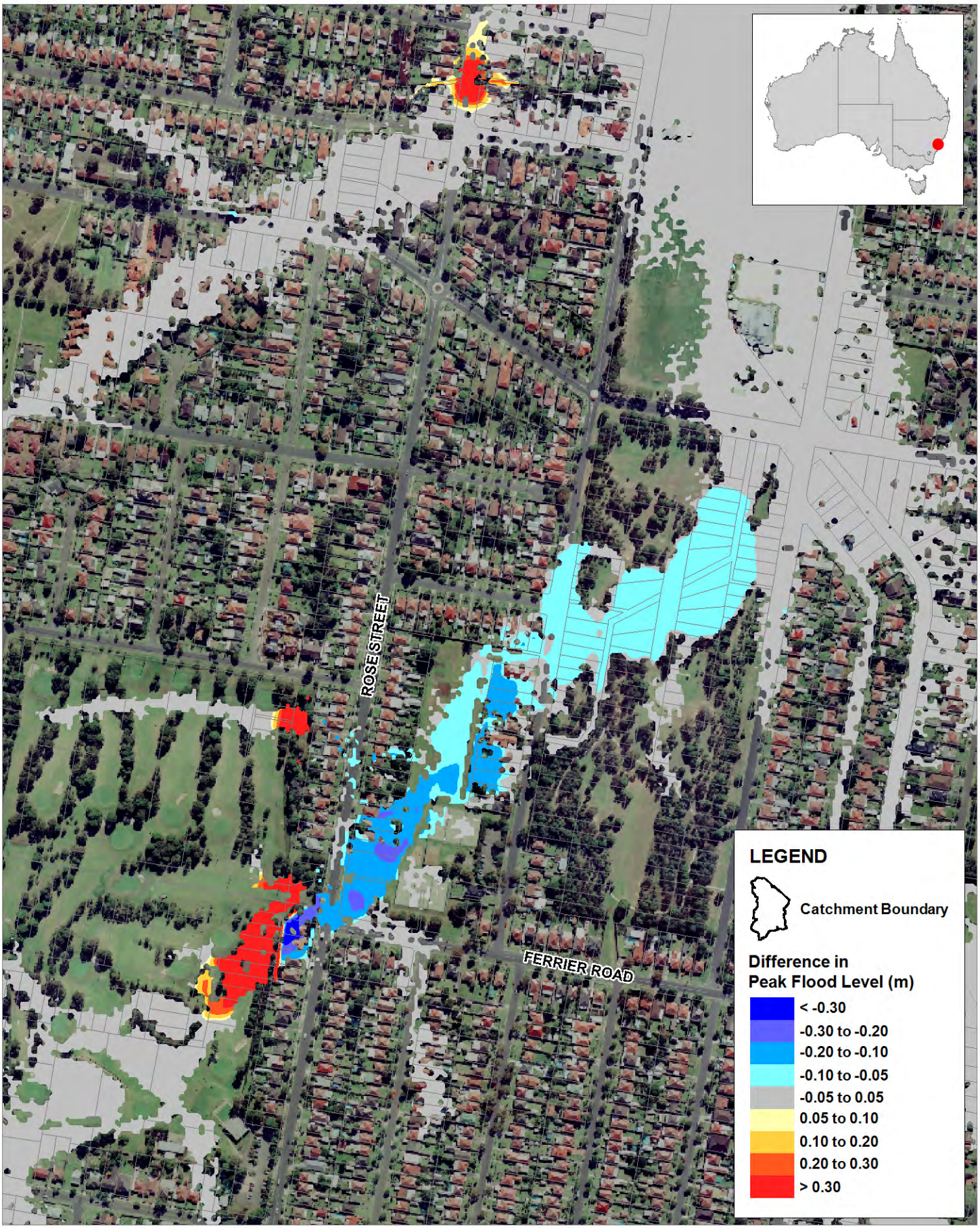
N

0 400 800m

Approx. Scale

BMT WBM
www.bmtwbm.com.au

Filepath : I:\B14677.i.gjr\DRG\additional mapping b18608\FLD_002_11102011_DR_Q100_Impact_Sefton.wor




Title:

# Peak Flood Level Impact, 100 Year ARI Event
# Sefton Golf Course Detention Basin

Figure: 5

Rev: A



N

0 100 200m

Approx. Scale

BMT WBM
www.bmtwbm.com.au

Filepath : I:\B14677.i.gjr\DRG\additional mapping b18608\FLD_006_11102011_DR_Q100_Impact_Sefton_inset.wor


Title:

# Peak Flood Level Impact, 100 Year ARI Event
# Band Hall Reserve Channel Widening and Revegetation

Figure: 6

Rev: A



N

0 400 800m

Approx. Scale

BMT WBM
www.bmtwbm.com.au

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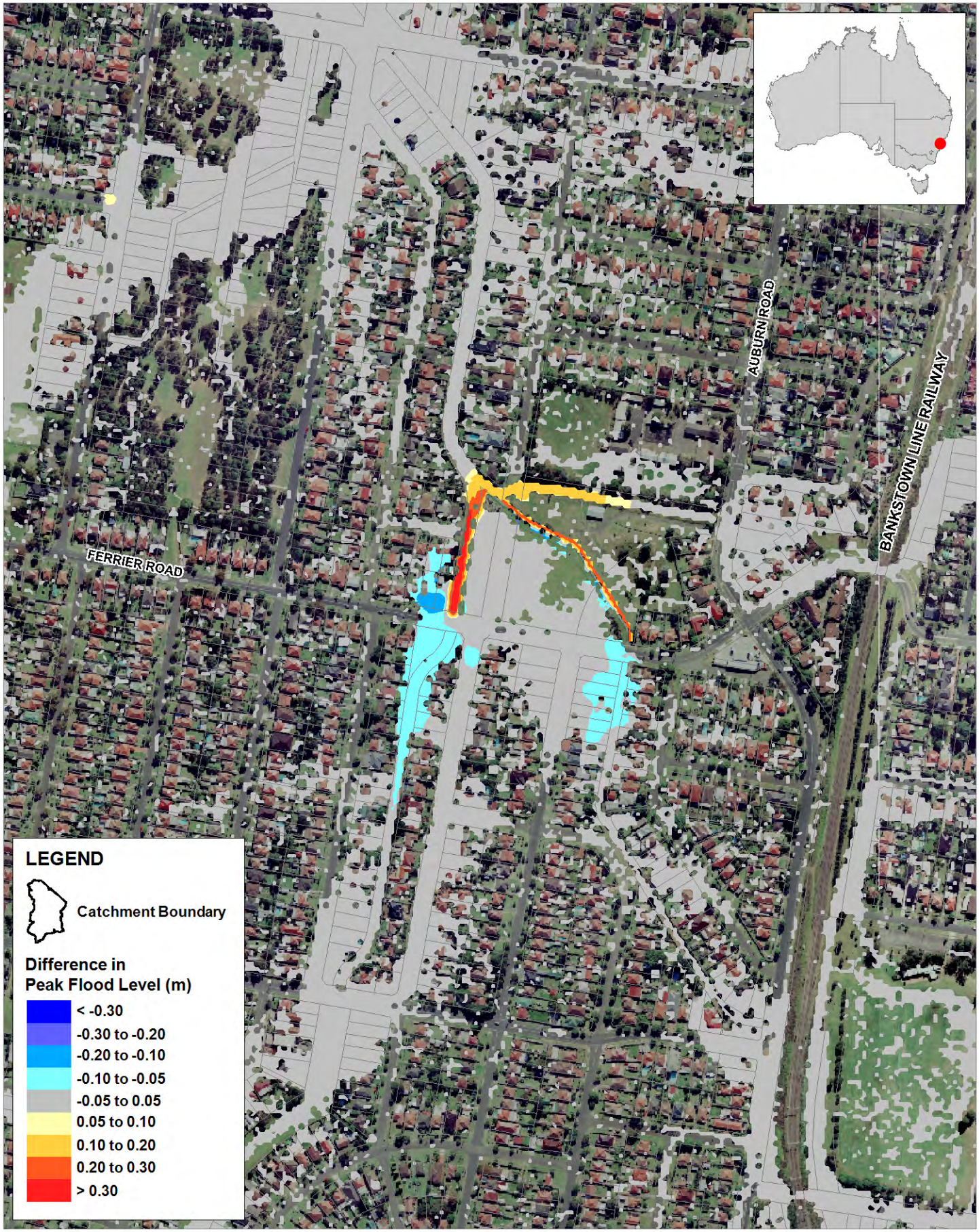


Title:

# Peak Flood Level Impact, 100 Year ARI Event
# Band Hall Reserve Channel Widening and Revegetation

Figure: 7

Rev: A



N

0 100 200m

Approx. Scale

BMT WBM
www.bmtwbm.com.au

Filepath : I:\B14677.i.gjr\DRG\additional mapping b18608\FLD_003_11102011_DR_Q100_Impact_Channel.wor

# APPENDIX C - A FRAMEWORK FOR HOLISTIC RISK BASED FLOODPLAIN PLANNING

# A FRAMEWORK FOR HOLISTIC RISK BASED FLOODPLAIN PLANNING

S Molino[1], S Roso[2]
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[2]Moreton Bay Regional Council, QLD

## Abstract

While a merits based approach has been the cornerstone of floodplain management in NSW for the past 25 years, it can be argued that only some flood risks are fully considered in NSW floodplain management plans. Similarly, some councils in Queensland have introduced planning controls which consider risks to critical infrastructure and evacuation failure differently to residential building flooding but the practice is not widespread and the risks considered are narrow.

This paper draws on some recent work undertaken by the authors as part of the development of a larger floodplain management framework for Moreton Bay Regional Council in Queensland to present an approach to flood risk evaluation and mitigation which could have universal application.

The methodology first recognises that there are a multitude of flood risks which need to be managed. These include risks that have been considered for decades such as over floor flooding and risk to life, but also others which have been less explicitly dealt with such as isolation, roads being cut, infrastructure shutdown and building failure.

It then considers all of the factors which contribute to the consequences of flooding for the specific risk which is being assessed across the full range of floods. This will include hydraulic hazard, rate of rise, duration, vulnerability, criticality and population size.

A set of risk matrices are then developed and thresholds of acceptable, tolerable and unacceptable risk suggested. Using these matrices, a suite of potential risk mitigation options are then presented which are more objective based than prescriptive. This allows floodplain managers to design the means of managing the flood risks in whatever way is practical, affordable and acceptable providing that the risk reduction objectives have been met for all types of risks across the full range of floods.

This work is currently in its early stages and the purpose of presenting this paper is to receive industry feedback on the methodology as well as opinions on appropriate thresholds of risk tolerance.

## Background

It is common to define risk as being a function of both probability and consequence. When it comes to floodplain management, risk assessments often reduce the probability to that of a particular flood event occurring and the consequence to a particularly clearly defined threshold being exceeded. For example the probability of above floor flooding occurring. This allows simple lines to be drawn on maps for town planning purposes but overlooks what needs to be considered when fully evaluating risk (Molino, 2010). Furthermore, while there has been a widely accepted threshold of a 1 in 100 probability for above floor flooding there is no industry norm for the acceptability of other flood risks.

As part of Moreton Bay Regional Council's development of comprehensive, consistent floodplain management across its local government area, GHD and Molino Stewart were

engaged to develop a framework for floodplain risk management. The following outlines the approach being taken.

## A Flood Risk Assessment Approach

The basic approach was to develop a set of risk tables which show what combinations of hazard and probability are acceptable, tolerable and unacceptable. This is consistent with the approach set out in the National Emergency Risk Assessment Guidelines (EMA, 2010).

The following is a generalised table in which "acceptable risk", "tolerable risk" and "unacceptable risk", have the following definitions:

- Acceptable risk – individuals and society can live with this risk without feeling the necessity to reduce the risks any further. This is coloured green in the table
- Tolerable risk - –society can live with this risk but believe that as much as is reasonably practical should be done to reduce the risks further. Note that individuals may find this risk unacceptable and choose to take their own steps, within reason, to make this risk tolerable. This is coloured yellow.
- Unacceptable risk – individuals and society will not accept this risk and measures must be put in place to bring them down to at least a tolerable level. This is coloured red.

| | Low Hazard | Medium Hazard | High Hazard |
|---|---|---|---|
| *Low Probability* | | | |
| *Medium Probability* | | | |
| *High Probability* | | | |

*Figure 1 – Risk Matrix*

This generalised table was expanded both horizontally and vertically for each type of risk which was considered. Vertically, various probability thresholds were inserted while horizontally a range of hazard categories were created which reflected the particular risk in question.

The following risk categories were considered:

- Risk of isolation
- Risk to road access
- Risk to life in residential buildings
- Risk to life in non-residential buildings
- Risk to residential property
- Risk to non-residential property
- Risk to critical infrastructure

## Determination of Flood Hazard Categories

The starting point for flood risk assessments is determining the flood hazard. The flood hazard relates to how dangerous a site on a floodplain can be (HNFMSC, 2006). It depends on the behaviour of the flood at that location and changes with the probability of the event, generally the rarer the flood the greater the hazard.

Many aspects of hazard relate to the behaviour of the floodwaters themselves but other influences of hazard relate to the topography, development and the people.

The following factors can all have an influence on the true flood hazard categories:

- Depth and Velocity of Floodwaters
- Rate of Rise and Duration of Flooding
- Topography
- Effective Flood Access
- Evacuation Problems
- Effective Warning Time / Rate of Rise of Floodwaters
- Flood Preparedness
- Obstruction and Blockages
- Type of Development
- Vulnerability
- Critical and Cumulative Consequences
- Water Entering Buildings

Most of these are being considered in the MBRC project but the point at which they are considered in the risk assessment process varies. The following sections explain the logic and process which is being applied.

## Hydraulic Hazard

Hydraulic hazard is a major contributor to flood hazard and is independent of what is placed in the floodplain yet it is only meaningful when compared to how depth and velocity would impact on what is placed in the floodplain.

It is recognised that there are thresholds of hydraulic hazard which have different consequences for different things placed in the floodplain. An accepted practice has been to develop hazard category tables or graphs, and though there are variants on where the thresholds are drawn, they all work on the idea that a certain combination of depth and velocity will have certain consequences for different things exposed to that flood hazard.

Floodplain Management in Australia (CSIRO, 2000) and the NSW Floodplain Development Manual (NSW Government, 2005) each have their own hydraulic threshold behaviour diagrams which have three hazard categories. Figure 2, which has five hydraulic hazard categories, was used for this project as its thresholds are related to different types of hazards which one might be interested in although it can be argued where the actual lines between hazard categories are drawn (Shand et al, 2010).

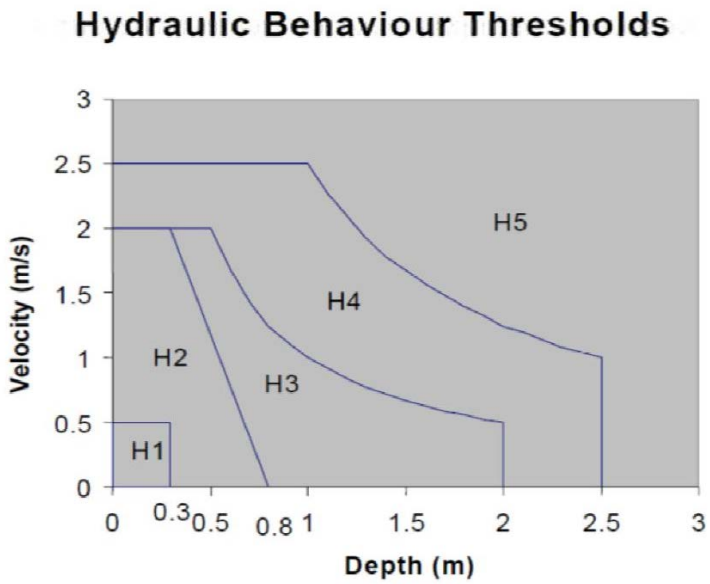


*Figure 2 - Hydraulic Behaviour Thresholds for Newcastle LGA (BMT WBM, 2008)*

The hydraulic hazard thresholds in this diagram are very similar to the hazard categories which are embedded in WaterRIDE which is the program being used by MBRC.

Using WaterRIDE it would be very straightforward to map for a design event of a given probability the extent of the various hydraulic hazard areas which can then be used to help with decision making.

The hydraulic hazard categories in the diagram are summarised in the Table 1.

The following set of tables has been developed for each type of flood risk which needs to be considered for any type of flooding in MBRC. The hazard is defined using both the hydraulic hazard category and, where relevant for that particular type of risk, the other hazards which contribute to the overall hazard rating.

A more comprehensive analysis than the hydraulic hazard categorisation alone is also needed to establish the risks which need to be managed and this can only be made from within the strategic framework of a floodplain management plan. The determination of the risks requires the detailed results of a flood study and the hydraulic hazard categorisation along with an assessment of all the hazard factors.

*Table 1 - Revised Hydraulic Hazard Categories*

| ***Low Risk to Life and property*** | | **High Risk to Life and property** | | |
|---|---|---|---|---|
| ***H1*** | **H2** | **H3** | **H4** | **H5** |
| *No significant life risk*<br>*Property risk only to items which come in direct contact with floodwaters such as building contents* | Low life risk. Able bodied adults can walk safely.<br>Cars can float and precautions must be followed to keep them out of floodwaters | Able bodied adults cannot safely walk<br>Only large vehicles (trucks) can safely travel. | Major life risk<br>Light frame buildings (e.g. houses) can fail structurally | Extreme life risk<br>Majority of buildings could fail |

## Duration of Flooding

The duration of flooding or length of time a community, town or single dwelling (for example, a farmhouse) is cut off by floodwaters can have a significant impact on the costs and disruption associated with flooding. For example:

- An extended period of isolation in stressful situations can exacerbate post-event anxiety and trauma-related disorders;
- Shortages of water and food may occur thereby placing high demands on limited emergency services; and
- Medical emergencies may occur with treatment delayed or at worst prevented.

Flood duration is not relevant to all risks but is taken into when determining the hazards for some risk assessments.

## Vulnerability

Another consideration in assessing consequences is vulnerability. This is taken into account to some extent in the hazards diagram which recognises that there are thresholds above which all people are vulnerable to flooding or all timber framed buildings are vulnerable to flooding. But all people and all timber framed buildings are not the same.

Children, the elderly or people with a disability will be more vulnerable than an able bodied adult which is what the hazard diagram is based upon. Isolation through flooding will be more of an issue for those with medical conditions which may require emergency access than those in good health. Likewise, a light framed building which has plywood as frame bracing (as occurs in many modern brick veneer homes) will be more vulnerable to structural failure than one with a water resistant bracing system (HNFMSC, 2006, EAA, 2011). Furthermore, some building contents are less vulnerable to flood damage than others and the depth of flooding within a building may also have an impact on whether the contents will be damaged.

## Critical and Cumulative Consequences

The consequences will also differ depending on the use to which an asset is put. For example, the consequences for a community will be different if the hospital is closed due to flood damage than if a commercial operation is closed, at least in the short term. Furthermore the closure of a regional hospital will be of greater consequence than the closure of a local hospital and the closure of a large business employing many locals will be of greater consequence than the closure of a small shop.

Finally, the issue of cumulative consequences must also be taken into consideration. If one home is flooded during a major storm event, the consequences are different at a societal level than if 1,000 buildings are flooded even if the chance of them being flooded were the same. If the 1,000 flooded buildings are scattered along the Qld coast the consequences at the local level are likely to be tolerable because by and large local communities and facilities would continue to function and with some external resources would be able to help those affected recover. If however the flooded buildings were all at the one location resources would be more stretched, particularly if 1,000 buildings constituted the majority of a single town. The flooding of a business which employs 200 people could have similar consequences to the closure of 100 businesses which each employ two people.

## Determination of Probability Thresholds

Apart from the 1 in 100 event being widely used as a threshold for above floor flooding, there is little guidance available on what would be appropriate for other flood consequences. Wind loading codes generally require buildings to be structurally sound in events up to something equivalent to a 1 in 500 or 1 in 1,000 event depending on their use. Something similar could be applied with regard to flooding. A recent survey, however, suggests that the community finds these probabilities too frequent for these consequences (Molino, 2012).

## Creating Risk Tables

Taking into consideration the hazard and probability issues discussed in the preceding sections, the following risk tables were created. It needs to be stressed that these are draft tables and both the hazard categories and probability thresholds presented in them are presented as a starting point for discussion rather than recommendations for adoption.

***Risk of Isolation***

| ***Event range (1 in X)*** | **Maximum hazard category of surrounding floodwater** | | | | | | |
|---|---|---|---|---|---|---|---|
| | H1 | H2 | | H3-H5 | | | |
| | | <24 hrs | >24 hrs | <24 hrs | | >24 hrs | |
| | | | | Non vulnerable population | Vulnerable population | < 1,000people | > 1,000people |
| *1,000 - PMF* | | | | | | | |
| *100-1,000* | | | | | | | |
| *50 to <100* | | | | | | | |
| *>10 to <50* | | | | | | | |
| *10* | | | | | | | |

***Risk to Road Access****

| *Event Range (1 in X)* | Road Type >H1 flooding | | | | | | |
|---|---|---|---|---|---|---|---|
| | Collector Road | Distributor Road | Sub Arterial | Arterial | Highway | Motorway | Critical Evacuation Route |
| *1,000 - PMF* | | | | | | | |
| *100-1,000* | | | | | | | |
| *50 to <100* | | | | | | | |
| *>10 to <50* | | | | | | | |
| *10* | | | | | | | |

***Risk to Life - all residential buildings in the floodplain***

| *Event range (1 in X)* | Maximum hazard category of floodwater surrounding residential building | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | H1 | H2 | | H3 | | | H4 | | H5 |
| | | <24hrs | >24hrs | <2hrs | >2hrs but <24hrs | >24hrs | <24hrs | >24hrs | |
| *1,000 - PMF* | | | | | | | | | |
| *100-1,000* | | | | | | | | | |
| *50 to <100* | | | | | | | | | |
| *>10 to <50* | | | | | | | | | |
| *10* | | | | | | | | | |

***Risk to Life - all commercial buildings in the floodplain***

| *Event range (1 in X)* | Maximum hazard category of floodwater surrounding commercial building | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | H1 | H2 | | H3 | | | H4 | | H5 |
| | | <24hrs | >24hrs | <2hrs | >2hrs but <24hrs | >24hrs | <24hrs | >24hrs | |
| *1,000 - PMF* | | | | | | | | | |
| *100-1,000* | | | | | | | | | |
| *50 to <100* | | | | | | | | | |
| *>10 to <50* | | | | | | | | | |
| *10* | | | | | | | | | |

***Risk to Property - applies to all residential property***

| ***Event Range (1 in X)*** | **Above Floor Flooding** | **Ground floor ceiling depth flooding** | | **H4** | | **H5** |
|---|---|---|---|---|---|---|
| | | Two storey dwelling or second floor and above in unit block | Single storey dwelling or ground floor in unit block | Multistorey flood resistant unit block | All other dwellings | |
| *1,000 - PMF* | | | | | | |
| *100-1,000* | | | | | | |
| *50 to <100* | | | | | | |
| *>10 to <50* | | | | | | |
| *10* | | | | | | |

***Risk to Property - applies to all commercial and industrial property***

| *Event Range (1 in X)* | Vehicle parking and flood resistant materials/stock storage | Above floor flooding – ground floor | | H4 | H5 |
|---|---|---|---|---|---|
| | | multi storey building | Single storey building | | |
| *1,000 - PMF* | | | | | |
| *100-1,000* | | | | | |
| *50 to <100* | | | | | |
| *>10 to <50* | | | | | |
| *10* | | | | | |

***Risk to Critical Infrastructure***

| Infrastructure Type | Within infrastructure categorisation | | | | | | |
|---|---|---|---|---|---|---|---|
| *Water Supply* | Local water supply network | Trunk mains | Reservoirs/Towers | Water Treatment Plant processing infrastructure | Water Treatment Plant throughput pumps and pipes and mains leading out of WTP | | Source (e.g. Dam) and main trunk |
| *Electricity* | 11 kV distribution system | 33 kV power cables | 33/11 kV substation | 110 kV power cables | 110/33 kV substation | | 275/110 kV substation & 275kV and higher voltage power cables |
| *Telecommunications* | Cables connecting mini exchanges | Mini exchanges | Other mobile phone towers cables connecting terminal exchanges and mobile phone towers to switching centres and each other | Terminal Exchanges And critical mobile phone (cellular) transmission towers | intercity cables and cables between switching centres | | Radio transmission infrastructure used by emergency services. Telephone switching centres |
| *Emergency Services* | | | | Minor Evacuation Centre | Station (Police/Fire brigade/Ambulance/SES) | | Major Evacuation Centre or Control Centre (Police/Fire brigade/Ambulance/SES) |
| *Sewage and waste* | | | Gravity Pipes | Sewage pumps and waste tips or landfill | Sewage Water Treatment Plant | | |
| *Health services* | | | Medical Centres | Private Hospitals and aged care facilities | Local Public Hospitals | | Regional Public Hospitals |
| Duration / Event Range | | | | | <24hrs | >24hrs | |
| 1,000 - PMF | | | | | | | |
| 100-1,000 | | | | | | | |
| 50 to <100 | | | | | | | |
| >10 to <50 | | | | | | | |
| 10 | | | | | | | |

## Risk Management Measures

The preceding tables are intended to provide broad guidance on the acceptability or otherwise of various flood risks. Those risks which are identified as unacceptable must be managed and it is also desirable to manage those which are tolerable. Risk management actions should have the objective of making otherwise unacceptable risks at least tolerable and tolerable risks more tolerable, if not acceptable.

It is also possible that implementation of a single measure alone will not reduce the risks sufficiently and an additional measure will be required to deal with the residual risk. The treatment of residual risk needs to be considered until the residual risk is acceptable or tolerable, a worthwhile treatment is not available or the treatment is not affordable.

Any risk management process also needs to be able to deal with existing risk as well as future risk, particularly future risk created by future development.

The process proposed for MBRC is that the preceding risk tables be populated with risk management measures which are appropriate to the level of unmitigated risks. These tables can then serve two purposes.

1. Existing risks can be assessed to determine whether additional risk management measures are required
2. Future risks can be managed through planning controls or approval conditions to ensure that the required risk management measures are implemented.

Once again the following tables are provided as a starting point for discussion rather than recommended risk management measures. Nevertheless, they do reflect considerable experience with risk assessments for floodplains and developments in Queensland, NSW and Victoria and discussions Steven Molino has had with state and local government planners and engineers and emergency service personnel in those states.

It should be noted that most of the risk management measures are objective based rather than prescriptive. In other words they set out what needs to be achieved by the risk management measure rather than specifying what exactly needs to be done. This allows the methodology to have wide application and the adopted measures to be designed to suit local conditions.

It should also be noted that in some cases only one means of mitigation is considered appropriate and in other cases there is a choice of measures. For some of the more extreme risks it is necessary to have more than one measure because a single risk management measure alone would not be sufficient and there would be an unacceptable residual risk.

## The Next Steps

GHD is currently trialling the methodology for storm tide flooding in MBRC local government area. We are also seeking feedback from the floodplain management profession on the methodology as a whole as well as appropriate hazard categories, acceptability thresholds and mitigation measures.

***Risk of Isolation***

| Event range | Maximum hazard category of surrounding floodwater | | | | | | |
|---|---|---|---|---|---|---|---|
| | H1 | H2 | | H3-H5 | | | |
| | | <24 hrs | >24 hrs | <24 hrs | | >24 hrs | |
| | | | | Non vulnerable population | Vulnerable population | < 1,000people | > 1,000people |
| *1,000 - PMF* | | | | | 1,2,3 or 4 | 1,2,3 or 4 | 1,2,3 or 4 |
| *100-1,000* | | | | | 1,2,3 or 4 | 1,2,3 or 4 | 1,2,3 or 4 |
| *50 to <100* | | | 1,2 or 3 | 1,2 or 3 | 1,2 or 3 | 1,2 or 3 | 1 or 2 |
| *>10 to <50* | | | 1,2 or 3 | 1 or 2 | nil | 1 or 2 | 1 or 2 |
| *10* | | | 1,2 or 3 | 1 or 2 | nil | 1 | 1 |

Potential Risk Mitigation Options

1. Ability for entire population to be accommodated until road access is restored in buildings which are not flooded. Emergency power supply, food fresh drinking water supplies and road access to hospital grade medical facilities be available for full duration of the flood
2. Warning system, community education program and evacuation plan which can be demonstrated to evacuate all people to a location outside of the flood affected area before evacuation routes are cut by H2 flooding.
3. Ability to use large vehicles to access through H3 floodwaters for essential supplies and medical evacuations
4. Ability to use fixed wing or rotary aircraft for essential supplies and medical evacuations

***Risk to Road Access****

| *Event Range* | Road Type | | | | | | |
|---|---|---|---|---|---|---|---|
| | Collector Road | Distributor Road | Sub Arterial | Arterial | Highway | Motorway | Critical Evacuation Route |
| *1,000 - PMF* | | | | | | 4 or 5 | 2 or 3 |
| *100-1,000* | | | | | 4 or 5 | 4 or 5 | 2 or 3 |
| *50 to <100* | | | | 4 or 5 | 4 or 5 | 4 and 5 | 1 or 2 |
| *>10 to <50* | | | 4 or 5 | 4 or 5 | 4 and 5 | 1, 4 and 5 | 1 or 2 |
| *10* | | 4 or 5 | 4 or 5 | 4 and 5 | 1 | 1, 4 and 5 | 1 and 2 |

Potential Risk Mitigation Options

1. Route raising to ensure its probability of flooding is at least tolerable
2. Route capacity and warning time are sufficient for all to evacuate before road is cut
3. Route raising to ensure its probability of flooding is acceptable
4. Alternative route is available which is not flooded at this probability and is no more than two categories lower on the road hierarchy
5. Route is cut for no more than 24 hours

***Risk to Life - all residential buildings in the floodplain***

| Event range | Maximum hazard category of floodwater surrounding residential building | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | H1 | H2 | | H3 | | | H4 | | H5 |
| | | <24hrs | >24hrs | <2hrs | >2hrs but <24hrs | >24hrs | <24hrs | >24hrs | |
| *1,000 - PMF* | | | | | 1,2,3,5 or 6 | 1,2,3 or 4 | 1,2,3,5 or 6 | 1,2,3 or 4 | 1,2,3 or 4 |
| *100-1,000* | | | | | 1 and (2,3,5 or 6) | (1 and 3), 2 or 4 | 1 and (2,3,5 or 6) | (1 and 3), 2 or 4 | (1 and 3), 2 or 4 |
| *50 to <100* | | | 1,2,3 or 5 | | (1 and 5), (2 and 5), or 4 | (1 and 2), or 4 | 4 | 4 | 4 |
| *>10 to <50* | 1,2,3 or 5 | 1,2,3 or 5 | 1,2 or 3 | 1,2,3 or 5 | (1 and 5), (2 and 5) or 4 | (1 and 2) or 4 | 4 | 4 | 4 |
| *10* | 1,2,3 or 5 | 1,2,3 or 5 | 1,2 or 3 | 1,2,3 or 5 | (1 and 5), (2 and 5) or 4 | 4 | 4 | 4 | 4 |

Potential Risk Mitigation Options

1. Warning system, community education program and evacuation plan which can be demonstrated to evacuate all people to a location outside of the flood affected area before evacuation routes are cut by H2 flooding.
2. Able bodied occupants are able to walk to a flood free location ahead of rising floodwaters should they not evacuate until floodwaters enter the premises
3. The building is flood resistant, there is a flood free refuge within the building and there is sufficient clean water, food and emergency power supply for the duration of the flood and there is a practical means of medical evacuation
4. Voluntary purchase of building
5. The building is flood resistant and ground floor level is above peak flood level
6. The building is flood resistant and there is a flood free refuge within the building

***Risk to Life - all commercial buildings in the floodplain***

| *Event range* | Maximum hazard category of floodwater surrounding commercial building | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | H1 | H2 | | H3 | | | H4 | | H5 |
| | | <24hrs | >24hrs | <2hrs | >2hrs but <24hrs | >24hrs | <24hrs | >24hrs | |
| *1,000 - PMF* | | | | | 1 or 2 | 1, 2 or 3 | 1, 2 or 3 | 1, 2 or 3 | 1, 2 or 3 |
| *100-1,000* | | | | | 1 or 2 | 1, 2 or 3 | 1, 2 or 3 | (1 and 2) or 3 | (1 and 2) or 3 |
| *50 to <100* | | | | | 1, 2 or 3 | (1 and 2) or 3 | (1 and 2) or 3 | (1 and 2) or 3 | (1 and 2) or 3 |
| *>10 to <50* | | | | 1 and 2 | (1 and 2) or 3 | (1 and 2) or 3 | 3 | (1 and 2) or 3 | 3 |
| *10* | | | 1 or 2 | 1 and 2 | (1 and 2) or 3 | 3 | 3 | 3 | 3 |

Potential Risk Mitigation Options

1. Warning system, community education program and evacuation plan which can be demonstrated to evacuate all people to a location outside of the flood affected area before evacuation routes are cut by H2 flooding.
2. The building is flood resistant and there is a flood free refuge within the building
3. Voluntary purchase of building

***Risk to Property - applies to all residential property***

| *Event Range* | Above Floor Flooding | Ground floor ceiling depth flooding | | H4 | | H5 |
|---|---|---|---|---|---|---|
| | | Two storey dwelling or second floor and above in unit block | Single storey dwelling or ground floor in unit block | Multistorey flood resistant unit block | All other dwellings | |
| *1,000 - PMF* | | | | 3 | 2 or 3 | 3 |
| *100-1,000* | | | 1 or 3 | 3 | 2 or 3 | 3 |
| *50 to <100* | 1 | | 1 or 3 | 3 | 2 or 3 | 3 |
| *>10 to <50* | 1 | 3 | 1 or 3 | 3 | 3 | 3 |
| *10* | 1 or 3 | 3 | 3 | 3 | 3 | 3 |

Potential Risk Mitigation Options

1. Voluntary house raising of single storey dwellings of suitable construction
2. Building reinforcement for flood resistance
3. Voluntary purchase

***Risk to Property - applies to all commercial and industrial property***

| *Event Range* | Vehicle parking and flood resistant materials/stock storage | Above floor flooding – ground floor | | H4 | H5 |
|---|---|---|---|---|---|
| | | multi storey building | Single storey building | | |
| *1,000 - PMF* | | | | 3 | 3 |
| *100-1,000* | | | | 3 | 3 or 4 |
| *50 to <100* | 1 | | 2 | 3 | 4 |
| *>10 to <50* | 1 | 4 | 4 | 4 | 4 |
| *10* | 4 | 4 | 4 | 4 | 4 |

Potential Risk Mitigation Options

1. Barriers to prevent vehicles, stock or equipment from leaving the site
2. Storage area for stock and equipment above 1 in 100 level in areas where there is sufficient warning time to relocate stock
3. Building reinforcement for flood resistance
4. Voluntary purchase

## Risk to Critical Infrastructure

| *Infrastructure Type* | Within infrastructure categorisation | | | | | | |
|---|---|---|---|---|---|---|---|
| *Water Supply* | Local water supply network | Trunk mains | Reservoirs/Towers | Water Treatment Plant processing infrastructure | Water Treatment Plant throughput pumps and pipes and mains leading out of WTP | | Source (e.g. Dam) and main trunk |
| *Electricity* | 11 kV distribution system | 33 kV power cables | 33/11 kV substation | 110 kV power cables | 110/33 kV substation | | 275/110 kV substation & 275kV and higher voltage power cables |
| *Telecommunications* | Cables connecting mini exchanges | Mini exchanges | Other mobile phone towers cables connecting terminal exchanges and mobile phone towers to switching centres and each other | Terminal Exchanges And critical mobile phone (cellular) transmission towers | intercity cables and cables between switching centres | | Radio transmission infrastructure used by emergency services. Telephone switching centres |
| *Emergency Services* | | | | Minor Evacuation Centre | Station (Police/Fire brigade/Ambulance/SES) | | Major Evacuation Centre or Control Centre (Police/Fire brigade/Ambulance/SES) |
| *Sewage and waste* | | | Gravity Pipes | Sewage pumps and waste tips or landfill | Sewage Water Treatment Plant | | |
| *Health services* | | | Medical Centres | Private Hospitals and aged care facilities | Local Public Hospitals | | Regional Public Hospitals |
| *Duration* / ***Event Range*** | | | | | <24hrs | >24hrs | |
| ***1,000 - PMF*** | | | | | 2 or 3 | 2 or 3 | 2 and 3 |
| ***100-1,000*** | | | | 2 or 3 | 2 or 3 | 3 | 2 and 3 |
| ***50 to <100*** | | 1, 2 or 3 | 2 or 3 | 2 or 3 | 3 | 3 | 2 and 3 |
| ***>10 to <50*** | 1 or 3 | 2 or 3 | 3 | 3 | 3 | 3 | 2 and 3 |
| ***10*** | 1 or 3 | 3 | 3 | 3 | 3 | 3 | 2 and 3 |

Potential Risk Mitigation Options for Infrastructure

1. Means of restoring basic service within 48 hours.

2. Provide backup/alternative system/service to provide adequate service for more than 48hrs. This includes power, telecommunications, access and consumables required to provide critical services

3. Relocation of infrastructure.

## Conclusions

Flood risk assessment needs to consider a wider range of risks than has been traditionally considered in the past and these need to be considered in a transparent and repeatable way. It would be preferable if there were nationally adopted standards for acceptable risks to guide developers, planners, regulators and the courts.

The methodology presented in this paper proposes a methodology which would achieve those objectives but more discussion would be needed within the floodplain management profession to better define acceptable and tolerable risk threshold.

The advantage of the proposed methodology are that it is suitable for existing and future development, it considers existing and residual risk and it is outcomes focussed rather than prescribing risk management measures.

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