LOWER SHOALHAVEN RIVER

FLOODPLAIN RISK MANAGEMENT STUDY

MAY 2008

NEXUS ENVIRONMENTAL PLANNING PTY LTD

WEBB, McKEOWN & ASSOCIATES PTY LTD

SHOALHAVEN CITY COUNCIL

LOWER SHOALHAVEN RIVER FLOODPLAIN RISK MANAGEMENT STUDY

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Webb, McKeown & Associates Pty Ltd
Level 2, 160 Clarence Street, SYDNEY 2000
Telephone: (02) 9299 2855
Facsimile: (02) 9262 6208
20035:LShoalFPMSa.wpd

Prepared by: _____

Verified by: _____

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FOREWORD

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

Under the Policy, the management of flood liable land remains the responsibility of local government. The State Government subsidises flood mitigation works to alleviate existing problems and provides specialist technical advice to assist Councils in the discharge of their floodplain management responsibilities.

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

1. *Floodplain Risk Management Committee*
   - formation of an advisory committee comprising representatives of Council, community groups and relevant government agencies.
2. *Data Collection*
   - compilation of existing data and collection of additional data.
3. *Flood Study*
   - determines the nature and extent of the flood problem.
4. *Floodplain Risk Management Study*
   - evaluates management options for the floodplain in respect of both existing and proposed development.
5. *Floodplain Risk Management Plan*
   - involves formal adoption by Council of a plan of management for the floodplain.
6. *Implementation of the Plan*
   - construction or implementation of floodplain risk management measures to protect existing development,
   - use of Environmental Planning Instruments (such as Local Environmental Plans and Development Control Plans) to ensure new development is compatible with the flood hazard.

The Lower Shoalhaven River Floodplain Risk Management Study constitutes the fourth stage of the risk management process. This study has been prepared by Webb, McKeown & Associates for Shoalhaven City Council and provides the basis for the future management of flood prone lands in the Lower Shoalhaven River floodplain.

This study was commenced in 2000. Subsequently there has been a number of changes to policies. A summary of the key changes are provided in Appendix J.

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SUMMARY

The Shoalhaven River catchment covers an area of some 7000 square kilometres with approximately 120 square kilometres of floodplain downstream of Nowra. Terara was the original settlement on the south bank, however, the devastating floods of 1860 and 1870 caused most of the population to move to the higher ground at Nowra with the subsequent decline of Terara. Nowra is now the main centre of population but there are a number of smaller developed centres which exist on the floodplain downstream of Nowra. The majority of the Lower Shoalhaven River floodplain is used for agricultural purposes and contains numerous rural homesteads.

Historical flood records are available since 1860 and the largest floods were 1870, 1873, 1925, 1860, 1916, 1891 and 1978 (in order of magnitude). The flood of April 1870 was probably greater than a 1% Annual Exceedance Probability (AEP) event. It inundated the Terara township by over a metre and swept away approximately one third of the village. Five lives were lost in rural areas along the Shoalhaven River. According to some accounts, the earlier 1860 flood was even more devastating and carried away over 50 buildings. Several lives were lost as well as some 79 acres (32 hectares) of land. More recent significant floods occurred in August 1974, June 1975, October 1976 and March 1978.

Two hundred years ago the main entrance and the natural mouth of the river was at Shoalhaven Heads. This entrance is now intermittent following the construction in 1822 of the Berry's Canal link between the Shoalhaven River and the Crookhaven River, to the south. Shoalhaven Heads is opened by the occurrence of floods and subject to closure by natural onshore oceanic processes. Normal flows presently reach the ocean at Crookhaven Heads, via the man made channel "Berrys Canal", which has a more protected and permanent entrance due to the headland.

This Floodplain Risk Management Study examines flooding issues relating to the floodplain area associated with the Lower Shoalhaven River (Figure 1).

The study was initiated by Shoalhaven City Council (SCC) to address the management of the flood problems of the Lower Shoalhaven River floodplain area. The primary objectives of the Study were to define the nature and extent of the hazard; to identify, assess and optimise measures aimed at reducing the impact of flooding on both existing and future development; and to make recommendations for the future management of the study area.

This Floodplain Risk Management Study builds on the Lower Shoalhaven River Flood Study (completed in April 1990) which defines design flood levels within the floodplain. Once the Management Study is completed and a preferred scheme adopted, an overall Floodplain Risk Management Plan will be prepared.

THE EXISTING FLOOD PROBLEM

Based upon the surveyed floor level database obtained by Council in Jan/Feb 2001 (refer Table D1 of Appendix D), Table (i) indicates the estimated number of buildings likely to be flooded for a range of event magnitudes. The corresponding tangible damages are indicated in Table (ii). Likely damages to public utilities are discussed in Appendix A. No allowance has been made for potential losses through bank collapse or complete destruction of buildings.

Table (i): Buildings Inundated

Area	Extreme	1% AEP	2% AEP	5% AEP	10% AEP
Nowra	104	34	12	5	3
Riverview Road Area	117	7	2	nil	nil
Terara Village	55	44	13	1	nil
Bomaderry	77	33	27	24	11
Shoalhaven Heads	199	134	92	60	39
Greenwell Point	382	350	275	211	137
Orient Point/Crookhaven	207	132	90	64	27
TOTAL	**1141**	**734**	**611**	**365**	**217**

Note: The above assessment is based on the assumed modelling scenario (Flood Study Design Conditions) where the entrance at Shoalhaven Heads is closed at the start of the flood event and allowed to scour out progressively with the passage of floodwaters and surveyed floor level information gathered by Council in Jan/Feb 2001. The building is considered to be inundated if the design flood level is above the surveyed floor level for the property. Includes at least one level at each caravan park.

The average annual tangible damages (AAD) for the Lower Shoalhaven River floodplain are estimated to be of the order of $1.8 million (year 2000 costs). This figure excludes the Riverview Road and Terara Village areas, damages to public property, much of the rural areas and intangible damages. The net present value of these damages (year 2000 costs) is around $25.4 million ($26.6 million including Riverview Road and Terara Village) assuming a 50 year design life at 7% discount rate.

Table (ii): Estimated Flood Damages

Design Flood Frequency	**Damages ($ million)(year 2000 costs)**	
	Entrance Condition at Start of Flood	
	Closed	**Open**
Extreme	47.7 (63.0)	47.1
0.2% AEP	41.8 (54.1)	37.5
0.5% AEP	35.8 (41.1)	30.5
1% AEP	28.2 (30.1)	25.9
2% AEP	21.8 (22.4)	17.5
5% AEP	7.2 (7.3)	3.1
10% AEP	2.6 (2.7)	1.0
Average Annual	**1.8 (1.9)**	**1.2**

Note: ( ) bracketed values include damages for the Terara Village and Riverview Road areas (refer References 5 and 6).

STUDY AREA ISSUES

A range of issues relating to the Lower Shoalhaven Floodplain have been raised, discussed at Council/committee meetings by the community as part of the consultation process, or were outlined in the study brief. These issues include:

- Shoalhaven Heads entrance conditions,
- dredging of the bay area lying between Coolangatta village and Jerry Bailey Road,
- Crookhaven River and Broughton Creek - enlargement of flood mitigation drains and their environmental impact (e.g. removal of wetlands and acid sulphate soils),
- evacuation access to and from Greenwell Point,
- Greenwell Point - subdivision of land categorised as high hazard floodway area, erosion of foreshore,
- insufficient capacity of Bolong Road bridge and Broughton Creek,
- localised flood problems,
- urban expansion areas and associated road infrastructure,
- impact of infill development in the floodplain,
- floodgates and drains,
- acid sulfate soils,
- wetlands, threatened and endangered species,
- flood warning system,
- Bomaderry Creek flood warning,
- access to flood warning information,
- Pig Island - evacuation concerns for present and future owners,
- stock evacuation during floods,
- riverbank erosion,
- siltation in the river,
- stormwater drainage and lack of kerb and guttering.

FLOODPLAIN RISK MANAGEMENT MEASURES

A list of all possible floodplain risk management measures which could conceivably be applied in the study area were developed and provided to the Floodplain Management Committee for information and consideration. The Floodplain Management Committee then considered each measure in terms of their suitability and effectiveness for reducing social, ecological, environmental, cultural and economic impacts. As part of this process, a number of measures were identified as not worthy of further consideration.

A summary of the various measures considered during the course of the study is presented in Table (iii) together with a brief assessment of their viability for implementation as part of the ultimate Floodplain Management Plan for the Lower Shoalhaven River Study area.

Table (iii): Summary of Floodplain Risk Management Measures Considered in the Study

MEASURE	REFER SECTION	PURPOSE	COMMENT	BENEFIT- COST ASSESSMENT	IMPLEMENTATION VIABILITY
FLOOD MODIFICATION:					
SHOALHAVEN HEADS ENTRANCE MANAGEMENT	Section 5.2.1	Formalise management of the entrance conditions to establish if or when the entrance can be opened to allow floodwaters out to the ocean through Shoalhaven Heads and so reduce flood levels for areas immediately upstream.	May lower levels for catchment runoff dominated events but may raise them for ocean dominated events. Previous studies have shown that it is not viable to maintain a permanent entrance. Local community very aware of the problem. A discussion paper (Appendix G) has been prepared outlining the issues. It is essential that some form of entrance management scheme is included in the Plan.	Some 39 properties would benefit in small events (10% AEP). Ongoing maintenance costs and potential environmental issues.	Recommended as an interim measure.
FLOOD MITIGATION DAMS, RETARDING BASINS, OSD	Section 6.2.1	Reduce flows from upper catchment areas.	Tallowa Dam has insufficient storage capacity for flood benefit. Welcome Reef site is unlikely to proceed and few other opportunities available for such measures.	Generally not viable from a purely flooding perspective.	Not appropriate.
FLOODWAYS	Section 6.2.2	Provide a defined overbank area where a significant volume of water flows during floods.	Few opportunities available for such measures.	High capital maintenance and environmental costs typically make this measure impractical.	Not appropriate.
CATCHMENT TREATMENT	Section 6.2.3	Reduce runoff from catchment.	Negligible impact on a large catchment but the general principles should still be applied.	Low if only consider benefits as a reduction in flood levels.	Not appropriate.
RIVER IMPROVEMENT WORKS • Dredging • Realignment • Reconstruction • Remove hydraulic restrictions	Section 6.3.1	Increase hydraulic capacity of the Shoalhaven River to reduce flood levels.	More applicable on smaller rivers. For the Shoalhaven River these measures provide only marginal hydraulic benefit, are not economically viable and would raise significant environmental concerns. • Limited benefit and high cost. • Not applicable • Environmental concerns. • Not applicable. - high cost, - environmental impacts, - limited benefit. A detailed analysis of all these measures was not undertaken due to the high cost, limited benefit and significant environmental damage resulting from these works. These measures are not compatible with best management practice for floodplain management on the Lower Shoalhaven River and have been rejected for inclusion in the Plan.	Relatively minor benefit for significant ongoing costs.	Not generally appropriate.

MEASURE	REFER SECTION	PURPOSE	COMMENT	BENEFIT- COST ASSESSMENT	IMPLEMENTATION VIABILITY
IMPROVED LOCAL DRAINAGE	Section 6.3.2	To reduce the incidence of local runoff ponding in yards and/or streets.	Flooding in this manner does not inundate buildings. Further investigation is a matter for Council and the local residents. Issue should be dealt with as part of Council's Stormwater Management Planning.		Not appropriate as mainstream flood management measure.
LEVEES	Section 6.3.3	Prevent or reduce the frequency of flooding of protected areas.	Viability of levees typically dependent on nature of flooding and physical situation. Can create problems in addition to solving. A number of levee options were considered but typically involve a high economic cost and significant social and environmental consequences. There is some potential opportunity to provide cost effective protection to parts of Greenwell Point but further detailed investigation is required.	Some 137 properties at Greenwell Point could be protected in a 10% AEP event with an estimated B/C of slightly >1.0. In a 1% AEP event up to 350 could be protected for a B/C of around 2.6.	Greenwell Point situation has some potential worthy of further investigation.
FLOOD REFUGE MOUNDS	Section 6.3.4.	Reduce loss of stock in rural areas by raising area of land.	Property owner decision and at their expense. Hydraulic implications need to be considered.	Varies.	Depends on individual property situation.
PROPERTY MODIFICATION:					
VOLUNTARY PURCHASE	Section 6.4.1	Purchase of the most hazardous flood liable properties.	High cost per property. Applicable for isolated high hazard residential buildings but cannot be economically justified to purchase all buildings. It could be considered as a long term means of reducing the number of flood liable buildings.	Costs likely to far outweigh benefits. B/C typically <0.5.	Some potential for up to 203 properties inundated above habitable floor level in 10% AEP.
HOUSE RAISING	Section 6.4.2	Prevent flooding of existing buildings by raising habitable floor levels above the flood level.	All flood damages will not be prevented. House raising may not be practical for social and heritage reasons. Can be expensive.	Costs up to $640K. With approximately $1.25M reduction in AAD. B/C around 2.0.	Some potential for up to 16 properties.
FLOOD PROOFING	Section 6.4.3	Sealing entrances to buildings to minimise ingress of water and reduce the damage.	Flood proofing should be considered. Maybe more beneficial for commercial properties.	Local benefits can be high for nominal cost.	Has some merit for appropriate situations particularly commercial/industrial areas at Bomaderry.
REVIEW AND FORMALISE CURRENT FLOOD POLICY	Section 6.6.1	Formalise Council's Policy with regards to flood prone land.	Council's existing policy needs to be updated in accordance with the guidelines provided in the 2001 Floodplain Management Manual.	Considered to be high.	Recommended.
FLOOD PLANNING LEVELS	Section 6.6.2	Establish Flood Planning Levels to define an area of land subject to flood related development controls.	Provides the means by which Council controls development in flood prone areas.	Future Benefits.	Recommended.
REVIEW AND UPDATE SECTION 149 PLANNING CERTIFICATES	Section 6.6.3	Used to advise owners whether their property is affected by flood related development controls. Update to address latest terminology/approaches and include findings from this study.	A review should be undertaken. It is essential that the words are unambiguous and clearly inform the purchasers of the relevant constraints.	Considered to be high.	Recommended.
REVIEW AND UPDATE LEP AND DCP	Section 6.6.4	Update to include findings from this study.	Council undertaking concurrent initiatives.	Considered to be high.	Recommended.

MEASURE	REFER SECTION	PURPOSE	COMMENT	BENEFIT- COST ASSESSMENT	IMPLEMENTATION VIABILITY
PLANNING REGULATIONS - CARAVAN PARKS	Section 6.6.5	Ensure safe evacuation procedures are in place.	Council's policy needs to be enforced. A risk assessment for all parks should be undertaken.	Considered to be high.	Recommended.
MONITOR FILLING OF THE FLOODPLAIN	Section 6.6.6	Ensure minor development is monitored to minimise significant loss of floodplain storage or adverse impact on flood behaviour.	Minor filling of flood fringe areas of floodplain has shown to have no significant impact on flood levels. However continuous monitoring is required to ensure cumulative fill in the floodplain does not alter local flood behaviour.	Considered to be high.	Monitor.
MONITOR GREENHOUSE EFFECT	Section 6.6.7	To ensure that flood levels do not rise and consequently impact upon minimum floor levels or Flood Planning Levels.	The increase is predicted to be relatively minor but must be closely monitored.	Considered to be high.	Monitor.
RESPONSE MODIFICATION:					
FLOOD WARNING	Section 6.5.1	Enable people to evacuate and reduce actual flood damages.	System currently in place but could be enhanced.	High	Monitor.
EVACUATION PLANNING	Section 6.5.2	To ensure that evacuation can be undertaken in a safe and efficient manner.	The SES has a Local Flood Plan. This could be enhanced to provide more detail on the particular problems at Greenwell Point and Shoalhaven Heads.	Benefits likely to be significant for relatively low costs.	Recommended.
AWARENESS AND READINESS PROGRAM	Section 6.5.4	Educate people to minimise flood damages and reduce the flood problem.	A cheap effective method but requires continued effort. Examples of methods are provided.	Benefits likely to be significant for relatively low costs.	Recommended.

GLOSSARY

Taken from the 2001 Floodplain Management Manual

acid sulfate soils

Are sediments which contain sulfide mineral pyrite. These sediments 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 prepared by the Acid Sulfate Soil Management Advisory Committee (ASSMAC).

Annual Exceedance 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).

Australian Height Datum (AHD)

A common national surface level datum approximately corresponding to mean sea level.

Average Annual Damage (AAD)

Depending on its size (or severity), each flood will cause a different amount of flood damage to a flood prone area. AAD is the average damage per year that would occur in a nominated development situation from flooding over a very long period of time.

Average Recurrence Interval (ARI)

The long term average number of years between the occurrence of a flood as big as, or larger than, the selected event. For example, floods with a discharge as great as, or greater than, the 20 year ARI flood event will occur on average once every 20 years. ARI is another way of expressing the likelihood of occurrence of a flood event.

caravan and moveable home parks

Caravans and moveable dwellings are being increasingly used for long-term and permanent accommodation purposes. Standards relating to their siting, design, construction and management can be found in the Regulations under the Local Government Act, 1993.

catchment

The land area draining through the main stream, as well as tributary streams, to a particular site. It always relates to an area above a specific location.

consent authority

The council, government agency or person having the function to determine a development application for land use under the Environmental Planning and Assessment Act (EP&A Act). The consent authority is most often the council, however there are instances where legislation or an environmental planning instrument (EPI) specifies a Minister or public authority (other than a council), or the Director General of Planning NSW, as having the function to determine an application.

development

Is defined in Part 4 of the Environmental Planning and Assessment Act (EP&A Act).

infill development: refers to the development of vacant blocks of land that are generally surrounded by developed properties and is permissible under the current zoning of the land. Conditions such as minimum floor levels may be imposed on infill development.

new development: refers to development of a completely different nature to that associated with the former land use. For example, the urban subdivision of an area previously used for rural purposes. New developments involve rezoning and typically require major extensions of existing urban services, such as roads, water supply, sewerage and electric power.

redevelopment: refers to rebuilding in an area. For example, as urban areas age, it may become necessary to demolish and reconstruct buildings on a relatively large scale. Redevelopment generally does not require either rezoning or major extensions to urban services.

disaster plan (DISPLAN)	A step by step sequence of previously agreed roles, responsibilities, functions, actions and management arrangements for the conduct of a single or series of connected emergency operations, with the object of ensuring the coordinated response by all agencies having responsibilities and functions in emergencies.
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 for example, metres per second (m/s).
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. The use of sustainability and sustainable in this manual are related to ESD.
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.
flash flooding	Flooding which is sudden and unexpected. It is often caused by sudden local or nearby heavy rainfall. Often defined as flooding which peaks within six hours of the causative rain.
flood	Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or local overland flooding associated with major drainage before entering a watercourse, and/or coastal inundation resulting from super-elevated sea levels and/or waves overtopping coastline defences excluding tsunami.
flood education, awareness and readiness	**flood education** seeks to provide information to raise awareness of the flood problem so as to enable individuals to understand how to manage themselves an their property in response to flood warnings and in a flood event. It invokes a state of flood readiness. **flood awareness** is an appreciation of the likely effects of flooding and a knowledge of the relevant flood warning, response and evacuation procedures. **flood readiness** is an ability to react within the effective warning time.
flood fringe areas	The remaining area of flood prone land after floodway and flood storage areas have been defined.
flood liable land	Is synonymous with flood prone land (i.e. land susceptible to flooding by the probable maximum flood (PMF) event). Note that the term flood liable land now covers the whole of the floodplain, not just that part below the flood planning level, as indicated in the 1986 Floodplain Development Manual (see flood planning area).
flood mitigation standard	The average recurrence interval of the flood, selected as part of the floodplain risk management process that forms the basis for physical works to modify the impacts of flooding.
floodplain	Area of land which is subject to inundation by floods up to and including the probable maximum flood event, that is, flood prone land.
floodplain risk management options	The measures that might be feasible for the management of a particular area of the floodplain. Preparation of a floodplain risk management plan requires a detailed evaluation of floodplain risk management options.
floodplain risk management plan	A management plan developed in accordance with the principles and guidelines in this manual. Usually includes both written and diagrammatic information describing how particular areas of flood prone land are to be used and managed to achieve defined objectives.
flood plan (local)	A sub-plan of a disaster plan that deals specifically with flooding. They can exist at State, Division and local levels. Local flood plans are prepared under the leadership of the State Emergency Service.

flood planning area	The area of land below the flood planning level and thus subject to flood related development controls. The concept of flood planning area generally supersedes the "flood liable land" concept in the 1986 Floodplain Development Manual.
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 "standard flood event" of the first edition of this manual.
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 flood damages.
flood prone land	Is land susceptible to flooding by the Probable Maximum Flood (PMF) event. Flood prone land is synonymous with flood liable land.
flood risk	Potential danger to personal safety and potential damage to property resulting from flooding. The degree of risk varies with circumstances across the full range of floods. Flood risk in this manual is divided into 3 types, existing, future and continuing risks. They are described below. **existing flood risk:** the risk a community is exposed to as a result of its location on the floodplain. **future flood risk:** the risk a community may be exposed to as a result of new development on the floodplain. **continuing flood risk:** the risk a community is exposed to after floodplain risk management measures have been implemented. For a town protected by levees, the continuing flood risk is the consequences of the levees being overtopped. For an area without any floodplain risk management measures, the continuing flood risk is simply the existence of its flood exposure.
flood storage areas	Those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood. The extent and behaviour of flood storage areas may change with flood severity, and loss of flood storage can increase the severity of flood impacts by reducing natural flood attenuation. Hence, it is necessary to investigate a range of flood sizes before defining flood storage areas.
floodway areas	Those areas of the floodplain where a significant discharge of water occurs during floods. They are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flows, or a significant increase in flood levels.
freeboard	A factor of safety typically used in relation to the setting of floor levels, levee crest levels, etc. It is usually expressed as the difference in height between the adopted flood planning level and the flood used to determine the flood planning level. Freeboard provides a factor of safety to compensate for uncertainties in the estimation of flood levels across the floodplain, such 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.
habitable room	**in a residential situation:** a living or working area, such as a lounge room, dining room, rumpus room, kitchen, bedroom or workroom. **in an industrial or commercial situation:** an area used for offices or to store valuable possessions susceptible to flood damage in the event of a flood.
hazard	A source of potential harm or a situation with a potential to cause loss. In relation to this manual the hazard is flooding which has the potential to cause damage to the community. Definitions of high and low hazard categories are provided in the Floodplain Management Manual.
hydraulics	Term given to the study of water flow in waterways; in particular, the evaluation of flow parameters such as water level and velocity.
hydrograph	A graph which shows how the discharge or stage/flood level at any particular location varies with time during a flood.

hydrology	Term given to the study of the rainfall and runoff process; in particular, the evaluation of peak flows, flow volumes and the derivation of hydrographs for a range of floods.
local overland flooding	Inundation by local runoff rather than overbank discharge from a stream, river, estuary, lake or dam.
local drainage	Are smaller scale problems in urban areas. They are outside the definition of major drainage in this glossary.
mainstream flooding	Inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam.
major drainage	Councils have discretion in determining whether urban drainage problems are associated with major or local drainage. For the purpose of this manual major drainage involves: • the floodplains of original watercourses (which may now be piped, channelised or diverted), or sloping areas where overland flows develop along alternative paths once system capacity is exceeded; and/or • water depths generally in excess of 0.3 m (in the major system design storm as defined in the current version of Australian Rainfall and Runoff). These conditions may result in danger to personal safety and property damage to both premises and vehicles; and/or • major overland flow paths through developed areas outside of defined drainage reserves; and/or • the potential to affect a number of buildings along the major flow path.
mathematical/computer models	The mathematical representation of the physical processes involved in runoff generation and stream flow. These models are often run on computers due to the complexity of the mathematical relationships between runoff, stream flow and the distribution of flows across the floodplain.
merit approach	The merit approach weighs social, economic, ecological and cultural impacts of land use options for different flood prone areas together with flood damage, hazard and behaviour implications, and environmental protection and well being of the State's rivers and floodplains. The merit approach operates at two levels. At the strategic level it allows for the consideration of social, economic, ecological, cultural and flooding issues to determine strategies for the management of future flood risk which are formulated into Council plans, policy and EPIs. At a site specific level, it involves consideration of the best way of conditioning development allowable under the floodplain risk management plan, local floodplain risk management policy and EPIs.
minor, moderate and major flooding	Both the State Emergency Service and the Bureau of Meteorology use the following definitions in flood warnings to give a general indication of the types of problems expected with a flood: **minor flooding:** causes inconvenience such as closing of minor roads and the submergence of low level bridges. The lower limit of this class of flooding on the reference gauge is the initial flood level at which landholders and townspeople begin to be flooded. **moderate flooding:** low-lying areas are inundated requiring removal of stock and/or evacuation of some houses. Main traffic routes may be covered. **major flooding:** appreciable urban areas are flooded and/or extensive rural areas are flooded. Properties, villages and towns can be isolated.
modification measures	Measures that modify either the flood, the property or the response to flooding. Examples are indicated in Table 2.1 and further discussion is given in Appendix J of the Floodplain Management Manual.
peak discharge	The maximum discharge occurring during a flood event.

Probable Maximum Flood (PMF)	The largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation. Generally, it is not physically or economically possible to provide complete protection against this event. The PMF defines the extent of flood prone land, that is, the floodplain. The extent, nature and potential consequences of flooding associated with the PMF event should be addressed in a Floodplain Risk Management study.
Probable Maximum Precipitation (PMP)	The greatest depth of precipitation for a given duration meteorologically possible over a given size storm area at a particular location at a particular time of the year, with no allowance made for long-term climatic trends (World Meteorological Organisation, 1986). It is the primary input to the estimation of the probable maximum flood.
probability	A statistical measure of the expected change of flooding (see annual exceedance probability).
risk	Change of something happening that will have an impact. It is measured in terms of consequences and likelihood. In the context of the manual it is the likelihood of consequences arising from the interaction of floods, communities and the environment.
runoff	The amount of rainfall which actually ends up as streamflow, also known as rainfall excess.
stage	Equivalent to “water level”. Both are measured with reference to a specified datum.
stage hydrograph	A graph that shows how the water level at a particular location changes with time during a flood. It must be referenced to a particular datum.
survey plan	A plan prepared by a registered surveyor.
water surface profile	A graph showing the flood stage at any given location along a watercourse at a particular time.
wind fetch	The horizontal distance in the direction of wind over which wind waves are generated.

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1. INTRODUCTION

The Shoalhaven River catchment covers an area of some 7000 square kilometres with approximately 120 square kilometres of floodplain downstream of Nowra (Figure 1). Terara was the original settlement on the south bank, however, the devastating floods of 1860 and 1870 caused most of the population to move to the higher ground at Nowra with the subsequent decline of Terara. Nowra is now the main centre of population but there are a number of smaller developed centres which exist on the floodplain downstream of Nowra. The majority of the Lower Shoalhaven River floodplain is used for agricultural purposes and contains numerous rural homesteads.

This study is primarily concerned with the floodplain areas downstream of the township of Nowra, generally termed the floodplain of the Lower Shoalhaven River.

1.1 The Flood Problem

Historical flood records are available since 1860 and Table 1 lists floods for which some information is available. The largest floods were 1870, 1873, 1925, 1860, 1916, 1891 and 1978 (in order of magnitude). There is still debate about the exact magnitude of these events but according to Reference 1 the 1870 flood was 1.2 m higher than the March 1978 event. Further details are provided in the reference.

Table 1: Historical Flood Events

Month	Year	Month	Year
February	1860	April	1945
June	1864	May	1948
April	1867	June	1949
June	1867	June	1951
March	1870	May	1955
April	1870	February	1956
May	1871	July	1956
February	1873	October	1959
June	1891	March	1961
February	1898	November	1961
July	1899	June	1964
July	1900	September	1967
July	1904	August	1974
January	1911	June	1975
October	1916	October	1976
December	1920	March	1978
July	1922	April	1988
11 May	1925	August	1990
27 May	1925	June	1991
April	1927	8 August	1998
January	1934	19 August	1998
February	1934	October	1999
September	1938	November	2000

Note: Data prior to 1980 were obtained from the *Lower Shoalhaven River Flood History at Nowra Bridge 1860-1980* (Reference 1).

The local newspaper, the "Shoalhaven News", was produced in Terara (the main settlement at the time) in the period 1860-1873 and a good description is available of the eight major floods which occurred in that time. The flood of April 1870 was probably greater than a 1% AEP event. It inundated the Terara township by over a metre and swept away approximately one third of the village and five lives were lost in rural areas along the Shoalhaven River.

> *".....The spot where once stood the post office, the telegraph office, the steam company's store and wharf, where all was life, business and activity, is now one vast vacant blanket and forms part of the Shoalhaven River. The streets turned into innumerable fullies, sand banks and creeks, fences were washed away and the whole formation of the town completely destroyed....."* Quotation taken from Shoalhaven - History of the Shire of Shoalhaven by W A Bailey.

According to some accounts, the earlier 1860 flood was even more devastating and carried away over 50 buildings. Several lives were lost as well as some 79 acres (32 hectares) of land.

A major feature of both these floods was erosion of the river bank. Historical plans indicate the bank may have migrated south by up to 400 m (Reference 2). None of the floods since 1870 have matched these two events for destruction of property or loss of land.

More recent significant floods occurred in August 1974, June 1975, October 1976 and March 1978.

Flood levels have been recorded at Nowra Bridge since approximately 1960, however, despite a rigorous investigation of all available data, the peak level of many historical events are not precisely known. A series of nine automatic water level recorders have now been installed along the river and all future events should be accurately recorded.

Table 2 lists the known or estimated heights of the major historical events and compares them with the design flood levels derived in the Flood Study (Reference 3).

Table 2: Peak Levels of Major Floods (mAHD)

	Historical Events				Design Events (AEP)				
	1860	**1870**	**1974**	**1978**	**5%**	**2%**	**1%**	**0.5%**	**Extreme**
Nowra Bridge	5.5	6.55	4.9*	5.3*	5.3	5.8	6.3	6.8	8.9
Shoalhaven River at Terara	4.8	5.7	4.4*	4.7*	4.8	5.1	5.5	5.8	7.4
Numbaa	U	U	U	3.7#	3.3	3.6	4.1	4.4	6
Shoalhaven Heads (Wharf Rd)	U	U	U	U	2.7	2.9	3.3	3.6	4.2
Greenwell Point	U	U	1.65#	U	2.4	2.9	3.4	3.7	5.2
Orient Point	U	U	U	U	2.2	2.6	3	3.3	4.7
Estimated AEP at Nowra Bridge	3%	0.7%	8%	5%					
Estimated Average Recurrence Interval (ARI) at Nowra Bridge	30 years	150 years	12 years	20 years					

NOTES: * Recorded level taken from the Lower Shoalhaven River Flood History at Nowra Bridge 1860-1980.

E The levels for the 1860 and 1870 floods at Nowra Bridge and in the Shoalhaven River at Terara are estimated as no actual levels were recorded. The levels shown are based on other historical flood data taken from the Lower Shoalhaven River Flood History at Nowra Bridge 1860-1980.

U Unknown

Recorded level in Shoalhaven River Flood Study Compendium of Data.

1.2 Floodplain Risk Management Process

Shoalhaven City Council has commissioned the following studies in accordance with the guidelines of the Floodplain Management Manual (Reference 4):

Stage 1: Flood Study - completed in April 1990 (Reference 3),
Stage 2: Floodplain Risk Management Study initiated August 2000,
Stage 3: Floodplain Risk Management Plan initiated August 2000.

The Flood Study (Stage 1 of the process - Reference 3) established the design flood levels for the study area with selected values presented in Table 2. The “1% AEP” or “1 in 100" flood has a 1 in 100 chance of being equalled or exceeded in any year. On a LONG TERM average it will happen once in every 100 years, but it is wrong to think it can only happen once in a century. Because floods are random events there is still a 1 in 100 chance of the flood occurring next year no matter what happens this year.

The Floodplain Risk Management Study (Stage 2) seeks to fully identify the flood problem in terms of risks to floodplain occupants and their assets, and then to canvass various measures to mitigate the effects of flooding. The end product is the Floodplain Risk Management Plan (Stage 3) which will describe how flood liable lands are to be managed in the future. This process requires community interaction to ensure that the proposals are fully supported. Ultimately Council will complete the process through implementation of the actions identified in the Plan (depending upon financial and other constraints).

1.3 Previous Floodplain Management Studies

Shoalhaven City Council has recently completed (February 2002) specific studies for the village of Terara (Reference 5) and the residential area near Riverview Road (Reference 6). Whilst these areas form part of the present study area, local issues and outcomes contained in these reports have not been repeated in this document.

2. BACKGROUND

2.1 Catchment Description

The Shoalhaven River rises approximately 50km inland of Moruya and follows a northerly direction for 170km before turning east for a further 90km to reach the Pacific Ocean at Crookhaven Heads. The Shoalhaven River has a length of around 332 kilometres from its headwaters to the mouth and a total catchment area of some 7000 square kilometres. Downstream of Nowra, the Lower Shoalhaven River floodplain consists of approximately 120 square kilometres of primarily rural land.

The Shoalhaven catchment can be described in terms of three broad regions:

- upstream of Welcome Reef where the catchment comprises rolling plateau,
- between Welcome Reef and Burrier, where the catchment contains steep forested gorge terrain,
- between Burrier (38 kilometres upstream of Nowra) and the coast (Lower Shoalhaven) it is a typical alluvial floodplain.

The area was first settled in 1822 when Alexander Berry established a settlement at Coolangatta, near the mouth of the Shoalhaven River. Much of the floodplain landscape and areas around Berry (some 12 kilometres to the north of Nowra) has changed from this time as the land was progressively cleared for agriculture and timber getting.

Two hundred years ago the main entrance and the natural mouth of the river was at Shoalhaven Heads. This entrance is now intermittent following the construction in 1822 of the Berry's Canal link between the Shoalhaven River and the Crookhaven River, to the south. Shoalhaven Heads is opened by the occurrence of floods and subject to closure by natural onshore oceanic processes. Normal flows presently reach the ocean at Crookhaven Heads, via the man made channel "Berry's Canal", which has a more protected and permanent entrance due to the headland.

The floodplain for the Lower Shoalhaven River area was formed by the infilling of an old coastal lagoon and flood behaviour in the area has been extensively modified since European settlement. The southern part of the floodplain is drained by the Crookhaven River, which rises near Nowra, while the northern section is drained by Broughton Creek, which rises upstream of Berry. The present river channel is characterised by natural levees along its course and a number of flood mitigation works including drainage channels, floodgates, levee embankments and bank stabilisation works have been constructed to mitigate the impacts of flooding.

The excavation of Berry's Canal has probably had the greatest impact on the riverine system. Firstly it created a second entrance for the Shoalhaven River at Crookhaven Heads but the process also caused significant erosion/sedimentation in the lower reaches. Berry's Canal is now several hundred metres wide and continually expanding whilst the original entrance at Shoalhaven Heads experiences significant sedimentation and only opens every few years. It should be noted however, that the entrance at Shoalhaven Heads was not a permanently open channel at the time of European settlement (Berry dug the canal to create a navigable ocean/river passage). Reference 7 provides further details on this issue and documents historical survey plans and records.

2.2 Description of Study Area

2.2.1 Climate

The study area of the Lower Shoalhaven River Catchment is relatively low in elevation and in close proximity to the coast. This results in generally mild temperatures with an average 15.5°C and 26.5°C for June and January respectively. Rainfall is more pronounced during the summer/autumn months (November to April), with the least rainfall occurring in July, August and September. The average annual rainfall for Nowra is 1110 mm. Both mean monthly temperatures and pan evaporation are highest in the summer months.

2.2.2 Geology and Soils

The geology of the study area is dominated by Permian age sandstones and silt stones. The soils present in the area strongly reflect the underlying geology. Moderate to strongly acidic podsolic are the most commonly found soils, and due to the parent geology, most are of poor nutrient status, with low water holding capacity. The high nutrient status soils of alluvial origin have generally been cleared. Kaolinite is the dominant clay material and humic or organic soils are present in wetland areas peripheral to lagoons and estuaries.

Erosion

Streambank erosion resulting in loss of valuable farmland and increased sedimentation into water bodies is a major concern for the community. Streambank and associated gully erosion in the Southern Tablelands region of NSW is recognised as the primary source of sediments on the Shoalhaven.

A general decline of riparian vegetation that reduces bank stability has exacerbated streambank erosion within the Shoalhaven River catchment. The clearing of vegetation may be partly attributed to farming practices, such as uncontrolled grazing by stock and river access by stock for drinking, rather than off-waterway storage systems. Other causes of erosion include such activities as improper modification of land drainage and changing of streamflow patterns at crossings and the grading of table drains adjacent to roads.

Further details on streambank erosion are provided in Appendix C.

Potential Acid Sulfate Soils (PASS)

Acid sulfate soils contain pyrite (iron sulfide) which when exposed to the atmosphere oxidises to form sulfuric acid. Potential acid sulfate soils are poorly drained and rich in pyrite but are nearly neutral or only slightly acidic in the field. They become acid sulfate soils only when exposed to the air after drainage of the land or excavation.

The occurrence of coastal acid sulfate soils is related to past rising sea levels when marine derived clays, containing sulfur and iron, were deposited in mangroves and estuaries. They are now likely to be found in low lying coastal areas with saline or brackish water such as deltas, coastal flats and backswamps, and in seasonal or permanent freshwater swamps which were previously brackish. A map of the potential acid sulfate soils for the study area is shown on Figure 2. To prevent the formation of acid sulphate soils and prevent affected sites being over drained, a high water table should be monitored and maintained with appropriate drainage management measures.

Clause 27 of Shoalhaven Council's LEP (1985) deals with the issue of potential development on acid sulfate soil areas. This Clause requires Council consent for any development on land identified as having a high probability of ASS which may be exposed through drainage, earthworks or other means.

2.2.3 Land Uses

The land use zoning of the study area (refer Figure 3) generally reflects the soil type and topography. Within the Lower Shoalhaven floodplain, there are five developed centres comprising of residential, industrial and commercial uses (Nowra, North Nowra, Bomaderry, Greenwell Point and Shoalhaven Heads). Almost half of the Lower Shoalhaven River catchment has been cleared for agriculture, with two-thirds of this area cleared for native pasture (grazing) and one third cleared for improved pasture.

The main land use activities comprise of tourism, dairying, fishing, oyster farming and urban development. The growth industries of tourism, building and service sectors are becoming more popular than the traditional primary industries of dairying, timber and fishing. Open space (non agricultural) areas of the study area consist primarily of public gardens, parkland, national parks, urban bushland, buffer zones, creek channels, military training ground, sporting ovals and playgrounds.

The major industrial estates are located at Bomaderry, North Nowra and Nowra. The growth industries of building and services at these locations has provided abundant scope for market expansion.

The water bodies, freshwater streams and estuaries of the Lower Shoalhaven floodplain are currently used for both recreational and commercial activities.

A breakdown of the main land uses on the Lower Shoalhaven floodplain is detailed below in terms of percentage of floodplain area:

- rural 45%,
- National Parks 38%,
- environment protection 12%,
- special uses 1%,
- residential 1%,
- open space 0.8%,
- business and industrial 0.2%.

2.2.4 Ecology

Vegetation mapping by NPWS showed that over 80% of the City of Shoalhaven Local Government Area (LGA) is under natural vegetation cover. Of all the privately owned land in the LGA only 40% is cleared because of the poor and fragile soils present in the area.

The LGA has a diverse fauna and flora and a large number of endemic species. Environmental studies undertaken recently (Reference 8) for the Nowra and Bomaderry area have identified concentrations of endangered fauna and flora above expected levels. The location or distribution of these sites across the study area is indicated on Figure 2. There are 67 fauna and 25 flora species listed under the Threatened Species Conservation Act 1995, and a further 47 plant species listed as Rare or Threatened Australian Plant species. The Little Tern which is found near Comerong Island (between Shoalhaven and Crookhaven Heads) has been identified as a threatened species and Council has developed a management plan which includes a program of fencing, warden patrols, fox baiting and educational measures for protecting its habitat.

Located on the northern side of the Shoalhaven River to Nowra, is an area of high natural beauty and natural value (also known as the Grotto). The cliff line along the river forms a natural barrier between the river foreshore area and the plateau above. The vegetation varies from sandstone heath through to rainforest.

The following sub-sections describe the flora, fauna and aquatic environment.

Flora

Eucalypt forests and woodlands dominate the area with cleared land being prevalent in the alluvial valleys and in regions closer to the coast. Most of the natural vegetation in the urban areas has been cleared for the different types of land uses. The changes to natural vegetation since the arrival of European settlement may be partly inferred from the land use pattern within the region.

Specialised flora and fauna have developed in the rainforests, wetlands, coastal sand dunes and heath areas. The diverse habitats of the beaches, estuaries, wetlands and lakes along the coast make the area important for both wildlife purposes as well as important commercially for recreational and fishing opportunities for the human population. The coastal slopes support a number of wet and dry schlerophyll forest types. The understorey generally consists of ferns, grasses and small shrubs.

Fauna

The fragmentation and isolation of bushland reserves resulting from European settlement and urbanisation, has seen natural areas too small in size and too distant from larger areas to support many indigenous fauna species. The introduction of non-native fauna (e.g cats, foxes and rabbits) which have subsequently turned feral, as well as high rates of companion animal (cat and dog) ownership have resulted in higher levels of predation and increased competition for resources. Although coast dunes, swamp communities and areas dominated by rainforest are small in actual area they contribute a large amount to faunal diversity.

Aquatic Environment

The aquatic environment is an important ecosystem because many organisms live in it or they rely on the numerous habitats that exist beneath and around the water. Aquatic animals often need more than one type of habitat and if one is damaged or destroyed the impact on this animal can be life threatening. Some of the important habitats found in local waterways include:

- seagrasses - often found in shallow, sheltered inshore areas,
- intertidal sand and mud flats - foreshores or intertidal areas provide an important habitat for fish and invertebrates, both as a nursery and for adult species,
- mangroves and other bank vegetation - mangroves and other bank vegetation are generally specially adapted plants. The plant, their roots and fallen branches can provide habitat for fish, birds, molluscs, worms, crustacea, butterflies and other insects,
- the water.

2.2.5 Waterways

The stream morphology of the Shoalhaven River channel downstream of Nowra Bridge has experienced major changes in the period since European settlement. Unfortunately little is known about the morphology prior to this point except from river sediment sampling. These changes include:

- the construction of Berrys Cut in 1822 and the subsequent scouring of Berrys Canal. This has contributed to shoaling of the Shoalhaven Heads entrance and subsequent periodic closure as the main river entrance has shifted to Crookhaven Heads,
- bank recession of up to 700 m has occurred in the vicinity of the confluence of Berrys Canal and the Shoalhaven River over the last 150 years,
- from 1822 to the early 1900's the river was dredged to maintain navigability. Over 1.1 million tons were removed in the period 1893 to 1911. The dredged material was either dumped on Old Man Island or taken out to sea,
- there has been major retreat of the northern river bank (except near the downstream end of Pig Island) with maximum erosion near Broughton Creek,
- Pig Island has increased in width (650 m to 850 m) and in length (1680 m to 2400 m),
- the south channel around Pig Island has migrated to the south-east causing retreat of the Terara foreshore by up to 400 m,
- Numbaa Island may possibly not have existed prior to 1800,
- an 1822 survey plan indicates that the southern bank at Riverview Road has since moved northwards by up to 150 m.

A study by the Public Works in 1988 (Reference 7) could not establish the fundamental reasons why the river morphology in the vicinity of Terara and Nowra has changed since European settlement. Further downstream, much of the change can be attributed to Berry's Cut and the diversion of flow to Crookhaven Heads.

The main agents of erosion are flood scour, tidal scour and wind waves. To some extent the natural processes have been countered by scour protection works, but these works are under increasing pressure as the banks on which they rest are undercut. In places there has been a total loss of some protection works.

Overall the Public Works study (Reference 7) concluded that the rate of river bank erosion is not slowing (except locally where protection works have been employed) and states:

> *"There is no end in sight to the erosion pattern in the study area, necessitating further understanding of the processes and leading to a management strategy that will combine remedial measures (where economically justifiable) with appropriate land use planning. The results of this report should be used in determining set back distances for all developments near river banks (including levees) in the interim period pending the devising of a management strategy."*

It is important that stream morphology is considered in this study as it can affect the mobility of management measures such as riverbank levees or require establishment of building setbacks from the river banks.

2.2.6 Water Quality

Shoalhaven City Council has undertaken extensive monitoring of its waterways in order to better understand the behaviour of ecosystems and identify trends or sources of pollution. This issue is relevant to this study as potentially some management measures (dredging or opening Shoalhaven Heads) have the potential to affect water quality.

The 2000/2001 State of the Environment Report included the results from the water quality monitoring program from 1998 to 2000. The Council developed a method of providing an overall view of the catchment water quality which involved taking a water sample test result for a particular indicator and multiplying it by a weighting. The weighting is based on local experiences and different parameters which are tested locally.

There were five monitoring sites for the Shoalhaven River and three were within the Lower Shoalhaven River floodplain. The three monitoring sites were:

1. near Nowra Sailing Club,
2. at Numbaa Island,
3. at the confluence of the Shoalhaven River and Berrys Canal.

The results of the water quality index for the Lower Shoalhaven River rate in the medium to good range, though they varied over the two year monitoring period. The trend for all the monitoring sites within the Lower Shoalhaven appear to be consistent between sites.

The dissolved oxygen levels for the 1998/2000 monitoring period indicate levels were greater than 50% for the entire period but were only greater than 100% on seven occasions for all three sites. The monitoring site near Numbaa Island (in the middle of the floodplain) appears to have the best results with 80 levels higher than 80%.

The mean faecal coliform level for the three monitoring sites was above the swimming guideline limit of 150 CFU/100 mL for the period of 1998/2000. The middle monitoring site near Numbaa Island had the lowest mean faecal coliform levels at about 180 CFU/100 mL. The other two sites had levels of about 215 CFU/100 mL. These levels only indicate the mean levels for faecal coliforms and therefore there may have been days when the level was well below the 150 CFU/100 mL and other days when the level was extremely high.

The total phosphorus levels were generally below the adopted guideline level of 0.05 mg/L. On two occasions all three monitoring sites recorded levels above 0.05 mg/L. The monitoring site at the confluence of the Shoalhaven River and Berrys Canal (the most downstream site) appeared to be the most vulnerable with two recorded levels noticeably higher than the upstream sites.

The total nitrogen levels were similar to the total phosphorus and tended to be around 0.3 mg/L or less. The adopted guideline level of 0.5 mg/L was only exceeded once in the 2 year recording period.

2.2.7 Urban Stormwater Drainage Systems

The urban stormwater drainage systems adjoining the Lower Shoalhaven comprises a combination of natural creeks and/or pipe systems. Within the highly developed urban areas pipes and channels collect and convey runoff to reduce nuisance flooding. Outside of the urban areas, unlined 'natural' watercourses convey the surface water flow to the creeks and river/estuaries. Shoalhaven City Council has installed some stormwater quality improvement devices within the Lower Shoalhaven River catchment to manage and improve the quality of the stormwater runoff.

In response to a directive by the Environment Protection Agency of NSW, a detailed Stormwater Management Plan (Reference 9) has been prepared by Council to address the various stormwater issues and problems identified within the Shoalhaven City LGA. For the Lower Shoalhaven River floodplain the SMP lists 19 potential management options. These options range from installing additional litter bins to installing litter and sediment traps at the outlet from the underground piped drainage network. The detailed design of these pollutant traps will have to ensure flows in excess of their design capacity can bypass the structure and not cause water to pond or flood upstream. Two of the management options, a grated covering over an open channel in Lyrebird Park and the offline sedimentation basin in the Flinders Industrial Estate will need to consider their effect on flood levels in the immediate area.

2.2.8 Social Characteristics

Population Demographics

The total population of the City of Shoalhaven is approximately 90,000 (2002 estimate), but this population increases by a factor of up to four during holiday periods. The Nowra/Bomaderry area is the major population centre for the city with the remainder largely located along the coastal fringe. The rate of population increase was over 29% since 1991. By 2016 the estimated population will be 113,000.

Community Profile

The permanent population mainly live in the larger urban areas of Nowra and Bomaderry. There are a large number of caravans and “coastal village” holiday homes which make up approximately a third of the residential dwellings for the area. This results in the population increasing significantly during peak holiday periods.

Aboriginal Heritage

Evidence of Aboriginal occupation has been found throughout the floodplain and therefore the floodplain is culturally significant to indigenous people, both physically and spiritually. It is believed that many areas along the banks of the river as well as the tributaries and elevated land above the floodplain may also contain evidence of aboriginal occupation.

After the initial meeting between the European explorers and the Aborigines of the area it appears there was co-operation from both sides. Local Aborigines helped explorers find an overland route between Jervis Bay and the highland settlements. Alexander Berry also revealed, in his writings, that a peaceful and co-operative relationship existed between the settlers and the Aborigines.

It is thought the settlement of the coastal plain and draining of the wetlands had the greatest effect on the Aboriginal population. In the 1890's there were epidemics of Cholera and Typhoid which further reduced the local Aboriginal population. Following this the remaining Aborigines were relocated to Rosebury Park.

More information about the indigenous people and important heritage sites from the area can be obtained from Council.

European Heritage

Items of heritage significance are listed in the Shoalhaven City Council Heritage Study 1995-1998, January 1998 (Reference 10). The types of heritage items include buildings, channels, graves, roads, trees, etc. Their level of significance varies from national to local significance with some provisional items. There are numerous heritage sites scattered across the floodplain and their distribution is indicated on Figure 2. The items are generally located in existing developed areas such as Nowra, Bomaderry, Terara, Coolangatta and Greenwell Point and several items have been identified on Numbaa Island and across the rural areas of the floodplain. Further details regarding the significant heritage sites can be obtained from Council.

These heritage sites have experienced and survived the effects of flooding through the years and as such no specific management measures to protect them are envisaged. However, the implementation of any significant flood mitigation works which may potentially affect these heritage sites would require detailed consideration of the impacts on heritage quality.

2.3 Flood Study Review

The Lower Shoalhaven River Flood Study (Reference 3) was completed in 1990. The draft Compendium of Data (Reference 2) documented the historical flood and other data which were used in the preparation of the Flood Study.

In the Flood Study a computer based hydrologic model, termed the Watershed Bounded Network Model (WBNM), was established for the entire Shoalhaven River catchment. This model converts rainfall input data into estimates of streamflow for use in a hydraulic model (called the CELLS Model) to determine flood behaviour (flood levels, flow distribution and velocities). This hydraulic model covered the lower floodplain area from a point approximately 12 kilometres upstream of Nowra Bridge to the Pacific Ocean at both Shoalhaven Heads and Crookhaven Heads.

Both models were calibrated and verified to data recorded for the flood events of August 1974, June 1975, October 1976, March 1978 and April 1988.

Design rainfall data were obtained from Australian Rainfall and Runoff (1987 edition) and input to the models to produce design flood information for the extreme, 1%, 2% and 5% AEP floods. The extreme flood provides an indication of the likely effects of a Probable Maximum Flood (PMF).

The Flood Study also considered:

- appropriate design ocean levels,
- the effect of the relative timing of the ocean peak and peak discharge,
- the effect of closure of the Shoalhaven Heads entrance and subsequent scouring during the flood,
- variation in adopted width and friction values at the Shoalhaven Heads entrance.

The study concluded that, for a 1% AEP flood, the peak level at Shoalhaven Heads would be 0.75 m higher if the entrance was initially closed rather than open at the beginning of the flood. This difference would reduce to 0.01 m at Nowra Bridge.

The models used in the Flood Study were “state of the art” at the time the investigation work was undertaken (1986 to 1988). Little has changed in hydrologic modelling since that time but a new generation of hydraulic models has appeared. These new models still rely on calibration against historical flood information to produce accurate simulation of flood events. Given the amount of historical data used to calibrate and verify the CELLS Model, it is considered that the application of an “up to date” hydraulic model would not significantly alter the estimated design flood levels for locations where historical levels are available. The results from the Flood Study are therefore considered suitable for use in this Floodplain Risk Management Study.

Design Flood Levels

Design flood levels were established in the Flood Study for the 1%, 2% and 5% AEP events and the extreme event. As part of the present study levels for the 0.2%, 0.5% and 10% AEP design floods were also established using the same models and procedures applied in the Flood Study. Selected peak design levels are shown in Table 3.

Table 3: Selected Design Flood Levels (1) (mAHD)

Flood Location	Extreme	0.2% AEP	0.5% AEP	1% AEP	2% AEP	5% AEP	10% AEP
Nowra Bridge	8.9	7.3	6.8	6.3	5.8	5.3	4.8
Shoalhaven River at Terara	7.4	6.1	5.8	5.5	5.1	4.8	4.4
Numbaa Island	6	4.8	4.4	4.1	3.6	3.3	3
Shoalhaven Heads at Wharf Road	4.2	3.9	3.6	3.3	2.9	2.7	2.5
Greenwell Point	5.2	4.1	3.7	3.4	2.9	2.4	2
Orient Point	4.7	3.7	3.3	3	2.6	2.2	2

Note:
(1) Assumes that the Shoalhaven Heads entrance is closed at the start of the flood event and then scours out with the passage of floodwaters.

It should be noted that the design flows were determined using a rainfall-runoff routing approach, as opposed to a statistical frequency analysis of historical flood records. Therefore, any change in the estimates of the 1860 and 1870 flood levels at Nowra Bridge, or elsewhere, will not alter the design flood results.

The best means of improving the accuracy of the adopted design flood data is by collecting better flood data from future flood events. For this reason a post flood evaluation and review program should be undertaken following each flood and a possible program has been developed and included in Appendix E.

2.4 Review of Existing Policies and Strategies

2.4.1 Council's Interim Flood Policy

Council adopted an interim flood policy in September 1987 which was last revised in August 2002. The main points of the policy are:

- the Flood Planning Level is defined as the 1% AEP flood level plus freeboard,
- the freeboard to the floor levels of habitable rooms of commercial and residential developments is generally 0.5 m in a floodway and 0.3 m elsewhere. Local exceptions to these rules may apply depending on the particular circumstances,
- where the proposed development could be damaged by flooding, the structure is to be suitably designed to meet the guidelines,

- materials used in construction below the minimum floor level are to be compatible with immersion in floodwaters,
- for proposed dwelling extensions, where it is impractical to raise the floor level, the minimum floor level requirement will be treated on its merits,
- creation of new residential lots by subdivision will not be permitted in floodway areas.

The Interim Flood Policy was originally developed following the release of the first NSW Government Floodplain Development Manual in 1986. The latest revision was then initiated as a result of the new Floodplain Management Manual (Reference 4) which was released in January 2001. The amendments to the Policy were mainly of a nominal nature to update terminology references. The general content of the document and its interrelationship with Council's various other planning instruments is therefore becoming dated compared to current trends in Best Practice.

As a result of preliminary findings from this floodplain risk management study process, Council have initiated a number of concurrent actions to update and formalise this interim policy in accordance with the latest Floodplain Management Manual (Reference 4). These actions include the preparation of a specific flood related Development Control Plan (DCP No. 106) and a revision of the Local Environmental Plan (LEP).

Further discussion on Council's flood policy is provided in Section 5.2.15 and Section 6.6.1.

2.4.2 Council's Existing Planning Instruments and Related Documents

Over the years, Council has developed and implemented a wide range of planning instruments, policies/strategies and related documents to deal with developments in flood lands. As this process has been of a gradual nature and often driven by changing regulations or development needs, the resulting documents are becoming increasingly out of date, disjointed and often conflicting. The various documents as they pertain to floodplain management were critically reviewed from a planning perspective in the initial stages of this study, the outcomes of these findings are summarised by the discussion paper included in Appendix F. It should be noted that these findings were an early input to the study process which identified a number of problems or issues to be addressed. As this is an iterative process, these findings are largely outdated or superseded by the subsequent steps and measures initiated by Council to address the problems identified. Further discussion of this issue is presented in Section 6.6.

This Floodplain Management Study will provide recommendations to ensure that Council's planning instruments and local policies for development on flood prone land is consistent with contemporary Best Management Practice and the principles outlined in the NSW Government's Floodplain Management Manual (Reference 4).

3. EXISTING FLOOD PROBLEM

3.1 Flooding Mechanism

Flooding within the Lower Shoalhaven floodplain can result from any or all of the following:

- flow from the Shoalhaven River catchment,
- backwater flooding from the floodplain (e.g. Worrigee Swamp) which initially occurs as a result of local runoff but in larger events is augmented by flow over the river bank elsewhere,
- overbank flooding from Broughton Creek,
- local flooding at the Shoalhaven Heads township,
- ocean waves penetrating through the two entrances (Shoalhaven Heads and Crookhaven Heads).

The relative effects of these mechanisms depends on the prevailing meteorologic conditions (influence of regional storm cells), volume of flow in the river, the local rainfall and the nature of the entrance at Shoalhaven Heads. The extent of flooding in the vicinity of Nowra and Bomaderry is predominantly influenced by the volume of runoff from the upper catchment as well as local rainfalls. Flooding of the lower reaches at Shoalhaven Heads, Greenwell Point and Orient Point is more influenced by entrance and ocean conditions in conjunction with the volume of flow down the river. Similar peak flood levels could be attained by either adverse entrance/ocean conditions with a moderate catchment flow or alternatively, a large catchment flow with favourable entrance/ocean conditions.

3.2 Hydraulic Classification

The Floodplain Management Manual (Reference 4) defines three hydraulic categories which can be applied to define different areas of the floodplain. The hydraulic categories are to be used for assessing the potential suitability of future types of land use and areas of possible development, rather than the assessment of individual or isolated development proposals. The hydraulic categories of flood prone land include:

> "*Floodways* are 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."
>
> *"Flood storage* areas are those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood. The extent and behaviour of flood storage areas may change with flood severity, and loss of flood storage can increase the severity of flood impacts by reducing natural flood

attenuation. Hence, it is necessary to investigate a range of flood sizes before defining flood storage areas."

"Flood fringe areas are the remaining area of flood prone land after floodway and flood storage areas have been defined."

The above hydraulic classifications have been applied to the Lower Shoalhaven floodplain based on a detailed assessment of flood behaviour, the available topographic information and interpretation of model results from the Flood Study (Reference 3). An overview of the classifications for the floodplain study area is indicated on Figure 4 and shown in greater detail for the main existing development areas on Figures 4a to 4d. These maps have been prepared on a broad scale and are of a qualitative nature which incorporates consideration of a number of factors as outlined above. Therefore, they should only be relied on for a general indication of the classification. The classifications are based on the existing topographic information and technology available at the time of the study in order to indicate the main flow paths and areas which have surface levels below the Flood Planning Level (1% AEP flood level plus 0.5 m freeboard). There can be some variation in the hydraulic classification depending upon the size of the flood. As such, it is quite possible that a more detailed assessment of individual locations may suggest a different classification is applicable. Under these circumstances it is recommended that the situation be reviewed in light of any more detailed information and considered on its merits.

3.3 Flood Hazard Classification

Flood hazard is a measure of the overall adverse effects of flooding and the risks they pose. It incorporates threat to life, danger and difficulty in evacuating people and possessions and the potential for damage, social disruption and loss of production. Land is typically classified as either *low* or *high* hazard for a range of flood events.

The hazard classification for a given area is partially a qualitative assessment based on a number of factors as summarised in Table 4 and discussed in detail below. The accompanying Figure 4 and Figures 4a to 4d define the low and high hazard classifications for the Lower Shoalhaven River floodplain resulting from such an assessment.

The following hazards have been identified:

- **High hazard floodway** - areas where a significant volume of water flows during floods with high velocities and large depths.
- **High hazard flood storage** - those parts of the floodplains that are important for temporary storage of floodwaters, floodwaters tend to rise slowly, have low velocities but large depths.
- **High hazard flood fringe** - these areas comprise the beach and back dune areas. During a large flood it is possible that floodwaters will overtop these areas and the

area may become a Floodway. These areas can also be affected by wave runup action from the ocean.

- **Low hazard flood storage** - as for high hazard flood storage except depths and velocities tend to be less.
- **Low hazard flood fringe** - those remaining areas of land affected by flooding after the floodway and flood storage areas have been defined.

In events larger than the 1% AEP some areas of low hazard will become high hazard. It is also possible that some areas not flooded in the 1% AEP event will become high hazard areas in the Extreme or PMF event. These will only occur at the limits of the high hazard area and accurate identification of these areas would require additional survey data. In events smaller than the 1% AEP there may be a decrease in the area of high hazard. Again, additional survey is required to more accurately define these areas.

Table 4: Flood Hazard Classification

Criteria	Relative Weighting	Comment
Size of the Flood	Medium-High	Up to a 10% AEP event there is generally little inundation from the Shoalhaven River except around Greenwell Point. In the 5% AEP event the majority of the floodplain is inundated.
Flood Awareness of the Community	Medium	Based upon the results of the questionnaire.
Depth and Velocity of Floodwaters	High	Velocities will be high (over 2 m/s) near the river bank but will reduce to approximately 1 m/s or less across the overbank areas of the floodplain. Across the majority of the floodplain the depth of inundation in a 1% AEP will be above 2 m.
Effective Warning and Evacuation Times	Medium	The existing ALERT system should provide adequate warning. The exact amount of warning time will depend upon: • the rainfall intensities, • the amount of preceding rain, • the ability of the system to make accurate predictions, • the ability of the duty personnel to disseminate the available information, • the awareness of the community to respond to the warnings. Each flood is different and there is insufficient information to provide a reliable estimate of the actual warning time in a future flood event.
Rate of Rise of Floodwaters	Low	Residents will be aware that the river is rising but may be surprised at how rapidly the floodplain becomes inundated following overtopping of the river banks.
Duration of Flooding	Medium	The duration of inundation for the design flood event is of the order of 20 hours and the flood will generally recede in approximately two days. Residents/properties could therefore be isolated for a reasonable period.
Effective Flood Access	High	The access routes generally present no unexpected hazards but many will only be passable for vehicular traffic up to approximately a 10% AEP event.

Criteria	Relative Weighting	Comment
Evacuation Difficulties	High	These are likely to be high for many areas on account of: • many of the key roads joining the different settlement areas are relatively low lying and therefore can be cut early in a flood event, • the distance to high ground can be significant, • the emergency services (SES, Police) will be "stretched" answering calls throughout the area.
Additional Concerns such as Bank Erosion, Debris, Wind Wave Action	Medium - Low	There are likely to be a number of additional concerns which will increase the potential hazard. Probably the most significant is bank collapse, as occurred in the floods of 1860 and 1870 at Terara. Debris and wind wave action will also cause damage to structures and increase the risk to life.

Size of Flood

The severity of the flood hazard is largely related to the relative size of the event. Relatively low flood hazard is generally associated with frequent, minor floods while rare major floods are more likely to present high hazard situations. A flood hazard is usually assigned based on a specific flood event such as the Flood Planning Level or other event of note. The 1% AEP flood event is most commonly used as a base for planning and FPM purposes.

For the Lower Shoalhaven floodplain, the 10% and 5% AEP flood events would only produce low to medium hazard conditions for the majority of affected areas. The 1% AEP flood would generally present greater hazard classifications and was therefore adopted as the basis for the overall mapping presented on Figure 4.

For the purposes of this mapping exercise and to assist delineation of the extent of the floodplain area incorporated within the Flood Planning Area, the extent of hydraulic and hazard mapping actually portrays the outer limit of the proposed main Flood Planning Level (1% AEP flood level plus 0.5 m freeboard). An indication of the relative extent of the Extreme flood is also shown to complete the picture and provide some guidance on the maximum extent of land potentially susceptible to flooding (Flood Prone Land).

As with the hydraulic classification, these figures provide a broad indication of potential hazard only. A more detailed assessment of a specific localised area may reveal some differences. In events larger than the 1% AEP some areas of low hazard will become high hazard. It is also possible that some areas not flooded in the 1% AEP event will become high hazard areas in the Extreme or PMF event. These will only occur at the limits of the high hazard area and accurate identification of these areas would require additional survey data. In events smaller than the 1% AEP there may be a decrease in the area of high hazard. Again, additional survey is required to more accurately define these areas.

Flood Awareness of the Community

A flood aware community will be wise to the dangers of flooding and also possibly be well prepared with measures and plans in place to deal with the recurrence of flood events. Based on the responses to the questionnaire (Diagram 1 of Section 4.2), the local floodplain community generally consider themselves to be well aware of the flooding issues in their area because these areas are low lying and have previously experienced flood events considered as minor to moderate. Since a large (say 1% AEP or greater) flood has not occurred in recent living memory, the community may not be fully aware of the potential implications (depths and velocities) or possible extent of flooding. Large flood events will affect more people and more areas in a variety of ways and it is unlikely that any of the local residents have a true appreciation or feel for what to expect or how to respond in a major flood. General Community Awareness also tends to decrease as the time between flood events increases.

Additionally, as discussed in Section 2.2.8 the area is also a popular tourist/holiday destination with the potential for a significant temporary increase in population. Many of these "visitors" are very unlikely to have been exposed to previous flood events in the area or be aware of any local evacuation/response measures and procedures.

The average level of awareness for the overall Lower Shoalhaven floodplain community is expected to be moderate at best and the hazard categorisation presented in Figure 4 has taken this into consideration, particularly for Greenwell Point and Shoalhaven Heads.

Depth and Velocity of Floodwaters

The flood hazard classification is often determined on the basis of the predicted flood depth and velocity. A high flood depth will generally cause a hazardous situation while a low flood depth may only cause a minor inconvenience but these are dependent on the corresponding velocity being experienced.

For the Lower Shoalhaven floodplain the flood depth is generally the more dominant factor as velocities are mostly not that high in the overbank areas. The hazard (and hydraulic) classifications are therefore primarily dependent on the existing ground level and distance from the waterway, which varies 0 to 3 km away from a waterway. Some of these areas are inundated up to 1 metre above ground level, with velocities up to 1 m/s. The resulting hazard classifications are shown on Figure 4 and Figures 4a to 4d for more detail in key areas.

A comparison of historical and design velocity results obtained from the model established for the Lower Shoalhaven River Flood Study (Reference 3) are presented in Table 5.

Table 5: Comparison of Modelled Historical and Design Flood Velocities

Ref. No.	Location	Velocity (m/s)				
		1978#	1% AEP	2% AEP	5% AEP	10% AEP
1	Nowra Bridge	3.3	4.7	4.0	3.3	2.7
2	Bomaderry	0.1	0.3	0.2	0.1	0.1
3	U/s Numbaa	0.3	0.4	0.3	0.3	0.3
4	Brundee	0.9	0.9	0.8	0.7	0.8
5	Comerong Ferry	0.7	1.0	1.0	1.0	0.9
6	Shoalhaven Heads (Wharf Rd)	2.3	2.2	2.0	1.6	1.2
7	Greenwell Point	0.5	0.5	0.5	0.4	0.4

Note: Refer to Figure 1 for location of model gridpoints.
Results from model with 1978 inflow hydrographs.

Effective Warning and Evacuation Times

The effective flood warning time is dependent on the rate at which floodwaters rise, the efficiency of the flood warning system, and the awareness and promptness of the community to act. In small catchments floodwaters tend to rise and peak not long after the peak rainfall burst and will then subside relatively quickly. Larger catchments like the Shoalhaven River respond to rainfalls more gradually with the flood peaks occurring more slowly with the accumulation of larger volumes of runoff.

The flood levels experienced on the Lower Shoalhaven floodplain tend to rise and fall relatively slowly as indicated by the stage hydrographs for the design flood events included in Appendix H at the locations indicated on Figure 1.

An indication of catchment response or available warning times is presented in Table 6 for the 1% AEP 36 hour design event (refer Appendix H) as well as the historical 1978 flood (Reference 1). It should be noted that design events are based on theoretical peak storm bursts and as such are more likely to be conservative estimates compared to conditions associated with actual or historical flood events. This issue can have significant implications for flood planning and response. It is even of greater concern for areas protected by levees, such as at Riverview Road, Nowra where the level of assumed protection may be compromised by different flood behaviour conditions. Different hydrograph shapes (i.e. those of a similar size peak but different volumes and/or rates of rise) can affect the flood gradient and consequently the location and/or sequence in which the levee may be overtopped. This issue has been specifically investigated with more details provided in Reference 11.

Table 6: Comparison of Catchment Response/Warning Times

Ref. No. (1)	Location	Time to Peak Water Level (2)	
		1% AEP 36h Design Event	1978 Flood
1	Nowra Bridge	20 hrs	31 hrs
2	Bomaderry	22 hrs	36 hrs
3	U/s Numbaa	23 hrs	36 hrs
4	Brundee	23 hrs	36 hrs
5	Comerong Ferry	25 hrs	34 hrs
6	Shoalhaven Heads (Wharf Road)	24 hrs	30 hrs
7	Greenwell Point	25 hrs	38 hrs

Notes:
(1) Refer Figure 1 for location of model results.
(2) Times taken from the average peak rainfall burst. Refer Figure H1 of Appendix H for 1% AEP design stage hydrographs.

As discussed in Section 6.5.1 there is an ALERT flood warning system for the Lower Shoalhaven floodplain and the SES has emergency evacuation procedures in place. Warning systems are typically more effective for areas such as this where the rate of rise of the floodwaters is slow enough to allow sufficient time for the evacuation plan to be implemented. The flood warning system may therefore be beneficial in reducing damages in the Bomaderry, Shoalhaven Heads and Orient Point foreshore areas but would not be as effective, to the Greenwell Point area where the access road may be cut relatively early in an event.

Rate of Rise of Floodwaters

The rate of rise of floodwaters is generally related to the catchment size, but it is also influenced by the catchment slope, soil types and land use. The rise in level at Nowra Bridge where the floodplain is effectively constricted between the river banks may occur relatively quickly. Whereas for the Shoalhaven Heads and Greenwell Point areas, the rise experienced is delayed, taking a relatively long time as the expansive storage areas of the overall floodplain are filled. An indication of the rate of rise at several key locations within the study area is shown by the comparison of 1% AEP Design stage hydrographs on Figure H1 in Appendix H. A detailed study into the effects of different rates of rise on the Riverview Road Levee at Nowra (Reference 11) provides more insight into this issue.

Duration of Flooding

The greater the duration of flood inundation the greater the disruption to the community and the potential impacts on damages (particularly where rural/agricultural damages are involved). The duration of inundation is closely related to the duration and size of the storm event over the catchment.

For the Lower Shoalhaven floodplain, the critical 1% AEP flood event was estimated to be caused by the 36 hour storm (Figure H1) due to the overall volume of runoff produced by the catchment and the accumulated peak flow. These longer duration storm events would typically result in the duration of flooding being of the order of some 2 to 3 days depending on prevailing ocean/entrance conditions.

The comparison of stage hydrographs presented in Appendix H provides an indication of the durations for which flooding may be experienced at different levels for a range of design flood events. Table 7 provides a summary of the estimated periods that floodwaters are above a specified level. For example, at Nowra Bridge flood levels are expected to be at or above RL4.0 mAHD for up to 24 hours in the 1% AEP 36 hour design event (Figure H1). In the historical 1978 event the corresponding duration of inundation was just over 30 hours (refer Reference 3).

Table 7: Approximate Period of Inundation

Ref. No.	Location	Critical Level *	Time to Critical Level after Critical Level Reached at Nowra Bridge (hrs)					Period of Flood Level above Critical (hrs)				
			Extreme	1% AEP	2% AEP	5% AEP	10% AEP	Extreme	1% AEP	2% AEP	5% AEP	10% AEP
1	Nowra Bridge	3.0	n/a	n/a	n/a	n/a	n/a	>24hrs	>24hrs	>24hrs	>24hrs	>24hrs
2	Bomaderry	3.6	~5hrs	5hrs	~6hrs	~8hrs	level not reached	>25hrs	~24hrs	~20hrs	~14hrs	#
3	U/S Numbaa	2.0	<1hr	<1hr	<1hr	<1hr	<1hr	>26hrs	>24hrs	>24hrs	>24hrs	>24hrs
4	Brundee	2.5	~4hrs	~5hrs	~5hrs	~6hrs	~7hrs	>27hrs	>24hrs	~24hrs	~18hrs	~15hrs
5	Comerong Ferry	1.8	0	-2hrs	0	<1hrs	<1hr	>28hrs	>24hrs	~24hrs	~24hrs	~20hrs
6	Shoalhaven Heads	2.0	<1hr	0	<1hrs	<1hrs	<1hr	>29hrs	~24hrs	~24hrs	~22hrs	~21hrs
7	Greenwell Point	1.5	~1hr	~7hrs	~4hrs	~7hrs	#	>30hrs	~24hrs	~18hrs	~9hrs	#

Notes: Refer to Figure 1 for locations.

n/a Not applicable.

Area not inundated at this level.

* Corresponding level at Nowra Bridge.

Critical Level at Bomaderry - Approximate lowest level of floor in residential building in Bomaderry.

U/S Numbaa - Ground Level.

Brundee - Approximate level of Greenwell Point Road in area.

Comerong Ferry - Level when ferry service withdrawn.

Shoalhaven Heads - Approximate level at which inundation of Hay Avenue commences.

Greenwell Point - Approximate level at which inundation of several houses has commenced.

These figures are indicative and based on a design flood and may differ significantly from an actual flood event.

Evacuation Access

Access and evacuation difficulties arise from:

- high depths and velocities of floodwaters over access routes,
- difficulties associated with wading (uneven ground, obstructions such as fences),
- the distance to higher, flood free ground,
- number of people and vehicular capacity of evacuation routes,
- inability to contact or communicate with evacuation and emergency services,
- availability of suitable equipment (rescue boats, heavy trucks, etc.),
- poor community awareness of evacuation procedures, and/or unwillingness to leave properties in sufficient time,
- poorly planned development areas.

Within the Lower Shoalhaven floodplain there are several locations which are likely to require evacuation:

- flood prone rural properties spread across the floodplain,
- properties located on Numbaa, Pig and Comerong Islands,
- flood prone properties around the fringes of the floodplain including those at Orient Point, Culburra and near Nowra,
- the industrial area of Bomaderry,
- low lying properties of Greenwell Point,
- parts of Shoalhaven Heads.

Generally speaking there is plenty of warning and opportunity for properties around the fringe of the floodplain to evacuate to higher ground. Additionally, these areas are only exposed to a nominal risk or hazard in the larger events.

Access to those properties situated within the floodplain proper or to the outlying settlements of Greenwell Point, Shoalhaven Heads and Terara can become completely cut off or isolated in the smaller flood events or relatively early in the larger events.

In many instances, people may be unaware that the road is cut further along the route and may even become trapped if the road is then cut at some point behind them. Key road levels along the main access routes across the floodplain is presented in Table 8 and shown on Figure 8.

Table 8: Critical Levels for Evacuation Access

Route (refer Figure 8 for sites)		Min. RL (mAHD)	Location	Time (hrs) to Min. RL (1% AEP Event)
Bolong Road	A	3.22	1000 m west of Hanigans Lane	15
	B	2.14	2200 m east of Hanigans Lane	12
	C	1.34	1200 m west of Broughton Ck Bridge	7
	D	1.59	Bend near Edward Wollstonecraft Lane	3
Shoalhaven Heads	E	1.60	Shoalhaven Heads Road	5½
Terara Road	F	2.87	400 m east of Ferry Lane	16
Comerong Island Road	G	2.41	800 m east of Millbank Road	11½
	H	1.88	800 m west of Jindy Andy Lane	10½
Jindy Andy Lane	I	1.22	700 m south of Comerong Island Road	13½
	J	1.16	100 m north of Greenwell Point Road	13½
Greenwell Point Road	K	1.46	600 m west of Mayfield Road	14
	L	1.48	Jindy Andy Lane intersection	14
	M	1.60	Stratherick Lane	15
Adelaide Street	N	1.08	Between Church Street and West Street	~1½ (12)
Haiser Road	O	1.23	Intersection with Keith Avenue	~2½ (13)
	P	1.04	Southern end Haiser Road	~2 (12)
Greens Road	Q	1.17	Southern end of Greens Road	~2½ (13)
	R	1.15	Intersection with Leonore Avenue	~2½ (13)
Fraser Road	S	1.12	Midway along	~2½ (13)

Notes:

(1) This is the approximate time from a water level of RL 1.0 mAHD at the Nowra Bridge gauge till water begins to inundate the road low point. The road may still remain trafficable for some time after this depending on the rate of rise of floodwaters.

(2) Many of the above road low points will be inundated before the critical SES trigger level of 3.0 mAHD is reached at Nowra Bridge.

(3) Times will vary from flood to flood depending on the volume and rate of runoff, local catchment runoff and the ocean/tide conditions for lower reaches.

(4) For the 5% AEP and small events an accurate estimate of timing is not possible as it will depend upon the extent of local catchment runoff.

(5) ~ indicates the time until inundation from elevated ocean levels. A value in brackets indicates the time until a second peak due to river flooding.

The township of Greenwell Point (refer Photograph 3) experiences access and evacuation difficulties in as little as the 10% AEP design event and greater. Survey of Greenwell Point Road found approximately 5.7 km of the road below or equal to a level of 2 mAHD (refer Figure 8). The 10% AEP flood levels are generally above this level. Greenwell Point Road is the only access route for Greenwell Point and closure of this road can occur relatively early in a flood event, resulting in the whole town (developed area) becoming isolated from Nowra and any essential services it provides. As a consequence, the hazard classification for this area has been increased even though depths and velocities are not always high and some warning may be available.

While the development located on high ground in the middle of the township may be flood free the only access to or from the area would still be cut. The residents of all these properties will still be isolated for extended periods of time (possibly days). Such a situation would not directly endanger the residents but could leave them without power, water or sewer, as well as access to food or medical supplies without the need for third party intervention. Evacuation of these properties is not as critical as the surrounding areas which are directly flood affected, but

measures need to be enacted early in the event to facilitate evacuation from the area or those electing to stay should have sufficient supplies available.

3.4 Flood Damages

The quantification of flood damages is an important part of the floodplain risk management process. By quantifying flood damages for a range of design events, appropriate cost effective management measures can be analysed in terms of their benefits (reduction in damages) versus the cost of implementation.

The extent of disruption to the community and overall cost of flood damages depend upon many factors which include:

- the magnitude (depth, velocity and duration) of the flood,
- land usage and susceptibility to damage,
- awareness of the community to flooding,
- effective warning time,
- the availability of an evacuation plan or damage minimisation program,
- physical factors such as erosion of the river bank, flood borne debris, sedimentation.

The estimation of flood damages tends to focus on the physical impact for the human environment in the floodplain but there is also a need to consider the ecological costs and benefits associated with flooding of the floodplain. Flood damages are often defined as being “tangible” or “intangible”. Tangible damages are those for which a monetary value can be assigned. This is in contrast to intangible damages which cannot easily be attributed a monetary value. Intangible damages include emotional distress for humans and loss of habitat for wildlife (fast flowing floodwaters can scour out the creeks and remove vegetation and debris which once acted as shelter and a source of flood for aquatic wildlife). Further discussion on the various types of damage with details of how the costs were calculated for this study is included in Appendix A.

Based upon the surveyed flood level database obtained by Council in Jan/Feb 2001 (refer Table D1 of Appendix D), Table 9 indicates the estimated number of buildings likely to be flooded for a range of events. The corresponding tangible damages are indicated in Table 10. Likely damages to public utilities are discussed in Appendix A. No allowance has been made for potential losses through bank collapse or the complete destruction of buildings.

Table 9: Buildings Inundated

Area	Extreme	1% AEP	2% AEP	5% AEP	10% AEP
Nowra	104	34	12	5	3
Riverview Road Area - comprises approx. 190 buildings	117	7	2	nil	nil
Terara Village - comprises approx. 55 buildings	55	44	13	1	nil
Bomaderry	77	33	27	24	11
Shoalhaven Heads	199	134	92	60	39
Greenwell Point	382	350	275	211	137
Orient Point/Crookhaven	207	132	90	64	27
TOTAL	**1141**	**734**	**511**	**365**	**217**

Note: The above assessment is based on the assumed modelling scenario (Flood Study design conditions) where the entrance at Shoalhaven Heads is closed at the start of the flood event and allowed to scour out progressively with the passage of floodwaters (includes at least one level at each caravan park).

The standard way of expressing flood damages is in terms of Average Annual Damages (AAD). These are calculated by multiplying the tangible damages that can occur in a given flood by the probability of the flood occurring in a given year and then summing across the range of floods. By this means the smaller floods, which occur more frequently, are given a greater weighting than the rare catastrophic floods.

Based on the damages estimated for the different flood events, the AAD for the Lower Shoalhaven River floodplain are estimated to be of the order of $1.8 million (year 2000 costs) as shown in Table 10. This figure excludes the Riverview Road and Terara Village areas, damages to public property, much of the rural areas and intangible damages. The net present value of these damages (year 2000 costs) is around $25.4 million ($26.6 million including Riverview Road and Terara Village) assuming a 50 year design life at 7% discount rate.

Table 10: Estimated Flood Damages (year 2000 costs)

Design Flood Frequency	Damages ($ million)	
	Entrance Condition at Start of Flood	
	Closed	Open
Extreme	47.7 (63.0)	47.1
0.2% AEP	41.8 (54.1)	37.5
0.5% AEP	35.8 (41.1)	30.5
1% AEP	28.2 (30.1)	25.9
2% AEP	21.8 (22.4)	17.5
5% AEP	7.2 (7.3)	3.1
10% AEP	2.6 (2.7)	1.0
Average Annual	**1.8 (1.9)**	**1.2**

Note: ( ) bracketed values include damages for the Terara Village and Riverview Road areas (refer References 5 and 6).

Given the variability of flooding and property values, etc., the total likely damages figure in any given flood event (as shown in Table 10) is useful to get a "feel" for the relative order of magnitude of the overall flood problem, but is of only limited value for precise economic evaluation. When considering the economic effectiveness of a proposed mitigation option, the key question is the total damages prevented over the life of the option. This is a function of not only the high value damages which occur in the larger less frequent floods but also of the lesser but more frequent damages which occur in small floods.

An indication of the average annual damages apportioned to the different areas of existing development on the Lower Shoalhaven River floodplain is provided in Table 11. Clearly, the worst affected area is at Greenwell Point followed by Bomaderry and Shoalhaven Heads. The most significant contributing factor to the problems at Greenwell Point and Shoalhaven Heads is the number of properties (and consequent damages) flooded in the 10% AEP event. At Bomaderry a major proportion of the damages is incurred in the 2% AEP and greater events due to the inundation of the industrial development and in particular several large operations such as the Paper Mill, Manildra and Dairy Farmers.

Table 11: Geographical Apportionment of Average Annual Flood Damages

Area	Average Annual Damages (year 2000 costs)	
	Entrance Condition at Start of Flood	
	Closed	Open
Nowra	$47,900	$41,000
Riverview Road	$70,000 (1)	$65,000
Terara Village	$25,000 (2)	$23,000
Bomaderry	$543,700	$507,000
Shoalhaven Heads	$274,000	$136,100
Greenwell Point	$798,200	$377,000
Orient Point/Culburra/Crookhaven	$177,600	$91,200
TOTAL	**$1.9 million**	**$1.2 million**

Notes:
(1) Entrance closed value calculated in Riverview Road Area Study (Reference 6) - refer to Section 1.3.
(2) Entrance closed value calculated in Terara Village Study (Reference 5) - refer to Section 1.3.

4. COMMUNITY CONSULTATION

4.1 Components

A rigorous public consultation program was carried out as part of this study (for details refer Appendix B) and included:

- a letter of introduction,
- questionnaires for the first and second phase of the process,
- floodplain management committee meetings which included interested representatives of the public,
- newsletters,
- public meetings,
- public exhibition of material.

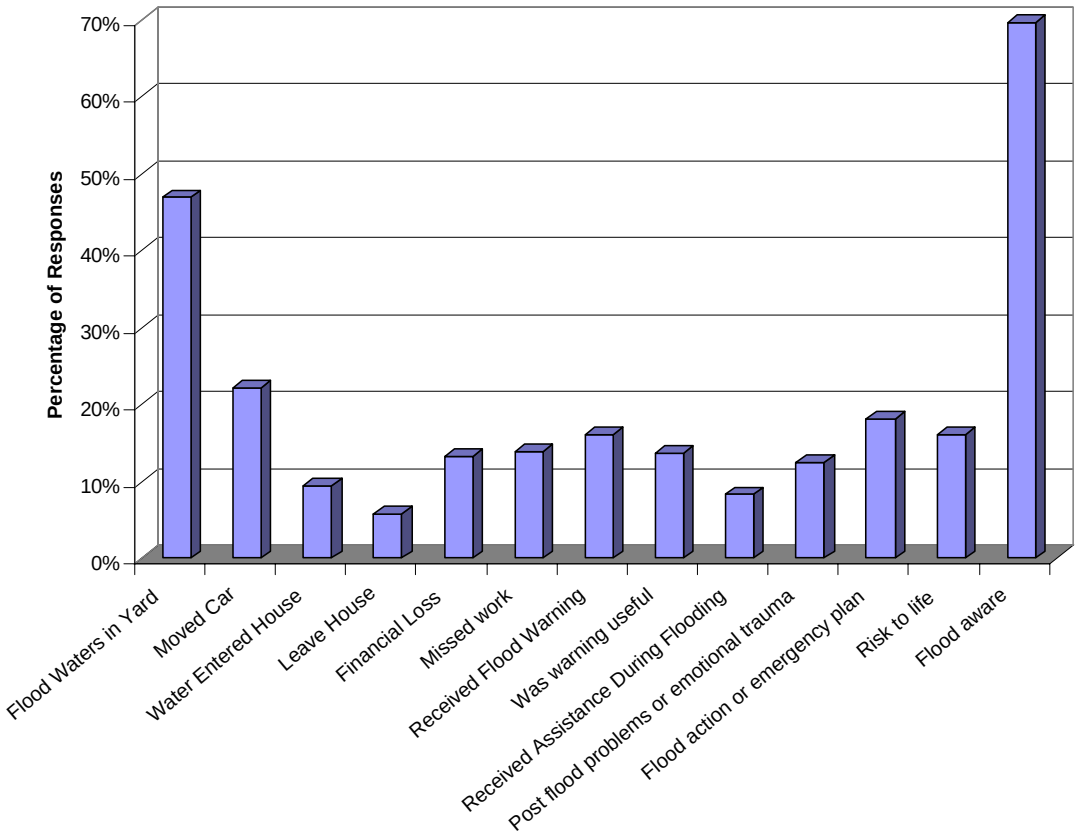
The direction of the study and emphasis placed upon the issues and various management measures was influenced by feedback from the public consultation program. A summary of the responses to the different stages of the program are included below.

4.2 Questionnaire - December 2000

Historical flood data, information on public awareness and possible means by which the flooding problem might be addressed were sought through the distribution of a questionnaire (Appendix B). This was sent out with an accompanying introduction letter, to residents of properties which were thought to lie within the floodplain. Terara Village and Riverview Road residents were excluded from this process as they had recently been consulted as part of their own specific studies (refer Section 1.3).

The questionnaire was sent out to 1767 residents and/or property owners within the Lower Shoalhaven River floodplain and approximately 20% were returned. 85% of the responses were related to residential houses and 93% of the respondents owned the property in question. The average time for people residing at their property was 14.2 years. Of those responding, approximately 60% requested to be kept informed by joining the contact group and 57% were concerned about flooding. Diagram 1 summarises the residents responses to their experiences on a range of flood related issues.

Diagram 1: Flood Experiences - Summary of Questionnaire Responses



21% of respondents felt they had useful additional information regarding flooding. Some responses included photos, letters or just comments about the information available.

When asked how and to what extent people felt they might be affected by different size flood events the results, as shown in Table 12, were found to be varied . In general, the majority thought their yard would be inundated during a small to medium flood while 40% of response felt their house would be affected in the extreme event.

Table 12: Respondents Perception of Potential Flood Affectation

Size of Flood Event	Potential Affectation (1)		
	Evacuation Access (%)	Yard Inundation (%)	Building Inundation (%)
Small to medium flood which is more likely to occur	8	16	11
In a large flood which is more likely to occur	10	29	25
In the largest possible flood event	12	43	40

(1) Results indicate the % of respondents who thought that they might be affected under the given flood magnitude.

Nearly 20% of respondents had "no idea" about how much time they would have available to implement emergency measures if a major flood occurred. The range of time estimates is detailed below:

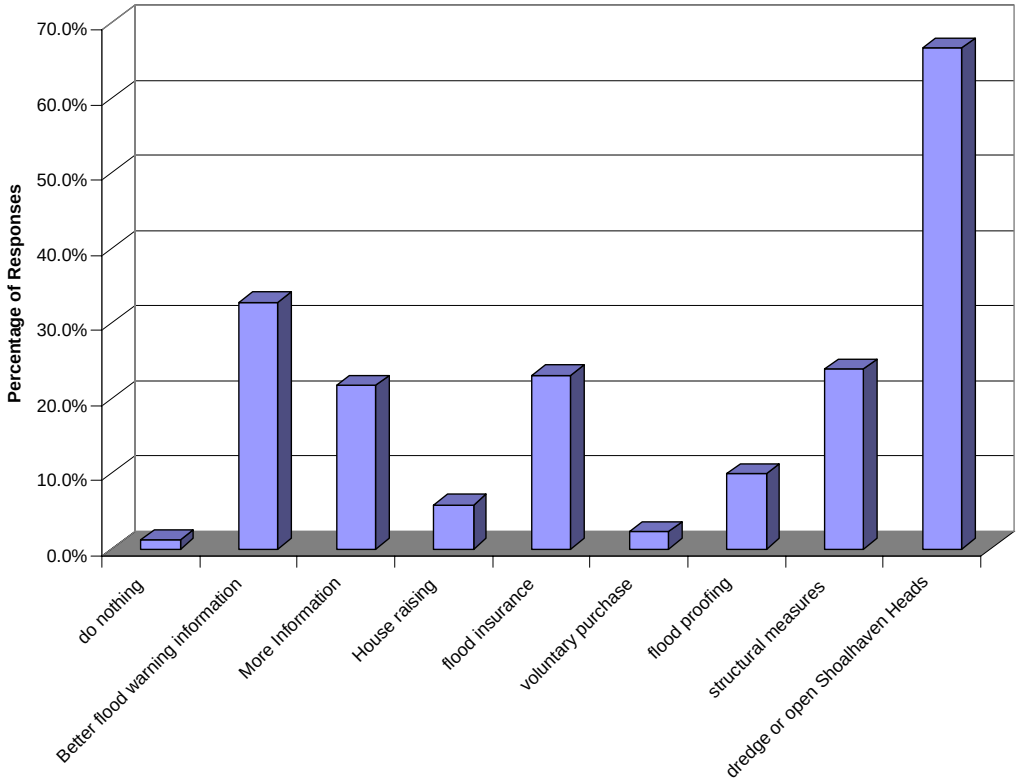
No idea	=	19%
1 day	=	18%
12 hours	=	14%
6 hours	=	12%
Less than 6 hours	=	16%
		79%

Note: 21% did not answer the question.

In order to gain an appreciation of community ideas and thoughts on what management measures might be worthy of further consideration, nine possible measures were listed in the questionnaire as potential means of addressing the flood problems, and residents were invited to indicate their preferences as well as suggest other alternatives. A summary of the responses is included in Diagram 2. The opening of the Shoalhaven Heads entrance was seen as the most popular solution (67%) with better flood warning information (33%) also considered important. Around 22% thought that some form of structural measure might work. The individual property solutions such as house raising and voluntary purchase were least favoured with less than 5% support.

Further details are included in Appendix B.

Diagram 2: Possible Floodplain Risk Management Measures



4.3 Stakeholder Options Workshop

A workshop was held on 16 May 2001 to discuss management measures for the Lower Shoalhaven River floodplain. The workshop was held at Council Offices and was attended by members of the Shoalhaven Floodplain Management Advisory Committee, Councillors and staff representatives of relevant Council departments.

Based on the results of the investigation to date, background information on flooding issues within the Lower Shoalhaven River floodplain was presented along with some preliminary ideas on potential floodplain risk management measures.

The workshop attendees were split into two groups to discuss the possible management measures and to develop any other new suggestions or ideas. The resulting measures were then included in a second Community Information Sheet (refer Appendix B) and sent to all residents within the floodplain in order to update them on the study progress and seek further feedback on the preferred risk management options. The Community Information Sheet also invited the community to participate in the forthcoming open shop days and allow them the opportunity to ask questions, relay their concerns or make comments on the study.

4.4 Open Shop Day

An Open Shop day was held in June 2001 consisting of two sessions. Residents were advised of the date of the meeting via the posted newsletter (1767 were sent out) and by advertisements in the local papers and community radio. All members of the Floodplain Management Committee were invited by letter.

	Venue	Date	Attendees (approx.)
1	Shoalhaven Heads Community Centre	28 June 2001 - 9:00am to 12 noon	25
2	Nowra - Council Offices	28 June 2001 - 2:00pm to 5:00pm	10

The findings of the study to date were displayed at each of the Open Shops and attendees were afforded the opportunity to provide verbal and/or written feedback (questionnaire). A detailed summary of the comments obtained from the open shops is included in Appendix B with an overview provided below.

Shoalhaven Heads Open Shop

Approximately 25 people attended at the Shoalhaven Heads Community Centre. The general feelings at the meeting were of frustration in relation to the opening of the entrance during flood events. The concerned members of the community expressed their frustration about the lack of action taken to relieve flooding for the area and the number of studies undertaken for no result. Most people who attended the Open Shop seemed prepared to “live” with flooding because they did not want to move from the area but they believed the potential peak heights reached by floodwaters could be lowered if the entrance was opened early in the event to allow floodwaters to flow out to the ocean.

The Open Shop forum became a “round table” discussion involving the consultant, a member of Council staff and interested community members. The topic of discussion was primarily focussed on the opening of the entrance at Shoalhaven Heads. The various issues associated with its opening and the legal implications for Council with regards to the human intervention were discussed. The issues included the location of the “dry notch” in the beach berm relative to the deepest parts of the bay upstream as well as the predicted flood level and timing which should trigger the opening. The possibility of blocking or filling Berrys Canal was also raised and briefly touched on.

Ten further comment sheets which focussed on opening the entrance, development in the floodplain and backwater effects during a flood were submitted by attendees. Most comments suggested the entrance should be opened during times of flood and they hoped a formal action plan to properly facilitate the process would be developed and implemented.

Nowra Open Shop

The Nowra Open Shop held at Council Chambers was relatively quiet with approximately 10 people attending during the afternoon. The people who attended had varying reasons; which included concerns about residential property flood levels, flooding of commercial property, riverbank erosion and issues pertaining to the local Riverwatch program.

Three comment sheets were completed and these touched on issues such as:

- the Shoalhaven Heads entrance,
- flood warning time,
- the need for maintaining road closures for all vehicles during a flood (to minimise wave effects),
- erosion of the riverbank,
- overgrown and blocked creeks and drains.

4.5 Public Meetings

A public meeting was held at Council chambers in the evening of 28th June 2001 to formally present an update on the study findings as summarised in the community information sheet and also to allow for discussion and questions at the completion of the presentation.

The meeting was attended by about 30 people which included Councillors, Council staff and interested members of the community. The general discussion which followed on from the presentation by the consultant included the following issues:

- levees along the river,
- the Shoalhaven Heads entrance,
- flood mitigation drains in the floodplain,
- development in the floodplain by Manildra Pty Ltd (on northern river bank east of Bomaderry Creek),
- acid sulphate soils.

The detailed comments from the Public Meetings are included in Appendix B.

4.6 December 2003 Newsletter

As a result of the findings to date and in anticipation of the public exhibition of the draft study a third newsletter was sent to the residents of the floodplain at Shoalhaven Heads and Greenwell Point. The newsletters are included in Appendix B and they primarily included issues and options specific to the areas of Shoalhaven Heads and Greenwell Point.

The number and type of responses are summarised in Table 13.

Table 13: Summary of Responses for December 2003 Shoalhaven Heads and Greenwell Point Newsletters

Area	Type of Response		
	Telephone	**Letter**	**E-mail**
Shoalhaven Heads	1	1	2
Greenwell Point	1	0	1

Most of the responses included comments relating to the issues and options discussed in the newsletters. One response required feedback on flood compatible development and house raising options. The other issues raised included:

- levee bank locations,
- Shoalhaven Heads entrance maintenance,
- raising of Greenwell Point Road,
- the extended inundation of areas during a flood and with a king tide,
- water quality.

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5. STUDY AREA ISSUES

5.1 General Issues for the Whole Study Area

A range of issues relating to the Lower Shoalhaven Floodplain have been raised at Council/committee meetings, by the community as part of the consultation process, by the Consultant, or were outlined in the study brief. These issues include:

- Shoalhaven Heads entrance conditions and management thereof,
- dredging of Zealands Creek,
- Crookhaven Creek and Broughton Creek - enlargement of flood mitigation drains and their environmental impact (e.g. removal of wetlands and acid sulphate soils),
- evacuation access to and from Greenwell Point,
- Greenwell Point - subdivision of land categorised as high hazard floodway area, erosion of foreshore,
- insufficient capacity of Bolong Road bridge and Broughton Creek,
- localised flood problems,
- urban expansion areas and associated road infrastructure,
- impact of infill development in the floodplain,
- floodgates and drains,
- acid sulfate soils,
- wetlands, threatened and endangered species,
- flood warning system,
- Bomaderry Creek flood warning,
- access to flood warning information,
- Pig Island and Comerong Island - evacuation concerns for present and future owners,
- Numbaa levee,
- stock evacuation during floods,
- riverbank erosion,
- proposed levee stabilisation works at Terara,
- siltation in the river,
- stormwater drainage and lack of kerb and guttering.

5.2 Specific Issues

A number of specific issues were raised during the course of the study (from questionnaires, interviews, feedback, etc.) and the details are summarised in the following sections.

5.2.1 Shoalhaven Heads Entrance

The possible opening of the Shoalhaven Heads entrance (Photograph 1) during a flood is a major issue for both the residents of the floodplain, particularly at Shoalhaven Heads, and Shoalhaven City Council. In order to properly address this issue, a discussion paper

(Shoalhaven Heads Entrance Flood Management Paper - refer Appendix G) was prepared in June 2001 as part of this study.

The purpose of this paper was to :

- compile existing information in relation to the Shoalhaven Heads entrance,
- document the history of human intervention at the Shoalhaven Heads entrance during times of flood,
- assess the relative merits of human intervention during times of flood,
- provide a strategy for future flood/opening occasions,
- discuss and propose a mechanism for the appropriate management of the Shoalhaven Heads entrance which addresses the flooding concerns whilst taking into account the environmental considerations.

Photograph 1: Shoalhaven Heads Entrance - June 1991 Flood

The Paper was only concerned with intervention to minimise flood impacts for existing development and not for reducing the Flood Planning Level which might apply for future development. The possible opening of the entrance during times of flood is only one floodplain risk management measure and therefore needs to be considered in terms of the legal, social, environmental and economic requirements as well as the relative merits compared to other potential solutions. Based on the information presented in the discussion paper, Council subsequently prepared a Shoalhaven River Entrance Management Plan for Flood Mitigation.

For proposed and future developments in Shoalhaven Heads it is proposed to apply specific land use zones and Flood Planning Level for all flood prone lands. These aspects are discussed further in Section 6.6. Many areas of Shoalhaven Heads are relatively low lying and therefore vulnerable to inundation from floodwaters in even the smaller (more frequent) events. As indicated in Table 9, 39 buildings are inundated in a 10% AEP flood and the overall Annual Average Flood Damages for Shoalhaven Heads alone is $274,000 (year 2000 costs). By placing development restrictions on all new development in flood prone areas it is hoped that eventually less properties will be inundated. Education and evacuation planning will further help reduce the risk to life and these issues are discussed in more detail in Section 6.5.

5.2.2 Zealands Creek

Zealands Creek enters the northern side of the Shoalhaven River approximately 2 km upstream from the Pacific Ocean. It drains into Berrys Bay which is separated from the Shoalhaven River by Hay Avenue. Berrys Bay and Zealands Creek are relatively shallow due to continued sedimentation in the area. As a result, the boat ramp at the end of Hay Avenue has become largely inaccessible to larger vessels due to the sedimentation. Over the years several proposals have been put forward to dredge a channel through Berry's Bay to Zealands Creek and hence make the creek more accessible.

The sediments in the area consist of fine colloidal silts and there are potential acid sulphate soils at a depth of 0.6 m below the soil surface. Dredging the channel will improve flows in the Bay and the creek but disturbance of sediments will have a large affect on the oyster leases which operate within the creek and surrounding bay area. The other concern is the disposal of the dredged material. When the dredging was last proposed several years ago (about 1996), a nearby land owner had agreed to take the material for filling of his land. Other suitable methods currently available for disposal of the fill material are difficult to define within the scope of this study.

This issue, whether it is carried out or not, will have no significant effect upon flood damages or hazard in the local area. For this reason it has not been addressed further.

5.2.3 Hay Avenue Development

Council has received a development application for a proposed cluster housing development in Hay Avenue, Shoalhaven Heads (Photograph 2). The proposal involves the construction of nine residences (with raised floors) in place of an existing caravan park, spanning three lots. Inundation of the land and evacuation access are the main issues of concern for the Hay Avenue area (and this development in particular) as it is classified as being within a high hazard floodway area. This area is currently deferred from the 1985 Local Environmental Plan and is administered under IDO (Interim Development Order) No. 1.

A report to the Floodplain Management Committee dated 24th August 2000 stated that the development would increase the permanent population in a high hazard flood liable area. Consequently, if the development were to be approved then there would be an increased reliance on rescue services during flood emergencies, as the development would not have sufficient resources to act during these events. Additionally, approval of such a development would establish a precedent for the area. Resolution of an appropriate zoning and development controls for this area needs to be addressed as part of the Management Plan and included within the LEP framework.

Photograph 2: Hay Avenue, Shoalhaven Heads - March 1978 Flood

5.2.4 Greenwell Point - Subdivision of Land and Evacuation Access

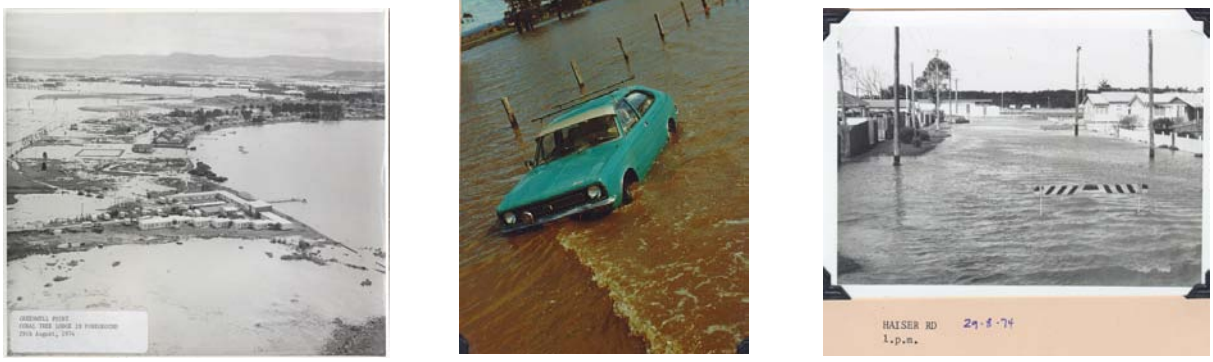
Greenwell Point is particularly susceptible to flooding because it is relatively low lying and situated at the confluence of the Shoalhaven and Crookhaven Rivers. The location of Greenwell Point on the waters edge where the rivers meet the Pacific Ocean also makes the area very popular for location and aesthetic reasons. Hence, there is increasing pressure for general redevelopment/extensions and further residential subdivisions within the high hazard floodway area of the Greenwell Point village. The nature of flooding surrounding Greenwell Point means the entire area is isolated in a major event. Overbank flooding from the two rivers which join to the east inundates the flood storage area to the west and cuts the main access route of Greenwell Point Road (refer to Photograph 3 and Table 8) in events as small as a 10% AEP flood event. As the period of time since the last significant flood (1978) increases, the public memory and perception of the damages and hardship caused by flooding diminishes.

Any proposal for further subdivision of land at Greenwell Point will increase the population at risk and potential damages due to flooding for the area. There will also be a greater reliance on emergency services, since the subdivision is likely to attract new people to the area who are not necessarily flood aware.

Ensuring that high hazard flood prone land situated in the existing developed areas is zoned low density and enforcing minimum floor height restrictions will prevent large increases in population or potential flood damages. Land not classified as flood prone should have similar low density restrictions because the entire area can be isolated from services such as fresh water, sewer and electricity during major flood events. Even though there will be no threat to property in the flood free areas there will still be a burden for emergency services because of the isolation. Any further expansion or new development beyond the current residential zoning should not be permitted at all.

Evacuation access to or from the area becomes an issue when Greenwell Point Road is cut by floodwaters (refer Table 8 and Figure 8). There is little, if any, opportunity to raise this road because it crosses the main floodplain and has the potential to dam water and change the nature of flooding in the area. The road would need to be raised significantly (refer Figure 8) to provide flood free access in the 1% AEP event and substantial waterway openings would then be required to minimise the adverse hydraulic impacts for surrounding properties. The potential impacts would be difficult to mitigate completely and the overall costs would be prohibitive. It may be possible however, to carry out selective raising of the road in the worst affected locations so as to reduce the frequency with which the access may be cut (to some consistent frequency) and thus increase the evacuation time available. As a large number of Greenwell Point properties are potentially inundated or affected in a 10% AEP flood event, consideration should be given to ensuring a consistent level of road serviceability is available for an event of this magnitude as a minimum.

These land use and evacuation issues are discussed further in Section 6.5 and will be addressed in the Plan. Several structural options have been put forward for protecting the eroding foreshore and waterfront homes but none of these are readily acceptable because of environmental, economic and aesthetic reasons.



Photograph 3: Greenwell Point - August 1974 Flood

5.2.5 Urban Expansion Areas and Associated Road Infrastructure

Council has identified the need for a future additional road crossing over the Shoalhaven River near Nowra. Currently there are two southbound and two northbound lanes on separate bridge carriageways. Traffic crossing the river is forecast to increase from the current 45,000 vehicles per day (VPD) to around 71,000 VPD by 2016 which would exceed the capacity of the bridge. As well as the increased traffic volume crossing the river, the Princes Highway will also require upgrading. These issues are discussed in the Nowra Bomaderry Structure Plan (Reference 8) which investigated a Nowra/Bomaderry bypass, including a new bridge and upgrading of the highway. Also under consideration is the proposed East Nowra Sub-Arterial (ENSA) road to join Greenwell Point Road to North Street as an alternate access route to the coastal villages and developing areas of East Nowra. Closely associated with the possibility of providing additional road infrastructure is the opportunity to increase the extent of development which could be serviced by the new road network.

These concepts may have an effect on the behaviour of floodwaters on the Lower Shoalhaven floodplain. The extent of their effect will depend on the location and extent of the developments. The preferred alignment runs east of the existing river crossing and is referred to as the Inner Eastern Bypass, *"crossing the river between Manildra and the Dairy Co-op at the western end of Pig Island and running west of Old Southern Road"* (Reference 8).

Other areas of possible development upon the floodplain are at the existing retail complex located to the east of the Princes Highway and south of Moss Street.

These issues need to be addressed as part of the Management Plan and preliminary hydraulic investigations have been undertaken to provide some insight into the potential impacts from flood levels (refer Section 6.6.9 for more details).

5.2.6 Civic Centre Development

Shoalhaven City Council is currently undertaking preliminary assessments to ascertain the feasibility of locating the future Civic Centre Complex within the area surrounded by Scenic Drive, Mandalay Avenue, Hyam Street and Bridge Road at Nowra (Photograph 4). Although details have not yet been finalised, the proposed complex is considering the incorporation of a hotel, conference centre, theatre, cultural centre, art gallery, leisure centre with a 50 m pool, a complex of multi-storeyed residential apartments and an oval.

The proposed site is located on the southern bank of the Shoalhaven River, approximately 200 m upstream of Nowra Bridge. The ground levels within the proposed site vary between 1.5 mAHD and 8.0 mAHD, however, Scenic Drive generally protects the area against inundation from the Shoalhaven River in the smaller events up to approximately a 5% AEP event.

Photograph 4: Nowra Bridge and Civic Centre Site - March 1978 Flood

Webb, McKeown & Associates, undertook a preliminary hydraulic assessment (Reference 13) of the site for Shoalhaven City Council in August 2000 and the investigations concluded:

- the development is feasible from a flooding perspective,
- the maximum impact on Shoalhaven River flood levels of the proposed development is +0.02 m (Extreme flood) with negligible impact (+0.01 m or less) in the 1 % AEP.

5.2.7 Industrial Development at Bomaderry

One of the main areas zoned for industrial purposes (Figure 3) is located at Bomaderry. The area shown in Photograph 5 comprises a mix of small to medium businesses and there are also three major industrial developments situated on the floodplain along Bolong Road, immediately downstream of Bomaderry. The major landowners are the Paper Mill, Dairy Farmers Co-operative and the Manildra Group. The following provides a summary of past and proposed development in the area.

Manildra Group: The plant produces refined products (starch, glucose, industrial alcohol, gluten) from wheat and the operation has expanded rapidly since the late 1980's. Its location provides ready road and rail access together with a constant supply of water. The complex has grown with the introduction of updated machinery within the complex and construction of a CO_2 tank and six (6) large effluent storage ponds on the adjoining floodplain. The ponds comprise earthen embankment walls constructed up to 5 m above the surrounding ground level and occupy some 16 hectares of land on the northern floodplain. The most recent pond was completed in late 2001 and holds approximately 350 ML (approximate dimensions of 380 m by 240 m).

Up to 5 ML of effluent is produced by the plant each day and consists of starch and wheat solids that cannot otherwise be removed. The effluent is temporarily stored in the ponds at a pH of 3 to reduce development of obnoxious odours. The pH is then raised to 7 (neutral) prior to release as either a slurry for ground injection or for irrigation over some 2000 hectares of land owned by Manildra on the northern floodplain. The effluent cannot be directly released to the Shoalhaven River and monitoring devices are employed to ensure the groundwater or surface runoff do not become contaminated. In January 2003 Manildra prepared an EIS for construction of another pond (Pond No. 7) and further expansion of the plant operations.

Photograph 5: Bomaderry - August 1990 Flood

Flood studies undertaken as part of the approval process indicate that flood levels across the northern floodplain and along the eastern fringes of Bomaderry have increased up to 0.05 m in the 1% AEP due to the works undertaken since 1990. There are no practical means of reducing these hydraulic impacts. As a result, the potential flood damages on the northern floodplain have been increased.

It is likely that the plant will expand further in the future as the demand for ethanol as a substitute for oil based petrol increases. However the nature and extent of the future works are unknown at this point in time. Manildra is working towards removing the effluent ponds in the next 5 to 10 year period through the installation of drying facilities.

Thus it would appear unlikely that construction of any further ponds will be required. The construction of additional plant is however, more likely to occur. The potential hydraulic effects of these works can be minimised through locating them in the "shadow" of other buildings or away from the main flow paths. The effects cannot be totally eliminated however, and a suitable hydraulic investigation will be required for any substantive works outside the "footprint" of the existing plant. A previous detailed hydraulic study in October 2000 concluded that no further computer modelling was required to evaluate the hydraulic impacts within the existing "footprint". The following guidelines are proposed:

- any proposal on the floodplain must be accompanied by a hydraulic report undertaken by a suitably qualified expert. The scale and extent of the report will depend upon the nature and location of the proposed works,
- any proposed works must be designed and located to minimise any increase in flood damages to other users/occupiers of the floodplain and to Manildra Pty Ltd,
- approval for further works must take into account the social, environmental, economic and hydraulic consequences of undertaking or not undertaking the proposed development.

Dairy Farmers: The Dairy Farmers complex is less than 15 years old and the main building is raised above the 1% AEP flood level. The only subsequent development has been the construction of a 1 hectare effluent storage pond in 2000. No further works are proposed at this time.

Paper Mill: The plant is over 30 years old and experienced the floods of the 1970's. No significant further works are proposed at this time. However, it is likely that some redevelopment will eventuate as the plant approaches the end of its current useful life. A full hydraulic assessment will be required at that time to assess the potential impacts upon flooding of any future redevelopment.

Minor Industrial Developments: These will occur from time to time as old plant operations are replaced or new lands are developed. Again, a full hydraulic assessment will be required to assess the potential impacts upon flooding.

5.2.8 Riverview Road Area

This area was first developed in the early 1960's with the Riverview Road subdivision initiated in the 1970's. The area experienced minor flooding in the 1970's (Photograph 6). In 1986/87 the river bank levee was upgraded to provide protection up to the 1% AEP event (no freeboard allowance included). There is continuing pressure to develop the remaining vacant land and in 1995 a 55 lot subdivision to the south of Riverview Road was approved. The original proposal has subsequently been modified. Council also has a proposal to develop part of the vacant land as a recreation area. There are approximately 190 residential buildings (single dwellings and flats) in the area, the majority of which are brick and less than 30 years old.

Photograph 6: Riverview Road - August 1974 Flood

The land (approximately bounded by the Princes Highway, Moss Street, Ferry Lane and the Shoalhaven River) was originally excluded from the current LEP for the LGA. It was excluded, at the time of preparation of the LEP in 1985 as there was no resolution on the appropriate zoning.

A Floodplain Management Study and Plan (Reference 6) addressing the specific issues and concerns for this particular area were finalised in 2002. The study outcomes recommended future zonings for the area in order that it could be included in an updated LEP. The bulk of the deferred areas were rezoned in July 2001 (through LEP Amendment No. 182) to Residential 2(a4) or Rural 1(g), with two remaining lots still administered under Interim Development Order No. 1 (IDO No. 1).

5.2.9 Terara Village and Levee

The village of Terara was the site of the original European settlement on the southern bank of the Shoalhaven River. In the early and middle part of the nineteenth century it was a thriving centre for commerce and agriculture. It was the major trading centre of the district and ocean going vessels berthed at the Illawarra Steam Navigation Company wharf. In 1870 the

population of Terara was almost 1000 whilst the township of Nowra had barely been formed. The floods of 1860 and 1870 swept large parts of the village into the river and consequently the population centre moved to higher ground at Nowra.

Today the village of Terara and adjoining properties consist of approximately 60 residential buildings and a school. The houses are a mixture of modern brick buildings and historic timber or stone buildings. The village area (bounded by Nobblers Lane, Terara Road/South Street, Southern Road and West Berry Street) was originally zoned Village but the Local Environmental Plan (LEP) of May 1985 changed the zoning to 1(g) Rural. Existing lots which contain a dwelling house retain the existing use rights. The remaining, vacant lots cannot be developed for residential buildings under the 1(g) zoning unless, amongst other considerations, Council is satisfied that the dwelling house is essential for the proper and efficient use of the land for agriculture or turf farming. The size of the lots would form a major factor in this consideration. There is no industrial/commercial or proposed industrial/commercial zoning at Terara.

Up until 2005 the village was protected (to the height of the levee bank) from direct Shoalhaven River inundation by an earthen grassed levee which was generally up to 1 m above natural surface. There was also considerable vegetation along the river bank and on the levee. The bank was extensively eroded in parts, posing a clear threat of undermining the levee. There was also ongoing problems with river bank erosion.

The Terara Village Floodplain Management Study and Plan was completed in 2002 (TVFMP - Reference 5) and provides a series of specific measures to address the existing and future flood problems of this particular area. These generally consist of response and property modification measures. Major structural works (e.g. new levee banks or raising of the existing levee) were not proposed for this area.

One of the main recommendations of the TVFMP however, was the need for a geotechnical and structural audit of the riverbank levee adjacent to Terara Village. This levee is known as the Terara Levee and is referred to as the Stage 1 levee. While not essential or specifically required, it was considered that if subsequent refurbishment works to improve the structural adequacy of the Stage 1 levee were found to be necessary as part of the audit then, these could be combined with consideration of possible minor regrading or raising of the levee crest.

There was no proposal or recommendation within the TVFMP to raise the levee to provide additional flood protection. This measure has been considered, but was rejected on economic, social, environmental and hydraulic grounds. It was considered appropriate to nominally raise the crest to a uniform level but only if the “structural works” were required. These works would be justified as the additional cost would be minimal and a slightly raised uniform crest would eliminate low spots and assist in reducing high velocity flows through the village. It should be noted that the majority of the village would still be inundated by floodwaters entering from upstream and downstream.

In accordance with the TVFMP recommendations, several investigations have since been undertaken and a summary of the outcomes is included as Appendix I and further discussion of the key results presented in Section 6.3.3. The Stage 1 levee has now (2006) been rebuilt in accordance with the outcomes of Reference 5.

5.2.10 Filling of Land

The December 2000 questionnaire results, June 2001 Open Shop days and public meeting highlighted the community's concern for filling of land on the floodplain and what affect it might have on flood levels in the area. The impact of the filling was perceived to be most evident for the smaller more frequent events where surface flows are minor but the filling may alter the flow path.

Filling of low lying land is sometimes undertaken to provide a level building pad area to assist with raising the floor level above the Flood Planning Level. Where the filling of the land is situated within the floodplain it can result in:

- the loss of temporary floodplain storage which could cause an increase in peak flow and flood level downstream (unlikely to be an issue on the Lower Shoalhaven River floodplain unless a significant quantity of fill or loss of floodplain storage (say greater than 1000 m^3) is to be undertaken),
- the loss of available flow path which could result in an increase in flood level upstream,
- redirection of local runoff onto adjoining properties,
- the cumulative effects of filling needs to be considered in the Plan.

While small or individual instances of filling may be shown to have minimal impact in isolation, the cumulative effects of filling can have a greater overall impact and this needs to be managed by pre-determined considerations and controls established for the Plan. Further discussion of this issue is included in Section 6.6.6.

5.2.11 Flood Mitigation Drains and Structures

Shoalhaven City Council has a database of flood mitigation assets for the Lower Shoalhaven River floodplain. The assets have been numbered and are identified on eleven Flood Mitigation Project Maps. The database includes information on the levees, floodgates and drains. Not all details regarding the assets are known but some of the information available in the database includes: number, size, length, width, height, area of floodgates, length of drain and length of levees.

The floodgates and drains across the floodplain are usually located within private property and are therefore operated or modified by the property owners for their own benefit. Occasionally in the past such operation and/or modification works have had an effect on downstream properties and are known to have uncovered acid sulphate soils (acid sulphate soils are discussed further in Section 2.2.2). The community's concern is related to the potential effects associated with the continued unmonitored or uncontrolled operation of these gates and drains.

5.2.12 Flood and Emergency Plans

Shoalhaven City Local Flood Plan, February 2004 (Reference 14)

Shoalhaven City Council produced an updated local flood plan in February 2004 as a supporting plan to the Shoalhaven DISPLAN (Disaster Plan). The plan is divided into several key sections which serve to outline the preparation measures (Preparedness), the conduct of response operations (Response) and the co-ordination of immediate recovery measures (Recovery) for flooding within the Shoalhaven Council Area. The following summarises the content of this plan with respect to the abovementioned sections.

The Introduction includes the purpose of the plan, the Authority under which the plan is issued (State Emergency & Rescue Management Act, 1989 and the State Emergency Services Act, 1989), the area covered by the plan and the people and organisations who have specific responsibilities with respect to implementation of the plan. The general responsibilities of emergency service organisations and supporting services are detailed in the Shoalhaven Local Disaster Plan. The areas with specific flood risk are included in detail in an annexure.

The Preparedness section outlines the measures which need to be in place in preparation for the occurrence of flood events in the plan area. This includes:

- public education to ensure that the residents of the Council area are aware of the flood threat in their area and how to protect themselves against it,
- the steps the Shoalhaven State Emergency Service Local Controller (SES Controller) will undertake to activate the plan,
- other sources of flood information and intelligence,
- the various types of warnings which indicate potential flooding problems are imminent.

The Response section outlines how the plan will be implemented and managed during and after a flood event. This includes:

- Control - the type of operation,
- Operations Centre - where they are located and who is responsible for their operation,
- Liaison - co-ordination between organisations with specific responsibilities,
- Communications - devices and methods for communication,
- Information - how information will be disseminated to the public in relation to river heights, flood behaviour, road conditions and closures, advice on temporary mitigation and the confirmation of warnings,
- Road Control - who is responsible for closing and opening flood affected roads,

- Flood Rescue - procedures for conducting flood rescues,
- Evacuations - defines responsibility for undertaking of evacuations, how they will be conducted and the location of evacuation centres,
- Logistics and Resupply - identifies where to obtain any supplies required during implementation of the plan,
- Stranded Travellers - provides guidelines on establishing contact between stranded travellers and their concerned relatives or friends.

The Recovery section outlines the activities which need to be undertaken after the event as part of the clean up operation and restoring the situation to normal conditions. Looking after any evacuees will be the responsibility of the Shoalhaven Disaster Welfare Service. All evacuees are to be registered with the Illawarra-Shoalhaven Police District Headquarters.

It is recommended that this Local Flood Plan should be reviewed or updated to incorporate the information and findings collated as part of this study. Further general discussion of Response Modification Measures such as Evacuation Planning and Flood Awareness and Readiness is included in Sections 6.5.2 and 6.5.3 respectively.

Shoalhaven City State Emergency Service Standard Operating Procedures - Floods (Reference 15)

The "Shoalhaven City SES Standard Operating Procedures - Floods" manual describes the critical levels at which flood warnings should be issued based on pre-determined times and levels in the Shoalhaven River at various locations. There is a list of major roads that need to be checked during flood events. The manual details the Warden Areas that must be checked, the evacuation centre and the catering organisation for flood events. It also includes a "Flood Intelligence Card" for Shoalhaven Heads, which outlines the issues that need to be considered in determining the potential extent of flooding. Much of the information obtained for the purposes of this study should assist the SES in ensuring the best information is available for their planning purposes. Such information includes the floor level survey information, associated property flood affectation, hazard mapping and availability of design flood hydrographs for different locations across the floodplain.

Tallowa Dam, Dam Safety Emergency Plan, October 1998 (Reference 16)

This Plan outlines the chain of command and the procedures that need to be undertaken in the event of an emergency involving the dam. It discusses different types of dam failure and their consequences, predicted heights with and without catchment flooding, and the effects a PMF event could have on the dam as well as at key locations downstream to Shoalhaven Heads. An estimate of properties and people who would be first affected by a dambreak for "Sunny Day" and other flooding scenarios are also included.

The activation of this Plan may require the implementation of the local, district or state disaster plans. The document recommends that the local and district DISPLANs refer to this document and consider the people and properties which would be first affected in a dambreak emergency.

These various documents need to be constantly updated (say a review every two years) to ensure that the information and guidelines are current and in accordance with best management practice.

5.2.13 River Bank Erosion and Instability

The channel of the Shoalhaven River is dynamic and responds to natural (annual rainfall, floods, droughts, Greenhouse Effect) and man-made changes in the catchment (Berrys Canal, deforestation, urban development, filling on the floodplain, bank protection works). The response of the channel can be viewed as short term (annual) or long term (decades) changes.

The short term trends do not always follow the long term trends. Reference 7 has documented these changes, the most significant long term changes include:

- creation of Berrys Canal and associated impacts (less frequent opening of Shoalhaven Heads),
- floods of 1860 and 1870,
- evolution and changes to Pig Island, Numbaa Island and Old Man Island.

Erosion and sedimentation are natural processes with alluvial river banks constantly changing. In the past, sedimentation and consequent loss of navigable access was a major issue. Today this is of less importance and the loss of land through erosion is more significant. Appendix C provides further background on the issue of bank erosion which is also being investigated separately.

5.2.14 Numbaa, Pig and Comerong Islands

These islands have similar flood related issues, which include:

- bank erosion,
- evacuation concerns,
- protection of existing residential developments in a floodway,
- isolation in times of a flood,
- protection of stock and equipment.

The majority of these problems relate to the fact that these localities are islands (formed by sedimentation) situated in the middle of a large river channel. While structural measures for protecting these islands are not an option, development restrictions, flood preparedness and evacuation planning will help to protect the people and property at risk. Bank erosion was identified by many in the community and is discussed in further detail in Appendix C.

5.2.15 Council's Interim Flood Policy

In response to the original NSW State Government policy on flooding and floodplain management (defined in the Floodplain Development Manual of 1986), Shoalhaven City Council adopted an Interim Flood Policy in September 1987 which was last revised in August 2002.

The Interim Flood Policy defines Council's objectives with regard to flooding issues, the land to which the policy applies, as well as the general conditions and standards to be implemented for development affected by flooding.

The adopted flood standard (the new terminology is Flood Planning Level or FPL, as per the FMM 2001 - Reference 4) for the Shoalhaven LGA is stated to be the 1% AEP, but some local areas have a specific flood level quoted (in mAHD) instead of, or as well as, the applicable AEP/ARI.

Freeboard for development in a floodway is set at 0.5 m for most areas and 0.3 m for the flood storage and fringe areas. Some particular areas are noted as exceptions to these rules, such as Sussex Inlet (commercial development freeboard 0.0 m), Browns Creek, Currambeen Creek and Lake Conjola (freeboard all areas 0.3 m). There are usually very few sustainable reasons for such variations with more consistent values across the entire LGA easier to implement and administer.

With continuing advancements in floodplain management Best Practice and the release of the revised NSW Government Policy (in the form of the 2001 Floodplain Management Manual) Council's Interim Flood Policy is now outdated and requires revision. Further discussion of this issue is included in Section 6.6.1.

5.2.16 Environmental Issues

The floodplain of the Shoalhaven River exhibits a rich diversity of flora and fauna (Figure 2) as well as supporting a significant agricultural industry. Increasingly, the viability of the floodplain could be threatened by a number of activities including:

- inappropriate enlargement of flood mitigation drains which may cause removal of natural wetlands or cause exposure of acid sulphate soils. This occurs less frequently today as our understanding of acid sulphate soils becomes more widely known,
- the presence of floodgates on the drains. More appropriate management of the floodgates may enhance the bio-diversity of the floodplain and at the same time prevent inundation during floods. A similar approach has been trialed in the Hunter Valley near Maitland as well as the Clarence River near Grafton and Macleay River near Kempsey,
- the potential for loss of threatened or endangered species as a result of significant floodplain developments or management measures.

5.2.17 Other Issues

In addition to all the above, several other issues have been identified by the residents as listed below:

- Bolong Road bridge and Broughton Creek have insufficient capacities,
- many residents ask that local landowner modifications to the existing mitigation drains should be more closely controlled and monitored,
- many residents feel that there are insufficient floodgates on the drains that cross the floodplain,
- the walls (levees) which run along the river bank appear to be in a very poor state of repair and are unsightly,
- there is inadequate stormwater drainage and kerb and guttering in many local residential areas.

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6. FLOODPLAIN RISK MANAGEMENT MEASURES

6.1 Introduction

The floodplain risk management study aims to identify and assess risk management measures which will mitigate flooding and the associated risks or hazards to people and property as well as reduce flood damages. The risk management measures must be assessed against the legal, structural, environmental, social and economic conditions or constraints of the local area. The potential floodplain risk management measures can be separated into three broad categories as follows:

Flood modification measures modify the flood's physical behaviour (depth, velocity). Typical measures include flood mitigation dams, retarding basins, on-site detention, channel improvements, levees, floodways or catchment treatment.

Property modification measures modify the existing land use or building and development controls for future development. This is generally accomplished through such means as re-zoning, development control plans, flood access, flood proofing (house raising or sealing entrances), or voluntary purchase.

Response modification measures modify the community's response to the potential hazards of flooding. This is achieved by informing flood-affected property owners as well as the wider community about the nature of flooding so that they can make better informed decisions. Examples of such measures include provision of flood warning and emergency services, improved information, awareness and education of the community and provision of flood insurance.

A number of methods are available for judging the relative merits of competing measures. The benefit/cost (B/C) approach has long been used to quantify the economic worth of each option on a relative basis and also enable ranking (prioritisation) against similar projects in other areas. The benefit/cost ratio is the ratio of the Net Present Worth of the reduction in flood damages (benefit) to the cost of the works. The ratio generally only incorporates the reduction in tangible damage as it is difficult to accurately include intangibles such as anxiety, risk to life, ill health and other social or environmental effects. The reduction in tangible damage to all public utilities has not been specifically included in this study as there was insufficient information available to properly identify and quantify the extent of affectation and benefits to be achieved (refer Appendix A2.4).

The potential environmental or social impacts of any proposed flood mitigation works are often of great concern to society and these cannot be evaluated using the classical benefit/cost approach. The public consultation program (Appendix B) has ensured that all identified social and environmental factors have been considered in the decision making process. The risk

management measures discussed below include those which were identified in the study brief as well as those developed by WM or brought up by the local community.

6.2 Discussion of Possible Floodplain Risk Management Measures Not Considered Further

A list of issues, and identification of all possible floodplain risk management measures which could conceivably be applied in the study area were developed and presented to a workshop of various stakeholders for information and consideration. The workshop, which incorporated the Floodplain Management Committee, then considered each measure in terms of their suitability and effectiveness for minimising or reducing their social, ecological, environmental, cultural and economic impacts. As part of this process, a number of measures were identified as not worthy of further consideration.

Table 14 contains a breakdown of the measures not considered further, those definitely considered and those requiring further investigation for potential consideration. Detailed discussion of the various measures is included in the following sections.

Table 14: Summary of Floodplain Risk Management Measures

Category	Not Considered	Potential	Considered
Flood Modification Measures	• Flood Mitigation Dams • Floodways	• Catchment Treatment • Levees	• General Channel and Creek Improvement Works • Shoalhaven Heads Entrance Works • Monitor Filling of Floodplain
Property Modification		• Voluntary Purchase • House Raising	• Rezoning • Consider the Greenhouse Effect • Flood Proofing • Flood Planning Levels • Update LEP which would include review of Hay Avenue at Shoalhaven Heads • Prepare Flood DCP No. 106 (Draft prepared) • Update Local Flood Policy 33A
Response		• Flood Insurance	• Flood Warning • Evacuation Planning • Flood Awareness and Readiness

6.2.1 Flood Mitigation Dams, Retarding Basins, On-Site Detention

Flood storage dams, or dams which have significant flood storage capability, such as Burrendong Dam (approximately 1 million megalitres storage), can significantly reduce downstream peak flood levels. However dams are extremely expensive and can generally only be justified for flood mitigation in economic terms if combined with a water supply or power generation capacity. Construction of large dams will also have a significant environmental effect and should be evaluated on a catchment wide basis.

The Tallowa Dam was constructed in the early 1970's downstream of the Shoalhaven River/Kangaroo River confluence as part of the Shoalhaven Water Supply Scheme. The dam was also constructed to maintain a water supply for the Bendela Pumping Station and has an active storage capacity of approximately 36 000 megalitres. As the volumes of each of the 1974, 1975 and 1978 floods were in excess of 1 million megalitres, the mitigating capacity of the dam is negligible.

Stage 2 of the Water Supply Scheme would involve construction of a major dam at Welcome Reef, which could have a capacity in excess of 2 million megalitres. At this time it appears unlikely that Welcome Reef Dam will be constructed, and even if it were built it would only control 50% of the overall catchment affected to Nowra. Floods originating in the Kangaroo Valley or Yalwal Creek would be unaffected.

There is little opportunity for reducing the flood peaks experienced at Nowra or further downstream by constructing new dams or upgrading existing dams. The flood mitigation benefits of Welcome Reef should be considered when evaluating the viability of the dam, but this would be a minor component of the decision making process.

Retarding basins and on-site stormwater detention systems are increasingly being used in developing catchments. Both these measures are appropriate for controlling flooding in small catchments (say up to 20 km^2) or to mitigate the effects of increased runoff caused by development. However, they would have negligible impact on flood levels in the Shoalhaven River and lower floodplain areas.

6.2.2 Floodways

Floodways are lower overbank areas which can carry significant flow volumes in times of flood. In some instances, on smaller streams, an artificial floodway can be created in an environmentally sensitive manner to achieve a reduction in upstream flood levels. However, given the size of the Shoalhaven floodplain, and the volume of water involved, artificial floodways are not considered to be a viable management measure.

6.2.3 Catchment Treatment

Catchment treatment modifies the characteristics of the catchment to reduce runoff contributing to the stream/tributaries and lower floodplain areas. For an urban catchment, this involves planning to maximise the amount of pervious area, maintaining natural channels where practical, and the use of on-site detention. For a rural catchment, this involves limiting deforestation or contour ploughing of hill slopes.

Again this is a measure which can be effective on small catchments such as Zealands Creek, Bomaderry Creek and Broughton Creek but has negligible impact on the overall volumes of water involved in a Shoalhaven River flood. The overall Lower Shoalhaven catchment is quite large (120 km^2) and predominantly consists of undisturbed natural bushland. As a general concept, catchment treatment techniques should be encouraged for the smaller developed catchments along with water quality and erosion/sedimentation controls (which are more appropriately addressed by the Stormwater Management Plan - Reference 9) but these will not affect the extent or duration of inundation.

6.2.4 Rezoning

The option to rezone flood prone land can provide a means of reducing the problem. For example, rezoning of flood liable land for higher density (flood compatible) development could encourage people to purchase and demolish existing flood prone property and redevelop the area in accordance with Council's design floor level policy and other acceptable best management practices. Such redevelopment could only be encouraged in areas where flood free access was readily available, where the existing flood hazard was low, and the zoning permitted. The possibility of rezoning areas of flood prone land has not been considered on a whole of floodplain/catchment basis but may be applicable for isolated areas after a detailed evaluation incorporating strategic planning considerations. Council's current policy does not allow for higher density development on flood prone land but population growth in the future may require this issue to be considered further. However, the Ministerial Direction defined by Clause G25 (Flood Liable land) of Section 117(2) of the EP&A Act (now Direction No. 15) prohibits the rezoning of flood prone land (described as rural, open space, etc.) to a zoning described for residential, business, industrial, village or similar purposes.

An example of an area where rezoning is required is the properties located along Hay Avenue at Shoalhaven Heads (presently classified Village) as an appropriate zoning could not be resolved when formulating the Draft LEP of 1985. Further discussion of this issue is included in Section 6.6.8.

6.2.5 Flood Insurance

Flood insurance (Reference 17) does not reduce flood damages but can be considered as transforming the random sequence of losses into a regular series of payments. Many residents regard flood insurance as a preferred flood mitigation measure as indicated in the responses to the December 2000 Questionnaire (refer Section 4.2). At present, flood insurance is not readily available for houses, although it is available for some commercial and industrial properties. As part of the education program the community should be informed about flood insurance and its limitations.

6.3 Assessment of Flood Modification Measures

6.3.1 River Improvement Works

Description

River improvement works, such as removal of hydraulic restrictions, may have the potential to reduce flood levels by increasing the hydraulic capacity of the river. Dredging could also improve the hydraulic capacity by increasing the inbank flow area.

Discussion

Removal of vegetation may reduce flood levels on small creeks but would provide negligible benefit on the main Shoalhaven River. Additionally, by increasing the hydraulic capacity they can also increase the stream velocities which can increase erosion. Vegetation removal is likely to further destabilise the banks which are currently eroding. Realignment or reconstruction of the channel and removal of hydraulic restrictions such as the islands (Pig, Numbaa, Old Man) were considered but rejected due to:

- legal implications,
- high cost,
- land ownership and compensation issues,
- likely impact on the erosional and sedimentation regime,
- unlikely to be sustainable (i.e. will require ongoing maintenance dredging),
- environmental concerns,
- bank stability concerns,
- loss of agricultural land.

"Terara Sand and Gravel" has operated a dredge since 1992 to extract approximately 35 000 m^3 (or 50 000 tonnes) per annum. Currently the dredge only works within a limited area upstream of the Terara village and provides minimal hydraulic benefit as it creates localised holes rather than reducing the bed level by a uniform amount over a large distance.

For the Terara Village FPMS a hydraulic model was used to evaluate the effect of increasing the dredged area to reduce the general bed level. Three scenarios were analysed for both the 5% AEP and the 1% AEP events:

- Scenario A - 260 000 m^3 removed,
- Scenario B - 550 000 m^3 removed,
- Scenario C - 1 000 000 m^3 removed.

Dredging was assumed to extend over a 4.5 km length of the river from approximately midway along the Riverview Road levee to approximately midway between Pig Island and Numbaa Island. The resultant changes in peak flood level are shown in Table 15. The indicated reductions in flood level will have an insignificant affect on the flood hazard at Terara or elsewhere.

Table 15: Dredging - Reduction in Peak Flood Level (in m)

Dredging Scenario	**A**		**B**		**C**	
Location/Flood AEP	**1%**	**5%**	**1%**	**5%**	**1%**	**5%**
Terara	0.02	*	0.03	*	0.07	*
Pig Island	0.02	0.02	0.04	0.04	0.07	0.08
Ferry Lane	0.03	0.03	0.06	0.06	0.11	0.12

Note:

* values are not provided for the 5% AEP event at Terara as the land is only just inundated at this level and the peak levels relate more to local drainage, or backwater levels in the swamp than the main river levels.

The cost of dredging largely depends on the size of the dredge and the associated land-based operation. An indicative range is \$8/m^3 to \$10/m^3 (year 2000 costs). Assuming \$9/m^3 the scenario costs would be:

- Scenario A - \$2.3 million,
- Scenario B - \$5.0 million,
- Scenario C - \$9.0 million.

On top of these costs there is currently a royalty of \$1.20/m^3 (year 2000 costs), although this might be renegotiated if the work was solely for flood mitigation purposes with no financial gain.

Potential use of the extracted material depends on the quality of the material and the local market. The existing dredge operation provides sand for local concrete manufacturing and filling at approximately \$12/m^3 to \$20/m^3 (year 2000 costs). Preliminary investigation suggests that decreasing the price will not significantly increase demand. In fact the current operator adjusts the extraction rate to meet the demand and could easily produce up to twice the current volume of material. Most of the material removed in the three scenarios would, therefore, not find a market and disposal sites would need to be found. This would add to the economic cost and also have consequent environmental implications.

A dredging operation normally extracts approximately 30% solids and 70% liquid and legislation requires that the liquid be settled before returning to the river. The present operator uses a trench on Pig Island for settling but this is already a source of contention and preliminary investigations suggest that this issue would be a significant problem for a larger operator.

Dredging is an extractive industry which requires an EIS to be prepared as part of the approval process. An EIS would cost of the order of $100 000 and would require an evaluation of a range of environmental and social issues.

Further investigation would also be required to determine the long term effectiveness of dredging. It is possible that a subsequent flood would simply deposit material in the dredged area, thus negating the benefit. There is also the possibility that dredging may induce local bank failure as a result of affecting the sedimentation/erosional regime of the area.

Conclusions

Dredging will marginally reduce flood levels but will not greatly affect the inundation of buildings in large floods. It is not an effective floodplain management measure as it provides only marginal hydraulic benefit, is not economically viable or sustainable and would raise significant environmental concerns.

None of these measures are compatible with current best practice for floodplain management on the Lower Shoalhaven River.

6.3.2 Local Drainage

Description

Overflows from the local drainage system are most widely identified as flooding by the community. Such overflows are a concern to the community because they generally occur more frequently than mainstream flooding. Local drainage problems invariably involve ponding of water at localised low points because the drainage system has limited capacity.

Discussion

Local drainage problems are more of an inconvenience to the community rather than a threat to life or property. The most obvious problems are the lack of kerb and guttering and blocked drains. The community identified local drainage issues for the following areas:

- Orient Point,
- Greenwell Point,
- Shoalhaven Heads,
- Nowra,
- Culburra.

Issues relating to local stormwater drainage were also raised in the City of Shoalhaven Urban Stormwater Management Plan (Reference 9). This Management Plan recommends works such as:

- bank stabilisation,
- improved maintenance of silt fencing in table drains,
- improved building controls,
- formalised kerbside drainage,
- sealing of road surfaces.

From a main stream flooding point of view these recommended works should have little impact on "main stream" flood behaviour or issues. Regular maintenance of drainage works should however reduce the occurrence of localised ponding of water during rainfall events.

Conclusions

While local drainage flooding is a very visible and immediate problem it is generally a minor concern during mainstream large flood events, when houses and lives are threatened. Local drainage issues highlighted by this study will be addressed by Council and included more appropriately in the Stormwater Management Process. The City of Shoalhaven Urban Stormwater Management Plan, April 2000 (Reference 9) addresses the existing local drainage issues and how to deal with future local drainage problems.

6.3.3 Levees

Description

Levees involve the construction of raised embankments around flood affected areas so as to prevent the ingress of floodwaters. The suitability of such a measure however depends on a number of factors pertaining to the physical features surrounding the affected area and the nature of flood behaviour. Within the Lower Shoalhaven floodplain there are several areas of existing development which have been exposed to hazardous flooding situations in the past where levees may have provided some benefit.

A levee was built along the southern bank of the Shoalhaven River from Nowra Bridge to Terara in the mid 1970's. Following several floods in the 1970's the height of the levee at Terara was increased to its present level whereas previously, the crest was probably only 0.5 m above the adjacent natural ground surface. In 1986 the levee from Nowra Bridge to Ferry Lane (referred to as the Riverview Road Levee) was increased to the 1% AEP flood level, approximately 2 m above the adjacent natural ground surface. There are other smaller "local" or natural levees within the Lower Shoalhaven River floodplain, but generally they are of an unknown standard (construction or level of flood protection) and would not be considered large enough to warrant detailed investigation. One such levee is located along the northern bank of Zealands Creek (opposite Hay Avenue at Shoalhaven Heads - refer Figure 5).

It is possible that some form of levee protection may help to address the existing problems experienced at Shoalhaven Heads and Greenwell Point which are two of the main areas contributing to the overall flood damages (Section 3.4).

Discussion

The benefits of levees in floodplain management have long been recognised for the protection of large areas of existing flood liable development. However, in recent years a number of disbenefits have also become clear.

They are expensive (the Riverview Road levee cost approximately $600/m length in 1986), and can be intrusive (aesthetically displeasing) for riverside residents. There is also the concern that they may exacerbate river bank erosion or collapse. It is also important to ensure that adequate internal drainage can be provided so that the protected area is not flooded by the ponding of local (internal) runoff.

Unless a levee is built to the PMF level, which would generally be unacceptable economically and socially, it will eventually be overtopped in a very large event. When this happens, initial velocities will be high and substantial damage will occur. Failure of the levee may also occur during a flood event, prior to overtopping. The situation will probably be exacerbated by the fact that the levee has engendered a false sense of security in the local population and substantially lowered flood awareness. This was the case at Nyngan in 1990.

Construction of a levee may also lead to a push to alter Council's Flood Policy and allow further development of low lying flood liable areas. Previous reports on flooding at Riverview Road considered that levees should only be used to protect existing dwellings and should not be promoted to facilitate further development on the floodplain.

The inundation of floodplains by floodwaters is a naturally occurring phenomenon and limiting this feature may result in a reduction in the environmental quality of the area. For this reason major levees along the banks of the Shoalhaven River are not supported.

However, small local levees to protect isolated communities have been considered. The two main areas are at Shoalhaven Heads and at Greenwell Point (refer Figure 5). The main problem with these local levees are:

- relatively high cost to fully protect the number of properties affected,
- the size of the levees (length, height and width) would need to be considerable and could be difficult to accommodate in many locations due to existing physical constraints,
- they are visually obtrusive and not supported by many residents, particularly those who "see" the levee but are afforded no real benefit (such as a new house at a high level or a two storey house without habitable areas at ground level),
- levees can and do fail during a flood. They can also be overtopped in floods larger than the design event,
- local drainage behind the levee can be a major issue. This can be addressed through the use of flap gated culverts but will generally always have some residual problems,
- vehicle access across the levee can present major practical problems.

At Shoalhaven Heads, the properties most at risk are located at Hay Avenue and within the backwater area of Zealands Creek. Protection of the Hay Avenue properties would involve construction of a levee through private property along the main river bank (Alignment A - Figure 5). This would present a number of social, aesthetic and practical problems and is not considered a viable solution for these properties.

Most of the remaining problem involves the properties along Jerry Bailey Road which directly back onto Zealands Creek as well as the several caravan parks up towards Shoalhaven Heads Road. Construction of a levee along the rear of these properties (Alignment B - Figure 5) would be difficult due to space limitations, environmental concerns and cost versus potential benefits. A levee which crossed the southern end of the Zealands Creek floodplain from River Road/Hay Avenue to high ground along Bolong Road (Alignment C - Figure 5) would also not be feasible on environmental grounds, and while providing protection from main river backwater flooding, it could potentially exacerbate local internal flooding from Zealands Creek. A small (low level) privately constructed levee already exists in this area (not marked on Figure 5) and it is understood that a short section (100 to 150 m long) is up to 0.5 m lower and readily overtopped in the frequent flood events. As the materials and method of construction of this levee is unknown its existence provides no additional advantages in terms of cost savings as it would need to be re-constructed in accordance with appropriate current standards.

The protection of most flood affected properties at Greenwell Point would require the construction of nearly 4.5 km of levees (refer Figure 5). Some 2.5 km of this would need to be positioned along the foreshore areas through a combination of reserves and private property. Construction costs alone (excluding design, property acquisition, internal drainage, etc.) are likely to well exceed $3 million and probably closer to $4 or $5 million. The net present worth of the reduction in flood damages (assuming 1% AEP protection and 50y design life at 7% discount rate) could be of the order of $8 million which would infer a B/C ratio of around 2.6. Providing a smaller levee, affording protection in a 10% AEP event, could still achieve a $4 to

$5 million NPW reduction in damages with a B/C closer to 1.0. Thus from a purely economic perspective, some form of levee protection would be considered a viable measure for Greenwell Point.

However, there are a number of significant other issues which are likely to influence the ultimate decision of whether this measure could be implemented. In particular, the levee alignment is dependent on obtaining suitable space and/or access rights around the foreshore (through reserves and private property), geotechnical ground conditions, environmental concerns and predominantly social and aesthetic concerns as the structure would significantly alter the amenity of the foreshore outlook and access to both properties and the surrounding waterways would be adversely affected. The levee would also create internal drainage issues and hydraulic impacts for the floodplain areas immediately upstream.

Further detailed investigation of this measure may develop or identify alternative options (refer Figure 5 for alternative alignment possibilities) to overcome some of these concerns while still achieving sufficient benefits. This may also however create other issues such as the isolation of some properties which then cannot be protected (particularly those along the foreshore areas).

Conclusions

Levees are a potential means of reducing the flood hazard for existing development and have been considered at Shoalhaven Heads and at Greenwell Point. In both situations there are a number of issues which limit their feasibility or viability as a practical means for addressing the nature of the flood problems experienced in these areas. Some form of possible Levee protection at Shoalhaven Heads is not considered to be viable or practical. However, further investigation of the possible levee solutions available for Greenwell Point is warranted.

Levees are also considered to be economically, socially and environmentally unacceptable as a means of protecting future development from the risks of flooding.

6.3.4 Flood Refuge Mounds

Description

Flood refuge mounds are an effective means of reducing stock losses during a flood. They are widely used on floodplains in New South Wales and could provide some benefit for the farming properties situated on the Lower Shoalhaven floodplain.

Discussion

Many farmers have already constructed these mounds on the floodplain and used them during the floods in the 1970's. The main issue with flood refuge mounds are the possible hydraulic impacts associated with localised flow diversions or increase in flood levels. These issues need to be addressed but are unlikely to be of sufficient magnitude to prevent construction of such structures. Farmers need to consider the most effective location for the mounds (such as utilising existing high ground areas and avoiding flow path areas) and be aware that unless the animals are herded onto them earlier in the flood the access routes will be cut.

The cost to construct the mounds depends entirely upon the availability of fill material. Unless this can be obtained locally it is unlikely to be financially viable. Funding under the NSW Floodplain Management Program is unlikely to be available for these works and they are usually funded by the individual proponent. It is possible that funding may be available from other sources such as the Department of Agriculture.

Conclusions

Flood refuge mounds are an effective means of reducing stock losses. The construction of suitable new mounds say up to 200 m^2 in area per farm, funded by the proponent are supported provided it can be demonstrated the hydraulic impacts are likely to be minimal. To assist in this regard, mounds should be sited to make best use of existing high ground wherever possible and shaped to minimise obstruction of likely flow path areas.

6.3.5 Shoalhaven Heads Entrance Management

The issues regarding the management of the Shoalhaven Heads Entrance have been discussed previously in Section 5.2.1. Appendix G summarises a discussion paper on the management of Shoalhaven Heads to minimise flooding to the community. Subsequently Council prepared the Shoalhaven River Entrance Management Plan for Flood Mitigation (Reference 12). The issues addressed in the reports need to be updated as more information on floods and the outcomes of Council's existing management policy becomes available over time.

6.4 Assessment of Property Modification Measures

6.4.1 Voluntary Purchase

Description

Voluntary purchase involves the acquisition of flood affected properties (particularly those frequently inundated in high hazard areas) and demolition of the residence to remove it from the floodplain. This option is mainly used in the more hazardous areas over the long term as a means of removing isolated or remaining buildings to free both residents and potential

rescuers from the danger and cost of future floods. It also helps to restore the hydraulic capacity of the floodplain (storage volume and waterway area).

Discussion

Voluntary purchase of all the residential buildings situated in the Lower Shoalhaven River floodplain and inundated above floor level in the extreme flood would cost between $200 and $600 million and as such cannot be economically or socially justified. Generally, Government funding of Voluntary Purchase Schemes is only available as a last resort for situations where buildings are located in a high hazard area and are frequently flooded (20%, 10% or 5% AEP events) with limited alternative options available to manage the situation.

The results of the December 2000 Questionnaire (Diagram 2 of Section 4.2) indicated that voluntary purchase is not favoured by a large part of the community. This is a common response as indicated by the recent example of the Brushgrove Levee Feasibility Study where voluntary purchase was estimated to be an economically viable measure of reducing flood damages to property. Despite its recommendations, the local community did not accept voluntary purchase because it would have a significant impact on their way of life. Among their concerns are:

- it can be difficult to establish a fair market value (the State Valuation Office values the property as if it is not affected by flooding),
- in many cases residents may not wish to move for a reasonable purchase price,
- progressive removal of properties may impose stress on the social fabric of an area,
- it may be difficult to find alternative equivalent priced housing in the nearby area with similar aesthetic values or features.

While widespread voluntary purchase in the study area would not be viable, the possible purchase of certain isolated buildings in conjunction with other measures may be worthy of further consideration where there are no suitable alternatives. Analysis of the surveyed floor levels revealed some 203 properties (includes residential and commercial but excludes caravan parks) are inundated above floor level for the 10% AEP and larger flood events. A street by street summary of properties affected is included in Table 16 with a more detailed property listing indicating the severity of inundation (individual depths above ground and floor level) included in Table D2 of Appendix D.

Table 16: Summary of Properties Inundated Above Floor Level in a 10% AEP Event

Location	Street	Number of Properties
Greenwell Point	Adelaide Street	50
Greenwell Point	Haiser Road	30
Greenwell Point	Comarong Street	13
Greenwell Point	Greens Road	10
Greenwell Point	Bailey Avenue	6
Greenwell Point	Church Street	4
Greenwell Point	Crookhaven Drive	3
Greenwell Point	Fraser Avenue	1
Greenwell Point	Greenwell Point Road	2
Greenwell Point	Keith Avenue	8
Greenwell Point	Leonore Avenue	5
Greenwell Point	Morrissey Way	1
Greenwell Point	Pyree Street	1
Greenwell Point	South Street	1
Greenwell Point	West Street	2
Orient Point	Addison Road	18
Orient Point	Prince Edward Avenue	4
Orient Point	Sunshine Street	2
Orient Point	Orama Crescent	1
Orient Point	Orient Point Road	1
Orient Point	Raglan Street	1
Shoalhaven Heads	Hay Avenue	15
Shoalhaven Heads	Jerry Bailey Road	15
Shoalhaven Heads	Wharf Road	3
Shoalhaven Heads	Shoalhaven Heads Road	4
Shoalhaven Heads	Bolong Road	1
Shoalhaven Heads	McIntosh Street	1
Bomaderry	Bolong Road	10
Bomaderry	Worthington Way (private)	1
Nowra	Various	3
	TOTALS	**217**

The costs associated with purchasing all 217 properties identified are likely to be well in excess of $40 million which would exceed the potential benefits to be achieved. The net present value of the total floodplain damages is estimated to be around $25 million but even with the purchase of all properties, there would still be a residual damages cost. Such a large scale scheme would also be impractical to implement for a number of reasons and it is unlikely to be accepted by the majority of affected property owners. This should not preclude however, the consideration of voluntary purchase for smaller numbers of properties which are potentially more isolated or badly affected (e.g. depth of inundation above floor level >0.5 m in a 10% AEP event). This would reduce the total number of properties to less than 30 which may be more feasible. However, these properties are relatively scattered across the floodplain and aside from a reduction in total damages there would be little benefit achieved in their isolated removal from the floodplain and surrounding development. Additionally, as most of the worst affected properties are spread through the Greenwell Point area their removal would have a considerable social impact with strong resident resistance. It would be better to allow or encourage redevelopment of these properties with appropriate minimum floor levels and other flood compatible development controls. Alternatively, the consideration of levees (Section 6.3.3) and/or other measures may be more viable.

Conclusions

The adoption of a widespread voluntary purchase scheme is unlikely to be embraced by the majority of affected property owners and the associated social and economic costs would not justify the benefits. There are no readily identifiable areas or groups of houses where voluntary purchase stands out as the only or most viable management measure. Additionally, it is unlikely that it would be embraced by a majority of affected property owners. Broadscale voluntary purchase is therefore not recommended but Council could consider surveying up to 30 of the worst affected properties listed in Table D2 of Appendix D to determine if the situation really warrants voluntary purchase and if the residents might be interested.

6.4.2 House Raising

Description

House raising is suitable for most non-brick single storey buildings on piers and is particularly relevant to those situated in low hazard areas of the floodplain. The cost of house raising is typically of the order of $40,000 (year 2000 costs) per house and this approach provides more flexibility in planning, funding and implementation than the likes of voluntary purchase.

Discussion

A review of the floor level survey data and building types suggests that house raising could be suitable for approximately 16 properties which are inundated in the 10% AEP event. Details of these properties are highlighted in Table D2 of Appendix D.

Assuming each of these houses was raised 3 m (one floor), the net present worth of the estimated benefits (reduction in Average Annual Damages) would be around $1.25 million (year 2000 costs). The cost of the measure would be up to $640,000 (year 2000 costs) giving a B/C ratio in the order of 2.0.

The grants for funding of this measure generally only cover the basic costs of raising the structure. Additionally, the subsidy is usually offered on a relative basis depending on the severity of the problem and potential damages cost. Residents will most likely have to contribute their own funds to make up any difference and to facilitate any associated works or modifications. The results of the questionnaire survey indicated a low level of community acceptance for house raising. This is not to say however, that this attitude could not change in the aftermath of future flood events or with a change in property ownership.

It should also be noted that house raising does not alter or reduce the flood hazard classification for a property and in fact residents will tend to remain with their house rather than be evacuated early in the event. The main benefit of house raising is the reduction in flood damages experienced by the individual property.

Conclusions

House raising is a viable measure for those properties satisfying the criteria. Its adoption for implementation is however dependent on individual resident acceptance and funding availability. The 16 properties which have been flagged as potentially suitable (refer Table D2 of Appendix D) should be approached to ascertain their current position in the matter and verify the property eligibility for raising and subsidised funding. It should be remembered that while current property owners may not be interested in this option, the success of prospective or future purchases may be dependent on this option being available. An indication of the property's eligibility for house raising could be recorded on the Section 149 Certificate to ensure future potential purchasers are made aware of their options.

Commercial stock losses could also be reduced if businesses raised the level of their storage areas or stored stock above the flood planning level.

6.4.3 Flood Proofing

Description

Flood proofing involves the sealing of entrances, windows, vents etc. to prevent or limit the ingress of floodwater. It is generally only suitable for brick buildings with concrete floors and it can prevent ingress for outside depths up to approximately one metre. Greater depths may cause structural problems for the structure unless water is allowed to enter. An existing house could be sealed for approximately $10 000 (year 2000 costs) while the cost for extensions could be much less. Additionally, flood proofing can involve the raising of easily damaged/high cost items such as commercial stock, equipment and/or machinery. New buildings should have floor levels above the FPL and should be built in a manner which reduces the risk of flood damage for events greater than the FPL.

Discussion

This measure is rarely used in NSW for residential buildings and is more suited to commercial premises (such as may be found at Bomaderry) where there are only one or two entrances and maintenance and operation procedures can be better enforced.

Flood proofing requires the sealing of doors and possibly windows (new frame, seal and door); sealing and re-routing of ventilation gaps in brickwork; sealing of all underfloor entrances and checking of brickwork to ensure that there are no gaps or weaknesses in the mortar.

It will not reduce the flood hazard and in fact the hazard may be increased in the case that the measure results in occupants staying in their premises and a large flood inundates the building to high depths above floor level. There are no other significant environmental or social problems. From the results of the December 2000 Questionnaire (Diagram 2 - Section 4.2) this measure was acceptable to approximately 9% of the respondents and rated higher than either house raising or voluntary purchase. The implementation of this measure would be at the discretion of the owners of property for which the process is suitable.

Conclusions

This measure generally costs much less than house raising giving it a higher B/C ratio and it is therefore worthy of further detailed consideration particularly for regularly flooded commercial properties where the damages can be greater. Preliminary work would include detailed inspection of buildings and interviews with the property owners. This measure would be particularly applicable for the flood affected businesses located in the commercial/industrial area of Bomaderry.

A public awareness program should be initiated to inform owners of commercial and residential properties about the potential of this measure and allow them to undertake the works at their own convenience. It must be made clear that this measure will not completely protect the occupants or the house in large events, evacuation may still be necessary which could pose some hazard or risk.

6.5 Assessment of Response Modification Measures

6.5.1 Flood Warning

Description

Flood warning, and the implementation of evacuation procedures by the State Emergency Services (SES), are widely used throughout NSW to reduce flood damages and protect lives. The Bureau of Meteorology (BOM) is responsible for flood warnings on major river systems such as the Shoalhaven River. The local SES also has their own system for monitoring the height of the Shoalhaven River. The flood warning system is based on a series of gauges which automatically record rainfall or river levels at upstream locations and telemeter the information to a central location.

Adequate flood warning gives residents time to move goods, stock and vehicles above the reach of floodwaters and to facilitate organised evacuations from those areas at risk. The effectiveness of a flood warning scheme depends on:

- the maximum potential warning time before the onset of flooding,
- the actual warning time provided before the onset of flooding, this depends on the adequacy of the information gathering network and the skill and knowledge of the operators,
- the flood awareness of the community responding to a warning.

Studies have shown that flood warning systems generally have high benefit/cost ratios if sufficient warning time is provided. Even with an effective flood warning system, some tangible and intangible flood damages will still occur.

Discussion

An ALERT system (Automated Local Evaluation in Real Time) has been operated in the catchment by Shoalhaven City Council and the BOM since 1989. The $120 000 installation cost was shared between the two authorities. It consists of fifteen (15) rainfall and eight (8) stream sensor stations and a number of repeater stations. The system has not been tested in a large flood but has performed successfully in several smaller events which occurred in the 1990's. Some operational problems (radio interference, battery life, software problems) have occurred but these have now been addressed.

Although Council monitors the situation during flood events, the responsibility for issuing flood warnings rests with the BOM and at a local level the SES. Council does not issue warnings. Council's role during floods is to assist the SES with regards to road closures, evacuations and other related matters. Council uses the ALERT system to provide information to the SES for events below the minimum level at which the BOM issues official warnings.

Council does not have a facility to forecast flood levels but is currently investigating this matter. If Council had its own forecasting model it would provide additional benefits such as:

- it would act as a fall back system if the BOM system failed, it would also provide a "second opinion",
- it may assist in minor and local flooding situations not monitored by the BOM,
- Council may wish to take interim actions to protect its assets based upon its own forecasting rather than waiting for the official BOM warning,
- decisions regarding the conditions at the entrance and whether to assist with its opening can be made.

The main improvement that could be made to the existing system is the use of computer based models to generate real time flow estimates and (ultimately) flood levels. Access to better flood event information over the internet will increase the community's awareness during and after the event. The availability of better flood warning information rated second highest preferred floodplain management measures in the responses to the December 2000 Questionnaire (Diagram 2 - Section 4.2).

Gauging stations at the Shoalhaven and Crookhaven River entrances to monitor prevailing ocean conditions, wind direction and water levels would assist in managing the Shoalhaven River entrance issue during flood events. Additionally, upgrading of the existing flood level recorders (located at the various floodgate structures controlling the swamp drains) to more modern telemetered gauges would provide much needed additional information on water levels across the broader floodplain areas. This would also give the SES a better idea on the status of certain evacuation routes servicing the rural properties situated in the broader floodplain.

The cost of this measure (year 2000 costs) would be in the order of $5,000 to $10,000 (year 2000 costs) for each gauge established and say $10,000 to $20,000 to develop a system which provides better access to flood event information for the general community.

Conclusions

The ALERT system is a suitable approach for providing flood warning advice for the Shoalhaven River. The system should be continually monitored and upgraded as required. More sophisticated computer modelling, installation of gauges and rectification of the minor existing system problems are the main issues with the present system. Additional telemetered gauges are recommended for installation at the Shoalhaven and Crookhaven River entrances as well as the existing floodgate structures located across the floodplain. Council should also prepare a Flood Warning Manual to ensure that the existing knowledge held by current Council and SES staff is adequately documented for future reference and implementation.

6.5.2 Evacuation Planning

Description

A comprehensive Local Flood Plan was prepared by the SES in October 1999 and updated in February 2004 (refer Section 5.2.12). It includes sections on:

- *Flood Preparedness* - including public education, activation, flood intelligence, and warnings.
- *Response* - including control, operations centre, liaison, communications, information, road control, flood rescue, evacuation, logistics and re-supply, and stranded travellers.
- *Recovery* - including welfare, registration and inquiry, all clear, recovery co-ordination, and debrief.

Discussion

The effectiveness of the plan to undertake evacuations of the Lower Shoalhaven floodplain has not been tested. The main problems with all flood evacuations are:

- they must be carried out quickly and efficiently,
- they are hazardous for both the rescuers and the evacuees,
- residents are generally reluctant to leave their homes, causing delays and placing more stress on the rescuers and increasing the risk to the residents,
- the number of people to be evacuated,
- the mobility of any special requirements to evacuate residents,
- evacuation routes may be cut some distance from the residences and people do not appreciate the danger.

The rate of rise of the river determines the amount of time the SES has to implement an evacuation plan. The size and extent of the Shoalhaven River catchment means the rate of rise in the river is relatively slow (refer Section 3.3) and this allows for some time to evacuate the lower lying areas. Some of the smaller creeks within the floodplain may experience flash flooding in which little if any time is available to evacuate. Additional information on the sensitivity of flood gradients immediately downstream of Nowra Bridge due to various rates of rise scenarios is presented in Reference 11.

While the rate of rise is critical the time of inundation is also a major issue which needs to be considered. Table 7 includes information on the length of time areas of the floodplain are inundated. As can be seen from the results the Local Flood Plan will also need to allow for extended periods of inundation and how this will be managed within each area with regards to access and supply of essential services and supplies.

Discussions have been held with the SES and Council to review the effectiveness of the plan and to provide recommendations for further enhancement. This Floodplain Risk Management Study contains details on the following:

- when and where evacuation routes are cut,
- the number of buildings affected at various flood heights,
- road closures,
- the potential for bank erosion/collapse.

Where appropriate this information should be used by the SES.

Another issue of concern to many residents is the damage caused by the wash from sightseer's and/or emergency services vehicles travelling along the roads. This is alleged to have flooded some houses in the 1970's (at Terara) which would otherwise have remained dry and some of the businesses at Bomaderry have also complained of experiencing similar problems in more recent flood events.

At present the Local Flood Plan predominantly only covers floods up to the 1% AEP event. Larger events up to the Extreme or PMF must also be considered as these pose the greatest risk to life and general disruption to the community at large.

Conclusions

The Local Flood Plan should be updated to provide design flood height information for events greater than the 1% AEP, such as the 0.2%, 0.5% AEPs and extreme events. It should also reference this Study as this provides additional information that may be of assistance.

The floor level data obtained for this Floodplain Risk Management Study has been provided to the SES to enable officers to accurately determine which houses will be inundated first and hence require early notification to evacuate in a flood event. These details have already been linked to Council's GIS database as part of this study to assist with mapping of the affected

properties. Appendices A, B and C of the Local Flood Plan should be upgraded to include the current maps and data sheets. The SES should give detailed consideration into whether evacuation routes need to be raised to provide better access (refer Section 6.5.3 below). In particular, the long road to Greenwell Point which can be cut well away from the developed areas in relatively small events, and the early loss of the punt service to Comerong Island.

Vehicles should be prevented from travelling along closed roads as the wash generated by the vehicles can cause additional damages to property and the local environment. The consequent effects of driving through ponded water on closed roads should be included in the flood awareness and readiness programs discussed in Section 6.5.4.

It is also recommended that the Plan be reviewed and updated on an ongoing basis as additional or better information becomes available. Such updates would be particularly relevant in the aftermath of an actual flood event where direct lessons may be learnt from the implementation of the Plan to real life situations.

6.5.3 Evacuation Access

Description

One of the main ways of improving evacuation (apart from more equipment, personnel or training) is to ensure that there are adequate evacuation access routes available and appropriate warning as to when the routes will become impassable. For example, roads could be raised or "low" spots eliminated to ensure trafficability.

Maintaining appropriate access to or from affected areas during times of flooding is important to ensure:

- people have the chance to evacuate themselves and valuables/belongings before becoming inundated or trapped by raising floodwaters,
- emergency services (SES, ambulance, police, etc.) are not restricted or exposed to unnecessary hazards in carrying out their duties,
- areas are not isolated for extended periods of time, preventing people from going about their normal routines or business or restricting access to essential services.

Discussion

Discussions with the SES indicate that there are no obvious roads that require immediate attention. There are a number of issues to be considered in raising roads including:

- the relatively high cost,
- the level they should be raised to and for what length. How much benefit is provided?
- whether the raising of the road causes an unacceptable hydraulic impact,
- the entire evacuation route needs to be raised to a minimum serviceability level for properties upstream from the affected area to high ground. If there are remaining "low spots" the work is of little benefit and may lead people into trying to evacuate themselves and putting their lives at risk.

As discussed in Section 3.3, within the Lower Shoalhaven floodplain there are several situations where access may present a significant problem during times of flood. These areas incorporate the settlement of Greenwell Point, Comerong, Pig and Numbaa Islands and to a lesser extent Shoalhaven Heads, Orient Point and Culburra.

Recent survey of Greenwell Point Road indicates that the road is cut by floodwaters in events less than a 10% AEP. The stage hydrograph for the 10% AEP flood event (included in Appendix H as Figure H4) shows that at the time Greenwell Point Road is cut (approximately RL 1.5 mAHD - Brundee) properties in Greenwell Point are also becoming inundated.

At Greenwell Point there is only one road (Greenwell Point Road) leading into the settlement. The road is relatively flat and low lying with approximately 5.7km below RL2.0 mAHD and is readily inundated in small or frequent flood events. Access for the entire township is therefore significantly restricted and likely to be lost early in the larger events.

There is little opportunity to raise Greenwell Point Road for its entire length (some 8.5 km) because it crosses the main floodplain and therefore has the potential to dam water and change the nature of flooding in the local area. Significant waterway provisions would need to be incorporated to allow floodwaters to pass through to the downstream areas and thus minimise potential impacts for upstream properties. While this approach would not solve all the problems for the flood affected township it would increase the time available for evacuation. The cost of raising the full length of road is likely to be well in excess of $8.5 million (assuming a unit rate of up to $1,000/m (year 2000 costs) to account for waterway provisions and problems with services and property access) and would therefore not be cost effective.

Instead, it may be more feasible to address any localised weak spots (“low points”) in the route to ensure a consistent minimum level of serviceability/trafficability is attained. As a significant number of the Greenwell Point properties are flood affected in as little as the 10% AEP event, the benefits of providing any greater level of serviceability would quickly be outweighed by the increase in costs. Flood levels along the road indicated that if the low points along the road were raised to RL1.9 mAHD, and additional waterway crossings installed, the depth of inundation during a 10% AEP flood event would be in the order of 200 mm or less. Since velocities in the area are generally low or close to zero the hydraulic hazard would also be very low and conventional vehicles should still be able to drive to higher ground. Based on the limited survey information provided at 19 sites (Table 8 and Figure 8) it is estimated that approximately 4.1km would need to be raised by up to 400 mm to achieve a minimum level of RL1.9 mAHD. The potential to create adverse hydraulic impacts is also reduced as the extent and level of roadworks is also minimised. Further detailed investigation of this issue is required to fully identify the optimum level of serviceability along with the associated extent and cost of works.

With regard to the evacuation access for the different "Island" settlements (Comerong, Numbaa and Pig) the critical issue is the loss of ferry services with rising water levels early in an event. The increase in river currents (velocities) also presents a problem which can make boat evacuation quite dangerous. From a physical works point of view, there is little which can be done to improve this situation due to the various constraints which exist. The simplest solution would be to ensure people are evacuated before access is lost but as this would need to occur at relatively low river levels it would often result in needless (false alarm) evacuations.

Conclusions

The possible raising of Greenwell Point Road to a minimum serviceability level of RL1.9 mAHD should be investigated in detail.

6.5.4 Flood Awareness and Readiness

Description

The success of any flood warning system depends on:

Flood Awareness: How aware is the community to the threat of flooding? Have they been adequately informed and educated?

Flood Readiness: How prepared is the community to react to the threat? Do they (or the SES) have damage minimisation strategies (such as sand bags, raising of possessions) which can be implemented?

Flood Evacuation: How prepared are the authorities and the evacuees to evacuate households to minimise damages and the potential risk to life? How will the evacuation be implemented, where will the evacuees be moved to?

Discussion

A community with high flood awareness will suffer less damage and disruption during and after a flood because people are aware of the potential of the situation and listen carefully to official warnings on the radio and television. There is often a large, local, unofficial warning network which has developed over the years and residents know how to effectively respond to the warnings by raising goods, moving cars, lifting carpets, etc. Photographs and other sentimental or non-replaceable items are generally put in safe places. Some residents may have developed storage facilities or buildings, etc., which are flood compatible. The level of trauma or anxiety may be reduced as people have "survived" previous floods and know how to handle both the immediate emergency and the post flood rehabilitation phase in a calm and efficient manner.

The level of flood awareness within a community is difficult to evaluate although the responses to the December 2000 Questionnaire suggests that nearly 70% of the Lower Shoalhaven floodplain inhabitants believe they are "flood aware". This will vary over time and depends on a number of factors including:

- *Frequency and impact of previous floods.* A major flood causing a high degree of flood damage in the previous few years will increase flood awareness. However if no floods have occurred, or there has been a number of small floods which cause little damage or inconvenience, then the level of flood awareness may be low. This is the case for the Lower Shoalhaven.

- *History of residence.* Families who have owned properties for generations will have established a considerable depth of knowledge regarding flooding and a high level of flood awareness. A community which predominantly rents homes and stays for a short time will have a low level of flood awareness.

- *Whether an effective public awareness program has been implemented.*

For floodplain risk management to be effective it must become the responsibility of the whole community. A public consultation program was therefore incorporated into this present study to involve the public and various organisations in the decision making process. An important part of the program was simply to inform the community that there is a flood problem. It is difficult to accurately assess the benefits of an awareness program but it is generally considered that the benefits far outweigh the costs. The perceived value of the information and level of awareness, diminishes as the time since the last flood increases. A major hurdle is often convincing residents that large floods will occur in the future. Some residents have in the past opposed an awareness program because they consider (rightly or wrongly) that it may in some way reduce the value of their property by highlighting flooding issues.

Conclusions

Based on feedback from the questionnaire, public meetings and general discussions, the majority of residents of the Lower Shoalhaven River floodplain have a medium level of flood awareness. Their level of readiness is therefore probably medium to low.

The SES has a medium to high level of awareness of the problem and the requirements necessary to effect evacuations. As the time since the last significant flood (1978) increases, the experience and knowledge of the SES units will diminish. It should be noted that the previous two major floods were in 1860 and 1870. More consideration should be given to the problems of evacuating the low lying areas of Greenwell Point (in particular Adelaide Street) and Shoalhaven Heads (in particular Hay Avenue and Jerry Bailey Road). It is imperative that relevant elements of this FRMS (and Plan) be integrated into the local SES flood planning.

A suitable Flood Awareness Program should be implemented by Council using appropriate elements from Table 17. The details of the program and necessary follow up should be properly documented to ensure that they do not lapse with time and to establish the most effective methods of communication.

Table 17: Flood Education Methods

Method	Comment
Letter/Pamphlet from Council	These may be sent (annually or bi-annually) with the rate notice or separately. A Council database of flood liable properties/addresses makes this a relatively inexpensive and effective measure. The pamphlet can inform residents of subsidies, changes to flood planning levels or any other relevant information. These should also be handed out as part of rental property information. Caravan parks should also have this information displayed in prominent locations for tourists to the area.
School Project or Local Historical Society	This provides an excellent means of informing the younger generation about flooding. It may involve talks from various authorities and can be combined with water quality, estuary management, etc.
Displays at Council Offices, Library, Schools, Local Fairs	This is an inexpensive way of informing the community and may be combined with related displays. Include photographs, newspaper articles and information on development controls and standards, flood evacuation and readiness procedures.
Historical Flood Markers or Depth Indicators on Roads	Signs or marks can be prominently displayed in parks, on telegraph poles or such like to indicate the level reached in previous floods. Depth indicators on roads advise drivers of the potential hazards. Particularly appropriate near local waterways and low points which become flow paths during large events.
Articles in Local Newspapers	Ongoing articles in the newspapers will ensure that the problem is not forgotten. Historical features and remembrance of the anniversary of past events (1860, 1870, 1978) make good copy.
Collection of Data from Future Floods	Collection of data assists in reinforcing to the residents that Council is aware of the problem and ensures that the design flood levels are as accurate as possible. A Post-Flood Evaluation Program (Appendix E) documents the steps to be taken following a flood.
Notification of Section 149 Planning Certificate Details	Floodplain property owners were indirectly informed that they were potentially flood affected as part of the public consultation program and floor level survey. Future residential property owners are advised during the property searches at the time of purchase by details provided on the Section 149 certificate (refer Flood Policy). This notification should be extended to the rural zoned properties as well.
Type of Information Available	A recurring problem is that new owners consider they were not adequately advised that their property was flood affected on the Section 149 Planning Certificate during the purchase process. Council may wish to advise interested parties, when they inquire during the property purchase process, of the flood information currently available, how it can be obtained and the cost.
Establishment of a Flood Affectation Database	The database developed from the information collated in this study could provide details on which houses require evacuation, which roads will be affected (or damaged) and cannot be used for rescue vehicles, which public structures will be affected (e.g. sewer pumps to be switched off, telephone or power cuts). This database should be reviewed after each flood event and could be maintained by the various relevant authorities (SES, Police, Council).
Flood Readiness Program	Providing information to the community regarding flooding informs it of the problem. However, it does not necessarily prepare people to react effectively to the problem. A Flood Readiness Program would ensure that the community is adequately prepared for the event of flooding. The SES would take a lead role in this.

Method	Comment
Foster Community Ownership of the Problem	Flood damage in future events can be minimised if the community is aware of the problem and takes appropriate actions to find solutions. For example, Council should have a maintenance program to ensure that its drainage systems are regularly maintained. Residents have a responsibility to advise Council if they see a maintenance problem such as a blocked drain. This can be linked to water quality or other water related issues including estuary management.

6.6 Planning and Future Development Control Measures

Flood related planning issues have been considered in detail for this study by Nexus Environmental Planning with the key findings, including a range of suggested planning options (Appendix F4), presented in Appendix F. Discussion of some of the issues is presented below.

6.6.1 Review and Formalise the Interim Flood Policy

Description

In 1986 the NSW Government released guidelines for controlling development of floodplains (the Floodplain Development Manual) as part of its overall Policy on flooding. As a consequence Council were required to prepare and adopt their own specific Interim Flood Policy in order to provide some indemnity protection against possible future damages claims. The government has since released two revised and updated manuals (2001 & 2005 - Reference 4) which has changed some of the terms and definitions as well as the fundamental principles for guidelines for managing the flood risks associated with development on the floodplain. The interim policy has subsequently been revised in August 2002 but due to the passage of time and interrelationship with a number of Council's other planning documents, the overall policy approach and implementation is becoming inconsistent and out of date compared with current best practice. The Policy therefore needs to be updated and formalised in accordance with current standards in order for Council to maintain the indemnity cover afforded by the NSW Government legislation. It should be noted that an "Interim" Policy has no status in the 2001 Manual.

Discussion

A review of Council's Interim Flood Policy was undertaken as part of this Floodplain Risk Management Study and the outcomes are summarised in Table 18. As a result of the review, Council have already initiated a number of actions to address the situation. These actions include the preparation of a generic Development Control Plan for flood prone land and revision of the LEP.

Table 18: Review of Current Flood Policies and Related Issues

Issue	Change			Comment
	No	Possibly	Yes	
INTERIM FLOOD POLICY:				
Formalise Flood Policy Documentation			✔	Council's interim policies document the relevant conditions but this could be expanded upon (to include a number of issues detailed below) and include current flood level information. This would assist residents in understanding them.
Current Flood Standard (taken as the 1% AEP)			✔	The philosophy and terminology of a single "Flood Standard" has now been superseded by the application of appropriate "Flood Planning Levels" for different development types. This issue is discussed further in Section 6.6.1. Of particular importance, the results for the entrance closed design scenario should be adopted in accordance with the recommendations of the Flood Study.
More Flexibility for Non-Residential Properties	✔			A more flexible policy was considered for non residential property.
Effect of Wave Runup	✔			Not considered an issue for the Lower Shoalhaven River floodplain.
Adopt a consistent Freeboard of 0.5 m.			✔	This is an acceptable freeboard to adequately account for any reasonable variation above the adopted flood level. It is noted that Shoalhaven Council currently allows a variation to 0.3 m freeboard in certain circumstances. A single value is recommended for consistency and ease of implementation.
Expand to include all Land Use categories. This may be required to cover expansion of existing uses.			✔	The interim policies only mention residential, commercial and industrial developments. It could be expanded to include Special Uses such as hospitals, police stations or Council offices or infrastructure which may experience significant damages if flooded. For example, there are some 23 sewerage pumping stations inundated in a 1% AEP event and 28 in the extreme flood.
Minimum Set Back from Normal Water Level		✔		At present the Council policies do not specify a minimum setback from the banks of a watercourse or foreshore. This issue is likely to be covered by the Rivers and Foreshore Improvement Act but could be highlighted for new development in areas where riverbank erosion is potentially an issue.
The Greenhouse Effect (see also Section 6.6.7)			✔	The Greenhouse Effect (raising of ocean levels) has the potential to impact upon design flood levels. Council's policies should state the importance of the Greenhouse Effect on design flood levels and monitor the situation.

Issue	Change			Comment
	No	Possibly	Yes	
Adopt the Floodplain Management Plan as a part of a Development Control Plan (DCP No. 106) on flooding			✔	Although the Lower Shoalhaven River Floodplain Risk Management Plan will be a stand alone document, it should be directly linked or form part of a generic Flooding DCP (No. 106) applicable to the overall LGA. This is to ensure that local floodplain management is fully incorporated into Councils' planning framework and utilised in the assessment of Development Applications. The process to develop a Flooding DCP (No. 106) commenced in early 2002.
Effect of Fill on Local Drainage (for building pads)			✔	Fill for building pads may affect local drainage and adversely affect adjoining properties. The cumulative affects of such filling can be much greater and therefore individual filling cases need to be considered in a much broader context relating to the overall floodplain. Guidelines to control any filling on the floodplain need to be formalised.
SECTION 149 PLANNING CERTIFICATE:				
Revise Wording		✔		The wording could be revised to more precisely describe what is intended and the implications. Many residents throughout NSW complain that they do not understand the wording on Section 149 Planning Certificates.
Criteria Used to Identify Lots		✔		The floor, ground and flood level information should be continually updated as more accurate survey information becomes available.
Application to Rural Lands		✔		The issuing of a Section 149 Planning Certificate is currently not mandatory for rural zoned lands. As a majority of the Lower Shoalhaven Floodplain is rural, some form of notification process should be introduced to ensure the flood hazards, risks and applicable controls are appropriately identified for all such properties.
Include Flood Prone Lands up to the Extreme or PMF		✔		The Floodplain Management Manual requires greater recognition of the floods larger than the 1% AEP. Consideration should be given to identifying affected properties up to the PMF. This will require examination of the implications throughout the local government area.
LOCAL FLOOD PLAN - SES:				
Review and Update			✔	This plan should be reviewed and updated to include the surveyed floor level information and flood affectation produced as part of this study. The GIS information is to be made available for the SES to assist with planning, management and control of flood evacuation procedures.
Improve Flood Awareness and Education Program			✔	This is a relatively inexpensive measure which provides significant benefits with few adverse social or environmental consequences.

Issue	Change			Comment
	No	Possibly	Yes	
Undertake a Workshop to update the SES, Police, banks, building societies and other authorities.			✔	This will ensure that all appropriate authorities are fully informed of the flood hazard and extent of affectation. At present there appears to be some concern regarding the use of "flood information" by the lending authorities.
POST FLOOD EVENT EVALUATION PROGRAM:				
Formalise Documentation			✔	A suggested program has been included in this Report (Appendix E) and should be included within Council's Floodplain Management Program. It is essential that the Evaluation Program is acted upon immediately following an event and should include utility impacts, warning effectiveness, evacuation issues as well as any positive feedback.

Conclusions

Amongst many other things, the Interim Flood Policy needs to set standards for development within the floodplain which will minimise damage to property whilst also ensuring minimal effect on the hydraulic behaviour of floodwaters. Council are in the process of updating the LEP to suit the current planning requirements (a standard LEP instrument) and standards associated with floodplain risk management (as per FMM 2001 - Reference 4). As part of this process a generic DCP which deals with flood related development controls is also being prepared (DCP No. 106). This DCP will effectively provide the framework of Council's Flood Policy for those areas included by a finalised Floodplain Risk Management Plan. The outcomes from this present study process will then be referred to provide the specific controls applicable to the Lower Shoalhaven River floodplain area.

6.6.2 Flood Planning Levels

Description

Under the former NSW Government approach as outlined in the Floodplain Development Manual (1986), the term *Standard Flood* was used to indicate the area within a floodplain that was subject to planning controls. In most cases, the *Standard Flood* equated to the 1% AEP or 1 in 100 ARI flood level. The previous use of a particular flood level to determine the *Standard Flood* resulted in there being little or no variation to the criteria used when determining if planning controls should apply to a specific floodplain, or indeed if they should apply to specific areas within a floodplain. In essence, if a parcel of land fell within the *Standard Flood* level, then planning controls applied to that land.

Flood Planning Levels (FPLs), however, have replaced the *Standard Flood* (as outlined by the FMM 2001 - Reference 4) as the means by which a Council determines the extent of land that is subject to flood related controls or the nature of controls that apply. They differ from the Standard Flood approach as FPLs are a combination of flood levels and freeboard allowance. The use of FPLs has now been adopted to signify that a more wide ranging approach is

adopted in their selection. Unlike the adoption of the *Standard Flood* level that applied to the entire Local Government Area, individual FPLs can be adopted for an individual floodplain or even a local area within a floodplain. It may well be that the 1% AEP flood level (plus freeboard) is an appropriate FPL for one floodplain, whereas the 2% AEP flood level (plus freeboard) may be appropriate for another floodplain. As discussed in the review of current planning documents relating to the Lower Shoalhaven River Floodplain area (Appendix F), the definition of FPL allows for the adoption of different flood levels as determined by Floodplain Risk Management Studies and contained in Floodplain Risk Management Plans. This approach allows for data collected within a specific floodplain to be utilised to streamline the establishment of an FPL for that floodplain, rather than relying on a single Council-wide *Standard Flood* level.

Since August 2002 Shoalhaven City Council has adopted the use of FPL's and specified it to be the 1% AEP flood level plus freeboard.

Discussion

The selection of appropriate FPLs involves consideration of:

- social,
- economic,
- environmental, and
- risk to life and limb,

consequences associated with the occurrence and mitigation of various size floods.

Selecting the appropriate FPL for a particular floodplain involves trading off the social and economic benefits of a reduction in the frequency, inconvenience, damage and risk to life and limb caused by flooding against the social, economic and environmental costs of restricting land use in flood prone areas and of implementing management measures. It is one of the main means of minimising flood damages from new developments. Some of the flood related issues which should be considered are shown in Table 19.

Table 19: Flood Related Issues to be Considered in the Selection of Flood Planning Levels

ISSUE	COMMENT
Flood Behaviour up to the PMF	Relative change in behaviour over the full range of events up to the PMF. Depth and velocity which define hazard.
Old Standard Flood or FPL	Is it accepted by the community? How significant will any change be and what are the implications for existing versus future development?
Wind Wave Effects	Not applicable in this instance.
Land Use	Existing and potential. How will this be affected?
Freeboard	The value of freeboard to be added to the adopted base flood level to establish the FPL. Freeboard is intended to account for a range of factors including any uncertainties in the estimated flood levels. A value of 0.5 m is typically adopted.
Availability of Land	Is there other land suitable for development in the area?
Impact of Floodplain Management Strategies	How will these impact upon existing and future development?
Land Values and Social Equity	Will changes affect other land owners?
Impact of Future Flooding	How will this affect existing and future development.
Impact of Future Development	How will this affect flood behaviour.
Resultant Change in Flood Damages	Percentage and absolute change.
Flood Awareness and Preparedness of the Community	Consider present community awareness and to enhance or maintain it in the future.
False Sense of Security	Will this be created?
Flood Warning/Flood Evacuation	Effectiveness of emergency response in small and large events. Availability of evacuation access.
Environmental and Ecological Issues	Will these be affected? Aesthetics of streetscape or amenity considerations.
Interrelationship with other Planning and/or Building Controls	The potential to create conflict with other controls (such as height restrictions) needs to be considered.
Duty of Care	How has this been taken into account?

Conclusions

FPLs are generally required to be defined or applied for the following broad land use categories:

- community services (schools, halls),
- critical services (hospitals, police stations, Council offices),
- residential (single and multi unit),
- rural areas,
- commercial/industrial,
- recreational facilities,
- caravan parks,
- additions/extensions to existing structures,
- public utilities (electricity, sewer, water, phone, etc.).

For each of the above land use categories the key relevant development controls include:

- floor level,
- building components,
- structural soundness,
- impact upon others,
- flood evacuation,
- flood awareness.

Different FPLs may be assigned to the different land use categories and for each type of development control within a category. For example, the floor level of a residential building may be set at the 1% AEP flood level + 0.5 m freeboard, structural soundness at the 0.5% AEP level (plus freeboard) and the evacuation level may possibly be the Extreme level. This is just one example of how the adoption and implementation of FPLs is a more flexible approach to the management of land use in the floodplain when compared to the blanket adoption of the *Standard Flood* over the entire floodplain or LGA. This is because the FPL selected for the relevant development controls considers the effective warning time, the type of development and flood duration.

In order to maintain consistency with the interim policy FPL which has been implemented by Council for some years now, it is recommended that the 1% AEP flood level plus 0.5 m freeboard be generally adopted as the Flood Planning Level for the overall Lower Shoalhaven River floodplain. This level is considered to incorporate an appropriate level or balance of risk versus cost to the community for general residential development. Variations of the FPL have been recommended for alternative types of development in accordance with the potential risks or costs involved. The adoption of such a level is also in accordance with accepted standards which have been implemented in similar situations throughout NSW. Based on the results of the Flood Study (Reference 3) the appropriate 1% AEP Design Flood levels for adoption are those corresponding with the Shoalhaven Heads **"Entrance Closed"** scenario and consistent with the outcomes of the Shoalhaven Heads Entrance Management Plan for Flood Mitigation (Reference 12).

The proposed development requirements indicated in Table 20 demonstrate the potential interaction of development categories with applicable controls/requirements and relevant Flood Planning Levels. The development types correspond to those outlined in the generic Flood DCP (DCP No. 106).

Table 20: Flood Related Development Controls - General Development

HAZARD CATEGORY	OUTSIDE FLOOD PLANNING AREA (Above the Flood Planning Level but below the PMF)										WITHIN FLOOD PLANNING AREA (Below the Flood Planning Level)																													
											HIGH HAZARD																				LOW HAZARD									
											FLOODWAY										FLOOD STORAGE OR FLOOD FRINGE										FLOODWAY, FLOOD STORAGE OR FLOOD FRINGE									
LAND USE CATEGORY	CRITICAL UTILITIES	SPECIAL USES	RESIDENTIAL DEVELOPMENT	COMMERCIAL / INDUSTRIAL DEVELOPMENT	SUBDIVISION	OPEN SPACE / NON URBAN	EARTHWORKS	MINOR DEVELOPMENT	EXEMPT DEVELOPMENT		CRITICAL UTILITIES	SPECIAL USES	RESIDENTIAL DEVELOPMENT (existing use rights only)	DUAL OCCUPANCY OR STRATA	COMMERCIAL / INDUSTRIAL DEVELOPMENT (existing use rights only)	SUBDIVISION	OPEN SPACE / NON URBAN	EARTHWORKS	MINOR DEVELOPMENT	EXEMPT DEVELOPMENT	CRITICAL UTILITIES	SPECIAL USES	RESIDENTIAL DEVELOPMENT	DUAL OCCUPANCY OR STRATA	COMMERCIAL / INDUSTRIAL DEVELOPMENT	SUBDIVISION	OPEN SPACE / NON URBAN	EARTHWORKS	MINOR DEVELOPMENT	EXEMPT DEVELOPMENT	CRITICAL UTILITIES	SPECIAL USES	RESIDENTIAL DEVELOPMENT	DUAL OCCUPANCY OR STRATA	COMMERCIAL / INDUSTRIAL DEVELOPMENT	SUBDIVISION	OPEN SPACE / NON URBAN	EARTHWORKS	MINOR DEVELOPMENT	EXEMPT DEVELOPMENT
FLOOR LEVEL	2	2	1	1									1		1				1 or 4				1	1	1				4				1	1	1				4	
BUILDING COMPONENTS	2	1	1	1									1		1		1		1	1			1	1	1		1		1	1			1	1	1		1		1	1
STRUCTURAL SOUNDNESS	1	1											2		2		3		3	3			3	3	3		3		3	3									
FLOOD AFFECTATION	1	1											1		1		1			1			1	1	1		1	2		1									
EVACUATION/ ACCESS	1	1											1,2		1,2				2				1,2	1,2	1,2				2				1,2	1,2	1,2	1,2			2	
FLOOD EVACUATION PLAN	1	1											1		1				1				1	1	1				1										
MANAGEMENT & DESIGN	1	1											1,2		1		1,2			1			1,2	1,2	1		1,2			1							1,2			1

NOT SUITABLE FOR DEVELOPMENT

NOT REQUIRED

NOTE: FOR DEFINITIONS OF THE LAND USE CATEGORY REFER TO THE RELEVANT COUNCIL DOCUMENTATION.

FPL = MINIMUM FLOOR LEVEL REQUIREMENT:	
1	1% AEP FLOOD LEVEL + 0.5 m FREEBOARD
2	PROBABLE MAXIMUM FLOOD (PMF) LEVEL
3	5% AEP FLOOD LEVEL + 0.5 m FREEBOARD
4	EXISTING HABITABLE FLOOR LEVEL OR HIGHER AS PRACTICAL
5	1% AEP FLOOD LEVEL
BUILDING COMPONENTS:	
1	ANY PORTION OF THE BUILDING OR STRUCTURE BELOW THE FPL TO BE BUILT FROM FLOOD COMPATIBLE MATERIALS
2	ANY PORTION OF THE BUILDING OR STRUCTURE BELOW THE PMF TO BE BUILT FROM FLOOD COMPATIBLE MATERIALS
STRUCTURAL SOUNDNESS:	
1	APPROPRIATE CONSULTING ENGINEER'S REPORT - THE BUILDING CAN WITHSTAND FORCES OF FLOODWATERS INCLUDING DEBRIS AND BUOYANCY FORCES UP TO THE PMF SCENARIO
2	APPROPRIATE CONSULTING ENGINEER'S REPORT - THE BUILDING CAN WITHSTAND FORCES OF FLOODWATERS INCLUDING DEBRIS AND BUOYANCY FORCES UP TO A 0.2% AEP FLOODING SCENARIO
3	APPROPRIATE CONSULTING ENGINEER'S REPORT - THE STRUCTURE WILL NOT BECOME FLOATING DEBRIS DURING A 1% AEP FLOODING SCENARIO
FLOOD AFFECTATION:	
1	APPROPRIATE CONSULTING ENGINEER'S REPORT FOR BUILDING FOOTPRINT AREA OVER 250 SQ. METRES - THE DEVELOPMENT WILL NOT INCREASE FLOOD HAZARD OR FLOOD DAMAGE TO OTHER PROPERTIES OR ADVERSELY AFFECT FLOOD BEHAVIOUR FOR A 5% AEP UP TO THE PMF SCENARIO
2	APPROPRIATE CONSULTING ENGINEER'S REPORT FOR EARTHWORKS VOLUME EXCEEDING 250 CUBIC METRES - THE EARTHWORKS WILL NOT INCREASE FLOOD HAZARD OR FLOOD DAMAGE TO OTHER PROPERTIES OR ADVERSELY AFFECT FLOOD BEHAVIOUR FOR A 5% AEP UP TO THE PMF SCENARIO
EVACUATION/ACCESS:	
1	RELIABLE EMERGENCY VEHICLE ACCESS IS REQUIRED FOR AMBULANCE, SES, FIRE BRIGADE, POLICE AND OTHER EMERGENCY SERVICES
2	RELIABLE ACCESS FOR PEDESTRIANS IS REQUIRED
FLOOD EVACUATION PLAN:	
1	APPROPRIATE ENGINEER'S REPORT DEMONSTRATING THAT PERMANENT, FAIL-SAFE, MAINTENANCE-FREE MEASURES ARE INCORPORATED IN THE DEVELOPMENT TO ENSURE THAT THE TIMELY, ORDERLY AND SAFE EVACUATION OF PEOPLE IS POSSIBLE FROM THE AREA AND THAT IT WILL NOT ADD SIGNIFICANT COST AND DISRUPTION TO THE COMMUNITY OR THE SES
MANAGEMENT AND DESIGN:	
1	APPLICANT TO DEMONSTRATE THAT THERE IS AN AREA WHERE HAZARDOUS AND VALUABLE GOODS CAN BE STORED ABOVE THE FLOOD PLANNING LEVEL
2	APPLICANT TO DEMONSTRATE THAT THERE IS AN AREA WHERE ANIMALS CAN FIND REFUGE ABOVE THE FLOOD PLANNING LEVEL

6.6.3 Review and Update Section 149 Planning Certificates

Description

Section 149 Planning Certificates provide information on the planning controls and policies that apply to a particular parcel of land. For existing owners and prospective purchasers, the Section 149 Planning Certificate is an important source for information on whether there are flood related development controls imposed on the property. It should be noted that identification of potential flood affectation on a Section 149 Planning Certificate is mandatory for residential zoned properties but not for rural zoned properties.

Discussion

As part of the FPMS process a floor level survey (Appendix D) was undertaken to identify the number of properties in the floodplain affected by floodwaters up to the Extreme event. The floor and ground level data collected as part of this study has been incorporated into Council's GIS database and related to the applicable design flood level information to assist Council in defining the potential flood affectation of the property so that it can be included in the Section 149 Planning Certificate.

It should be noted that the Section 149 Planning Certificates should not be the only form of acknowledgement that a property is flood prone. The community should be adequately informed about the extent of flood prone land and why the flood classification can change from one property or area to another. This is particularly relevant for the rural zoned areas of the floodplain.

Conclusions

The flood affected properties identified by this study will require their Section 149 Planning Certificates to be updated as part of the floodplain management process. At the same time, the wording or description included on the certificate should be revised to better describe the flooding implications and/or planning/building restrictions in a consistent manner based on the outcomes of this FPRM process. Details of flood level information should be continually updated as more accurate survey/flood level information becomes available.

A means for appropriately notifying the flood prone rural zoned lands should also be implemented to ensure potential purchasers are fully informed of the flood risks and hazards.

It is also recommended that a public awareness program be developed to inform all flood prone properties, identified by this study, of their current flood affectation and any development constraints imposed by their Section 149 status.

6.6.4 Review and Update Local Environmental Plans and Development Control Plans

[Note: This Section currently affected by parallel DCP process - information will need to be revised depending on outcomes.]

Description

The detailed review of existing planning documents and policies undertaken as part of this study (Appendix F), has highlighted a number of issues and/or inconsistencies with respect to flood related development controls and the principles outlined in the Floodplain Management Manual (Reference 4).

Council's Local Environmental Plan (LEP 1985) and the various related Development Control Plans (DCP) are now in the process of being reviewed and updated to incorporate the latest terminologies and approaches to controlling development within the floodplain.

The LEP usually specifies the nature of development allowable on any area of land and whether Council consent is required. A DCP prior to 2005 usually applied to a particular issue or locality where specific development controls are imposed. However under the NSW Government's 2005 planning reform a single DCP is proposed. Council has prepared Flood DCP No. 106 which incorporates general flood related development controls while the specific issues or problems pertaining to the different floodplain areas will be addressed by the individual Floodplain Risk Management Plans. DCP No. 106 only applies to those areas where a Floodplain Risk Management Plan has been prepared. For all other flood liable areas a DCP is being prepared to replace the Interim Flood Policy.

Discussion

The primary objective of the NSW Government Flood Policy is *"to reduce the impact of flooding and flood liability on individual owners and occupiers, and to reduce private and public losses resulting from flooding, utilising ecologically positive methods wherever possible"*.

Appropriate development controls involve consideration of the social, economic, environmental and risk to life and limb consequences associated with the occurrence and management of floods ranging in magnitude. This involves trading off the various benefits of reducing the impacts of flooding on development against the costs of restricting land use in flood prone areas and of implementing appropriate management measures.

Based on the outcomes from the preliminary planning review for this study (Appendix F) and a separate investigation assessing the risks associated with floodplain management for the entire Shoalhaven LGA, Shoalhaven City Council are actively addressing all planning/development related issues and policies pertaining to floodplain management.

Revision of the LEP is currently underway with a draft version having been prepared for discussion with Government Agencies, prior to being adopted by Council and is intended to be released for public exhibition in the near future. The development of a DCP relating to Floodplain Management issues has also been recommended and subsequently DCP No. 106 has been prepared and is effective from October 2006.

DCP No. 106 will provide guidance for the preparation and assessment of development applications in the floodplain within these areas covered by a Floodplain Risk Management Plan. A new DCP will supercede the Interim Flood Policy and will address situations where no formal floodplain risk management plan exists. It will also incorporate the relevant outcomes of FRM Plans that have been prepared for specific floodplains (such as this study).

Any other existing DCPs which incorporate or reference flooding issues will also need to be reviewed and updated to ensure consistency is maintained.

Conclusions

The amended LEP is to be finalised as a matter of priority. DCP No. 106 should also be finalised with provision to reference and incorporate the main development controls specifically identified for the Lower Shoalhaven River Floodplain as part of this study (refer Table 20). Council should also review all other DCP's or relevant planning documents to ensure any flood related references are up-to-date and consistent.

6.6.5 Planning Regulations - Caravan Parks

Description

There are approximately 14 caravan parks located in the Lower Shoalhaven River floodplain area, as shown on Figure 6. The floor level database information gathered by Council includes summary details for each Park (such as amenities/administration buildings and number of sites) but does not include detailed information on individual caravan sites within these parks. A summary of the key information relating to each Park (including applicable flood levels) is presented in Table D3 of Appendix D.

Discussion

Caravan parks within the floodplain present their own unique problems, and any one of the following may increase the risk to people and property within the park:

- evacuation access is typically limited with only a single entrance/exit which may be controlled by gates,
- only a poor quality (or no) site map is generally available to show emergency services the internal road system with the layout of van sites or the types of vans,
- permanent van sites often have fixed annexes which may contain high cost equipment such as fridges, freezers, stoves and lounges,
- there is generally poor internal lighting which may fail during a flood,
- there may be no flood emergency plan or it has not been tested in recent times,

- there is generally a problem in communicating to the residents due to the lack of or failure of the public address system or telephone network,
- short term residents will have little awareness of the flood risk or damage minimisation measures,
- a large number of vans may be vacant thus increasing the workload and possible risk to life of the "rescuers" in removing vans,
- vans are typically left on site permanently with their mobility for movement restricted by tie downs, poorly maintained or missing wheels and/or draw bars,
- there is the risk that vans may float and crash into each other or obstruct exit routes,
- caravans have little structural integrity and thus can easily be damaged or completely destroyed by flowing water,
- the internal fittings (cupboards, fridges, beds) are usually non-removable and quickly damaged by floodwaters.

In theory caravans are "mobile" or "moveable dwellings" and can be easily moved to high ground in a flood. In practice however, experience has shown that this is unlikely to occur for some of the above reasons.

While all of the parks are at some risk in the 1% AEP flood, the most vulnerable parks for the 10% AEP flood event appear to be (refer Figure 6 for site locations):

- Anglers Rest (No. 1),
- Camelia Caravan Park (No. 3),
- Coral Tree Lodge (No. 5),
- Jans Caravan Park (No. 7),
- Mountain View Village (No. 8),
- Pine Van Park (No. 9),
- Shoalhaven Heads Tourist Park (No. 11)
- Shoalhaven Ski Park (No. 12),
- Tall Timbers Caravan Park (No. 13).

Shoalhaven Council has an Interim Flood Policy for Caravan Parks on Flood Prone Land (August 1995). It contains special provisions for caravan parks on the floodplain such as:

- rapid knock down annexes,
- quick release ties on the vans to prevent them floating away,
- an effective evacuation strategy documented in a Flood Action Plan,
- restrictions on the type of vans, e.g. untowable vans not permitted in certain areas, no rigid annexes,
- specific inclusion of caravan parks in the SES Local Flood Plan.

Council are responsible for implementing development controls on a Park by Park basis. Table 21 summarises the controls applicable for the different types of development associated with caravan parks depending on the hazard categorisation.

In principle the provisions outlined in Table 21 should ensure minimal damage to caravans during a flood. There is also a risk to life as residents attempt to save their property.

Table 21: Graded Development Controls for Caravan Parks in Flood Liable Areas

	OUTSIDE FLOOD PLANNING AREA (FPL to PMF)			WITHIN FLOOD PLANNING AREA (below the Flood Planning Level)								
	ALL HAZARD CATEGORIES			HIGH HAZARD						LOW HAZARD		
				FLOODWAY			FLOOD STORAGE OR FLOOD FRINGE			FLOODWAY, FLOOD STORAGE OR FLOOD FRINGE		
	New Park	Renewal or Extension within Existing Park		New Park	Renewal or Extension within Existing Park		New Park	Renewal or Extension within Existing Park		New Park	Renewal or Extension within Existing Park	
DEVELOPMENT CONTROL CONSIDERATION		MANUFACTURED HOME (UNTOWABLE) OR RIGID ANNEXE	MOVEABLE DWELLING - includes caravan or relocatable home with or without Flexible Annexe		MANUFACTURED HOME (UNTOWABLE) OR RIGID ANNEXE	MOVEABLE DWELLING - includes caravan or relocatable home with or without Flexible Annexe		MANUFACTURED HOME (UNTOWABLE) OR RIGID ANNEXE	MOVEABLE DWELLING - includes caravan or relocatable home with or without Flexible Annexe		MANUFACTURED HOME (UNTOWABLE) OR RIGID ANNEXE	MOVEABLE DWELLING - includes caravan or relocatable home with or without Flexible Annexe
FLOOR LEVEL									1		2	1
BUILDING COMPONENTS									1		1	1
STRUCTURAL SOUNDNESS									1		2	2
FLOOD AFFECTATION	1											
FLOOD AWARENESS	1	1	1						1		1	1
RAPID KNOCK DOWN									1			1

NOT SUITABLE FOR DEVELOPMENT

NOT REQUIRED

FLOOR LEVEL:	
1	EXISTING HABITABLE FLOOR LEVEL OR HIGHER AS PRACTICAL
2	HABITABLE FLOOR LEVEL TO BE EQUAL TO OR GREATER THAN THE 1% AEP FLOOD LEVEL + 0.5 m FREEBOARD
BUILDING COMPONENTS:	
1	ANY PORTION OF THE DWELLING OR STRUCTURE BELOW THE FPL SHOULD BE BUILT FROM FLOOD COMPATIBLE MATERIALS
STRUCTURAL SOUNDNESS:	
1	CONSULTING ENGINEERS REPORT TO PROVE THE STRUCTURE SUBJECT TO A FLOOD UP TO A 1% AEP FLOOD EVENT CAN WITHSTAND THE FORCE OF FLOWING FLOODWATER INCLUDING DEBRIS AND BUOYANCY FORCES
FLOOD AFFECTATION:	
1	APPROPRIATE CONSULTING ENGINEERS REPORT TO PROVE THAT THE DEVELOPMENT WILL NOT INCREASE THE FLOOD HAZARD OR FLOOD DAMAGE FOR OTHER PROPERTIES OR ADVERSELY AFFECT FLOOD BEHAVIOUR FOR EVENTS UP TO PMF SCENARIO
FLOOD AWARENESS:	
1	SITE SPECIFIC FLOOD EVACUATION AND MANAGEMENT PLAN (Please note: Before any moveable dwellings are approved, the flood evacuation plan has to be amended to show that sufficient resources will be available at all times to evacuate and move in sufficient time all moveable dwellings within the park - both existing and new to a location above the PMF level)
RAPID KNOCK DOWN:	
1	SUBJECT TO SATISFYING RAPID KNOCK DOWN CONDITION IN LESS THAN 24 HOURS

Conclusions

Caravan parks on the floodplain can represent a significant hazard to occupants and rescuers alike during a flood event. The flood warning system for the Lower Shoalhaven should afford some additional time to facilitate the removal of vans or belongings. Council's Interim Flood Policy and the development controls outlined in Table 21 provide suitable guidelines to minimise damages but only if they are rigidly enforced. It is recommended that the flood related caravan park development controls outlined in Table 21 be incorporated into the generic Flood DCP No. 106 currently being prepared by Council and also cross-referenced in any specified caravan park DCP's.

This issue should be investigated further by a detailed field inspection to accurately assess the hazards and risks for each park. Following this, consideration should be given to implementing adequate safety provisions for each park in order of priority based on the degree of risk involved. At a minimum any "at risk" parks should be clearly identified in the SES Flood Plan and a site specific evacuation plan developed by the park so that the SES are made aware of any specific resourcing requirements or outstanding issues for dealing with that park.

6.6.6 Filling of the Floodplain

Description

Filling of the floodplain is often used to provide a level building pad (facilitating slab on ground type construction) and to thus raise floor levels and reduce the flood damages experienced by new development. Filling of land within the floodplain affects the temporary storage volume available and may also impact upon the local flow paths. These impacts on flood behaviour must be strategically managed.

Discussion

Filling of flood prone land is generally a viable method for reducing the potential damages for new development on the floodplain (either filling of a building pad or as a stock refuge). However the possible adverse hydraulic impacts need to be properly considered and addressed. Council needs to adopt a process whereby the effects of filling of flood liable land can be strategically managed to ensure that a number of small developments do not result in a major hydraulic impact overall. Strategic management of filling could include:

- identifying lots with fill in a theme layer of Council's GIS,
- ensuring an appropriate hydraulic investigation includes both local and mainstream impacts,
- ensuring future subdivisions on flood liable land incorporates local overland flow paths in its design,
- educating the community about flooding and the need to evacuate even if the house is above the FPL.

Since it is difficult to estimate the likely extent or location of future development proposals, for the purposes of this exercise it was assumed that the western fringe areas of the floodplain to the north and south were areas for potential development. Therefore, in order to simulate and gauge the possible hydraulic impacts associated with the cumulative development around the fringe areas of the floodplain, the flood model was modified to assume up to 10% of the floodplain storage volume was lost due to filling for development. It was assumed that up to approximately 130 ha on the northern floodplain and approximately 200 ha on the southern floodplain could be filled (refer Figure 7).

The modelling results indicate broadscale increases in flood levels of between 20 to 30 mm. In the context of the overall floodplain, such nominal increases may not appear to be significant and would not affect flood planning levels for future development. However, any increase in flood level has the potential to impact on surrounding properties particularly those in the immediate vicinity of the filling. The cumulative increases may be unclear when the filling is undertaken in a piecemeal or adhoc fashion.

Council will still need to monitor the cumulative effects of filling of flood prone land to ensure that localised impacts are not significant or, a number of small developments do not result in a major hydraulic impact overall. Each application for filling must be assessed on its merits and this can only be achieved if an appropriate hydraulic investigation has been undertaken. These preliminary broadscale modelling results suggest that a small fill volume suitable for creating a building pad of around half a normal residential block (say 20 x 15 x 1.5 m = 450 m^3), or less, represents a very small percentage of the total floodplain storage volume and therefore would be unlikely to have any significant impact on flood levels, however it may have a very localised affect on flow paths.

Conclusions

Council's generic flood policy (or Flood DCP No. 106) should include some general limits on filling and excavation within the floodplain and keep a record of the cumulative fill and excavation over time. The assumed areas and locations discussed above could be used as a guide. The predominant hydraulic classification for the Lower Shoalhaven Floodplain overbank areas is "Flood Storage". Nominal filling of individual lots around the fringe areas (as infill development or redevelopment) has negligible impact on flood levels in general and therefore should be permissible provided there are no adverse impacts on local flow paths or other issues/problems with evacuation access, etc. For areas outside these limits, a rigorous hydraulic investigation will be required. This latter approach is required because it is impossible to foreshadow the likely extent of future filling across the overall floodplain and the reasons for it. Ideally, a balanced cut/fill exercise for each individual development is to be preferred but realistically this will not always be possible. The other alternative to filling around the flood liable fringe areas is to construct the buildings on piered foundations to minimise the loss of floodplain storage.

6.6.7 The Greenhouse Effect

Description

The Greenhouse Effect is associated with the presence of certain gases in the atmosphere which allow the sun's rays to penetrate to the earth but reduce the amount of energy being radiated back. It is this trapping of reflected heat which has enabled life to exist on earth.

Recently, there has been concern that increasing amounts of greenhouse gases resulting from human activity may be raising the average surface temperature. As a consequence, this may affect the prevailing climate conditions and cause a rise in sea level. The extent of any permanent climatic or sea level change can only be established through scientific observations over several decades. Nevertheless, it is prudent to consider the possible range of impacts with regard to flooding and the level of flood protection provided by any mitigation works.

Discussion

The Bureau of Meteorology has indicated that there is no intention at present to revise design rainfalls to take account of the Greenhouse Effect, as the possible mechanisms are far from clear and there is no indication that the changes would in fact increase rainfalls in major storms. Even if an increase in total annual rainfall does occur, the impact on storm rainfalls may not be adverse.

It has also been suggested that the cyclone belt may move further southwards due to the Greenhouse Effect. The possible impacts of this on design rainfalls cannot be ascertained at this time as little is known about the mechanisms that determine the movement of cyclones under existing conditions.

Another possible consequence of the Greenhouse Effect could be a rise in sea level. This issue is complicated by other long term influences on mean sea level changes. The available literature suggests that a gradual increase in sea level is likely to occur with a rise of perhaps 0.05 m to 0.3 m within the next 50 years (Reference 18, pg 27).

This will have a significant impact at Shoalhaven Heads if it equates to a similar increase in the design ocean level, but modelling results demonstrate that any change in ocean levels will have minimal impact on flood levels further upstream.

Of more significance will be the impact on the erosional and sedimentation regime at Shoalhaven Heads. The Greenhouse Effect may vary the frequency and length of closures but, at this stage, there is not enough information to allow any definite conclusions on this.

Raising the minimum floor level by the likely magnitude of the rise in sea level for new developments at Shoalhaven was considered but rejected for three reasons. Firstly, the freeboard allowance to some extent includes an allowance for this factor. Secondly, it is unclear if the Greenhouse Effect will raise flood levels as the impact may be to increase the

frequency of beach openings. Thus the beach berm at the time of the flood will be lower resulting in reduced flood levels. Finally, the increase will be a gradual rise over 50 years. As the life of a modern house is probably 50 years or less it is likely that the bulk of houses constructed today will not be around to experience the 0.3 m rise (if it occurs). As we learn more about the impacts of the Greenhouse Effect, Council's Flood Policy can be progressively updated.

Conclusions

The Greenhouse Effect may affect design flood levels on the Lower Shoalhaven River at Shoalhaven Heads and to a lesser extent at Greenwell Point. The impact at the Shoalhaven Heads entrance is likely to be noticeable but there is no definitive information at this stage. Council should continue to monitor the available literature and reassess Council's Flood Policy every five (5) to ten (10) years or as appropriate.

6.6.8 Hay Avenue

Description

The Hay Avenue Village area at Shoalhaven Heads comprises of some 29 lots (primarily residential) most of which back on to the foreshore of the lower Shoalhaven River. The ground level within the area varies from 1.2 mAHD to 2.1 mAHD. The area is classified as High Hazard Floodway and there are ongoing applications submitted to Council for development within the area.

Discussion

Removal of the existing development from this high hazard situation cannot be justified as:

- it would cause significant social problems,
- the amenity and vistas of these river frontage properties is highly sought after and aside from the high property value cost, many or most residents are likely to reject any reasonable offer of voluntary purchase.

Under the present zoning, applications for further development can be made and with insufficient strategic flood type development controls in place, Council are required to consider each application on its merits.

The main categories of development which could be considered are:

- new flood compatible residential buildings (single dwelling and unit development) as redevelopment of the existing properties or infill development of the 2 vacant lots,
- new non-residential buildings (commercial),
- new residential subdivision of existing lots,
- additions/extensions to existing structures,
- expansion of the existing caravan park.

Appropriate planning restrictions are therefore required to ensure the density of the population at risk is not increased and the nature of any redevelopment does not adversely impact on the visual or social amenity of the area. This process will therefore involve consideration of the social, economic, environmental and risk to life and limb consequences associated with the occurrence of various size floods as well as the most appropriate measures to manage the situation. This requires trading off the various benefits of reducing the impact of flooding on development against the costs of restricting land use in flood prone areas and of implementing management measures.

A number of potential management measures have been considered for this area. Voluntary Purchase of the entire area could not be economically, socially or environmentally justified and the construction of a levee (Section 6.3.3) is not recommended. While response modification measures will help to reduce flood damages from event to event, it is considered that appropriate planning regulations offer the only real long term solution by controlling further development of the area.

Conclusions

Any increase in the population for this area will add to the existing evacuation access issues, and increase the demand on rescue services and the risk to life. Filling of lots and/or raising of the road may adversely increase flood levels or redirect flows elsewhere. For development associated with existing properties, appropriate floor level and building controls need to be implemented to ensure any future extension type structures are flood compatible.

To assist in this regard, the deferred zoning for this "Village" area needs to be resolved to ensure that both Council and Property owners alike have a better understanding of the controls applying to the area. A similar situation previously existed for the Riverview Road area (Reference 6) where it was finally resolved to adopt a 2(a4) zoning for the residential lots.

6.6.9 Urban Expansion Areas and Associated Road Infrastructure

Description

Council has identified a possible need for further urban expansion preferably in close proximity to the existing development of Nowra and its associated services/facilities. Associated with the increased development is the need for a future additional crossing of the Shoalhaven River and an associated road infrastructure network. Figure 7 shows the approximate extent of land to be filled between existing high ground and the future additional crossing.

Discussion

The areas identified for potential future redevelopment extend out from the existing developed areas situated around the fringes of the floodplain as discussed in Section 6.6.6. Extensive filling of the floodplain would therefore be required to ensure the new houses would not be inundated in the 1% AEP event. Any new road crossing of the river would also require filling in the formation of approach embankments and both of these aspects have the potential to

create significant adverse hydraulic impacts. Some preliminary hydraulic modelling was therefore undertaken so as to provide an indication of the order of magnitude of the potential impacts. It should be noted that the preliminary hydraulic modelling only included filling of the floodplain from the potential road and west to high ground. There was no consideration of the actual bridge structure. Further detailed investigations will have to consider the effect of the bridge piers and deck, and the bridge approaches, on flood levels in the floodplain.

For the purposes of this exercise, the existing CELLS model established for the Flood Study (Reference 3) was modified to represent the possible extent of filling involved for the two scenarios as shown on Figure 7. In this regard, changes were made to the storage volume relationship for the relevant "cells" as well as the dividing weirs.

The model results for filling of the floodplain fringe areas indicated negligible impacts of 0 to 30 mm. The area filled equated to approximately 3% of the entire Lower Shoalhaven floodplain.

The preliminary modelling of the road and filled area near Nowra as indicated on Figure 7 would increase flood levels for the 1% AEP by up to 100 mm.

Conclusions

While filling of the floodplain fringe areas appears to have a negligible effect on flood levels throughout the floodplain, the hydraulic modelling of the filled roadway and associated land has an impact in the order of 100 mm. More detailed modelling will be required when more details of the road are known.

6.7 Bank Erosion

Description

The channel morphology study (Reference 7) describes historical erosion rates along the river based on surveys and aerial photographs. Terara has a history of bank erosion and in the 1860 and 1870 floods over 50 hectares of land was lost near the village. In each of these floods the bank receded by 50 m to 100 m and a number of buildings were lost.

Bank protection works have probably been in place at Terara and at other locations since the 19th century. However, bank erosion is an ongoing issue for the majority of river bank residents.

The possibility of further significant bank erosion cannot be dismissed and the potential impact on floodplain users needs to be considered as part of the Lower Shoalhaven River Estuary Management Program.

Discussion

The cost of bank erosion to the community is impossible to accurately quantify. At Terara in the 1860 and 1870 floods, bank erosion, as opposed to inundation by floodwaters, was probably the most significant factor contributing to damage. However bank erosion would appear not to have been a major factor in subsequent floods.

The extent of bank erosion is not necessarily linked to the magnitude of the flood and may even occur at non-flood times. The 1860 and 1978 floods appear to have reached similar levels at Terara and Nowra Bridge yet there was no significant damage to the bank in 1978. While 1860 and 1870 were both large events, serious erosion could potentially occur in a quite small flood given appropriate conditions.

The estimate of average annual damages (Section 3.4) has not taken account of the effects of bank erosion and a rigorous understanding of the problem is outside the scope of this study. Nevertheless it is reasonable to infer that in moderate to large floods, bank erosion could be a significant factor. If it does occur during a flood there will be a significant increase in the risk to life, particularly if residents remain to safeguard their property.

Conclusions

Bank erosion can be controlled to some extent by extensive and costly river bank works and many attempts at this have been made over the years. From an economic viewpoint these works are unlikely to be cost effective and could ultimately be ineffective anyway. It would appear that there is a high likelihood that bank retreat may cause the loss of significant areas either over a period of years through tidal wind and wave action, or quite rapidly as a result of a flood occurrence.

There is little that can be done to prevent erosion during a flood but the impacts of tidal wind and wave action can be reduced by rock protection or re-vegetation in the inter-tidal zone. This issue should be considered further by Council's Estuary Management Committee and should include the possibility of a set back for development from the river bank. A consistent treatment for the bank should also be incorporated in any assessment. It is essential that some physical measures be implemented as soon as possible to minimise further bank loss.

7. SUMMARY OF PROPOSED MANAGEMENT ACTIONS

General

This floodplain risk management study process has identified and assessed a range of risk management measures which would help mitigate flooding to reduce existing and future flood damages.

Table iii) in the Summary itemises all of the management measures considered in this Study and lists those proposed for implementation as part of the Lower Shoalhaven Floodplain Risk Management Plan.

The following provides a brief overview of those management measures considered to be suitable for addressing the particular flood problems of the main affected areas of the floodplain.

Greenwell Point

Due the extent of existing development situated in relatively low lying conditions, this area represents the greatest flood risk and flood damages with around 300 properties potentially flooded in a 10% AEP event and 137 buildings inundated above floor level. Additionally, evacuation access from the floodplain can be cut in smaller (more frequent) events or relatively early in the larger events.

In order to address the existing and future flood problems the following measures should be considered for implementation:

- raising of 4.1km of Greenwell Point Road to bring its minimum level to RL1.9 mAHD. In conjunction with this an additional waterway crossing should be built to allow more water to pass under the raised road,
- voluntary purchase might be offered to the worst affected areas/properties but this is unlikely to be fully embraced by all affected residents,
- some form of levee protection would help to reduce the quantum of flood damages potentially suffered but may be unacceptable for practical, aesthetical or social reasons. This issue should be investigated in detail to assess the feasibility of all possible options,
- house raising should be offered to those affected properties deemed to be structurally suitable,
- the evacuation access route should be upgraded to provide a consistent level of serviceability for at least the 10% or 5% AEP flood standard,
- a strategic evacuation plan should be developed to ensure all logistical issues are properly addressed,
- appropriate development controls need to be established and applied to allow for flood compatible redevelopment to occur. Significant new development should be prevented but may need to be considered on its merits due to increasing development pressures.

Shoalhaven Heads

The nature of flooding experienced at Shoalhaven Heads is directly influenced by the conditions prevailing at the entrance (open or closed at the start of the flood). In the 10% AEP design scenario where the entrance is assumed to be closed at the start of the flood (and allowed to scour out with the passage of floodwaters) some 116 properties are potentially flooded with 39 buildings inundated above floor level. The worst affected areas are along Hay Avenue (classified as high hazard floodway) and Jerry Baily Road. The following measures are proposed for implementation:

- in the short to medium term, a formalised flood management policy outlining a decision making process and action plan, which appropriately incorporates the range of issues associated with the entrance conditions, should be developed and implemented. This should only be considered as an interim measure until the residual flood problems can be properly addressed through other more appropriate long term measures,
- house raising should be offered to those affected properties deemed to be structurally suitable for raising,
- appropriate development controls need to be established and applied to allow for flood compatible redevelopment to occur,
- the interim village zoning for the Hay Avenue properties needs to be resolved. A 2(a4) zoning as applied to the Riverview Road area (Reference 6) is to be preferred,
- some nominal raising of Hay Avenue to increase the evacuation access time available may be appropriate.

Bomaderry

At Bomaderry, much of the problem is related to the commercial/industrial development. In a 10% AEP event only 34 properties have been identified as flood liable with 11 inundated above floor level. This affectation increases to 53 properties and 33 buildings in the 1% AEP. The biggest issue however is the significant increase in estimated flood damages at the 2% AEP level. This is mostly due to the increased damages which can be incurred by such development but it is also directly influenced by the several large operations relating to the Paper Mill, Manildra and Dairy Farmers.

The most appropriate measures for this area include:

- flood proofing of the building structures and where practical provision should be made for the raising of sensitive/high cost equipment and stock above the Flood Planning Level,
- development of appropriate flood evacuation plans for individual developments,
- improve flood warning communication channels,
- introduce appropriate programs to increase flood awareness and readiness,
- establish and apply appropriate flood compatible development controls for any redevelopment.

Rural Areas

The greatest proportion of the floodplain is zoned rural. Many of the properties (and their residents) have existed on the floodplain for some time and have witnessed and survived a number of flood events. As such, the houses are typically already raised above ground level and the occupants are reasonably flood aware and prepared with their own action/evacuation plans.

With time however, the rural population usage interests are changing to introduce new people and demands on the land. It is therefore necessary to consider the following measures for such areas:

- allow appropriate stock refuge mounds where necessary,
- introduce appropriate notification of flood affectation (similar to the mandatory Section 149 Planning Certificates for residential properties) to ensure existing and prospective property owners are aware of the prevailing flood hazards and risks,
- ensure appropriate flood compatible development controls are developed and applied,
- restrict or prevent new development wherever possible,
- improve communication of flood warnings and correlate to flood evacuation/action plans for local areas or individual properties.

Orient Point

Most of the properties affected in this area are situated around the foreshore of Curleys Bay where the flood hazard is relatively low (velocities are low and evacuation access to high ground is readily available). There are approximately 27 buildings inundated above floor level in a 10% AEP event. Management measures which could be implemented to address these problems include:

- house raising should be offered to those affected properties deemed to be structurally suitable,
- incorporate details of all affected properties within the SES flood evacuation plan,
- appropriate development controls need to be established and applied to allow for flood compatible redevelopment to occur.

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8. ACKNOWLEDGMENTS

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- Shoalhaven Natural Resources and Floodplain Management Committee,
- Shoalhaven City Council,
- Department of Natural Resources (formerly Department of Infrastructure, Planning and Natural Resources),
- State Emergency Services,
- local residents of the Lower Shoalhaven River floodplain.

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FIGURE 1

LOWER SHOALHAVEN RIVER FLOODPLAIN
LOCALITY MAP AND STUDY AREA

Bomaderry
Shoalhaven Heads
Terara
Nowra
Worrigee Swamp
Greenwell Point
Orient Point
Culburra
CURLEYS BAY
BEVAN ISLAND
OLD MAN ISLAND
COMERONG ISLAND
PIG ISLAND
NUMBAA ISLAND
SHOALHAVEN RIVER
CROOKHAVEN RIVER
BROUGHTON CREEK
ZEALANDS CREEK
NOWRA CREEK
CROOKHAVEN CREEK
PRINCES HIGHWAY
BOLONG RD
COMERONG ISLAND ROAD
RIVERVIEW RD
COOLANGATTA RD
GERROA RD
GREENWELL POINT ROAD
BERRYS CANAL
YALWAL RD
ALBATROSS RD
CURRAWONG RD

1
2
3
4
5
6
7

LEGEND:

- Model result locations (refer Table 7 in report)

0.5 0 0.5 1 1.5 2 2.5 km

SCALE

N

FIGURE 2

ENVIRONMENTAL ISSUES

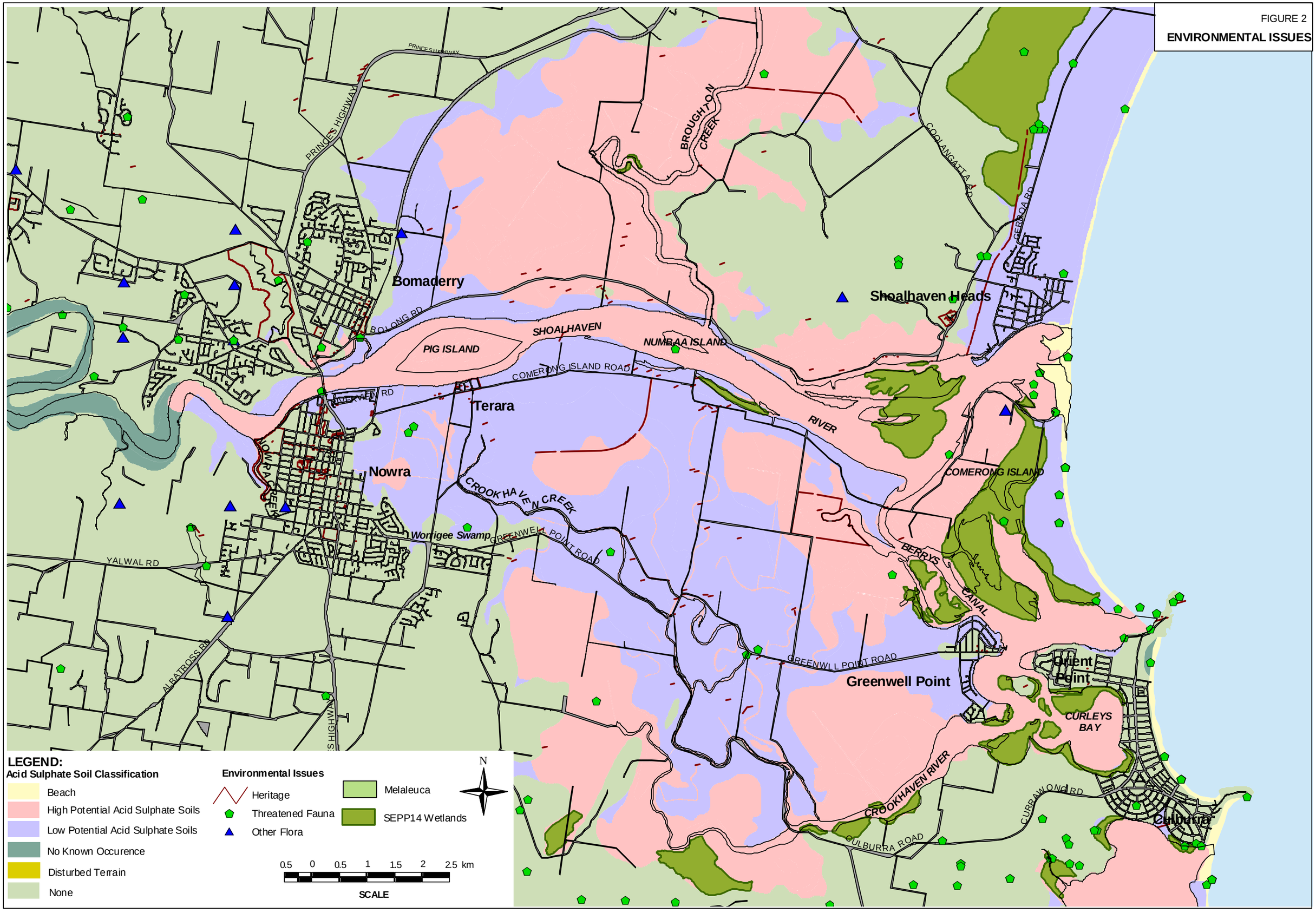


FIGURE 3
LAND USE

PRINCES HIGHWAY
BROUGHTY CREEK
COOLANGATTA RD
GERROA RD
Bomaderry
Shoalhaven Heads
BOLONG RD
SHOALHAVEN
NUMBAA ISLAND
PIG ISLAND
COMERONG ISLAND ROAD
RIVERVIEW RD
Terara
RIVER
NOWRA CREEK
Nowra
CROOKHAVEN CREEK
COMERONG ISLAND
Worrigee Swamp
GREENWELL POINT ROAD
YALWAL RD
BERRYS
CANAL
ALBATROSS RD
PRINCES HIGHWAY
GREENWLL POINT ROAD
Greenwell Point
Orient Point
CURLEYS BAY
CROOKHAVEN RIVER
CURRAWONG RD
Culburra
CULBURRA ROAD

LEGEND:

LEP Zoning

- Rural
- Residential
- Business
- Industrial
- Special Use
- Open Space
- Environmental Protection
- National Park
- Natural Hazard
- Excluded From LEP
- Township
- Village
- Roads

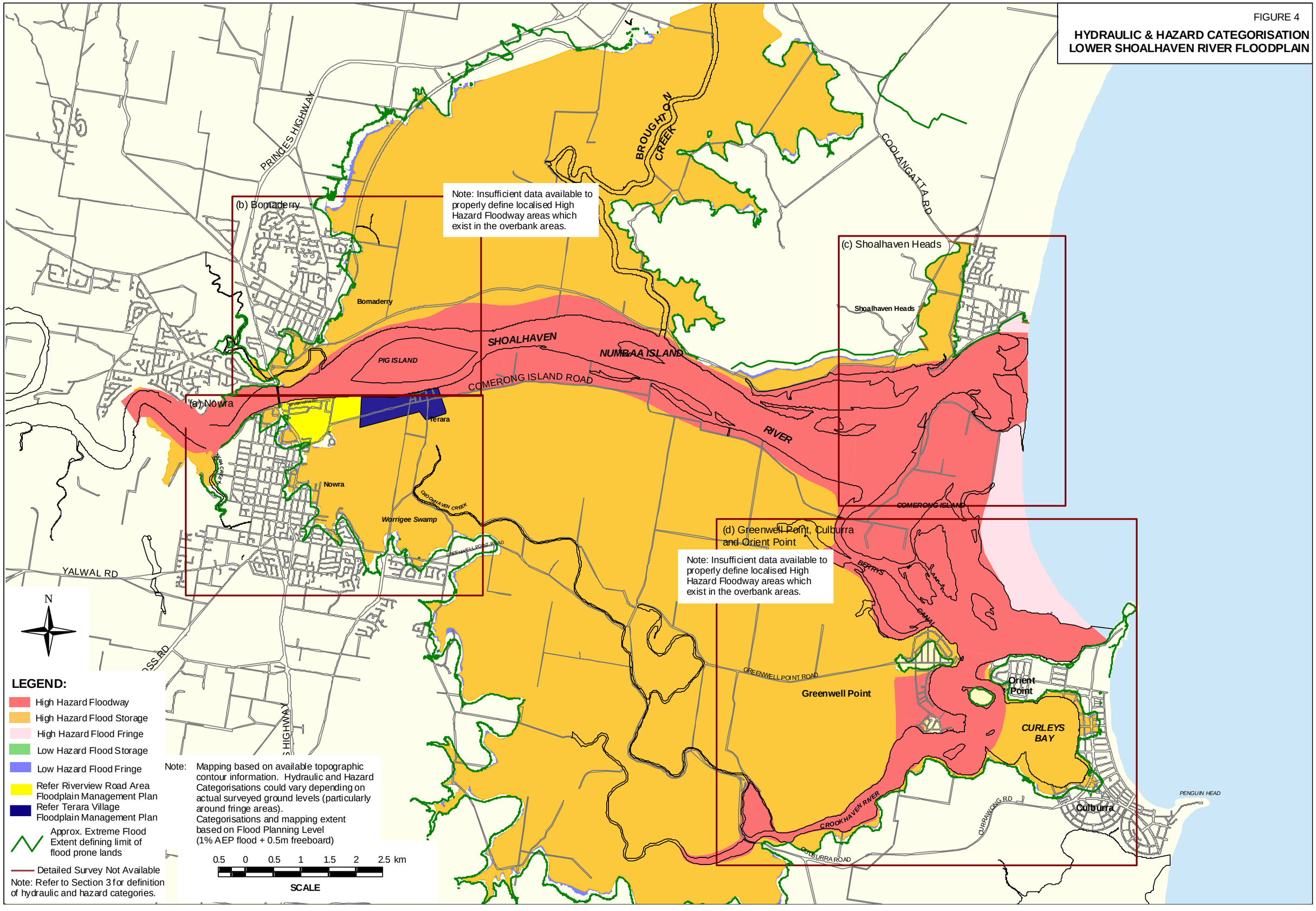
N

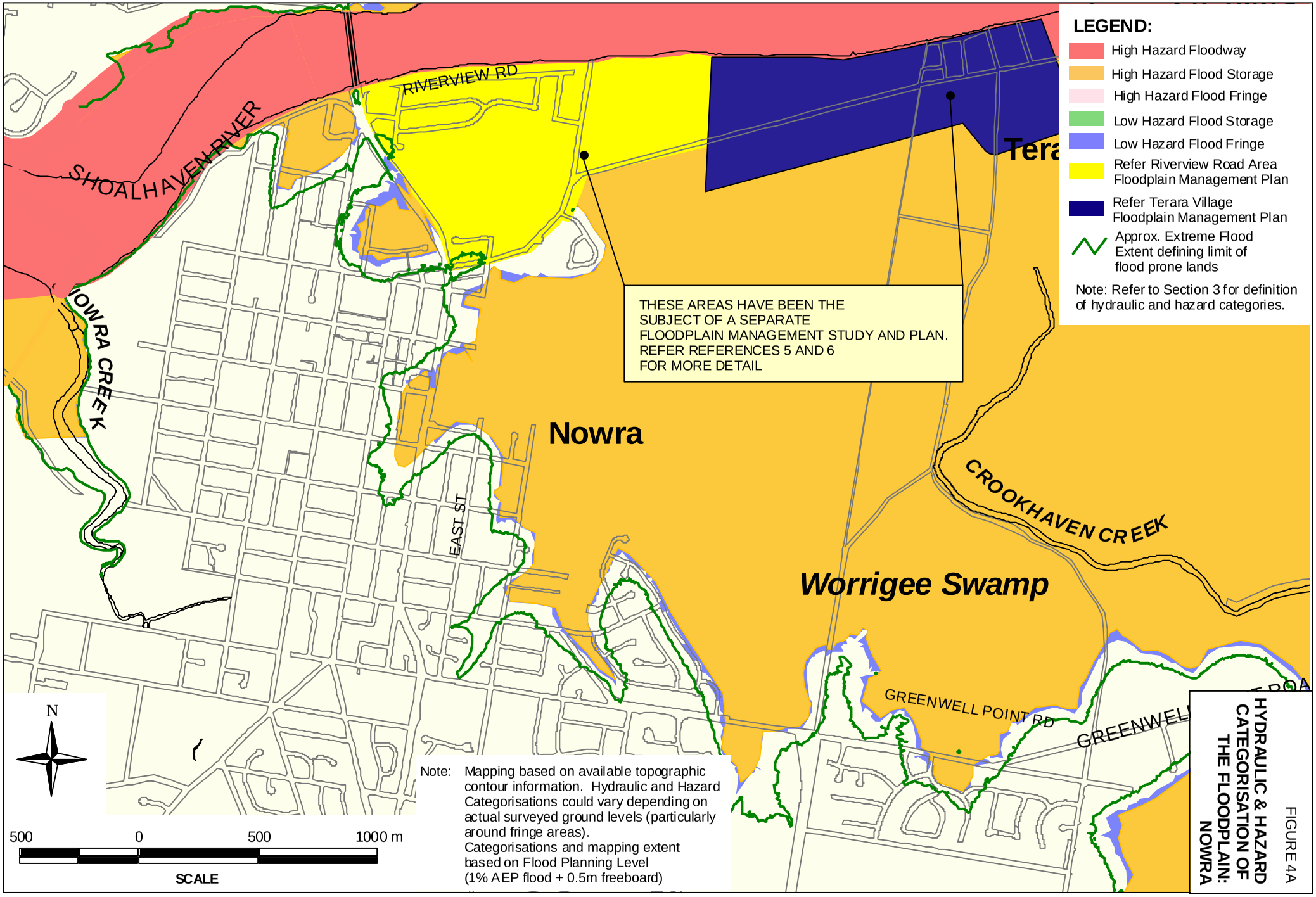
0.5 0 0.5 1 1.5 2 2.5 km

SCALE

FIGURE 4

HYDRAULIC & HAZARD CATEGORISATION
LOWER SHOALHAVEN RIVER FLOODPLAIN




LEGEND:
High Hazard Floodway
High Hazard Flood Storage
High Hazard Flood Fringe
Low Hazard Flood Storage
Low Hazard Flood Fringe
Refer Riverview Road Area Floodplain Management Plan
Refer Terara Village Floodplain Management Plan
Approx. Extreme Flood Extent defining limit of flood prone lands
Note: Refer to Section 3 for definition of hydraulic and hazard categories.
THESE AREAS HAVE BEEN THE SUBJECT OF A SEPARATE FLOODPLAIN MANAGEMENT STUDY AND PLAN. REFER REFERENCES 5 AND 6 FOR MORE DETAIL
SHOALHAVEN RIVER
RIVERVIEW RD
Tera
NOWRA CREEK
Nowra
EAST ST
CROOKHAVEN CREEK
Worrigee Swamp
GREENWELL POINT RD
GREENWELL
N
500 0 500 1000 m
SCALE
Note: Mapping based on available topographic contour information. Hydraulic and Hazard Categorisations could vary depending on actual surveyed ground levels (particularly around fringe areas).
Categorisations and mapping extent based on Flood Planning Level (1% AEP flood + 0.5m freeboard)
HYDRAULIC & HAZARD CATEGORISATION OF THE FLOODPLAIN: NOWRA
FIGURE 4A

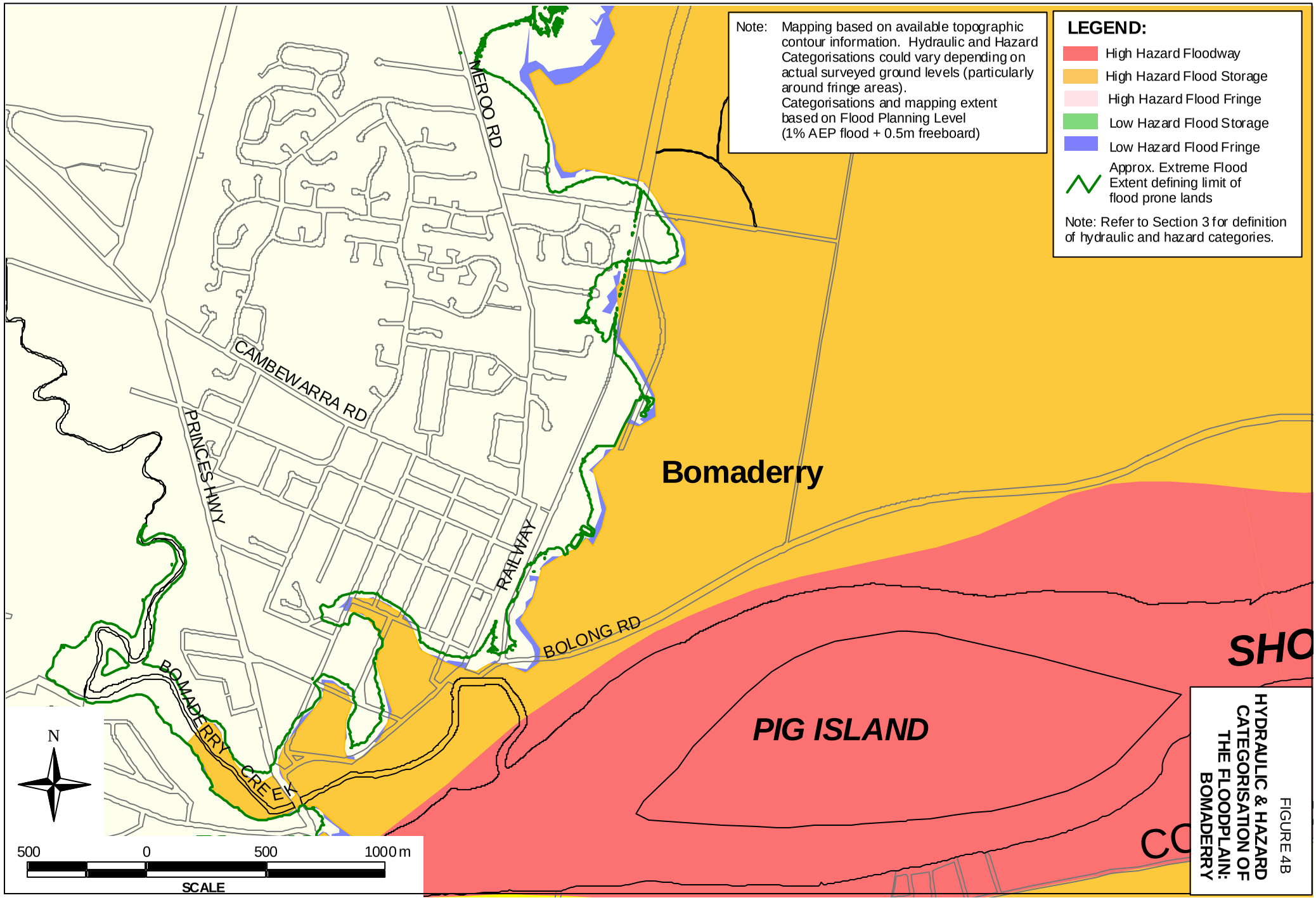

Note: Mapping based on available topographic contour information. Hydraulic and Hazard Categorisations could vary depending on actual surveyed ground levels (particularly around fringe areas).
Categorisations and mapping extent based on Flood Planning Level (1% AEP flood + 0.5m freeboard)
LEGEND:
High Hazard Floodway
High Hazard Flood Storage
High Hazard Flood Fringe
Low Hazard Flood Storage
Low Hazard Flood Fringe
Approx. Extreme Flood Extent defining limit of flood prone lands
Note: Refer to Section 3 for definition of hydraulic and hazard categories.
MEROO RD
CAMBEWARRA RD
PRINCES HWY
RAILWAY
BOLONG RD
BOMADERRY CREEK
Bomaderry
PIG ISLAND
SHO
CO
N
500 0 500 1000 m
SCALE
FIGURE 4B
HYDRAULIC & HAZARD CATEGORISATION OF THE FLOODPLAIN: BOMADERRY

FIGURE 4C

HYDRAULIC & HAZARD CATEGORISATION OF THE FLOODPLAIN: SHOALHAVEN HEADS

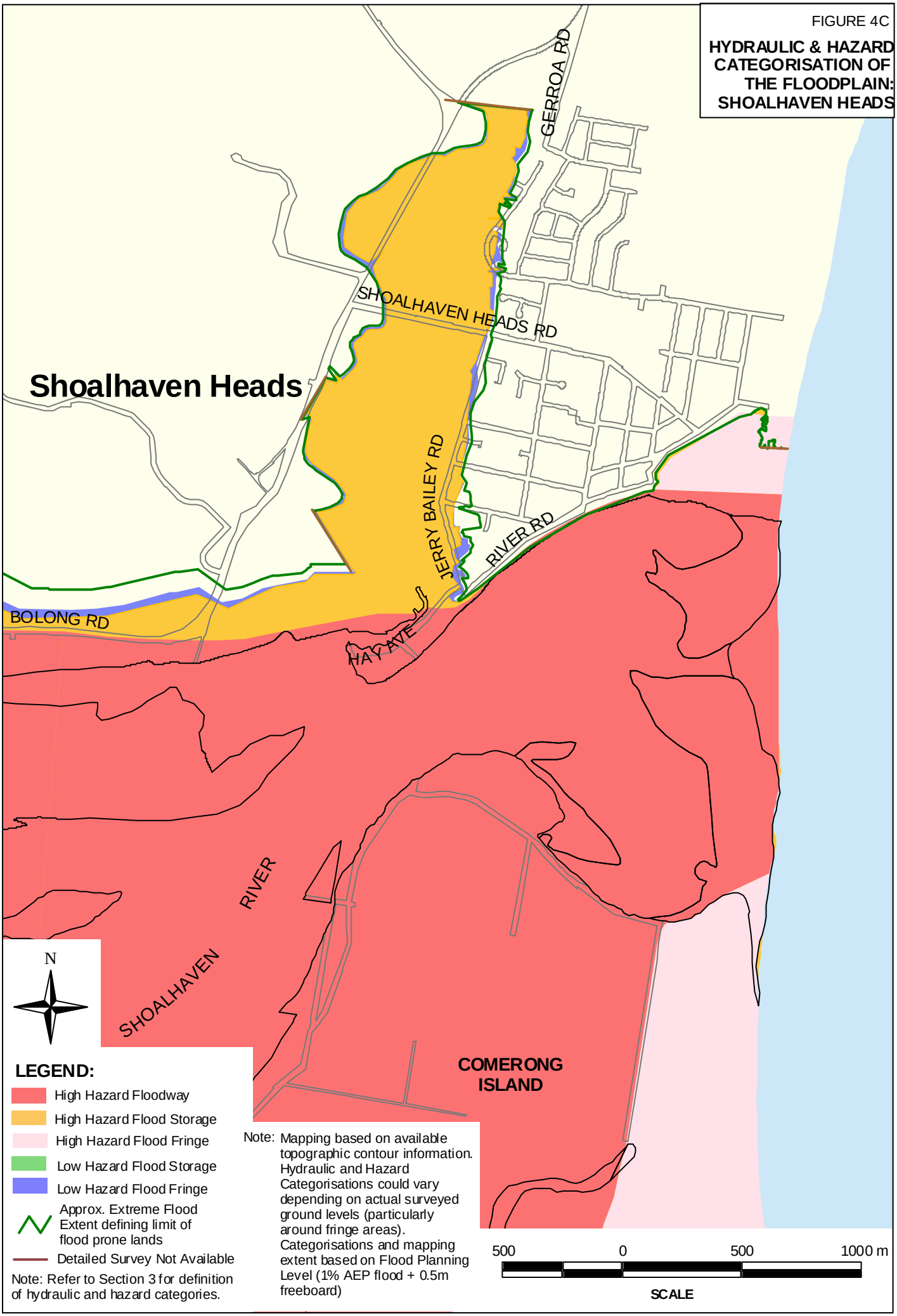


FIGURE 4D

HYDRAULIC & HAZARD CATEGORISATION OF THE FLOODPLAIN: GREENWELL POINT AND ORIENT POINT

BERRYS CANAL

ADELAIDE ST

GREENWELL POINT ROAD

Greenwell Point

GREENS RD

HAISER RD

Orient Point

CURLEYS BAY

PRINCE EDWARD AVE

Culburra

CURRAWONG RD

CROOKHAVEN RIVER

LEGEND:

- High Hazard Floodway
- High Hazard Flood Storage
- High Hazard Flood Fringe
- Low Hazard Flood Storage
- Low Hazard Flood Fringe
- Approx. Extreme Flood Extent defining limit of flood prone lands

Note: Refer to Section 3 for definition of hydraulic and hazard categories.

N

500 0 500 1000 m

SCALE

Note: Mapping based on available topographic contour information. Hydraulic and Hazard Categorisations could vary depending on actual surveyed ground levels (particularly around fringe areas).
Categorisations and mapping extent based on Flood Planning Level (1% AEP flood + 0.5m freeboard)

FIGURE 5

POSSIBLE LEVEE ALIGNMENTS SHOALHAVEN HEADS AND GREENWELL POINT

BERRYS CANAL

APPLE ORCHARD ISLAND

HAVEN ISLAND

CROOKHAVEN RIVER

GREENWELL POINT

ADELAIDE ST

GREENWELL POINT RD

GREENS RD

ORIENT POINT

GOODNIGHT ISLAND

CURLEYS BAY

CROOKHAVEN RIVER

Alternate Possible Alignment

SHOALHAVEN HEADS RD

B

SHOALHAVEN HEADS

BOLONG RD

C

RIVER RD

A

SHOALHAVEN RIVER

BEVAN ISLAND

OLD MAN ISLAND

COMERONG ISLAND

N

500 0 500 1000 m

SCALE

FIGURE 6
CARAVAN PARKS

PRINCES HIGHWAY
BROUGHTON CREEK
COOLANGATTA RD
GERROA RD
Bomaderry
BOLONG RD
SHOALHAVEN
PIG ISLAND
NUMBAA ISLAND
Shoalhaven Heads
COMERONG ISLAND ROAD
RIVERVIEW RD
Terara
RIVER
NOWRA CREEK
Nowra
CROOKHAVEN CREEK
COMERONG ISLAND
Worrigee Swamp
GREENWELL POINT ROAD
YALWAL RD
BERRYS CANAL
ALBATROSS RD
PRINCES HIGHWAY
Greenwell Point
Orient Point
CURLEYS BAY
CROOKHAVEN RIVER
CURRAWONG RD
Culburra

1 2 3 4 5 6 7 8 9 10 11 12 13 14

LEGEND

1 ● Caravan Parks

Note: Refer to Table D3 of Appendix D for Caravan Park details.

0.5 0 0.5 1 1.5 2 2.5km
SCALE

N

FIGURE 7

APPROXIMATE EXTENT OF ASSUMED FILL AREAS

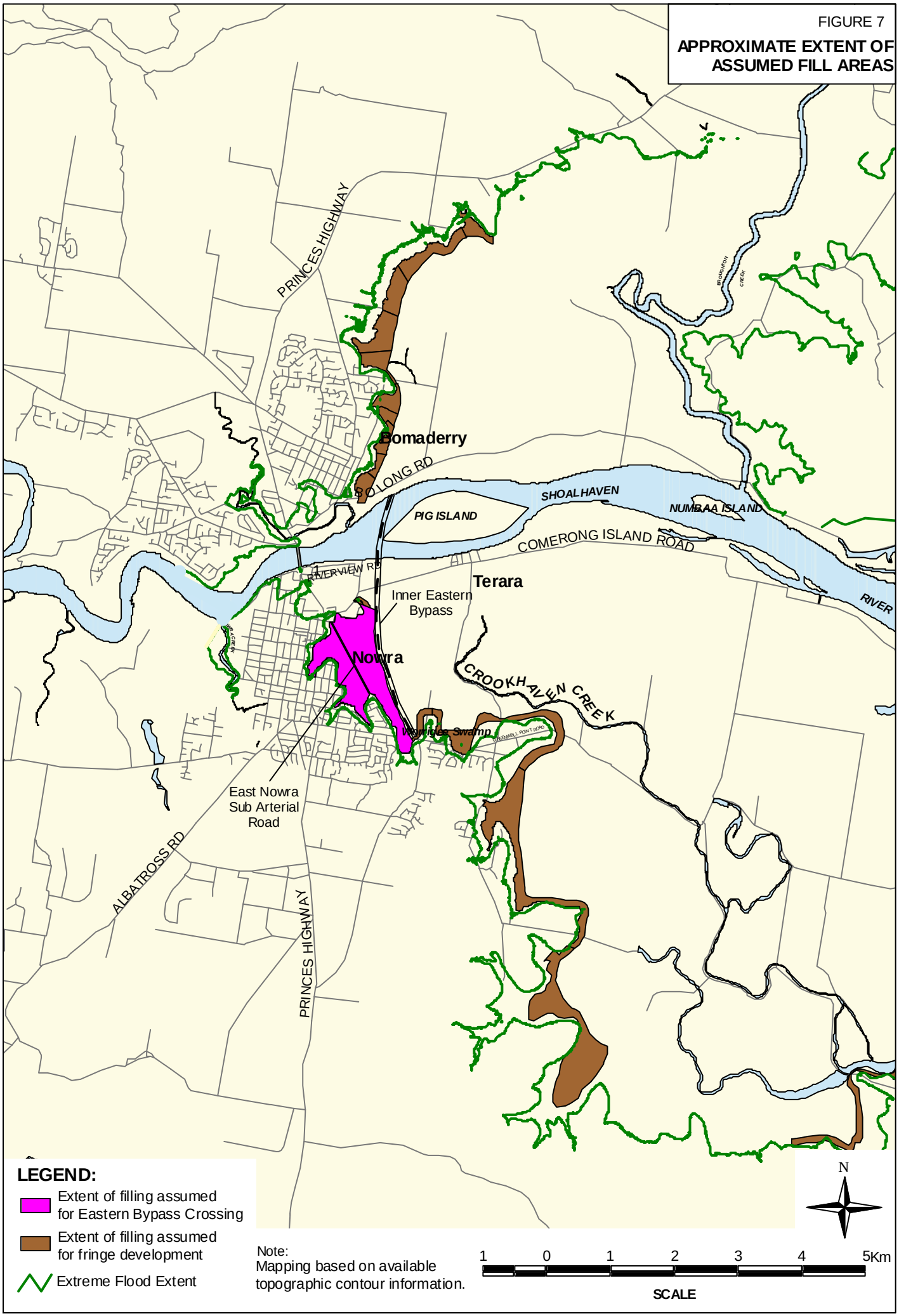


FIGURE 8

CRITICAL LEVELS FOR EVACUATION ACCESS ROUTES

Bomaderry

BOLONG ROAD

B

C

E

SHOALHAVEN HEADS RD

Shoalhaven Heads

A

PIG ISLAND

NUMBAA ISLAND

D

COMERONG ISLAND ROAD

RIVERVIEW RD

TERARA ROAD

G

H

Terara

F

I

SHOALHAVEN RIVER

NOWRA CREEK

Nowra

CROOKHAVEN CREEK

Worrigee Swamp

GREENWELL POINT ROAD

JINDY ANDY LANE

J L

K

BERRYS CANAL

N

M

Greenwell Point

GREENWELL POINT ROAD

Orient Point

O

R S P

Q

CURLEYS BAY

LEGEND:

▲ For description refer Table 8

N

0.5 0 0.5 1 1.5 2 2.5 Km

SCALE

APPENDIX A: DESCRIPTION AND ASSESSMENT OF FLOOD DAMAGES

APPENDIX A: DESCRIPTION AND ASSESSMENT OF FLOOD DAMAGES

A1. DESCRIPTION OF FLOOD DAMAGES

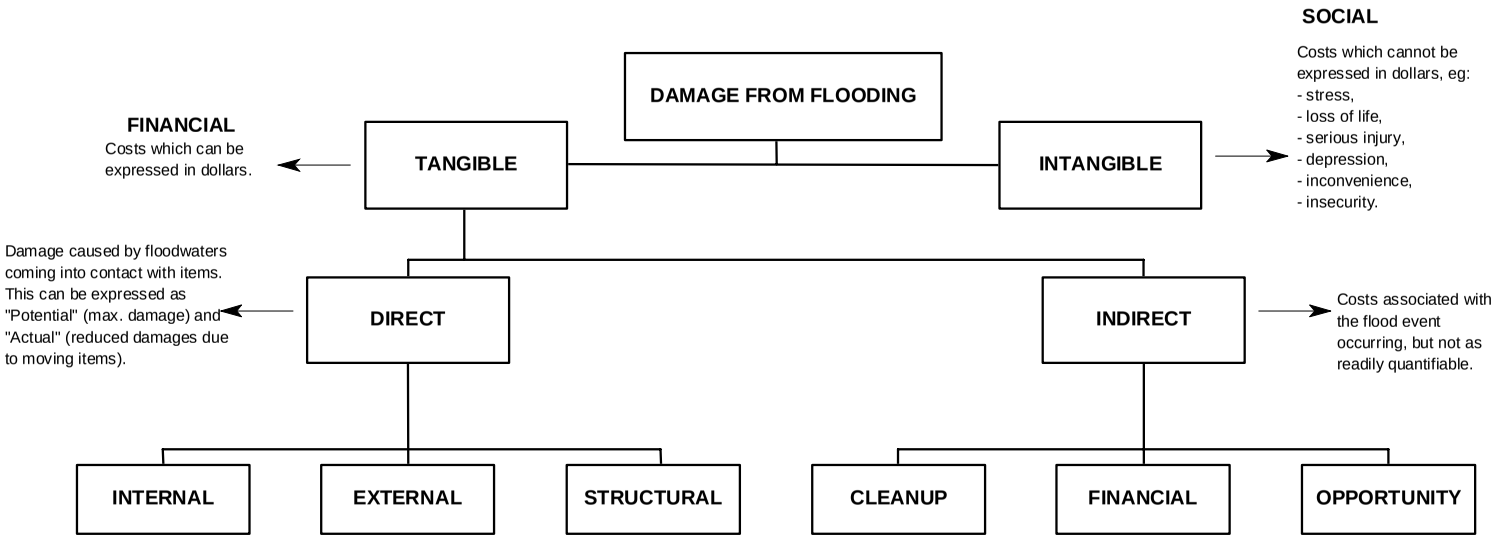
A1.1 General

A database provided by Shoalhaven Council (Appendix D) has been used to identify the number of buildings inundated above floor level for various design events. For each property a habitable floor level (or work floor level for non-residential buildings) and a typical ground level were obtained. The ground level reflects yard damages to the grounds, garage, etc.

Flood damages can be defined as being *tangible* or *intangible* and a schematic breakdown of the damages categories is provided as Table A1. Tangible damages are those for which a monetary value can be assigned, in contrast to intangible damages, which cannot easily be attributed a monetary value.

There are few records of actual flood damages to buildings or private property although these undoubtedly occurred in the 1971 event and floods of the early 1990's.

Table A1: Flood Damages Categories



RESIDENTIAL	Contents of Buildings: Clothes, Carpets, Furniture, Valuables, Fittings, Appliances	External Items: Vehicles, Laundries, Caravans, Sheds, Tools, Gardens, Fences	Physical Damage to Buildings: Gyprock, Cupboards, Scour of Footings, Houses becoming buoyant (floating off footings)	Clean Carpets, Walls, Clothes; Re-instate Furniture; Remove Mud and Debris	Loss of wages, Living costs (temporary accomodation and food), Time to repair/replace damaged items	Not Applicable
RURAL	Contents of Buildings: Clothes, Carpets, Furniture, Valuables, Fittings, Appliances	External Items: Vehicles, Sheds (stables/barns), Machinery, Tools, Fences, Feed storage, Saddles, Crops &/or Stock, Irrigation Systems	Physical Damage to Structures: Damage to Homestead, Sheds, Access tracks, Protection levees	Clean Homestead and Out-buildings; Remove Debris; Dispose of affected crops &/or stock	Loss of Farm Production and Income, Re-instatement of Pastures, Supplementary feeding of stock (by hand or outside agistment), Stock movement/ transport, Living costs (temporary accomodation and food)	Sowing or harvesting of Crops, Sale of Stock (at depreciated value or dependent on market influences)
COMMERCIAL	Contents of Buildings: Products, Stock, Fittings, Tools, Machinery, Raw Materials	External Items: Vehicles, Machinery, Display, Raw Materials/Stockpiles, Fences	Physical Damage to Buildings	Dispose of damaged products, stock, materials; Cleaning and Re-instatement	Loss of Productivity and Income, Bank Interest Charges	Loss of existing &/or Potential Trade
PUBLIC AUTHORITIES	Contents of Public Buildings and Facilities	Public Property and Facilities: Parks, Signs, Machinery, Equipment	Physical Damage to Infrastructure: Electricity, Water, Telephone, Gas, Road & Rail Transport Links	Remove Mud & Debris from Facilities, Public & Private Property Repairs (temporary & permanent)	Disruption of Services, Community Service Relief Grants	Provision of Public Service

A1.2 Tangible Damages

Tangible damages can be sub-divided into *direct* damages, which occur due to physical contact with the floodwaters, and *indirect* damages which occur as a result of the disruption of business, trade and other activities. Direct and indirect damages may be referred to as *Potential* or *Actual* damages. Potential damages are the assumed damages if no damage reduction measures are employed and are thus greater than the actual damages. The ratio of actual to potential damages depends upon a number of factors including:

- magnitude of the flood,
- prior flood experience of the community,
- length of warning time.

Direct Damages

Direct damages can be sub-divided between the rural and urban sector. Under direct urban damages there are three broad categories: *Residential, Commercial* and *Public Sector*.

The direct damages under these categories can be grouped under the following headings:

- *Internal* - building contents,
- *Structural* - structure and building fabric,
- *External* - yard, garage, vehicle and other machinery (air conditioning).

Damages to commercial and industrial buildings are much more difficult to quantify for two reasons:

- damages to a given property vary much more than with houses, as they are heavily influenced by the type of business being carried out and the amount of stock carried. This will also vary over time as different businesses use the building,
- industrial enterprises in particular cannot simply be averaged out. Where large factories or warehouses are involved, the only way to get a good estimate of potential damages is to do a site specific survey of the enterprise.

As flood damages can vary greatly between areas depending upon the type of buildings and contents, an average damages figure is estimated for each of the above categories (residential, commercial and public sector) following a flood. This is generally presented as a flood depth versus flood damages function.

Public sector (non-building) damages include:

- recreational/tourist facilities,
- water and sewerage supply,
- gas supply,
- telephone supply,
- electricity supply including transmission poles/lines, sub-stations and underground cables,
- roads and bridges including traffic lights/signs,

- railway line and associated structures,
- costs to employ the emergency services.

Damages to the public sector can contribute a significant proportion of the total flood costs. In the Inverell flood of February 1991, direct costs to the local Council accounted for 10% of the total direct damages. A single item such as a bridge or a sub-station may account for a large proportion of the damages bill in a particular flood.

Indirect Damages

Indirect damages are more difficult to quantify. They can be sub-divided into three broad cost categories:

- *Clean-up* - clean carpets, furniture, refrigerator, etc. It also includes the cost of alternative accommodation,
- *Financial* - loss of wages, loss of trade for the commercial/industrial sector,
- *Opportunity* - non-provision of commercial and public services.

In a particular locality it would require an extensive survey to evaluate the costs of lost working hours, disruption to business and trade. Nevertheless an indication of the damages can be obtained from previous studies. Generally the indirect damages have been expressed as a percentage of the direct damages. The figure varies greatly depending upon a number of factors including:

- magnitude of flood,
- time away from home/work,
- category (residential, commercial, industrial).

An average percentage (indirect as a percentage of direct) from a number of post flood surveys is:

- Residential - 15%,
- Commercial - 30%,
- Industrial - 50%.

It should be noted that there can be a considerable range (± 100%) around the above figures for commercial and industrial properties in different locations.

A1.3 Intangible Damages

Intangible damages are those flood damages which by their nature are difficult to quantify in monetary terms. An example of a *direct* intangible damage is the "loss of visual quality" of an area or the "loss of a heritage item". Most intangible damages are *indirect* and commonly occur after the flood peak has passed.

Intangible damages can be categorised as follows:

Residential

Post flood damages surveys have linked flooding to stress, ill-health and trauma in the residents. For example the loss of memorabilia, pets, insurance papers, etc., may cause stress and subsequent ill-health. In addition, flooding may affect personal relationships by contributing to marriage breakdowns and lead to stress in domestic/work situations. Residents may worry each time heavy rain occurs and there is a threat of flooding. This may be reflected in increased sickness or depression requiring psychiatric help. These effects can induce a lowering in the quality of life of the flood victims.

Flood victims may also suffer injuries during a flood or during the clean-up process. Whilst the direct costs of the injuries may be accounted for in the flood damages survey, the physiological effect or discomfort may last for a long time.

The most extreme "intangible damage" that can arise from flooding is death, and unfortunately this is not a rare occurrence. There are many examples of deaths of local residents and rescue workers during floods.

Commercial/Industrial/Rural

Whilst a large number of businesses carry insurance for loss of trade during and following a flood until the clean-up is complete, they may still suffer a financial loss. For example the confidence in the business of regular clients may be reduced permanently. Clients may take their business elsewhere during the flood/clean-up period and may never revert to the original supplier.

Services

The loss of services to customers, e.g., transport disruption, loss of education, loss of power, etc., occur as a result of floods and these are generally not costed within the tangible damages category.

Environmental

Environmental damage may occur as a result of flooding, for example flora and fauna may be lost. However the riverine environment is a natural system and it is difficult to quantify the effects of flooding on natural processes. Some flora and fauna can in fact benefit from flooding. Also in the short term there may be a deterioration in water quality or vegetation, which may recover in the long term. Wetlands develop over time as a result of flooding and require periodic flooding for their long term survival.

Probably the most significant potential environmental impact is the release of pollutants as a result of flooding. Generally this is as a result of flooding of commercial/industrial establishments.

The loss of man-made structures which have a "heritage" or non-replaceable value are a real cost which cannot be quantified. Modifications to the pattern of flooding through flood mitigation works may change the existing ecosystem. Although the changes can be beneficial or adverse.

In summary, there is a comprehensive body of available literature on intangible damages which provides many examples. However the costing of such damages in dollar terms is often not possible. These "costs" should not be ignored when determining floodplain management options. The literature suggests that the value of intangible damages may equal or exceed tangible damages. It is therefore often necessary to imply a value for the intangible damages to achieve a better appreciation of proposed works and measures.

A2. ASSESSMENT OF FLOOD DAMAGES

A2.1 General

A2.1.1 Introduction

Quantification of flood damages is generally based upon post-flood damage surveys. An alternative procedure is to undertake a self-assessment survey of the flood liable residents. This latter approach is more expensive and may not accurately reflect what actually occurs in a flood. Floods by their nature are unpredictable and it is unlikely that a self-assessment survey would have predicted the scale of the damages which occurred in Nyngan in 1990. For this reason it was decided to use the post-flood damage approach in assessing flood damages. A listing of the most widely known post flood damage surveys is shown in Table A2. More recent information from the November 1996 flood at Coffs Harbour is also available but this has not been critically analysed for the purposes of establishing relationships of depth vs damage.

Table A2: Residential Flood Damage Surveys

Location	Year of Flood	Comments
Brisbane	1974	400 residential properties.
Lismore	1974	100 properties. The data were obtained several years after the last major flood.
Forbes	1974	35 properties. The data were obtained several years after the latest major flood.
Sydney (Georges River)	1986	96 properties (2 studies undertaken)
Nyngan	1990	24 residential, 14 commercial and 6 public properties, 4-5 weeks after the flood.
Inverell	1991	4 residential, 20 commercial and 10 public properties, 2-3 weeks after the flood.

The most comprehensive surveys are those carried out for Sydney (Georges River), Nyngan and Inverell. Some of the problems in applying data from these studies to other areas can be summarised as follows:

- varying building construction methods, e.g. slab on ground, pier, brick, timber,
- different average age of the buildings in the area,
- the quality of buildings may differ greatly,
- inflation must be taken in account,
- different fixtures within buildings, e.g. air-conditioning units,
- change in internal fit out of buildings over the years or in different areas, e.g. more carpets and less linoleum or change in kitchen/bathroom cupboard material,
- external (yard) damages can vary greatly. For example in some areas vehicles can be readily moved whilst in other areas it is not possible,
- different approaches in assessing flood damages. Are the damages assessed on a "replacement" or a "repair and reinstate where possible" basis? Some surveys include structural damage within internal damage whilst others do not,

- varying warning times between communities means that the potential to actual damage ratio may change,
- variations in flood awareness of the community.

A2.1.2 Summary of Survey Data

Flood damages data from the following surveys are provided in Table A3.

- Inverell 1991 - Reference A1,
- Nyngan 1990 - Reference A2,
- Sydney (Georges River) 1986 - Reference A3.

References A1 and A2 were undertaken by Water Studies Pty Ltd and Reference A3 by the Centre for Resource and Environmental Studies (CRES) at the Australian National University, Canberra.

Table A3: Summary of Post Flood Damage Surveys
(Note: Costs quoted at the time of the flood)

	Nyngan	**Inverell**	**Georges River**
TOTAL FLOOD DAMAGES	$47 Million	$20.6 Million	$17 Million
Year	**1990**	**1991**	**1986**
Flooded Premises and Total Cost per section in $M (in brackets):			
Residences	717 ($18.9)	126 ($2.3)	1000
Commercial/Industrial Premises	98 ($11.3)	264 ($14.9)	215
Public Authorities/Utilities	42 ($17.0)	36 ($3.4)	Not Known
Total	857	426	
Damage ($M) per Category and % of Total Flood Damages (in brackets):			
Direct	28.6 (60%)	10.7 (52%)	16.9 (89%)
Indirect	18.7 (40%)	9.8 (48%)	2.1(11%)
Average Damages per Premise and % of Total Flood Damages (in brackets):			
Average Residential	$26 400(40%)	$18 000(11%)	$8 000(48%)
Average Commercial/Industrial	$117 000(24%)	$54 000(72%)	$40 000(52%)
Average Public	$400 000(36%)	$93 000(17%)	Not Known
Average Residential Damages by Category and % of Total Residential Damages (in brackets):			
Direct - Internal	$8 900(34%)	$8 100(42%)	Not Known
Direct - External	$4 500(19%)	$2 500(19%)	$3 500 (44%)
Direct - Structural	$5 200(20%)	$5 000(27%)	Not Known
Indirect - Financial	$4 800(20%)	$300(1%)	Assumed as
Indirect - Clean Up	$2 200(7%)	$2 100(11%)	15% of Direct
Average depth of inundation above floor	0.8 m	0.6 m	Not Known
Average Commercial Damages by Category and % of Total Commercial Damages (in brackets):			
Direct - Internal	$28 600 (25%)	$17 100 (33%)	Not Known
Direct - External	$1 100 (1%)	$5 500 (12%)	Not Known
Direct - Structural	$3 000(3%)	$750 (1%)	Not Known
Indirect - Financial	$79 500 (70%)	$23 000 (45%)	Assumed as
Indirect - Clean Up	$2 000 (1%)	$4 900 (9%)	55% of Direct
Average Annual Damage	$0.63M	Unknown	$14.4M

NOTES:

1. 93% of all properties in Nyngan were flooded above floor level.
2. The AAD figure for Sydney (Georges River) is $0.88M for residential and $13.5M for commercial/industrial.

A2.2 Tangible Damages - Residential Properties

Tangible direct damages are generally calculated under the following components:

- Internal,
- Structural,
- External.

Tangible indirect damages can be subdivided into the following groups:

- accommodation and living expenses,
- loss of income,
- clean up activities.

Damages may be calculated as either estimated actual damages or estimated potential damages. If potential damages are calculated an Actual/Potential (A/P) ratio is estimated based upon (as well as other factors) the likely flood awareness of the community and the available warning time.

The flood awareness of the community is likely to be high with the available flood warning time medium. For these reasons the A/P ratio will be relatively high (say 80%). At Nyngan (February 1990) the A/P ratio for average residential damages was 77%. It should be remembered that not all items can necessarily be saved (kitchen cupboards, carpets) and that many residents may be away. Based upon the available data it is considered that the A/P ratio for the study area will be similar to that at Nyngan or Inverell.

A2.2.1 Direct Internal Damages

Water Studies

In the Water Studies approach internal damages are based upon the following formulae provided in Reference A1.

$$\frac{D}{D_2} = 0.06 + 1.42H - 0.61H^2 \qquad \text{for } H < 1.0\text{m}$$

$$\frac{D}{D_2} = 0.75 + 0.12H \qquad \text{for } H > 1.0\text{m}$$

where,

H	=	height of flooding above floor level (m)
D	=	damage at height (H) above floor level
D_2	=	damage at height of 2 m above floor level

At Nyngan and Inverell D_2 was \$12 500 for small houses and \$14 500 for medium/large houses. These values are in \$1991's. The reference states that *"Damages to individual properties scatter widely around the relationship, which can only be used to reliably estimate the aggregated damage to a collection of flood prone dwellings and not the damage to a single dwelling.".* Structural damages are not included in the above figures.

CRES

In the CRES approach (Reference A3) internal and structural damages are combined. Data are provided for three groups of buildings, namely Poor, Medium and Good. The data are shown in \$1986's in Table A4.

Table A4: Residential Stage-Damage for Actual Direct Damage to Structure and Contents (\$1986's)
(Taken from the Georges River Study: Reference A3 - Table A2.2.7)

Over floor Depth	Poor	Medium	Good	Average
0.0 m	370	1045	2400	1270
0.1 m	740	2090	4799	2540
0.6 m	3012	5713	10360	6360
1.5 m	7102	7595	13190	9300
1.8 m	7210	7711	13391	9440

A2.2.2 Direct Structural Damages

In the CRES approach internal and structural damages are combined. In the Water Studies approach structural damage was adopted as approximately \$5 000 at both Nyngan and Inverell.

A2.2.3 Direct External Damages

The majority of external damages is attributable to vehicles. However there is a high likelihood that a significant percentage of the vehicles can be moved to high ground even with minimal flood warning.

At Nyngan external damages were estimated as \$4 500, mostly for vehicles, and at Inverell at \$2 500 of which \$1 500 was for vehicles. In the Sydney 1986 data obtained by CRES an external damages figure of \$600 was adopted per property experiencing over ground flooding. In addition a sum of \$2 000 per property experiencing over ground flooding in excess of 0.6 m was included.

A2.2.4 Indirect Damages

In the Inverell study the indirect damages were taken as $200 for accommodation, $100 for loss of income and $2 100 for clean up activities. The total indirect damages ($2 400) therefore, represented approximately 20% of the direct damages. At Nyngan indirect damages were high due to the extended period residents were away from their homes and were estimated at $7 700 per dwelling flooded above floor level. In this case the indirect damages amounted to approximately 40% of the direct damages. CRES adopted a figure for indirect damages of 15% of the direct damages (Georges River Study).

A2.3 Adopted Tangible Damages - Residential Properties

Appropriate depth/damage values for the various component items were established with due consideration of the above historical data and information. The following sections document the component items and the resulting damage curve values (depth v damage) adopted for use in this study are summarised in Table A5.

Table A5: Adopted Residential Depth/Damage Data ($2001)

Depth over Floor/Yard (m)	Total	Direct Internal Damages	External Damages	Indirect and Structural Damages
0.1	**6118**	3918	200	2200
0.3	**15222**	8622	767	6600
0.5	**23350**	12350	1500	11000
1.0	**28400**	17400	1500	11000
1.5	**29600**	18600	1500	11000
2.0	**30800**	19800	1500	11000

A2.3.1 Direct Internal Damages

The Water Studies approach to the determination of internal damages was adopted for use in this study. As noted previously the A/P ratio for Nyngan is likely to be similar to that for the study area. A single D_2 value of $20 000 at 2.0 m depth was adopted for all residential buildings regardless of the type of the building.

A2.3.2 Direct Structural Damages

Structural damages were assumed to be a linear relationship from $0 at 0 m to $8 000 at 0.5 m. Above this value it was considered that there would be no additional structural damages.

In floods larger than a 1% AEP event there is the possibility that some buildings may collapse or have to be destroyed. The cost of these damages have not been included in the analysis.

A2.3.3 Direct External Damages

External damages (laundry/garage/yard/vehicle) were assumed to be a linear relationship from $0 at 0 m above ground level to $1 500 at 0.5 m.

A2.3.4 Indirect Damages

Indirect damages were assumed to be a linear relationship from $0 at 0 m above floor level to a maximum of $3 000 at 0.5 m.

A2.4 Tangible Damages - Public Utilities

The damages to public utilities include:

- water and sewerage supply,
- telecommunications,
- road/rail transport,
- other public assets.

Little data are available for establishing costs to public utilities, and the data from Nyngan and Inverell show that it can vary from 17% to 36% of the total damages bill.

The following is a summary of the likely damages to public property. Actual damages for all public utilities were not specifically estimated in this study as they are dependent on a number of factors which are often difficult to quantify. Additionally the values can sometimes represent only a small percentage of the total relative to other contributing factors.

Sewerage

The are about 19 sewage pumping stations within the St Georges Basin Floodplain. The survey undertaken as part of this study revealed that the ground surrounding all the pumping stations is generally flood affected for the 1 in 10 year ARI event and greater. Some properties within the floodplain still have septic systems which can result in the possible release of sewerage when they are inundated.

The damages are therefore largely intangible through the loss of supply of the system, such as inconvenience, disruption and health risk due to the present of raw sewage. The tangible damages to the infrastructure systems are typically only of a nominal value if the pumps and associated structure are damaged during the flood. For the purposes of this study the costs associated with repairs and maintenance of a sewage pumping stations are assumed to vary linearly from $0 at 0 m above the concrete plinth, to $2800 at 0.5 m depth.

Recreational Facilities/Roads

There will be some direct tangible damages in terms of cleanup and/or repairs but the major factors are intangible damages to the community through the loss of use of the facilities.

Telephone, Electricity, Water Supply

These facilities should experience only minor (if any) direct flood related damages. Telephone and electricity supplies may however, be severed at the time of the flood for other reasons (lightning, wind or ground saturation).

Evacuation and Clean-Up Costs

It is estimated that the evacuation and clean-up costs to Council for each event is $40 000.

A2.5 Caravan Parks

There are a significant number of caravan parks located within the floodplain study area, and within each caravan park there are numerous individual van sites often with elaborate annexes attached. The potential damages from such parks are likely to be significant and it was therefore considered appropriate to include some allowance within the overall damages estimate. Damages to amenities buildings were assumed to be similar to external yard damages varying from $0 at 0 m to a maximum of $3000 at 0.5 m. Caravan damages were assumed to vary linearly from $0 at 0.5 m (depth above average ground level for park) to a maximum of $3500 at 2.0 m depth. A value of 0.5 m was adopted (instead of 0 m) as an average depth for commencing caravan damages to account for variation in ground/caravan levels across a site (typically incorporating between 30 to 100 caravans) and to make some allowance for the lower relative value of items which may be stored at ground level or in an annex. Additionally, these items would often be raised or removed first if flooding was imminent and the greatest damage value is usually incurred when floodwaters inundate the caravan itself (floor typically 0.5 m above ground).

Because of the total number of sites which exist in the 16 caravan parks, initial calculations produced significant damages results for only shallow depths of inundation. The revised depth approach was therefore considered to provide a more reasonable weighting of possible damages.

A2.6 Annual Average Damages

It should be emphasised that these **figures include only tangible (direct or indirect) damages to buildings and residents, the cost of intangible damages has not been evaluated**. Available literature suggests that the extent of **intangible damages may equal or exceed the tangible damages. Damages to the public sector have not been accurately assessed in this study**. Recent studies show that **damages to public property can vary significantly but may comprise 50% of the private tangible flood damages**.

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A3. REFERENCES

A1. NSW Department of Water Resources
Inverell Flood Damage Survey February 1991 Flood
Water Studies Pty Ltd - November 1991.

A2. NSW Department of Water Resources
Nyngan 1990 Flood Investigation - Chapter 9
Water Studies Pty Ltd - October 1990.

A3. Public Works, Department of Water Resources
Losses and Lessons from the Sydney Floods of August 1986 Vol. 1 and Vol. 2
Centre for Resource and Environmental Studies, Australian National University, and Environmental Management Pty Ltd Sydney - September 1990.

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APPENDIX B: PUBLIC CONSULTATION PROGRAM

APPENDIX B: PUBLIC CONSULTATION PROGRAM

The following text was provided to the Floodplain Management Committee at the start of the study.

Council has requested that the community be involved in the preparation of the Floodplain Management Studies (FMS) and Floodplain Management Plans (FMP) for the Lower Shoalhaven River floodplain area to ensure that affected persons are aware of the study and to ensure that the consultants have considered and reported on suggestions raised by the community.

To meet the requirements of the consultant's brief in this regard a public consultation program has been prepared for implementation during all stages of the study process.

B1. OBJECTIVES

The consultation program seeks to:

- increase community awareness of the findings of the 1990 Flood Study and of the ongoing process of preparing the FMS and FMP,
- encourage community participation in the FMS and FMP preparation,
- encourage feedback on the draft FMP document to assist Council in their consideration of the final outcomes.

B2. KEY CONSIDERATIONS

In developing the consultation program, the following considerations were regarded as important:

- The expected role of the community needs to be clearly established. This means that the ground rules for community involvement need to be clearly set out so that the community knows what is expected of them. In general a wide range of community views will be sought and discussed. Final decision making will rest with the Floodplain Management Committee (FMC) and Council.

- The program will focus on residents and property owners of the flood liable areas although advertisements in the local press will make the general community aware of the study.

- The consultation program closely follows the study work program and will be seen as an important element of that process. However it is not seen as an end in itself but rather as a means of ensuring that the final product has been prepared in full consideration of all issues raised by the community.

- The consultation program will be carried out by the consultants and thus will be seen to be somewhat independent of any vested interests in the area. An alternative is to engage an independent facilitator to conduct the meetings.

- Consultation methods will seek to provide an independent and impartial forum to ensure that the community fully understands the proposals being considered for inclusion in the study, and can exchange ideas and discuss the full implications of proposals with relevant technical experts in a friendly and non-intimidatory environment. It is not intended that the program be a forum for debate or argument, rather one for the exchange of ideas and the recording of community views.

B3. PROPOSED PROGRAM

The proposed consultation program has three distinct phases:

- **Phase 1** is a short inception period during which broad agreement to the details of the study are to be resolved including matters such as:
  - means of disseminating information,
  - determining the format of the newsletter, questionnaire and advertisements,
  - identifying the community to be consulted,
  - details of the dates and agendas and participants for public meetings.

- **Phase 2** includes the range of activities during the preparation of the FMS.

- **Phase 3** includes the range of activities associated with the exhibition of the draft FMP and the review of submissions.

The following main elements of the program are presented for consideration.

B3.1 Phase 1 - Inception

Means of Disseminating Information: It is proposed that the community be consulted initially via a Letter of Introduction and a Questionnaire which will be distributed by mail to the approximately 460 homes and businesses which occupy or own land within the study area. If people wish to respond or provide comment they will be asked to write to a Reply Paid Number at Webb McKeown's office. Subsequently two A4 newsletters will be provided.

The above material will be mailed to any other interested party nominated by the Committee. Council will distribute material to members of the Floodplain Management Committee.

Council will display the various material in local libraries, Council Offices, community centres and any other appropriate locations.

Advertisements will be placed by Council in the local and national papers at the time of distribution of the newsletter. Council will also issue press releases to local radio, television, and newspapers. These will also announce the dates of the public meetings.

The exact format of the newsletter and advertisements will be the subject of discussion but the broad issues to be covered are set out under Phase 2.

Agenda: The following dates are to be determined:

- 1st Floodplain Management Committee Meeting, 24 August 2000
- Period of Investigation of Strategies by Consultant,
- Date of Distribution of 1st Newsletter,
- Date of 1st Public Meetings,
- Period for Preparation of Draft FMS and FMP by Consultant,
- Date of Distribution of 2nd Newsletter,
- Date of 2nd Public Meetings,
- Date of Draft FMP submitted to Council.

Other FMC meetings will occur at regular intervals.

Community to be Involved: Any residents occupying land (within the study area) which is below 4.0 mAHD will be invited to be involved in the process. Material will be provided to resident owners, non-resident owners and tenants. The advertisements will capture residents who have involvement in the area but do not occupy low lying land. All government and local progress associations will be contacted by direct mail.

Identification of Stakeholders: Any body which has a significant interest in the study should be identified and included in the mailing list. Depending on the number of groups they could be asked to attend the FMC meetings, attend meetings with the project group, or be talked to individually by the consultant.

How Public Interest will be Generated: The success of the study can be measured by how the outcomes of the study are supported by the community. To achieve a high level of support the community needs to be involved in the decision making process. The proposed program aims to generate public interest in the following ways:

- advertisements in local newspapers and press releases provided to local radio, television and newspapers,
- distribution of the letter of introduction and two newsletters,
- two public meetings,
- displays at Council,
- local progress associations and/or representatives on the Floodplain Management Committee should advise their members.

B3.2 Phase 2 - Preparation of the FMS

Preparation and Release of Newsletter: The newsletter will seek to:

- advise the community of the study, its purpose, timetable and expected outcomes,
- summarise the findings of the Flood Study,
- provide concise representations of the strategies proposed in the FMS,
- outline the consultation program and inform the community on how to become involved in the process,
- invite a submission on the draft FMS,
- advise of the forthcoming public meetings to discuss the findings of the FMS.

Discussions with Stakeholder Groups: It is expected that representatives of these groups will attend the FMC meetings. Alternatively it may be possible to meet with these groups prior to or following the FMC meetings.

Public Meetings: Two meetings will be held with residents.

It is expected that the meetings would run for approximately 2 hours and be chaired by a Councillor. The meetings would address the following issues:

- a presentation of the study process,
- an outline of the flooding characteristics of the area,
- a presentation of the strategies,
- community response to those strategies,
- discussion of other strategies to be considered,
- where to from here?

The meeting will include display of graphical material including aerial photos, maps and the proposed strategies.

Technical Workshop: A technical workshop would be held with relevant officers of Council (from a range of relevant disciplines such as engineering, planning and recreation), and State Government departments with an interest in the outcome of the FMS. This workshop would discuss the strategies presented in the FMS and any others nominated by the group. This workshop may form part of a FMC meeting and should occur after the public meetings.

The results of the workshop, discussions and submissions will be reported to the Council and will be presented to the FMC for consideration and recommendation prior to proceeding with the completion of the draft FMP.

B3.3 Phase 3 - Preparation of the Draft FMP

Once a draft FMS has been prepared and approved for exhibition by the committee the activities outlined below will occur. During this time the Draft FMP will be prepared. When the Draft FMP has been approved for exhibition by the committee the activities outlined below for the Draft FMS will occur for the Draft FMP.

- An exhibition of the draft FMS and then draft FMP will be prepared by Council and exhibited at Council Chambers and major libraries. It is not expected that the exhibitions will be elaborate or space consuming. The consultants would provide maps, plans, etc.

- Advertisements will be placed in the state (SMH) and local newspapers advising of the availability of the draft FMS and then draft FMP for comment. The advertisements will advise on where the draft study is exhibited and how comments can be made. The consultants would prepare the advertisements which would be placed by Council. Local radio, television stations and newspapers would also be issued with a press release from Council.

- A second newsletter will be prepared and circulated in a similar manner to the first newsletter with the addition of those who expressed an interest during the study process.

- Public meeting(s) will be held to discuss the draft and to hear comments of the community.

- Council and the consultants will review submissions on the Draft Reports and report to the FMC.

B3.4 Role of the Consultants

Webb, McKeown & Associates: Webb, McKeown & Associates (B Withnall) would participate in the meetings and workshop. He would provide technical support and present the findings of the study in a manner understandable by non-technical members of the public. WM would prepare the newsletters and format of the consultation program.

Nexus Environmental Planning: Nexus Environmental Planning would participate in the FMC meetings and provide planning input where appropriate.

LOWER SHOALHAVEN RIVER FLOODPLAIN MANAGEMENT STUDY & PLAN

COMMUNITY INFORMATION SHEET DECEMBER 2000

INTRODUCTION

This Community Information Sheet has been issued to inform you of the Floodplain Management Studies (FMS) being prepared for the Lower Shoalhaven area.

Shoalhaven City Council has appointed Webb, McKeown & Associates Pty Ltd (Consulting Engineers) to develop a sustainable plan for floodplain management of this area.

An integral part of the study process is the implementation of a community consultation program and this newsletter constitutes part of this process.

Your questions and/or comments are welcome at any time during the course of the study. Details on how to contact the study team are provided on the back of this sheet.

FLOODPLAIN MANAGEMENT PROCESS

The implementation of sound floodplain management practice is an important process (Diagram 1) which can be used to optimise development potential, and to obtain social and economic benefits from the reduction in tangible and intangible flood damages.

Following the establishment of an FPM Committee, the **first step** in the process is preparation of a Flood Study to establish design flood levels. (Design flood levels are levels which have a known likelihood of occurrence.

For example the 1% annual exceedance probability event (AEP) has a 1% or 1 in 100 chance of being equalled or exceeded in any year.) The Flood Study was completed in April 1990. Floodplain Management Plans for two subareas of the study area (Terara Village and Riverview Road Area) have been completed in 2000.

The **second step** is preparation of this FMS which identifies a range of floodplain management measures to address the problems and areas of concern.

The **third stage** is preparation of a Plan which documents how the work and strategies identified in the FMS are to be implemented.

The **final stage** is the undertaking of the works.

OBJECTIVES OF THE STUDY

The objectives for this FMS are as follows:

- to manage flooding as an integral part of the planning and development process,
- to systematically identify and address flooding problems,
- to prepare a schedule of works or strategies to manage the existing flood problem and reduce future flood damages,
- to implement a unified approach,
- to ensure sustainable development principles are achieved,
- to maintain and enhance the quality of the Lower Shoalhaven and Crookhaven Rivers.

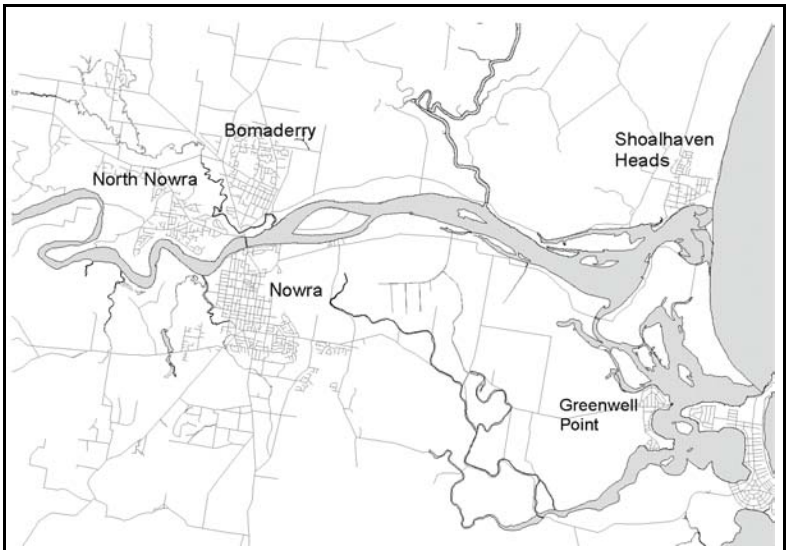

Diagram 2: The Lower Shoalhaven River Floodplain Study Area

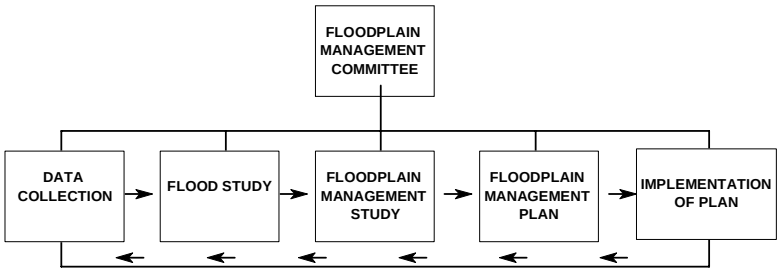

Diagram 1: The Floodplain Management Process

THE STUDY AREA

The Lower Shoalhaven River Floodplain extends from 2 kilometres upstream of Nowra Bridge to the Pacific Ocean, and from Broughton Creek near Berry to the Crookhaven River. The entrance at Shoalhaven Heads is generally closed and estuarine flows reach the ocean via Berry's Canal and out at Crookhaven Heads (Diagram 2).

The Shoalhaven River catchment can be described in terms of three broad regions:

- upstream of Welcome Reef where the catchment comprises rolling plateau
- between Welcome Reef and Burrier, where the catchment contains steep forested gorge terrain
- between Burrier and the coast (Lower Shoalhaven) which is a typical alluvial floodplain.

Two hundred years ago the main entrance was at Shoalhaven Heads. This entrance is now intermittent following the construction of Berry's Canal link to the Crookhaven River in 1822.

THE FLOOD PROBLEM

The Lower Shoalhaven River Floodplain is mainly occupied by Dairy farms and urban areas of Nowra, Bomaderry, Terara, Shoalhaven Heads, Culburra, Greenwell Point and Orient Point. During floods, the opening of Shoalhaven Heads may be mechanically assisted to reduce flood impacts.

A flood history in the Shoalhaven has been recorded since 1860.

MANAGEMENT MEASURES

Possible floodplain management measures to address the various problems may be categorised under the following headings.

Flood Modification - structural works to modify flood behaviour.

Property Modification - modifies land use and development controls in accordance with flood risk/hazard.

Response Modification - planning, education and awareness measures which aim to modify the community's response to flood hazard.

Photo 1. Nowra in Flood 1978

HOW DO I GET INVOLVED?

Community input to the FMS is essential and a range of consultation activities are planned to coincide with the various stages of the study. Activities will include:

- your direct feedback to the project team or Shoalhaven City Council,
- individual discussions with residents, businesses and other stakeholders,
- input from your local representatives on the Floodplain Management Committee,
- questionnaire,
- open shop days,
- public meeting,
- public exhibition of the draft FMS and Plan.

Submissions are welcome at any stage of the study process. Any interested party is also invited to join the "Contact Group" to receive updates throughout the study process.

Your local community representatives on the FPM committee are:
Mr Alan Voysey Ph 4487741
Mr Jim Knapp Ph 44217872
Mr Bill Kennedy Ph 0412427345

WHO TO SPEAK TO?

The Project Manager is:
Mr Bruce Withnall
and our full-time consultation "Listener" is:
Ms Joanna Kuswadi

They can be contacted at:

Reply Paid 1752
Webb, McKeown & Associates
Level 2, 160 Clarence Street
SYDNEY NSW 2000

Telephone: (02) 9299 2855
Facsimile: (02) 9262 6208

Email:
lowershoalhaven@webbmckeown.com.au

Up to date information is available on the Study Website.

Internet:
www.webbmckeown.com.au/lowershoalhaven

You may also wish to contact Mr Ajith Goonatilleke, Strategic Drainage Engineer, Shoalhaven City Council on (02) 44 293238 to discuss any aspects of the project.

Should you only wish to make a brief comment or seek clarification on any issue, or have any comments, please do not hesitate to contact us.

RESULTS - LOWER SHOALHAVEN RIVER

FLOODPLAIN MANAGEMENT STUDY QUESTIONNAIRE

December, 2000

No. Sent: 1767 ; No. Returned: 360 (20%)

Your response to this questionnaire will help Council in its investigation of flooding issues for the Lower Shoalhaven River area. Please tick a G box where requested.

1. Please provide your name and address details below.
   Name: _____ Telephone: _____
   Address: _____

   Please indicate if you wish to be included as a member of the "Contact Group" mailing list to be directly updated or involved in the progress of the study.

   208 (58%) Yes

   If you are contactable by e-mail please provide your address: _____

2. How long have you been at this address? _____ Years

3. Type of development?

360 (85%)	House	**12 (3%)**	Commercial (specify)	
3 (<%)	Residential Units	**12 (3%)**	Agricultural/Rural	

4. Your status with regard to this property?
   335 (93%) Owner/Occupier **2 (>1%)** Tenant **4 (1%)** Other (please specify) _____

5. Do you think (or know) that your property may be flood liable? **208 (58%)** Yes **158 (42%)** No

6. Have you ever experienced any of the following at your current address?
   Please respond (tick) to each issue as appropriate.

	Yes	No	Not Applicable
Have floodwaters ever entered your yard?	**169 (47%)**	**188 (52%)**	G
Has flooding ever caused you to move your car?	**80 (22%)**	**276 (77%)**	G
Have floodwaters ever entered your house?	**34 (9%)**	**323 (90%)**	G
Has flooding ever caused you to leave your house?	**21 (6%)**	**335 (93%)**	G
Have you ever incurred a financial loss from flooding?	**48 (13%)**	**311 (86%)**	G
If YES please indicate an approximate amount (in $'s). _____			
Have you ever missed work during a flood?	**50 (14%)**	**305 (85%)**	G
Have you ever received a flood warning?	**58 (16%)**	**300 (83%)**	G
If YES was the warning useful?	**49 (14%)**	**302 (84%)**	G
Have you ever received assistance during a flood?	**30 (8%)**	**326 (91%)**	G
From whom - specify? _____			
Have you ever experienced any post flood problems or emotional trauma?	**45 (13%)**	**314 (87%)**	G
Do you have a flood action or emergency plan?	**65 (18%)**	**291 (81%)**	G
Do you think there is a risk to life in your area from flooding?	**58 (16%)**	**300 (83%)**	G
Do you think that you are flood aware?	**251 (70%)**	**105 (29%)**	G

7. If you have experienced flooding at your property, do you have any useful information to provide?
   (If yes please attach or indicate the type of information available.) **75 (21%)** Yes **285 (79%)** No

8. To what extent do you think you may be affected by flooding in the following events?

	Evacuation Access	Yard Inundated	Buildings Inundated
In a small to medium flood which is more likely to actually be experienced (say once in every 20 years on average)(e.g 1978 Flood)	**28 (8%)**	**153 (43%)**	**39 (11%)**
In a large flood which is less likely to occur (say once in every 100 years on average)	**37 (10%)**	**105 (29%)**	**89 (25%)**
In the largest possible flood event imaginable	**42 (12%)**	**59 (16%)**	**144 (40%)**

9. How much time do you think you would have in a major flood to undertake emergency measures?

69 (19%) no idea **65 (18%)** 1 day **49 (14%)** 12 hours **42 (12%)** 6 hours **56 (17%)** less than 6 hours

10. Is the issue of flooding in general (from severe rain and ocean conditions) of concern to you?

205 (57%) Yes G No

If Yes please indicate (tick) the various means by which you would like the problem to be addressed.

4 (1%) do nothing
118 (33%) better flood warning information
78 (22%) more information regarding damage minimisation or evacuation procedures
21 (6%) house raising
83 (23%) flood insurance
8 (2%) voluntary purchase of building/land
36 (10%) sealing (flood proofing) the entrances to the building
86 (24%) implement localised structural measures such as levees
240 (67%) dredge river channel and /or open Shoalhaven Heads entrance

Other - specify:_____

_____

11. Please provide any further comments that you think appropriate.

122 (34%) provided further comments

_____

After completing this questionnaire please check that you have answered every question. Please mail (no stamp required) the completed questionnaire within 7 days to:

REPLY PAID 1752
Webb, McKeown & Associates Pty Ltd
Level 2, 160 Clarence Street
SYDNEY NSW 2000
Attention: Ms Joanna Kuswadi

Alternatively, if you have access to the internet you may complete the questionnaire at the study website www.webbmckeown.com.au/lowershoalhaven

OR

Fax: (02) 9262 6208

Thank you for your assistance

LOWER SHOALHAVEN RIVER FLOODPLAIN MANAGEMENT STUDY & PLAN

COMMUNITY INFORMATION SHEET JUNE 2001

INTRODUCTION

This Community Information Sheet (No.2) has been issued to inform you of the progress of the Floodplain Management Study (FMS) being prepared for the Lower Shoalhaven River Floodplain.

Shoalhaven City Council has appointed Webb, McKeown & Associates Pty Ltd (Consulting Engineers) to develop a sustainable plan of management for the floodplain in this area.

An integral part of the study process is the implementation of a community consultation program and this newsletter constitutes part of this process.

Your questions and/or comments are welcome at any time during the course of the study. Details on how to contact the study team are provided on the back of this sheet.

FLOODPLAIN MANAGEMENT PROCESS

The implementation of sound floodplain management practice is an important process which can be used to optimise development potential, and to obtain social and economic benefits from the reduction in tangible and intangible flood damages without compromising the natural and built environments.

Following the establishment of an FPM Committee, the first step in the process is preparation of a Flood Study to establish design flood levels. Design flood levels are levels which have a known likelihood of occurrence. For example the 1% annual exceedance probability event (AEP) has a 1% or 1 in 100 chance of being equalled or exceeded in any year. The Flood Study report was completed and published in April 1990.

The second step is the preparation of this FMS which identifies a range of floodplain management measures to address the problems and areas of concern. The third stage involves preparation of a Plan which documents how the proposal works and strategies identified in the FMS are to be implemented in terms of resourcing and timing. The final stage of the process is the undertaking of the works.

OBJECTIVES OF THE STUDY

The objectives for this FMS are as follows:

- to manage flooding as an integral part of the planning and development process,
- to systematically identify and address flooding problems,
- to prepare a schedule of works or strategies which will manage the existing flood problem and reduce future flood damages over a full range of flood events,
- to implement a unified approach,
- to ensure sustainable development principles are achieved,
- to maintain and enhance the quality of the Lower Shoalhaven River area,
- to gain community participation in the decision making process and thus assist community understanding and acceptance of the Management Study findings and the subsequent Plan.

THE STUDY AREA

The Lower Shoalhaven River Floodplain (Diagram 1) extends from 2 kilometres upstream of Nowra Bridge to the Pacific Ocean, and from Broughton Creek near Berry in the north, to the Crookhaven River in the south. The entrance at Shoalhaven Heads is generally closed and estuarine flows reach the ocean via Berry's Canal and out through Crookhaven Heads.

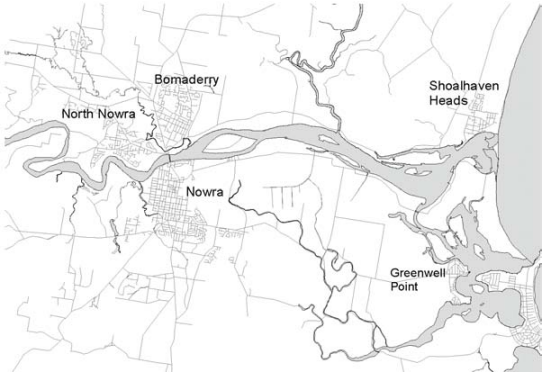

Diagram 1: Lower Shoalhaven River Floodplain

The Shoalhaven River catchment can be described in terms of three broad regions:

- upstream of Welcome Reef where the catchment comprises rolling plateau,
- between Welcome Reef and Burrier, where the catchment contains steep forested gorge terrain,
- between Burrier and the coast (Lower Shoalhaven) which is a typical alluvial floodplain.

Two hundred years ago the main entrance was at Shoalhaven Heads. Following the construction of Berry's Canal link to the Crookhaven River in 1822, the opening of this entrance is now intermittent.

THE FLOOD PROBLEM

As part of the second step of the floodplain management process a survey of most residential and commercial (but excluding rural) properties within the floodplain was conducted in the early part of this year. The ground and building floor level information obtained was then compared against the design flood levels established by the Flood Study in the first step. A summary of the estimated number of buildings inundated for a range of design flood events is included in the table below.

Event	Number of Buildings Inundated above floor
10%	223
5%	369
2%	492
1%	676
Extreme	955

Flood Damages

Based on the floor level and flood affectation information, the estimated damages which could be incurred for a range of flood events are indicated in the table below.

Frequency	Existing Damages ($ million)
Extreme	47.7
1% AEP	30.2
2% AEP	21.9
5% AEP	7.5
10% AEP	2.7
Average Annual Damages	1.86

Given the above values, the average annual damages cost to the community is estimated to be of the order of $1.86M over a 50 year timeframe.

Hydraulic/Hazard Mapping

The second step of the process also involves areas of the floodplain being defined in terms of their potential flood hazard exposure (high or low) and their hydraulic characteristics (floodway, flood storage and flood fringe).

Flood hazard is a measure of the overall adverse affects of flooding. It is typically based on the depth and velocity of floodwaters but also incorporates potential threat to life, danger and difficulty in evacuating people and possessions, as well as potential for damage and social disruption. Areas are classified as either low or high hazard, depending on these risks over a range of flood events.

The hydraulic classifications applied to areas of the floodplain are as follows:

- **Floodways** - those areas where a significant volume of water flows during floods.
- **Flood Storage** - those areas of the floodplain that are important for temporary storage of floodwaters during the passage of a flood.
- **Flood Fringe** - the remaining area of land affected by flooding after the above two have been defined.

DECEMBER 2000 QUESTIONNAIRE

The response from the December 2000 Questionnaire was overwhelming and highlighted the community's concerns for flooding issues. Some 360 (20%) of the questionnaires were returned with 57% of respondents concerned about flooding and 58% believing they were flood liable. Approximately 21% of responses returned indicated they had useful information available and 34% of responses contained additional comments or discussion. A large number (23%) of responses were identified as requiring some form of feedback.

Other issues for consideration and useful information were also included in the resources and this highlights the community's awareness of their local environment. The additional concerns raised by the community include:

- access to flood warning information,
- Bomaderry Creek flood warning,
- evacuation access of Greenwell Point,
- erosion of river banks,
- siltation of Shoalhaven River.

Stormwater drainage problems were a common issue but unfortunately these are not within the scope of the present study. Details of these concerns will be forwarded to Council. Other issues we hope to resolve through the issue of this newsletter.

The management options discussed below were developed based on these community and government concerns with regard to the entire floodplain. More specific and localised concerns are important and will be considered during the implementation stage of the process.

A survey of community views on management measures worthy of detailed consideration was also undertaken and the results are summarised in Diagram 2.

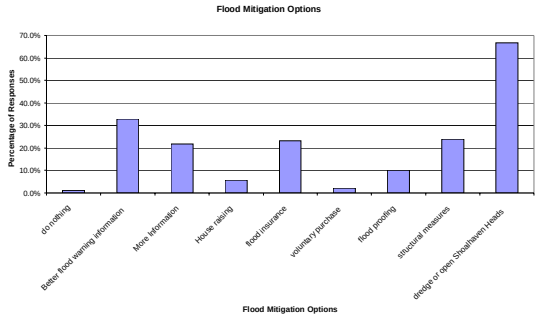

Diagram 2: Community Assessment of Management Options

MANAGEMENT MEASURES

The possible floodplain management measures to address the various flooding problems may be categorised under the following headings.

Flood Modification - structural works to modify flood behaviour.

Property Modification - modifies buildings and land uses

Response Modification - planning, education and awareness measures which aim to modify the community's response to flood hazard.

Planning and Future Development Control Measures - review and improve existing plans, operating procedures and development controls.

The Floodplain Management Committee together with Council representatives (including Councillors and Council officers from various departments) discussed possible flood mitigation measures for the Lower Shoalhaven River Floodplain at a recent workshop. The possible management measures were based on information obtained from the Flood Study and questionnaire and other investigations relating to the Floodplain. The workshop then discussed the priority and implementation of these measures.

Possible flood mitigation measures under consideration for the Lower Shoalhaven River Floodplain are included in the table below.

Action	Management Option
Flood Modification	
F1	River improvement works
F2	Local drainage
F3	Flood Mounds
Property Modification	
P1	Voluntary purchase
P2	House raising
P3	Flood proofing
Response Modification	
R1	Update existing flood warning system which links rainfall to river conditions
R2	Update SES Flood Plan to incorporate findings of FPM Study
R3	Undertake a workshop to update the SES, Police and other authorities.
R4	Develop a flood evacuation/damage minimisation strategy for caravan parks identified as medium to high hazard.
R5	Update the flood readiness program and implement to educate the community about flooding.
R6	Formalise a during and post flood evaluation program to ensure future events are well documented.
R7	Issue advice or notification to flood liable properties informing them of their particular circumstances.
Planning and Future Development Control Measures	
PL1	Review and formalise the current Flood Policy
PL2	Review and update Section 149 Certificates
PL3	Council to obtain advice on Greenhouse effect and re-assess the Flood Policy
PL4	Review and update LEP and DCP's in line with current information, FPM Manual and Coastal Management Manual.

Shoalhaven Heads

Previous studies regarding the Shoalhaven Heads entrance issue have indicated that there is a wide range of strong and divergent views regarding the relative benefits and disbenefits of opening the entrance either during a flood or more permanently for non-flood times. The Draft Policy for Opening Shoalhaven River Entrance at Shoalhaven Heads, February 2000 aimed to compile existing information and provide a operational strategy for future occasions.

Recommendations from the Policy include:

- preferred physical opening location,
- dune strengthening strategy,
- responsible officer for mechanical intervention works,
- monitoring and maintenance procedures for 'dry' notch,
- statutory requirements,
- stakeholder involvement and concurrence required, consult NPWS, DLWC, Fisheries and DUAP.

The specific management measures suitable for consideration to address the problems at Shoalhaven Heads include:

- maintaining a low level notch in the sand berm,
- planting or removal of vegetation,
- dredging within the bay to prevent sand build up,
- excavation of entrance during a flood,
- better controls for development,
- flood warning and evacuation procedures,
- install real time gauge to assist flood warning and evacuation.

HOW DO I GET INVOLVED?

Community input to the FMS is essential and a range of consultation activities are planned to coincide with the various stages of the study. Your next opportunity to participate will be at the Open Shop Day and Public Meeting. The locations, dates and times for these are listed below.

Any interested party is invited to attend the upcoming Open Shop Day, where a representative from the consultant will be on hand. Interested parties are also invited to the Public Meeting at which the consultant will present the findings of the study so far and the flood mitigation options available for the Lower Shoalhaven River floodplain.

Location	Date	Time
OPEN SHOP DAY		
Shoalhaven Heads Community Centre - Shoalhaven Heads Rd	28th June 2001	9:00 am - 12:00 noon
Nowra - Foyer of Council Administration Centre	28th June 2001	2:00 - 5:00pm
PUBLIC MEETING		
Nowra - Reception Room at Council Chambers	28th June 2001	7:00pm onwards

Submissions and enquires are welcome at any stage of the study process. Any interested party is also invited to join the "Contact Group" to receive updates throughout the study process.

Your local community representatives on the FPM Committee are:
Mr Alan Voysey Ph: 4448 7741
Mr Jim Knapp Ph: 4421 7872
Mr Bill Kennedy Ph: 0412 427 345

WHO TO SPEAK TO?

The Project Manager is:
Mr Bruce Withnall
and our full-time consultation "Listener" is
Ms Karen Lancaster

They can be contacted at:
Webb, McKeown & Associates
Level 2, 160 Clarence Street
SYDNEY NSW 2000
Telephone: (02) 9299 2855
Facsimile: (02) 9262 6208
Email: lowershoalhaven@webbmckeown.com.au

Information pertaining to the Study is also available on the website: www.webbmckeown.com.au/stgeorges

You may also wish to contact Mr Ajith Goonatilleke, Strategic Drainage Engineer, Shoalhaven City Council on (02) 4429 3238 to discuss any aspects of the project.

Should you only wish to make a brief comment, seek clarification on any issue, or have any comments, please do not hesitate to contact us.

Lower Shoalhaven River Floodplain Management Study
Public Meeting - 7:00pm - 9:00pm 28/6/01

The Public Meeting held at Council Offices was attended by about 30 people which included Councillors, Council staff and interested members of the community. The general discussion which followed on from the presentation by the consultant included several issues as described below.

- Why was a levee allowed to be built on the southern side of the river at Riverview Road? Won't the levee push flows to the north?
- Historical studies have shown that the levee has only a slight effect on the flood levels.
- The SKM report investigated levees on both sides of the river and dredging of the river. The dredging was seen to have little impact on reducing flood levels.
- Scepticism about flood photograph dates, number of houses inundated, calculation and results of damages estimates.
- The FPMS is a risk management process which can result in some people not being informed about flood events and how to handle them.
- The SES has a flood event classification of minor, moderate, and major. They receive predicted flood levels from the BOM which allows them to initiate their local flood evacuation plans.
- The last flood was in 1999.
- What does the height of Nowra bridge mean for a property downstream of the bridge.
- The flood of 1938 was significant for Shoalhaven Heads but was not for the Nowra area.
- A recent flood saw an excavator wait at the entrance to the river awaiting permission to open the entrance. Is their a protocol for opening the entrance in times of flooding?
- The Council has been reviewing the flood levels for Shoalhaven Heads in relation to Nowra. The opening of the entrance must consider the prevailing tidal conditions, other State Government department guidelines and legislation.
- There are legal requirements which must be complied with before the entrance can be opened.

- Is there a possibility for a State Government Act of Parliament to enforce the opening of the entrance?

- What is happening to monitor the flood mitigation drains within the floodplain?

- The Manildra property is currently constructing large ponds within the floodplain. What effect will these have on flooding and does Council check their designs versus what is constructed?

- Council requires a flood study to be undertaken for any large development within the floodplain. Currently these are done as the development is undergoing approval which is a rather “ad hoc” approach.

- Is anything to be done regarding the acid sulfate soils?

- Modifications to Broughton Creek have allowed water to flow further up the creek and cover over the acid sulfate soils and maintain a habitable environment for wildlife.

- The 1870 flood was 18 inches higher than the 1978 flood event.

- Has their been any studies for the closed and open entrance options?

Open Shop Days - Lower Shoalhaven River

Summary of Additional Comments Sheets

Open Shop	Suburb	Comments
Nowra	Greenwell Point	Particularly concerned about riverbank erosion and the damage it causes to existing recreation areas and the potential to affect private property.
Nowra	Culburra Beach	Private property's risk to flooding. A nearby creek is very overgrown can something be done to alleviate the risk of flooding in the area.
Nowra	Shoalhaven Heads	The need for a permanent notch at Shoalhaven Heads entrance. Early warning of a flood and sand bags for buildings. The enforcement of road closures during a flood to prevent trucks creating waves and they drive through the closed road.
Shoalhaven Heads	Shoalhaven Heads	Open Shoalhaven Heads entrance when there is a flood and maintain a permanent entrance.
Shoalhaven Heads	Shoalhaven Heads	Automatic flood gauges at Nowra. Permanent marker to indicate level when Shoalhaven Heads entrance will be opened. A formal plan to allow for Shoalhaven Heads Entrance to be opened during a flood event. No further development allowed on land below the 100 year ARI flood level
Shoalhaven Heads	Coolongatta	A management plan which includes a fixed height to maintain a notch at the Shoalhaven Heads entrance and details regarding opening the entrance during a flood. Floods cause too much damage when the entrance is closed. A definite plan regarding opening of the entrance is needed.
Shoalhaven Heads	Shoalhaven Heads	A permanent notch must be maintained. Extreme flood heights must not be allowed to occur.
Shoalhaven Heads	Shoalhaven Heads	Open and maintain an opening at Shoalhaven Heads Entrance. At the first sign of a flood the opening should be in place.
Shoalhaven Heads	Shoalhaven Heads	Keep the Shoalhaven Heads entrance open at all costs.
Shoalhaven Heads	Shoalhaven Heads	Have legislation in place to enable immediate action to open Shoalhaven Heads entrance. Encourage sand dune modification and vegetation so as to consolidate and focus the river breakout point and to prevent the width of the mouth spreading. It is viable to maintain a deep canal in the river which directs flow to Shoalhaven Heads entrance.
Shoalhaven Heads	Shoalhaven Heads	Limit flow to Berry Canal. Maintain a notch at Shoalhaven Heads entrance. The sand build-up in the estuary exacerbates flooding. Eliminate flooding risk. Provide improved environmental outcomes. Not prevent boat usage of Berry Canal. Use Nature, don't fight it.
Shoalhaven Heads	Shoalhaven Heads	Re-zoning and filling land in the floodplain will impact upon flood storage. Filling of land behind the "Tall Timbers" caravan park has already had an effect in the area.

LOWER SHOALHAVEN RIVER FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN

SHOALHAVEN HEADS MANAGEMENT MEASURES

A COMMUNITY INFORMATION NEWSLETTER DECEMBER 2003

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THE CONSULTATION PROCESS SO FAR . . .

In December 2000, a questionnaire which asked about people's knowledge and experience of flooding was sent to all residents in the floodplain. Some 360 (20%) of the questionnaires were returned with 57% of respondents concerned about flooding and 58% believed they were flood liable.

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Since that time the Project Team have been investigating and refining the options available and preparing a draft report to summarise the process to date and outcomes achieved.

THE NEXT STEP

To ensure you (the community) are aware of the flood related issues or problems in your particular area and the potential options available to address them, we provide the following brief summary of the risks and issues associated with the flooding problem and management options under consideration. Particular attention is given to the Shoalhaven Heads area and we seek your comments and feedback.

Hay Avenue, Shoalhaven Heads
March 1978

THE FLOOD PROBLEM

The first step in the overall Floodplain Management process involved the preparation of a detailed flood study (completed 1990) which defined flood behaviour for the Lower Shoalhaven River floodplain. The flood study results have been utilised as part of this study, to delineate the various areas of the floodplain in terms of their potential hazard exposure and their hydraulic characteristics. (Refer to Figure 2)

Flood hazard is a measure of the overall adverse affects of flooding. It is typically based on the depth and velocity of floodwaters but also incorporates potential threat to life, danger and difficulty in evacuating people and possessions, as well as potential for damage and social disruption. Areas are classified as either low or high hazard, depending on these risks over a range of flood events.

The hydraulic classifications applied to areas of the floodplain area as follows:

- **Floodways** - those areas where significant volume of water flows during floods.
- **Flood Storage** - those areas of the floodplain that area important for temporary storage of floodwaters during the passage of a flood.
- **Flood Fringe** - the remaining area of land affected by flooding after the above two have been defined.

A floor level survey of residential buildings has also been conducted in the settled areas of the floodplain. This information was then used to estimate the number of habitable dwellings inundated for a range of flood events and the potential cost of flood damages to the community. The results of the survey are included in Figure 1 which shows the worst affected settlements are situated close to the ocean entrances at Greenwell Point, Shoalhaven Heads and Orient Point. An indication of the estimated flood damages which could be incurred is presented in Table 1.

Figure 1. Number of buildings Inundated

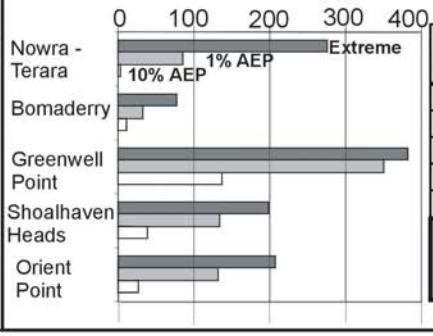

Table 1. Estimated Floodplain Damages

Frequency	Existing Damages ($ million)
Extreme	47.7
1% AEP	30.2
2%AEP	21.9
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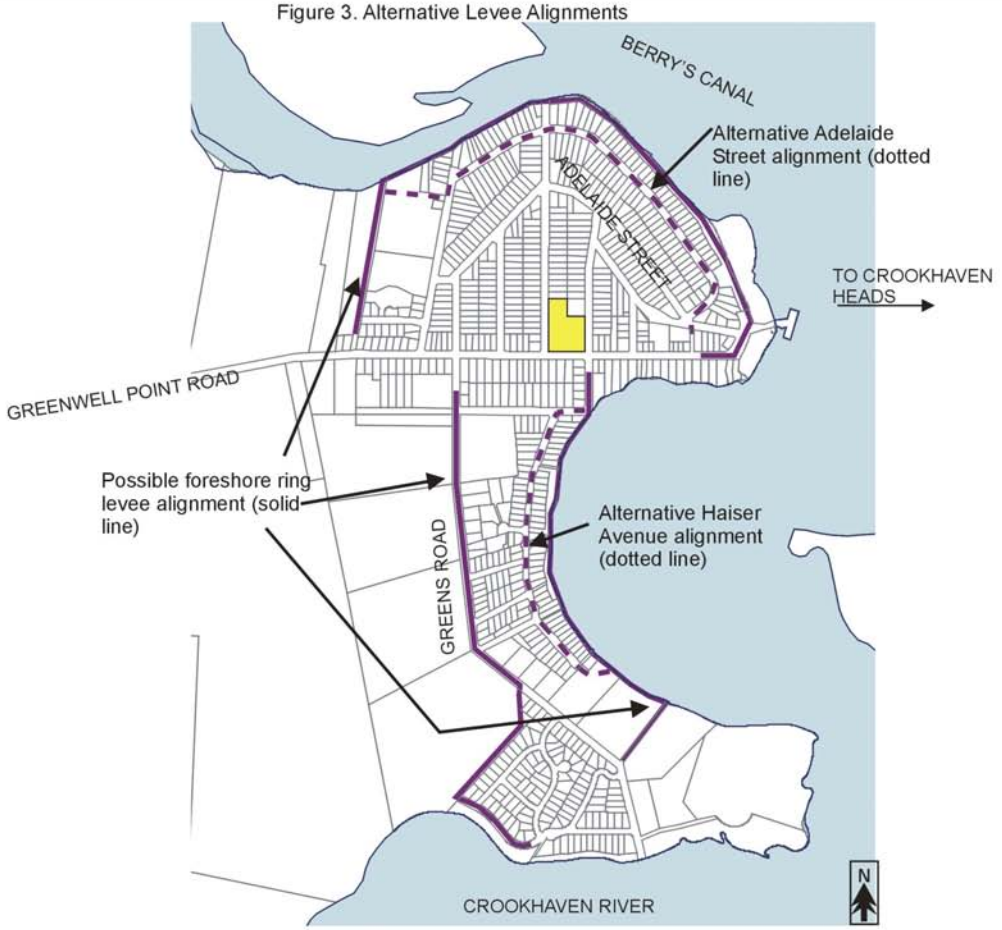
A COMMUNITY INFORMATION NEWSLETTER DECEMBER 2003

Figure 3. Alternative Levee Alignments



SPECIFIC POSSIBLE MANAGEMENT MEASURES FOR GREENWELL POINT:

- No significant new development should be permitted in the urban zoned areas or immediate vicinity of Greenwell Point. Such development would adversely increase the number of people isolated and therefore at risk during flood events. Existing use rights would not necessarily be denied but would be subject to strict controls.

- Consider levee protection for the low lying areas of Greenwell Point. The feasibility of possible levee alignment alternatives (refer Figure 3) should be investigated in more detail:

  ➤ Providing a ring levee around the entire urban residential area of Greenwell Point would not eliminate the flood risk from larger events. Additionally, Greenwell Point would still be isolated and subject to disruption of essential services such as sewer, electricity, and water. A levee around the foreshore edge may protect most properties from main river flooding but it may also cause local runoff to pond behind the levee and hence increase the duration of inundation. Additionally, bank stability issues may prevent or limit the possibility of constructing a levee in some areas of the foreshore.

  ➤ A levee along Adelaide Street would be beneficial to those properties situated on the higher side and may increase evacuation time for foreshore properties but it would not reduce the potential cost of flood damages experienced by the excluded foreshore properties.

  ➤ Raising Greens Road to form a levee may improve the evacuation time for residents in the area to the east of Greens Road but this may also increase the depth and time of inundation for upstream properties to the west. While providing some protection from the damages caused by floodwaters, these levees would significantly impose on the existing environment and aesthetic appeal of the Greenwell Point area.

  As such, the construction of levees should only proceed if further detailed investigation identifies that they are economically justifiable and socially acceptable.

- Offer subsidised house raising to suitable structures. Such schemes are voluntary and require the owner to contribute to the costs.

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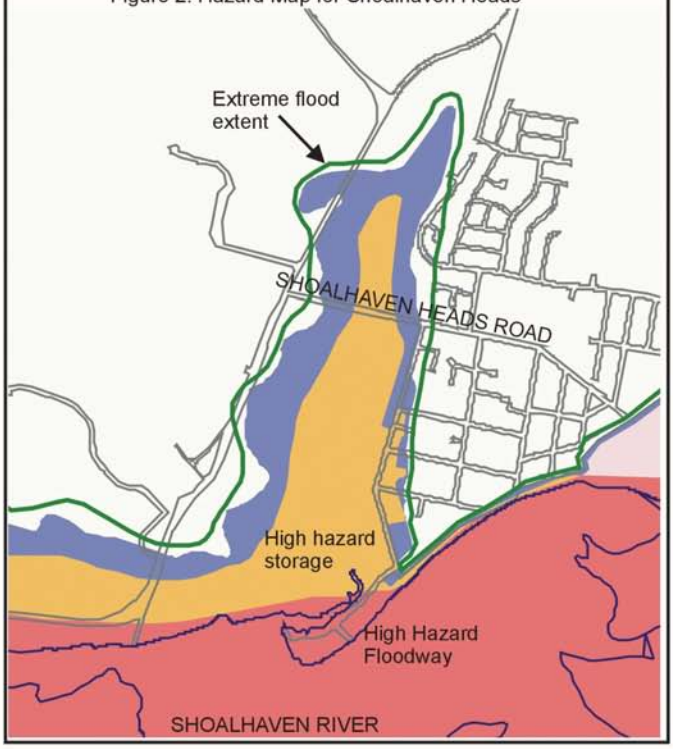
SHOALHAVEN HEADS ISSUES

The nature of flooding experienced at Shoalhaven Heads is directly influenced by whether the entrance is open or closed at the start of a flood. As the entrance is normally closed, this is the basis of flood planning agreed to by Council and the State Government. Council is committed to maintaining the "dry notch weir" and undertaking mechanical intervention at "the Heads" to relieve the impacts of flooding. However, this is not an assured mitigation measure and is not able to be relied upon for planning purposes.

A summary of the key issues, hazards and risks requiring management include:

- The potential flood affectation of many homes, tourist accommodation and shops exposing their occupants to financial and personal risks. Many are at risk of frequent flooding with Hay Avenue properties situated in a High Hazard Floodway area. (Refer to Figure 2)
- Many residents (property owners, tourists or tenants) are unaware of the general flood risks or potential flood affectation of their particular property.
- Evacuation access via Shoalhaven Heads Rd is restricted in the smaller or more frequent floods (refer to Photographs) and can be cut relatively early in the larger events.
- The potential for a significant portion of the local community to become isolated without utility services or outside help during small floods and larger portions to then be flooded as waters continue to rise in larger events.
- The significant flood damages cost to the community.
- The potential demand for increased development either by infill/redevelopment and renovations in; or expansion of; the existing settlement. Such development increases the demands on rescue services as well as damages cost to the community.
- The potential variation in flood levels and impacts due to the entrance conditions prevailing at Shoalhaven Heads (open or closed at the start of the flood).

Figure 2. Hazard Map for Shoalhaven Heads



Shoalhaven Heads Road 1998

Jerry Bailey Road 1998

POSSIBLE MANAGEMENT MEASURES

General:

- Develop and implement planning controls which ensure future development is compatible with the current understanding of flood risks and hazards. Council are in the process of revising the LEP and developing a specific flood related DCP.
- Redevelopment of existing dwellings will also be subject to strict controls to improve flood compatibility and thus reduce hazards and risks for existing problem areas.
- Develop and implement an ongoing community awareness and education program.
- Issue Section 149 certificates to all property owners to advise current understanding of flood affectation.
- Adopt Flood Planning Levels which specify the lowest permissible floor level for habitable rooms in any given area. FPLs are typically based on the 1% AEP flood level plus 0.5 m freeboard. For the Lower Shoalhaven floodplain, design flood levels assuming the entrance initially closed conditions would apply.

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COMMENTS AND FEEDBACK WELCOME

The aim of the study is to reduce the flood hazards or risks for existing and future users or occupiers of the floodplain through the implementation of appropriate management measures. Realistically, this objective can only be achieved with the support of those most affected being you, the community. We therefore consider your views (positive or negative) to be most important to this process. Your comments or feedback on any of the above would be most appreciated.

Shoalhaven Heads Caravan Park 1998

Shoalhaven Heads Caravan Park April 1988

WHO TO CONTACT?

Should you have any queries or wish to provide feedback comments please contact the following:

Webb, McKeown & Associates Pty Ltd
Consultant Listener: Ms Karen Lancaster
Ph: (02) 9299 2855
Fax: (02) 926206208
Post: Level 2, 160 Clarence Street,
SYDNEY NSW 2000

E-Mail:
lowershoalhaven@webbmckeown.com.au

Shoalhaven City Council details is as follows:

Ms Daniella Heubusch
Strategic Flooding & Drainage Engineer
Ph: (02) 4429 3354
E-mail: Heubusch@shoalhaven.nsw.gov.au

Coolangatta 1998

NOTES: Definitions from Floodplain Management Manual, NSW Government, January 2001
* AEP - Annual Exceedance Probability - the chance of a flood of a given or larger size occurring in any one year, usually expressed as percentage. For example, if a peak flood discharge of 500m^3/s has an AEP of 5%, it means that here is a 5% chance (that is one-in-20 chance) of a peak flood discharge of 500m^3/s or larger occurring in any one year.
# 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 (FPL) and the flood used to determine the flood planning level. Freeboard provides a factor of safety to compensate for uncertainties in the estimate of flood levels across the floodplain. Freeboard is included in the flood planning level.

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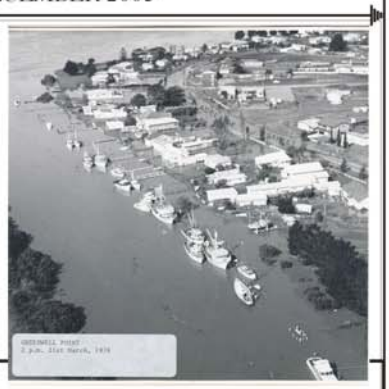
THE NEXT STEP

To ensure you (the community) are aware of the flood related issues or problems in your particular area and the potential options available to address them, we provide the following brief summary of the risks and issues associated with the flooding problem and management options under consideration. Particular attention is given to the Greenwell Point area and we seek your comments and feedback.



Adelaide Street, Greenwell Point - March 1978

THE FLOOD PROBLEM

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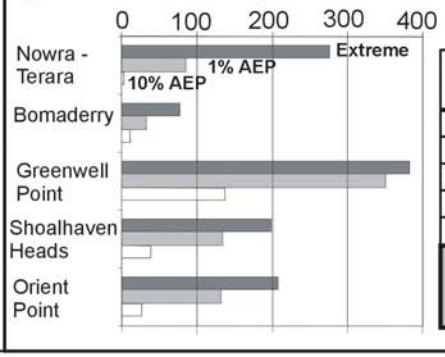

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A COMMUNITY INFORMATION NEWSLETTER DECEMBER 2003

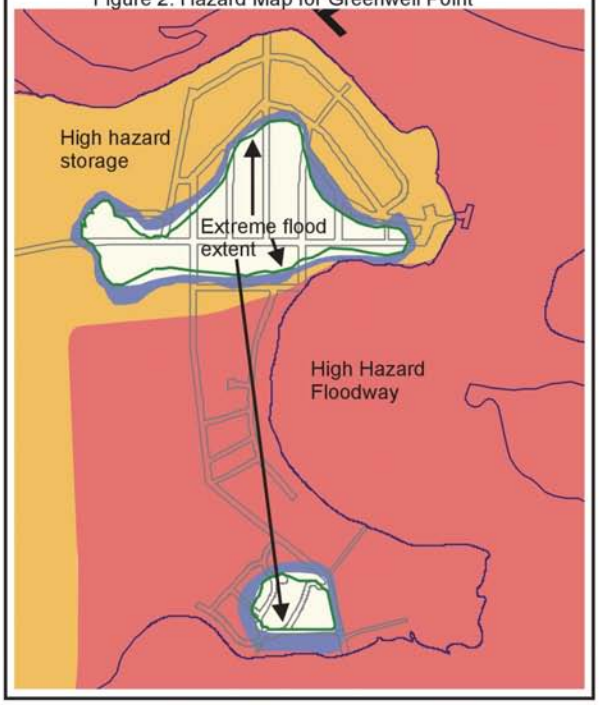
GREENWELL POINT ISSUES

Due to the extent of existing development situated in relatively low lying conditions, the Greenwell Point area represents the greatest flood risk and contribution to flood damages across the Lower Shoalhaven floodplain.

A summary of the key issues, hazards and risks requiring management include:

- The potential flood affectation of many homes, tourist accommodation and shops exposing their occupants to financial and personal risks. Many are at risk of frequent flooding (around 300 properties and 137 buildings above floor level in 10% AEP* - Fig.1) and are situated in High Hazard Floodway areas.
- Many residents (property owners, tourists or tenants) are unaware of the general flood risks or potential flood affectation of their particular property.
- Evacuation access to or from Nowra via Greenwell Point Rd is severely restricted in the smaller or more frequent floods and can be cut relatively early in the larger events (refer Photograph) such that evacuation is necessary before there is any real evidence of flooding at Greenwell Point.
- The potential for the whole local community to become isolated without utility services or outside help during small floods and for a significant portion of the community to then be flooded as waters continue to rise in larger events.
- The significant flood damages cost to the community.
- The potential demand for increased development either by infill/redevelopment and renovations in; or expansion of; the existing settlement. Such development increases the demands on rescue services as well as damages cost to the community.
- The potential variation in flood levels and impacts due to the entrance conditions prevailing at Shoalhaven Heads (open or closed at the start of the flood).
- River bank stability during floods could lead to structural failures or rule out the possibility of foreshore levees in some locations.

Figure 2. Hazard Map for Greenwell Point



Greenwell Point August 1974

POSSIBLE MANAGEMENT MEASURES

General:

- Develop and implement planning controls which ensure future development is compatible with the current understanding of flood risks and hazards. Council are in the process of revising the LEP and developing a specific flood related DCP.
- Redevelopment of existing dwellings will also be subject to strict controls to improve flood compatibility and thus reduce hazards and risks for existing problem areas.
- Develop and implement an ongoing community awareness and education program.
- Issue Section 149 certificates to all property owners to advise current understanding of flood affectation.
- Adopt Flood Planning Levels (FPLs) which specify the lowest permissible floor level for habitable rooms in any given area. FPLs are typically based on the 1% AEP flood level plus 0.5 m freeboard#. For the Lower Shoalhaven floodplain, design flood levels assume the entrance is initially closed which is normally the case.
- Formalise an Entrance Management Policy for Shoalhaven Heads including procedures and conditions for manual opening in times of flood.

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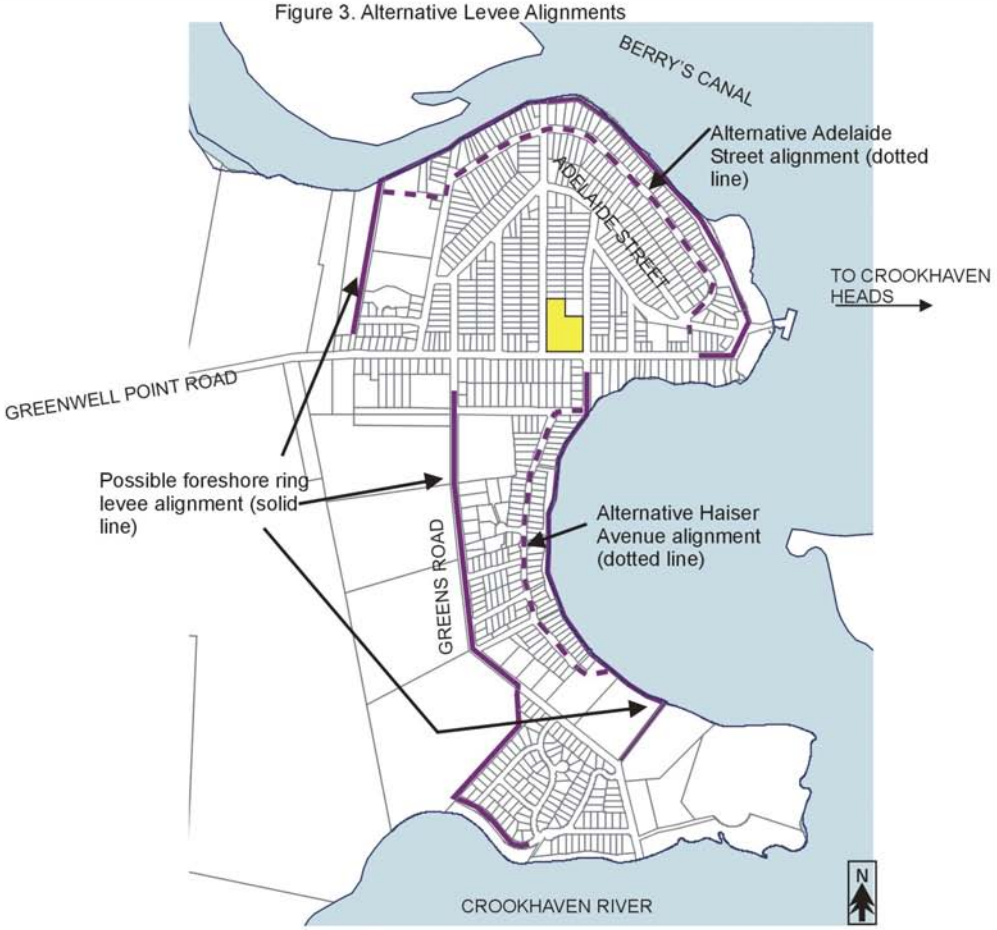
Figure 3. Alternative Levee Alignments



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- Consider levee protection for the low lying areas of Greenwell Point. The feasibility of possible levee alignment alternatives (refer Figure 3) should be investigated in more detail:

  - Providing a ring levee around the entire urban residential area of Greenwell Point would not eliminate the flood risk from larger events. Additionally, Greenwell Point would still be isolated and subject to disruption of essential services such as sewer, electricity, and water. A levee around the foreshore edge may protect most properties from main river flooding but it may also cause local runoff to pond behind the levee and hence increase the duration of inundation. Additionally, bank stability issues may prevent or limit the possibility of constructing a levee in some areas of the foreshore.

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Greenwell Point Road 1974

Greenwell Point August 1974

Haiser Road August 1974

WHO TO CONTACT?

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Shoalhaven City Council details are as follows:

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APPENDIX C: BANK EROSION AND FAILURE

C1. GENERAL

The terms bank erosion and bank failure are often used interchangeably. However, the two terms have different specific meanings. *Erosion* occurs when individual soil particles of the bank's surface material are removed. *Failure* occurs when a relatively large section of the bank fails and slides into the channel.

The major factors contributing to river bank erosion are:

- altered flow patterns, tidal currents and/or velocities,
- wave attack (from boats and wind),
- rainfall,
- seepage,
- overbank drainage,
- changes in land use (e.g. removal of native vegetation, introduction of livestock).

The major causes of river bank failure can generally be categorised as either an increase in the shear stresses in the bank or a decrease in the shear strength of the soil. These causes, which can individually or in combination lead to bank failure are:

- increase in shear stress within the bank:
    - changes in channel shape due to bed scour or erosion of the bank face,
    - increase of load on top of the bank,
    - rapid drawdown of water against the bank face,
- decrease in shear strength of soil:
    - swelling of clays due to absorption of water,
    - pressure of groundwater from within the bank,
    - creep, or minor movements of the soil,
    - removal of vegetation from banks.

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C2. BANK EROSION

Soil particles carried away from a bank by flowing water are removed by a tractive force which tends to pull particles along with the flow. An *alteration in flow patterns, tidal currents and/or velocities*, whether natural (e.g. flooding) or caused by man (e.g. excavation) can increase the tractive force. The potential for erosion depends on the bank particle's resistance, which is based on its size and cohesive properties. Larger particles weigh more and are harder to move, thus gravel is more resistant to erosion than sand. Highly cohesive particles such as clay particles are more resistant than less cohesive particles such as silt particles.

Flow patterns vary across the width of a river, particularly at bends. The velocity (and correspondingly the tractive force) significantly increases towards the outside of the bend, causing a greater erosion potential on the outside bank. On the inside of the bend the velocity decreases allowing suspended sediments to deposit and build a point bar.

Local scour around obstacles in the bed or banks of the channel is caused by the turbulence of eddies and velocity concentrations in the flow generated by the obstacle. The extent of scour is related to the size and streamlining of the obstacle. Typical obstacles which cause scour are irregular bank lines, bridge piers, weirs, boat docks, rubble, and trees.

When *waves* set up by passing boats or wind reach the river bank, the repeated agitation can dislodge soil particles. Waves will alter the exposed bank wherever the energy cannot be dissipated in non-destructive hydrodynamic turbulence, such as progressive breaking on a stable beach, movement through the interstitial spaces of a rip rap slope, or diffraction and transfer of momentum through vegetation or other fixed or floating bodies. Additional damage can be caused by boats which moor.

Raindrops striking an exposed river bank tend to loosen soil particles and reduce the infiltration capacity of the soil. With the infiltration capacity reduced, more and more of the rainfall will run down the bank, increasing the tractive force of the runoff and thereby increasing the potential for erosion.

Seepage effects can be either steady or unsteady. Steady effects relate to discharge from, and recharge to, the regional groundwater regime through the channel bank. Pressure from groundwater movement inside the bank forces water on to the face of the bank, loosening soil particles at the bank's surface. The resulting downslope movement of seepage water and loosened soil particles can further erode the bank. Groundwater seepage can be observed as a wet bank face or as piping flow from small holes on the slope.

Unsteady seepage effects relate to changes in pore water pressure in the bank due to fluctuations in the water level in the channel, and are independent of the steady seepage into or out of the bank. These result from long-period changes such as flooding and tidal activity, or short-period changes such as water level drawdown due to boat and surface waves. The flow of pore water within the soil depends on the rate of change of the water level in the channel, the permeability, and the drawdown or wave height. Silty and sandy soils are most at risk as they cannot respond quickly enough to avoid relatively high pressure gradients, yet the seepage velocity may be significant.

Overbank drainage is closely related to the problem of river bank surface erosion due to rainfall and seepage, and can be responsible for severe sheet and rill erosion. Whilst erosion due to overbank drainage can occur naturally, it is more likely to occur when the land near the top of the bank has been disturbed by clearing and ploughing and no provisions have been made for surface drainage control.

Changes in land use which influence river flow past the bank and the amount of sediment in the flow can cause an otherwise erosion-free bank to suffer severe erosion. Three major changes in land use which can increase the potential for erosion are vegetation clearing (e.g. for agricultural purposes), allowing livestock to trample banks, and urbanisation. The inevitable results of removing vegetative cover, disturbing surface soils, and decreasing the area available for rainfall infiltration are downstream flooding and increased sediment loads. In addition to higher tractive forces during the flood, the sediment load deposited by the flood reduces the channel's flood-carrying capacity so that the river may attempt to widen itself to carry the flow, thus further eroding the banks.

C3. BANK FAILURE

Bank failure due to *changes in channel shape* such as toe scour is perhaps the most dramatic and serious cause of bank recession, resulting in sudden loss of the bank and its vegetation. Scour typically tends to occur at the toe of the bank, over steepening the slope and instigating collapse of the bank through slip circle failure or slumping. Resultant talus which normally stabilises the toe is subsequently removed through sediment transport under strong river and/or tidal flows and the recession process is repeated.

An *increase in the load on top of the bank* causes an increase in shear stress within the bank, thereby increasing the potential for bank failure. Loads can be increased by man-made structures such as roads, bridges, buildings, etc., as well as by living things such as livestock.

Bank failure due to *rapid drawdown* (or a rapid drop in water surface elevation) is most likely to occur as floodwaters recede, or when the bank is subject to fluctuations in water surface elevations. During periods of high water, banks can become saturated by inflow from the river. When the bank face is covered by water, a pressure balance exists between the water in the channel and the weight of the saturated bank, helping to keep the bank in place. If the water elevation of the river is suddenly lowered and the soil cannot drain quickly, a pressure imbalance will exist (A pressure imbalance can also be caused by infiltration due to rainfall or runoff, or by groundwater sources deep within the bank). If the bank has insufficient shear strength to resist, the imbalance may cause bank failure.

The *swelling of clay materials* within banks due to the absorption of water can cause erosion by decreasing the shear strength of the bank. When the exposed wet clay and silt dry out, shrinkage and cracking can occur near the bank's surface, forming a layer of soil that can be easily eroded. The next time that water moves over the bank face, all or part of the layer may be removed. As the newly exposed material dries out, the cycle can repeat itself.

High *pore water pressure* in the bank material due to seepage or rapid lowering of the water level in the channel, will reduce the shear strength of the soil and can trigger a deep-seated rotational failure.

Soil creep can be observed as the development of bank cracks running generally parallel to a river. Wetting and drying cycles can cause swelling and shrinking of soils which contain clay. This encourages the generation of vertical fissures and the formation of soil blocks with desiccation cracks. This in turn encourages soil creep which can be responsible for bank failure.

The *root mat from vegetated banks* (mangroves have a particularly effective root mat) can modify the geotechnical properties of the soil, such that the shear strength of the bank can be increased and some tensile strength provided. Vegetation can therefore help to maintain the stability of river banks by helping prevent tension crack formation. Removal of the vegetation can cause the river bank to suffer mass failure.

APPENDIX D: FLOOR LEVEL DATABASE

D1. DESCRIPTION OF DATABASE

The floor levels of properties believed to lie within the floodplain were surveyed during January and February 2001 as part of a project by Shoalhaven City Council. The floor levels were then linked with Council's property database using a Geographic Information System (GIS).

The database provided a GIS tag, street address, habitable floor level in mAHD and type of floor/building construction. The following assumptions were made in the analysis:

- floor level data were generally only obtained for habitable buildings. Thus garden sheds, garages, oyster cleaning sheds and other non-habitable buildings were not included,
- all buildings were primarily used for residential purposes,
- no allowance was made whether the building was permanently or temporarily occupied (data unavailable),
- critical levels for important infrastructure such as sewage pumping stations were also obtained,
- only details of office administration and amenities buildings were included in the survey for caravan parks.

Table D1 provides a listing of the property database whilst Table D2 lists only those properties that are inundated in the 10% AEP event. Table D3 provides a summary of caravan parks located on the floodplain.

Table D1: Property Database

LEGEND:

Material: B - brick; W/B - weatherboard; F - fibro; M - metal

Zone Location: BD - Bomaderry; SH - Shoalhaven Heads; GP - Green Point; OP - Orient Point; NW - Nowra

Type: AB - ablution block; CP - caravan park; O - office; F - farm; I - industrial; PS - pumping station; D - dwelling; U - units; C - commercial

Size: S - small; M - medium; L - large

ZONE /LOCATION	ST No	STREET NAME	RELEVANT CELL IN HYDRAULIC MODEL	UPN	TYPE	STOREYS	MATERIAL	SIZE	GROUND RL	FLOOR RL	REMARKS
SH	6	HAY AVE	CEL82	1378	D	2	6 - Stone	3 - L	1.44	1.42	1st FLOOR RL 3.985
SH	2	WHARF RD	CEL82	2146	D	2	4 - B	3 - L	0.00	1.50	1st FLOOR RL4.295
SH	76	JERRY BAILEY RD	CEL82	1461	D	2	6 - Stone	3 - L	1.85	1.78	Ist FLOOR RL 4.485
SH	38	HAY AVE	CEL82	1361	D	1	3 - F	1 - S	1.76	1.80	
SH	10	HAY AVE	CEL82	1376	D	2	4 - B	3 - L	1.56	1.82	
SH	4	HAY AVE	CEL82	1379	D	1	3 - F	3 - L	1.22	1.89	
SH	26	HAY AVE	CEL82	1367	D	2	3 - F	3 - L	1.64	1.92	
SH	78	JERRY BAILEY RD	CEL82	1462	D	2	6 - Stone	2 - M	1.74	1.96	
SH	1282	BOLONG RD	CEL82	163	D	2	6 - Stone	2 - M	1.80	1.98	Ist FLOOR RL 4.555 SEPTIC TANK RL 1.765
SH		JERRY BAILEY RD	CEL82	87123	C				1.97	1.99	S/HEADS AUTO SERVICES
SH	2	HAY AVE	CEL82	60304	D	2	4 - B	3 - L	1.90	2.14	
SH	12	HAY AVE	CEL82	1375	D	1	2 - WB	2 - M	1.96	2.28	
SH	50	HAY AVE	CEL82	1356	D	1	3 - F	1 - S	2.08	2.29	
SH	3	WHARF RD	CEL82	48018	D	1	3 - F	1 - S	1.46	2.31	LOT 1
SH	70	JERRY BAILEY RD	CEL82	85406	D	1	3 - F	1 - S	2.00	2.33	
SH	40	HAY AVE	CEL82	5407	D	1	4 - B	3 - L	2.13	2.33	
SH	48	SHOALHAVEN HEADS RD	CEL82	1957	D	1	4 - B	2 - M	2.93	2.33	
SH	20	HAY AVE	CEL82	75026	D	1	3 - F	1 - S	1.31	2.36	
SH	91	JERRY BAILEY RD	CEL82	1495	D	1	3 - F	1 - S	1.70	2.37	made up ground level
SH	16	HAY AVE	CEL82	1373	D	1	3 - F	1 - S	1.49	2.38	
SH	1	WHARF RD	CEL82	48017	D	1	3 - F	1 - S	1.50	2.38	LOT 4
SH	22	HAY AVE	CEL82	75028	D	1	3 - F	1 - S	1.41	2.41	
SH	90	JERRY BAILEY RD	CEL82	6417	U	2	4 - B	2 - M	2.18	2.41	No 8 - LOWEST
SH	119	JERRY BAILEY RD	CEL82	1481	D	1	5 - M	1 - S	1.90	2.41	
SH	31	JERRY BAILEY RD	CEL82	1507	D	1	5 - M	2 - M	2.42	2.42	
SH	93	JERRY BAILEY RD	CEL82	1494	D	1	3 - F	1 - S	1.74	2.43	
SH	99	JERRY BAILEY RD	CEL82	1491	D	1	3 - F	1 - S	1.87	2.43	
SH	60	JERRY BAILEY RD	CEL82	1455	D	1	3 - F	2 - M	2.14	2.44	
SH	14	HAY AVE	CEL82	1374	D	1	3 - F	1 - S	1.59	2.46	
SH	101	JERRY BAILEY RD	CEL82	1490	D	1	3 - F	2 - M	1.95	2.46	
SH	107	JERRY BAILEY RD	CEL82	1487	D	1	3 - F	2 - M	1.92	2.47	
SH	84	JERRY BAILEY RD	CEL82	1464	D	2	6 - Stone	3 - L	2.17	2.48	
SH	55	HAY AVE	CEL82	1381	D	1	3 - F	1 - S	2.06	2.50	
SH	42	HAY AVE	CEL82	1360	D	1	3 - F	2 - M	1.70	2.50	
SH	42	HAY AVE	CEL82	1360	D	1	3 - F	2 - M	1.72	2.51	
SH	1	RENOWN AVE	CEL82	1788	D	1	3 - F	2 - M	1.73	2.52	
SH	20	HAY AVE	CEL82	75026	D	1	5 - M	1 - S	1.69	2.52	
SH	63	HAY AVE	CEL82	1474	D	1	3 - F	1 - S	2.34	2.52	
SH	56	HAY AVE	CEL82	1353	D	1	5 - M	1 - S	1.95	2.53	
SH	113	JERRY BAILEY RD	CEL82	1484	D	1	5 - M	2 - M	1.95	2.54	
SH	1276	BOLONG RD	CEL82	166	D	1	3 - F	2 - M	1.51	2.54	SEPTIC TANK RL1.895
SH	61	HAY AVE	CEL82	1385	D	1	4 - B	3 - L	2.14	2.56	
SH	56	JERRY BAILEY RD	CEL82	1453	D	2	6 - Stone	2 - M	2.45	2.56	
SH	74A	JERRY BAILEY RD	CEL82	5442	D	1	3 - F	1 - S	2.07	2.57	
SH	34	HAY AVE	CEL82	1363	D	2	4 - B	2 - M	2.12	2.59	
SH	10	HAY AVE	CEL82	1376	D	1	3 - F	1 - S	1.39	2.60	
SH	97	JERRY BAILEY RD	CEL82	1492	D	1	3 - F	3 - L	1.93	2.60	
SH	57	HAY AVE	CEL82	1383	D	1	3 - F	1 - S	2.00	2.62	
SH	115	JERRY BAILEY RD	CEL82	1483	D	1	3 - F	1 - S	1.96	2.62	
SH	75	JERRY BAILEY RD	CEL82	1501	D	2	6 - Stone	2 - M	2.41	2.64	
SH	105	JERRY BAILEY RD	CEL82	1488	D	1	3 - F	2 - M	2.16	2.64	
SH	18	HAY AVE	CEL82	15294	D	2	4 - B	3 - L	1.58	2.65	1st FLOOR RL5.31
SH	1274	BOLONG RD	CEL82	167	D	2	4 - B	3 - L	2.15	2.68	MEZZANINE RL 3.895 SEPTIC RL 1.495
SH	32	HAY AVE	CEL82	1364	D	1	3 - F	2 - M	2.26	2.68	
SH	67	JERRY BAILEY RD	CEL82	1504	D	2	6 - Stone	2 - M	2.33	2.69	

LEGEND:

Material: B - brick; W/B - weatherboard; F - fibro; M - metal

Zone Location: BD - Bomaderry; SH - Shoalhaven Heads; GP - Green Point; OP - Orient Point; NW - Nowra

Type: AB - ablution block; CP - caravan park; O - office; F - farm; I - industrial; PS - pumping station; D - dwelling; U - units; C - commercial

Size: S - small; M - medium; L - large

ZONE /LOCATION	ST No	STREET NAME	RELEVANT CELL IN HYDRAULIC MODEL	UPN	TYPE	STOREYS	MATERIAL	SIZE	GROUND RL	FLOOR RL	REMARKS
SH	8	HAY AVE	CEL82	1377	D	2	4 - B	3 - L	1.60	2.73	
SH	65	JERRY BAILEY RD	CEL82	1505	D	2	6 - Stone	2 - M	2.40	2.73	
SH	88	JERRY BAILEY RD	CEL82	1466	D	1	3 - F	2 - M	1.92	2.73	
SH	111	JERRY BAILEY RD	CEL82	1485	D	1	4 - B	2 - M	1.96	2.73	
SH	86	JERRY BAILEY RD	CEL82	1465	D	1	4 - B	2 - M	1.96	2.74	
SH	46	JERRY BAILEY RD	CEL82	1448	D	2	6 - Stone	3 - L	2.52	2.74	GRANNY FLAT RL 3.45
SH	72	JERRY BAILEY RD	CEL82	85407	D	1	3 - F	1 - S	1.99	2.76	
SH	77	JERRY BAILEY RD	CEL82	1500	D	2	4 - B	3 - L	2.57	2.76	
SH	96	JERRY BAILEY RD	CEL82	1469	D	1	5 - M	2 - M	2.26	2.76	
SH	59	HAY AVE	CEL82	1384	D	1	3 - F	1 - S	1.94	2.77	CHECK FL -2.74 ???
SH	1272	BOLONG RD	CEL82	2279	D	1	3 - F	1 - S	2.10	2.78	NO SEPTIC FD
SH	36	HAY AVE	CEL82	1362	D	1	3 - F	1 - S	2.30	2.78	
SH	1268	BOLONG RD	CEL82	169	D	1	3 - F	2 - M	2.19	2.79	SEPTIC RL 2.72
SH	52	JERRY BAILEY RD	CEL82	1451	D	1	3 - F	2 - M	2.25	2.79	
SH	121	JERRY BAILEY RD	CEL82	1480	D	1	3 - F	2 - M	2.10	2.79	
SH	79	JERRY BAILEY RD	CEL82	1499	D	1	4 - B	2 - M	2.54	2.84	
SH	3	RENOWN AVE	CEL82	1789	D	1	3 - F	2 - M	0.00	2.84	
SH	1262	BOLONG RD	CEL82	172	D	1	5 - M	2 - M	2.16	2.86	SEPTIC RL 2.73
SH	83	JERRY BAILEY RD	CEL82	1496	D	1	4 - B	2 - M	2.45	2.86	
SH	48	JERRY BAILEY RD	CEL82	1449	D	2	3 - F	3 - L	2.40	2.90	
SH	2	DAVENPORT RD	CEL82	1079	D	1	3 - F	2 - M	2.86	2.90	
SH	50	JERRY BAILEY RD	CEL82	1450	D	1	4 - B	2 - M	2.37	2.90	
SH	63	JERRY BAILEY RD	CEL82	1506	D	1	3 - F	1 - S	2.38	2.91	
SH	109	JERRY BAILEY RD	CEL82	1486	D	1	3 - F	2 - M	1.99	2.91	
SH		SHOALHAVEN HEADS RD	CEL82	1955	C	1	4 - B	3 - L	2.78	2.92	SERVICE STATION
SH	1264	BOLONG RD	CEL82	74705	D	1	3 - F	1 - S	2.32	2.92	SEPTIC RL 2.52
SH	54	JERRY BAILEY RD	CEL82	1452	D	1	6 - Stone	2 - M	2.18	2.92	
SH	52	HAY AVE	CEL82	1355	D	1	3 - F	2 - M	2.38	2.96	
SH	13	JERRY BAILEY RD	CEL82	1515	D	2	6 - Stone	2 - M	2.82	2.96	
SH	21	JERRY BAILEY RD	CEL82	1512	D	2	4 - B	3 - L	2.96	2.96	Gr Fl WORKSHOPS
SH	127	JERRY BAILEY RD	CEL82	1477	D	1	3 - F	1 - S	2.39	3.01	
SH	1260	BOLONG RD	CEL82	173	D	2	4 - B	3 - L	2.11	3.02	SEPTIC RL 2.34
SH	3	JERRY BAILEY RD	CEL82	1519	D	1	4 - B	2 - M	2.70	3.02	
SH	9	JERRY BAILEY RD	CEL82	1516	D	2	6 - Stone	2 - M	2.94	3.04	
SH	71	JERRY BAILEY RD	CEL82	1502	D	1	3 - F	2 - M	2.30	3.04	
SH	81	JERRY BAILEY RD	CEL82	1497	D	1	4 - B	2 - M	2.48	3.04	
SH	62	JERRY BAILEY RD	CEL82	1456	D	1	4 - B	2 - M	2.07	3.04	
SH	1	JERRY BAILEY RD	CEL82	1520	C	2	4 - B	3 - L	3.00	3.04	SHOALHAVEN REAL ESTATE + unit @ 3.11m
SH	103	JERRY BAILEY RD	CEL82	1489	D	2	4 - B	3 - L	2.08	3.04	UPPER FLOOR RL 4.58
SH	60	HAY AVE	CEL82	1351	U	1	4 - B	3 - L	2.50	3.06	LOWEST UNIT 3 units highest =4.44
SH	44	SHOALHAVEN HEADS RD	CEL82	1960	D	1	4 - B	2 - M	2.32	3.07	
SH	129	JERRY BAILEY RD	CEL82	1476	D	1	4 - B	2 - M	2.37	3.08	
SH	1278	BOLONG RD	CEL82	165	D	1	2 - WB	1 - S	1.71	3.10	NO SEPTIC FD
SH	58	SCOTT ST	CEL82	81239	D	2	4 - B	3 - L	2.89	3.13	
SH	35	JERRY BAILEY RD	CEL82	74485	D	1	4 - B	2 - M	2.93	3.14	
SH	44	JERRY BAILEY RD	CEL82	1447	D	1	4 - B	2 - M	2.75	3.14	
SH	5	JERRY BAILEY RD	CEL82	1518	D	1	4 - B	1 - S	2.86	3.14	
SH	61	SHOALHAVEN HEADS RD	CEL82	1996	D	1	4 - B	2 - M	2.84	3.15	
SH	42	JERRY BAILEY RD	CEL82	1446	D	1	4 - B	2 - M	3.04	3.16	
SH	87	JERRY BAILEY RD	CEL82	81021	D	1	4 - B	2 - M	2.61	3.16	2 VILLAS
SH	2	BRAMALL RD	CEL82	894	D	1	4 - B	2 - M	3.05	3.17	
SH	64	JERRY BAILEY RD	CEL82	1457	D	1	3 - F	2 - M	1.91	3.18	
SH	125	JERRY BAILEY RD	CEL82	1478	D	1	4 - B	2 - M	2.54	3.19	
SH	95	JERRY BAILEY RD	CEL82	1493	D	1	4 - B	2 - M	2.31	3.20	
SH	1266	BOLONG RD	CEL82	74707	D	1	4 - B	2 - M	2.37	3.22	SEPTIC RL 2.38
SH	38	JERRY BAILEY RD	CEL82	1444	D	1	4 - B	2 - M	2.93	3.22	
SH	123	JERRY BAILEY RD	CEL82	1479	D	1	4 - B	2 - M	2.61	3.22	REAR OFFICE RL 2.79
SH	1	BRAMALL RD	CEL82	892	D	1	4 - B	2 - M	2.70	3.23	

LEGEND:

Material: B - brick; W/B - weatherboard; F - fibro; M - metal

Zone Location: BD - Bomaderry; SH - Shoalhaven Heads; GP - Green Point; OP - Orient Point; NW - Nowra

Type: AB - ablution block; CP - caravan park; O - office; F - farm; I - industrial; PS - pumping station; D - dwelling; U - units; C - commercial

Size: S - small; M - medium; L - large

ZONE /LOCATION	ST No	STREET NAME	RELEVANT CELL IN HYDRAULIC MODEL	UPN	TYPE	STOREYS	MATERIAL	SIZE	GROUND RL	FLOOR RL	REMARKS
SH	54	HAY AVE	CEL82	1354	D	1	5 - M	1 - S	2.41	3.23	
SH	1270	BOLONG RD	CEL82	168	D	1	3 - F	1 - S	2.39	3.24	SEPTIC RL 2.32
SH	48	HAY AVE	CEL82	73667	D	1	3 - F	2 - M	1.71	3.26	
SH	25	JERRY BAILEY RD	CEL82	1510	D	1	3 - F	2 - M	2.58	3.26	
SH	23	JERRY BAILEY RD	CEL82	1511	D	1	4 - B	1 - S	2.71	3.28	
SH	30	JERRY BAILEY RD	CEL82	1442	U	1	4 - B	2 - M	3.06	3.28	UNIT 21 LOWEST (St No 30-34) 21 UNITS -2 UNDER 4.5m
SH	48	SHOALHAVEN HEADS RD	CEL82	1957	D	1	4 - B	3 - L	2.53	3.28	
SH	39	JERRY BAILEY RD	CEL82	74487	D	1	3 - F	2 - M	2.77	3.28	GRANNY FLAT RL 2.955
SH	1280	BOLONG RD	CEL82	164	D	2	5 - M	3 - L	1.44	3.29	SEPTIC TANK RL1.77
SH	27	JERRY BAILEY RD	CEL82	1509	D	1	4 - B	2 - M	2.48	3.30	
SH	50	SCOTT ST	CEL82	81235	D	1	4 - B	2 - M	2.34	3.30	
SH	49	JERRY BAILEY RD	CEL82	74492	D	1	3 - F	1 - S	2.70	3.31	
SH	69	JERRY BAILEY RD	CEL82	1503	D	1	3 - F	1 - S	2.30	3.31	
SH	85	JERRY BAILEY RD	CEL82	81020	D	1	4 - B	2 - M	2.77	3.32	2 VILLAS
SH	44	SCOTT ST	CEL82	75066	D	1	4 - B	2 - M	3.11	3.32	
SH	59	SCOTT ST	CEL82	75057	D	1	4 - B	2 - M	3.17	3.32	
SH	3	HAY AVE	CEL82	84596	VAN				3.15	3.33	ANNEXE FI - MOB HOME & VAN
SH	45	JERRY BAILEY RD	CEL82	74490	D	1	4 - B	3 - L	3.10	3.34	
SH	46	SCOTT ST	CEL82	84299	D	1	4 - B	2 - M	3.04	3.34	
SH	131	JERRY BAILEY RD	CEL82	1475	D	1	3 - F	1 - S	3.08	3.34	
SH	1	RAVENSCLIFFE RD	CEL82	1755	D	1	4 - B	2 - M	2.74	3.34	
SH	63	SHOALHAVEN HEADS RD	CEL82	1995	D	2	4 - B	3 - L	3.22	3.34	
SH	19	JERRY BAILEY RD	CEL82	1513	D	1	4 - B	2 - M	2.81	3.35	
SH	33	JERRY BAILEY RD	CEL82	74484	D	1	4 - B	2 - M	2.87	3.36	
SH	61	SCOTT ST	CEL82	75056	D	1	4 - B	2 - M	3.17	3.36	
SH	51	JERRY BAILEY RD	CEL82	74493	D	1	2 - WB	1 - S	2.60	3.36	
SH	2	RAVENSCLIFFE RD	CEL82	1787	D	1	3 - F	2 - M	2.91	3.36	
SH	62	HAY AVE	CEL82	1350	D	2	4 - B	3 - L	2.86	3.37	CHECK FL - 3.34 ???
SH	60	SCOTT ST	CEL82	81240	D	1	4 - B	2 - M	2.82	3.38	
SH	41	JERRY BAILEY RD	CEL82	74488	D	1	3 - F	2 - M	2.86	3.39	
SH	53	JERRY BAILEY RD	CEL82	74494	D	1	4 - B	2 - M	2.43	3.40	
SH	57	SCOTT ST	CEL82	75058	D	2	4 - B	3 - L	3.19	3.40	
SH	7	JERRY BAILEY RD	CEL82	1517	D	1	4 - B	1 - S	2.68	3.40	
SH	52	SCOTT ST	CEL82	81236	D	2	4 - B	2 - M	3.22	3.41	ROOMS IN REAR GARAGE
SH	54	SCOTT ST	CEL82	84301	D	1	4 - B	2 - M	3.14	3.41	
SH	36	JERRY BAILEY RD	CEL82	1443	D	1	2 - WB	1 - S	2.98	3.42	
SH	48	SCOTT ST	CEL82	84300	D	1	4 - B	2 - M	3.15	3.42	
SH	63	SCOTT ST	CEL82	75049	D	2	4 - B	3 - L	3.07	3.43	
SH	29	JERRY BAILEY RD	CEL82	1508	D	1	3 - F	2 - M	2.56	3.46	
SH	66	SCOTT ST	CEL82	81243	D	1	4 - B	1 - S	3.28	3.46	
SH	40	SCOTT ST	CEL82	85709	D	1	4 - B	2 - M	3.27	3.46	
SH	17	JERRY BAILEY RD	CEL82	1514	D	1	5 - M	1 - S	2.70	3.48	
SH	64	SCOTT ST	CEL82	81242	D	1	4 - B	2 - M	3.10	3.48	
SH	42	SHOALHAVEN HEADS RD	CEL82	1961	D	1	4 - B	2 - M	2.39	3.48	
SH	40	JERRY BAILEY RD	CEL82	1445	D	1	4 - B	2 - M	2.82	3.49	
SH	53	HAY AVE	CEL82	73066	D	1	2 - WB	2 - M	2.44	3.52	
SH	8	JERRY BAILEY RD	CEL82	1433	D	2	6 - Stone	2 - M	3.47	3.52	
SH	43	JERRY BAILEY RD	CEL82	74489	D	1	3 - F	2 - M	2.68	3.52	
SH	15	JERRY BAILEY RD	CEL82	55324	D	2	2 - WB	3 - L	3.08	3.54	
SH	65	SCOTT ST	CEL82	75048	D	1	4 - B	2 - M	3.13	3.54	
SH	47	JERRY BAILEY RD	CEL82	74491	D	1	3 - F	1 - S	2.70	3.54	
SH	36	SCOTT ST	CEL82	85708	D	1	4 - B	2 - M	3.31	3.55	
SH	10	RENOWN AVE	CEL82	1809	D	1	5 - M	2 - M	3.07	3.56	
SH	62	SCOTT ST	CEL82	81241	D	1	4 - B	2 - M	3.06	3.56	
SH	117	JERRY BAILEY RD	CEL82	1482	D	2	4 - B	4 - VL	2.08	3.63	1st FL RL 4.74
SH	67	SCOTT ST	CEL82	75047	D	1	4 - B	2 - M	3.13	3.63	
SH	108	JERRY BAILEY RD	CEL82	5444	D	1	3 - F	2 - M	3.17	3.68	
SH	106	JERRY BAILEY RD	CEL82	5443	D	1	2 - WB	2 - M	3.01	3.69	
SH	51	SCOTT ST	CEL82	75061	D	1	4 - B	2 - M	3.59	3.70	

LEGEND:

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ZONE /LOCATION	ST No	STREET NAME	RELEVANT CELL IN HYDRAULIC MODEL	UPN	TYPE	STOREYS	MATERIAL	SIZE	GROUND RL	FLOOR RL	REMARKS
SH	10	JERRY BAILEY RD	CEL82	1434	D	2	3 - F	2 - M	3.58	3.72	
SH	44	HAY AVE	CEL82	1359	D	1	4 - B	3 - L	1.74	3.73	
SH	34	SCOTT ST	CEL82	85707	D	1	4 - B	2 - M	3.58	3.74	
SH	69	SCOTT ST	CEL82	75046	D	1	4 - B	2 - M	3.32	3.76	
SH	66	JERRY BAILEY RD	CEL82	1458	D	1	4 - B	2 - M	1.94	3.78	
SH	58	HAY AVE	CEL82	1352	D	1	5 - M	1 - S	3.36	3.93	
SH	32	SCOTT ST	CEL82	85706	D	1	4 - B	2 - M	3.81	4.00	
SH	114	JERRY BAILEY RD	CEL82	1473	U	1	4 - B	1 - S	3.80	4.00	5 VILLA UNTS
SH	4	RAVENSCLIFFE RD	CEL82	1786	D	1	3 - F	2 - M	3.64	4.04	
SH	28	JERRY BAILEY RD	CEL82	1441	D	1	3 - F	2 - M	3.75	4.07	
SH	2	ABLETT COURT	CEL82	75050	D	1	4 - B	2 - M	3.98	4.16	
SH	76	SCOTT ST	CEL82	81245	D	1	4 - B	2 - M	4.04	4.19	
SH	8	WELLS PL	CEL82	57132	D	1	4 - B	2 - M	3.56	4.21	
SH	3	RAVENSCLIFFE RD	CEL82	1756	D	1	4 - B	2 - M	3.07	4.22	
SH	73	SCOTT ST	CEL82	75044	D	1	4 - B	2 - M	4.00	4.24	
SH	8	RAVENSCLIFFE RD	CEL82	5448	D	1	4 - B	2 - M	3.95	4.28	
SH	22	JERRY BAILEY RD	CEL82	1439	D	1	4 - B	3 - L	3.90	4.29	
SH	74	JERRY BAILEY RD	CEL82	5442	D	1	3 - F	3 - L	3.95	4.30	
SH	5	RENOWN AVE	CEL82	1790	D	1	4 - B	2 - M	3.38	4.34	
SH	9	RENOWN AVE	CEL82	5449	D	1	3 - F	1 - S	3.99	4.38	
SH	12	RENOWN AVE	CEL82	1808	D	1	4 - B	2 - M	3.90	4.38	
SH	20	JERRY BAILEY RD	CEL82	1438	D	1	5 - M	1 - S	3.40	4.39	
SH	30	SCOTT ST	CEL82	86320	D	1	4 - B	2 - M	4.26	4.41	
SH	112	JERRY BAILEY RD	CEL82	1472	D	1	3 - F	1 - S	3.48	4.42	
SH	3	BRAMALL RD	CEL82	891	D	2	6 - Stone	3 - L	4.02	4.42	
SH	1	RIVER RD	CEL82	11867	D	1	3 - F	2 - M	4.38	4.44	
SH	24	HAY AVE	CEL82	48016	VACANT				1.22	99.90	VACANT
SH	46	HAY AVE	CEL82	73669	VACANT				1.60	99.90	VACANT
BD	26	ALFRED ST	CEL4	30056	D	1	B/F	M	7.45	7.12	
BD	28	ALFRED ST	CEL4	30055	D	1	B/F	M	7.16	7.19	
BD	30	ALFRED ST	CEL4	30054	D	1	B	M	7.44	7.59	
BD	32	ALFRED ST	CEL4	30053	D	1	B/F	M	7.88	8.60	
BD	1	BEINDA ST	CEL9	30121	C	1	B	M	4.75	5.01	
BD	3	BEINDA ST	CEL9	85030	C	1	B	M	4.75	5.01	
BD	5	BEINDA ST	CEL9	30119	D	1	WB	M	6.74	7.30	
BD	7	BEINDA ST	CEL9	30118	D	1	F	M	7.36	7.73	
BD	9	BEINDA ST	CEL9	30117	D	1	B	M	8.36	8.68	
BD	11	BEINDA ST	CEL9	30114	D	1	F	M	9.14	9.51	
BD	21	BOLONG RD	CEL15	41976	C	2	B/F	M	4.91	6.91	
BD	23	BOLONG RD	CEL15	41976	D	1	WB	M	5.71	6.41	
BD	22	BOLONG RD	CEL15	88945	C	1	M	L	3.60	4.09	
BD	22	BOLONG RD	CEL15	88945	C	1	M/B	M	3.60	3.64	
BD	24	BOLONG RD	CEL15	88946	C	1	BF	L	3.60	4.11	
BD	25	BOLONG RD	CEL15	41975	C	1	B	S	6.12	6.35	
BD	27	BOLONG RD	CEL15	41974	D	1	F	M	6.80	7.35	
BD	29	BOLONG RD	CEL15	41977	D	1	B	M	7.24	7.81	
BD	33	BOLONG RD	CEL9	42235	I	1	B/METAL	L	4.83	5.42	
BD	34	BOLONG RD	CEL15	41309	C	1	B	M	7.24	7.24	
BD	36	BOLONG RD	CEL15	70412	C	1	M	M	4.94	4.56	
BD	39	BOLONG RD	CEL9	30217	U	1	B	M	2.90	4.63	
BD	41	BOLONG RD	CEL9	75422	U	1	METAL	L	2.90	4.15	
BD	53	BOLONG RD	CEL9	30212	D	1	WB	M	6.17	6.75	
BD	55	BOLONG RD	CEL9	30210	D	1	B	M	6.40	7.90	
BD	63	BOLONG RD	CEL9	87506	D	1	WB	M	7.94	9.44	
BD	64	BOLONG RD	CEL9	30230	C	1	F	M	3.48	4.27	
BD	66	BOLONG RD	CEL9	30231	D	1	WB	M	5.96	6.42	
BD	67	BOLONG RD	CEL9	42238	D	1	B	M	7.45	8.32	
BD	68	BOLONG RD	CEL9	30232	D	1	F	M	5.95	6.36	
BD	70	BOLONG RD	CEL9	30233	D	1	B	M	6.11	7.08	
BD	72	BOLONG RD	CEL9	30234	D	1	B	M	5.97	6.08	
BD	74	BOLONG RD	CEL9	30235	D	1	B	M	6.01	7.85	
BD	76	BOLONG RD	CEL9	30236	D	2	B	M	4.27	4.93	
BD	78	BOLONG RD	CEL9	30237	C	SPLIT	B	M	5.57	5.58	

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BD		BOLONG RD	CEL9	30237	C	2	B	L	5.87	6.37	
BD		BOLONG RD	CEL9	30237	U	1	M/F	L	4.56	4.46	
BD	9	BOWADA ST	CEL9	30246	D	1	WB	M	10.53	12.44	
BD	11	BOWADA ST	CEL9	39203	D	1	B	M	11.46	12.47	
BD	13	BOWADA ST	CEL9	39204	D	1	B	M	11.46	12.47	
BD	15	BOWADA ST	CEL9	30245	D	SPLIT	B	M	11.67	13.10	
BD		BOWADA ST	CEL9	78799	U	1	B	M		8.65	8.65(L) 11.02(H)
BD		BRINAWARR ST	CEL9	5281	U	2	B	M	5.87	8.45	
BD	121	BRINAWARR ST	CEL9	30248	D	2	B	M	8.17	10.90	
BD	123	BRINAWARR ST	CEL9	30249	D	2	B/WB	M	8.18	9.94	
BD	32	BRINAWARR ST	CEL9	86430	D	1	B	M	4.81	5.70	
BD	14	CONCORDE WAY	CEL4	30517	U	1	B	L	6.63	6.36	
BD	41	COOMEA ST	CEL9	30532	D	1	F	S	8.08	8.94	
BD	43	COOMEA ST	CEL9	30531	D	1	F	M	6.72	7.51	
BD	45	COOMEA ST	CEL9	40510	D	1	WB	M	5.31	8.37	
BD	17	EDWARDS AVE	CEL4	30617	D	1	F	M	7.70	8.10	
BD	19	EDWARDS AVE	CEL4	30619	D	1	B	M	7.87	8.18	
BD	21	EDWARDS AVE	CEL4	30620	D	1	F	M	7.95	8.31	
BD	27A	EDWARDS AVE	CEL4	77678	D	1	B	M	5.32	6.98	
BD	27B	EDWARDS AVE	CEL4	77680	D	1	B	M	5.60	6.03	
BD	57	EDWARDS AVE	CEL4	82967	D	1	WB	M	3.64	6.21	
BD	62	EDWARDS AVE	CEL4	68949	D	1	B	M	8.86	10.67	
BD	65A	EDWARDS AVE	CEL4	43948	D	1	B	M	6.91	6.58	
BD	65B	EDWARDS AVE	CEL4	44777	D	1	B	M	4.56	4.68	
BD	72A	EDWARDS AVE	CEL4	68950	D	1	B	M	5.91	9.65	
BD	72B	EDWARDS AVE	CEL4	68952	D	1	F	M	4.68	6.51	
BD	82	EDWARDS AVE	CEL4	68953	D	1	B	M	6.81	7.02	
BD	79	FLETCHERS LANE	CEL4	43942	D	1	WB	M	7.21	7.56	
BD	5	KATELA AVE	CEL4	83812	D	1	B	M	7.49	7.22	
BD	6	KATELA AVE	CEL4	83813	D	1	B	M	6.74	6.86	
BD	7	KATELA AVE	CEL4	83814	D	1	B	M	5.93	6.13	
BD	8	KATELA AVE	CEL4	83815	D	1	B	M	6.06	5.77	
BD	9	KATELA AVE	CEL4	83816	D	1	B	M	6.63	6.87	
BD	77	MEROO ST	CEL9	40783	D	1	WB	M	6.75	7.49	
BD	474	PRINCES HWY	CEL9	86639	D	2	B	M	6.08	6.35	
BD	476	PRINCES HWY	CEL9	42148	D	1	B	M	9.90	9.71	
BD	480	PRINCES HWY	CEL9	42147	C	1	B	M	10.25	8.05	
BD	28	RAILWAY ST	CEL15	81543	U	1	B/METAL	M	6.60	6.70	
BD	10	RAILWAY ST	CEL15	78311	U	1	B/METAL	L	7.24	7.59	
BD	16	RAILWAY ST	CEL15	41925	U	1	F	L		7.37	
BD	24	RAILWAY ST	CEL15	31158	U	1	B	M	6.55	6.81	
BD	26	RAILWAY ST	CEL15	31159	U	1	B/METAL	M	6.45	6.49	
BD	32	RAILWAY ST	CEL15	31161	U	1	B	L	6.53	6.63	
BD	23	TARAWARA ST	CEL9	31419	D	2	B	M	4.24	5.14	
BD	25	TARAWARA ST	CEL9	31418	D	1	B/WB	M	3.91	6.56	
BD	27	TARAWARA ST	CEL9	31417	D	1	B	M	4.24	4.87	
BD	29	TARAWARA ST	CEL9	31416	D	1	WB	M	4.09	4.83	
BD	31	TARAWARA ST	CEL9	31415	D	2	B/WB	M	4.43	6.74	
BD	33	TARAWARA ST	CEL9	72935	D	1	B	M		6.78	
BD	35	TARAWARA ST	CEL9	72937	D	1	B	M	4.59	7.37	
BD	4	WORTHINGTON WAY (PRIV)	CEL9	84492	C	1	M	M	4.10	5.04	
BD	5	WORTHINGTON WAY (PRIV)	CEL9	84495	C	1	M	L	3.61	5.02	
BD	6	WORTHINGTON WAY (PRIV)	CEL9	84497	C	1	B/WB	M	3.17	4.37	
BD	7	WORTHINGTON WAY (PRIV)	CEL9	84496	C	1	B/METAL	L	3.75	5.04	
BD	8	WORTHINGTON WAY (PRIV)	CEL9	84493	C	1	B/WB	M	3.27	5.00	
GP		GREENS RD	CEL85	1178	C	1	B	L	1.42	1.96	
GP		GREENWELL POINT RD	CEL85	88267	D	2	B	L	2.21	3.03	
GP		SOUTH ST	CEL85	7198	D	1	F	M	1.69	1.96	
GP	1	ADELAIDE ST	CEL81	15196	D	1	WB	M	1.14	1.94	

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GP	3	ADELAIDE ST	CEL81	632	D	1	F	M	1.25	1.74	
GP	4	ADELAIDE ST	CEL81	633	D	1	F	M	1.56	3.03	
GP	5	ADELAIDE ST	CEL81	53218	D	1	WB	M	1.29	1.84	
GP	6	ADELAIDE ST	CEL81	634	D	2	B/F	M	1.57	1.59	
GP	7	ADELAIDE ST	CEL81	15194	D	1	F	M	1.30	1.64	
GP	8	ADELAIDE ST	CEL81	635	D	1	B	M	1.40	2.14	
GP	9	ADELAIDE ST	CEL81	15193	D	1	F	M	1.19	1.76	
GP	10	ADELAIDE ST	CEL81	637	D	1	B	M	1.39	2.10	
GP	11	ADELAIDE ST	CEL81	15192	D	1	WB	S	1.19	1.63	
GP	12	ADELAIDE ST	CEL81	636	D	2	B	M	1.44	1.64	
GP	13	ADELAIDE ST	CEL81	631	D	1	B	M	1.31	1.97	
GP	14	ADELAIDE ST	CEL81	638	D	1	B/F	M	1.41	1.84	
GP	15	ADELAIDE ST	CEL81	15191	D	2	B	L	1.28	1.69	
GP	16	ADELAIDE ST	CEL81	639	D	2	B	M	1.51	1.63	
GP	17	ADELAIDE ST	CEL81	15190	D	1	WB	M	1.18	2.08	
GP	18	ADELAIDE ST	CEL81	640	D	2	B/WB	M	1.38	1.76	
GP	19	ADELAIDE ST	CEL81	15189	D	1	F	M	1.78	1.79	
GP	20	ADELAIDE ST	CEL81	641	D	1	B	M	1.30	2.22	
GP	21	ADELAIDE ST	CEL81	5410	D	1	F	M	1.79	2.37	
GP	22	ADELAIDE ST	CEL81	642	D	2	B	M	1.22	1.55	
GP	23	ADELAIDE ST	CEL81	5411	D	1	F	M	1.79	2.29	
GP	24	ADELAIDE ST	CEL81	643	D	2	B	M	1.28	1.46	
GP	25	ADELAIDE ST	CEL81	630	D	1	B/WB	M	1.43	2.39	
GP	26	ADELAIDE ST	CEL81	644	D	2	B/WB	M	1.44	1.47	
GP	27	ADELAIDE ST	CEL81	15393	D	SPLIT	WB	M	1.31	3.01	
GP	28	ADELAIDE ST	CEL81	645	D	1	F	M	1.38	2.05	
GP	29	ADELAIDE ST	CEL81	628	D	E	F	M	1.27	3.87	
GP	31	ADELAIDE ST	CEL81	627	D	2	B	M	1.36	1.46	
GP	32	ADELAIDE ST	CEL81	647	D	1	B	M	1.40	1.98	
GP	33	ADELAIDE ST	CEL81	626	D	1	F	M	1.34	1.95	
GP	34	ADELAIDE ST	CEL81	648	D	1	F	M	1.42	1.90	
GP	35	ADELAIDE ST	CEL81	625	D	1	F	M	1.34	1.99	
GP	36	ADELAIDE ST	CEL81	649	D	2	BF	M	1.43	1.76	
GP	37	ADELAIDE ST	CEL81	624	D	1	F	S	1.46	2.09	
GP	38	ADELAIDE ST	CEL81	650	D	2	B	M	1.57	1.81	
GP	39	ADELAIDE ST	CEL81	623	D	2	F	M	1.40	1.42	
GP	40	ADELAIDE ST	CEL81	651	D	1	WB	M	1.60	3.06	
GP	41	ADELAIDE ST	CEL81	622	D	1	WB	S	1.52	2.10	
GP	42	ADELAIDE ST	CEL81	652	D	1	F	M	1.58	1.04	
GP	43	ADELAIDE ST	CEL81	621	D	1	B	M	1.36	2.09	
GP	44	ADELAIDE ST	CEL81	653	D	1	WB	M	1.56	2.23	
GP	45	ADELAIDE ST	CEL81	620	D	1	WB	M	1.33	1.96	
GP	46	ADELAIDE ST	CEL81	654	D	1	B	M	1.62	2.19	
GP	47	ADELAIDE ST	CEL81	619	D	1	B	M	1.35	2.55	
GP	48	ADELAIDE ST	CEL81	655	D	2	BF	M	1.45	1.60	
GP	49	ADELAIDE ST	CEL81	618	D	1	WB	S	1.38	1.88	
GP	50	ADELAIDE ST	CEL81	656	D	2	B/WB	M	1.43	1.48	
GP	51	ADELAIDE ST	CEL81	617	D	1	B	M	1.28	2.03	
GP	52	ADELAIDE ST	CEL81	657	D	1	F	M	1.32	2.01	
GP	53	ADELAIDE ST	CEL81	616	D	1	B	M	1.36	1.77	
GP	54	ADELAIDE ST	CEL81	658	D	1	F	M	1.27	1.99	
GP	55	ADELAIDE ST	CEL81	615	D	2	B/WB	M	1.42	1.40	
GP	56	ADELAIDE ST	CEL81	659	D	1	WB	M	1.48	3.07	
GP	57	ADELAIDE ST	CEL81	614	D	1	F	M	1.44	1.87	
GP	58	ADELAIDE ST	CEL81	660	D	1	F	M	1.76	2.04	
GP	59	ADELAIDE ST	CEL81	613	D	1	F	M	1.46	1.64	
GP	60	ADELAIDE ST	CEL81	661	D	1	WB	M	1.86	2.53	
GP	61	ADELAIDE ST	CEL81	612	D	2	B/WB	M	1.47	2.98	
GP	62	ADELAIDE ST	CEL81	662	D	2	B/WB	M	1.60	1.93	
GP	63	ADELAIDE ST	CEL81	611	D	E	F	M	1.51	1.67	
GP	64	ADELAIDE ST	CEL81	663	D	2	B/WB	M	1.63	1.78	
GP	65	ADELAIDE ST	CEL81	610	D	1	F	S	1.78	2.29	
GP	66	ADELAIDE ST	CEL81	664	D	2	B	M	1.58	1.70	

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GP	67	ADELAIDE ST	CEL81	609	D	2	B	M	1.84	1.85	
GP	68	ADELAIDE ST	CEL81	665	D	1	F	M	1.70	2.19	
GP	69	ADELAIDE ST	CEL81	608	D	1	B	M	1.85	3.02	
GP	70	ADELAIDE ST	CEL81	666	D	1	WB	M	1.77	2.32	
GP	71	ADELAIDE ST	CEL81	607	D	1	F	M	1.74	1.78	
GP	72	ADELAIDE ST	CEL81	667	D	1	F	M	1.78	2.22	
GP	73	ADELAIDE ST	CEL81	606	D	2	B/F	M	1.80	1.88	
GP	74	ADELAIDE ST	CEL81	668	D	2	B	M	1.89	1.96	
GP	75	ADELAIDE ST	CEL81	605	D	1	WB	M	1.83	2.47	
GP	76	ADELAIDE ST	CEL81	669	D	2	WB	M	1.86	2.43	
GP	77	ADELAIDE ST	CEL81	604	D	1	F	M	1.72	2.22	
GP	78	ADELAIDE ST	CEL81	670	D		B/WB	M	1.93	4.48	
GP	79	ADELAIDE ST	CEL81	603	D	1	F	M	1.68	2.20	
GP	80	ADELAIDE ST	CEL81	671	D	2	BF	M	2.06	2.02	
GP	81	ADELAIDE ST	CEL81	602	D	E	B/F	M	1.55	1.66	
GP	82	ADELAIDE ST	CEL81	672	D	2	WB	M	1.90	2.36	
GP	83	ADELAIDE ST	CEL81	601	D	2	B	M	1.67	1.83	
GP	84	ADELAIDE ST	CEL81	673	D	1	F	M	1.82	2.31	
GP	85	ADELAIDE ST	CEL81	600	D	1	F	M	1.69	2.30	
GP	86	ADELAIDE ST	CEL81	674	D	2	B	M	1.86	1.93	
GP	87	ADELAIDE ST	CEL81	599	D	1	F	M	1.74	2.31	
GP	88	ADELAIDE ST	CEL81	675	D	1	F	M	1.83	2.43	
GP	89	ADELAIDE ST	CEL81	598	D	1	WB	M	1.75	2.28	
GP	90	ADELAIDE ST	CEL81	676	D	2	WB	M	1.76	1.79	
GP	91	ADELAIDE ST	CEL81	597	D	1	F	M	1.72	2.44	
GP	92	ADELAIDE ST	CEL81	677	D	1	F	M	1.87	2.28	
GP	93	ADELAIDE ST	CEL81	596	D	E	F	M	1.72	4.52	
GP	94	ADELAIDE ST	CEL81	678	D	2	B/WB	M	1.77	2.54	
GP	95	ADELAIDE ST	CEL81	595	D	1	B	M	1.70	2.99	
GP	96	ADELAIDE ST	CEL81	997	D	1	B	M	2.81	3.11	
GP	97	ADELAIDE ST	CEL81	594	D	1	F	M	1.74	2.07	
GP	98	ADELAIDE ST	CEL81	996	D	2	B	M	2.50	2.81	
GP	99	ADELAIDE ST	CEL81	593	D	1	F	M	1.76	2.05	
GP	5	BAILEY AVE	CEL85	761	D	2	B	M	1.94	2.01	
GP	9	BAILEY AVE	CEL85	759	D	2	B/WB	M	1.75	2.01	
GP	11	BAILEY AVE	CEL85	758	D	1	B	M	1.82	3.34	
GP	12	BAILEY AVE	CEL85	749	D	1	B	M	1.57	3.25	
GP	13	BAILEY AVE	CEL85	757	D	2	B/WB	M	1.65	1.79	
GP	14	BAILEY AVE	CEL85	750	D	2	B/WB	M	1.52	1.67	
GP	15	BAILEY AVE	CEL85	756	D	2	WB	M	1.60	1.68	
GP	16	BAILEY AVE	CEL85	751	D	2	B/WB	M	1.57	1.62	
GP	17	BAILEY AVE	CEL85	755	D	2	B/WB	M	1.55	1.76	
GP	19	BAILEY AVE	CEL85	754	D	2	B	M	1.60	1.92	
GP	21	BAILEY AVE	CEL85	753	D	2	B	M	1.65	1.95	
GP	23	BAILEY AVE	CEL85	752	D	SPLIT	B	M	1.71	3.14	
GP	1	BARTLETT DR	CEL85	784	D	1	B	M	1.78	3.15	
GP	2	BARTLETT DR	CEL85	762	D	2	B	M	1.84	2.03	
GP	3	BARTLETT DR	CEL85	783	D	1	B	M	1.96	3.13	
GP	4	BARTLETT DR	CEL85	763	D	2	B/WB	M	2.73	3.05	
GP	19	BARTLETT DR	CEL85	776	D	1	WB	M	5.56	7.32	
GP	23	BARTLETT DR	CEL85	774	D	2	B/WB	M	3.30	3.24	
GP	1	BINDAREE ST	CEL81	843	D	2	B	M	2.59	2.76	
GP	2	BINDAREE ST	CEL81	834	D	1	B	M	2.73	2.82	
GP	3	BINDAREE ST	CEL81	842	D	1	F	M	2.56	2.67	
GP	4	BINDAREE ST	CEL81	835	D	2	WB	M	2.67	2.80	
GP	5	BINDAREE ST	CEL81	840	D	1	B	M	2.93	3.07	
GP	6	BINDAREE ST	CEL81	836	D	1	B	M	3.43	4.54	
GP	7	BINDAREE ST	CEL81	839	D	1	B	M	3.30	3.95	
GP	8	BINDAREE ST	CEL81	837	D	1	B	M	4.40	4.74	
GP	1	CHURCH ST	CEL81	906	D	1	F	M	1.68	1.73	
GP	1A	CHURCH ST	CEL81	629	D	1	F	M	1.34	1.81	
GP	3	CHURCH ST	CEL81	907	D	1	WB	M	1.57	1.93	
GP	5	CHURCH ST	CEL81	908	D	1	B	M	1.36	3.10	

LEGEND:

Material: B - brick; W/B - weatherboard; F - fibro; M - metal

Zone Location: BD - Bomaderry; SH - Shoalhaven Heads; GP - Green Point; OP - Orient Point; NW - Nowra

Type: AB - ablution block; CP - caravan park; O - office; F - farm; I - industrial; PS - pumping station; D - dwelling; U - units; C - commercial

Size: S - small; M - medium; L - large

ZONE /LOCATION	ST No	STREET NAME	RELEVANT CELL IN HYDRAULIC MODEL	UPN	TYPE	STOREYS	MATERIAL	SIZE	GROUND RL	FLOOR RL	REMARKS
GP	7	CHURCH ST	CEL81	909	D	2	B/WB	M	1.28	1.37	
GP	9	CHURCH ST	CEL81	910	D	1	B	M	1.31	2.18	
GP	11	CHURCH ST	CEL81	911	D	2	B	M	1.49	3.03	
GP	2	COMARONG ST	CEL81	5515	D	1	WB	M	2.01	3.03	
GP	4	COMARONG ST	CEL81	5514	D	1	WB	M	1.54	3.00	
GP	5	COMARONG ST	CEL81	950	D	2	B/WB	M	1.80	2.20	
GP	7	COMARONG ST	CEL81	951	D	2	B	M	2.05	2.10	
GP	8	COMARONG ST	CEL81	5512	D	2	B/WB	M	2.26	2.84	
GP	9	COMARONG ST	CEL81	952	D	E	B/WB	M	1.52	3.96	
GP	11	COMARONG ST	CEL81	955	D	2	B/WB	M	1.59	1.64	
GP	13	COMARONG ST	CEL81	954	D	1	B	M	1.57	3.06	
GP	15	COMARONG ST	CEL81	953	D	2	B	M	1.70	2.93	
GP	18	COMARONG ST	CEL81	1015	D	2	B/WB	M	1.66	2.03	
GP	19	COMARONG ST	CEL81	957	D	1	WB	M	1.65	3.08	
GP	21	COMARONG ST	CEL81	956	D	1	WB	M	1.66	3.11	
GP	22	COMARONG ST	CEL81	5419	D	2	B	M	2.39	3.00	
GP	23	COMARONG ST	CEL81	959	D	1	WB	M	1.46	2.53	
GP	24	COMARONG ST	CEL81	5420	D	1	WB	M	2.50	3.09	
GP	25	COMARONG ST	CEL81	960	D	2	BF	M	1.91	1.94	
GP	27	COMARONG ST	CEL81	961	D	1	B	M	2.10	2.34	
GP	29	COMARONG ST	CEL81	962	D	1	F	S	1.82	2.34	
GP	30	COMARONG ST	CEL81	1014	D	1	F	M	2.23	2.63	
GP	31	COMARONG ST	CEL81	963	D	2	B/WB	M	1.58	1.73	
GP	32	COMARONG ST	CEL81	1013	D	1	WB	M	2.47	2.95	
GP	33	COMARONG ST	CEL81	964	D	1	WB	M	1.63	3.05	
GP	34	COMARONG ST	CEL81	1012	D	1	B	M	2.54	3.87	
GP	35	COMARONG ST	CEL81	965	D	1	F	S	1.50	2.00	
GP	36	COMARONG ST	CEL81	1011	D	1	WB	M	2.60	3.08	
GP	37	COMARONG ST	CEL81	966	D	2	B/WB	M	1.43	1.50	
GP	38	COMARONG ST	CEL81	1010	D	1	F	M	2.40	2.75	
GP	39	COMARONG ST	CEL81	967	D	2	BF	M	1.38	1.41	
GP	40	COMARONG ST	CEL81	1009	D	1	B	M	2.65	2.99	
GP	42	COMARONG ST	CEL81	1008	D	2	B	M	2.52	3.32	
GP	43	COMARONG ST	CEL81	968	D	1	B	M	1.50	2.98	
GP	44	COMARONG ST	CEL81	1007	D	SPLIT	B	M	2.47	3.26	
GP	45	COMARONG ST	CEL81	969	D	1	WB	M	1.52	2.09	
GP	46	COMARONG ST	CEL81	1006	D	1	B	M	2.53	3.10	
GP	47	COMARONG ST	CEL81	970	D	2	B/WB	M	1.75	1.94	
GP	48	COMARONG ST	CEL81	1005	D	1	WB	M	2.36	3.03	
GP	49	COMARONG ST	CEL81	971	D	2	BF	M	1.69	1.85	
GP	50	COMARONG ST	CEL81	1004	D	2	B/WB	M	2.31	2.42	
GP	51	COMARONG ST	CEL81	972	D	2	BF	M	1.52	1.55	
GP	52	COMARONG ST	CEL81	1003	D	1	F	M	2.35	2.94	
GP	53	COMARONG ST	CEL81	973	D	1	F	S	1.70	2.01	
GP	54	COMARONG ST	CEL81	1002	D	2	B/WB	M	2.27	2.60	
GP	55	COMARONG ST	CEL81	974	D	2	B/WB	M	1.70	1.72	
GP	57	COMARONG ST	CEL81	975	D	1	B	M	1.70	3.02	
GP	58	COMARONG ST	CEL81	1000	D	2	B	M	2.35	2.60	
GP	59	COMARONG ST	CEL81	976	D	2	B/WB	M	1.52	1.50	
GP	61	COMARONG ST	CEL81	977	D	2	B/WB	M	1.67	1.80	
GP	62	COMARONG ST	CEL81	998	D	2	B	L	2.45	3.58	
GP	63	COMARONG ST	CEL81	978	D	1	B	M	2.00	3.15	
GP	65	COMARONG ST	CEL81	979	D	1	WB	M	2.16	2.66	
GP	67	COMARONG ST	CEL81	980	D	1	F	M	2.49	2.84	
GP	69	COMARONG ST	CEL81	981	D	1	F	S	2.36	2.53	
GP	71	COMARONG ST	CEL81	982	D	1	F	M	2.35	2.89	
GP	73	COMARONG ST	CEL81	983	D	2	BF	M	2.47	2.51	
GP	75	COMARONG ST	CEL81	984	D	2	B/WB	M	2.58	2.46	
GP	77	COMARONG ST	CEL81	985	D	1	B	M	2.55	2.95	
GP	79	COMARONG ST	CEL81	986	D	1	F	M	2.30	2.95	
GP	81	COMARONG ST	CEL81	987	D	1	F	M	2.15	2.56	
GP	83	COMARONG ST	CEL81	988	D	1	WB	M	2.33	2.49	
GP	85	COMARONG ST	CEL81	989	D	1	F	M	2.25	2.96	

LEGEND:

Material: B - brick; W/B - weatherboard; F - fibro; M - metal

Zone Location: BD - Bomaderry; SH - Shoalhaven Heads; GP - Green Point; OP - Orient Point; NW - Nowra

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Size: S - small; M - medium; L - large

ZONE /LOCATION	ST No	STREET NAME	RELEVANT CELL IN HYDRAULIC MODEL	UPN	TYPE	STOREYS	MATERIAL	SIZE	GROUND RL	FLOOR RL	REMARKS
GP	87	COMARONG ST	CEL81	990	D	1	WB	M	2.34	2.84	
GP	89	COMARONG ST	CEL81	991	D	1	B	M	2.40	2.98	
GP	91	COMARONG ST	CEL81	992	D	1	F	S	2.22	2.92	
GP	93	COMARONG ST	CEL81	993	D	1	F	S	2.14	3.00	
GP	95	COMARONG ST	CEL81	994	D	1	F	M	2.32	2.99	
GP	97	COMARONG ST	CEL81	995	D	1	WB	M	2.47	3.00	
GP	1	CROOKHAVEN DR	CEL85	1054	D	2	B/WB	M	1.61	1.78	
GP	2	CROOKHAVEN DR	CEL85	1032	D	1	B	M	4.17	4.43	
GP	3	CROOKHAVEN DR	CEL85	1053	D	2	B	M	1.53	1.70	
GP	4	CROOKHAVEN DR	CEL85	1033	D	1	F	M	4.46	4.64	
GP	5	CROOKHAVEN DR	CEL85	1052	D	1	B	M	1.62	2.34	
GP	7	CROOKHAVEN DR	CEL85	1051	D	1	B	M	1.84	3.06	
GP	9	CROOKHAVEN DR	CEL85	1050	D	1	B	M	1.67	2.90	
GP	11	CROOKHAVEN DR	CEL85	1049	D	2	WB	M	1.68	1.77	
GP	13	CROOKHAVEN DR	CEL85	1048	D	2	BF	M	1.74	2.50	
GP	15	CROOKHAVEN DR	CEL85	1047	D	SPLIT	B	M	2.32	2.98	
GP	17	CROOKHAVEN DR	CEL85	1046	D	1	B	M	1.76	3.17	
GP	19	CROOKHAVEN DR	CEL85	1045	D	2	B/WB	M	2.37	2.47	
GP	3	FRASER AVE	CEL85	1105	D	1	WB	M	1.31	1.80	
GP	10	FRASER AVE	CEL85	1106	D	E	WB	M	1.67	3.64	
GP	11	GREENS RD	CEL85	1163	D	1	F	M	1.90	2.66	
GP	117	GREENS RD	CEL85	1206	D	2	WB	M	1.50	1.77	
GP	119	GREENS RD	CEL85	1205	D	1	B	M	1.53	2.12	
GP	123	GREENS RD	CEL85	1204	D	2	B/WB	M	1.49	1.56	
GP	125	GREENS RD	CEL85	1203	D	2	B/WB	M	1.45	1.63	
GP	127	GREENS RD	CEL85	1202	D	1	WB	M	1.39	3.00	
GP	129	GREENS RD	CEL85	1201	D	1	WB	M	1.65	2.73	
GP	13	GREENS RD	CEL85	1164	D	1	B	M	2.20	3.01	
GP	131	GREENS RD	CEL85	1200	D	1	F	M	1.83	3.97	
GP	133	GREENS RD	CEL85	1199	D	2	B/WB	M	3.11	4.25	
GP	35	GREENS RD	CEL85	1174	D	1	B	M	1.75	2.45	
GP	46	GREENS RD	CEL85	87767	D	1	B	M	1.48	2.93	
GP	54	GREENS RD	CEL85	87466	D	1	B	M	1.60	3.10	
GP	56	GREENS RD	CEL85	84686	D	1	B	M	1.63	3.02	
GP	58	GREENS RD	CEL85	84687	D	2	B	M	1.56	3.12	
GP	61	GREENS RD	CEL85	1175	D	2	B	L	1.52	1.59	
GP	62	GREENS RD	CEL85	1188	D	1	WB	M	1.40	1.86	
GP	64	GREENS RD	CEL85	1187	D	1	F	M	1.31	2.23	
GP	66	GREENS RD	CEL85	1186	D	1	B	M	1.43	1.98	
GP	68	GREENS RD	CEL85	1185	D	1	F	M	1.44	1.68	
GP	70	GREENS RD	CEL85	1184	D	1	F	M	1.37	1.67	
GP	72	GREENS RD	CEL85	1183	D	1	WB	S	1.37	1.87	
GP	74	GREENS RD	CEL85	1182	D	1	F	M	1.32	1.90	
GP	76	GREENS RD	CEL85	1181	D	1	F	M	1.36	1.66	
GP	112	GREENWELL POINT RD	CEL85	15378	D	1	F	M	1.87	1.71	
GP	117	GREENWELL POINT RD	CEL85	15377	C	2	B	L	2.18	2.53	
GP	15	GREENWELL POINT RD	CEL81	86337	D	1	WB	M	2.26	2.80	
GP	27	GREENWELL POINT RD	CEL81	1235	D	1	B	M	4.00	4.18	
GP	29	GREENWELL POINT RD	CEL81	1236	D	1	B	M	4.47	4.75	
GP	31	GREENWELL POINT RD	CEL81	1237	D	2	B	M	3.23	3.33	
GP	84	GREENWELL POINT RD	CEL85	1211	BOATSHED	1	WB	S	1.64	1.39	
GP	86	GREENWELL POINT RD	CEL85	53125	D	2	B	M	1.20	4.61	
GP	94	GREENWELL POINT RD	CEL85	5517	D	2	B	M	2.95	2.36	
GP	3	HAISER RD	CEL85	1271	D	1	F	M	1.61	2.29	
GP	4	HAISER RD	CEL85	1344	D	1	B	M	1.77	2.35	
GP	5	HAISER RD	CEL85	1272	D	1	WB	S	1.69	2.51	
GP	6	HAISER RD	CEL85	1343	D	2	B	M	1.73	1.75	
GP	7	HAISER RD	CEL85	1273	D	1	WB	M	1.65	2.64	
GP	8	HAISER RD	CEL85	15204	D	1	B	M	1.70	1.86	
GP	9	HAISER RD	CEL85	1274	D	2	B	M	1.69	2.27	
GP	10	HAISER RD	CEL85	1342	D	1	B	M	1.72	2.06	
GP	11	HAISER RD	CEL85	1275	D	2	B	M	1.69	2.03	
GP	12	HAISER RD	CEL85	1341	D	1	F	M	1.78	2.15	

LEGEND:

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ZONE /LOCATION	ST No	STREET NAME	RELEVANT CELL IN HYDRAULIC MODEL	UPN	TYPE	STOREYS	MATERIAL	SIZE	GROUND RL	FLOOR RL	REMARKS
GP	13	HAISER RD	CEL85	1276	D	1	WB	M	1.63	2.27	
GP	14	HAISER RD	CEL85	1340	D	2	B	M	1.90	2.31	
GP	15	HAISER RD	CEL85	1277	D	1	B	M	1.78	2.46	
GP	16	HAISER RD	CEL85	1339	D	1	WB	M	1.90	2.38	
GP	17	HAISER RD	CEL85	1278	D	1	B	M	1.85	2.39	
GP	18	HAISER RD	CEL85	1338	D	1	B	M	2.16	3.05	
GP	19	HAISER RD	CEL85	1280	D	2	B/WB	M	1.76	2.00	
GP	21	HAISER RD	CEL85	1279	D	2	B/WB	M	1.82	2.04	
GP	22	HAISER RD	CEL85	1336	D	1	WB	M	1.86	2.02	
GP	23	HAISER RD	CEL85	1282	D	2	B/F	M	1.72	1.75	
GP	24	HAISER RD	CEL85	1335	D	1	F	M	1.58	2.16	
GP	25	HAISER RD	CEL85	1281	D	1	WB	M	1.52	2.55	
GP	26	HAISER RD	CEL85	1334	D	2	B/F	L	1.66	1.76	
GP	27	HAISER RD	CEL85	1283	D	2	F	M	1.60	1.82	
GP	28	HAISER RD	CEL85	1333	D	1	F	M	1.60	1.73	
GP	29	HAISER RD	CEL85	1284	D	2	B/WB	M	1.73	1.77	
GP	30	HAISER RD	CEL85	1332	D	2	B/F	L	1.66	2.00	
GP	31	HAISER RD	CEL85	1285	D	1	WB	M	1.64	2.16	
GP	32	HAISER RD	CEL85	1331	D	2	F	M	1.59	1.69	
GP	34	HAISER RD	CEL85	1330	D	2	F	M	1.62	2.24	
GP	35	HAISER RD	CEL85	1286	D	1	F	M	1.66	2.25	
GP	36	HAISER RD	CEL85	1329	D	1	F	M	1.54	2.01	
GP	37	HAISER RD	CEL85	1288	D	1	F	M	1.56	2.10	
GP	38	HAISER RD	CEL85	1328	D	1	F	M	1.46	2.16	
GP	39	HAISER RD	CEL85	5439	D	1	WB	M	1.58	2.03	
GP	41	HAISER RD	CEL85	1289	D	1	F	M	1.51	1.91	
GP	42	HAISER RD	CEL85	1327	D	2	B/F	M	1.42	1.63	
GP	43	HAISER RD	CEL85	1290	D	2	B/WB	M	1.47	1.55	
GP	44	HAISER RD	CEL85	1326	D	2	B/F	L	1.45	1.84	
GP	45	HAISER RD	CEL85	1291	D	2	B	L	1.67	2.08	
GP	46	HAISER RD	CEL85	1325	D	1	F	M	1.53	1.77	
GP	47	HAISER RD	CEL85	1292	D	1	F	M	1.52	1.98	
GP	48	HAISER RD	CEL85	1324	D	2	B	L	1.71	1.98	
GP	49	HAISER RD	CEL85	1293	D	1	B	M	1.49	2.29	
GP	50	HAISER RD	CEL85	1323	D	2	B	M	1.57	1.99	
GP	51	HAISER RD	CEL85	1294	D	2	B/F	M	1.54	1.56	
GP	52	HAISER RD	CEL85	1322	D	2	F/WB	M	1.62	1.65	
GP	53	HAISER RD	CEL85	1295	D	1	F	M	1.39	1.71	
GP	54	HAISER RD	CEL85	1321	D	1	B	M	1.73	2.07	
GP	55	HAISER RD	CEL85	1296	D	1	F	M	1.31	1.87	
GP	56	HAISER RD	CEL85	1320	D	1	F	M	1.60	1.92	
GP	57	HAISER RD	CEL85	1297	D	1	WB	M	1.34	1.71	
GP	58	HAISER RD	CEL85	1319	D	1	F	M	1.45	2.02	
GP	59	HAISER RD	CEL85	1298	D	1	F/WB	M	1.39	1.58	
GP	60	HAISER RD	CEL85	1318	D	1	WB	M	1.47	2.04	
GP	61	HAISER RD	CEL85	1299	D	1	WB	M	1.30	1.71	
GP	62	HAISER RD	CEL85	1317	D	1	F	M	1.25	1.87	
GP	63	HAISER RD	CEL85	1300	D	2	B	L	1.77	3.08	
GP	64	HAISER RD	CEL85	1316	D	1	WB/F	M	1.30	1.83	
GP	65	HAISER RD	CEL85	1301	D	1	F	M	1.25	1.79	
GP	66	HAISER RD	CEL85	1315	D	1	F	M	1.28	1.87	
GP	67	HAISER RD	CEL85	73165	D	2	B	M	1.61	1.78	
GP	68	HAISER RD	CEL85	1314	D	1	WB	M	1.24	1.75	
GP	69	HAISER RD	CEL85	1302	D	2	WB	M	1.23	1.46	
GP	70	HAISER RD	CEL85	15203	D	1	F	M	1.29	2.00	
GP	71	HAISER RD	CEL85	1303	D	1	B/F	M	1.47	3.09	
GP	72	HAISER RD	CEL85	1313	D	1	F	M	1.51	1.81	
GP	73	HAISER RD	CEL85	1304	D	2	B	L	1.45	1.56	
GP	74	HAISER RD	CEL85	1312	D	1	WB	M	1.81	1.98	
GP	76	HAISER RD	CEL85	1311	D	1	F	M	1.79	2.35	
GP	78	HAISER RD	CEL85	1310	D	1	F/WB	M	1.96	2.65	
GP	80	HAISER RD	CEL85	1309	D	1	B	M	1.94	2.44	
GP	82	HAISER RD	CEL85	1308	D	1	F	M	1.93	2.25	

LEGEND:

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Zone Location: BD - Bomaderry; SH - Shoalhaven Heads; GP - Green Point; OP - Orient Point; NW - Nowra

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Size: S - small; M - medium; L - large

ZONE /LOCATION	ST No	STREET NAME	RELEVANT CELL IN HYDRAULIC MODEL	UPN	TYPE	STOREYS	MATERIAL	SIZE	GROUND RL	FLOOR RL	REMARKS
GP	84	HAISER RD	CEL85	1307	D	1	F	M	1.88	2.38	
GP	86	HAISER RD	CEL85	1306	D	1	B	M	1.36	2.35	
GP	2	HUME ST	CEL85	1287	D	2	B	M	1.84	2.31	
GP	4	HUME ST	CEL85	77546	D	1	B	M	1.60	3.08	
GP	5	HUME ST	CEL85	87025	D	1	B	M	1.47	3.10	
GP	47	JERVIS ST	CEL85	1549	D	1	B	M	1.80	3.10	
GP	1	KEITH AVE	CEL85	1550	D	1	B	M	1.45	1.94	
GP	2	KEITH AVE	CEL85	1560	D	1	WB	M	1.49	1.59	
GP	3	KEITH AVE	CEL85	1551	D	1	WB	M	1.64	3.23	
GP	4	KEITH AVE	CEL85	1559	D	1	F	M	1.42	1.89	
GP	5	KEITH AVE	CEL85	1552	D	1	F	S	1.83	2.14	
GP	7	KEITH AVE	CEL85	1553	D	2	B	M	1.66	1.91	
GP	8	KEITH AVE	CEL85	1557	D	2	B/F	M	1.60	1.74	
GP	9	KEITH AVE	CEL85	1554	D	2	WB	M	1.44	1.57	
GP	11	KEITH AVE	CEL85	1555	D	2	F	M	1.46	1.67	
GP	13	KEITH AVE	CEL85	1556	D	2	B/F	M	1.45	1.82	
GP	1	LEONORE AVE	CEL85	1561	D	1	WB	M	1.49	1.82	
GP	3	LEONORE AVE	CEL85	1562	D	2	B/F	M	1.47	1.48	
GP	5	LEONORE AVE	CEL85	1563	D	2	B/F	M	1.55	1.47	
GP	7	LEONORE AVE	CEL85	1564	D	2	B/WB	M	1.42	1.70	
GP	8	LEONORE AVE	CEL85	1566	D	1	F	M	1.46	1.88	
GP	10	LEONORE AVE	CEL85	1565	D	1	F	M	1.43	2.56	
GP	1	MORRISSEY WAY	CEL85	1691	D	2	B/WB	M	2.15	1.87	
GP	3	MORRISSEY WAY	CEL85	1690	D	1	B	M	2.74	3.07	
GP	5	MORRISSEY WAY	CEL85	1689	D	2	B	M	3.27	3.32	
GP	4	PYREE ST	CEL81	5437	D	2	WB	M	1.65	1.75	
GP	5	PYREE ST	CEL81	1156	D	1	WB	M	2.29	3.12	
GP	6	PYREE ST	CEL81	5436	D	2	B/F	M	2.25	2.52	
GP	7	PYREE ST	CEL81	1157	D	1	B	M	2.90	3.06	
GP	9	PYREE ST	CEL81	1158	D	1	B	M	3.39	3.94	
GP	11	PYREE ST	CEL81	1159	D	1	F	M	3.90	4.55	
GP	13	PYREE ST	CEL81	1160	D	2	B/WB	L	4.90	4.96	
GP	15	PYREE ST	CEL81	1161	D	1	F	S	5.75	5.90	
GP	16	SOUTH ST	CEL85	2028	D	1	F	S	1.92	2.31	
GP	18	SOUTH ST	CEL85	2027	D	1	WB	M	1.76	1.70	
GP	20	SOUTH ST	CEL85	2026	D	1	F	S	1.62	2.16	
GP	22	SOUTH ST	CEL85	2025	D	1	F	S	1.58	2.15	
GP	24	SOUTH ST	CEL85	15380	D	2	B	M	1.63	3.29	
GP	3	WEST ST	CEL81	15207	D	1	F	M	1.31	1.91	
GP	4	WEST ST	CEL81	2144	D	2	B/F	M	2.17	2.30	
GP	5	WEST ST	CEL81	2125	D	1	B	M	1.40	2.11	
GP	6	WEST ST	CEL81	2143	D	1	WB	M	1.88	2.39	
GP	7	WEST ST	CEL81	2126	D	2	WB	M	2.03	2.52	
GP	8	WEST ST	CEL81	2142	D	1	B	M	1.42	3.05	
GP	9	WEST ST	CEL81	2127	D	1	WB	M	2.50	2.97	
GP	10	WEST ST	CEL81	2141	D	1	B	M	1.35	3.13	
GP	11	WEST ST	CEL81	2128	D	1	B	M	2.52	3.16	
GP	12	WEST ST	CEL81	2140	D	1	F	M	1.96	2.25	
GP	14	WEST ST	CEL81	2139	D	1	WB	M	1.67	2.21	
GP	16	WEST ST	CEL81	2138	D	1	F	M	1.80	2.05	
GP	17	WEST ST	CEL81	2129	D	1	B	M	2.51	3.01	
GP	18	WEST ST	CEL81	2137	D	1	B	M	2.12	2.57	
GP	20	WEST ST	CEL81	949	D	1	WB	M	1.65	3.00	
GP	22	WEST ST	CEL81	948	D	1	F	M	1.82	1.91	
GP	26	WEST ST	CEL81	1155	D	SPLIT	B	M	2.08	2.18	
GP	29	WEST ST	CEL81	2135	D	1	B	M	2.46	3.12	
GP	31	WEST ST	CEL81	2134	D	1	B	M	2.54	3.11	
GP	33	WEST ST	CEL81	2133	D	1	B	M	2.52	3.05	
GP	35	WEST ST	CEL81	2132	D	1	F	M	2.51	2.68	
GP	37	WEST ST	CEL81	2131	D	1	WB	M	3.06	3.70	
NW		MORTON PDE	CEL31	7032	I	2	B	L	3.09	3.78	
NW		OAKBANKS PL	CEL52	81044	D	1	B	M	5.48	4.20	
NW	9	AMALFI CRES	CEL31	31807	D	2	B/WB	M	4.81	4.60	

LEGEND:

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NW	11	AMALFI CRES	CEL31	31806	D	1	B	M	4.21	4.55	
NW	22	AMALFI CRES	CEL31	31797	D	2	B	M	4.05	4.79	
NW	24	AMALFI CRES	CEL31	31798	D	1	B	M	3.67	3.97	
NW	24A	AMALFI CRES	CEL31	32556	D	1	B	M	3.24	4.72	
NW	25	AMALFI CRES	CEL31	31804	D	1	B	M	3.76	4.05	
NW	26	AMALFI CRES	CEL31	31799	D	1	B	M	3.76	4.62	
NW	27	AMALFI CRES	CEL31	31803	D	1	B	M	3.93	4.43	
NW	28	AMALFI CRES	CEL31	31800	D	1	B	M	4.02	4.78	
NW	29	AMALFI CRES	CEL31	31802	D	1	B	M	3.70	4.46	
NW	30	AMALFI CRES	CEL31	31801	D	1	B	M	4.03	4.50	
NW	72	BENNETT PL	CEL52	87135	D	1	B	M	4.72	4.68	
NW	75	BENNETT PL	CEL52	87129	D	2	B	M	4.41	4.82	
NW	76	BENNETT PL	CEL52	87134	D	1	B	M	4.48	3.87	
NW	80	BENNETT PL	CEL52	87133	D	1	B	M	4.18	3.69	
NW	82	BENNETT PL	CEL52	87132	D	1	B	M	3.90	4.28	
NW	84	BENNETT PL	CEL52	87131	D	1	B	M	3.91	4.03	
NW	1	DRYDEN CL	CEL31	55725	D	1	F	M	3.64	4.58	
NW	2	DRYDEN CL	CEL31	55724	D	1	B	M	3.81	4.49	
NW	3	DRYDEN CL	CEL31	36891	D	1	B	M	3.58	4.52	
NW	1/5	DRYDEN CL	CEL31	88429	U	1	B	M	3.14	4.68	
NW	2/5	DRYDEN CL	CEL31	88430	U	1	B	M	3.14	4.68	
NW	3/5	DRYDEN CL	CEL31	88431	D	1	B	M	2.51	3.80	
NW	4/5	DRYDEN CL	CEL31	88432	U	1	B	M	3.14	4.70	
NW	4	ELLISON CL	CEL52	72280	D	1	B	M	5.55	4.18	
NW	5	ELLISON CL	CEL52	72281	SHED	1	M	L	5.55	4.80	
NW	430	GREENWELL POINT RD	CEL52	59068	D	1	WB	M	2.85	3.31	
NW	45	GREENWELL POINT RD	CEL31	31989	D	1	B	M	4.36	4.82	
NW	8	JANE ST	CEL31	40265	C	1	BF	L	3.60	4.00	
NW	10	JANE ST	CEL31	86019	C	1	BF	L	3.60	4.00	
NW	160	JUNCTION ST	CEL31	37165	C	1	B	L	4.80	4.96	
NW	118	KINGHORNE ST	CEL31	37249	I	1	B	L	4.80	4.96	
NW	8	MORTON PDE	CEL31	32272	D	1	WB	M	3.73	4.71	
NW	9	MORTON PDE	CEL31	32289	D	1	B	M	3.87	4.63	
NW	10	MORTON PDE	CEL31	32273	D	1	WB	M	4.10	4.97	
NW	11	MORTON PDE	CEL31	32288	D	1	B	M	4.60	5.00	
NW	25	MORTON PDE	CEL31	37135	D	1	WB	M	2.95	4.70	
NW	26	OAKBANKS PL	CEL52	81051	D	1	B	M	5.48	4.27	
NW	101	PLUNKETT ST	CEL31	37656	C	1	B	M	4.47	4.88	
NW	103	PLUNKETT ST	CEL31	48061	C	1	B	M	3.95	4.31	
NW	105	PLUNKETT ST	CEL31	48062	C	1	M	L	3.70		
NW	107	PLUNKETT ST	CEL31	48063	C	1	B	S	3.61	3.69	
NW	111	PLUNKETT ST	CEL31	32315	F	2	B	M	3.35	3.62	
NW	113	PLUNKETT ST	CEL31	32316	D	1	WB	M	3.91	4.51	
NW	122	PLUNKETT ST	CEL31	40903	C	1	F	M	4.40	4.87	
NW	144	PLUNKETT ST	CEL31	32329	D	2	B	M	4.52	4.45	
NW	145	PLUNKETT ST	CEL31	32325	D	2	B	M	4.67	4.61	
NW	146	PLUNKETT ST	CEL31	32328	C	1	M	M	2.74	3.00	
NW	147	PLUNKETT ST	CEL31	32326	D	1	B	M	3.68	3.84	
NW	108	SALISBURY DR	CEL31	32546	D	2	B	M	5.40	4.68	
NW	110	SALISBURY DR	CEL31	32547	D	1	B	M	5.04	4.80	
NW	112	SALISBURY DR	CEL31	32548	D	1	B	M	5.18	4.88	
NW	114	SALISBURY DR	CEL31	32549	D	1	B	M	5.24	4.70	
NW	118	SALISBURY DR	CEL31	32551	D	1	B	M	5.55	4.88	
NW	122	SALISBURY DR	CEL31	32553	D	1	B	M	4.82	4.79	
NW	124	SALISBURY DR	CEL31	32554	D	1	B	M	3.48	4.27	
NW	54	SALISBURY DR	CEL31	32518	D	1	B	M	5.55	4.87	
NW	60	SALISBURY DR	CEL31	32521	D	1	B	M	5.03	4.59	
NW	62	SALISBURY DR	CEL31	32555	D	1	B	M	4.85	4.91	
NW	64	SALISBURY DR	CEL31	32522	D	1	B	M	4.72	4.98	
NW	68	SALISBURY DR	CEL31	32525	D	1	B	M	4.85	4.30	
NW	84	SALISBURY DR	CEL31	32533	D	SPLIT	B	M	4.74	4.74	
NW	90	SALISBURY DR	CEL31	32536	D	1	B	M	5.00	4.82	
NW	92	SALISBURY DR	CEL31	32538	D	1	B	M	5.17	4.95	

LEGEND:

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NW	96	SALISBURY DR	CEL31	32540	D	SPLIT	B	M	5.40	4.51	
NW	3	SECCOMBE ST	CEL31	32604	D	1	B	M	4.66	4.87	
NW	1A	SHORLAND PL	CEL31	87489	U	2	B	M	3.94	4.60	
NW	11/1A	SHORLAND PL	CEL31	87489	U	1	B	M	3.94	3.85	
NW	127	ST ANNS ST	CEL31	49990	D	1	B	M	4.15	4.62	
NW	153	ST ANNS ST	CEL31	32468	D	1	B	M	3.55	4.65	
NW	1	TARRABA CRES	CEL31	32691	D	1	B	M	4.63	4.65	
NW	3	TARRABA CRES	CEL31	32690	D	1	B	M	4.93	4.07	
NW	5	TARRABA CRES	CEL31	32689	D	1	WB	M	4.73	4.62	
NW	7	TARRABA CRES	CEL31	32688	D	1	WB	M	4.65	4.60	
NW	9	TARRABA CRES	CEL31	32687	D	1	B	M	4.52	4.78	
NW	13	TARRABA CRES	CEL31	32685	D	1	B	M	4.74	4.98	
NW	15	TARRABA CRES	CEL31	32684	D	1	B	M	4.92	4.89	
NW	5	WESTBROOK RD	CEL31	41964	D	2	B	M	5.14	5.01	
NW	13	WESTBROOK RD	CEL31	32702	D	1	B	M	5.54	5.02	
NW	111	WORRIGEE RD	CEL52	46723	SHED	1	F	L	4.98	4.44	
NW	125	WORRIGEE RD	CEL52	85263	D	2	B	M	4.78	4.66	
NW	139	WORRIGEE RD	CEL52	85265	D	1	B	M	5.66	4.92	
NW	153	WORRIGEE RD	CEL52	85267	D	1	B	M	4.67	4.89	
NW	91B	WORRIGEE RD	CEL52	46724	D	1	B	M	3.55	3.97	
NW	104	WORRIGEE ST	CEL31	68936	C	SPLIT	B	L	3.39	3.27	
OP		PRINCE EDWARD AVE	CEL86	85231	U	1	B	M	2.51	3.03	
OP	4	ADDISON RD	CEL86	2544	D	1	WB	M	2.50	3.50	
OP	5	ADDISON RD	CEL86	2545	D	1	WB	S	1.58	2.25	
OP	6	ADDISON RD	CEL86	2543	D	2	B	M	2.53	3.54	
OP	7	ADDISON RD	CEL86	2546	D	1	WB	M	1.84	2.28	
OP	8	ADDISON RD	CEL86	2542	D	1	WB	S	3.58	4.26	
OP	9	ADDISON RD	CEL86	2547	D	1	WB	M	1.49	1.90	
OP	11	ADDISON RD	CEL86	2548	D	2	B	M	1.48	1.97	
OP	13	ADDISON RD	CEL86	2549	D	1	F	M	1.58	1.86	
OP	15	ADDISON RD	CEL86	2550	D	2	B/WB	M	1.46	1.79	
OP	17	ADDISON RD	CEL86	2551	D	2	B	M	1.49	1.73	
OP	19	ADDISON RD	CEL86	2552	D	2	B	M	1.66	1.86	
OP	21	ADDISON RD	CEL86	2553	D	1	F	M	1.68	2.04	
OP	23	ADDISON RD	CEL86	2554	D	2	B	M	1.78	1.89	
OP	25	ADDISON RD	CEL86	2555	D	2	WB	M	1.83	1.71	
OP	27	ADDISON RD	CEL86	2556	D	SPLIT	WB	M	1.61	1.68	
OP	29	ADDISON RD	CEL86	2557	D	1	WB	M	1.61	1.97	
OP	31	ADDISON RD	CEL86	82038	D	1	F	S	1.64	1.83	
OP	33	ADDISON RD	CEL86	2559	D	E	B/WB	M	2.43	1.92	
OP	35	ADDISON RD	CEL86	2560	D	2	B/F	M	1.66	2.12	
OP	37	ADDISON RD	CEL86	2561	D	1	WB	M	1.70	2.67	
OP	38	ADDISON RD	CEL86	2527	D	E	B/F	M	3.28	5.97	
OP	39	ADDISON RD	CEL86	2562	D	1	WB	M	1.62	2.07	
OP	40	ADDISON RD	CEL86	2526	D	1	B	M	2.94	3.30	
OP	41	ADDISON RD	CEL86	2563	D	1	F	M	1.61	1.94	
OP	42	ADDISON RD	CEL86	2525	D	1	F	M	2.71	3.60	
OP	43	ADDISON RD	CEL86	2564	D	1	B	M	1.72	2.23	
OP	44	ADDISON RD	CEL86	2524	D	1	B	M	2.48	2.98	
OP	45	ADDISON RD	CEL86	2565	D	2	B	L	1.64	1.66	
OP	46	ADDISON RD	CEL86	2523	D	1	B	M	2.07	3.08	
OP	47	ADDISON RD	CEL86	2566	D	1	F	S	1.64	1.93	
OP	48	ADDISON RD	CEL86	2522	D	1	B	M	1.86	2.08	
OP	49	ADDISON RD	CEL86	2567	D	1	B	M	1.57	2.15	
OP	52	ADDISON RD	CEL86	2520	D	E	B/WB	M	1.47	4.45	
OP	54	ADDISON RD	CEL86	2519	D	2	B/F	M	1.39	1.38	
OP	55	ADDISON RD	CEL86	2570	D	1	WB	M	1.38	1.82	
OP	57	ADDISON RD	CEL86	2571	D	1	B	M	1.66	2.09	
OP	58	ADDISON RD	CEL86	2517	D	2	B/WB	M	1.43	1.58	
OP	59	ADDISON RD	CEL86	2572	D	1	WB	M	1.85	1.91	
OP	60	ADDISON RD	CEL86	2516	D	1	F	S	1.55	2.50	
OP	61	ADDISON RD	CEL86	2573	D	1	WB	M	2.15	2.24	
OP	62	ADDISON RD	CEL86	2515	D	2	B/WB	M	1.68	1.87	

LEGEND:

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OP	63	ADDISON RD	CEL86	2574	D	1	B	M	2.81	3.17	
OP	64	ADDISON RD	CEL86	2514	D	1	F	M	1.83	2.41	
OP	65	ADDISON RD	CEL86	2575	D	1	B	M	3.03	3.41	
OP	66	ADDISON RD	CEL86	2513	D	1	F	S	2.10	2.71	
OP	67	ADDISON RD	CEL86	84727	D	1	WB	M	3.28	3.74	
OP	67A	ADDISON RD	CEL86	84728	D	1	WB	M	3.48	3.83	
OP	68	ADDISON RD	CEL86	2512	D	1	F	M	2.47	3.10	
OP	69	ADDISON RD	CEL86	2577	D	1	WB	M	3.70	4.20	
OP	70	ADDISON RD	CEL86	2511	D	1	F	M	2.83	3.01	
OP	72	ADDISON RD	CEL86	2510	D	1	F	S	3.17	3.58	
OP	74	ADDISON RD	CEL86	2509	D	1	F	M	3.62	4.27	
OP	2	BELGRAVE ST	CEL86	2664	D				4.96	5.69	
OP	1	BRIGHTON PDE	CEL86	2723	D	1	WB	M	2.72	2.10	
OP	2	BRIGHTON PDE	CEL86	2725	D	1	WB	M	3.61	4.01	
OP	3	BRIGHTON PDE	CEL86	2722	D	1	B	M	2.60	3.00	
OP	4	BRIGHTON PDE	CEL86	2724	D	1	B	M	3.43	3.78	
OP	5	BRIGHTON PDE	CEL86	2721	D	SPLIT	B	M	2.56	2.97	
OP	6	BRIGHTON PDE	CEL86	2726	D	1	B	M	3.48	4.10	
OP	7	BRIGHTON PDE	CEL86	2720	D	1	B	M	2.61	2.77	
OP	8	BRIGHTON PDE	CEL86	2727	D	1	WB	M	3.27	4.19	
OP	9	BRIGHTON PDE	CEL86	2719	D	1	B	M	2.60	2.58	
OP	11	BRIGHTON PDE	CEL86	2718	D	1	F	M	1.97	2.51	
OP	13	BRIGHTON PDE	CEL86	2717	D	1	WB	M	1.97	2.44	
OP	15	BRIGHTON PDE	CEL86	2716	D	1	B	M	1.87	2.26	
OP	17	BRIGHTON PDE	CEL86	2715	D	1	B	M	2.20	2.98	
OP	19	BRIGHTON PDE	CEL86	2714	D	SPLIT	B/WB	M	2.22	3.08	
OP	21	BRIGHTON PDE	CEL86	2713	D	1	B	M	3.35	3.05	
OP	23	BRIGHTON PDE	CEL86	2712	D	1	B	M	4.22	4.54	
OP	25	BRIGHTON PDE	CEL86	2711	D	1	F	M	4.08	4.68	
OP	27	BRIGHTON PDE	CEL86	2710	D	1	B	M	4.37	5.10	
OP	29	BRIGHTON PDE	CEL86	2709	D	1	WB	M	4.23	4.15	
OP	31	BRIGHTON PDE	CEL86	2708	D	1	WB	M	4.51	4.83	
OP	33	BRIGHTON PDE	CEL86	2707	D	1	B	M	4.43	4.31	
OP	37	BRIGHTON PDE	CEL86	2705	D	1	B	M	4.28	4.25	
OP	39	BRIGHTON PDE	CEL86	2704	D	1	B	M	4.07	4.15	
OP	41	BRIGHTON PDE	CEL86	2703	D	1	WB	M	3.36	4.00	
OP	43	BRIGHTON PDE	CEL86	2702	D	2	B/WB	M	1.93	2.11	
OP	45	BRIGHTON PDE	CEL86	2701	D	1	B	M	2.05	2.08	
OP	1	FERN WAY	CEL86	3192	D	1	WB	M	2.47	3.22	
OP	2	FERN WAY	CEL86	3178	D	1	WB	M	2.40	3.28	
OP	3	FERN WAY	CEL86	3191	D	1	B	M	2.88	3.61	
OP	8	FERN WAY	CEL86	3181	D	1	F	M	3.63	3.43	
OP	10	FERN WAY	CEL86	3182	D	1	B	M	3.76	3.74	
OP	1	ORAMA CRES	CEL89	3594	D	2	B/WB	M	1.61	1.80	
OP	3	ORAMA CRES	CEL89	3593	D	1	B	M	1.48	2.03	
OP	5	ORAMA CRES	CEL89	3592	D	1	WB	M	1.57	2.01	
OP	7	ORAMA CRES	CEL89	3591	D	1	F/WB	S	1.59	1.91	
OP	9	ORAMA CRES	CEL89	3590	D	1	WB	M	1.72	2.20	
OP	10	ORAMA CRES	CEL89	3599	D	2	B	M	2.38	3.45	
OP	11	ORAMA CRES	CEL89	3589	D	2	B	M	1.66	1.87	
OP	13	ORAMA CRES	CEL89	3588	D	1	F	S	1.81	2.13	
OP	14	ORAMA CRES	CEL89	3601	D	1	B/WB	M	1.85	2.43	
OP	15	ORAMA CRES	CEL89	17712	D	2	B/F	M	1.71	1.96	
OP	16	ORAMA CRES	CEL89	3602	D	2	B/WB	M	1.71	2.57	
OP	17	ORAMA CRES	CEL89	3587	D	1	WB	M	1.77	2.20	
OP	19	ORAMA CRES	CEL89	3586	D	2	F	M	1.93	2.66	
OP	21	ORAMA CRES	CEL89	3585	D	2	B/F	M	2.05	2.14	
OP	22	ORAMA CRES	CEL89	3605	D	2	B	M	2.07	2.74	
OP	23	ORAMA CRES	CEL89	3584	D	E	B/F	M	2.13	5.20	
OP	24	ORAMA CRES	CEL89	3606	D	2	B	M	2.25	2.86	
OP	29	ORAMA CRES	CEL89	3582	D	2	B	M	1.99	2.46	
OP	31	ORAMA CRES	CEL89	3581	D	1	F	M	2.01	2.86	
OP	2	ORIENT POINT RD	CEL86	3710	D	1	WB	M	4.17	4.38	

LEGEND:

Material: B - brick; W/B - weatherboard; F - fibro; M - metal

Zone Location: BD - Bomaderry; SH - Shoalhaven Heads; GP - Green Point; OP - Orient Point; NW - Nowra

Type: AB - ablution block; CP - caravan park; O - office; F - farm; I - industrial; PS - pumping station; D - dwelling; U - units; C - commercial

Size: S - small; M - medium; L - large

ZONE /LOCATION	ST No	STREET NAME	RELEVANT CELL IN HYDRAULIC MODEL	UPN	TYPE	STOREYS	MATERIAL	SIZE	GROUND RL	FLOOR RL	REMARKS
OP	4	ORIENT POINT RD	CEL86	3711	D	1	WB	M	4.20	4.50	
OP	6	ORIENT POINT RD	CEL86	3712	D	1	WB	M	4.13	4.47	
OP	8	ORIENT POINT RD	CEL86	3713	D	2	WB	M	4.15	3.77	
OP	14	ORIENT POINT RD	CEL86	3716	D	1	F	S	4.04	4.48	
OP	16	ORIENT POINT RD	CEL86	3717	D	1	B	M	2.46	2.31	
OP	18	ORIENT POINT RD	CEL86	3718	D	2	B/WB	M	2.36	2.01	
OP	20	ORIENT POINT RD	CEL86	3719	D	1	F	M	2.66	2.90	
OP	22	ORIENT POINT RD	CEL86	3720	D	2	B/WB	M	2.44	2.10	
OP	24	ORIENT POINT RD	CEL86	3721	D	2	WB	M	2.30	2.25	
OP	26	ORIENT POINT RD	CEL86	3722	D	1	WB	M	2.08	3.10	
OP	28	ORIENT POINT RD	CEL86	3723	D	1	WB	M	1.82	2.07	
OP	30	ORIENT POINT RD	CEL86	3724	D	1	WB	M	1.82	2.17	
OP	32	ORIENT POINT RD	CEL86	3725	D	1	B/F	S	1.83	2.04	
OP	34	ORIENT POINT RD	CEL86	3726	D	1	WB	M	1.81	3.02	
OP	36	ORIENT POINT RD	CEL86	3727	D	1	F	M	1.69	2.04	
OP	38	ORIENT POINT RD	CEL86	3728	D	1	F	M	1.76	2.65	
OP	40	ORIENT POINT RD	CEL86	3729	D	1	B	M	1.88	3.02	
OP	42	ORIENT POINT RD	CEL86	3730	D	2	B/F	M	1.87	1.79	
OP	44	ORIENT POINT RD	CEL86	3731	D	1	WB	M	1.80	2.22	
OP	46	ORIENT POINT RD	CEL86	3732	D	2	B	M	1.89	2.11	
OP	48	ORIENT POINT RD	CEL86	3733	D	SPLIT	B	M	1.85	3.05	
OP	50	ORIENT POINT RD	CEL86	3734	D	2	B/WB	M	2.01	2.04	
OP	52	ORIENT POINT RD	CEL86	15168	D	2	B	M	2.22	2.08	
OP	54	ORIENT POINT RD	CEL86	15167	D	1	WB	S	2.36	2.49	
OP	58	ORIENT POINT RD	CEL86	3736	D	1	F	M	3.31	3.41	
OP	60	ORIENT POINT RD	CEL86	3737	D	1	B	M	3.77	3.94	
OP	34	ORONTES ST	CEL86	3801	D	2	B	M	3.77	3.98	
OP	45	OSTERLEY AVE	CEL86	3826	D	1	WB	S	4.06	4.11	
OP	47	OSTERLEY AVE	CEL86	3827	D	1	B	S	3.23	4.38	
OP	1	PALM WAY	CEL86	3944	D	1	WB	M	3.03	3.42	
OP	3	PALM WAY	CEL86	3943	D	1	B	M	3.03	3.47	
OP	5	PALM WAY	CEL86	3942	D	1	WB	M	3.45	4.01	
OP	13	PENGUINS HEAD RD	CEL86	4212	D	2	F	M	4.35	4.32	
OP	17	PENGUINS HEAD RD	CEL86	4210	F	2	B/WB	M	4.28	4.02	
OP	19	PENGUINS HEAD RD	CEL86	4209	D	1	F	M	3.96	4.42	
OP	21	PENGUINS HEAD RD	CEL86	4208	D	1	F	M	4.21	4.77	
OP	123	PRINCE EDWARD AVE	CEL86	4383	D					6.11	
OP	127	PRINCE EDWARD AVE	CEL86	4385	D					5.70	
OP	148	PRINCE EDWARD AVE	CEL86	4254	D	2	F	M	2.81	3.19	
OP	150	PRINCE EDWARD AVE	CEL86	4253	D	1	B	M	2.45	2.94	
OP	152	PRINCE EDWARD AVE	CEL86	4252	D	1	WB	M	2.11	2.85	
OP	156	PRINCE EDWARD AVE	CEL86	4250	D	1	WB	M	1.81	2.98	
OP	158	PRINCE EDWARD AVE	CEL86	4249	D	2	B	M	1.65	1.99	
OP	160	PRINCE EDWARD AVE	CEL86	4248	D	2	B/WB	M	1.85	2.10	
OP	162	PRINCE EDWARD AVE	CEL86	4247	D	2	B/F	M	1.93	1.99	
OP	170	PRINCE EDWARD AVE	CEL86	4245	D	1	F	M	2.72	3.55	
OP	174	PRINCE EDWARD AVE	CEL86	4243	D	1	WB	M	3.72	4.43	
OP	40	PRINCE EDWARD AVE	CEL86	4304	D	2	B/WB	M	3.49	3.66	
OP	41	PRINCE EDWARD AVE	CEL86	4344	D	1	WB	M	3.47	1.03	
OP	42	PRINCE EDWARD AVE	CEL86	4303	D	2	B/F	M	3.39	3.58	
OP	43	PRINCE EDWARD AVE	CEL86	4345	D	1	B	M	3.25	3.50	
OP	45	PRINCE EDWARD AVE	CEL86	84223	D	1	B	M	2.92	3.38	
OP	45A	PRINCE EDWARD AVE	CEL86	84224	D	1	B	M	3.00	3.23	
OP	46	PRINCE EDWARD AVE	CEL86	4301	D	1	WB	M	2.78	3.31	
OP	47	PRINCE EDWARD AVE	CEL86	4347	D	1	B	M	2.56	2.94	
OP	49	PRINCE EDWARD AVE	CEL86	4348	D	SPLIT	B	M	2.38	3.56	
OP	51	PRINCE EDWARD AVE	CEL86	4349	D	1	WB	M	2.11	3.12	
OP	52	PRINCE EDWARD AVE	CEL86	15178	D	1	B	M	2.43	3.08	
OP	53	PRINCE EDWARD AVE	CEL86	4350	D	E	F	M	2.00	4.75	
OP	54	PRINCE EDWARD AVE	CEL86	4298	D	2	B/WB	M	2.53	2.98	
OP	55	PRINCE EDWARD AVE	CEL86	4351	D	1	B	M	1.59	3.13	
OP	57	PRINCE EDWARD AVE	CEL86	4352	D	1	F	S	1.47	1.83	
OP	58	PRINCE EDWARD AVE	CEL86	4296	D	2	B	M	2.25	2.52	

LEGEND:

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Size: S - small; M - medium; L - large

ZONE /LOCATION	ST No	STREET NAME	RELEVANT CELL IN HYDRAULIC MODEL	UPN	TYPE	STOREYS	MATERIAL	SIZE	GROUND RL	FLOOR RL	REMARKS
OP	59	PRINCE EDWARD AVE	CEL86	4353	D	2	B/WB	M	1.48	1.55	
OP	61	PRINCE EDWARD AVE	CEL86	4354	D	2	B	M	1.75	1.91	
OP	62	PRINCE EDWARD AVE	CEL86	4295	D	1	B	M	2.34	3.04	
OP	63	PRINCE EDWARD AVE	CEL86	4355	D	1	B	M	1.69	3.02	
OP	64	PRINCE EDWARD AVE	CEL86	4294	D	1	B	M	2.32	2.45	
OP	65	PRINCE EDWARD AVE	CEL86	4356	D	1	WB	M	2.17	3.08	
OP	66	PRINCE EDWARD AVE	CEL86	4293	D	1	B	M	1.95	2.68	
OP	67	PRINCE EDWARD AVE	CEL86	4357	D	1	WB	M	2.27	3.18	
OP	68	PRINCE EDWARD AVE	CEL86	4292	D	2	B/WB	M	2.12	2.28	
OP	69	PRINCE EDWARD AVE	CEL86	4358	D	1	WB	M	2.67	3.07	
OP	70	PRINCE EDWARD AVE	CEL86	4291	D	1	B	M	2.25	2.67	
OP	71	PRINCE EDWARD AVE	CEL86	4359	D	1	F	M	2.88	3.44	
OP	72	PRINCE EDWARD AVE	CEL86	4290	D	2	B	M	2.55	2.90	
OP	73	PRINCE EDWARD AVE	CEL86	4360	D	1	WB	M	3.22	3.27	
OP	74	PRINCE EDWARD AVE	CEL86	4289	D	1	F	M	2.79	3.24	
OP	75	PRINCE EDWARD AVE	CEL86	4361	D	1	B	M	3.75	4.10	
OP	1	RAGLAN ST	CEL86	4417	D	1	WB	M	1.75	2.27	
OP	3	RAGLAN ST	CEL86	4418	D	1	WB	M	1.64	1.66	
OP	2	SUNSHINE ST	CEL86	4514	D	1	WB	M	3.83	3.96	
OP	4	SUNSHINE ST	CEL86	4515	D	1	WB	M	3.69	3.98	
OP	17	SUNSHINE ST	CEL86	82037	D	1	F	M	1.64	1.90	
OP	18	SUNSHINE ST	CEL86	15114	D	SPLIT	B/WB	M	1.50	1.48	
OP	1	THE BOWERY	CEL86	4547	D	1	F	M	2.16	3.04	
OP	3	THE BOWERY	CEL86	4546	D	1	B	M	2.84	3.32	
OP	1	THE STRAND	CEL86	19311	D	1	B	M	2.90	2.73	
OP	2	THE STRAND	CEL86	4824	D	1	WB	M	2.47	3.14	
OP	3	THE STRAND	CEL86	4838	D	1	B	M	3.37	3.82	
OP	4	THE STRAND	CEL86	4825	D	E	B/WB	M	2.67	5.63	
OP	5	THE STRAND	CEL86	4837	D	1	B	M	3.08	3.74	
OP	6	THE STRAND	CEL86	4826	D	1	WB	M	2.81	3.52	
OP	7	THE STRAND	CEL86	4836	D	2	WB	M	3.10	3.30	
OP	9	THE STRAND	CEL86	4835	D	1	F	M	3.45	4.39	
OP	20	THE TRIANGLE	CEL86	4841	D	1	B	M	3.64	4.03	
OP	21	THE TRIANGLE	CEL86	4840	D	1	F	M	3.19	4.52	
OP	22	THE TRIANGLE	CEL86	4870	D	2	B	M	2.41	2.51	
OP	23	THE TRIANGLE	CEL86	4869	D	2	B	L	2.62	3.12	
OP	24	THE TRIANGLE	CEL86	4868	D	1	B	M	2.77	3.09	
OP	26	THE TRIANGLE	CEL86	4866	I	2	B	M	3.76	3.73	
OP	24	WHISTLER ST	CEL86	5050	D	2	B/WB	M	2.47	3.27	
OP	26	WHISTLER ST	CEL86	5051	D	2	B/WB	M	2.50	3.41	
OP	30	WHISTLER ST	CEL86	5053	D					4.49	
NW	27	BRIDGE RD	CEL7	89900	C	2	B	M	3.87	4.66	
NW	8	HYAM ST	CEL7	78585	D	1	B	M	6.18	6.38	
NW	13	HYAM ST	CEL7	37072	D	1	B	M	4.60	5.45	
NW	27	HYAM ST	CEL7	37073	D	1	WB	S	5.92	6.31	
NW	19	MANDALAY AVE	CEL7	40455	D	1	F	M	6.74	6.96	
NW	12	SCENIC DR	CEL7	37802	D	1	F	M	5.68	6.43	
CARAVAN PARKS											
SH		JERRY BAILEY ROAD	CAMELIA C VAN PARK		AB				0.00	3.06	AMENITIES
SH		40 SHOALHAVEN HEADS RD	COASTAL PALMS C VAN PK	55324	AB				2.66	2.89	AMENITIES 1
SH		40 SHOALHAVEN HEADS RD	COASTAL PALMS C VAN PK	55324	AB				0.00	2.88	AMENITIES 2
SH			HAY AVE		AB				1.64	1.78	PUBLIC TOILET (MENS)
SH			HAY AVE		AB				0.00	1.77	PUBLIC TOILET (LADIES)
SH		HAY AVENUE	JANS C VAN PARK		AB				0.00	1.98	AMENITIES

LEGEND:

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SH		14 SHOALHAVEN HEADS RD	MOUNTAIN VIEW VILLAGE	187	AB				3.55	3.70	
SH			RIVER RD		AB	1	4 - B	1 - S	3.52	3.52	COUNCIL WC RESERVE JB & RIVER
SH		MCINTOSH ST	S/HEADS TOURIST PK	81456	AB	1	4 - B	2 - M	0.00	2.88	NW OF RECEPTION
SH		MCINTOSH ST	S/HEADS TOURIST PK	81456	AB	1	4 - B	2 - M	0.00	2.38	NE OF RECEPTION
SH		MCINTOSH ST	S/HEADS TOURIST PK	81456	AB	1	4 - B	1 - S	0.00	2.48	MENS TOILET
SH		MCINTOSH ST	S/HEADS TOURIST PK	81456	AB	1	4 - B	2 - M	0.00	2.52	SE OF RECEPTION
SH		MCINTOSH ST	S/HEADS TOURIST PK	81456	AB	1	4 - B	1 - S	0.00	2.00	SCC TOILETS
SH		SHOALHAVEN HEADS RD	TALL TIMBERS C VAN PK	75949	AB				2.38	2.67	
SH			HAY AVE		BOX				3.00	3.68	UNDER SIDE OF ELEC BOX P/S1
SH			JERRY BAILEY RD		BOX				1.17	1.66	UNDER SIDE OF ELEC BOX P/S2
SH			McINTOSH STREET		BOX				0.00	3.34	UNDER SIDE OF ELEC BOX P/S5
SH			SCOTT ST		BOX				0.00	3.03	ELECT BOX SEWER P/S10
SH			SEWER TREAT PLANT		BOX				0.00	5.39	BASE ELECT BOX
SH			SHOALHAVEN HEADS RD		BOX				2.72	3.14	UNDER SIDE OF ELEC BOX P/S3
SH		JERRY BAILEY ROAD	CAMELIA C VAN PARK	1438	CABIN				2.38	2.87	LOWEST
SH		JERRY BAILEY ROAD	CAMELIA C VAN PARK	1512	CABIN				3.16	3.57	HIGHEST
SH		40 SHOALHAVEN HEADS RD	COASTAL PALMS C VAN PK	55324	CABIN				0.00	4.04	No 154 HIGHEST CABIN
SH		HAY AVENUE	JANS C VAN PARK		CABIN				0.00	2.19	CABIN No 4 (4 CABINS ONLY)
SH		HAY AVENUE	JANS C VAN PARK		CABIN				0.00	2.24	CABIN No 3
SH		HAY AVENUE	JANS C VAN PARK		CABIN				1.70	2.16	CABIN No 1
SH		14 SHOALHAVEN HEADS RD	MOUNTAIN VIEW VILLAGE	187	CABIN				0.00	2.48	CABIN No 5 LOWEST
SH		MCINTOSH ST	S/HEADS TOURIST PK	81456	CABIN				0.00	2.52	DUNE CABIN No 14 LOWEST
SH		MCINTOSH ST	S/HEADS TOURIST PK	81456	CABIN				0.00	3.10	CABIN No Y9 HIGHEST
SH		MCINTOSH ST	S/HEADS TOURIST PK	81456	CABIN		2 - WB	1 - S	0.00	2.78	CABIN No G23
SH		SHOALHAVEN HEADS RD	TALL TIMBERS C VAN PK	75949	CABIN				0.00	3.81	No 181 HIGHEST
SH		SHOALHAVEN HEADS RD	TALL TIMBERS C VAN PK	75949	CABIN				0.00	2.46	No 115 LOWEST
SH		MCINTOSH ST	S/HEADS TOURIST PK	81456	CABIN 1	1	3 - F	1 - S	0.00	2.18	CABIN No 1
SH		MCINTOSH ST	S/HEADS TOURIST PK	81456	CABIN 18	1	3 - F	1 - S	0.00	3.00	DUNE CABIN No 18 HIGHEST
SH		32 SHOALHAVEN HEADS RD	BURRAWONG PARK	81244	CABIN				0.00	2.84	CABIN LOWEST

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Type: AB - ablution block; CP - caravan park; O - office; F - farm; I - industrial; PS - pumping station; D - dwelling; U - units; C - commercial

Size: S - small; M - medium; L - large

ZONE /LOCATION	ST No	STREET NAME	RELEVANT CELL IN HYDRAULIC MODEL	UPN	TYPE	STOREYS	MATERIAL	SIZE	GROUND RL	FLOOR RL	REMARKS
SH		32 SHOALHAVEN HEADS RD	BURRAWONG PARK		CABIN				0.00	3.48	CABIN HIGHEST
SH		JERRY BAILEY ROAD	CAMELIA C VAN PARK	1439	CP	1	3 - F	1 - S	3.53	3.70	OFFICE/STOREROOM/RES
SH		32 SHOALHAVEN HEADS RD	BURRAWONG PARK	55323	CP/O	2	4 - B	3 - L	2.57	2.57	
SH		40 SHOALHAVEN HEADS RD	COASTAL PALMS C VAN PK	55324	CP/O	1	4 - B	2 - M	2.69	3.01	
SH		14 SHOALHAVEN HEADS RD	MOUNTAIN VIEW VILLAGE	187	CP/O	2	6 - Stone	3 - L	2.62	2.66	
SH		MCINTOSH ST	S/HEADS TOURIST PK	81456	CP/O	1	4 - B	2 - M	0.00	2.96	MANAGERS RES & OFFICE
SH		SHOALHAVEN HEADS RD	TALL TIMBERS C VAN PK	75949	CP/O	1	4 - B	1 - S	2.24	2.46	
SH		SHOALHAVEN HEADS RD	TALL TIMBERS C VAN PK	75949	MANAGER	1	4 - B	2 - M	2.50	3.00	
SH		SHOALHAVEN HEADS RD	TALL TIMBERS C VAN PK	75949	OFFICE	1	4 - B	2 - M	2.38	2.41	
SH		JERRY BAILEY ROAD	CAMELIA C VAN PARK	1511	VAN				2.30	2.42	No 1 LOWEST ANNEXE
SH		JERRY BAILEY ROAD	CAMELIA C VAN PARK	1510	VAN				0.00	4.97	No 13 HIGHEST ANNEXE
SH		40 SHOALHAVEN HEADS RD	COASTAL PALMS C VAN PK	55324	VAN				0.00	2.48	No 85 LOWEST VAN
SH		40 SHOALHAVEN HEADS RD	COASTAL PALMS C VAN PK	55324	VAN				0.00	2.70	No 101 HIGHEST VAN
SH		HAY AVENUE	JANS C VAN PARK	1364	VAN				0.00	2.20	HIGHEST
SH		HAY AVENUE	JANS C VAN PARK	1365	VAN				0.00	1.66	No 8 LOWEST
SH		HAY AVENUE	JANS C VAN PARK	1366	VAN				0.00	2.20	No 23 HIGHEST
SH		14 SHOALHAVEN HEADS RD	MOUNTAIN VIEW VILLAGE	187	VAN				0.00	1.70	No 2 LOWEST (ANNEXE)
SH		MCINTOSH ST	S/HEADS TOURIST PK	81456	VAN				0.00	1.46	A15 LOWEST ANNEXE
SH		MCINTOSH ST	S/HEADS TOURIST PK	81456	VAN				0.00	2.14	H2
SH		MCINTOSH ST	S/HEADS TOURIST PK	81456	VAN				0.00	1.79	H9
SH		SHOALHAVEN HEADS RD	TALL TIMBERS C VAN PK	75949	VAN				0.00	3.57	No 145 HIGHEST (ANNEXE)
SH		SHOALHAVEN HEADS RD	TALL TIMBERS C VAN PK	75949	VAN				0.00	1.96	No 116 LOWEST (ANNEXE)
SH			RENOWN AVE						3.28	4.31	TELSTRA INSTALLATION
SH	38	38 SCOTT ST	SCOTT ST	85710					3.65	3.74	CONC SLAB SEWER PUMP P/S7
BD	PS8	MEROO RD	CEL4	56541	PS					4.82	PUMP STATION
BD		SEWERAGE TREATMENT WORKS	CEL4	31162	PS					4.05	AMENITIES AND ELECTRICAL
BD	PS7	BOLONG RD	CEL18	41299	PS					3.84	PUMP STATION
BD	PS4	BOLONG RD	CEL9	77211	PS					4.33	PUMP STATION
BD	PS5	BOLONG RD	CEL15	41946	PS					4.73	PUMP STATION
BD		BOLONG RD	CEL15	42254	PS					3.73	ELEC PLINTH
BD	PS9	CONCORDE WAY	CEL4	30518	PS					5.74	PUMP STATION

LEGEND:

Material: B - brick; W/B - weatherboard; F - fibro; M - metal

Zone Location: BD - Bomaderry; SH - Shoalhaven Heads; GP - Green Point; OP - Orient Point; NW - Nowra

Type: AB - ablution block; CP - caravan park; O - office; F - farm; I - industrial; PS - pumping station; D - dwelling; U - units; C - commercial

Size: S - small; M - medium; L - large

ZONE /LOCATION	ST No	STREET NAME	RELEVANT CELL IN HYDRAULIC MODEL	UPN	TYPE	STOREYS	MATERIAL	SIZE	GROUND RL	FLOOR RL	REMARKS
BD	PS6	PRINCES HWY	CEL9	40811	PS					6.87	PUMP STATION
GP	NO 15	PUMP STN (WEST ST)	CEL81	47727	PS					2.33	ELECT PLINTH
GP	NO 16	PUMP STN (HUME ST)	CEL85	56433	PS					2.24	ELECT PLINTH
GP	NO 14	PUMP STN (CHURCH ST)	CEL85	628	PS					2.24	ELECT PLINTH
GP	NO 17	PUMP STN (GREENS RD)	CEL85	56768	PS					2.16	ELECT PLINTH
GP	NO 13	PUMP STN (ADELAIDE ST)	CEL85	38350	PS					2.32	ELECT PLINTH
NW	PS2	LYREBIRD PARK	CEL31	40938	PS					3.90	
NW	PS13	SALISBURY DR	CEL31	40938	PS					3.94	
NW	PS11	WONDALGA CRES	CEL31	53579	PS					4.45	
NW	PS6	KMART	CEL31	90361	PS					4.49	
NW	PS10	NORTH ST	CEL31	55591	PS					4.32	
NW	PS9	PLUNKETT ST	CEL31	32328	PS					3.21	
NW	PS22	GREENWELL PT RD	CEL52	75531	PS					5.78	
NW	PS12	WORRIGEE RD	CEL52	53472	PS					3.93	
NW	PS20	ASCALON CL	CEL52	80557	PS					5.21	
NW		NOWRA TREATMENT WORK	CEL31	54977	PS					4.05	
NW	PS4	NOWRA POOL	CEL7	68869	PS					5.12	
OP	PS2	NEAR 1 ORANA	CEL86	3595	PS					2.11	
OP	PS1	NEAR 34 ORONTES	CEL86	3825	PS					3.01	
OP	PS3	NEAR 3 RAGLAN	CEL86	4418	PS					2.27	
OP	PS5	NEAR 47 ADDISON	CEL86	2569	PS					2.24	
OP	PS12	1 BRIGHTON	CEL86	2723	PS					2.23	
NW	PS4	SCENIC DR	CEL7	68869	PS					5.12	
GP	109	ADELAIDE ST	CEL81	10825	D	1	F	M		1.76	OFFICE
GP	111	ADELAIDE ST	CEL81	10824	AMENITIES	1				1.79	AMENITIES
GP	113	ADELAIDE ST	CEL81	10823	CABIN	1				2.08	CABIN
GP			CEL81		SITES Aprox. 37					1.36	1.36(L) 2.35(H)
GP	142	GREENS RD	CEL85	15197	CORAL TREE LODGE				1.63		CORAL TREE LODGE
GP		OFFICE	CEL85		OFFICE	1	B	M	1.63	1.72	OFFICE
GP		AMENITIES	CEL85		AMENITIES	1	B	M		1.74	AMENITIES
GP		CABIN	CEL85		CABIN	1				1.80	1.80(L) 2.21(H)
GP		UNIT	CEL85		U	1				1.64	UNIT
GP		SITES Approx.100	CEL85		SITES Approx.100					1.62	1.62(L) 1.83(H)
NW	15	WEST ST	CEL81	2130	PINE VAN PARK				1.29		PINE VAN PARK
NW		OFFICE	CEL81		OFFICE				1.29	3.01	OFFICE
NW		AMENITIES	CEL81		AMENITIES					2.25	AMENITIES
NW		CABIN	CEL81		CABIN					2.51	CABIN
NW		SITES Approx.100	CEL81		SITES Approx.100					1.57	1.57(L) 2.38(H)
			CEL81								
SH		SHOALHAVEN SKI PARK	CEL5	70745	OFFICE		B	S		6.98	OFFICE
SH		AMENITIES	CEL5		AMENITIES		B	M		7.92	AMENITIES
SH		MANAGER	CEL5		MANAGER		B	M		8.00	MANAGER
SH		SITES (Approx 100)	CEL5		SITES (Approx 100)					2.67	2.67(L) 7.86(H)
NW		GOLF DRIVING RANGE	CEL6	33909	C					2.43	
		SELBYS SOUTH COAST			C		B	L		4.00	C
		REGANS MOWERS			C					4.36	
OP		CULBURRA BEACH VAN PARK	CEL86						1.99		
OP		MANAGER	CEL86		MANAGER		F	S	1.99	4.22	MANAGER
OP		AMENITIES	CEL86		AMENITIES					4.06	AMMENITIES
OP		SITES (APPROX.40)	CEL86		SITES (APPROX.40)					2.22	2.22(L) 4.80(H)
OP		CABIN	CEL86		CABIN					3.85	CABIN
NW		SCENIC DR	CEL7	37800	UNITS(17-22)		F	L	3.55	3.55	UNITS(17-22)
NW		RIVERHAVEN MOTEL			MOTEL						RIVERHAVEN MOTEL
BD		**Boweld Factory - Steel fabricating factory**									
BD		Factory floor	CEL57	30223	C					4.71	
BD		Residence	CEL57		D				4.47	7.53	
BD		Office	CEL57		C					8.22	

LEGEND:

Material: B - brick; W/B - weatherboard; F - fibro; M - metal

Zone Location: BD - Bomaderry; SH - Shoalhaven Heads; GP - Green Point; OP - Orient Point; NW - Nowra

Type: AB - ablution block; CP - caravan park; O - office; F - farm; I - industrial; PS - pumping station; D - dwelling; U - units; C - commercial

Size: S - small; M - medium; L - large

ZONE /LOCATION	ST No	STREET NAME	RELEVANT CELL IN HYDRAULIC MODEL	UPN	TYPE	STOREYS	MATERIAL	SIZE	GROUND RL	FLOOR RL	REMARKS
BD		**Dairy Farmers - The plant was constructed approximately 15 years ago and is elevated over 1.5 m above the general ground level.**									
BD		Transformer & Switchroom	CEL29		I						
BD		Main floor	CEL29	84373	I						CALCULATED BY FLOOR AREA OF 5000 m^2 / 200
BD		**Paper Mill Plant - comprises some 60 buildings. The majority are at ground level with the main plant on two floors.**									
BD		Administration	CEL57	86630	C					3.40	Floor levels range from 3.4 to 3.7m
BD		Finished product store	CEL57	42261	I					3.72	Paper is stored in rolls on the floor or on pallets for shipping.
BD		Manildra Starches	CEL26	84372	I					4.00	Approx only

Table D2: Properties Inundated above Floor Level 10% AEP Flood

No.	LOCATION	ST No	STREET NAME	GROUND RL	FLOOR RL	DEPTH OF INUNDATION ABOVE 10% AEP		DEPTH OF INUNDATION ABOVE 1% AEP	
						Ground	Floor	Ground	Floor
1	Nowra		GOLF DRIVING RANGE		2.43		2.81		5.20
2	Nowra		SCENIC DR	3.55	3.55	1.35	1.35	3.02	3.02
3	Shoalhaven Heads	6	HAY AVE	1.44	1.42	1.05	1.06	1.86	1.88
4	Shoalhaven Heads	2	WHARF RD	0.00	1.50	2.49	0.99	3.30	1.81
5	Greenwell Point	42	ADELAIDE ST	1.58	1.04	0.44	0.98	1.54	2.08
6	Bomaderry	22	BOLONG RD	3.60	3.64	1.00	0.96	2.38	2.34
7	Orient Point	41	PRINCE EDWARD AVE	3.47	1.03		0.91		2.17
8	Bomaderry		BOLONG RD		3.73		0.87		2.24
9	Shoalhaven Heads		HAY AVENUE		1.66		0.84		1.66
10	Bomaderry	PS7	BOLONG RD		3.84		0.75		1.85
11	Shoalhaven Heads	76	JERRY BAILEY RD	1.85	1.78	0.64	0.70	1.46	1.52
12	Shoalhaven Heads	38	HAY AVE	1.76	1.80	0.72	0.68	1.54	1.50
13	Shoalhaven Heads	10	HAY AVE	1.56	1.82	0.93	0.67	1.74	1.48
14	Greenwell Point	7	CHURCH ST	1.28	1.37	0.74	0.64	1.84	1.75
15	Greenwell Point	55	ADELAIDE ST	1.42	1.40	0.60	0.62	1.70	1.72
16	Greenwell Point	39	COMARONG ST	1.38	1.41	0.64	0.60	1.74	1.71
17	Shoalhaven Heads	4	HAY AVE	1.22	1.89	1.27	0.60	2.08	1.42
18	Greenwell Point	39	ADELAIDE ST	1.40	1.42	0.62	0.60	1.72	1.70
19	Shoalhaven Heads	26	HAY AVE	1.64	1.92	0.85	0.57	1.66	1.38
20	Orient Point	54	ADDISON RD	1.39	1.38	0.55	0.56	1.81	1.82
21	Greenwell Point	24	ADELAIDE ST	1.28	1.46	0.74	0.56	1.84	1.66
22	Greenwell Point	31	ADELAIDE ST	1.36	1.46	0.66	0.56	1.76	1.66
23	Greenwell Point	84	GREENWELL POINT RD	1.64	1.39	0.30	0.55	1.56	1.81
24	Greenwell Point	26	ADELAIDE ST	1.44	1.47	0.58	0.55	1.68	1.65
25	Greenwell Point	50	ADELAIDE ST	1.43	1.48	0.58	0.54	1.69	1.64
26	Shoalhaven Heads	78	JERRY BAILEY RD	1.74	1.96	0.75	0.53	1.56	1.34
27	Greenwell Point	37	COMARONG ST	1.43	1.50	0.58	0.52	1.69	1.62
28	Greenwell Point	59	COMARONG ST	1.52	1.50	0.50	0.52	1.60	1.62
29	Bomaderry	22	BOLONG RD	3.60	4.09	1.00	0.51	2.38	1.88
30	Shoalhaven Heads	1282	BOLONG RD	1.80	1.98	0.69	0.51	1.50	1.32
31	Shoalhaven Heads		JERRY BAILEY RD	1.97	1.99	0.52	0.50	1.34	1.32
32	Bomaderry	24	BOLONG RD	3.60	4.11	1.00	0.49	2.38	1.86
33	Greenwell Point	69	HAISER RD	1.23	1.46	0.71	0.48	1.97	1.74
34	Greenwell Point	5	LEONORE AVE	1.55	1.47	0.39	0.47	1.65	1.73
35	Greenwell Point	22	ADELAIDE ST	1.22	1.55	0.80	0.46	1.90	1.57
36	Greenwell Point	51	COMARONG ST	1.52	1.55	0.50	0.46	1.60	1.57
37	Greenwell Point	3	LEONORE AVE	1.47	1.48	0.47	0.46	1.73	1.72
38	Orient Point	18	SUNSHINE ST	1.50	1.48	0.44	0.46	1.70	1.72
39	Bomaderry	41	BOLONG RD	2.90	4.15	1.71	0.46	3.19	1.94
40	Greenwell Point	6	ADELAIDE ST	1.57	1.59	0.44	0.42	1.55	1.53
41	Greenwell Point	48	ADELAIDE ST	1.45	1.60	0.57	0.42	1.67	1.52
42	Greenwell Point	43	HAISER RD	1.47	1.55	0.47	0.39	1.73	1.65
43	Orient Point	59	PRINCE EDWARD AVE	1.48	1.55	0.46	0.39	1.72	1.65
44	Greenwell Point	11	ADELAIDE ST	1.19	1.63	0.82	0.38	1.93	1.49
45	Greenwell Point	16	ADELAIDE ST	1.51	1.63	0.50	0.38	1.61	1.49
46	Greenwell Point	123	GREENS RD	1.49	1.56	0.45	0.38	1.71	1.64
47	Greenwell Point	51	HAISER RD	1.54	1.56	0.40	0.38	1.66	1.64
48	Greenwell Point	73	HAISER RD	1.45	1.56	0.49	0.38	1.75	1.64
49	Greenwell Point	7	ADELAIDE ST	1.30	1.64	0.72	0.38	1.82	1.48
50	Greenwell Point	12	ADELAIDE ST	1.44	1.64	0.58	0.38	1.68	1.48
51	Greenwell Point	59	ADELAIDE ST	1.46	1.64	0.56	0.38	1.66	1.48
52	Greenwell Point	11	COMARONG ST	1.59	1.64	0.42	0.38	1.53	1.48
53	Greenwell Point	9	KEITH AVE	1.44	1.57	0.50	0.37	1.76	1.63
54	Greenwell Point	59	HAISER RD	1.39	1.58	0.55	0.36	1.81	1.62
55	Orient Point	58	ADDISON RD	1.43	1.58	0.51	0.36	1.77	1.62
56	Greenwell Point	81	ADELAIDE ST	1.55	1.66	0.46	0.36	1.57	1.46
57	Shoalhaven Heads	2	HAY AVE	1.90	2.14	0.59	0.35	1.40	1.17
58	Greenwell Point	61	GREENS RD	1.52	1.59	0.42	0.35	1.68	1.61
59	Greenwell Point	2	KEITH AVE	1.49	1.59	0.45	0.35	1.71	1.61
60	Greenwell Point	63	ADELAIDE ST	1.51	1.67	0.50	0.34	1.61	1.45
61	Bomaderry	64	BOLONG RD	3.48	4.27	1.13	0.34	2.61	1.82
62	Greenwell Point	15	ADELAIDE ST	1.28	1.69	0.74	0.32	1.84	1.43
63	Greenwell Point	16	BAILEY AVE	1.57	1.62	0.37	0.32	1.63	1.58
64	Greenwell Point	66	ADELAIDE ST	1.58	1.70	0.44	0.32	1.54	1.42
65	Greenwell Point	125	GREENS RD	1.45	1.63	0.49	0.31	1.75	1.57
66	Greenwell Point	42	HAISER RD	1.42	1.63	0.52	0.31	1.78	1.57

No.	LOCATION	ST No	STREET NAME	GROUND RL	FLOOR RL	DEPTH OF INUNDATION ABOVE 10% AEP		DEPTH OF INUNDATION ABOVE 1% AEP	
						Ground	Floor	Ground	Floor
67	Greenwell Point	55	COMARONG ST	1.70	1.72	0.32	0.30	1.42	1.40
68	Greenwell Point	52	HAISER RD	1.62	1.65	0.32	0.29	1.58	1.55
69	Greenwell Point	1	CHURCH ST	1.68	1.73	0.34	0.29	1.44	1.39
70	Greenwell Point	31	COMARONG ST	1.58	1.73	0.44	0.29	1.54	1.39
71	Shoalhaven Heads		HAY AVENUE		2.20		0.29		1.12
72	Greenwell Point	76	GREENS RD	1.36	1.66	0.58	0.28	1.84	1.54
73	Orient Point	45	ADDISON RD	1.64	1.66	0.30	0.28	1.56	1.54
74	Orient Point	3	RAGLAN ST	1.64	1.66	0.30	0.28	1.56	1.54
75	Bomaderry	PS4	BOLONG RD		4.33		0.28		1.76
76	Greenwell Point	3	ADELAIDE ST	1.25	1.74	0.76	0.28	1.87	1.38
77	Greenwell Point	14	BAILEY AVE	1.52	1.67	0.42	0.27	1.68	1.53
78	Greenwell Point	70	GREENS RD	1.37	1.67	0.57	0.27	1.83	1.53
79	Greenwell Point	11	KEITH AVE	1.46	1.67	0.48	0.27	1.74	1.53
80	Greenwell Point	4	PYREE ST	1.65	1.75	0.36	0.26	1.47	1.37
81	Greenwell Point	15	BAILEY AVE	1.60	1.68	0.34	0.26	1.60	1.52
82	Greenwell Point	68	GREENS RD	1.44	1.68	0.50	0.26	1.76	1.52
83	Orient Point	27	ADDISON RD	1.61	1.68	0.33	0.26	1.59	1.52
84	Greenwell Point	9	ADELAIDE ST	1.19	1.76	0.82	0.26	1.93	1.36
85	Greenwell Point	18	ADELAIDE ST	1.38	1.76	0.64	0.26	1.74	1.36
86	Greenwell Point	36	ADELAIDE ST	1.43	1.76	0.58	0.26	1.69	1.36
87	Greenwell Point	109	ADELAIDE ST		1.76		0.26		1.36
88	Greenwell Point	32	HAISER RD	1.59	1.69	0.35	0.25	1.61	1.51
89	Greenwell Point	53	ADELAIDE ST	1.36	1.77	0.66	0.24	1.76	1.35
90	Greenwell Point	3	CROOKHAVEN DR	1.53	1.70	0.41	0.24	1.67	1.50
91	Greenwell Point	7	LEONORE AVE	1.42	1.70	0.52	0.24	1.78	1.50
92	Greenwell Point	18	SOUTH ST	1.76	1.70	0.18	0.24	1.44	1.50
93	Bomaderry	6	WORTHINGTON WAY (PRIV)	3.17	4.37	1.44	0.24	2.92	1.72
94	Nowra	27	BRIDGE RD	3.87	4.66	1.03	0.24	2.70	1.91
95	Greenwell Point	64	ADELAIDE ST	1.63	1.78	0.38	0.24	1.49	1.34
96	Greenwell Point	71	ADELAIDE ST	1.74	1.78	0.28	0.24	1.38	1.34
97	Greenwell Point	112	GREENWELL POINT RD	1.87	1.71	0.07	0.23	1.33	1.49
98	Greenwell Point	53	HAISER RD	1.39	1.71	0.55	0.23	1.81	1.49
99	Greenwell Point	57	HAISER RD	1.34	1.71	0.60	0.23	1.86	1.49
100	Greenwell Point	61	HAISER RD	1.30	1.71	0.64	0.23	1.90	1.49
101	Orient Point	25	ADDISON RD	1.83	1.71	0.11	0.23	1.37	1.49
102	Greenwell Point	19	ADELAIDE ST	1.78	1.79	0.24	0.22	1.34	1.33
103	Greenwell Point	90	ADELAIDE ST	1.76	1.79	0.26	0.22	1.36	1.33
104	Greenwell Point	111	ADELAIDE ST		1.79		0.22		1.33
105	Greenwell Point	61	COMARONG ST	1.67	1.80	0.34	0.22	1.45	1.32
106	Greenwell Point	28	HAISER RD	1.60	1.73	0.34	0.21	1.60	1.47
107	Orient Point	17	ADDISON RD	1.49	1.73	0.45	0.21	1.71	1.47
108	Shoalhaven Heads	12	HAY AVE	1.96	2.28	0.53	0.21	1.34	1.02
109	Greenwell Point	38	ADELAIDE ST	1.57	1.81	0.44	0.20	1.55	1.31
110	Greenwell Point	1A	CHURCH ST	1.34	1.81	0.68	0.20	1.78	1.31
111	Greenwell Point	8	KEITH AVE	1.60	1.74	0.34	0.20	1.60	1.46
112	Shoalhaven Heads	50	HAY AVE	2.08	2.29	0.41	0.20	1.23	1.02
113	Greenwell Point	6	HAISER RD	1.73	1.75	0.21	0.19	1.47	1.45
114	Greenwell Point	23	HAISER RD	1.72	1.75	0.22	0.19	1.48	1.45
115	Greenwell Point	68	HAISER RD	1.24	1.75	0.70	0.19	1.96	1.45
116	Greenwell Point	83	ADELAIDE ST	1.67	1.83	0.34	0.18	1.45	1.29
117	Greenwell Point	17	BAILEY AVE	1.55	1.76	0.39	0.18	1.65	1.44
118	Greenwell Point	26	HAISER RD	1.66	1.76	0.28	0.18	1.54	1.44
119	Shoalhaven Heads	3	WHARF RD	1.46	2.31	1.02	0.18	1.84	1.00
120	Greenwell Point	5	ADELAIDE ST	1.29	1.84	0.72	0.18	1.83	1.28
121	Greenwell Point	14	ADELAIDE ST	1.41	1.84	0.60	0.18	1.71	1.28
122	Greenwell Point	11	CROOKHAVEN DR	1.68	1.77	0.26	0.17	1.52	1.43
123	Greenwell Point	117	GREENS RD	1.50	1.77	0.44	0.17	1.70	1.43
124	Greenwell Point	29	HAISER RD	1.73	1.77	0.21	0.17	1.47	1.43
125	Greenwell Point	46	HAISER RD	1.53	1.77	0.41	0.17	1.67	1.43
126	Greenwell Point	67	ADELAIDE ST	1.84	1.85	0.18	0.16	1.28	1.27
127	Greenwell Point	49	COMARONG ST	1.69	1.85	0.32	0.16	1.43	1.27
128	Shoalhaven Heads	70	JERRY BAILEY RD	2.00	2.33	0.49	0.16	1.30	0.98
129	Greenwell Point	1	CROOKHAVEN DR	1.61	1.78	0.33	0.16	1.59	1.42
130	Greenwell Point	67	HAISER RD	1.61	1.78	0.33	0.16	1.59	1.42
131	Shoalhaven Heads	40	HAY AVE	2.13	2.33	0.36	0.16	1.18	0.98
132	Shoalhaven Heads	48	SHOALHAVEN HEADS RD	2.93	2.33	-0.44	0.16	0.38	0.98
133	Greenwell Point	13	BAILEY AVE	1.65	1.79	0.29	0.15	1.55	1.41
134	Greenwell Point	65	HAISER RD	1.25	1.79	0.69	0.15	1.95	1.41
135	Orient Point	15	ADDISON RD	1.46	1.79	0.48	0.15	1.74	1.41

No.	LOCATION	ST No	STREET NAME	GROUND RL	FLOOR RL	DEPTH OF INUNDATION ABOVE 10% AEP		DEPTH OF INUNDATION ABOVE 1% AEP	
						Ground	Floor	Ground	Floor
136	Orient Point	42	ORIENT POINT RD	1.87	1.79	0.07	0.15	1.33	1.41
137	Bomaderry		BOLONG RD	4.56	4.46	0.05	0.15	1.53	1.63
138	Greenwell Point	57	ADELAIDE ST	1.44	1.87	0.58	0.14	1.68	1.25
139	Greenwell Point	3	FRASER AVE	1.31	1.80	0.63	0.14	1.89	1.40
140	Greenwell Point	49	ADELAIDE ST	1.38	1.88	0.64	0.14	1.74	1.24
141	Greenwell Point	73	ADELAIDE ST	1.80	1.88	0.22	0.14	1.32	1.24
142	Shoalhaven Heads	20	HAY AVE	1.31	2.36	1.18	0.13	2.00	0.95
143	Greenwell Point	72	HAISER RD	1.51	1.81	0.43	0.13	1.69	1.39
144	Shoalhaven Heads	91	JERRY BAILEY RD	1.70	2.37	0.79	0.12	1.60	0.94
145	Greenwell Point	27	HAISER RD	1.60	1.82	0.34	0.12	1.60	1.38
146	Greenwell Point	13	KEITH AVE	1.45	1.82	0.49	0.12	1.75	1.38
147	Greenwell Point	1	LEONORE AVE	1.49	1.82	0.45	0.12	1.71	1.38
148	Orient Point	55	ADDISON RD	1.38	1.82	0.56	0.12	1.82	1.38
149	Greenwell Point	34	ADELAIDE ST	1.42	1.90	0.60	0.12	1.70	1.22
150	Shoalhaven Heads		MCINTOSH ST		2.38		0.12		0.94
151	Shoalhaven Heads	16	HAY AVE	1.49	2.38	1.00	0.11	1.82	0.93
152	Greenwell Point	64	HAISER RD	1.30	1.83	0.64	0.11	1.90	1.37
153	Orient Point	31	ADDISON RD	1.64	1.83	0.30	0.11	1.56	1.37
154	Orient Point	57	PRINCE EDWARD AVE	1.47	1.83	0.47	0.11	1.73	1.37
155	Shoalhaven Heads	1	WHARF RD	1.50	2.38	0.99	0.11	1.80	0.92
156	Greenwell Point	3	WEST ST	1.31	1.91	0.70	0.10	1.81	1.21
157	Greenwell Point	22	WEST ST	1.82	1.91	0.20	0.10	1.30	1.21
158	Greenwell Point	44	HAISER RD	1.45	1.84	0.49	0.10	1.75	1.36
159	Greenwell Point	62	ADELAIDE ST	1.60	1.93	0.42	0.09	1.52	1.19
160	Greenwell Point	86	ADELAIDE ST	1.86	1.93	0.16	0.09	1.26	1.19
161	Greenwell Point	3	CHURCH ST	1.57	1.93	0.44	0.09	1.55	1.19
162	Shoalhaven Heads	22	HAY AVE	1.41	2.41	1.08	0.08	1.90	0.90
163	Shoalhaven Heads	90	JERRY BAILEY RD	2.18	2.41	0.31	0.08	1.12	0.90
164	Greenwell Point	62	GREENS RD	1.40	1.86	0.54	0.08	1.80	1.34
165	Greenwell Point	8	HAISER RD	1.70	1.86	0.24	0.08	1.50	1.34
166	Orient Point	13	ADDISON RD	1.58	1.86	0.36	0.08	1.62	1.34
167	Orient Point	19	ADDISON RD	1.66	1.86	0.28	0.08	1.54	1.34
168	Shoalhaven Heads	119	JERRY BAILEY RD	1.90	2.41	0.59	0.08	1.40	0.90
169	Greenwell Point	1	ADELAIDE ST	1.14	1.94	0.88	0.08	1.98	1.18
170	Greenwell Point	25	COMARONG ST	1.91	1.94	0.10	0.08	1.21	1.18
171	Greenwell Point	47	COMARONG ST	1.75	1.94	0.26	0.08	1.37	1.18
172	Greenwell Point	72	GREENS RD	1.37	1.87	0.57	0.07	1.83	1.33
173	Greenwell Point	55	HAISER RD	1.31	1.87	0.63	0.07	1.89	1.33
174	Greenwell Point	62	HAISER RD	1.25	1.87	0.69	0.07	1.95	1.33
175	Greenwell Point	66	HAISER RD	1.28	1.87	0.66	0.07	1.92	1.33
176	Greenwell Point	1	MORRISSEY WAY	2.15	1.87	-0.21	0.07	1.05	1.33
177	Orient Point	62	ADDISON RD	1.68	1.87	0.26	0.07	1.52	1.33
178	Shoalhaven Heads		JERRY BAILEY ROAD	2.30	2.42	0.19	0.07	1.02	0.90
179	Shoalhaven Heads	31	JERRY BAILEY RD	2.42	2.42	0.07	0.07	0.88	0.88
180	Greenwell Point	33	ADELAIDE ST	1.34	1.95	0.68	0.07	1.78	1.17
181	Orient Point	1	ORAMA CRES	1.61	1.80	0.25	0.06	1.26	1.07
182	Shoalhaven Heads	93	JERRY BAILEY RD	1.74	2.43	0.75	0.06	1.56	0.88
183	Shoalhaven Heads	99	JERRY BAILEY RD	1.87	2.43	0.62	0.06	1.44	0.88
184	Greenwell Point	8	LEONORE AVE	1.46	1.88	0.48	0.06	1.74	1.32
185	Greenwell Point	45	ADELAIDE ST	1.33	1.96	0.68	0.06	1.79	1.16
186	Greenwell Point	74	ADELAIDE ST	1.89	1.96	0.12	0.06	1.23	1.16
187	Shoalhaven Heads	60	JERRY BAILEY RD	2.14	2.44	0.35	0.05	1.16	0.87
188	Greenwell Point	4	KEITH AVE	1.42	1.89	0.52	0.05	1.78	1.31
189	Orient Point	23	ADDISON RD	1.78	1.89	0.16	0.05	1.42	1.31
190	Greenwell Point	13	ADELAIDE ST	1.31	1.97	0.70	0.05	1.81	1.15
191	Bomaderry	36	BOLONG RD	4.94	4.56	-0.34	0.04	1.03	1.42
192	Greenwell Point	74	GREENS RD	1.32	1.90	0.62	0.04	1.88	1.30
193	Orient Point	9	ADDISON RD	1.49	1.90	0.45	0.04	1.71	1.30
194	Orient Point	17	SUNSHINE ST	1.64	1.90	0.30	0.04	1.56	1.30
195	Greenwell Point	32	ADELAIDE ST	1.40	1.98	0.62	0.04	1.72	1.14
196	Shoalhaven Heads	14	HAY AVE	1.59	2.46	0.90	0.03	1.72	0.85
197	Greenwell Point	41	HAISER RD	1.51	1.91	0.43	0.03	1.69	1.29
198	Greenwell Point	7	KEITH AVE	1.66	1.91	0.28	0.03	1.54	1.29
199	Orient Point	59	ADDISON RD	1.85	1.91	0.09	0.03	1.35	1.29
200	Orient Point	61	PRINCE EDWARD AVE	1.75	1.91	0.19	0.03	1.45	1.29
201	Shoalhaven Heads	101	JERRY BAILEY RD	1.95	2.46	0.54	0.03	1.36	0.84
202	Shoalhaven Heads		SHOALHAVEN HEADS RD		2.46		0.03		0.86
203	Greenwell Point	35	ADELAIDE ST	1.34	1.99	0.68	0.03	1.78	1.13
204	Greenwell Point	54	ADELAIDE ST	1.27	1.99	0.74	0.03	1.85	1.13

No.	LOCATION	ST No	STREET NAME	GROUND RL	FLOOR RL	DEPTH OF INUNDATION ABOVE 10% AEP		DEPTH OF INUNDATION ABOVE 1% AEP	
						Ground	Floor	Ground	Floor
205	Greenwell Point	19	BAILEY AVE	1.60	1.92	0.34	0.02	1.60	1.28
206	Greenwell Point	56	HAISER RD	1.60	1.92	0.34	0.02	1.60	1.28
207	Orient Point	33	ADDISON RD	2.43	1.92	-0.49	0.02	0.77	1.28
208	Shoalhaven Heads	107	JERRY BAILEY RD	1.92	2.47	0.57	0.02	1.38	0.84
209	Greenwell Point	35	COMARONG ST	1.50	2.00	0.52	0.02	1.62	1.12
210	Shoalhaven Heads		14 SHOALHAVEN HEADS RD		2.48		0.02		0.84
211	Orient Point	47	ADDISON RD	1.64	1.93	0.30	0.01	1.56	1.27
212	Shoalhaven Heads		40 SHOALHAVEN HEADS RD		2.48		0.01		0.84
213	Shoalhaven Heads	84	JERRY BAILEY RD	2.17	2.48	0.32	0.01	1.14	0.82
214	Greenwell Point	52	ADELAIDE ST	1.32	2.01	0.70	0.01	1.80	1.11
215	Greenwell Point	53	COMARONG ST	1.70	2.01	0.32	0.01	1.42	1.11
216	Greenwell Point	1	KEITH AVE	1.45	1.94	0.49	0.00	1.75	1.26
217	Orient Point	41	ADDISON RD	1.61	1.94	0.33	0.00	1.59	1.26

Shading indicates properties possibly suitable for house raising.

Table D3: Summary of Caravan Parks

No.	Location	Park	Facility Type	Ground RL	Floor RL	Flood Levels	
						1% AEP	10% AEP
1	Greenwell Point	**ANGLERS REST**					
			Office		1.76	3.12	2.02
			Amenities		1.79	3.12	2.02
			Cabin		2.08	3.12	2.02
			Sites (Approx 37)		1.36	3.12	2.02
2	Shoalhaven Heads	**BURRAWONG PARK**					
			Office	2.57	2.57	3.32	2.49
			Cabin		2.84	3.32	2.49
3	Shoalhaven Heads	**CAMELIA CARAVAN PARK**					
			Office	3.53	3.70	3.32	2.49
			Amenities		3.06	3.32	2.49
			Cabin	2.38	2.87	3.32	2.49
			Caravan	2.30	2.42	3.32	2.49
4	Shoalhaven Heads	**COASTAL PALMS CARAVAN PK**					
			Office	2.69	3.01	3.32	2.49
			Amenities	2.66	2.89	3.32	2.49
			Amenities		2.88	3.32	2.49
			Caravan		2.48	3.32	2.49
5	Greenwell Point	**CORAL TREE LODGE**					
			Office	1.63	1.72	3.20	1.94
			Amenities		1.74	3.20	1.94
			Cabin		1.80	3.20	1.94
			Unit		1.64	3.20	1.94
			Sites (App. 100)		1.62	3.20	1.94
6	Orient Point	**CULBURRA BEACH VAN PARK**					
			Manager	1.99	4.22	3.20	1.94
			Amenities		4.06	3.20	1.94
			Sites (Approx 40)		2.22	3.20	1.94
			Cabin		3.85	3.20	1.94
7	Shoalhaven Heads	**JANS CARAVAN PARK**					
			Amenities		1.98	3.32	2.49
			Cabin	1.70	2.16	3.32	2.49
			Caravan		1.66	3.32	2.49
8	Shoalhaven Heads	**MOUNTAIN VIEW VILLAGE**					
			Office	2.62	2.66	3.32	2.49
			Amenities	3.55	3.70	3.32	2.49
			Cabin		2.48	3.32	2.49
			Caravan		1.70	3.32	2.49
9	Greenwell Point	**PINE VAN PARK**					
			Office	1.29	3.01	3.12	2.02
			Amenities		2.25	3.12	2.02
			Cabin		2.51	3.12	2.02
			Sites (App. 100)		1.57	3.12	2.02
10	Nowra	**RIVERHAVEN MOTEL**					
			Unit	3.55	3.55	6.57	4.90
11	Shoalhaven Heads	**SHOALHAVEN HEADS TOURIST PK**					
			Office		2.96	3.32	2.49
			Amenities		2.88	3.32	2.49
			Amenities		2.38	3.32	2.49
			Amenities		2.48	3.32	2.49
			Amenities		2.52	3.32	2.49
			Amenities		2.00	3.32	2.49
			Cabin		2.52	3.32	2.49
			Cabin		2.18	3.32	2.49
			Caravan		1.46	3.32	2.49
12	Nowra	**SHOALHAVEN SKI PARK**					
			Office		6.98	9.02	6.11
			Manager		8.00	9.02	6.11
			Amenities		7.92	9.02	6.11
			Sites (Approx 40)		2.67	9.02	6.11
13	Shoalhaven Heads	**TALL TIMBERS CARAVAN PARK**					
			Office	2.24	2.46	3.32	2.49
			Manager	2.50	3.00	3.32	2.49
			Office	2.38	2.41	3.32	2.49
			Amenities	2.38	2.67	3.32	2.49
			Cabin		2.46	3.32	2.49
			Caravan		1.96	3.32	2.49
14	West of Terara	**SHOALHAVEN RIVER CARAVAN PARK - Refer Reference 6**					

APPENDIX E: POST FLOOD EVALUATION AND REVIEW

APPENDIX E: POST FLOOD EVALUATION AND REVIEW

E1. GENERAL

Design flood levels along the Shoalhaven River are provided in the *Lower Shoalhaven River Flood Study* - April 1990. Copies of this report are held by Shoalhaven City Council and the Department of Natural Resources. The design levels were determined using computer models of the catchment and lower floodplain which were calibrated to five historical floods (August 1974, June 1975, October 1976, March 1978 and April 1988).

The accuracy of the design flood levels can be improved with further flood and rainfall data to confirm the calibration of the computer models. The following procedure has been developed to ensure that the information available from future floods is accurately obtained and analysed.

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E2. PROCEDURE

Step 1 - Future Flood: Detailed data should be collected if the river level exceeds (say) 4.8 m at Nowra Bridge. The design flood levels at Nowra Bridge are shown in Table E1.

Step 2 - Collect Peak Levels: Where possible, river levels and times should be recorded during the event by SES, Council employees or local residents. It is imperative that immediately following the event, the peak height of the flood be marked immediately following the event either from debris marks or eyewitness reports. Debris marks can be lost within hours of the peak as a result of wind, rain or human interference.

Council should despatch personnel to inspect the length of the river (on both banks) to identify, mark and photograph debris. The levels can be picked up later by a surveyor. The data should be recorded in a report showing the photograph, time of recording (if during the flood) and level to AHD. Council should consider if a circular or notice in local papers is warranted to obtain further information.

If possible, flow velocity measurements should be taken (by the DNR or other suitably qualified authority) from Nowra Bridge.

Step 3 - Buildings Inundated: If floodwaters enter buildings, the occupant should be interviewed to obtain any relevant flood information such as a preliminary indication of the damages, peak level and to obtain photographs. The floor level database used in the Floodplain Risk Management Study indicates which buildings are likely to be flooded in a given size event.

Step 4 - Reports from Authorities: Council should obtain written reports on the flood and its implications from various affected sections of Council, the SES and any other relevant public authority on the flood. Data should be obtained from the DNR automatic water level recorders and, Sydney Water and Bureau of Meteorology rain gauges. These data can be obtained at any time although it is better if they are collected soon after the event in order to identify and correct any gross errors in other data.

Steps 5 to 8 only apply to floods estimated to be greater than a 5% AEP.

Step 5 - Major Floods: Flood levels which indicate an AEP of greater than 5% should be used to re-examine the calibration of the hydrologic/hydraulic models. Data from any other floods which have not been previously analysed should be included in this re-examination.

Step 6 - Rainfall Data: Rainfall data from Sydney Water and Bureau of Meteorology gauges is continuously recorded and can be readily obtained at any time. If warranted, additional rainfall information can be sought from residents at the same time as flood data are requested.

Step 7 - Hydrologic/Hydraulic Modelling: The new data should be run through the WBNM and CELL models. If the models do not produce satisfactory results then all available information (including that from floods used in the Flood Study) needs to be considered to see if the model parameters should be changed. Consideration should be given to upgrading the hydraulic model. This will require a considerable amount of additional survey. Any changes would lead to a revision of design flood levels. A report should be produced documenting the results and any adjustments made to Council's Floodplain Management Plans and S149 Certificates.

Step 8 - Shoalhaven Heads Entrance Survey: The amount of sand that has accumulated at the mouth of the Shoalhaven Heads entrance has a significant influence upon flood levels in the local area. It is essential that as much information as possible is obtained on the topography pre and post flood. Generally this will only be possible from aerial photography but also may include a post flood hydrographic survey. Such a survey was undertaken following the April 1988 flood and this proved very useful in calibrating the hydraulic model. These data should be obtained as soon after the flood as possible.

Table E1: Design Flood Levels (mAHD)

Event (AEP)	Nowra Bridge	Shoalhaven River at Terara	Greenwell Point	Shoalhaven Heads
Extreme	8.9	7.4	5.2	4.2
0.2%	7.3	6.1	4.1	3.9
0.5%	6.8	5.8	3.7	3.6
1%	6.3	5.5	3.4	3.3
2%	5.8	5.1	2.9	2.9
5%	5.3	4.8	2.4	2.7
10%	4.8	4.4	2	2.5

APPENDIX F: REVIEW OF RELATED PLANNING DOCUMENTS

APPENDIX F: REVIEW OF RELATED PLANNING DOCUMENTS

DISCUSSION OF PLANNING ISSUES

LOWER SHOALHAVEN RIVER FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN

ST GEORGES BASIN FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN

F1. INTRODUCTION

The NSW State Government's Flood Policy (**"the Policy"**) is directed at providing solutions to existing flooding problems in developed areas and to ensuring that new development is compatible with the flood hazard and does not create additional flooding problems in other areas.

Under the Policy, the management of flood prone land remains the responsibility of local government. The Policy provides for technical and financial support by the State Government through the following four sequential stages:

Flood Study

- determines the nature and extent of the flood problem.

Floodplain Risk Management Study

- evaluates management options for the floodplain in respect of both existing and proposed development. Considers social, ecological and economic factors relating to flood risk.

Floodplain Risk Management Plan

- involves formal adoption by Council of a plan of management for the floodplain.

Implementation of the Plan

- construction of flood mitigation works to protect existing development,
- use of Local Environmental Plans and/or Development Control Plans to ensure new development is compatible with the flood hazard.

The Lower Shoalhaven River and St Georges Basin Floodplain Risk Management Studies and Plans constitute the second and third stages of the management process. Although the catchments of the Lower Shoalhaven River and St Georges Basin are distinctly different, for the purpose of discussing planning issues which relate to flooding, both catchments are collectively termed the **"Study Area"**.

The NSW Government Floodplain Management Manual states that:

> *"Management options investigated in a floodplain risk management study may include modification measures for property, the flood, and community response ... These measures are aimed at*
>
> - *modifying development of flood prone properties (property modification measures); or*
> - *achieving more effective community response to the onset and aftermath of floods (response modifications measures). This response is to consider the need for excavation and expected operational limitations; or*
> - *modifying flood behaviour (flood modification measures).*
>
> *.... Options considered should include land use and development controls."*

As part of the preparation of a Floodplain Risk Management Plan, there is a requirement that the existing planning controls which relate to the catchment be reviewed, and suggestions made regarding the means by which those controls could be amended and/or supplemented with regard to land potentially impacted by floodwaters.

This Discussion Paper provides information from the NSW Government Floodplain Management Manual as it applies to the development of planning controls for flood affected land, summarises the land use controls which currently apply to land affected by flood waters within the Study Area, and provides a series of options for the consideration of Shoalhaven City Council for amendment of the existing controls.

F2. NEW SOUTH WALES GOVERNMENT FLOODPLAIN MANAGEMENT MANUAL

As stated in the Floodplain Management Manual (**"the Manual"**):

> *"The primary objective of the* [NSW Government flood prone land] *policy is to reduce the impact of flooding and flood liability on individual owners and occupiers of flood prone property, and to reduce private and public losses resulting from floods, utilising ecologically positive methods wherever possible."*

The Manual contains a number of definitions which are relevant to any discussion of the planning measures which could be adopted to assist in the management of development in the floodplain. These definitions include:

flood — relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or overland runoff before entering a watercourse and/or coastal inundation resulting from super elevated sea levels and/or waves overtopping coastline defences.

floodplain — area of land which is subject to inundation by floods up to the probable maximum flood event, i.e. flood prone land.

flood planning levels — are 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 "standard flood event" of the first edition of this Manual.

flood planning area — the area of land below the flood planning level and thus subject to flood related development controls. The concept of flood planning area supersedes the "flood liable land" concept of the 1986 Floodplain Development Manual.

flood prone land — is land susceptible to flooding by the probable maximum flood (**"PMF"**) event. Flood prone land is synonymous with flood liable land.

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F3. EXISTING LAND USE PLANNING CONTROLS

F3.1 City of Shoalhaven Local Environmental Plan, 1985

Land use within the Study Area is generally regulated by the City of Shoalhaven Local Environmental Plan, 1985 (**"LEP, 1985"**).

LEP, 1985 was gazetted on 17 May, 1985 and it is an aims and objectives based planning instrument. With regard to the aims of the plan relating to natural hazards such as flooding, LEP, 1985, at its sub-clause (2) (1) (e), states:

> *"2. (1) The Aims of this plan are:*
>
> *.....*
>
> *(e) to ensure that the council gives due regard to the effect of natural hazards upon development;"*

LEP, 1985 contains general reference to the management of development on flood affected land, however, it does provide some specific controls relating to the control of development on land which is subject to flooding.

Sub-clause 6 (1) of LEP, 1985 provides a series of definitions of terms contained within the LEP. There are no definitions contained within sub-clause 6 (1) specifically relating to flooding.

Zone Objectives

The maps which accompany LEP, 1985 indicate that a number of zones apply to the control of land use within the City of Shoalhaven. Two of the zones relate directly to land which is flood affected, those being:

- Zone No. 1 (g) (Rural "G" (Flood Liable) Zone), and
- Zone No. 9 (a) (Natural Hazards "A" (Urban Flooding) Zone).

Sub-clause 9 (3) of LEP, 1985 states that:

> *"(3) In determining a development application, the Council must take into account the aims and objectives of this plan and the objectives of the zone within which the development is proposed."*

With regard to flooding, the following zone objectives apply:

Zone No. 1 (c) (Rural "C" (Rural Lifestyle) Zone) has as its objective (b):

> *"(b) to meet the reasonable lifestyle needs of residents and provide adequate public safety in relation to bushfire, flooding, landslip and traffic while promoting and sustaining a high level of environmental quality in the zone."*

Zone 1 (g) (Rural "G" (Flood Liable) Zone) has the following objectives:

> *"(a) to limit the erection of structures on land subject to periodic inundation;*
>
> *(b) to ensure that dwelling-houses are erected on land subject to periodic inundation only in conjunction with agricultural use;*
>
> *(c) to ensure that the effect of innundation is not increased through development;*
>
> *(d) ....;*
>
> *(e) ...."*

Zone 2(a4) (Residential "A4" (Restricted Development) Zone) has as its objective:

> *"The objectives are to identify locations in existing urban areas with development problems where special consideration will be required before development can be approved."*

Zone 3(h) (Business "H" (Restricted Development) Zone) has as its objective:

> *"The objectives are to identify locations in existing business areas with development problems where special consideration will be required before development can be approved."*

Zone 4(e) (Industrial "E" (Restricted Development) Zone) has as its objective:

> *"The objectives are to identify locations in existing industrial areas with development problems where special consideration will be required before development can be approved."*

Clause 30 of LEP, 1985 (discussed below) relates to land within the 2(a4), 3(h) and 4(e) zones and refers specifically to land which is likely to be flood affected.

Certain land uses which are permissible with consent in the 1(g) and 2(a4) zones are inconsistent with the stated objectives of the zone, these include bed and breakfast accommodation and community facilities in the 1(g) zone and bed and breakfast accommodation in the 2(a4) zone. As stated in the Manual:

> *"One of the most critical aspects of a floodplain risk management plan is the selection of appropriate land uses in flood prone areas. A **balance** needs to be struck. On one hand flood prone land should not be unnecessarily sterilised, but on the other, proposed land uses need to be appropriate to the hazards and hydraulics of flood behaviour."*

The Manual describes several factors which determine flood hazard, including evacuation problems. In this regard, the Manual states:

> *"The level of damage and disruption caused by a flood are influenced by the difficulty of evacuating flood affected people and property. Evacuation may be difficult because of:*
>
> - *the number of people requiring assistance;*
> - *the depth and velocity of floodwaters;*
> - *mobility of people;*
> - *the distance to flood free ground;*
> - *the inability to contact emergency services;*
> - *bottlenecks, i.e. large numbers of people and great volumes of goods that have to be moved over roads which cannot cope with the increased volume;*
> - *the time of day and weather conditions; and*
> - *the lack of suitable evacuation equipment such as boats, heavy trucks etc.*
>
> *Consideration of the impact on evacuation strategies of increased occupation of the floodplain is one of the key tests of cumulative impact in preparing floodplain risk management plans."*
>
> *"Generally in lowering the density of development the evacuation assistance required is also reduced due to the lower number of people at risk. However, in the instance of rural residential developments proposed a reasonable distance inside the floodplain, the location generates spacial evacuation needs due to the length and uncertainty of the evacuation route."*

The use of flood affected land for bed and breakfast accommodation is potentially in conflict with the above stated aims of floodplain risk management. Careful consideration must be given by the Council as to the appropriateness of such development on such land where the effect of innundation may be increased through development of such land uses in the floodplain.

With regard to community uses, these can often include hospitals, schools, police stations, Council buildings, churches, telephone exchanges, electricity sub-stations water and sewerage works, fire stations and the like. It is generally considered that any development or redevelopment of land for Community/Special Use purposes should be undertaken on land that is flood free, however, the management of the floodplain must allow for minor development and minor additions to existing development as the need arises. It is recommended, however, that no new lands be set aside for Community/Special Use purposes within the floodplain. The permissibility of Community Uses in the 1(g) zoned land is considered to be inconsistent with this generally held floodplain risk management principle.

Zone No. 9 (a) (Natural Hazards "A" (Urban Flooding) Zone) has as its objective:

> *"The objectives are to identify land within a floodway in urban areas and because of the potential hazard to restrict the use thereof."*

Flood Mapping

It is noted that *"the flood line"* is indicated on the maps which accompany LEP, 1985 and that it generally corresponds with the boundary of the 1(g) zone. The notation on the maps states:

> *"**FLOOD LINE AND FLOOD ZONE NOTES***
>
> - *The areas indicated as flooding on this map have been delineated using the most reliable information available to council at the time. This information should be checked by survey.*
>
> - *The areas delineated as flood zones should not be taken as the only areas that flood. The flood zones generally approximate the 1:100 year flood from the best information available at the time of zoning. You are advised to check with council."*

Flood Related Clauses

Clause 12 of LEP, 1985 relates to subdivision in zone No. 1(c). Sub-clause 12 (2) states that:

> *"(2) For the purposes of this clause "environmentally constrained area" includes:*
>
> *(a) ....;*
>
> *(b) ....;*
>
> *(c) flood liable land;*
>
> *(d) ....;*
>
> *(e) ....;"*

Sub-clause 12 (3) provides the matters which the Council must consider when determining an application to subdivide land to which the clause applies. There is no direct reference in sub-clause 12 (3) to the issue of flooding.

Clause 14 of LEP, 1985 provides details of the requirements of the Council for the development of a dwelling house in the 1(a), 1(b), 1(d) and 1(g) zones. Sub-clauses 14 (3), 14 (4) and 14 (5) relate to development of a dwelling house on land within the 1(g) zone as follows:

> *"(3) Subject to subclause (4), the Council may consent to the erection of a dwelling-house in Zone No. 1(g) if the allotment:*
>
> *(a) has an area of not less than 40 hectares;*
>
> *(b) is a 1964 holding;*
>
> *(c) is a concessional allotment described in paragraph (a) of the definition of "concessional allotment" in clause 6(1); or*
>
> *(d) comprises and allotment created under clause 11(1) of Interim Development Order No.1 - Shire of Shoalhaven before 20 September 1974.*

(4) Subject to clause 29, the Council must not grant consent in accordance with this clause to the erection of a dwelling-house on any parcel of land within Zone No. 1(g) unless:

(a) the parcel is predominantly prime crop and pasture land; and

(b) the Council is satisfied that the dwelling-house is essential for the proper and efficient use of the land for agriculture or turf farming.

(5) Notwithstanding subclauses (3) and (4), the Council may consent to the erection of a dwelling-house on land within Zone No. 1(g) that is a concessional allotment described in paragraph (b), (c) or (d) of the definition of "concessional allotment" in clause 6(1) or is the residue of land remaining after the creation of allotments referred to in clause 11(4), or the residue created under clause 11(5), as in force immediately before the commencement of City of Shoalhaven Local Environmental Plan 1985 (Amendment No.127), subject to the assessment specified in clause 29(3) and may impose conditions of the same kind as specified in clause 29(4)."

Clause 29 of LEP, 1985 provides for the objectives for development on flood liable land as follows:

*"**Development of flood liable land***

29. (1) Subject to subclause (2), the Council must not consent to the carrying out of development on land which, in its opinion, is flood liable.

(2) the Council may consent to the carrying out of development on flood liable land if:

(a) the development is for a purpose ancillary or incidental to the use of the land for the purpose of agriculture; or

(b) the development comprises the extension or alteration of an existing dwelling-house; or

(c) the land is in any urban zone under this plan; or

(d) the Council has received a flood assessment report, in relation to the land, that addresses each of the matters referred to in subclause (3), and the Council is of the opinion that the development is feasible despite the land being flood liable.

(3) In considering an application to which subclause (2) applies, the Council must make an assessment of:

(a) the likely levels, velocity, sedimentation and debris carrying effects of flooding;

(b) the structural sufficiency of any building the subject of the application and its ability to withstand flooding;

(c) the effect which the development, if carried out, will or is likely to have on the flow characteristics of floodwaters;

(d) whether or not access to the site will be possible during a flood; and

(e) the likely demand for assistance from emergency services during a flood.

(4) In granting consent to a development application made pursuant to subclause (2), the Council may impose conditions that set floor levels, require filling, structural changes or additions or require other measures to mitigate the effects of flooding or assist in emergency situations."

Although clause 29 relates to "flood liable land", as indicated in the above discussion of clause 6 of LEP, 1985, there is no definition of Flood Liable Land in LEP, 1985. If the reader of LEP, 1985 is to understand the nature of the controls Council has placed on development in the floodplain, the term "Flood Liable Land", or its current equivalent term must be defined in the LEP. This aspect is discussed further in Section 4 of this Discussion Paper.

Clause 30 of LEP, 1985 relates to structures in the 2(a4), 3(h) and 4(e) zones as follows:

> "***Structures in Zones Nos. 2(a4), 3(h) and 4(e)***
>
> *30. In respect of an application for consent to erect a structure on land within Zone No.2(a4), 3(h) or 4(e), the Council must make an assessment of:*
>
> *(a) the likelihood of floodwaters entering the structure;*
>
> *(b) the effect of soil instability; and*
>
> *(c) the likelihood of damage due to coastal erosion,*
>
> *and may attach to any consent conditions which, in the opinion of the Council, will prevent or reduce the incidence of flooding or instability."*

Sub-clauses 40 H (2) & (3) relate specifically to the expansion of the Bomaderry urban area as follows:

> "***Special requirements in respect of expansion of Bomaderry urban area***
>
> *40 H (1) .....*
>
> *(2) The Council shall not consent to a subdivision of land to which this clause applies unless the Council has taken into consideration whether adequate flood free access will be provided from that land to the adjoining urban area.*
>
> *(3) In this clause "flood free access" means access by use of land that is above the 1 in 100 year flood level."*

F3.2 Development Control Plans

Shoalhaven City Council has prepared a number of Development Control Plans (**"DCPs"**) to complement its LEP, 1985. The DCPs which are relevant to the Study Area are:

- Development Control Plan No.63 - Tourist Development in Rural Areas.
- Development Control Plan No.71 - Medium Density Housing.
- Development Control Plan No.98 - Exempt & Complying Development.
- Development Control Plan No.57 - Dual Occupancy Guidelines.
- Development Control Plan No.43 - East Nowra.

Development Control Plan No.63 - Tourist Development in Rural Areas.

The introduction to this DCP states that:

> *"Tourism is one of the main industries within the Shoalhaven City area. It provides significant input into the local economy and provides local employment opportunities.*
>
> *It is therefore important to preserve and enhance the many aspects of the area to ensure that this important industry is not adversely affected."*

With regard to flooding, the DCP states that:

> *"The house may be damaged in times of flood and the septic tank will be swamped.*
>
> *Effluent contaminates ground water and passes directly to creeks and streams.*
>
> *Buildings and septic tanks should be located on high, safe ground above flood level."*

Control Element (E) Natural Hazards of the DCP deals with flooding and has as its aim:

> *"To ensure that developments take into consideration local flooding."*

In this regard the "Standard" adopted by the DCP is as follows:

> *"Where developments propose access over creeks and other water courses consideration should be given to the level of crossing that will be proposed. Flood free access is required to be provided, to a minimum 1 in 20 year recurrent level. In some instances Council may require a separate flood assessment to be prepared for any crossings. The extent of this assessment will depend largely on the individual risks associated with each crossing."*

The DCP also requires that the Applicant for development provide information on the implication of flooding for the development and access.

Development Control Plan 71 - Medium Density Housing

The purpose of the DCP is to encourage high quality medium density housing in the Shoalhaven Local Government Area. The only reference to flooding in the DCP is at Section 4.0 Advice, Procedures and Checklists which details the information required by the Council as part of the Development Application as follows:

> *"**Flooding***
>
> *Where a site is likely to be affected by flooding, information on the flooding of the site, public road access, the proposed treatment of the site and source of data on flooding"*

Development Control Plan No.89 - Exempt & Complying Development

This DCP has been developed:

- to detail circumstances when Council's approval is not required (exempt development), and
- to detail circumstances when routine developments requiring Council's approval may be dealt with quickly when they meet predetermined standards (complying development).

The DCP, at its Table 3, provides a list of the locations where, if development is proposed, it is not complying development. In this regard, one such area is land that:

> *"is identified as bush fire prone, flood prone or contaminated land, or land subject to subsidence, slip or erosion;"*

Development Control Plan No.57 - Dual Occupancy Guidelines

The purpose of the DCP is to provide dual occupancy development whilst maintaining and enhancing the amenity and environmental character of the area. With regard to flooding, the only reference in the DCP is to land in the vicinity of Riverview Road, Nowra as follows:

> *"**2.4.2 Land in the Vicinity of Riverview Road, Nowra***
>
> *The Riverview Road area has been identified as subject to high hazard flooding. Generally, Council does not favour any increase in population density in this area but a limited form of Dual Occupancy Development will be considered for the purpose of accommodating relatives of the owner, subject to the following provisions -*
>
> *a) ....*
>
> *b) Compliance with the construction standards for this area contained in Council's Interim Flood Policy ....*
>
> *c) ...."*

Since the coming into force of sub-clause 2.4.2 of DCP 57, the Council has prepared and exhibited a draft Local Environmental Plan (Amendment No.311 to LEP, 1985) essentially rezoning the land in the vicinity of Riverview Road, Nowra in accordance with the recommendation contained in the Riverview Road Area - Nowra Floodplain Management Plan.

Development Control Plan No.50 - Sussex Inlet Town Centre

This DCP generally applies to the commercial zoned land within the Sussex Inlet Town Centre. There are a number of objectives attached to the DCP of which objective 4 (d) relates to flooding as follows:

> *"4. (d) Establishing footpath levels which provide total access to buildings and account for flood heights required on new developments."*

The only other reference to flood issues within the DCP is at Section 5 (c) which deals with height restrictions as follows:

> *"**(c) Height Restrictions***
>
> *Height restrictions apply to all development within the Development Control Plan area to ensure that the scale of urban development relates to existing buildings and is in keeping with the scale of the natural surroundings. As the land is relatively flat the height limit is 8 metres above the flood level of 2 metres, however, non habitable architectural elements may be permitted to exceed this restriction."*

F3.3 Development Guidelines for Permanent Occupancy of Caravan Parks

The introduction to this document states that:

> *"These development guidelines have been prepared to support the provisions of State Environmental Planning Policy No.21 - Caravan Parks and to provide development guidelines where permanent occupancy is being considered within caravan parks."*

The "Locational Requirements" of the Guidelines have as one performance criteria:

> *"Development is not located in areas which are affected by flooding, bush fire or any other environmental hazard."*

The "Acceptable Solutions" section of this control element states, inter alia:

> *"Where sites are affected by flooding, compliance with Council's interim policy for "Caravan parks on Floodprone Land" is demonstrated."*

Section 3.5 of the Guidelines, when dealing with the information to be submitted with a development application, states:

> *"**Flooding***
>
> *Where the site is subject to flooding, information on the flooding of the site, public road access, proposed treatment of the site and source of data on flooding must be submitted with the application."*

F3.4 Flood Policies

F3.4.1 Interim Flood Policy General Conditions for the Whole of City and Specific Areas

Council has adopted the "Interim Flood Policy General Conditions for the Whole of City and Specific Areas" (**"the Policy"**) which:

> *"... applies to all land within the City of Shoalhaven identified as being within area affected by a standard flood on any river, lake or stream."*

The primary objective of the Policy is:

> *" ... to reduce the impact of flooding and flood liability on individual property owners and occupies, and to reduce private and public losses resulting from flooding."*

The Policy objectives are:

"• *To bring to the attention of the community Council's Policy in relation to building on flood liable land within the City.*

- *To ensure that buildings and other development in flood liable areas are designed and constructed to withstand the likely stresses of the standard flood or appropriate higher flood where overtopping occurs.*
- *To limit development which may reduce the ability of the floodplain and, in particular, the floodway, to carry water and subsequently add to the height of floods.*
- *To reduce flood losses by restricting and controlling development in order that it is less susceptible to flood damage and minimises risks to residents and those involved in rescue operations during floods.*
- *To minimise the financial burden to owners of flood liable land and to the general public."*

Section 8 of the Policy states that:

> *"The standard flood shall be nominally 1:100 year for the interim period, based on the following considerations:*
>
> - *In most areas, it is not practicable to define any other flood return period, such as 1:50 etc.*
> - *Council's previous Development application assessments were based on the nominal 1:100 year flood standard.*
> - *This is in agreement with the advice of the Executive of Flood Mitigation Authorities of NSW.*
> - *This is a widely accepted standard in Australia and overseas.*
> - *The Courts have recognised 1 in 100 years as the current community standard.*
> - *1 in 100 years is the standard adopted by lending authorities."*

The Policy contains numerous controls on development on land to which the Policy applies, for example:

> *"For residential development, the freeboard to the floor level of habitable rooms shall be 0.5 metres in floodways and 0.3 metres in flood storage and flood fringe areas. For commercial and industrial development in newly created lots, the freeboard shall, likewise, be 0.5 metres in floodways and adjacent to major streams, and 0.3 metres in flood storage and flood fringe areas.*
>
> *In existing subdivided areas, other local rules may apply – see specific areas eg Sussex Inlet commercial area (flood storage) a 0.0 metres freeboard is adopted."*
>
> *"The floor level of habitable rooms must be no lower than the Minimum Floor Level. For proposed dwelling extensions where it is impractical to raise the floor level, applications for extensions of the building at the existing level will be treated on their individual merits up to a maximum cumulative total increase in habitable floor area of:*
>
> - *50 m^2 for residential and rural residential dwellings.*
> - *100 m^2 for dwellings associated with bona fide large area rural enterprises such as dairying.*

Materials used in construction below Minimum Floor Level are to be compatible with immersion as stated in Appendix F of the NSW Floodplain Development Manual. It is recommended that the construction methods and materials of the "suitable" class be utilised and that those in the "marked effects" and "severe effects" be not utilised."

F3.4.2 Flood Policy Interim - Caravan Parks on Flood Prone Land

Council has adopted the "Flood Policy Interim - Caravan Parks on Flood Prone Land" (**"the Caravan Policy")** which states:

"For a Council to obtain indemnity under the New South Wales Flood Policy, it is obliged to follow the steps set out in the diagram below. In the interval, until all of the required final steps have been carried out and a Floodplain Management Plan prepared for each area, an interim local policy is required and this has been determined by the Floodplain Management Committee. This Caravan Parks Code forms part of this interim local policy.

The Floodplain Development Manual divides flood situations into three hydraulic categories, for each of which there are two hazard categories, as shown. For the purposes of Caravan Parks in this document, fringe areas and storage areas have been combined as one.

As part of the overall interim flood policy, Council's City Services Division has determined standard flood levels (nominally 1%) for all localities within the City. Some Parks within, or immediately adjacent to the Shoalhaven River banks, are in high hazard flood storage or flood fringe areas. In these latter areas, where there are new parks or park extensions, Council requires the van sites to be filled, such that the floor of the caravan is at the standard flood level.

This policy has also been prepared to comply with the Local Government Department Technical Bulleting No. 6."

Specific controls are contained within the Caravan Policy, for example:

> *"**Freeboard***
>
> *Where Unregistered Moveable Dwellings (UMD's) are permitted, the floor level shall have 0.3 metres freeboard above the standard flood level.*
>
> ***Tie Downs***
>
> *Where high hazard conditions occur, and vans could either float or be swept away, each van and rigid annexe shall be equipped with quick release tie down of a suitable design.*
>
> *All vans in high hazard areas shall be tied down in case removal becomes impractical.*
>
> ***Rapid Knock Down***
>
> *All annexes in high hazard floodway situations must be of rapid knock down, flexible design.*
>
> *In low hazard, flood storage or flood fringe areas (ie low velocity), annexes may be inundatable as an alternative to rapid knock down."*

F3.5 Section 149 Planning Certificates

Council currently has a number of notations which it places on s.149 Planning Certificates which alert the purchaser of that certificate that the land the subject of the certificate is affected by flooding. The wording attached to such a s.149 Planning Certificate is dependant upon the zone within which it is located, whether the land is shown on the LEP, 1985 Map as being within the "Flood Line", and the flood controls which apply to the land.

F4. PLANNING OPTIONS

F4.1 Amendments to City of Shoalhaven Local Environmental Plan, 1985

Whilst it is recognised that LEP, 1985, in its amended format, is a modern planning instrument, as part of the implementation of both the Lower Shoalhaven River and St Georges Basin Floodplain Management Plans and Studies, it is recommended that LEP, 1985 be amended to incorporate generic provisions to better reflect the need for the control of development of flood affected lands within the City of Shoalhaven as a whole. Those provisions would thus relate to both the Study Area and to any other flood affected areas within the City of Shoalhaven and provide a consistent approach to the management of flood affected land.

Definitions

LEP, 1985 contains a number of definitions. Any Floodplain Risk Management Plan (**"FRMP"**) adopted by Council for each of the study areas will rely on precise definitions of terms which relate to floodplain risk management. Indeed, Council is likely to prepare FRMPs for other catchments in the Local Government Area, and as such it is suggested that definitions be contained within the LEP such that all planning documents (DCPs and/or FRMPs) are based on up to date and consistent floodplain risk management definitions within LEP, 1985.

The adoption of a standard set of definitions which relate to the control of the floodplain will ensure that Council is consistent in its preparation of DCPs and FRMPs for both the Study Area and other flood affected areas. It is recommended that the following definitions, which are consistent with the NSW Floodplain Management Manual, be considered for inclusion in LEP, 1985:

Floodplain	means the area of land which is subject to inundation by floods up to and including the probable maximum flood event, that is, **flood prone land**.
Flood planning level	means the combination of flood level and freeboard selected for planning purposes, as determined in floodplain risk management studies and incorporated in floodplain risk management plans.
Flood planning area	means the area of land below the flood planning level and thus subject to flood related development controls.
Flood prone land	means the land susceptible to flooding by the probable maximum flood event (that is, land within the floodplain) as indicated on the map marked "Flood Prone Land" deposited in the office of the Council as amended from time to time.

The incorporation of the above definitions into LEP, 1985 will allow consistency in the interpretation of any planning controls which relate to a parcel of land and allow the LEP to accord with the thinking of the NSW government for control of development on land affected by flood waters. All subsequent planning documents, be they DCPs or FRMPs, will be required to be drafted having regard to the above definitions and thus avoid confusion which has often occurred in the past where planning documents have contained conflicting definitions.

The adoption of the above definitions will recognise that flood prone land is not restricted to land affected by the 1 in 100 year or 1% AEP flood event, but the entire floodplain. These definitions also recognise that, unlike Flood Studies and Floodplain Risk Management Plans, planning controls do not necessarily need to relate to the entire floodplain. Rather, they should relate to that part of the floodplain contained within a selected Flood Planning Level i.e. the Flood Planning Area.

It will also be necessary for Council to amend existing DCPs to reflect the above definitions such that those documents accord with the parent LEP. As indicated in the above Section 3 of this Discussion Paper, the existing DCPs and Policies are not consistent in their definitions nor are they predicated on current floodplain risk management practices.

Restrictions on certain development

The existing clauses within LEP, 1985 contain terminology which is inconsistent with the current floodplain risk management terminology. Indeed, if the above recommended definitions are inserted into LEP, 1985, amendments will also be required to the existing clauses to maintain consistency within the LEP. As noted in Section 3 of this report, clauses 12, 14, 29 & 30 of LEP, 1985 are the relevant clauses.

In the case of clause 12 of LEP, 1985, reference is made to “flood liable land” which is not defined in the LEP. Flood liable land is, however, defined in the Council Interim Flood Policy as:

> *“**Flood Liable Land** - Land which will be inundated by the standard flood.”*

The Standard Flood is defined in the Interim Flood Policy as:

> *“**The Standard Flood** - The flood selected for planning purposes - based on an understanding of flood behaviour and associated flood risk.”*

The Policy continues that:

> *"The standard flood shall be nominally 1:100 year for the interim period, ..."*

The terms "Flood Liable Land" and "Standard Flood" no longer exist in modern floodplain risk management parlance and have been replaced by the terms "Flood Planning Area" and "Flood Planning Level" respectively as defined above. It is recommended that sub-clause 12 (2) be amended to reflect the above definitions.

With regard to sub-clause 12 (3), as noted in Section 3 of this Discussion Paper, there is no direct reference to flooding in the matters for consideration of Council when it determines a development application for subdivision in the 1(c) zone. In order to reflect the need to address floodplain risk management techniques in the determination of development applications on land which is flood affected, it is recommended that a further sub-clause be inserted into clause 12 of LEP, 1985 to ensure that flooding of land is considered by the Council. In this regard, because the Council has embarked on a program of preparation of Floodplain Risk Management Plans, it is suggested that reference to those FRMPs be inserted into the clause as follows:

> *"12. (3) In determining an application to subdivide land to which this clause applies, the Council must ensure that:*
>
> *(a) ....*
>
> *(b) ....*
>
> *(c) ....*
>
> *(d) it has taken into account the potential for flooding of the land and any Floodplain Risk Management Plan or development control plan adopted by the Council applying to the land."*

Subject to amendments made to Clause 29 as discussed below, clause 14 of LEP, 1985 will also require amendment to ensure continuity of assessment of development applications for dwelling houses in the 1(g) zone.

Clause 29 of LEP, 1985 provides a number of matters for consideration by the Council when assessing a development application on land which is "Flood Liable". From reading clause 29, it is unclear as to what the term "flood liable land" refers as it is not defined in the LEP. Again, this clause requires amendment to ensure that the term "Flood Liable" is replaced by the

recommended terminology i.e. “Flood Prone Land” and “Flood Planning Area”. As indicated above, the term Flood Prone Land refers to all land which is likely to be inundated up to and including the Probable Maximum Flood while the Flood Planning Area is the land which falls within the Flood Planning Level and is thus land which is subject to planning controls. As such, sub-clause 29 (1) should be amended to reflect the fact that the Council only wishes to receive development applications over land which is the subject of development controls, i.e. the land within the Flood Planning Area. The amended clause could read:

> *“**Development of flood prone land***
>
> *29. (1) Subject to subclause (2), the Council must not consent to the carrying out of development on land which, in its opinion, is within the flood planning area.”*

Existing sub-clauses 29 (2), (3) & (4) provide the matters which the Council will consider when assessing an application on “flood liable land”. If the above recommendation is adopted these sub-clauses will need to be altered to reflect correct floodplain risk management terminology i.e. remove the use of the term “flood liable” as this refers to land inundated up to and including the Probable Maximum Flood.

An alternative to the above recommended amendment to clause 29 would be to replace the entire clause with one which better reflects modern floodplain risk management practices. The following special provisions are recommended for the consideration of Council:

> *“**Development within the flood planning area***
>
> *(1) A person shall not carry out development for any purpose on land that is in the Flood Planning Area except with the consent of the council.*
>
> *(2) Before granting consent to development in the Flood Planning Area, the council must consider the following:*
>
> *(a) the extent and nature of the flooding or inundation hazard affecting the land, and*
>
> *(b) whether or not the proposed development would increase the risk of flooding or inundation affecting other land, buildings, works or land uses in the vicinity, and*
>
> *(c) whether the risk of flooding or inundation affecting the proposed development could be reasonably*

mitigated, and

(d) the social impact of flooding, including the ability of emergency services to access, evacuate, rescue and support residents of flood prone areas, and

(e) the characteristics of floodwaters as provided by any Floodplain Risk Management Plan applying to the land, and the requirements of that Floodplain Risk Management Plan.

(3) The council shall not grant consent to the carrying out of any development or works for any purpose on land within the Flood Planning Area unless it is satisfied that:

(a) the development or work would not unduly restrict the flow characteristics of flood waters, and

(b) the development or work would not unduly increase the level of flow of floodwaters on land in the vicinity, and

(c) the development or work would not exacerbate the adverse consequences of floodwaters flowing on the land with regard to erosion, siltation and destruction of vegetation, and

(d) the structural characteristics of any building or work, the subject of the application, are capable of withstanding flooding in accordance with the requirements of the Council, and

(e) any proposed building is adequately flood proofed, and

(f) the development would not imperil the safety of persons on land inundated by floodwaters, and

(g) flood free access is available to the development or work, and

(h) the development would not increase dependency on emergency services.

(4) The council may grant consent to facilities which, in its opinion, are considered to be essential in times of major flooding only in locations where it can be shown that they will be fully operational during a Probable Maximum Flood."

The above clauses allow flexibility in land use planning in that they relate to Flood Prone Land i.e. the entire floodplain, while applying development controls only to that land which has been identified as falling within the Flood Planning Area. This approach will also allow the Council flexibility in the adoption of flood planning levels should the circumstances of a particular floodplain demand that a level other than the 1 in 100 year event should apply.

It is recognised, however, that the adoption of the above recommendations will result in controls contained within the LEP being tied to Flood Planning Levels which, by definition, have been established during the preparation of floodplain risk management studies and incorporated into floodplain risk management plans. The question remains as to how development on those flood affected areas which have not been the subject of floodplain risk management studies/plans can be controlled through the planning process. In this regard, it is recommended that the Council considers an alternative definition of "**Flood planning level**" as follows:

Flood planning level means 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 or where no floodplain risk management studies or plans have been prepared, the flood level determined by the Council for that area.

The above alternative definition will allow the Council to adopt modern planning definitions to control development on the floodplain while at the same time allowing existing flood policies/restrictions to remain in place for areas where Floodplain Risk Management Studies and Floodplain Risk Management Plans have not been prepared.

In order for the above regime to be effective, however, the Council will need to revise existing policies to ensure that they are consistent with the above recommended changes to LEP, 1985 and indeed are consistent with modern floodplain risk management practices.

As noted above, Council has prepared mapping which delineates the flood line, which is generally the 1 in 100 year flood level. At present, the flood line is shown on the Map; i.e. the LEP, 1985 Map.

As Council will appreciate, the map attached to the LEP forms part of the legislation of NSW and any amendment to that map requires an amendment to the legislation. To effect such a change, an amending LEP must be prepared, exhibited and then made by the Minister for Urban Affairs and Planning.

It is apparent that land which is flood affected, and hence flood prone land, is dynamic, and changes to the delineation of that land will occur as flood experience and refinement of flood models are attained. Because of the dynamics involved in flood prediction, it is recommended that Council adopt a similarly dynamic means of noting flood prone land and/or the flood planning area in graphic format.

It is recommended, rather than have the flood mapping tied to the LEP map, that there be a separate series of maps held by Council which delineate land which has been determined as flood prone and/or within the flood planning area. Such an approach will accord with the above recommended definition of Flood Prone Land, while at the same time allowing Council to amend its flood mapping without the need for a formal amendment to the LEP.

Such an approach has been adopted by other Councils in recent time, notably Port Stephens Council in its Local Environmental Plan, 2000 which contains the following definition of Flood Prone Land:

> *"**flood prone land** means land indicated on the map marked "Flood Prone Land" as amended from time to time."*

Similarly, Hastings Local Environmental Plan, 2001, at its clause 25 which relates to flood liable land, states

> *"For the purposes of this clause, **flood liable land** is:*
>
> *(a) land likely to be inundated in the 1 in 100 year flood, as identified on mapping held in the office of the Council, or ..."*

Although neither the Hastings LEP, 2001 nor the Port Stephens LEP, 2000 have been drafted having regard to the current terminology relating to floodplain risk management, they have adopted the approach of not having the dynamic flood mapping tied to the mapping of the LEP.

F4.2 Floodplain Management Plan

The Floodplain Risk Management Plans (**"FRMPs"**) being prepared by Council will provide a set of specific development and flood protection guidelines which will assist in the control of development on Flood Prone Land and in particular the land within the Flood Planning Area. The planning controls which apply to the land within the Flood Planning Area should not only be specifically related to the particular area but should also be in accordance with the guidelines contained in the draft Floodplain Management Manual.

As stated in the Manual:

> *"One of the most critical aspects of a floodplain risk management plan is the selection of appropriate land uses in flood prone areas. A **balance** needs to be struck. On one hand flood prone land should not be unnecessarily sterilised, but on the other, proposed land uses need to be appropriate to the hazards and hydraulics of flood behaviour."*

There is currently a mix of land uses located within the Study Area. There is potential for development and redevelopment, particularly in the residential areas. It is generally considered that any development or redevelopment of land for Special Use purposes including hospitals, schools, police stations, Council buildings, churches, telephone exchanges, electricity sub-stations water and sewerage works, fire stations and the like should be undertaken on land that is flood free, however, the management of the floodplain must allow for minor development and minor additions to existing development as the need arises. It is recommended, however, that no new lands be set aside for Special Use purposes within the floodplain of the Study Area. This approach is reflected in the above recommended amendment to clause 29 of LEP, 1985.

One option for the control of redevelopment in the Flood Planning Area is to rezone those lands such that redevelopment is restricted to low risk land uses. Such an approach would necessitate the removal of some existing zones from that area. The NSW Flood Prone Land Policy does not support the use of zoning to unjustifiably restrict development simply because the land is flood prone. As such, the option of generic rezoning of land is considered inappropriate and is not considered further. This is not to say that spot rezoning should not be employed as a means of implementing floodplain management techniques.

With regard to the land identified as being within zone 1(g) Flood Liable, if the Council adopts the recommended definitions, it will also have to amend the title of this zone. The term Flood Liable Land has always been synonymous with Flood Prone Land, however, the current definition of Flood Prone Land incorporates all land with the potential to be inundated up to and including the Probable Maximum Flood. As such, the "Flood Liable" zone will be inappropriately named.

It is also recommended that the Council give consideration to the total removal of the 1(g) zone as it relies on generally inaccurate flood data for the establishment of its boundaries and relates only to the 1 in 100 year flood event. In addition, as per the above discussion of attachment of flood mapping to the LEP, the boundaries of the 1(g) zone are tied to flood data held by the Council. If, as the Council pursues the undertaking of floodplain risk management studies/plans, it is determined that the 1 in 100 year event is not appropriate or indeed that the *"flood line"* is inaccurate, then an amendment to LEP, 1985 will be required to reflect the findings of that updated data such that the Council is seen to be providing correct flooding advice to the general public.

The recommended changes to clause 29, together with floodplain risk management plans prepared by the Council, should ensure that any development proposed on land that is currently within the 1(g) zone would be suitably assessed in the development application stage such that inappropriate development is excluded from those flood affected lands.

If, however, the Council is of the opinion that the 1(g) zone should remain, it is recommended that a comprehensive strategic planning exercise be undertaken to determine more accurately the land which is flood affected and indeed the land which falls within the Flood Planning Area. It is that land which, following the implementation of changes to LEP, 1985 definitions, will be the subject of development control and indeed to which clause 29 will apply. As such, the delineation of the Flood Planning Area will delineate the boundaries of the renamed 1(g) zone. A strategic planning exercise such as this will require a considerable amount of time to complete and should not stall the updating of the remaining sections of LEP, 1985. As noted in the suggested definition of Flood Planning Level, which determines the Flood Planning Area, the Flood Planning Level can be determined either through the floodplain risk management study/plan process or by the Council where no such plans have been completed. As such, the renamed 1(g) zone could include a combination of Flood Planning Areas determined by floodplain risk management studies/plans or the 1 in 100 year flood level for areas not subject to floodplain risk management plans.

If the 1(g) zone is to remain, it is recommended that the change to its name be made as part of any initial amendment to LEP, 1985 with the results of the strategic planning exercise (changes to mapping boundaries) implemented in a subsequent amending LEP.

The FRMPs will contain a series of guidelines for the redevelopment of the Study Area. The FRMPs will also account for the requirements of some landowners for both major and minor additions to existing development within the Study Area.

Control guidelines which should be contained in the FRMP will differ according to the level of hazard identified in the Floodplain Risk Management Study which precedes the FRMP.

Assessment of hazard for both study areas will provide the basis upon which the development of planning controls can be formulated. It is envisaged that the next stage of the floodplain risk management process will provide a series of suggested controls for the consideration of the Council.

F4.3 Section 149 Planning Certificates

Planning Certificates issued under s.149 of the Environmental Planning and Assessment Act, 1979 are a major source of planning related information about the development potential of a parcel of land.

Schedule 4 of the Environmental Planning and Assessment Regulation, 2000 prescribes matters which must be included in a s.149 Planning Certificate. With regard to flood affected land, Items 1 (1) (c) and 7 of the Regulation are relevant, those being:

> *"1 (1) (c) each development control plan applying to the land that has been prepared by the council under section 72 of the Act."*
>
> *"7 Whether or not the land is affected by a policy:*
>
> *(a) adopted by the council, or*
>
> *(b) adopted by any other public authority and notified to the council for the express purpose of its adoption by that authority being referred to in planning certificates issued by the council,*
>
> *that restricts the development of the land because of the likelihood of land slip, bushfire, flooding, tidal inundation, subsidence, acid sulphate soils or any other risk."*

Shoalhaven City Council has a series of notations which it places on s.149 Planning Certificates detailing that it has a policy to restrict development of land due to the land being flood affected. With regard to land affected by the FRMPs for the Study Area, it is recommended that the Planning Certificate also include advice that the FRMP applies to that land.

In this regard, it is recommended that:

- Pursuant to the Environmental Planning and Assessment Regulation, 2000, the Council prepare a notation to the effect that it has adopted a policy to restrict development on land due to it being flood affected; that notation being a generic statement of fact which would appear on all s.149 Planning Certificates.

- Where the Council has evidence that the land which is the subject of a particular s.149 Planning Certificate is indeed within the Flood Planning Area, it should provided a further notification on the certificate to that effect. Such a notification should also include advice that a Floodplain Risk Management Plan has also been prepared if appropriate.

- Where the Council has evidence that the land which is the subject of the s.149 Planning Certificate is outside the Flood Planning Area, but is still Flood Prone Land, a separate notation should be provided which indicates that the Council considers the land in question to be above the Flood Planning Level but could be flooded in rarer events than that adopted as the basis for determination of the Flood Planning Level. This notification could also state that for this reason the Council's local

floodplain risk management policy does not impose flood related development controls on the land in question.

In addition, Council could elect to adopt FRMPs as DCPs. Such an approach would allow land to which the DCPs apply to be further notified on the planning certificate in addition to the individual notification described above.

F4.4 Flood Policy

As part of the implementation of the FRMPs for the Study Areas, it is recommended that the Council also review the content of its flood policies to ensure that terminology contained within those documents accords with definitions and terminology contained within an amended LEP, 1985 and any adopted DCP for the Study Area and the Local Government Area in general. It is recommended that the Council consider the preparation of a DCP which would contain both the updated Flood Policy provisions and the generic planning controls which would relate to the control of development on flood affected land. Such a DCP would replace the Interim Flood Policy and be notified on s.149 Planning Certificates.

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APPENDIX G: SHOALHAVEN HEADS ENTRANCE - FLOOD MANAGEMENT BACKGROUND TO DISCUSSION PAPER

APPENDIX G: SHOALHAVEN HEADS ENTRANCE - FLOOD MANAGEMENT BACKGROUND TO DISCUSSION PAPER

G1. INTRODUCTION

The purpose of the Discussion Paper on the Shoalhaven Heads Entrance Flood Management was to facilitate the development of a simple and clear policy to responsibly manage the entrance, waterbird habitat and structural integrity of the Shoalhaven Heads Entrance. Following on from the Discussion Paper Council prepared a draft Entrance Management Plan for Flood Mitigation in October 2006 which was subsequently finalised. The following sections provide background to the discussion paper but not the detail as this has been superceded by the October 2006 Plan.

The Shoalhaven River Entrance Management Plan for Flood Mitigation should be reviewed concurrently with the review of the Lower Shoalhaven River Floodplain Risk Management Study and Plan.

G2. BACKGROUND

Since the initial excavation of Alexander Berry's Canal in 1822, the Shoalhaven River has gradually eroded the canal to a width of over 400 m and the Crookhaven River has become the permanent ocean-river entrance. Survey plans in 1805 and 1822 indicate that the Shoalhaven River had a permanent, albeit relatively narrow entrance, which was largely unnavigable. Berry lost two men crossing the bar and for this reason dug the "canal" to provide ocean going access to upstream settlements.

Subsequently due to estuarine-coastal processes, the Shoalhaven Heads entrance has developed into a silted and sometimes stagnant water body cut off from the ocean by a 100 m wide sand dune. It has only opened in major flood events (say 20% AEP or greater events) and remained opened, or partially opened, for several months or years depending on the prevailing conditions.

The effect of the canal in diverting more of the tidal flow into the Crookhaven entrance is exacerbated by wave action. This tends to enhance the flood tide at the Shoalhaven Heads entrance bringing sand into the bay which is then not completely scoured out by the weaker ebb tide, resulting in the build up of sand/silt deposits in the area.

For a number of years experts, local residents and Council have debated the relative merits of the following general courses of action:

- maintaining a permanent open entrance at Shoalhaven Heads,
- employing artificial means (pumps, dredges, bulldozers) to manipulate the opening for various purposes (recreation, visual and water quality, fishing, environmental and flooding),

- closing Berry's Canal or constructing floodgates,
- allowing nature to take its course.

The Independent Inquiry into the Shoalhaven River System, July 1999 concluded that the maintenance of a permanent open entrance and the closure of Berry's Canal are not economically viable and should not be pursued further. However there has always been an argument for human intervention to minimise the impacts of flooding on development at Shoalhaven Heads.

Human intervention at Shoalhaven Heads for flooding purposes could involve any or all of the following activities:

- opening the sand dunes during a flood with a bulldozer,
- maintaining a low level notch in the dune so as to enable floodwaters to overtop and erode the dune or assist mechanical opening during flood events,
- dredging (as recommended in a 1986 report) of the waterway from the main river at Old Man Island to Shoalhaven Heads.

Previous studies regarding the Shoalhaven Heads entrance issue have indicated that there is a wide range of strong and divergent views regarding the relative benefits and disbenefits of opening the entrance either during a flood or in non-flood times. The discussion paper was developed as part of the floodplain management process and was motivated by the desire to minimise the effects of flooding on upstream properties. The approach adopted was to consider and balance all of the relevant issues and propose appropriate management solutions which address the main problems.

G3. OBJECTIVES

The objectives were:

- to document the history of human intervention at the Shoalhaven Heads entrance during times of flood,
- to assess the relative merits of human intervention during times of flood,
- to discuss and propose a policy for the appropriate management of the Shoalhaven Heads entrance which addresses the flooding concerns whilst taking into account the environmental considerations.

G4. LIMITATIONS

The entrance management policy was ONLY concerned with intervention to minimise flood impacts for existing development. The possible opening of the entrance during times of flood is only one of a range of floodplain management measures and should not be considered in isolation as the overall solution to the flood problem. Other management measures were also considered as part of the overall (wider) floodplain management study.

The justification to open the entrance for water quality, recreational, aesthetic or purposes other than flooding is beyond the scope of the Floodplain Risk Management Study but was considered separately in the context of an Estuary Management Study.

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APPENDIX H: DESIGN STAGE HYDROGRAPHS

FIGURE H1

1% AEP
DESIGN STAGE HYDROGRAPHS

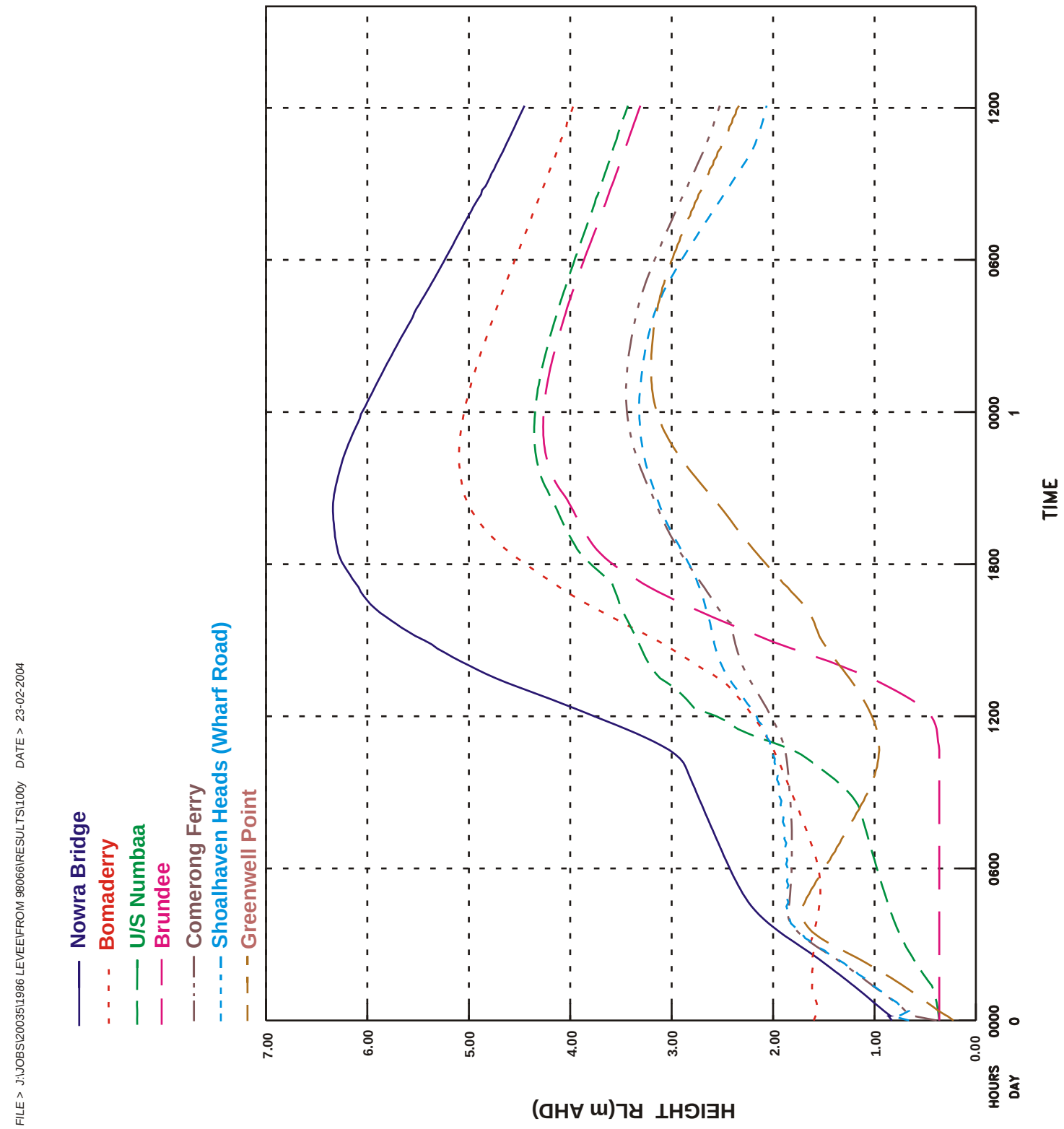

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FIGURE H2

2% AEP
DESIGN STAGE HYDROGRAPHS

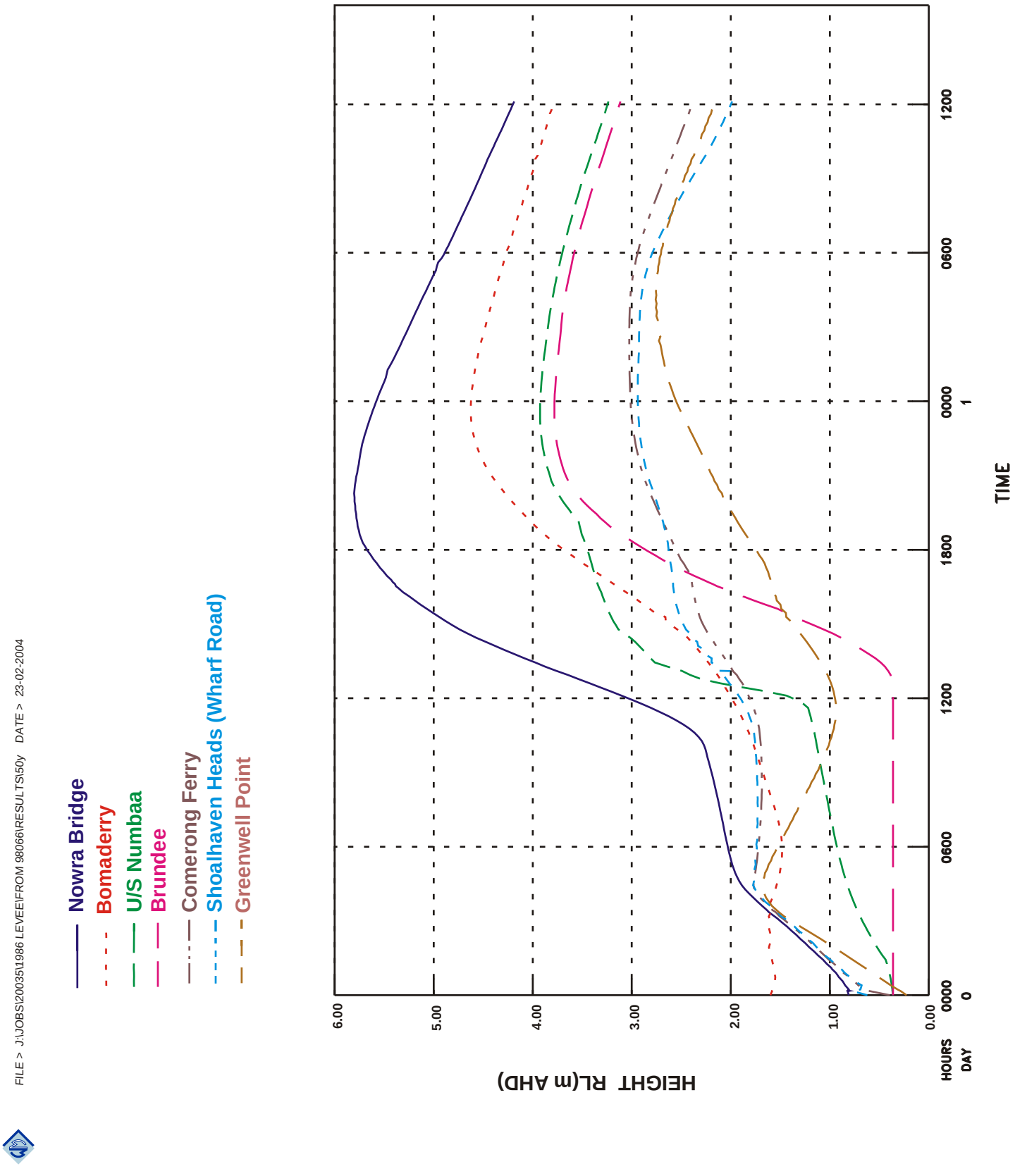

FIGURE H3

5% AEP
DESIGN STAGE HYDROGRAPHS

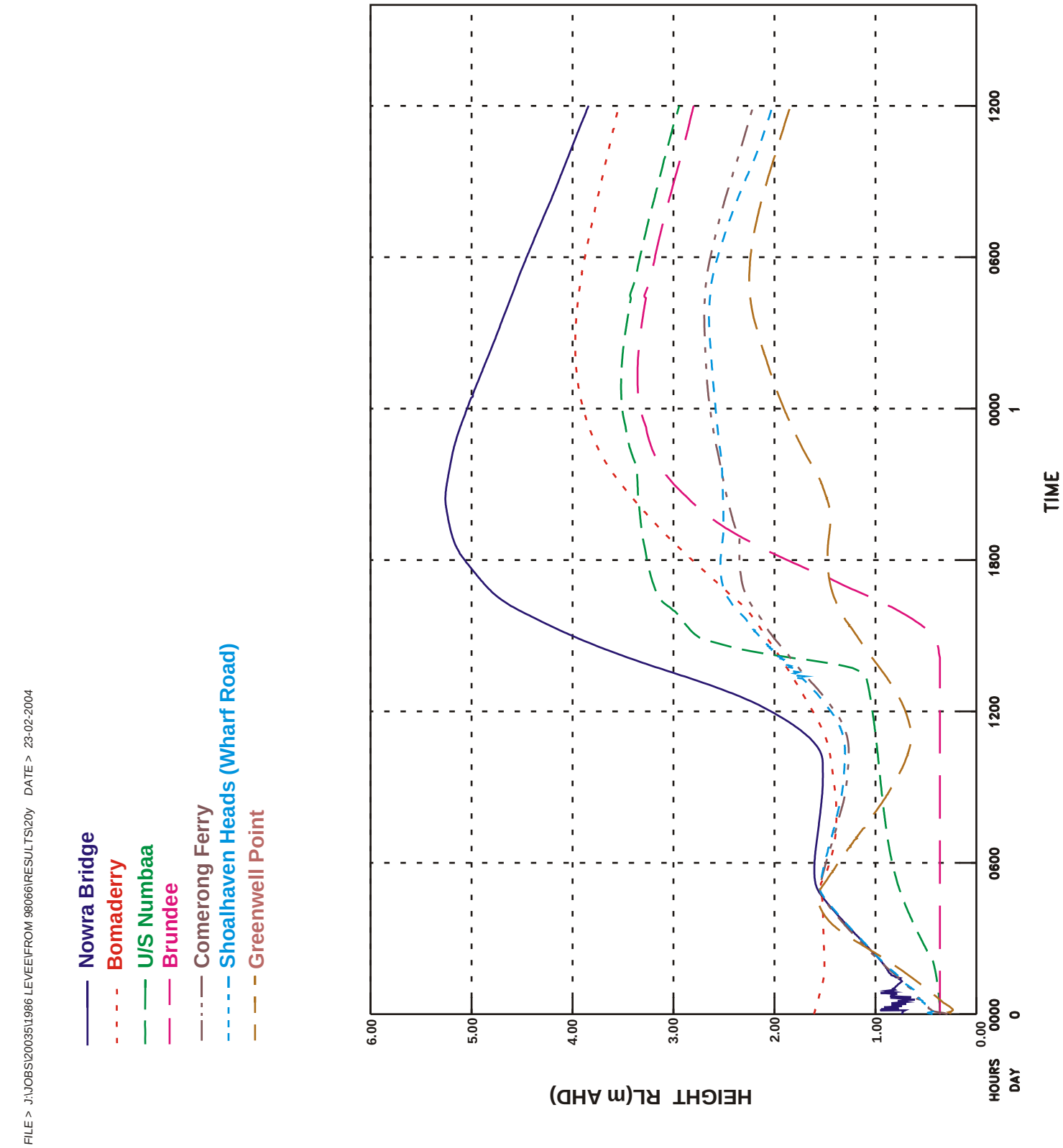

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FIGURE H4

10% AEP
DESIGN STAGE HYDROGRAPHS

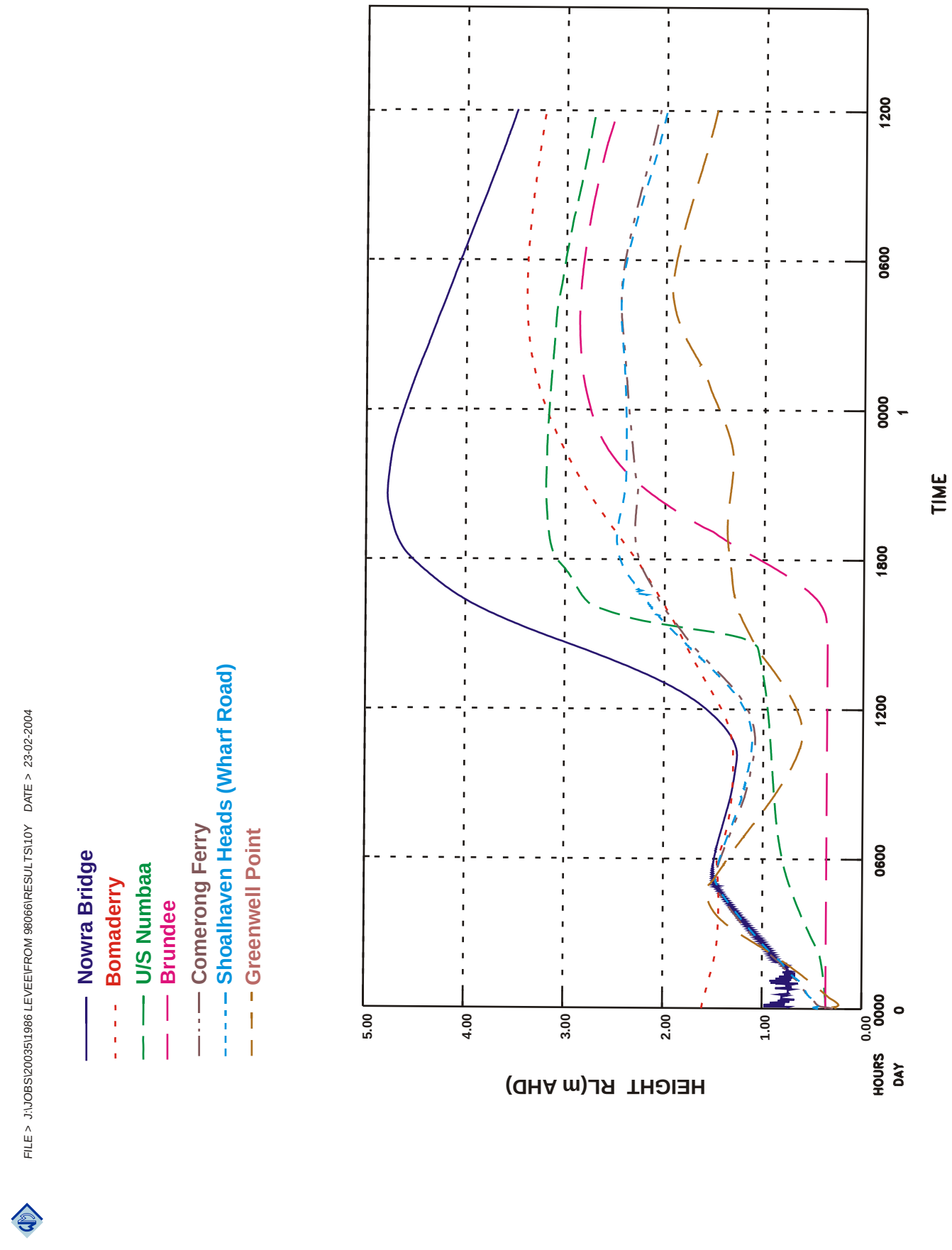

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FIGURE H5

0.5% AEP
DESIGN STAGE HYDROGRAPHS

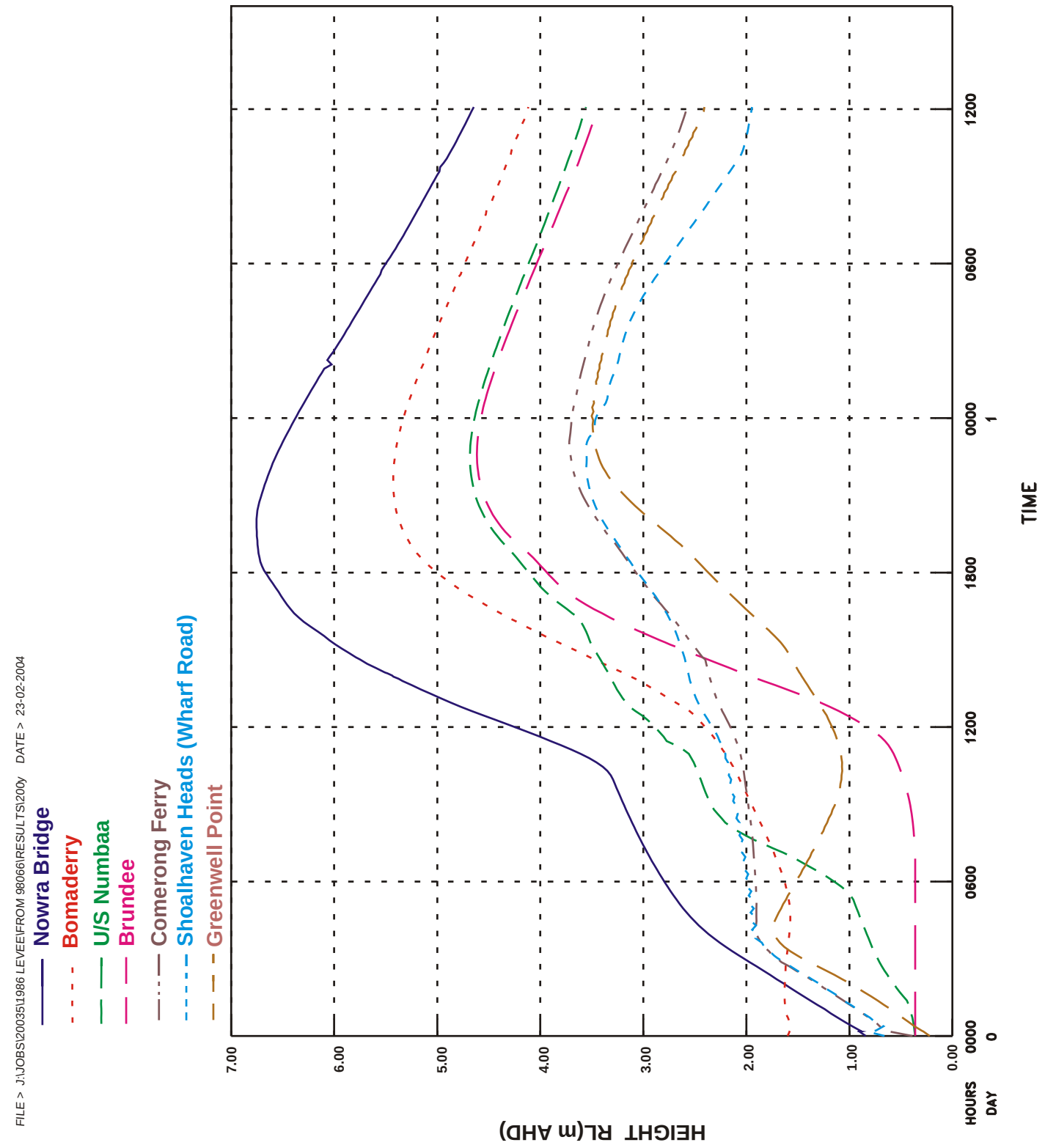


FIGURE H6

0.2% AEP
DESIGN STAGE HYDROGRAPHS

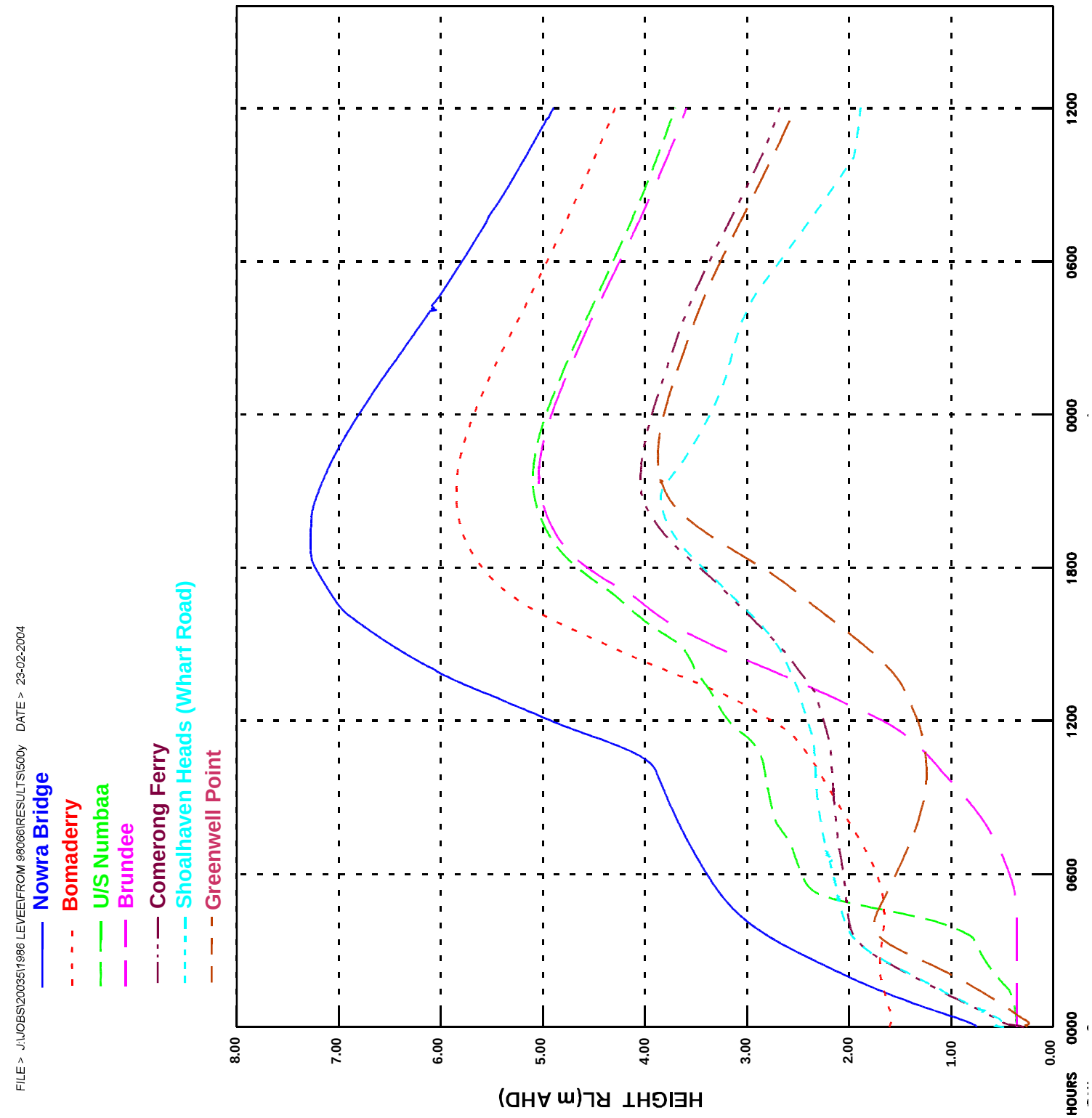
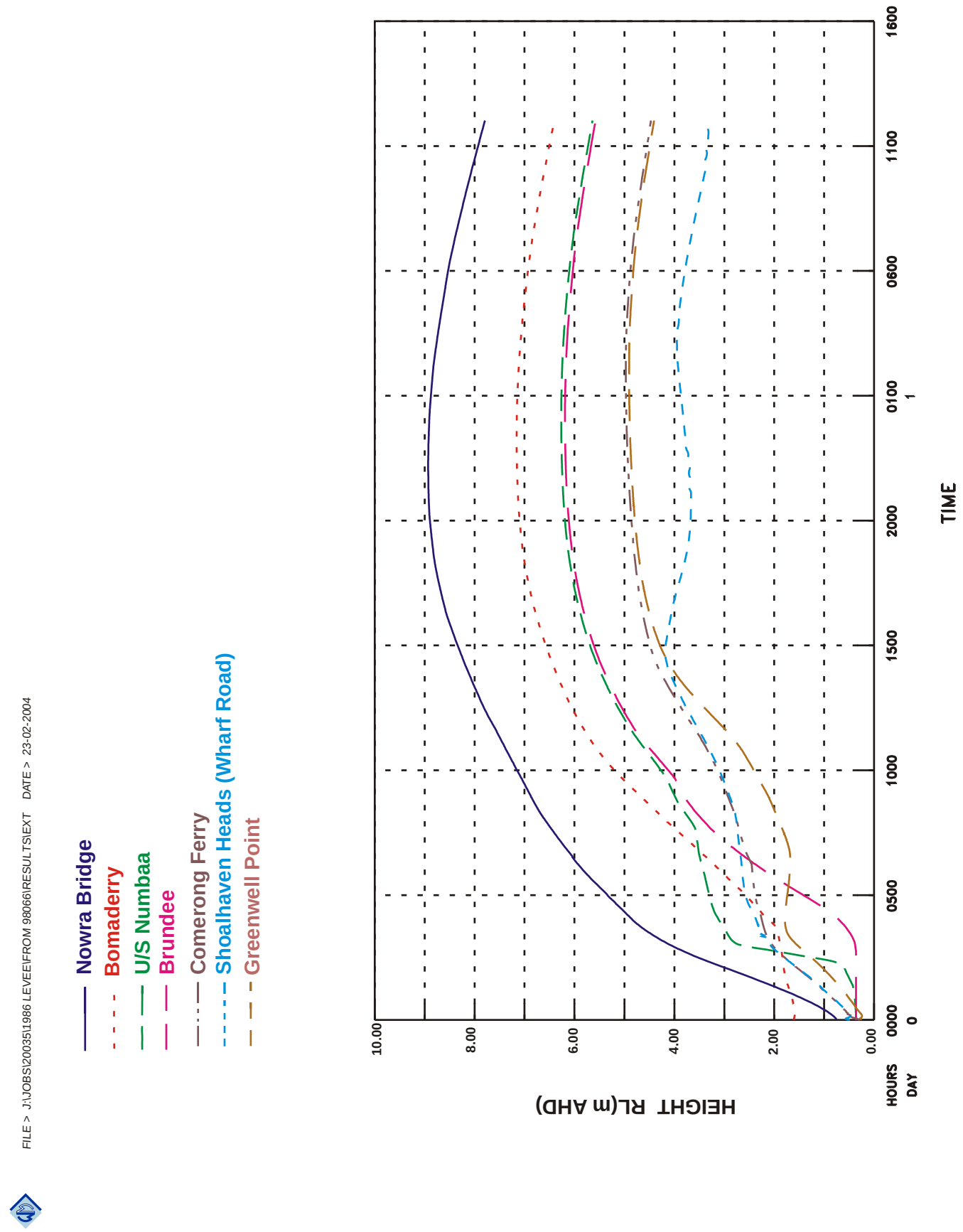


FIGURE H7

EXTREME
DESIGN STAGE HYDROGRAPHS



APPENDIX I: SUMMARY OF TERARA LEVEE INVESTIGATIONS

APPENDIX I: SUMMARY OF TERARA LEVEE INVESTIGATIONS

I1. NOVEMBER 2004: PROPOSED LEVEE WORK FROM FERRY LANE TO BRYANT STREET, TERARA - HYDRAULIC AND FLOODPLAIN MANAGEMENT ASSESSMENT

I1.1 Background

Terara Village is the original settlement on the southern bank of the Shoalhaven River, approximately 2.5 kilometres downstream of Nowra Bridge. The devastation of the 1860 and 1870 floods caused most of the population to move to the higher ground at Nowra with the subsequent decline of Terara. The village has continued to be flooded periodically, but people are still attracted to the area as a place to live. The population is now housed in a collection of heritage listed buildings as well as more modern premises, and there is some pressure for further development. Several isolated rural residential properties as well as the Shoalhaven Caravan Park are situated between the village and Ferry Lane.

Shoalhaven City Council adopted the Terara Village Floodplain Management Plan in 2002 (refer Section 5.2.9) and is progressively implementing the recommendations of that Plan. This present report provides further detail with regard to the recommendation for some form of refurbishment of the river bank levee.

I1.2 Floodplain Management Studies

The Terara Village Floodplain Management Study (February 2002 - TVFMS) identified the existing flood problem and canvassed a range of measures to mitigate the effects of flooding and minimise the damages for future development. The study area was defined as the village and surrounding rural properties east of the drain. Properties to the west of the drain were investigated as part of the separate Riverview Road Area Floodplain Management Study (February 2002 - RRFMS).

I1.3 Levee Upgrading Proposal of Council - May 2004

Following on from the levee audit in 2002, Council proceeded to investigate a proposal to upgrade the levee with the works being considered in two stages:

Stage 1: Upgrading and raising of the levee adjacent to Terara (approximately from Nobblers Lane to Bryant Street) up to the 5% AEP flood level + 300 mm freeboard.

Stage 2: Possible upgrading works from Ferry Lane to the start of the Stage 1 levee near Nobblers Lane.

I1.4 Levee Audit

The history of the levee along the southern bank of the Shoalhaven River at Terara is not well documented but it is understood that it was constructed by Council and the levee is included in Council's Asset Register. The levee comprises a raised mound, up to 2 m high in places but less than 0.5 m in others, and there is no formal design or documentation. The levee is largely located within private property and was probably initiated informally around 1963, with subsequent additional works undertaken following the 1974 flood.

A levee audit of the river bank from Ferry Lane to Bryant Street (Stage 1 and 2 levee) was undertaken by Sinclair Knight Merz (SKM) in March 2002. The extent of this audit was greater than envisaged in the TVFMP which only assumed an audit of the Stage 1 levee.

A preliminary levee design (Ferry Lane to Bryant Street) has also been completed by SKM (Draft Nov 2003). The proposed works include raising the levee to the 5% AEP flood level + freeboard.

I1.5 Hydraulic Impact Assessment Report of March 2004

In March 2004, Webb McKeown undertook hydraulic modelling to assess the potential impacts of raising the levee from Ferry Lane to Bryant Street up to the 5% AEP flood level + freeboard. The study concluded that there would be an increase in flood levels on the northern floodplain by up to +0.06 m. A preliminary economic, social and environmental assessment of these impacts was also undertaken.

I1.6 Objectives of the November 2004 Investigation

The following three issues were to be addressed:

1. Provide advice regarding the eastern and western limits of the Stage 1 levee.
2. Undertake further hydraulic modelling to determine the extent of raising of the Stage 2 levee that would result in negligible hydraulic impact elsewhere.
3. Provide floodplain management advice regarding the relative merits of filling the low points in the Stage 2 levee.

I2. ISSUE 1: LIMITS OF THE STAGE 1 LEVEE

I2.1 Background

If failure of the Stage 1 levee were to occur, either in flood or non flood times, there is the risk that some urban infrastructure including buildings, roads and other assets in the village may be lost. The SKM levee audit identified the likely modes of failure and proposed toe and bank works to reduce such likelihood. As indicated in the TVFMP some raising of the levee could also be undertaken at the same time as any works required to improve the structural integrity of the levee. SKM originally suggested a crest level grading from approximately 5.1 m at the upstream end down to 5.0 mAHD at Bryant Street. However this has since been revised to 5.0 m and 4.9 mAHD. This equates to approximately the 5% AEP flood level plus 0.3 m freeboard or the 2% AEP flood level. The freeboard is a factor of safety to account for uncertainties in the estimation of flood levels.

I2.2 Benefits of Raising the Stage 1 Levee

As indicated in the TVFMS the sole benefit of raising the Stage 1 levee is that following completion of the works, floodwaters would initially "enter" the village from all sides except the river bank. This would mean that inundation of the village would first occur from relatively slow rising floodwaters rather than higher velocity floodwaters which would result from overtopping of the levee.

It should be noted that raising of the Stage 1 levee would make very little difference to the extent or frequency of inundation of the village. This is because floodwaters would typically enter the village as a result of overtopping of the Stage 2 levee and the river bank downstream of Bryant Street combined with local rain over the floodplain. Raising of the Stage 2 levee or constructing a "ring" levee, are the only means of potentially reducing the extent and frequency of inundation of the village. A field inspection of the river bank and land at the eastern and western limits of the Stage 1 levee was undertaken on 6th May 2004. Following discussions with Council and DNR (formerly DIPNR) representatives the following issues relating to the limits of the Stage 1 levee were agreed upon.

I2.3 Eastern Limit of Stage 1 Levee

Either Southern Road or Bryant Street could be adopted as defining the eastern limit of the Stage 1 levee (Photographs I1 to I4). Beyond Bryant Street there is no benefit to the village and this introduces access problems for the Pig Island ferry. Between Southern Road and Bryant Street the levee is within private property (Shepherd & Chalmers) and according to SKM has a much reduced risk of toe or rotational/slumping failure. Consequently, there is no "structural" requirement to upgrade the levee in this reach. However, there is some value in strengthening the bank near the crest as it is relatively narrow. Presently the crest is at

approximately 4.5 mAHD with a design crest of 4.95 mAHD. SKM indicated a provisional cost of $12,000 would be required to upgrade this section.

It is recommended that the upgrading works within the Shepherd & Chalmers properties should be undertaken provided the residents have no objections and there are no additional costs associated with landtake, loss of vegetation or similar. Maintenance of the structure should remain with the property owners as the levee is currently privately owned and within private property. The costs for these works should be closely monitored as the works provide only a limited hydraulic benefit. If costs rise significantly or other issues arise Council may elect to not implement works in this reach.

It has been suggested that a tie back should be provided at Bryant Street from the levee crest to a point inland. We are unaware of any justification for the tie back at this location as it would not provide any significant benefit in reducing flood levels or velocities. On the contrary, we consider that there are a number of possible disadvantages with the construction of such a tie back. These include additional cost, removal of vegetation, local drainage issues, access issues, maintenance and whether an easement or land purchase would be required. Bryant Street was adopted as the downstream (eastern) end of the Stage 1 levee.

Photograph I1: Mound within Shepherd and Chalmers properties (i.e. between Southern Road and Bryant Street)

Photograph I2: Shepherd and Chalmers Properties looking downstream

Photograph I3: Bank within Shepherd and Chalmers properties looking downstream

Photograph I4: Mound on Bryant Street at ferry access

I2.4 Western Limit of Stage 1 Levee

In the TVFMP the western end of the "Terara Levee" was shown at Nobblers Lane as this is where the existing structure blends into the natural surface. There is only a "slight" mound (crest at approximately 4.5 mAHD) within McCulloch's property (refer Photographs I5 and I6). It is noted that in the nursery just west of McCulloch's property, the bank appears to have been relatively recently upgraded and has a crest at similar or slightly higher levels (refer Photographs I7 and I10).

Photograph I5: Existing mound within McCulloch property looking downstream

Photograph I6: Bank upstream of McCulloch property

Photograph I7: Bank within nursery looking downstream

Photograph I8: Bank within nursery looking upstream

Photograph I9: Steep banks within nursery looking upstream

Photograph I10: Bank within nursery looking upstream

The western limit was determined to be at some within the nursery just upstream of the western boundary of McCulloch's property.

I3. ISSUE 2: HYDRAULIC MODELLING OF THE STAGE 2 LEVEE

I3.1 Background

Two alternative scenarios were considered. Scenario 1 assumed just filling of the "low" points while Scenario 2 assumed that the high points were removed and the crest level is set at the same grade as the flood profile. The latter involves regrading the entire levee crest.

For Scenario 1 the maximum raising that could be achieved with less than 0.01 m impact is approximately to the 6.7% AEP or 1 in 15 ARI flood level with no freeboard. The main two areas of filling are at Terara Sand & Gravel (chainage 1130) and at chainage 1250.

Scenario 2 was considered but apart from two "high points" at chainage 486 m and 1200 m the maximum height that would be removed from the crest peaks is 0.3 m. It would be unrealistic (cost, returfing, remove vegetation) to remove this amount from the crest of an earthen levee for the minimal hydraulic advantage that could be gained.

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I4. ISSUE 3: FLOODPLAIN MANAGEMENT ADVICE REGARDING ANY WORKS ON THE STAGE 2 LEVEE

I4.1 Filling the Low Points in the Stage 2 Levee

The following provides a summary of the main floodplain risk management issues associated with upgrading and raising of the Stage 2 levee by filling the low points.

I4.1.1 General Issues

- Raising of the Stage 2 levee was not a recommendation of the TVFMP. If works are to be undertaken then the reasoning behind the decision must be documented in a formal strategy of Council. This could either be an amendment to the TVFMP or as part of the Lower Shoalhaven River Floodplain Risk Management Study and Plan.

- Some form of public consultation should be undertaken, particularly with local landowners who are impacted by the works.

- In the absence of sufficient, reliable historical data on river gradients, the proposed gradient of the Stage 1 and Stage 2 levees is based on the hydraulic model results. Whilst this is the best available information, further data needs to be collected from future events to confirm the hydraulic gradient or design flood profile.

- Whilst the present river bank is relatively stable, there is the risk that significant loss of land could occur during a flood as happened in the 1860 and 1870 events. If this were to occur again, any benefit from the levees would be lost. The levee as a floodplain risk management asset would also be lost.

- Levees can fail during floods or even in non flood times.

I4.1.2 Possible Benefits

1. The level at which floodwaters will first overtop the levee could be raised from approximately less than a 1 in 5 ARI (20% AEP) event to a 1 in 15 ARI (6.7% AEP) event with minimal adverse hydraulic impact. Thus the frequency of overtopping would be reduced. It should be noted that the lowest point in the Stage 2 levee is presently the access to Terara Sand & Gravel which is well below the 1 in 5 ARI event. This is probably the most difficult part to raise and would involve either some form of stop log structure or further raising of the mound. We would only recommend the latter approach as there is less risk of failure. A key issue to consider is that the level of protection offered by the levee is only as good as its most vulnerable point.

2. For events which are less than an overtopping event, there is a reduced likelihood of structural damage to the levee as a result of overtopping. Flood levels on the southern floodplain will also be reduced for these events. Unfortunately due to the influence of local rainfall over the area, the reductions in level or inundation extent cannot be accurately quantified.

3. For events that do overtop the levee (after raising) there would be a slight reduction in flood level at the village. The maximum reductions in level at Terara village for raising to the 6.7 AEP % (1 in 15 ARI) event are:

2% AEP	-0.10 m
1% AEP	-0.09 m
0.5% AEP	-0.08 m

4. There would be no benefit in the Extreme flood. The benefit is greatest in the smaller floods and decreases with the magnitude of the flood. It should be noted that for the TVFMS study area there is only 1 building inundated in the 5% AEP, 13 in the 2% AEP, 44 in the 1% AEP and 51 in the 0.5% AEP. There are a further 4 buildings inundated in larger events.

5. In theory the raising of the levee would increase the time available to evacuate the Terara residents to Nowra. Based on the theoretical rate of rise from 4 m to 4.5 mAHD (from the lowest point in the existing levee to approximately the 1 in 15 ARI (6.7% AEP)) in the Shoalhaven River in a 0.5% AEP event the likely maximum increase in evacuation time is 1.5 hours. This may or may not be of benefit as possibly local rain will have already impeded traffic on Terara Road. It should be noted that the above information is based on a theoretical design flood hydrograph. The rate of rise will also vary depending upon the event. During the March 1978 flood, the rate of rise near the peak was much slower (approximately 6 hours for a similar increase in level). However an increase of 0.5 m in 2 hours was experienced in the early stages of the March 1978 flood.

6. A more uniform crest profile is obtained by filling the low points. This may reduce the likelihood of localised scour and possible failure in a small overtopping event.

I4.1.3 Possible Concerns

1. The following statements are the opinions of Webb McKeown and it is recommended that Council obtain advice to ascertain the legal ramifications. The original levee from Ferry Lane to Nobblers Lane (referred to as the Stage 2 levee) was constructed by Council and is a designated Council asset. There is therefore some liability on Council to maintain the asset and also possibly some liability if it was to fail and cause damage. Council must ensure that any future works do not compromise the integrity of the levee.

2. The residents of Terara and surrounding area are obviously aware that there is a raised bank between Ferry Lane and Nobblers Lane (Stage 2 levee). However they are also aware that it was not built to the same engineering standards as the Riverview Road levee. Thus in a future flood event they would still have concerns that the existing Stage 2 “levee” might fail and/or would be overtopped. Many would be aware that it was overtopped during the floods in the 1970's, particularly March 1978. If Council undertakes works on the levee then the residents might perceive that the upgraded levee will reduce the risk of failure and reduce the extent and frequency of inundation. Whilst this may be true, the concern is that this perception may provide a “false sense of security” and as a result residents may make the wrong decisions during the next flood. For example, rather than evacuating to Nowra they may stay in their house and run the risk of being trapped, drowned or placing the lives of SES at risk to rescue them at a later time. In order to reduce the likelihood of the proposed works “sending the wrong message” it is suggested that a Flood Awareness and Preparedness Program could be initiated in conjunction with the provision of more detailed information about the levee works. This measure is one of the High Priority recommendations of the TVFMP. This Program (amongst others) should highlight that the levee works do not eliminate the risk of levee failure, overtopping or bank collapse. Also evacuation of Terara village must occur before overtopping of the levee commences, and any decision by the SES to evacuate must be obeyed by the residents. Residents must not remain in their houses.

3. Whilst the “filling of the low spots” has been minimised to achieve less than 0.01 m increase in flood level, some residents on the northern bank or on Pig Island may still consider that they have been disadvantaged by the works being undertaken. This would particularly be the case in the smaller more frequent events (20% AEP to 5% AEP). The present hydraulic model is not capable of accurately defining any of these minor changes in flow patterns or directions. These impacts could only be evaluated using a 2D hydraulic model.

4. Raising the levee will result in more flow being contained within the banks and consequently result in some slight increase in velocity in the river. Residents may argue that this will increase the potential for bank scouring and/or failure during a flood.

5. The value of raising the Stage 2 levee (or indeed the Stage 1 levee) would be judged by its performance in the next flood. If the next flood was a 2% AEP event which overtopped the levee then the raising works would be perceived to have produced no benefit. This statement is obviously relevant for all levee upgrades or designs.

6. Raising of the Stage 2 levee will require some form of sealing at all the access points to the river. The most significant would be at Terara Sands & Gravel, though we understand there are others. If the access can be sealed to the landowners satisfaction with a raised mound of similar construction to the levee then this would be acceptable. However some form of "temporary" sealing structure, such as stop boards raises the question whether there is any guarantee or fail safe that these works would actually be undertaken during a flood. The benefit of the levee is only as good as its weakest link.

7. It is likely that the proposed raising works, if undertaken in isolation without a need to improve the structural integrity of the levee, would have a low benefit/cost ratio in terms of reducing tangible flood damages. This can only be determined if a cost for just the raising works is obtained.

8. The issue of landtake cost and possible creation of an easement needs to examined further. This may raise additional problems for Council and/or landowners.

9. There may be some slight reduction in aesthetic amenity as a result of the raising of the Stage 2 levee.

10. Raising the levee may cause some loss of vegetation or other adverse environmental impact. It will also further limit the natural "environmental" benefit of floodwaters escaping onto the floodplain on a more regular/frequent basis.

11. Raising the levee may provide an argument for new development in the area or a reduction in development control standards on the basis that the frequency of flooding has been reduced.

12. The philosophy of raising river bank levees and constricting the river flow to a defined channel has been questioned in recent times by many Australian and overseas floodplain managers for the various reasons indicated above.

13. Filling the “low points” in the levee may adversely affect the existing local drainage regime. This would possibly result in more frequent inundation or a longer duration of inundation.

I4.2 Conclusions

The main concerns regarding possible works on the Stage 2 levee include the liability, maintenance, economic justification and creation of “false sense of security” issues. The latter can hopefully be adequately addressed through implementation of a suitable Flood Awareness and Preparedness Program.

The assessment of possible effects associated with filling the low points can be summarised as follows:

Hydraulic Impacts: The works have been designed so that the cumulative impacts of the Stage 1 and Stage 2 works produce less than +0.01 m increase in flood level. There will be some reduction in flood level for Terara Village on the southern bank of up to 0.1 m in events up to a 2% AEP flood event.

Social Impacts: As the extent of filling is relatively minor, there are unlikely to be any significant adverse social impacts (views, aesthetics).

Environmental Impacts: The main environmental impact is the removal of trees from the bank area.

Economic Impacts: The cost of filling the low points is unknown at this stage but it is unlikely to be justifiable on economic grounds.

Based on the above assessment we conclude that filling of the low points will produce no significant adverse impacts but cannot be justified if undertaken solely as a floodplain risk management measure.

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I5. MARCH 2004: HYDRAULIC IMPACT ASSESSMENT PROPOSED LEVEE WORKS FROM FERRY LANE TO TERARA

I5.1 Background

Following from the results of the SKM Terara Levee Audit of March 2002, Council began investigating proposed levee upgrading works extending from Ferry Lane to Bryant Street, Terara along the southern bank of the Shoalhaven River. Webb, McKeown & Associates were engaged by Council to assess the potential hydraulic impacts of three levee options and in particular the potential impacts for industrial developments on the northern side of the river.

The CELLS hydraulic model established for the Lower Shoalhaven River Flood Study (1990) was utilised.

Weirs 47 and 62 which represent the southern bank of the river within the model were refined using the recent bank survey for the Terara Levee Audit. The model was then re-run for the full range of design events to provide a set of base conditions against which to assess the impacts of the levee proposal.

The three design levee options tested were:

Option 1: Weirs 47 and 62 within the model were adjusted to the 5% AEP design level + 300 mm freeboard.

Option 2: Weirs 47 and 62 within the model were adjusted to the 5% AEP design level + 400 mm freeboard.

Option 3: Weir 62 adjacent to Terara Village was adjusted to the 5% AEP design level + 300 mm freeboard.

It should be noted that for modelling purposes the effective level of protection of Option 2 becomes approximately the level of the 2% AEP event.

I5.2 Results

The results for the alternative levee configurations are shown in Tables I1, I2 & I3 respectively.

Results are shown for key locations only and it should be noted that changes in flood level do occur elsewhere on the floodplain.

Table I1: Relative Impact (m) - Levee at 5% AEP Design Level plus 300 mm Freeboard

Location	Event (AEP)					
	10%	5%	2%	1%	0.5%	Extreme
SHOALHAVEN RIVER:						
Nowra Bridge X17	*	*	0.02	0.02	0.02	*
Ferry Lane Cell 19	*	*	0.03	0.03	0.03	*
Terara Cell 27	*	*	0.04	0.04	0.04	*
BOMADERRY:						
Cell 11	*	*	0.03	0.03	0.03	*
Cell 15	*	*	0.03	0.03	0.03	*
NORTHERN FLOODPLAIN:						
Cell 26	*	*	0.05	0.03	0.03	*
Cell 33	*	*	0.05	0.03	0.02	*

Refer Lower Shoalhaven River Flood Study for result locations. * Impact ±0.01 m or less.

Table I2: Relative Impact (m) - Levee at 5% AEP Design Level plus 400 mm Freeboard

Location	Event (AEP)					
	10%	5%	2%	1%	0.5%	Extreme
SHOALHAVEN RIVER:						
Nowra Bridge X17	*	*	0.03	0.04	0.04	*
Ferry Lane Cell 19	*	*	0.03	0.05	0.04	*
Terara Cell 27	*	*	0.04	0.06	0.06	*
BOMADERRY:						
Cell 11	*	*	0.03	0.04	0.04	*
Cell 15	*	*	0.03	0.04	0.04	*
NORTHERN FLOODPLAIN:						
Cell 26	*	*	0.06	0.05	0.05	*
Cell 33	*	*	0.05	0.04	0.04	*

Refer Lower Shoalhaven River Flood Study for result locations. * Impact ±0.01 m or less.

Table I3: Relative Impact (m) - Levee adjacent to Terara Village at 5% AEP Design Level plus 300 mm Freeboard

Location	Event (AEP)					
	10%	5%	2%	1%	0.5%	Extreme
SHOALHAVEN RIVER:						
Nowra Bridge X17	*	*	*	*	*	*
Ferry Lane Cell 19	*	*	*	*	*	*
Terara Cell 27	*	*	*	*	*	*
BOMADERRY:						
Cell 11	*	*	*	*	*	*
Cell 15	*	*	*	*	*	*
NORTHERN FLOODPLAIN:						
Cell 26	*	*	*	*	*	*
Cell 33	*	*	*	*	*	*

Refer Lower Shoalhaven River Flood Study for result locations. * Impact ±0.01 m or less.

I6. HYDRAULIC IMPACTS

The potential hydraulic impacts of the proposed levee works may be summarised as:

Southern Floodplain: Option 2 (5% AEP + 400 mm) would provide some level of protection on the southern floodplain for events up to and including the 2% AEP event (the modelling cannot account for wind or wave action etc.). In a 2% AEP event either Option 1 or 2 will reduce peak flood levels by up to 1 m. Peak flood levels will be reduced by up to 0.4 m in a 1% AEP event and up to 0.3 m in a 0.5% AEP event. These are the maximum reduction in flood levels and are not necessarily representative of the average reduction over the southern floodplain.

For events equal or less than the overtopping event (say a 2% AEP) Options 1 and 2 prevent floodwaters entering over the levee. However, the water level "behind" the levee is also affected by local rain and backwater of floodwaters through the drainage ditches. The model does not accurately simulate these two features. Thus it is not possible to say with confidence what the actual reduction in flood levels in Terara and along Terara Road will be in events up to and including the overtopping event (say the 2% AEP).

Option 3 produces a maximum reduction in level of up to 0.04 m.

Northern Floodplain: Options 1 or 2 (300 mm or 400 mm freeboard) will cause increases in flood level on the northern floodplain of up to around 0.06 m in the 2%, 1% and 0.5% AEP events, but there will be no significant change in a 10%, 5% AEP or the Extreme event. There is a 0.01m increase or less for all events for Option 3.

Main River: The proposed levee with a 400 mm freeboard (Option 2) would cause increases in flood levels in the main river channel of up to around 0.06 m for the 2%, 1% and 0.5% AEP events. Increases up to around 0.04 m would be experienced with the lesser 300 mm freeboard (Option 1). There would be no significant change in an Extreme event. There is a 0.01m increase or less for all events for Option 3.

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I7. OTHER FLOODPLAIN MANAGEMENT CONSIDERATIONS

Construction of a levee from Ferry Lane to Bryant Street, Terara may raise a number of other floodplain management issues apart from the hydraulic consideration reported above. These might include:

- the implications of using "stop logs" on the river access route at Chainage 1120,
- the possible increase in flood damages or flood hazard as a result of the increases in flood levels,
- the possible social and environmental implications,
- the possible implications of cumulative flood increases as a result of past and future works on the floodplain,
- the Terara Village Floodplain Management Study assessed such a levee but concluded that only levee works adjacent to the village of Terara should be undertaken. It may be appropriate to reassess the various issues that were considered in that study to provide justification for the preferred levee proposal.

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APPENDIX J: UPDATES TO STUDY SINCE COMMENCEMENT

APPENDIX J: UPDATES TO STUDY SINCE COMMENCEMENT

J1. BACKGROUND

The Lower Shoalhaven River Floodplain Risk Management Study and Plan were commenced in 2000 and as part of the process all available information was collected at that time. However, Floodplain Risk Management is a dynamic process which is continually evolving both at a State and Council level.

Since 2000 there has been a number of changes to both State and Council policy which may influence the outcomes of the Study and Plan.

This Appendix documents the major changes that have occurred. The approach of documenting the changes, rather than updating the words in the text to reflect the changes, was undertaken as the latter approach would require a complete reworking of the study and would further delay publication of the final reports.

J2. UPDATED STATE GOVERNMENT POLICY

The NSW Government's policy on floodplain management since 1986 has been documented in the following reports:

- Floodplain Development Manual, December 1986,
- Floodplain Management Manual, January 2001,
- Floodplain Development Manual, April 2005.

The Lower Shoalhaven River Floodplain Risk Management Study and Plan was undertaken under the auspices of the January 2001 manual. The April 2005 edition was produced to replace the 1986 manual relating to the management of flood liable land in accordance with Section 733 of the Local Government Act 1993 (the January 2001 edition was never gazetted). This provided Councils and their staff, with indemnity for decisions made and information provided in good faith from the outcome of the management process.

There is no listing of the various changes between the 2001 and the 2005 manuals. The foreword of the 2005 manual states:

> *"In 2003 major changes were made to the composition of agencies with responsibilities for floodplain risk management. In particular the creation of the Department of Infrastructure, Planning and Natural Resources means that one agency now has responsibility for both land use planning and natural resource functions on the floodplain.*

This necessitated changes to the 2001 Manual and provided an opportunity, in light of experience with the 2001 Manual, to further clarify the intent of the policy. In particular, this clarification will reduce the potential for inconsistent interpretation by consent authorities, particularly with respect to the interaction between the determination of flood planning levels and the consideration of rare floods up to the PMF."

J3. SHOALHAVEN CITY LOCAL FLOOD PLAN

The October 1999 version of the above was originally reviewed as part of this report. Subsequently this report was updated in a February 2004 version.

J4. COUNCIL'S PLANNING DOCUMENTS

A review was undertaken of the Shoalhaven City 1985 Local Environmental Plan (LEP) and various DCP's. In late 2005 the State Government has advised Councils that a single LEP is now required and must be completed within three years. This program will also affect other planning instruments such as DCPs.

The proposed planning template introduces many new concepts which require further investigation by Council.

J5. FLOOD WARNING SYSTEM - ALERT

Continual progress has been made by Council on the enhancing of the Alert flood warning system.

J6. CARAVAN PARKS - GRANT FUNDING

Shoalhaven City Council has accepted a grant and prepared a consultant brief for a caravan park risk assessment study within its local government area. This study should be completed in 2007-08.