ARMADALE REDEVELOPMENT AUTHORITY

WUNGONG URBAN WATER REDEVELOPMENT SCHEME 2006 (An Amendment to the Brookdale Redevelopment Scheme 2005)

ENVIRONMENTAL REVIEW (EPA ASSESSMENT No. 1647)

VOLUME I

VERSION 3

NOVEMBER 2006

REPORT NO: 2006/222

ATA Environmental
environmental scientists

THIS REPORT HAS BEEN PREPARED BY ATA ENVIRONMENTAL

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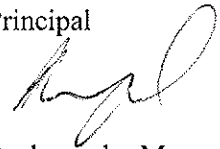
Approved by:	Signed:		
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Invitation to make a submission
The Armadale Redevelopment Authority (ARA) invites people to make a submission on this Environmental Review of the Wungong Urban Water Redevelopment Scheme 2006 (Amendment No. 1 to the Brookdale Redevelopment Scheme 2005). Both electronic and hard copy submissions are most welcome.

ARA has initiated Amendment No. 1 to guide subdivision, development and landuse in accordance with the Wungong Urban Water Master Plan. In accordance with the Environmental Protection Act, an Environmental Review has been prepared which describes the Amendment and the likely effects on the environment. The Environmental Review is available for a public review period of 60 days from 16 November 2006 closing on 19 January 2007.

Comments on the Environmental Review from government agencies and from the public will be forwarded by the ARA to the EPA and will help the EPA to prepare an assessment report in which it will make recommendations to government.

Why write a submission?
A submission is a way to provide information, express your opinion and put forward your suggested course of action - including any alternative approach. It is useful if you indicate any suggestions you have to improve the Amendment.

Submissions will be treated as public documents unless provided and received in confidence subject to the requirements of the Freedom of Information Act, and may be quoted in full or in part in the EPA's report.

Why not join a group?
If you prefer not to write your own comments, it may be worthwhile joining with a group interested in making a submission on similar issues. Joint submissions may help to reduce the workload for an individual or group, as well as increase the pool of ideas and information. If you form a small group (up to 10 people) please indicate all the names of the participants. If your group is larger, please indicate how many people your submission represents.

Developing a submission
You may agree or disagree with, or comment on, the general issues discussed in the Environmental Review. It helps if you give reasons for your conclusions, supported by relevant data. You may make an important contribution by suggesting ways to make the Amendment more environmentally acceptable.

When making comments on specific elements of the Environmental Review:

- clearly state your point of view;
- indicate the source of your information or argument if this is applicable;
- suggest recommendations, safeguards or alternatives.

Points to keep in mind
By keeping the following points in mind, you will make it easier for your submission to be analysed:

- attempt to list points so that issues raised are clear. A summary of your submission is helpful;
- refer each point to the appropriate section, chapter or recommendation in the Environmental Review;

- if you discuss different sections of the Environmental Review, keep them distinct and separate, so there is no confusion as to which section you are considering;
- attach any factual information you may wish to provide and give details of the source.

Make sure your information is accurate.

Remember to include:

- your name;
- address;
- date; and
- whether and the reason why you want your submission to be confidential.

Information in submissions will be deemed public information unless a request for confidentiality of the submission is made in writing.

The closing date for submissions is: [date]
Submissions should be

EITHER emailed to:

ARA.Info@ara.wa.gov.au

OR addressed to:

Armadale Redevelopment Authority
PO Box 816
ARMADALE W.A. 6992

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9. *Brookdale Master Plan – Cultural Heritage Survey* (Heritage and Conservation Professionals 2004)

LIST OF ACRONYMS

AAMGL	Average Annual Maximum Groundwater Level
ACMC	Aboriginal Cultural Material Committee
AHD	Average Height Datum
AHMP	Aboriginal Heritage Management Plan
ARA	Armadale Redevelopment Authority
ARI	Average Recurrence Interval
ASSMP	Acid Sulfate Soils Management Plan
BMP	Best Management Practice
CALM	Conservation and Land Management, Department of (now DEC)
CCW	Conservation Category Wetland
CGL	Controlled Groundwater Level
CoA	City of Armadale
CSIRO	Commonwealth Scientific and Research Organisation
DAP	Detailed Area Plan
DEC	Department of Environment and Conservation
DEP	Department of Environmental Protection
DIA	Department of Indigenous Affairs
DLI	Department of Land Information
DoE	Department of Environment (now DEC)
DoW	Department of Water
DPI	Department for Planning and Infrastructure
DWMS	District Water Management Strategy
EIA	Environmental Impact Assessment
EPA	Environmental Protection Authority
EPP	Environmental Protection (Swan Coastal Plain Lakes) Policy 1992
ER	Environmental Review
EWP	Environmental Water Provisions
EWR	Environmental Flow Requirements
FCT	Floristic Community Type
FMP	Foreshore Management Plan
GPT	Gross Pollutant Trap
IUWM	Integrated Urban Water Management
LGA	Local Government Authority
LWMS	Local Water Management Strategy
MOU	Memorandum of Understanding
MRS	Metropolitan Region Scheme
MUW	Multiple Use Wetland
NES	National Environmental Significance
PMR	Perth Metropolitan Region
POS	Public Open Space
REW	Resource Enhancement Wetland
SASSMP	Strategic Acid Sulfate Soils Management Plan
SCP	Swan Coastal Plain
SEA	Strategic Environmental Assessment
SRILWMP	Southern River Integrated Land and Water Management Plan
SRT	Swan River Trust
SUP	Share Use Path
TEC	Threatened Ecological Community
TPS	Town Planning Scheme
TSP	Total Suspended Particulates
PM_{10}	Particulate Matter (sub-10μ particles)

UWMS	Urban Water Management Strategy
UWMP	Urban Water Management Plan
Vpd	Vehicles per day
WAPC	Western Australian Planning Commission
WIPS	Wungong Implementation Plans for Sustainability
WMP	Wetland Management Plan
WRC	Water and Rivers Commission
WSUD	Water Sensitive Urban Design

1. INTRODUCTION

1.1 Project Background

Identified as one of eight strategic regional centres under the Metropolitan Centres Policy Statement for the Perth Metropolitan Region (1991 and 2000), it was considered that Armadale as a regional centre was yet to share in the crucial public and private sector investment that had and is being enjoyed by many other areas in the metropolitan area (Armadale Redevelopment Authority 2004).

The purpose of the Armadale redevelopment is to establish a physical, social and environmental framework enabling the City to build on its existing strengths and assets, and develop the multi-dimensional place of civic, cultural and economic significance that a strategic regional centre should be. In establishing the City's place in the metropolitan hierarchy, the redevelopment of Armadale is designed to draw upon and accentuate the points of difference that give Armadale its unique character (Armadale Redevelopment Authority 2004).

In December 1999 the City of Armadale hosted an Enquiry by Design Workshop, managed by the then Ministry for Planning's Urban Design and Major Places unit and covering the city centre and a number of other centres. The Workshop provided the opportunity to establish consensus on issues facing the city, to determine improvements in the urban structure, to examine ways to strengthen the city's economic base and growth potential, and to develop responsive and sustainable plans for key sites.

In early 2001 the State Government announced among its pre-election commitments the establishment of the Armadale Redevelopment Authority (ARA) and, after assuming government, established the ARA.

The Armadale Redevelopment Scheme gazetted in 2004 contained the following objectives:

- Aid in the revitalisation of Armadale as an effective strategic regional centre;
- Encourage development which will contribute to a more diverse and sustainable economic base in the region, and to an improved range of employment and residential opportunities that will benefit the existing community and new community members;
- Encourage development which will respect and build upon the existing qualities of the municipal district of Armadale, contributing to the creation and maintenance of attractive, safe and sustainable places that are characterised by high quality planning and design;
- Discourage development that would be detrimental to the character of the municipal district of Armadale, by virtue of its form, scale, operational characteristics and impacts on local amenity;
- Encourage sustainable development outcomes in accordance with sustainability strategies adopted by the Authority; and
- Encourage the conservation of places of cultural or environmental heritage significance, including significant vegetation.

The Armadale Redevelopment Scheme was adopted prior to the area under consideration for this Scheme Amendment, (now known as the Wungong Urban Water Master Plan Area) being included within the ARA's jurisdiction. Therefore, whilst the Scheme objectives set out the intention of the ARA in relation to development within its boundaries, it does not include specific provisions relating to the Master Plan area (TPG Town Planning and Urban Design 2006).

The Brookdale Redevelopment Scheme was subsequently gazetted in 2005 to provide for the orderly and proper control of development within the Scheme area consisting of approximately 1500ha of Brookdale adjacent to the Armadale city centre on the edge of Perth's southeast corridor (Figure 1). The provisions of the *Armadale Redevelopment Act 2004* superseded the provisions of the Metropolitan Region Scheme and Local Authority Scheme and consequently the Amendment area is currently zoned 'Brookdale Special Development Precinct'.

Redevelopment of the Amendment area is to provide a model for the development of an urban environment in accordance with the principles of sustainability, while providing viable residential development capitalising on Brookdale's proximity to the Armadale city centre and existing physical infrastructure. The redevelopment has been guided through a collaborative planning process that has involved a core team of 64 people from 38 organisations over a three year period.

The key objectives of the Redevelopment Scheme are to:

a) guide the creation of places that respond to the needs of people and the natural environment;
b) promote appropriate built forms which are site/climate responsive, will enhance residential amenity, and are appropriate for their intended use;
c) promote sustainable development and landuse which reduces demand for water, energy and other resources;
d) guide landuse, built form and density to create a vibrant and diverse urban environment;
e) encourage the conservation and preservation of places of cultural, environmental and/or heritage significance, wetlands and ecosystems;
f) encourage the efficient provision of services incorporating Urban Water Management Principles; and
g) establish a mechanism for cost sharing of infrastructure, open space and other designated public facilities

The Scheme places a moratorium on new subdivision and development until a Master Plan, and subsequently a Structure Plan, has been prepared for the area. The amended Scheme will be known as the 'Wungong Urban Water Redevelopment Scheme 2006'.

The end result of the planning process associated with the development of the Wungong Urban Water Redevelopment Scheme 2006 has been the preparation of the Wungong Urban Water Master Plan (Figure 2) and the *Wungong Urban Water Implementation Plans for Sustainability* report that provides the supporting documentation for the Master Plan, the Redevelopment Scheme, and Policies and Design Guidelines, in a Place Based planning approach, which is aimed at ensuring best practice in sustainable urban development. (TPG Town Planning and Urban Design 2006).

The ARA has adopted a Policy Manual for the ARA area. It is proposed that new policies relating to the Scheme area be identified and included in the Policy Manual as 2.7 Precinct 7: Brookdale and any modifications to existing policies be identified through the implementation of the *Wungong Urban Water Implementation Plans for Sustainability* report (TPG Town Planning and Urban Design 2006).

Amendment No. 1 to the Brookdale Redevelopment Scheme 2005 has been initiated to implement the Wungong Urban Water Master Plan No. 1, and is the subject of this Environmental Review report.

1.2 The Responsible Authority

The responsible authority for planning for the redevelopment of the Brookdale Redevelopment Area is the ARA. The ARA operates under the terms of the *Armadale Redevelopment Act 2001* which provides the ARA with planning and associated powers and also sets out the ARA's functions. The planning and development control functions of the ARA are essentially the same as those applying to the other redevelopment projects currently operating in the Perth metropolitan region. The ARA also has economic and social development functions which recognise the nature of current issues in Armadale and the potential role of the ARA in that regard (Armadale Redevelopment Authority 2004).

The redevelopment project is overseen by a six-person Board, of whom two members are nominees of the City of Armadale. The operational structure of the Authority varies somewhat from that of the other redevelopment projects, with the project being serviced from within the Department for Planning and Infrastructure (DPI) portfolio, with input primarily from LandCorp and the DPI.

1.3 Environmental Review Process

The Environmental Protection Authority (EPA) previously agreed to a request by the ARA to carry out a Strategic Environmental Assessment (SEA) of the Brookdale Redevelopment Area (February 2005). However because the ARA has subsequently chosen to progress planning for the area in parallel with the environmental assessment process, the formal environmental assessment of the amendment is replacing the SEA process.

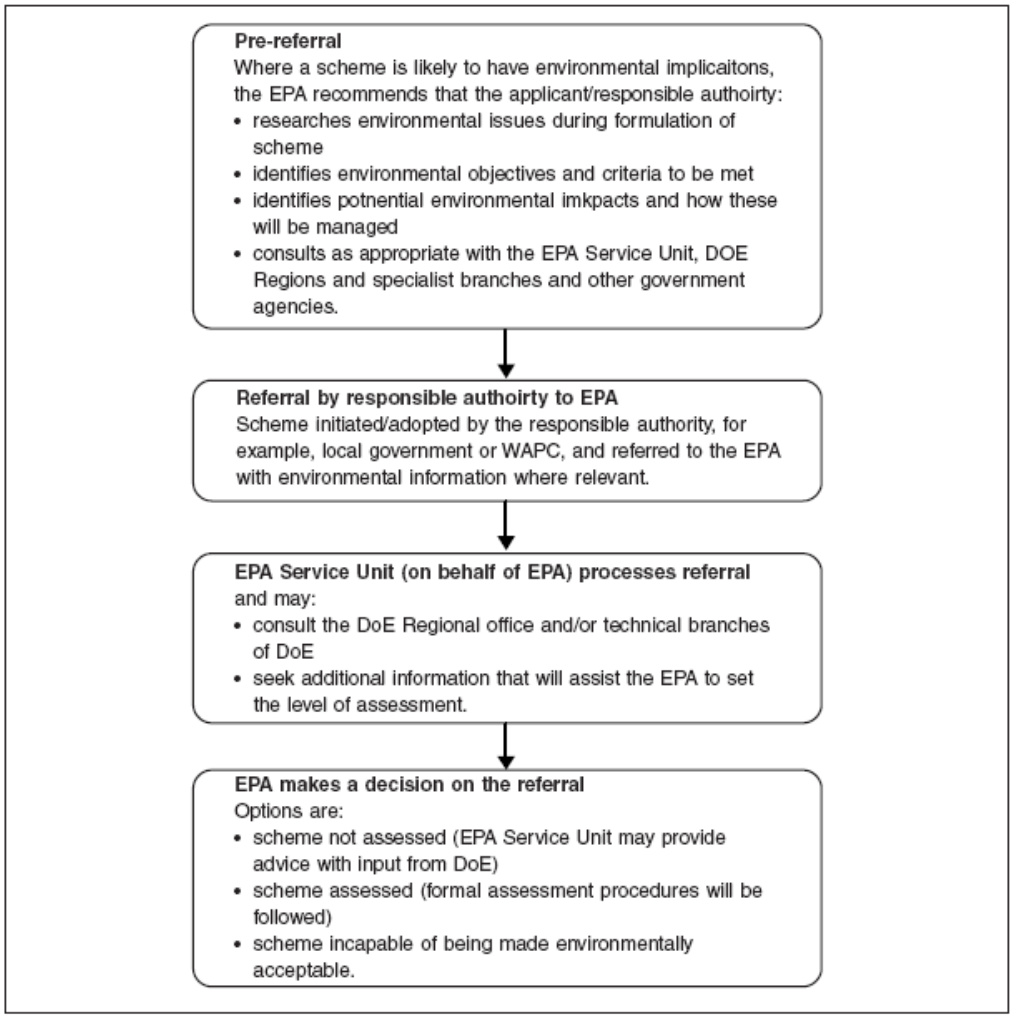
As previously mentioned (Section 1.1) the purpose of Scheme Amendment No. 1 is to incorporate provisions in the Wungong Urban Water Redevelopment Scheme 2006 (An Amendment to the Brookdale Redevelopment Scheme 2005) to guide subdivision, development and landuse in accordance with the Wungong Urban Water Master Plan (Armadale Redevelopment Authority 2006a).

The proposed Scheme Amendment was referred by the ARA to the EPA for setting a level of assessment on the 9th August 2006. The EPA released its decision to assess the Amendment on the 21st August 2006 as it considered that the proposed development would have the potential to have a significant environmental impact on the subject land. Accordingly the level of assessment was set at "Assessed: Environmental Review (ER) Required" (EPA Assessment No. 1647). The EPA is assessing the ARA's Amendment No. 1 to the Brookdale Redevelopment Scheme 2005 under Division 3 part IV *Environmental Protection Act 1986*.

On the 18th September 2006 the EPA issued Environmental Review Instructions setting out the work required for the ER in relation to a number of key environmental factors considered relevant to the scheme and those likely to be deferred environmental factors.

The Instructions for the scope and content of the environmental review of Amendment No. 1 are based on the work previously required by the EPA for the SEA as set out in the SEA scoping document approved by the EPA on 1st August 2005 (ATA Environmental 2006 *Armadale Redevelopment Authority: Brookdale Redevelopment Area Strategic Environmental Assessment Environmental Scoping Document: Assessment No. 1550* Version 6 July 2005 Report No. 2004/213, ATA Environmental, Perth). Much of the work specified in the scoping document had already been carried out by the ARA.

The scheme referral process is shown below.

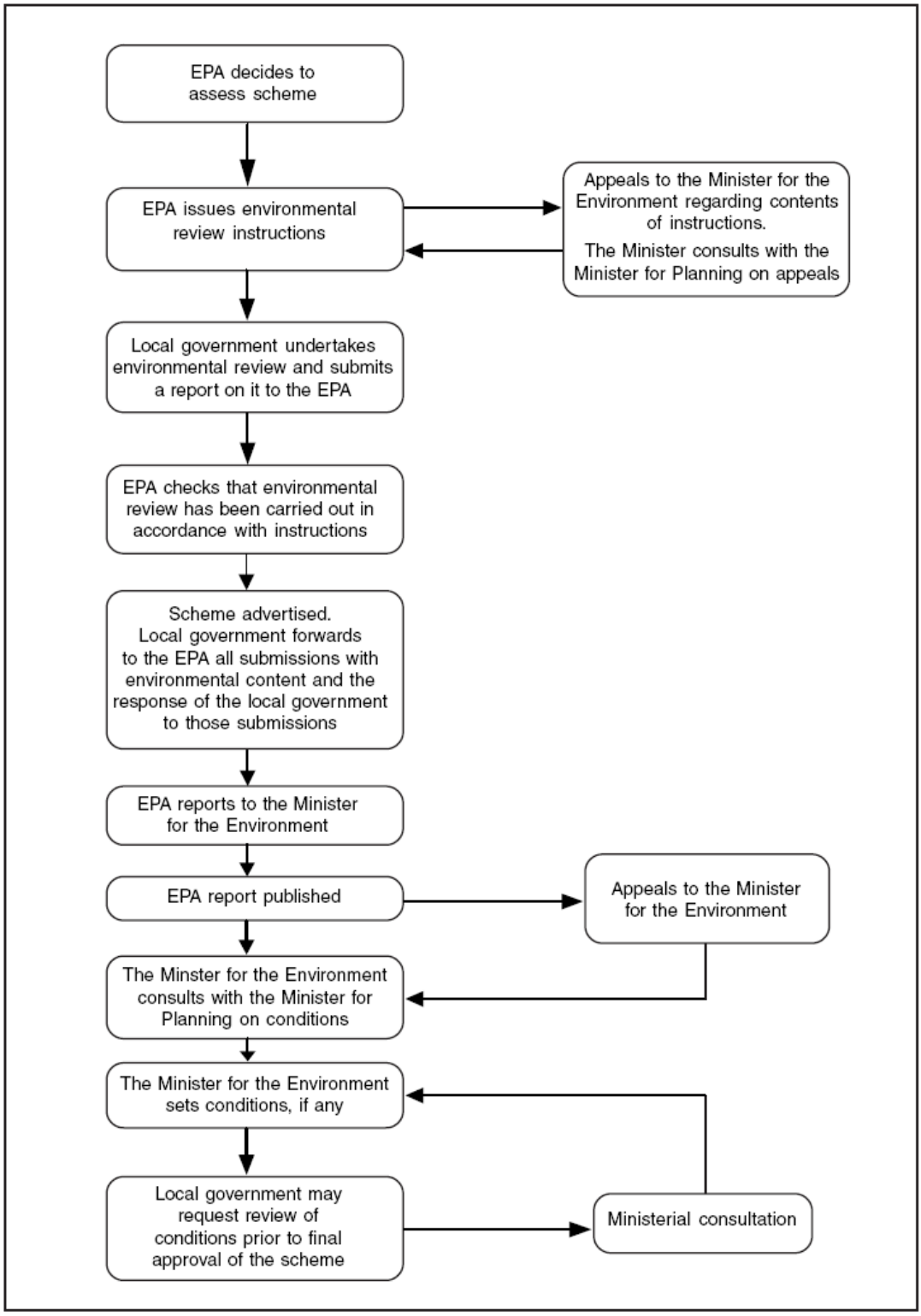


Source: Environmental Protection Authority (2005b)

The information presented in this ER report will assist the EPA to evaluate the impact of the amendment on the various environmental factors and provide independent environmental advice to Government. An additional function of the ER report is to clearly communicate details of the proposed amendment and its future implications so that the EPA can obtain public comment on the possible environmental impacts of the proposal.

The Environmental Impact Assessment (EIA) process for schemes including statutory timelines are set out in Table A4 of the EPA's Guidance Statement No. 33: *Environmental Guidance for Planning and Development* (Environmental Protection Authority 2005b).

In most instances of scheme referrals the responsible authority is deemed to be the Local Government Authority in which the subject land is located. In the case of the scheme amendment for the Brookdale Redevelopment Area, the ARA is the designated responsible authority. The EIA process being followed is similar to that shown in Figure A3 of Guidance Statement No. 33 (Chapter A3, p. 5) (Environmental Protection Authority 2005b) as shown below.



Source: Environmental Protection Authority (2005b)

The ARA, as the responsible authority, has undertaken the ER and submitted a report on it to the EPA (this document). The EPA has checked that the ER has been carried out in accordance with instructions. The ER is made available for public comment concurrently

with the draft Wungong Urban Water Redevelopment Scheme map and text. Advice on how to make a submission on this ER is presented at the front of this document.

Submissions on environmental matters received from government agencies, private organisations and individuals during that period will be considered by the ARA, which will prepare a response that may include:

- Clarification of parts of the Review to resolve misunderstandings.
- Modification of the Scheme as appropriate in response to environmental issues.
- Provision of additional information to support particular proposals.

The submissions and the ARA's response, together with the ER document and the scheme itself, will then be considered by the EPA. The EPA will report to the Minister for the Environment on the environmental factors relevant to the scheme and the conditions to which the scheme should be subject, and may make such recommendations in the report as it sees fit. The EPA's advice will be published and will be open to public appeal for two weeks. The Minister for the Environment will then consult with the Minister for Planning and Infrastructure regarding the conditions of approval and any other relevant matters before the conditions are set.

1.4 Structure and Content of the Environmental Review

The ER has been structured in accordance with the EPA Instructions and describes the existing environmental factors relevant to the scheme, the potential environmental impacts and proposed environmental management strategies to be implemented to prevent any deleterious impacts from occurring.

The environmental factors identified in the Instructions include:

Integration

- Sustainability

Biophysical

- Native terrestrial vegetation and flora
- Native terrestrial fauna
- Wetlands
- Waterways
- Key natural areas and ecological corridors

Pollution Management

- Water management
  - surface water quantity and quality
  - groundwater quantity and quality
- Land
  – Site contamination
  - Acid sulfate soils
- Air
  - Dust and particulates
  - Gaseous emissions

- Odour
- Greenhouse gases
- Noise and Vibration

Social Surroundings

- Disease vector and nuisance insects
- Heritage
  - Aboriginal heritage
  - Non-Aboriginal heritage

Each of the relevant environmental factors has been individually addressed in Section 4 of this document.

A copy of the Environmental Review Instructions for this Scheme Amendment has been included as Attachment 1 of this volume.

1.5 Statutory Requirements

In addition to meeting the requirements of the *Environmental Protection Act 1986*, the ARA in developing the Amendment area is required to comply with, amongst others, any or all of a number of Acts of Parliament and Regulations at the State or Commonwealth level as listed below. A brief description of some of the more relevant legislation for this proposal (bolded) is also given.

- *Aboriginal and Torres Strait Islander Heritage Protection Act 1984*
- ***Aboriginal Heritage Act 1972***
- ***Armadale Redevelopment Act 2001***
- *Conservation and Land Management Act 1994*
- *Contaminated Sites Act 2003*
- ***Environmental Protection Act 1986***
- *Environmental Protection (Noise) Regulations 1997*
- *Environmental Protection (Swan Coastal Plain Lakes) Policy 1992*
- *Fire and Emergency Services Authority of Western Australia Act 1998*
- ***Health Act 1911 and Regulations***
- *Heritage of Western Australia Act 1990*
- *Land Administration Act 1997*
- *Local Government Act 1995*
- *Metropolitan Water Supply Sewerage and Drainage Act 1909*
- *Native Title Act 1993*
- *Rights in Water and Irrigation Act 1914*
- ***Water and Rivers Commission Act 1995***
- *Waterways Conservation Act 1997*
- ***Water Agency Powers Act 1984***
- ***Wildlife Conservation Act 1950***

In addition, the following Commonwealth legislation may be relevant:

- ***Environment Protection and Biodiversity Conservation Act 1999***

Aboriginal Heritage Act 1972

The purpose of this legislation that is regulated and enforced by the Department of Indigenous Affairs (DIA), is to protect relics and significant areas of land from undue interference, while at the same time leaving traditional Aboriginal cultural rights in relation to such objects or areas unaffected, in so far as they are not inconsistent with the provisions of the Act.

The Act establishes the Aboriginal Cultural Material Committee. The Aboriginal Cultural Material Committee (ACMC) provides advice for the assessment of Section 18 Notices which developers are obliged to submit so the ACMC can determine whether or not an Aboriginal site should be disturbed by the development. The ACMC makes a recommendation to the Minister for Indigenous Affairs who makes the final decision as to whether consent for a development should be granted. Sacred beliefs and ritual or ceremonial usage are to be the primary considerations in the evaluation of places under the Act.

The Act also permits the Trustees of the Western Australia Museum to delegate their powers and duties for the care and protection of sites and objects to a representative group of Aboriginal people whom have a traditional interest in the place.

Armadale Redevelopment Act 2001

A key function of the Authority is in relation to planning and development control within the Redevelopment Area. Under the Act, the Authority is authorised to plan, undertake, promote and coordinate the development and redevelopment of land in the redevelopment area and for that purpose prepare and keep under review a redevelopment scheme for that area and to control developments in that area.

Under section 17 of the Act, the Authority has the powers it needs to perform its functions. To this end, the Authority may acquire, hold, manage and dispose of land; subdivide, amalgamate, improve, develop and alter land.

In performing its functions the Authority may act alone or in conjunction with any person or any department of the Public Service, or other agency or instrumentality, of the State or the Commonwealth and must have regard to, and must seek to enhance and preserve, the cultural heritage significance of the redevelopment area.

Environment Protection and Biodiversity Conservation Act 1999 **(Commonwealth)**

The Act provides protection for matters of National Environmental Significance (NES) and is administered by the Department of Environment and Heritage and the Commonwealth Environment Minister. These are:

- World and National Heritage properties;
- Ramsar wetlands of international importance;
- Nationally threatened animal and plant species and ecological communities;
- Internationally protected migratory species;
- Commonwealth marine areas; and
- Nuclear actions.

The procedure for joint assessments is identified in the document *Basis for a National Agreement on Environmental Impact Assessment.* These joint assessments generally take the form of the local state process, following which the Commonwealth publishes its own report.

Environmental Protection Act 1986

This Act is administered by the Department of Environment and Conservation (DEC). The Act provides for conservation, preservation, protection, enhancement and management of the environment and for matters incidental to or connected with it. The Act establishes head powers to provide mechanisms for the development of Environmental Protection Policies (EPP), the referral and assessment of proposals (Environmental Impact Assessment - EIA), the control of pollution and enforcement.

The Act also provides for an Environmental Protection Authority (EPA) that is a statutory authority and is the primary provider of independent environmental advice to Government (Environmental Protection Authority 2005). The EPA is assisted by the EPA Service Unit comprising the Environmental Impact Assessment and Policy Divisions of the DEC.

Health Act 1911 and Regulations

The objective of this Act is to consolidate the law relating to Public Health. The Health Department of Western Australia administers the Act and each local government authority is authorised and directed to carry out the provisions of the Act in its district.

The Act contains far-reaching provisions on a wide range of matters, which are divided into parts: Sanitary Provisions (Part 5), Dwellings (Part 6), Public Buildings (Part 7), Nuisances and Offensive Trades, Animal Produce, Drugs, Medicines, Disinfectants, Therapeutic Substances and Pesticides (Part 7A), Food (Part 8) and various Disease, Hospital and Medical related provisions (Parts 9-13).

Water Agency Powers Act 1984

Under this Act, land developers are required to enter into an agreement with the Water Corporation for the provision of works.

Water and Rivers Commission Act 1995

The Water and Rivers Commission administers the *Water and Rivers Commission Act 1995* to ensure that the State's water resources are managed to support sustainable development and conservation of the environment, for the long-term benefit of the community.

Wildlife Conservation Act 1950

The *Wildlife Conservation Act 1950* provides for the "conservation and protection of wildlife" and is administered by the DEC.

Native flora and fauna are protected under the provisions of Section 14 of the Act. The Act provides penalties for taking protected flora or fauna unlawfully. It also contains provisions for the declaration of species as "rare or likely to become extinct" (ie, endangered). "Fauna" is defined as meaning any animal indigenous to any State or Territory of the Commonwealth or the territorial waters thereof (i.e. it includes fish), and "flora" as any plant, which is native to the State.

2. THE PROPOSAL

2.1 Description of the Proposal

In 2004 the State Government expanded the ARA's jurisdiction to include approximately 1500ha of Brookdale to facilitate its viable redevelopment as a high quality urban area encompassing world best practice in sustainability. The ARA envisages that the redevelopment project will set in place planning guidelines and a management framework to enable the development over a 15 to 20 year period of an area currently supporting a population of approximately 1000 people living in rural-residential and urban development.

Located adjacent to the Armadale Strategic Centre at the edge of Perth's South East Corridor, the Amendment area is bounded by Armadale Road, Eighth Road, Ninth Road, Rowley Road, Hopkinson Road and the Tonkin Highway (Figure 1).

A number of high impact landuses currently exist, formerly existed or are within the vicinity of the Amendment area. These can be seen as potential constraints on development and include uses such as: the Brookdale liquid-waste disposal facility (closed at the end of 2003), Water Corporation pump station site, Tonkin Highway extension, poultry farms and market gardens. As part of the master planning for the Amendment area, the potential impact and management of each of these constraints are being considered.

Much of the Amendment area is low-lying and a significant environmental issue is the presence of a high water table, extensive areas of palusplain wetlands, linkages to the headwaters of the Wungong River and export of nutrients and sediment to waterways, including the Swan and Canning Rivers system. A particular focus of the redevelopment project will be the development of innovative approaches to achieve best practice urban water management. To this end, the ARA has formed working partnerships with a range of leading authority's including:

- CSIRO;
- Department of Environment and Conservation (DEC);
- Water Corporation;
- Department of Planning and Infrastructure (DPI); and
- City of Armadale.

As a consequence of the EPA's advice to the Western Australian Planning Commission (Environmental Protection Authority 2000a), nutrient and drainage management and potential impacts on wetlands, groundwater and ultimately the Swan and Canning Rivers were deemed to be critical issues that required considerable attention prior to changes in landuse within the Southern River area. In response to these concerns, the then Water and Rivers Commission developed the Southern River/Forrestdale/Brookdale/Wungong Urban Water Management Strategy (UWMS) released in April 2002 (JDA 2002). The development of this strategy involved a steering committee including key state and local government agencies, and representatives of the DEC.

In its review of the UWMS, the EPA requested that a Memorandum of Understanding (MOU) be signed by all agencies involved in the implementation of the UWMS. Signatories to the MOU include the Water Corporation, EPA Western Australian Planning Commission (WAPC), CSIRO, the Cities of Armadale and Gosnells and the ARA. The master planning for this project has been informed by and developed within the context of the UWMS (JDA 2002) and the Integrated Land and Water Management Plan currently being prepared by the Water Corporation under the MOU.

The redevelopment project will provide for a medium sized urban development within the Amendment area based on the principles of sustainability that will:

1. Provide commercially viable urban development that will act as a demonstration of best practice in sustainable urban residential development for Perth and Western Australia.

2. Provide management and administration frameworks (including partnerships where appropriate) with agreed roles and responsibilities for implementation, regulation, monitoring, evaluation and reporting thereby providing a mechanism for refining and improving the development process amongst key stakeholders.

3. Provide a demonstration of best practice in sustainable water cycle management that will include:

    a) water conservation measures at all scales of the development (individual lots and streetscapes);

    b) improved stormwater management through water sensitive urban design (WSUD) principles;

    c) optimised water harvesting and water reuse; and

    d) provision of the protection of ecological values of riparian and groundwater dependant ecosystems within the development and protection of receiving environments.

The Wungong Urban Water Master Plan developed for the Amendment area by the ARA will set the framework for the development of the Amendment area and will ultimately create up to 15,000 lots thereby providing for a sustainable population growth of up to 40,000 residents over a 15-20 year period.

The entire Amendment area is being master planned as one entity to ensure integration and appropriate physical, environmental and visual connections exist between proposed residential development, community facilities and areas of public open space. The Master Plan responds to and draws maximum benefit from the Amendment areas natural and physical characteristics. Integral elements of the Master Plan include the creation of environmental corridors, sensitive integration of the wetlands and watercourses with areas of proposed residential development and creation of vista and view corridors.

Specifically, the Master Plan involves:

1. The urban developable area will comprise predominantly urban and suburban landuse.

2. Developing commercial activity and community centres in strategic locations throughout the Amendment area.

3. Setting aside areas for education facilities, public open space (both active and passive) and sporting complexes.

4. Protecting the natural watercourses (Wungong River and Neerigen Brooks) and wetlands through implementation of non-developable buffers.

5. Protecting significant trees and under-represented remnant vegetation.

6. Developing an integrated urban water management system from the micro to macro scales ensuring that water quality and quantity is maintained relative to pre-development conditions. Water quality management will be in accordance with Department of Water (DoW) guidelines and water quantity in alignment with the aims of the State Water Strategy.

Key landuse elements of the Master Plan include urban and suburban development, special rural zones comprising larger lots, local and larger central activity centres, and innovative use of linear public open space (POS) linkages to create a sense of place and link with urban water management and the protection and enhancement of the existing natural environment. These linear POS areas are called "Avenues" in the Master Plan, and form a significant proportion of the overall total available POS within the Amendment area (Figure 2).

The urban development area has a medium density and is primarily residential urban fabric. A range of building types including adaptive and aged housing, assisted care and hostel accommodation will be encouraged. In order to promote diversity an average density of 220m^2 per dwelling site (max 180m^2 per dwelling site) is proposed. Higher density developments within this range will be encouraged to locate on sites with proximity to public open space, appropriate services and good access.

The suburban development area is a residential environment of primarily detached dwellings interspersed with some grouped housing sites incorporating freestanding villas or townhouses. Within the proposed range of building types it is envisaged adaptive and aged housing (non-assisted care) will be included. Opportunities to work from home will be provided. Some diversity in built form is to be encouraged within a primarily suburban context. The prevailing density of 500m^2 per dwelling site will apply with nominated sites up to 220m^2 per dwelling site subject to Detailed Area Plans and in proximity to public open space, appropriate services and good access (Armadale Redevelopment Authority 2006b).

A rural residential area is located between 12th Road and the Wungong River. As an outcome of the structure planning process, this code may also be applied to other areas located adjacent to wetlands or conservation/ heritage areas or areas subject to specific environmental or servicing constraints. These areas may include designated environmental buffers and provide for a transition in land-use between significant sites and natural areas/wetlands and more intensive development.

The area is characterised by single dwellings on large lots in a general rural or natural environmental setting. Specific building, service and landuse management measures may be applied to developments in respect to specific constraints or to protect areas of significance.

Key elements of the Master Plan in relation to urban water management include:

- Use of the Avenues for detention, retention, conveyance, and treatment of stormwater;
- Re-creation of existing trapezoidal drains within the Amendment area to Living Streams;
- Provision of appropriate buffer zones to ensure protection of the Wungong River, its associated tributaries, and significant wetlands;
- Maintenance of flow paths through the Amendment area for upstream catchments;
- Provision of a treatment train approach to stormwater management including both structural and non structural controls, consistent with DEC requirements;
- Implementation of a controlled groundwater level (CGL) in identified areas to minimise large scale trucking of fill consistent with sustainability principles;

- Implementation of water efficiency and demand management measures to reduce both in and ex-house domestic water use; and
- Minimisation of importation of scheme water through provision of a non-potable fit for purpose supply for domestic and POS irrigation, toilet flushing, laundry use (cold water inlet) and potentially hot water system.

2.2 Implementation of Statutory Provisions

The Wungong Urban Water Redevelopment Scheme 2006 is proposed to be adopted over the Scheme Area to ensure its orderly and proper planning and development in accordance with the Wungong Urban Water Master Plan (Master Plan) (Figure 2).

As discussed in Section 1.1, the Scheme is based on a "Place Based Planning Approach" that sets the parameters for development of subsequent detailed structure plans which will ultimately determine specific landuse and development standards. Place Based Planning is a new approach to town planning and a commitment to refining or reshaping existing planning and design policy to make it more appropriate to a specific place. Place Based Planning guides development on the 'lot' and within the 'streetscape'. It also applies policies that ensure a variety of development within a place to create a more sustainable and liveable place. The approach requires that statutory planning provisions provide sufficient guidance to ensure principal planning objectives are achieved, while allowing sufficient flexibility for detailed site responsive planning to occur (TPG Town Planning and Urban Design 2006).

Place Based Planning therefore aims to make planning provisions more appropriate to a specific place and more adaptable to changing lifestyles. This approach differs from traditional planning schemes that typically include tables that determine development density, landuse, setbacks and car parking without consideration of the requirements of the site where development is to occur or the nature of the landuse and built form that is proposed. The Master Plan supports the development of neighbourhoods with mixed housing densities, mixed-use development and high quality main-streets.

The Wungong Urban Water Redevelopment Scheme 2006 will be amended to incorporate the Master Plan and Place Based Planning Codes to ensure development within the area occurs in accordance with the Master Plan (Armadale Redevelopment Authority 2006a). The Scheme defines the objectives or 'vision' of the Master Plan and will describe the broad elements of the Plan. The Scheme will include the enacting provisions relating to the preparation and adoption of Structure Plans and cost sharing requirements to enable implementation of the Master Plan. It will also set the parameters for the more detailed structure planning which will follow, but not define density, landuses and detailed development standards – these provisions will be determined in the Structure Plans and Design Guidelines (TPG Town Planning and Urban Design 2006).

The flow chart, shown over the page, details the statutory planning provisions necessary to implement the Master Plan. The Master Plan has progressed through various iterations following a collaborative planning approach, is a statutory document which provides the basis for the *Wungong Implementation Plan for Sustainability* (WIPS), along with supporting policies and design guidelines (refer to Guidelines for Development on the flow chart).

BROOKDALE MASTER PLAN – PLANNING STRUCTURE

The following is a summary of the statutory and non-statutory planning provisions necessary to implement the Wungong Urban Water Master Plan.

Masterplan

The Master Plan describes the proposed planning regime for the area. It is a statutory document that explains the objectives contained in the various statutory planning provisions. It also includes data and analysis relevant to the planning process.

Environmental Review

An Environmental Review addressing the environmental factors relevant to the scheme amendment is assessed by the Environmental Protection Authority.

Scheme Amendment

To Implement the Master Plan in the Brookdale Redevelopment Scheme

The Brookdale scheme currently places a moratorium on new subdivision and development. It is intended to amend the scheme to incorporate the Master Plan and implement "place based" planning provisions.

Under the proposed amendments the scheme will define the aims and objectives of the Master Plan to ensure that principle initiatives such as the 'tree lined avenues' and 'urban water management measures' are achieved. These objectives will be contained in the parameters set for the development of guidelines for structure plans and subdivisions and for 'place based codes' which will contain specific development standards. The revised scheme will provide an alternative to the traditional application of landuse, density and parking schedules and adopt a more site responsive approach which allows for these things to be determined at the structure plan level.

The scheme will also establish a process for developers to contribute to necessary infrastructure costs and insure that significant heritage and environmentally significant sites are conserved.

Guidelines for Structure Plans & Subdivisions

The redevelopment area is divided into a number of structure plan cells (shown on the scheme maps). Structure Plans must be approved by the ARA for each cell before subdivision can occur. Guidelines will be produced by the ARA and approved under the provisions of Part 4 of Scheme following consultation. These will provide guidance to landowners on the elements (specified in Part 6 of the scheme) which are to be included in structure plans.

Contribution Plan

Infrastructure & Scheme Cost Estimates approved by Minister under Part 7 of the Scheme

Structure Plans

These plans will guide future subdivision and indicate the 'permitted' and 'discretionary' uses which may be included within each cell, designate areas of for public open space and those areas which are to be conserved, average development densities which are to apply and define the extent and application of the various 'place based codes'. The structure plans will also address the provision of infrastructure and any necessary cost sharing provisions.

Guidelines for Development

Place based codes will contain specific development standards to guide development on the 'lot' and within the 'streetscape'. These standards will relate for built form, density, landscaping etc. they will be Approved by ARA under Part 4 of Scheme.

SUBDIVISION APPROVAL

Issued by WAPC after referral to ARA

DEVELOPMENT APPROVAL

ARA Sustainability Audit

The Master Plan or Scheme Map, incorporated into the Scheme Amendment as Appendix One, adopts the Liveable Neighbourhoods approach to neighbourhood design, and incorporates New Urbanism and Transit Oriented Development principles. The Scheme establishes a process for developers to contribute to necessary infrastructure costs (refer to Contribution Plan on the flow chart) and ensures that significant heritage and environmentally significant sites are conserved.

In addition, the ARA has prepared an environmental report (this document) to facilitate a Section 48A environmental assessment, and a District Water Management Strategy has been prepared on behalf of the ARA and submitted to the DEC/DoW for their consideration. The Water Group is preparing an implementation plan and business case for a non-potable supply network. A groundwater model is currently being finalised by CSIRO to use as a decision support tool in identifying the preferred non-potable option for the water cycle.

The technical investigations undertaken as part of the environmental impact assessment process that this ER report details, have been instrumental in informing the rationale for the establishment of the following Scheme objectives that are detailed in Part 1 of the Scheme including:

a) Guide the creation of places that respond to the needs of people and the natural environment;
b) Promote appropriate built forms which are site/climate responsive, will enhance residential amenity, and are appropriate for their intended use;
c) Promote sustainable development and landuse which reduces demand for water, energy and other resources;
d) Guide landuse, built form and density to create a vibrant and diverse urban environment;
e) Encourage the conservation and preservation of places of cultural, environmental and/or heritage significance, including significant vegetation, wetlands and ecosystems;
f) Encourage the efficient provision of services incorporating Urban Water Management Principles;
g) Establish a mechanism for cost sharing of infrastructure, open space and other designated public facilities;
h) To facilitate and encourage the provision of diversified employment opportunities; and
i) Generally to encourage, promote and facilitate economic and social development.

Part 3 of the Scheme describes the general objectives of the Master Plan established for the Wungong Urban Water Scheme Area and objectives for various ‘Place Based Codes’ described on the Master Plan (Figure 2).

A Structure Plan is required for each of the 13 Structure Plan Areas (or ‘cells’), shown overlaid on the Master Plan (refer to Appendix 2 of the Scheme) and referenced into the Scheme (Part 6 of the Scheme designates requirements for the preparation of Structure Plans while Appendix 2 designates the extent of structure plan cells). The cell boundaries have been determined with consideration of the infrastructure, land ownership, water sub-catchments and physical boundaries that separate them. A Developer is required to prepare a Structure Plan for the entire Structure Plan area (not just for the land owned by that Developer) to demonstrate how development in the cell will occur on a comprehensive basis.

The ARA will produce Guidelines for Structure Plan under Part 6 of the Scheme and these will provide guidance to developers on the elements that are to be addressed within the Structure Plan.

Each Structure Plan will be required to demonstrate linkages to adjoining Structure Plan areas, initiate sustainable land management practices, provide a basis for servicing and transport authorities to plan their future requirements, address sustainability issues, rollout of infrastructure provision, detail landuse, density, range of uses and outline cost sharing requirements in the Structure Plan area. The Structure Plan is required to be generally in accordance with the Master Plan, and with any relevant Policy or Design Guidelines adopted by the ARA, and Liveable Neighbourhoods.

Structure Plans will be assessed by the ARA in accordance with the provisions of Part 6 of the Scheme that require formal advertising of draft plans and the consideration of any submissions prior to determination by the ARA. Part 6 of the Scheme precludes subdivision or development until a Structure Plan has been approved for the relevant Structure Plan area.

Following adoption of the Structure Plan by the ARA, a Developer may submit an application for subdivision to the WAPC. The subdivision application is required to be generally consistent with the approved Structure Plan and any relevant Policy and Design Guidelines adopted by the ARA. The ARA is responsible for subdivision approval where it is the landowner.

Further, adoption of a Structure Plan and/or approval of a Plan of Subdivision permits a Developer to lodge an application(s) for development approval, in accordance with the Scheme and relevant ARA Policies. The Scheme establishes the circumstances in which Development Approval is required.

Part 4 of the Scheme provides for the adoption of planning policies and guidelines by the ARA and these will guide the development and assessment of structure plans and subdivisions.

2.3 Implementation of Environmental Management Plans/Strategies

This ER report provides information relating to the proposal by the ARA to progress the redevelopment of the Amendment area in keeping with the Wungong Urban Water Master Plan. The document includes a description of the Amendment area, the characteristics of the proposal and identifies significant environmental issues.

Section 4 of the report identifies the key environmental factors of significance that were identified in the ER Instructions issued by the EPA that may be impacted both during the construction and the operational phase of the proposed redevelopment of the Amendment area from its current rural/rural residential setting to an urban residential development. In addition, the report identifies how these impacts may be managed and specifies further studies or monitoring that will ameliorate environmental impacts potentially resulting from more intensive landuse.

A number of management plans have been identified to protect and enhance key environmental attributes of the Wungong Urban Master Plan area. Table 1 summarises those plans/strategies or tasks that have already been/or will be required to be undertaken by either the ARA, land developers or others through the development process (timeframe): The timing schedule and responsibility for the preparation and/or implementation of these Plans is detailed in Table 1.

TABLE 1
ENVIRONMENTAL MANAGEMENT STRATEGIES/PLANS – PREPARATION TIMING AND RESPONSIBILITY

No.	Requirement	Purpose	Preparation Timing	Responsibility
1	**Structure Plan Guidelines**	To provide advice to landowners/Developers within the Amendment area in relation to specific Structure Plan requirements, departures from Liveable Neighbourhoods in relation to design criteria and to set specific targets or criteria for particular aspects of design.	Will be prepared prior to landowners preparing Structure Plans.	**ARA**
2	**Policies**	Identification of Policies required to support requirements of the Master Plan and Implementation Plans for Sustainability. The existing ARA Policy Manual will be updated to reflect new Policies or modifications to existing policies for administration.	Will be prepared on an 'as needs' basis to assist planning.	**ARA**
3	**Design Guidelines**	Preparation of Detailed Design Guidelines to implement Place Based Design requirements. The Guidelines will relate to each landuse area including retail/commercial, residential and open space, and provide guidance on design requirements for individual sites and the public realm.	Will be prepared prior to the implementation of Structure Plans.	**ARA**
4	**Developer Contribution Arrangements**	To ensure infrastructure and other costs are equitably shared between landowners/Developers within the Precinct.	Arrangements, including when payments are due, are set out under Part 7 of the Scheme.	**ARA**
5	**Structure Plans**	To be prepared for each Structure Plan Area Cell identified in Appendix 2 of the Scheme.	Will be prepared prior to any change in landuse in a Structure Plan area.	**Developer (to the satisfaction of the ARA)**
6	**Detailed Area Plans (DAP)**	Provide detailed design requirements for each lot within a subdivision stage, in accordance with the Design Guidelines. In addition, Developers will be required to ensure density targets identified on Structure Plans are achieved through Detailed Area Plans (DAP). The ARA will prepare model DAPs for reference by Developers.	Will be prepared in respect to the preparation and assessment of subdivision plans.	**Developer (to the satisfaction of the ARA)**
7	**District Water Management Strategy**	Consistent with EES (2006) requirements, provision of an District Water Management Strategy (DWMS) which addresses: ▪ Recognition of the principles, objectives and requirements of total water cycle management as outlined in the draft Statement of Planning Policy No 2.9: Water Resources Policy (WAPC 2004), Liveable Neighbourhoods Edition 3 (WAPC 2004) and the Stormwater Management Manual for WA including the Decision Process (DoW 2004 –	A DWMS has been prepared and is included in this Environmental Review in Appendix 5. The DWMS has informed the Master Plan	**ARA**

No.	Requirement	Purpose	Preparation Timing	Responsibility
		current); ▪ Interim Water Related Design Objectives for the District Structure Plan Area; ▪ Broad description of constraints to total water management within the proposal area due to existing infrastructure, existing land uses, possible groundwater pollution plumes and groundwater capture zones of significant wetlands and other water dependent ecosystems; ▪ Where necessary, more detailed desk top assessment of past land use with the potential for contamination including high levels of nutrients and identification of areas affected or potentially affected by acid sulfate soils; ▪ Discussion of potential water sources for drinking water and other uses having consideration of impacts of use/allocation and infrastructure and management requirements, highlighting the preferred options for supply of non-potable water for fit-for-purpose use (where proposed) and giving consideration to infrastructure needs; ▪ Results of more detailed water quality monitoring, as well as other more detailed surface and groundwater investigations and modelling, focusing on potential risk areas; ▪ Conceptual stormwater management plan in consultation with the Department of Water, Water Corporation and Local Government; ▪ Recommendation for strategies and responsibilities for local surface and groundwater monitoring, both pre and post development including data analysis, presentation and reporting mechanisms; ▪ Identification of specific issues/areas likely to require specialised investigation and management at later stages of planning; and ▪ Recommended implementation framework identifying funding and ongoing maintenance responsibilities. ▪		
8	**Local Water Management Strategy**	A Local Water Management Strategy (LWMS) will need to be developed for each precinct of the Master Plan Area. The LWMS should address the following: ▪ Principles, objectives and requirements for total water cycle management as outlined in the draft *Water Resources SPP* (WAPC 2004), *Liveable Neighbourhoods Edition 3* (WAPC 2004) and the *Stormwater Management Manual for WA* including the Decision Process; ▪ Objectives for water management as outlined in the final Southern River Integrated Land and Water Management Plan (ILWMP) and the DWMS. Compliance with these objectives should be demonstrated both within the LWMS and at time of subdivision; ▪ Existing site characteristics such as geology, hydrogeology and groundwater characteristics in more detail than the ILWMP or DWMS;	Will be prepared prior to any change in landuse in a Structure Plan area	**Developer (to the satisfaction of the ARA)**

No.	Requirement	Purpose	Preparation Timing	Responsibility
		▪ Site constraints and opportunities (such as environmental assets, landscape and landform), identifying the critical management issues; ▪ Conceptual urban water management system, including: o Quantification of land required for storage and retention of stormwater for the 100 year ARI, 10 year ARI and 1 year ARI storm events; o Map of existing groundwater levels and any proposed controlled groundwater level (CGL) (including use of subsoil drains) with justification for this control; o Demonstrated understanding of the concepts and key issues associated with BMP choice - identification of types of BMPs for management of water quality and quantity and indicative drawings of possible treatment trains and design approaches; o Fit-for-purpose water use strategy, including mechanisms to conserve potable water and minimise wastewater (including those relating to development design and construction); and o Infrastructure and management requirements for proposed water, wastewater and stormwater systems, having consideration of infrastructure already existing and identifying any necessary approvals; ▪ Issues to be addressed at subdivision stage (in an Urban Water Management Plan); ▪ Recommended monitoring framework, pre- and post-development; and ▪ Proposed implementation of strategy including roles, responsibilities and funding for monitoring and maintenance. The LWMS will be submitted to the ARA/CoA for approval. As part of this process, the document will be formally advertised to allow the regulatory agencies to comment. The ARA/ CoA will review any comments received and decide whether or not to approve the LWMS and with or without conditions/revisions.		
9	**Urban Water Management Plan**	The landowner will need to ensure that an Urban Water Management Plan (UWMP) is developed and submitted together with all applications for subdivision. The UWMP should address: ▪ Objectives as outlined in the SRILWMP, the DWMS and the LWMS. ▪ Demonstration of compliance with these criteria and objectives should be achieved through appropriate assessment tools, calculations or assessments, to the satisfaction of the DoW; ▪ Agreed/approved measures to achieve water conservation and efficiencies of use including sources of water for non-potable uses and detailed designs, controls, management and	Will be prepared in respect to the preparation and assessment of subdivision plans.	**Developer**

No.	Requirement	Purpose	Preparation Timing	Responsibility
		operation of any proposed system; ▪ Management of groundwater levels, including maintenance of ecosystem health and any proposed dewatering; ▪ Detailed stormwater management design including the size, location and design of public open space areas, integrating major and minor flood management capability; ▪ 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; ▪ Measures to achieve protection of waterways, wetlands (and their buffers), remnant vegetation and ecological linkages; ▪ Adequacy of buffers proposed in the Local Structure Plan having consideration of any controlled groundwater level (CGL) proposed; ▪ Where an artificial water body is proposed, identify its purpose, design and management; ▪ Management of subdivisional works (to ensure no impact on regional conservation areas, maintenance of any installed BMPs and management of any dewatering and soil/sediment, including dust); ▪ Management of disease vector and nuisance insects such as mosquitoes and midges; ▪ Monitoring program and/or contribution; and ▪ Implementation plan including roles, responsibilities, funding and maintenance arrangements. Contingency plans should also be indicated where necessary.		
10	**Water Quality Management Plan**	Undertake a risk based assessment of human and environmental exposure pathways associated with onsite wastewater and/or greywater reuse and negotiate with the relevant agencies regarding its future application.	Will be prepared as part of the WIPS process.	**ARA**
11	**Environmental Assessment**	Preparation of an Environmental Review to assist assessment by the EPA under Division 3 Part IV *Environmental Protection Act 1986.*	An Environmental Review document (this document) has been prepared. The gazetted Scheme will incorporate any environmental conditions that are set by the Minister for the Environment.	**ARA**
12	**Landscape and Irrigation**	To guide rehabilitation and management of remnant vegetation, new landscape planting and water sensitive urban design features within development, including waterwise landscaping, by	Will be prepared prior to any change in landuse in a	**Developer**

No.	Requirement	Purpose	Preparation Timing	Responsibility
	Management Strategy	promoting landscape packages and ensuring local nurseries stock and promote waterwise species. Establish water use consumption targets for public uses within the precinct.	Structure Plan area	
13	**Landscape Plan**	A Landscape Plan will be required at the subdivision stage (although a Concept Plan identifying trees to be retained and removed will be required at the Structure Plan stage.)	Will be prepared in respect to the preparation and assessment of a subdivision plan.	**Developer**
14	**Traffic Management Plan**	To be prepared for each Structure Plan area, including traffic volumes, traffic management and typical/special street cross sections.	Will be prepared prior to any change in landuse in a Structure Plan area.	**Developer**
15	**Fauna Relocation and Management Plan**	In key fauna habitat areas, a Fauna Relocation and Management Plan will be prepared and implemented by the landowner as a condition of subdivision approval to the satisfaction of the DEC, that includes, but is not limited to, the following: ▪ Any clearing of native vegetation that is required during subdivision, will be conducted in stages to reduce impacts on resident fauna and fauna habitat; ▪ A 'fauna friendly' clearing protocol will be used as part of any clearing operations where all tree hollows, nests and vegetated debris will be inspected for fauna prior to clearing; • All hollow logs and branches cleared will be returned to other remnant vegetation areas as part of the rehabilitation works; • If clearing of vegetation from key habitats is unavoidable then a suitable offset plan will be developed that includes the planting and revegetation of POS areas; • Translocation of fauna will be undertaken in accordance with DEC policy; and • Creation of additional tree hollows to result in no net loss of potential fauna habitat.	Will be prepared in respect to the preparation and assessment of a subdivision plan.	**Developer**
16	**Bush Fire Management Plan**	Prior to the approval of a Detailed Area Plan the developer shall prepare and have approved by the relevant authorities, and to the satisfaction of the Fire and Emergency Service Authority (FESA) and CoA, a Bush Fire Management Plan to be implemented as part of the subdivision. The Bush Fire Management Plan shall include, but it not limited to, the following: ▪ Addressing key fire management issues; ▪ Provision of a detailed risk assessment for wildfires within the development area, or in adjoining areas; ▪ Strategies for fire management such as separation distances and other mechanisms that will be implemented through the planning stages; ▪ Fire management strategies and programs that will be undertaken by the developer to	Will be prepared in respect to the preparation and assessment of a subdivision plan.	**Developer**

No.	Requirement	Purpose	Preparation Timing	Responsibility
		minimise the risk from fire to the community throughout the life of the development; and ▪ Compliance with relevant State Government policies, regulations and guidelines.		
17	**Rehabilitation Management Plan**	Landowners proposing to develop land either containing or bordering a Bush Forever site will be required to prepare and implement a Rehabilitation Management Plan to the satisfaction of the DPI's Bush Forever Office and the ARA as a condition of subdivision approval. The Rehabilitation Management Plan will include, but is not limited to, the following: ▪ Rehabilitation and revegetation strategy (native local provenance to be used); ▪ Enhancement of ecological corridors; ▪ Mitigation strategies; ▪ Monitoring criteria to determine the success of rehabilitation and revegetation and evaluation program; ▪ Community consultation strategy; ▪ Progress and compliance reporting; and ▪ Timing, implementation and review schedules.	Will be prepared in respect to the preparation and assessment of a subdivision plan.	**Developer**
18	**Green Smart Accreditation**	ARA will apply for registration of the Master Plan as a Green Smart Project and seek automatic recognition of any development approved by the Authority under its policies.	Will be prepared as part of the WIPS process.	**ARA**
19	**Foreshore Management Plan**	Protection of the conservation values identified for the Wungong River and Neerigen Brook foreshore reserves; and to mitigate clearing in areas adjacent to foreshores and enhance linkages and habitat values of foreshore reserves including: ▪ Comprehensive weed eradication program; ▪ Revegetating and restoring foreshore POS adjoining conservation areas with appropriate indigenous flora; ▪ Increase the area contained within POS adjoining Bush forever sites; ▪ Creation of habitat and wildlife corridors; ▪ Investigate areas of straightened sections of Wungong River suitable for meander; ▪ Controlling vehicle and pedestrian access; ▪ Provision of public facilities; ▪ Soil and plant source material hygiene; ▪ Fire management including provision of fire hydrants; ▪ Encouraging community involvement and awareness promoting control of pets; ▪ Water conservation principles; ▪ Monitoring criteria to determine the success of the vegetation and weed eradication	Will be prepared as part of the WIPS process.	**ARA** **Developers will be responsible for implementation of the Foreshore Management Plan as a requirement of subdivision approval.**

No.	Requirement	Purpose	Preparation Timing	Responsibility
		program; ▪ Weed management; ▪ Progress and compliance reporting; and ▪ Timing and implementation schedule. The delineation of waterways buffers will be finalised in liaison with the DEC as part of the development of the Foreshore Management Plan. It is the ARA's expectation that final waterways buffers will be determined prior to any Structure Plans being approved.		
20	**Site Contamination Study and Remediation Plan**	Site contamination risk categories have been discussed in Section 4.9.3 of this document and their locations identified on Figure 12. A Protocol for Assessing Potentially Contaminated Land is detailed in Table 18 of this document. Site Contamination Study and Remediation Plans are to be prepared and implemented in accordance with DEC's Contaminated Sites Management Series.	Will be prepared in respect to the preparation and assessment of either a structure plan or subdivision plan depending upon timing as specified in Table 18 of this document.	**Developer**
21	**Strategic Acid Sulfate Soils Management Plan**	To plan and manage development that may potentially impact on ASS/Potential ASS to avoid adverse effects on the natural and built environment and human activities and health. Detailed design and management guidelines will be developed on the basis of this plan and the design and management strategies proposed will be tested by the ARA in conjunction with the DEC through pilot scale field trials to demonstrate effectiveness.	Will be prepared as part of the WIPS process.	**ARA**
22	**Acid Sulfate Soils Management Plan**	To be prepared and implemented for each Structure Plan area, depending on outcomes of Strategic ASS Management Plan.	Will be prepared prior to any change in landuse in a Structure Plan area.	**Developer**
23	**Air Quality Management Plan**	To ensure that emissions do not adversely affect environmental values or the health, welfare and amenity of people and landuses by meeting accepted guidelines, standards and criteria. To be consistent with Best Management Practice. Key elements of the Air Quality Management Plan (AQMP) will include a Dust Management Plan taking into account seasonal influences and distance to sensitive premises and incorporating any or all of the following measures: ▪ Where possible retaining vegetation; ▪ Limiting area of exposed soil; ▪ Hydromulching or alternative effective stabilisation immediately following completion of	Will be prepared as part of the WIPS process. To be implemented as a	**Prepared by the ARA.** **Developers will be**

No.	Requirement	Purpose	Preparation Timing	Responsibility
		bulk works; ▪ Use of water to increase moisture in soil in sensitive or high traffic areas; ▪ Minimising fetch distance; ▪ Wind fencing; ▪ Timing of earthworks (daily and seasonally); ▪ Consideration of wind direction and strengths (eg. Sea breezes) when planning bulk earthwork cells; ▪ Consideration of distance to and direction of sensitive locations (eg may construct closer to residents during time of year when dust not expected to be as much of a problem); ▪ Appropriate shape/layout of earthworks area (boundary perpendicular to problem wind direction); ▪ Staging of subdivision (need to consider dust in the early stages of planning, not just at time of construction); and ▪ Site perimeter monitoring including sensory alarms or dial out capability.	condition of subdivision approval.	**responsible for implementation of the AQMP.**
24	**Cultural Heritage Interpretation Plan**	To detail the ways in which historic themes evident in the European cultural history of Brookdale can be integrated with the redevelopment of the Amendment area.	Will be prepared as part of the WIPS process.	**ARA**
25	**Aboriginal Heritage Management Plan**	To ensure development does not affect historical and cultural associations within the area and comply with the requirements of relevant Aboriginal and heritage legislation an Aboriginal Heritage Management Plan (AHMP) will be prepared. The AHMP will be prepared in consultation with key interest groups facilitate the management and protection of Aboriginal heritage assets in the Amendment area. The AHMP will outline the extent of Aboriginal Heritage assets in the Amendment area and identify options for the protection of those assets. The objectives of the AHMP are: ▪ Protect and enhance the Aboriginal heritage values of the Amendment area to the greatest possible extent; ▪ Minimise adverse impacts on Aboriginal heritage assets within the Amendment area arising from proposed development activity; ▪ Ensure that Aboriginal heritage assets scheduled for retention within the Amendment area are not damaged, defaced or destroyed by construction or related activity or personnel engaged in construction activity; ▪ Identify appropriate management interventions to ensure the long term preservation of Aboriginal heritage assets scheduled for retention within the Amendment area;	Will be prepared as part of the WIPS process.	**ARA**

No.	Requirement	Purpose	Preparation Timing	Responsibility
		▪ Implement a program of monitoring to ensure the suitability and/or effectiveness of any management intervention implemented in relation to Aboriginal heritage assets; ▪ Establish protocols and procedures governing the management of Aboriginal cultural and/or skeletal materials identified during the course of development within the Amendment area; and ▪ Establish mechanisms to ensure on going engagement with the aboriginal community in respect of aboriginal heritage and other relevant matters of concern.		
26	**S18/S16 Clearances**	To be prepared under the provisions of the *Aboriginal Heritage Act 1972.*	Will be prepared in respect to the preparation and assessment of either a structure plan or subdivision plan depending upon land ownership.	**Developer**
27	**Clearing of Native Vegetation**	Approval will be required under the *Environmental Protection Act 1986* (unless it is of a kind that is exempt in accordance with Schedule 6 *Environmental Protection Act 1986* or Regulation 5 under the Clearing of Native Vegetation Regulations).	Will be prepared in respect to the preparation and assessment of a subdivision plan.	**Developer**
28	**Tree Surveys**	To identify the location of all trees, condition, species and height within the Structure Planning area.	Will be undertaken prior to any change in landuse in a Structure Plan area.	**Developer**
29	**Greenhouse Gas Emissions Management Plan**	To minimise greenhouse gas emissions to levels as low as practicable on an ongoing basis and consider offsets to further reduce cumulative emissions, this broad scale Plan include measures to minimise greenhouse emissions from transport and minimise traffic impacts by reducing the need for car use through the provision and encouragement of public transport, walking and cycling.	Will be prepared as part of the WIPS process.	**ARA**
30	**Mosquito and Midge Management Plan**	In order to protect the health, welfare and amenity of future residents from disease vectors (mosquitoes) and nuisance insects (midges), landowners proposing to develop land in close proximity to seasonal Conservation Category and Resource Enhancement wetlands and waterways will be required to prepare and implement a Mosquito and Midge Management Strategy in consultation with the HDWA.	Will be prepared in respect to the preparation and assessment of a subdivision plan.	**Developer**

No.	Requirement	Purpose	Preparation Timing	Responsibility
		Management options for the known/potential breeding sites could include, but not be restricted to, any of the following: ▪ vegetation control when the wetland is dry; ▪ maintenance of drainage ditches is undertaken to ensure good flow rates are maintained; ▪ landscaping to improve drainage; ▪ encouraging predator species to help control and mosquito and midge larvae; ▪ larviciding using treatment options which specifically target mosquito and midge larvae but do not impact on the predator species; ▪ public education; ▪ building requirements which ensure that development does not take place directly next to mosquito breeding areas; ▪ house design to prevent mosquitoes entering dwellings.		
31	**Construction Management Plan**	Prior to final subdivision approval, the developer shall prepare and have approved by the ARA, and to the satisfaction of the DEC, a Construction Management Plan for all development sites adjoining a Bush Forever site, TEC and all wetlands covered by a Wetland Management Plan, to be implemented as part of the development. The Construction Management Plan shall include, but is not limited to, the following: ▪ The minimisation of clearing and vegetation disturbance; ▪ The control and monitoring of dust, noise and smoke; ▪ The prevention and control of the introduction/or spread of dieback; and ▪ The inclusion of environmental protection specifications in all construction related contracts.	Will be prepared in respect to the preparation and assessment of a subdivision plan.	**Developer**
32	**Geotechnical Survey**	To establish and map soil types, permeability, plasticity, acid sulphate soils and nutrient retention capacity.	Will be undertaken prior to any change in landuse in a Structure Plan area.	**Developer**
33	**Wetland Management Plan**	Landowners proposing to develop land adjoining an EPP, Conservation Category or Resource Enhancement wetland or its buffer will be required to prepare and implement a Wetland Management Plan to the satisfaction of the DEC, the ARA and other relevant authorities. The Wetland Management Plan will include, but is not limited to, the following: ▪ Summary of management commitments/recommendations;	Will be prepared prior to the finalisation of a Structure Plan. The Plan will be implemented as a	**Developer**

No.	Requirement	Purpose	Preparation Timing	Responsibility
		▪ Description of the site and context; ▪ Site-specific determination of wetland buffer in keeping with Attachment B4-3 of the EPA's Guidance Statement No. 33: *Environmental Guidance for Planning and Development* (2005); ▪ Site-specific environmental issues (for example: conservation, ecological linkage, recreation, stormwater management, water quality, fire management, flooding, heritage, reserve boundaries, mosquitoes and midges, dieback, weeds, utility services and corridors, introduced fauna, feral animals, education, visual amenity, vandalism, trampling, liability and risk from community use); ▪ Management aim and objectives; ▪ Management responsibilities; ▪ Management actions/measures to achieve the objectives; ▪ Diagrammatic management plan; ▪ Funding and resources; ▪ Monitoring criteria and evaluation plan to enable compliance with objectives and criteria to be checked and response; ▪ Stakeholder consultation; and ▪ Timing, implementation and review schedules.	requirement of subdivision approval.	
34	**Agricultural Practice Implementation Plan**	Landowners proposing to develop land within close proximity of market gardens, commercial plant nurseries and/or orchards will be required to prepare and implement an Agricultural Practice Implementation Plan in keeping with the WAPC's Planning Bulletin No. 63. The Plan will be required to consider spray drift as the principle issue of concern, but also potential noise, dust and odour impacts on the proposed development and implementation of prescribed management measures to ameliorate conflict.	Will be prepared in respect to the preparation and assessment of a subdivision plan.	**Developer**

2.4 The Avenues

To create an innovative and more appropriate starting point to the redevelopment of the Amendment area, landscape architects from the University of Western Australia were engaged by the ARA to demonstrate how the landscape itself could genuinely inform the character and structure of the suburban development of the Amendment area. The Landscape Structure Plan proposed an urban development with an integrated urban water management system structured around a matrix of Avenues and Living Streams while also maintaining and enhancing Brookdale's natural and rural character (Armadale Redevelopment Authority 2006).

The Avenues represent the key distinguishing landscape architectural element of the Landscape Structure Plan and are an integral component of the Wungong Urban Water Master Plan. The Landscape Structure Plan is included as Appendix 1: *Brookdale A Landscape Structure Plan for the Suburban Development of the Wungong River System* (The University of Western Australia 2004).

The Avenues are a series of parallel POS corridors with long lines of eucalyptus trees that structure the urban development of the Amendment area and constitute its primary public open space matrix. The Avenues will assist in providing wildlife corridors across the whole of the Amendment area, potentially connecting with off-site landscape systems, and adding significantly to the overall amount of indigenous vegetation in the Armadale region.

As part of the Wungong Urban Water Master Planning process, a detailed assessment of Avenue orientation was undertaken to determine an optimal orientation for the Avenues. Relationships between district solar orientation and constraints such as topography, ecology, heritage, road layout, ownership and lot orientation were investigated. The results demonstrated that the highly desirable east west lot orientation is possible for more than 90% of the Amendment area which is in excess of the Liveable Neighbourhood's target of 75%. The investigations also showed a similar lot yield south of the Wungong River where the avenues run east west compared to north of the Wungong River where avenues run along a northeast to southwest axis in line with existing roads and ownership boundaries. This innovative solar orientation planning at a district level will make it easier for builders to achieve energy performance targets, households will consume less energy and more people will enjoy the benefits of northern winter sun entering their main living areas (Armadale Redevelopment Authority 2006).

Two types of Avenue are proposed and shown on the Master Plan:

- Park Avenues; and
- Road Avenues.

Park Avenues

The Park Avenues are proposed to be an integral part of the comprehensive urban water management system and offer natural character, vistas, wind mitigation, habitat corridors, open space and an uninterrupted pedestrian matrix through the suburb. Park avenues will contain rows of Eucalypts on each side of a linear green space with a central swale that leads to the Wungong River. They can be individually styled so that they feel and look different whilst all performing the same multiple functions. Park Avenues are located at approximately 400m intervals, and they function to significantly increase the pedestrian permeability of the development and the number of residents living next to areas of high amenity public open space (Armadale Redevelopment Authority 2006). A concept plan for a Park Avenue, prepared by the University of Western Australia's Department of Landscape Architecture, is shown on Figure 3.

Road Avenues

Road Avenues provide links between neighbourhood connectors and local access streets. A footpath is included on both sides of a 6m carriageway. These roads are not intended to carry large volumes of through traffic or to act as bus routes. Cross sections have been developed for each road classification based on the role and predicted traffic volume for each road. Each of these cross sections is discussed below and key characteristics are summarised in Table 2. (Details and descriptions have been provided by Worley Parsons Resources and Energy Infrastructure, Duncan Foster pers. comm.).

Figure 4a shows the Functional Road Hierarchy designed for the Amendment area.

To achieve the Road Avenues concept a minimum verge width of 7.5m is required. Proposed cross sections for the Road Avenues, Park Avenues and access roads were developed by GHD Engineers. These original cross sections have been used as the basis for the development of these cross sections for each road classification within the Amendment area maintaining the required verge width to achieve the avenues (Duncan Foster pers. comm.).

TABLE 2
SUMMARY OF NEIGHBOURHOOD INTEGRATOR CROSS SECTIONS

	ROAD CLASSIFICATION				
	District Entry Road 'A'	**District Entry Road 'B'**	**Neighbourhood Connector**	**Road Avenue**	**Access Road**
Speed Limit	60 km/h	60 km/h	50 km/h	50 km/h	50 km/h
Verge	7.5m on side w/footpath 8.5m on side w/SUP *	7.5m on side w/footpath 8.5m on side w/SUP	7.5m on side w/footpath 8.5m on side w/SUP	7.5m on each side	4m
Carriageway width	Two 3.75m lanes	Two 3.75m lanes	7.5m	6m	5.5-6m
Median	6m	2m	-	-	-
TOTAL	**29.5m**	**25.5m**	**23.5m**	**21m**	**14m**
Footpath	SUP on one side, footpath on alternate side	SUP on one side, footpath on alternative side	SUP on one side, footpath on alternate side	Footpath on both sides	Footpath on at least one side

Source: Worley Parsons 2006
Note: * SUP – Shared Use Path

All proposed road cross sections are illustrated in Figure 4b.

District Entry Road 'A'

This is the highest order road within the Amendment area and applies only to two major road entries to the area (Forrest Road and Eighth Road). This cross section would be applied only to the first section of these roads as illustrated in Figure 4b.

The 6m median will allow for substantial planting at the entry to the area as well as the inclusion of right turn pockets at key intersections.

A shared use path is provided on one side of the road with a 1.5m wide footpath on the alternate side. In both locations where this cross section is used the shared use path should be connected to existing paths along Armadale Road and Tonkin Highway.

District Entry Road 'B'

This classification applies only to Rowley Road at its intersection with Tonkin Highway. While the actual intersection with Tonkin Highway is the responsibility of Main Roads WA, this cross section will be applied from Tonkin Highway through to the nearest neighbourhood centre.

Neighbourhood Connectors

These streets form the major 'spines' of the network throughout the Amendment area. These roads will serve as bus routes and provide links between neighbourhood and town centres. A shared use path should be provided on at least one side of the road with a footpath on the alternate side.

In neighbourhood centres the reserve width can be decreased with a 2m median introduced and embayed parking to serve active landuses. At the entry to town/neighbourhood centres the carriageway should be paved to signal a change in the road environment. Nibs should be provided at intersections within neighbourhood centres to facilitate pedestrian crossing.

Within the town centre, intersections should be signalised and include a dedicated pedestrian phase. Two lanes would be required for queuing vehicles at these intersections, with parking discontinued 20m prior to the intersection and recommencing 20m after.

Road Avenues

Road Avenues provide links between neighbourhood connectors and local access streets. A footpath is included on both sides of the 6m carriageway. These roads are not intended to carry large volumes of through traffic nor act as bus routes.

Park Avenues

Park Avenues utilise a similar cross section to Local Access Streets with a 6m carriageway and only one path. In the case of park avenues a continuous 2.5m shared use path is provided on the park side of the street rather than the property side. Crossing points to the shared use path will be provided from paths on intersection roads.

These roads may run continuously parallel to a park avenue or only for short sections of the avenue. Parking embayments may also be provided along these roads to provide access to the Park Avenue.

Local Access Street

These are the lowest order streets within the Amendment area and their design is intended to discourage through traffic. A footpath is required on at least one side of these streets and embayments for on street parking could be provided at locations near public open space or multiple dwellings.

2.5 Land Status, Ownership and Legal Descriptions

The Amendment area is predominantly in private ownership with several large Crown land holdings. The land ownership pattern comprises approximately 280 separate landowners with the majority of the landowners possessing titles to landholdings less than 5ha in size. Many of the small lots appear to be held by owner-occupiers. Table 3 shows the landholding status as of August 2005.

TABLE 3
LANDHOLDING STATUS FOR THE AMENDMENT AREA

	Area (ha)	Developable Area Proportion (%)
Crown Land	422.0204	28.66
Consolidated Holdings	391.4127	26.58
Small Lot Ownership	658.7287	44.76
Total Area	**1472.1618**	**100**

Source: TPG Town Planning and Urban Design (2006) based on 2005 data

There are a number of major landowners in terms of the size of landholdings within their control. Land to the immediate south of Rowley Road is in single ownership. Land immediately to the north of Rowley Road but south of the Wungong River is in fractured ownership and affected by a number of roads at varying orientations.

To the north of the Wungong River there is a well-defined inter-cardinal road system and lots follow this orientation. There are several large landholdings and areas of land currently under options while many of the smaller lots remain in individual ownership.

2.6 Community Consultation

2.6.1 Introduction

Community and landowner input is a key feature of the planning process for the new Brookdale. A comprehensive communication strategy was in place before the announcement by the Minister for Planning and Infrastructure, Alannah MacTiernan, in April 2004 that the State Government, with the support of the City of Armadale, had ceded planning and development control powers over the Brookdale redevelopment area to the Armadale Redevelopment Authority. The Minister's announcement included the strategy's key messages that Brookdale would be developed by a partnership of Government, industry and the community, and that the ARA planning team would consult with the community at workshops and information sessions during the master planning process.

The proactive strategy has been effective in helping the ARA and its partner the CSIRO encourage, develop and maintain two-way communication with all Brookdale landowners and gain broad acceptance of the Master Plan.

Initial community consultation has been undertaken by the CSIRO as part of a survey aimed at identifying the Amendment area's cultural and historical assets and to determine the "identity" desired by the local community. The on-going consultation programme has involved interviewing representatives (including indigenous, long-term residents and regional representatives) of the following groups:

- Decision makers;
- Service providers;
- Community groups and volunteers;
- Youth;
- Environmental groups; and
- Businesses.

Initial consultation with Amendment area landowners was undertaken in October 2004 in a workshop setting that dealt with the findings of the opportunities and constraints analyses undertaken by the ARA's technical consultants. More recently in December 2005, another series of public meetings was held to update landowners on the progress of the preliminary Master Plan and technical investigations undertaken to date.

2.6.2 Consultation Activities

Activities undertaken in the past two years comprise:

- Ministerial media statements;
- Letters to landowners;
- A water symposium that brought together experts in all aspects of urban development and water management;
- Two editions of a four-page newsletter called the *Brookdale Bulletin*;
- Major landowners' workshops; and
- Residents' and landowners' information evenings.

These activities and publications have provided stakeholders and the general community with substantial information on the vision for the redevelopment, the planning process, evolution of the Master Plan, environmental investigations and consultation with the local Aboriginal community on heritage issues.

In addition, the CSIRO has conducted a social research project aimed at developing an identity for the Amendment area. The project asked long-term residents about their history and attachment to the area and its natural environment, to build a picture of the region. It also asked people in the wider community about their lifestyles, concerns, aspirations for the future, what they like and don't like about the Amendment area and how it could be improved.

From this information, CSIRO researchers have recommended options for the development of concepts to be tested in focus groups in the final stage of the study. These concepts are aimed at guiding potential developers, urban planners and landscape architects to give Brookdale the best possible start.

2.6.3 Calendar of Key Events

December 1999	Enquiry by Design Workshop.
30 October 2003	'From Catchment to Consumer' water symposium. Minister announces ARA-CSIRO partnership in developing Brookdale as a showcase of urban water management and energy efficient housing.
23 April 2004	Minister announces addition of Brookdale to ARA's redevelopment areas.

7 October 2004	Briefing session for Brookdale landowners and residents. ARA consultants working on the Master Plan briefed landowners and residents on environmental, engineering, planning and hydrology aspects of the proposed redevelopment.
December 2004	First major landowners' meeting.
March 2005	Letter and fact sheet to landowners on soil sampling analysis to establish ground water levels and identify drainage solutions. Survey of landowners – 22 of 24 respondents indicated they wish to develop their land. Most of the 22 wanted to start development within the next five years.
21 March 2005	Second major landowners' meeting.
23 March 2005	General landowners' meeting – Master Plan presented, process and core studies outlined. Comment form distributed at meeting. *Brookdale Bulletin* Issue 1 distributed at meeting, mailed to those not present.
June 2005	Local and State Government stakeholders' briefing.
2 September 2005	DPI briefing on planning issues including sustainability, public open space, schools, transport, lot layout, wetlands.
13 December 2005	General landowners' meeting - update on Master Plan. Comment form distributed at meeting.
7 February 2006	Major landowners' workshop on Master Plan progress and governance structure.

2.6.4 Overview of Issues and Responses

Issues discussed with stakeholders to date included:

- Overview of master planning process;
- Aims for Brookdale development – social and environmental;
- Avenue concept for the Master Plan;
- Wetland buffers;
- Location of town centre;
- Location and size of activity centres;
- Location of schools;
- Minimisation of fill; and
- Efficient management of water.

Key stakeholder responses included:

- One of two landholders is against developing his land, citing reasons including that urbanisation will drive away native wildlife; wishes to remain as Wungong (traditional and cultural links), not Brookdale; negative impact on commercial uses (eg trucks no longer being able to operate in the area).
- Major landowners see need to develop strategy in partnership with ARA to progress implementation.

- Strategic issues include level of detail in the Master Plan; interpretation of principles; ability to develop character precincts; impact of fragmented land ownership on implementing the plan's intent; drainage solutions.
- Realignment of Forrest Road.
- Interconnectivity between neighbourhoods is important.
- Viability of development.
- Need to create an environment that is attractive to homebuyers.
- Rigidity in implementation of Master Plan due to its level of detail.
- Will the drainage solution provided by the avenues design result in improved viability?

Key ARA/CSIRO responses included:

- ARA committed to substantial interaction with major landowners.
- There will be flexibility in the preparation of local structure plans.
- Holistic approach to the development is more difficult, but will achieve a better result.
- ARA to assess Master Plan approach to drainage.

3. EXISTING ENVIRONMENT

This section provides background information relating to the climate, landforms, soils and geology found in or pertaining to the Amendment area. This information has been presented as it complements and is often integral to the more detailed information relating to the environmental factors investigated during the environmental review process discussed in section 4.

3.1 Climate

The Amendment area experiences a Mediterranean climate having wet, mild winters and warm, dry summers.

Annual rainfall recorded at Armadale Post Office (Bureau of Meteorology Site No 9001) has been measured since 1908, and shows a maximum annual total recorded of 1369mm in 1917 and a lowest recorded annual total of 499mm in 1914. The long-term average for the station is 869mm (1908-2003) with a more recent average from 1975-2003 being 810mm.

Over the summer period (December-February), the average summer rainfall for the Amendment area is 30mm (~3 % of annual total) compared to 154mm and 298mm (~25% of annual total) for Sydney and Melbourne respectively.

Windy conditions are experienced from late winter through spring and summer. The prevailing winds in July and August are west, northwest and north, while summer winds deviate from the southwest through to the south and east in the typical anti-cyclonic cycle.

3.2 Landforms

The Amendment area has limited notable landform characteristics although the low-lying wetlands and drainage lines provide some visual relief. Topographic contours for the Amendment area, based on Department of Land Information (DLI) 1m contours, indicate that the majority of land ranges from approximately 22mAHD along the western boundary to 34mAHD in the east with the terrain generally declining in elevation from east to west. Land rises relatively steeply to 50mAHD in the southeastern corner of the Amendment area. There is comparatively little change in elevation west of the Wungong River (Figure 5).

The Amendment area is located within four different landform units. These are the Southern River, Beermullah, Guildford and Forrestfield Landform units.

Southern River
Located along sandplains with low dunes and many intervening swamps; iron or humus podzols, peats and clays. This soil unit occurs where sand appears to have been blown over the alluvial soils and so the swamps often have a clay base (Churchward and McArthur 1980). This landform and soil unit covers the northwest corner of the Amendment area.

Bermullah
Located in poorly drained plains comprising saline and sodic soils with well-structured B horizons (solonetzic soils), bog iron ore and some shallow sands over bog iron ore (Churchward and McArthur 1980). This landform and soil unit covers the southwestern part of the Amendment area.

Guildford
Located along flat plains as medium textured alluviual deposits comprising sandy yellow duplex soils and yellow earths (Churchward and McArthur 1980). This landform and soil unit covers most of the eastern side of the Amendment area.

Forrestfield
Located on the lateritised foothills of the Darling Scarp and is dominated by gravelly yellow duplex soils on crests; and yellow or grey sands on fringes (Churchward and McArthur 1980). This landform and soil unit is present as a thin strip on the eastern side of the Amendment area, adjacent to the railway line.

Landform locations are shown on Figure 6.

3.3 Soils

According to Jordan (1986) the Amendment area is comprised of eight different soil types:

S_{p1} – Peaty Sand
Characterised by grey to black, fine to medium-grained, moderately sorted quartz sand, slightly peaty and of lacustrine (lake) origin.

S_{p2} - Peat Rich Sand
Fine to medium-grained quartz sand with much brown to black organic material, grades to peat, of lacustrine (lake) origin.

M_{sc1} – Clayey Sandy Silt
Pale, brown, angular to rounded sand, low cohesion, of alluvial origin.

C_{sg} – Gravely Sandy Clay
Characterised by variable, with lenses of silt and gravel, quartz sand, subangular with aeolian (wind blown) rounded component; heavy minerals common; gravel rounded, of colluvial origin.

L_{s5} – Limestone
Characterized by white to cream, fine grained, algal lamination is common.

S_8
White to pale grey at surface, yellow at depth, fine to medium-grained, moderately sorted, subangular to subrounded, minor heavy minerals of aeolian origin.

S_{10} – Sand
White to pale grey at surface, yellow at depth, fine to medium- grained, moderately sorted, subangular to subrounded, minor heavy minerals of aeolian origin. This soil type is over sand-clay to clayey sand of the Guildford Formation, of aeolian origin.

C_s – Sandy Clay
This soil type is characterised by white-grey to brown, fine to coarse-grained, subangular to rounded sand, clay of moderate plasticity, gravel and silt layers near the scarp.

The locations of each of the soil types within the Amendment area are shown on Figure 7a.

3.4 Geology

The Armadale 1:50 000 Environmental Geology map (Jordan 1986) indicates that the geology is made up of a variable thickness of Bassendean Sand of aeolian origin overlying Guildford Formation of alluvial origin. A covering of Colluvium with zones of Muchea Limestone and Peaty Swamp Deposits are also reported to occur across the Amendment area.

Based upon interpretations of ATA Environmental borehole logs, inspection of selected boreholes by GHD, a CSIRO drilling program, and Cooperative Research Centre for Landscape Environments and Mineral Exploration (CRC LEME) geophysical surveys the different geological units occurring at the site have been summarised below (JDA 2006).

3.4.1 Superficial Formations

The lithology of Superficial Formation is extremely variable, broadly presented by interbedded sand and clay with proportion of sand and clay varied spatially and vertically. Shallow confinements (1-5m) are common, which are represented by clays, ferricretes (coffee rock), limestone, silcrete and calcareous deposits.

Bassendean Sand (Qpb)
Bassendean sand consists of light brown, loose, sand of variable thickness overlying the sandy clay of the Guildford Formation. The sands vary from 0m thickness in the low lying swampy interdunal areas to around 5m depth on the northwestern portion of the site forming elevated sand dune areas.

Colluvium
According to the 1:50 000 Environmental Geology map, a small covering of colluvium (slope wash) is present in the southeastern corner of the Amendment area. The colluvium consists of a gravelly sandy clay with lenses of silt and gravel (Jordan 1986).

Guildford Formation (Qpa)
Alluvial clayey sands of the Guildford Formation are generally pale grey and pale brown in colour with distinct red, orange and yellow mottling that contain ferricrete gravel as the profile passes through the upper ferruginised (iron rich) zone.

Limestone
According to the 1:50 000 Environmental Geology map a small outcrop of Muchea Limestone is located on the northwestern portion of the Amendment area and consists of white to cream, fine grained algal laminated limestone. The limestone is reported to rarely exceed thicknesses greater than 1 m (Commander 2003).

Peat
Two boreholes on the western and southeastern portion of the Amendment area intersected peaty sand in low-lying swampy areas within 1m of ground surface. The peaty sand is generally grey to black, fine to medium grained, moderately sorted quartz sand with variable amounts of dark brown fibrous peat (JDA 2006).

3.4.2 Mesozoic Formations

There is very limited data available to define the geological characteristics within the Amendment area. Regional geological data indicates it is likely that the Osborne Formation and Leederville Formation underlie the Superficial deposits.

Descriptions of these Formations are provided below, however it should be noted that spatial interpretation of bore logs and available results of geophysical surveys undertaken by CSIRO, indicate that the Pinjar Member of the Leederville Formation and the Osborne Formation may be absent within the Amendment area, with the Wanneroo member of the Leederville Formation underlying the Superficial Formation (JDA 2006).

Osborne Formation

The Osborne Formation comprises a basal sandstone unit (Henley Sandstone Member), a middle shale unit (Kardinya Shale Member), and an upper, interbedded sandstone and shale succession (Mirrabooka Member). The majority of the southern part of the Amendment area is underlain by the Mirrabooka Member. The Osborne Formation is of shallow marine origin, has a maximum thickness of about 180 m, and is Early Cretaceous in age.

Leederville Formation

Generally the Leederville Formation consists predominantly of discontinuous, interbedded sandstones, siltstones and shales with some conglomerate to the east, near the Darling Scarp (JDA 2006).

According to the currently available information the thickness of the formation in the area is within 10m. Regional data indicates it is likely that within the Amendment area the formation is presented by the Mariginiup Member, Wanneroo Member and Pinjar Member.

Mariginiup Member

The Mariginiup Member consists of thinly interbedded and discontinuous grey to black siltstones and shales with minor, very thin (<1m) beds of mostly fine grained sandstone. It is predominantly of marine origin, commonly glauconitic, micaceous, in places fossiliferous and variably cemented with a pyritic or calcareous cement.

Wanneroo Member

The Wanneroo Member consists of discontinuous interbedded sandstones, silstones and shales of marine and non-marine origin. The sandstone interbeds are weakly consolidated, pale grey, fine to very coarse grained (predominantly coarse), poorly sorted, angular to subangular, and slightly silty. The siltstones and shales are grey, somewhat micaceous, and exist as beds of thickness similar to that of the sandstones. Along the southeastern margin of the Perth Region, and in many areas adjacent to the Darling Fault, granitic scree boulders from the Darling Scarp are commonly found within the Wanneroo Member.

Pinjar Member

The Pinjar Member consists of discontinuous, interbedded sandstones, siltstones and shales of marine and non-marine origin, with individual sandstone beds approximately 4 to 6m thick. The sandstones are weakly consolidated, grey, fine to very coarse grained, poorly sorted, subangular to subrounded and commonly silty. The siltstones and shales are dark grey to black, typically micaceous, thinly laminated with fine-grained sandstone and with minor lignitic fragments to the north.

4. ENVIRONMENTAL ASSESSMENT

4.1 Sustainability

4.1.1 EPA Objective

To ensure, as far as practicable, that the proposal meets or is consistent with the sustainability principles in the EPA's Position Statement No. 6 Towards Sustainability and The Western Australian State Sustainability Strategy.

4.1.2 Applicable Legislation, Criterion or Guidance

- Government of Western Australia (2003) *Western Australian State Sustainability Strategy*.
- Western Australian Planning Commission (2003a) Statement of Planning Policy No. 2: *Environment and Natural Resources Policy*.
- Armadale Redevelopment Authority (2003) *Implementation Strategy for Sustainability*.
- Environmental Protection Authority (2004e) EPA Position Statement No. 6: *Towards Sustainability*.

4.1.3 Existing Environment

Sustainability is defined as *"...meeting the needs of current and future generation through an integration of environmental protection, social advancement and economic prosperity"* (Government of Western Australia 2003).

The Perth Metropolitan Area is currently experiencing a number of environmental pressures, including air, water and land pollution and loss of biodiversity, and is predicted to experience significant growth over the next twenty years (Government of Western Australia 2003). Urban planning plays an important role in determining the extent of environmental impacts. For instance, higher urban densities and greater use of public and non-motorised modes of transport will make a significant contribution to energy conservation. This approach to urban development is promoted in the Statement of Planning Policy No. 2: *Environment and Natural Resources* (WAPC 2003a).

Agenda 21 represents international consensus on actions necessary to move the world towards the goal of sustainable development. It recognises that local government and the wider communities they represent are increasingly becoming the lead agencies to achieve sustainable development through the integration of environmental, economic and social goals.

There is growing interest in creating a sustainable environment that is one in which there is a balance between social and community needs, economic prosperity and the long-term preservation of the environment. Concerns are not just restricted to sustaining the physical environment; the ability to sustain an economic, financial and social environment is also important.

The *State Sustainability Strategy* (Government of Western Australia 2003) outlines a range of objectives associated with natural resource management, settlement, community and business which the ARA has sought to include within its Implementation Strategy where relevant.

The Statement of Planning Policy: *Environment and Natural Resources Policy* (WAPC 2003a) has as one of its objectives the sustainable use of natural resources including biodiversity, land, water and energy, and requires the promotion of energy efficient development and urban design.

The Department of Planning and Infrastructure (DPI) has developed its *Liveable Neighbourhoods Community Design Code* (WAPC 2004b) to implement the objectives of the State Planning Strategy that aims to guide the sustainable development of Western Australia to 2029. The objective of *Liveable Neighbourhoods* is to facilitate the development of sustainable communities in Western Australia through the elements of community design, movement network, lot layout, public parkland, urban water management and utilities.

In 2005, the Western Australian Planning Commission (WAPC) released a discussion document outlining the basis of a future sustainability scorecard against which future development be assessed. The sustainability checklist consists of a number of high level questions.

The ARA has developed its *Implementation Strategy for Sustainability* based upon the principles contained in some of the documents previously referred to (Armadale Redevelopment Authority 2003a). The Strategy addresses specific objectives of the *State Sustainability Strategy* (for urban renewal and revitalisation) and outlines the ARA's approach to achieving sustainable outcomes for the landholdings under the jurisdiction of the ARA including the Amendment area. The principles contained in the Strategy guide the master planning for the Amendment area to ensure that a coherent, integrated approach is taken to the implementation of sustainable development in the Amendment area. The Strategy objectives have been given statutory weight by the adoption of Planning Policy 1.2: Sustainable Development under the Armadale Redevelopment Scheme.

The ARA has also developed a *Sustainability Action Plan* that outlines its commitment to sustainability. The Action Plan accompanies the ARA's *Implementation Strategy for Sustainability*. Together these two documents outline the strategic directions to establish, monitor and implement the ARA's strategy for sustainability (Armadale Redevelopment Authority 2003b).

The first phase of the Master Plan involved the Sustainability Review Team (an inter-agency and stakeholder body established to oversee the project) developing sustainability objectives that set the vision for the development of the Amendment area. These objectives are aligned with the key elements of the Sustainability Audit outlined in the *Implementation Strategy for Sustainability* (Armadale Redevelopment Authority 2003). The performance of the master planning with respect to the achievement of these objectives will be progressively evaluated through the planning development process. The Sustainability Objectives are outlined in Table 4.

The ARA has identified a number of key aspects of environmental sustainability that have relevance to the planning and development functions of the Authority (Armadale Redevelopment Authority 2004). They include:

- **The protection of natural environments**: Within the Amendment area, this relates mainly to wetland areas, but other significant natural habitats will also be identified and conserved as indicated in the Master Plan.

- **Promoting energy efficient and sustainable transport modes**: Planning Policies 12.8 and 1.9 on Urban Design and Movement, establish the ARA's position with regard to encouraging and facilitating options to the private car for personal travel, including walking, cycling and public transport. The Master Plan incorporates alternative transport pathways throughout the Amendment area.

- **Promoting energy and resource efficiency in the development process**: Through the application of its Design Guidelines and the development control process, the ARA will promote energy and resource efficiency and innovation in building design and technology, and in the use of materials.

- **Waste reduction, waste management and recycling**: The ARA will exercise its planning functions to ensure that developments within the Amendment area maximise efficiency in the use of natural, non-renewable resources, make appropriate provision for managing the waste products of human activity, and embody opportunities to collect and recycle suitable material wherever possible.

As with all other precincts within the ARA's jurisdiction, a Wungong Urban Water Implementation Plans for Sustainability report (WIPS) will be prepared for the Amendment area based on the principles contained within the ARA's *Implementation Strategy for Sustainability* (Armadale Redevelopment Authority 2003). The WIPS will follow a similar framework to that of *Liveable Neighbourhoods* in that it will outline the approach for delivering development in a sustainable manner through definition of policy, guidelines, infrastructural requirements and statutory structure and funding. In preparing and reviewing the WIPS, due consideration will be given to the WAPC's Statement of Planning Policy No. 1: *State Planning Framework Policy* (WAPC 2006) and to produce a Local Planning Strategy style document in support of the amendment to the ARA's Redevelopment Scheme.

The WIPS will:

- Identify the constraints and opportunities for the achievement of sustainability outcomes;
- Investigate and determine approaches for the future use and development of the land to maximise the sustainability of development outcomes;
- Define desired outcomes and performance criteria for the Amendment area; and
- Generate a detailed project delivery programme for the servicing, development and use of the land, public consultation and participation and the promotion of sustainability.

The ARA has developed an online draft Sustainability Audit Tool to assess the sustainability performance of all development applications. The Sustainability Audit is made under the Scheme provisions and forms part of the development application and building application assessment and approvals processes. Assessment of all applications using the tool will ensure that future development is consistent with the ARA's broader sustainability objectives. The Sustainability Audit tool is based on a number of key social, economic and environmental elements each having Key Performance objectives and Performance Measure Indicators. The environmental elements contained in the Draft Audit include Natural Resources: land, water, air, biodiversity/habitat and other resources (Armadale Redevelopment Authority 2003).

TABLE 4
SUSTAINABILITY OBJECTIVES FOR THE WUNGONG URBAN WATER MASTER PLAN AREA

Number	Indicator	Aim	Wungong Sustainability Principles
Social / Economic			
1	**Cultural heritage**	Armadale's places of Indigenous and Non-Indigenous cultural heritage significance are integral to its character and the community's 'sense of place' and shall be identified, promoted and protected.	▪ Identify, promote and protect Brookdale's character and the community's "sense of place" ▪ Encourage innovative and high quality urban form that contributes to the public domain and assists the development of a strong and identifiable sense of place ▪ Recognise the history of the region (Natural, Aboriginal and Cultural) as an attractor
2	**Community services / facilities**	To encourage the early provision of community facilities that builds and supports the community and enhances social capital.	▪ Challenge the boundaries between public and private land and the 10% public open space requirement ▪ Increase the socio-economic diversity of the area ▪ Brookdale to be socially inclusive of surrounding values ▪ Relate with the regional centre ▪ Consider the location of community facilities to support identified needs and movement

Number	Indicator	Aim	Wungong Sustainability Principles
3	**Urban Design / Public art**	Encourage innovative and high quality urban form that contributes to the public domain and assists the development of a strong and identifiable sense of place	▪ Incorporate shade and shelter provisions for pedestrian thoroughfares and public open space ▪ Identify, promote and protect Brookdale's character and the community's "sense of place" ▪ Incorporate public participation in public art
4	**Security / safety**	Promote the safety and passive security of all sectors of the community, including visitors and people working in Armadale, both during and after hours.	▪ Maximise passive security ▪ Urban design to support crime prevention (Crime Prevention through Environmental Design)
5	**Visual impact - scale / character**	Enhance visual amenity to engender community pride	▪ Identify, promote and protect Brookdale's character and the community's "sense of place"
6	**Noise**	To minimise noise pollution	
7	**Employment**	To expand the local employment base to assist in development of the local economy and to reduce the need for people to commute long distances for work	▪ Increase the socio-economic diversity of the area ▪ Increase the employment self sufficiency ratio within the lower South-East corridor ▪ Encourage innovative new businesses and linkages

Number	Indicator	Aim	Wungong Sustainability Principles
8	**Local enterprise opportunities / synergies**	The local economy will benefit through establishment of synergies and new markets	▪ Increase the socio-economic diversity of the area ▪ To benefit the Brookdale community with synergies to the local economy ▪ Relationship with the regional centre ▪ Actively promote green business ▪ Encourage innovative new businesses and linkages within the Armadale region
9	**Thermal comfort**	To ensure an holistic approach is taken in design to maximise a comfortable environment in subdivision design and built form	▪ Incorporate shade and shelter provisions for pedestrian thoroughfares and communal open space ▪ Ensure solar access is incorporated in lot design
10	**Indoor Air Quality**	To ensure the provision of adequate quantity and quality of fresh air in occupied spaces	
Addition	**Disability Access**	To ensure adequate access to facilities for people with disabilities	▪ To provide a safe, convenient and legible movement network for people with disabilities, including those using wheelchairs and similar aids
11	**Daylighting**	To improve the health of building and comfort of building occupants by providing natural light to interiors	

Number	Indicator	Aim	Wungong Sustainability Principles
Energy, Materials and Transport			
12	**Recycling**	Minimise disposal of waste materials to landfill	▪ Minimise the creation of waste and encourage recycling ▪ Work towards zero waste by 2020 ▪ Maximise the recovery and recycling of resources from waste
13	**Resource exchange**	Encourage relationships between operations whereby the outputs of one activity become the input for one or more separate activities, thus closing the manufacturing loop.	▪ Encourage resource reuse ▪ Identify and quantify waste streams and develop appropriate management plans to achieve sustainability
14	**Private vehicle use**	Reduce CO_2 emissions from transport and minimise traffic impact	▪ Reduce the need for car use through provision and encouragement of public transport, walking and cycling

Number	Indicator	Aim	Wungong Sustainability Principles
15	**Public transport use**	Reduce the need for car use through provision and encouragement of public transport options	▪ Reduce the need for car use through the provision of effective and efficient public transport, and to encourage walking and cycling ▪ Suburban design representing movement requirements ▪ Better access to all facilities and amenities ▪ Connectiveness with transport nodes
16	**Walking / cycling**	Reduce the need for car use through provision and encouragement of walking / cycling	▪ Encourage suburban design that reduces the dependency on vehicles ▪ Incorporate safe routes to schools, bus stops and stations ▪ Incorporate dual use footpaths and dedicated bike paths ▪ Incorporate a movement network for users with disabilities
17	**Building orientation**	To encourage solar access for occupied buildings to reduce heating, cooling and lighting energy	▪ Minimise the energy required to achieve adequate levels of thermal comfort, ventilation and lighting in occupied spaces ▪ Encourage the use of solar hot water systems to reduce electricity consumption
18	**Energy efficient design**	To minimise the energy required to achieve adequate levels of thermal comfort, ventilation and lighting in occupied spaces	▪ Encourage passive solar design
19	**Lighting**	To minimise the energy required for lighting and to maximise daylight opportunities	▪ Maximise natural daylight within the built form ▪ Encourage the use of compact fluorescent lights

Number	Indicator	Aim	Wungong Sustainability Principles
20	**Renewable energy**	To promote buildings that generate part of their energy demand from a renewable energy source.	▪ Minimise the energy required to achieve adequate levels of thermal comfort, ventilation and lighting in occupied spaces
21	**Recycled content**	To promote the utilisation and reuse of recycled materials in building/facilities design	▪ Promote the use of recycled materials in building/facilities design
23	**Sustainable Timber**	To promote the use of recycled timber or timber from certified environmentally responsible forest management practices.	▪ Promote the use of recycled materials in building/facilities design ▪ Promote the use of recycled timber or renewable timber from plantation forest
24	**Construction & demolition waste**	To minimise the creation of waste and encourage recycling	▪ Minimise the creation of waste and encourage recycling

Number	Indicator	Aim	Wungong Sustainability Principles
Landuse and Ecology			
25	**Biodiversity / Habitat**	To protect biodiversity and enhance the quantity and quality of the Armadale region's native vegetation	▪ Provision for the protection and enhancement of ecological values of riparian and groundwater dependant ecosystems within the development and protection of receiving environments ▪ Identify pre- and post-development water quality parameters for development ▪ Rejuvenate the Wungong River, Neerigen Brook and wetlands ▪ Remediate contamination and / or ensure future landuse does not lead to contamination ▪ Manage water to create a vibrant and diverse community (?) ▪ Incorporate habitat corridors ▪ Ensure that Bush Forever and wetland conservation obligations are adhered to
26	**Air pollution**	To minimise air born pollutants	▪ Reduce CO_2 emissions from transport and minimise traffic impact ▪ Reduce the need for car use through provision of effective and efficient public transport and encouragement of walking and cycling ▪ Encourage the elimination of existing wood fires and prohibit the installation of wood fires in new buildings
27	**Land / Groundwater**	To remediate pollutants and / or ensure future landuse does not lead to contamination	▪ Prepare an overarching Nutrient Management Plan for the redevelopment area
29	**Native Plantings**	To protect biodiversity and enhance the quantity and quality of the Armadale regions native vegetation	▪ Incorporate and encourage native plantings within areas of public open space and the streetscape.

Number	Indicator	Aim	Wungong Sustainability Principles
Addition	**Landscape**	To identify and promote significant natural landscape elements	▪ Minimise cut to fill ▪ Protect view scapes ▪ Retain natural vegetation ▪ Retain significant natural wetlands
30	**Environmental Management**	To promote environmental management during the construction process	▪ Conserve topsoil ▪ Retain native vegetation ▪ Retain established trees (including fruit and mature exotics)
Water			
31	**Water efficient fixtures / appliances**	Require water efficiency in the built environment	▪ Achieve at least the State's water Strategy water consumption aim of 155kL/person/year ▪ Mandate minimum in house fixtures and fittings
32	**Water recycling**	To promote water recycling in order to minimise use of mains water	▪ Water conservation measures at all scales and stages (education and post occupancy) of the development (individual lots, streetscapes) ▪ Optimising water harvesting and water reuse (i.e. Brookdale to be a minimum water in, minimum water out ecoburb) Create a water cycle ethic ▪ Achieve at least the State's water strategy water consumption aim of 155kL/person/year ▪ Aim to use no drinking water outside of the house ▪ Install a 3rd pipe treated waste water supply

Number	Indicator	Aim	Wungong Sustainability Principles
33	**Landscape irrigation**	To promote water efficient landscaping irrigation	▪ Encourage best practice irrigation techniques ▪ To irrigate from non-potable water supplies ▪ Minimise irrigation requirements for public open spaces through the planting of low water use native species of local provenance
34	**WSUD / water balance**	To ensure the quality, quantity and discharge rate of stormwater run-off does not adversely impact groundwater or create erosion.	▪ Water conservation measures at all scales and stages (education and post occupancy) of the development (individual lots, streetscapes) ▪ Adoption of site specific water sensitive urban design principles ▪ Create a water cycle ethic ▪ Achieve at least the State's water Strategy water consumption aim of 155kL/person/year ▪ Use natural elements to define the shape of the urban form - follow natural drainage lines ▪ Create an environmental ethic that protects the Wungong River ▪ Treat water to make it available for reuse ▪ Ensure that there is no increase in nutrient loads to the Southern River as a result of the redevelopment

4.1.4 Potential Impacts

Development may proceed in an unsustainable manner resulting in poor quality urban development and adverse environmental, social and economic consequences.

4.1.5 Management Strategies

The requirement for development approval is set out in section 45 of the *Armadale Redevelopment Act 2001*. All proposed developments and landuses in the Amendment area are therefore subject to the need for ARA development approval.

All new residential, multi-residential, commercial (office and other), industrial (office and other), civic, retail and recreational development will be required to complete a Sustainability Audit as identified in the ARA's *Implementation Strategy for Sustainability* (Armadale Redevelopment Authority 2003a). The audit is a statutory document that has been adopted under the relevant legislation and must be carried out in accordance with the legislative requirements. The audit does not need to be completed for renovations or extensions to existing buildings.

The Sustainability Audit forms part of the development application and building application assessment and approval processes and must therefore be carried out/completed/submitted under the head of power provided by the Act (ARA Planning Policy 1.2: Sustainable Development). The requirements of the audit are detailed in Armadale Redevelopment Regulations 2003 which was amended in December 2004 allowing the ARA to require a sustainability certificate to accompany a development application.

To lodge an application for development approval or building approval, an applicant will be required to submit both a Sustainability Certificate and proof or evidence of compliance. A checklist of submission requirements (a list of additional documents/proof of compliance that must be submitted with a development application) will be generated on completion of the audit process (Armadale Redevelopment Authority 2003a).

In addition to the City of Armadale site inspections, a final site visit will be undertaken by the ARA to ensure compliance with the various indicators identified in the audit.

Section 52 of the Armadale Redevelopment Act allows the ARA to issue a notice to a person who is contravening a condition of development approval to stop doing so or to cease, alter or remove any unlawful development.

4.1.6 Predicted Outcome

Based on the review of the available literature, studies undertaken to date and strategies developed, it is considered that the implementation of the proposed redevelopment of the Wungong Urban Water Master Plan area can be managed to meet the EPA's environmental objective in relation to Sustainability.

4.2 Native Terrestrial Vegetation and Flora

4.2.1 EPA Objective

To maintain the abundance, diversity, geographic distribution and productivity of flora at species and ecosystems levels through the avoidance or management of adverse impacts and improvement in knowledge.

4.2.2 Applicable Legislation, Criterion or Guidance

- Environmental Protection Authority (2003) Guidance Statement No. 10: *Level of Assessment for Proposals Affecting Natural Areas within the System 6 Region and Swan Coastal Plain Portion of the System 1 Region.*
- Environmental Protection Authority (2004b) Guidance Statement No. 51: *Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessments in Western Australia*.
- Environmental Protection Authority (2005b) Guidance Statement No. 33: *Environmental Guidance for Planning and Development.*
- *Environment Protection Act 1986*
- *Environment Protection and Biodiversity Conservation Act 1999*
- *Wildlife Conservation Act 1950*
- Commonwealth of Australia (2001) *National Targets and Objectives for Biodiversity Conservation 2001-2005*.
- Commonwealth of Australia (1996) *National Strategy for the Conservation of Australia's Biological Diversity*.

4.2.3 Existing Environment

ATA Environmental conducted a vegetation and flora assessment of the Amendment area in 2005. The complete report is included as Appendix 2: *Flora and Vegetation Assessment – Brookdale Redevelopment Area* (ATA Environmental 2006a). The following is an abridged version of the assessment findings.

Vegetation Complexes

A large proportion of the Amendment area has been cleared for a variety of purposes. According to broad scale mapping, the remnant vegetation within the Amendment area belongs to the Southern River, Guildford, Forrestfield and Beermullah Vegetation Complexes. A broad description of these vegetation complexes according to Heddle *et al*. (1980) is as follows:

Southern River Vegetation Complex
Open Woodland of Marri (*Corymbia calophylla*) - Jarrah (*Eucalyptus marginata*) -Banksia species with fringing Woodland of Flooded Gum (*Eucalyptus rudis*) - Paperbark (*Melaleuca rhaphiophylla*) along creek beds.

Guildford Vegetation Complex
A mixture of Open Forest to Tall Open Forest of Marri-Wandoo (*Eucalyptus wandoo*)-Jarrah and Woodland of Wandoo (with rare occurrences of *Eucalyptus lane-poolei*). Minor components include Flooded Gum-*Melaleuca rhaphiophylla*.

Forrestfield Vegetation Complex
Vegetation ranges from Open Forest of *Corymbia calophylla – Eucalyptus wandoo – Eucalyptus marginata* to Open Forest of *Eucalyptus marginata – Corymbia calophylla - Casuarina fraseriana – Banksia* spp. Fringing Woodland of *Eucalyptus rudis* in the gullies that dissect this landform.

Beermullah Vegetation Complex
Mixture of Low Open Forest of Swamp Sheoak (*Casuarina obesa*) and Open Woodland of Marri-Wandoo-Jarrah. Minor components include Closed Scrub of *Melaleuca* species and occurrences of *Actinostrobus pyramidalis.*

Figure 7b shows the location of the vegetation complexes within the Amendment area.

Floristic Community Types

The flora and vegetation survey of the Amendment area identified that the areas of remnant vegetation belonged to the following Floristic Community Types (FCTs):

- Floristic Community Type 3a - *Corymbia calophylla – Kingia australis* woodlands on heavy soils;
- Floristic Community Type 4 - *Melaleuca preissiana* damplands; and
- Floristic Community Type 6 - Weed dominated wetlands on heavy soils.

Areas of degraded native vegetation, particularly upland vegetation, were not assigned to a FCT due to the high degree of disturbance.

Vegetation Types

The majority of the vegetation that originally occurred throughout the Amendment area has been cleared as a result of past and present landuses. As a result, most of the Amendment area vegetation comprises pasture, agricultural and horticultural crops, planted trees, and private gardens.

The flora and vegetation survey undertaken by ATA Environmental identified a total of 38 vegetation types within the areas of remnant native vegetation. A brief description of the vegetation types follows:

Note: An asterisk prefacing a plant species indicates that it is an introduced species.

Woodlands

Six Low Open Woodlands to Woodlands dominated by *Melaleuca preissiana* on sandy soils. These six vegetation types belong to MrMpDsLOW, MpLOW, MpCcLOW, MpKgLOW, MrMpLOW, MpApLW and MpOS. There was evidence of disturbance associated with these vegetation types and as a consequence the condition was considered to range from Degraded to Very Good.

Six Low Woodlands to Open Woodlands dominated by *Corymbia calophylla* over pasture. These six vegetation types belong to CcLOW, CcNfLW, CcOW, CcErOW, CcEmOW and CcW. There was evidence of disturbance associated with these vegetation types and as a consequence the condition was considered to range from Completely Degraded to Very Good.

One Low Open Woodland to 8m dominated by *Corymbia calophylla* with occasional *Nuytsia floribunda, Kingia australis* and **Eucalyptus* sp. over a Low Open Shrubland dominated by *Allocasuarina humilis, Xanthorrhoea preissii,*Zantedeschia aethiopica, Dasypogon bromeliifolius* and *Acacia lasiocarpa* var. *lasiocarpa* on loamy soils. This vegetation type belongs to CcNfEsLOW. This vegetation type is considered analogous with the TEC 3a. There was a low level of disturbance associated with this vegetation type and the condition was considered to be Very Good.

Twelve Low Open Woodlands to Open Forests dominated by *Eucalyptus rudis* and *Melaleuca rhaphiophylla.* These twelve vegetation types belong to MrErOF, CcMpMrLOF, MrErLW, ErCcEcOW, ErMrTlOW, ErMrWOW, ErMrW, MrLOW, MrMpGfLOW, ErZaLOW, ErW and ErMrOW. There was evidence of disturbance associated with these vegetation types and as a consequence the condition was considered to range from Completely Degraded to Very Good.

One Low Open Woodland to 6m dominated by *Eucalyptus todtiana* over pasture. This vegetation type belongs to EtLOW. There was evidence of high levels of disturbance associated with this vegetation type and as a consequence the condition was considered to be Degraded.

Two Low Woodland to Open Forests dominated by *Banksia menziesii* and *Banksia attenuata* over introduced grasses. These vegetation types belong to BmBiBaLW and BmBaLOF. There was moderate evidence of disturbance associated with this vegetation type and as a consequence the condition was considered to range from Good to Very Good.

One Low Woodland to 5m of *Banksia attenuata* over introduced grasses. This vegetation type belongs to BaLW. There was evidence of high levels of disturbance associated with this vegetation type and as a consequence the condition was considered to range from Degraded to Good.

One Open Woodland to 11m dominated by *Eucalyptus camaldulensis* var. *obtusa*, *Corymbia calophylla* with scattered *Eucalyptus rudis* over introduced grasses. This vegetation type belongs to EcCcErOW. This vegetation type was considered to be in a Degraded condition.

Shrublands

Two Tall Open Shrublands to Tall Scrub dominated by *Melaleuca preissiana* over introduced grasses. These two vegetation types belong to MpKgTOS and KgCTS. There was evidence of moderate levels of disturbance associated with these vegetation types and as a consequence the condition was considered to range from Degraded to Very Good.

One Very Open Shrubland to 2m dominated by *Melaleuca preissiana* with occasional scattered *Corymbia calophylla* over a Herbland dominated by **Rumex crispus, Juncus pallidus* and **Watsonia meriana* var. *bulbillifera* over pasture. This vegetation type belongs to MpCcVOS. There was evidence of high levels of disturbance associated with this vegetation type and as a consequence the condition was considered to be Degraded.

One Tall Open Scrub to 4.5m dominated by *Acacia saligna* over pasture. This vegetation type belongs to AsTOS. There was evidence of high levels of disturbance associated with this vegetation type and as a consequence the condition was considered to be Completely Degraded.

Planted species

Pasture or private gardens with scattered native and non-native trees and shrubs. This vegetation type belongs to PsNs. This vegetation type was recorded over most of the Amendment area. This vegetation type includes but is not limited to scattered native species such as *Melaleuca rhaphiophylla, Melaleuca preissiana, Corymbia calophylla, Eucalyptus rudis* and non-native species such as **Araucaria heterophylla, *Pinus radiata, *Salix babilonica, Schinus terebinthifolia, *Opuntia stricta, *Eucalyptus caesia, *Eucalyptus ?cladocalyx and *Lophostemon grandiflorus* subsp. *riparius* which were commonly found planted in private gardens and private properties. There was evidence of high levels of disturbance associated with this vegetation type and as a consequence the condition was considered to range from Completely Degraded to Good.

Herblands

One Open Herbland dominated by *Juncus pallidus, *Cotula coronopifolia* and *Myriophyllum* sp. in association with watercourses. This vegetation type belongs to JpCcMOH. There was evidence of high disturbance and the condition was considered to be Degraded.

Grasslands

Open Grassland dominated by **Cortaderia selloana* over an Open Shrubland of *Xanthorrhoea preissii* over introduced grasses. This vegetation type belongs to CsOG. This vegetation type was considered to be in a Degraded condition.

Vegetation Condition

The condition of the vegetation was assessed according to the condition rating scale of Keighery as described in Bush Forever (2000). Keighery's condition rating scale ranges from Pristine (where the vegetation exhibits no visible signs of disturbance) to Completely Degraded (where the vegetation structure is no longer intact and without native plant species). Vegetation condition for the Amendment area is mapped on Figures 4a-4f of Appendix 2 and ranges from Very Good to Completely Degraded. The majority of the land in the Amendment area is used for rural activities. Therefore, the majority of the remnant vegetation has been adversely affected through past and present landuses.

Vegetation Significance

Regional Significance

Areas of regionally significant vegetation in the Swan Coastal Plain portion of the Perth Metropolitan Region were identified in the whole of Government report entitled "Bush Forever". The criteria for the selection of regionally significant bushland areas included Representation of Ecological Communities; Diversity; Rarity; Maintaining Ecological Systems or Natural Processes; Scientific or Evolutionary importance; and General Criteria for the Protection of Wetlands. The primary criterion for consideration of regional significance was the target of protecting at least 10% of each vegetation complex or 400ha, whichever is larger, in at least five separate areas.

Table 5 identifies the amount remaining and protected for each vegetation complex that occurs in the Amendment area. The Southern River Vegetation Complex has 17% of the original extent remaining on the Swan Coastal Plain, of which approximately 10% is currently protected or proposed to be protected through the implementation of Bush Forever. The Guildford, Bermullah and Forrestfield vegetation complexes have only 6%, 6% and 9% of their original extent remaining, respectively, on the Swan Coastal Plain, of which 3%, 5% and 5% respectively are currently protected.

TABLE 5
CONSERVATION STATUS OF VEGETATION COMPLEXES IN THE AMENDMENT AREA

Vegetation Complex	Original Area on SCP/PMR (ha)	Remaining Area on SCP/PMR (ha)	% Remaining	Some Existing Protection (ha)	Implementation of Bush Forever	Area Total	Proposed Protection
Southern River	31,148	5,370	17	1,775	1,372	3,147	10
Guildford	24,513	1,369	6	389	451	840	3
Forrestfield	11,328	1,020	9	219	375	594	5
Beermullah	6,707	433	6	139	214	353	5

Source: Government of Western Australia (2000)

A portion of three Bush Forever sites occur within the Amendment area or nearby (Figure 7b). These sites are:

- Site 264 – Lambert Lane Bushland, Wungong
- Site 266 – Wungong Brook, Byford
- Site 345 – Forrestdale Lake and Adjacent Bushland, Forrestdale

Some of the vegetation remnants in Good to Very Good condition could be considered to be representative of the Vegetation Complexes associated with the area (i.e. Southern River, Guildford, Forrestfield, and Bermullah). Areas of Good to Very Good vegetation within the Amendment area but not within a current Bush Forever site could still be considered regionally significant due to the poor protection status of all four vegetation complexes in the area. (refer to Figure 7a).

A search of DEC's Threatened Ecological Communities database identified one TEC occurs within the boundary of the Amendment area: SCP 3a – *Corymbia calophylla – Kingia australis* Woodlands on heavy soils, Swan Coastal Plain. SCP 3a is classified as Critically Endangered by the DEC (Table 6).

The TEC search also identified SCP10a – Shrublands on dry clay flats has been recorded to the west of the Amendment area adjacent to Forrestdale Lake in Bush Forever Site 345. This TEC is classified as Endangered by the DEC however it is not listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999.*

In addition, the DEC identified several occurrences of TECs that have been recorded nearby (within 10km) that may potentially occur in the Amendment area (Table 6).

TABLE 6
THREATENED ECOLOGICAL COMMUNITIES IDENTIFIED FROM THE DEC DATABASE SEARCH

Muchea Limestone	Shrublands and Woodlands on Muchea Limestone
SCP 02	Southern wet Shrublands
SCP 08	Herb rich Shrublands in clay pans
SCP 09	Dense Shrublands on clay flats
SCP 10a	Shrublands on dry clay flats
SCP 20b	*Banksia attenuata* and/or *Eucalyptus marginata* Woodlands of the eastern side of the SCP
SCP 3a	*Corymbia calophylla – Kingia australis* Woodlands on heavy soils
SCP 3b	*C. calophylla-E. marginata* Woodlands on sandy clay soils of the southern SCP
SCP 3c	*Corymbia calophylla-Xanthorrhoea preissii* Woodlands and Shrublands
Muchea Limestone	Shrublands and Woodlands on Muchea Limestone
SCP 02	Southern wet Shrublands
SCP 08	Herb rich Shrublands in clay pans
SCP 09	Dense Shrublands on clay flats
SCP 10a	Shrublands on dry clay flats
SCP 20b	*Banksia attenuata* and/or *Eucalyptus marginata* Woodlands of the eastern side of the SCP
SCP 3a	*Corymbia calophylla – Kingia australis* Woodlands on heavy soils

SCP 3b	*C. calophylla-E. marginata* Woodlands on sandy clay soils of the southern SCP
SCP 3c	*Corymbia calophylla-Xanthorrhoea preissii* Woodlands and Shrublands

The TEC *Corymbia calophylla – Kingia australis* woodlands on heavy soils (FCT 3a) occurs in the south east corner of the Amendment area within Bush Forever Site 264 and extends into adjoining areas outside of the Amendment area.

A 500 m notification area has been identified by the DEC around TEC 3a (*Corymbia calophylla – Kingia australis* woodlands on heavy soils) and TEC 10a (Shrublands on dry clay flats). The 500m notification area is identified by the DEC around each occurrence of a TEC in order to help ensure that developers within proximity of a TEC are notified of the existence of the TEC and consider the potential impacts of their development on the TEC. In this regard the notification area is not a buffer in the same context as a wetland buffer (Val English DEC, pers. comm.). The 500m notification area encroaches into the Amendment area.

The other FCTs identified in the Amendment area, ie FCT 4 - *Melaleuca preissiana* damplands; and FCT 6 - Weed dominated wetlands on heavy soils, are not listed as TECs.

Thirty-eight vegetation types were described and mapped in the Amendment area, however, as the descriptions show (Section 3.2.1, Appendix 2) many vegetation types are structurally similar but differ slightly in their floristic composition.

All the remnant vegetation within Conservation Category wetlands, is considered regionally significant, as correspondence from the DEC states that palusplain wetlands of Conservation Category are poorly represented in the entire Keysbrook consanguineous suite and Bennett Brook suite with approximately 1% and 4.18% respectively remaining on the Swan Coastal Plain.

The stands of Marri, wetland areas along the Wungong River and other areas as identified in Figure 8 also have regional significance as a wildlife corridor (See Sections 7.1 to 7.3, Appendix 3 for more detail).

National Significance

Floristic Community Type 3a is listed as a Critically Endangered on the Endangered Community List under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999.* This FCT occurs in Bush Forever site 264 in the south-east corner of the Amendment area and extends into adjacent areas outside of the Amendment area.

Local Significance

The majority of the Amendment area is identified on the *Geomorphic Swan Coastal Plain* dataset as an extensive palusplain wetland. Vegetation mapping of extensive wetlands on the Swan Coastal Plain indicate that 94% of palusplain has been cleared (Hill *et al.,* 1996). There is a relatively small amount of upland vegetation remaining in the Amendment area and on the eastern side of the Swan Coastal Plain generally. While most of the vegetation in the Amendment area has been affected by weeds and clearing, some areas such as the upland vegetation within the Amendment area, which belong to vegetation types BmBiBaLW, BmBaLOF and BaLW are in Very Good to Good condition. These areas are considered locally significant as they are the only areas within the Amendment area that give an indication as to what the original upland vegetation would have looked like before disturbance occurred. In view of the substantial clearing on the eastern side of the Swan Coastal Plain, vegetation types BmBiBaLW, BmBaLOF and BaLW are

considered locally significant and should be considered for protection in POS in any future development.

All the remnant vegetation found within Resource Enhancement wetlands was affected by grazing, partial clearing and an abundance of weeds. As a result, the vegetation condition was considered to be mostly Good to Degraded (Figures 4a-4g, Appendix 2) and not a good example of the original native vegetation in the region. However, due to the overall paucity of remnant native vegetation remaining in the Amendment area the vegetation in the RE wetlands could be considered locally significant.

Outside of the wetlands and watercourses present in the Amendment area there is very little remnant native vegetation. However, some of the stands of trees that exist along the current road system and elsewhere may be considered locally significant as they have aesthetic appeal as well as providing some wildlife corridor value for birds. These avenues of trees along road reserves should be retained in future residential development where possible.

Declared Rare and Priority Flora

The flora and vegetation assessment undertaken by ATA Environmental for the Amendment area can be read in more detail in Appendix 2: *Flora and Vegetation Assessment Brookdale Redevelopment Area* (ATA Environmental 2006a). A summary is provided below.

A total of 199 plant species were recorded from the Amendment area during the 2005 survey. The total includes two cycads, two gymnosperms, 65 Monocotyledons and 130 Dicotyledons. The flora assessment was undertaken during a time when the majority of ephemeral species such as lilies and orchids would have been recorded. As such the flora list is considered to represent at least 90% of the species likely to occur in the Amendment area. A full flora species recorded from the Amendment area and a list of all plant species recorded from each of the 63 non-permanent quadrats (10m x 10m) located within representative vegetation types is provided in Appendix 2.

Of the 199 plant species recorded, 117 (59%) were native and 82 (41%) were introduced or non-endemic plant species. Families with the highest representation of taxa were the Myrtaceae (Eucalyptus family – 31 taxa; 25 native, six introduced), the Papilionaceae (pea family – 22 taxa; 11 native, 11 introduced) and the Proteaceae (Banksia family – 14 taxa; 14 native).

The number of plant species is low for an area of this size but is consistent with the mostly degraded and cleared nature of the Amendment area.

Species of flora are defined as rare or priority conservation status where their populations are restricted geographically or threatened by local processes. The DEC recognised these threats of extinction and consequently applied regulations towards population and species protection. Rare Flora are gazetted under subsection 2 of section 23F of the *Western Australian Wildlife Conservation Act 1950* and therefore it is an offence to "take" or damage rare flora without approval from the Minister for the Environment. Table 7 shows the DEC's code and description of Rare and Priority Flora categories.

TABLE 7
CODE AND DESCRIPTION OF RARE AND PRIORITY FLORA CATEGORIES

Code	Declared Rare and Priority Flora Category Descriptions
R	DRF (Declared Rare Flora) -Extant Taxa. Taxa, which have been adequately searched for and are deemed to be in the wild either rare, in danger of extinction, or otherwise in need of special protection.
X	DRF (Declared Rare Flora) -Presumed Extinct Taxa. Taxa which have not been collected, or otherwise verified, over the past 50 years despite thorough searching, or of which all known wild populations have been destroyed more recently.
1	Priority One -Poorly Known Taxa. Taxa, which are known from one or a few (generally <5) populations, which are under threat.
2	Priority Two -Poorly Known Taxa. Taxa which are known from one or a few (generally <5) populations, at least some of which are not believed to be under immediate threat.
3	Priority Three -Poorly Known Taxa. Taxa, which are known from several populations, at least some of which are not believed to be under immediate threat.
4	Priority Four -Rare Taxa. Taxa which are considered to have been adequately surveyed and which whilst being rare, are not currently threatened by any identifiable factors.

Source: Department of Conservation and Land Management (2006)

Prior to conducting the field survey, a search of the DEC's Declared Rare and Priority Flora database was undertaken to identify significant flora that could potentially occur in the survey area.

Table 8 (over page) shows the species of Declared Rare or Priority Flora occurring in the Brookdale-Armadale area identified in the DEC database searches. Additional species not identified by the DEC database search but known to be present in nearby Bush Forever sites are also included in Table 8.

In addition to the Declared Rare and Priority listed flora, Bush Forever also identifies other species of significance that occur on the Bassendean Dune system and Foothills and Pinjarra Plain that might occur in the Amendment area. These species are considered significant on the basis of their geographical location or endemism on the Swan Coastal Plain (see Tables 6.2 and 6.3 Bush Forever Volume 2).

No Declared Rare Flora or Priority flora species were recorded from the Amendment area during the 2005 flora and vegetation assessment.

None of the significant species listed in Bush Forever were recorded in the Amendment area in the quadrats selected for the field survey or other areas surveyed. *Eucalyptus lanepoolei*, *Synaphea acutiloba* and *Lomandra spartea* are known to occur in Bush Forever Site 264 (Lambert Lane Bushland) (Government of Western Australia 2000).

TABLE 8
DECLARED RARE AND PRIORITY FLORA FOUND IN THE BROOKDALE-ARMADALE AREA

SPECIES	CONSERVATION STATUS
Acacia horridula	P3
Acacia oncinophylla subsp. *patulifolia*	P2
Apodasmia ceramophila	P2
Anthotium junciforme	P4
Aotus cordifolia	P3
Apodasmia ceramophila (ms)	P3
Baeckea sp. Perth Region (pn)	P2
Calytrix simplex subsp. *simplex*	P1
Centrolepis caespitose	R
Diuris purdiei	R
Drakaea elastica	R
Drakaea micrantha (ms)	R
Drosera occidentalis subsp. *occidentalis*	P4
Dryandra kippistiana var. *paenepeccata*	P3
Hakea tuberculata	P3
Johnsonia pubescens subsp. *cygnorum*	P2
Lepidosperma rostratum	R
Schoenus pennisetis	P1
Stylidium longitubum	P3
Synaphea odocoileops	P1
Thelymitra magnifica (ms)	P1
Thysanotus glaucus	P4
Tripterococcus paniculatus (ms)	P1
Verticordia lindleyi subsp. *lindleyi*	P4
Verticordia plumosa var. *pleiobotrya*	R
Villarsia submersa	P4

Locally Significant Species

Outside of the wetlands and watercourses present in the Amendment area there is very little remnant native vegetation. However, some of the stands of trees that exist along the current road system and elsewhere may be considered locally significant as they have aesthetic appeal as well as providing some wildlife corridor value for birds. These avenues of trees along road reserves should be retained in future residential development.

Additionally the species *Kingia australis* is considered locally significant as it is an iconic species and unusual in the Perth Metropolitan Region.

4.2.4 Potential Impacts

The proposed development of the Amendment area will mostly be constructed on cleared land and pasture. However, the development could lead to the following impacts on native vegetation:

- Some stands of native trees and shrubs that exist along the current road system and elsewhere may be removed due to development;
- Degradation of Bush Forever sites, including the area of Threatened Ecological Community SCP3a *Corymbia calophylla – Kingia australis* woodlands on heavy soils due to impacts of

uncontrolled human access, increased fire frequencies, weed invasion, introduction and spread of dieback, rubbish dumping, and changes in hydrology; and
- Increase in the number of native trees and shrubs in the area as a result of planting in avenues, drainage corridors, wetlands and wetland buffers.

4.2.5 Management Strategies

The Wungong Urban Water Master Plan acknowledges that there are areas of significant vegetation within the Amendment area. In particular, the Master Plan retains the three Bush Forever sites (Bush Forever Sites 264, 266 and 345). The Master Plan also incorporates areas of locally significant vegetation in public open space or within allocated wetland buffer zones.

The Master Plan incorporates a system of avenues which are to be revegetated with native trees and shrubs and will provide wildlife corridors across the whole of the Amendment area, potentially connecting with off-site landscape systems. The avenues will add significantly to the overall amount of indigenous vegetation in the Armadale region. Removal of non-native vegetation in a manner that replaces it with native vegetation and minimises potential soil erosion is encouraged, except where the non-native vegetation has identified landscape or heritage value.

TEC 3a is located in the south-east corner of the project area within Bush Forever Site 264 (Lambert Lane Bushland, Wungong and CALM Reserve 42044). The 500m notification buffer encroaches into the Amendment area. TEC 3a is also identified as a Conservation Category Wetland (CCW). In order to ensure that future development will not adversely impact on the TEC, a non-development buffer will be required around the TEC/CCW. In addition, a vegetation or wetland management plan will be required to be prepared by the landowner as part of the Structure Planning process to address issues such as fencing access, weed control, revegetation, fire management and monitoring. District and local stormwater drainage infrastructure requirements should be designed to not adversely impact on the TEC.

There is a general preclusion against the removal of any established trees within the Amendment area. As part of the Structure Planning process, Developers will be required to prepare a Concept Plan that includes a detailed Tree Survey for the Structure Plan Area. The Tree Survey will identify trees for protection. Where trees are not listed for protection, rationale shall be provided for not retaining them in accordance with a Tree and Other Vegetation Preservation Policy to be adopted by the ARA. For those trees earmarked for protection, a Landscape Plan will be required to be prepared at the subdivision stage.

The Tree and Other Vegetation Preservation Policy will incorporate the following objectives:

- Reinforces the value ARA places on the retention of trees and other vegetation within the Brookdale Precinct;
- Provide guidance to landowners, applicants and the ARA in relation to the retention, removal or modification of existing trees and native vegetation within the area;
- Identifies criteria for trees and other vegetation required to be retained;
- Identifies criteria where trees and other vegetation may be considered for removal; and
- Identifies exemptions from these policy requirements.

Objectives of the Policy should reflect the following:

- To protect and improve biodiversity within the Brookdale area, including the protection of dead trees that may serve as habitation for fauna;
- To provide habitat for fauna and facilitate the movement of fauna between regional and public open space areas;
- To provide landmarks for the community through the retention of established trees;

- To provide comfortable streetscape and public open space amenity by the provision of shade and cooling for open space users, pedestrians, cyclists and vehicles parked within embayment parking areas;
- To assist in providing attractive streetscapes and public open space areas;
- To assist in reflecting the history of the area through the retention of existing trees and vegetation;
- To protect and enhance the natural landscape amenity of the Precinct by protecting visually sensitive areas from tree removal or clearing;
- To assist in managing greenhouse gas emissions; and
- To assist in minimising erosion, and maintaining hydrological balance.

The ARA will use the Tree and Other Vegetation Preservation Policy when assessing the Concept Plans.

4.2.6 Predicted Outcome

Based on the review of the available literature, results of the vegetation surveys undertaken and knowledge of the extent of the development, it is considered that the implementation of the proposed redevelopment of the Wungong Urban Water Master Plan area can be managed to meet the EPA's environmental objective in relation to Native Terrestrial Vegetation and Flora.

4.3 Native Terrestrial Fauna

4.3.1 EPA Objective

To maintain the abundance, diversity, geographic distribution and productivity of fauna at species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge.

4.3.2 Applicable Legislation, Criterion or Guidance

- *Wildlife Conservation Act 1950*
- *Environment Protection and Biodiversity Conservation Act 1999*
- *Environmental Protection Act 1986*
- Environmental Protection Authority (2004c) Guidance No. 56: *Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia.*

4.3.3 Existing Environment

A Level 2 fauna assessment was conducted for the Amendment area. According to Position Statement No. 3 (Environmental Protection Authority 2002) a Level 2 fauna survey involves a desktop study, reconnaissance survey and a comprehensive fauna survey. The Level 2 fauna assessment for the Amendment area involved searches of the Western Australian Museum's (WAM) *FaunaBase*, the DEC's Threatened and Priority Species database, the Commonwealth *Environment Protection and Biodiversity Conservation Act (EPBC Act)* 1999 database; and a ten day trapping program (13-22 December 2005) supplemented by an avifauna survey, night spotlighting, hand searches and opportunistic sightings. These data were used to confirm the faunal assemblages predicted within the Amendment area based on the numerous surveys on the Swan Coastal Plain. The complete report titled *Vertebrate Fauna Assessment – Brookdale Redevelopment Area* (ATA Environmental 2006c) is included as Appendix 3 of this report.

Fauna Habitat

The majority of the Amendment area comprises cleared paddocks for pasture and is highly degraded. Consequently the habitat available is generally highly degraded and fragmented in nature. Most of these areas are generally small in size and mostly isolated with only a few sizable remnants that are relatively undisturbed and considered to be in a good condition.

Five main fauna habitat types were identified within the Amendment area:

- Open woodland of Marri (*Corymbia calophylla*) usually with Swamp Paperbark (*Melaleuca rhaphiophylla*) and/or Moonah (*Melaleuca preissiana*) generally over introduced herbs and grasses;
- Open woodland dominated by Swamp Paperbark (*M. rhaphiophylla*) and/or Moonah (*M. preissiana*) and occasionally scattered with Flooded Gum (*Eucalyptus rudis*) generally over introduced herbs and grasses;
- Open woodland of Moonah (*M. preissiana*) and Spearwood (*Kunzea glabrescens*) over an open heath;
- *Banksia attenuata, B. menziesii* and/or *B. ilicifolia* open woodland; and
- Pasture or private gardens with scattered native and non-native trees and shrubs generally over introduced grasses.

Riparian vegetation is associated with the Wungong River and the fauna habitat along the river varies from good to degraded in condition. The vegetation was mainly woodland dominated by *Melaleuca* spp. and Flooded Gum (*Euclayptus rudis*) and occasionally Marri (*Corymbia calophylla*). The Wungong River foreshore area has not been fenced off and cattle and horses have access to the riparian vegetation which contributes to its disturbed nature. There is very little to no understorey and it is mostly introduced grasses.

Location of fauna habitats are shown on Figure 8.

Fauna Survey Results

The search of on-line databases and surveys in similar habitats within the Swan Coastal Plain predicted that nine species of amphibian, 42 species of reptile, 31 species of mammal (21 native and 10 introduced) and 165 species of bird may be present within the Amendment area. The fauna survey conducted in December 2005 caught or sighted 6137 individuals representing seven amphibian species, 16 reptile species, three native and ten introduced mammal species and 71 bird species. A detailed list of species recorded is provided in Appendix 3.

Amphibians

The nine frog species predicted to occur within the Amendment area are generally widespread in the Perth metropolitan region where suitable habitat remains and several are known to persist in very badly degraded wetlands. *Crinia georgiana* is mainly restricted to the clay soils of the Darling Scarp and clay-based swamps on the eastern side of the Swan Coastal Plain. ATA Environmental recorded seven of the nine species from 3039 individuals. This high number of amphibians was due to the presence of many wetland areas.

All the frog species recorded within the Amendment area rely on wetlands for breeding. *Litoria adelaidensis, Litoria moorei, Crinia insignifera, Crinia glauerti* and *Crinia georgiana* were only found within open woodland of *Meleleuca preissiana* and *Melaleuca rhaphiophylla* and the wetter *Corymbia calophylla* woodlands within the Amendment area. Alan Tingay and Associates (1993a) also found that *Crinia glauerti* was restricted to the wetter open woodland of *M. preissiana* and *M. rhaphiophylla* habitat. *Limnodynastes dorsalis* and *Heleioporus eyrei* were

found within the *Banksia* woodland and open woodland of *C. calophylla* habitats as well as the open woodlands of *M. preissiana* and *M. rhaphiophylla* of the Amendment area. These two species are known to move away from wetlands outside the breeding season and have been recorded in *Banksia* and *Eucalyptus* woodlands by other surveys (Alan Tingay and Associates 1993a; Arnold *et al.* 1991).

Reptiles

Undisturbed semi-arid and mesic biotopes generally have between 17 and 35 reptile species (How 1998; Thompson *et al.* 2003a). ATA Environmental trapped 15 reptile species comprising 130 individuals and recorded an additional one species opportunistically. The Amendment area is mostly cleared and highly disturbed however, and lacks large, relatively undisturbed areas of remnant vegetation. Therefore, it would be expected to have a lower species richness compared with undisturbed sites.

Sites on the Swan Coastal Plain typically contain a high number of skinks, fewer elapids and less geckoes, pygopods, agamids, varanids and blind snakes (Alan Tingay and Associates 1993a; b; How 1998). The Bold Park site for example contains 12 skinks, six elapids two geckoes, two pygopods, two agamids, one blind snake and one varanid (How 1998). The Brookdale area was very similar in its reptile assemblage containing eight skinks, two elapids, two pygopods, two varanids, one blind snake and one gecko. Generally, most reptile species were recorded within all habitat types of the Amendment area as is typical for reptile assemblages on the Swan Coastal Plain (Arnold *et al.* 1991). *Acritoscincus trilineatum* and *N. scutatus* were associated with the open woodland of *M. preissiana* and *M. rhaphiophylla* habitat, as was predicted from previous surveys on the Swan Coastal Plain. *Ctenotus australis, M. lineoocellata* and *C. fallens* were recorded in the drier upland habitat types of the *Banksia* woodland and *M. preissiana* and *Kunzea glabrescens* tall shrubland over heath within the Amendment area.

Mammals

For biotopes or habitats that are less diverse, the number of small trappable mammal species is generally between five and eight (Masters 1993; How and Cooper 2000; unpublished data for the Goldfields). ATA Environmental trapped four species of mammal during the Amendment area survey; the House Mouse, Black Rat, Brush-tail Possum and Southern Brown Bandicoot (Quenda), and opportunistically recorded an additional nine species of mammal (Gould's Wattled Bat, Feral Fox, Feral Cat, Rabbit; Domestic Dog, Cow, Sheep, Horse and Alpaca). The species richness for native mammals within the Brookdale area is very similar to that recorded within other bushland remnants on the Swan Coastal Plain (How *et al.* 1996; Harvey *et al.* 1997) as few species of native mammals remain on urban bushland remnants on the Swan Coastal Plain (How and Dell 1994).

ATA Environmental recorded the Brushtail Possum from the open woodland of *C. calophylla* habitat associated with tree hollows for nesting and the Quenda was trapped within dense *M. preissiana* and *K. glabrescens* tall shrubland over open heath habitat. The House Mouse and Black Rat were widespread across the Amendment area. The absence of larger mammals such as the Western Grey Kangaroo and Western Brush Wallaby from the Amendment area is probably attributable to the small size and fragmented nature of the remnant vegetation areas. Larger mammals in particular, require large areas of relatively intact habitat (Cardno BSD 2005). ATA Environmental recorded one species of bat, Gould's Wattled Bat, (*Chalinolobus gouldii*) within the open woodland of *C. calophylla* habitat of the Amendment area. The species is known to be common on the Swan Coastal Plain.

Birds

The suite of bird species predicted within the Amendment area is typical of remnant vegetation on the Swan Coastal Plain. A large number of waterbirds would be expected to make up the species list due to the presence of a number of wetland habitats within the Amendment area. Bird species such as a number of honeyeater species may not be present, or present in low numbers, due to a lack of *Banksia* woodland habitat within the Amendment area. Species such as the Splendid Fairy-wren, Inland Thornbill and Western Thornbill could be expected to occur in the wetland habitats, including areas with *Eucalyptus* species. The open woodland of *C. calophylla* would be expected to have an assemblage of hollow-nesting species including parrots, cockatoos, kingfishers, pardalotes and owls.

ATA Environmental recorded 71 species from 2635 individuals of the 167 species predicted from other surveys on the Swan Coastal Plain. The bird assemblage recorded was very similar to that predicted for the Amendment area. A number of waterbirds including the Australasian Grebe, Pelican, Eurasian Coot, Purple Swamphen two species of cormorant (Little Black Cormorant and Little Pied Cormorant), three species of heron (White-necked Heron, White-faced Heron and Nankeen Night Heron) and two species of ibis (Straw-necked Ibis and Australian White Ibis) were restricted to wetland areas such as the Wungong River. One of the most abundant species recorded was the Splendid Fairy-wren probably due to the predominance of wetland habitats within the Amendment area. The Barn Owl, Southern Boobook Owl, Tawny Frogmouth, Forest Red-tailed Black-Cockatoo, Regent Parrot, Elegant Parrot and Sacred Kingfisher were recorded within the open woodland of *C. calophylla* habitat of the Amendment area similar to other surveys (Watkins *et al.* 1993; Cole 2003).

The most abundant species recorded within the Amendment area were generally species that have benefited from land clearing and habitat fragmentation on the Swan Coastal Plain including the Straw-necked Ibis, Silvereye, Galah, Brown Honeyeater, Red Wattlebird, Magpie-lark, Australian Magpie and Australian Raven.

Biodiversity Value

Species of mammals, reptiles, birds and amphibians present or likely to visit the Amendment area would also be present or visit other similarly vegetated areas in the region. The Amendment area itself is highly disturbed and is mostly in a degraded condition. Most of the land has been historically cleared for grazing and housing. The areas of remnant vegetation remaining include the Wungong River, Bush Forever sites and some of the wetland areas. These remnant habitat areas are also in a degraded condition, with some areas in a good condition. Horses and cattle have had access to most of these areas and the understorey has been highly disturbed. Large sections of the Amendment area are significantly weed infested, with extensive areas of assessed habitat containing dumped rubbish and car bodies. The high levels of grass and weed species have resulted in a very high abundance of introduced fauna species such as House Mice and Black Rats and faunal assemblages typical of many isolated urban bushland remnants.

Although there is little intact remnant vegetation remaining within the Amendment area and a substantial proportion of the site is in a degraded condition, there are some key habitats and corridor linkages that should be maintained and rehabilitated to retain and even improve the biodiversity value of the Amendment area and enable connectivity with other remnant bushland areas. At a local scale, areas of habitat that were mapped as Degraded or Completely Degraded contain remnant upper storey trees (mostly Marri) that still provide habitat for local bird and mammal species such as possums and bats.

Key habitats which were identified from the fauna assessment that should be retained are shown in Figure 8 and listed below:

- The Conservation Category Wetland that is part of the Bush Forever Site No. 345 and surrounding habitat;
- Significant stands of Marri trees in the northern section of Amendment area, adjacent to the Wungong River to the west;
- The entire Wungong River including the Bush Forever Site No. 266;
- The Resource Enhancement wetlands in the centre of the Amendment area between Wungong River and Neerigen Brook South; and
- Bush Forever Site No. 264.

Within the Amendment area, the development of a network of ecological corridors will conserve the key habitats identified including the riparian vegetation along the Wungong River and other wetland areas and link these areas with each other and other remnant bushland adjacent to the Amendment area. The main ecological corridors recommended across the Amendment area as shown on Figure 8 are:

- North-south corridor following Wungong River and incorporating the wetland area in the middle of the Amendment area;
- West-east ecological corridor linking the Bush Forever Site No. 345 to the Wungong River; and possibly
- East-west corridor linking Bush Forever Site No. 264 with Bush Forever Site No. 266.

Specially Protected (Threatened) Fauna

The conservation significant fauna species listed in Table 9 were listed in *FaunaBase*, the DEC's Threatened fauna database and Department of Environment and Heritage (DEH) *EPBC Act* database as being potentially found in the Amendment area. Conservation significant species may be listed as Threatened under the Commonwealth *Environment Protection and Biodiversity Conservation Act (EPBC Act) 1999*, Scheduled under the Western Australian *Wildlife Conservation Act 1950* and Priority under the DEC Priority Fauna List. Definitions of the classification system for significant fauna are provided in Appendix 3.

Three threatened species of fauna and 17 migratory species of birds listed under the Commonwealth *EPBC Act 1999* were identified as potentially occurring within the Amendment area. Six Schedule 1 and two Schedule 4 species listed under the Western Australian *Wildlife Conservation Act 1950* and nine Priority fauna species under the DEC Priority Fauna List potentially occur within the Amendment area.

TABLE 9
SIGNIFICANT FAUNA SPECIES RECORDED OR LISTED AS POTENTIALLY OCCURRING IN THE AMENDMENT AREA

Species	DEC Schedule / Priority	Status under Commonwealth *EPBC Act*	Comment
Carnaby's Black-Cockatoo *Calyptorhynchus latirostris*	Schedule 1	Endangered	Species or species habitat *occurs* within Amendment area
Baudin's Black-Cockatoo *Calyptorhynchus baudinii*	Schedule 1	Vulnerable	Species or species habitat *occurs* within Amendment area
Chuditch, Western Quoll *Dasyurus geoffroii*	Schedule 1	Vulnerable	Species *unlikely* within Amendment area
Forest Red-tailed Black-Cockatoo *Calyptorhynchus banksii naso*	Schedule 1		Species or species habitat *recorded* within Amendment area

Species	DEC Schedule / Priority	Status under Commonwealth *EPBC Act*	Comment
Australasian Bittern *Botaurus poiciloptilus*	Schedule 1		Species or species habitat *possible* within Amendment area
Native Bee *Neopasiphe simplicior*	Schedule 1		Species or species habitat *possible* within Amendment area
Carpet Python *Morelia spilota imbricata*	Schedule 4		Species or species habitat *possible* within Amendment area
Peregrine Falcon *Falco peregrinus*	Schedule 4	Migratory	*Possible* infrequent visitor to the Amendment area
Barking Owl *Ninox connivens connivens*	Priority 2		Species or species habitat *possible* within Amendment area
Masked Owl *Tyto novaehollandiae novaehollandiae*	Priority 3		Species or species habitat *possible* within Amendment area
Southern Brush-tailed Phascogale *Phascogale tapaotafa tapaotafa*	Priority 3		Species or species habitat *possible* within Amendment area
Native Bee *Leioproctus contrarius*	Priority 3		Species or species habitat *possible* within Amendment area
Western Brush Wallaby *Macropus irma*	Priority 4		Species or species habitat *possible* within Amendment area
Rakali, Water Rat *Hydromys chrysogaster*	Priority 4		Species or species habitat *possible* within Amendment area
Little Bittern *Ixobrychus minutus*	Priority 4		Species or species habitat *possible* within Amendment area
Freshwater Mussel *Westralunio carteri*	Priority 4		Species or species habitat *possible* within Amendment area
Quenda, Southern Brown Bandicoot *Isoodon obesulus fusciventer*	Priority 5		Species or species habitat *recorded* within Amendment area
Rainbow Bee-eater *Merops ornatus*		Migratory	Species or species habitat *recorded* within Amendment area
Fork-tailed Swift *Apus pacificus*		Migratory	Species *may occasionally* occur within region
Great Egret *Ardea alba*		Migratory	Species or species habitat *likely* to occur within Amendment area
Cattle Egret *Ardea ibis*		Migratory	Species or species habitat *likely* to occur within Amendment area
Common Sandpiper *Tringa hypoleucos*		Migratory	Species or species habitat *likely* to occur within Amendment area
Common Greenshank *Tinga nebularia*		Migratory	Species or species habitat *likely* to occur within Amendment area

Species	DEC Schedule / Priority	Status under Commonwealth *EPBC Act*	Comment
Wood Sandpiper *Tringa glareola*		Migratory	Species or species habitat *likely* to occur within Amendment area
Marsh Sandpiper *Tringa stagnatilis*		Migratory	Species or species habitat *likely* to occur within Amendment area
Sharp-tailed Sandpiper *Calidris acuminata*		Migratory	Species or species habitat *likely* to occur within Amendment area
Curlew Sandpiper *Calidris ferruginea*		Migratory	Species or species habitat *likely* to occur within Amendment area
White-rumped Sandpiper *Calidris fuscicollis*		Migratory	Species or species habitat *possible* within Amendment area
Pectoral Sandpiper *Calidris melanotos*		Migratory	Species or species habitat *possible* within Amendment area
Little Stint *Calidris minuta*		Migratory	Species or species habitat *likely* to occur within Amendment area
Red-necked Stint *Calidris ruficollis*		Migratory	Species or species habitat *likely* to occur within Amendment area
Long-toed Stint *Calidris subminuta*		Migratory	Species or species habitat *likely* to occur within Amendment area
Little Ringed Plover *Charadrius dubius*		Migratory	Species or species habitat *possible* within Amendment area

Carnaby's Black-Cockatoo (*Calyptorhynchus latirostris*)

- Endangered under the *EPBC Act*
- DEC Schedule 1

Carnaby's Black-Cockatoo inhabits the south-west of Western Australia. Its preferred habitat is the woodland where it preferentially feeds on plants of the Proteaceae family. Preferred nesting trees include the smooth-barked Salmon Gum (*Eucalyptus salmonophloia)* and Wandoo (*E. wandoo*), which contain deep hollows. Nesting also occurs in Marri (*Corymbia calophylla)* and Tuart (*E. gomphocephala*). Carnaby's Black-Cockatoo forages in woodland and kwongan heath that is dominated by proteaceous species. Its main foods are the seeds of Hakeas, Grevilleas, Banksias and Eucalypts.

Carnaby's Black-Cockatoos were observed feeding within the Amendment area on one occasion. Eleven significant trees containing hollows suitable for breeding Black-Cockatoos were recorded within the Amendment area (refer to Figure 5 of Appendix 3 for their location). The hollows were mostly found in Marri (*Corymbia calophylla*) trees and two Flooded Gums (*Eucalyptus rudis*).

Baudin's Black-Cockatoo (*Calyptorhynchus baudinii*)

- Vulnerable under the *EPBC Act*
- DEC Schedule 1

This species is most common in the far south-west of Western Australia where it breeds. It is known to breed from the southern forests north to Collie and east to near Kojonup. Baudin's Cockatoo is typically found in vagrant flocks and utilises the taller, more open Jarrah and Marri woodlands, where it feeds mainly on Marri seeds and various Proteaceous species. When seasonally present on the coastal plain, Baudin's Black-Cockatoo are more likely to occur in the vicinity of eastern areas of the coastal plain.

Baudin's Black-Cockatoos are likely to utilise the Amendment area for feeding and possibly breeding purposes. Eleven significant trees containing potentially suitable hollows were recorded.

Chuditch (*Dasyurus geoffroii*)
- Vulnerable under the *EPBC Act*
- DEC Schedule 1

Formally known from over 70% of Australia, the Chuditch now has a patchy distribution throughout the Jarrah forest and mixed Karri/Marri/Jarrah forest of southwest WA, but they have been found in dry sclerophyll forests, riparian vegetation, beaches and deserts.

Although able to utilise bush remnants and corridors and previously recorded within the vicinity of the Amendment area, the Chuditch is unlikely to be present due to the small area of remnant vegetation and its degraded condition.

Forest Red-tailed Black-Cockatoo (*Calyptorhynchus banksii naso*)
- DEC Schedule 1

Forest Red-tailed Black-Cockatoos frequent the humid to subhumid south-west feeding on a variety of *Eucalyptus* species, from Gingin in the north, Albany in the south and west to Cape Leeuwin and Bunbury. Nesting occurs in hollows with a depth of 1-5m predominately in Marri (*C. calophylla*), Jarrah (*E. marginata*) and Karri (*E. diversicolor*). Forest Red-tailed Black-Cockatoos were formerly common but are now uncommon and patchily distributed.

Forest Red-tailed Black-Cockatoos were recorded frequently within the Amendment area. Flocks of up to nine Forest Red-tailed Black-Cockatoos were observed feeding on the vegetation within the Amendment area on most days. They were observed in the Marri woodlands surrounding trapping Site 1 and in the northwestern corner of the Amendment area. Eleven significant trees containing potentially suitable hollows were recorded.

Australasian Bittern (*Botaurus poiciloptilus*)
- DEC Schedule 1

The Australasian Bittern inhabits bulrushes and reedbeds of wetland areas, but will venture out onto mudflats to feed on amphibians, small lizards or snakes, crustaceans and insects.

The Australasian Bittern may inhabit the dense vegetated wetland habitat located at Site 1.

Native Bee (*Neopasiphe simplicior*)
- DEC Schedule 1

This species of native bee has been collected on flowers of *Goodenia filiformis, Lobelia tenulor, Angianthus preissianus* and *Velleia* sp. It is known only from bushland within Forrestdale Lake and Armadale Golf Course.

The Amendment area is within the distribution range for this species, but none of the plant species listed above were found to occur within the Amendment area, probably due to the disturbed nature of much of the vegetation.

Carpet Python (*Morelia spilota imbricata*)

- DEC Schedule 4

The Carpet Python is a large snake found across the south-west of Western Australia, from Northampton, south to Albany and eastwards to Kalgoorlie including undisturbed remnant bushland near Perth and the Darling Ranges. This subspecies has been recorded from semi-arid coastal and inland habitats, *Banksia* woodland, Eucalypt woodlands and grasslands.

The Carpet Python may occur within the Amendment area, however, ATA Environmental considers it unlikely due to the small areal extent and highly disturbed nature of the remnant vegetation.

Peregrine Falcon (*Falco peregrinus*)

- DEC Schedule 4

The Peregrine Falcon is uncommon, although widespread throughout much of Australia excluding the extremely dry areas and has a wide and patchy distribution. It shows habitat preference for areas near cliffs along coastlines, rivers and ranges and within woodlands along watercourses and around lakes. It favours hilly or mountainous country and open woodlands and may be an occasional visitor to the Amendment area.

ATA Environmental's assessment is that this species is possibly an infrequent visitor to the Amendment area and the potential loss of habitat due to development is unlikely to have an impact on this species.

Barking Owl (*Ninox connivens connivens*)

- DEC Priority 2

This subspecies is sparsely distributed along the coastal and sub-coastal regions of Western Australia, from Esperance to Greenough River. The southern subspecies occurs primarily in dry sclerophyll woodland, particularly associated with riparian vegetation in the south-west and on forest edges in the south-east. They nest in large hollow in live Eucalypts, often near open country. The Barking Owl primarily feeds on insects in the non-breeding season and birds and mammals during the breeding season.

The Barking Owl may occur within the Amendment area as suitable habitat exists, particularly along the Wungong River and the wetland areas at Site 1.

Masked Owl (*Tyto novaehollandiae novaehollandiae*)

- DEC Priority 3

Little information is available on the Masked Owl. It is distributed from Yanchep east to Yealering, south to Gnowangerup and Albany and occasionally seen north to Geraldton. This species inhabits forests and woodlands and nests in tree hollows. It is locally common around Karridale and Manjimup, but is generally uncommon elsewhere.

The Masked Owl may potentially occur within the Amendment area due to the presence of suitable habitat.

Southern Brush-tailed Phascogale (*Phascogale tapaotafa tapaotafa*)

- DEC Priority 3

The present range of this species is believed to have been reduced to 50% of its former range. It is now known from Perth and south to Albany, west of Albany Highway. It occurs in low densities in the northern Jarrah forest with highest densities found in the Perup/Kingston area, Collie River valley, and near Margaret River and Busselton. This arboreal marsupial occurs in forest and woodland where suitable tree hollows are available.

This species was recorded from Martin in 2003 (CALM, 2005) and it is possible, but unlikely, that this species is present within the small areas of habitat remaining in the Amendment area.

Native Bee (*Leioproctus contrarius*)

- DEC Priority 3

This species of native bee is apparently dependent on flowers of Goodeniaceae and possibly *Lechenaultia stenosepala*. Recent surveys have shown that it is more widespread than previously thought.

This species has been recorded from Forrestdale Lake in 1952 and 1954 (CALM 2005) which is adjacent to the Amendment area. It is possible this species occurs within the Amendment area as a plant species from the Goodeniaceae family was recorded during the flora and vegetation survey.

Western Brush Wallaby (*Macropus irma*)

- DEC Priority 4

This species was very common in the early days of settlement, however, its range has been seriously reduced and fragmented and there is a significant decline in abundance within most remaining habitat. It is now distributed across the south-west of Western Australia from north of Kalbarri to Cape Arid. The optimum habitat is open forest or woodland, particularly favouring open, seasonally wet flats with low grasses and open scrubby thickets.

The Western Brush Wallaby has been recorded from Forrestdale Lake (CALM 2005) but it is unlikely to occur within the Amendment area due to the small size and degraded condition of the remnant vegetation.

Water Rat (*Hydromys chrysogaster*)

- DEC Priority 4

The Water Rat is widely distributed around Australia and occurs in fresh brackish waters in the south-west of Western Australia that contain its main prey items including molluscs and crustaceans. In winter months, they spend less time in the water and tend to feed on larger vertebrate prey. Nests are constructed in logs or tunnels dug into banks.

The Water Rat is possibly found along the Wungong River, although no evidence was observed during hand searches of the riparian area.

Little Bittern (*Ixobrychus minutus*)

- DEC Priority 4

This species inhabits freshwater swamps, lakes and rivers with dense reed beds, tall sedges and well-vegetated margins. It is also found in saline environments such as mangroves, saltmarsh and coastal lagoons.

The Little Bittern may inhabit the densely vegetated wetland habitat located at Site 1.

Freshwater Mussel (*Westralunio carteri*)
- DEC Priority 4

This species of freshwater mussel is endemic to Western Australia.

This species was recorded from Roleystone in 1987 and is potentially present within the Wungong River.

Southern Brown Bandicoot (*Isoodon obesulus fusciventer*)
- DEC Priority 5

Quenda prefer dense scrub (up to one metre high), often in or near swampy vegetation. They will often feed in adjacent forest and woodland that is burnt on a regular basis and in areas of pasture and cropland lying close to dense cover. Major threats to Quenda include habitat fragmentation and loss of habitat on the coastal plain and wheat belt, fire in fragmented habitat, predation by foxes, predation of young by cats and predation around residential areas by dogs.

The Southern Brown Bandicoot was recorded during the trapping survey from Site 2. Twenty bandicoots including four juveniles were trapped, and an additional five bandicoots were recorded during spotlighting. No bandicoots were trapped within Site 1 and there was no evidence of diggings or scratchings in the area surrounding Site 1. Although they were not trapped at Site 1 bandicoots may still occur within this area at low densities. The wetland area at Site 2 had a very dense understorey habitat that Southern Brown Bandicoots prefer and is part of the large Bush Forever Site 345 (Forrestdale Lake and Adjacent Bushland). Figure 6 in Appendix 3 shows the areas of suitable Southern Brown Bandicoot habitat within the Amendment area.

Rainbow Bee-eater (*Merops ornatus*)
- Migratory species under the *EPBC Act*

This species is found across the better-watered parts of Western Australia including islands. It prefers lightly wooded, preferably sandy, country near water. It is a resident, breeding visitor, postnuptial nomad, passage migrant and winter visitor, wintering from the Gascoyne north to Indonesia. It moves south mainly in late September and early October and north from February to April. It is scarce to very common across its range.

The Rainbow Bee-eater was moderately common within the Amendment area with 34 individuals being recorded, mainly in the vicinity of the trapping Site 1. It is likely that the Rainbow Bee-eater utilises the Amendment area for feeding and breeding purposes. For breeding it requires clearings or paddocks with soil soft enough for nest tunnelling and this type of habitat is found within the Amendment area.

Fork-tailed Swift (*Apus pacificus*)
- Migratory species under the *EPBC Act*

This species breeds in north-east and mid-east Asia and winters in Australia and southern New Guinea. It is a visitor to most parts of Western Australia, beginning to arrive in the Kimberley in late September, in the Pilbara and Eucla in November and in the south-west land division in mid-December, and leaving by late April. It is common in the Kimberley, uncommon to moderately common near north-west, west and south-east coasts and rare to scarce elsewhere. Usually flocks (up to 2000) occur when changed weather conditions (e.g., storms and cyclones) occur.

The Fork-tailed Swift may occur within the Amendment area but it is unlikely to rely on the site for survival.

Great Egret (*Ardea alba*)

- Migratory species under the *EPBC Act*

This migratory species is common and very widespread in any suitable permanent or temporary habitat, including wetlands, flooded pastures, dams, estuarine mudflats, mangroves and reefs.

The Great Egret is likely to be found throughout the Amendment area due to the presence of suitable habitat such as wetlands and flooded pastures.

Cattle Egret (*Ardea ibis*)

- Migratory species under the *EPBC Act*

This species is often seen in flocks with livestock. The Cattle Egret's close association with livestock and habitat adaptability has helped this species spread. It is usually associated with moist pastures with tall grass, shallow open wetlands and margins and mudflats.
The Cattle Egret is likely to be found throughout the Amendment area due to the presence of suitable habitat including wetlands and moist pastures.

Common Sandpiper (*Tringa hypoleucos*)

- Migratory species under the *EPBC Act*

This species is widespread and scattered within Australia but is generally uncommon. It is found on a variety of coastal and interior wetlands including narrow muddy edges of billabongs, river pools, mangroves and among rocks and snags, reefs and rocky beaches. It tends to perch on branches, posts and boats.

This species is likely to be found within the wetland areas of the Amendment area when they are seasonally inundated or moist.

Common Greenshank (*Tringa nebularia*)

- Migratory species under the *EPBC Act*

This species occupies a variety of habitats, both inland and coastal areas. Away from the coast it uses both permanent and temporary wetlands including billabongs, swamps, lakes, floodplains, sewage farms and flooded irrigated crops. The Common Greenshank generally prefers wet and flooded mud and clay rather than sand.

This species has previously been recorded within Forrestdale Lake (Storey *et al.*, 1993) and is likely to be found within the Amendment area as suitable habitat exists.

Wood Sandpiper (*Tringa glareola*)

- Migratory species under the *EPBC Act*

The Wood Sandpiper is a migrant to Australia and prefers freshwater swamps, lakes and flooded pastures. It often uses artificial wetlands such as large farm dams.

This species has previously been recorded within Forrestdale Lake (CALM, 2005) and is likely to be found within the Amendment area as suitable habitat exists.

Marsh Sandpiper (*Tringa stagnatilis*)

- Migratory species under the *EPBC Act*

The Marsh Sandpiper is a common summer migrant to Australia. It is found on coastal and inland wetlands, both salt and freshwater including estuarine and mangrove mudflats, beaches, shallows of swamps, lakes, billabongs, temporary floodwaters, sewage farms and saltwork ponds.

This species has previously been recorded within Forrestdale Lake (CALM, 2005) and is likely to be found within the Amendment area as suitable habitat exists.

Sharp-tailed Sandpiper (*Calidris acuminata*)

- Migratory species under the *EPBC Act*

This species is common to Australia and inhabits both freshwater and salt wetlands. In particular it is found along the muddy edges of lagoons, swamps, lakes, dams, soaks, sewage farms and temporary floodwaters.

This species has previously been recorded within Forrestdale Lake (CALM, 2005) and is likely to be found within the Amendment area as suitable habitat exists.

Curlew Sandpiper (*Calidris ferruginea*)

- Migratory species under the *EPBC Act*

This species is widespread and is a common summer migrant to Australian coastal sites and some are found across suitable interior sites. It is usually found on inter-tidal mudflats of estuaries, lagoons, mangrove channels and around lakes, dams, floodwaters and flooded saltbush surrounds of inland lakes.

This species has previously been recorded within Forrestdale Lake (CALM, 2005) and is likely to be found within the Amendment area as suitable habitat exists.

White-rumped Sandpiper (*Calidris fuscicollis*)

- Migratory species under the *EPBC Act*

This species is a rare vigrant to Australia and most records are from south-western and south-eastern Australia. It tends to inhabit inland rather than marine wetlands and is found on the margins of swamps, lagoons, lakes, muddy pools and occasionally on tidal mudflats.

This species has previously been recorded within Forrestdale Lake (CALM, 2005) and is likely to be found within the Amendment area as suitable habitat exists.

Pectoral Sandpiper (*Calidris melanotos*)

- Migratory species under the *EPBC Act*

This species is a regular uncommon visitor to Australia and is scattered throughout Australia. It usually inhabits coastal wetlands but can also be found inland on permanent and temporary wetlands. It uses sites with mudflats, fringing vegetation or swamps with heavy overgrowth of vegetation.

This species is likely to be found within the wetland areas of the Amendment area when they are seasonally inundated or moist.

Little Stint (*Calidris minuta*)

- Migratory species under the *EPBC Act*

The Little Stint is rare in Australia with few sightings scattered across coastal southern Australia and the Northern Territory. The Little Stint is found most places where Red-necked Stints are found including mudflats, salt marshes, beaches and saltfields.

This species has previously been recorded within Forrestdale Lake (CALM, 2005) and is likely to be found within the Amendment area as suitable habitat exists.

Red-necked Stint (*Calidris ruficollis*)

- Migratory species under the *EPBC Act*

This species is a common migrant in large numbers and inhabits a diversity of habitats. It is found on tidal and inland mudflats, salt marshes, beaches, saltfields and temporary floodwaters.

This species has previously been recorded within Forrestdale Lake (CALM, 2005) and is likely to be found within the Amendment area as suitable habitat exists.

Long-toed Stint (*Calidris subminuta*)

- Migratory species under the *EPBC Act*

This species is a regular visitor to Australia and is scarce but most common in WA. It prefers shallow, fresh water and brackish swamps, lakes with muddy edges and is often among the low vegetation rather than on open mudflats.

This species has previously been recorded within Forrestdale Lake (CALM, 2005) and is likely to be found within the Amendment area as suitable habitat exists.

Little Ringed Plover (*Charadrius dubius*)

- Migratory species under the *EPBC Act*

This species is a rare but regular visitor to Australia. It inhabits the muddy edges or mudflats of tidal or freshwater wetlands including estuaries, lakes, lagoons, dams and ponds.

This species has previously been recorded within Forrestdale Lake (CALM, 2005) and is likely to be found within the Amendment area as suitable habitat exists.

In addition to the conservation significant fauna listed under State and/or Commonwealth legislation a number of locally significant species may occur within the Amendment area including the Hooded Robin, Golden Whistler, *Varanus rosenbergi*, *Varanus tristis*, *Brachyrophis semifasciata*, *B. fasciolata* and *Tiliqua occipitalis*. These species are considered locally significant because they occur on the edge of their distribution or as an isolated population and it is important that these species are also protected by preserving their habitats and entire ecosystems.

4.3.4 Potential Impacts

While the proposed development will mostly be constructed on cleared land and pasture, development may have the following impacts on fauna:

- Clearing of fauna habitat may result in the direct loss of individual species and a potential loss of local biodiversity;
- Some stands of trees may be removed as part of the development reducing the feeding resources and habitat for a number of bird species and mammal species such as the Brushtail Possum;

- Any clearing or infilling of wetland areas will potentially result in the direct loss of a number of species of amphibians and force waterbird species to find alternative habitats; and
- Increased human presence resulting from higher density housing may lead to:

    - Increased numbers of domestic pets close to conservation areas and result in predation of native fauna;
    - Increase in the spread of weeds, changing the quality of fauna habitat available to the native fauna species; and
    - Pollution of the waterways and wetlands which may have a direct impact on the native fauna species present.

Carnaby's Black-Cockatoos and Forest Red-tailed Black-Cockatoos were both recorded feeding in the Marri woodlands. Although there is little remnant vegetation remaining and the habitat is degraded, the Eucalypt trees across the site are important feeding areas for these species. Eleven trees with suitable breeding hollows were located within the Amendment area. Clearing the vegetation may result in the loss of a small area of habitat and foraging sites for these cockatoos as well as the Masked Owl and Barking Owl. There are several large Bush Forever sites to the north, west and south and the Darling Range Regional Park (35,000ha) to the east of the Amendment area within a 10km radius. These areas are similar habitat comprising predominantly *Banksia* and *Melaleuca* woodlands and provide alternative feeding sources.

The Rainbow Bee-eater was common within the Amendment area and is likely to utilise the area for feeding and breeding purposes. It is unlikely that the land clearing will substantially modify, destroy or isolate an area of important habitat for the Rainbow Bee-eater as there are a range of alternative nesting areas in the region.

The Southern Brown Bandicoot would most probably be lost if the suitable bushland habitat is cleared. Other species of conservation significance that may occur within the Amendment area including Southern Brush-tailed Phascogale, Water Rat and Carpet Python Chuditch may also be lost if habitat is cleared. Species such as the Western Brush Wallaby and Chuditch if present, will try to move to adjacent remnant habitat.

Increased human presence resulting from higher density housing may lead to increased numbers of domestic pets close to conservation areas. Dogs have caused problems for migratory waterbirds and bandicoots through disturbance and predation in other parts of Perth, while cats may prey on smaller birds and other wildlife.

4.3.5 Management Strategies

Preservation of Key Habitats and Creation of Ecological Corridors

The Master Plan for the Amendment area indicates that all the key fauna habitats identified in the survey will be retained and the proposed north-south and east-west ecological corridors will be incorporated as part of the Landscape Structure Plan and Wungong Urban Water Master Plan.

The width of the ecological corridors will be guided primarily by the buffers required around the wetlands, Wungong River and Neerigen Brook. The ecological corridors will target mainly bird species that can easily move through the understorey habitat. Rehabilitation of the understorey habitat within the ecological corridors would encourage the smaller mammal, reptile and amphibian species to move throughout the area.

In key fauna habitat areas, a Fauna Relocation and Management Plan will be prepared and implemented by the landowner as a condition of subdivision approval to the satisfaction of the DEC that includes, but is not limited to, the following:

- Any clearing of native vegetation that is required during subdivision, will be conducted in stages to reduce impacts on resident fauna and fauna habitat;
- A 'fauna friendly' clearing protocol will be used as part of any clearing operations where all tree hollows, nests and vegetated debris will be inspected for fauna prior to clearing;
- All hollow logs and branches cleared will be returned to other remnant vegetation areas as part of the rehabilitation works;
- If clearing of vegetation from key habitats is unavoidable then a suitable offset plan will be developed that includes the planting and revegetation of POS areas;
- Translocation of fauna will be undertaken in accordance with DEC policy; and
- Creation of additional tree hollows to result in no net loss of potential fauna habitat.

A Fauna Relocation and Management Plan will be prepared by the Developer in respect to the preparation and assessment of a subdivision plan.

Clearing of Native Vegetation

Approval required under the *Environmental Protection Act 1986* (or is of a kind that is exempt in accordance with Schedule 6 or Regulation 5 under the Clearing of Native Vegetation Regulations).

There is a general preclusion against the removal of any established trees within the Amendment area. As part of the Structure Plan process, Developers will be required to prepare a Concept Plan that includes a detailed Tree Survey for the Structure Plan Area. The Tree Survey will identify trees for protection. Where trees are not listed for protection, rationale shall be provided for not retaining them in accordance with a Tree and Other Vegetation Preservation Policy to be adopted by the ARA. For those trees earmarked for protection, a Landscape Plan will be required at the subdivision stage.

The Concept Plan and Landscape Plan will be a requirement of guidelines to be adopted under Part 4 of the Scheme in respect to the preparation and assessment of structure plan/and/or subdivision.

The Tree and Other Vegetation Preservation Policy will incorporate the following objectives:

- Reinforces the value ARA places on the retention of trees and other vegetation within the Brookdale Precinct;
- Provide guidance to landowners, applicants and the ARA in relation to the retention, removal or modification of existing trees and native vegetation within the area;
- Identifies criteria for trees and other vegetation required to be retained;
- Identifies criteria where trees and other vegetation may be considered for removal; and
- Identifies exemptions from these policy requirements.

Objectives of the Policy should reflect the following:

- To protect and improve biodiversity within the Brookdale area, including the protection of dead trees that may serve as habitation for fauna;
- To provide habitat for fauna and facilitate the movement of fauna between regional and public open space areas;
- To provide landmarks for the community through the retention of established trees;

- To provide comfortable streetscape and public open space amenity by the provision of shade and cooling for open space users, pedestrians, cyclists and vehicles parked within embayment parking areas;
- To assist in providing attractive streetscapes and public open space areas;
- To assist in reflecting the history of the area through the retention of existing trees and vegetation;
- To protect and enhance the natural landscape amenity of the Precinct by protecting visually sensitive areas from tree removal or clearing;
- To assist in managing greenhouse gas emissions; and
- To assist in minimising erosion, and maintaining hydrological balance.

The ARA will use the Tree and Other Vegetation Preservation Policy when assessing the Concept Plans.

Environmental Protection and Biodiversity Conservation Act 1999

As part of complying with the Commonwealth environmental approvals process relating to the *EPBC Act* 1999, landowners proposing to clear native vegetation may need to refer their proposed subdivision design to the Commonwealth Department of Environment and Heritage due to the potential presence of Carnaby's Black-Cockatoo, Rainbow Bee-eater and other listed migratory species known to occur within the Amendment area.

4.3.6 Predicted Outcome

Based on the review of the available registers, the results of fauna surveys undertaken and knowledge of the extent of the development and habitat enhancement proposed, it is considered that the implementation of the proposed redevelopment of the Wungong Urban Water Master Plan area can be managed to meet the EPA's environmental objective in relation to Native Terrestrial Fauna.

4.4 Wetlands

4.4.1 EPA Objective

To maintain the integrity, ecological functions and environmental values of wetlands.

4.4.2 Applicable Legislation, Criterion or Guidance

- Environmental Protection Authority (1992) Environmental Protection (Swan Coastal Plain Lakes) Policy 1992 (EPP Lakes).
- Government of Western Australia (1997) *Wetlands Conservation Policy for Western Australia*.
- Environmental Protection Authority (2004g) Position Statement No. 4 - *Environmental Protection of Wetlands.*
- Western Australian Planning Commission (2005a) Statement of Planning Policy No. 2.9 - *Water Resources* (Draft).
- Water and Rivers Commission (2001a) Water and Rivers Commission Position Statement: Wetlands.
- Department of Environment and Swan River Trust (2005) *A Decision Process for Stormwater Management in Western Australia.*
- Essential Environmental Services (2006) *Interim Approach for Integrating Urban Water Management with Landuse Planning within the Southern River Area: Guidance for Developers.*

4.4.3 Existing Environment

As part of Wungong Urban Water Master Planning process, the ARA commissioned ATA Environmental to conduct wetland re-evaluations and boundary investigations within the Amendment area.

The process of changing a management category of a wetland follows a protocol set out by the DEC's Wetland Program. The protocol allocates wetlands to one of three categories (Conservation, Resource Enhancement and Multiple Use) (refer to Table 10). The process includes a site inspection with photographs, a flora survey, mapping of the wetland boundaries and completion of a questionnaire for wetlands through the EPA (Environmental Protection Authority) Bulletin 686. Full details on the survey methodology and findings are reported in Appendix 4: *Brookdale Redevelopment Area - Wetland Assessment* (ATA Environmental 2006b).

TABLE 10
WETLAND MANAGEMENT CATEGORY DESCRIPTION AND MANAGEMENT OBJECTIVES

Management Category	General Description	Management Objectives
C – Conservation (incorporates EPA Bulletin 686 categories H and C)	Wetlands support a high level of ecological attributes and functions.	Highest priority wetlands. Objective is to preserve and enhance the existing conservation values of the wetlands through various mechanisms including: Reservation in national parks, crown reserves and State owned land, Protection under Environmental Protection Policies, and Wetland covenanting by landowners. No development or clearing is considered appropriate. These are the most valuable wetlands and the Commission will oppose any activity that may lead to further loss or degradation.
R - Resource enhancement (incorporates EPA Bulletin 686 categories O and R)	Wetlands which may have been partially modified but still support substantial ecological attributes and functions.	Priority wetlands. Ultimate objective is for management, restoration and protection towards improving their conservation value. These wetlands have the potential to be restored to Conservation Category. This can be achieved by restoring wetland function, structure and biodiversity. Protection is recommended through a number of mechanisms.
M - Multiple use (aligns with EPA Bulletin 686 category M)	Wetlands with few important attributes and functions remaining.	Use, development and management should be considered in the context of ecologically sustainable development and best management practice catchment planning through landcare. Should be considered in strategic planning (e.g. drainage, town/landuse planning).

Source: WRC (2001a)

Wetlands of the Amendment Area

The Amendment area contains a large area of the Keysbrook consanguineous wetland suite and a smaller area of the Bennett Brook consanguineous wetland suite (Hill *et al*. 1996). Additionally, all areas of the vegetated palusplain (Figure 6) within the Keysbrook suite are considered significant (DEC's Wetland Program pers. comm.). Palusplain wetlands of Conservation Category are poorly represented in the entire Keysbrook consanguineous suite and Bennett Brook suite with approximately 1% and 4.18% respectively remaining on the Swan Coastal Plain.

Most of the Amendment area is classified on the DEC's *Geomorphic Wetlands Swan Coastal Plain* dataset mapping as Multiple Use wetland, as is the adjoining non-urban land. Most of the Multiple Use wetland is palusplain (seasonally waterlogged flat wetland) (UFI 13500) with small areas of dampland (seasonally waterlogged basin wetland) (UFI 13192). All Multiple Use wetlands are shown on Figure 6.

The DEC's *Geomorphic Wetlands Swan Coastal Plain* dataset mapping indicates that the following Resource Enhancement (RE) wetlands are currently mapped in the Amendment area (Figure 6):

- Small RE sumpland (UFI 7677) (seasonally inundated basin) occurs in the northern region of the Amendment area off Wollaston Avenue.
- Large RE floodplain (UFI 7768) occurs in the northern region of the Amendment area on the eastern side of Twelfth Road.
- Large RE floodplain (UFI 7676) occurs in the northern region of the Amendment area on the eastern side of Twelfth Road.
- Large RE artificial lake (UFI 7678) occurs on the northern region of the Amendment area.
- Small RE artificial channel (UFI 7978) occurs on the eastern side of the Amendment area south of Forrest Road.
- Small RE palusplain wetland (MIN 63-V15) is located on the southern region of the Amendment area.
- Small RE sumpland (MIN 98Sr) (seasonally inundated basin) is located on the southern region of the Amendment area.
- Small RE palusplain wetland (MIN 63-V13) is located in the southern region of the Amendment area.
- Small RE palusplain wetland (UFI 7827) is located in the southern region of the Amendment area.
- A large RE palusplain wetland (MIN 63-V21) (the Wungong River) is located on the southern region of the Amendment area.
- RE palusplain wetland (UFI 12182) is located in the eastern region of the Amendment area.

Four Conservation Category Wetlands are currently mapped within the Amendment area (Figure 6):

- palusplain at the northwestern boundary (UFI 7584);
- palusplain at the southwestern end of Wollaston Avenue boundary (UFI 7685);
- palusplain in the southeastern portion (Lambert Road Bushland); and
- palusplain along the southeastern boundary (UFI 12148).

Four wetlands have statutory protection under the *Environmental Protection (Swan Coastal Plain Lakes) Policy 1992* (EPP) (Figure 6). This policy prohibits the filling, mining, pollution or changing of drainage into or out of wetlands without authorisation under the *Environmental Protection Act 1986.*

Wetland Vegetation Description

As previously discussed in Section 4.2.3, the majority of the vegetation that originally occurred throughout the Amendment area has been cleared as a result of past and present landuses. Currently a significant proportion of the Amendment area vegetation is comprised of planted trees, pasture and private gardens and is considered to be in a Completely Degraded or Degraded condition. The best quality vegetation that remains in the Amendment area is mostly located within Resource Enhancement and Conservation Category wetlands (refer to Figures 3-17 of Appendix 4 for detailed vegetation types and condition associated with the wetlands). There were

twenty different vegetation types with varying conditions from Good to Very Good associated with wetlands in the Amendment area (refer to Section 4.2.3).

For a detailed description of vegetation types and spatial distribution for wetlands present within the Amendment area refer to Appendix 2 (ATA Environmental 2006a).

Wetland Boundary and Classification Re-evaluation

As part of the environmental assessment of the Amendment area, ATA Environmental undertook a detailed field investigations and aerial photography interpretation of all wetlands within the Amendment area to enable wetland boundaries to be more accurately delineated and mapped. The full report is provided in Appendix 4.

As a result of the wetland assessment, a number of wetland boundaries were found to vary from previously mapped wetlands boundaries as indicated in the DECs *Geomorphic Wetlands Swan Coastal Plain* dataset. The following information summarises some of the details associated with the wetland boundary re-evaluation undertaken by ATA Environmental and reviewed by the DEC's Wetlands Program (refer to Appendix 4 for complete details).

Conservation Category wetland UFI 7584
The Conservation Category wetland (CC) (UFI 7584) is classified in the DEC's *Geomorphic Wetlands Swan Coastal Plain* dataset as a palusplain (seasonally waterlogged flat). It is located in the northwest corner of the Amendment area and is bounded by Hanlin Road to the east and bisected by Tonkin Highway to the west. The DEC has reviewed the wetland assessment conducted by ATA Environmental and as a consequence the boundary of this wetland has been modified, consistent with the delineation provided by ATA Environmental.

Conservation Category wetland UFI 7685
The CC wetland (UFI 7685) is classified by DEC's *Geomorphic Wetlands Swan Coastal Plain* dataset as a palusplain (seasonally waterlogged flat) and is located on the western side of the Amendment area. The CC wetland is situated on the western side of Wollaston Avenue and north of Forrest Road.

Resource Enhancement and Multiple Use wetland UFI 12182
This wetland was originally classified by the DEC's *Geomorphic Wetlands Swan Coastal Plain* dataset as a CC wetland palusplain (seasonally waterlogged flat). It is located on the southeast corner of the Amendment area south of Ninth Road and abuts Wungong Road. The DEC has reviewed the wetland assessment conducted by ATA Environmental and as a consequence wetland UFI 12182 has been modified to Resource Enhancement with the boundary reflecting the extent of remnant vegetation and the remainder being Multiple Use (Figure 5, Appendix 4).

Conservation Category and Multiple Use wetland UFI 12148
This wetland was originally classified by the DEC's *Geomorphic Wetlands Swan Coastal Plain* dataset as a Palusplain (seasonally waterlogged flat). Wetland (UFI 12148) is located on the southeast corner of the Amendment area within the Keenan Street road reserve. It is bounded by Lot 14 and 15 Keenan Street to the north. The DEC has reviewed the wetland assessment conducted by ATA Environmental and as a consequence the southern boundary of this wetland has been modified to reflect the extent of remnant vegetation, with the remainder being Multiple Use category.

Resource Enhancement wetland UFI 7768
The Resource Enhancement (RE) wetland (UFI 7768) is classified as by the DEC's *Geomorphic Wetlands Swan Coastal Plain* dataset as a RE floodplain (seasonally inundated flat) and occurs in

the northern region of the Amendment area on the eastern side of Twelfth Road. It is bounded by Twelfth Road to the west and Armadale Road to the north.

Resource Enhancement wetland UFI 7676
The Resource Enhancement (RE) wetland (UFI 7676) is classified by the DEC's *Geomorphic Wetlands Swan Coastal Plain* dataset as a floodplain (seasonally inundated flat) and is located on the northwest corner of the Amendment area. It is bounded by Twelfth Road to the east and Armadale Road to the north.

Resource Enhancement wetland UFI 7678
The Resource Enhancement R(E) wetland (UFI 7678) is classified by the DEC's *Geomorphic Wetlands Swan Coastal Plain* dataset as an artificial lake. It is located in the northwest corner of the Amendment area and is bounded by Twelfth Road to the west and Wollaston Avenue to the east.

Resource Enhancement wetland UFI 7677
The Resource Enhancement (RE) wetland (UFI 7677) is classified by the DEC's *Geomorphic Wetlands Swan Coastal Plain* dataset as a sumpland (seasonally inundated basin) and is located in the northeast corner of the Amendment area east of Wollaston Avenue. The DEC has reviewed the wetland assessment conducted by ATA Environmental and as a consequence the boundary of this wetland has been modified to reflect the landform, consistent with the delineation provided by ATA Environmental.

Resource Enhancement wetland MIN 63-V15
The Resource Enhancement (RE) wetland (MIN 63-V15) is classified in the DEC's *Geomorphic Wetlands Swan Coastal Plain* dataset mapping as palusplain (seasonally waterlogged flat). It is located in the southeast corner of the Amendment area and is located east of Eleventh Road and South of Neerigen Brook South. The DEC has reviewed the wetland assessment conducted by ATA Environmental and as a consequence the boundary of this wetland has been modified to reflect the extent of remnant vegetation, consistent with the delineation provided by ATA Environmental.

Resource Enhancement wetland MIN 98Sr
The Resource Enhancement (RE) wetland (MIN 98Sr) classified in the DEC's *Geomorphic Wetlands Swan Coastal Plain* dataset as a sumpland (seasonally inundated basin) and is located east of the proposed Hilbert Road and south of Neerigen Brook South. The DEC has reviewed the wetland assessment conducted by ATA Environmental and as a consequence the boundary of this sumpland has been modified to reflect the landform, consistent with the delineation provided by ATA Environmental.

Resource Enhancement wetland MIN 63-V13
The Resource Enhancement (RE) wetland (MIN 63-V13) is classified in the DEC's *Geomorphic Wetlands Swan Coastal* Plain dataset mapping as a palusplain (seasonally waterlogged flats) and is located on the southern portion of the Amendment area west of Eleventh Road. This wetland covers part of Lot 8 Eleventh Road. The DEC has reviewed the wetland assessment conducted by ATA Environmental and as a consequence the boundary of this wetland has been modified to reflect the extent of remnant vegetation, consistent with the delineation provided by ATA Environmental.

Resource Enhancement wetland UFI 7827
The Resource Enhancement (RE) wetland (UFI 7827) classified in the DEC's *Geomorphic Wetlands Swan Coastal* Plain dataset mapping as a palusplain (seasonally waterlogged flat). It is located on the southern corner of the Amendment area, west of Eleventh Road and south of Neerigen Brook South. This wetland covers part of Lots 8 and 111 Eleventh Road. The DEC has reviewed the wetland assessment conducted by ATA Environmental and as a consequence the

boundary of this wetland has been modified to reflect the extent of remnant vegetation, consistent with the delineation provided by ATA Environmental.

Resource Enhancement wetland MIN 63-V21

The Resource Enhancement (RE) wetland (MIN 63-V21) is classified in the DEC's *Geomorphic Wetlands Swan Coastal* Plain dataset mapping as a palusplain (seasonally waterlogged flat). It is located on the southern corner of the Amendment area and is bounded by Hilbert Road to the east, Rowley Road to the south and Eleventh Road to the east. The DEC has reviewed the wetland assessment conducted by ATA Environmental and as a consequence the boundary of this wetland has been modified to reflect the extent of remnant vegetation, consistent with the delineation provided by ATA Environmental.

Resource Enhancement wetland UFI 7978

The Resource Enhancement (RE) wetland (UFI 7978) is classified in the DEC's *Geomorphic Wetlands Swan Coastal Plain* dataset mapping as a small artificial channel and is located in the centre east corner of the Amendment area west of Powell Crescent.

Wetland Hydrology

With regard to changes to wetland boundaries and likely impact on the District Water Management Strategy (DWMS), it is considered that these changes are likely to be local refinements only and will not significantly impact the DWMS presented in Appendix 5: *Brookdale Redevelopment Master Plan – District Water Management Strategy* (JDA Consultant Hydrologists, GHD Engineers and CSIRO 2006). Current *Geomorphic Wetlands Swan Coastal Plain* dataset mapping has therefore been presented in Figure 15 of Appendix 5 and used as the basis for planning in the DWMS.

A summary of wetland hydrology is provided in Table 11, which provides estimates of seasonal groundwater variations based on groundwater monitoring and a summary of any linkages to surface drainage networks via photography interpretation. Based on this analysis, most of the wetlands currently form part of the existing surface drainage system, and either receive surface flow or have outlets which control water level variation within the wetland.

Installation of water level monitoring equipment has recently been undertaken by CSIRO to continuously monitoring water levels within wetlands and enable further refinement of wetland hydrology prior to development.

Detailed groundwater modelling of the Amendment area is currently being undertaken by CSIRO and JDA on behalf of the ARA to further improve estimates of the post development water balance including surface water flows and groundwater levels under a range of different water supply, drainage and climate scenarios. The District Water Management Strategy (JDA 2006) states that while outcomes of the modelling are considered unlikely to modify the strategy for wetland management, they will provide developers with important additional baseline information to assist in the assessment of suitable non-potable water supply options and also enable more detailed analysis of wetlands as part of the local structure planning process.

With respect to Forrestdale Lake, the Ramsar listed wetland located approximately 1.5km west of the Amendment area Rockwater (2006) recently completed regional groundwater modelling of the whole of the Southern River UWMS area as part of the Southern River MoU process. The analysis assessed the impact of a range of climatic variations and planned development scenarios. Water levels at Forrestdale Lake were used a key indicator in assessing resulting changes in groundwater levels (JDA 2006).

Modelling indicated conventional development across the Southern River-Forrestdale UWMS Area would result in changes in water level at Forrestdale Lake of a 4 cm reduction in summer minimum and a 17cm increase in winter maximum. These changes are considerably less than current inter-annual water level variations for Lake Forrestdale. Modelling also considered the installation of subsoil drainage in the Amendment area below the AAMGL. This modelling found no change would result in the Forrestdale Lake water levels to that expected under a conventional development scenario. On the basis of these modelling outcomes, drains located below AAMGL in the Amendment area will not affect groundwater levels in Lake Forrestdale.

Modelling also considered the drawdown zone created by implementation of a controlled groundwater level (CGL) via installation of subsoil drainage in the Amendment area below the Average Annual Maximum Groundwater Level (AAMGL).

Site-specific analysis undertaken by CSIRO and reported in Appendix 5 (refer to Section 4.3.2) indicates that a much lesser zone of influence than was previously estimated in JDA (2004) could be implemented. The largest zone of influence was observed as approximately 100m in sandy soils adjacent to the Wungong River. These results have been used to define subsoil exclusion zones for protection of wetlands and sensitive environments where CGL's are implemented in the DWMS. JDA's mapping of subsoil exclusion zones are shown in relation to where the AAMGL is located above the clay layers to define areas to be targeted for groundwater level control. This information is shown in Figure 30 of Appendix 5.

TABLE 11
WETLAND CLASSIFICATION AND HYDROLOGY SUMMARY

Wetland Identifier	**Location**	**Wetland Type**	**Current Class**	**Surface Flow In or Out of Wetland**	Estimated AAMGL (m AHD)	Seasonal Variation (m AHD)
UFI 7584	Waterworks Rd/ Hanlin Road	Dampland	CC	None	24	1.0
UFI 7678	Hanlin Road/ Twelfth Road	Artificial Lake	RE	Located within Wungong River 100 year floodplain	24	1.1
UFI 7676	Twelth Road/ Tenth Road	Flood Plain	RE	Local Authority Drain Inflow Wungong River Outflow Located within Wungong River 100 year floodplain	24	1.2
UFI 7677	Wollaston Ave/ Tenth Road	Sumpland	RE	None	28.5	1.1
UFI 7685	Forrest Road/ Wollaston Ave	Palusplain	CC	Located on Wungong River	24	1.5
UFI 7768	Twelfth Road	Flood Plain	RE	Located on Wungong River	23	2.0
UFI 7978	Powell Cr/ Ninth Road	Palusplain	RE	Located on Neerigen Brook South	32-34	1.3
MIN 98Sr	Hilbert Road/ Neerigen Brook	Sumpland	RE	Outflow channel to Neerigen Brook South. Possible overflow from Neerigen Brook South and/or Brickworks A Drain during major storm events	26-27	1.1
MIN 63-V15	Eleventh Road/ Neerigen Brook South	Palusplain	RE	Possible overflow from Brickworks A Drain during major storm events	27	1.0
MIN 63-V13	Eleventh Road/ Neerigen Brook South	Palusplain	RE	Located on Brickworks A Drain	27	1.1
UFI 7827	Eleventh Road/ Neerigen Brook South	Palusplain	RE	Possible overflow from Brickworks A Drain during major storm events	28	1.1
MIN 63-V21	Wungong River/ Rowley Road	Palusplain	RE	Located on Wungong River	26-33	1.1

Wetland Identifier	Location	Wetland Type	Current Class	Surface Flow In or Out of Wetland	Estimated AAMGL (m AHD)	Seasonal Variation (m AHD)
UFI 12182	Wungong Road/ Ninth Road	Palusplain	RE	Located on Brickworks B Drain	39-45	0.6
UFI 12148	Eleventh Road/ Mill St	Palusplain	M	None	42-45	5.6

M = Multiple use wetland, RE = Resource enhancement, CC = Conservation category, NA = Not applicable
Source: JDA (2006)

4.4.4 Potential Impacts

Through importing fill, cut and fill, or limiting the seasonal maximum groundwater rise to below the Annual Average Maximum Groundwater Level (AAMGL), potential changes may occur to the existing water regime within the Amendment area wetlands. As a consequence the ambient water characteristics of these wetlands may be impacted with resultant changes to wetland vegetation and wetland habitat values and their buffers.

Potential changes to hydrology arising from the proposal may impact wetlands and other groundwater dependent ecosystems outside of the Amendment area. As an indirect impact, the potential lowering of the water table may result due to the long term change of landuse from rural to urban.

The proposed redevelopment of the Amendment area will mostly occur on cleared and pasture land thereby avoiding Resource Enhancement and Conservation Category wetlands, which contain remnant vegetation. Unless appropriate management measures are put in place, the redevelopment of the Amendment area may have the following impacts on wetlands:

- Potential for adverse wetland buffer impacts due to development interface unless appropriate management measures are committed to;
- Changes in water quality and quantity leading to wetland ecosystem changes; and
- Increased weed infestation, damage to vegetation and fauna habitat, soil compaction around and within wetlands.

4.4.5 Management Strategies

The Wungong Urban Water Master Plan acknowledges that there are a number of significant wetlands (EPP, Conservation and Resource Enhancement wetlands) within the Amendment area and proposes their protection from development through the provision of adequate wetland buffers around the individual wetlands mapped boundaries.

Wetland Management

Landowners proposing to develop land adjoining an EPP, Conservation Category or Resource Enhancement wetland or its buffer will be required to prepare and implement a Wetland Management Plan to the satisfaction of the DEC, the ARA and other relevant authorities. It is anticipated that the Plan will be prepared during structure planning and will be implemented as a condition of subdivision approval.

The Wetland Management Plan will include, but is not limited to, the following:

- Summary of management commitments/recommendations;
- Description of the site and context;

- Site-specific determination of wetland buffer in keeping with Attachment B4-3 of the EPA's Guidance Statement No. 33: *Environmental Guidance for Planning and Development* (2005);
- Site-specific environmental issues (for example: conservation, ecological linkage, recreation, stormwater management, water quality, fire management, flooding, heritage, reserve boundaries, mosquitoes and midges, dieback, weeds, utility services and corridors, introduced fauna, feral animals, education, visual amenity, vandalism, trampling, liability and risk from community use);
- Management aim and objectives;
- Management responsibilities;
- Management actions/measures to achieve the objectives;
- Diagrammatic management plan;
- Funding and resources;
- Monitoring criteria and evaluation plan to enable compliance with objectives and criteria to be checked and response;
- Stakeholder consultation; and
- Timing, implementation and review schedules.

The Wetland Management Plan will be prepared by developers prior to the finalisation of a Structure Plan. The Plan will be implemented by developers as a requirement of subdivision approval.

The District Water Management Strategy

The District Water Management Strategy proposed the following approach to wetland management (refer to Appendix 5 Section 4.4 for further details):

Maintenance of Wetland Hydrology

Where wetlands and watercourses currently form part of the surface drainage system, they will be permitted to continue to receive surface flow, particularly for large infrequent event storage. More detailed assessment of wetland hydrology will be required at the local structure planning level of individual wetlands to assess their capacity to accept surface flows and maintain existing wetland hydrology. Continuous water level recording currently being undertaken by CSIRO will assist this process.

Use of Wetland Buffers

Use of wetland buffers for Resource Enhancement category wetlands will be permitted to contain stormwater attenuation areas. Design of these areas would typically be for detention of frequently occurring storm events with discharge separate to the wetland. Overflow of major events to the wetland would also be permitted.

Establishment of Subsoil Exclusion Buffers

If a CGL is to be implemented, maintenance of wetland water levels will be required through establishment of 100m subsoil exclusion zones for protection of significant wetlands and sensitive environments.

Calculation of these boundaries has been based on site-specific field investigations of four transects in the study area and on current DEC wetland boundaries.

Water Quality

Water quality will be required to be maintained based on source control and treatment train approach to stormwater and groundwater quality management to minimise export of nutrients to receiving water bodies.

Monitoring

Ongoing pre and post development monitoring of water levels and water quality of identified significant wetlands will be undertaken by the ARA in keeping with a regional monitoring program.

4.4.6 Predicted Outcome

Based on the results of wetland assessments undertaken and knowledge of the probably extent of the proposed development and wetland enhancement management strategies required to be implemented, it is considered that the implementation of the proposed redevelopment of the Wungong Urban Water Master Plan area can be managed to meet the EPA's environmental objective in relation to Wetlands.

4.5 Waterways

4.5.1 EPA Objective

To maintain the integrity, ecological functions and environmental values of waterways.

4.5.2 Applicable Legislation, Criterion or Guidance

- Department of Environment guidelines for protecting waterways (including River Restoration Series, Water Notes, Statewide policies).
- Department of Environment (2004) *Stormwater Management Manual for Western Australia*, February 2004.
- Department of Environment (2005) Decision Process for Stormwater Management in W.A. (Draft).
- Essential Environmental Services (2006) Interim Approach for Integrating Urban Water Management with Landuse Planning within the Southern River Area: Guidance for Developers.
- JDA Consultant Hydrologists (2002) Southern River/Forrestdale/Wungong /Brookdale Structure Plan Urban Water Management Strategy. Report for Water & Rivers Commission, May 2002.
- Western Australian Planning Commission (2004a) Draft Statement of Planning Policy No. 2.9: *Water Resources* (Draft).

4.5.3 Existing Environment

The Amendment area is located mainly within the catchment of Southern River. The Southern River discharges into the Swan and Canning Rivers system an important resource of the State where the degradation of water quality is threatening biological diversity and ecological, economic, cultural, recreational and aesthetic values (Environmental Protection (Swan and Canning Rivers) Policy Approval Order 1998). The southwestern portion of the project area drains to the Peel-Harvey estuarine system (JDA 2004b) which is similarly under stress.

Historically watercourses in the Amendment area were largely discontinuous, with channelisation of the watercourses to a more formal drainage system occurring over time with most works having been completed before 1970. Current watercourse alignments for Neerigen Brook (North and South) and Brickworks Drains (A and B) typically follow historical alignments.

Waterways within the Amendment area represent a highly modified hydrological environment. The Wungong River is the main waterway of the Amendment area. The Wungong River starts as a narrow channel that is fed from flows originating in the Darling Scarp and broadens as it passes through the alluvial fans deposited at the foot of the Scarp. The River passes through a series of natural floodplains and man-made channels and flows in a northwesterly direction through the Amendment area until adjoined by the Neerigen Brook South then Neerigen Brook North in the region of Armadale Road. Flow is currently regulated by the Water Corporation's Wungong Dam, located approximately 8km upstream of the Amendment area (JDA 2004b).

A portion of the Wungong River between Forrest Road and Hilbert Road has been straightened to form a drain. JDA conducted an investigation based on visual interpretation of a 1925 map obtained from the Battye Library and aerial photographs from 1953 to 2003. Changes to watercourse alignments are shown on Figure 5 of Appendix 5. The information provided in the figure indicates that initial straightening commenced in 1925 and was completed before 1970. Prior to straightening, it is likely that the water during peak flows would have spread out across the surrounding wetlands. Modifying the alignment and creating a defined channel has resulted in a reduced floodway enabling more intensive development to occur in proximity to the River. Modification of the straightened section of the Wungong River to a more natural living stream is a desired outcome of land use change within the Wungong Urban Water development area. Areas of modification will however be limited by hydraulic, ASS considerations and the desire to maintain existing riparian vegetation adjacent to the watercourse which would otherwise need removal to facilitate meandering and creation of more shallow batters for the watercourse. Areas considered suitable for realignment with respect to vegetation considerations will be identified in the Foreshore Management Plan (FMP), with hydraulic calculations and cross section design undertaken in the Local Water Management Strategy (LWMS).

A network of Water Corporation, local authority and private drains exists throughout the Amendment area as shown in Figure 9. The drains are a combination of natural drainage lines and excavated drains, extended or deepened (as steep sided trapezoidal channels) to enhance drainage from the area.

The Water Corporation's main drainage within the Amendment area includes (JDA 2004b):

- Wungong River, which then becomes Southern River north of Armadale Road.
- Neerigen Brook, modified to a Water Corporation Main Drain at South West Highway where it splits into North and South Branches that discharge to Wungong River.
- Keane Road Branch Drain, which discharges to Forrestdale Main Drain and ultimately the Southern River.
- Birrega Main Drain and tributaries Sub O and Sub Q, which discharge to the Serpentine River and the Peel Harvey catchment.

The Brickworks A and B Drains are also major drains which flow through the Amendment area, however they are not designated Water Corporation Main Drains and do not have an easement (JDA 2004a).

Wungong River, Brickworks Drain, Neerigen Brook and Birrega Main Drain all have significant catchments upstream (east) of the Amendment area and as most of the urban areas upstream of the Amendment area were developed prior to the implementation of WSUD, they currently discharge without compensation into these drains (JDA 2004b).

Water Corporation modelling indicates current capacity for Neerigen Brook North and South drains within the Amendment area is less than 1 in 5 year capacity. While this may provide a development constraint in terms of development staging, it will also facilitate upgrading of these assets early in the development timeframe to meet existing level of service requirements.

Most of the wetlands within the Amendment area, as shown on Figure 6, currently form part of the existing surface drainage system, and either receive surface flow or have outlets which control water level variation in the wetlands (refer to Table 11 in Section 4.4.3).

As part of the flora and vegetation assessment of the Amendment area, the areas contained within the foreshore areas of the Wungong River and Neerigen Brook (and adjoining wetlands) vegetation have been mapped and is included in Appendix 2 (ATA Environmental 2006a). The vegetation was predominantly woodland dominated by *Melaleuca* spp. and Flooded Gum (*Euclayptus rudis*) and occasionally Marri (*Corymbia calophylla*). The vegetation condition varied along the extent of the foreshores from Good to Completely Degraded.

Historically the foreshore areas of the Wungong River and Neerigen Brook have been used for summer pasture and watering points for cattle and horses. Unimpeded stock access across the waterways has occurred in some stretches of the waterways resulting in trampling of understorey and collapsing of embankments. The vegetation assessment found many areas to be heavily infested with a variety of introduced weed species. The Foreshore Management Plan to be prepared by the ARA as part of the WIPS process will detail areas of foreshore that will require intensive rehabilitation.

A section of the Wungong River was included as a main fauna survey site during the fauna assessment undertaken for the Amendment area. Details relating to the findings of the assessment have previously been discussed (refer to Section 4.3.2 and Appendix 3). The assessment found that the riparian vegetation associated with the Wungong River and the fauna habitat along the river varies from good to degraded in condition. The assessment also found that as the Wungong River foreshore area had not been fenced off in sections and cattle and horses have had access to the riparian vegetation, this has been a major factor contributing to its disturbed nature. Consequently very little to no understorey was evident and what was present was mostly introduced grasses/weeds.

The fauna assessment also found that within the Amendment area, the implementation of a network of ecological corridors will help to conserve the key habitats identified including the riparian vegetation along the Wungong River and other wetland areas and link these areas with each other and other remnant bushland adjacent to the Amendment area. The main ecological corridors recommended across the Amendment area as shown on Figure 8 are:

- North-south ecological corridor following Wungong River and incorporating the wetland area in the middle of the Amendment area;
- West-east ecological corridor linking the Bush Forever Site No. 345 to the Wungong River; and possibly; and
- East-west ecological corridor linking Bush Forever Site No. 264 with Bush Forever Site No. 266.

Ecological corridors are discussed in more detail in Section 4.6.3.

As discussed in Sections 4.2 and 4.4, portions of the Wungong River have particular environmental significance. Portions of the river system have been identified as Resource Enhancement, Conservation Category and EPP wetlands, and Bush Forever Site No. 266 is located on the Wungong River south of Rowley Road.

Flow estimates and water quality are addressed in Section 4.7.

Floodplain Mapping

Flow estimates endorsed by the DEC/DoW, and subsequently used by the DEC/DoW to review existing floodplain mapping for Southern River and Wungong River are shown in Table 13 (refer also to Appendix 5, Appendix B).

The DEC floodplain mapping for Wungong River is shown in Appendix 5 (refer to Figure 9). This mapping shows the majority of the floodplain to be flood fringe rather than floodway, and hence this area is available for development from a flood perspective.

No floodplain mapping of Neerigen Brook North and South Course, and Brickworks Drain has been previously undertaken. The ARA has recently commissioned studies to provide these estimates to support later stages of local planning.

Environmental Flow Requirements

There are no current environmental flow requirements (EWR's) or environmental water provisions established for the Wungong River. EWR's are defined as the water regimes needed to maintain the ecological values of water dependent ecosystems at a low level of risk.

The Swan Canning Cleanup Program's *Caring for the Canning – A Plan to Revitalise the Canning, Southern and Wungong Rivers* report (Swan River Trust 2002), provided preliminary estimates of ecological water requirements at various locations of the Canning River system, including Wungong River at South West Highway, approximately 1km upstream of the Amendment area. EWR estimates from SRT (2002) are shown in Table 15 (refer to Section 4.7.3), with EWR's in excess of current median flows generally only in spring (September to November).

Swan River Trust (2002) states the figures to be preliminary only and based on limited hydrological and ecological data. It does not propose the flow volumes calculated be released to the river system. It states to determine an actual future flow regime requires further research and appropriate calculation of environmental water provisions (EWP's) considering social, consumptive and economic uses of the river.

The Water Corporation currently make summer releases to Wungong River via an off take on the water supply trunk main at South West Highway. Based on 2004/05 records, it is understood this total release is in the order of 0.8GL/yr, at a flow rate of approximately 5ML/d (60 l/s) (Appendix 5, Section 2.4.7). It is understood that these releases are made for consumptive purposes rather than for environmental purposes.

Living Streams

With respect to the tributary drains of Wungong River (Neerigen Brook North, Neerigen Brook South, Brickworks A and B), the upgrading of these drains will be required prior to development, dependent on staging of land development. To assist this process the ARA is currently undertaking hydraulic modelling to determine existing floodplains of these watercourses (JDA 2006).

Both the Water Corporation and the DEC have indicated modification of the alignment and configuration of these drains would be considered, and reconfiguration of the drains to living streams is being encouraged by the DEC.

The Master Plan proposes to maintain Neerigen Brook North and South on their existing alignments, but proposes the realignment of both Brickworks drains and where possible, modification of the drains to living streams is proposed. It should be noted that while re-alignments shown on the Master Plan for the Brickworks Drains appear as very linear, it is intended that the living streams would meander within these corridors.

Modelling of required flood widths for reconfiguration of these drains to living streams was undertaken by JDA (2004b) and is further discussed in Section 4.7.3. Schematics for living streams, shown over page, have been prepared by JDA and this detail has been extracted from Appendix 5 (refer to Figure 23. A single channel grassed swale living stream configuration is shown and further modelling of an alternative living stream configuration was also undertaken to indicate land take implications of alternative configurations. Modelling indicates that the dual channel configuration with a separate 100 year overflow channel increases the flood width and hence the land take by approximately 50% (JDA 2006)

Implications of meandering of the watercourses in terms of land take were modelled by increasing the watercourse length by approximately 20%, resulting in a reduced gradient. This was found to increase flood widths by typically less than 10%.

Currently minimum widths for living stream (including buffers) allowed for in the Master Plan are approximately 70m for Neerigen Brook North and 50m for the relocated Brickworks A and B drains and Neerigen Brook South. This is consistent with the above land take requirements for safe conveyance of the 100-year flood from upstream catchments through the Amendment area. The widths contained in the Master Plan are significantly wider than the existing drainage easements. Final waterways buffers will be determined in liaison with the DEC as part of the development of the Foreshore Management Plan that is currently being prepared as part of the WIPS process.

Section 4.7.3 also discusses the monitoring programme and results undertaken to date with respect to nutrient analysis.

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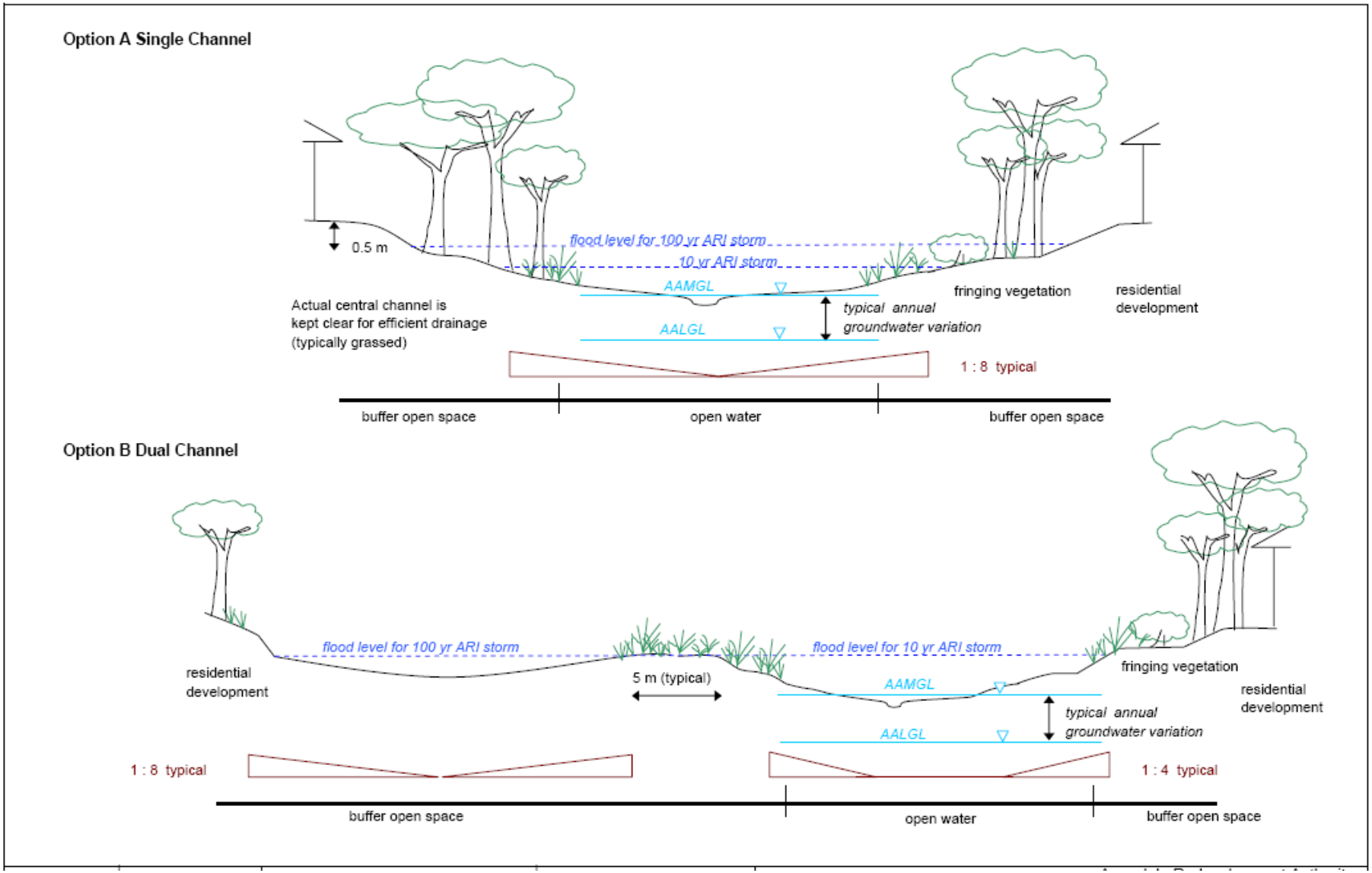

Option A Single Channel
0.5 m
flood level for 100 yr ARI storm
10 yr ARI storm
AAMGL
AALGL
typical annual
groundwater variation
fringing vegetation
residential
development
Actual central channel is
kept clear for efficient drainage
(typically grassed)
1 : 8 typical
buffer open space
open water
buffer open space
Option B Dual Channel
flood level for 100 yr ARI storm
flood level for 10 yr ARI storm
residential
development
5 m (typical)
AAMGL
AALGL
typical annual
groundwater variation
fringing vegetation
residential
development
1 : 8 typical
1 : 4 typical
buffer open space
open water
buffer open space

4.5.4 Potential Impacts

If not appropriately managed, urbanisation may potentially lead to the clearing of remnant native vegetation and habitat near waterways, the deterioration of water quality and changed flow characteristics in the Amendment area waterways. This can lead to implications for ecological, economic and social values both within the Amendment area and downstream in the significant Swan and Canning riverine system and Peel-Harvey catchment.

Development of a DWMS considering total water cycle management provides opportunities for considering options to revitalise the Wungong River, improving both flow quantity and quality to its current state.

Potential changes to the hydrology of watercourses within and downstream of the Amendment area include:

- water quality, particularly with regard to increasing nutrient export (Phosphorus, Nitrogen) from the Amendment area; and
- peak flow rates and annual discharge volumes, particularly with regard to increased flood risk and erosion.

Potential increase of sediment loads to watercourses may occur as a result of construction /earth working activities during redevelopment of the Amendment area.

4.5.5 Management Strategies

Management strategies for regional flood management, modelling for living streams and stormwater management are discussed in detail in Section 4.7.5. Strategies for wetlands along waterways are discussed in Section 4.4.5.

Foreshore Management

A Foreshore Management Plan for the Wungong River and Neerigen Brook will be prepared by the ARA as part of the WIPS process to the satisfaction of the DEC, SRT, DPI and the City of Armadale. The Foreshore Management Plan will include, but is not limited to, the following:

- Comprehensive weed eradication program;
- Revegetating and restoring foreshore POS adjoining conservation areas with appropriate indigenous flora;
- Increase the area contained within POS adjoining Bush Forever Sites;
- Creation of habitat and wildlife corridors;
- Investigate areas of straightened sections of Wungong River suitable for meander;
- Controlling vehicle and pedestrian access;
- Provision of public facilities;
- Soil and plant source material hygiene;
- Fire management including provision of fire hydrants;
- Encouraging community involvement and awareness promoting control of pets (eg. cats and dogs);
- Water conservation principles;
- Monitoring criteria to determine the success of the revegetation and weed eradication program;
- Progress and compliance reporting; and
- Timing and implementation schedule.

The delineation of waterways buffers will be finalised in liaison with the DEC as part of the development of the Foreshore Management Plan that is currently being prepared as part of the WIPS process. It is the ARA's expectation that final waterways buffers will be determined prior to any Structure Plans being approved.

Landowners proposing to develop land in close proximity to the Wungong River or Neerigen Brook will be required to implement the FMP as a requirement of subdivision approval.

Watercourse Enhancement

Watercourse enhancement will be integrated into the overall landscape planning for the Amendment area. The DEC, Water Corporation, and local Indigenous groups have provided positive feedback toward modification of watercourse alignments and configurations, providing an opportunity for transformation of existing drains to living streams.

Strategies for management of watercourses are detailed in the DWMS (Appendix 5) and include:

- Enhancement to existing open trapezoidal drainage channels to establish living ephemeral streams;
- Improvement of flows and restoration of riparian vegetation;
- Establishment of buffers;
- Specification of indicative sizes of regional flood protection infrastructure and provision of adequate areas in the Master plan for this purpose;
- Continued water balance modelling and assessment of non-potable water supply options ;
- BMPs for stormwater and groundwater quantity and quality management; and
- Ongoing regional pre and post development monitoring programs and establishment of compliance reporting mechanisms.

As part of the local structure planning process and prior to finalisation of precinct structure plans, landowners proposing to develop land in the Amendment area will be required to develop a Local Water Management Strategy (LWMS) in collaboration with the ARA, implementing the DWMS.

As part of the subdivision application process an urban water management plan (UWMP) will be required to be prepared by the landowner, consistent with requirements as detailed in the DWMS and ESS (2006).

Recommended Minimum Setbacks to Development

Currently minimum widths for living streams (including buffers) allowed for in the Master Plan are approximately 70m for Neerigen Brook North and 50m for the relocated Brickworks A and B drains and Neerigen Brook South. This is consistent with the land take requirements for safe conveyance of the 100-year flood from upstream catchments through the Amendment area. Final buffers to the Wungong River and Neerigen Brook will be determined in liaison with the DEC as part of the development of the Foreshore Management Plan that is currently being prepared as part of the WIPS process.

4.5.6 Predicted Outcome

Based on the results of studies undertaken, knowledge of the extent of the development, watercourse enhancement and other management strategies proposed, it is considered that the implementation of the proposed redevelopment of the Wungong Urban Water Master Plan area can be managed to meet the EPA's environmental objective in relation to Waterways.

4.6 Key Natural Areas and Ecological Corridors

4.6.1 EPA Objective

To protect and enhance the environmental values of areas identified as having significant environmental attributes.

4.6.2 Applicable Legislation, Criterion or Guidance

- *Environment Protection and Biodiversity Conservation Act 1999*
- *Wildlife Conservation Act 1950*
- Del Marco *et al.* (2004) *Local Government Biodiversity Planning Guidelines for the Perth Metropolitan Area*

4.6.3 Existing Environment

Wildlife or ecological corridors are considered to provide avenues for movement of individuals and populations of both flora and fauna. An ecological corridor is defined as a 'habitat that permits the movement of organisms between ecological isolates' (Newmark 1993). These corridors can be important for the survival of species as they provide access to feeding and breeding locations as well as access to other populations and therefore to a wider gene pool.

Corridors are difficult to define as each species has its own set of criteria that makes a suitable corridor. A vegetation corridor suitable for the Splendid Fairy Wren would need to have an understorey of dense shrubs to provide shelter. The Quenda too requires low, denser shrubs to allow it to shelter from predators such as feral cats and foxes, and generally favours riparian or swamp vegetation. The Honey Possum will require food plants (eg banksias) that flower at various time of the year (Connell and ATA Environmental 2001). A range of corridors with varying widths of between 10 and 500m may be required to accommodate the varying requirements of different flora and fauna species to enable them to be viable.

Work undertaken as part of the flora, vegetation and fauna assessments for this ER have provided the basis for the development of a network of ecological corridors undertaken as part of a wider coordinated approach to environmental management that will enable the ecological linkage requirements and mechanisms promoting re-establishment of ecological linkage, including hydrological and wetland conservation across the Amendment area to occur.

An assessment of viability of an ecological community is undertaken through measuring the size, shape, perimeter to area ratio, condition and connectivity – proximity and linkage to other natural areas (Del Marco *et al.* 2004). The widths nominated on Figure 8 are indicative only with the final position and widths to be determined during Structure Planning to ensure the viability of these corridors and to determine management measures required to maintain the corridors.

The value of a corridor to wildlife is largely dependent on the quality of habitat it provides and the abundance of animals in a corridor is linked to the availability of certain habitat components such as food, nesting sites as well as the spatial distribution of strips of vegetation (Alan Tingay and Associates 1998). While corridor design can encourage movement of fauna into areas where there is greater risk of mortality (eg roads) and can facilitate the movement of predators into habitat areas, the large edge to area ratio of linear corridors increases their susceptibility to impacts from the surrounding landscape.

As previously mentioned in Sections 4.2 and 4.3, much of the Amendment area is considered to be highly degraded due to historical landuse practices. A number of natural areas remain within the Amendment area some of these are degraded being basically overstorey over weeds and the

fauna assessment results indicate that only a limited number of species will use these as linkages or habitat.

The incorporation of Park Avenues as a landscape focus in the Master Plan will allow for some level of local connectivity or linkage to be introduced into the Amendment area landscape. While the planned rows of Eucalypts will mainly provide overstorey corridors for species of birds, understorey development may assist in providing safe refuges and corridors for smaller mammals.

The Master Plan also proposes over the longer term, to remove the majority of constructed drains and create a system of pipes, swales, multiple use corridors and brooks linking with Park Avenues, public open space, wetlands and the Wungong River. It is proposed that the brooks be landscaped as 'Living Streams' creating 'natural' waterways. The rehabilitation of existing steep sided drains within the Amendment area to Living Streams will be undertaken consistent with DEC and DoW principles (TPG 2006).

It is anticipated that Living Streams will achieve multiple outcomes such as:

- Improving water quality management to meet environmental targets specified in the DWMS, and minimise pollutants to receiving water bodies;
- Improve the health of the Swan Canning River system;
- Preserve and enhance ecological function and conserve natural assets;
- Be an integral part of minimising the import of scheme water, as an integral part of the proposed non-potable water supply scheme;
- Assist in defining clear environmental linkages within the Amendment area, which will ensure residents of the area will have a far greater understanding of the water cycle and its relationship with modern living, with consequent social benefits; and
- Provide regional benefits by creating a multiple use corridor extending from the hills of the Darling Scarp to Southern River at Armadale Road and assist in providing corridors for residents and fauna.

A number of key natural areas are currently in good condition, however due to the fragmented nature of their distribution across the Amendment area, their long-term viability and conservation values may be limited without some level of connectivity being established or maintained. Key natural areas identified in this ER as having regional and local significance include:

- Conservation Category Wetlands (refer to Figure 6 for location):
  i) UFI 7584 – located at the north-western boundary;
  ii) UFI 7685 – located at the south-western end of Wollaston Avenue;
  iii) UFI 12148 – located at the south-eastern boundary; and
  iv) Lambert Lane Conservation Category Wetland which includes Threatened Ecological Community SCP 3a.

- Wetlands having statutory protection under the *Environmental Protection (Swan Coastal Plain Lakes) Policy 1992*(EPP) (refer to Figure 6 for location):
  i) UFI 7676 – located along the northern part of the Wungong River;
  ii) UFI 7678 – located to the west of the Wungong River and east of Twelfth Road;
  iii) UFI 7677 – located to the west of Wollaston Ave; and
  iv) Min 98Sr – located to the east of Hilbert Road.

- Locally significant stands of Marri trees in the northern section of Amendment area, adjacent to the Wungong River to the west (refer to Figure 5 in Appendix 3);

- Areas of upland vegetation within the Amendment area that belong to vegetation types BmBiBaLW, BmBaLOF and BaLW and are in Very Good to Good condition. These

vegetation types are present in the Southern River vegetation Complex, Guilford vegetation complex and the Bermullah vegetation complex. These vegetation complexes have been extensively cleared and are now poorly represented in the conservation estate (≤10% of the original extent is protected) on the Swan Coastal Plain within the Perth region (Government of Western Australia 2000). In Bush Forever 2000, Volume 1 it is stated that there will be a general presumption against clearing bushland containing Threatened Ecological Communities or representation of vegetation complexes of which less than 10% currently remains on the Swan Coastal Plain portion of the Perth Metropolitan Region (generally involving vegetation complexes of the eastern side of the Swan Coastal Plain). Therefore vegetation types BmBiBaLW, BmBaLOF and BaLW are considered regionally significant.

- The Wungong River; and

- Bush Forever Sites (refer to Figure 7b for location):
  i) 264 - Lambert Lane Bushland, Wungong;
  ii) 266 - Wungong River, Byford; and
  iii) 345 - Forrestdale Lake and Adjacent Bushland, Forrestdale.

Bush Forever

Bush Forever is a 10-year strategic plan that formally commenced in 2000 to protect around 51,200ha of regionally significant bushland within 290 Bush Forever Sites. Where achievable, a target of at least 10% of each of the original 26 vegetation complexes of the Swan Coastal Plain portion of the Perth Metropolitan Region are aimed for (Government of Western Australia 2000).

Bush Forever was prepared by the Ministry for Planning (MFP) (now DPI), DoE (now DEC), Department for Conservation and Land Management (now DEC) and the WRC (now part of the DEC). The policy represents an update of the earlier System Six Study and recommendations in the Perth Metropolitan Region and is the final version of the draft Perth's Bushplan.

The Amendment area includes three Bush Forever Sites that encompass areas considered to be of regional significance (Figure 7b). The sites and implementation categories recommended in Government of Western Australia (2000) include:

- Bush Forever Site 264 - Lambert Lane Bushland, Wungong – proposed Parks and Recreation Reservation.
- Bush Forever Site 266 - Wungong River, Byford – Part B: creekline; regional creekline mechanism (with mapped vegetation) existing Parks and Recreation reservation in the MRS.
- Bush Forever Site 345 - Forrestdale Lake and Adjacent Bushland, Forrestdale – Part B: Rural Complementary Mechanism.

The Master Plan allows for the integration of these sites into areas of POS.

Greenways

Regional ecological linkages have been identified for the Perth Metropolitan Region as part of the Perth Biodiversity Project (Del Marco *et al.* 2004). The aim is to provide to a network of good or better condition stepping stones linking like habitat with a maximum distance of 500m to 1000m between them to connect the regionally significant natural areas (Del Marco *et al.* 2004 p. 67). The Perth Biodiversity Project indicatively shows ecological linkages along the Wungong River and the Birrega Main Drain. The Master Plan for the Amendment area shows the location of Park Avenues and Living Streams, both of which will also assist in providing some ecological linkage opportunities for some species of fauna.

A Strategic Plan for Perth's Greenways (Alan Tingay and Associates 1998) has identified existing and potential Greenways within the Perth Metropolitan Region. The development of the Strategic Plan was guided by a steering committee with representation from State agencies, local governments and community groups; and had extensive public involvement and comment. Released at the end of 1998, the Plan builds on and connects areas of remnant vegetation, wetlands and walking trails within the Metropolitan Region and was intended to complement Perth Bushplan and the System 6 update being undertaken at that time.

Priority was given to identifying strategic Greenways that provide east-west corridors that link the coast to freshwater and bushland habitats, linkages along foreshore areas and between wetlands and between large areas of remnant vegetation.

Greenways at both local and regional scales have been used to link urban centres with their hinterlands (Walmsley 1995). At a local scale, Greenways lining streets, linking pocket parts with playgrounds, squares and community gardens allow new neighbourhoods to coalesce (Alan Tingay and Associates 1998).

The Strategic Plan for Perth's Greenways identifies three corridors within the Amendment area, including Southern River-Canning River-Darling Range Regional Park (Greenway No. 86), Armadale Townsite-Armadale Settler's Common-Forrestdale Lake-Thomsons Lake (Greenway No. 85) and the Railway Armadale Line located at the eastern boundary of the site (Greenway No. 120). The Master Plan allows for the integration of the Wungong River corridor of Greenway No. 86 into the Master Plan through the corridors inclusion as POS (foreshore reserve). A Foreshore Management Plan currently being prepared by the ARA as part of the WIPS process includes the provision for recreational facilities such as walk trails, cycle routes and picnic facilities within and adjacent to the Greenway enabling the bushland to be appreciated by a wide range of people. The location of the Greenways within the Amendment area has been included in Figure 6.

4.6.4 Potential Impacts

Potential adverse nutrient export and drainage impacts on receiving wetlands/watercourses associated with each of the Bush Forever sites may occur if contaminated stormwater resulting from development is permitted to drain to the sites.

Development in the vicinity of wetlands/watercourses may result in temporarily interrupted or altered water balances and water quality within these water bodies that may affect wetland and groundwater-dependent vegetation.

Clearing of fauna habitat, including trees and understorey that form habitat 'stepping stones' between larger areas of habitat, may result in the direct loss of individual species and a potential loss of local biodiversity;

Some stands of trees may be removed as part of the development reducing the feeding resources and habitat for a number of bird species and mammal species such as the Brushtail Possum;

Potential impacts include the introduction of further weeds during construction activities and an increased use of the area by both residents and visitors potentially resulting in trampling of riparian vegetation and disturbance of fauna.

4.6.5 Management Strategies

Foreshore Management

A Foreshore Management Plan for the Wungong River and Neerigen Brook will be prepared by the ARA as part of the WIPS process to the satisfaction of the DEC, SRT, DPI and the City of Armadale. The Foreshore Management Plan will include, but is not limited to, the following:

- Comprehensive weed eradication program;
- Revegetating and restoring foreshore POS adjoining conservation areas with appropriate indigenous flora;
- Increase the area contained within POS adjoining Bush Forever Sites;
- Creation of habitat and wildlife corridors;
- Investigate areas of straightened sections of Wungong River suitable for meander;
- Controlling vehicle and pedestrian access;
- Provision of public facilities;
- Soil and plant source material hygiene;
- Fire management including provision of fire hydrants;
- Encouraging community involvement and awareness promoting control of pets (eg. cats and dogs);
- Water conservation principles;
- Monitoring criteria to determine the success of the revegetation and weed eradication program;
- Progress and compliance reporting; and
- Timing and implementation schedule.

The delineation of waterways buffers will be finalised in liaison with the DEC as part of the development of the Foreshore Management Plan that is currently being prepared as part of the WIPS process. It is the ARA's expectation that final waterways buffers will be determined prior to any Structure Plans being approved.

Landowners proposing to develop land in close proximity to the Wungong River or Neerigen Brook will be required to implement the FMP as a requirement of subdivision approval.

Preservation of Key Habitats and Creation of Ecological Corridors

In key fauna habitat areas, a Fauna Relocation and Management Plan will be prepared and implemented by the landowner as a condition of subdivision approval to the satisfaction of the DEC that includes, but is not limited to, the following:

- Any clearing of native vegetation that is required during subdivision, will be conducted in stages to reduce impacts on resident fauna and fauna habitat;
- A 'fauna friendly' clearing protocol will be used as part of any clearing operations where all tree hollows, nests and vegetated debris will be inspected for fauna prior to clearing;
- All hollow logs and branches cleared will be returned to other remnant vegetation areas as part of the rehabilitation works;
- If clearing of vegetation from key habitats is unavoidable then a suitable offset plan will be developed that includes the planting and revegetation of POS areas;
- Translocation of fauna will be undertaken in accordance with DEC policy; and
- Creation of additional tree hollows to result in no net loss of potential fauna habitat.

The Fauna Relocation and Management Plan will be prepared by the Developer in respect to the preparation and assessment of a subdivision plan.

Clearing of Native Vegetation

Approval is required under the *Environmental Protection Act 1986* (or is of a kind that is exempt in accordance with Schedule 6 or Regulation 5 under the Clearing of Native Vegetation Regulations).

There is a general preclusion against the removal of any established trees within the Amendment area. As part of the Structure Plan process, Developers will be required to prepare a Concept Plan that includes a detailed Tree Survey for the Structure Plan Area. The Tree Survey will identify trees for protection. Where trees are not listed for protection, rationale shall be provided for not retaining them in accordance with a Tree and Other Vegetation Preservation Policy to be adopted by the ARA. For those trees earmarked for protection, a Landscape Plan will be required at the subdivision stage.

The Concept Plan and Landscape Plan will be a requirement of guidelines to be adopted under Part 4 of the Scheme in respect to the preparation and assessment of structure plan/and/or subdivision.

The Tree and Other Vegetation Preservation Policy will incorporate the following objectives:

- Reinforces the value ARA places on the retention of trees and other vegetation within the Brookdale Precinct;
- Provide guidance to landowners, applicants and the ARA in relation to the retention, removal or modification of existing trees and native vegetation within the area;
- Identifies criteria for trees and other vegetation required to be retained;
- Identifies criteria where trees and other vegetation may be considered for removal; and
- Identifies exemptions from these policy requirements.

Objectives of the Policy should reflect the following:

- To protect and improve biodiversity within the Amendment area, including the protection of dead trees that may serve as habitation for fauna;
- To provide habitat for fauna and facilitate the movement of fauna between regional and public open space areas;
- To provide landmarks for the community through the retention of established trees;
- To provide comfortable streetscape and public open space amenity by the provision of shade and cooling for open space users, pedestrians, cyclists and vehicles parked within embayment parking areas;
- To assist in providing attractive streetscapes and public open space areas;
- To assist in reflecting the history of the area through the retention of existing trees and vegetation;
- To protect and enhance the natural landscape amenity of the Precinct by protecting visually sensitive areas from tree removal or clearing;
- To assist in managing greenhouse gas emissions; and
- To assist in minimising erosion, and maintaining hydrological balance.

The ARA will use the Tree and Other Vegetation Preservation Policy when assessing the Concept Plans.

Bush Forever Sites

Landowners proposing to develop land either containing or bordering a Bush Forever site will be required to prepare and implement a Rehabilitation Management Plan to the satisfaction of the

DPI's Bush Forever Office and the ARA. The Rehabilitation Management Plan will include, but is not limited to, the following:

- Rehabilitation and revegetation strategy (native local provenance to be used);
- Enhancement of ecological corridors;
- Mitigation strategies;
- Monitoring criteria to determine the success of rehabilitation and revegetation and evaluation program;
- Community consultation strategy;
- Progress and compliance reporting; and
- Timing, implementation and review schedules.

The Rehabilitation Management Plan will be prepared by the developer in respect to the preparation and assessment of a subdivision plan.

Wetlands

Landowners proposing to develop land adjoining an EPP, Conservation Category or Resource Enhancement wetland or its buffer will be required to prepare and implement a Wetland Management Plan to the satisfaction of the DEC, the ARA and other relevant authorities

The Wetland Management Plan will include, but is not limited to, the following:

- Summary of management commitments/recommendations;
- Description of the site and context;
- Site-specific determination of wetland buffer in keeping with Attachment B4-3 of the EPA's Guidance Statement No. 33:*Environmental Guidance for Planning and Development* (2005);
- Site-specific environmental issues (for example: conservation, ecological linkage, recreation, stormwater management, water quality, fire management, flooding, heritage, reserve boundaries, mosquitoes and midges, dieback, weeds, utility services and corridors, introduced fauna, feral animals, education, visual amenity, vandalism, trampling, liability and risk from community use);
- Management aim and objectives;
- Management responsibilities;
- Management actions/measures to achieve the objectives;
- Diagrammatic management plan;
- Funding and resources;
- Monitoring criteria and evaluation plan to enable compliance with objectives and criteria to be checked and response;
- Stakeholder consultation; and
- Timing, implementation and review schedules.

The Wetland Management Plan will be prepared by developers prior to the finalisation of a Structure Plan. The Plan will be implemented by developers as a requirement of subdivision approval.

Recommended Minimum Setbacks to Development

Currently indicative minimum widths for Living Streams (including buffers) allowed for in the Master Plan are approximately 70m for Neerigen Brook North and 50m for the relocated Brickworks A and B drains and Neerigen Brook South. This is consistent with the land take requirements for safe conveyance of the 100-year flood from upstream catchments through the Amendment area as discussed in Section 4.5.3.

The delineation of final waterways buffers to the Wungong River and Neerigen Brook will be determined in liaison with the DEC as part of the development of the Foreshore Management Plan that is currently being prepared by the ARA as part of the WIPS process. It is the ARA's expectation that final buffers will be determined prior to any Structure Plans being approved.

A 500m notification area to the TEC *Corymbia calophylla – Kingia australis* Woodland on heavy soils (FCT 3a) occurs in the south east corner of the Amendment area encompassing Bush Forever Site 264 and the CALM Reserve 42044 north of Lambert Lane and east of Wilson Street has previously been discussed in section 4.2.3. The TEC is a type of wetland and a buffer will be provided around the Bush Forever site during structure planning.

4.6.6 Predicted Outcome

Based on the results of studies undertaken, knowledge of the extent of the development and management strategies proposed, it is considered that the implementation of the proposed redevelopment of the Wungong Urban Water Master Plan area can be managed to meet the EPA's environmental objective in relation to Key Natural Areas and Ecological Corridors.

4.7 Surface Water Quantity and Quality

4.7.1 EPA Objectives

To maintain the quantity of water (surface and ground) so that existing and potential environmental values, including ecosystem maintenance, are protected.

To ensure that water quality does not adversely affect environmental values or the health, welfare and amenity of people and landuses by meeting statutory requirements and acceptable standards.

4.7.2 Applicable Legislation, Criterion or Guidance

- Australian and New Zealand Guidelines for Fresh and Marine Water Quality, National Water Quality Management Strategy, October 2000, Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand (2000a).
- Australian Guidelines for Water Quality Monitoring and Reporting, National Water Quality Management Strategy, October 2000, Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand (2000b).
- Australian Guidelines for Urban Stormwater Management, National Water Quality Management Strategy, 2000, Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand (2000c).
- Department of Environment guidelines for protecting waterways (including River Restoration Series, Water Notes, Statewide policies).
- Department of Environment (2004) *Stormwater Management Manual for Western Australia*, February 2004.
- Department of Environment (2005) Decision Process for Stormwater Management in W.A. (Draft).
- Environmental Protection Authority (2000) Southern River-Forrestdale-Brookdale-Wungong Draft Structure Plan – A Submission by the Environmental Protection Authority under section 16(j), of the Environmental Protection Act, *Bulletin 987*, August 2000.

- Essential Environmental Services (2006) *Interim Approach for Integrating Urban Water Management with Landuse Planning within the Southern River Area: Guidance for Developers.*
- Government of Western Australia (1998) Environmental Protection (Swan and Canning Rivers) Policy Approval Order 1998, Western Australian Government Gazette 10 July 1998 No 140
- Government of Western Australia (1992) Environmental Protection (Peel Inlet – Harvey Estuary) Policy Approval Order 1992, Western Australian Government Gazette 11 December 1992
- JDA Consultant Hydrologists (2002) *Southern River/Forrestdale/Wungong /Brookdale Structure Plan Urban Water Management Strategy*. A report for Water & Rivers Commission, May 2002.
- Western Australian Planning Commission. (2004a) Draft Statement of Planning Policy 2.9: *Water Resources*.

4.7.3 Existing Environment

The Southern River-Forrestdale-Brookdale-Wungong District Structure Plan (Western Australian Planning Commission 2001) provided a guide to the future development and management of key environmental issues for the locality of Southern River in the City of Gosnells and Forrestdale, Brookdale and Wungong in the City of Armadale.

In its response to the draft Structure Plan, the EPA in Bulletin 987 (Environmental Protection Authority 2000) raised environmental concerns in relation to ground and surface water management required for development in the area, and identified the need for an overarching drainage and nutrient management plan for the area. The EPA in Bulletin 987 (Environmental Protection Authority 2000) considered that nutrient and drainage management and potential impacts on wetlands, groundwater and the Swan and Canning Rivers are critical issues for the region which require considerable attention prior to changes in land use. The EPA noted that the Southern River (into which the Wungong flows) was the third highest contributor of phosphorus to the Swan-Canning River. This is of concern as the river system is highly eutrophic and prone to large algae blooms.

In February 2001, the Water and Rivers Commission (WRC) commissioned a consultants team to undertake the development of an overarching urban water management strategy for the Structure Plan Area, led by a steering committee including representatives from the WRC, Department of Environmental Protection, Swan River Trust, and Department of Conservation and Land Management.

In April 2002, as a result of this process, WRC released the Southern River/Forrestdale/ Brookdale/Wungong Urban Water Management Strategy (UWMS JDA 2002) detailing an integrated urban water management strategy for the Southern River/Forrestdale/ Brookdale/Wungong District Structure Plan area. The UWMS addressed issues raised by the EPA (2000) at a regional scale.

The UWMS marked a distinct shift in the traditional management approach to pollutants on the Swan Coastal Plain. The UWMS aimed for a reduction in pollutant input with the land use change proposed in the Southern River/Forrestdale/Brookdale/Wungong District Structure Plan (WAPC 2001), largely through the implementation of source control initiatives. It considered nutrient input control to be the only way in which land use change foreshadowed in the Structure Plan can be managed satisfactorily.

The UWMS also recommended a more flexible average annual maximum groundwater level (AAMGL) policy be adopted where it could be shown wetland groundwater levels would not be

adversely affected and limiting peak seasonal groundwater levels did not significantly increase nutrient export. This approach to groundwater management has since been adopted more widely than the UWMS Study Area by DoE/DoW (DoE and Swan River Trust 2005).

The UWMS proposed attenuation of rainfall runoff rates to the levels that presently occur under the predominantly rural land use within the Structure Plan Area. This criterion was applied, consistent with WSUD principles, to ensure peak flows to receiving environments are not increased by proposed land use changes. In addition, the criterion ensures that velocity and flow and erosion potential will not be increased substantially as a result of land use change.

Living streams situated within multiple use corridors were proposed to convey floodwaters. These streams were typically located to follow existing Water Corporation and local authority drainage alignments, with new alignments selected on the basis of known drainage constraints including consideration of significant wetlands and historical land use. The design philosophy for living streams was to create natural watercourses, with geomorphology and native vegetation typical of the local area.

In its review of the UWMS, the EPA requested that a Memorandum of Understanding (MOU) be signed by all agencies involved in the implementation of the UWMS. This MOU was signed by the Water Corporation, Departments of Environment and Planning and Infrastructure, CSIRO, the Cities of Armadale and Gosnells, the Shire of Serpentine-Jarrahdale and the ARA. The MOU required the preparation of an Integrated Land and Water Management Plan (ILWMP) by Water Corporation to facilitate orderly implementation of the UWMS.

While the ILWMP is yet to be completed and released by Water Corporation (currently in final draft status), progress has been significant and a range of supporting technical studies have been completed, and used in the development of the Wungong Urban Water Master Plan District Water Management Strategy (DWMS, JDA,2006-Appendix 5). Preparation of the DWMS involved a steering committee including representatives of CSIRO, Water Corporation, Department of Water, and Department of Health.

The objectives and principles used for developing the District Water Management Strategy (Table 12) reflect outcomes of previous higher level regional strategy studies, and other key reference documents.

The DWMS is required to be consistent with the regional ILWMP. To this end the objectives in the DWMS are consistent with the stormwater management approach detailed in the UWMS, and the interim criteria for stormwater management developed for the ILWMP. ILWMP criteria are detailed in Essential Environmental Services (2006) and are contained in Appendix 5 (Section 1.2.4).

A detailed list of reference studies used as the basis for information in this document on surface water is contained in Appendix 5 (Section 6). Investigations specific to the Amendment area have been undertaken by JDA Consultant Hydrologists, GHD, CSIRO, DoW, and Water Corporation, as part of the preparation of the DWMS.

Watercourses within the Amendment area represent a highly modified hydrological environment.

The Amendment area is located mainly within the catchment of Southern River, with the south-western portion draining to the Peel Harvey Catchment (JDA 2004b).

The Wungong River is the main watercourse of the Amendment area and flows in a north westerly direction through the Amendment area toward Southern River. Wungong River flow is currently regulated by the Water Corporation's Wungong Dam, located approximately 8km upstream of the

Amendment area (JDA 2004b). Regulation of the Wungong River, for public water supply purposes, commenced in 1925 with a pipehead dam, with the current dam having been in operation since 1979. Storage capacity of the dam is 60 GL (or million cubic metres) and regulation is in excess of 80% of the long term mean annual flow of approximately 25 GL.

A network of Water Corporation, local authority and private drains exists throughout the Amendment area as shown in Figure 9. The drains are a combination of natural drainage lines and excavated drains, extended or deepened (as steep sided trapezoidal channels) to enhance drainage from the area. Where the drain invert is below the adjacent water table, the drain lowers the water table locally. JDA (2004a) report that the drains were generally installed in the middle part of the last century to reduce the incidence of inundation and waterlogging from surface flows and also to lower the groundwater table in adjacent farmland.

Water Corporation main drainage within the Amendment area includes (JDA 2004b):

- Wungong River, which then joins the Southern River several kilometres north of Armadale Road;
- Neerigen Brook, modified to a Water Corporation Main Drain at South West Highway where it splits into North and South Branches that discharge to Wungong River;
- Keane Road Branch Drain, which discharges to Forrestdale Main Drain and ultimately the Southern River; and
- Birrega Main Drain and tributaries Sub O and Sub Q, which discharge to the Serpentine River.

The Brickworks A and B Drains are also major drains which flow through the Amendment area, however they are not designated Water Corporation Main Drains and do not have an easement (JDA 2004a).

The Wungong River, Brickworks Drain, Neerigen Brook and Birrega Main Drain all have significant catchments upstream (east) of the Amendment area. Most of the urban areas upstream of the Amendment area were developed prior to the implementation of WSUD and currently discharge without compensation into these drains (JDA 2004b).

Most of the wetlands currently form part of the existing surface drainage system, and either receive surface flow or have outlets which control water level variation in the wetlands (refer to Table 11).

TABLE 12
SUMMARY OF PRINCIPLES AND OBJECTIVES FOR URBAN WATER MANAGEMENT

Key Guiding Principles		
• Facilitate implementation of sustainable best practice in urban water management for Brookdale • Encourage environmentally responsible development to meet the intent and recommendations of the UWMS • Provide clarity for agencies involved with implementation • Facilitate adaptive management responses to the monitored outcomes of development • To minimise public risk, including risk of injury or loss of life • To maintain the total water cycle		
Category	**Principles**	**Objectives**
Water Supply	• Consider all potential water sources in water supply planning • Integration of water and landuse planning • Sustainable and equitable use of all water sources having consideration of the needs of all users, including community, industry and environment • To maximise the reuse of stormwater • Minimise use of potable water where drinking quality water is not essential	• Residential consumption target for potable water of 40-60 kL/person/year
Category	**Principles**	**Objectives**
Surface Water and Groundwater	• To retain natural drainage systems and protect ecosystem health • To protect from flooding and waterlogging • To implement economically viable stormwater systems • To ensure stormwater management recognises and maintains social aesthetic and cultural values • Post development annual discharge volume and peak flow rates to remain at predevelopment levels or defined EWR's • Minimise change in peak winter levels at groundwater dependent wetlands due to change in groundwater flux associated with urbanisation	• For ecological protection, 1 in 1 year ARI volume and peak flow rates maintained at predevelopment conditions • Where there are identified impacts on significant ecosystems, maintain or restore desirable environmental flows and/or hydrological cycles as specified by the Department of Environment • For flood management, manage up to the 1 in 100 year ARI event within the development area to predevelopment peak flows unless otherwise negotiated with Water Corporation • Post development end of winter operating levels at wetlands maintained at pre-development levels, unless otherwise determined by EWR's
Surface Water Quality	• To maintain or improve surface water quality within development areas • Reduce the average annual load of stormwater pollutants discharged by development compared to if it used a traditional piped conveyance system.	• As compared to a development which does not actively manage water quality : 60% reduction in TSS (annual loads) 60% reduction in TP 45% reduction in TN 70% reduction in Gross Pollutants
Groundwater Quality	• To maintain or improve groundwater quality within development areas • Where waterways/open drains intersect the water table, minimise the discharge of pollutants from groundwater to the waterway • 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 and habitat in specified environment	• Where waterways/open drains intersect the water table, as compared to a development which does not actively manage water quality: 60% reduction in TP (annual loads) 45% reduction in TN • Where development associated with sensitive environment, as per Department of Environment's requirements

Source: JDA (2006) Table 1

Previous Drainage Planning

The Water Corporation has existing drainage scheme reviews for Neerigen Brook North and South Course (Water Corporation 1999) and Brickworks Drain (Water Corporation 1997).

These scheme reviews considered ultimate development within the Amendment area and provided the basis for drainage planning as presented in the UWMS (JDA 2002). Although the reports do not specifically consider upgrading of the existing drains for current landuse to meet existing level of service requirements, it is understood Neerigen Brook North and South may be currently under capacity, with existing capacity less than 5 year ARI.

It is understood Water Corporation is currently in the process of reviewing its drainage planning in this area with current studies expected to be complete in late 2006. Its previous planning was based on construction of two large regional basins on Neerigen Brook South Course and Brickworks Drain to attenuate flows from existing and proposed development areas upstream and within the Amendment area, prior to these watercourses discharging to the Wungong River.

Given the DEC/DoW's current approach to stormwater management, it is considered unlikely the DEC/DoW would support large regional basins. The DWMS (JDA 2006) adopts current DEC/DoW principles of maximising infiltration opportunities and distributed storage.

Annual and Seasonal Flow Estimates

The three existing gauging stations located on Southern/Wungong River and its tributaries are shown in Appendix 5 (Appendix C, Figure C1). Two of the gauging stations (Kargotich and Abbey Road) are Water Corporation stations, with the third station at Fremantle Road near the confluence of Southern River and Canning River owned and operated by the DEC/DoW. Historical flow data for the existing gauging station at Fremantle Road is contained in Appendix 5 (Appendix C, Figure C2).

There are no gauging stations located immediately within the Amendment area, and as such no direct streamflow records exist for any of the major watercourses of Neerigen Brook, Wungong River or Brickworks Drain.

Based on calibrated runoff estimates for storm events detailed in JDA (2005) and annual streamflow rainfall runoff estimates for Southern River contained in Swan River Trust (1994), annual runoff is estimated as approximately 15% of rainfall. On the basis of 1975-2003 average monthly rainfall estimates via Armadale Post Office (Bureau of Meteorology site 9001) and estimated catchment areas, annual and seasonal runoff for the major watercourses of the Amendment area are shown in Table 13. Further details of the basis of these calculations are contained in JDA (2006) Section 2.4.4.

Wungong River is partially diverted into Birrega Main Drain due to the backwater of an existing weir on Wungong River immediately downstream of the Wungong River/Birrega Main Drain confluence. According to a snapshot survey undertaken by the DEC and CSIRO in September and November 2005 up to 30% of flow is diverted to Birrega Main Drain from Wungong River at this location.

More detailed pre development surface flow monitoring is currently in progress to provide improved knowledge of annual flows.

TABLE 13
ANNUAL FLOW ESTIMATES

Location	Catchment Area (ha)	Annual Flow Estimate (Millions of Cubic Metres/year)
Neerigen Brook North – Confluence to Wungong River	2662	1.6
Neerigen Brook South - Confluence to Wungong River		1.6
Brickworks A Drain - Confluence to Wungong River	372	0.5
Brickworks B Drain - Confluence to Wungong River	421	0.5
Wungong River at Armadale Road	5900	6.7
Wungong River at South West Highway	1360	1.6
Birrega Main Drain at Wungong River Offtake	-	0.5

Source: JDA (2006) Section 2.4.4

Peak Flow Estimates

JDA (2004b) identified considerable differences in peak flow estimates for Wungong River and its tributaries (Neerigen Brook, Brickworks Drain) in various previous studies conducted by the Water Corporation and the then Water Authority of Western Australia. The differences in peak flow estimates were identified as significant in the planning context for the Amendment area, particularly large discrepancies in estimates for Brickworks Drain. On this basis, JDA was commissioned by ARA to undertake a hydrologic study to review peak flow estimates for the Southern River and Wungong River catchment from its confluence with Canning River upstream to the South West Highway crossing (JDA 2005).

Results of this analysis detailing peak flow estimates at various locations within the Amendment area for various average recurrence storm events are presented in Table 14.

Further discussion regarding peak flow estimates and comparisons with previous estimates is contained in Appendix 5 (Section 2.4.5).

TABLE 14
PEAK FLOW ESTIMATES

Location	Peak Flow Estimates (m^3/s) for Various ARI				
	2 Year	5 Year	10 Year	20 Year	100 Year
Wungong River/Southern River					
Wungong River : Kargotich Gauging Station	7.3	7.7	8.6	13.4	18.2
Wungong River : Upstream of Birrega Main Drain Offtake	5.7	6.2	6.9	11.1	17.2
Wungong River : Upstream of Neerigen Brook South	11.6	12.8	14.4	23.2	36.0
Wungong River : Armadale Rd	20.60	22.0	24.9	39.2	60.0
Southern River : Canning River Confluence	22.3	25.7	31.5	52.4	77.3
Tributaries					
Brickworks Drain : Combined A & B Courses	3.0	3.1	3.5	5.5	8.4
Neerigen Brook : Abbey Rd	7.3	7.8	8.6	11.6	17.4
Neerigen Brook South Course Downstream End	5.5	5.7	6.4	10.3	15.6
Neerigen Brook : North Course Downstream End	4.1	4.3	4.8	6.7	9.9

Source: JDA (2006) Section 2.4.5

Floodplain Mapping

Flow estimates contained in Table 14 were endorsed by DEC/DoW, and subsequently used by DEC/DoW to review existing floodplain mapping for Southern River and Wungong River (Appendix 5, Appendix B).

The DEC floodplain mapping for Wungong River is shown in Appendix 5 (Figure 9). This mapping shows the majority of the floodplain to be flood fringe rather than floodway, and hence available for development.

No floodplain mapping of Neerigen Brook North and South Course, and Brickworks Drain has been previously undertaken. ARA has commissioned studies to provide these estimates to support later stages of local planning.

Environmental Flow Requirements

As previously discussed in Section 4.5.3, there are no current environmental flow requirements (EWR's) or environmental water provisions established for the Wungong River. EWR's are defined as the water regimes needed to maintain the ecological values of water dependent ecosystems at a low level of risk.

Preliminary estimates of ecological water requirements at various locations of the Canning River system, including Wungong River at South West Highway approximately 1km upstream of the Amendment area (Swan River Trust 2002) are shown in Table 15, with EWR's in excess of current median flows generally only in spring (September to November).

TABLE 15
PRELIMINARY ENVIRONMENTAL WATER REQUIREMENTS FOR WUNGONG RIVER AT SOUTH WEST HIGHWAY

Month	Historic flows at s616153[1] (Median ML)	Existing flows at s616153[2] (Median ML)	Monthly flow (ML) required to maintain the following water dependent ecosystem						
			Fish Passage	Macro Invertebrates	Channel form	Riparian vegetation	Seasonal Adjust-ment	EWR for Average Climate	EWR for Dry Climate
Jan	95	29	-	25	-	-	-	25	21
Feb	109	32	-	22	-	-	-	22	18
Mar	168	30	-	25	-	-	-	25	21
Apr	409	35	-	24	-	-	-	24	26
May	756	70	-	25	-	-	-	25	21
Jun	4876	218	-	24	-	-	89	89	43
Jul	5662	361	-	25	356	366	-	366	205
Aug	3880	344	-	25	-	-	283	283	175
Sep	2929	210	267	25	-	-	-	267	183
Oct	2743	132	276	25	-	-	-	276	164
Nov	363	74	-	24	-	-	-	90	59
Dec	162	50	-	25	-	-	90	25	15
Annual	26958	1718	-	-	-	-	-	1517	951

1. Station s616153 located on Wungong River at Kargotich Weir. Historical flows based on period of record from 1961-1975 pre Wungong Dam as reported in SRT (2002).
2. Existing flows based on period of record from 1977-1996 post construction of Wungong Dam as reported in SRT (2002).

The Swan River Trust (2002) states the figures to be preliminary only and based on limited hydrological and ecological data. It does not propose the flow volumes calculated be released to the river system. It states to determine an actual future flow regime requires further research and

appropriate calculation of environmental water provisions (EWP's) considering social, consumptive and economic uses of the river.

The Water Corporation currently make summer releases to Wungong River via an off take on the water supply trunk main at South West Highway. Based on 2004/05 records, it is understood this total release is in the order of 0.8GL/yr, at a flow rate of approximately 5ML/d (60 l/s) (Appendix 5, Section 2.4.7). These releases are understood to be made for consumptive purposes rather than environmental releases.

Surface Water Quality Monitoring Data

EPA Bulletin 987 (Environmental Protection Authority 2000) noted that the Southern River (into which the Wungong flows) was the third highest contributor of phosphorus to the Swan-Canning River.

High levels of phosphorus and nitrogen present in the Swan and Canning River systems and wetlands promote the growth of blue green and other problem algae. Algae use excess phosphorus and nitrogen to grow and multiply rapidly to large numbers, thriving when weather is warm and sunny and when water flow is slow.

Predevelopment surface water quality investigations for the Amendment area were undertaken by CSIRO, and DEC/DoW. Detailed reporting of the investigations methodologies and resulting technical reports are included in Appendix 5 (Section 2.4.8, Figure 10, and Appendix D).

Monthly surface water quality sampling was undertaken by DEC/DoW at 20 sites within the Amendment area from May to October 2004. Samples were analysed for the basic and major ions, nutrients and metals. Monitoring locations are shown on Figure 10 of Appendix 5 with results presented in Table 16 in relation to ANZECC (2000) and Swan River Trust (1999) guideline values. Summarising the results:

- Overall median concentrations for both TP and TN were less than both Swan Canning Cleanup Program (SRT 1999) and ANZECC (2000) guidelines values.
- Only water in drains on the west side of Wungong River was found to have Total Phosphorous (TP) concentrations above 0.1 mg/L, the long term phosphorus target of the Swan Canning Cleanup Program (Swan River Trust 1999). TP was high in the Water Corporations Birrega Main Drain and the Keane Rd Branch Drain.
- Total Nitrogen (TN) concentration was occasionally high in the Neerigen North, Birrega Main Drain, and in the upper reaches of the Brickwork Drain.
- Water quality in the drains and creeks did not appear to deteriorate between upstream urban areas as it passed through the Amendment area to Wungong River.

The DEC conducted two additional snapshot surveys of water quality and flows in September and November of 2005 (refer to Appendix 5 – Appendix D). It was observed that the uncompensated conductivity increased slightly in all locations, whereas the flow and nutrient concentrations generally decreased between September and November. It was noted that parts of the surface water drainage network were already dry by November.

Note that while ANZECC (2000) indicates that guidelines are not intended to be directly applied to stormwater quality, they are applicable where stormwater systems are regarded as having conservation value. Default trigger values (concentrations below which there is a low risk of adverse biological effects) applicable for protection of aquatic ecosystems in south-west Australia are presented in Table 16. These trigger values were derived from ecosystem data for unmodified or slightly-modified ecosystems, and are not based on any objective biological criteria. ANZECC

(2000) recommend they should only be applied where site-specific values do not exist or until site-specific values can be derived (JDA 2006).

TABLE 16
PRE-DEVELOPMENT SURFACE WATER QUALITY SUMMARY

Parameter and unit of measurement	ANZECC Guideline Value	SCCP Guideline Value	Surface Water Monitoring Summary					
			Samples	Min	Max	Mean	Median	Std Devn
Physical Properties								
pH	6.5-8.0	-	141	6.3	10.8	7.5	7.3	0.7
Temperature (C)	-		141	9.8	27.9	16.5	16.3	3.0
EC (ms/cm)	0.12-0.30	-	133	0.01	4.85	0.56	0.40	0.59
Alkalinity $CaCO_3$ (mg/L)	-	-	31	21	130	48	35	29
Dissolved Oxygen (%)	80-120	-	133	6.4	169.0	87.1	88.6	26.4
TSS (mg/L)	-	-	123	1.1	230.0	19.0	8.0	31.4
Basic and Major Ions								
Calcium Ca (mg/L)	-	-	31	5.6	40.0	15.2	12.0	9.8
Choride Cl (mg/L)	-	-	31	25.0	1400.0	133.8	95.0	237.2
Sodium Na (mg/L)	-	-	31	13.0	860.0	81.2	53.0	146.2
Potassium K (mg/L)	-	-	31	1.6	9.2	2.7	2.2	1.4
Sulphate SO_4 (mg/L)	-	-	31	4.0	280	35	19	48
Silica SiO_2 (mg/L)	-	-	31	1.6	25.0	7.3	5.7	5.2
Flouride F (mg/L)	-	-	28	0.10	0.50	0.19	0.20	0.12
Nutrients								
FRP (mg/L)	0.040	-	124	0.003	0.690	0.035	0.007	0.101
Total P (mg/L)	0.065	0.1	131	0.010	2.500	0.096	0.040	0.256
Total N (mg/L)	1.2	1.0	129	0.16	16.00	1.42	0.77	2.18
Ammonia – N (mg/L)	0.08	-	119	0.01	0.31	0.03	0.02	0.05
NOx (mg/L)	0.15	-	119	0.01	15.00	0.94	0.33	2.15
Metals								
Aluminium Al (mg/L)	0.055	-	31	0.1	0.6	0.2	0.2	0.1
Iron Fe (mg/L)	-	-	31	0.05	7.70	0.51	0.25	1.35
Magnesium Mg (mg/L)	-	-	31	4.6	420.0	22.6	8.5	73.8
Manganese Mn (mg/L)	1.9	-	31	0.05	0.75	0.09	0.05	0.13

Source: JDA 2006

1. Values adopted for Lowland River, South West Australia
2. ANZECC (2000a) trigger values for freshwater for a 95% level of protection (slightly to moderately disturbed ecosystem)
3. SCCP Targets for TN and TP based on 20 year target values

Surface Water Quality Modelling

A study was undertaken by the DoE's Aquatic Science Branch on behalf of Water Corporation (Kelsey and Zammitt 2003) to examine the possible impacts of urban development on water quality in the Southern River / Forrestdale / Wungong/Brookdale Structure Plan Area. The large scale catchment model (LASCAM) was used to estimate the change in flow and nutrient loads in local and receiving waterways which would occur post-development.

At a regional scale, the study found that post development phosphorus concentrations would increase without implementation of Water Sensitive Urban Design (WSUD) measures by approximately 17%. With implementation of some WSUD measures the study indicated phosphorus concentrations will increase by 36% (ie 19% worse than without application of any WSUD) due to the high concentration of phosphorus in subsurface flows from a soil profile saturated with phosphate. Conversely, the study found Nitrogen concentrations would decrease post development even without application of WSUD measures.

Kelsey and Zammitt (2003) concluded implementation of WSUD would not reduce phosphorous export in catchments with sandy soils and high water tables where infiltration is the preferred

method of treatment and that WSUD measures other than infiltration would need to be developed to remove phosphorus.

Review of Kelsey and Zammitt (2003) indicated WSUD is modelled in LASCAM on the basis of simply reducing post development runoff (ie increasing infiltration) by reducing the impervious area in the catchment to the current level. This assumption is not considered to accurately reflect a post development urban environment in which a range of BMP measures such as source controls, education campaigns, land use planning mechanisms, street sweeping, bioretention systems, swales, living streams, created ephemeral wetlands and GPTs, are all applied as a treatment train approach to achieve desired environmental outcomes. This treatment train approach is applied in the DWMS (Appendix 5), consistent with the requirements of the UWMS.

It is understood LASCAM is unable to conceptualise this range of WSUD measures.

JDA (2004b) detailed the use of a Nutrient Input Decision Support System (NiDSS) to demonstrate likely changes in nutrient inputs pre and post development within the Amendment area, with and without implementation of WSUD. JDA (2004b) found implementation of a managed WSUD program based on a combination of at-source (land use planning, POS landscaping and design, street sweeping, native plantings, education campaigns) and structural controls (GPT's) would reduce phosphorus input to below existing inputs with rural land use. In these calculations, JDA (2004b) estimates of nutrient input reduction through fertiliser application reduction were conservatively based as reducing nutrient application from over-fertilisation to manufacturer recommended rates only, and assumed only 20-30% take up rate of any fertiliser education programs by residents. Consideration of promotion of phosphorus-free fertilisers was not modelled but would provide further reductions in inputs.

JDA (2004) also found higher density development (R35) may be more suited near areas of environmental significance as the post development nutrient input rates without implementation of WSUD measures are similar to the existing pre-development land use. This finding has been implemented in the master planning process for the Amendment area.

In addition to these studies, CSIRO is also undertaking a study examining Nutrient cycling reactions act as a source and a sink of nutrients in surface and groundwater. The degree to which nutrient cycling plays a role in mobilising/immobilising nutrients within the catchment will be examined in three ways, investigation of soil cores, stream sediment survey; and in-situ monitoring of the temporal variation in soil water/groundwater chemistry with changes in soil moisture and dissolved oxygen. The soil cores and stream sediment chemistry will be investigated to identify possible sources/sinks of nutrients in the soil profile and stream bed sediments.

Outcomes of this work will inform selection of specific BMP in LWMS and UWMP stages of the development process.

4.7.4 Potential Impacts

Potential changes to the hydrology of watercourses including water quality, peak flow rates, and annual discharge volumes may occur as a result of redevelopment of the Amendment area.

Potential exists for flooding within the Amendment area and of receiving environments.

Potential adverse export of nutrients and other pollutants and drainage may impact on receiving wetlands and watercourses as a result of development. A key issue is the potential for the increased export of phosphorus, contributing to eutrophication and algal bloom problems. Parts of

the project area are in the catchment of the Swan and Canning Rivers system and the Peel-Harvey estuarine system which have serious water quality problems.

Potential increase of sediment loads to watercourses may occur as a result of construction /earth working activities during redevelopment of the project area.

Inappropriate disturbance of acid sulfate soil may adversely affect surface water quality.

Development in the vicinity of wetlands/watercourses may result in temporarily interrupted or altered water balances, water quality and flow rates.

4.7.5 Management Strategies

Water Management Framework

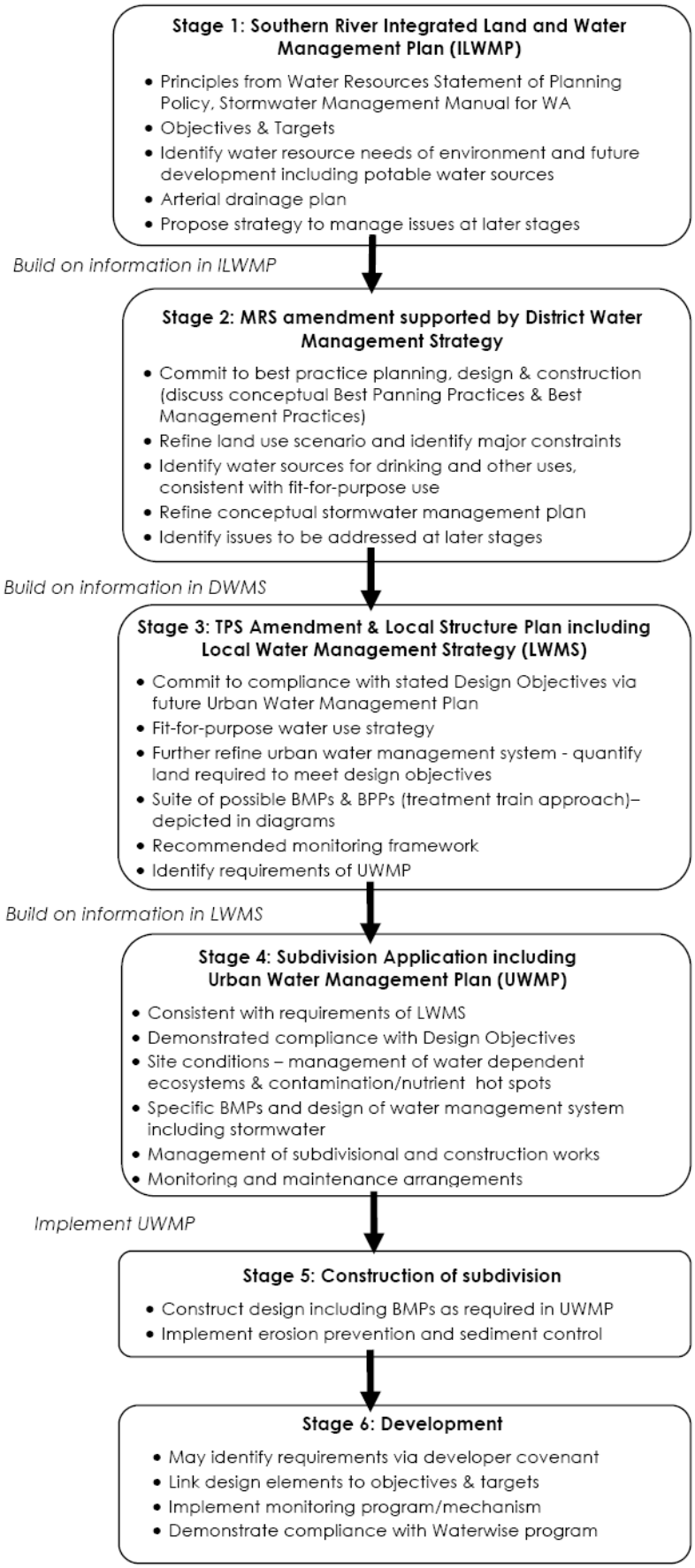
As part of the Southern River MoU process, Essential Environmental Services was engaged by the Southern River Steering Committee to develop a framework for water resource management within the Southern River/Forrestdale/Brookdale/Wungong Structure Plan area (Essential Environmental Services 2006). The framework has been developed with the input of Water Corporation, Local and State Government agencies including DEC/DoW, EPA, Swan River Trust, and Department of Planning and Infrastructure.

The process, detailed in Interim Approach for Integrating Urban Water Management with Land Use Planning within the Southern River Area: Guidance for developers (Essential Environmental Science 2006) will be followed for development within the Amendment area. This process includes the following stages following from the regional UWMS and ILWMP documents, and the Amendment area's District Water Management Strategy (DWMS, Appendix 5).

- Local Structure Plan Process – Development of a Local Water Management Strategy (LWMS) for each precinct.

- Subdivision Application process - Development of an Urban Water Management Plan (UWMP) for each subdivision.

The following flowchart details the implementation model reproduced from ESS (2006) for integrating water planning into the planning approvals process in the Southern River/Brookdale/Forrestdale/Wungong District Structure Plan Area. Further specific details regarding content to be included in both LWMS's and UWMP are contained in the DWMS (Appendix 5, Sections 5.1.2 and 5.1.3).


Stage 1: Southern River Integrated Land and Water Management Plan (ILWMP)
• Principles from Water Resources Statement of Planning Policy, Stormwater Management Manual for WA
• Objectives & Targets
• Identify water resource needs of environment and future development including potable water sources
• Arterial drainage plan
• Propose strategy to manage issues at later stages
Build on information in ILWMP
Stage 2: MRS amendment supported by District Water Management Strategy
• Commit to best practice planning, design & construction (discuss conceptual Best Panning Practices & Best Management Practices)
• Refine land use scenario and identify major constraints
• Identify water sources for drinking and other uses, consistent with fit-for-purpose use
• Refine conceptual stormwater management plan
• Identify issues to be addressed at later stages
Build on information in DWMS
Stage 3: TPS Amendment & Local Structure Plan including Local Water Management Strategy (LWMS)
• Commit to compliance with stated Design Objectives via future Urban Water Management Plan
• Fit-for-purpose water use strategy
• Further refine urban water management system - quantify land required to meet design objectives
• Suite of possible BMPs & BPPs (treatment train approach)– depicted in diagrams
• Recommended monitoring framework
• Identify requirements of UWMP
Build on information in LWMS
Stage 4: Subdivision Application including Urban Water Management Plan (UWMP)
• Consistent with requirements of LWMS
• Demonstrated compliance with Design Objectives
• Site conditions – management of water dependent ecosystems & contamination/nutrient hot spots
• Specific BMPs and design of water management system including stormwater
• Management of subdivisional and construction works
• Monitoring and maintenance arrangements
Implement UWMP
Stage 5: Construction of subdivision
• Construct design including BMPs as required in UWMP
• Implement erosion prevention and sediment control
Stage 6: Development
• May identify requirements via developer covenant
• Link design elements to objectives & targets
• Implement monitoring program/mechanism
• Demonstrate compliance with Waterwise program

Regional Flood Management

Regional flood management is achieved in the Master Plan through recognition of existing flow paths through the Amendment area for upstream catchments, and provision of adequate widths to accommodate safe passage of the 100 year flood. With respect to Wungong River this will be achieved by development consistent with the DEC floodplain mapping and its floodplain management strategy:

- Proposed development (ie, filling, building, etc) that is located outside of the floodway is considered acceptable with respect to major flooding. However, a minimum habitable floor level of 0.50 metre above the adjacent 100 year ARI flood level is recommended to ensure adequate flood protection; and
- Proposed development (ie, filling, building, etc) that is located within the floodway and is considered obstructive to major flows is not acceptable as it would increase flood levels upstream. No new buildings are acceptable in the floodway.

The Master Plan recognises more detailed local studies and survey data may result in refinement of the floodway, however foreshore buffer widths provided in the Master Plan are considered robust enough to accommodate any changes to floodway width which may result through detailed local studies.

With respect to tributary drains of Wungong River (i.e. Neerigen Brook North, Neerigen Brook South, Brickworks A and B), the capacity of these drains is less than 5 year ARI. Upgrading of these drains will therefore be required prior to development, dependent on staging. To assist this process, the ARA is currently undertaking hydraulic modelling to determine existing floodplains of these watercourses (JDA 2006).

Both the Water Corporation and the DEC/DoW have indicated modification of the alignment and configuration of these drains would be considered, and reconfiguration of the drains to living streams is encouraged by the DEC.

The Master Plan proposes to maintain Neerigen Brook North and South on their existing alignments, but proposes the realignment of both Brickworks drains and where possible, modification of the drains to living streams is proposed. While re-alignments shown on the Master Plan for the Brickworks Drains appear as very linear, it is intended the living streams would meander within these corridors.

Current widths for living stream (including buffers) allowed for in the Master Plan are approximately 70m for Neerigen Brook North and 50m for the relocated Brickworks A and B drains and Neerigen Brook South. This is consistent with calculated land take requirements for safe conveyance of the 100 year flood from upstream catchments through the Amendment area (Appendix 6, Section 4.2.1). Widths contained in the Master Plan are significantly wider than the existing drainage easements.

Water Corporation's current review of its drainage planning in this area will provide more detailed modelling and hence more accurate estimates of peak flows for the Wungong River tributaries of Neerigen Brook North and South Course, and Brickworks Drains. Current width allocations within the Master Plan are considered robust to accommodate with refinements in peak design flows resulting from these investigations.

All future subdivisional development upstream of the Amendment area will be responsible for attenuation of its own streamflow to pre (current) development levels consistent with the DEC/DoW policy.

Local Stormwater Management

A schematic of the local stormwater system is shown in Appendix 5 (Figure 24).

Local stormwater management is proposed to be undertaken consistent with water sensitive design practices. Urban stormwater is also proposed as a contribution to non potable supply within the area.

The local stormwater management system will consist of a series of pipes, swales, Park Avenue multiple use corridors, Living Streams, and ephemeral basins (retention/detention) to attenuate and infiltrate peak surface water flows in a distributed manner, and provide water quality treatment for the proposed development prior to discharge from the Amendment area to the receiving Wungong River.

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

Dependent on local conditions, stormwater runoff generated by the impervious areas of the road reserve will be collected in gully or side entry pits and then flow into a local piped (or swale) drainage system. These flows will typically require compensation before discharge to a Park Avenue for conveyance of flow in excess of infiltration capacity to Wungong River. Compensation of flow will be achieved through:

- Provision of detention storage within Park Avenues;
- Use of existing wetlands which currently receiving surface flows from existing drainage networks; and
- Use of community parks currently defined in the Master Plan.

The location of storages have not been specified on the Master Plan to allow individual development areas the flexibility to locate/relocate detention/infiltration areas based on more detailed site specific investigations and minimise fill requirements. Calculation of indicative storage space requirements for detention storages are detailed in Section 4.2.3 of Appendix 5.

Some areas immediately adjacent to Park Avenues would be allowed to discharge uncompensated to the Park Avenue, subject to detailed design. It is expected roads immediately adjacent to the Avenues would typically discharge to the Avenue via overland flow (eg non raised kerb) rather than via a formal pipe drainage system.

Consistent with principles and objectives shown in Table 12, stormwater will be required to maintain 1 in 1 year ARI event post development discharge volumes and peak flow rates at predevelopment conditions all parts of the catchment. Roof drainage and road drainage will therefore be connected to soakwells to promote at-source infiltration, except where local site conditions do not allow this to occur. The use of bottomless manholes for infiltration of road drainage will be encouraged consistent with DoW stormwater management principles.

Detention/retention basins will generally be designed to attenuate runoff for storm events up to 100 year ARI, with basin outflow designed to not exceed predevelopment (existing) levels. The minimum building floor levels will comply with DoW and City of Armadale requirements for a 0.5m above the estimated 100 year ARI flood level.

Waterway and Wetland Interaction

Discussions with the DoW and DoE's published *Decision Process for Stormwater Management in WA* have indicated flow to wetlands (including Conservation Category Wetlands) may be considered by the DoW for storm events greater than 1 in 5 year ARI. Similarly more frequent events may be permitted to enter wetland areas where existing drainage to the wetland exists and the surface flow is required to maintain wetland hydrology.

Discussions with the DoW have indicated flood storage within buffer areas may be considered, particularly in buffers for resource enhancement wetlands.

More detailed assessment of wetland hydrology will be required to be undertaken at the local structure planning level to assess the wetlands capacity to accept surface flows and maintain existing wetland hydrology.

Post Development Surface Flow

Change of landuse within the Amendment area will result in the following changes with regard to surface flow:

- No change in peak flows discharging from the Amendment area during individual storm events, consistent with design criteria and flood management requirements.
- Increases in average total annual runoff from the Amendment area estimated to be approximately 10% from 15% currently to 25% post development. This 10% increase is estimated to equate to an additional average discharge of approximately 1.2 GL per year from the Amendment area. As discussed in Section 4.1 of Appendix 5, part of this additional surface flow is proposed to be recycled for domestic water supply purposes if approved by the Department of Health.

Detailed groundwater modelling of the Amendment area is currently being undertaken by CSIRO on behalf of ARA to further improve estimates of the post development water balance including surface water flows and groundwater levels under a range of different water supply, drainage and climate scenarios. Modelling outcomes will assist in the assessment of suitable non-potable water supply options. No model outcomes from this process are available as yet.

The DWMS also considers the following recommendations be implemented to contribute to further improvement of Wungong River flows:

- Removal or modification of the existing weir on Wungong River immediately downstream of Birrega Main Drain so as not to divert flows intended for Wungong River into Birrega Main Drain.
- Negotiations be undertaken with Water Corporation regarding opportunities to release water directly from Wungong Dam rather than the current release of chlorinated water from the South West Highway water supply main.
- Given the ARA's commitment to stormwater reuse initiatives in the Amendment area, and the resulting reduction of imported potable scheme water to the area, Water Corporation and Department of Environment consider opportunities for provision of increased releases to improve dry period flows in Wungong River. Additional studies by DEC will be required as part of this process to more accurately define environmental water releases for Wungong River.

Watercourse Enhancement

Watercourse enhancement will be integrated into the overall landscape planning for the Amendment area. The DEC, Water Corporation, and local Indigenous groups have provided positive feedback toward modification of watercourse alignments and configurations, providing the opportunity for transformation of existing drains to living streams.

Strategies for enhancements of watercourses are detailed in the DWMS (Appendix 5) and include:

- Enhancement to existing open trapezoidal drainage channels to establish living ephemeral streams;
- Improvement of flows and restoration of riparian vegetation;
- Establishment of buffers;
- Specification of indicative sizes of regional flood protection infrastructure and provision of adequate areas in the Master Plan for this purpose;
- Continued water balance modelling and assessment of non-potable water supply options ;
- BMPs for stormwater and groundwater quantity and quality management; and
- Ongoing regional pre and post development monitoring programs and establishment of compliance reporting mechanisms.

As part of the local structure planning process, landowners proposing to develop land in the Amendment area will be required to develop a Local Water Management Strategy (LWMS) in collaboration with the ARA, implementing the DWMS. These LWMS's will address local construction management issues including sediment and erosion control consistent with DoW's Stormwater Management Manual (2004). The LWMS will address:

- Principles, objectives and requirements for total water cycle management as outlined in the draft Water Resources SPP (WAPC 2004), Liveable Neighbourhoods Edition 3 (WAPC 2004) and the Stormwater Management Manual for WA including the Decision Process;
- Objectives for water management as outlined in the ILWMP and DWMS. Compliance with these objectives should be demonstrated both within the LWMS and at time of subdivision;
- Existing site characteristics such as geology, hydrogeology and groundwater characteristics in more detail than the ILWMP or DWMS;
- Site constraints and opportunities (such as environmental assets, landscape and landform), identifying the critical management issues;
- Conceptual urban water management system, including:
    - Quantification of land required for storage and retention of stormwater for the 100 year ARI, 10 year ARI and 1 year ARI storm events;
    - Map of existing groundwater levels and any proposed controlled groundwater level (CGL) (including use of subsoil drains) with justification for this control;
    - Demonstrated understanding of the concepts and key issues associated with BMP choice - identification of types of BMPs for management of water quality and quantity and indicative drawings of possible treatment trains and design approaches;
    - Fit-for-purpose water use strategy, including mechanisms to conserve potable water and minimise wastewater (including those relating to development design and construction); and
    - Infrastructure and management requirements for proposed water, wastewater and stormwater systems, having consideration of infrastructure already existing and identifying any necessary approvals;
- Issues to be addressed at subdivision stage (included in an Urban Water Management Plan);
- Recommended monitoring framework, pre- and post-development; and
- Proposed implementation of strategy including roles, responsibilities and funding for monitoring and maintenance.

As part of the subdivision application process an urban water management plan (UWMP) will be required by the landowner, consistent with requirements as detailed in the DWMS and ESS (2006). The UWMP should address:

- Objectives as outlined in the ILWMP, this DWMS and the LWMS. Demonstration of compliance with these criteria and objectives should be achieved through appropriate assessment tools, calculations or assessments, to the satisfaction of the DoW;
- Agreed/approved measures to achieve water conservation and efficiencies of use including sources of water for non-potable uses and detailed designs, controls, management and operation of any proposed system;
- Management of groundwater levels, including maintenance of ecosystem health and any proposed dewatering;
- Detailed stormwater management design including the size, location and design of public open space areas, integrating major and minor flood management capability;
- 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;
- Measures to achieve protection of waterways, wetlands (and their buffers), remnant vegetation and ecological linkages;
- Adequacy of buffers proposed in the Local Structure Plan having consideration of any controlled groundwater level (CGL) proposed;
- Where an artificial water body is proposed, identify its purpose, design and management;
- Management of subdivisional works (to ensure no impact on regional conservation areas, maintenance of any installed BMPs and management of any dewatering and soil/sediment, including dust);
- Management of disease vector and nuisance insects such as mosquitoes and midges;
- Monitoring program and/or contribution; and
- Implementation plan including roles, responsibilities, funding and maintenance arrangements. Contingency plans should also be indicated where necessary.

A Foreshore Management Plan for the Wungong River and Neerigen Brook will be prepared by the ARA as part of the WIPS process. The Plan will be prepared to the satisfaction of the DEC, SRT, DPI and the City of Armadale. The Foreshore Management Plan will include, but is not limited to, the following:

- Comprehensive weed eradication program;
- Revegetating and restoring foreshore POS adjoining conservation areas with appropriate indigenous flora;
- Increase the area contained within POS adjoining Bush Forever Sites;
- Creation of habitat and wildlife corridors;
- Investigate areas of straightened sections of Wungong River suitable for meander;
- Controlling vehicle and pedestrian access;
- Provision of public facilities;
- Soil and plant source material hygiene;
- Fire management including provision of fire hydrants;
- Encouraging community involvement and awareness promoting control of pets (eg. cats and dogs);
- Water conservation principles;
- Monitoring criteria to determine the success of the revegetation and weed eradication program;
- Progress and compliance reporting; and
- Timing and implementation schedule.

The delineation of waterways buffers will be finalised in liaison with the DEC as part of the development of the Foreshore Management Plan. It is the ARA's expectation that final waterways will be determined prior to any Structure Plans being approved.

Landowners proposing to develop land in close proximity to the Wungong River or Neerigen Brook will be responsible for implementation of the Foreshore Management Plan as a requirement of subdivision approval.

Water Quality

Landowners proposing to develop land in close proximity to wetlands and watercourses will be required to allow for development setbacks (buffers) consistent with the management advice provided by the DEC in the case of wetlands and in the Foreshore Management Plan prepared by the ARA. This will result in an overall increase in foreshore area thereby protecting related riparian vegetation.

With respect to criteria developed for water quality as part of the Southern River MoU process (Essential Environmental Service 2006), the criteria are established centrally around use of Model for Stormwater Improvement Conceptualisation (referred to as MUSIC) to assess the suitability of selected Best Management Practices (BMP's) for a particular area. The DEC/DoW have recently calibrated the model for the Southern River catchment area, are currently investigating modifications to the model to improve its suitability in assessing BMP performance for the Swan Coastal Plain.

To this end, the formulation of the water quality strategy at the regional level has focussed on implementing current known BMPs as detailed in the DEC's Stormwater Management Manual for Western Australia (2004) and the Decision Process for Stormwater Management in Western Australia. (DoE and SRT 2005), with an emphasis on nutrient input source control consistent with the approved UWMS (JDA 2002), and maintaining 1 in 1 year ARI post development discharge volumes and peak flow rates at pre development levels.

Selection of individual BMP's and performance assessment using MUSIC in relation to target criteria will be required to be undertaken at the local structure planning level and documented in the Local Water Management Strategy (LWMS).

With respect to water quality management the DWMS proposes the use of a treatment train approach including source control techniques as specified in the Southern River UWMS (JDA 2002). The proposed water quality management approach for the Amendment area includes use of the following techniques:

- Non Structural Controls
  - Planning practices (POS locations and configuration, WSUD promotion in local structure planning)
  - Construction practices (construction sites, soil amendment)
  - 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 trapezoidal drains to living streams (WC and local authority drains)
  - Creation of ephemeral retention/detention areas within community park/wetland

buffers/POS areas
- Use of Park Avenues for overland conveyance, infiltration, and water quality treatment (bioretention)
- Application of Gross Pollutant Traps for outlets to sensitive environments

- Monitoring
  - Establishment of regional pre and post development monitoring network
  - Annual reporting, including ongoing assessment of BMP's performance and suitability to provide ongoing guidance and review for future WSUD planning within the Amendment area.

4.7.6 Predicted Outcome

The framework, criteria and approach for stormwater management within the Amendment area is consistent with a framework for water resource management within the Southern River/Forrestdale/Brookdale/Wungong Structure Plan area (EES, 2006), developed with the input of Water Corporation, Local and State Government agencies including DEC, DoW, EPA, Swan River Trust, and Department of Planning and Infrastructure

Based on the results of hydrological studies undertaken, knowledge of the extent of the development, proposed wetland and watercourse enhancement, and adoption of urban management strategies and BMP's consistent with the recommended approach to stormwater management by the Department of Water, it is considered that the implementation of the proposed redevelopment of the Wungong Urban Water Master Plan area can be managed to meet the EPA's objectives in relation to Surface Water Quality and Quantity.

4.8 Groundwater Quantity and Quality

4.8.1 EPA Objective

To maintain the quantity of water (surface and ground) so that existing and potential environmental values, including ecosystem maintenance, are protected.

To ensure that water quality does not adversely affect environmental values or the health, welfare and amenity of people and landuses by meeting statutory requirements and acceptable standards.

4.8.2 Applicable Legislation, Criterion or Guidance

- Australian and New Zealand Guidelines for Fresh and Marine Water Quality, National Water Quality Management Strategy, October 2000, Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand (2000a).
- Australian Guidelines for Water Quality Monitoring and Reporting, National Water Quality Management Strategy, October 2000, Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand (2000b).
- Australian Guidelines for Urban Stormwater Management, National Water Quality Management Strategy, 2000, Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand (2000c).
- Department of Environment (2004) Stormwater Management Manual for Western Australia, February 2004.
- Department of Environment (2005) Decision Process for Stormwater Management in W.A. (Draft).

- Environmental Protection Authority (2000) Southern River-Forrestdale-Brookdale-Wungong Draft Structure Plan – A Submission by the Environmental Protection Authority under section 16(j), of the Environmental Protection Act, Bulletin 987, August 2000.
- Essential Environmental Services. (2006), Interim Approach for Integrating Urban Water Management with Landuse Planning within the Southern River Area: Guidance for Developers.
- Government of Western Australia (1998), Environmental Protection (Swan and Canning Rivers) Policy Approval Order 1998, Western Australian Government Gazette 10 July 1998 No 140.
- Government of Western Australia (1992), Environmental Protection (Peel Inlet – Harvey Estuary) Policy Approval Order 1992, Western Australian Government Gazette 11 December 1992.
- JDA Consultant Hydrologists (2002) Southern River/Forrestdale/Wungong /Brookdale Structure Plan Urban Water Management Strategy, report for Water & Rivers Commission, May 2002.
- Western Australian Planning Commission. 2004a, Draft Statement of Planning Policy 2.9: Water Resources.

4.8.3 Existing Environment

Section 4.7.3 details the planning context and previous studies undertaken for the Amendment area.

Groundwater investigations specifically undertaken for the Amendment area include:

- Nutrient Input Balance Modelling (JDA, 2004b);
- Predevelopment Water Quality Monitoring (JDA);
- Predevelopment Water Quality Monitoring Data Analysis (CSIRO); and
- Development of a detailed groundwater model of the Amendment area by coupling the groundwater model MODHMS to the MODFLOW model developed by Rockwater for the Southern River UWMS area and refining the grid size and parameters used in the model to the local scale (CSIRO/GHD).

A Technical Review Group has been established to oversee the modelling exercise being undertaken by CSIRO. This group will be composed of suitably qualified individuals representing the Department of Environment and Conservation, Department of Water and Water Corporation, as well as any other individuals with specific expertise that the key stakeholders nominate. The aim of this group will be to review the assumptions, data inputs, outputs, boundary conditions and key algorithms of the model to ensure that the results of the modelling exercise are sufficiently robust to appraise the likely impacts of development and various non-potable water sources.

In addition to these studies, CSIRO is also undertaking a study examining nutrient cycling reactions act as a source and a sink of nutrients in surface and groundwater. The degree to which nutrient cycling plays a role in mobilising/immobilising nutrients within the catchment will be examined in three ways, investigation of soil cores, stream sediment survey; and in-situ monitoring of the temporal variation in soil water/groundwater chemistry with changes in soil moisture and dissolved oxygen. The soil cores and stream sediment chemistry will be investigated to identify possible sources/sinks of nutrients in the soil profile and stream bed sediments. Outcomes of this work will inform selection of specific BMP in LWMS and UWMP stages of the development process.

These studies have been undertaken in addition to the regional groundwater modelling detailed in Rockwater (2006) as part the preparation of an Integrated Land and Water Management Plan (ILWMP). The Rockwater study examined changes in the water balance and groundwater levels

resulting from urbanisation, water conservation, water reuse and climate change over the whole of the Southern River/Forrestdale/Brookdale/Wungong Structure Plan Area.

A detailed list of reference studies used as the basis for information regarding groundwater in this document is contained in Appendix 5 (Section 6).

It should be noted that government agency policy positions on controlling groundwater levels below the average annual maximum groundwater level have changed since the release of EPA (2000). The former DoE and Swan River Trust's recently released *Decision Process for Stormwater Management in WA* (DoE and Swan River Trust 2005) now allows for consideration of controlled groundwater levels (CGL's) within a development area subject to demonstration of manageable environmental impacts.

Superficial Aquifer

The superficial aquifer underlying the Amendment area is known as the Armadale Area and is an unconfined aquifer extending throughout the coastal plain with the water table typically close to the surface creating numerous wetlands. The aquifer is recharged by direct rainfall and from minor ephemeral streams flowing from the Darling Plateau and discharging onto the coastal plain (Davidson 1995). Recharge rates vary considerably based on geology and landuse.

The Armadale Area is approximately 68 km^2 in area with flow lines extending from the Darling Scarp and terminating at Forrestdale Lake and Southern River in the west, Canning River to the north and the northern boundary of the Byford Area in the south. The Amendment area is located in the central and eastern part of the Armadale Area with groundwater flow generally to the west.

Within the Amendment area the superficial aquifer has a total thickness of approximately 15 to 30m with the base of the superficial formation falling from 15 m AHD towards the eastern boundary of the Amendment area down to -5m AHD at the western boundary (JDA 2006).

Rockwater (1995) reported artesian conditions in the western parts of the south-east corridor with upward heads indicative of groundwater discharge. In the eastern part adjacent to the foothills hydraulic heads are generally downwards consistent with groundwater recharge conditions.

The lithology of the superficial formation is quite complex, which has also determined a complex hydrogeological system. The sandy deposits are saturated and may potentially yield water, particularly in areas with reasonable thickness of well-connected sandy deposits, including connection to the surface. This occurs in the north and north-east of the Amendment area.

Hydraulic conductivity is likely to be <5 m/day. Clay deposits in the south–east are expected to have very low permeability (JDA 2006).

Leederville Aquifer

The Leederville aquifer is a major semi-confined aquifer that is present to the north and west of the Gnangara Mound and to the south and east of the Jandakot Mound. Groundwater in the Leederville flows toward the west and is recharged by vertical leakage through the semi confining Guildford Formation via the superficial aquifer (Davidson 1995). The relationship of the Leederville aquifer to the superficial aquifer is shown in Figure 11 of Appendix 5.

The most productive water bearing strata within the Leederville Formation as indicated by review of drilling logs is likely to occur in the Wanneroo Member and deeper. Some limited confinement might be provided within the upper Leederville Formation (Pinjar Member) considering the low vertical hydraulic conductivity in this Formation (<10^{-4} m/day). However this Formation is likely

to be absent at least in some parts of the Amendment area and the two aquifers hydraulically connected.

The southern part of the Leederville aquifer is less transmissive and hydraulic conductivity varies between 0.2 m/day and 0.6 m/day with an average 0.5 m/day (Davidson 1995). The average storage coefficient in the Leederville aquifer is commonly estimated as 10^{-4}.

The total Leederville aquifer recharge south of the Swan River is estimated as 8.14 GL/year, equating to 2.8GL/year per $100km^2$. Leederville recharge within Armadale is therefore estimated as 8-10mm/year (0.62GL/year over $68km^2$).

CSIRO analysis of the piezometric heads in deeper bores in the vicinity of the Amendment area has shown that there is a general decline in the heads with time (refer to Figure 12 of Appendix 5). This indicates, subject to water quality restraints, potential exists for deep aquifer storage and recovery within the Amendment area.

Average Annual Maximum Groundwater Level (AAMGL)

A spatial network of 26 bores was installed by JDA in December 2003 on behalf of ARA to improve the level of groundwater data within the Amendment area (Figure 10). Of these, 14 were installed by hand auger, and 12 installed by a drilling rig with a cemented steel surface casing as the core network available for predevelopment water level and quality monitoring requirements. The 12 bores installed by drilling rig consisted of 50mm PVC screened for the lower 3.5m, with 0.5m bentonite seal above the screen. Hand augered bores consisted of 50mm PVC capped at both ends and screened for approximately the lower 1.0m. Bore details and lithological logs are presented in Appendix 5 (Appendix E).

The estimated AAMGL for the Amendment area is shown in Figure 10. The majority of the Amendment area has an AAMGL within 1m of the existing natural surface. Application of a seasonal and interannual adjustment to measured levels at the JDA bores were based on nearby long term DEC bores T115 and T120. Calculations are detailed in Appendix 5 (Section 2.5.3). The estimated accuracy of the regional AAMGL contours is considered to be ± 0.50m on the coastal plain, and less accurate on the steeper eastern part of the Amendment area.

The AAMGL was found to vary from approximately 23mAHD in the northwest of the Amendment area to approximately 45mAHD in the elevated southeast region, with a general east to west groundwater flow towards Wungong River.

Large areas of the Amendment area have an AAMGL within 1.2m of natural surface and therefore would require fill to provide clearance above groundwater for development. JDA (2004b) estimated without implementation of a Controlled Groundwater Level (CGL), approximately 1016 ha (or 69% of the total Amendment area) are estimated to require fill to provide a 1.2 m clearance above AAMGL for development. This equated to an estimated fill volume of 7.5 million cubic metres.

Depth to estimated AAMGL from natural surface based on 1m topographic contours and presentation of long-term DEC monitoring bore data from the Amendment area is shown in Appendix 5 (Figure 13 and Appendix E).

The shallow AAMGL over the majority of the Amendment area provides an opportunity for the implementation of a CGL located below AAMGL to reduce development costs and minimise large-scale trucking of fill, consistent with sustainability principles (Figure 11).

Approximately 60% of the Amendment area is estimated to have its AAMGL located in sandy soils overlaying clay (Appendix 6, Section 4.3.1), indicating its suitability for CGL implementation.

Areas immediately adjacent to Wungong River are likely to have fill levels dominated by surface drainage considerations and the 100 year flood level in Wungong River rather than groundwater clearance. This constrains application of a possible CGL in these areas.

Seasonal and Inter-Annual Water Table Variation

Monthly water level monitoring data for winter 2004 recorded by JDA, and continuous water level monitoring since August 2005 by CSIRO is included in Appendix 5 (Appendix F).

Estimates of seasonal water table variation based on 2004 monitoring data are summarised below:

- Seasonal water table variation varies considerably across the Amendment area ranging from approximately 1 to 2 m in areas of sandy soils ranging from 3 to 6m in areas of clay (refer Appendix 5: Appendix F).
- The areas of highest water table variation were found to be located in the elevated eastern boundary of the Amendment area.

Differences in the seasonal water table variations within the Amendment area are likely to be due to local differences in soil types, impacts of nearby drains located below the water table and the impact of existing groundwater abstractions (JDA 2006).

In addition to the seasonal variation, DEC bore T115 indicates maximum and minimum groundwater levels may also vary by up to 1.5m interannually.

The CSIRO pre-development continuous water level monitoring program is ongoing and will provide additional data to refine seasonal and interannual water table variation data within the Amendment area during local structure planning.

Impact of Water Table Drawdown for Drains Below AAMGL

JDA (2004b) provided estimates of the depth of drawdown of groundwater levels for various drain depths below AAMGL as a function of distance from the drain. The results showed the zone of influence to be approximately 400m, with only minor variations in AAMGL elevation expected at greater distances from the drain. This result indicated that some additional control of groundwater levels over and above that provided by existing drains, could be provided within the Amendment area by the construction of new drains of subsoil drainage below AAMGL, without adversely impacting significant wetlands provided a subsoil exclusion buffer of approximately 400m is provided.

The estimates were made based on groundwater modelling only and JDA (2004b) recommended further investigation of groundwater drawdown based on site specific investigations.

Four transects were selected for field investigation in conjunction with CSIRO to represent a range of soil types (sand to sandy-clay) and various drain depths below AAMGL. Four bores were drilled along each transect and continuous data loggers installed by CSIRO to measure water tables along the transects for winter 2005. Transect locations, recorded data and its analysis is shown in Appendix 5 (Appendix M).

The site-specific analysis indicated a much lesser zone of influence than previously estimated in JDA (2004b). The largest zone of influence was observed as approximately 100m observed in

sandy soils adjacent to Wungong River where the drain invert was approximately 2.5m below AAMGL. Areas of sandy clay showed lesser zones of influence, typically less than 20m.

These results are used to define subsoil exclusion zones for protection of wetlands and sensitive environments where a controlled groundwater level is implemented.

Water Quality

EPA Bulletin 987 (Environmental Protection Authority 2000) noted that the Southern River (into which the Wungong flows) was the third highest contributor of phosphorus to the Swan-Canning River.

High levels of phosphorus and nitrogen present in the Swan and Canning River systems and wetlands promote the growth of blue green and other problem algae. Algae use excess phosphorus and nitrogen to grow and multiply rapidly to large numbers, thriving when weather is warm and sunny and when water flow is slow.

Historical landuses within the Amendment area including broad acre agriculture and grazing, piggeries, poultry farms and liquid waste disposal facilities, have to varying degrees affected groundwater quality within the Amendment area, and currently operate largely without the application of WSUD and any water quality controls

Groundwater quality sampling of the superficial aquifer was undertaken by JDA commencing June 2004 at quarterly frequency for a 12-month period for 12 spatially distributed monitoring bores. Samples were analysed for the basic and major ions, nutrients and metals. Additional water quality monitoring was then undertaken during winter 2005 by CSIRO. Monitoring data is detailed in Appendix 5 (Appendix G).

Groundwater quality monitoring sites and data are summarised in Table 17. Spatial representation of data over the Amendment area is shown in Appendix 5 (Figure 14). Summarising the results of monitoring:

- Overall median concentrations for both TP and TN were greater than both Swan Canning Cleanup Program (SRT 1999) and ANZECC (2000) guidelines values.
- pH was found to typically be between 5 and 6, with the lowest in the vicinity of upper reaches of the Brickworks A Drain. pH generally increases in the east of the Amendment area.
- Salinity is generally elevated in bores located on the west side of Wungong River, with concentrations ranging to 20,000mg/L.
- Seasonally, groundwater salinity is lowest at times of maximum water table, due to seasonal recharge. Similarly, major ions and metals concentrations were found to be the highest in June and also decline with seasonal recharge.
- TP concentrations were highest to the west of Wungong River and between Neerigen Brook north and south branches, with TP concentrations greater than 0.1mg/L in 50% of samples. There was no well defined seasonal trend in TP concentration, though it appears TP may be higher in spring.
- TN concentrations in Brookdale groundwater are generally high, with concentrations in almost 40% of samples in excess of 3 mg/L, and elevated readings in excess of 40mg/L in some areas. TN concentrations were found to increase with seasonal groundwater table rise due to infiltration.
- Both sampling programs in 2004 and 2005 indicated similar characteristics of groundwater quality.

TABLE 17
PRE-DEVELOPMENT GROUNDWATER QUALITY SUMMARY

Parameter and unit of measurement	ANZECC Guideline Value	SCCP Guideline Value	Groundwater Monitoring Summary					
			Samples	Min	Max	Mean	Median	Std Devn
Physical Properties								
Ph	6.5-8.0	-	54	4.7	6.8	5.9	6.0	0.5
Temperature (C)	-	-	36	16.2	24.5	19.8	18.5	2.7
EC (ms/cm)	0.12-0.30	-	54	0.20	25.45	2.87	0.89	5.34
Alkalinity as $CaCO_3$ (mg/L)	-	-	54	5	190	51	45	41
Hardness as $CaCO_3$ (mg/L)	-	-	54	16	8900	632	96	1754
Basic and Major Ions								
Calcium Ca (mg/L)	-	-	54	0.7	640.0	55.5	17.0	131.8
Chloride Cl (mg/L)	-	-	54	16.	12000	982	175	2314
Sodium Na (mg/L)	-	-	54	13.0	4000	434	125	833
Potasium K (mg/L)	-	-	54	0.1	38.0	8.2	3.7	10.3
Sulphate as SO4 (mg/L)	-	-	54	8	2000	165	71	349
Silica Si (mg/L)	-	-	54	3.3	49.0	13.2	10.0	10.0
Bicarbonate HCO3 (mg/L)	-	-	54	6	230	60	49	50
Nutrients								
PO4-P (FRP) (mg/L)	0.040	-	54	0.01	1.10	0.07	0.01	0.19
Total P (mg/L)	0.065	0.1	54	0.01	1.60	0.24	0.13	0.31
Total N (mg/L)	1.2	1.0	54	0.10	57.00	6.93	1.80	12.58
Ammonia_N (mg/L)	0.08	-	54	0.05	7.10	0.39	0.07	1.05
Nitrate NO3 (mg/L)	0.15	-	54	0.1	160.0	16.5	0.9	35.8
Nitrite NO2 (mg/L)	0.15	-	54	0.09	24.00	1.03	0.10	4.36
TKN (mg/L)	-	-	54	0.05	31.00	3.21	1.00	5.29
Metals								
Aluminium Al (mg/L)	0.055	-	54	0.005	0.720	0.053	0.005	0.134
Iron Fe (mg/L)	-	-	54	0.01	1.90	0.16	0.05	0.30
Magnesium Mg (mg/L)	-	-	54	3.3	1800.0	119.1	17.0	345.0
Manganese Mn (mg/L)	1.9	-	54	0.001	1.900	0.111	0.012	0.314

1. Values adopted for Lowland River, South West Australia
2. ANZECC (2000a) trigger values for freshwater for a 95% level of protection (slightly to moderately disturbed ecosystem)
3. SCCP Targets for TN and TP based on 20 year target values

This section discusses the calculation of nutrient input change expected to result from existing rural land use compared to proposed land use in the Amendment area using the NiDSS model as detailed in JDA(2004b). It should be noted that although land use within the final Masterplan differs from the original land use breakdown used in JDA (2004b), key outcomes of NiDSS modelling remain unchanged.

NiDSS is a tool developed by JDA Consultant Hydrologists to assist in landuse 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. 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 are then 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)
- estimates of the cost of removal (in PV terms) for a selected WSUD program.

NiDSS was applied to the Amendment area to model existing land use and proposed 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) on rural residential lots.

Predevelopment nutrient application rates were estimated as 18 kg/ha/yr for TP and 54 kg/ha/yr TN. In summary, proposed change of land use from predominantly rural to urban (R15) without implementation of WSUD measures is predicted to result in an increased nutrient input from 18 kg/ha/yr to 33 kg/ha/yr for phosphorus and 54 kg/ha/yr to 133 kg/ha/yr for nitrogen. This result for the Amendment area is consistent with previous estimates contained in the UWMS (JDA 2002).

With the implementation of a managed WSUD program based on a combination of at-source control (land use planning, POS landscaping and design, street sweeping, native plantings, education campaigns, GPT's), phosphorus input to the Amendment area can be reduced to or below existing levels. Modelled scenarios included assuming education campaign effectiveness of 20% or 33%, that is 1 in 5 or 1 in 3 people will adopt the WSUD measures. These effectiveness percentages are considered to be realistic.

In these calculations, JDA (2004b) estimates of nutrient input reduction through fertiliser application reduction were conservatively based as reducing nutrient application from over-fertilisation to manufacturer recommended rates only, and consideration of promotion of phosphorus free fertilisers would provide further reductions in inputs.

NiDSS modelling was also performed for higher density urban development with a zoning of R35. Modelling indicated that a change from predominantly rural to urban (R35) without implementation of WSUD measures results in an estimated nutrient input decrease from 18 kg/ha/yr to 11 kg/ha/yr for phosphorus and similar rates for nitrogen at 54 kg/ha/yr to 56 kg/ha/yr. This decrease is due to the reduced area available for nutrient input (ie. lawns and gardens) as the lot sizes are smaller.

This result indicated higher density development (R35) may be more suited near areas of environmental significance as the post development nutrient input rates without implementation of WSUD measures are similar to the existing pre-development landuse.

This result has been accommodated in master planning for the Amendment area.

4.8.4 Potential Impacts

Potential adverse export of nutrients and other pollutants and drainage may impact on receiving wetlands and watercourses as a result of development. A key issue is the potential for the increased export of phosphorus, contributing to eutrophication and algal bloom problems. Parts of the project area are in the catchment of the Swan and Canning Rivers system and the Peel-Harvey estuarine system which have serious water quality problems.

Potential changes to groundwater hydrology including water quality and water levels may occur as a result of redevelopment of the Amendment area.

Potential for groundwater rise to cause flooding within the Amendment area.

Potential adverse nutrient export and drainage may impact on receiving wetlands and watercourses.

Potential for dewatering of the superficial aquifer during construction to impact wetlands and receiving waterways.

4.8.5 Management Strategies

Water Management Framework

As part of the Southern River MoU process, Essential Environmental Services was engaged by the Southern River Steering Committee to develop a framework for water resource management within the Southern River/Forrestdale/Brookdale/Wungong Structure Plan area (Essential Environmental Services 2006). The framework has been developed with the input of Water Corporation, Local and State Government agencies including DoE/DoW, EPA, Swan River Trust, and Department of Planning and Infrastructure.

The process, detailed in Interim Approach for Integrating Urban Water Management with Land Use Planning within the Southern River Area: Guidance for developers (Essential Environmental Science 2006) will be followed for development within the Amendment area. This process includes the following stages following from the regional UWMS and ILWMP documents, and the Amendment area's District Water Management Strategy (DWMS Appendix 5).

- Local Structure Plan Process – Development of a Local Water Management Strategy (LWMS) for each precinct.
- Subdivision Application process - Development of an Urban Water Management Plan (UWMP) for each subdivision.

The flowchart shown in Section 4.7.5 details the implementation model reproduced from ESS (2006) for integrating water planning into the planning approvals process in the Southern River/Brookdale/Forrestdale/Wungong District Structure Plan Area.

Further specific details regarding content to be included in both LWMS's and UWMP are contained in the DWMS (Appendix 5, Sections 5.1.2 and 5.1.3).

Groundwater Level Management

The implementation of a CGL is proposed, dependent on a range of local site conditions to be examined in detail at the local structure planning level including the soil type and its relationship to groundwater levels (regional and/or perched) table, seasonal groundwater variation in the area, the presence of ASS, the existence of pollutants or nutrients within the groundwater, and the need to protect wetlands and the receiving environment (JDA 2006). The approval of the use of a CGL below the AAMGL is the responsibility of the DoW.

The DWMS has identified areas at a regional scale where development should consider the opportunity for implementing a controlled groundwater level to minimise large scale trucking of fill (Appendix 5, Figure 30).

Minimum separation between building floor levels for development and groundwater will be achieved by filling of house pads and/or installation of subsoil drainage to limit groundwater to the AAMGL/CGL.

If a CGL is to be implemented, maintenance of wetland water levels will be required through implementation of subsoil exclusion buffers around significant wetlands.

Detailed groundwater modelling of the Amendment area is currently being undertaken by CSIRO on behalf of ARA to further improve estimates of the post development water balance including

surface water flows and groundwater levels under a range of different water supply, drainage and climate scenarios. Modelling outcomes will assist in the ongoing assessment of suitable non-potable water supply options for domestic non-potable and POS irrigation use, which include stormwater reuse through aquifer recharge. GHD's pre-feasibility study considering use of the Leederville Aquifer which found recharge of pre treated stormwater within the Amendment Area as technically feasible, is contained in Appendix 5 (DWMS Appendix I).

Other initiatives to minimise importation of scheme water to the amendment Area as stated in the DWMS (Appendix 5, Section 4.1) include water use efficiency and demand management measures consistent with waterwise practices (water efficient fixtures, landscaping , subsurface irrigation etc).

Modelling outcomes from CSIRO are not as yet available. Model establishment and calibration is currently in progress.

Groundwater Quality Management

With respect to water quality management the DWMS proposes the use of a treatment train approach including source control techniques as specified in the Southern River UWMS (JDA 2002). The proposed water quality management approach for the Amendment area includes:

- Non Structural Controls
  - Planning practices (POS locations and configuration, WSUD promotion in local structure planning)
  - Construction practices (construction sites, soil amendment)
  - 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 trapezoidal drains to living streams (WC and local authority drains)
  - Creation of ephemeral retention/detention areas within community park/wetland buffers/POS areas
  - Use of Park Avenues for overland conveyance, infiltration, and water quality treatment (bioretention)
  - Application of GPTs for outlets to sensitive environments
- Monitoring
  - Establishment of regional pre and post development monitoring network
  - Annual reporting, including ongoing assessment of BMP's performance and suitability to provide ongoing guidance and review for future WSUD planning within the Amendment area.

With respect to criteria developed for water quality as part of the Southern River MoU process (Essential Environmental Service 2006), the criteria are established centrally around use of Model for Stormwater Improvement Conceptualisation (referred to as MUSIC) to assess the suitability of selected Best Management Practices (BMP's) for a particular area. The DEC/DoW have recently calibrated the model for the Southern River catchment area, are currently investigating modifications to the model to improve its suitability in assessing BMP performance for the Swan Coastal Plain.

To this end, the formulation of the water quality strategy at the regional level has focussed on implementing current known BMPs as detailed in the DEC's Stormwater Management Manual for

Western Australia (2004) and the Decision Process for Stormwater Management in Western Australia. (DoE and SRT 2005), with an emphasis on nutrient input source control consistent with the approved UWMS (JDA 2002), and maintaining 1 in 1 year ARI post development discharge volumes and peak flow rates at pre development levels.

Selection of individual BMP's and performance assessment using MUSIC in relation to target criteria will be required to be undertaken at the local structure planning level and documented in a Local Water Management Strategy (LWMS).

With respect to implementation of a CGL, demonstrated management of water quality considerations will need to be demonstrated to the DEC/DoW at local structure planning in an LWMS to satisfy key objectives criteria based on application of the MUSIC model.

Dewatering

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

Prior to the commencement of any dewatering, construction contractors will be required to apply for and obtain from 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.

4.8.6 Predicted Outcome

The framework, criteria and approach for stormwater management within the Amendment area is consistent with a framework for water resource management within the Southern River/Forrestdale/Brookdale/Wungong Structure Plan area (EES 2006), developed with the input of Water Corporation, Local and State Government agencies including DEC, DoW, EPA, Swan River Trust, and Department of Planning and Infrastructure.

Based on the results of hydrological studies undertaken, knowledge of the extent of the development, proposed wetland and watercourse enhancement, and adoption of urban management strategies and BMP's consistent with the recommended approach to stormwater management by the Department of Water, it is considered that the implementation of the proposed redevelopment of the Wungong Urban Water Master Plan area can be managed to meet the EPA's objectives in relation to Groundwater Quality and Quantity.

4.9 Site Contamination

4.9.1 EPA Objective

To ensure that remediation of contaminated sites achieves an acceptable standard that protects the environment, is compatible with the intended landuse, and is consistent with appropriate criteria.

To maintain the integrity, ecological functions and environmental values of land.

4.9.2 Applicable Legislation, Criteria or Guidance

- *Contaminated Sites Act 2003;*
- Department of Environment and Conservation (DEC; formerly Department of Environment, DoE) *Contaminated Sites Management Series*, including the following:
- *Development of Sampling and Analysis Programs* (DEP 2001a);
- *Reporting of Site Assessments* (DEP 2001b);
- *Potentially Contaminating Activities, Industries, and Landuses* (DEP 2001c);
- *Assessment Levels for Soil, Sediment, and Water* (DoE 2003); and
- *Contaminated Sites and the Landuse Planning Process* (DoE 2006).

The *Contaminated Sites Act 2003* (WA) that will come into force in Western Australia on 1 December 2006 will permit the DEC to develop a database of contaminated sites in the state. The Act imposes wide-ranging reporting obligations by requiring that the following people make initial reports of known or suspected contaminated sites to the DEC:

- Any person who knows or suspects they have (at any time in the past) caused or contributed to contamination on a site (even if they no longer own or occupy the site) owners (including mortgagees in possession) who know or suspect contamination of their site,
- occupiers of (or people in control of) sites which they know or suspect are contaminated; and
- auditors engaged to report on the site in accordance with the *Contaminated Sites Act 2003.*

The Act provides an initial six month period for contamination to be reported. Once a report of contamination is made, the site will be classified by the DEC, usually within 45 days. There are seven potential classifications, but those of most concern are considered to be:

- contaminated - remediation required;
- contaminated - restricted use;
- remediated for restricted used; and
- possibly contaminated - investigation required.

Memorials will be lodged on the titles to all land that is subject to these classifications. No authorities will be able to issue subdivision or development approvals for these sites without considering the DEC's advice about the contamination. Details about sites within the first three classifications above will be available in a free public database. Details of all reported sites will be available to the public via a basic or detailed search.

Sites classified "contaminated - remediation required" will need to be remediated. The timeframe for action will depend upon the risk the contamination poses. Some contamination may be able to be managed in accordance with normal operations, while other sites will need to be remediated immediately. The DEC's Guideline "The Use of Risk Assessment in Contaminated Site Classification" helps determine this. In instances where remediation is required or desired, the Act sets out a basic "hierarchy of responsibility" of those who will be responsible.

4.9.3 Existing Environment

The site geology and hydrogeology has been reviewed in previous reports (ATA 2005b), and is summarised briefly below. Geological units found in the Amendment area mainly comprise Guildford Formation (Unit C_s), thin Bassendean Sand over Guildford Formation (Unit S_{10}) or Bassendean Sand (Unit S_8). Small areas of Holocene Swamp Deposits (Unit Sp_1) and Alluvium (Unit Msc_1) are also present in low-lying or drainage areas (Jordan, 1986). Characteristics associated with the mapped units suggest all of the land contained within the Amendment area either is or may be prone to high watertable conditions. Within the Amendment area the

superficial aquifer has a total thickness of approximately 20 to 30m with the base of the superficial formation falls from 15m AHD near the eastern boundary of the Amendment area down to –5m AHD at the western boundary (JDA 2004a). Groundwater flow is generally westwards towards the coastline (JDA 2004a).

In order to determine what land within the Amendment area has been developed and subject to potentially contaminating activities, the following steps were undertaken:

- A literature review was conducted to identify previous studies that had been performed in relation to the assessment of soil contamination within the Amendment area. This included, but was not limited to a review of the report titled '*Inventory of Known and Inferred Point Sources of Groundwater Contamination in the Perth Basin, WA'* (Hirschberg 1991) and *Perth Groundwater Atlas* (WRC 1997).
- An examination of recent and historical aerial photographs of the Amendment area. Photos reviewed were from approximately 4-year intervals between 1949 and 2003, and copies of the 1953, 1970, 1981, and 2003 photographs are included as an appendix in ATA (2004b).
- Visits to the site to provide additional information on current landuses and ground truth observations made using the aerial photographs and information derived from Hirschberg (1991) and WRC (1997).
- Where considered pertinent, enquiries were also made to the City of Armadale for information relevant to the study.

A review of the information derived from this assessment indicates that much of the development area is currently and has in the past been used for pasture. Typical soil contaminants associated with this type of landuse comprise pesticides; although these contaminants are usually found in low levels over widespread areas and in most cases are at concentrations that do not require remediation.

Other activities in the Amendment area comprise residential, rural, horticultural and commercial landuse. Soil contaminants generated by these activities may include pesticides, heavy metals, and/or hydrocarbons, among other parameters. The actual likelihood of soil contamination in these instances is generally established by conducting a site-specific review of historical activities, and verified by collecting some soil samples for analysis.

Areas within the Amendment area for which evidence exists of activities that warrant further investigation include horticultural activities, such as market gardens and orchards (either operating or non-operational) and a poultry farm. These activities may have caused soil contamination that could potentially affect the environment and future residents unless appropriate site remediation occurs prior to redevelopment (if required). Figure 12 delineates "high risk" areas as the lots (or portions of lots) where activities with significant potential to cause soil contamination currently occur, or have occurred in the past.

Evidence from historical aerial photographs indicates that the land located on Allwood Avenue was at least in part used previously for market gardening prior to subdivision for residential landuse (in 1992 as Brookwood Estate). Enquiries to the City of Armadale indicate that no assessment of soil contamination was undertaken prior to the land being developed. This land is consequently mapped as "high risk".

The former Brookdale Liquid Waste Treatment Facility located on Waterworks Road, ceased operation at the Direction of the Minister for the Environment in December 2003, and is being decommissioned.

The Decommissioning and Rehabilitation Plan prepared by Waste Management (WA) for the Brookdale Liquid Waste Treatment Facility has three phases. A Detailed Site Investigation (DSI)

Plan has been prepared and approved by the Minister on the advice of the EPA which provides for sampling of soil and groundwater to determine the extent, if any, of contamination of the site. A Site Management Plan is then required to undertake any rehabilitation of contaminated areas that may result from the outcomes of the sampling undertaken through the implementation of the DSI Plan. If required, an going Water Monitoring Plan may be required depending on the outcomes of the first two phases.

Waste Management (WA) has completed the sampling of soil and groundwater to determine the extent, if any, of contamination of the site, and the report on the outcomes is due to be received by the EPA in December 2006. This will determine the extent to which the implementation of stages two and three of the Decommissioning and Rehabilitation Plan will be required.

Pending the outcome of the Plan, this area is mapped as "high risk" for the purposes of this study.

In summary, based on the aerial photography, published information, and site observations, the majority of the land within the Amendment area can be described as comprising:

- undeveloped land consisting predominantly of remnant vegetation;
- partially cleared landused for grazing and pasture;
- land developed for agricultural or horticultural purposes; or
- land developed for residential purposes.

Sites with different types of landuse have different risks of containing contaminated soil. However, due to the large number of individual lots (approximately 280) within the Amendment area and its large areal extent, it is not possible to perform comprehensive and cost-effective site-specific soil sampling and analysis to assess whether the land is potentially contaminated at this stage.

Contamination issues will need to be identified and addressed prior to development. In light of the time and cost limitations at this stage of the planning process, an approach has been adopted that categorises and maps each of the various properties within the Amendment area and their associated activities on the basis of the relative potential risk for soil contamination. Available evidence (from historical aerial photographs, published information, and site observations) has been utilised to categorise lots within the Amendment area according to inferred risk of contamination, and a management protocol has been assigned to each of these risk categories. This strategy has been designed to ensure that potential contamination is identified, assessed and remediated to a standard that is compatible with the future land development. A similar approach to the management of potential site contamination was adopted as part of the East Wanneroo development in the City of Wanneroo (ATA Environmental 1999).

The risk categories are discussed further below, and the risk classifications for the Amendment area are summarised on Figure 12, providing an indication of the intensity of past landuses. A discussion of the management protocols assigned to each of the categories is presented in Section 4.8.5.

Within the Amendment area, lots and activities have been classified into the following risk-based categories:

(i) land where evidence suggests a low risk of contamination by past and/or current landuses;
(ii) land where evidence suggests a moderate risk of contamination by past and/or current landuses; and
(iii) land where evidence suggests a high risk of contamination by past and/or current landuses.

The following approach was used for assigning land to each category:

(i) Land with a low risk of contamination.

Landuses assigned to this risk category were:

- land which was largely uncleared;
- land which was used for residential or rural residential purposes;
- land which was used as pasture; and
- land used for horse agistment.

(ii) Land with a moderate risk of contamination.

Any land that did not fall into categories (i) or (iii) was assigned to risk category (ii).

(iii) Land with a high risk of contamination.

Land was assigned to this risk category where:

- A previous report identified that contamination either was present or likely to be present.
- One of the following landuses was identified:
  - market gardens or other horticultural activities such as vineyards or orchards;
  - nurseries;
  - large scale agricultural activities (e.g. poultry farms and former piggeries); and
  - industrial activities involving maintenance to a number of vehicles, storage of quantities of fuels, oils or chemicals or manufacturing or fabrication of equipment.

4.9.4 Potential Impacts

Potentially unacceptable health and environmental impacts are associated with the disturbance/development of contaminated soils within the Amendment area.
Soil contamination has the potential to result in both health and environmental impacts. The nature of these impacts will vary based on a wide range of factors including:

- the nature and concentration of the contaminant;
- the nature of the surrounding environment; and
- the type of landuse proposed for the site.

These factors will determine whether a contaminant poses a health threat to users of the site or whether the contaminant may migrate through the soil water or air and impact on surrounding environment. The assessment of the nature and significance of impacts associated with soil contamination is a complex task that may involve several scientific disciplines as well as an assessment of the financial implications of remediation. Often decision-making is based on risk assessment tools that identify exposure pathways for contaminants and model the level of impact on either human or environmental receptors.

4.9.5 Management Strategies

A management protocol has been developed for each of the three risk categories in Section 4.9.3, as presented in Table 18. The protocol has been developed on the basis that a more detailed assessment of soil contamination is required for land where soil contamination is considered likely to be present. Table 18 details the actions required to assess land in each category, indicates the

timing for each action, and indicates where clearance (from the WAPC, on advice from the DEC) is required.

The management protocol presented in Table 18 is proposed for further assessment of potential soil contamination at individual sites. The protocol is designed to achieve the intent of the risk-based approach to the assessment of site contamination as preferred by the DEC and details the actions required to assess land in each category. The methodology presented will provide a high degree of confidence that potentially contaminated land is identified, assessed and (where necessary) remediated to the satisfaction of DEC prior to development commencing. The protocol applies equally to all lots in the Amendment area.

TABLE 18
PROTOCOL FOR ASSESSING POTENTIALLY CONTAMINATED LAND

RISK CATEGORY	ACTIONS	OUTCOME	TIMING	CLEARED BY
(i) Low	Site visit to confirm desktop investigations/ results	Land cleared as not contaminated or assigned as Category (ii) – Moderate risk	Subdivision	WAPC on advice from DEC
(ii) Moderate	Preliminary site investigation (PSI) following DEC guidelines (including a limited soil sampling program if necessary)	Land cleared as not contaminated or assigned as Category (iii) – High risk	Subdivision	WAPC on advice from DEC
(iii) High	1. Complete PSI if not already performed	Land assessed as not contaminated or potential for contamination confirmed (go to Step 2)	Structure Planning	
	2. Develop and implement Sampling and Analysis Plan	Compare Results to Assessment Criteria. Assign subject land as not contaminated if criteria not exceeded, or else remediate (go to Step 3)	Subdivision	WAPC on advice from DEC
	3. Develop Remediation Plan	Remediation strategy for contamination finalised (go to Step 4)	Subdivision	
	4. Implement Remediation Plan	Contamination removed or treated. Perform Validation Sampling Assessment (go to Step 5)	Subdivision	
	5. Refer Validation Report to DEC for Assessment	DEC issues advice that land has been remediated in a manner approved for landuse	Prior to proposed development	WAPC on advice from DEC

Following the commencement of the *Contaminated Sites Act 2003* (WA) on 1 December 2006, sites with known or suspected contamination should be reported to the DEC and memorials will be placed on titles of land where contamination is known or suspected.

A Site Contamination Study and Remediation Plan will be prepared by the Developer in accordance with the DEC's Contaminated Sites Management Series and in respect to the preparation and assessment of either a structure plan or subdivision plan depending upon timing as specified in Table 18 of this document.

4.9.6 Predicted Outcome

Based on the results of studies undertaken, knowledge of the extent of the development and existing sources of contamination, remediation and other mitigation proposed, it is considered that the implementation of the proposed redevelopment of the Wungong Urban Water Master Plan area can be managed to meet the EPA's environmental objective in relation to Site Contamination.

4.10 Acid Sulfate Soils

4.10.1 EPA Objective

To ensure that remediation of contaminated sites achieves an acceptable standard that protects the environment, is compatible with the intended landuse, and is consistent with appropriate criteria.

To maintain the integrity, ecological functions and environmental values of land.

4.10.2 Applicable Legislation, Criterion or Guidance

- Western Australian Planning Commission (2003b) Planning Bulletin 64: *Acid Sulfate Soils* (or version current at time of investigation and management).
- Department of Environment and Conservation (DEC) Acid Sulfate Soils Guideline Series and other general guidance as provided at the DEC's website at www.environment.wa.gov.au

4.10.3 Existing Environment

Acid sulfate soils (ASS) are wetland soils and unconsolidated sediments that contain iron sulfides which, when exposed to atmospheric oxygen in the presence of water, form sulfuric acid. ASS commonly occurs in low-lying coastal lands such as Holocene marine muds and sands. When disturbed, these soils may produce sulfuric acid which can mobilise iron, arsenic, aluminium, manganese and other heavy metals. The release of these reaction products can be detrimental to biota, human health and built infrastructure.

The presence of ASS has been a recognised issue of concern in Western Australia since 2003. The DEC and the Western Australian Planning Commission (WAPC) have released guidance notes on ASS, covering the requirement for assessing sites and the management of sites where ASS are identified. ASS investigations are commonly required as part of the conditions of subdivision or as a requirement for a dewatering license application.

The WAPC's Planning Bulletin 64 (WAPC 2003b) identifies the majority of the Amendment area as a "moderate" risk area for ASS. Some areas along the eastern boundary and in the northwest of the Amendment area are mapped as "low" risk areas, and scattered areas in the northwest quadrant of the Amendment area are mapped as "high" risk of ASS. The WAPC risk mapping for the project is shown in Figure 13.

The low-lying nature of the Brookdale area presents a number of challenges to achieving a commercially viable development. In order to comply with the DEC's Average Annual Maximum Groundwater Level (AAMGL) policy, which requires that the AAMGL to be maintained and fill imported to give adequate separation between the land surface and the groundwater, approximately 7.5Mm^3 of fill will be required. Importing this volume of fill would significantly impact on the project feasibility and as a result, alternative approaches are being examined (JDA 2004a).

Accordingly, the opportunity for limiting the seasonal rise of water table for the Amendment area by the use of drains is being investigated. Subsoil exclusion zones would be developed around designated wetland and natural vegetation areas to protect these areas against any limiting of peak seasonal groundwater levels by setting sub soil drainage below AAMGL. Potential areas to target for establishment of a controlled groundwater level would therefore be defined as those areas outside subsoil exclusion zones with less than 1.2m between the land surface and groundwater. This area is estimated as 718ha or 50 % of total Amendment area (JDA 2004a).

The lowering of the groundwater level, if implemented, may result in an increased risk that any ASS present in the areas to be drained will become acidic. If this occurs, then it is possible that the drainage waters will become acidic and this may in turn mobilise any contaminants present in the soil. An *Acid Sulfate Soil Management Strategy* was therefore prepared to ensure that the redevelopment of the Amendment area does not result in unacceptable environmental impacts (ATA Environmental 2004).

The large area of the Amendment area means that applying conventional ASS investigation and management methods would be impractical and uneconomic, and alternative approaches are required. The *Acid Sulfate Soil Management Strategy* (ATA Environmental 2004) therefore recommended a staged approach to the assessment and management of ASS within the Amendment area as follows:

- Completion of investigations to describe the spatial distribution and properties of acidic and potentially acidic soils in the development area;
- Development of a draft Acid Sulfate Soil Management Framework for the development;
- Completion of field or pilot trials of any novel or innovative management techniques that may need to be proved in the development setting; and
- Production of the final Strategic Acid Sulfate Soil Management Plan applicable to the overall development.

An initial stage of ASS investigations has been completed by ATA Environmental in mid-2005 and is included for reference as Appendix 6 – *Stage 1A Acid Sulfate Soils Investigation – Brookdale Redevelopment Area* (ATA Environmental 2005b). These investigations comprised the collection and analysis of samples from a total of 23 sample locations. Seven locations were positioned in the five areas not wholly located within the subsoil exclusion boundaries and where a high risk of ASS occurring is identified; fourteen locations were positioned on a 1km grid in groundwater control areas; one additional grid sample location was also included in the sampling program as it coincided with a sample location within an area where a high risk of ASS occurring is identified; and one additional sample location was included to ensure data from a location within the mapped geological unit Msc_1 be considered as part of Stage 1A investigations. Refer to Figure 13 for ASS sample locations.

Full details on the results of the investigations completed to date are included in Appendix 6 (ATA Environmental 2005b). The locations at which ASS were identified during the Stage 1A investigation and the risk mapping published by WAPC (2003b) are shown in Figure 2 of Appendix 6.

The soil investigation results have been separated into two groups:

- surface soils, located at up to 0.5m BGL; and
- subsurface soils, located at depths of $\geq$0.5m BGL.

Although test results indicated that the surface soils should be generally classified as acidic, it was concluded that no further investigations are required of these surface soils in relation to the proposal to lower the regional groundwater table. This conclusion is based on the fact that these

soils have historically been exposed to a wetting and drying cycle as a result of seasonal fluctuations in the watertable, and drainage of these soils is unlikely to generate significant acidity. This hypothesis was supported by the observation that no actual acid sulfate soils (i.e. soils with pre-oxidation (pH_F and pH_{KCl}) pH values of < 4) were identified during this investigation (ATA Environmental 2005b).

The subsurface soil results were collated into five groups based on field texture, colour, field observations, field test results and laboratory results. Of the five groups, two (dark to very dark grey and black sands and peat; and very dark brown and very dark greyish brown sands) were identified as Potential Acid Sulfate Soils (PASS) and one group (grey and light grey sands) was identified as potential PASS. The remaining two groups (other sands; and clays) were identified as non-ASS.

Overall, the results of the Stage 1A investigation indicated that the risk mapping published by WAPC (2003b) over predicted the areal extent of ASS. This is most likely due to the inconsistencies between the geological units mapped by Jordan (1986) (on which the WAPC (2003b) risk mapping is largely based) and the geological units identified in the field. The Stage 1A investigations also identified one area within the southeast corner of the Amendment area that may pose a "high" risk of ASS occurring that was not mapped by WAPC (2003b).

In order to evaluate potential impacts on groundwater quality, an estimation of the amount of metal leachate concentrations for eleven individual metals was undertaken using very conservative assumptions about the release and transport of contaminants in the subsurface. This methodology is expected to over-predict the concentrations of metals leaching from the soils into the groundwater. Nevertheless, comparison of the predicted leachate concentrations (C_W) to the assessment criteria indicates that the C_W values are likely to meet the short-term (20 year) trigger values for irrigation, with the exception of iron (ATA Environmental 2005b, pp39, Section 5.4).

When assessing the impacts or level of risk on groundwater quality, the key receptors considered in the Stage 1 ASS investigations (ATA Environmental 2005b) were human health and the environment. The results of the metal leachate calculations were therefore compared to the following assessment criteria:

- The NHMRC and NRMMC (2004) *Australian Drinking Water Guidelines*;
- The ANZECC and ARMCANZ (2000a) *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* – Fresh Water Aquatic Ecosystems values. Two criteria were selected as follows:
  - Recommended values typical slightly to moderately disturbed systems; and
  - Values for 80% species level of protection.
- The ANZECC and ARMCANZ (2000a) water quality for irrigation and general water use. Two irrigation criteria were selected as follows:
  - Long-term Trigger Values (LTV); and
  - Short-term Trigger Values (STV).

Results were considered to "meet the trigger values for irrigation" if the calculated leachate concentration was less than the LTV or STV specified in ANZECC and ARMCANZ (2000a). Based on the calculated metal leachate concentrations, leachate concentrations for nine of the metals considered were less than the short-term irrigation trigger values (STV).

The calculated leachate concentration of iron was 269mg/L, which is higher than the STV of 10mg/L. It must be noted at this point that the method used to calculate the leachate concentrations is highly conservative and did not take into consideration many important factors such as attenuation in the soil or groundwater aquifer due to physical, chemical, and biological processes or the separation distance between the source of the metal and the nearest receptor.

Elevated concentrations of iron in groundwater will have the following impacts:

- Reduced quality of drinking water. Iron has a taste threshold of about 0.3mg/L in water, and becomes objectionable above 3mg/L;
- An undesirable rust-brown appearance of water which can cause staining and blockages in irrigation systems;
- Growths of iron bacteria may cause taste and odour problems and lead to pipe restrictions, blockages and corrosion (NHMRC and NRMMC, 2004, Iron Fact Sheet); and
- At surface water discharge locations (e.g. drains, wetlands), flocculation of iron in the water may result in aquatic communities being smothered.

Iron has been measured in concentrations of up to 36mg/L in groundwater samples collected in the Amendment area (see Table 17). A dilution factor of 7.5 or greater would result in iron leachate concentrations being within the background range, and a dilution factor of 27 would be required for leachate concentrations to comply with the STV. Whilst the above dilution factors are not considered unrealistic, ATA Environmental (2005b) recommended that any strategy to lower the regional watertable (and hence potentially increase iron groundwater concentrations) include a water quality treatment and management strategy.

The problems associated with groundwater use (taste, staining, pipe blockages) etc. could be managed by a regional policy preventing the installation of new groundwater bores within the Amendment area. Existing bore users may need to be compensated for the loss of the use of their bore, or deeper bores installed to maintain the quality of their water supply.

In addition, treatment systems may need to be installed at the point of discharge into sensitive surface water receptors. The simplest system would involve the flocculation of dissolved iron and removal from the water body, which would also aid in the reduction of other metal concentrations through co-precipitation processes.

The calculated leachate concentration of selenium (0.14mg/L) was also higher than the corresponding STV of 0.05mg/L. The leachate concentrations were calculated using soil concentration data, and for selenium all 118 soil samples analysed had a selenium concentration below the limit of reporting (5mg/kg). Concentrations reported as below the limit of reporting were given a value equal to half the reporting limit, prior to calculation of the summary statistics (single-value substitution). Although this method of correction is frequently used, it can lead to misleading summary statistics, particularly when a large fraction of the data set is left-censored. For example, use of this approach for selenium generated a finite mean concentration for selenium that is reflective of method detection limits rather than true ambient conditions.

Therefore, the calculated leachate concentration is only a very rough estimate at best. As indicated previously, the method used to calculate leachate concentrations does not take into account any attenuation processes such as adsorption onto clay or dilution in the groundwater aquifer. As indicated in ATA Environmental (2005b, pp38, Table 11) the default health-based dilution attenuation factor (DAF) used by the USEPA (2004) for 0.2ha sites is 20, which if applied to the C_w (i.e.0.14/20 = 0.007) the concentration of selenium in the leachate would comply with all but the most stringent (Fresh Water Aquatic Ecosystems) water quality criteria.

4.10.4 Potential Impacts

The lowering of the groundwater level, if implemented, may result in an increased risk that any ASS present in the areas to be drained will become acidic. The environmental, social and economic consequences that may result if acid sulfate soils are disturbed include (DoE 2003):

- Adverse changes to the water quality of the soil, groundwater, surface water, wetlands, watercourses and estuaries;
- Soil acidification;
- Degradation of water-dependant ecosystems and ecosystem services;
- Loss of habitat and biodiversity;
- Invasion and dominance of wetlands and waterways by acid tolerant water plants and plankton species;
- Loss of plant yield;
- Poor quality water sources for stock, irrigation and human use;
- Bared soil surfaces in discharge areas;
- Increased human health risks associated with arsenic, aluminium and other heavy metal contamination in surface and groundwater, and acid dust;
- Loss of visual amenity from rust coloured stains, scums and slimes from iron precipitates;
- Corrosion of metallic and concrete structures (concrete cancer) such as roads, bridges, pumps, drainage pipes and foundations;
- Blockage of perforated plastic pipe drainage systems by iron precipitates;
- If houses or other urban infrastructure are built directly on acid sulfate soils that are being exposed to oxygen, there is a risk that structural damage to houses will take place; and
- Financial burden of treating and rehabilitating affected areas, and maintenance of infrastructure.

4.10.5 Management Strategies

The work completed during the Stage 1A investigation has assembled a large and useful body of data on the geology of the Amendment area and the potential for acidification to occur. The data from this stage of investigation suggests that it may be possible to complete the development using a design based on controlled drainage without extensive acidification occurring. It is envisaged that approval for the use of drainage will only be given by EPA/DEC if a high degree of confidence exists that extensive acidification is unlikely to occur as a result of its implementation.

Before a development strategy based on lowering the water table by drainage is put forward for approval, the following additional investigation work will be undertaken:

- Before detailed design of any drainage system commences, the next stage of soil sampling will be implemented. This will involve sampling on a nominal 500m grid within the groundwater control areas that were not sampled in the Stage 1A investigations. The soil analytical suite for the next stage of sampling will be expanded to include soil metal leachate concentrations, with both deionised water and/or acetic acid used as leaching solutions.

- The scope and nature of an additional testing regime involving kinetic acidity testing to allow an assessment of the response of potentially acidic soils to long term exposure to oxidising conditions over time is being determined by the ARA in discussions between the consultant team for the project, CSIRO and staff from the Land and Water Quality Branch of the DEC. It is recognised that such testing would be useful to assist assessment of the long-term impacts of potentially acidic soils being exposed due to lowering of the water table.

As part of the WIPS process, the ARA will develop a Strategic Acid Sulfate Soil Management Plan (SASSMP) with the aim of providing practical, cost-effective and environmentally acceptable soil and water management techniques for development of the entire Amendment area.

The SASSMP will outline to a level of detail satisfactory to the DEC, tailored to suit the approach to implementation of controlling groundwater levels (i.e. whether on a staged development basis or overall regional basis), the treatments required for each of the soil types identified (up to 5m below ground level (BGL)) and describe the management/treatment options for ground and surface waters. It will also include a specification of ongoing monitoring and compliance and proposed contingency measures in the event the agreed performance criteria are not met.

The SASSMP will provide guidance on the broad-scale aspects of the development. . It is envisaged that the SASSMP will include detailed guidelines that provide guidance on the design and management philosophies that will need to be adopted by developers. The SASSMP will also detail the nature an extent of any further ASS investigations including field or pilot scale trials of management techniques for soil or drainage waters if they have not been demonstrated to be effective in the development setting. It is envisaged that the ARA would undertake any field trials that may be required to prove the efficacy of proposed management measures but that further soil sampling, beyond that described above, to provide more detailed spatial data on the distribution of acid sulfate soils will be completed by developers as part of the subdivision approval process.

The ARA recognises that the use of a drainage system to control water table levels will only be approved if it is considered that the risk of acidification is extremely low. Notwithstanding, it is considered appropriate that the design of the drainage system incorporate contingency measures that would allow for the treatment of drainage waters in the unlikely event that monitoring results suggested that acidification was occurring. Such treatment measures would only be implemented in the event that monitoring programs suggested that the early signs of acidification were present.

Although it is not possible to determine accurately either the need for, or scale of treatment that would be required at this time, the SASSMP will include conceptual information on contingency measures that could be adopted.

The final SASSMP and any associated design and management guidelines will be approved by the DEC and the City of Armadale as the responsible local government authority. It is likely that the SASSMP will be revised periodically in consultation with the DEC and the City of Armadale on the basis of the results of any field trials and ongoing monitoring programs.

An Acid Sulfate Soils Management Plan (ASSMP) will be required to be prepared and implemented for each Structure Plan area, depending on outcomes of the SASSMP. The ASSMP will be a requirement of guidelines to be adopted under Part 4 of the Scheme in respect to the preparation and assessment of structure plan/and/or subdivision.

4.10.6 Predicted Outcome

Based on the results of field and laboratory studies undertaken, knowledge of the extent of the development and mitigation or procedural controls proposed, it is considered that the implementation of the proposed redevelopment of the Wungong Urban Water Master Plan area can be managed to meet the EPA's objectives in relation to Acid Sulfate Soils.

4.11 Air Quality – Dust, Gaseous Emissions and Odour

4.11.1 EPA Objectives

To ensure that emissions do not adversely affect environment values or the health, welfare and amenity of people and nearby landuses by meeting accepted guidelines, standards and criteria.

4.11.2 Applicable Legislation, Criterion or Guidance

- Western Australian Planning Commission (1997) Statement of Planning Policy No. 4 - *State Industrial Buffer Policy*.
- Western Australian Planning Commission (2004) Draft Statement of Planning Policy No. 4.1 - *State Industrial Buffer Policy*.
- Environmental Protection Authority (2000b) *Prevention of Air Quality Impacts from Land Development Sites*. Guidance Statement No. 18, Environmental Protection Authority, Perth.
- Environmental Protection Authority (2005a) *Guidance for the Assessment of Environmental Factors: Separation Distances between Industrial and Sensitive Landuses*, No. 3, June 2005.
- Department of Environmental Protection (2000) *Perth Air Quality Management Plan*.
- Department of Environmental Protection (2000) *Air Quality and Air Pollution Modelling Guidance Notes.*
- *Environmental Protection Act 1986*
- National Environment Protection (Ambient Air Quality) Measure.
- National Environment Protection (Air Toxics) Measure.
- Environmental Protection Authority (2002b) *Interim Guidance on Odour as a relevant environmental factor*. Guidance Statement No. 47.

4.11.3 Existing Environment

Dust and Particulates

Dust is considered to be fine solid particles in the size range from 0.1 to 100 microns (μ) (1 micron = 0.001mm). Deposited matter and larger fraction dust (>50μ) are commonly identified as a neighbourhood nuisance. These may result from natural processes, or anthropogenic (man generated) activities such as may occur during land development. Dust particles less than 10μm are of concern as they have a greater capability to penetrate the lungs and are often generated by mechanical grinding activities in industry and emissions from internal combustion engines.

Fine particulate matter generated in large quantities in urban centres is increasingly being identified as posing a significant health risk to humans. The increasing awareness of the effect of airborne particles on health has seen a general move away from concern and measurement of TSP (Total Suspended Particulate) to PM_{10} (sub-10μ particles). Several standards for even smaller particles, for example $PM_{2.5}$ (sub-2.5μ particles) have been set or are currently being considered.

In recognition of the fact that land development sites can generate wind-borne dust which may adversely impact on nearby and downwind landuses, the EPA has released guidelines for the prevention of dust (and smoke) from such sites (EPA Guidance Statement No. 18: Prevention of Air Quality Impacts from Land Development Sites 2000). This guidance statement sets best-practice standards for land clearing in relation to air quality impacts.

The main objectives of the guidance statement are:

- To clearly define the role and responsibilities of developers, engineers, contractors, local government and the DEP in the control of dust and smoke from land developments.
- To provide a procedure whereby the potential of a development site to cause pollution is assessed before site works start.
- To put in place measures and contingency arrangements to minimise dust leaving the site during and after development of the site.

The guidelines identify factors that should be considered and describes appropriate measures to stabilise disturbed areas during development in order to minimise the generation of dust and potential for adverse impact on surrounding sensitive premises.

The sources of dust present in the atmosphere are numerous and range from point sources such as industrial activities, to rural activities or natural sources. In the Perth Metropolitan Region, major sources of atmospheric dust include vehicle emissions and solid fuel heaters (DEP 2000). Potential dust sources within and in proximity to the Amendment area include open areas susceptible to wind blown dust such as paddocks, unsealed trafficked areas, earthworks associated with rural activities (farming, market gardens, orchards and vineyards) or development and maintenance of infrastructure (roads). The location of these potential dust sources are shown in Figure 14.

The potential for nuisance dust generation is dictated by the condition of the soil (soils with a higher moisture content are less susceptible to generating dust) as well as wind conditions. Windy conditions are experienced from late winter through spring and summer. The prevailing winds in July and August are west, northwest and north, while summer winds deviate from the southwest through to the south and east. Summer wind patterns are most conducive to dust generation, and hence mitigation strategies to control dust are especially required during the summer months.

Gaseous Emissions

The major sources of pollutant relevant international standards are presented in Table 19 below.

There are limited point sources of gaseous emissions within the Amendment area (Figure 14). Key sources of gaseous emissions outside the Amendment area boundary include clay brickworks (South Armadale Brickworks) and cement products manufacturing facility (BGC concrete batching plant) both located to the east of the Amendment area. The Amendment area boundary was recently modified in the vicinity of the brickworks to reflect that planning approval had previously been granted by the WAPC to the landowner prior to the moratorium on development being introduced by the ARA. A minimum 600m buffer from the brickworks facility boundary will be maintained within the Amendment area. The cement works is approximately 70m from the Amendment area boundary.

Table 20 indicates that the generic buffer distances that are taken into account in the absence of site-specific modelling studies are 300m to 10000m for both clay brick and cement products manufacturing. At the time that land is proposed to be developed in close proximity to these premises, consideration is required to be given by developers to ensure conflict is not introduced and that generic buffers are not compromised prior to developers undertaking site-specific modelling studies as part of the structure planning process.

A number of major transport routes (Forrest Road, Rowley Road, Tonkin Highway) pass through the Amendment area and with the redevelopment of the Amendment area, increased vehicle journeys will result that have the potential to increase the amount of gaseous emissions presently occurring within the Amendment area.

Figure 14 shows the location of a number of orchards and market gardens currently located within the Amendment area (this information has been based on air photo interpretation and ground-truthing).

Odour

Most odour complaints against industry have centred around animal products processing activities such as poultry farms and processing, rendering works, piggeries, tanneries and cattle feedlots, although sewage treatment plants, landfill sites, composting facilities, soil blenders, fibreglass works and hot mix asphalt plants have also been significant sources of public complaint.

Based on a review of aerial photography and a brief site inspection, some areas within the Amendment area primarily rural or rural-residential with the dominant landuse being cattle grazing, horse agistment. Other landuses that are either existing or proposed could have implications for development of the landholdings both in the short and long-term depending on the eventual staging of urban development. These include, the Westfield sewer pumping station (located near corner of Tonkin Highway and Armadale Road), the landfill (located to the south west of the Amendment area), orchards, vineyards, poultry farms and plant nurseries either within or in close proximity to the Amendment area,. These landuses are shown on Figure 14.

According to the landuses and associated buffers presented in the Southern River/ Forrestdale/Brookdale/Wungong District Structure Plan (WAPC 2001a), development of some of the eastern landholdings could be impacted by poultry farms, located to the east of the Perth-Bunbury railway line, if these premises continue to remain operational. Existing cement products manufacturing works and brickworks do not at present a significant risk where operating licence conditions imposed on these facilities are adequately met.

TABLE 19
GASEOUS AIR POLLUTANTS, SOURCES AND GUIDELINES

POLLUTANT	MAJOR SOURCES	EFFECTS / COMMENTS	WHO[1]/ NEPM[2] GUIDELINES
Carbon monoxide (CO)	Motor-vehicle exhaust; some industrial processes	poisonous to humans when inhaled. CO reduces the oxygen carrying capacity of blood and places additional strain on the heart and lungs	**WHO** Health guidelines: 10 mg/m^3 (10 ppm) over 8 hr; 30 mg/m^3 over 1 hr (25 ppm). **NEPM** 9ppm 8 hr ave. not to be exceeded more than 1 day/yr
Sulphur dioxide (SO_2)	Minor contribution from mobile sources. Heat and power generation facilities that use oil or coal containing sulphur; sulphuric acid plants.	A human irritant, SO_2 undertakes atmospheric reactions to contribute to acid rain	**WHO** Health guidelines: 350 µg/m^3 (0.122 ppm) over 1 hr; 500 µg/m^3 over 10 min (0.175 ppm). **NEPM** 0.20ppm 1 hr ave. not to be exceeded more than 1 day/yr, 0.08 ppm 24 hr ave. not to be exceeded more than 1 day/yr, 0.02 ppm annual ave. not to be exceeded more than 1 day/yr
Carbon dioxide (CO_2)	All combustion sources.	Health hazard at high concentrations. Possibly injurious to health at concentrations greater than 5,000 ppm over 2-8 hr;	**NEPM** 9.0 ppm 8 hr ave. not to be exceeded more than 1 day/yr,
Lead (Pb)	Added to some fuels, Pb is emitted from motor-vehicle exhaust; lead smelters; battery plants	Affects intellectual development in children.	**WHO** Health guideline: 0.5-1 µg/m^3 over a year. **NEPM** 0.5 µg/m^3 annual average not to be exceeded.
Nitrogen oxides (NO, NO_2)	A side effect of high combustion temperatures causing bonding of nitrogen and oxygen in Motor-vehicle exhaust; heat and power generation; nitric acid; explosives; fertilizer plants.	Irritant, precursor to photochemical smog formation. React with hydrocarbons and sunlight to form photochemical oxidants.	**WHO** Health guideline: 150 µg/m^3 (0.08 ppm) over 24 hr; 400 µg/m^3 over 1 hr (0.21 ppm) for NO_2; **NEPM** (NO_2) 0.12 ppm 1 hr ave. not to be exceeded more than 1 day/yr, 0.03 ppm 1 annual ave. not to be exceeded
Photochemical oxidants (primarily ozone [O_3]; also peroxyacetyl nitrate [PAN] and aldehydes)	Formed in the atmosphere by reaction of nitrogen oxides, hydrocarbons, and sunlight.	An irritant, Photochemical oxidants contribute to haze, material damage, and, aggravates respiratory illnesses.	**WHO** Health guideline: 150-200 µg/m^3 (0.076-0.1 ppm) over 1 hr; 100-120 µg/m^3 over 3 hr (0.05-0.06 ppm). **NEPM** (O_3) 0.1 ppm 1 hr ave. not to be exceeded more than 1 day/yr, 0.08 ppm 4 hr ave. not to be exceeded more than 1 day/yr,
Particulates as PM_{10}	Stack emissions, vehicle exhausts, open land areas.	Adverse respiratory and health implications.	**NEPM** 50 µg/m^3 24 hr ave. not to be exceeded more than 5 days/yr,
Non-methane hydrocarbons (includes ethane, ethylene, propane, butanes, pentanes, acetylene)	Either unburnt or evaporative Motor-vehicle emissions; solvent evaporation; industrial processes; solid waste disposal; fuel combustion.	irritant, cancer risk, odour, precursor to photochemical smog formation. React with nitrogen oxides and sunlight to form photochemical oxidants.	

[1] Word Health Organisation [2.] NEPM

4.11.4 Potential Impacts

Dust

As development expands there is inevitably a rise in the level of activities that may cause deterioration in air quality. Communities become increasingly concerned about possible health and environmental effects. Aggrieved members of the public may contact the developer, their contractors or LGA in an attempt to bring about resolution of this matter.

TSP is typically associated with adverse aesthetic effects rather than health effects. These particles tend to settle out on surfaces causing soiling and discolouration. Being larger particles, TSP settles from the atmosphere quickly, falling within a short distance of the source with a distribution dependent on ambient conditions (wind speed / direction) to determine impacted area. TSP values in the Perth Metropolitan area declined over the period 1992 to 1999 (DEP 2001).

Inhalable particles are associated with increases in respiratory illnesses such as asthma, bronchitis and emphysema, with an increase in risk related to their size, chemical composition and concentration. Particles in the PM10 size fraction have been strongly associated with increases in the daily prevalence of respiratory symptoms, hospital admissions and mortality (NEPC 1998). Being fine aerosols, PM10 particles remain in suspension over extended periods, being removed largely by wet deposition.

The PM10 monitoring sites in the Perth Metropolitan area have shown little variation in their annual mean daily maximum 24-hour PM10 concentrations from 1992 to 1999 (DEP 2001).

Potential impacts from dust emissions on existing landusers within the Amendment area are not considered to pose a significant risk. Upon the commencement of staged development works, there will be a potential for additional cleared areas to be exposed and susceptible to dust. This potential for dust impacts are expected to be temporary and will be mitigated as the development progresses thereby reducing the area of exposed land. Notwithstanding, measures will need to be employed to minimise dust emissions from active areas and to stabilise exposed areas during site earthworks and associated development activities.

As detailed in Section 4.11.3, landuses within the Amendment area comprise residential, rural, horticultural and commercial landuse. There is a likelihood that these activities may contribute to soil contaminants such as pesticides, heavy metals, and/or hydrocarbons. The actual likelihood of soil contamination will need to be established prior to development by conducting a site-specific review of historical activities, and verified by collecting some soil samples for analysis. Figures 12 and 14 delineate “high risk” areas of contamination where activities with significant potential to cause site contamination currently occur, or have occurred in the past.

Earthworks associated with remediation and/or development of potentially contaminated areas may result in the generation of dust containing concentrations of pollutants other than PM10. Accordingly, depending on the outcome of further contaminated sites investigations for specific risk areas, additional management measures may need to be employed to monitor and control the generation of dust from these areas.

Gaseous Emissions

Specific comments in relation to gaseous air pollutants are provided in Table 19 above.

Air quality in Perth is described in DEP 2001. This report summarises air monitoring data for five National Environment Protection Measure (NEPM) air pollutants; carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), sulfur dioxide (SO_2), and particulate matter, from 21 air monitoring stations for the period from January 1992 to December 1999. The Perth Air Quality Monitoring System (AQMS) includes a station at Kenwick to the northwest of the Amendment area.

The review of the air quality data concludes that although Perth's air quality is relatively satisfactory for the majority of the time, there are a number of days on which it displays diminished quality. Results indicate an increase in O_3 concentrations and regular exceedances of both O_3 and particle standards each year linked principally to emissions from mobile sources (DEP 2001). These emissions are spread along the road system largely as a function of traffic density, and as a consequence are reflected in local as well as regional air quality results.

Exposure to high concentration of particulate matter may result in irritation of the eyes and respiratory tract, damage to lung tissue and decrease in lung function. Because of their acidic properties, acid gases can act as an irritant, particularly under conditions of high humidity. Vegetation damage is also known to occur at low concentrations of some acid gases.

Potential impacts that need to be considered during site contamination remediation include dust and particulates and gaseous emissions.

Odour

A number of potential odour sources located both within and surrounding the Amendment area may result in loss of amenity to future residents. These odour sources include the Water Corporation's Westfield pumping station, landfill site on Hopkinson Road, poultry farms, flower nurseries, horse stables and market gardens.

The Water Corporation Westfield Main Pumping Station servicing the South East Corridor is located in the northwest corner of the Amendment area. This pumping station will be expanded in capacity to approximately 1300 litres/second at ultimate capacity. A buffer of 300m is proposed for the pump station. The Corporation also has plans to construct and operate a wastewater recycling plant at this site. A buffer of 500m from the inner plant boundary is sought by the Water Corporation (M. Thurner pers. comm.). As yet the Corporation is unable to identify the final location of the recycling plant within its landholding. Accordingly the 500m buffer as shown on Figure 14 has been taken from the lot boundary and will be modified subject to final siting of the plant.

Odorous air pollutants are often judged important primarily for their nuisance value and the number of complaints they generate. In only a few cases are there adverse health effects documented in measurable physiological terms. However, odours detected from the treatment of biological wastes may indicate contamination of the air by pathogens.

Odour nuisance is generally defined by the FIDO factors: Frequency, Intensity, Duration, and Offensiveness. In the quantification of odour nuisance problems, frequency refers to the number of times an odour occurs, intensity refers to the strength of the odour, duration refers to the length of time the odour is encountered, and offensiveness refers to the unpleasantness or character of the odour. Australian Standard 4323.3 (AS/NZS, 2001) describes a method for the determination of odour concentration by dynamic olfactometry.

As with other air pollutants, an odour dispersion model can be used to predict the environmental odour impact and become a regulatory tool. A number of models have been used to predict odour concentration near a source. Modelling is undertaken on the basis of the findings of the odour panel and impacts of local measured weather conditions.

4.11.5 Management Strategies

As part of the WIPS process, a broad scale Air Quality Management Plan (AQMP) consistent with Best Management Practice will be prepared by the ARA to the satisfaction of the DEC and other relevant authorities to ensure that emissions do not adversely affect environmental values or the health, welfare and amenity of people and landuses by meeting accepted guidelines, standards and criteria and consistent with Best Management Practice.

Implementation of the AQMP will be a requirement of guidelines to be adopted under Part 4 of the Scheme in respect to the preparation and assessment of structure plan/and/or subdivision.

Dust

Dust management at development sites within the Amendment area will need to comply with conditions prescribed in development approvals and/or EPA Guidance Statement No. 18 *Prevention of Air Quality Impacts from Land Development Sites* (Environmental Protection Authority 2000b) which provides guidance on the implementation of nuisance dust control over development sites greater that 2000m^2 in area.

Key elements of the guidance documents and the AQMP will include dust management plans taking into account seasonal influences and distance to sensitive premises and incorporating any or all of the following measures:

- Where possible retaining vegetation;
- Limiting areas of exposed soil;
- Hydro-mulching or alternative effective stabilisation immediately following completion of bulk works;
- Use of water to increase moisture in soil in sensitive or high traffic areas;
- Minimising “fetch” distance;
- Wind fencing;
- Timing of earthworks (daily and seasonally);
- Consideration of wind direction and strengths when planning bulk earthwork ‘cells’;
- Consideration of distance to and direction of sensitive locations (eg may construct closer to residents during time of year when dust not expected to be as much of a problem etc);
- Appropriate shape/layout of earthworks area (boundary perpendicular to problem wind direction);
- Staging of subdivision (need to consider dust in the early stages of planning, not just at time of construction); and
- Site perimeter monitoring including high level alarms or dial out capability where predetermined trigger levels indicate potential exceedances of prescribed standards such as those specified for PM_{10} in Schedule 2 of the *National Environment Protection (Ambient Air Quality) Measure*.

Adopting a range of these measures on a site-specific basis will limit potential dust impacts arising from the redevelopment of the Amendment area.

During implementation of civil works or remediation of potentially contaminated areas (including excavation, stockpiling, handling and offsite disposal via trucks), a programme to minimise the likelihood of emissions and monitoring of these impacts will be established. Subject to the nature and extent of soil contamination in the area, and the proximity to sensitive premises, the programme will include:

- Procedures for controlling dust lift off during handling of contaminated material, such as the use of water carts, wind fencing or mulching;
- Implementation of regular visual inspections of exposed areas susceptible to dust in order to maintain a proactive approach to dust mitigation;
- Development of specific air quality targets and goals to assess performance and compliance;
- Establishment of a dust monitoring network to determine the extent of dust impacts and if appropriate, the relative concentrations of pollutants of concern. Monitoring equipment will be selected on the basis of soil constituents and surrounding landuses, but may include the use of Hi-Volume dust samplers, continuous aerosol monitoring (DustTrak) or (Tapered Element Oscillating Microbalance (TEOM) used for real time small particle dust monitoring;
- Development of an internal and external reporting protocol in the event of an exceedance of adopted criteria; and
- Implementation of a complaints handling protocol to receive and respond to legitimate complaints in relation to dust.

Gaseous Emissions

Control of air pollution is part of a larger process of air quality management. There are five components in the air quality management cycle:

1. The measurement and monitoring of ambient air quality.
2. The assessment of what the air quality measurements mean and their impacts on the environment.
3. Setting of goals in the management process, with these goals for air quality management becoming the ambient air quality standards.
4. Establishing an air quality management plan to achieve the goals which have been set.
5. Implementing air pollution controls and other activities to follow the air quality management plan.

The Perth Air Quality Management Plan (AQMP) (DEP 2000e) puts in place a broad strategy based on this model that in part addresses major contributors to diminished air quality consistent with Australian and international practice. Traffic management is an element of the Perth AQMP. Traffic management can improve the flow of traffic on the roads, reducing emissions per vehicle kilometer traveled and enhancing urban mobility.

A combination of traffic engineering measures, demand management measures, and measures giving priority to public transport vehicles will be embodied in the road system design in high volume travel demand corridors within the Amendment area.

Vehicle emissions within the Amendment area during the construction phase will need to comply with the Environment Protection and Heritage Council (EPHC) National Environment Protection Measures (NEPMs), Ambient Air Quality Measures, 1998 and National Environmental Protection (NEP) Air Toxics- Air Quality Measures, 2003 (Draft) and other applicable guidance.

Where contaminated site remediation management plans are required, they will need to address management of dust and particulates and gaseous emissions, as appropriate.

Odour

Management options include the exclusion of residential development close to odourous site in keeping with EPA and WAPC guidance. Generic industrial buffer distances are specified in Environmental Protection Authority (2005a) *Guidance for the Assessment of Environmental Factors: Separation Distances between Industrial and Sensitive Landuses*. However, ideally a site-specific technical analysis should be undertaken to determine appropriate buffer areas following modelling of odour impact zones to agreed criteria.

Where on-site buffer separation cannot be provided by an industry, a range of mechanisms for securing buffer areas is set out in Appendix 2 of WAPC (2004). These include economic mechanisms / direct acquisition, land exchanges, acquisition of rights in lands to restrict development, payments to industry and relocation of industry, amongst others.

Methods available for controlling odour emissions from industrial point sources include:

- Condensation;
- Incineration;
- Wet scrubbing;
- Entrainment separators, venturi scrubbers and spray-type scrubbers;
- Gas scrubbing stages containing chemical oxidants;
- Activated-Carbon adsorption columns; and
- Biofiltration.

Traditional methods developed for the control of industrial organic chemicals are generally inappropriate for use in the control of odours from diffuse sources (such as waste treatment lagoons), because of low chemical concentrations, complex compositions and large airflow volumes.

Some methods available for controlling odour emissions from diffuse sources include:

- Exclusion of development close to the site (buffer zone).
- Ensuring that the operation is carried out under best management practice.
- The management of odours from industrial sites is achievable, although generally capital intensive. The most acceptable solution is avoidance of the odour in the first instance by the implementation of cleaner production practices, substitution of odorous substances or practices, and good site management.

Buffers

Buffers separating residential areas and potential conflicting landuses may be required to be maintained due to the potential for impacts from spray drift, noise, odour, dust, fugitive light and other emissions. In the absence of site-specific studies, the EPA typically recommends separation distances to sensitive landuses as identified in Table 20 (Environmental Protection Authority 2005a).

The Master Plan shows that the land located within the Hopkinson Road landfill site buffer is subject to 'Restricted Development' until such time as the landfill site ceases operation and/or the Master Plan is amended.

TABLE 20
RECOMMENDED SEPARATION DISTANCES TO SENSITIVE LANDUSES

LANDUSE	SOURCE TYPE	RECOMMENDED SEPARATION DISTANCE
Orchards and Market Gardens	Diffuse	500m
Class 2 Landfill	Diffuse	500m for sensitive uses (subdivisions), 150m for single residences & an internal buffer of 35m from boundary
Plant Nurseries (no composting)	Diffuse	100m
Horse Stables [1]	Diffuse	100m – 500m
Dog Kennels (in vicinity of Urban)	Diffuse	500m
Cattery	Diffuse	200m
Clay Brick Manufacturing [1]	Point	300m - 1000m
Concrete batching plant or cement products (bricks) manufacture[1]	Point	300m – 1000m
Metal Fabrication[1]	Point	500-1000m
Milk processing	Point	200m-500m
Vineyard (viticulture)	Diffuse	500m
Wastewater Pumping Station[1]	Point	20m – 150m
Piggery [1]	Point/Diffuse	500m – 5000m

Source: Environmental Protection Authority (2005a)
[1] Separation distance dependant on size of works/capacity

An Agricultural Practice and Implementation Plan may need to be prepared for land proposed to be developed within close proximity of market gardens, commercial plant nurseries and/or orchards in keeping with the WAPC's Planning Bulletin No. 63: *Policy for Dealing with Potential Conflicts between Residential Subdivision and Market Gardens in East Wanneroo* (Western Australian Planning Commission 2003). The Plan will be required to consider spray drift as the principle issue of concern, but also potential noise, dust and odour impacts on the proposed development and implementation of prescribed management measures to ameliorate conflict. These plans may need to be prepared by developers as a part of the subdivision approval process.

The provisions of this policy do not apply where a market garden is planning to relocate prior to the release of the lots in the residential subdivision. In this case, the proponent will need to provide to the WAPC evidence of the intended close such as a statutory declaration, written undertaking form the market gardener, unconditional offer and acceptance for the sale of the property or removal of market garden infrastructure (WAPC 2003).

Where applicable, an Agricultural Practice and Implementation Plan will be prepared by the developer in respect to the preparation and assessment of a subdivision plan.

4.11.6 Predicted Outcome

Based on the results of field visits undertaken, contemporary dust control measures to be adopted and management plans to be prepared, it is considered that the implementation of the proposed redevelopment of the Wungong Urban Water Master Plan area can be managed to meet the EPA's objectives in relation to Dust, Gaseous Emissions and Odour.

4.12 Air Quality – Greenhouse Gases

4.12.1 EPA Objective

To minimise emissions to levels as low as practicable on an on-going basis and consider offsets to further reduce cumulative emissions.

4.12.2 Applicable Legislation, Criterion or Guidance

- Environmental Protection Authority (2002c) *Guidance Statement for Minimising Greenhouse Gas Emissions*, Statement No. 12 October 2002.
- Western Australian Greenhouse Task Force (2004) *Western Australian Greenhouse Strategy*.
- Environmental Protection Authority (2004e) *Towards Sustainability. Position Statement No. 6*. Perth. August 2004.

4.12.3 Existing Environment

Since the pre-industrial era, human activities are known to have significantly increased the atmospheric concentrations of greenhouse gases with average temperatures today being about 0.7 degrees higher than 100 years ago. There have been significant changes in rainfall patterns, such as the decline in the south-west of Western Australia (Environmental Protection Authority 2004).

The Third Assessment Report of the Inter-governmental Panel on Climate Change (IPCC) concluded that 'most of the warming observed over the last 50 years is attributable to human activity' (IPCC 2001). The modelling in the Third Assessment Report shows that the best case scenario of predicted increase in temperature, based on the most optimistic estimates of fossil fuel use reduction and cautious interpretation of the science, is a further 1.5 degrees by the end of this century. The model predicts associated changes in rainfall and sea level, as well as in the frequency and severity of extreme events. Even under this optimistic scenario, there is clear potential for serious impacts on human life particularly in agriculture and the pattern of settlement, and on natural systems such as forests and bushland.

The 1997 Kyoto conference saw recognition by leaders of the world community that climate change demands concerted political action. Under the Kyoto Protocol the developed world as a whole, which has been responsible for about 80 per cent of the human production of greenhouse gases from fossil fuels, is obliged to reduce emissions to 95 per cent of the 1990 level by the 2008-2012 period. Greenhouse gases covered by the Kyoto Protocol to the United Nations Framework Convention on Climate Change are carbon dioxide, methane, nitrous oxide, ozone, hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride. The major direct and indirect greenhouse gas emission relevant to the Amendment area is carbon dioxide.

Australia has ratified the Framework Convention but not the Kyoto Protocol. During the recent United Nations Climate Change Conference in Montreal, more than 150 nations endorsed the need to extend the effective timeframe of the protocol. Whilst Australia did not support the motion, Australia's 1997 commitment to limit its emissions (up to 2012) to 108 per cent of the 1990 figure stands.

The National Greenhouse Strategy (Commonwealth of Australia 1998) provided some information as to the implementation of Australia's commitment within the Kyoto Protocol framework. Whilst the strategy currently does not define the apportionment of Australia's

carbon 'budget' between States or between different activities, it is prudent for WA to contribute to the national effort to meet Australia's overall target.

The EPA's position with respect to greenhouse gas issues is detailed in the EPA's Guidance Statement No. 12: Minimising Greenhouse Gases (Environmental Protection Authority 2002c). Whilst the Guidance is mainly applied to projects of an industrial nature, it has some relevance to the proposal in that it reflects the intent of sustainability principles raised in the EPA's *Towards Sustainability'* Position Statement (Environmental Protection Authority 2004e) where initiatives should take into account the relative importance and opportunities for reduction in various areas such as agriculture, manufacturing, commercial energy use, domestic energy use and transport. They should also adopt the simple principles that have guided the National Strategy, namely:

- The need to have a Greenhouse response which is tailored to Australia's national interests;
- The need to integrate Greenhouse considerations with other government commitments;
- The pursuit of Greenhouse action consistent with equity and cost effectiveness and with multiple benefits;
- Recognition of the importance of partnerships between governments, industry and the community in delivering an effective Greenhouse response; and
- The need for action to be informed by research.

The use of efficient technology should be encouraged at all levels, from domestic appliances to major industrial production facilities. More efficient technology brings economic benefits as well as reducing emissions.

4.12.4 Potential Impacts

During the redevelopment of the Amendment area, greenhouse gases will be released to the atmosphere as a result of:

- Decomposition of cleared vegetation and release of carbon from the soil as part of site development;
- Combustion of fuel utilised in mobile equipment during earthworks and sub-division development;
- Life cycle emissions related to the production, handling and use of raw materials for development of the project, and subsequent dwellings; and
- Direct emissions related to the generation, management and disposal of construction industry and domestic wastes.

Once the Amendment area is developed, the associated 'operational' greenhouse budget will be dictated by:

- The design of individual buildings and how these minimise energy demands, particularly in relation to seasonal heating and cooling;
- Indirect emissions associated with the consumption of power from the electricity grid for domestic use including heating and cooling;
- Direct emissions from the combustion of fossil fuels such as natural gas for domestic and cooling heating purposes;
- Direct emissions from the combustion of fuels associated with transport activities within and around the redevelopment envelope; and
- Direct emissions related to the generation, management and disposal of domestic wastes.

The pattern of development in urban areas has led to rapid growth in transport use. EPA Position Statement *Towards Sustainability* establishes that a sustainable community should be organised around the principle of making the services people want readily accessible. Mobility is a second-order priority, needed to cope with accessibility problems. The pattern of development also influences demand for various other services, ranging from supply of water and electricity to the management of waste.

The present pattern of transport contributes to environmental problems ranging from local air quality to global climate change. Given mobility of society, a serious issue for analysis is the sustainability of present transport patterns. Structural decisions taken now will influence choices for many decades, where much of the future transport tasks in Western Australia will be a direct consequence of the pattern of urban development (Environmental Protection Authority 2004).

Data collected on the fuel-efficiency of transport alternatives show that cars take twice as much energy per passenger-kilometre as the average for buses, four times the energy of tram or light rail systems, seven times the energy of electric trains and fifty times the energy of bicycles (Newman and Kenworthy 1999). This suggests that the order of preference for urban transport is an important matter to be evaluated on sustainability grounds. There is a link between infrastructure provision and the pattern of transport that should be addressed as part of the proposed redevelopment.

4.12.5 Management Strategies

The proposed redevelopment of the Amendment area is seen as an opportunity to increase utilization of 'greenhouse friendly' goods and services that take maximum advantage of new opportunities in response to climate change including:

- Application of best practice to maximise energy efficiency and minimise emissions;
- Comprehensive analysis to identify and implement appropriate offsets; and
- Proponents undertaking an ongoing program to monitor and report emissions and periodically assess opportunities to further reduce greenhouse gas emissions over time.

Building and design guidelines that relate to the management of the environment to meet environmentally sustainable objectives (including the reduction greenhouse gas emissions) have been previously presented in Table 4.

The Master Plan will also incorporate key environmental considerations such as the protection of urban bushland, and sustainable urban planning principles that consider housing density and the spatial relationship between housing and employment opportunities, housing and services as shops, schools and recreational facilities.

The Master Plan will offer the opportunity for individuals to maximize bicycle use thereby reducing the reliance on cars or heavier vehicles. Australia's National Cycling Strategy that sets out the principles for encouraging safe cycling will also be adopted as far as possible. The transportation planning study for the Amendment area is based on reduced number of car trips per household in accordance with Travel Smart principles. Requirements for road infrastructure is premised on this fact (refer to Figure 4a).

As part of its *Implementation Strategy for Sustainability*, the ARA has identified a number of key aspects of environmental sustainability that have relevance to the planning and development functions of the Authority (Armadale Redevelopment Authority 2004). These

have been discussed previously in Section 4.1.3, however, those that have particular relevance to Greenhouse include:

- **Promoting energy efficient and sustainable transport modes**: Planning Policies 12.8 and 1.9 on Urban Design and Movement, establish the ARA's position with regard to encouraging and facilitating options to the private car for personal travel, including walking, cycling and public transport. The Master Plan incorporates alternative transport pathways throughout the Amendment area.

- **Promoting energy and resource efficiency in the development process**: Through the application of its Design Guidelines and the development control process, the ARA will promote energy and resource efficiency and innovation in building design and technology, and in the use of materials.

- **Waste reduction, waste management and recycling**: The ARA will exercise its planning functions to ensure that developments within the Amendment area maximise efficiency in the use of natural, non-renewable resources, make appropriate provision for managing the waste products of human activity, and embody opportunities to collect and recycle suitable material wherever possible.

As part of the WIPS process and in keeping with the ARA's sustainability plan, a broad scale Greenhouse Gas Emissions Management Plan will be prepared by the ARA. The Plan will include measures to minimise greenhouse emissions from transport and minimise traffic impacts by reducing the need for car use through the provision and encouragement of public transport, walking and cycling.

Proposed developments within the Amendment area will be considered in the context of EPA Guidance Statement No. 12 *Minimising Greenhouse Gas Emissions* (Environmental Protection Authority 2002c), EPA Position Statement No. 6 *Towards Sustainability* (Environmental Protection Authority 2004), *the* DPI's *Liveable Neighbourhoods Community Design Code* (Western Australian Planning Commission 2004b), and the State Greenhouse Strategy as appropriate. The ARA has developed an online Sustainability Audit Tool to assess the sustainability performance of all development proposals (refer Section 4.1.3).

4.12.6 Predicted Outcome

Based on the results of studies undertaken, and management strategies proposed, it is considered that the implementation of the proposed redevelopment of the Wungong Urban Water Master Plan area can be managed to meet the EPA's objectives in relation to Greenhouse Gases.

4.17 Noise and Vibration

4.17.1 EPA Objective

To protect the amenity of residents from noise and vibration impacts resulting from activities associated with the proposal by ensuring the noise and vibration levels meet statutory requirements and acceptable standards.

4.17.2 Applicable Legislation, Criterion or Guidance

- Department of Environmental Protection (1997) *Environmental Protection (Noise) Regulations 1997*: *Summary of Regulations*.
- Department of Environmental Protection (2000a) *Road and Rail Transport Noise* Draft Guidance No. 14 (Version 3).
- Western Australian Planning Commission (2005a) Draft Statement of Planning Policy Road and Rail Transport Noise.
- Western Australian Planning Commission (2005b) Draft Statement of Planning Policy Metropolitan Freight Network.
- Western Australian Planning Commission (2005b) Draft Statement of Planning Policy 5.1 - Land Use Planning in the in the Vicinity of Perth Airport.
- Australian Standard *AS2670/1990 Evaluation of human exposure to whole body vibration.*
- Australian Standard *AS3671/1989 Acoustics – Road traffic noise-building siting and construction.*

4.17.3 Existing Environment

The Perth Metropolitan Region and South east Corridor Structure Plan (Ministry for Planning 1996) and the Southern River/Forrestdale/Wungong/Brookdale District Structure Plan (WAPC 2000) indicate significant growth is expected in areas including Gosnells, Armadale, Byford and Mundijong. The expected growth will result in increased travel and transport demand in the region. Planned changes to accommodate this increased traffic include extension of the Tonkin Highway from Gosnells to Mundijong (Main Roads 2001).

Noise and vibration can impact on the health, welfare and amenity of both current and future residents within the proposed Amendment area. The effects of high levels of noise can range from mild nuisance to sleep disturbance, and resulting potentially serious health impacts. Common sources of noisy activities include commercial or industrial premises, heavy vehicle transport on main roads, rail lines and some entertainment facilities. Domestic noise may also be prominent, with residential air conditioning, pool pumps and dog barking common sources of complaint.

Environmental noise can consist of:

- point sources (for example, fans and chimney stacks). The sound energy spreads out spherically, so that the sound pressure level is the same for all points at the same distance from the source, and decreases by 6 dB per doubling of distance); and

- a line source where the source is narrow in one direction and long in the other compared to the distance to the observer (such as a conveyor carrying aggregate, or it can be composed of many point sources operating simultaneously, such as a stream of vehicles on a busy road).

and derived from any or a combination of mobile sources (trains, planes and motor vehicles), domestic, industrial and commercial sources.

The most important factors affecting noise propagation are:

- type of source (point or line);
- distance from source;
- atmospheric absorption;

- wind;
- temperature and temperature gradient;
- obstacles such as barriers and buildings;
- ground absorption;
- reflections; and
- rain and humidity.

A range of control measures exist that if applied will reduce noise levels in the receiving community. Distance from source and frequency content of the noise is the most influential in atmospheric (or free field) attenuation of noise on flat terrain. In particular, low frequencies are not well attenuated by atmospheric absorption (Brüel and Kjær 2000).

Road Network

A comprehensive noise assessment was undertaken as part of the environmental investigations for the Tonkin Highway Extension from Mills Road West to link to the South West Highway in the vicinity of Jarrahdale Road (Main Roads 2001). The Tonkin Highway Extension forms the western boundary of the Amendment area, and accordingly noise and vibration data presented is relevant to this assessment. Current land use is a mixture of rural, semi rural and urban areas.

The existing noise level environment (2001) and the change in this environment (2006 and 2021) was considered during the noise assessment undertaken by Main Roads with noise level monitoring being undertaken at three locations:

- 20 Zenobia Terrace, Westfield
- 18A Allen Road, Westfield; and
- Lot 104 Stockmans Close, Oakford.

Noise monitoring locations 1 and 2 occur to the north of the Amendment area. Stockmans Close is located south of the Amendment area but would reasonably approximate rural / semi-rural background values prior to the development of the Tonkin Highway Extension.

At each of the measurement locations, an automatic noise data logger was utilized to measure hourly sound pressure levels in accordance with Australian Standard 2702-1984 (Acoustics – Method for Measurement of Road Traffic Noise). The logger records statistical data of which the L_{Aeq} L_{A10} and L_{A90} levels are reported (Main Roads 2001). Monitoring was undertaken on two occasions to obtain acceptable results. Calculations were made for the relative position of the lines of traffic for the following future flow rates:

- Year 2006 (soon after opening of the road project)
- Year 2021 (approximately 15-20 years after road opening)

The calculated noise levels were determined using the computer program ‘TNoise’ and based on a variety of input data such as percentage heavy vehicles, average propagation height (Main Roads 2001).

Average data from three monitored sites is included in Table 20 as are the modelling results.

Noise modelling carried out for Main Roads for the Tonkin Highway is reported in more detail in Herring Storer Acoustics (2002) *Tonkin Highway Extension Albany Highway to Mundijong Road Detailed Noise Modelling and Assessment Final Report*.

TABLE 20

AVERAGE $L_{A\ eq(8hour)}$ $L_{A\ eq(24hour)}$ AND $L_{A\ 10(18hour)}$ FROM SELECTED MONITORED DATA BETWEEN 18 SEPTEMBER – 5 NOVEMBER 1998

Loc[n]	Address	$L_{A\ 10(8hour)}$	$L_{A\ eq(24hour)}$	[1] $L_{A\ eq(18hour}$		
		1998	1998	1998	2006	2021
1	20 Zenobia Terrace Westfield	46	44	41	65	66
2	18A Allen Rd, Westfield	44	44	41	65	68
3	Lot 104 Stockmans Close Oakfield	45	44	42	62	65

Source Main Roads (2001)

Notes
$L_{A\ 10}$ Arithmetic average where the noise level is exceeded for 10% of the time.
$L_{A\ eq}$ Equivalent average noise level, normally expressed during the day or night.
[1] Modeled data (TNoise) showing Increase in noise levels due to Tonkin Hwy extension in 2006 and 2021. For assumptions, see Main Roads 2001.

Ministerial Statement (No. 595) published in June 2002 set conditions on the construction of the Tonkin Highway and includes a table of proponent commitments that Main Roads are required to implement as part of their environmental approvals. A Noise Management Plan required by commitment 13 is required to be implemented in accordance with the following conditions:

- Manage noise from the highway such that existing residents are not exposed to a noise level above $55dB(A)_{LAeqNight}$
- Adopt a 'best practicable' approach such that a noise level below $55dB(A)_{LAeqNight}$ will be investigated and implemented (Note: 'practicable' as defined by the Environmental Protection Act)
- Where future urban land has been zoned in the MRS allow land developers, where reasonable and appropriate, to construct noise management measures (noise walls or barriers) in the road reserve.

Traffic noise and vibration impacts on future residents will need to comply with the *Environmental Protection (Noise) Regulations*, specifically Draft EPA Guidance No. 14 (Version 3) *Road and Rail Transport Noise* (DEP May 2000), Western Australian Planning Commission (2005) *Draft Statement of Planning Policy Road and Rail Transport Noise* and with Australian Standard *AS2670/1990 Evaluation of human exposure to whole body vibration.*

Noise monitoring locations 1 and 2 occur to the North of the redevelopment area. Stockman's Close is located south of the redevelopment area but would reasonably approximate rural / semi-rural background values prior to the development of the Tonkin Highway Extension.

The Amendment area consists of a mixture of urban and rural developments with a significant heavy vehicle transport corridor (Armadale Rd classified as a District Distributor Type A road) forming the northern boundary.. Measured data indicates limited influence of mainly transport derived noise in semi rural areas, with modeled data indicating the increase in ambient noise due principally to additional transport noise.

Worley Parsons undertook a desktop traffic model of the Brookdale Master Plan (Worley Parsons unpublished report). The functional road hierarchy is presented in Figure 4a with

cross sections presented in Figure 4b. Forrest and Rowley Roads are designated District Entry Roads A and B respectively, with the former carrying forecast daily traffic volumes of between 10,000 and 13,000 vehicles (vpd) depending on road network design assumptions.

Worley Parsons notes that, based on professional judgement, roads forming the periphery of the Amendment area or roads connecting to Tonkin Highway or Armadale Rd (or providing direct links to these roads) could be expected to carry higher volumes of through traffic, possibly by an additional 2000 vpd. In contrast, the Armadale Rd to Rowley Rd segment of the Tonkin Highway is predicted to support 25,500 vpd in 2006, rising to 43,000 by 2021.

Rail Network

There are two main sources of noise and vibration relating to the operation of the rail network: the operation of trains and the maintenance and construction of rail infrastructure.

The level of noise associated with rail traffic is related to the type of engine or rolling stock used the speed of the train and track type and condition. The greater Perth metropolitan area is served by electric trains which are generally quieter than diesel, with areas affected by freight trains (eg Kwinana, Canning Vale) often experiencing higher noise levels than areas affected by passenger trains.

The problem of noise is compounded by the requirements of railway operations (especially night operations) and factors such as stopping patterns and topography which can lead to localised problems.

Rail noise can be considerable, but generally affects a far smaller group of the population than road or aircraft noise as it is generally confined to residents living along rail lines in urban areas (ABS 1997). While changes to locomotives and rolling stock mean that they have become quieter over the last few years, railway noise remains a problem because of longer, more frequent and faster trains and the build up of the urban environment.

The Perth to Bunbury Railway in part forms the Eastern boundary of the Amendment area. The service is currently limited to two trains daily (four train journeys) to Bunbury and intermediate stops in the form of the Australind Service. Based on current scheduling, the eastern precincts of the Amendment area will be subjected to noise and vibration as the Australind service passes through between approximately 0750 and 1830 daily.

The Australind is a twice daily narrow gauge diesel service on welded rail. The maximum speed in the Armadale area is 80 km/hour. Neither the City of Armadale nor Public Transport Authority has received complaints in relation to noise from the operations of the Australind service.

Aircraft

Perth Airport has main and cross runways located approximately 22km from the northern boundary of the Brookdale precinct of the Armadale Redevelopment Area. Aircraft landing on runway 03 and approaching from the South and departing from runway 21 and continuing to the South may travel over the Amendment area. The Standard Arrival Routes (STARS) for Perth Airport were modified in 2005 to reflect new operational requirements. Between 7000 and 9000 arrivals and departures of both jet and non-jet aircraft and helicopters occur monthly based on STARS.

However data from Airservices Australia (Air Services 2005a; Air Services 2005b; Air Services 2006a and Air Services 2006b) reviewing jet and non-jet aircraft movement and track information together with noise data over the most recently reported 12 months indicates that very few aircraft from Perth Airport over fly this area, and those who do generally do so at an altitude of between 3000 to 5000 feet (arrivals) and over 5000 ft (departures) respectively.

The Perth component of the Noise and Flight Path Monitoring System (NFPMS) has five permanently installed Noise Monitoring Terminals (NMT) the closest is located approximately 14 km from the northern boundary of the Brookdale precinct at the Gibbs St Primary School in Cannington. This NMT is located to lie directly below the South Eastern approach and departure from runways 03 and 21 respectively and is not relevant to the Amendment area.

Where noise events are relatively continuous or repetitive (such as departures from the Perth Airport), the total noise "dose" or cumulative noise exposure becomes an important factor in people's reactions to aircraft noise. Australian Noise Exposure Forecast (ANEF) provides a measure of the total aircraft-generated noise energy received at locations near an airport during a typical 24-hour period. The ANEF value at a given point near an airport is calculated by summing the noise energy received at that point from all of the aircraft operating into and out of that airport during a day, with an added penalty for night-time noise (flights after 10 p.m.). Points of equal ANEF value are then joined to form contours of equal noise exposure. At Perth Airport, an ANEF plan for the long-term airport capacity of 350,000 aircraft movements has been produced. It is expected that 350,000 movements will be achieved in approximately 50 years. The contours show the average daily aircraft noise exposure associated with the long term airport development, including extensions to and construction of new runways. The subject land falls outside the 20 ANEF (350,000 aircraft) contour.

Noise from Industrial Sources

Much of the Amendment area is undeveloped and background noise would reasonably approximate rural / semi-rural values. The Amendment area however abuts South Armadale where a number of established industrial and light industrial land uses occur. The former Brookdale Liquid Waste Treatment facility occurs in the North East corner of the subject land, although current land use is now limited to a sewerage pumping station.

Noise emissions from the range of industries identified from within the can originate from a number of operational and transport related sources within the Brookdale Redevelopment Area such as static mixers, metal cutting and finishing, cooling plant and compressors, truck movements and related management activities such as reversing beepers and external telephone horns.

The South Armadale Brickworks is the only significant heavy industry within or adjoining the redevelopment area. The boundary is over 500m from the redevelopment area and with the exception of related transport activities adding to traffic noise, this source is unlikely to be significant. A cement product manufacturing works producing paving bricks and other products and several light industries adjoin the railway reserve to the East of the Amendment area, but again with the exception of possible transport noise, these activities will only occur during daylight hours and are unlikely to exceed daytime criteria in areas identified for noise sensitive land uses.

Boundary inspections of each of these premises confirmed major noise impacts to be attributable to the transport aspects of the operation.

Noise from Commercial Buildings and Developments

Noise from shopping centres and entertainment venues such as taverns and nightclubs have potential to impact on nearby noise sensitive premises. The most likely sources of fixed or mobile plant noise from commercial premises include air conditioning and refrigeration plant, and possibly transport related aspects such as associated car parks or loading docks. Commercial activity centres are shown in the Master Plan presented in Figure 2.

The major commercial area within the Amendment area is proposed to be located in a North – South alignment from Eleventh Rd to the wetland buffer adjoining the Hilbert Rd wetland. A range of commercial premises including supermarket, café / restaurants and specialty stores are anticipated to be located within this 'main street' concept area. Entertainment venues may also be located within this area. Otherwise small community retail properties are identified centrally in each of the walkable catchments. Small service and convenience stores are anticipated to be located within these zonings.

Other commercial premises that need careful acoustic design to meet the noise regulations include service stations with carwash facilities, and fast food outlets.

Residential and commercial air conditioning units are a common source of neighbourhood noise complaints. Significant annual sales of residential and commercial air conditioning units in conjunction with increased levels of high density urban development represents significant potential for the an increased number of complaints from this source.

Construction Noise

Noise and vibration received at existing residences from construction equipment will need to comply with the requirements of the *Environmental Protection (Noise) Regulations* 1997 and specifically Regulation 13 'Construction Sites'.

Exposure to high noise (above 85 dBA) is common in the construction industry, and hearing loss is prevalent in the building trades. Hearing conservation programs in construction, which are the best defense against noise-induced hearing loss from occupational noise, usually depend on workers' use of hearing protection devices rather than noise controls. Accordingly these high construction noise levels may carry to adjoining noise sensitive premises.

The methods and techniques for construction to be adopted for development within the Amendment area may include any or all of the following:

- Earth moving and compaction;
- Precast concrete fabrication and site erection (including tilt-wall);
- Cast-in-place concrete formwork, shoring, pumping, and finishing;
- Metal process/plumbing piping shop fabrication and site erection;
- Heavy timber fabrication and site fabrication and site erection of wood trusses;
- Brick masonry site erection;
- Concrete masonry unit (CMU) site erection;
- Stone masonry manufacture and site erection;
- Site installation of Exterior Insulation Finishing Systems (EIFS);
- Glass curtain wall (including store-front construction) fabrication and site erection;
- Site construction of both plastic and metal utility piping;
- Ventilation and air conditioning (VAC) ductwork fabrication and site erection; and
- Electro-mechanical fitting out

Each construction process brings with it a range of potential environmental impacts, including noise, which can be managed through the implementation of contemporary control measured well understood in the construction industry.

4.17.4 Potential Impacts

Noise

Problems related to noise may include stress, high blood pressure, sleep loss, distraction and lost productivity, and a general reduction in the quality of life.

Implementation of the Redevelopment Master Plan will likely bring about additional noise and vibration impacts due to increased residential densities and transport. In a planning context, while noise-sensitive developments should ideally be separated from major sources of noise such as road and rail, this is often impractical or undesirable to separate transport corridors from residential and other land uses which they serve.

Noise features that make us listen and take notice are tones or changes in sound level. The more prominent the tone, and the more abrupt the change in sound level, the more noticeable the noise. This is particularly true for transport noise where tyre 'hum' is punctuated by engine noise and gear changing. Significant road transport noise increases have resulted from the construction of the Tonkin Highway extension and setbacks and measures have been identified. Similar but smaller scale impacts on major heavy vehicle transport corridors such as Armadale Road are not anticipated to be as great due to the lower vehicle numbers, light to heavy vehicle mix and reduced speeds.

Through careful Structure Planning, more effective management of industrial, transport and general noise can help to protect occupiers of sensitive land uses.

Vibration

The construction of industrial premises (and for that matter high and even low density residential premises) and installation of services may also produce vibrations that, when transmitted through the ground, may damage nearby residences (cracks or failures), impact on the natural environment, or affect the amenity of members of the public. Similarly members of the public may be inconvenienced by noise and vibration from heavy transport related activities concerned with the movement of product or raw materials on public roads.

However the causes of vibration are normally temporary (for example as a result of a construction program), and unless extreme are unlikely to cause any permanent damage to sound buildings. Physical damage to structures has been documented in relation to blasting and pile driving which are not anticipated as elements of development within the Amendment area. Compactors and vibrating rollers used in the road or construction industry are the source of a number of vibration complaints most directed to state and local government authorities in the absence of significant rail corridors.

4.17.5 Management Strategies

Regulation of environmental noise (excluding transport) occurs through the *Environmental Protection (Noise) Regulations 1997*. These regulations provide a mechanism through which design and planning features need to be considered in new plant establishment or refurbishment of existing facilities. The Regulations specify assigned noise levels for the premises receiving noise, according to the type of premises receiving the noise, the time of

day and presence of commercial and industrial land use zonings, and major roads within a 450m radius of the receiver.

Properties within the Amendment area are predominantly in private ownership with several large Crown land holdings. The land ownership pattern comprises approximately 280 separate landowners with the majority of the landowners possessing titles to landholdings less than 5ha in size.

The selection of the right approach to noise mitigation within each of these properties will depend on the nature of the noisy activity, the location of noise receivers, the cost and viability of various solutions, the degree of noise mitigation required any special characteristics of the noise and the individual site factors. Given the early planning stage, detailed noise mitigation strategies for each individual lot and / or landowner are neither possible nor desirable at this stage. Experience in WA and elsewhere indicates a mixture of noise control measures will result in the most environmentally acceptable outcome for all concerned.

Noise impact assessment and management at the Amendment area will be incorporated into processes for making land use planning decisions and at all subsequent stages of the land use planning process as and when planning is sufficiently mature to allow for informed decision making.

During this initial strategic planning stage a focus has been to identify the potential for land use conflict due to noise, and to develop management strategies between existing and proposed land uses. By avoiding the co-location of noise sensitive and noise-producing premises the Armadale Redevelopment Authority has attempted to prevent noise problems.

Where this is not possible, noise controls need to be incorporated into new noise producing developments at the subdivision and individual building approval stages.

During subdivision, when a decision has been made to for example locate residential and commercial land use areas close to one another but subdivision development has not started, there will be an opportunity to design the internal subdivision layout to minimise noise impacts. Noise mitigation strategies that can be used at this stage of development include, amongst others:

- blocking direct propagation of noise using the natural topography to prevent line of sight between the noise source and noise sensitive areas;
- locating activities that are not noise sensitive, such as parkland, between residences and the noise sources;
- orienting dwellings so that living areas face away from noise sources;
- defining areas affected by noise where building design needs to incorporate noise mitigation.

During he building design stage, noise control measures can also be applied to individual buildings (for example, those in close proximity to heavy transport routes or rail corridors) to ensure that internal noise levels are acceptable. Internal noise can also be minimised by, amongst others:

- locating living areas away from the area most exposed to a noise source;
- using thick or double-glazed windows, solid walls and doors, and window and door seals; and

- carefully selecting the location for installation of noise sources (such as air conditioners and gas water heaters).

Similar approaches during the approvals process can be used to prevent noise escaping from properties that generate noise. Consideration of the impact of a new building's noise sources (e.g. air conditioning unit) is important in minimising impacts on existing or future neighbours. Site layouts for premises with noisy activities should consider using building structures to shield noisy operations and should locate areas of access to the site or buildings away from noise-sensitive areas.

There are three main areas where noise mitigation measures can be applied:

- at the source.
- in the transmission path.
- at the noise receiver.

Noise mitigation measures are generally most effective at the noise source and in the noise transmission path. Noise mitigation at receiver locations is generally least preferred because external noise levels may remain high.

Road Network

The management of transport noise and vibration on residences can be integrated in road design and construction materials as well as acoustic design. Through application of sound construction practises, both construction and transport noise can be managed to achieve statutory standards.

Road noise and vibration experienced by future residents, any noise reduction required by building construction can be achieved by incorporating any or all of the following measures:

- Construction of noise barriers between the roadway and future residential lots;
- Specification of road surface construction materials; and/or.
- Specification of construction methods and materials (eg double brick construction) including fitting housing with acoustic treatment materials.

Given the early stage of the planning process and the lack of clarity of projected land use to the south of the Amendment area, ARA proposes to adopt an integrative approach to defining noise management measures related to transport noise. This approach will consider the circumstances of each development adjoining significant transport routes within the development area as it may be modified during the period of implementation.

During the subdivision planning stage, consideration will also be given to road reserve space and setbacks. This will include conducting studies to identify distances from Tonkin Highway, Armadale Road and the railway, within the following categories:

- "Unacceptable" - no noise-sensitive development to occur within this buffer;
- "Conditionally Acceptable" - noise-sensitive development permitted in this area subject to certain specified noise/vibration mitigation measures; and
- "Acceptable" - noise-sensitive development permitted without noise constraint based on known traffic density and reasonable projections at the time of the assessment.

Rail Network

The Australind service operates along the rail corridor and is currently limited to two trains (four train journeys) daily, scheduled to pass between approximately 0750 and 1830. No complaints in relation noise or vibration have been received by wither the Public Transport Authority or City of Armadale. Transwa advise that there is no current plan to expand this or develop other services along this segment of the rail network.

Developers intending to implement noise sensitive developments along the exiting rail corridor will assess noise and vibration impacts associated with existing and reasonable future expansion of rail services on this segment of the rail network and implement appropriate mitigation procedures including suitable setbacks, construction of barriers or building design construction modifications.

Aircraft

The subject land falls outside the 20 ANEF (350,000 aircraft) contour predicted for 50 years into the future and accordingly does not require any further action to comply with Statement of Planning Policy (SPP) 5.1. The low numbers of over flights at Brookdale would indicate that aircraft noise is unlikely to be a specific issue in the future under the current STARS and given anticipated track density. In the event of significant change of either of these two determinates, the need to implement planning of building design measures will be reviewed.

Noise from Industrial Sources

No significant industrial sources occur within the Amendment area, although a number adjoin. Notwithstanding most point source industrial noise can be managed by the application of noise avoidance or abatement techniques. Noise control of industrial premises, for example, could include any or all of the following treatments:

- enclosing and or treating fans;
- retrofit of enclosures, and silencers on existing plant;
- stringent maximum noise criteria applied to procurement of new plant;
- construction of earthen bunds or barriers;
- selective location of major openings away from neighbouring residences;
- management procedures to control the types of equipment or operating conditions at certain times of the day or under certain weather conditions;
- enclosing major plant; and
- insulation of plant enclosures.

New industry wishing to establish within or adjacent to the Amendment area and prescribed under the *Environmental Protection Act (1986)* will need to do so under the Works Approval and Licencing provisions of the Act, including compliance with *Environmental Protection (Noise) Regulations 1997.*

Noise from Commercial Buildings and Developments

There are generally two approaches to controlling noise at source: use of noise-efficient technology and best management practices. Both these approaches are effective in reducing the amount of noise at the source so that the surrounding environment is protected.
These measures involve:

- Selecting and using the most advanced and affordable technology, equipment, plant and machinery, so that the noise emitted is minimised, including the use of noise control equipment; and
- Adopting particular operational procedures that minimize noise.

Examples of noise-efficient and best management technology include the following (amongst others):

- Considering alternatives or changing the activity;
- Choosing quiet equipment; ensuring that equipment has an efficient muffler system, and is regularly maintained;
- Managing equipment operation including choosing or altering operational time;
- Using proximity-sensitive 'smart' reversing alarms;
- Choosing fan design features that will reduce noise;
- Using vibration isolation;
- Building an enclosure;
- Relocating the noise source or changing the orientation of equipment; and
- Following 'quiet' work practices and will be implemented during the subdivision and building design stage.

Options for controlling the transmission path and controlling the noise at the receiver location also exist.

Construction Noise

Each construction process brings with it a range of potential environmental impacts, including noise, which can be managed through the implementation of contemporary control measured well understood in the construction industry.

Vibration

Vibrations are best limited at source by the proper balancing of the offending component, by improved insulation through the installation of mounts, and in the case of vibration resulting from construction site compaction, by altering roller/plate compactor settings. This will have the effect, however, of increasing the length of time required to achieve an acceptable level of compaction. With adequate separation distances and the careful plant design, vibration attributable to stationary sources can be effectively controlled.

In cases where susceptible buildings may be subject to vibration from either construction or as a consequence of ongoing industrial activities, a building survey by a materials engineer to determine structural defects can be undertaken. The results of the initial survey can be compared to that following the development.

4.14.6 Predicted Outcome

Based on the results of desktop studies undertaken, and management measures proposed, it is considered that the implementation of the proposed redevelopment of the Wungong Urban Water Master Plan area can be managed to meet the EPA's environmental objective in relation to Noise and Vibration.

4.14 Disease Vector and Nuisance Insects

4.14.1 EPA Objective

To ensure that measures to manage disease vector and nuisance insects and protect the health, welfare and amenity of the community do not adversely affect environmental values.

4.14.2 Applicable Legislation, Criterion or Guidance

- Environmental Protection Authority (2000c). *Guidance Statement for the Management of Mosquitoes by Land Developers*, No. 40, June 2000.
- *Health Act 1911 and Regulations.*

4.14.3 Existing Environment

Midges

Midges (small flies belonging to the insect family Chironomidae) do not bite or sting and are therefore not vectors of disease. However due to the fact that they form dense swarms they are known as a 'nuisance' insect. Midges are often associated with disturbed urban wetlands (where they breed) having highly elevated nutrient levels. Algal blooms associated with nutrient enrichment provide an increased source of food for midge larvae that prefer to feed on three main forms of algae: benthic (within sediments), phytoplankton and epiphytic. Algal blooms also limit visibility thereby decreasing midge larvae predation. Low predator diversity can result from the combined effects of increased pollutants, low oxygen levels and decreased habitat diversity associated with the loss of native aquatic vegetation. These factors in combination enable midge populations to increase to nuisance proportions.

Forrestdale Lake located to the west of the Amendment area is a Ramsar wetland recognised as one of the best remaining examples of brackish, seasonal lakes with extensive fringing sedgeland once typical of the Swan Coastal Plain. Forrestdale Lake regularly supports more than 1% of the national population of five shorebirds: Red-capped Plower; Black-winged Stilt; Red-necked Avocet; Long-toed Stint and Curlew Sandpiper (www.naturebase.net – Information Sheet on Ramsar Wetlands). Forrestdale Lake is part of the Bush Forever Site 345 – 'Forrestdale Lake and adjacent Bushland, Forrestdale' (Government of Western Australia 2000).

Like a number of other urban wetlands, the lake is a known midge breeding wetland that has been the source of complaints by local residents for many years (City of Armadale 2000). Most complaints in the past have originated from residents located to the northeast corner of the Lake and this is thought to be due to the area being in the path of the prevailing southwesterly breezes (Conservation Commission and Department of Conservation and Land Management 2005). The City of Armadale commenced aerial spraying of the lake in 1975 and since then the lake has been treated on an 'as needs' basis using Temphos (granulated organo-phosphate). The Forrestdale Lake Management Plan does however note that the incidence of midge swarms has decreased in the recent past as a result of low rainfall in the Perth region which has resulted in the lake drying out in early summer before major midge swarms develop (Conservation Commission and Department of Conservation and Land Management 2005 p.26).

In 1987 in response to complaints from residents surrounding the Lake, a midge monitoring programme conducted by Murdoch University commenced. A District Control Plan for treatment was established in 1991 by the then Department of Conservation and Land

Management (now DEC) to manage the aerial treatment of the lake under a joint funding arrangement with the City of Armadale (Conservation Commission and Department of Conservation and Land Management 2005). In response to concerns about the impact of Temphos both on macro-invertebrates and the entire food chain, the lake is not treated if the water level is less than 30cm in depth (Conservation Commission and Department of Conservation and Land Management 2005 p.27).

Mosquitoes

Mosquitoes present health risks and nuisance to humans. There is the potential for the wetlands, waterways and pools (natural, modified and constructed) within the Amendment area to support habitat for mosquitoes. The physical attributes of water bodies including nutrient enrichment degradation are known to be major factors in the density of mosquito larvae found in wetlands and stagnant pools.

Mosquitoes are known to present serious health risks to humans by acting as transmitters or vectors of pathogenic arbovirus (Environmental Protection Authority 2000c). In Western Australia, mosquito species can be divided according to their breeding habitat. These include coastal wetlands that are influenced by tides, permanent reed swamps or wetlands with emergent vegetation, containers; and temporary ground pools. While *Ochlerotatus camptorhynchus*(southern saltmarsh mosquito and *Ochlerotatus vigilax* (summer saltmarsh mosquito), both considered vectors of Ross River virus (RRv), commonly breed in coastal wetlands, *Ochlerotatus camptorhynchus* may also breed in temporary fresh groundwater sites. Both species also have the ability to disperse over long distances. Other species that are known to be disease vectors are *Ochlerotatus notoscriptus* (container mosquito) (RRV) *Culex annulirostris* (common banded mosquito) (RRV, Barmah Forest virus (BFv) and Murray Valley encephalitis, Kunjin virus), *Coquillettidia* sp. *near linealis* (RRv and BFv).

Communications with the Environmental Health Services at the City of Armadale indicated that neither midges nor mosquito surveys had been undertaken in the Amendment area by either the City of Armadale or the Health Department. The DEC continues to monitor and spray for midges at Forrestdale Lake where the midges were in high numbers and affecting surrounding residents. However, it was considered by the City officers, that midges would not be an issue across the Amendment area and up to the time of correspondence the only area in the Shire where mosquitoes had been identified as a problem was in a small part of the City.

Freshwater wetlands have the potential to provide favourable conditions to support a wide variety of mosquito species. Some of these species will have the capacity to be vectors of mosquito borne diseases such as Ross River virus and Barmah Forest virus.

Based on the characteristics of the wetlands located within the Amendment area and in keeping with the investigation, reporting and management requirements contained within the EPA's Guidance Statement No. 40, the ARA committed to undertaking further investigations into vector insects.

The purpose of the study is to establish baseline data regarding mosquito breeding sites, numbers and species diversity. The study is the first detailed and long-term study, of this type, to be undertaken within the Amendment area.

An initial report containing data gathered over the period late October 2005 – early September 2006 is included in this report. A comprehensive report will be prepared at the end of the study period in November 2006.

Site Selection

Detailed aerial photographs of the Amendment area were studied to identify potential mosquito breeding sites prior to the ground survey being undertaken. A brief areal survey was carried out in mid-December and on the basis of this initial survey sampling locations were selected (refer Table 22). It is intended that a comprehensive areal survey across the Amendment area will be undertaken in late winter/early spring when water levels in the wetlands are likely to be at their annual maxima.

Larval Survey

Larval monitoring shows which species are actually breeding in the wetland. Larvae of different species feed at different water levels within a breeding site with *Ochlerotatus/Aedes* species being typically bottom feeders, *Anopheles* species usually feed at the surface, *Culex* species in the middle range below the surface and *Coquillettidia* and *Mansonia* remaining attached to submerged vegetation (Department of Health Western Australia 2006).

Potential mosquito breeding sites were sampled using a standard larval dipper. Sampling was carried out at a number of locations around each potential breeding site, with 5 – 10 dips at each location. Late instar larvae and pupae were collected by pipette into 60ml plastic jars. Details of the sampling locations were recorded on the jar label. A number of fourth instar larvae were transferred into vials containing 70% alcohol and later identified. Pupae and a number of fourth instar larvae were reared to confirm identification.

Adult Mosquito Survey

Monitoring of adult mosquitoes was undertaken to determine which species are breeding elsewhere as well as which are breeding on-site. This monitoring was carried out at eight sites using carbon dioxide baited EVS traps (Figure 15). The trap locations were chosen using the following criteria:

- Proximity to mosquito breeding site;
- Bush areas likely to harbour mosquitoes;
- Secure areas where there was little risk of the traps being tampered with or stolen; and
- Accessibility of the site.

TABLE 22
ADULT AND LARVAL MOSQUITO SAMPLING LOCATIONS

Site No.	Adult or Larval	Location Description
J1	Larval	Northwest corner of the Amendment area/corner Armadale Road and Tonkin Highway.
J2	Larval	CCW Lot 75 Hanlin Road.
J3	Larval	Lots 103, 22 and northwest corner Lot 102 east of Hanlin Road and bordered by Waterworks and Twelfth Road. Lot 22 along the Twelfth Road side where there are four small soaks with emergent vegetation.
J4	Larval	Main wetland on east side of Twelfth Road.
J5	Larval	RE wetland Lot 80 Wollaston Road.
J6	Larval	Extensive wetland along both sides of Willows Road, including Lot 5064, sections of Lots 16 and 14 and 80 Wollaston Road.
J7	Larval	Lot 108 Eleventh Road
J8	Larval	Lot 76 Hilbert Road
J9	Larval	Lot 95 corner of Whiteley and Eleventh Roads/Drain dissecting Lot 95 on opposite corner of Whiteley and Eleventh Roads.
J10	Larval	Constructed wetland on Lot 4402 between Hilarion Elbow and Paave View.

Site No.	Adult or Larval	Location Description
J11	Larval	MU wetland on Lot 9 corner of Wungong and Eleventh Roads.
A1	Adult	Located at the rear boundary of the fish farm on Twelfth Road. Breeding/harbourage site. This site offers the potential to record the presence of *Oc notoscriptus*, a known Ross River virus vector. This is an intensive aquaculture operation, with a large number of breeding tanks rearing koi fish. Unstocked tanks may provide ideal conditions for *Oc notoscriptus.*
A2	Adult	Southwest corner of the main wetland. Breeding and harbourage area.
A3	Adult	Lot 22 Forrest Road near Hanlin Road, on the eastern edge of the conservation wetland. Breeding and harbourage area.
A4	Adult	North side of the main wetland near Armadale Road.
A5	Adult	Western side of the resource enhancement wetland on Lot 80 Wollaston Road.
A6	Adult	Next to house opposite Lot 95 cnr Whiteley and Eleventh Roads.
A7	Adult	Lot 111 northwest of Hilarion Elbow. Close to the new residential area. Harbourage area but likely to be an early season breeding site.
A8	Adult	End of Lambert Lane. Harbourage area.

Results

General – Breeding Sites

The Amendment area contains a number of seasonal wetlands that were still holding water at the time of the survey. Water levels in the wetlands, however, had already peaked with some sites dry or with minimal areas of residual water. Most of the waterbodies were shallow (<200mm) with dense emergent fringe vegetation. Most of these shallow wetlands had significant numbers of *Anopheles annulipes* and *Culex australicus* larvae present along the shallow edges where water depth was <100mm. Predator species such as damsel fly larvae, water beetles and small fish were present.

The area received record low rainfall over the winter period. As a result of this, a number of the wetlands that held water in November 2005, were still dry by mid September 2006 and are therefore unlikely to receive sufficient recharge this year.

Larval Survey

A ground survey undertaken following the aerial photograph interpretation of the Amendment area found that *Anopheles annulipes* and *Culex australicus* larvae were present at all sampling locations, unless otherwise stated:

- Site 1 - Present
- Site 2 - Present
- Site 3 - Significant larval numbers found in all soaks.
- Site 4 - Extensive larval activity along the southern and western sections of the wetland.
- Site 5 - Present
- Site 6 - Present
- Site 7 - Present
- Site 8 - Present
- Site 9 - Present
- Site 10 - No mosquito larvae were found at the time of the survey
- Site 11 - No mosquito larvae were found at the time of the survey

All of these sites will be resurveyed in early spring 2006 when water levels are at their annual maxima.

In all cases where the seasonal wetlands listed had larvae present at the time of the survey, the dominant species were *Anophele annulipes* and *Culex australicus*. Most of the wetlands within the Amendment area had dried out by the end of November 2005. The main wetland along Twelfth Road contained *Anopheles annulipes* and *Culex australicus* larvae initially present at the beginning of the survey. These were replaced by *Culex annulirostris* as the dominant species by the end of November 2005.

One of the main objectives of the baseline survey will be to assess whether the seasonal wetlands as they begin to recharge after winter rainfall will be to determine whether *Ochlerotatus camptorhynchus*, the main vector for Ross River virus normally found in saltmarsh areas but occasionally in freshwater habitats, will be present in any further larval surveys.

Low larval numbers were present over the winter period. No larvae of the species *Ochlerotatus camptorhynchus* were present in any of the samples.

Adult Mosquito Monitoring Program

Eight monitoring sites were chosen for the adult mosquito monitoring study (Table 22) with six trapping sessions have been carried out to date.

There was found to be a need for one more monitoring site and this was added to the program at the beginning of winter 2006.

Given the relatively high larval numbers present earlier on in the study, numbers of adults subsequently trapped were lower than anticipated. The abundance of predators and the rapidly receding water levels at most sites are the most likely reasons for this finding.

Trap Results

A total of ten different species have been trapped in the 14 sessions to date. They include:

- *Ochlerotatus alboannulatus*
- *Ochlerotatus camptorhynchus*
- *Ochlerotatus notoscriptus*
- *Ochlerotatus ratcliffei*
- *Culex australicus*
- *Culex annulirostris*
- *Culex globocoxitus*
- *Anopheles annulipes*
- *Anopheles atratipes*
- *Coquillettidia* species nr *linealis*

The most productive sites have been Sites A1 and A2. These have been the sites with the highest numbers of the vector species *Ochlerotatus notoscriptus* and *Culex annulirostris.* The highest number of *Ochlerotatus notoscriptus* trapped at site A1 has been 36 and at site A2, 59. *Culex annulirostris* was present at Site A1 in high numbers over the period mid November through to the end of January 2006 with a high of 297 recorded at the beginning of January 2006. Site A2 recorded moderate to high numbers of this species over the same period, with a high of 167 at the beginning of January 2006. It was also the only site where males of this species were found in the trap catches.

Very low numbers of *Ochlerotatus camptorhynchus* were present in trap catches at a couple of sites over the period May – September 2006.

The other sites generally had catches of less than 50.

It is anticipated that trap numbers will remain very low – moderate until the wetlands become inundated again. It is recommended that the trapping schedule be changed to monthly for all sites other than sites A1 and A2.

4.14.4 Potential Impacts

Midges

Midge numbers proliferate in disturbed urban wetlands having highly elevated nutrient levels that encourage algal bloom formation (eutrophication) associated with nutrient enrichment. These conditions are more likely to occur when indiscriminate use of garden fertilisers occurs in close proximity to wetlands. Clearing of native sedges around wetland and riparian edges also encourages midge breeding.

Mosquitoes

The preliminary results indicate that with the presence of the species *Ochlerotatus notoscriptus* and *Culex annulirostris* in high numbers over the period mid-November 2005 – September 2006, there is, given favourable conditions, the potential for mosquitoes breeding onsite to have an impact on present and future residents within and adjacent to the Amendment area.

4.14.5 Management Strategies

In order to protect the health, welfare and amenity of future residents from disease vectors (mosquitoes) and nuisance insects (midges), landowners proposing to develop land in close proximity to seasonal Conservation Category and Resource Enhancement wetlands and waterways will be required to prepare and implement a Mosquito and Midge Management Strategy in consultation with the HDWA as a condition of subdivision approval.

Management options for the known/potential breeding sites could include, but not be restricted to, any of the following:

- Vegetation control when the wetland is dry;
- Maintenance of drainage ditches is undertaken to ensure good flow rates are maintained;
- Landscaping to improve drainage;
- Encouraging predator species to help control and mosquito and midge larvae;
- Larviciding using treatment options which specifically target mosquito and midge larvae but do not impact on the predator species;
- Public education;
- Building requirements which ensure that development does not take place directly next to mosquito breeding areas; and
- House design to prevent mosquitoes entering dwellings.

(These strategies are discussed in the Department of Health (2006) *Mosquito Management Manual*).

A Mosquito and Midge Management Strategy will be prepared by developers in respect to the preparation and assessment of a subdivision plan.

4.14.6 Predicted Outcome

Based on field investigations undertaken to date and management measures proposed, it is considered that the implementation of the proposed redevelopment of the Wungong Urban Water Master Plan area can be managed to meet the EPA's objectives in relation to Disease Vector and Nuisance Insects.

4.15 Aboriginal Heritage

4.15.1 EPA Objective

To ensure changes to the biophysical environments do not adversely affect historical and cultural associations and comply with relevant heritage legislation.

4.15.2 Applicable Legislation, Criterion or Guidance

- *Aboriginal Heritage Act 1972*
- *Native Title Act 1993*
- *Aboriginal and Torres Strait Islander Heritage Protection Act 1984*
- Environmental Protection Authority (2004h). *Assessment of Aboriginal Heritage Guidance Statement No. 41*.

4.15.3 Existing Environment

An Aboriginal heritage survey of the Amendment area has been prepared on the basis of a desktop review of available documentary resources and field investigations into potential Aboriginal heritage issues associated with the proposal to develop the Brookdale urban deferred areas. The full report is included as Appendix 7: *Brookdale Master Plan Area – Report on Aboriginal Heritage Investigation – Vol. 1 Phase 1: Archaeological Reconnaissance Survey* (Tempus Archaeology 2006a). The following is an abridged version of Appendix 8.

Archaeological Survey - Desktop Research

A desktop review of Aboriginal heritage databases and other relevant material was completed to identify known and potential heritage issues that might impact on the redevelopment of the Amendment area. This involved an assessment of the degree of past survey coverage, data gaps and identification of issues requiring further research (Tempus Archaeology 2006a).

The Department of Indigenous Affairs (DIA) online Aboriginal Heritage Management System and available 'grey literature' was interrogated as part of the desktop research. This resulted in the identification of nine Aboriginal sites that are located within, or immediately adjacent to, the Amendment area (Tempus Archaeology 2006a).

Further details regarding the desktop research and site information are contained in Appendix 7.

Archaeological Survey - Field Research

As well as reviewing documentary resources, a Phase I archaeological reconnaissance was undertaken across accessible portions of the Amendment area. The Phase I archaeological reconnaissance survey was conducted over a 38 day period between September 2004 and March 2005.

Prior to the commencement of the field reconnaissance, the ARA initiated a programme of land owner/occupier notification. This involved the issue of a form letter outlining the nature of the proposed investigations and a request to access landholdings. Of the 250 or so individual landowners within the Amendment area, 118 did not respond, six declined consent, five provided conditional consent, and 119 provided unconditional consent to access land. Based on these responses, a non-contiguous area of approximately 930ha (or 67% of the Amendment area) was made available for the purposes of the Phase I archaeological reconnaissance.

During the course of the Phase I archaeological reconnaissance some sixty (60) stone artefact clusters (BAS-001 to -060), five (5) potential modified trees (BPMT-001 to -005) and seventy-nine (79) isolated finds of flaked stone artefacts (BIF-001 to -079) were identified and recorded. (Tempus Archaeology 2006a). Specific details for each site are provided in Appendix 8.

Most of the newly recorded Aboriginal archaeological sites are quartz-rich open artefact scatters located within disturbance exposures and other areas of high ground surface visibility associated with outcrops of Bassendean Sand (Qpb) and Thin Bassendean Sand over Guildford Formation (Qpb/Qpa). With the exception of DIA Site ID 18,605, 18186 and sites BAS-001, BAS-002, BAS-003, BAS-005, BAS-012, BAS-014, BAS-015, BAS-016, BAS-017, BAS-022, BAS-023, BAS-040, BAS-044, BAS-047, BAS-051, BAS-055, and BAS-060, the clusters are relatively small in extent, with *apparent* site areas of less than 30m² (although in many cases these extents were defined on the basis of visibility and/or geomorphic criteria). The actual disposition of archaeological material was in most cases highly discontinuous, with only 10% to 50% of estimated site areas actually containing artefacts, typically at a density of less than 0.05 artefacts/m^2 overall.

For management purposes, an *archaeological sensitivity model* was developed using survey data captured as part of the Phase I archaeological reconnaissance (Table 23). The *archaeological sensitivity model* indicates that the Amendment area can be partitioned into three main zones as shown on Figure 16.

- Archaeological Sensitivity Zone 1 is a zone of high archaeological potential. It comprises outcrops of Bassendean Sand (Qpb) or Thin Bassendean Sand over Guildford Formation (Qpb/Qpa) located within 300m of a source of permanent of seasonal water at an elevation of greater than 1.0m above the AAMGL. The surveyed portions of this zone contain 83% of known Aboriginal archaeological sites, with an overall density of approximately 27 sites/km^2.

- Archaeological Sensitivity Zone 2 is a zone of low to moderate archaeological potential. It comprises outcrops Bassendean Sand (Qpb) or Thin Bassendean Sand over Guildford Formation (Qpb/Qpa) greater than 300m from a source of water and/or less than 1.0m above the AAMGL. The surveyed portions of this zone contain 16% of known Aboriginal archaeological sites at a density of approximately five sites/km^2.

- Archaeological Sensitivity Zone 3 is a zone of very low archaeological potential. It comprises the balance of the Amendment area. The surveyed portions of this zone contain less than 1% of known Aboriginal archaeological sites, with an overall density of less than one site/km^2.

TABLE 23
ARCHAEOLOGICAL SENSITIVITY ZONES WITHIN THE AMENDMENT AREA

Sensitivity Zone	% Amendment Area	Area Inspected (sq.km.)	No. Sites	% Sites
Zone 1	39%	4.3314	116	83
Zone 2	49%	4.2590	22	16
Zone 3	12%	1.1615	1	1
TOTAL	**100%**	**9.7518**	**139**	**100**

Source: Tempus Archaeology (2006a)

The archaeological sensitivity zones outlined above should be used as planning tools for the management of Aboriginal archaeological sites within the Amendment area, particularly in reference to those areas that have not been subject to detailed archaeological investigation. The sensitivity of particular areas is based on the predicted average density of surface archaeological material per square kilometre. At present, the sensitivity model does not take into account the present of near- or sub-surface cultural deposits (Tempus Archaeology 2006a).

Ethnographic Consultation

An ethnographic community consultation was undertaken by Mr Don Sauman (Cythera) and Dr Edward McDonald (Ethnosciences). The full report is included as Appendix 8: *Brookdale Master Plan Area – Report on Aboriginal Heritage Investigation – Vol. 2 Aboriginal Community Consultation* (Tempus Archaeology 2006b). The following is an abridged version of Appendix 7.

The ethnographic community consultation involved a two-stage process:

- a preliminary consultation and project notification process; and
- an ethnographic survey/community consultation meetings with Aboriginal consultants from stakeholder groups.

The preliminary consultation and notification process was undertaken in May-June 2005. Sauman (Cythera) conducted the consultation with members of the Swan Valley Nyungah Community/Nyungah Circle of Elders:

- Bropho
- Wilkes
- Warrell
- Garlett and
- Corunna families

McDonald (Ethnosciences) consulted with other identified Aboriginal stakeholder groups:

- Ballaruk Aboriginal Corporation

- Bibbulmun Tribal Group
- Hansen Family
- Walley and Nannup Families
- Independent Environmental Nyungahs
- Collard Family
- Jacob Family

Responses from the groups consulted included:

- Concerns about the waterways and wetlands in the Amendment area and a wish to ensure they were not detrimentally impacted upon;
- Concern about the preservation of archaeological sites in the Amendment area;
- Requests that cultural interpretation be integral to the proposed development; and
- A request for detailed on-site consultation.

The ethnographic survey/community consultation was undertaken in the latter part of 2005, with Sauman and McDonald undertaking the consultation with the same groups.

Sauman conducted an initial consultative meeting with members of the Combined Metropolitan Native Title Working Group/Nyungah Circle of Elders on 23 November 2005.

A second consultative meeting was held on 21 December 2005. Discussions centred on the issue of compensation for loss of land and guaranteed involvement in the Aboriginal heritage management process.

Subsequent to the 21 December meeting, a request was made for one Aboriginal consultant to be provided with assistance in preparing a statement setting out conditions acceptable to the Combined Metropolitan Native Title Working Group/Nyungah Circle of Elders. Don Sauman offered his time *pro bono*, and a draft copy was forwarded to the Aboriginal consultant for his review. No response has been forthcoming.

Dr McDonald coordinated two consultative meetings (Wednesday August 17, and December 21, 2005). The August meeting involved with 21 representatives of six Nyungar groups/families (Ballaruk Aboriginal Corporation, Bibbulmun Tribal Group, Independent Environmental Nyungahs the Hansen Family, the Walley and Nannup Families, and the Collard Family). Four members of the Jacobs family participated in the December meeting.

Outcomes

Apart from the archaeological sites and the area's waterways/wetlands (in particular the Wungong River and Neerigen Brook), no other places of heritage value were identified by the Nyungar participants.

The Nyungar stakeholders expressed concern about the protection of the area's waterways and wetlands and the quality of their water and the management of run-off.

The proposal to rehabilitate the watercourses in the Amendment area and to create living streams was supported, this included support for the proposal to realign number of man-made drains and 'creeks' in the Amendment area.

The Nyungar participants requested that as many as possible of the archaeological sites should be protected in their landscape context and did not want to see small artefact scatters preserved in isolation.

At the same time the participants recognised and accepted that some of the archaeological sites could not be preserved if the development was to proceed. Participants also expressed the view that the Nyungar community should be involved in the management of the Amendment area's Aboriginal heritage.

There was a general endorsement from the Nyungar participants for the creation of interpretative material in the project and of an interpretative centre in the Brookdale area.

A number of other general issues were raised by Nyungar participants, namely that:

- A Nyungar working party be formed to work with the authorities to ensure that Indigenous knowledge was used whenever possible;
- Nyungar participation in the project (employment and contract opportunities and so on) be made a priority; and
- Consideration be given to the issue of compensation for land alienated from the Indigenous community.

Dr McDonald's report on the ethnographic consultation undertaken on behalf of the ARA is included as Appendix 8 in the volume of technical appendices.

Key ARA Responses

The ARA indicated that Nyungar concerns about the Amendment area's waterways and wetlands were also of primary concern and a key aspect of the project's sustainability focus.

The ARA indicated that they were committed to preserving the areas Aboriginal heritage wherever possible and were supportive of the idea of cultural interpretation.

The ARA responded that it wished to enhance Indigenous participation in the project, including drawing on Indigenous knowledge, maximising employment and contract opportunities and working closely with the Indigenous community in all stages of the planning and development of the Brookdale project.

All Aboriginal sites in Western Australia are protected by the *Aboriginal Heritage Act 1972* (AHA). Under the AHA, it is an offence for any person to disturb or destroy any Aboriginal site in this state unless permission has been granted by the Minister for Indigenous Affairs. An Aboriginal site is defined under the Act as:

- Any place of importance and significance where persons of Aboriginal descent have, or appear to have, left any object, natural or artificial, used for, or made or adapted for use for, any purpose connected with the traditional cultural life of the Aboriginal people, past or present;

- Any sacred, ritual or ceremonial site, which is of importance and special significance to persons of Aboriginal descent;

- Any place which, in the opinion of the Committee, is or was associated with the Aboriginal people and which is of historical, anthropological, archaeological or ethnographical interest and should be preserved because of its importance and significance to the cultural heritage of the State;

- Any place where objects to which this Act applies are traditionally stored, or to which, under the provisions of this Act, such objects have been taken or removed.

4.15.4 Potential Impacts

Aboriginal archaeological sites identified within the Amendment area typically comprise clusters of flaked stone artefacts located in surface and/or near-surface contexts. As such, these sites are highly susceptible to impacts resulting from:

- Natural processes;
- Cultural processes; and
- Development activity.

Development has the potential to impact on the Amendment area's waterways and wetlands. Protection of these areas was identified as important during the ethnographic consultation.

4.15.5 Management Strategies

Heritage Protection is dealt with extensively under Part 8 of the Scheme. Section 8.1 (1) requires the ARA to prepare and maintain a heritage strategy that identifies those places or areas within the Scheme Area considered to be of Indigenous and/or non-Indigenous cultural heritage significance and worthy of conservation under the provisions of the Scheme.

In preparing the heritage strategy, the Authority shall have regard to:

(a) Register of Aboriginal Sites;
(b) The Register of the National Estate
(c) The State Register of Heritage Places;
(d) Any list of indigenous heritage places and the City's Municipal inventory prepared and adopted by the City of Armadale; and
(e) Any Indigenous and non-Indigenous heritage areas identified under the provisions of the City of Armadale Town Planning Scheme No. 4.

The Authority is required to hold the heritage strategy under ongoing review, and shall amend the heritage strategy in the light of changed circumstances relating to any Indigenous and/or non-Indigenous heritage place or area, including the addition to the heritage strategy of any places or areas of Indigenous and/or non-Indigenous heritage significance identified subsequent to the preparation and adoption by the Authority of the heritage strategy.

To this end, an Aboriginal Heritage Management Plan (AHMP) will be prepared by the ARA in consultation with key interest groups that will help facilitate the management and protection of Aboriginal heritage assets within the Amendment area. The AHMP will outline the extent of Aboriginal Heritage assets in the Amendment area and identify options for the protection of those assets. The targets of the AHMP are to:

- Protect and enhance the Aboriginal heritage values of the Amendment area to the greatest possible extent;

- Minimise adverse impacts on Aboriginal heritage assets within the Amendment area arising from proposed development activity;

- Ensure that Aboriginal heritage assets scheduled for retention within the Amendment area are not damaged, defaced or destroyed by construction or related activity or personnel engaged in construction activity;

- Identify appropriate management interventions to ensure the long-term preservation of Aboriginal heritage assets scheduled for retention within the Amendment area;

- Implement a programme of monitoring to ensure the suitability and/or effectiveness of any management intervention(s) implemented in relation to Aboriginal heritage assets;

- Establish protocols and procedures governing the management of Aboriginal cultural and/or skeletal material(s) identified during the course of development within the area;

- Establish mechanisms to ensure on-going engagement with the Aboriginal community in respect of Aboriginal heritage and other relevant matters of concern.

Section 8.4 of the Scheme requires the Authority to have regard to heritage matters. Therefore in dealing with a development application relating to an Indigenous and/or non-Indigenous heritage place or area included in the heritage strategy, the Authority shall comply with the requirements of clause 2.7, but shall have regard to:

(a) the extent to which the proposed development is likely to affect the cultural heritage significance of the place or area; and
(b) the provisions and requirements of its adopted heritage strategy, both in the general and with regard to any provisions or requirements contained in the heritage strategy that are specific to the heritage place or area which are the subject of the application.

A preliminary analysis of the proposed Master Plan indicates that upwards of 75% of known Aboriginal archaeological sites could be retained through sensitive design and implementation, as follows:

- DIA Site ID18186 and newly recorded sites BAS-003, BAS-009, BAS-010, BAS-012, BAS-013, BAS-014, BAS-015, BAS-017, BAS-019, BAS-020, BAS-021, BAS-022, BAS-023, BAS-024, BAS-025, BAS-027, BAS-028, BAS-038, BAS-040, BAS-041, BAS-046, BAS-047, BAS-048, BAS-049, BAS-050, BAS-053, BAS-054, BAS-058, BAS-059 and part BAS-051 could be wholly/partially retained within POS.

- Newly recorded sites BAS-008, BAS-011, BAS-016, BAS-033, BAS-037, BAS-043, BAS-044, BAS-045, BAS-055, BAS-057, part BAS-051could be wholly/partially retained within stream/vegetation buffers and wetland enhancement areas.

- Newly recorded sites BAS-029, BAS-030 and part BAS-042could be wholly/partially retained within areas of compatible land-use, including school green areas and avenues/swales.

- Newly recorded sites BAS-018, BAS-026, BAS-031, BAS-032, BAS-034, BAS-035, BAS-036, BAS-039, BAS-052, and BAS-056 are not located within areas considered to represent compatible land-uses.

- The design for the area containing newly recorded sites BAS-001, BAS-002, BAS-004, BAS-005, BAS-006, BAS-007 and BAS-060 is currently under review.

In order for Aboriginal archaeological sites to be incorporated into POS and other compatible areas, some form of management intervention may be required. This could involve, but not be limited to:

- Minimal intervention (preservation *as is*)

- Site stabilization;
- Site revegetation; and
- Burial-in-place (reversible).

Sites that cannot be incorporated within POS or other broadly compatible landuse categories may require archaeological mitigation/salvage in accordance with the requirements of the *Aboriginal Heritage Act 1972*.

A key limitation to the effective management of Aboriginal heritage sites within the Amendment area is that the Aboriginal archaeological resource remains imperfectly understood. To assist in the coordination and sustainability of management and research on Aboriginal heritage assets within the Amendment area, a Research Agenda is to be developed to:

- Provide a systematic framework for the conduct of archaeological surveys across the remaining unsurveyed land in the Amendment area considered to have a high potential to contain Aboriginal heritage assets;

- Identify further investigations required to establish the nature, composition or significance of new and previously recorded heritage assets while keeping to a minimum the use of destructive archaeological evaluation techniques; and

- Facilitate the assessment of management requirements for specific sites.

Negotiations are underway with the DIA to ensure that data obtained within the Amendment area is efficiently transferred to the DIA for incorporation into a database that will be available for the public to access.

Where an Aboriginal site is present within the Amendment area, the landowner (or authorised agent) will be required to obtain consent under section 18 of the *Aboriginal Heritage Act 1972* for future development activity. Under the current administration of the *Aboriginal Heritage Act 1972*, an application to use land should be sought under section 18 of the *Aboriginal Heritage Act 1972* even where no Aboriginal sites have been recorded.

As a part of the AHMP, protocols and procedures are to be developed to protect known and as yet unrecorded Aboriginal heritage assets within the Amendment area during the course of development.

Management of Areas of Graded Archaeological Sensitivity

Any proposed development within the Amendment area will take into account the potential impact on undocumented surface or sub-surface archaeological material(s). Graded areas of archaeological sensitivity area outline in Figure 16.

- Any activity involving ground disturbance in an area of high archaeological sensitivity will be preceded by archaeological survey (unless previously undertaken) and evaluation to assess potential impact(s) and facilitate the development of a mitigation plan.

- Any activity in an area of medium archaeological sensitivity should be preceded by archaeological survey (unless previously undertaken) and limited evaluation and/or monitoring in order to assess impact(s) and facility the development of a mitigation plan.

- Any activity in an area of low archaeological sensitivity should be subject to a post-disturbance inspection.

Environmental Management Plans for the Wungong River and the protection of Resource Enhancement and Conservation Category wetlands will take into account the protection of their heritage and cultural values.

4.15.6 Predicted Outcome

Based on a review of the available registers, field investigations, measures to be adopted and commitments given, it is considered that the implementation of the proposed redevelopment of the Wungong Urban Water Master Plan area can be managed to meet the EPA's objectives in relation to Aboriginal Heritage.

4.16 Non-Aboriginal Heritage

4.16.1 EPA Objective

To ensure changes to the biophysical environment do not adversely affect historical and cultural associations and comply with relevant heritage legislation.

4.16.2 Applicable Legislation, Criterion or Guidance

- *Heritage of Western Australia Act 1990.*

4.16.3 Existing Environment

A cultural heritage survey of Amendment area has been prepared on the basis of a desktop review of available documentary resources and is included as Appendix 9: *Brookdale Master Plan – Cultural Heritage Survey* (Heritage and Conservation Professionals 2004). Places of heritage significance have been assessed on the basis of their aesthetic, historical, social and scientific significance as defined by the Heritage Council of Western Australia.

As well as reviewing documentary resources, a physical survey of the Amendment area was undertaken. This comprised a drive through survey of the Amendment area that was limited to places that were visible from the road or were previously identified in existing heritage lists and reports. No private properties were accessed during this survey (Heritage and Conservation Professionals 2004).

There are currently no places located in the Amendment area that are included on the Register of Heritage Places and therefore there are no statutory requirements under the *Heritage of Western Australia Act 1990*. There are, however, two places within the Amendment area that are included on City of Armadale Municipal Inventory (adopted 1995).

The following is a summary of places within the Amendment area that are included on heritage lists together with statutory implications arising from those listings and a description of the site (Heritage and Conservation Professionals 2004).

Wungong River (Brook)
Listings: Department of Indigenous Affairs Site.
Statutory Implications: DIA

Neerigen Brook
Listings: Department of Indigenous Affairs Site.
Statutory Implications: DIA

The Wungong River (Brook) and Neerigen Brook are identified as significant sites for Aboriginal people and were also used for recreation by settlers in the area in the early to mid twentieth century. The interpretation of these may include landscape treatments and/or the incorporation of appropriate signage.

John Haynes Homestead and Dairy (1933)
Listings: City of Armadale Municipal Inventory (adopted 1995)
Statutory Implications: Protected under City of Armadale Town Planning Scheme

The dairy is located at Lot 99 Eleventh Road, Brookdale and the property appears to have been originally part of the landholdings owned by Mr. Hand, who ran an abattoir on the Amendment area. The place has been used for farming purposes since the 1930s as a dairy, piggery and for poultry. In 1995 when the City of Armadale Inventory was prepared, the dairy was identified as the last operating dairy in the Armadale area (HCP 2004).

Gladalan Nursery (1940s/1950s)
Listings: City of Armadale Municipal Inventory (adopted 1995)
Statutory Implications: Protected under City of Armadale Town Planning Scheme

The place is located at Lot 46 Gray Road, Brookdale and dates from c. 1937 at which time Gladys and Alan Brown purchased the property. The nursery got its beginning when the Browns sold excess onion seedlings from their farm. By the 1950s a glasshouse and various sheds have been constructed on the property to facilitate its operation as a nursery (HCP 2004). When the City of Armadale Inventory was prepared, Gladalan Nursery had become one of the largest employers in Armadale. The nursery has since ceased operations (HCP 2004).

The main opportunity for inclusion of cultural heritage issues within the proposed redevelopment of the Amendment area is through the use of interpretation (HCP 2004). Interpretation can be used to integrate some aspects of the historical development of the Amendment area into the redevelopment. Ways of interpreting the history of the area include the retention of elements including areas and landscape features; public art, signage and naming of streets; the retention of road alignments and subdivision patterns and through landscape treatments and urban design.

4.16.4 Potential Impacts

There are currently no places in the Amendment area that are included on the Heritage Council's Register of Heritage Places or classified by the National Trust.

Both the Wungong River and Neerigen Brook are registered by the DIA and as discussed in Section 4.15.3 have ethnographic significance for the Aboriginal community and Cultural processes; and development has the potential to impact on the Amendment area's waterways and wetlands. Protection of these areas was identified as important during the ethnographic consultation.

Two places in the Amendment area (Gladalan Nursery John Haynes Homestead and Nursery) are included on the City of Armadale's Municipal Heritage Inventory and these may be demolished unless protected through listing on a recognised register.

4.16.5 Management Strategies

As previously discussed in Section 4.15.5, Heritage Protection is dealt with extensively under Part 8 of the Scheme. Section 8.1 (1) requires the ARA to prepare and maintain a heritage strategy that identifies those places or areas within the Scheme Area considered to be of Indigenous and/or non-Indigenous cultural heritage significance and worthy of conservation under the provisions of the Scheme.

In preparing the heritage strategy, the Authority shall have regard to:

(a) Register of Aboriginal Sites;
(b) The Register of the National Estate
(c) The State Register of Heritage Places;
(d) Any list of indigenous heritage places and the City's Municipal inventory prepared and adopted by the City of Armadale; and
(e) Any Indigenous and non-Indigenous heritage areas identified under the provisions of the City of Armadale Town Planning Scheme No. 4.

The Authority is required to hold the heritage strategy under ongoing review, and shall amend the heritage strategy in the light of changed circumstances relating to any Indigenous and/or non-Indigenous heritage place or area, including the addition to the heritage strategy of any places or areas of Indigenous and/or non-Indigenous heritage significance identified subsequent to the preparation and adoption by the Authority of the heritage strategy.

To this end, the ARA will prepare and implement an Interpretation Plan as part of the WIPS process to detail the ways in which historic themes evident in the European cultural history of Brookdale can be integrated with the redevelopment of the Amendment area.

Section 8.4 of the Scheme requires the Authority to have regard to heritage matters. Therefore in dealing with a development application relating to an Indigenous and/or non-Indigenous heritage place or area included in the heritage strategy, the Authority shall comply with the requirements of clause 2.7, but shall have regard to:

(a) the extent to which the proposed development is likely to affect the cultural heritage significance of the place or area; and
(b) the provisions and requirements of its adopted heritage strategy, both in the general and with regard to any provisions or requirements contained in the heritage strategy that are specific to the heritage place or area which are the subject of the application.

4.16.6 Predicted Outcome

Based on a review of the available registers, field investigations, measures to be adopted and commitments given, it is considered that the implementation of the proposed redevelopment of the Wungong Urban Water Master Plan area can be managed to meet the EPA's objectives in relation to Non-Aboriginal Heritage.

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FIGURES

ATTACHMENT 1

ENVIRONMENTAL REVIEW INSTRUCTIONS

Environmental Protection Authority

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Telephone: (08) 6364 6500. Facsimile: (08) 6364 6522.

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Executive Director
Armadale Redevelopment Authority
PO Box 816
ARMADALE WA 6992

Attention: Jamie Douglas

Our Ref DEC363
Enquiries Maxine Dawson
6467 5246

AMENDMENT NO. 1 BROOKDALE REDEVELOPMENT SCHEME 2005

Instructions for the above scheme amendment were issued to you on 14 September 2006. The appeal period on these instructions has now closed and no appeals were received during this time. Therefore the instructions issued to you immediately prior to the commencement of the appeal period are now the final instructions on which you will be expected to base your environmental review document.

I enclose a copy of the instructions with the EPA's objectives included.

for R Claudius
A/DIRECTOR
EIA DIVISION

Enc.

Cc ATA Environmental

ENVIRONMENTAL ASSESSMENT OF PLANNING SCHEMES AND THEIR AMENDMENTS

Brookdale Redevelopment Scheme 2005

Amendment No. 1

(Assessment No. 1647)

ENVIRONMENTAL REVIEW INSTRUCTIONS

1. Introduction

The *Environmental Protection Act 1986* (the Act) sets out that where a planning scheme, or an amendment to a scheme, is judged to have a significant environmental impact it will be subject to an assessment by the Environmental Protection Authority (EPA) under Section 48A of the Act. These schemes/amendments are being assessed because they raise significant environmental factors.

Where a scheme/amendment is subject to an assessment by the EPA, the responsible authority is required to produce an Environmental Review addressing the environmental factors relevant to the scheme/amendment. The EPA issues instructions for the scope and content of the Environmental Review. Below are the instructions for the above scheme amendment.

The Environmental Review is then made publicly available with the amendment document to enable members of the public and relevant agencies to comment on the possible environmental impacts of the scheme amendment. Additional information on the purpose and functions of environmental assessment of a scheme amendment is given in Attachment 1.

The scheme amendment that is the subject of this assessment is Amendment No. 1 to the Brookdale Redevelopment Scheme 2005. A map showing the location of the land the subject of the scheme amendment is shown as Attachment 2. The responsible authority for the scheme is the Armadale Redevelopment Authority.

2. Instructions

2.1 Status of the instructions

These instructions are the instructions for the preparation of the Environmental Review.

2.2 General information

The fundamental requirements of the Environmental Review document are to:

a) describe the state of the environment affected by the scheme amendment, indicating at least the scheme amendment area and its immediate surroundings;

b) describe the purpose of any zoning or reservation;

c) identify those environmental factors which should be considered in relation not only to the scheme amendment being assessed but also to later levels of planning, such as subdivision and development;

d) identify those environmental factors which require alternative procedures or processes to address any requirements for on-going long-term management;

e) for those environmental factors not relevant to the scheme amendment being assessed, describe the process (approvals and the like) necessary to address those factors later, including likely referral to the EPA; and

f) for those factors relevant to the scheme amendment being assessed, describe the extent to which the environment could be protected from both direct and indirect impacts, including:
   - identifying the portions of the environment of highest conservation value and describing how the scheme amendment plans to protect them;
   - listing those land-uses that will be permitted without further environmental approval being required under proposed zoning;
   - predicting the potential environmental impacts of these land uses;
   - describing the scheme provisions which will allow management of those impacts to ensure the environment is protected to an acceptable level in the best manner possible; and
   - identifying potential conflicts of land uses having environmental implications and how the environmental impacts are to be managed.

The Environmental Review document should consist of sections that deal with the above requirements. The recommended format for the Environmental Review document is enclosed as Attachment 3.

An important aspect of the environmental impact assessment process is the review by the public. The EPA wants to receive public input into the possible environmental impacts of this scheme amendment and its implementation. To facilitate adequate public input, the Environmental Review should be made available as widely as possible and at reasonable cost.

2.3 Environmental factors relevant to this scheme amendment

The EPA, following consideration of the factors related to the scheme amendment, is likely to identify some key factors which need to be given special attention and which should form the principal basis of the EPA assessment report to the Minister for the Environment. These key factors are termed the "environmental factors relevant to the scheme amendment".

The EPA may also identify other environmental factors which it considers to be relevant to the scheme amendment but are likely to be best addressed at a later level of planning. These factors are considered to be significant enough to warrant attention as part of the environmental review of this scheme amendment to the extent that the Responsible Authority should show how these factors could be addressed at a later level of planning. These factors are called "environmental factors not assessed". Please note that no "not assessed" environmental factors have been identified at this stage.

The EPA, in consultation with the Responsible Authority and the relevant agencies, has identified a list of factors likely to be found to be the "environmental factors relevant to the scheme amendment". This list is provided to assist with the preparation of the Environmental Review document, but during the course of the preparation of the document other factors may be found also to be relevant, and they should be included in the detailed discussion.

2.4 General scope of the Environmental Review - Limit of the Environmental Review

The scheme amendment has been initiated to incorporate provisions in the Brookdale Redevelopment Scheme 2005 to guide subdivision, development and land use in accordance with the Wungong Urban Water Master Plan.

2.5 Environmental factors relevant to the scheme amendment

The EPA has identified some environmental factors which are relevant to the scheme amendment area and should be addressed in the Environmental Review document. These factors are listed over (see Table 1).

Table 1: Environmental factors relevant to the scheme amendment

		SCOPE OF WORK
Factor	**EPA Objective**	**Work required for the Environmental Review:** • **Specific requirements and generic requirements in these Instructions** • **Studies and reporting on the findings generally as set out in the scoping document: ATA Environmental 2006 *Brookdale Redevelopment Area Strategic Environmental Assessment Environmental Scoping Document* prepared for Armadale Redevelopment Authority Version 6 July 2005 Report No. 2004/213.**
Sustainability	To ensure, as far as practicable, that the proposal meets or is consistent with the principles in the EPA's Position Statement No. 6 *Towards Sustainability* and the *Western Australian State Sustainability Strategy.*	*How will the Amendment ensure that development proceeds in a sustainable manner?* • Set out the proposed measures and procedures. Refer to the Government's *Western Australian State Sustainability Strategy,* the EPA's Position Statement No. 6 *Towards Sustainability* and Armadale Redevelopment Authority's *Implementation Strategy for Sustainability.*
Native terrestrial vegetation and flora	To maintain the abundance, diversity, geographic distribution and productivity of flora at species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge.	*How will any significant native vegetation and flora likely to be impacted by the Amendment be protected or enhanced?* • Identify and assess the values and significance of the vegetation and flora within the Amendment area and immediate adjacent area. Address values and significance having regard for the local, regional and State context. • Carry out studies consistent with EPA Guidance Statement 51 *Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia.* • Carry out studies to delineate the location of threatened ecological communities and to assist in determining buffers around these. • Propose strategies to protect vegetation and flora values, and, in the event that significant vegetation and flora is impacted, describe measures to be implemented, to ensure that the abundance, diversity, geographic distribution and productivity of significant vegetation and flora is maintained.
Native terrestrial fauna	To maintain the abundance, diversity, geographic distribution and productivity of fauna at species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge.	*How will any significant fauna assemblages and fauna species likely to be impacted by the Amendment be protected or enhanced?* • Identify and assess the values and significance of faunal assemblages and species within the Amendment area and immediate adjacent area. Address values and significance having regard for the local, regional and State context. • Carry and studies consistent with EPA Guidance Statement 56 *Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia.* • Examine fauna protection and enhancement strategies including connectivity of fauna habitats. • In the event that significant fauna and faunal assemblages are impacted, describe measures to be implemented to ensure that the abundance, diversity, geographic distribution and productivity of significant fauna is maintained.

Factor	EPA objective	Work required for the Environmental Review
Wetlands	To maintain the integrity, ecological functions and environmental values of wetlands.	*How will the wetland values (for example, ecological and hydrological functions and human use values) likely to be impacted by the Amendment, be protected or enhanced?* • Identify and assess the values and significance of wetlands within the Amendment area and adjacent area and describe them in a local, regional and State context. • Carry out investigations to identify wetland boundaries, wetland management categories and wetland buffers in accordance with DEC requirements. • Describe and assess the potential direct and indirect impacts that may result from any use or development, allowed by the Amendment, on any wetlands, including their buffers, within the Amendment area and adjacent area. • Report on projected water balance and nutrient changes and environmental water requirements in relation to wetlands. • Examine the potential impacts of development and water management strategies on wetlands. If a controlled groundwater level is proposed, investigate the likely zone of influence to help establish subsoil drainage setbacks from wetlands. • Propose strategies to protect significant wetlands, and, in the event that significant wetlands may be impacted, describe appropriate zoning, scheme provisions and management mechanisms to be implemented, including but not limited to buffer requirements and setbacks, stormwater management, effluent management, rehabilitation and restoration, access and use, fencing and management plans, to ensure that the integrity, functions, environmental values and long term viability of the wetlands will be maintained.
Waterways	To maintain the integrity, ecological functions and environmental values of waterways.	*How will the ecological and hydrological functions of waterways potentially affected by the Amendment, be protected or enhanced?* • Identify and assess the values and significance of the waterways, floodplain areas and foreshore areas within the Amendment area and adjacent area. • Establish buffers to watercourses. • Describe and assess the potential direct and indirect impacts that may result from any use or development, including any potential changes to water regime and hydrologic function. • Propose measures and strategies for waterways and floodplains, including but not limited to realigning and meandering of non-natural waterway alignments, provision of adequate buffers and setbacks, foreshore reserves, flood management, drainage, rehabilitation and restoration, fencing, and management plans. Nutrient management needs to be specifically addressed.
Key natural areas and ecological linkages	To protect the environmental values of areas identified as having significant environmental attributes.	*How will the Amendment ensure that natural areas and ecological linkages are protected or enhanced?* • Determine the location and width of ecological linkages within the Amendment area having regard for the natural attributes and values of the site and adjoining area, and significance of linkages in the local, regional and State context. • In this section, synthesise information from the above chapters. Prioritise natural areas and ecological linkages to be protected, and list strategies to protect these.

Factor	EPA objective	Site specific factors	Work required for the Environmental Review
Water management	To maintain the quantity of water (surface and ground) so that existing and potential environmental values, including ecosystem maintenance, are protected. To ensure that water quality does not adversely affect environmental values or the health, welfare and amenity of people and land uses by meeting statutory requirements and acceptable standards.	Surface water quantity and quality, groundwater quantity and quality	*How will the Amendment ensure that surface and groundwater quantity and quality are not adversely affected as a result of use and development allowed by the Amendment?* • Describe the existing water regime. • Summarise the results of water studies (including monitoring and modelling) relevant to the Brookdale area. • Carry out field investigation and analyses to determine the zone of influence and nutrient export should control of the groundwater level be proposed. • Examine the feasibility of aquifer storage and recharge, rate of groundwater transport from contaminated sites and modelling of groundwater in response to development. • Assess the implications any development may have on surface and ground water quantity, and surface and ground water quality. • Describe the measures that are proposed to ensure: o the quantity and quality of surface and ground water is maintained so that existing and potential uses, including ecosystem maintenance are protected; o water conservation and water use efficiency; o stormwater and wastewater management and reuse in the water cycle context.
Land	To ensure that remediation of contaminated sites achieves an acceptable standard that protects the environment, is compatible with the intended land use, and is consistent with appropriate criteria. To maintain the integrity, ecological functions and environmental values of land.	Site contamination	*How will the Amendment ensure that contaminated sites are identified and remediated to an acceptable standard that protects the environment and is compatible with the intended land use and the* Contaminated Sites Act 2003. • Identify known and suspected contaminated sites (consider guidance in the DEC Contaminated Sites Management Series). • Describe the measures that are proposed to ensure that contaminated sites are identified and remediated to a standard that protects the environment, is compatible with the intended land use system, and is consistent with the appropriate criteria and legislation.
		Acid sulfate soils	*How will the Amendment ensure that there are no potential adverse impacts on the natural and built environment and human activities arising from Acid Sulfate Soils?* • Carry out investigations to identify land where there is a risk of disturbing Acid Sulfate Soils based on DEC Acid Sulfate Soils guidelines. • Describe the measures and strategies that are proposed to assess and manage Acid Sulfate Soils.

Factor	EPA objective	Site specific factors	Work required for the Environmental Review
Air	To ensure that emissions to air do not adversely affect environmental values or the health, welfare and amenity of people and land uses by meeting statutory requirements and acceptable standards.	Dust and particulates	*How will the Amendment ensure that existing and potential emissions (dust and particulates) do not adversely affect environmental values or the health, welfare and amenity of people and land uses?* • Identify existing and potential sources of dust and particulates in and near the Amendment area. • Examine the potential for a broad scale air quality monitoring program to be prepared and implemented. • Describe measures and strategies that are proposed to manage dust and particulate issues in the Amendment area and potentially arising from development under the Amendment.
		Gaseous emissions	*How will the Amendment ensure that existing and potential gaseous emissions do not adversely affect environmental values or the health, welfare and amenity of people and land uses?* • Identify existing and potential sources of gaseous emissions in and near the Amendment area, and address buffers. • Investigate the potential for land in the Brookdale Redevelopment Area to be affected by emissions from the South Armadale brickworks. • Describe measures and strategies that are proposed to manage gaseous emission issues in the Amendment area and potentially arising from development under the Amendment.
		Odour	*How will the Amendment ensure that existing and potential odour emissions do not adversely affect the amenity of people?* • Identify existing and potential sources of odour that may affect people in and near the Amendment area, and address buffers. • Describe measures and strategies that are proposed to manage odour issues in the Amendment area from existing and proposed facilities, and potentially arising from development under the Amendment.
	To minimise emissions to levels as low as practicable on an on-going basis and consider offsets to further reduce cumulative emissions.	Greenhouse gases	*How will greenhouse gas emissions be minimised and managed during development and subsequently?*
Noise	To protect the amenity of the community from noise and vibration impacts associated with development or land use by ensuring that statutory requirements and acceptable standards are met.		*How will noise be managed to protect the amenity of nearby residents?* • Identify existing and potential noise sources and carry out studies for strategic planning purposes to assess predicted noise from major noise generators along boundaries of the Amendment area. • Describe measures and strategies that are proposed to manage noise issues in the Amendment area.

Factors	EPA objective	Site specific factor	Work required for the Environmental Review
Disease vector and nuisance insects	To ensure that measures to manage disease vector and nuisance insects and protect the health, welfare and amenity of the community do not adversely affect environmental values.		*How will disease vector and nuisance insects be managed to protect the health, welfare and amenity of people?* • Carry out baseline surveying of mosquito populations to establish their presence, extent and likely impact on or adjacent to the project area. • Describe measures and strategies that are proposed to manage disease vector and nuisance insect issues in the Amendment area.
Heritage	To ensure that changes to the biophysical environment do not adversely affect historical and cultural associations and comply with relevant heritage legislation.	Aboriginal heritage	*How will the Amendment ensure that any changes to the biophysical environment do not unacceptably affect historical and cultural associations?* • Carry out archaeological investigations and ethnographic studies to identify and assess the values and significance of Aboriginal cultural and heritage sites. • In relation to changes to the biophysical environment, describe and assess the potential direct and indirect impacts that may result from any use or development allowed by the Amendment on Aboriginal cultural and heritage sites. • Describe measures and strategies that are proposed to manage changes to the biophysical environment to ensure that any changes do not unacceptably affect historical and cultural associations.
		Non-Aboriginal heritage	*How will the Amendment ensure that any changes to the biophysical environment do not unacceptably affect historical and cultural associations?* • Identify non-Aboriginal heritage sites and their significance. • Describe measures and strategies that are proposed to manage changes to the biophysical environment to ensure that any changes do not unacceptably affect historical and cultural associations.

2.6 Environmental factors not assessed (previously known as 'Deferred factors')

- None identified at this stage.

Other environmental factors

For context, the Environmental Review should also provide at least a summary discussion of all environmental aspects of the scheme amendment area. For environmental factors not required to be addressed in detail (that is, factors not listed in the table above, such as topography or landscape amenity), the Environmental Review should provide an outline description and indication of the extent of environmental management.

During the Environmental Review process, should it appear that significant environmental impacts may be associated with any of these other factors, then the EPA Service Unit should be approached for advice on the work to address the factor.

Attachment 1

Information on the purposes and functions of the environmental assessment of schemes and their amendments

Purpose of the environmental assessment

The purpose of an environmental assessment is to ensure that the scheme takes proper account of the relevant environmental factors. To do this the EPA reports to the Minister for the Environment on the environmental factors relevant to the scheme, recommends environmental conditions under which the scheme may operate and provides other recommendations as it sees fit.

Functions of an Environmental Review

The primary function of the Environmental Review is to provide information about the environmental factors related to the proposed scheme to the EPA to enable it to evaluate the significant effects on the environment of the scheme and provide independent environmental advice to Government.

An additional function of the document is to clearly communicate details of the proposed scheme and its future implications to the public so that the EPA can obtain informed public comment on relevant environmental factors and their areas. Effective public information and involvement is an essential part of environmental impact assessment.

These instructions are issued to assist in identifying matters that should be addressed within the Environmental Review document. However, other relevant matters may arise during the preparation of the Environmental Review document and these should also be included.

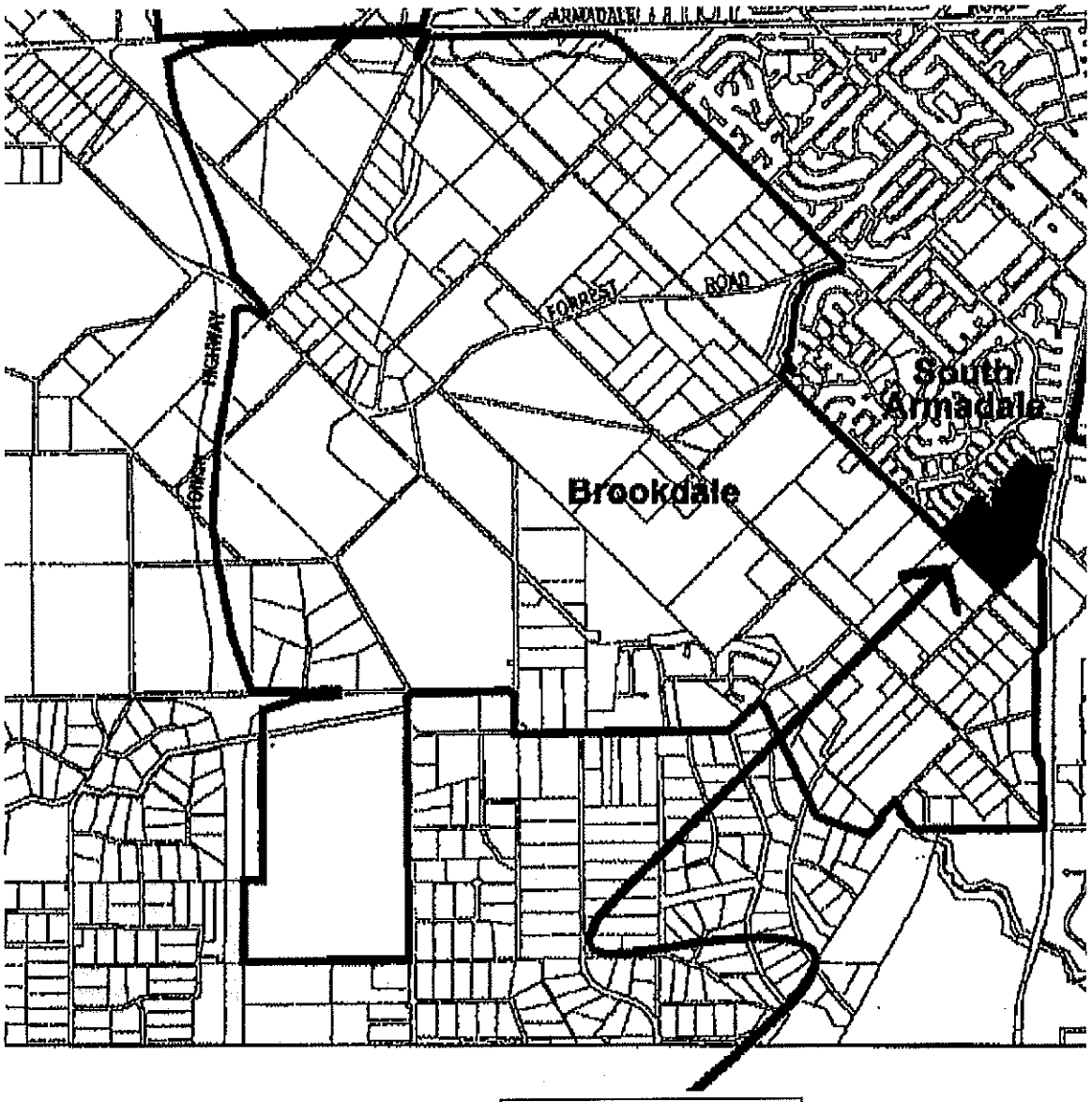
The Environmental Review document will be made publicly available during the advertised period for the scheme and submissions from other agencies and the public will be sought. The Responsible Authority is required to forward submissions relating to the Environmental Review to the EPA and respond to the EPA on environmental factors or conditions and procedures which may apply should the proposal be implemented that are raised in those submissions. Based on the information in the Environmental Review document, the response to submissions and its own investigations the EPA will then report to the Minister for the Environment.

Please note:

Statements of fact, conclusions or theories used to justify arguments should be substantiated and supported by technical work undertaken to prepare the Environmental Review. In addition, statements of fact, conclusions and arguments should be based on information that has a high degree of scientific certainty. Where these are not met the EPA will provide advice consistent with the precautionary principle.

Attachment 2

Location of scheme amendment



Shaded area not included

Attachment 3

Environmental Review Document Structure

The legislation requires that the Environmental Review Document be part of the amendment documentation. For our purposes it would be useful for it to be a separate volume, perhaps an appendix to the amendment document.

The following structure is suggested:

1. How to make a submission

- Include a standard sheet to guide the reader how to make a submission.

2. Introduction

- Clarify who is the Responsible Authority.
- Provide a paragraph or two to explain the background to the Environmental Review document and the process to date (see recent examples of Environmental Reviews) eg the Environmental Review Document is prepared in accordance with S48A of the *Environmental Protection Act* 1986; and, the Environmental Review Document should be read in conjunction with the amendment document.
- Refer the reader to a process flow chart, which could be Appendix A1. The flow chart could be adapted from the EPA's Draft Guidance Statement No. 33 *Environmental Guidance for Planning and Development*.

3. Summary of Amendment

- Should include a description of scheme / amendment and its purpose.
- Cross reference to the amendment document, particularly the scheme text / provisions, wherever possible.
- Include a clear location map and any other figures to describe the amendment, including an existing land use plan.

4. Environmental Factors Relevant to the Scheme

These factors will be specified by the EPA in the final instructions. Each factor should be addressed using the following format:

4.1 Environmental factor: eg wetlands

- Provide background on the current state of the environment.
- Discuss any polices relevant to the environmental factor.

4.2 Preliminary EPA objective / proposed alternative objective

- The EPA objectives for each environmental factor will be provided to the Responsible Authority following the issuing of the final instructions.

4.3 Potential impacts

- This section should outline the potential impacts that could result from the implementation of the scheme / amendment.

4.4 Proposed management

- How the scheme / amendment, provisions or zoning pattern address the impacts on environment.
- How scheme provisions will be implemented and how subsequent planning stages will address the impacts on the environment.

4.5 Proposed outcome

- Given the proposed management, can the EPA objective be met?
- On evaluation of the above (4.1 to 4.4), if it appears the EPA objective cannot be met this section provides the opportunity to offer an alternative objective and justify why the EPA should accept the alternative objective.

5. Environmental Factors Not Assessed (if applicable)

- These will have been identified in the instructions
- Alternatively, the document may argue why an environmental factor relevant to the scheme, as determined by the EPA, is considered to be a 'factor not assessed'.
- This section should largely follow the same format as Section 4 above.

6. Summary of scheme provisions

- This Section should concisely list the proposed management of the environmental factors particularly scheme provisions (from Section 4).

7. References

8. List of Acronyms, Glossary (if necessary)

Appendices

A1 Flow chart of process

A2 Instructions and EPA objectives

A3 Other information