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### CONTENTS

1 EXECUTIVE SUMMARY 1

2 INTRODUCTION 5

2.1 BACKGROUND 5

2.2 DISTRICT WATER MANAGEMENT PLANNING 5

2.3 KEY PRINCIPLES AND OBJECTIVES 6

2.3.1 Drainage Management Strategy for North East Corridor (GB Hill & Partners, 1995) 6

2.3.2 Gnangara Land Use and Water Management Strategy (WAPC, 2001) 6

2.3.3 Decision Process for Stormwater Management (DoE, 2005) 7

2.3.4 City of Swan Policies (2006) 7

2.3.5 Stormwater Management Manual for Western Australia (DoW, 2007) 7

2.3.6 North East Corridor Urban Water Management Strategy (GHD, 2007) 8

2.3.7 Better Urban Water Management (WAPC, 2008) 8

2.3.8 Swan Urban Growth Corridor Drainage & Water Management Plan (DoW, 2009) 9

2.3.9 City of Swan Town Planning Scheme No. 17, Provisions of Schedule 4 9

3 PRE-DEVELOPMENT ENVIRONMENT 15

3.1 LOCATION AND TOPOGRAPHY 15

3.2 CLIMATE 15

3.3 SURFACE GEOLOGY 15

3.4 SURFACE WATER HYDROLOGY 15

3.4.1 Existing Surface Drainage 15

3.4.2 Floodplain Mapping 16

3.4.3 Environmental Water Requirements 16

3.4.4 Surface Water Quality 17

3.5 GROUNDWATER HYDROLOGY 18

3.5.1 Superficial Aquifer 18

3.5.2 Mirrabooka Aquifer 18

3.5.3 Leederville Aquifer 19

3.5.4 Protection of Public Drinking Water Supply 19

3.5.5 Groundwater Resources for Irrigation at Albion 20

3.6 WETLANDS 20

3.7 ACID SULFATE SOILS 21

3.8 EXISTING LAND USE 23

3.9 CAVERSHAM AIRBASE SUBSURFACE DRAINAGE 23

3.10 HYDROLOGICAL OPPORTUNITIES AND CONSTRAINTS 23

4 ALBION TOWN PROPOSAL 25

4.1 GENERAL DESCRIPTION 25

4.2 DISTRICT STRUCTURE PLAN 25

5 SURFACE WATER INVESTIGATION 26

5.1 SURFACE WATER DATA 26

5.2 MEAN ANNUAL RUN-OFF ESTIMATES 26
LIST OF TABLES

Table 1. Summary of LWMS Principles and Objectives
Table 2. Albion Groundwater Resources
Table 3. Summary of Hydrological Constraints and Opportunities
Table 4. Mean Annual Run-off Estimates
Table 5. Peak Flow Estimates
Table 6. Albion Groundwater Levels
Table 7. Albion Groundwater Quality Relative to Swan/Canning Cleanup Programme
Table 8. Summary of ASS Investigations
Table 9. Shallow Groundwater Dissolved Metals Analysis
Table 10. Wetlands in the Albion Structure Plan area.
Table 11. Management system for the implementation of the Wetland Management Strategy
Table 12. Post-development 100yr ARI Peak Flow Attenuation Storage Requirements
Table 13. LWMS Monitoring Programme
LIST OF FIGURES
1. Location Plan
2. Existing Surface Water Catchments and Peak Flows
3. Perth Annual Rainfall 1880 to 2004
4. Soils
5. Wetland Mapping
6. Land Use
7. Superficial Aquifer Groundwater Flow Areas
8. Groundwater Management Areas
9. Arterial Drainage Catchments
10. Monitoring Bore Locations
11. Estimated AAMGL Contours
12. Depth to AAMGL
13. Estimated AALGL Contours
14. Acid Sulphate Soil Risk: Test Results
15. Albion Structure Plan
16. Post Development Drainage Strategy

LIST OF PLATES
1 to 4 Albion Surface Water Monitoring (July 2006)

APPENDICES
A. Decision Process for Stormwater Management for WA (DoE, 2005)
B. BH Series Bore Logs (PB, 2005)
C. Historic Water Levels of DoW Bores
D. Groundwater Monitoring Bore Data Time Series Plots
E. Correspondence regarding Acid Sulfate Soils
F. Shallow Groundwater Sampling 21/9/06: Laboratory Analysis
G. Albion Nutrient Input Modelling
H. Executive Summary North East Corridor Urban Water Management Strategy (GHD, 2007)
I. Letter Department of Water to DPI re: North East Corridor – the Vale Development Plan 2, The Albion Structure Plan and the Caversham Structure Plan 30/4/07
J. Typical Section of Active Open Space and St Leonards Creek
1 EXECUTIVE SUMMARY

This Local Water Management Strategy (LWMS) has been prepared to satisfy City of Swan Town Planning Scheme No. 17, Provisions of Schedule 4 condition prior to approval of a Structure Plan.

Water management is a key consideration to development of Albion. The North East Corridor Drainage Strategy (GB Hill, 1995) prepared for Water Authority of WA as part of the North East Corridor Structure Plan, provides a regional framework for water management associated with urban development. A review of that Strategy was recently completed and published as the North East Corridor Urban Water Management Strategy (GHD, 2007). GHD (2007) recommends that District and Local Water Management Strategies be prepared consistent with it. Further it states that the highest priority is the Henley Brook-West Swan-Caversham District Water Management Plan, which is currently being prepared by GHD Consultants. However, TPS 17 acknowledges that a LWMS can proceed without a DWMP. Preliminary information has been received (GHD, 2008), with which this LWMS is consistent. This position is confirmed by letter from Department of Water to DPI 30/4/07 (see Appendix I).

This LWMS presents both district level and local level drainage information consistent with GB Hill (1995) and GHD (2007). The LWMS is based on hydrological data collected since 2001.

The Albion study area extends over 3 surface water catchments namely Horse Swamp, St Leonards Creek and Wandoo Creek catchments. St Leonards Creek and Wandoo Creek drain to the east and discharge directly into the Swan River. Horse Swamp catchment drains to the west and provides runoff to Whiteman Park and Bennett Brook. The LWMS describes the existing surface water and shallow water regime and presents a concept design of water management post-development to maintain that regime consistent with Water Sensitive Urban Design (WSUD). This includes infiltration of storm water where possible and the incorporation of surface water flow paths in swales within multiple use corridors together with flood attenuation storage. A total 18.9 ha of flood storage has been estimated as required for Albion.

For nutrient management, a programme of source control measures is described consistent with the latest Department of Water approach to urban water management.

The LWMS includes a strategic Acid Sulphate Soil (ASS) investigation which concludes that the issue can be managed at a level consistent with typical developments on the Swan Coastal Plain in similar geographical settings. The investigation has been confirmed by Department of Environment and Conservation (DEC) email 4/3/08 as acceptable to support the District Structure Plan (see Appendix E).

A programme of ongoing hydrological monitoring is described to be carried through to the Local Structure Plan stage to assist with drainage infrastructure layout and nutrient management.

The table below summarises Albion LWMS compliance with the Provisions of Schedule 4 of TPS 17 condition referred to above.

The City of Swan has adopted 2 policies directly applicable to the Albion LWMS, namely:
- Urban Growth Policy (City of Swan 2006a)
- Environmental Planning Policy (City of Swan 2006b)

The LWMS has been drafted consistent with these policies.
### SUMMARY OF ALBION LWMS COMPLIANCE

<table>
<thead>
<tr>
<th>Albion LWMS Provision Condition</th>
<th>Compliance with Condition</th>
</tr>
</thead>
</table>
| **A)** In the absence of a District Water Management Strategy (DWMS), the LWMS must include information addressing the following, which would normally be contained in a DWMS:  
  - Commit to best practice planning, design & construction;  
  - Refine land use scenario and identify major constraints;  
  - Identify water sources for drinking and other uses, consistent with fit-for-purpose water use strategy use;  
  - Refine conceptual stormwater management plan;  
  - Identify issues to be addressed at later stages. | Management of surface water, ground water, wetland water quality and construction (Section 9.2 to 9.6)  
  - Protect and enhance existing natural environment amongst the residential developments ranging from R10-R60; local, larger cultural activity centres; innovative use of linear POS linkages. (Section 4.2)  
  - Substituting scheme water for alternative sources (e.g. roof runoff, storm water, rainwater tanks, treated wastewater, domestic greywater (Section 9.1).  
  - LWMS applies principles of water sensitive urban design: both structural and non-structural techniques are utilised (Section 9).  
  - Monitoring to identify developing issues; contingency plan (Section 10). |
<p>| <strong>B)</strong> Further refine urban water management system and quantify land required to meet design objectives; | Site specific surface water and groundwater management strategies are described with land allocations calculated (Section 9). |
| <strong>C)</strong> Suite of possible BMP’s and design BPP’s depicted in diagrams; | Describe both structural and Non-structural BMP controls (Section 9.5). |
| <strong>D)</strong> Identify requirements of an Urban Water Management Plan (UWMP) and commit to compliance with stated design objectives via future UWMP; | A UWMP to be prepared for each of the development areas of Albion at the Local Structure Plan stage by the developer (Sections 10.1 &amp; 10.7). |
| <strong>E)</strong> Incorporate best practice water sensitive urban design principles to maximise on-site infiltration; | On site infiltration (Section 9) |
| <strong>F)</strong> Undertake monitoring of nutrient levels within groundwater to enable comparisons between pre-development and post-development conditions; | Pre-development groundwater nutrient monitoring has been completed for 2 years. The developer commits to 5 years of post-development monitoring (Section 10.4). |
| <strong>G)</strong> Undertake groundwater monitoring programs to ensure that current groundwater levels are maintained; | Pre-development groundwater level monitoring has been completed for 2 years. The developer will commits to 5 years of post-development monitoring (Section 10.4). |
| <strong>H)</strong> Recommend monitoring framework; | The framework for post-development surface water |</p>
<table>
<thead>
<tr>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>I)</strong> Incorporate appropriate stormwater collection and disposal methods and water sensitive design principles to minimise the risk of contamination to groundwater;</td>
<td>and groundwater monitoring for levels, flows and water quality established (Section 10.4)</td>
</tr>
<tr>
<td><strong>J)</strong> Incorporate connection to main sewerage system for all dwellings to reduce the potential for contamination of drinking water supplies;</td>
<td>Application of a stormwater treatment train focusing on source controls to remove nutrients that may contaminate the groundwater (Section 9.5)</td>
</tr>
<tr>
<td><strong>K)</strong> Where possible control stormwater quantity through a waterways system linked to “treatment train” process;</td>
<td>Deep sewerage will be installed to convey wastewater from the site (Section 9.5).</td>
</tr>
<tr>
<td><strong>L)</strong> Ensure that changes to surface flow volumes are not significantly altered, and that peak surface flows are not increased;</td>
<td>Application of a stormwater treatment train focusing on source controls to remove nutrients that may contaminate the groundwater (Section 9.5)</td>
</tr>
<tr>
<td><strong>M)</strong> Ensure that the rate, quantity and quality of wastewater infiltrating Priority 3 UWPCA within the Estate is maintained at levels compliant with the minimum requirements for the protection of a Priority 3 Groundwater Source Protection Area;</td>
<td>Deep sewerage will be installed to convey wastewater from the site (Section 9.5).</td>
</tr>
<tr>
<td><strong>N)</strong> Protect in areas of open space, significant wetlands and vegetation with an appropriate buffer determined in accordance with DEC’s current policies;</td>
<td>Calculated pre-development peak flows have been adopted as post-development peak discharge rates (Section 9.2)</td>
</tr>
<tr>
<td><strong>O)</strong> Consider siting and risk prevention factors for potentially polluting commercial activities;</td>
<td>Significant wetlands and vegetation have been identified. Appropriate protection buffers and rehabilitation identified (Section 8)</td>
</tr>
<tr>
<td><strong>P)</strong> Minimise fertiliser sources and incorporate effective nutrient stripping features into drainage systems;</td>
<td>There will be no potentially polluting commercial activities proposed within the Albion DSP, in accordance with SPP 2.2 “Gnangara Groundwater Protection” (Section 3.5.4)</td>
</tr>
<tr>
<td><strong>Q)</strong> Specify ongoing maintenance requirements and ongoing management responsibility;</td>
<td>Stormwater system operation and maintenance requirements identified (Section 10.2)</td>
</tr>
<tr>
<td><strong>R)</strong> Specify contingency plans in the event that the criteria are temporarily not achieved; and</td>
<td>Contingency actions have been identified consistent with the DWMP (Section 10.6).</td>
</tr>
<tr>
<td><strong>S)</strong> Identify issues to be addressed at later stages.</td>
<td>A UWMP to be prepared for each of the development areas of Albion at the Local Structure Plan stage by the developer (Section 10.7).</td>
</tr>
</tbody>
</table>
Schedule 4 also requires the preparation of a Strategic Acid Sulfate Soils Management Plan. This provision has been addressed in Section 7 of this LWMS. The table below summarises the Albion LWMS compliance with this condition.

**SUMMARY OF ALBION ASSMP COMPLIANCE**

<table>
<thead>
<tr>
<th>Albion Strategic ASSMP Provision Condition</th>
<th>Compliance with Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A)</strong> Field validation of ASS areas and the delineation of high and medium risk areas and broad scale determination of acid generating potential soil; and</td>
<td>Broad scale field assessment completed by Douglas Partners to validate ASS risk and acid generating potential of the soils (Section 7).</td>
</tr>
<tr>
<td><strong>B)</strong> Develop a strategic plan for further investigation and associated management plan for all further stages of development.</td>
<td>A commitment is made to further detailed investigations once the depth and location of ground disturbing activities are known (Section 7.6 and Appendix D).</td>
</tr>
</tbody>
</table>
2 INTRODUCTION

2.1 Background

In March 1994 the Department of Planning and Infrastructure released a Structure Plan for the future urban development of the North-East Corridor of the Perth Metropolitan region. This report provided the basis for a major amendment to the Metropolitan Region Scheme (MRS) to rezone 2524 ha of land to urban purposes.

Initial planning for the Albion Townsite development commenced in December 1997 with the submission of the Albion Town/Henley Brook Structure Plan to the Western Australian Planning Commission (WAPC).

In December 1998 the WAPC lifted the deferment on the urban zone for the Albion/Henley Brook Town. Pursuant to the MRS the amended area was referred to the City of Swan for inclusion in its Town Planning Scheme No. 9 (TPS).

Following a review of the amended area by the EPA, a number of environmental factors were identified needing further evaluation prior to the TPS amendment. An Environment Review was requested by the EPA to enable further assessment of the environmental impacts of the proposed amendment. The draft Environmental Review documentation was completed in April 2006 (Ecoscape, 2006).

The City of Swan Town Planning Scheme 17 is now a statutory document. Consequently, Amendment 364 to Town Planning Scheme No 9 and the associated Environmental Review is no longer required. This LWMS, incorporating the ASS Management Plan, is submitted as part of the Albion Structure Plan under TPS 17.

2.2 District Water Management Planning

State government agencies are currently implementing a more integrated approach to urban water management and land planning. Under this framework urban water management strategies are developed in support of the land planning stages. Adopting this approach enables consistency in water management planning within each district with improved outcomes. This transition marks a move away from traditional drainage and nutrient management practices to a total water cycle approach.

From a water management perspective the district drainage is generally west to east, towards the Swan River. As a result the Albion development area forms a distinct district precinct and local precinct independent of the balance of the urban growth corridor. For this reason, we consider the preparation of this Local Water Management Strategy addresses the district water planning issues for Albion. Additional information has been included in this report to provide a district context and address the TPS No. 17 Provisions of Schedule 4, Section 3 LWMS provision ‘a’ as outlined in section 2.3.6.1. In particular this LWMS discusses in some detail the wetland and vegetation management strategy and acid sulfate soil management strategy.
2.3 Key Principles and Objectives

This LWMS uses the following documents to define its key principles and objectives.

2.3.1 Drainage Management Strategy for North East Corridor
(GB Hill & Partners, 1995)

The regional drainage strategy for the North East Corridor was prepared in 1995 for the Water Corporation in association with the North East Corridor Plan. The report outlines the development areas proposed within the Corridor (including the Study Area) and developed an approach to manage groundwater and drainage constraints within the area to facilitate development.

The Strategy reviews regional groundwater modelling and provides modelling of urban drainage scenarios, including estimating allowable post development discharges from various catchments within the north-east corridor, and providing indicative storage volumes for stormwater detention.

The Strategy shows surface drainage catchments for both pre and post development. In particular, the Strategy confirmed that a prior drainage proposal (WAWA, 1992) for a single West Swan catchment should be replaced by 4 individual catchments namely Bennett St, West Swan, Horse Swamp and Wandoo Creek catchments.

With respect to water quality management the strategy adopted an end of pipe system through the use of Water Pollution Control Ponds (WPCP) as the primary mechanism for nutrient removal. This approach has since been superseded, and DOW recommends the use of the treatment train approach to water quality management, which includes the use of source controls to minimise nutrient input/application. See 2.3.7 below.

2.3.2 Gnangara Land Use and Water Management Strategy (WAPC, 2001)

The overall aim of the Gnangara Land Use and Water Management Strategy (GLUWMS) is to protect the groundwater and environmental features of the Gnangara Mound while allowing compatible development of the land for the benefit of the community. The key objectives of the strategy are listed as:

- Protect the public groundwater supply by promoting land use and development which are consistent with the objectives for the protection and management of the UWPCA and key environmental features

- Provide planning framework for landholders, local and state government for land use decision making which complements groundwater protection

- Preserve wetlands and significant vegetation

- Sustain compatible economic and recreational activities.
2.3.3 Decision Process for Stormwater Management (DoE, 2005)
DoE and Swan River Trust released the Decision Process for Stormwater Management in WA (DoE and Swan River Trust, 2005) to provide a framework for the planning and design of stormwater management systems and assist in meeting the objectives specified above. A copy of the Decision Process is contained as Appendix A.

2.3.4 City of Swan Policies (2006)
The City of Swan has adopted 2 policies directly applicable to the Albion LWMS, namely:

- Urban Growth Policy (City of Swan 2006a)
- Environmental Planning Policy (City of Swan 2006b)

The LWMS has been drafted consistent with these policies.

2.3.5 Stormwater Management Manual for Western Australia (DoW, 2007)
The Water and Rivers Commission (now Department of Water, DoW) released A Manual for Managing Urban Stormwater Quality in Western Australia in 1998 to define and practically describe Best Management Practices (BMP's) to reduce pollutant and nutrient inputs to stormwater drainage systems. The Manual also aimed to provide guidelines for the incorporation of water sensitive design principles into urban planning and design, which would enable the achievement of improved water quality from urban development.

The document was released to provide a guideline for best planning and management practices and was intended for use by Water and Rivers Commission, but also by other State and Local Government Authorities and sectors of the urban development industry.

DoW has recently completed a major review of the Manual in consultation with a working team comprising industry and government representatives. The revised manual was officially launched in August 2007.

DoW's current position on Urban Stormwater Management in Western Australia is outlined in Chapter 2: Understanding the Context of the Stormwater Management Manual for Western Australia (DoW 2007), which details the management objectives, principles and a stormwater delivery approach for WA. Principle objectives for managing urban water 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
- Water Conservation: To maximise the reuse of stormwater
- Ecosystem Health: To retain natural drainage systems and protect ecosystem health
- Economic Viability: To implement stormwater systems that are economically viable in the long term
- Public Health: To minimise the public risk, including risk of injury or loss of life to the community
- Protection of Property: To protect the built environment from flooding and waterlogging
• Social Values: To ensure that social aesthetic and cultural values are recognised and maintained when managing stormwater

• Development: To ensure the delivery of best practice stormwater management through planning and development of high quality developed areas in accordance with sustainability and precautionary principles

To provide a decision framework for planning and design of stormwater management systems and assist in meeting the objectives specified above, the Department of Environment (now Department of Environment and Conservation / DoW) and Swan River Trust released the Decision Process for Stormwater Management in WA in 2005.

2.3.6 North East Corridor Urban Water Management Strategy (GHD, 2007)

This Strategy was developed to support the North East Corridor Structure Plan. The Strategy is based on a review of GB Hill & Partners (1995) and proposes new criteria and methods for managing the quantity and quality of surface runoff, for managing groundwater levels and quality, for protecting wetlands and waterways and for managing the potential risk from acid sulphate soils.

The Executive Summary from this Strategy is included as Appendix H.

The updated Strategy endorses the Water Sensitive Urban Design principles adopted by the 1995 Strategy, but it recommends alternative approaches to the relatively costly water pollution control ponds previously proposed.

The new Strategy recommends that as District or Local Structure Plans are prepared for the North East Corridor, they are supported by District Drainage and Water Management Plans (DWMP’s). The Strategy recognises that in some areas Local Structure Plans are prepared without the completion of a District Structure Plan. In this instance the Strategy recommends that the Department of Water, in consultation with the Department of Planning and Infrastructure and The City of Swan, prepare a DWMP for areas where development is anticipated without a District Structure Plan. It notes that the highest priority is the Henley Brook-West Swan-Caversham DWMP. The Strategy also notes that should local structure planning proceed before the completion of the necessary DWMP, the proponent should be required to prepare a Local Water Management Plan that addresses the issues that would otherwise have been included in the DWMP.

The latter is the approach which has been taken in this Albion LWMS.

2.3.7 Better Urban Water Management (WAPC, 2008)

The guideline document Better Urban Water Management (WAPC, 2008), focuses on the process of integration between land use and water planning and specifying the level of investigations and documentations required at various decision points in the planning process, rather than the provision of any specific design objectives and criteria for urban water management.

This LWMS has been developed to be consistent with the framework and process detailed in the guideline document. The 4 stage process as outlined in BUWM (2008) is as follows:

• **Stage 1 : Regional Water Management Strategy (RWMS)**
  For Albion: North East Corridor Urban Water Management Strategy – see Section 2.3.5
• **Stage 2 : District Water Management Strategy (DWMS)**
  For Albion: Swan Urban Growth Corridor Drainage and Water Management Plan – see section 2.3.8

• **Stage 3 : Local Water Management Strategy (LWMS)**
  For Albion: Albion Local Water Management Strategy – this document

• **Stage 4 : Urban Water Management Plan (UWMP)**
  To be developed prior to subdivision application

This Albion LWMS has been prepared to reflect the current transitional nature of the planning process from traditional drainage and nutrient management practices to a total water cycle approach as discussed in Section 2.2.

### 2.3.8 Swan Urban Growth Corridor Drainage & Water Management Plan (DoW, 2009)

Released by DoW in January 2009, the DWMP has been prepared to support development of the Sub-regional Structure Plan for the Swan Urban Growth Corridor.

The district scale hydrological strategy presented in the DWMP includes:

- Regional maximum groundwater level contours for current climate and wet climate scenarios prepared by GHD.
- Guidance on management of groundwater levels and groundwater quality protection.
- Hydrological modelling (flows, flood levels) of the significant tributaries and key wetlands for both the pre-development and post-development condition.
- Surface water modelling of sub-catchment predevelopment peak discharge based on soil type (clay, vegetated sand, cleared sand, inundated wetlands) and existing land use (rural/special rural/urban, and pervious/impervious).
- Post-development 5yr and 100 yr ARI peak runoff compensation volumes for sub-catchments and the hydraulic backwater conditions. Modelling allows discharge at pre-development peak discharge rates and assumes 1yr ARI is infiltrated.
- Development proposal monitoring requirements.

This LWMS complies with the DWMP.

### 2.3.9 City of Swan Town Planning Scheme No. 17, Provisions of Schedule 4

#### 2.3.9.1 Requirement for LWMS and Strategic ASSMP

The Provisions of Schedule 4 – Special Use Zone include Section 3 with a requirement prior to the final approval of a Structure Plan for the developer to prepare the following Environmental Management Plans, specified enlisted paragraphs:

- para 3.2.1 Strategic Acid Sulfate Soils (ASS) Management Plan
- para 3.2.2 Local Water Management Strategy (LWMS)
para 3.2.3 Noise Management Plan (NMP)

para 3.2.4 Quantitative Risk Assessment Plan

para 3.2.5 Bushland Management Plans

The LWMS is to be implemented to the satisfaction of the local authority, giving due regard to advice received from the Department of Environment and Conservation and the Department of Water.

The LWMS shall include:

a) In the absence of a District Water Management Strategy (DWMS), the LWMS must include information addressing the following, which would normally be contained in a DWMS:
   i. Commit to best practice planning, design & construction;
   ii. Refine land use scenario and identify major constraints;
   iii. Identify water sources for drinking and other uses, consistent with fit-for-purpose water use strategy use;
   iv. Refine conceptual stormwater management plan;
   v. Identify issues to be addressed at later stages.

b) Further refine urban water management system and quantify land required to meet design objectives;

c) Suite of possible BMP’s and design BPP’s depicted in diagrams;

d) Identify requirements of an Urban Water Management Plan (UWMP) and commit to compliance with stated Design Objectives via future UWMP;

e) Incorporate best practice Water Sensitive Urban Design principles to maximise on-site infiltration;

f) Undertake monitoring of nutrient levels within groundwater to enable comparisons between pre-development and post-development conditions;


g) Undertake groundwater monitoring programs to ensure that current groundwater levels are maintained;

h) Recommend monitoring framework;

i) Incorporate appropriate stormwater collection and disposal methods and water sensitive design principles to minimise the risk of contamination to groundwater;

j) Incorporate connection to main sewerage system for all dwellings to reduce the potential for contamination of drinking water supplies;

k) Where possible control stormwater quantity through a waterways system linked to a “treatment train” process;

l) Ensure that changes to surface flow volumes are not significantly altered, and that peak surface flows are not increased;

m) Ensure that the rate, quantity and quality of wastewater infiltrating Priority 3 UWPCA within the Estate is maintained at levels compliant with the minimum requirements for the protection of a Priority 3 Groundwater Source Protection Area;
n) Protect in areas of open space, significant vegetation and wetlands with an appropriate buffer determined in accordance with DEC’s current policies;

o) Consider siting and risk prevention factors for potentially polluting commercial activities;

p) Minimise fertiliser sources and incorporate effective nutrientstripping features into drainage systems;

q) Specify ongoing maintenance requirements and ongoing management responsibility;

r) Specify contingency plans in the event that the criteria are temporarily not achieved; and

s) Identify issues to be addressed at later stages.

A summary of LWMS Principles and Objectives from these documents is presented in Table 1.

The Strategic ASS Management Plan shall include:

a) Field validation of ASS areas and the delineation of high and medium risk areas and broad scale determination of acid generating potential soil; and

b) Develop a strategic plan for further investigation and associated management plan for all further stages of development
## TABLE 1: SUMMARY OF LWMS PRINCIPLES AND OBJECTIVES

<table>
<thead>
<tr>
<th>Key Guiding Principles</th>
<th>Category</th>
<th>Principles</th>
<th>Objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Facilitate implementation of sustainable best practice in urban water management for Albion</td>
<td>Water Supply</td>
<td>• Consider all potential water sources in water supply planning</td>
<td>• Minimise the use of potable water where drinking water quality is not essential, particularly ex-house use.</td>
</tr>
<tr>
<td>• Encourage environmentally responsible development</td>
<td></td>
<td>• Integration of water and land use planning</td>
<td>• Consumption target for potable water of 155 kL/person/yr for the residential sector consistent with the State Water Strategy (WA Govt, 2003).</td>
</tr>
<tr>
<td>• Provide clarity for agencies involved with implementation</td>
<td></td>
<td>• Sustainable and equitable use of all water sources having consideration of the needs of all users, including community, industry and environment</td>
<td></td>
</tr>
<tr>
<td>• Facilitate adaptive management responses to the monitored outcomes of development</td>
<td></td>
<td>• To maximise the reuse of stormwater</td>
<td></td>
</tr>
<tr>
<td>• To minimise public risk</td>
<td>Surface Water Flows and Groundwater Levels</td>
<td>• To retain natural drainage systems and protect ecosystem health</td>
<td>• For ecological protection, 1 in 1 year ARI volume and peak flow rates maintained at pre-development conditions</td>
</tr>
<tr>
<td>• To maintain the total water cycle</td>
<td></td>
<td>• To protect from flooding and waterlogging</td>
<td>• Where there are identified impacts on significant ecosystems, maintain or restore desirable environmental flows and/or hydrological cycles</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• To implement economically viable stormwater systems</td>
<td>• For flood management, manage up to the 1 in 100 year ARI event within the development area to pre-development peak flows unless otherwise negotiated</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Post development annual discharge volume and peak flow rates to remain at predevelopment levels or defined environmental water requirements</td>
<td>• Post development end of winter operating levels at significant wetlands maintained at pre-development levels, unless otherwise determined by EWR’s</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Minimise change in peak winter levels at groundwater dependent wetlands due to urbanisation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Groundwater and Surface Water Quality</td>
<td>• To maintain or improve groundwater and surface water quality.</td>
<td>• Implement current known best management practice as detailed in the DoE’s Stormwater Management Manual for Western Australia (2004) and the Decision Process for Stormwater Management in Western Australia. (DoE &amp; SRT, 2005), with an emphasis on a treatment train approach including nutrient input source control, and maintaining 1 in 1 year ARI post development discharge volumes and peak flow rates at pre-development levels.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Reduce the average annual load of stormwater pollutants discharged by development compared to if it used a traditional piped conveyance system.</td>
<td>• There will not be any potentially polluting commercial activities proposed within the Albion DSP, in accordance with SPP 2.2 “Gnangara Groundwater Protection”</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Where waterways/open drains intersect the water table, minimise the discharge of pollutants from groundwater.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Where development is associated with an ecosystem dependent upon a particular hydrologic regime, minimise discharge or pollutants to shallow groundwater and receiving waterway and maintain water quality in specified environment.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Protection of public drinking water supplies.</td>
<td></td>
</tr>
</tbody>
</table>
2.3.9.2 Requirements for UWMP and ASS Site Assessment and Management Plan

The Provisions of Schedule 4 also describes in Section 4 the requirement prior to approval of a Local Structure Plan of an Urban Water Management Plan, consistent with the LWMS to the satisfaction of the relevant authorities to be implemented as part of the development. An ASS Site Assessment and Management Plan is also required prior to final approval of the local structure plan.

The UWMP shall include:

a) Demonstrate compliance with design objectives;
b) Site conditions – management of water dependant ecosystems and contamination/nutrient hotspots;
c) Specific BMP’s and design of water management systems;
d) The results of detailed environmental and hydrological studies;
e) Precise predictions and post-development modelling;
f) Details of location and design of drainage infrastructure;
g) Details of monitoring programme to evaluate ground and surface water quality, flows and levels, including the location and design of any current and proposed monitoring stations;
h) Descriptions and cost-benefit analysis (including whole of life costing) for any structural or non-structural controls;
i) Precise and measurable targets and limits for ground and surface water quality, flows and levels that are to be maintained for the development area. This will be accompanied by a clear description of the roles and responsibilities agreed upon by each agency and the agencies commitment for action to be taken, and;
j) Details of rehabilitation works to be undertaken in existing wetlands where relevant.

The LWMS is therefore required by the Provisions condition to show in summary:

- District Water Management Strategy information (a,b)
- Incorporation of WSUD (c, e, i, k, p)
- Monitoring of surface water and groundwater (f, g, h)
- Management of flood risk (l)
- Protection of UWPCA groundwater (j, m, o)
- Protection of wetlands and significant vegetation (n)
- Specify ongoing maintenance requirements and ongoing management responsibility (q)
- Contingency Plans (r)
- Identify issues to be addressed at later stages, including in UWMP (d, s)

The requirement to present in the LWMS specific contingency plans in the event that the criteria are temporarily not achieved (r) is difficult, as the criteria are to be set as part of the UWMP.

It is also noted that the UWMP is to include precise predictions and post-development modelling (e), so limited modelling only has been included in the LWMS in terms of storm water.
The ASS Site Assessment and Management Plan shall to include:

a) Detailed field assessment of ASS in proposed disturbance areas;

b) The preparation of ASS management plans in accordance with the DEC’s current guidelines, and;

c) Preparation of a monitoring program for groundwater discharge areas as part of the UWMP.
3 PRE-DEVELOPMENT ENVIRONMENT

3.1 Location and Topography

The Albion Townsite area (herein referred to as the Study Area) comprises of a total of 667 ha. Located approximately 18 km north east of Perth on the eastern portion of the Swan Coastal Plain, it is situated between Whiteman Park to the West and the Swan Valley to the east (Figure 1).

In its regional context, the Study Area is located within the catchment of the Swan River.

The topography of the site is shown in Figure 2, with the land typically falling from west to east. The majority of the area gently grades from approximately 34 m AHD in the west to 22 m AHD in the east.

Topographic data is based on aerial survey completed in August 2005 producing 0.2 m contours. The accuracy of this data is considered appropriate for decision making at the planning level of the LWMS.

3.2 Climate

The Study Area experiences a Mediterranean climate which consists of warm dry summers and cool wet winters.

The long term (1880-2005) average annual rainfall at Bureau of Meteorology’s Perth Metropolitan Office station (009225) is 860mm as shown in Figure 3. The data shows a maximum recorded annual total of 1339 mm in 1945 and a lowest recorded annual total of 509 mm in 1940. The average rainfall has decreased significantly since 1975, to an average annual rainfall of 786mm, reflecting a 9% reduction compared to the long term average (Figure 3).

The average annual pan evaporation is approximately 2200 mm (Luke et al, 1988).

3.3 Surface Geology

The Perth 1:50 000 Environmental Geology map (Gozzard, 1986) indicates that the site of the proposed redevelopment is made up of a variable thickness of Bassendean Sand of aeolian origin overlying Guildford Formation of alluvial origin (Figure 4).

The geological map legend indicates the Bassendean Sand consists of a white to pale grey sand, at surface, grading yellow with depth, fine to medium grained sand. The underlying Guildford Formation consists of white to brown, fine to coarse grained, clayey sands and sandy clays of variable low to high plasticity.

Small pockets of peaty clay associated with wetlands are evident in low points in the dune system.

3.4 Surface Water Hydrology

3.4.1 Existing Surface Drainage

The surface drainage within the Study Area is dominated by St Leonards Creek, Wandoo Creek and Horse Swamp. The corresponding catchments for these surface features are shown in Figure 2. St Leonards Creek Catchment is in the northern part of the Study Area, with the upper part of the catchment
extending north west to Gnangara Road. The creek drains south east towards the Swan River. Wandoo Creek drains eastward to the Swan River from the south west section of the Study Area. The remaining part of the Study Area in the south east forms part of the Horse Swamp Catchment.

The existing drains which traverse the Study Area are a combination of natural drainage lines and excavated drains, extended or deepened to enhance drainage from the area. Drains were generally installed in the middle part of the last century to reduce the incidence of inundation and water logging and to lower the water table in adjacent farmland. Where the drain invert is below the adjacent groundwater table, the drain lowers the water table locally.

The arterial drainage is shown in Figure 9 (GB Hill, 1995) is accepted as the existing surface drainage, although Lord St along the western boundary of the Structure Plan area is on fill, completed since GB Hill (1995) and may have created an artificial catchment boundary between Horse Swamp, Wandoo Creek and St Leonards Creek. This could be corrected by appropriate additional culverts beneath Lord Street.

GB Hill (1995) refers to an earlier proposal to protect Horse Swamp from the stormwater generated from Albion, by diverting the flow from Whiteman Park towards the east. It was resolved by GB Hill (1995) that the natural catchment boundaries should be preserved and surface runoff conveyed to Whiteman Park. This approach is followed in the LWMS. Because of below average rainfall in recent years there has been a correspondingly lower water table and less surface water.

### 3.4.2 Floodplain Mapping

There is no floodplain mapping available for St Leonards Creek or Wandoo Creek. A flood study has been completed for the Swan River between Middle Swan Rd and Walyunga National Park (WAWA, 1987). The flood mapping indicates a level of 8.25 m AHD at the St Leonards Creek confluence with the Swan River and a level of 7.88 m AHD at the Wandoo Creek confluence for the 100yr ARI.

A flood study was completed by WAWA (1989) for Bennett Brook. The mapping indicates the 100 yr ARI flood level is largely contained within the banks of the Brook. The 100 yr ARI flood level immediately downstream of Mussel Pool is 19.18 m AHD.

These flood plain maps for the Swan River and Bennett Brook do not extend over Albion.

### 3.4.3 Environmental Water Requirements

There are no current Environmental Water Requirements (EWR’s) or Environmental Water Provisions (EWP’s) established for the Swan River. The provisions of EWR’s are discussed in River Plan, (SRT, 2005) but no resources are currently allocated to determining the required flow rates.

Albion is within the area covered by the East Gnangara Environmental Water Provisions Plan PER (WRC, 1997) which recommends EWR’s and EWP’s for groundwater. The Plan presents criteria for wetland water levels, seepage flows and groundwater minimum levels aimed at protecting significant vegetation assemblages.

There are no EWR’s for wetlands or seepages identified in Albion in the Plan, but minimum groundwater levels are specified for Whiteman Park. The nearest criterion bore to Albion Structure Plan is bore MM55 B, in Whiteman Park which has a EWR and EWP level of 29.5 m AHD (Figure 10).
The Plan anticipates that intervention in the form of reduced groundwater abstraction will be required in 12% of years to ensure compliance with the EWP for this bore.

Compliance with EWR’s has been difficult in the East Gnangara area. When the proposed Lexia well field was approved in 1997, water levels in a number of significant wetlands had already been declining since at least 1994. By the time the Lexia well field commenced pumping in 2000/01 some wetland water levels were already in non-compliance and have remained so virtually to date.

EPA (2004) notes the reason for non-compliance at MM55B is primarily climate change and public water supply abstraction. EPA (2004) presents the view that the current total allocation limits and licensed allocation levels on the Gnangara Mound are too high and above sustainable levels. The subsequent report by EPA (EPA, 2005) noted that MM55B, together with many other monitoring bores in the East Gnangara area, had fallen below its EWR in 2004/05 also.

EPA (2005) recommends, amongst other things, that the Minister for Environment require the sustainable limits for all groundwater abstraction from the Gnangara Mound are reviewed and revised by the (then) WRC as a high priority.

Hence, the Albion Structure Plan is being submitted at a time of declining groundwater levels associated with a number of causes including reduction in annual rainfall, abstraction by public and private users and possibly the affect of pine plantations on the Gnangara Mound.

### 3.4.4 Surface Water Quality

An important objective of the Albion development is to ensure the post-development surface water quality is at least commensurate with pre-development conditions.

Monitoring of surface water quality by JDA commenced at Albion in July 2006 (see Plates 1 to 4). Data will be available at more detailed design stages. Current estimates of surface water quality for Albion are based on a number regional studies as follows:

- **The Swan River Trust (1999) Swan-Canning Cleanup Program Action Plan** provides an assessment of Nitrogen and Phosphorus discharge rates for the Bennett Brook catchment for the period 1995 to 1997. The study classified the catchment as moderate discharge (median concentration 1-2 mg/L) for Total Nitrogen and low discharge for Total Phosphorus (median concentration less than 0.1 mg/L). No estimate is made for St Leonards Creek or Wandoo Creek.

- **A National Pollutant Inventory project** estimated Nitrogen and Phosphorus in Runoff from Coastal Catchments of the Swan-Canning Estuary (Acacia Springs Environmental, 2000). The results were derived by extrapolating TN and TP export rates from 14 gauging stations across the Swan-Canning Catchment. The results of the Study estimate the average annual export rate as follows:

  - Bennett Brook 1.4 kg/ha/yr TN and 0.37 kg/ha/yr TP.
  - St Leonards Creek 1.61 kg/ha/yr TN and 0.78 kg/ha/yr TP.

It is not possible to compare these results to the SRT (1990) estimates, which are concentrations whereas the NPI estimates are nutrient loads.
The Bennett Brook Catchment Group in conjunction with the Water & Rivers Commission conducted sampling at two sites in the upper reaches of the Bennett Brook in Whiteman Park. The study is part of the Ribbons of Blue program to improve community participation in waterways protection. The data consists of a snapshot sample at each site collected in September 2002. The data is insufficient to be utilised as part of this study.

The NPI nutrient load estimates provide the current best estimate of nutrient loads for individual creeks. These nutrient values have been adopted as the design objective for stormwater discharge in this LWMS. These targets will be reviewed and refined as part of the UWMP to establish more detailed nutrient concentration criteria for Albion when additional monitoring data becomes available.

### 3.5 Groundwater Hydrology

There are four distinct aquifers underlying the Study Area, each being assigned the name of the major geological unit contributing to it.

From natural surface level in descending order they are:

- Superficial aquifer (unconfined)
- Mirrabooka aquifer (semi-confined)
- Leederville aquifer (confined)
- Yarragadee aquifer (confined)

The Yarragadee aquifer is not considered in detail in this report because private groundwater abstraction is not economically viable due to its depth below ground surface and it is generally brackish to saline.

#### 3.5.1 Superficial Aquifer

Groundwater in the superficial aquifer is contained in sand and clay which have an accumulated average saturated thickness of about 40 m. It is a complex unconfined aquifer system. Water levels in the superficial aquifer impact directly on the health of the wetlands in the area.

Recharge to the superficial aquifer is directly from rainfall at a rate of between 10 and 30% of the mean annual rainfall. The greatest recharge occurs in areas of Bassendean Sand and the least in clayey areas.

Groundwater from the superficial aquifer discharges to the underlying Mirrabooka aquifer, or Leederville aquifer, by leakage in areas where there are downward potentiometric levels and where confining beds are absent. The Superficial aquifer discharges locally into the creeks where the water table rises to the surface, generally in winter.

The Superficial aquifer groundwater flow system underlying the Study Area is known as the Gnangara Mound (Davidson, 1995), Figure 7. The Gnangara Mound groundwater flow system is a vast shallow groundwater resource to the north of Perth. At Albion, groundwater flow is to the east and southeast. Groundwater salinity is generally less than 1000 mg/L beneath Albion.

#### 3.5.2 Mirrabooka Aquifer

The Mirrabooka aquifer is a locally important semi-confined aquifer which occurs in Albion and throughout the western half of the Swan Groundwater Area. It is in general hydraulic continuity with the overlying superficial aquifer.
The Mirrabooka aquifer is recharged by leakage from the superficial aquifer, which is estimated to be 4% of rainfall. Groundwater flow in the Mirrabooka aquifer is south-east, parallel to that of the superficial aquifer. The groundwater salinity is generally less than 500 mg/L.

The Mirrabooka aquifer is a locally important resource for public drinking water supply.

### 3.5.3 Leederville Aquifer

The Leederville Aquifer is a major aquifer that is present to the north and west of the Gnangara Mound and has an average thickness of about 300m. Beneath Albion the flow is westwards.

The Leederville Aquifer is reserved for public water supply in this area and new allocations are generally not permitted.

### 3.5.4 Protection of Public Drinking Water Supply

Underground Water Pollution Control Areas (UWPCAs) are declared over the recharge areas of Perth’s public groundwater supply schemes to protect the quality of drinking water. In these areas the DoE administers the by-laws of the Metropolitan Water Supply and Sewerage and Drainage Act 1909 to manage potential contamination by land uses within these areas.

The north-east portion of the Albion Structure Plan Area is located within the Mirrabooka UWPCA area as set out in the Gnangara Land Use and Water Management Strategy (2001) (Figure 8). Within the UWPCA boundary areas are identified as Priority 1, 2 and 3 source protection areas, with Priority 1 providing the highest level of protection. The area of Albion within the UWPCA boundary is classified as a Priority 3 area. The definition of a Priority 3 area is as follows;

“Priority 3 (P3) classification areas are defined to manage the risk of pollution to the water source from catchment activities. Protection of P3 areas is mainly achieved through the guided or regulated environmental (risk) management for land use activities. P3 areas are declared over land where water supply sources co-exist with other land uses such as residential, commercial and light industrial development. Land uses considered to have significant pollution potential are opposed or restrained.”

In addition to the UWPCA boundary each groundwater production well has a well head protection zone (WHPZ) to protect drinking water sources in the immediate vicinity of the well. The WHPZ is a circular buffer unless otherwise specified. In a P3 area a buffer of 300m extends around the well head.

There are three Water Corporation Production wells with WHPZ affecting the Albion Structure Plan area. Bore M182 is located on Woollcott Ave and bores M282 and M285 are located on the north side of Park St. All of the wells abstract from the semi-confined Mirrabooka aquifer (Figure 6).

Residential development, including group housing, is permitted within a P3 area where the land is already zoned urban deferred in the MRS, as is the case for the Albion Structure plan area. The restriction to development within the WHPZ buffer is the exclusion of storage tanks. The Structure Plan developed is consistent with these restrictions and the protection of the public drinking water supply.

There will also be no potentially polluting commercial activities proposed within the Albion DSP, in accordance with SPP 2.2 “Gnangara Groundwater Protection”
3.5.5 Groundwater Resources for Irrigation at Albion

The Study Area extends over two groundwater management areas (GWA); the Swan Groundwater Area and the Mirrabooka Groundwater Area. Within the Swan GWA the Study Area falls in the South Swan sub-area for the superficial aquifer. In the Mirrabooka GWA the sub-area is Whiteman Park.

The Department of Water has indicated that there is a considerable volume of licensed groundwater abstraction in the South Swan sub-area, with this area fully allocated. There may be opportunities for water trading within these sub-areas.

Additional recharge of stormwater in Whiteman Park will be investigated as a potential source for groundwater abstraction from the superficial aquifer for Albion.

The Superficial aquifer in the Whiteman Park sub-area (Mirrabooka GWA) is currently 23% allocated of a total estimated groundwater resource of 3,370,000 kL available for allocation. However there are some concerns over the sustainability of the groundwater allocations in this area with groundwater levels declining below the EWR’s in recent years.

Table 2 summarises the current quotas, allocation and unallocated water for both the Superficial and Mirrabooka aquifers as presented in WRC (1997) and as advised on 24/7/06 (Carolyn Hills, DoW pers.comm).

Table 2 shows that the South Swan sub-area is effectively fully allocated within both the Superficial and Mirrabooka Aquifers. The Whiteman Park sub-area has unallocated water in the Superficial Aquifer. These values are subject to change and review by the Department of Water on a regular basis. We will seek the latest advice from the Department of Water at UWMP stage.

**TABLE 2: ALBION GROUNDWATER RESOURCES**

<table>
<thead>
<tr>
<th>Groundwater Area</th>
<th>Sub-area</th>
<th>Superficial Aquifer (ML/yr)</th>
<th>Mirrabooka Aquifer (ML/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Current Quota</td>
<td>Current Allocation</td>
</tr>
<tr>
<td>Source: WRC (1997)</td>
<td></td>
<td>3300</td>
<td>3000</td>
</tr>
<tr>
<td>Swan</td>
<td>South Swan</td>
<td>1300</td>
<td>300</td>
</tr>
<tr>
<td>Mirrabooka</td>
<td>Whiteman Park</td>
<td>4300</td>
<td>4300</td>
</tr>
<tr>
<td>Source: 24 July 2006 DoW advice</td>
<td></td>
<td>3370</td>
<td>800</td>
</tr>
</tbody>
</table>

3.6 Wetlands

The wetlands in the Albion Structure Plan area are all components of the Bennett Brook Suite (B/P4) and the Jandakot suite (B3). Fieldwork by Ecoscape (2006) indicated that many of the wetlands have been subjected to severe alteration or modification which may affect their management classification as follows;
- Sumpland 128 has been substantially degraded and should not be considered a wetland
- Palusplains 77 & 91 have been significantly degraded due to clearing of native vegetation and subsequent grazing
- Sumplands 129 & 130 are in moderate condition but have been affected by grazing and runway construction
- Sumpland 127 southern portion has been filled or possibly drained for grazing and is no longer recognisable as a wetland
- St Leonards Creek through much of Albion has been augmented by artificial drainage channels
- The portions of Sumplands 131 and 132 located in Albion Structure Plan area are in good condition
- Dampland 104 is in moderate condition and has substantial vegetation cover

The revised mapping of St Leonards Creek proposed by Ecoscape (2006) is shown in Figure 5.

The comments on wetland classification and management categories taken from Ecoscape (2006) are confirmed by ATA (2006a).

### 3.7 Acid Sulfate Soils

Acid Sulfate soil is the common name given to naturally occurring soil and sediment containing iron sulfides. In WA, the acid sulfate soils of most concern are those that formed in the last 10,000 years after the last major sea level rise.

During the period of high sea levels, new coastal landscapes were created as a result of rapid sedimentation, and acid sulfate soils were created when bacteria in these organically rich waterlogged sediments converted the sulfate from the seawater, and iron from sediments, into iron sulfides.

These naturally occurring iron sulfides are generally found in a layer of waterlogged soil or sediment, and are benign in their natural state. When disturbed and exposed to air, however, they oxidise and produce sulfuric acid, iron precipitates, and concentrations of dissolved heavy metals such as aluminium, iron and arsenic.

Release of acid and metals as a result of the disturbance of acid sulfate soils can cause significant harm to the environment and infrastructure.

The principal environmental, social and economic impacts of acid sulfate soils have been documented as follows:

- Adverse changes to soils and water quality
- Deterioration of ecosystems and the ecosystem services associated with soils, groundwater, wetlands, watercourses and estuarine environments
- Local and regional loss of biodiversity in areas affected by acid sulfate soils leachate
- Loss of groundwater and surface water resources used for irrigation and other purposes
- Reduction in opportunities for agriculture and aquaculture
- Human health concerns particularly from arsenic contamination of groundwater in areas affected by acid sulfate soils
- Corrosion of engineering works and infrastructure such as bridges, culverts, floodgates, weirs, drainage pipes and sewerage lines
- Loss of visual amenity from plant deaths, weed growth and invasion by acid tolerant waterplants and algae
- Costs to the community in terms of financial outlays and the community’s and government’s time and effort in minimising impacts and rehabilitating disturbed areas.

In WA the main impacts associated with acid sulfate soils to date have been:
- Wetlands degradation
- Localised reduction in habitat and biodiversity
- Deterioration of surface and groundwater quality
- Loss of groundwater for irrigation
- Increased health risks associated with arsenic and heavy metals contamination in surface and groundwater, and acid dust
- Risk of long-term infrastructure damage through corrosion of sub-surface pipes and foundations by acid water

The acid sulfate soil risk maps published by the Western Australian Planning Commission (WAPC, 2003) provides the following three acid sulfate soil risk categories:
- High risk of actual acid sulfate soil (AASS) and potential acid sulfate soil (PASS) <3m from surface;
- Moderate to low risk of AASS and PASS occurring generally at depths of >3m; and
- Low to no risk of AASS and PASS occurring generally at depths of >3m

Note that the high risk is for less than 3m deep, whereas moderate to low risk and low to no risk are for greater than 3m depth.

A desk top study of Albion, (PB, 2005) proposed a fourth category of acid sulfate risk, “medium - high risk”. The distribution of risk categories within Albion, as proposed by PB (2005), is presented as the background to Figure 14, rather than the WAPC (2003) map. Figure 14 indicates the majority of land has a medium - high and medium risk with small areas of high and low risk associated generally with wetlands and high sandy ground respectively. Department of Environment and Conservation has accepted Figure 14 can be used for ASS Risk Mapping (Steven Wong pers.comm. 15/9/06).

An investigation to better identify the constraints of ASS and application of management within the LWMS is addressed in the Acid Sulfate Soil Investigation (Chapter 7), which supersedes the mapping shown in Figure 14.
3.8 Existing Land Use

An aerial photograph showing existing land use within the Study Area is shown in Figure 6.

Existing land use within the Study Area is generally broad acre grazing north of Youle-Dean Road. South of Youle-Dean Road is the disused RAAF Caversham Airbase and Caversham Raceway. Ownership of this land has recently transferred to Department of Housing and Works. There was a poultry farm, recently closed, on the southern side of Park Road as indicated on Figure 6.

3.9 Caversham Airbase Subsurface Drainage

Anecdotal evidence suggests that a subsurface drainage network was installed under the old Caversham Airbase site to control groundwater levels. Review of plans provided to the Department of Housing and Works on transfer of ownership of this land does not show the drains.

The existence and details of the subsurface drainage will be investigated further at local structure plan stage (refer to Figure 15) and confirmed in the relevant UWMP.

3.10 Hydrological Opportunities and Constraints

The characteristics of the pre-development environment of the Study Area described above provide a number of key constraints and opportunities for the application of innovative approaches in water management with land use change:

- Groundwater mapping within the Study Area has allowed for regional assessment of groundwater levels (AAMGL) in relation to existing natural surface levels. The shallow AAMGL over the majority of the Study Area indicates that fill may be required to provide sufficient clearance between the groundwater and buildings.
- Clayey soils are likely to limit infiltration opportunities in some regions of the Study Area. These clayey soils (together with a high water table) are also likely to impact the opportunity for use of the superficial aquifer at a regional scale for aquifer storage and recovery of stormwater.
- Seasonality of rainfall in Perth, together with the high water table constrains the use of large scale regional basins to store stormwater for summer POS irrigation purposes. These basins are used in the eastern states where lack of high water table and comparatively high summer rainfall make such schemes viable.
- Historical land uses within the Study Area including grazing and poultry farms have to varying degrees affected groundwater quality within the Study Area, and currently operate without the application of any water quality controls. Change in land use provides an opportunity to improve groundwater quality through application of sustainability principles, water sensitive urban design, and establishment of water quality targets, monitoring and compliance reporting.
- Seven wetlands have been mapped in the District Structure Plan area. Five of these have previously been assigned a management category of Resource Enhancement, and the remaining two have previously been classified as Multiple Use. All wetlands in the District Structure Plan area have been highly modified, and retain few ecological attributes. However, there is an opportunity to retain and rehabilitate some wetlands in the District Structure Plan area. Two wetlands (one Resource Enhancement and one Multiple Use) are partially contained in the western portion of Bush Forever Site 200, located south of the District Structure Plan area. These two wetlands will be retained and the portion in the Bush Forever site will remain unmodified.
Whiteman Park is experiencing record low groundwater levels and reduced winter surface water flows and associated drying out of key wetlands. The opportunity exists to supplement Whiteman Park with surface water flow from Albion (western catchment). A meeting was held February 2008 with Whiteman Park staff to discuss this opportunity. Informal support for enhanced surface water flow through Whiteman Park to Horse Swamp was provided during this meeting. A formal request for support of Whiteman Park Board is being negotiated. This flow would largely infiltrate and recharge the superficial aquifer. Part of this additional recharge may be available for abstraction at Albion in the Whiteman Park sub-area of the Mirrabooka groundwater area.

Any such enhancement of surface water flow through Whiteman Park would need to be consistent with the overarching philosophy of the North East Corridor Urban Water Management Strategy (GHD, 2007) for maintaining the pre-development hydrological regime.

A summary of these constraints and opportunities in relation to the categories established for principles and objectives are summarised in Table 3. The response to these constraints and application of resulting opportunities within the LWMS is addressed in the Water Management Strategy (Chapter 9).

### TABLE 3: SUMMARY OF HYDROLOGICAL CONSTRAINTS AND OPPORTUNITIES

<table>
<thead>
<tr>
<th>Category</th>
<th>Constraint</th>
<th>Opportunities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Supply</td>
<td>• Clayey soils and high water table limit use of superficial aquifer for</td>
<td>• Investigate groundwater recharge to deeper parts of the Superficial Aquifer.</td>
</tr>
<tr>
<td></td>
<td>aquifer storage and recovery at a regional scale.</td>
<td>• Improved surface water yields for Whiteman Park.</td>
</tr>
<tr>
<td></td>
<td>• Seasonality of rainfall and limited use of infiltration to groundwater</td>
<td>• The additional stormwater recharge in Whiteman Park may be available in part for abstraction in the Whiteman Park sub-area of the Mirrabooka groundwater area for Albion</td>
</tr>
<tr>
<td></td>
<td>storage for POS irrigation</td>
<td></td>
</tr>
<tr>
<td>Groundwater</td>
<td>• Shallow groundwater over majority of Study Area requiring significant fill</td>
<td>• Establishment of subsoil exclusion buffers to protect wetlands</td>
</tr>
<tr>
<td></td>
<td>• Many existing Resource Enhancement wetlands highly degraded</td>
<td>• Rehabilitation of degraded wetlands</td>
</tr>
<tr>
<td></td>
<td>• Acid Sulfate Soils</td>
<td></td>
</tr>
<tr>
<td>Surface Water</td>
<td>• Flow paths for existing upstream drainage to be maintained post development</td>
<td>• Revitalisation of the Swan River</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Improve runoff volumes for downstream users.</td>
</tr>
<tr>
<td>Surface Water Quality</td>
<td>• Surface water quality entering Study Area is from pre WSUD drainage</td>
<td>• Improve quality of surface water discharging to Swan River though transforming existing trapezoidal drains within the Study Area to living streams</td>
</tr>
<tr>
<td></td>
<td>systems</td>
<td></td>
</tr>
<tr>
<td>Groundwater Quality</td>
<td>• Groundwater quality affected by historical land uses</td>
<td>• Improve groundwater quality through application of sustainability principles, WSUD BMP’s, water quality targets, monitoring and compliance reporting.</td>
</tr>
<tr>
<td></td>
<td>• Clayey soil to limit infiltration opportunities in some areas</td>
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</tr>
</tbody>
</table>
4 ALBION TOWN PROPOSAL

4.1 General Description

The redevelopment of Albion will provide a residential development capitalising on Albion’s proximity to the Swan Valley setting and existing physical infrastructure.

Key objectives of the redevelopment are:

- Provide commercially viable urban development which will act as a tool for promotion of best practice in sustainable urban residential development;
- Improved stormwater management through water sensitive urban design;
- Optimised water harvesting and water reuse; and
- Provision for the protection of ecological values of riparian and groundwater dependent ecosystems within the development and protection of receiving environments.

4.2 District Structure Plan

Based on the above objectives and recognising key constraints and opportunities of the site a District Structure Plan was developed as shown in Figure 15.

Key land use elements of the Structure Plan include residential development ranging from R10 to R60, local and larger central activity centres, and innovative use of linear POS linkages to create a sense of place and link with urban water management and the protection and enhancement of the existing natural environment.

Key elements of the Structure Plan related to urban water management include:

- Use of linear POS for detention, retention, conveyance, and treatment of stormwater.
- Re-creation of existing trapezoidal drains within the Study Area to Living Streams.
- Provision of preliminary buffer zones (50m for wetlands, 30m to watercourses) to ensure protection of tributaries and significant wetlands.
- Extent of wetland buffers are subject to review and refinement at Local Structure Plan stage and documented in Wetland Management Plans.
- Maintenance of flow paths through the Study Area for upstream catchments.
5 SURFACE WATER INVESTIGATION

5.1 Surface Water Data

The nearest long-term monitoring site is the John Street gauging Station on Henley Brook, approximately 1.5 km north of the Study Area.

JDA monitoring of surface water flows within the Study Area commenced during July 2006. Plates 1 to 4 show instrumentation of water level recorders and rising stage samplers.

Due to the very low rainfall over the 2006 winter period, limited data only was able to be collected. In winter 2007, higher rainfall did not result in surface run-off, probably due to the lower water table elevation associated with previous drier years. However, monitoring of the sites will continue up until the subdivision stage and used for the preparation of the UWMP.

5.2 Mean Annual Run-off Estimates

Mean annual runoff for the three creeks in the existing pre-development catchment condition can be estimated as a proportion of mean annual rainfall.

Water Authority (1995) includes estimates of storm event run-off rates for 10 yr average recurrence interval (ARI) and above, from which we estimate the mean annual run-off is approximately 10% of rainfall. This is consistent with estimates contained in Swan River Trust (1994) for Bennett Brook.

Using 1975 to 2005 average annual rainfall of 786 mm and estimated catchment areas, mean annual run-off estimates are presented in Table 4.

Note that these estimates should be considered preliminary and indicative only, and subject to review as pre-development surface flow monitoring data is collected. No surface flow has occurred in 2006 to date due to lower than average rainfall.

TABLE 4: MEAN ANNUAL RUN-OFF ESTIMATES

<table>
<thead>
<tr>
<th>Creek</th>
<th>Location</th>
<th>Catchment Area (ha)</th>
<th>Mean Annual Flow Estimate (Mm³/year)</th>
<th>Mean Annual Flow Rate (L/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>St Leonards Creek</td>
<td>Murray Rd</td>
<td>536¹</td>
<td>0.42</td>
<td>13</td>
</tr>
<tr>
<td>Wandoo Creek</td>
<td>Structure Plan eastern and southern boundary</td>
<td>122</td>
<td>0.09</td>
<td>3</td>
</tr>
<tr>
<td>Bennett Brook</td>
<td>Lord St</td>
<td>168</td>
<td>0.13</td>
<td>4</td>
</tr>
</tbody>
</table>

Notes
1. Includes Catchment Area upstream of the Study Area
5.3 Peak Flow Estimates

Two reports were published in early 1995 containing estimates of peak flow rates in creeks under existing pre-development catchment conditions within Albion and for other creeks in the North East Corridor.

Water Authority (1995) design flood estimates for Strelly Brook, St Leonards Creek and Henley Brook. St Leonards Creek estimates are presented in Table 5.

### TABLE 5: PEAK FLOW ESTIMATES

<table>
<thead>
<tr>
<th>Creek</th>
<th>Catchment Areas (ha)</th>
<th>2 yr ARI (m³/s)</th>
<th>10 yr ARI (m³/s)</th>
<th>100 yr ARI (m³/s)</th>
<th>Critical Storm Duration (hr)</th>
<th>Proposed Urban Area (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GB Hill (1995)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>St Leonards Creek to Swan River</td>
<td>1030</td>
<td>0.7</td>
<td>1.0</td>
<td>n/a</td>
<td>24</td>
<td>250</td>
</tr>
<tr>
<td>Wandoo Creek to Swan River</td>
<td>460</td>
<td>0.6</td>
<td>0.9</td>
<td>n/a</td>
<td>36</td>
<td>131</td>
</tr>
<tr>
<td>Horse Swamp Creek to Horse Swamp</td>
<td>720</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>228</td>
</tr>
<tr>
<td>Henley Brook to Swan River</td>
<td>1370¹</td>
<td>0.4</td>
<td>0.6</td>
<td>n/a</td>
<td>36</td>
<td>n/a</td>
</tr>
<tr>
<td><strong>Water Authority (1995)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>St Leonards Creek to Henley St</td>
<td>200</td>
<td>n/a</td>
<td>0.5</td>
<td>0.8</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>St Leonards Creek to Lawson Rd</td>
<td>410</td>
<td>n/a</td>
<td>1.0</td>
<td>1.6</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>St Leonards Creek to Casuarina Pl</td>
<td>900</td>
<td>n/a</td>
<td>2.1</td>
<td>3.4</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>St Leonards Creek To Swan River</td>
<td>1000</td>
<td>n/a</td>
<td>2.4</td>
<td>4.1</td>
<td>n/a</td>
<td>n/a</td>
</tr>
</tbody>
</table>

Volumetric run-off coefficients of 0.16 and 0.21 were assumed for 10 and 100 yr ARI. The total catchment of St Leonards Creek to Swan River is 1000 ha and the 10 and 100 yr ARI flood estimates were 2.4 and 4.1 m³ respectively.

Flood estimates were also given for St Leonards Creek to Henley Street, Lawson Road and Casuarina Place. Design flows are approximately proportional to catchment areas, see Figure 2. From Table 5, the 10 and 100 yr flow estimates through Albion to Murray Street are estimated as 1.1 and 1.8 m³/s respectively.

A second report in 1995 (GB Hill 1995), prepared for the Water Authority of WA, was a drainage management strategy associated with the North East Corridor Structure Plan. The report includes estimates of pre-development flows in all creeks within the North East Corridor including those within Albion. The catchment boundaries used are shown on Figure 2. For St Leonards Creek to Swan River this report concludes 1.0 m³/s for 10 yr ARI, compared with 2.4 m³/s by Water Authority (1995).

The study by Water Authority (1995) was relied on by Water Corporation, in preference to that by GB Hill (1995) with respect to pre-development flows for tributaries of Henley Brook through the Egerton property (Vale Development) north of Gnangara Rd. For assessment of the Albion proposal we also propose using the pre-development flow estimates by Water Authority (1995) as summarised in Table 5.
The updated North East Corridor Urban Water Management Strategy (GHD, 2007) did not present any estimates of peak flow rates under pre-development conditions, nor did it refer to the earlier estimates made by GB Hill (1995). Rather it stated that hydrologic and hydraulic modelling is expected to be required to identify pre-development and post-development run-off, to determine flood channel capacities of receiving waterways and to develop an arterial drainage strategy that identifies flood paths and land requirements to major and minor events as part of the implementation framework presented in Chapter 8 of that Strategy. It was envisaged that such modelling would be conducted by Department of Water over a six month period between April and September 2007. The Department of Water was also to be responsible for preparation of the Henley Brook-West Swan-Caversham DWMS over a six month period commencing September 2007 completed April 2008. The Strategy further noted that the assumed timeframe relies on surface water modelling being undertaken as part of the Henley Brook-West Swan-Caversham DWMS and that such modelling would be either uncalibrated/unvalidated, or based on limited stream flow monitoring undertaken in the winter 2007.

The updated North East Corridor Urban Water Management Strategy (GHD, 2007) states as a design criteria for water quantity management:

- "Ensure that the flood channel capacity of the receiving waterway is not exceeded, by retaining or detaining the runoff from storm events in the landscaped areas in public open space or linear multiple use corridors."

From further discussions with the Department of Water, this criteria is not intended to limit discharge of the drainage system to less than pre-development flow rates due to capacity constraints in existing infrastructure (pers. comm. Bill Till).

In this LWMS we have adopted this requirement by analysing the flow capacity of the culverts beneath the perimeter roads of Albion to validate if the existing infrastructure has capacity to convey the pre-development flow rates. Where constraints exist the downstream waterway has been assessed to identify if additional flow can be accommodated within the waterway if the infrastructure is upgraded.

Our assessment of the culvert capacities has taken note of previous drainage studies in the Swan Valley by GHD (1982). The Swan Valley Drainage Study (GHD, 1982) summarised catchments and road culvert capacities in the Swan Valley, including the Albion development, but did not estimate design flows. From this study the St Leonards Creek culvert on Murray Road has an invert of 23.5 m AHD and an estimated capacity of 1.3 m$^3$/s, roughly equal to the existing 10 yr ARI flow estimate of 1.1 m$^3$/s.

The direction of surface drainage from Albion is towards culverts beneath Murray Rd, Harrow St and Lord St. Along the eastern boundary it is likely that shallow surface water flow occurs towards Wandoo Creek, although none was observed during winter 2006. We have allowed for a surface water outlet post-development along the eastern boundary and confirmed the approximate location on site with Officers of City of Swan (Adrian Wong and Grant MacKinnon) on 18 October 2006.

Preliminary peak flow estimates have been circulated in February 2008 by Department of Water from the surface water modelling conducted by GHD as part of the Albion-Caversham-West Swan DWMS. These preliminary estimates are generally consistent with the flow rates presented in this LWMS. We have been advised that GHD flow estimates are subject to revision.
6 GROUNDWATER INVESTIGATION

6.1 Pre-Development AAMGL

6.1.1 Groundwater Level Data

There have been three stages of groundwater investigations at the Study Area with 24 bores being installed since 2001. The first series of these bores are the ALB bores (ALB1 to ALB10) which were monitored by WRC from September 2001 to April 2002. Parsons Brinkerhoff resumed monitoring of these bores in June 2002 and installed an additional 14 bores (BH1 to BH11 and APW 1, 2, 5). Since June 2006 JDA have continued monitoring groundwater levels in these bores.

The monitoring bore locations are shown in Figure 10. All 24 bores can be used to define the typical quality of shallow groundwater within and immediately around the Study Area. They can be separated as follows:

- BH1, 2, 3 and ALB 1 and 2 are up gradient of the Study Area
- Bores ALB 7, 8, 10 and APW 1 and 2 are down gradient of the Study Area

Completion details of bores BH1 to BH11 included in PB (2005) and Appendix B show the bores to be completed with 50 mm diameter Class 9 PVC machined slotted for the lower 3 m, total depth approximately 6m below water table in June 2002 when installed. The construction details of ALB bores has been requested from DoW.

Times series plots of water levels and water quality parameters are presented in Appendix B including the more recent JDA data used as an independent check on the earlier data.

6.1.2 DoW Groundwater Levels Data

There are four DOE bores located near the Study Area (Figure 10). Bores MM52 and MM56B are within the Study Area and bores MM27 and MM71 are located west of Lord Street. Water levels in these bores have been recorded since 1977. JDA have measured water levels on 6 January 2006 for AAMGL calculations.

6.1.3 Method for AAMGL Calculation

AAMGL is defined as the average of annual maximum water levels, although no particular period of record is defined. For the Study Area the AAMGL has been calculated using the length of record for the DOE bores which extends from 1977 to present.

Water levels measured in DOE bores on 6 January 2006 were compared to their long term AAMGL's (1977 - present) based on available historical data (Appendix C). Based on these recorded levels, the correction to convert the 4 DoE bores to AAMGL ranged between 0.48 m and 0.97 m, with an average of 0.72 m. The measurements by JDA in the monitoring bores on 6 January 2006 were therefore corrected to AAMGL by adding 0.72 m (Table 6).
6.1.4 Estimated AAMGL

Table 6 presents the AAMGL values for all 24 bores. The values for each bore based on correlation of monitoring bores with long-term DoW monitoring bores. These values are contoured in Figure 11 taking into account the natural surface elevation in Creek lines.

The direction of groundwater flow is typically south to south east. Figure 11 shows the AAMGL varies from 34 m AHD in the north-west near the corner of Park and Lord Streets, to 18 m AHD in the south-east near the corner of Harrow and Malvern Streets.

**TABLE 6: ALBION GROUNDWATER LEVELS**

<table>
<thead>
<tr>
<th>Bore No</th>
<th>max Recorded Level</th>
<th>Date</th>
<th>06/01/2006 Water Level</th>
<th>30/03/2006 Water Level</th>
<th>AAMGL</th>
<th>Min Recorded Level</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(mAHD)</td>
<td>Date</td>
<td>(mAHD)</td>
<td>(mAHD)</td>
<td>(mAHD)</td>
<td>Date</td>
<td>(mAHD)</td>
</tr>
<tr>
<td>ALB1</td>
<td>31.9 Oct-01</td>
<td></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>29.8 Apr-04</td>
<td></td>
</tr>
<tr>
<td>ALB2</td>
<td>33.9 Oct-01</td>
<td></td>
<td>32.56</td>
<td>32.01</td>
<td>33.28</td>
<td>31.9 Apr-04</td>
<td></td>
</tr>
<tr>
<td>ALB3</td>
<td>30.8 Oct-01</td>
<td></td>
<td>29.65</td>
<td>29.35</td>
<td>30.37</td>
<td>29.1 Apr-04</td>
<td></td>
</tr>
<tr>
<td>ALB4</td>
<td>29.6 Oct-01</td>
<td></td>
<td>28.53</td>
<td>28.19</td>
<td>29.25</td>
<td>28.2 Mar-03</td>
<td></td>
</tr>
<tr>
<td>ALB5</td>
<td>28 Oct-01</td>
<td></td>
<td>26.45</td>
<td>26.05</td>
<td>27.17</td>
<td>25.9 Mar-03</td>
<td></td>
</tr>
<tr>
<td>ALB6</td>
<td>28.1 Oct-01</td>
<td></td>
<td>27.14</td>
<td>26.84</td>
<td>27.86</td>
<td>26.8 Mar-03</td>
<td></td>
</tr>
<tr>
<td>ALB7</td>
<td>21.7 Oct-01</td>
<td></td>
<td>18.2</td>
<td>17.2</td>
<td>17.2</td>
<td>17.2 Mar-04</td>
<td></td>
</tr>
<tr>
<td>ALB8</td>
<td>23.9 Oct-01</td>
<td></td>
<td>23.01</td>
<td>22.57</td>
<td>23.73</td>
<td>22.4 Apr-04</td>
<td></td>
</tr>
<tr>
<td>ALB9</td>
<td>23.5 Oct-01</td>
<td></td>
<td>22.62</td>
<td>22.21</td>
<td>23.34</td>
<td>22.1 Apr-04</td>
<td></td>
</tr>
<tr>
<td>ALB10</td>
<td>21.7 Oct-01</td>
<td></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>19.9 May-04</td>
<td></td>
</tr>
<tr>
<td>APW1</td>
<td>21.9 Sep-04</td>
<td></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>19.9 Apr-04</td>
<td></td>
</tr>
<tr>
<td>APW2</td>
<td>21.1 Sep-04</td>
<td></td>
<td>20.48</td>
<td>20.24</td>
<td>21.2</td>
<td>19.9 Apr-04</td>
<td></td>
</tr>
<tr>
<td>APW5</td>
<td>23.8 Sep-03</td>
<td></td>
<td>23.15</td>
<td>22.77</td>
<td>23.87</td>
<td>22.6 Apr-04</td>
<td></td>
</tr>
<tr>
<td>BH1</td>
<td>35.1 Sep-03</td>
<td></td>
<td>34.3</td>
<td>33.94</td>
<td>35.02</td>
<td>33.7 Mar-03</td>
<td></td>
</tr>
<tr>
<td>BH2</td>
<td>30.5 Sep-03</td>
<td></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>29.3 Jun-02</td>
<td></td>
</tr>
<tr>
<td>BH3</td>
<td>34.7 Sep-03</td>
<td></td>
<td>33.93</td>
<td>34.44</td>
<td>34.65</td>
<td>33.3 Apr-03</td>
<td></td>
</tr>
<tr>
<td>BH4</td>
<td>37.5 Sep-03</td>
<td></td>
<td>26.69</td>
<td>26.33</td>
<td>27.41</td>
<td>26.2 Apr-04</td>
<td></td>
</tr>
<tr>
<td>BH5</td>
<td>27.2 Oct-04</td>
<td></td>
<td>26.75</td>
<td>26.23</td>
<td>27.47</td>
<td>26.1 Apr-04</td>
<td></td>
</tr>
<tr>
<td>BH6</td>
<td>21.3 Sep-03</td>
<td></td>
<td>20.74</td>
<td>20.35</td>
<td>21.46</td>
<td>20.2 Apr-04</td>
<td></td>
</tr>
<tr>
<td>BH7</td>
<td>22.7 Sep-03</td>
<td></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>21.3 Apr-04</td>
<td></td>
</tr>
<tr>
<td>BH8</td>
<td>13.4 Sep-03</td>
<td></td>
<td>12.01</td>
<td>10.98</td>
<td>12.73</td>
<td>10.6 May-03</td>
<td></td>
</tr>
<tr>
<td>BH9</td>
<td>16 Sep-03</td>
<td></td>
<td>15.2</td>
<td>14.54</td>
<td>15.92</td>
<td>13.9 Apr-04</td>
<td></td>
</tr>
<tr>
<td>BH10</td>
<td>21.5 Sep-03</td>
<td></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>19.9 May-04</td>
<td></td>
</tr>
<tr>
<td>BH11</td>
<td>19.9 Sep-03</td>
<td></td>
<td>19.28</td>
<td>18.87</td>
<td>20</td>
<td>18.6 Mar-03</td>
<td></td>
</tr>
</tbody>
</table>

Notes:
1. From data presented by PB (2005)
2. Measured by JDA
3. AAMGL Calculated from JDA 6/1/08 Data and DOE long term data
4. No AAMGL is given for ALB7 as the water level variation is larger than expected at water table suggesting a variation in bore construction.

6.1.5 Depth to AAMGL

Contours of depth below natural surface to AAMGL are presented in Figure 12. There is over 1.5m of clearance in the southern section of the Study Area and in parts of the north and east. These areas are associated with the Bassendean Sand Dunes (Figure 4). There is ponding of groundwater in areas associated with both resource enhancement and multiple use wetlands. The majority of the Study Area has a depth to AAMGL less than 0.6m.
6.2 Seasonal Variation in the Water Table

On the Swan Coastal Plain annual maximum and minimum water levels typically occur in Sept/Oct and in May/June respectively. For ALB 1 to 10 bores the highest recorded water levels were in Oct 2001 soon after the bores were installed. For APW 1, 2, 5 and BH 1 to 11 the highest recorded water levels were in Sept 2003. However, please note that no water levels were measured in 2005. 2005 rainfall was approximately long-term average but 2006 has been well below average so that June 2006 levels are also below average for this time of year.

The typical seasonal variation of bore water levels is 1.2 m from Table 6 and from the original data presented in Appendix D. An average minimum groundwater level (AAMGL) has therefore been estimated as AAMGL – 1.2 m and is shown contoured in Figure 13.

6.3 Groundwater Quality

Shallow groundwater quality at Albion particularly in relation to nutrient is summarised in Table 7 in terms of median value for all bores, up-gradient and down-gradient bores. Table 7 shows that for total phosphorus there is some evidence of an increase of up-gradient and down-gradient bores from 0.04 to 0.09 mg/L, compared with a median value of 0.06 mg/L for all bores. This compares with this Swan/Canning Cleanup Programme target of 0.1 mg/L TP.

For total nitrogen for up-gradient and down-gradient bore concentrations are similar at 1.9 to 2.0 mg/L. The Swan/Canning Cleanup Programme target of 1.0 mg/L is approximately 50% of the current concentration of shallow groundwater beneath Albion.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>FRP / Ortho-P (mg/L)</th>
<th>TP (mg/L)</th>
<th>NO₃ (mg/L)</th>
<th>TN (calc) (mg/L)</th>
<th>pH</th>
<th>EC (µS/cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median value (all 24 bores 9/01 – 12/04)</td>
<td>0.017</td>
<td>0.06</td>
<td>0.039</td>
<td>1.9</td>
<td>5.9</td>
<td>440</td>
</tr>
<tr>
<td>Up-gradient bores (5 bores: BH1, 2, 3: ALB 1, 2)</td>
<td>0.014</td>
<td>0.04</td>
<td>0.039</td>
<td>2.0</td>
<td>5.9</td>
<td>470</td>
</tr>
<tr>
<td>Down-gradient bores (5 bores: ALB 7, 8, 10: APW 1, 2)</td>
<td>0.020</td>
<td>0.09</td>
<td>0.054</td>
<td>1.9</td>
<td>6.2</td>
<td>940</td>
</tr>
<tr>
<td>Swan Canning Cleanup Programme (SRT, 2000)</td>
<td>-</td>
<td>0.1</td>
<td>-</td>
<td>1.0</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
7 ACID SULFATE SOIL INVESTIGATION

This chapter describes the strategic ASS investigation performed for the preparation of this LWMS between 10 February and 19 April 2006 (Douglas Partners, 2006). The results of this investigation are presented in this section to fulfil the requirements of the Strategic ASS Management Plan as provided in City of Swan TPS No 17 Provisions of Schedule 4, Section 3 Strategic Acid Sulfate Soils (ASS) Management Plan, and outlined in section 2.3.6.1 of this report. The results of this investigation have been accepted by DEC 4/3/08 as sufficient to support the District Structure Plan (see Appendix E).

The WAPC (2004) risk categories refer to soil depths less than and greater than 3 m. Due to the size of the Albion investigation area the strategic investigation was undertaken to a depth of 2.4 m. It is considered that this investigation depth provides sufficient information at this stage of planning and further detailed work will be undertaken at the Local Structure Plan approval stage when the locations and depths of ground-disturbing activities are known.

7.1 Sub-surface Conditions

The sub-surface conditions encountered at the locations investigated comprised the following three generalised profiles:

- **Profile ‘A’ – Sand:**
  - Encountered at 102 of the 114 boreholes
  - Occurs in all acid sulfate soil risk areas;
    - **Topsoil:**
      - Grey-brown and dark brown, fine to medium grained sand with rootlets;
      - Intersected at 0.0 m to 0.4m in thickness;
      - Intersected at 0.1m to 0.25m thickness at most locations;
    - **Sand:**
      - Generally light grey and grey-brown;
      - Encountered for thicknesses of 2.0m to 2.4m;
      - Loose to medium dense with some very loose layers at some locations

- **Profile ‘B’ – Sand/Silty Sand:**
  - Encountered at seven of the 114 boreholes;
  - Two of the boreholes where this profile was encountered (BH91 & BH95) occur in areas classified as high acid sulfate soil risk (Figure 14);
  - Four of the other boreholes (BH8, BH9, BH48, BH56) occurred in medium to high acid sulfate soil risk areas;
  - BH 93 occurred in a medium risk area;
    - **Topsoil:**
      - Grey-brown and dark brown, fine to medium grained sand with rootlets;
      - Intersected at 0.0m to 0.3m in thickness;
    - **Sand:**
      - Generally light grey and grey-brown;
      - Encountered for thicknesses of 2.0m to 2.4m;
      - Overlain by silty sand at BH 48 and BH 56;
      - Generally loose to medium dense;
    - **Silty Sand:**
      - Generally grey-brown to dark brown
      - Encountered from 0.1 to 2.3m below the existing surface
      - Underlain by sand at BH 48 and BH 56;
      - Generally loose to medium dense;

- **Profile ‘C’ – Sand/Clayey Sand/Sandy Clay**
- Encountered at five of the 114 boreholes;
- Three of the boreholes where this profile was encountered (BH 18, BH 36 and BH 41) occur in areas classified as high acid sulfate soil risk (Figure 14);
- The other boreholes (BH 71 and 76) occurred in medium to high acid sulfate soil risk areas;

- **Topsoil:**
  - Dark brown, fine to medium grained sand with rootlets;
  - Intersected at 0.15m to 0.3m in thickness;

- **Sand:**
  - Generally light grey and grey-brown
  - Not encountered in BH 41 and BH 76;
  - 0.75 to 0.95 m in thickness at the other three locations;
  - Generally loose to medium dense;

- **Clayey sand/sandy clay:**
  - Generally grey, grey-brown and grey-green;
  - Intersected for 0.9m and underlain by sand at BH 36
  - Encountered from depths of 0.2m to 1.1m to the extent of the boreholes at 2.4m at the other four locations
  - Sand generally loose to medium dense, clay generally firm.

### 7.2 In-House Laboratory Testing

The soil pH (pH_F) and the pH of the soil after oxidation with a 30 percent solution of peroxide (pH_FOX) were measured for selected soil samples in accordance with Douglas Partners (2004).

The pH_F and pH_FOX measurements were obtained using a Hanna pH metre, which was calibrated each day prior to undertaking the measurement using two calibration solutions of pH 6.88 and pH 4.00 respectively.

### 7.3 Acid Sulfate Soil Laboratory Testing

Soil samples were selected from borehole locations to undergo titratable actual acidity (TAA) and chromium reducible sulfur (SCR) analysis. The soil samples were selected for TAA and SCR analysis with due consideration of the following:

- Lowest reported pH_FOX within a soil strata at each test location;
- Lowest reported pH_FOX within different soil strata at each test location, including topsoil;
- Calculated difference between pH_F and pH_FOX, and
- Visual identification of the soils encountered.
7.4 Quality Control

As specified under Australian Standard 4482.1 “Guide to Sampling of Potentially Contaminated Soil”, the analysis program also allowed for the collection and analysis of quality control samples known as “blind replicate samples”. The laboratory results of the blind replicate sample provide an indication of the repeatability of results.

As a measure of the consistency of the results, the relative percentage difference (RPD) was calculated for replicate results.

7.5 Acid Sulfate Soil Assessment Criteria

In-house Laboratory Testing

The criterion for comparison of the in-house screening tests indicate actual acid sulfate soil (AASS) or potential acid sulfate soil (PASS) are based upon the following guidance specified in Department of Environment (2004):

- pH_F < 4 indicates oxidation has occurred in the past and that AASS are present;
- pH_FOx < 3, plus a pH_FOX reading at least one pH unit below the corresponding pH_F, plus a strong reaction with peroxide, strongly indicates the presence of PASS.

Titratable Actual Acidity and Chromium Reducible Sulfur Laboratory Testing

The net acidity, calculated from the results of the titratable actual acidity and chromium reducible sulfur testing was compared against the Texture-based acid sulfate soil “Action Criteria: presented in Appendix 3 of Department of Environment (2004). The requirement for management of acid sulfate soil following disturbance is necessary if the calculated net acidity is greater than the action criterion. The net acidity is calculated as follows:

- \[ \text{Net Acidity (} \% \text{ sulfur)} = \text{SCR} + \text{s-TAA} + \text{Retained Acidity (} \% \text{ sulfur)} \]

For the purposes of assessing acid sulfate and given that the sub surface conditions are generally sandy, an action criterion of 0.03% sulfur would be considered applicable.

In-house Laboratory Results

The in-house laboratory results indicate the following:

- pH_F:
  - actual acid sulfate soils are not likely to be present to depths up to 2.4m below the existing ground surface at any of the investigation locations.
- pH_FOX
  - 114 of 780 (approximately 15%) samples tested indicated that potential acid sulfate soils are likely to occur within the areas investigated;
- Potential acid sulfate soils are likely to be present at some depths at 55 of the 114 investigation locations (approximately 50%).

- Potential acid sulfate soils are likely to be present at and possibly below the following depths at the following locations:
  - Topsoil – 21, 25, 26, 32, 33, 44, 45, 48, 51, 56, 70, 92, 94, 103, 108, 110 and 111;
  - 0.4m – 2, 7, 22, 23, 43, 49, 101 and 109;
  - 1.2m – 3, 14, 18, 34 and 35;
  - 1.6m – 5, 6, 15, 31 and 41
  - 2.0m – 4, 13, 16, 17, 32, 36, 40, 54 and 96; and
  - 2.4m – 9, 27, 28, 42, 46, 47, 82, 84, 85, 87, 88 and 95.

It should be noted, however, that the results of the in-house laboratory testing are indicative only and should be confirmed with the laboratory analysis.

**Laboratory Results**

Based upon the laboratory results it is indicated that:

- Net acidities $\geq 0.03\%$ were detected at approximately 24% (27 out of 114) of the investigation locations;

- The percentage occurrence of acid sulfate soils in terms of the risk categories, as shown on Figure 14, were:
  - high risk  - 30% (at 13 of 43 locations)
  - medium - high risk  - 34% (at 13 of 38 locations)
  - medium risk  - 4% (at 1 of 24 locations)
  - low risk  - 0% (not detected at any of nine locations);

- Slightly more than 14% of the samples tested (29 out of 202) had net acidities $\geq 0.03\%$

- Net acidities equal to or greater than 0.03\% occur through the profile to 2.4m depth

- Test locations where one or more soil samples were identified as having net acidities of equal to or greater than 0.03\%, and thus will require management of acid sulfate soils if excavated are:
  2, 3, 4, 5, 14, 24, 26, 28, 36, 39, 45, 46, 51, 53, 54, 56, 63, 68, 70, 75, 90, 94, 99, 101, 102, 103 and 105.

Of the 114 boreholes, 27 confirmed the presence of PASS by laboratory testing. Of these 27 sites, 26 were in areas mapped in Figure 14 as high (13) and medium - high (13) and 1 was in the medium risk area. None were in low risk area.
The results are colour coded in Figure 14 as follows:

- Black denotes no indication of ASS
- Green denotes in-house screening indicates PASS
- Blue denotes laboratory testing indicates $\geq 0.03\%S$
- Red denotes in-house and laboratory indicates potential ASS $\geq 0.03\%S$

Figure 14 and Table 8 present a summary of the strategic ASS investigation for each borehole with the mapped risk compared with the test results.

Within the low risk area, Figure 14 and Table 8 show only null results.

Within the medium risk area on Figure 14, 1 borehole out of 24 has a laboratory result which indicates PASS (borehole 63).

Within the medium-high risk area on Figure 14, 13 boreholes out of 38 have a laboratory result which indicates PASS.

Within the high risk area on Figure 14, 13 boreholes out of 43 have a laboratory result which indicates PASS.

Even within the high risk area, only 30% of sites tested were confirmed by laboratory results to be potential PASS.
# TABLE 8: SUMMARY OF ASS INVESTIGATIONS

<table>
<thead>
<tr>
<th>Bore Hole Location</th>
<th>Mapped ASS Risk¹ (Fig 11)</th>
<th>Test Results²</th>
<th>Bore Hole Location</th>
<th>Mapped ASS Risk¹ (Fig 11)</th>
<th>Test Results²</th>
<th>Bore Hole Location</th>
<th>Mapped ASS Risk¹ (Fig 11)</th>
<th>Test Results²</th>
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<td>M</td>
<td>-</td>
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</tbody>
</table>

**Notes**

1. H = High, MH = Medium - High, M = Medium, L = Low
2. I = In house screening indicates PASS (55 locations), L = Laboratory testing indicates 0.03% S, I + L = In house screening indicates PASS and laboratory testing indicates 0.03% S (16 locations), - = No indication of ASS (59 locations)
7.6 Investigation Conclusions

Based on the results of the study Douglas Partners concluded:

**General**

- The acid sulfate soil conditions at the site would not prevent the development of Albion, nor place unreasonable requirements on the development.

- It would be appropriate to undertake detailed planning for management of acid sulfate soil issues at the development stage when the locations and extent of ground and groundwater disturbing activities are known;

**Acid Sulfate Soils**

- Net acidities greater than the criterion of 0.03% were detected mostly in the areas classified as ‘medium to high risk’ and ‘high risk’ (Figure 14) up to depths of 2.4m below the existing surface.

- The risk of acid sulfate soils occurring in the areas classified as either ‘medium to high risk’ or ‘high risk’ (Figure 14) is similar at about 30%.

- The risk of acid sulfate soils occurring in the areas classified as either ‘medium risk’ or ‘low risk’ (Figure 14) is very low at about 4% or less;

**Soil**

- The following three main soil profiles were encountered to the depth of the investigation at 2.4m below the existing ground surface:
  
  - Profile ‘A’ – sand;
    - Topsoil over sand;
    - Encountered at 102 of the 114 boreholes;
    - Encountered in all acid sulfate soil risk areas;
  
  - Profile ‘B’ – sand/silty sand;
    - Topsoil over sand;
    - Contains layers of silty sand;
    - Encountered at seven of the 114 boreholes;
    - Encountered in “medium”, “medium-high” and “high” acid sulfate soil risk areas;
- Profile ‘C’ – sand/clayey sand/sandy clay
  - Topsoil over sand;
  - Contains layers of clayey sand and sandy clay;
  - Encountered at five of the 114 boreholes;
  - Encountered in “medium- high “ and “high” acid sulfate soil risk areas;

**Management**

- It is fully expected that similar requirements of soil and groundwater management, which have been successfully implemented for other projects, would be applicable to the overall development plan area. These requirements include lime dosing of soil and groundwater as appropriate, control of soil movement and groundwater discharge, and monitoring of soil and groundwater quality; and

- This study is considered to be sufficient for characterising the investigated areas for the purposes of the Structure Plan submission. Further detailed studies will be required at the Local Structure Plan approval stage when the locations and extent of ground and groundwater disturbing activities are known.

### 7.7 DoE Review and Comments

The Douglas Partners (2006) report was forwarded to Department of Environment by the City of Swan on 4/8/2006. Department of Environment provided a letter dated 8/8/06 to the City of Swan with review and comments on the report, which is attached as Appendix E.

The recommendations made in this letter are;

- Soil treatment should be based on the highest result expressed as total sulfidic acidity unless the source of the titratable acidity s shown to be benign

- That a groundwater investigation be conducted to determine background groundwater quality prior to any earthworks commencing

- That further investigation be undertaken to determine total net acidity and consider there potential off site impact

- That acid base accounting is used for the assessment of acid sulphate soils and predicting the lime requirement in this area.

Douglas Partners response to the Department of Environment and Conservation (DEC) dated 20/11/06 (Appendix E) confirms these recommendations will be followed in the Local Structure Plan investigations.

DEC confirmed on 4/3/08 that the investigation results are sufficient to support the District Structure Plan (Appendix E).
7.8 Groundwater Quality

The shallow groundwater has been tested for a range of parameters relevant to ASS. Samples of shallow groundwater were collected on 21/9/06 from 10 bores namely BH4, 8, 9, 10 and ALB2, 4, 5, 6, 7, 9 as shown on Figure 10 and tested for dissolved and total metals, major irons and nutrients. These 10 bores were selected on the basis of being slotted closest to the water table, rather than at greater depth.

Laboratory analyses are presented in Appendix F and dissolved aluminium and zinc concentrations are presented in Table 9.

**TABLE 9: SHALLOW GROUNDWATER DISSOLVED METALS ANALYSIS**

<table>
<thead>
<tr>
<th>Bore No.</th>
<th>Dissolved Aluminium (mg/L)</th>
<th>Total Aluminium (mg/L)</th>
<th>Dissolved Zinc (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BH 4</td>
<td>1.60</td>
<td>1.70</td>
<td>0.028</td>
</tr>
<tr>
<td>BH 8</td>
<td>&lt;0.01</td>
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<td>0.047</td>
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<tr>
<td>BH 9</td>
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</tr>
<tr>
<td>BH 10</td>
<td>&lt;0.01</td>
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<tr>
<td>ALB 2</td>
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<td>4.00</td>
<td>0.032</td>
</tr>
<tr>
<td>ALB 4</td>
<td>0.38</td>
<td>0.49</td>
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<td>ALB 7</td>
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<td>Detection Limit</td>
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<td>0.01</td>
<td>0.005</td>
</tr>
<tr>
<td>Criterion for moderately disturbed aquatic ecosystems (ANZECC, 2000)</td>
<td>0.055</td>
<td>N/A</td>
<td>0.008</td>
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</table>

Notes
1. Trigger value for 95% species protection, freshwater
2. Samples taken 21/89/06 (see Appendix F)

The following comments are made on the results presented in Table 9:

- The dissolved aluminium in six of the ten bores (BH4, ALB2, 4, 5, 6, 9) is very high when compared to the criterion for moderately disturbed freshwater aquatic systems (ANZECC, 2000)
- The dissolved zinc in all bores is high when compared to the criterion for moderately disturbed freshwater aquatic systems (ANZECC, 2000)
- Under existing land use the groundwater pH is likely to increase during winter as the shallow groundwater rises to the surface and becomes aerated during discharge to creeks and drains
- Shallow groundwater which discharges from Albion could not be measured during winter 2006 as a result of lower rainfall and the water table generally not reaching the invert of the drains and creeks to provide surface water which could be sampled.
- As a result of groundwater transformation during discharge to the surface, higher pH is likely to result in reduced dissolved metal concentrations.

Additional sampling of shallow groundwater and creek and drain flows will be performed during winter 2008, if rainfall is sufficient for the drains and creeks to flow.
8 SIGNIFICANT WETLAND AND VEGETATION PROTECTION STRATEGY

The wetlands in the Albion Structure Plan area are all components of the Bennett Brook Suite (B/P4) (Hill et al., 1996). The wetlands of this suite are found on Bassendean Dune system and are well represented on the Swan Coastal Plain (Ecoscape, 2006).

The Structure Plan area includes a variety of wetland types, including: dampland, sumpland, palusplain as well as both natural and artificial channel wetlands (Ecoscape, 2006). The wetlands in the Structure Plan area have been mapped and described by Hill et al. (1996) (see Figure 5).

Most of the study area is mapped in the DEC’s Geomorphic Wetlands Swan Coastal Plain dataset as palusplain (UFI 13396; 18806) or sumpland (UFI 8805; 8807; 8814; 8808). The management category and condition of the wetlands in the Structure Plan area is provided in Table 10. Most of these wetlands have been substantially modified which has implications for their management classification, as many retain few ecological attributes in their current condition. No EPP wetlands were identified in the Structure Plan area.

TABLE 10: WETLANDS IN THE ALBION STRUCTURE PLAN AREA

<table>
<thead>
<tr>
<th>Wetland No.</th>
<th>Type</th>
<th>Management Category</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>77 (UFI 13396)</td>
<td>Palusplain</td>
<td>Multiple Use</td>
<td>Have been significantly degraded due to clearing of native vegetation and grazing by livestock.</td>
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<tr>
<td>91 (UFI 8806)</td>
<td>Palusplain</td>
<td>Resource Enhancement</td>
<td></td>
</tr>
<tr>
<td>128 (UFI 8808)</td>
<td>Sumpland</td>
<td>Multiple Use</td>
<td>Has been filled and should no longer be considered a wetland.</td>
</tr>
<tr>
<td>129 (UFI 8807)</td>
<td>Sumpland</td>
<td>Resource Enhancement</td>
<td>Wetlands are in good condition though impacts of past grazing and runway are evident.</td>
</tr>
<tr>
<td>130 (UFI 8814)</td>
<td>Sumpland</td>
<td>Resource Enhancement</td>
<td></td>
</tr>
<tr>
<td>104 (UFI 8804)</td>
<td>Dampland</td>
<td>Resource Enhancement</td>
<td>Substantially vegetated in moderate condition.</td>
</tr>
<tr>
<td>127 (UFI 8805)</td>
<td>Sumpland</td>
<td>Resource Enhancement</td>
<td>Southern portion filled or possibly drained with subsequent grazing. The southern half is no longer recognisable as a wetland. The northern half is in good condition.</td>
</tr>
<tr>
<td>131 (UFI 8808)</td>
<td>Sumpland</td>
<td>Resource Enhancement</td>
<td>Portions in Bush Forever site are in excellent condition.</td>
</tr>
<tr>
<td>132 (UFI 8815)</td>
<td>Sumpland</td>
<td>Multiple Use</td>
<td></td>
</tr>
</tbody>
</table>

Note: Only portions of Wetlands 131 and 132 are located in the Albion Structure Plan area.

The design and management of the Albion development will focus on maintaining the natural attributes and values the area supports particularly in relation to the significant wetlands and vegetation.
Implementation of the proposed Albion Structure Plan will result in the:

- Retention of wetlands with environmental values and their associated buffers;
- Construction of an ephemeral watercourse system for primarily the function of drainage and nutrient management;
- Modification or filling/draining of some wetlands; and
- Retention of significant vegetation.

### 8.1 Significant Wetlands

#### 8.1.1 Wetlands to be Retained

Implementation of the Albion Structure Plan will result in the retention of the following wetlands:

- Resource Enhancement Dampland – Wetland 104 (UFI 8804);
- Northern half of Resource Enhancement Sumpland – Wetland 127 (UFI 8805);
- St Leonards Creek;
- Portion of Resource Enhancement Sumpland Wetland 131 (UFI 8808) that is located within the Structure Plan area;
- Portion of Multiple Use Sumpland Wetland 132 (UFI 8815) that is located in the Structure Plan area; and
- Portions of Palusplain Wetlands 77 (UFI 13396) and 91 (UFI 18806) will be retained and modified (filled or channelled) for drainage purposes.

These wetlands are being retained for their ecological, hydrological and social functions.

#### 8.1.2 Wetland Vegetation

This chapter presents a summary of strategies for protection of significant wetland and vegetation taken from ATA (2006a, b, c). One road crossing St Leonards Creek is proposed in the District Structure Plan. This crossing is proposed to be located in a degraded section of the creek, and will result in minimal disturbance to existing remnant vegetation and will not adversely impact on the flow rates of St Leonards Creek.

Due to the small amount of intact native vegetation remaining in the Albion Structure plan area, a key objective of the LWMS is to ensure that all areas of good quality native vegetation within the retained wetlands and their buffers should be protected from clearing.
Wetland 104 contains a dense stand of Paperbark woodland that will be retained in its current form as a part of the development, ensuring the protection of its biological functions and values. Enhancement of degraded areas will further improve its conservation values. Low profile passive recreation opportunities (such as boardwalks and lookout/decking) are considered acceptable within the core wetland area (see section 7.1.5) if no good quality native vegetation is cleared.

The northern portion of Wetland 127 contains large Paperbark trees and will be protected from clearing. Rehabilitation of this area as a natural wetland will improve its ecological and social functions. Parts of this wetland also provide excellent passive recreational opportunities.

Installation of infrastructure (such as seating, BBQs etc) and landscaping in cleared areas could result in an aesthetic and functional open space refuge for future residents.

The portions of Wetlands 131 and 132 located in Bush Forever Site No. 200 (ATA 2006b) will be retained and protected thereby maintaining their conservation values. These wetlands will not be impacted upon by the proposed development. The Bushland Management Plan prepared for Bush Forever Site No. 200 provides management guidelines for the site and addresses a range of issues including access management, rehabilitation and stormwater management. The Bushland Management Plan removes the need for the preparation of Wetland Management Plans for the portions of Wetlands 131 and 132 located in the Albion Structure Plan area.

St Leonards Creek is the only example of a creekline wetland with native vegetation in the Structure Plan area. Revised wetland mapping proposed by Ecoscape, (2006) and presented here in Figure 5 shows the extent of St Leonards Creek as a natural wetland, as distinct from the artificial channels (drains) further upstream within the Albion area.

Consistent with Ecoscape (2006) it is proposed that St Leonards creek will be retained in its present form and rehabilitated. The Creekline provides an opportunity for combined conservation and passive recreation objectives. It is feasible to provide facilities such as a dual use path and seating within the buffer.

The protection of vegetation and fauna, rehabilitation of degraded areas and integration of low-key passive recreational facilities will need to be detailed within a Wetland Management Plan to be prepared for each wetland at the Local Structure Plan stage and implemented at the subdivision stage.

8.1.3 Management of Wetland Buffers

Buffers are important components around wetlands. Buffers:

- Separate water bodies and wetland vegetation from human activities on surrounding land;
- Provide habitat opportunities for fauna; and
- Improve water quality entering the wetland.

A vegetated buffer of 50m surrounding Wetland 104 (UFI 8804) and Wetland 127 (UFI 8805) is currently proposed. The buffers and their treatment will be refined during the preparation of Wetland Management Plans with consideration for reduced buffer widths with a commitment to rehabilitate degraded buffers.
A buffer zone of 30m (measured from the winter high water level) of vegetation will be rehabilitated on either side of the St Leonards Creekline, in line with commitment made to Aboriginal groups during consultation (Ecoscape, 2006). This buffer is consistent with the EPA’s (1997) recommended buffer width of 30m for seasonally flowing watercourses.

8.1.4 Stormwater Management

The Local Water Management strategy applies the principles of Water Sensitive Urban Design. Both structural (e.g. detention and infiltration methods, vegetated swales and gross pollutant traps) and non structural (e.g. regular drainage maintenance and education) techniques for urban water management are proposed.

Surface water will be discharged from Albion at the same locations where the Lord Street to Whiteman Park and eastwards to St Leonards Creek and Wandoo Creek.

To compensate for the loss of functions and attributes of some wetlands, an ephemeral watercourse system will be constructed to drain the Albion area. A treatment train approach will ensure that a range of wetland functions and values will be replaced.

The drainage system will accommodate surface drainage from urban areas and subsoil drains, while at the same time protecting wetlands and groundwater dependent vegetation, and control of peak flows into downstream water bodies.

Wetland 104 is at the head of a drainage network and will not receive additional drainage (Ecoscape, 2006). An artificial drainage line flows out from Wetland 104, discharging to St Leonards Creek. This channel will be retained in order to maintain the current hydrological regime (Ecoscape, 2006).

Wetland 127 currently receives stormwater from the adjacent road. It is intended that this wetland will be enhanced and form a part of a drainage swale system.

St Leonards Creek will receive additional drainage from the ephemeral watercourse system (Ecoscape, 2006). The St Leonards Creek buffer will be rehabilitated and enhanced. A treatment train system which promotes infiltration and incorporates swales, filter strips and nutrient stripping features for primary treatment of stormwater before discharge to receiving bodies will be implemented (see Appendix J).

Parts of Palusplain Wetlands 77 and 91 will be modified (filled and channelled) and incorporated into the proposed drainage system. It may be appropriate to revegetate some areas (e.g. where the drainage system discharges) using locally native plants as a part of a treatment train approach.

Due to the present condition of the wetlands in the Structure Plan area, it is appropriate for wetland buffers to contain stormwater management infrastructure (such as swales and detention basins) provided no good quality native vegetation is cleared. Overflow of larger storm events into wetland areas is also acceptable if the discharge does not have adverse impacts on wetland vegetation.

8.1.5 Passive Recreation Management

Given the condition of the wetlands in the Albion Structure Plan area, it is considered acceptable that passive recreational pursuits such as walking, bird watching, picnicking and nature studies will be suitable activities in most wetland areas and their buffers.
Controlled public access is recommended to prevent deterioration of the conservation values and assist with the regenerative processes. Access paths and boardwalks through open space will avoid areas likely to become inundated during winter. Dual use paths can be incorporated into buffer areas where appropriate (e.g. St Leonards Creek buffer) linking into regional networks and common destination points (such as commercial and educational nodes).

An integrated approach to landscaping treatments will be beneficial to ensure conservation and recreation objectives are achieved. A POS Landscaping Strategy will be developed to identify aesthetic treatments and consider how adjoining areas of POS can be integrated. For example how the possible Threatened Ecological Community POS and the St Leonards Creek POS might link together in a cohesive manner that advances the conservation objectives of both areas whilst providing passive recreation opportunities.

The use of wetland open space for passive recreation will require the installation of facilities (e.g. dual use paths, seating, barbecues etc). Specifications regarding the location, design and materials will be contained in the Wetland Management Plan.

The landscape strategy will include strategies for interpretative signage within wetland POS areas. Signage might include information relating to the:

- Environmental value and significance of the vegetation and wetlands;
- Native fauna that utilise the wetland;
- Wetland processes e.g. wetlands naturally dry up in summer months; and
- Potential presence of biting insects or other animals

### 8.1.6 Wetland Rehabilitation

Any disturbed areas during the construction of paths, boardwalks or other activities, degraded areas and buffers will be rehabilitated using local native plant species. Preference will be for the re-establishment of low-growing shrubs in bare areas to increase ground cover in order to reduce weed establishment and invasion. Revegetation of wetlands will consider treatment opportunities such as nutrient stripping.

The Wetland Management Plans to be prepared at the Local Structure Plan stage will provide more details on rehabilitation including species selection, spacing, ground preparation, monitoring requirements and management contingencies.

### 8.1.7 Weed Management in Wetlands

A number of weed species are already present in the wetland areas. Urbanisation has the potential to introduce and spread more weeds throughout the Study Area. A program to eliminate weeds is not realistic, but with suitable management, the extent of weed infestations can be substantially reduced. The main objective with weed management is to minimise the incidence of weeds and enhance the native vegetation. Consideration will be given to the interface treatment between landscaped areas and native vegetation to prevent the spread of grass species into native vegetation.

Interfaces with wetlands will have a clearly demarked change of management regime. Detailed treatments such as kerbing, level changes and the use of paths as an edge treatment to restrict the possible spread of grass.
8.1.8 Monitoring

A wetland monitoring program will be included in the Wetland Management Plans. The purpose of a wetland monitoring program is to gather baseline information and monitor post-development impacts. A monitoring program will entail monitoring:

- Water quality of the wetland,
- Groundwater in the local vicinity; and
- Changes in vegetation.

8.1.9 Wetland Management Plans

This Strategy has been prepared as part of the Structure Plan process. The discussion of issues therefore is at a level consistent with the details required at this broad planning stage. At the Local Structure Plan stage, more information will be required for the development and management specifications for each wetland area. This will be covered in Wetland Management Plans for each wetland. The aim of the Wetland Management Plan will be to:

- Preserve the wetland's ecological values;
- Design and program for the restoration sites in association with constructed waterways and wetlands, to provide habitat areas for native fauna;
- Incorporate water sensitive urban design principles;
- Incorporate buffers of public open space around significant wetlands;
- Reduce the potential for prevalence of anaerobic conditions by incorporating natural and artificial flushing, aeration and mixing of the water bodies;
- Reduce the potential for eutrophication of the water bodies by incorporating nutrient stripping features throughout the drainage systems;
- Ensure that the hydrological regime and water balance for the wetland system is consistent with regimes in wetlands within the local area in order to be capable of supporting the range of biota;
- Implement an appropriate monitoring program to detect the species of mosquitoes present, the location of potential breeding areas, the population size of mosquito species and the presence of Ross River virus and Barmah Forest virus before, during and after the development; and
- Reduce the potential for wetlands of the development to act as foci for breeding populations of mosquitoes known to carry Ross River virus and Barmah Forest virus. Mosquito breeding potential should be considered during the detailed wetland design, construction and rehabilitation stages, and should primarily involve reducing the opportunities for ponding and/or stagnation of water.

8.1.10 Wetland Management System

Table 11 summarises the proposed management system for the implementation of the Wetland Management Strategy.
TABLE 11: MANAGEMENT SYSTEM FOR THE IMPLEMENTATION OF THE WETLAND MANAGEMENT STRATEGY

<table>
<thead>
<tr>
<th>Component</th>
<th>Timing</th>
<th>Responsibility and Timing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preparation of Wetland Management Plans</td>
<td>Local Structure Plan stage</td>
<td>Developer</td>
</tr>
<tr>
<td>Implementation of Wetland Management Plan</td>
<td>Before, during and after construction of subdivision</td>
<td>Developer</td>
</tr>
<tr>
<td>Management of Wetland areas</td>
<td>Before, during and after construction of subdivision</td>
<td>Developer for the first 2 years then the City of Swan</td>
</tr>
<tr>
<td>Monitoring</td>
<td>Before, during and after construction</td>
<td>Developer for the first 5 years then the City of Swan</td>
</tr>
</tbody>
</table>

Where wetlands are located across two or more land holdings (e.g. Wetland 104), all land owners will be required to implement the components of the Wetland Management Plan on their land. In some cases, there will be a need to coordinate the timing of certain actions (such as fencing). This issue will be explored further in the Wetland Management Plans.

8.2 Significant Vegetation

The Environmental Review prepared by Ecoscape (2006) identifies the following significant areas of native vegetation:

- The possible Threatened Ecological Community (FCT 20a) located in the north-eastern portion of the Structure Plan area; and
- Bush Forever Site No. 200 southern portion of the Study Area.

Detailed Bushland Management Plans have been prepared for these two areas (ATA, 2006b,c)

8.2.1 Bush Forever Site No. 200

Stormwater from most of the Albion development will be able to be treated on site or be directed to the east and west without affecting the Bush Forever site. The development area immediately north of the Bush Forever site, however, slopes to the south towards the site. As a result, there will be a tendency for the stormwater to flow towards and through the Bush Forever site. This natural flow path is confirmed in Figure 10.9 of the Swan Urban Growth Corridor Drainage and Water Management Plan (DoW, 2009) and will be maintained post-development consistent with the DWMP drainage strategy for sub-catchment ‘Ag’.

The general principle for stormwater management in this area will be to infiltrate as much stormwater as possible within swales located in the urban development. The northeast portion of the Bush Forever site is degraded and maybe a suitable site for a stormwater detention basin. DPI has advised, in a letter to the City of Swan dated 28 May 2008, that it would support this proposal provided that an Environmental Management Plan for rehabilitation for bird habitat is provided. Note that the intent is to mimic as closely as possible the pre-development surface water flows. In extreme rainfall events and wet years overland...
flow through the Bush Forever site probably occurs at present and this will be allowed to continue post-development.

Overflow of larger storm events should be permissible within the lower lying portions of the Bush Forever site. These areas are the Paperbark (Melaleuca rhaphiophylla and Melaleuca preissiana) woodlands and the Marri (Corymbia calophylla) woodland located on the eastern part of this western half of the Bush Forever site.

Water quality from the overflow storm events is usually very good and will not affect the wetland vegetation in the Bush Forever site if it does not cause prolonged, deep inundation. The size of the overflow event (e.g. 1, 5, 10, 100 yr ARI storm event) will be discussed with the Department of Environment and Conservation. The approach is to mimic the existing hydrologic regime as closely as possible, which includes overland flow through the Bush Forever Site in certain rainfall events and high rainfall years.

8.2.2 Possible Threatened Ecological Community

The topographical position of the possible TEC combined with the design of the drainage system for the Structure Plan area will ensure that drainage is not diverted into the possible TEC, thereby preventing any potential adverse impacts on the possible TEC.
9 LOCAL WATER MANAGEMENT STRATEGY

9.1 Water Conservation Strategy

9.1.1 Key Design Criteria

Urban development through Albion will lead to a significant demand for water for new residents, to be used in-house and ex-house, as well as for irrigation of public open spaces and commercial/industrial purposes.

The design criteria for Albion will be consistent with the DWMP. The criteria present for water conservation are as follows:

- Consumption target of water of 100 kL/person/yr including not more than 40-60 kL/person/yr of scheme water.
- Meeting 5 Star Plus provisions for all new dwellings
- The use of native plants is to be promoted with native species constituting a minimum of 30-35% of the total POS area.
- The use of site rainwater tanks to be promoted, to achieve water consumption targets.

9.1.2 Water Efficiency and Reuse Initiatives for Households

The achievement of water conservation requires the implementation of water demand management measures at each household. These include water efficient fixtures and fittings within the home, such as taps, showerheads and appliances; and waterwise landscaping. Employing these measures can save up to 20% of the conventional water demand. The same waterwise landscaping measures can be applied to irrigation of public open space (POS).

The BCA 5 Star Plus initiative implemented by the Government of Western Australia 1 September 2007 requires new homes to have water efficient hot water systems, showerheads, taps and toilets. Stage 2 of the initiative will require an alternative water supply (such as rainwater tanks) for flushing toilets and for washing machines where single dwellings are located on larger lots. Stage 2 is set to be implemented in 2008, but a date has not yet been determined.

Domestic irrigation consumes some 57% of water supplied to households. Groundwater abstraction is usually the easiest and most cost effective method of providing an alternative to scheme water for irrigation.

Landowners will investigate opportunities for improved water use efficiency appropriate to their soil types and location.

9.1.3 Landscape Water Efficiency Initiatives

As discussed in Section 2.5.5 the commercial groundwater resources in the South Swan groundwater management sub-area are extremely limited with uncertainty over the sustainability of groundwater resources available within the Whiteman Park sub-area. Landscape water initiatives will therefore be necessary to minimise the use of scheme water for irrigation of public landscape areas.
The proposed strategy for water efficiency is as follows:

- Where possible transfer groundwater entitlements to obtain a partial or fully non-potable irrigation supply.
- Native plants will constitute a minimum of 35% of the total POS area.
- Waterwise gardens will be advocated for residential lots including guidelines, education and incentives provided to residents consistent with the strategy currently being implemented at the Vale sub-division in the City of Swan.
- Irrigated amenity grassland will be minimised and integration with drainage management will provide passive recreation where practical.

### 9.2 Surface Water Management Strategy

#### 9.2.1 Key Design Criteria

The design criteria for Albion will be consistent with the DWMP. The criteria presented in the DWMP are as follows

- The 1 year 1 hour ARI event shall be retained and/or detained at source for the duration of the event through the use of retention (soakage) or storage devices.
- The Post-development critical 1 year ARI peak flow and volume and the 100 year ARI peak flow shall be consistent with pre-development flows at:
  - the discharge points of all subdivisions into waterways;
  - the discharge points from the Structure Plan area (Figure 16);
- Flows from developed areas must be attenuated, in accordance with Figure 16, in flood detention/storage areas incorporated into POS within the subdivision and located outside defined floodways.
- Post development flows of all ARI events must be discharged at flow rates which are consistent with pre-development flow rates for those same events;
- Floodways as defined in the DWMP are to contain the regional 100 year ARI event flow. Floodways may not be developed or obstructed in any way, and are entirely separate from the stormwater detention storage.
- Development outside of the floodway should ensure finished floor levels at a minimum of 0.5m above the 100 year flood level;
- The existing cross sectional area of waterways must be maintained. Restoration of waterways is essential and in some cases channel realignments and channel profile modifications may be carried out, provided it is demonstrated that the predevelopment cross-sectional area has been preserved;
- Defined major arterial roads should remain passable in the 100 year ARI event.
- Minor roads should remain passable in the 5 year ARI event;
Water Quality treatment systems and Water Sensitive Urban Design Structures must be designed in accordance with the Stormwater Management Manual for Western Australia (DoW, 2007) and Australian Runoff Quality (Engineers Australia, 2006).

The drainage system for Albion is designed to maximise the benefits of WSUD and enhance the numerous natural drainage channels meandering through the Study Area. The main objectives of the drainage design are to control flood events to pre-development levels and minimise discharge from the site in regular (1yr ARI) rainfall events. These objectives are achieved through the following features of the structure plan:

- MUC corridors to accommodate existing natural drainage paths. Water quality treatment BMP’s, consistent with the Stormwater Management Manual for Western Australia (DoW, 2007) and Australian Runoff Quality (Engineers Australia, 2006) are to be incorporated along the corridors to treat frequent rainfall events.
- Detention storages to reduce peak outflows from the structure plan area to pre-development rates. Open swales to convey discharge from the detention storages.
- Significant conveyance of stormwater flows using overland flow structures within the MUC corridors.

9.2.2 Strategy

Pre-development runoff rates, from published reports, are described in section 5.3.

The change in land use shown in the Albion Structure Plan (Figure 15) will alter the existing water balance between runoff, infiltration and evapotranspiration, except in wetlands to be retained and within parts of the multiple use corridors.

In particular, the areas mapped as multiple use palusplain to be filled as part of the development of Albion will tend to have lower runoff rates and correspondingly higher infiltration associated with the import of fill material. Areas not mapped as palusplain are likely to have increased runoff rates associated with greater impervious areas, comprising road reserves etc.

The 100 yr ARI temporary flood storage requirement for each creek system to reduce peak flows to pre-development rates has been analysed by XP-SWMM modelling for a range of storm durations and is summarised in Table 12.

The surface water catchments are based on detailed topographic data collected by the proponent, which is consistent with earlier mapping referred to in Section 5.3. The DWMP shows slightly different catchment boundaries. It is proposed as part of this strategy to alter some of the catchment boundaries consistent with land ownership boundaries. It is JDA’s opinion that this will not significantly affect estimated peak flows or volumes. To support this JDA is collecting surface water monitoring data in winter 2008 to supplement that of winter 2006/07 to better define surface water flow patterns through the Albion DSP area. JDA anticipates that the catchment boundary definition for pre-development flows can be resolved when this better data is collected.

Figure 16 shows the catchment areas to the 3 tributaries, including the proposed modifications, within the structure plan area. Schematic drainage areas have been calculated such that the revised catchment area will still comply with pre-development discharge rates. The flood detention storage areas are indicative assuming a water level rise of 1 m in the 100 yr ARI storm event. Adequate area will be provided for stormwater detention storage outside of floodways as described by the preliminary DWMP information (GHD, 2008), utilising;
- multiple use corridors
- St Leonards Brook corridor
- Wetland buffers
- Local open space – drainage
- Local active open space (a small proportion of this area).

Consistent with DoW drainage design guidelines, the detention storage will mostly be accommodated within open swale drainage systems within multiple use corridors. An existing lake is located in the Horse Swamp catchment just south of Woolcott Rd. This lake will be retained and utilised for flood detention storage in major rainfall events.

Detention storages have been modelled as 1:6 side slopes with base area less than top water area. The invert level of detention storages will be AAMGL, with the exception of the existing lake that will be utilised for detention storage in flood events.

**TABLE 12: POST-DEVELOPMENT 100 YR ARI PEAK FLOW ATTENUATION STORAGE REQUIREMENTS**

<table>
<thead>
<tr>
<th>Catchment</th>
<th>Catchment Area (ha)</th>
<th>Drainage Detention Area at 100 yr ARI Water Level (ha)</th>
<th>Proportion of Catchment Area (%)</th>
<th>Required Temporary Storage Volume (m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>St Leonards Creek</td>
<td>281</td>
<td>8.4</td>
<td>3</td>
<td>61 000</td>
</tr>
<tr>
<td>Wandoo Creek</td>
<td>139</td>
<td>4.0</td>
<td>3</td>
<td>23 000</td>
</tr>
<tr>
<td>Horse Swamp</td>
<td>181</td>
<td>6.5</td>
<td>4</td>
<td>27 000</td>
</tr>
<tr>
<td>Total</td>
<td>601</td>
<td>18.9</td>
<td>3</td>
<td>111 000</td>
</tr>
</tbody>
</table>

**9.3 Groundwater Management Strategy**

**9.3.1 Key Design Criteria**

The design criteria for Albion will be consistent with the DWMP. The criteria for groundwater management are as follows;

- Where the AAMGL is at or within 1.2m of the surface the importation of clean fill and/or the provision of sub surface drainage will be required to ensure that adequate separation of building floor slabs from groundwater is achieved. In such instances, the sub-surface drainage will need to be placed at or above AAMGL;

- The bio-retention system and drainage inverts are set at or above AAMGL although existing inverts below AAMGL may remain;

- Subsurface drainage is to be installed at or above AAMGL;
Subsurface drainage must be designed with free-draining outlets;

9.3.2 Strategy

The pre-development AAMGL in the Study Area is currently estimated to be at or close to the ground surface, as shown in Figure 12. The pre-development AAMGL will not be lowered by subsoil drainage as the fill required to raise the natural surface or flood protection will also provide sufficient clearance between the finished land surface and groundwater levels.

In order to prevent groundwater table rise about the pre-development AAMGL, subsoil drainage is proposed for the Study Area given the shallow depth to water table.

Subsoil drainage will be incorporated with the drainage network and will be set at the elevation of AAMGL. This integration of the two systems of drainage will minimise upfront construction costs and ongoing maintenance costs. This will result in the subsoil system taking stormwater runoff during rainfall events, but will allow additional infiltration from the slotted subsoil pipes.

At the basins a low flow pipe will be used to join stormwater inflow and outflow pipe systems to allow subsoil drainage to operate.

9.4 Significant Wetland and Vegetation Management

As discussed in Chapter 8, wetland and vegetation management plans for Albion will be prepared at the Local Structure Plan stage.

9.5 Water Quality Management

9.5.1 Key Design Criteria

The principle of improving water quality in comparison to existing water quality will be adopted. The design criteria for Albion will be consistent with the DWMP. The criteria presented in the DWMP are as follows:

- Bio-retention structures to be sized at 1.5-2% of the constructed impervious area they receive runoff from.

- Where development is associated with a waterway or open drain that intersects the shallow water table pollutants may discharge from the shallow groundwater to the receiving environment. If it is proposed to use a computer modelling tool to size structural controls, the following design targets are recommended until such time as appropriate site-specific targets are developed:

  As compared with a development that does not actively manage water quality, achieve:
  - at least 60% reduction of total phosphorus;
  - at least 45% reduction of total nitrogen.

- Where development is associated with an ecosystem that is dependant on a particular hydrologic regime for survival, the water quality discharged to the groundwater must be in accordance with the requirements of the Department of Environment and Conservation.
9.5.2 Strategy

To achieve the water quality objectives for Albion it is proposed to focus on implementing current known best management practice as detailed in the Stormwater Management Manual for Western Australia (DoW, 2007) and Australian Runoff Quality (Engineers Australia, 2006).

The LWMS proposes the use of a treatment train approach including source control techniques. The proposed water quality management approach includes:

- **Installation and connection to the deep sewerage system**
  To convey wastewater from the site consistent with the land use compatibility of a Priority 3 groundwater catchment area.

- **Non Structural Controls**
  Planning practices (POS locations and configuration)
  Construction practices (construction management, soil amendment, use of native plantings)
  Maintenance practices (street sweeping, stormwater system, POS areas)
  Educational and participatory practices (capacity building programs, community education)

- **Structural Controls**
  Retention and infiltration of frequent events where possible (soakwells, swales, bottomless manholes)
  Conversion of existing open drains to living streams
  Creation of ephemeral retention/detention areas within POS areas
  GPT’s at outlets to sensitive environments

- **Monitoring**
  Establishment of regional pre and post development monitoring network
  Reporting, including ongoing assessment of BMP’s performance and suitability to provide ongoing guidance and review for future WSUD planning within the Study Area.

9.5.3 Post-Development Nutrient Input

NiDSS is a tool developed by JDA Consultant Hydrologists to assist in land use management planning, and allow quantitative estimation of nutrient input rates and the potential reduction in nutrient input (including costings) for various combinations of water sensitive urban design (WSUD) water quality management measures. NiDSS focuses on the adoption of an integrated catchment approach to water quality management, including measures to minimise nutrient inputs at source, and provides a logical framework for the evaluation of the effectiveness of various best management practices for nutrient input management.

It calculates the total expected nutrient input for a particular development proposal based on aggregating individual nutrient inputs from different land uses (lots, POS, road reserves, conservation areas) prior to implementation of stormwater management measures. The impact of individual source and in-transit controls on nutrient input can then be determined by either turning on/off individual controls or varying the effectiveness of these measures. The results present information on:

- estimates of total phosphorus (TP) and total nitrogen (TN) application to an area;
- estimates of reductions due to source control measures (education, street sweeping);
- estimates of reductions due to in-transit controls (Gross Pollutant Traps, WPCP’s); and
• estimates of the cost of removal (in PV terms) for a selected WSUD program.

NiDSS was applied to the Study Area to model existing land use and the proposed Structure Plan land use. Nutrient application rates were adopted from the Southern River Urban Water Management Strategy (JDA, 2002), which based application rates on a nutrient input survey conducted by JDA of medium density residential areas, and on previous work of Gerritse et al. (1991,1992) at CSIRO on rural residential lots.

Results of NiDSS modelling are presented in Appendix G. Summarising modelling results:

• Pre-development (existing) rural land use is estimated to have nutrient input loadings of greater than 12 kg/ha/yr for TP and 38 kg/ha/yr of TN. These estimates are based on assuming typical rural land use nutrient application rates for pasture, and do not reflect higher application rates for more nutrient intensive land use practices which may occur locally within the Study Area.

• With the proposed urban land use and assuming no WSUD, the Study Area is estimated to have nutrient input loadings of 23 kg/ha/yr for TP and 99 kg/ha/yr of TN. With implementation of a typical WSUD program including:
  1. Gross Pollutant Traps,
  2. Street Sweeping,
  3. Education Campaigns (targeting fertiliser application rates),
  4. Focus on Native Plantings for Residential and POS Areas (and use of P free fertilisers and soil amendment practices),

it is estimated nutrient input loadings can be lowered by approximately 55% to at or below current application levels under existing land use. An example program is shown in Appendix G.

These results together with the results of pre-development water quality monitoring indicate both stormwater runoff quality and groundwater quality from the proposed urban development will be better than existing surface water and groundwater quality under current land use in the Study Area (Appendix D).

9.5.4 Nutrient Management from School Oval Adjacent to St Leonards Creek

The oval associated with the proposed Primary School located adjacent to St Leonards Creek has the potential to export nutrients into the waterway. The export of nutrients from the oval can be managed using a number of strategies, including the:

Application of soil amendment agents such as water-holding crystals (generally cross-linked polyacrylamides) and water-absorbent foam that may improve soil water-holding capacity during the establishment of the turf (Loch, 2007). This decreases the amount of water that needs to be applied and the possibility of nutrient leaching during the establishment phase. Other soil amendment agents such as the application of a medium with high-phosphorous retention index, can help bind nutrients in the soil profile.

- Selection of turf species that have reduced watering requirements.
- Use of slow release fertilisers to minimise leaching from the oval into St Leonards Creek. This is in line with the Guidelines for Fertiliser Use on the Swan Coastal Plain of Western Australia (SRT, 2000).
Consideration of factors such as the seasonal change in climate, minimising drift of water due to wind, keeping droplet size at an optimum and the water retention capacity of the soil (DEP, 2001) when designing an irrigation system for the oval.

Ensuring all of these factors are taken into account will reduce the risk of over-watering and therefore run-off of nutrients into the creek. An approximate 30m buffer between the development and the St Leonard’s Creek will be provided. This will be revegetated using local native species (preferably of local provenance) in accordance with EPA Guidance Note 6 Rehabilitation of Terrestrial Ecosystems (EPA, 2006) to protect and enhance the environmental attributes of St Leonards Creek. The use of native species in the buffer will enhance the environmental values of St Leonards Creek, as well as reduce irrigation and fertiliser requirements.

Interception swales between amenity grass and the buffer areas will further restrict run off potential (see Appendix J).

9.6 Construction Management

9.6.1 Dewatering

Dewatering of the superficial aquifer will be required for some elements of development construction. As the volume of dewatering will be small compared to aquifer storage and this is infiltrated back into the superficial aquifer, the impact upon the aquifer will be minimal.

Drawdown will occur at the dewatering site, and mounding where the water is infiltrated. It should be noted that there will be only minor net loss of groundwater by evaporation, as all water abstracted will be infiltrated.

Prior to the commencement of any dewatering, construction contractors will be required to apply for and obtain from DoE/DoW a ‘Licence to Take Water’. All dewatering will be carried out in accordance with the conditions of this licence.

Where possible, construction will be timed to minimise impacts on groundwater and any dewatering requirements.

9.6.2 Acid Sulphate Soils

As discussed in Chapter 7, the strategic ASS investigation carried out in 2006 (Douglas Partners, 2006) concluded that the ASS issues were typical for areas in similar settings on the Swan Coastal Plain and that standard management would be appropriate for excavation to install services in Albion. This will include appropriate handling methods by the construction contractor to manage any potential acid sulphate soils. Handling should be in accordance with the Acid Sulfate Soils Guidelines Series Treatment and Management of Disturbed Acid Sulphate Soils (DoE, 2003). These guidelines specify holding times and specific methods for treatment of such soils.

To confirm the status of soils, the site engineer or scientist will regularly inspect the excavations and spoil, and ensure such soils where encountered are appropriately tested and managed before reuse or disposal off-site.

Further assessment of ASS will be conducted at the Local Structure Plan stage.
10 IMPLEMENTATION PLAN

10.1 Subdivision Application Process

Consistent with processes defined in EES (2005), Urban Water Management Plans (UWMP’s) will be developed and submitted with subdivision applications. UWMP’s will address:

- Demonstrated compliance with LWMS criteria and objectives to the satisfaction of CoS and DoW.
- Consistent with the North East Corridor Urban Water Management Strategy (GHD, 2007)
- Agreed/approved measures to achieve water conservation and efficiencies of water use.
- Detailed stormwater management design including the size, location and design of public open space areas, integrating major and minor flood management capability.
- Management of groundwater levels.
- Specific structural and non-structural BMPs and treatment trains to be implemented including their function, location, maintenance requirements, expected performance and agreed ongoing management arrangements.
- Should any artificial water bodies be proposed, identify its purpose, design and management.
- Management of sub-divisional works.
- Implementation plan including roles, responsibilities, funding and maintenance arrangements.
- Contingency plans (where necessary).

10.2 Stormwater System Operation & Maintenance

The surface drainage system will require regular maintenance to ensure its efficient operation. It is considered the following operating and maintenance practices will be implemented periodically:

- removal of debris to prevent blockages;
- street sweeping to reduce particulate build up on road surfaces and gutters;
- cleaning of sediment build up and litter layer on the bottom of basins;
- mowing of grassed open channel sections monthly and grass clippings removed;
- undertake education campaigns regarding source control practices to minimise pollutant runoff into stormwater drainage system; and
- check subsoil drainage function.
10.3 Pre-Development Monitoring

Groundwater and surface water monitoring programs are designed to allow the impact of the land use change to be assessed.

GHD (2007) Table 6 proposes surface water monitoring and regional groundwater monitoring by the Department of Water for 3 winters commencing April 2007 through September 2009. For Albion, to support or replace this requirement, such monitoring is being conducted by the proponent as described below. This is consistent with GHD (2007) statement that should local structure planning proceed prior to the completion of the necessary DWMP, the proponent should be required to prepare an LWMS that addresses the issues that would otherwise have been included in the DWMP, including the necessary groundwater and surface water monitoring. TPS 17 Scheme Provisions confirm this interpretation.

Table 13 presents a summary of the monitoring programme implemented since January 2006 comprising both groundwater and surface water monitoring. This will continue till October 2008.

### TABLE 13: LWMS MONITORING PROGRAMME

<table>
<thead>
<tr>
<th>Monitoring Type</th>
<th>Locations</th>
<th>Water Levels</th>
<th>Nutrients</th>
<th>pH, EC Temp</th>
<th>Duration</th>
<th>Responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groundwater</td>
<td>Quarterly</td>
<td>Quarterly</td>
<td>Quarterly</td>
<td>ALB1 to 10, APW1, 2, 5, BH1 to 11</td>
<td>3 yrs (completed Oct 2008)</td>
<td>Developer</td>
</tr>
<tr>
<td>Rainfall³</td>
<td>See Fig 7</td>
<td>Continuous</td>
<td>N/A</td>
<td>N/A</td>
<td>“</td>
<td>Developer</td>
</tr>
<tr>
<td>Surface Water²</td>
<td>S1 to S4</td>
<td>Continuous</td>
<td>Monthly</td>
<td>Monthly</td>
<td>“</td>
<td>Developer</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes:
1. All locations are shown on Figure 10
2. Surface water sampling when flow occurs
3. Equipment installed July 2006

10.4 Post-Development Monitoring

10.4.1 Groundwater Monitoring

The objectives of the groundwater monitoring are centred on the impacts of swales and sub-soil drainage on water levels and water quality associated with infiltration of stormwater to the watertable.

**Water quality parameters**

The water quality parameters to be measured are as follows:

- pH
- TDS (calculated from Electrical Conductivity)
- Total phosphorus (TP)
- Orthophosphate (PO₄)
- Total Nitrogen (TN)
- Total Kjeldahl Nitrogen (TKN)
Ammonium (NO₄)
Nitrate and Nitrite (NOₓ)

It is proposed that the pH and Electrical conductivity will be measured on site by a qualified professional, with all other parameters measured by a sample submitted to a certified NATA accredited laboratory. All groundwater sampling will be completed in accordance with Australian Standard AS/NZS 5667.11:1998.

Sampling Frequency

Groundwater quality sampling will be the responsibility of the developer, of the development stage, for a total of 5 years from the completion of the development according to the following schedule:

- Monthly for the first year
- Quarterly for the following 4 years

Sampling Sites

Monitoring should occur at 22 locations utilising the existing bores as far as possible (refer Figure 10). Where the existing bore cannot be retained due to construction, a replacement bore should be constructed as close as possible to the previous site. Relocation of monitoring sites should be documented in the relevant UWMP when more detailed layouts and drainage planning is available.

10.4.2 Surface Water Monitoring

Post-development monitoring of surface water flows will be focused around quantifying the effectiveness of the drainage system design in:

- Capturing of the first flush rainfall event following the summer months.
- Treating water quality discharging from the development.

We propose the use of automated samplers and a rain gauge to determine the flow characteristics of the catchment and sample surface discharges.

Water Quality parameters

The water quality parameters to be measured are as follows

- pH
- TDS (calculated for Electrical Conductivity)
- Total phosphorus (TP)
- Orthophosphate (PO₄)
- Total Nitrogen (TN)
- Total Kjeldahl Nitrogen (TKN)
- Ammonium (NO₄)
- Nitrate and Nitrite (NOₓ)
- Total Suspended Solids (TSS)
Sampling frequency

Surface water quality sampling will be the responsibility of the developer, of the development stage, for a total of 5 years from the completion of the development according to the following schedule:

- Automated sampling for the first year with samples obtained for at least 5 storm discharges at the sampling location.
- Option of grab sampling for 4 years dependant on the results of the auto-sampling in the first year.

Sampling Locations

Details of sampling locations will be identified as part of the UWMP when more detailed layouts and drainage planning is available and the MUC corridors have been designed, but should include as a minimum the pre-development Sites S2 and S3 (Figure 10).

10.5 Reporting

Reporting will be co-ordinated by the developer and submitted to CoS and DoW for review. The reports will compare the monitoring results with the target design criteria and performance objectives and determine what, if any, further actions may be necessary, and provide ongoing assessment of the suitability of existing monitoring and reporting frequencies.

Assessment of performance compliance against water quality criteria will require careful consideration to account for inter seasonal and inter annual variability, and as both surface and groundwater quality will be a function of historical land use practices not only within the development area, but over the entire upstream catchment.

Scheduling of reports will be addressed at Local Structure Plan stage.

10.6 Contingency Plan

The proposed process for contingency action in the assessment of performance compliance is;

- Assess if it is an isolated, development area or regional occurrence.
- Determine if it is due to the development or other external factors.
- Perform appropriate contingency action as required, which will include communication with Department of Water, Swan River Trust and City of Swan of the recorded values.
- Record in the annual report any action taken.
- If necessary, inform residents of any required works and their purpose.

The short term and long term water quality targets for the Swan River are provided in the Swan River Trust Healthy Rivers program and summarised in Table 6-4 (pg 34) of the DWMP. To achieve these targets the Department of Water is currently developing site specific design objectives for water quality as discussed in Section 6.3 of the DWMP.

In the interim, Local Structure Plan water quality treatment systems and WSUD structures will be designed, implemented and managed in accordance with the Stormwater Management Manual for
Western Australia (DoW, 2007) and Australian Runoff Quality: A Guide to Water Sensitive Urban Design (Engineers Australia, 2006) consistent with the requirements of the DWMP.

10.7 Urban Water Management Plan (UWMP)

As part of the planning process a UWMP is to be completed at the Local Structure Plan stage. The requirements of the UWMP are listed in section 2.3.6.2 of this report. A UWMP for each of the Local Structure Plan areas within Albion will be prepared by the developer as described in Section 10.1.

This approach is consistent with the North East Corridor Urban Water Management Strategy (GHD, 2007) for the instance where the proponent prepares an LWMS in the absence of a DWMP.

The UWMP for the LSP2 area will need to investigate and confirm the existence of the sub-surface drainage system under the old Caversham Airbase site.
11 REFERENCES


City of Swan (2006a) Urban Growth Policy. Policy No. POL-C-102 Version 1 adopted 24/5/06

City of Swan (2006b) Environmental Planning Policy. Policy No. POL-C-104 Version 1 adopted 24/5/06

Department of Environment and Swan River Trust. (2005), A Decision Process for Stormwater Management in Western Australia.

Department of Environment (2004) Acid Sulfate Soil Guideline Series Identification and investigation of acid sulfate soils, Perth, Western Australia

Department of Water. (2007), Stormwater Management Manual for Western Australia.

Department of Water (2009) Swan Urban Growth Corridor Drainage and Water Management Plan


Environmental Protection Authority (2006) *Guidance for the Assessment of Environmental Factors – No. 6 – Rehabilitation of Terrestrial Ecosystems*. Environmental Protection Authority, June 2006


Swan River Trust (2000) *Guidelines for Fertiliser Use on the Swan Coastal Plain of Western Australia*

Swan River Trust (2005), *River Plan*


FIGURES
Figure 1: Location Plan

Scale 1:50,000

Data Source: Street Express (2006)

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Albion Local Water Management Strategy

Perth

Albion

Study Area
Figure 2: Existing Surface Water Catchments and Peak Flows

- Peak Flow: 4.02 m³/s
- Peak Flow: 1.86 m³/s
- Peak Flow: 4.85 m³/s
- Peak Flow: 0.92 m³/s
- Peak Flow: 0.61 m³/s
- Peak Flow: 4.02 m³/s
- Peak Flow: 1.91 m³/s

Catchments:
- St. Leonards Creek
- Horse Swamp
- Wandoo Creek


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Albion Local Water Management Strategy
Rainfall at Perth Regional Station

Data Source: Bureau of Meteorology (2005)

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Figure 3: Perth Annual Rainfall Data 1880 to 2004
Notes: S8 & S10 - SAND - very light grey at surface, yellow at depth, fine to medium-grained, sub-rounded quartz, moderately well sorted of eolian origin. (S8 is Bassendean sand over Gilford F.)

Mgs1 - PEBBLY SILT - strong brown silt with common, fine to occasionally coarse-grained, sub-rounded laterite quartz, heavily weathered granitite pebble, some fine to medium-grained quartz sand, of alluvial origin.

Cps - PEATY CLAY - dark grey and black with variable and content of lacustrine origin.
Figure 5: Wetland Mapping

DoE Geomorphic Wetlands
Management Category

- Multiple Use
- Resource Enhancement
- Conservation

Bush Forever Site

104 Wetland Number in "Wetlands of the Swan Coastal Plain Vol 28"


Job No. J4070
Scale 1:17,500

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Albion Local Water Management Strategy
Figure 6: Land Use
Figure 7: Superficial Aquifer Groundwater Flow Areas
Figure 8: Groundwater Management Areas

LEGEND:
- Groundwater Area Boundaries
- Sub-Area Boundaries
- Structure Boundary

Data Source: Ecoscape (Australia) Pty Ltd (2006)
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Job No. J4070
Scale 1 : 150,000

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Albion Local Water Management Strategy

Figure 8: Groundwater Management Areas
Figure 9: Arterial Drainage Catchments
Figure 10: Monitoring Locations

<table>
<thead>
<tr>
<th>Study Area</th>
<th>Groundwater Monitoring Bores</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DOE</td>
</tr>
<tr>
<td></td>
<td>PB</td>
</tr>
<tr>
<td></td>
<td>WRC</td>
</tr>
<tr>
<td></td>
<td>JDA Surface Water Monitoring Sites</td>
</tr>
</tbody>
</table>

Job No. J4070
Scale 1:25,000

Multiplex Developments Australia Pty Ltd
Albion Local Water Management Strategy

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Figure 11: Estimated AAMGL Contours
Figure 12: Depth to AAMGL
Figure 13: Estimated AALGL Contours
Figure 14: Acid Sulphate Soil Risk: Test Results

Data Source: Douglas Partners (2006)

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Albion Local Water Management Strategy

Job No. J4070

Figure 14: Acid Sulphate Soil Risk: Test Results
Data Source: Chappell & Lambert (2008)

Figure 15: Albion Structure Plan

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Albion Local Water Management Strategy

NOTES:

1. Gas Pipeline
   - Pipeline corridor is to be located outside of Structure Plan area.

2. Possible Conservation
   - Further detailed investigation is required if a TEC is not present within the PAD界定 Open Space.

3. Open Space
   - The Town Centre will have a maximum retail floor area of 2,500m² including a large Neighbourhood Centre.

4. Schools
   - The Education Precinct includes a High School, Primary School, Early Education Support Centre and Active Open Space site. The design criteria of this precinct will be refined at LSP stage.

All Primary Schools are required to have road frontage on three sides.
### Stormwater Management Area

<table>
<thead>
<tr>
<th>Catchment</th>
<th>Area (ha)</th>
<th>Area partially for Detention (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>St Leonards Creek</td>
<td>230.9</td>
<td>15.35</td>
</tr>
<tr>
<td>Wandoo Creek</td>
<td>85.0</td>
<td>9.70</td>
</tr>
<tr>
<td>Horse Swamp</td>
<td>185.9</td>
<td>7.89</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>501.8</strong></td>
<td><strong>32.76</strong></td>
</tr>
</tbody>
</table>

---

**Figure 16: Post Development Drainage Strategy**
Photograph 1. SITE S1 St Leonards Creek Culvert at Murray Road (20 July 2006)

Photograph 2. SITE S2 St Leonards Creek tributary - Coner of Murray Rd and Woolcott Ave (20 July 2006)
Photograph 3: Site S3 at Horse Swamp culvert at Woolcott Avenue

Figure 4: Site P1 Pluviograph near Horse Swamp
APPENDIX A

Western Australian Stormwater Management Objectives

**Water Quality**
To maintain or improve the surface and groundwater quality within the 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.

**Water Conservation**
To maximise the reuse of stormwater.

**Ecosystem Health**
To retain natural drainage systems and protect ecosystem health.

**Economic Viability**
To implement stormwater management systems that are economically viable in the long term.

**Public Health**
To minimise the public risk, including risk of injury or loss of life, to the community.

**Protection of Property**
To protect the built environment from flooding and waterlogging.

**Social Values**
To ensure that social, aesthetic and cultural values are recognised and maintained when managing stormwater.

**Development**
To ensure the delivery of best practice stormwater management through planning and development of high quality developed areas in accordance with sustainability and precautionary principles.

Western Australian Stormwater Management Principles

- Incorporate water resource issues as early as possible in the land use planning process.
- Address water resource issues at the catchment and sub-catchment level.
- Ensure stormwater management is part of total water cycle and natural resource management.
- Define stormwater quality management objectives in relation to the sustainability of the receiving environment.
- Determine stormwater management objectives through adequate and appropriate community consultation and involvement.
- Ensure stormwater management planning is precautionary, recognises inter-generational equity, conservation of biodiversity and ecological integrity.
- Recognise stormwater as a valuable resource and ensure its protection, conservation and reuse.
- Recognise the need for site specific solutions and implement appropriate non-structural and structural solutions.
<table>
<thead>
<tr>
<th>Protect water quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stormwater remains clean and retains its high value</td>
</tr>
<tr>
<td>Implement best management practice on-site.</td>
</tr>
<tr>
<td>Implement non-structural controls, including education and awareness programs.</td>
</tr>
<tr>
<td>Install structural controls at source or near source.</td>
</tr>
<tr>
<td>Use in-system management measures.</td>
</tr>
<tr>
<td>Undertake regular and timely maintenance of infrastructure and streetscapes.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Protect infrastructure from flooding and inundation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stormwater runoff from infrequent high intensity rainfall events is safely stored and conveyed</td>
</tr>
<tr>
<td>Safe passage of excess runoff from large rainfall events towards watercourses and wetlands.</td>
</tr>
<tr>
<td>Store and detain excess runoff from large rainfall events in parks and multiple use corridors.</td>
</tr>
<tr>
<td>Safely convey excessive groundwater to the nearest watercourse.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Minimise runoff</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slow the migration of rainwater from the catchment and reduce peak flows</td>
</tr>
<tr>
<td>Retain and infiltrate rainfall within property boundaries.</td>
</tr>
<tr>
<td>Use rainfall on-site or as high in the catchment as possible.</td>
</tr>
<tr>
<td>Maximise the amount of permeable surfaces in the catchment.</td>
</tr>
<tr>
<td>Use non-kerbed roads and carparks.</td>
</tr>
<tr>
<td>Plant trees with large canopies over sealed surfaces such as roads and carparks.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Maximise local infiltration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fewer water quality and flooding problems</td>
</tr>
<tr>
<td>Minimise impervious areas.</td>
</tr>
<tr>
<td>Use vegetated swales.</td>
</tr>
<tr>
<td>Use soakwells and minimise use of piped drainage systems.</td>
</tr>
<tr>
<td>Create vegetated buffer and filter strips.</td>
</tr>
<tr>
<td>Recharge the groundwater table for local bore water use.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Make the most of nature’s drainage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost effective, safe and attractive alternatives to pipes and drains</td>
</tr>
<tr>
<td>Retain natural channels and incorporate into public open space.</td>
</tr>
<tr>
<td>Retain and restore riparian vegetation to improve water quality through bio-filtration.</td>
</tr>
<tr>
<td>Create riffles and pools to improve water quality and provide refuge for local flora and fauna.</td>
</tr>
<tr>
<td>Protect valuable natural ecosystems.</td>
</tr>
<tr>
<td>Minimise the use of artificial drainage systems.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Minimise changes to the natural water balance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avoid summer algal blooms and midge problems and protect our groundwater resources</td>
</tr>
<tr>
<td>Retain seasonal wetlands and vegetation.</td>
</tr>
<tr>
<td>Maintain the natural water balance of wetlands.</td>
</tr>
<tr>
<td>No direct drainage to Conservation Category Wetlands or their buffers, or to other conservation value wetlands or their buffers, where appropriate.</td>
</tr>
<tr>
<td>Recharge groundwater by stormwater infiltration.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Integrate stormwater treatment into the landscape</th>
</tr>
</thead>
<tbody>
<tr>
<td>Add value while minimising development costs</td>
</tr>
<tr>
<td>Public open space systems incorporating natural drainage systems.</td>
</tr>
<tr>
<td>Water sensitive urban design approach to road layout, lot layout and streetscape.</td>
</tr>
<tr>
<td>Maximise environmental, cultural and recreational opportunities.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Convert drains into natural streams</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower flow velocities, benefit from natural flood water storage and improve waterway ecology</td>
</tr>
<tr>
<td>Create stable streams, with a channel size suitable for 1 in 1 year ARI rainfall events, equivalent to a bankfull flow.</td>
</tr>
<tr>
<td>Accommodate large and infrequent storm events within the floodplain.</td>
</tr>
<tr>
<td>Create habitat diversity to support a healthy, ecologically functioning waterway.</td>
</tr>
</tbody>
</table>

**Note:** Selection of appropriate methods should be determined by site conditions.
Preamble

The Decision Process for Stormwater Management in WA provides a decision framework for the planning and design of stormwater management systems. The methodology outlined in the decision process will result in minimising potential changes in the volume of surface water flows and peak flows which, if not managed, would lead to adverse impacts on water regime, water quality, habitat diversity and biodiversity in receiving water bodies resulting from land development (i.e. residential, rural-residential, commercial and industrial). The process also addresses the management of flood events for the protection of properties. The decision process sits within the objectives, principles and delivery approach outlined in the Stormwater Management Manual for Western Australia (DoE, 2004). This includes: minimising risk to public health and amenity; implementing systems that are economically viable in the long term; and ensuring that social, aesthetic and cultural values are maintained.

A significant stormwater management measure is to minimise the ‘effective imperviousness’ of a development area. Effective imperviousness is defined as the combined effect of the proportion of constructed impervious surfaces in the catchment, and the ‘connectivity’ of these impervious surfaces to receiving water bodies. The purpose of minimising effective imperviousness is to reduce the transportation of pollutants to receiving water bodies and to retain the post development hydrology as close as possible to the pre-development hydrology. This is achieved by ‘disconnecting’ constructed impervious areas from receiving water bodies and by reducing the amount of constructed impervious areas.

To retain the pre-development hydrology of a site, the order of management priorities is: the magnitude of peak flows; the volume of catchment run-off; and the seasonality of catchment run-off.

Rainfall, for the majority of events occurring each year, should be retained or detained on-site (i.e. as high in the catchment and as close to the source as possible, subject to adequate site conditions). Runoff from constructed impervious areas (e.g. roofs and paved areas) should be retained or detained through the use of soakwells, pervious paving, vegetated swales or gardens. For detention systems, the peak 1 year Average Recurrence Interval (ARI) discharge from constructed impervious areas should be attenuated to the pre-development discharge rate. Events larger than 1 year ARI can overflow ‘off-site’.

For larger rainfall events (i.e. greater than 1 year ARI events), runoff from constructed impervious areas should be retained or detained to the required design storm event in landscaped retention or detention areas in public open space or linear multiple use corridors. Any overflow of runoff towards waterways and wetlands should be by overland flow paths across vegetated surfaces. Further detention may be required to ensure that the pre-development hydrologic regime of the receiving water bodies is largely unaltered, particularly in relation to peak flow rates and, where practical, discharge volume.

1 Water bodies are defined as waterways, wetlands, coastal marine areas and groundwater aquifers.

2 Retention is defined as the process of preventing rainfall runoff from being discharged into receiving water bodies by holding it in a storage area. The water may then infiltrate into groundwater, evaporate or be removed by evapotranspiration of vegetation. Retention systems are designed to prevent off-site discharges of surface water runoff, up to the design ARI event.

3 Detention is defined as the process of reducing the rate of off-site stormwater discharge by temporarily holding rainfall runoff (up to the design ARI event) and then releasing it slowly, to reduce the impact on downstream water bodies and to attenuate urban runoff peaks for flood protection of downstream areas.

4 ARI is defined as the average, or expected, value of the periods between exceedances of a given rainfall total accumulated over a given duration. For further information, refer to Australian Rainfall & Runoff (IEA, 2001) and the Bureau of Meteorology website via <www.bom.gov.au/hydro/has/ari_aep.shtml>. 
Urban pollutants, whether in particulate or soluble forms, are conveyed by stormwater almost every time a storm event occurs. Studies in urban areas have shown that there is no general trend of increased concentrations of contaminants such as nutrients and metals with increasing storm sizes. Figure 1 shows that most hydraulic structures can be expected to treat over 99% of the expected annual runoff volume when designed for a 1 year ARI peak discharge. Unlike flood mitigation measures, stormwater quality treatment devices do not need to be designed for rainfall events of high ARI to achieve high hydrologic effectiveness (i.e. the percentage of mean annual runoff volume subjected to treatment) and therefore a high level of beneficial environmental outcomes.

![Figure 1. Treatment efficiency of stormwater hydraulic structures for Perth, Western Australia (adapted from Wong, 1999)](image)

Stormwater management systems should be based on adequate field investigations and the conditions of the site. Prior to design, developers should consult with the Department of Environment, local government authority and other relevant stakeholders. For further information, refer to the *Decision Process for Stormwater Management in WA* flow chart.

**References and further reading**


Decision Process for Stormwater Management in WA (DoE and SRT, 2005)

1. Stormwater management systems shall be designed in accordance with the objectives, principles and delivery approach outlined in the Stormwater Management Manual for Western Australia (DoE, 2004). This includes: minimising risk to public health and amenity; protecting the built environment from flooding and waterlogging; implementing systems that are economically viable in the long term; and ensuring that social, aesthetic and cultural values are maintained.

2. Prior to design, developers shall consult with the Department of Environment (DoE), local government authorities and other relevant stakeholders. Maintenance requirements should be considered at this stage.

3. Adequate field investigations shall be undertaken to determine the appropriate hydrologic regime for the site and potential site constraints, such as contaminated sites, acid sulfate soils or highly elevated nutrient levels in groundwater. Baseline and/or ongoing monitoring of groundwater and surface water quality and quantity may be required.

4. Stormwater management systems may be subject to additional design and performance criteria if they have the potential to impact on sensitive receiving environments. Sensitive receiving environments include (but are not limited to): conservation areas or reserves, wetlands and waterways with conservation values, Waterways Management Areas, the Swan River Trust Management Area, Environmental Protection Policy areas, and some areas of native vegetation. Sensitive native vegetation includes (but is not limited to) Declared Rare Flora, Priority Species, Threatened Ecological Communities, Threatened Fauna Habitats and vegetation identified in Bush Forever (WAPC, 2000), including vegetation located east of the Southern River Vegetation Complex on the Swan Coastal Plain.

Water quantity management

1. Is the proposal completely or partly within a known contaminated site (i.e. a contaminated site listed on the contaminated sites register, or identified through adequate field investigations) or high acid sulfate soil risk area?

   Yes (to either question)

   Avoid mobilisation or disturbance of the in-situ contaminants

   If yes to question 1 - seek further advice from the DoE.

   If yes to question 2 - consult with the DoE about best management practices to minimise nutrient leaching through the soil profile (i.e. structural and non-structural controls suitable to the site conditions).

   No (most situations)

2. Does the soil or groundwater contain highly elevated nutrient levels? A definition for highly elevated nutrient levels has not been provided, as nutrient breakthrough is highly variable and is dependent on the soil type (e.g. organic, clay and iron oxihydroxide content) and local wetting and drying cycles.

   Generally, rainfall from 1 year average recurrence interval (ARI) events should be retained or detained on-site (i.e. as high in the catchment and as close to the source as possible), unless it can be clearly demonstrated that achievement of this objective is impractical due to site conditions.

   Generally, for detention systems, preserve the pre-development 1 year ARI peak discharge rate. Use best management practices (structural and non-structural) to treat water quality.

   Greater than 1 year and up to 100 year ARI events

   Mitigate runoff from constructed impervious areas for greater than 1 year ARI events, in landscaped retention or detention areas in public open space or linear multiple use corridors. Any overflow of runoff towards waterways and wetlands shall be by overland flow paths across vegetated surfaces.

   Less than and up to 1 year ARI events

   Design for greater than 1 year and less than 10 year ARI events

   Design for 10 to 100 year ARI events

Water quality management

1. On-site field investigations are required to determine the appropriate water quality management measures for the site, including consideration of potential pathways of nutrients towards receiving water bodies. Receiving water bodies are defined as waterways, wetlands, coastal marine areas and groundwater aquifers.

2. The components of the water quality treatment train must be designed so that their combined effect meets the water quality management objectives as specified in the relevant regional water quality management targets (e.g. local government stormwater management plans, the Regional Natural Resource Management Strategy, Swan-Canning Cleanup Program Action Plan (SRT, 1999) and the Environmental Protection (Peel Inlet-Harvey Estuary) Policy 1992 (EPA, 1992)). The requirements for demonstration of compliance shall depend upon the scale of the proposed land development. Demonstration of compliance may be achieved by the use of appropriate assessment methods, to the satisfaction of DoE.

Protect waterways and wetlands

1. Retain and restore waterways and wetlands. For waterways, the approach should be consistent with the River Restoration Manual (WRC, 1999,2003), Draft Waterways WA - A Policy for Statewide Management of Waterways in Western Australia (WRC, 2000), Foreshore Policy 1 - Identifying the Foreshore Area (WRC, 2002) and, in the Swan and Canning Catchments, the Environmental Protection (Swan and Canning Rivers) Policy 1998 (EPA, 1998). For wetlands, the approach should be consistent with the Environmental Protection of Wetlands Position Statement No. 4 (EPA, 2004) and the Wetlands Conservation Policy for WA (Government of WA, 1997). On the Swan Coastal Plain, the approach to managing wetlands should also be consistent with the Environmental Protection (Swan Coastal Plain Lakes) Policy, 1992 (EPA, 1992) and the Position Statement: Wetlands (WRC, 2001).

2. There shall be no new constructed stormwater infrastructure within Conservation category wetlands and their buffers, or other conservation value wetlands and their buffers, or within a waterway foreshore area (e.g. no pipes or constructed channels within these wetlands and their buffers, or within waterway foreshore areas), unless authorised by the DoE or the Environmental Protection Authority. For Resource Enhancement and Multiple Use category wetlands, stormwater management shall be consistent with the objectives outlined in the Position Statement: Wetlands (WRC, 2001).

3. The creation of artificial lakes or permanent open water bodies generally will not be supported when they involve the artificial exposure of groundwater (e.g. through excavation, or lined with artificial materials). If yes to question 2 - consult with the DoE about best management practices to minimise nutrient leaching through the soil profile (i.e. structural and non-structural controls suitable to the site conditions).

4. Stormwater management systems may be subject to additional design and performance criteria if they have the potential to impact on sensitive receiving environments. Sensitive receiving environments include (but are not limited to): conservation areas or reserves, wetlands and waterways with conservation values, Waterways Management Areas, the Swan River Trust Management Area, Environmental Protection Policy areas, and some areas of native vegetation. Sensitive native vegetation includes (but is not limited to) Declared Rare Flora, Priority Species, Threatened Ecological Communities, Threatened Fauna Habitats and vegetation identified in Bush Forever (WAPC, 2000), including vegetation located east of the Southern River Vegetation Complex on the Swan Coastal Plain.

Management of groundwater levels

1. Any proposals to control the seasonal or long-term maximum groundwater levels through a Controlled Groundwater Level (CGL) approach shall demonstrate through adequate field investigations, to the satisfaction of the Department of Environment, that local and regional environmental impacts are adequately managed.

2. The CGL may be defined as the controlled (i.e. modified) groundwater level (measured in metres Australian Height Datum) at which the DoE will permit drainage inverts to be set. The CGL must be based on local and regional environmental water requirements, determined in accordance with the Environmental Water Provision Policy for Western Australia (WRC, 2000) and the Urban Development and Determination of Ecological Water Requirements of Groundwater Dependent Ecosystems (DoE, in preparation).

3. Where appropriate, field investigations must be undertaken to identify acid sulfate soils (ASS). Any reduction in groundwater level should not expose ASS to the air, as this may cause groundwater contamination. Refer to the ASS Guideline Series, including Identification and Investigation of Acid Sulfate Soils (DoE, 2004). If field investigations identify ASS, seek further advice from DoE.

4. Adequate field investigations shall be undertaken to determine the appropriate hydrologic regime for the site and potential site constraints, such as contaminated sites, acid sulfate soils or highly elevated nutrient levels in groundwater. Baseline and/or ongoing monitoring of groundwater and surface water quality and quantity may be required.

5. Stormwater management systems may be subject to additional design and performance criteria if they have the potential to impact on sensitive receiving environments. Sensitive receiving environments include (but are not limited to): conservation areas or reserves, wetlands and waterways with conservation values, Waterways Management Areas, the Swan River Trust Management Area, Environmental Protection Policy areas, and some areas of native vegetation. Sensitive native vegetation includes (but is not limited to) Declared Rare Flora, Priority Species, Threatened Ecological Communities, Threatened Fauna Habitats and vegetation identified in Bush Forever (WAPC, 2000), including vegetation located east of the Southern River Vegetation Complex on the Swan Coastal Plain.

6. Hydraulic requirements shall be determined by ecosystem requirements and the hydrologic form of the local and downstream environment. Physical survey measurements and a biological profile should be undertaken.


8. The effective imperviousness of a development shall be minimised. The process for achieving this is outlined below:

   Less than and up to 1 year ARI events

   Mitigate runoff from constructed impervious areas for greater than 1 year ARI events, in landscaped retention or detention areas in public open space or linear multiple use corridors. Any overflow of runoff towards waterways and wetlands shall be by overland flow paths across vegetated surfaces.

   Greater than 1 year and up to 100 year ARI events

   Design for greater than 1 year and less than 10 year ARI events

   Design for 10 to 100 year ARI events

   Mitigate runoff from constructed impervious areas for greater than 1 year ARI events, in landscaped retention or detention areas in public open space or linear multiple use corridors. Any overflow of runoff towards waterways and wetlands shall be by overland flow paths across vegetated surfaces.

   Less than and up to 1 year ARI events

   Mitigate runoff from constructed impervious areas for greater than 1 year ARI events, in landscaped retention or detention areas in public open space or linear multiple use corridors. Any overflow of runoff towards waterways and wetlands shall be by overland flow paths across vegetated surfaces.
References and further reading


Environmental Protection Authority 2004, *Environmental Protection of Wetlands Position Statement No. 4*, Environmental Protection Authority, Western Australia. Available via <www.epa.wa.gov.au> or by telephoning (08) 9222 7000.

Government of Western Australia 1997, *Wetlands Conservation Policy for Western Australia*. Copies may be viewed at the Department of Environment library, telephone (08) 9278 0300.


APPENDIX B

BH Series Bore Logs
(PB, 2005)
# BORE COMPLETION DETAILS

## ALBION PARK TOWNSITE - Monitor Bore BH1

<table>
<thead>
<tr>
<th>LITHOLOGICAL DESCRIPTION</th>
<th>LOG</th>
<th>COMPLETION</th>
<th>DETAILS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SAND:</strong> Slightly moist, grey, loose, medium to fine, moderate - well sorted, sub-angular - sub-rounded, quartz sand.</td>
<td></td>
<td></td>
<td><strong>GENERAL INFORMATION</strong></td>
</tr>
</tbody>
</table>
| **FERRICRETÉ:** Wet, brown, poorly cemented, medium - coarse, moderately sorted, sub-angular - sub-rounded, quartz sand. | | | **Location:** Albion Park  
**Driller:** Proline Drilling  
**Rig Type:** 6" Hollow Stem Auger  
**Date Drilled:** 28/05/02  
**Easting (GDA94):** 402347  
**Northing (GDA94):** 6480306  
**Surface RL:**  
**Top of Casing:** |
| **SAND:** Saturated, brown-grey with moderate iron staining, loose - dense, medium to coarse, moderate - well sorted, sub - well-rounded, quartz sand with trace silt at depth. | | | **FIELD WATER QUALITY** |
| | | | **pH:** 8.25  
**Temp:**  
**Conductivity, µS/cm:** 496 |
| | | | **FILTER PACK MATERIAL** |
| | | | **Size:** Formation Collapse  
**From:** 3.2  
**To:** 10  
**Open Area:** |
| | | | **CEMENT DETAILS** |
| | | | **Casing cemented from:** 0  
**To:** 0.3  
**Bentonite Seal from:** 2.7  
**To:** 3.2 |
| | | | **HYDRAULIC DATA:** |
| | | | **Top of Aquifer:**  
**Static W.L.:** 2.57  
**Tested by:** GF  
**Airlift Yields:** Very Good (~10 L/s)  
**Observations:** Strong Sulphur Smell  
**Duration:** 20 mins  
**Drawdown:**  
**Recovery:** |
| | | | **Notes:**  
Hand auger to 1.5m B.G.L in case of buried services.  
Sand is Bassendean Sand |

---

**PPK**  
Environment & Infrastructure  
Department of Housing & Works  
Date: 5/06/2002  
Drawn By: GMF  
Job No.: 2140038A
## BORE COMPLETION DETAILS

### ALBION PARK TOWNSITE - Monitor Bore BH2

<table>
<thead>
<tr>
<th>LITHOLOGICAL DESCRIPTION</th>
<th>LOG</th>
<th>COMPLETION</th>
<th>DETAILS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SAND</strong>: Slightly moist, grey, loose, medium to fine, moderate - well sorted, sub-angular - sub-rounded, quartz sand.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>FERRICRETE</strong>: Wet, brown, poorly cemented, medium - coarse, moderately sorted, sub-angular - sub-rounded, quartz sand.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>SAND</strong>: Saturated, brown-grey with moderate iron staining, loose - dense, medium to coarse, moderate - well sorted, sub-rounded, quartz sand with trace silt at depth.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>SAND</strong>: As above, dense - very dense.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Silty SAND</strong>: Saturated, light tan, dense, quartz sand as above with 20-30cm thick lenses of soft-firm sandy silt.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### GENERAL INFORMATION
- **Location**: Albion Park
- **Driller**: Proline Drilling
- **Rig Type**: Hollow Stem Auger
- **Date Drilled**: 28/05/02
- **Eastings (GDA94)**: 403611
- **Nortings (GDA94)**: 6460427
- **Surface RL**: Top of Casing

### FIELD WATER QUALITY
- **pH**: 8.41
- **Temp**: 
- **Conductivity, µS/cm**: 496

### FILTER PACK MATERIAL
- **Size**: Formation Collapse
- **From**: 2.2 To: 10
- **Open Area**: 

### CEMENT DETAILS
- **Casing cemented from**: 0 To: 0.3
- **Bentonite Seal from**: 1.4 To: 2.2

### HYDRAULIC DATA
- **Top of Aquifer**: 
- **Static W.L.**: -1.64
- **Tested by**: GF
- **Airlift Yields**: Average (~3 L/s)
- **Observations**: Strong Sulphur Smell
- **Duration**: 20 mins
- **Drawdown**: 
- **Recovery**: 

### Notes:
- Hand auger to 1.5m BGL in case of buried services.
- Sand is Bassende Sand
- Basal Silty Sand is Guildford Formation

---

**PPK**

**Environment & Infrastructure**

**Department of Housing & Works**

**Date**: 5/06/2002

**Drawn By**: GMF

**Job No.**: 2140038A
BORE COMPLETION DETAILS
ALBION PARK TOWNSITE - Monitor Bore BH3

LITHOLOGICAL DESCRIPTION | LOG | COMPLETION | DETAILS
---|---|---|---
SAND: Slightly moist - moist, brown-red, loose, medium-coarse, moderately sorted, sub-well-rounded, quartz sand.

SAND: As above, grey-brown.

SAND: Wet, red-brown/grey, loose - dense, medium - coarse, moderately sorted, sub-well-rounded, quartz sand.

SAND: Saturated, light grey-brown, dense, coarse, moderately sorted, well rounded, quartz sand. Grading to tan at 6m, becoming more coarse with depth.

Sandy CLAY: Dark brown, stiff, with minor coarse angular sand.

GENERAL INFORMATION
Location: Albion Park
Driller: Proline Drilling
Rig Type: 6" Hollow Stem Auger
Date Drilled: 27/05/02
Easting: (GDA94): 401715
Northing: (GDA94): 6479847
Surface RL: Top of Casing:

FIELD WATER QUALITY
pH: 7.53
Temp:
Conductivity, µS/cm: 213

FILTER PACK MATERIAL
Size: Formation Collapse
From: 3 To: 10
Open Area:

CEMENT DETAILS
Casing cemented from: 0 To: 0.3
Bentonite Seal from: 2.3 To: 3.0

HYDRAULIC DATA:
Top of Aquifer:
Static W.L.: 2.53
Tested by: GF
Airlift Yields: Good (~5 L/s)
Observations: Strong Sulphur Smell
Duration: 20 mins
Drawdown:
Recovery:

Notes:
Sand is coarse channel sands overlain by Bassendean Sand.

PPK
Environment & Infrastructure

Department of Housing & Works

Date: 13/06/2002
Drawn By: GMF
Job No.: 2140038A
### BORE COMPLETION DETAILS

#### ALBION PARK TOWNSITE - Monitor Bore BH4

<table>
<thead>
<tr>
<th>LITHOLOGICAL DESCRIPTION</th>
<th>LOG</th>
<th>COMPLETION</th>
<th>DETAILS</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROADBASE / FILL: Dry, orange-brown, clayey, ferricrete gravels.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SAND: Slightly moist, grey, loose to fine, moderately sorted, sub-angular - sub-rounded quartz sand. Becoming tan/brown with depth, wet at 4.0m.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FERRICRETE: Wet - saturated, dark brown - black (iron stained), poorly cemented, fine to coarse, moderately sorted, sub - well-rounded quartz sand. Becoming dense with depth, grading to brown/grey with depth.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SAND: Slightly moist, grey, dense, coarse to fine, moderately sorted, sub-angular - sub-rounded quartz sand. Coarse fraction increasing with depth.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**GENERAL INFORMATION**
- Location: Albion Park
- Driller: Proline Drilling
- Rig Type: Hollow Stem Auger
- Date Drilled: 28/05/02
- Easting: (GDA94): 402379
- Northing: (GDA94): 6478273
- Surface RL:
- Top of Casing:

**FIELD WATER QUALITY**
- pH: 8.38
- Temp:
- Conductivity, μS/cm: 236

**FILTER PACK MATERIAL**
- Size: Formation Collapse
- From: 4.9 To: 9.8
- Open Area:

**CEMENT DETAILS**
- Casing cemented from: 0 To: 0.3
- Bentonite Seal from: 4.1 To: 4.9

**HYDRAULIC DATA:**
- Top of Aquifer:
- Static W.L.: -4.57
- Test by: GF
- Airlift Yields: Very Good (~10 L/s)
- Observations: Strong Sulphur Smell
- Duration: 20 mins
- Drawdown:
- Recovery:

**Notes:**
- Hand auger to 1.5m BGL in case of buried services.
- Sand is Bassendean Sand

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**PPK**

Environment & Infrastructure

Department of Housing & Works

Date: 5/06/2002

Drawn By: GMF

Job No.: 2140038A
**BORE COMPLETION DETAILS**

**ALBION PARK TOWNSITE - Monitor Bore BH5**

<table>
<thead>
<tr>
<th>Lithological Description</th>
<th>Log</th>
<th>Completion</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAND: Moist, grey-tan, loose, medium - coarse, moderately sorted, sub-angular - sub-rounded, quartz sand. Becoming lighter grey with depth.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FERRICRETE: Wet, black - dark-brown, loose, medium - coarse, moderately sorted, sub-angular - sub-rounded, quartz sand.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SAND: Saturated, brown, slightly dense, coarse - very coarse / granular, moderately sorted, sub-rounded, quartz sand. Trace of silt at end of hole.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**GENERAL INFORMATION**
- Location: Albion Park
- Driller: Proline Drilling
- Rig Type: 4" Hollow Stem Auger
- Date Drilled: 27/5/02
- Easting (GDA94): 401684
- Northing (GDA94): 6476351
- Surface RL: 
- Top of Casing: 

**FIELD WATER QUALITY**
- pH: 8.28
- Temp: 
- Conductivity, μS/cm: 540

**FILTER PACK MATERIAL**
- Size: Formation Collapse
- From: 2.6 To: 10
- Open Area:

**CEMENT DETAILS**
- Casing cemented from: 0 To: 0.3m
- Bentonite Seal from: 2.0 To: 2.8

**HYDRAULIC DATA:**
- Top of Aquifer:
- Static W.L.: 2.80 mBGL
- Tested by: GF
- Airlift Yields: Good (~5 L/s)
- Observations: Strong Sulphur Smell
- Duration: 20 mins
- Drawdown:
- Recovery:

**Notes:**
- Sands are very coarse - granular channel sands, high water yields on airlift. Formation collapsed on retrieval of augers, thus no gravel pack was added.

---

**PPK Environment & Infrastructure**

Department of Housing & Works

Date: 4/06/2002

Drawn By: GMF

Job No: 2140038A
# BORE COMPLETION DETAILS

## ALBION PARK TOWNSITE - Monitor Bore BH6

<table>
<thead>
<tr>
<th>LITHOLOGICAL DESCRIPTION</th>
<th>LOG</th>
<th>COMPLETION</th>
<th>DETAILS</th>
</tr>
</thead>
</table>
| SAND: Slightly moist, dark grey - tan, loose, medium grained, moderately sorted, sub-well-rounded, quartz sand. | | 0.3 | **GENERAL INFORMATION**  
Location: Albion Park  
Driller: Proline Drilling  
Rig Type: 6" Hollow Stem Auger  
Date Drilled: 27/05/02  
Easting: (GDA94): 401942  
Northing: (GDA94): 6476550  
Surface RL:  
Top of Casing: |
| SAND: As above, light grey-brown, grading to coarse - very coarse quartz sand at 3.0m, wet at 2.0m. | | 3.2 | **FIELD WATER QUALITY**  
PpH:7.93  
Temp:  
Conductivity, µS/cm: 224 |
| FERRICRETE: Wet-saturated, dark brown - grey, moderately cemented, medium - coarse, moderately sorted, sub rounded, quartz sand.  
SAND: Saturated, light grey-brown, dense, coarse - very coarse, moderately sorted, well rounded, quartz sand. Trace silt content at 6.0m, decreasing with depth. | | 3.5 | **FILTER PACK MATERIAL**  
Size: Formation Collapse  
From: 2  
To: 10  
Open Area: |
| Sandy CLAY: Saturated, light grey - creamy white, firm, with angular, med grained quartz sand. | | 9.8 | **CEMENT DETAILS**  
Casing cemented from: 0  
To: 0.3  
Bentonite Seal from: 1.65  
To: 2 |
| | | 10 | **HYDRAULIC DATA:**  
Top of Aquifer:  
Static W.L.: 1.63  
Tested by: GF  
Airlift Yields: Good (~5 L/s)  
Observations: Water is cloudy grey  
Duration: 20 mins  
Drawdown:  
Recovery: |
| | | | **Notes:**  
Sand is Bassendean Sand  
Basal Clay is Guildford Formation |

**PPK**

Environment & Infrastructure

Department of Housing & Works

Date: 13/06/2002

Drawn By: GMF

Job No.: 2140038A
## BORE COMPLETION DETAILS

**ALBION PARK TOWNSITE - Monitor Bore BH7**

<table>
<thead>
<tr>
<th>LITHOLOGICAL DESCRIPTION</th>
<th>LOG</th>
<th>COMPLETION</th>
<th>DETAILS</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAND: Slightly moist, dark grey - tan, loose, medium grained, moderately sorted, sub-well-rounded, quartz sand.</td>
<td>0</td>
<td>1.5</td>
<td>GENERAL INFORMATION</td>
</tr>
<tr>
<td>SAND: As above, light grey - tan, medium grained, moderately sorted, sub rounded quartz sand, grading to very coarse, well rounded quartz sand with depth.</td>
<td>1.5</td>
<td>2.2</td>
<td>Location: Albion Park</td>
</tr>
<tr>
<td>FERRICRETE: Wet-saturated, brown poorly cemented, medium - coarse, moderately sorted, sub rounded, quartz sand, with trace silt.</td>
<td>2.2</td>
<td>5</td>
<td>Driller: Proline Drilling</td>
</tr>
<tr>
<td>SAND: Saturated, light grey-brown, dense, coarse, moderately sorted, well rounded, quartz sand with trace silt.</td>
<td>5</td>
<td>5.5</td>
<td>Rig Type: 6&quot; Hollow Stem Auger</td>
</tr>
</tbody>
</table>

### FIELD WATER QUALITY
- pH: 7.32
- Temp: 
- Conductivity, μS/cm: 372

### FILTER PACK MATERIAL
- Size: Formation Collapse
- From: 2 To: 10
- Open Area:

### CEMENT DETAILS
- Casing cemented from: 0 To: 0.3
- Bentonite Seal from: 1.7 To: 2.2

### HYDRAULIC DATA:
- Top of Aquifer: 5.5
- Static W.L.: 2.415
- Tested by: GF
- Airlift Yields: Good (~5 L/s)
- Observations: Water is Cloudy Grey
- Duration: 20 mins
- Drawdown:
- Recovery:

### Notes:
- Sand is Bassendean Sand
- Basal Clay is Guildford Formation

**PPK Environment & Infrastructure**

**Department of Housing & Works**

**Date:** 13/06/2002

**Drawn By:** GMF

**Job No.:** 2140038A
LITHOLOGICAL DESCRIPTION | LOG | COMPLETION | DETAILS
--- | --- | --- | ---
ROADBASE: Moist, tan-orange, dense, gravelly, silt, very poorly sorted, ferricrete sands and gravels.

Sandy Gravelly SILT: Moist, becoming dry with depth, tan-brown with minor orange motting, stiff, silty clay with gravel (minor), very poorly sorted, sub-angular silty sand. Gravel fraction decreasing with depth to a silty sand at 3.0m.

Clayey Sandy SILT: Saturated, tan-brown, stiff clay to medium sand, poorly sorted, sand is medium to fine, sub-angular, quartz, occurring lenses 10-20cm thick, sand content increasing with depth.

Clayey SAND: As above, clay and silt content increasing with depth.

GENERAL INFORMATION
Location: Albion Park
Driller: Proline Drilling
Rig Type: 6' Hollow Stem Auger
Date Drilled: 29/05/02
Easting: (GDA94): 404194
Northing: (GDA94): 6475581
Surface RL: Top of Casing:

FIELD WATER QUALITY
pH: 
Temp: 
Conductivity, μS/cm:

FILTER PACK MATERIAL
Size: 0.5 - 1mm
From: 2.8 To: 8
Open Area:

CEMENT DETAILS
Casing cemented from: 0 To: 0.3
Bentonite Seal from: 1.45 To: 2.8

HYDRAULIC DATA:
Top of Aquifer:
Static W.L.: 4.48
Tested by: OF
Airlift Yields: Very Low
Observations:
Duration: 20 mins
Drawdown:
Recovery:

Notes:
Profile is Guildford Formation
Bore located on Cnr Cranleigh St and West Swan Road, Opposite Margaret River Chocolate Company

PPK Environment & Infrastructure
Department of Housing & Works
Date: 13/06/2002
Drawn By: GMF
Job No.: 2140038A
# BORE COMPLETION DETAILS

## ALBION PARK TOWNSITE - Monitor Bore BH9

<table>
<thead>
<tr>
<th>LITHOLOGICAL DESCRIPTION</th>
<th>LOG</th>
<th>COMPLETION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravelly SAND: Moist, brown/grey - creamy white, dense, gravel - fine sand, poorly sorted, sub-angular - sub-rounded, limestone gravels (roadbase) in quartz sand.</td>
<td>1.3</td>
<td>0.95</td>
</tr>
<tr>
<td>Gravelly SAND: Moist, orange-brown, dense, gravel plus medium - fine sand, bimodal, sub-angular - sub-rounded, ferricrete gravels in quartz sand.</td>
<td>2.0</td>
<td>0.95</td>
</tr>
<tr>
<td>SAND: Saturated, tan-brown, dense, medium fine, moderately sorted, sub-angular - sub-rounded, quartz sand.</td>
<td>3.0</td>
<td>0.95</td>
</tr>
<tr>
<td>Sandy GRAVEL: Saturated, orange - tan-brown coarse sand - gravel, poorly sorted, sub angular clasts of cemented quartz sands plus ferricrete gravels.</td>
<td>4.5</td>
<td>0.95</td>
</tr>
<tr>
<td>Silty SAND: Saturated, tan, dense, medium sand - clay, poorly sorted, sub-angular, silty clayey quartz sand, with minor ferricrete grains.</td>
<td>5.0</td>
<td>0.95</td>
</tr>
<tr>
<td>Clayey Sandy SILT: Saturated, grey, firm - stiff, low plasticity, sand is coarse - fine, angular - sub-angular, quartz.</td>
<td>6.0</td>
<td>0.95</td>
</tr>
</tbody>
</table>

## GENERAL INFORMATION
- **Location:** Albion Park
- **Driller:** Proline Drilling
- **Rig Type:** 6" Hollow Stem Auger
- **Date Drilled:** 29/05/02
- **Easting:** (GDA94): 404564
- **Northing:** (GDA94): 6477063
- **Surface RL:** Top of Casing

## FIELD WATER QUALITY
- **pH:** 8.27
- **Temp:**
- **Conductivity, µS/cm:** 1430

## FILTER PACK MATERIAL
- **Size:** 0.5 - 1mm
- **From:** 0.95
- **To:** 4
- **Open Area:**

## CEMENT DETAILS
- **Casing cemented from:** 0
- **To:** 0.3
- **Bentonite Seal from:** 0.3
- **To:** 0.95

## HYDRAULIC DATA:
- **Top of Aquifer:**
- **Static W.L.:** 2.37
- **Tested by:** GF
- **Airlift Yields:** Very Low
- **Observations:**
- **Duration:** 20 mins
- **Drawdown:**
- **Recovery:**

## Notes:
- Profile is Guilford Formation
- Bore located on Cnr Edward St and West Swan Road

---

**PPK Environment & Infrastructure**

Department of Housing & Works

**Date:** 5/06/2002

**Drawn By:** GMF

**Job No.:** 214003BA
# BORE COMPLETION DETAILS

ALBION PARK TOWNSITE - Monitor Bore BH10

<table>
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<tr>
<td>ROADBASE: Sandy limestone gravels.</td>
<td>2.5</td>
<td>0.3</td>
<td></td>
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<tr>
<td>SAND: Wet, creamy tan, loose - dense, medium - fine, moderately sorted, sub-angular - sub-rounded quartz sand.</td>
<td>3</td>
<td>0.6</td>
<td></td>
</tr>
<tr>
<td>SAND: Saturated, sand as above, minor silt increasing with depth.</td>
<td>4</td>
<td>1.7</td>
<td></td>
</tr>
<tr>
<td>Sandy Silty CLAY: White - grey, saturated, firm sand is medium - coarse, angular quartz.</td>
<td>5.1</td>
<td>2.2</td>
<td></td>
</tr>
</tbody>
</table>

**GENERAL INFORMATION**
- Location: Albion Park
- Driller: Proline Drilling
- Rig Type: 6" Hollow Stem Auger
- Date Drilled: 28/05/02
- Easting: (GDA94): 404513
- Northing: (GDA94): 6478971
- Surface RL:
- Top of Casing:

**FIELD WATER QUALITY**
- pH: 8.38
- Temp:
- Conductivity, μS/cm: 1501

**FILTER PACK MATERIAL**
- Size: 0.5 - 1mm
- From: 2 To: 10
- Open Area:

**CEMENT DETAILS**
- Casing cemented from: 0 To: 0.3
- Bentonite Seal from: 1.7 To: 2.2

**HYDRAULIC DATA:**
- Top of Aquifer:
- Static W.L: 2.33
- Tested by: GF
- Airlift Yields: Very Low
- Observations:
- Duration: 20 mins
- Drawdown:
- Recovery:

**Notes:**
- Sand in Bassendean Sand
- Basal Clay is Guildford Formation
- Old NE Corridor Pelzo (NE2-9) removed with crane on rig prior to drilling

---

PPK Environment & Infrastructure

Department of Housing & Works

Date: 4/06/2002

Drawn By: GMF

Job No.: 2140038A
**BORE COMPLETION DETAILS**

**ALBION PARK TOWNSITE - Monitor Bore BH11**

<table>
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<th>COMPLETION</th>
<th>DETAILS</th>
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</thead>
<tbody>
<tr>
<td><strong>SAND</strong>: Slightly moist - moist, grey, loose, medium - fine, moderately sorted, sub-angular sub-rounded, clean quartz sand. Wet at 2.5m</td>
<td>![Log Diagram]</td>
<td>![Completion Diagram]</td>
<td><strong>GENERAL INFORMATION</strong></td>
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<tr>
<td><strong>FERRICRETE</strong>: Sand as above, saturated, grey-brown, very minor iron staining, moderately cemented quartz sand.</td>
<td>![Log Diagram]</td>
<td>![Completion Diagram]</td>
<td>Location: Albion Park</td>
</tr>
<tr>
<td><strong>SAND</strong>: Wet, brown - grey, dense, fine - coarse, moderately sorted, sub-angular - sub-rounded quartz sand. Trace silt at depth, grading to sub-rounded - rounded at depth.</td>
<td>![Log Diagram]</td>
<td>![Completion Diagram]</td>
<td>Driller: Proline Drilling</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Rig Type: 6&quot; Hollow Stem Auger</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Date Drilled: 28/05/02</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Easting (GDA94): 402844</td>
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<td></td>
<td></td>
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<td>Northing (GDA94): 6476072</td>
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<td></td>
<td>Top of Casing:</td>
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<td><strong>FIELD WATER QUALITY</strong></td>
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<td></td>
<td></td>
<td>pH: 8.10</td>
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<td>Temp:</td>
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<td>Conductivity, μS/cm: 1346</td>
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<td><strong>FILTER PACK MATERIAL</strong></td>
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<td>Size: Formation Collapse</td>
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<td>From: 2.6 To: 10</td>
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<td>Open Area:</td>
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<td><strong>CEMENT DETAILS</strong></td>
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<td>Casing cemented from: 0 To: 0.3</td>
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<td>Bentonite Seal from: 2.2 To: 2.6</td>
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<td>Top of Aquifer:</td>
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<td>Static W.L. 2.33</td>
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<td>Tested by: GF</td>
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<td></td>
<td></td>
<td>Airlift Yields: Good (~5 L/s)</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Observations: Strong Sulphur Smell</td>
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<td></td>
<td></td>
<td></td>
<td>Duration: 20 mins</td>
</tr>
<tr>
<td></td>
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<td>Drawdown:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Recovery:</td>
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<td></td>
<td></td>
<td></td>
<td><strong>Notes:</strong></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Located in vacant road reserve at end of Blundell St, behind turf farm.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Sand is Bassendean Sand.</td>
</tr>
</tbody>
</table>

**PPK**

Environment & Infrastructure

Department of Housing & Works

Date: 13/06/2002

Drawn By: GMF

Job No.: 2140038A
APPENDIX C

Historic Water Levels of DoW Bores
Figure C1: Hydrographs for DoE Bores MM56B, MM27, and MM52
Figure C2: Hydrographs for DoE Bore MM71B

Data Source: DoE Long-Term Monitoring Bore Data (2005)
APPENDIX D

Pre-Development Groundwater Monitoring
Data Time Series Plots

Figure D1: Water Levels in Albion Monitoring Bores

Water Level (mAHD)

Date

ALB1  ALB2  ALB3  ALB4  ALB5  ALB6  ALB7  ALB8  ALB9  ALB10  APW1  APW2  APW5  BH1  BH2  BH3  BH4  BH5  BH6  BH7  BH8  BH9  BH10  BH11

Multiplex Developments Australia Pty Ltd
Albion Local Water Management Strategy

Job No. J4070

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Figure D3: Total Nitrogen in Albion Monitoring Bores


Figure D4: Total Phosphorus in Albion Monitoring Bores

- ALB1
- ALB2
- ALB3
- ALB4
- ALB5
- ALB6
- ALB7
- ALB8
- ALB9
- ALB10
- APW1
- APW2
- APW5
- BH1
- BH2
- BH3
- BH4
- BH5
- BH6
- BH7
- BH8
- BH9
- BH10
- BH11

Figure D5: Ortho Phosphorus, PO4-P, in Albion Monitoring Bores

Dear Tracy

ACID SULFATE SOILS REPORT – ALBION STRUCTURE PLAN

Further to your letter of 4 August 2006 requesting the Department of Environment and Conservation (DEC) to review the report entitled Strategic Acid Sulfate Soil Investigation – Albion Townsite, Hanley Brook, the Land and Water Quality Branch of DEC has reviewed the report and provides the following comments.

- A review of the analytical results indicates that the soils generally have low sulfidic acidity and most results are below the action limit at 0.03%S. However, examination of the field results revealed that most field peroxide tests were below pH 4.5, which suggests that the soils still have a significant amount of acidity from other sources. This potential acidity may reflect organic acidity, and it may also reflect acidity from oxidation and titration of iron or manganese containing compounds. Although the sum of Sor+ TA shown in the report is generally at, or marginally above, the action criteria, the other forms of acidity should not be ignored as of no environmental consequences. Our experience with another project within the same locality has shown that the groundwater has been impacted with elevated iron and aluminium following a short period of dewatering. In view of this, the DEC recommends that soil treatment should be based on the highest result expressed as total sulfidic acidity, unless the source of the titratable acidity is shown to be benign.

- It is noted that groundwater sampling has not been undertaken. The watertable at Albion townsites varies between 0.5m and 2.0m below ground level, and is susceptible to contamination caused by inappropriate soil disturbing activities. The DEC recommends that a groundwater investigation be conducted to determine background groundwater quality prior to any earthworks commencing.

In conclusion, the preliminary site investigation has identified acid sulfate soil layers with a significant source of potential acidity likely from iron oxidation reaction. The oxidation and hydrolysis of iron can liberate acids, often a significant distance away from the site. It would therefore be appropriate to
undertake further investigation to determine total net acidity and consider their potential offsite impacts. The suspended peroxide oxidation combined acidity & sulfate (SPOCAS) method is useful to determine the organic, sulfidic and metal-associated acidity. In addition, acid base accounting is recommended for the assessment of acid sulfate soils and predicting the lime requirement in this area.

Please do not hesitate to contact Stephen Wong, Senior Environmental Officer of the Land and Water Quality Branch, on 6467 5377 if you wish to discuss the above further.

Yours sincerely,

Sharon Clark
MANAGER
LAND AND WATER QUALITY BRANCH

8 September 2006

c.c. Teresa Bryant, Environmental Impact Assessment Branch
    Bill Till, Department of Water
    Regional Manager, Swan Goldfields Agricultural Region
Manager, Land and Water Quality Branch
Department of Environment and Conservation
PO Box K822
PERTH WA 6842

Attention: Ms S. Clarke, Manager Land & Water Quality Branch

Dear Sharon

ALBION TOWNSITE STRUCTURE PLAN
ACID SULFATE SOILS REPORT

Douglas Partners is pleased to present this response to the Department of Environment and Conservation (DEC) letter to Tracy McQue, Senior Strategic Planner/Acting Manager, City of Swan dated 8 August 2006. The DEC’s letter was a response to a request from the City of Swan on 4 August 2006 to review of the Douglas Partners report entitled, “Strategic Acid Sulfate Soil Investigation – Albion Townsite, Henley Brook”.

This letter provides responses to each of the main issues that were raised in your letter.

“...the DEC recommends that soil treatment should be based on the highest result expressed as total sulfidic acidity, unless the source of the titratable acidity is shown to be benign.”

This recommendation is based partly on the DEC statement that, “...most of the field peroxide tests were below pH fox 4, which suggests that the soils still have a significant amount of acidity from other sources.” Although it is clear that most of the results are below 4, only approximately 14% of the results are below the criterion of 3.0 which is normally used by the DEC.

We consider that it is premature at this stage to base treatment strategies on “...the highest result expressed as total sulfidic acidity.” The DEC’s concern on general experience in the area are recognised, however, recommendations on treatment strategies should be based on consideration of the results of the proposed detailed investigations with due consideration of depths of ground disturbing activities.

“The DEC recommends that a groundwater investigation be conducted to determine background groundwater quality prior to any earthworks commencing.”

Douglas Partners agrees with this recommendation and it is normally undertaken at a later stage in the planning process when the locations and depths of ground disturbing activities are known.
"It would therefore be appropriate to undertake further investigation to determine total net acidity and consider their potential offsite impacts."

Douglas Partners agrees with this conclusion and it is intended that such investigations are undertaken when the locations and depths of the principal ground-disturbing activities are known.

In general, based on our knowledge and experience with management of acid sulfate soils, our current knowledge of site conditions and the proposed development plans, Douglas Partners reiterates that we consider that the acid sulfate soil and groundwater conditions are, from technical viewpoints, expected to be manageable.

If you have any queries or require further information, please do not hesitate to contact us.

Yours sincerely

DOUGLAS PARTNERS PTY LTD

Terry Waters
Branch Manager

Cc: Tracy McQue, City of Swan
Thanks Nikki

Further to our meeting on Friday 29 March 2008, your proposal to conduct further soil and groundwater sampling for submission with the Local Structure Plan is supported.

Regards
Stephen

---

Hi Stephen,

Thankyou for meeting with myself, Evan Jones (Multiplex) and Paul Zuvela (Coffey Environments) this morning, to discuss ASS at the Albion townsite, Henley Brook.

As agreed, please find below a reiteration of the main items discussed during the meeting and our agreed way forward for the site.

- The Douglas Partners (2006) regional ASS investigation (Report on Strategic Acid Sulfate Soil Investigation, Albion Townsite, Henley Brook) was undertaken to better understand ASS parameters and distribution at the site on a district (regional) scale.
  - The Douglas Partners (2006) investigation identified that ASS were present at the site and that there was some correlation with regional risk mapping.
  - The reporting was extremely broad scale.
  - However, the Douglas Partners investigation is sufficient to support the District Structure Plan as it indicates that ASS will be an issue at the site and as such, identifies that investigation of ASS at a finer resolution is required for more detailed planning (e.g. local structure plans and subdivision approvals).

- Coffey Environments will be undertaking further investigation into ASS and groundwater at the site in March 2008, to support submission of a Local Structure Plan.
  - The investigation will address DEC concerns with regard to the Douglas Partners (2006) investigation and as such will include:
    - installation of groundwater monitor bores (upgradient, down gradient and within site);
    - sampling and field analysis at 0.25m intervals; and
    - analysis of samples at 0.5m intervals for the full suite of analytical parameters.
  - Locations will be sampled to at least 1m below groundwater level to ensure the wetting zone is adequately characterised.
Sample locations will be chosen to:
- firm up risk mapping boundaries as originally delineated by DEC mapping and ground-truthed during the Douglas Partners (2006) investigation;
- increase understanding of soil chemistry at site (including recovery of samples from areas identified as high, medium and low risk);
- confirm any visual indicators of potential ASS impacts.

The report on the ASS investigation will include:
- transects across site (at least 2) showing geology and lateral ASS distribution.
- soil sampling analytical results and interpretation
- groundwater sampling results and interpretation
- no management plans are required to be developed for this level of investigation.

Multiplex and Coffey Environments are happy to share the resultant data with the DEC for addition to the DEC ASS database.

Please let me know if you have any comments on the above. We appreciate your time today, it was fruitful and ensures that our investigations are inline with the requirements of the DEC and will be sufficient to support the Local Structure Plan when it is submitted.

Kind Regards,
Nikki
UNNIKKE MESKANEN
Senior Environmental Scientist
Coffey Environments
Dilworth House, 2 Bulwer Street Perth WA 6000
T (+61) (8) 6462 7900 F (+61) (8) 6462 7938 M 0429 357 315
WWW.COFFEY.COM

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Please update your databases, address books and bookmarks to:

www.coffey.com
firstname_lastname@coffey.com

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APPENDIX F

Shallow Groundwater Sampling 21/9/06: Laboratory Analysis
LABORATORY REPORT

ARL Lab No: 22201-20
Date: 19 October 2006

CLIENT: Jim Davies and Associates
P.O. Box 117
SUBLIACO WA 6904

ATTENTION: Mr. Scott Wills

SAMPLE DESCRIPTION: Twenty water samples as received for analysis of ammonia-N, NOx-N, total kjeldahl nitrogen, total nitrogen, filtered reactive phosphorus, total phosphorus and total dissolved solids (TDS). Two water samples as received for analysis of total suspended solids (TSS).

DATE RECEIVED: 21 September 2006

LOCATION / JOB NO: J3755c6

METHOD REFERENCES:

- Total Suspended Solids in Water  ARL No. 016
- Total Dissolved Solids in Water  ARL No. 017
- NOx-N  ARL No. 032
- Total Kjeldahl Nitrogen  ARL No. 034
- Ammonia  ARL No. 035
- Total and Filtered Reactive Phosphorus  ARL No. 036

Kim Rodgers
Laboratory Manager
### Nutrients Quality Control Data

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<th>Matrix Spike</th>
<th>Certified Reference Material</th>
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<tr>
<td>Ammonia</td>
<td></td>
<td></td>
<td>94%</td>
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<tr>
<td>Total Kjeldahl Nitrogen</td>
<td>93%</td>
<td></td>
<td>98%</td>
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<tr>
<td>NOx-N</td>
<td>105%</td>
<td></td>
<td>107%</td>
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<tr>
<td>Reactive Phosphorus</td>
<td>100%</td>
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<tr>
<td>Total Phosphorus</td>
<td>105%, 110%</td>
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<td>92%</td>
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### Inorganics Quality Control Data

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<td>Total Dissolved Solids</td>
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<td>110%</td>
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<td>Total Suspended Solids</td>
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**Nutrients**

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<td>RS002 Nutrients</td>
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<td>BH9 Nutrients</td>
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<td>0.3</td>
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<td>NOx-N</td>
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<td>0.03</td>
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LABORATORY REPORT

CLIENT: J.D.A. Consultant Hydrologists
PO Box 117,
SUBIACO WA 6904

ATTENTION: Mr. Scott Wills

SAMPLE DESCRIPTION: Ten water samples as received for analysis of metals.

DATE RECEIVED: 21 September 2006

LOCATION / JOB NO: J3755c7

METHOD REFERENCES:

Metals in Water

Kim Rodgers
Laboratory Manager
<table>
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<tr>
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<td></td>
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<tr>
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<tr>
<td>Potassium</td>
<td>-</td>
<td></td>
<td>94%</td>
</tr>
<tr>
<td>Manganese</td>
<td>-</td>
<td></td>
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<tr>
<td>Sodium</td>
<td>-</td>
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<tr>
<td>Nickel</td>
<td>-</td>
<td></td>
<td>96%</td>
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<tr>
<td>Selenium</td>
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<tr>
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### Metals

**Date Prepared**: 21/09/2006  

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LABORATORY REPORT

ARL Lab No: 22221-30
Date: 17 November 2006

CLIENT: Jim Davies & Associates
PO Box 117
SUBIACO WA 6904

ATTENTION: Mr Scott Wills

SAMPLE DESCRIPTION: Ten water samples as received for analysis of total acidity, alkalinity, chloride, sulphate, total aluminium, and total iron.

DATE RECEIVED: 21 September 2006

LOCATION / JOB NO: J3755c8

METHOD REFERENCES:

Chloride
Total Acidity in Water
Sulphate in Water
Metals in Water
Alkalinity

ARL No. 018
ARL No. 021
ARL No. 028
ARL No. 029, 038, 039, 040, 065, 066
ARL No. 037

Kim Rodgers
Laboratory Manager
**Metals Quality Control Data**

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<tr>
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**Inorganics Quality Control Data**

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## Metals

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### Metals

**Date Prepared:** 21/09/2006  
**Date Analysed:** 24/10/2006, 15/11/06  

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<tr>
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<td>22/09/2006</td>
</tr>
<tr>
<td>Bicarbonate</td>
<td>22/09/2006</td>
</tr>
<tr>
<td>Carbonate</td>
<td>22/09/2006</td>
</tr>
<tr>
<td>Hydroxide</td>
<td>22/09/2006</td>
</tr>
<tr>
<td>Total Acidity</td>
<td>22/09/2006</td>
</tr>
<tr>
<td>Chloride</td>
<td>27/09/2006</td>
</tr>
<tr>
<td>Sulphate</td>
<td>25/09/2006</td>
</tr>
</tbody>
</table>

<table>
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<tr>
<th>Sample Marks</th>
<th>Date Analysed</th>
<th>Units</th>
<th>Method Detection Limit</th>
<th>22228 JDA J3755 ALB6 Ions 21-Sep-06</th>
<th>22229 JDA J3755 ALB7 Ions 21-Sep-06</th>
<th>22230 JDA J3755 ALB8 Ions 21-Sep-06</th>
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</thead>
<tbody>
<tr>
<td>Alkalinity</td>
<td>22/09/2006</td>
<td>mg CaCO₃/l</td>
<td>5</td>
<td>27</td>
<td>140</td>
<td>17</td>
</tr>
<tr>
<td>Bicarbonate</td>
<td>22/09/2006</td>
<td>mg CaCO₃/l</td>
<td>5</td>
<td>27</td>
<td>140</td>
<td>17</td>
</tr>
<tr>
<td>Carbonate</td>
<td>22/09/2006</td>
<td>mg CaCO₃/l</td>
<td>5</td>
<td>&lt; 5</td>
<td>&lt; 5</td>
<td>&lt; 5</td>
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<tr>
<td>Hydroxide</td>
<td>22/09/2006</td>
<td>mg CaCO₃/l</td>
<td>5</td>
<td>&lt; 5</td>
<td>&lt; 5</td>
<td>&lt; 5</td>
</tr>
<tr>
<td>Total Acidity</td>
<td>22/09/2006</td>
<td>mg CaCO₃/l</td>
<td>5</td>
<td>58</td>
<td>30</td>
<td>52</td>
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<tr>
<td>Chloride</td>
<td>27/09/2006</td>
<td>mg/l</td>
<td>5</td>
<td>92</td>
<td>210</td>
<td>54</td>
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<tr>
<td>Sulphate</td>
<td>25/09/2006</td>
<td>mg/l</td>
<td>3</td>
<td>6</td>
<td>43</td>
<td>14</td>
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APPENDIX G

Albion Nutrient Input Modelling
1. ALBION NUTRIENT INPUT MODELLING

1.1 NiDSS

NiDSS (Nutrient Input Decision Support System) is a tool developed by JDA Consultant Hydrologists to assist in landuse management planning, by allowing quantitative estimation of nutrient input rates and the potential reduction in nutrient input for various combinations of WSUD management measures. It focuses on the adoption of an integrated catchment approach to water quality management, including measures to minimise nutrient inputs at source, and provides a logical framework for the evaluation of the effectiveness of various best management practices for nutrient input management.

It calculates the total expected nutrient input for a particular development proposal based on aggregating individual nutrient inputs from different land uses (housing lots, POS, road reserves, conservation areas etc.) prior to implementation of stormwater management measures. The impact of individual source and in-transit controls on nutrient input can then be determined by either turning on/off individual controls or varying the effectiveness of these measures. The results present information on:

- Estimates of total phosphorus (TP) and total nitrogen (TN) inputs to an area
- Estimates of reduced nutrient input due to source control measures (education, street sweeping)
- Estimates of reduced nutrient inputs due to in-transit controls (Stormwater Pollutant Traps, WPCP's)
- Estimates of the cost of nutrient reduced for a selected WSUD program.

NiDSS modelling was applied to the Albion Draft Structure Plan to model both the existing and proposed land use nutrient input rates. The nutrient application rates were adopted from Southern River/Forrestdale/Brookdale/Wungong UWMS (JDA, 2002), which based application rates on a nutrient input survey conducted by JDA of medium density residential areas and on previous work of Gerritse et al (1991, 1992).

1.2 Water Quality Management Options

Details of various structural water quality control measures applicable to Albion are shown in Tables 1 and 2. These tables have been adapted from the Southern River/Forrestdale/Brookdale/Wungong Urban Water Management Strategy (JDA, 2002) and summarises the suitability of pollutant removal efficiencies, constraints and relative capital and operating costs.

Table 1 indicates that structural controls are only effective in removing gross pollutants and coarse sediment. They are ineffective in removing fine sediments and oil and grease, and in particular nutrients. They also have a moderate potential for allowing pollutants to be remobilised.

Table 2 also indicates that the majority of these structural controls are associated with a high ongoing/maintenance or capital cost. Consequently, they are considered to be inefficient in pollutant removal and should not be relied on for the majority of water quality management control.
<table>
<thead>
<tr>
<th>Treatment Measure</th>
<th>Pollutant Removal Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>neg : Negligible [0-10% removal]</td>
</tr>
<tr>
<td></td>
<td>L : Low [10-50% removal]</td>
</tr>
<tr>
<td></td>
<td>M : Moderate [50-75% removal]</td>
</tr>
<tr>
<td></td>
<td>H : High [75-100% removal]</td>
</tr>
<tr>
<td>Litter baskets/ pits/ bags</td>
<td>H</td>
</tr>
<tr>
<td>Litter / trash racks</td>
<td>M</td>
</tr>
<tr>
<td>Gross Pollutant Traps</td>
<td>H</td>
</tr>
<tr>
<td>Detention storages</td>
<td>L</td>
</tr>
<tr>
<td>Vegetated Swales</td>
<td>L</td>
</tr>
<tr>
<td>Bio retention systems</td>
<td>L</td>
</tr>
</tbody>
</table>

Adapted from JDA (2002).
TABLE 2: POTENTIAL CONSTRAINTS FOR VARIOUS STRUCTURAL CONTROLS

<table>
<thead>
<tr>
<th>Treatment Measure</th>
<th>Potential Constraint</th>
<th>Relative Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>H</td>
</tr>
<tr>
<td>Steep site/catchment slope</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>High water table</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Limited land availability</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Polluted groundwater</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Covered treatment measure is required</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>High sediment input</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Treatment measure requires pre-treatment</td>
<td>•</td>
<td>✓</td>
</tr>
<tr>
<td>Hydraulic head loss limitation</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>Ongoing operation / maintenance costs</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>Capital cost</td>
<td>•</td>
<td>•</td>
</tr>
</tbody>
</table>

Adapted from JDA (2002).

With non-structural source controls, it is more difficult to predict their effectiveness on pollutant removal efficiencies. There are smaller costs and greater efficiencies associated with preventing nutrient application, compared to incorporating more expensive end of pipe infrastructure (structural controls).

Based on this concept and the fact that the structural controls discussed earlier are inefficient in pollutant removal, it is recommended that the water quality management program developed for Albion Structure Plan largely reflect non-structural source controls rather than the end of pipe structural controls. For this the following non-structural source controls are proposed where possible:

- **Landuse Planning**
  Inclusion of water quality considerations in land use planning decisions – land zonings and layout, and POS design and location.

- **Education Campaigns**
  Distribution of leaflets, posters and newsletters (topics include but not limited to drains to rivers – Henley and Ellen Brook, fertilising habits, composting, car washing detergents and practices, lawn and garden cutting disposal, techniques for minimising stormwater runoff pollutants), drain stencilling and plaques, erection of informative signs in public areas, newspaper articles etc.
- **Refinement of Management and Maintenance Activities**
  Education of staff and regular review of work practices, refinement of street sweeping programmes and practices, landscaping, and enforcement through infringement and pollution control regulation.

- **Balanced Planting Regime**
  Retention of existing, and landscaping with native vegetation in POS areas, and encouragement of native plantings in residential lots where possible.

- **Street Sweeping**
  Undertaking of co-ordinated street cleaning programs to remove sediment build up, particularly during development and housing construction phase.

### 1.3 Modelled Nutrient Input- Pre-Development

Pre-development estimates of nutrient input rates over Albion from NiDSS are shown in Table 3. Also shown are estimates of post development nutrient input rates based on residential development with a mixture of R35 zoning (285m²) and R15 zoning (670m² lots) without any water sensitive urban design (WSUD) measures implemented.

In summary, without implementation of water sensitive urban design it is estimated that urbanisation of the Albion development area would result in a total nitrogen input increase from 22.2 t/yr to between 57.9 t/yr while phosphorus would increase from 7.3 t/yr to 13.5 t/yr.

The impact of WSUD measures in reducing nutrient inputs is addressed in Table 3. NiDSS model outputs attached.

### 1.4 Modelled Nutrient Input- Post Development with WSUD

The potential for an increase in nutrient input following urban development can generally be managed by the application of various water management options. Furthermore, a combination of these options can be used to develop an effective water quality management program to effectively reduce post development inputs to pre-development levels.

Presented in Tables 3 and 4 are two examples on how an effective water quality management program, based on source controls can reduce Total Nitrogen and Total Phosphorus input from post development to pre-development levels using NiDSS (details attached). In these examples, it assumes an education effectiveness of 25% and 33% respectively, that is, 1 in 4 or 1 in 3 people will adopt the WSUD principles as listed. These effectiveness percentages are not considered to be unrealistic.

Note that these management options shown in Table 4 represent effective example programs only. There are many other various combinations of management options available that can also be used to achieve a similar result.
Table 3 indicates that with the use of WSUD measures the nutrient input to an urban system can be controlled and minimized to a point similar to pre development levels.

### TABLE 3: STAGE 1 NUTRIENT INPUT ANALYSIS (USING NIDSS MODEL)

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Pre Development</th>
<th>Post Development (without WSUD)</th>
<th>Post Development (with WSUD Scenario 1)</th>
<th>Post Development (with WSUD Scenario 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Phosphorus Input (t/yr)</td>
<td>7.3</td>
<td>13.5</td>
<td>1.8</td>
<td>5.5</td>
</tr>
<tr>
<td>Total Nitrogen Input (t/yr)</td>
<td>22.2</td>
<td>57.9</td>
<td>10.1</td>
<td>26.2</td>
</tr>
</tbody>
</table>

### TABLE 4: MANAGEMENT OPTIONS ADOPTED IN EXAMPLE WSUD PROGRAMS

<table>
<thead>
<tr>
<th>NIDSS WSUD Parameter</th>
<th>WSUD Scenario 1</th>
<th>WSUD Scenario 2</th>
<th>Description of WSUD Parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Street Sweeping</td>
<td>100%</td>
<td>0%</td>
<td>% of area street sweeping applies to</td>
</tr>
<tr>
<td>Education Effectiveness</td>
<td>25%</td>
<td>33%</td>
<td>% of people adopting WSUD principles</td>
</tr>
<tr>
<td>(i.e. number of people that adopt WSUD listed below)</td>
<td>1 in 4</td>
<td>1 in 3</td>
<td></td>
</tr>
<tr>
<td>Community Education on Fertiliser Use</td>
<td>✓</td>
<td>✓</td>
<td>Fertiliser application as per manufacturers recommendations</td>
</tr>
<tr>
<td>Community Education on Pet Waste</td>
<td>✓</td>
<td>✓</td>
<td>Proper disposal of waste in rubbish bins</td>
</tr>
<tr>
<td>Balanced Planting Regime¹ (from Exotic gardens)</td>
<td>100%</td>
<td>50%</td>
<td>% of exotic garden replaced with a balanced planting regime</td>
</tr>
<tr>
<td>Balanced Plating Regime¹ (from Lawn area)</td>
<td>100%</td>
<td>50%</td>
<td>&amp; of lawn area replaced with a balanced planting regime</td>
</tr>
<tr>
<td>Native tree planting in areas of POS</td>
<td>100%</td>
<td>50%</td>
<td>Native plants used in POS plantings</td>
</tr>
</tbody>
</table>

¹. Balanced Planting Regime also includes native plants.
Albion Nutrient Input Modelling – Current Land Use
# Albion Nutrient Input Decision Support System

**Version 2.0 March 2005**

**Report Date:** 24-Jul-06

## Catchment Name
- Albion

## Option Description
- Current Landuse

---

### Catchment Area
- 576 ha

## Land Use Breakdown

- **Residential - R15**
  - lower density residential areas (excludes road reserve area)

- **Residential - R35**
  - higher density residential areas (excludes road reserve area)

- **Road Reserves - Minor**
  - maintenance of verge by landowners

- **Road Reserves - Major**
  - maintenance of verge by local authority

- **POS - Active**
  - ovals, grassed areas

- **POS - Passive / Basins**
  - native vegetation, airstrip, unfertilised areas

- **Rural - Pasture**
  - general pasture

- **Rural - Residential ~R2.5/R5**
  - low density

- **Rural - Poultry**
  - specific high nutrient input land use

- **Commercial/Industrial**
  - town centre etc

---

### Nutrient Input Without WSUD

#### Residential

- **Garden**
  - kg/ha/yr: 0.00
  - kg/gross ha/yr: 0.00
  - kg/yr: 0
  - %: 0.0%

- **Lawn**
  - kg/ha/yr: 0.00
  - kg/gross ha/yr: 0.00
  - kg/yr: 0
  - %: 0.0%

- **Pet Waste**
  - kg/ha/yr: 0.00
  - kg/gross ha/yr: 0.00
  - kg/yr: 0
  - %: 0.0%

- **Car Wash**
  - kg/ha/yr: 0.00
  - kg/gross ha/yr: 0.00
  - kg/yr: 0
  - %: 0.0%

- **Sub Total**
  - kg/ha/yr: 0.00
  - kg/gross ha/yr: 0.00
  - kg/yr: 0
  - %: 0.0%

#### POS

- **Garden/Lawn**
  - kg/ha POS/yr: 73.40
  - kg/gross ha/yr: 0.00
  - kg/yr: 0
  - %: 0.0%

- **Pet Waste**
  - kg/ha/yr: 0.00
  - kg/gross ha/yr: 0.00
  - kg/yr: 0
  - %: 0.0%

- **Sub Total**
  - kg/ha/yr: 0.00
  - kg/gross ha/yr: 0.00
  - kg/yr: 0
  - %: 0.0%

#### Road

- **Major Roads**
  - kg/ha RR/yr: 29.36
  - kg/gross ha/yr: 0.03
  - kg/yr: 17
  - %: 0.1%

- **Reserve**
  - **Minor Roads**
    - kg/ha/yr: 132.00
    - kg/gross ha/yr: 0.00
    - kg/yr: 0
    - %: 0.0%

  - **Sub Total**
    - kg/ha/yr: 0.03
    - kg/gross ha/yr: 0.03
    - kg/yr: 0
    - %: 0.1%

#### Rural

- **Pasture**
  - kg/ha Rural/yr: 60.00
  - kg/gross ha/yr: 33.60
  - kg/yr: 19,354
  - %: 87.0%

- **Poultry Farms**
  - kg/ha/yr: 175.00
  - kg/gross ha/yr: 0.88
  - kg/yr: 504
  - %: 2.3%

- **Residential (R2.5/R5)**
  - kg/ha/yr: 15.20
  - kg/gross ha/yr: 4.10
  - kg/yr: 2,364
  - %: 10.6%

- **Sub Total**
  - kg/ha/yr: 38.58
  - kg/gross ha/yr: 22,222
  - kg/yr: 22,238
  - %: 99.9%

**Total**
- kg/ha/yr: 38.61
- kg/gross ha/yr: 22,238
- kg/yr: 100.0%

---

### Nutrient Input Reduction

- **Total Nutrient Input - No WSUD (kg/yr):** 22,238
- **Reduction due to WSUD (kg/yr):** 0
- **Percentage Overall Reduction:** 0.0%
- **Percentage Development Reduction:** 0.0%
- **Cost of Selected Program ($/kg/yr):** $0

---

### Residential Areas (R15-R35) : Nutrient Removal via Source Control

- **Native Gardens (Lots - Garden)**
  - % Area of Removal: 0%
  - kg/ha/yr: 0.00
  - kg/gross ha/yr: 0.00
  - kg/yr: 0
  - %: 0.0%

- **Native Gardens (Lots - Lawn)**
  - % Area of Removal: 0%
  - kg/ha/yr: 0.00
  - kg/gross ha/yr: 0.00
  - kg/yr: 0
  - %: 0.0%

- **Native Gardens (POS)**
  - % Area of Removal: 0%
  - kg/ha/yr: 0.00
  - kg/gross ha/yr: 0.00
  - kg/yr: 0
  - %: 0.0%

- **Community Education : Fertiliser**
  - % Area of Removal: 0%
  - kg/ha/yr: 0.00
  - kg/gross ha/yr: 0.00
  - kg/yr: 0
  - %: 0.0%

- **Community Education : Pet Waste**
  - % Area of Removal: 0%
  - kg/ha/yr: 0.00
  - kg/gross ha/yr: 0.00
  - kg/yr: 0
  - %: 0.0%

- **Community Education : Car Wash**
  - % Area of Removal: 0%
  - kg/ha/yr: 0.00
  - kg/gross ha/yr: 0.00
  - kg/yr: 0
  - %: 0.0%

- **Street Sweeping**
  - % Area of Removal: 0%
  - kg/ha/yr: 0.00
  - kg/gross ha/yr: 0.00
  - kg/yr: 0
  - %: 0.0%

**Totals**
- % Area of Removal: 0%
- kg/ha/yr: 0
- kg/gross ha/yr: 0
- kg/yr: 0
- %: 0.0%

---

### Residential Areas (R15-R35) : Nutrient Removal via In-Transit Control

- **Gross Pollutant Trap**
  - % Area of Removal: 100%
  - kg/ha/yr: 0.00
  - kg/gross ha/yr: 0.00
  - kg/yr: 0
  - %: 0.0%

- **Water Pollution Control Pond**
  - % Area of Removal: 100%
  - kg/ha/yr: 0.00
  - kg/gross ha/yr: 0.00
  - kg/yr: 0
  - %: 0.0%

**Total**
- % Area of Removal: 100%
- kg/ha/yr: 0.00
- kg/gross ha/yr: 0.00
- kg/yr: 0
- %: 0.0%

---

### Net Nutrient Input

- **Nutrient Input : Residential Area without WSUD**
  - kg/ha/yr: 0.00
  - kg/gross ha/yr: 0.00
  - %: 0.0%

- **Nutrient Input : Residential Area**
  - kg/ha/yr: 38.61
  - kg/gross ha/yr: 22,238
  - %: 99.9%

- **Removal via Source Control**
  - kg/ha/yr: 0.00
  - kg/gross ha/yr: 0.00
  - %: 0.0%

- **Removal via In-Transit Control**
  - kg/ha/yr: 0.00
  - kg/gross ha/yr: 0.00
  - %: 0.0%

**Total Removal**
- kg/ha/yr: 0.00
- kg/gross ha/yr: 0.00
- %: 0.0%

**Net Nutrient Input**
- kg/ha/yr: 38.61
- kg/gross ha/yr: 22,238
- %: 100.0%
### NiDSS Core Data & Cost Calculations

**Nutrient Input Decision Support System**  
Version 2.0 March 2005

#### Analysis Type (1,2)

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<table>
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<tr>
<th></th>
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#### Ave lat/ha

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#### Discount Rate

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<th></th>
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<tbody>
<tr>
<td></td>
<td>0%</td>
</tr>
</tbody>
</table>

#### Community Education Information

- **Who Cares About the Environment?** (NSW EPA, 2000) Survey
  - 17% stated environment one of two most important issues for govt to address
  - Of these 27% stated water as most important environmental issue
  - 17% stated education most important issue to protect environment
  - Impact assumed to reduce fertiliser applications to minimum rates

#### Fertiliser Application Information/Assumptions

- Lots assumed fertilised by property owner
- Minor Road Reserves fertilised by property owner (verge assumed 40% road reserve)
- Major Road Reserves fertilised by local authority (verge assumed 40% road reserve)
- Active POS fertilised by local authority
- Passive POS not fertilised
- Rural Land Use and Poultry Farms have no reductions due to WSUD applied

#### Pet Waste

- **Data Source**
  - Pets per lot and disposal: via JDA Survey (2001)
  - TP & TN application via Gerritse et al. (1991)

#### Pet Waste Application Rates

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>TN</td>
<td>TP</td>
<td>Total Residential Area</td>
</tr>
<tr>
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<td>---</td>
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</tr>
<tr>
<td>0.90</td>
<td>0.20</td>
<td>0.90</td>
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</tbody>
</table>

#### Waste Disposal

- **R zoning**
  - Cost Data
    - Distribution $1.00 per house
    - Total PV Cost $0
  - Removal 0 kg/year
  - Cost per kg $0

#### Car Wash

- **Data Source**
  - Frequency based on JDA Survey (2001)
  - TN/TP based on Polyglaze Autowash data via CRC for Freshwater Ecology (Canberra)
  - Cost Estimate via JDA. Distribution cost and frequency is for brochure

#### Car Wash Application Rates & Washing Frequency

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>wash</td>
<td>TN</td>
<td>TP</td>
</tr>
<tr>
<td>---</td>
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<td>---</td>
</tr>
<tr>
<td>0.02</td>
<td>0.00</td>
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</tr>
</tbody>
</table>

#### Lot Fertiliser

- **Data Source**
  - Mean Fertiliser Applications via JDA survey (2001)
  - % garden and lawns estimated via Aerial photography JDA (2001) for various suburbs with similar zonings
  - Minimum Fertiliser Applications via product recommended application data

#### Lot Fertiliser Application Rates

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>kg/ha</td>
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</tr>
<tr>
<td>0.869</td>
<td>0.0667</td>
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</tbody>
</table>

#### POS Fertiliser

- **Data Source**
  - Application rates based on City of Armadale application to active POS areas in years 1999-2000
### Rural Land Use Fertiliser

**Data Source:** Estimates via Gerritse et al (1992) for pasture

**Application Rates**

<table>
<thead>
<tr>
<th>Region</th>
<th>Fertiliser mean application</th>
<th>TN or TP specified</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rural</td>
<td>60 20 60.00 kg TN/ha Rural/yr</td>
<td>60.00 kg TP/ha Rural/yr</td>
</tr>
</tbody>
</table>

### Poultry Farms

**Data Source:** Estimates via Gerritse et al (1992) based on 14000 hens on 42 ha property

**Application Rates**

<table>
<thead>
<tr>
<th>Region</th>
<th>Fertiliser mean application</th>
<th>TN or TP specified</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poultry</td>
<td>175 75 175.00 kg TN/ha farm/yr</td>
<td>175.00 kg TP/ha farm/yr</td>
</tr>
</tbody>
</table>

### Street Sweeping

**Data Source:** Street Sweeping Revisited - Nutrients and Metals in Particulate Size Fractions of Road Sediment

**Cost Calculation**

- Estimated Removal Rate (assumes no WSUD upstream)
- **Cost Data**
  - Cost: $55/km
- **Area to Apply**: 0.0 ha
- **Potential Reduction (kg/gross ha/yr)**
  - TN: 0.75 kg/gross ha/yr
  - TP: 0.35 kg/gross ha/yr
- **Total PV Cost**: $0

### In-Transit Controls - Stormwater Nutrient Load

**Data Source:** Nutrients in Perth Urban Surface Drainage Collectments Characterised by Applicable Attributes, Tan (1991)

**Estimated Stormwater Nutrient Load** (assumes no WSUD upstream)

- **Typical Phosphorus Stormwater Load (Perth Urban Areas)**: 0.40 kg/gross ha/yr
- **Typical Nitrogen Stormwater Load (Perth Urban Areas)**: 2.53 kg/gross ha/yr

### Gross Pollutant Trap

**Data Source:** Approximate average retention value via JDA(2001) - GeoTrap Laboratory Test Report

**Estimated Removal Rate**

<table>
<thead>
<tr>
<th>Region</th>
<th>Percentage Removal</th>
<th>TN or TP specified</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPT</td>
<td>35% 50% 35%</td>
<td>Maintenance $75</td>
</tr>
</tbody>
</table>

**Cost Calculation**

- **Capital Cost**: $1,880 per ha
- **Maintenance**: $72 per ha/year
- **Removal**: 0.0 kg/year
- **Cost per kg**: $0

### Water Pollution Control Pond

**Data Source:** TP removal efficiency and cost via Northbridge Drive WPCP Conceptual Design (JDA, 1997)

**Estimated Removal Rate**

<table>
<thead>
<tr>
<th>Region</th>
<th>Percentage Removal</th>
<th>TN or TP specified</th>
</tr>
</thead>
<tbody>
<tr>
<td>WPCP</td>
<td>35% 50% 35%</td>
<td>Maintenance $1,800,000 per year</td>
</tr>
</tbody>
</table>

**Cost Calculation**

- **Capital Cost**: $1,800,000
- **Maintenance**: $23,325 per year
- **Removal**: 0.0 kg/year
- **Operating**: $0
- **Total PV Cost**: $0
**Catchment Summary of Nutrient Removal due to Source Controls**

**Without WSUD**

<table>
<thead>
<tr>
<th>Component</th>
<th>Checkbox Result</th>
<th>% Area to Apply Removal to</th>
<th>Level before Removal (kg/gross ha/yr)</th>
<th>Potential Removal (kg/gross ha/yr)</th>
<th>Adopted Removal (kg/gross ha/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Native Gardens (Lots-Garden)</td>
<td>FALSE</td>
<td>0%</td>
<td>0.03</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Native Gardens (Lots-Lawn)</td>
<td>FALSE</td>
<td>0%</td>
<td>0.03</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Native Gardens (POS)</td>
<td>FALSE</td>
<td>0%</td>
<td>0.03</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Education Campaign - Fertiliser</td>
<td>FALSE</td>
<td>0%</td>
<td>0.03</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Education Campaign - Pet Waste</td>
<td>FALSE</td>
<td>0%</td>
<td>0.03</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Education Campaign - Car Wash</td>
<td>FALSE</td>
<td>0%</td>
<td>0.03</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Street Sweeping</td>
<td>FALSE</td>
<td>0%</td>
<td>0.03</td>
<td>0.75</td>
<td>0.00</td>
</tr>
<tr>
<td>Gross Pollutant Traps</td>
<td>FALSE</td>
<td>100%</td>
<td>0.03</td>
<td>0.89</td>
<td>0.00</td>
</tr>
<tr>
<td>Water Pollution Control Pond</td>
<td>FALSE</td>
<td>100%</td>
<td>0.03</td>
<td>0.89</td>
<td>0.00</td>
</tr>
</tbody>
</table>

**Education Campaign Fertiliser Reduction**

<table>
<thead>
<tr>
<th></th>
<th>Fertiliser Applied to Native Gardens kg/gross ha/yr</th>
<th>Removed due for further reduction kg/gross ha/yr</th>
<th>Available kg/gross ha/yr</th>
<th>% applied reduction to min level</th>
<th>education campaign effectiveness reduction kg/gross ha/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Garden</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>83%</td>
<td>0%</td>
</tr>
<tr>
<td>Lawn</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>73%</td>
<td>0%</td>
</tr>
<tr>
<td>Road Reserve Minor</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>73%</td>
<td>0%</td>
</tr>
</tbody>
</table>

**Total** 0.00

**Nutrient Removal via In-Transit Controls**

Stormwater Load Available for Removal (ie no WSUD) 2.530 kg/gross ha/yr

<table>
<thead>
<tr>
<th>Component</th>
<th>reduction due to WSUD%</th>
<th>adjusted rate to use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross Pollutant Traps</td>
<td>0.00%</td>
<td>2.530</td>
</tr>
<tr>
<td>Water Pollution Control Pond</td>
<td>0.00%</td>
<td>2.530</td>
</tr>
</tbody>
</table>
# NiDSS : WSUD Option Summary

## Nutrient Input Decision Support System

**Version 2.0 March 2005**  
**JDA Consultant Hydrologists**  
**Report Date : 24-Jul-06**

### Catchment Name
Albion

### Catchment Area
576 ha

### Total Phosphorus Input : Summary of Options

<table>
<thead>
<tr>
<th>Option</th>
<th>Development Input kg/year</th>
<th>Rural Input kg/yr</th>
<th>Total Input kg/yr</th>
<th>WSUD Reduction kg/yr</th>
<th>Net Input kg/yr</th>
<th>Input Rate kg/ha/yr</th>
<th>Overall Reduction %</th>
<th>Development Reduction %</th>
<th>Cost of Reduction $/kg/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing Land Use</td>
<td>45</td>
<td>5,882</td>
<td>5,927</td>
<td>0</td>
<td>5,927</td>
<td>17.1</td>
<td>0.0%</td>
<td>0.0%</td>
<td>$0.0</td>
</tr>
<tr>
<td>Proposed Land Use - No WSUD</td>
<td>5,843</td>
<td>288</td>
<td>6,131</td>
<td>0</td>
<td>6,131</td>
<td>17.1</td>
<td>0.0%</td>
<td>0.0%</td>
<td>$0.0</td>
</tr>
<tr>
<td>Proposed Land Use - With WSUD</td>
<td>5,843</td>
<td>288</td>
<td>6,131</td>
<td>2,864</td>
<td>3,267</td>
<td>9.4</td>
<td>46.7%</td>
<td>49.0%</td>
<td>$72.5</td>
</tr>
</tbody>
</table>

### Total Nitrogen Input : Summary of Options

<table>
<thead>
<tr>
<th>Option</th>
<th>Development Input kg/year</th>
<th>Rural Input kg/yr</th>
<th>Total Input kg/yr</th>
<th>WSUD Reduction kg/yr</th>
<th>Net Input kg/yr</th>
<th>Input Rate kg/ha/yr</th>
<th>Overall Reduction %</th>
<th>Development Reduction %</th>
<th>Cost of Reduction $/kg/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing Land Use</td>
<td>1,278</td>
<td>17,646</td>
<td>18,916</td>
<td>0</td>
<td>18,916</td>
<td>54.7</td>
<td>0.0%</td>
<td>0.0%</td>
<td>$0.0</td>
</tr>
<tr>
<td>Proposed Land Use - No WSUD</td>
<td>27,258</td>
<td>10,933</td>
<td>28,351</td>
<td>0</td>
<td>28,351</td>
<td>81.9</td>
<td>0.0%</td>
<td>0.0%</td>
<td>$0.0</td>
</tr>
<tr>
<td>Proposed Land Use - With WSUD</td>
<td>27,258</td>
<td>10,933</td>
<td>28,351</td>
<td>11,709</td>
<td>16,642</td>
<td>48.1</td>
<td>41.3%</td>
<td>43.0%</td>
<td>$19.1</td>
</tr>
<tr>
<td>Option Description</td>
<td>Residential (R15-R35)</td>
<td>Nutrient Removal via Source Control</td>
<td>Nutrient Removal via In-Transit Control</td>
<td>Net Nutrient Input</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>------------------------------------</td>
<td>-----------------------</td>
<td>-------------------------------------</td>
<td>----------------------------------------</td>
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<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>% Area of Influence</td>
<td>Removal</td>
<td>Removal</td>
<td>Removal</td>
<td>Capital</td>
<td>Operating</td>
<td>Cost</td>
<td>Cost</td>
</tr>
<tr>
<td>Residential Areas (R15-R35)</td>
<td></td>
<td>0%</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>Native Gardens (Lots - Garden)</td>
<td></td>
<td>0%</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>Native Gardens (Lots - Lawn)</td>
<td></td>
<td>0%</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>Native Gardens (POS)</td>
<td></td>
<td>0%</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>Community Education : Fertiliser</td>
<td></td>
<td>0%</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>Community Education : Pet Waste</td>
<td></td>
<td>0%</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>Community Education : Car Wash</td>
<td></td>
<td>0%</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>Street Sweeping</td>
<td></td>
<td>0%</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>Totals</td>
<td></td>
<td>0%</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
</tr>
</tbody>
</table>

**Residential Areas (R15-R35) : Nutrient Removal via Source Control**
- Gross Pollutant Trap
- Water Pollution Control Pond

**Residential Areas (R15-R35) : Nutrient Removal via In-Transit Control**
- Gross Pollutant Trap
- Water Pollution Control Pond

**Net Nutrient Input**
- kg/gross ha/yr
- kg/yr
- %
### Community Education Information

WHO Cares About the Environment? (NSW EPA, 2000) Survey
- 17% stated environment one of two most important issues for govt to address
- 27% stated water as most important environmental issue
- 17% stated education as most important issue to protect environment
Impact assumed to reduce fertiliser applications to minimum rates

### Fertiliser Application Information/Assumptions

Lots assumed fertilised by property owner
- Minor Road Reserves fertilised by property owner (verge assumed 40% road reserve)
- Major Road Reserves fertilised by local authority (verge assumed 40% road reserve)
- Active POS fertilised by local authority
- Passive POS not fertilised
- Rural Land Use and Poultry Farms have no reductions due to WSUD applied

### Pet Waste

**Data Source**
- Pets per lot and disposal: via JDA Survey (2001)
- TP & TN application via Gerritse at al (1991)
Cost Estimate via JDA. Distribution cost and frequency is for brochure, bag cost is for POS's

**Application Rates**

<table>
<thead>
<tr>
<th>Category</th>
<th>Cats</th>
<th>Sml Dogs</th>
<th>Med Dogs</th>
<th>Lge Dogs</th>
<th>Number of Dogs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pets Per Lot</td>
<td>0.90</td>
<td>2.75</td>
<td>5.50</td>
<td>8.25</td>
<td></td>
</tr>
<tr>
<td>R15 (kg/yr)</td>
<td>0.20</td>
<td>0.70</td>
<td>1.40</td>
<td>2.10</td>
<td></td>
</tr>
<tr>
<td>R35 (kg/yr)</td>
<td>0.16</td>
<td>0.12</td>
<td>0.16</td>
<td>0.19</td>
<td></td>
</tr>
</tbody>
</table>

### Car Wash

**Data Source**
- Frequency based on JDA Survey (2001)
- TN/TP based on Polyglaze Autowash data via CRC for Freshwater Ecology (Canberra)
Cost Estimate via JDA. Distribution cost and frequency is for brochure

**Application Rates & Washing Frequency**

<table>
<thead>
<tr>
<th>Car Wash detergent</th>
<th>Frequency</th>
<th>TN/kg</th>
<th>TP/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>(one car every x weeks)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Lot Fertiliser

**Data Source**
- Mean Fertiliser Applications via JDA survey (2001)
- % garden and lawn estimated via Aerial photography JDA(2001) for various suburbs with similar zonings
- Minimum Fertiliser Applications via product recommended application data

**Application Rates**

<table>
<thead>
<tr>
<th>Garden</th>
<th>Lawn</th>
<th>Garden</th>
<th>Lawn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fertiliser mean application</td>
<td>0.85</td>
<td>0.27</td>
<td>0.75</td>
</tr>
<tr>
<td>Fertiliser min application</td>
<td>0.27</td>
<td>0.09</td>
<td>0.24</td>
</tr>
</tbody>
</table>

### POS Fertiliser

**Data Source**
- Application rates based on City of Adelaide application to active POS areas in years 1995-2000

**Application Rates**

<table>
<thead>
<tr>
<th>POS</th>
<th>Fertiliser mean application</th>
<th>0.85</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fertiliser min application</td>
<td>0.27</td>
</tr>
</tbody>
</table>
**NiDSS Core Data & Cost Calculations**

**Nutrient Input Decision Support System**

**Version 2.0 March 2005**

### Rural Land Use Fertiliser

**Data Source:** Estimates via Gerritse et al (1992) for pasture

**Application Rates**

<table>
<thead>
<tr>
<th></th>
<th>Fertiliser mean application</th>
<th>TN or TP</th>
<th>specified</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rural</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Poultry Farms

**Data Source:** Estimates via Gerritse (et al) 1992

**Application Rates**

<table>
<thead>
<tr>
<th></th>
<th>Fertiliser mean application</th>
<th>TN or TP</th>
<th>specified</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poultry</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Street Sweeping

**Data Source:** Street Sweeping Revisited - Nutrients and Metals in Particle Size Fractions of Road Sediment

**Application Rates**

<table>
<thead>
<tr>
<th></th>
<th>Fertiliser mean application</th>
<th>TN or TP</th>
<th>specified</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Cost Calculation**

- **Estimated Removal Rate**
  - (assumes no WSUD upstream)

- **Cost Data**
  - Cost $55/km

Note: Street sweeping applied to developed areas only - not existing rural land use areas not to be developed

### In-Transit Controls - Stormwater Nutrient Load

**Data Source:** Nutrients in Perth Urban Surface Drainage Catchments Characterised by Applicable Attributes, Tan (1991)

**Cost Data**

- **Estimated Stormwater Nutrient Load**
  - (assumes no WSUD upstream)

- **Cost Calculation**
  - Total PV Cost $0

**Note:** Stormwater applied to developed areas only - not existing rural land use areas not to be developed

### Gross Pollutant Trap

**Data Source:** Approximate average retention value via JDA(2001) - GeoTrap Laboratory Test Report

**Estimated Removal Rate**

<table>
<thead>
<tr>
<th></th>
<th>Percentage Removal</th>
<th>TN or TP</th>
<th>Capital Cost</th>
<th>Maintenance</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPT</td>
<td></td>
<td>35%</td>
<td>$1,880</td>
<td>$72</td>
</tr>
</tbody>
</table>

**Note:** GPT's applied to developed areas only - not existing rural land use areas not to be developed

### Water Pollution Control Pond

**Data Source:** TN and TP removal efficiency and cost via Henley Brook Waterway WPCP (operational stage) JDA, 1991

**Estimated Removal Rate**

<table>
<thead>
<tr>
<th></th>
<th>Percentage Removal</th>
<th>TN or TP</th>
<th>Capital Cost</th>
<th>Maintenance</th>
</tr>
</thead>
<tbody>
<tr>
<td>WPCP</td>
<td></td>
<td>35%</td>
<td>$1,600,000</td>
<td>$23,000</td>
</tr>
</tbody>
</table>

**Note:** WPCP's applied to developed areas only - not existing rural land use areas not to be developed
## Analysis Type

**Total Phosphorus**

## Catchment Summary of Nutrient Removal due to Source Controls

**Without WSUD**

<table>
<thead>
<tr>
<th>Component</th>
<th>Checkbox Result</th>
<th>% Area to Apply</th>
<th>Level before Removal</th>
<th>Potential Removal</th>
<th>Adopted Removal (kg/gross ha/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Native Gardens (Lots-Garden)</td>
<td>FALSE</td>
<td>0%</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Native Gardens (Lots-Lawn)</td>
<td>FALSE</td>
<td>0%</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Native Gardens (POS)</td>
<td>FALSE</td>
<td>0%</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Education Campaign - Fertiliser</td>
<td>FALSE</td>
<td>0%</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Education Campaign - Pet Waste</td>
<td>FALSE</td>
<td>0%</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Education Campaign - Car Wash</td>
<td>FALSE</td>
<td>0%</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Street Sweeping</td>
<td>FALSE</td>
<td>0%</td>
<td>0.00</td>
<td>0.35</td>
<td>0.00</td>
</tr>
<tr>
<td>Gross Pollutant Traps</td>
<td>FALSE</td>
<td>100%</td>
<td>0.00</td>
<td>0.20</td>
<td>0.00</td>
</tr>
<tr>
<td>Water Pollution Control Pond</td>
<td>FALSE</td>
<td>100%</td>
<td>0.00</td>
<td>0.20</td>
<td>0.00</td>
</tr>
</tbody>
</table>

**Total**

0.00 kg/gross ha/yr via developed area

7290 kg/yr

---

### Education Campaign Fertiliser Reduction

<table>
<thead>
<tr>
<th>Component</th>
<th>Fertiliser Applied to Native Gardens kg/gross ha/yr</th>
<th>Removed due for further reduction kg/gross ha/yr</th>
<th>% applied reduction to min level</th>
<th>education campaign effectiveness</th>
<th>reduction kg/gross ha/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Garden</td>
<td>0.00</td>
<td>0.00</td>
<td>89%</td>
<td>0%</td>
<td>0.00</td>
</tr>
<tr>
<td>Lawn</td>
<td>0.00</td>
<td>0.00</td>
<td>80%</td>
<td>0%</td>
<td>0.00</td>
</tr>
<tr>
<td>Road Reserve Minor</td>
<td>0.00</td>
<td>0.00</td>
<td>80%</td>
<td>0%</td>
<td>0.00</td>
</tr>
<tr>
<td>Total</td>
<td>0.00</td>
<td>0.00</td>
<td>80%</td>
<td>0%</td>
<td>0.00</td>
</tr>
</tbody>
</table>

### Nutrient Removal via In-Transit Controls

**Stormwater Load Available for Removal**

0.400 kg/gross ha/yr (ie no WSUD)

<table>
<thead>
<tr>
<th>Component</th>
<th>reduction due to WSUD</th>
<th>adjusted upstream rate to use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross Pollutant Traps</td>
<td>0.00%</td>
<td>0.400</td>
</tr>
<tr>
<td>Water Pollution Control Pond</td>
<td>0.00%</td>
<td>0.400</td>
</tr>
</tbody>
</table>
### Catchment Name

**Albion**

**Catchment Area**

576 ha

### Total Phosphorus Input: Summary of Options

<table>
<thead>
<tr>
<th>Option</th>
<th>Development Input kg/year</th>
<th>Rural Input kg/yr</th>
<th>Total Input kg/yr</th>
<th>WSUD Reduction kg/yr</th>
<th>Net Input kg/yr</th>
<th>Input Rate kg/ha/yr</th>
<th>Overall Reduction %</th>
<th>Development Reduction %</th>
<th>Cost of Reduction $/kg/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Existing Land Use</td>
<td>45</td>
<td>5,882</td>
<td>5,927</td>
<td>0</td>
<td>5,927</td>
<td>17.1</td>
<td>0.0%</td>
<td>0.0%</td>
<td>$0.0</td>
</tr>
<tr>
<td>2 Proposed Land Use - No WSUD</td>
<td>5,843</td>
<td>288</td>
<td>6,131</td>
<td>0</td>
<td>6,131</td>
<td>17.7</td>
<td>0.0%</td>
<td>0.0%</td>
<td>$0.0</td>
</tr>
<tr>
<td>3 Proposed Land Use - With WSUD</td>
<td>5,843</td>
<td>288</td>
<td>6,131</td>
<td>2,864</td>
<td>3,267</td>
<td>9.4</td>
<td>46.7%</td>
<td>49.0%</td>
<td>$72.5</td>
</tr>
</tbody>
</table>

### Total Nitrogen Input: Summary of Options

<table>
<thead>
<tr>
<th>Option</th>
<th>Development Input kg/year</th>
<th>Rural Input kg/yr</th>
<th>Total Input kg/yr</th>
<th>WSUD Reduction kg/yr</th>
<th>Net Input kg/yr</th>
<th>Input Rate kg/ha/yr</th>
<th>Overall Reduction %</th>
<th>Development Reduction %</th>
<th>Cost of Reduction $/kg/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Existing Land Use</td>
<td>1,276</td>
<td>17,646</td>
<td>18,916</td>
<td>0</td>
<td>18,916</td>
<td>54.7</td>
<td>0.0%</td>
<td>0.0%</td>
<td>$0.0</td>
</tr>
<tr>
<td>2 Proposed Land Use - No WSUD</td>
<td>27,258</td>
<td>1,093</td>
<td>28,351</td>
<td>0</td>
<td>28,351</td>
<td>81.9</td>
<td>0.0%</td>
<td>0.0%</td>
<td>$0.0</td>
</tr>
<tr>
<td>3 Proposed Land Use - With WSUD</td>
<td>27,258</td>
<td>1,093</td>
<td>28,351</td>
<td>11,709</td>
<td>16,642</td>
<td>48.1</td>
<td>41.3%</td>
<td>43.0%</td>
<td>$19.1</td>
</tr>
</tbody>
</table>
Albion Nutrient Input Modelling – Residential Development
**Albion**

**Total Nutrient Input - No WSUD (kg/yr)**

<table>
<thead>
<tr>
<th>Nutrient Input Decision Support System</th>
<th>Reduction due to WSUD (kg/yr)</th>
<th>Percentage Overall Reduction</th>
<th>Percentage Development Reduction</th>
<th>Cost of Selected Program ($/kg/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>57,380</td>
<td>31,216</td>
<td>54.4%</td>
<td>54.4%</td>
<td>$11</td>
</tr>
</tbody>
</table>

**Catchment Name**: Albion

**Option Description**: Residential Development with WSUD

**Catchment Area**: 576 ha

**Land Use Breakdown**

- **Residential**: 58.5% lower density residential areas (excludes road reserve area)
- **Residential**: 18.5% higher density residential areas (excludes road reserve area)
- **Road Reserves - Minor**: 9.4% maintenance of verge by landowners
- **Road Reserves - Major**: 4.0% maintenance of verge by local authority
- **POS - Active**: 13.2% ovals, grassed areas
- **POS - Passive / Basins**: 17.0% native vegetation, airstrip, unfertilised areas
- **Rural - Pasture**: 5.0% general pasture
- **Rural - Residential - R2.5/R5**: 0.0% low density
- **Rural - Poultry**: 0.0% specific high nutrient input land use
- **Commercial/Industrial**: 1.4% town centre etc

**Nutrient Input Without WSUD**

<table>
<thead>
<tr>
<th>Component</th>
<th>Residential Garden</th>
<th>Residential Lawn</th>
<th>Residential Pet Waste</th>
<th>Residential Car Wash</th>
<th>Sub Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>kg/ha/yr</td>
<td>70.75</td>
<td>71.63</td>
<td>12.37</td>
<td>0.04</td>
<td>74.18</td>
</tr>
<tr>
<td>kg/gross ha/yr</td>
<td>27.93</td>
<td>39.42</td>
<td>6.81</td>
<td>0.02</td>
<td>42.729</td>
</tr>
<tr>
<td>kg/yr</td>
<td>16,089</td>
<td>22,707</td>
<td>3,920</td>
<td>11</td>
<td>31,216</td>
</tr>
<tr>
<td>Percentage</td>
<td>28.0%</td>
<td>38.6%</td>
<td>6.8%</td>
<td>0.0%</td>
<td>54.4%</td>
</tr>
</tbody>
</table>

**Nutrient Input Without WSUD**

<table>
<thead>
<tr>
<th>Component</th>
<th>Residential Garden</th>
<th>Residential Lawn</th>
<th>Residential Pet Waste</th>
<th>Residential Car Wash</th>
<th>Sub Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>kg/ha/yr</td>
<td>73.45</td>
<td>16.41</td>
<td>12.37</td>
<td>0.04</td>
<td>96.22</td>
</tr>
<tr>
<td>kg/gross ha/yr</td>
<td>1.77</td>
<td>4.24</td>
<td>71.63</td>
<td>0.02</td>
<td>78.82</td>
</tr>
<tr>
<td>kg/yr</td>
<td>5,581</td>
<td>1,247</td>
<td>22,707</td>
<td>11</td>
<td>27,216</td>
</tr>
<tr>
<td>Percentage</td>
<td>9.7%</td>
<td>2.2%</td>
<td>39.6%</td>
<td>0.0%</td>
<td>54.4%</td>
</tr>
</tbody>
</table>

**Nutrient Input Without WSUD**

<table>
<thead>
<tr>
<th>Component</th>
<th>POB Garden/Lawn</th>
<th>POB Pet Waste</th>
<th>POB Sub Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>kg/ha/yr</td>
<td>73.45</td>
<td>16.41</td>
<td>96.22</td>
</tr>
<tr>
<td>kg/gross ha/yr</td>
<td>1.77</td>
<td>4.24</td>
<td>78.82</td>
</tr>
<tr>
<td>kg/yr</td>
<td>5,581</td>
<td>1,247</td>
<td>27,216</td>
</tr>
<tr>
<td>Percentage</td>
<td>9.7%</td>
<td>2.2%</td>
<td>54.4%</td>
</tr>
</tbody>
</table>

**Nutrient Input Without WSUD**

| Component                  | Road Major Roads   | Road Reserve Minor Roads | Sub Total | |
|----------------------------|--------------------|--------------------------|-----------| |
| kg/ha/yr                   | 29.36              | 12.41                    | 13.58     | |
| kg/gross ha/yr             | 1.17               | 7.147                    | 7.823     | |
| kg/yr                      | 676                | 12.5%                    | 13.6%     | |

**Nutrient Input Without WSUD**

| Component                  | Rural Pasture      | Rural Poultry Farms     | Rural Residential (R2.5/R5) | Sub Total | |
|----------------------------|--------------------|-------------------------|-----------------------------|-----------| |
| kg/ha/yr                   | 60.00              | 175.00                  | 15.20                        | 0.05      | |
| kg/gross ha/yr             | 0.00               | 0.00                    | 0.00                         | 0.00      | |
| kg/yr                      | 0                  | 0                       | 0                            | 0         | |
| Percentage                 | 0.0%               | 0.0%                    | 0.0%                         | 0.0%      | |

**Net Nutrient Input**

<table>
<thead>
<tr>
<th>Component</th>
<th>kg/ha/yr</th>
<th>kg/yr</th>
<th>Percentage</th>
<th>Cost $</th>
<th>Cost $/yr</th>
<th>Cost $/kg/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential Areas (R15-R35)</td>
<td>Residential</td>
<td>53.38</td>
<td>30,745</td>
<td>53.6%</td>
<td>$0</td>
<td>$0.0</td>
</tr>
<tr>
<td></td>
<td>Rural Areas</td>
<td>0.00</td>
<td>0.0</td>
<td>0.0%</td>
<td>$0</td>
<td>$0.0</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>53.38</td>
<td>30,745</td>
<td>53.6%</td>
<td>$0</td>
<td>$0.0</td>
</tr>
</tbody>
</table>

**Total Phosphorus**

<table>
<thead>
<tr>
<th>Component</th>
<th>kg/ha/yr</th>
<th>kg/yr</th>
<th>Percentage</th>
<th>Cost $</th>
<th>Cost $/yr</th>
<th>Cost $/kg/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential Areas (R15-R35)</td>
<td>Residential</td>
<td>54.19</td>
<td>31,216</td>
<td>54.4%</td>
<td>$0</td>
<td>$0.0</td>
</tr>
<tr>
<td></td>
<td>Rural Areas</td>
<td>0.02</td>
<td>471</td>
<td>0.8%</td>
<td>$0</td>
<td>$0.0</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>54.19</td>
<td>31,216</td>
<td>54.4%</td>
<td>$0</td>
<td>$0.0</td>
</tr>
</tbody>
</table>

**Net Nutrient Input**

<table>
<thead>
<tr>
<th>kg/ha/yr</th>
<th>kg/yr</th>
<th>Percentage</th>
<th>Cost $</th>
<th>Cost $/yr</th>
<th>Cost $/kg/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential Areas (R15-R35)</td>
<td>45.42</td>
<td>26,164</td>
<td>45.6%</td>
<td>$0</td>
<td>$0.0</td>
</tr>
</tbody>
</table>
## NiDSS Core Data & Cost Calculations

**Nutrient Input Decision Support System**

**Version 2.0 March 2005**

### Analysis Type (1, 2)

<table>
<thead>
<tr>
<th>Ave Lots/Net ha</th>
<th>% of total residential area as ~R15</th>
<th>% of total residential area as ~R35</th>
</tr>
</thead>
<tbody>
<tr>
<td>21.0</td>
<td>30%</td>
<td>23%</td>
</tr>
</tbody>
</table>

### Community Education Information

- **Who Cares About the Environment?** (NSW EPA, 2000) Survey
  - 17% stated environment one of two most important issues for govt to address
  - 27% stated water as most important environmental issue
  - 17% stated education most important issue to protect environment
  - Impact assumed to reduce fertiliser applications to minimum rates

### Fertiliser Application Information/Assumptions

- Jobs assisted fertilised by property owner
- Minor Road Reserves fertilised by property owner (verge assumed 40% road reserve)
- Major Road Reserves fertilised by local authority (verge assumed 40% road reserve)
- Active POS fertilised by local authority
- Passive POS not fertilised
- Rural Land Use and Poultry Farms have no reductions due to WSUD applied

### Pet Waste

**Data Source**

- Pets per lot and disposal: via JDA Survey (2001)
- TP & TN application via Gerritse at al (1991)
- Cost Estimate via JDA. Distribution cost and frequency is for brochure, bag cost is for POS's

**Application Rates**

<table>
<thead>
<tr>
<th>TN</th>
<th>TP</th>
<th>Survey Results</th>
<th>Cost Calculation</th>
</tr>
</thead>
<tbody>
<tr>
<td>kg/yr</td>
<td>kg/yr</td>
<td>specified</td>
<td>R15</td>
</tr>
<tr>
<td>Cats</td>
<td>0.90</td>
<td>0.20</td>
<td>0.90</td>
</tr>
<tr>
<td>Small Dogs</td>
<td>2.75</td>
<td>0.70</td>
<td>2.75</td>
</tr>
<tr>
<td>Medium Dogs</td>
<td>5.50</td>
<td>1.40</td>
<td>5.50</td>
</tr>
<tr>
<td>Large Dogs</td>
<td>8.25</td>
<td>2.10</td>
<td>8.25</td>
</tr>
<tr>
<td>Waste Disposal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lot</td>
<td>35%</td>
<td>55%</td>
<td>R35</td>
</tr>
<tr>
<td>Bins</td>
<td>55%</td>
<td>80%</td>
<td>R35</td>
</tr>
</tbody>
</table>

**Car Wash**

**Data Source**

- Frequency based on JDA Survey (2001)
- TN/TP based on Polyglaze Autowash data via CRC for Freshwater Ecology (Canberra)
- Cost Estimate via JDA. Distribution cost and frequency is for brochure

**Application Rates & Washing Frequency**

<table>
<thead>
<tr>
<th>Car wash detergent</th>
<th>Washing Frequency</th>
<th>Cost Calculation</th>
</tr>
</thead>
<tbody>
<tr>
<td>kg/vehicle</td>
<td>kg/vehicle</td>
<td>specified</td>
</tr>
<tr>
<td>0.00099</td>
<td>0.00099</td>
<td>0.00099</td>
</tr>
<tr>
<td>Cost Data</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distribution</td>
<td>$1.10</td>
<td>per house</td>
</tr>
<tr>
<td>Frequency</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Years</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Lot Fertiliser**

**Data Source**

- Mean Fertiliser Applications via JDA survey (2001)
- % garden and lawn estimated via Aerial photography for various suburbs with similar zonings
- Minimum Fertiliser Applications via product recommended application data

**Application Rates**

<table>
<thead>
<tr>
<th>% garden</th>
<th>Infirmer mean application</th>
<th>TN or TP</th>
<th>Infirmer min application</th>
<th>TN or TP</th>
<th>Education Campaign Fertiliser Reduction</th>
<th>TN or TP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>kg TN/ha/year</td>
<td>kg TP/ha/year</td>
<td>kg TN/ha/year</td>
<td>kg TP/ha/year</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Garden</td>
<td>0.899</td>
<td>0.899</td>
<td>0.0002</td>
<td>0.0004</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lawn</td>
<td>0.899</td>
<td>0.899</td>
<td>0.0002</td>
<td>0.0004</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Garden and Lawn Areas**

<table>
<thead>
<tr>
<th>% garden</th>
<th>Infirmer mean application</th>
<th>TN or TP</th>
<th>Infirmer min application</th>
<th>TN or TP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>kg TN/ha</td>
<td>kg TP/ha</td>
<td>kg TN/ha</td>
<td>kg TP/ha</td>
</tr>
<tr>
<td>R15</td>
<td>0.28</td>
<td>0.28</td>
<td>0.28</td>
<td>0.28</td>
</tr>
<tr>
<td>R35</td>
<td>0.44</td>
<td>0.44</td>
<td>0.44</td>
<td>0.44</td>
</tr>
</tbody>
</table>

**POS Fertiliser**

**Data Source**

- Application rates based on City of Armadale application to audit POS areas in years 1999-2000

**Application Rates**

<table>
<thead>
<tr>
<th>POS</th>
<th>Infirmer mean application</th>
<th>TN or TP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>kg TN/ha POS/yr</td>
<td>kg TP/ha POS/yr</td>
</tr>
<tr>
<td>R15</td>
<td>0.28</td>
<td>0.28</td>
</tr>
<tr>
<td>R35</td>
<td>0.44</td>
<td>0.44</td>
</tr>
</tbody>
</table>
### Rural Land Use Fertiliser

**Data Source:** Estimates via Gerritse et al (1992) for pasture

**Application Rates**

<table>
<thead>
<tr>
<th>Rural</th>
<th>Nitrogen (N)</th>
<th>Phosphorus (P)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Application Rate</td>
<td>42 kg N/ha</td>
<td>12 kg P/ha</td>
</tr>
<tr>
<td>Specified Rate</td>
<td>40 kg N/ha</td>
<td>10 kg P/ha</td>
</tr>
</tbody>
</table>

### Poultry Farms

**Data Source:** Estimates via Gerritse et al (1992)

**Application Rates**

<table>
<thead>
<tr>
<th>Poultry</th>
<th>Nitrogen (N)</th>
<th>Phosphorus (P)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Application Rate</td>
<td>175 kg N/ha</td>
<td>75 kg P/ha</td>
</tr>
<tr>
<td>Specified Rate</td>
<td>175 kg N/ha</td>
<td>75 kg P/ha</td>
</tr>
</tbody>
</table>

### Street Sweeping

**Data Source:** Street Sweeping Revisited - Nutrients and Metals in Particle Size Fractions of Road Sediment

**Application Rates**

<table>
<thead>
<tr>
<th>Sweeping</th>
<th>Nitrogen (N)</th>
<th>Phosphorus (P)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specified Rate</td>
<td>0.75 kg/gross ha/yr</td>
<td>0.35 kg/gross ha/yr</td>
</tr>
</tbody>
</table>

**Cost Calculation**

<table>
<thead>
<tr>
<th>Area to Apply</th>
<th>Cost per kg</th>
<th>Total PV Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>568.2 ha</td>
<td>$443</td>
<td>$253,640</td>
</tr>
</tbody>
</table>

### In-Transit Controls - Stormwater Nutrient Load

**Data Source:** Nutrients in Perth Urban Surface Drainage Catchments Characterised by Applicable Attributes, Tan (1991)

**Estimated Stormwater Nutrient Load**

| Typical Phosphorus Stormwater Load (Perth Urban Areas) | 0.40 kg/gross ha/yr |
| Typical Nitrogen Stormwater Load (Perth Urban Areas) | 2.53 kg/gross ha/yr |

### Gross Pollutant Trap

**Data Source:** Approximate average retention value via JDA (2001) - GeoTrap Laboratory Test Report

**Estimated Removal Rate**

<table>
<thead>
<tr>
<th>GPT</th>
<th>Nitrogen (N)</th>
<th>Phosphorus (P)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage Removal</td>
<td>35%</td>
<td>35%</td>
</tr>
</tbody>
</table>

**Cost Calculation**

<table>
<thead>
<tr>
<th>Area to Apply</th>
<th>Cost per kg</th>
<th>Total PV Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>568.2 ha</td>
<td>$1,880</td>
<td>$1,043,120</td>
</tr>
</tbody>
</table>

### Water Pollution Control Pond

**Data Source:** Stormwater Nutrient Load via Managing Urban Stormwater Treatment Techniques (NSW EPA 1997)

**Estimated Removal Rate**

<table>
<thead>
<tr>
<th>WPCP</th>
<th>Nitrogen (N)</th>
<th>Phosphorus (P)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage Removal</td>
<td>35%</td>
<td>35%</td>
</tr>
</tbody>
</table>

**Cost Calculation**

<table>
<thead>
<tr>
<th>Area to Apply</th>
<th>Cost per kg</th>
<th>Total PV Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>568.2 ha</td>
<td>$1,800,000</td>
<td>$3,015,976</td>
</tr>
</tbody>
</table>
## Nutrient Removal Calculations

### Analysis Type

- **Total Nitrogen**

### Catchment Summary of Nutrient Removal due to Source Controls

#### Without WSUD

- **Total Nitrogen Input:** 57380 kg/yr
- **Nutrient Removal:** 99.62 kg/gross ha/yr via developed area

<table>
<thead>
<tr>
<th>Component</th>
<th>Checkbox Result</th>
<th>% Area to Apply</th>
<th>Level before Removal</th>
<th>Potential Removal</th>
<th>Adopted Removal (kg/gross ha/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Native Gardens (Lots-Garden)</td>
<td>TRUE</td>
<td>50%</td>
<td>99.62</td>
<td>27.93</td>
<td>13.97</td>
</tr>
<tr>
<td>Native Gardens (Lots-Lawn)</td>
<td>TRUE</td>
<td>50%</td>
<td>85.65</td>
<td>39.42</td>
<td>19.71</td>
</tr>
<tr>
<td>Native Gardens (POS)</td>
<td>TRUE</td>
<td>50%</td>
<td>65.94</td>
<td>9.69</td>
<td>4.84</td>
</tr>
<tr>
<td>Education Campaign - Fertiliser</td>
<td>TRUE</td>
<td>100%</td>
<td>61.10</td>
<td>2.96</td>
<td>2.96</td>
</tr>
<tr>
<td>Education Campaign - Pet Waste</td>
<td>TRUE</td>
<td>100%</td>
<td>49.56</td>
<td>2.96</td>
<td>2.96</td>
</tr>
<tr>
<td>Education Campaign - Car Wash</td>
<td>TRUE</td>
<td>100%</td>
<td>46.60</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Street Sweeping</td>
<td>TRUE</td>
<td>100%</td>
<td>46.59</td>
<td>0.35</td>
<td>0.35</td>
</tr>
<tr>
<td>Gross Pollutant Traps</td>
<td>TRUE</td>
<td>100%</td>
<td>46.24</td>
<td>0.41</td>
<td>0.41</td>
</tr>
<tr>
<td>Water Pollution Control Pond</td>
<td>TRUE</td>
<td>100%</td>
<td>45.83</td>
<td>0.41</td>
<td>0.41</td>
</tr>
</tbody>
</table>

### Education Campaign Fertiliser Reduction

<table>
<thead>
<tr>
<th>Component</th>
<th>Fertiliser Applied No WSUD (kg/gross ha/yr)</th>
<th>Removed due to Native Gardens (kg/gross ha/yr)</th>
<th>Available for further reduction (kg/gross ha/yr)</th>
<th>% applied reduction to min level</th>
<th>education campaign effectiveness</th>
<th>education reduction (kg/gross ha/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Garden</td>
<td>27.93</td>
<td>13.97</td>
<td>13.97</td>
<td>83%</td>
<td>33%</td>
<td>3.83</td>
</tr>
<tr>
<td>Lawn</td>
<td>39.42</td>
<td>19.71</td>
<td>19.71</td>
<td>73%</td>
<td>33%</td>
<td>4.72</td>
</tr>
<tr>
<td>Road Reserve Minor</td>
<td>12.41</td>
<td>0.00</td>
<td>12.41</td>
<td>73%</td>
<td>33%</td>
<td>2.96</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>11.54</td>
</tr>
</tbody>
</table>

### Nutrient Removal via In-Transit Controls

- **Stormwater Load Available for Removal:** 2.530 kg/gross ha/yr (i.e., no WSUD)

<table>
<thead>
<tr>
<th>Component</th>
<th>reduction due to WSUD</th>
<th>adjusted upstream rate to use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross Pollutant Traps</td>
<td>53.58%</td>
<td>1.174</td>
</tr>
<tr>
<td>Water Pollution Control Pond</td>
<td>53.99%</td>
<td>1.164</td>
</tr>
</tbody>
</table>
## Nutrient Input Decision Support System

### Version 2.0 March 2005

**JDA Consultant Hydrologists**

**Report Date:** 24-Jul-06

### Catchment Name

**Albion**

**Catchment Area:** 576 ha

### Total Phosphorus Input: Summary of Options

<table>
<thead>
<tr>
<th>Option</th>
<th>Development Input kg/yr</th>
<th>Rural Input kg/yr</th>
<th>Total Input kg/yr</th>
<th>WSUD Reduction kg/yr</th>
<th>Net Input kg/yr</th>
<th>Input Rate kg/ha/yr</th>
<th>Overall Reduction %</th>
<th>Development Reduction %</th>
<th>Cost of Reduction $/kg/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Existing Land Use</td>
<td>45</td>
<td>5,882</td>
<td>5,927</td>
<td>0</td>
<td>5,927</td>
<td>17.1</td>
<td>0.0%</td>
<td>0.0%</td>
<td>$0.0</td>
</tr>
<tr>
<td>2 Proposed Land Use - No WSUD</td>
<td>5,843</td>
<td>288</td>
<td>6,131</td>
<td>0</td>
<td>6,131</td>
<td>17.7</td>
<td>0.0%</td>
<td>0.0%</td>
<td>$0.0</td>
</tr>
<tr>
<td>3 Proposed Land Use - With WSUD</td>
<td>5,843</td>
<td>288</td>
<td>6,131</td>
<td>2,864</td>
<td>3,267</td>
<td>9.4</td>
<td>46.7%</td>
<td>49.0%</td>
<td>$72.5</td>
</tr>
</tbody>
</table>

### Total Nitrogen Input: Summary of Options

<table>
<thead>
<tr>
<th>Option</th>
<th>Development Input kg/yr</th>
<th>Rural Input kg/yr</th>
<th>Total Input kg/yr</th>
<th>WSUD Reduction kg/yr</th>
<th>Net Input kg/yr</th>
<th>Input Rate kg/ha/yr</th>
<th>Overall Reduction %</th>
<th>Development Reduction %</th>
<th>Cost of Reduction $/kg/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Existing Land Use</td>
<td>1,275</td>
<td>17,840</td>
<td>18,916</td>
<td>0</td>
<td>18,916</td>
<td>54.7</td>
<td>0.0%</td>
<td>0.0%</td>
<td>$0.0</td>
</tr>
<tr>
<td>2 Proposed Land Use - No WSUD</td>
<td>27,258</td>
<td>1,093</td>
<td>28,351</td>
<td>0</td>
<td>28,351</td>
<td>81.9</td>
<td>0.0%</td>
<td>0.0%</td>
<td>$0.0</td>
</tr>
<tr>
<td>3 Proposed Land Use - With WSUD</td>
<td>27,258</td>
<td>1,093</td>
<td>28,351</td>
<td>11,709</td>
<td>16,642</td>
<td>48.1</td>
<td>41.3%</td>
<td>43.0%</td>
<td>$19.1</td>
</tr>
</tbody>
</table>
### Nutrient Input Without WSUD

<table>
<thead>
<tr>
<th>Land Use Category</th>
<th>Description</th>
<th>Nutrient Input (kg/yr)</th>
<th>% of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>Garden</td>
<td>7,363</td>
<td>54.7%</td>
</tr>
<tr>
<td></td>
<td>Lawn</td>
<td>3,447</td>
<td>26.6%</td>
</tr>
<tr>
<td></td>
<td>Pet Waste</td>
<td>888</td>
<td>7.3%</td>
</tr>
<tr>
<td></td>
<td>Car Wash</td>
<td>42</td>
<td>0.3%</td>
</tr>
<tr>
<td></td>
<td>Sub Total</td>
<td>11,833</td>
<td>88.0%</td>
</tr>
<tr>
<td>POS</td>
<td>Garden/Lawn</td>
<td>198</td>
<td>1.5%</td>
</tr>
<tr>
<td></td>
<td>Pet Waste</td>
<td>314</td>
<td>2.3%</td>
</tr>
<tr>
<td></td>
<td>Sub Total</td>
<td>512</td>
<td>3.8%</td>
</tr>
<tr>
<td>Road</td>
<td>Major Roads</td>
<td>24</td>
<td>0.2%</td>
</tr>
<tr>
<td></td>
<td>Reserve</td>
<td>1,083</td>
<td>8.1%</td>
</tr>
<tr>
<td></td>
<td>Sub Total</td>
<td>1,107</td>
<td>8.2%</td>
</tr>
<tr>
<td>Rural</td>
<td>Pasture</td>
<td>0</td>
<td>0.0%</td>
</tr>
<tr>
<td></td>
<td>Poultry Farms</td>
<td>0</td>
<td>0.0%</td>
</tr>
<tr>
<td></td>
<td>Residential (R2.5/R5)</td>
<td>0</td>
<td>0.0%</td>
</tr>
<tr>
<td></td>
<td>Sub Total</td>
<td>0</td>
<td>0.0%</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>23,35</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

### Residential Areas (R15-R35) - Nutrient Removal via Source Control

<table>
<thead>
<tr>
<th>Description</th>
<th>Education Effectiveness %</th>
<th>% Area of Influence</th>
<th>Removal kg/gross ha/yr</th>
<th>Removal kg/ha/yr</th>
<th>Removal kg/yr</th>
<th>Capital Cost $</th>
<th>Operating Cost $</th>
<th>Cost $/kg/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Native Gardens (Lots - Garden)</td>
<td>50%</td>
<td>3.39</td>
<td>1.68</td>
<td>7.36</td>
<td>0</td>
<td>0</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>Native Gardens (Lots - Lawn)</td>
<td>50%</td>
<td>2.99</td>
<td>1.72</td>
<td>7.36</td>
<td>0</td>
<td>0</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>Native Gardens (POS)</td>
<td>50%</td>
<td>0.17</td>
<td>0.99</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>Community Education - Fertiliser</td>
<td>100%</td>
<td>3.14</td>
<td>1.62</td>
<td>13.5</td>
<td>0</td>
<td>5,328</td>
<td>5,328</td>
<td></td>
</tr>
<tr>
<td>Community Education - Pet Waste</td>
<td>100%</td>
<td>0.23</td>
<td>0.30</td>
<td>2.4</td>
<td>0</td>
<td>5,209</td>
<td>5,209</td>
<td></td>
</tr>
<tr>
<td>Community Education - Car Wash</td>
<td>100%</td>
<td>0.02</td>
<td>0.14</td>
<td>0</td>
<td>0</td>
<td>242.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Street Sweeping</td>
<td>100%</td>
<td>0.15</td>
<td>0.85</td>
<td>0</td>
<td>0</td>
<td>372.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Totals</td>
<td>35%</td>
<td>6.93</td>
<td>3.88</td>
<td>27.4</td>
<td>0</td>
<td>0</td>
<td>0.0</td>
<td></td>
</tr>
</tbody>
</table>

### Residential Areas (R15-R35) - Nutrient Removal via In-Transit Control

<table>
<thead>
<tr>
<th>Description</th>
<th>% Area of Influence</th>
<th>Removal kg/gross ha/yr</th>
<th>Removal kg/ha/yr</th>
<th>Removal kg/yr</th>
<th>Capital Cost $</th>
<th>Operating Cost $</th>
<th>Cost $/kg/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross Pollutant Traps</td>
<td>100%</td>
<td>0.08</td>
<td>0.4</td>
<td>0.4</td>
<td>1,068,153</td>
<td>40,908</td>
<td>2,188.5</td>
</tr>
<tr>
<td>Water Pollution Control Pond</td>
<td>100%</td>
<td>0.08</td>
<td>0.4</td>
<td>0.4</td>
<td>2,518,234</td>
<td>34,975</td>
<td>3,911.8</td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
<td>0.16</td>
<td>0.8</td>
<td>0.8</td>
<td>3,586,387</td>
<td>75,883</td>
<td>3,046.4</td>
</tr>
</tbody>
</table>

### Net Nutrient Input

<table>
<thead>
<tr>
<th>Description</th>
<th>kg/gross ha/yr</th>
<th>kg/ha</th>
<th>% of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nutrient Input - Residential Area without WSUD</td>
<td>23.35</td>
<td>7,363</td>
<td>100.0%</td>
</tr>
<tr>
<td>Nutrient Input - Rural Area</td>
<td>0.00</td>
<td>0</td>
<td>0.0%</td>
</tr>
<tr>
<td>Removal via Source Control</td>
<td>13.91</td>
<td>7,363</td>
<td>56.4%</td>
</tr>
<tr>
<td>Removal via In-Transit Control</td>
<td>0.17</td>
<td>0.7</td>
<td>0.7%</td>
</tr>
<tr>
<td>Total Removal</td>
<td>13.91</td>
<td>7,363</td>
<td>56.1%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Description</th>
<th>kg/ha</th>
<th>% of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net Nutrient Input</td>
<td>9.56</td>
<td>5,507</td>
</tr>
</tbody>
</table>
### NiDSS Core Data & Cost Calculations

**Nutrient Input Decision Support System**  
Version 2.0 March 2005

#### Community Education Information

**Who Cares About the Environment?** (NSW EPA, 2000) Survey
- 17% stated environment one of two most important issues for govt to address
- Of these, 27% stated water as most important environmental issue
- 17% stated education most important issue to protect environment

Impact assumed to reduce fertiliser applications to minimum rates

#### Fertiliser Application Information/Assumptions

Lots assumed fertilised by property owner
- Minor Road Reserves fertilised by property owner (verge assumed 40% road reserve)
- Major Road Reserves fertilised by local authority (verge assumed 40% road reserve)
- Active POS fertilised by local authority
- Passive POS not fertilised
- Rural Land use and Poultry Farms have no reductions due to WSUD applied

#### Pet Waste

**Data Source**
- Pets per lot and disposal via JDA Survey (2001)
- Cost Estimate via JDA. Distribution cost and frequency is for brochure, bag cost is for POSs

**Application Rates**

<table>
<thead>
<tr>
<th>Category</th>
<th>Weight (kg/yr)</th>
<th>Fertiliser (kg per lot)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cats</td>
<td>0.90</td>
<td>0.16</td>
</tr>
<tr>
<td>Small Dogs</td>
<td>2.75</td>
<td>0.12</td>
</tr>
<tr>
<td>Medium Dogs</td>
<td>5.50</td>
<td>0.16</td>
</tr>
<tr>
<td>Large Dogs</td>
<td>8.25</td>
<td>0.19</td>
</tr>
</tbody>
</table>

#### Waste Disposal

**R zoning**  
Cost Data
- Cost of bags per year: $2.50
- Cost of mailout per year: $1,881

**R15, R35 specified**  
Cost Data
- Total PV Cost: $86,814
- Remoteness: 42.6 kg/year
- Frequency: 2 years

#### Car Wash

**Data Source**
- Frequency based on JDA Survey (2001)
- TN/TP based on Polyglaze Autowash data via CRC for Freshwater Ecology (Canberra)
- Cost Estimate via JDA. Distribution cost and frequency is for brochure

**Application Rates & Washing Frequency**

<table>
<thead>
<tr>
<th>Fertiliser mean application</th>
<th>WN</th>
<th>TP</th>
</tr>
</thead>
<tbody>
<tr>
<td>kg TN/ha POS/yr</td>
<td>0.00009</td>
<td>0.00005</td>
</tr>
<tr>
<td>kg TP/ha POS/yr</td>
<td>0.00009</td>
<td>0.00005</td>
</tr>
</tbody>
</table>

**Cost Data**
- Distribution per house: $55,469
- Removal: 181.9 kg/year
- Frequency: 2 years
- Cost per kg: $2.75

#### Lot Fertiliser

**Data Source**
- Mean Fertiliser Applications via JDA survey (2001)
- % garden and lawn estimated via aerial photography
- Reduction for various suburbs with similar zonings

**Application Rates**

<table>
<thead>
<tr>
<th>Garden</th>
<th>Lawn</th>
<th>Fertiliser mean application</th>
<th>WN</th>
<th>TP</th>
</tr>
</thead>
<tbody>
<tr>
<td>kg TN/ha POS/yr</td>
<td>0.00009</td>
<td>0.00005</td>
<td></td>
<td></td>
</tr>
<tr>
<td>kg TP/ha POS/yr</td>
<td>0.00009</td>
<td>0.00005</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Education Campaign**

<table>
<thead>
<tr>
<th>WN</th>
<th>TP</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00009</td>
<td>0.00005</td>
</tr>
</tbody>
</table>

**POS Fertiliser**

**Data Source**
- Application rates based on City of Armadale application to public POS areas in years 1999-2000

**Application Rates**

<table>
<thead>
<tr>
<th>WN</th>
<th>TP</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00009</td>
<td>0.00005</td>
</tr>
</tbody>
</table>
## Rural Land Use Fertiliser

**Data Source:** Estimates via Gerritse et al (1992) for pasture

**Application Rates**

<table>
<thead>
<tr>
<th>Rural</th>
<th>Fertiliser mean application</th>
<th>TN or TP specified</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>25 kg/ha/yr</td>
<td></td>
</tr>
</tbody>
</table>

## Poultry Farms

**Data Source:** Estimates via Gerritse (et al) 1992

**Based on 14,000 hens on 42 ha property**

**Application Rates**

<table>
<thead>
<tr>
<th>Poultry</th>
<th>Fertiliser mean application</th>
<th>TN or TP specified</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>150 kg/ha/yr</td>
<td></td>
</tr>
</tbody>
</table>

## Street Sweeping

**Data Source:** Street Sweeping Revisited - Nutrients and Metals in Particle Size Fractions of Road Sediment

**Cost based on Davies & Pierce (1998), $55/km**

<table>
<thead>
<tr>
<th>Cost Calculation</th>
<th>Estimated Removal Rate (assumes no WSUD upstream)</th>
<th>Percentage Removal</th>
<th>Area to Apply</th>
<th>Total PV Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sweeping</td>
<td>due to</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>reduction</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>10%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>90%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## In-Transit Controls - Stormwater Nutrient Load

**Data Source:** Nutrients in Perth Urban Surface Drainage Catchments Characterised by Applicable Attributes, Tan (1991)

**Data Used to Calculate Nutrients in Stormwater Available for Removal by In-Transit Controls**

**Removal quantities are for no WSUD and are reduced in calcs based on upstream measures used**

**Estimated Stormwater Nutrient Load**

<table>
<thead>
<tr>
<th>Estimated Stormwater Nutrient Load (assumes no WSUD upstream)</th>
<th>Percentage Removal</th>
<th>Area to Apply</th>
<th>Total PV Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TN</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>TP</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.40</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.53</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Gross Pollutant Trap

**Data Source:** Approximate average retention value via JDA(2001) - GeoTrap Laboratory Test Report

**Cost of GeoTrap, Humesceptor, Downstream Defender, CDS**

<table>
<thead>
<tr>
<th>Cost Calculation</th>
<th>Estimated Removal Rate (assumes no WSUD upstream)</th>
<th>Percentage Removal</th>
<th>Area to Apply</th>
<th>Total PV Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GPT</td>
<td>TN</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>TP</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>35%</td>
<td>48.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>50%</td>
<td>65.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>50%</td>
<td>65.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Water Pollution Control Pond

**Data Source:** WPCP removal efficiency and cost via Hanley Brook Storm WPCP (conceptual design) JDA, 1991

**Cost of managing Urban Stormwater Treatment Techniques (NSW EPA 1997)**

<table>
<thead>
<tr>
<th>Cost Calculation</th>
<th>Estimated Removal Rate (assumes no WSUD upstream)</th>
<th>Percentage Removal</th>
<th>Area to Apply</th>
<th>Total PV Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>WPCP</td>
<td>TN</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>TP</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>35%</td>
<td>34</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>50%</td>
<td>34</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: GPT’s and WPCP’s applied to developed areas only - not existing rural land use areas not to be developed.
**Catchment Summary of Nutrient Removal due to Source Controls**

**Without WSUD**

<table>
<thead>
<tr>
<th>Component</th>
<th>Checkbox</th>
<th>% Area to Apply</th>
<th>Level before Removal</th>
<th>Potential Removal</th>
<th>Adopted Removal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Native Gardens (Lots-Garden)</td>
<td>TRUE</td>
<td>50%</td>
<td>23.35</td>
<td>12.78</td>
<td>6.39</td>
</tr>
<tr>
<td>Native Gardens (Lots-Lawn)</td>
<td>TRUE</td>
<td>50%</td>
<td>16.90</td>
<td>5.97</td>
<td>2.99</td>
</tr>
<tr>
<td>Native Gardens (POS)</td>
<td>TRUE</td>
<td>50%</td>
<td>13.98</td>
<td>0.34</td>
<td>0.17</td>
</tr>
<tr>
<td>Education Campaign - Fertiliser</td>
<td>TRUE</td>
<td>100%</td>
<td>13.80</td>
<td>3.16</td>
<td>3.16</td>
</tr>
<tr>
<td>Education Campaign - Pet Waste</td>
<td>TRUE</td>
<td>100%</td>
<td>10.64</td>
<td>0.75</td>
<td>0.75</td>
</tr>
<tr>
<td>Education Campaign - Car Wash</td>
<td>TRUE</td>
<td>100%</td>
<td>9.90</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>Street Sweeping</td>
<td>TRUE</td>
<td>100%</td>
<td>9.87</td>
<td>0.15</td>
<td>0.15</td>
</tr>
<tr>
<td>Gross Pollutant Traps</td>
<td>TRUE</td>
<td>100%</td>
<td>9.73</td>
<td>0.08</td>
<td>0.08</td>
</tr>
<tr>
<td>Water Pollution Control Pond</td>
<td>TRUE</td>
<td>100%</td>
<td>9.64</td>
<td>0.08</td>
<td>0.08</td>
</tr>
</tbody>
</table>

**Nutrient Removal via In-Transit Controls**

| Stormwater Load Available for Removal (ie no WSUD) | 0.400 kg/gross ha/yr |

<table>
<thead>
<tr>
<th>Component</th>
<th>reduction due to WSUD</th>
<th>adjusted upstream rate to use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross Pollutant Traps</td>
<td>58.35%</td>
<td>0.167</td>
</tr>
<tr>
<td>Water Pollution Control Pond</td>
<td>58.71%</td>
<td>0.165</td>
</tr>
</tbody>
</table>
## Nutrient Input Decision Support System

**Version 2.0 March 2005**

**JDA Consultant Hydrologists**

**Report Date:** 24-Jul-06

### Catchment Name
- **Albion**

### Catchment Area
- **576 ha**

### Total Phosphorus Input: Summary of Options

<table>
<thead>
<tr>
<th>Option</th>
<th>Development Input kg/year</th>
<th>Rural Input kg/yr</th>
<th>Total Input kg/yr</th>
<th>WSUD Reduction kg/yr</th>
<th>Net Input kg/yr</th>
<th>Input Rate kg/ha/yr</th>
<th>Overall Reduction %</th>
<th>Development Reduction %</th>
<th>Cost of $/kg/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Existing Land Use</td>
<td>45</td>
<td>5,882</td>
<td>5,927</td>
<td>0</td>
<td>5,927</td>
<td>17.1</td>
<td>0.0%</td>
<td>0.0%</td>
<td>$0.0</td>
</tr>
<tr>
<td>2 Proposed Land Use - No WSUD</td>
<td>5,843</td>
<td>288</td>
<td>6,131</td>
<td>0</td>
<td>6,131</td>
<td>17.7</td>
<td>0.0%</td>
<td>0.0%</td>
<td>$0.0</td>
</tr>
<tr>
<td>3 Proposed Land Use - With WSUD</td>
<td>5,843</td>
<td>288</td>
<td>6,131</td>
<td>2,864</td>
<td>3,267</td>
<td>9.4</td>
<td>46.7%</td>
<td>49.0%</td>
<td>$72.5</td>
</tr>
</tbody>
</table>

### Total Nitrogen Input: Summary of Options

<table>
<thead>
<tr>
<th>Option</th>
<th>Development Input kg/year</th>
<th>Rural Input kg/yr</th>
<th>Total Input kg/yr</th>
<th>WSUD Reduction kg/yr</th>
<th>Net Input kg/yr</th>
<th>Input Rate kg/ha/yr</th>
<th>Overall Reduction %</th>
<th>Development Reduction %</th>
<th>Cost of $/kg/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Existing Land Use</td>
<td>1,270</td>
<td>17,646</td>
<td>18,916</td>
<td>0</td>
<td>18,916</td>
<td>54.7</td>
<td>0.0%</td>
<td>0.0%</td>
<td>$0.0</td>
</tr>
<tr>
<td>2 Proposed Land Use - No WSUD</td>
<td>27,258</td>
<td>1,093</td>
<td>28,351</td>
<td>0</td>
<td>28,351</td>
<td>81.9</td>
<td>0.0%</td>
<td>0.0%</td>
<td>$0.0</td>
</tr>
<tr>
<td>3 Proposed Land Use - With WSUD</td>
<td>27,258</td>
<td>1,093</td>
<td>28,351</td>
<td>11,709</td>
<td>16,642</td>
<td>48.1</td>
<td>41.3%</td>
<td>43.0%</td>
<td>$19.1</td>
</tr>
</tbody>
</table>
APPENDIX H

Executive Summary North East Corridor
Urban Water Management Strategy
GHD,(2007)
Executive Summary

This Urban Drainage and Water Management Strategy has been developed to support the North East Corridor Structure Plan. As a Regional Drainage and Water Management Strategy it should be used as the foundation for developing more detailed District and Local Drainage and Water Management Plans that will support District and Local Structure Plans.

This strategy has been based on a review of the previous 1995 Drainage Management Strategy for the North East Corridor (Water Authority, 1995). Although endorsing the Water Sensitive Urban Design principles adopted by the 1995 strategy, it recommends alternative approaches to the relatively costly Water Pollution Control Ponds previously proposed.

This document proposes strategies for managing the quantity and quality of surface run-off, for managing groundwater levels and quality, for protecting wetlands and waterways and for managing the potential risks from Acid Sulphate Soils. It has been completed at a time when State Government agencies are proposing a more integrated approach to urban water management and land use planning. Subsequent and more detailed District and Local Drainage and Water Management Plans should include an assessment of some of the broader aspects of urban water management not addressed in this strategy, including potential water sources for potable and non-potable use, water conservation and re-use.

**Water quantity management**

To maintain the ecological water requirements of the receiving environment, the drainage system shall:

- Seek to maintain the pre-development hydrology by retaining or detaining on site (or as close to source as practical), runoff resulting from rainfall events up to and including the 1 year ARI event

To protect infrastructure and assets from flooding, the drainage system drainage shall:

- Be designed for the safe conveyance of excessive runoff from extreme events, specifically the 100 year ARI event;
- Ensure that the flood channel capacity of the receiving waterway is not exceeded, by retaining or detaining the runoff from storm events in landscaped areas in public open space or linear multiple use corridors.

**Water quality management**

To protect water quality in the Swan River and other receiving wetlands and waterways, District Water Management Strategies should include specific water quality design targets for each sub-catchment. In all cases the water quality design targets must be consistent with the long-term Swan River targets.

Run-off from roads and other impervious areas must be diverted through a treatment system before infiltration or discharge for all flows up to the 1-year ARI event. Water
Pollution Control Ponds at the outlet from sub-catchment are no longer recommended in this area as the primary treatment measure for managing water quality and have been deleted from this updated strategy.

Structural and non-structural measures, to improve water quality in the North East Corridor, and relevant to the local hydrology and proposed Structure Plans must be developed and implemented through District and/or Local Drainage and Water Management Plans.

Groundwater management
To protect buildings and other infrastructure, adequate separation from maximum groundwater levels must be provided. In some areas it may be possible to reduce the need for imported fill by the use of subsoil drainage where it can be demonstrated that:

- Nutrient export from the site will not be increased, and
- Subsoil drainage is laid at or above the Controlled Groundwater Level (CGL) set at a level that is does not i) flow excessive water resources above the need to manage winter ground water, ii) flow out into receiving water bodies excessive nutrient above the acceptable nutrient level iii) affect groundwater dependent ecosystem.

Although District Drainage and Water Management Plans should provide guidance for CGLs, these should be reviewed at local structure plan scale to protect specific environmental values and after the results of more detailed groundwater monitoring information is available.

Wetland and waterways management
To protect significant wetlands in the North East Corridor, the following principles should be adopted:

- Existing drains located within conservation and resource enhancement wetlands should be retained to maintain the existing hydrological regime.
- No new drainage infrastructure shall be located in conservation category wetlands or their buffers.
- Where overland flow paths discharge to conservation category wetlands, peak flows should not be increased by development.
- Drainage inverts below existing AAMGL will only be permitted where wetland groundwater levels will not be adversely affected.

To protect watercourses of high conservation value and environmental significance, land and water planning must include for the restoration, revegetation and reservation of appropriate riparian buffers.

Acid sulphate soils
In areas where there is a risk of Acid Sulphate Soils (ASS) or Potential Acid Sulphate Soils (PASS), an initial site investigation shall be undertaken to assess soil conditions. An Acid Sulphate Soil Management Plan may be needed for any excavations or dewatering activities, prepared in accordance with guidelines published by the Department of Water.
District Drainage and Water Management Plans

In accordance with the approach adopted for the Southern River area (Southern River MOU Steering Committee, 2006), it is recommended that as District or Local Structure Plans are prepared for the North East Corridor, they are supported by Drainage and Water Management Plans (DWMP).

It is recognised that in some areas Local Structure Plans are prepared without the completion of a District Structure Plan. For this reason it is recommended that the Department of Water, in consultation with the Department for Planning and Infrastructure and the City of Swan, prepare a DWMP for areas where development is anticipated without a District Structure Plan. The highest priority is the Henley Brook-West Swan-Caversham DWMP, including those catchments south of Gnangara Road.

Should Local Structure Planning proceed before the completion of the necessary DWMP, the proponent should be required to prepare a Local Water Management Plan that addresses the issues that would otherwise have been included in the DWMP.
APPENDIX I

Letter Department of Water to DPI re: North East Corridor – the Vale Development Plan 2, The Albion Structure Plan and the Caversham Structure Plan 30/4/07
Dear Ray

RE: North East Corridor – The Vale Development Plan Two, The Albion Structure Plan & The Caversham Structure Plan

I refer to your e-mail dated 14 March 2007 in response to the Department of Water's (DoW) letter dated 21 February 2007 regarding the above. I apologise for the delay in responding.

The DoW has reviewed its previous comments and agrees with you that proposals with existing approvals should proceed in accordance with the conditions of approval. In this context the words "will not support" as quoted in our previous correspondence are withdrawn.

The DoW encourages the identification of opportunities to align drainage water management planning and implementation with current best management practice where possible. Where drainage and water management planning is in progress, the DoW is happy to work with all stakeholders to ensure good water resource management outcomes in a time frame consistent with existing land planning processes. Below are additional comments on the three main development areas.

The Vale Development Plan Two:
The DoW acknowledges that the original Drainage Nutrient Management Plan (DNMP) was approved by the EPA in 1995 as part of conditions set under the Environmental Protection Act 1986. The DoW also considers that the Vale Development Plan Two DNMP has been prepared in accordance with the original principles and objectives of these conditions.

Please note that Acid Sulphate Soils and Wetlands are now managed by the Department of Environment and Conservation. Comments provided by the DoW regarding this were for your consideration only as institutional arrangements were being clarified.

Albion Structure Plan
The DoW advised that a draft North East Corridor (Regional) Urban Water Management Strategy for the area was completed and awaiting approval for publication. The document has subsequently been approved for publication and distributed to stakeholders, including DPI on 2 April 2007. This document provides principles for the preparation of District and Local Water
Management Strategies and now formally supersedes the 1995 NE Corridor Drainage Strategy as the Departments policy position. Where possible drainage and water management for the area should be consistent with this document.

In responding to your request for a copy of the letter sent from ENV to the City of Swan: The Department is not authorised to provide a copy of this document and your request should be forwarded to the City of Swan.

Caversham Local Water Management Strategy
The DoW acknowledges that the Caversham North land is relatively unconstrained. However, as mentioned in the DoW's original response, the Caversham Local Water Management Strategy (September 2006 version) is not considered to sufficiently address stormwater management of the site due to the need for further work on groundwater and geotechnical issues and the management measures to be adopted. Specific comments on this strategy were attached to the Department's original response, as well as being provided to the City of Swan. Note that the document was forwarded to the Department by the Council and referred to as a 'proposed' (draft) LWMS. As indicated in our response it was lacking sufficient data and the response was on the basis that an updated document would be subsequently submitted for formal consideration and response.

In your e-mail you mention that Cardno BSD are undertaking additional work and modifications requested by the DoW. To date, there has been no contact from Cardno BSD and the Department is awaiting receipt of an updated document for formal consideration.

Should you require clarification of the above or have any further question, I can be contacted on 6364 6603.

Yours sincerely

[Signature]

Greg Davis
Manager of Waterways and Drainage Branch
30 April 2007

cc Ross Sheridan: Swan-Avon Regional Manager
APPENDIX J

Typical Section of Active Open Space and
St Leonards Creek