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JDA CONSULTANT HYDROLOGISTS

Your Ref: P471
Our Ref: J3335p

6 January 2005

James Mackintosh
Department of Environment
Kwinana Peel Region
PO Box 332 Mandurah WA 6210

Dear James,

THE RIDGE BALDIVIS: WESTERN CATCHMENT DRAINAGE & NUTRIENT MANAGEMENT PLAN

Further to our telephone conversation on 6/01/05, please find enclosed a revised version of the above DNMP dated 6/01/05 to include the amendments required as outlined in your letter dated 22/12/04. The following are the amendments made to address DoE numbered requests:

1&2. We have added Chapter 8: Nutrient Management to cover information on the fertiliser requirements for the development of POS and contingency plan in terms of fertiliser and irrigation reduction and soil amendments.

3. We have committed to install an additional monitoring bore on the western edge of the POS as outlined in section 9.2.2 Groundwater.

4. We have confirmed with Scott Allen (SKM) that 2 dry basins will be utilised in the eastern catchment (as amended on p1).

If you have any queries, please do not hesitate to contact Jim Davies or Dino Rahrugh.

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Yours sincerely,

Jim Davies

JDA Consultant Hydrologists

cc. Scott Allen, SKM ; Bruce Young, Peet & Co.; Peter Kata, DoE.

Peet Baldivis Syndicate Limited

The Ridge – Western Catchment

Drainage & Nutrient Management Plan

6 January 2005

JDA Consultant Hydrologists

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CONTENTS

1. INTRODUCTION 1

2. WESTERN CATCHMENT CHARACTERISTICS 2

2.1 LOCATION AND TOPOGRAPHY 2
2.2 CLIMATE 2
2.3 GEOLOGY/GEOMORPHOLOGY 2
2.4 WETLANDS 2
2.5 PROPOSED LAND USE 3

3. OBJECTIVES AND CRITERIA 4

3.1 RECENT DEVELOPMENTS IN WSUD 4
3.2 GROUNDWATER MANAGEMENT 5
3.3 FLOOD MANAGEMENT 6
3.4 WATER QUALITY MANAGEMENT 6
3.5 NUTRIENT MANAGEMENT 6

4. PROPOSED WATER MANAGEMENT SYSTEM 7

5. GROUNDWATER MANAGEMENT 8

5.1 GROUNDWATER LEVELS 8
5.2 BASIN AAMGL & AALGL ESTIMATION 8
5.2.1 Department of Environment Monitoring Sites 8
5.2.2 Estimated AAMGL 8
5.2.3 Estimated AALGL 9

6. FLOOD MANAGEMENT 10

6.1 INFILTRATION BASIN DESIGN CRITERIA 10
6.2 SOIL HYDRAULIC CONDUCTIVITY INVESTIGATION 10
6.3 INFILTRATION MODELLING 10
6.3.1 Infiltration Parameters 10
6.3.2 Modelling Results 10
6.4 ESTIMATED GROUNDWATER TIME OF TRAVEL 11

7. WATER QUALITY MANAGEMENT 12

7.1 EXISTING WATER QUALITY 12
7.2 WATER QUALITY TARGETS 12
7.3 WATER QUALITY CONTROLS 12

8. NUTRIENT MANAGEMENT 15

8.1 NUTRIENT MANAGEMENT 15
8.2 CONTINGENCY PLAN 16

9. MAINTENANCE, MONITORING, & REPORTING 17

9.1 MAINTENANCE 17
9.2 MONITORING PROGRAMME 17
9.2.1 Surface Water 17

9.2.2 *Groundwater* 17
9.2.3 *Reporting* 18

10.CONCLUSIONS **20**

11.REFERENCES **21**

LIST OF FIGURES

1. Location Map
2. Bureau of Meteorology Mandurah Rainfall Data
3. Mandurah Rainfall IFD Curve
4. Environmental Geology
5. Proposed Development Plan
6. JDA Monitoring Bores and Pre-Development AAMGL
7. DoE Bores Hydrograph & AAMGL
8. POS Detailed Plan showing swale and infiltration basin

LIST OF TABLES

1. DNMP Key Objectives and General Criteria
2. JDA Monitoring Bores Survey Details
3. Estimated AAMGL Levels
4. Infiltration Basin Design 10 & 100 Year ARI Storm Events
5. Pre-development Groundwater Quality Data Summary: November 2004 Monitoring
6. Pollutant Removal Efficiencies for Various Structural Controls
7. Summary of Nutrient and Irrigation Management
8. Nutrient Management Performance Objective, Criteria & Contingency Plan
9. Maintenance, Monitoring, and Education – Requirements and Responsibilities

APPENDICES

A DoE Interim Position Statement Principles and Objectives February 2003
B Lithological Logs of Monitor Bores installed in POS
C Laboratory Report of Water Quality

1. INTRODUCTION

This report details the Western Catchment Drainage and Nutrient Management Plan (DNMP) prepared by JDA Consultant Hydrologists for "The Ridge" development (Lot 731 Eighty Rd) Baldivis on behalf of Peet Baldivis Syndicate Limited.

The Western Catchment is defined by a ridge separating it from the Eastern Catchment. The Eastern Catchment drains to two dry infiltration basins and is not dealt with in this DNMP.

The DNMP details a total water management strategy for development of the Study Area, incorporating stormwater drainage management and nutrient management based on the principles of Water Sensitive Urban Design (WSUD) (Whelans et al. 1993).

With respect to the proposed stormwater infiltration basin,the DNMP includes the results of a groundwater level and quality investigation, mapping of the average annual maximum and lowest groundwater levels (AAMGL & AALGL), and the sizing of the basin.

The DNMP complies with recent changes in urban stormwater management for Western Australia implemented by the Department of Environment (DoE), with the DoE adopting a whole of catchment approach to urban water management. This shift places an emphasis on maximising infiltration, source controls, and non-structural water quality techniques. This contrasts with previous WSUD and Best Management Practice (BMP) techniques that concentrated on only the use of end of pipe solutions for water quality control.

2. WESTERN CATCHMENT CHARACTERISTICS

2.1 Location and Topography

The Ridge Estate is bounded by Eighty Rd to the west, private cleared land to the north and east and by State Forest to the south (Figure 1). The Western Catchment basin is located within the designated Public Open Space (POS) area in the southwestern corner of the estate (Figure 1). The Western Catchment area is approximately 25.7 ha.

Land slopes generally in a westerly direction from the eastern ridge to Outridge Swamp, with a fall of typically 1:75. Land slopes from a high of 35 m AHD on the ridge to 5 m AHD along Eighty Road.

2.2 Climate

The climate for the Study Area is Mediterranean with a mild wet winter and a hot dry summer. Rainfall for the Study Area is similar to Mandurah, with a long-term average annual rainfall of approximately 873 mm (based on Bureau of Meteorology Station 009572 Mandurah Park, since 1889). Average monthly rainfalls are shown in Figure 2.

The average annual rainfall for Mandurah has decreased significantly since the mid 1970's. Since 1975, the average annual rainfall has been 816 mm, representing a 6.5% reduction compared to the long-term average (Figure 2). The Indian Ocean Climate Initiative (IOCI) published a consolidated report on 5 years of strategic research (IOCI, 2002). In terms of rainfall IOCI (2002) finds that southern Western Australia appears to have undertaken a step change since 1975 with less annual rainfall. IOCI (2002) concludes that climate affected sectors in southern Western Australia should actively revise their previous climate baseline and adapt accordingly to both natural and human induced changes in climate and climate variability.

Rainfall intensity frequency duration (IFD) curves for Mandurah are shown in Figure 3, based on ARR (1987) which has not been revised to take account of the drier climate.

2.3 Geology/Geomorphology

The Western Catchment is comprised of Tamala Limestone overlain by Spearwood Sands (S. Southern), characteristic of conditions on the Swan Coastal Plain (Figure 4). The sands are pale and olive yellow, medium to coarse grained and moderately sorted of residual origin. They are derived from Tamala Limestone and have some capacity to attenuate pollutants due to small clay content. The Study Area is classified as degraded surface of eolian origin, Spearwood dunes (Gozzard, 1983).

Outridge Swamp to the west of Eighty Road is mapped as sandy clay (CS1), comprising greyish black with variable quartz sand content, of lacustrine origin (Gozzard, 1983).

2.4 Wetlands

Draft EPP Wetlands Mapping (EPA, 2004) shows that the Western Catchment is located within the draft EPP Wetlands Policy Boundary. Both Lake Walyungup and Outridge Swamp, which are located within 1.5 kms from the Western Catchment are categorised as draft EPP wetlands in the mapping.

The Draft EPP (Swan Coastal Plain) Policy 2004 declares to maintain the protection of the 1992 EPP Lakes and additional wetlands that are considered to have high conservation value but are currently not protected. The draft recommends protection by controlling activities that can destroy or degrade the environmental values under the Environmental Protection Act 1986 such as filling, mining, draining, discharging, or clearing (EPA, 2004). Hill et al (1995) show Lake Walyungup and Outridge Swamp to be "lake" and "sumpland" respectively, both of conservation category wetland management status.

Within the Western Catchment at the south-east corner there is a management category sumpland.

2.5 Proposed Land Use

The Development Plan for the Western Catchment is shown in Figure 5.

This provides for residential development of 228 lots ranging in area from 504 m^2 to 1952 m^2, with an average lot area of 650 m^2.

The south-west POS area of 16,256 m^2 is proposed to contain a basin for infiltration of stormwater.

3. OBJECTIVES AND CRITERIA

3.1 Recent Developments in WSUD

The Department of Environment (formerly Water and Rivers Commission, WRC) is the state government agency responsible for preparation of regional drainage management strategies in WA, to guide development and allow the planning and provision of sufficient infrastructure, particularly for water quality and quantity, to ensure land use change is environmentally sustainable.

Water Sensitive Urban Design (WSUD) for urban development was previously guided by WRC's "Manual for Managing Urban Stormwater Quality in Western Australia" (1998). Following further research and a paradigm shift to "at source controls", the DoE has released parts of the revised manual titled "Stormwater Management Manual for Western Australia". However, DoE's current position on Urban Stormwater Management in WA as outlined in the WRC Interim Position Statement Principles and Objectives February 2003 (Appendix A) still applies, since nothing on this subject has been released under the new manual. Principal objectives for managing urban water quality and quantity in WA are stated as:

- **Water Quality.**
  To maintain or improve the surface and groundwater quality within development areas relative to pre-development conditions.
- **Water Quantity.**
  To maintain the total water cycle balance within development areas relative to the pre-development conditions.

The following stormwater management hierarchy are then presented to achieve these objectives:

- **Retain and restore natural drainage systems.**
  Retain and restore existing valuable elements of the natural drainage system, including waterway, wetland, groundwater features and processes.
- **Implement non-structural source controls.**
  Minimise pollutant inputs principally via planning, organisational and behavioural techniques, to minimise the amount of pollution entering the drainage system
- **Minimise runoff.**
  Infiltrate or reuse rainfall as high in the catchment as possible. Install structural controls at or near the source to minimise pollutant inputs and the volume of stormwater
- **Use of 'in-system' management measures.**
  Includes vegetative measures, such as swales and riparian zones, and structural quality improvement devices such as gross pollutant traps

The Southern River/Forrestdale/Brookdale/Wungong Urban Water Management Strategy (UWMS) (JDA, 2002) represents the first regional drainage management strategy locally to adopt a source control approach to urban water management. The UWMS marks a shift of emphasis from attempts to trap or retard pollutant in their journey from land application to discharge, to a more fundamental "Prevention is better than Cure" philosophy. The UWMS aims for a reduction in pollutant input with land use change compared with current broadscale agricultural activity and therefore a subsequently lower long-term export to its receiving environment.

On the above basis, general objectives and general criteria for water quality management, groundwater management, and flood management within the Study Area are detailed in Table 1. The objectives and criteria have been developed with consideration of local and State stormwater management objectives and are generally consistent with the requirements of the following documents:

- Urban Stormwater Management in WA – Interim Position Statement, Principles and Objectives, Water & Rivers Commission (2003)

- West Australian Water Quality Guidelines for Fresh and Marine Waters (Environmental Protection Authority Bulletin 711),
- ANZECC Australian and New Zealand Guidelines for Fresh and Marine Water Quality National Water Quality Management Strategy (2000a),
- A Manual for Managing Urban Stormwater Quality in Western Australia (WRC, 1998),
- Design criteria for the City of Rockingham

Table 1: DNMP Key Objectives and General Criteria

Category	Objective	General Criteria
Groundwater Management	Maintain groundwater levels within their current natural regime particularly with respect to defined environmental water requirements (EWR or provisions (EWP) for lakes or wetlands.	Maintain pre development average annual maximum groundwater level (AAMGL)
Flood Management	Provide flood protection to developed areas Protect downstream areas from flooding and erosion	Import fill to establish clearance for development above groundwater and flood levels Apply infiltration techniques for management of stormwater discharge where possible. Infiltration techniques to be used as high in the catchment as possible.
Water Quality Management	Maintain water quality within the area of the proposed basin (lake) to enhance the ecological function and conservation value of the lake.	Water quality targets based on ANZECC (2000a) guidelines and predevelopment monitoring outcomes Adoption of DoE recommended structural and non structural source control techniques and WSUD BMP's to maintain Nitrogen and Phosphorus level within the EPA guideline limit
Nutrient Management	Reduce the level of nutrients entering the lakes and groundwater. Achieve maximum water use efficiency.	Maintain nutrient levels in soils at desired / ideal concentrations Maintain groundwater and surface water quality based on ANZECC (2000a) guidelines and predevelopment monitoring outcomes

3.2 Groundwater Management

The AAMGL policy was developed in the early 1990's by the (then) WRC as a mechanism to prevent nutrient rich groundwater being drained from an area as surface water, polluting water bodies downstream, preventing the drying out the wetlands and saving the groundwater dependent vegetation. The AAMGL policy requires new open drains or subsoil drains to be laid at or above the AAMGL, with fill imported to give adequate separation between the land surface and groundwater.

WRC have however recently adopted a more flexible AAMGL policy (JDA 2002) where post development drainage levels can be set below the AAMGL where it can be shown that wetland groundwater levels will not be adversely affected and limiting peak seasonal groundwater levels does not significantly increase nutrient export.

Given consideration of the proximity of the Western Catchment to the Conservation Category Wetlands, and the need to infiltrate stormwater runoff within the development area, no lowering of groundwater below the AAMGL is proposed.

3.3 Flood Management

The generally adopted design criteria for new development areas is that post development flows are attenuated to pre-development levels. Flood management criteria is therefore generally based on maintaining the peak flow at the downstream boundary of the Western Catchment with existing design peak flows, to protect downstream areas from flooding and erosion. For the Western Catchment under pre-development conditions there would be some overland flow across Eighty Road to Outridge Swamp. Under the proposed development there will be no surface outflow whatsoever, but rather all stormwater will be infiltrated, with no surface outflow.

In the case of the Western Catchment, the basin has been designed based on the previously mentioned flood management criteria while satisfying the City of Rockingham design guidelines.

3.4 Water Quality Management

The approach adopted for water quality management for the Study Area is based on determining existing water quality by monitoring pre-development, establishing targets based on ANZECC (2000a) and EPA Bulletin 711, implementing water quality measures to achieve targets, and monitoring post development to assess performance.

With respect to stormwater management guidelines, no specific standards or criteria for water quality management are established in WRC's Manual for Managing Urban Stormwater in Western Australia. The DoE have recently commenced a major review of this Manual, and until the manual update is completed, DoE have encouraged the use of "source controls" and "in transit" controls as the primary approach for stormwater quality management.

There are no specific published targets by DoE for water quality discharge to Lake Walyungup and Outridge Swamp. With respect to other pollutants, water quality targets provided in ANZECC (2000a) are considered the most appropriate reference, however their application is primarily for unmodified or slightly modified ecosystems and do not readily apply to stormwater management.

Water quality targets based on ANZECC (2000a) and EPA Bulletin 711 should be considered indicative only and subject to review as more data becomes available. This approach to target review is consistent with ANZECC (2000b) and ensures that established targets are achievable, and the implementation of inappropriate pollution control measures to achieve unrealistic targets is minimised.

For water quality management the following general criteria are proposed:

- ☐ preliminary water quality targets based on ANZECC (2000a), EPA Bulletin 711, and predevelopment monitoring outcomes.
- ☐ minimise pollutant input to surface water and groundwater by use of DoE recommended non-structural and structural source control techniques and WSUD BMP's.

3.5 Nutrient Management

The general key objectives for nutrient management are to indicate that fertiliser application can be managed sustainably, and that irrigation management and practice will minimise nutrient leaching and water wastage, and further assist in the improvement and maintenance of soil and water quality. For Western Catchment, objectives and criteria have been developed with consideration of WSUD principles, BMPs, and management objectives of the City of Rockingham.

4. PROPOSED WATER MANAGEMENT SYSTEM

The proposed water management system is consistent with water sensitive design practices and meets key DNMP objectives and criteria as presented in Chapter 3.

The stormwater drainage system will be designed using a major/minor approach. The minor drainage system is defined as the system of underground pipes, swales, kerbs, gutters etc. designed to carry runoff generated by low frequency ARI storms, typically less than 5 year ARI. The major drainage system is defined as the arrangement of roads, drainage reserves, detention basins and open space planned to convey the stormwater runoff from extreme events which exceeds the capacity of the minor system.

Stormwater runoff generated by the impervious areas of the road reserve will be collected in gully or side entry pits and conveyed by a formal piped drainage system to an infiltration basin located at the lowest western end of the catchment. Roof runoff from private dwellings will be connected to soakwells to promote at-source infiltration.

The infiltration basin is to be unfenced, landscaped and located within the POS area. The infiltration basin has been designed to contain runoff from the critical duration 100 year ARI storm event, with no surface discharge from this event to the environment.

Minimum separation between building floor levels and the average annual maximum groundwater level (AAMGL) will be achieved by grading of the entire development area including road reserves. Minimum building floor levels will comply with DoE requirements of a 1.2m clearance above AAMGL. Generally there is far in excess of this minimum.

Water quality management will be achieved through a treatment train approach including the application of source controls (including street sweeping and education campaigns), and maximising infiltration consistent with DoE's recommended approach to stormwater management. Gross Pollutant Traps (GPT's) will be installed on both outlets to the infiltration basin.

Each side entry pit has an open based manhole to promote infiltration in all rainfall events, thus distributing infiltration as widely as possible across the Western Catchment.

5. GROUNDWATER MANAGEMENT

5.1 Groundwater Levels

A site investigation in the main POS area was conducted by JDA on 13 January 2004, with five groundwater monitoring bores installed by 75 mm hand auger. The bores were labelled ER1 to ER5 and consisted of 50 mm PVC capped at both ends and slotted for the lower 30 cm into the water table. The location of the bores can be seen on Figure 6. The logs for the bores are attached as Appendix B.

Natural surface and top of casing (TOC) levels were surveyed to Australian Height Datum (m AHD) by Whelans and received by JDA on 2 February 2004. The details of the survey are shown in Table 2.

Groundwater levels were measured on 13 January 2004 and the measured water levels are presented in Table 2. the water table was almost level over the site with a minimum water level of 1.54 m AHD at ER4 to a maximum of 1.58 m AHD at ER5.

Table 2: JDA Monitoring Bores Survey Details

Bore	GDA Coordinates		TOC [m AHD]	Natural Surface [m AHD]	Water Level	
	Easting	Northing			[m bTOC]	[m AHD]
ER1	386962	6419592	4.23	3.26	2.67	1.56
ER2	386936	6419666	5.10	4.51	3.54	1.56
ER3	387066	6419692	7.61	7.02	6.05	1.56
ER4	387072	6419625	7.62	6.98	6.08	1.54
ER5	387013	6419630	5.55	4.64	3.97	1.58

5.2 Basin AAMGL & AALGL Estimation

5.2.1 Department of Environment Monitoring Sites

There are three Department of Environment (DoE) superficial aquifer monitoring bores located within 3.5 km of the Study Are – T340(O), T390(O), and T430(O). There is also a staff gauge on Lake Walyungup, 1.5 km from the Study Area.

On 13 January 2004, the water level in bores T340(O), T390(O) and T430(O) and the Lake Walyungup staff gauge were 0.58 m AHD, 1.66 m AHD, 0.93 m AHD, and 1.31 m AHD respectively.

5.2.2 Estimated AAMGL

To estimate Average Annual Maximum Groundwater Level (AAMGL) for the JDA bores a seasonal adjustment of 0.84 m was applied to the levels measured on the 13 January 2004. The adjustment was based on the adjacent DoE monitoring bore T390(O), which was the closest of the DoE bores to the Study Area and considered to be the most representative bore to use for this analysis (Table 3, Figure 7).

The estimated AAMGL for each of the locations are presented in Table 3.

The seasonal water table variation is estimated at approximately 1 m, based on records from the three DoE monitoring bores. Maximum annual variation was up to 1.6 m and minimum was 0.2 m in records dating from 1975.

Table 3: Estimated AAMGL Levels

Bore	Water Level 13 January 2004 [m AHD]	Estimated AAMGL[1] [m AHD]
JDA Bores		
ER1	1.56	2.40
ER2	1.56	2.40
ER3	1.56	2.40
ER4	1.54	2.38
ER5	1.58	2.42
DoE Bores and Staff Gauge		
T340(O)	0.58	2.28
T390(O)	1.66	2.50
T430(O)	0.93	2.34
Lake Walyungup Staff Gauge	1.31	2.35

[1] A correction of 0.84 m applied to 13/1/04 readings based on DoE bore T390(0)

In summary AAMGL is estimated as 2.40 m AHD at the infiltration basin and generally across the site.

5.2.3 Estimated AALGL

To estimate Average Annual Lowest Groundwater Level (AALGL) a seasonal variation of 1.0 m was applied, based on long term DoE monitor bore data. AALGL is therefore estimated as 1.4 mAHD.

The base of the basin is proposed to be -0.5 mAHD (Figure 8) to give approximately 2 m depth throughout the year, to prevent temperature rise and increase risk of water quality problems.

6. FLOOD MANAGEMENT

6.1 Infiltration Basin Design Criteria

The proposed basin configuration is to have a single landscaped infiltration basin located in the POS area to receive and infiltrate stormwater runoff. The basin has been designed to contain and infiltrate events up to the 100 year average recurrence interval (ARI) event.

The proposed basin is designed based on the City of Rockingham Design Criteria for Infiltration Basin that is to contain up to the 72 hr storms for both the 10yr and 100yr ARI events.

6.2 Soil Hydraulic Conductivity Investigation

JDA conducted field infiltration testing for the Study Area. The results of this testing indicated further detailed investigation of subsoil conditions were required. Coffey Geosciences Pty Ltd conducted the more detailed geotechnical investigations, reported in Coffey Geosciences (2004).

Borehole locations used for infiltration testing by Coffey Geosciences are shown in Figure 6.

Coffey Geosciences (2004) recommends an insitu design permeability value at the location of the proposed infiltration basin of 5 m/day be adopted. This rate was adopted by JDA for infiltration modelling described below.

6.3 Infiltration Modelling

The proposed infiltration basin was modelled using MODRET 6.0 for Windows, a computer program that calculates unsaturated and saturated infiltration losses from stormwater retention/detention basins in unconfined aquifers. This model is featured in WRC's Manual for Managing Urban Stormwater Quality in Western Australia (1998) as a recommended model for infiltration basin design in areas of high water table.

6.3.1 Infiltration Parameters

The following key design parameters have been adopted for design:

- Contributing catchment area of 6.5 ha
- Runoff coefficient for road and road reserves of 0.65 for the 10yr event.
- Runoff coefficient for road and road reserves for the 100 year event as:
  - 0.90 for 3.647 ha of the contributing catchment.
  - 0.50 for 2.873 ha of the contributing catchment.
- The base of the superficial aquifer at the site was modelled as –2 m AHD based on nearby DoE monitoring bore T390 showing a possible confining layer at this level.
- The effective porosity was assumed to be 0.15.
- A hydraulic conductivity of 5 m/day was adopted as previously discussed in Section 6.2.

6.3.2 Modelling Results

Modelling the 10yr and 100yr ARI storm event using MODRET was completed. Details of the geometry of the proposed basin were provided by SKM.

Table 4 details the results for both the 10yr and 100 yr ARI.

Table 4: Infiltration Basin Design 10 & 100 Year ARI Storm Events

	10 Year	100 Year
Basin Invert (m AHD)	-0.5	-0.5
Critical Duration Storm (hrs)	72	72
Total Runoff Volume (m^3)	5,000	8,600
Maximum Water Depth (m)	1.33	1.77
Basin TWL (m AHD)	3.73	4.17
Basin Base Area (m^2)	1,875	1,875
Flood Storage (m^3)	4,025	6,800

[1] Initial water table 2.4 mAHD (AAMGL)

6.4 Estimated Groundwater Time of Travel

The estimated time of travel of infiltration from the basin to Outridge Swamp is calculated using Darcy's formula ($v = K_h i$), where velocity of flow (v) is a product of the regional estimate of horizontal hydraulic conductivity (K_h) and the regional water table gradient (i).

For a (K_h) of 5 m/day and a water table gradient (i) of 0.01, Darcy's velocity is calculated to be 0.05 m/day or 18 m/year.

The actual groundwater flow velocity (average linear velocity) is calculated as the Darcy velocity divided by the effective porosity (n). A regional value of n is 0.15, so that the average linear velocity is estimated as 0.033 m/day, or 120 m/year.

The distance between Outridge Swamp and the infiltration basin is approximately 200 m, so that the estimated travel time is 606 days, or 1.7 years.

Note that this estimate of groundwater travel time should be considered indicative only, assuming estimates of groundwater gradient and hydraulic conductivity for the study area as representative of regional values.

The implication is that the water infiltrated in the infiltration basin has a travel time of between 1 & 2 years to allow for water quality improvement including nutrient adsorption prior to discharge to Outridge Swamp.

This groundwater time of travel between the basin and Outridge Swamp would be the same whether the basin is finished as a wet or dry basin. Hence from the point of view of the impact on downstream wetlands such as Outridge Swamp, the proposed wet basin is equivalent to a dry basin.

7. WATER QUALITY MANAGEMENT

7.1 Existing Water Quality

Groundwater water quality sampling was undertaken in the Study Area on 10 November 2004 at 2 bores, ER4 and ER5. The sites were selected to provide a representation of groundwater quality on the upstream and the middle of the proposed infiltration basin location. Groundwater quality data for the 2 sites are summarised in Table 5 with the laboratory report contained in Appendix C.

Guideline trigger values for protection of aquatic ecosystems in south-west Australia are shown in Table 5 based on Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC, 2000a). The trigger values were derived from ecosystem data for unmodified or slightly-modified ecosystems, and are not based on any objective biological criteria. ANZECC (2000a) recommends they should only be applied where site-specific values do not exist or until site-specific values can be derived.

The groundwater nutrient concentrations measured 10 November 2004 as presented in Table 5 are less than ANZECC guidelines for both filterable reactive P and total P. The average of the two monitor bores total nitrogen is less than the ANZECC guideline value (Appendix C).

Table 5: Pre-development Groundwater Quality Data Summary: November 2004 Monitoring

Parameter	***ANZECC Guideline Values*** [2]	**JDA November 2004 Groundwater Monitoring**	
		ER4	**ER5**
Major Ions[1]			
PH	*6.5-8.0*	NM	NM
EC (mS/cm)	*0.30-1.50*	NM	NM
TDS (mg/L)	-	NM	NM
Nutrients			
Nitrate-N (mg/L)	*0.1*	0.75	0.75
Nitrite-N (mg/L)	*0.1*	<0.05	<0.05
Total Kjeldahl Nitrogen (mg/L)	-	0.33	1.1
Total Nitrogen (mg/L)	*1.5*	1.1	1.8
Filterable Reactive P (mg/L)	*0.03*	<0.01	<0.01
Total Phosphorus (mg/L)	*0.06*	0.01	0.02

1. Values adopted for a wetland, South West Australia
2. ANZECC (2000a) trigger values for freshwater for a 95% level of protection (slightly to moderately disturbed ecosystem)
3. NM = not measured

7.2 Water Quality Targets

The approach adopted for water quality management for the Western Catchment is to determine existing water quality by monitoring, establishing targets, implementing water quality measures to achieve targets, and monitoring post development to assess performance. To this end it is recommended interim water quality targets for Phosphorus and Nitrogen be set consistent with pre-development monitoring results, with an improvement in the existing water quality proposed as the initial target. These interim targets should be reviewed as more monitoring data becomes available.

7.3 Water Quality Controls

Recent developments in urban stormwater quality management have seen a shift of emphasis from attempts to trap or retard pollutant in their journey from land application to discharge, to a more fundamental "Prevention is better than Cure" philosophy. This has seen a movement toward catchment management measures and pollutant input control rather than on purely engineering approaches.

WRC's A Manual for Managing Urban Stormwater Quality in Western Australia (1998) is currently under review and the revised document, which has been partly released, will provide a greater emphasis on strengthening source controls and catchment management measures to reduce pollutant input, while still incorporating previously accepted water sensitive urban design measures and best management practice treatment trains.

Structural source controls are usually tested in laboratory situations by manufacturers with some technical information available on the likely performance under various conditions. This information can be used to estimate performance in terms of nutrient and pollutant retention ability together with associated capital and maintenance costs to assess the likely unit cost rate of removal.

It is more difficult to predict the effectiveness of non-structural source controls in water quality management. This is because non-structural measures cannot be readily tested by the conventional input/output methods, and for this reason, until recently there has traditionally been a reluctance to include non-structural source controls in stormwater management programs in other states.

Control of pollutants at source using non-structural measures by minimisation or prevention of input, is an efficient cost effective water quality management option.

Non-structural source controls proposed for the Western Catchment include :

- **Education**
  Nutrient awareness information to be included in the settlement letter to each purchaser, associated with landscaping package details.
- **Native Vegetation**
  Retention of existing native vegetation in passive POS areas
  Partial use of native plantings in other POS areas
- **Street Sweeping**
  Develop and undertake co-ordinated street cleaning programs to remove sediments
- **Maintenance Activities**
  Ongoing review and refinement of maintenance activities

Structural control measures to be applied to the Study Area and their pollutant removal efficiencies are summarised in Table 6.

Table 6: Pollutant Removal Efficiencies for Various Structural Controls

Treatment Measure	**Pollutant Removal Efficiency** **neg** : Negligible [0-10% removal] **M** :Moderate [50-75% removal] **L** : Low [10-50% removal] **H** : High [75-100% removal]									Potential for pollutant re-mobilisation
	Litter and gross pollutants (>500 µm)	Coarse sediment (>200 µm)	Fine sediment & suspended solids (<200 µm)	Total phosphorus	Dissolved phosphorus	Total nitrogen	Dissolved nitrogen	Oil and grease	Oxygen demanding substances (BOD)	
Litter / trash racks	M	L	neg	neg	neg	neg	neg	neg	L	M
Stormwater Pollutant Traps	H	H	M	L	neg	L	neg	L	L	M
Infiltration basin/swale	L	H	H	M	neg	L	neg	L	M	L

Adapted from JDA (2002)

There are two stormwater pipes which will discharge to the infiltration basin. Each of these will have a Humeguard stormwater pollutant trap sized appropriately. These traps have been delivered to site and are awaiting installation once this DNMP is approved.

In addition the infiltration basin has been contoured to allow for primary filtering of any pollutants within the POS area prior to discharge to the basin waterbody itself.

The swales within the POS around the infiltration basin have a storage volume of 649 m^3, to store the short duration 1 yr ARI storm runoff.

Therefore pollutants will not directly enter the basin but rather be retained and infiltrate in the swale area. Only larger storms will have runoff directly to the basin.

As explained in Section 6.4 the estimated groundwater time of travel between the basin and Outridge Swamp would be the same whether the basin was completed as a wet basin or a dry basin. Hence from the point of view of impact on downstream wetlands the wet basin is equivalent to a dry basin.

The proposed combination of non-structural source controls and structural control measures described above represents a treatment train approach to stormwater quality improvement consistent with DoE position paper. It represents a commitment by the Developer, Peet & Co and by their design consultants SKM and Epcad to produce a sustainable development which will protect the important environmental features downgradient.

8. NUTRIENT MANAGEMENT

8.1 Nutrient Management

Management of nutrient application within the POS area is outlined in the "The Ridge at Baldivis – Landscape and Irrigation Works: Stage 1" (EPCAD 2005). It presents details of irrigation and nutrient application rates and general maintenance measures including a turf calendar. Nutrient and irrigation application rates have been developed specifically for the Ridge, Baldivis by the landscape contractor to ensure excess nutrient application is minimised for the various areas (trees, garden beds, and lawn). The City of Rockingham has been involved with and approved this POS Landscape and Irrigation Works Plan.

A summary of the nutrient application details and irrigation rates from this Plan are presented in Table 7. Nutrient composition for the fertiliser for grass area is 9% Phosphorus and 10% Nitrogen. Based on the application rate of 150 kg/ha/yr, this equates to 13.5 kg/ha/yr of Phosphorus and 15 kg/ha/yr of Nitrogen application. Based on these rates, the total nutrient application in considered low (DEP/WRC 2001 and Sports Turf Technology 2004).

Table 7: Summary of Nutrient and Irrigation Management

POS Area	Fertiliser Application						Irrigation	
	Frequency	Type	Method	Rate (kg/ha/yr)	Maximum Nutrients Applied		Frequency (per week)	Rate (per week)
					P (kg)	N (kg)		
Grass	Jan	-	Tractor mounted fertiliser spreader for broad acre areas, 40 kg spinner for smaller areas	-	-	-	Twice	40 mm
	Feb	-		-	-	-	Twice	40 mm
	Mar	-		-	-	-	Twice	40 mm
	Apr	NPK 1098		150 kg/ha[2]	7[1]	8[1]	Twice	20-30 mm
	May	-		-	-	-	Twice	20-30 mm
	Jun-Aug	-		-	-	-	-	-
	Sep	-		-	-	-	Twice	20-30 mm
	Oct	-		-	-	-	Twice	20-30 mm
	Nov	NPK 1098		150 kg/ha[2]	7[1]	8[1]	Twice	40 mm
	Dec	-		-	-	-	Twice	40 mm
Garden	Twice/yr	Osmocote Controlled Release	Hand	200 kg/ha[2]	3.5[2]	12[2]	As per above	As per above
Trees	Annually	Osmocote Fertiliser Tablet	Place below ground	5 tablets[3]	2.2g/ tree[3]	7.5g/ tree[3]	As per above	200 L per tree per session

1. Assumes 1.06ha POS grass area with fertiliser (9% Phosphorus and 10% Nitrogen) applied at 150kg/ha/yr.
2. Assumes 0.4ha POS garden area with fertiliser (4.4% Phosphorus and 15% Nitrogen) applied at 200 kg/ha/yr.
3. Assumes 5x10g Osmocote Tree Tablets per tree with 4.4% Phosphorus and 15% Nitrogen composition.

8.2 Contingency Plan

Table 8 details a contingency plan that was developed based on the adoption of WSUD principles and BMPs.

Table 8: Nutrient Management Performance Objective, Criteria & Contingency Plan

Performance Objective	Criteria	Contingency Plan
Maintain nutrient levels in soils at desired/ideal concentrations	☐ Nutrient concentrations in soil do not meet desired / ideal concentrations (as defined by soil/water consultant) for soil type ☐ Excess turf/vegetation growth	☐ Review fertiliser application program ☐ Increase sampling and incorporate recommendations of soil/water consultant ☐ Use of soil amendments to ensure desired soil conditions ☐ Review irrigation practises to ensure no leaching of nutrients to groundwater ☐ Identify and control or prevent source of increase nutrient input
Improve and/or maintain groundwater quality	☐ Increase in nutrient concentrations relative to baseline monitoring data[1]	☐ Review fertiliser application program ☐ Increase groundwater sampling ☐ Use of soil amendments to retain nutrients within root zone ☐ Refinement of irrigation system to suit soil, drainage and climatic conditions
Improve and/or maintain wet basin water quality within ANZECC (2000) guidelines	☐ Water quality exceeds guidelines based on ANZECC (2000) guidelines	☐ Review fertiliser application program, particularly application technique near wet basin ☐ Increase sampling to verify results ☐ Identify if conditions favourable for release of nutrients from wet basin bed, if so adopt appropriate management practices to ensure release is ceased ☐ Review irrigation practices to ensure no surface runoff ☐ Identify and control or prevent source of increased nutrient input ☐ Increase fringing vegetation densities as outlined in the approved Landscape Management Plan
Achieve maximum water use efficiency	☐ Increased runoff from POS area	☐ Refinement of irrigation system to suit soil, drainage, and climatic conditions ☐ Aeration of soil profile (by coring or spiking) ☐ Application of surfactants to "non-wetting" areas
	☐ Increased leaching of nutrients into groundwater	☐ Refinement of irrigation system to suit soil, drainage and climatic conditions ☐ Use of soil amendments to retain nutrients within root zone

1. Groundwater quality monitoring data to be collected immediately to provide sufficient baseline data for future comparison.

9. MAINTENANCE, MONITORING, & REPORTING

9.1 Maintenance

The following maintenance practices will be implemented periodically to ensure efficient operation of the water management system:

- Removal of debris from the drainage swale
- Maintenance of SPT's to remove trapped gross pollutants
- Street sweeping to reduce particulate build up on road surfaces and gutters
- Monitoring invasion of exotic plants in the basin/swale
- Cleaning of sediment build up on the bottom of the basin/swale
- Mowing of grassed infiltration basin/swale with appropriate disposal of clippings

A summary of the maintenance practices, and their frequencies and responsibilities are contained in Table 7. These practices, frequencies, and responsibilities are consistent with other developments with similar drainage systems in proximity to the Study Area.

A quarterly monitoring and reporting process is proposed for maintenance practices. Non performance of any of these practices will be resolved in consultation with the City of Rockingham.

9.2 Monitoring Programme

The monitoring programme has been designed to allow quantitative assessment of hydrological impacts of proposed development within the Study Area. In particular the programme addresses the monitoring of discharges from the development via the proposed infiltration basin.

The programme may need to be modified as data are collected to increase or decrease the monitoring effort in a particular area or to alter the scope of the programme itself. The programme is intended for a 2 year period. The program will be reviewed periodically to ensure suitability and practicality.

A NATA approved laboratory will conduct all analyses of nutrients. All samples will be obtained and handled according to Australian Standards.

9.2.1 Surface Water

Surface water monitoring will focus on water quality discharging to the infiltration basin to determine nutrient concentrations, with loads estimated from annual rainfall records.

Discharge at the infiltration basin inlet will be monitored over 2 years post-development by sampling the basin inflow a minimum of 2 times over autumn and winter. Monitoring of the following parameters is proposed:

- In situ - pH, EC and Temperature
- nutrients – Ammonium, Nitrates, TN, FRP and TP

9.2.2 Groundwater

Quarterly monitoring of water levels and groundwater quality is proposed. Monitoring at 4 sites is proposed, including 2 upgradient and 2 downgradient of the infiltration basin. An additional monitoring bore will also be installed on the western edge of the POS for determining the groundwater quality exiting the wet basin and POS area.

Monitoring bores will be 50mm PVC casing completed into the regional water table and slotted for approximately 1 metre from below the summer water table to natural surface. Bores will be located as near as possible to existing bore sites, and surveyed to Australian Height Datum (AHD).

Groundwater samples will be analysed for the same parameters as the surface water samples.

9.2.3 Reporting

The preparation of annual monitoring reports is to be co-ordinated by the developer and submitted to the Department of Environment and City of Rockingham for review. The report will compare the monitoring results with the design criteria and performance objectives and determine what, if any, further actions may be necessary.

Table 9: Maintenance, Monitoring, and Reporting – Requirements and Responsibilities

Item	Specific Requirement & Frequency	Responsibility
Maintenance		
Removal of debris from basin	Removal of litter and other debris from basin	Developer for statutory maintenance period City of Rockingham thereafter
Maintenance of SPT	Removal of gross pollutants on a bi-monthly basis during autumn and winter and quarterly during spring and summer	Developer for statutory maintenance period City of Rockingham thereafter
Street sweeping	Street sweeping on a monthly basis during autumn and winter and quarterly during spring and summer	Developer for statutory maintenance period City of Rockingham thereafter
Monitoring invasion of exotic plants in basin/swale	Removal of exotic plants from basin as they are generally ineffective nutrient filters	Developer for statutory maintenance period City of Rockingham thereafter
Cleaning of sediment build up on the bottom of the basin	Removal of sediment and remediation of basin as and when required	Developer for statutory maintenance period City of Rockingham thereafter
Mowing of grass in the basin	Fortnightly mowing of the grass in the basin including appropriate disposal of clippings	Developer for statutory maintenance period City of Rockingham thereafter
Maintenance reporting	Quarterly maintenance monitoring and reporting to City of Rockingham	Developer for statutory maintenance period City of Rockingham thereafter
Monitoring		
Surface Water Monitoring	Water quality of discharge to infiltration basin minimum of 2 times per year over autumn and winter.	Developer for 2 years
Groundwater Monitoring	Quarterly monitoring of groundwater levels and water quality.	Developer for 2 years
Monitoring Reporting	Annual monitoring reports comparing results to design criteria and performance objectives to DoE and City of Rockingham	Developer for 2 years
Education		
Education	Nutrient awareness information to be included in the settlement letter to each purchaser, associated with landscaping package details. At the end of the 2 year maintenance period a further information fact sheet would be distributed with the aim of reducing applications of fertilizer on private lots.	Developer

10. CONCLUSIONS

☐ Urban water management for the Study Area will be achieved through implementation of recognised water sensitive urban design best management practices as detailed in this Drainage and Nutrient Management Plan. The DNMP provides an opportunity for application of urban water management principles and techniques to an area immediately adjacent to the State Forest and Outridge Swamp Conservation Category Wetland where currently no land use controls are applied.

☐ Flood management will be achieved by an infiltration basin/swale designed to contain runoff from the critical duration 100 year ARI storm event, with no basin discharge for this event to the adjacent Outridge Swamp Conservation Category Wetland and State Forest.

☐ Water quality management will be achieved through a treatment train approach including the application of source controls (including street sweeping and education), and maximising infiltration consistent with the Department of Environments recommended approach to stormwater management. Stormwater Pollutant Traps (SPT's) will be installed on both outlets to the infiltration basin/swale.

☐ Nutrient application management was outlined in EPCAD 2005 report with an approval by the City of Rockingham. Contingency plan has been prepared in accordance with WSUD and BMPs

☐ To ensure lot purchasers are aware of the importance of their surrounding environment, nutrient awareness information will be included with their settlement letter. This information will outline the ecology of the nearby Conservation Category Wetlands and the positive steps which can be taken by residents to prevent further degradation of the wetland system. The information will include discussion on topics such as fertilising laws, garden irrigation, washing cars and vehicles, garden maintenance, feeding wildlife, waste disposal and picking up after dogs.

☐ Maintenance practices will be implemented periodically to ensure efficient operation of the water management system including SPT eduction, street sweeping, and regular basin/swale mowing and debris removal. A quarterly monitoring and reporting process to the City of Rockingham by the developer is proposed for maintenance practices during the statutory maintenance period.

☐ A surface and groundwater monitoring programme will be undertaken for 2 years by the developer to enable assessment of hydrological impacts of proposed development within the Western Catchment. The preparation of annual monitoring reports is to be co-ordinated by the developer and submitted to the Department of Environment and City of Rockingham for review.

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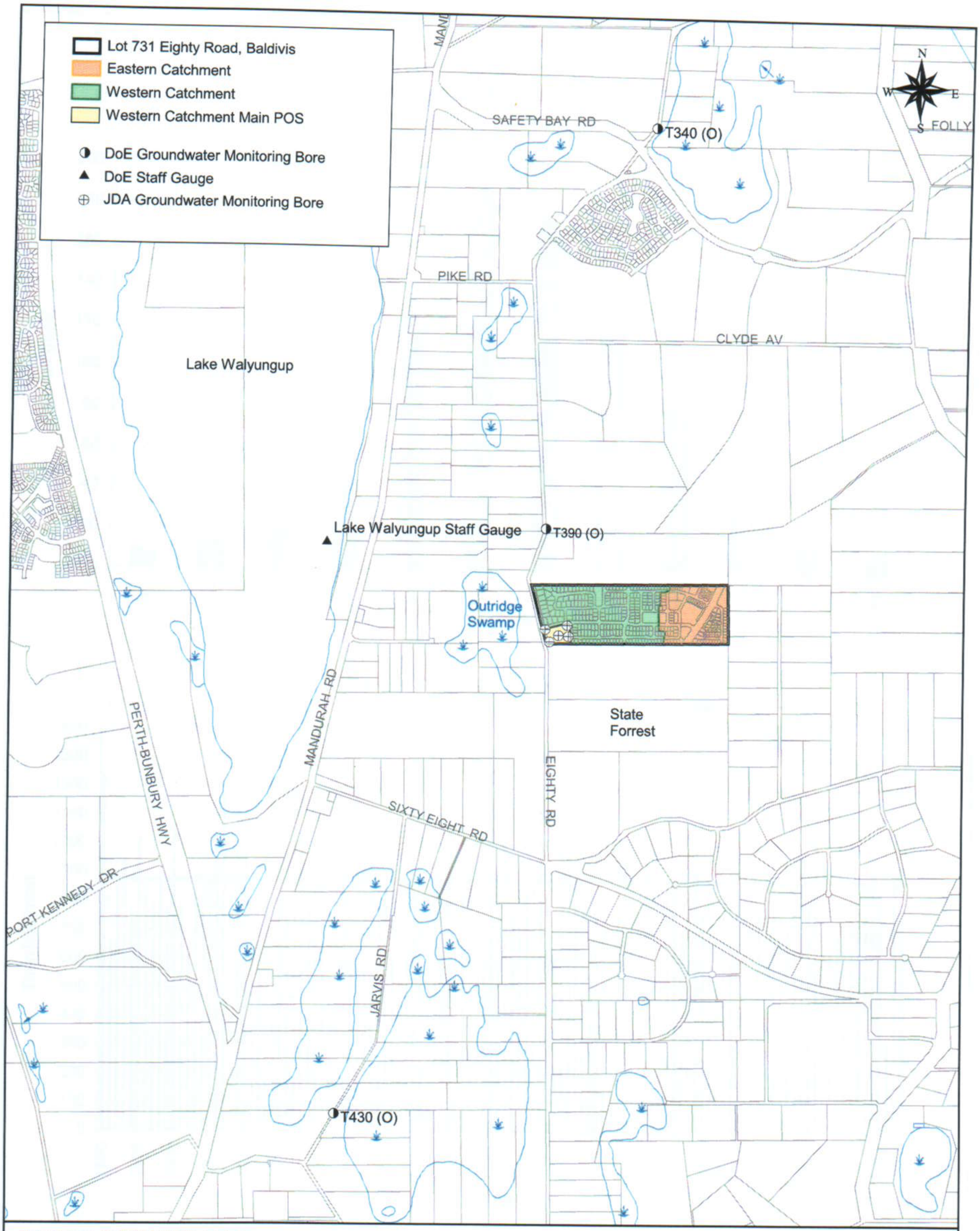

Data Source: DoE (2004) WIN database
SKM (2004) Dainage Catchment Plan dwg DE01026-C800

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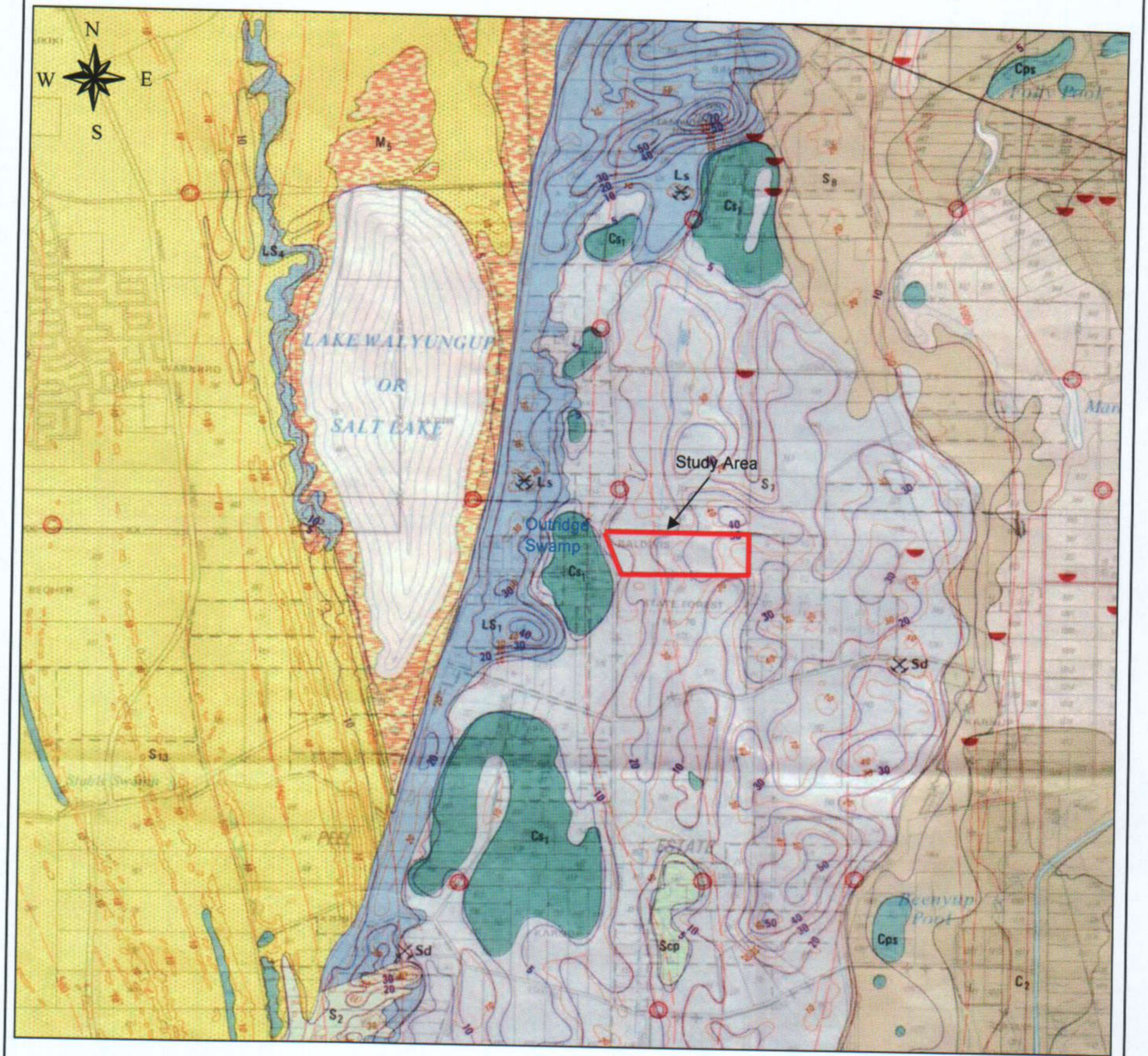
Scale 1:30000

Peet Baldivis Syndicate Limited
The Ridge: Western Catchment Drainage & Nutrient Management Plan

Figure 1: Location Map

S7 SAND - pale and olive yellow, medium to coarse grained, sub-angular quartz, trace of feldspar, moderately sorted, of residual origin

Cs_1 SANDY CLAY - greyish black, firm, variable quartz sand content, occasionally some silt in matrix, of lacustrine origin



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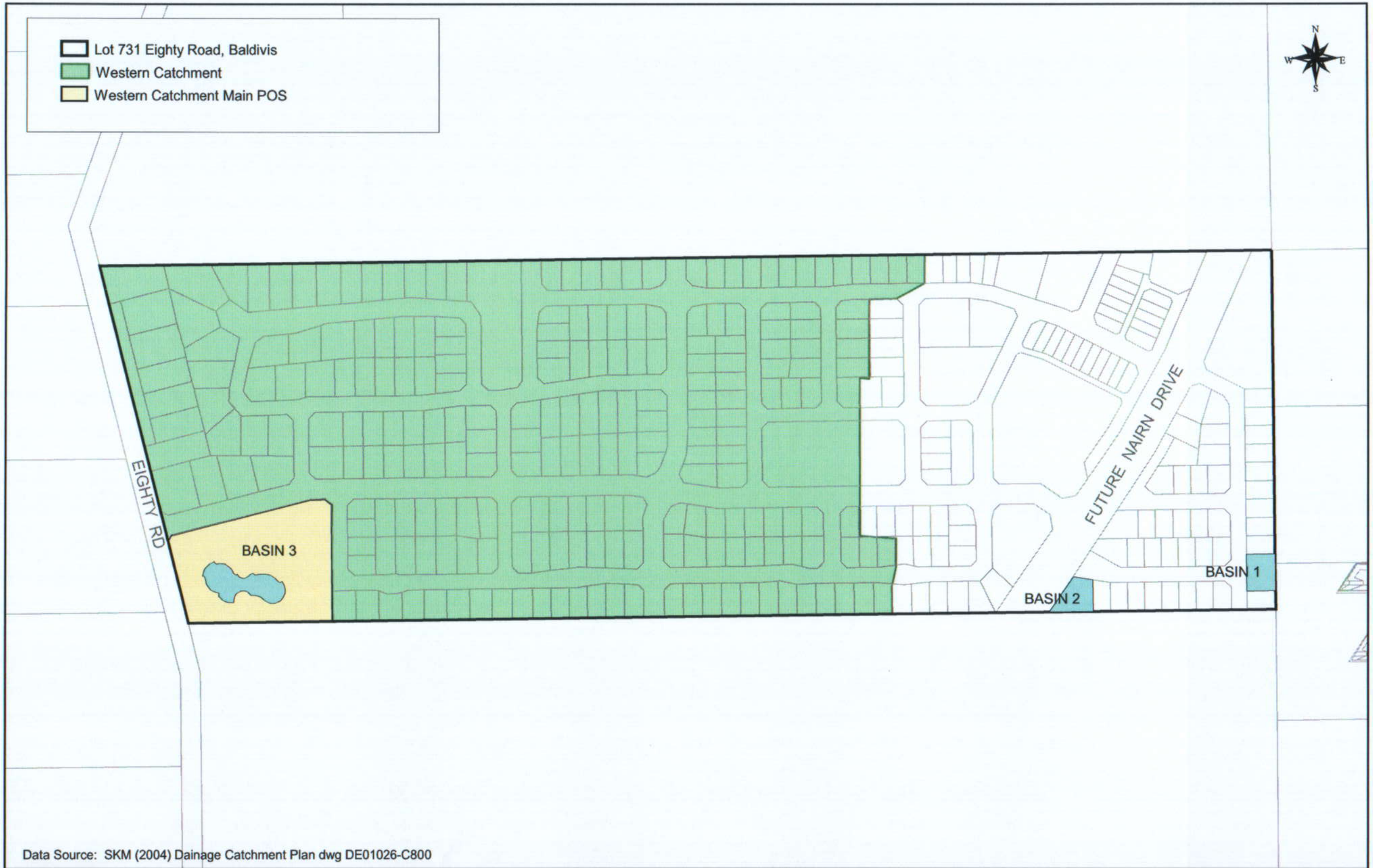
JDA Consultant Hydrologists	Job No. J3335 Scale 1:50000	Peet Baldivis Syndicate Limited The Ridge: Western Catchment Drainage & Nutrient Management Plan **Figure 4: Environmental Geology**



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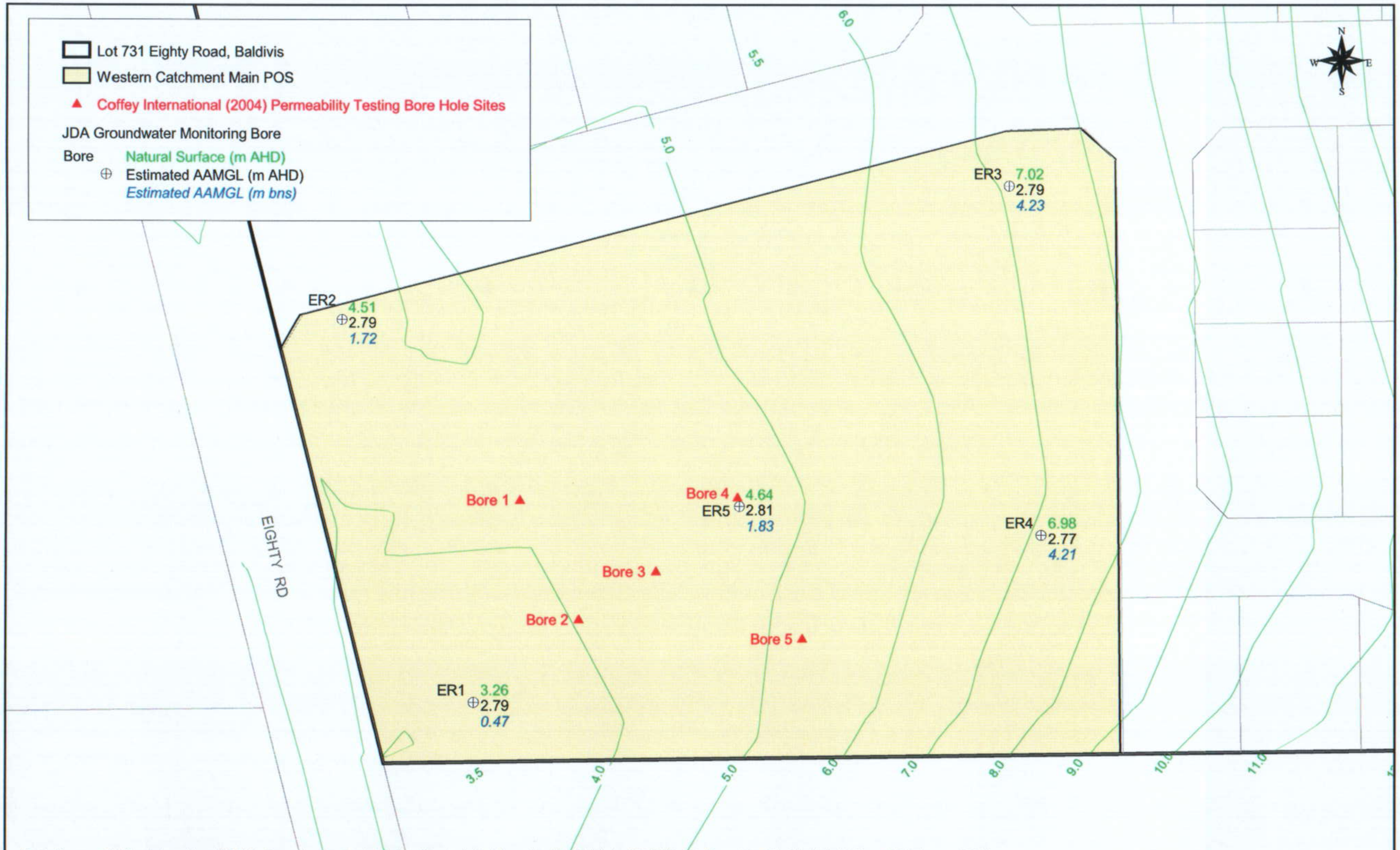
Peet Baldivis Syndicate Limited

The Ridge: Western Catchment Drainage & Nutrient Management Plan

Figure 5: Proposed Development Plan



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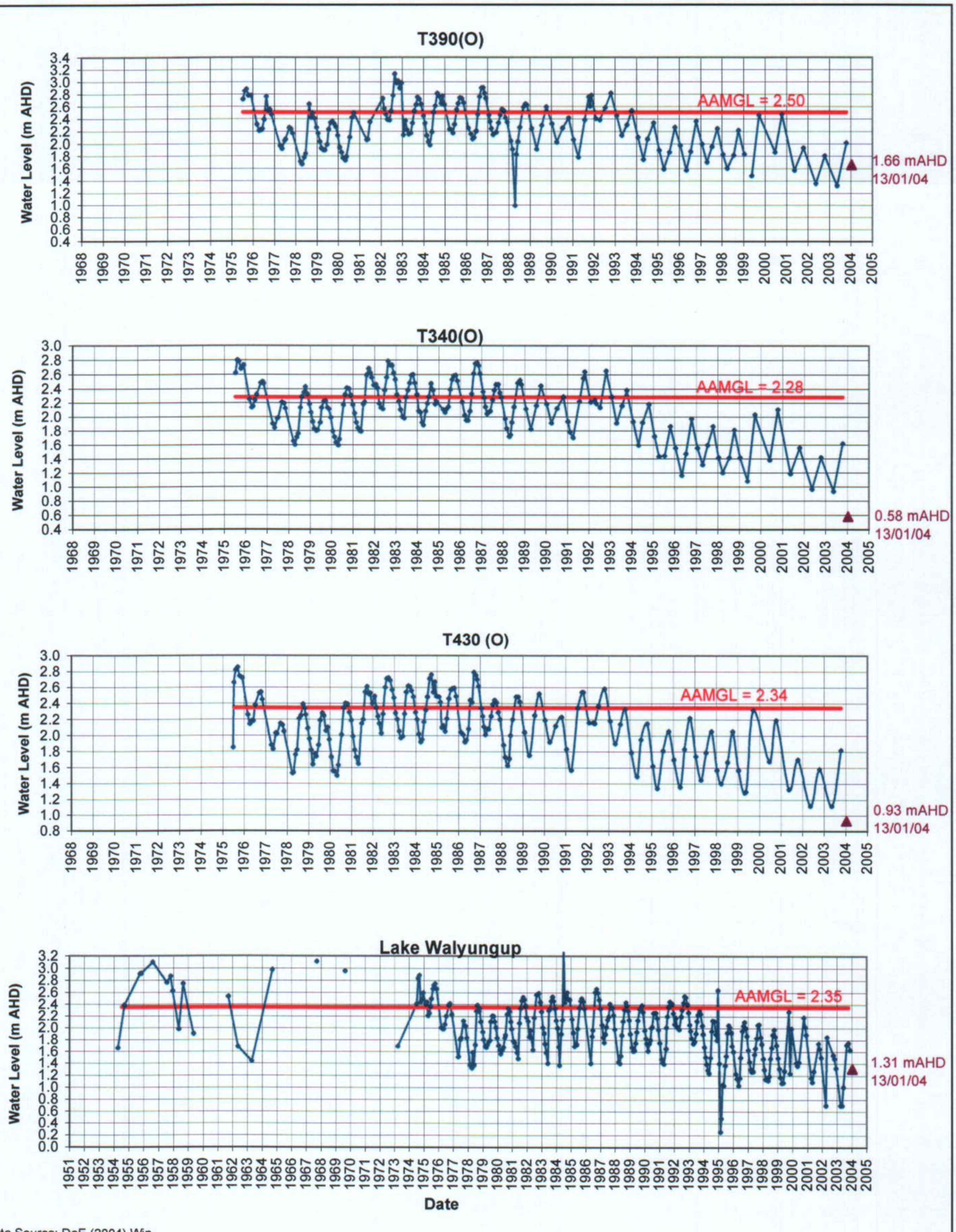
JDA Consultant Hydrologists

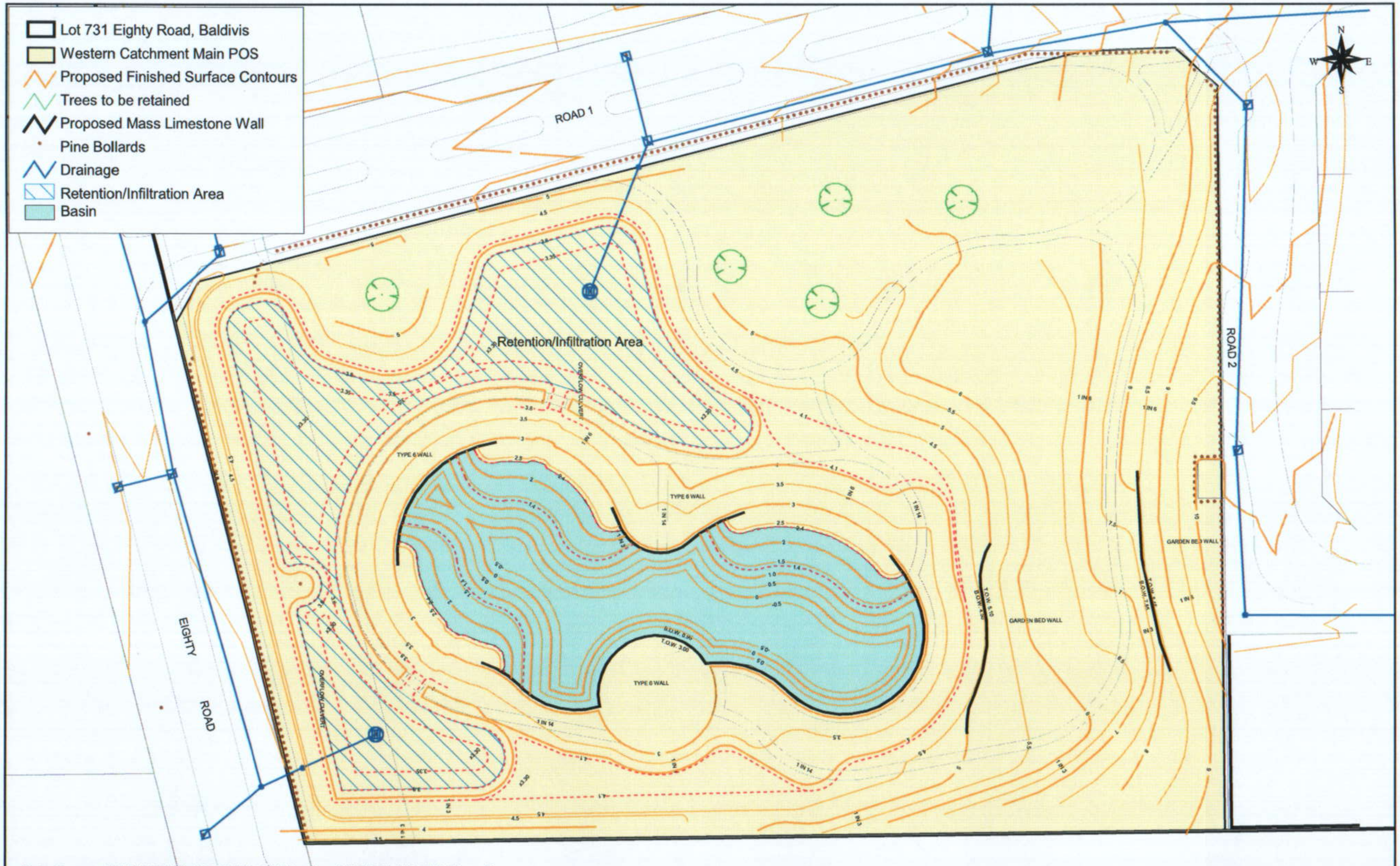
Job No. J3335
Scale 1:1000
0 20 40 60 80 100 Metres

Peet Baldivis Syndicate Limited
The Ridge: Western Catchment Drainage & Nutrient Management Plan
Figure 6: JDA Monitoring Bores and Pre-Development AAMGL



Data Source: DoE (2004) Win

JDA Consultant Hydrologists	Job No. J3335	Peet Baldivis Syndicate Limited The Ridge: Western Catchment Drainage & Nutrient Management Plan **Figure 7: DoE Bores Hydrograph & AAMGL**



Data Source: SKM (2004) P.O.S. 150 Detail Plan dwg DE01026.100 SK010 rev C

JDA Consultant Hydrologists

Job No. J3335

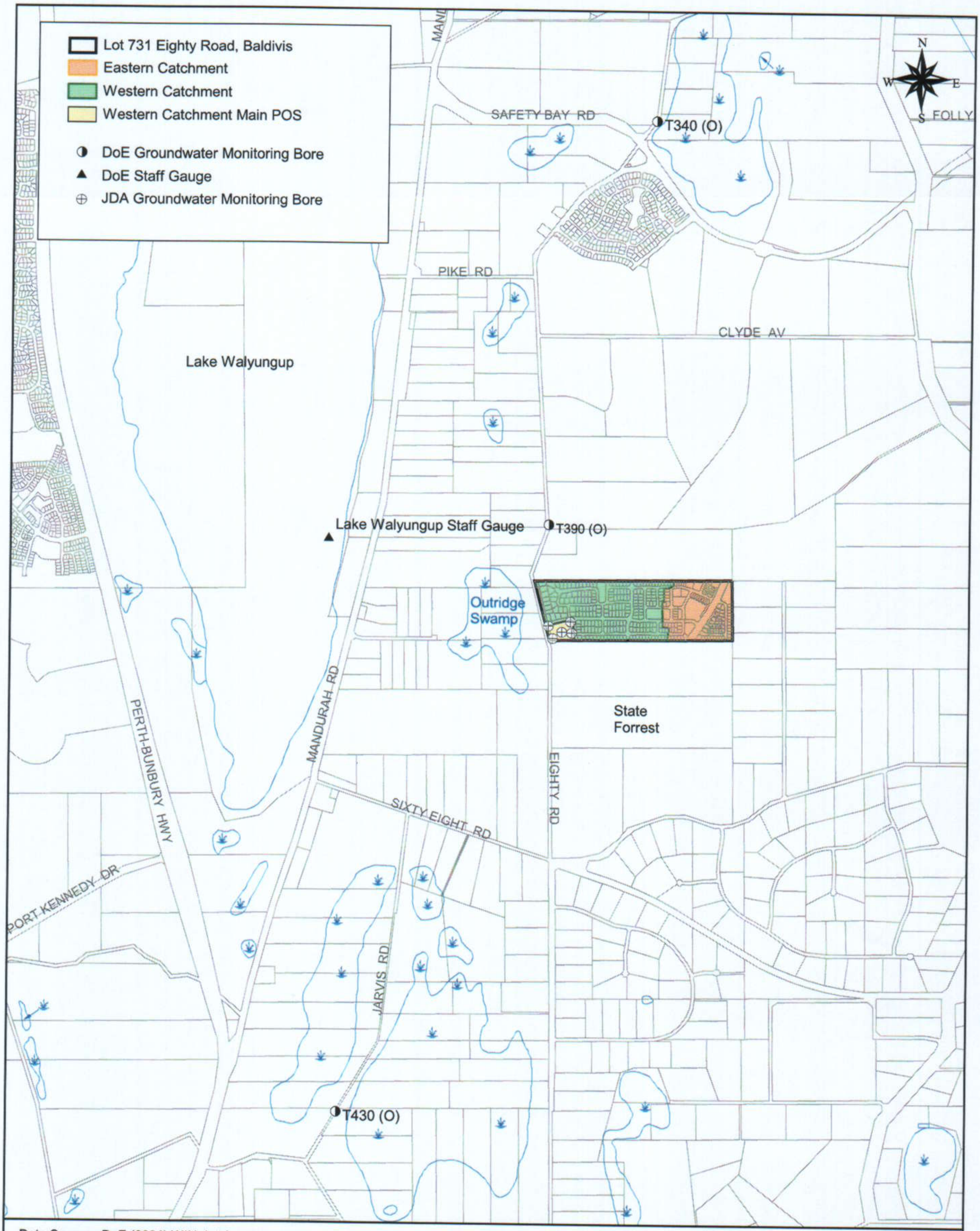
Scale 1:800

0 20 40 60 80 Metres

Peet Baldivis Syndicate Limited

The Ridge: Western Catchment Drainage & Nutrient Management Plan

Figure 8: POS Detailed Plan showing Swale and Infiltration Basin



Data Source: DoE (2004) WIN database
SKM (2004) Dainage Catchment Plan dwg DE01026-C800

0 0.5 1 1.5 km

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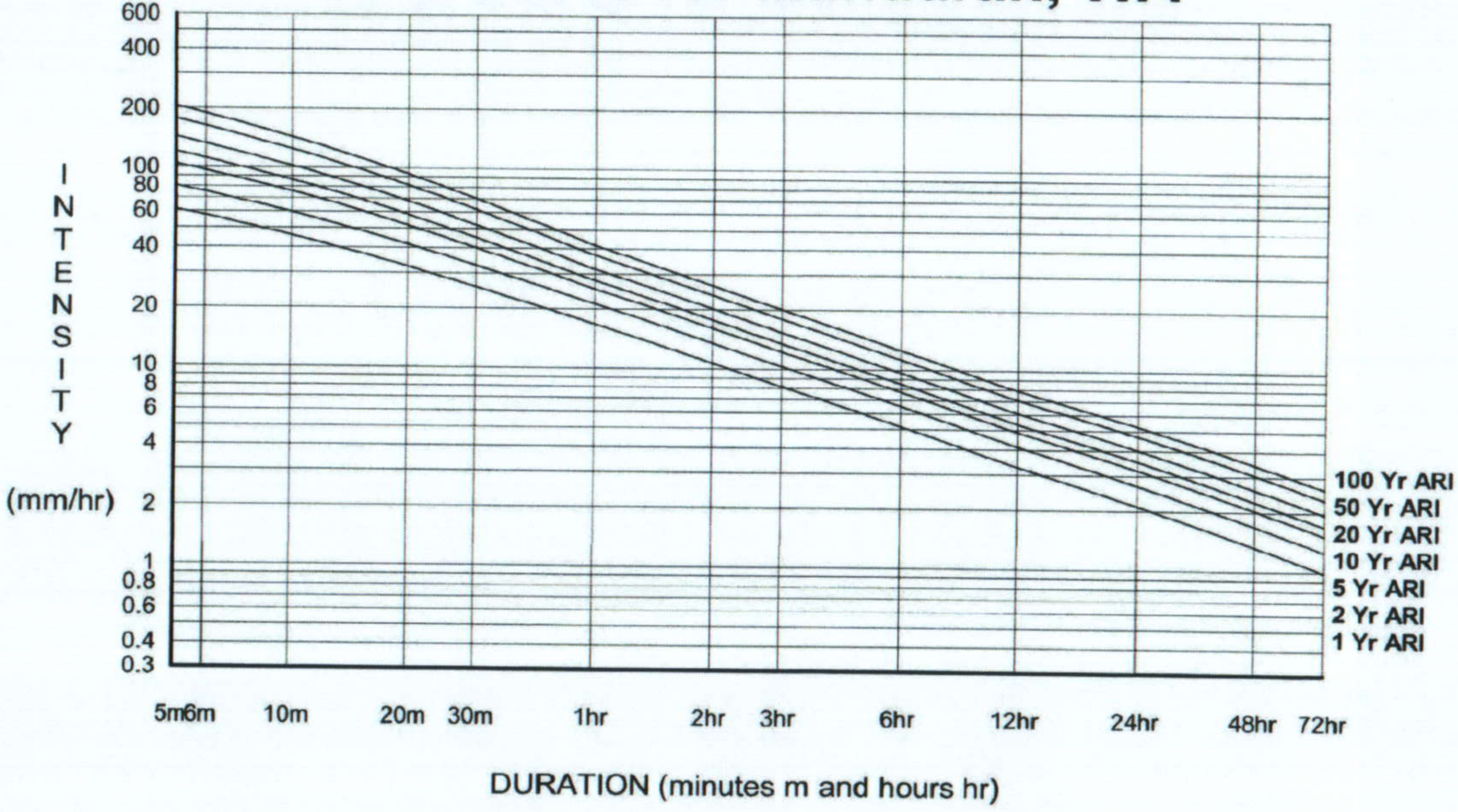
Peet Baldivis Syndicate Limited
The Ridge: Western Catchment Drainage & Nutrient Management Plan

Figure 1: Location Map

I F D Curve for Mandurah, WA



Data Source: AusIFD

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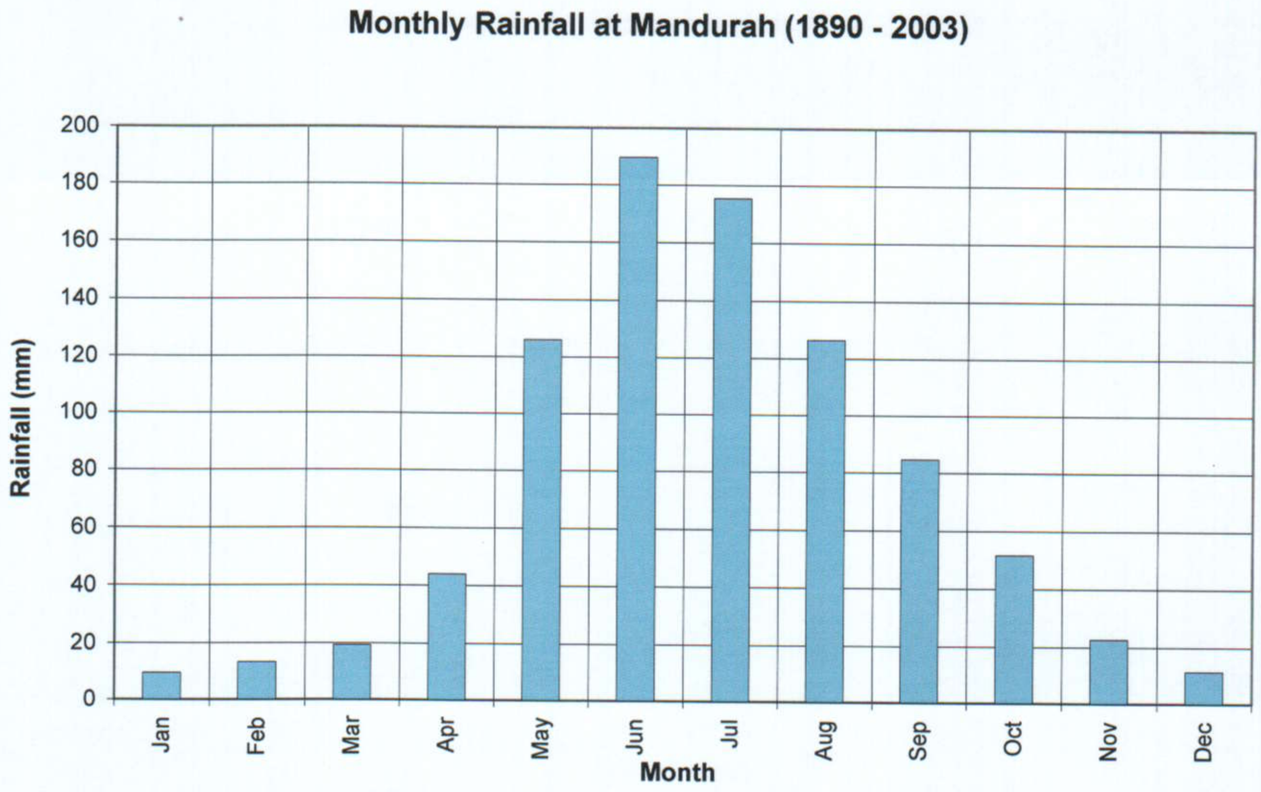
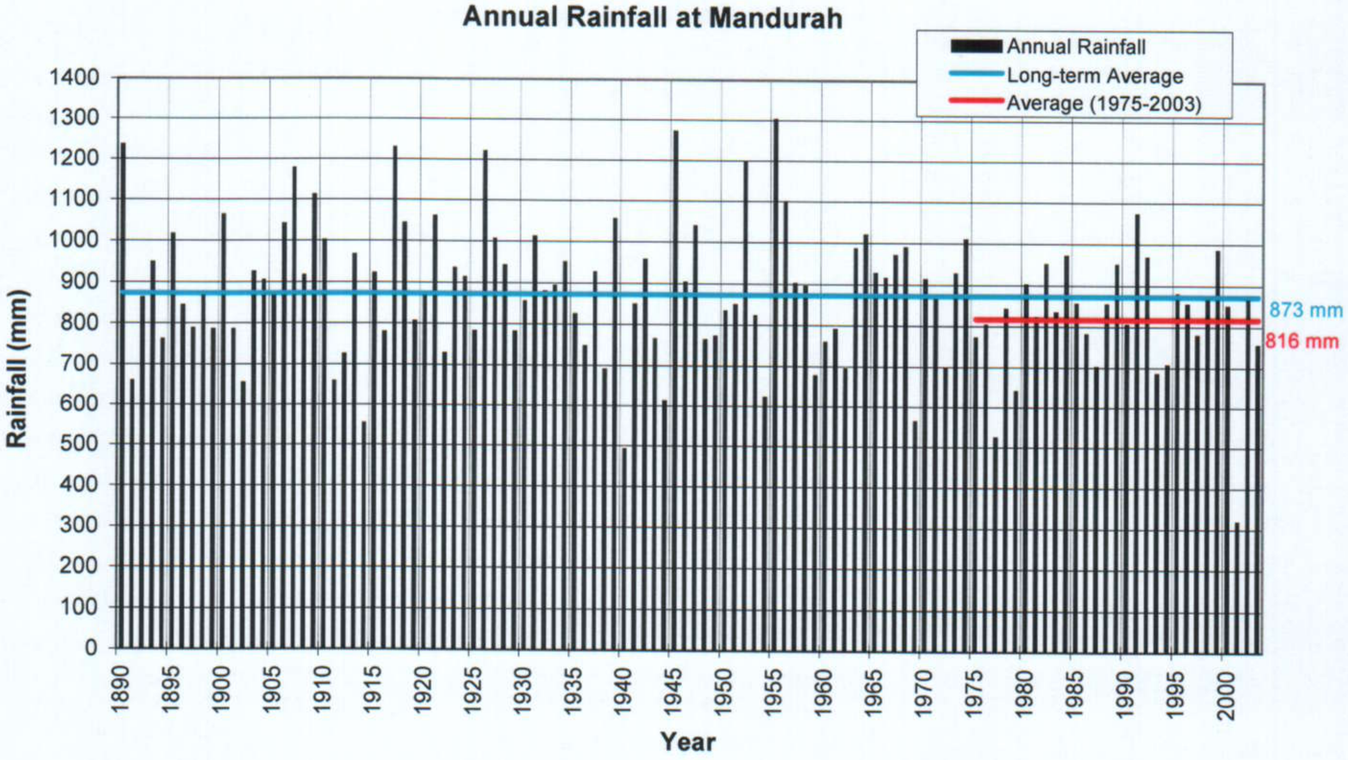
The Ridge: Western Catchment Drainage & Nutrient Management Plan
Figure 3: Mandurah Rainfall IFD Curve



Monthly Rainfall at Mandurah (1890 - 2003)



Annual Rainfall at Mandurah

Data Source : Bureau of Meteorology (2004)

JDA Consultant Hydrologists	Job No. J3335	Peet Baldivis Syndicate Limited The Ridge: Western Catchment Drainage & Nutrient Management Plan **Figure 2: Bureau of Meteorology Mandurah Rainfall Data**

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interim position statement

URBAN STORMWATER MANAGEMENT IN WA

principles & objectives

February 2003

Government of Western Australia
Water and Rivers Commission

1 Purpose

This Position Statement provides the interim principles and objectives for stormwater management while the *Manual for Managing Urban Stormwater Quality in Western Australia* (WRC, 1998) is being revised. The revised Manual will supersede the Position Statement and 1998 Manual. Institutional and financial arrangements for managing stormwater are being reviewed in parallel with the Manual revision.

The purpose of this Position Statement is to provide coordinated guidance to developers, environmental consultants, Local Government, the Water Corporation and State Government Departments on current best management practice principles relevant to urban stormwater management for new urban development in Western Australia. These principles are also applicable to redevelopment projects, however additional mechanisms are required to address stormwater management issues in existing developed areas.

The principles outlined in this Position Statement should be used in the preparation of structure plans, Town Planning Schemes/amendments, subdivision and development applications, while the new Manual is being prepared.

2 Strategic Context

There are a number of National and State strategies that provide the framework and principles for the development of Best Management Practice for stormwater management in Western Australia.

For 25 years Perth and the South West of Western Australia in particular have experienced significantly lower than average rainfall and run-off into storage dams. In response to the water resource constraints that exist in many areas of Western Australia, the State Government is developing an overall water strategy for the State and has released the *Draft State Water Conservation Strategy* (July 2002). The Draft Strategy aims to improve water use efficiency across all water use sectors throughout the State by delivering water, energy and overall savings to the Government and the community. The emphasis of the Strategy is the application of economic instruments to ensure optimal investment in water conservation. The barriers to the implementation of water efficiency options are often financial and institutional, and in some cases related to a lack of information (*Draft State Water Conservation Strategy, July 2002*). Accordingly, the Strategy aims to remove these barriers to investment in water efficiency options. The *Draft State Water Conservation Strategy* makes 38 recommendations on improving water efficiency in WA, including promotion of water sensitive urban design, use of water efficient fittings in all new developments / redevelopments and penalties for using sprinkler systems in the rain.

A vision of the *Western Australian State Sustainability Strategy: 'Focus on the Future (Consultation Draft September 2002)'* is that water is used with care and is provided sustainably to meet needs. The objectives of the Strategy include to reduce water consumption, achieve significant wastewater reuse and to extend responsibility for water supply to the planning system (water sensitive design) and to local government (Regional Councils) for groundwater supplies. The recommendations of the Sustainability Strategy include water wise gardens, greywater recycling, water efficient appliances, wastewater reuse, water sensitive urban design, rainwater tanks and bores in suitable areas.

The revision of the *Manual for Managing Urban Stormwater* aims to facilitate delivery of some of the recommendations of the *State Sustainability Strategy* and *State Water Conservation Strategy*. The principles outlined in these State Strategies apply to stormwater management and should be adopted by all stormwater managers in an aim to achieve the targets and objectives set by the Strategies.

3 Preamble

The *Manual for Managing Urban Stormwater Quality in WA* (WRC, 1998) is currently undergoing a major review to better address integrated urban stormwater management, and is targeted for staged release during 2003. Integrated stormwater management considers stormwater as an element of the total water cycle. Total water cycle management recognises that water supply, stormwater and sewage services are interrelated components of catchment systems, and therefore must be dealt with using an holistic water management approach. This approach better enables urban water to be seen as a resource and helps maximise opportunities for water efficiency, re-use and recycling. The revised Manual will continue to build on the philosophy of total catchment management and Water Sensitive Urban Design (WSUD), incorporating current best management practice, as suited to WA conditions. The Manual review is necessary due to:

- Experience and knowledge gained since the release of the 1998 Manual in respect to the systems implemented in WA and their maintenance requirements;
- Research findings by CSIRO and the Cooperative Research Centres for Catchment Hydrology and Freshwater Ecology;
- An increased urgency for stormwater managers to consider the health of aquatic ecosystems, including streams, rivers and wetlands;
- A paradigm shift to an emphasis on local infiltration systems and 'at-source' controls;
- A need for current information on: 'at source' controls; retrofitting to improve the effectiveness of existing drainage infrastructure and; guidelines on the monitoring of the performance of stormwater management systems.

This paper provides early advice as to changes being incorporated into the 1998 Manual, in respect to stormwater management principles and objectives. This paper should be read in conjunction with the 1998 Manual, and serves to supersede any inconsistent or contradictory content within the 1998 Manual.

4 Background

The creation of impervious surfaces in urban areas, particularly roads, has resulted in increased stormwater flow volumes. Conveyance of stormwater runoff, via extensive open drain and pipeline systems, directly into natural water bodies can result in the export of large amounts of nutrients and other pollutants and loss of local groundwater recharge, causing a deterioration in environmental quality and biodiversity characteristics of local and regional catchments.

The gradual increase in environmental awareness and standards demanded by the community over the last 10-20 years in WA, has seen the objective of 'water quality management' and 'water conservation' added to the original objective of 'flood prevention' for stormwater management.

Consequently WSUD was developed in the late 1980s, principally to harmonise urbanisation with water resource management. 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.

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

The principles of WSUD have been adapted across Australia, with approaches varying between States in response to predominant conditions (eg. soil permeability and rainfall pattern).

The *National Water Quality Management Strategy - Australian Urban Stormwater Management Guidelines* (ARMCANZ, ANZECC 2000) has set out a stormwater management preference hierarchy as follows:

1. **Retain and restore valuable ecosystems:** retain or restore existing valuable elements of the stormwater system, such as natural channels, wetlands and riparian vegetation;
2. **Source control:** non structural measures: non-structural techniques (eg. education) for limiting changes to the quantity and quality of stormwater at the source;
3. **Source control:** structural measures: constructed management techniques installed at or near the source to manage stormwater quantity and quality;
4. **In-system management measures:** constructed management techniques installed within stormwater systems to manage stormwater quantity and quality before discharge into receiving waters. These are only proposed if there are residual impacts that cannot be cost-effectively mitigated by source or near-source controls.

The *National Water Quality Management Strategy* is supported in WA by the *State Water Quality Management Strategy* (May 2001).

5 Objectives for urban water quality and quantity in WA

5.1 Water quality

To maintain or improve the surface and groundwater quality within development areas relative to pre-development conditions.

5.2 Water quantity

To maintain the total water cycle balance within development areas relative to the pre-development conditions.

6 Stormwater management principles in WA

The stormwater management hierarchy applied in WA is as follows:

1. Retain and restore natural drainage systems – retain and restore existing valuable elements of the natural drainage system, including waterway, wetland and groundwater features and processes.
2. Implement non-structural source controls – minimise pollutant inputs principally via planning, organisational and behavioural techniques, to minimise the amount of pollution entering the drainage system.
3. Minimise runoff – infiltrate or reuse rainfall as high in the catchment as possible. Install structural controls at or near the source to minimise pollutant inputs and the volume of stormwater.
4. Use of 'in-system' management measures – includes vegetative measures, such as swales and riparian zones, and structural quality improvement devices such as gross pollutant traps.

6.1 Retain and restore natural drainage systems

Retention and restoration of natural drainage features and treatment processes such as natural creek lines, streamside vegetation, wetlands and intertidal zones are at the top of the management hierarchy. Urban stormwater should be managed to be consistent with the protection of natural drainage and treatment processes and conservation of biodiversity and natural heritage values. The Commission's objectives for wetlands on the Swan Coastal Plain (WRC, 2001) are for the preservation of Conservation Category wetlands, the management and restoration of Resource Enhancement wetlands, and the application of ecologically sustainable development in respect to Multiple Use wetlands. Conservation Category wetlands are considered to be the most valuable wetlands, as they have high natural values and support high levels of ecological attributes and functions.

An additional management objective of the Commission is protection of the ecological function of healthy waterways throughout WA (WRC, 2000). The *Environmental Protection (Swan and Canning Rivers) Policy* (EPA, 1998) provides for the protection of 'beneficial uses' of the Swan and Canning Rivers including the maintenance of ecological processes.

Specific principles applying to urban stormwater management design in WA are as follows:

1. Existing values of waterways, wetlands and associated vegetation should be protected from development impacts.
2. There will be no direct drainage into Conservation Category Wetlands and permanently inundated wetlands (lakes) protected under the *Environmental Protection (Swan Coastal Plain Lakes) Policy* (EPA, 1992). Stormwater management design shall maintain the wetland's natural water regime (including water quality, quantity and regime requirements).
3. Existing natural drainage lines (ie. urban ephemeral streams) should be integrated within public open space, or 'multiple use corridors'. Long term social, environmental and economic benefits can be achieved for multiple use corridors, through good planning and design (ARMCANZ, ANZECC 2000).
4. Conversion of existing drains into 'natural' meandering streams with flood storage accommodated along the streamline, should be undertaken. In this approach, infiltration and detention of the stormwater is maximised at base flow and low intensity rainfall events. During infrequent high rainfall events the water flow velocities are minimised and flood storage is maximised. There are a number of good examples of restored streamlines in Perth and the south-west of WA. For more information please refer to the *River Restoration Manual* (WRC, 2002).

6.2 Implement non-structural source controls

These measures are based on the principle of stormwater quality management at 'the source' to minimise the input of pollutants into the drainage system. At-source controls are implemented through land use planning, community education, and management/maintenance practices.

Non-structural source controls will be fully addressed in the revied Stormwater Management Manual. In the interim however the *Australian Guidelines for Urban Stormwater Management* (ARMCANZ, ANZECC 2000) provides further information in this regard.

6.3 Minimise runoff

The principal means of minimising runoff is by infiltration of rainwater and capture of rainwater for reuse, as close to where it falls to the ground and as high in the catchment as possible. It may be desirable to vary the amount of stormwater infiltrated depending on the site conditions and potential use of stormwater. Natural levels of flow to receiving water bodies may be desirable, as long as the rate of delivery and water quality are not significantly different to natural levels.

By infiltrating runoff and slowing migration of rainwater into receiving natural water bodies, there is maximum opportunity for nutrients to be 'bound' to soil particles and to be 'taken up' by plants or treated by microbes in the groundwater aquifer. Under the philosophy that 'prevention is better than cure', infiltration strategies should be implemented in conjunction with non-structural source controls (see Section 5.2), in order to prevent pollution of groundwater by all potential pollutants including hydrocarbons, heavy metals and nutrients.

Structural controls can be installed at or near the source to minimise pollutant inputs and the volume of stormwater. Structural controls are constructed management techniques such as rainwater tanks, vegetated swales, bio-retention systems and water reuse systems.

The predominantly sandy and porous soils in WA's main urban areas, provides the opportunity to maximise local infiltration and groundwater recharge. Local infiltration measures include porous paving, non-kerbed roads, vegetated swales and buffer/filter strips, retention areas and detention areas. Further information on these measures are provided in Sections 2 and 3 of the *Manual for Managing Urban Stormwater Quality* (WRC, 1998).

'Treatment trains' combine a number of local infiltration measures in sequence, to improve performance or overcome site factors that may limit the effectiveness of single measures (eg. runoff from a non-kerbed road flowing into a vegetated swale, allowing infiltration and treatment, and any overflow eventually flowing to a natural drainage path). Treatment trains may be integrated with natural drainage lines within multiple use corridors (Section 5.1).

Traditionally, urbanisation has resulted in more frequent runoff events, which cause more frequent pollutant inputs to waterways and waterbodies. Greater runoff volumes also generate higher pollutant loadings (ARMCANZ, ANZECC 2000). Reducing runoff, particularly from frequent storm events, assists in reducing the pollutant loads in receiving waters. For example, infiltration of a 1 in 1 year ARI event in Perth is effectively capturing 99% of the average yearly runoff from the site.

Specific principles applying to urban drainage design are as follows:

1. Rainfall from a 1:1 year ARI event should be retained and infiltrated 'on-site', unless it can be clearly demonstrated that achievement of this objective is impractical due to the hydrologic conditions of the site. This technique also ensures capture of 'first flush' events.
2. Runoff from all impervious areas, ie. roads and buildings, should be directed to soakwells or other infiltration structures which are able to accommodate a 1:1 year ARI event prior to overflow.
3. Controls which incorporate vegetation are generally considered an effective water quality management measure. These should be used both as single management measures (eg. swales and filter strips) and as links between infiltration measures.
4. Large and infrequent storm events, such as 1:5 and 1:10 year ARI events, can be mitigated through the use of landscaped retention or detention areas, that may be integrated within public open space/linear multiple use corridors.

6.4 'In-system' management measures

Stormwater management systems dependent on 'end of pipe treatment' by the collection of runoff from large areas of land (eg. suburb) into large constructed basins (eg. infiltration, wet detention, retention basins and constructed wetland basins) should only be considered where reliance on local infiltration is not practicable due to local hydrological, soil or geological constraints. Smaller basins higher in the catchment or other techniques to achieve detention, including natural forms, may achieve more effective outcomes. The potential benefits of various techniques will vary from case to case.

Information on large scale collection measures are referred to in Sections 2 and 3 of the *Manual for Managing Urban Stormwater Quality* (WRC, 1998).

7 Planning for stormwater management

Best practice stormwater management planning will involve a combination of approaches (as shown in Figure 1). The protection of stormwater quality will depend on the successful integration and coordination of actions across disciplines and the establishment of partnerships between Local and State Government, industry and the community.

The first priority in managing stormwater is to ensure stormwater management issues are considered in the land use planning process. Stormwater management need to be addressed at a strategic level, as early in the planning process as possible (eg. regional strategies, Local Planning Strategies). An Urban Water Management Strategy should be an essential part of the preparation of structure plans, Town Planning Schemes/amendments, subdivision and development applications (such as for large group housing developments). Urban Water Management Strategies are to be prepared in accordance with the principles and objectives outlined in this Position Statement and are to include a performance monitoring program to meet the requirements of the Water & Rivers Commission. Reference should also be made to Section 7 of the *Australian Guidelines for Urban Stormwater Management* (ARMCANZ, ANZECC 2000). For more information please contact the Stream & Stormwater Management Section, Catchment Management Branch, Water and Rivers Commission (Ph. 9278 0300).

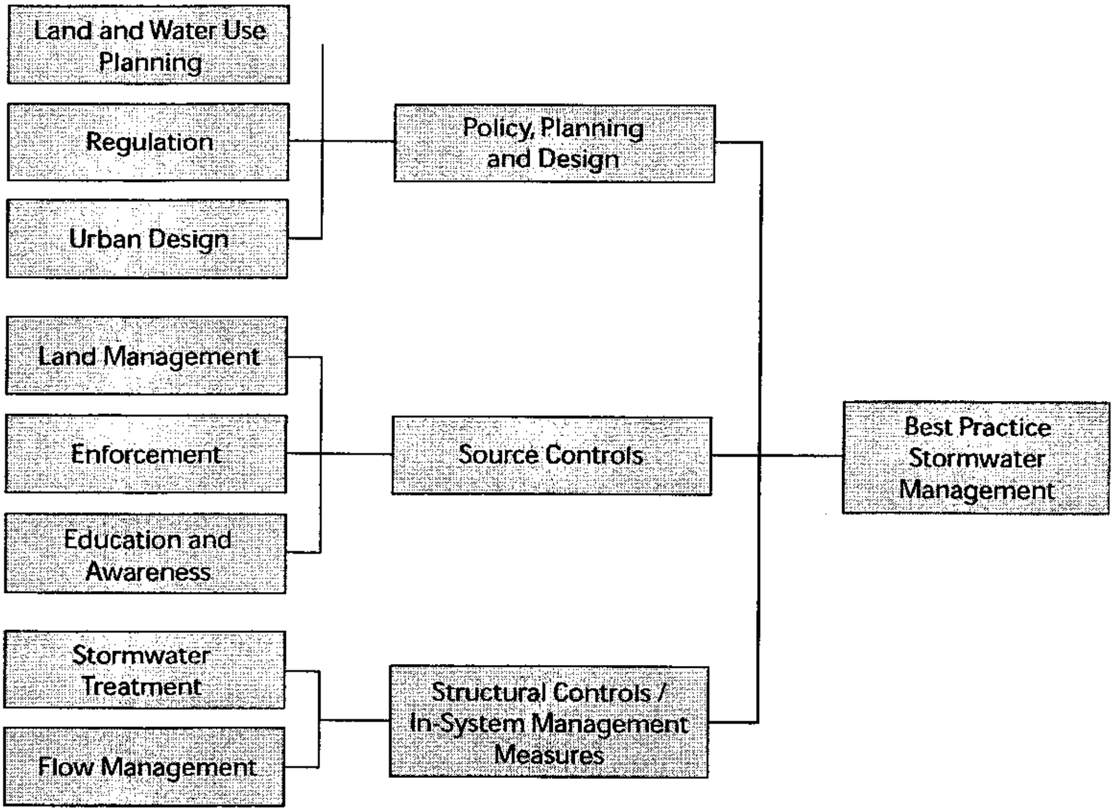

Figure 1: Best Management Practice of stormwater requires integration of a range of measures (ARMCANZ, ANZECC 2000)

8 References & further information

1. ARMCANZ, ANZECC - *National Water Quality Management Strategy: Australian Guidelines for Urban Stormwater Management* (2000).
2. CSIRO - *Urban Stormwater: Best Practice Environmental Guidelines* (1999), Prepared for the Stormwater Committee.
3. Department of Environmental Protection - *Potentially Contaminating Activities, Industries and Landuses* (December 2001).
4. Department of Environmental Protection - *Reporting of Known or Suspected Contaminated Sites – Draft* (April 2001).
5. Eastern Metropolitan Regional Council – *Stormwater Quality Management Plan Guidelines* – Draft (*release pending*).
6. Government of Western Australia, *Wetlands Conservation Policy for Western Australia (1997).*
7. Swan River Trust - *Swan-Canning Cleanup Program Action Plan* (1999).
8. Water & Rivers Commission - *Manual for Managing Urban Stormwater Quality in WA* (1998).
9. Water & Rivers Commission - *River Restoration Manual* (2002).
10. Water and Rivers Commission - *Position Statement: Wetlands* (June 2001).
11. Water and Rivers Commission - *Waterways WA: A policy for statewide management of waterways in WA – Draft Statewide Policy No. 4* (2000).
12. Water and Rivers Commission - *Stormwater Management at Industrial Sites – Draft Water Quality Protection Note* (*release pending*).
13. Wong, T. H. F. *Improving Urban Stormwater Quality – From Theory to Implementation,* Journal of the Australian Water Association, Vol. 27 - No. 6, November/December, 2000.

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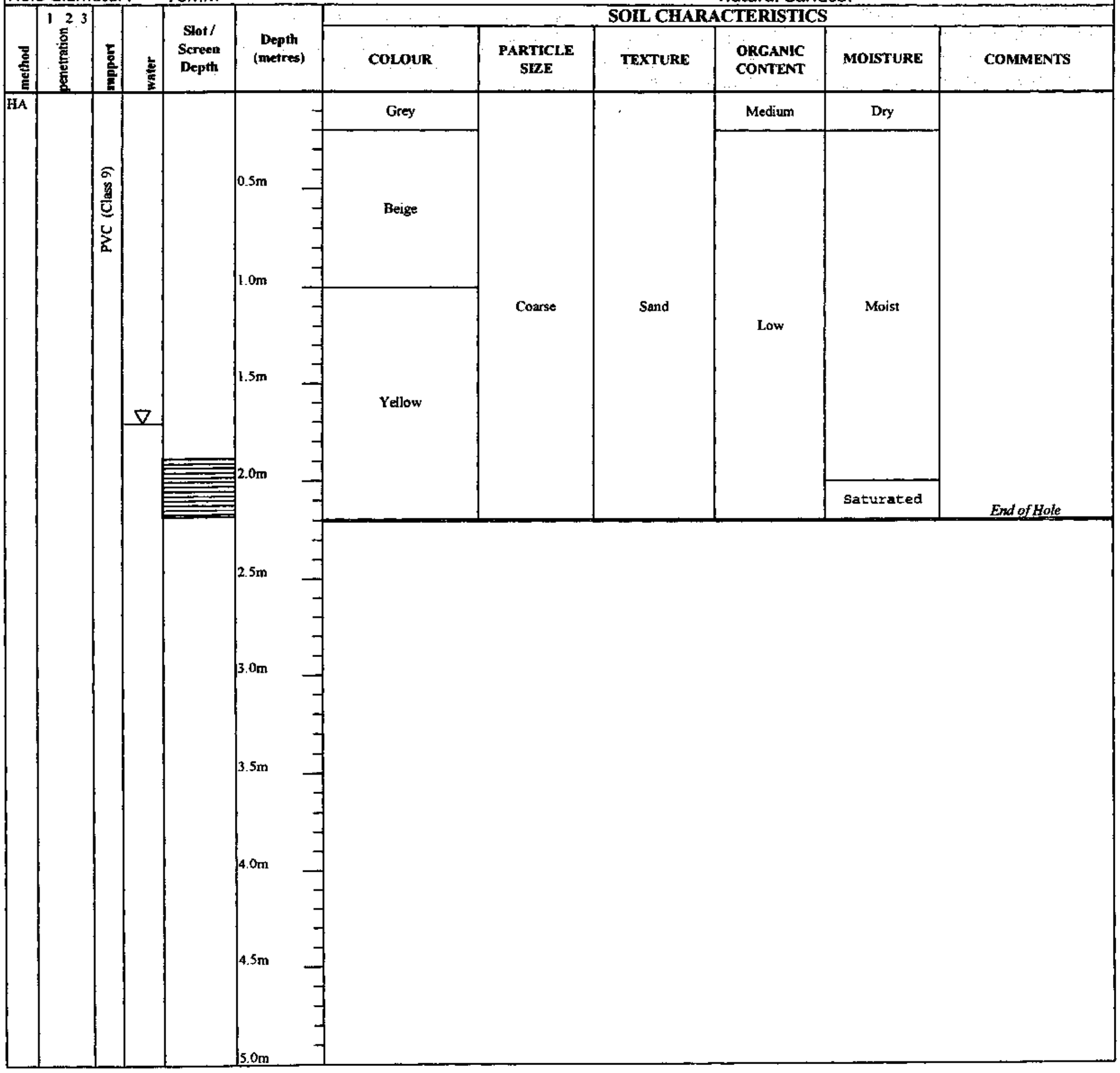
APPENDIX B

LITHOLOGICAL LOG

Client:	SKM	Job No:	J3335
Project:	Lot 731 Eighty Road, Baldivis	Hole commenced:	13/01/04
Bore location:	0386962E 6419592N	Hole completed:	13/01/04
Datum:	MGA94/AHD	Logged by:	AS/KN
Bore Name:	JDA ER1	Total Depth:	2.2 m
Drill type:	Hand Auger	R.L. TOC:	
Hole diameter:	75mm	Natural Surface:	



SOIL CHARACTERISTICS

COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
Grey	Coarse	Sand	Medium	Dry	
Beige			Low	Moist	
Yellow				Saturated	*End of Hole*

NOTES ON BORELOG

COLOURS: Solid colours are BLACK, WHITE, BEIGE

Dark:	Brown,	Red,	Orange,	Yellow,	Grey,	Blue	Tones : solid colour, blemish or mottle
Medium:	Brown,	Red,	Orange,	Yellow,	Grey,	Blue	
Light:	Brown,	Red,	Orange,	Yellow,	Grey,	Blue	

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSE

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATED

STATIC WATER LEVEL

Date: 13/1/04

WL below TOC 2.67 m

Stickup above NS: 0.97 m

WL 1.70 m below NS

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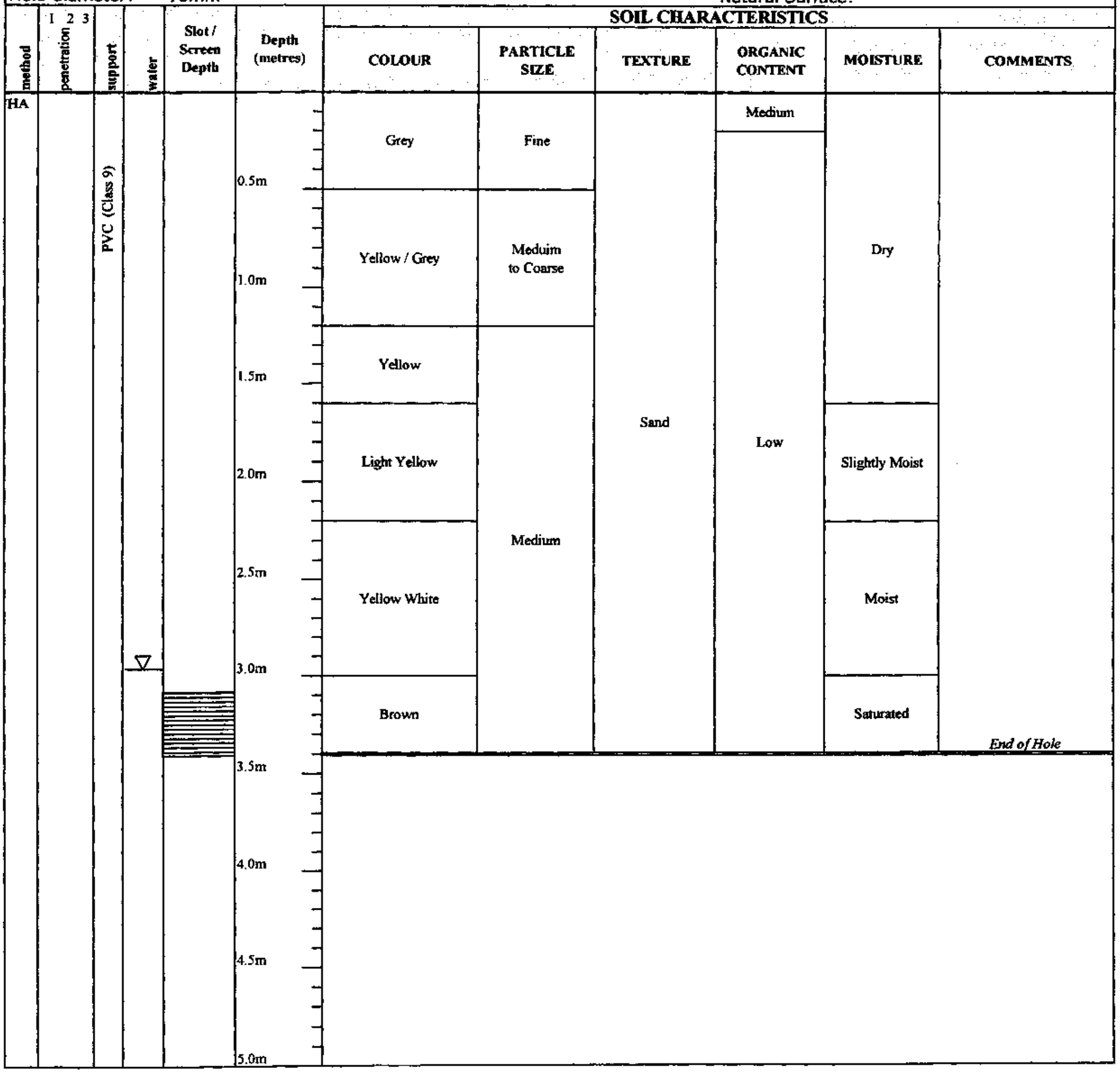
LITHOLOGICAL LOG

Client:	SKM	Job No:	J3335
Project:	Lot 731 Eighty Road, Baldivis	Hole commenced:	13/01/04
Bore location:	0386936E 6419666N	Hole completed:	13/01/04
Datum:	MGA94/AHD	Logged by:	AS/KN
Bore Name:	JDA ER2	Total Depth:	3.4 m
Drill type:	Hand Auger	R.L. TOC:	
Hole diameter:	75mm	Natural Surface:	



SOIL CHARACTERISTICS

COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
Grey	Fine	Sand	Medium	Dry	
Yellow / Grey	Meduim to Coarse		Low		
Yellow	Medium				
Light Yellow				Slightly Moist	
Yellow White				Moist	
Brown				Saturated	*End of Hole*

NOTES ON BORELOG

COLOURS: Solid colours are BLACK, WHITE, BEIGE
Dark : Brown, Red, Orange, Yellow, Grey, Blue
Medium : Brown, Red, Orange, Yellow, Grey, Blue
Light : Brown, Red, Orange, Yellow, Grey, Blue
Tones : solid colour, blemish or mottle

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSE

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATED

STATIC WATER LEVEL

Date: 13/1/04

WL below TOC 3.54 m

Stickup above NS: 0.59 m

WL 2.95 m below NS

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LITHOLOGICAL LOG

Client:	SKM	Job No:	J3335
Project:	Lot 731 Eighty Road, Baldivis	Hole commenced:	13/01/04
Bore location:	0387066E 6419692N	Hole completed:	13/01/04
Datum:	MGA94/AHD	Logged by:	AS/KN
Bore Name:	JDA ER3	Total Depth:	5.6 m
Drill type:	Hand Auger	R.L. TOC:	
Hole diameter:	75mm	Natural Surface:	

method	penetration 1 2 3	support	water	Slot / Screen Depth	Depth (metres)	COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
						SOIL CHARACTERISTICS					
HA						Grey					
		PVC (Class 9)			0.5m		Medium			Dry	
						Brown					
					1.0m		Fine to Medium				
					1.5m						
					2.0m						
					2.5m			Sand	Low		
					3.0m	Yellow Orange	Medium			Moist	
					3.5m						
					4.0m						
					4.5m						
					5.0m						

NOTES ON BORELOG

COLOURS: Solid colours are BLACK, WHITE, BEIGE

Dark :	Brown, Red, Orange, Yellow, Grey, Blue	Tones : solid colour, blemish or mottle
Medium :	Brown, Red, Orange, Yellow, Grey, Blue	
Light :	Brown, Red, Orange, Yellow, Grey, Blue	

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSE

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATED

STATIC WATER LEVEL

Date: ....

WL below TOC ....

Stickup above NS:..................m

WL..............................m below NS

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LITHOLOGICAL LOG

Client:	SKM	Job No:	J3335
Project:	Lot 731 Eighty Road, Baldivis	Hole commenced:	13/01/04
Bore location:	0387066E 6419692N	Hole completed:	13/01/04
Datum:	MGA94/AHD	Logged by:	AS/KN
Bore Name:	JDA ER3 continued	Total Depth:	5.6 m
Drill type:	Hand Auger	R.L. TOC:	
Hole diameter:	75mm	Natural Surface:	

method	penetration 1 2 3	support	water	Slot / Screen Depth	Depth (metres)	COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
HA		PVC (Class 9)	▽	▤	5.5m	Yellow	Medium	Sand	Low	Moist Saturated	End of Hole
					6.0m						
					6.5m						
					7.0m						
					7.5m						
					8.0m						
					8.5m						
					9.0m						
					9.5m						
					10.0m						

NOTES ON BORELOG

COLOURS: Solid colours are BLACK, WHITE, BEIGE
Dark : Brown, Red, Orange, Yellow, Grey, Blue
Medium : Brown, Red, Orange, Yellow, Grey, Blue
Light : Brown, Red, Orange, Yellow, Grey, Blue
Tones : solid colour, blemish or mottle

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSE

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATED

STATIC WATER LEVEL

Date: 13/1/04

WL below TOC 6.05 m

Stickup above NS: 0.59 m

WL 5.46 m below NS

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LITHOLOGICAL LOG

Client:	SKM	Job No:	J3335
Project:	Lot 731 Eighty Road, Baldivis	Hole commenced:	13/01/04
Bore location:	0387072E 6419625N	Hole completed:	13/01/04
Datum:	MGA94/AHD	Logged by:	AS/KN
Bore Name:	JDA ER4	Total Depth:	7.0 m
Drill type:	Hand Auger	R.L. TOC:	
Hole diameter:	75mm	Natural Surface:	

method	penetration 1 2 3	support	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
HA		PVC (Class 9)				Grey	Fine	Sand*	Medium	Dry	
					0.5m	Yellow	Medium to Coarse		Low		
					1.0m		Medium			Moist	
					1.5m						
					2.0m						
					2.5m						
					3.0m						
					3.5m						
					4.0m						
					4.5m	White	Medium to Fine				
					5.0m		Medium				*Small Clay Content

NOTES ON BORELOG

COLOURS: Solid colours are BLACK, WHITE, BEIGE

Dark :	Brown, Red, Orange, Yellow, Grey, Blue	Tones : solid colour, blemish or mottle
Medium :	Brown, Red, Orange, Yellow, Grey, Blue	
Light :	Brown, Red, Orange, Yellow, Grey, Blue	

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSE

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATED

STATIC WATER LEVEL

Date: ....

WL below TOC ....

Stickup above NS:................m

WL.............................m below NS

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LITHOLOGICAL LOG

Client:	SKM	Job No:	J3335
Project:	Lot 731 Eighty Road, Baldivis	Hole commenced:	13/01/04
Bore location:	0387072E 6419625N	Hole completed:	13/01/04
Datum:	MGA94/AHD	Logged by:	AS/KN
Bore Name:	JDA ER4 Continued	Total Depth:	7.0 m
Drill type:	Hand Auger	R.L. TOC:	
Hole diameter:	75mm	Natural Surface:	

method	penetration 1 2 3	support	water	Slot / Screen Depth	Depth (metres)	COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
HA		PVC (Class 9)				White	Medium	Sand	Low	Moist	
			▽		5.5m	Yellow				Saturated	
					6.0m						
					6.5m						
				▤	7.0m						*End of Hole*
					7.5m						
					8.0m						
					8.5m						
					9.0m						
					9.5m						
					10.0m						

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Medium :	Brown, Red, Orange, Yellow, Grey, Blue
Light :	Brown, Red, Orange, Yellow, Grey, Blue

Tones : solid colour, blemish or mottle

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSE

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATED

STATIC WATER LEVEL

Date: 13/1/04

WL below TOC 6.08 m

Stickup above NS 0.64 m

WL 5.44 m below NS

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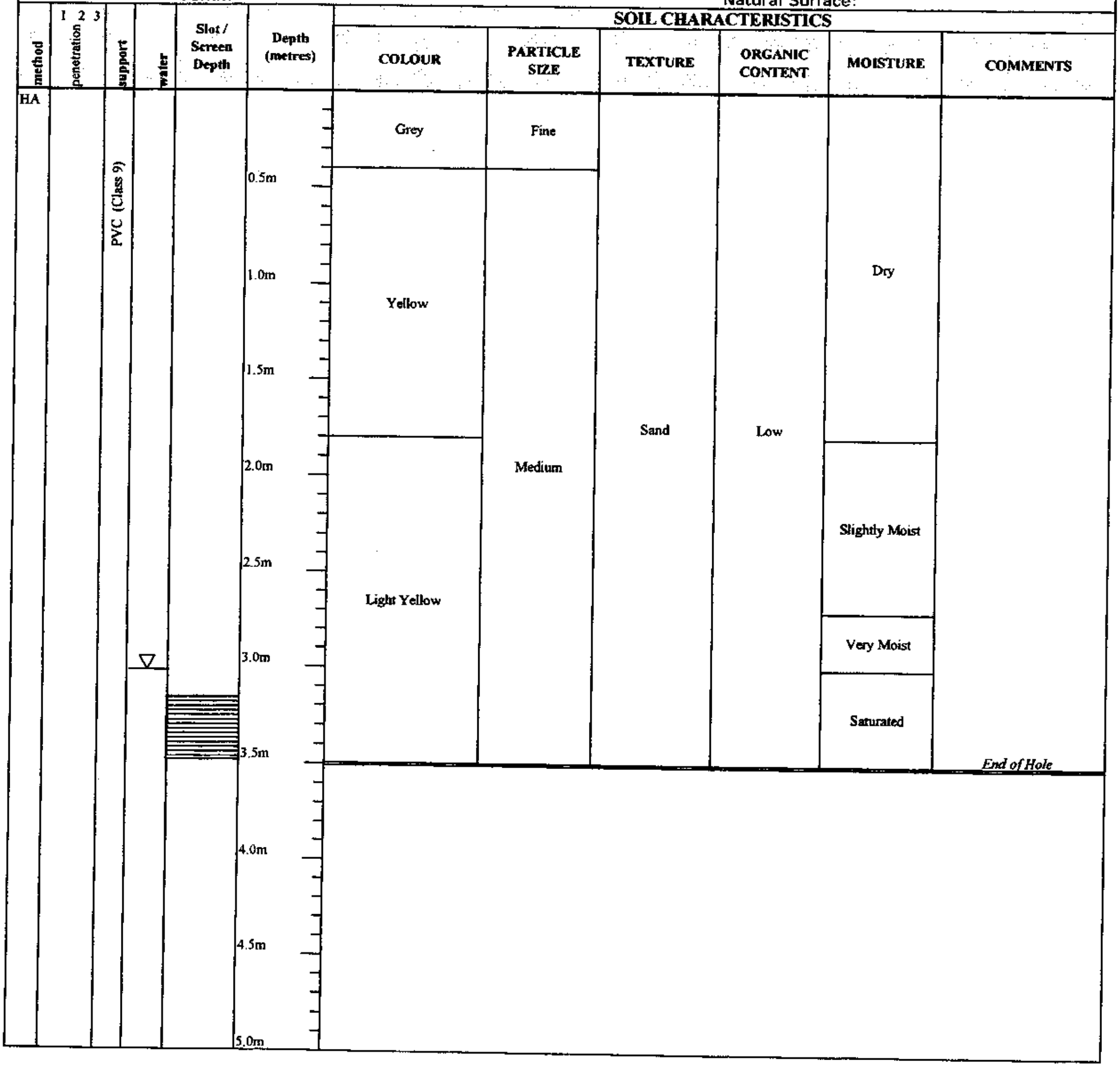
LITHOLOGICAL LOG

Client:	SKM	Job No:	J3335
Project:	Lot 731 Eighty Road, Baldivis	Hole commenced:	13/01/04
Bore location:	0387013E 6419630N	Hole completed:	13/01/04
Datum:	MGA94/AHD	Logged by:	AS/KN
Bore Name:	JDA ER5	Total Depth:	3.5 m
Drill type:	Hand Auger	R.L. TOC:	
Hole diameter:	75mm	Natural Surface:	



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Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATED

STATIC WATER LEVEL

Date: 13/1/04

WL below TOC 3.97 m

Stickup above NS 0.91 m

WL 3.06 m below NS

[redacted]

mpl Laboratories

Certificate of Analysis

Testing Facility: Perth

Job No: **43153**
Client: JDA CONSULTANT HYDROLOGISTS
Address: PO BOX 117
SUBIACO WA 6904

Client Reference: J3335C1
Date Received: 15/11/2004
Date Sampled: 10/11/2004
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

NATA

This Laboratory is accredited by the Nationa Association of Testing Authorities, Australia. Th tests reported herein have been performed i accordance with its terms of accreditation. Th document shall not be reproduced except in ful Accreditation No 2226

IDENT **UNITS**	**External Ident**	**NO3_N** **mg/L**	**NO2_N** **mg/L**	**TKN** **mg/L**	**NH3** **mg/L** **+**	**Tot-N** **mg/L**	**Tot-P** **mg/L**	**PO4_P** **mg/L** **+**	**Turb** **NTU** **+**
UM001	ER4	0.75	<0.05	0.33	0.07	1.1	0.01	<0.01	980
UM002	ER5	0.75	<0.05	1.1	0.08	1.8	0.02	<0.01	1500
DM001 Lab Dup	ER4	0.77	<0.05	0.33	0.08	1.1	0.01	<0.01	--
LQL		**0.05**	**0.05**	**0.05**	**0.05**	**0.1**	**0.01**	**0.01**	**0.1**

+ indicates sample received outside holding time recommended by AS/NZ 5667.1:1998

Checked: ______________

Approved Signatory: ______________

Date: 22/11/2004
Page 1 of 1