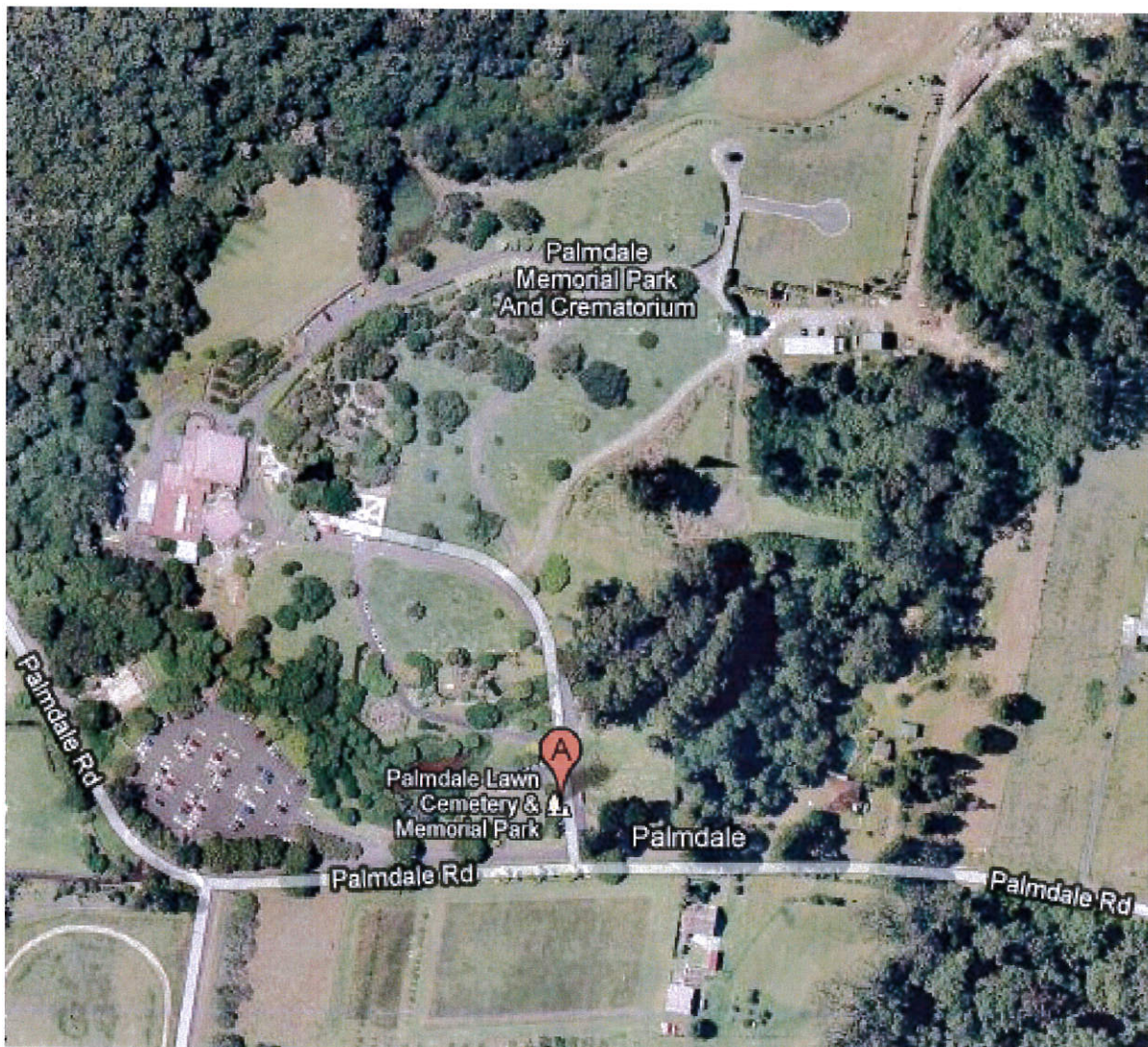


PALMDALE LAWN CEMETERY
& MEMORIAL PARK



PALMDALE LAWN CEMETERY
OURIMBAH

FLOOD HAZARD ASSESSMENT





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Palmdale Lawn Cemetery - Ourimbah

FLOOD HAZARD ASSESSMENT

FEBRUARY 2011

Project Palmdale Lawn Cemetery - Ourimbah		Project Number 110069	
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PALMDALE LAWN CEMETERY - OURIMBAH

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APPENDICEES

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1. SUMMARY

Palmdale Lawn Cemetery and Memorial Park on Palmdale Road at Ourimbah is proposing to undertake extension works on their site. As the existing cemetery site and proposed development area (Lot 3) is flood liable a flood depth and hazard map (Figure 1) has been prepared for the 100 year ARI event based on available flood height and survey data.

The survey used to develop the flood depth and hazard map (Figure 1) is limited and additional survey is required to provide a more accurate assessment.

The existing cemetery site was inundated in the June 2007 flood (unknown magnitude) and we have not been advised of any significant damage to the cemetery (headstones, garden) as a result of that event.

There is always the potential that filling or construction of structures or other works on the floodplain within Lot 3 will impact on flood levels upstream. At this time we have not been advised of any of these activities and the hydraulic effects would need to be evaluated when this information is made available. We do not anticipate that extension of the cemetery and memorial park (headstones, gardens) would have any significant impact on flood levels unless filling is involved.

2. INTRODUCTION

2.1. Background

Palmdale Lawn Cemetery and Memorial Park on Palmdale Road at Ourimbah (refer Photo 1 below) is proposing to undertake extension works on their site.

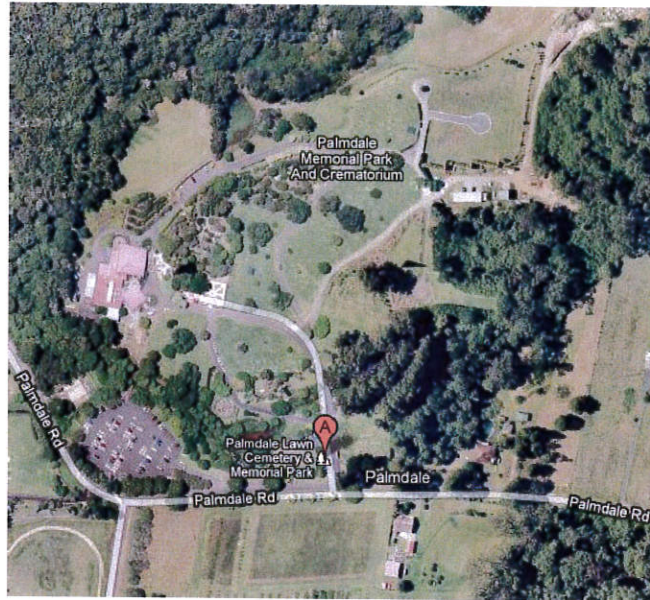


Photo 1: Locality Plan

The site is located on the floodplain of Canada Drop Down Creek (Photo 2), a tributary of Ourimbah Creek which drains into Tuggerah Lakes.

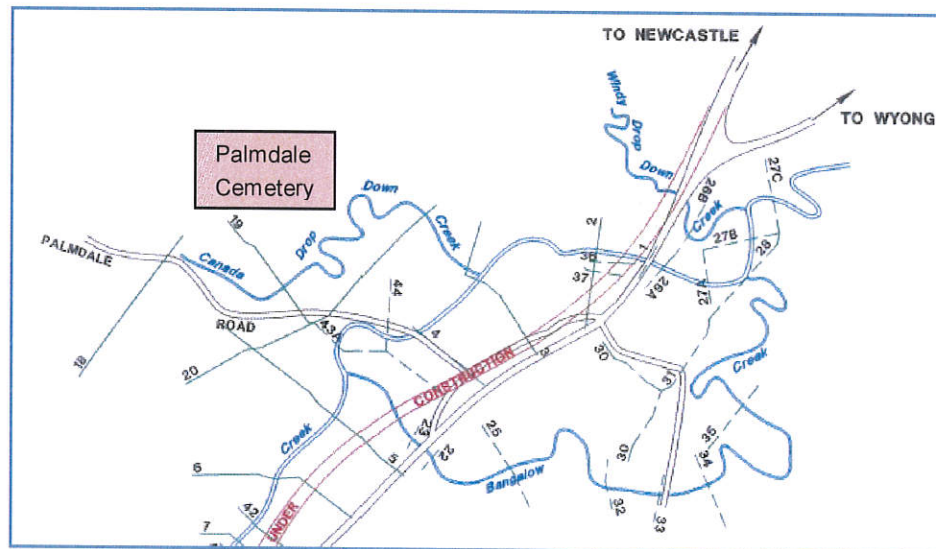


Photo 2: Creek System

As the proposed works may impact or be impacted by flooding Wyong Shire Council requires that a flood hazard and hydraulic categorisation assessment be undertaken. A glossary of flood related terms used in this report is provided as Appendix A.

WMAwater (formerly Webb, McKeown & Associates Pty Ltd) was engaged by the Palmdale Lawn Cemetery and Memorial Park group to provide an assessment of the flood hazard/hydraulic categorisation and provide comment on the likely impacts of any proposed works.

WMAwater have over 25 years of experience in the field of hydrology and hydraulic modelling in NSW and are familiar with the local area having undertaken Reference 1.

2.2. Available Data

2.2.1. Flood Height

A Wyong Shire Council and State Government funded Flood Study was completed for Upper Ourimbah Creek in June 1997 (Reference 1). In this study a one dimensional unsteady flow hydraulic model (Rubicon) was used to determine design flood levels based on inflows from the WBNM runoff routing hydrologic model.

The results (Table 1) are provided as peak flood levels at cross sections 18, 19 and 20 as shown on Photo 2.

Table 1: Design Flood Levels (m AHD) taken from Reference 1

Section	Average Recurrence Interval of Event					
	5 year	10 year	20 year	50 year	100 year	PMF
18	14.97	15.14	15.35	15.52	15.68	18.75
19	14.46	14.62	14.82	14.98	15.16	18.67
20	13.28	13.51	13.84	14.25	14.67	18.47

There are limitations with the use of this flood height data, namely:

- The use of current two dimensional hydraulic models will provide a more accurate definition of flood levels across the site than the one dimensional hydraulic model used in the Flood Study. The use of two dimensional models has only become common in the last 5 to 10 years with the increase in computer speed and availability of software,
- The accuracy of design flood levels is largely dependant upon the availability of historical flood levels which are used to "calibrate" the hydraulic model. In the 1997 Flood Study only limited historical flood data was available from the February 1992 and March 1977 events. In June 2007 a significant flood event occurred in the Newcastle/Gosford region. The accuracy of the design flood levels would be enhanced with the incorporation of the June 2007 data in the modelling process.

2.2.2. Survey Data

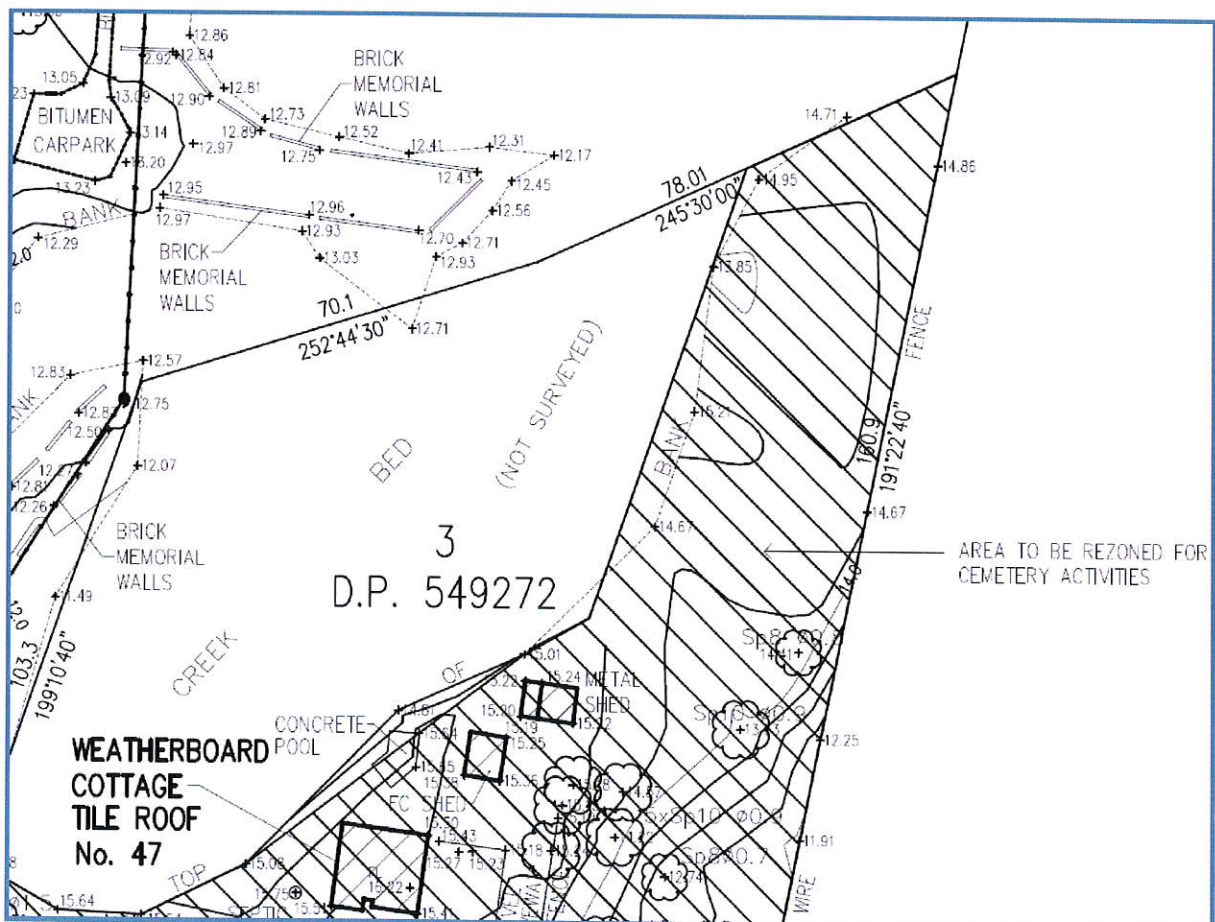
In order to map the flood depths and extent a digital terrain model (DTM) of the ground is required. If available, airborne laser scanning (ALS) survey is used to define the DTM as this provides a very accurate and complete definition of ground levels (with the exception of very heavily vegetated areas such as the creek channel itself). An investigation was undertaken to

determine the availability of ALS data for this area but as far as we are aware no such data exists. Thus the DTM had to be constructed from the available ground survey (Appendix B).

There are limitations with the use of this survey data, namely:

- Figure 1 indicates the extent of the available survey. Thus for areas outside of the red boundary shown on Figure 1 the extent of inundation is unknown,
- The flood extents and depths/hazard mapping were generated from a digital terrain model of the ground surface (obtained from the survey as shown in Appendix B) and a water surface grid from the hydraulic model results. This process is undertaken using computer software and the accuracy of the final mapping is limited by the density of the surveyed ground levels and the interpolation procedures in the software.

The north east part of Lot 3 (refer plan below) between the top of bank and the boundary fence (identified as "area to be rezoned for cemetery activities") has ground levels at around 14.7m AHD with no significant relief. The 100 year ARI flood level is at approximately 15.2m AHD (Section 19 of Table 1) and thus the maximum depth in the 100 year ARI event will be of the order of 0.5m (Low hazard).



3. HAZARD AND HYDRAULIC CATEGORY ASSESSMENT

The aim of this study was to provide a flood hazard and hydraulic categorisation assessment of the site. This assessment should also incorporate the likely impacts of climate change.

3.1. Hazard Assessment

Provisional hazard as outlined in the NSW Government Floodplain Development Manual (Reference 2) is evaluated on the basis of hydraulic principles (velocity and depth) according to the diagram below.

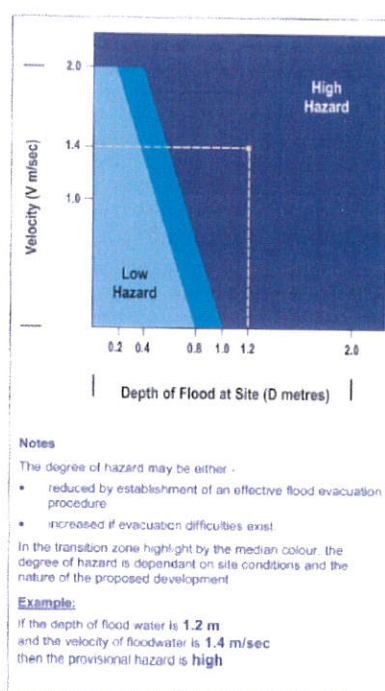


FIGURE L2 - Provisional Hydraulic Hazard Categories

As detailed velocity distributions across the floodplain are not available the provisional hazard has been defined according to the peak water depth in the 100 year ARI event. Water depths in the 100 year ARI were determined from the available flood height data and linking this data with the DTM produces the flood depth and consequently the provisional flood hazard in the 100 year ARI event (refer Figure 1). Thus up to 0.8m depth is LOW hazard and greater than 0.8m is HIGH hazard.

The "true" hazard as opposed to the provisional hazard should also take into account other factors such as warning time, rate of rise and evacuation etc. At this time it is not possible to evaluate the "true" hazard as this would depend on the future use of the land. If the future use is extension of the existing cemetery and memorial park areas then the "true" hazard may be low as there is very little or nil chance of the land being in use by persons during a flood or the flood inflicting any significant damage to the structures (as there are none). This can only be evaluated once details of the proposed works are known.

3.2. Hydraulic Categorisation

There is no quantitative approach for determination of hydraulic categorisation. For this initial assessment all land with water depths greater than 0.5m in the 100 year ARI event can be taken as Floodway with the remainder as Flood Fringe.

3.3. Climate Change Assessment

Climate change has the potential to increase ocean levels by up to 0.9m by the year 2100 and/or increase the intensities of design rainfalls (and thus flood levels).

A climate change induced increase in ocean level will have no impact on flood levels at this location.

The effect of an increase in design rainfalls can be estimated from the data shown in Table 1. A 10% increase in rainfall intensity approximates the increase from a 50 year to the 100 year ARI event. Thus it can be estimated that flood levels will rise by approximately 0.2m to 0.4m for a 10% increase in rainfall intensity. The increase from a 20 year to the 100 year ARI event approximates a 30% increase in rainfall intensity and represents a 0.3m to 0.8m rise in flood levels.

3.4. General Discussion

The primary objective of the NSW Government's flood prone lands policy is to ensure that flood prone land is used to its maximum potential and that a merit based development assessment approach is applied. At this time we have not received a detailed "works to be constructed" plan but provide the following comments:

- The land is currently used as a cemetery and memorial park and has experienced the June 2007 flood event. We have not been advised of any significant flood damage in the June 2007 event to the existing cemetery and memorial park use of the site (apart from sedimentation and possibly damage to garden beds) and thus presume that any extension of the same use would also experience minimal impact in a flood. The only damage we understand in June 2007 was to vehicles and offices and the café. Any extension of these developments will require a more detailed assessment,
- We presume that no public or staff will be permitted onto the site during a flood, there is no need for public or staff to enter the site during a flood and nobody has a residence on the site, thus the risk to life on the site during a flood is virtually nil,
- We presume that all works will be constructed in a manner compatible with the flood hazard and thus any post flood recovery works (to electricity cables, water supply, landscaping etc.) can be quickly undertaken,
- We are not in a position to comment or otherwise on the suitability of the land for use as a cemetery and whether erosion may disturb the area,
- There is always the potential that filling or construction of structures or other works on the floodplain will impact on flood levels upstream. At this time we have not been advised of any of these activities and the hydraulic effects would need to be evaluated

when this information is made available. We do not anticipate that extension of the cemetery and memorial park (headstones, gardens) would have any significant impact on flood levels unless filling is involved.

4. REFERENCES

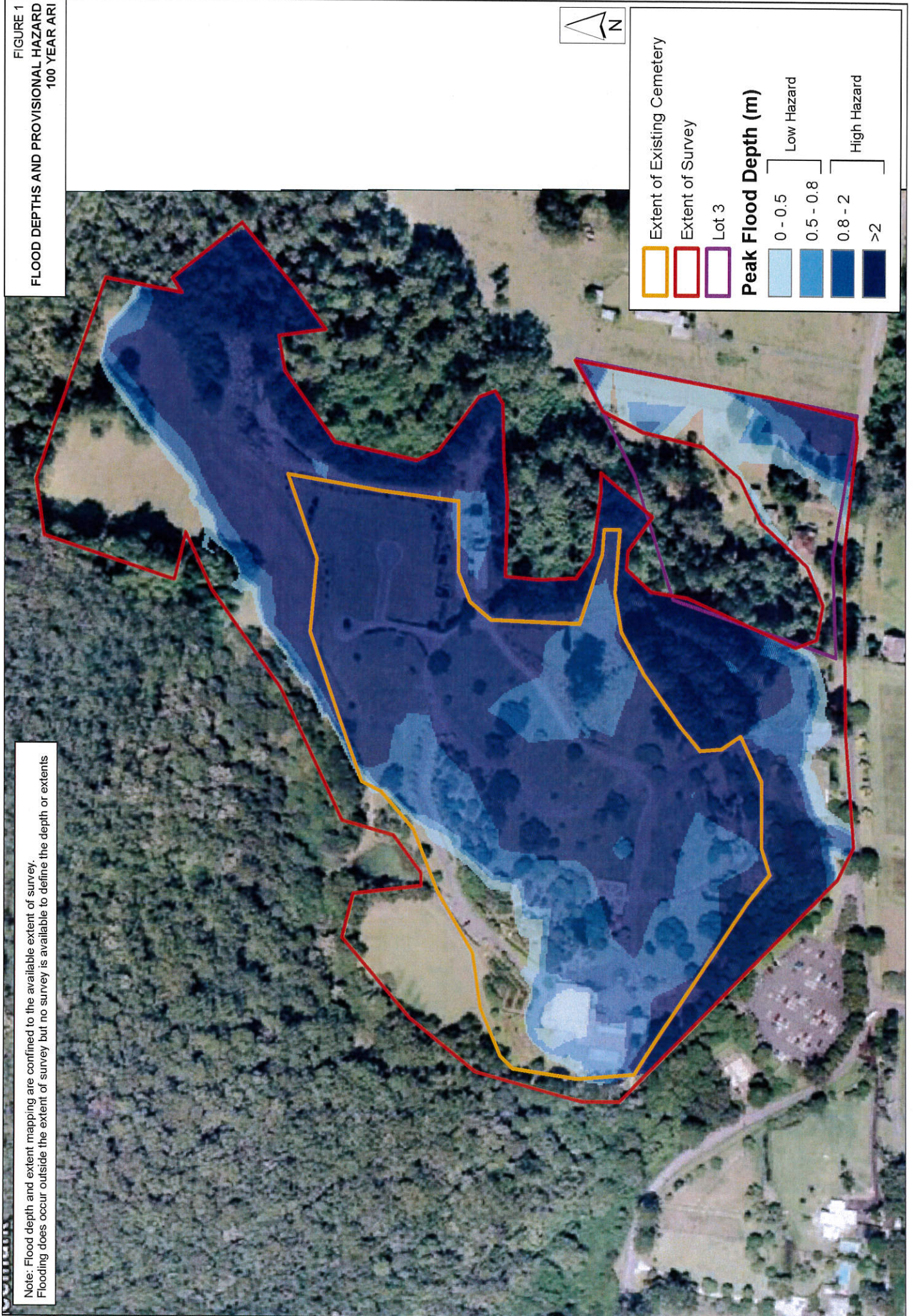
1. Wyong Shire Council
Upper Ourimbah Creek Flood Study
Webb, McKeown & Associates Pty Ltd, June 1997
2. NSW Government
Floodplain Development Manual
April 2005



Figures

Note: Flood depth and extent mapping are confined to the available extent of survey.
Flooding does occur outside the extent of survey but no survey is available to define the depth or extents

FIGURE 1
FLOOD DEPTHS AND PROVISIONAL HAZARD
100 YEAR ARI





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.



