

PROPOSED CARAVAN PARK MOUNT DEE ROAD, MAITLAND

FLOOD HAZARD and SITE SUITABILITY ASSESSMENT





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1. INTRODUCTION

Maitland City Council is in receipt of a request to amend the Maitland Local Environmental Plan 1993 (LEP) to permit a caravan park on land at Mount Dee Road, Maitland (Photo 1) as the proposed use of the land for a caravan park is prohibited in the 1(a) Prime Rural Zone.



Photo 1 Locality Plan (courtesy of Google Maps)

The applicant submitted a Planning Proposal in March 2010 which outlined the development proposal and the justification to amend the LEP. The proposal seeks to allow development *“for the purposes of a tourist park, which will include park amenities, toilets, showers, laundry, reception office and manager residences, recreational buildings and areas, tourist park catering facilities, cabins, powered caravan sites and camp sites”*.

An Addendum to the March 2010 submission was provided in June 2010. The Addendum provides further information and justification of the proposal’s merits in respect of the flood prone nature of the land in response to a request from Council.

Maitland City Council provided a letter on 22nd September 2010 seeking additional information from the applicant regarding the:

1. Details of the type of accommodation in the tourist park (short/long stay or permanent residents),
2. Site survey,

3. A comprehensive hydraulic assessment from a “specialised flood consultant” to discuss the nature of flooding and the compatibility of the proposed use.

The applicant provided a response to Council's letter of 22nd September 2010 on 15 November 2010. The response did not include advice from a “specialised flood consultant” regarding the compatibility of the proposed use.

In December 2010 WMAwater was engaged by Maitland City Council to review the proposal in relation to the extent and nature of flooding on the site, the compatibility of the proposed caravan park use in relation to the specific flooding character and any recommendations regarding development of the subject site.

WMAwater has over 25 years of experience in the field of hydrology and hydraulic modelling in NSW and are familiar with the local area having completed the September 2010 Hunter River: Branxton to Green Rocks Flood Study which was funded by Maitland City Council and the Department of Environment, Climate Change and Water (DECCW).

This assessment comments on the flood related aspects of the proposed development and does not comment on any related planning matters.

A glossary of flood related terms is provided in Appendix A.

2. HAZARD AND SITE SUITABILITY ASSESSMENT

2.1. Caravan Parks in the Floodplain

Throughout NSW there are a large number of caravan parks on the floodplain. The main reason for this is the recreational attraction of the water (either for water skiing such as on the Hawkesbury or Shoalhaven Rivers or swimming and boating as on Tuggerah Lakes, Shoalhaven Heads or Lake Macquarie). Over the years the nature of caravan parks has changed and now many have permanent on site-vans and cabins as well as permanent residents as opposed to the more traditional use by tents and mobile vans.

In the past a caravan park in the floodplain was not considered a significant floodplain management issue as tourists would not stay in their tents or caravans by the water if flood producing rains started and would just pack up and leave the area as the “recreational water attraction” of the park is lost if a flood occurs. Thus in the past a caravan park was viewed as an appropriate use of the floodplain. However this change in nature of caravan parks has meant that Councils have now to carefully consider the appropriateness of existing and future parks on the floodplain in terms of their floodplain management responsibilities.

Some Councils (Shoalhaven City Council) have a specific code for caravan parks in the floodplain and detail approaches to minimise risk to life and damages. All DECCW funded floodplain management studies must address the specific issues of caravan parks in the floodplain as they present their own unique problems (compared to residential homes), namely:

- there is generally poor access with a single entrance/exit which may be controlled by gates,
- a poor (or no) site map is generally available to show the internal road system or the types of vans,
- fixed annexes on caravans or cabins which may contain high cost equipment such as freezers or stoves,
- there may be poor internal lighting which may fail during a flood,
- there is probably no flood emergency plan or it has not been tested recently,
- there may be 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 flood awareness of the flood risk or damage minimisation measures,
- a number of cabins or vans may be vacant thus increasing the workload and possible risk to life of the “rescuers” in removing vans or raising goods in cabins,
- some vans may not be able to be moved (flat tyres, rust etc.),
- there is the risk that vans may float and crash into each other or obstruct exit routes,
- caravans and most cabins have little structural integrity and thus can easily be damaged by floodwaters or completely destroyed resulting in total loss. We are unsure whether insurance would cover or not this loss or even if it is possible to insure a permanent van/cabin in the floodplain,

- the internal fittings (cupboards, fridges, beds) are usually non-removable and quickly damaged by floodwaters,
- there is a significant risk to life issue, particularly for older less mobile permanent residents who may have no where else to go, may attempt to “save” their home and goods and/or may require evacuation by the SES or local residents/friends/family may attempt to help and place themselves at risk.

For existing caravan parks in the floodplain Councils address the issue by enforcing Flood Evacuation Plans and associated damage minimisation procedures.

2.2. Nature of Flood Problem on Proposed Site

Figure 1 provides a ground survey of the site based on Council’s airborne laser scanning (ALS) survey. The peak water levels (in mAHD) on the site (taken from Site G Dagworth Bridge in Table on page v) of the September 2010 Hunter River: Branxton to Green Rocks Flood Study) are:

Probable Maximum Flood	= 12.2	(100%)
200 year ARI (approximates the February 1955 flood)	= 10.8	(99.5%)
100 year ARI	= 9.7	(98%)
50 year ARI	= 8.5	(92%)
20 year ARI	= 7.6	(87%)
June 2007	= around 6.1	(70%)

An approximate site coverage is shown in the above table in brackets, thus in the 100 year ARI (1% AEP event) the site would have only 2 % of the site not inundated by floodwaters.

It should be noted that the above design flood levels are from Hunter River flooding. However flooding of the site can also occur from local catchment flooding from Wallis and Fishery Creeks and this is what happened in June 2007. Flooding from the Hunter River only occurs when the Oakhampton Spillways are overtopped to a significant amount. In both the January 1971 and June 2007 events the Oakhampton No 1 spillway was overtopped but as far as we are aware there was insufficient volume of floodwaters to significantly raise the flood levels in the study area.

To obtain an accurate assessment of flooding at the site design flood levels would need to be obtained from design rainfall analysis over the Wallis and Fishery Creeks catchments in the absence of flooding from the Hunter River. However the design flood levels from the Wallis and Fishery Creek catchments would likely only exceed the corresponding Hunter River design flood levels in events below say a 50 year ARI.

2.3. Flood Hazard

Hazard is defined as *“a source of potential harm or a situation with a potential to cause loss”*. A Flood Study allows hazard to be defined based on pure hydraulic principles (water depth and

velocity) which will obviously change with the flood magnitude. Graphs taken from the NSW Government's Floodplain Development Manual used to define the Provisional Hazard are provided below. However the Manual states ***"It is not appropriate to use Figure G2 to determine the hazard implications of individual developments"***.

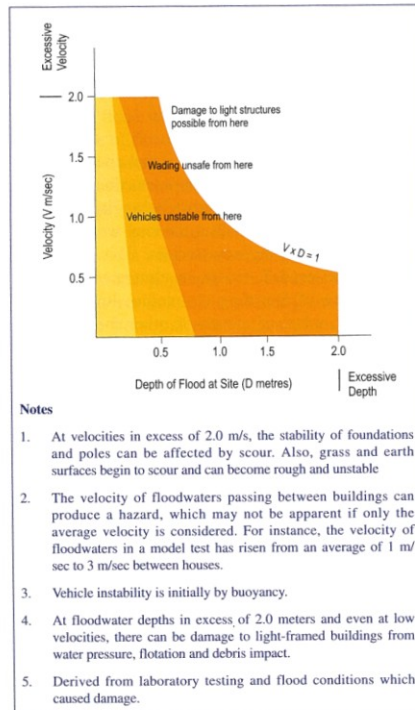


Figure G1
Velocity & Depth Relationships

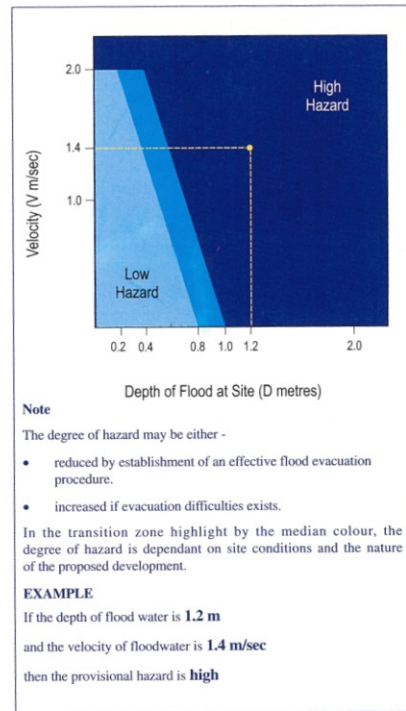


Figure G2
Provisional Hydraulic Hazard Categories

The Hunter River: Branxton to Green Rocks Flood Study indicates the Provisional Hazard for various design flood events. Figure 52 indicates that in the 100 year ARI (1% AEP) event the majority of the site is High Hazard.

The above diagrams and figures in the Flood Study do not reflect the effects of other factors that influence hazard namely:

- size of the flood,
- effective warning time,
- flood readiness,
- rate of rise of floodwaters,
- depth and velocity of floodwaters,
- duration of flooding,
- evacuation problems,
- effective flood access and,
- type of development.

Our qualitative assessment of the "true" flood hazard is that it is High. Our reasons for this are (assuming the development includes permanent and semi permanent residents and vans):

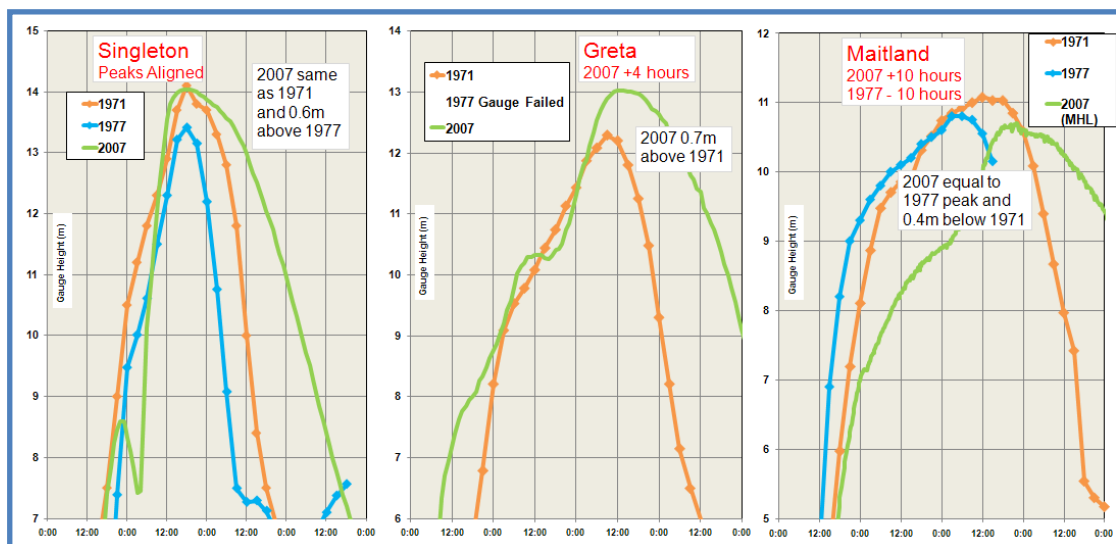
- the flood warning advice from the Bureau of Meteorology (BOM) is the best that is

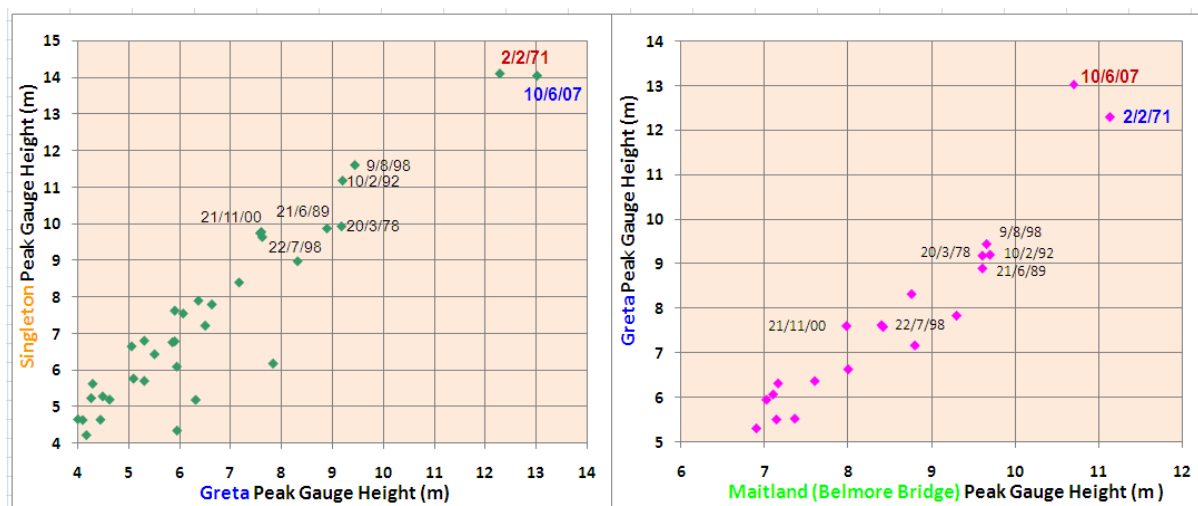
available but it should not be relied upon as the basis for approval of a development (refer Section 2.4),

- tourist developments typically have a very low level of flood awareness and thus the capability to evacuate quickly when required,
- the rate of rise of floodwaters, whilst slow compared to a small rivers will likely catch people unawares once the Oakhampton Spillways become overtopped,
- the depth of flood waters in the 100 year ARI event will be at least 4 metres over 50% of the site and across Mount Dee Road,
- the duration of flooding will be several days (as it was in June 2007) as floodwaters only drain out slowly back to the Hunter River along Wallis Creek,
- there will be significant evacuation problems (children, less mobile people, owners wishing to save their caravans and goods, adverse weather issues, distance to high ground, cars may not start or vans cannot be moved, isolated nature of development, possible bottlenecks along access roads, large number of people required to be evacuated, risk to life may panic people),
- the flood access route is poor as it is relatively long and most importantly is lower than the van sites, thus it will be inundated first and if residents do not evacuate initially they will become isolated,
- the Floodplain Development Manual indicates that caravan parks typically have special evacuations needs.

2.4. Flood Warning

The BOM is the Federal Government agency responsible for providing flood warnings with the SES providing the combat role in flood emergencies. Flood warning is an imprecise science that relies on past flood records to predict what will happen in future floods. Unfortunately no two floods are the same and this was exemplified in the June 2007 event which was predicted to be greater than the February 1971 event but ended up being 0.4m lower at Maitland (Belmore Bridge). For flood warning to be accurate the historical records should indicate a “perfect” correlation between upstream and downstream flood levels. The graphs below do not demonstrate this and indicate the variability in historical flood records. For this reason it is impossible to accurately predict the height or timing of a flood event.





The BOM have updated their flood warning methodology based on the June 2007 event but obviously this new approach has never been tested.

Accurate flood warning at Maitland is particularly difficult in that a small difference in water level (predicted v actual) at Belmore Bridge can produce a significant difference in level at the site if this means the Oakhampton Spillways are overtopped or not. Residents do not appreciate that whilst the flood mitigation works provide protection up to a given level (approximately a 20 year ARI), once the Oakhampton Spillways are overtopped the flood levels in the study area will rise to a greater extent than in the Hunter River at Belmore Bridge.

Residents generally do not obey flood warning advice in the first instance and leave it to the last minute. This may be too late at the site as the access roads are lower than many of the van pads, thus once residents decide to evacuate (as they realise their pads will become inundated) it may be too late.

Flood warning and evacuation plans are generally the only means to protect existing caravan parks (other than to prohibit their use) however the Floodplain Development Manual states (referring to caravan parks, motels etc.) *“due to the transient nature and special needs of occupants, such plans should not be used as the basis of development consent for new developments of this type”*.

2.5. Evacuation Route

As noted previously the access route along Mount Dee Road is lower than many parts of the proposed park (the lowest point is at approximately 6 mAHD and would have been very close to being inundated in June 2007). Having a relatively low level access route that is inundated first is not the optimal evacuation route, the optimal is to have a route that rises out of the floodwaters to high ground rather than into the floodwaters. There is no other possible way out from the site as Junction Street is lower than Mount Dee Road and evacuation must occur otherwise residents will become stranded and may drown as there is practically no flood free ground on the site in events greater than the 100 year ARI.

Other issues with the Mount Dee Road route are;

- It is a secondary road with no street lighting,
- The route is relatively long (1 kilometre) and thus is not walkable and residents may get “stuck” in the middle and be surrounded by rising flood waters,
- The route has several bends and crosses Fishery Creek which will make travel times slow, particularly towing caravans. Once the route is inundated, even by 100mm, the travel time will increase significantly.

2.6. Flood Compatibility of Proposed Development

The aim of floodplain management is reduce the impact of flooding and flood liability on existing occupiers of the floodplain and to ensure that future users of the floodplain do not experience an unacceptable level of risk, whilst at the same time ensuring that the floodplain is used to its optimal potential.

In principle the use of the proposed site for tourists/holiday makers who travel to the site by car and wish to stay a few days, either in their own caravan that they have towed to the site or in their tent could be an appropriate flood compatible use of the land. These people would be entirely mobile, have the ability and desire to quickly evacuate from the site and have no wish to stay during a flood to protect property etc. The facilities provided on the site (toilets etc.) would need to be flood proofed to minimise damages and the risk of electrocution or sewage discharge and the manager’s residence constructed to a structural standard to prevent damage in events up to the 200 year ARI event plus 0.5m.

The use of the site for permanent or long term residents or the storage and letting of cabins/caravans is considered an inappropriate flood compatible use as it is likely to result in a high level of damages and an unacceptable risk to life during a flood. The proposed mitigation approach by the applicant relies entirely on adequate flood warning and a successful evacuation from the site during a flood. This approach is not failsafe and thus would likely require assistance from the SES (who would be otherwise engaged elsewhere in the Maitland area protecting existing residents) and is not in accordance with best practice in floodplain management in NSW.

It should be noted that the flood mitigation works around Maitland do not reduce flood levels in say the February 1955 event compared to what actually happened. Thus when a repeat of this flood occurs (and there are no other changes to the floodplain or catchment) a similar extent of inundation would occur as happened in February 1955. Also, as the flood mitigation works were completed prior to the February 1971 flood the lower level in June 2007 at Maitland, compared to the level in February 1971, was not due to construction of the flood mitigation works.

In summary, the flood mitigation works eliminate small floods (less than say a 20 year ARI) from inundating Central Maitland and in larger events ensure an orderly overflow into the floodplain from the Hunter River but they do not eliminate flooding or the risk to life.



Figures

FIGURE 1
GROUND LEVELS

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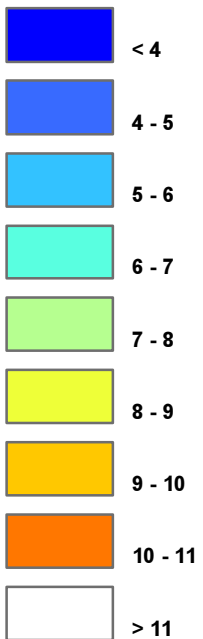


Mount Dee Road

Junction St

Proposed Development Site

Elevation (mAHD)





APPENDIX A: GLOSSARY

Taken from the Floodplain Development Manual (April 2005 edition)

acid sulfate soils	Are sediments which contain sulfidic mineral pyrite which may become extremely acid following disturbance or drainage as sulfur compounds react when exposed to oxygen to form sulfuric acid. More detailed explanation and definition can be found in the NSW Government Acid Sulfate Soil Manual published by Acid Sulfate Soil Management Advisory Committee.
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 500 m ³ /s or larger event occurring in any one year (see ARI).
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 LG Act.
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 EP&A Act. The consent authority is most often the Council, however legislation or an EPI may specify a Minister or public authority (other than a Council), or the Director General of DIPNR, 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 relate 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 awareness	Flood awareness is an appreciation of the likely effects of flooding and a knowledge of the relevant flood warning, response and evacuation procedures.
flood education	Flood education seeks to provide information to raise awareness of the flood problem so as to enable individuals to understand how to manage themselves and their property in response to flood warnings and in a flood event. It invokes a state of flood readiness.
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 covers the whole of the floodplain, not just that part below the flood planning level (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 Manual.
Flood Planning Levels (FPLs)	FPL's are the combinations of flood levels (derived from significant historical flood events or floods of specific AEPs) and freeboards selected for floodplain risk management purposes, as determined in management studies and incorporated in management plans. FPLs supersede the "standard flood event" in the 1986 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 readiness	Flood readiness is an ability to react within the effective warning time.
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	Freeboard provides reasonable certainty that the risk exposure selected in deciding on a particular flood chosen as the basis for the FPL is actually provided. It is a factor of safety typically used in relation to the setting of floor levels, levee crest levels, etc. 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 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 with further discussion in the Manual.

peak discharge

The maximum discharge occurring during a flood event.

Probable Maximum Flood (PMF)

The PMF is the largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation, and where applicable, snow melt, coupled with the worst flood producing catchment conditions. 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 a range of events rarer than the flood used for designing mitigation works and controlling development, up to and including the PMF event should be addressed in a floodplain risk management study.

Probable Maximum Precipitation (PMP)

The PMP is 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 PMF estimation.

probability

A statistical measure of the expected chance of flooding (see AEP).

risk

Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. In the context of the manual it is the likelihood of consequences arising from the interaction of floods, communities and the environment.

runoff

The amount of rainfall which actually ends up as 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.