DEE WHY AND CURL CURL LAGOONS FLOODPLAIN RISK MANAGEMENT PLAN

November 2005

FINAL REPORT

VOLUME 3 – DRAFT MANAGEMENT PLAN

Prepared by:
Lyall & Associates
Consulting Water Engineers
Level 1, 26 Ridge Street
North Sydney NSW 2060

Tel: (02) 9929 4466
Fax: (02) 9929 4458
Email: lacewater@bigpond.com

Job No: AL128	Date: 10 November 2005	Principal: BWL
File:/docs/reports/DY Vol3.doc	Rev No: 3.0	Reviewer: SAB

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1 INTRODUCTION

1.1 The Floodplain Risk Management Process

A comprehensive *Floodplain Risk Management Plan* (*FPMP*) has been prepared for the Dee Why and Curl Curl Lagoon catchments as part of a Government program to mitigate the impacts of major floods and reduce the hazards in the floodplain. The Plan has been prepared as part of the Floodplain Risk Management Process in accordance with NSW Government's Flood Prone Land Policy.

Figure 1.1 shows the elements of the Floodplain Risk Management Process. The first steps in the process of preparing an FRMP were the collection of Flood Data and the completion in November 2002 of detailed Flood Studies for the two lagoons and their main tributaries (Lyall & Associates Consulting Water Engineers, 2002). The flood study was the formal starting process of defining management measures for flood liable land and represents a detailed technical investigation of flood behaviour.

Warringah Council subsequently commissioned Lyall & Associates Consulting Water Engineers to prepare the *Floodplain Risk Management Study and Plan* for the Dee Why and Curl Curl Lagoon catchments and surrounding areas.

1.2 Purpose of the Plan

The overall objective of the *Floodplain Risk Management Study and Plan* was to assess the impacts of flooding, review policies and options for management of flood affected land and to develop an *FRMP* which:

i) Sets out the recommended program of works and measures aimed at reducing over time, the social environmental and economic impacts of flooding and establishes a program and funding mechanism for the *FRMP*.

ii) Proposes modifications to existing Council policies to ensure that the future development of flood affected land is undertaken so as to be compatible with the flood hazard and risk.

iii) Reviews existing policies for managing the lagoon entrances and their impacts on flooding and makes recommendations for improvements.

iv) Ensures the *FRMP* is consistent with local emergency management planning.

v) Ensures that the *FRMP* has the support of the community.

1.3 The Study Area

This *FRMP* deals with the floodplain of Greendale Creek and Curl Curl Lagoon, as well as the floodplain of Dee Why Creek and Dee Why Lagoon. Dee Why Creek drains the Dee Why Lagoon North Catchment. For the purposes of this study the boundary between lagoon and creek has been adopted as the Pittwater Road culvert of the Dee Why system and the recently constructed rock fish ladder on the Curl Curl System.

The Dee Why Lagoon South Catchment which also drains to Dee Why Lagoon and includes the Dee Why Town Centre, is drained by a piped trunk stormwater system and does not form part of the present study.

1.4 Relevant Investigations

The Study and Plan drew on the results of several recent investigations on flooding in the study catchments, including:

- The Dee Why and Curl Curl Lagoon Flood Studies completed in November 2002
- The Dee Why and Curl Curl Catchments Property Survey Report
- The Dee Why Lagoon Estuary Management Study and Plan
- The Curl Curl Lagoon Estuary Management Plan

1.5 Community Consultation

The Floodplain Management Committee provided valuable direction over the course of the investigations, bringing together views from key Council staff, other departments and agencies, and importantly, the views of the community gained through:

- the delivery of a Questionnaire to occupiers and owners of property located in the floodplain (i.e land inundated by the PMF);
- media releases in the Manly Daily; and
- a purpose built web site, which allowed the wider community to gain an understanding of the issues being addressed as part of the study. It also allowed the Questionnaire to be downloaded should visitors to the site wish to provide input to the study.

1.6 Structure of Floodplain Risk Management Study and Plan

The *Dee Why and Curl Curl Lagoon Floodplain Risk Management Study and Plan* is incorporated in three Volumes.

Volume 1 comprises the Risk Management Study and is supported by eight Appendices which provide additional details of the investigations undertaken for the preparation of the Study and Plan. These Appendices are bound in **Volume 2**.

Volume 3 comprises the draft Floodplain Risk Management Plan for Dee Why and Curl Curl Lagoon catchments and is based on the review and recommended selection of Floodplain Management options presented in **Volume 1.**

A summary of the *draft Floodplain Risk Management Plan* proposed for the study area is shown on **Table 6.1**. The draft Plan is based on planning and development controls, flood awareness and preparedness and upgrading of warning and response procedures.

2 FLOODING PATTERN AND IMPACT

2.1 Flood Pattern

Dee Why Lagoon is the second largest of four coastal lagoons located within the Warringah Local Government Area (LGA). The lagoon has a total surface area of approximately 30 ha and a total catchment contributing stormwater inflows to the lagoon of approximately 520 ha, of which Dee Why Creek comprises 260 ha of catchment area.

The catchment of Dee Why Creek draining to Dee Why Lagoon is primarily urban with some light industry, open space and vegetated areas. Pittwater Road, the main arterial road for the northern beaches, separates the lagoon and beach system from the urban development. As a result the lagoon still has many natural features and ecological processes.

Curl Curl Lagoon is the smallest of the four coastal lagoons within the Warringah LGA. The lagoon has a total surface area of approximately 5.7 ha and a catchment area of approximately 440 ha which consists largely of residential and industrial land uses.

Curl Curl Lagoon catchment comprises extensive areas of commercial/industrial land use between Pittwater Road and Harbord Road, with the remainder of the catchment comprising residential and open space areas.

In the lower reaches of the creeks, water levels are influenced by the storage in the lagoons, initial water levels and the prevailing entrance conditions prior to the commencement of surface runoff. Dee Why and Curl Curl Lagoons are examples of Intermittently Closed and Open Lakes and Lagoons (ICOLLS). On Dee Why Creek, the lagoon influences flood levels for a distance of about 200 m upstream of Pittwater Road. Upstream of this location, flood levels are controlled by the hydraulic conveyance capacity of the channel and its overbank areas as well as the bed slope of the stream. On Greendale Creek, Curl Curl Lagoon influences levels as far as Harbord Road, which denotes the upstream end of the open channel section of creek.

Lagoon and Entrance Conditions

Table 2.1 shows the berm heights and lagoon water levels used in the Flood Study (LACE, 2002).

TABLE 2.1
BERM HEIGHT AND LAGOON LEVELS ADOPTED FOR DESIGN FLOOD ESTIMATION (LACE, 2002)

	Berm Height RL m AHD	Lagoon Water Level RL m AHD
Dee Why Lagoon	2.0	1.8
Curl Curl Lagoon	2.2	2.0

Due to the storage effects of the lagoons and the steep bed slope of Dee Why Creek upstream of Pittwater Road, peak water levels do not increase greatly with increasing severity of flooding. The range of flood levels for various flood events is shown on **Table 2.2** below. Velocities of flow in the Dee Why Lagoon are negligible and consequently this area functions hydraulically as a large, wide storage basin.

TABLE 2.2
PEAK FLOOD LEVELS
DEE WHY CREEK AND LAGOON
RL m

Flood Frequency % AEP	Lagoon	Billarong Ave	d/s Campbell Ave
20	2.3	3.3	4.52
1	2.55	3.59	4.91
PMF	3.41	4.35	5.71

On Curl Curl Lagoon, there is a significant flood slope along the extent of the lagoon due to the higher flow velocities associated with the comparatively narrow width of the waterway. **Table 2.3** shows flood levels for a range of locations and flood magnitudes.

TABLE 2.3
PEAK FLOOD LEVELS
GREENDALE CREEK AND CURL CURL LAGOON
RL m

Flood Frequency % AEP	Lagoon Entrance	Griffin Rd Bridge	d/s Harbord Rd
20	2.59	3.15	5.19
1	2.81	3.63	5.69
PMF	3.87	5.68	6.11

Time of Rise of Floodwaters

Flooding on the two catchments is “flash flooding” in nature with a rapid rate of rise after the onset of heavy rainfall. On Dee Why Creek, the stream at a typical location downstream of Campbell Avenue would commence to rise about 20 minutes after the beginning of heavy rainfall and in the case of the 1% AEP flood would rapidly rise by 1.8 m to a peak level of RL 4.91 m over the following 30 minutes. Further downstream on Dee Why Lagoon, the rate of rise is somewhat slower due to the storage effects of the waterbody, with water levels rising from RL 1.8 m to 2.55 m AHD over a period of 1.5 hours.

On Greendale Creek about 250 m downstream of Harbord Road, the stream commences to rise about 12 minutes after the commencement of heavy rainfall and rises by 3.6 m to a peak of RL 5.69 m AHD over a further 24 minutes. At Curl Curl Lagoon, the level would commence to

rise 18 minutes after the storm commences and would rise by 1.65 m to a peak of RL 3.63 m AHD over the following 80 minutes.

2.2 Flood Impact

The numbers of flood affected properties are shown on **Tables 2.4 and 2.5**. These tables make the distinction between flood "affected" properties, where the water would be expected to be on the land around the house and flood "damaged" properties, where the flood waters would be above the floor of the property and cause some damage. **Tables 2.6** and **2.7** show the economic impacts resulting from floods of various frequencies up to the Probable Maximum Flood.

TABLE 2.4
TOTAL NUMBER OF PROPERTIES INUNDATED
DEE WHY CREEK AND LAGOON STUDY AREA

Flood Event % AEP	No. of Properties Flooded					
	Residential		Commercial/ Industrial		Public Buildings	
	A	D	A	D	A	D
20	47	9	4	0	1	0
10	53	12	4	0	2	0
2	67	14	4	2	2	0
1	73	17	6	2	3	0
PMF	143	67	12	6	4	3

TABLE 2.5
TOTAL NUMBER OF PROPERTIES INUNDATED
GREENDALE CREEK AND CURL CURL LAGOON

Flood Event % AEP	No. of Properties Flooded					
	Residential		Commercial/ Industrial		Public Buildings	
	A	D	A	D	A	D
20	8	2	20	10	1	0
10	19	3	24	13	2	0
2	59	9	29	24	2	0
1	77	23	35	24	2	0
PMF	153	104	49	40	3	2

Note: A - flood affected property (includes flooding in allotments and above floor flooding
D - flood damaged property (above floor flooding only)

TABLE 2.6
FLOOD DAMAGES ON FLOODPLAIN OF DEE WHY CREEK AND LAGOON
$ x 10^3

Flood Event % AEP	Residential	Commercial/ Industrial	Public Buildings	Total
20	150	0	0	150
10	205	0	0	205
2	290	30	0	320
1	335	325	0	660
PMF	1,670	2,600	640	4,910

TABLE 2.7
FLOOD DAMAGES ON FLOODPLAIN OF GREENDALE CREEK AND CURL CURL LAGOON
$ x 10^3

Flood Event % AEP	Residential	Commercial/ Industrial	Public Buildings	Total
20	20	1,010	0	1,030
10	35	1,250	0	1,285
2	160	2,010	0	2,170
1	635	2,500	0	3,135
PMF	3,615	6,100	700	10,415

2.3 Flood Hazard

Flood hazard categories may be assigned to flood affected areas in accordance with the procedures outlined in the Floodplain Management Manual.

Flood prone areas may be provisionally categorised into *Low Hazard* and *High Hazard* areas depending on the depth of inundation and flow velocity. Flood depths as high as 0.8 m in the absence of any significant flow velocity represent *Low Hazard* conditions. Similarly, areas of flow velocities up to 2.0 m/s but with minimal flood depth also represent *Low Hazard* conditions.

Flood hazards categorised on the basis of depth and velocity only are provisional. They do not reflect the effects of other factors that influence hazard.

These other factors include:

- Size of flood – major floods though rare can cause extensive damage and disruption.
- Effective warning time – flood hazard and flood damage can be reduced by evacuation if adequate warning time is available.
- Flood awareness – flood awareness greatly influences the time taken by flood affected residents to respond effectively to flood warnings. The formulation and implementation of response plans for the evacuation of people and possessions promote flood awareness.
- Rate of rise of floodwaters – situations where floodwaters rise rapidly are potentially more dangerous and cause more damage than situations in which flood levels increase slowly.
- Duration of flooding – the duration of flooding (or length of time a community is cut off) can have a significant impact on costs associated with flooding. The duration is shorter in smaller, steeper catchments.
- Evacuation problems and access routes – the availability of effective access routes from flood prone areas directly influences flood hazard and potential damage reduction measures.

Hazard categories may be reduced or increased after consideration of the above factors.

After consideration of the above factors in the *Floodplain Risk Management Study* report, it was considered that there was no reason to adjust the provisional flood hazard and that the final determination of hazard in the floodplains could be based on depth and velocity alone.

Figures 2.1 and **2.2** show the extent of flooding for the 1% AEP and Probable Maximum Floods and the 1% AEP high/low hazard boundaries. These figures also shows houses and commercial properties which would be affected by flooding in the event of a 1% AEP design flood.

The plans showing the extent of flooding and inundation within flood affected properties (**Figures 2.1** and **2.2**) are approximate only, being based on available mapping, generally at 2 metre contour spacing and the cross sections of the creeks and floodplains comprising the hydraulic model developed in the Flood Study. Additional survey would be required to identify flood extents within individual properties.

3 FLOOD MODIFICATION MEASURES

3.1 General

No engineering works such as levees, channel improvements or the implementation of retarding basins are proposed for the *draft Floodplain Risk Management Plan*.

Several schemes, outlined below were examined in the *Floodplain Risk Management Study*, but were rejected on technical, economic or environmental grounds.

3.2 Upgrading Bridge over Dee Why Creek at Pittwater Road

The low lying Tarra Crescent/Billarong Avenue area about 100 m upstream of the bridge over Pitttwater Road is a centre of flood damages. Nine residential properties in this area would be flooded at the 20% AEP flood, with a maximum depth of inundation over floor level amounting to 0.45 m. In the event of a 1% AEP flood, 17 properties including several along Pittwater Road and in the Grafton Crescent area, would be inundated.

Widening the existing 5 m wide bridge would reduce the constriction imposed on flows by the existing opening and result in a reduction in peak water levels and consequent flood damages in the upstream urban area.

The maximum width of opening which could practically be provided within existing land use constraints is about 20 m. Larger openings would require extensive excavations and training works on both the upstream and downstream sides of the road, and would impact on the playing fields and commercial development facing Pittwater Road. However, a 20 m wide opening would only provide the mitigation of upstream damages for floods up to the 10% AEP and cannot be justified economically.

The existing bridge would be overtopped in the event of a 20% AEP flood. However, due to the small size of the catchment, the duration of interruption to traffic would be short, amounting to less than 1 hour for floods up to the 10% AEP magnitude and around 1.5 hours for the 1% AEP flood. Consequently, upgrading the bridge is not likely to proceed for serviceability reasons.

3.3 Protection of Tarra Crescent Area by a Levee Scheme

Protection of the Tarra Crescent residential area by a levee scheme was evaluated. However, the following technical factors render a levee scheme infeasible:

(1) There is a large local sub-catchment to the north which presently drains through this area en route to Dee Why Creek. Overland flows from this sub-catchment are conveyed with the prevailing grade along both Billarong Avenue and Tarra Crescent. It is not practicable to divert this runoff away from the area which would be protected by the levee. As there are no sites available for the temporary storage of surface runoff, water would pond behind the levee and would be unable to escape until floodwaters receded.

(2) There are no ridges of high ground available on the northern floodplain of Dee Why Creek to form the upstream and downstream limits of a levee scheme. The obvious route for a levee is along the grassed area between the creek and the boundaries of the allotments on the southern side of Tarra Crescent. Natural surface levels are in the range RL 3 to 3.5 m,

compared with flood levels of RL 3.6 to 3.9 m in the Billarong Avenue area for the 1% AEP flood. However, unless the levee was constructed to the elevation of the PMF, there would always be the chance that it would be overtopped. On Dee Why Creek, flooding is of a "flash flooding" nature with a very short time of rise after the initiation of heavy rainfall. Consequently, sudden overtopping could take place with no time available for the evacuation of residents. These considerations would suggest that a flood greater than the 1% AEP event and possibly the PMF, should be adopted for design purposes.

(3) In the Billarong Avenue area, the PMF flood level is RL 4.35 m. A levee with a 500 mm freeboard would be around 1.5 to 1.8 m height and would detract from the amenity of the area. In the event of a flood of this magnitude, Pittwater Road would be surcharged by backwater influences from the lagoon and consequently the levee would need to be continued northwards, either by raising the road or continuing the levee as a block wall along the western side of the road.

3.4 Mechanical Opening of Lagoon Entrances

The lagoons are typical of many coastal lagoons which are normally closed to the ocean as a result of the build up of a sand berm and then break out either naturally or due to human intervention. When the lagoons are closed, water levels are perched above ocean levels and when opened, drain to the ocean. Curl Curl Lagoon totally drains, exposing the bed.

Many of the entrance openings are not due to natural processes but are caused by people cutting a channel through the sand berm to start the water flowing out of the lagoon. The increased frequency of openings due to human intervention has a major impact on lagoon ecology by reducing the ability for fish and other organisms to establish in the lagoon. In addition, opening of the entrance may impact on the swimming water quality of the beach as the quality of the water discharging can be poor.

The lagoons are also occasionally opened mechanically by Council as a flood mitigation procedure. During times of steady rainfall or when heavy rain occurs in the catchment in the preceding week, Council Officers monitor the water levels in the lagoon. The opening of the lagoon is achieved by using a bulldozer which excavates a pilot channel across the beach berm. The opening is timed to coincide with the receding ocean high tide to establish optimum hydraulic conditions for the opening flow.

Council has prepared an Entrance Management Policy for each of the lagoons which recognises that there are a number of issues to be considered in addition to flood mitigation, including swimming, water quality on the respective beaches after a lagoon opening has occurred and the impacts of openings, either by Council or unauthorised, on water quality and environmental conditions within the water bodies.

<u>Dee Why Lagoon Entrance</u>

The current practice is to open Dee Why Lagoon when the water level exceeds the obvert of the stormwater pipe draining into the channel at the end of Billarong Avenue. The elevation of the top of pipe is about RL 1.8 m. This elevation corresponds with the starting water surface elevation prior to the arrival of the flood wave on Dee Why Creek adopted in the flood study (LACE, 2002) and is about 1.4 m below the peak 20% AEP flood level in the Tarra Crescent/Billarong Avenue area (see **Table 2.2**).

The water surface profile within the area of the lagoon is quite flat, consistent with the very low flow velocities within the waterway. However, there is a considerable increase in peak water levels across the bridge, indicative of the fact that the bridge imposes a constriction on the flow. The bridge constriction reduces the sensitivity of flood levels in this area to entrance conditions.

Curl Curl Lagoon Entrance

Curl Curl Lagoon is opened when the water level exceeds the obvert of the reinforced concrete pipe in the drainage pit at the end of Surf Road. The level of the pipe obvert is RL 2.08 m. As the pipe is not readily visible, the visual indicator adopted is when the lagoon water level surface reaches the underside of the cast iron grate over the pit, which corresponds to a level of RL 2.21 m.

The latter elevation is about 200 mm above the starting water surface elevation adopted in the flood study (LACE, 2002) and is about 700 mm below the 20% AEP flood level in the vicinity of the low lying property at the southern end of Surf Road (see **Table 2.3**).

There is a considerable flood slope within Curl Curl Lagoon due to the comparatively narrow extent of the waterway resulting in significant flow velocities. This feature reduces the sensitivity of flood levels to entrance conditions in this area.

Prediction and Monitoring of Rainfall by BOM

The impacts on upstream flood levels of varying the elevation of the entrance berms are evaluated in **Appendix E**. The hydraulic analysis demonstrated that flooding in the low lying residential sectors on Dee Why Creek is not sensitive to variations in the berm level of Dee Why Lagoon.

In the case of Curl Curl Lagoon, a minor reduction in peak water levels of around 200 mm events could be achieved for a medium flood in the low lying Surf Road area by ensuring that the berm is no higher than RL 1.4 m prior to the occurrence of the flood. In Surf Road, there are several low lying properties which would be flooded in the event of minor (20% AEP) flooding with the berm at the RL 2.2 m level adopted for the Flood Study. Reducing the flood level by lowering the berm would be beneficial in this area and would justify mechanical opening prior to the flood.

Regardless of the hydraulic model results, however, residents on both lagoons are convinced that lowering the berm prior to the occurrence of a flood would have a beneficial impact and would support enforcement of such a policy, as outlined in the respective Entrance Management Policies.

Due to the “flash flooding” nature of the two catchments and the limited storage volumes contained in each lagoon, water levels in the potential damage centres respond quickly to heavy rainfall. A predictive flood warning model would have limited success in mitigating flooding. There would be insufficient time to interrogate mathematical models of the catchments and mobilise the forces necessary to effect an opening of the lagoons if the requirement for such action were “triggered” on the initiation of heavy rainfall over the catchment.

The alternative approach outlined in the Entrance Management Policy, 1996 for initiating an opening, namely several days of prior rainfall resulting in a significant rise in lagoon levels, is appropriate, although there may be occasions when the lagoon is opened and the heavy rainfalls required to initiate flooding do not eventuate.

The reliability of the decision making process could be strengthened by linking the procedure to the prediction and monitoring of rainfall by the Bureau of Meteorology, which could be supplied on a customised website which could be set up by the BOM's Special Services Unit. The cost of such a service would be modest, amounting to an initial cost of around five to six thousand dollars and an annual cost of around three thousand dollars. It has been included in the *Floodplain Risk Management Plan*.

The BOM's Prediction and Monitoring service would comprise:

a) Daily monitoring of the weather situation by BOM and supply of information on the Customised Web page set up for Council.

b) Daily Forecast: The weather forecast is included on the Customised Web page and provides rainfall probabilities in the Sydney area for the next 4 days, including expected amounts, plus expert comment by a duty Meteorologist. The Web page also provides access to the latest rainfall, radar images and weather information.

c) In the event of expected rainfalls of significance in the vicinity of the Dee Why – Curl Curl catchments, the BOM would phone Council to advise. This advice would be forwarded when information becomes available to BOM of predicted heavy rainfall on the catchment. It will in most cases provide a minimum of 3 hours warning time. However, a thunderstorm cell could develop within 30 minutes or directly over the catchment, in which case, warning times would be shorter.

d) During a flood emergency there would be telephone access to a BOM Meteorologist. This will allow Council to obtain a second opinion before initiating an opening.

e) In addition, Public Weather warnings would be directly faxed to Council after issue by BOM.

4 PROPERTY MODIFICATION MEASURES

4.1 Planning Controls

The results of the Floodplain Management Study indicate that an important measure for Warringah Council to adopt in the floodplain would be strong floodplain management planning applied consistently by all branches of Council. A *draft Local Flood Policy* has been prepared for the guidance of Council officers in the evaluation of development proposals and is included in **Volume 2** of the *Floodplain Risk Management Study* as **Appendix D**.

The building and development controls set out in the policy involve the imposition of measures aimed at flood proofing developments in flood affected areas. They include the specification of:

- Minimum floor levels for habitable floors (including appropriate freeboard provision);
- Localised flood mitigation works including land fills, levee banks and flood walls;
- Appropriate construction methods and building materials
- Egress routes from buildings.
- Provision of underfloor areas for the passage of floodwaters.

New buildings, or additions to existing buildings would be subjected to these building controls with the long term objective of having all buildings in the area ultimately flood proofed. Controls need to be imposed on a merit basis, balancing restrictive development conditions with the impact of development on flood behaviour in the floodplain.

For the Low Hazard flood prone areas in the catchments the setting of floor levels will, over time, reduce flood damages. In the Low Hazard areas the occurrence of above floor flooding is generally infrequent and the depth of flooding above floor level in a 1% AEP flood is less than in the High Hazard areas. Floor level provisions for new buildings are appropriate in these areas.

For the High Hazard areas identified in this study, floor levels clearly need to be set for any new buildings. This may not be sufficient where flood mitigation works are not proposed as, regardless of the house floor levels, the land use may not be compatible with the frequency, depth and velocity of flooding. Features of the proposed Local Flood Policy set out in preliminary draft form in **Appendix D** are:

(1) The proposed Flood Planning Level (FPL), which is defined as the minimum floor level for new residential, commercial and industrial development in the catchments, is based on the 1% AEP flood level plus an allowance of 500 mm for freeboard. For special uses and essential services, the proposed Flood Planning Level is based on the Probable Maximum Flood Level plus an allowance of 300 mm for freeboard. The policy applies to new development in the floodplain (i.e. land inundated by the Probable Maximum Flood).

(2) There is the requirement for no net displacement of flood storage resulting from proposed developments, regardless of their location in the flood affected area and in addition, no loss of floodway area in High Hazard areas. The boundary between the High Hazard and Low Hazard areas generally conforms with the extent of the 1% AEP floodway, except in the deeper areas of Dee Why Lagoon which mainly functions as a flood storage. Accordingly, the terms “High Hazard” and “floodway” are synonymous. That is, in these two catchments, floodways are High Hazard areas and within that zone, developments

should not impact on the waterway cross sectional area available for the conveyance of flow (i.e. the floodway area). A preference is identified for suspended floors, allowing the flow of water and maintenance of flood storage in preference to compensatory excavation within the property to meet the requirements of the policy.

(3) In the case of car park areas, there is the requirement that all openings to basement car parks should be above the FPL in recognition of the "flash flooding" nature of the catchments and the hazardous nature of these facilities should their entrances be surcharged. In the case of open car parks, a maximum permissible depth of inundation of 200 mm is nominated at the 1% AEP level of flooding. The draft policy does not permit car parks on High Hazard land.

(4) The draft policy does not permit subdivision in high hazard areas or where additional flood affected residential allotments will be created. This is in recognition of the NSW Government's Flood Policy to reduce the impacts of flooding over time.

(5) In regard to information to be submitted with the Development Application, the draft policy aims to balance the applicant's costs of preparing the submission with the flood risk. The information contained in the Floodplain Risk Management Study and Plan will provide Council with data on flood levels, extent of flooding and delineation of high and low hazards. Use of this data will allow applicants to categorise their site and identify flood constraints. In Low Hazard areas it is a relatively simple task to prepare the documentation, which requires presentation of the flood information on the site survey and demonstrated conformance with the requirements for no net displacement of flood storage and minimising inundation of car park areas. More detailed studies would only be required for developments in High Hazard areas and/or in situations where the applicant opts to seek independent advice on the Flood Planning Level and Hazard Classification. Experience with other floodplain management studies indicates that applicants sometimes challenge Council's flood information and that therefore, a procedure for dealing with this situation would be advisable.

4.2 Flood Mapping

The plans showing the extent of flooding and flood affected properties (**Figures 2.1 and 2.2**) are approximate only, being based on available contour mapping and limited cross sections of the creeks and their floodplains. This level of accuracy in the flood mapping is supported by DNR, as the costs associated with undertaking detailed ground survey in each flood affected property presently lies outside the scope of the NSW Government's floodplain program.

Under the program, it is Council's responsibility to identify the flood risk in individual properties, with the onus being on the property owner to carry out sufficient survey to allow a more accurate picture of flood affection to be described in the allotment.

For example, to allow Council to assess individual development proposals, a detailed local survey would be required to allow the extent of flooding and the flood hazard to be evaluated using the results of the Flood Study for the Dee Why and Curl Curl Lagoons (LACE, 2002). For this reason, applicants will be required to submit a detailed survey plan of the site for which development is proposed.

4.3 Voluntary Purchase Scheme

Removal of housing is a means of correcting previous decisions to allow buildings in high hazard areas in the floodplain. The voluntary purchase of residential property in hazardous areas has been part of subsidised floodplain management programs in NSW for over 10 years.

Where a property is considered to qualify for a voluntary purchase scheme, the owner is notified that the body controlling the scheme (usually but not always Council) is prepared to purchase the property when the owner is ready to sell. There is no compulsion whatsoever to sell at any time. The price is determined by independent valuers and the Valuer General, and by negotiations between Council and the owners. Valuations are based on an equivalent residence which is not affected by flooding.

The timing of any agreed purchase is at the discretion of the landowner. Once the property is purchased, buildings are usually demolished. The land must then be used for flood compatible activities and is usually rezoned for open space.

The review undertaken in the *Floodplain Risk Management Study* showed that implementation of a large scale voluntary purchase scheme was not economically viable and could not be justified on social grounds.

4.4 House Raising

The analysis undertaken in the *Floodplain Risk Management Study* showed that the implementation of a voluntary house raising program was not economically viable and that most properties were subject to technical constraints which would prevented them from being raised.

5 RESPONSE MODIFICATION MEASURES

5.1 Flood Warning and Response

As part of the Dee Why Lagoon and Curl Curl Lagoon Flood Studies, water surface levels have been computed for the range of flood events between 5 and 1% AEP, as well as the PMF. The floor levels of properties potentially affected by flooding have also been surveyed. A plan has been prepared as part of this present study, showing the approximate extent of flooding, high hazard areas and the locations of flood affected properties in each catchment (**Figures 2.1 and 2.2**). Consequently there is sufficient information available to identify areas at risk from flooding for the full range of flood events likely to trigger flood response procedures.

The Local Flood Plans should be reviewed and further developed by SES so as to produce a graded response plan involving:

- Ranking the threatened houses according to their hazard situation, taking account of depth and velocity of floodwaters, and means of access, as a flood develops.

- Preparing a detailed response plan which focuses on initial evacuations from the most hazardous locations, followed by further evacuations in descending exposure to hazardous conditions.

- Preparing a plan for traffic management, which takes account of the sequence of road flooding as a flood develops. This plan would aim to:

  - maximise opportunities for the community to evacuate,
  - prevent unnecessary traffic through the affected area,
  - ensure access for SES operations.

Implementation of the Flood Intelligence Card system, as recommended in Flood Warning: an Australian Guide (published by Emergency Management Australia, 1995) would be an appropriate activity in connection with developing this graded response plan.

5.2 Flood Awareness

A number of measures are recommended to maintain awareness in the community of the threat posed by floods:

- Clear flood advice should be contained on S.149 Certificates issued by Council when property is bought. These certificates should contain clear advice and consistent requirements for floor levels for new development. The draft Local Flood Policy should be reviewed, amended as required and adopted by the Council as a Development Control Plan. The reader of a S.149 Certificate relating to a property in flood affected land would be alerted to the controls in place for development and redevelopment of the catchments.

- Council should continue to promote knowledge of the characteristics of flooding among the affected property owners. These characteristics should include information on the frequency of flooding and the depths at various locations. This information could be included in a flood information booklet containing both general and site specific data and distributed with the rate

notices. The information contained in the Community Newsletters prepared for the community consultation phase of this study will be of assistance in the preparation of suitable documentation. The community must also be made aware that a flood greater than historic levels or the planning level can, and will, occur at some time in the future. The need for a flood response and preparedness plan to address such an occurrence must be clearly explained.

- Consideration should be given to establishing flood height markers at a number of key locations to remind the community of historic and predicted flood levels for the 1% AEP flood. Consideration should also be given to showing levels which would be reached by the Probable Maximum Flood.

- The *Floodplain Risk Management Plan* should be publicised and exhibited in Council offices and at community gathering places to make residents aware of the measures being proposed.

6 RECOMMENDED MEASURES AND FUNDING

Broad funding requirements for the recommended measures to be included in the *draft Floodplain Risk Management Plan* are given in **Table 6.1** below. These measures **(Figures 6.1 and 6.2)** will achieve the objectives of reducing the flood risk to existing and future development for the full range of floods.

TABLE 6.1
RECOMMENDED MEASURES FOR INCLUSION IN DRAFT FLOODPLAIN RISK MANAGEMENT PLAN

Measure	Required Funding	Comments
Implement recommended development controls based on *draft Local Flood Policy*	$25,000	▪ Control development in floodplain as summarised in *draft Local Flood Policy (Appendix D of Volume 2)*. ▪ Flood controls for different land uses based on design 1% AEP flood plus 500 mm freeboard. ▪ Controls for essential services and SEPP 5 development based on PMF plus 300 mm freeboard. ▪ Controls to be applied for all new development in the floodplain (i.e. land inundated by PMF). ▪ Prepare more detailed flood mapping with levels and velocity data to assist with Council's evaluation of development proposals. ▪ Flood advice to be shown on S.149 Certificates.
Include BOM's Prediction and Monitoring of heavy rainfall into Entrance Monitoring Policy for each Lagoon.	$5-6,000 start up and $3,000 annually.	▪ The reliability of Council's decision to open the lagoons could be strengthened by linking the procedure to the prediction and monitoring of rainfall by the BOM.
Mechanical opening of the lagoon entrance	Council costs	▪ Openings to be carried out in consultation with BOM and in accordance with Council's Entrance Management Policy.
Ensure flood data in *this Floodplain Risk Management Study and Plan* is available to SES for inclusion in flood emergency response procedures.	SES costs	▪ Local Flood Plans to be reviewed by SES using information on flood prone development incorporated in *Floodplain Risk Management Study* and Plan and shown in Figures 2.1 and 2.2 herein. ▪ Consider implementation of Flood Intelligence Card System.
Implement flood awareness and education program.	$25,000	▪ Consider installation of flood markers. ▪ Distribute flood information booklet with rate notices.
Flood data collection	Council costs	▪ Collect further data after each flood.

7 IMPLEMENTATION PROGRAM

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

- Floodplain Management Committee to consider and adopt recommendations of this study. In particular, the Committee should review the basis for ranking floodplain management measures (as set out in **Table 4.1** of the *Floodplain Risk Management Study* and the proposed works and measures to be included in the proposed plan as set out in **Table 6.1**.
- After public comment and appropriate revisions the Final Plan should be considered and recommended by Council's Committee.
- Council considers the Floodplain Management Committee's recommendations.
- Exhibit the *draft Plan* and *Study Report* and seek community comment.
- Consider public comment, modify the Plan if and as required, and submit the final Plan to Council.
- Council adopt the Plan and submit an application for funding assistance from the Floodplain Management Program administered by DNR and/or the Natural Disaster Mitigation Program administered by the State Emergency Management Committee and other agencies.
- As funds become available from DNR, other Government agencies and/or Council's own resources implement the measures in accordance with the established priorities.

The 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 the shire planning strategies and importantly, the outcome of some of the studies proposed in this report as part of the Plan. In any event, a thorough review every five years is warranted to ensure the ongoing relevance of the Plan.

8 REFERENCES

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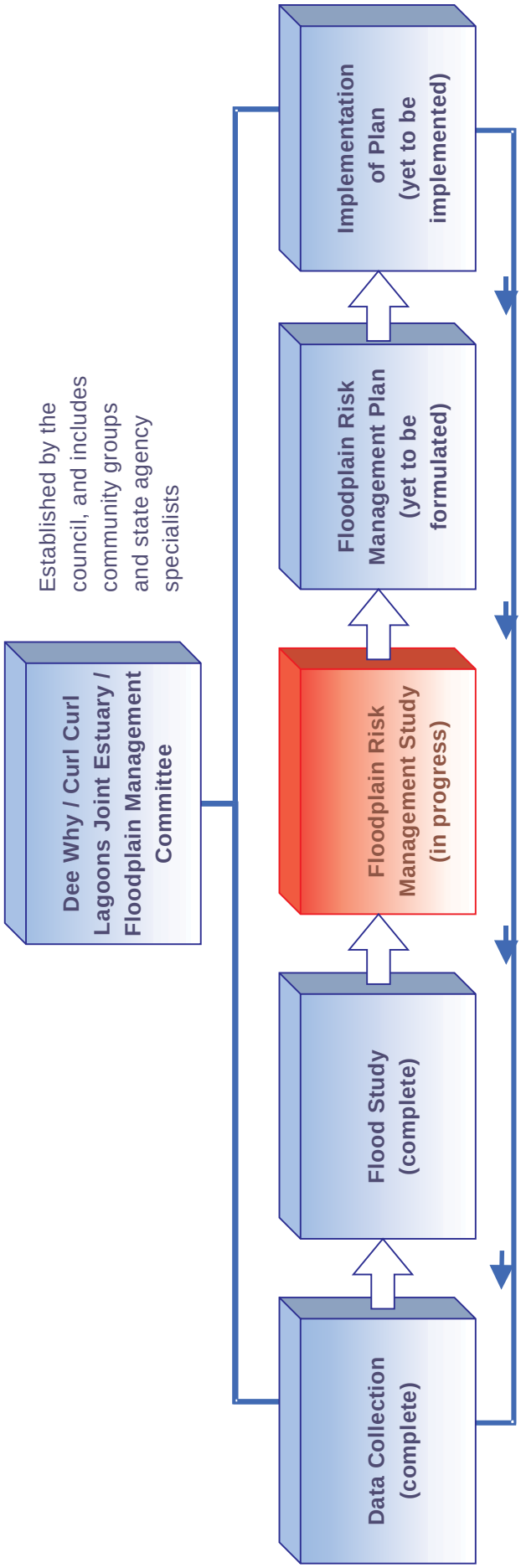
9 DEFINITIONS

The Floodplain Management Manual, 2001 contains a number of definitions which are relevant to the discussion of planning measures to assist in the management of development in the floodplain. These definitions include:

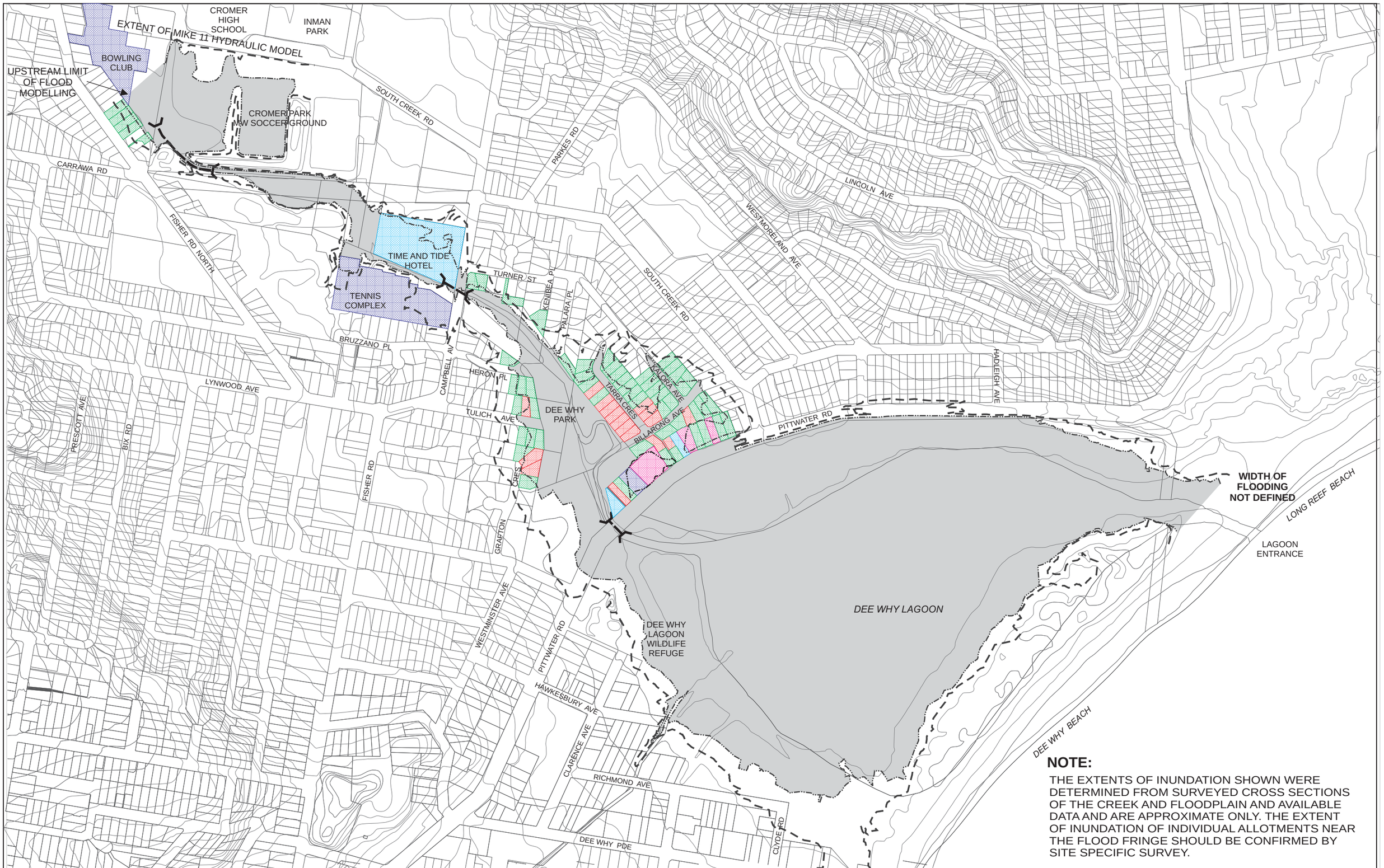
TERM	DEFINITION
Australian Height Datum (AHD)	A common national surface level datum approximately corresponding to mean sea level.
Average Annual Damage (AAD)	Depending on its size (or severity), each flood will cause a different amount of flood damage to a flood prone area. AAD is the average damage per year that would occur in a nominated development situation from flooding over a very long period of time.
Annual Exceedence Probability (AEP))	The annual probability of occurrence of a flood of a particular magnitude or greater. For example, floods with a discharge as great as or greater than the 5% AEP event have a 5 % chance of occurrence in any one year. A 5% AEP flood is also equivalent to a 20 year Average Recurrence Interval (ARI) flood event which would occur on the average once in any 20 year period. AEP and ARI are ways of expressing the likelihood of occurrence of a flood event.
Flash Flooding	Flooding which is sudden and unexpected. It is often caused by sudden local or nearby heavy rainfall. Often defined as flooding which peaks within six hours of the causative rain.
Flood Liable Land	Is synonymous with flood prone land (i.e.) land susceptible to flooding by the probable maximum flood (PMF) event. Note that the term flood liable land now covers the whole of the floodplain.
Floodplain	Area of land which is subject to inundation by floods up to and including the probable maximum flood event, that is, flood prone land.
Floodplain Risk Management Options	The measures that might be feasible for the management of a particular area of the floodplain. Preparation of a floodplain risk management plan requires a detailed evaluation of floodplain risk management options.
Flood Risk Management Plan	A management plan developed in accordance with the principles and guidelines in this manual. Usually includes both written and diagrammatic information describing how particular areas of flood prone land are to be used and managed to achieve defined objectives.

TERM	DEFINITION
Flood Planning Levels (FPLs)	Are the combinations of flood levels and freeboards selected for planning purposes, as determined in floodplain risk management studies and incorporated in floodplain risk management plans.
Flood Storage Areas	Those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood. The extent and behaviour of flood storage areas may change with flood severity, and loss of flood storage can increase the severity of flood impacts by reducing natural flood attenuation. Hence, it is necessary to investigate a range of flood sizes before defining flood storage areas.
Floodway Areas	Those areas of the floodplain where a significant discharge of water occurs during floods. They are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flow, or a significant increase in flood levels.
Freeboard	A factor of safety typically used in relation to the setting of floor levels, levee crest levels, etc. It is usually expressed as the difference in height between the adopted flood planning level and the flood used to determine the flood planning level. Freeboard provides a factor of safety to compensate for uncertainties in the estimation of flood levels across the floodplain, such and wave action, localised hydraulic behaviour and impacts that are specific event related, such as levee and embankment settlement, and other effects such as “greenhouse” and climate change. Freeboard is included in the flood planning level.
High Hazard	Where land in the event of a 1% AEP flood is subject to a combination of flood water velocities and depths greater than the following combinations: 2 metres per second with shallow depth of flood water depths greater than 0.8 metres in depth with low velocity. Damage to structures is possible and wading would be unsafe for able bodied adults.
Low Hazard	Where land may be affected by floodway or flood storage subject to a combination of floodwater velocities less than 2 metres per second with shallow depth or flood water depths less than 0.8 metres with low velocity. Nuisance damage to structures is possible and able bodied adults would have little difficulty wading.

TERM	DEFINITION
Mainstream flooding	Inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam.
Mathematical/computer models	The mathematical representation of the physical processes involved in runoff generation and stream flow. These models are often run on computers due to the complexity of the mathematical relationships between runoff, stream flow and the distribution of flows across the floodplain.
Merit approach	The merit approach weighs social, economic, ecological and cultural impacts of land use options for different flood prone areas together with flood damage, hazard and behaviour implications, and environmental protection and well being of the State's rivers and floodplains.
Modification measures	Measures that modify either the flood, the property or the response to flooding.
Peak discharge	The maximum discharge occurring during a flood event.
Probable maximum flood (PMF)	The largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation. Generally, it is not physically or economically possible to provide complete protection against this event. The PMF defines the extent of flood prone land, that is, the floodplain. The extent, nature and potential consequences of flooding associated with the PMF event should be addressed in a floodplain risk management study.
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 (World Meteorological Organisation, 1986). It is the primary input to the estimation of the probable maximum flood.
Probability	A statistical measure of the expected chance of flooding (see annual exceedance probability).
Risk	Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. In the context of the manual it is the likelihood of consequences arising from the interaction of floods, communities and the environment.
Runoff	The amount of rainfall which actually ends up as stream flow, also known as rainfall excess.



DEE WHY AND CURL CURL LAGOONS
FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN
Figure 1.1
FEATURES OF FLOODPLAIN RISK MANAGEMENT PROCESS



NOTE:

THE EXTENTS OF INUNDATION SHOWN WERE DETERMINED FROM SURVEYED CROSS SECTIONS OF THE CREEK AND FLOODPLAIN AND AVAILABLE DATA AND ARE APPROXIMATE ONLY. THE EXTENT OF INUNDATION OF INDIVIDUAL ALLOTMENTS NEAR THE FLOOD FRINGE SHOULD BE CONFIRMED BY SITE SPECIFIC SURVEY.

N

0 200 400m

Scale

INDICATIVE EXTENT OF FLOODING, 1% AEP

INDICATIVE EXTENT OF FLOOD PRONE LAND, PMF

CULVERT AND HEADWALL

FLOOD AFFECTED PROPERTIES, 1% AEP

RESIDENTIAL

COMMERCIAL

PUBLIC

FLOOD AFFECTED PROPERTIES WITH ABOVE FLOOR INUNDATION, 1% AEP

RESIDENTIAL

COMMERCIAL

PUBLIC

DEE WHY AND CURL CURL LAGOONS
FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN

Figure 2.1

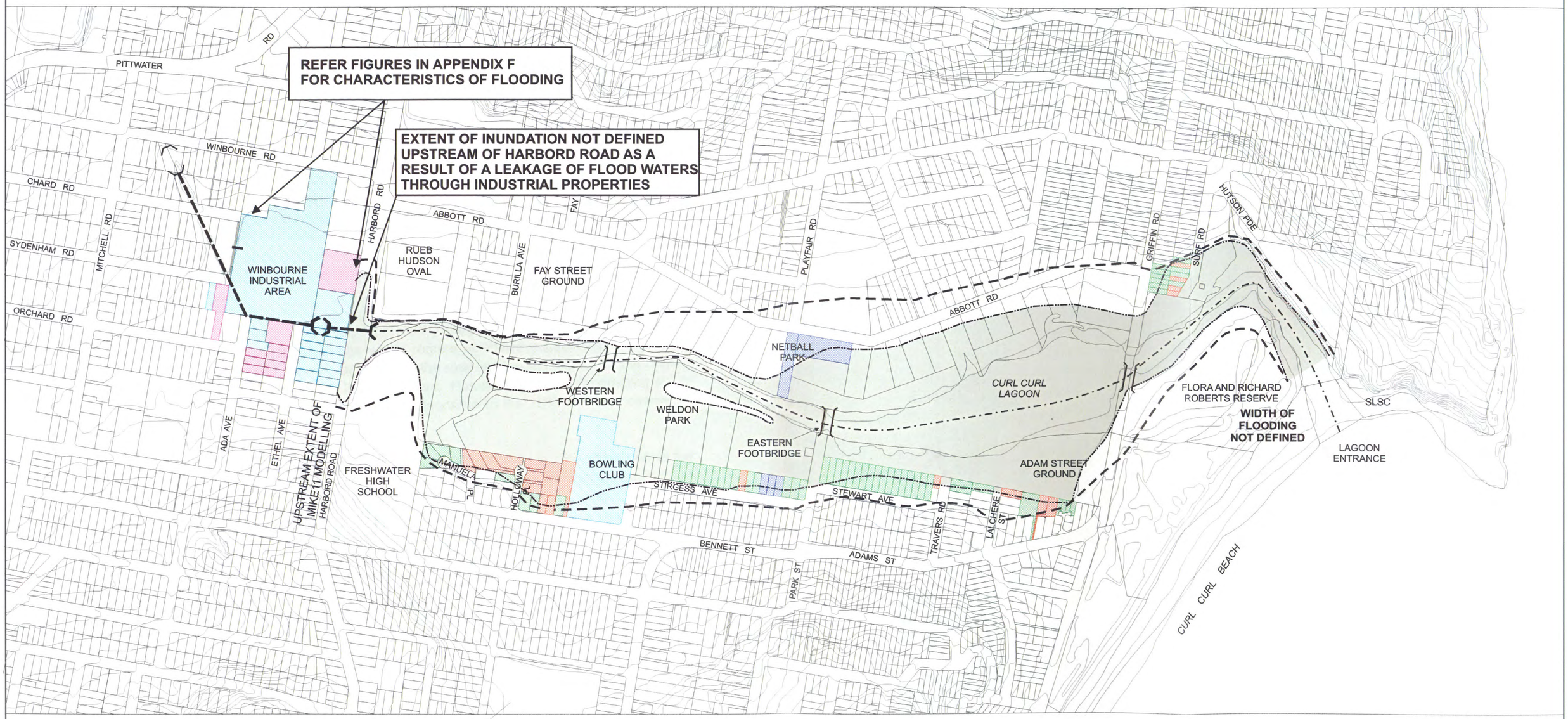
FLOOD EXTENT AND AFFECTED PROPERTIES

1% AEP EVENT

DEE WHY CREEK AND LAGOON

NOTE:

THE EXTENTS OF INUNDATION SHOWN WERE DETERMINED FROM SURVEYED CROSS SECTIONS OF THE CREEK AND FLOODPLAIN AND AVAILABLE DATA AND ARE APPROXIMATE ONLY. THE EXTENT OF INUNDATION OF INDIVIDUAL ALLOTMENTS NEAR THE FLOOD FRINGE SHOULD BE CONFIRMED BY SITE SPECIFIC SURVEY.



N

0 200 400m

Scale

INDICATIVE EXTENT OF FLOODING, 1% AEP

INDICATIVE EXTENT OF FLOOD PRONE LAND, PMF

CULVERT AND HEADWALL

FLOOD AFFECTED PROPERTIES, 1% AEP

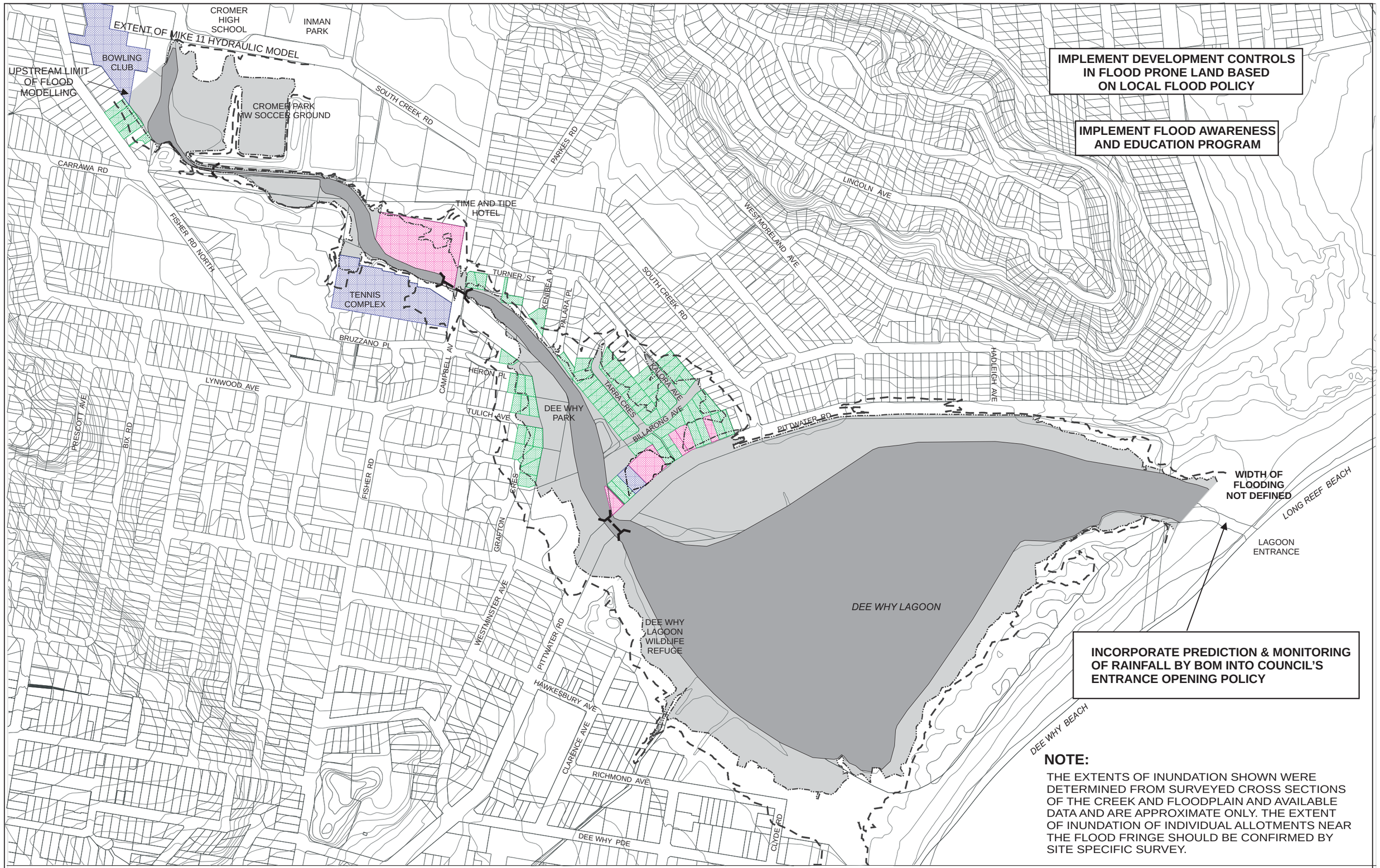
- RESIDENTIAL
- COMMERCIAL
- PUBLIC

FLOOD AFFECTED PROPERTIES WITH ABOVE FLOOR INUNDATION, 1% AEP

- RESIDENTIAL
- COMMERCIAL
- PUBLIC

DEE WHY AND CURL CURL LAGOONS
FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN

Figure 2.2
FLOOD EXTENT AND AFFECTED PROPERTIES
1% AEP EVENT
GREENDALE CREEK AND CURL CURL LAGOON

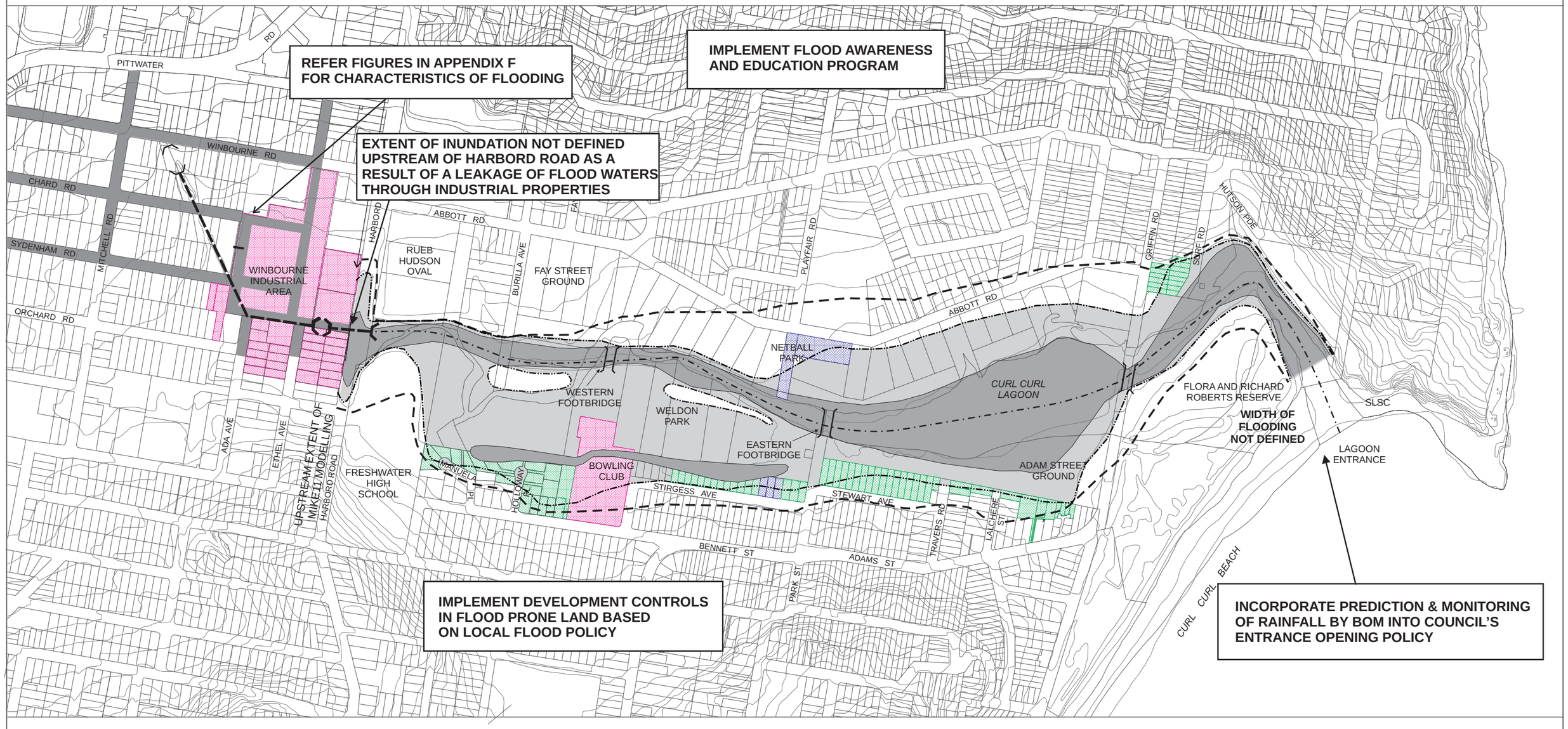


DEE WHY AND CURL CURL LAGOONS
FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN

Figure 6.1
FLOODPLAIN MANAGEMENT MEASURES
DEE WHY CREEK AND LAGOON

NOTE:

THE EXTENTS OF INUNDATION SHOWN WERE DETERMINED FROM SURVEYED CROSS SECTIONS OF THE CREEK AND FLOODPLAIN AND AVAILABLE DATA AND ARE APPROXIMATE ONLY. THE EXTENT OF INUNDATION OF INDIVIDUAL ALLOTMENTS NEAR THE FLOOD FRINGE SHOULD BE CONFIRMED BY SITE SPECIFIC SURVEY.



N

0 200 400m

Scale

CULVERT AND HEADWALL

INDICATIVE EXTENT OF FLOODING, 1% AEP

INDICATIVE EXTENT OF HIGH HAZARD ZONE, 1%AEP

INDICATIVE EXTENT OF FLOOD PRONE LAND, PMF

PROPERTIES SUBJECT TO FLOODING, 1% AEP

RESIDENTIAL

COMMERCIAL

PUBLIC

DEE WHY AND CURL CURL LAGOONS
FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN

Figure 6.2

FLOODPLAIN MANAGEMENT MEASURES
CURL CURL LAGOON