NARROMINE SHIRE COUNCIL

NARROMINE FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN

VOLUME 2 – APPENDICES

MAY 2008

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NARROMINE FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN

APPENDIX A

FLOOD DAMAGES

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SYNOPSIS

Estimation of flood damages was carried out at Narromine to provide information on the impact of flooding on the community to assist the Floodplain Management Committee in the selection of the Flood Planning Level and allow a "broad brush" economic assessment of various flood management measures. Damages from floods ranging between the 2% AEP and PMF events were assessed.

Data for the flood damages model comprised the depth of inundation over the floodplain, as well as information on the unit values of damages to residential, commercial and industrial property.

The depth of inundation was determined from the results of the hydraulic modelling undertaken in the Flood Study (LACE, 2006) and from floor levels estimated from Narromine sewerage plans. The type of structure and potential for property damage were assessed from a visual inspection. Floor levels were surveyed of recent residential development in the Crossley Drive area and in the industrial estate in Industrial Avenue on the northern side of the Mitchell Highway.

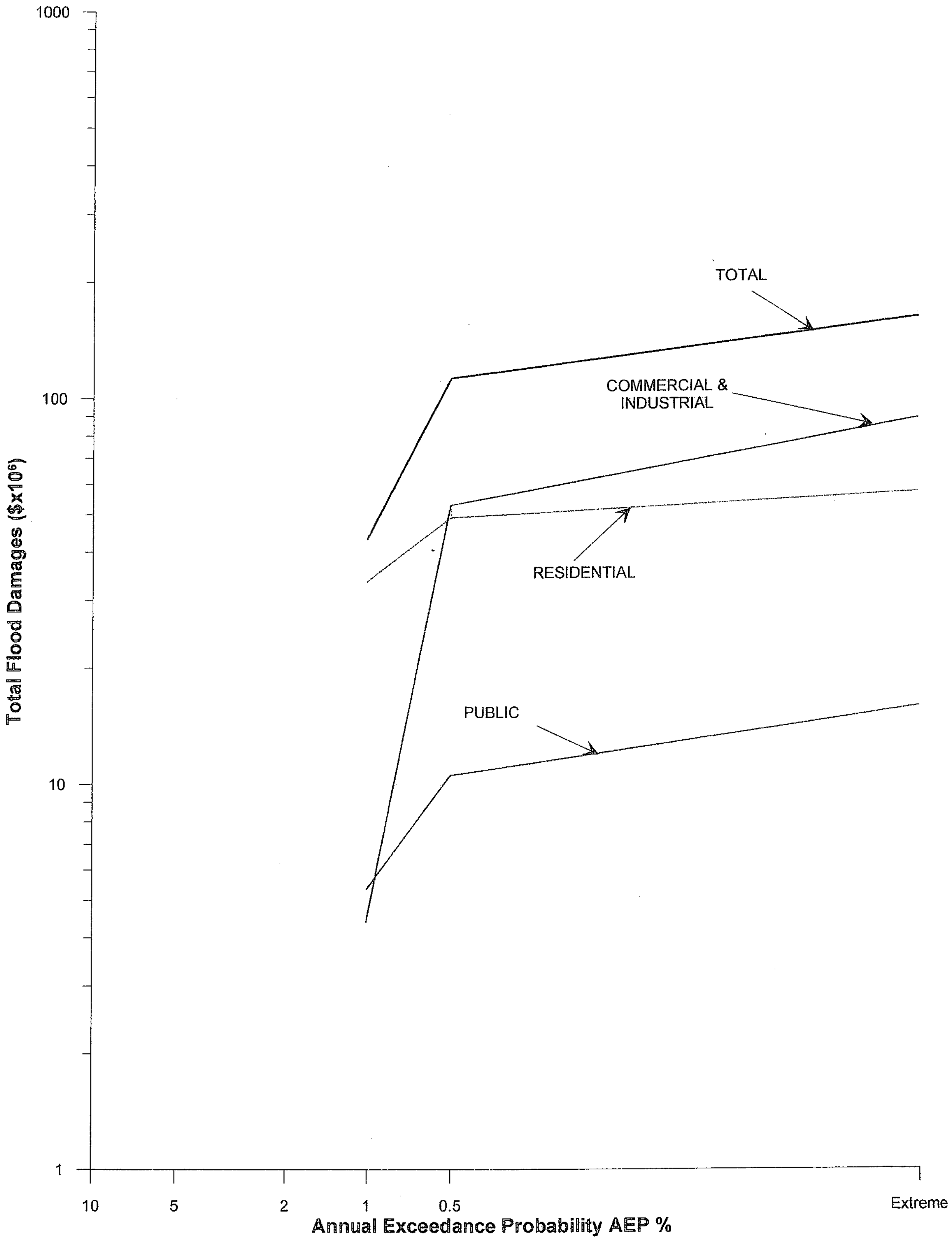
There are no data available on historic flood damages in the study area, principally due to the absence of recent major flooding. Damage assessments undertaken after flooding in other flood liable urban centres have been adjusted and used to estimate damages likely to be experienced to residential and commercial development and public buildings in the town.

The estimated damages, which could occur for various floods, are summarised in **Table S1** below. This table shows the number of properties in the study area which experience "above floor" inundation for the respective flood events. In addition, a larger number of properties experience flooding within their allotments but not of sufficient severity to inundate floor levels.

Table S1 shows the sub-division of damages into the three categories of "Residential", "Commercial" and "Public Buildings". These damages are shown graphically on **Figure A8.1.** The analysis demonstrated that most of the economic impacts of flooding would be experienced to residential property in Narromine. The floor levels of about half the houses in town would be inundated in the event of a 1% AEP flood.

TABLE S1
FLOOD DAMAGES IN STUDY AREA

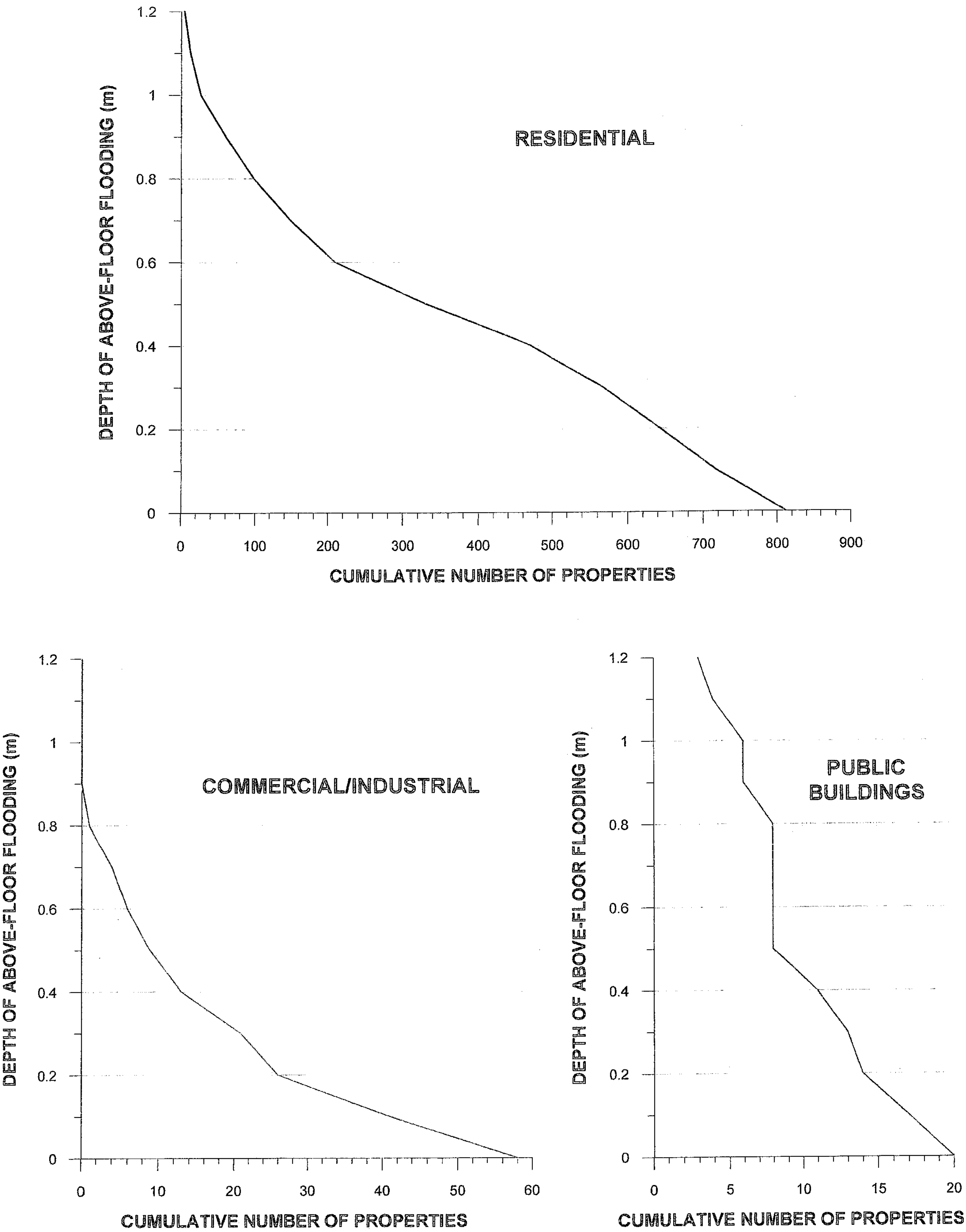
Flood Event % AEP	No. of Properties with Floors Inundated			Total Damage ($\$ \times 10^6$)
	Residential	Commercial	Public	
2	–	–	–	–
1	747	58	20	44
0.5	1070	142	39	113
Extreme Flood	1174	144	40	162



NARROMINE FLOODPLAIN RISK MANAGEMENT STUDY

Figure A8.1

DAMAGE - FREQUENCY CURVES



NARROMINE FLOODPLAIN
RISK MANAGEMENT STUDY

Figure A4.1

HISTOGRAM OF FLOODED PROPERTIES

1. INTRODUCTION AND SCOPE

1.1 Introduction

Damages from flooding belong to two categories:

- **Tangible Damages**
- **Intangible Damages**

Tangible damages are defined as those to which monetary values may be assigned, and may be subdivided into direct and indirect damages. Direct damages are those caused by physical contact of floodwater with damageable property. They include damages to commercial and residential building structures and contents as well as damages to infrastructure services such as electricity and water supply. Indirect damages result from the interruption of community activities, including traffic flows, trade, industrial production, costs to relief agencies, evacuation of people and contents and clean up after the flood.

Generally, tangible damages are estimated in dollar values using survey procedures, interpretation of data from actual floods and research of government files.

The various factors included in the **intangible damage** category may be significant. However, these effects are difficult to quantify due to lack of data and the absence of an accepted method. Such factors may include:

- inconvenience
- isolation
- disruption of family and social activities
- anxiety, pain and suffering, trauma
- physical ill-health
- psychological ill-health.

1.2 Scope of Investigation

In the following sections, damages to residential, commercial and industrial properties and public buildings have been estimated at Narromine. Damages to community assets have also been assessed where data were available.

1.3 Terminology

Definitions of the terms used in this Appendix are presented in **Section 8** which also summarises Tangible Flood Damages at Narromine.

2. DESCRIPTION OF APPROACH

The damage caused by a flood to a particular property is largely a function of the depth of flooding above floor level and the value of the property and its contents. The warning time available for residents to take action to lift property above floor level also influences damages actually experienced. A spreadsheet model which had been developed for previous investigations of this nature was used to estimate damages on a property by property basis according to the type of development, the location of the property and the depth of inundation.

Using the results of the revised Flood Study (LACE, 2006), a peak flood elevation for each event was interpolated at each property. The interpolated property flood levels were input to the spreadsheet model which also contained property characteristics and stage-damage relationships. The depth of flooding was computed as the difference between the interpolated flood level and the surveyed floor elevation at each property. Damage was estimated by depth-damage curves entered as a series of points with the losses in each property category identified for depths of inundation of up to 3 metres.

The depth-damage curves for residential damages were determined using procedures described in *"Floodplain Management Guideline No 4. Residential Flood Damage Calculation", 2004* published by DNR. Damage curves for commercial and industrial developments were derived from previous floodplain management investigations.

It should be understood that this approach is not intended to identify individual properties liable to flood damages and the values of damages in individual properties, even though it appears to be capable of doing so. The reason for this caveat lies in the various assumptions used in the procedure, the main ones being:

- the assumption that computed water levels and topographic data used to define flood extents are exact and without any error;
- the assumption that the water surfaces between hydraulic model cross sections are adequately represented by interpolation and are not subject to localised influences;
- the estimated floor levels being based on an assumed height above natural surface in the respective allotments, rather than by a formal floor level survey.
- the use of "average" stage-damage relationships, rather than a relationship for each property;
- the uncertainty associated with assessing an appropriate factor to convert potential to actual flood damages for each property.

The consequence of these assumptions is that some individual properties may be inappropriately classified as flood liable, while others may be excluded. Nevertheless, when applied over a broad area these effects would tend to cancel, and the resulting estimates of overall damages, would be expected to be reasonably accurate.

The information contained in the spreadsheets used to prepare the estimates of flood damages for the catchments should not therefore be used to provide information on the above-floor inundation of individual residences or commercial properties.

3. SOURCES OF DATA

3.1 General

To estimate *Average Annual Flood Damages* for a specific area it is necessary to estimate the damages for several floods of different magnitudes, i.e. of different frequencies, and then to integrate the area beneath the damage – frequency curve over the whole range of frequencies. To do this it is necessary to have data on the damages sustained by all types of property over the likely range of inundation. There are several ways of doing this:

- The ideal way would be to conduct specific damage surveys in the aftermath of a range of floods, preferably immediately after each. An example approaching this ideal is the case of Nyngan where surveys were conducted in May 1990 following the disastrous flood of a month earlier (DWR, 1990). This approach would not be practicable in the present case due to the absence of recent major flooding at Narromine.

- The second best way is for experienced loss adjusters to conduct a survey to estimate likely losses that would arise due to various depths of inundation. This approach is used from time to time, but it can add significantly to the cost of a floodplain management study (LMJ, 1985). It was not used for the present investigation.

- The third way is to use generalised data such as that published by CRES (Centre for Resource & Economic Studies, Canberra) and used in the Floodplain Management Study for Forbes (SKM, 1994). These kind of data are considered to be suitable for generalised studies, such as broad regional studies. They are not considered to be suitable for use in specific areas, unless none of the other approaches can be satisfactorily applied.

- The fourth way is to adapt or transpose, data from other flood liable areas. This was the approach used for Narromine. For the assessment of residential damages the *DNR Guideline No 4, 2004* procedure was adopted, which was based on data collected following major flooding in Katherine in 1998, with adjustments to account for changes in values due to inflation, and after taking into account the nature of development and flooding patterns in the Narromine area. The data collected during site inspection in the flood liable areas of Narromine assisted in providing the necessary adjustments. Commercial and industrial damages were assessed via reference to recent floodplain management investigations (Bewsher Consulting, 2003).

3.2 Property Data

The properties were divided into three categories: residential, commercial/industrial and public buildings.

For residential properties, the data used in the damages estimation included:

- the location/address of each property
- an estimate of the residence's value, age and size
- an assessment of the construction type and foundations
- a description of any external buildings/structures

- floor level of the residence

The residential descriptions were used to classify the properties into three categories which relate to the magnitude of likely flood damages (**Table 4.1**).

For commercial/industrial properties and public buildings, the Property Survey obtained information regarding:

- the location of each property
- the nature of each enterprise
- an estimation of the floor area
- floor level

The property descriptions were used to classify the commercial developments into categories (i.e. high, medium or low value properties) which relate to the magnitude of likely flood damages.

Properties lying within the Extreme Flood extent of inundation as determined from the updated Flood Study (LACE, 2006) were included in the database.

4. RESIDENTIAL DAMAGES

4.1 Damage Functions

The procedures identified in *Floodplain Management Guideline No 4* allow for the preparation of a depth versus damage relationship which incorporates structural damage to the building, damage to internals and contents, external damages and clean up costs. In addition, there is the facility for including allowance for accommodation costs and loss of rent. Separate curves are computed for three residential categories:

- Single storey slab on ground construction
- Single storey elevated floor
- Two storey residence

The level of flood awareness and available warning time are taken into account by factors which are used to reduce "potential" damages to contents to "actual" damages. "Potential" damages represent losses likely to be experienced if no action were taken by residents to mitigate impacts. A reduction in the potential damages to "actual" damages is usually made to allow for property evacuation and raising valuables above floor level, which would reduce the damages actually experienced. The ability of residents to take action to reduce flood losses is mainly limited to reductions in damages to contents, as damages to the structure and clean up costs are not usually capable of significant mitigation.

The factor is known as the Damage Reduction Factor (DRF) and is site specific, being dependent on a number of factors related to the time of rise of floodwaters, the recent flood history and flood awareness of residents and emergency planning by the various Government Agencies (Bureau of Meteorology and State Emergency Service).

In the present case, there is a well developed and tested flood warning system operated by the Bureau of Meteorology, as well as detailed response procedures incorporated in the Narromine Local Flood Plan, 2007 developed by SES which are implemented during flood alerts. Consequently, there would be several days warning of a flood event in which to warn residents and for them to take action to mitigate flood losses. The DRF should also be related to the depth of inundation.

Contents may be raised above flood level to about 0.9 m, which corresponds with the height of a typical table/bench height. The spreadsheet provides two factors, one for above and one for below the typical bench height. The DRF is also multiplied by a factor known as the "Contents Damage Repair Limitation Factor" (CDRLF) which allows for the fact that repairs need to be self-funded as flood insurance is not available. A factor of 0.85 was adopted for CDRLF in the present study. The "Total Contents Adjustment Factor" derived by multiplying CDRLF by DRF was 0.76 for depths of inundation of 0.9 m and 0.85 for greater depths.

Table 4.1 below shows total flood damages estimated for the three classes of residential property using the procedures identified in *Guideline No 4.*

TABLE 4.1
DAMAGES TO RESIDENTIAL PROPERTIES

Type of Residential Construction	1 m Depth of Inundation Above Floor Level	2m Depth of Inundation Above Floor Level
Single Storey Slab on Ground	$62,300	$83,500
Single Storey High Set	$67,500	$90,800
Two Storey Residence	$45,900	$60,700

Note: These damages include allowances for structural, contents, external and clean up costs.

4.2 Total Residential Damages

Table 4.2 summarises residential damages for a range of floods. The damage estimates were carried out for floods between the 2% AEP and the Extreme Flood, which were modelled hydraulically in the Flood Study, 2006.

TABLE 4.2
RESIDENTIAL DAMAGES AT NARROMINE

Flood Event % AEP	No. of Properties with Floors Inundated	Flood Damages $\$ \times 10^6$
2	–	–
1	747	33.6
0.5	1070	49.2
Extreme Flood	1174	57.2

5. COMMERCIAL AND INDUSTRIAL DAMAGES

5.1 Direct Commercial and Industrial Damages

The method used to calculate damages requires each property to be categorised in terms of the following:

- damage category
- floor area
- floor elevation.

The damage category assigned to each enterprise was either "low", "medium" or "high", depending on the nature of the enterprise and the likely effects of flooding. Damages were then determined on the basis of floor area.

It has recently been recognised following the 1998 flood in Katherine that previous investigations using stage damage curves contained in proprietary software tends to seriously underestimate true damage costs (*DNR Guideline No 4, 2004*). DNR are currently researching appropriate damage functions which could be adopted in the estimation of commercial and industrial categories as they have already done with residential damages. However, these data were not available for the Narromine study.

For a resent study on Towradgi Creek on the south coast of NSW, DNR advised that damage estimates derived from the software should be increased by at least a factor of two (Bewsher Consulting, 2003). For a medium value commercial enterprise e.g. food shops, banks or dry cleaners, this would result in damage estimate of $160,000 for a depth of inundation above floor level of 2 m and $110,000 for 1 m. This estimate includes external and internal damages plus clean up costs and is equivalent to unit damage rates of $ 800 and $500/m^2 respectively for a 200 m^2 property.

The following damage rates were adopted for potential external and internal damages and clean up costs for both commercial and industrial properties They are indexed to a depth of inundation of 2 metres. At floor level and 1.2 m inundation, zero and 70% of these values respectively were assumed to occur:

Low value enterprise	$500/m^2	(e.g. Commercial: small shops, cafes, joinery, public halls. Industrial: auto workshop with concrete floor and minimal goods at floor level, Council or Government Depots, storage areas.)
Medium value enterprise	$800/m^2	(e.g. Commercial: food shops, hardware, banks, professional offices, retail enterprises, with furniture/fixtures at floor level which would suffer damage if inundated. Industrial: warehouses, equipment hire.)
High value enterprise	$1,100/m^2	(e.g. Commercial : electrical shops, clothing stores, bookshops, newsagents, restaurants, schools, showrooms and retailers with goods and furniture, or other high value items at ground or lower floor level. Industrial: service stations, vehicle showrooms, smash repairs.)

The factor for converting potential to actual damages depends on a range of variables such as the available warning time, flood awareness and the depth of inundation. Given sufficient warning time a well prepared business will be able to temporarily lift property above floor level. However, unless property is actually moved to flood free areas, floods which result in a large depth of inundation, will cause considerable damage to stock and contents.

For the present study, potential damages were converted to actual damages using a multiplier which ranged between 0.7 and 0.9 depending on the depth of inundation above the floor. The factors also took into consideration the absence of recent floods in the town.

5.2 Indirect Commercial and Industrial Damages

Indirect commercial and industrial damages comprise costs of removal of goods and storage, loss of trading profit and loss of business confidence.

Disruption to trade takes the following forms:

- The loss through isolation at the time of the flood when water is in the business premises or separating clients and customers. The total loss of trade is influenced by the opportunity for trade to divert to an alternative source. There may be significant local loss but due to the trade transfer this may be considerably reduced at the regional or state level.

- In the case of major flooding, a downturn in business can occur within the flood affected region due to the cancellation of contracts and loss of business confidence. This is in addition to the actual loss of trading caused by closure of the business by flooding.

Loss of trading profit is a difficult value to assess and the magnitude of damages can vary depending on whether the assessment is made at the local, regional or national level. Differences between regional and national economic effects arise because of transfers between the sectors, such as taxes, and subsidies such as flood relief returned to the region.

Some investigations have lumped this loss with indirect damages and have adopted total damage as a percentage of the direct damage. In other cases, loss of profit has been related to the gross margin of the business, i.e. turnover less average wages. The former approach has been adopted in this present study. Indirect damages have been taken as 50% of direct actual damages.

5.3 Total Commercial and Industrial Damages

Table 5.1 summarises estimated commercial and industrial damages within the flood liable portion of Narromine.

TABLE 5.1
COMMERCIAL AND INDUSTRIAL DAMAGES AT NARROMINE

Flood Event % AEP	Number of Properties with Floors Inundated	Damages $ x 10^6		
		Direct	Indirect	TOTAL
2	–	–	–	–
1	58	2.8	1.9	4.7
0.5	142	34	19	53
Extreme Flood	144	58	31	89

6. DAMAGES TO PUBLIC BUILDINGS

6.1 Direct Damages – Public Buildings

Included under this heading are government buildings, churches, swimming pools and parks. Damages were estimated individually on an areal basis according to the perceived value of the property. Potential internal damages were indexed to a depth of above floor inundation of 2 m as shown below. At floor level and 1.2 m depth of inundation, zero and 55% of these values respectively were assumed to occur for "Very Low Value" properties; and zero and 70% for the other categories.

Very low value	$150/m^2	(eg. park buildings)
Low value	$500/m^2	
Medium value	$800/m^2	(eg. council buildings, churches, fire station)
High value	$1100/m^2	(eg. schools, police station)

These values were obtained from the Nyngan Study (DWR, 1990) as well as commercial data presented in the Forbes/Eugowra Water Studies report.

External and structural damages were taken as 12.5 and 15% of internal damages respectively. An allowance was also made for damages to external buildings. It was estimated that 50% of public properties had external buildings and for each, damages were taken as 25% of internal damages to the main building.

6.2 Indirect Damages – Public Buildings

A value of $8,000 was adopted for the clean-up of each property. This value is based on results presented in the Nyngan Study and adjusted for inflation. Total "welfare and disaster" relief costs were assessed as 50% of the actual direct costs, as for commercial properties.

6.3 Total Damages – Public Buildings

TABLE 6.1
DAMAGES TO PUBLIC BUILDINGS AT NARROMINE

Flood Event % AEP	Number of Properties with Floors Inundated	Damages $ x 10^6		
		Direct	Indirect	TOTAL
2	–	–	–	–
1	20	3.6	2.0	5.6
0.5	39	6.8	3.8	10.6
Extreme Flood	40	10	6	16

7. DAMAGES TO INFRASTRUCTURE AND COMMUNITY ASSETS

Infrastructure in the Narromine, such as electrical and telephone supply, sewerage and water supply systems, and road network, are potentially prone to damaging flooding. Community assets such as parks and other recreational amenities could also suffer damages. No data are available on damages experienced during historic flood events. However, a qualitative matrix of the effects of flooding on these categories is presented in **Table 7.1**.

TABLE 7.1
QUALITATIVE EFFECTS OF FLOODING ON INFRASTRUCTURE AND COMMUNITY ASSETS AT NARROMINE

Damage Sector	Flood Event % AEP)				
	5	2	1	0.5	Extreme Flood
Electricity	0	0	X	X	X
Telephone	0	0	X	X	X
Roads	0	0	X	X	X
Bridges	0	0	X	X	X
Sewerage	0	0	0	0	0
Water Supply	0	0	X	X	X
Parks and Gardens	0	0	X	X	X

Notes: 0 = No significant damages likely to be incurred.
X = Some damages likely to be incurred.

8 SUMMARY OF TANGIBLE DAMAGES

8.1 Tangible Damages

Flood damages under existing conditions have been computed for a range of flood frequencies from 2 % AEP to the Extreme Flood. The 1 % AEP is the "threshold" flood magnitude at which significant damages are experienced in Narromine.

The total damages for each flood event are shown on **Table 8.1**. Cumulative average annual damages were assessed and are also shown. **Figure A8.1** shows the resulting damage - frequency curves and **Figure A8.2** shows the cumulative average annual damage.

TABLE 8.1
TOTAL DAMAGES AT NARROMINE

Flood Event % AEP	No. of Properties with Floors Inundated			Total Damages $ x 10^6	Cumulative AAD$ x 10^6
	Residential	Commercial/ Industrial	Public		
2	–	–	–	–	–
1	747	58	20	44	0.2
0.5	1070	142	39	113	0.6
Extreme Flood	1174	144	40	162	1.3

8.2 Definition of Terms

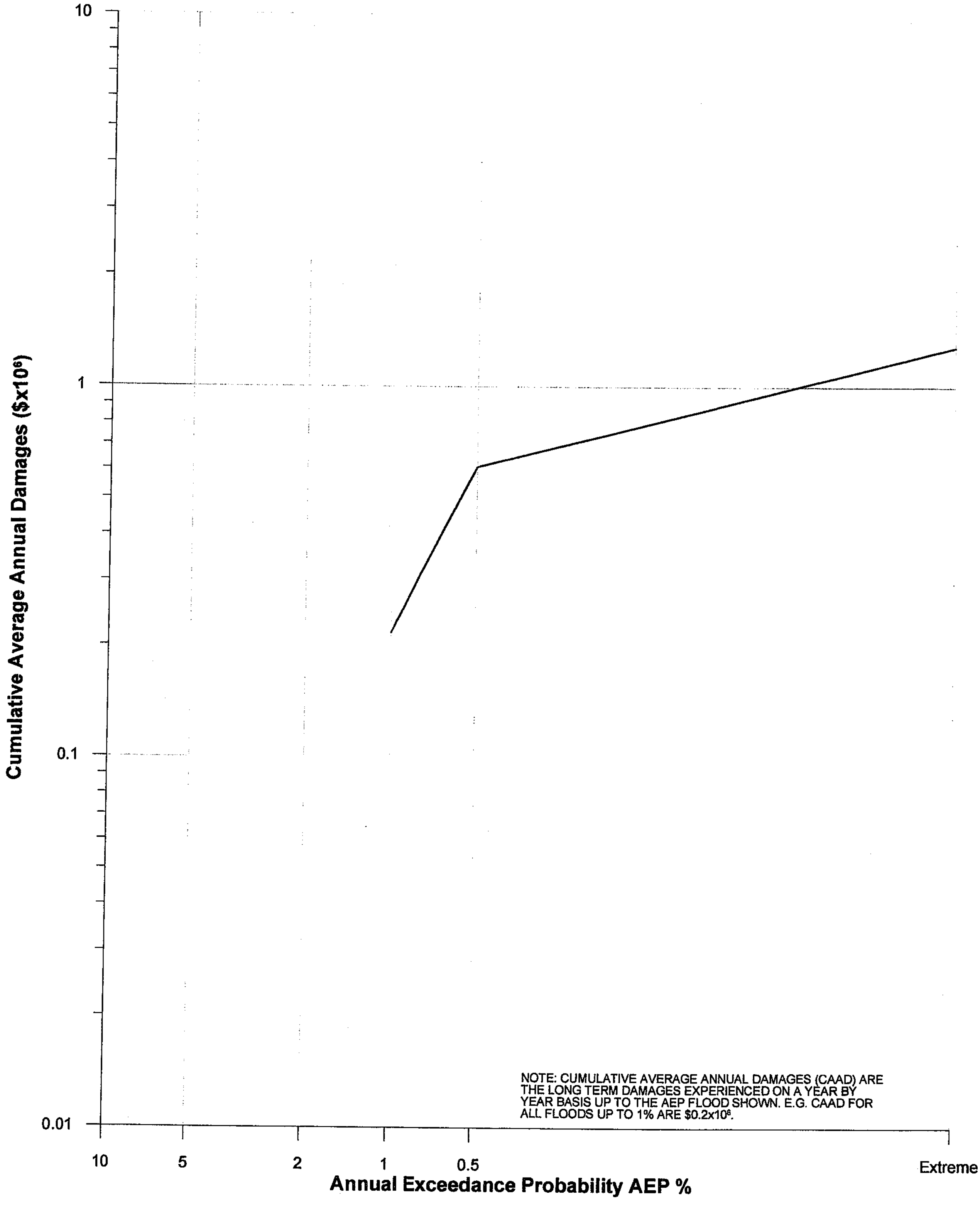
Average Annual Damages (also termed "expected damages") are determined by integrating the area under the damage-frequency curve. They represent the time stream of annual damages, which would be expected to occur on a year by year basis over a long duration.

Using an appropriate discount rate, average annual damages may be expressed as an equivalent "*Present Worth Value*" of damages and used in the economic analysis of potential flood management measures.

Cumulative Annual Average Damages may be referenced to a particular flood frequency. They represent the average damages which would be expected on an annual basis for all flood events up to and including that nominated frequency.

For example, the cumulative average annual value of damages at Narromine for all floods up to the 1 % AEP level is around $0.2 Million (**Table 8.1**). A flood management scheme which has a design 1 % AEP level of protection, by definition, will eliminate damages up to this level of flooding. If the scheme has no mitigating effect on larger floods, then these damages represent the benefits of the scheme expressed on an average annual basis.

Under current NSW Treasury guidelines, economic analyses are carried out assuming a 20 year economic life for projects and discount rates of 7% pa. (best estimate) and 10% and 4% pa. (sensitivity analyses).



NARROMINE FLOODPLAIN MANAGEMENT STUDY

Figure A8.2

CUMULATIVE AVERAGE ANNUAL DAMAGES

8.3 Present Worth of Damages in Narromine Study Area

The *Present Worth Values* of damages likely to be experienced in the study area for all flood events up to the 1 % AEP, a 20 year economic life and discount rates of 4, 7 and 10 per cent are shown on **Table 8.2.** Corresponding values for all floods up to the Extreme Flood are shown on **Table 8.3.**

For a discount rate of 7% pa, the *Present Worth Value* of damages for all flood events up to the Extreme Flood is about $13.8 Million for a 20 year economic life. Therefore a scheme costing up to $13.8 Million could be economically justified if it eliminated damages for all flood events up to this level. Similarly, a scheme providing a 1 % AEP level of protection could be economically justified if it cost up to $2.2 Million.

More expensive schemes would have a benefit/cost ratio less than 1, but may still be justified according to a multi-objective approach which considers other criteria in addition to economic feasibility.

TABLE 8.2
PRESENT WORTH OF DAMAGES AT NARROMINE
ALL ECONOMIC FLOODS UP TO 1% AEP
ECONOMIC LIFE OF 20 YEARS
$ X 10^6

Discount Rate – per cent		
4	7	10
2.7	2.2	1.8

TABLE 8.3
PRESENT WORTH OF DAMAGES AT NARROMINE
ALL FLOODS UP TO EXTREME FLOOD
AND ECONOMIC LIFE OF 20 YEARS
$ X 10^6

Discount Rate – per cent		
4	7	10
17.7	13.8	11.1

9. REFERENCES

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NARROMINE FLOODPLAIN
RISK MANAGEMENT STUDY AND PLAN

APPENDIX B

EFFECTS OF BURRENDONG DAM
FLOOD MITIGATION STORAGE
AT NARROMINE

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FIGURES

1. INTRODUCTION

1.1 Background

Burrendong Dam, which was constructed in 1965, is situated below the junction of the Macquarie and Cudgegong Rivers 120 km above the town of Narromine and controls a catchment area of 13,900 km^2. Several important tributaries including the Little and Bell Rivers join the Macquarie River between the dam and Dubbo which is located 78 km below Wellington. The Talbragar River enters the Macquarie River downstream of Dubbo.

Catchment areas are shown in **Table 1.1**.

TABLE 1.1
CATCHMENT AREAS

Location	Catchment Area (km^2)
Burrendong Dam	13,900
Wellington upstream of confluence with Bell River	14,250
Bell River at Wellington	1,860
Dubbo	19,950
Narromine	26,000

Burrendong Dam has a total storage volume of 1,680 GL, of which 480 GL is allocated to flood mitigation. This flood mitigation storage can greatly reduce the peaks of floods flowing through the dam. Because the dam controls 50 per cent of the combined catchment at Narromine, this effect is carried downstream and significantly reduces flood peaks there.

Previous investigations on the effects of the dam in mitigating downstream flooding were carried out by I.E.S.C. in 1971 and by the then Water Resources Commission (now Department of Environment and Climate Change) in 1978. Those studies were updated in the Wellington Flood Study (DLWC, 1995).

1.2 Scope of Investigation

This investigation is a review of the procedure adopted by the operators during flood events to mitigate downstream flooding and the capacity of the dam to reduce flood peaks at Narromine on a long term basis. The review is based on the results of previous investigations undertaken by DECC and Consultants.

An investigation of the frequency of pre- and post-dam flood peaks at Narromine was carried out in the Narromine Flood Behaviour Study, 1998 and is summarised in this study.

2. FLOOD OPERATING PROCEDURE AT BURRENDONG DAM

2.1 Procedure

The flood operation procedure for Burrendong Dam is based on the following considerations:

- The principle that outflows from the dam are not permitted to exceed inflows to storage until after the rate of inflow into storage has begun to subside.
- An operation procedure which is designed to obtain maximum benefit from the use of available surcharge storage in reducing the intensity of peak outflows from the dam.

The flood operation procedure involves

- The estimation of the likely flood inflow rate up to four hours in advance, together with adoption of a flood recession assuming the estimated inflow is a flood peak. The estimation of the flood inflow is based on rainfall information and river levels recorded at three upstream telemetric stations: the Macquarie River at Bruinbun, the Cudgegong River at Yamble Bridge and the Turon River at Sofala. These data indicate the trend of the inflow hydrograph to the storage. An important result of this step is to give the minimum volume that will flow into the storage after the time of the estimation.
- Based on this predicted inflow hydrograph, the procedure determines a constant outflow so as to make maximum use of available surcharge storage. During the rising stages of a flood the actual rate of inflow (based upon the change in storage level measured at the dam) is monitored, and the above estimation procedure is usually revised at hourly intervals.

DECC staff at the dam are responsible for transmitting information on the dam storage level, rainfall and recorded upstream flows to the Parramatta office. There, the staff in the Operations Division are responsible for calculating the required outflow and gate openings, and for relaying this information to the dam officers. The procedure aims at maximising the flood mitigation potential of the storage and if possible, also takes account of downstream tributary flows, particularly on the Bell River. That is, releases are delayed where possible to follow, and not compound, the flood peaks from the various downstream tributaries.

During operation of the gates, a minimum gate freeboard of 0.3 metres should be maintained until the storage reaches a surcharge level of RL 353.8 m. After this, the gates are to be gradually withdrawn at such a rate that when RL 356.9 m is reached, the gates will be clear of the water.

Burrendong Dam has a huge lake surface area (some 8,900 ha at RL 350.8 m), so that any raising of the storage level behind the radial gates represents a significant additional volume of flood water that can be stored.

Thus, raising of the gates not only increases the spillway discharge but also allows a greater storage potential. This means that for major flood inflows, when the storage level is likely to exceed RL 350.8 m, additional flood mitigation storage is obtained for each incremental raising of the gates.

Close contact is maintained with the Bureau of Meteorology which is the agency responsible for issuing the warning of likely flooding along the river. The State Emergency Service (SES) is then responsible for evaluating and acting upon that warning.

2.2 Attenuation of Flood Peaks Through Burrendong Dam – Historic Floods

The two largest floods to have occurred since construction of Burrendong Dam occurred in January-February 1971 and August 1990.

2.2.1 February 1971 Flood

The first peak of the double peaked flood of January-February 1971 occurred at the dam on 31st January, where the peak inflow of 1,920 m^3/s was reduced to a peak outflow of 730 m^3/s. Flow in the Bell River was not significant during this peak. Under pre-dam conditions, the flood peak would have reached about 10.8 m on the Wellington (Mitchell Highway) gauge early on 1st February, but actually reached 6.8 m.

At the dam, the second flood inflow peak of 2,550 m^3/s was reduced to an outflow of 1,300 $m^{3/}s$, which occurred at 20:00 hours on 10 February. By this time, the Bell River was in flood, with a peak discharge of 760 $m^{3/}s$ recorded at Neurea at 22:00 hours on 9 February. The peak level recorded on the Macquarie River at the Mitchell Highway gauge in Wellington was 10.2 m. However, under pre-dam conditions, it would have reached 12.6 m.

At Narromine, the peak stage recorded at the Timbrebongie bridge gauge was 13.12 m and the peak discharge was 1,800 $m^{3/}s$. This is equivalent a peak between that of the 2% and 5% AEP design flood.

2.2.2 August 1990 Flood

The flooding of July-August 1990 also illustrates the attenuating effects of the dam. Three separate floods were experienced, with the last being the most severe and occurring over the three days 2 to 4 August. The peak inflow to the dam was 6,500 $m^{3/}s$, the highest experienced over the life of the structure. The flood mitigation storage had been emptied at the time of arrival of the flood and attenuated the peak to an outflow of 2,100 $m^{3/}s$. At the Mitchell Highway gauge in Wellington, the recorded peak height was 13.1 m, which is equivalent to the 2% AEP level under post-dam conditions (DLWC, 1995). Under pre-dam conditions, the flood peak would have been 3.5 m higher. On the Bell River, the peak level at the Maughan Street gauge was slightly less than a 2% AEP level on that stream. The peak discharge was about 1,400 $m^{3/}s$.

The 1971 and 1990 floods are the only two events to have reached the critical level of 9 m on the Mitchell Highway gauge at Wellington over the life of Burrendong Dam. DECC has carried out behavioural analyses which investigated the potential of the dam to attenuate historic floods that occurred prior to its construction. If the dam had been in existence since 1909, when records commenced, only 6 floods would have reached 9 m on the gauge (including the 1971 and 1990 events), whereas 30 floods would have reached this height if the dam had not been built.

At Narromine the August 1990 flood reached a peak level of 13.48 m on the gauge, just below the major flood level at the town and about 400 mm below the 2% AEP design flood level.

No information is available on the flood level which would have occurred at Narromine if Burrendong Dam had not been in place to mitigate the August 1990 flood. However, by studying the record of stream flows on the Macquarie River, it is possible to carry out flood frequency analysis under pre- and post- Burrendong Dam conditions to provide information on the likely behaviour of the flood mitigation storage on a long term basis. The results of such an investigation are presented in the next section.

3. ATTENUATION EFFECTS OF FLOOD MITIGATION STORAGE

The ability of the dam to reduce downstream flood peaks depends partly on the storage contents at the time of arrival of the flood.

Data presented in the Wellington Flood Study (DLWC, 1995) may be used to evaluate the performance of the dam in attenuating flows with various initial storage contents (**Table 3.1**). Values shown in columns (2) to (5) were derived (by DLWC) by routing recorded floods through the dam using the current gate operation procedures.

Column (6) shows the probability distribution of post-dam flood peaks on the Macquarie River at Narromine. These last results were obtained from a probability analysis of flood peaks experienced at Narromine since construction of the dam in 1966 (see **Section 4**).

If the policy were to be changed so that the dam was operated solely as a conservation storage, i.e. with the flood mitigation storage (airspace) used for additional conservation storage, then the peak outflows at the dam would be higher. Column (3) shows the range of peak outflows that would occur if the dam was full at the onset of all floods. A considerable attenuation of the inflow peaks would still be achieved, for example, the 1% AEP flood peak would be reduced from 5,900 m^3/s to 3,200 m^3/s.

If the flood mitigation storage component were to be increased then it would be expected that downstream flood peaks would be further reduced. For example, Column (5) shows that with the dam at 50 % of its conservation storage level prior to the arrival of the flood, all floods up to the 1% AEP magnitude would be stored. Downstream flood peaks would be made up of flows from the various tributaries.

TABLE 3.1
RESULTS OF ROUTING FLOODS THROUGH BURRENDONG DAM

Frequency (% AEP) (1)	Peak Inflows to Dam (m^3/s) (2)	Peak Outflows (m^3/s) for Dam Condition at Onset of Flood Inflow as follows:			Peak Discharges at Narromine (Based on historic flood peaks since construction of the dam) (6)
		Dam-Full (No Air Space) (3)	Dam at Conservation Storage Level (4)	Dam at 50% Conservation Storage Level (5)	
5	3,600	1,700	350	–	1,500
2	5,000	2,400	900	–	2,600
1	5,900	3,200	1,500	–	3,800
0.5	7,200	3,900	2,200	350	5,600

Data taken from DLWC, 1995 and Bewsher Consulting, 1998

4. PRE- AND POST-DAM FLOOD PEAKS AT NARROMINE

Figure B4.1 shows the pre-dam and post-dam probability distributions of flood peaks at Narromine. These data were prepared from the results of the analysis of peak discharges at Narromine for the periods 1909 – 1964 (pre-dam) and 1966 – 1998 (post-dam) presented in Bewsher Consulting, 1998 and the recent Narromine Flood Study LACE, 2006.

These results show that on a long term basis, the dam results in a considerable reduction in flood impacts even as far downstream as Narromine. For example, a peak flood level of RL 239.1 m under present day conditions would have an annual chance of occurrence of 0.5%. However, prior to construction of the dam, this level, which approximates the peak of the February 1955 flood, was a more frequent event, having an annual probability of 1%.

The 1% AEP flood under present day conditions would reach a level of RL 238.7 m, a reduction of 400 mm due to the mitigating effects of the dam. Nevertheless, the analysis presented in **Appendix A** predicts that damages at Narromine, for that flood, would be of the order of $44 Million. However, prior to construction of the dam, a peak of this magnitude would have a 2% chance of occurrence.

The above data indicate that the dam has halved the annual probability of occurrence of major floods at Narromine.

5. REFERENCES

Bewsher Consulting (1998), *"Narromine Flood Behaviour Study".*

Department of Land and Water Conservation, NSW (1995), *"Flood Study Report Wellington".*

International Engineering Service Consortium (1971), *"An Economic Evaluation of the Usage of Burrendong Dam Flood Storage".*

Lyall and Associates Consulting Water engineers (2006), *"Narromine Flood Study".*

McCormick R M (1978), *"Report of Flood Frequency Studies for Macquarie River at Wellington and Dubbo".*

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NARROMINE
FLOODPLAIN RISK MANAGEMENT
STUDY AND PLAN

APPENDIX C

FLOOD POLICY

MAY 2009

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ANNEXURES

1 INTRODUCTION

This Flood Policy was prepared to provide specific development controls to guide development of land in flood prone areas in Narromine.

The Flood Policy incorporates the findings of the *Narromine Flood Study, 2006,* the *Narromine Floodplain Risk Management Study and Plan, 2009,* the procedures set out in the NSW *Floodplain Development Manual, 2005* and the revised ministerial direction regarding flood prone land (issued on 31 January 2008 under Section 117 of the EP&A Act, 1979).

1.1 What does the Plan do?

The Flood Policy provides information and guidelines to assist people who want to develop or use land affected by potential flooding within the town of Narromine. Development may include, among other things:

- dwelling construction;
- filling land to provide building platforms above flood level;
- commercial and industrial development;
- sub-dividing land.

1.2 Objectives

The objectives of this Flood Policy are:

(a) To provide detailed controls for the assessment of applications on land affected by floods in accordance with the provisions of *Narromine LEP 1997* (as amended) and the *Narromine Floodplain Risk Management Study and Plan, 2009.*

(b) To alert the community to the hazard and extent of land affected by floods.

(c) To inform the community of Council's policy in relation to the use and development of land affected by the potential floods in Narromine.

(d) To reduce the risk to human life and damage to property caused by flooding through controlling development on land affected by floods.

1.3 Will the Plan affect my property?

The Flood Policy applies to all development permissible with the consent of Council on land in Narromine zoned under Narromine LEP 1997 that lies within the indicative extent of the **Extreme Flood,** as shown in **Figure C1.1.** As shown on this figure, most of the urban area of Narromine would be flooded in the event of a 1% AEP flood (a flood with a 1% chance of being equalled or exceeded in any year).

INDICATIVE EXTENTS OF INUNDATION

- 1% AEP Flood Event
- 0.5% AEP Flood Event
- Extreme Flood Event

NARROMINE FLOODPLAIN RISK MANAGEMENT STUDY

Figure C1.1

INDICATIVE EXTENTS OF INUNDATION
1%, 0.5% AEP AND EXTREME FLOOD EVENT

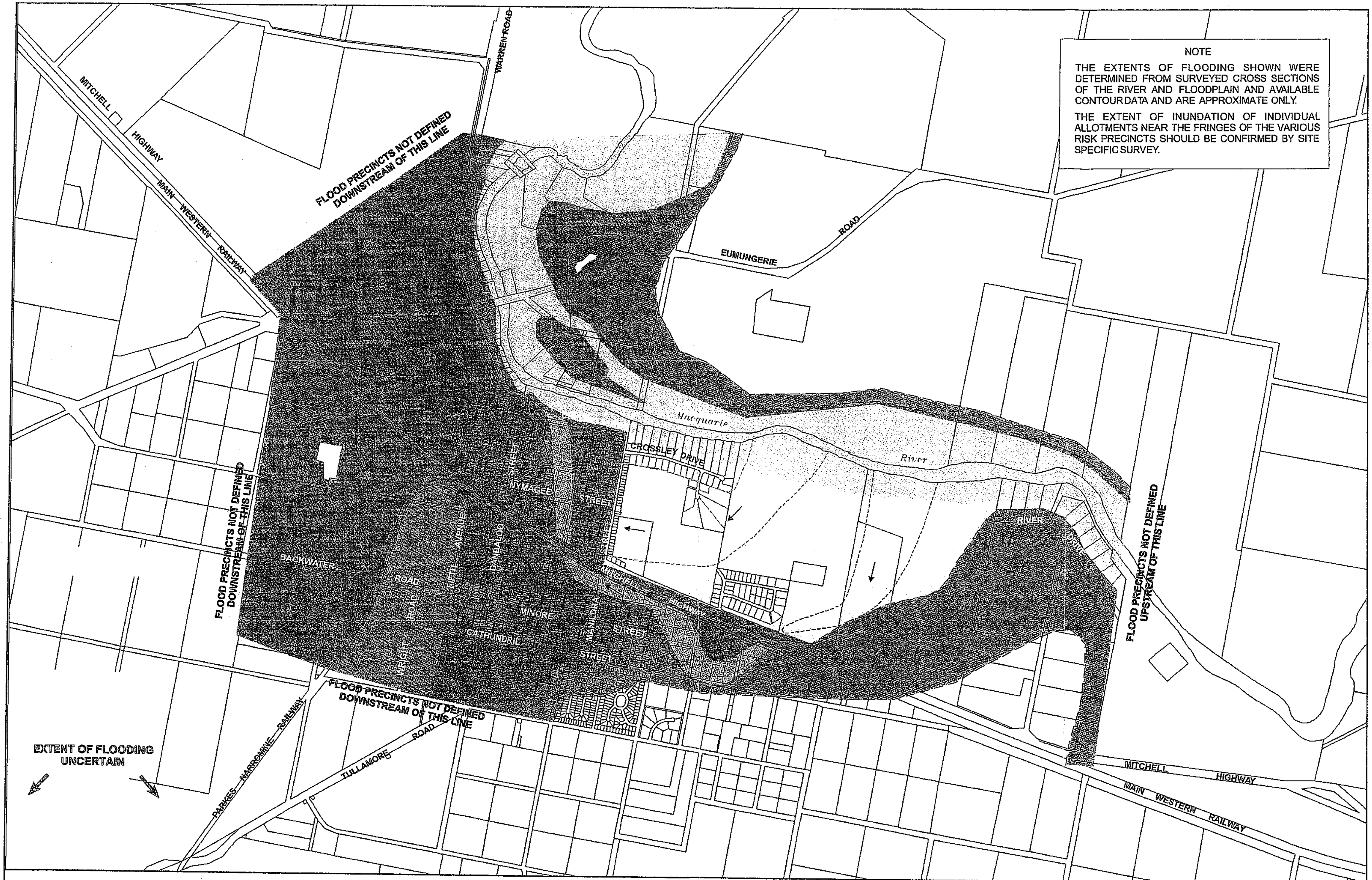
2 HOW TO USE THIS PLAN

The Flood Policy provides criteria which Council will use for the determination of development applications in flood prone areas in Narromine. The criteria recognise that different controls apply to different land uses and levels of potential flood inundation or hazard.

The procedure Council will apply for determining the specific controls applying to proposed development in flood prone areas in Narromine is set out below. Upon enquiry by a prospective applicant, Council will make an initial assessment of the flood affectation and flood levels at the site using the following procedure and the results of the *Narromine Flood Study, 2006.*

- Assess whether the development is located in Flood Prone land, that is, land within the extent of the **Extreme Flood** from **Figure C1.1**.
- Determine which part of the floodplain the development is located in from the **Flood Risk Precinct** diagram **(Figure C3.1)**.
- Identify the category of the development from **Annexure 1: Land Use Category.**
- Determine the appropriate **Flood Planning Level** for the category of development from **Annexure 2** and the flood level at the site from the results of the *Narromine Flood Study, 2006.*
- Confirm that the development conforms with the controls set out in **Annexure 2: Development Controls Matrix.**

A survey plan showing natural surface levels over the site as well as other information relating to the modifications to levels due to the proposed development will be required as part of the DA Documentation. The required format is presented in **Annexure 4.** Provision of the survey plan by the applicant at the initial enquiry stage will assist Council in providing flood related information.



NARROMINE FLOODPLAIN RISK MANAGEMENT STUDY

Figure C3.1

FLOOD RISK PRECINCTS

3 WHAT ARE THE CRITERIA FOR DETERMINING APPLICATIONS?

3.1 General

Development controls on flood prone land are set out in **Annexure 2** of this Flood Policy. The controls recognise that different controls are applicable to different land use, location within the floodplain and levels of potential flood inundation and flood hazard.

The controls applicable to proposed development depend upon:

- The type of development proposed.
- The **Flood Risk Precinct** in which the development is located.

3.2 Land Use Categories and Flood Planning Levels

Eight land use categories have been adopted. The specific land uses are listed in **Annexure 1**.

The **Flood Planning Level (FPL)** is the minimum floor level for the land uses:

- For new residential development in Narromine, the **FPL** is the peak 1% AEP flood level at the particular development site, plus an allowance of 500 mm for freeboard.
- For commercial and industrial development the **FPL** is the peak 1% AEP flood level plus an allowance of 500 mm for freeboard. Council may at its discretion allow an amendment to this FPL, subject to local conditions (refer **Note B** of **Section 3.3**)
- Essential Community Facilities and Critical Utilities require a higher level of flood protection. The FPL is the 0.5% AEP flood plus 500 mm freeboard. In addition, these uses are to be designed to be able to continue to function in the event of an Extreme Flood.
- For Flood Vulnerable Residential Development (nursing homes, aged care facilities and the like) the **FPL** is the peak 0.5% AEP flood level plus an allowance of 500 mm for freeboard. Council may at its discretion allow an amendment to this requirement, subject to local topographic conditions (**refer Note C** of **Section 3.3**).

3.3 What Controls Apply to Proposed Development?

The Flood Policy applies to all flood prone land (that is, land inundated by flood events up to the magnitude of the **Extreme Flood**.) The types of controls have been graded relative to the severity and frequency of potential floods, having regard to six **Flood Risk Precincts** within the floodplain, shown on **Figure C3.1** and defined below:

- The ***"Macquarie River Floodway"***. This is the area conveying most of the flow in the Macquarie River in the event of a 1% AEP flood. The Flood Policy does not permit new development in this area.
- The ***"Manildra Street/River Drive Precinct"*** is the area on the southern floodplain between the river and the Mitchell Highway. This Precinct includes two flow paths which act as conveyances for floodwaters breaking out from the low points in the river bank between Manildra Street and River Drive. Some of the flow travels eastwards to Manildra Street via the Manildra Floodway flow path (shown as green dashed lines on **Figure C3.1**) and the

remainder is conveyed via the Town Cowal Floodway (shown as red dashed lines) through the railway culverts to the southern side of town. **Note A** below provides further commentary on development controls in this precinct.

- The ***"Town Cowal Floodway"*** This area, shown shaded light blue on **Figure C3.1,** was zoned as a floodway according to the Narromine LEP, 1997 and was defined using survey data available at that time. (A floodway is an area where significant flow velocities would be expected at the 1% AEP flood and which should be kept clear of future development). More recent survey data has allowed a better assessment to be made of the location of the floodway (in a hydraulic sense), which is shown as red dashed lines on **Figure C3.1**. The Flood Policy allows for an interpretation by Council (at its discretion) of the true extent of the land which should be defined as a floodway (and hence kept clear), based on this new information, as well as natural surface levels identified in the site survey to be provided by applicants in support a Development Application. The procedure Council will adopt in its interpretation is described in **Note D.**

- The ***"High Hazard Ponding Area"*** is the precinct on the eastern side of the Parkes Narromine railway embankment. There are sparse data on natural surface levels available in this area. However, on the basis of available information it appears that although flow velocities would be low, peak depths of inundation in excess of 1 m would be expected in the event of the 1% AEP flood. In this area in-fill residential development would be permitted. However, prior to consideration of any sub-division proposal, Council would require the applicant to provide a Flood Study to demonstrate that the area could be safely be developed without adverse impacts on local flooding patterns. The Flood Study would specifically consider the potential backwater effects resulting from surcharge of culverts in the Parkes – Narromine Railway embankment.

- The ***"Intermediate Floodplain"*** is the remaining land inundated by the 1% AEP flood and not falling in the above categories of flood prone land. All land uses would be permitted in this zone, subject to minimum floor level requirements for the various categories of development. Refer **Note B** and **Note C** which discuss requirements for non-residential uses.

- The ***"Outer Floodplain"*** is the remainder of the floodplain between the 1% AEP flood extent and the Extreme Flood. In this area the same controls would apply over minimum floor levels as for the ***Intermediate Floodplain***. The purpose of the ***Outer Floodplain*** would mainly be to define the potential flooded area, i.e. the extent of the "Floodplain".

Note A. Assessing Developments in "*Manildra Street/River Drive Precinct*"

Maintenance of the flow path for the conveyance of floodwaters is required within the confines of the dashed lines representing the Manildra Floodway. Council will allow either of the following two methods of flood proofing individual allotments:

- Buildings set on individual fill platforms extending over the footprint of the building, with the balance of the allotment remaining at existing natural surface level. No more than 50 per cent of the gross width of the allotment in the north- south direction (i.e. normal to the direction of flow) is to be filled to minimise obstructions to flow. The minimum finished level of fill is to be the 1% AEP level, with the minimum floor level of the building to be the residential **FPL** (1% AEP plus 500 mm).

- Alternatively, (and more desirably) the building could be constructed on piers with the area beneath left open for the conveyance of flow. The combined width of supporting piers and any obstructions in the north- south direction (i.e. normal to the direction of flow) is to be no more than 50 per cent of the gross width of the allotment.

Note B. Assessing Commercial and Industrial Development Proposals

Most of the commercial and industrial development in Narromine is located in the "*Intermediate Floodplain,*" with an industrial area in the southern portion of the "*Manildra Street/River Drive Precinct*" in a location where flooding is of a ponding nature.

The *Flood Policy* nominates the same FPL as for residential development (i.e. minimum floor levels set at the 1% AEP flood level plus 500 mm). However, where it is not practicable to achieve this level, Council may approve a lesser level commensurate with the local streetscape. In this eventuality, the applicant is to provide an area within the development for the temporary storage of goods at a minimum level equal to the 1% AEP flood plus 500 mm of freeboard. This area should be the larger of 20 % of the gross floor area, or 20 m^2.

Note C. Developments Requiring a Higher Level of Protection

The policy nominates the 0.5% AEP flood level plus 500 mm as the **FPL** for Flood Vulnerable Residential Development (which includes nursing homes, aged care facilities and the like). However, where it is not practicable to achieve this level, Council may approve a lesser level commensurate with local site conditions, but no lower than the residential **FPL**. In this eventuality, the applicant is to ensure that valuable equipment necessary for the operation of the facility is located at or above the nominated FPL, either permanently or via relocation to a temporary storage area of an area suitable for this purpose.

Note D. Assessing Developments in *"Town Cowal Floodway (LEP, 1997)"*

Council recognises that the detailed survey of individual parcels of land in and bordering this area may reveal further inconsistencies between the limits of the ***Town Cowal Floodway*** as zoned in the LEP, 1997 and the Town Cowal Floodway (Hydraulic Categorisation) as shown by the red dashed lines on **Figure C3.1**. In such cases, Council may modify development controls to take into account inconsistencies of flood affectation of the land which may be revealed in the site survey. Council may (at its discretion and with the benefit of additional investigation and data provided by applicants) allow a modification using the following procedure:

- The 1% AEP extent of inundation is to be drawn on the detailed contour survey (the applicant is to base this extent on a survey plan showing natural surface contours at intervals of no more than 100 mm.)
- In recognition that flow velocities in the Floodway are relatively mild, especially near the flood fringe, Council may permit development to intrude a small distance into the Floodway.
- In setting limits for intrusion into the flood fringe, Council would require the width of flow after cumulative development along the Floodway to be no less than 80 per cent of the un-developed width. That is, Council may allow a 10 per cent intrusion into both the Northern and Southern sides of the Floodway, provided that the intrusion does not extend into land which is inundated by more than 500 mm in the

event of a 1% AEP flood. The site survey will need to extend beyond the limits of the area of the particular site as directed by Council, so that the full width of waterway may be defined. In accordance with the requirements of the Floodplain Development Manual, 2005, Council will not evaluate the development in isolation, but in a cumulative manner, as it if was one of several developments along both sides of the Floodway.

3.4 Checking of Completed Finished Floor Height

After the building has been built to the relevant **FPL**, Council officers will check compliance with this requirement at the relevant inspection stage. The applicant is to provide a benchmark on the site, levelled to Australian Height Datum (AHD).

3.5 Fencing

Any proposed fencing is to be shown on the plans accompanying a development application to allow Council to assess the likely effect of such fencing on flood behaviour.

In the ***Town Cowal Floodway*** and ***Manildra Street/River Drive*** precincts, where flow velocities may be significant, fences which minimise obstructions to flow are to be adopted. Where impermeable fences such as Colorbond, galvanised metal, timber or brush are proposed, fencing panels should be either:

a) removable so that panels can be laid flat; or

b) horizontally hinged where a portion of at least 1 m high is capable of swinging open to allow floodwater to pass. Trees/landscaping and other structures are not to impede the ability of a hinged fence to open.

3.6 Other Uses and Works

All other development, building or other works within any of the categories that require Council's consent will be considered on their merits. In consideration of such applications, Council must determine that the proposed development is in compliance with the objectives of this Policy.

3.7 Other Documents Which May Need to be Read in Conjunction with this Plan

- *Narromine Local Environmental Plan 1997;*
- *Relevant Council policies, development control plans and specifications;*
- *Narromine Flood Study, 2006;*
- *Narromine Floodplain Risk Management Study and Plan, 20098;*
- *NSW Government Floodplain Development Manual, 2005;*
- *Ministerial Direction regarding flood prone land (issued 31 January 2007 under Section 117 EP&A Act, 1979).*

3.8 What Information Do You Have to Submit to Council ?

Annexure 4 outlines the requirements for data required by Council to assess its flood affectation.

4 DESCRIPTION OF TERMS

Note: For expanded list of definitions, refer to Glossary contained within the NSW Government's Floodplain Development Manual, 2005.

TERM	DEFINITION
Annual Exceedence Probability (AEP)	The chance of a flood of a given or larger size occurring in any one year, usually expressed as a percentage. For example, if a peak flood discharge of 500 m^3/s has an AEP of 5%, it means that there is a 5% chance (that is one-in-20 chance) of a peak flood discharge of 500 m^3/s or larger occurring in any one year (see average recurrence interval).
Flood Affected Properties	Properties that are either encompassed or intersected by the **Flood Planning Level (FPL).**
Floodplain	Area of land which is subject to inundation by floods up to and including the Extreme Flood event, that is, Flood Prone land.
Flood Planning Level (FPL) (General Definition)	The combinations of flood levels and freeboards selected for planning purposes, as determined in floodplain risk management studies and incorporated in floodplain risk management plans.
Flood Planning Level (for Narromine)	Flood levels selected for planning purposes, as determined in the *Narromine Flood Study, 2006* and referenced in the *Floodplain Risk Management Study 2009* and associated *Floodplain Risk Management Plan*. FPL's for the various land use categories are given in **Sections 3.2** and **3.3** of this Policy.
Flood Prone/Liable Land	Land susceptible to flooding by the Extreme Flood. Flood prone land is synonymous with flood liable land.
Floodway	Those areas of the floodplain where a significant discharge of water occurs during floods. They are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flow, or a significant increase in flood levels. In the Narromine urban area, there are three hydraulic floodway areas; The **Macquarie River Floodway**, the **Town Cowal Floodway** and the **Manildra Floodway.**
Freeboard	A factor of safety typically used in relation to the setting of floor levels, levee crest levels, etc. It is usually expressed as the difference in height between the adopted flood planning level and the flood used to determine the flood planning level. Freeboard provides a factor of safety to compensate for uncertainties in the estimation of flood levels across the floodplain, such as wave action, localised hydraulic behaviour and impacts that are specific event related, such as levee and embankment settlement, and other effects such as "greenhouse" and climate change. Freeboard is included in the **Flood Planning Level.**

TERM	DEFINITION
Freeboard	A factor of safety typically used in relation to the setting of floor levels, levee crest levels, etc. It is usually expressed as the difference in height between the adopted flood planning level and the flood used to determine the flood planning level. Freeboard provides a factor of safety to compensate for uncertainties in the estimation of flood levels across the floodplain, such as wave action, localised hydraulic behaviour and impacts that are specific event related, such as levee and embankment settlement, and other effects such as "greenhouse" and climate change. Freeboard is included in the **Flood Planning Level.**
Intermediate Floodplain	This is defined as the remaining area which is inundated by the 1 % AEP flood and outside the extents of the **Macquarie River Floodway**, the **Town Cowal Floodway** and the **Manildra Street/River Drive Precinct.** In this zone there would still be a significant risk of flood damages, but these damages may be minimised by the application of appropriate minimum floor level and other development controls, as appropriate.
Extreme Flood	The largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation. Generally, it is not physically or economically possible to provide complete protection against this event. The **Extreme Flood** defines the extent of flood prone land, that is, the floodplain.
Outer Floodplain	This is defined as all other land located in the **Floodplain** which lies within the extent of the **Extreme Flood Event** but not lying within the extent of the 1% AEP flood. In this area the risk of damages is low and land uses permitted by the Narromine LEP, 1997 would be permitted, subject to minimum floor level requirements.

ANNEXURE 1
LAND USE CATEGORIES

Essential Community Facilities	Critical Utilities and Landuses	Flood Vulnerable Residential	Residential	Commercial/Industrial	Recreation or Non Urban	Subdivision and Filling	Minor Development and Additions
Commercial premises, Place of Assembly or Public building that may provide an important contribution to the notification and evacuation of the community during flood events; Hospitals; Institutions; Educational establishments.	Telecommunication facilities; Public Utility Installation that may cause pollution of waterways during flooding, or if affected during flood events would significantly affect the ability of the community to return to normal activities after the flood events. Hazardous industry; Hazardous storage establishments.	Group home; Housing for aged or disabled persons; and Units for aged persons; Child care centre.	Dwelling; Residential flat building; Home industry; Boarding house; Professional consulting rooms; Public utility undertakings (other than critical utilities); Utility installation (other than critical utilities); Caravan Park.	Bulk Store; Bus depot; Bus station; Car repair stations; Club; Commercial premises (other than where referred to elsewhere); General store; Health care professional; Hotel; Intensive livestock keeping; Junkyard; Liquid fuel depot; Motel; Motor showroom; Place of Assembly (other than essential community facilities; Place of public worship; Public building (other than essential community facilities); Recreation facility; Refreshment room; Road transport terminal; Rural industry; Service station; Shop; Tourist facilities; Warehouse.	Agriculture; Extractive industry; Forestry; Mine; Plantation forest; Retail nursery; Recreation area; Roadside stall; Stock and saleyard.	Subdivision of land involving the creation of new allotments for any particular purpose (excludes boundary adjustments); Earthworks or filling operations covering 100 m^2 or more than 0.3 m deep.	(a) In the case of residential development: i) an addition to an existing dwelling of not more than 30 m^2 (habitable floor area) or ii) the construction of an outbuilding with a maximum floor area of 20 m^2. (b) In the case of shops and offices. i) new shops with a floor area not more than 50 m^2; or ii) change of use which involves no building. (c) In the case of other development an addition to existing premises of not more than 10% of the floor area which existed at the date of commencement of this policy.

ANNEXURE 2

DEVELOPMENT CONTROLS MATRIX

Outer Floodplain

	Essential Community Facilities	Critical Utilities and Uses	Flood Vulnerable Residential	Residential	Business & Commercial/Industrial	Recreation and Non Urban	Sub-Division	Minor Development and Additions
Floor Level	2	2	2	1	1			1
Building Components	2	2	2	1	1			1
Structural Soundness	2	2	2					
Flood Affectation								
Evacuation	2	2	2					
Management and Design	2,3	2,3	5		3,4	3		

Intermediate Floodplain

	Essential Community Facilities	Critical Utilities and Uses	Flood Vulnerable Residential	Residential	Business & Commercial/Industrial	Recreation and Non Urban	Sub-Division	Minor Development and Additions
Floor Level	2	2	2	1	1			1
Building Components	2	2	2	1	1			1
Structural Soundness	2	2	2					
Flood Affectation							1	
Evacuation	2	2	2					
Management and Design	2,3	2,3	5		3,4	3	1	

[illegible]

	Essential Community Facilities	Critical Utilities and Uses	Flood Vulnerable Residential	Residential	Business & Commercial/Industrial	Recreation and Non Urban	Sub-Division	Minor Development and Additions
Floor Level				1	1			1
Building Components				1	1			1
Structural Soundness				1	1			1
Flood Affectation							1	
Evacuation				1	1		1	
Management and Design					3,4	3	1	

Manildra Street/River Drive

	Essential Community Facilities	Critical Utilities and Uses	Flood Vulnerable Residential	Residential	Business & Commercial/Industrial	Recreation and Non Urban	Sub-Division	Minor Development and Additions
Floor Level				1	1			1
Building Components				1	1			1
Structural Soundness				1	1			1
Flood Affectation							1	
Evacuation				1	1		1	
Management and Design					3,4	3	1	

Town Cowal Floodway (LEP 1997)

	Essential Community Facilities	Critical Utilities and Uses	Flood Vulnerable Residential	Residential	Business & Commercial/Industrial	Recreation and Non Urban	Sub-Division	Minor Development and Additions
Floor Level								1
Building Components								1
Structural Soundness								1
Flood Affectation								
Evacuation								
Management and Design						3		

Macquarie River Floodway

	Essential Community Facilities	Critical Utilities and Uses	Flood Vulnerable Residential	Residential	Business & Commercial/Industrial	Recreation and Non Urban	Sub-Division	Minor Development and Additions
Floor Level								1
Building Components								1
Structural Soundness								1
Flood Affectation								
Evacuation								
Management and Design						3		

Not Relevant   Unsuitable Land Use

Floor Level
1. Floor levels to be equal to or greater than 1% AEP flood level plus 500 mm freeboard.
2. Floor levels to be equal to or greater than 0.5% AEP flood level plus 500 mm freeboard.

Building Components
1. All structures to have flood compatible building components below 1% AEP flood level plus 500 mm freeboard.
2. All structures to have flood compatible building components below 0.5% AEP flood level plus 500 mm freeboard.

Structural Soundness
1. Structure to be designed to withstand the forces of floodwater, debris and buoyancy up to 1% AEP flood plus 500 mm freeboard.
2. Structure to be designed to withstand forces of floodwater, debris and buoyancy up to 0.5% AEP flood plus 500 mm freeboard.

Flood Affection
1. Flood Risk Report required to demonstrate that the development will not increase flood affectation elsewhere.
   Note: When assessing Flood Affectation the following must be considered:
   i. Loss of conveyance capacity in the floodway or areas where there is significant flow velocity.
   ii. Changes in flood levels and flow velocities caused by the alteration of conveyance of floodwaters.

Evacuation
1. Reliable access for pedestrians or vehicles required in the event of 1% AEP flood.
2. Reliable access for pedestrians or vehicles required in the event of 0.5% AEP flood.

Management and Design
1. Applicant to demonstrate that potential development as a consequence of a subdivision proposal can be undertaken in accordance with this Policy and the Plan.
2. Applicant to demonstrate that facility is able to continue to function in event of Extreme Flood Level.
3. No external storage of materials which may cause pollution or be potentially hazardous during Extreme Flood.
4. Where it is not practicable to provide floor levels to 1% AEP plus 500 mm freeboard, applicant is to provide an area to store goods at that level and implement a Business Floodsafe Plan (as published by SES).
5. Where it is not practicable to provide floor levels to 0.5% AEP plus 500 mm freeboard, applicant is to provide an area to store valuable equipment at that level.

ANNEXURE 3

FLOOD COMPATIBLE MATERIALS

Building Component	Flood Compatible Material	Building Component	Flood Compatible Material
Flooring and Sub Floor Structure	• Concrete slab-on-ground monolith construction. Note: clay filling is not permitted beneath slabo-on-ground construction which could be inundated. • Pier and beam construction or • Suspended reinforced concrete slab	**Doors**	• Solid panel with waterproof adhesives • Flush door with marine ply filled with closed cell foam • Painted material construction • Aluminium or galvanised steel frame
Floor Covering	• Clay tiles • Concrete, precast or in situ • Concrete tiles • Epoxy formed-in-place • Mastic flooring, formed-in-place • Rubber sheets or tiles with chemical set adhesive • Silicone floors formed-in-place • Vinyl sheets or tiles with chemical-set adhesive • Ceramic tiles, fixed with mortar or chemical set adhesive • Asphalt tiles, fixed with water resistant adhesive • Removable rubber-backed carpet	**Wall and Ceiling Linings**	• Brick, face or glazed • Clay tile glazed in waterproof mortar • Concrete • Concrete block • Steel with waterproof applications • Stone natural solid or veneer, waterproof grout • Glass blocks • Glass • Plastic sheeting or wall with waterproof adhesive
Wall Structure	Solid brickwork, blockwork, reinforced, concrete or mass concrete	**Insulation**	• Foam or closed cell types
Windows	Aluminium frame with stainless steel or brass rollers	**Nails, Bolts, Hinges and Fittings**	• Galvanised • Removable pin hinges

ANNEXURE 4

SITE SURVEY REQUIREMENTS

Initial Enquiries

Check with Council staff to see whether or not the proposal:

- Is located on Flood Prone Land
- Is permissible in the Flood Risk Precinct and to determine the FPL for the particular category of land use.

A plan showing the location of your site and natural surface contours will assist Council to provide you with initial information.

Survey Required in support of a Development Application

A site survey is to accompany development proposals to confirm the flood affectation of the allotment and its location within the flood risk precinct system.

A Development Application is to include the following flood related site data:

- A plan identifying the location of the property within the floodplain.
- Plan of the existing site layout including the site dimensions, site area, contours (0.10 m intervals or as nominated by Council), existing trees, other natural features, existing structures, north point, location of building (if development involves a building), floor plan showing proposed layout of building, vehicular access.
- Plans should indicate:
  - a) The existing ground levels to Australian height datum around the perimeter of the proposed building; and
  - b) The existing or proposed floor levels to Australian height datum.
- Minor additions to an existing dwelling must be accompanied by documentation from a registered surveyor confirming existing floor levels.
- In the case of a proposed subdivision, the plan is to also show the proposed site layout, the areas of each lot and access roads and the following information.

Extent of Cut and Fill – All areas subject to cut and fill require the depths of both to be shown as well as the measures proposed to retain both. Applications shall be accompanied by a survey plan (with existing and finished contours at 0.10 m intervals) showing relative levels to Australian height datum.

Vegetation Clearing – Landscaping details including a description of trees to be removed existing and proposed planting, retaining walls, boundary fences.

Stormwater Drainage – Any existing and all proposed stormwater drainage to be indicated on the site plan.

Council require plans presented on A3 sheets as a minimum and may require an electronic copy based on the Autocad software for further evaluation.

NARROMINE FLOODPLAIN

RISK MANAGEMENT STUDY AND PLAN

APPENDIX D

EXHIBITS FROM NARROMINE FLOOD STUDY, 2006

MAY 2008

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FIGURES

N

0 200 400 m

Scale

LEGEND

3.50	MIKE11 Node
0.63	1% AEP
1.47	0.5% AEP
1.52	1955 Flood (with 2006 Floodplain)

NOTE:

Depths are in metres

NARROMINE FLOOD STUDY

Figure D3.2

MAXIMUM DEPTH OF INUNDATION
1%, 0.5% AEP AND 1955 FLOOD

NOTE:
Maximum flood levels are to m AHD

0 200 400 m
Scale

LEGEND

3.50 MIKE11 Node
239.54 1% AEP
239.77 0.5% AEP
240.22 Extreme Flood
238.0 Water Surface Elevation Contour

NARROMINE FLOODPLAIN RISK MANAGEMENT STUDY

Figure D3.7

MAXIMUM FLOOD LEVELS AND 1% AEP FLOOD CONTOURS