GOULBURN
CITY COUNCIL

Wollondilly River and Mulwaree Chain of Ponds Floodplain Risk Management Study and Plan

Volume II

Appendices and Drawings

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WOLLONDILLY RIVER AND MULWAREE CHAIN OF PONDS FLOODPLAIN RISK MANAGEMENT STUDY and PLAN

VOLUME TWO

APPENDICES

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Erratum Slip

Given the size of the Indicative flood extent maps (figures 31222-001 to 005) and Hazard Maps (figures 31222-006 to 007), they are not published in this Study and Plan but are available to view in hard copy format at Goulburn City Council.

APPENDIX A

REVIEW OF TECHNICAL REPORTS & STUDIES

Table A.1 Technical Reports and Studies

STATE AND COMMONWEALTH LEGISLATION		
Document	**Summary**	**Comment**
Goulburn Flood Study Report & Map WRC (Mar-86)	This flood study report was undertaken to provide technical advice on flooding in the Goulburn area, and serves as a hydraulic and hydrologic input in the development of floodplain management plans.	The hydrologic component of the flood study employed Regional Flood Frequency analysis to determine peak discharges for various return periods. This method was chosen because the Mulwaree Ponds has no streamflow records and the Wollondilly River has a very limited record. The hydraulic component of the flood study involved the determination of maximum water levels and velocities occurring throughout the study area during passage of the standard flood (1 in 100 years) and other lesser floods. This was done using a HEC-2 water surface profile model. The model also determined the floodway limits. The inundation limits were located by field survey. Both the hydrologic and the hydraulic components of this study are being reviewed and updated where necessary to provide relevant information for the FMS&P. The study also provides a base for flood hazard identification, estimates potential flood damages, identified priority areas for monitoring future floods and proposed flood mitigation that included: ▪ Detailed floor level and land use survey to provide information for mitigation option comparison ▪ Construction of a levee in North Goulburn, protecting Avoca and Derwent Street area ▪ Construction of a levee in Eastgrove, running along Charlotte Street and Emma Street ▪ House raising/Voluntary purchase program for the Eastgrove area ▪ Zoning and Development Controls ▪ Public Awareness Program This study will provide information regarding the nature of the flooding and design flood levels and preliminary options for consideration in the preparation of the FMS&P.

Document	Summary	Comment
Goulburn Racecourse Flood Protection Options – Hydraulic Assessment. Water Resources Consulting Services (Apr-93)	This study was commissioned to undertake a hydraulic impact assessment of flood mitigation options for the Goulburn racecourse. Goulburn Racecourse is located to the west of Mulwaree Ponds immediately upstream of Bungonia Road at Goulburn. The floodplain is approximately 1 km wide there, and is defined by the Main Southern Railway embankment to the west and natural high ground to the east. The racecourse complex occupies approximately 70% of the floodplain. The bulk of the racecourse is located on low-lying ground and is therefore subject to inundation by flood events as small as the 20% AEP event (5 year ARI). Adjacent to the racecourse, between Braidwood Road and the Railway embankment, is some existing residential development. Much of this residential development is currently subject to inundation, and has the potential to be adversely affected by any flood protection measures considered for the racecourse.	The study analysed two main options – "Ring" levee and "U" levee for which 5 different levels of protection, i.e. levee crest levels, were investigated under floods of various magnitudes ranging from a 20% AEP event to the 1% year AEP event. The hydraulic impacts are mainly the changes in flood level and flood velocity due to the different levee options. The HEC-2 hydraulic model developed for the Goulburn Flood Study (WRC, 1986) was used in the hydraulic assessment. However, the model was amended to assess only the Mulwaree Ponds branch and incorporate the Goulburn-Bypass which crosses the floodplain a short distance upstream of the racecourse. The analyses indicated that all levee options investigated had an adverse effect on flooding in the vicinity of the racecourse and that these effects extend to Thorne's Bridge, approximately 1.4km upstream of the racecourse. Options with higher crest levels also increased significantly the flood velocities through Lansdowne Bridge, located immediately downstream of the racecourse on Bungonia Road. However, a levee with a crest level equivalent to 20% AEP (5year ARI) event has the least impact and therefore it is recommended that any further investigations should focus on this option. To date, there has been no formal progress on these works.
Goulburn Water Supply - Second Yield Study. DPWS (Nov-98)	This study was commissioned to assess the feasibility of various water supply augmentation options. Further cases were assessed as part of the process of narrowing in on a preferred feasible option.	22 hydrology investigations were undertaken to provide secure yield estimates for specified operating and streamflow conditions. Results indicated that the secure yield provides for an expected security of 20% restrictions occurring on average once in 10 years for 5% of the time. This study may provide background information for use in the FMS&P.
Sooley Dam Imminent Failure Flood Estimation. PWD (1991)	Sooley Dam is a straight concrete gravity dam located on Sooley Creek, a minor tributary of the	The imminent failure flood was estimated by scaling the different duration PMF hydrographs to give a dam outflow of 700 m^3/s, the failure flood.

Document	Summary	Comment
Sooley Dam Imminent Failure Flood Estimation. PWD (1991) (Cont)	Wollondilly River. The dam is part of the Wollondilly catchment upstream of Goulburn. It is used to supplement Goulburn's water supply. It has a capacity of 4520 ML and is normally kept as full as possible. This study was commissioned to estimate the imminent failure flood for Sooley Dam.	The PMF was estimated using a synthetic unit hydrograph and a runoff routing model, RORB. The latter method gave higher discharges, which were adopted as they were more conservative and considered to be more accurate than the unit hydrograph estimates. The peak PMF inflow was 3680 m^3/s for a 5 hour duration, giving a peak outflow of 3410 m^3/s. Little attenuation of the inflow hydrographs resulted from reservoir routing. The IFF/PMF ratio was in the order of 0.25 for the RORB method and 0.33 for the unit hydrograph method. This report provides background information to the estimation of the PMF in the Sooley Dam catchment, which will be referred to during review of the hydraulic modelling for the FMS&P.
Sooley Dam Dambreak Flooding Analysis. Public Works (Dec-91)	A malfunctioning floodgate on Sooley Dam during the 1961 flood was said to have increased the effect of that flood in Goulburn. The floodgates are designed to open automatically before the dam is overtopped but on this occasion one opened earlier than required. This may have caused an early secondary peak in the Wollondilly River hydrograph at Goulburn. However, the relatively small size of the dam and its catchment indicate that the malfunction had no effect on the magnitude of the peak flood height at Goulburn. The storage is considered to have no mitigating affect on Wollondilly floods at Goulburn due to its relatively small capacity and its distance upstream. This study assessed the downstream impacts should there be a failure of Sooley Dam.	Flooding as a result of the failure of Sooley Dam for several antecedent conditions was simulated using the computer program MIKE-11. Three possible failure mechanisms were assumed: two wide, high level breaches; and one narrower, low level breach. The worst case was the low level breach. For this case, the results showed that the velocity of the dambreak flow past the residences nearest the river is about 2.8m/s. For the 1:20 and 1:40 year floods the inundation depths of 10% of residences most affected by the dambreak flood would be typically about 2.0 to 2.6 metres. The dambreak flood rise at Victoria Street Bridge would start about 15 minutes after breaching commenced, and most of the flood rise would occur in the next 45 minutes. Three residential areas of Goulburn are most at risk from loss of life: ▪ the area on the south bank of the Wollondilly River near Marsden Bridge ▪ immediately upstream of Victoria Street Bridge ▪ immediately downstream of Victoria Street Bridge. In addition to affected residences suffering damage there would be substantial damage to public property. The effects of dam failure on Goulburn will be considered in the assessment of flood risks during the development of the FMS&P.

Document	Summary	Comment
Sooley Dam Raising – Concept Design Report. DPWS (Jun-99)	Sooley Dam is a concrete gravity dam with an overfall spillway. The dam is 155m long and has a dam crest width of 1.07 m. The maximum storage capacity of the dam is 4,140 ML, and has a catchment area of 125 km2. The maximum design flood was established as the critical PMF having a storm duration of 4 hours and a peak inflow of 3,867 m3/s. Although it was upgraded in 1961, the existing dam is considered inadequate by today's standards. Shortcomings include insufficient storage to meet the future demands of the City of Goulburn. The dam is also unable to handle the current design PMF.	DPWS Dams & Civil (1992) concluded that the existing spillway is only capable of handling a peak inflow of 20% of the PMF with a 1.1m depth of overtopping at limiting stability. Increase in inflow would increase overtopping and may erode supporting downstream foundations, impairing dam security. Hence, the need to provide for increased spillway discharge capacity in combination with strengthening and modification of the existing dam structures to handle the PMF design flood surcharge. This report will be considered in the assessment of flood risks during the development of the FMS&P.
Pejar Dam Dambreak Study. DPWS (Jul-01)	Pejar Dam is an earth and rockfill dam built in 1979 by PWD to supplement water supply for Goulburn. The dam is located on Wollondilly River and is about 25km northwest of Goulburn. It has a full supply capacity of 9000ML and a catchment area of 142 km2. The objective of this study is to determine the effects of Pejar Dam failure on the Wollondilly River and a preliminary study of flooding conditions along the valley and in Goulburn town.	The Mike 11 hydrodynamic program has been used for dambreak modelling of the study area. 4 conditions were investigated in this study. It was found that the downstream flooding for the Dam Crest Flood (DCF) and PMF cases studied is mainly due to the downstream tributary inflows. However, some of the buildings inundated could be attributed to the Pejar Dam failure. A plausible breach development time for the Pejar Dam has been estimated to be about 45 minutes. The travel time of the dambreak flood wave front is estimated to be about 20 minutes at Pomeroy, which is about 36 km upstream of Goulburn. The results from this study indicated that, according to Dam Safety Committee's current DSC 13, Pejar Dam should be categorised as a "High" Hazard Dam for both conditions of Sunny Day Hazard Rating and Incremental Flood Hazard Category for DCF. The effects of dam failure on Goulburn will be considered in the assessment of flood risks during the development of the FMS&P.

Document	Summary	Comment
Goulburn Sewerage Effluent Reuse at Kenmore – EIS. DPWS (Nov-99)	This study undertook presented an Environmental Impact Statement on effluent reuse at Kenmore.	Refer to attachment – Biological and Physical Environment review report
Goulburn EIS Proposed Construction of a Wet Weather Storage Facility GCC (Oct-99)	This study undertook presented an Environmental Impact Statement on the construction of a wet weather storage facility at Council's Effluent Irrigation Farm	Refer to attachment – Biological and Physical Environment review report
State Highway No. 2 - Hume Highway Proposed Bridges Over Mulwaree River & Gundary Creek Floodplain. Lyall & Macoun (Apr-89)	This report presents the results of MIKE-11 hydraulic modelling for the Goulburn Bypass. The MIKE-11 modelling was commissioned to provide a new assessment of the effects of the by-pass on upstream properties, following landholder representations to the RTA.	The MIKE-11 model improved the accuracy of estimations of hydraulic characteristics reported by the previous HEC-2 models, as MIKE-11 accounts for the storage and an additional branch was incorporated to allow for Gundary Creek. For the 1 in 100 year flood, the bridge waterway requirements; expected afflux for the current and recommended proposal and expected velocities were assessed. Design flood flows for Mulwaree Ponds were estimated using regional flood frequency analysis and for Gundary Creek using the probabilistic rational method and the probability of floods occurring simultaneously in both catchments was considered in the final design discharges adopted. The existing (1984) design was for 4 sets of twin bridges. Following hydraulic assessment, it was recommended that 5 sets of bridges be incorporated, both to increase the bridge waterway area and to relocate bridges on the left (western) bank. The afflux for the 1% design flood was 0.28 m and 0.26 m for the 5% event. The flood profiles for the 20%, 5% and 1% events were presented, to a distance 1.3 km downstream of the bypass. It was envisaged that the information presented in this report could be used in lieu of being able to review the MIKE-11 model developed for this study, as the model has not been able to be located. However, cross-sectional information was not presented.

Document	Summary	Comment
Draft Goulburn Land Capability Study. ERM Mitchell McCotter (Feb-98)	This report assesses the physical ability of the land to manage houses, roads and on-site effluent disposal; as well as existing capacity of the sewerage facilities, capability for septic effluent disposal and available on-site effluent disposal technologies.	Refer to attachment – Biological and Physical Environment review report
Local Environmental Study. Goulburn CC Town Planning (Oct-89)	This study examines the socio-economic characteristics of Goulburn and its capacity for growth and change, as a prelude to the local environmental plan.	Refer to attachment – Biological and Physical Environment review report
Goulburn Waterways Study – resource inventory & action plan. Woodlots & Wetlands P/L (1998)	This document aims to establish the health of the river corridors and provide GCC with a plan to reduce the impact of Goulburn on waterways.	Refer to attachment – Biological and Physical Environment review report
Hume Highway EIS - Goulburn Bypass National Highway No. 31 – Working Papers. Sinclair Knight & Partners (Jun-85)	These working papers cover: agriculture, aboriginal & historic Archaeological sites; flora and fauna; noise investigations and traffic assessments.	Refer to attachment – Biological and Physical Environment review report
Reconnaissance Capability Study. NSW Soil Conservation Service (1998)	The study involved the collection and evaluation of physical resource data to assess the physical limitations of the area for urban development and its capability for various levels of fural use.	Refer to attachment – Biological and Physical Environment review report
State of the Environment Report 1994. GCC (1994)	This document reports on the quality of the environment, within the boundaries of the LGA, by description and statistical analysis of data available to GCC.	Refer to attachment – Biological and Physical Environment review report
Goulburn State of the Environment Report 1995/96 GCC (1996)	This study presents the environmental situation and statistics for Goulburn in 1995/96.	Refer to attachment – Biological and Physical Environment review report

Document	Summary	Comment
Supplementary State of the Environment Report 1997/98. GCC (1998)	This document supplements the 1996/97 SOE.	Refer to attachment – Biological and Physical Environment review report
Supplementary State of the Environment Report - 1998/99 GCC (1999)	This document supplements the 1996/97 SOE.	Refer to attachment – Biological and Physical Environment review report

Table A.2 Management Plans

MANAGEMENT PLANS		
Document	**Summary**	**Comment**
Urban Stormwater Management Plan. GCC (Apr-00)	The objective of the Urban Stormwater Management Plan is to increase protection of the environment through improved stormwater management. This plan facilitates the coordinated management of urban stormwater runoff within Goulburn City to an improved cost-effective level by targeting the control of stormwater quality and quantity at the source. Goulburn City is situated at the confluence of the Mulwaree and Wollondilly Rivers, and the LGA covers an area of 54.6 km^2. All urban stormwater drains either into the Mulwaree Ponds or the Wollondilly River.	The existing urban drainage network drains approximately 2185 ha. The Wollondilly River receives approximately 35% of urban drainage while the Mulwaree Ponds receive approximately 65%. In excess of 90% of urban stormwater drainage discharges directly into either of the two streams upstream of the confluence and within areas of major urban concentration. Goulburn's location at the confluence of these two rivers means the city has a significant effect on their catchments. It has influence upstream because of the dams and weirs and transport infrastructure; while downstream its effects are on river morphology and ecology. Goulburn's population has been relatively static, about 4 people/ha (large ratio of open space per person, 9.6 ha/1000 persons). Many areas of open space are in the form of privately and publicly owned urban parks and gardens. Goulburn Waterways Study shows that the recreational grade of the waterways, low temperatures, high turbidity and high faecal coliform levels, is poor for primary recreational activities such as swimming. However, the waterways may be suitable for secondary contact recreation, such as boating. In general, Goulburn soil profiles have poor drainage characteristics. Areas of eroded land with the city include: land to the west of Governors Hill and Rocky Hill, land to the west of Cathcart Street extending south to land adjacent to the Goulburn Bypass, and land west of the railway line. Interannual rainfall variability at Goulburn is relatively high. The wettest year on record was 1950 (1361mm); the driest was 1944 (239mm). On average, the wettest month is October and the driest February. The warmer months receive 55-65 mm on average, and the cooler months 45-50 mm. Annual average rainfall is 667mm.

Document	Summary	Comment
		The Wollondilly River in comparison to the Mulwaree River has a steeper, more rugged catchment and a more defined channel. As a result, flooding is restricted to a narrow floodplain area. Mulwaree River occupies a much more extensive floodplain area in the vicinity of Goulburn. The Mulwaree River has large quantities of gross pollutants, turbid inflow from large stormwater drains and slimy sediment on the base of the river. Issues raised in this report will be considered during the development of mitigation measures in the FMS&P.
Mulwaree/Goulburn Local Flood Plan. SES (Jan-98)	The document reviewed is the January 1998 Edition of the Plan. It is understood that the SES wishes to extensively revise and upgrade the document, utilising the findings of the FMS&P.	In light of the proposed review, the following are raised for consideration: ♦ The roles and responsibilities of "SES Flood Wardens", their location during a flood and the areas they "supervise" need to be clearly stated within the Plan; ♦ The current arrangements for predicting flood heights at Marsden Weir and flood conditions in Mulwaree Ponds needs revision and to be brought into a more accurate procedure. This could be done as part of an ALERT system currently installed for Warragamba Dam; ♦ Communications should include the use of mobile phones and the communications capacity should be examined to ensure sufficient channels are available in the event of extreme flooding; ♦ The current evacuation centre at St Patrick's College needs to be supplemented by at least one other centre to cater for residents of Eastgrove who may be isolated from the main part of the City by major to extreme flooding; ♦ Given the rather tenuous nature of the warning system, a "reliance" on sandbags without taking other precautions – raising possessions, evacuation of personal items – may lead to later problems should flood levels exceed predicted levels; and ♦ While general areas of the City have been identified as being at risk, there is a need for a more detailed listing of properties, their occupants and special needs in the event of flooding. This is particularly so when access may also be cut in major/extreme floods.

Document	Summary	Comment
New South Wales State Storm Plan. SES (Aug-00)	This is a general document (effective from August 2000) for use principally by the State Emergency Service and other emergency service agencies. It describes the types of "storms" that may affect NSW, particularly coastal regions, and the measures that SES and other agencies should take before, during and after storms. It specifically states that no local storm plan should be prepared as the principles in the document apply state-wide.	The implications of this document for the study area are general only: ♦ There is no strict storm season; ♦ There is a need for the community to be aware of measures to take as a storm approaches. This will be addressed through, *inter alia*: • educational campaigns on community preparedness and damage mitigation strategies; • tree preservation orders; • debris management and removal. ♦ The local council will participate in these activities under the leadership of the SES; and ♦ The local council will provide resources to the SES. It should be noted that warning times for storms are generally short, usually a maximum of 6 hours. This places a significant responsibility on the community to be aware of the requirements for mitigating storm damage.
Interim Goulburn Dam Failure Emergency Sub-plan, GCC (?)	This interim sub-plan was prepared by Goulburn City Council for use by the Goulburn State Emergency Service Local Controller. The plan only covers those aspects with regard to Goulburn City Council's responsibilities concerning the possible failure of Sooley Dam. The dam is currently at threat of failure if overtopped by 1.1m of water. This imminent failure flood (IFF) is about 0.7m below the PMF.	The sub-plan is interim, being only for the period when remedial works at Sooley Dam were carried out, and as such does not cover all aspects of an emergency plan in accordance with the State Flood Plan. The sub-plan covers preliminary flood operations and flood emergency operations: preparedness measures, the conduct of response operations and the co-ordination of immediate recovery measures in relation to flooding in Goulburn as a result of the possible failure of Sooley Dam. Included in the sub-plan is a map of inundation levels for 1:100 AEP flood and an antecedent 1:100 AEP flood plus a dambreak at IFF level. A list of residences affected by 1:100 floods and the additional residences affected by the dambreak is provided. It details the names, addresses and telephone numbers. This document will be considered during the development of risk management measures in the FMS&P.

Document	Summary	Comment
Goulburn City Riverways Wollondilly River & Mulwaree Ponds Landscape & Ecological Study Draft Plan of Management, Land Systems P/L (Jun-98)	The aim of this report is to determine a balanced resolution to conserving and enhancing the river's character and ecological processes.	Refer to attachment – Biological and Physical Environment review report

APPENDIX B

REVIEW OF STATE & COMMONWEALTH LEGISLATION & PLANNING POLICIES, & LOCAL PLANNING INSTRUMENTS

Table B.1 Relevant State and Commonwealth Legislation

STATE AND COMMONWEALTH LEGISLATION		
Legislation	**Summary**	**Comment**
Environmental Planning and Assessment Act 1979	Contains the core legislation relating to planning and development activities within New South Wales.	Flood mitigation works may potentially be subject to the environmental assessment provisions of Part IV and V of the Act.
Local Government Act 1993	Enables councils to provide goods, services and facilities, and to carry out activities, appropriate to the current and future needs of local communities and of the wider public as well as the responsibility for administering some regulatory systems and a role in the management, improvement and development of the resources of their areas.	Section 733 covers the exemption of councils from liability in regard to advice given in good faith or anything done or omitted to be done in good faith relating to the flooding of land. This includes the preparation of LEPs and DCPs, the granting or refusal of development consent, any information contained in Section 149 Certificates and the carrying out of flood mitigation works.
Native Vegetation Conservation Act 1997	Aims to provide a framework for the conservation and sustainable management of the native vegetation of NSW including controls on the clearing of vegetation.	The clearing of native vegetation for flood mitigation works may require an application to be made to the Department of Land and Water Conservation (DLWC) for approval.
Fisheries Management Act 1994	Aims to conserve, develop and share fishery resources of the State. Incorporates provisions to protect threatened marine and freshwater species under the EP&A Act.	If a threatened species, population or ecological community or its habitat is likely to occur in any waterway identified for flood mitigation works, then an eight part test must be completed under the provisions of Section 5A the EP&A Act to determine whether a Species Impact Statement (SIS) is required. In addition the Act also requires that NSW Fisheries be notified whenever any barrier to fish movement is constructed, altered or modified.
Threatened Species Conservation Act 1995	Protects threatened flora and fauna native to NSW by integrating threatened species conservation provisions into the environmental planning system.	If a threatened species, population or ecological community or its habitat is likely to occur in any area identified for flood mitigation works, then an eight part test must be completed under the provisions of Section 5A of the EP&A Act to determine whether a SIS is required.

Legislation	Summary	Comment
Rivers and Foreshores Improvement Act 1948 (as amended)	Protects natural and artificial water bodies and protected land, which includes the bank, shore or bed of those water bodies, adjacent land within 40m of the top of their banks or shores and associated deposits of material.	Although repealed by the Water Management Act 2000, DLWC is still utilising the provisions of this Act while procedures under the Water Management Act are finalised. A Part 3A permit will be required for any excavation or other works within 40m of any river that may obstruct or detrimentally affect water flow.
Water Management Act 2000	Provides for the sustainable and integrated management of the water sources of the State, including the protection, enhancement and restoration of these water sources.	Repeals and replaces a number of Acts including the Rivers and Foreshores Improvement Act. However, in certain circumstances, such as the excavation of material within 40m of a natural or artificial water body, DLWC is still using the provisions of the Rivers and Foreshores Improvement Act.
Heritage Act 1977	Governs the conservation of heritage in NSW.	Statutory approvals would be necessary for any flood mitigation works impacting upon items of State heritage significance.
National Parks and Wildlife Act 1974	Establishes the National Parks and Wildlife Service and its responsibilities to administer National Parks and other lands and manage threatened species. The Act also includes provisions for the protection of Aboriginal heritage.	In undertaking flood mitigation works, NPWS must be consulted prior to any site development to confirm the exact location of Aboriginal sites and consent must be received prior to disturbance.
Sydney Water Act 1994	Established the Sydney Water Corporation, responsible for the supply of water, the provision of sewerage and stormwater drainage systems and the disposal of waste water in Sydney and other regions.	Applies as the Goulburn LGA falls within the Sydney Catchment Area. Generally, the most relevant provisions have been repealed as a result of the Sydney Water Catchment Management Act 1998. The Sydney Catchment Authority is now responsible for most matters relevant to land use planning in the Sydney Catchment.
Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth)	Protects matters of national environmental significance such as world heritage properties, Ramsar wetlands, nationally listed threatened species and ecological communities, migratory species, Commonwealth lands and nuclear actions	If a nationally listed threatened species, endangered ecological community or migratory species may be significantly impacted by any flood mitigation works, then a referral must be submitted to Environment Australia to determine whether approval is required under the Act.

Legislation	Summary	Comment
Sydney Water Catchment Management Act 1998	Established the Sydney Catchment Authority and gives it certain functions regarding the protection and management of certain catchment areas, with respect to the supply of water to Sydney Water and other bodies.	Applies as the Goulburn LGA falls within the Sydney Catchment Area. The Act allows for the carrying out of infrastructure activities by the Authority, with the Minister as the consent authority. The Sydney Catchment Authority replaces Sydney Water for required consultation during the preparation of a Local Environmental Plan that affects land within the catchment area.. The Act specifies that a Regional Environmental Plan is to be prepared for land within the Sydney Catchment area. This REP is currently being prepared and has been released in draft form. In the interim, the catchment is protected through SEPP 58, which will be repealed when the REP is introduced.

Table B.2 Relevant State Planning Instruments

STATE PLANNING INSTRUMENTS		
Instrument	**Summary**	**Comment**
NSW Flood Prone Land Policy 1984	Identifies the roles and responsibilities of local government for the management of flood prone land. To assist local governments in their role, the State government development a program of technical and financial assistance for councils to undertake flood mitigation works and property acquisitions. The objective 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" (NSW Govt, 2001, 1).	The policy provides for the development of sustainable strategies for managing human occupation and use of the floodplain from within a risk management hierarchy covering avoidance, minimisation (using planning controls) and finally mitigation works. Appendix A of the 2001 Floodplain Management Manual provides more information on the application of the policy. The policy is applied through guidelines specified in the Floodplain Management Manual.
NSW Floodplain Management Manual 2001	Supports the State government's Flood Prone Land Policy and provides a framework for implementing the policy at a local level. The Manual considers the costs and benefits of floodplain occupation in full recognition that associated management decisions need a more integrated approach to consider the broader issues. The 2001 Manual supersedes the original 1986 Manual.	The Manual sets out 'best practice' guidelines for flood planning. These guidelines should be used as the basis for preparing local planning instruments. The Goulburn LEP 1990 has generally been prepared in accordance with the principles contained in the 1986 Manual and makes specific reference to the Manual. However the 1986 Manual has been superseded by the new guidelines contained in the 2001 Manual. Planning instruments within Goulburn do not currently reflect the changes in practice set out in the new Manual, specifically, FPLs and hydraulic and hazard categories. The Manual states that council should have a Flood Prone Land Policy. Goulburn does not have a Flood Prone Land Policy and does not meet this guideline of the Manual.
Section 117 Direction – No. G25 **DUAP 1987**	Sets out provisions to ensure that the NSW Flood Policy is reflected in LEPs. Draft LEPs generally must not rezone flood liable land for residential development while any flood liable land classified as 'high hazard' must be zoned 'Special Uses – high hazard, floodway, environment protection or a similar zone, in a draft LEP.	Goulburn LEP 1990 is generally consistent with this direction. The use of the 1(d) Rural (Flood Hazard) Zone reflects an attempt to restrict inappropriate development on flood liable land, while no flood liable areas have been rezoned to allow residential development. The 1(d) zone, however, does not appear to incorporate the concept of FPLs and appears to have been applied in a blanket fashion.

Instrument	Summary	Comment
Circular C9 – Floodplain Development Manual **DUAP 1989**	Aims to assist councils by relating the 1986 Floodplain Development Manual to the EP&A Act 1979 and by providing guidance to implementation of the Flood Policy.	Circular C9 sets out guidelines for the preparation of Draft LEPs. It appears that Goulburn LEP 1990 generally reflects these guidelines and has been prepared in accordance with Circular C9. In particular, Goulburn has a single comprehensive LEP is accordance with the Circular's recommendations.
State Environmental Planning Policy No. 58 – Protecting Sydney's Water Supply	Implemented to ensure that development in the hydrological catchment for Sydney's drinking water does not have a detrimental impact on water quality.	Designates the Minister for Urban Affairs and Planning as the consent authority for a range of developments when they fall within the area covered by the SEPP. Goulburn is covered by SEPP 58. SEPP 58 is to be replaced by a Regional Environmental Plan, currently in draft form. The REP will introduce more comprehensive control and strategies for the management of Sydney's catchments.
Draft Regional Environment Plan – Sustaining the Catchments	Will replace SEPP 58 when gazetted. Contains controls and strategies for the management and protection of water quality in areas within the drinking water catchments of Sydney and adjacent centres.	The Draft REP covers Goulburn and has some significant implications for planning within Goulburn. • Clause 7 lists matters that must be addressed in the preparation or amendment of LEPs and includes the requirement for Council to show areas that fall within the hydrological catchment on an LEP map and indicate any Water Quality Protection Areas. • The draft REP requires that a number of councils, including Goulburn, must undertake a comprehensive review of their principal LEPs to ensure consistency with the REP. The specific details for the review are provided in Clause 8. • Clause 14 includes development controls for certain developments. Under the Draft REP, consent is required for flood mitigation works and there must be concurrence with the Chief Executive of the Sydney Catchment Authority (SCA). The Goulburn LEP is currently inconsistent with this provision as flood mitigation works are permitted without consent in the 1(d) zone. • Clause 9 requires the SCA to prepare Rectification Action Plans (RAP) for certain existing developments. Council's are required to assist in the preparation of these plans. The Goulburn Sewerage Treatment Plant could potentially be the subject of a RAP. • Part 2 of the Draft REP has implications for Council in the preparation of Catchment Management Strategies. •

Instrument	Summary	Comment
State Environmental Planning Policy No. 5 – Housing for Older People or People with a Disability	Contains controls and guidelines relating to the provision of housing for older people or people with a disability.	SEPP 5 does not apply to "environmentally sensitive land", which Schedule 1 defines as including land in a floodway, subject to natural hazard or in a water catchment. As such, SEPP 5 do not apply to the flood prone areas of Goulburn.
Circular F13 - Total Catchment Management (TCM) and Planning **DUAP 1995**	Introduces the DUAP document entitled "Total Catchment Management and Planning" which promotes an understanding of the relationship between TCM and planning legislation, and encourages councils to integrate TCM into their works and practices. The document highlights land use planning issues which relate to flooding.	The issues highlighted by "TCM and Planning" should be considered in a Floodplain Management Plan and relevant planning instruments. Relevant government agencies should be consulted during the assessment process, and mitigation options should aim to promote continued sustainable use of the catchment. The majority of Goulburn's planning instruments were prepared before "TCM and Planning" was released and therefore do not incorporate its provisions.
NSW State Rivers and Estuaries Policy	Sets out a framework for the consideration of issues affecting rivers, estuaries and their adjacent riverine plains. Factors such as vegetation, water chemistry and geomorphology are to be considered within the overall framework of total catchment management. DLWC is the agency responsible for implementation of the policy.	The principles in this policy are designed to encourage the proper management of natural ecosystems and processes occurring in rivers and estuaries. The management of natural systems in accordance with this policy will have implications for flood management. Goulburn is subject to this policy and thus consideration should be given to the objectives and principles it contains.

Table B.3 Relevant Local Planning Instruments

LOCAL PLANNING INSTRUMENTS		
Instrument	**Summary**	**Comment**
Goulburn Local Environmental Plan 1990	Establishes development controls and planning provisions for the Goulburn City Local Government Area. The Goulburn LEP 1990 makes a number of references to development on land subject to flooding. Clause 8 of the LEP covers Zone 1(d) – Rural (Flood Hazard) Zone. The objectives of the 1(d) Zone provide for proper land use management on land subject to flooding and flood mitigation works are permitted without consent. All other development is permitted with consent. It should be noted that under the Draft REP – Sustaining the Catchments flood mitigation works within the catchment require consent.	The 1(d) Rural (Flood Hazard) Zone appears to have been implemented as a form of 'holding' zone to cover flood liable land. It is a blanket zone that does not differentiate between different hazard levels. While the objectives indicate the zone is intended to provide for proper land use management, no indication is given as to the type of land use or development considered suitable within this zone. The use of the 1(d) Rural (Flood Hazard) Zone does not consider FPLs or hydraulic and hazard categories and therefore is considered inappropriate. Clause 18(1) lists specific matters for consideration within the rural, open space and environmental protection zones, with part (j) specifically requiring Council to consider the risk from flooding and the adequacy of proposed mitigation measures. This indicates an awareness of the need to consider flood risk and to determine if proposed mitigation measures are suitable when assessing development applications. This clause is appropriate and appears to ensure that Council considers flood risk. Clause 38 specifically covers development on flood liable land. Clause 38(3) sets out certain matters that the Council must be satisfied with before granting consent to any development on flood liable land. There is some ambiguity as to the application of these matters and specifically, it is unclear whether Council must be satisfied on all the matters or only some of the matters. With the exception of parts (e), (f) and (g), which clearly all apply, there is no use of "and" or "or" to determine if all the other parts apply. If Council must be satisfied on all these matters, then the list is appropriate and should ensure that proper consideration is given to developments occurring on flood liable land. If this is not the case, and Council must only be satisfied on some of the matters, then the list is not adequate. While Clause 38(4) sets out some specific development controls applying to flood liable land, these controls have been applied in a blanket manner with no recognition given to different hazard levels. Furthermore, specific development controls, such as building materials, structural soundness and excavation, are absent from both the LEP and all the DCPs. Clause 38 makes reference to the map marked "Goulburn Local Environmental Plan 1990 – Flood Liable Land". If, as is our understanding, this map does not exist, Council does
Instrument	**Summary**	**Comment**
Goulburn Local Environmental Plan 1990 (continued...)		not have a map that shows the flood risk and zoning on the same map. This constitutes poor practice and raises serious questions about the effectiveness of flood planning. Furthermore, not having a map identified within the LEP may constitute a breach of the EP&A Act 1979.
DCP No. 1 – Residential Development Policy	Sets controls for residential development	The DCP makes minor reference to development on flood liable land. Specifically, Section 3.2.4 of the DCP has the objective of minimising risk to occupants of subdivisions. The

1997	within the Living Area Zone.	design methods for this section state that: ii) Development on flood liable land for housing in not recommended. The DCP makes no further references relevant to flooding. While it is evident that residential development is not desired on flood liable land, in the absence of the LEP flood map, it is uncertain as to whether any residential land is subject to flooding. If there is residential land subject to flooding, the controls in this DCP are inadequate. However, if there is no residential land subject to flooding, then the DCP would not need to include flood related development controls.
DCP No. 2 – Industrial Development Policy 1991	Provides controls for all industrial development within Goulburn.	DCP 2 contains no provisions relevant to flooding. In the absence of the LEP flood map, it is uncertain if any industrial land is subject to flooding. However, it appears that there is land zoned industrial subject to flooding, and as such, the lack of flood related controls in this DCP is a deficiency.
DCP No. 3 – Off Street Parking Policy 1991	Offers a comprehensive guide for the provision of parking for developments.	Not applicable.
DCP No. 4 – Development within rural, open space and environmental protection zones 1991	Contains specific controls for development occurring within the rural, open space and environmental protection zones.	Part 6(a) has an extensive list of development considered inconsistent with the Rural (Flood Hazard) Zone. As mentioned above, as there is no differentiation between hazard levels within the 1(d) Zone, no consideration is given to developments that could be appropriate in lower risk areas. There are no other provisions considered relevant to development on flood prone land. Although some flood controls, such as floor height, have been included in the LEP, there is a lack of necessary development controls regarding matters such as building materials, structural soundness, excavation and so on.
DCP No. 5 – Advertising Policy 1999	Specifies controls applying to advertising	Not applicable.

Instrument	Summary	Comment
DCP No. 6 – Development Policy (Conservation Area) 1994	Contains Council's requirements for development that has impacts on heritage within Goulburn.	DCP 6 contains no provisions relevant to flooding. Given that there are heritage items on flood liable land, including some items listed on the State register, this would appear to be a deficiency. Specifically, there are no controls or provisions for the protection of heritage items from potential flood damage.
Interim DCP No. 7 – Protection of Waterways 1997	Designed to ensure proper management of waterways within Goulburn.	The DCP contains a range of controls that are aimed at facilitating and encouraging the natural operation of waterways and minimising the impacts of development on waterways. Generally, this DCP appears to have little relevance to planning controls for flood prone land.

Section 149 Certificates	Provide information on the planning controls and other restrictions that apply to development on a specific parcel of land.	Section 149 planning certificates give information on the development potential of a parcel of land and outline the planning restrictions that apply to that parcel of land. Schedule 4 of the EP&A Regulation 2000 lists the prescribed matters to be included in a s. 149 certificate while the Floodplain Management Manual outlines flood related information that should be included. Council must indicate on a s.149 certificate whether it, or another public authority, has a policy that restricts development of the land due to hazard risk, such as flooding. Following best practice guidelines, Council should indicate whether the property is subject to flood risk, even if the land is not subject to flood planning controls. That is, certificates for properties not within flood planning level but still subject to the PMF should indicate that a flood risk exists even though no flood planning controls exist. Such a system should counter the misconception that land not subject to flood planning controls is flood free. While no examples of Council's s.149 certificates were reviewed, there are questions to the accuracy of Council's s.149 certificates given that there is no map showing flood hazard and zoning. Without an appropriate map, there are doubts as to how Council would have the necessary property information to provide accurate s.149 certificates. This raises further questions regarding the legal responsibility and risk profile of Council.
Goulburn Section 94 Contributions Plan	Provides for the levying of developer contributions in accordance with s.94 of the EP&A Act 1979.	Section 94 is relevant to flooding as it covers the levying of development fees for the provision of drainage systems. This is of particular relevance to the management of overland flow paths.

APPENDIX C

HERITAGE ITEMS

Schedule of Heritage Items Listed on Registers

The Register of the National Estate is maintained by the Australian Heritage Commission, which is the National body for the protection of heritage. This register contains heritage items of significance to Australia, as well as any items owned or managed by the Commonwealth Government. An item entered in the Register of the National Estate can fall into several categories:

Indicative Place	The item is currently being assessed by the Australian Heritage Commission, and a decision has not yet been made on whether to include it on the Register.
Interim List	The item has been proposed for entry into the Register, and the Australian Heritage Commission is seeking further information, including any public objections, before deciding whether to include it in the Register proper.
Registered	The item is in the Register of the National Estate.
Destroyed	The item was destroyed before it could be assessed or listed.

Entry of a property or other heritage item into the Register of the National Estate means that the entered item is protected under the *Australian Heritage Commission Act 1975*. Section 30 of that Act provides that the Commonwealth Government must not take any action that would adversely affect an item on the Register, unless there is no other alternative. Listing on the Register does not place any restrictions or requirements on property owners, local or state government bodies.

a State Heritage Register

The State Heritage Register is a list of places and items of State heritage significance endorsed by the Heritage Council and the Minister. Items listed on the State Heritage Register are recognised as having heritage significance of State wide importance due to their historical, scientific, cultural, social, archaeological, architectural, natural, or aesthetic value. These items are protected by the State Government under the *Heritage Amendment Act 1998*. No action that may harm an item listed on the State Heritage Register is permitted under this Act.

b State Heritage Inventory

The State Heritage Inventory is a listing maintained by the Heritage Office of New South Wales, and contains any items that are listed in LEP's, REP's or the State Heritage Register. Listing on the State Heritage Inventory itself does not give an item legal protection, but does indicate that the item is protected by another legal instrument.

Please note: The Goulburn LGA also contains a number of heritage conservation areas that are afforded legal protection under the Environmental Planning and Assessment Act 1979 that are not listed in the table.

Item Name	Address	Register of the National Estate	State Heritage Register	State Heritage Inventory	Local Environmental Plan
Alpine Lodge Hotel	244-248 Sloane Street Goulburn		Yes	Yes	
AMP Society Building	191 Auburn Street Goulburn	Indicative Place			
Antrim House	11 George Street			Yes	Yes
ANZ Bank (former)	256 Auburn Street Goulburn	Registered			
Belmore Park	Auburn Street Goulburn	Registered			
Bishops Residence and Presbytery and Front Fence	36 Verner Street Goulburn	Registered			
Bull and Woodward Archway	10 Market Street Goulburn	Registered			
Catholic Cathedral Group	Bourke Street Goulburn	Registered			
Christ Church Rectory	128 Addison Road Goulburn			Yes	Yes
CML Building	Clifford Street Goulburn		Yes	Yes	
Connollys Mill	Sloane Street Goulburn		Yes	Yes	
Fire Station (former)	11 Montague Street Goulburn	Registered			
Garroorigang and Stables	Braidwood Road Goulburn	Registered		Yes	Yes
Goulburn Brewery	Bungonia Road Goulburn	Registered	Yes	Yes	
Goulburn Civic Precinct	Montague Street Goulburn	Indicative Place			
Goulburn Courthouse (former) and Police Station (former)	Sloane Street Goulburn	Registered	Yes	Yes	
Goulburn Courthouse Group	Montague Street Goulburn	Registered	Yes	Yes	
Goulburn Courthouse, Setting and Fence	Montague Street	Registered			
Goulburn Gaol	Maud Street Goulburn	Registered	Yes	Yes	
Goulburn General Cemetery	Hume Hwy Goulburn	Indicative Place			

Item Name	Address	Register of the National Estate	State Heritage Register	State Heritage Inventory	Local Environmental Plan
Goulburn High School	123 Goldsmith Street Goulburn	Indicative Place			
Goulburn Post Office	165 Auburn Street Goulburn	Registered	Yes	Yes	
Goulburn Pumping Station, Marsden Weir and Appleby Steam Engine	Wollondilly River		Yes	Yes	
Goulburn Town Hall	163 Auburn Street Goulburn	Registered			
Goulburn Viaduct (Mulwaree Ponds)	Main Southern Railway		Yes	Yes	
Hebburn Steam Winding Engine	Crookwell Road Goulburn	Registered			
House	57 Goldsmith Street Goulburn	Indicative Place			
House	42 Goldsmith Street Goulburn	Indicative Place			
House	22 Argyle Street Goulburn			Yes	Yes
House	133 Kinghorne Street Goulburn			Yes	Yes
Jewish Cemetery				Yes	Yes
Kenmore Hospital	Taralga Road Goulburn	Indicative Place			
Lansdowne Bridge	Bungonia Road Goulburn	Registered	Yes	Yes	Yes
Lawrenny	6 Lawrenny Avenue Goulburn			Yes	Yes
Leigh House with stables	2 Chantry Street Goulburn			Yes	Yes
Locomotive Round House and Wellington Shed	Braidwood Road Goulburn			Yes	Yes
Louise Garden	Clifford Street Goulburn	Indicative Place			
Marsden Steam Museum	Crookwell Road Goulburn	Registered			
Mulwaree Private Hotel	158-166 Sloane Street Goulburn	Registered			

Item Name	Address	Register of the National Estate	State Heritage Register	State Heritage Inventory	Local Environmental Plan
Orphanage	Taralga Road Goulburn			Yes	Yes
Our Lady of Mercy Convent and Chapel	Clinton Street Goulburn	Registered			
Railway Station Group	Sloane Street Goulburn	Registered	Yes	Yes	
Riversdale	Maud Street Goulburn	Registered			
Rocky Hill War Memorial	Memorial Road Goulburn	Indicative Place			
Saints Peter and Paul Cathedral and Fence	Bourke Street Goulburn	Registered			
Sloane Street Group	155-188 Sloane Street Goulburn	Registered			
South African War Memorial	Market Street Goulburn	Registered			
Southern Railway Hotel (former)	188 Sloane Street Goulburn	Registered			
St Clair	318 Sloane Street Goulburn	Registered	Yes	Yes	
St Nicholas Anglican Church	15-17 Kinghorne Street Goulburn			Yes	Yes
St Patrick's College	Clintons Street			Yes	Yes
St Patricks Roman Catholic Cemetery	Middle Arm Road Goulburn	Indicative Place			
St Saviours Anglican Cathedral	Bourke Street Goulburn	Registered			
Tarrawingee	10 Opal Street Goulburn			Yes	Yes
Tenneriffe	Mary's Mount Road Goulburn			Yes	Yes
Terraces and Former Shop	176-186 Sloane Street Goulburn	Registered			
Terraces	168-174 Sloane Street Goulburn	Registered			
The Potteries	Common Street Goulburn			Yes	Yes
The Reactory	Gilmore Street Goulburn			Yes	Yes
Wynella	Off Mazamet Road Goulburn			Yes	Yes

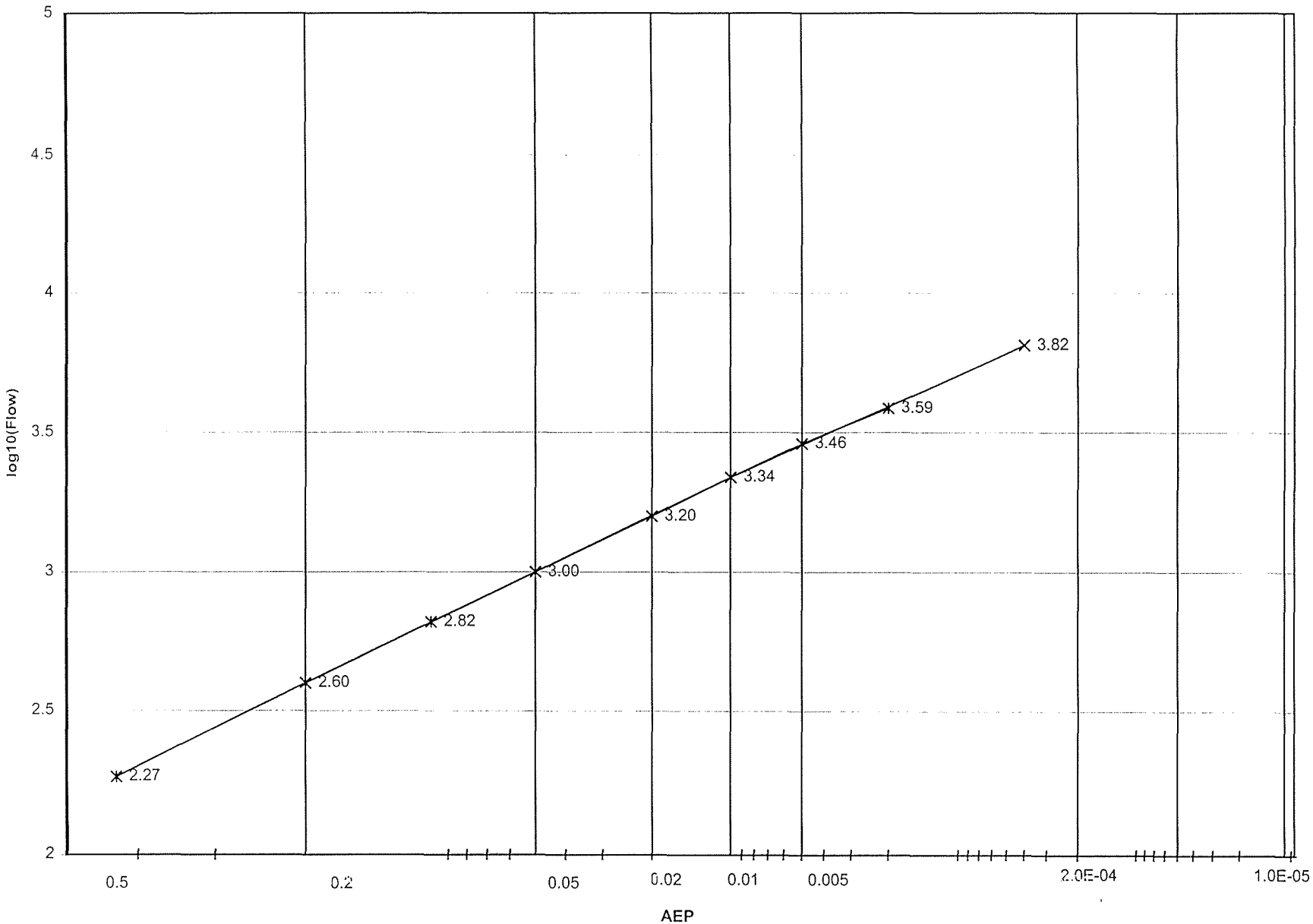
APPENDIX D

REGIONAL FLOOD FREQUENCY ANALYSIS & HYDRAULIC MODELLING RESULTS

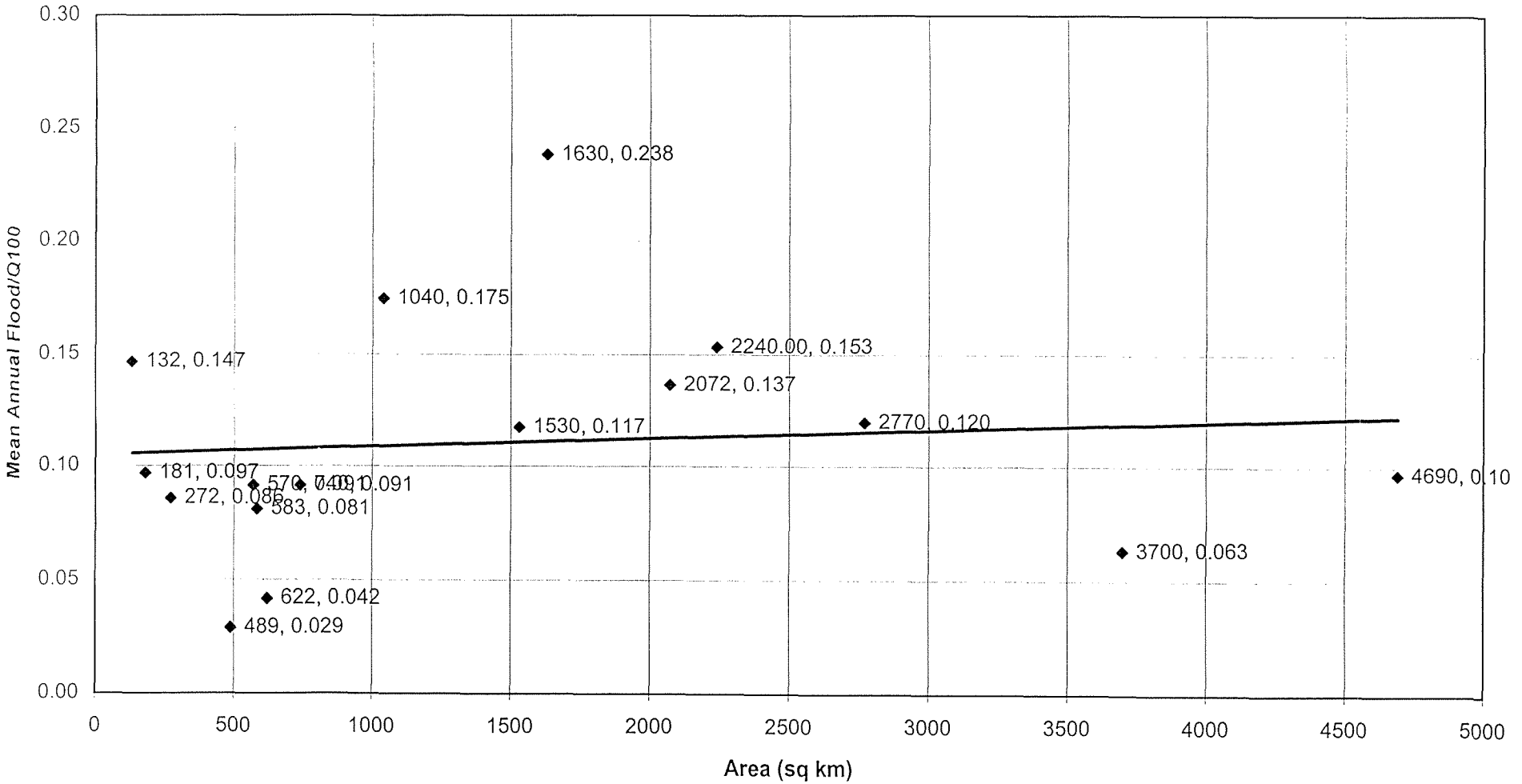
PART A

REGIONAL FLOOD FREQUENCY ANALYSIS

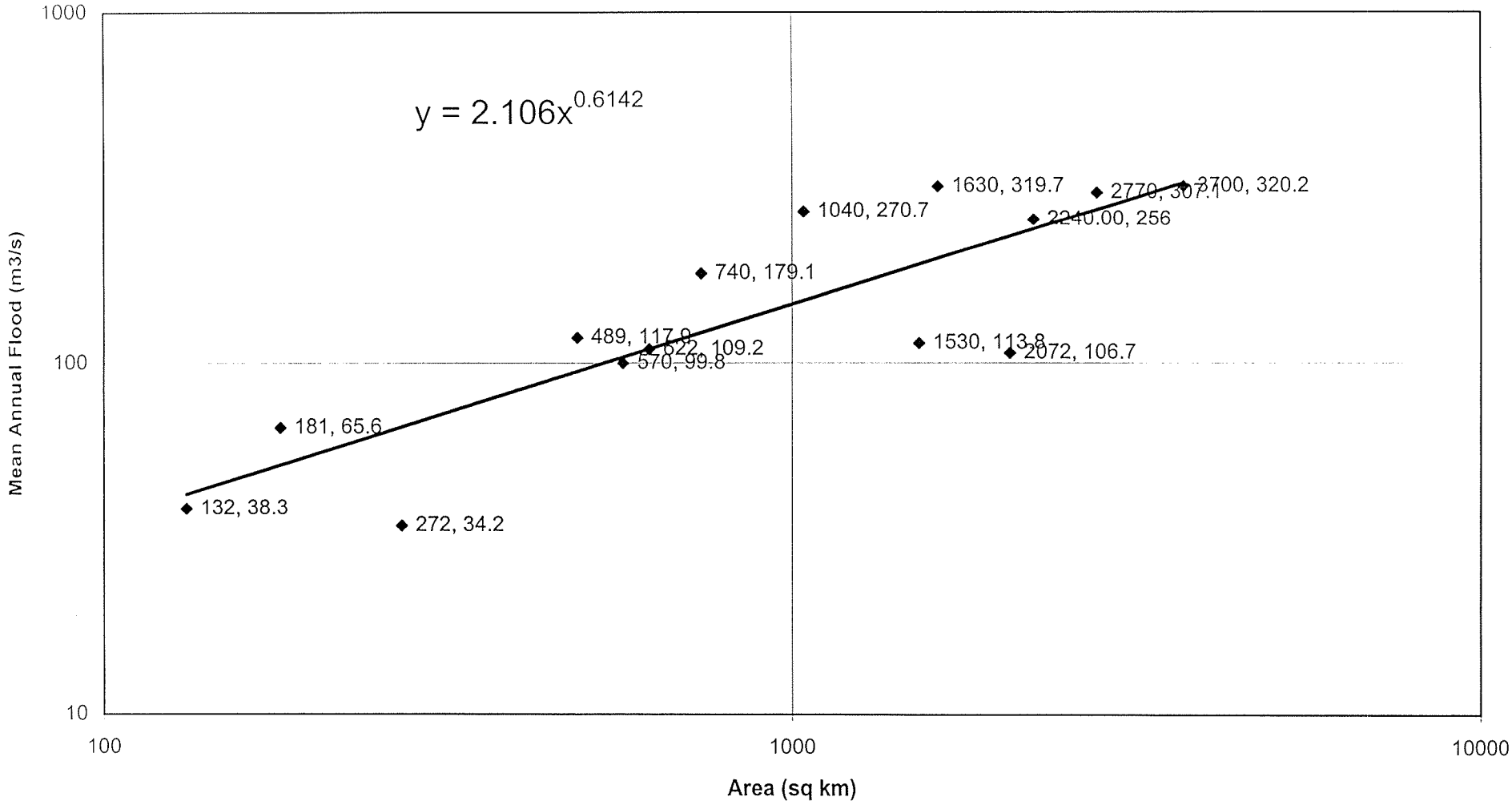
Wollondilly River & Mulwaree Ponds
Regional Flood Frequency Analysis



Wollondilly River and Mulwaree Ponds FRMS&P
Q2/Q100 vs Area



Wollondilly River and Mulwaree Ponds FRMS&P
MAF vs Area



PART B

HYDRAULIC MODELLING RESULTS

20% AEP Flood Event						
River	Reach	Cross Section	Total Discharge (m3/s)	Min. Channel Elevation (m)	Water Surface Elevation (m)	Total Velocity (ave) (m/s)
Wollondilly	Upstream	22	258	629	632.2	0.97
Wollondilly	Upstream	21	258	629	632	1.04
Wollondilly	Upstream	20	Inline Weir			
Wollondilly	Upstream	19	258	625.8	630.6	0.61
Wollondilly	Upstream	18.6	258	625.47	630.4	1.07
Wollondilly	Upstream	18.3	258	625.41	630.4	1.08
Wollondilly	Upstream	18	Bridge			
Wollondilly	Upstream	17.6	258	625.32	630.2	1.09
Wollondilly	Upstream	17.3	258	625.2	630.1	1.08
Wollondilly	Upstream	17	258	624.25	628.6	1.44
Wollondilly	Upstream	16	258	622.99	628.2	1.20
Wollondilly	Upstream	15	258	622.85	628	1.40
Wollondilly	Upstream	14	258	622.82	628	1.29
Wollondilly	Upstream	13.5	Bridge			
Wollondilly	Upstream	13	258	622.72	628	1.25
Wollondilly	Upstream	12	258	622.66	627.9	1.19
Wollondilly	Upstream	11	258	622.61	627.8	1.21
Wollondilly	Upstream	10	258	621.81	627.2	0.96
Wollondilly	Upstream	9	258	621.75	627.2	0.94
Wollondilly	Upstream	8.5	Bridge			
Wollondilly	Upstream	8	258	621.66	627.1	0.95
Wollondilly	Upstream	7	258	621.79	627	1.01
Wollondilly	Upstream	6	258	620.32	626.7	0.58
Wollondilly	Upstream	5	258	619.5	626.7	0.60
Wollondilly	Downstream	4	398	619.47	626.6	0.46
Wollondilly	Downstream	3	398	619.42	626.4	1.04
Wollondilly	Downstream	2	398	619.15	626.2	0.72
Wollondilly	Downstream	1	398	618.76	626	0.35
Mulwarree	1	34	258	628	631.3	0.84
Mulwarree	1	33	258	627.23	630.6	0.58
Mulwarree	1	32	258	627.55	630.4	0.64
Mulwarree	1	31	258	627.55	630	0.68
Mulwarree	1	29.5	Mult Open			
Mulwarree	1	28	258	627.55	629.8	0.80
Mulwarree	1	27	258	626.21	629.5	0.30
Mulwarree	1	26	258	626.11	629.3	0.38
Mulwarree	1	25	258	626.09	629.3	0.51
Mulwarree	1	24	258	625.87	629.2	0.48
Mulwarree	1	23	258	625.75	629.2	0.48
Mulwarree	1	22	258	625.28	629.1	0.36
Mulwarree	1	21	258	625.28	629.1	1.18
Mulwarree	1	20.5	Bridge			
Mulwarree	1	20	258	625.28	629	1.20
Mulwarree	1	19	258	625.03	629	0.40
Mulwarree	1	18	258	625.95	628.9	0.49
Mulwarree	1	17	258	625.2	628.5	0.53
Mulwarree	1	16	258	624	627.4	0.75
Mulwarree	1	15	258	621.92	627.1	0.41
Mulwarree	1	14	258	622.1	627.1	0.44
Mulwarree	1	13	258	621.77	627	0.49
Mulwarree	1	12.5	Bridge			
Mulwarree	1	12	258	621.67	626.9	0.49
Mulwarree	1	11	258	621.14	626.9	0.29
Mulwarree	1	10	258	620.75	626.9	0.65
Mulwarree	1	9	258	620.7	626.8	0.67
Mulwarree	1	7.6	Bridge			
Mulwarree	1	6	258	620.7	626.8	0.67
Mulwarree	1	5	258	620.61	626.8	0.64
Mulwarree	1	4	258	620.47	626.7	0.62
Mulwarree	1	3	258	620.33	626.7	0.60
Mulwarree	1	2	258	620.19	626.6	0.58

10% AEP Flood Event						
River	Reach	Cross Section	Total Discharge (m3/s)	Min. Channel Elevation (m)	Water Surface Elevation (m)	Total Velocity (ave) (m/s)
Wollondilly	Upstream	22	428	629	632.7	1.30
Wollondilly	Upstream	21	428	629	632.4	1.42
Wollondilly	Upstream	20	Inline Weir			
Wollondilly	Upstream	19	428	625.8	631.8	0.76
Wollondilly	Upstream	18.6	428	625.47	631.6	1.24
Wollondilly	Upstream	18.3	428	625.41	631.5	1.25
Wollondilly	Upstream	18	Bridge			
Wollondilly	Upstream	17.6	428	625.32	631.4	1.27
Wollondilly	Upstream	17.3	428	625.2	631.3	1.26
Wollondilly	Upstream	17	428	624.25	629.9	1.51
Wollondilly	Upstream	16	428	622.99	629.5	1.37
Wollondilly	Upstream	15	428	622.85	629.3	1.45
Wollondilly	Upstream	14	428	622.82	629.3	1.39
Wollondilly	Upstream	13.5	Bridge			
Wollondilly	Upstream	13	428	622.72	629.3	1.36
Wollondilly	Upstream	12	428	622.66	629.2	1.29
Wollondilly	Upstream	11	428	622.61	629.1	1.24
Wollondilly	Upstream	10	428	621.81	628.5	0.96
Wollondilly	Upstream	9	428	621.75	628.5	1.01
Wollondilly	Upstream	8.5	Bridge			
Wollondilly	Upstream	8	428	621.66	628.4	1.02
Wollondilly	Upstream	7	428	621.79	628.4	0.99
Wollondilly	Upstream	6	428	620.32	628.1	0.63
Wollondilly	Upstream	5	428	619.5	628	0.66
Wollondilly	Downstream	4	661	619.47	628	0.49
Wollondilly	Downstream	3	661	619.42	627.8	1.33
Wollondilly	Downstream	2	661	619.15	627.5	0.89
Wollondilly	Downstream	1	661	618.76	627.3	0.40
Mulwarree	1	34	428	628	631.6	1.02
Mulwarree	1	33	428	627.23	630.9	0.63
Mulwarree	1	32	428	627.55	630.8	0.65
Mulwarree	1	31	428	627.55	630.3	0.96
Mulwarree	1	29.5	Mult Open			
Mulwarree	1	28	428	627.55	630.1	1.07
Mulwarree	1	27	428	626.21	629.9	0.32
Mulwarree	1	26	428	626.11	629.8	0.42
Mulwarree	1	25	428	626.09	629.7	0.52
Mulwarree	1	24	428	625.87	629.7	0.50
Mulwarree	1	23	428	625.75	629.6	0.47
Mulwarree	1	22	428	625.28	629.6	0.39
Mulwarree	1	21	428	625.28	629.4	1.66
Mulwarree	1	20.5	Bridge			
Mulwarree	1	20	428	625.28	629.4	1.72
Mulwarree	1	19	428	625.03	629.3	0.49
Mulwarree	1	18	428	625.95	629.2	0.58
Mulwarree	1	17	428	625.2	628.9	0.56
Mulwarree	1	16	428	624	628.6	0.38
Mulwarree	1	15	428	621.92	628.5	0.39
Mulwarree	1	14	428	622.1	628.4	0.41
Mulwarree	1	13	428	621.77	628.4	0.54
Mulwarree	1	12.5	Bridge			
Mulwarree	1	12	428	621.67	628.3	0.54
Mulwarree	1	11	428	621.14	628.3	0.31
Mulwarree	1	10	428	620.75	628.2	0.73
Mulwarree	1	9	428	620.7	628.2	0.81
Mulwarree	1	7.6	Bridge			
Mulwarree	1	6	428	620.7	628.2	0.81
Mulwarree	1	5	428	620.61	628.1	0.72
Mulwarree	1	4	428	620.47	628.1	0.70
Mulwarree	1	3	428	620.33	628.1	0.68
Mulwarree	1	2	428	620.19	628	0.66

5% AEP Flood Event						
River	Reach	Cross Section	Total Discharge (m3/s)	Min. Channel Elevation (m)	Water Surface Elevation (m)	Total Velocity (ave) (m/s)
Wollondilly	Upstream	22	648	629	633.3	1.56
Wollondilly	Upstream	21	648	629	633	1.71
Wollondilly	Upstream	20	Inline Weir			
Wollondilly	Upstream	19	648	625.8	633	0.91
Wollondilly	Upstream	18.6	648	625.47	632.8	1.41
Wollondilly	Upstream	18.3	648	625.41	632.7	1.42
Wollondilly	Upstream	18	Bridge			
Wollondilly	Upstream	17.6	648	625.32	632.6	1.43
Wollondilly	Upstream	17.3	648	625.2	632.5	1.43
Wollondilly	Upstream	17	648	624.25	631.1	1.61
Wollondilly	Upstream	16	648	622.99	630.7	1.50
Wollondilly	Upstream	15	648	622.85	630.5	1.56
Wollondilly	Upstream	14	648	622.82	630.5	1.58
Wollondilly	Upstream	13.5	Bridge			
Wollondilly	Upstream	13	648	622.72	630.5	1.55
Wollondilly	Upstream	12	648	622.66	630.4	1.42
Wollondilly	Upstream	11	648	622.61	630.4	1.14
Wollondilly	Upstream	10	648	621.81	629.8	0.92
Wollondilly	Upstream	9	648	621.75	629.8	1.12
Wollondilly	Upstream	8.5	Bridge			
Wollondilly	Upstream	8	648	621.66	629.7	1.13
Wollondilly	Upstream	7	648	621.79	629.7	0.95
Wollondilly	Upstream	6	648	620.32	629.5	0.69
Wollondilly	Upstream	5	648	619.5	629.4	0.72
Wollondilly	Downstream	4	1000	619.47	629.4	0.52
Wollondilly	Downstream	3	1000	619.42	629.1	1.62
Wollondilly	Downstream	2	1000	619.15	628.7	1.05
Wollondilly	Downstream	1	1000	618.76	628.5	0.45
Mulwarree	1	34	648	628	631.9	1.16
Mulwarree	1	33	648	627.23	631.3	0.66
Mulwarree	1	32	648	627.55	631.3	0.47
Mulwarree	1	31	648	627.55	630.9	1.11
Mulwarree	1	29.5	Mult Open			
Mulwarree	1	28	648	627.55	630.7	1.21
Mulwarree	1	27	648	626.21	630.6	0.29
Mulwarree	1	26	648	626.11	630.5	0.39
Mulwarree	1	25	648	626.09	630.5	0.47
Mulwarree	1	24	648	625.87	630.5	0.44
Mulwarree	1	23	648	625.75	630.5	0.41
Mulwarree	1	22	648	625.28	630.4	0.36
Mulwarree	1	21	648	625.28	630.2	1.95
Mulwarree	1	20.5	Bridge			
Mulwarree	1	20	648	625.28	630.1	2.02
Mulwarree	1	19	648	625.03	630.1	0.44
Mulwarree	1	18	648	625.95	630.1	0.45
Mulwarree	1	17	648	625.2	630	0.40
Mulwarree	1	16	648	624	629.9	0.30
Mulwarree	1	15	648	621.92	629.8	0.40
Mulwarree	1	14	648	622.1	629.8	0.41
Mulwarree	1	13	648	621.77	629.8	0.61
Mulwarree	1	12.5	Bridge			
Mulwarree	1	12	648	621.67	629.6	0.61
Mulwarree	1	11	648	621.14	629.6	0.33
Mulwarree	1	10	648	620.75	629.6	0.80
Mulwarree	1	9	648	620.7	629.5	0.97
Mulwarree	1	7.6	Bridge			
Mulwarree	1	6	648	620.7	629.5	0.97
Mulwarree	1	5	648	620.61	629.5	0.79
Mulwarree	1	4	648	620.47	629.5	0.77
Mulwarree	1	3	648	620.33	629.4	0.76
Mulwarree	1	2	648	620.19	629.4	0.74

2% AEP Flood Event						
River	Reach	Cross Section	Total Discharge (m3/s)	Min. Channel Elevation (m)	Water Surface Elevation (m)	Total Velocity (ave) (m/s)
Wollondilly	Upstream	22	1026	629	634.7	1.73
Wollondilly	Upstream	21	1026	629	634.5	1.80
Wollondilly	Upstream	20	Inline Weir			
Wollondilly	Upstream	18.6	1026	625.47	634.3	1.68
Wollondilly	Upstream	18.3	1026	625.41	634.2	1.69
Wollondilly	Upstream	18	Bridge			
Wollondilly	Upstream	17.6	1026	625.32	634	1.71
Wollondilly	Upstream	17.3	1026	625.2	633.9	1.70
Wollondilly	Upstream	17	1026	624.25	632.4	1.87
Wollondilly	Upstream	16	1026	622.99	631.9	1.77
Wollondilly	Upstream	15	1026	622.85	631.6	1.89
Wollondilly	Upstream	14	1026	622.82	631.6	2.00
Wollondilly	Upstream	13.5	Bridge			
Wollondilly	Upstream	13	1026	622.72	631.6	1.97
Wollondilly	Upstream	12	1026	622.66	631.5	1.76
Wollondilly	Upstream	11	1026	622.61	631.5	1.32
Wollondilly	Upstream	10	1026	621.81	630.8	1.07
Wollondilly	Upstream	9	1026	621.75	630.8	1.48
Wollondilly	Upstream	8.5	Bridge			
Wollondilly	Upstream	8	1026	621.66	630.7	1.50
Wollondilly	Upstream	7	1026	621.79	630.7	1.12
Wollondilly	Upstream	6	1026	620.32	630.3	0.91
Wollondilly	Upstream	5	1026	619.5	630.2	0.97
Wollondilly	Downstream	4	1585	619.47	630.1	0.71
Wollondilly	Downstream	3	1585	619.42	629.6	2.39
Wollondilly	Downstream	2	1585	619.15	628.8	1.66
Wollondilly	Downstream	1	1585	618.76	628	0.80
Mulwarree	1	34	1026	628	632.4	1.21
Mulwarree	1	33	1026	627.23	632.1	0.64
Mulwarree	1	32	1026	627.55	632.1	0.44
Mulwarree	1	31	1026	627.55	631.8	1.29
Mulwarree	1	29.5	Mult Open			
Mulwarree	1	28	1026	627.55	631.5	1.38
Mulwarree	1	27	1026	626.21	631.5	0.30
Mulwarree	1	26	1026	626.11	631.5	0.40
Mulwarree	1	25	1026	626.09	631.5	0.47
Mulwarree	1	24	1026	625.87	631.5	0.43
Mulwarree	1	23	1026	625.75	631.4	0.41
Mulwarree	1	22	1026	625.28	631.4	0.38
Mulwarree	1	21	1026	625.28	631.4	0.41
Mulwarree	1	20.5	Bridge			
Mulwarree	1	20	1026	625.28	631	0.48
Mulwarree	1	19	1026	625.03	631	0.44
Mulwarree	1	18	1026	625.95	631	0.46
Mulwarree	1	17	1026	625.2	630.9	0.40
Mulwarree	1	16	1026	624	630.9	0.34
Mulwarree	1	15	1026	621.92	630.8	0.51
Mulwarree	1	14	1026	622.1	630.8	0.51
Mulwarree	1	13	1026	621.77	630.7	0.82
Mulwarree	1	12.5	Bridge			
Mulwarree	1	12	1026	621.67	630.6	0.83
Mulwarree	1	11	1026	621.14	630.6	0.43
Mulwarree	1	10	1026	620.75	630.5	1.05
Mulwarree	1	9	1026	620.7	630.4	1.35
Mulwarree	1	7.6	Bridge			
Mulwarree	1	6	1026	620.7	630.4	1.35
Mulwarree	1	5	1026	620.61	630.3	1.05
Mulwarree	1	4	1026	620.47	630.3	1.03
Mulwarree	1	3	1026	620.33	630.2	1.02
Mulwarree	1	2	1026	620.19	630.1	1.00

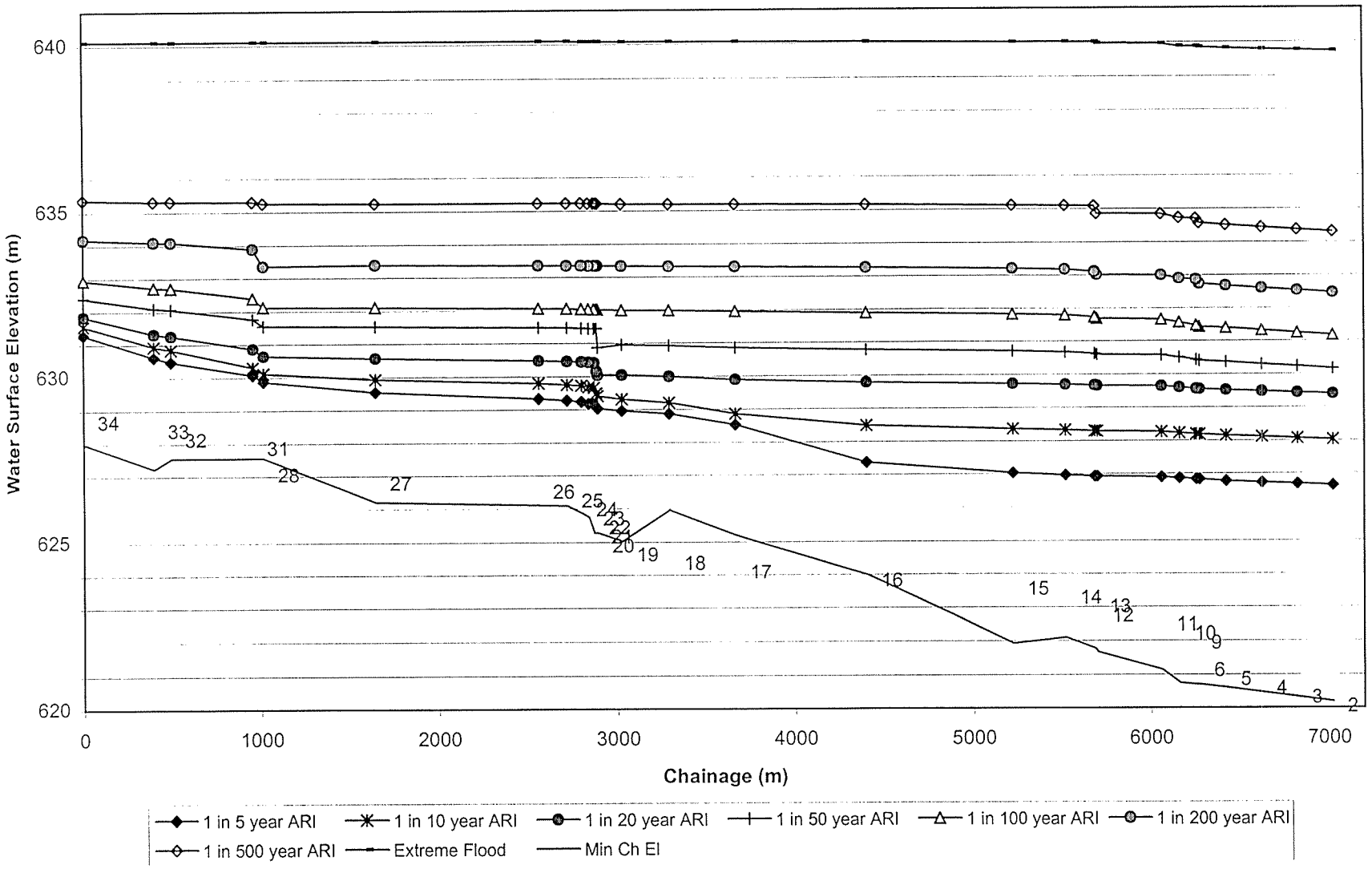
1% AEP Flood Event						
River	Reach	Cross Section	Total Discharge (m3/s)	Min. Channel Elevation (m)	Water Surface Elevation (m)	Total Velocity (ave) (m/s)
Wollondilly	Upstream	22	1415	629	636	1.79
Wollondilly	Upstream	21	1415	629	636	1.79
Wollondilly	Upstream	20	Inline Weir			
Wollondilly	Upstream	19	1415	625.8	636	1.25
Wollondilly	Upstream	18.6	1415	625.47	635.7	1.71
Wollondilly	Upstream	18.3	1415	625.41	635.6	1.75
Wollondilly	Upstream	18	Bridge			
Wollondilly	Upstream	17.6	1415	625.32	635.4	1.77
Wollondilly	Upstream	17.3	1415	625.2	635.3	1.78
Wollondilly	Upstream	17	1415	624.25	633.6	2.01
Wollondilly	Upstream	16	1415	622.99	633.1	1.87
Wollondilly	Upstream	15	1415	622.85	632.8	2.04
Wollondilly	Upstream	14	1415	622.82	632.8	2.25
Wollondilly	Upstream	13.5	Bridge			
Wollondilly	Upstream	13	1415	622.72	632.7	2.27
Wollondilly	Upstream	12	1415	622.66	632.6	1.96
Wollondilly	Upstream	11	1415	622.61	632.6	1.35
Wollondilly	Upstream	10	1415	621.81	632	1.07
Wollondilly	Upstream	9	1415	621.75	631.9	1.71
Wollondilly	Upstream	8.5	Bridge			
Wollondilly	Upstream	8	1415	621.66	631.7	1.74
Wollondilly	Upstream	7	1415	621.79	631.7	1.14
Wollondilly	Upstream	6	1415	620.32	631.3	1.02
Wollondilly	Upstream	5	1415	619.5	631.2	1.11
Wollondilly	Downstream	4	2185	619.47	631.1	0.80
Wollondilly	Downstream	3	2185	619.42	630.4	2.93
Wollondilly	Downstream	2	2185	619.15	629.1	2.14
Wollondilly	Downstream	1	2185	618.76	627.4	1.29
Mulwarree	1	34	1415	628	633	1.20
Mulwarree	1	33	1415	627.23	632.8	0.65
Mulwarree	1	32	1415	627.55	632.7	0.44
Mulwarree	1	31	1415	627.55	632.4	1.49
Mulwarree	1	29.5	Mult Open			
Mulwarree	1	28	1415	627.55	632.2	1.59
Mulwarree	1	27	1415	626.21	632.2	0.32
Mulwarree	1	26	1415	626.11	632.1	0.44
Mulwarree	1	25	1415	626.09	632.1	0.50
Mulwarree	1	24	1415	625.87	632.1	0.46
Mulwarree	1	23	1415	625.75	632.1	0.45
Mulwarree	1	22	1415	625.28	632.1	0.42
Mulwarree	1	21	1415	625.28	632.1	0.45
Mulwarree	1	20.5	Bridge			
Mulwarree	1	20	1415	625.28	632.1	0.45
Mulwarree	1	19	1415	625.03	632.1	0.42
Mulwarree	1	18	1415	625.95	632.1	0.45
Mulwarree	1	17	1415	625.2	632	0.36
Mulwarree	1	16	1415	624	632	0.36
Mulwarree	1	15	1415	621.92	631.9	0.56
Mulwarree	1	14	1415	622.1	631.9	0.56
Mulwarree	1	13	1415	621.77	631.8	0.97
Mulwarree	1	12.5	Bridge			
Mulwarree	1	12	1415	621.67	631.7	0.97
Mulwarree	1	11	1415	621.14	631.6	0.48
Mulwarree	1	10	1415	620.75	631.6	1.18
Mulwarree	1	9	1415	620.7	631.5	1.63
Mulwarree	1	7.6	Bridge			
Mulwarree	1	6	1415	620.7	631.4	1.62
Mulwarree	1	5	1415	620.61	631.4	1.19
Mulwarree	1	4	1415	620.47	631.3	1.18
Mulwarree	1	3	1415	620.33	631.2	1.16
Mulwarree	1	2	1415	620.19	631.2	1.15

0.5% AEP Flood Event						
River	Reach	Cross Section	Total Discharge (m3/s)	Min. Channel Elevation (m)	Water Surface Elevation (m)	Total Velocity (ave) (m/s)
Wollondilly	Upstream	22	1868	629	637.3	1.89
Wollondilly	Upstream	21	1868	629	637.2	1.9
Wollondilly	Upstream	20	Inline Weir			
Wollondilly	Upstream	19	1868	625.8	637.2	1.41
Wollondilly	Upstream	18.6	1868	625.47	637.0	1.74
Wollondilly	Upstream	18.3	1868	625.41	636.9	1.77
Wollondilly	Upstream	18	Bridge			
Wollondilly	Upstream	17.6	1868	625.32	636.7	1.78
Wollondilly	Upstream	17.3	1868	625.2	636.6	1.78
Wollondilly	Upstream	17	1868	624.25	635.2	2.02
Wollondilly	Upstream	16	1868	622.99	634.8	1.8
Wollondilly	Upstream	15	1868	622.85	634.5	1.97
Wollondilly	Upstream	14	1868	622.82	634.5	2.15
Wollondilly	Upstream	13.5	Bridge			
Wollondilly	Upstream	13	1868	622.72	634.3	2.22
Wollondilly	Upstream	12	1868	622.66	634.2	1.91
Wollondilly	Upstream	11	1868	622.61	634.2	1.27
Wollondilly	Upstream	10	1868	621.81	633.8	0.87
Wollondilly	Upstream	9	1868	621.75	633.7	1.77
Wollondilly	Upstream	8.5	Bridge			
Wollondilly	Upstream	8	1868	621.66	633.5	1.8
Wollondilly	Upstream	7	1868	621.79	633.5	0.94
Wollondilly	Upstream	6	1868	620.32	633.2	0.96
Wollondilly	Upstream	5	1868	619.5	633.1	1.07
Wollondilly	Downstream	4	2884	619.47	633.1	0.77
Wollondilly	Downstream	3	2884	619.42	632.4	2.97
Wollondilly	Downstream	2	2884	619.15	631.6	1.93
Wollondilly	Downstream	1	2884	618.76	631.2	0.81
Mulwarree	1	34	1868	628	634.3	0.91
Mulwarree	1	33	1868	627.23	634.2	0.53
Mulwarree	1	32	1868	627.55	634.2	0.35
Mulwarree	1	31	1868	627.55	634.2	0.2
Mulwarree	1	29.5	Mult Open			
Mulwarree	1	28	1868	627.55	633.9	1.44
Mulwarree	1	27	1868	626.21	633.9	0.26
Mulwarree	1	26	1868	626.11	633.9	0.34
Mulwarree	1	25	1868	626.09	633.9	0.41
Mulwarree	1	24	1868	625.87	633.9	0.38
Mulwarree	1	23	1868	625.75	633.9	0.38
Mulwarree	1	22	1868	625.28	633.9	0.36
Mulwarree	1	21	1868	625.28	633.9	0.38
Mulwarree	1	20.5	Bridge			
Mulwarree	1	20	1868	625.28	633.9	0.38
Mulwarree	1	19	1868	625.03	633.9	0.36
Mulwarree	1	18	1868	625.95	633.9	0.39
Mulwarree	1	17	1868	625.2	633.9	0.31
Mulwarree	1	16	1868	624	633.8	0.34
Mulwarree	1	15	1868	621.92	633.8	0.55
Mulwarree	1	14	1868	622.1	633.8	0.53
Mulwarree	1	13	1868	621.77	633.7	1.02
Mulwarree	1	12.5	Bridge			
Mulwarree	1	12	1868	621.67	633.6	1.02
Mulwarree	1	11	1868	621.14	633.6	0.46
Mulwarree	1	10	1868	620.75	633.5	1.14
Mulwarree	1	9	1868	620.7	633.5	1.14
Mulwarree	1	7.6	Bridge			
Mulwarree	1	6	1868	620.7	633.3	1.16
Mulwarree	1	5	1868	620.61	633.3	1.15
Mulwarree	1	4	1868	620.47	633.2	1.14
Mulwarree	1	3	1868	620.33	633.2	1.13
Mulwarree	1	2	1868	620.19	633.1	1.11

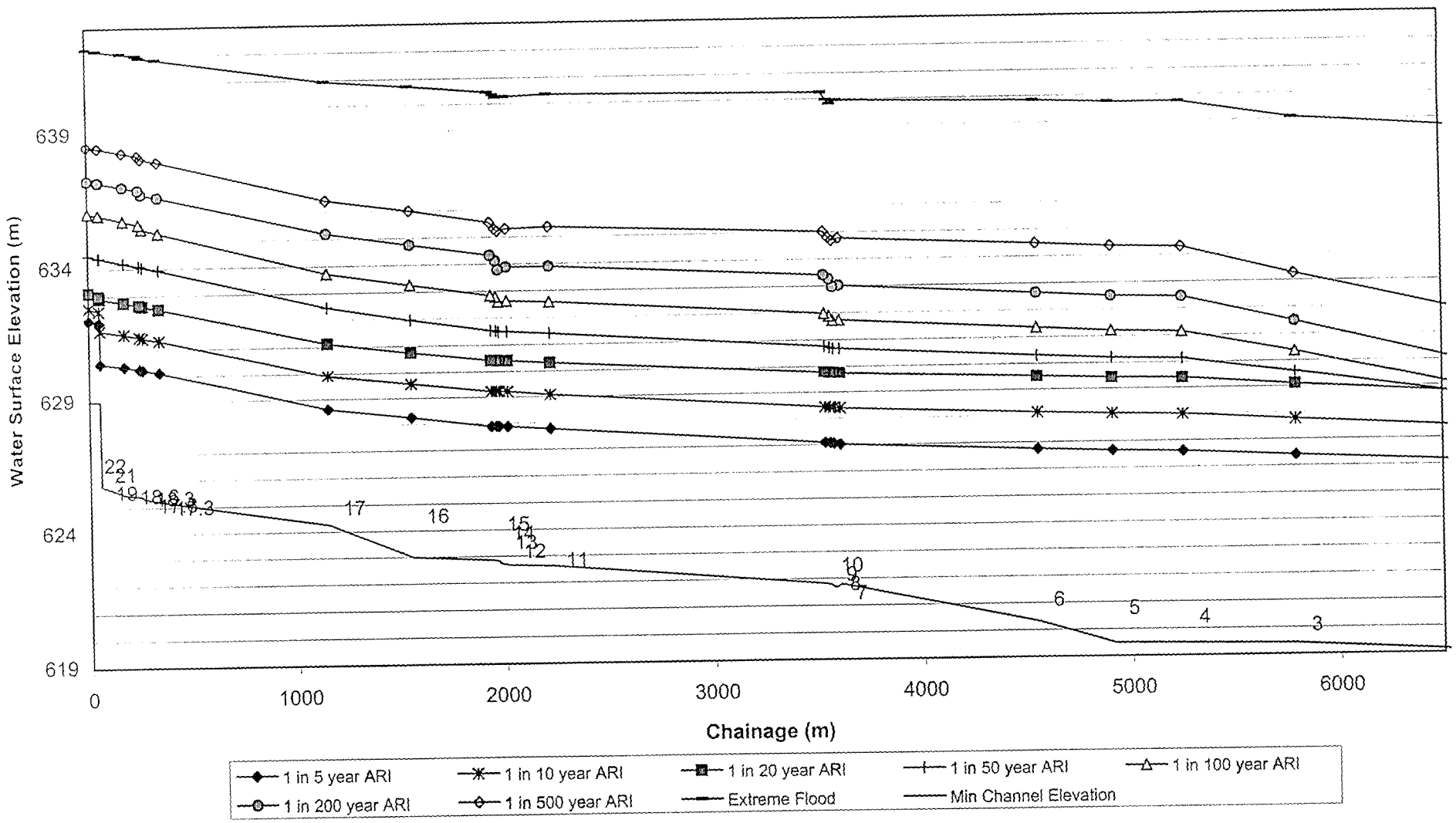
0.2% AEP Flood Event						
River	Reach	Cross Section	Total Discharge (m3/s)	Min. Channel Elevation (m)	Water Surface Elevation (m)	Total Velocity (ave) (m/s)
Wollondilly	Upstream	22	2519	629	638.6	2.09
Wollondilly	Upstream	21	2519	629	638.6	2.11
Wollondilly	Upstream	20	Inline Weir			
Wollondilly	Upstream	19	2519	625.8	638.6	1.64
Wollondilly	Upstream	18.6	2519	625.47	638.4	1.87
Wollondilly	Upstream	18.3	2519	625.41	638.3	1.89
Wollondilly	Upstream	18	Bridge			
Wollondilly	Upstream	17.6	2519	625.32	638.2	1.89
Wollondilly	Upstream	17.3	2519	625.2	638.1	1.89
Wollondilly	Upstream	17	2519	624.25	636.7	2.15
Wollondilly	Upstream	16	2519	622.99	636.3	1.85
Wollondilly	Upstream	15	2519	622.85	636.0	2.07
Wollondilly	Upstream	14	2519	622.82	636.0	2.22
Wollondilly	Upstream	13.5	Bridge			
Wollondilly	Upstream	13	2519	622.72	635.8	2.27
Wollondilly	Upstream	12	2519	622.66	635.7	2.02
Wollondilly	Upstream	11	2519	622.61	635.8	1.35
Wollondilly	Upstream	10	2519	621.81	635.5	0.82
Wollondilly	Upstream	9	2519	621.75	635.3	2.00
Wollondilly	Upstream	8.5	Bridge			
Wollondilly	Upstream	8	2519	621.66	635.3	2.00
Wollondilly	Upstream	7	2519	621.79	635.3	0.85
Wollondilly	Upstream	6	2519	620.32	635.1	0.94
Wollondilly	Upstream	5	2519	619.5	635.0	1.13
Wollondilly	Downstream	4	3890	619.47	635.0	0.82
Wollondilly	Downstream	3	3890	619.42	634.1	3.26
Wollondilly	Downstream	2	3890	619.15	633.4	2.02
Wollondilly	Downstream	1	3890	618.76	633.0	0.86
Mulwarree	1	34	2519	628	635.8	0.79
Mulwarree	1	33	2519	627.23	635.8	0.49
Mulwarree	1	32	2519	627.55	635.7	0.33
Mulwarree	1	31	2519	627.55	635.7	0.20
Mulwarree	1	29.5	Mult Open			
Mulwarree	1	28	2519	627.55	635.7	0.20
Mulwarree	1	27	2519	626.21	635.7	0.25
Mulwarree	1	26	2519	626.11	635.7	0.32
Mulwarree	1	25	2519	626.09	635.7	0.38
Mulwarree	1	24	2519	625.87	635.7	0.37
Mulwarree	1	23	2519	625.75	635.7	0.38
Mulwarree	1	22	2519	625.28	635.7	0.35
Mulwarree	1	21	2519	625.28	635.7	0.37
Mulwarree	1	20.5	Bridge			
Mulwarree	1	20	2519	625.28	635.7	0.37
Mulwarree	1	19	2519	625.03	635.7	0.35
Mulwarree	1	18	2519	625.95	635.7	0.38
Mulwarree	1	17	2519	625.2	635.7	0.30
Mulwarree	1	16	2519	624	635.6	0.35
Mulwarree	1	15	2519	621.92	635.6	0.59
Mulwarree	1	14	2519	622.1	635.6	0.55
Mulwarree	1	13	2519	621.77	635.6	0.52
Mulwarree	1	12.5	Bridge			
Mulwarree	1	12	2519	621.67	635.4	0.53
Mulwarree	1	11	2519	621.14	635.4	0.49
Mulwarree	1	10	2519	620.75	635.3	1.18
Mulwarree	1	9	2519	620.7	635.3	1.17
Mulwarree	1	7.6	Bridge			
Mulwarree	1	6	2519	620.7	635.2	1.19
Mulwarree	1	5	2519	620.61	635.1	1.18
Mulwarree	1	4	2519	620.47	635.1	1.17
Mulwarree	1	3	2519	620.33	635.0	1.15
Mulwarree	1	2	2519	620.19	635.0	1.14

Extreme Flood Event						
River	Reach	Cross Section	Total Discharge (m3/s)	Min. Channel Elevation (m)	Water Surface Elevation (m)	Total Velocity (ave) (m/s)
Wollondilly	Upstream	22	4244	629	642.1	2.44
Wollondilly	Upstream	21	4244	629	642.1	2.45
Wollondilly	Upstream	20	Inline Weir			
Wollondilly	Upstream	19	4244	625.8	642.1	2.04
Wollondilly	Upstream	18.6	4244	625.47	642	2.08
Wollondilly	Upstream	18.3	4244	625.41	641.9	2.09
Wollondilly	Upstream	18	Bridge			
Wollondilly	Upstream	17.6	4244	625.32	641.8	2.08
Wollondilly	Upstream	17.3	4244	625.2	641.7	2.07
Wollondilly	Upstream	17	4244	624.25	640.8	1.99
Wollondilly	Upstream	16	4244	622.99	640.6	1.88
Wollondilly	Upstream	15	4244	622.85	640.3	2.13
Wollondilly	Upstream	14	4244	622.82	640.3	2.22
Wollondilly	Upstream	13.5	Bridge			
Wollondilly	Upstream	13	4244	622.72	640.3	2.21
Wollondilly	Upstream	12	4244	622.66	640.3	2.06
Wollondilly	Upstream	11	4244	622.61	640.3	1.40
Wollondilly	Upstream	10	4244	621.81	640.2	0.75
Wollondilly	Upstream	9	4244	621.75	640	2.30
Wollondilly	Upstream	8.5	Bridge			
Wollondilly	Upstream	8	4244	621.66	639.8	2.32
Wollondilly	Upstream	7	4244	621.79	639.9	0.78
Wollondilly	Upstream	6	4244	620.32	639.8	0.88
Wollondilly	Upstream	5	4244	619.5	639.7	1.18
Wollondilly	Downstream	4	6554	619.47	639.7	0.89
Wollondilly	Downstream	3	6554	619.42	639.1	2.51
Wollondilly	Downstream	2	6554	619.15	638.7	1.64
Wollondilly	Downstream	1	6554	618.76	638.5	0.89
Mulwarree	1	34	4244	628	640.1	0.67
Mulwarree	1	33	4244	627.23	640.1	0.44
Mulwarree	1	32	4244	627.55	640.1	0.30
Mulwarree	1	31	4244	627.55	640.1	0.19
Mulwarree	1	29.5	Mult Open			
Mulwarree	1	28	4244	627.55	640.1	0.19
Mulwarree	1	27	4244	626.21	640.1	0.24
Mulwarree	1	26	4244	626.11	640.1	0.30
Mulwarree	1	25	4244	626.09	640.1	0.37
Mulwarree	1	24	4244	625.87	640.1	0.37
Mulwarree	1	23	4244	625.75	640.1	0.38
Mulwarree	1	22	4244	625.28	640.1	0.35
Mulwarree	1	21	4244	625.28	640.1	0.36
Mulwarree	1	20.5	Bridge			
Mulwarree	1	20	4244	625.28	640.1	0.36
Mulwarree	1	19	4244	625.03	640.1	0.35
Mulwarree	1	18	4244	625.95	640.1	0.38
Mulwarree	1	17	4244	625.2	640.1	0.30
Mulwarree	1	16	4244	624	640	0.38
Mulwarree	1	15	4244	621.92	640	0.67
Mulwarree	1	14	4244	622.1	640	0.57
Mulwarree	1	13	4244	621.77	640	0.56
Mulwarree	1	12.5	Bridge			
Mulwarree	1	12	4244	621.67	640	0.56
Mulwarree	1	11	4244	621.14	639.9	0.53
Mulwarree	1	10	4244	620.75	639.9	1.09
Mulwarree	1	9	4244	620.7	639.9	1.09
Mulwarree	1	7.6	Bridge			
Mulwarree	1	6	4244	620.7	639.8	1.09
Mulwarree	1	5	4244	620.61	639.8	1.08
Mulwarree	1	4	4244	620.47	639.8	1.07
Mulwarree	1	3	4244	620.33	639.7	1.06
Mulwarree	1	2	4244	620.19	639.7	1.05

Mulwarree Ponds
Flood Profiles



Wollondilly River
Flood Profiles

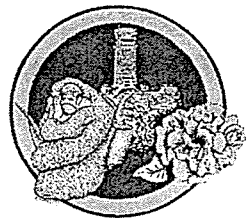


31222
22/07/2002

Results.xls

APPENDIX E

COMMUNITY CONSULTATION SURVEY FORM



SMEC

Goulburn City Council

WOLLONDILLY RIVER AND MULWAREE CHAIN OF PONDS FLOODPLAIN MANAGEMENT STUDY AND PLAN

This survey has been prepared to assist the preparation of a detailed Flood Management Study and Plan for the floodplain of the Wollondilly River and Mulwaree Ponds at Goulburn. As your property may be subject to flooding, it would be greatly appreciated if you could complete the questions below and return the survey in the attached pre-paid envelope by **7th September, 2001**. If you have any questions about this survey or the Study, please call Shireen Murphy at SMEC Australia on
(02) 9925 5555.

All responses to this survey are **entirely confidential** and will not be published. However, the data contained will be consolidated within the Floodplain Management Plan to assist in determining which works and measures may mitigate the impacts of flooding on the residents.

Survey of Residential Premises

DEMOGRAPHIC INFORMATION

1 Address of property: _____

2 How long have you lived: (a) at this address? _____

(b) in the Goulburn area?_____

3 Do you: *(please ✓)*

☐ Own (or purchasing) your home? OR ☐ Rent your home?

4 How many people normally reside in your house/unit? _____

5 Age of occupants: (*please indicate how many people of each age bracket reside at the above address)*

0-15 ____ 16-25 ____ 26-50 ____ 51-65 ____ >65 ____

FLOOD HISTORY

6 As far as you are aware, has your property ever been affected by flooding?

☐ Yes ☐ No ***(If you answered NO to question 6, please go to Q.13)***

7 Which year(s) has your property been affected by floods?

☐ 1974 ☐ 1961 ☐ 1959 Other _____

8 (a) what was the source of the flood?

☐ Wollondilly River or Mulwaree Ponds (floodwaters rising in the river)

☐ Overflowing stormwater drains (water flowing down the roads)

☐ Inadequate drainage (pooling of water on and around your property)

☐ Overflow from neighbouring properties

☐ Other _____

(b) what was the nature of the flooding at its peak/worst?

depth _____ metres (approx)

velocity/speed: ☐ stationary ☐ walking pace ☐ running pace

9 Do you have, or know of any photographs or records of these flood events?

☐ Yes ☐ No

(If you do) would it be possible for us to use this information to validate our data?

☐ No ☐ Yes - please indicate best point of contact _____

10 Has flooding ever caused:

		If so, was the level of damage: (R) repairable, or (D) destroyed?: *(please indicate $ amount if known)*		
Damage to your garden?	No ☐	Flower beds	Lawn	Paving
Damage to possessions?	No ☐	Car	Machinery	Other
Damage to your house?	No ☐	Floor/Structure	Walls	Furniture
Loss of utilities?	No ☐	Electricity	Phone	Water
Loss of irreplaceable items?	No ☐	What were these items?		
Other damage?	No ☐	Please specify		

EVACUATION

11 (a) Have you ever been forced to evacuate your premises during flooding?

☐ Yes ☐ No

(b) *(if yes)* How long was it before you could return to your home?

☐ One day ☐ A few days ☐ One week

12 (a) Did flooding in Goulburn ever threaten your life or the life of a family member?

☐ Yes ☐ No

(b) If yes, please provide details.

_____

_____

HOUSING LOCATION

13 Why do you choose to reside in (or purchase) a property that is flood affected?
(you may tick more than one)

☐ Has always been my home

☐ Affordable housing

☐ Flood effects are minor

☐ Unaware of flooding risk

14 (a) When purchasing the property were you made aware that you were moving into a flood prone area?

☐ Yes ☐ No

(b) If yes, who alerted you to the fact?

☐ Council ☐ Real estate agent ☐ Neighbours ☐ Local Knowledge

Other_____

GENERAL FLOOD IMPACTS

15 How many floods have you witnessed in the Goulburn Local Government Area?

☐ None ☐ One ☐ Two ☐ Three - five ☐ Five +

(If you answered "None" for question 15, please go to question 20)

Where were these floods?_____

16 Did these floods disrupt any of the following activities?

Activity		Effects: (T) Longer travel time; (O) Time Off (work/school/leisure) (I) Inconvenienced	Length of disruption	
			Hours	Days
Shopping	Yes / No			
Visiting Friends	Yes / No			
School	Yes / No			
Work	Yes / No			
Leisure	Yes / No			
Other	Yes / No			

17 What emotions did you feel during the flooding experience?
(you may tick more than one)

☐ Panic ☐ Anxiety ☐ Frustration ☐ Inconvenience ☐ Excitement ☐ None

Other/Comment _____

_____

FLOOD WARNING AND AWARENESS

18 In the flood events that you experienced, how much warning was given of flooding?

Time (mins/hrs/days)_____

19 What was the source of the flood warning?

☐SES ☐ Council ☐ Self

☐Radio ☐ Newspaper ☐ Neighbours / Friends

Other_____

RISK NOTIFICATION

20 In the past, have you received information in the mail about what to do in the event of a flood?

☐ Yes ☐ No

(a) *If yes,* who prepared / distributed this information?

☐ SES ☐ Council ☐ Dept Land & Water Conservation ☐ Other Government Departments

Other_____

(b) Was this information adequate to make you aware of what to do in the event of a flood?

☐ Yes ☐ No

25 (a) What actions would you take in the event of a flood?

_____

_____

_____

_____

YOUR SAY

Would you like to be involved in future public meetings and workshops about this project?

☐ Yes ☐ No

Details *(optional)*

Name: _____

Telephone: _____

Email: _____

Please ensure that your address is complete at Question 1 above.

Thank you for your time in completing this survey. Please return it in the attached pre-paid envelope by 7 September, 2001. If you have any questions about this survey or the Study, please call Shireen Murphy at SMEC Australia on (02) 9925 5555.

Please feel free to add any information or comments on the back of this page.

APPENDIX F

SOCIAL IMPACT OF FLOODING

Table F.1 Location of Respondents and Properties affected by flooding.

Street	Number of respondents	%
Avoca Street	11	12.4%
Bathurst Street	1	1.1%
Bellevue Street	4	4.5%
Braidwood Road	4	4.5%
Buffalo Crescent	7	7.9%
Bungonia Road	2	2.2%
Chantry Street	1	1.1%
Clyde Street	1	1.1%
Cole Street	1	1.1%
Derwent Street	2	2.2%
East Street	2	2.2%
Eaton Street	1	1.1%
Eleanor Street	6	6.7%
Emma Street	9	10.1%
Fitzroy Street	3	3.4%
Gibson Street	2	2.2%
Glenelg Street	1	1.1%
Gurrundah Road	1	1.1%
Hercules Street	2	2.2%
Hetherington Street	1	1.1%
Hoskin Street	1	1.1%
Lower Sterne Street	1	1.1%
Lower Sterne Street	2	2.2%
Major Drive	1	1.1%
May Street	2	2.2%
Murray Street	1	1.1%
Not Stated	1	1.1%
Park Road	5	5.6%
Parkside Place	3	3.4%
Sterne Street	1	1.1%
Sydney Road	1	1.1%
Victoria Street	6	6.7%
Wollondilly Ave	1	1.1%
Wombeyan Caves Road	1	1.1%
TOTAL	**89**	**100**

Table F.2 Number of floods experienced by respondents

Number of floods witnessed or know of	Number of respondents	%
Five +	31	34.8%
Three-five	27	30.3%
Two	6	6.7%
One	8	9.0
None	9	10.1
Not Stated	8	9.0
TOTAL	**89**	**100**

Table F.3 Emotions Felt During and After Flooding.

Category	Emotions A	Emotions B	Emotions C	Emotions D
Level of Negative Emotional Impact	High	Moderate	Low	N/A
No. of People Expressing These Emotions (% of respondents)	21 (29.1)	4 (5.6)	23 (31.9)	24 (33.3)
Emotions Conveyed	Fear Panic Anxiety	Frustration Concern Annoyance	Inconvenience Flooding of local roads	Excitement Not Affected "No big deal" "Relax, nothing to worry about, stay calm" "used to it"

Note: The categorisation of information above is an interpretation made after talking to local residents and various authorities.

Table F.4 Emotions Among those Directly Affected by Flooding

Category	Emotions A	Emotions B	Emotions C	Emotions D
Level of Negative Emotional Impact	High	Moderate	Low	N/A
No. of People Expressing These Emotions (% of those affected by flooding)	15 (33.3)	4 (8.9)	11 (24.4)	15 (33.3)
Emotions Conveyed	Long term depression, inability to cope, desperation. Distress Panic Anxiety "Unable to pursue farming operations on floodplain. Loss of livestock caused distress. The nature of the flooding on the floodplain is such that one can see trapped livestock & not reach them. Worse with bypass"	Frustration Annoyance	Inconvenience "Flood is not covered by my insurance policy"	Excitement "House never in danger" "just working quickly to get belongings out / up"

Table F.5 Emotions Among those Required to Evacuate

Category	Emotions A	Emotions B	Emotions C	Emotions D
Level of Negative Emotional Impact	High	Moderate	Low	N/A
No. of People Expressing These Emotions (% of those affected by flooding)	8 (61.5)	1 (7.7)	1 (7.7)	2 (15.4) 1 not stated (7.7)
Emotions Conveyed	Anxiety Panic Long term depression, inability to cope, desperation.	Frustration Annoyance	Inconvenience "Flood is not covered by my insurance policy"	Excitement Relaxed "just working quickly to get belongings out / up"

APPENDIX G

MINUTES FROM PUBLIC MEETINGS

Wollondilly River & Mulwaree Ponds
Floodplain Management Study & Plan

Public Meeting
29th August, 2001

Neil Benning gave a presentation to the meeting, covering:

- Floodplain management, risk management and types of flood hazard
- The floodplain risk management process
- The contents of a floodplain risk management study and plan
- Typical management measures
- Existing and future issues within Goulburn
- The work program
- The community consultation program
- Outputs and outcomes
- Progress to date and future direction of the study

Issues raised by the participants were:

- The 1986 Study had no community consultation and concern with accurancy of results from tht study "how accurate are the flood levels obtained/recorded?"
- A lot of people are affected by flooding but are not aware of it. Low awareness in the community.
- Why council doing this study now? Community felt that they have been left to deal with flooding on their own.
- Goulburn Landcare to be involved in this project? They were aware of this project only 2 days ago.
- Willows in ground contributing factor to flooding from rivers.
- Felt that dredging should have been done in other areas/or expanded to reduce flooding undersize pipes near the viaduct.
- How big does the study area cover? Mulwaree shire may affect Goulburn area. Tailings dam upstream noted.
- How does community give feedback or relay information?
- Requested more advertising on this project / wants better communication with community eg newspapers, radio, etc.
- The railway bridge near Mulwaree River is overgrown on banks.

Wollondilly River & Mulwaree Ponds
Floodplain Management Study & Plan

Public Meeting

21 February, 2002

Jeffery Coggan
Dianne Coggan
Colleen Harbinson
Eric Weston
Ingrid Hume
Mick Jackson
Bart Yeo
Ron Warburton
John Foord
Shirley Fraser
Marina Hollands
Ted Philpott
Tempe Hornibrook
David Kingsford

Larry Meng
Alice Crawford
Kath Mills
Faye O'Hara
Jane Carter
Keith Allen
Bob Morgan
Robert Bell, SES
Warwick Murray, SES
Peter Mowle, GCC
Lorena Blacklock, GCC
Neil Benning, SMEC
Shireen Murphy, SMEC

Neil Benning gave a presentation to the meeting, covering:

- flood damages
- number of properties affected
- mitigation options and recommendations
- future direction of the study

Issues raised by the participants were:

- a copy of the power point presentation was requested by some of the community. This will be arranged through Council

- one of the residents living near the bypass raised the issue of the impact of the bypass. It was noted that there is a limited impact on small floods. Water was backed up and doesn't get away. It was suggested that a deep channel be cut through Eastgrove. However, it was noted by other participants that this would not be feasible from a hydraulic, environmental and economic point of view.

- The hydraulic impact of the willows was raised. In the channel they have a major impact, and thus the effect in the Wollondilly is more defined. The impacts include decreased velocity, debris, debris rafts, artificial increase in flood levels. Across the Mulwaree, the majority of flow occurs in the floodplain, and as the willows are mainly in the channel there is less effect.

  Willows are holding the banks together. The removal of willows will lead to increased velocity, increased erosion and increased silt, therefore there removal must be done in a way that it must be done in such a way that the banks remain protected. This may mean leaving stumps in place while native vegetation, which grows slowly, becomes established. Care also needs to be taken not to move the problem downstream.

- A question was asked regarding what environmental enhancement, one of the options being considered for the plan, would entail. It was explained that this aims at restoring what was originally out on the floodplains. A suitable vegetation management plan would be done in consultation with DLWC.

- It was asked if new retarding basins would be put in. This is currently a policy of GCC for new developments. There are already 8 within the city – 3 wet, 5 dry (filled for 30 to 40 minutes) during a storm event. The wet basins are predominantly for water quality. As examples, there are basins at Wollondilly Gardens Estate and the Police Academy.

- The possible levee sites within Goulburn were discussed. A question was asked regarding the height of the Roberts Park levee. It was noted that this will assessed during detailed investigations into this option. At this time, drainage issues would also be considered.

- The funding of measures was raised. It was noted that measures included within the floodplain management plan may be eligible for funding from the State and Commonwealth government, using a 1/3 GCC 2/3 Government split. Funding may also be available through the NHT for the vegetation management plan.

- It was noted that SMEC will be undertaking work to update the flood frequency study and the model developed in the previous Flood Study, however, a full update of this study will not be done.

Written submissions were requested in within three weeks, as per the attached letter from Council.

APPENDIX H

FLOOD DAMAGES

1 Introduction

Flood damages for flood affected properties in Goulburn were computed using a suite of computer modules developed by SMEC. These modules can be used to compute damages for commercial, industrial and public utility properties. In the Goulburn study, damages for the residential sector were computed on a property by property basis using information collected during field visits, while damages for commercial properties were based on information provided by the property owners in combination with information collected on commercial properties in previous studies undertaken by SMEC.

To base damage estimates on data collected within the study area is usually the best approach, but the generalised procedure is used for studies that involve many commercial, industrial and utility properties where large surveys are not practical or where there is only a limited amount of information available. The latter is the case in Goulburn, as it has been many years since a flood of significant size has been experienced and information on actual damages has been lost with time. Therefore, damage estimations for Goulburn used a combination of data collected and generalised procedures.

A description of the modules used to compute damages is given below.

2 Generalised Procedure for Damages

The procedures use information obtained from a detailed site survey. For the Goulburn study, the survey included all residential and commercial buildings located on land inundated by floodwaters up to an extreme flood event. This survey was designed to establish the data necessary to establish the location and damage to property occupied by buildings, due to a particular flood event. The forms used for these surveys are included in this Appendix. Consequently, the following data is usually obtained:

- addresses of buildings comprising street number and street name as per site visits and Council records
- provision of a building description, ie flat, house, unit, cellar, workshop, etc;
- designation of building types between:
  - residential;
  - commercial;
  - industrial;
  - public institution; and
  - public utility;
- identification of the type of material used in the construction of external walls and floor types (residential only);
- an estimation of the height above ground with a staff;
- an estimation of ground level at each building location, from topographic information;
- an indication of carparking facilities (commercial/industrial only);

- information on flood history (commercial/industrial only);
- an estimate of actual flood damages experienced, including closure time and loss of turnover (commercial/industrial only);
- an estimate of potential flood damages (commercial/industrial only);
- any future development plans (commercial/industrial only);
- identification of the water course responsible for causing possible flood damage to the building; and
- an identification chainage to locate the building at a point along the designated water course.

The value of damages to all property occupied by buildings can be computed for the following categories for particular flood events:

- existing conditions; and
- proposed design conditions with different flood mitigation options.

An allowance for the additional cost of repairs and clean-up is included, together with a reduction factor to account for potential warning time. Vacant land is considered to contribute negligible damages overall and is normally excluded from the study. For each category above, total damages resulting from all flood events are plotted to produce a damage/frequency curve from which the Average Annual Potential Damage (AAD) is derived. For the purposes of damage assessment in Goulburn, flood damages for industrial properties were combined with flood damages for commercial properties.

3 Data Presentation

3.1 Building Databases

Building databases were established using *Microsoft Access,* one for the commercial/industrial sector and one for the residential sector. The information held within the database included the street addresses, enabling retrieval of data for specific locations. Other information held within the residential property database comprised the following:

- Floor level (either estimated or surveyed);
- Building type (residential, commercial, industrial, public institution, public utility);
- Building description (house, unit, storage shed/warehouse, workshop, garage, etc);
- Material type (commercial and residential);
- Number of stories;
- Value Code (residential only); and
- Estimates of building and contents value and turnover (commercial only, not comprehensive)

3.2 Building Damage Assessment

The value of damages to residential buildings is estimated by assigning a value code to each property and incorporating the equations described in the following section into the *MS Access* database. Commercial properties were assessed using actual damage data collected through surveys of commercial property owners in Goulburn and previous studies undertaken by SMEC. The damage curves were developed for low, medium and high levels of flooding.

In the Goulburn study damages were estimated for all residential and commercial buildings subjected to floodwaters of 20%, 10%, 5%, 2%, 1%, 0.5%, 0.2% AEP and the extreme flood event for existing conditions. **It is stressed that the results are estimates only and do not reflect actual damages in an actual flood. Only an actual flood can provide precise damages.**

4 Property Damage

4.1 General

Damage evaluation to individual properties is based on a designation of building type corresponding to a Landuse number, ie:

- Residential - Landuse 1
- Commercial - Landuse 2
- Industrial - Landuse 3
- Public institution - Landuse 4
- Public utility - Landuse 5

Each landuse type, except for residential, is further categorised as either a low, medium or high damage category in an attempt to estimate more accurately the direct potential damage to individual properties.

4.2 Residential Properties

4.2.1 Evaluation

In evaluating property damage for **residential landuse type** the following equations are used:

For Depth of over floor flooding (H) < 1 m

$$D = D_2(0.06 + 1.42H - 0.61H^2)\ R\ (1 + ID) + D_{CLEAN} \quad (1)$$

For Depth of over floor flooding (H) ≥ 1 m

$$D = D_2\ (0.75 + 0.12H)\ R\ (1 + ID) + D_{CLEAN} \quad (2)$$

Where D = Value of damage to property ($)

D_2 = Assessed value of residential property damage at 2 m depth of flooding (H) ($)

H = Depth of over floor flooding (m)

R = Reduction factor by virtue of a flood warning provision. 0.9 was adopted in this study.

ID = Indirect damage factor. 0.25 was adopted for the Goulburn study.

D_{Clean} = Clean-up cost ($)

For residential landuse an assessed value of residential property damage at a height of 2 m above floor level was adopted as the size based on the table of values as adopted by PPK, 1993 in their Tamworth study, with adjustments to account for the different land values in Goulburn.

The values adopted for the current study are given below:

Residential Property Type	Internal	External	Structural
Low value property	$9,698	$1,062	$4,892
Medium Low value property	$11,625	$1,275	$6,330
Medium value property	$14,535	$1,575	$8,445
Medium High value property	$16,860	$1,845	$10,575
High value property	$20,055	$2,205	$13,725

4.2.2 Measures of "Size"

To make an allowance for the difference in comparable "size" between houses, flats and units, the following formulation was derived:

D_2 = X (Int + Ext) + (Y x Struct) (4)

D_2 = Annual assessed value of residential property at 2 m depth of flooding (H) or size (S) ($)

Where

X = Total number of units/flats located on title block

Y = Total number of buildings which contain X

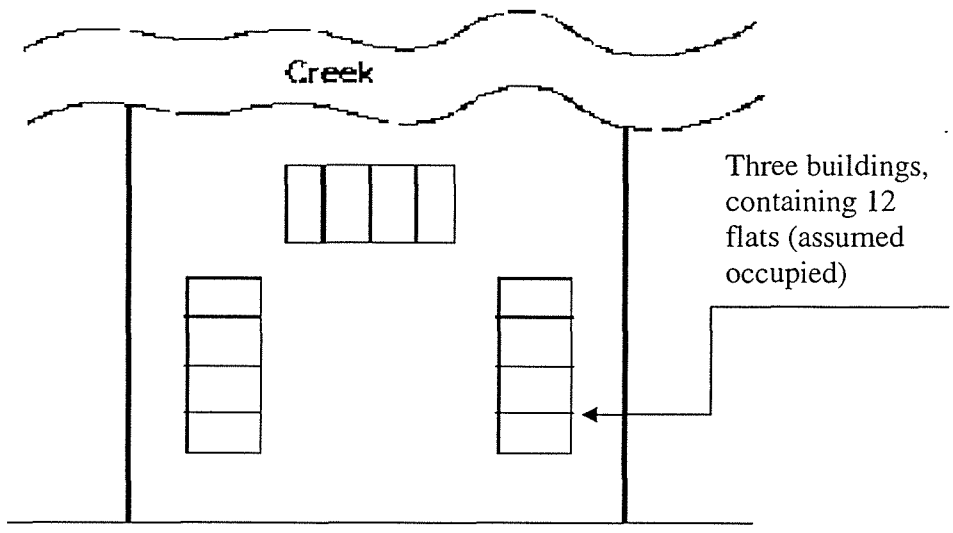
Int = Internal property value ($)

Ext = External property value ($)

Struct = Structural property value ($)

An example of the use of Equation 4 is the case illustrated in Sketch H.1 on the following page where 12 flats are assumed to have internal and external values of $16 000 and $1 750, respectively, and there are three buildings having a structural value of $10 000 each.

Thus D_2 = 12 (16 000 + 1 750) + 3 x 10 000 = $243 000



Sketch H.1: Example of the Application of Equation (4)

4.2.3 Reduction Factor due to Flood Warning

The reduction factors or actual damage factors were determined from a review of previous studies (Upper Nepean (SMEC 2001), Gunnedah (SMEC 1999) and Tamworth (PPK 1993)), and the history of flooding in Goulburn. A reduction factor of 10% was adopted.

4.2.4 Indirect Potential Damages

The indirect potential damages expressed as a percentage of direct damages were determined with the aid of previous studies and accounting for conditions in Goulburn. For residential properties, where clean-up costs were calculated as a separate item, a factor of 25% was allowed for the indirect potential costs.

i Potential clean-up costs

To calculate the potential clean-up costs for residential properties, a clean-up equation was adopted as used in the 1980 SMEC study, River Torrens, Adelaide and adjusted to suit Goulburn conditions:

$$D_{Clean} = \text{Daily rate} \times Z \times \ln\left(\frac{H}{0.023}\right) \quad (5)$$

Where D_{Clean} = Potential clean-up costs ($)
Daily rate = Earnings per day of one worker ($/day)
H = Depth of over floor flooding (m)
Z = Factor accounting for sediment load and deposition

After consideration of other studies, Tamworth (PPK, 1993) and River Torrens (SMEC, 1980) and recent ABS data for Goulburn, a value of Z = 7 was adopted to account for sediment load and deposition and a daily rate of $70/day. This gave:

$$D_{Clean} = 490 \ln\left(\frac{H}{0.023}\right) \qquad (6)$$

4.2.5 Special Conditions

Due to the inclusion of the natural logarithm function ln(A) in all equations used to evaluate damages, a value of 'A'< 1 would result in negative values creating instances of negative damages for small depths of over floor flooding ranges. Considering D_{Clean}, if D_{Clean} is to be greater than zero, h must be greater than 0.023 m.

Accordingly, for depths of flooding between zero and (0.023 + 0.01) m (=0.033 m), D_{Clean} was estimated from Equation (6) as if the depth, H, was in fact 0.033 m:

$$D_{Clean} = 490 \ln (0.033/0.023) = \$176.90$$

4.3 Commercial Properties

4.3.1 Evaluation

For commercial properties, damage curves were constructed for the following business types:

- agricultural/light industrial;
- garden;
- hair/beauty;
- motel/b&b/caravan park;
- office;
- pub/hotel/RSL;
- restaurant/café;
- retail; and
- club.

As far as possible, these curves were constructed using actual flood damage information. A number of local property owners and business operators were interviewed, to ascertain the actual level and the potential level of damage experienced in recent floods. While some business operators have extensive knowledge of flooding within their premises, the last major flood experienced in the Goulburn area that affected a large number of properties was in 1961, therefore, a significant majority of the commercial/industrial operators now in Goulburn do not have experience with flooding.

The actual damage estimates supplied were insufficient for an assessment of future flood damages. Some business operators were able to supply information on potential future damages.

Therefore, damage estimates in this study were predominantly based on potential flood damages, using values provided by business operators in Goulburn in the commercial surveys and supplemented by an extensive database of damages gathered by SMEC in previous floodplain management studies. (Gunnedah Floodplain Management Study (SMEC 1999); Upper Nepean River Floodplain Management Study & Plan (SMEC 2001)).

The damage curves for each business were collated from data on the estimated value of damage sustained through the various components of a business. These components were:

- Stock;
- Fittings;
- Fixtures;
- Wiring;
- Equipment;
- Electrical; and
- Other.

Using information supplied by the business operators, these components were categorised as being affected by a low, medium, or high flood and thus a curve was able to be developed to cover the spectrum of floods experienced for each type of business.

For each of the design flood levels listed in Section 3.2, the depth of flooding experienced by a business was determined by subtracting the estimated flood level from the flood level. The depth of flooding was then looked-up on damage curve appropriate for the business type to determine the potential flood damage sustained for that depth of flooding.

4.3.2 Indirect Potential Damages

Indirect commercial damage may include costs of removal and storage, loss of business confidence and loss of trading profit. Smith's study of Lismore (1980) found that indirect costs were 18.5% of direct damage suffered by the commercial sector and 35% in the industrial sector. It is normal to include clean up costs as a direct damage. If it is incorporated into the equation as a percentage of indirect costs, then the indirect costs can be up to 25% of the total direct costs (Smith 1980).

The indirect potential damages expressed as a percentage of direct damages were determined with the aid of previous studies and accounting for conditions in Goulburn. For commercial properties a factor of 25% was adopted, which included the clean-up costs.

4.4 Infrastructure / Public sector

A major component of infrastructure damage is concerned with transport – damages to roads, bridges and culverts and locally to rail and air connections where applicable. Other losses are to services such as water, sewage treatment plants, gas, electricity and telephones. The variability in terms of location, the period of inundation, problems of sedimentation and erosion are such that no standard technique is possible. Australian and international literature suggests that infrastructure damage is normally within the range of 7% to 20% of that to the private sector. (DI Smith et al 1986).

In this study, data on previous flood damage to roads was not available so the above estimate was adopted for damage to roads. Seven percent of the potential damages to the private sector was applied up to the 2% AEP, ten percent for the 1% AEP, fifteen percent for the 0.5% and 0.2% AEP and twenty percent for the extreme flood.

4.5 Flood Level Interpolation

The HEC-RAS hydraulic model only provides estimates of flood levels at specific cross sections along the creeks being modelled. Intermediate flood levels are therefore computed by interpolation, based on chainage.

GOULBURN FLOODPLAIN MANAGEMENT STUDY

Survey for Commercial or Industrial Premises

SMEC's PROPERTY REFERENCE NUMBER: _____

Date:	FOR OFFICE USE ONLY
Surveyor:	Ground Level (mAHD):
Height to Floor (m):	Floor Level (GL plus height):

Introduction

SMEC Australia has been commissioned by Goulburn City Council to undertake a Floodplain Management Study and prepare a Floodplain Management Plan for the Goulburn area. As you may be aware, floodwaters from the catchment accumulate near the area along Braidwood Road, and have in the past caused damage to business premises, loss of trade due to flooding and associated clean up activities. These are direct impacts of flooding. As a result of these losses businesses are sometimes forced to put off renovations, delay purchase of new equipment or employing new staff. These are the indirect impacts of flooding.

The following survey aims to obtain information from you on how the flooding has affected this business and its premises. In completing this survey we need you to consider the impact of floods, including extreme flood events. It is important to list both direct and indirect impacts of flooding in your response.

All responses to this questionnaire are entirely confidential and will not be published. However, the data contained will be consolidated within the Floodplain Management Plan to support possible works and measures to mitigate the impacts of flooding.

Item 1 - Business Details

*a) Business Name:*_____
*b) Business Type:*_____
*c) Street Address:*_____
*d) Length of time in business:*_____

d) Type of Buildings:
(Eg: storage shed/warehouse, workshop, garage, cellar, shop, office, residence)

	Type	General contents of building	Number of storeys	Floor size (m^2)
Main building				
Additional buildings				
Additional buildings				

e) Building Material (concrete, timber, brick, fibro, plasterboard, steel, carpet, lino, tiles, other):

	Floor	Floor covering	Internal walls	Internal frame
Main building				
Additional building				
Additional building				

f) Do you provide exclusive car parking facilities for staff or customers?

☐ No ☐ Staff only ☐ Customers only ☐ Staff & customers Total No. spaces _____

g) If you answered yes to f) what type of car parking do you provide?

☐ Above ground ☐ Basement *If basement, how many levels?* _____

h) Do you see your car parking needs changing? If so how and in what time frame?

_____

_____

Item 2 - Flood History

a) Has the property ever been affected by flooding?(tick appropriate box)

☐ No	Go to item 3
☐ Yes	Please indicate details below

Year of flood	Estimated flood height (m):		Comments
	Above floor level	Above ground level	

b) Please indicate the damage that was caused to merchandise or stock; fittings, fixtures or equipment; foundations or walls.

Damaged Items	Description of item	Was the item raised? How high (m)?	Was the item damaged and repairable (R) or destroyed (D)?	Repair or replacement cost
Stock				
Fittings (eg doors, shelves, cupboards)				
Fixtures (eg floor coverings, painting)				
Wiring and cabling (eg telecom)				
Equipment (eg machinery,furniture)				
Electrical Equipment (eg photocopiers, computers)				
Foundations (eg settlement or slabs lifting)				
Internal walls (eg collapse or warping of walls)				
Other				

Comments or additional information _____

_____

_____

c) *Have you ever received customer complaints about flood related incidents?*

☐ No ☐ Yes

If yes, please comment:_____

_____

_____

d) *How much business was lost as a result of past flood events?* (Including the actual flood and time cleaning up) Year of flood: _____

During the flood

Business closure time (days):	
Estimated turnover loss per day ($):	
If business remained open, did you suffer reduced turnover?	
If yes, what was the estimated percentage reduction in daily turnover?	
For how long was turnover reduced (days)?	

After the flood

Clean-up time (days):	
Was the business closed during clean up?	
If business remained open, did you suffer reduced turnover?	
If yes, what was the estimated percentage reduction in daily turnover?	
For how long was turnover reduced (days)?	

Comments or additional information:_____

_____

_____

Item 3 - Potential loss of goods

a) *In the event of a flood (if never experienced flooding) or in a larger flood than previously experienced, please identify your potential loss in each of the following categories (ie. Total amount of goods, fixtures and equipment subject to inundation)- consider 0.01m, 0.5m and 1m depths:*

Item that could be damaged by flooding	Description of item	Height of item above floor level (m)	Is the item raiseable ? Y/N	Would the item be damaged and repairable (R) or need replacing (D)?	Repair or replacement cost
Stock					
Fittings (eg doors, shelves, cupboards)					
Fixtures (eg floor coverings, painting)					
Wiring and cabling					
Equipment (eg machinery, motors, furniture)					
Electrical Equipment (eg: computers)					

Note: SMEC will use previous information to estimate damages for structures, internal walls and clean up.

b) *Could all raiseable items be moved out of rising floodwaters if you had prior notification? (approximately 30mins maximum)*

☐ Yes ☐ No

Comments or additional information:

_____
_____
_____
_____

Item 4 – Future Business Improvements

a) Do you have any plans for improvements to your property or to purchase new equipment? If so please provide details below, including costs:

_____
_____
_____
_____
_____
_____

b) Does the possible impact of flooding deter you from carrying out the works listed above? Please give reasons.

_____
_____
_____
_____
_____
_____

Item 5 - Do you have other comments from this survey?

(Eg loss of clients, especially permanently; loss of client confidence; other affects from flooding)

_____
_____
_____
_____
_____
_____

Thank you for your assistance
Please return in the enclosed pre-paid envelope.

If you have any questions please contact:

Ms Shireen Murphy or Ms Magdeline Koo

Ph: 02 9925 5555 or 1800 659 264
SMEC Australia
PO Box 1052
North Sydney 2060

GOULBURN FLOODPLAIN MANAGEMENT STUDY & PLAN

Consultant : SMEC

Collected By : _____

Street : _____

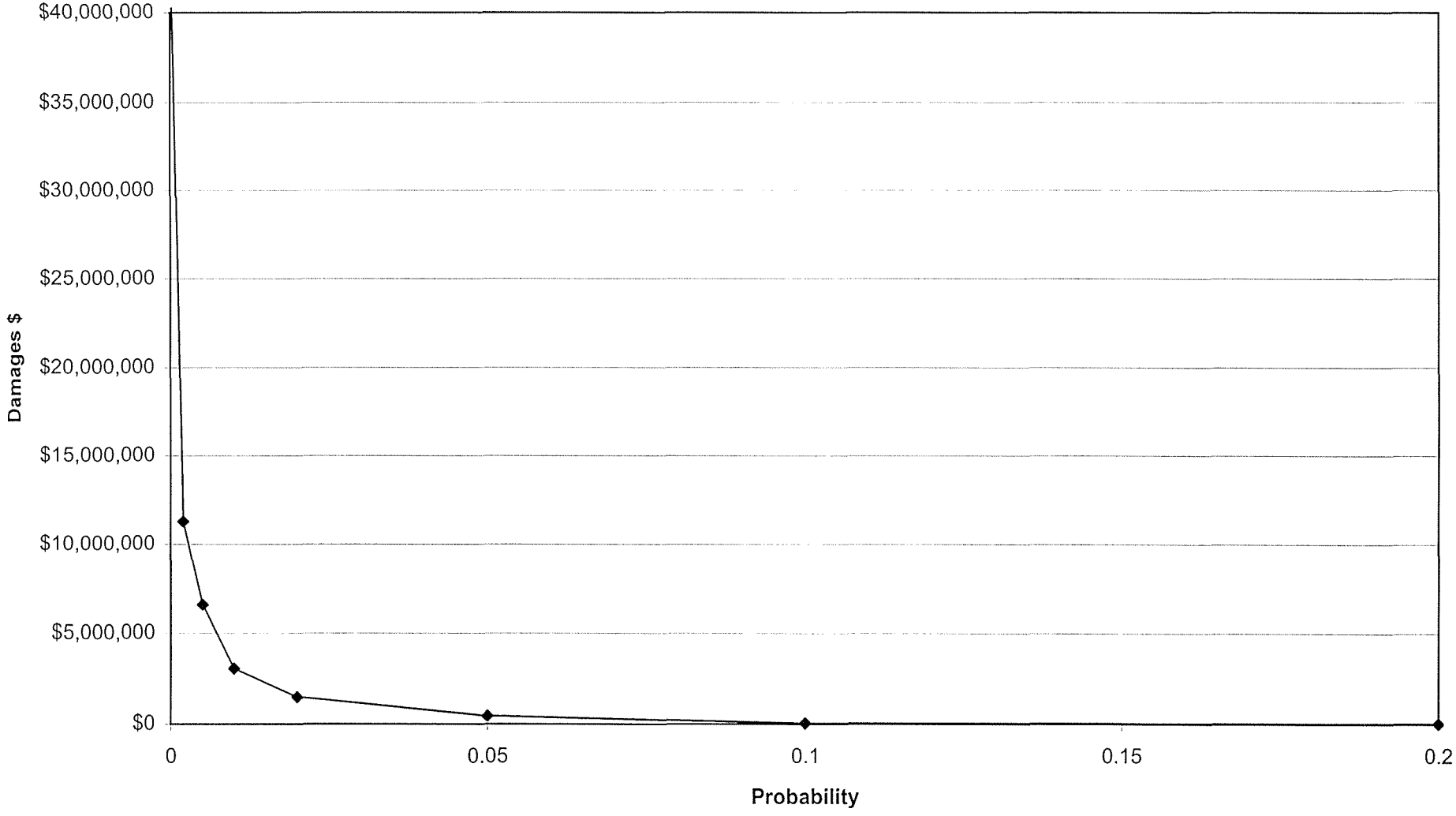
Date : _____

House No.	Unit No.	Resid. Code	Comments	Floor Levelling			Construction Type (Ground Floor)					Storeys	Value Code A,B,C,D,E
				Ground Level	Height to Floor	Floor Level	Floor		Walls				
							Timber	Conc	Fibro	Brick	Other		

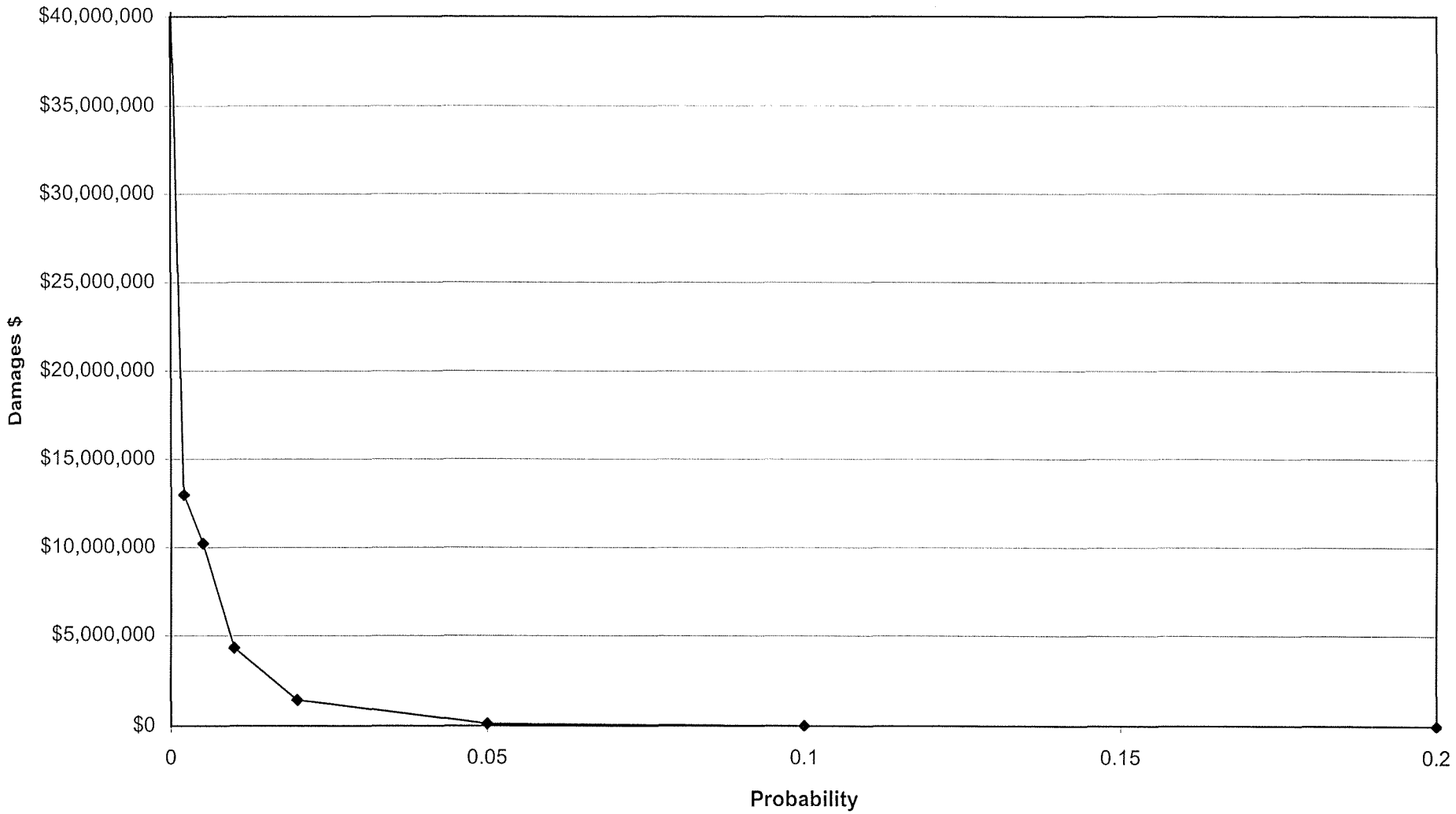
Residential Code = A.Detached House B.Dual Occ C. Unit D.Terrace E.Other (details)

Non-Residential Code = 1.Retail 2.Warehouse 3.Office 4.Industrial 5.Educational 6.Health Care

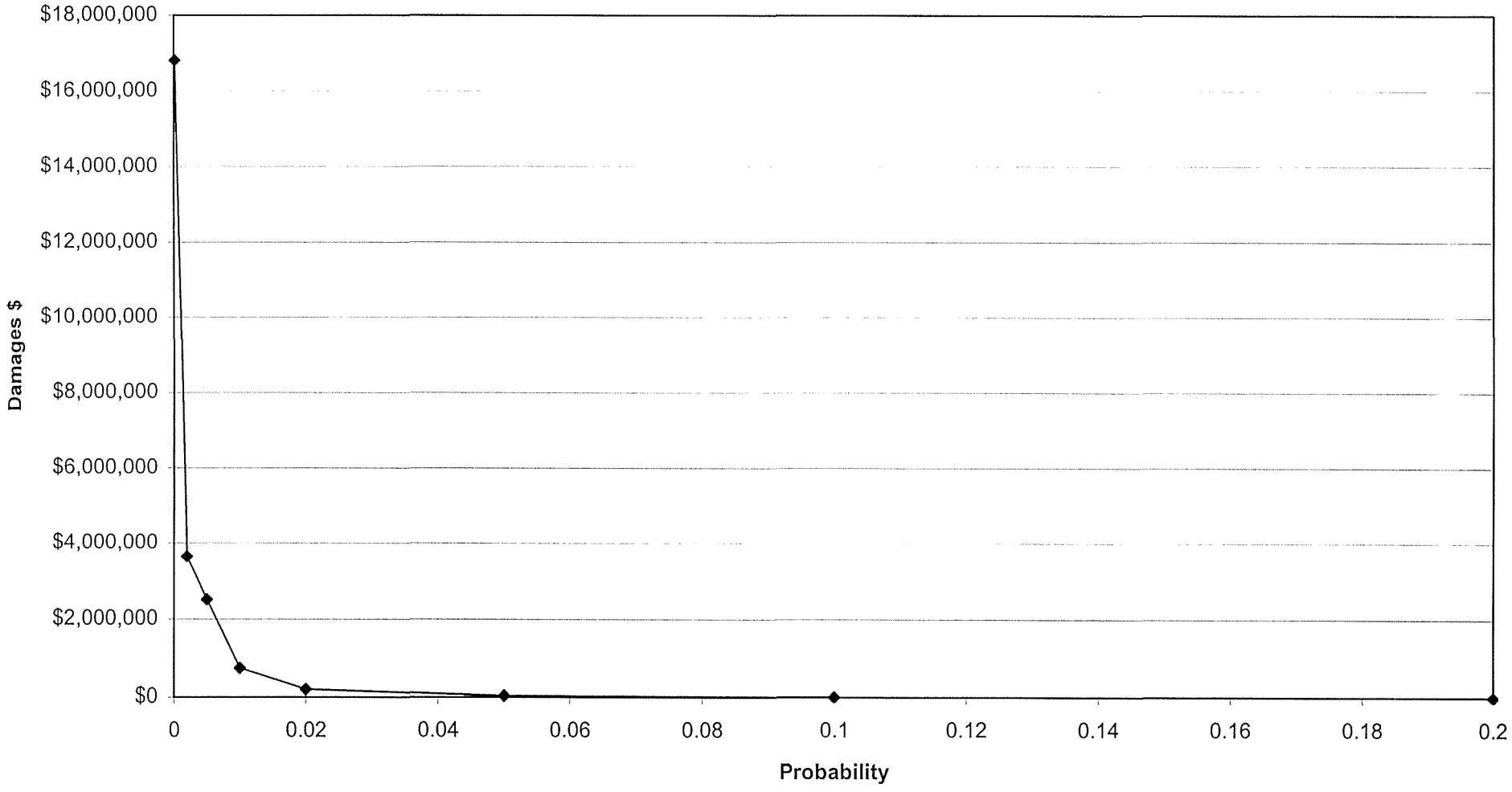
Probability vs Damages
Goulburn LGA - Residential Sector



Probability vs Damages
Goulburn LGA - Commercial Sector



Probability vs Damages
Goulburn LGA - Infrastructure



APPENDIX I

OPTION ASSESSMENT

	Score 1	Score 2	Score 3	Score 4	Score 5	DLWC	Score 6 (SMEC)	Average Score	Comments
Floodplain Environmental Enhancement	53	70	64	60	59	58	59	60.43	Generally positive for the environment, has social attractions but has limited impact on flood regime
Zoning LEP, Development Control provisions in DCP	57	49	57	60	56	57	60	56.57	Standard measure and highly desirable
Flood Warning and Emergency Plans	61	50	55	59	54	55	56	55.71	Standard measure and highly desirable
Evacuation & Recovery Procedures	59	50	55	58	53	55	56	55.14	Standard measure and highly desirable
Community Awareness & Preparedness	57	51	55	58	54	55	53	54.71	Standard measure and highly desirable
Flood Proofing Code	64		57	52	50	52	52	54.50	Probably best applied to new or re-development in low hazard areas
Voluntary purchase (XXXX properties)	55	50	55	58	56	52	55	54.43	Not a significant number of properties in high hazard areas.
Voluntary house raising (XXXX properties)	47	49	51	52	51	52	53	50.71	May apply in Eastgrove
Eastgrove Levee	43	46	32	51	53	47	48	45.71	Questionable economics, poor environmentally due to visual impacts. Problems with false sense of security.
Victoria Street Levee	44	45	32	49	53	48	47	45.43	Questionable economics, poor environmentally due to visual impacts. Problems with false sense of security.
Mulwaree River Levee (Lake)	43			34		45	41	40.75	Very poor economically and environmentally.
Flood Control Dam	33			43	28	52	41	39.40	No feasible sites available

APPENDIX J

EASTGROVE & VICTORIA STREET LEVEE ALIGNMENTS

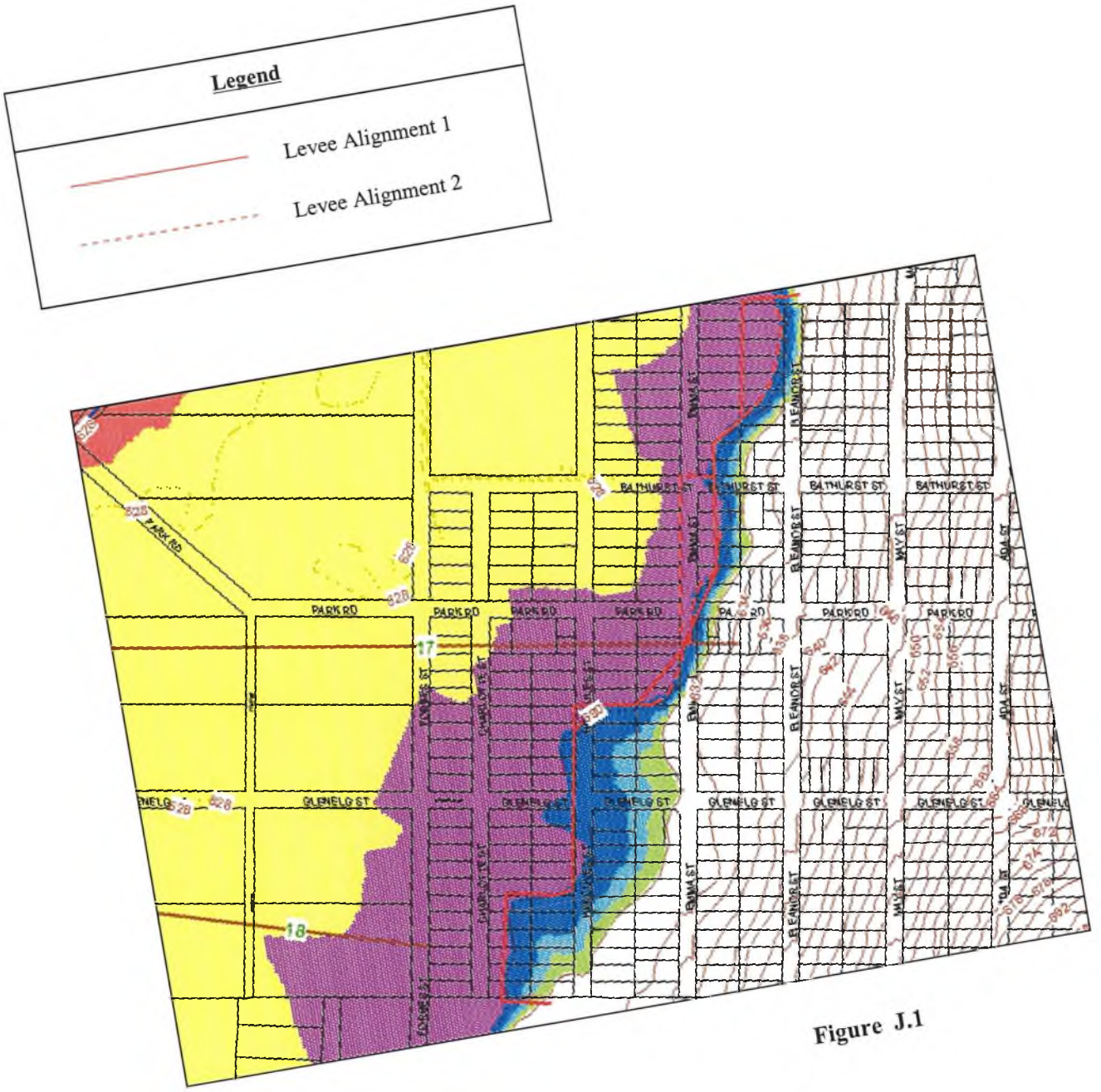


Figure J.1

Eastgrove Precinct
Levee options : 1% AEP Flood Event

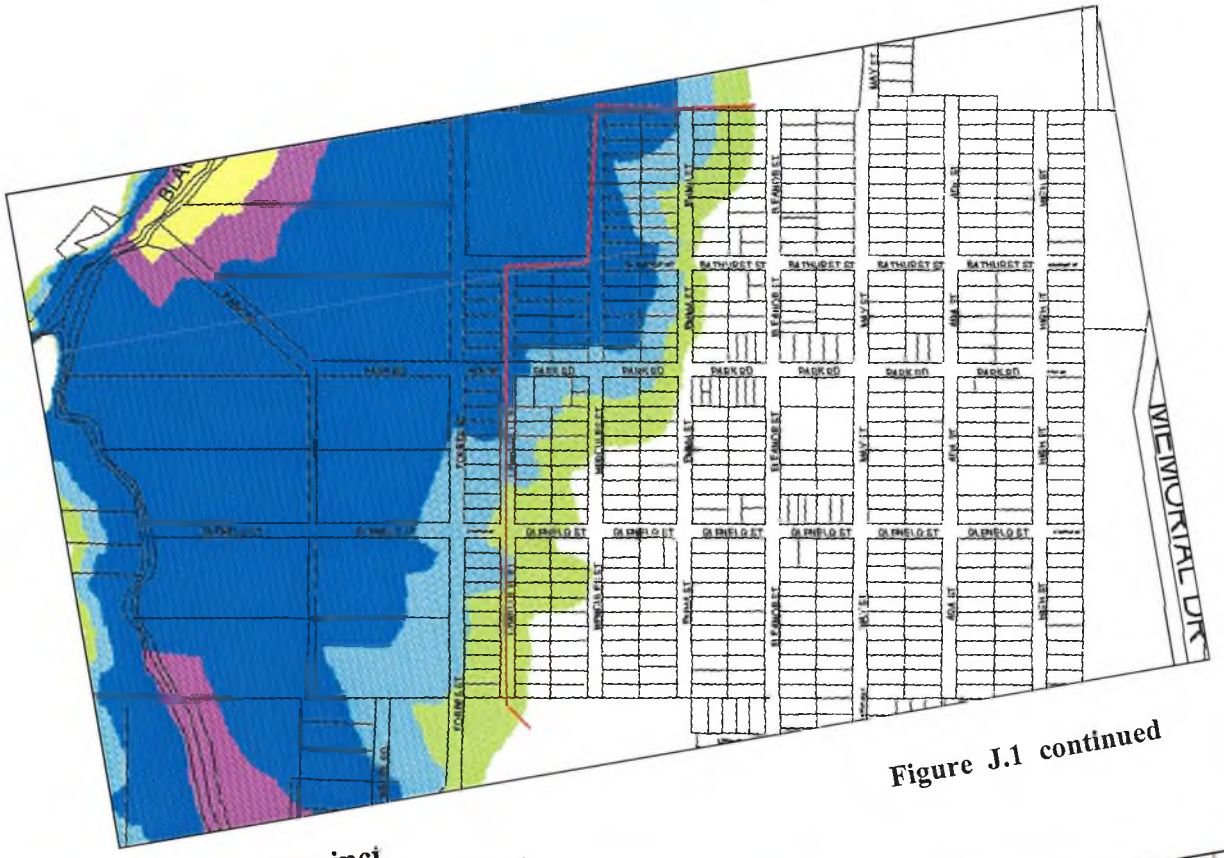


Figure J.1 continued

Eastgrove Precinct
Levee options : 5% AEP Flood Event

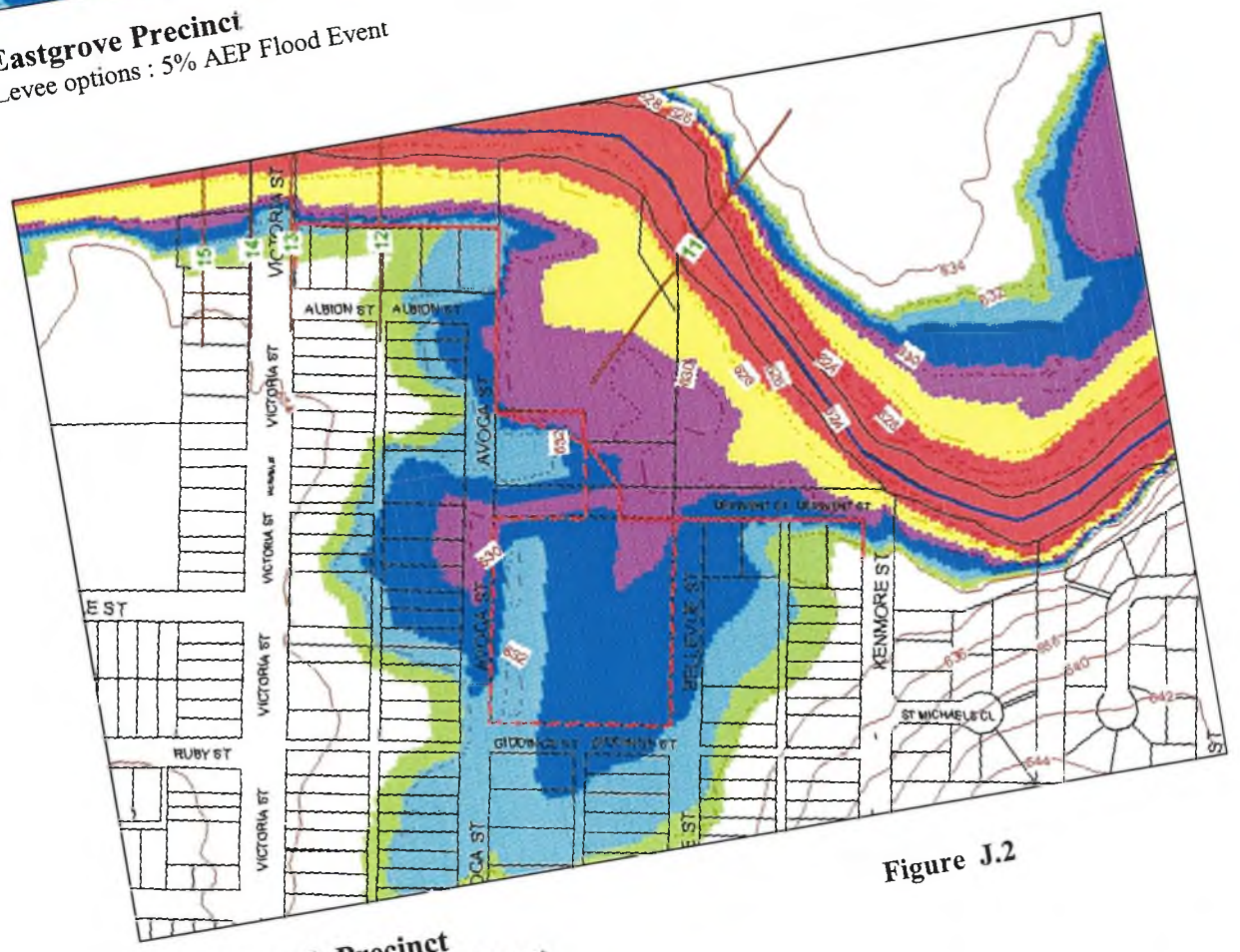


Figure J.2

Roberts Park Precinct
Levee options : 1% AEP Flood Event

SMEC

APPENDIX K

SCHEDULE OF FLOOD COMPATIBLE BUILDING MATERIALS & CONSTRUCTION METHODS

Flood Compatible Building Materials and Construction Methods

The use of the following flood compatible building materials and construction methods is **mandatory for all developments**.

Flooring and sub-floor structure	• pier and beam construction, or • suspended reinforced concrete slabs.
External wall structures	• solid brickwork, blockwork, reinforced concrete or mass concrete.
Main power supply	• Subject to the approval of the relevant power authority, incoming electricity mains, service equipment and meters shall be located 1m above the flood planning level. Means shall be available to easily disconnect the building from the main power supply.
Wiring	• All wiring, power outlets, switches, etc, should, to the maximum extent possible, be located 1m above the flood planning level. All electrical wiring installed at or below the Flood planning level should be suitable for continuous submergence in water and should contain no fibrous components. Only submersible-type splices should be used at or below the Flood planning level. All conduits located below the relevant flood level should be so installed that they will be self-draining if subjected to flooding.
Equipment	• All equipment installed below or partially below the flood planning level should be capable of disconnection by a single plug and socket assembly.
Fuel	• Heating systems using gas or oil as a fuel should have a manually operated valve located in the fuel supply line to enable fuel cut-off.
Installation	• Heating equipment and fuel storage tanks should be mounted on and securely anchored to a foundation pad of sufficient mass to overcome buoyancy and prevent movement that could damage the fuel supply line. All storage tanks should be vented to an elevation of 500 millimetres above the flood planning level.
Services	• All sewer connections to buildings on land at or below the FPL are to be fitted with reflux valves to prevent backflow of sewage in a flood event. Sewer surcharge gullies must be located above the FPL.

The use of the following flood compatible building materials and construction methods is recommended for all developments.

Floor covering	• clay tiles; • concrete, precast or in situ; • concrete tiles; • epoxy, formed-in-place; • mastic flooring, formed-in-place; • rubber sheets or tiles with chemical set adhesives; • silicone floors former-in-place; • vinyl sheets or tiles with chemical set adhesives; • ceramic tiles, fixed with mortar or chemical set adhesive; • asphalt tiles, fixed with water resistant adhesives; or • removable rubber-backed carpet
Windows	• aluminium frame.
Doors	• solid panel with water proof adhesives; • flush door with marine ply filled with close cell foam; • painted material construction; • aluminium or galvanised steel frame.
Wall and ceiling linings	• brick, face or glazed; • clay tile glazed in waterproof mortar; • concrete; • concrete block; • steel with waterproof applications; • stone (natural solid or veneer), waterproof grout; • glass blocks; • glass; or • plastic sheeting or wall with waterproof adhesive.
Insulation	• foam or closed cell types
Reconnection	• Should any electrical device and/or part of the wiring be flooded, it should be thoroughly cleaned or replaced and checked by an approved electrician before reconnection.
Ducting	• All ducting located at or below the Flood planning level should be provided with openings for drainage and cleaning. Self-draining may be achieved by locating the ducting at a suitable grade. Where ducting must pass through a watertight wall or floor below the relevant flood level, the ducting should be protected by a closure assembly operated from above the flood planning level.