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Water Resources and Environmental Engineering

FLOODPLAIN MANAGEMENT REVIEW AND SUPPLEMENTARY PLAN

North Wentworthville

JANUARY 2002

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TABLE OF CONTENTS

Page No

ANNEXURE 1
PLANNING CONTRIOLS AND
SUGGESTED CLAUSES FOR DCP

LIST OF TABLES

LIST OF FIGURES

APPENDICES

1 INTRODUCTION

1.1 Background

A significant number of residential and commercial properties are affected by flooding from Coopers Creek, Finlaysons Creek and Toongabbie Creek at North Wentworthville. As a result of two significant flood events that occurred during the late 1980s, three of the most severely affected property owners were offered voluntary purchase and a further seven were provided with subsidised loans from the Upper Parramatta River Catchment Trust to raise their houses above flood level. However, approximately 100 other residential properties are affected by flooding of the land in a 1 in 100 Annual Exceedance Probability (AEP) flood of which about 35 would have floodwater above the floor level.

In 1997, the Upper Parramatta River Catchment Trust (the Trust) commissioned Bewsher Consulting to undertake the North Wentworthville Floodplain Management Study and to prepare a Draft Plan. The study was funded by the Trust and was directed by a Floodplain Management Committee comprising representatives of Parramatta City Council's technical staff, the Trust, Sydney Water and community representatives drawn from the North Wentworthville Flood Action Group and the Winston Hills and Toongabbie Bushcare Group.

The Management Study and Draft Floodplain Management Plan were publicly exhibited in February/March 1999 concurrently with Council's initial exhibition of the Comprehensive Local Environmental Plan (CLEP).

After assessment of the Draft Management Plan several issues were raised by Council staff in relation to the proposed recommendations. On 27 March 2000 a report was submitted to Council recommending:

(c) *Council request the Upper Parramatta River Catchment Trust to initiate the provision of further supplementary information relating to a benefit/cost evaluation supported by a feasibility study, concept design and accurate cost estimate for Option 1.3 "Further Waterway Capacity for Toongabbie Creek at Briens Road". Also, that the Trust be advised of Council's commitment to making a financial contribution to the additional work.*

(e) *The planning implications of each of the recommended options included in the Executive Summary be fully examined and considered during Council's finalisation of the Comprehensive Local Environmental Plan consistent with Council's resolution of 2 November 1998.*

Further, when adopting the Draft Comprehensive LEP on the 4th September 2000, Council resolved to defer the finalisation of the zoning of the North Wentworthville study area pending the supplementary flooding information and Urban Neighbourhood Area (Village) Study to be undertaken. The Urban Neighbourhood Area (Village) Study would identity and detail the future character of the area and determine the preferred zoning under Council's Comprehensive LEP.

1.2 Study Objectives

In order to resolve the issues outlined above, Parramatta City Council commissioned Allen Jack + Cottier and Perrens Consultants to prepare a report that will provide Council with a tool to implement flood mitigation measures throughout the study area, determine the most appropriate zoning and guide future development. The objectives of the project are to:

1. Determine the appropriate flood mitigation measures for the study area and develop detailed investigations and costings;
2. Determine the preferred zoning for the study area to enable the finalisation of Council's Comprehensive LEP 2000;
3. Determine an appropriate urban design form;
4. Develop urban design principles and public domain framework, as well as design guidelines for the site.

1.3 Scope of this Report

This report addresses the following matters concerning floodplain management set out in the first two objectives above:

1. Preparation of a supplementary review of the Floodplain Management Study and Draft Plan including brief comments on the rationale, priority and justification of all structural and non-structural options, and where necessary identify additional options. (Chapter 2).

2. Determine flood levels and hazards resulting from implementation of the structural options agreed upon, develop concept designs and costings and assess the economic, social and environmental impacts. (Chapter 3).

3. Prepare a revised Floodplain Management Plan. (Chapter 4).

2 REVIEW OF 1998 DRAFT FLOODPLAIN MANAGEMENT PLAN

2.1 Historical Context

Two changes of significance have occurred since the preparation of the North Wentworthville Floodplain Management Study Report and Draft Plan:

- Publication of the Government's *"Floodplain Management Manual"* in March 2001 to supersede the *"Floodplain Development Manual"* published in 1986.

- Further revision of the computer flood modelling by the Trust which has led to some changes in the estimated flood levels within the study area.

2.2 Requirements of the Floodplain Management Manual

Although the new *"Floodplain Management Manual"* had not been published at the time of the preparation of the original Floodplain Management Study, much of the underlying philosophy and principles had evolved over a number of years and were understood by officers of the Department of Land and Water Conservation (DLWC) and specialist consultants such as Bewsher Consulting. Therefore, the publication of the new manual did not produce any real surprises, but confirmed the evolution in floodplain management practice that had been occurring over a number of years.

The new *"Floodplain Management Manual"* emphasises the following matters that are of relevance to this review. (*Comments relating to the North Wentworthville Floodplain Management Study are set in italics and brackets*).

1. The manual emphasises floodplain risk management and distinguishes two distinct elements of flood risk namely, the danger to personal safety and the potential for property damage. Both elements need to be considered and may require different management measures. In addition, the risk assessment also needs to take account of the flood hazard along any evacuation route. (In some situations, the critical location for flood access may be some distance from the area being considered). *(The approach taken in the Floodplain Management Study is consistent with this philosophy).*

2. The new manual replaces the terms "designated flood" or "standard flood" with the term "flood planning level" (FPL). The two important aspects of the adoption of FPLs are:

   - Different FPLs may be set to reflect different flood hazards at different locations on the floodplain or the different consequences of flooding to different types of development.
   - The FPL now incorporates any adopted freeboard.

   The Floodplain Management Study recommends FPLs that are consistent with the new manual and includes a freeboard of 500 mm above the nominated flood:

   - *Public facilities (eg toilets and changing rooms) associated with open space within the flood fringe area up to the 1 in 100 AEP flood: FPL = 1 in 20 AEP flood level + 500 mm.*
   - *Residential and commercial premises only permitted outside the high hazard floodway: FPL = 1 in 100 AEP flood level + 500 mm.*
   - *Critical utilities only located in the outer floodplain zone (ie outside 1 in 100 AEP flood line : FPL = probable maximum flood level).*

3. The manual requires an examination of the continuing flood risk occurring above the flood used to derive the FPL up to and including the probable maximum flood (PMF) so that the impacts of very rare floods are considered, particularly in planning for emergency management. *(The Floodplain Management Study makes reference to extreme flood levels being in the order of 2 m above the 1 in 100 AEP flood levels, but does not contain modelling data to confirm this estimate. It is understood that the Trust proposes to assess PMF levels later in 2002. The occurrence of an extreme flood event would pose significant problems in the study area because of the relatively short warning time. The Floodplain Management Plan recommends a number of actions to address this problem).*

4. The manual requires a strategic approach to the assessment and consideration of all three of the following types of risk that affect flood prone areas:

   - existing flood risk associated with existing development;
   - future flood risk associated with any new development; and
   - continuing risk that remains after floodplain management measures are implemented.

   (The analysis contained in the Floodplain Management Study and the recommended actions in the Floodplain Management Plan are consistent with this approach).

5. The manual highlights the need for flood modification measures proposed in management plans to address environmental, ecological, social and cultural issues and the principles of ecologically sustainable development (ESD). *(The Floodplain Management Study identifies a number of options in which environmental benefits can be achieved within the floodplain by:*

   - *Weed eradication and bush regeneration along the creek corridors;*
   - *Works to address scour in Finlaysons Creek and restore natural flows in the creek.*

   However, these recommendations are not supported by any justification for reducing flood impacts. While such actions are consistent with the State policy for the management of the riparian zone, there is no direct nexus with reducing flood risk).

6. The new manual extends the principles of floodplain management from the riverine environment into the major local drainage systems. This change removes the artificial distinction between riverine and local overland flooding which is not understood by the general public and results in similar consequences. *(This principle is applied in the Floodplain Management Study by the recommendation for further analysis of overland flow flooding in Strickland Place. There may also be other parts of the study area that warrant further attention in regard to overland flow from the stormwater drainage system.).*

2.3 Study Process

Three important requirements of any Floodplain Management Plan are that:

- It should be managed by a Floodplain Management Committee that contains local community representation.
- It should involve opportunities for the local community to express their views and comment on the proposed plan.
- The various elements of risk management (existing, future and continuing flood risks) should be dealt with using a "merits" based approach that reflects the level of risk that is acceptable to the local community.

During the course of the Floodplain Management Study the local community was consulted by way of surveys and newsletters. Two public meetings were held to provide information and present the results of the study. In addition, the draft Floodplain Management Plan was placed on public exhibition for six weeks. The study process was therefore consistent with the requirements of the new "*Floodplain Management Manual*" in relation to the process to be used for the preparation of a Floodplain Management Plan. In retrospect, however, the process of implementation of the Plan might have been expedited if there had been greater representation of Council planners on the Floodplain Management Committee.

The merits of various proposed options and the recommended FPL's for future development contained in the original Draft Floodplain Management Plan presumably reflect the views of the community and Council at that time. A difficulty with the implementation of the Plan has, however, occurred because the plan recommends the following:

- Planning controls that are not consistent with policies relating to floodplain management that have been implemented in other areas of the LGA. Whatever the "merits" at the local level, Councillors are very concerned at the prospect of setting different standards for floodplain management in North Wentworthville compared to other areas of the LGA. This particularly applies to the proposal to encourage flood compatible development on flood affected land by allowing multi-unit housing.

- The proposed area to be zoned for flood compatible multi-unit housing development lies at the northern end of North Wentworthville. Whilst this area, along with much of North Wentworthville, is within walking distance of Westmead Hospital, there is no planning nexus between this location and other important criteria such as proximity to a transport node.

Despite these two outstanding issues, the North Wentworthville Floodplain Management Study was undertaken substantially in accordance with the requirements of the State Government's new *"Floodplain Management Manual"* (2001). As noted above, many of the initiatives introduced in the new manual are referred to in the Floodplain Management Study.

2.3.1 Hydraulic Analysis

The Floodplain Management Study relied on the results of the hydraulic modelling and associated assessment of the flood extent and hazard areas undertaken by the Trust. Since 1998, the Trust has undertaken further detailed analyses and refined its hydraulic model. The result of that refinement has been that estimates of flood levels for a particular AEP have been revised downwards. Figure 1 shows the revised extent of flooding and the high hazard zone while Figure 2 shows the properties subject to inundation with floods of various AEP. Table 1 summarises the major areas of difference between the 1998 and 2001 estimates.

Table 1
Differences Between Flood Levels (m AHD) Estimated in 1998 and 2001

Location	1 in 20 AEP		1 in 100 AEP	
	1998	2001	1998	2001
Coopers Creek at Fulton Ave	17.32	17.23	17.34	17.46
Coopers Creek behind 16 Manuka St	15.74	15.63	16.29	16.20
Coopers Creek in front of 13 Chetwyn Place	15.74	15.63	16.28	16.20
Coopers Ck/Toongabbie Ck at end of Hopkins St	15.73	15.63	16.25	16.20
Rear of 14 Mayfield St	15.64	15.52	16.12	16.04
Intersection of Mayfield St and Briens Rd	14.63	14.72	15.56	15.31
Toongabbie Creek at Briens Rd	15.52	15.41	16.07	16.00

2.3.2 Flood Damaged Properties

Although the differences in flood level estimates above are generally in the order of only 0.1 m, these differences are sufficient to alter the numbers of properties that are flood damaged (inundated above floor level) as set out in Table 2.

Table 2
Differences Between Estimated Numbers of Properties Subject to Flood Damage

Flood AEP	1998	2001
1 in 5	4	0
1 in 20	10	8
1 in 100	41	33
1 in 500	71	62

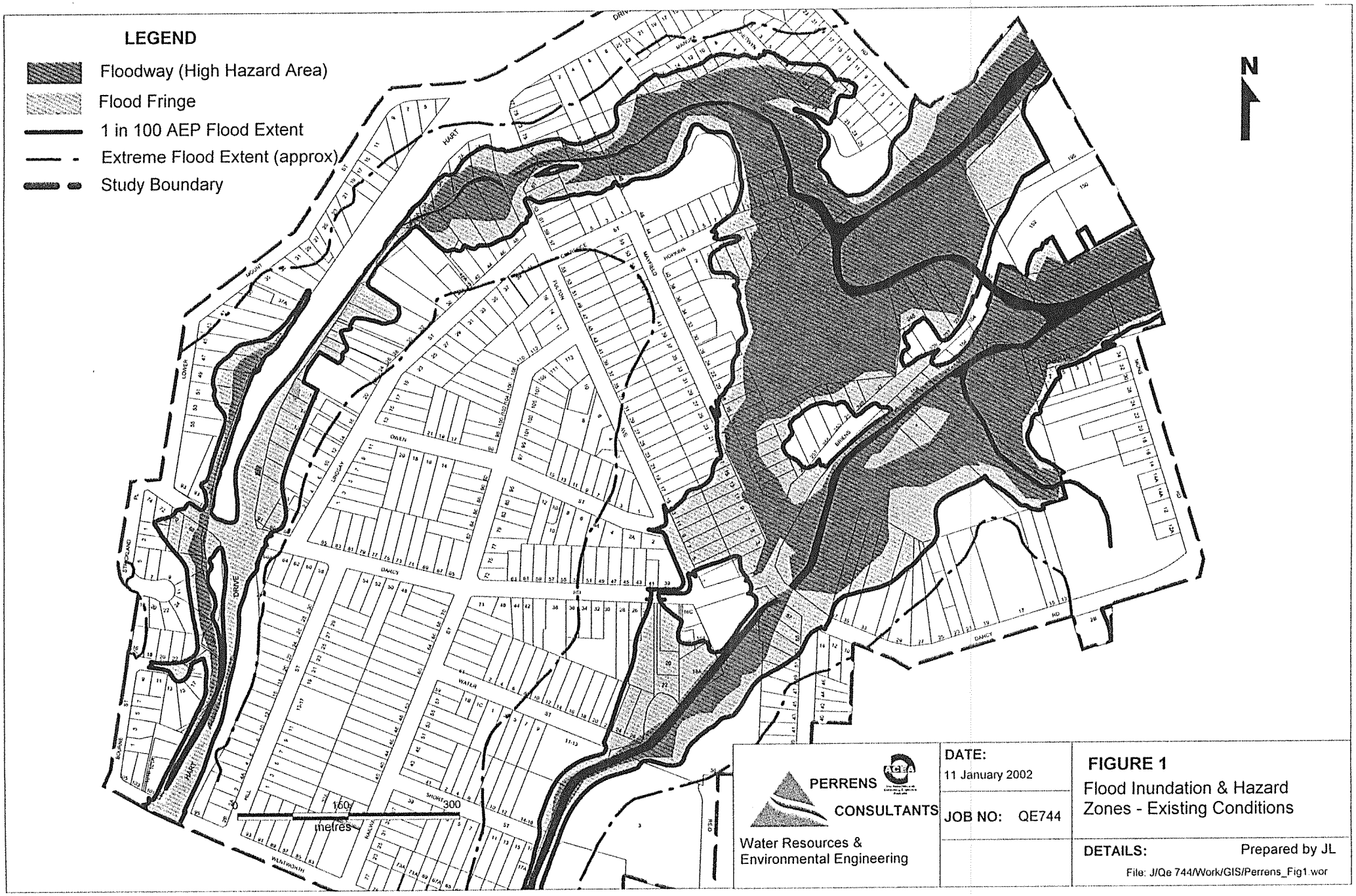
The differences in flood level estimates do not have a significant influence on the total number of properties that are likely to have flood water on the land. Table 3 summarises the approximate numbers of properties that have significant land area of the block (>10%) affected by flood water as shown of Figure 3.

Table 3
Differences Between Estimated Numbers of Properties Affected by Yard Flooding

Flood AEP	1998	2001
1 in 5	87	80
1 in 20	118	105
1 in 100	174	165
1 in 500	226	210

2.3.3 Flood Damages

Estimates of flood damages contained in the Floodplain Management Study were based on a single value for damage regardless of flood depth. For this review, the damages have been re-assessed using flood damage functions related to flood depth similar to those used in flood damage assessment models such as ANUFLOOD. This method of flood damage estimation


LEGEND
Floodway (High Hazard Area)
Flood Fringe
1 in 100 AEP Flood Extent
Extreme Flood Extent (approx)
Study Boundary
N
0
150
300
metres
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DATE:
11 January 2002
JOB NO: QE744
FIGURE 1
Flood Inundation & Hazard
Zones - Existing Conditions
DETAILS:
Prepared by JL
File: J/Qe 744/Work/GIS/Perrens_Fig1.wor

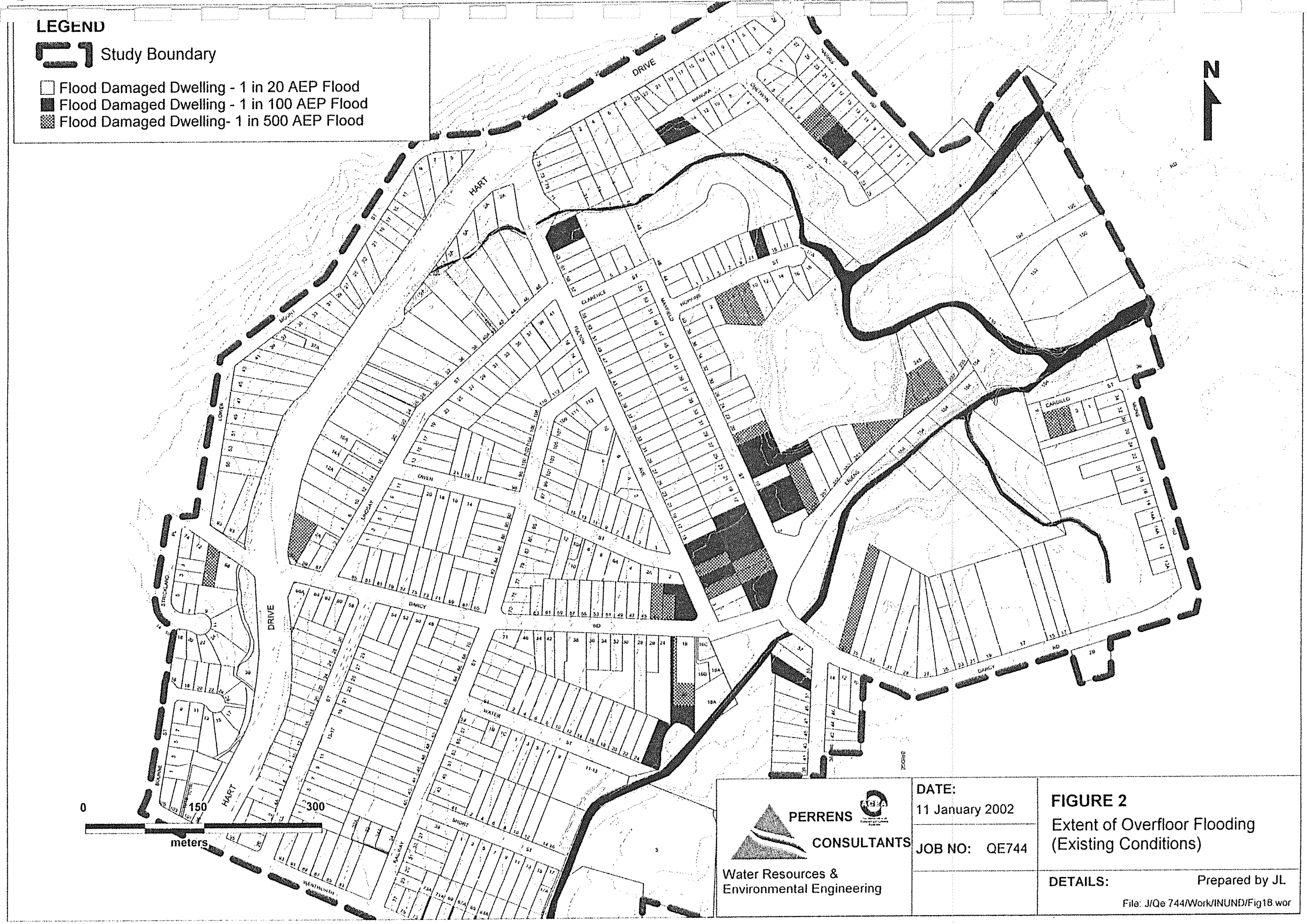

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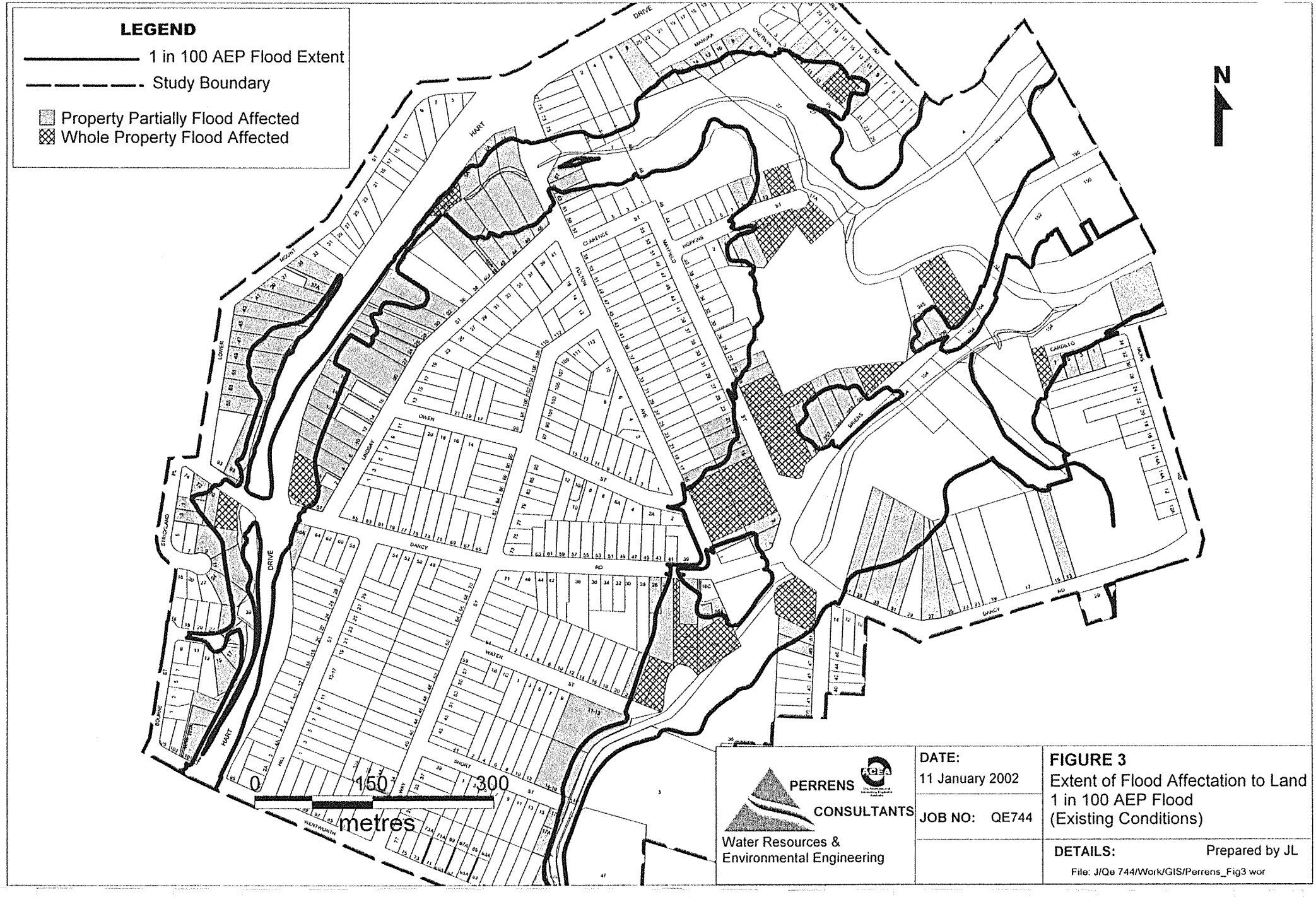
FIGURE 2

Extent of Overfloor Flooding (Existing Conditions)

DETAILS: Prepared by JL

File: J/Qe 744/Work/INUND/Fig18.wor


LEGEND
1 in 100 AEP Flood Extent
Study Boundary
Property Partially Flood Affected
Whole Property Flood Affected
N
0
150
300
metres
PERRENS CONSULTANTS
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DATE:
11 January 2002
JOB NO: QE744
FIGURE 3
Extent of Flood Affectation to Land
1 in 100 AEP Flood
(Existing Conditions)
DETAILS: Prepared by JL
File: J/Qe 744/Work/GIS/Perrens_Fig3 wor

assesses damage as a function of the damage that would occur with flood water 1.8 m deep. A further feature of this method is that damage is considered to commence once flood level reaches 4 cm below the level of the floor. At that level, water is likely to affect flood boards and electrical wiring.

The damage data used in this analysis is based on assessment of historic flood damages from flooding in Camden, Georges River, Nyngan and Forbes updated to account for CPI since the date of the flood. Despite recent floods in Wollongong and Coffs Harbour, consistent flood damage data are not available from these towns. Based on current advice from the Department of Land and Water Conservation, total damage in an average house at 1.8 m depth of flooding has been taken to be $60,000.

The revised flood damage estimates in Table 4 account for changes to both the numbers of properties inundated as well as the different method of flood damage assessment adopted for this report. It can be seen that the estimated damages from floods have been significantly reduced as a result of the reduced number of affected properties and the assessment of damage related to depth of flooding. The overall effect is to reduce the average annual damages from about $100,000 to about $20,000. Most of this reduction is attributable to the significant reduction in damages for the small events (1 in 5 and 1 in 20 AEP) for which flood depths are of the order of a few hundred millimetres in most flood affected properties. This reduction in the estimated average annual damages will clearly influence the benefit cost analysis of any proposed projects. For a benefit:cost ratio of 1.0, this level of average annual damage would warrant the expenditure of only about $250,000 in order to eliminate all flood damages up to the 1 in 500 AEP flood. Clearly, any expenditure on reduction in flood damage is unlikely to be warranted on purely economic criteria.

However, decisions about investment in floodplain management works and actions are not based on strict economic criteria alone. Important social and environmental factors need to be considered also. In particular, the social benefits of reduced frequency of flooding in an area may warrant investment of public money in flood mitigation works.

Table 4
Differences Between Estimated Flood Damages

Flood AEP	1998	2001
1 in 5	$100,000	$0
1 in 20	$250,000	$6,000
1 in 100	$1,200,000	$480,000
1 in 500	$2,700,000	$1,760,000
Average Annual Damage	$110,000	$19,000

2.4 Floodplain Management Options

As noted above, the assessment of options for inclusion in a Floodplain Management Plan must consider a range of social and environmental issues as well as economic factors. These social and environmental issues, which must be assessed in qualitative terms, include:

- Reduced frequency of flooding of residential land
- Reduced frequency and extent of areas of high hazard
- Reduced impacts in an extreme flood.
- Improvements in environmental and visual amenity.

Having considered the flood extent and hazards together with the numbers of properties flood affected and damaged, the Floodplain Management Study identified 22 structural and non-structural options to reduce the impact of flooding on the North Wentworthville area. The options were grouped as follows:

- Options which modify flood behaviour (including physical works in public and private land);
- Property modification options (including voluntary purchase and development control options);
- Options that modify people's response to flooding (including education and flood awareness programs).

Of the 22 options identified, a total of 14 were recommended for implementation. One of the key recommendations was the implementation of a set of graded planning controls for three flood zones and, by implication, the adoption of the following Flood Planning Levels:

• Critical utilities	Extreme flood
• Residential and commercial buildings	1 in 100 AEP flood level + 500 mm
• Open space facilities	1 in 20 AEP flood level + 500 mm

The recommended planning controls are set out in Figure 4.

Tables 5, 6 and 7 summarise and update the options identified in the Floodplain Management Study and provide comments on the validity of each option in the light of this review.

The tables also include separate column that show the original recommended actions and those now recommended as a result of this review. Table 5 also includes a reassessment of the number of properties that are likely to be saved from inundation at the 1 in 100 AEP flood level. This re-assessment includes the analysis relating to the proposed construction of a flood relief culvert under Briens Road (detailed as Options 1.3a and 1.3b in Table 5) as set out in further detail in Chapter 3 below. Table 5 also includes an additional option (1.12) identified as a result of this review.

Table 6 includes a reassessment of the numbers of properties likely to be affected by the various options. It also includes an assessment of two options under the general heading of "Building and Development Controls" that relate to:

- Setting of appropriate FPLs for different types of development;
- Controlling building location and land levels in areas where overland flow between buildings is required to minimise the impacts of flooding.

Development Control Consideration	GROUND LEVEL OF LAND																				
	OUTER FLOODPLAIN Above 100 yr ARI Flood To EXF							FLOOD FRINGE Between the High Hazard Area to the 100yr ARI Flood							FLOODWAY High Hazard Area						
	ESSENTIAL COMM FACILITIES	CRITICAL UTILITIES	SUBDIVISION & FILLING	RESIDENTIAL	COMMERCIAL OR IND	OPEN SPACE	MINOR DEVELOPMENT	ESSENTIAL COMM FACILITIES	CRITICAL UTILITIES	SUBDIVISION & FILLING	RESIDENTIAL	COMMERCIAL OR IND	OPEN SPACE	MINOR DEVELOPMENT	ESSENTIAL COMM FACILITIES	CRITICAL UTILITIES	SUBDIVISION & FILLING	RESIDENTIAL	COMMERCIAL OR IND	OPEN SPACE	MINOR DEVELOPMENT
FLOOR LEVEL		3		2	2		4				2	2	1	4						1	4
BUILDING COMPONENTS		2		1	1						1	1	1	1						1	1
STRUCTURAL SOUNDNESS		3								2	2,3	2	2	2						1	1
FLOOD AFFECTATION		2	2	2	2					1,3	2,3	2,3	2,3	2,3						1,3	1,3
EVACUATION / ACCESS		2	3	3	3					1,3	3	3	3							1,3	3
FLOOD AWARNESS		3	1,3	3	3	3	3			1,2,3	2,3	2,3	2,3	2,3						2,3	2,3
MANAGEMENT DECISION		1	4							4	1,2,3	1,2,3	1,2,3	1,3						1,2,3	1,2,3

NOTES

Not Relevant
Unsuitable Landuse

EXF refers to an approximation of the maximum flood

FLOOR LEVEL

1 All floor levels to be equal to or greater than the 20 year flood plus 0.5 m (freeboard).
2 Habitable floor levels to be equal to or greater than the 100 yr ARI flood plus 0.5 m (freeboard), and other floor levels to be equal to or greater than the 100 yr ARI flood (no freeboard).
3 All floor levels to be equal to or greater than the EXF plus 0.5 m freeboard.
4 Floor levels to be as close to the design floor level as practical & no lower than the existing floor level when an addition to an existing building.

FLOOD COMPATIBLE BUILDING COMPONENTS

1 All structures to have flood compatible building components below or at the 100 yr ARI flood level plus 0.5 m freeboard.
2 All structures to be constructed of flood compatible materials below or at the EXF level.

STRUCTURAL SOUNDNESS

1 Engineers report to prove that any structure subject to the 100 yr ARI flood inclusive, can withstand the forces or debris, floodwater and buyancy.
2 Applicant demonstrates that any structure subject to the 100 yr ARI flood inclusive, should withstand the forces of floodwater, debris and buoyancy.
3 Applicant demonstrates that any structure subject to a flood up to & including the EXF level, should withstand the forces of floodwater, debris and buoyancy.

FLOOD EFFECT ON OTHERS

1 Engineers report required to prove that the development of an existing allotment will not increase flood affectation elsewhere.
2 The impact of the development on flooding elsewhere to be considered
3 No net reduction in flood storage below the 100 yr ARI flood level.

EVACUATION ACCESS

1 Reliable access for pedestrians required during a 100 yr ARI flood.
2 Reliable access for pedestrians & vehicles required at or above the extreme flood level.
3 Consideration required when regarding an appropriate flood evacuation strategy & pedestrian / vehicular access route for both before and during a flood.

FLOOD AWARNESS

1 Restrictions to be placed on title advising of minimum floor levels required relative to the flood level.
2 S149(2) certificates to notify affectation by the 100 yr ARI flood.
3 S149(2) certificates to notify affectation by the EXF flood.

MANAGEMENT & DESCISION

1 Flood plan required when the floor level is below the design floor level.
2 Applicant to demonstrate that there is an area where goods may be stored above the 100 yr ARI flood level, plus (0.5m freeboard) during floods.
3 No external storage of materials below the 100 yr ARI flood level plus 0.5 m freeboard, which may be potentially hazardous during floods.
4 Applicant to demonstrate that potential development as a consequence of sub-division approval can be undertaken in accordance With this policy

Figure 4

Planning Matrix Controls Proposed by Bewsher Consulting

(Note: Revised controls for inclusion in Floodplain Management Plan are set out in Annexure 1)

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Table 5 Summary and Qualitative Assessment of Floodplain Management Options that Modify Flood Behaviour

Option No.	DESCRIPTION	AIM OR CRITERIA	COMMENTS FROM REVIEW	Capital Cost / Financial Feasibility	Community Acceptance	Environmental Impacts	Impacts on Flood Behaviour	Consequences of Extreme Flood	Reduction in flooded properties in 1% Flood	Technical Feasibility	Administrative / Political / Legal Aspects	Recommended in original Floodplain Managmt Study	Recommended as a result of this Review
1.1	Enlarge Coopers Creek culverts at Wentworth Ave., Darcy Rd., Hart Dr. and Fulton Ave.	To reduce flood levels on private property and reduce frequency and depth of roadway inundation.	Revised analysis shows only one residence and the Scout Hall affected at 1 in 20 AEP Flood.	>$1M --	+	O	+	O	1	-	O	No	No
1.2	Enlarge Finlaysons Creek culverts at Wentworth Ave. and Darcy Rd.	To reduce flood levels on private property and reduce frequency and depth of roadway inundation.	Possible benefit to only two houses at the intersection of Lydbrook St and Darcy Rd.	$200K --	+	O	+	O	2	-	O	No	No
1.3a)	Provision of further waterway capacity for Toongabbie Creek at Briens Rd. Option a) – 4 cell culvert.	To reduce flood levels on private property.	Will also reduce roadway inundation and high hazard area. Will eliminate 1 in 20 AEP flooding in 2 houses.	$650K --	+ +	-	+	O	18	-	O	Yes	Yes
1.3b)	Provision of further waterway capacity for Toongabbie Creek at Briens Rd. Option b) – 8 cell culvert.	To reduce flood levels on private property.	Will also reduce roadway inundation and high hazard area. Will eliminate 1 in 20 AEP flooding in 2 houses.	$1.2M --	+ +	-	+	O	18	-	O	na	No
1.4	Widen and/or deepen creeks.	To eliminate 1 in 100 AEP inundation of property throughout the study area	Significant environmental damage would result from sufficient excavation to significantly affect flood levels.	$15M --	+ +	--	--	O	41	--	--	No	No
1.5	Construction of levee at Chetwyn Pl. and Manuka St.	To eliminate 1in 100 AEP inundation above floor level of houses in Chetwyn Pl and Manuka St.	Three of the four houses could be saved from 1 in 100 AEP inundation by Option 1.3a). The other would be saved from inundation by Option 1.3b).	$200K --	+	O	O	O	5	-	O	No	No
1.6	Construct upstream flood retarding basins on Toongabbie creek, Coopers Creek and Finlaysons Creek.	To store creek flows temporarily during floods thus reducing peak levels downstream.	No sites of sufficient capacity available within the catchment.	No sites	+ +	-	+ +	O	41	-	O	No	No
1.7	On-site detention and rainwater tanks.	To store property stormwater temporarily during floods thus reducing peak levels downstream.	Would mainly affect local overland flow flooding. Minimal impact on mainstream flooding.	$0 to Council	+	O	O	O	O	O	O	Yes	Yes

Table 5 Summary and Qualitative Assessment of Floodplain Management Options that Modify Flood Behaviour

Option No.	DESCRIPTION	AIM OR CRITERIA	COMMENTS FROM REVIEW	Capital Cost / Financial Feasibility	Community Acceptance	Environmental Impacts	Impacts on Flood Behaviour	Consequences of Extreme Flood	Reduction in flooded properties in 1% Flood	Technical Feasibility	Administrative / Political / Legal Aspects	Recommended in original Floodplain Managmt Study	Recommended as a result of this Review
1.8	Develop a plan that would achieve preservation/enhancement of creek corridors involving weed eradication, bushland regeneration, landscaping works, etc.	To make creek corridors a public asset.	Unlikely to have significant effect on flood levels. No direct nexus between proposed works and flooding.	$30K --	++	++	0	0	0	0	0	Yes	Yes
1.9	Undertake study of local catchment flooding in the vicinity of Strickland Pl.	Assess the extent of the problem and measures that may be undertaken to reduce the problem.	Assessment of Local overland flow problems warranted throughout study area.	$20K --	+	0	0	0	0	0	0	Yes	Yes
1.10	Works to address scour in Finlaysons Creek (and restore low flows to natural creek).	To address serious scour and also risk of major bank collapse (and restore natural flow regime, etc).	This issue is now being addressed by Sydney Water and the Trust.	$200K --	++	++	0	0	0	0	0	Yes	Yes
1.11	Undertake hydraulic modelling of the lower Coopers Creek floodplain prior to the construction of Hart Drive.	To address public concern about the potential impact of the roadway on the local flood regime.	This issue not raised in any community consultation.	$30K --	+	0	0	0	0	0	0	Yes	No
1.12	Improve the hydraulic capacity of Coopers Creek in the vicinity of the sewer crossing downstream of Fulton Ave. Option of further widening of the creek warrants further assessment.	To reduce flood levels on two of the most severely affected properties (65 and 67 Fulton Ave).	Sewer acts as hydraulic control. Improvement of hydraulic capacity would allow lowered downstream flood levels (as a result of Option 1-3) to benefit these properties.	$50K --	++	0	0	0	2	-	0	na	Yes

Key: ++ Strongly supported, significant benefits
+ Supported, some benefits
0 Neutral
- Not supported, some negative impacts
-- Strongly against, significant negative impacts

Table 6 Summary and Qualitative Assessment of Floodplain Management Options that Modify Flood Affectation of Existing and Future Properties

Option No.	DESCRIPTION	AIM OR CRITERIA	COMMENTS FROM REVIEW	Capital Cost / Financial Feasibility	Community Acceptance	Environmental Impacts	Impacts on Flood Behaviour	Consequences of Extreme Flood	Reduction in flooded properties in 1% Flood	Technical Feasibility	Administrative / Political / Legal Aspects	Recommended in original Floodplain Management	Recommended as a result of this Review
2.1	Further voluntary purchase of severely flood affected properties.	Purchase and demolish up to 5 residential properties that are potentially frequently flooded above floor level.	Original proposal suggested 3 properties that were assessed as affected by the 1 in 5 AEP flood. New assessment indicates that no properties are affected by this flood. Two of the most severely affected properties could be assisted by Options 1.3 and 1.12.	$1.1M -	+	O	O	+ +	3	na	-	Yes	Yes
2.2	Further house raising of severely flood affected properties.	Modify existing houses affected at 1 in 20 AEP so that floor levels are raised above the 1 in 100 AEP flood level.	Of 8 properties affected at 1 in 20 AEP flood level, only 1 is suitable for raising. To give 500 mm freeboard, raising of 600 mm would be required.	$0.25M +	+	-	O	+ +	1	na	-	No	Yes
2.3	Flood proofing of individual properties.	Reducing the impacts of flooding on individual properties by waterproofing walls, putting shutters across doors and using materials that are relatively unaffected by submersion etc.	Limited scope for application. May warrant consideration for 67 Fulton Ave, Scout Hall and Pre-school at 26 Water Street.	$30K?	-	O	O	+	?	na	O	No	Yes
2.4a)	Building and development controls.	Controlling future impacts, for example by setting minimum floor levels for future development and extensions to existing dwellings.	As recommended in the draft Plan, consistent floor level controls should be imposed on all buildings on flood liable land.	$0	+	O	+	+ +	na	+ +	+ +	Yes	Yes
2.4b)	Building and development controls.	Controlling future development in areas subject to overland flow, for example by setting maximum site coverage, limiting land filling and controlling fences/walls in order to allow overland flow between buildings.	Particularly applicable to Nos 8, 10, 12 Mayfield St. Option for possible land swap with No 22 Mayfield St which is currently a vacant block (zoned 6a). Provision may also apply to other locations of overland flow problems such as Strickland Pl.	$0	+	O	+	+ +	na	+ +	+ +	Yes	Yes

Table 6 Summary and Qualitative Assessment of Floodplain Management Options that Modify Flood Affectation of Existing and Future Properties

Option No.	DESCRIPTION	AIM OR CRITERIA	COMMENTS FROM REVIEW	Capital Cost / Financial Feasibility	Community Acceptance	Environmental Impacts	Impacts on Flood Behaviour	Consequences of Extreme Flood	Reduction in flooded properties in 1% Flood	Technical Feasibility	Administrative / Political / Legal Aspects	Recommended in original Floodplain Management	Recommended as a result of this Review
2.4c)	Building and development controls.	Controlling future impacts by ensuring appropriate zoning.	Particularly applicable to Nos 53 – 57 Lydbrook Street which are currently zoned 2(c).	$0	-	O	+	+ +	++	+ +	+ +	Yes	Yes
2.5	Multi-unit housing development of flood affected areas.	Encourage flood compatible development to reduce future flood damages.	Not favoured by Councillors. Lacks nexus with other attributes necessary for greater density. Also, Floodplain Management Plan will need to ensure that any future re-development is consistent with the flood hazard zones.	$0 -	O	O	+	+	na	+ +	-	Yes	No
2.6	Demolition and reconstruction of severely flood affected houses.	Encourage flood compatible development to reduce future flood damages.	Options 2.1 and 2.2 more likely to be viable for this area.	$0.4M - -	+	O	+	+	2	+	-	No	No

Key: ++ Strongly supported, significant benefits
+ Supported, some benefits
O Neutral
- Not supported, some negative impacts
- - Strongly against, significant negative impacts

Table 7 Summary and Qualitative Assessment of Floodplain Management Options that Modify the Way People Respond to Floods

Option No.	DESCRIPTION	AIM OR CRITERAI	COMMENTS FROM REVIEW	Capital Cost / Financial Feasibility	Community Acceptance	Environmental Impacts	Impacts on Flood Behaviour	Consequences of Extreme Flood	Reduction in flooded properties in 1% Flood	Technical Feasibility	Administrative / Political / Legal Aspects	Recommended fin original Floodplain Management	Recommended as a result of this Review
3.1	Issue flood certificates for all properties.	To raise flood awareness of individual property owners.	Property owners will need frequent reminders of the possibility of flooding and the appropriate actions (see Option 3.5).	$0	++	O	O	+	na	+	O	Yes	Yes
3.2	Improved emergency planning and management.	SES to upgrade current emergency assistance plans.	Link to Option 3.5.	$15K	++	O	O	O	na	+	+	Yes	Yes
3.3	Increased community education and flood awareness.	To make public more aware of flood issues.	Link to Option 3.5.	$0.1M	++	O	O	+	na	+	+	Yes	Yes
3.4	Improved flood warning systems.	To provide an indication to SES, Council or the Police of conditions likely to cause flooding.	Bureau of Meteorology working on improved flash flood warning system. Key problem is likely to be dissemination of the warning to the people who need to know most (eg a home owner working in an office in the city).		++	O	O	+	na	+	+	Yes	Yes
3.5	Preparation of flood action plans for individual properties	To tell residents WHAT they should do, WHERE they should go and WHO they should contact in the event of a flood.	Individual plans should be prepared for all remaining houses flooded in 1 in 20 AEP flood. General plan should be prepared for properties still affected by 1 in 100 AEP flood. Flood action plan also required for all houses affected by the PMF.	$10K	++	O	O	++	na	O	O	Yes	Yes

Key:
- ++ Strongly supported, significant benefits
- + Supported, some benefits
- O Neutral
- - Not supported, some negative impacts
- -- Strongly against, significant negative impacts

3 STRUCTURAL OPTIONS

3.1 Hydraulic Analysis

For this study the hydraulic model developed by the Trust was obtained and run for three scenarios:

- Existing conditions (results from this analysis are set out in Section 2.3 above);
- Construction of a 4 cell flood relief culvert under Briens Road;
- Construction of an 8 cell flood relief culvert under Briens Road;

The proposed culvert would comprise the stated number of cells each 3.6 x 3.6 m located approximately 150 m south west of the Briens Road bridge over Toongabbie Creek at the locations shown on Figures 5 and 6 (see Section 3.2 for concept design details). The elevation of Briens Road would remain unaltered.

3.1.1 Flood Levels

Figures 5 and 6 show the properties subject to over floor flooding with the two flood relief culvert options which may be compared with the "base case" conditions shown in Figure 2. Table 8 lists estimated flood levels for current conditions and for the two culvert options at the same locations identified in Table 1 as well as selected locations downstream of the culvert in Finlaysons Creek and Toongabbie Creek. The main effect of the two options for a culvert under Briens Road would be to lower flood levels in the "billabong" behind the houses on the eastern side of Mayfield Street. This lowering of flood levels has an effect that can be seen upstream as far as the sewer crossing on Coopers Creek. Lower flood levels are also noticeable in the flow path which conveys flow from the "billabong" to the intersection of Briens Road and Mayfield Road. This reduces the area subject to flood hazard. The lowering effect is negligible at the intersection of Mayfield Street and Briens Road. Table 9 shows the differences in flood levels compared to current conditions that would be achieved with the two culvert options.

Table 8
Effect of 4 and 8 Cell Culverts on Flood Levels (m AHD)

Location	1 in 20 AEP			1 in 100 AEP		
	Current	4 Cell	8 Cell	Current	4 Cell	8 Cell
Coopers Creek d/s Fulton Ave	16.96	16.80	16.89	17.42	17.42	17.42
Coopers Creek behind 16 Manuka St	15.63	15.05	14.87	16.20	15.86	15.67
Coopers Creek in front of 13 Chetwyn Place	15.63	15.04	14.86	16.20	15.85	15.67
Coopers Ck/Toongabbie Ck at end of Hopkins St	15.63	15.04	14.86	16.20	15.86	15.67
Rear of 14 Mayfield St	15.52	14.86	14.63	16.04	15.69	15.48
Intersection of Mayfield St and Briens Rd	14.72	14.66	14.65	15.31	15.21	15.23
Toongabbie Creek at Briens Rd	15.41	14.76	14.59	16.00	15.64	15.44
Finlaysons Creek 50 m d/s of proposed culvert	14.40	14.46	14.52	15.18	15.18	15.20
Toongabbie Creek at junction with Finlaysons Ck	14.40	14.42	14.43	15.18	15.17	15.18
Toongabbie Creek 150 m d/s of bridge	14.25	14.27	14.28	15.04	15.03	15.04

Table 9
Effect of 4 and 8 Cell Culverts on Flood Levels (m) Compared to Existing Conditions

	1 in 20 AEP		1 in 100 AEP	
	4 Cell	8 Cell	4 Cell	8 Cell
Coopers Creek d/s Fulton Ave	-0.16	-0.07	-0.00	-0.00
Coopers Creek behind 16 Manuka St	-0.58	-0.76	-0.34	-0.53
Coopers Creek in front of 13 Chetwyn Place	-0.59	-0.77	-0.35	-0.53
Coopers Ck/Toongabbie Ck at end of Hopkins St	-0.59	-0.77	-0.34	-0.53
Rear of 14 Mayfield St	-0.66	-0.89	-0.35	-0.56
Intersection of Mayfield St and Briens Rd	-0.06	-0.07	-0.10	-0.08
Toongabbie Creek at Briens Rd	-0.65	-0.82	-0.36	-0.56
Finlaysons Creek 50 m d/s of proposed culvert	+0.06	+0.12	+0.00	+0.02
Toongabbie Creek at junction with Finlaysons Ck	+0.02	+0.03	-0.01	+0.00
Toongabbie Creek 150 m d/s of bridge	+0.02	+0.03	-0.01	+0.00

From the data in Tables 8 and 9 it can be seen that the main effects of the culvert options are:

- The four cell culvert would reduce flood levels by up to 660 mm in a 1 in 20 AEP flood in a large area around the billabong.
- For a 1 in 100 AEP flood the reduction in flood level with the four cell culvert would be a maximum of 350 mm.
- The effect of the reduced flood level extends up Coopers Creek as far as the sewer crossing located just downstream of Fulton Avenue.
- There is a significant rise in the maximum flood level immediately upstream of the sewer crossing in Coopers Creek even with the four cell culvert in place under Briens Road. This increase amounts to 0.7 m in a 1 in 20 AEP flood and 1.3 m in a 1 in 100 AEP flood. If this increase in flood level could be reduced by improving the hydraulic efficiency of the channel, Numbers 65 and 67 Fulton Ave would no longer be affected by flooding in a 1 in 100 AEP flood. A reduction in flood level upstream of the sewer of approximately 0.3 m in a 1 in 100 AEP flood would be required.
- The eight cell culvert would produce reductions in flood level of up to 900 mm in a 1 in 20 AEP flood and 600 mm in a 1 in 100 flood in a large area around the billabong.
- The maximum increase in flood level in Finlaysons Creek immediately downstream of the proposed culvert would be 120 mm in the event of a 1 in 20 AEP flood with the eight cell culvert option. The four cell option would give only 60 mm increase.
- In the case of a 1 in 100 AEP flood, the downstream flood level increase would be restricted to a maximum of 20 mm for the eight cell culvert.
- In all cases the hydraulic model shows that the culverts would have no effect on flood levels in Toongabbie Creek at a point 150 m downstream of the bridge.

It is clear that the construction of a culvert would have a significant effect in reducing flood levels upstream of Briens Road while having minimal effects downstream. Any flood level increases in Finlaysons Creek would be confined to a section between the culvert outlet and Toongabbie Creek where there is no development.

3.1.2 Flood Hazards

The main effect of culvert construction on areas of flood hazard accessible to the community would be to reduce the affected area at the southern end of Mayfield Street, the eastern end of Hopkins Street and the middle section of Chetwyn Place.

3.1.3 Affected Properties

The construction of either of the culvert options would have significant effects on the number of flood damaged properties in the North Wentworthville area. Figures 5 and 6 show the properties that would be flood damaged for different magnitude floods while Tables 10 and 11 summarise the estimated numbers of properties involved for the "existing conditions" (shown in Figure 2) and the two culvert options. Table 12 lists all properties that are flood affected at the 1 in 100 AEP flood under current conditions. For each property the table lists whether or not it is flooded in the 1 in 20 AEP and 1 in 100 AEP floods under existing conditions and with the 4 and 8 cell culvert options.

Table 10
Estimated Numbers of Properties Subject to Flood Damage

Flood AEP	Existing Conditions	4 Cell Culvert	8 Cell Culvert
1 in 5	0	0	0
1 in 20	8	6	6
1 in 100	33	18	18
1 in 500	62	54	52

Table 11
Estimated Numbers of Properties Affected by Yard Flooding

Flood AEP	Existing Conditions	4 Cell Culvert	8 Cell Culvert
1 in 5	25	20	20
1 in 20	120	100	100
1 in 100	165	140	135
1 in 500	210	200	190

Table 12
Properties subject to Flood Damage
(Y = Flood Damaged, N = Not Damaged)

Street	No.	1 in 20 AEP			1 in 100 AEP		
		Now	4 cell	8 cell	Now	4 cell	8 cell
Briens Road	237	Y	N	N	Y	Y	Y
Chetwyn Place	15	N	N	N	Y	N	N
Chetwyn Place	17	N	N	N	Y	N	N
Darcy Road	22	N	N	N	Y	Y	Y
Darcy Road	4/39	N	N	N	Y	N	N
Darcy Road	5/39	N	N	N	Y	N	N
Darcy Road	Scout Hall	Y	Y	Y	Y	Y	Y
Fulton Avenue	7	N	N	N	Y	N	N
Fulton Avenue	11	N	N	N	Y	N	N
Fulton Avenue	13	N	N	N	Y	N	N
Fulton Avenue	65	Y	Y	Y	Y	Y	Y
Fulton Avenue	67	Y	Y	Y	Y	Y	Y
Hopkins Street	13	N	N	N	Y	N	N
Lindsay Street	42a[1]	Y	Y	Y	Y	Y	Y
Lydbrook Street	53	N	N	N	Y	Y	Y
Lydbrook Street	55	Y	Y	Y	Y	Y	Y
Lydbrook Street	57	Y	Y	Y	Y	Y	Y
Manuka Street	16	N	N	N	Y	N	N
Manuka Street	18	N	N	N	Y	Y	Y
Mayfield Street	1	N	N	N	Y	N	N
Mayfield Street	3	N	N	N	Y	Y	Y
Mayfield Street	4	N	N	N	Y	Y	Y
Mayfield Street	6	N	N	N	Y	Y	Y
Mayfield Street	8	N	N	N	Y	Y	Y
Mayfield Street	9	N	N	N	Y	Y	Y
Mayfield Street	10	Y	N	N	Y	Y	Y
Mayfield Street	11	N	N	N	Y	Y	Y
Mayfield Street	12	N	N	N	Y	N	N
Mayfield Street	13	N	N	N	Y	N	N
Mayfield Street	14	N	N	N	Y	N	N
Mayfield Street	15	N	N	N	Y	N	N
Mayfield Street	16	N	N	N	Y	N	N
Water Street	26	N	N	N	Y	Y	Y

[1] Flooding affects uninhabited ground flood only.

3.1.4 Flood Damages

Table 13 summarises the changes in estimated flood damages that would occur as a result of construction of either of the culvert options.

Table 13
Estimated Flood Damages ($x1,000)

Flood AEP	Existing Conditions	4 Cell Culvert	8 Cell Culvert
1 in 5	$0	$0	$0
1 in 20	$6	$4	$4
1 in 100	$480	$281	$247
1 in 500	$1,760	$1,458	$1,343
Average Annual Damages	$19.1	$13.0	$11.7

The data in Table 13 shows that the construction of the culvert options would reduce the average annual damages by $6,100 and by $7,400 respectively.

3.2 Culvert Concept Design

3.2.1 Concept Design

The concept design involves the placement of four cells each 3,600 mm x 3,600 mm in cross section. The total length of culvert would be about 35 m and it would have a 1% gradient towards Finlaysons Creek. Some channel excavation and scour protection works would be required upstream of the culvert and scour protection works would be required at the outlet to Finlaysons Creek.

The proposed culvert is located at a location where "the billabong" comes closest to the excavated channel of Finlaysons Creek. The culvert would be orientated at an angle to direct flow into Finlaysons Creek in a downstream direction in order to minimise the scour effects from the culvert flow.

If an eight cell culvert was to be constructed, two additional cells would be added each side of the four cell culvert.

3.2.2 Cost Estimates

Cost estimates for both culvert options are set out in Table 14.

Table 14
Summary of Estimated Culvert Construction Costs ($x1,000)

Item	Four Cell Culvert	Eight Cell Culvert
Establishment and temporary road diversion	$110	$160
Excavation and disposal of fill	$31	$62
Concrete slab and wing walls	$61	$116
Culverts	$308	$616
Scour protection	$45	$90
Road reinstatement	$35	$67
Contingency	$50	$75
Total (rounded)	**$640**	**$1,190**

3.3 Economic, Social and Environmental Impacts

Table 13 shows that the 4 cell and 8 cell culverts would reduce the average annual damages by $6,100 and $7,400 respectively. Table 15 provides a simple economic assessment of the net present value (NPV) of the benefits and the benefit:cost ratio (BCR) for these construction options at assumed discount rates of 4%, 7% and 11% (in accordance with NSW Treasury Guidelines) and 9% (as used by Sydney Water).

Table 15
Economic Assessment of Culvert Options

	Discount Rate (%)	4 Cell Culvert	8 Cell Culvert
Capital Cost ($x1,000)		$640	$1,190
NPV of benefits($x1,000)	4%	$105	$128
BCR of project	4%	0.16	0.11
NPV of benefits($x1,000)	7%	$76	$92
BCR of project	7%	0.12	0.08
NPV of benefits ($x1,000)	9%	$63	$76
BCR of project	9%	0.10	0.06
NPV of benefits($x1,000)	11%	$53	$64
BCR of project	11%	0.08	0.05

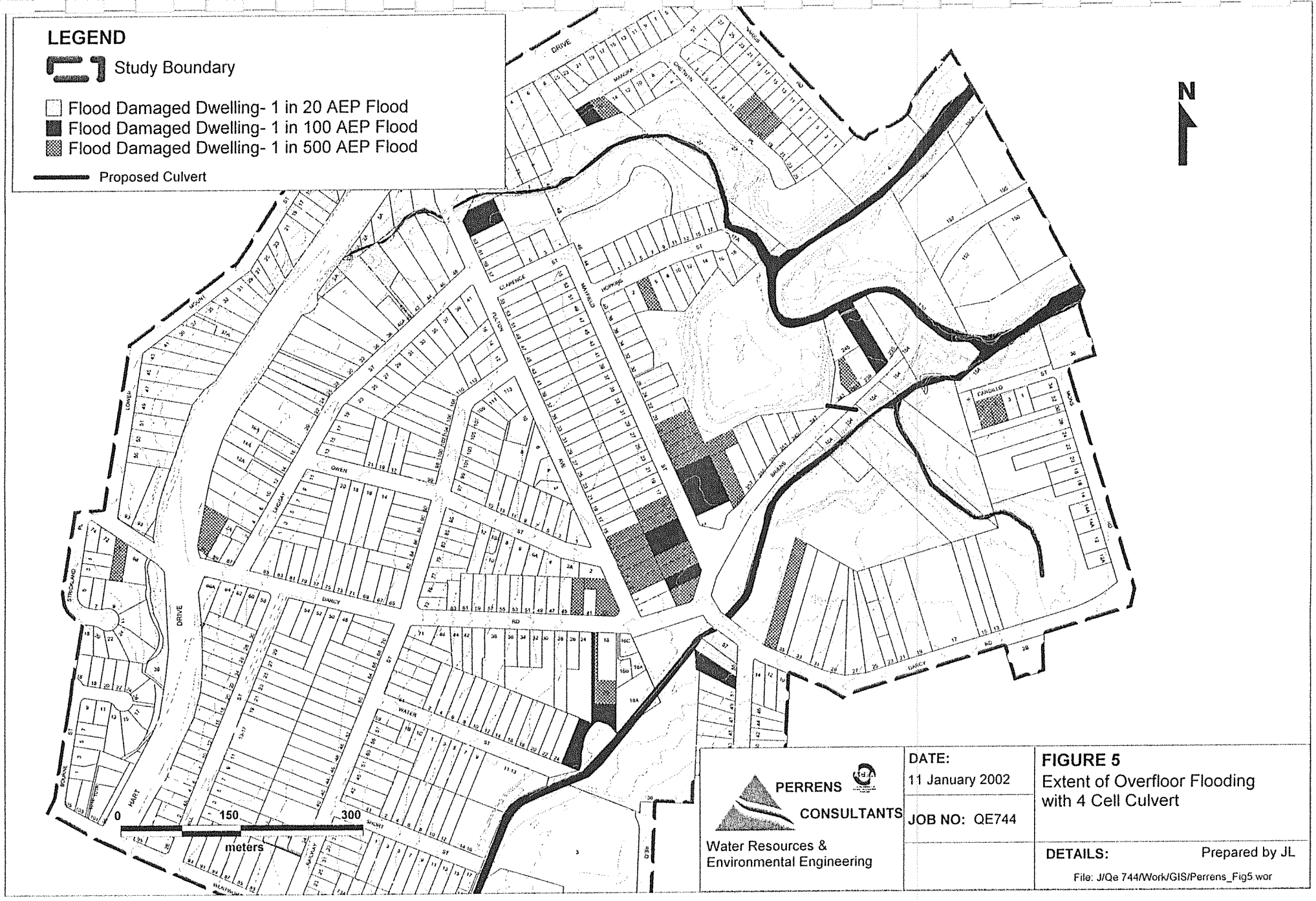
The analysis in Table 15 shows that on strictly economic terms, neither of the culvert construction options would warrant further consideration. It can be seen that all BCR values are significantly less than 1.0. It can also be seen that in all cases, the BCR for the four cell culvert is higher than the 8 cell culvert option. The 4 cell option is therefore more economic than the 8 cell option.

While neither of the culvert construction options are warranted on purely economic terms, there are other significant reasons to warrant the construction of the culvert:

- The construction of the culvert would significantly decrease the number of households who suffer the distress of flooding within the house.
- The construction would significantly reduce the area of high hazard in the vicinity of the intersection of Briens Road and Mayfield Street. This would assist emergency services to gain access and enable individuals to evacuate themselves if they deem necessary.

The construction of the culvert would not require the removal of any significant trees. The necessary scour protection would be provided to ensure that the banks were protected upstream and the existing excavated channel of Finlaysons Creek was not eroded.

During detailed design there is an opportunity to include a low flow channel in the bed of the culvert and a small water level control weir at the inlet to this channel. This water level control weir could be used to control the water level remaining in "the billabong" after a storm and to allow variation of this level for management purposes in order to enhance the ecological values of "the billabong".


LEGEND
Study Boundary
Flood Damaged Dwelling- 1 in 20 AEP Flood
Flood Damaged Dwelling- 1 in 100 AEP Flood
Flood Damaged Dwelling- 1 in 500 AEP Flood
Proposed Culvert
N
0
150
300
meters
PERRENS
CONSULTANTS
Water Resources &
Environmental Engineering
DATE:
11 January 2002
JOB NO: QE744
FIGURE 5
Extent of Overfloor Flooding
with 4 Cell Culvert
DETAILS:
Prepared by JL
File: J/Qe 744/Work/GIS/Perrens_Fig5.wor

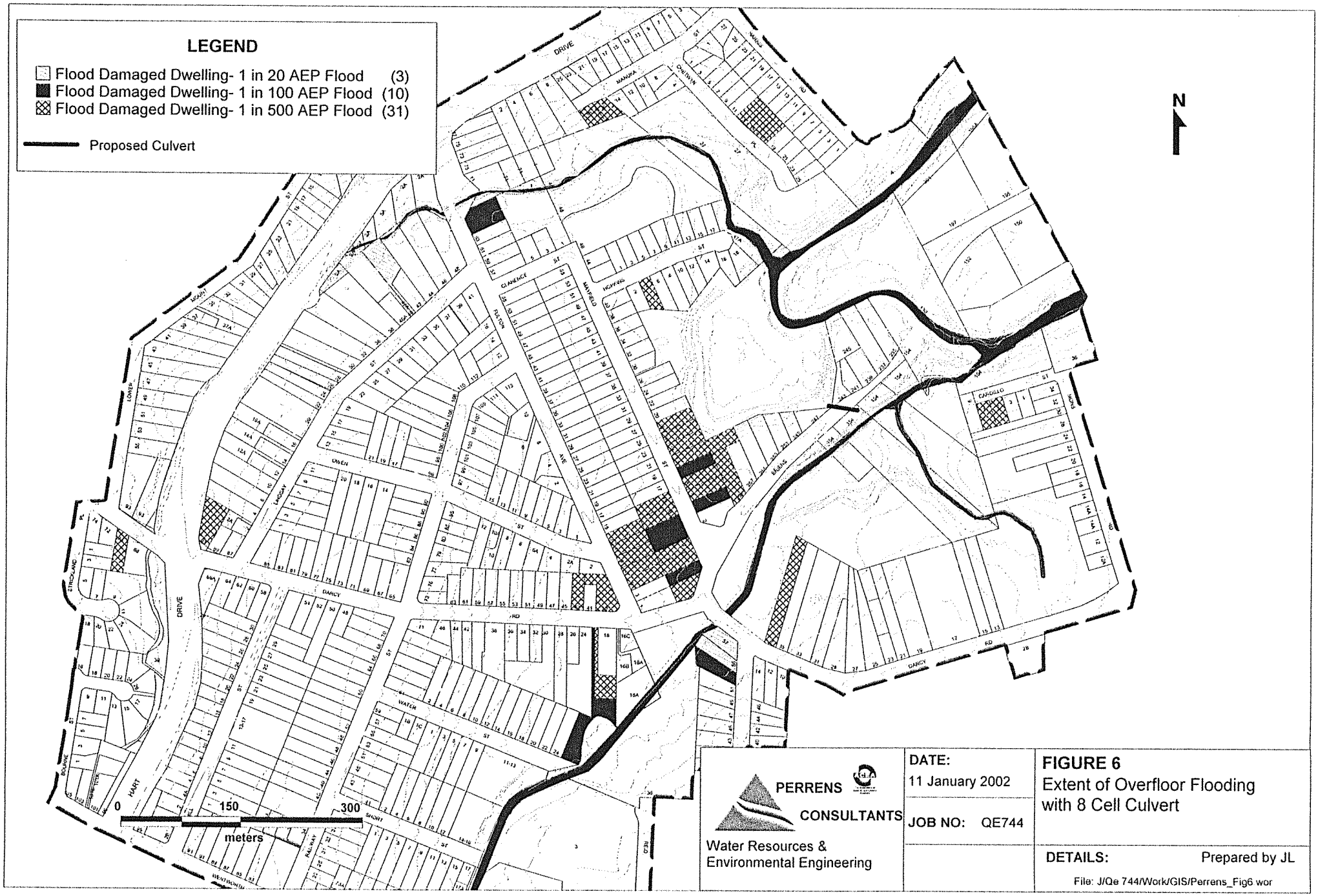
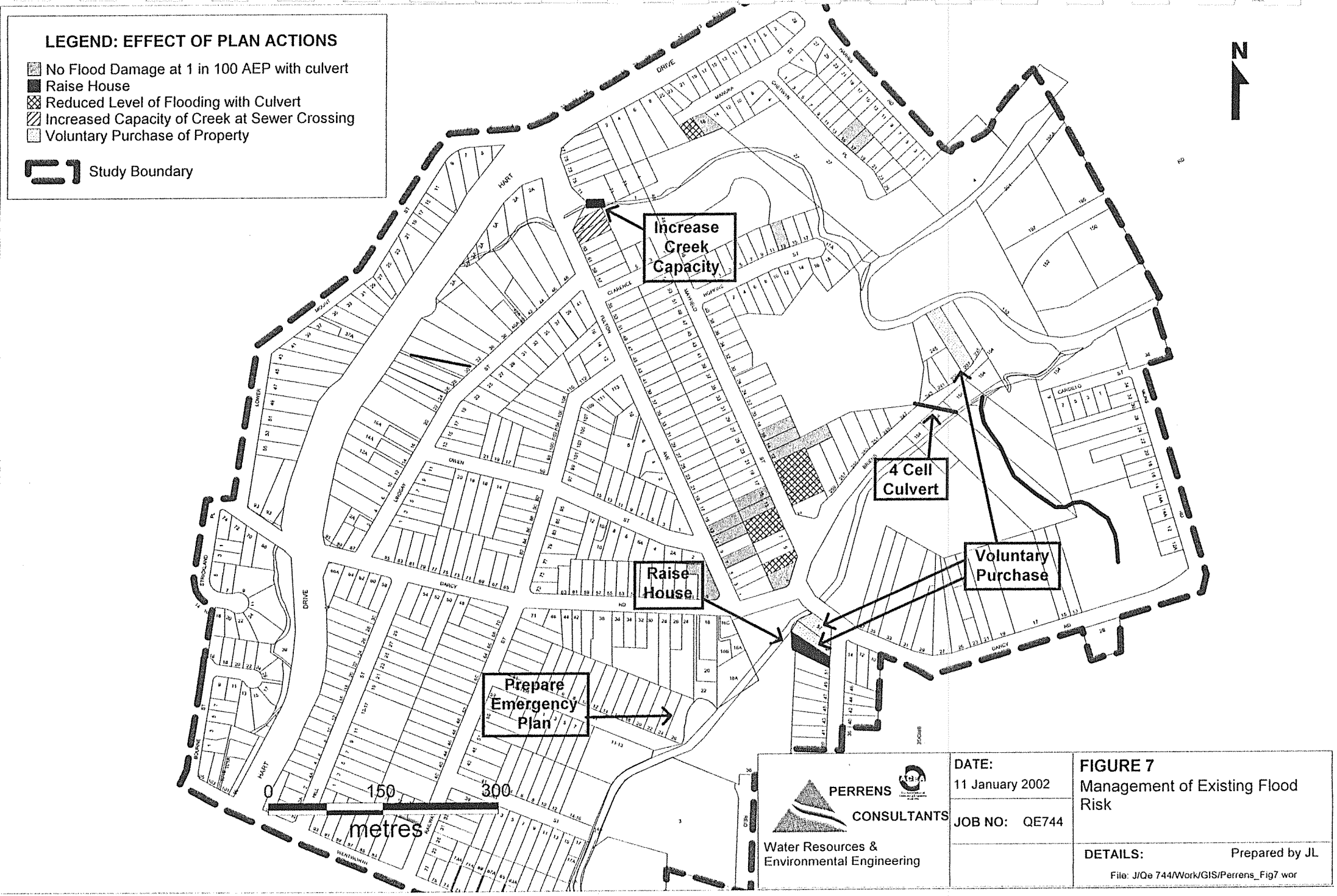
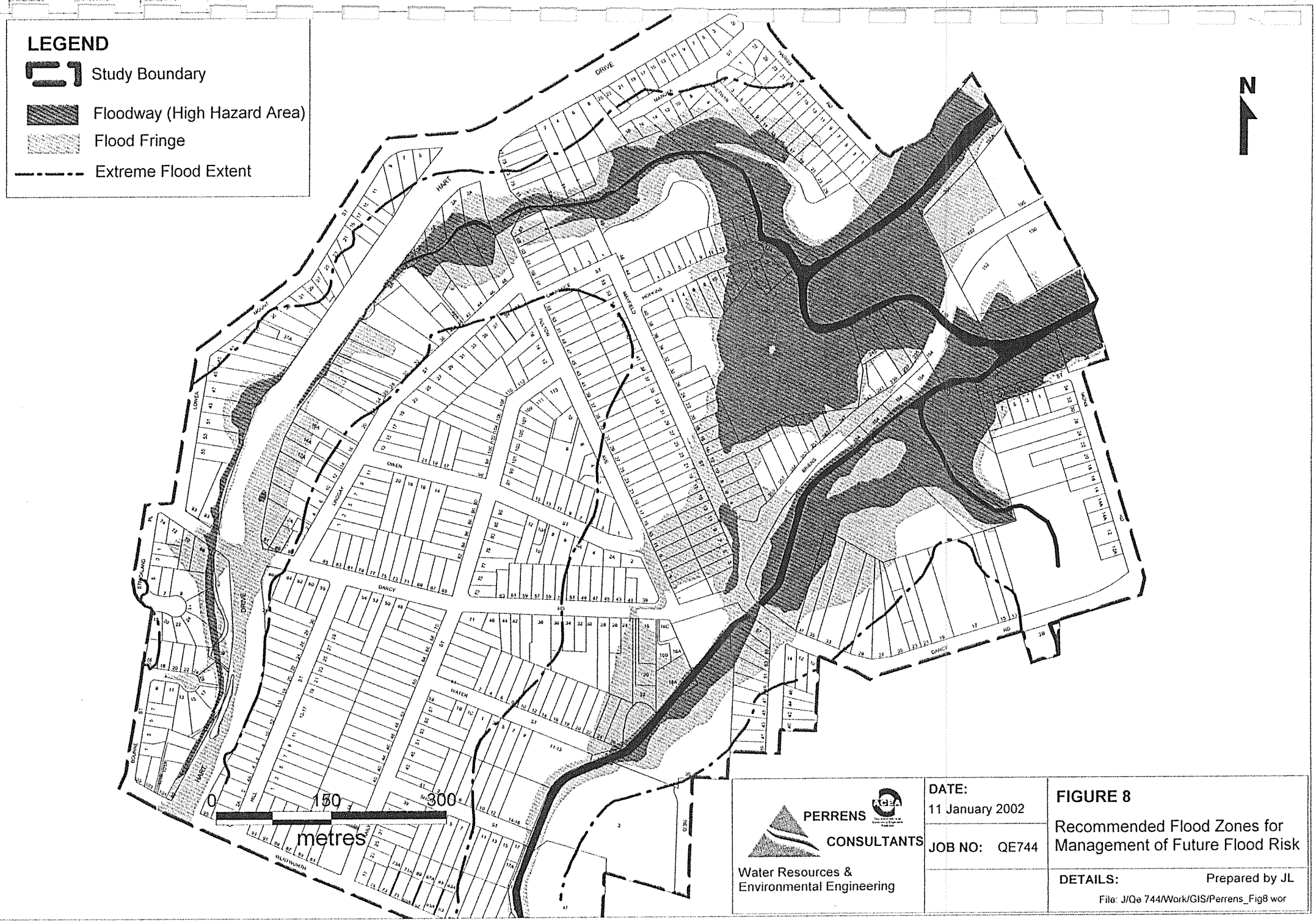

LEGEND
Flood Damaged Dwelling- 1 in 20 AEP Flood (3)
Flood Damaged Dwelling- 1 in 100 AEP Flood (10)
Flood Damaged Dwelling- 1 in 500 AEP Flood (31)
Proposed Culvert
N
0
150
300
meters
PERRENS
CONSULTANTS
Water Resources &
Environmental Engineering
DATE:
11 January 2002
JOB NO: QE744
FIGURE 6
Extent of Overfloor Flooding
with 8 Cell Culvert
DETAILS: Prepared by JL
File: J/Qe 744/Work/GIS/Perrens_Fig6 wor

Table 16
Proposed Management of Existing Flood Risk

Street	House No	Floor Level	Depth of Flooding[1] (1 in 100 AEP)		Building Construction	Proposed Action: Manage Existing Flood Risk	Cost ($ x 1,000 per property)	Floor Level Relative to FPL (m)	Comments and Additional Action: Manage Future Flood Risk
			Current	4 Culvert					
Briens Road	237	15.19	0.88	0.50	Timber	Voluntary purchase	$285	na	na
Chetwyn Place	15	16.02	0.18	-0.17	Brick Veneer	4 cell culvert	$45	-0.33	Min floor level for extensions/redevelopment
Chetwyn Place	17	16.16	0.04	-0.31	Brick Veneer	4 cell culvert	$45	-0.29	Min floor level for extensions/redevelopment
Darcy Road	Scout hall	18.92	0.57	0.57	Basement - cnr of Lower Mount St -	No action	$0	-1.07	Flood awareness/emergency response plan
Darcy Road	5/39	15.53	-0.01	-0.09	Hair Dressing Salon - Fulton St	No action	$0	-0.41	Flood awareness/emergency response plan
Darcy Road	4/39	15.54	-0.02	-0.10	Groceries – Fulton St	No action	$0	-0.40	Flood awareness/emergency response plan
Darcy Road	22	15.69	-0.02	-0.02	?	No action	$0	-0.48	Min floor level for extensions/redevelopment
Fulton Avenue	7	15.34	0.04	-0.12	Brick Veneer	4 cell culvert	$45	-0.38	Min floor level for extensions/redevelopment
Fulton Avenue	11	15.33	0.05	-0.11	Timber	4 cell culvert	$45	-0.39	Min floor level for extensions/redevelopment
Fulton Avenue	13	15.40	-0.02	-0.18	Timber	4 cell culvert	$45	-0.32	Min floor level for extensions/redevelopment
Fulton Avenue	65	17.20	0.22	0.22	Timber	Increase capacity at sewer crossing (or consider for voluntary purchase)	$50 ($285)	na	House remains in high hazard. Better to offer voluntary purchase?
Fulton Avenue	67	17.20	0.22	0.22	Brick Veneer	Increase capacity at sewer crossing (or consider for voluntary purchase)	$50 ($285)	na	House remains in high hazard. Better to offer voluntary purchase?
Hopkins Street	13	16.14	0.05	-0.29	Brick Veneer	4 cell culvert	$45	-0.21	Min floor level for extensions/redevelopment
Lindsay Street	42a	17.53	0.42	0.42	2 Storey – uninhabited ground floor	No action – uninhabited ground floor		-0.91	Ensure ground floor never converted to habitable
Lydbrook Street	57	15.00	0.62	0.62	Fibro	Voluntary purchase	$285	na	na
Lydbrook Street	55	15.42	0.22	0.22	Fibro	Voluntary purchase	$285	na	na
Lydbrook Street	53	15.55	0.10	0.11	Fibro	Raise house 600 mm	$45	0.0	Min floor level for extensions/redevelopment
Manuka Street	18	15.78	0.42	0.08	2 Storey Brick veneer	4 cell culvert + flood proofing	$65	-0.58	Min floor level for extensions/redevelopment
Manuka Street	16	16.22	-0.02	-0.36	2 Storey Brick Veneer	4 cell culvert	$45	-0.14	Min floor level for extensions/redevelopment
Mayfield Street	1	15.34	-0.03	-0.13	Timber	4 cell culvert	$45	-0.37	Min floor level for extensions/redevelopment
Mayfield Street	3	15.18	0.13	0.03	Timber	4 cell culvert	$45	-0.53	Min floor level for extensions/redevelopment
Mayfield Street	4	15.14	0.24	0.08	Timber	4 cell culvert	$45	-0.58	Min floor level for extensions/redevelopment
Mayfield Street	6	15.30	0.32	0.01	Timber	4 cell culvert	$45	-0.49	Min floor level for extensions/redevelopment
Mayfield Street	8	15.30	0.32	0.01	Timber	4 cell culvert	$45	-0.49	Min floor level for extensions/redevelopment
Mayfield Street	9	15.03	0.35	0.19	Brick Veneer	4 cell culvert	$45	-0.69	Min floor level for extensions/redevelopment
Mayfield Street	10	15.32	0.64	0.35	Timber	4 cell culvert	$45	-0.85	Min floor level for extensions/redevelopment
Mayfield Street	11	14.92	0.46	0.30	Brick Veneer	4 cell culvert	$45	-0.80	Min floor level for extensions/redevelopment
Mayfield Street	12	15.77	0.19	-0.10	Brick Veneer	4 cell culvert	$45	-0.40	Min floor level for extensions/redevelopment
Mayfield Street	14	15.77	0.19	-0.10	Timber	4 cell culvert	$45	-0.40	Min floor level for extensions/redevelopment
Mayfield Street	13	15.63	-0.01	-0.32	Timber	4 cell culvert	$45	-0.18	Min floor level for extensions/redevelopment
Mayfield Street	15	15.62	0.00	-0.31	Timber	4 cell culvert	$45	-0.19	Min floor level for extensions/redevelopment
Mayfield Street	16	16.06	-0.02	-0.37	Timber	4 cell culvert	$45	-0.13	Min floor level for extensions/redevelopment
Water Street	26	15.65	0.16	0.16	Pre School (Brick Veneer)	Emergency response plan?	$20	-0.66	Min floor level for extensions/redevelopment

Note 1: Negative numbers indicate flood level below floor level.


LEGEND: EFFECT OF PLAN ACTIONS
No Flood Damage at 1 in 100 AEP with culvert
Raise House
Reduced Level of Flooding with Culvert
Increased Capacity of Creek at Sewer Crossing
Voluntary Purchase of Property
Study Boundary
N
Increase Creek Capacity
4 Cell Culvert
Voluntary Purchase
Raise House
Prepare Emergency Plan
0
150
300
metres
PERRENS CONSULTANTS
Water Resources & Environmental Engineering
DATE: 11 January 2002
JOB NO: QE744
FIGURE 7
Management of Existing Flood Risk
DETAILS: Prepared by JL
File: J/Qe 744/Work/GIS/Perrens_Fig7 wor


LEGEND
Study Boundary
Floodway (High Hazard Area)
Flood Fringe
Extreme Flood Extent
N
0
150
300
metres
PERRENS CONSULTANTS
Water Resources & Environmental Engineering
DATE:
11 January 2002
JOB NO: QE744
FIGURE 8
Recommended Flood Zones for Management of Future Flood Risk
DETAILS:
Prepared by JL
File: J/Qe 744/Work/GIS/Perrens_Fig8 wor

4 FLOODPLAIN MANAGEMENT PLAN

In accordance with the requirements of the Floodplain Management Manual (2001), this Plan identifies three broad categories of management actions:

- management of the existing flood risk faced by the existing development;
- management of future flood risk that might arise from new development or redevelopment of the existing housing stock;
- management of the continuing flood risk that remains after all floodplain management measures are implemented.

4.1 Management of Existing Flood Risk

The management of existing flood risks is concerned with reducing flood impacts on the existing housing stock and community facilities. With the benefit of hindsight it can be seen that some buildings are located inappropriately or have floor levels that give rise to an unnecessarily high risk of flood damage. Management of the existing flood risk is concerned with correcting the worst of these existing problems.

There are a number of aspects of the existing flood risk that have been considered in developing a comprehensive management strategy. The strategy outlined below is based on the following principles and criteria:

- Priority has been given to the most cost effective actions. In this instance, construction of a flood relief culvert can be accomplished at a cost of approximately $45,000 per property that would be saved from flooding in the 1 in 100 AEP flood. This cost is similar to the estimated cost of $35-$45,000 for raising the timber and fibro houses. The main considerations in adopting the culvert option are:
  - House raising could be carried out to provide a floor level at or above the adopted FPL (including 500 mm freeboard) which would give a higher level of security only to those particular houses.
  - The flood relief culvert will provide benefits over a wider area and will reduce the incidence of flooding in other houses in the area, not just those that are actually saved from flooding in the 1 in 100 AEP flood.
  - Construction of the flood relief culvert will also reduce the area affected by high hazard conditions and also reduce the frequency of flooding of many blocks of land.
- Voluntary purchase should be offered to all properties that would remain within the high hazard flood zone associated with the 1 in 100 AEP flood after all other mitigation works have been under taken. (55 and 57 Lydbrook Street, 237 Briens Road. Possibly consider 65 and 67 Fulton Avenue if flood impacts cannot be significantly reduced by creek widening).
- After all other mitigation works have been undertaken, any remaining houses that would be flood damaged in 1 in 20 AEP flood should be offered subsidies to raise the house (fibro or timber houses- 53 Lydbrook Street).
- Specific site works are not considered warranted to reduce flood impacts on commercial premises and community facilities (ie Scout Hall). For those premises the residual flood

risk should be managed by preparing a flood awareness program and an emergency response plan.

- Special consideration should be given to the pre-school at 26 Water Street. The land is subject to flooding in a 1 in 5 AEP flood and the building would be inundated in a 1 in 100 AEP flood. If it does not already exist, the owner should be required to prepare a site specific evacuation plan to ensure that all children are evacuated safely and accounted for. Council should place appropriate conditions on any proposal to convert the site back for fully residential purposes.

The adopted actions to manage the existing flood risk for each affected property are set out in Table 16 (separate A3 sheet) and shown on Figure 7 and include:

1. Flood relief culvert under Briens Road (Option 1.3).
2. Channel widening near sewer downstream of Fulton Avenue (subject to further feasibility study) (Option 1.12).
3. Voluntary acquisition of three most flood affected properties (Option 2.1).
4. House raising of the one remaining private property flood damaged in a 1 in 20 AEP flood (Option 2.2).

4.2 Management of Future Flood Risk

Management of future flood risk is concerned with ensuring that future development is not subject to unacceptable risk and that existing flood conditions are not exacerbated by unwise future development. The adopted measures to manage the future flood risk are:

1. Prepare mapping showing the extent of flood liable land as defined by the PMF. This mapping should be based on data to be provided by the Trust. The Trust expect to complete further analysis to define PMF flood levels during 2002. Provisionally, flood liable land should be taken as land within the "extreme flood" line as shown on Figure 8.
2. Adopt a flood planning level (FPL) of the 1 in 100 AEP flood level applicable at the each building lot plus 500 mm.
3. Rezoning of 53 - 57 Lydbrook Street as a matter of priority (Option 2.4c). The existing zoning of 2(c) is inappropriate in view of the flood risks in that location.
4. Development controls – floor levels (Option 2.4a). All properties on flood liable land are to have minimum floor level equal to the FPL. (Council will need to develop and maintain a register of the floor level and the FPL applicable to each property that lies within the PMF).
5. Carry out additional studies to determine possible additional overland flow zones affected by stormwater overflows (other than areas affected by mainstream flooding), such as in the vicinity of Strickland Place (Option 1.9).
6. Development controls – overland flow paths (Option 2.4b). All properties lying within a designated overland flow zone (as derived from Option 1.9) are to be subject to controls relating to:
   - No filling to alter ground levels.
   - No additional brick walls (other than main house) that might divert flow.
   - Fences must permit unimpeded overland flow of water (eg open mesh, hinged bottom panel or "lay flat" posts).
   - Any redevelopment or extensions must allow minimum of 5 m setback from both side boundaries to permit overland flow.

7. Development controls – OSD and rainwater tanks (Option 1.7). All new developments or extensions must provide for OSD or rainwater tanks in accordance with Council's policies.

Details of the recommended land use and planning controls as set out Annexure 1. A DCP to reflect these controls should be prepared by Council.

4.3 Management of Continuing Flood Risk

The management of continuing flood risk is concerned with ensuring that impacts on the community are minimised in the event of floods larger than those used to designate planning controls such as FPLs. This will be achieved by the following actions:

1. Issue of flood certificates to all properties that are subject to flood related planning controls (ie within the extent of the PMF). (Option 3.1).
2. Emergency planning and management (Option 3.2). In the light of the results from this study, the SES should update their flood plan and specifically include actions to assist properties remaining in the high hazard zone and properties along Briens Road that may become isolated in a major flood.
3. Public education (Option 3.3). Council is to prepare general flood information and awareness materials for delivery to all flood liable properties. Material should specifically address the expected rate of rise and overflow points in the local area, and actions to be taken in times of flood. Information materials are to be distributed to flood liable properties each year (say with the rates notice).
4. Improved flood warning (Option 3.4). Council and the Local SES will develop a mechanism for dissemination of flash flood warnings given by the Bureau of Meteorology (when their system becomes fully operational). The value of future flash flood warnings from the Bureau will be heavily dependent on dissemination of the warnings to the local community with minimum delay.
5. Flood action plans (Option 3.5) are to be prepared covering the following elements:
   - WHAT residents should do in preparation for a flood and in the event of evacuation,
   - WHERE they should go if evacuation is necessary,
   - WHO they should contact to obtain flood warnings and after an evacuation.

   General action plans should be prepared for, and distributed to, all flood liable households. Specific action plans should be prepared for:
   - The most flood liable properties; those that are likely to suffer damage in the 1 in 20 AEP flood (this mechanism can be used until the management actions to manage existing flood conditions have been implemented – see Section 4.1).
   - Properties adjacent to high hazard areas - to ensure that residents do not try to cross high hazard areas.
   - Commercial properties – to outline steps to minimise flood damage and to ensure safe and timely evacuation.
   - Community facilities (eg Scout Hall) – to include routine steps to minimise damage in the event of a flood while the premises are unattended.

4.4 Associated Measures

A number of other actions have been adopted that relate to management of the creek corridor in the Plan area, but do not necessarily have a direct impact on flood flows, flood levels or flow velocity:

1. Sydney Water and the Trust are preparing a scheme to restore sections of Finlaysons Creek to natural conditions and fix the scour hole that has developed at the end of the concrete lined section of Finlaysons Creek. These proposals are supported.
2. The original Draft Floodplain Management Plan (Bewsher Consulting) recommended a program of works to preserve and enhance the creek corridors. Such works have the potential to significantly enhance the ecological, aesthetic and recreational amenity of the creek corridors in the North Wentworthville area. Such a program is unlikely to conflict with the aims and objectives of the Floodplain Management Plan. Care will be needed to ensure that any revegetation does not occur in a manner that significantly increased the hydraulic resistance of the channels thereby causing an increase in flood levels. On the other hand, there is a significant opportunity to integrate the construction of a flood relief culvert under Briens Road with measures to allow the control and management of water levels in "the billabong". The ability to control and manage water levels is an important precursor to any effective restoration of the wetland values of "the billabong".

4.5 Funding Requirements and Sources

Table 17 summarises the budget estimates for the implementation of the Floodplain Management Plan. This budget will be reviewed and amended in the light of the outcome of studies undertaken to further assess Option 1.12.

Table 17
Budget and Priority for Floodplain Management Plan Actions

Option No	Description	Capital Cost ($x1,000)		Maintenance Cost ($/year)	Priority
		Total	Council		
Management of Existing Flood Risk					
1.3	Construction of flood relief four cell culvert under Briens Road.	$640	$213	$5	1
1.12	Channel improvement near sewer downstream of Fulton Avenue. (Further studies required to assess feasibility and costs).	$100	$33	$0	2
2.1	Voluntary acquisition of three most flood affected properties.	$855	$285	$0	1
2.2	House raising of one remaining property flood damaged in a 1 in 20 AEP flood.	$40	$13	$0	2
Management of Future Flood Risk					
2.4 a)	Adopt a flood planning level (FPL) of the 1 in 100 AEP flood level applicable at the locality plus 500 mm. Adopt land use, planning and floor level controls as set out in Annexure 1.	$0	$0	$0	1
1.9	Additional studies to determine possible overland flow zones.	$45	$0	$0	1
2.4 b)	Development controls – overland flow paths (Option 2.4b).	$0	$0	$0	1
1.7	Development controls – OSD and rainwater tanks.	$0	$0	$0	3
Management of Residual Flood Risk					
3.1	Provide a flood certificate to all property owners on a regular basis.	$0	$0	$0	1
3.2	Emergency planning and management	$25	$0		1
3.3	Public education, community participation and flood awareness programs for whole LGA.	$120	$40	$20	3
3.4	Improved flood warning systems.	$0	$0	$0	3
3.5	Flood action plans.	$0	$0	$0	1
Associated Measures					
1.10	Works to address scour in Finlaysons Creek (funded by Sydney Water).	$?	$0	$0?	1
1.8	Develop plan to preserve/enhance creek corridors.	$45	$45	$?	1
Total		$1,810	$609	$25	

Council has significant funds of its own to dedicate to floodplain management works in the LGA. Also, flood control and major trunk drainage works attract "dollar for dollar" funding from the Upper Parramatta River Catchment Trust. Given that the extent of flood inundation problems at North Wentworthville represent one of the worst flood affected areas in the LGA it is expected that most of the funding for works in the catchment will come from Council and Trust funds.

Council may also gain some assistance with implementing parts of the Plan from the State Government and possibly the Federal Government. Depending on the merits, funding assistance may be on a 2:1 basis, (ie Council contributes one third of the total capital costs).

For options to receive Government funding it should be shown that they are of significant benefit to the community. Funding of investigation and design activities as well as any works and ongoing programs such as voluntary purchase is normally available. Ongoing maintenance would be the responsibility of Council.

Eligibility for funding does not guarantee that funding will be forthcoming. Funding is available on a competitive basis against other floodplain management projects elsewhere in the State.

4.6 Implementation

The Plan is based on information available at the time of preparation (January 2002). There are, however, a number of matters that require action in order to initiate implementation of the Plan by Council. These include:

- Further flood level and flow analysis to allow consultation with landholders likely to be directly affected by the construction of the proposed culvert under Briens Road.
- Finalisation of the analysis of the probable maximum flood (PMF) by the Trust so that the limit of flood liable land (the extent of the PMF) can be shown on Council's planning maps.
- Further analysis of the effectiveness in reducing flood levels by means of possible channel improvements in Coopers Creek downstream of Fulton Avenue. If this analysis indicated that works in this area are impractical or not cost effective, further consideration should be given to including numbers 65 and 67 Fulton Avenue in a voluntary purchase program.

The steps in progressing the floodplain management process following formal adoption by Council are as follows:

- Council allocates priorities to components of the Plan, based on local considerations and budgetary constraints;
- Council submits an application for funding assistance to the Trust and the DLWC;
- As funds become available from Council and the Trust's own resources and/or the DLWC, Council commences to implement the Plan in accordance with the established priorities.

The absence of State and Federal Government funding for a particular option should not preclude Council from independently funding the work that has been identified in the Plan that has significant benefits for the community and is cost effective.

4.7 On-going Review of Plan

The Floodplain Management Plan must be regarded as a dynamic instrument requiring review and modification over time. The catalyst for change could include new flood events and experiences, legislative change, alterations in the availability of funding or changes to the area's planning strategies. In any event, a thorough review every five years is warranted to ensure the ongoing relevance of the Plan.

FLOODPLAIN MANAGEMENT PLAN

ANNEXURE 1
Planning Controls and
Suggested Clauses for DCP

Definitions of Land Use Categories applicable to North Wentworthville

Essential Community Facilities

Community facility, Place of Assembly, or Public building which may provide an important contribution to the notification and evacuation of the community during flood events, Hospitals and Education establishments.

Critical Utilities

Generating work or Public Utility Undertakings or Utility Installations which may cause pollution of waterways during flooding, are essential to evacuation during periods of flood or if affected during flood events would unreasonably affect the ability of the community to return to normal activities after flood events.

Subdivision and Filling

Subdivision of land which involves the creation of new allotments for any particular purpose and earthworks or filling operations covering 100 m^2 or more than 0.1 m deep.

Residential

Dwelling house; Home industry; Home occupation; Medium density housing; Multi-unit housing; Nursing home; Professional consulting rooms; Serviced apartments; Units for aged persons; Residential flat building; Villa homes.

Public utility undertakings and Utility installations (other than critical utilities).

Commercial or Industrial

Bus depot; Bus station; Car repair stations; Child care centre; Club; Commercial premises (other than where referred to elsewhere); Hotel; Industry; Institution; Motel; Motor showroom; Office; Place of assembly (other than essential community facilities); Place of public worship; Public building (other than essential community facilities; Recreation Facility; Refreshment Room; Restaurant; Road transport terminal; Service station; Shop; Tourist facilities; Transport terminal; Warehouse.

Non Urban Activities or Open Space

Open space and minor ancillary structures (eg toilet blocks).

1. Essential Community Facilities-

Prohibited in all areas below extreme flood level.

2. Critical Utilities

2.1 Outer Flood Plain

Land between the FPL (1 in 100 AEP + 500 mm) and the extreme flood level

FLOOR LEVEL	All floor levels to be equal to or greater than the extreme flood level plus 0.5 m freeboard.
FLOOD COMPATIBLE BUILDING COMPONENTS	All structures to be constructed of flood compatible materials below or at the extreme flood level.
STRUCTURAL SOUNDNESS	Applicant demonstrates that any structure subject to a flood up to and including the extreme flood level, should withstand the forces of floodwater, debris and buoyancy.
FLOOD EFFECT ON OTHERS	The impact of the development on diversion of flow and flood levels to be considered.
EVACUATION ACCESS	Reliable access for pedestrians and vehicles required at or above the extreme flood level.
FLOOD AWARENESS	S149(2) certificates to notify affectation by the extreme flood.

2.2 Flood Fringe

Land between the high hazard area and FPL

Prohibited

2.3 Floodway

High hazard area

Prohibited

3. Subdivision and Filling

3.1 Outer Flood Plain

Land between the FPL (1 in 100 AEP + 500 mm) and the extreme flood level

FLOOD EFFECT ON OTHERS	The impact of the development on diversion of flow and flood levels to be considered.
EVACUATION ACCESS	Consideration required when regarding an appropriate flood evacuation strategy and pedestrian/vehicular access route for use before and during a flood.

FLOOD AWARENESS	Restrictions to be placed on title advising of minimum floor levels required relative to the flood level. S149(2) certificates to notify affectation by the extreme flood.
MANAGEMENT AND DECISION	Applicant to demonstrate that potential development as a consequence of sub-division approval can be undertaken in accordance with this policy.

3.2 Flood Fringe

Land between the high hazard area and FPL

STRUCTURAL SOUNDNESS	Applicant demonstrates that any structure subject to the 1 in 100 AEP flood, should withstand the forces of floodwater, debris and buoyancy.
FLOOD EFFECT ON OTHERS	Engineers report required to prove that the development of an existing allotment will not increase flood affectation elsewhere. No net reduction in flood storage below the 1 in 100 AEP flood level. No alteration in land levels along overland flow paths or in high hazard zone on private property or public road. No diversion of flow towards high hazard zone on private property or public road.
EVACUATION ACCESS	Reliable access for pedestrians required during a 1 in 100 AEP flood. Consideration required when regarding an appropriate flood evacuation strategy and pedestrian/vehicular access route for use before and during a flood.
FLOOD AWARENESS	Restrictions to be placed on title advising of Flood Planning Level. S149(2) certificates to notify affectation by the 1 in 100 AEP flood. S149(2) certificates to notify affectation by the extreme flood.
MANAGEMENT AND DECISION	Applicant to demonstrate that potential development as a consequence of sub-division approval can be undertaken in accordance with this policy.

3.3 Flood way

High hazard area

Prohibited

4. Residential

4.1 Outer Flood Plain

Land between the FPL (1 in 100 AEP + 500 mm) and the extreme flood level

FLOOR LEVEL	Habitable floor levels to be equal to or greater than the Flood Planning Level.
BASEMENT PARKING	Vehicle access must cross a crest level equal to or greater than the Flood Planning Level. Minimum level of any window sill or other means of possible water access to the basement must be equal to or greater than the Flood Planning Level.
FLOOD COMPATIBLE BUILDING COMPONENTS	All structures to have flood compatible building components below or at the Flood Planning Level.
FLOOD EFFECT ON OTHERS	The impact of the development on diversion of flow and flood levels to be considered.
EVACUATION ACCESS	Consideration required when regarding an appropriate flood evacuation strategy and pedestrian/vehicular access route for both before and during a flood.
FLOOD AWARENESS	S149(2) certificates to notify affectation by the extreme flood.

4.2 Flood Fringe

Land between the high hazard area and FPL

FLOOR LEVEL	Habitable floor levels to be equal to or greater than the Flood Planning Level.
BASEMENT PARKING	Vehicle access must cross a crest level equal to or greater than the Flood Planning Level. Minimum level of any window sill or other means of possible water access to the basement must be equal to or greater than the Flood Planning Level.
FLOOD COMPATIBLE BUILDING COMPONENTS	All structures to have flood compatible building components below or at the Flood Planning Level.
STRUCTURAL SOUNDNESS	Applicant demonstrates that any structure subject to the 1 in 100 AEP flood, can withstand the forces of floodwater, debris and buoyancy.

FLOOD EFFECT ON OTHERS	Engineers report required to prove that the development of an existing allotment will not increase flood affectation elsewhere. No net reduction in flood storage below the 1 in 100 AEP flood level. No alteration in land levels along overland flow paths or in high hazard zone on private property or public road. No diversion of flow towards high hazard zone on private property or public road.
EVACUATION ACCESS	Consideration required when regarding an appropriate flood evacuation strategy and pedestrian/vehicular access route for both before and during a flood.
FLOOD AWARENESS	S149(2) certificates to notify affectation by the 1 in 100 AEP flood. S149(2) certificates to notify affectation by the extreme flood.

4.3 Floodway

High hazard area

Prohibited

5. Commercial and Industrial

5.1 Outer Flood Plain

Land between the FPL (1 in 100 AEP + 500 mm) and the extreme flood level

FLOOR LEVEL	Habitable floor levels to be equal to or greater than the Flood Planning Level
BASEMENT PARKING	Vehicle access must cross a crest level equal to or greater than the Flood Planning Level Minimum level of any window sill or other means of possible water access to the basement must be equal to or greater than the Flood Planning Level.
FLOOD COMPATIBLE BUILDING COMPONENTS	All structures to have flood compatible building components below or at the Flood Planning Level
STRUCTURAL SOUNDNESS	Applicant demonstrates that any structure subject to the 1 in 100 AEP flood, can withstand the forces of floodwater, debris and buoyancy.

FLOOD EFFECT ON OTHERS	The impact of the development on diversion of flow and fl levels to be considered.
EVACUATION ACCESS	Consideration required when regarding an appropriate flood evacuation strategy and pedestrian/vehicular access route for use before and during a flood.
FLOOD AWARENESS	S149(2) certificates to notify affectation by the extreme flood.

5.2 Flood Fringe

Land between the high hazard area and FPL

FLOOR LEVEL	Habitable floor levels to be equal to or greater than the Flood Planning Level.
BASEMENT PARKING	Vehicle access must cross a crest level equal to or greater than the Flood Planning Level. Minimum level of any window sill or other means of possible water access to the basement must be equal to or greater than the Flood Planning Level.
FLOOD COMPATIBLE BUILDING COMPONENTS	All structures to have flood compatible building components below or at the Flood Planning Level.
STRUCTURAL SOUNDNESS	Applicant demonstrates that any structure subject to the 1 in 100 AEP flood, can withstand the forces of floodwater, debris and buoyancy.
FLOOD EFFECT ON OTHERS	Engineers report required to prove that the development of an existing allotment will not increase flood affectation elsewhere. No net reduction in flood storage below the 1 in 100 AEP flood level. No alteration in land levels along overland flow paths or in high hazard zone on private property or public road. No diversion of flow towards high hazard zone on private property or public road.
EVACUATION ACCESS	Consideration required when regarding an appropriate flood evacuation strategy and pedestrian/vehicular access route for use before and during a flood.
FLOOD AWARENESS	S149(2) certificates to notify affectation by the 1 in 100 AEP flood. S149(2) certificates to notify affectation by the extreme flood.
MANAGEMENT AND DECISION	Flood plan required when the floor level is below the FPL. **Applicant to demonstrate that there is an area where goods may be stored above the FPL during floods.** No external storage of materials below the FPL which may be potentially hazardous during floods.

5.3 Floodway

High hazard area

Prohibited

6. Buildings in Open Space

6.1 Outer Flood Plain

Land between the FPL (1 in 100 AEP + 500 mm) and the extreme flood level

FLOOD AWARENESS	S149(2) certificates to notify affectation by the extreme flood.

6.2 Flood Fringe

Land between the high hazard area and FPL

FLOOR LEVEL	All floor levels to be equal to or greater than the 20 year flood plus 500 mm (freeboard).
FLOOD COMPATIBLE BUILDING COMPONENTS	All structures to have flood compatible building components below or at the FPL.
STRUCTURAL SOUNDNESS	Applicant demonstrates that any structure subject to the 1 in 100 AEP flood can withstand the forces of floodwater, debris and buoyancy.
FLOOD EFFECT ON OTHERS	Engineers report required to prove that the development of an existing allotment will not increase flood affectation elsewhere. No net reduction in flood storage below the 1 in 100 AEP flood level. No alteration in land levels along overland flow paths or in high hazard zone on private property or public road. No diversion of flow towards high hazard zone on private property or public road.
EVACUATION ACCESS	Consideration required when regarding an appropriate flood evacuation strategy and pedestrian/vehicular access route for use before and during a flood.
FLOOD AWARENESS	S149(2) certificates to notify affectation by the 100 yr ARI flood. S149(2) certificates to notify affectation by the EXF flood.

6.3 Floodway

High hazard area

Prohibited

7. Overland flow paths

All properties lying within a designated overland flow zone to be subject to controls relating to:

- No filling to alter ground levels.
- No additional brick walls (other than main house) that might divert flow.
- Fences must permit unimpeded overland flow of water (eg open mesh, hinged bottom panel or "lay flat" posts).
- Any redevelopment or extensions must allow minimum of 5 m setback from both side boundaries to permit overland flow.

8. OSD and rainwater tanks

All new developments or extensions must provide for OSD or rainwater tanks in accordance with Council's policies.

LEGEND

Study Boundary

Flood Damaged Dwelling - 1 in 20 AEP Flood
Flood Damaged Dwelling - 1 in 100 AEP Flood
Flood Damaged Dwelling- 1 in 500 AEP Flood

N

0 150 300
meters

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DATE: 11 January 2002
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FIGURE 2
Extent of Overfloor Flooding (Existing Conditions)

DETAILS: Prepared by JL
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LEGEND

- 1 in 100 AEP Flood Extent
- Study Boundary
- Property Partially Flood Affected
- Whole Property Flood Affected

N

0 150 300 metres

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DATE: 11 January 2002

JOB NO: QE744

FIGURE 3
Extent of Flood Affectation to Land
1 in 100 AEP Flood
(Existing Conditions)

DETAILS: Prepared by JL

File: J/Qe 744/Work/GIS/Perrens_Fig3.wor

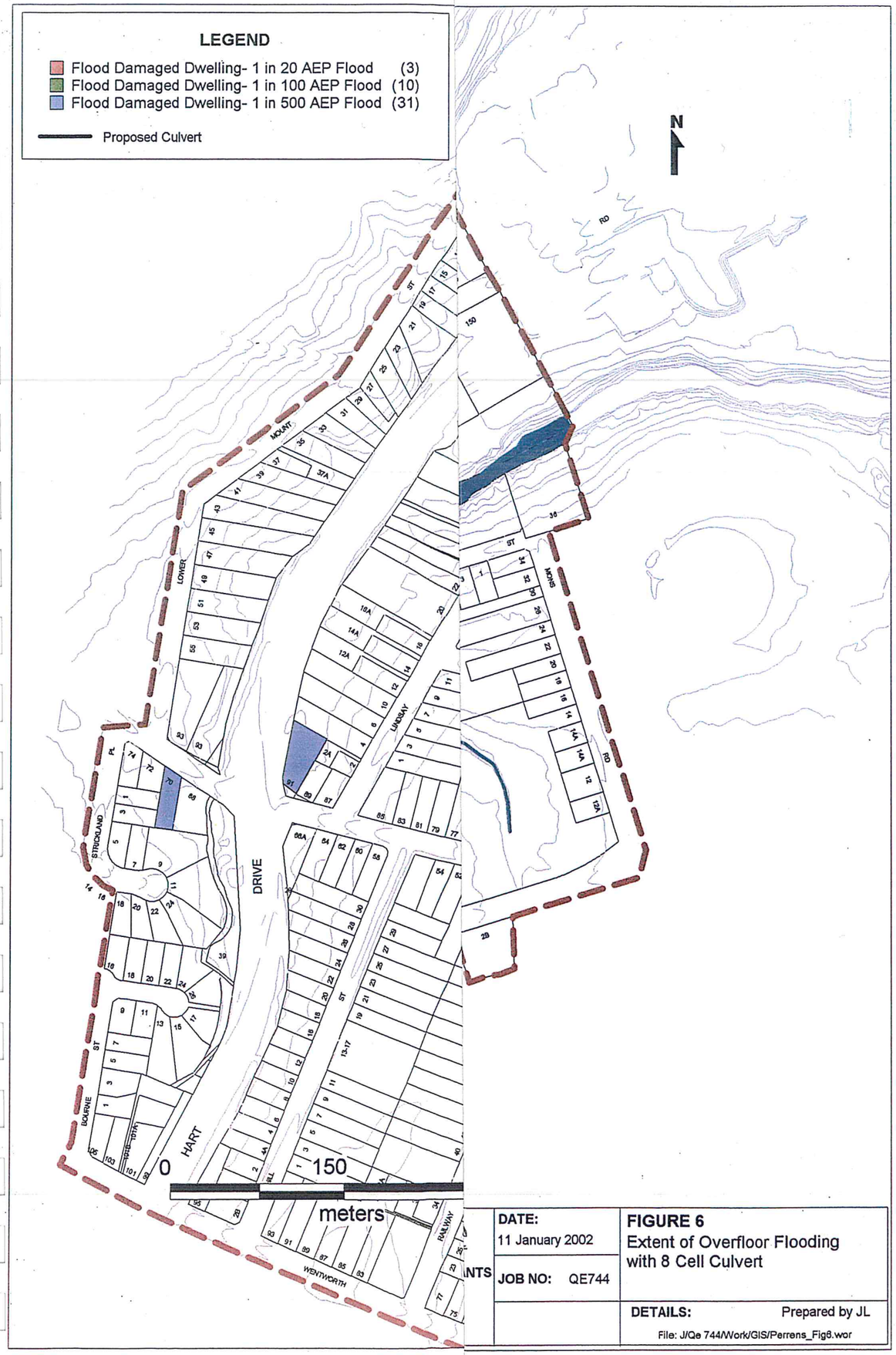
LEGEND

- Study Boundary
- Flood Damaged Dwelling- 1 in 20 AEP Flood
- Flood Damaged Dwelling- 1 in 100 AEP Flood
- Flood Damaged Dwelling- 1 in 500 AEP Flood
- Culvert

N

0 150 300 meters

PERRENS CONSULTANTS Water Resources & Environmental Engineering	DATE: 11 January 2002 JOB NO: QE744	**FIGURE 5** Extent of Overfloor Flooding with 4 Cell Culvert
		DETAILS: Prepared by JL File: J/Qe 744/Work/GIS/Perrens_Fig5.wor



	DATE: 11 January 2002	**FIGURE 6** Extent of Overfloor Flooding with 8 Cell Culvert
NTS	JOB NO: QE744	
		DETAILS: Prepared by JL
		File: J/Qe 744/Work/GIS/Perrens_Fig6.wor

LEGEND: EFFECT OF PLAN ACTIONS

- No Flood Damage at 1 in 100 AEP with culvert
- Raise House
- Reduced Level of Flooding with Culvert
- Increased Capacity of Creek at Sewer Crossing
- Voluntary Purchase of Property

Study Boundary

Increase Creek Capacity

4 Cell Culvert

Voluntary Purchase

Raise House

Prepare Emergency Plan

N

0 150 300 metres

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Water Resources & Environmental Engineering

DATE: 11 January 2002

JOB NO: QE744

FIGURE 7
Management of Existing Flood Risk

DETAILS: Prepared by JL

File: J/Qe 744/Work/GIS/Perrens_Fig7.wor

LEGEND

- Study Boundary
- Floodway (High Hazard Area)
- 1 in 100 AEP Flood Fringe
- Extreme Flood Extent

N

0 150 300

metres

PERRENS CONSULTANTS Water Resources & Environmental Engineering	DATE: 11 January 2002 JOB NO: QE744	**FIGURE 8** Recommended Flood Zones for Management of Future Flood Risk
		DETAILS: Prepared by JL File: J/Qe 744/Work/GIS/Perrens_Fig8.wor