Appendix I

Water Sensitive Urban Design Report by GCA

Proposed Tourism and Recreation Precinct, Tahmoor

Water Sensitive Urban Design Report for Rezoning

EG Property Group

FINAL

Revision: 2
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1	Draft Issue	AS	01.12.10	IH	03.12.10	IH	03.12.10
2	Final issue for planning proposal	AS	21.02.11	IH	21.02.11	IH	21.02.11

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Glossary

Annual Exceedance Probability (AEP)	The chance of a flood of a given or larger size occurring in any one year, usually expressed as a percentage. For example, if a peak flood discharge of 500 m^3/s has an AEP of 5%, it means that there is a 5% chance (or one-in-twenty) of a 500 m^3/s or larger event occurring in any one year.
Average Recurrence Interval (ARI)	The long-term average number of years between the occurrence of a flood as big as, or larger than, the selected event. For example, floods with a discharge greater than or equal to the 20 year ARI flood event will occur on average once every 20 years.
flood	Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or local overland flooding associated with major drainage before entering a watercourse, and/or coastal inundation resulting from super-elevated sea levels and/or waves overtopping coastline defences excluding a tsunami.
floodplain	Area of land which is subject to inundation by floods up to and including the probable maximum flood event.

List of acronyms

ARI	Annual Recurrence Interval
ARR	Australian Rainfall and Runoff (Engineers Australia, 1997)
AEP	Annual Exceedance Probability
EGPG	EG Property Group
GCA	Geoff Craig and Associates Pty Limited (trading as GCA Engineering Solutions)
GMS	Wollondilly Growth Management Strategy 2010
LGA	Local Government Area
NOW	Department of Environment and Climate Change NSW Office of Water
PRM	Probabilistic Rational Method (in accordance with ARR)
SQID	Stormwater Quality Improvement Device
WSC	Wollondilly Shire Council

Executive summary

RPS has prepared a planning proposal on behalf of the land owner of 165-185 River Road, Tahmoor. The planning proposal outlines the proposed land use zones for the 111ha property, and the reasons why the land owner's vision to convert the site into a Tourism and Recreation Precinct has the potential to make a substantial contribution to the region.

GCA has reviewed the site's existing features and the concept development Masterplan for the Tourism and Recreation Precinct, and identified opportunities for stormwater management in accordance with the principles of Water Sensitive Urban Design (WSUD). This process has resulted in several elements being identified, for potential incorporation to future work for the development, including:

- vegetated swales alongside roads within the development
- on-site stormwater harvesting measures within each development lot
- enhancement of an existing farm dam to provide increased aquatic biodiversity and stormwater treatment.

Surface runoff quality modelling was undertaken using the MUSIC computer model for existing and post-development conditions with the identified treatment measures. The MUSIC model results indicate that the overall treatment train effectiveness (of the above measures) would meet the criteria outlined in Australian Runoff Quality (Engineers Australia, 2006) for total suspended solids, total nitrogen, and total phosphorus, which are typically key considerations for surface runoff from rural residential developments.

Surface runoff flow rate modelling using the DRAINS computer model indicates that the development will have negligible impact on flow rates within the receiving waters, and that measures in excess of those outlined above are not considered necessary to mitigate the potential impacts of the development on surface runoff flow rates.

Overall it is considered that the proposed development, consisting of large lot rural residential and some recreational / tourism features, will be a low-impact development in terms of surface water hydrology and water quality.

It is the recommendation of this study that the site's surface water hydrology and quality considerations are not considered as constraints that would preclude the development of the proposed Tourism and Recreation precinct. Further, the proposed WSUD stormwater management plan would integrate with the future landscaping and urban design features. In this regard, the proposed WSUD features would enhance the lives of the local residents as well as the general experience of those visiting the site to use the facilities.

1. Introduction

1.1 Background

The owner of a precinct of four adjacent lots south-east of the main township of Tahmoor has a development vision see it transformed from a dormant 111 ha parcel of rural land to a new, recreation-themed residential estate and tourist hub, namely the Tahmoor Tourism and Recreation Precinct (the Proposed Development). A planning proposal for rezoning of the land has been prepared by RPS on behalf of the land owner, for consideration by Wollondilly Shire Council (WSC).

GCA was engaged to assess the existing site constraints and opportunities for stormwater management for the Proposed Development, consistent with the principles of Water Sensitive Urban Design (WSUD), with the aim of supporting the planning proposal.

This study report:

- discusses existing features of the site and immediate surrounds that are relevant to defining the existing (baseline) local surface water hydrology and surface runoff water quality
- estimates existing (baseline) flow rates in local drainage lines
- estimates existing (baseline) surface runoff quality in local drainage lines
- proposes and discusses a potential stormwater management option for the development
- suggests potential devices for management of stormwater runoff from the development, including potential stormwater harvesting and re-use measures
- evaluates the likely performance of the identified stormwater strategy against recognised best management practice (BMP) guidelines for new developments.

This study has employed simplified analysis in order to demonstrate the likely performance of the potential stormwater management philosophy for the precinct. It is expected that further analysis will be completed in future when detailed site investigation work is undertaken and the Masterplan has been refined. The future detailed work would also involve further consultation with Council to confirm the requirements for stormwater management and engineering design, amongst other matters.

1.2 Structure of this report

This report is structured in 5 sections as follows:

Section 1 Introduction, which provides information on the study background, the proposed development, and a general description of the site and existing drainage catchment.

Section 2 Stormwater management plan and evaluation methodology, including a discussion of key principles and criteria that have been adopted for this study.

Section 3 Surface runoff hydrology, including a discussion of surface runoff flow rates from the development for existing and post-development conditions based on DRAINS stormwater computer modeling.

Section 4 Surface runoff quality, including a discussion of anticipated pollutant concentrations for existing and post-development conditions using the results from MUSIC water quality computer modelling.

Section 5 Conclusions and recommendations.

1.3 Site location and features

The 111ha Proposed Development site is located at 165-185 River Road, Tahmoor and comprises Lot A and Lot B DP369710 and Lot 85 & 86 DP751270. It is located south-east of the township of Tahmoor, in the Upper Nepean region of Western Sydney. Figure 1 shows the location of the site relative to several surrounding townships.

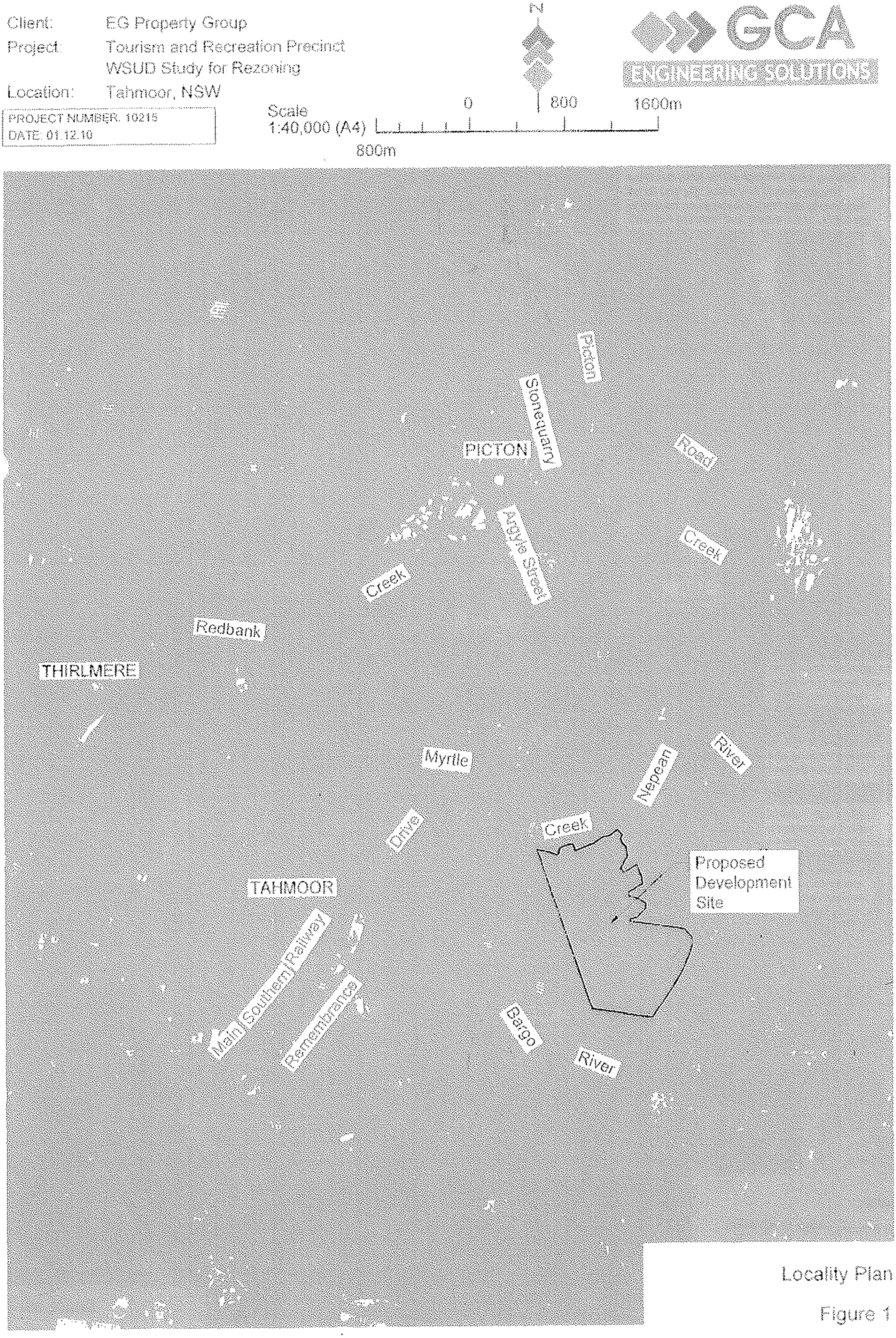
The site is bounded by Bargo River to the south, Nepean River to the east, and Myrtle Creek on the north. The confluence of Bargo River / Nepean River is located near the south-eastern corner of Lot 85 DP751270, and the confluence of Myrtle Creek and Nepean River is located to the north-east of Lot 86 DP751270. The site is not located within the special areas (drinking water catchment) administered by the Sydney Catchment Authority, being located downstream of all major regional municipal drinking water storages.

The majority of the site currently comprises improved pasture for agricultural purpose. Residential dwellings are located in the western, northern, and south-eastern parts of the site. Several other constructed features including garages, general storage areas, stables, sheds and stockpiles are also present, which are consistent with the rural / agricultural land use. The land is currently used for grazing cattle, and has also been historically used as a horse stud

A plan showing the existing site and key local features is shown on Figure 2.

Client: EG Property Group
Project: Tourism and Recreation Precinct
WSUD Study for Rezoning
Location: Tahmoor, NSW

PROJECT NUMBER. 10215
DATE: 01.12.10



Locality Plan

Figure 1

Client EG Property Group
Project Tourism and Recreation Precinct
WSUD Study for Rezoning
Location Tahmoor, NSW

PROJECT NUMBER 10215
DATE 01.12.10

Scale 1:5,000 (A3) 0 100 200 300m 100m

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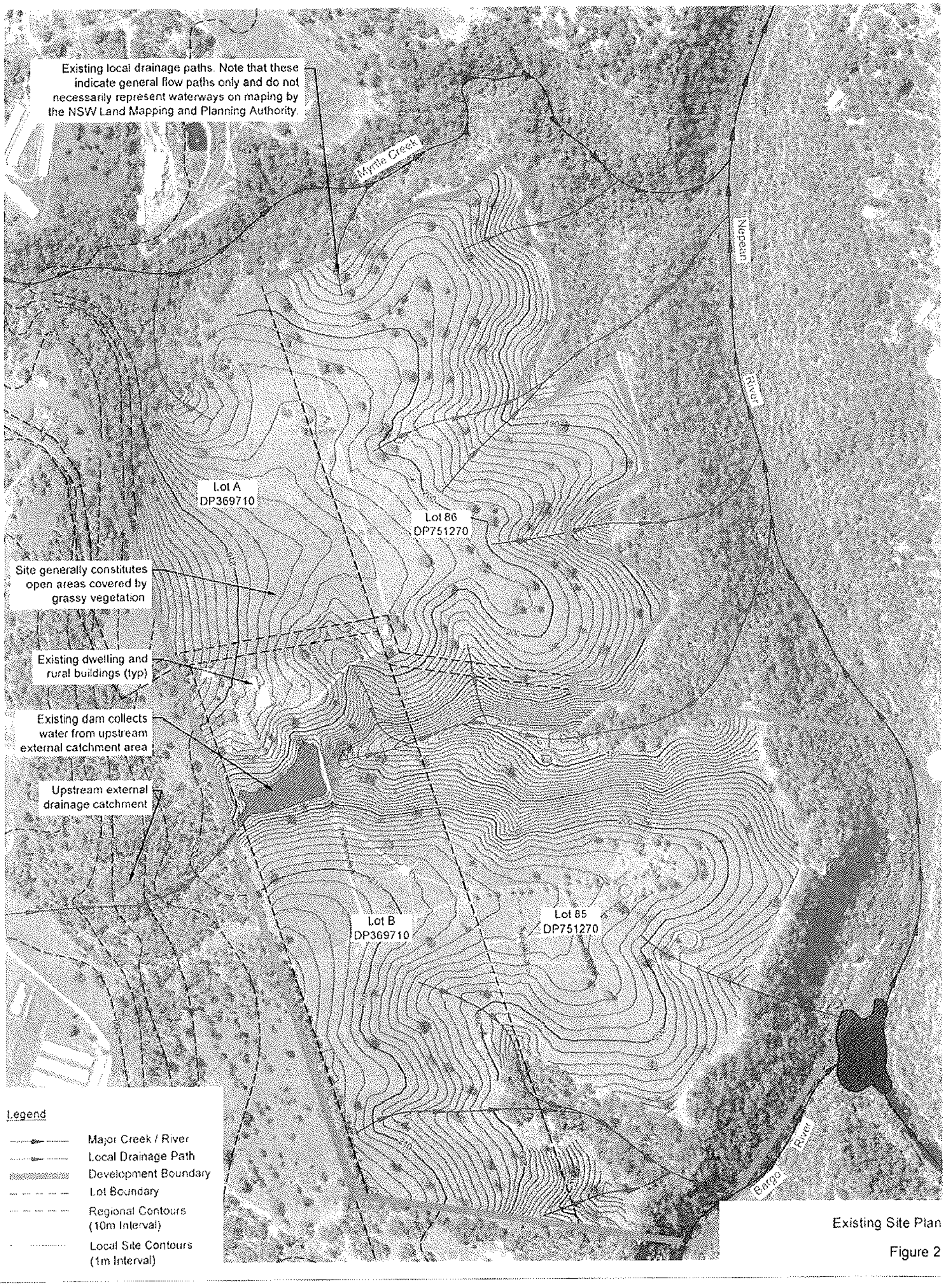

Existing Site Plan

Figure 2

1.4 Existing drainage catchment

The site is situated within Hawkesbury-Nepean catchment, Western Sydney Region, Upper Nepean sub-catchment, as defined by the Hawkesbury-Nepean Catchment Management Authority (CMA).

The site drains to three major regional drainage paths; Myrtle Creek, Nepean River, and Bargo Creek, which are part of the Hawkesbury-Nepean River system. The Hawkesbury-Nepean River system drains 21,400 km^2 of catchment area and with over 470km of river, is the longest coastal catchment in NSW. The site is located in the headwaters of the catchment, with the total regional catchment area to the site being only 141km^2. The Nepean River collects flow from Bargo Creek and Myrtle Creek, before flowing further downstream through many townships before transitioning to the Hawkesbury River, approximately 70km north. The Hawkesbury River then continues many more kilometres downstream, around Sydney, before eventually connecting with the Tasman sea past Brooklyn nearly 35km north-east of Sydney along the NSW coastline.

Site elevations vary between RL180 and RL220m AHD. Relatively flat surface slopes (0-5%) are present near local hill crests, which steepen up to 15-20% or more in several deep gullies that define the key local flow paths into Myrtle Creek, Nepean River, and Bargo River. A graphic representation of the site's surface slope characteristics is shown on Figure 3.

Various existing dams are present within the site; one in Lot B DP369710 with approximate surface area 7000m^2, and several others that are much smaller. The large dam collects stormwater runoff from around 23ha of upstream catchment area that is external to the development site.

The site is largely cleared, with existing vegetation primarily consisting of pasture grass.

From borehole logs by JBS Environmental (completed as part of the preliminary contamination assessment, JBS ref: 41274-15405, August 2010), the site appears to be primarily underlain by silty sand, sandy clay, and clay. Some weathered sandstone was encountered at relatively shallow depths (<2m) in parts of the site. However, according to groundwater bore logs interpreted by JBS Environmental, the actual sandstone bedrock is located at depths of 100m or more below ground surface. The existing site soil landscape is likely to result in relatively low natural stormwater infiltration rates, although this should be investigated as part of any future proposal that may be sensitive to this assumption.

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Scale 1:5 000 (A3) 0 100 200 300m
100m

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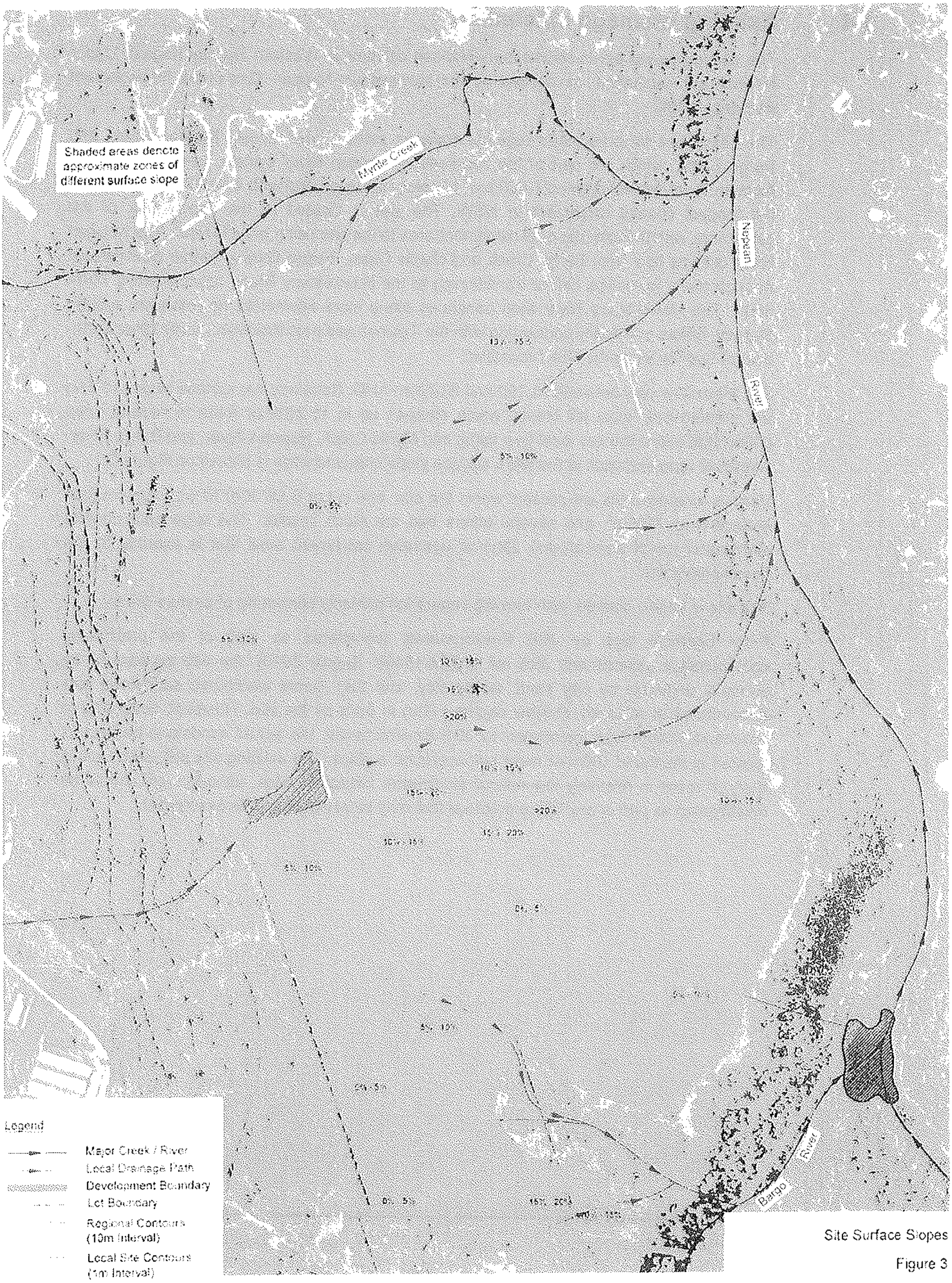


Site Surface Slopes

Figure 3

1.5 Proposed development

From the planning proposal by RPS, the proponent is seeking a mixture of Zone R5 Large Lot residential, Part RE2 Private Recreation and Part E2 Environmental Conservation, with no minimum lot size.

This report is based on a concept Masterplan for the site prepared by Fitzpatrick+partners (refer Appendix A), including:

- Large rural-residential lots ranging between 0.5ha (north-west of site), 0.8 to 1.5ha through the mid section of the site, with larger 3ha (and above) lots being located at the interface with the significant riparian zones in the north, east and south-east.
- A large number of community facilities including nature walks, parks, look outs, tennis courts, playground, and cycle ways. The existing large dam on the site may be augmented to facilitate fishing, remote controlled boating, and other general recreational activities, and may also provide some stormwater treatment benefits for part of the site.
- A conference / function centre in the south eastern corner, surrounded by lawn and landscaped areas.

The concept Masterplan incorporates riparian corridors as identified by the Worley Parsons *Riparian Corridor and Site Flooding Assessment* (31 August 2010), discussed in the following section.

Note that the concept Master plan may be refined at the time of subdivision Development Application to suit the final zone boundaries adopted in the LEP amendment, as well as other planning and technical considerations that may arise. It is expected that an updated stormwater management strategy would be prepared at that time.

1.6 Other relevant studies

Riparian and Site Flooding Assessment, Worley Parsons (31 August 2010)

Worley Parsons conducted a stream classification and flood review of the site. The report documents the results from site specific assessment of the likely riparian value of several local drainage lines, including ground truthing of local waterways designated by mapping held by the NSW Land Mapping and Planning Authority (LMPA).

The report indicates that several of the local drainage paths shown on LMPA mapping should not be classified as 'waterways', and that no buffer zones are applicable. The exceptions to this are the major regional flow paths (Nepean River, Bargo River, and Myrtle Creek) and a local drainage path (referred to as W2D by Worley Parsons) located in the south-eastern corner of the site.

The Riparian Corridor and Site Flood Assessment recommended a 100m buffer from the Nepean and Bargo Rivers, 30m from Myrtle Creek and 10m from W2D.

The Worley Parsons report also considers flooding within the site from flow within the major regional flow paths and W2D. The approximate flow rates, velocities and flow widths for the 100 year Average Recurrence Interval (ARI) event, as estimated by Worley Parsons, are summarised in Table 1-1

Table 1-1: **Summary of estimated 100 year ARI flow rates, velocities and flow widths in key local and regional drainage paths (after Worley Parsons, 2010)**

Drainage Line	Approximate Peak		
	Flow Rate (m^3/s)	Flow Velocity (m/s)	Flow Width (m)
W2D	6.6	2.8	< 10
*Myrtle Creek	86.2	2.9 to 4.2	26 to 27
*Bargo River	878	3.4	60
*Nepean River	5,600	6.3	130

The above flow rates and widths in the three major regional drainage lines (prefixed by '*') are significant as they provide insight to the potential capacity for these receiving waters to buffer minor variations in surface runoff flow rates and quality from the proposed development. Note that the figures represent the flow rates in the Nepean River immediately adjacent to the site, and flow rates will increase significantly further downstream as the contributing catchment area increases.

1.7 Information sources

The following information was used for this study:

- Site detail survey with 1m contour interval, prepared by Watson Buchan Pty Ltd.
- Conceptual Masterplan prepared by Fitzpatrick Partners (Appendix A).
- Climate data from the Australian Government Bureau of Meteorology (BOM)
- Topographic data with 10m contour interval (west of the site) from the NSW Department of Lands.
- Riparian and Site Flooding Assessment, Worley Parsons, August 2010.

2. Stormwater management plan and evaluation methodology

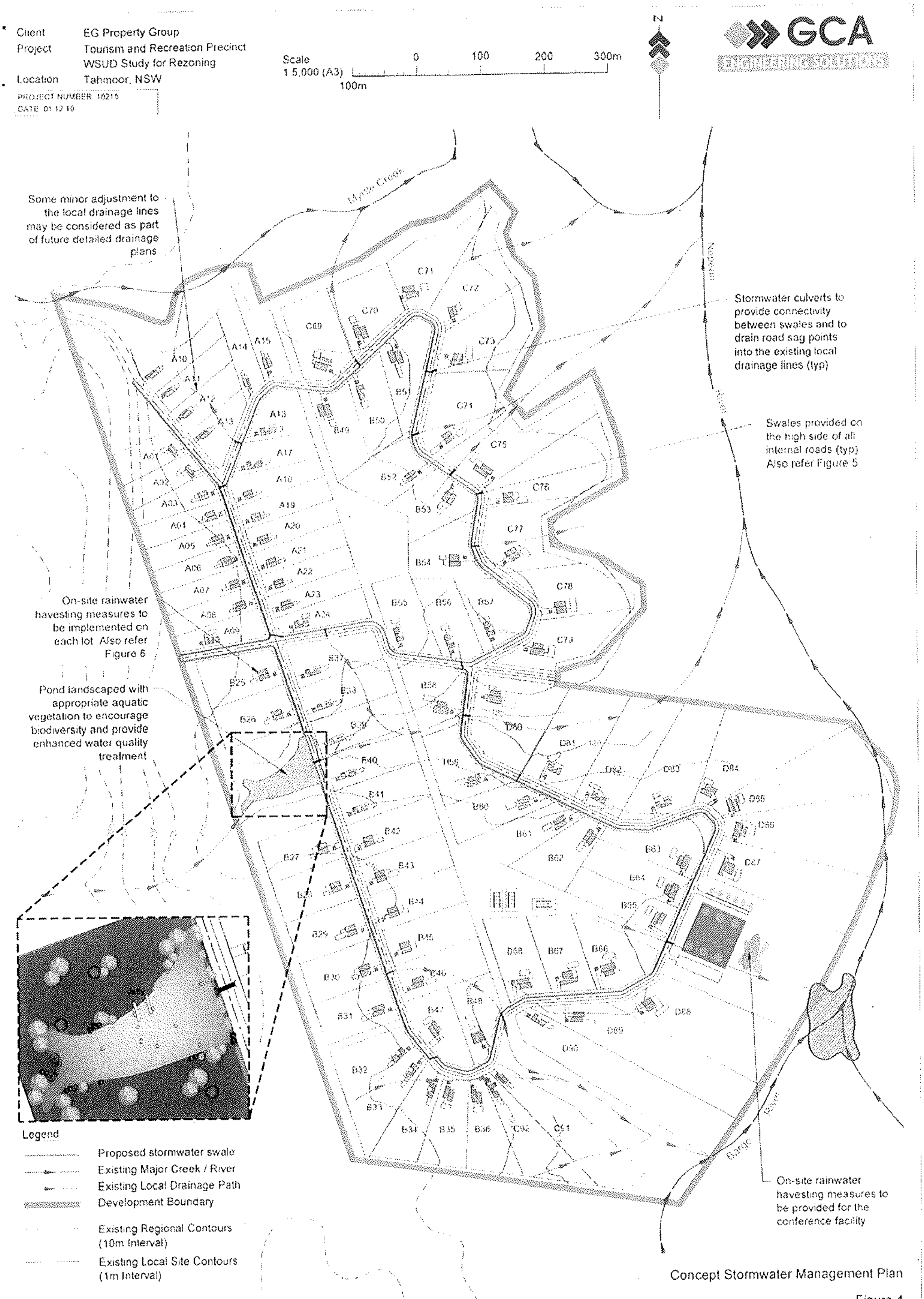
Provided below is a brief description of the identified stormwater management plan and methodology for evaluating the likely performance of the plan.

2.1 Stormwater management plan

An assessment of the site's topography, features, and concept Masterplan (all discussed previously) was first undertaken to identify potential opportunities for stormwater management. The result of the process was the concept WSUD stormwater management plan as presented on Figure 4, which incorporates the following key elements:

- Swales along the high sides of roads to collect, treat, and convey stormwater runoff from load and lot areas (where applicable) towards the existing main drainage lines. One-way road crossfall may also be considered to maximise the road area draining to swales. This would avoid the need for large earthworks footprints where swales would otherwise be constructed on the low side (in fill), as well as additional driveway culvert crossings.

  A conceptual detail of a typical swale is shown on the typical road cross section (Figure 5). Also shown on Figure 5 is a typical swale crossing to facilitate property access. The typical details are generally in accordance with WSC's standard requirements for rural residential roads.
- Rainwater harvesting and re-use within the dwellings on each lot. A conceptual schematic of the on-site rainwater harvesting system is shown on Figure 6. Although it is anticipated that each lot will have an on-site wastewater management system, it is possible that grey water recycling may also be considered at a future point in the development process.
- Stormwater drainage culverts to provide interconnectivity between the road swales, and at road sag points to discharge water from the swales into the existing local drainage lines.
- Conversion of the existing on-site farm dam to improve the diversity of aquatic ecology and provide some water quality treatment benefit over and above the potential recreational and community benefits.



Concept Stormwater Management Plan

Figure 4

Client: EG Property Group
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WSUD Study for Rezoning
Location: Tahmoor, NSW

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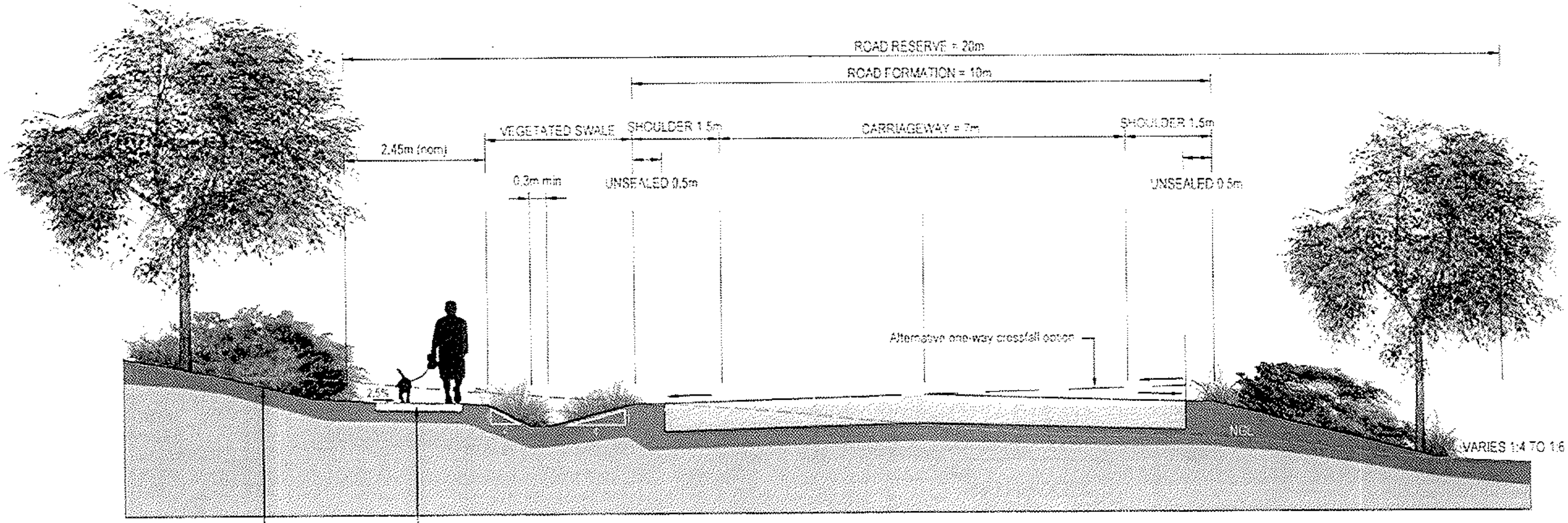
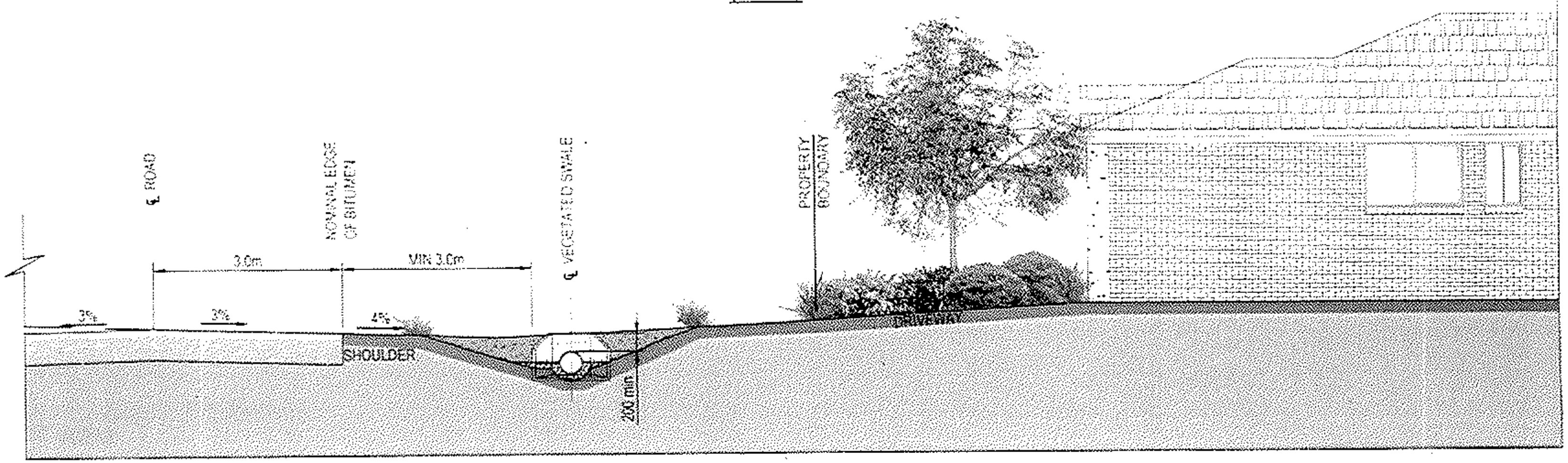


Typical Road Cross Section
(N.T.S.)



Typical Swale Crossing Detail
(N.T.S.)

Road typical cross section and
swale crossing detail
Figure 5

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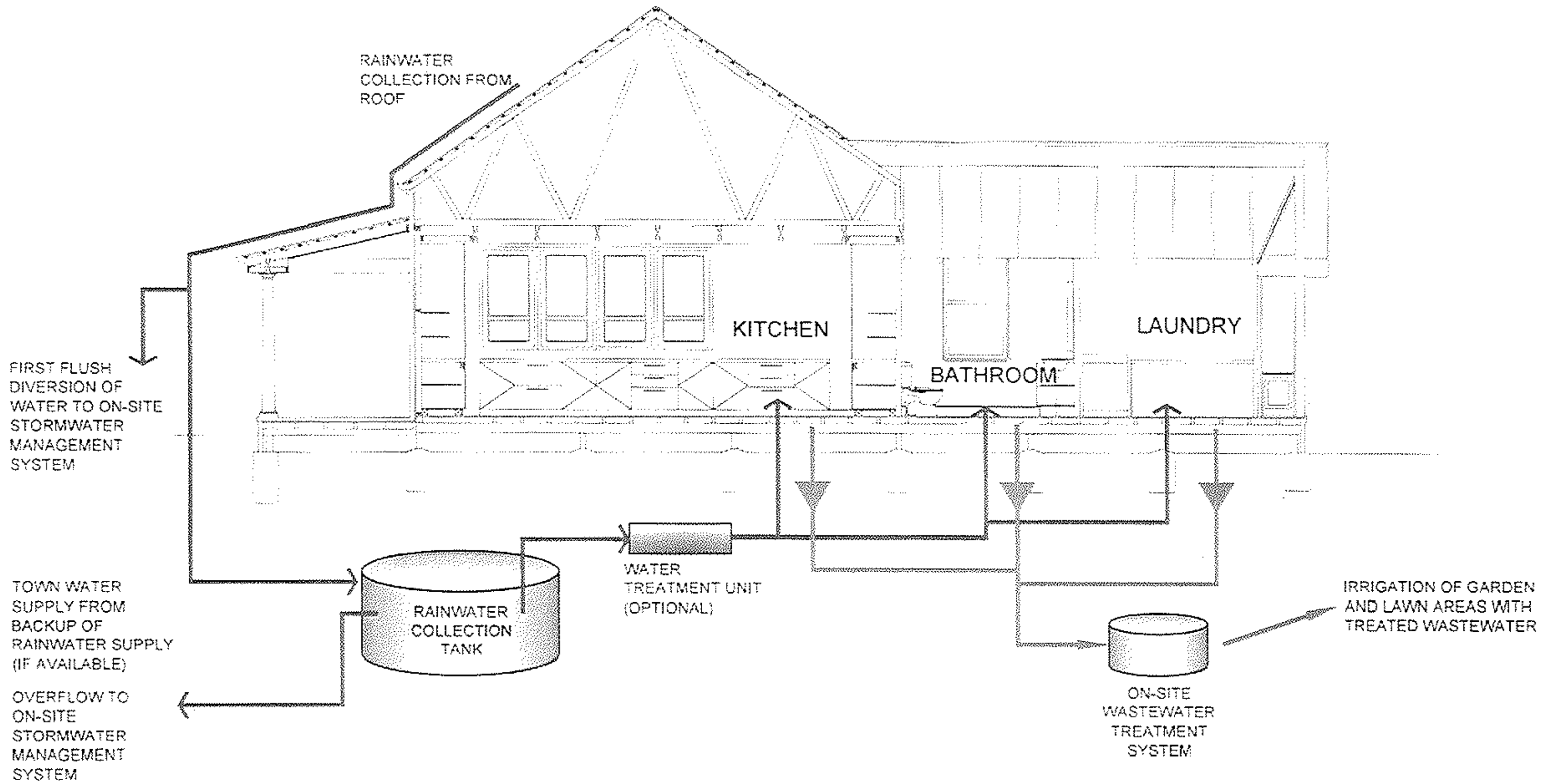

NOTE:
1) ALL RAINWATER HARVESTING SYSTEMS SHOULD BE INSTALLED TO RELEVANT AUSTRALIAN STANDARDS, AND GUIDELINES FROM NSW HEALTH AND OTHER GOVERNMENT DEPARTMENTS (INCLUDING DECCW).
2) ON-SITE WASTEWATER TREATMENT SYSTEM TO BE ASSESSED AND SPECIFIED BY OTHERS.

On-site Rainwater Harvesting Schematic

Figure 6

2.2 Evaluation: hydrology (surface runoff flow rates)

Urbanisation of catchment areas increases the proportion of impervious areas, which in turn tends to increase surface runoff flow rates within major drainage paths. This can alter the natural morphology of river systems through increased erosion and scour, and alter the existing flooding regime. Best practice stormwater management is to use 'at-source' controls to ensure that surface flow rates leave urban areas at acceptable rates that do not adversely impact the downstream system.

It is important to consider the magnitude of existing flow rates within the receiving waters and whether the potential increase in surface runoff flow rates (as a result of the development) is likely to have any significant adverse impacts. The frequency of occurrence for flow rates in receiving waters that are larger than the local surface runoff flow rates is an important factor.

The assessment of the site's potential impact on surface runoff flow rates is discussed further in Section 3 and includes:

- Comment on the change to local catchments. Namely, the marginal redistribution of local catchment areas due to construction of internal roads, and the small increase in impervious area due to road, dwelling, and hardstand construction.
- An assessment of the potential increase on flow rates using the DRAINS computer model.
- A comparison of the magnitude of local flow rates and increase in flow rates against the existing flow rates within the major regional flow paths, which are the receiving waters for surface runoff from the Proposed Development.

For the DRAINS model, catchments contributing to runoff within the site were identified from survey information compiled by Watson Buchan Pty Ltd, along with 10m contour data for upstream catchments obtained from the NSW Department of Lands. The existing catchment was assumed to be fully pervious, which is a conservative approach.

The developed catchment areas and impervious area for the developed sub-catchments were estimated from the site's topography (refer Figures 2 and 3), and the concept Masterplan developed by Fitzpatrick+partners (refer Appendix A).

The peak surface runoff flow rates for existing and post-development conditions were compared against estimates of flow rates within receiving waters Myrtle Creek, Nepean River, and Bargo River, obtained using the Rational Method from *Australian Rainfall and Runoff*, 1997.

2.3 Evaluation: surface runoff quality

Development of an area can increase the concentrations of nutrients and other pollutants in surface water runoff, with potential adverse impacts on the quality of water within downstream receiving waters and aquatic ecosystems.

The site is currently used for agricultural (grazing) purposes, a land use that can result in higher annual average nutrient export loads than low to medium density urban land use types. To this end, it is possible that the conversion of the site from agricultural to very low density rural residential land use could actually assist with reducing nutrient export through reduced intensity of agricultural land use. However, it is also important to take into account the marginal increase in the proportion of site impervious areas that may result from dwelling and internal road construction.

The proposed site was modelled for existing and post-development conditions using the MUSIC computer program to quantitatively evaluate the likely performance of the identified WSUD stormwater strategy. MUSIC (Model for Urban Stormwater Improvement Conceptualisation) is a continuous water quality model used to determine the performance of water quality treatment devices that form a 'treatment train'.

The pollutants considered in the water quality modelling were total suspended solids (TSS), total nitrogen (TN) and total phosphorus (TP), which are typical components of urban stormwater runoff.

MUSIC input parameters include

- rainfall and potential evapotranspiration data
- catchment area and percentage impervious
- hydrologic parameters
- statistical pollutant generation parameters

MUSIC outputs include

- average annual pollutant export loads
- treatment train effectiveness, expressed in terms of pollutant reduction.

Input parameter values used for modelling were derived from BOM Climate Data, parameter values in the MUSIC User Manual (2009) and other published papers.

WSC's drainage standards and development control plans were examined in an attempt to define quantitative water quality treatment criteria for the development. However, none were apparent. Further discussion with Council's engineers also did not confirm any defined WSC treatment standards.

The treatment criteria published in Australian Runoff Quality (ARQ, Engineers Australia, 2006) were therefore adopted as the default position for this study. The ARQ treatment criteria are generally adopted by Councils throughout NSW for areas other than special drinking water catchments or particularly sensitive environmental areas They are summarised in Table 2-1, over page.

Table 2-1: Stormwater treatment objectives for Victoria and New South Wales (after Table 1.2, *ARQ*, 2006)

Pollutant	Stormwater treatment objective
Total Suspended Solids (TSS)	80% retention of average annual load
Total Phosphorus (TP)	45% retention of average annual load
Total Nitrogen (TN)	45% retention of average annual load

3. Surface runoff (stormwater) hydrology

This section discusses the results from DRAINS computer modelling to investigate the potential impact of the development on local surface runoff flow rates, and flow rates within the receiving waters.

3.1 DRAINS models

Hydrological assessment was carried out for two different scenarios using *DRAINS – Urban Drainage Model*. Preparation of the two DRAINS models involved:

1) Development of an 'existing' scenario model in DRAINS, using detailed survey data and other topographical data for upstream catchment areas.
2) Update of the 'existing' DRAINS model to include the change in site features that could arise due to development as noted on the concept Masterplan.

3.1.1 Model subcatchment data

DRAINS model subcatchment plans for existing and developed scenarios are shown on Figures 7 and 8, respectively. DRAINS model input data is summarised in Appendix B.

Note that the total increase in impervious area (as a proportion of the entire development site) is expected to be less than 5%. The increase in percentage impervious for individual local subcatchments is expected to vary between 0% and 11%. To place these figures into context, low density residential development generally increases the percentage impervious by approximately 60%, which more intense commercial and industrial development increasing the percentage impervious by up to 90% or more. Hence, the Proposed Development is considered to be low impact in this regard.

3.1.2 Design rainfall

The DRAINS models were run using *Australian Rainfall and Runoff* (ARR, Engineers Australia, 1997) design storms of varying durations from 15 minutes to 6 hours, for ARI's of 1, 5, 10, 20 and 100 years.

A summary of the Intensity-Frequency-Duration (IFD) rainfall parameters used in the DRAINS models is provided below. Note that the 2-year and 50-year rainfall intensities were obtained from WSC's Specification 'D5' for the Tahmoor area.

Catchment Skewness = 0.02		
2-year ARI,	1 hour intensity =	30.0 mm/hr
	12 hour intensity =	7.2 mm/hr
	72 hour intensity =	2.1 mm/hr
50-year ARI,	1 hour intensity =	62.1 mm/hr
	12 hour intensity =	14.2 mm/hr
	72 hour intensity =	4.7 mm/hr
Frequency Factors	$F_2 = 4.29$	
	$F_{50} = 15.77$	

The critical storm duration for each ARI was selected as the duration that produced the highest DRAINS model peak flow rate at each of the nominated outfall locations shown on Figures 7 and 8.

3.1.3 Loss parameters

Table 3-1 summarises the catchment storage and loss parameter values adopted in the DRAINS models. The loss parameter values were obtained from WSC's Specification D5, Section *D5-07*. Note that the RAFTS hydrologic module was used in DRAINS.

Table 3-1: Storage and loss parameter values adopted for the RAFTS hydrologic module in DRAINS

Parameter	Value
Storage Multiplier, Bx	1.4
Pervious Area Initial Loss (mm)	10.0
Pervious Area Continuing Loss (mm)	2.5
Impervious Area Initial Loss (mm)	0.0
Impervious Area Continuing Loss (mm)	0.0

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Scale 1:5,000 (A3) 100m 0 100 200 300m

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Legend

Existing Major Creek / River
Existing Local Drainage Path
Existing subcatchment boundary
Existing Regional Contours (10m Interval)
Existing Local Site Contours (1m Interval)
[N1] Model subcatchment

Existing Model Subcatchment Plan

Figure 7

Client: EG Property Group
Project: Tourism and Recreation Precinct WSUD Study for Rezoning
Location: Tahmoor, NSW

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Scale 1:5,000 (A3) 0 100 200 300m 100m

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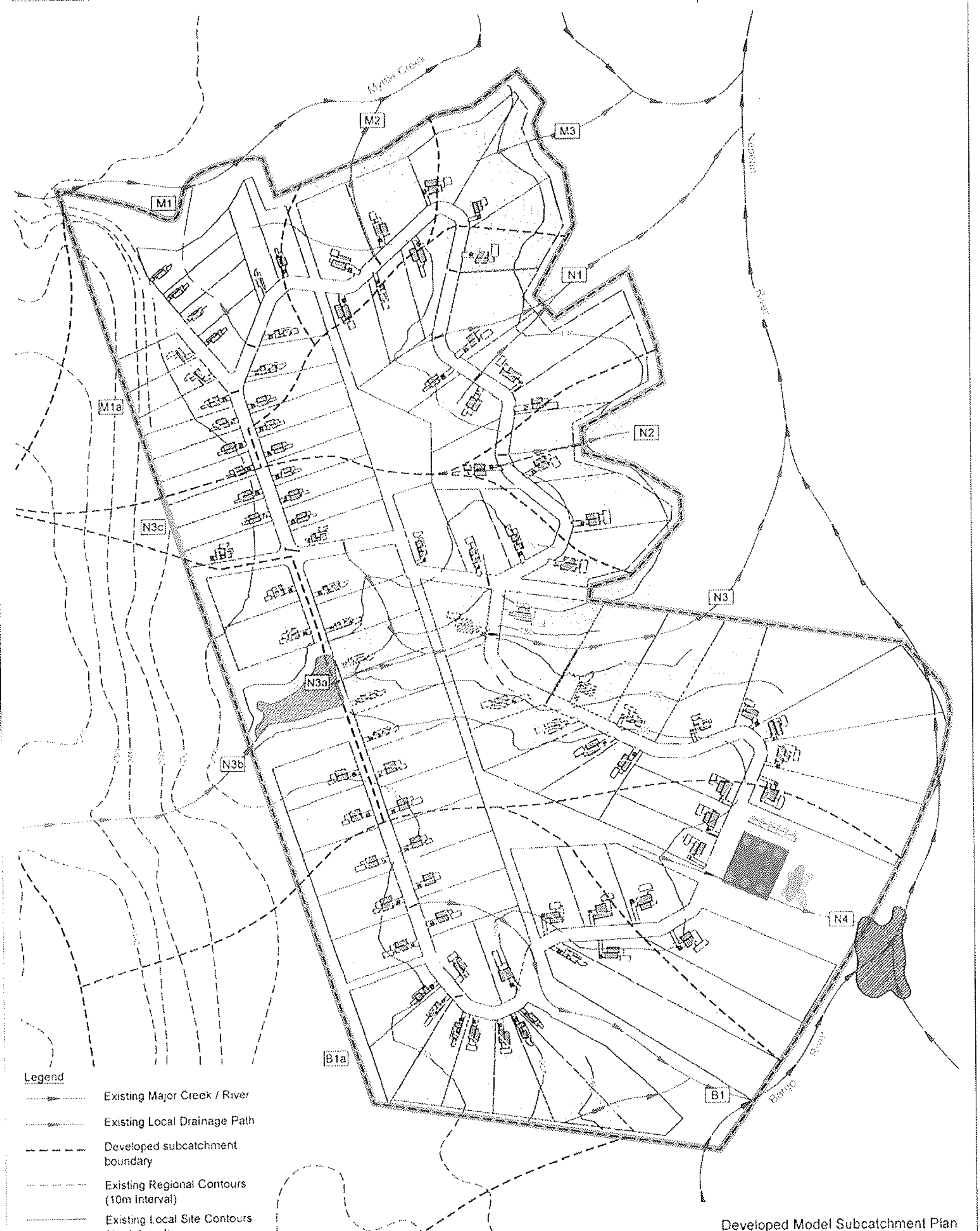


Developed Model Subcatchment Plan

Figure 8

3.2 Regional flow rates

Flow rates in the receiving waters immediately downstream of the site were estimated using the Probabilistic Rational Method, and are summarised in Table 3-2. The flow rates for the 100 year ARI event compare well with estimates in Worley Parsons (2010), which were discussed in Section 1.6. Rational Method calculations are provided in Appendix C.

Table 3-2: Estimated peak flow rates in the receiving waters for 1, 5, 10, 20 and 100 year ARI events from the regional catchment (using Probabilistic Rational Method)

Receiving water	Flow (m^3/s) for ARI				
	1 yr	5 yrs	10 yrs	20 yrs	100 yrs
Myrtle Creek	13	31	40	52	87
Bargo River	132	319	413	536	862
Nepean River	837	2,200	2,950	3,935	5,565

3.3 Existing local flow rates

The results from the existing scenario DRAINS model are provided in Table 3-3. Flow rate locations are indicated on the subcatchment plan (Figure 7).

Table 3-3: DRAINS model results for existing scenario

	Flow (m^3/s) for ARI				
Location	1 yr	5 yrs	10 yrs	20 yrs	100 yrs
M1	0.60	1.47	1.76	2.24	3.22
M2	0.14	0.37	0.45	0.56	0.78
M3	0.11	0.30	0.37	0.46	0.63
N1	0.33	0.92	1.09	1.32	1.90
N2	0.20	0.51	0.60	0.76	1.11
N3	1.94	5.15	6.23	7.70	11.10
N4	0.31	0.87	1.02	1.24	1.80
B1	1.26	3.33	4.07	5.07	7.06

The flow rates in Table 3-3 were found to be generally higher than Rational Method flow estimates for these points. This is considered reasonable given the additional site-specific information that is included in a DRAINS model and the steeper slopes that are present in some portions of the site.

A summary of DRAINS model results by immediate major receiving water is provided in Table 3-4.

Table 3-4: Existing DRAINS model results grouped by flow from this site into the receiving waters

	Flow (m^3/s) for ARI				
Receiving water	**1 yr**	**5 yrs**	**10 ys**	**20 ys**	**100 ys**
Myrtle Ck	0.85	2.14	2.58	3.26	4.63
Bargo River	1.26	3.33	4.07	5.07	7.06
Nepean River	4.89	12.92	15.59	19.35	27.60

From the flow rates from Table 3-4 and the estimated existing flow rates in the receiving waters from Section 3.2, the peak local surface runoff flow rates are equivalent to:

- 6 % of the existing peak flow rates within Myrtle Creek
- 1 % of the existing peak flow rates within Bargo Creek
- Less than 1% of the existing peak flow rates within the Nepean River

The above comparison does not infer that the site's peak local surface runoff flow rates will comprise exactly the above proportions during an actual regional flood event. Rather, it is only intended to indicate the relative magnitudes of local flow rates to receiving body flow rates.

The receiving bodies will tend to experience flow rates magnitudes more frequently than the local surface flow rates. For example, the contribution of the 100 year ARI local surface runoff flow rate to Nepean River (27.6m^3/s) will be experienced by the Nepean River on a much more frequent basis due to regional rainfall, perhaps as frequently as a sub-monthly basis. As another example, the 100 year ARI local surface runoff flow rate to Myrtle Creek could occur within Myrtle Creek perhaps even on a 3 to 6-monthly basis due to rainfall over the more regional catchment. This indicates that there is likely to be a substantial buffer capacity in these receiving bodies to take minor variations in surface runoff flow rates as a result of the small increase in impervious areas on this site following development.

3.4 Post-development local flow rates

The results from the post-development scenario DRAINS model are provided in Table 3-5. The estimated relative increase on existing local flow rates are indicated in brackets. Flow rate locations are indicated on the subcatchment plan (Figure 8). Note that the DRAINS models did not include the on-site stormwater harvesting measures, swales, and other features that may contribute to on-site detention. The analysis is therefore considered quite conservative, and likely over-estimates the post-development surface runoff flow rates and relative increase on existing conditions.

A summary of post-development DRAINS model results by receiving water is provided in Table 3-6. The values in brackets are the potential relative increase (%) on existing local flow rates by receiving water.

Table 3-5: DRAINS model results for post-development scenario

	Flow (m^3/s) for ARI				
Location	**1 yr**	**5 yrs**	**10 ys**	**20 ys**	**100 ys**
M1	0.79 (32%)	1.88 (28%)	2.33 (32%)	2.95 (32%)	4.16 (29%)
M2	0.22 (57%)	0.52 (41%)	0.65 (44%)	0.824 (47%)	1.17 (50%)
M3	0.12 (9%)	0.33 (10%)	0.4 (8%)	0.489 (6%)	0.69 (10%)
N1	0.38 (15%)	0.99 (8%)	1.22 (12%)	1.54 (17%)	2.14 (13%)
N2	0.27 (35%)	0.63 (24%)	0.78 (30%)	0.971 (28%)	1.36 (23%)
N3	2.3 (19%)	5.78 (12%)	6.93 (11%)	8.62 (12%)	12.4 (12%)
N4	0.4 (29%)	1.05 (21%)	1.28 (25%)	1.59 (28%)	2.2 (22%)
B1	1.4 (11%)	3.78 (14%)	4.6 (13%)	5.68 (12%)	7.97 (13%)

Table 3-6: Post-development DRAINS model results grouped by receiving waters

	Flow (m^3/s) for ARI				
Receiving Waters	**1 yr**	**5 yrs**	**10 ys**	**20 ys**	**100 ys**
Myrtle Ck	1.13 (33%)	2.73 (28%)	3.38 (31%)	4.263 (31%)	6.02 (30%)
Nepean River	1.4 (11%)	3.78 (14%)	4.6 (13%)	5.68 (12%)	7.97 (13%)
Bargo River	5.88 (20%)	14.96 (16%)	18.19 (17%)	22.66 (17%)	32.09 (16%)

The above DRAINS model results from Table 3-5 and 3-6 indicate that there may be some increase in local surface runoff flow rates as a result of the development. However, from the post-development model flow rates in Table 3-6, and the regional flow rates in receiving waters (Section 3.2), the increase in local flow rates would be equivalent to:

- 2 % of the existing peak flow rates within Myrtle Creek for equivalent ARI
- 0.1 % of the existing peak flow rates within Bargo River for equivalent ARI
- Less than 0.1% of the existing peak flow rates within Nepean River for equivalent ARI.

Accordingly, it is considered that the proposed development will have negligible increase in surface runoff flow rates within the downstream receiving waters, and on this basis it is not expected that measures specifically intended for the detention of stormwater from the development will be warranted. However, it is noted that there may be opportunities to incorporate on-site detention behind raised road embankment at sag points, should this become desirable for some reason in the future.

Note that in both scenarios the existing dam was not included, which is equivalent to assuming that the dam is full at the start of the rainfall event and no reservoir routing will occur. This is a reasonable approach for this simplified analysis. Future detailed analyses will need to consider this however in order to correctly design the pond outlet and overflow structures and ensure that downstream dwellings will be safe from flooding.

4. Surface runoff (stormwater) quality

This section discusses the results from MUSIC computer modelling to investigate the potential impact of the development on local surface runoff quality.

4.1 MUSIC parameters

4.1.1 Catchment plan and land use types

The existing scenario and post-development scenario MUSIC models employed the subcatchment breakdown as previously indicated on Figures 7 and 8 (refer Section 3). MUSIC model subcatchment data is provided in Appendix D.

The 'existing' land use was conceptualised as an 'agricultural' land use type, and the post-development scenario was modelled as a 'rural residential' land use type. The pollutant generation characteristics of these land use types are summarised Section 4.1.4.

As previously indicated in Section 3, the total site's impervious area may only increase by around 5%, with the increase in percentage impervious of individual local subcatchments varying between 0% and 11%.

4.1.2 Rainfall and evapotranspiration

The closest rainfall gauging station to the site is Picton (Council depot), located approximately 6km north. The Picton gauging station has collected daily rainfall data since 1880, providing a reliable basis for the evaluation of several key long term local rainfall statistics. A summary of these statistics is provided in Table 4-1.

Table 4-1 Annual Rainfall Statistics for Picton (Council Depot) Station #68052

Statistic	Value
Mean Annual Rainfall	802mm
Highest Annual Rainfall	1723mm (1950)
Lowest Annual Rainfall	303mm (1944)
Decile 1 Annual Rainfall	503mm
Decile 5 (Median) Annual Rainfall	754mm
Decile 9 Rainfall	1130mm

Unfortunately, the Picton rainfall station does not have pluviograph data available on a 6 minute time step as required for development of a realistic MUSIC stormwater model. The closest rainfall station with the required data format is Bowral (Parry Drive), located approx. 35km south-west.

Data for Bowral (Parry Drive) spans the period 1992 to 2006. The average annual data for this period was 543mm, and highest annual rainfall of 759mm. This means that the available rainfall dataset is closer to 'dry' conditions for the Tahmoor / Picton area, but does have at least one year that is representative of median annual rainfall conditions. Bowral (Parry Drive) was confirmed as best available for this development site following analysis of several other rainfall stations within a 50km radius.

Monthly average areal potential evapotranspiration (PET) values for the area were estimated from regional mapping developed by BOM. Evapotranspiration values are given in Table 4-2. The resulting estimated total annual areal PET is 1205mm.

Table 4-2: Monthly average areal PET values

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
PET (mm/month)	160	135	105	90	60	45	45	70	90	120	135	150

4.1.3 Time step

The model was run with a time step of 6 minutes. This time step is considered to provide a reasonable compromise between computational speed, file size, model reliability and output sensitivity for this development site.

4.1.4 Event mean concentrations

The MUSIC model requires pollutant generation parameters for baseflow and stormflow conditions. Baseflow is derived from the groundwater store, which is recharged from the pervious soil store. Stormflow is generally generated from the impervious area, and under some conditions the pervious area as well.

The pollutant parameters for the adopted land use types were selected using a combination of values in *Urban Stormwater Quality: A Statistical Overview* (Duncan, 1999) and *Stormwater flow and quality, and the effectiveness of non-proprietary stormwater treatment measures* (Fletcher et al, 2004). The adopted values are summarised in Table 4-3.

Table 4-3: Annual pollutant concentration statistics for the adopted land use types

	Total Suspended Solids (TSS) log_{10} mg/L		Total Phosphorus (TP) log_{10} mg/L		Total Nitrogen (TN) log_{10} mg/L	
	Mean	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**
Agricultural - Baseflow	1.30	0.13	-1.05	0.13	0.04	0.13
Agricultural - Stormflow	2.15	0.31	-0.22	0.3	0.48	0.26
Rural Residential – Baseflow	1.15	0.17	-1.22	0.19	-0.05	0.12
Rural Residential – Stormflow	1.95	0.32	-0.66	0.25	0.30	0.19

4.1.5 Hydrology

Hydrology parameters used in MUSIC for the existing and post-development site states were the default parameters for the Sydney region provided in the MUSIC User Manual, reproduced in Table 4-4.

Table 4-4: Summary of adopted MUSIC hydrologic parameters

State	**Existing** Agricultural	**Post-development** Rural Residential
Impervious Area Properties		
Impervious Percentage	0	Varies (refer to model data)
Rainfall Threshold (mm/day)	1	1
Pervious Area Properties		
Soil Storage Capacity (mm)	200	200
Initial Storage (% of Capacity)	30	30
Field Capacity (mm)	170	170
Infiltration Capacity Coefficient - a	200	200
Infiltration Capacity Exponent - b	1	1
Ground Water Properties		
Initial Depth (mm)	10	10
Daily Recharge Rate (%)	25	25
Daily Baseflow Rate (%)	5	5
Daily Seepage Rate (%)	0	0

4.2 Existing (baseline) MUSIC results

The average annual pollutant loadings from the site for Total Suspended Solids, Total Phosphorus and Total Nitrogen for the existing land use state are shown in

Table 4-5.

Table 4-5: MUSIC predicted average annual pollutant export for existing conditions

Pollutant	Existing average annual pollutant export load
Total Suspended Solids (TSS) (kg/yr)	8,590
Total Phosphorus (TP) (kg/yr)	47
Total Nitrogen (TN) (kg/yr)	185

4.3 Post-development MUSIC results

The average annual pollutant loads predicted by the post-development MUSIC model (including the proposed swales, on-site rainwater harvesting, and pond) are shown in Table 4-6.

Table 4-6: MUSIC predicted average annual pollutant export for post-development conditions (with the identified treatment measures)

Pollutant	Post-development average annual pollutant export load
TSS (kg/yr)	4,840
TP (kg/yr)	27
TN (kg/yr)	225

The post-development MUSIC model results indicate that post-development TSS and TP export could be up to 50% lower and that TN up to 20% higher than existing average annual load. The ARQ treatment criteria (as adopted by most Council's in NSW) is based on a percentage reduction in post-development average annual pollutant export compared with the post-development situation where no controls are provided. This approach acknowledges that it is not generally practical to treat runoff to pre-development conditions, which is only generally adopted in highly sensitive catchments (eg. Sydney's drinking water catchment).

The treatment train effectiveness, expressed as a percentage reduction in post-development pollutant loads generated by the sources (roads, impervious areas, etc), is summarised in Table 4-7.

Table 4-7: Predicted effectiveness of the identified treatment measures for the Proposed Development

Pollutant	Post-development source generation	Export – after treatment	Treatment Train Effectiveness[1]	Treatment Criteria from ARQ
TSS (kg/yr)	26,194	4,841	82%	80%
TP (kg/yr)	66.45	27.02	59%	45%
TN (kg/yr)	406.3	224.1	45%	45%

1. Expressed as a percentage reduction in average annual pollutant load, compared with the situation where no controls are provided (i.e. percentage reduction in post-development 'source' loads).

From Table 4-7 it follows that the treatment train proposed for this site is expected to be effective in reducing post-development average annual pollutant loads in accordance with the ARQ treatment criteria for Water Sensitive Urban Design.

5. Summary and conclusions

RPS has prepared a planning proposal on behalf of the land owner of 165-185 River Road, Tahmoor. The planning proposal outlines the proposed land use zones for the 111ha property, and the reasons why the land owner's vision to convert the site into a Tourism and Recreation Precinct has the potential to make a substantial contribution to the region.

This report has documented an analysis of the local site features and the proposed development concept, and identified a potential concept stormwater management for the future development in accordance with Water Sensitive Urban Design principles.

Several opportunities for WSUD features have been identified for the development, including:

- vegetated swales within the road reserve
- on-site stormwater harvesting measures
- enhancement of an existing farm dam to provide increased aquatic biodiversity and stormwater treatment.

Surface runoff quality modelling was undertaken using the MUSIC computer model for existing and post-development conditions with the identified treatment measures. The MUSIC model results indicate that the overall treatment train effectiveness would meet the criteria outlined in Australian Runoff Quality (Engineers Australia, 2006) for total suspended solids, total nitrogen, and total phosphorus, which are typically key considerations for surface runoff from rural residential developments.

Surface runoff flow rate modelling was undertaken using the DRAINS computer modelling to estimate discharge flow rates from the local drainage lines into the receiving waters for existing and post-development conditions. The magnitude of the flow rates, as well as the anticipated minor increase in flow rates following development of the site, was compared against flow rate estimates within the receiving waters (Nepean River, Myrtle Creek, Bargo River). The comparison indicates that the development will have negligible impact on flow rates within the receiving waters, and that measures above those identified for water quality control are not considered necessary.

Overall, it is considered that the proposed development, consisting of large lot rural residential and some recreational / tourism features, will be a low-impact development in terms of surface water hydrology and water quality.

In summary, the proposed WSUD stormwater management plan would integrate with the future landscaping and urban design features, enhancing the lives of the local community, and provide appropriate level of treatment for surface runoff.

It is the recommendation of this study that the site's surface water hydrology and quality considerations are not considered as constraints that would preclude the development of the proposed Tourism and Recreation precinct and further, best practice stormwater management measures would be provided to facilitate the proposed development.

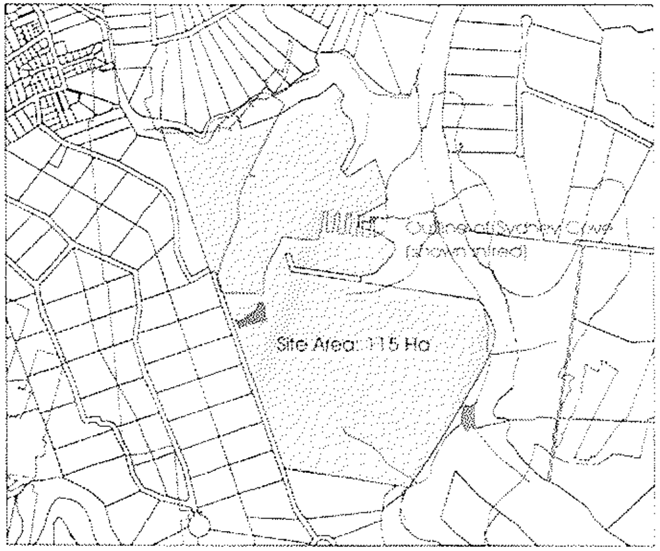
The site's stormwater management concept can be further refined in future, in consultation with Council, incorporating the results of detailed site investigation and any further enhancements to the development Masterplan.

Appendix A

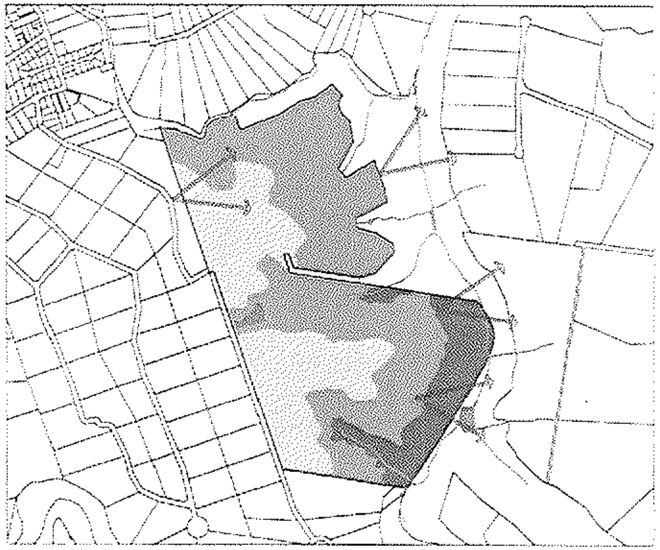
Concept Masterplan

LOOK OUT
0,5 ha ZONING
CENTRAL PARK PLAYGROUND
BIKE / HORSE TRAIL
NATURE EDUCATION WAY
CENTRAL PARK PLAYGROUND
TENNIS COURTS
ACCOMMODATION
CONFERENCE CENTRE
1,5 - 2 ha ZONING
BIKE / HORSE TRAIL
NATURE EDUCATION WAY
LOOK OUT

MASTERPLAN

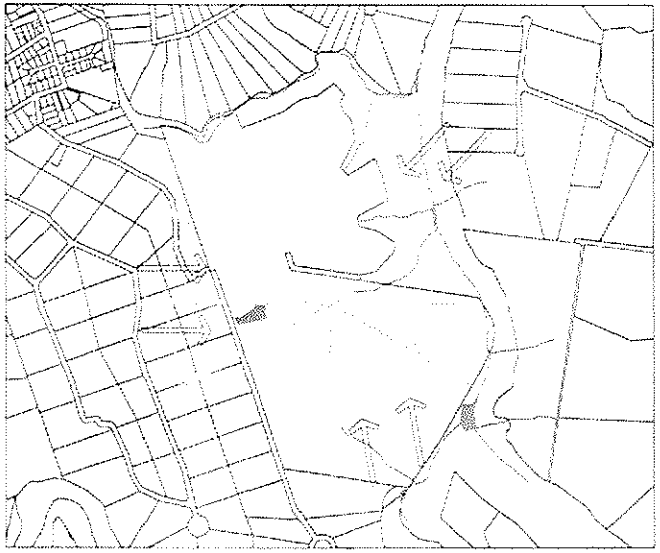


Scale Comparison

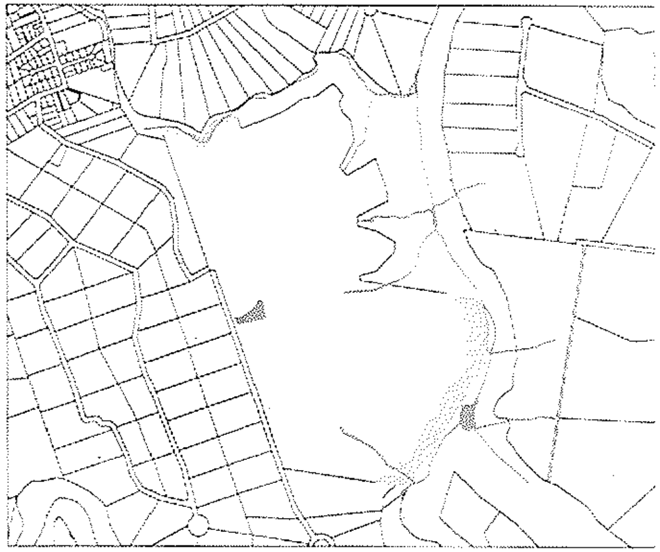


Views Out

EEC Shale Transition Forest



Sun Paths



Waterway Riparian Zones

Asset Protection Zone

Appendix B

DRAINS Model Data

Proposed Tourism and Recreation Precinct, Tahmoor
Water Sensitive Urban Design Report for Rezoning

Appendix B - DRAINS Model Subcatchment Data
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EXISTING SCENARIO DRAINS MODEL

Subcatchment	Total Area (ha)	% Impervious	Average Slope (%)
M1	10.57	0%	10%
M1a	4.23	0%	15%
M2	4.56	0%	5%
M3	3.55	0%	5%
N1	13.04	0%	5%
N2	4.77	0%	10%
N3	35.96	0%	10%
N3a	5.27	0%	5%
N3b	22.50	0%	15%
N3c	0.97	0%	15%
N4	12.13	0%	5%
B1	22.62	0%	5%
B1a	22.76	0%	15%

DEVELOPED SCENARIO DRAINS MODEL

Subcatchment	Total Area (ha)	% Impervious	Average Slope (%)
M1	11.25	9%	10%
M1a	4.23	0%	15%
M2	4.56	11%	5%
M3	3.55	2%	5%
N1	12.60	5%	5%
N2	4.77	6%	10%
N3	34.20	7%	10%
N3a	6.79	4%	5%
N3b	22.50	0%	15%
N3c	0.97	0%	15%
N4	12.13	7%	5%
B1	22.62	6%	5%
B1a	22.76	0%	15%

	Manning 'n'
Impervious	0.014
Pervious	0.1

Appendix C

Rational Method Calculations

Peak Flow Calcs for Myrtle Creek - Probablistic Rational Method

Equations Extracted from ARR, BOOK VIII, SECTION 1

A	9560000 m^2
	9.56 km^2
Zone	B
$^{50}I_{12}$	13.96 mm/hr
$^{2}I_{12}$	7.08 mm/hr
C_{10}	0.47
t_C	1.79 hours
	107.5 minutes

C Factor Calculations

ARI	C_{10}	FF_Y	C_Y
1	0.47	0.62	0.291
2	0.47	0.74	0.348
5	0.47	0.88	0.414
10	0.47	1	0.470
20	0.47	1.12	0.526
50	0.47	1.27	0.597
100	0.47	1.41	0.663

Flow Calculations

ARI	t_C	I range	t_C range	I t_C (mm/hr)	Q (m3/s)
1	107.5	18.31 15.53	90 120	16.69	13
2	107.5	23.79 20.11	90 120	21.64	20
5	107.5	31.05 26.26	90 120	28.26	31
10	107.5	35.39 29.9	90 120	32.19	40
20	107.5	41.06 34.66	90 120	37.33	52
50	107.5	48.56 40.95	90 120	44.12	70
100	107.5	54.33 45.77	90 120	49.34	87

Summary

ARI	C_{10}	t_C (mins)	FF_Y	C_Y	I t_C (mm/hr)	Q (m3/s)
1	0.47	107.5	0.62	0.291	16.69	13
2	0.47	107.5	0.74	0.348	21.64	20
5	0.47	107.5	0.88	0.414	28.26	31
10	0.47	107.5	1.00	0.470	32.19	40
20	0.47	107.5	1.12	0.526	37.33	52
50	0.47	107.5	1.27	0.597	44.12	70
100	0.47	107.5	1.41	0.663	49.34	87

Peak Flow Calcs for Bargo River - Probablistic Rational Method

Equations Extracted from ARR, BOOK VIII, SECTION 1

A	141000000 m^2
	141 km^2
Zone	B
$^{50}I_{12}$	14.98 mm/hr
$^{2}I_{12}$	7.3 mm/hr
C_{10}	0.57
t_C	4.98 hours
	299.0 minutes

C Factor Calculations

ARI	C_{10}	FF_Y	C_Y
1	0.57	0.62	0.353
2	0.57	0.74	0.422
5	0.57	0.88	0.502
10	0.57	1	0.570
20	0.57	1.12	0.638
50	0.57	1.24	0.707
100	0.57	1.36	0.775

Flow Calculations

ARI	t_C	I range	t_C range	I t_C (mm/hr)	Q (m3/s)
1	299.0	10.07 8.48	270 360	9.56	132
2	299.0	13.05 11	270 360	12.39	205
5	299.0	17.08 14.4	270 360	16.22	319
10	299.0	19.47 16.42	270 360	18.49	413
20	299.0	22.59 19.05	270 360	21.45	536
50	299.0	26.72 22.54	270 360	25.37	703
100	299.0	29.89 25.22	270 360	28.39	862

Summary

ARI	C_{10}	t_C (mins)	FF_Y	C_Y	I t_C (mm/hr)	Q (m3/s)
1	0.57	299.0	0.62	0.353	9.56	132
2	0.57	299.0	0.74	0.422	12.39	205
5	0.57	299.0	0.88	0.502	16.22	319
10	0.57	299.0	1.00	0.570	18.49	413
20	0.57	299.0	1.12	0.638	21.45	536
50	0.57	299.0	1.24	0.707	25.37	703
100	0.57	299.0	1.36	0.775	28.39	862

Peak Flow Calcs for Upper Nepean River - Probablistic Rational Method

Equations Extracted from ARR, BOOK VIII, SECTION 1

A	705000000 m^2
	705 km^2
Zone	B
$^{50}I_{12}$	20.84 mm/hr
$^{2}I_{12}$	8.56 mm/hr
C_{10}	0.9
t_C	9.19 hours
	551.2 minutes

C Factor Calculations

ARI	C_{10}	FF_Y	C_Y
1	0.9	0.62	0.558
2	0.9	0.74	0.666
5	0.9	0.88	0.792
10	0.9	1	0.900
20	0.9	1.12	1.008
50	0.9	1.10	0.990
100	0.9	1.14	1.026

Flow Calculations

ARI	t_C	I range	t_C range	I t_C (mm/hr)	Q (m3/s)
1	551.2	7.74 6.43	540 720	7.66	838
2	551.2	10.27 8.56	540 720	10.16	1327
5	551.2	14.32 12.04	540 720	14.18	2201
10	551.2	16.87 14.24	540 720	16.71	2947
20	551.2	20.1 17.04	540 720	19.91	3933
50	551.2	24.48 20.84	540 720	24.25	4706
100	551.2	27.92 23.83	540 720	27.67	5563

Summary

ARI	C_{10}	t_C (mins)	FF_Y	C_Y	I t_C (mm/hr)	Q (m3/s)
1	0.90	551.2	0.62	0.558	7.66	838
2	0.90	551.2	0.74	0.666	10.16	1327
5	0.90	551.2	0.88	0.792	14.18	2201
10	0.90	551.2	1.00	0.900	16.71	2947
20	0.90	551.2	1.12	1.008	19.91	3933
50	0.90	551.2	1.10	0.990	24.25	4706
100	0.90	551.2	1.14	1.026	27.67	5563

Appendix D

MUSIC Model Data

Proposed Tourism and Recreation Precinct, Tahmoor
Water Sensitive Urban Design Report for Rezoning

Appendix D - MUSIC Model Subcatchment Data

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DEVELOPED SCENARIO MUSIC MODEL

	No. of Lots / Treatment Train			Roof Area Nodes ('Roofs') 100% Impervious, assume 400m² roof area per lot												Lot Area Nodes ('Rural Residential') 0% Impervious			Road Area Nodes ('Sealed Roads') 100% Impervious, 9m sealed width		Agricultural 0% Impervious
Treatment Train No	1	2	3	1				2				3				1	2	3	1	2	
Treatment Train	RWT, Swale	RWT, Swale, Pond	RWT	RWT, Swale	RWT Vol	RWT Area	Reuse	RWT, Swale, Pond	RWT Vol	RWT Area	Reuse	RWT	RWT Vol	RWT Area	Reuse	Swale	Pond	Bypass	Swale	Swale, Pond	
Catchment				ha	kL	m²	L/day	ha	kL	m²	L/day	ha	kL	m²	L/day	ha	ha	ha	ha	ha	ha
M1	8	0	7	0.320	240	120	6,000	0.000	0	0	0	0.280	210	105	5,250	5.689	0.000	4.536	0.425	0.000	0.000
M1a	0	0	0	0.000	0	0	0	0.000	0	0	0	0.000	0	0	0	0.000	0.000	0.000	0.000	0.000	4.230
M2	3	0	3	0.120	90	45	2,250	0.000	0	0	0	0.120	90	45	2,250	1.177	0.000	2.900	0.243	0.000	0.000
M3	0	0	1	0.000	0	0	0	0.000	0	0	0	0.040	30	15	750	0.150	0.000	3.315	0.045	0.000	0.000
N1	4	0	3	0.160	120	60	3,000	0.000	0	0	0	0.120	90	45	2,250	7.408	0.000	4.579	0.333	0.000	0.000
N2	1	0	2	0.040	30	15	750	0.000	0	0	0	0.080	60	30	1,500	0.646	0.000	3.834	0.170	0.000	0.000
N3	12	0	18	0.480	360	180	9,000	0.000	0	0	0	0.720	540	270	13,500	7.982	0.000	23.887	1.130	0.000	0.000
N3a	0	4	0	0.000	0	0	0	0.160	120	60	3,000	0.000	0	0	0	0.000	6.497	0.000	0.000	0.135	0.000
N3b	0	0	0	0.000	0	0	0	0.000	0	0	0	0.000	0	0	0	0.000	0.000	0.000	0.000	0.000	22.500
N3c	0	0	0	0.000	0	0	0	0.000	0	0	0	0.000	0	0	0	0.000	0.000	0.000	0.000	0.000	0.970
N4	4	0	2	0.160	120	60	3,000	0.000	0	0	0	0.080	60	30	1,500	2.704	0.000	3.566	0.620	0.000	0.000
B1	9	0	11	0.360	270	135	6,750	0.000	0	0	0	0.440	330	165	8,250	6.614	0.000	14.646	0.555	0.000	0.000
B1a	0	0	0	0.000	0	0	0	0.000	0	0	0	0.000	0	0	0	0.000	0.000	0.000	0.000	0.000	22.760

Notes:

1. The DRAINS model data for the existing catchment was used in the existing scenario DRAINS model - refer appendix B.
2. MUSIC model adopts a 'lumped' approach. For example, the application of 240kL rainwater storage is for the entire catchment and needs to be divided by the number of lots to obtain a per-lot rainwater storage.