5. DEFINING THE FLOOD PROBLEM

5.1 FLOOD DAMAGES DATABASE

A flood damages database was assembled for the Double Bay catchment study area. The database allows assessment of the potential impacts of flooding, including the number of buildings inundated. It also allows economic assessments of the existing flood problem and various flood mitigation measures.

About 970 buildings were included in the initial damages database where the building footprint was approximately located within the probable maximum flood (PMF) extent. Turner Surveying was engaged to survey floor levels for about 620 buildings whose footprints were located within the 100 year ARI flood extent derived from the Flood Study (i.e. prior to the "blocked" model run). For these buildings and where access permitted, the surveyor provided the information listed in **Table 5.1**.

TABLE 5.1 – Information Provided by Surveyor

	Residential	**Commercial**
Geographic coordinates of the surveyed points (MGA 94)	Yes	Yes
Building floor level	Yes (lowest habitable floor)	Yes (main shop floor)
Ground level	Yes (adjacent to building)	No
Garage level	Yes (where applicable)	No
Specific land use	Yes (house, townhouse, unit, villa, etc)	Yes (name and type of business)
Building description	Yes (wall type, floor type, number of habitable stories, number of ground floor units)	Yes (number of stories within single premises)
Floor area	No	Yes
Photograph	Yes (external)	Yes (external and internal)

For buildings without surveyed information (i.e. for the most part, subject to inundation only in floods less frequent than the 100 year ARI flood), levels were estimated using the Digital Elevation Model (DEM) developed for the Flood Study, based on ALS survey flown in December 2005. Ground levels were extracted at a point near the building. For buildings within the expanded 100 year ARI extent following the "blocked" model run, floor levels were estimated using Google Street View to assess floor heights above the ground. For the remainder of buildings, floor levels were estimated by adding an assumed "height above ground" to each ground level estimate. A 0.3m height above ground was assumed for the residential sector and a 0.2m height above ground was assumed for the commercial sector, based on the surveyed sample.

Flood surfaces for the 5 year, 10 year, 20 year and 100 year ARI floods and the PMF were used to extract flood levels for each building in the database. The 100 year flood surface was the maximum envelope of the “blocked” and “unblocked” model runs described in **Section 4.1.3**; the unblocked results were used for the other design events.

An initial assessment suggested that a surprisingly large number of dwellings and shops were flooded above floor level in frequent events (even in the 1 year flood). Possible reasons for this result were explored. In some cases the result is genuine, with rather small drainage pipes and with several floors at or even below ground level, especially in the commercial area. One Bay Street shopkeeper interviewed by the consultant had seen flooding three times in five years, suggesting that flooding is frequent.

However, complexities were identified for properties affected by overland flow paths on the steeply sloping valley sides. One issue is the approximated ground surface in the DEM, which is a function of the spacing of the ALS ground survey points. No ALS ground survey points are provided at buildings or under dense tree cover. The result is that especially on steep slopes, the DEM ground level used to generate the flood surfaces may be higher than the surveyed floor level, so that even very shallow flooding will be seen to inundate the floor. A second issue is the potential in the modelling for floodwater to be trapped against a building which in the TUFLOW model has a high roughness. A third issue is the significant influence on overland flows of local features such as fences, walls and landscaping, which are not fully represented in the model. Another issue is that some buildings may not be shown as flooded due to a protocol adopted in the TUFLOW model to raise the ground level at buildings by 200mm.

In order to address the above issues, it was decided that the most accurate representation of the potential for flooding at a building would be to apply the *minimum flood level within a radius of 10 metres* from the building’s tag point (most often a point at the building’s front door). Properties where the flooding was associated with only shallow overland flooding (defined as the region where the maximum 100 year flood depth within a radius of 10 metres from the building’s tag point was less than 0.3m) were listed separately.

Table 5.2 summarises the attributes and sources of information included in the Double Bay catchment flood damages database.

TABLE 5.2 – Attributes Recorded in Flood Damages Database

Attribute	Comment/Source
Land use	Residential or commercial/other land use.
PIN (UDN_CD5)	Council's unique identifier for each property.
Address	Council.
Building description	Turner Surveying, September-December 2009. Some estimated.
Residential type	Turner Surveying, September-December 2009. Some estimated from Google Street View.
Residential code	Refers to the categories used for residential flood damage calculation (DECC, 2007).
Commercial type/name	Turner Surveying, September-December 2009. Some estimated from Google Street View.
Commercial code	Refers to categories used for commercial damage calculation (ANUFLOOD).
Comment	Various sources.
Ground level and source	Surveyed levels from Turner Surveying. Estimated levels from DEM derived from ALS survey flown December 2005.
Floor level and source	Surveyed levels from Turner Surveying. Estimated levels derived by adding average floor height to DEM ground level.
Existing design flood levels (5 year, 10 year, 20 year, PMF)	Revised flood modelling (refer to **Section 4.1.2**) using unblocked conditions.
Existing design flood levels (100 year)	Maximum envelope of blocked and unblocked model run (refer to **Section 4.1.3**).

5.2 TYPES OF FLOOD DAMAGE

The definitions and methodology used in estimating flood damages are well established. **Figure 5.1** summarises all the types of flood damages considered in this study. The two main categories are "tangible" and "intangible" damages. Tangible flood damages are those that can be more readily evaluated in monetary terms. Intangible damages relate to the social cost of flooding and therefore are much more difficult to quantify.

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

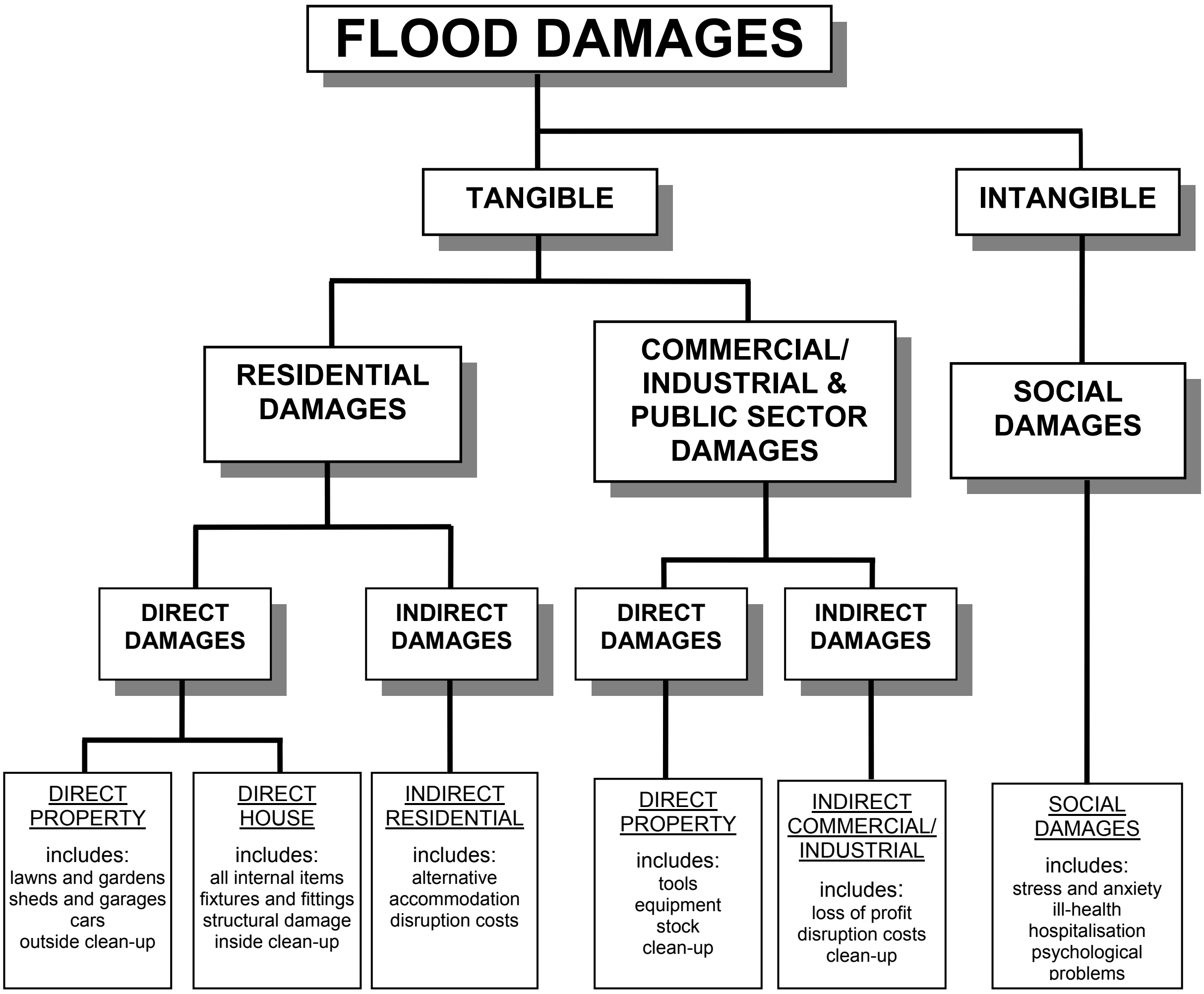


FIGURE 5.1 – Types of Flood Damage

5.3 BASIS OF FLOOD DAMAGES CALCULATIONS

Flood damages have been calculated by applying one of several stage-damage curves to every property included in the database. These curves relate the amount of flood damage that would potentially occur at different depths of inundation, for a particular property type, whether residential or commercial/industrial.

5.3.1 Residential

DECC's (2007) *Residential Flood Damages* Floodplain Risk Management Guideline is the key reference for assessing residential flood damages in NSW. This provides a standard method for deriving site-specific residential stage-damage curves. Changes in Average Weekly Earnings (AWE) were used as a basis for escalating residential damages to current values, in accordance with advice received from OEH.[3] Designated floor types (low-set single storey/slab on ground; high set single storey; double storey) were derived from the building survey, or assumed to be double storey if not surveyed. Given the large number of units in the study area, a separate "units" category was added, the damages for which were set at 75% of the "low set single storey" category. If not recorded, the number of ground floor units was set at four. An average house size of 190m^2 was adopted, based on a sample of 50 houses measured from the aerial photography. Flood warning times are negligible given the small, steep catchment and very short times of concentration. The level of awareness was set at low. It is noted that the residential stage-damage curves make allowance for both clean-up costs and the cost of time in alternative accommodation. Nevertheless, a further measure of indirect damages was estimated by taking 20% of the total direct damages, in keeping with advice received from OEH.

DECC's (2007) *Residential Flood Damages* Guideline allows for the average value of contents in dwellings to be varied, typically on the basis of house size. One other reason for varying the base figure ($60K for a 240m^2 house) could be the socio-economic status of an area – Double Bay is an affluent area, so residents would be expected to have more valuable contents than the NSW average. From the community questionnaire, the median value of contents that respondents estimated would be destroyed for a flood depth 0.3m above the floor was $60-80K (**Section 3.5.4**). This compares to a value of $43K calculated for double-storey houses in the Double Bay catchment—the most common type of housing in the study area—using the standard guideline. Census data indicates that median household income is nearly double that of the NSW average. This is likely to translate to greater household wealth, though it is noted that median housing loan repayments and rent is higher than the NSW average (**Table 2.2**). Given this information, the average value of contents calculated for the average house size of 190m^2 was *doubled* (to $95K). The inputs and outputs for the residential stage-damage functions are shown in **Appendix C**.

5.3.2 Commercial

No standard stage-damage curves for direct commercial and industrial damages have been recommended for use in NSW. The Queensland Department of Natural Resources and Mines published a guideline recommending adoption of the stage-damage data developed for the computer program ANUFLOOD (NRM, 2002). ANUFLOOD provides base-line stage-damage data for three sizes and for five value classes of commercial properties. The baseline data published in the *ANUFLOOD User Manual* (Greenaway & Smith, 1993) were factored to November 2009 values by adding the GST and applying changes in AWE, as recommended in DECC (2007); the resulting data is listed in **Appendix C**.[4]

[3] AWE ("Earnings; Persons; Total earnings") for November 2009 was 955.00 (ABS, 2010), yielding a ratio of 1.42 when compared to the base data from November 2001.

[4] It was observed that the commercial stage-damage data for large commercial properties reported in Greenway & Smith (1993) is inconsistent with that reported in Smith (1994), which has since been reported in the influential

Double Bay shop floor areas were estimated by the surveyor. Value classes were estimated by reference to NRM (2002) and to photographs taken inside shops where permission was granted (see **Appendix C**). Given a suspicion that the ANUFLOOD stage-damage curves were "on the low side" (Dingle Smith, ANUFLOOD author, Apr 2010, pers. comm.), as well as the highly specialist nature of many Double Bay shops (e.g. fashion shops carrying designer labels), the commercial stage-damage data was also *doubled*.[5]

Actual losses were estimated by applying a ratio of actual to potential damages of 0.99, consistent with the damage reduction factor applied to the residential sector. Indirect commercial/industrial losses were estimated as 20% of direct actual commercial/industrial damages, in accordance with advice received from OEH.

5.3.3 Building Failure

An allowance is made in the DECC (2007) stage-damage data for structural damage but not for actual building failure. Middleman-Fernandes (2010) demonstrated that where buildings fail, stage-damage functions underestimate loss. Given the modest depths and velocities likely to be experienced in Double Bay, no allowance was included for building failure.

5.3.4 Infrastructure

In accordance with advice received from OEH, the actual value of damage to infrastructure (including roads and bridges, water supply and sewerage, electricity and telephone supplies, natural gas supplies) was estimated at 15% of the "total damages". No allowance was made for possible damage reduction in response to flood warnings.

5.3.5 Motor Vehicles

Data from the Australian Bureau of Statistics indicate a motor vehicle ownership rate of 1.2 per household in the study area (**Table 3.5**). Not all cars will be present during working hours, but others will commute to the study area for shopping or work. For this study's assessment of damages, no account was taken of commercial car parks or vehicles in the commercial area.[6] Cars were assumed to be located at the surveyed garage level (where applicable) or surveyed ground level as the residences with which they are associated.[7]

Based on insurance data from the Katherine flood (Jan 1998), Wollongong flood (Aug 1998) and Canberra bushfire (Jan 2003), it is assumed that the average cost of a written-off motor vehicle is in the order of $12,000. Damage is expected to begin at a depth over the ground of 0.3m, and a write-off is assumed to occur at a depth of 0.6m over the ground. For consistency with other components of the damages assessment, the same damage reduction factor of 0.99 was applied in estimating actual motor vehicle damages.

---

publication *Economic Costs of Natural Disasters in Australia* (BTE, 2001). Without means of corroborating the accurate data, the original stage-damage data was used in this study.

[5] The special character of the Double Bay shopping precinct is conveyed in www.doublebayonline.com/shop.php, www.doublebayonline.com/eat-drink.php and www.doublebayonline.com/pamper.php (accessed April 2010).

[6] A Secure Parking commercial car park at 1-13 Cross Street appears to be highly exposed to flooding, with a surveyed ground level of 2.17m AHD and a 5 year flood level of 3.17m AHD.

[7] For car parks below ground level, the surveyed low-point on the driveway crest was used where available, in preference to the garage or ground level.

5.3.6 Social

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

5.4 ECONOMIC ANALYSIS

An economic appraisal is required for all proposed capital works in NSW, including flood mitigation measures, in order to attract funding from the State Government's Capital Works Program. The NSW Government has published two Treasury Policy Papers to guide this process: *NSW Guidelines for Economic Appraisal* (NSW Treasury, 2007) and a summary in *Economic Appraisal Principles and Procedures Simplified* (NSW Treasury, 2007).

An economic appraisal is a systematic means of analysing all the costs and benefits of a variety of proposals. In terms of flood mitigation measures, benefits of a proposal are generally quantified as "the avoided costs associated with flood damages". The avoided costs of flood damage are then compared to the capital (and on-going) costs of a particular proposal in the economic appraisal process.

Average annual damage (AAD) is a measure of the cost of flood damage that could be expected each year by the community, on average. It is a convenient yardstick to compare the economic benefits of various proposed mitigation measures with each other and the existing situation.

The "present value" of flood damage is the sum of all future flood damages that can be expected over a fixed period (usually 20 years) expressed as a cost in today's value. The present value is determined by discounting the future flood damage costs back to the present day situation, using a discount rate of 7%.

A flood mitigation proposal may be considered to be potentially worthwhile if the benefit–cost ratio (the present value of benefits divided by the present value of costs) is greater than 1.0. In other words, the present value of benefits (in terms of flood damage avoided) exceeds the present value of (capital and on-going) costs of the project.

However, whilst this direct economic analysis is important, it is not unusual to proceed with urban flood mitigation schemes largely on social grounds, that is, on the basis of the reduction of intangible costs and social and community disruption. In other words, the benefit–cost ratio could be calculated to be less than 1.0.

Net present value is a useful tool to complement the benefit–cost ratio in the economic appraisal process. A flood mitigation proposal may be considered to be potentially worthwhile if the net present value (the present value of benefits minus the present value of capital and on-going costs) is greater than zero.

5.5 SUMMARY OF INUNDATION PATTERNS

A summary of the predicted number of buildings in the Double Bay catchment flooded above floor level in each design event is provided in **Table 5.3**. An indication of likely flood depths in the 100 year ARI event is provided in **Table 5.4**. The distribution of buildings expected to be flooded above floor level in the 20 year and 100 year events is shown in **Figure 5.2**.

Key results are:

- 39 houses would be flooded above floor level in the 20 year ARI flood;
- 93 businesses would be flooded above floor level in the 20 year flood;
- 62 houses would be flooded above floor level in the 100 year ARI flood;
- 142 businesses would be flooded above floor level in the 100 year flood;
- Half of the above-floor inundation in the 100 year flood would be very shallow (< 0.2m);
- Identified residential “hot-spots” include: 1) an area along Manning Road opposite the Lough Playing Fields where floodwater ponds behind the Bondi Ocean Outfall Sewer (BOOS) conduit which effectively forms a de facto detention basin; and 2) the low-lying area near Guilfoyle Park;
- Commercial premises along Cross Street near New South Head Road and near the intersection of Knox Street and Bay Street are exposed to frequent flooding; and
- Roads that could be inundated to serious depths in the 100 year event include Manning Road near Nos. 91-93 (2.2m), Kiaora Road above New South Head Road (0.8m), Cross Street near Nos. 1-13 (0.8m) and Guilfoyle Avenue (1.5m).

5.6 SUMMARY OF CALCULATED DAMAGES

Calculated flood damages are reported in **Table 5.5**, with a breakdown of the components contributing to average annual damages shown in **Table 5.6**.

Key results are:

- A 20 year ARI flood is expected to cause damages of $18.6 million;
- A 100 year ARI flood is expected to cause damages of $25.0 million;
- <u>The annual average damage within the study area is about $3.7 million</u>, which is a measure of the cost of flood damage that could be expected each year, on average, by the community;
- <u>The present value of damages within the study area is about $38.8 million</u>, which represents the maximum sum that could be spent on flood mitigation measures if an economic benefit/cost ratio of 1.0 is required and all flood damages can be avoided.
- By far the largest single contributor to flood damages is direct commercial damage.
- If motor vehicles are added, the annual average damage would increase by $340K.

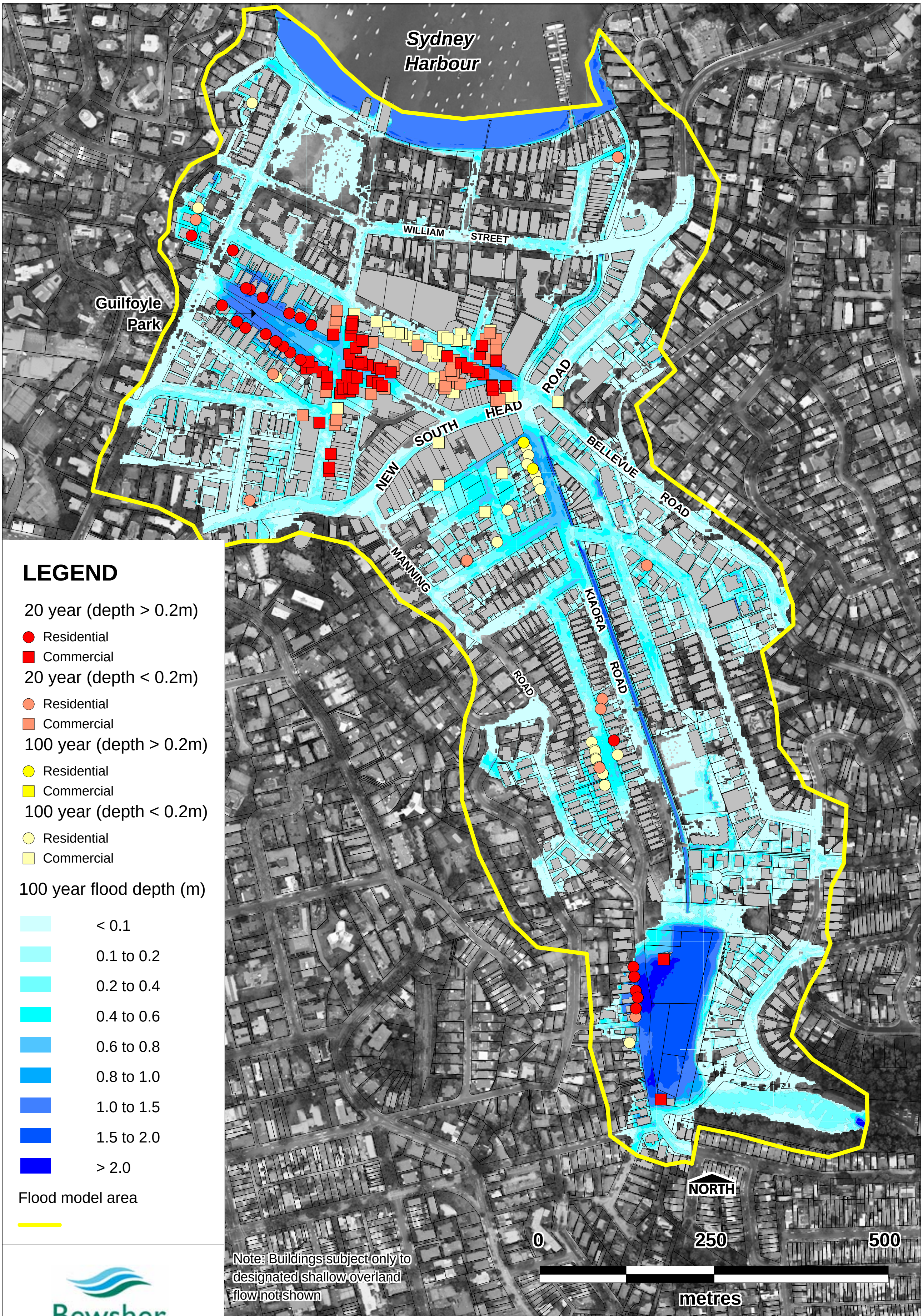
TABLE 5.3 – Summary of Buildings Inundated

Flood ARI	Shallow Overland Flood Depth *			Remainder of Floodplain			TOTAL		
	Res.	Comm.	Total	Res.	Comm.	Total	Res.	Comm.	Total
5 year	5	4	9	27	65	92	32	69	101
10 year	5	4	9	32	81	113	36	86	122
20 year	5	5	10	34	88	122	39	93	132
100 year	5	22	27	57	120	177	62	142	204
PMF	N/a	N/a	N/a	318	290	610	318	290	610

* Shallow overland flood depth defined as flooding where the maximum 100 year flood depth within a radius of 10 metres from the building's tag point was less than 0.3m. Because of the shallow depth it is difficult to predict floor level inundation accurately. Therefore there is less confidence in these inundation estimates than in the remainder of the floodplain.

TABLE 5.4 – Building Inundation Depths in the 100 Year Flood

Land use	Below Floor Flooding (Number of Buildings)		Above Floor Flooding (Number of Buildings)				
	-0.5 to -0.2	-0.2 to 0.0	0.0 to 0.2	0.2 to 0.5	0.5 to 1.0	> 1.0m	TOTAL
Residential	161	53	32	12	12	5	62
Commercial	76	49	72	42	24	4	142



Bewsher

File: Damage_20-100-d.WOR
Job No.: J1806
Date: 15 Sep 2010

FIGURE 5.2 - Distribution of Buildings Inundated in the 20 Year and 100 Year Floods by Over-floor Depth

TABLE 5.5 – Summary of Flood Damages by Event (excluding motor vehicles)

Flood Event	Predicted Actual Damage in Flood Event ($2009)	Average Annual Damage ($2009) *	Present Value of Damage ($2009) *
5 year	$10.3M	$3.7M	$38.8M
10 year	$12.3M		
20 year	$18.6M		
100 year	$25.0M		
PMF	$159.0M		

* Based on treasury guidelines of a 7% discount rate and expected life of 20 years

TABLE 5.6 – Components of Flood Damage for the Double Bay catchment (AAD)

	Damage Component	Method Assessed	Cost ($2009)	
A.	Direct Residential Dwelling Damage	DECC (2007) curves	$534,000	15%
B.	Direct Residential Property Damage	DECC (2007) curves	$365,000	10%
C.	Indirect Residential Damage	20% of (A + B)	$180,000	5%
D.	Direct Commercial Damage	ANUFLOOD curves	$1,386,000	38%
E.	Indirect Commercial Damage	20% of D	$277,000	8%
F.	Infrastructure Damage	15% of (A + B + D)	$345,000	9%
G.	Social Damage	25% of (A + B + D)	$575,000	16%
	TOTAL		**$3,662,000**	100%
H.	Residential Area Vehicle Damage	BC curves	$341,000	

6. EVALUATION OF FLOODPLAIN MANAGEMENT OPTIONS

Floodplain management measures can be divided into three general groups:

1) those that modify flood behaviour;
2) those that modify property in order to minimise flood damage; and
3) those that modify people's response to flooding.

Measures that modify flood behaviour usually include structural works that attempt to lower flood levels, or to divert floodwaters away from areas that would otherwise flood. These type of measures are often favoured by the community.

Measures that modify property in order to minimise flood damage include voluntary house purchase, voluntary house raising or house reconstruction, "flood-proofing" and controls on new development.

Measures that modify people's response to flooding include measures that provide additional warning of flooding, improve emergency management planning and improve public awareness of the flood risk.

A range of assessment criteria have been used for evaluating potential floodplain management measures within the study area. These are described below. A qualitative assessment has been undertaken for each floodplain risk management option according to these criteria. **Table 6.1** provides the scores used for each criterion for this qualitative assessment.

- **Number of buildings protected in the 100 year flood**

  A prime indicator of the effectiveness of a measure in reducing the potential for flood damage and the risk to life is the reduction in the number of buildings that are affected by significant floods.

- **Financial feasibility**

  Measures proposed within the FRMP must be capable of being funded. There are various sources of funding that may be utilised, including funding related to the development of new release areas (Section 94 Contributions) and funding from Council, with assistance from the Government's Floodplain Management Program administered by OEH, for the alleviation of existing flood problems.

- **Economic merit**

  The ratio of the benefit divided by the cost (i.e. the benefit/cost ratio) is a common measure of assessing economic feasibility. Theoretically, no investment should be made on a measure if the benefit/cost ratio does not exceed one (i.e. if the benefits do not exceed the costs). However, traditionally many floodplain risk management measures have been undertaken where this is not the case because the intangible benefits (i.e. social benefits and reduced risks to life, which are not readily quantified) are considerable. Benefit/cost ratios can also be useful in ranking competing options.

- **Community acceptance**

  An understanding of community attitudes towards any proposed floodplain management measures is essential. Strongly negative community attitudes often would be enough to deter the implementation of a proposal which otherwise had merit. Community views on potential floodplain management measures were assessed early in the study through distribution of the community questionnaire. These results were discussed in **Section 3.5**. Further opportunity for comment was provided during public exhibition of the draft Double Bay Catchment FRMP (**Section 3.7**).

- **Environmental impact**

  Floodplain management measures involving structural works may often have significant environmental impacts. Impacts such as those on vegetation, Aboriginal heritage, visual amenity and soil erosion/sedimentation must be considered when evaluating works within floodplains.

- **Impact on flood behaviour**

  The impact on flood behaviour caused by any measure needs to be considered for upstream and downstream locations. These impacts can include changes in flood levels, changes in velocities or alteration of flow directions. Reducing impacts in one location can lead to adverse impacts elsewhere (e.g. increasing the conduit capacity in upper catchment areas or filling significant flood storage areas is – in the absence of compensatory measures – expected to increase downstream flows).

- **Performance during rare floods**

  All measures must be assessed in the knowledge that rare floods, i.e. higher than the 100 year flood, or higher than any known historical flood, will happen at some time in the future. It is vital that the options do not expose the community to unacceptable risks by providing a false sense of security.

- **Technical feasibility**

  If the proposed measures involve structural works, these works must be able to be constructed and be free from major technical constraints.

- **Political/administrative feasibility**

  Any recommended measure will have more chance of success if it involves little if any disruption to current political and administrative structures, attitudes and responsibilities. Council and other authorities also have various strategic objectives concerning development within the study area.

Potential floodplain management measures for the study area are discussed below. Each measure is included in a qualitative assessment matrix (**Table 6.2**) to assess its relative merits, thereby determining whether it should be included in the draft Double Bay Catchment FRMP.

TABLE 6.1 – Explanation of Assessment Scores for Qualitative Assessment Matrix

CRITERIA	RANKING SCORE				
	– –	–	Ω	+	+ +
REDUCTION IN NUMBER OF HOUSES FLOODED ABOVE FLOOR LEVEL IN 1% AEP FLOOD	number of houses flooded above floor in 1% AEP flood would increase	number of houses flooded above floor in 1% AEP flood could increase	no existing houses protected from over-floor flooding in 1% AEP flood	1 or 2 existing houses protected from over-floor flooding in 1% AEP flood	more than 2 existing houses protected from over-floor flooding in 1% AEP flood
FINANCIAL FEASIBILITY	Very unlikely to receive funding	May not receive funding	Neutral	Would possibly receive funding	Very likely to receive funding
ECONOMIC MERIT	Benefit–Cost Ratio less than 0.1	Benefit–Cost Ratio = 0.1–0.3	Benefit–Cost Ratio = 0.3–0.7	Benefit–Cost Ratio = 0.7–1.0	Benefit–Cost Ratio greater than 1.0
COMMUNITY ACCEPTANCE	Strongly against in community survey and community workshop	Not supported in community survey and community workshop	Neutral	Supported in community survey and community workshop	Strongly supported in community survey and community workshop
ENVIRONMENTAL IMPACT AND ECOLOGICAL ENHANCEMENT	Significant negative environmental impact	Some negative environmental impact	No environmental impact and no opportunity for ecological enhancement	Some opportunity for ecological enhancement	Significant opportunity for ecological enhancement
IMPACT ON FLOOD BEHAVIOUR	Significantly increase flood levels and/or velocities	Some increase in flood levels and/or velocities	No change	Some reduction in flood levels and/or velocities	Significantly reduces flood levels and/or velocities
CONSEQUENCES IN EXTREME FLOODS	Significantly increases risk	Some increase in risk	No change in risk	Some reduction in risk	Significant reduction in risk
TECHNICAL FEASIBILITY	Very difficult	Difficult	Neutral	Easy	Very easy and straight forward
POLITICAL/ ADMINISTRATIVE / LEGAL IMPACT	Significant changes required which are very unlikely to be supported	Some changes required which may not be supported	No changes or impact	Some changes required are likely to be supported	Significant changes required which are likely to be strongly supported

TABLE 6.2 – Qualitative Matrix Assessment of Floodplain Risk Management Options

Note: Decisive factors for recommending or not recommending an option are highlighted in tan

MEASURE NO.*	FLOODPLAIN RISK MANAGEMENT MEASURE	DESCRIPTION OF OPTION	REDUCTION OF DWELLINGS FLOODED ABOVE FLOOR LEVEL IN 1% AEP FLOOD		FINANCIAL FEASIBILITY		ECONOMIC MERIT		COMMUNITY ACCEPTANCE	ENVIRON-MENTAL IMPACTS AND ECOLOGICAL ENHANCE-MENTS	IMPACTS ON FLOOD BEHAVIOUR	CONSE-QUENCES IN EXTREME FLOODS	TECHNICAL FEASIB-ILITY OR DIFFICULTY	ADMINIS-TRATIVE / POLITICAL / LEGAL IMPACTS	RECOMMENDED FOR FURTHER CONSIDERATION
				NO. DWELLINGS		CAPITAL COST		BENEFIT–COST RATIO							
1	**FLOOD MODIFICATION MEASURES**														
1.1.1	Detention basin	Cooper Park embankment	Ω	0	+	$120K	–	Low	+	Ω	Ω	Ω	+	Ω	No
1.1.2		Lough Playing Fields excavation	++	6	– –	$3.5-4.0M	–	Low	–	–	+	Ω	– –	–	No
1.2.1	Drainage upgrades	Manning Road conduit	++	6	–	High	–	Low	+	Ω	+/– Worse d/s	Ω	– –	–	No
1.2.2		Bellevue Road conduit scheme	Ω	0	–	$3.0-3.5M	+	High#	+	Ω	++	+	– –	–	Further study (yes)
1.2.3		Bay Street/Knox Street conduit scheme	++	18 (and ~70 shops)	–	$5.5-6.0M	++	1.8	+	Ω	++	+	– –	–	Yes
1.2.4		Ocean Avenue conduit scheme			–	$3.5-4.0M									
1.2.5		Pipe outlet joining SWC32	Ω	0	+	$15K	+	High#	+	Ω	+	Ω	+	Ω	Yes
1.3a	SWC32 channel naturalisation options	Fully naturalise channel from William Street to Sydney Harbour	Ω	0	+	$0.5M	–	Low	+/–	++	Ω?	–	–	–	No
1.3b		Remove channel lids and common wall from William Street to Harbour	Ω	0	+	$350K	–	Low	+/–	Ω	+?	–	+	–	No
1.3c		Remove channel lids and common wall from New South Head Road to William Street	Ω	0	+	$450K	–	Low	?	Ω	+?	–	+	–	No

MEASURE NO.*	FLOODPLAIN RISK MANAGEMENT MEASURE	DESCRIPTION OF OPTION	REDUCTION OF DWELLINGS FLOODED ABOVE FLOOR LEVEL IN 1% AEP FLOOD		FINANCIAL FEASIBILITY		ECONOMIC MERIT		COMMUNITY ACCEPTANCE	ENVIRON-MENTAL IMPACTS AND ECOLOGICAL ENHANCE-MENTS	IMPACTS ON FLOOD BEHAVIOUR	CONSE-QUENCES IN EXTREME FLOODS	TECHNICAL FEASIB-ILITY OR DIFFICULTY	ADMINIS-TRATIVE / POLITICAL / LEGAL IMPACTS	RECOMMENDED FOR FURTHER CONSIDERATION
				NO. DWELLINGS		CAPITAL COST		BENEFIT–COST RATIO							
1.4	**Debris control**	Secure fencing adjacent to Kiaora Road drain	++	11 (and 3 shops)	+	$300K	+	>0.9	?	Ω	++	Ω	+	–	Yes
1.5	**Levee**	Manning Road levee	++	6^	+	$400K^	++	2.9^	?	Ω	+/– Local catchment flooding worse	–	–	–	No
1.6	**Flow diversion**	Cross Street surface flow diversion works	Ω	0 (several shops)	+	Low	+	High[#]	?	Ω	+/– Local catchment flooding worse	Ω	– –	– –	No
2	**PROPERTY MODIFICATION MEASURES**														
2.1a		Voluntary purchase and demolition of two properties	+	2	–	$3.7M?	–	0.2	?	Ω	Ω	+	+	–	No
2.1b	**Manning Road sag-point problem**	Voluntary house redevelopment of six properties	++	6	+	$600K (based on $100K/house subsidy)	++	1.3	?	Ω	Ω	+	+	–	Further study (yes?)
2.1c		Flood-proofing by using solid walls	++	6	+	$120K (based on $20K/house subsidy)	+	High[#]	?	Ω	+/– Local catchment flooding worse	Ω	– –	Ω	No
2.2	**Planning and development controls**	Update flood risk management provision in DCP	Ω	0	++	Low	++	>1[#]	?	Ω	Ω	++	++	Ω	Yes

MEASURE NO.*	FLOODPLAIN RISK MANAGEMENT MEASURE	DESCRIPTION OF OPTION	REDUCTION OF DWELLINGS FLOODED ABOVE FLOOR LEVEL IN 1% AEP FLOOD		FINANCIAL FEASIBILITY		ECONOMIC MERIT		COMMUNITY ACCEPTANCE	ENVIRON-MENTAL IMPACTS AND ECOLOGICAL ENHANCE-MENTS	IMPACTS ON FLOOD BEHAVIOUR	CONSE-QUENCES IN EXTREME FLOODS	TECHNICAL FEASIB-ILITY OR DIFFICULTY	ADMINIS-TRATIVE / POLITICAL / LEGAL IMPACTS	RECOMMENDED FOR FURTHER CONSIDERATION
				NO. DWELLINGS		CAPITAL COST		BENEFIT–COST RATIO							
3	**RESPONSE MODIFICATION MEASURES**														
3.1	**Improve flood warning system**	Install real-time rain gauge in Double Bay catchment	Ω	0	–	$9K + $1K p.a. maintenance	–	Low	?	Ω	Ω	Ω	+	Ω	No
3.2	**Improve emergency management planning**	Prepare Woollahra Local Flood Plan including flood intelligence from the *Double Bay FRMS&P*	Ω	0	+	SES staff costs	++	>1#	+	Ω	Ω	+	++	Ω	Yes
3.3a	**Improve public flood readiness**	Prepare Double Bay Commercial District flood-proofing brochure	Ω	0	+	$20K	++	>1#	+	Ω	Ω	+	++	Ω	Yes
3.3b		Prepare Double Bay Commercial District flood emergency response plan template	Ω	0	+	$10K	++	>1#	+	Ω	Ω	+	++	Ω	Yes
3.3c		Conduct a Business FloodSafe breakfast (SES).	Ω	0	+	$5K	++	>1#	+	Ω	Ω	+	++	Ω	Yes
3.3d		Install signage at Lough Playing Fields and Manning Road	Ω	0	+	$10K	+	>1#	?	Ω	Ω	+	++	–	Yes
4	**MISCELLANEOUS MEASURES**														
4.1	**Flood data capture**	Prepare a questionnaire and institute processes so as to allow rapid deployment following flooding in Woollahra LGA	Ω	0	+	$10K	++	>1#	+	Ω	Ω	Ω	++	Ω	Yes

Notes:

* To locate the report section in which the measure is described, for Measure No. 1.1.1 read Section 6.1.1.1, and so on.

It has not been possible to carry out a full economic analysis as some of the benefits are intangible. Accordingly the BCR has been estimated.

^ Excluding consideration of local catchment flooding and the drainage upgrade required to address it.

6.1 FLOOD MODIFICATION MEASURES

6.1.1 Detention basins

Finding:
Lough Playing Fields (LPF) already function as an effective detention basin. There are no benefits in providing detention storage in Cooper Park. Increasing the storage area at the LPF is not feasible.

Detention basins are areas of open space which collect and store stormwater runoff for release at a controlled rate. They tend to reduce peak flows and levels downstream of the basin sites. *Formal* detention basins are those specifically designed for this purpose, while *informal* detention basins are areas that function as basins even though they were not designed for this purpose. The *Double Bay Catchment Flood Study* (Bewsher Consulting, 2008) shows that there is an informal detention basin at the Lough Playing Fields, which is created by the elevated ground associated with the Bondi Ocean Outfall Sewer (BOOS) conduit constructed in the 1880s.

6.1.1.1 Cooper Park

A potential site for creating additional detention storage is at Cooper Park upstream of the Lough Playing Fields. This could be formed relatively easily by constructing an embankment along the upstream side of Suttie Road (**Figure 6.1**). A flood model run was conducted to assess the benefits of a basin for the alleviation of downstream flooding. It was found that the 100 year flood levels behind the modelled embankment rose from about 9.9m AHD to 11.9m AHD, with a maximum depth of ponding of about 2.1m. But this provided very limited benefits downstream, with a reduction in the flood level at the Lough Playing Fields of only 0.1m, and negligible reductions further downstream. Due to its limited flood mitigation benefits, the construction of a detention basin at Cooper Park is not supported.

FIGURE 6.1 – Potential Basin Site at Cooper Park

6.1.1.2 Lough Playing Fields

The Lough Playing Fields function as a de facto detention basin. Increasing the height of the basin crest would increase the water level and hence worsen flood problems in adjacent Manning Road properties. There may be potential for increasing storage through excavation. However, **Figure 6.2** shows that under existing conditions the basin is just being overtopped in the 100 year event and appears to be working well, so providing additional storage would not achieve much downstream benefit unless some trunk conduit flows were also diverted into the basin.

The opportunity of modifying the basin so as to alleviate flooding in the Manning Road sag-point on the western side of the basin was also considered. It is estimated that about three metres of excavation would be required. This however would entail a very significant cost (especially if the material needed to be trucked away) and would not be achievable given the limited depth of fill covering the trunk stormwater conduit. There would also be acid sulphate soil considerations (**Section 2.3**) and safety concerns with the increased maximum water depth in the basin. Accordingly, excavation is not recommended.

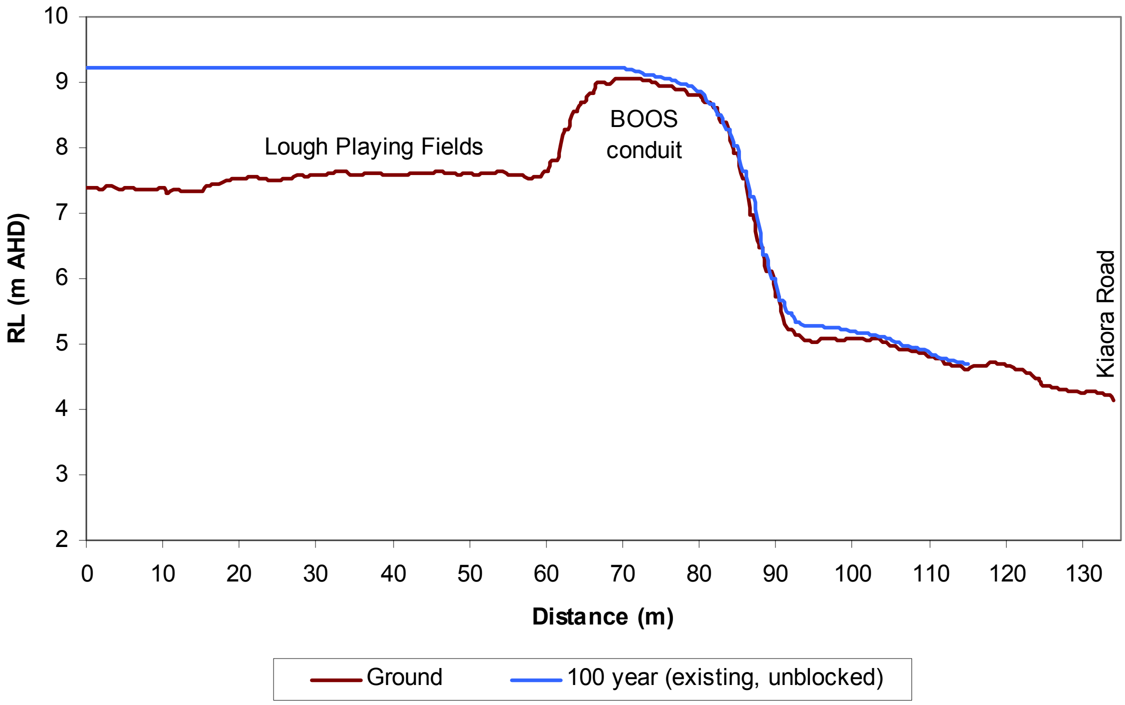


FIGURE 6.2 – Profile of the Lough Playing Fields de facto detention basin

6.1.2 Drainage upgrades

Recommendations:
1) Conduct further investigation of the Bellevue Road conduit scheme and implement as appropriate
2) Implement the Bay Street/Knox Street conduit scheme
3) Implement the Ocean Avenue conduit scheme
4) Minor works to improve the local pipe outlet near Nos. 24-26 Glendon Road

6.1.2.1 Manning Road conduit

Another option for alleviating the existing flood problem associated with the Manning Road sag-point would be to significantly upgrade street drainage so that the large volume of water stored in the Lough Playing Fields basin could be discharged into the open channel downstream of the BOOS conduit. But as reported above, this de facto basin serves a useful function for property in the lower catchment, and installing pipework to effectively bypass the basin would substantially exacerbate problems downstream.

In addition, due to the grade of the land, the new pipework would in places need to be several metres deep, which would be prohibitively expensive to construct.

6.1.2.2 Bellevue Road conduit scheme

Both historical observations and flood model results provide a picture of high velocity overland flows coming off the eastern valley side in the vicinity of Yamba Road and Bellevue Road. These flows then travel downhill through private property to Carlotta Road. Conditions are typically very hazardous to both pedestrians and vehicles.

One option here is to install a New Jersey kerb along the centreline of Bellevue Road such that the floodwaters would be confined to the eastern half of the road reserve as they are directed north-west towards New South Head Road. This would, however, reduce everyday trafficability for residents and through traffic and increase the flood-time hazard for parked and moving vehicles in the eastern half of the road. It is also likely to exacerbate existing flood problems in the vicinity of New South Head Road and Cross Street and is therefore not supported.

Another option here is for an extension of the pipe system in Bellevue Road (see **Figure 6.3**). This new pipe would need substantial inlet capacity at the junction of Yamba Road and Bellevue Road. It would discharge into the Sydney Water ("2nd amplification") tunnel via a vertical shaft at the junction of Bellevue and Fairfax Roads. Modelling shows that this tunnel is operating at a maximum of 60-70% full under existing conditions, which indicates capacity for conveying some additional flow. However, any excess flow would surcharge at the tunnel's inlet location on the open channel near Carlotta Road and its impact would need to be assessed as part of additional investigations of this piping option. The cost of this scheme is estimated at $3.0-3.5M.

An alternative to the Bellevue Road conduit scheme is for a similar drainage upgrade north-west along Carlotta Road to the SWC tunnel. This would have the advantage of covering a shorter distance (225 metres compared to 300 metres) and therefore would cost less. However, of greater significance is that it would provide no reduction in inundation depths to properties between Bellevue Road and Carlotta Road nor reduce hazardous conditions in Bellevue Road itself. For these reasons this Carlotta Road option is not preferred. Rather, the Bellevue Road scheme is recommended for further consideration.

6.1.2.3 Bay Street/Knox Street conduit scheme

Much of the flooding in the Double Bay commercial area is a function of overland flows spilling from the direction of New South Head Road (and some of these flows also contribute to flooding in the Guilfoyle Avenue sag-point). This situation can be alleviated by laying major conduits in Bay Street and Knox Street, with a series of major inlets in New South Head Road itself (see **Figure 6.4**). The cost of this scheme is estimated at $5.5-6.0M. Whilst this sounds prohibitive, assuming all buildings in the area benefiting from the drainage upgrade would become immune from inundation in the 50 year and more frequent events, the benefit-cost ratio (calculated in conjunction with the Ocean Avenue conduit scheme described below) is favourable. The construction phase of this scheme would be quite disruptive to local traffic (including traffic using New South Head Road) and business. The potential short-term business costs have not been assessed.

6.1.2.4 Ocean Avenue conduit scheme

In major storms much of the overland flow in Ocean Avenue spills into the Guilfoyle Avenue sag-point. Inundation in this area would be substantially reduced by upgrading the existing pipe system (see **Figure 6.4**). The cost of this scheme is estimated at $3.5-4.0M. Whilst this sounds prohibitive, assuming all buildings in the area benefiting from the drainage upgrade would become immune from inundation in the 50 year and more frequent events, the benefit-cost ratio (calculated in conjunction with the Bay/Knox Street conduit scheme described above) is favourable. The construction phase of this scheme would be quite disruptive to local traffic, and any short-term business interruption costs associated with the construction of the scheme have not been assessed.

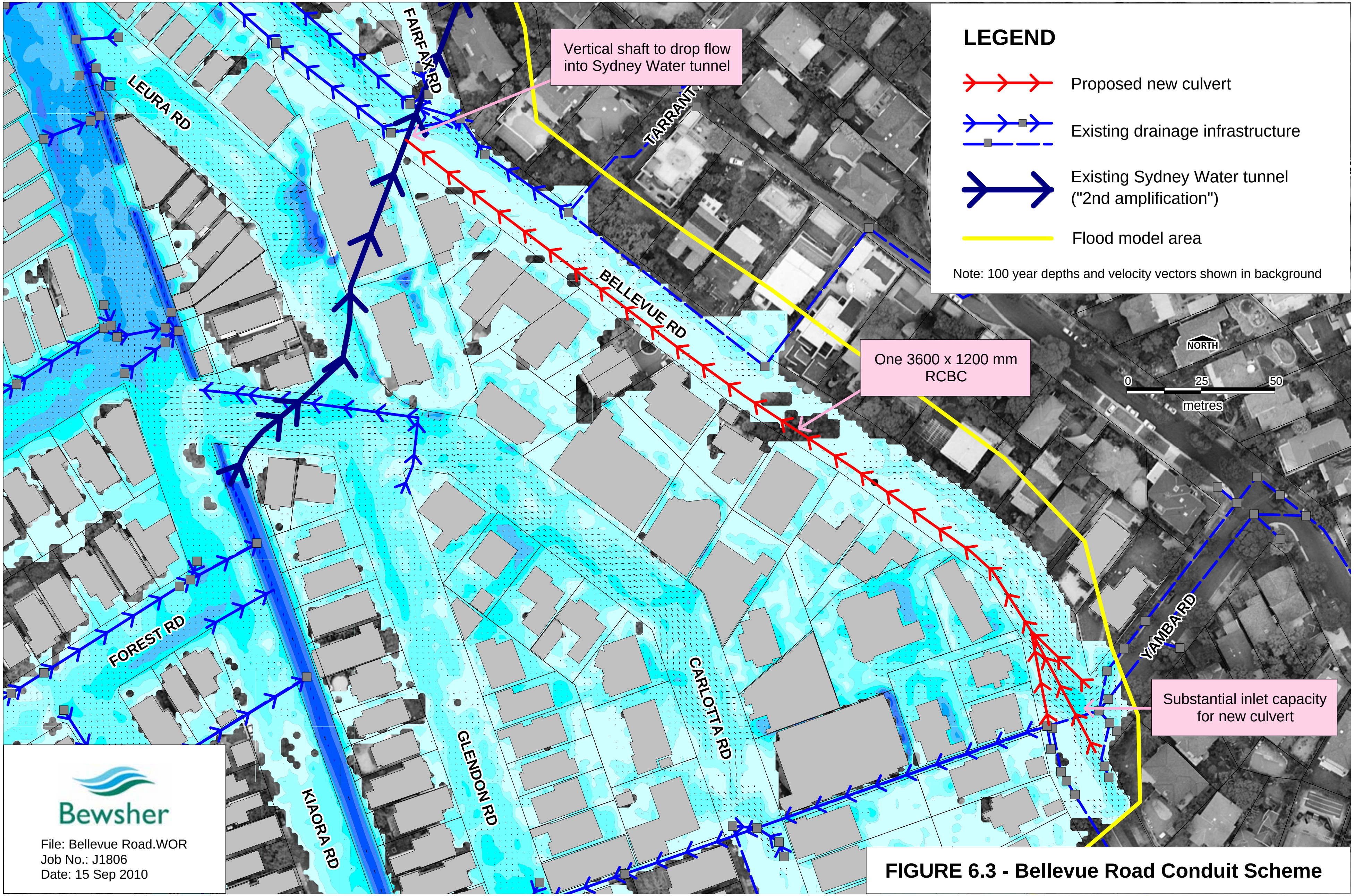


FIGURE 6.3 - Bellevue Road Conduit Scheme

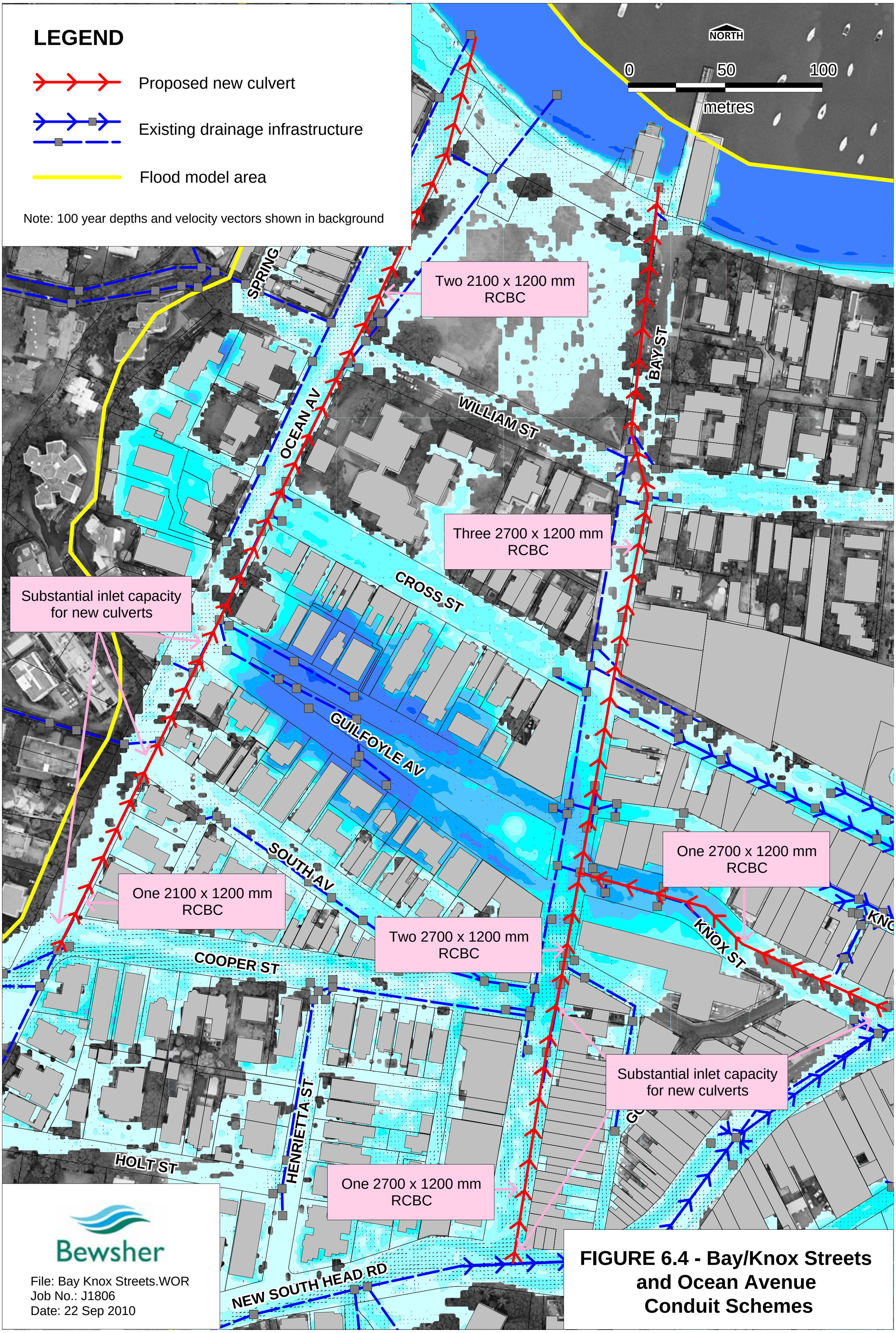


FIGURE 6.4 - Bay/Knox Streets and Ocean Avenue Conduit Schemes

6.1.2.5 Pipe outlet joining SWC32

A member of the Floodplain Management Committee drew attention to the way a local pipe is configured to join the main Sydney Water Corporation (SWC) conduit. **Figure 6.5** shows the pipe junction in the vicinity of Nos. 24-26 Glendon Road. Despite the angular junction, observations during floods suggest that the ability of flow from the pipe joining the main drain is impeded. Some hydraulic improvement to the pipe capacity could be achieved by minor works (~$15K) to this outlet, though the agreement of Sydney Water would be required.

FIGURE 6.5 – Pipe Outlet Joining SWC32

6.1.3 Stormwater channel SWC32 naturalisation options

Finding:
Removing the lids and inner walls of the SWC32 channel could marginally improve conveyance but would increase safety risks while providing few landscape enhancements. Naturalisation of the channel could reduce hydraulic capacity and is problematic due to its impacts on access to properties and significant trees.

An investigation was conducted in 2003 to assess the feasibility of various options to naturalise the main SWC32 stormwater channel from William Street to Sydney Harbour (4Site Natural Solutions, 2003). Key extracts are presented in **Appendix D** of this report. It was found that options to naturalise the existing channel would reduce the hydraulic capacity of that channel and worsen flooding upstream. The only naturalisation option which might possibly maintain hydraulic capacity would require the removal of the main western and the smaller eastern culverts which together form SWC32, but this was problematic due to its impacts on adjacent properties and significant landscape trees. It would also be expensive (Bewshers estimate the cost as about $0.5M). The report recommended that the (then) damaged culvert be repaired and that a landscape plan be prepared to create functional open space that adds landscape value and provides passive recreational opportunities. It is understood that Sydney Water Corporation has undertaken the necessary repairs.

A more affordable option is to remove the lids and the separating common wall of the parallel conduits (estimated cost $350K). However, this would have the same adverse impacts on access for the Pearce Street properties and on the trees, and the channel would still have the appearance of a stormwater channel, with safety fencing required too.

Consideration has also been given to options for SWC32 upstream between New South Head Road and William Street. Removal of the lids and separating common wall of the parallel conduits would marginally increase hydraulic capacity. But it is estimated to cost about $450K, and even with safety fencing would not eliminate the additional flood hazard. The landscape benefits of this work are also questionable.

Regarding naturalisation, there is insufficient space between Jamberoo Lane and Cross Lane for a channel naturalisation scheme which would at least preserve the current trunk system capacity.

Accordingly, none of the naturalisation options considered in the earlier report or for the area upstream appears to be feasible.

6.1.4 Debris control for SWC32

Recommendation:
1) Replace existing fencing with flood-resistant fencing along length of open channel from BOOS conduit to New South Head Road, to minimise potential for culvert blockage

As assessed in **Section 4.1.3**, 50% blockage of the major culvert openings along SWC32 would result in increased flood levels of 0.35m at Kiaora Avenue in the 100 year event. Consideration has therefore been given to various forms of debris control structures to prevent the major culvert openings being blocked.

One option could be to acquire land beside the open channel and build a sizeable structure that diverts debris to one side for subsequent removal. One potential site is on the western side of the channel near the junction of Kiaora Road and Forest Road, which is just upstream of the "2nd amplification" culvert entrance.

Another option is to replace existing fencing along the margins of the open channel, which has not been designed to resist of hydraulic forces of debris and water during major floods (e.g. see **Figure 4.2b,c,d**), with structurally designed safety fencing. Since such fencing would prevent objects both large and small from inadvertently entering the channel it is considered to be superior to the single debris control structure option. Replacing the fencing on both sides of the channel from the BOOS conduit to New South Head Road is estimated to cost about $300K, with about $60K for the reach from Carlotta Road to Leura Road. The assessed benefits of the option are substantial – if the major culverts are not 50% blocked in the 100 year event, 11 houses would be free of above-floor inundation, with tangible savings of at least $280K, yielding a BCR of 0.9.[8] The fencing option is recommended in the FRMP.

[8] The total benefits would be greater, because for this assessment no flood level reductions were applied to the other modelled design floods, because without fencing culverts could potentially be blocked greater than 50%, and because no measure of the intangible public safety benefits of fencing was included.

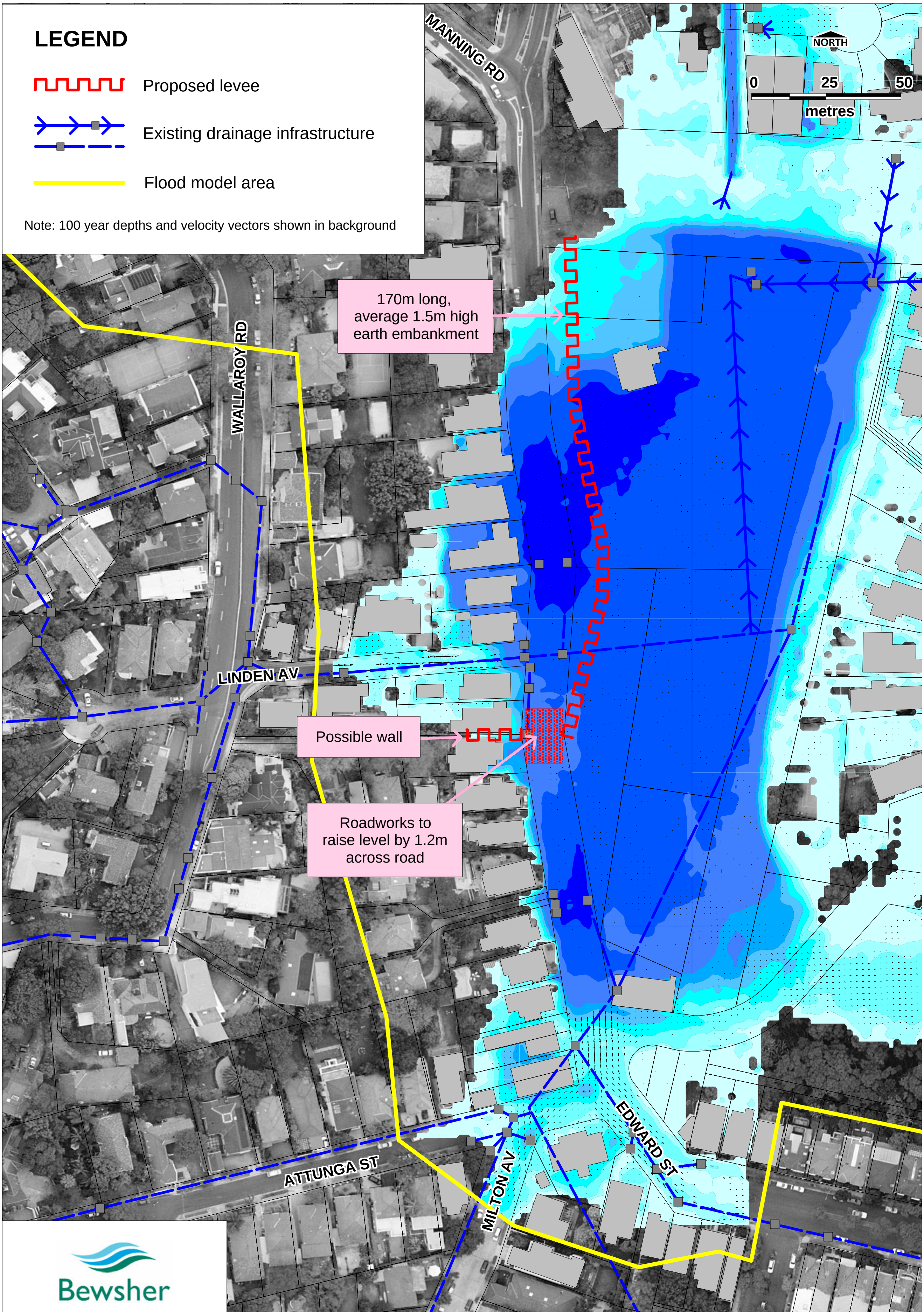
6.1.5 Manning Road levee

Finding:
A flood wall along the western side of the Lough Playing Fields adjacent to Manning Road could protect houses from flooding from major floodwaters but could exacerbate flooding from the local catchment when runoff is trapped behind the levee.

An option to protect properties adjacent to the Manning Road sag-point from above-floor flooding would be to construct an earth embankment along the western side of the Lough Playing Fields (see **Figure 6.6**).[9] **Figure 6.7** presents a potential scheme estimated to cost about $400K. In order to separate runoff from the Attunga Street/Milton Avenue/Edward Street local catchments from runoff from the Linden Avenue local catchment, the levee would link into a slighter higher area of Manning Road, which would also need to be raised by a maximum of 1.2m. There would also need to be footpath works and a solid wall between Nos. 101 and 103 Manning Road. But even with this arrangement, runoff from the Linden Avenue local catchment would pond in the northern Manning Road sag-point, and for some events the flood-time hazard to vehicles on Manning Road and properties could actually be exacerbated by the works. This means that in addition to the levee, an upgrade of the pipe system draining the Linden Avenue local catchment and Manning Road would be required, at high cost. Another consideration of such a levee is the aesthetic impact – the attitudes of Manning Road residents about potentially impeded views to the playing fields have not been ascertained at this stage. Because of the difficulties in managing local catchment flooding, the measure is not recommended.

FIGURE 6.6 – Western side of Lough Playing Fields with Manning Road on left

[9] An embankment would have a footprint about 15 metres wide so could mean some loss of amenity in the playing fields. Another option is for a concrete wall.



Bewsher

File: Manning Rd levee.WOR
Job No.: J1806
Date: 27 Sep 2010

FIGURE 6.7 - Manning Road Levee/Overland Flow Works

6.1.6 Cross Street surface flow diversion

Finding:
Whilst works in Cross Street to direct flows spilling over New South Head Road towards the SWC channel could reduce flood problems, there is insufficient space for works, and other flows could get trapped behind the raised road.

A large number of businesses are flooded near the junction of Cross Street and New South Head Road. One option considered was to do works in Cross Street such that all the overland flow spilling off New South Head Road could be diverted to follow the drainage reserve on top of the SWC closed system (i.e. near Jamberoo Lane). However the water is potentially deep and fast flowing and would most likely require so much engineering work that the road would need to be permanently closed to allow it to work, which is unacceptable for such a busy intersection. There is also a potential for runoff from Knox Lane and the western end of Cross Street, which drains towards Jamberoo Lane, to get trapped behind the raised road causing its own problems. In addition, the extra flow near Jamberoo Lane and Sherbrooke Avenue could result in an incremental increase in flooding in those areas.

6.2 PROPERTY MODIFICATION MEASURES

6.2.1 Manning Road options

Recommendation:
1) Approach six landholders to gauge level of interest in an option to provide $100K/property subsidy for redevelopment in a manner compatible with flood risk management provisions in DCP.

As noted above, six houses adjacent to the Manning Road sag-point are expected to be inundated above floor level when floodwater is trapped behind the BOOS conduit which forms a de facto detention basin. Several structural options have been considered but not recommended (see **Sections 6.1.1.2**, **6.1.2.1** and **6.1.5**).

Among the property modification measures that could be considered are voluntary house purchase, voluntary house redevelopment, and flood-proofing. Houses are generally only eligible for inclusion in a voluntary house purchase (VP) scheme where potential flooding depths and velocities are deemed to be "dangerous", and only single-storey houses are typically included since two-storey houses afford the opportunity for sheltering above the level of flooding within the building (provided the building is not likely to collapse). Although velocities are low, the calculated above-floor flood depths in the 100 year event (~1.4m) are such that two single-storey houses might be considered for inclusion in a VP scheme if other options are not feasible. However, based on the median value of properties in Woollahra,[10] the benefit-cost ratio (BCR) is unfavourable (0.2).

Another property modification measure that could be considered is voluntary house development. This is a variant of voluntary house raising (VHR), which is generally not suitable for brick/rendered or double-storey buildings. Fairfield City Council developed a scheme for such "difficult" houses whereby a limited subsidy was available to homeowners to demolish and rebuild a new house with appropriate building controls in accordance with the flood risk management provisions in Council's DCP. They also provided homeowners with an option of selling their property to Council, after which Council would demolish the existing dwelling and sell the land on the open market. A new owner would then be able to build a new house on the property with appropriate building controls (Frost & Rice, 2003). These options could be considered for houses adjacent to the Manning Road sag-point. A partial subsidy of, say, $100K per dwelling, could be provided as an incentive for homeowners to redevelop their properties with habitable floor levels above the 100 year level, substantially reducing flood damages (BCR 1.3). Consideration of overshadowing and streetscape issues would also be required.

Another option that could be considered for these properties is flood-proofing. Fairfield Council offered eligible houses a limited subsidy to flood-proof electrical services by raising power points and installing a water sensor device to shut off power, and to replace building materials liable to water damage. In cases where flood depths were less than 1 metre, a subsidy was offered to exclude the entry of flow into the ground floor area of the home using solid fences (but still allowing an adequate flow path down one side so as not to adversely affect neighbouring properties) (Frost & Rice, 2003). It appears as though some of the Manning Road houses may already be benefiting from solid fences. But garages and pedestrian gates will act as points for water entry in a major flood. Constructing continuous solid front fences across the front of these properties would also cause local overland flows draining the hillside from Wallaroy Road to get trapped on the inside of the walls. Hence, flood-proofing these properties via local flood walls does not appear to be feasible.

[10] The median property price for houses in Woollahra for the 12 months to June 2010 was $1.8M.

A review of potential property modification measures suggests that the only feasible option to address the inundation of properties adjacent to the Manning Road sag-point is voluntary house redevelopment. The practicality of this option depends greatly on the attitude of the affected property holders, since participation in any scheme is by definition *voluntary*. Hence it is recommended that Council approach these landholders to gauge the level of interest in a potential scheme.

6.2.2 Planning context

> *Recommendation:*
> *1) Update flood risk management provisions in DCP in accordance with best practice and so as to incorporate climate change flood risk considerations.*

State Environmental Planning Policies (SEPP)

No SEPP (including deemed SEPPs previously prepared as Regional Environmental Plans) has been prepared dealing specifically with the issue of flooding, but some regulate development in response to potential flood risks.

SEPP (Housing for Seniors or People with a Disability) 2004 applies where dwellings, hospitals and similar uses are permissible to permit residential development for older and disabled persons to a scale permitted by the SEPP. Clause 6(2)(a) of the SEPP restricts its application from land identified as "floodways" or "high flooding hazard" in another environment planning instrument such as LEP.

Regional Planning Strategies

The draft East Subregional Strategy (2007) translates the broader Sydney Metropolitan Strategy into actions relevant to LGAs including Woollahra. Action E5.3.1 requires that Council reviews planning policies relating to flood prone land, in accordance with the Government's Flood Prone Land Policy and Floodplain Development Manual.

Advisory Circulars

On January 31, 2007 the Planning Minister announced a new Guideline for development control on floodplains, accompanied by a Department of Planning Circular dated January 31, 2007 (PS 07-003). The new Guideline issued by the Minister relates to a package of directions and changes to the *Environmental Planning and Assessment (EPA) Act 1979* and the *EPA Regulation 2000*, and amends the Floodplain Development Manual. The Guideline includes directions in regard to Section 117 Directions, the content of DCPs and Section 149 Planning Certificates.

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

Section 117 Directions

Ministerial directions pursuant to Section 117(2) of the EPA Act specify matters which local councils must take into consideration in the preparation of LEPs. Direction 4.3, as currently applies, deals specifically with flood prone land and aims to ensure that the development of flood prone land is consistent with the NSW Government's Flood Prone Land Policy and the Floodplain Development Manual, and that LEP provisions are commensurate with flood hazard.

Changes to Environmental Plan Making in NSW

The EPA Act facilitates the reproduction of planning instruments (including Woollahra LEP 1995) into a standardised format, commonly referred to as the "*LEP template*". Section 33A of the EPA Act deals with the prescribing of a "standard instrument" for LEPs and other environmental planning instruments (EPIs).

The DoP have released a draft flood clause intended to be included into Template LEPs for comment. The explanatory information notes that Councils are first encouraged to identify flood planning areas through their strategic planning and to zone appropriately where possible. To control development otherwise permissible, the clause allows for flood prone land to be identified by both an LEP map layer and by reference to the adopted FPL to capture areas not yet subject to Council flood mapping. The clause requires DAs on flood prone land to be subject to certain basic considerations to minimise flood risks to acceptable levels.

Development Control Plans (DCPs)

A DCP provides detailed controls that typically incorporate the majority of flood risk management measures recommended by a Floodplain Risk Management Plan (FRMP) for future development. In addition to a LEP and SEPPs, Section 79C(1)(a)(iii) of the EPA Act requires that Council also consider any DCP in force when assessing a DA.

Over the last few years Council has placed on exhibition separate DCPs relating to stormwater and flooding. These documents are also to address foreshore hazards. Due to the inter-related nature of these issues, it is important that the work undertaken with the preparation of the Double Bay Catchment FRMP is incorporated in the production of a consolidated DCP. It would also be appropriate to incorporate climate change considerations in the consolidated DCP, as reflected within various policies of the State Government including the *NSW Sea Level Rise Policy Statement* (DECCW, 2009), the *NSW Coastal Planning Guideline: Adapting to Sea Level Rise* (DoP, 2010) and the *Flood Risk Management Guide: Incorporating Sea Level Rise Benchmarks in Flood Risk Assessments* (DECCW, 2010).

The preparation of this DCP will be undertaken in accordance with the procedures specified by the EPA Act, separate to this FRMP process.

Section 149 Planning Certificates

A S149 Planning Certificate is issued under the EPA Act, and must be attached to a contract prepared for the sale of property. The matters to be contained within a S149(2) Certificate are prescribed within Schedule 4 of the EPA Regulation. A S149(5) Certificate requires councils to advise of "*other relevant matters affecting the land of which it may be aware*" but are marginally more expensive and are not mandatorily required to be attached to property sale contracts.

It is recognised that S149 certificates should not be solely relied upon as broad community education tools as they have only limited circulation. The majority of flood-affected properties would not be reached in a given year. However, if no notification of flood affectation appears, then it is often misunderstood to mean that property is "flood-free" rather than there are no development controls. S149 certificates should not confuse or mislead people as to whether there are any risks of floods affecting a particular property.

In the Consultants' opinion, it is desirable that all properties in the floodplain (i.e. up to the probable maximum flood where known of by available mapping) be notified on both S149(2) and S149(5) certificates. A future LEP flood clause and definitions and DCP provisions can establish a consistent basis for Section 149 Certificates.

6.3 RESPONSE MODIFICATION MEASURES

6.3.1 Improve flood warning

Finding:
Although there is potential to install a real-time rain gauge in the catchment, the "flashy" nature of inundation means that no tangible benefits would be achieved.

Due to its relatively small size and steep sides, inundation in the Double Bay catchment is typically "flash flooding", occurring within minutes of heavy rain.

For flash flood catchments, the provision of an effective flood warning service is problematic. The "total flood warning system" has five components that need to be completed during a flood emergency – prediction, interpretation, message construction, communication and appropriate response (Commonwealth of Australia, 2009). But several challenges to the effective operation of such a system have been identified for flash flood catchments (McKay, 2004, 2008):

a) Flash floods are less predictable than larger scale flooding. Rainfall over small catchments is usually not well predicted by numerical weather prediction models.

b) For flash floods, there is insufficient time to develop reliable flood warnings and for effective dissemination and response to the flood warnings. More rapid user response is required, which necessitates specialised communication systems and a high level of public flood awareness.

c) A reliance on rainfall triggers increases the frequency of false alarms.

d) The use of water level triggers does not allow sufficient time for response.

For these reasons, the Bureau of Meteorology traditionally has not issued specific flood predictions for flash flood catchments. The Bureau does offer more general services that may be of some benefit in alerting the emergency services and community to the threat of flooding (**Table 6.3**).

Consideration was given to installing a real-time rain gauge in the catchment, possibly on the catchment divide at Bellevue Hill or Bondi Junction, which could marginally increase the warning time available to the emergency services. However, the Bureau's view is that there is no merit in increasing the number of rain gauges or establishing a site specific flood warning service for a flash flood area unless a total warning system is proposed, which involves direct communication of warnings to the affected population as well as on-going education and practice to ensure the population is capable of initiating its own response. Accordingly, installing a rain-gauge is not included in the FRMP.

TABLE 6.3 – Bureau of Meteorology Warning Services of Potential Benefit in Flash Flood Catchments

Sources: McKay, 2004, p.3; www.bom.gov.au

General Weather forecast
General weather forecasts may indicate the likelihood of heavy rain from synoptic scale events, typically with more than 24 hours notice.

Flood Watch
A Flood Watch is issued by the NSW Flood Warning Centre, typically providing 24 to 48 hours notice that flooding is *possible* based upon current catchment conditions and future rainfall, which is predicted by computer models of the atmosphere.

Severe Weather Warning
A Severe Weather Warning is issued for synoptic scale events when one or more of the following hazardous phenomena are forecast:

- Gale force winds (average 10-minute wind speed exceeding 62 km/h)
- Damaging winds (peak wind gusts exceeding 89 km/h)
- Destructive winds (peak wind gusts exceeding 124 km/h)
- Torrential rain and/or flash flooding
- Damaging surf conditions leading to significant beach erosion

Severe Thunderstorm Warning
A Severe Thunderstorm Warning is issued by the Severe Weather Team, typically providing 0.5 to 2 hours' notice of impending severe storms. These forecasts are based upon radar and, if available, data from field stations, reports from storm spotters, as well as an analysis of the synoptic situation. For the Greater Sydney region the Bureau issues more detailed graphical Severe Thunderstorm Warnings when actual thunderstorms have been detected.

6.3.2 Improve emergency management planning

Recommendation:
1) SES to prepare a Woollahra Local Flood Plan including flood intelligence from this study

At the current time, no Local Flood Plan (LFP) has been prepared for Woollahra Local Government Area. LFPs typically detail:

- responsibilities for managing flood emergencies;
- what is to be done to prepare for floods;
- the conduct of response operations; and
- the coordination of immediate recovery measures from flooding.

Given the growing understanding of historical and potential flood problems across the LGA —including in the Double Bay, Rose Bay and Rushcutters Bay catchments and at Cecil Street, Paddington—the preparation of a LFP is strongly recommended. Flood studies and floodplain management studies contain much information that will be useful for this task, including:

- design flood levels, depths and extents for every property within the floodplain;
- surveyed or estimated ground and floor levels for every property within the floodplain;
- mapped flood risk precincts including high hazard areas;
- the location of buildings subject to above-floor inundation (see **Figure 5.2**); and
- roads subject to inundation (see **Section 5.5**).

6.3.3 Improve public flood readiness

Recommendations:
1) Prepare a flood-proofing brochure for the Double Bay commercial district
2) Prepare a flood emergency response plan template for the Double Bay commercial district (possibly in conjunction with the flood-proofing brochure)
3) Conduct a Business FloodSafe breakfast (possibly in conjunction with the launch of the flood-proofing brochure and flood emergency response plan template)
4) Install safety signage at the Lough Playing Fields and near the Manning Road sag-point

Actual flood damages can be reduced, and safety increased, where communities are "flood-ready".

> *People who understand the environmental threats they face and have considered how they will manage them when they arise will cope better than people who lack such comprehension… Many people who live and work in flood liable areas have little idea of what flooding could mean to them – especially in the case of large floods of severities well beyond their experience or if a long period has elapsed since flooding last occurred. It falls to the [SES], with assistance from councils and other agencies, to raise the level of flood consciousness and to ensure that people are made ready for flooding. In other words, flood-ready communities must be purposefully created. Once created, their flood-readiness must be purposefully maintained and enhanced.* (Keys, 2002, p.52)

Building and maintaining flood-ready communities in the Double Bay study area is challenging due to the high turnover of population (see **Table 2.2**) and what seems to be the low profile of flood hazards in community consciousness (consider the response rate of about 4% to the questionnaire – **Section 3.5**).

Council has taken some steps to raise community awareness of the risks of flooding throughout the study area. The community consultation undertaken for this FRMS&P and the intended public exhibition, is in itself an important means of raising community awareness.

A variety of educational measures are recommended to gradually build and sustain a reasonable degree of community flood awareness, particularly for the commercial district:

6.3.3.1 Prepare Double Bay Commercial District flood-proofing brochure

Under existing conditions a large number of commercial properties in Double Bay are subject to frequent inundation. Even if proposed structural works to ameliorate the situation are implemented, many benefits could be had if businesses are "flood-ready". One option for assisting businesses is for Council (perhaps with SES input) to prepare a brochure tailored to the Double Bay business community, offering guidance about flood-proofing options, such as suitable floor coverings, furniture and storage methods.

6.3.3.2 Prepare Double Bay Commercial District flood emergency response plan template

One output of the Eastwood and Terry's Creek FRMS&P (Bewsher Consulting, 2009) was the preparation of a 5-page flood emergency response plan template for businesses in Eastwood. A reason for this was to raise the quality of emergency response plans submitted to Council in support of DAs say for a change of use. However, the template is also a valuable community education mechanism, helping proprietors to understand and plan for the inevitable future flooding. A similar resource is also recommended for the Double Bay business community. It could be prepared in conjunction with the flood-proofing brochure described above (or combined into one resource).

6.3.3.3 *Conduct a Business FloodSafe breakfast*

Running workshops can be a highly effective method of improving flood readiness for those present and offers the chance for proprietors to share ideas. Hence, it is recommended that Council and the SES organise a "business breakfast" for the Double Bay business community. This could be combined with the launch of the flood-proofing brochure and flood emergency response plan template described above (which are similar to the SES Business FloodSafe Toolkit, though more concise and tailored to the Double Bay situation).

6.3.3.4 *Install signage at Lough Playing Fields*

During major floods, there is potential for deep flooding to be experienced in the Lough Playing Fields and at the Manning Road sag-point (up to 2.2m in the 100 year event). Installation of appropriate signage to promote public safety is recommended (e.g. "Park/Road Subject to Flooding").

6.3.3.5 *Certificates*

In the Consultant's view, perhaps the key measure for raising a community's awareness of flooding is via the regular issuing of flood certificates to all occupiers of the floodplain. These flood certificates would inform individual property owners of the flood situation at their *particular property*. It is the site-specific nature of this advice (cf. a generic brochure) that offers the best chance of overcoming the scepticism typical of a community that has not experienced serious flooding for some years. Only after floodplain occupants accept that *they* could have a problem are they ready to take on board ideas about addressing that problem. A certificate would contain information such as the expected flood levels in a range of design floods and could also provide information on ground and floor levels where this information is available.

However, the community questionnaire showed that this idea is strongly opposed by the community (**Figure 3.3**), and is therefore not included in the recommended Plan.

6.4 MISCELLANEOUS MEASURES

Recommendation:
1) Prepare a questionnaire and guidelines for the capture of flood data after a flood event

6.4.1 Flood data capture questionnaire

Collecting data about the height and extent of inundation soon after a flood event is important to improve the quality of future drainage and flood studies. This may involve using paint to mark flood peaks, with subsequent survey. The affected community may also be able to supply hydrological information, though care needs to be taken to allow affected people to recover and for Council to assist this recovery. The Floodplain Management Committee has requested a recommendation for the preparation of a questionnaire and guidelines to facilitate the efficient and strategic capture of information from the community in the first few weeks following a flood.

7. FLOODPLAIN RISK MANAGEMENT PLAN

7.1 RECOMMENDATIONS

A Floodplain Risk Management Plan (FRMP) showing the preferred floodplain risk management measures for the Double Bay catchment study area is presented in this chapter. The recommended measures have been selected from the range of measures discussed in **Chapter 6**, after an assessment of each measure's impact on flood risk, as well as consideration of environmental, social, and economic factors. The recommended measures are presented in **Table 7.1** and on **Figure 7.1**. The principal components of the Plan are presented below according to priority, which is assessed on the basis of how easily (quickly) each measure can be implemented and on value for money. The timing of the proposed works will depend on Council's overall budgetary commitments, and the availability of funds from other sources.

7.2 PRIORITISED MEASURES

High priority measures include:

- Install debris control fencing adjacent to SWC32 from the BOOS conduit to New South Head Road, to prevent objects entering the drain and potentially blocking culverts;
- Amend the flood risk management provisions in the DCP in accordance with best practice and to incorporate climate change flood risk considerations;
- Improve emergency management planning by preparing a Local Flood Plan for Woollahra LGA;
- Improve public flood readiness by 1) preparing a Double Bay Commercial District flood-proofing brochure, 2) preparing a Double Bay Commercial District flood emergency response plan template, 3) conducting a Business FloodSafe breakfast (SES), and 4) installing safety signage at Lough Playing Fields and Manning Road; and
- Prepare a questionnaire and institute processes to facilitate the rapid capture of flood data following future flooding in Woollahra LGA.

Medium priority measures include:

- Further investigate and if feasible implement the Bellevue Road conduit scheme as outlined in **Figure 6.3**;
- Implement the Bay Street/Knox Street conduit scheme as outlined in **Figure 6.4**;
- Implement the Ocean Avenue conduit scheme as outlined in **Figure 6.4**; and
- Carry out minor outlet works for the pipe joining SWC32 near Nos. 24-26 Glendon Road.

Low priority measures include:

- Further investigate (including consultation) and if practical invite owners of six Manning Road properties to join a voluntary house redevelopment scheme, which would offer a subsidy to landowners to redevelop buildings in a flood-compatible manner (refer to **Section 6.2.1**).

7.3 FUNDING AND IMPLEMENTATION

The total capital cost of implementing the Plan is estimated to be $13.0-14.5M, with negligible maintenance costs. The timing of proposed works will depend on overall budgetary commitments of Council and the availability of funds from other sources. It is envisaged that the Plan would be implemented progressively over a 5 to 10 year time frame.

A variety of sources of funding may be drawn upon to implement the Double Bay Catchment FRMP including:

- Council funds;
- State funding for flood mitigation measures through OEH;
- Commonwealth and State funding through the Natural Disaster Resilience Program;
- Funds from other organisations (e.g. SES, Sydney Water) and private owners;
- Section 94 Contributions from future development where flooding may be exacerbated by such development; and
- Volunteer labour from community groups.

Council can expect to receive the majority of financial assistance through OEH. These funds are available to implement measures that contribute to reducing existing flood problems. Funding assistance is usually provided on a 2:1 basis (State: Council) or a 1:1:1 basis (Commonwealth:State:Council).

Although much of the Plan may be eligible for Government assistance, funding can not be guaranteed, since the limited Government funds are allocated on an annual basis to competing projects throughout the State. Options that receive Government funding must be of significant benefit to the community. Funding of investigation and design activities as well as any works is normally available. Maintenance, however, is usually the responsibility of Council.

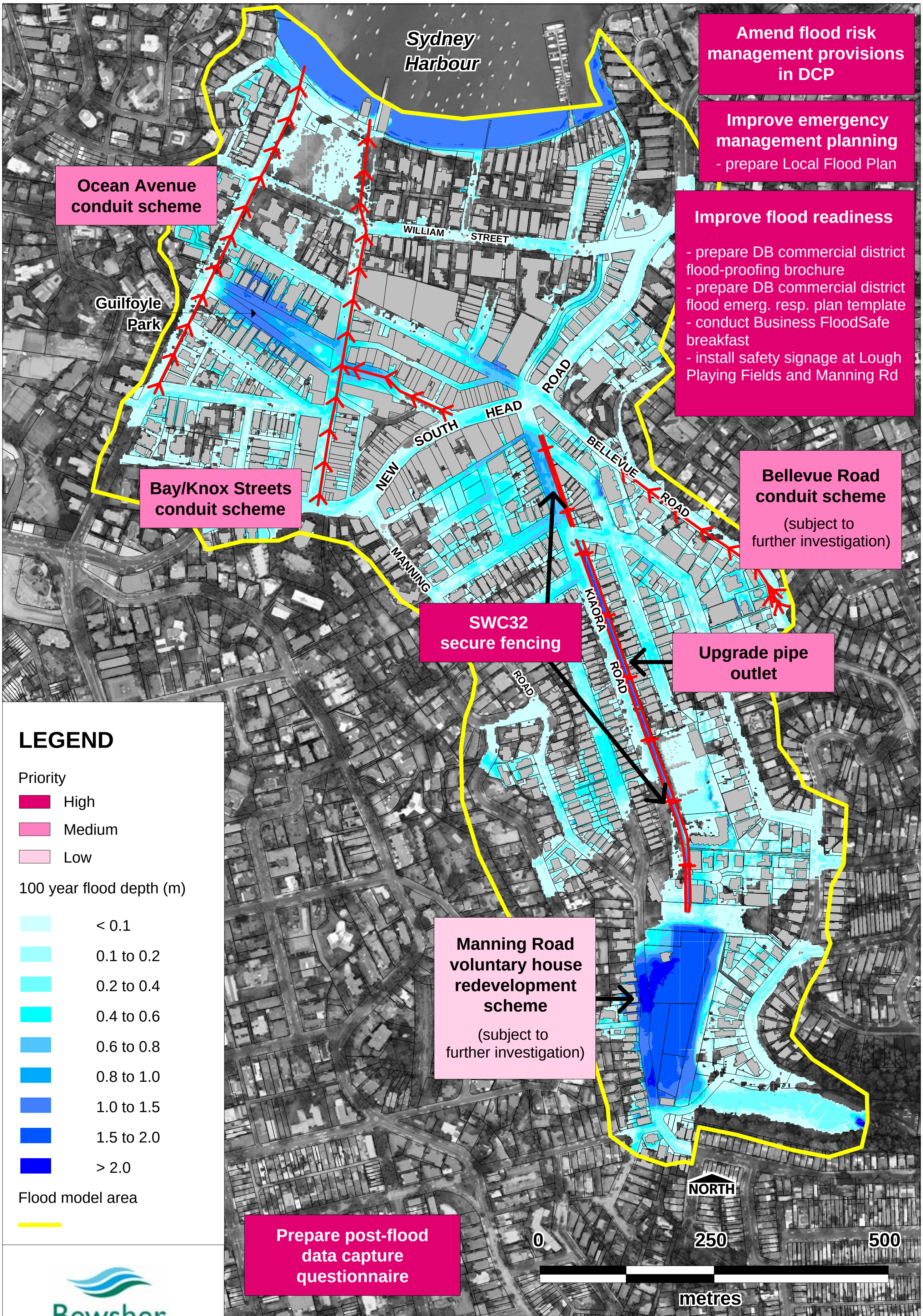
7.4 ON-GOING REVIEW OF PLAN

The *Double Bay Catchment FRMP* should be regarded as a dynamic instrument requiring review and modification over time. The catalyst for change could include flood events, revised flood modelling, better information about potential climate change flood impacts, legislative change, alterations in the availability of funding, or changes to the area's planning strategies. In any event, a thorough review every five years is recommended to ensure the ongoing relevance of the Plan.

TABLE 7.1 – Double Bay Catchment Floodplain Risk Management Plan

Measure No.^	Description	Capital Expenditure		Priority
		Est. Cost ($)	**Funding Sources**	
1.2.2	Bellevue Road conduit scheme (further study first)	$3.0-3.5M	Council, OEH	Medium
1.2.3	Bay Street/Knox Street conduit scheme	$5.5-6.0M	Council, OEH	Medium
1.2.4	Ocean Avenue conduit scheme	$3.5-4.0M	Council, OEH	Medium
1.2.5	Outlet works for pipe joining SWC32 near Nos. 24-26 Glendon Road	$15K	Council, OEH	Medium
1.4	Install debris control fencing adjacent to Kiaora Road drain	$300K	Council, OEH, Sydney Water	High
2.1b	Voluntary house redevelopment of six properties (further study first)	$600K	Council, OEH	Low
2.2	Amend flood risk management provisions in DCP	Nominal	Council	High
3.2	Improve emergency management planning ▸ Prepare Woollahra Local Flood Plan	Nominal	SES	High
3.3	Improve public flood readiness ▸ Prepare Double Bay Commercial District flood-proofing brochure ▸ Prepare Double Bay Commercial District flood emergency response plan template ▸ Conduct a Business FloodSafe breakfast (SES) ▸ Install signage at Lough Playing Fields and Manning Road	$45K	Council, OEH, SES	High
4.1	Prepare a questionnaire and institute processes to facilitate rapid flood data capture	$10K	Council, OEH	High
	TOTAL	**$13.0-14.5M**		

^ To locate the report section in which the measure is described, for Measure No. 1.2.2 read Section 6.1.2.2, and so on.



Bewsher

File: J1806_FRMP.WOR
Job No.: J1806
Date: 17 Mar 2011

FIGURE 7.1 - Recommended Measures

8. REFERENCES

4Site Natural Solutions, October 2003, *Feasibility Review for Stormwater Channel Restoration, SWC32, Double Bay*, prepared for Sydney Water Corporation.

ABS (Australian Bureau of Statistics), 2010, 6302.0 Average Weekly Earnings, Australia, Series ID A2734032A.

Bewsher Consulting, June 2008, *Double Bay Catchment Flood Study*, prepared for Woollahra Municipal Council.

Bewsher Consulting, October 2009, *Eastwood and Terrys Creek Floodplain Risk Management Study & Plan – Main Report*, prepared for the City of Ryde.

BTE (Bureau of Transport Economics), 2001, *Economic Costs of Natural Disasters in Australia*, BTE Report 103, Commonwealth of Australia, Canberra.

Commonwealth of Australia, 2009, *Flood Warning* (3rd Edition), Australian Emergency Manuals Series, Manual 21, Attorney-General's Department, Barton, Canberra.

CSIRO/BOM (Bureau of Meteorology), 2010, *State of the Climate*.

DECC (Department of Environment and Climate Change), October 2007, *Practical Consideration of Climate Change: Floodplain Risk Management Guideline*.

DECC (Department of Environment and Climate Change), October 2007, *Residential Flood Damages: Floodplain Risk Management Guideline*.

DECCW (Department of Environment, Climate Change and Water NSW), October 2009, *NSW Sea Level Rise Policy Statement*.

DECCW (Department of Environment, Climate Change and Water NSW), August 2010, *Flood Risk Management Guide: Incorporating Sea Level Rise Benchmarks in Flood Risk Assessments*.

DoP (Department of Planning), August 2010, *NSW Coastal Planning Guideline: Adapting to Sea Level Rise*.

Frost, S. & Rice, M., 2003, 'Voluntary House Raising Program: The Fairfield Experience', *Paper presented to Floodplain Management Authorities of NSW 43rd Annual Conference, Forbes, 25-28 February 2003*.

Greenaway, M.A. & Smith, D.I., 1993, *ANUFLOOD: Programmer's Guide and User's Manual*, Centre for Resource and Environmental Studies, Australian National University, Canberra.

Keys, C., 2002, 'A combat agency and its hazard: a New South Wales State Emergency Service perspective on the management of flooding', *The Australian Journal of Emergency Management*, 17(2), 14-18, 50-55.

McKay, G. 2004, 'Flash flood warning systems – Are they a waste of time?', in *Staying Afloat: Floodplain Management Authorities of NSW 44th Annual Conference, May 11-14 2004, Coffs Harbour*, pp.1-7.

McKay, G. 2008, 'Guidelines for local flash flood warning system proposals', in Floodplain Management Authorities of NSW 48th Annual Conference, February 26-29 2008, Wollongong.

Middleman-Fernandes, M.H., 2010, 'Flood damage estimation beyond stage-damage functions: an Australian example', *Journal of Flood Risk Management*, 3, 88-96.

NRM (Natural Resources and Mines, September 2002, *Guidance on the Assessment of Tangible Flood Damages*.

NSW Government, December 1986, *Floodplain Development Manual*, PWD.

NSW Government, April 2005, *Floodplain Development Manual: the management of flood liable land*, DIPNR.

NSW Treasury, July 2007, *NSW Government Guidelines for Economic Appraisal*, Treasury Policy Paper 07-5.

NSW Treasury, July 2007, *Economic Appraisal Principles and Procedures Simplified*, Treasury Policy Paper 07-6.

Smith, D.I., 1994, 'Flood damage estimation—a review of urban stage damage curves and loss functions', *Water South Africa*, 20, 231-238.

Woollahra Municipal Council, February 2001, *Cooper Park Plan of Management*.

Woollahra Municipal Council, October 2004, *Acid Sulfate Soils: Guide for Preparing Acid Sulfate Soils reports*.

9. FREQUENTLY ASKED QUESTIONS

Why do flood levels change over time?

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

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

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

How are these studies funded?

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

What is the difference between the inundation that can occur in the three Flood Risk Precincts and the inundation in the Overland Flow Precinct?

After heavy rain, different inundation can occur in parts of the catchment. Where the inundation is associated with watercourses and major drainage systems, it is referred to as flooding and these areas have been mapped within flood risk precincts. All the deeper and more dangerous flood prone areas are included within the flood risk precincts. Where shallower inundation occurs distant from these watercourses and major drainage systems, including that resulting from runoff on its way to the watercourses and major drainage systems, this inundation has been mapped within the overland flow precinct. Further, where this type of inundation is very shallow and typically less than 0.1m-0.2m deep in a 100 year rainfall event, such inundation has not been mapped in a flood risk precinct or the overland flow precinct.

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

The classification of a 'Low Flood Risk Precinct' can differ slightly between councils. Generally it means that your property is adjacent to a watercourse or major drainage system and whilst it would not be inundated in a 100 year flood, it still has a very slight chance of inundation from larger (i.e. rarer) floods.

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

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

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

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

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

My property is in the Overland Flow Precinct. What does this mean?

Properties that are classified within the 'Overland Flow Precinct' are not subject to the flood problems that occur in Flood Risk Precincts. The overland flow precinct areas are generally distant from watercourses and major drainage systems where the inundation depths do not exceed 0.3m-0.5m typically. As the risks to people and property in these areas are lower than those in the flood risk precincts, less stringent controls are applied here.

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

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

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

Ultimately, however, the market determines the value of any residential property. Individual owners should seek their own valuation advice if they are concerned that the flood risk precinct categorisation may influence their property value.

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

The State Government changed the meaning of the terms 'flood prone', 'flood liable' and 'floodplain' in 2001. Prior to this time, these terms generally related to land below the 100 year flood level. Now it is different. These terms now relate to all land that could possibly be inundated, up to an extreme flood known as the probable maximum flood (PMF). This is a very rare flood.

The reason the Government changed the definition of these terms was because there was always some land above the 100 year flood level that was at risk of being inundated in rarer and more extreme flood events. History has shown that these rarer flood events can and do happen (e.g. the 1990 flood in Nyngan, the November 1996 flood in Coffs Harbour, the January 1998 flood in Katherine, the August 1998 flood in Wollongong, the 2002 floods in Europe, Hurricane Katrina in 2005, etc).

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

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

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

Most banks and lending institutions do not account for flood risks when assessing home loan applications unless there is a very significant risk of flooding at your property. The system of Flood Risk Precinct classification will make it clear to all concerned, the nature of the flood risks. Under the previous system, if a prospective lending authority made appropriate enquiries, they could have identified the nature of the flood risk during assessment of home loan applications. As a result, it is not likely that the classification of your property within a Flood Risk Precinct will alter your ability to obtain a home loan. Nevertheless, property owners who are concerned about their ability to obtain a loan should clarify the situation with their own lending authority.

How have the flood risk maps been prepared?

Because some large and rare floods have often not been experienced or accurately recorded since European settlement commenced, computer models are used to simulate the depths and velocities of major floods. These computer models are normally established and operated by flooding experts employed by local and state government authorities. Because of the critical importance of the flood level estimates produced by the models, such modelling is subjected to very close scrutiny before flood information is formally adopted by a council. Maps of flood risks (e.g. 'low', 'medium' and 'high') and overland flows are prepared after consideration of such issues as:

- flood levels and velocities for a range of possible floods;
- ground levels;
- flood warning time and duration of flooding;
- suitability of evacuation and access routes; and
- emergency management during major floods.

What is the probable maximum flood (PMF)?

The PMF is the largest flood that could possibly occur. It is a very rare and improbable flood. Despite this, a number of historical floods in Australia have approached the magnitude of a PMF. Every property potentially inundated by a PMF will have some flood risk, even if it is very small. Under the State Government's Floodplain Development Manual (2005), councils must consider all flood risks, even these potentially small ones, when managing floodplains. As part of the State Government's Manual, the definitions of the terms 'flood liable', flood prone' and 'floodplain' refer to land inundated by the PMF.

What is the 100 year flood?

A 100 year flood is the flood that will occur or be exceeded on average once every 100 years. It has a probability of 1% of occurring in any given year. If your area has had a 100 year flood, it is a fallacy to think you will need to wait another 99 years before the next flood arrives. Floods do not happen like that. Some parts of Australia have received a couple of 100 year floods in one decade. On average, if you live to be 70 years old, you have a better than even chance of experiencing a 100 year flood.

Why do councils prepare floodplain management studies and plans?

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

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

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

Will the flood risk and overland flow precinct maps be changed?

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

10. GLOSSARY

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

1% AEP flood	A **flood** that occurs (or is exceeded) on average once every 100 years. Also known as a 100 year flood. See **annual exceedance probability (AEP)** and **average recurrence interval (ARI)**.
2% AEP flood	A **flood** that occurs (or is exceeded) on average once every 50 years. Also known as a 50 year flood. See **annual exceedance probability (AEP)** and **average recurrence interval (ARI)**.
5% AEP flood	A **flood** that occurs (or is exceeded) on average once every 20 years. Also known as a 20 year flood. See **annual exceedance probability (AEP)** and **average recurrence interval (ARI)**.
10% AEP flood	A **flood** that occurs (or is exceeded) on average once every 10 years. Also known as a 10 year flood. See **annual exceedance probability (AEP)** and **average recurrence interval (ARI)**.
20% AEP flood	A **flood** that occurs (or is exceeded) on average once every 5 years. Also known as a 5 year flood. See **annual exceedance probability (AEP)** and **average recurrence interval (ARI)**.
100 year ARI flood	A **flood** that occurs (or is exceeded) on average once every 100 years. Also known as a 1% flood. See **annual exceedance probability (AEP)** and **average recurrence interval (ARI)**.
50 year ARI flood	A **flood** that occurs (or is exceeded) on average once every 50 years. Also known as a 2% flood. See **annual exceedance probability (AEP)** and **average recurrence interval (ARI)**.
20 year ARI flood	A **flood** that occurs (or is exceeded) on average once every 20 years. Also known as a 5% flood. See **annual exceedance probability (AEP)** and **average recurrence interval (ARI)**.
10 year ARI flood	A **flood** that occurs (or is exceeded) on average once every 10 years. Also known as a 10% flood. See **annual exceedance probability (AEP)** and **average recurrence interval (ARI)**.
5 year ARI flood	A **flood** that occurs (or is exceeded) on average once every 5 years. Also known as a 20% flood. See **annual exceedance probability (AEP)** and **average recurrence interval (ARI)**.
acid sulphate soils	Sediments which contain sulfidic mineral pyrite which may become extremely acid following disturbance or drainage as sulfur compounds react when exposed to oxygen to form sulfuric acid. More detailed explanation and definition can be found in the NSW Government Acid Sulfate Soil Manual published by the Acid Sulfate Soil Management Advisory Committee.
afflux	The increase in flood level upstream of a constriction of flood flows. A road culvert, a pipe or a narrowing of the stream channel could cause the constriction.

annual exceedance probability (AEP)	AEP (measured as a percentage) is a term used to describe the frequency or probability of floods occurring. Large floods occur rarely, whereas small floods occur more frequently. For example, a 1% AEP flood occurs (or is exceeded) on average once every 100 years. It is also referred to as the '100 year flood' or the '1 in 100 year flood'.
Australian Height Datum (AHD)	A common national plane of level approximately equivalent to the height above sea level. All flood levels, floor levels and ground levels are normally provided in metres AHD.
average annual damage (AAD)	Average annual damage is the average flood damage per year that would occur in an area over a long period of time.
average recurrence interval (ARI)	ARI (measured in years) is a term used to describe the frequency or probability of floods occurring. Large floods occur rarely, whereas small floods occur more frequently. For example, a 100 year ARI flood is a flood that occurs (or is exceeded) on average once every 100 years. See also **annual exceedance probability (AEP)**.
BoM	The Australian Bureau of Meteorology.
catchment	The land area draining through the main stream, as well as tributary streams, to a particular site.
Development Control Plan (DCP)	A DCP is a plan prepared in accordance with Section 72 of the *Environmental Planning and Assessment Act, 1979* that provides detailed guidelines for the assessment of development applications.
discharge	The rate of flow of water measured in terms of volume per unit time, for example, cubic metres per second (**m^3/s**). Discharge is different from the speed or **velocity** of flow, which is a measure of how fast the water is moving.
ecologically sustainable development (ESD)	Using, conserving and enhancing natural resources so that ecological processes, on which life depends, are maintained and the total quality of life, now and in the future, can be maintained or increased. A more detailed definition is included in the *Local Government Act 1993*.
effective warning time	The time available after receiving advice of an impending **flood** and before the floodwaters prevent appropriate flood response actions being undertaken. The **effective warning time** is typically used to move farm equipment, move stock, raise furniture, evacuate people and transport their possessions.
emergency management	A range of measures to manage risks to communities and the environment. In the flood context it may include measures to prevent, prepare for, respond to and recover from flooding. In NSW, the State Emergency Service (SES) is the principal agency involved in emergency management during floods.
flood	A relatively high stream flow that overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam. It includes local overland flooding associated with major drainage before entering a watercourse. In addition, it includes coastal inundation resulting from raised sea levels, or waves overtopping the coastline.
flood awareness	An appreciation of the likely effects of flooding and a knowledge of the relevant flood warning, response and evacuation procedures.

flood hazard	The potential for damage to property or risk to persons during a **flood**. Flood hazard is a key tool used to determine flood severity and is used for assessing the suitability of future types of land use.
flood liable land	Land susceptible to flooding up to the **probable maximum flood (PMF)**. Also called **flood prone land**. Note that the term 'flood liable land' now covers the whole of the **floodplain**, not just that part below the 100 year flood level.
flood planning levels (FPLs)	The combination of flood levels and **freeboards** selected for planning purposes, as determined in **floodplain risk management studies** and incorporated in **floodplain risk management plans**. The concept of flood planning levels supersedes the designated flood or the flood standard used in earlier studies.
flood prone land	Land susceptible to flooding up to the **probable maximum flood (PMF**). Also called **flood liable land**.
flood proofing	A combination of measures incorporated in the design, construction and alteration of individual buildings or structures subject to flooding, to reduce or eliminate damages during a **flood**.
flood risk precinct	An area of land with similar flood risks and where similar development controls may be applied by a council to manage the flood **risk**. (The flood risk is determined based on the existing development in the precinct or assuming the precinct is developed with normal residential uses). Usually the floodplain is categorised into three flood risk precincts — 'low', 'medium' and 'high' — although other classifications can sometimes be used. (See also **risk**).
Flood Study	A study that investigates flood behaviour, including identification of flood extents, flood levels and flood velocities for a range of flood sizes.
floodplain	The area of land that is subject to inundation by floods up to and including the **probable maximum flood** (PMF) event, that is, **flood prone land** or **flood liable land**.
Floodplain Risk Management Plan	The outcome of a **Floodplain Risk Management Study**. (Note that the term 'risk' is often dropped in common usage and 'Floodplain Risk Management Studies or Plans' are referred to as 'Floodplain Management Studies and Plans'.)
Floodplain Risk Management Study	These studies are carried out in accordance with the *Floodplain Development Manual* (NSW Government, 2005) and assess options for minimising the danger to life and property during **floods**. These options aim to achieve an equitable balance between environmental, social, economic, financial and engineering considerations. The outcome of a Floodplain Risk Management Study is a **Floodplain Risk Management Plan**.
floodway	Floodways are those parts of a 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.
flow	See **discharge**

freeboard	A factor of safety expressed as the height above the flood level. Freeboard provides a factor of safety to compensate for uncertainties in the estimation of flood levels across the **floodplain**, such and wave action, localised **hydraulic** behaviour and impacts that are specific event related, such as levee and embankment settlement, and other effects such as 'greenhouse' and climate change.
geographical information system (GIS)	A system of software designed to support the management, manipulation, analysis and display of spatially referenced data.
geomorphology	The study of landforms.
high flood hazard	For a particular size **flood**, there may be a possible danger to personal safety, able-bodied adults may have difficulty wading to safety, evacuation by trucks may be difficult and/or there may be a potential for significant structural damage to buildings.
hydraulics	Term given to the study of water flow; in particular, the assessment of flow parameters such as water level and **velocity**.
hydrology	Term given to the study of the rainfall and runoff process; in particular, the estimation of **peak discharges**, flow volumes and the derivation of hydrographs (graphs that show how the discharge at any particular location varies with time during a flood).
Local Environmental Plan (LEP)	A Local Environmental Plan is a plan prepared in accordance with the *Environmental Planning and Assessment Act*, 1979, that defines zones, permissible uses within those zones and specifies development standards and other special matters for consideration with regard to the use or development of land.
low flood hazard	For a particular size flood, able-bodied adults would generally have little difficulty wading and trucks could be used to evacuate people and their possessions should it be necessary.
m AHD	Metres **Australian Height Datum (AHD)**.
m/s	Metres per second. Unit used to describe the **velocity** of floodwaters. 10km/h ≈ 2.8m/s.
m^3/s	Cubic metres per second or 'cumecs'. A unit of measurement for flows or **discharges**. It is the rate of flow of water measured in terms of volume per unit time.
merit approach	The principles of the merit approach are embodied in the *Floodplain Development Manual* (NSW Government, 2005) and weigh up social, economic, ecological and cultural impacts of land use options for different **flood prone** areas together with flood damage, **hazard** and behaviour implications, and environmental protection and well being of the State's rivers and **floodplains**.
OEH	NSW Office of Environment and Heritage. Prior to April 2011, the State Government's Flooding Unit was part of the Department of Environment, Climate Change and Water (DECCW), previous to that the Department of Environment and Climate Change (DECC), previous to that the Department of Natural Resources (DNR), and previous to that the Department of Infrastructure, Planning and Natural Resources (DIPNR).

overland flow path	The path that floodwaters can follow when not confined within a flow channel. Overland flow paths can occur through private property or along roads.
peak discharge	The maximum **flow** or **discharge** during a flood.
present value	In relation to flood damage, is the sum of all future flood damages that can be expected over a fixed period (usually 20 years) expressed as a cost in today's value.
probable maximum flood (PMF)	The largest flood likely to ever occur. It has a very rare chance of occurring. The PMF defines the extent of **flood prone land** or **flood liable land**, that is, the **floodplain**.
reliable access	During a **flood**, reliable access means the ability for people to safely evacuate an area subject to imminent flooding within the **effective warning time**, having regard to the depth and **velocity** of floodwaters, the suitability of the evacuation route and other relevant factors.
risk	Risk is measured in terms of consequences and likelihood. In the context of floodplain management, it is the likelihood and consequences arising from the interaction of floods, communities and the environment. For example, the potential inundation of an aged person's facility presents a greater flood risk than the potential inundation of a sportsground amenities block (if both buildings were to experience the same type and probability of flooding). Reducing the probability of flooding reduces the risk, increasing the consequences increases risk. (See also **flood risk precinct**).
risk management	The process of identifying, analysing, evaluating, treating, monitoring and communicating risks. A generic framework for risk management in Australia is provided in the joint Australian and New Zealand Standard AS/NZS 4360;1999.
runoff	The amount of rainfall that ends up as flow in a stream, also known as rainfall excess.
SES	State Emergency Service of New South Wales.
Section 149 Certificates	In NSW, councils issue these certificates to potential property purchasers under Section 149 of the NSW Environmental Planning and Assessment Act. It is compulsory to attach S149(2) certificates to contracts for sale of land and these certificates generally identify policies affecting development of the land. Other information and risks concerning the property are generally provided on S149(5) certificates (which are not compulsory in contracts for sale of land).
stage–damage curve	A relationship between different water depths and the predicted flood damage at that depth.
velocity	The term used to describe the speed of floodwaters, usually in **m/s** (metres per second). 10km/h = 2.8m/s.