



Lake Illawarra Floodplain Risk Management Plan

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Prepared for Lake Illawarra Authority, Wollongong
City Council & Shellharbour City Council

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Foreword

The State Government's Flood Policy is directed towards providing solutions to existing flood risks in developed areas and ensuring that new development is compatible with the flood risk and does not create additional flooding risks in other areas.

Under the policy, the management of flood liable land is the responsibility of Local Government and in the case of Lake Illawarra, also involves the Lake Illawarra Authority (LIA) as the overarching management body for the Lake. The State Government subsidises flood mitigation works to alleviate existing problems and provides specialist technical advice to assist Councils in the discharge of their floodplain management responsibilities.

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

- | | |
|-------------------------------------|---|
| 1. Formation of a Committee | Established by LIA and includes Council, community group representatives and State agency specialists. |
| 2. Data Collection | Past data such as flood levels, rainfall records, land use, soil types etc. |
| 3. Flood Study | Determines the nature and extent of the floodplain. |
| 4. Floodplain Risk Management Study | Evaluates management options for the floodplain in respect of both existing and proposed development. |
| 5. Floodplain Risk Management Plan | Involves formal adoption by Council of a plan of management for the floodplain. |
| 6. Implementation of the Plan | Implementation of actions outlined in the Plan which may include construction works, planning modification or emergency response modifications. |

The *Lake Illawarra Floodplain Risk Management Plan* completes the fifth stage of the management process for the Lake Illawarra Floodplain. This plan has been prepared for the Lake Illawarra Authority, Wollongong City Council and Shellharbour City Council by Cardno to prioritise identified strategies from the *Floodplain Risk Management Study* (Cardno, 2012) for implementation.

Executive Summary

Background and Purpose

The Lake Illawarra Flood Study was completed in 1999 by Lawson and Treloar and published in 2001. This study identified flood levels for the Lake Illawarra Floodplain based on the Lake conditions in 1997. The subsequent *Floodplain Risk Management Study* (FRMS) was commenced in 2000. Following the commencement of the FRMS large-scale entrance works were completed in 2001 and 2007, resulting in different conditions to those assessed under the flood study. The FRMS (Cardno, 2012) addresses the flood conditions post-entrance works.

This *Floodplain Risk Management Plan* provides a summary of the assessments undertaken as part of the Flood Study (Lawson and Treloar, 2001) and FRMS (Cardno, 2012) and provides an implementation action list for floodplain risk management within the Lake Illawarra Floodplain that resulted from these assessments.

Study Area

The floodplain of Lake Illawarra has a highly urbanised area that extends to cover the suburbs of Windang, Oak Flats, Albion Park Rail, Yallah, Koonawarra, Kanahooka, Berkeley, Lake Heights, Kemblawarra and Primbee, on the south coast of NSW. The floodplain lies within both the Wollongong City Council and the Shellharbour City Council local government areas. The catchment of 23,500 hectares consists of a range of land uses. The Lake is generally open to the sea through an entrance channel that has historically, during times of lower catchment flow, undergone a sediment accretion cycle thereby reducing the conveyance capacity of the channel. However, this channel has undergone change with the construction of breakwaters on both the southern and northern sides of the entrance over the past 10 years.

A number of properties adjacent to the Lake are susceptible to above-floor flooding in the 100 Year Annual Recurrence Interval (ARI) and the Extreme Flood/Probable Maximum Flood (PMF) events.

Flood Behaviour

Historically, flooding has occurred in the Lake foreshore areas at a number of locations. The combination of heavy rainfall over the catchment and varying degrees of shoaling in the Lake entrance, have resulted in a range of floods in the Lake.

Rainfall runoff from the steeper western parts of the catchment flows eastward downslope to quickly reach the much flatter coastal floodplain. Here the flow gathers and slows markedly with resulting increased flood depths. Flood flows in the lower parts of the catchment are complicated by bridge and culvert crossings over the feeder creeks before entering the body of Lake Illawarra. Floodwaters within the Lake and its surrounding floodplain are characterised by slow velocities and a near horizontal water surface. Closer to the Lake entrance inlet, the floodwaters accelerate into the entrance channel to pass under the Windang Road Bridge and out to the Tasman Sea. The high velocities in the entrance channel scour sediment from the entrance channel, widening and deepening the channel as the flood progresses, with the channel width limited by the training walls. The rate and depth of flooding of the Lake and its foreshores are controlled not only by the rate of catchment runoff but also to a large extent by the size and degree of shoaling of the Lake entrance channel at Windang and the coincident ocean level.

The Lake Illawarra Flood Study (Lawson and Treloar, 2001) identified that foreshore flooding resulting from the design flood events occurs around most of the Lake, but in particular at Primbee, Albion Park Rail, Yallah, Oak Flats and Kanahooka. The flood study considered the 2, 5, 10, 20, 50 and 100 Year ARI events, together with an extreme event (of the order of a Probable Maximum Flood). The Lawson and Treloar (2001) Flood Study used numerical modelling for hydrology and hydraulics (RAFTS and MIKE11) for the determination of peak Lake flood levels, discharges and velocities. The modelling indicated that critical duration of flooding for the Lake was 36 hours.

Following the completion of the flood study, large-scale entrance works were completed in 2001 and 2007, resulting in different conditions to those assessed under the flood study. Whilst the pre-2001 conditions were adopted as the base case conditions for the purposes of the Floodplain Risk Management Study, updated modelling was undertaken as part of the climate change assessment (described below). The updated modelling included the existing entrance conditions which included the entrance works.

Climate Change

The Inter-governmental Panel on Climate Change (IPCC) Assessment Report 2007 (Known as 'Climate Change 2007') concludes that climate change and sea level rise are inevitable. The *Floodplain Development Manual* (NSW Government, 2005) requires that Flood Studies and Floodplain Risk Management Studies consider the impacts of climate change and sea level rise on flood behaviour.

More recently, the NSW Government released the *NSW Sea Level Rise Policy Statement* (DECCW, 2009) and the *Flood Risk Management Guide – Incorporating Sea Level Rise Benchmarks in Flood Risk Assessments* (DECCW, 2010). These documents have been prepared to assist local councils, the development industry and consultants to incorporate the sea level rise planning benchmarks in floodplain risk management planning and flood risk assessments for new development. The information in these documents updates the sea level rise information in the *NSW Floodplain Development Manual* (NSW Government, 2005) and should be read in conjunction with the Manual. These documents also update the sea level rise section of the *Floodplain Risk Management Guideline: Practical Consideration of Climate Change* (DECC 2007). However, the 2007 guideline provides additional information relating to the management of the impacts of climate change on existing developed areas and on potential changes to flood-producing rainfall events caused by climate change.

In accordance with the advice presented in the documents above, the following tasks have been undertaken within this FRMS to address the issue of climate change:

- Hydraulic modelling of four climate change scenarios (based on IPCC predictions and OEH recommendations);
- Mapping of 100 Year ARI flood extents for the four climate change scenarios;
- An analysis of the properties impacted by flooding under the various climate change scenarios;
- An assessment of the consequences of adopting each of the four scenarios as part of the relevant planning provisions (LEP and DCP) and exploration of different approaches to address this issue; and
- Recommendations for planning provisions to be included in the Floodplain Risk Management Plan.

Floodplain Management

Using the merits-based approach advocated in the NSW State Government's *Floodplain Development Manual* (2005), and in consultation with the community, the Lake Illawarra Authority, Shellharbour City and Wollongong City Council's and state agency stakeholders, a number of potential options for the management of flood risk were identified within the *Floodplain Risk Management Study* (Cardno, 2012). These options included flood modification measures, property modification measures and emergency response modification measures to reduce flood risk.

A limited list of flood modification options were assessed against a range of criteria (technical, economic, environmental and social). These options included:

- Entrance stabilisation,
- Removal of Windang Bridge causeway and replacement with a bridge,
- Culverts through Windang Causeway.

In addition to these options, the Lake Illawarra Authority also requested that an assessment of the cumulative impact of filling portions of the Lake foreshore be undertaken.

Property modification and emergency response modification measures considered for the floodplain include:

- Voluntary House Raising (VHR);
- Voluntary House Purchase (VP);
- Amendments to existing planning instruments and preparation of new plans and policies;
- Improvements to flood warning and evacuation procedures, and
- Public awareness and education.

Assessment of Floodplain Management Options

Hydraulic modelling of the options described above was undertaken as part of the FRMS along with an assessment of the economic, social, environmental, land use and planning issues. The assessment found that neither of the options associated with the modification of Windang Bridge or its causeway are feasible on economic grounds (i.e. these options have very low cost-benefit ratios). However, the works for the stabilisation and modification of the entrance channel should partly reduce the flood risk to the area, provided that the channel is maintained.

The VHR and VP options were found to provide only marginal benefits. Instead it is recommended that habitable floor levels should be set at the flood planning level (FPL) when all properties are redeveloped in the future.

A combination of the various types of options has been considered for inclusion in this *Floodplain Risk Management Plan*.

Floodplain Risk Management Plan

This *Floodplain Risk Management Plan* is a summary of the proposed activities and planning strategies to manage the flood risk for the Lake floodplain. The implementation action list can be found in **Section 7** of this Plan. The implementation of this Plan is the next step of the floodplain management process and it is recommended that this Plan be reviewed in approximately five years time.

Table of Contents

Foreword	ii
Executive Summary	iii
Glossary	ix
1 Introduction	1
1.1 Purpose of the Plan.....	1
1.2 Plan Context.....	1
1.3 Plan Structure.....	2
2 Study Area	4
2.1 Study Limits.....	4
2.2 Catchment	4
2.3 Tributaries, Lake and Foreshore Areas	4
3 Flood Behaviour, Issues and Objectives	7
3.1 Flood Behaviour	7
3.1.1 General Description	7
3.1.2 Design Flood Modelling.....	7
3.1.3 Climate Change Modelling	8
3.1.4 Design Flood Levels and Extents.....	10
3.2 Floodplain Issues	16
3.3 Floodplain Management Objectives.....	16
4 Flood Planning	17
4.1 Flood Hazard.....	17
4.1.1 Provisional Flood Hazard	17
4.1.2 True Flood Hazard	17
4.2 Flood Risk Precincts	21
4.3 Flood Planning Levels.....	21
4.4 Development Control Matrices.....	25
4.4.1 Wollongong City Council LGA.....	25
4.4.2 Proposed Development Control Matrices	25
4.5 Sea Level Rise Planning Areas.....	26

Lake Illawarra Floodplain Risk Management Plan

Prepared for Lake Illawarra Authority, Wollongong City Council & Shellharbour City Council

5	Consultation	29
5.1	Lake Illawarra Committee	29
5.2	Social Concerns Identified Through the Stormwater Management Plan	29
5.3	Community Meeting	30
5.4	Public Exhibition	31
6	Flood Management Options	32
7	Implementation Action Plan	38
8	References	42

List of Tables

Table 3.1 Climate Change Scenarios	9
Table 3.2 100 Year ARI Existing and Climate Change Flood Levels	10
Table 3.3 Design Flood Levels	12
Table 4.1 Factors Affecting Flood Hazard	17
Table 6.1 Summary of FRMS Assessment.....	33
Table 7.1 Implementation Action List.....	39
Table 7.2 Design Flood Levels to be used for Planning Purposes	40

List of Figures

Figure 1.1: Study Area	3
Figure 2.1: Lake Illawarra Catchment.....	6
Figure 3.1: 100 Year ARI Extent.....	13
Figure 3.2: Probable Maximum Flood Extent.....	14
Figure 3.3: 100 Year ARI Climate Change Flood Extents	15
Figure 4.1: 100 Year ARI Hazard Mapping.....	19
Figure 4.2: PMF Hazard Mapping.....	20
Figure 4.3: Flood Risk Precincts – Concessional Development	23
Figure 4.4: Flood Risk Precincts – Non-Concessional Development	24
Figure 4.5: Sea Level Rise Planning Areas – Concessional Development	27
Figure 4.6: Sea Level Rise Planning Areas – Non-Concessional Development	28
Figure 6.1: Properties Identified for House Raising	37

Appendices

Appendix A DCP Matrices

Glossary

Annual Exceedence Probability (AEP)	Refers to the chance of a flood of a given or larger size occurring in any one year, usually expressed as a percentage. E.g., if a peak flood discharge of 500m ³ /s has an AEP of 5%, it means that there is a 5% chance (that is one-in-20 chance) of a 500m ³ /s or larger events occur in any one year.
Annual Recurrence Interval (ARI)	The long-term average number of years between the occurrence of a flood as big as or larger than the selected event. For example, floods with a discharge as great as or greater than the 20 year ARI flood event will occur on average once every 20 years. ARI is another way of expressing the likelihood of occurrence of a flood event.
Australian Height Datum (AHD)	A common national surface level datum approximately corresponding to mean sea level.
Average Annual Damage (AAD)	Depending on its size (or severity), each flood will cause a different amount of flood damage to a flood prone area. AAD is the average damage per year that would occur in a nominated development situation from flooding over a very long period of time.
Building Area	Building area is the footprint of a building and does not include the garage. Allowable developable area in a lot is to be derived from floor space ratio for the land consistent with zoning. The Development Control Matrices in Appendix A allow for minimum filling (i.e. only footprint of a building) in foreshore of Lake Illawarra to facilitate development consistent with the zoning.
Cadastre, cadastral base	Information in map or digital form showing the extent and usage of land, including streets, lot boundaries, water courses etc.
Catchment	The area draining to a site. It always relates to a particular location and may include the catchments of tributary streams as well as the main stream.
Concessional Development	As defined in the Wollongong City Development Control Plan (2009) Chapter E13 – Floodplain Management, Appendix A, being development such as additions or alterations to an existing dwelling (20 – 40 m ²) to the habitable floor area; garages or outbuildings (with a maximum floor area of 20m - 40m ²); and redevelopment for the purposes of substantially reducing the extent of flood affectation to an existing building.
Design flood	A significant event to be considered in the design process; various works within the floodplain may have different design events. E.g. some roads may be designed to be overtopped in the 100 Year ARI flood event.
Development	Is defined in Part 4 of the Environmental Planning and Assessment Act, 1979: Infill development: refers to the development of vacant blocks of land that are generally surrounded by developed properties and is permissible under the current zoning of the land. Conditions such as minimum floor levels may be imposed on infill development. New development: refers to development of a completely different nature to that associated with the former land use. E.g., the urban subdivision of an area previously used for rural purposes. New developments involve re-zoning and typically require major extensions of existing urban services, such as roads, water supply, sewerage and electric power. Redevelopment: refers to rebuilding in an area. E.g., as urban areas age, it may become necessary to demolish and reconstruct buildings on a relatively

	large scale. Redevelopment generally does not require either re-zoning or major extensions to urban services.
Discharge	The rate of flow of water measured in terms of volume over time. It is to be distinguished from the speed or velocity of flow, which is a measure of how fast the water is moving rather than how much is moving.
Extreme Flood Event	The largest flood that could conceivably occur at a particular location, estimated for Lake Illawarra using a modified approach based on the Probable Maximum Precipitation methodology discussed in the Lake Illawarra Flood Study (Lawson and Treloar, 2001). Generally it is not physically or economically possible to provide complete protection against this event. The extreme event defines the extent of flood prone land, that is, the floodplain. (See also Probable Maximum Flood).
Flash flooding	Flooding which is sudden and often unexpected because it is caused by sudden local heavy rainfall or rainfall in another area. Often defined as flooding which occurs within 6 hours of the rain that causes it.
Flood	Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, Lake or dam, and/or local overland flooding associated with major drainage before entering a watercourse, and/or coastal inundation resulting from super-elevated sea levels and/or waves overtopping coastline defences excluding tsunami.
Flood fringe	The remaining area of flood-prone land after floodway and flood storage areas have been defined.
Flood hazard	Potential risk to life and limb caused by flooding.
Flood planning levels	Flood levels selected for planning purposes, as determined in floodplain risk management studies and incorporated in floodplain management plans. Selection should be based on an understanding of the full range of flood behaviour and the associated flood risk. It should also take into account the social, economic and ecological consequences associated with floods of different severities. Different FPLs may be appropriate for different categories of land use and for different flood plains. As FPLs do not necessarily extend to the limits of flood prone land (as defined by the probable maximum flood), floodplain management plans may apply to flood prone land beyond the defined FPLs.
Flood storages	Those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood.
Floodplain	Area of land which is subject to inundation by floods up to and including the probable maximum flood event, that is, flood prone land.
Floodplain management measures	The full range of techniques available to floodplain managers.
Floodplain management options	The measures which might be feasible for the management of a particular area.
Flood-prone land	Land susceptible to inundation by the probable maximum flood (PMF) event, i.e. The maximum extent of flood liable land. Floodplain Risk Management Plans encompass all flood-prone land, rather than being restricted to land subject to designated flood events.

Floodway areas	Those areas of the floodplain where a significant discharge of water occurs during floods. They are often, but not always, aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flow, or significant increase in flood levels. Floodways are often, but not necessarily, areas of deeper flow or areas where higher velocities occur. As for flood storage areas, the extent and behaviour of floodways may change with flood severity. Areas that are benign for small floods may cater for much greater and more hazardous flows during larger floods. Hence, it is necessary to investigate a range of flood sizes before adopting a design flood event to define floodway areas.
Geographical information systems (GIS)	A system of software and procedures designed to support the management, manipulation, analysis and display of spatially referenced data.
High hazard	Possible danger to life and limb; evacuation by trucks difficult; able-bodied adults would have difficulty wading to safety; potential for significant structural damage to buildings.
Hydraulics	The term given to the study of water flow in a river, channel or pipe, in particular, the evaluation of flow parameters such as stage and velocity.
Hydrograph	A graph which shows how the discharge or stage/flood level at any particular location varies with time during a flood.
Hydrology	The term given to the study of the rainfall and runoff process; in particular, the evaluation of flow parameters such as water level and velocity.
Integrated survey grid (ISG)	ISG is a global co-ordinate system based on a Transverse Mercator Projection. The globe is divided into a number of zones, with the true origin at the intersection of the Central Meridian and the Equator.
Low hazard	Should it be necessary, people and their possessions could be evacuated by trucks; able-bodied adults would have little difficulty wading to safety.
Mainstream flooding	Inundation of normally dry land occurring when water overflows the natural or artificial banks of the principal watercourses in a catchment. Mainstream flooding generally excludes watercourses constructed with pipes or artificial channels considered as stormwater channels.
Management plan	A document including, as appropriate, both written and diagrammatic information describing how a particular area of land is to be used and managed to achieve defined objectives. It may also include description and discussion of various issues, special features and values of the area, the specific management measures which are to apply and the means and timing by which the plan will be implemented.
Mathematical/computer models	The mathematical representation of the physical processes involved in runoff and stream flow. These models are often run on computers due to the complexity of the mathematical relationships. In this report, the models referred to are mainly involved with rainfall, runoff, pipe/culvert and overland stream flow.
Non-concessional development	Any development that is not concessional development (see concessional development).
NPER	National Professional Engineers Register. Maintained by the Institution of Engineers, Australia.

Lake Illawarra Floodplain Risk Management Plan

Prepared for Lake Illawarra Authority, Wollongong City Council & Shellharbour City Council

Peak discharge	The maximum discharge occurring during a flood event.
Probability	A statistical measure of the expected frequency or occurrence of flooding. For a fuller explanation see Annual Exceedence Probability.
Probable maximum flood (PMF)	The largest flood that could conceivably occur at a particular location, estimated from probable maximum precipitation (see also Extreme Flood Event). Generally it is not physically or economically possible to provide complete protection against this event.
Probable maximum precipitation (PMP)	The greatest depth of precipitation for a given duration meteorologically possible over a given size storm area at a particular location at a particular time of the year, with no allowance made for long-term climatic trends. It is the primary input to the estimation of the probable maximum flood.
Risk	Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. For this study, it is the likelihood of consequences arising from the interaction of floods, communities and the environment.
Runoff	The amount of rainfall that actually ends up as stream or pipe flow, also known as rainfall excess.
Stage	Equivalent to 'water level'. Both are measured with reference to a specified datum.
Stage hydrograph	A graph that shows how the water level at a particular location changes with time during a flood. It must be referenced to a particular datum.
Stormwater flooding	Inundation by local runoff. Stormwater flooding can be caused by local runoff exceeding the capacity of an urban stormwater drainage system or by the backwater effects of mainstream flooding causing the urban stormwater drainage system to overflow.
Topography	A surface which defines the ground level of a chosen area.
Wholesale	The wholesale area relates to the full area of the proposed site(s) or lot(s) for development. The Development Control Matrices in Appendix A do not allow wholesale filling of floodplain in the foreshore of Lake Illawarra.

1 Introduction

This *Floodplain Risk Management Plan* for the Lake Illawarra Foreshore has been prepared by Cardno for the Lake Illawarra Authority on behalf of Wollongong City Council and Shellharbour City Council. The Plan has been prepared in accordance with the NSW Government *Floodplain Development Manual* (2005).

1.1 Purpose of the Plan

The purpose of the Lake Illawarra *Floodplain Risk Management Plan* is to provide Wollongong and Shellharbour Councils with:

- A plan including flood management actions and flood planning guidelines for the Lake Illawarra floodplain and catchment that addresses existing, future and continuing flood risks;
- A basis for sound management of land within the Lake Illawarra catchment and ensure that both Councils' flood management policies are consistent with current legislation and best practice in relation to floodplain management; and
- A Plan for which funding assistance can be sought from various state and commonwealth agencies to enable implementation.

1.2 Plan Context

Lake Illawarra is a shallow coastal lagoon located about eight kilometres south of Wollongong on the undulating coastal plain between the ocean and the cliffs of the Illawarra Escarpment (see **Figure 1.1**). In the past, flooding of the Lake Illawarra foreshore has caused property damage, restricted property access and has been a general inconvenience to residents and tourists. These flooding issues, combined with considerable development pressure along the Lake foreshore, have prompted the Lake Illawarra Authority, Wollongong and Shellharbour City Councils, through the Lake Illawarra Floodplain Management Committee to prepare a comprehensive and integrated *Floodplain Risk Management Plan* for the Lake Illawarra foreshore area.

This Plan follows on from the *Floodplain Risk Management Study* (Cardno, 2012) and forms stage 5 of the six stages of the Floodplain Risk Management Process which includes:

1. Formation of a Committee;
2. Data Collection;
3. Flood Study;
4. Floodplain Risk Management Study (FRMS);
5. Floodplain Risk Management Plan (FRMP); and
6. Adoption and Implementation of Plan.

As prescribed in the floodplain management process, the Lake Illawarra Floodplain Management Committee was formed in 1997. This committee is chaired by the Lake Illawarra Authority (an independent party established by the NSW Government in 1988 to improve the environment of the Lake Illawarra, its foreshores and related environs).

The Lake Illawarra Authority, under the direction of the two Councils, commissioned the Lake Illawarra Flood Study in 1997. This study was completed by Lawson & Treloar in 1999 and the final version published in 2001. Significant entrance management works have been undertaken since the completion of the hydraulic modelling undertaken within the *Flood Study*. The works include:

- Stage 1 entrance management works (southern training wall and channel dredging) were completed in 2001.
- Stage 2 entrance management works (northern training wall) were completed in 2007.

As these works were undertaken after the completion of the *Flood Study* (Lawson & Treloar, 2001) they were not included in the hydraulic modelling used to define flood behaviour (including levels) within the floodplain. Since the completion of the entrance works, hydraulic modelling has been undertaken to assess potential climate change scenarios and is reported in the *Floodplain Risk Management Study* (Cardno, 2012). This modelling included the completed entrance works and also remodelled the 100 Year ARI flood. The results are not significantly different to the results for the “pre-2001” conditions.

The *Floodplain Risk Management Study* (Cardno, 2012) was commissioned in August 2000 and subsequently extended to include this *Floodplain Risk Management Plan*. The FRMS included updated hydraulic modelling to address the potential flood impacts of several climate change scenarios, an assessment of suitable planning provisions for the floodplain (including the incorporation of climate change) and an assessment of floodplain management options to mitigate and manage the risks associated with flooding. The FRMS has been prepared jointly with this FRMP.

This FRMP provides a summary of the findings of the FRMS and provides recommendations for adoption and implementation by both Councils. Further details on the content of this FRMP is provided below.

1.3 Plan Structure

This *Floodplain Risk Management Plan* contains the following information:

- Background on the purpose and context of the FRMP (**Section 1**);
- Details and characteristics of the study area (**Section 2**);
- Review of flooding behaviour, issues and objectives (**Section 3**);
- Overview of flood planning requirements (**Section 4**);
- Consultation undertaken in the preparation of this FRMP (**Section 5**);
- Overview of floodplain management options assessed within the FRMS (**Section 6**);
and
- An implementation action list (**Section 7**).

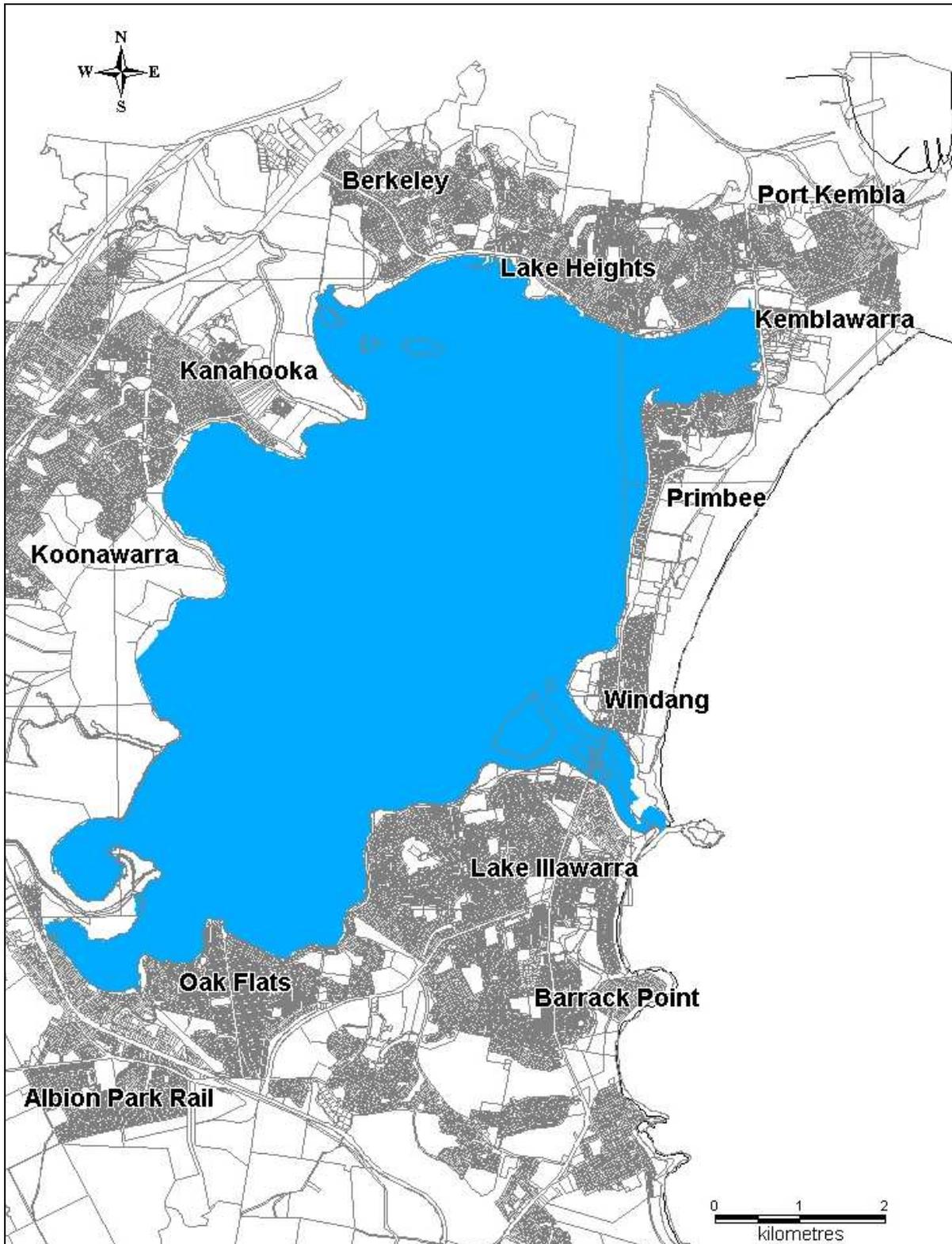


Figure 1.1: Study Area

2 Study Area

2.1 Study Limits

The hydrological investigations for this study covered the whole of the Lake Illawarra catchment. However, it should be noted that hydraulic modelling was limited to cover the body of Lake Illawarra, areas of the Lake foreshore east of the F6 freeway and the Lake entrance area. The estimation of flood behaviour in the tributary streams was not addressed within the *Flood Study* (Lawson and Treloar, 2001), and consequently, the *Floodplain Risk Management Study* (Cardno, 2012) and this Plan are also confined to the Lake foreshore areas.

Figure 2.1 shows a catchment map and the main study area.

2.2 Catchment

Lake Illawarra is a shallow coastal lagoon located on the undulating coastal plain between the ocean and the cliffs of the Illawarra Escarpment. The Lake catchment of approximately 23,500 hectares (excluding the Lake waterway area) is characterised by a low coastal plain, dominated by the western backdrop of the Illawarra Escarpment. The escarpment rises to a height in the catchment of 760m at Mount Murray, but more impressive is the slope of the escarpment, which rises over 400m over a horizontal distance of approximately 3km.

Generally, elevated areas of the catchment closer to the escarpment are rural or forested in character and slope steeply while the lower areas closer to the Lake are flatter and have a mixture of residential, commercial and heavy industrial development. Two major transport links, the F6 freeway and the Illawarra railway line traverse the catchment from north to south.

2.3 Tributaries, Lake and Foreshore Areas

The Lake body has an area of approximately 35km². Tributaries of Lake Illawarra include (anticlockwise from the northern foreshores):

- Minnegang Creek
- Budjong Creek
- Hooka Creek
- Mullet Creek
- Brooks Creek
- Yallah Creek
- Duck Creek
- Wollingurry Creek
- Marshall Mt Creek
- Macquarie Rivulet
- Frazer Creek
- Albion Creek
- Horsley Creek
- Oakey Gully.

Of these watercourses, the Macquarie Rivulet and Mullet Creek catchments contribute some 70% of the total catchment area.

The Lake has an average depth of approximately 1.7m with the maximum depth being about 4m. Prior to the completion of entrance works in 2007, the mean water level in the

Lake was approximately 0.3m AHD with a small tidal range of 0.03m in the northern regions. The entrance works (southern training wall, completed in 2001, and northern training wall, completed in 2007) have fixed the mouth of the Lake to the north of Windang Island. Since the entrance works were completed, the mean lake level has dropped to approximately 0.13 m AHD with a mean tidal range of 0.07 m across the Lake. The condition of the entrance channel is affected by ocean storms, wave action, floods and tides.

The catchment and foreshores of the Lake have been modified through past and current activities such as agriculture, and industrial and urban development, resulting in a decline in water quality in the Lake. Changes to the foreshore have also altered flora and fauna and resulted in the introduction of non-native species.

Lake Illawarra Floodplain Risk Management Plan

Prepared for Lake Illawarra Authority, Wollongong City Council & Shellharbour City Council

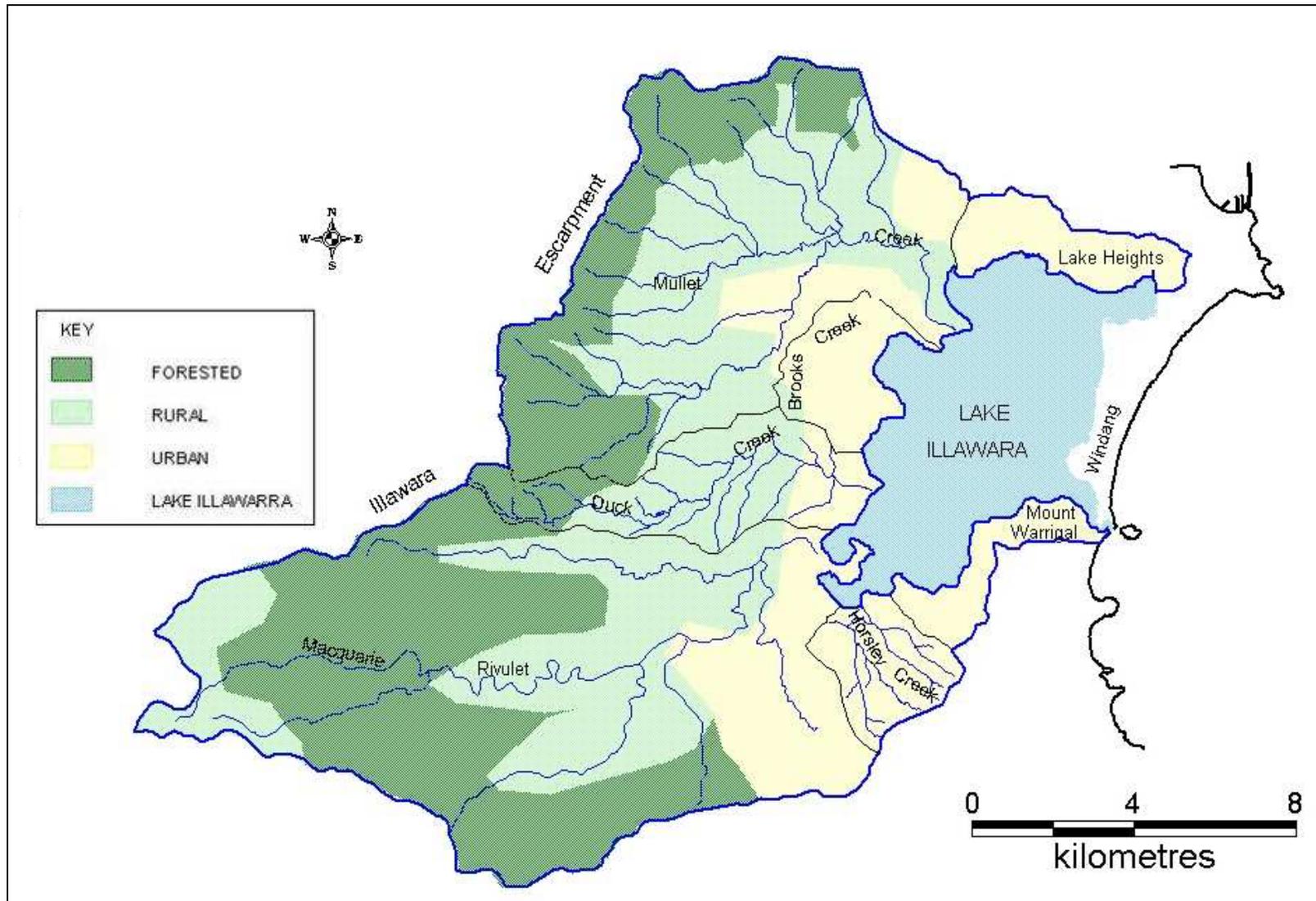


Figure 2.1: Lake Illawarra Catchment

3 Flood Behaviour, Issues and Objectives

3.1 Flood Behaviour

3.1.1 General Description

Historically, flooding has occurred in the Lake foreshore areas at a number of locations. The combination of heavy rainfall over the catchment and varying degrees of shoaling in the Lake entrance, have resulted in a range of floods in the Lake.

As outlined in the *Flood Study* (Lawson and Treloar, 2001), the steep slope of the escarpment has a marked influence on rainfall in the catchment. Onshore winds blowing storms onto the catchment are forced by the escarpment to rise steeply, which in turn cools the air more rapidly thereby increasing the rate of precipitation over the escarpment. This phenomenon, known as orographic rainfall, has historically resulted in higher rainfall intensities over the western parts of the catchment than near the ocean.

Rainfall runoff from the steeper western parts of the catchment flows eastward downslope to quickly reach the much flatter coastal floodplain. Here the flow gathers and slows markedly with resulting increased flood depths. Flood flows in the lower parts of the catchment are complicated by bridge and culvert crossings over the feeder creeks before entering the body of Lake Illawarra.

Floodwaters within the Lake body and its surrounding floodplain are characterised by slow velocities and a near horizontal water surface. Closer to the Lake entrance inlet, the floodwaters accelerate into the entrance channel to pass under the Windang Road Bridge and out to the Tasman Sea. The high velocities in the entrance channel scour sediment from the entrance channel, widening and deepening the channel as the flood progresses, with the channel width limited by the training walls.

The rate and depth of flooding of the Lake and its foreshores are controlled not only by the rate of catchment runoff but also to a large extent by the size and degree of shoaling of the Lake entrance channel at Windang and the coincident ocean level.

3.1.2 Design Flood Modelling

The *Lake Illawarra Flood Study* (Lawson and Treloar, 2001) identified that foreshore flooding resulting from the design flood events occurs around most of the Lake, but in particular at Primbee, Albion Park Rail, Yallah, Oak Flats and Kanahooka. The flood study considered the 2, 5, 10, 20, 50 and 100 Year ARI events, together with an extreme event (of the order of a Probable Maximum Flood). The estimate of an extreme flood hydrograph could not be made by directly applying the Generalised Short Duration Method (GSDM) of Bulletin 53 (Bureau of Meteorology, 1994), which was the most up to date method available at the time of the assessment. While the Lake Illawarra catchment, with an area of 270 km², is within the limits of the Bulletin 53 method with respect to catchment area, the method is limited to storms of duration less than 6 hours. The critical duration for peak flood level for the 100 Year ARI event, which was estimated at 36 hours, is shown to be considerably longer than the 6 hour limit. The hydrographs obtained by this methodology are at best a coarse estimate of extreme flood event flows. Due consideration of the methodology used to generate the hydrographs should be exercised when quoting the Lake levels estimated using the extreme flow estimates. Further details on the approach utilised can be found in the *Flood Study* (Lawson and Treloar, 2001).

The Lawson and Treloar (2001) *Flood Study* used numerical modelling for hydrology and hydraulics (RAFTS and MIKE11) for the determination of peak Lake levels, discharges and

velocities. The modelling indicated that critical duration of flooding for the Lake was found to be 36 hours.

The models developed for the *Flood Study* were used to assess the likely improvements afforded by flood modification options proposed in the *Floodplain Risk Management Study*. Full details of these assessments can be found in the FRMS, a summary of the outcomes is provided in **Section 6**.

More recently, a Delft3D model for Lake Illawarra was developed during design investigations for the northern training wall undertaken in 2003 and 2004. Since this time there have been significant developments with the Delft3D model, particularly the implementation of the latest generation of sediment transport models. The established Delft3D model of Lake Illawarra was upgraded to include the TRANMOR-2004 sand transport model which has demonstrated improved simulation of sediment transport and morphological changes in coastal entrances compared to earlier transport models.

Since the completion of the recent entrance works in mid-2007 and the climatic shift to wetter conditions which have prevailed since mid-2007, the entrance to Lake Illawarra has been in a more open state than in the five years prior. To ensure that the model can simulate the hydrodynamics of the current entrance condition, OEH undertook a data collection exercise in March 2008 to sample flood and ebb tide currents and discharges through the entrance. A full survey of Lake Illawarra was also undertaken in March 2008. The Delft3D model has been calibrated to the tidal flow data collected in March 2008 and also to the minor flood and entrance breakout event in May 2003, for which there was already existing data including bathymetry, catchment flows and ocean conditions (Cardno Lawson Treloar, 2004). The model has achieved good calibration for both tidal and flood flow conditions.

The results from the Delft3D model now supersede the Flood Study (Lawson and Treloar, 2001).

3.1.3 Climate Change Modelling

The Inter-governmental Panel on Climate Change (IPCC) Assessment Report 2007 (Known as 'Climate Change 2007') concludes that climate change and sea level rise are inevitable. The *Floodplain Development Manual* (NSW Government, 2005) requires that Flood Studies and Floodplain Risk Management Studies consider the impacts of climate change and sea level rise on flood behaviour.

More recently, the NSW Government released the *NSW Sea Level Rise Policy Statement* (DECCW, 2009) and the *Flood Risk Management Guide – Incorporating Sea Level Rise Benchmarks in Flood Risk Assessments* (DECCW, 2010). These documents have been prepared to assist local councils, the development industry and consultants to incorporate the sea level rise planning benchmarks in floodplain risk management planning and flood risk assessments for new development. The information in these documents updates the sea level rise information in the *NSW Floodplain Development Manual* (NSW Government, 2005) and should be read in conjunction with the Manual. These documents also update the sea level rise section of the *Floodplain Risk Management Guideline: Practical Consideration of Climate Change* (DECC 2007). However, the 2007 guideline provides additional information relating to the management of the impacts of climate change on existing developed areas and on potential changes to flood-producing rainfall events caused by climate change.

In accordance with the advice presented in the documents above, the following tasks have been undertaken within this FRMS to address the issue of climate change:

- Hydraulic modelling of four climate change scenarios (based on IPCC predictions and OEH recommendations);
- Mapping of 100 Year ARI flood extents for the four climate change scenarios;
- An analysis of the properties impacted by flooding under the various climate change scenarios;
- An assessment of the consequences of adopting each of the four scenarios as part of the relevant planning provisions (LEP and DCP) and exploration of different approaches to address this issue; and
- Recommendations for planning provisions to be included in the Floodplain Risk Management Plan.

The Lake Illawarra climate change assessment was undertaken prior to the release of the NSW Sea Level Rise Policy (DECCW, 2009) and at the time of the assessment the *DECC Floodplain Risk Management Guideline* (2007) provided the most recent predictions of sea level rise in NSW and discussed the potential increase in peak rainfall intensities as a result of climate change. The sea level rise predictions provided in the more recent guidelines (DECCW, 2010) do not differ significantly from the DECC (2007) guideline. The comparison of the predictions is provided below in **Table 3.1**.

Table 3.1 Climate Change Scenarios

DECC 2007			DECCW 2010	
Climate Change Scenario	SLR	Rainfall Changes	Climate Change Scenario	SLR
Low Level Rise (Low Greenhouse Gas Emissions Scenario)	0.18m	10%	-	-
Medium Level Rise (Low Greenhouse Gas Emissions Scenario)	0.55m	20%	2050	0.4m
High Level Rise (Low Greenhouse Gas Emissions Scenario)	0.91m	30%	2100	0.9m

The medium and high level rise DECC (2007) scenarios were adopted for assessment in this study. However, for the purposes of consistency with current policy and guidelines, the terminology from the DECCW 2010 guidelines has been adopted (i.e. 2050 instead of Medium Level Rise and 2100 instead of High Level Rise). The low level rise scenario has simply been referred to as the 0.18m SLR scenario.

The following four scenarios have been assessed as part of the climate change assessment for Lake Illawarra:

1. **0.18m SLR:** Sea Level Rise of 0.18m, no change in rainfall intensity.
2. **2050 SLR:** Sea Level Rise of 0.55m, no change in rainfall intensity.
3. **2100 SLR:** Sea Level Rise of 0.91m, no change in rainfall intensity.
4. **2050 SLR + 20%:** Sea Level Rise of 0.55m, 20% increase in rainfall intensity.

Climate change modelling of the four climate change scenarios was undertaken to investigate the potential climate change impacts on flood levels within Lake Illawarra. The modelling was undertaken using a full-process Delft3D model of Lake Illawarra. The model includes catchment flows as well as realistic ocean boundary conditions, for example, tides, waves and storm surge. The model includes sediment transport calculations and

morphological change so that the opening of the entrance during a flood is realistically simulated.

Further details relating to the model set up (e.g. boundary conditions) can be found in the *Floodplain Risk Management Study* (Cardno, 2012).

Table 3.2 presents peak water levels for the existing flood study (MIKE-11 model), the existing condition in the Delft3D model as described above, and the specified climate change scenarios. The agreement between the flood study levels obtained from the MIKE-11 model and the existing case Delft3D scenario is very good. The slightly lower peak level from the Delft3D model is principally due to the rate of entrance opening being more rapid than what was adopted in the previous flood modelling, which did not include dynamic entrance opening.

Table 3.2 100 Year ARI Existing and Climate Change Flood Levels

	100-year ARI Flood Levels (m AHD)					
	Flood Study - 2001 MIKE11 Model	Existing Case Delft3D Model	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Hydrology	36-hour, 100-year ARI	36-hour, 100-year ARI	36-hour, 100-year ARI	36-hour, 100-year ARI	36-hour, 100-year ARI	36-hour, 100-year ARI +20%
Climate Change	Existing	Existing	0.18m SLR	0.55m SLR	0.91m SLR	0.55m SLR
Griffins Bay	2.30	2.24	2.41	2.63	3.04	2.88
Tallawarra Power Station	2.30	2.24	2.41	2.63	3.04	2.88
Horsley Inlet	2.30	2.24	2.41	2.63	3.04	2.88
Cudgerie	2.26	2.24	2.41	2.63	3.04	2.88
Windang Bridge	2.08	2.15	2.35	2.55	3.01	2.77
Entrance Channel	1.98	1.71	1.89	2.25	2.32	2.25

Due to attenuation through the Lake entrance, predicted sea level rise conditions at the ocean interface will not take full effect across the Lake.

A comparison of the results from Scenario 2 and 4, show that a 20 percent increase in rainfall generally results in an increase in flood levels of 0.25m for the majority of the Lake's foreshore. This information has been used to inform the selection of a freeboard for the Lake Illawarra floodplain.

3.1.4 Design Flood Levels and Extents

The design flood levels presented in **Table 3.3** represent a combination of the hydraulic modelling results from the Flood Study (MIKE11) and the climate change assessment undertaken as part of the FRMS (Delft3D).

Flood extent maps were prepared from the model results and aerial laser survey provided by Shellharbour Council and Wollongong Council. The following flood extents are the most up to date information available at the time of issue of this Plan and are provided in **Figures 3.1 to 3.3**:

- **Figure 3.1 – 100 Year ARI Flood Extent** (Delft3D Modelling, 2008).

- **Figure 3.2 – PMF Extent** (MIKE11 Modelling, 2001).
- **Figure 3.3 – 0.18m SLR 100 Year ARI Flood Extent** (Delft3D Modelling, 2008).
- **Figure 3.3 – 2050 SLR 100 Year ARI Flood Extent** (Delft3D Modelling, 2008).
- **Figure 3.3 – 2100 100 Year ARI Flood Extent** (Delft3D Modelling, 2008).
- **Figure 3.3 – 2050 + 20% Rainfall Increase Climate Change 100 Year ARI Flood Extent** (Delft3D Modelling, 2008).

Lake Illawarra Floodplain Risk Management Plan

Prepared for Lake Illawarra Authority, Wollongong City Council & Shellharbour City Council

Table 3.3 Design Flood Levels

	Location*	Peak Flood Level (m AHD)								
		100 Year ARI	100 Year ARI (2050 SLR)	100 Year ARI (2100 SLR)	50 Year ARI	20 Year ARI	10 Year ARI	5 Year ARI	2 Year ARI	Extreme Event (PMF)
	Modelling Method / Date	Delft3D (2008)	Delft3D (2008)	Delft3D (2008)	MIKE11 (2001)					
1	Griffins Bay	2.24	2.63	3.04	2.03	1.81	1.57	1.40	1.11	3.24
2	Tallawarra Power Station	2.24	2.63	3.04	2.03	1.81	1.57	1.40	1.11	3.24
3	Horsley Inlet	2.24	2.63	3.04	2.03	1.81	1.57	1.40	1.11	3.24
4	Cudgerree Island Channel	2.24	2.64	3.04	1.99	1.81	1.54	1.40	1.08	3.19
5	Windang Bridge	2.15	2.55	3.01	1.83	1.63	1.42	1.26	0.99	2.98
6	Entrance Channel	1.71	2.25	2.32	1.74	1.55	1.35	1.20	0.95	2.84

* Locations illustrated on Figures 3.1 to 3.3
 2050 SLR – Sea Level Rise prediction for 2050.
 2100 SLR – Sea Level Rise prediction for 2100.

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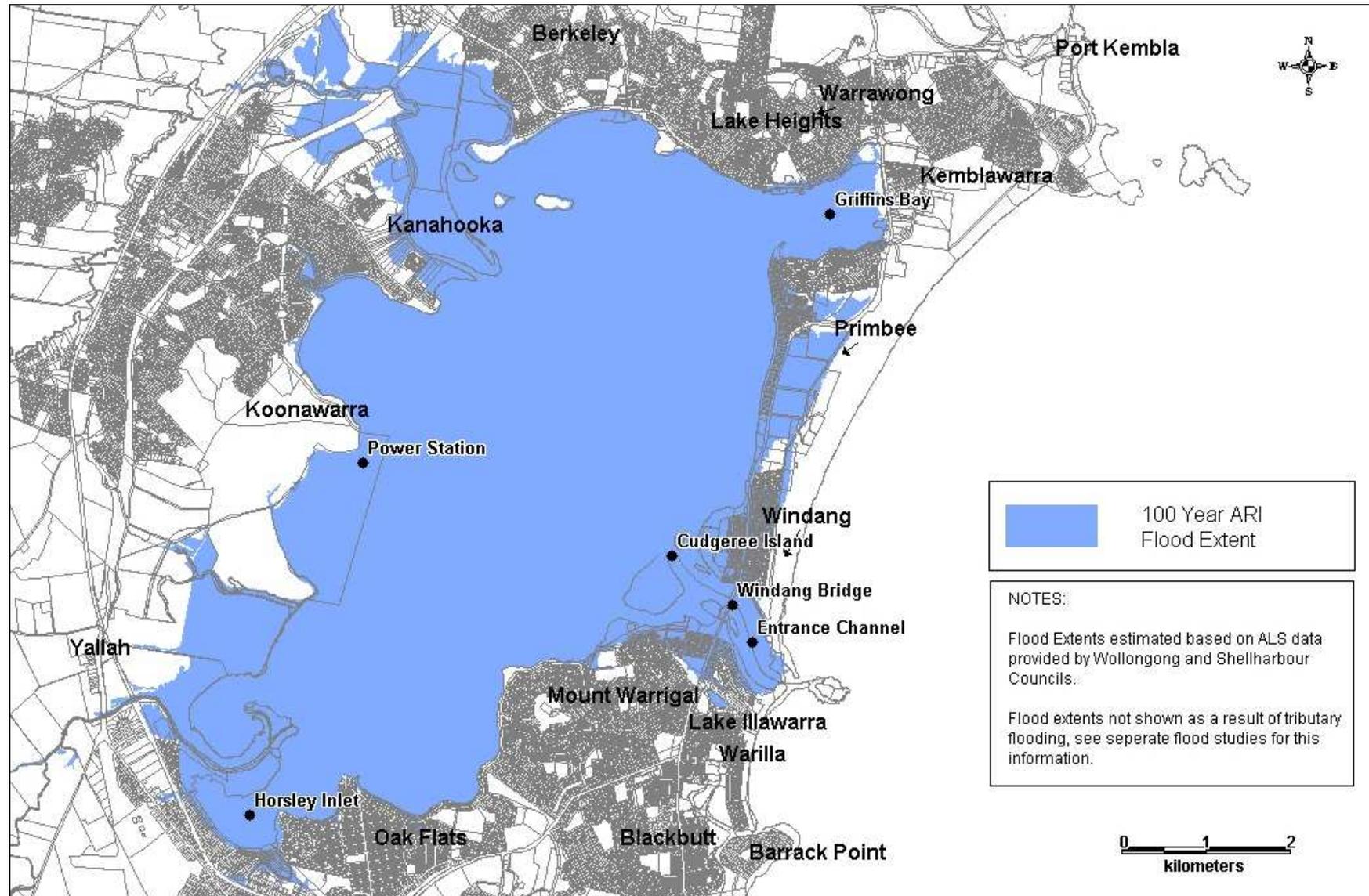


Figure 3.1: 100 Year ARI Extent

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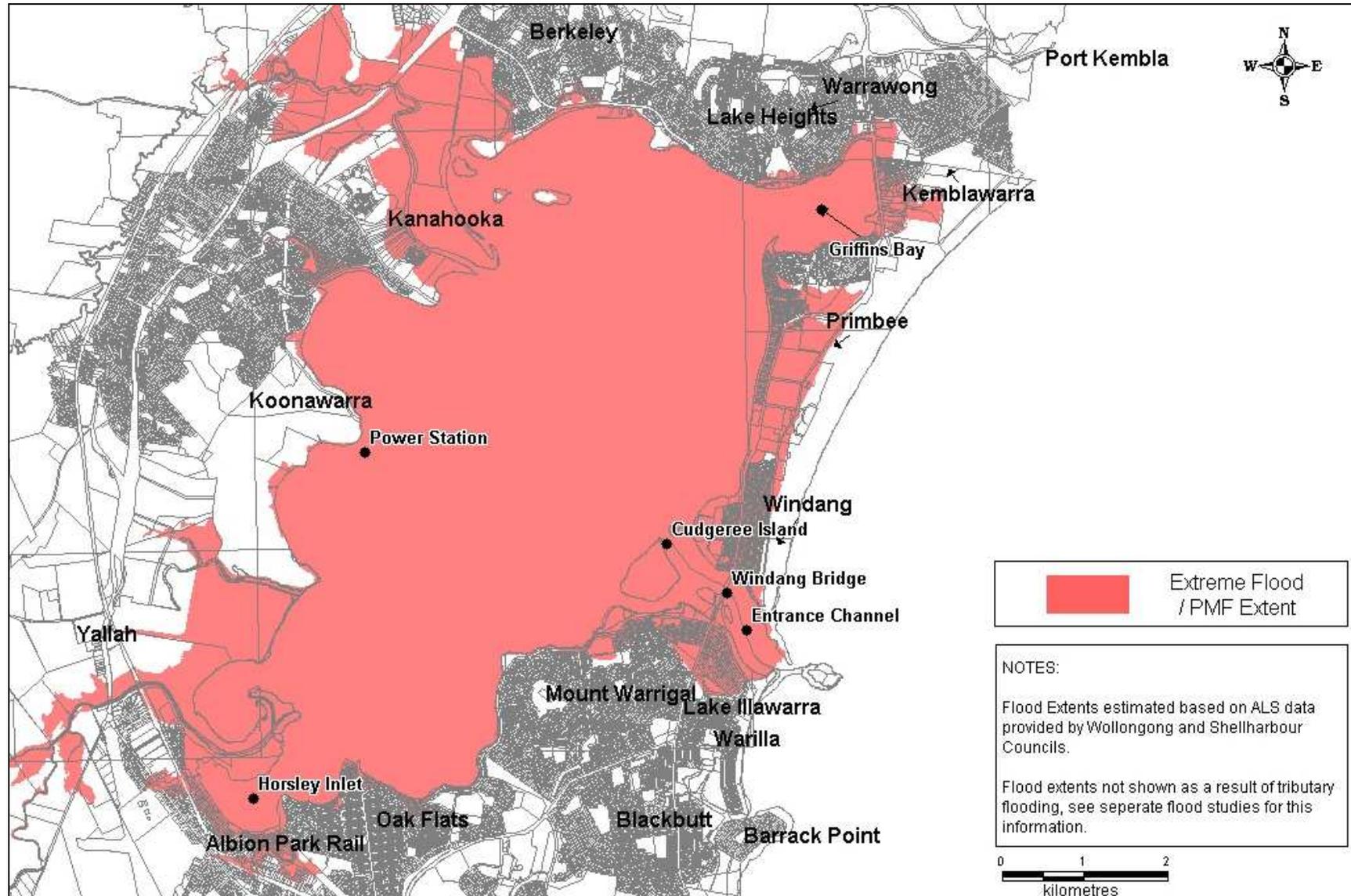


Figure 3.2: Probable Maximum Flood Extent

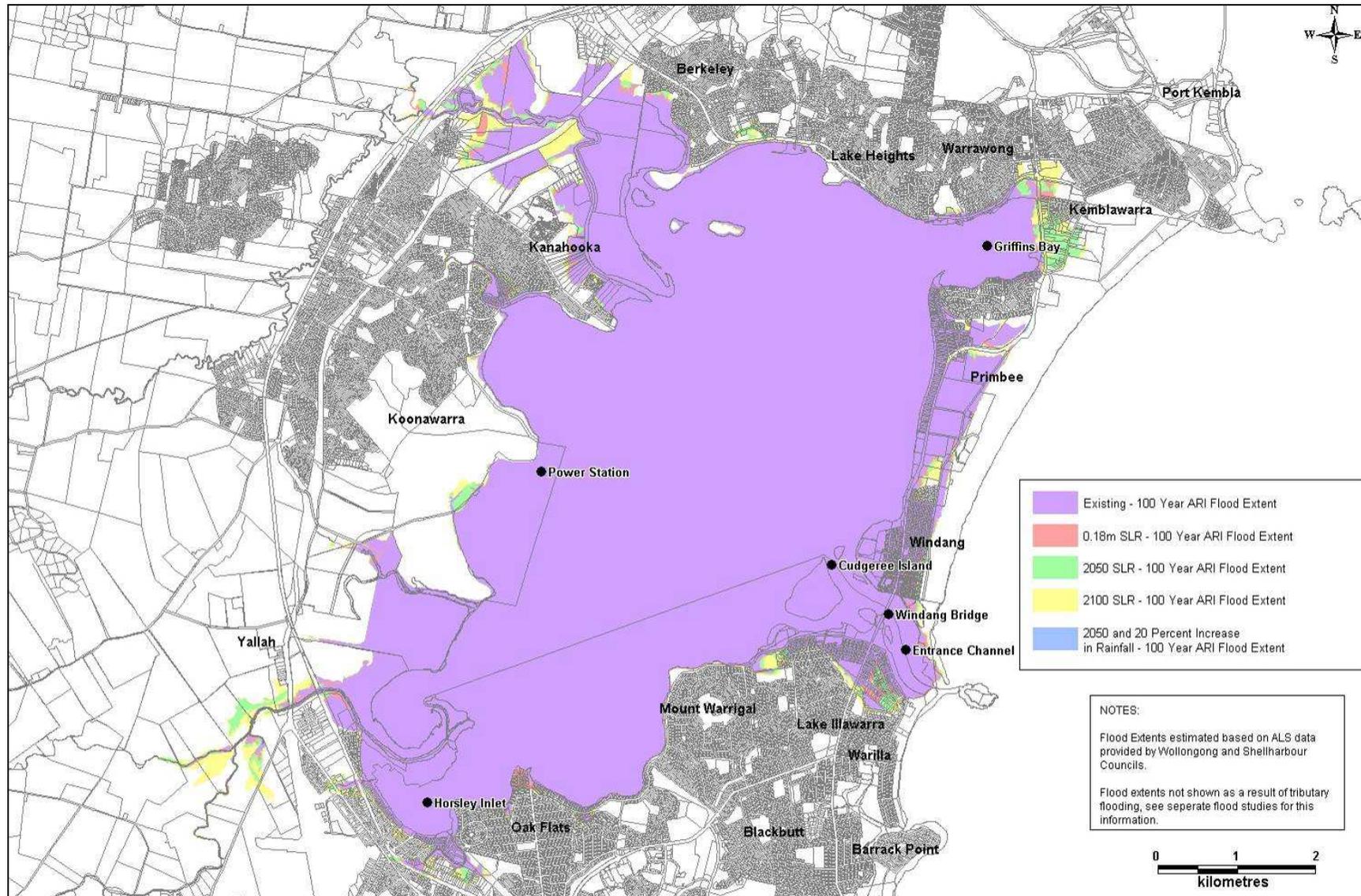


Figure 3.3: 100 Year ARI Climate Change Flood Extents

3.2 Floodplain Issues

A number of issues are pertinent to the Lake Illawarra Floodplain and have been raised either by:

- The Floodplain Management Committee;
- The Community (through the Stormwater Management Plan process); or
- Review of the flood behaviour.

Issues pertinent to the floodplain include:

- flooding of existing developed areas (residential and commercial) and the economic and social effects (e.g. damage to property, social disruption);
- development pressures likely to exacerbate flooding;
- interaction between flooding requirements and water quality requirements;
- interaction between flooding and ecological requirements (e.g. requirements of seagrass beds);
- impact of entrance management on flooding; and
- impact of flooding on tourism (particularly Caravan Park areas).

This Plan seeks to address these issues through the implementation of the actions identified (**Section 7**).

3.3 Floodplain Management Objectives

The objectives of floodplain management for Lake Illawarra are primarily to:

- reduce the risk to life and limb;
- reduce the risk to property and resulting reduction in losses;
- minimise the disruption as a result of flooding;
- ensure compatibility with ecological objectives identified through the Lake Management Process; and
- ensure compatibility with objectives identified through the Stormwater Management Process.

This Plan seeks to ensure that these objectives are met in the implementation of the actions identified (**Section 7**).

4 Flood Planning

4.1 Flood Hazard

Flood hazard can be defined as the risk to life and limb and damage caused by a flood. The hazard caused by a flood varies both in time and place across the floodplain. The *Floodplain Development Manual* (NSW Government, 2005) describes various factors to be considered in determining the degree of hazard. These factors are:

- Size of Flood;
- Effective Warning Time;
- Flood Readiness;
- Rate of Rise of Floodwaters;
- Depth and Velocity of Floodwaters;
- Duration of Flooding;
- Evacuation Problems;
- Effective Flood Access; and
- Type of Development.

“Provisional” flood hazard is flood hazard categorisation based on hydraulic principles only (depth and velocity). When provisional flood hazard is considered in conjunction with the above listed factors it provides a comprehensive analysis of the flood hazard, known as the “true hazard”.

4.1.1 Provisional Flood Hazard

Provisional flood hazard is determined through a relationship developed between the depth and velocity of floodwaters (Appendix L, NSW Government, 2005). The *Floodplain Development Manual* (2005) defines two categories for provisional hazard - High and Low.

The hydraulic model results for the critical duration flood events from the Lake Illawarra Flood Study (Lawson and Treloar, 2001) were processed utilising flood level and velocity to determine provisional hazard. Provisional flood hazards for the 100 year ARI and the PMF events were determined as part of the FRMS (Cardno, 2012).

4.1.2 True Flood Hazard

Provisional flood hazard categorisation based around initial hydraulic evaluations described above does not consider a range of other factors that influence the “true” flood hazard. Therefore provisional hazard categorisation has been assessed in conjunction with the other factors (discussed below) to determine true hazard categories.

The factors summarised in **Table 4.1** have been assessed to determine their impact on flood hazard categorisation. The full details of this assessment are provided in the FRMS (Cardno, 2012).

Table 4.1 Factors Affecting Flood Hazard

Factor	Agreed Criteria
Size of Flood	True high hazard to be determined by 100 Year ARI.
Effective Warning Time	The whole floodplain has a fairly long warning time and therefore, no particular areas would be subject to a higher or lower hazard category on the basis of this factor.

Factor	Agreed Criteria
Flood Readiness	Due to the time elapsed since the last major flood event, flood readiness in the Lake Illawarra floodplain is not considered an appropriate factor to alter flood hazard categories.
Rate of Rise of Floodwaters	Rate of rise of flood waters in the Lake Illawarra floodplain is fairly low, as such no additional high hazard category areas have been included due to this factor.
Depth and Velocity of Floodwaters	Provisional Flood Hazard.
Duration of Flooding	All properties which are inundated for 24 hours or more are already classified as high hazard, under provisional categories.
Evacuation Problems	Due to the regulations on permissible development within the floodplain no additional properties were defined as high hazard due to evacuation problems.
Effective Flood Access	Access to Windang Peninsula can be effectively “cut off” during flood events for significant amounts of time. In order to manage the risk associated with this isolation, specific development controls have been developed for this area. See Section 4.4 .
Type of Development.	This does not affect hazard mapping extents, however this has been addressed within the development control matrices (Section 4.4 and Appendix A).

The true hazard assessment undertaken for the Lake Illawarra floodplain identified that it is not necessary to revise the provisional flood hazard mapping for true hazard factors. However, additional development controls were identified for inclusion to address the issue of effective flood access on the Windang Peninsula.

The hazard mapping for the Lake Illawarra Floodplain is shown in **Figures 4.1 and 4.2**. It should be noted that High Hazard areas could extend further up the creek systems which flow into Lake Illawarra than shown in the figures, due to catchment flood flows in the creek systems as well as those hazard areas caused by backwater flooding associated with Lake Illawarra. Reference should be made to the respective Floodplain Risk Management Studies of those creek systems for further information.

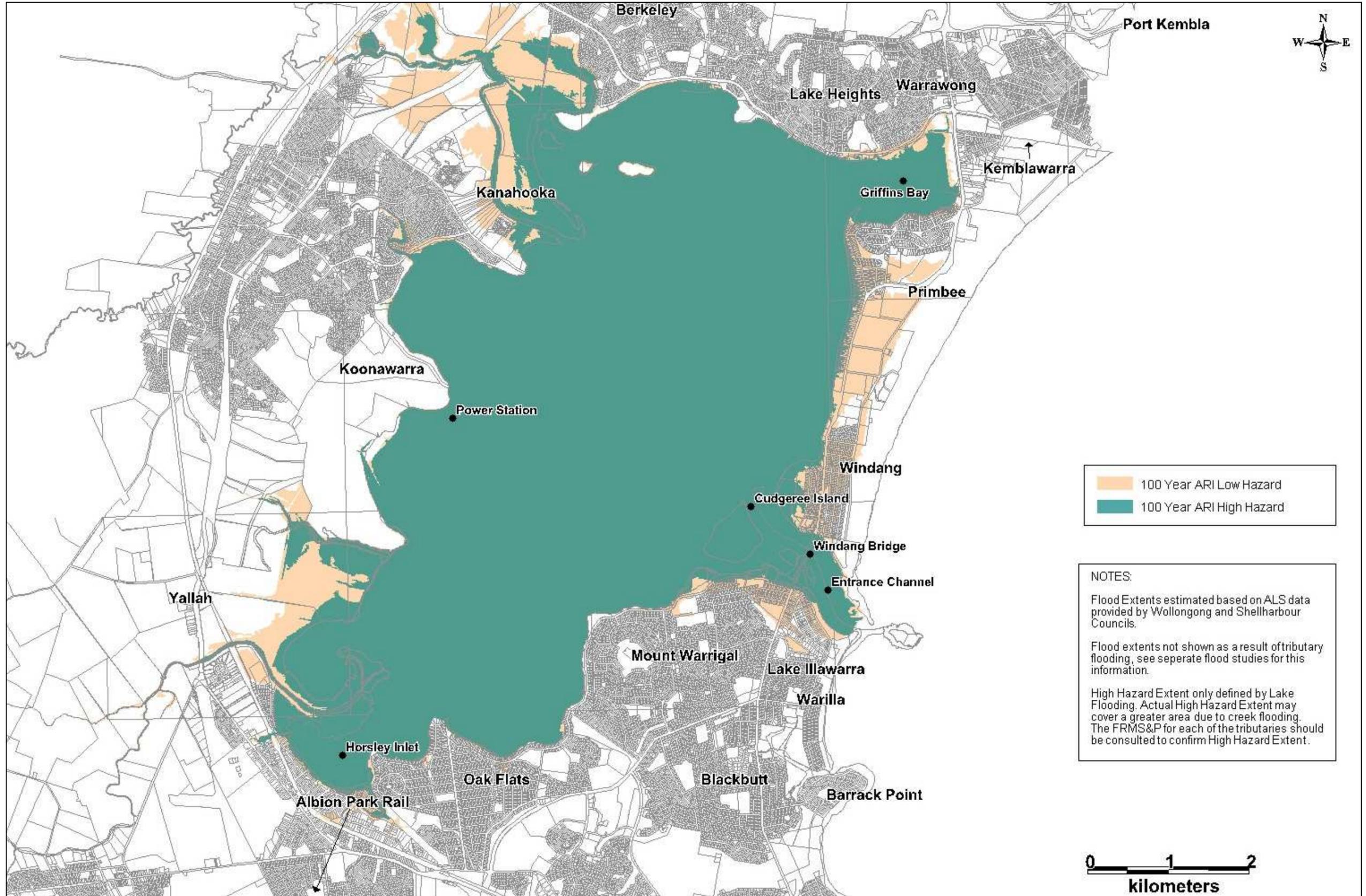


Figure 4.1: 100 Year ARI Hazard Mapping

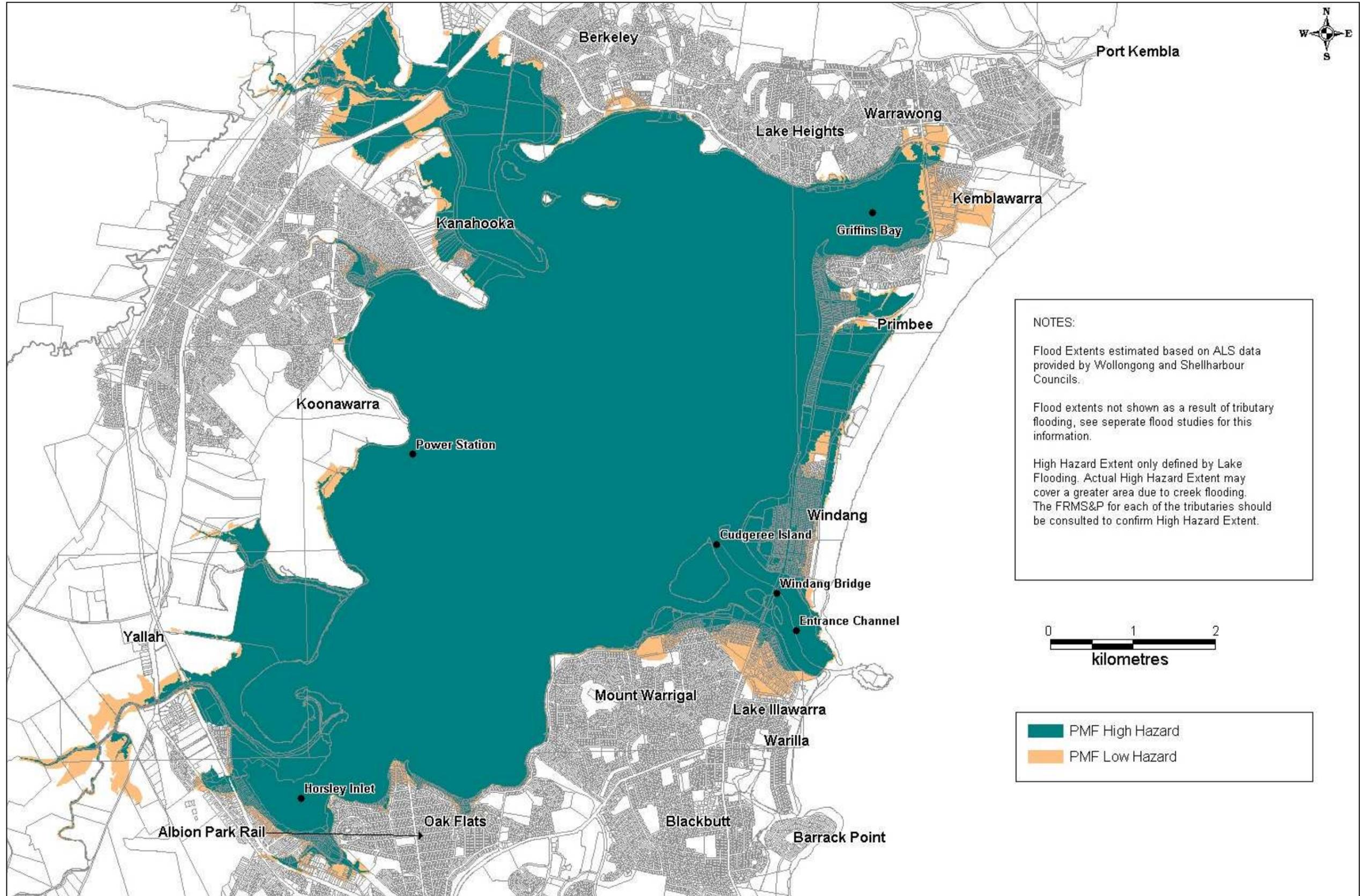


Figure 4.2: PMF Hazard Mapping

4.2 Flood Risk Precincts

Both Wollongong City Council and Shellharbour City Council have adopted an approach to defining the floodplain into 'flood risk precincts' for the definition of flood risk for planning purposes. The following definitions for the application of flood risk precincts have been utilised for this study:

High Flood Risk Precinct - is defined as the area within the envelope of land subject to high hazard in a 100 Year ARI flood event. High hazard is defined in accordance with the *Floodplain Development Manual* (NSW Government, 2005). The area that forms the high risk precinct is essentially the 100 Year ARI high hazard area on **Figure 4.1**.

Medium Flood Risk Precinct - is defined as the land between the high risk precinct and the area that lies below the 100 Year ARI level (plus 0.5 metre freeboard), and

Low Flood Risk Precinct - is defined as all other land within the floodplain (i.e. within the extent of the Extreme Flood/Probable Maximum Flood) but not identified as high or medium flood risk precinct. The Extreme Flood/PMF extent is shown in **Figure 3.2**.

The flood risk precincts have been modified to incorporate potential increases in flood levels as a result of climate change. A detailed planning assessment undertaken as part of the FRMS (Cardno, 2012), recommended that climate change (sea level rise) should be incorporated into the medium risk precinct. As such, the medium risk precinct for concessional and non-concessional development has been defined as follows:

- Concessional Development: 100 Year ARI flood extent with 2050 sea level rise plus 0.5m freeboard.
- All Other Development: 100 Year ARI flood extent with 2100 sea level rise plus 0.5m freeboard.

This flood risk precinct mapping for these two cases is shown in **Figures 4.3 and 4.4**.

4.3 Flood Planning Levels

To date, both Wollongong City Council and Shellharbour City Council have adopted the 100 Year ARI flood as the basis for the interim flood planning level for development around the foreshore of the Lake for all land uses with habitable floor levels to be set at the 100 Year ARI + 0.7 m (freeboard).

A similar flood planning level is commonly adopted across NSW as the flood planning level for residential development (Gillespie, 2005). However, the opportunity exists for the variation of the flood planning level on an area basis, on a land-use basis or a combination of area/land use through the adoption of floodplain management 'zones'.

Variation can be made in either the recurrence interval event selected as the 'planning event' or the freeboard adopted.

With respect to the 'planning event' consideration, this is often considered with regard to the design life of a structure, or the lifespan of a person. A commonly adopted design life for a structure may be 50 – 100 years with human lifespan being at the upper end of this range.

Therefore, as outlined in the *Floodplain Development Manual* (NSW Government, 2005), the size of flood and the probability of experiencing the given flood in a period of say 70

years is worthy of consideration in selection of an appropriate recurrence interval. A 100 Year ARI flood has a 50.3% chance of occurring at least once in a period of 70 years and a 15.6% chance of occurring at least twice in the same period. Therefore, the adoption of the 100 Year ARI as the planning flood is considered reasonable for both design life and a human life span and for consistency across NSW and other floodplains within the two local government areas.

The common elements are factored into a freeboard of 0.5 m (Gillespie, 2005):

- Uncertainty in flood modelling (0.2 m);
- Local wave action (0.1 m) (wind wave action is site specific);
- Afflux (0.1 m); and
- Climate change – Sea Level Rise (0.1 m).

A freeboard of 0.5m has been proposed for the Lake Illawarra Floodplain based on the following elements:

- Local wave action (0.2m). See the FRMS (Cardno, 2012) for details on the derivation of this value;
- Afflux (0.1m);
- Climate change impacts on hydrology (0.25m). This value has been determined by comparing the climate change modelling results for Scenario 2 (Medium level ocean rise – 0.55m and no change in rainfall intensity) and Scenario 4 (Medium level ocean rise – 0.55m and medium level increase in rainfall intensity – 20%). The results are provided in **Table 3.2**. The difference between the two sets of results is, on average 0.25m. This would indicate that the impact of the increased rainfall is approximately 0.25m for the 100 year ARI event.

It should be noted that these elements result in a freeboard of 0.55m, this level of accuracy is not considered appropriate for the purposes of flood planning and therefore a freeboard of 0.5 m is recommended.

No general allowance for uncertainty in flood modelling has been made as information is available on the key uncertainty, being hydrology. Many of the uncertainties have been accounted for in conservative assumptions used in the modelling process.

Sea level rise has not been incorporated into freeboard, but rather into the flood risk precinct mapping (provided in **Figures 4.3 and 4.4**) for planning purposes.

There are some cases where proposed development is recommended to be designed in accordance with the PMF (see **Section 4.4** for more details on the types of developments that this applies to). In these cases no freeboard would be applied.

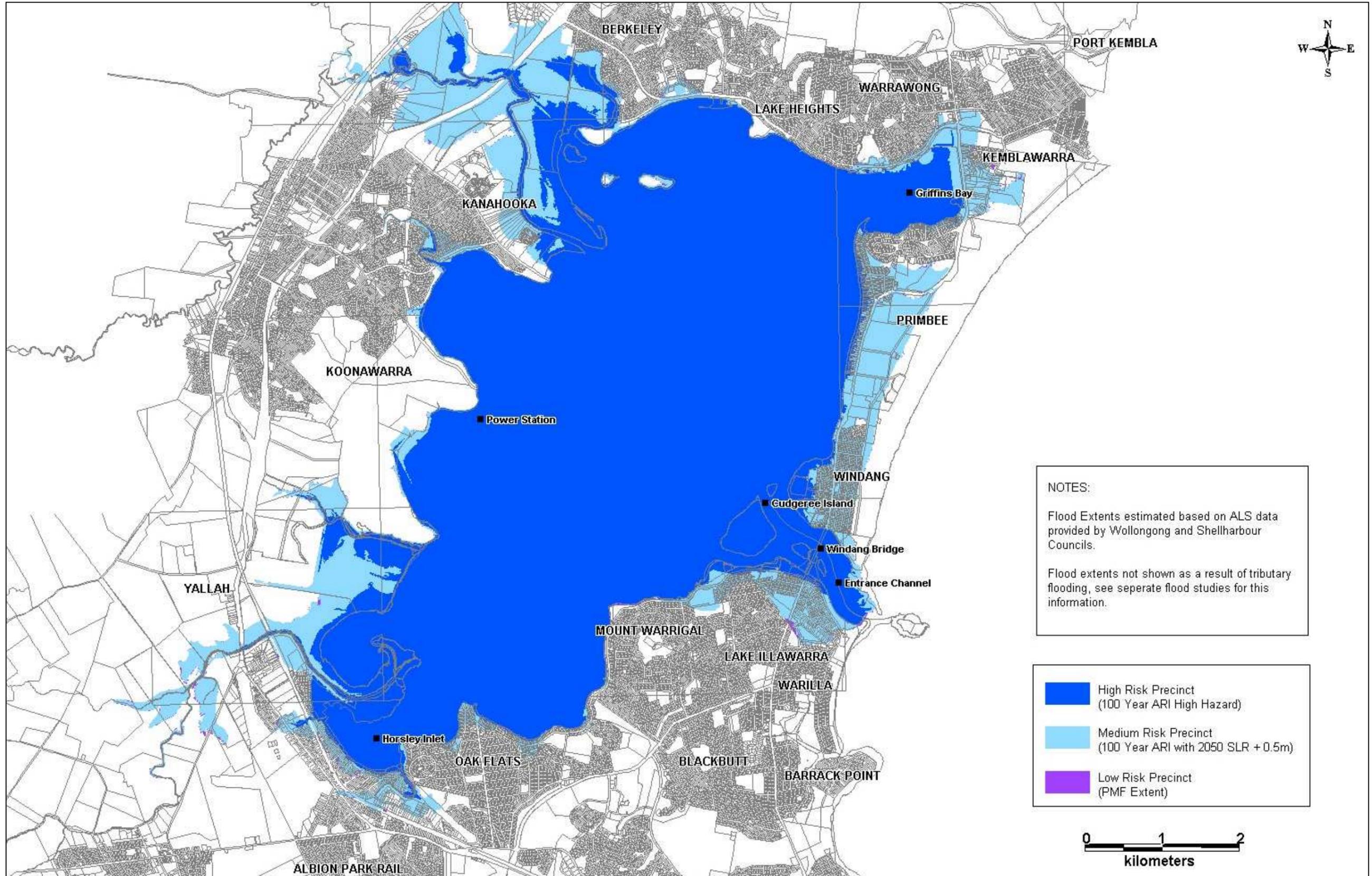


Figure 4.3: Flood Risk Precincts – Concessional Development

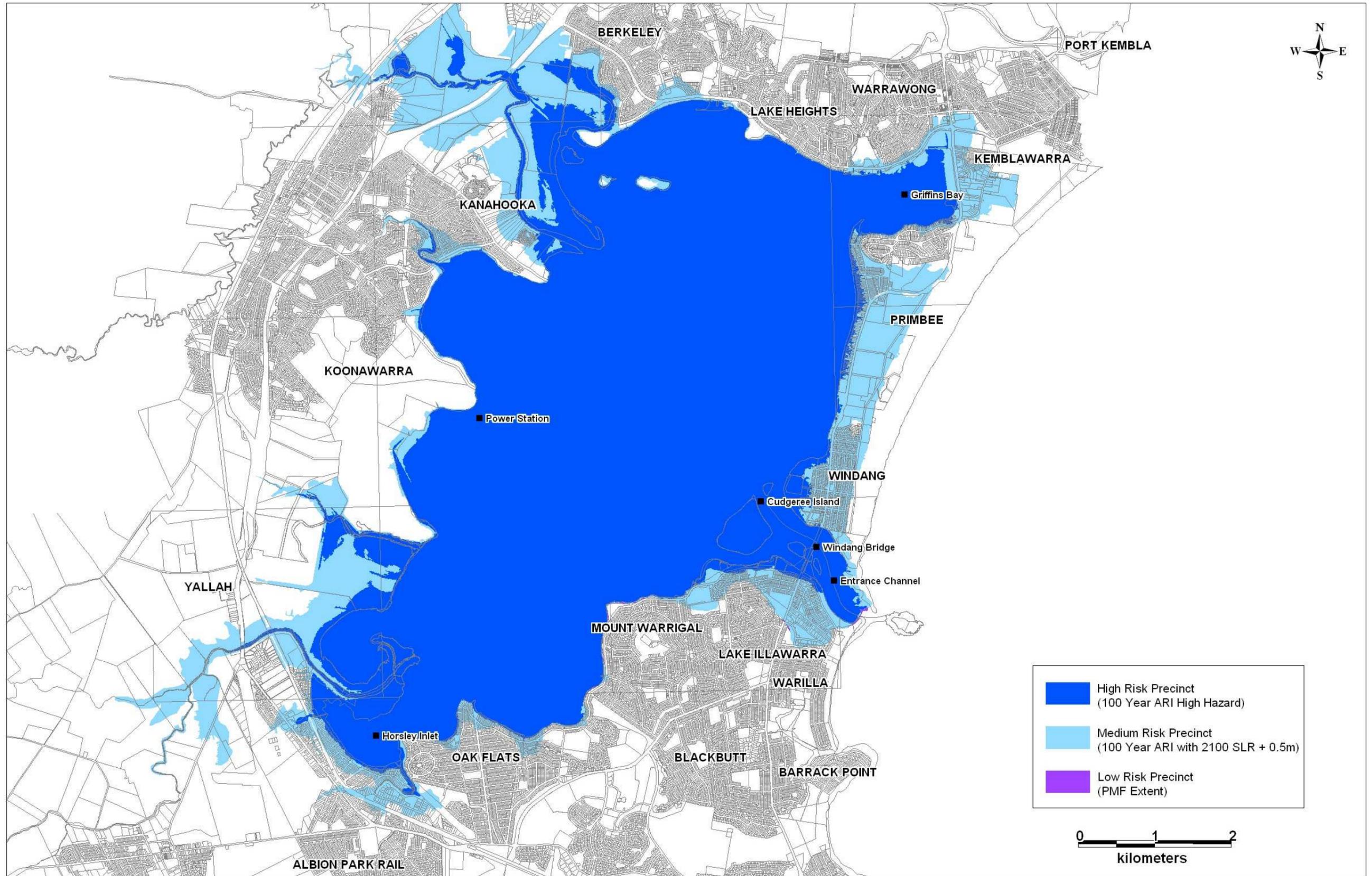


Figure 4.4: Flood Risk Precincts – Non-Concessional Development

4.4 Development Control Matrices

4.4.1 Wollongong City Council LGA

In 2010, Wollongong City Council's Development Control Plan (DCP) came into effect. Chapter E13 of the DCP outlines development controls relating to floodplain management. Shellharbour Council adopted the Floodplain Risk Management Development Control Plan (Amendment 1) in April 2006. This DCP is consistent with that of WCC with particular regard to the risk based approach utilising flood risk precincts and planning matrices for development control purposes. It incorporates a generic matrix in the absence of a catchment specific floodplain risk management plan and allows these to be annexed to the DCP as specific plans are developed and adopted by Council.

Development in the Lake Illawarra floodplain is therefore assessed in a manner consistent with these DCPs. Whilst the DCPs have common elements for the management of flooding with respect to development across the entire LGAs, the DCPs allow for each floodplain within the LGAs to have a separate series of requirements (in the form of a matrix). A planning investigation has been undertaken for Lake Illawarra and described below to allow for the relevant part of the DCPs to be prepared.

4.4.2 Proposed Development Control Matrices

Due to the issues associated with Effective Flood Access on the Windang Peninsula (**Section 4.1.2**), two development control matrices have been developed for the Lake Illawarra Floodplain. The first applies to all lands within the floodplain (i.e. PMF extent) except for the Windang Peninsula; the second applies to those lands within the Windang Peninsula as identified on **Figure A1** (in **Appendix A**).

The matrices in **Appendix A** have been developed to be consistent with the WCC Development Control Plan (2010) and Shellharbour Council's Floodplain Risk Management Development Control Plan (2006) and the Shellharbour DCP (2006). The matrices in **Appendix A** are an adaptation of this approach, suitable for the specific flood behaviour of the Lake Illawarra system.

The matrices in **Appendix A** have been prepared to recognise the following issues:

- Emergency services and flood evacuation centres should be prohibited in the floodplain;
- Communications facilities (such as telephone exchanges etc) and electricity substations to be protected and out of the floodplain;
- Need for development applications to be supported by a professionally prepared flood impact assessment. This would require the demonstration of the impacts of flooding on the development and surrounding areas;
- Prohibition or strict controls for any development within all areas associated with high flood hazard;
- Flood proofing of new development, extensions or improvements with appropriate water resistant materials such that flood damage to the structure will be negligible;
- Development can only proceed with consent from Council, on land that is subject to periodic inundation if the development is not likely to:
 - impede the flow of water,
 - aggravate the consequences of flood waters on land having regard to siltation, destruction of vegetation and erosion,
 - increase the level of flood waters in the area, or
 - endanger the safety of persons who occupy the land in the event of a flood.

- Set floor heights for new dwellings and new parts of a dwelling to an acceptable level of flood risk and applicable to specific land uses (floor levels may vary between residential, commercial and industrial development);
- Where substantial development is to occur, raise floor heights of any existing dwellings to an acceptable level of flood risk to match any new parts of the dwelling;
- Ensure adequate freeboard is incorporated into the design of new homes or the raising of any existing dwellings;
- The need for strategic site planning for all sites including:
 - the provision of suitable evacuation (if safe and effective evacuation routes cannot be provided, the proposed land-use is inappropriate),
 - consideration of the topography of the site with regard to the variation of flood hazard and the sites of development (buildings may be better located on higher ground of a site where the impact of flood behaviour and potential damage will be reduced and evacuation can be facilitated),
 - orientation and type of fences (fences can obstruct flood flows, increase levels and possibly hamper evacuation).
- Require appropriate construction supervision and certification for developments in high hazard areas.

Climate change issues have also been incorporated into the proposed DCP matrices (**Appendix A**).

Once this Plan is adopted, it is recommended that the matrices proposed in **Appendix A** be added to the relevant DCPs for the respective Councils. This approach will ensure consistency between the Council areas with regard to Planning controls and methodology for development of the Lake foreshore.

4.5 Sea Level Rise Planning Areas

In accordance with the *Draft Flood Risk Management Guide: Incorporating Sea Level Rise Benchmarks in Flood Risk Assessments* (DECCW, 2010) the sea level rise planning areas have been mapped. Sea Level Rise Planning Areas have been identified for both Concessional Development and Non-Concessional Development. The Sea Level Rise Planning Areas are provided in **Figures 4.5 and 4.6**.

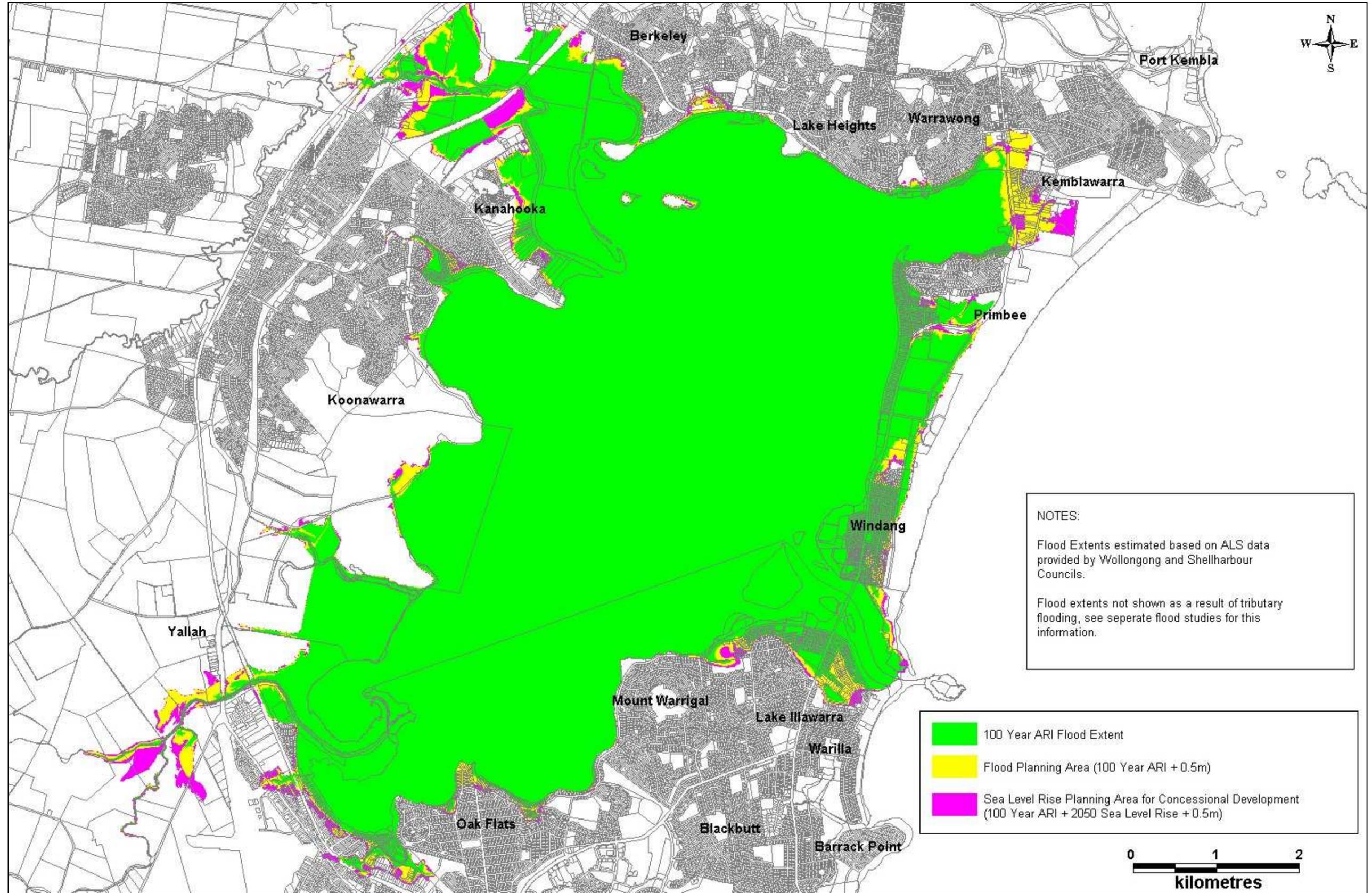


Figure 4.5: Sea Level Rise Planning Areas – Concessional Development

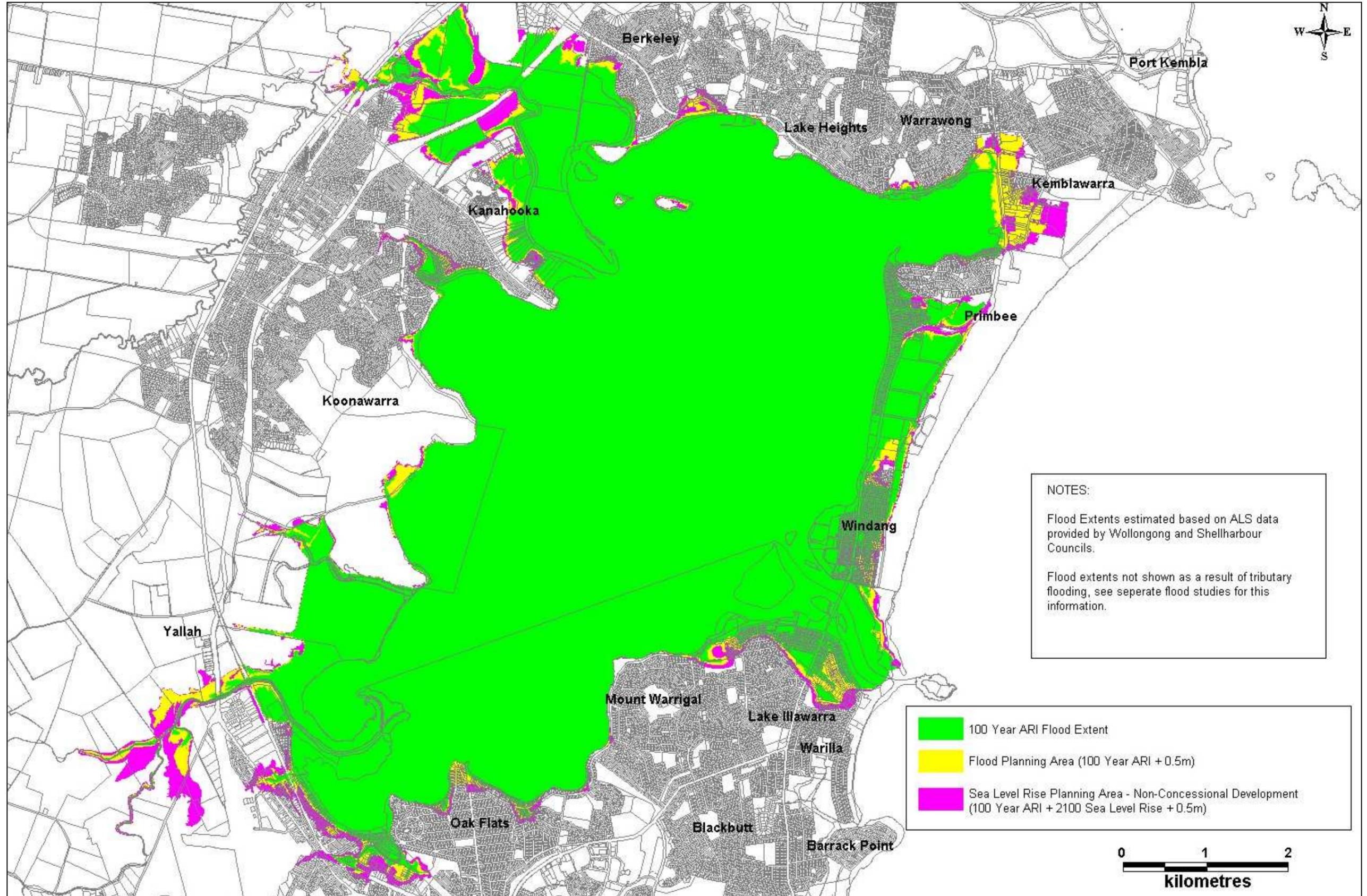


Figure 4.6: Sea Level Rise Planning Areas – Non-Concessional Development

5 Consultation

The local community, both flood prone and otherwise, has a key role to play in the development, implementation and success of a management plan. If it is to be accepted and successful, it is essential that clear and concise communications flow between the committee and the community so that affected individuals and community groups can 'have their say' and learn of their roles and responsibilities.

5.1 Lake Illawarra Committee

The Lake Illawarra Floodplain Management Committee was formed in 1997. This committee is chaired by the Lake Illawarra Authority (an independent party to both Wollongong City Council and Shellharbour City Council).

Representatives on the committee include:

- Councillor of Wollongong City Council;
- Councillor of Shellharbour City Council;
- Chair of the Lake Illawarra Authority;
- Technical representative (engineering) from Wollongong City Council;
- Technical representative (engineering) from Shellharbour City Council;
- Technical representative from Office of Environment and Heritage;
- State Emergency Service;
- Convenors of relevant neighbourhood committees; and
- Other community representatives as nominated.

For this Plan, the Committee sought to identify a range of appropriate floodplain management measures and assess their effectiveness for managing the floodplain including mitigation of the effects of flooding on existing or proposed development and infrastructure, and to ensure that any new development would have no above-floor flooding for the designated flood.

In formulating flood management strategies the following issues were considered:

- the existing flood risks;
- stabilisation of the Lake Illawarra entrance area; and
- mitigation works for protection of existing development, including modifications to Windang Bridge.

Several options were identified by the Committee for assessment as part of the *Floodplain Risk Management Study* to address the issues above, as well as the impact of filling of portions of the Lake Illawarra foreshore associated with possible future development proposals.

5.2 Social Concerns Identified Through the Stormwater Management Plan

The Shellharbour Community Environment Forum was held in October 1998 (Forbes Rigby, 2000). The main concerns drawn from it were:

- Pollution of waterways;
- Flooding;
- Degradation of riparian vegetation;
- Destruction of wetlands;
- Inappropriate development;
- Clearing and weed infestation; and
- Vandalism, off-road vehicle use, and car dumping.

Specific values/objectives identified with regard to flooding include:

- public safety - low risk to humans and property from physical hazards and natural forces; and
- flood proof issues from a pollution perspective.

5.3 Community Meeting

A public meeting, organised by the Lake Illawarra Authority was held on 31 July 2000 from 7:00 - 8:30pm at the Windang Bowling Club and was attended by approximately 45 residents and representatives of various authorities including:

- Lake Illawarra Authority
- Wollongong City Council (both Councillor's and Council personnel)
- Shellharbour City Council (both Councillor's and Council personnel)
- Department of Natural Resources (now OEH).

The purpose of the meeting was to convey the results of the flood study to the community as well as provide an opportunity for the community to voice concerns and identify locations where floodplain management options are required.

At this meeting, the findings of the Flood Study were presented with an opportunity for comments and questions regarding flooding in the area at the end of the formal presentation.

Resident queries and comments at this meeting, relevant to the floodplain management study included:

- Query regarding development at Yallah;
- Evacuation required of the Yallah area in the 1984 flood event;
- Griffins Bay - a potential second entrance to the Lake as a flood mitigation option; and
- Extension of Windang bridge on the southern side of the embankment (instead of the causeway).

The option of a second entrance at Griffins Bay was based on community belief that there was a second entrance to the Lake at this location some 60 years ago. A review of aerial photography taken in 1949 indicates that a drain (Tank Trap) was excavated from Griffins Bay to the hind dune area of Perkins Beach. Thus the drain was not a contemporary second natural entrance. However, geomorphological evidence suggests an entrance to the Lake could have existed at the northern end of the Lake, thousands of years ago. If there ever was an entrance at this location it is most likely that it was closed off by coastal processes thousands of years ago.

In terms of floodplain management options that were pursued, the option of a second entrance to the Lake at Griffins Bay was considered but deemed technically not feasible

and likely to not produce a suitable economic benefit due to the substantial cost to construct (> \$10 million).

The option of the modification of Windang Bridge is outlined in the FRMS.

5.4 Public Exhibition

The draft *Floodplain Risk Management Study and Plan* was publicly exhibited in 2005 for comment. Comments were received and incorporated in the previous revised version.

To allow public review and comment on the additional aspects incorporated into the revised *Floodplain Risk Management Study* (Cardno, 2012) and the draft *Floodplain Risk Management Plan* (such as the climate change assessment and the true hazard assessment), the documents were placed on public exhibition again from 11 July 2011 until 5 August 2011.

Two public information sessions were held on 19 and 20 July 2011, and the Study and Plan were available on the two Councils websites for viewing.

Comments received during the exhibition period have been incorporated into this Final Plan.

6 Flood Management Options

The *Floodplain Risk Management Study* (Cardno, 2012) identified and assessed a number of flood risk management options for the Lake Illawarra Floodplain. A range of options were included in this assessment combining a mixture of:

- Property modification actions;
- Emergency response modification actions;
- Flood modification actions; and
- Climate change planning provisions.

Table 6.1 provides a summary of the options assessment undertaken as part of the FRMS (Cardno, 2012). The implementation action list (**Section 7**) has been derived from the most suitable of these options.

Table 6.1 Summary of FRMS Assessment

Floodplain Risk Management Option	Assessment Outcomes	Recommended for Implementation
Option A: Entrance Stabilisation	<p>The Stage 1 and Stage 2 works associated with this option are now complete. The Stage 1 works were assessed within this FRMS. The hydraulic modelling found that the Stage 1 works resulted in a reduction in 100 Year ARI flood levels around the Lake foreshore of 0.09m and a reduction of 0.27m at the entrance.</p> <p>Stage 2 works were assessed as part of <i>Lake Illawarra Entrance Improvement – Proposed Northern Training Wall off Perkins (Windang) Beach</i> (Lawson and Treloar, 2004).</p>	No. Works already complete.
Option B1: Extension of Windang Bridge by 100m & Dredging of Back Channel	<p>Hydraulic modelling showed a reduction in 100 Year ARI flood levels around the Lake foreshore of 0.01m and an increase of 0.02m at the entrance.</p> <p>This option results in a reduction in AAD of \$12,000. The benefit-cost ratio for the unprepared case is 0.06. This value does not show a significant economic benefit associated with the option.</p>	No.
Option B2: Extension of Windang Bridge by 350m & Dredging of Back Channel	<p>Hydraulic modelling showed a reduction in 100 Year ARI flood levels around the Lake foreshore of 0.05m and an increase of 0.10m at the entrance.</p> <p>This option results in a reduction in AAD of \$34,000. The benefit-cost ratio for the unprepared case is 0.06. This value does not show a significant economic benefit associated with the option.</p>	No.
Option C1: 20 Culverts at Windang	<p>Hydraulic modelling showed a reduction in 100 Year ARI flood levels around the Lake foreshore of 0.03m and an increase of 0.07m at the entrance.</p> <p>This option results in a reduction in AAD of \$27,000. The benefit-cost ratio for the unprepared case is 0.11. This value does not show a significant economic benefit associated with the option.</p>	No.
Option C2: 40 Culverts at Windang	<p>Hydraulic modelling showed a reduction in 100 Year ARI flood levels around the Lake foreshore of 0.04m and an increase of 0.09m at the entrance.</p> <p>This option results in a reduction in AAD of \$32,000. The benefit-cost ratio for the unprepared case is 0.08. This value does not show a significant economic benefit associated with the option.</p>	No.

Lake Illawarra Floodplain Risk Management Plan

Prepared for Lake Illawarra Authority, Wollongong City Council & Shellharbour City Council

Floodplain Risk Management Option	Assessment Outcomes	Recommended for Implementation
Impacts of Foreshore Filling	The cumulative impact on flooding of filling all future developable areas in the floodplain would result in up to a 0.05m increase in 100 Year ARI and PMF levels. This relates to an increased in AAD of \$23,000 and an increase of 12 properties impacted by flooding in the PMF.	It is recommended that no further wholesale filling of flood affected sites is undertaken, unless supported by a sensitivity analysis indicating that there is no significant impact on flood levels. Also, filling that impacts on active flow areas in the stream networks feeding Lake Illawarra will not be supported.
Development Controls	Two DCP matrices have been prepared which are consistent with the format utilised in the Councils' DCPs, which includes controls relevant to the Lake Illawarra Floodplain.	Yes.
Recommendations for LEPs	Several recommendations have been made for inclusion in Councils' LEPs which are described in detail in Section 13 of the Floodplain Risk Management Study (Cardno, 2012). It is recommended that WCC review land zonings in the LEP as soon as practical to determine where the cumulative effects of any intensification of use could impact on emergency response given the potential isolation hazard in Windang. It is recommended that the Planning Zone R2 –Low Density Residential be replaced with Planning Zone E4 – Environmental Living in the Windang Peninsula area (within the extents of the Peninsula defined in Figure 6.5 of the Floodplain Risk Management Study, Cardno, 2012).	Yes.

Lake Illawarra Floodplain Risk Management Plan

Prepared for Lake Illawarra Authority, Wollongong City Council & Shellharbour City Council

Floodplain Risk Management Option	Assessment Outcomes	Recommended for Implementation
Incorporation of Climate Change into Development Controls	<p>Concessional Development:</p> <ul style="list-style-type: none"> ▪ Planning provisions to be based on 2050 sea level rise predictions. ▪ High Risk Precinct, remains equal to the existing true high hazard extent; ▪ Medium Risk Precinct is to be updated to be equal to the 2050 SLR extent plus a freeboard of 0.5m; and ▪ Low Risk Precinct remains equal to the existing PMF extent. <p>Non-Concessional Development:</p> <ul style="list-style-type: none"> ▪ Planning provisions to be based on 2100 sea level rise predictions. ▪ High Risk Precinct, remains equal to the existing true high hazard extent; ▪ Medium Risk Precinct is to be updated to be equal to the 2100 SLR extent plus a free board of 0.5m; and ▪ Low Risk Precinct remains equal to the existing PMF extent. 	Yes
Section 149 Recommendations	Recommendations for additional wording to be included on Section 149 Certificates (See Section 13.5).	Yes
House Raising Program (95 Properties)	The program would protect 95 eligible properties. The house raising program (if all 95 properties participated) would result in a reduction in AAD of \$26,000. This results in a benefit:cost ratio of 0.09. This ratio is considered too low to substantiate proceeding with this option.	No.
House Raising Program (11 Properties)	The program would protect the 11 worst affected properties (that are eligible for house raising, as shown in Figure 6.1). The house raising program (if all 11 properties participated) would result in a reduction in AAD of \$10,000. This results in a benefit:cost ratio of 0.31. Whilst having a low benefit:cost ratio (substantially less than 1), the consideration of the raising of these 11 properties is recommended.	Yes.
Voluntary Purchase Program	No properties have been identified for voluntary purchase for the floodplain.	No.
Flood Warning System	It is recommended that the current flood warning system in place at the Caravan Park areas be expanded to be publicly accessible and to allow residents to register for an email or SMS alert.	Yes.
Local Flood Plan Update - Evacuation Plan	It is recommended that a flood evacuation plan be prepared based on the results of the Flood Study (discussed in Section 3) and incorporated into the Local Flood Plan (working with the SES).	Yes.
Entrance Opening Policy	Continued implementation of LIA's entrance opening policy.	Yes.
Information and Education Brochure	It is recommended that Councils update and reissue an information brochure every two years to the community.	Yes.
Information and Education Program	It is recommended that a detailed information and education program be developed for the floodplain.	Yes.
Flood Planning Levels	<ol style="list-style-type: none"> 1. Adopt the flood levels provided in Table 3.3 for flood planning purposes. 2. Adoption a freeboard of 0.5m for flood planning purposes. 	Yes.

Lake Illawarra Floodplain Risk Management Plan

Prepared for Lake Illawarra Authority, Wollongong City Council & Shellharbour City Council

Floodplain Risk Management Option	Assessment Outcomes	Recommended for Implementation
Flood Risk Precincts	Adoption the flood risk precincts shown in Figure 4.3 for concessional development and those shown in Figure 4.4 for non-concessional development.	Yes.
Catchment wide regional controls	It is recommended the 2 Councils prepare catchment wide regional controls to offset future development impacts in major catchments.	Yes
Strategic Land Use Planning	It is recommended that the strategic land use planners of SCC and WCC consider the longer term land use planning on the lake foreshore in line with the NSW Coastal Planning Guideline: Adapting to SLR (DoP, 2010), This may require further assessment of impact of SLR on tidal planes in addition to SLR planning areas.	Yes
Review of the impacts of climate change induced rainfall changes on flooding behaviour in the floodplain.	It is noted that the degree and timeframe for change in flood producing rainfall remains unclear in the scientific literature but there is work currently being undertaken in the current update of ARR (expected to be released in 2012). It is therefore recommended that further consideration of changes to flood producing rainfall events be undertaken following release of the current ARR review or when other policy or specific and widely accepted research becomes available.	Yes
Maintenance of Stormwater Drains	Councils to regularly maintain the stormwater drainage network within the catchment. To include cleaning of pits to reduce the risk of blockage of the system resulting in surcharging during regularly occurring storm events. This should be undertaken on a quarterly basis and on an as-needed basis when complaints are received.	Yes

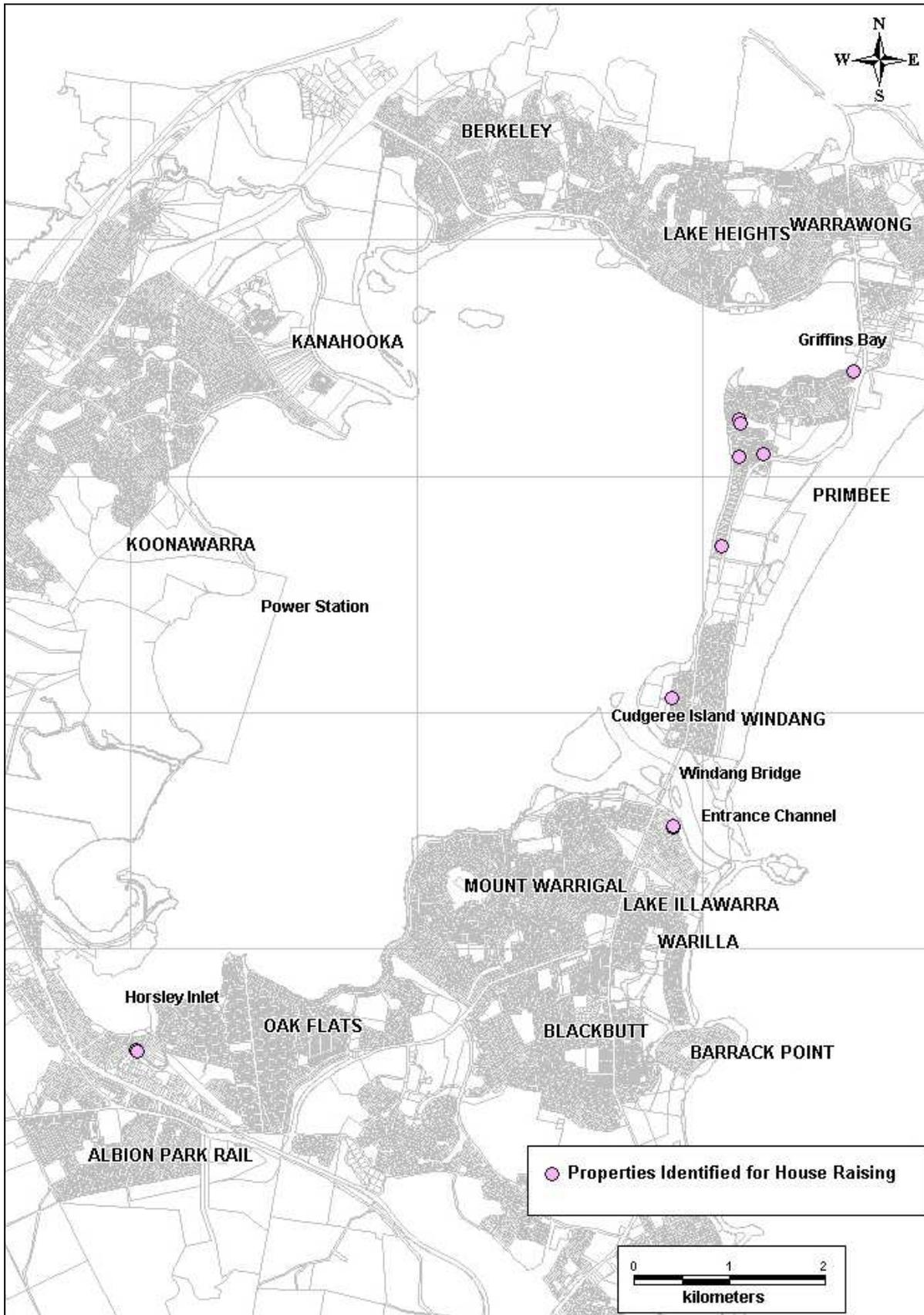


Figure 6.1: Properties Identified for House Raising

7 Implementation Action Plan

The actions listed in **Table 7.1** are recommended for adoption and implementation by Wollongong and Shellharbour Councils. **Table 7.1** provides the following information:

- An estimate of capital and recurrent costs for each action;
- The agency or organisation responsible for funding the action; and
- The priority for implementation.

The steps in progressing the floodplain management process from this point onwards are:

1. Floodplain Management Committee to consider and support recommendations of this Plan for adoption by Council
2. Council's consider the Floodplain Management Committee's recommendations
3. Exhibit the draft Plan and seek community comment
4. Consider public comment, modify the Plan if and as required, and submit the final Plan to both Councils
5. Councils to adopt the Plan and submit applications for funding assistance to OEH and other agencies as appropriate
6. As funds become available from OEH, the Commonwealth program and/or other state government agencies and/or each Council's own resources implement the measures in accordance with the established priorities.

It is recommended that high priority be given to flood planning controls and that Wollongong Council reviews the recommended development control matrix for consistency with the LEP, DCP and exceptional circumstances approvals and that Shellharbour Council reviews the recommended development control matrix for consistency with their LEP and DCP.

This Plan should be regarded as a dynamic instrument requiring review and modification over time. The catalysts for change could include new flood events and experiences, legislative change, alterations in the availability of funding, reviews of either Councils planning strategies and importantly, the outcome of new studies, particularly those relating to climate change. In any event, a thorough review every five years is warranted to ensure the ongoing relevance of the Plan.

Lake Illawarra Floodplain Risk Management Plan

Prepared for Lake Illawarra Authority, Wollongong City Council & Shellharbour City Council

Table 7.1 Implementation Action List*

Action	Estimated Cost		Funding Sources/Responsibility	Priority**
	Capital	Recurrent		
Review, adoption and implementation of newly created Planning Matrices (Appendix A) within WCC Development Control Plan (2009). This includes the adoption of the Flood Risk Precincts shown on Figures 4.3 and 4.4 , the flood levels provided in Table 7.2 and a freeboard of 0.5m. Review LEP provisions in the vicinity of the Windang Peninsula to ensure compatibility of zoning with isolation hazard.	\$15,000	-	Wollongong City Council	High
Review, adoption and implementation of newly created Planning Matrices (Appendix A) within Floodplain Risk Management Development Control Plan (Shellharbour City Council). This includes the adoption of the Flood Risk Precincts shown on Figures 4.3 and 4.4 , the flood levels provided in Table 7.2 and a freeboard of 0.5m. Seek exceptional circumstances exemption from DP&I for the application of flood planning controls in the same manner as WCC.	\$15,000	-	Shellharbour City Council	High
Adopt a policy of no future foreshore filling of flood-affected land.	\$5,000 (per Council)	-	Wollongong City Council/ Shellharbour Council	High
Shellharbour Council to include local provisions for flood planning land in their updated LEP when it is prepared.	\$5,000	-	Shellharbour Council	High
It is recommended the two Councils prepare catchment-wide regional controls to offset future development impacts in major catchments.	\$30,000	-	Wollongong City Council/ Shellharbour Council	High
It is recommended that a detailed information and education program be developed for the floodplain.	\$10,000	\$2,000	Wollongong City Council /Shellharbour Council	High
Continued implementation of LIA's entrance opening policy (if required).	-	\$10,000	LIA	High
House Raising (11 Properties).	\$440,000	-	Wollongong City Council/Shellharbour Council	High
Maintenance of stormwater drains (Quarterly and On-Demand)	-	\$100,000	Wollongong City Council /Shellharbour Council	High
Update wording on Section 149 Certificates.	\$10,000 (per Council)	-	Wollongong City Council/ Shellharbour Council	Medium

Lake Illawarra Floodplain Risk Management Plan

Prepared for Lake Illawarra Authority, Wollongong City Council & Shellharbour City Council

Action	Estimated Cost		Funding Sources/Responsibility	Priority**
	Capital	Recurrent		
Further expansion of 'flood intelligence' for the State Emergency Service including information transfer from Councils to SES, preparation of a flood evacuation plan showing flood-free road routes and locations of flood-free evacuation centres to be incorporated in the Local Flood Plan.	\$15,000	-	SES/Councils	Medium
Detailed consideration of expanding the current Caravan Park flood warning system to an email or SMS flood information service for all residents in the floodplain.	\$15,000	\$10,000	Councils/SES	Medium
It is recommended that Councils update and arrange for the reissue of an information brochure every two years to the community.	-	\$1,000	Wollongong City Council /Shellharbour Council	Medium
Review of the impacts of climate change induced rainfall changes on flooding behaviour in the floodplain as updated climate change data becomes available.	\$50,000	-	Wollongong City Council /Shellharbour Council	Medium

*Implementation is dependent on the availability of funds and Council/SES/LIA resources

**High – 2 – 5 years for implementation

**Medium 5 – 10 years for implementation

Table 7.2 Design Flood Levels to be used for Planning Purposes

	Location*	Peak Flood Level (m AHD)								
		100 Year ARI	100 Year ARI (2050 SLR)	100 Year ARI (2100 SLR)	50 Year ARI	20 Year ARI	10 Year ARI	5 Year ARI	2 Year ARI	Extreme Event (PMF)
	Modelling	Delft3D (2008)	Delft3D (2008)	Delft3D (2008)	MIKE11 (2001)					
1	Griffins Bay	2.24	2.63	3.04	2.03	1.81	1.57	1.40	1.11	3.24
2	Tallawarra Power Station	2.24	2.63	3.04	2.03	1.81	1.57	1.40	1.11	3.24
3	Horsley Inlet	2.24	2.63	3.04	2.03	1.81	1.57	1.40	1.11	3.24
4	Cudgerie Island Channel	2.24	2.64	3.04	1.99	1.81	1.54	1.40	1.08	3.19

Lake Illawarra Floodplain Risk Management Plan

Prepared for Lake Illawarra Authority, Wollongong City Council & Shellharbour City Council

	Location*	Peak Flood Level (m AHD)								
		100 Year ARI	100 Year ARI (2050 SLR)	100 Year ARI (2100 SLR)	50 Year ARI	20 Year ARI	10 Year ARI	5 Year ARI	2 Year ARI	Extreme Event (PMF)
	Modelling	Delft3D (2008)	Delft3D (2008)	Delft3D (2008)	MIKE11 (2001)					
5	Windang Bridge	2.15	2.55	3.01	1.83	1.63	1.42	1.26	0.99	2.98
6	Entrance Channel	1.71	2.25	2.32	1.74	1.55	1.35	1.20	0.95	2.84

* Locations illustrated on Figures 3.1 – 3.2.

* Note: FPL = Design Flood Level + Freeboard (0.5m)

8 References

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Appendix A

Proposed DCP Matrices

LAKE ILLAWARRA FLOODPLAIN DCP MATRIX

Evacuation	
1	Reliable access for pedestrians required during a 100 year ARI flood.
2	Reliable access for pedestrians and vehicles required during a PMF event.
3	Reliable access for pedestrians or vehicles is required from the building, commencing at a minimum level equal to the lowest habitable floor level to an area of refuge above the PMF, or a minimum of 20m ² of the gross floor area of the dwelling to be above the PMF level.
4	The development is to be consistent with any relevant flood evacuation strategy or similar plan.
5	Applicant to demonstrate that evacuation of potential development as a consequence of a subdivision proposal can be undertaken in accord with this Plan.
Management and Design	
1	Applicant to demonstrate that potential development as a consequence of a subdivision proposal can be undertaken in accordance with DCP.
2	Site Emergency Response Flood Plan required (except for single dwelling-houses) where floor levels are below the PMF
3	Applicant to demonstrate that area is available to store goods above the 100 year ARI flood plus 0.5m (freeboard)
4	Applicant to demonstrate that area is available to store goods above the PMF level
5	No external storage of materials below the design floor level which may cause pollution or be hazardous during any flood

WINDANG PENINSULA FLOODPLAIN DCP MATRIX

Planning Consideration	Flood Risk Precincts (FRP's)																																
	Low Flood Risk								Medium Flood Risk								High Flood Risk (and Interim Riverine Corridor)								Isolation Risk - Applies to the entire Windang Peninsula as shown on Figure A1 - These controls apply in addition to those applied in flood risk precincts.								
	Essential Community Facilities	Critical Utilities	Subdivision	Residential	Commercial & Industrial	Tourist Related Development	Recreation & Non-Urban	Concessional Development	Essential Community Facilities	Critical Utilities	Subdivision	Residential	Commercial & Industrial	Tourist Related Development	Recreation & Non-Urban	Concessional Development	Essential Community Facilities	Critical Utilities	Subdivision	Residential	Commercial & Industrial	Tourist Related Development	Recreation & Non-Urban	Concessional Development	Essential Community Facilities	Critical Utilities	Subdivision	Residential	Commercial & Industrial	Tourist Related Development	Recreation & Non-Urban	Concessional Development	
Floor Level	3										2, 6 or 7	2or5	2	1	2,4,6								1	2,4,6									
Building Components	2		2		2						2	1	2	1	1								1	1									
Structural Soundness	3		3		3						3	2	3	2	2								1	1									
Flood Affection	2,3				2,3	2,3					2,3	2,3	2,3	2,3	2,3								1,3	1,3									
Evacuation	2,4		3,4	4	3,4						3,4	1,4	3,4	1	1								1	1				3,4	4	3,4			
Management & Design	4,5											2,3,5	2,3,5	2,3,5	2,3,5							2,3,5	2,3,5				1		1				
	Not Relevant		Unsuitable Land Use																														
Floor Level																																	
1	All Floor Levels to be equal to or greater than the 20 year ARI flood plus 0.5m (freeboard) unless justified by site specific assessment.																																
2	Habitable floor levels to be equal to or greater than the 100 year ARI flood plus 0.5m (freeboard).																																
3	All Floor Levels to be equal to or greater than the PMF.																																
4	Floor levels to be as close to design floor level as practical & no lower than existing floor level (alterations or additions only).																																
5	Floor levels of shops to be as close to the design floor level as practical (i.e. 100 Year ARI + 0.5m). Where it is below the design floor level, more than 30% of the floor area to be above the design floor level or premises to be flood proofed below the design floor level.																																
6	Garage floor level to be no lower than 300mm above finished adjacent ground.																																
7	Garage floor level to be no lower than the 100 year ARI flood level minus 300mm or 300mm above finished adjacent ground (whichever is the greater).																																

WINDANG PENINSULA FLOODPLAIN DCP MATRIX

Building Components & Method	
1	All structures to have flood compatible building components below or at the 100 year ARI flood level plus 0.5m (freeboard).
2	All structures to have flood compatible building components below or at the PMF level.
Structural Soundness	
1	IEAust NPER Structural Engineers report to certify that any structure can withstand the forces of floodwater, debris & buoyancy up to & including a 100 year ARI flood plus 0.5m (freeboard).
2	Applicant to demonstrate that any structure can withstand the forces of floodwater, debris & buoyancy up to & including a 100 year ARI flood plus 0.5m (freeboard).
3	IEAust NPER Structural Engineers report to demonstrate that any structure can withstand the forces of floodwater, debris & buoyancy up to & including a PMF event.
Flood Affection	
1	IEAust NPER Hydraulic Engineers report required to certify that the development will not increase flood affection elsewhere.
2	The impact of the development on flooding elsewhere to be considered.
3	No wholesale filling of sites around the foreshore of the lake is permitted, unless supported by a sensitivity analysis indicating that there is no significant impact on flood levels. Also, filling that impacts on active flow areas in the stream networks feeding Lake Illawarra will not be supported. However, filling within existing building areas is permitted. Filling of depressions outside of existing building areas may only be permitted subject to it being demonstrated that there is no loss of flood storage across the site for all events up to the PMF.
Evacuation	
1	Reliable access for pedestrians required during a 100 year ARI flood.
2	Reliable access for pedestrians and vehicles required during a PMF event.
3	Reliable access for pedestrians or vehicles is required from the building, commencing at a minimum level equal to the lowest habitable floor level to an area of refuge above the PMF, or a minimum of 20m ² of the gross floor area of the dwelling to be above the PMF level.
4	The development is to be consistent with any relevant flood evacuation strategy or similar plan.
Management and Design	
1	No increase in development density further than the existing development type (i.e. single dwelling can not become dual occupancy or multi unit).
2	Site Emergency Response Flood Plan required (except for single dwelling-houses) where floor levels are below the PMF
3	Applicant to demonstrate that area is available to store goods above the 100 year ARI flood plus 0.5m (freeboard)
4	Applicant to demonstrate that area is available to store goods above the PMF level
5	No external storage of materials below the design floor level which may cause pollution or be hazardous during any flood
6	No increase in the number of persons staying overnight on site

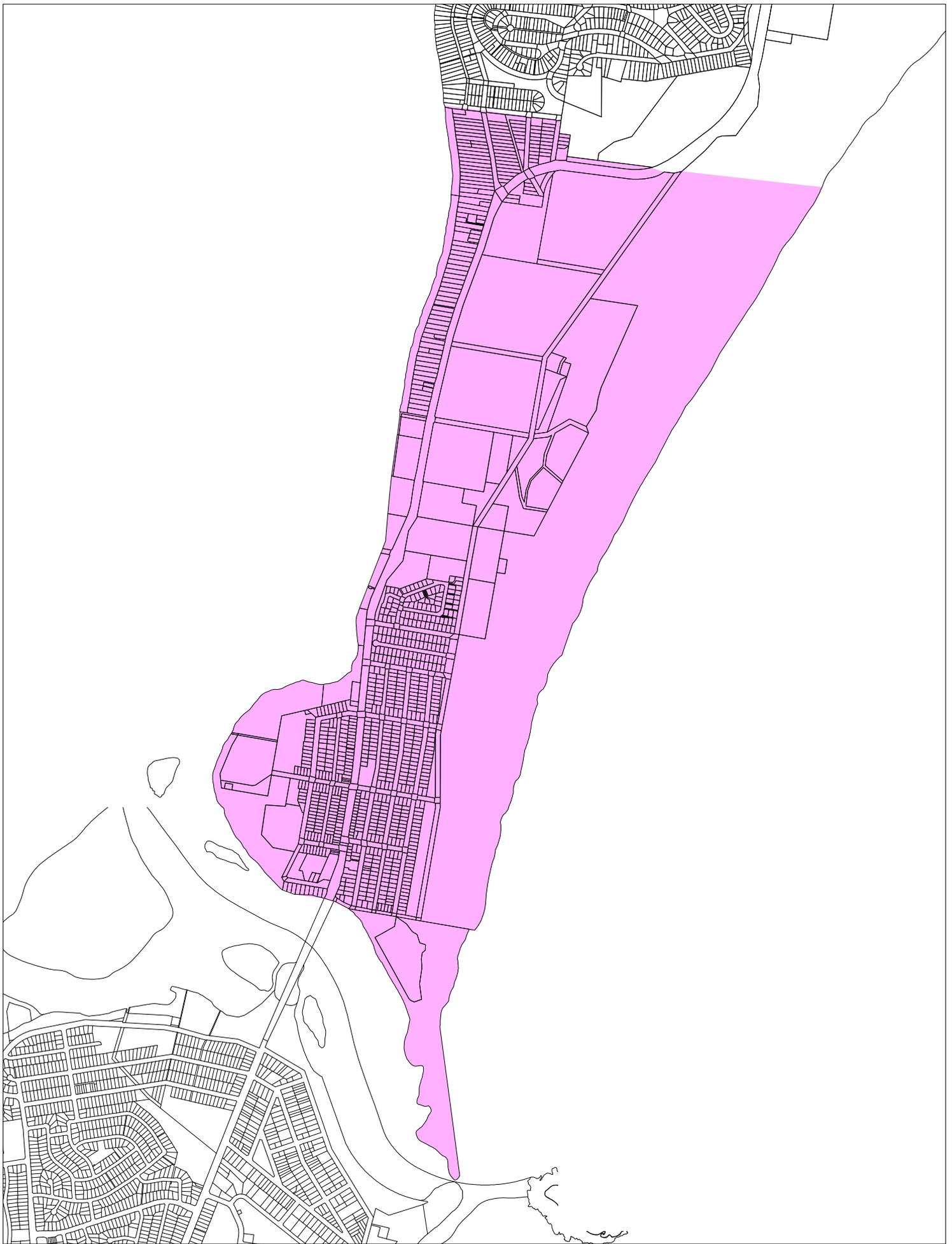


FIGURE A1
WINDANG PENINSULA
DCP MATRIX AREA