Sutherland Shire COUNCIL

Gwawley Bay Catchment Floodplain Risk Management Study and Plan

Flooding along Parraweena Road, Taren Point in May 2003

Final Report

June 2015

FloodMit

SUTHERLAND SHIRE COUNCIL

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Report of Sutherland Shire Council's
Floodplain Management Committee, prepared by

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FOREWORD

In New South Wales the prime responsibility for local planning and the management of flood liable land rests with local government. To assist local government with floodplain management, the NSW Government has adopted a Flood Prone land Policy in conjunction with the *Floodplain Development Manual*.

The Policy is directed at providing solutions to existing flood problems and to ensure that new development is compatible with the flood hazard and does not create additional flood problems.

The Policy sets out four sequential stages in the development of a floodplain management plan:

1	Flood Study	- Assessment to define the nature and extent of flooding.
2	Floodplain Risk Management Study	- Comprehensive evaluation of management options with respect to existing and proposed development.
3	Floodplain Risk Management Plan	- Formal adoption by Council of a management plan for floodplain risks
4	Implementation of the Plan	- Measures undertaken to reduce the impact of flooding on existing development, and implementing controls to ensure that new development is compatible with the flood hazard.

A flood study report was prepared by Bewsher Consulting in November 2012. The flood study established a computer model of flood behaviour throughout the catchment, and provided information on the extent and depth of flooding for a range of design events.

This Floodplain Management Study and Plan constitutes the second and third stages of the management process for the Gwawley Bay catchment and has been prepared for Sutherland Shire Council by FloodMit Pty Ltd. The study has investigated what can be done to minimise the effects of stormwater flooding in the Gwawley Bay catchment and has recommended a strategy in the form of a draft Floodplain Management Plan.

A draft cop of the report was placed on public exhibition from 22 April to 22 May 2015. It is to be further considered by Sutherland Shire Council prior to formal adoption.

Funding and technical assistance was provided for the study through both Sutherland Shire Council and the Office of Environment and Heritage (OEH) under the State Government's Floodplain Management Program.

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EXECUTIVE SUMMARY

Reasons for the Study and Plan

Widespread flooding problems were reported throughout Sutherland Shire from a storm that occurred on 13 May 2003. An initial assessment of flooding throughout the Shire (Bewsher, 2004) identified the Gwawley Bay catchment as having the most significant flood problems, and ranked this catchment as the highest priority for further flood investigations.

The Gwawley Bay Catchment Flood Study (Bewsher, 2012) established a computer based flood model for the catchment and identified flood behaviour for a range of design floods from relatively frequent events up to more extreme floods. The model provides information on the extent and depth of inundation in various events, including design flood heights, flood velocities and hydraulic hazards.

During 2014 FloodMit Pty Ltd was commissioned to undertake a floodplain management study and plan for the catchment. The floodplain management study further reviews flooding problems within the catchment and investigates measures to reduce these problems and better manage the flood risk. The recommended measures to be implemented throughout the catchment are included in a draft floodplain management plan. The measures are anticipated to be progressively implemented by Sutherland Shire over a 5-10 year period.

Responsibilities

The prime responsibility for planning and management of flood prone lands in NSW rests with local government. The NSW Government provides assistance on state-wide policy issues and technical support. Financial assistance is also provided to undertake flood and floodplain management studies and for the implementation of works identified in the floodplain management plan.

Sutherland Shire's Georges River and Gwawley Bay Floodplain Management Committee oversaw the Study. This committee includes Councillors and staff from Sutherland Shire, staff from the Office of Environment and Heritage (OEH), the State Emergency Service (SES), Roads and Maritime Services (RMS) and a number of community representatives.

Funding for the study was jointly provided by Sutherland Shire and OEH

The Study Area

The study area is the catchment that drains to Gwawley Bay, at Sylvania Waters. A smaller catchment that drains to the Production Road Channel, on the east side of Taren Point Road, is also included in the study area.

The study area is shown on **Figure 1.1**. It is located wholly within Sutherland Shire, and includes Sylvania Waters and parts of the surrounding suburbs of Sylvania, Taren Point, Caringbah, Miranda and Gymea.

Consultation

Community consultation has been an important component of the project. Consultation activities have included:

i) regular meetings of the floodplain management committee;

ii) letters and questionnaires distributed during the earlier flood study, and again in 2014 as part of the floodplain management study; and

iii) exhibition of the draft floodplain management study and plan.

Modelling of Flood Behaviour

The flood study adopted a two-dimensional hydraulic model (TUFLOW) to analyse flood behaviour. The stormwater pipe system and stormwater channels are included in the model as one-dimensional elements that are linked to a two-dimensional grid that represents the surface terrain. When the capacity of the drainage elements are exceeded, flow spills onto the surface grid and surface flow across the floodplain and various overland flowpaths are analysed.

The same model has been used in the floodplain management study to assess various floodplain management options and to provide additional mapping of flood behaviour.

Flood Risk Mapping & Development Controls

The area potentially affected by flooding has been divided into three flood risk precincts (high, medium and low). Different development controls are then applied to new development proposals depending on the type of the development and the flood risk precinct in which the development is located. This is a similar approach adopted by Council for the Georges River. An outline of the flood risk precincts is provided below:

i) The high flood risk precinct – where high flood damages, potential risk to life, or evacuation problems are anticipated. It is recommended that most development is restricted within this area.

ii) The medium flood risk precinct – where there is still a significant risk of flood damage, but where these damages can be minimised by the application of appropriate development controls.

iii) The low flood risk precinct – where the risk of flood damage is low. Most land uses would be permitted within this area (subject to other planning considerations).

The Flood Problem

A flood damages database has been prepared for the study area to quantify the flood problem and to assist in evaluating the merit of a range of flood mitigation measures.

The database includes details on over 1,500 properties throughout the study area that could be potentially affected by flooding. The database has further been divided into seven geographical areas to help identify the spatial distribution of the flood problem over the study area. Key results from the database are included in **Table 1** and **Table 2**.

Table 1
Summary of Buildings Inundated

Area	Buildings Inundated above floor level in 100yr flood		
	Residential	Commercial and Industrial	Total
1. Gwawley Creek (South of Box Rd)	36	2	38
2. Gwawley Creek (North of Box Rd)	26	0	26
3. Southgate Branch	20	0	20
4. Southern Branch	12	13	25
5. Eastern Branch (Parraweena Rd)	2	32	34
6. Sylvania Waters	70	6	76
7. Production Rd Channel	0	15	15
TOTAL	**166**	**68**	**234**

TABLE 2
Predicted Total Flood Damages under Existing Conditions

Area	Damage in Flood Event ($M)			Average Annual Damage ($M)	Present Value of Damage ($M)
	20 Yr	100 Yr	PMF		
1. Gwawley Creek (South of Box Rd)	6.0	7.1	15.8	1.3	13.4
2. Gwawley Creek (North of Box Rd)	3.8	4.5	8.4	0.8	8.8
3. Southgate Branch	4.0	4.6	9.5	0.9	9.2
4. Southern Branch	6.9	8.2	20.4	1.4	15.2
5. Eastern (Parraweena Rd) Branch	3.4	4.7	12.8	0.8	8.1
6. Sylvania Waters	9.1	13.9	47.2	2.0	21.0
7. Production Rd Channel	0.9	1.1	3.0	0.2	2.0
TOTAL	**34.0**	**44.0**	**117**	**7.3**	**77.6**

Flood Mitigation Options Investigated

Problem areas throughout the study area have been identified, and potential floodplain management options investigated, on the basis of:

i) the extent of inundation experienced throughout the catchment;

ii) the location of buildings potentially affected by above floor flooding, based on the flood damages database;

iii) problem areas identified by the community, based on results from the community questionnaires and Council's Customer Complaints register; and

iv) problem areas identified by Council and Committee members.

Specific flood mitigation options for the study area are discussed in **Section 7**.

It will not be feasible to find solutions to all of the flooding problems within the study area, given the magnitude of the problem and the number of buildings potentially affected by flooding. Where specific solutions are not feasible, other catchment-wide measures will provide some benefit. Floodplain management measures that apply on a catchment-wide basis, including planning and development controls, public awareness initiatives, emergency management operations, and stormwater maintenance issues are discussed in **Section 8**.

The Recommended Floodplain Management Measures

The draft Gwawley Bay Catchments Floodplain Management Plan is summarised in **Table 3**.

It is important to note that not all flooding problems in the study area have been alleviated. A complete solution to the flooding problem is not cost effective from a floodplain management perspective. However, problems can be reduced gradually over time as sensible redevelopment occurs in accordance with Council's planning controls.

TABLE 3
Recommended Floodplain Management Plan

Item	Area	Description	Report Section	Indicative Cost	Potential Funding Sources	Priority
1	A1	**Gwawley Creek Upstream of Corea Oval**	7.1			
		a) Verify stormwater pipe system downstream of Garnet Rd		N/A	SSC	Low
		b) Identify stormwater improvements (if any)		$10,000	SSC, OEH	Low
		c) Investigate options for overland flow path		$10,000	SSC, OEH	Low
2	A2	**Gwawley Creek Downstream of Corea Oval**	7.2			
		a) Regular maintenance of GPT structure and creek corridor (Refer also to Item 14)		N/A	SSC	Medium
3	A4	**Kiama St Drain to Port Hacking Rd**	7.3			
		a) Modify inlet to reduce blockage		$50,000	SSC, OEH	Medium
		b) Remove obstructions from overland flowpaths		N/A	Owner	High
4	A6	**Belgrave Esplanade (Southern Branch)**	7.4			
		a) Consider amplifying culvert in conjunction with future maintenance requirements		$2,100,000	SSC, OEH	Low
		b) Include bollards across waterway to prevent culvert blockage		$50,000	SSC, OEH	Medium
5	A3	**Upstream Southgate Shopping Centre**	7.5			
		a) Review flooding with detailed computer model		$30,000	SSC, OEH,	High
		b) Improvements to inlet structure under Southgate		$100,000	Southgate	High
6	A6	**Gwawley Creek downstream Port Hacking Rd**	7.6			
		a) Measures to prevent blockage at Port Hacking Rd culvert		$30,000	SSC, OEH	Medium
		b) Improved overland flow path from Dalman Pl to Gwawley Ck		$10,000	SSC, OEH	Medium
7	A6	**Belgrave Esplanade (Eastern Branch)**	7.7			
		a) Include bollards across waterway to prevent culvert blockage		$50,000	SSC, OEH	Medium
8	A5	**Box Road (Eastern Branch)**	7.8			
		a) Extend 4.6x2.6 culvert through Box Rd		$360,000	SSC, OEH	Medium
		b) Fencing around upstream open channel to prevent blockage		$20,000	SSC, OEH	Medium
		c) Improved overland flow path as part of future redevelopment		N/A	Developer	Low
9	A5	**Parraweena Road (Eastern Branch)**	7.9			
		a) Investigate feasibility of providing increased culvert capacity downstream of Parraweena Rd		$20,000	SSC, OEH	Low
		b) Improved overland flow path as part of future redevelopment		N/A	Developer	Low
10	A7	**Production Road Channel**	7.10			
		a) Investigation & design		$40,000	SSC, OEH	Medium
		b) Channel Improvement Works		$2,500,000	SSC, OEH	Medium
11	A1-A7	**Planning & Development Controls**	8.1			
		a) Review and simplify DCP provisions		$10,000	SSC	High
		b) Incorporate minor amendments for car parking and evacuation requirements for the Gwawley Bay catchment		N/A	SSC	High
12	A1-A7	**Emergency Management Operations**	8.3			
		a) Update Local Flood Plans		$20,000	SSC,SES,OEH	High
13	A1-A7	**Improved Public Awareness**	8.4			
		a) Update Council's GIS database with flood data		$10,000	SSC	High
		b) Update mapping in "Shire Maps"		$20,000	SSC	Medium
		c) Provide flood certificates		$20,000	SSC	Medium
14	A1-A7	**Stormwater Maintenance**	8.5			
		a) Develop formal maintenance program		N/A	SSC	Medium
15	A1-A7	**Basement Car Parking Review**	8.6			
		a) Identify problem areas and investigate options		$20,000	SSC	Medium
		TOTAL		$5,480,000		

Timing and Funding

The total cost of implementing all the recommended measures is approximately $5.5M.

It is envisaged that the Plan would be implemented progressively over a 5 to 10 year time frame.

The timing of the proposed works will depend on the overall budgetary commitments of Council and the availability of funds from other sources (eg State Government, potential Section 94 contributions, etc).

1 INTRODUCTION

1.1 BACKGROUND

The Gwawley Bay catchment is an urban stormwater catchment in Sutherland Shire, which drains to Gwawley Bay at Sylvania Waters, and then into the Georges River.

The catchment experiences a range of flooding problems, including:

i) surface runoff across the catchment;

ii) surcharging flows from the stormwater pipe system;

iii) overtopping from Gwawley Creek and other open drains; and

iv) backwater flooding in Gwawley Bay from the Georges River.

The Gwawley Bay Catchment Flood Study (Bewsher, 2012) identified those areas within the catchment potentially affected by stormwater inundation. This was based on a two-dimensional computer model (TUFLOW) that was developed for the catchment as part of the study. The model provides information on the depth and extent of stormwater inundation for events ranging from relatively frequent storms to more extreme floods.

FloodMit Pty Ltd was subsequently commissioned to undertake a floodplain management study and plan for the catchment. The floodplain management study further reviews flooding problems within the catchment and investigates measures to reduce these problems and better manage the flood risk. The recommended measures to be implemented throughout the catchment are included in a draft floodplain management plan included in this report. The measures are anticipated to be progressively implemented by Sutherland Shire over a 5-10 year period.

Development of the study and plan was overseen by Council's floodplain management committee. The committee includes councillors and staff from Sutherland Shire, the Office of Environment and Heritage (OEH), the State Emergency Service (SES), Roads and Maritime Services (RMS) and a number of community representatives.

Funding for the study was jointly provided by the Sutherland Shire and OEH. Subsidised funding is also available through OEH for measures identified in the floodplain management plan. Funding assistance is provided on a 2:1 (State:Council) basis.

1.2 THE STUDY AREA

The study area is the catchment that drains to Gwawley Bay, at Sylvania Waters. Gwawley Bay is located on the south side of the Georges River, between Captain Cook Bridge and Tom Uglys Bridge. A smaller catchment that drains to the Production Road Channel, on the east side of Taren Point Road, is also included in the study area.

The study area is shown on **Figure 1.1**. It is located wholly within Sutherland Shire, and includes Sylvania Waters and parts of the surrounding suburbs of Sylvania, Taren Point, Caringbah, Miranda and Gymea.

The total catchment area is 9.2km^2. It largely consists of residential development with more intensive commercial and industrial development located in the lower catchment area.

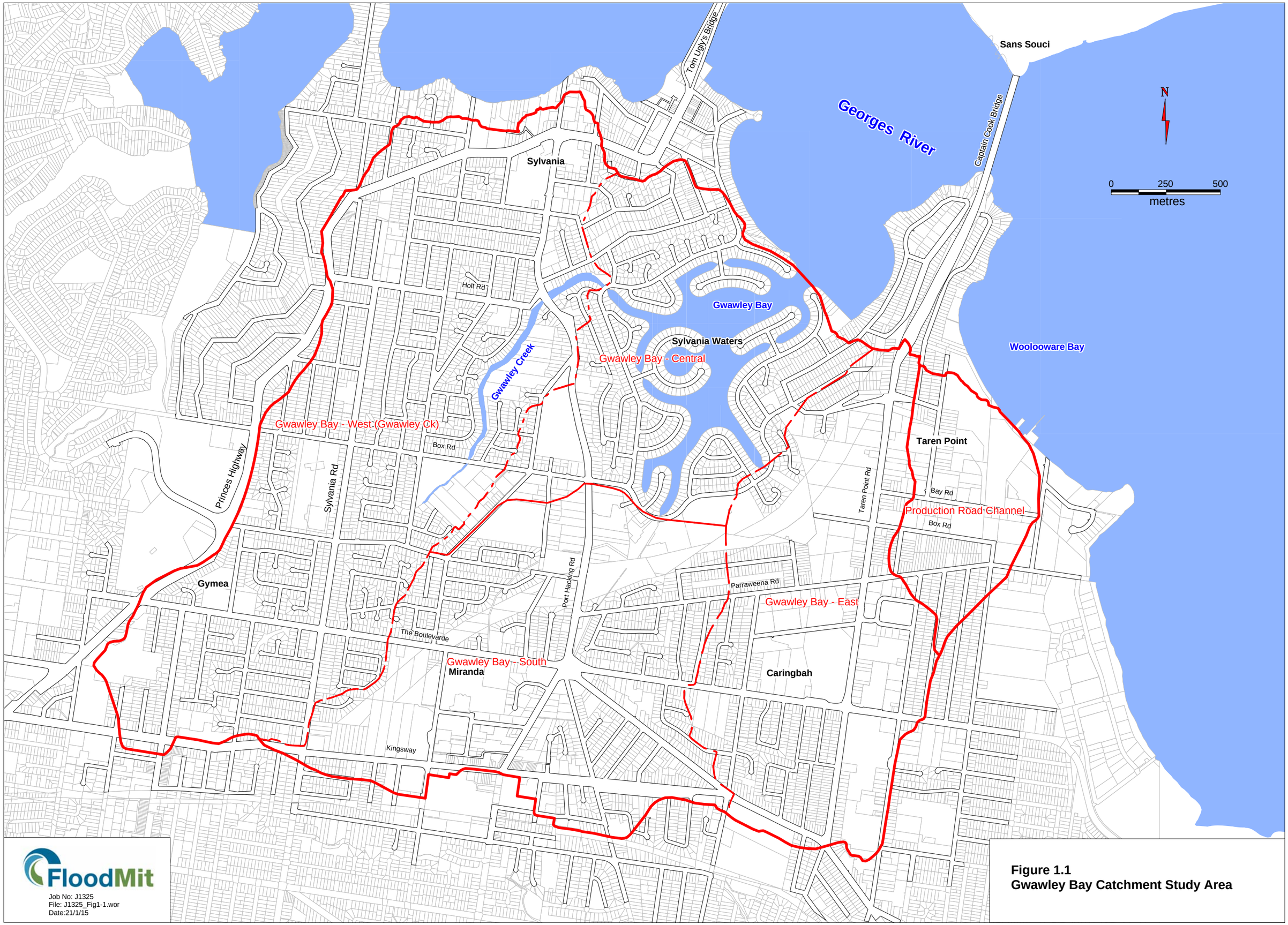

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Figure 1.1
Gwawley Bay Catchment Study Area

1.3 THE GOVERNMENT'S FLOODPLAIN MANAGEMENT PROCESS

The prime responsibility for planning and management of flood prone land in New South Wales rests with local government. The NSW Government provides assistance on state-wide policy issues and technical support. Financial assistance is also provided to undertake floodplain management studies and plans, such as the current project, and for the implementation of works identified in these studies.

A Flood Prone Land Policy and a *Floodplain Development Manual* (NSW Government, 2005) forms the basis of floodplain management in New South Wales.

The objectives of the Policy include:

i) reducing the impact of flooding and flood liability on existing developed areas by flood mitigation works and measures, including ongoing emergency management measures, the raising of houses where appropriate, and development controls; and

ii) reducing the potential for flood losses in new development areas by the application of ecologically sensitive planning and development controls.

The implementation of the Flood Prone Lands Policy, shown on **Figure 1.2**, generally culminates in the preparation and implementation of a Floodplain Management Plan. The Policy also provides for the Plan to be reviewed from time to time, for example on a regular basis or after a significant flood event.

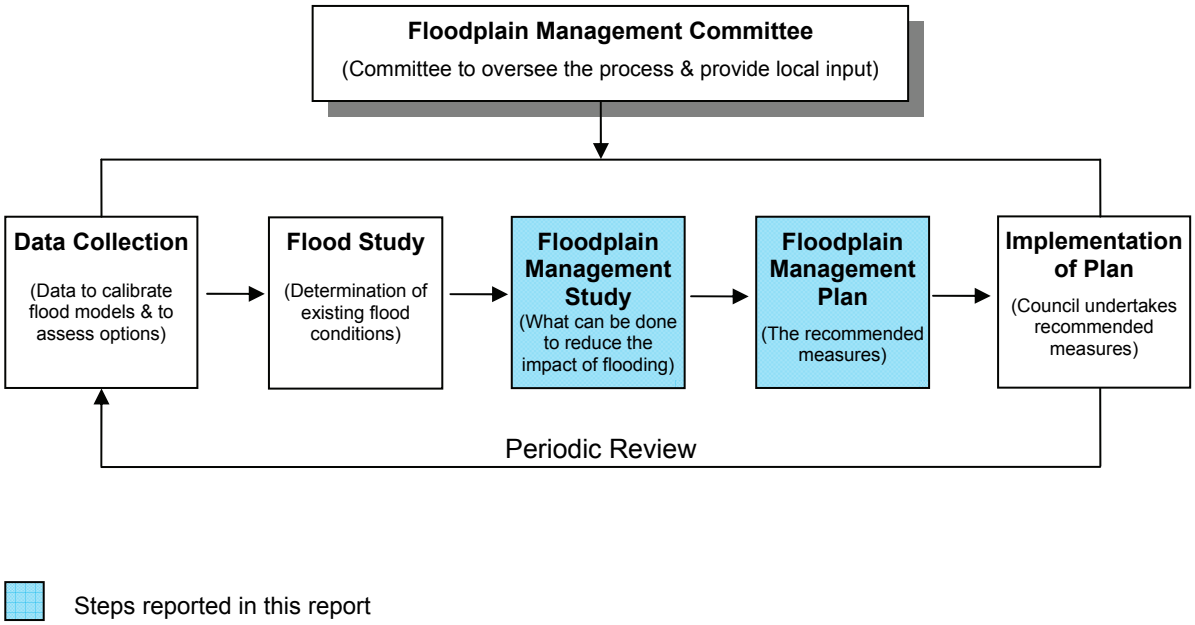

FIGURE 1.2
The Floodplain Management Process

1.4 STRUCTURE OF REPORT

This report is structured as follows:

Chapter 1 – Introduction to the Study

Chapter 2 – Background information, including a description of the catchment, previous investigations, environmental and heritage issues

Chapter 3 – A review of consultation activities undertaken during the study

Chapter 4 – Description of flood behaviour, including delineation of the catchment into different flood risk management areas

Chapter 5 – A flood damage assessment throughout the catchment for a range of flood events

Chapter 6 – A review of floodplain management considerations, including adoption of flood planning levels, types of floodplain management measures that have been considered to alleviate flooding problems, and climate change considerations

Chapter 7 – An assessment of potential flood mitigation options in specific areas

Chapter 8 – An assessment of catchment-wide floodplain management measures, including planning considerations, public awareness initiatives and other measures applying to the whole study area

Chapter 9 – The recommended floodplain management plan

2 BACKGROUND INFORMATION

2.1 CATCHMENT DESCRIPTION

The study area includes the catchment that drains to Gwawley Bay (863Ha) and a smaller catchment that drains to Woolooware Bay via the Production Road Channel (54Ha). The Gwawley Bay catchment has been subdivided into four different subcatchments, as shown on **Figure 1.1**. These are referred to in this report as the western, southern, eastern and central subcatchments.

Gwawley Creek drains the western part of the Gwawley Bay Catchment. The catchment commences near the Kingsway at Gymea, and flows in a northerly direction through the stormwater pipe system to Corea Oval, where Gwawley Creek first becomes evident (Photo 1). Gwawley Creek continues flowing in a northerly direction towards Box Road. A major gross pollutant trap has been constructed on the downstream side of Box Road (Photo 2). The creek continues in a northerly direction to Port Hacking Road, and into Gwawley Bay at Sylvania Waters. Gwawley Creek is the only natural waterway within the Gwawley Bay catchment.

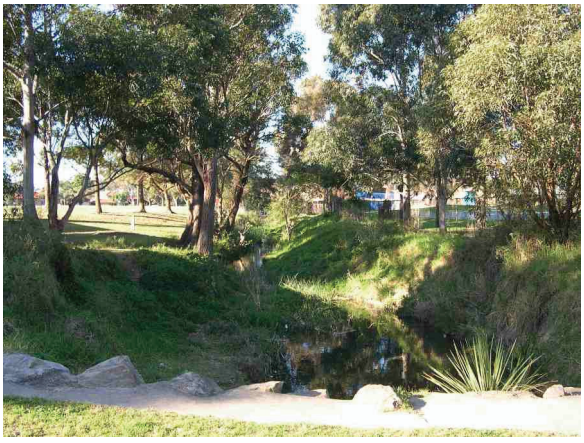

Photo 1 – The start of Gwawley Creek in Corea Oval

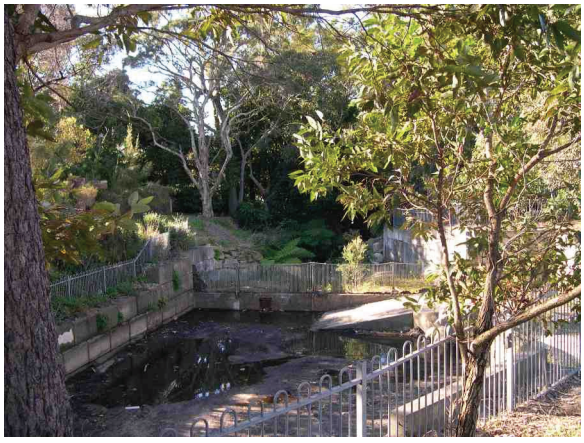

Photo 2 – Gwawley Creek & GPT downstream of Box Road

The southern part of the Gwawley Bay catchment commences near Westfield Miranda. The catchment drains to the north through the stormwater pipe system to Seymour Shaw Park. A constructed concrete lined channel with sandstone block wall continues from The Boulevarde through to Kiama Street (Photo 3). A drain continues under industrial development between Kiama Street and Port Hacking Road, before emerging into a larger concrete lined drain and finally the southern extremity of Gwawley Bay near the Southern Districts Rugby Club.

The eastern part of the Gwawley Bay Catchment commences near the intersection of the Kingsway and Taren Point Road, at Caringbah. The catchment drains to the north through the stormwater pipe system to Parraweena Road, and then on to Gwawley Bay through a series of short channels and culverts. A mix of commercial and industrial development occurs in the lower part of this catchment area, with significant flooding problems in the vicinity of Kumulla Road, Parraweena Road, and Box Road being noted in the past.

The Gwawley Bay central catchment area is the remaining catchment that drains directly to Gwawley Bay through the stormwater pipe system. There are approximately 70 stormwater outlets that discharge to the Bay.

The Production Road channel catchment commences south of Parraweena Road at Caringbah. The catchment drains a largely industrial area through the stormwater pipe system to Bay Road. A constructed earth channel continues from Bay Road through to Woolooware Bay, on the eastern side of Production Road (Photo 4). The capacity of the channel has been restricted through the growth of mangroves and recent siltation. Significant flood problems have been noted in the past in the vicinity of Box Road and Bay Road.

Photo 3 – Open Drain in Southern Subcatchment

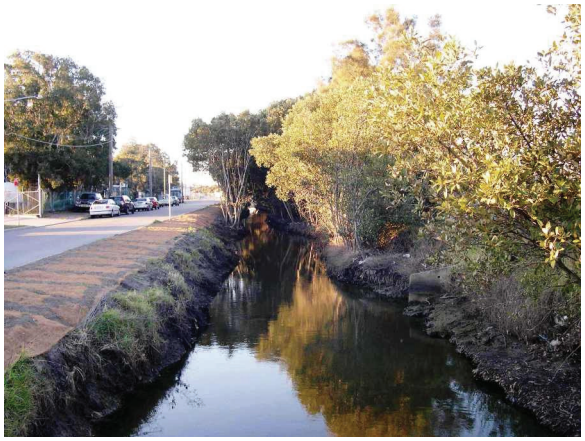

Photo 4 – Production Rd Channel downstream of Bay Rd

Major road transport routes through the catchment include the Princes Highway (along the western boundary), Taren Point Road, Port Hacking Road, and The Boulevarde. A future motorway, linking the F6 Freeway at Waterfall through to Ultimo via the Captain Cook Bridge, is also located within the catchment. A reservation for the future road has been in place since 1951.

The drainage system has been modified as development through the catchment has occurred. Many low lying areas have been filled and natural watercourses have been replaced by stormwater pipes or concrete channels. Gwawley Creek remains as one of the only natural creek systems within the catchment. Gwawley Bay itself has been dredged and artificial islands created through land reclamation to form the Sylvania Waters canal development.

Many areas of the catchment experience stormwater inundation problems when the underground stormwater system is exceeded. Other areas experience inundation problems when the creek and other open drains exceed their capacity and inundate adjacent land. Much of the lower catchment area is low lying, and also affected by backwater levels from the Georges River. Pressure for industrial and commercial development in the lower catchment area has also resulted in the blockage of some overland flowpaths, further exacerbating flooding problems.

2.2 PREVIOUS FLOOD STUDY

The Gwawley Bay Catchment Flood Study was completed for Sutherland Shire in November 2012 (Bewsher, 2012). It represented the first stage of the floodplain management process for the Gwawley Bay catchment.

The flood study is based on:

i) preparation of a digital elevation model of the catchment, derived using airborne laser scanning (ALS) survey acquired by Council in 2005;

ii) field survey of watercourses, culverts and bridges within the study area;

iii) aerial photography of the catchment flown in October 2005 and March 2006 (aerial photography flown in April 2012 was available for the floodplain management study);

iv) digitised building footprints derived from the aerial photography;

v) a database of Council's stormwater drainage system;

vi) the establishment of a RAFTS hydrologic model to estimate catchment flows; and

vii) the establishment of a TUFLOW hydraulic model to estimate flood levels and velocities.

The RAFTS model divided the catchment into 248 smaller subcatchments. These boundaries were based on topography, the pipe drainage network, and other areas where inflows to the TUFLOW model were desired. Design storms with durations ranging from 25 minutes to 12 hours were applied to the RAFTS model to derive catchment flows. Storm intensities were based on intensity-frequency-duration data derived by Council for use in Sutherland Shire. This data was found to closely agree with values calculated in accordance with *Australian Rainfall and Runoff* (Institution of Engineers Australia, 1987). Catchment flows are summarised in Appendix B of the Flood Study report (Bewsher, 2012).

Flow hydrographs generated using the above approach were then applied to the TUFLOW model to derive flood levels and flood velocities. Surface flows are represented in the TUFLOW model through a two-dimensional grid covering the study area. A 3 metre square grid was adopted for this assessment. Gwawley Creek and other waterways and drains were included in the model as 1D elements. All stormwater pipes with a diameter of 750mm or greater were included in the model. Upon review of model results, a further 227 smaller pipelines were included in the model to improve the representation of flood behaviour. Buildings and other obstructions were incorporated in the model by raising the terrain surface and/or increasing the surface roughness.

The model assumes 50% blockage for all culverts in the study area. A blockage allowance ranging from 20% (on-grade pits) to 50% (sag pits) was also applied to the stormwater pipe network, consistent with recommendations in *Australian Rainfall and Runoff* (Institution of Engineers, Australia, 1987).

The lower catchment area can experience flooding from either surface flows in the Gwawley Bay Catchment, or backwater flooding when the Georges River is in flood. Surface flows in the Gwawley Bay catchment typically occurs from a 2 hour thunderstorm over the catchment, whereas flooding in the Georges River typically occurs from an East-Coast Low with prolonged rainfall over 36 to 48 hours duration combined with elevated storm tide conditions in Botany Bay. As it is unlikely that both flooding scenarios will occur at the same time, the flood study considered both flooding mechanisms separately. The design 100 year flood level in the lower catchment area has then been taken as the maximum of either:

i) the design 100 year flows in the Gwalwey Bay catchment coinciding with a normal high tide level of RL 0.6m AHD in the Georges River; and

ii) the design 100 year Georges River flood level of RL 1.7m AHD (Bewsher 2004) with no catchment flows in the Gwawley Bay catchment.

The Gwawley Bay Flood Study provides maps showing the extent of inundation and flood level contours for the 5 year, 20 year, 100 year and Probable Maximum Flood (PMF) under existing catchment conditions. The flood study model and inundation maps provide the technical basis for current floodplain management study.

A copy of the flood study can be downloaded from Council's web site at www.sutherlandshire.nsw.gov.au/Outdoors/Environment/Flooding

2.3 HISTORICAL FLOOD DATA

The Gwawley Bay Catchment Flood Study notes the most significant flooding within the Gwawley Bay catchment as occurring on the 13th May 2003. Newspaper reports and correspondence received by Council record heavy damage to houses, factories and motor vehicles. About 60 factories are reported to have been flooded in Parraweena Road and Bay Road at Taren Point.

Council also received a total of 130 complaints within the Gwawley Bay study area following this event. A total of 44 complaints referred to flooding within people's property, and a total of 14 complaints referred to flooding above floor level.

A questionnaire was distributed to 1500 residents within the study area during 2007, as part of the flood study. The questionnaire sought information on a range of matters related to flooding, including dates when flooding problems had been experienced. Whilst the May 2003 flood was the most dominant flood referred to, a number of other dates were also listed ranging from 1973 through to 2004.

A second questionnaire was distributed in 2014 as part of the current floodplain management study. These results indicate that more recent flooding has been experienced throughout the study area, with significant flooding reported to have occurred during 2013 (9 reports). Results of the questionnaire are further reported in Section 3.

Photo 5 – Stormwater channel, Dyinda Pl, Miranda (1983)

Photo 6 – Downstream of Dyinda Pl, Miranda (1983)

Photo 7 –Parraweena Road, Taren Point (2003)

Photo 8 – Parraweena Road, Taren Point

2.4 ENVIRONMENTAL ISSUES

The Gwawley Bay catchment has been significantly modified since the 1940's (photos 9 & 10). Low to medium density residential development has occurred throughout the majority of the catchment since this time. Land was reclaimed from Gwawley Bay during the 1960's and 70's by constructing more than eight kilometres of retaining walls, including the formation of three artificial islands, to form a canal development known as the Sylvania Waters Estate. Commercial and industrial development has also occurred in more recent time, particularly in low lying areas on the eastern side of the study area.

Despite this development, there remains a high proportion (10%) of open space identified for public and private recreation. There are eight schools within the study area which contribute additional open space through playing fields (5%). The road reserve for the future Southern Motorway also provides additional open space in the short term (4%).

Photo 9 – Gwawley Bay Catchment (1943)

Photo 10 – Gwawley Bay Catchment (2012)

Many of the natural watercourses have been replaced by stormwater drains and concrete lined channels. Gwawley Creek, which drains approximately 38% of the Gwawley Bay catchment, is one of the few natural watercourses remaining in the catchment. The creek is 1.5km long and densely vegetated, providing a valuable habitat corridor within the catchment. The corridor has been identified as a "Core Area" under the *Greenweb Strategy* (Sutherland Shire, 2001), which aims to conserve and enhance the Shire's bushland and biodiversity through interconnecting linkages and corridors.

Gwawley Creek drains the western subcatchment area to Gwawley Bay, downstream of Port Hacking Road. The southern and eastern subcatchments drain to the Bay via concrete lined stormwater drains. These drains discharge stormwater to short reaches of natural waterway areas upstream of Belgrave Esplanade before entering the Bay. Floating debris and litter are intercepted by floating litter booms at each of these three discharge points. A more substantial gross pollutant trap is located on Gwawley Creek at Box Road (Photo 2). Some community members have noted that the floating litter booms are an eyesore, and should be relocated further upstream to less prominent locations.

Water quality from Gwawley Creek (Leichardt Crescent); the southern subcatchment drain (Silverwater Crescent) and the eastern subcatchment drain (Gwawley Oval) has been monitored by Council since 2006. Water quality is rated as "Fair" at each of these stations, but rated "Poor" for human contact (Council website). These stations show a slight improvement over the period from 2006/07 to 2012/13.

The Production Road channel drains a largely industrial area to Woolooware Bay, immediately to the east of the Gwawley Bay catchment. This is a constructed trapezoidal earth channel with an invert up to 1m below mean sea level. Mangroves have become established in the channel, which has led to increased siltation and reduced channel capacity. The mangroves provide positive environmental benefits at the expense of increased flooding potential.

A significant portion of the lower study area is located on land that is below RL 2.0m AHD. Subsequently much of the drainage infrastructure including stormwater pipes, drains and culverts are located with invert levels below mean sea level. This has a number of consequences, including:

i) the capacity of these structures will be reduced at normal tidal levels, and significantly reduced at higher levels;

ii) there may be a propensity for siltation of waterways and other structures from either sediments from the upper catchment area or marine sediments from Botany Bay;

iii) Mangroves can become established in waterway areas and potentially exacerbate flooding, as noted above for the Production Road channel;

iv) Stormwater outlet pipes to Gwawley Bay may be affected by oyster growth, reducing the capacity of these structures and/or interfering with the operation of flood gates where fitted;

v) The capacity of other culverts may be reduced by oyster growth through reduced cross sectional area and increased roughness.

2.5 HERITAGE ISSUES

Heritage issues are important in forming an understanding of the social and cultural context of the study area and ensuring that flood mitigation measures do not unduly impact upon the heritage of the area. Heritage items are classified as having either Local, Regional or State significance. Advice from the Heritage Council is required prior to any item of State Significance being demolished, defaced or damaged.

The Heritage Branch of the Office of Environment and Heritage maintains the State Heritage Register which lists items significant to NSW. There are eleven items of State Significance within the Sutherland LGA. These include:

i) Audley historic recreational complex;

ii) Como Rail Bridge;

iii) The Cronulla Fisheries Centre;

iv) Cronulla Railway Station group;

v) Cronulla Sand Dune and Wanda Beach Coastal Landscape;

vi) Fernleigh;

vii) Heathcote Hall;

viii) Kamay Botany Bay National Park and Towra Point Nature Reserve;

ix) Loftus Junction railway signal box;

x) Lyons House; and

xi) Woronora Dam.

None of the above items are located within the Gwawley Bay study area.

Over five hundred items of a local significance are listed in the Heritage Schedule of the draft Sutherland Shire LEP 2013. Those heritage items that are relevant to the current study area are listed in **Table 2.1,** and are also shown on **Figure 2.1**.

Table 2.1
Heritage Items within the Study Area

ID	Address	Description	Significance
3702	23 Canberra Road (cnr Pembroke St)	House	Local
3113	223A Port Hacking Road	Gwawley Creek stormwater canal	Local
A3908	Within road reservation, between Belgrave Esplanade, Box Road and Gwawley Parade	Gwawley Bay oyster claires	Archaeological
3707	Part of Frank Vickery Village No 16/101-151 Port Hacking Road	House	Local
3116	Northern end of The Boulevarde	Miranda Centre War Memorial	Local
3102	Kiora Road	Street trees, alternate planting of Lophostemon confertus (Brush Box) and Cinnamomum camphora (Camphor Laurels)	Local
3114	Northern side of The Boulevarde, between Aster Avenue and Ingara Avenue	Remnant stand, consisting of Eucalyptus racemosa (Snappy Gum or small-leaf Scribbly Gum)	Local
3115	The Boulevarde, opposite Edward Avenue	Cultural plantings, consisting of Melaleuca quinquenervia (Broad-leaved Paperbark), school frontage	Local
1506	Kingsway, mainly southern side, between Talara Road and Premier Street	Street plantings, Eucalyptus	Local
3801	Sylvania Waters waterway	Sylvania Waters canal development	Local
*	5 Evelyn Street North, Sylvania	House	Local

* This item is not included in draft SSC LEP 2013, but is included in SSC LEP 2006. This house, known as “Gunyah”, is believed to be the Shire’s oldest house. It was built as part of the original Thomas Holt Sutherland House Estate between 1879 and 1880 (Council web site).

It is noted that four of the identified heritage items (shaded yellow above) could be potentially affected by stormwater inundation in a 100 year event, and may consequently impact on recommendations that may be provided in these areas.

Legend

Heritage Items (Refer to Table 2.1)

Area inundated in 100 year flood

Georges River

Woolooware Bay

Sans Souci

Tom Ugly's Bridge

Captain Cook Bridge

N

0 250 500

metres

Sylvania

Holt Rd

Gwawley Creek

Gwawley Bay - Central

Gwawley Bay - West (Gwawley ck)

Box Rd

Princes Highway

Sylvania Rd

Taren Point

Taren Point Rd

Bay Rd

Production Road Channel

Box Rd

Gymea

Port Hacking Rd

Parraweena Rd

Gwawley Bay - East

The Boulevarde

Gwawley Bay - South

Miranda

Caringbah

Kingsway

3702

3707

3801

A3908

3113

3114

3115

3116

3102

1506

FloodMit

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Figure 2.1
Heritage Items within the Study Area

3 COMMUNITY CONSULTATION

3.1 CONSULTATION PROCESS

Community consultation is an important component in the development of a floodplain management plan. Consultation provides an opportunity to collect feedback and ideas from the community on problem areas and potential floodplain management measures. It also provides a mechanism to alert the community about the flood risk, and to improve their awareness and readiness for flooding.

Much of the community consultation for the Gwawley Bay Floodplain Management Study has been coordinated through the Council's Lower Georges River and Gwawley Bay Catchment Floodplain Management Committee. Questionnaires and letters to residents were distributed as part of the initial flood study investigations. A second questionnaire was distributed during the floodplain management study. Public exhibition of the floodplain management study and plan is also intended prior to formal consideration by Council.

Elements of the consultation process are discussed further below.

3.2 FLOODPLAIN MANAGEMENT COMMITTEE

The Lower Georges River and Gwawley Bay Catchment Floodplain Management Committee has overseen the preparation of the floodplain management study and plan. The committee comprises representatives from:

i) Sutherland Shire Council (elected councillors and staff);

ii) Office of Environment and Heritage (OEH);

iii) State Emergency Service (SES);

iv) Roads and Maritime Services (RMS); and

v) A number of community representatives.

Six committee meetings were held over the course of this study. Details of these meetings, including the topics covered at these meetings, are provided in **Table 3.1**.

Table 3.1
Meetings of the Floodplain Management Committee

Meeting	Date	Topics Covered
1	30 Jan 2014	Pictorial tour of the catchment Review of the Gwawley Bay Catchment Flood Study Scope of the floodplain management study Mapping and development controls
2	10 April 2014	Flood damage assessment (including working paper) Proposed community questionnaire Climate change impacts
3	10 July 2014	Results from the community questionnaire Types of floodplain management measures that could be considered
4	30 Oct 2014	Flooding "hot spots" within the catchment Potential floodplain management options (including working paper)
5	5 March 2015	Presentation of draft floodplain management study and plan
6	18 June 2015	Feedback from exhibition and final report

A catchment tour of flooding “hot spots” was also held with some Committee members during October 2014.

As many of the representatives on the Committee are themselves members of other associations or groups, the committee provides a valuable mechanism for the views of many interested parties to be represented.

3.3 FLOOD STUDY QUESTIONNAIRE

A letter and questionnaire was distributed to residents and business owners adjacent to waterways and other main drainage paths as part of the earlier flood study (Bewsher, 2012). The questionnaire sought information on flooding that had been experienced throughout the catchment; issues of importance; and ideas on reducing flooding. Approximately 1500 questionnaires were distributed with 228 being completed and returned (15%).

Some 25 respondents indicated that they had experienced flooding above floor level. The most common date noted was May 2003. Flooding was also noted to have occurred on a number of other occasions as well.

Key issues of concern to residents included:

i) the need to keep drains clear of debris, rubbish and vegetation (18 respondents);

ii) inadequate stormwater drainage (15 respondents); and

iii) a desire for more information to be made available on flooding (13 respondents);

Community ideas for reducing flood problems mainly centred on:

i) providing improved stormwater drainage (27 respondents);

ii) better maintenance of the stormwater system (22 respondents); and

iii) keeping drains clear of rubbish, debris and vegetation (21 respondents).

3.4 FLOODPLAIN MANAGEMENT QUESTIONNAIRE

A second letter and questionnaire was distributed throughout the study area as part of the current floodplain management study during 2014. This was desirable given the time that had elapsed since the first flood study questionnaire. It also provided an opportunity to seek additional information on problem areas and community attitudes to a range of floodplain management measures.

The letter and questionnaire (see Appendix B) was distributed to owners of homes and business that could be potentially inundated during a 100 year storm. The letter provided residents with an update on the completed flood study and progress on the floodplain management study. The questionnaire sought information on residents’ experience of flooding; the location and cause of flooding problems; attitudes to development controls and flood notification; opinions on different types of management measures; and other issues.

A total of 1,410 questionnaires were distributed during May 2014, with 222 returned (16%). The majority of responses (92%) were from home owners.

Of those returned, 25% had resided at the property for less than 5 years, and 46% for less than 10 years. Consequently, nearly half of respondents had not experienced the 2003 flood, which was previously identified as a significant event within the catchment.

A total of 71 respondents (32%) reported some form of flooding within their property. This included:

i) flooding above the floor level of the main building (13 respondents);

ii) flooding above the garage or shed floor level (26 respondents); and

iii) minor property inundation (32 respondents).

Flooding was noted to have occurred in 2013 (9 respondents); 1975 (5 respondents); the 1980's (6 respondents) and the 1970's (15 respondents). Interestingly, only two respondents referred to the 2003 flood.

The cause of flooding was noted as:

i) inadequate stormwater drainage (21 respondents);

ii) heavy rainfall (17 respondents);

iii) blockage problems (14 respondents); and

iv) inadequate local drainage from neighbouring property (10 respondents).

One question, included at the request of the SES representative on the floodplain management committee, asked for details of anyone at the property who may require special assistance in a local emergency. Some 23 respondents noted occupants of the property with some form of disability where assistance may be required. This information has been passed on to the SES.

Community attitudes to controls on new development are depicted in **Figure 3.1**. The majority of respondents (28%) believed that there should be restrictions on new development such as minimum floor levels. Others believed that all development should be prohibited on land with dangerous flood conditions (26%), or on land subject to flooding (25%). A significant number also felt that advice on flood risk should be provided but no development restrictions should be provided (24%). Only a minor proportion of respondents felt that no advice or development restrictions should be provided (7%).

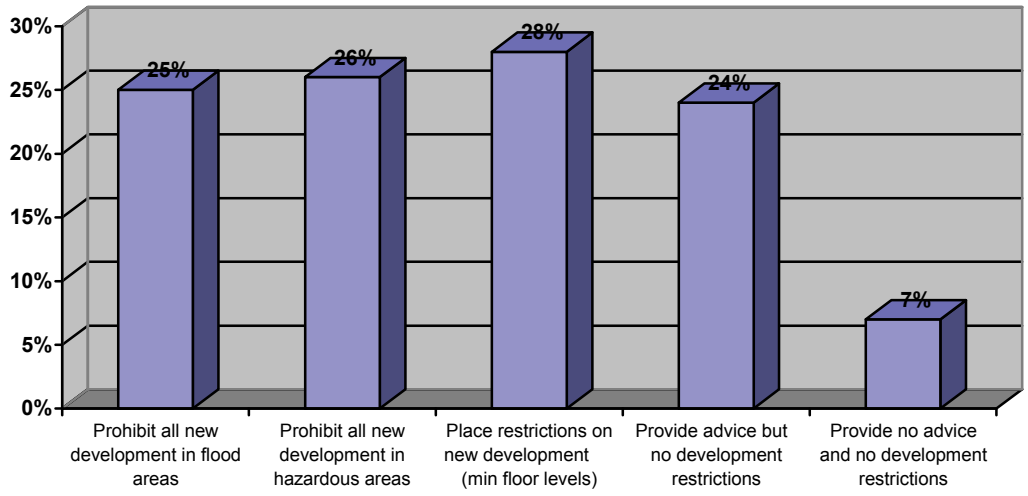

Figure 3.1
Community Attitudes to Controls on New Development

Attitudes to Council notifying residents about the flood threat are illustrated in **Figure 3.2**. The majority of respondents (54%) believe that Council should provide flood notifications to all owners on a regular basis. A relatively high proportion (36%) also believed that prospective purchasers of property should be notified of the flood risk. A smaller number (23%) believed that flood notifications should only be provided to those people who make enquiries to Council.

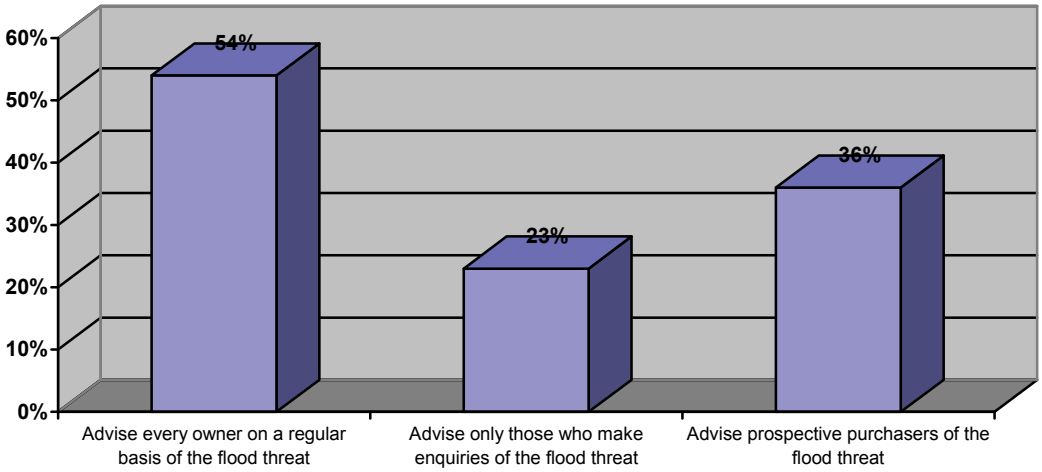

Figure 3.2
Community Attitudes to Flood Notification

Residents were also asked their opinion (yes or no) on a range of floodplain management measures. Opinions on measures that attempt to modify flood behaviour are illustrated on **Figure 3.3**. The most preferred options include regular maintenance to keep drains and culverts clear of debris (90%); the construction of debris control structures at culverts (76%); and enlarging the stormwater pipe system (60%). Other measures including the amplification of culverts; provision of on-site detention basins in new development; and the construction of detention basins generally received less support.

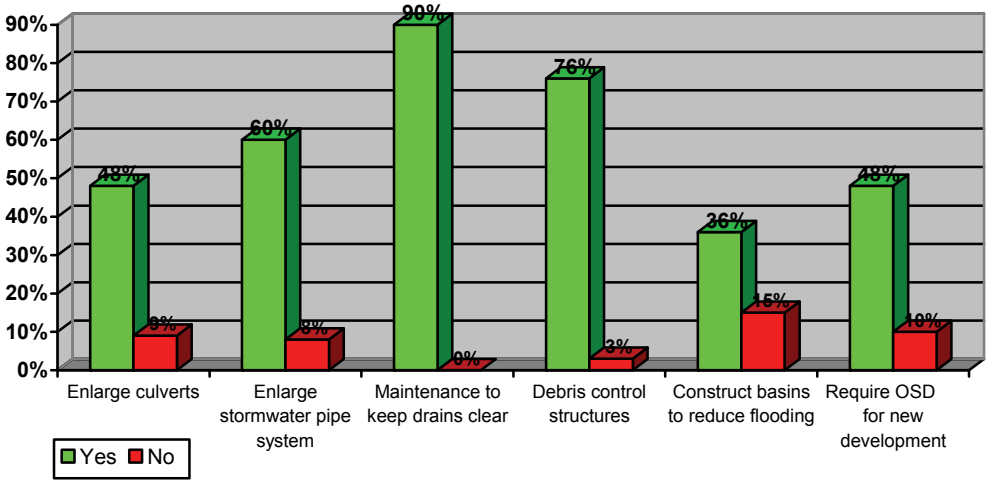

Figure 3.3
Community Opinions on Structural Measures

Opinions on measures that attempt to control development and flood awareness are illustrated on **Figure 3.4**. The most preferred measures include ensuring that residents are aware of the flood risk (75%); ensuring that new development does not block overland flowpaths (72%); and providing suitable controls on new development (56%). More restrictive controls, such as prohibiting subdivision on flood liable land or rezoning, received mixed support.

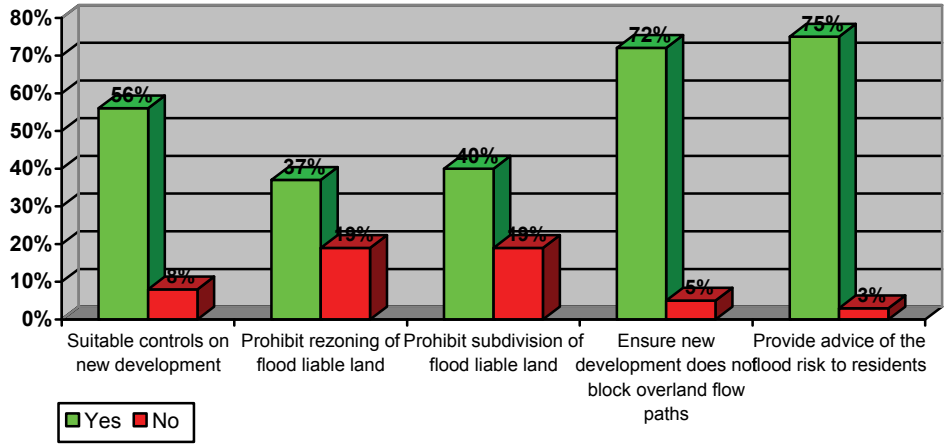

Figure 3.4
Community Opinions on Non Structural Measures

Other issues and comments provided are summarised in **Table 3.2**. The most frequently raised comments include the need for better maintenance to remove the likelihood of rubbish and debris from blocking drains (19 respondents); that there were no flooding problems (15 respondents); and concern over the impact of the study on insurance premiums (7 respondents).

Table 3.2
Community Ideas on Reducing Flood Problems and Other Issues

Issues and Comments Raised by the Community		
Rank	**Description**	**Times raised**
1	Better maintenance & removal of debris	19
2	No flooding problems at this location	15
3	Concern over insurance premiums	7
4	Need to increase stormwater drainage capacity	5
5	Need to consider tree species to control leaves and roots blocking drainage	5
6	Concern over inclusion of sea level rise in flood mapping	4
7	Need to dredge Gwawley Bay and drains leading to the bay	4
8	Better maintenance of gross pollutant traps	4
9	Regular street sweeping to remove leaves	4
10	Concern that new development is increasing runoff	4
11	Maintain clear waterways in Sylvania Waters	4

3.5 PUBLIC EXHIBITION OF DRAFT REPORT

A draft floodplain management study and plan was placed on public exhibition over the period from 22 April to 22 May 2015.

The exhibition was advertised in the St George and Sutherland Shire Leader and promoted on Council's web site (under "Join the Conversation"). Council also wrote to approximately 1500 residents and business owners who had previously been contacted as part of the community questionnaire, advising of the exhibition.

A poster display and copies of the report were available to view at Sutherland Shire Council and all Shire libraries. A digital copy of the report was also available to download from Council's web site.

Issues raised during the exhibition period are summarised in Table 3.3

Table 3.3
Issues Raised during Public Exhibition

ID	Date	Source	Issues Raised	Response
1	23/4	Web site	Problem finding report on web site. No flooding during April 2015 Storm	Digital copy provided.
2	23/4	Web site	Problem finding report on web site.	Digital copy provided.
3	28/4	Email	Lived in Sylvania Waters for 21 yrs. Never experienced a flood. No flooding during April 2015 storm.	Noted.
4	28/4	Web site	Concern that Council should not be committing rate payer funding to dredge Sylvania Waters.	Relates to other press article and not associated with this study.
5	29/4	Letter	Concerned over insurance costs	Noted.
6	30/4	Web site	Problem finding report on web site	Digital copy provided.
7	4/5	Letter	Lived in Sylvania Waters since 1969 and never experienced a flood. Minor flooding in 1973 due to blockage of drains.	Noted.
8	5/5	Personal meeting	Previous flooding of basement parking at units in 4-10 Miranda Road, during 2003 floods.	Recommend investigation of potential basement parking issues throughout the catchment.
9	14/5	Email	Lived in Sylvania since 1987 and never experienced a flood. Objects to being categorised as flood prone.	Noted.
10	18/5	Letter	Owner of business in Kunulla Rd and long term resident of Sylvania Waters. Both properties have never flooded. Sylvania Waters should not be classified as a floodplain.	Noted. Clarified that land has been categorised as Low, Medium or High flood risk, rather than "floodplain" and that this categorisation applies to the land rather than the building.
11	22/5	Letter	Letter from KJ Planning on behalf of resident in Alexander Ave, Taren Point. Concerned regarding accuracy of mapping and impact of designating a property as flood prone.	Noted. Clarified mapping process and flood risk classification. The property in question is only marginally impacted by the low flood risk area.
12	25/5	FPMC Member	Noted that flooding was evident in Parraweena Road on 22 April 2015. Need to ensure that proposed investigations in this area are integrated with other downstream recommendations, and also consider problems further upstream.	Noted. Some minor changes to the recommendations in this area have been made in view of these comments.

The most predominant issue raised in response to the exhibition was a concern that flooding had not been experienced at a particular property or area, and consequently the property or area should not be classified as *"flood prone"*. These comments are possibly more pertinent to the original flood study (which examines flood behaviour) than the current floodplain management study and plan (which investigates what can be done to minimise flooding). Nevertheless, it remains a concern to some residents within the study area.

The floodplain management study dispenses with the notion of a single *"flood prone"* classification, and instead categorises land that could potentially be inundated as either: *"Low Risk"*, *"Medium Risk"*, or *"High Risk"*. This is much the same classification system used for bush fire risk and other natural hazards. It is also important to recognise that the flood risk classification refers to the land, and not the building, within the property. There will be many instances where land may be partially within a flood risk area because of its proximity to a waterway, creek or overland flowpath, but the building is either on higher ground or has a higher floor level and may have no risk of flooding. This issue has been discussed by the floodplain management committee, and has led to a recommendation that flood information sheets be provided to residents, when requested, providing information on the flood liability of both the property and any existing buildings within that property. This is further discussed in Section 8.4.

Some minor changes to the draft report have also been made in response to feedback from the exhibition. These changes include:

i) further discussion of the public exhibition (this section);

ii) that further investigations are included in the floodplain management plan to review potential flooding problems associated with basement car parking, and to formulate options to alleviate flooding problems where applicable; and

iii) investigations to augment the capacity of the Parraweena Road culvert are integrated with other measures that have been proposed further downstream.

4 DESCRIPTION OF FLOOD BEHAVIOUR

4.1 DESIGN FLOOD LEVELS

The *Gwawley Bay Catchment Flood Study* (Bewsher 2012) provides information on flood behaviour for a range of design floods under existing catchment conditions. These results are based on a RAFTS hydrologic model to estimate catchment flows and a TUFLOW hydraulic model to estimate flood levels, depths and velocities.

TUFLOW is a sophisticated two-dimensional computer model that simulates flood behaviour in creeks and channels. The stormwater pipe system and stormwater channels are included in the model as one-dimensional elements that are linked to a two-dimensional grid that represents the surface terrain. When the capacity of the drainage elements is exceeded, floodwater spills onto the surface grid and flows across the floodplain and various overland flowpaths.

The surface terrain is based on digital elevation model that was derived from airborne laser scanning (ALS) survey that was acquired by Council during 2005. This is then represented in the flood model using a 3m x 3m regular grid across the area potentially affected by flooding. All buildings and other structures within the catchment were digitised from aerial photography and included in the flood model.

The model was used to generate design flood conditions for the 5 year, 20 year and 100 year average recurrence interval floods. A probable maximum flood (PMF) was also assessed to provide an upper limit of the potential magnitude of flooding. Maps showing the extent of flood inundation and flood level contours for these events are included in the flood study report. This provides Council with the necessary information to specify minimum building floor levels for new development.

Flood levels were also extracted from the flood model for each property within the study area and assembled within a geographical database as part of the current floodplain management study. The database is intended to assist in identifying problem areas within the catchment and to evaluate various flood management strategies. The database will also assist Council in releasing flood data to the community, either through issuing Section 149 Certificates, Flood Certificates, or when other enquiries are made.

Further information concerning the establishment of the flood model and design flood level results and mapping is provided in the flood study report.

4.2 FLOOD RISK MANAGEMENT PRECINCTS

4.2.1 Introduction

Floodplain management is about managing the risk of flooding across a floodplain or overland flow catchment. Rather than relying on a singular flood (say a 1 in 100 year average recurrence interval event) to identify and manage risks associated with flooding, different probability flood events and flood consequences need to be considered.

The approach to floodplain management within Sutherland Shire evolved from the *Georges River Floodplain Management Study and Plan* (Bewsher 2004), which was prepared for Liverpool, Fairfield, Bankstown and Sutherland Councils. The study recommended that the floodplain of the Georges River be delineated into three different flood risk precincts; namely high, medium and low. Different development controls were proposed for new development

depending on the nature of the development and the flood risk where the development was located.

All four councils adopted this approach and incorporated the recommended development controls within their respective development control plans (DCPs). Whilst originally developed for the Georges River floodplain, the same approach was adopted for other floodplains and catchment areas potentially affected by flooding. A number of other councils throughout NSW have adopted similar flood risk management classifications.

It is important not to confuse 'flood risk' with 'flood hazard' or 'provisional flood hazard'. The terms 'hazard' and 'provisional hazard' are defined in the 2005 *Floodplain Development Manual* and relate to the magnitude of a *specific* flood. For example, a site may experience high hazard conditions in a 100 year flood and low hazard conditions in a 5 year flood. On the other hand, flood risks (as used to define land use planning precincts) do not relate to a single flood, but rather to all floods.

4.2.2 Flood Risk Precincts

The flood risk classification adopted by Sutherland Shire is summarised below. This is consistent with the recommendations provided in the *Georges River Floodplain Management Study and Plan* (Bewsher, 2004) and the *Lower Georges River Floodplain Management Study and Plan* (Bewsher, 2011).

High Flood Risk Precinct is the area of land below the 100 year flood that is either subject to a high hydraulic hazard or where there are significant evacuation difficulties. The high flood risk precinct is where high flood damages, potential risk to life, or evacuation problems are anticipated. Most development should be restricted in this precinct.

Medium Flood Risk is the area below the 100 year flood that is not subject to a high hydraulic hazard and where there are no significant evacuation difficulties. In this precinct there would still be a significant risk of flood damage or risk to life, but these damages and risks can be minimised by the application of appropriate development controls.

Low Flood Risk is all other land that could potentially be inundated (ie within the extent of the probable maximum flood) but not identified as either a high flood risk or a medium flood risk precinct. The low flood risk precinct is that area above the 100 year flood and most land uses would be permitted within this precinct.

4.2.3 Review of Flood Risk Precincts for Gwawley Bay

Flooding within the Gwawley Bay catchment can occur from a number of sources, including: surface runoff across the catchment; surcharging flows from the stormwater pipe system; overtopping of Gwawley Creek and other open drains; or backwater flooding from the Georges River. Whilst inundation within the catchment can occur from any of these sources, a significant component of the flooding problems experienced within the catchment is due to shallow overland flow on its way to Gwawley Creek or the other main drainage channels.

Figure 4.1 illustrates the area of the catchment that is inundated in a 100 year flood. Approximately 32% of this area is inundated by less than 0.1m in depth. The consequence of shallow overland flooding in these areas will be less significant in terms of flood damage and risk to life than flooding that might be experienced immediately adjacent to say the Georges River. Consequently, to maintain the same flood risk classification and development controls in these shallow overland flow areas may be unreasonable.

Similar stormwater catchment studies undertaken for the City of Ryde (Bewsher, 2009) and for Bankstown City Council (Bewsher, 2013) have attempted to identify shallow overland flow areas and to include these areas within a separate overland flow precinct. In the case of the Gwawley Bay catchment these areas were less easily defined as a separate precinct, with shallow areas intermixed with more important overland flowpaths. The introduction of a fourth precinct would also add another layer of flood risk management controls required in Council's DCP.

In view of the above, it is recommended that shallow areas of inundation (less than 0.1m in the 100 year floods) be removed from the medium flood risk precinct and included in the low flood risk precinct. Consideration was given to adopting an inundation depth of 0.2 to 0.3m for this classification, however, this was found to compromise the definition and continuity of important overland flowpaths.

The recommended flood risk management precincts for the Gwawley Bay Catchment are included on **Figure 4.2**.

4.2.4 Floodway Mapping

The merit of mapping floodways throughout the catchment has been considered. Floodways are defined as areas of significant flow that, even if partially blocked, would cause a significant redistribution of flood flow. In the previous Floodplain Development Manual, floodways were delineated on the basis of the product of flood depth and velocity being greater than 1.0 in the 100 year flood. In the case of the current study area, generally all such areas have been identified to be in the high provisional hazard area in the 100 year flood, and therefore have been incorporated into the high flood risk precinct. The proposed planning controls (i.e. those in Council's DCP) prohibit all new development, apart from recreational or non-urban uses, within the high flood risk precinct. Any 'concessional development' for existing property is permissible only upon the conditions that an engineer's report certifies that the development will not increase flood affectation elsewhere, and that safe evacuation is possible. For this reason, it was concluded that a separate exercise to control development within floodways would add little practical value.

LEGEND

Area inundated by more than 0.1m

Area inundated by less than 0.1m

Georges River

Captain Cook Bridge

Sylvania

Holt Rd

Gwawley Bay

Sylvania Waters

Gwawley Creek

Woolooware Bay

Taren Point

Box Rd

Princes Highway

Sylvania Rd

Taren Point Rd

Bay Rd

Box Rd

Gymea

Port Hacking Rd

Parraweena Rd

The Boulevarde

Miranda

Caringbah

Kingsway

N

0 250 500

metres

FloodMit

Job No: J1325
File: J1325_Fig4-1.wor
Date: 2/2/15

Figure 4.1
Extent of Inundation in 100 year Flood Including Shallow Overland Flow Areas

LEGEND

- Low Flood Risk Precinct
- Medium Flood Risk Precinct
- High Flood Risk Precinct
- Normal Waterway Area (included in High Risk Precinct)

N

0 250 500
metres

Georges River

Captain Cook Bridge

Sylvania

Holt Rd

Gwawley Bay

Sylvania Waters

Woolooware Bay

Gwawley Creek

Box Rd

Princes Highway

Sylvania Rd

Taren Point

Taren Point Rd

Bay Rd

Box Rd

Port Hacking Rd

Parraweena Rd

Gymea

The Boulevarde

Miranda

Caringbah

Kingsway

FloodMit

Job No: J1325
File: J1325_Fig4-2.wor
Date: 2/2/15

Figure 4.2
Recommended Flood Risk Management Precincts for Gwawley Bay Catchment

4.3 SUMMARY OF PROPERTY INUNDATION

A flood damages database has been prepared for the study area. The database provides information on properties and buildings that are potentially affected by flooding in the study area. The database has been used to estimate flood damages and to highlight problem areas within the catchment. It has also been used to evaluate the economic merit of various flood mitigation measures considered in this report.

A summary of homes and other buildings estimated to be inundated above floor level is included in **Table 4.1**. There are 166 residential buildings and 68 commercial or industrial buildings that are estimated to be inundated in the 100 year flood. The flood problem is significantly exacerbated in more extreme flood events. A total of 868 residential buildings and 104 commercial or industrial buildings are estimated to be inundated in a PMF event.

Table 4.1
Summary of Buildings Inundated in Different Events

Flood Event	Residential	Commercial and Industrial	Total
20 Year	119	53	172
100 Year	166	68	234
PMF	868	104	972

The depth of inundation for homes and other buildings estimated to be inundated above floor level in the 100 year flood is summarised in **Table 4.2**. It is evident that about half of these buildings are inundated by less 0.2m in a 100 year flood. As the typical accuracy for estimating floor levels where survey levels are not available is of the order of ±0.2m, some care needs to be taken when referring to or identifying individual properties that may be affected.

There are other uncertainties when predicting areas of shallow inundation, which may be influenced by local features such as fences, walls, landscaping, or other obstructions that may not be fully represented in the flood model.

Table 4.2
Depth of Above Floor Flooding for Buildings Inundated in the 100 year Flood

Depth over Floor in 100 year Flood	Residential	Commercial and Industrial	Total
0.0 to 0.2m	84	34	118
0.2 to 0.4m	36	17	53
0.4 to 0.6m	23	11	34
0.6 to 0.8m	11	3	14
0.8 to 1.0m	6	2	8
Greater than 1.0m	6	1	7
	166	68	234

The location of buildings potentially inundated above floor level in a 100 year flood is provided in **Table 4.3** and shown on **Figure 4.3**.

Table 4.3
Buildings Inundated in 100 Year Flood (by Location)

Area	Buildings Inundated above floor level in 100yr flood		
	Residential	Commercial and Industrial	Total
1. Gwawley Creek (South of Box Rd)	36	2	38
2. Gwawley Creek (North of Box Rd)	26	0	26
3. Southgate Branch	20	0	20
4. Southern Branch	12	13	25
5. Eastern Branch (Parraweena Rd)	2	32	34
6. Sylvania Waters	70	6	76
7. Production Rd Channel	0	15	15
TOTAL	**166**	**68**	**234**

These results show a number of hotspots throughout the catchment in a 100 year event, where floodplain management options could be considered to alleviate these problems. These areas include:

i) Various overland flow problems, which are distributed relatively evenly throughout the catchment, but particularly between The Boulevarde and Meadow Place (28 homes) and between Roma Place and Holt Road (8 homes) in the Gwawley Creek catchment.

ii) Up to 8 homes immediately upstream of the Southgate Shopping Centre, between Formosa Street and Juniper Place. These homes experience the greatest inundation depths within the catchment, with 6 of the 8 homes inundated by more than 1.0m in a 100 year event.

iii) Up to 6 homes in Dalman Place, downstream of the Southgate Shopping Centre, as this road becomes a major overland flow path towards Gwawley Creek.

iv) A number of industrial complexes near the intersection of Port Hacking Road and Garnet Road, in the southern catchment area. An upstream open drain passes under these buildings.

v) Up to 46 townhouse units (not all may be at ground level) at 3 Ramu Close, in Sylvania Waters. Inundation depths up to 0.6m are experienced by some of these units.

vi) Industrial development located between Kumulla Road, Parraweena Road and Box Road, in the eastern catchment. This area is also reported to have had significant flooding problems in the past.

vii) A number of homes in Sylvania Waters, including homes on Murray Island (7 homes), Goulburn Peninsular (9 homes) and Hawkesbury Esplanade (6 homes). One home on Murray Island has a surveyed floor level of RL 1.13m AHD, which at this level could be inundated by tidal conditions alone on almost an annual basis. Many of the homes in Sylvania Waters are located just above the estimated 100 year flood level. Many of these homes will be sensitive to small variations in flood levels, or the accuracy of estimated floor levels.

viii) A number of industrial buildings between Box Road and Bay Road, in the Production Road channel catchment. Many of these buildings have reported flooding in the past.

LEGEND

Building inundated in 20 Year Flood

Building inundated in 100 Year Flood

Building inundated in PMF Flood

Georges River

Captain Cook Bridge

Sylvania

Holt Rd

Gwawley Bay

Sylvania Waters

Gwawley Creek

Woolooware Bay

N

0 250 500

metres

Princes Highway

Sylvania Rd

Box Rd

Taren Point

Taren Point Rd

Bay Rd

Box Rd

Gymea

Port Hacking R

Parraweena Rd

The Boulevarde

Miranda

Caringbah

Kingsway

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Figure 4.3
Buildings Potentially Inundated above Floor Level in Various Events

4.4 ROAD INUNDATION PROBLEMS

An understanding of where roads are likely to be cut by floodwater is an important issue for residents within the catchment. Residents that are directly affected may need to evacuate their homes. Other residents may be indirectly affected where road closures restrict them travelling to or from work, school, or other destinations.

Road access is also an important issue for the planning of emergency management operations in response to flooding. Emergency personnel need to know which roads are likely to be inundated, and the possible depth in a major flood. There may also be opportunities to identify critical locations where road raising or other drainage improvements are desirable for improved flood access.

Inundation depths have been determined for all roads in the study area that are estimated to be inundated in a 100 year flood. Inundation depths have been determined by subtracting the 100 year flood level from a digital terrain model of the catchment derived from Council's ALS survey. Inundation depths have been trimmed to the road reserve and colour coded to represent different flood depths over the road, as shown on **Figure 4.4**. The location and inundation depths at major arterial roads (greater than 0.3m) and other local roads (greater than 0.6m) are included in **Table 4.4**.

Table 4.4
Road Inundation Problem Locations (Inundated in 100 year flood)

Ref *	Location (Refer to Figure 4.4)	Depth (m)
Major Arterial Roads (Greater than 0.3m inundation)		
1	Port Hacking Rd, Miranda (opposite Garnet Rd)	Over 1.0m
2	Port Hacking Rd, Miranda (300m north of Garnet Rd)	0.6 to 1.0m
3	Port Hacking Rd, Sylvania (at Gwawley Creek)	0.3 to 0.6m
4	Taren Point Rd, Taren Point (Bay Rd to Holt Rd)	0.3 to 0.6m
5	Taren Point Rd, Caringbah (at Parraweena Rd)	0.3 to 0.6m
Local Roads (Greater than 0.6m inundation)		
6	Formosa St, Sylvania (Southgate)	Over 1.0m
7	Juniper Pl, Sylvania (near Southgate)	Over 1.0m
8	Jean Ave, Miranda	Over 1.0m
9	Gabo Pl, Gymea	Over 1.0m
10	Taiwan Pl, Sylvania	Over 1.0m
11	Parraweena Rd, Miranda (near Taren Point Rd)	0.6 to 1.0m
12	Parraweena Rd, Miranda (near Meldrum Ave)	0.6 to 1.0m
13	Meldrum Ave, Miranda	0.6 to 1.0m
14	Nyngan Pl, Miranda	0.6 to 1.0m
15	Dalman Pl / Evelyn St, Sylvania	0.6 to 1.0m
16	Belgrave Esp / Goulburn Peninsula, Sylvania Waters	0.6 to 1.0m
17	Murray Island, Sylvania Waters (north-east side)	0.6 to 1.0m
18	Miranda Rd, Miranda (near Five Ways)	0.6 to 1.0m
19	Violet St, Miranda (near Jason St)	0.6 to 1.0m
20	Corea St / Meadow Pl, Miranda	0.6 to 1.0m
21	Amos Pl, Sylvania	0.6 to 1.0m
22	Leichhardt Cr, Sylvania	0.6 to 1.0m

* Locations shown on Figure 4.4

Inundation Depth Over Road

- Up to 0.3m
- 0.3 to 0.6m
- 0.6 to 1.0m
- Over 1.0m

1 Refer to Table 4.4 for Locations

Georges River

Captain Cook Bridge

Sylvania

Gwawley Bay

Sylvania Waters

Woolooware Bay

Gwawley Creek

Holt Rd

Box Rd

Princes Highway

Sylvania Rd

Taren Point

Taren Point Rd

Bay Rd

Box Rd

Port Hacking Rd

Parraweena Rd

Gymea

The Boulevarde

Miranda

Caringbah

Kingsway

7 6 15 17 3 10 22 21 20 4 16 2 1 14 12 13 11 5 19 8 9 18

N

0 250 500

metres

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Figure 4.4
Road Inundation Problem Areas
(100 year Flood)

5 FLOOD DAMAGE ASSESSMENT

5.1 FLOOD DAMAGES DATABASE

The preparation of a flood damages database is an important component of the floodplain management study. The database provides information on properties that could potentially be inundated for various events. It allows problem areas to be identified so that options can be investigated in these areas. It also provides flood damage estimates that can be used to evaluate the economic benefits of undertaking various options within the catchment.

The database includes information on:

i) property details (address and Lot & DP numbers);

ii) the type of property (residential, commercial, industrial);

iii) an estimate of the number of ground floor units within the building (where applicable);

iv) the ground level adjacent to the building, based on field survey or estimated using a terrain model developed from Council's Airborne Laser Scanning (ALS) survey;

v) the surveyed floor level (where available) or an estimate based on available Streetview photography;

vi) a digital photo of buildings that have been surveyed, linked to the database;

vii) flood levels for the 20 year, 100 year, and PMF floods; and

viii) a damage code to select an appropriate stage-damage curve to be applied to each building.

The data is represented as both a property database in GIS format, and as a flood damages database (including damage calculations) in Lotus 123 format.

5.2 SELECTION OF PROPERTIES IN DATABASE

There are approximately 7,000 residential, commercial or industrial buildings within the study area. Only some of these buildings will be potentially affected by flooding and need to be included in the database.

Each building is represented spatially by a digitised polygon, which represents the size and location of the building footprint. These polygons were derived as part of Council's ALS survey acquired in 2005. Some changes to building footprints are inevitable since this time, as redevelopment within the catchment occurs. However, the location of buildings at this time provides a good starting point for defining problem areas within the catchment and in counting the costs of flooding.

Buildings that are included in the property database are those that have some part of their footprint within the 100 year flood extent. A total of 1,532 buildings were identified on this basis. This does not mean that all of these buildings will be inundated. Most of these buildings will be elevated above ground level, and may have no likelihood of being inundated above floor level in any event. Minor structures, such as garages and sheds, were not included.

Some buildings contain a number of separate residential or business units within a single building footprint. For example, there may be a number of units contained within a block of apartments, or there may be a number of business units within a particular building complex. In these circumstances, the number of ground floor units was estimated. The number of units is then used as a multiplying factor when determining flood damages.

5.3 GEOGRAPHICAL BOUNDARIES

The catchment area has been subdivided into a number of smaller geographical areas so that the distribution of flood problems across the study area can be quantified. These areas are largely based on catchment boundaries, or areas that have common flooding issues, rather than suburb boundaries.

A total of 7 different geographical areas have been defined for the property database, as shown on **Figure 5.1**. The number and type of buildings included in each area are summarised in **Table 5.1**.

Table 5.1
Buildings included in the Property Database

Area	Description	Buildings included in Property Database		
		Residential	Commercial and Industrial	Total
1	Gwawley Creek (South of Box Rd)	281	5	286
2	Gwawley Creek (North of Box Rd)	194	0	194
3	Southgate Branch	115	3	118
4	Southern Branch	220	25	245
5	Eastern (Parraweena Rd) Branch	28	69	97
6	Sylvania Waters	558	9	567
7	Production Rd Channel	0	25	25
	TOTAL	1,396	136	1,532

5.4 BUILDING FLOOR LEVELS

The potential for flooding to be experienced at each building was reviewed on the basis of the area and depth of the building footprint inundated in a 100 year flood. These buildings were identified towards the end of the Flood Study, and subsequently surveyed by council during 2010. A total of 288 building floor levels were surveyed.

Some 33 other building floor levels were also available in the Parraweena Road to Box Road area from a floor level survey that was completed in 1993.

All remaining floor levels in the database were estimated visually using Google Streetview. The height of the floor level was estimated visually from the available Streetview photography, and this height added to the ground level at the point of observation from Council's ALS survey. The floor level using this approach has a typical accuracy of ±0.2m. It is noted that there were a few instances where suitable photography was unavailable, or where further development has occurred since the date of the photography.

The floor level estimates are considered appropriate for the purpose of identifying potential problem areas within the study area, and for deriving flood damage estimates across the catchment. The levels must be treated with some caution, however, and should not be used to provide advice on an individual property basis, or included on Section 149 certificates

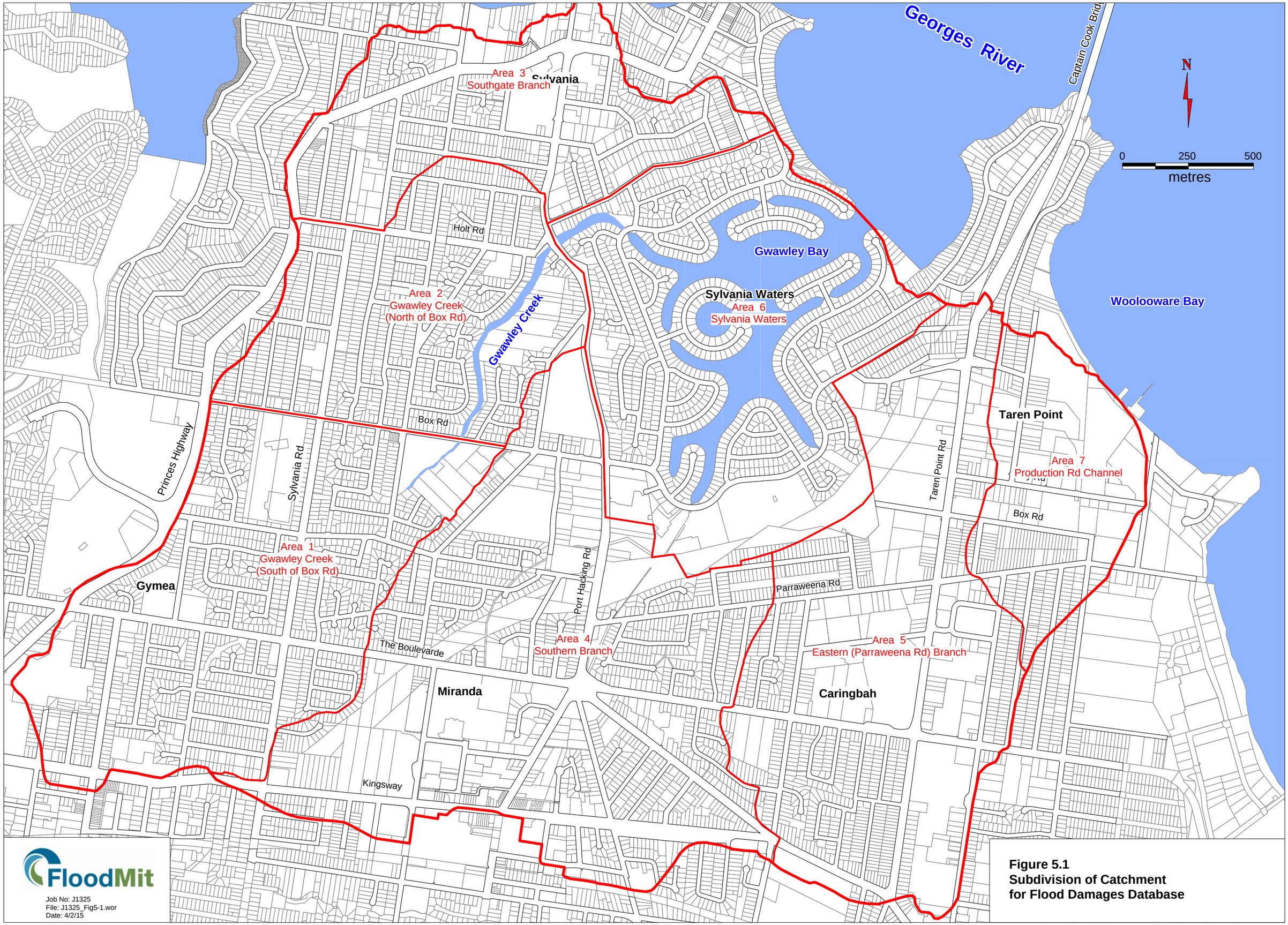

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Figure 5.1
Subdivision of Catchment for Flood Damages Database

5.5 TYPES OF FLOOD DAMAGE

The types of flood damages examined in this study are summarised in **Figure 5.2**. The main categories include 'tangible' and 'intangible' flood damages. Tangible flood damages are those that can be more readily evaluated in monetary terms, while intangible damages relate to the social cost of flooding and therefore are much more difficult to quantify.

Tangible flood damages are further divided into direct and indirect damages. Direct flood damages relate to the loss or loss in value of an object or a piece of property caused by direct contact with floodwaters. Indirect flood damages relate to loss in production or revenue, loss of wages, additional accommodation and living expenses, and any extra outlay that occurs because of the flood.

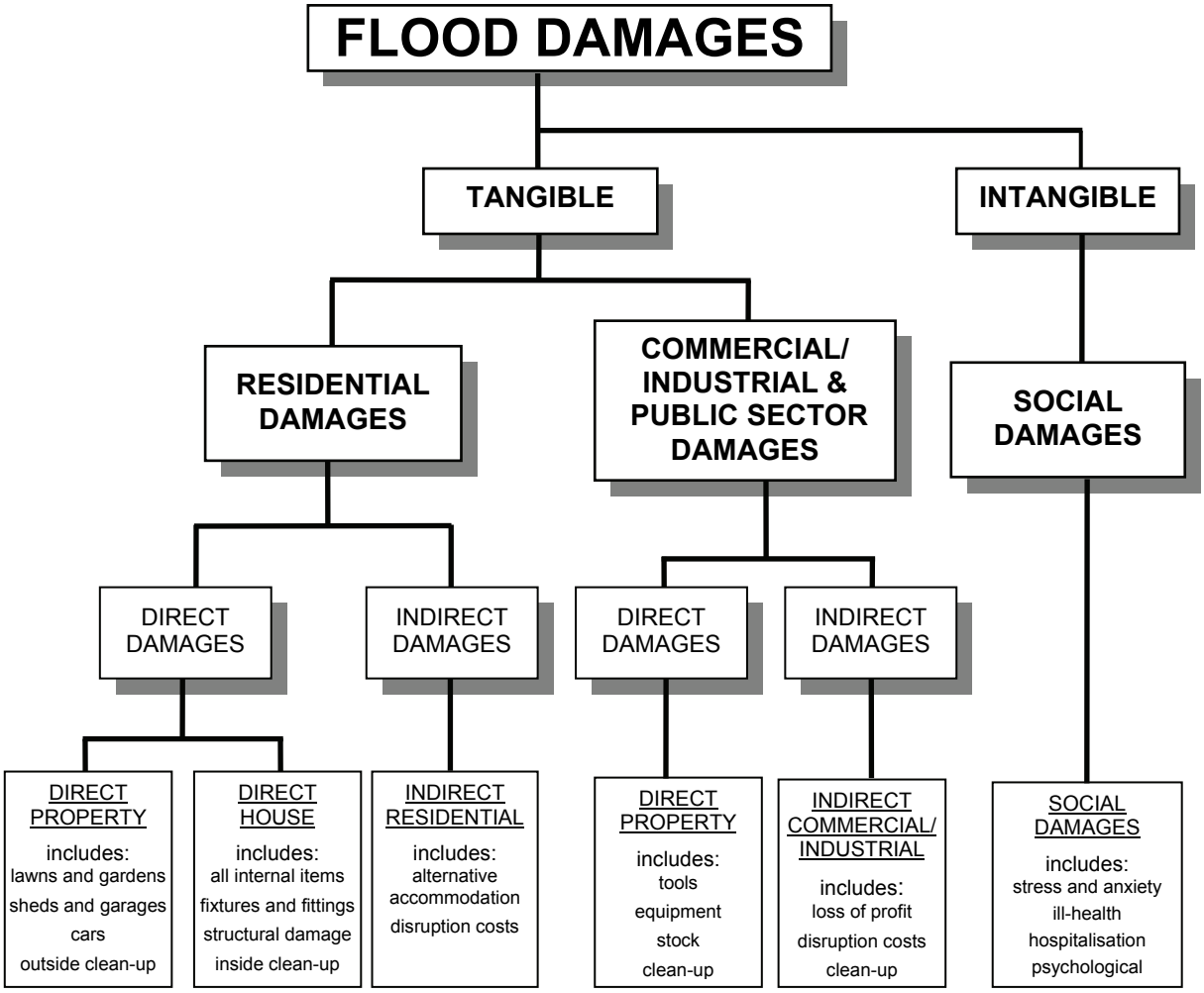

FIGURE 5.2
Types of Flood Damage

5.6 BASIS OF FLOOD DAMAGES CALCULATIONS

Potential flood damages have been calculated by applying a number of stage-damage curves to each building in the property database. These curves relate the amount of flood damage that would potentially occur at different depths of inundation, for a particular building type.

Guidelines for the preparation of site-specific *residential* stage-damage curves are available (DECCW, October 2007). The guidelines provide for the development of representative stage-damage curves for typical houses in different floodplains, based on work undertaken by the Risk Frontiers in the Natural Hazards Research Centre at Macquarie University. This approach is recommended by OEH to ensure the consistent assessment of flood mitigation projects across NSW. The new procedures have been adopted for estimating residential flood damages within the Gwawley Bay catchment. Commercial and industrial flood damage estimates have been determined on the basis of previous flood damage surveys undertaken in NSW.

The different flood damage components are further discussed below.

5.6.1 Residential

Residential flood damages have been calculated in accordance with guidelines listed above. This is based on standardized stage-damage curves representing low set buildings, high set buildings and two-storey buildings. The standard damage curves have been adjusted based on a number of parameters specific to the study area, including:

i) regional cost variations (1.0);

ii) average house size (240m^2);

iii) typical duration of immersion (6 hours);

iv) average contents value ($60,000);

v) level of flood awareness (low);

vi) effective warning time (1 hour); and

vii) damage reduction factor (ratio of actual to potential losses) of 0.96 based on the flood awareness and effective warning time.

Damage estimates for ground floor units or small villas were further reduced by 25% to account for the likely reduction in flood damages to these premises due to their smaller size.

It is noted that the residential stage-damage curves make allowance for both clean-up costs ($5,900 per flooded house) and the cost of time in alternative accommodation. Nevertheless, a further measure of indirect damages has been estimated by taking 20% of the total direct damages, in keeping with advice received from OEH.

5.6.2 Commercial/Industrial

No standard stage-damage curves are available for *commercial* and *industrial* damages. The stage-damage relationships used to estimate these damages in this study were based on specific consideration of the types of development within the catchment, information available from previous investigations, and flood damage surveys undertaken following major floods in Coffs Harbour (1996); Inverell (1991); Forbes (1990); Nyngan (1990); and the Georges River (1986). For consistency with the residential damages assessment, predicted losses were estimated by applying a ratio of actual to potential damages of 0.96. Indirect commercial/industrial losses were estimated as 20% of direct actual commercial/industrial damages, in accordance with advice received from OEH.

5.6.3 Infrastructure

The predicted value of damage to infrastructure (including roads and bridges, water supply and sewerage, electricity and telephone supplies, natural gas supplies) has been estimated at 15% of the 'total damages'. No allowance has been made for possible damage reduction in response to flood warnings.

5.6.4 Motor Vehicles

Losses to private motor vehicles have been modelled as a separate component of the process. This is to ensure that the assessment of flood mitigation measures is not unduly influenced by this component of damages. It has been assumed that there are on average 1.7 motor vehicles per residential household in the study area, based on data from the Australian Bureau of Statistics. Assuming that about 25% of these cars will be present during working hours (40 hours per week), and 90% will be present during non-working hours (128 hours per week), then the expected number of vehicles present at any given time that a flood may occur is estimated at about 1.3 per household.

Vehicles are assumed to be at the ground level assigned to each dwelling in the database. Based on insurance data from the Katherine flood (Jan 1998), Wollongong flood (Aug 1998) and Canberra bushfire (Jan 2003), it is assumed that the average cost of a written-off motor vehicle is of the order of $12,000. Damage is expected to begin at a depth over the ground of 0.3m, and a write-off is assumed to occur at a depth of 0.6m over the ground.

5.6.5 Social

Intangible, or social, flood damages are not readily quantifiable in monetary terms. Physical contact with floodwaters can cause residents to suffer physical and mental impacts to their health. Evacuation, the loss of personal property and cleaning up can trigger significant stress and trauma. While difficult to quantify, in keeping with advice received from OEH, social damages have been estimated as 25% of 'total damages', which are interpreted as the sum of direct residential damages and direct commercial/industrial damages.

5.7 ECONOMIC ASSESSMENT

Flood damages under existing conditions have been calculated for each building in the flood damages database for the following floods:

i) 5 Year flood ;

ii) 20 Year flood;

iii) 100 year flood; and

iv) the PMF event.

Flood Damages are summed throughout the catchment to provide the total flood damage for each flood. The 'average annual damage' (AAD) and 'present value' of flood damage is also calculated. These are financial terms that are often used in the economic appraisal of flood damages and flood mitigation measures. The AAD is a measure of the cost of flood damage that could be expected each year, on average, by the community. The present value of flood damage is usually calculated to allow a direct comparison with the capital and on-going costs of proposed flood mitigation measures. This has been determined on the basis of a 7% discount rate and an expected life of 20 years, in accordance with guidelines provided by the NSW Treasury.

The flood damages database provides a valuable tool for assessing the economic merits of potential flood mitigation measures that may be considered throughout the study area. Flood

level estimates within the flood damages database can be readily updated to reflect new conditions arising from proposed flood mitigation measures. The flood damages are then recalculated and the savings in flood damages can be calculated.

5.8 SUMMARY OF FLOOD DAMAGES

Flood damage calculations have been determined from the flood damages database for various areas within the study area. **Table 5.2** summarises the predicted flood damages for a range of floods, including estimates of the annual average flood damage and the present value of flood damage. **Figure 5.3** shows the total estimated flood damage for various floods, whilst **Figure 5.4** shows the different components of flood damage in the Gwawley Bay catchment.

TABLE 5.2
Predicted Total Flood Damages under Existing Conditions

Area	Damage in Flood Event ($M)			Average Annual Damage ($M)	Present Value of Damage ($M)
	20 Yr	100 Yr	PMF		
1. Gwawley Creek (South of Box Rd)	6.0	7.1	15.8	1.3	13.4
2. Gwawley Creek (North of Box Rd)	3.8	4.5	8.4	0.8	8.8
3. Southgate Branch	4.0	4.6	9.5	0.9	9.2
4. Southern Branch	6.9	8.2	20.4	1.4	15.2
5. Eastern (Parraweena Rd) Branch	3.4	4.7	12.8	0.8	8.1
6. Sylvania Waters	9.1	13.9	47.2	2.0	21.0
7. Production Rd Channel	0.9	1.1	3.0	0.2	2.0
TOTAL	**34.0**	**44.0**	**117**	**7.3**	**77.6**

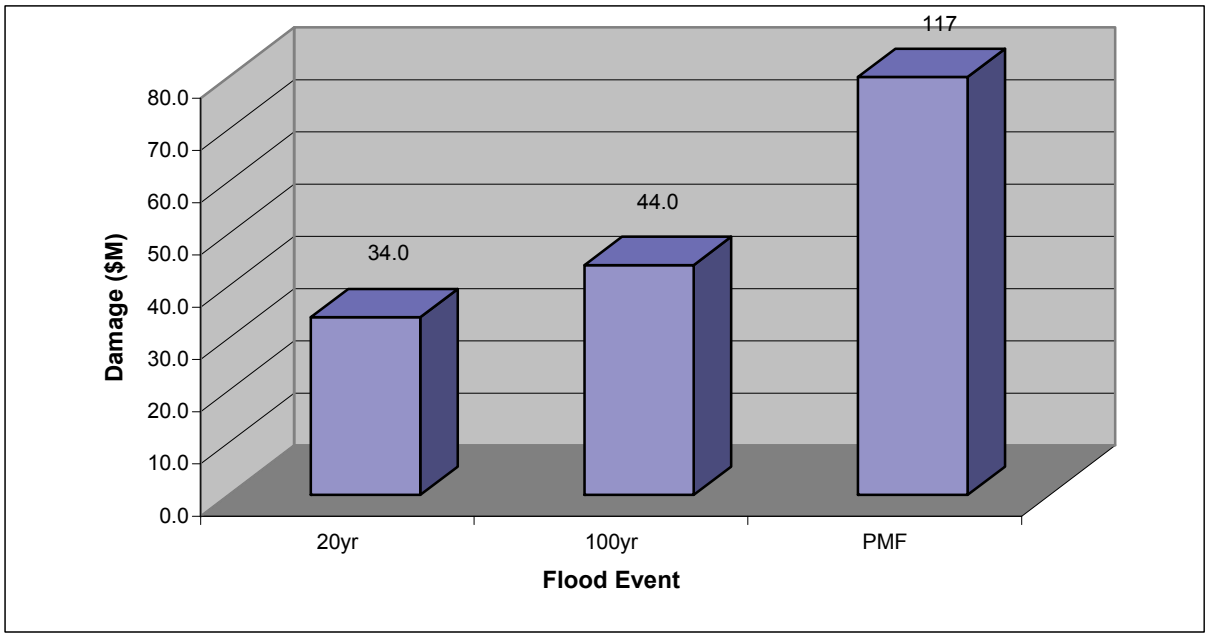

FIGURE 5.3
Total Estimated Flood Damage for Different Floods

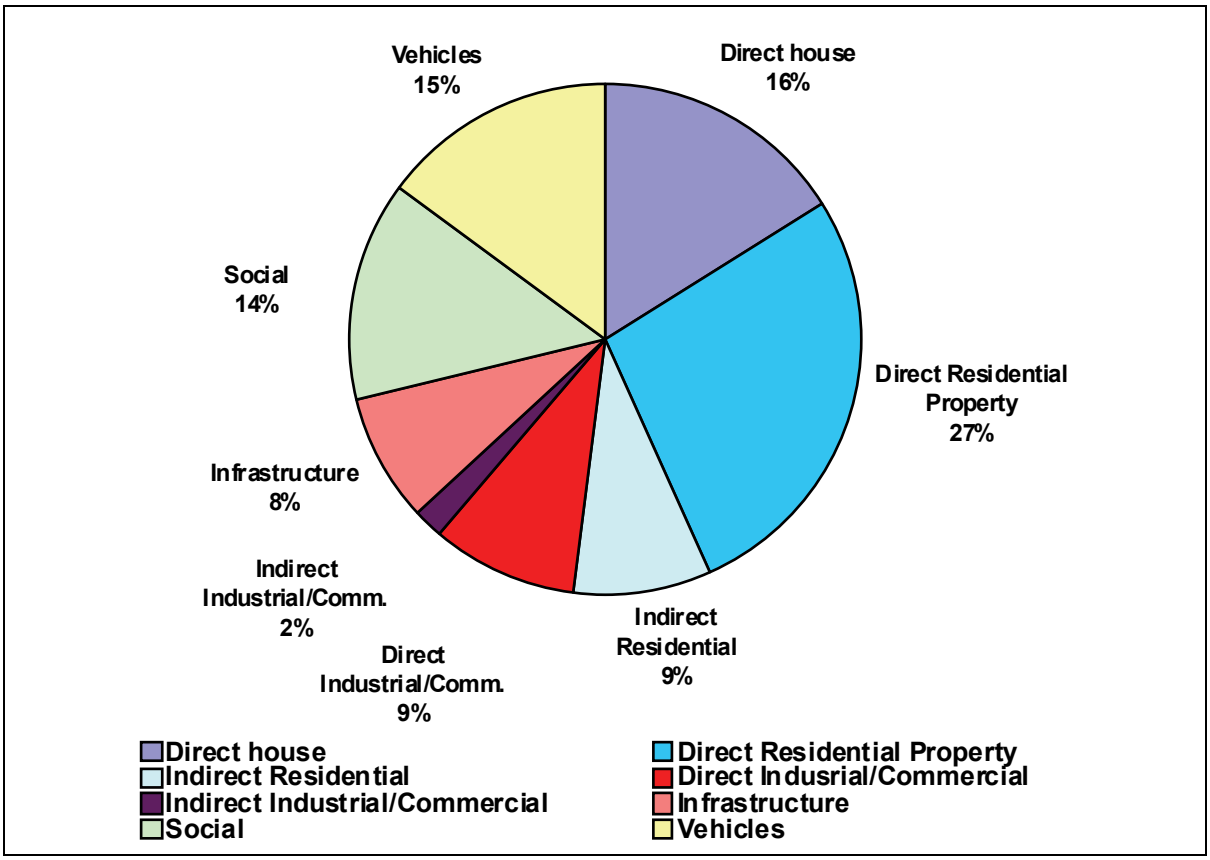

FIGURE 5.4
Components of Flood Damage
(Average Annual Damage)

The following points are relevant from the above results:

i) Components of expected average annual flood damages within the study area are estimated as:

- Direct House Damage	$1.2M	(16%)
- Direct Property Damage	$2.0M	(27%)
- Indirect Residential Damage	$0.6M	(9%)
- Direct Industrial & Commercial	$0.7M	(9%)
- Indirect Industrial & Commercial	$0.1M	(2%)
- Infrastructure & Public Sector Damage	$0.6M	(8%)
- Vehicular damage (residential)	$1.1M	(15%)
- Social Damages	$1.0M	(14%)
- TOTAL	$7.3M	

ii) The estimated total flood damage in a 100 year flood is $44M. This is the total flood damage that could be expected in a major flood.

iii) The present value of future flood damage is estimated at $78M.

iv) The estimated total average annual flood damage (from all floods) is $7.3M per annum. This is the long term average cost to the community every year as a result of flooding.

v) The highest damage cost throughout the study area is sustained by the residential sector. Most of this damage is incurred to property around homes and clean up costs (27%) rather than direct damage caused by inundation of homes above floor level (16%).

vi) The distribution of annual average flood damage across the different catchment areas is as follows:

Gwawley Creek (South of Box Rd)	$1.3M	(17%)
Gwawley Creek (North of Box Rd)	$0.8M	(11%)
Southgate Branch	$0.9M	(12%)
Southern Branch	$1.4M	(19%)
Eastern (Parraweena Rd) Branch	$0.8M	(11%)
Sylvania Waters	$2.0M	(27%)
Production Rd Channel	$0.2M	(3%)

vii) The most significant flood damage (27%) is experienced in the Sylvania Waters area, particularly in extreme flood events, which would inundate proportionately greater number of homes than elsewhere in the catchment.

viii) Other flood problems are relatively evenly spread throughout the catchment.

6 FLOODPLAIN MANAGEMENT CONSIDERATIONS

6.1 THE FLOOD PLANNING LEVEL

6.1.1 Introduction

The flood planning level is the flood level selected for flood risk management planning purposes. The area of land that is affected by the flood planning level is known as the flood planning area.

The main application of the flood planning level is in specifying minimum floor levels for new residential development and other premises, but it is also applied to secondary matters including parking levels, access conditions, structural soundness and other management considerations. The selection of the flood planning level is therefore an important component of a floodplain management study.

Historically, the majority of councils within NSW have adopted a singular flood planning level, most commonly the 100 year flood level plus 0.5m freeboard, for all development types and controls. The adoption of a singular flood planning level has a number of disadvantages. It can be unduly restrictive to minor development types, such as playing field facilities and minor property extensions. It may also be desirable to include a higher level of protection for sensitive land uses and critical facilities, including hospitals and evacuation centres.

6.1.2 Sutherland Shire's Approach

To overcome the shortcomings of a singular flood planning level, a graded set of controls that consider the variation of risk with flood frequency and landuse was adopted by Sutherland Shire following recommendations in the *Georges River Floodplain Risk Management Study and Plan* (Bewsher, 2004). In essence, the approach makes use of a range of flood planning levels for various land uses within the area potentially affected by flooding.

The 100 year flood level plus 0.5m freeboard is, however, still the principal floor level control for residential land uses.

6.1.2 Flood Planning Guideline

On 31st January 2007 the NSW Planning Minister announced a guideline for development controls on floodplains (the *"2007 Flood Planning Guideline"*). The guideline in effect relates to a package of directions and changes to the Environmental Planning and Assessment Act, Regulation and Floodplain Development Manual.

The Guideline confirms that unless there are *"exceptional circumstances"*, Councils are to adopt the 100 year flood as the flood planning level for residential development, with the exception of some sensitive forms of residential development such as seniors living housing. Controls on residential development above the 100 year flood may be imposed subject to *"exceptional circumstances"* justification being agreed to by the Department of Natural Resources (now the Office of Environment and Heritage) and the Department of Planning prior to the exhibition of a draft LEP or draft DCP.

The guideline provides some conflicting information regarding the inclusion of freeboard within the flood planning level. Senior officers from both departments subsequently confirmed that the residential flood planning level should also include a freeboard allowance of typically 0.5m.

6.1.3 Inclusion of a Sea Level Rise Allowance

A Sea Level Rise Policy Statement was issued by the NSW Government in October 2009 (DECCW, 2009). The policy statement nominates sea level rise planning benchmarks to be considered by consent authorities when dealing with development approvals in the coastal zone. The planning benchmarks are an increase above 1990 mean sea levels of 40cm by 2050 and 90cm by 2100. The policy also notes that *"planning and investment decisions should consider the sea level rise projections over time frames that are consistent with the intended timeframes of the decision"* and that *"these decisions should consider likely levels over the expected life of an asset"*.

The *NSW Coastal Planning Guideline* (NSW Govt, August 2010) recommends that flood planning areas include an allowance for sea level rise, and that intensification of landuse in these areas should be avoided through appropriate strategic and landuse planning. The *Flood Risk Management Guide* (NSW Govt, August 2010) further notes that any projected increase in flood levels arising from future sea level rise should not be considered as being included in the usual 0.5m freeboard allowance when specifying building controls.

In line with the above guidelines, the *Lower Georges River Floodplain Management Study* (Bewsher, 2011) recommended that a separate sea level rise allowance of 0.4m (based on the 2050 planning benchmark) be applied to the majority of new infill residential development along the Lower Georges River. This allowance would similarly apply at the mouth of Gwawley Bay, and progressively diminish away from the river.

On 8th September 2012 the NSW Government announced the first stage of a number of coastal management reforms, which included the removal of the uniform adoption of the sea level rise planning benchmarks previously specified. In their place, Council now has the flexibility to adopt different sea level rise allowances based on local conditions.

In the absence on more detailed information on sea level rise projections for Botany Bay and the Lower Georges River, it is recommended that Council maintains the planning benchmarks previously nominated by the State Government. These levels should be monitored and reviewed as further data and analysis becomes available.

6.1.4 Recommendations for Gwawley Bay Catchment

The 100 year flood level (plus freeboard) has been retained as the principal floor level control for residential land uses in the study area. This decision was based on a consideration of:

i) the unacceptable increase in flood risks and damages, should a lower level be adopted;

ii) an unacceptable impost on future development, if a higher level was adopted;

iii) inconsistencies with recent development approvals if a level different from the 100 year flood was adopted;

iv) consistency with the 2007 Flood Planning Guideline;

v) recognition that the community views the residential floor level control as the principal component of the Council floodplain controls, and that changes to this control should not be made unless very strong arguments exist.

In addition to the 0.5m freeboard, a sea level rise allowance should also be included when specifying minimum floor level controls for future development affected by sea level rise projections. Further quantification of sea level rise impacts throughout the study area is included in Section 6.2.

6.2 CLIMATE CHANGE CONSIDERATIONS

Design flood levels provided in the *Gwawley Bay Flood Study* (Bewsher, 2012) and the flood risk mapping recommended in this floodplain management study are based on existing conditions, and include no allowance for potential climate change impacts.

The sensitivity of design flood levels to potential climate change impacts is nevertheless an important consideration when dealing with future development proposals. It is also important that floodplain management measures are adaptable to these potential impacts.

Future climate change can potentially affect flood behaviour through:

i) increased sea levels; and
ii) increased severity of flood producing storms or other weather systems.

6.2.1 Impact of Future Sea Level Rise

Global mean sea level is estimated to have increased by 0.19m over the period from 1901 to 2010. It has also been estimated to increase by an average of 3.2mm/year since 1993 (IPCC, 2014). Further acceleration is likely as a result of thermal expansion from future warming, and the melting of glaciers, the Greenland ice sheet and the Antarctic ice sheet.

Sea level rise around the Australian coastline by 2100 is likely to be similar to the projected global rise of 0.28 to 0.61m under a low greenhouse gas emissions scenario or 0.52 to 0.98m under a high emissions scenario (CSIRO, 2014). Under all scenarios, sea level will continue to rise after 2100, with estimates ranging from 1.0m to more than 3.0m by 2300.

Flooding in the Lower Georges River is dominated by tide and oceanographic conditions in Botany Bay. The *Lower Georges River Floodplain Management Study* (Bewsher, 2011) investigated the sensitivity of sea level increases of up to 0.9m on the 100 year design flood level in the Lower Georges River. The results indicated that an increase in sea level would result in an equivalent increase in the design 100 year flood level between Botany Bay and the Como Railway Bridge. After this point, the impact gradually diminishes with increasing distance upstream.

The impact of sea level rise will similarly affect design flood levels at the mouth of Gwawley Bay, and will fairly rapidly diminish away from the river.

Figure 6.1 shows the impact of a sea level rise of +0.4m on the design 100 year flood within the Gwawley Bay catchment, based on the previously nominated sea level rise planning benchmark for the year 2050. The main area that would be impacted by such an increase is the waterway area of Gwawley Bay, including low lying areas of Murray Island and Barcoo Island. James Cook Island and low lying areas on Hawkesbury Esplanade are impacted to a lesser degree. There are negligible impacts (less than 0.1m) upstream of Belgrave Esplanade in the Gwawley Creek catchment and Southern Branch. An impact of 0.1 to 0.2m extends within the Eastern (Parraweena Rd) Branch up to Box Road, and then reduces to less than 0.1m further upstream. Impacts in the Production Road channel extend up to Bay Road.

Figure 6.2 similarly shows the impact of a sea level rise of +0.9m, based on the previously nominated sea level rise planning benchmark for the year 2100. This would result in more significant impacts within the Sylvania Waters area, including inundation of additional areas not previously flooded. The impact in the Gwawley Creek catchment extends upstream to Port Hacking Road, and to Nyngan Place in the Southern Branch. The impact at Box Road in the Eastern (Parraweena Rd) Branch increases by up to 0.5m, but diminishes quickly further upstream. Impacts in the Production Road channel further increase and extend upstream to Box Road.

LEGEND

Impact of 0.4m Sea Level Rise Increase on Design 100 Year Flood Levels

- +0.3 to +0.4m
- +0.2 to +0.3m
- +0.1 to +0.2m
- Less than +0.1m
- Newly inundated area

Georges River

Captain Cook Bridge

Sylvania

Holt Rd

Gwawley Bay

Sylvania Waters

Gwawley Creek

Box Rd

Woolooware Bay

N

0 200 400

metres

Taren Point

Taren Point Rd

Bay Rd

Box Rd

Princes Highway

Sylvania Rd

Port Hacking Rd

Parraweena Rd

Gymea

The Boulevarde

Miranda

Caringbah

Kingsway

FloodMit

Job No: J1325
File: J1325_Fig6-1.wor
Date: 9/2/15

Figure 6.1
Impact of 0.4m Sea Level Rise Increase on Design 100 Year Flood Levels

LEGEND

Impact of 0.9m Sea Level Rise Increase on Design 100 Year Flood Levels

- +0.8 to +0.9m
- +0.7 to +0.8m
- +0.6 to +0.7m
- +0.5 to +0.6m
- +0.4 to +0.5m
- +0.3 to +0.4m
- +0.2 to +0.3m
- +0.1 to +0.2m
- Less than +0.1m
- Newly inundated area

Georges River

Captain Cook Bridge

N

0 200 400

metres

Woolooware Bay

Sylvania

Holt Rd

Gwawley Creek

Gwawley Bay

Sylvania Waters

Box Rd

Princes Highway

Sylvania Rd

Port Hacking Rd

Taren Point

Taren Point Rd

Bay Rd

Box Rd

Parraweena Rd

Gymea

The Boulevarde

Miranda

Caringbah

Kingsway

FloodMit

Job No: J1325
File: J1325_Fig6-2a.wor
Date: 25/2/15

Figure 6.2
Impact of 0.9m Sea Level Rise on Design 100 Year Flood Levels

The *NSW Coastal Planning Guideline* (NSW Govt, August 2010) and the *Flood Risk Management Guide* (NSW Govt, August 2010) place an onus on Council to identify the increased area of flooding as a result of future sea level rise, and to consider these impacts when assessing new development proposals. Council does have some flexibility to consider whether a 2050 or 2100 planning horizon should be considered. As the majority of new development in this area will predominantly consist of redevelopment to existing dwellings or businesses, it is considered that a 2050 planning horizon would be sufficient for this purpose. The adoption of a longer planning horizon, and consequently a higher sea level rise allowance, may be impractical due to existing ground and building levels.

It is recommended that a sea level rise allowance of 0.4m at the mouth of Gwawley Bay, and progressively reducing away from the Georges River as shown on Figure 6.1, be added to the normal 0.5m freeboard allowance when specifying minimum floor levels for new development. This is a consistent approach that was recommended for the Lower Georges River (Bewsher, 2011).

6.2.2 Impact of Increased Rainfall Severity

Climate change could also lead to an increase in the severity of flood producing storms and other weather systems, although the magnitude of these changes is less certain. Evidence to date suggests that whilst mean annual rainfall over Australia is likely to reduce, the intensity of extreme daily rainfall could increase.

The Floodplain Management Guideline (DECC, 2007) recommends sensitivity assessments for a range of rainfall intensities, but there is little guidance on what value to adopt or how it should be applied. There is also still a great deal of uncertainty in the likely change in future rainfall, with estimates for extreme one day rainfall events for the Sydney Metropolitan catchments ranging from -7% to +10% to the year 2070 (CSIRO, 2007). The *Flood Risk Management Guide* (NSW Govt, Aug 2010) acknowledges that the impact of climate change on design rainfall intensities has not yet been accurately quantified, and that freeboard could be considered to include a small allowance for increases in rainfall intensity.

Prior to assessing potential increases in design rainfall due to climate change impacts, it is worth reviewing the basis of the current design rainfall estimates, which are currently in the process of being updated.

Design rainfall intensities adopted for the *Gwawley Bay Catchment Flood Study* (Bewsher, 2012) were derived from Intensity-Frequency-Duration (IFD) rainfall data provided by the Bureau of Meteorology. This data was based on the analysis of rainfall records from the Bureau's network of daily-read and continuously-read rainfall stations up to 1987. The network of rainfall stations has significantly expanded since this time, and there are now nearly 30 years of additional data that has been collected. Revised (draft 2013) rainfall intensities were recently released by the Bureau. The revised IFD data, based on the longer period of records now available, provides design rainfall intensities for Gwawley Bay that are up to 29% lower than the previous (1987) design rainfall intensities adopted in the Flood Study (**Table 6.1**).

The Bureau cautions that the revised IFD rainfall data should not be used to define design flood levels until other parameters are also updated (rainfall temporal patters, aerial reduction factors, and loss rates). A review of the design flood levels within the Gwawley Bay Catchment would be warranted once the new rainfall data and associated parameters are formally adopted.

Given the uncertainty of future increases in rainfall intensities due to climate change, and the probable reduction in rainfall intensities based on the inclusion of data collected over the last

30 years, no special allowance for climate change would appear to be warranted at this stage. Any impacts due to future climate change is anticipated to be small and could be considered as part of the usual 0.5m freeboard when specifying design floor levels for new development. This should be reviewed as further information and guidance on future rainfall variations are released

Table 6.1
Variation in Design Rainfall Intensities for Gwawley Bay
(Based on critical 2 hour storm duration)

Method	Design Rainfall Intensities (mm/hour) for different Average Recurrence Intervals						
	1 year	2 year	5 year	10 year	20 year	50 year	100 yr
Flood Study (1987) IFD Data	19.7	25.6	33.8	38.8	45.1	53.6	60.1
Revised (draft 2013) IFD Data	17.5	19.3	25.2	29.2	33.2	38.5	42.6
Difference	-11%	-25%	-25%	-25%	-26%	-28%	-29%

6.3 TYPES OF FLOODPLAIN MANAGEMENT MEASURES

Floodplain management measures can be divided into three general groups:

(i) those that modify flood behaviour;

(ii) those that modify property in order to minimise flood damage; and

(iii) those that modify people's response to flooding.

Measures that modify flood behaviour usually include structural or engineering works that attempt to lower flood levels, or to divert floodwaters away from areas that would otherwise flood. Examples include retarding basins, channel improvements, stormwater drainage improvements, bridge and culvert amplification, levee banks, dredging, and flow diversions.

Measures that modify property in order to minimise flood damage include voluntary purchase, house raising and controls on new development. Voluntary purchase involves the acquisition and removal of flood affected homes by Council. It is an expensive flood mitigation measure that is usually only considered where the depth of inundation and flood velocity results in significant risk to life. Few residential homes in the study area would meet this criterion. House raising involves raising low-lying homes above a nominated level, usually the 100 year flood plus freeboard, to reduce flood damage. This is mainly suited to timber clad homes that are already on piers, or are otherwise easy to raise. Redevelopment, with appropriate minimum floor level controls, can often achieve the same objective as house raising, but provides a more aesthetic outcome. The application of appropriate development controls will ensure that the potential for flood damage is gradually reduced over time as future redevelopment occurs.

Measures that modify people's response to flooding usually include measures that provide additional warning of flooding, improved public awareness of the flood risk and improvements to emergency management planning. The Bureau of Meteorology provide a flood warning scheme on the Georges River. This largely benefits upstream communities within the Georges River floodplain and will provide limited benefits within the Gwawley Bay catchment. The rapid response to flooding from local thunderstorms limits the effectiveness of a flood warning scheme for the study area. Nevertheless, improved community awareness of the flood risk and appropriate emergency management response plans will help residents and the SES to take appropriate action in response to future flooding.

6.4 IDENTIFICATION OF HOT SPOT LOCATIONS

Flooding problems within the catchment have been reviewed to identify those areas most at risk or where a number of flood related issues have been raised.

These areas have been identified on the basis of:

i) the extent of inundation experienced throughout the catchment;

ii) the location of buildings potentially affected by above floor flooding, based on the flood damages database;

iii) problem areas identified by the community, based on results from the community questionnaires and Council's Customer Complaints register; and

iv) problem areas identified by Council and Committee members.

Ten hot spot locations were identified within the catchment, as shown on **Figure 6.3**. Potential floodplain management options for these areas are discussed in **Section 7**.

6.5 OTHER CATCHMENT WIDE MEASURES

It will not be feasible to find solutions to all of the flooding problems within the study area, given the magnitude of the problem and the number of properties and buildings potentially affected by flooding. Where specific solutions are not feasible, other catchment-wide measures will provide some benefit, including land use planning, flood awareness and emergency management planning. Landuse planning and development controls are key mechanisms that will influence future development (and redevelopment) within the study area, and the benefits will accrue gradually over time.

Catchment-wide measures are further discussed in **Section 8**.

6.6 PROPOSED SOUTHERN SYDNEY MOTORWAY

A reservation for a future motorway, linking the F6 Freeway at Waterfall through to Ultimo via Captain Cook Bridge, is located within the catchment. The motorway has been under consideration since at least 1951, when the road reserve for the motorway was first established. It is understood that the Roads and Maritime Service engaged consultants during 2014 to progress preliminary designs for the motorway.

The proposed motorway, when constructed, will represent a major development within the Gwawley Bay catchment, which could have a significant impact on flood behaviour unless compensatory flood mitigation measures are incorporated in the design. Potential impacts from the proposed motorway include:

i) a loss in floodplain storage in areas currently subject to flooding;

ii) a reduction in the capacity of these areas to convey stormwater flows;

iii) an increase in the impervious area of the catchment; and

iv) local increases in flood levels at waterway crossings.

The RAFTS and TUFLOW models established as part of the Gwawley Bay Catchment Flood Study were provided to the consultants undertaking the preliminary investigations for the RMS to ensure that flooding impacts are adequately addressed. A close review of potential flood impacts is recommended when the preliminary design is available.

LEGEND

- Area impacted by 100 year Flows
- Building potentially affected (database)
- Major flood problems reported
- Significant flood problems reported
- Minor flood problems reported
- Issues raised by community
- Stormwater pipe network

Georges River

Captain Cook Br

Sylvania

Site 5
Southgate Branch

Southgate Branch

Holt Rd

Site 6
Gwawley Creek
Downstream of Port Hacking Rd

Gwawley Bay

Sylvania Waters

Gwawley Creek (North of Box Rd)

Gwawley Creek

Sylvania Waters

Woolooware Bay

N

0 200 400
metres

Site 7
Belgrave Esplanade
(Eastern Branch)

Taren Point

Princes Highway

Box Rd

Site 2
Gwawley Creek
Downstream of Box Road

Site 4
Belgrave Esplanade
(Southern Branch)

Site 8
Box Road (Eastern Branch)

Site 10
Production Rd Channel

Sylvania Rd

Site 3
Kiama Street Drain

Taren Point Rd

Bay Rd

Production Road Catchment

Box Rd

Site 1
Gwawley Creeek
Upstream Corea Oval

Site 9
Parraweena Rd
(Eastern Branch)

Port Hacking Rd

Parraweena Rd

Gymea

Gwawley Creek (South of Box Rd)

Eastern Branch (Parraweena Rd)

Southern Branch

The Boulevarde

Miranda

Caringbah

Kingsway

FloodMit

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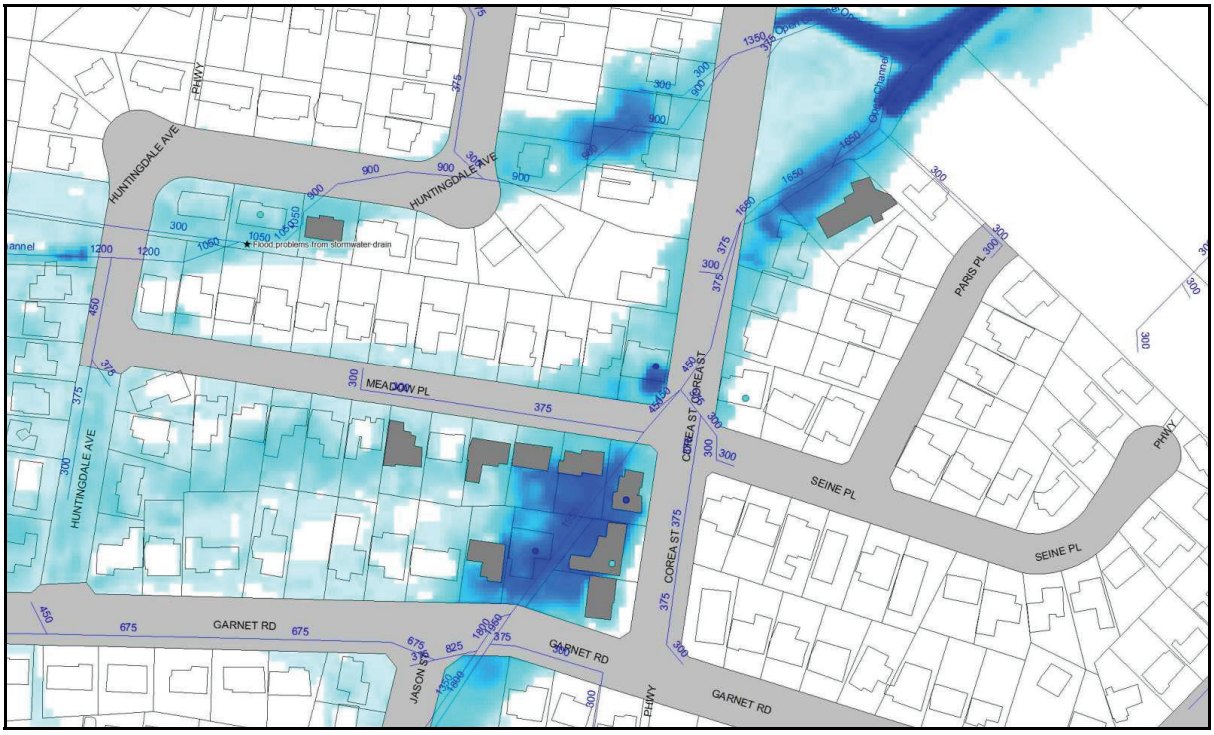
Figure 6.3
Identification of Hot Spot Locations within the Catchment

7 FLOOD MODIFICATION MEASURES FOR SPECIFIC AREAS

7.1 SITE 1 – GWAWLEY CREEK UPSTREAM OF COREA OVAL



Issues

There is a cluster of eight houses, between Garnet Road and Meadow Place, which are potentially inundated in the 100 year flood. The depth of flooding within this area is estimated at up to 1.5m. The main cause of flooding is insufficient drainage capacity and the absence of an appropriate overland flow path between these houses.

Potential Measures

CCTV inspection of the stormwater pipe system between Garnett Road and Corea Oval indicate significant discrepancies in the stormwater pipe system shown on Council plans. Further field verification of the pipe system between Garnet Road and Corea Oval is recommended, including updating of Council's drainage plans. Pending the outcome of this review, further modelling and/or drainage augmentation measures may be appropriate.

The lack of an overland flow path between these houses is also contributing to the flooding problems within this area. Opportunities to open up a flow path between these houses should be sought, including providing permeable fences, relocating minor structures, and repositioning buildings as redevelopment occurs.

Recommendations

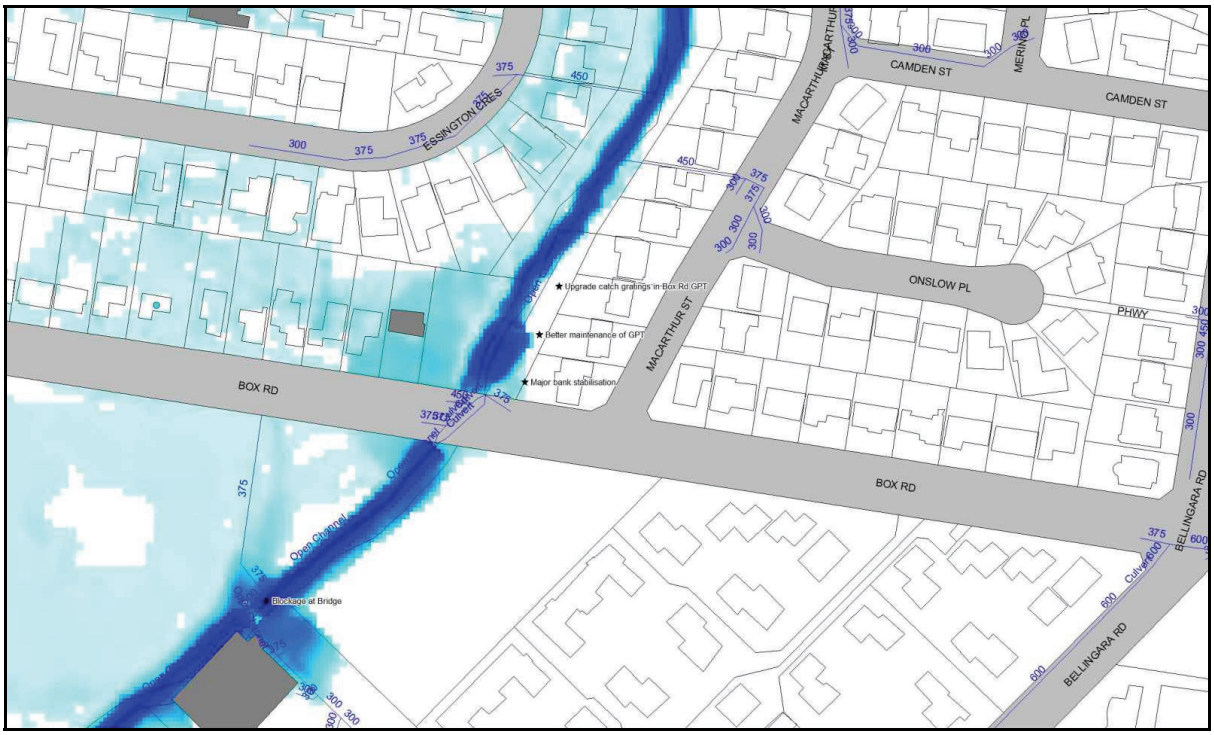
The following measures are recommended for further consideration:

a) confirm the stormwater pipe system from Garnet Rd to Corea Oval;

b) Upgrade drainage capacity to remove restrictions (if applicable);

c) Open up an overland flow path between houses.

7.2 SITE 2 – GWAWLEY CREEK DOWNSTREAM OF COREA OVAL



Issues

There are very few houses adjacent to Gwawley Creek, downstream of Corea Oval, estimated to be inundated in the 100 year flood. Those houses that are inundated are mostly affected by stormwater flows heading to the creek, rather than high flood levels in the creek itself.

The main issues raised in this area concern maintenance issues with the gross pollutant trap (GPT) structure downstream of Box Road, and other environmental issues associated with the creek corridor, including collection of rubbish, foul odours, rats, and bank stability. Blockage problems were also noted upstream of the Box Road culvert and an upstream pedestrian bridge.

Potential Measures

It was suggested that the grates around the outlet of the Box Road GPT be raised to capture more floating debris. This measure has already been noted by Council, and was recently implemented.

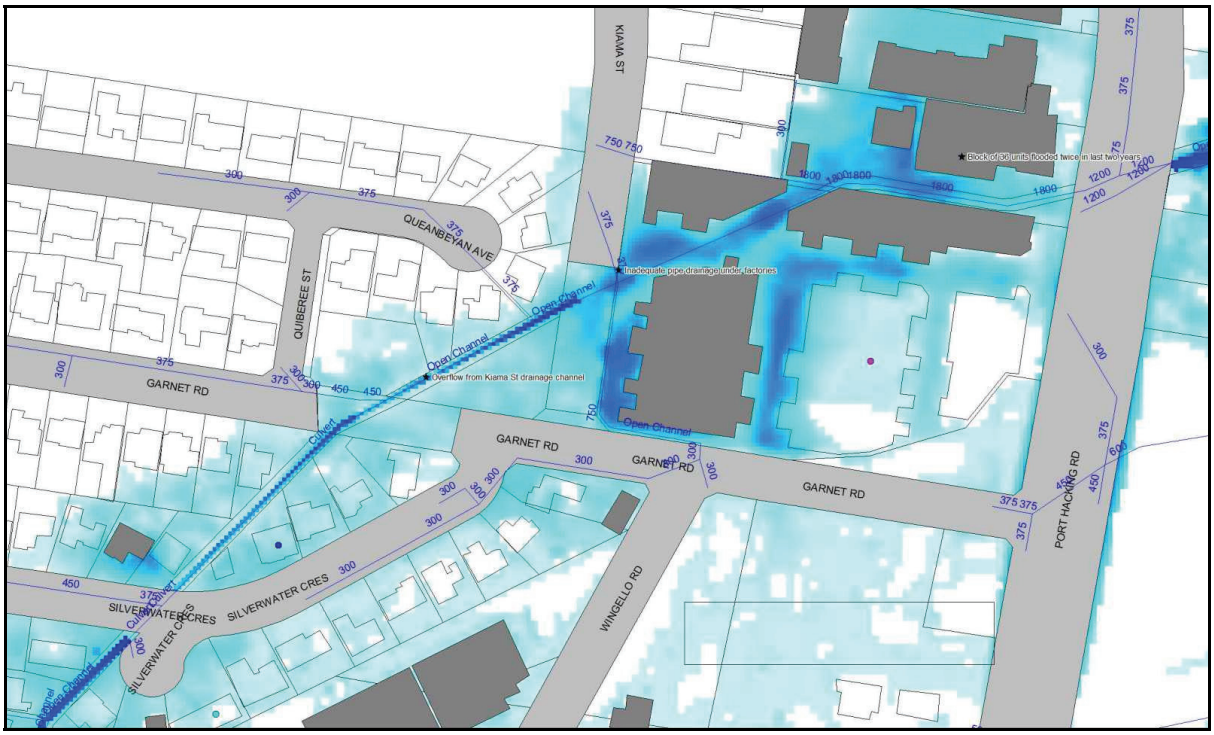
A review of Council's maintenance program to clean the GPT is warranted, including extending this program to include the upstream and downstream creek corridor.

Recommendations

The following measure is recommended for further consideration:

a) Regular maintenance of the GPT structure and creek corridor.

7.3 SITE 3 – KIAMA STREET DRAIN



Issues

The Kiama Street Drain is a small open channel between The Boulevarde and Kiama Street. The drain continues as an 1800mm stormwater pipe under a downstream industrial estate with some provision for overland flow between the industrial units.

The open channel is estimated to overflow in the 100 year flood, resulting in shallow inundation to a relatively wide area. Six residents have reported significant flooding problems. Up to three houses and the Blakehurst Nursery are potentially inundated in the 100 year flood. The industrial estate, comprising 36 units, is also estimated to be inundated, with some occupants reporting flooding twice over the last two years.

Potential Measures

Potential blockage problems at the inlet of the 1800mm pipeline under the industrial development (at Kiama Street) have been reported by some residents. There are two additional grated inlets to the pipeline immediately downstream, and model results indicate that this area is not unduly sensitive to assumed blockage factors. Nevertheless, Council has proposed to install a gross pollutant trap (GPT) at Kiama Street, which is anticipated to reduce the potential for blockage at this structure.

The industrial estate has been designed with two overland flowpaths between the main buildings. A site inspection in October 2014 revealed a large shipping container located within the northern overland flowpath, which would significantly reduce the capacity of the flowpath. It was also noted that the southern overland flowpath was significantly elevated near the junction with the first flowpath, limiting the flow that was able to enter this second flowpath. Design plans and compliance issues associated with this industrial estate should be reviewed and measures taken to ensure that both overland flowpaths remain unimpeded.

There is limited scope to widen the upstream open channel, or to increase the height of the banks to prevent overtopping, due to the proximity of existing buildings, and the ability of the surrounding area to drain to the channel. There may, however, be some opportunity to

reduce the flows in the existing channel by constructing an upstream detention basin in Seymour Shaw Park.

A detention basin in Seymour Shaw Park was investigated by constructing an earth embankment or masonry wall on the northern side of the park, adjacent to The Boulevarde, as shown on **Figure 7.1**. Preliminary basin design parameters are shown in **Table 7.1**.

The basin embankment is typically 2.1m above the adjacent natural ground level, with a 1050mm diameter pipe through the embankment as the basin outlet. The basin would reduce the 100 year peak flow at The Boulevarde from 18.7m^3/s to 4.6m^3/s. Further downstream, at Kiama Street, the 100 year flow is reduced from 27.6m^3/s to 20.7m^3/s. Benefits include the elimination of flooding across The Boulevarde; containment of flows within the Kiama Street drain; reduction in above floor flooding for 3 houses; and reduced inundation around the grounds of a number of other houses.

Table 7.1
Potential Basin (Option A) at Seymour Shaw Park

Design Parameters	
Low Flow Outlet	1x1050 diameter pipe at RL16.5m AHD
Spillway	50m at RL 20.1m AHD (subject to design)
Embankment Height	RL 20.6m AHD
RAFTS Results (100yr)	
Critical Duration	2 hrs
Peak Inflow (m^3/s)	18.7 m^3/s
Peak Outflow (m^3/s)	4.6 m^3/s
Maximum Basin Level	20.1m AHD
Maximum Storage	24,100 m^3
Peak Flow at Kiama Street	20.7 m^3/s

Disadvantages include construction costs and increased flooding to the playing fields in the park. The park currently includes a number of netball courts, tennis courts, football fields, and a more formal football stadium in the north-east corner, which would be affected infrequently for up to several hours. This stadium is the NSW Premier League home ground for the Sutherland Sharks. It is understood that it is a synthetic field that would suffer significant damage if inundated. Consequently an alternative basin option was investigated.

An alternative basin (Option B) could be formed by an earth embankment adjacent to The Boulevarde and then running along the western side of the football stadium. The height of the embankment would need to be increased to RL 22.0m AHD with spillway at 21.5m AHD to provide a similar storage volume. This is an increase in top water level of 1.4m over the previous option. The maximum depth in the basin increases from 2.1m to 3.5m in a 100 year flood, which is a greater depth than would normally be recommended for safety concerns. The higher embankment will further intrude on existing playing fields and increase costs.

Given the impact of inundating the football stadium, and the increased height requirements for an alternative configuration, a detention basin in Seymour Shaw Park is difficult to justify.

Recommendations

The following measures are recommended for further consideration:

a) Modification to the 1800mm pipe inlet at Kiama Street, in conjunction with the proposed GPT structure, to reduce the potential for culvert blockage; and

b) Ensure that overland flowpaths through the industrial development are unimpeded, and operate as intended.

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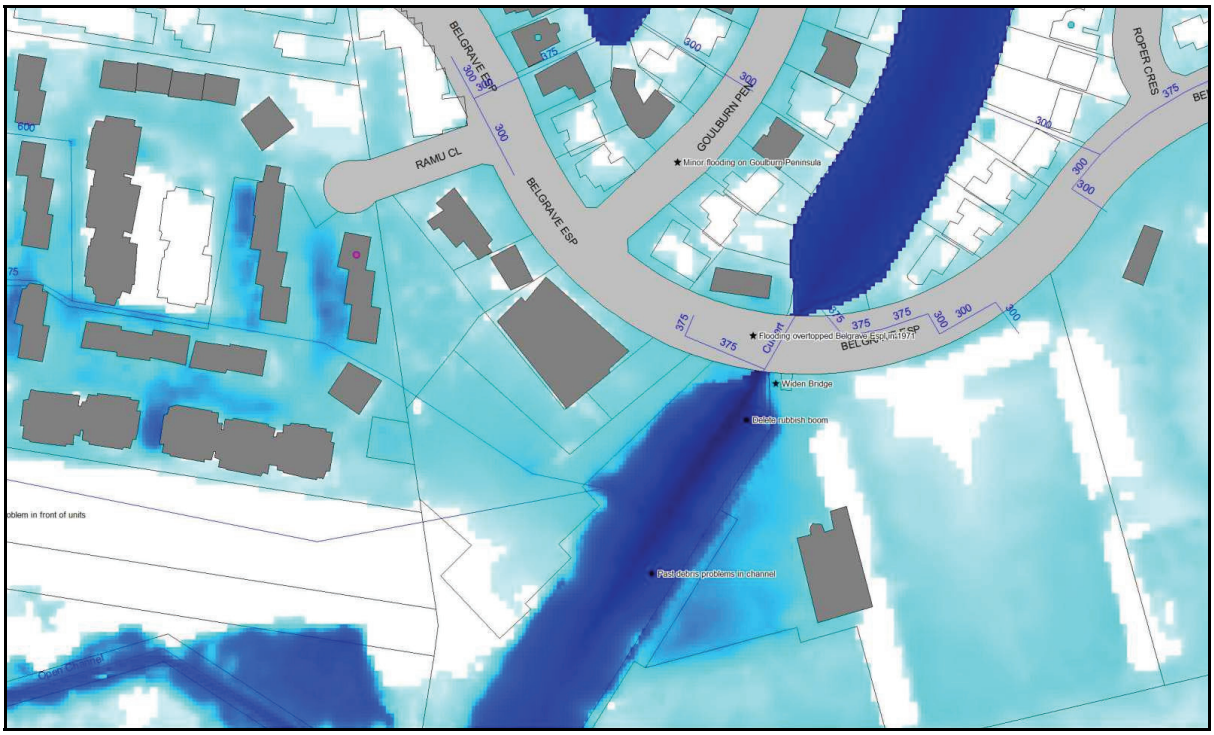
Figure 7.1
Potential Basin in Seymour Shaw Park

7.4 SITE 4 – BELGRAVE ESPLANADE (SOUTHERN BRANCH)



Issues

The culvert under Belgrave Esplanade is a rectangular section approximately 4.0m wide by 3.8m high with invert at -2.36m AHD. This structure restricts flood flows and results in an increase in upstream flood levels. Floodwater overtops Belgrave Esplanade by up to 0.5m, with the majority of flow directed along Belgrave Esplanade in both an easterly and westerly direction. This then exacerbates existing flooding problems that are encountered along Belgrave Esplanade and a number of other roads in Sylvania Waters.

Property potentially affected by flooding in the 100 year flood in this area includes:

i) 8 houses upstream of Belgrave Esplanade, in Nyngan Place (5), Parraweena Road (2) and Teak Place (1);

ii) Various units upstream of Belgrave Esplanade, at 1-3 Ramu Close (12 unit blocks);

iii) Forshaw Rugby Function Centre and two other sporting facility buildings upstream of Belgrave Esplanade;

iv) Doltone House Reception Centre, an adjacent house, and a preschool in Belgrave Esplanade;

v) 37 houses downstream of the proposed culvert measures, in Belgrave Esplanade (11), Goulburn Peninsula (14), Macintyre Crescent (5), Hampton Road (5), Nymboida Crescent (1), and Roper Crescent (1).

Potential Measures

Flooding can be improved by either widening the existing culvert, or taking measures to ensure that the structure is not blocked by debris.

An option to double the capacity of the existing culvert has been investigated. This would involve providing a new 4.0m wide x 3.8m high box culvert adjacent to the existing structure,

and increasing the width of the upstream and downstream channels to match the wider structure, as shown on **Figure 7.2**. The proposed culvert modification measures were included in the TUFLOW model to determine the impact on flood behaviour.

The impact on flood levels can be summarised as follows:

i) Flood levels in the 100 year flood are reduced by 0.23m immediately upstream of Belgrave Esplanade. This benefit extends over a distance of 220m before tapering off towards Nyngan Place.

ii) Flood levels in the canal immediately downstream of Belgrave Esplanade increase by a maximum of 0.02m due to the improved capacity of the structure. An increase of 0.01m persists throughout much of the canal system. This increase is not considered significant as flood levels throughout the canal system are dominated by higher flood levels when the Georges River is in flood.

iii) Overtopping of Belgrave Esplanade is still predicted to occur, but the depth of overtopping has been reduced from approximately 0.6m to 0.4m.

iv) The volume of floodwater that spills out from the upstream canal into Belgrave Esplanade and the surrounding road system is reduced. Flood levels in the surrounding road system are consequently reduced by up to 0.2m.

The proposed culvert amplification measures provide a modest reduction in flood levels over a fairly broad area. Flooding of up to 18 homes is estimated to be eliminated in the 100 year flood, whilst an additional 40 homes and 5 commercial properties would experience reduced inundation depths.

A preliminary cost estimate for this proposal was determined at $2.1M. Subsequent advice from council is that the necessary relocation of services may substantially increase this estimate. The savings in average annual flood damage (from all floods) is estimated at $40,000 per annum. The present value of flood benefits, assuming a term of 20 years and discount rate of 7%, is estimated at $0.45M, providing a benefit/cost ratio of 0.2. This is not a particularly favourable ratio and suggests that the proposed measure might only be viable if it can be done in conjunction with other measures that are required to restore the sea walls in this area.

Similar benefits may be possible, at significantly reduced costs, by eliminating the potential for blockage at the existing structure. This would involve the construction of bollards across the wider channel section, upstream of the existing culvert, to ensure that there is no likelihood of the culvert becoming blocked by debris or floating cars from Forshaw Park. If this can be guaranteed, then removal of the assumed 50% blockage allowance could be considered at this structure.

Recommendations

The following measures are recommended for further consideration:

a) Amplification of the existing culvert under Belgrave Esplanade if there is any opportunity to do this in conjunction with other maintenance requirements;

b) Inclusion of bollards across the waterway area upstream of the culvert to reduce the likelihood of culvert blockage.

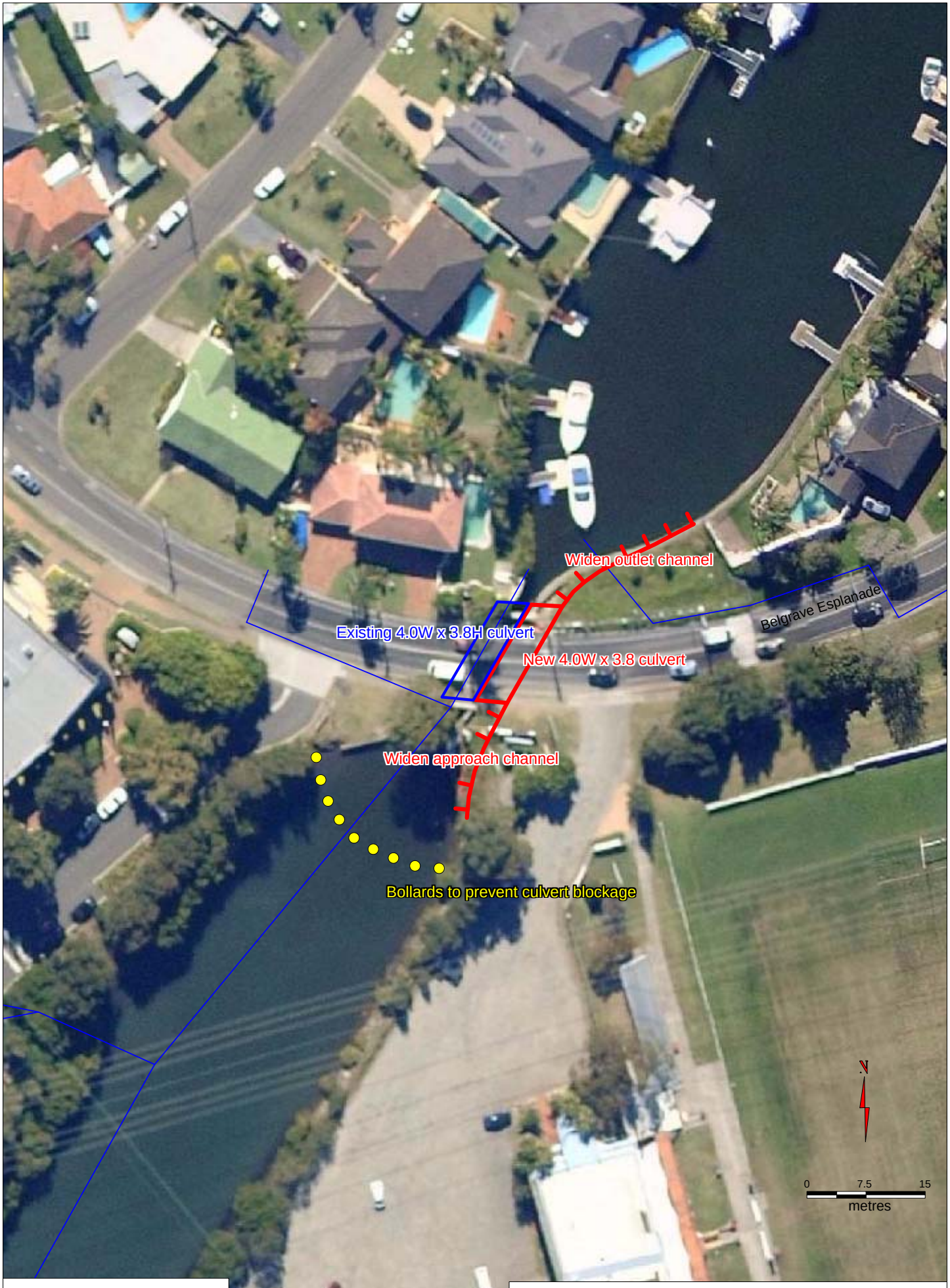


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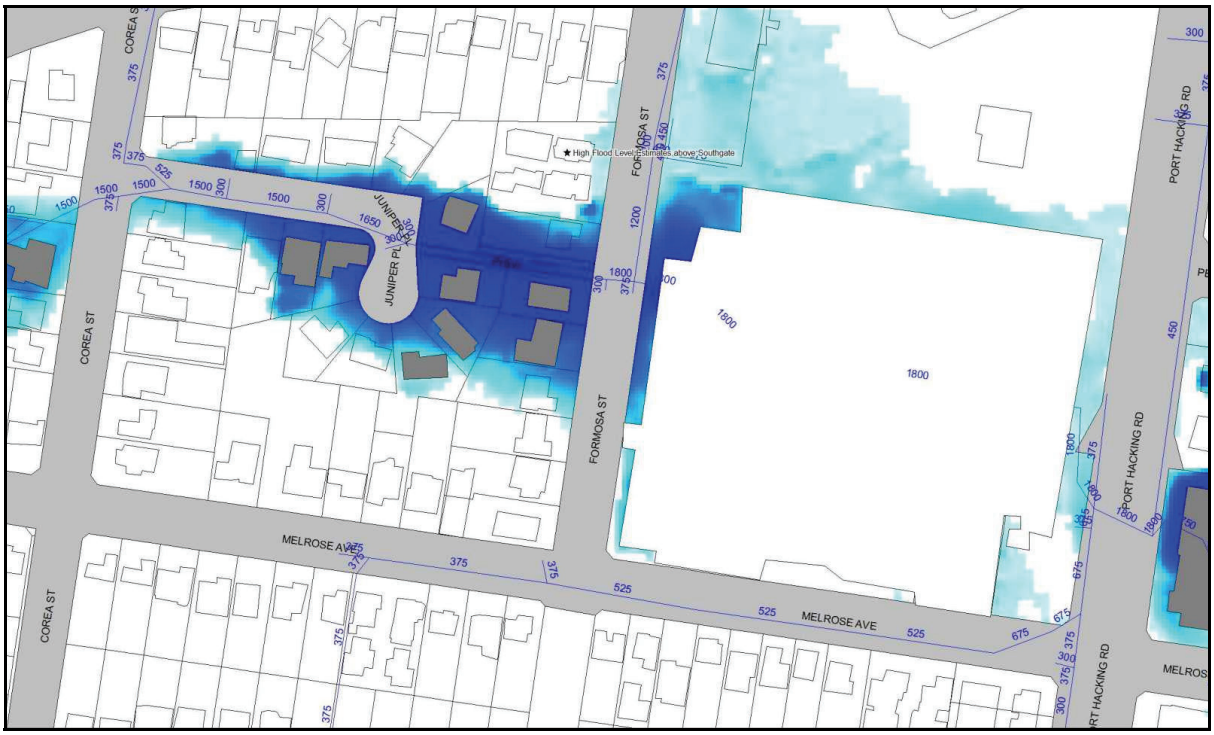
Figure 7.2
Potential Measures at Belgrave Esplanade (Southern Branch)

7.5 SITE 5 – SOUTHGATE BRANCH



Issues

Southgate Shopping Centre was constructed across an overland flowpath downstream of Formosa Street. Results from the flood study indicate that significant ponding occurs between Formosa Street and Juniper Place. Inundation depths between 2.5 to 3.0m were estimated in the 100 year flood, with up to 8 houses flooded above floor level.

No responses were received from residents in this area as part of questionnaires distributed during the flood study (2007) and the floodplain management study (2014), nor have any issues regarding flooding been raised with Council in this area.

It is estimated that approximately 6.5m^3/s is conveyed via an 1800mm pipeline upstream of Southgate, and 14m^3/s conveyed as overland flow in the 100 year flood. This overland flow overtops Formosa Street and is directed towards an orifice in the wall of Southgate Shopping Centre (see photos 1 and 2), where it is able to enter a larger 2.1m wide x 3.0m high box culvert, which continues under the shopping centre to Port Hacking Road. The restricted opening in the wall causes upstream flood levels to increase.

Potential Measures

Upstream flood levels appear to be largely dominated by the restricted opening to the larger culvert under Southgate Shopping Centre. The modelling undertaken as part of the flood study allows for 50% blockage of this structure, which will further increase upstream flood levels. This is not an unreasonable assumption, as the grate that is bolted across the opening probably provides at least 30% blockage by itself. There is also some evidence that this opening has become more restricted in recent years, which could further elevate flood levels. A comparison of conditions in October 2007 with those in August 2014 (see photos 11 and 12) indicate that a wall has been constructed just upstream of the inlet structure, and a concrete slab constructed over the lower part of the opening, reducing its height.

Photo 11 – Inlet to main culvert under Southgate (Oct 2007)

Photo 12 Inlet to main culvert under Southgate (Aug 2014)

The inlet to the box culvert is a particularly complex structure and appears to allow some of the floodwater, in excess of the capacity of the box culvert, to spill across the basement car parking area. The car park freely drains to Port Hacking Road, so inundation depths are anticipated to be shallow. This was not included in the flood study model, and could have an impact on flood behaviour, particularly when assessing options that allow additional inflow at this location. This is further complicated by the fact that no design drawings for this structure, or the culvert under Southgate, could be located. Council arranged a CCTV inspection in the box culvert and upstream 1800 pipeline during July 2014, which confirms general dimensions, but provides no information on invert levels or the inlet structure.

Two options have been considered to reduce flood levels upstream of Formosa Street, as shown on **Figure 7.3**. These options are contingent on confirmation of the drainage infrastructure in this area, and further detailed computer modelling.

The first option includes restoring the capacity of the main inlet structure to that which was originally envisaged (subject to confirmation of design details) and removal of the potential for this structure to be blocked by debris and the steel grate over this structure. This will reduce the existing restriction of flows to the larger box culvert under the shopping centre, and lower upstream flood levels. A consequence of allowing additional flow through the inlet is that this may further increase flows across the basement car park.

The second option includes extending the 2.1m x 3.0m box culvert some 50m upstream of Southgate, to the sag point in the public footpath upstream of Formosa Street. Additional inflow pits would be provided at this location to ensure the maximum capacity of the box culvert is realised. This option will prevent overtopping of Formosa Street and nuisance ponding upstream of the road. The incremental benefit over Option 1 is low (net present value of $0.2M) and it is unlikely that the additional expense of this option could be justified.

Recommendations

The following measures are recommended for further consideration:

a) Preparation of a more detailed computer model to confirm flood behaviour, incorporating more detailed information on the stormwater system, Southgate drainage facilities, and the potential for floodwater to flow through the basement car park;

b) Re-instatement of the intended capacity of the inlet structure to the culverts under Southgate, including the construction of bollards in front of this structure to prevent blockage by debris, shopping trolleys, or floating cars.

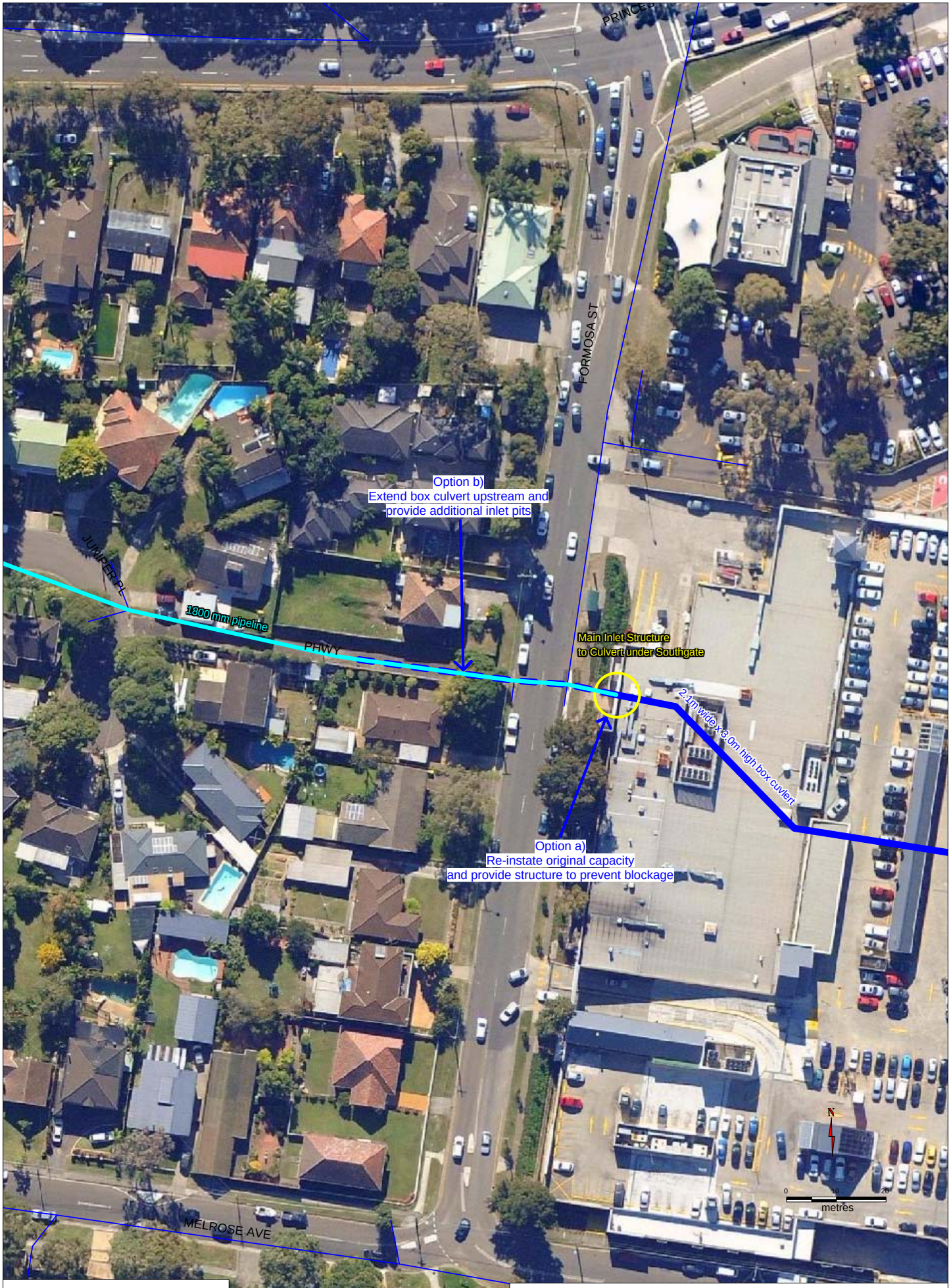


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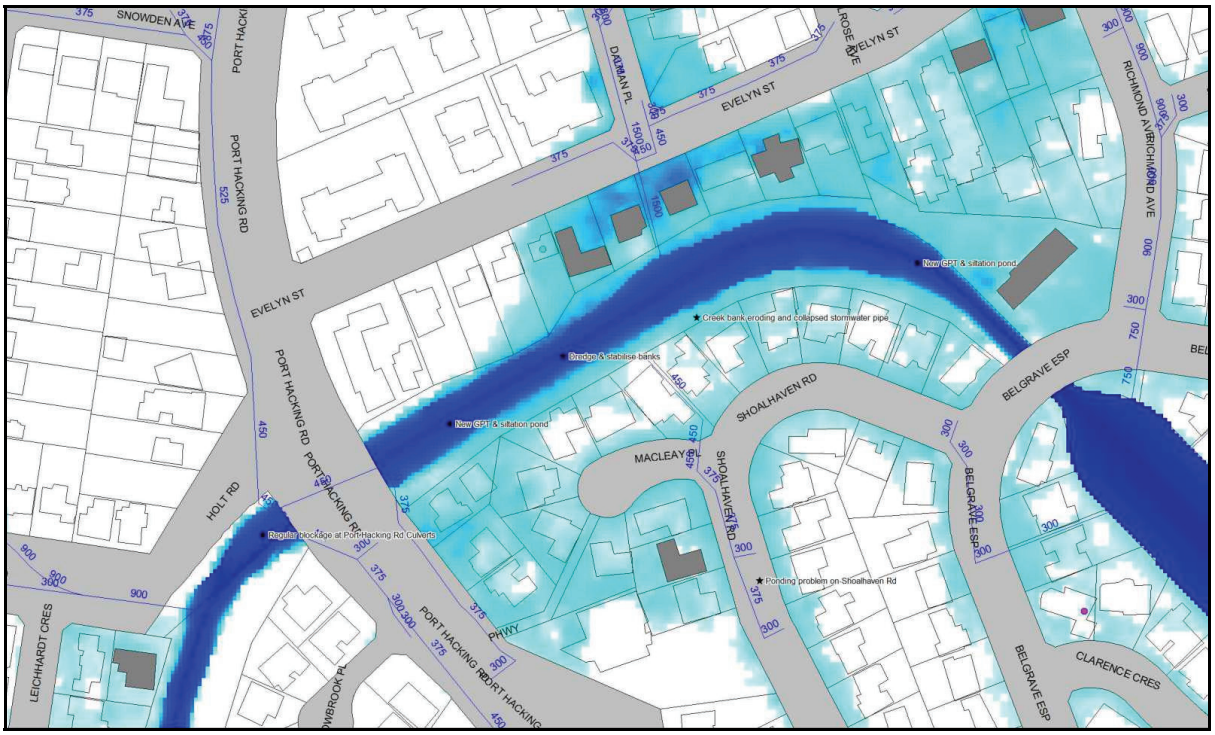
Figure 7.3
Potential Options Upstream of Southgate Shopping Centre

7.6 SITE 6 – GWAWLEY CREEK DOWNSTREAM OF PORT HACKING RD



Issues

The main issues raised in the lower section of Gwawley Creek, between Port Hacking Road and Belgrave Esplanade, are of an environmental nature. These include regular blockage of the Port Hacking Road culvert; the removal of the Port Hacking Road floating debris structure; dredging of the waterway area; repair of an outlet pipe on the southern bank; creek bank erosion; and the completion of bank protection measures on the southern bank.

Several houses on the north side of Gwawley Creek are potentially inundated in the 100 year flood by an overland flowpath from Dalman Place.

Potential Measures

It is understood that Council is considering a range of environmental enhancements of this part of the waterway, including the construction of a new GPT structure upstream of Port Hacking Road. Model results indicate that the flood level upstream of Port Hacking Road is particularly sensitive to the assumed blockage of this structure. Flood level reductions of up to 0.5m could be obtained if the GPT includes provision to prevent blockage at the culvert.

The use of permeable or raised fencing for houses in Evelyn St, adjacent to Dalman Place, could provide some reduction of flooding experienced at this location.

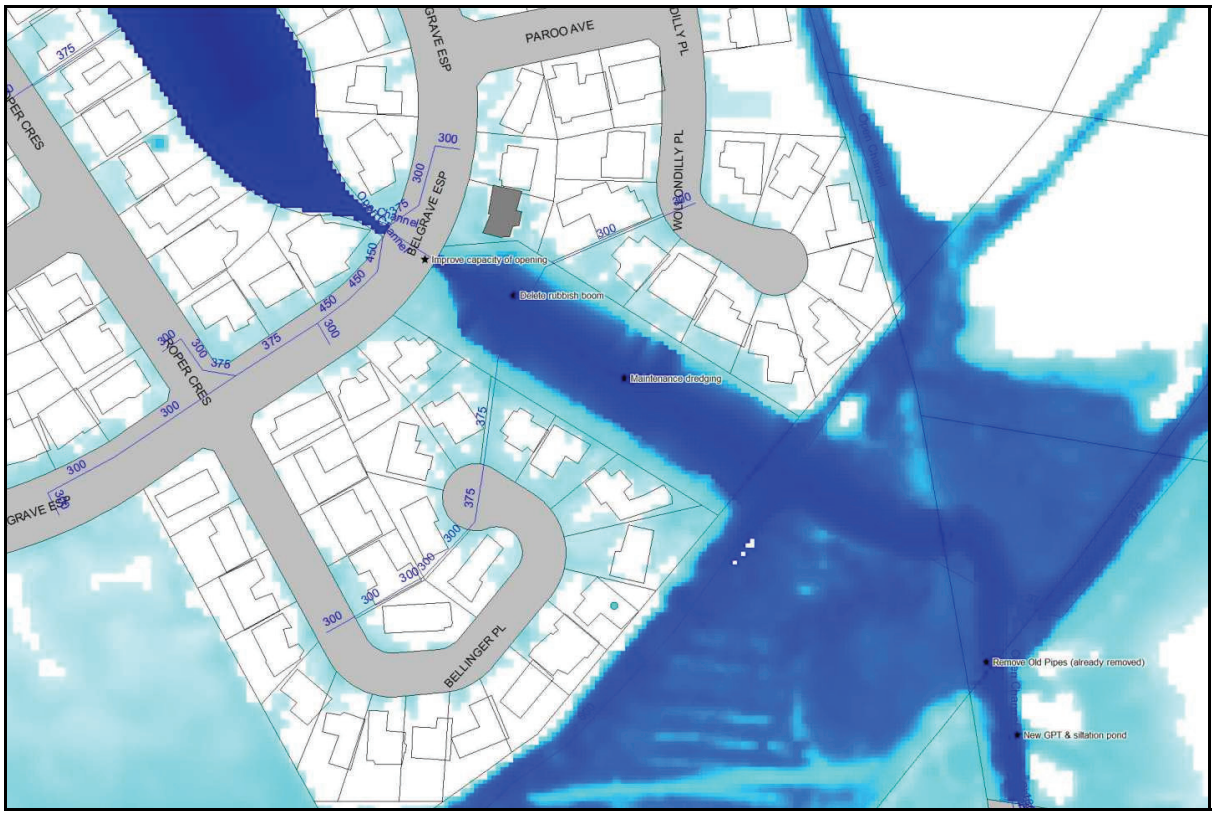
Recommendations

The following measures are recommended for further consideration:

a) Including provisions that limit the potential for culvert blockage at Port Hacking Road in the new GPT that is under consideration upstream of this culvert;

b) Encouraging the use of permeable or raised fencing for houses in Evelyn Street, adjacent to Dalman Place.

7.7 SITE 7 – BELGRAVE ESPLANADE (EASTERN BRANCH)



Issues

One house is potentially affected by flooding on the upstream side of Belgrave Esplanade in the 100 year flood. Other issues raised in this area are mainly of an environmental nature, including relocating the existing floating debris structure; maintenance dredging; and the removal of old pipes at a former upstream crossing of the creek.

Potential Measures

Removal of the potential for culvert blockage at the Belgrave Esplanade culvert could reduce the 100 year flood level by as much as 0.3m, and alleviate flooding of one house in this event. The reduction in flood levels would also help in reducing backwater effects that extend upstream to at least Box Road, where more significant flooding problems are encountered and other options have been proposed.

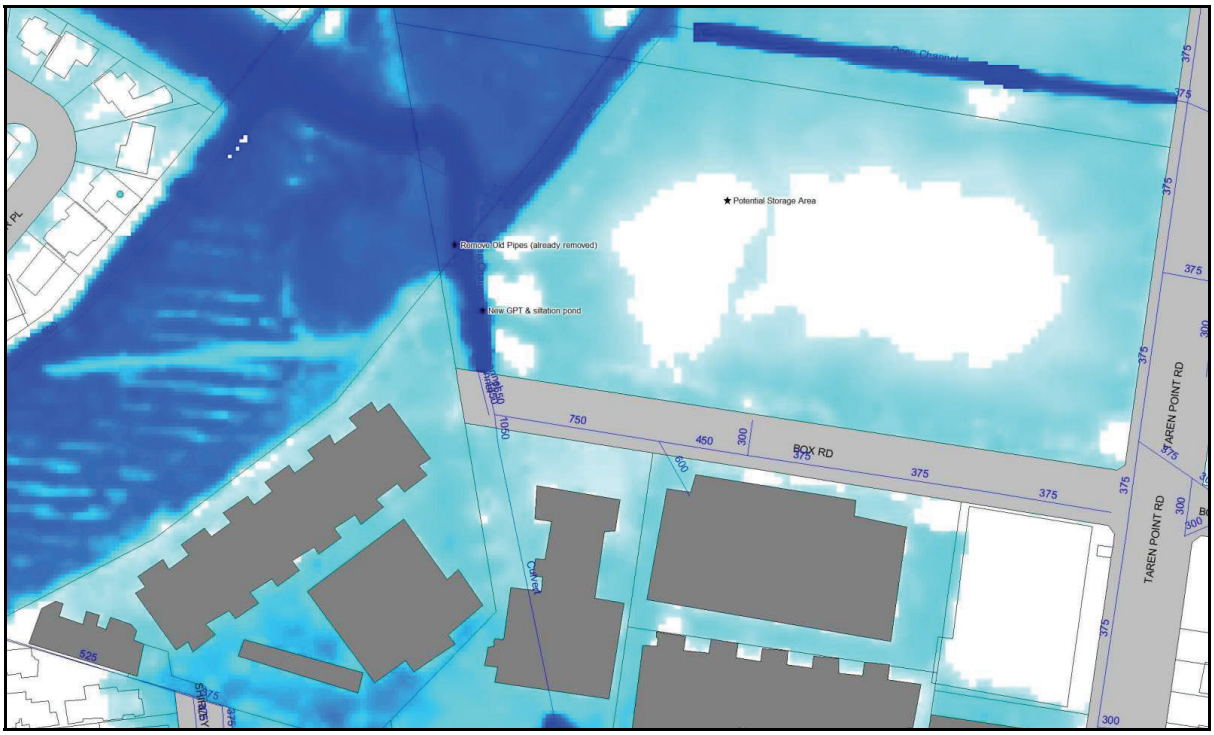
Removal of an obstruction caused by a number of abandoned pipes at a former channel crossing approximately 45m downstream of Box Road was identified at an early stage of the study. These abandoned culverts have since been removed by Council and this obstruction is no longer present.

Recommendations

The following measure is recommended for further consideration:

a) Inclusion of bollards across the waterway area upstream of the Belgrave Esplanade Culvert (Eastern Branch) to reduce the likelihood of culvert blockage.

7.8 SITE 8 – BOX RD (EASTERN BRANCH)



Issues

A basin was proposed within Gwawley Oval to allow the storage of excess stormwater during flooding, to reduce downstream flooding problems.

The most significant flood problems in this area occur upstream of Box Road. The culvert under Box Road, which consists of two 1650mm diameter pipes, is significantly undersized when compared with the 4600x2600 box culvert through the upstream property. This restricts the upstream stormwater drainage system and contributes to the flooding problems experienced upstream of Box Road. There are also limited overland flowpaths between existing commercial buildings in this area, which further contributes to the flooding problems experienced.

Potential Measures

Potential measures that could be considered in the vicinity of Box Road are shown on **Figure 7.4**.

A detention basin has been investigated in Gwawley Oval. Much of this site is located above the estimated 100 year flood. A basin could be formed by either constructing a raised embankment to impound flood flows from the catchment area to the east, or by excavating the basin so flood flows from the main channel can spill into the excavated area near the peak of the flood. The first option would increase flood levels upstream of the basin, and potentially aggravate flooding problems on Taren Point Road. The second option is preferable, but relies on significant excavation to provide sufficient flood storage to have any appreciable impact on downstream flooding. Excavation of the basin site to RL 1.25m AHD (approximately 1.0m below natural level) would provide up to 25,000m^3 of active flood storage volume. This is an expensive option which provides marginal downstream benefits, and is difficult to justify when compared with other more effective options that could be considered at Belgrave Esplanade.

Options to reduce flooding problems through commercial/industrial property upstream of Box Road were recently investigated as part of redevelopment considerations for the property at 72-78 Box Road, Taren Point.

One of the measures includes removal of a drainage restriction under Box Road. The stormwater drainage system through 72-78 Box Road comprises a large 4.6m wide x 2.6m high box culvert, which significantly reduces to 2x1650 pipes under Box Road. The extension of the box culvert through to the end of Box Road, to replace the existing pipes, would provide improved drainage capacity. Further investigation is recommended to determine whether the proposed box culvert can be accommodated without increasing the height of Box Road, which would then further impact on overland flows across the site. An alternative may be to consider extending the downstream channel to the upstream side of Box Road, and bridging over this channel to provide access to the last property on Box Road.

The 4.6x2.6 box culvert extends upstream to a small reach of open channel at the upstream side of 72-78 Box Road. Providing structurally sound fencing around the open channel to reduce the likelihood of debris from being washed into this channel, and subsequently blocking the inlet of the box culvert, will maximise the capacity of this structure.

Despite the above drainage improvements, some surface flow across the property will continue during large floods. Opening up an overland flowpath through the site, in conjunction with redevelopment proposals under consideration, will help to manage this risk.

The above options, in conjunction with improvements noted for Belgrave Esplanade to remove the potential for blockage of this structure, is estimated to reduce the 100 year design flood level by up to 0.1m adjacent to Box Road, and by up to 0.3m at the upstream end of 72-78 Box Road. This will also have some benefit in reducing flood levels at Parraweena Road, where the design flood level reduces by up to 0.1m.

Recommendations

The following measures are recommended for further consideration:

a) Extending the 4.6x2.6 box culvert within 72-78 Box Road through to the end of Box Road to replace the existing 2x1650 pipes at this location, subject to confirmation that this can be achieved without raising the level of Box Road;

b) Constructing fencing around the open channel immediately upstream of the 4.6x2.6 box culvert to reduce the likelihood of culvert blockage;

c) Providing an overland flowpath for flows in excess of the box culvert capacity in conjunction with future development proposals for this site.

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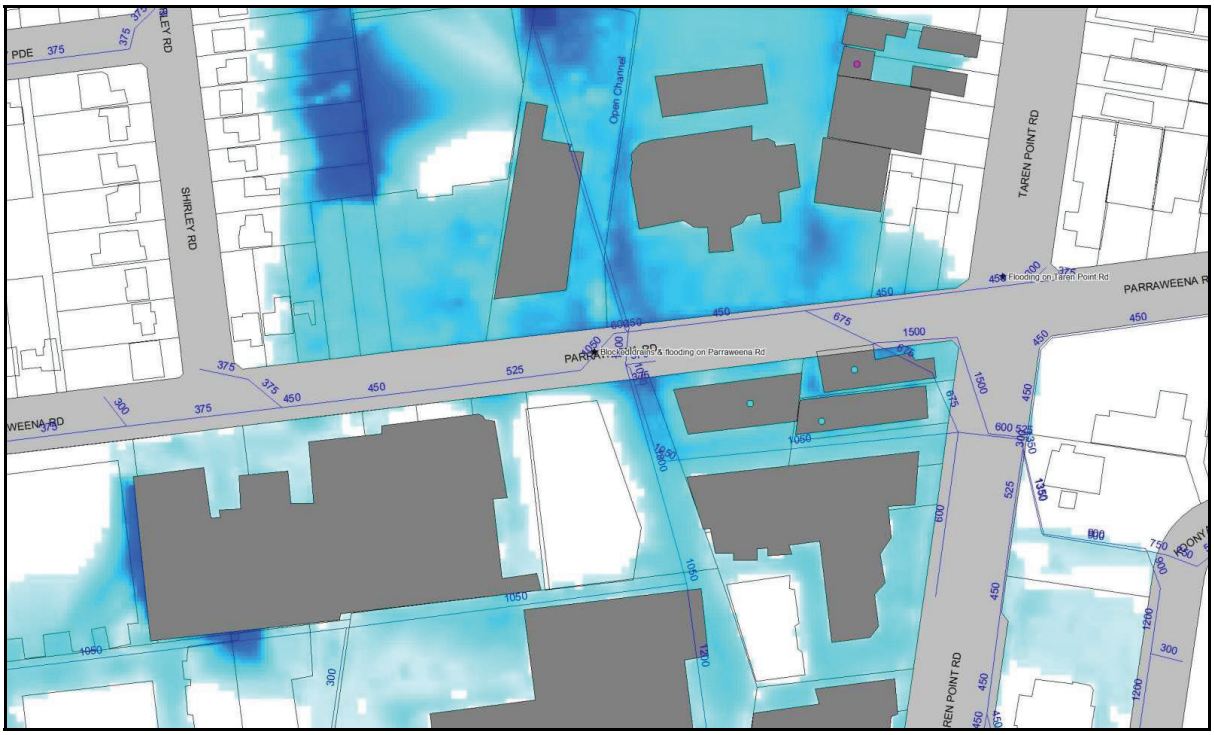
Figure 7.4
Potential Options in the Vicinity of Box Road (Eastern Branch)

7.9 SITE 9 – PARRAWEENA RD (EASTERN BRANCH)



Issues

Parraweena Road has been inundated on a number of occasions, with flooding extending up to Taren Point Road. The maximum depth of inundation over Parraweena Road is of the order of 1.0m in the 100 year flood. This branch of the catchment contains an estimated 32 commercial and industrial properties potentially affected by the 100 year flood, the majority of which are within close proximity to Parraweena Road.

Potential Measures

The drainage infrastructure upstream of Parraweena Road comprises 2.4x1.2 plus 3.05x1.3 plus 1.2x1.2 culverts, providing a total culvert area of 8.3m^2. The drainage infrastructure under Parraweena Road comprises 4x1.0x0.95 culverts (3.8m^2), which further reduces to 2x1400 pipes (3.1m^2) between Parraweena Road and the downstream open channel. A 4.6x2.6 culvert (12.0m^2) then continues through to Box Road. The deficiency in stormwater capacity from Parraweena Road to the downstream open channel, combined with restricted overland flowpath, contributes to flooding problems in this area.

There is limited height clearance on Parraweena Road, and the presence of gas, electricity, Telstra and Sydney Water services within the road reserve may make drainage improvements cost prohibitive. Nevertheless, further investigations are recommended to determine what opportunities there are to improve the capacity of this system. These investigations need to be integrated with other downstream recommended measures, with a view to alleviating flooding problems in this vicinity.

It is noted that there are a number of new commercial buildings currently under construction on the southern side of Parraweena Road. It is understood that the design of these buildings is in accordance with Council's flood risk management controls. These controls ensure that the development is compatible with the flood risk, through appropriate minimum floor levels and other requirements, and that the development does not exacerbate existing flooding

problems elsewhere. This is an example of where flood problems can be gradually reduced as redevelopment occurs.

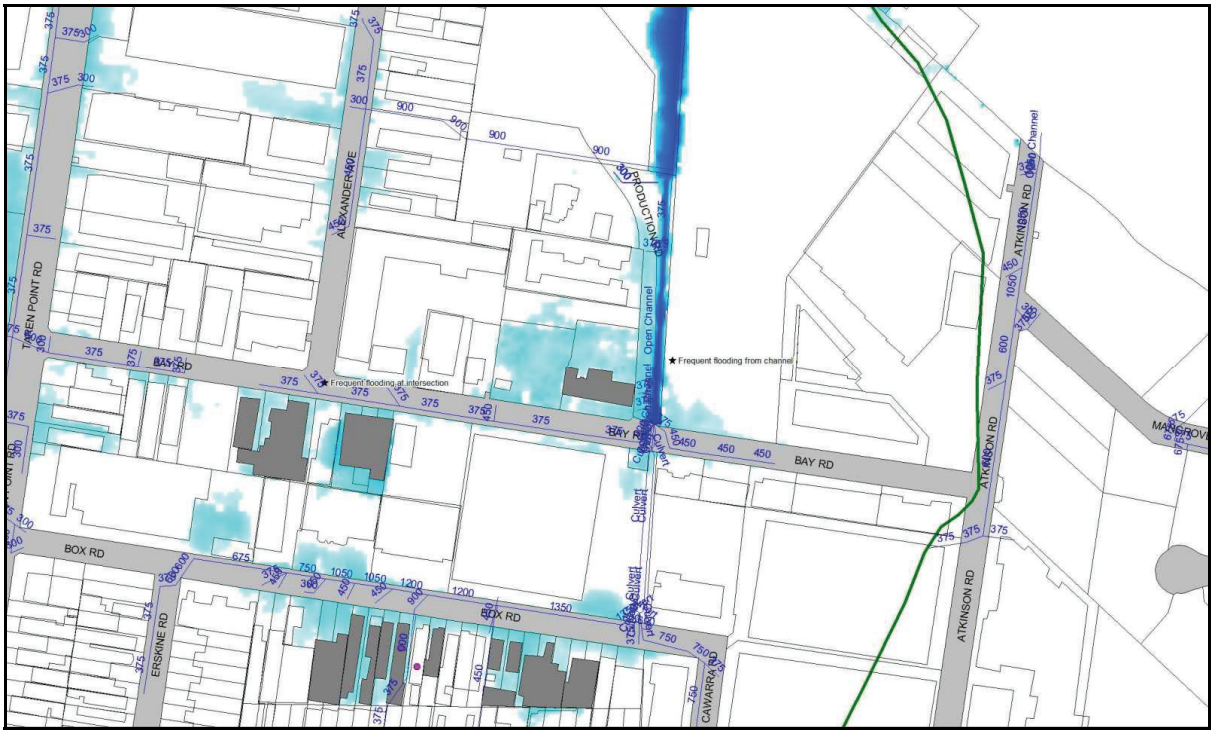
Recommendations

The following measures are recommended for further consideration:

a) Investigate the feasibility of providing increased culvert capacity from Parraweena Rd to the downstream open channel, over a distance of 135m;

b) Providing an improved overland flowpath downstream of Parraweena Road as part of future redevelopment proposals.

7.10 SITE 10 – PRODUCTION RD CHANNEL



Issues

The Gwawley Bay Catchment Flood Study indicates significant flooding under existing conditions along Box Road, Bay Road and Production Road. There have been a number of reports of flooding from business owners in this area in the past. The flood damages database indicates that approximately 15 industrial buildings would be inundated above floor level in a 100 year flood between Box Road and Bay Road.

Inundation depths along Box Road, Bay Road and Production Road are estimated to be up to 0.4m in depth in a 100 year flood. This will hamper access and evacuation from affected development during periods of flooding.

Most of the flooding problems originate from high flood levels that are experienced in the upstream reaches of the Production Road channel (see **Figure 7.5**). A recently implemented flood management option, providing box culverts between Box Road and Bay Road, is also restricted by high flood levels experienced in the Production Road channel, which reduces its effectiveness in reducing flood levels in Box Road.

One of the problems with the Production Road channel is the flat gradient between Bay Road and Woolooware Bay, which is largely controlled by culverts at either end. The culvert at Bay Road (3x3.0x1.2 RCBC) has an invert level of RL -0.567m AHD. The downstream culvert at Woolooware Bay (3x3.0x1.5 RCBC) has a marginally higher invert level of RL -0.47m AHD. The channel between these culverts is variable, with the channel invert being as high as +0.4m AHD in some places. Siltation problems and increased density of mangroves in the channel has undoubtedly exacerbated flooding problems in recent years.

Potential Measures

The viability of constructing a detention basin on the vacant land on the east side of the Production Road channel to lower flows in the adjacent channel was investigated. However, this was not considered to be an appropriate location due to:

i) the land is in private ownership and zoned for commercial/industrial purposes;

ii) the site is mostly above the 100 year flood level and likely to be developed in the near future;

iii) land acquisition costs would be prohibitively high; and

iv) its location in the lower catchment is not well suited for a basin.

Four options have been considered to provide increased capacity in the Production Road channel. Typical cross sections for these options are shown on **Figure 7.6**. Each option was assessed using the TUFLOW model and allowing for future drainage improvements within the catchment. Options were assessed for the 100 year flood coinciding with high tide, and including a sea level rise allowance of +0.4m. The options are discussed below.

Option 1 was previously investigated by Bewsher Consulting during 2010. The culverts at Bay Road are increased in size from 3x3x1.2 RCBCs to 2x3.6x1.5 plus 1x3.0x1.5 RCBCs and extended from Bay Road through to the end of the Production Road cul-de-sac, over a distance of approximately 190m. The channel downstream of the extended box culvert is increased to 13m base width, and invert lowered to between -0.6m AHD and -1.0m AHD. The regrading of the channel necessitates the removal of the culvert at Woolooware Bay, which provides further flood benefits by removing the flood losses at this structure and the potential for culvert blockage. The downstream channel was assumed to be formed within the existing channel by excavating the benched area on the western side of the channel and reconstructing the eastern bank with rock lined material, consistent with that which has been constructed on the western side.

Option 1 provides the greatest flood level reductions. Flood levels are reduced to RL 1.04m AHD at Bay Road, which maximises the design capacity of the culvert between Box Road and Bay Road. Despite this flood level reduction, flooding can still occur from a Georges River/Botany Bay flood, which has a limiting 100 year design flood level of RL 1.7m AHD.

A concern with this option is the long term maintenance of the extended box culverts. The invert of this structure is up to 600mm below mean sea level, and the structure will be submerged in all but very low tides. There is some likelihood that siltation within the structure will occur through either marine sediments or from the upstream catchment, as has occurred within the existing channel. Maintenance to clear the culverts of silt or other obstructions is anticipated to be difficult due to its long length and limited height.

Whilst this scheme provides the greatest flood level reductions, it is considerably more expensive than the other options investigated. It also provides some environmental disadvantages and longer term maintenance issues. The main benefit of the scheme

appears to be the ability to widen Production Road over the top of the culverts, or to allow additional development within the vicinity of the former channel.

Option 2 replaces the extended box culvert with an improved open channel. The base width of the channel is increased to 10m, and the invert level lowered to provide a slight gradient between Bay Road (-0.567m AHD) and the end of Production Road (-0.6m AHD). The channel is largely formed within the confines of the existing channel, but near vertical side slopes (1V:0.5H) are required to achieve this. It is assumed that the banks would be constructed using large sandstone blocks or gabion baskets. The downstream channel improvement measures that were proposed in Option 1 are retained for this option (ie 13m base width channel, with inverts lowered to between RL -0.6m AHD and -1.0m AHD, and the removal of the Woolooware Bay culverts).

Option 2 reduces the 100 year flood level at Bay Road to RL 1.40m AHD, and at Box Road to RL 1.65m AHD. These levels are below the minimum levels on both roads, and are considered to provide satisfactory flood level reductions.

Option 2 costs are reduced by the deletion of the extended box culverts. It also provides environmental benefits and less maintenance issues over Option 1.

Option 3 is similar to Option 2, but the culverts at Woolooware Bay are not removed as part of this option. Consequently, the upstream channel is assumed to be lowered to no more than -0.5m AHD, to match the invert level of this structure.

Flood level results were found to be sensitive to the blockage assumptions at the Woolooware Bay culvert. The afflux across this structure was estimated at 130mm with no blockage, and up to 500mm assuming 50% blockage.

The 100 year flood level at Bay Road is estimated at RL 1.46m AHD (unblocked) or RL 1.64m AHD (blocked). The flood level at Box Road is estimated at RL 1.69m AHD (unblocked) or RL 1.84m AHD (blocked). The flood level is reduced to below the minimum level of both roads for the unblocked scenario, whilst some minor inundation (90mm) of Bay Road can be expected for the blocked scenario.

The unblocked scenario provides flood levels that are only marginally higher than for Option 2, which suggests that there is limited benefit in lowering the channel invert any lower than about RL -0.5m AHD.

Option 3 is still considered to provide satisfactory flood level reductions, despite minor flooding on Bay Road if there are blockage problems at the Woolooware Bay culvert. This option is recommended for further consideration. The removal and/or reconstruction of the Woolooware Bay culvert could also be considered in conjunction with Option 3 to provide further flood mitigation benefits.

Option 4 is similar to Option 3, but the side slopes for the upstream channel adjacent to Production Road is assumed to maintain a similar form to the existing channel, but with the invert level lowered to a uniform -0.5m AHD. The channel banks are assumed to be stabilised earth banks with a slope of 1V:2H. The base width of the channel is reduced from 10m (Options 2 and 3) to 3m (Option 4). The downstream improvements recommended for Option 3 remain the same, including a 13m base width channel at a uniform invert level of -0.5m AHD, and retaining the Woolooware Bay culverts.

Results downstream of Production Road were found to be relatively similar to Option 3, and also sensitive to the blockage assumptions at the Woolooware Bay culvert.

The flood gradient markedly increases upstream of the Production Road cul-de-sac, which is largely a result of the reduced capacity of the upstream channel. At Bay Road the flood level is RL 1.69m AHD (unblocked) or 1.77m AHD (blocked). At Box Road the estimated 100 year flood level is RL 1.89m AHD (unblocked) or 1.95m AHD (blocked). Flooding of both roads is likely to occur under both the unblocked and blocked scenario.

Option 4 will be the least expensive of the four options, but also provides the least flood mitigation benefits. The reduction in flooding that is attained is not sufficient to alleviate flooding on Production Road, Bay Road and Box Road and continuing flooding problems are likely to be experienced to a number of low lying industrial buildings.

A preliminary cost estimate for the preferred option (Option 3) is $2.5M. The average annual flood damage in this vicinity is $190,000 and the present value of future flood damage estimated at $2.0M. This provides a relatively favourable benefit/cost ratio of up to 0.8.

All of the channel options include the removal and/or thinning of existing mangroves within the channel. Approval from NSW Fisheries will be required.

Recommendations

Option 3 is recommended for further consideration. It reduces flooding to a level which alleviates most of the flooding concerns within this part of the catchment. Further reductions can be obtained through the removal and/or reconstruction of the downstream culvert at Woolooware Bay to reduce the impacts of potential blockage at this structure.

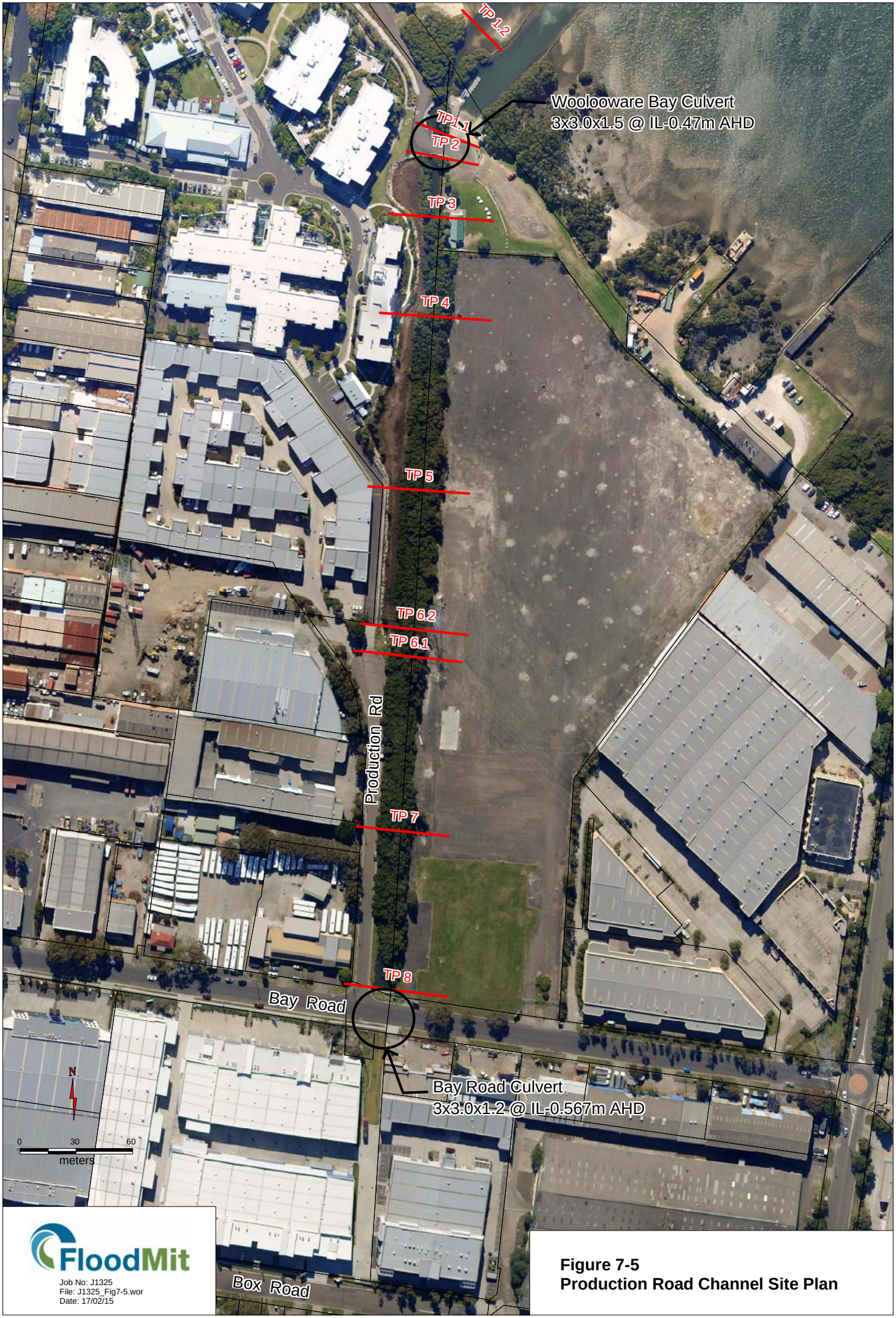


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Figure 7-5
Production Road Channel Site Plan

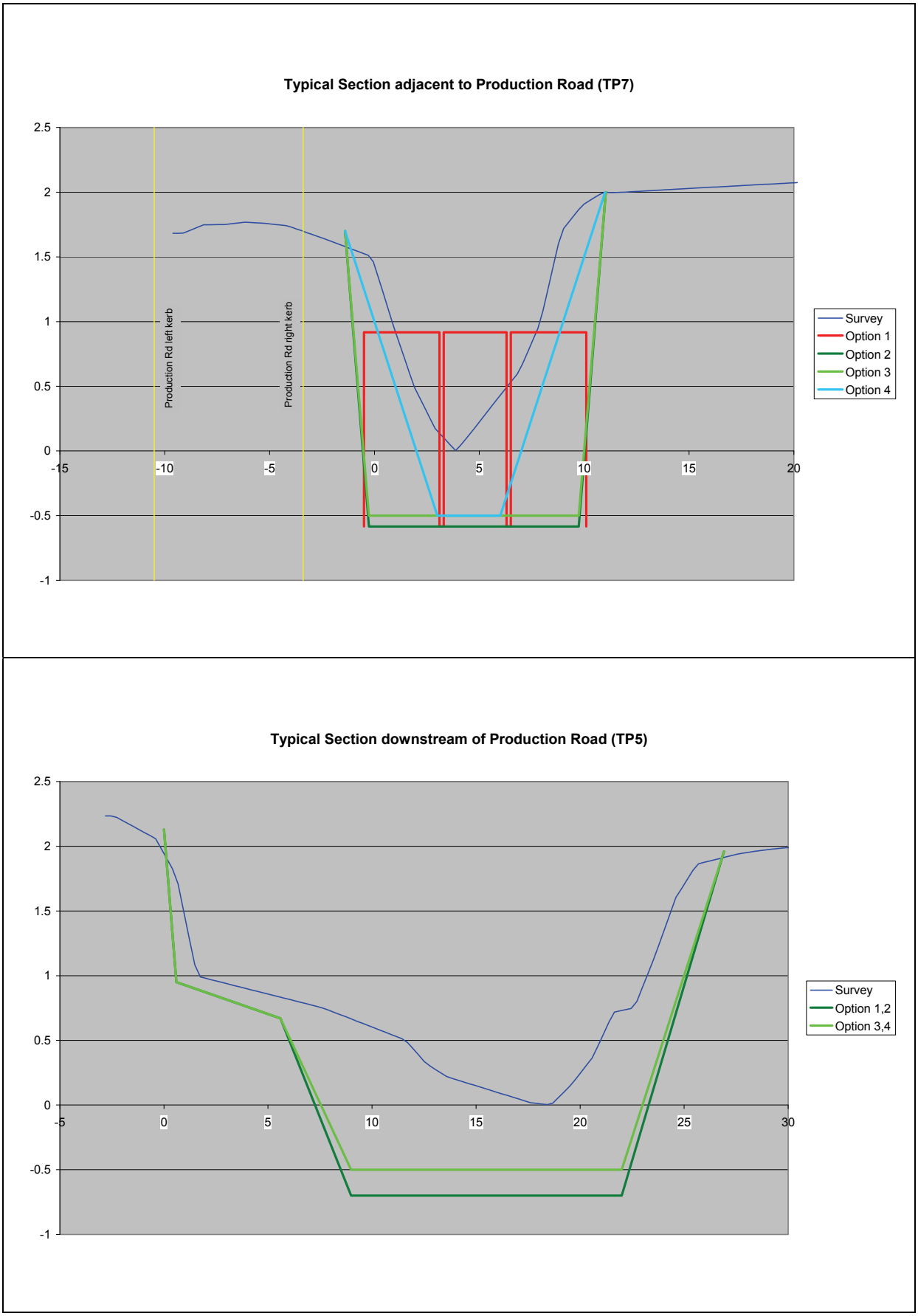

Figure 7.6
Representative Cross Sections for Proposed Channel Options

8 CATCHMENT-WIDE FLOODPLAIN MANAGEMENT MEASURES

8.1 PLANNING ISSUES

8.1.1 Background

Land use planning and development controls are a key mechanism by which Council can manage flood-affected areas within the catchment. These mechanisms will influence future development (and redevelopment) and therefore the benefits will accrue gradually over time. Without comprehensive floodplain planning, existing problems may be exacerbated and opportunities to reduce flood risks may be lost.

The adoption of suitable development controls for property potentially affected by flooding was supported by respondents to the community questionnaire (56% in favour and 8% opposed). There was also strong support (72% in favour and 5% opposed) for controls to ensure that new development does not block existing overland flowpaths.

Council's existing planning approach to flood risk management originated from the Georges River Floodplain Management Study and Plan (Bewsher & Don Fox Planning, 2004), which was completed for Liverpool, Fairfield, Bankstown and Sutherland Councils. The study included a comprehensive review of flood risk management policies and recommended consistent planning and development controls for each of the participating councils. The recommended approach consisted of dividing the floodplain into three different flood risk management precincts (termed high, medium and low) and then applying different development controls for new development depending on the flood risk and the type of development proposed. The controls for the Georges River were summarised in a single schedule attached to a DCP providing additional information on the flood policy, objectives, definitions and other directions. It was intended that other schedules would be formulated and inserted into the DCP as floodplain management studies were undertaken in other catchment areas. This approach allows different controls for different catchment areas, depending on the different characteristics of flooding.

Council endorsed the floodplain management provisions included in the Georges River Floodplain Management Study and Plan, and with some modifications, incorporated these into the Sutherland Shire Development Control Plan (SSDCP, 2006). A review of the flood risk management chapter of the DCP was undertaken as part of a subsequent Lower Georges River Floodplain Management Study and Plan (Bewsher, 2011) prepared for Sutherland Council. The review noted some significant changes from the approach originally recommended, including:

i) An additional flood risk category has been added, namely land mapped with an "Initial Assessment on Potential Flood Risk";

ii) In response to the Department of Planning's 2007 Flood Planning Guideline, flood related development controls are not imposed on residential development above the flood planning level (100 year plus 0.5m freeboard);

iii) Instead of a capacity for schedules to be attached to the DCP for individual catchment areas, the format is more text-based;

iv) The controls in the amended DCP appear to be more conservative than previously specified (eg in requiring open car parking spaces to be no lower than the 100 year flood, rather than the 20 year flood).

One of the more significant differences is the removal of the individual schedules for different catchment areas. This provides some practical difficulties in updating the DCP to include specific recommendations that may be made in other catchment areas as subsequent floodplain management studies are undertaken.

8.1.2 Principle Development Controls for Residential Development

A discussion of the controls currently included in Council's DCP for new residential development is provided below. Other controls apply for land in Employment Zones, Urban Centres, Short Term Caravan Parks, and for other critical and sensitive land uses.

Initial Assessment Flood Risk

The area mapped as Initial Assessment Flood Risk will be replaced by Low/Medium/High flood risk precincts as part of the floodplain management study. The controls relating to Initial Assessment Flood Risk will no longer be relevant in the Gwawley Bay catchment.

Low Flood Risk Precinct

Council's DCP states that *"No flooding controls are applied to residential development on land with low flood risk"*. This is further qualified by stating that *"Where the siting of a residential development is confined to an area above the flood planning level (1% plus 500mm), which is mapped as having a low level of flood risk or no risk, the proposal will be considered to satisfy the objectives for Flood Risk Management and no flood related development controls will be imposed."*

There is some conflict in the above statements in that some properties located near the boundary of the Low Flood Risk and Medium Flood Risk precincts may not be above Council's flood planning level. To remove this ambiguity, both statements could be replaced by a single statement such as *"No flooding controls are applied to residential development on land mapped as having a Low Flood Risk subject to the floor level being above Council's flood planning level (1% plus freeboard)."*

Medium Flood Risk Precinct

The Medium Flood Risk precinct is where the majority of flood related planning controls are applied to ensure that the development is compatible with the flood risk and does not exacerbate flooding on neighbouring properties. There are six controls that relate to new residential development located in the Medium Flood Risk precinct. These include:

i) Habitable floor levels are to be no lower than the 100 year flood level plus 0.5m freeboard. Non-habitable floor levels can be reduced to the 20 year flood level. Concessions are also provided for minor alterations and additions. These controls are consistent with those recommended in the Georges River Floodplain Management Study. Some property in the lower catchment area may also be affected by future sea level rise, and a further sea level rise allowance would need to be included for habitable floor levels (see Section 6.2.1).

ii) Any building components below the 100 year flood plus freeboard are to be resistant to immersion.

iii) An engineers report is to be provided to certify that the structure can withstand the forces of floodwater, debris and buoyancy up to the 100 year flood level plus freeboard.

iv) An engineers report is to be provided to certify that the development will not increase flooding elsewhere.

v) The minimum level of open car parking spaces is the 100 year flood level, or the crest of the road at the location where the site has access. Garages are to be located at the 100 year flood level plus 0.2m freeboard. Basement parking requires special provisions, including the crest of the driveway leading to the basement being a minimum of 0.2m above the 100 year flood. These requirements are generally more restrictive than those recommended in the Georges River Floodplain Management

Study. Consideration could be given to relaxing the requirements for garages to say the 20 year flood level in the Gwawley Bay Catchment given that the majority of the catchment experiences shallow overland flow conditions. The entrance crest level to basement car parking is a commendable addition to the previously recommended controls. There are many units within the study area with basement parking and flooding has been a reported problem in several basement car parks. Consideration could be given to increasing the crest height at the entrance to basement parking to be a minimum of 0.5m above the 100 year flood given the risk to life associated with sudden immersion of these areas. A further sea level rise allowance would also be appropriate in the lower catchment area.

vi) Reliable access for pedestrians or vehicles is required from the building, commencing from the lowest habitable floor level to an area of refuge above the PMF level. These conditions could be relaxed in the Gwawley Bay catchment, and other stormwater catchments, where the majority of flooding is shallow overland flow, and where the duration of flooding is usually short, to allow for "shelter-in-place" at a higher level within the development that is above the PMF level. This can often be a safer alternative than having people attempting to evacuate their premises through flooded roads.

High Flood Risk Precinct

New residential development within the High Flood Risk precinct is generally prohibited unless the characteristics of the site can be altered (for example by filling) to remove the high flood risk classification. This requires a flood assessment to ensure that such activity does not increase flooding elsewhere.

Minor additions and alterations, or a change in use that does not increase flood risk, is permissible subject to various controls.

8.1.3 Proposed Changes to Planning Controls

The main limitation of the flood risk management chapter included in the Sutherland Shire DCP is considered to be the largely text-based format of the controls that are specified for various development types and flood risks. The development controls occupy some 25 pages of text, including various overlapping conditions, exceptions and other exclusions. This can lead to some confusion in determining the controls that apply for a particular circumstance. It also makes it difficult to vary these controls in other catchment areas to recognise unique characteristics of these areas as floodplain management studies are completed. There are also a number of important terms (including flood prone land, concessional development, reliable access) which are not defined.

Further review of the flood risk management chapter is encouraged, ideally reverting to a format similar to that recommended in the Georges River Floodplain Management Study. This would include a common preamble, policy statement, objectives and definitions, followed by the prescriptive controls attached as a separate (one page) schedule for each catchment area where a floodplain management study has been undertaken. A separate schedule can be included with default controls for areas where floodplain management studies have not been completed.

Changes that would apply to all catchment areas include:

i) removal of inconsistent wording regarding the controls relating to residential development within the Low Flood Risk precinct;

ii) inclusion of definitions in the DCP provisions, including important terms such as flood prone land, flood liable, reliable access, concessional development, etc; and

iii) areas affected by future sea level rise include an additional sea level rise allowance to be added to the normal 0.5m freeboard allowance when specifying minimum floor levels for new residential, commercial and industrial development.

Changes that would apply specifically to the Gwawley Bay catchment include:

i) relaxation of the requirement for residential garages to be located a minimum of 0.2m above the 100 year flood level, to say the 20 year flood level;

ii) that the minimum crest height leading to basement car parks be increased from 0.2m above the 100 year flood to 0.5m above the 100 year flood, in recognition of the number of units in the catchment with basement car parks that have previously been inundated, and the increased risk to life from the sudden immersion of these areas; and

iii) that shelter-in-place be considered an acceptable alternative to off-site evacuation requirements where part of the building is located above the PMF flood level, given the shallow inundation depths within the catchment and the short duration of flooding.

8.2 FLOOD WARNING MEASURES

Flood warning is an important component of floodplain management. It provides advice on impending flooding so relevant agencies and residents can take action to minimise property damage and personal risk.

Flood warning systems usually monitor rainfall and river gauges in the upper catchment in real time and, through hydrologic and hydraulic models, predict the resulting flow and flood levels at some time in the future in the lower catchment.

The Bureau of Meteorology is the government agency responsible for issuing flood warnings throughout Australia. Dissemination of the flood warning and action to evacuate or otherwise assist people in the event of flooding is the responsibility of the State Emergency Service. As a general rule, the Bureau only provides a flood warning service where there is likely to be at least 6 hours warning of impending flooding.

The Bureau provide an excellent flood warning system for the Georges River, providing flood warnings at Liverpool weir, Milperra and East Hills. This warning system will mainly benefit communities on the Georges River floodplain upstream of the Como Railway Bridge, and will provide limited benefits for residents within the Gwawley Bay Catchment.

The Gwawley Bay catchment is a small urban catchment, where the response to flooding is rapid (often within an hour of rainfall). This provides little opportunity to provide a warning of flooding based on rainfall that has already occurred; to disseminate that warning to the public; and for the public to take appropriate action to reduce their exposure to flooding.

The development of a formal flood warning scheme for the Gwawley Bay catchment is considered to be of little value.

8.3 EMERGENCY MANAGEMENT PLANNING

The State Emergency Service (SES) has formal responsibility for emergency management operations in response to flooding. Other organisations normally provide assistance, including the Bureau of Meteorology, council, police, fire brigade, ambulance and community groups. Emergency management operations with regard to the flooding risk in the Gwawley Bay catchment is provided under the Sutherland Shire Local Flood Plan.

Information from the current floodplain management study will provide valuable data when the local flood plan is next updated. This includes:

i) the flood risk management mapping provided at Figure 4.2;
ii) Information from the property database, including the location and number of residential, commercial and industrial buildings potentially inundated in the 100 year flood (Table 4.3 and Fig 4.3);
iii) Information from the community questionnaire, including a list of residents who may be affected by flooding and who have indicated that they may require special assistance from the SES in a local emergency;
iv) Road inundation problem areas (Table 4.4 and Figure 4.4).

8.4 PUBLIC AWARENESS

Raising and maintaining flood awareness provides residents with an appreciation of the flood problem and what measures can be taken to reduce potential flood damage and to minimise personal risk during future floods.

Respondents to the community questionnaire ranked the provision of flood advice to residents as a favoured option for the Gwawley Bay catchment (third highest ranked option with 75% in favour and 3% opposed). The majority of respondents (54%) also believed that Council should advise all owners on a regular basis of the flood threat.

Advice on flooding is currently provided through Section 149 Planning Certificates. A Section 149 (Part 2) certificate is a mandatory certificate required to be attached to contracts for the sale of a property, which confirms the zoning of the land and any policy restrictions that apply to the land, including flood risk management policies. A Section 149 (Part 5) is a non-mandatory certificate that allows for additional information on matters such as flood risk to be provided.

There is some confusion regarding the meaning of Section 149 Certificates. The certificate applies to any part of the property that may be affected by flooding, and does not necessarily provide information on how much of the property is affected, or whether the building on the property is affected. The issue of a flood certificate or flood advice, which provides additional information on flooding, could remove much of this ambiguity. The advice could include information on flood levels that apply to a property, the floor level of the building (if available), and a map showing the different flood risk precincts that apply to the property. The flood advice could be attached to the Section 149 (Part 5) Certificate or where other enquiries are made. The release of information to the public through flood certificates was a recommendation from investigations undertaken on the Georges River (Bewsher 2004, 2011) and is further endorsed as part of the current floodplain management study.

An ongoing public awareness campaign is recommended, that includes:

i) Consolidation of the recent flood risk mapping and flood data prepared during the flood study and floodplain management study into Council's computer based GIS system. This will provide Council with valuable flood information that can be easily retrieved, and which will form the basis of information that can be supplied to the public when requests are made, or on a periodic basis.
ii) Updating the "Shire Maps" included in Council's web site to include the flood risk mapping from the current study.
iii) Additional information on the flood risk and the flood levels that apply to a particular property is provided on a flood certificate or flood advice. These certificates could be appended to the Section 149(5) certificates; provided whenever flood information is requested for a property; or provided on a regular basis to all residents in the study area.

8.5 STORMWATER MAINTENANCE ISSUES

One of the key findings from the community questionnaire was concern by residents that leaves, litter and other debris were a major problem within the study area. The highest ranking idea on reducing flood problems within the catchment was for *"better maintenance and removal of debris from drains and culverts"*, which was raised by 19 different respondents (Table 3.2). This was also the most favoured flood mitigation option supported by the community (90%).

Leaves and litter can be a significant problem in urban catchments. Blockage of stormwater pits can prevent surface flows from entering the underground pipe system; the capacity of stormwater pipes and channels can be reduced through the accumulation of leaves, rubbish and other debris; whilst culverts and channels can become blocked by larger obstacles such as shopping trolleys or cars.

Council maintains a number of street sweepers to keep gutters and drains clear of leaves. The service was reduced from five to two street sweepers during 2014 as a result of mechanical problems. Results of a community survey by Council during December 2014 emphasised that a primary concern for residents was the build up of leaf litter around drains impacting on their efficiency and ability to cope during storms, as well as environmental concerns with litter being washed into waterways. It is understood that Council intends to restore the service back to five street sweepers in 2015.

Council has also recently instigated a "Report It" page on Council's web site, which allows residents to report various matters to Council, including illegal dumping, blocked or broken drains, fallen tree branches, and other matters. A special "Report It" phone app has also been developed allowing residents to report a problem using their mobile phone. This provides information on progress of reports made and when action has been completed. This is a commendable initiative, which with the public's assistance, can help to identify and rectify potential blockage issues before it becomes a problem.

A formal maintenance program to inspect and maintain the capacity of the stormwater infrastructure in Gwawley Bay is recommended on a 6 monthly basis, or following any significant storm event within the catchment. Critical areas that need to be included in the maintenance program include:

i) the stormwater pits and grates in Formosa Street upstream of Southgate Shopping Centre;

ii) Port Hacking Road culvert on Gwawley Creek;

iii) the GPT Structure in Gwawley Creek, downstream of Box Road;

iv) the Gwawley Creek corridor, from Corea Oval to Gwawley Bay;

v) the Belgrave Esplanade culvert and upstream channel in the southern branch of the catchment;

vi) the open channel in the southern branch, from Kiama Street to The Boulevarde; and

vii) the Belgrave Esplanade culvert and upstream channel in the eastern (Parraweena Rd) branch of the catchment.

8.6 BASEMENT CAR PARKING REVIEW

There are a number of residential units within the study area with basement car parking potentially affected by stormwater inundation. Inundation of basement car parking poses a significant risk to personal safety due to rapid inundation once the entrance to these facilities is inundated.

Measures are included in Council's flood risk management development controls for new development to ensure that the entrance crest to the parking area is a minimum of 0.2m above the 100 year flood. This study recommends consideration of increasing this requirement to a minimum of 0.5m above the 100 year flood to provide a further factor of safety. However, there remain a number of existing basement parking facilities with a lower level of protection which are at risk of being inundated.

Problem areas have previously been reported at the end of Miranda Road, just upstream of The Boulevarde at Miranda. There are likely to be a number of other units with similar problems that have not yet been identified.

A review of units with basement car parking is recommended to identify those parking areas susceptible to inundation and to investigate options to alleviate flooding concerns.

9 RECOMMENDED FLOODPLAIN MANAGEMENT PLAN

9.1 THE RECOMMENDED MEASURES

The floodplain management measures that are recommended for inclusion in the Gwawley Bay Catchment Floodplain Management Plan are summarised in **Table 9.1** and are shown on **Figure 9.1**. The recommended measures are discussed briefly below.

9.1.1 Gwawley Creek Upstream of Corea Oval

A cluster of eight houses between Garnet Road and Meadow Place, Miranda, are potentially inundated in the 100 year flood. Further stormwater investigations are recommended to:

a) Verify the stormwater pipe system in this vicinity;

b) Identify restrictions in the pipe network (if any);

c) Investigate opportunities to open up an overland flow path between these houses.

The estimated cost of the review is $20,000. This does not include drainage augmentation measures that may be subsequently recommended.

9.1.2 Gwawley Creek Downstream of Corea Oval

The main issues raised in this area concern maintenance issues associated with the gross pollutant trap (GPT) downstream of Box Road, and other environmental issues associated with the creek corridor, including collection of rubbish, foul odours, rats and bank stability. Recommendations include:

a) Regular maintenance of the GPT structure and creek corridor, as part of a formal maintenance program for the catchment.

9.1.3 Kiama Street Drain to Port Hacking Road

Inundation problems have been experienced adjacent to an open drain between The Boulevarde and Kiama Street, Miranda. The drain passes under an industrial estate comprising 36 units, with some occupants reporting flooding twice over the last two years.

A detention basin in Seymour Shaw Park was investigated to reduce flows in the open drain, but found to unduly impact on a Premier League football stadium. Local measures in the immediate vicinity of the industrial estate are therefore recommended, including:

a) Improvements to the inlet of the drain passing under the industrial estate, in conjunction with a proposed GPT at this location, to minimise the potential for culvert blockage;

b) Reviewing compliance issues associated with two overland flowpaths through the industrial estate, to ensure that these operate as intended and remain clear of obstructions.

An allowance of $50,000 has been provided in the plan for these measures. This does not include the cost of the proposed GPT structure which is subject to separate funding.

9.1.4 Belgrave Esplanade (Southern Branch)

The capacity of the culvert under Belgrave Esplanade (Southern Branch) is limited, which when combined with a 50% blockage allowance results in overtopping of the road by up to 0.5m in the 100 year flood. This results in flooding problems along Belgrave Esplanade and other nearby streets.

Increasing the width of the existing culvert from 4.0m to 8.0m was found to reduce flood levels by up to 0.23m in the 100 year flood, benefitting up to 18 homes previously estimated to be inundated. The estimated cost of these works is high (in excess of $2.1M) resulting in a relatively low benefit/cost ratio (0.2). This option is difficult to justify on economic grounds alone, but it may be a viable proposition if and when the culvert needs to be re-constructed due to maintenance requirements.

An alternative, cost effective measure that is recommended is the inclusion of bollards across the waterway area upstream of the culvert to reduce the likelihood of culvert blockage. Removal of the likelihood of blockage at the structure could have the same hydraulic impact as doubling the width of the existing culvert. An allowance of $50,000 has been provided in the plan for this measure.

9.1.5 Measures upstream of Southgate Shopping Centre

Significant ponding occurs immediately upstream of the Southgate Shopping Centre, between Formosa Street and Juniper Place, with up to 8 homes potentially inundated in the 100 year flood.

Flood behaviour in this area is complex and dependent on an inlet structure to a larger box culvert under the shopping centre. No design drawings or investigation reports for this structure have been located to verify its intended operation and its representation in the flood model. There is also some evidence that the capacity of this structure has been reduced by recent activity, which may further exacerbate flooding conditions.

It is recommended that:

a) A more detailed computer model is prepared to review flood behaviour in this vicinity, incorporating more detailed information on the stormwater system, Southgate drainage facilities, and the potential for floodwater to flow through the basement car park. The estimated cost of the investigation is $30,000;

b) Improvements to the inlet structure to maximise the capacity of the box culverts under the shopping centre and reduce upstream flooding, including the construction of bollards in front of the structure to prevent blockage by debris, shopping trolleys, or floating cars. Whilst the design will be subject to the flood investigations, an allowance of $100,000 has been provided in the floodplain management plan for these measures.

9.1.6 Gwawley Creek Downstream of Port Hacking Road

It is understood that Council is considering a range of environmental enhancements in the lower section of Gwawley Creek, as part of a separate program of works. These works include the replacement of the Port Hacking Road floating debris structure with a new upstream GPT structure, maintenance dredging of the downstream waterway area, and other bank protection measures. Other floodplain management measures recommended in this area include:

a) providing measures to limit the potential for blockage at the Port Hacking Road culvert, in conjunction with the proposed GPT structure at this location;

b) improving an overland flow path between Dalman Place and Gwawley Creek, through the use of permeable or raised fencing.

An allowance of $40,000 has been provided for these measures.

9.1.7 Belgrave Esplanade (Eastern Branch)

Removal of the potential for culvert blockage at the Belgrave Esplanade Culvert could reduce flooding by up to 0.3m in the 100 year flood. This provides benefit upstream to Box Road, and would eliminate flooding to one house in Belgrave Esplanade.

Inclusion of bollards across the waterway area upstream of the Belgrave Esplanade culvert is recommended to reduce the likelihood of culvert blockage. An allowance of $50,000 has been provided in the plan for this measure.

9.1.8 Box Road (Eastern Branch)

Significant flooding problems are experienced to industrial and commercial development in Box Road, Parraweena Road, Kumullar Road and Taren Point Road. Part of the problem lies with a restricted culvert (2 x 1650 pipes) under Box Road, which reduces the capacity of a much larger box culvert (4.6m x 2.6m) from the upstream property at 72-78 Box Road. The potential for blockage at the upstream end of the box culvert, and the absence of a suitable overland flow path through this property, also contributes to the flooding problems experienced.

The following measures are recommended to improve flood conditions:

a) Extending the 4.6x2.6 box culvert from 72-78 Box Road through to the end of Box Road to replace the existing 2x1650 pipes at this location, subject to confirmation that this can be achieved without raising the level of Box Road. An allowance of $360,000 is provided in the Plan for this measure.

b) Constructing fencing around the open channel on the upstream side of the 4.6x2.6 box culvert to reduce the likelihood of culvert blockage. An allowance of $20,000 is provided for this measure;

c) Providing an overland flow path for flows in excess of the box culvert capacity in conjunction with future development proposals for this site. It is assumed that this would form part of future redevelopment conditions for this property.

9.1.9 Parraweena Road (Eastern Branch)

The stormwater drain capacity from Parraweena Road and downstream, over a distance of 135m, is relatively restricted compared with the upstream and downstream drainage capacity. The relatively narrow overland flow path downstream of Parraweena Road further exacerbates flooding conditions.

The following measures are recommended:

a) Investigations to determine the feasibility of providing increased culvert capacity from Parraweena Road to the downstream open channel, over a distance of 135m. These measures need to be integrated with other downstream measures that have been recommended. An allowance of $20,000 has been included for the review.

b) Providing an improved overland flow path downstream of Parraweena Road as part of future redevelopment proposals. It is assumed that this would form part of future redevelopment conditions.

9.1.10 Production Road Channel

The flood study identified significant flooding problems in the Production Road channel, mostly between Bay Road and Box Road. There are 15 industrial buildings estimated to be inundated above floor level in a 100 year flood. There have also been a number of reports of flooding from business owners in this area in the past.
Most of the flooding problems originate from high flood levels that are experienced within the upstream reaches of the Production Road channel. Siltation problems and increased density of mangroves in the channel has further reduced the capacity of this channel.

Four options were investigated to reduce flood levels within the channel. The recommended option (Option 3) improves the conveyance of the upstream channel (adjacent to Production Road) by widening the base width of the channel to 10m and providing steeper side banks constructed using large boulders, similar to the channel treatment in the downstream channel adjacent to the Anglican Retirement Village. The invert of the channel would also be lowered to RL -0.5m AHD to restore original design levels and match the invert levels of existing culverts at Bay Road and at Woolooware Bay. The cost of this option will be largely influenced by the availability of large boulders from nearby construction sites. An allowance of up to $2,500,000 is provided for these works. The average annual flood damage is estimated at $190,000 and the present value of future flood damages estimated at $2.0M, providing a relatively favourable benefit/cost ratio of up to 0.8.

9.1.11 Planning and Development Controls

Land use planning and development controls are key mechanisms by which Council can manage flood-affected areas within the Gwawley Bay catchment. This will ensure that new development is compatible with the flood risk, and will allow for existing problems to be gradually reduced over time through sensible redevelopment.

The existing DCP Provisions provide a sound basis to implement flood related planning controls in the study area and other stormwater catchments. Further review of the flood risk management chapter in Council's DCP could be considered to simplify the format of the planning controls as they relate to the different flood risk management precincts. Ideally this should include flexibility to impose different controls in different catchment areas as floodplain management studies are completed. Other changes that would apply to all catchment areas include:

a) Removal of inconsistent wording regarding the controls relating to residential development in the Low Flood Risk precinct;

b) Inclusion of definitions in the DCP provisions, including important terms such as flood prone land, flood liable, reliable access, concessional development, etc;

c) Provision to include a future sea level rise allowance, where appropriate, on top of the usual freeboard allowance when specifying minimum floor level controls for new development.

Some changes that could be considered specifically for the Gwawley Bay catchment include:

d) relaxation of the requirement for residential garages to be located a minimum of 0.2m above the 100 year flood level, to say the 20 year flood level;

e) The minimum crest height leading to basement car parks be increased from 0.2m above the 100 year flood to 0.5m above the 100 year flood;

f) Vertical evacuation to a higher level within a building be considered an acceptable alternative to off-site evacuation requirements, given the shallow inundation depths within the catchment and the short duration of flooding.

9.1.12 Emergency Management Planning

Information from the current floodplain management study will provide valuable data when the Sutherland Local Flood Plan is next updated. Whilst this is normally the responsibility of the SES, assistance could be offered through the floodplain management committee to assist in the development and review of the Local Flood Plan.

A nominal allowance of say $20,000 could be provided in the Floodplain Management Plan to assist with this review.

9.1.13 Improved Public Awareness

Raising and maintaining flood awareness provides residents with an appreciation of the flood problem and what measures can be taken to reduce potential flood damage and to minimise personal risk during future floods.

An ongoing public awareness campaign is recommended, that includes:

a) Consolidation of the recent flood risk mapping and flood data into Council's computer based GIS system;

b) Updating the "Shire Maps" included in Council's web site to include the flood risk mapping from the current study;

c) Providing information concerning the flood risk and flood levels for properties on a flood certificate or flood advice. This could be appended to Section 149(5) certificates or provided when requests about flooding are made.

A nominal amount of $50,000 has been provided for these initiatives.

9.1.14 Stormwater Maintenance

By far the most dominant complaint and issue raised by the community during the study concerned the perceived lack of maintenance by Council to keep the stormwater system clear of leaves and other rubbish. Recent Council initiatives, such as increasing the number of street sweepers and their "report it" web site will help in this regard.

It is recommended that a formal maintenance program is developed for the Gwawley Bay Catchment. Regular inspections of critical areas should be undertaken on a regular 6 monthly basis, or following any significant storm within the catchment. Critical areas that need to be included in the maintenance program include:

a) the stormwater pits and grates in Formosa Street upstream of Southgate Shopping Centre;

b) Port Hacking Road culvert on Gwawley Creek;

c) the GPT Structure in Gwawley Creek, downstream of Box Road;

d) the Gwawley Creek corridor, from Corea Oval to Gwawley Bay;

e) The Belgrave Esplanade culvert and upstream channel in the southern branch of the catchment;

f) The open channel in the southern branch, from Kiama Street to The Boulevarde; and

g) The Belgrave Esplanade culvert and upstream channel in the eastern (Parraweena Rd) branch of the catchment.

9.1.15 Basement Car Parking Review

There are a number of existing units with basement car parks that are susceptible to stormwater inundation. This poses a significant risk to personal safety due to the rapid rise in floodwater once the entrance crest to these facilities is inundated.

Further investigation is recommended to identify those units with basement parking susceptible to inundation and to investigate options to alleviate flooding concerns. A nominal amount of $20,000 has been provided in the plan for these investigations.

9.2 FUNDING AND IMPLEMENTATION

The total estimated cost of implementing the Floodplain Management Plan is estimated at $5.5M (2015). This does not include additional measures that may be recommended following further detailed investigations.

The timing of proposed works will depend on overall budgetary commitments of Council and the availability of funds from other sources. It is envisaged that the Plan would be implemented progressively over a 5 to10 year time frame.

There are a variety of sources of potential funding that could be considered to implement the Plan. These include:

i) Council funds;

ii) Developer or Owner contributions

iii) Section 94 contributions;

iv) State funding for flood risk management measures through the Office of Environment and Heritage

v) State Emergency Service, either through volunteered time or funding assistance for emergency management measures;

Council can expect to receive the majority of financial assistance through the Office of Environment and Heritage. These funds are available to implement measures that contribute to reducing existing flood problems. Funding assistance is likely to be available on a 2:1 (State:Council) basis.

Although much of the Plan may be eligible for Government assistance, funding can not be guaranteed. Government funds are allocated on an annual basis to competing projects throughout the State. Measures that receive Government funding must be of significant benefit to the community. Funding is usually available for the investigation, design and construction of flood mitigation works included in the floodplain management plan.

9.3 ON-GOING REVIEW OF PLAN

The Plan should be regarded as a dynamic instrument requiring review and modification over time. The catalyst for change could include new flood events and experiences, legislative change, alterations in the availability of funding, or changes to the area's planning strategies.

A thorough review every 5 years is warranted to ensure the ongoing relevance of the Plan.

TABLE 9.1
Recommended Floodplain Management Plan

Item	Area	Description	Report Section	Indicative Cost	Potential Funding Sources	Priority
1	A1	**Gwawley Creek Upstream of Corea Oval**	7.1			
		a) Verify stormwater pipe system downstream of Garnet Rd		N/A	SSC	Low
		b) Identify stormwater improvements (if any)		$10,000	SSC, OEH	Low
		c) Investigate options for overland flow path		$10,000	SSC, OEH	Low
2	A2	**Gwawley Creek Downstream of Corea Oval**	7.2			
		a) Regular maintenance of GPT structure and creek corridor (Refer also to Item 14)		N/A	SSC	Medium
3	A4	**Kiama St Drain to Port Hacking Rd**	7.3			
		a) Modify inlet to reduce blockage		$50,000	SSC, OEH	Medium
		b) Remove obstructions from overland flowpaths		N/A	Owner	High
4	A6	**Belgrave Esplanade (Southern Branch)**	7.4			
		a) Consider amplifying culvert in conjunction with future maintenance requirements		$2,100,000	SSC, OEH	Low
		b) Include bollards across waterway to prevent culvert blockage		$50,000	SSC, OEH	Medium
5	A3	**Upstream Southgate Shopping Centre**	7.5			
		a) Review flooding with detailed computer model		$30,000	SSC, OEH,	High
		b) Improvements to inlet structure under Southgate		$100,000	Southgate	High
6	A6	**Gwawley Creek downstream Port Hacking Rd**	7.6			
		a) Measures to prevent blockage at Port Hacking Rd culvert		$30,000	SSC, OEH	Medium
		b) Improved overland flow path from Dalman Pl to Gwawley Ck		$10,000	SSC, OEH	Medium
7	A6	**Belgrave Esplanade (Eastern Branch)**	7.7			
		a) Include bollards across waterway to prevent culvert blockage		$50,000	SSC, OEH	Medium
8	A5	**Box Road (Eastern Branch)**	7.8			
		a) Extend 4.6x2.6 culvert through Box Rd		$360,000	SSC, OEH	Medium
		b) Fencing around upstream open channel to prevent blockage		$20,000	SSC, OEH	Medium
		c) Improved overland flow path as part of future redevelopment		N/A	Developer	Low
9	A5	**Parraweena Road (Eastern Branch)**	7.9			
		a) Investigate feasibility of providing increased culvert capacity downstream of Parraweena Rd		$20,000	SSC, OEH	Low
		b) Improved overland flow path as part of future redevelopment		N/A	Developer	Low
10	A7	**Production Road Channel**	7.10			
		a) Investigation & design		$40,000	SSC, OEH	Medium
		b) Channel Improvement Works		$2,500,000	SSC, OEH	Medium
11	A1-A7	**Planning & Development Controls**	8.1			
		a) Review and simplify DCP provisions		$10,000	SSC	High
		b) Incorporate minor amendments for car parking and evacuation requirements for the Gwawley Bay catchment		N/A	SSC	High
12	A1-A7	**Emergency Management Operations**	8.3			
		a) Update Local Flood Plans		$20,000	SSC,SES,OEH	High
13	A1-A7	**Improved Public Awareness**	8.4			
		a) Update Council's GIS database with flood data		$10,000	SSC	High
		b) Update mapping in "Shire Maps"		$20,000	SSC	Medium
		c) Provide flood certificates		$20,000	SSC	Medium
14	A1-A7	**Stormwater Maintenance**	8.5			
		a) Develop formal maintenance program		N/A	SSC	Medium
15	A1-A7	**Basement Car Parking Review**	8.6			
		a) Identify problem areas and investigate options		$20,000	SSC	Medium
		TOTAL		$5,480,000		

Catchment - Wide Measures

11 - Planning and Development Controls

12 - Emergency Management Planning

13 - Improved Public Awareness

14 - Stormwater Maintenance

15 - Basement Car Parking Review

5. Measures upstream of Southgate
- Prepare detailed model of flood behaviour
- Increase capacity of inlet structure

6. Gwawley Ck d/s of Port Hacking Rd
- Measures to prevent blockage at PH Rd
- Improved overland flowpath from Dalman Pl

2. Gwawley Creek downstream of Corea Oval
- Regular maintenance of GPT structure and creek corridor (Refer also to Item 14)

7. Belgrave Esplanade (Eastern Branch)
- Install bollards to prevent blockage

10. Production Road Channel
- Widen and lower existing open channel

4. Belgrave Esplanade (Southern Branch)
- Consider culvert amplification
- Install bollards to prevent blockage

1. Gwawley Creek upstream of Corea Oval
- Identify stormwater restrictions
- Improve overland flow path

8. Box Rd (Eastern Branch)
- Extend large u/s culvert through Box Rd
- Fencing around channel to prevent blockage
- Provide improved overland flowpath

9. Parraweena Road (Eastern Branch)
- Investigate options to increase drain capacity
- Provide improved overland flowpath

3. Kiama St Drain to Port Hacking Rd
- Improve inlet to drain to prevent blockage
- Keep overland flowpaths clear

Georges River

Captain Cook Bri

Sylvania

Southgate Branch

Holt Rd

Gwawley Bay

Sylvania Waters

Gwawley Creek (North of Box Rd)

Gwawley Creek

Sylvania Waters

Woolooware Bay

Taren Point

Princes Highway

Sylvania Rd

Box Rd

Taren Point Rd

Bay Rd

Production Road Catchment

Box Rd

Port Hacking Rd

Parraweena Rd

Eastern Branch (Parraweena Rd)

Gymea

Gwawley Creek (South of Box Rd)

Southern Branch

The Boulevarde

Miranda

Caringbah

Kingsway

N

0 200 400

metres

FloodMit

Job No: J1325
File: J1325_Fig9-1b.wor
Date: 17/6/15

Figure 9.1
Recommended Floodplain Management Plan

10 ACKNOWLEDGEMENTS

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- residents of the study area;
- Councillors and Council staff from Sutherland Shire Council;
- Office of Environment and Heritage;
- State Emergency Service; and
- Members of the Floodplain Management Committee.

11 REFERENCES

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12 GLOSSARY

Note that terms shown in bold are described elsewhere in this Glossary.

100 year flood	A **flood** that occurs on average once every 100 years. Also known as a 1% flood. See **annual exceedance probability (AEP)** and **average recurrence interval (ARI)**.
50 year flood	A **flood** that occurs on average once every 50 years. Also known as a 2% flood. See **annual exceedance probability (AEP)** and **average recurrence interval (ARI)**.
20 year flood	A **flood** that occurs on average once every 20 years. Also known as a 5% flood. See **annual exceedance probability (AEP)** and **average recurrence interval (ARI)**.
afflux	The increase in flood level upstream of a constriction of flood flows. A road culvert, a pipe or a narrowing of the stream channel could cause the constriction.
annual exceedance probability (AEP)	AEP (measured as a percentage) is a term used to describe **flood** size. It is a means of describing how likely a flood is to occur in a given year. For example, a 1% AEP flood is a **flood** that has a 1% chance of occurring, or being exceeded, in any one year. It is also referred to as the '100 year flood' or 1 in 100 year flood'. The terms **100 year flood**, **50 year flood**, **20 year flood** etc, have been used in this study. See also **average recurrence interval (ARI)**.
Australian Height Datum (AHD)	A common national plane of level approximately equivalent to the height above sea level. All **flood levels**, floor levels and ground levels in this study have been provided in metres AHD.
average annual damage (AAD)	Average annual damage is the average flood damage per year that would occur in a nominated development situation over a long period of time.
average recurrence interval (ARI)	ARI (measured in years) is a term used to describe **flood** size. It is the long-term average number of years between floods of a certain magnitude. For example, a 100 year ARI flood is a flood that occurs or is exceeded on average once every 100 years. The terms **100 year flood**, **50 year flood**, **20 year flood** etc, have been used in this study. See also **annual exceedance probability (AEP)**.
catchment	The land draining through the main stream, as well as tributary streams.
Development Control Plan (DCP)	A DCP is a plan prepared in accordance with Section 72 of the *Environmental Planning and Assessment Act, 1979* that provides detailed guidelines for the assessment of development applications.
DNR	Department of Natural Resources, formerly the Department of Infrastructure, Planning & Natural Resources (DIPNR).
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.
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*.

effective warning time	The time available after receiving advice of an impending **flood** and before the floodwaters prevent appropriate flood response actions being undertaken. The **effective warning time** is typically used to move farm equipment, move stock, raise furniture, evacuate people and transport their possessions.
emergency management	A range of measures to manage risks to communities and the environment. In the flood context it may include measures to prevent, prepare for, respond to and recover from flooding.
EP&A Act	*Environmental Planning and Assessment Act, 1979*.
extreme flood	An estimate of the **probable maximum flood (PMF)**, which is the largest flood likely to occur.
flood	A relatively high stream flow that 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	An appreciation of the likely effects of flooding and a knowledge of the relevant flood warning, response and evacuation procedures.
flood hazard	The potential for damage to property or risk to persons during a **flood**. Flood hazard is a key tool used to determine flood severity and is used for assessing the suitability of future types of land use.
flood level	The height of the **flood** described either as a depth of water above a particular location (eg. 1m above a floor, yard or road) or as a depth of water related to a standard level such as **Australian Height Datum** (eg the flood level was 7.8m AHD). Terms also used include **flood stage** and **water level**.
flood liable land	Land susceptible to flooding up to the **probable maximum flood (PMF)**. Also called **flood prone land**. Note that the term flood liable land now covers the whole of the **floodplain**, not just that part below the **flood planning level**.
flood planning levels (FPLs)	The combination of flood levels and **freeboards** selected for planning purposes, as determined in **floodplain management studies** and incorporated in **floodplain management plans**. The concept of flood planning levels supersedes the designated flood or the flood standard used in earlier studies.
flood prone land	Land susceptible to flooding up to the **probable maximum flood (PMF**). Also called **flood liable land**.
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 damages during a **flood**.
Flood risk precinct	An area of land with similar flood risks and where similar development controls may be applied by a council to manage the flood **risk**. (The flood risk is determined based on the existing development in the precinct or assuming the precinct is developed with normal residential uses). Usually the floodplain is categorised into three flood risk precincts – 'low', 'medium' and 'high' – although other classifications can sometimes be used. (See also risk).
Flood Study	A study that investigates flood behaviour, including identification of flood extents, **flood levels** and flood velocities for a range of flood sizes.

floodplain	The area of land that is subject to inundation by floods up to and including the probable maximum flood event, that is, **flood prone land** or **flood liable land**.
Floodplain Risk Management Plan	The outcome of a **Floodplain Risk Management Study**. (Note that the term 'risk' is often dropped in common usage.
Floodplain Risk Management Study	Studies carried out in accordance with the *Floodplain Development Manual* (NSW Government, 2005) that assesses options for minimising the danger to life and property during **floods**. These measures, referred to as 'floodplain management measures/options', aim to achieve an equitable balance between environmental, social, economic, financial and engineering considerations. The outcome of a Floodplain Risk Management Study is a **Floodplain Risk Management Plan**.
floodway	Those areas of the **floodplain** where a significant discharge of water occurs during **floods**. Floodways 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**.
flow	see **discharge**
foreshore building line	A line fixed by resolution of Council in respect of land fronting any bay, river, creek, lagoon, harbour or ocean, which provides a setback distance where buildings or other structures would normally be prohibited.
freeboard	A factor of safety expressed as the height above the **design flood level**. Freeboard provides a factor of safety to compensate for uncertainties in the estimation of flood levels across the **floodplain**, such and wave action, localised **hydraulic** behaviour and impacts that are specific event related, such as levee and embankment settlement, and other effects such as "greenhouse" and climate change.
high flood hazard	For a particular size **flood**, there would be a possible danger to personal safety, able-bodied adults would have difficulty wading to safety, evacuation by trucks would be difficult and there would be a potential for significant structural damage to buildings.
hydraulics	Term given to the study of water flow in waterways; in particular, the evaluation of flow parameters such as water level and **velocity**.
hydrology	Term given to the study of the rainfall and runoff process; in particular, the evaluation of **peak discharges**, flow volumes and the derivation of hydrographs (graphs that show how the discharge or stage/flood level at any particular location varies with time during a flood).
Local Environmental Plan (LEP)	A Local Environmental Plan is a plan prepared in accordance with the *Environmental Planning and Assessment Act*, 1979, that defines zones, permissible uses within those zones and specifies development standards and other special matters for consideration with regard to the use or development of land.
low flood hazard	For a particular size flood, able-bodied adults would generally have little difficulty wading and trucks could be used to evacuate people and their possessions should it be necessary.
m AHD	metres **Australian Height Datum (AHD)**.
m/s	metres per second. Unit used to describe the **velocity** of floodwaters.

m^3/s	Cubic metres per second or 'cumecs'. A unit of measurement for creek or river flows or **discharges**. It the rate of flow of water measured in terms of volume per unit time.
merit approach	The principles of the merit approach are embodied in the *Floodplain Development Manual* (NSW Government, 2005) and weigh up social, economic, ecological and cultural impacts of land use options for different **flood prone** areas together with flood damage, **hazard** and behaviour implications, and environmental protection and well being of the State's rivers and **floodplains**.
overland flow path	The path that floodwaters can follow if they leave the confines of the main flow channel. Overland flowpaths can occur through private property or along roads. Floodwaters travelling along overland flowpaths, often referred to as 'overland flows', may or may not re-enter the main channel from which they left — they may be diverted to another water course.
peak discharge	The maximum **flow** or **discharge** during a flood.
present value	In relation to flood damage, is the sum of all future flood damages that can be expected over a fixed period (usually 20 years) expressed as a cost in today's value.
probable maximum flood (PMF)	The largest flood likely to ever occur. The PMF defines the extent of **flood prone land** or **flood liable land**, that is, the **floodplain**. The extent, nature and potential consequences of flooding associated with the PMF event are addressed in the current study.
reliable access	During a **flood**, reliable access means the ability for people to safely evacuate an area subject to imminent flooding within **effective warning time**, having regard to the depth and **velocity** of floodwaters, the suitability of the evacuation route, and other relevant factors.
risk	Risk is measured in terms of consequences and likelihood. In the context of floodplain management, it is the likelihood and consequences arising from the interaction of floods, communities and the environment. For example, the potential inundation of an aged person's facility presents a greater flood risk than the potential inundation of a sports ground amenities block (if both buildings were to experience the same type and probability of flooding). Reducing the probability of flooding reduces the risk, increasing the consequences increases risk. (See also **flood risk precinct**).
runoff	The amount of rainfall that ends up as flow in a stream, also known as rainfall excess.
SES	State Emergency Service of New South Wales.
stage–damage curve	A relationship between different water depths and the predicted flood damage at that depth.
velocity	the term used to describe the speed of floodwaters, usually in **m/s**.
water level	see **flood level**.
water surface profile	A graph showing the height of the **flood** (**flood stage**, **water level** or **flood level**) at any given location along a watercourse at a particular time.

APPENDIX A

FREQUENTLY ASKED QUESTIONS

FLOODPLAIN RISK MANAGEMENT STUDIES

FREQUENTLY ASKED QUESTIONS

Why do flood levels change over time?

There is a chance that floods of various magnitudes will occur in the future. As the size of a flood increases, the chance that it will occur becomes rarer. Because some of these rare floods have never been experienced or accurately recorded since European settlement, the height of future floodwaters is normally predicted using computer models. These computer models simulate flood levels and velocities for a range of flood sizes and flood probabilities. Given the importance of estimating flood levels accurately, councils and the NSW Department of Environment, Climate Change and Water (DECCW) engage experts to establish and operate the computer models.

From time to time the computer models are revised and predicted flood levels can change. The resultant change in flood levels however is normally very small. The reasons why the computer models are revised can include:

- new rainfall or ground topography information becomes available;
- new floods occur which provide additional data from which to fine-tune the models;
- better computer models become available as the science of flood modelling improves and computer capabilities increase; or
- flood mitigation works may have been carried out, or development within the catchment may have occurred, that was not previously simulated in the models.

How are these studies funded?

Flood studies and floodplain risk management studies are often carried out under State Government guidelines and are funded on a 1:1:1 basis among the Federal and State Governments, and councils. This funding arrangement is also available for the construction of flood mitigation works.

My property is in a Low Flood Risk Precinct. What does this mean?

The classification of a 'Low Flood Risk Precinct' can differ slightly between councils. Generally it means that your property would not be inundated in a 100 year flood but still has a very slight chance of inundation from larger (i.e. rarer) floods.

If you are a residential property owner, there will be virtually no change to how you may develop your property. However, there may be controls on the location of essential services such as hospitals, evacuation centres, nursing homes and emergency services.

My property is in a Medium Flood Risk Precinct. What does this mean?

The classification of a 'Medium Flood Risk Precinct' can differ slightly between councils. Often it means that your property is inundated in a 100 year flood, however conditions are not likely to be hazardous during such a flood. If you are a residential property owner development controls will probably be similar to those that currently exist.

My property is in a High Flood Risk Precinct. What does this mean?

The classification of a 'High Flood Risk Precinct' can differ slightly between councils. Often it means that your property will be inundated in a 100 year flood and that hazardous conditions may occur. This could mean that there would be a possible danger to personal safety, able bodied adults may have difficulty wading to safety, evacuation by trucks may be difficult, or there may be a potential for significant structural damage to buildings. This is an area of higher hazard where stricter controls may be applied.

Will my property value be altered if I am in a Flood Risk Precinct?

Any change in a council's classification of properties can have some impact on property values. Nevertheless, councils normally give due consideration to such impacts before introducing a system of flood risk classifications or any other classification system (e.g. bushfire risks, acid sulphate soil risk, etc). If your property is now classified as being in a Flood Risk Precinct, the real flood risks on your property have not changed, only its classification has altered. A prospective purchaser of your property could have previously discovered this risk if they had made enquiries themselves.

If you are in a Low Flood Risk Precinct, generally there will be no controls on normal residential type development. Previous valuation studies have shown that under these circumstances, your property values will not alter significantly over the long term. Certainly, when a new system of classifying flood risks is introduced, there may be some short-term effect, particularly if the development implications of the precinct classification are not understood properly. This should only be a short-term effect however until the property market understands that over the long-term, the Low Flood Risk Precinct classification will not change the way you use or develop your property.

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 risk precinct categorisation may influence their property value.

My property was never classified as 'flood prone' or 'flood liable' before. Now it is in a Low Flood Risk Precinct. Why?

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 January 1998 flood in Katherine, the August 1998 flood in Wollongong, the 2002 floods in Europe, Hurricane Katrina in 2005, etc).

Will I be able to get house and contents insurance if my house is in a Flood Risk Precinct?

In contrast to the USA and many European countries, flood insurance has generally not been available in Australia for residential property. Following the disastrous floods in Coffs Harbour in November 1996 and in Wollongong in August 1998, very limited flood cover began to be offered by some insurance companies. From 2008, many insurance companies started offering wider cover although the extent of the cover particularly for very flood prone properties is still not well known and may differ between insurers. The most likely situation is that your insurer will now offer you some flood cover although this will be dependent of the flood level information that the insurer has for your property. (This may not necessarily be the same as that available from Council). If flood cover is offered, the classification of your property within a Flood Risk Precinct per se, is unlikely to alter the availability of cover. Obviously insurance policies and conditions may change over time or between insurance companies, and you should confirm the specific details of your situation with your insurer.

Will I be able to get a home loan if my land is in a Flood Risk Precinct?

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 system of Flood Risk Precinct 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 could have identified the nature of the flood risk during assessment of home loan applications. As a result, it is not likely that the classification of your property within a Flood Risk Precinct 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.

How have the flood risk maps been prepared?

Because some large and rare floods have often not been experienced or accurately recorded since European settlement commenced, computer models are used to simulate the depths and velocities of major floods. These computer models are normally established and operated by flooding experts employed by local and state government authorities. 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 (e.g. 'low', 'medium' and 'high') 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 major floods.

What is the probable maximum flood (PMF)?

The PMF is the largest flood that could possibly occur. 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's Floodplain Development Manual (2005), councils must consider all flood risks, even these potentially small ones, when managing floodplains. As part of the State Government's Manual, the definitions of the terms 'flood liable', flood prone' and 'floodplain' refer to land inundated by the PMF.

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 a fallacy 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. On average, if you live to be 70 years old, you have a better than even chance of experiencing a 100 year flood.

Why do councils prepare floodplain management studies and plans?

Under NSW legislation, councils have the primary responsibility for management of development within floodplains. To appropriately manage development, councils need a strategic plan which considers the potential flood risks and balances these against the beneficial use of the floodplain by development. To do this, councils have to consider a range of environmental, social, economic, financial and engineering issues. This is what happens in a floodplain risk management study. The outcome of the study is the floodplain risk management plan, which details how best to manage flood risks in the floodplain for the foreseeable future.

Floodplain risk management plans normally comprise a range of works and measures such as:

- improvements to flood warning and emergency management;
- works (e.g. levees or detention basins) to protect existing development;
- voluntary purchase or house raising of severely flood-affected houses;
- planning and building controls to ensure future development is compatible with the flood risks; and
- measures to raise the community's awareness of flooding so that they are better able to deal with the flood risks they face.

Will the Flood Risk Precinct maps be changed?

Yes. All mapping undertaken by council is subjected to ongoing review. As these reviews take place, it is conceivable that changes to the mapping will occur, particularly if new flood level information or ground topography information becomes available. However, this is not expected to occur very often and the intervals between revisions to the maps would normally be many years. Many councils have a policy of reviewing and updating floodplain management studies and plans about every five to ten years. This is the likely frequency at which the maps may be amended.

APPENDIX B

CONSULTATION MATERIAL

Sutherland Shire COUNCIL

Administration Centre
4-20 Eton Street, Sutherland
NSW 2232 Australia
Please reply to:
General Manager,
Locked Bag 17,
Sutherland NSW 1499
Australia
Tel 02 9710 0333
Fax 02 9710 0265
DX4511 SUTHERLAND
Email ssc@ssc.nsw.gov.au
www.sutherlandshire.nsw.gov.au
ABN 52 018 204 808
Office Hours
8.30am to 4.30pm
Monday to Friday

Peter Le, 9710 0119
File Ref: GS/06/140545

5 May 2014

[Property Owner's Name]
[Address Line 1]
[Address Line 2]

Dear Resident,

Gwawley Bay Catchment Floodplain Management Study
Your Property at: [Property Address]
[In response, please quote File Ref GS/06/140545]

This letter is being sent to residents and business owners within the Gwawley Bay catchment who may be affected by flooding or other stormwater problems. Council would like to provide a brief update on investigations that are being undertaken, and also to enquire whether there are any specific issues in the vicinity of your property that you would like included in these investigations.

The study area is shown on the enclosed map. It includes those areas that may experience problems as a result of surface runoff across the catchment; surcharging flows from the stormwater drainage system; or overtopping of open drains, Gwawley Creek or Gwawley Bay. The Gwawley Bay flood study was adopted by Council in February 2013, which identified those areas potentially affected by stormwater inundation. The Study can be viewed online at Council's web site (see under Environment/Waterways).

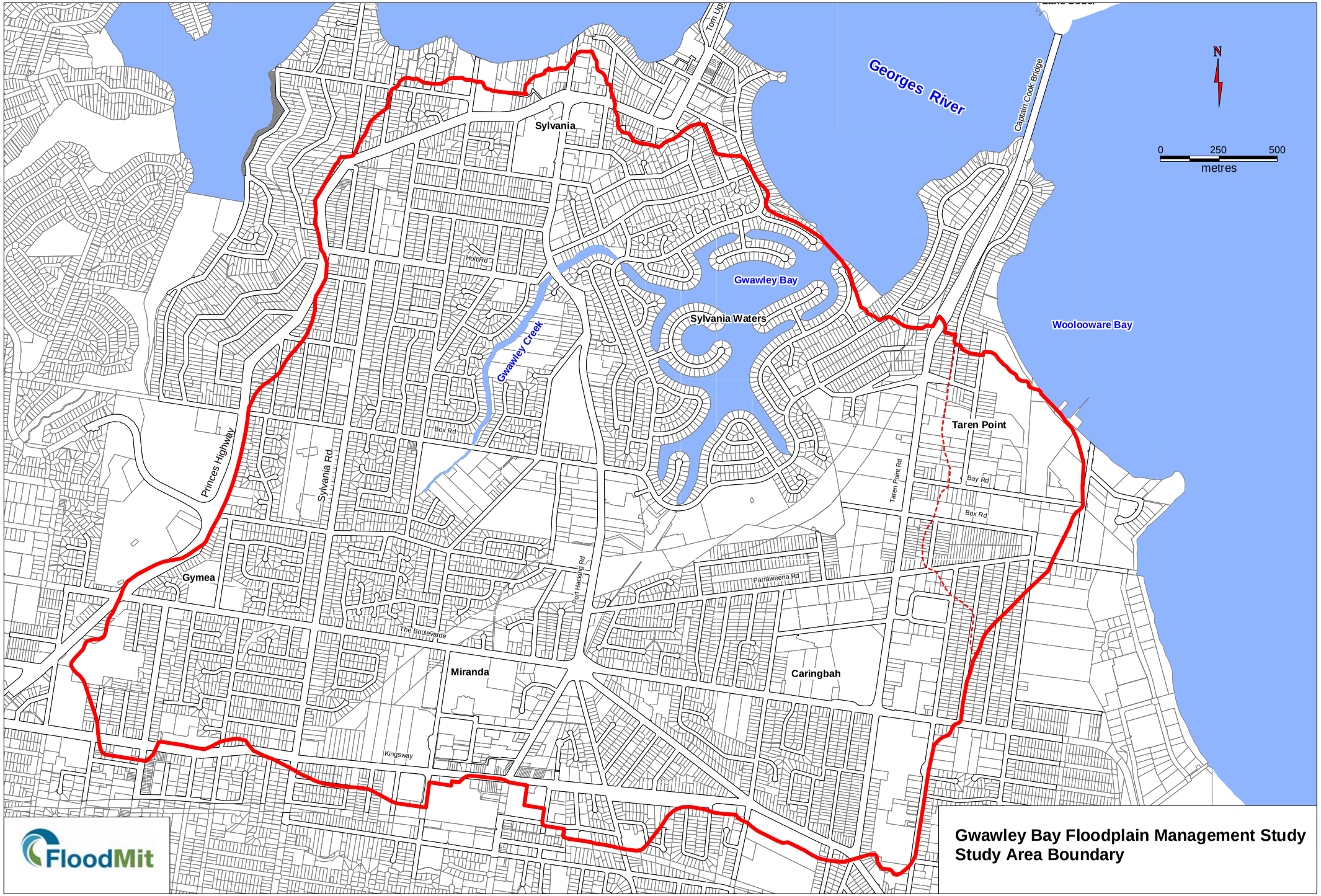
Council has now commissioned a floodplain management study to review problem areas identified in the earlier study and to investigate measures to reduce these problems and better manage the flood risk within the catchment. The study is being overseen by Council's floodplain management committee, and is receiving technical and financial assistance from the NSW State Government through the Office of Environment and Heritage.

If there are any problem areas or other issues that you would like investigated within the vicinity of your property we would be most pleased to hear from you. A questionnaire is enclosed to help compile this information. It would be appreciated if the questionnaire could be returned in the pre-paid envelope provided by 13 June.

If you have any questions on the study, or require further information, please don't hesitate to contact me.

Yours faithfully

G C Amos
for J W Rayner
General Manager


Georges River
Captain Cook Bridge
Sylvania
Gwawley Bay
Sylvania Waters
Woolooware Bay
Gwawley Creek
Taren Point
Princes Highway
Sylvania Rd
Box Rd
Holt Rd
Taren Point Rd
Bay Rd
Parraweena Rd
Port Hacking Rd
The Boulevarde
Kingsway
Gymea
Miranda
Caringbah
N
0
250
500
metres
FloodMit
Gwawley Bay Floodplain Management Study
Study Area Boundary

Gwawley Bay Catchment Floodplain Management Study
Questionnaire for Residents and Business Owners

The information provided from this questionnaire will help us to identify any flooding problems within the catchment, and to consider measures that may reduce these problems. It will also help us to determine which issues are important to you.

The questionnaire is voluntary. No names or addresses will be included in any published material.

---

1. The address of your property? _____

2. Within the study area, do you own:
   - ❑ A residential house
   - ❑ A residential unit or apartment
   - ❑ A business premises

3. Since what year have you owned/occupied this property? _____

4. Please provide details of anyone at this property who may require special assistance from the State Emergency Service in a local emergency (Note: This information will be forwarded to the Local SES Controller)

   _____

   _____

   _____

5. Has your property previously flooded?
   - ❒ Yes, above the main building floor level — In what year did this happen? _____
   - ❒ Yes, above the garage or shed floor — Depth above floor? _____
   - ❒ Minor flooding within property only — Depth above garage/shed? _____
   - ❒ No flooding within this property

6. If your property has experienced flooding, can you identify the cause?

   _____

   _____

   _____

7. Are there any flooding or stormwater problems that you are aware of beyond your property?

   _____

   _____

   _____

8. What controls do you consider Council should place on new development to minimise flood related risks? (please tick one box only)
   - ❒ Prohibit all new development on land that could flood
   - ❒ Prohibit all new development only on land that has dangerous flood conditions
   - ❒ Place restrictions on development such as minimum floor levels
   - ❒ Provide advice on flooding but provide no development restrictions
   - ❒ Provide no advice or development restrictions

Please see over

9. What notifications do you consider Council should provide to residents? (tick one or more)

- ❒ Advise every owner on a regular basis of the known flood threat
- ❒ Advise only those who enquire to Council about the flood threat
- ❒ Advise prospective purchasers of property about the flood threat

10. Which of the following measures do you favour, or not favour, to reduce the flood risk throughout the catchment? (if undecided please leave blank)

Yes	No	
❒	❒	Increase the capacity of culverts
❒	❒	Increase the capacity of the stormwater pipe system
❒	❒	Maintenance programs to keep drains clear of debris and litter
❒	❒	Construction of debris control structures at culverts to prevent blockage
❒	❒	Construction of basins to temporarily store catchment runoff
❒	❒	Require on-site detention to control runoff from larger developments
❒	❒	Ensure that there are adequate controls on future development (eg floor levels)
❒	❒	Prohibit rezoning of land for development that has a flood risk
❒	❒	Prohibit subdivision of land that has a flood risk
❒	❒	Ensure that new development does not block overland flow paths
❒	❒	Ensure that information about potential flood risks is available to residents

11. Are there any other measures that you would like to be considered?

_____

_____

_____

_____

12. Other comments you'd like to make

_____

_____

_____

_____

13. Your Contact Details (in case we need to ask you anything further)

Name: _____

Email: _____

Phone: _____

Please return your completed questionnaire by <u>FRIDAY 13th JUNE 2014</u>
using the enclosed reply-paid envelope (no postage stamp is required).
Alternatively you can email this form or other comments to Gwawley@floodmit.com.au

Thank you for your participation

FloodMit

Sutherland Shire COUNCIL