CAMPBELL ESTATE, CANNING VALE: URBAN WATER MANAGEMENT PLAN

On behalf of :

CITY OF GOSNELLS

Prepared by:
ENV Australia
ACN 091 839 520
Level 7
182 St Georges Terrace
Perth WA 6000
Telephone (08) 9289 8360 Facsimile (08) 9322 4251

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STATEMENT OF LIMITATIONS

Scope of Services

This environmental site assessment report ("the report") has been prepared in accordance with the scope of services set out in the contract, or as otherwise agreed, between the Client and ENV.Australia Pty Ltd (ENV) ("scope of services"). In some circumstances the scope of services may have been limited by a range of factors such as time, budget, access and/or site disturbance constraints.

Reliance on Data

In preparing the report, ENV has relied upon data, surveys, analyses, designs, plans and other information provided by the Client and other individuals and organisations, most of which are referred to in the report ("the data"). Except as otherwise stated in the report, ENV has not verified the accuracy or completeness of the data. To the extent that the statements, opinions, facts, information, conclusions and/or recommendations in the report ("conclusions") are based in whole or part on the data, those conclusions are contingent upon the accuracy and completeness of the data. ENV will not be liable in relation to incorrect conclusions should any data, information or condition be incorrect or have been concealed, withheld, misrepresented or otherwise not fully disclosed to ENV.

Environmental Conclusions

In accordance with the scope of services, ENV has relied upon the data and has conducted environmental field monitoring and/or testing in the preparation of the report. The nature and extent of monitoring and/or testing conducted is described in the report.

On all sites, varying degrees of non-uniformity of the vertical and horizontal soil or groundwater conditions are encountered. Hence no monitoring, common testing or sampling technique can eliminate the possibility that monitoring or testing results/samples are not totally representative of soil and/or groundwater conditions encountered. The conclusions are based upon the data and the environmental field monitoring and/or testing and are therefore merely indicative of the environmental condition of the site at the time of preparing the report, including the presence or otherwise of contaminants or emissions. Also it should be recognised that site conditions, including the extent and concentration of contaminants, can change with time.

Within the limitations imposed by the scope of services, the monitoring, testing, sampling and preparation of this report have been undertaken and performed in a professional manner, in accordance with generally accepted practices and using a degree of skill and care ordinarily exercised by reputable environmental consultants under similar circumstances. No other warranty, expressed or implied, is made.

Report for Benefit of Client

The report has been prepared for the benefit of the Client and no other party. ENV assumes no responsibility and will not be liable to any other person or organisation for or in relation to any matter dealt with or conclusions expressed in the report, or for any loss or damage suffered by any other person or organisation arising from matters dealt with or conclusions expressed in the report (including without limitation matters arising from any negligent act or omission of ENV or for any loss or damage suffered by any other party relying upon the matters dealt with or conclusions expressed in the report). Other parties should not rely upon the report or the accuracy or completeness of any conclusions and should make their own enquiries and obtain independent advice in relation to such matters.

Other Limitations

ENV will not be liable to update or revise the report to take into account any events or emergent circumstances or facts occurring or becoming apparent after the date of the report.

The scope of services did not include any assessment of the title to or ownership of the properties, buildings and structures referred to in the report nor the application or interpretation of laws in the jurisdiction in which those properties, buildings and structures are located.

EXECUTIVE SUMMARY

The City of Gosnells (the City) has granted approval to to develop a portion of the land bound by Nicholson Road, Ranford Road and Campbell Road, Canning Vale (hereafter Campbell Estate). The development proposal is based on an Outline Development Plan (October 2004), and Addendum to the Outline Development Plan (June 2005) produced by Roberts Day Town Planning and Design 2004.The West Canning Vale Outline Development Plan (ODP) provides a framework for the progressive subdivision and development of the area bounded by Campbell, Nicholson and Ranford Roads. The ODP has been approved by both the City of Gosnells and the Western Australian Planning Commission.

On the advice of the Environmental Protection Authority and the Hon. Minister for the Environment, the City of Gosnells has recognised that an Urban Water Management Plan and Wetland Management Plan are critical to facilitate to the future development of the area, ensuring that a range of environmental objectives are achieved. The objectives of the Urban Water Management Plan (UWMP) are to address the following factors:

- water quality, quantity and conservation mechanisms;
- broad drainage design; and
- location of drainage swales and other drainage infrastructure.

This document is a draft for stakeholder review and has been released for public comment prior to finalisation. The document represents a strategy to address the entire ODP area and more detailed work, such as sizing and locations of swales and drains, will occur through the subdivision process.

The main recommendations of the Plan are:

Drainage System

- The district drainage system will accept water from roads, some lots and public open space. In the north of the site, where the potential for infiltration is limited, the drainage system will also accept water from household roofs and paved areas.
- The drainage system will be a series of swales and compensating basins designed to limit the peak flow into the downstream Hughes Street Drain. The swales and compensating basins will be vegetated with local sedge and rush species to trap nutrients and sediments where appropriate.

Water Balance

- Maintaining levels of groundwater recharge close to pre-development levels is important to ensure that the wetland does not dry out or become too wet.

Groundwater recharge rates can change after development due to loss of deep rooted vegetation such as trees and excessive use of groundwater.

- It is expected that one third of households in Campbell Estate will have bores for irrigation, in line with the Perth metropolitan average and that the water balance post-development will be similar to the pre-development water balance.

Water Conservation

- Developers should provide householders with information on Waterwise gardening and water efficient appliances at settlement.

- Irrigation of Public Open Space should be managed to minimise the amount of water required.

Water Quality Management

- Developers will provide householders with information on low fertiliser use gardening at settlement.

- The amount of fertiliser used on Public Open Space should be minimised.

Monitoring and Contingency Planning

- Monitoring of surface water nutrient levels will be undertaken to assess the effectiveness of water quality management. If elevated nutrient levels are encountered, the information provided to householders and management of Public Open Space will be reviewed.

- Swales and compensating basins will be inspected annually for blockages, rubbish and vegetation issues.

1 INTRODUCTION

1.1 BACKGROUND

The City of Gosnells (the City) has granted approval to to develop a portion of the land bound by Nicholson Road, Ranford Road and Campbell Road, Canning Vale (hereafter Campbell Estate). The development proposal is based on an Outline Development Plan (October 2004), and Addendum to the Outline Development Plan (June 2005) produced by Roberts Day Town Planning and Design 2004.The West Canning Vale Outline Development Plan (ODP) provides a framework for the progressive subdivision and development of the area bounded by Campbell, Nicholson and Ranford Roads. The ODP has been approved by both the City of Gosnells and the Western Australian Planning Commission.

On the advice of the Environmental Protection Authority and the Hon. Minister for the Environment, the City of Gosnells has recognised that an Urban Water Management Plan and Wetland Management Plan are critical to facilitate to the future development of the area, ensuring that a range of environmental objectives are achieved. The objectives of the Urban Water Management Plan (UWMP) are to address the following factors:

- water quality, quantity and conservation mechanisms;
- broad drainage design; and
- location of drainage swales and other drainage infrastructure.

This UWMP has been prepared to facilitate and guide the future subdivision and development of Campbell Estate. The land has been zoned ‘Residential Development’ under the City of Gosnells Town Planning Scheme No. 6 and ‘Urban’ under Metropolitan Region Scheme.

1.2 OBJECTIVES

An Urban Water Management Plan should aim to manage both water quality and quantity on a subdivision scale. This includes measures to:

- Ensure that groundwater and surface water are managed in such a way that the site does not flood or become waterlogged;
- Reduce water and nutrient use in the subdivision; and
- Reduce water and nutrient export from the site.

In addition to this report, developers will be required to submit a report to the council on how they intend to meet these goals at the subdivision stage. This report would cover issues such as detailed urban water management and Public Open Space management.

2 SITE DESCRIPTION

2.1 RAINFALL AND EVAPORATION

The monthly rainfall, evaporation and net evaporation for Perth Airport are shown in Table 1. Rainfall in Perth occurs predominantly in winter and exceeds evaporation for four months of the year.

	Jan	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*	*Total*
Monthly Rainfall	9	15	16	41	103	168	162	119	72	46	26	11	786
Monthly Evaporation	316	274	245	156	96	66	68	81	108	164	222	282	2079
Net Evaporation	307	259	229	115	-7	-102	-94	-38	36	118	196	271	1292

Table 1 Rainfall and evaporation data for Perth Airport. Negative values denote months where rainfall exceeds evaporation. All values are in millimetres (mm)

2.2 EXISTING LAND USE

The Campbell Estate site is currently divided into 32 individual allotments zoned Residential Development under the City of Gosnells Town Planning Scheme. These lots range from undeveloped bushland to a more cleared state containing houses and gardens. The site forms a triangle bounded by Ranford Road to the north, Nicholson Road to the east and Campbell Road to the west. The approved Outline Development Plan is designed to provide a framework for development of the subdivision area.

2.3 TOPOGRAPHY AND SOILS

The Campbell Estate site is predominantly flat. Most of the site is between 24 and 26 m AHD, with a small hill of up to 35 m AHD in the southern corner of the site (Figure 3). The site slopes very gently in a northerly direction towards Ranford Road.

The site lies within the Southern River landform, described as sandplain with low dunes and many intervening swamps, characterised by iron and humus podsols, peats and clays (Churchward and McArthur, 1980).

Geotechnical investigation by Soil and Rock Engineering (1999) indicated that the soils of the site consisted of sands and silty sands. In the Govan Road area and the central north of the site, the sands had a high organic content. Coffee Rock was encountered at depths between 1.2 m and 5 m over all the site, except for the central and eastern parts close to Ranford Road.

2.4 SURFACE AND GROUNDWATER HYDROLOGY

2.4.1 Surface Hydrology

The surface expressions of water on the site are limited to artificial dams and some small local drains which run parallel to Campbell Road (Figure 4). These drains are designed to take additional stormwater from the roads and lots of the estate.

2.4.2 Groundwater Hydrology

Groundwater flow direction on the site is northerly, towards Southern River. The Average Annual Maximum Groundwater Level (AAMGL) across the site varies between 26 m AHD in the south of the site and 23 m AHD in the north (Figure 5). The depth to AAMGL varies between 4.6 m at the top of the hill in the southern corner of the site to roughly 0.5 m AHD to a minimum of 0.44 m AHD in the north-eastern section of the site (JDA, 2005). In general, the depth to AAMGL in the central and northern sections is less than 1 m, while in the south and south-eastern sections, the depth is greater than 1 m. The depth to groundwater will vary seasonally, with levels generally peaking in September or October.

Where coffee rock is present, the water table may be perched during summer. However, perching is probably limited as recorded water levels in coffee rock affected areas are similar to those in surrounding areas where coffee rock does not occur.

2.5 WETLANDS

The central and northern portion of the site forms part of a wetland system that would have extended beyond the site before urbanisation. The wetland areas of the site are damplands, and do not become flooded or inundated on a regular basis. However, maximum groundwater levels in these areas is very close to the surface and the soils are peatier than in surrounding areas.

Some parts of the wetland area are in very good condition and are considered by the Department of Environment (DoE) to constitute Conservation Category Wetlands (Figure°6). This is the highest category of protection that a wetland can obtain. Conservation Category wetlands in the north-east and central eastern parts of the site will be protected under the current Outline Development Plan. These wetlands will generally have a 50 m buffer area between the wetland and residential development.

This report does not aim to cover the wetlands in detail, except where this relates to the drainage and nutrient management on the site. Further description of the wetlands and their management is given in the Wetland Conservation Management Plan for the site (ENV, 2005).

2.6 VEGETATION

A rare flora search and vegetation survey of Campbell Estate indicates that the remnant vegetation is an example of the Southern River Complex (BBG, 1999). Four plant communities were mapped in the area, including:

- *Banksia attenuata – Banksia menziesii* Low Open Forest to low woodland;
- *Melaleuca preissiana* Low Woodland to Low Open Woodland;
- *Perycalymma ellipticum* Closed Heath; and
- Cleared and Parkland Cleared areas.

The condition of the vegetation on the site ranged from completely cleared to some areas of native vegetation in Very Good to Excellent condition. The vegetation and associated issues are further discussed in the *Wetland and Conservation Management Plan.*

3 DRAINAGE CONCEPT

3.1 DRAINAGE CONSTRAINTS

Drainage design in Western Australia is guided by the principles of Water Sensitive Urban Design (WSUD). These principles aim to maintain the hydrological balance of an area in as natural a state as possible while avoiding the flooding issues that can be caused by poor drainage design. The general principles of WSUD are to:

1. Retain and restore natural drainage lines – retain and restore existing valuable elements of the natural drainage system;

2. Implement non-structural source controls – planning, organisation and behavioural techniques to minimise the amount of pollution entering the drainage system;

3. Minimising runoff – by maximising local infiltration of rainfall as high in the catchment as possible; and

4. Use in-system management measures – collect and treat runoff where local infiltration is not practicable due to local hydrologic conditions. (EPA, 2005)

The drainage system must also seek to maintain the groundwater levels in the Conservation Category Wetland (CCW) areas in the east of the site. This includes ensuring that recharge is adequate to maintain the required groundwater levels upon which the CCW ecosystem is dependant. No direct drainage discharge into the CCW will be allowed.

The Campbell Estate drainage design will focus on the use of in-system management measures and some non-structural source controls. The high groundwater tables over the site and presence of impervious coffee rock means that the potential for local infiltration on the site is limited. The drainage system has been designed to balance these constraints and the principles of WSUD.

3.2 DRAINAGE DESIGN

3.2.1 Drainage Catchments

Based on the topography of the site, the development has been divided into four main drainage catchments, CE1, CE3A, CE3B and CE4 (Figure 7 and Appendix B). These catchments can be described as:

- Catchment CE1: The southern portion of the property with a total area of 17.8 ha. This area has a depth to Average Annual Maximum Groundwater Level (AAMGL) of greater than 1 m. As such, the house lots do not require a drainage connection for roof runoff or subsurface drainage;

- Catchment CE3A: The central portion of the property. This catchment has a minimum depth to AAMGL of less than 1 m. Because of this, infiltration of roof runoff is difficult and each lot will require a drain connection for roof runoff and subsurface drainage or lot filling to achieve the necessary clearance;

- Catchment CE3B: The north-eastern corner. This catchment also has shallow groundwater and will require a lot and subsurface drainage connection or lot filling to achieve the necessary clearance; and

- Catchment CE4: The north-western corner of the site. This catchment also requires lot and subsurface drainage.

A conceptual stormwater system has been designed by JDA in association with Ewing Consulting Engineers (ECE). The drainage water will be managed through a series of generally dry basins and swales through the buffers and Public Open Space adjacent to the wetland areas. The basins have been designed to detain and manage the 1 in 10 year storm within the main part of the basin, with the 1 in 100 year storm being able to be generally contained within the freeboard. From the basins in CE4 and CE3B, water will be piped under Ranford Road and into the Hughes Street Main Drain. Because of size restrictions in the Hughes Street Drain, Water Corporation has limited the total outflow rate for the 1 in 10 year storm been limited to 111 L/s.

The swales have been designed with a maximum batter of 1 in 6. This is adequate to avoid erosion issues associated with steep banks. The swales between the two Conservation Category Wetland areas will be a minimum of 5 metres wide to allow the protected bandicoots to move between the two areas. Bandicoots will only move through areas of thick sedge or shrubs.

The total basin area is estimated at 2.03 ha. The basins will all be less than 1 m deep, and generally less than 0.5 m deep when retaining the 1 in 10 year storm. The base of the basins and swales will be 0.5 m above the AAMGL to ensure that the basin is dry when not required for drainage. Maintaining the drainage system above the AAMGL also protects the wetland. As the drainage system is well above the AAMGL, groundwater will only flow into the drains from the wetland after extreme rainfall events. Having a drainage system that is dry except after rain reduces the risk of mosquito breeding in the system to almost zero.

3.2.2 Groundwater Tables

Construction of housing generally requires a minimum clearance of 1.5 m between the groundwater table and the foundations. Given the depths to groundwater over parts of the site, some areas will require either filling or subsurface drainage for development to occur. Of the two options, filling is preferred for a number of reasons:

- Subsurface drainage is usually undertaken at the AAMGL level. Subsurface drainage close to wetlands affects both the level of groundwater reached and the amount of groundwater recharge in the wetland. Reducing the amount of recharge can effectively 'dry out' a wetland.
- The main portions of the drainage system are designed to be kept dry (ie with their base at 0.5 m above AAMGL). Requiring lot drainage at AAMGL to drain into a channel at 0.5 m above that height would require pumping. Pumps are almost always cost prohibitive in drainage systems in terms of both infrastructure and maintenance costs.
- Filling can allow on-site infiltration of rainwater via soak wells that would otherwise be required to be transported off site. This increases infrastructure costs and goes against the principles of Water Sensitive Urban Design.

While subsurface drainage should not be used extensively or close to the wetland, the issue is best addressed at the subdivision stage of planning. At this point, the use of subsurface drainage and/or filling must be addressed to the satisfaction of the City of Gosnells.

3.3 COMPLIANCE WITH DEPARTMENT OF ENVIRONMENT STORMWATER MANAGEMENT PRINCIPLES

The primary aim for stormwater management within the subdivision is to minimise collection where possible and retain and treat stormwater where discharge is required. In addition, stormwater management on this site needs to ensure that the dampland characteristics of the Conservation Category Wetland are maintained. On-site retention and infiltration of stormwater (where feasible) will help to limit the impact of the development on the surrounding catchment and will assist in ensuring compliance with EPA principles given in Section 3.1.

The EPA principles have been integrated into Water Sensitive Urban Design (WSUD). The objectives of WSUD (CSIRO, 1999) are to:

- **Protect natural systems** - protect and enhance natural water systems within urban developments;

- **Integrate stormwater treatment into the landscape** - use stormwater in the landscape by incorporating multiple use corridors that maximise the visual and recreational amenity of developments;

- **Protect water quality** - protect the quality of water draining from urban development;

- **Reduce run-off and peak flows** - reduce peak flows from urban development by local detention measures and minimising impervious areas; and

- **Add value while minimising development costs** - minimise the drainage infrastructure cost of development.

JDA and ECE confirm that the preliminary engineering design includes the principles of WSUD through the following initiatives:

- Infiltrating water from lots where possible;

- Use of flush-edged kerbing adjacent to POS, where the water can cross-flow into basins or swales;

- Implementing a system of vegetated dry compensating basin structures in POS for the treatment of water that cannot be disposed of at source; and

- Vegetating basins and swales for nutrient stripping and detention. Where these structures are adjacent to wetlands, local species will be used (refer to the Wetland Conservation Area Management Plan (ENV, 2005)).

In the case of this catchment, the use of basins and swales for infiltration is not feasible because of the high groundwater table on site, which limits the capacity for infiltration. This is also true for infiltration from lots over much of the site. Road swales are not considered appropriate for the development because of the narrowness of the road reserves.

3.4 COMPLIANCE WITH WESTERN AUSTRALIAN PLANNING COMMISSION PLANNING BULLETIN NO. 61

Planning Bulletin No. 61: Urban Water Management (2004) represents the Western Australian Planning Commission (WAPC)'s guidelines and recommendations for urban stormwater management. The Bulletin recognises the needs for stormwater management in terms of flooding prevention and recognises the need for stormwater quality and quantity to be managed prior to reaching a receiving water body.

The Bulletin also endorses the work of the then Water and Rivers Commission in terms of the *Manual for Managing Urban Stormwater Quality in Western Australia* and *Urban Water Management in WA: Principles and Objectives* as well as the *State Sustainability Strategy*, *State Water Strategy* and WAPC Policies on Subdivision of Land and the Liveable Neighbourhoods Policy.

By planning a liveable neighbourhood that infiltrates stormwater where possible and follows the DoE's philosophy on stormwater, the Campbell Estate complies with WAPC Planning Bulletin No. 61.

3.5 BASIN SIZING AND LOCATION

Whilst basin locations have been chosen to suit the structure planning, some flexibility can be allowed within the areas set aside for Public Open Space to best suit final planning and topographic constraints. When the basins are built, they will be first marked on the ground and then assessed to see if the shape can be altered to minimise the clearing required without compromising on the storage volume. Already degraded areas and areas better suited to final designs will be preferred for clearing over better quality bushland. Basins should be located as close as possible to the edge of the buffer.

Basin	Base Area (ha)
CE1	0.28
CE3A	0.28
CE3B	0.38
CE4	0.72

Table 2 Basin base areas (JDA, 2005). The total area of the basin is larger than the base area and will depend to some extent on the shape of the basin.

Basin sizes required for the ODP area are given in Table 2. While basin sizes are known, the preliminary engineering design of the basins and swales will not be undertaken until the basin locations are confirmed. This design will be used to provide preliminary costings and to differentiate between district level infrastructure and subdivisional works.

3.6 MAINTENANCE

Maintenance of drainage systems is generally undertaken by the developer for the first year and then handed over to the City of Gosnells. While the systems proposed here are not unusual, some points need to be made:

Vegetated swales and compensating basins require some maintenance with respect to the build up of vegetation, rubbish and sediment. In particular:

- Debris should be removed to prevent the system becoming blocked.
- Basins and swales with native vegetation should be inspected every summer to determine the condition and volume of vegetation. Where the vegetation has become too thick and is blocking the drain, it shall be thinned or cut back. Areas that have become bare and are eroding should be replanted.
- Weed management for the swales shall be addressed as part of the wetland Weed Management Strategy. Exotic weeds should be removed when found.
- Drainage structures covered in grass or non-native vegetation should not be fertilised. Lawn clippings should be removed and composted.
- All lot drainage will be fitted with sand traps to ensure that sand and sediment do not build up in the swales. Householders are responsible for the maintenance of their own sand traps.
- Street-sweeping should be undertaken to reduce particulate build-up on the road surface and in gutters.

Street sweeping is an effective way of reducing the load of sediments and nutrients entering the drainage system. During housing construction, sediment and nutrient loads are elevated due to the lack of vegetation on lots and the higher levels of fertiliser associated with establishing lawns and gardens. Erosion from lots and sand piles can cause blockages of the swales and reduce their effective volume. During development, street sweeping shall take place on a minimum of monthly basis during winter and regularly during summer to minimise the impact of development on the swales and drainage water quality. Once the area has been developed, street sweeping should take place twice a year - once prior to the first winter rains and once during the winter wet period (DoE, in publication).

3.7 STAGING

Because the Campbell site is owned by a number of different landowners, parts of the catchment may be developed before other areas. If the desired swale and basin areas are not available at the start of the project, temporary basins will be developed and connected to the Hughes Road Main Drain or other drainage outlets through pipes or the existing drainage network. The detailed drainage design for this area will be developed after the UWMP is finalised.

Temporary basins must not be constructed without the approval of the council for both the basin and the clearing associated with developing such a basin. Once the proposed swale and basin areas are available, the temporary basins may be filled in and the land used for other purposes.

4 WATER QUANTITY MANAGEMENT

4.1 OBJECTIVE

One of the objectives of stormwater management in Western Australia is "to maintain the total water cycle balance within development areas relative to the pre-development." After development, the amount of recharge into a catchment may increase due to the decrease in water uptake by vegetation and the use of irrigation, or decrease where excessive groundwater extraction occurs.

The aim of water balance modelling in this catchment was to investigate ways to maintain the total water cycle balance and groundwater levels in the dampland. Dampland vegetation requires a winter groundwater level that is adequate to stimulate growth. If the winter groundwater level is not high enough, annual vegetation will not germinate and may die out. To ensure that this does not happen, the groundwater recharge should be preserved after development has occurred.

4.2 WATER BALANCE MODEL

To investigate the impact of development upon groundwater recharge, pre-development water balance was undertaken and then compared to four post-development scenarios. The post-development scenarios were:

- All irrigation from scheme water;
- Grassed POS irrigated by bore water and no household bores;
- Grassed POS irrigated by scheme water and one third of households having a bore; and
- All irrigation from bores.

Results from the ENV Water Balance Model are shown in Table 3 and Appendix A.

Assuming that 30% of lots do not have lot drainage[1] and all irrigation occurs via scheme water, the model indicates a124% increase in recharge to groundwater after development due to the higher rates of infiltration from grassed areas and the hard surfaces that are not connected to lot drainage. If only the grassed areas of POS are irrigated by bore, there will still be a net increase in groundwater recharge from the estate. However, if all the households and POS use bore water for irrigation, the situation reverses and the estate will use more water than it recharges. This would effectively dry out the wetland and potentially lead to exposure of acid sulphate soils. It is therefore not appropriate for households to be encouraged to have bores in this area.

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[1] This assumption is based on all catchments except Catchment CE1 having lot drainage (G.Locke, ECE, pers. comm.)

	Recharge (ML/yr)	% of Pre-development recharge
Pre-development	91.3	100%
All irrigation from scheme water	204.4	224%
POS irrigated by bore water and no household bores	141.1	154%
POS irrigated by bore water and one third of households having a bore	93.6	102%
POS irrigated by bore water and all households having a bore	-53.8	-59%

Table 3 Results of Water Balance Modelling.

Water Corporation estimates that approximately one third of Perth households have a bore (R. Burton, Pers. Comm). If this rate of bore use occurs at Campbell Estate and bore water is used for POS irrigation (as is common for residential estates), the post-development recharge rate will be similar to that experienced pre-development. This scenario is considered to be most appropriate as it maintains the pre-development water balance, and therefore wetland health, while allowing for the excess water infiltrating from grassed areas and hard surfaces in the development to be used efficiently.

4.3 WATER CONSERVATION

Average Perth household scheme water use has been estimated at 1259 L/house/day, of which approximately 56% is used for external uses such as gardens and swimming pools (Table 4) (Water Corporation, 2003). Assuming that 520 houses will be built at Campbell, this gives a total scheme water usage of 239 ML/year.

	Water Usage (L/house/day)	Estate Total (ML/year)
External Use	707	134
Internal Use	523	99
Leaks	29	6
Total Use	**1259**	**239**

Table 4 Average Perth household water use for single dwellings (based on Water Corporation, 2003)

Scheme water will be imported onto the Campbell Estate site for internal and external household use. Wastewater from internal household use will be exported from the site via the Water Corporation wastewater system. Reducing scheme water use in this system can either be undertaken by reduction of use through water saving devices and low water use gardens (which will also lead to a reduction in wastewater volumes) or by substitution with other sources.

4.3.1 Reduction of Water Use

Water conservation has been pushed strongly into the consciousness of new homeowners Western Australia over the last few years. Potential home owners can visit Waterwise Display Villages and use the large amount of information provided by Water Corporation on reducing water use in new homes and gardens. Development at Campbell Estate will encourage new households to reduce their water use by tapping into the information already provided by Water Corporation and other bodies such as Swan River Trust. In particular:

- Householders will be provided with relevant flyers on water efficiency when purchasing land;
- Any household landscaping packages should be developed using Waterwise accredited landscapers and irrigation specialists where appropriate; and
- Any display homes built in Campbell Estate should use and display Waterwise principles in both the house and garden.

4.3.2 Scheme Water Substitution

Scheme water substitution involves the use of groundwater, rainwater stored in tanks or grey water for the purposes which scheme water is normally used. Based on the Water Balance Model, encouraging groundwater usage at Campbell Estate may lower the recharge rate and hence affect the wetland. The use of other sources such as grey water and rainwater is more appropriate and should be encouraged to reduce the volume of scheme water imported. However, such practices are not currently widespread and are still being studied by Water Corporation, Department of Health and other stakeholders. Guidelines for domestic use for these water sources are still being developed. Because of this, it is felt that the issue of scheme water substitution is better managed at a later date when the Subdivision Level Urban Water Management Plans are developed.

4.4 IRRIGATION MANAGEMENT

The irrigation regime for the POS will vary in accordance with seasonal requirements. The *Environmental Guidelines for the Establishment and Maintenance of Turf and Grassed Areas* (DEP/WRC, 2001) recommends that irrigation occurs at a rate of 60% of the pan evaporation rate. Pan evaporation rates and a suggested irrigation program are given in Table 5. During the initial POS establishment phase, irrigation rates may be higher than the rates proposed for the standard watering schedules.

Time of year	**Average Daily Pan Evaporation (recommended irrigation)**	**Irrigation Program**	
		Irrigation Frequency	**Irrigation Rate**
Nov - Feb	Nov – 7.4 mm (4.4 mm) Dec – 9.1 mm (5.5 mm) Jan – 10.2 mm (6.1 mm) Feb – 9.8 mm (5.9 mm)	Every Second Day	10 mm per watering event (average 5 mm/day)
Mar - Apr	Mar – 7.9 mm (4.7 mm) Apr – 5.2 mm (3.1 mm)	Twice per week	10 mm per watering event (average 3 mm/day)
May - Aug	May – 3.1 mm (1.9 mm) June – 2.2 mm (1.3 mm) July – 2.2 mm (1.3 mm) Aug – 2.6 mm (1.6 mm)	As required for system maintenance (may be 5 mm/week)	Negligible. Rainfall usually exceeds evaporation for much of this period.
Sept - Oct	Sept – 3.6 mm (2.2 mm) Oct – 5.3 mm (3.2 mm)	Twice per week	10 mm per watering event (average 3 mm/day)

Table 5 Pan evaporation rates and irrigation rates for the Public Open Space. Pan evaporation rates for Perth Airport courtesy of Bureau of Meterology

The irrigation system will be monitored by the landscape contractors and adjusted where necessary in response to climatic conditions such as unseasonable rain or sun. Watering will be conducted early in the morning to coincide with the coolest part of the day. The irrigation system shall comply with the City of Gosnells specifications for POS irrigation systems. As a minimum, the infrastructure will be compatible with the City's Maxicom Central Control system for irrigation.

5 WATER QUALITY MANAGEMENT

5.1 WATER QUALITY AND NUTRIENT MANAGEMENT

Water quality management refers to the quality of both the stormwater and groundwater on the site. The most important factor in both stormwater and groundwater quality is the level of nitrogen and phosphorus nutrients, which can cause algal blooms and eutrophication in rivers and lakes.

The primary source of nutrients associated with sewered residential development is from fertilisers applied to POS and residential gardens. Although the majority of fertilisers applied to lawns and gardens are absorbed by the targeted vegetation, the inappropriate timing of fertilisers (eg prior to a large storm) or use in excess of manufacturers' recommendations may result in unnecessarily high levels of nutrients entering the drainage and groundwater systems. The management of water quality in a residential development should therefore concentrate on the management of POS and residential gardens.

5.2 WATER QUALITY AND CRITERIA

Water quality on site was measured by JDA in August 2005. The results are given in Table 6. The low electrical conductivity indicates that the water is fresh. Phosphorus levels in the water were generally lower than background levels found in the Perth region (JDA, 2005). The nitrogen concentrations are similar to levels found in the Perth region (JDA, 2005). Most of the nitrogen was in the form of Kjeldahl nitrogen rather than nitrate or ammonia (JDA, 2005).

Bore	**Electrical Conductivity (μS/cm)**	**Total Dissolved Salts (mg/L)**	**pH**	**Total Nitrogen (mg/L)**	**Total Phosphorus (mg/L)**	**AAMGL (m AHD)**
G2	950	522	3.30	2.3	<0.01	25.67
G5	630	346	5.10	2.2	<0.01	22.76
G7	150	82	5.10	3.8	<0.01	25.08
G9	430	236	4.85	5.3	0.06	23.39
G10	550	305	5.70	4.8	0.09	23.62
G12	160	88	4.35	2.2	<0.01	25.24
Average	478	263	4.73	3.4	0.03	-

Table 6 Groundwater Quality Results and AAMGLs

Urbanisation on the Swan Coastal Plain tends to increase the levels of nitrogen and phosphorus in the groundwater and in runoff from the site. This is due to the large input of nutrients from fertilisers and animal waste and the poor nutrient retention characteristics of Swan Coastal Plain soils. Studies undertaken in the Canning Vale area show that most of the nutrient input comes from fertilisers applied by householders to lawns and gardens (JDA, 2002). Nutrient management for both Public Open Space and households will be important in ensuring that nutrient levels are managed during and after development.

Water quality monitoring and contingencies are discussed in Section 6.2.

5.3 PUBLIC OPEN SPACE MANAGEMENT

Landscaping within the drainage structures and POS area adjacent to the wetlands should consist of native vegetation. Once this vegetation is established, it may not need irrigation or fertiliser applications. This treatment will also absorb nutrients and act as a filter for sediment.

Verge areas and the public open space areas may be grassed where these are not swales or within the buffer zones for the Conservation Category Wetlands. The nutrient management techniques to be used will include:

- Use of phosphorus-free and slow release fertilisers where possible;
- Minimal application of appropriate fertilisers;
- Appropriate selection of grass species; and
- Planting of native vegetation.

Design of any turf areas will comply with the City of Gosnells' landscaping policy, including the installation of a high phosphate retention index substrate prior to turfing. The fertilising of grassed areas must comply with the City of Gosnells' fertiliser application regime. Leaf tissue and soil analysis will be used to prescribe fertiliser needs. Fertiliser applications will follow the principle of "little and often" with small frequent applications to retain soil nutrient levels at the minimum level required for healthy turf growth rather than provide large doses to create soil storage, which increases the potential for leaching into the groundwater and surface runoff of nutrients. In particular:

- Swale and compensation basin areas and areas of native vegetation will not be fertilised;
- Non-native garden beds will be fertilised with a slow release granular product applied directly to the base of plants when required; and
- The landscaping contractor will keep records of fertiliser application, type and application rate until handover of the POS to the City of Gosnells.

5.4 REHABILITATION AND LANDSCAPING

Landscaping Plans for the POS areas will be formulated as the lots are developed. The plans will be developed by Landscape Designers to the satisfaction of the City of Gosnells. In general, landscaping of the areas along swales and compensating basins adjacent to the bushland will be based on local species.

The landscaping of the wetland and buffer areas will work as a graded system between bushland and residential landscapes with the swale forming a divide between the two. The wetland area will be retained, as will as much of the vegetation on the wetland side of the swale as possible (Figures 8 and 9). Vegetation that must be removed on the wetland side of the swale will be re-established with vegetation of the Southern River Complex, similar to what already exists in the wetland.

The swales and basins will be planted with sedge and rush species. Suggested species include *Baumea juncea*, *Isolepis nodosa, Juncus holosechoenus* and *Juncus pallidus* but other species can be considered with the approval of the City of Gosnells. On the residential side of the swale, the land will be grassed, with local trees such as Banksias, *Eucalyptus marginata* (jarrah) and *Eucalyptus callophylla* (marri) retained or replanted to provide shade. The grass in this area will be treated as a turfed area. The design and management of this area will be undertaken as described in Section 5.3. Paths will be provided in this area as required.

Landscaping on the wetland side of the swale is discussed in more detail in the *Wetland Conservation Area Management Plan* (ENV, 2005).

5.5 HOUSEHOLD NUTRIENT MANAGEMENT

Most of the grassed and garden area in the Campbell Estate will be managed by householders. Householders therefore will be informed of how their actions may impact upon the environment and water quality. Almost all of this impact comes from gardens, and hence information on these impacts will be provided to householders at settlement.

Landscaping packages provided by developers impact upon the garden landscape and hence upon fertiliser use in the estate. Any landscaping packages offered to new residents will include information on water and fertiliser-wise gardening and will not include a minimum allocation of lawn. The package will also provide soil amendment for residential lawn areas.

It is recommended that any in-depth education packages are developed and implemented by the developer. Any scheme should be based on the recommendations of the DoE in Sections 7 and 8 of the *Stormwater Management Manual for Western Australia* (in development).

6 MONITORING AND CONTINGENCY PLANNING

The aim of any monitoring in an area such as Campbell Estate is to determine whether the system is working as required and to make changes where required. The monitoring required in the Campbell Estate is summarised in Section 6.2: Monitoring Schedule. Suggested responses to issues raised in the monitoring are given in Section 6.3: Contingency Schedule.

6.1 WATER QUALITY MONITORING

Monitoring of stormwater quality is important for estimating the total amount of nutrients leaving a site. This determines the water quality downstream of the site and can be used as an early warning sign for changes in groundwater quality. As mentioned in the Wetland Conservation Management Plan, stormwater quality will be monitored for both of these reasons at Campbell.

The drainage system is designed to be a ‘dry’ system and hence water quality must be monitored during or just after rain because no water will be present in the system at other times. Monitoring will include total phosphorus and a total nitrogen suite including nitrate and nitrate, Kjeldahl nitrogen and ammonia. Monitoring should be undertaken twice per year, once after a rain event in April/May and once towards the end of the season in August/September. Samples will be taken at the outlet of each of the compensating basins on the site. Results will be put in a spreadsheet and retained as a historical record of water quality in perpetuity.

Nitrogen and phosphorus levels were measured by JDA in August 2005 (Table 6). This will be complimented by monthly groundwater monitoring between November 2005 and June 2006. This will be used to provide a baseline for post-development stormwater nutrient levels. If the stormwater nutrient levels go above the baseline levels, then the maintenance of the POS will be reassessed and further household education on fertiliser use undertaken.

If the nutrient levels in stormwater are above the guideline levels for more than two years, groundwater monitoring for nutrients should be undertaken.

Groundwater levels will also be monitored in March and September at four bores located on the site. These levels will be compared to the JDA groundwater levels (Appendix B) by a qualified environmental consultant.

All monitoring and analysis is to be undertaken by a qualified environmental scientist.

6.2 MONITORING SCHEDULE

Issue	Parameter	Source/Method	Frequency	Timeframe	Responsibility
Nutrient Management	Surface water quality	Sampling from outlet of each compensating basin	Twice per year after rain – Apr/May and Aug/Sept	Every year from 2005	Developer until asset handover and then council
Wetland levels	Groundwater monitoring	Record levels in the 4 bores, G3, G7, G8 and G9, as per *Wetland Conservation Area Management Plan* (ENV, 2005)	Monthly from November to June 2006 for baseline measurements and then twice per year in March and September. Nutrient levels are also to be measured between November 2005 and June 2006.	Every year from 2005	Developer until asset handover and then council
Landscaping and POS management	Fertiliser application	Keep records of fertiliser application location, type and application rate	As fertiliser applied. Provide records to council quarterly.	From landscaping occurs until handover to council	Landscaping Contractor
Drainage System Management	Hydraulic effectiveness	Inspect for debris and blockages	Annually, prior to first rains (Nov-Jan)	Every year from 2005	Developer until asset handover and then council
	Sedimentation minimisation	Inspect for sediment sources such as erosion of sand	While development is occurring, sweep streets monthly during winter and regularly during summer. Inspect for sediment issues regularly during development. After development, sweep streets in March and August.	Ongoing	Developer for 12 months and then council
	Vegetation	Inspect for bare patches, weeds and excessive growth	Annually, prior to first rains (Nov-Jan)	Every year from 2005	Developer until asset handover and then council
Reporting	All	Provide written report	Annually	Every year until handover to council	Developer

Table 7 Monitoring Schedule

6.3 CONTINGENCY SCHEDULE

Issue	Recommended Response	Timeframe	Responsibility
Increasing surface water nutrient levels	Review management of POS and householder education, consider increasing street sweeping frequency	Before the following May	Developer for two years and then council
	Consider groundwater nutrient monitoring if elevated levels for two consecutive years	Before the following May	Developer for two years and then council
Increasing or decreasing groundwater levels	Review of estate hydrology by a qualified environmental consultant to assess the reasons for the change and possible solutions.	Within six months	Developer for two years and then council
Drainage system issues	Clear out blockages	Prior to first rains (Nov - Jan)	Developer for two years and then council
	Thin vegetation if required	Prior to first rains (Nov - Jan)	Developer until asset handover and then council
	Improve vegetation condition through replanting, if required	Early winter (May-June)	Developer until asset handover and then council

Table 8 Contingency Schedule

7 SUMMARY

Drainage System

- Households in the south of the development where the watertable is more than 1.5°m below the ground surface will have on-site infiltration through soak wells.

- The drainage system will accept water from roads and public open space. In the north of the site, where the potential for infiltration is limited, the drainage system will also accept water from household roofs and paved areas.

Plate 1: A grassed swale (Source: www.wsud.org)

- The drainage system will be a series of swales and compensating basins designed to limit the peak flow into the downstream Hughes Street Drain. The swales and compensating basins will be vegetated with local sedge and rush species to trap nutrients and sediments.

Water Balance

- Maintaining pre-development levels of groundwater recharge is important to ensure that the wetland does not dry out or become too wet. Groundwater recharge rates can change after development due to loss of deep rooted vegetation such as trees and excessive use of groundwater.

- It is expected that one third of households in Campbell Estate will have bores for irrigation, in line with the Perth metropolitan average and that the water balance post-development will be similar to the pre-development water balance.

Water Conservation

- Householders will be provided with information on Waterwise gardening and water efficient appliances by the developer at settlement.

Plate 2: A Waterwise Garden(Source: www.ourwaterfuture.com.au)

- Irrigation of Public Open Space should be managed to minimise the amount of water required using turf recommendations, as referenced in this document.

Water Quality Management

- The developer should provide householders with information on low fertiliser use gardening at settlement.
- The amount of fertiliser used on Public Open Space should be minimised.

Monitoring and Contingency Planning

- Monitoring of surface water nutrient levels will be undertaken to assess the effectiveness of water quality management. If elevated nutrient levels are encountered, the information provided to householders and management of Public Open Space will be reviewed.
- Swales and compensating basins will be inspected annually for blockages, rubbish and vegetation issues.

7.1 SUMMARY OF DEVELOPER RESPONSIBILITES

In addition to the monitoring and contingencies set out in Section 6, developers have the responsibility for a number of areas in this document.

Maintenance of Drainage Systems (see Section 3.6):

Vegetated swales and compensating basins require some maintenance with respect to the build up of vegetation, rubbish and sediment. In particular:

- Debris should be removed to prevent the system becoming blocked.
- Basins and swales with native vegetation should be inspected annually to determine the condition and volume of vegetation. Where the vegetation has become too thick and is blocking the drain, it shall be thinned or cut back. Areas that have become bare and are eroding should be replanted. Exotic weeds should be removed when found.
- Drainage structures covered in grass or non-native vegetation should not be fertilised.
- Lawn clippings should be removed and disposed of appropriately.
- Street-sweeping should be undertaken to reduce particulate build-up on the road surface and in gutters

Plate 4: Street sweeper (Source: http://ci.sheridan.co.us/Public%20Works/pwveh.htm)

Household Water Conservation (Section 4.3)

- Householders should be provided with relevant flyers on water efficiency by the developer at settlement;
- Any household landscaping packages should be developed using Waterwise accredited landscapers and irrigation specialists where appropriate; and
- Any display homes built in Campbell Estate should use and display Waterwise principles in both the house and garden.

Household Nutrient Management (Section 5.3)

- All householders will be provided with information on fertiliser wise gardening at settlement; and
- Any landscaping packages offered to new residents will include information on water and fertiliser-wise gardening and will not include a minimum allocation of lawn.

Public Open Space Management (Section 5.5)

The nutrient management techniques to be used will include:

- Use of soil and leaf tissue analysis to decide whether fertilisation is required;
- Use of phosphorus-free and slow release fertilisers where possible;
- Minimal application of appropriate fertilisers;
- Appropriate selection of grass species;
- Planting of native vegetation; and
- Limiting irrigation to the minimal amount required.

7.1.1 Table of Developer Responsibilities

Recomm.	Section	Zone	Objective	Frequency	Responsibility
1	Drainage	Lots	·Households in the north of the development where the watertable is more than 1.5 m below the ground surface will have on-site infiltration through soak wells.	At construction	Developer
2	Drainage	Lot	Address the issue of filling and/or subsurface drainage to the satisfaction of the council.	At subdivision stage	Developer
3	Drainage	Lots, POS	The drainage system will accept water from roads and public open space. In the north of the site, where the potential for infiltration is limited, the drainage system will also accept water from household rooves and paved areas.	At construction	Developer
4	Drainage	Swales	The drainage system will be a series of swales and compensating basins designed to limit the peak flow into the downstream Hughes Street Drain. The swales and compensating basins will be vegetated with local sedge and rush species to trap nutrients and sediments.	At construction	Developer
5	Water Conservation	Lots	Any display homes built in Campbell Estate should use and display Waterwise principles in both the house and garden.	At construction	Developer
6	Sediment Management	Lots	All lot drainage will be fitted with sand traps to ensure that sand and sediment do not build up in the swales. Householders are responsible for the maintenance of their own sand traps.	At construction	Householder
7	Nutrient Management	POS	Appropriate selection of grass species.	At construction	Developer

Recomm.	Section	Zone	Objective	Frequency	Responsibility
8	Nutrient Management	POS	Planting of native vegetation.	At construction	Developer, in consultation with Council
9	Water Conservation	Lots	Developers should provide householders with information on Waterwise gardening and water efficient appliances	At settlement	Developer
10	Water Conservation	Lots	Householders should be provided with relevant flyers on water efficiency when purchasing land.	At settlement	Developer
11	Water Conservation	Lots	Any household landscaping packages should be developed using Waterwise accredited landscapers and irrigation specialists where appropriate	At settlement	Developer
12	Nutrient Management	Lots	Developers should provide householders with information on low fertiliser use gardening when the lots are sold.	At settlement	Developer
13	Nutrient Management	Lots	Any landscaping packages offered to new residents will include information on water and fertiliser- wise gardening and will not include a minimum allocation of lawn.	Point of sale	Developer
14	Water Conservation	POS	Irrigation of Public Open Space should be managed to minimise the amount of water required using turf recommendations, as referenced in this document.	Ongoing	Developer until handover and then council
15	Nutrient Management	Swales	Debris should be removed to prevent the system becoming blocked.	Ongoing	Developers for two years and then council

Recomm.	Section	Zone	Objective	Frequency	Responsibility
16	Nutrient Management	Swales	Basins and swales with native vegetation should be inspected annually to determine the condition and volume of vegetation. Where the vegetation has become too thick and is blocking the drain, it shall be thinned or cut back. Areas that have become bare and are eroding should be replanted. Exotic weeds should be removed when found.	Ongoing	Developer for two years and then council
17	Nutrient Management	Swales, POS	Drainage structures covered in grass or non-native vegetation should not be fertilised.	Ongoing	Developer for two years and then council
18	Nutrient Management	POS	Lawn clippings from the Public Open Space should be removed and appropriately disposed of.	Ongoing	Developer for two years and then council
19	Nutrient Management	Streets	Street-sweeping should be undertaken to reduce particulate build-up on the road surface and in gutters.	Ongoing	Developer for 12 months and then council
20	Nutrient Management	POS	The amount of fertiliser used on Public Open Space should be minimised through application of the principles applied in this document.	Ongoing	Developer for two years and then council.
21	Nutrient Management	POS	Monitoring of surface water nutrient levels will be undertaken to assess the effectiveness of water quality management. If elevated nutrient levels are encountered, the information provided to householders and management of Public Open Space will be reviewed.	Ongoing	Developer for two years and then council.
22	Wetland levels	Wetlands	·Groundwater levels are to be monitored to ensure that the levels in the wetlands are preserved (Wetlands Management Plan).	Ongoing	Developer for two years and then council.

Recomm.	Section	Zone	Objective	Frequency	Responsibility
From Wetland MP (9)	Wetland Management	CCW	Utilise the four (4) existing bores within the estate to monitor ground water levels monthly from November to June in the first year of the development.	At construction	Developer
From Wetland MP (15)	Wetland Management	POS	Create a landscaped environment within the POS that is predominantly open space, with some patches of vegetated landscape around compensation basins.	At construction	Developer
From Wetland MP (26)	Wetland Management	CCW	Establish an Inundation Transect that spans each of the CCWs. This should lie adjacent to the access track and should be contoured to the average ground level for the CCW.	At construction	Developer
From Wetland MP (29)	Wetland Management	CCW	Biannual monitoring of AAMGLs, percentage (%) inundation and storm water nutrients to be recorded on Data sheets provided in Appendix 1 of the Wetland Management Plan	Bi-annual	Developer for two years and then council
From Wetland MP (38)	Wetland Management	All	A weed management strategy, informed by weed mapping, will be developed and implemented by a suitably qualified and experienced environmental weed manager	At construction	Council

8 REFERENCES

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FIGURES

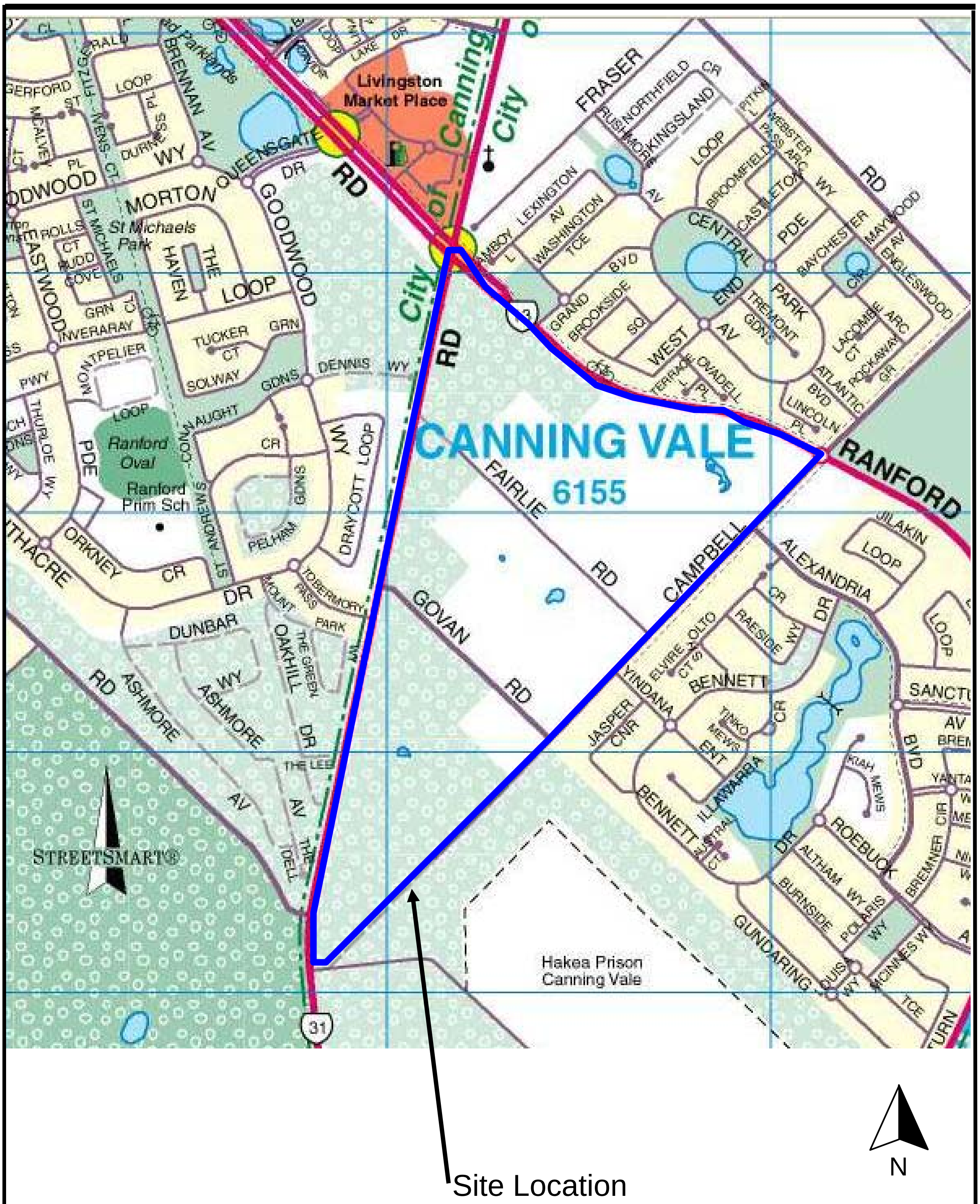


FIGURE 1: Site Location			
CLIENT: City of Gosnells and Fermanagh Pty Ltd			
DRAWN BY: MD	CHECKED BY: MD	JOB NUMBER: 05.128	env Australia
DATE: 28/9/05	REPORT ISSUE: FINAL		

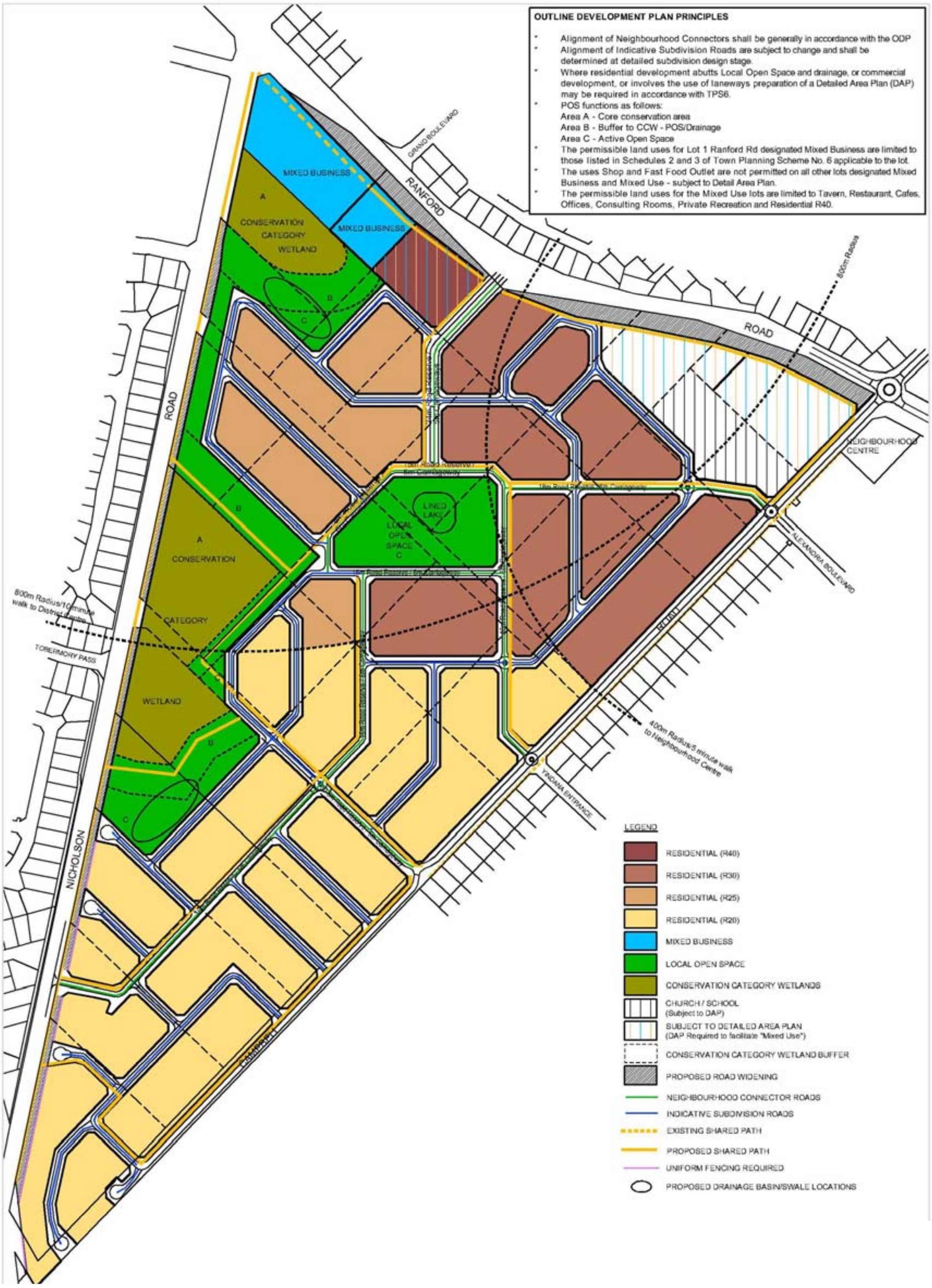


FIGURE 2: Outline Development Plan (Source: Roberts Day)		
CLIENT: City of Gosnells and Fermanagh Pty Ltd		
DRAWN BY: VC	CHECKED BY: MD	JOB NUMBER: 05.128
DATE: 22/9/05	REPORT ISSUE: FINAL	

env Australia

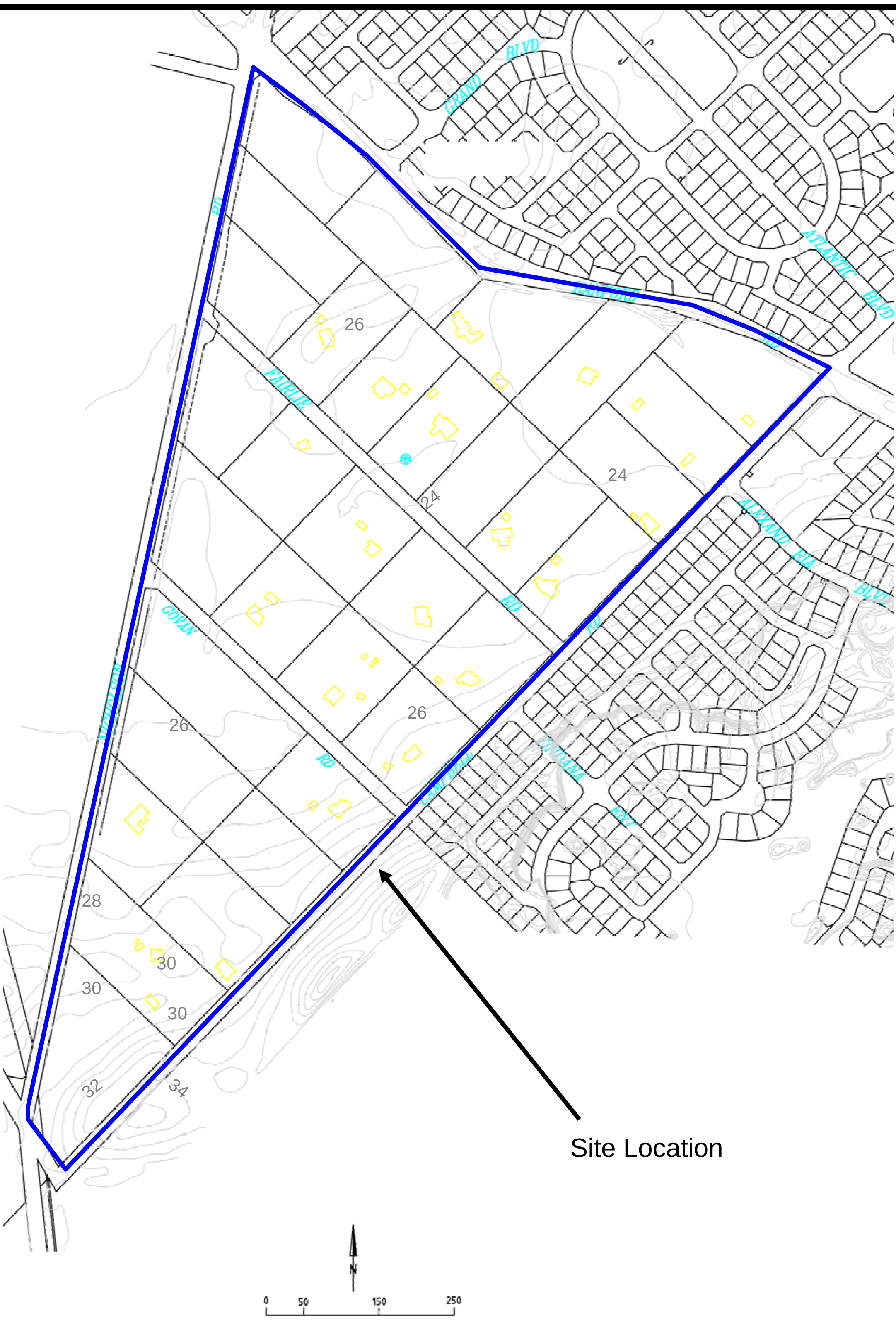


FIGURE 3: Topography		
CLIENT: City of Gosnells		
DRAWN BY: MD	CHECKED BY: MD	JOB NUMBER: 05.128
DATE: 30/9/05	REPORT ISSUE: FINAL	

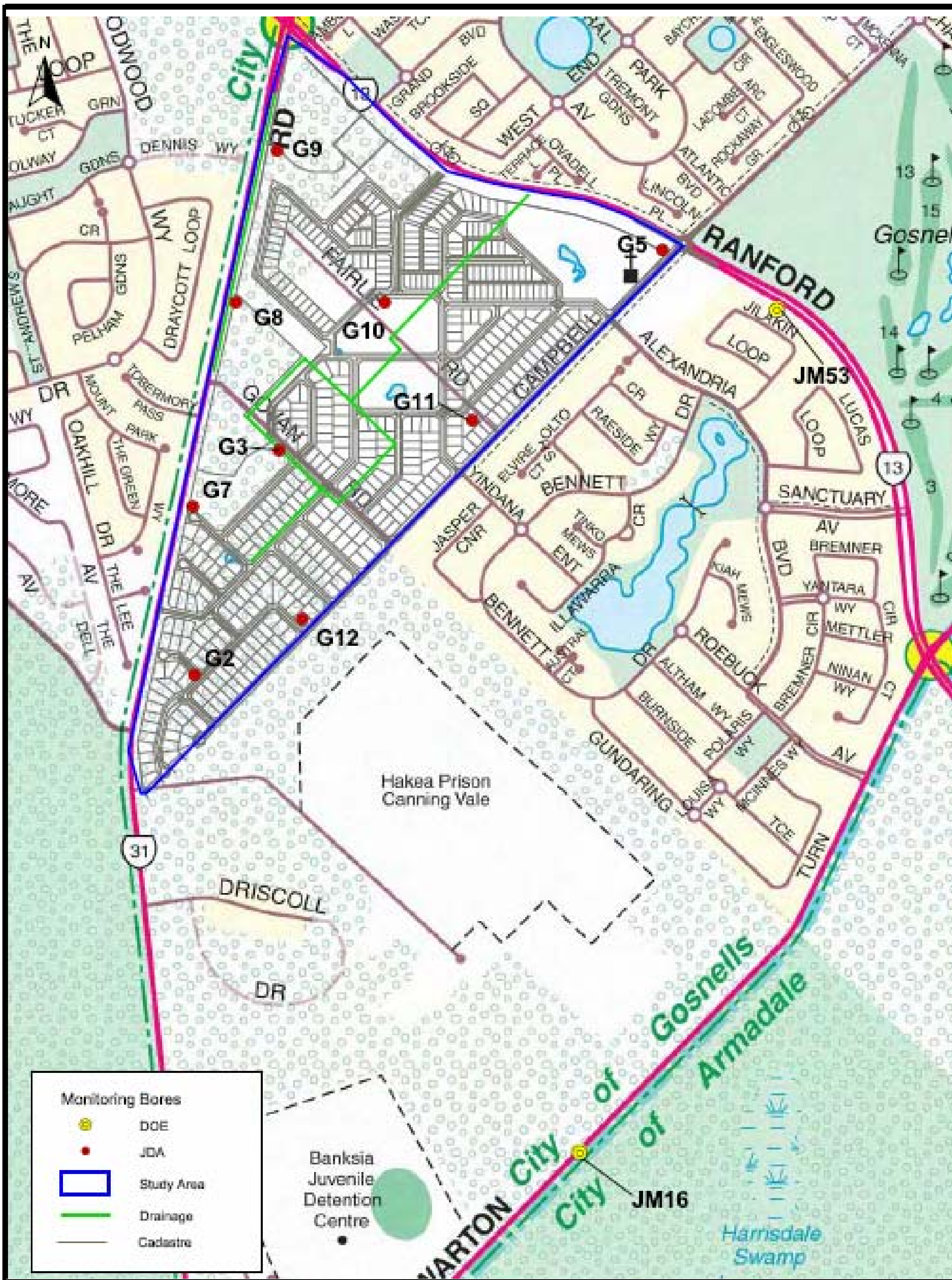
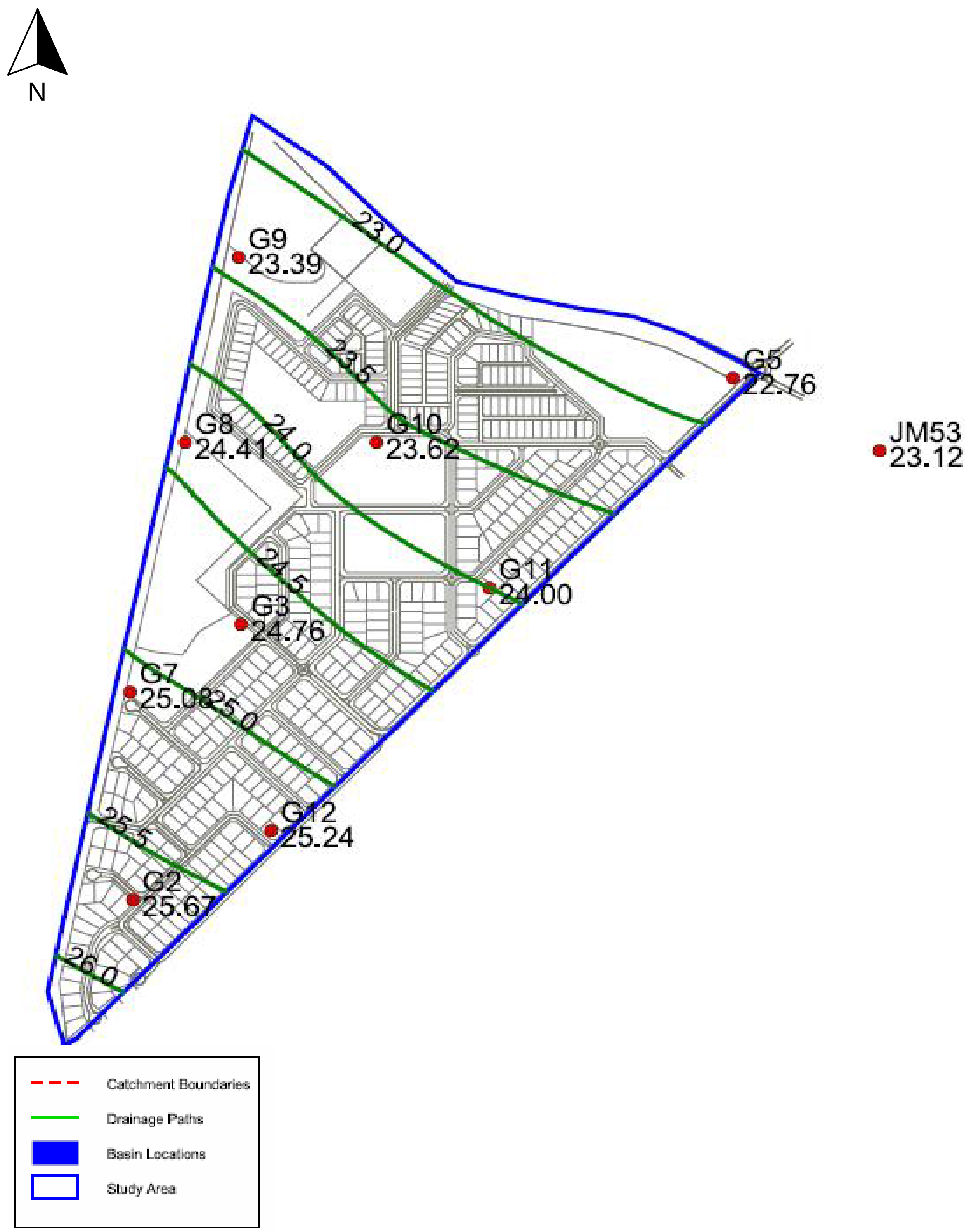
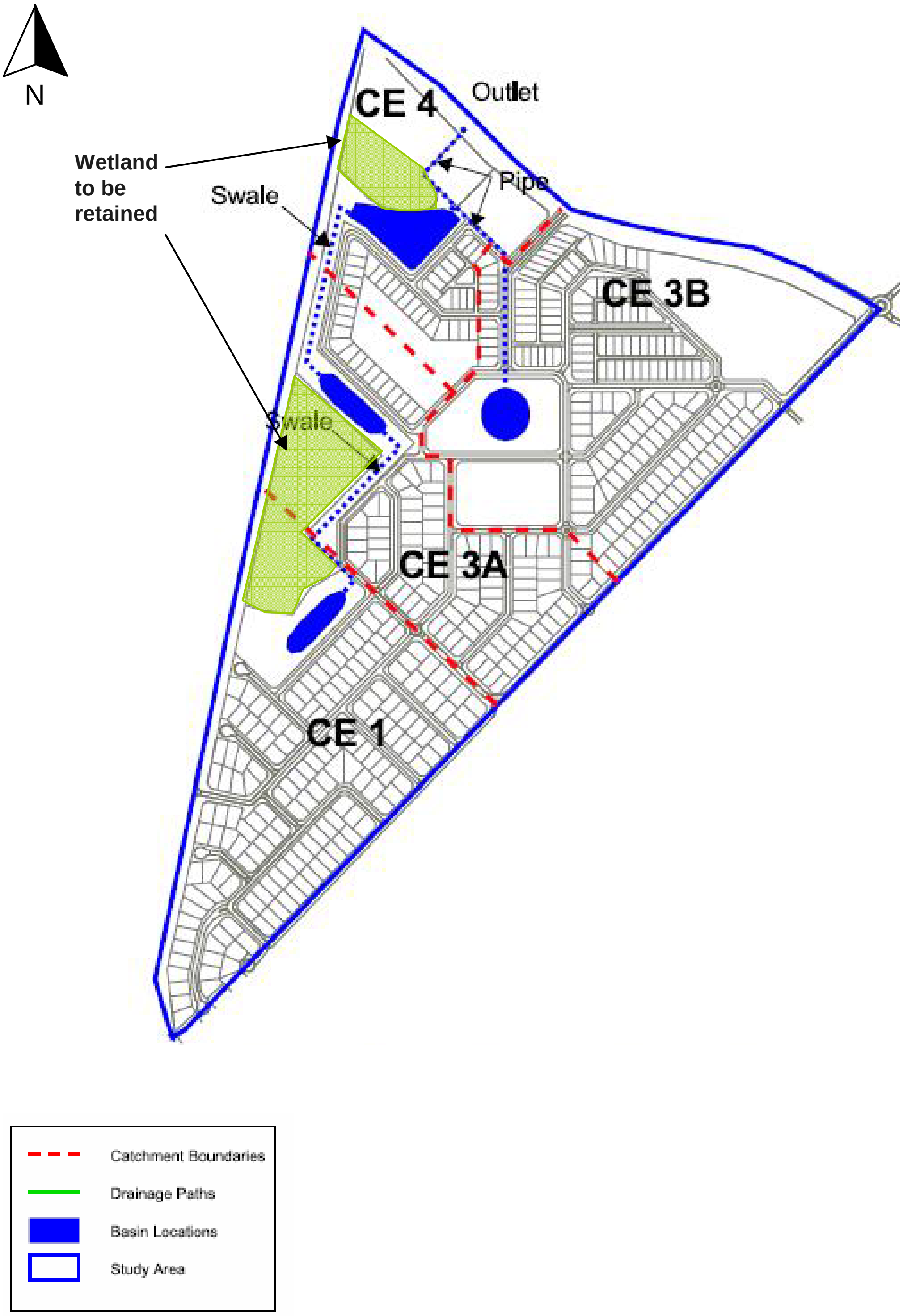


FIGURE 4: Current Drainage System and Monitoring Bore Locations (Source: JDA 2005)		
CLIENT: City of Gosnells and Fermanagh Pty Ltd		
DRAWN BY: VC	CHECKED BY: MD	JOB NUMBER: 05.128
DATE: 22/9/05	REPORT ISSUE: FINAL	



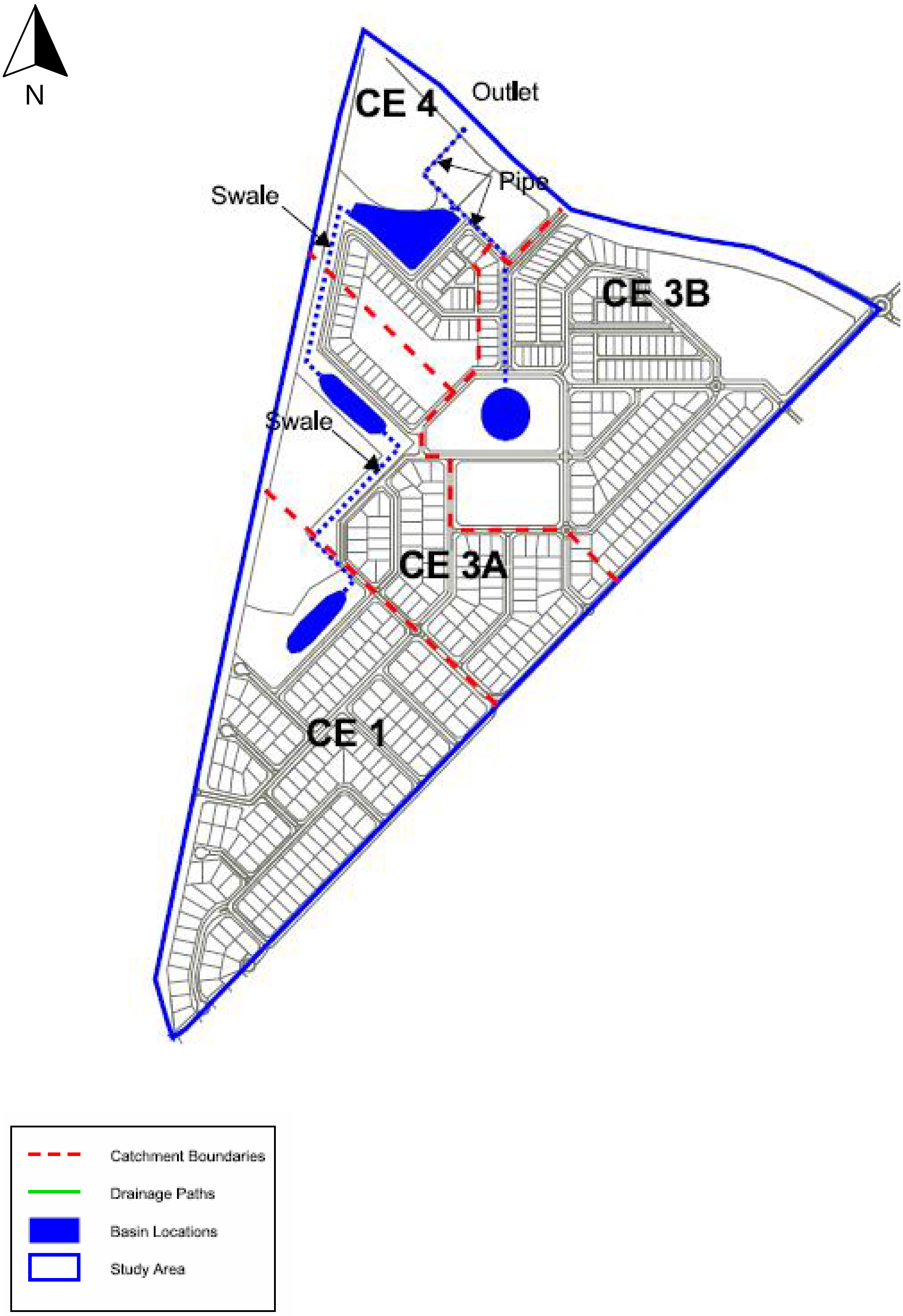
Scale: NTS

FIGURE 5: Estimated AAMGLs (Source: JDA,2005)			env Australia
CLIENT: City of Gosnells and Fermanagh Pty Ltd			
DRAWN BY: VC	CHECKED BY: MD	JOB NUMBER: 05.128	
DATE: 22/9/05	REPORT ISSUE: FINAL		



SCALE: NTS

FIGURE 6: Approximate location of wetland to be retained			
CLIENT: Fermanagh Pty Ltd			env Australia
DRAWN BY: VC	CHECKED BY: MD	JOB NUMBER: 05.128	
DATE: 22/9/05	REPORT ISSUE: FINAL		



SCALE: NTS

FIGURE 7: Preliminary Drainage Design and Catchments (Source: JDA, 2005)		
CLIENT: City of Gosnells and Fermanagh Pty Ltd		
DRAWN BY: VC	CHECKED BY: MD	JOB NUMBER: 05.128
DATE: 22/9/05	REPORT ISSUE: FINAL	

env Australia

APPENDIX A

Assumptions

Assumes 520 lots, as per advice from Roberts Day
Areas as per Roberts Day (2005)
Average house has a building area of 229 m2, paved area of 60 m2 and the remainder is garden (average 311 m2/lot)
Road areas are half road and half verge. All road verges are irrigated lawn.
Irrigation occurs at a rate of 60% of the evaporation rate between October and April.
70% of houses have lot drainage. Lot drainage and any sub-surface drainage are assumed not to affect recharge rates.

Rain on Hard Surfaces is 10% Evap, 90% to drain
Rain on Soft Surfaces is 10% Evap, 35% trans, 55% infiltration
Irrigation on Soft Surfaces is 25% evap, 55% trans, 20% infiltration
Irrigation occurs at 70% of Evaporation rate

	Jan	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*	*Total*
Monthly Rainfall	9	15	16	41	103	168	162	119	72	46	26	11	786
Monthly Evaporation	316	274	245	156	96	66	68	81	108	164	222	282	2079
Oct -Apr Evaporation	316	274	245	156						164	222	282	1659

Post Development Water Balance, Assuming all Irrigation from Scheme Water

TOTAL AREAS			Paved	Building	Grassed	Non Irrig POS	
Total	61.7	ha					
Commercial and Church	2.98	ha	1.19	1.49	0.30	0.00	
CCW	4.55	ha	0.00	0.00	0.00	4.55	
Road Widening	2.37	ha	2.37	0.00	0.00	0.00	
POS - drainage	2.08	ha	0.00	0.00	0.00	2.08	
Lake	0.2	ha	0.00	0.00	0.00	0.20	
Remaining POS	3.86	ha	0.00	0.00	3.86	0.00	
Total Roads	11.2	ha	5.60	0.00	5.60	0.00	
Residential	34.46	ha	3.12	15.18	16.16	0.00	
	0.0663	ha/lot	0.0060	0.0292	0.0311	0.0000	
TOTAL			12.29	16.70	25.95	6.83	61.77

METEROLOGICAL DATA	
Rainfall	740
Evap Rate	2074
Evap Rate	1659
(Oct - Apr)	

PRE-DEVELOPMENT RECHARGE **91.316 ML/year** ***Assumes 20% recharge***

ALL IRRIGATION ON SCHEME WATER
(All values in ML/year)

FROM RAINFALL					TOTAL
Rainfall	90.9	123.6	192.0	50.5	457.1
Evaporation	9.1	12.4	19.2	12.6	53.3
Transpiration	0.0	0.0	67.2	27.8	95.0
Infiltration	0.0	37.1	105.6	10.1	152.8
Drainage	81.8	74.2	0.0	0.0	156.0

RATIOS FOR RAINFALL				
Evaporatio	0.10	0.10	0.10	0.25
Transpirati	0.00	0.00	0.35	0.55
Infiltration	0.00	0.30	0.55	0.20
Drainage	0.90	0.60	0.00	0.00

FROM IRRIGATION	
Irrigation	258.3
Evaporation	64.6
Transpiration	142.0
Infiltration	51.7

RATIOS FOR IRRIGATION	
Evaporation	0.25
Transpiration	0.55
Infiltration	0.15

POST-DEVLOPMENT RECHARGE **204.4 ML/year**
224 **% of Pre-development recharge**

Post Development Water Balance, Assuming all Irrigation from Bore water

TOTAL AREAS			Paved	Building	Grassed	Non Irrig POS		METEROLOGICAL DATA	
Total	61.7	ha						Rainfall	740
Commercial and Church	2.98	ha	1.19	1.49	0.30	0.00		Evap Rate	2074
CCW	4.55	ha	0.00	0.00	0.00	4.55		Evap Rate	1659
Road Widening	2.37	ha	2.37	0.00	0.00	0.00		(Oct - Apr)	
POS - drainage	2.08	ha	0.00	0.00	0.00	2.08			
Lake	0.2	ha	0.00	0.00	0.00	0.20			
Remaining POS	3.86	ha	0.00	0.00	3.86	0.00			
Total Roads	11.2	ha	5.60	0.00	5.60	0.00			
Residential	34.46	ha	3.12	15.18	16.16	0.00			
	0.0663	ha/lot							
TOTAL			12.28	16.67	25.91	6.83	61.70		

PRE-DEVELOPMENT RECHARGE **91.316 ML/year** ***Assumes 20% recharge***

POS AND ALL HOUSEHOLDERS USE BORES FOR IRRIGA	FROM RAINFALL					TOTAL	RATIOS FOR RAINFALL				
(All values in ML/year)	Rainfall	90.9	123.4	191.8	50.5	456.6					
	Evaporation	9.1	12.3	19.2	12.6	53.2	Evaporation	0.10	0.10	0.10	0.25
	Transpiration	0.0	0.0	67.1	27.8	94.9	Transpiration	0.00	0.00	0.35	0.55
	Infiltration	0.0	37.0	105.5	10.1	152.6	Infiltration	0.00	0.30	0.55	0.20
	Drainage	81.8	74.0	0.0	0.0	155.8	Drainage	0.90	0.60	0.00	0.00
	FROM IRRIGATION						RATIOS FOR IRRIGATION				
	Irrigation			257.9							
	Evaporation			64.5			Evaporation			0.25	
	Transpiration			141.9			Transpiration			0.55	
	Infiltration			51.6			Infiltration			0.15	
	ALL BORES			-257.9							
	Assumes all irrigated POS on bores										

POST-DEVLOPMENT RECHARGE **-53.8 ML/year**
-59 **% Negative recharge - estate is using more water than it infiltrates**

Post Development Water Balance, Assuming All Households use Scheme Water for Irrigation, POS uses Bore water

TOTAL AREAS			Paved	Building	Grassed	Non Irrig POS		METEROLOGICAL DATA	
Total	61.7	ha						Rainfall	740
Commercial and Church	2.98	ha	1.19	1.49	0.30	0.00		Evap Rate	2074
CCW	4.55	ha	0.00	0.00	0.00	4.55		Evap Rate	1659
Road Widening	2.37	ha	2.37	0.00	0.00	0.00		(Oct - Apr)	
POS - drainage	2.08	ha	0.00	0.00	0.00	2.08			
Lake	0.2	ha	0.00	0.00	0.00	0.20			
Remaining POS	3.86	ha	0.00	0.00	3.86	0.00			
Total Roads	11.2	ha	5.60	0.00	5.60	0.00			
Residential	34.46	ha	3.12	15.18	16.16	0.00			
	0.0663	ha/lot							
TOTAL			12.28	16.67	25.91	6.83	61.70		

PRE-DEVELOPMENT RECHARGE **91.316 ML/year** ***Assumes 20% recharge***

POS USES BORES FOR IRRIGATION	FROM RAINFALL					TOTAL	RATIOS FOR RAINFALL				
(All values in ML/year)	Rainfall	90.9	123.4	191.8	50.5	456.6					
	Evaporation	9.1	12.3	19.2	12.6	53.2	Evaporatio	0.10	0.10	0.10	0.25
	Transpiration	0.0	0.0	67.1	27.8	94.9	Transpirati	0.00	0.00	0.35	0.55
	Infiltration	0.0	37.0	105.5	10.1	152.6	Infiltration	0.00	0.30	0.55	0.20
	Drainage	81.8	74.0	0.0	0.0	155.8	Drainage	0.90	0.60	0.00	0.00
	FROM IRRIGATION						RATIOS FOR IRRIGATION				
	Irrigation			38.4							
	Evaporation			9.6			Evaporation			0.25	
	Transpiration			21.1			Transpiration			0.55	
	Infiltration			7.7			Infiltration			0.15	
	POS BORES			-19.2							
	Assumes all irrigated POS on bores										

POST-DEVLOPMENT RECHARGE	**141.1**	**ML/year**
	154	**% of Pre-development recharge**

Post Development Water Balance, Assuming POS Irrigated from Bore water and One Third of Households Use Bores

TOTAL AREAS			Paved	Building	Grassed	Non Irrig POS	
Total	61.7	ha					
Commercial and Church	2.98	ha	1.19	1.49	0.30	0.00	
CCW	4.55	ha	0.00	0.00	0.00	4.55	
Road Widening	2.37	ha	2.37	0.00	0.00	0.00	
POS - drainage	2.08	ha	0.00	0.00	0.00	2.08	
Lake	0.2	ha	0.00	0.00	0.00	0.20	
Remaining POS	3.86	ha	0.00	0.00	3.86	0.00	
Total Roads	11.2	ha	5.60	0.00	5.60	0.00	
Residential	34.46	ha	3.12	15.18	16.16	0.00	
	0.0663	ha/lot					
TOTAL			12.28	16.67	25.91	6.83	61.70

METEROLOGICAL DATA	
Rainfall	740
Evap Rate	2074
Evap Rate	1659
(Oct - Apr)	

PRE-DEVELOPMENT RECHARGE **91.316** **ML/year** ***Assumes 20% recharge***

HOUSEHOLDS USE BORES FOR IRRIGATION
(All values in ML/year)

FROM RAINFALL					TOTAL
Rainfall	90.9	123.4	191.8	50.5	456.6
Evaporation	9.1	12.3	19.2	12.6	53.2
Transpiration	0.0	0.0	67.1	27.8	94.9
Infiltration	0.0	37.0	105.5	10.1	152.6
Drainage	81.8	74.0	0.0	0.0	155.8
FROM IRRIGATION					
Irrigation			257.9		
Evaporation			64.5		
Transpiration			141.9		
Infiltration			51.6		
HOUSEHOLD BORES			-110.6		

Assumes one third of households on bores and POS irrigation
Households irrigate gardens and verge

Irrigation Constants FROM RAINFALL				
Evaporatio	0.10	0.10	0.10	0.25
Transpirati	0.00	0.00	0.35	0.55
Infiltration	0.00	0.30	0.55	0.20
Drainage	0.90	0.60	0.00	0.00
FROM IRRIGATION				
Evaporation			0.25	
Transpiration			0.55	
Infiltration			0.15	

POST-DEVLOPMENT RECHARGE **93.6** **ML/year**
102 **% of Pre-development recharge**

APPENDIX B

Fermanagh Construction Pty Ltd

Glenariff Estate

Hydrology Investigation

September 2005

JDA Consultant Hydrologists

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1. INTRODUCTION

Glenariff Estate is located in Canning Vale and is an approximately triangular piece of land of 57 ha, bordered by Nicholson, Ranford and Campbell Roads. This land was formerly known as Campbell Road Estate.

JDA have previously been involved with the site, and estimated AAMGL and drainage basins in 1998/99 (JDA, 1998, 1999a, 1999b).

The current study involved further site investigation, revision of the estimated AAMGL and analysis of water quality from sampling. Drainage design has been revised based on the most recent ODP (Roberts Day Group, 2004, 2005) and shown in Figure 1.

This report addresses water table elevation, detention basin sizing and groundwater quality.

2. SITE DESCRIPTION

The Study Area currently comprises 1.5 to 2 ha lots which are used for rural living and hobby farms. Many of these lots are vacant.

The topography across the site shows a gentle gradient from the south to the north, and is generally low lying.

The surface soils across the site are sands (Bassendean Sand), generally white or tan and fine to medium grained. In the north western section of the site, cemented sands layers were encountered near the water table.

Surface drainage on the site is shown in Figure 2. A local authority drain runs towards the north east through the centre of the site, along lot boundaries but has no outlet. This drain is shallow and narrow and will only discharge low flow rates. A second drain runs along the eastern side of Nicholson Road between Ranford and Govan Roads. This drain also has no outlet and is believed to be an infiltration swale for Nicholson Rd runoff.

The central and northern sections of the site forms part of a larger wetland / dampland system. Conservation category wetlands (CCW) are present on the north and south sides of Govan Road adjacent to Nicholson Road. A third CCW is present in the north west corner of the site adjacent to Nicholson Road.

3. GROUNDWATER INVESTIGATION

Groundwater flows from south to north across the site. Clearance to groundwater is greatest in the southern section of the property (greater than 2 m) and relatively close to the surface in the northern section.

3.1 Site Investigation

On 27 July 2005, JDA staff visited the project site. Three existing monitoring bores (G2, G3 & G5), installed by JDA in 1998 (JDA, 1998) (two within the site and one within a road reserve) were located and the water level measured. JDA installed six new groundwater monitoring bores, designated G7 to G12, across the property to provide good coverage of groundwater level data. After installation, the water level in each bore was measured. Bore locations are shown in Figure 2.

These bores have since been surveyed by Fugro Spatial Solutions to GDA and Australian Height Datum (AHD).

Two nearby Department of Environment (DoE) superficial aquifer monitoring bores, JM11, JM53 and JM16 slotted at the top of the aquifer were also located and water level measured.

Information on the bores and measured water levels is shown in Table 1 below.

TABLE 1: RECORDED MONITORING BORE DATA

Bore	GDA Easting (m)	GDA Northing (m)	Top of Casing (m AHD)	Natural Surface (m AHD)	Stickup (m)	Water Level 27/7/05 (m BTOC)	Water Level 27/7/05 (m AHD)
G2	397702	6447916	29.45	28.77	0.68	3.70	25.75
G3	397865	6448359	26.10	25.56	0.54	1.26	24.84
G5	398606	6448751	23.72	23.20	0.52	0.88	22.84
G7	397698	6448250	27.40	26.72	0.68	2.24	25.16
G8	397781	6448649	25.87	25.36	0.51	1.38	24.49
G9	397861	6448946	24.97	24.48	0.49	1.50	23.47
G10	398069	6448650	24.49	24.17	0.32	0.79	23.70
G11	398239	6448417	25.96	25.42	0.54	1.88	24.08
G12	397910	6448028	30.30	29.84	0.46	4.98	25.32

3.2 AAMGL Calculation

The AAMGL was determined based on correlating recorded groundwater level data with data obtained from nearby DoE monitoring bores JM11, JM53 and JM16 (see Figure 2).

The DoE bore JM11 (near the corner of Ranford and Campbell Roads) was destroyed in 1996. Another bore (JM53) was installed in 1997 as a replacement, and is located on the other side of Ranford Rd from the original location. Due to their close proximity, the time series data from these bores was combined. JM16 is located south east of the site on Warton Road. Water level data for JM11/JM53 and JM16 is shown in Figure 3.

The AAMGL for JM11/JM53 & JM16 were determined for the last 10 years (Table 2). Previous years had higher levels, but it is considered existing drainage in Canning Vale prevents water table rising as high now.

The AAMGL for JDA monitoring bores was calculated based on adjusting the water level recorded at JDA bores by the difference between the water level measured in JM53 and JM16 on 27 July 2005 compared to their calculated AAMGL values.

The average of the difference for JM53 and JM16 was -0.08 m (Table 2). That is, water level on 27 July 2005 was on average 0.08m above AAMGL. The AAMGL's for JDA monitor bores shown in Table 3 are calculated by adding this value (-0.08m) to the measured water levels in Table 1.

Table 3 shows that the depth to AAMGL from natural surface varies across the site from a maximum of 4.60 m in the southern section to a minimum of 0.44 m in the north east section. In general, the central and northern section of the site has a depth to AAMGL of less than 1 m, while the south and south east sections are greater than 1 m.

Figure 4 shows the estimated AAMGL contours plotted across the site. The contours are smooth, with no anomalous values. Note that JM53 is consistent with the contours also.

TABLE 2: AAMGL ESTIMATION FOR DOE MONITORING BORES

Monitoring Bore	Years of Data Record	Estimated AAMGL (1996 – 2005) (m AHD)	Recorded Water Level on 27/7/05 (m AHD)	Difference between AAMGL & recorded water level[1] (m)
JM11 JM53	1975 – 1996 1997 - 2005	23.12	23.25	-0.13
JM16	1975 - 2005	25.68	25.72	-0.04

Note 1. Positive indicates water level below AAMGL; negative indicates above.

TABLE 3: AAMGL ESTIMATION FOR JDA BORES

Bore	Natural Surface (m AHD)	Water Level on 27/7/05 (m AHD)	AAMGL Correction (m)	AAMGL (m AHD)	Depth below Natural Surface to AAMGL (m)
G2	28.77	25.75	-0.08	25.67	3.10
G3	25.56	24.84	-0.08	24.76	0.80
G5	23.20	22.84	-0.08	22.76	0.44
G7	26.72	25.16	-0.08	25.08	1.64
G8	25.36	24.49	-0.08	24.41	0.95
G9	24.48	23.47	-0.08	23.39	1.09
G10	24.17	23.70	-0.08	23.62	0.55
G11	25.42	24.08	-0.08	24.00	1.42
G12	29.84	25.32	-0.08	25.24	4.60

Based on the survey information, it is believed that the drain located along the Nicholson Rd boundary (between Govan and Ranford Rds) is not deep enough to significantly affect groundwater levels. Similarly, the drain running north along the boundary of Lot 287 and 4 Fairlie Rd and Lot 3 Ranford Rd, while intercepting groundwater, is not believed to significantly affect groundwater levels in its current form.

4. DRAINAGE DESIGN

In 1999, JDA (1999b) used XP-RAFTS to model the Campbell Road Estate based on the preliminary planning for the property. In this study, the current ODP was used to model drainage with XP-STORM.

4.1 Data & Assumptions

Based on the current ODP, JDA modelled detention basins using XP-STORM for the 10 and 100 year ARI storm events. Detention basins have been designed to contain the 100 year average recurrence interval (ARI) critical storm event. The outlet pipe from the system that feeds through the Avenues Estate stormwater pipe system and lakes into the Hughes Street Main Drain further north of Figures 1 & 2, was sized to attenuate the post development flow for the 10 year ARI storm event.

The design discharge for the project area, including Glenariff Estate, to the Hughes Street Main Drain was an average compensated discharge (using COPAS) of 74 L/s (WAWA, 1994), based on a value of 1.13 L/s/ha for 65 ha. To determine peak discharge, the Water Corporation Main Drainage Manual (1998) allows a 1.5 peaking factor to be applied to average compensated design discharges calculated using the Modified COPAS equation (previously confirmed by JDA with David Wills, ex-Water Corporation Modified COPAS equation author, *pers comm*). Therefore a peak discharge of 111 L/s has been used as an allowable basin outflow from Glenariff Estate for the 10 year ARI event.

The Hughes Street Main Drain is the downstream control that determines the water levels in all upstream basins. Data for the design 10 and 100 year ARI Hydraulic Grade Line (HGL) for the connecting stub beneath Ranford Rd through the Avenues Estate to this drain in unavailable. Two modelling approaches have therefore been adopted, as for JDA (1999b):

- Scenario 1 assumes the outlet from Glenariff Estate can freely discharge into the Hughes Street Main Drain, and
- Scenario 2 assumes that the outlet pipe discharges into a just full pipe which ultimately discharges into the Hughes Street Main Drain.

Catchment areas were measured using the current subdivision plan from the Roberts Day Group. Catchment areas were divided into Lots, POS, Roads and CCW's. Areas for each catchment draining to a basin are presented in Table 4 and shown on Figure 5. Each of the land use types were assigned a runoff coefficient, as described in Table 5. The total catchment area is 57 ha, with a total impervious area of 15.8 ha, ie a gross runoff coefficient of 28%. Catchment CE1 was assumed to have a deep water table (greater than 2 m in winter), while catchments CE3A, CE3B and CE4 were assumed to have a shallow water table.

The invert levels of the basins were set at 0.5 m above the AAMGL to provide clearance and prevent waterlogging except during storm events, as presented in Table 6. Basins were assumed to be circular in shape, with 1 in 6 side slopes.

It was assumed that flow out of each basin will be limited by an outlet pipe. The required pipe diameters to attenuate flow sufficiently to meet the Water Corporation criterion are shown in Table 6. It was also assumed that a swale drain joins basins CE1 and CE3A, and basins CE3A and CE4, with 1 in 6 side slopes. Outflows from basins CE4 and CE3B are proposed to be conveyed using pipes.

TABLE 4: CATCHMENT DATA

Catchment / Basin	Catchment Area (ha)	Effective Impervious Area (ha)	Catchment Slope (m/km)
CE1	17.8	4.2	0.6
CE3A	12.1	3.6	0.6
CE3B	19.3	6.1	0.6
CE4	7.8	1.9	0.6
Total	57	15.8	-

TABLE 5: RUNOFF COEFFICIENTS

Land Use Type	Runoff Coefficient
Lots (shallow water table)	0.2
Lots (deep water table – > 2 m in winter)	0.1
POS	0.1
Roads	0.9
Conservation Category Wetlands	0.1

TABLE 6: BASIN DESIGN PARAMETERS

Basin	AAMGL at Basin (m AHD)	Basin Invert (m AHD)	Base Area (ha)	Outlet Pipe Diameter (mm)	Outlet Pipe Invert (mAHD)
CE1	24.9	25.4	0.28	375	25.4
CE3A	24.2	24.7	0.28	375	24.7
CE3B	23.7	24.2	0.38	375	24.2
CE4	23.4	23.9	0.72	300	23.9

The outlet on Ranford Road opposite Grand Boulevard (The Avenues) is shown to have an invert of 22.7 m AHD on Water Corporation as-constructed drawings (Greg Locke, Ewing Consulting Engineers, *pers comm)*. This level is being confirmed by survey (Asshe Craven, Fugro Survey, *pers comm*).

It was assumed that no discharge into the site occurs from the 300 mm diameter culvert under Nicholson Road, from Ranford Central development. City of Canning has confirmed that this pipe only drains runoff from the intersection of Nicholson Road together with the new road being constructed for Ranford Central, and hence will only have small runoff volume (Doug Martin, City of Canning, *pers comm*).

4.2 Modelling Results

A summary of modelling results for both scenarios 1 & 2 are presented in Tables 7 and 8 for the 10 year and 100 year ARI storm events respectively. An outlet pipe diameter from basin CE4 of 300 mm results in a critical 10 year ARI storm event peak discharge rate of 110 L/s for Scenario 1 and 105 L/s for Scenario 2, consistent with an average compensated discharge of 111 L/s.

The modelling results also show that flow rates and stage heights were not particularly sensitive to the outflow condition, with similar results for both scenarios.

The Top Water Level (TWL) for the critical 100 year ARI event for all basins has an area of 2.03 ha for both Scenario 1 and Scenario 2. This compares with the value of 3.15 ha as found by previous JDA modelling (JDA, 1999b). This difference is due partly to a smaller total area being modelled (57 ha compared to 65 ha previously) and also partly to the difference in models used. XP-RAFTS (as used previously) does not take into account storage within basin connections and so all storage is within the basins, while XP-STORM allows storage within the connecting swales.

The basins as shown in Figure 5 show the surface area at the 100 yr ARI TWL.

Sample hydrographs are shown in Figures 6 and 7. These show the outflow hydrographs for the 10 and 100 year ARI critical duration storm events.

The basins locations, as shown in Figure 5, have been placed to conform to the Structure Plan. However, there is flexibility in the precise location of the basins, provided that alternative locations meet the relevant level and hydraulic constraints.

TABLE 7: SUMMARY OF 10 YEAR ARI STORM EVENT RESULTS

Basin	Critical Storm Duration (hrs)	Volume Inflow (m^3)	Peak Inflow (m^3/s)	Outlet Invert (m AHD)	Peak Stage (m AHD)	Peak Depth (m)	Peak Outflow (m^3/s)	Peak Flood Storage (m^3)	10 yr TWL Area (ha)
SCENARIO 1									
CE1	48	4,680	0.177	25.4	25.73	0.33	0.126	1,000	0.321
CE3A	36	3,680	0.265	24.7	25.10	0.40	0.166	1,220	0.330
CE3B	36	6,210	0.246	24.2	24.68	0.48	0.090	2,000	0.451
CE4	72	2,410	0.187	23.9	24.40	0.50	0.075	3,850	0.817
Outlet	36						0.110		
SCENARIO 2									
CE1	48	4,680	0.177	25.4	25.73	0.33	0.126	1,000	0.321
CE3A	36	3,680	0.265	24.7	25.10	0.40	0.166	1,220	0.330
CE3B	36	6,210	0.246	24.2	24.68	0.48	0.090	2,000	0.451
CE4	72	2,410	0.187	23.9	24.42	0.52	0.070	4,010	0.821
Outlet	48						0.105		

TABLE 8: SUMMARY OF 100 YEAR ARI STORM EVENT RESULTS

Basin	Critical Storm Duration (hrs)	Volume Inflow (m^3)	Peak Inflow (m^3/s)	Outlet Invert (m AHD)	Peak Stage (m AHD)	Peak Depth (m)	Peak Outflow (m^3/s)	Peak Flood Storage (m^3)	100 yr TWL Area (ha)
SCENARIO 1									
CE1	48	7,340	0.223	25.4	25.79	0.39	0.160	1,190	0.328
CE3A	36	5,740	0.332	24.7	25.19	0.49	0.204	1,530	0.341
CE3B	24	8,240	0.479	24.2	24.91	0.71	0.091	3,080	0.484
CE4	72	3,820	0.251	23.9	24.70	0.80	0.081	6,390	0.875
Outlet	24						0.120		
SCENARIO 2									
CE1	48	7,340	0.223	25.4	25.79	0.39	0.160	1,190	0.328
CE3A	36	5,740	0.335	24.7	25.19	0.49	0.206	1,530	0.341
CE3B	24	8,240	0.479	24.2	24.92	0.72	0.092	3,120	0.486
CE4	72	3,820	0.251	23.9	24.72	0.82	0.076	6,560	0.879
Outlet	24						0.115		

5. WATER QUALITY

On 16 August 2005, water samples were taken from monitoring bores G2, G5, G7, G9, G10 and G12 and submitted to MPL Laboratories for analysis for Nitrogen, Phosphorus, pH and EC / TDS. Results are tabulated below in Table 9 and presented in Appendix A.

All samples showed very low levels for both total phosphorus and filterable reactive phosphorus. These levels are generally lower than background values found in the Perth region, consistent with negligible fertiliser application to the area.

Nitrate concentrations are similar to regional values, as are ammonium, TKN and total nitrogen, possibly due to nitrogen fixing vegetation.

Groundwater pH values were les than 6.0 in all bores, indicating that groundwater is acidic. Three bores showed a pH of less than 5 and one bore had a pH less than 4. These values are very low and may be an indicator that acid sulfate soils are present. We therefore recommend testing for acid sulfate soils. DoE mapping (WAPC, 2003) shows that a central section of the site is classed as having a high risk of actual acid sulfate soil and potential acid sulfate soil less than 3 m from the surface. The remainder of the site is classified as having a moderate to low risk of actual acid sulfate soil and potential acid sulfate soil occurring generally at depths greater than 3 m from the surface.

TABLE 9: GROUNDWATER QUALITY RESULTS

Bore	EC (µS/cm)	TDS (mg/L)	pH	NO_X (mg/L)	TKN (mg/L)	NH_4 (mg/L)	TN (mg/L)	FRP (mg/L)	TP (mg/L)
G2	950	522	3.30	0.11	2.2	0.02	2.3	<0.002	<0.01
G5	630	346	5.10	0.87	1.3	0.44	2.2	<0.002	<0.01
G7	150	82	5.10	0.065	3.7	0.17	3.8	<0.002	<0.01
G9	430	236	4.85	0.029	5.2	0.35	5.3	0.011	0.06
G10	550	305	5.70	0.014	4.8	0.36	4.8	<0.002	0.09
G12	160	88	4.35	0.76	1.5	0.01	2.2	<0.002	<0.01

6. CONCLUSIONS & RECOMMENDATIONS

Six monitoring bores were installed at the Study Area, in addition to the existing three bores on site. Two nearby DoE bores were monitored and used to estimate AAMGL within the Study Area.

Stormwater drainage was modelled using XP-STORM for the four proposed catchments and basins of the Study Area. The basins were sized to restrict outflow from the development to 111 L/s for the 10 year ARI storm event and contain the critical 100 year ARI storm event.

Total basin area (at 100 year ARI TWL) was estimated to be 2.03 ha.

The basins locations have been placed to conform to the Structure Plan. However, there is flexibility in the precise location of the basins, provided that alternative locations meet the relevant level and hydraulic constraints.

Discussions with City of Canning have indicated that only runoff from Nicholson Road flows into the drain along Nicholson Road via the existing culverts. Therefore no flow component has been included for any catchment west of Nicholson Road.

Water quality analysis indicates that phosphorus concentrations are very low, both at the upstream and downstream end of the Study Area. Nitrogen concentrations on site are consistent with regional values. TDS values are generally low and most bores recorded salinities less than 500 mg/L. Groundwater pH values were generally low, indicating water with high acidity. One bore had a pH value of 3.3, which may be indicative of acid sulfate soils.

JDA recommends acid sulfate soils testing be performed if any excavation or dewatering is required.

7. REFERENCES

Jim Davies & Associates (1998) *Campbell Estate, Canning Vale: Residential Development – Preliminary Hydrological Studies*, J2436b, 15 December 1998, fax report to Satterley Property Group.

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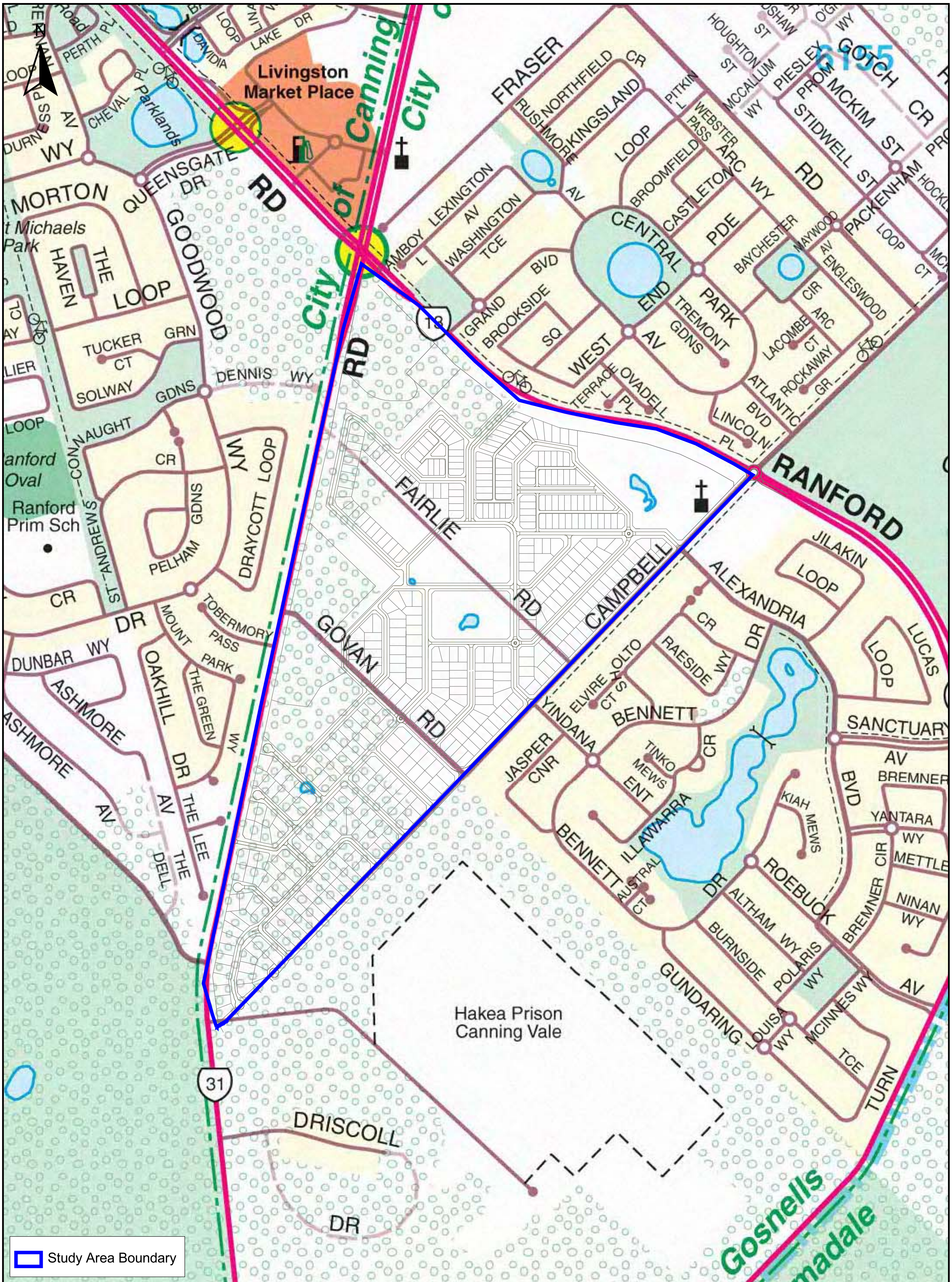
FIGURES



Data Source: Streetsmart Express 2004, RDA (2005)

0 200 400 600 800 Meters

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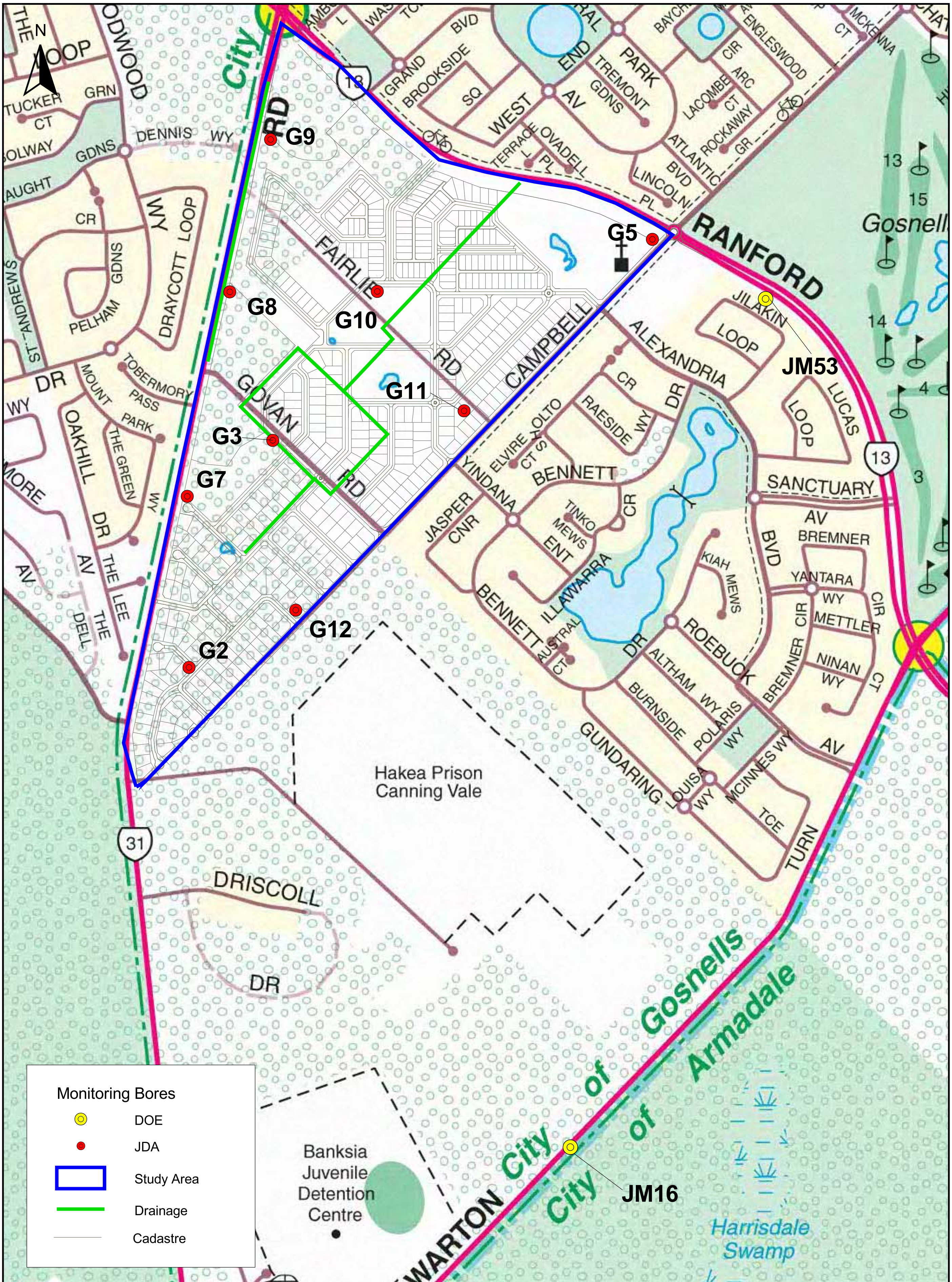
Figure 1: Outline Development Plan



Data Source: Streetsmart Express 2004, RDG (2005)

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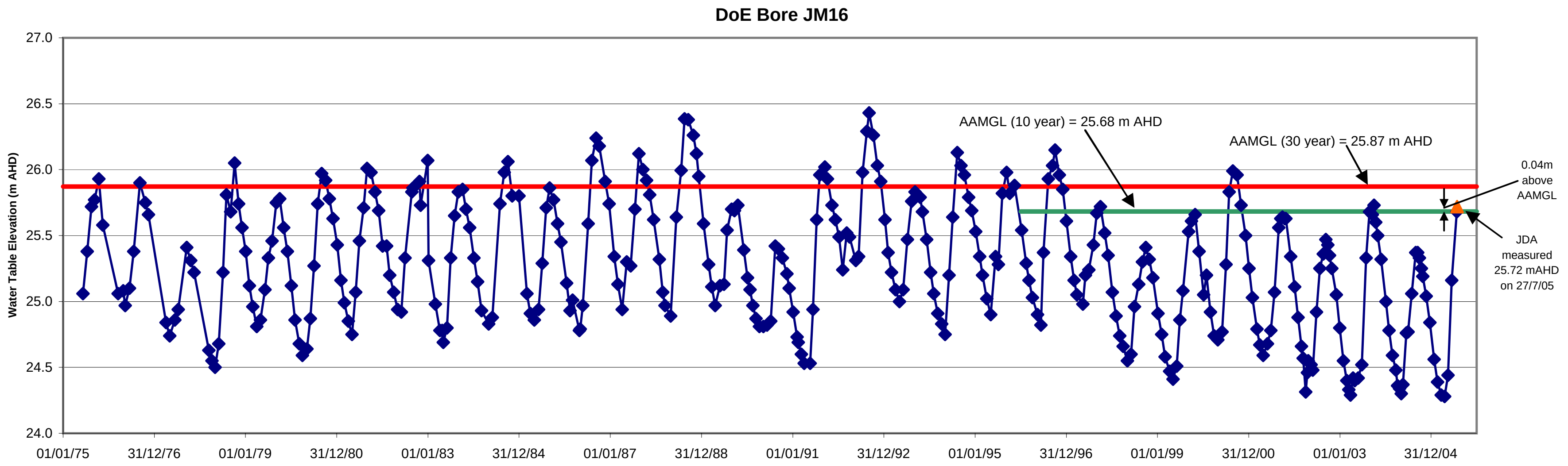
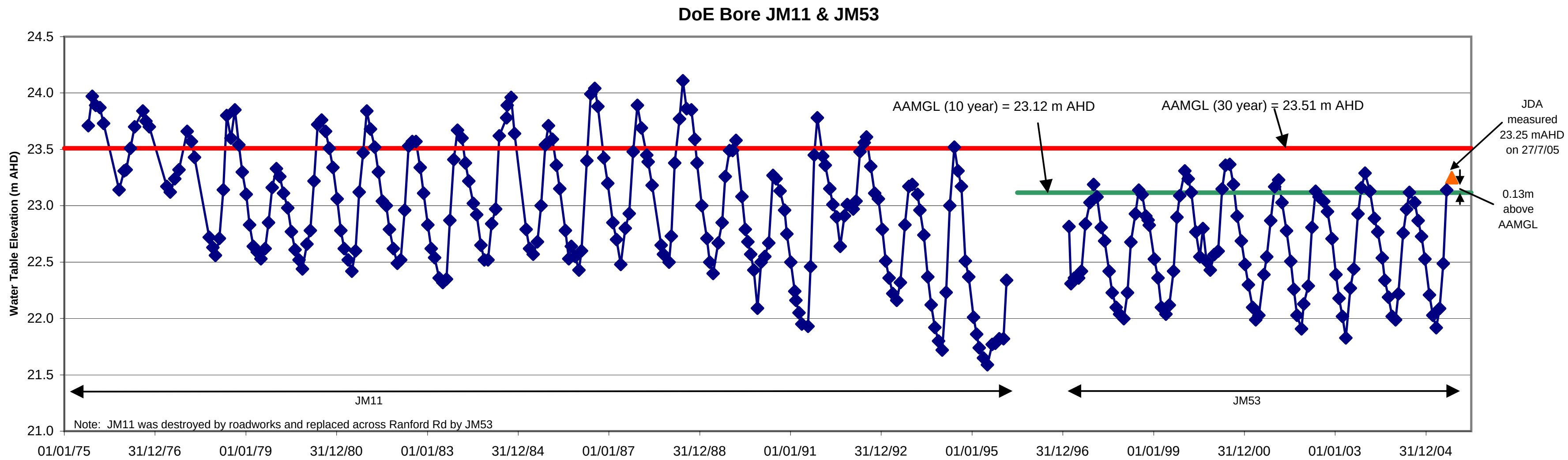
Figure 2: Bore Location & Existing Drainage Map





Data Source: Department of Environment

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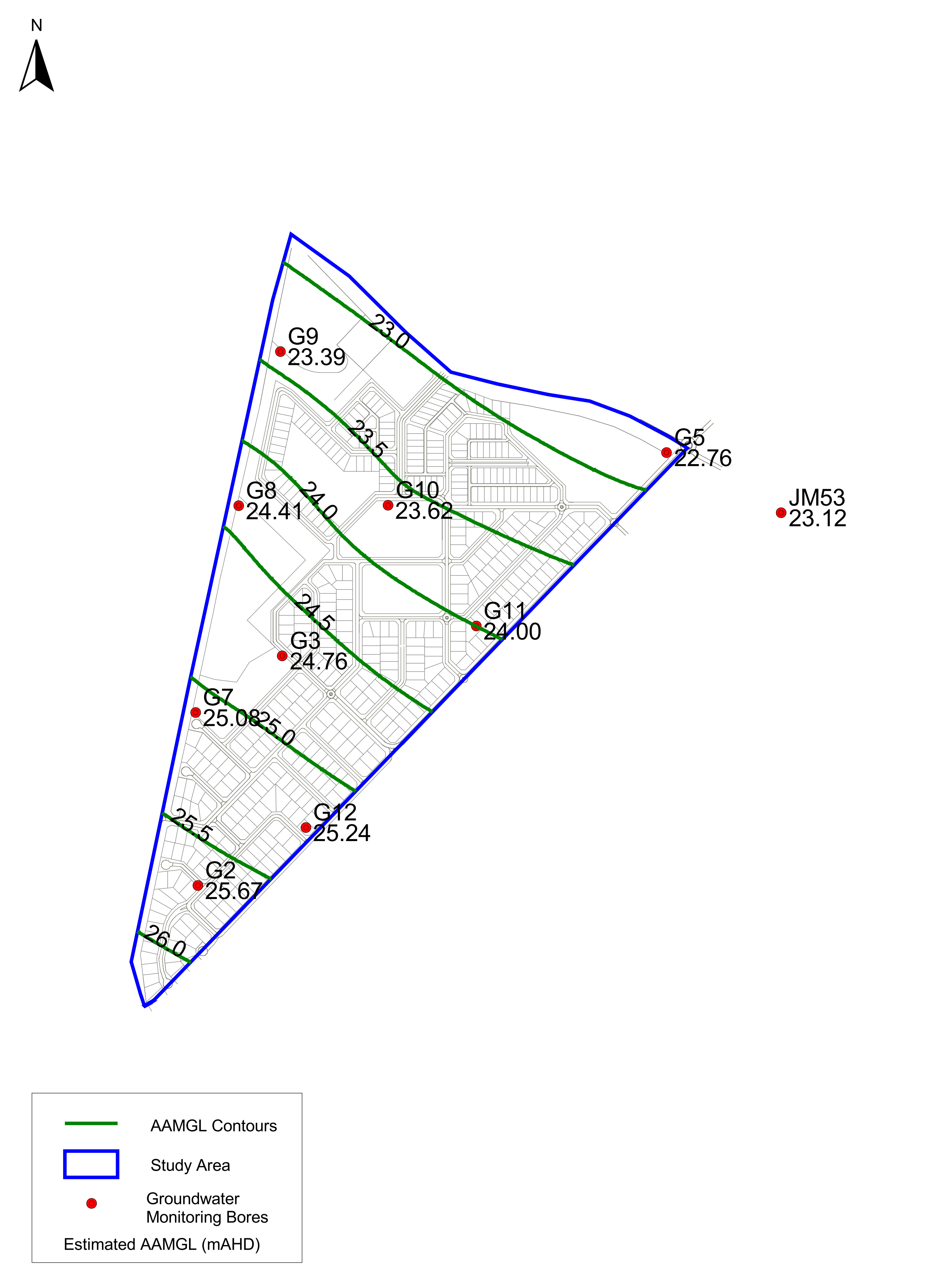
Figure 3: Time Series Data for DoE Monitoring Bores



Data Source: RDG (2005)

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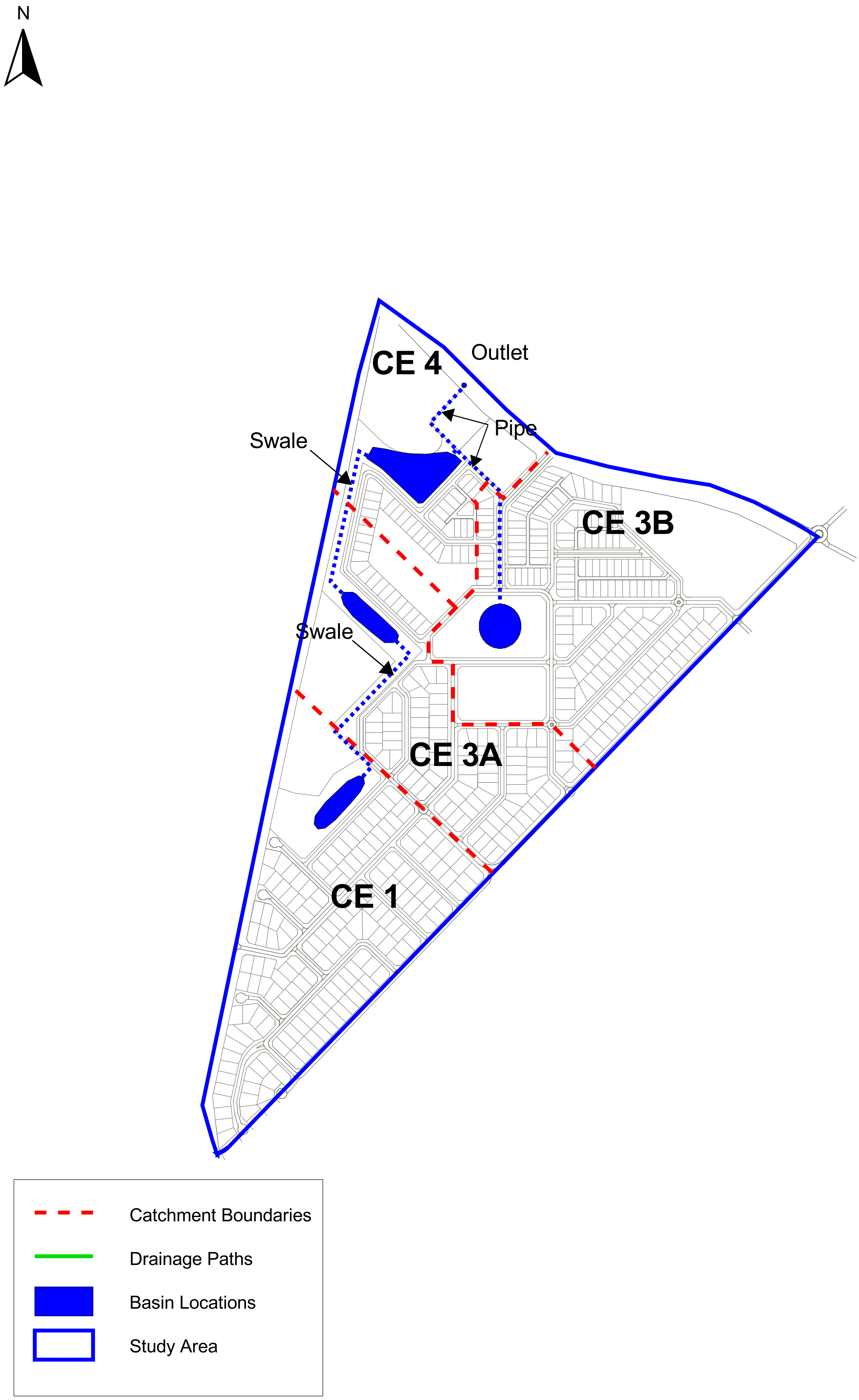
Figure 4: Estimated AAMGL



Data Source: RDG (2005)

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Figure 5: Schematic of XP-STORM Model

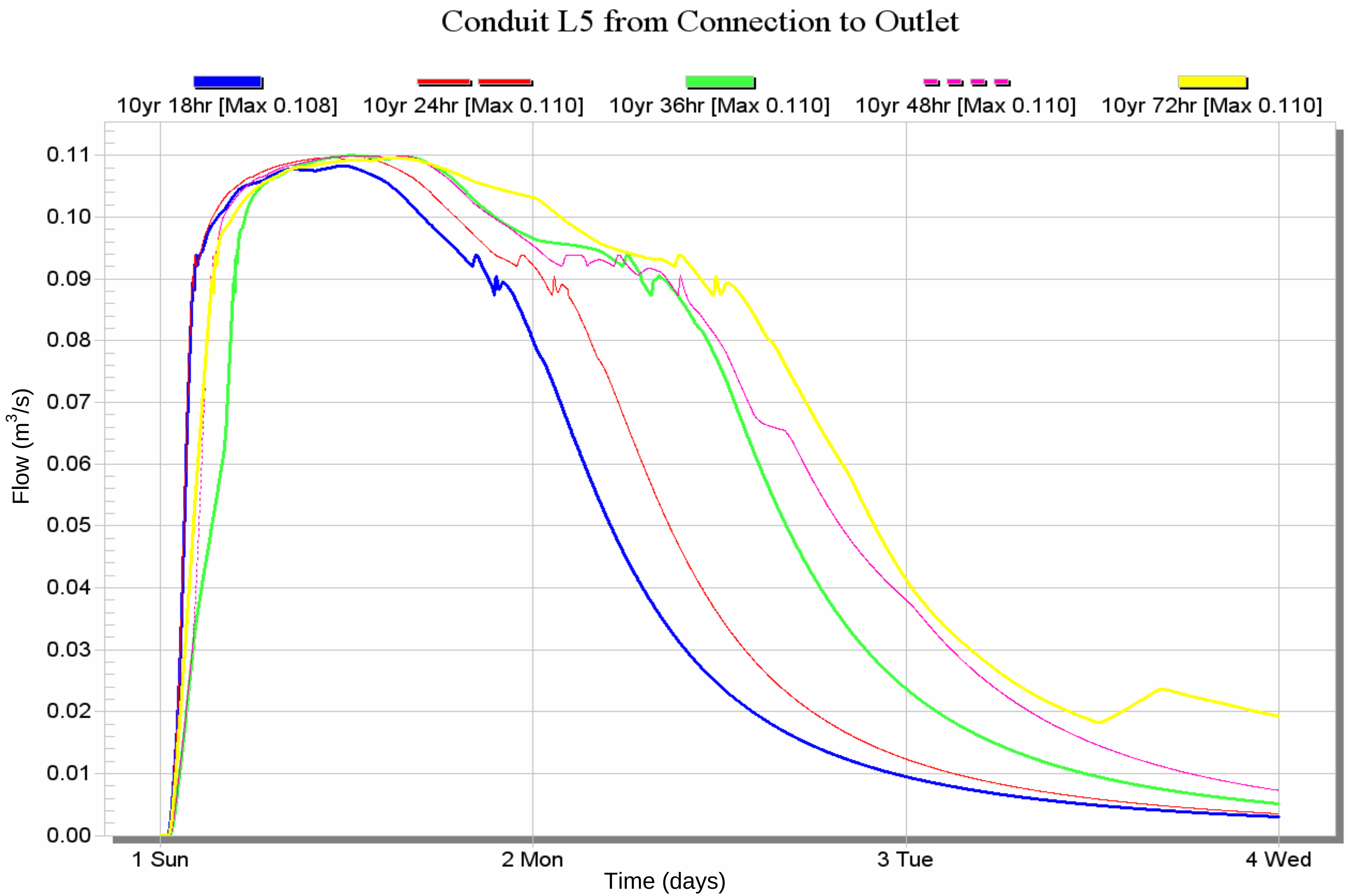

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Figure 6: Scenario 1, 10 Year ARI Storm Event Outflow Hydrograph - Glenariff Outlet to Ranford Road

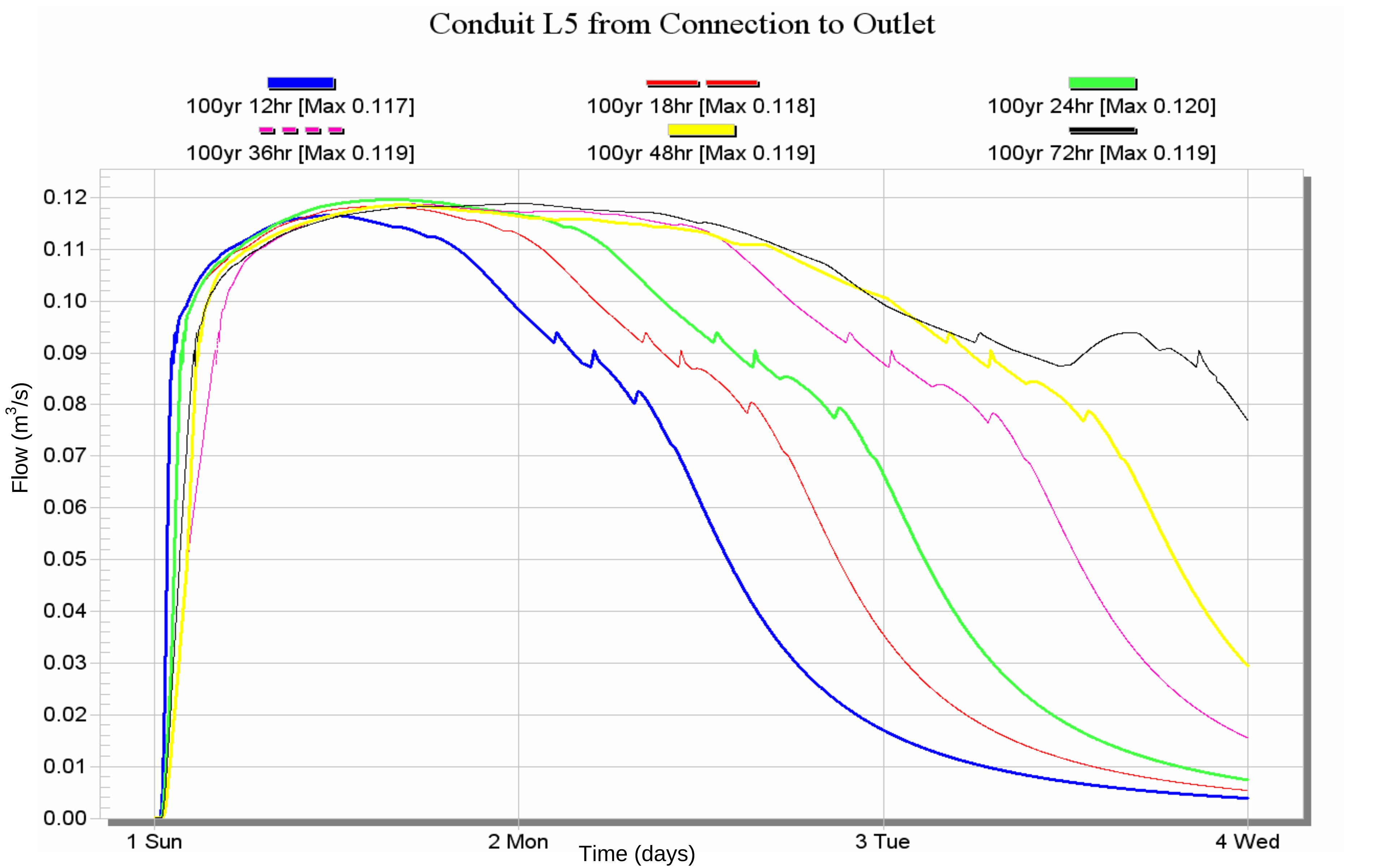

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Figure 7: Scenario 1, 100 Year ARI Storm Event Outflow Hydrograph - Glenariff Outlet to Ranford Road

APPENDIX A

Laboratory Analysis

mpl Laboratories

Certificate of Analysis

Testing Facility: Perth

Job No: **52272**
Client: JDA CONSULTANT HYDROLOGISTS
Address: PO BOX 117
SUBIACO WA 6904

Client Reference: J3530C1
Date Received: 16/08/2005
Date Sampled: 16/08/2005
Test Method: Water samples submitted by clients are analysed on an as received basis. Metals analysis on acidified samples as received. Analysis performed in accordance with MPL Laboratories WILAB 5, 6, 8 and 17.

Sampled By: CLIENT

IDENT UNITS	External ident	EC uS/cm	pH	NOx_N mg/L	TKN mg/L	Tot-N mg/L	NH4_N mg/L	Tot-P mg/L	PO4_P mg/L
M001	JDA J3530 G2	950	3.30	0.11	2.2	2.3	0.02	<0.01	<0.002
M002	JDA J3530 G5	630	5.10	0.87	1.3	2.2	0.44	<0.01	<0.002
M003	JDA J3530 G7	150	5.10	0.065	3.7	3.8	0.17	<0.01	<0.002
M004	JDA J3530 G9	430	4.85	0.029	5.2	5.3	0.35	0.06	0.011
M005	JDA J3530 G10	550	5.70	0.014	4.8	4.8	0.36	0.09	<0.002
M006	JDA J3530 G12	160	4.35	0.76	1.5	2.2	0.01	<0.01	<0.002
M001 Lab Dup	JDA J3530 G2	950	3.30	0.12	2.2	2.3	0.02	<0.01	<0.002
LQL		**1**	**0.05**	**0.005**	**0.05**	**0.05**	**0.005**	**0.01**	**0.002**

Checked: ____________ Approved Signatory: ____________

Date: 22/08/2005
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Suite 1, 27 York St, Subiaco WA 6008
PO Box 117, Subiaco WA 6904
Ph: +61 8 9388 2436
Fx: +61 8 9381 9279

www.jda-hydrologists.net.au

jdahydro@iinet.net.au

JDA Consultant Hydrologists

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