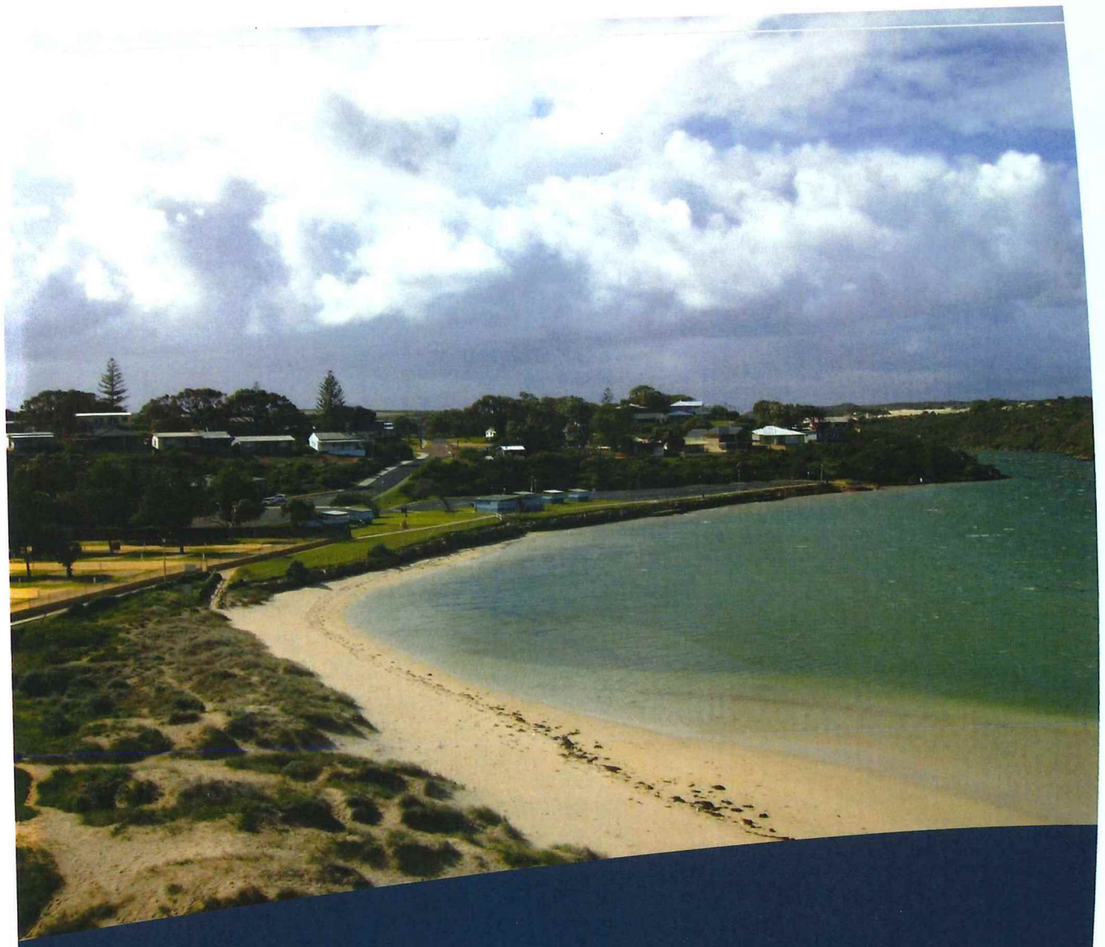
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SPN/0063
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Cardno
Shaping the Future



Moore River South

Revised Outline Development Plan

Prepared for Moore River Company Pty Ltd

September 2013

Project Number P7026

ENDORSEMENT PAGE

This structure plan is prepared under the provisions of the Shire of Gingin
Local Planning Scheme No.9

IT IS CERTIFIED THAT THIS STRUCTURE PLAN WAS APPROVED BY RESOLUTION OF THE WESTERN AUSTRALIAN PLANNING COMMISSION ON:

30 OCTOBER 2013

In accordance with Schedule 2, Part 4, Clause 28 (2) and refer to Part 1, 2. (b) of the *Planning and Development (Local Planning Schemes) Regulations 2015*.

Date of Expiry: **19 OCTOBER 2035**

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Executive Summary

The Moore River South revised Outline Development Plan (ODP) has been prepared by Cardno (WA) Pty Ltd (Cardno), on behalf of the Moore River Company, as a revision to the Outline Development Plan prepared by Masterplan Consultants W.A. Pty Ltd (Masterplan) and approved by the Western Australian Planning Commission in January 2000.

The revised ODP has been prepared in response to the acknowledgement by State Cabinet that the existing Future Development zone within the Shire of Gingin Local Planning Scheme No. 9 is consistent with previous zoning which has been in place since 1995 and that this zoning, subject to a reduction in the scale of the development, will provide the township of Guilderton and surrounding rural estates with a primary school, shopping and community facilities, and servicing infrastructure, which will result in the creation of a sustainable community catering for a population of up to 5,000 residents.

The Minister for Planning required that development under the revised ODP be in accordance with State Government environmental regulations and local planning controls.

The Minister also acknowledged that the Shire of Gingin and the Department of Planning will work closely with the Moore River Company to progress the revised ODP, which will be publicly advertised through the Shire's statutory process. Whilst the revised ODP will have to undergo the required public consultation process the Minister has emphasised the issue of whether the land should be developed or not is no longer open to debate and that the Government supports development in this area.

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Appendix E Moore River South - Environmental Justification and Assessment - Cardno - May 2010

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Appendix J Moore River South - Graceful Sun-Moth Survey - Cardno - June 2010

1 Introduction and Objectives

1.1 Introduction

The proposed Moore River South revised Outline Development Plan (ODP) has been prepared by Cardno (WA) Pty Ltd (Cardno), on behalf of the Moore River Development Company, as a revision to the Outline Development Plan prepared by Masterplan Consultants W.A. Pty Ltd (Masterplan) and approved by the Western Australian Planning Commission (WAPC) in January 2000. This revised ODP supersedes any previous ODP's for Moore River South.

The revised ODP area has been prepared in response to the acknowledgement by State Cabinet that the existing Future Development zone within the Shire of Gingin Local Planning Scheme No. 9 is consistent with previous zonings for the site which has been in place since 1995 and that this zoning, subject to a reduction in the scale of the development, will provide the township of Guilderton and surrounding rural estates with a primary school, shopping and community facilities, and servicing infrastructure, which will result in the creation of a sustainable community catering for a population of up to 5,000 residents.

The revised ODP has been reduced by approximately 100ha from 557ha covered by the currently endorsed ODP to 457ha (inclusive if some Future Development zoned area in the north). It includes the addition of several supporting technical studies that have been required as a result of changing legislation, with the recommendations of these reports informing the revised design. Although these technical studies support the revised the ODP they do not negate the possible need for additional studies at the detail design stage.

In summary, the main changes to the revised ODP include:

- Significantly reduced scale of development;
- Significantly increased setbacks from the Indian Ocean to allow for:
  - The physical processes setback (PPS) identified in the updated Coastal Assessment report (**Appendix I**);
  - Retention of the sites natural topography, particularly in relation to the coastal dunal system;
  - Acknowledgement and preservation of natural drainage areas; and
  - Retention of important flora and vegetation communities.
- Exclusion of land uses adjacent to Moore River, specifically the proposed tourist site;
- Generous allocation of public open space to ensure retention of remnant vegetation;
- Protection of key physical environmental attributes;
- Increased road widths to maximise the opportunity for capture of drainage at source; and
- Creation of an extensive area of foreshore reserve to be ceded free of cost to the Shire of Gingin and/or the State for the purpose of recreation and conservation.

1.2 Objectives of Revised Outline Development Plan

The key objectives of the revised ODP are to:-

- Provide a significantly reduced scale of development;
- Provide the township of Guilderton and surrounding rural estates with a primary school site, shopping and community facilities, and servicing infrastructure, which will result in the creation of a sustainable community catering for a population of up to 5,000 residents;
- Provide an adequate physical process setback from the coast to safeguard future development from coastal processes.

- Protect the Moore River from development through the provision of new foreshore reserves;
- Ensure the impacts of climate change are adequately considered;
- Provide extensive additional areas of foreshore reserve and adequate public open space;
- Retain, where possible, the natural topography of the subject site;
- Ensure the visual impact of the development from Guilderton is minimised;
- Concentrate development on areas that have been substantially cleared / degraded in the past;
- Retain remnant vegetation (including "Excellent" and "Pristine-Excellent" condition vegetation and Priority Flora populations), habitat trees and wildlife corridors;
- Minimise the disturbance of key physical environmental attributes;
- Prepare a Local Water Management Strategy with the emphasis on water sensitive urban design;
- Provide state of the art wastewater and water re-use technologies and demonstrate viable options for the management of these systems;
- Provide for a variety of housing densities and lot layouts;
- Cater for the tourist demands of the region both now and in the future;
- Encourage a less transient more permanent population in the longer term through the provision of locally based employment;
- Provide managed public access to and along the coast;
- Create a permeable road and pedestrian system;
- Encourage modes of transport other than the private car;
- Maximise road widths to encourage drainage within the road reserves;
- Prepare a framework for sustainable development; and
- Generally reflect a more sympathetic response to site attributes within a contemporary design response.

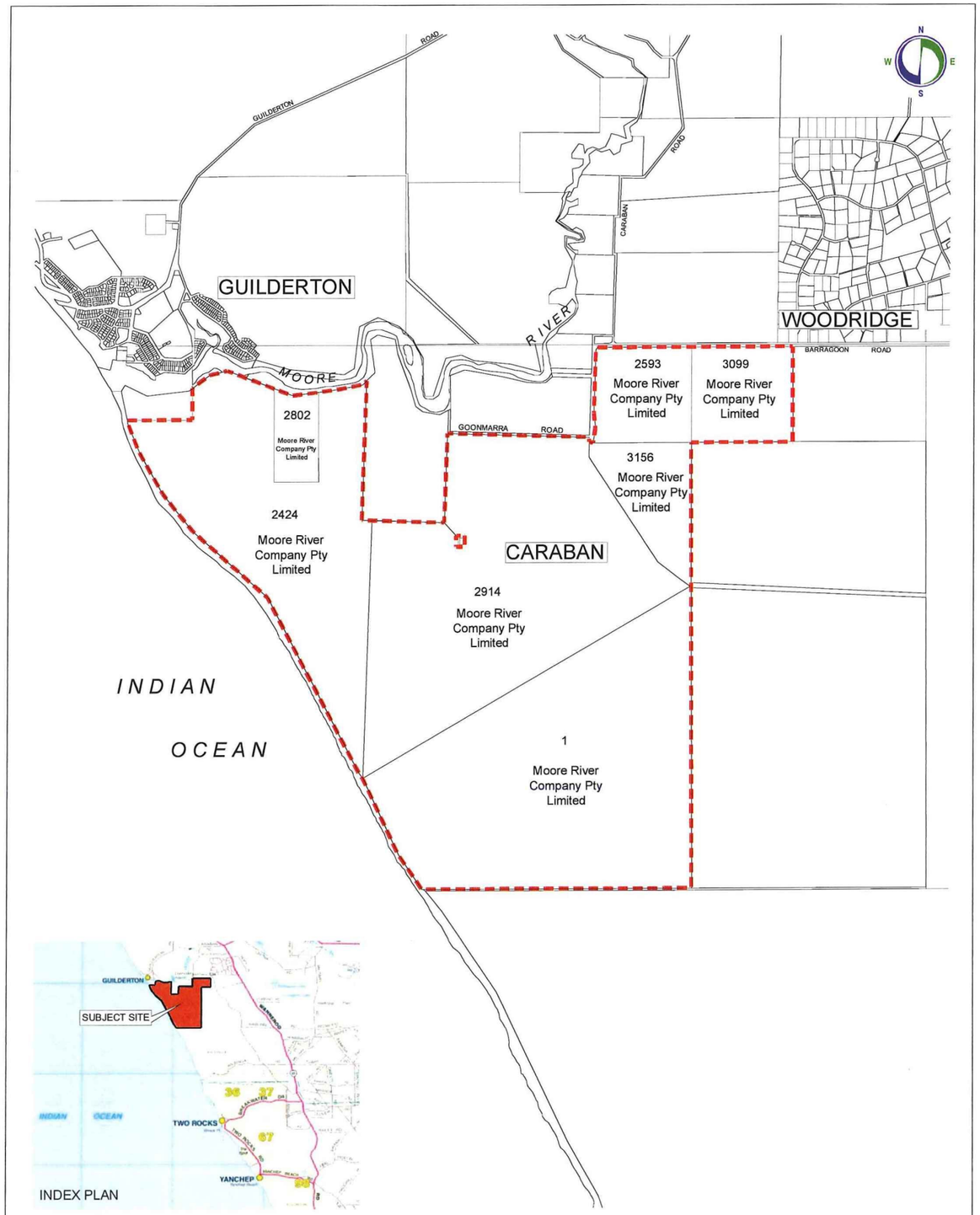
1.3 Site Location and Description

The revised ODP area is located on the south side of the Moore River, opposite the Guilderton townsite, and is located approximately 75 kilometres north of the Perth Central Business District. The revised ODP area is part of the Moore River Company's 2000 hectare property which has direct frontage and access to Barragoon Road and is connected to Indian Ocean Drive via Link Road and King Drive, Woodridge.

The revised ODP area rises steeply from the Indian Ocean, with a coastal dunal system attaining heights of 10m Australian Height Datum (AHD) and up to 30m AHD further inland. The site rises steeply from Moore River up to a dune crest along the shore which is up to 50m AHD.

The revised ODP area comprises Swan Location 2802 and portions of Swan Locations 2424 and 2914 as depicted on **Figure 1** - Land Ownership Plan on the overleaf. There is a frontage of approximately 2.6 kms to the Indian Ocean. The site is separated from the river mouth of the Moore River by a Crown Reserve No. 17949 (Loc. 3049), comprising of 19 hectares. The south eastern boundary of the revised ODP area accords with the Amendment No. 22 boundary and is subject to survey.

The Moore River Company's property has for many years and continues to be used for farming and grazing purposes and, as a result, much of the land has been cleared and converted to pasture.



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FIGURE 1

LAND OWNERSHIP PLAN
MOORE RIVER SOUTH OUTLINE DEVELOPMENT PLAN
MOORE RIVER SOUTH, SHIRE OF GINGIN

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DRAWN: FC APPROVED:
LOCAL AUTHORITY
SHIER OF GINGIN
PROJECT-PHASE-PLAN NUMBER REVISION
P7026 SK08

1.4 Planning History

The subject site has undergone extensive planning over the last 15 years, from the initial rezoning of the land in 1995 to allow for urban development to the lodgement of this current revised ODP in 2010.

1.4.1 Amendment No. 22 (1995)

On March 3 1995, 557 hectares of the Moore River Company land was rezoned from 'Rural' to 'Urban Development' under the Shire of Gingin Town Planning Scheme No. 8 (TPS8). The purpose and intent of this zone was to ensure that the district will derive the maximum possible benefit from the design, layout and provision of works and services for urban development. Council requires the preparation of an ODP prior to supporting or approving any proposal for subdivision or development of the land.

1.4.2 Outline Development Plan (2000)

An Outline Development Plan was prepared on behalf of the Moore River Company by Masterplan Consultants, and was adopted by the Western Australian Planning Commission (WAPC) on 17 January 2000. The 2000 ODP incorporated the whole 557 ha of the Urban Development zone with an envisaged ultimate population of 13,500 residents in 5,269 dwellings.

The approved 2000 ODP included: six residential precincts; two primary schools and one high school; community facilities; a district hospital site; three medical centres; three tourist sites; and commercial centres, including a district centre, neighbourhood centres and local shops.

1.4.3 Subdivision Application (2003)

On 27 October 2003 an application for subdivision was submitted to the WAPC by Masterplan Town Planning Consultants (Masterplan) for approval of 661 residential lots, 8 areas of public open space, a central retail area and roads, generally in accordance Stage 1 of the 2000 approved ODP. On 21 September 2004 the WAPC refused the subdivision application on the basis that the proposal was contrary to the current strategic planning for the Gingin coast area and the then State Governments expectations for the area.

The Moore River Company sought a review of the decision in the Town Planning Appeal Tribunal in November 2004 the then Minister for Planning and Infrastructure 'called in' the appeal and instructed the Tribunal to make a recommendation on the matter to hand. Following a hearing the Tribunal reached the view that it should recommend against approval. The matter remained in dispute until the recent decision of State Cabinet which gave rise to the preparation of the revised ODP.

1.5 Regional Setting

The Department of Planning and the Shire of Gingin have undertaken various studies which considered the future of the Guilderton/Moore River area in the context of its regional setting. The revised ODP area is located on the south side of the Moore River opposite the Guilderton townsite and will be the first settlement located north of the metropolitan region as identified on the Metropolitan Region Scheme. Its locational characteristics, relative to Perth, are not dissimilar to those of Mandurah in the south - as can be seen on **Figure 2** - Local Context Plan on the overleaf. Descriptions of the various regional studies and strategies prepared by the Department of Planning and the Shire of Gingin are found in Section 2.0 - Planning Context.

TO WANNEROO ROAD

GUILDERTON TOWNSITE

MOORE

WOODRIDGE ESTATE

KING DRIVE

BARRAGOON ROAD

WANNEROO ROAD

RURAL

RURAL

LEGEND

ZONES

- RESIDENTIAL LOW DENSITY R20
- RESIDENTIAL MEDIUM DENSITY R40
- COMMERCIAL NEIGHBOURHOOD
- TOURIST RESORT/CARAVAN PARK
- MIXED BUSINESS/RESIDENTIAL R5
- URBAN DEVELOPMENT ZONE

RESERVES

- PUBLIC USE PRIMARY SCHOOL
- PUBLIC USE COMMUNITY FACILITIES
- PARKS AND RECREATION PUBLIC OPEN SPACE
- PARKS AND RECREATION FORESHORE RESERVE
- COUNCIL DEPOT
- EMERGENCY SERVICES
- ODP BOUNDARY
- PHYSICAL PROCESSES SETBACK
- POSSIBLE BOAT LAUNCH FACILITY
- POTENTIAL SEWERAGE TREATMENT PLANT SITE (Indicative Only)
- STRATEGIC BEACH ACCESS

0 3,000 m

FIGURE 2

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LOCAL CONTEXT PLAN
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SHIRE OF GINGIN

NORTH

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LOCAL AUTHORITY
SHIRE OF GINGIN
PROJECT-PHASE-PLAN NUMBER REVISION
P7026 CON 003

2 Planning Context

2.1 Department of Planning / Western Australian Planning Commission

The Department of Planning (DoP) is the State planning authority and is concerned with all regional planning matters. In this instance, the DoP will make a recommendation to the Western Australian Planning Commission (WAPC) on the endorsement of this revised Outline Development Plan (ODP), but only after the matter has been advertised for public comment and the Shire of Gingin has made its own recommendation as to whether the revised ODP ought to be endorsed and any conditions that should be affected to that endorsement.

2.1.1 State Planning Strategy

The WAPC prepared and adopted the State Planning Strategy in 1997. The Strategy provides the overall vision of the State and will be further articulated and applied by policies and plans dealing with particular planning issues or regions of the State.

The State Planning Strategy states that the primary aim of planning is to provide for the sustainable use and development of land. The Strategy identifies the five key principles (Environment; Community; Economy; Infrastructure and Regional Development), which further define this primary aim and describe the considerations which influence good decision-making in land use planning and development.

The State Planning Strategy aims to guide the sustainable development of Western Australia to 2029. In accordance with the principles of the Strategy the revised ODP has been designed to incorporate sustainable design principles as considered further in Section 4.12 of this report

2.1.2 Statements of Planning Policy

2.1.2.1 State Planning Policy 1 - State Planning Framework

The State Planning Framework unites existing State and regional policies, strategies and guidelines within a central framework which provides a context for decision-making on land use and development in Western Australia. It also restates and expands upon the key principles of the State Planning Strategy in planning for sustainable land use and development.

The policy was initially gazetted on 22 December 1998 as Statement of Planning Policy No. 8. Subsequently, a variation to the policy, Statement of Planning Policy No 1 (Variation No 1) State Planning Framework Policy, was gazetted on 30 May 2000.

The Statement of Planning Policy has now been further updated to include additional regional strategies, regional and sub-regional structure plans, strategic policies and operational policies that have been endorsed by the WAPC since May 2000. This Statement of Planning Policy, which does not introduce new policies but simply brings together existing policies, strategies and plans approved by the WAPC, will continue to assist local governments in preparing schemes and will also clarify the State and regional policies that apply to a particular locality.

2.1.2.2 Statement of Planning Policy No. 2.6 – State Coastal Planning Policy

This policy, prepared in 2003 and updated in 2006, addresses land use planning and development issues specifically as they relate to the protection and management of the coast. The policy requires

strategic plans to guide local planning, development setbacks for protection against coastal processes such as erosion and storms, and the provision of coastal foreshore reserves.

Guidance is provided on determining coastal setbacks. The preparation of coastal planning strategies or coastal foreshore management plans in partnership with the broader community is also strongly advocated.

The policy provides high order guidance for decision-making on coastal planning matters and applies state wide. Implementation will be through local government town planning schemes, and regional and local strategies.

The objectives of this policy are to:

- Protect, conserve and enhance coastal values, particularly in areas of landscape, nature conservation, indigenous and cultural significance;
- Provide for public foreshore areas and access to these on the coast;
- Ensure the identification of appropriate areas for the sustainable use of the coast for housing, tourism, recreation, ocean access, maritime industry, commercial and other activities; and
- Ensure that the location of coastal facilities and development takes into account coastal processes including erosion, accretion, storm surge, tides, wave conditions, sea level change and biophysical criteria.

To comply with the provisions of SPP 2.6 the Moore River Development Company has engaged M P Rogers and Associates to provide a Coastal Setback Assessment as part of the original ODP. As part of the revised ODP M P Rogers have again been engaged to provide an updated Coastal Setback Assessment, which is included as **Appendix I**. The report concludes that the coastal dunal system at the development frontage are stable and accordingly recommends a physical processes setback of between 125 and 177m, which is incorporated, as a minimum, within the revised ODP design. At this stage the report assesses appropriate setbacks to the Moore River based SPP 2.9 and recommends a combined setback of 50m from high water mark or top of river bank. This assessment will be augmented by a detailed assessment of the Moore River foreshore under SPP 2.6 with the final setbacks and extent of foreshore reserve to be fixed within a Foreshore Management Plan. That Plan is in draft form and has been subject of a consultation process. The foreshore reserve width currently shown on the Plan has been based on the southern watershed and visual catchment to the river, resulting in a reserve width averaging approx.. 150m. The final extent of the foreshore reserve will will accommodate the outcomes of the SPP 2.6 assessment to be completed prior to endorsement of the Foreshore Management Plan.

2.1.2.3 Statement of Planning Policy No. 3 – Urban Growth and Settlement

This policy sets out the principles and considerations which apply to planning for urban growth and settlements in Western Australia. The objectives of this policy are:

- To promote a sustainable and well planned pattern of settlement across the State, with sufficient and suitable land to provide for a wide variety of housing, employment, recreation facilities and open space.
- To build on existing communities with established local and regional economies, concentrate investment in the improvement of services and infrastructure and enhance the quality of life in those communities.
- To manage the growth and development of urban areas in response to the social and economic needs of the community and in recognition of relevant climatic, environmental, heritage and community values and constraints.
- To promote the development of a sustainable and liveable neighbourhood form which reduces energy, water and travel demand while ensuring safe and convenient access to employment and

services by all modes, provides choice and affordability of housing and creates an identifiable sense of place for each community.
- To coordinate new development with the efficient, economic and timely provision of infrastructure and services.

Achieving sustainable forms of development is key to this policy and central to the planning system in Western Australia. It is the intention of the revised ODP to create a sustainable community and place to live that provides for an appropriately high level of local employment and economic growth, and to create a strong, vibrant and socially inclusive community, whilst preserving the coastal and estuarine environments of the locality.

2.1.2.4 Statement of Planning Policy 3.1 - Residential Design Codes (Variation 1)

The purpose of the Residential Design Codes (R-Codes) is to provide a comprehensive basis for the control, through local government, of residential development throughout Western Australia. They are intended to cover all requirements for planning control purposes and to minimise the need for councils to introduce separate planning policies or variations to these matters.

The main objectives of the R-Codes are:

- To provide for a full range of housing types and densities that meet the needs of all people;
- To provide for local variations in neighbourhood character;
- To ensure appropriate standards of amenity for all dwellings;
- To protect the amenity of adjoining residential properties; and,
- To encourage environmentally sensitive design.

Whilst the R-Codes are generally used during the later stages of the planning process in the assessment and determination of applications for residential development the density controls set out in the policy are relevant in the consideration of the design of the revised Outline Development Plan.

The R-Codes set out a range of density codes from low density R2 (with a minimum site area of 5000m²) to high density R160 with a minimum site area of 62.5m². In accordance with the objectives of this policy and the objectives of Liveable Neighbourhoods to provide for a range of housing types and densities the revised ODP proposes a mix of residential density codes from R20 (500m² average) to R40 (220m² average).

2.1.2.5 Draft Statement of Planning Policy No. 3.6 – Development Contributions for Infrastructure

This draft policy sets out the principles and considerations that apply to development contributions for the provision of infrastructure in new and established urban areas, and the form, content and process to be followed.

In summary, the objectives of this draft policy are:

- To promote the efficient provision of public infrastructure and facilities to meet the demands arising from new growth and development;
- To ensure that development contributions are necessary and relevant to the development to be permitted and are charged equitably among those benefiting from the infrastructure and facilities to be provided; and
- To ensure consistency and transparency in the system for apportioning, collecting and spending development contributions.

In the absence of relevant provisions within the Shire of Gingin LPS9, this policy sets out the format for developer contributions and provides a template for the form, content and process to be followed

in the provision of infrastructure contributions for new development. Developer contributions are considered in Section 12 of this report.

2.1.3 Regional Strategies

Regional Strategies cover a region or sub-region and interpret the Sate Planning Strategy at that level, providing a basis for cooperative action to be taken by State and local government on land use and development.

2.1.3.1 Central Coast Regional Strategy

The Central Coast Regional Strategy was endorsed by the WAPC in June 1994. The strategy addresses the future of the coastal area between Wilbinga (south of Moore River and immediately north of the Metropolitan Region Scheme boundary) and Dongara in the north. The strategy identifies urban growth areas and conservation areas, amongst other things. The WAPC has identified the subject site as an urban growth area of major local centre status. The revised ODP area, which is zoned 'Future Development, is consistent with this regional strategy.

2.1.4 Regional and Sub-regional Structure Plans

Regional and sub-regional structure plans provide for the comprehensive planning of regions, sub-regions or particular locations to guide change in the short to medium term.

2.1.4.1 Development Strategy and Structure Plan for the Gingin Coastal Region (Shire of Gingin 1992)

This Development Strategy and Structure Plan were prepared in 1992 to determine a direction for growth for the coastal region of the Shire of Gingin which stretches from the northern boundary of the Metropolitan Region Scheme for 70 kms to the Lancelin Naval Firing Range. This coastal strip comprises four main settlements, being Guilderton, Seabird, Ledge Point and Lancelin. The purpose of the study was to review the region's past and existing characteristics, examine key issues and trends and evaluate alternative planning strategies for future development. The four main issues addressed in this study were as follows:

1. Rapid northward direction of metropolitan region. The report states, in its executive summary, that "these processes are likely to increase pressures for large-scale urban development in the Coastal Region."
2. The economic potential of the region, particularly for tourism and emerging horticultural development.
3. The perceived threat to the fishing industry and quality of life in the four nominated towns from the pressures for urban and industrial development.
4. The capability of the region's coastal environment to accommodate development.

The development strategy adopted by the Gingin Shire Council earmarks Guilderton as a town of approximately 30,000 people with approximately 15,000 residents north of the river and 15,000 residents south of the river. The revised ODP area comprises 346 ha and will accommodate approximately 5,000 residents, and is therefore consistent with Council's Coastal Region Structure Plan.

2.1.4.2 North West Corridor Structure Plan

The North West Corridor Structure Plan was endorsed by the Minister for Planning in 1994 and established a growth framework for land north of Hepburn Avenue and extending to the northern boundary of the Metropolitan Region Scheme (approximately 4 kms north of the Two Rocks townsite).

The significance of the Structure Plan to this project is that the Minister had determined there will be a large open space between the Metropolitan Area and the Moore River Company's land holding. This green area is generally known as Wilbinga Open Space and is approximately 8000 hectares in area or twenty times larger than Kings Park. In general terms, Wilbinga measures approximately 10 kms east-west by 8 kms north-south. This open space is consistent with the conservation strategy determined in the Central Coast Regional Strategy.

2.1.4.3 Gingin Coast Structure Plan

In December 2003 the Minister for Planning approved the WAPC's release of the draft Gingin Coast Structure Plan. The public submissions received during the advertising period were collated and the responses evaluated by the Department of Planning in consultation with the community advisory group and steering committee. A key change to the structure plan following advertising related to the proposed change of land use of the area to the south of Moore River, being the site of this revised ODP.

The Gingin Coast Structure Plan designates the area south of Moore River as a 'Recreational and Tourist Node Investigation Area'. The structure plan report states that this type of settlement will be in response to the demand for tourist/visitor accommodation driven by tourist attractions and/or recreation-based activities in the locality and will be subject to planning, infrastructure, environmental and social considerations.

The Gingin Coast Structure Plan is a non-statutory document not endorsed by the Shire of Gingin and components of which, involving Moore River, do not have the support of the State Government.

The recommendations of the Gingin Coast Structure Plan in relation to the use of land south of Moore River as a Recreational and Tourist Node Investigation Area are contrary to the provisions of LPS9, the statutory land use planning control for the Shire and the draft Local Planning Strategy. The revised ODP has been designed to reflect the Future Development' zoning of the land under LPS9.

2.1.5 Strategic Policies

Strategic policy statements deal with particular strategic planning issues, and in some cases refine and expand upon aspects of a regional strategy. Of particular relevance to the revised ODP is the WAPC's Liveable Neighbourhoods policy document.

2.1.5.1 Liveable Neighbourhoods

Liveable Neighbourhoods is a strategic operational policy for the design and assessment of structure plans (region, district and local) and subdivision for new urban (predominantly residential) areas in the metropolitan area and country centres.

In general, Liveable Neighbourhoods replaces the current WAPC development control policies. Where there is conflict with existing policies, Liveable Neighbourhoods will prevail unless it can be demonstrated why it cannot or should not apply.

Liveable Neighbourhoods has been prepared to implement the objectives of the State Planning Strategy which aims to guide the sustainable development of Western Australia to 2029.

In summary, the 12 principal aims of Liveable Neighbourhoods are:

1. To provide for an urban structure of walkable neighbourhoods, clustering to form towns of compatible mixed uses in order to reduce car dependence for access to employment, retail and community facilities;

2. To ensure that walkable neighbourhoods and access to services and facilities are designed for all users, including those with disabilities;
3. To foster a sense of community and strong local identity and sense of place in neighbourhoods and towns;
4. To provide for access generally by way of an interconnected network of streets which facilitate safe, efficient and pleasant walking, cycling and driving;
5. To ensure active street-land use interfaces, with building frontages to streets to improve personal safety through increased surveillance and activity;
6. To facilitate new development which supports the efficiency of public transport systems where available, and provides safe, direct access to the system for residents;
7. To facilitate mixed use urban development which provides for a wide range of living, employment and leisure opportunities, capable of adapting over time as the community changes and which reflects appropriate community standards of health, safety and amenity;
8. To provide a variety of lot sizes and housing types to cater for the diverse housing needs of the community at a density that can ultimately support the provision of local services;
9. To ensure the avoidance of key environmental areas and the incorporation of significant cultural and environmental features of a site into the design of an area;
10. To provide for a more integrated approach to the design of open space and urban water management;
11. To ensure cost-effective and resource-efficient development to promote affordable housing; and
12. To maximise land efficiency wherever possible.

The revised ODP has been designed in accordance with the principles of Liveable Neighbourhoods, which are fundamental to the design philosophy. Key principles include the provision of walkable neighbourhoods, through an interconnected network of streets that provide convenient access to a mix of facilities and services that will meet the needs of both the new population and the existing population of the Guilderton and Woodridge townsites.

Importantly, the revised ODP proposes much wider streets and significantly more public open space than is required by Liveable Neighbourhoods. This has been done to achieve a greater level of site responsiveness and to create a 'point of difference'.

2.2 Shire of Gingin

The revised ODP area lies within the Shire of Gingin and is therefore required to comply with the Shire of Gingin Local Planning Scheme No. 9, the current statutory land-use planning control, as well as other relevant Council policies and strategy plans.

The Council of the Shire of Gingin and the WAPC adopted Amendment No. 22 to the superseded Shire of Gingin Town Planning Scheme No. 8, under which 557 hectares of the Moore River Development Company land was rezoned from "Rural" to "Urban Development", as the proposal was consistent with the various Shire and WAPC strategies and structure plans identified in the preceding sub-section. Under the Shire of Gingin Local Planning Scheme No. 9, the 557 hectares is zoned 'Future Development'. The 'Future Development zone identifies land suitable for urban development. Under this zone, an ODP is required to be prepared and endorsed to ensure that the area will derive the maximum possible benefit from the design, layout and provision of works and services. Subdivision and development will thereafter be approved in general conformity with the adopted ODP.

2.2.1 Shire of Gingin Local Planning Scheme No. 9

Under the provisions of the Shire of Gingin Local Planning Scheme No. 9 (LPS9) the revised ODP area is zoned Future Development. **Figure 3** on the overleaf is a zoning plan of the revised ODP area.

The purpose of the Future Development zone is to designate land considered to be suitable for future development and to prevent such land being used or developed in a manner which could prejudice its possible future use.

The provisions of the Future Development zone require that the subdivision and development of land within the Development Area is to be generally in accordance with an approved Structure Plan. A revised ODP has been prepared in accordance with the provision 5.7 of LPS9 which establishes the requirements for Structure Plan preparation.

2.2.2 Shire of Gingin Draft Local Planning Strategy

The Shire of Gingin's draft Local Planning Strategy (the Strategy) was prepared in September 2003 and has been held in abeyance along with Town Planning Scheme No. 9 since 2006. The Strategy is a planning tool that enables Council to set out its vision for the municipality, and the longer term directions for land use and development. The Strategy establishes a basic structure of population and employment, and outlines the broad strategies for housing, industry, shopping and business activities, and proposals for transport, open space and other public uses.

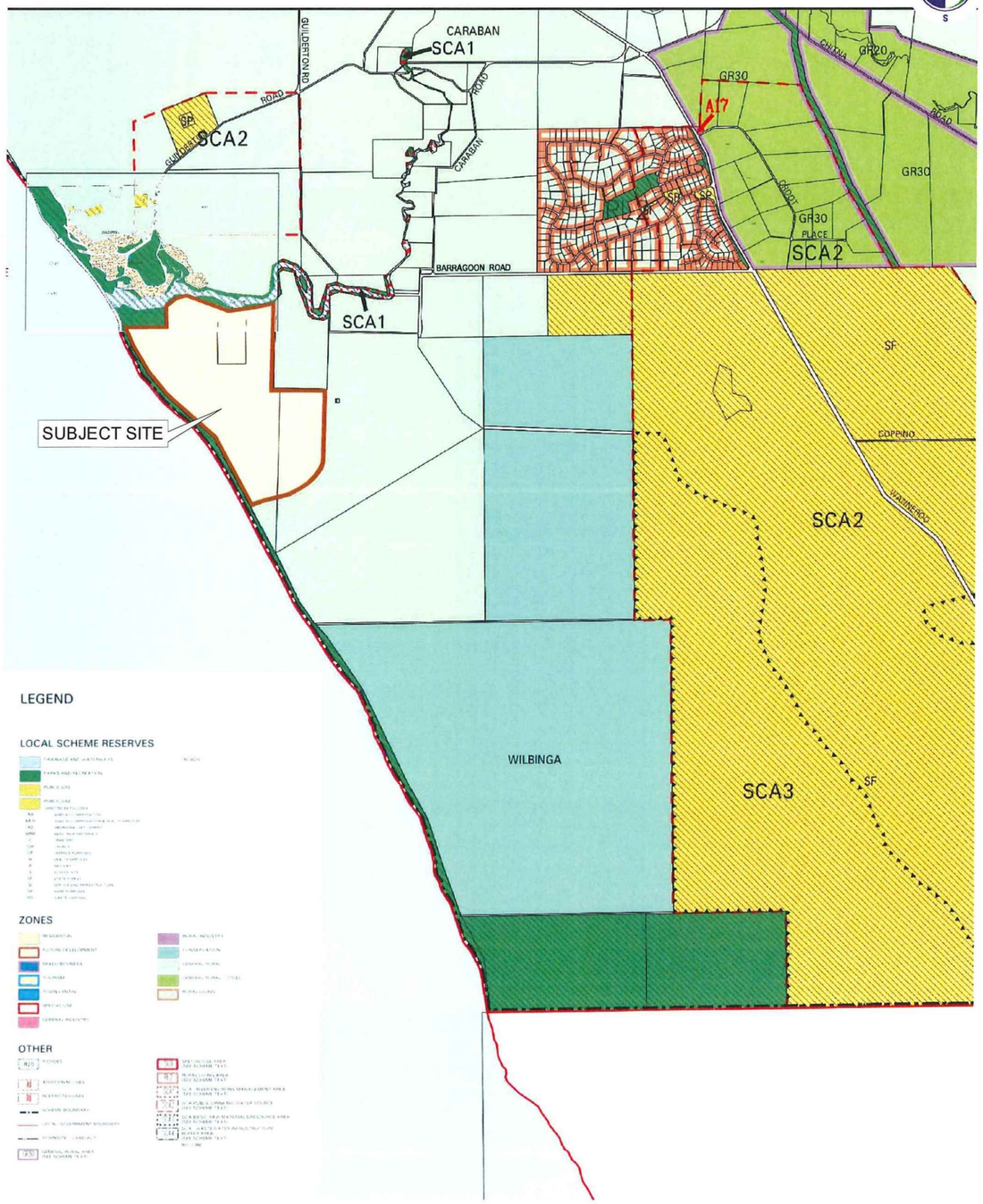
The Strategy recognises the Urban Development zoning of the revised ODP area and acknowledges that in the medium to long-term the area is anticipated to provide for a resident population of some 13,500 persons. However, the Strategy states that prior to actual urban development occurring on the south side of the Moore River, there will be a need for further detailed planning, and in particular addressing some key issues including coastal management, river management and integration with the existing Guilderton townsite.

The relevant objectives of the Strategy in relation to the revised ODP area are:

- To promote and support new urban expansion around the existing Guilderton townsite;
- To facilitate a high quality, environmentally sensitive and integrated form of urban expansion south of Moore River as part of the Guilderton townsite expansion plan;
- To increase local employment opportunities and local expenditure by increasing the level and diversity of business prospects both within and adjacent to the townsite;
- To promote increased level of community facilities within or adjacent to the Guilderton townsite; and
- To maintain the attraction and importance of Guilderton as a tourist destination, and recognise its popularity for non-permanent residents.

A number of strategies are identified to meet these objectives, including:

- Utilise rationalisation of zones and zoning controls to encourage the establishment of a greater mix of urban land uses, such as home offices, home based business, cottage industries and the like;
- Preparation and adoption of structure plans for identified expansion area incorporation the existing Outline Development Plan for south of Moore River, to ensure that subdivision and development of urban land only proceeds after comprehensive planning to ensure design standards, cost effective servicing sensitive to the environment and adequate level of community facility provision; and



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FIGURE 3

SHIRE OF GINGIN TPS No. 9

MOORE RIVER SOUTH OUTLINE DEVELOPMENT PLAN

MOORE RIVER SOUTH, SHIRE OF GINGIN

Cardno
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P.O. Box 447
West Perth 6872
Telephone (08) 9273 3888
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DATE: 11.09.2013 SCALE AT A4: 1:50 000
DESIGNED: CHECKED:
DRAWN: FC APPROVED:
LOCAL AUTHORITY
SHIER OF GINGIN
PROJECT-PHASE-PLAN NUMBER REVISION
P7026 CON07

- Promote, facilitate and undertake the preparation and implementation of localised coastal management plans which recognise the importance and attraction of the coast for urban townsite and nodal development, whilst simultaneously ensuring the reinstatement and ongoing protection of coastal systems in the context of urban townsite growth and activities.

The revised ODP reflects the provisions of the draft Strategy by facilitating the future development south of Moore River and providing the necessary technical and management plans to support the proposal and protect the coastal and estuarine environments.

2.2.3 Shire of Gingin Town Planning Policies

A provision within the Shire of Gingin LPS9 allows Council to make Town Planning Scheme Policies in relation to parts or all of the Scheme Area and in relation to one of more aspects of the control of development and land use.

A Town Planning Scheme Policy shall not bind the Council in respect of any application for Planning Consent but Council shall take into account the aims and provisions of the policy when making its decision. Policies relevant to the revised ODP are considered in the following section of this report:

2.2.3.1 Town Planning Policy No. 1.2 – Foreshore Protection Areas

Town Planning Policy 1.2 applies to the area depicted on the various Strategy Maps labelled as Foreshore Protection Areas and applies to the revised ODP area. The objective of the policy is to provide general development guidelines including setbacks, building height, pedestrian access and parking in areas where development is permitted in the foreshore area.

The revised ODP has been designed to ensure that the environmental attributes of the Foreshore Protection Area are preserved through the provision of increased setbacks to both the river and ocean and through the retention of the coastal dunal system, whilst maximising pedestrian access through strategic beach access points. Environmental protection measures will be set out in a Foreshore Management Plan, as required by the revised ODP's Statements of Planning Policy, included as Section 9 of this report.

The Guilderton Townsite Strategic Map which is contained within Section 4.0 of the Shire of Gingin Draft Local Planning Strategy requires that a coastal management plan be prepared for the subject site. Planning Policy Statement No. 6 (refer Section 9) states that a foreshore management plan shall be prepared under clause 5.1(x) and (xi) of State Planning Policy No. 2.6: State Coastal Planning Policy, at the subdivision stage.

2.2.3.2 Town Planning Policy No. 7.1 – Guilderton Foreshore Protection Area

This policy applies to areas depicted on the Guilderton Strategy Map as Foreshore Protection Areas. The objective of the policy is to provide for the improvement of river water quality to allow for recreational purposes and ensure that any development in or adjacent to the Foreshore Protection Area has minimal detrimental effect on the quality of the local environment over the long term.

The revised ODP responds to this policy by proposed expansion of the foreshore reserve system and precluding any development within the direct catchment of the Moore River.

2.2.3.3 Town Planning Policy No. 7.2 – Guilderton Expansion Area

Town Planning Policy No. 7.2 applies to the land south of Moore River and therefore specifically relates to the revised ODP area. The objective of the policy is to provide a comprehensive structure plan for large scale urban development in the area. The policy requires that structure plans should indicate urban cells, retail centres, schools, public open space, and the main infrastructure for the area. The policy also requires that urban cells to the south of Moore River will not be supported unless a trafficable bridge is provided to connect the existing townsite.

2.3 Environmental Protection Agency

In determining an informal level of assessment with public review for Amendment No. 22, the Environmental Protection Agency was aware of a commitment made by the proponent that the following four matters would be addressed in the preparation of an ODP:

- Preparation of a river foreshore management plan;
- Preparation of an ocean foreshore management plan;
- Preparation of a drainage management plan; and
- The development would be sewered.

During the advertising period of Amendment No. 22, the Minister for the Environment determined an informal level of (environmental) assessment where public review would apply. This decision was advertised and appeals were lodged in regard to the level of assessment.

In August 1994 the Minister for Environment advised Moore River Company that he had dismissed all appeals against the informal level of assessment of Amendment No. 22. It was considered there were no significant environmental concerns which would prevent urban development providing there was no direct drainage discharge to the river or ocean, the development was sewered and management plans were prepared for the coastal and river foreshore areas.

The revised ODP is of significantly lesser scale than that anticipated by Amendment 22 and the currently approved ODP for the site. The area of new reserves has increased enormously, and the proposal responds to all contemporary environmental criteria. It is considered that the revised ODP will not have a 'significant effect on the environment' for the purposes of the Environmental Protection Act.

3 Community Consultation

A comprehensive community consultation process was carried out as part of the approved 2000 Outline Development Plan (ODP). In accordance with an agreement between the then Department of Planning and the Shire of Gingin, three community workshops were held under the direction of an independent chairman - Dr Geoff Syme from the C.S.I.R.O. The main purpose of these workshops was to provide information to the public so that they could suggest principles and basis for guidelines for the ODP. Additionally, the following extract from the summary of the workshops identified the objectives for the workshops as being:

- To develop planning principles for the Outline Development Plan;
- To provide the reasoning or basis on which guidelines can be derived; and
- To ensure that the greatest breadth of input and ideas are gained from which the planners can work.

Key issues that arose from the workshops included:

- Retention or stabilisation of the 'desert';
- Requirement for adequate coastal and river foreshore setbacks;
- River not to be dredged and rivermouth bar to remain;
- Retention of the site as a conservation reserve;
- Provision of adequate employment;
- No discharge of stormwater into the river or ocean;
- Managed public access along river and coastal foreshore;
- Need for safe ocean boat launching facility;
- Provision of adequate servicing - power, water, sewer;
- Provision of adequate community facilities;
- Requirement for a bridge crossing; and
- Provision of a well balanced community.

The 2000 approved ODP was designed to reflect the outcomes of the workshop where possible. The workshops provided a breadth of input and ideas (principles and guidelines). Although the principles and guidelines established did not override the relevant planning principles at the time they were taken into account in the consideration and assessment of the approved 2000 ODP, by the proponent, the Shire, the WAPC and relevant Government agencies.

3.1 Revised Outline Development Plan

The revised ODP is essentially a revision to the approved 2000 ODP, which has been amended to reflect the Minister of Planning's acknowledgement of the Urban Development zoning of the land and its suitability to accommodate a reduced scale of development. Preparation of the revised ODP has considered the issues arising from consultation in relation to the approved 2000 ODP and the Gingin Coast Structure Plan. The most significant design response has been the proposed reduction of the scale of development and the incorporation of significant additional reserves and open space in response to expressed community opinion.

The revised ODP area has been reduced from 557ha to 457.34ha with a reduction in the envisaged total population from 13,500 to 5,000 residents. The overall impact on the environment has also been significantly reduced with additional setbacks provided to the coast and the previously proposed tourist development omitted from adjacent to the Moore River. Additional supporting technical studies have also been provided to address the amended design and reflect changes in legislation.

The revised ODP underwent formal consultation pursuant to the Shire of Gingin Town Planning Scheme No. 8 (TPS8), which requires that once an ODP has been prepared to the satisfaction of Council, the Council shall advertise, including notifying in writing, to all owners considered likely to be affected by the ODP, and inviting each owner to make a submission regarding any aspect of the Plan of interest to or affecting the landowner. TPS8 specifies a minimum time period of 28 days for submissions to be received. The public advertising process carried out under TPS8 was consistent with that required by newly gazetted TPS9.

Public advertising and a consultation exercise occurred over 42 days in March/April 2012. At its meeting held on 17 July 2012 the Council of the Shire of Gingin considered the 167 submissions from community stakeholders and Government agencies received in response to the consultation process and resolved that various refinements by made to the ODP and that some further information be provided prior to final endorsement of the document.. The Moore River Company has worked together with the Shire, Department of Planning and other Government Agencies to identify and implement modifications to the ODP to address relevant issues raised during consultation,

A full copy of the revised ODP that is the outcome of the assessment and consultation process is attached at the end of this report.

4 Environmental Assessment

In 1992 the Moore River Company engaged Alan Tingay and Associates, Environmental Consultants, to undertake an environmental assessment of a study area slightly in excess of the approved 2000 ODP area. The purpose of the study was to provide an assessment of environmental opportunities and constraints to urbanisation of the area. In the following years to 1996 further environmental studies were carried out to identify coastal stability and mobile dune stability, as well as additional management plans for the river foreshore reserve and the ocean foreshore reserve, which were used as supporting technical reports to the approved 2000 ODP.

Cardno, on behalf of the Moore River Company, have undertaken a new scope of work to re-evaluate the environmental issues, constraints and opportunities to assess the environmental impact of the revised Outline Development Plan (ODP) and to update the understanding of environmental values in line with current regulatory requirements.

The environmental consultancy services included a number of site specific environmental investigations including:

- Flora and vegetation assessment - Level 2 (Cardno 2010);
- Fauna assessment (Harewood 2010); and
- Ongoing ground water monitoring (Cardno October 2009 to July 2010 and ongoing).

A summary of these investigations along with a review and synthesis of other previously existing environmental information for the subject site is provided in the following section of this report. The key environmental features of the subject site include:

- Suitable habitat for both Carnaby's Black Cockatoo and the Graceful Sun Moth;
- Areas of remnant vegetation, including vegetation in "Excellent" and "Pristine-Excellent" condition;
- The coastal setting of the site; and
- Significant Flora species.

This information was incorporated into a comprehensive, collaborative and multi-disciplinary design for the revised ODP. Key environmental design features incorporated into the revised ODP design include:

- A generous and strategic allocation of Public Open Space (POS);
- A design that accommodates the retention of topography and landscape; and
- Protection of key physical environmental attributes such as habitat trees.

A key objective of the revised ODP is to retain the existing environmental character of the subject site wherever possible.

4.1 Site Topography, Geology, Landform and Soils

The revised ODP area is located within the Swan Coastal Plain, which is on the central portion of Perth Basin. The Perth Basin extends from the Darling fault in the east to the continental slope west of Rottnest Island, from the Murchison River in the north and the Southern Ocean in the south. The Perth Basin is sedimentary in origin.

The Swan Coastal Plain is comprised of a number of geomorphic entities running parallel to the coastline. From west to east, these include the Quindalup Dunes, Spearwood Dunes, Bassendean Dunes and the Pinjarra Plain. According to landform and soil mapping (Churchward and McArthur 1980), the subject site is comprised of the Quindalup dunes, which is described as unconsolidated

sand and shell fragments with some organic matter darkening the surface of the sand. The Quindalup dune system is described as a Holocene landform.

The topography of the subject site is undulating with the natural surface height ranging from 6m Australian Height Datum (mAHD) along the coast to 50 mAHD further inland. The subject site is characterised by a number of irregular dunes, which rise steeply away from the beach and Moore River, to a series of high dunes and valleys, and range from approximately 10 mAHD on the coast to 40 mAHD a short distance inland.

4.2 Geoheritage

Geoheritage is a complex expression of the geological and geographical landforms and the historical development of all ecological systems upon them. Geoheritage is the historical record of the processes that have produced the geology and landform in an area.

Based on the broad description of the landform and geology above and the Department of Agriculture online mapping, the majority of the subject site appears to be composed of the Quindalup Dunes. These can be associated with forms of geoheritage where unusual landforms occur, such as the record of Holocene dune building found at Port Kennedy.

From the available information, the revised ODP area does not contain any landforms of geoheritage which are currently targeted for protection. Additionally, none of the previous studies or planning for the site has noted the occurrence of significant or unusual geoheritage features.

4.3 Hydrology

4.3.1 Surface Water

The revised ODP area is located directly to the south of the mouth of Moore River. The Moore River catchment receives variable rainfall and as a result the river has only seasonal contact with the sea, when the volume of water flowing through it is sufficient to break through the sandbar across its mouth or when anthropogenic forces have opened the bar. Apart from Moore River to the north of the subject site, there are no known or mapped waterways.

4.3.2 Groundwater

4.3.2.1 Review of Existing Information

The revised ODP area represents the north-west portion of the Gnangara Mound groundwater system. This system extends from Moore River in the north, to the Swan River in the south, the Indian Ocean to the west and Ellen Brook to the east. The Gnangara Mound is a superficial aquifer which contains predominantly unconfined groundwater, which overlays the deeper and impermeable Osborne Formation and Lancelin Beds (Coolyena Group), which are approximately 500m deep (GSS 2009). The surface sediments that form these formations are broadly consistent with the soil characteristics discussed above and vary vertically and laterally with interweaving layers of sand, limestone, silt and clay.

The groundwater in the region is likely to be directly recharged by rainfall, which percolates into and moves slowly through the superficial formations.

4.3.2.2 Groundwater Site Investigations

Extensive site specific groundwater investigations are being undertaken across the revised ODP area to support the future planning process. The majority of the groundwater flows in a westerly direction with groundwater discharging over a saline wedge to the ocean. This is common with what occurs both in the vicinity of the Seabird town site, approximately 10 kilometres to the north, and in the Wilbinga area, which is located directly to the south of the Moore River Company's wider landholdings. In the northern portion of the subject site, groundwater is likely to flow in a north, north-westerly direction, towards Moore River.

Ten shallow groundwater bores have been installed within the revised ODP area at locations shown in **Figure 6** of the supporting Environmental Assessment and Justification Report (**Appendix E**), which will provide the best representation of anticipated groundwater systems and an accurate dissemination of data throughout the site. These locations were selected to allow for the identification of potential nutrient hotspots and development of underlying groundwater contours.

Groundwater levels have been measured on a monthly basis since October 2009 on all installed bores. These bores are measured using an audible dip meter to record standing water levels. The groundwater contours over the site identified during preliminary investigations indicate a westerly groundwater flow direction.

Groundwater quality sampling has been conducted in November 2009 and February 2010. Initial analysis (November 2009) was conducted for a full range of parameters including nutrients, nutrient species, metals, pesticides and hydrocarbons. The second round of groundwater quality analysis (February 2010) was conducted for nutrients and nutrient species. The Department of Water granted a licence for a test bore which was completed in late 2012 at the eastern extremity of Moore River Company's landholding adjacent to Wilbinga Nature Reserve, outside of the ODP area.. Results from the test bore confirm excellent quality of water of sufficient quantity to (more than) meet the requirements of the development.

The overall results of the water monitoring and test bore will be included in a 'H3' report to the Department of Water concurrent with endorsement of the ODP. Similarly, the Local Water Management Plan is at an advanced stage of completion with approval expected in April 2013.

Wetlands

Based on the mapping maintained by the DEC, the *Geomorphic Wetlands of the Swan Coastal Plain* dataset (Hill *et al.* 1996) and an environmental audit conducted by Tinley (1992), no wetlands are present within the subject site.

The wetlands in the vicinity of the revised ODP area are located in the coastal back-plain zone, found to the east of the subject site. From the site specific investigations as part of the Flora and Vegetation Survey (Cardno 2010), there was no evidence of wetland systems or wetland dependant vegetation.

4.3.3 Public Drinking Water Source Area

Public Drinking Water Source Areas (PDWSAs) are gazetted by the Department of Water (DoW) to protect the water quality of identified drinking water sources, which can be surface water or groundwater (DoW 2009). PDWSAs provide the community of Western Australia with the majority of its drinking water supplies and can be vulnerable to contamination by a range of land uses and water based activities.

According to the DoW *Geographic Atlas* (online) (2009) there are no declared Public Drinking Water Source Areas (PDWSAs) located within the subject site. However, a Priority 2 PDWSA is located approximately one kilometre to the north of the subject site. Development of the revised ODP area is unlikely to impact on this PDWSA as Moore River acts as a barrier to groundwater flow to the north. This PDWSA was proclaimed with the intention to provide the town of Guilderton with a safe drinking water supply.

4.4 Flora and Vegetation

Broad regional information indicates that the revised ODP area is located within the Swan Coastal Plain Subregion Drummond Botanical Subdistrict. The vegetation is broadly categorised as Banksia low woodland on leached sands with Melaleuca swamps on ill-drained soils and woodlands of Tuart (*Eucalyptus gomphocephala*), Jarrah (*Eucalyptus marginata*) and Marri (*Corymbia calophylla*) on less leached soils (Beard, 1990).

Regional vegetation complex mapping undertaken by Heddle *et. al.* 1986 for parts of Western Australia indicates that the subject site is primarily within the Quindalup Complex (refer **Figure 7**, **Appendix E**). The description given for the Quindalup Complex is:

> "Coastal dune complex consisting mainly of two alliances, the strand and fore dune alliance and the mobile and stable dune alliance. Local variations include low closed forest of *Melaleuca lanceolata – Collistris preissii* and closed scrub of *Acacia rostellifera*"

Previously, a flora and vegetation survey of the site was conducted by Alan Tingay and Associates in November 1992 (Alan Tingay and Associates 1993). This survey did not reveal any significant or protected flora or vegetation, however suggested that "significant stands of *Allocasurina lehmanniana* could be protected as much as possible within open space along the top of the Moore River Southern riverbank". In addition, the survey noted a feature could be made of some or all of the Tuart grove which also has an understorey of *A. lehmanniana*.

To update the flora and vegetation data, Cardno (2010), on behalf of the Moore River Company, conducted a detailed spring flora and vegetation in accordance with the Environmental Protection Authority's (EPA) *Guidance Statement No.51 Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia* (EPA 2004a) across the subject site. This included three separate visits, two in October and once in September by a team of experienced botanists to identify the presence of Declared Rare Flora (DRF), Priority Flora (PF) and/or Threatened Ecological Communities (TEC). The survey also identified the flora species present within the survey area and the condition of the vegetation.

4.4.1 Plant Communities

Eight broad plant communities have been described for the revised ODP area, which are:

*OaSc - Low Scrub B of Olearia axillaris and Scaevola crassifolia over Open Herbs of *Trachyandra divaricata *Tetragonia decumbens, *Cakile maritima, *Pelargonium capitatum, Hardenbergia comptoniana and Conostylis candicans on foredunes with Spinifex longifolius and Ficinia nodosa;*

*ArAp - Dense Thicket to Thicket of Acacia rostellifera over Low Scrub B of Acanthocarpus preissii over Open Low Grass of *Bromus diandrus, *Lolium rigidum and Poa porphyroclados, Open Herbs of Calandrinia sp. Southwest Coast, *Dischisma arenarium, Carpobrotus virescens, and *Tetragonia decumbens on lower slopes and within swales;*

*AlEg - Scrub of Allocasuarina lehmanniana subsp. lehmanniana, Spyridium globulosum and Myoporum insulare with emergent pockets of Low woodland A to Open Low Woodland A of Eucalyptus gomphocephala over Low Scrub B of Acacia lasiocarpa, Olearia axillaris and Leucopogon parviflorus over Low Open Sedges of Lepidosperma gladiatum with *Bromus diandrus and Austrostipa flavescens, Parietaria debilis, Senecio pinnatifolius, *Trachyandra divaricata, Daucus glochidiatus, *Crassula glomerata and Trachymene pilosa;*

MsAlSg - Heath A to Dwarf Scrub C of Melaleuca systena, Acacia lasiocarpa, Spyridium globulosum and Calothamnus quadrifidus with occasional pockets of Low Woodland A of Eucalyptus gomphocephala and Low Woodland B of Banksia attenuata over Open Herbs of Lomandra maritima, Parietaria debilis, Phyllanthus calycinus, Poranthera microphylla, Senecio pinnatifolius and Trachymene pilosa;

*MsAlAp - Low Heath B of Melaleuca systena, Acacia lasiocarpa, Acanthocarpus preissii and Calothamnus quadrifidus with occasional pockets of Low Woodland B of Banksia attenuata or Thicket to Scrub of Acacia rostellifera in the swales over Open Herbs of Conostylis candicans, Desmocladus asper and Heliophila pusilla, Lepidosperma pubisquameum, *Bromus diandrus and Poa porphyroclados on cream-grey shallow sands over limestone;*

*McSg - Thicket of Melaleuca cardiophylla, Spyridium globulosum, Leucopogon insularis and Acanthocarpus preissii over Low Grasses *Bromus diandrus, *Lolium rigidum and *Ehrharta longiflora with Desmocladus asper, Calandrinia sp. Southwest Coast, Stylidium maritimum (P3), Hibbertia spicata subsp. leptotheca (P3) and Beyeria cinerea subsp. cinerea (P3) on grey-brown shallow sands over limestone. This plant community was recorded along the southern bank of Moore River to the east of the large blow-out;*

*MsMhBs - Heath A to Dwarf Scrub C of Melaleuca systena/Melaleuca huegelii, Banksia sessilis, Spyridium globulosum, Templetonia retusa, Acacia truncata and Hakea lissocarpha over Open Herbs of Calandrinia brevipedata, Podotheca gnaphalioides and Trachymene coerulea subsp. coerulea with Austrostipa flavescens, Poa porphyroclados, *Bromus diandrus and Ehrharta villosa on dark grey-brown sand over limestone; and*

*MhMtMs - Low Heath C recently burnt (3-5 years) of Melaleuca huegelii/Acacia truncata, Melaleuca systena and Banksia sessilis, over Very Open Herbs of Desmocladus asper, Stylidium junceum, Calandrinia sp. Two-rocks, Carpobrotus virescens, *Crassula glomerata, and Gompholobium tomentosum with *Bromus diandrus and Poa porphyroclados on grey-brown shallow sands over limestone.*

* Refers to species that are known weeds.

The spatial distribution of these communities is shown in **Figure 8** of the supporting Environmental Assessment and Justification Report (**Appendix E**).

4.4.2 Vegetation Condition

The condition of the vegetation was assessed to assist in determining the conservation values of the site. The vegetation condition was rated according to Keighery (1994), a vegetation condition scale commonly used in the Perth Metropolitan Region, which is also appropriate for use in other urbanised and agricultural areas. The categories are listed and defined in Table 2 of the supporting Environmental Assessment and Justification Report (**Appendix E**).

Vegetation condition across the site ranged from 'Completely Degraded' to 'Pristine-Excellent', with the largest portions of vegetation being in a 'Completely Degraded' condition.

Areas of 'Completely Degraded' condition consisted of cleared paddock and tracks in the centre of the revised ODP area. The coastal foreshore reserve and adjacent eastern coastal dune is in an 'Excellent' to 'Pristine-Excellent' condition. The river foreshore area is in a 'Good' to 'Very Good' condition. Remaining patches of remnant vegetation east of the foreshore reserve were in a 'Degraded' to 'Very Good' condition.

4.4.3 Significant Flora

Species of flora are prescribed as "Declared Rare" or "Priority" conservation status where populations are restricted geographically or threatened by local processes. The DEC recognises these threats and subsequently applies regulations towards population protection and species conservation. The DEC enforces regulations under the Wildlife *Conservation Act 1950* to conserve Declared Rare Flora (DRF) and protect significant populations. Priority flora (PF) species are potentially rare or threatened and are classified in order of threat.

A search was conducted of the DEC's databases for DRF and priority floras that occur within the wider local area and the results are listed in Table 3 of the supporting Environmental Assessment and Justification Report (**Appendix E**). Twenty seven DRF and PF species have been identified as occurring in close proximity to the revised ODP area. Of these species, four are classified as DRF species. The flora survey undertaken by ATA Environmental in 1993 did not identify any listed DRF or PF species.

4.4.3.1 Flora Survey Results

During Cardno's 2010 survey no DRF species were recorded within the revised ODP area, however three PF species were recorded, these being:

- *Stylidium maritimum (P3);*
- *Hibbertia spicata subsp. leptotheca (P3); and*
- *Beyeria cinerea subsp. cinerea (P3).*

A number of species were identified in the 1993 report that were considered to have poor representation or uncommon distributions. These species were Allocasuarina lehmanniana, Billardieria erubescens and Thomasia triphylla.

4.4.4 Threatened Ecological Communities

In Western Australia, 'Threatened Ecological Communities' (TECs) are defined by the Western Australian TEC Scientific Advisory Committee (within the DEC) and are assigned to category of Priority 1 to Priority 5. While they are not afforded direct statutory protection at a State level (unlike DRF under the Wildlife Conservation Act 1950) their significance is acknowledged through other State environmental approval processes (i.e. Environmental Impact Assessment pursuant to Part IV of the Environmental Protection Act 1986).

Selected TECs are also afforded statutory protection at a Federal level pursuant to the Environmental Protection and Biodiversity Conservation Act 1999 (EPBC Act). The EPBC Act provides for the strong protection of TECs, which are listed under section 181 of the Act, and are defined as "Critically Endangered", "Endangered" or "Vulnerable" under Section 182.

A search was conducted of the DEC's TEC database and no known occurrences of TECs were recorded within the boundary of the revised ODP area.

In addition to listing as a TEC, a community may be listed as a Priority Ecological Community (PEC). An ecological community that is under consideration for listing as a TEC, but does not yet meet

survey criteria or has not been adequately defined, is placed on the list of PECs in either Category 1, 2 or 3. Ecological communities that are adequately known and are rare but not threatened, or meet criteria for Near Threatened, or that have been recently removed from the threatened list, are placed in Priority 4. These ecological communities require regular monitoring. Conservation Dependent ecological communities are placed in Priority 5 (DEC 2007).

No PECs have been recorded by the DEC within the revised ODP area.

4.4.5 Environmentally Sensitive Areas

Environmentally Sensitive Areas (ESAs) are areas prescribed under the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004*. As a result ESAs are only considered when a clearing permit is required under these regulations. ESAs have been identified to protect the native vegetation values of areas surrounding significant, threatened or scheduled ecosystems and communities.

A search of the Department of Environment Conservation (DEC) Native Vegetation Mapping database revealed that no ESAs are mapped over the subject site.

4.5 Terrestrial Fauna

As part of the overall assessment of the fauna and fauna habitat values within the revised ODP area, a review of existing available information was undertaken in addition to a site specific fauna survey. The comprehensive documentation of this is contained within the supporting report prepared by Greg Harewood (**Appendix G**).

A fauna survey was conducted across the subject site in November 1997 (ATA 1998). This survey found that the original ODP area supported a range of habitat types. During the fauna survey a number of species were recorded as being present including: two amphibian species; 18 reptile species; 69 bird species and eight mammal species (four of which were introduced species). Of the species found or determined to be likely found given the habitat and known range, a number of these were considered to be of conservation significance.

The fauna survey carried out in October 2009, in support of the revised ODP, and in accordance with EPA Guidance Statement No 56 Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia (EPA 2004b), found that 192 species could potentially utilise the site, although the number is likely to be significantly lower. A total of 38 native fauna species were observed (or positively identified from foraging evidence, scats, tracks skeletons or calls) within the subject site during the three day survey in October 2009. Three vertebrate fauna species of conservation significance were positively identified as utilising the revised ODP area, including:

- *Calyptorhynchus latirostris Carnaby's Black Cockatoo;*
- *Ardea alba Great Egret;*
- *Sunemon gratiosa Graceful Sun Moth; and*
- *Pandian haliaetus Osprey.*

Ten additional species of conservation significance were also identified as potentially using the site for some purposes at times, although their presence could not be confirmed. Additionally, given the varied habitat over the site, these species may only visit the area for short periods or as rare/uncommon vagrants. The additional conservation species are identified in Table 7 of the supporting Environmental Assessment and Justification Report (**Appendix E**).

The supporting fauna survey also recorded the location of significant habitat trees, which were defined as "native trees of the Eucalyptus or Corymbia genera having a diameter at breast height (DBH) greater than 500mm". The trees provide habitat for vulnerable and endangered Black Cockatoo species. The survey revealed 17 significant trees within the study area, all of which were tuart. These trees are generally in two distinct clusters over the site, in association with tuart woodlands mapped over the site.

The Site Analysis Plan (**Figure 4**) identifies the location of the significant habitat trees. The revised ODP has been designed to retain significant habitat trees within foreshore and parkland areas wherever possible. The large cluster of trees to the north of the site adjacent to Moore River are proposed to be retained within the foreshore reserve with smaller clusters to the south retained within areas of public open space.

A survey undertaken during March 2010 positively identified the Graceful Sun Moth at the site. The survey was undertaken in accordance with the DEC guidelines. In total 21 Graceful Sun Moths were sited over a period of 4 surveys throughout March. The Graceful Sun Moth inhabits coastal dune systems vegetated with Lomandra species. Current Graceful Sun Moth habitat is shown in **Figure 11** of the supporting Environmental Assessment and Justification Report (**Appendix E**).

4.6 Indigenous Heritage

An online search of relevant Aboriginal heritage information was undertaken using the Department of Indigenous Affairs (DIA) Aboriginal Inquiry System (DIA, 2010) that incorporates both the heritage site register and the heritage survey database. A number of sites were listed as occurring within the revised ODP area, which are illustrated in **Figure 12** of the supporting Environmental Assessment and Justification Report (**Appendix E)**

The majority of these sites are associated with the Moore River. An archaeological and ethnographic survey was completed for the subject site in December 1993 (Bavin 1993 and Tamora Pty Ltd 1993). These surveys reported that no additional archaeological sites were found within the revised ODP area and the three archaeological sites that were already been registered were not able to be relocated. The ethnographic survey revealed:

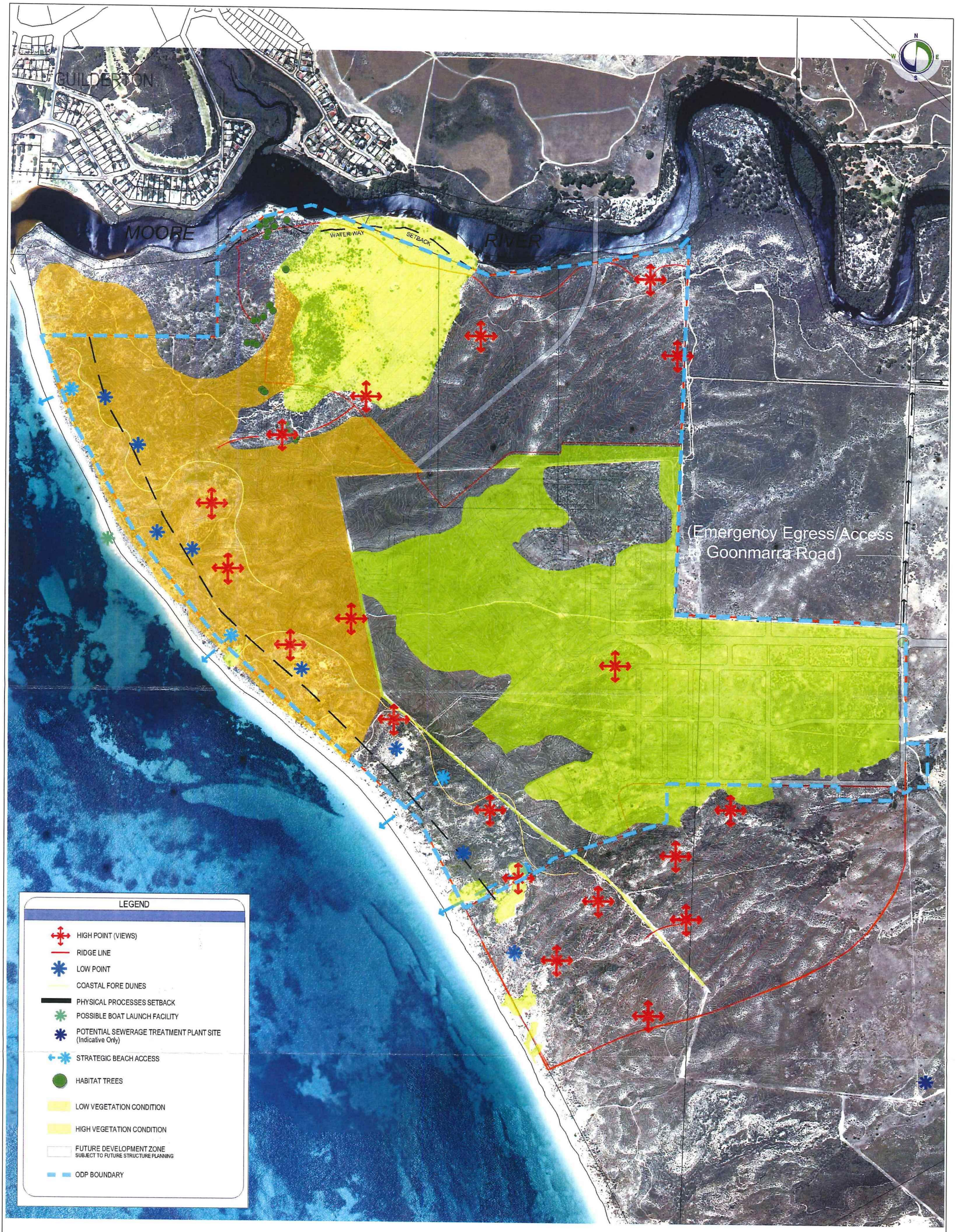
"There were no ethnographic sites of significance in the survey area. However the Moore River was formed during the Waugal journey (the Waugal is a creature from the dreamtime and created the waterways and landforms around the Perth region) and there should be a 30m zone between the banks of the river and the development" (Bavin 1993). This 30m buffer is accommodated within the foreshore reserves proposed within the revised ODP design.

There have been no site specific indigenous heritage investigations undertaken as part of the revised ODP design process as the previous site investigations were deemed sufficient.

4.7 Non-Indigenous Heritage

In order to determine the actual or potential presence of sites or features of non-indigenous heritage significance within the revised ODP area, a review of readily available information was undertaken to determine if there were any of the following within the subject site:

- World heritage sites;
- National heritage sites;
- Commonwealth heritage sites;
- Sites listed on the Register of the National Estate; and/or
- Heritage Council of WA sites.



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FIGURE 4

SITE ANALYSIS PLAN

MOORE RIVER OUTLINE DEVELOPEMNT PLAN

MOORE RIVER SOUTH, SHIRE OF GINGIN

Cardno
11 Harvest Terrace
P.O. Box 447
West Perth 6872
Telephone (08) 9273 3888
Facsimile (08) 9486 8664

DATE: 11.09.13
DESIGNED:
DRAWN: FC
LOCAL AUTHORITY
SHIRE OF GINGIN
PROJECT-PHASE-PLAN NUMBER
P7026 CON 005

SCALE AT A3: 1: 12 500
CHECKED:
APPROVED:
REVISION

Based on examination of the Shire of Gingin's Heritage Register there are no known heritage sites located within the revised ODP area, however the Moore River estuary adjacent to the site contains high heritage value.

To date there have been no site specific non-indigenous heritage investigations undertaken as part of the revised ODP design process. Given the nature of the site and the lack of identified heritage values it is considered unlikely that non-indigenous heritage values will be revealed at any stage of future planning and development.

4.8 Site Contamination

The Contaminated Sites Act 2003 and the associated Contaminated Sites Regulations 2006 took effect on 1 December 2006. The Act provides a legal framework for the management of contaminated sites in Western Australia, and requires owners, occupiers and polluters to report known or suspected contaminated sites to the DEC.

There are no identified contaminated sites found within the revised ODP area recorded on the DEC's Contaminated Sites database. This database does not include sites that have not yet been classified or sites that are classified as possibly contaminated - investigation required, contaminated - restricted use or remediated for restricted use.

Based on a review of the historical aerial photography for the revised ODP area and a number of onsite inspections it is considered unlikely that any of the observed existing or historical land uses would have caused significant soil or groundwater contamination within the subject site.

4.9 Acid Sulfate Soils

Acid Sulfate Soil (ASS) is a naturally occurring soil or sediment that contains iron sulphide (iron pyrite) minerals. In their natural state ASS are present in waterlogged anoxic conditions and do not present a risk to the environment. They become an issue when oxidised, producing sulphuric acid, which can convey a range of impacts on the surrounding environment, infrastructure and human health.

Mapping prepared by the Department of Planning (DoP) to support the WAPC's Planning Bulletin 64: Acid Sulfate Soils (WAPC 2009) does not cover the revised ODP area. The ASS Planning Guidelines (WAPC 2009) indicate that only the areas in Western Australia currently considered to be most at risk of disturbance of ASS soils are depicted in the mapping. ASS are commonly recorded from natural wetland and mangrove coastal areas, which is not consistent with the conditions over the subject site. The adjacent Moore River contains ASS but is beyond the revised ODP boundary and therefore does not affect the site.

4.10 Urban Water Management

There are no waterways or wetlands within the revised ODP area. The area represents the extreme north west corner of the Gnangara ground water mound. The groundwater generally slopes downward to the west to sea level near the coast but would also have some outlet to north into the Moore River. Recharge of the groundwater occurs through rainfall infiltration through the porous soil. Water table levels fluctuate minimally throughout the year - between 10cm and 30cm. Sandy ground conditions ensure the proposed development would be well drained.

The development of a Local Water Management Strategy (LWMS) is the appropriate mechanism to establish broad-level designs and management measures for flood mitigation and effective

stormwater management at structure planning stage. A LWMS is required to be approved by the relevant agencies prior to the approval of the first stage of subdivision.

To support the revised ODP and future subdivision of the site, a LWMS (refer **Appendix H**) has been prepared by Cardno on behalf of the Moore River Company. This document provides the detail of a LWMS document and covers the scope of a District Water Management Strategy (DWMS).

The development of the LWMS has been undertaken with the intention of providing a structure within which subsequent development can occur consistent with a 'total water cycle management' approach described in the document. It is also intended to provide overall guidance to the general stormwater management principles for the area and to guide future Urban Water Management Plans (UWMPs) that will support subdivision approval.

The LWMS for the revised ODP has been developed to:

- Provide a broad level stormwater management framework to support future urban development;
- Incorporate appropriate best management practices into the drainage systems that address the environmental and stormwater management issues identified;
- Minimise development construction costs, which will result in reduced land costs for future home owners;
- Minimise ongoing operation and maintenance costs for the land owners and Shire of Gingin;
- Develop a water conservation strategy for the area that will accommodate existing groundwater allocation constraints for the area; and
- Gain support from the Department of Water and Shire of Gingin for the proposed method to manage stormwater within Lot 27 and Lot 201 and potential impacts on downstream areas.

A number of broad level studies that include the revised ODP area provide a regional environmental context for the LWMS. These have been reviewed in order to provide suitable background information for Lot 27 and Lot 201 and also to provide an indication of the issues requiring further investigation. Further, a number of site-specific investigations into various aspects of Lot 27 and Lot 201 have recently been conducted as a part of the revised ODP process. In summary, the investigations conducted to date indicate that:

- The revised ODP area is situated within a sand and limestone dune, with the topography within the residential/commercial area ranging from 10 to 50mAHD.
- The Maximum Recorded Groundwater Levels (MGL) where observed in October 2009 ranging between 0.25mAHD and 0.49mAHD. The depth to groundwater for the residential/commercial areas is between 10 to 40mAHD. All locations within the development boundary have a separation distance between the existing topography and the MGL of at least 1.2m;
- Groundwater quality results are generally within or slightly above the default trigger values. The TN and NOX concentrations vary across the revised ODP area and were recorded up to 5 and 40 times the default trigger values respectively;
- All runoff is to be retained and infiltrated on site resulting in no discharge from the revised ODP area;
- No streamlines or surface water channels exist within the revised ODP area and hence no surface water quality data is available;
- The revised ODP area has been historically cleared and used for sheep and cattle grazing; and

The LWMS document outlines the proposed groundwater management strategy, surface water management strategy, water supply and conservation strategy, and a monitoring strategy. These strategies have been determined based on the physical constraints of the site, as well as to achieve the requirements of government authorities.

Due to the significant depth to groundwater across the site, no management of groundwater levels is required. The groundwater nutrient concentrations are generally moderate compared to default trigger values. As the water does not intersect the surface at any location no treatment of the groundwater will be conducted. Monitoring of groundwater quality will be implemented to ensure that the nutrient concentrations within the underlying are not significantly increased due to the development.

The principle behind the stormwater management strategy is to retain and infiltrate all runoff (as occurs in the pre-development environment) within the revised ODP area, with treatment of minor rainfall events within vegetated treatment areas. The strategy will utilise bio-pockets, swales, vegetated infiltration areas, constructed infiltration basins and natural depression infiltration areas.

The development is situated in an area that has no scheme water network. Given that the relevant aquifer is fully allocated, an adequate groundwater allocation from an existing groundwater source within the development site has been investigated, proven and secured. The new public drinking water supply from this source will meet the needs of the new development and also provide an opportunity for improved quality and quantity of potable water to Guilderton.

All waste water from the development will be treated and used to irrigate POS and School Ovals. Excess water produced during winter (due to reduce irrigation requirements) will be infiltrated into the underlying aquifer. This strategy will achieve the sewerage requirements of the development and reduce the total water consumption of the development. At a lot scale, households will be required to implement water saving strategies including rainwater tanks, water efficient appliances and water efficient gardens.

A summary of how the design criteria will be achieved and the proposed management strategy implemented (as presented within this LWMS document) is provided within Table 1 of the supporting Environmental Assessment and Justification Report, included as **Appendix E**.

The Moore River LWMS provides a framework that future landowners can follow to assist in establishing stormwater management methods that have been based upon site-specific investigations, are consistent with relevant State and Local Government policies and have been endorsed by the Shire of Gingin. The responsibility for working within the framework established within the LWMS rests with the individual landowners, although it is anticipated that future UWMPs will be developed in consultation with the Shire of Gingin, Department of Water and in consideration of other relevant policies and documents as well as the LWMS.

4.11 Coastal Assessment

Coastal areas represent the interface between the land and the sea and are recognised as sensitive and dynamic environments. The subject site is located within a coastal area and a foreshore reserve has been allocated to the west of the development. The foreshore is reserved for "Parks and Recreation" and is currently Unallocated Crown Land (UCL).

In 1994 M P Rogers and Associates, Consulting Engineers specialising in coastal, ocean and marine projects, was engaged by the Moore River Company to:

- Examine the stability of the coastline;
- Make recommendations on the appropriate setback from a coastal stability point of view; and
- Identify a site for a possible small boat launching facility which had the potential to accommodate a marina in the long term should such a facility be considered economically feasible.

This report was produced in November 1994 and revised in March 1996 and was included as a supporting technical report to the approved ODP.

To support the revised ODP, M P Rogers have been engaged to update their coastal setback assessment and to include an assessment of the physical processes setback to development with the most recent available data so as to provide an adequate level of protection to development from coastal erosion in the coming 100 years.

The WAPC Statement of Planning Policy No. 2.6 - State Coastal Planning Policy (SCPP) provides guidance on the siting of development on the Western Australian coastline. For new development on an undeveloped sandy shoreline, such as the shoreline adjacent to the revised ODP area, the SCPP recommends the following criteria to be used to calculate an appropriate coastal setback:

- S1 - Allowance for acute short term erosion caused by a series of severe storms, with elevated water levels and an Average Recurrence Interval (ARI) of approximately 100 years. The Department of Transport (DoT) suggests the use of the SBEACH model using three repeats of the severe storm experienced in July 1996 to conservatively represent the 100 year ARI storm with respect to coastal erosion;
- S2 - Allowance for chronic long-term trends caused by local coastal dynamics. This needs to provide a buffer for the coming 100 years. The policy recommends the use of 100 times the long-term average rate of recession or 20m, whichever is greater; and
- S3 - Possible long term erosion trends caused by Climate Change and associated sea level rise anticipated in the coming 100 years. The policy recommends the allowance of a 0.38m rise in the general sea level and the assumption that this may cause 38m recession of shoreline.

To determine the severe storm sequence allowance, SBEACH modelling was completed for three locations on the shoreline at Moore River South. The modelling was shown to result in unrealistic inshore water levels when input using the method requested by DOT. The storm was also therefore modelled to match the measured inshore water levels during the July 1996 event. The storm sequence is believed to represent the 100 year ARI event at Moore River South in relation to beach erosion.

The SBEACH results indicate that the vegetation line would recede approximately 17 m following the severe storm sequence. This was used as the S1 factor in determining the appropriate PPS.

Shoreline movement analysis was updated for the Moore River South coastline to examine shoreline movements over the past 40 years at intervals of approximately every 5 years. The analysis showed that the majority of the site has experienced long-term accretion, with rates of movement of the coastal vegetation line ranging from 0.1 to 0.9 m/yr. The 20 m safety allowance was included as the S2 component for the majority of the site. In the north of the site there has been some recent erosion up to 0.5 m/yr. A 50 m allowance for S2 in the northern section of the site was therefore included.

The recommended allowance of 38 m was included as the S3 component, based on the mean of the IPCC's median model estimate of sea level rise, and the Bruun Rule.

The recommended physical processes setback (PPS) was then adjusted to reflect new standards as outlined in the WAPC Position Paper and referred to in SPP 2.6. The revised setback is between 125 and 177m. This is presented in the setback plan, included as part of M P Rogers - Updated Coastal Setback Assessment and Revised Coastal Setback (October 2012)included as **Appendix I**. The PPS is measured from the Horizontal Setback Datum (HSD). For the accreting sandy coast of Moore River South, the HSD is taken as the seaward limit of coastal vegetation.

A coastal processes analysis of the Moore River in accordance with SPP 2.6 has not been undertaken. However, the proposed river foreshore reserve width of approximately 150m is a conservative estimate, using a setback that is more conservative than the coastal setback (which is defined by a technical study). The 150m wide reserve will incorporate the requirements for physical processes, as well as land required for incorporating the visual analysis, Aboriginal heritage purposes, and for community use and access. If a coastal processes analysis is conducted at a later date, this can inform development setbacks for any foreshore amenities, and may be used to inform the foreshore reserve to be ceded at the time of first stage of subdivision. The revised ODP has been designed to reflect the required PPS, which is incorporated within the proposed foreshore reserve. In accordance with the WAPC's Liveable Neighbourhoods policy the foreshore (i.e. the area seaward of the PPS) will be ceded free of cost to the Crown, without payment of compensation by the Crown, and will be in addition to the 10 per cent public open space contribution.

4.11.1 Boat Launching Facility

The revised ODP identifies a possible low key boat launching facility adjacent to the proposed Tourism site to the north west of the revised ODP area. The boat launching facility is not a formal component of the revised ODP but has been examined in response to an expression of community desire for such a facility in the area and that the development might present an opportunity for it to be provided. The impact of coastal processes on the proposed boat launching facility is considered in the supporting M P Rogers - Updated Coastal Setback Assessment (**Appendix I**).

Australian Standard AS3962 Guidelines for design of marinas outlines the requirements for the location and alignment of boat launching ramps. In summary, the location must:

- Be aligned to the dominant waves from swell, sea and boat wash;
- Be sheltered from waves larger than 0.2m;
- Have sufficient land approaches to permit queuing without blocking other traffic; and
- Have water approaches of sufficient area to allow queuing and low speed manoeuvres without blocking fairways and channels.

The Coastal Setback Assessment identifies that commonly occurring wave conditions at Moore River South would result in wave heights much greater than 0.2m and protective breakwaters would therefore be required to provide shelter to the facility. These breakwaters would have to be designed to sufficiently reduce the wave height for boat launching. The protective breakwaters would interrupt the longshore sand transport along the cost. If left unmanaged this could cause significant accretion of sediment on the up drift side of the facility, eventually impeding navigation into the facility, and erosion on the down drift side.

The assessment recommends that these effects would therefore have to be managed to minimise adverse effects on the surrounding coastline. This could be completed by sand bypassing, where sand is mechanically moved by one side of the facility to the other. Therefore, questions arise about who will be able to manage such a facility in perpetuity. Moore River Company has committed to making a contribution to a boat launch facility on the basis that the funding, design and ongoing management issues can be resolved to the satisfaction of all stakeholders.

4.11.2 Climate Change

The Intergovernmental Panel on Climate Change (IPCC) has presented various scenarios of possible climate change and the resultant sea level rise in the coming century (IPCC 2001). There is still some uncertainty as to which of these scenarios will occur. For example it is not known whether greenhouse gas emissions will fall, stay steady or increase in the coming decades and century, nor

The revised ODP has been formulated in a manner that facilitates achievement of the sustainable design objectives at the detailed subdivision stage. These include solar orientation, permeable layouts to encourage walking and cycling, application of Water Sensitive Urban Design guidelines, consideration of grey water recycling onto recreation reserves and development of management guidelines to foreshore reserves. The proponent will consider methods of encouraging sustainable building techniques relating to solar efficiency, appropriate building techniques and materials, garden design and efficient water usage.

4.13 Assessment of Issues, Opportunities and Constraints

As part of the revised ODP design process, the environmental attributes and values of the subject site have been assessed and the key aspects translated into spatial issues, opportunities and constraints in terms of possible design responses. These were then used to inform the type of design response so that the attributes and values were not significantly compromised.

Constraints were defined as attributes and values where there were clear government policies identifying significant environmental features and there is a clear presumption against impacts on these features. No constraints were identified within the revised ODP area.

Issues were defined as environmental features where there was no specific government policy which indicates there is a presumption against impacts on these environmental features. Issues are generally broader features, with no discrete boundaries; however, these features need consideration due to the potential environmental impacts and should be considered to demonstrate best practice environmental planning. The issues within the subject site included the presence of Carnaby's Black Cockatoo habitat, Graceful Sun Moth habitat, vegetation in "Excellent" and "Pristine-Excellent" condition and a required foreshore setback.

Opportunities were defined as areas where the environmental attributes and values are such that they are supportive of development. The opportunities within the subject site included the large areas of "Degraded" and "Completely Degraded" condition vegetation, the blow outs found on site and the depth of the groundwater.

The summarised environmental issues, opportunities and constraints of the subject side are shown in **Figure 4**.

4.14 Environmental Design Considerations

The environmental issues, opportunities and constraints identified in this section of the report has informed the design of the revised ODP. This reiterative process allowed for the design to recognise the environmental features of the revised ODP area. The findings of the Environmental Assessment and Justification Report concluded that the development would have no significant environmental impact on Moore River.

The key environmental features of the revised ODP area include:

- Suitable habitat for both Carnaby's Black Cockatoo and the Graceful Sun Moth;
- The coastal setting of the revised ODP area;
- Areas of remnant vegetation, including vegetation in "Excellent" and "Pristine-Excellent" condition; and
- Significant Flora species.

Each of these environmental features has been considered in the revised ODP design process. In particular the most significant design responses to environmental features of the revised ODP are set out in the following section of this report:

4.14.1 Strategic Allocation of Public Open Space

Public Open Space (POS) has been strategically allocated throughout the revised ODP area to retain remnant vegetation (including "Excellent" and "Pristine-Excellent" condition vegetation and Priority Flora populations), habitat trees and wildlife corridors. The allocated POS is in addition to the required foreshore reserve that will be ceded to the Crown. It is envisaged that the areas of POS will maintain and enhance the environmental integrity of the revised ODP area and provide opportunities for recreation and community interaction.

4.14.2 Retention of Topography and Landscape

The design of the revised ODP has taken into account the subject site's topography and landscape. The design aims to minimise modifications to the topography and landscape wherever possible, which will help facilitate vegetation retention, reduce risks of erosion and sand mobilisation and minimise the need for fill.

A key element of the design has been the retention of the coastal dunal system, which was seen as the main topographical feature of the site. This dunal system was also identified as containing important vegetation and flora communities worthy of retention. Another important function was the location of natural drainage basins within the lower troughs of the dunes, which would minimise the need for additional drainage basins to be provided within formal areas of public open space.

4.14.3 Protection of Key Physical Environmental Attributes

The revised ODP design aims to minimise the disturbance of key physical environmental attributes. This includes Carnaby's Black Cockatoo habitat trees and Indigenous Heritage sites. These physical environmental attributes have been addressed in a series of management plans.

In addition to the above features of the revised ODP, a future management framework will be put in place during the future planning and development process for the long term protection of the environmental features within the revised ODP area. This is likely to be based on additional site investigations and the preparation of various management plans and strategies to protect and maintain environmental features. These can be undertaken/prepared during future stages of development and are likely to include the following:

- Future detailed site investigations;
- Plan and Strategy Preparation;
- Foreshore Management Plan including the foreshore reserve and POS;
- Management Plans for Carnaby's Black Cockatoo and the Graceful Sun Moth;
- Dieback Hygiene Management Plan;
- Fire Management Plan;
- Revegetation, Rehabilitation and Landscaping Plan;
- Dust Management Plan;
- Landscape Strategy;
- Construction Management Plan;
- Stormwater and Drainage Management Plan;
- Traffic and Parking Strategy;
- Development and land ownership controls;
- Design guidelines; and



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FIGURE 5

BEACH ACCESS NODES
MOORE RIVER SOUTH OUTLINE DEVELOPMENT PLAN
MOORE RIVER SOUTH, SHIRE OF GINGIN

Cardno
11 Harvest Terrace
P.O. Box 447
West Perth 6872
Telephone (08) 9273 3888
Facsimile (08) 9486 8664

DATE: 11.09.2013 SCALE AT A4: 1:50 000
DESIGNED: CHECKED:
DRAWN: FC APPROVED:
LOCAL AUTHORITY
SHIER OF GINGIN
PROJECT-PHASE-PLAN NUMBER REVISION
P7026 CON08

5 Services Infrastructure

This section provides a summary of the servicing report prepared by Cardno in March 2010 in support of the revised Outline Development Plan (ODP), attached as **Appendix C**. The report updates the previous reports prepared in support of the approved 2000 ODP and investigates both availability as well as security of supply and emergency provisions for water, wastewater, power and telecommunications required for the revised ODP proposal.

The report reinvestigates the base or options available with consideration for alternative systems. The terminology of 'no risk' is used by the Water Corporation for their water and wastewater system in which there is a secure system for the use of water supply and, in the case of wastewater, a suitable treatment method together with a disposal solution for effluent.

The purpose of the engineering inputs to the revised ODP is to assess the extent and nature of the above facilities and to confirm, where possible, the feasibility of the various concepts for their implementation.

5.1 Physical Capacity of Land for Development

In general the ground conditions within the revised ODP area comprise sand overlying, to varying depths, Tamala limestone. In some locations the limestone outcrops at the surface as capstone. These conditions are well suited to urban development and would provide well drained and stable foundations for associated building.

Site ground conditions vary from alluvium and peaty sands along the Moore River to unstable dunes fringing the coast. These portions of the site are to be incorporated into foreshore reserves and therefore would not affect development proposals.

Maximum recorded groundwater levels within the area are typically less than 3m A.H.D. which is generally well below the minimum ground surface levels within the revised ODP area.

Surface slopes within the area are typically less than 10 percent and well suited therefore to urban development. In the parts of the site where slopes are steeper, in very undulating terrain, development would require the land to be earthworked to suit road and services requirements and to create suitable sites for building development.

Overall, therefore, it is considered that the site works which would be necessary for the urban development proposals within the revised ODP area, would be feasible in line with both the planning and environmental objectives for the site.

5.2 Drainage Management

The sandy ground conditions within the revised ODP area would ensure that the proposed development would be well drained. There are no low lying areas where the groundwater table is so high that any development would be flooded during wet weather.

It is proposed that all stormwater run-off be contained and disposed of on-site with no direct discharges to either the ocean or the Moore River. This would ensure that any nutrients in the stormwater would be sufficiently filtered out before it enters the groundwater system, below the revised ODP area, and would ensure, therefore, that the risk of any pollution of the receiving waters would be minimised.

Within the site, stormwater disposal would be via infiltration basins and swales located within road reserves and areas of open space. These could be shallow sided, landscaped areas which could be utilised as areas of passive open space during periods of dry weather. Temporary drainage basins have been included within the natural low lying troughs of the coastal dunal system that is being retained as a key topographical feature of the site.

A water sensitive design approach would be adopted for the design of the drainage system. This could include the incorporation of swales and basins within road verges to dissipate flows and maximise the recharge of the groundwater system.

5.3 Water Supply

The servicing report proposes a 'no risk' water supply option sourcing water through groundwater. The revised ODP area falls under the Gingin Groundwater Area (GGA), whereby all water is currently sourced through groundwater and the Water Corporation has a license agreement with the Officer of Water Regulation for Guilderton. Within this licence area the Water Corporation have allocation for three bores.

It is proposed that the water supply be derived from a new bore within the MRC landholding as being the “no risk” option, because the current bores owned by the Water Corporation are not enough to cater for the full future development water consumption. A water supply point at the eastern extremity of the landholding, adjacent to Wilbinga Nature Reserve, has been established in accordance with the requirements of the Water Corporation and Department of Water. Negotiations are underway with Water Corporation to become the licenced service provider, failing which other providers are available and will be secured prior to subdivision.

During the State Administrative Tribunal's consideration of the appeal in relation to the 2003 subdivision application, the Western Australian Planning Commission (WAPC) accepted, based on evidence provided by Water Corp, that there was a reasonable degree of certainty that the provision of a reticulated water supply would be feasible and that the approvals required for the provision of this services could be obtained, and that this issue was not grounds for refusal of the subdivision application.

The proponent has secured a licence from the Department of Water for a test bore within Moore River Company's land holding. The test results from that bore have demonstrated the availability of a high quality water resource sufficient to (more than) meet the needs of the development. The test bore location and technical specifications were implemented under the supervision of the Water Corporation to ensure that the supply would meet Water Corporation specifications to be operated as a public drinking water supply. The final documentation of the water and supply point has been approved by the relevant agencies.. A formal licence for the bore as the public drinking water supply point will be issued in approximately on appointment of the lincenece water supply provider. The demand for water will be significantly reduced form 'normal' due to the proposed re-use of treated effluent for non-potable purposes and at the requirement that new dwellings include water efficiency measures.

5.4 Sewerage

Based on the recommendations of the servicing report it is not considered that the collection and treatment of the wastewater will be problematic and during the summer months the final effluent, being class A+, will be disposed of by Public Open Space (POS) irrigation. During the winter months however, disposal by Managed Aquifer Recharge (MAR) is required which would assist in reducing existing salt and nitrate levels in the aquifer.

A centralised treatment plant is the preferred option for treatment with disposal by irrigation within the town site and possibly to agriculture. Given the "no risk" option being the preferred option for scheme water and a centralised treatment plant it would be expected, upon completion by the proponent, that the Water Corporation of Western Australia WCWA would become the licensed operator.

Disposal of treated wastewater to marine outfall is not an option for Moore River. For most of the year all the treated wastewater generated can be disposed of either by recycling to the surrounding rural lots for irrigation or by irrigation of POS. Climatic data shows that traditionally Moore River has a block of four months in winter when rainfall is high and exceeds evaporation. During this period irrigation would not be necessary and MAR would be the preferred option for disposal.

There are many potential uses for Class A+ recycled water. The most reliable at this stage is irrigation to the POS and is clearly possible for this scheme. During negotiation for the additional water allocation it is expected that a priority for use of the wastewater will emerge that represents a more beneficial use of this valuable resource.

The actual solution/technology is dependent on who the service provider will finally be and the economics of that selection. Detailed engineering will be necessary, in conjunction with the service provider, to ascertain the most economical solution.

5.5 Power and Telecommunications

The servicing report shows that sufficient power generating capacity and distribution is available in the area to cater for the revised ODP proposal and associated services.

The report shows that the existing telephone exchanges at Guilderton has sufficient capacity to serve the revised ODP proposal. The existing exchange will not be able to provide more advanced services such as high speed broadband but these services are available via mobile phone networks such as Next G and 4G. Mobile phone service coverage is provided from Telstra with mobile phone towers located at Moore River and on the Brand Highway between Gingin and Beermullah.

Currently, there is uncertainty if Telstra will provide underground infrastructure to service the revised ODP area, but if this service is not provided Telstra will provide home telephone communications via their mobile phone system at home phone rates.

5.6 Fire Management

The document 'Planning for Bushfire' is the key guidance for design of new development areas and has been used in the preparation of the revised ODP.

Large tracts of degraded pasture land within the development area are situated in low-hazard bushfire environments and will be available as emergency refuge sites in their own right. The new development will introduce scheme water and state of the art hydrant systems to Moore River. All bushfire protection and hazard perimeter criteria will able to be met and dual emergency access/egress routes will be implemented. Whilst the primary access road to the new development will be via Barragoon Road a system of unsealed but constructed alternative access routes will connect from the north east of the revised ODP area to Indian Ocean Drive via Goonmarra and Caraban Roads to provide an alternate emergency egress route. Goonmarra Road will be upgraded to an all-weather two wheel drive gravel road in accordance with the Guidelines, whilst Caraban Road is already sealed. This approach will provide alternate emergency access/egress routes from points east and west on Barragoon Road, with Link Road providing a third option through Woodridge in the event of a fire in the eastern portion of Wilbinga Nature Reserve.

The ODP also makes provision for an Emergency Services site within the development area, to be ceded to the Shire free of cost and suitable as a base for a new volunteer bushfire brigade to service the locality. The proponent has committed to making contributions to assist establishment of the brigade and the development will generate approx. $140,000 p.a. in Emergency Services Levies. A detailed Fire Management Plan will be submitted at subdivision stage in accordance with usual practice.

6 Traffic and Transport

6.1 Background

A traffic assessment was undertaken as part of the 2000 approved Outline Development Plan (ODP), which addressed road hierarchy, network analysis, traffic analysis, road and intersection requirements, public transport, river crossings and pedestrian and cyclist movement. The assessment nominated Barragoon Road as the principal access road. **Figure 6** – Access Plan, on the overleaf depicts the proposed access route to Indian Ocean Drive and emergency access route.

6.2 River Crossing Options

The approved ODP examined river crossing options to connect the serviced ODP area with Guilderton. An examination of options was undertaken by all consultants engaged in the project, identifying a possible river crossing corridor within which crossing options could be considered. The revised ODP has identified a location (within the possible river crossing corridor) for a possible river crossing, which is subject to change following further more detailed investigation.

Investigations have cast doubt over the feasibility, necessity and desirability for a vehicle bridge over the Moore River. However, the Shire of Gingin wants to preserve this option in accordance with the existing approved ODP and has resolved that the revised ODP retain the river crossing corridor on the basis that the Shire itself will investigate the matter within a Developer Contribution Plan (DCP) to be prepared by the Shire at a later date and subject to Guilderton Townsite Expansion Plans having been prepared. Therefore the road reserve shown on the revised ODP is notional and the final alignment will be determined in the Foreshore Management Plan and DCP processes and will be influenced by the final decision of the Shire with respect to a vehicular bridge.

The cost benefit of a pedestrian bridge is also doubtful at this stage. Notwithstanding, Moore River Company has made a commitment to proportionate funding of the pedestrian facility on the basis that funding, design and ongoing management issues can be resolved to the satisfaction of all stakeholders. Preliminary analysis indicates the pedestrian bridge would cost >$3M.

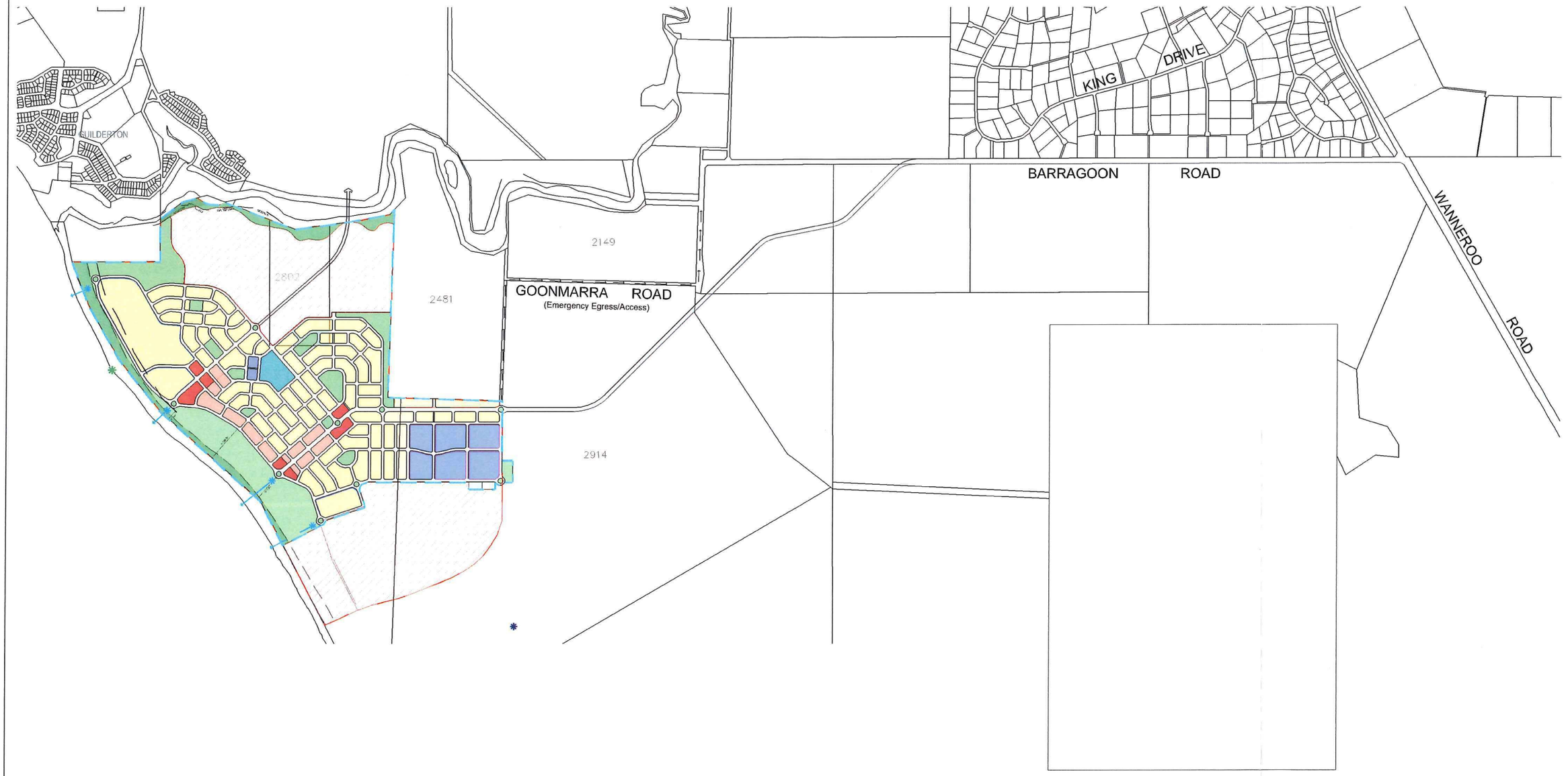
The detail of the possible construction of a river crossing will be the subject of further discussions between the proponent, the Shire of Gingin, the WAPC and any other relevant State government agency.

6.3 Traffic Assessment

An updated transport assessment (**Appendix D**) has been undertaken by Cardno Eppell Olsen in support of the revised ODP. This additional assessment was required pursuant to the Western Australian Planning Commission's: Structure Plans - Guidelines for Transport Assessments, 2006.

As part of the assessment a forecasting of future traffic volumes was undertaken using the Cube transport planning software package. As part of this the following sub-tasks were undertaken:

- A trip generation exercise was undertaken to assess the quantum of traffic likely to be generated by each landuse and the entire development. This was assessed to be around 13,000 vehicles per day (vpd).
- A distribution exercise was undertaken using a simple gravity model to determine the volume of flows between internal landuses and the external road network. Based upon this exercise it was assessed that 8,000vpd would come from / leave to the external road network



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FIGURE 6

LOCAL ACCESS PLAN
MOORE RIVER OUTLINE DEVELOPMENT PLAN
MOORE RIVER SOUTH, SHIRE OF GINGIN

NORTH

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SHIRE OF GINGIN
PROJECT-PHASE-PLAN NUMBER REVISION
P7026 CON 001

- A traffic assignment exercise was used to assign traffic to the road network, allowing the prediction of traffic volumes on roads throughout the structure plan. Most roads are expected to have less than 2000vpd, whilst the main spine road coming into the development is expected to have 8,000vpd.

(*The above estimates are based on full development and will therefore not be experienced within a 20 year horizon. Please also note that the abovementioned figures do not include a a traffic bridge across the Moore River, but that future modelling could take a traffic bridge into account, if the need was demonstrated.)*

Following this an examination of the preferred bus and pedestrian routes was undertaken based upon the traffic volume and the spatial location of landuses such as schools, retail and commercial areas. This information, with the addition of proposed drainage information, then informed the development of a road hierarchy and recommended road cross sections.

The highest order road (The road entering from Indian Ocean Drive to the development) would be classified as an integrator A, and is recommended to be between 23 – 27m in width, with a 4m median and a 4m pavement in each direction with a cycle lane of 1.5m. Within the town centre areas, the assessment recommends that this be downgraded to an Integrator B Main Street, which would consist of a 25m road reserve with 2m median and 3.5m pavement, with a 1.5m cycle lane and 2.5m parking. It is recommended that other roads would consist generally of 3.5m road lanes, except Industrial neighbourhood connectors which would have 4m road lanes.

All road reserves in the revised ODP area have been designed to exceed the above recommended widths, for example the Integrator A and B roads are both 30m wide.

The revised ODP also proposes access to the site from Indian Ocean Drive via Barragoon Road. This route is currently an unsealed road between Link Road and Indian Ocean Drive that would need upgrading in the first stage of development so that there is limited impact on the Woodridge residential area to the east of the site.

An additional assessment of sightline and basic geometric requirements for the access onto Indian Ocean Drive was undertaken. The recommendations from this were that, although the operating speed along Indian Ocean Drive around the Indian Ocean Drive / Barragoon Road access could be reduced from 110km/h to 90km/h so that safe sight distance requirements could be met the MRWA requirement for the intersection is that it be designed to 110km/h standard. Consequently the transport assessment includes a design for the intersection at the 110km/h standard for the purposes of the ODP (i.e. to demonstrate that such standard is achievable). The detail of the construction will be settled with MRWA at the pre-construction phase of the project.

The conclusion of the assessment is that the proposed transport network for the revised ODP proposal would operate acceptably under the network recommendations set out in the report.

7 Revised Outline Development Plan

7.1 Project Summary

The proponent, the Moore River Company, has commissioned the preparation of this revised Outline Development Plan (ODP) for land south of Moore River following the Minister for Planning's recognition that the area, with a reduction in the scale of development, can accommodate a sustainable community catering for a population of up to 5,000 residents.

In response to the criteria set by the Minister for Planning the revised ODP area has been reduced from 557ha to 457ha, which will leave a 110ha area of the Future Development zoned land unaffected by the proposal. The number of residential lots has been reduced from 5,000 to 2,000, which will see a reduction in the overall estimated population by approximately 8,500.

The area of land unaffected by the proposal will remain in the Future Development zone. This land will be unable to support development without a further structure planning approval process at some time in the future. Any future structure plan would need to assess the site in detail in accordance with the provisions of LPS9. **Figure 7** on the overleaf is the revised ODP for the subject site.

The following table identifies the allocation of the various land uses within the ODP area:

Table 1 Land Use Summary

TOTAL SITE AREA OF ODP (Includes Future Development Area in north of ODP area)	460.07ha
RESIDENTIAL POPULATION	5000 (inhabitants)
RESIDENTIAL LOTS / DWELLINGS	2000 (dwellings)
Residential Area	116.14 ha
COMMERCIAL	
Commercial Neighbourhood	6.5 ha
Mixed Business	24.27 ha
TOURIST RESORTS	
Tourism	30.32 ha
Caravan Park	6.04 ha
COMMUNITY	
Primary School	4.73 ha
Community Sites	1.26 ha
Council Depot	0.52 ha
Emergency Services	0.52 ha
RECREATION	
Foreshore Reserves	21.9646.45 ha
Public Open Space	65.4528.48 ha
Road Network	70.762 ha

GUILDERTON

MOORE RIVER

CROWN RESERVE
(Recreation and Landscape Protection Reserve)

Moore River Foreshore Reserve
To be ceded to the State and subject to a Foreshore Management Plan

This area included in Foreshore Management Plan and subject to future Structure Planning for land use purposes

20m wide road reserve and possible river crossing subject to detailed design of alignment and Developer Contribution Plan by Shire

Coastal development setback.

HOLIDAY RESORT
Cabins
Conference Facilities
Resort
Accommodation and Facilities

CARAVAN PARK
Chalets, Tents, Caravans and short stay / Overnight Accommodation
General Store

PRIMARY SCHOOL

TOURIST RESORT

Development of this area is subject to a Fire Management Plan and/or redesign to address exposure to fire risk from the adjoining vegetated land to the north.

Southern interface of ODP area with Future Development Zone to be addressed at subdivision stage.

Subject to future Structure Planning

2482

2481

+/-75m

+/-268.7m

+/-212m

LEGEND

ZONES

- RESIDENTIAL LOW DENSITY R20
- RESIDENTIAL MEDIUM DENSITY R40
- TOWN CENTRE
- TOURISM
- MIXED BUSINESS R5
- FUTURE DEVELOPMENT ZONE
  SUBJECT TO FUTURE STRUCTURE PLANNING

RESERVES

- PUBLIC USE PRIMARY SCHOOL
- PUBLIC USE COMMUNITY FACILITIES
- PARKS AND RECREATION
  PUBLIC OPEN SPACE
- PARKS AND RECREATION
  FORESHORE RESERVE
- COUNCIL DEPOT
- EMERGENCY SERVICES

- ODP BOUNDARY
- COASTAL DEVELOPMENT SETBACK
- POSSIBLE BOAT LAUNCH FACILITY
- POTENTIAL SEWERAGE TREATMENT PLANT SITE
  (Indicative Only)
- STRATEGIC BEACH ACCESS

ADOPTION SIGNATURE

This Outline Development Plan was endorsed by the council of the Shier of Gingin pursuant to clause 5.7.5 of the Shire of Gingin Town Planning Scheme No. 9

on 17 day of Sept 2013

Chief Executive Officer

and

Endorsed by the Western Australian Planing Commission

on 30 day of October 2013

~~WAPC Chairman~~

Signed by an officer duly authorised by the Western Australian Planning Commission pursuant to section 24 of the *Planning and Development Act 2005*

SHEET 1 OF 2 SHEETS FIGURE 7

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REVISED OUTLINE DEVELOPMENT PLAN
MOORE RIVER SOUTH
SHIRE OF GINGIN

Cardno
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P.O. Box 447
West Perth 6872
Telephone (08) 9273 3888
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DATE: 23.8.2013 SCALE AT A3: 1:12 500
DESIGNED: CHECKED:
DRAWN: FC APPROVED:
LOCAL AUTHORITY
SHIRE OF GINGIN
PROJECT-PHASE-PLAN NUMBER REVISION
P7026 CON 001 A

Planning Policy Statements

This Outline Development Plan (ODP), once approved, supersedes any previously approved ODP for the subject land. The implementation of the ODP will be facilitated through the subdivision and development approvals process, which pursuant to Town Planning Scheme 9 will be required to generally conform with the approved ODP. Future applications will be required to demonstrate compliance with the following key Planning Policy Statements:

1. Subdivision and Development

- The development of the subject land shall be undertaken generally in accordance with the endorsed Outline Development Plan (ODP). Subdivision of the ODP area requires approval from the Western Australian Planning Commission (WAPC) and shall be undertaken generally in accordance with the ODP.
- Development Applications and Detailed Area Plans will be required for all development generally excluding residential land use being R20-R40 which will be guided by the Residential Density Codes and Design and Settlement Guidelines if appropriate.
- The ODP map is the authoritive document in relation to proposed land uses and conditions attached to subdivision and development. In the event of an inconsistency between the ODP map and any other map contained in the ODP documentation the ODP map prevails to the extent of that inconsistency.

2. Retail Floor Space

A maximum of 500 m² of retail floor space shall be integrated with the caravan park and tourist resort components of the ODP and provide for local convenience shopping and services in the first stages of the overall development.

3. Design and Settlement Guidelines

Detailed Design and Settlement Guidelines (DSG) will be prepared and implemented by the proponent to guide the form and nature of buildings and structures in the ODP area. The DSG:

- Will set appropriate standards for design of dwellings and commercial and tourist development to meet sustainability criteria, building location and orientation, built form, building heights, scale and roof pitch, external colours and materials, curtilage and landscaping, vehicle parking and access and fencing.
- Will promote and encourage the installation of water tanks, water efficient taps and appliances and solar energy harnessing devices in every dwelling.
- Will require that any development in the northern holiday resort site will require consideration to the retention of vegetation and be designed sympathetically to the vegetation and topography of the site
- May include special provisions for the 'Mixed Business' precinct shown on the ODP map to set standards for lot sizes, separation of uses and setbacks in addition to the matters outlined above.
- Can be undertaken for the tourism sites independently from the residential and commercial sites.

The DSG is intended to supplement the Residential Design Codes. In the event of a contradiction or inconsistency between the DSG and the Residential Design Codes the Residential Design Codes will prevail.

The WAPC and the Local Government may require Detailed Area Plan(s) prior to subdivision of a tourism site and/or as a condition of subdivision approval for the Mixed Business and/or Residential Lots.

4. Staging of Subdivision and Development

The progressive subdivision and development of land identified for residential lots (both green title and strata) on the ODP shall proceed on the basis of a staging plan approved by the Shire and the West Australian Planning Commission that has regard for the necessity for the introduction of reticulated water and sewerage facilities to the ODP area and the early establishment of foreshore improvement works.

5. Tourist Units

The strata subdivision and/or development of any land identified on the ODP for tourist accommodation shall include common management arrangements to ensure the tourist units and any associated facilities are available at all times for tourists, visitors and travellers. These arrangements are not intended to preclude owner use of tourist accommodation for holiday purposes.

6. Foreshore Reserves

A foreshore management plan shall be prepared under clause 5.1(x) and (xi) of State Planning Policy No. 2.6: State Coastal Planning Policy prior to the first stage of subdivision.

The foreshore management plan must:

- Include the foreshore reserves for both the ocean and Moore River frontages of the development identified on the ODP and the adjacent Crown Reserve abutting the mouth of the Moore River ;
- Contain a schedule of works, public facilities, infrastructure and amenities provision and implementation schedule;
- Consider and respond to coastal processes, biophysical characteristics and any access requirements, both pedestrian and vehicle access, between the residential development front and Moore River;
- Include a strategy for the investigation of the feasibility and provision of a low key boat launching facility;
- Define and implement an appropriate foreshore reserve width along Moore River having regard to the above factors and specifically in response to SPP 2.6;
- Identify those with responsibility for implementation of the plan and management of the reserves thereafter;
- Be subject of its own public consultation process;
- Be approved, if acceptable, by the Shire of Gingin; and
- Identify required works to be fully implemented prior to the Shire's clearance of the conditions of any subdivision approval granted for the ODP area.

Inclusion of the whole of the land area between the residential development front and the Moore River is intended to allow consideration and a response to relevant issues. Any land use proposals beyond the proposed foreshore reserve do not fall within the scope of the foreshore management plan and would be subject to a separate future Structure Plan.

The staged construction of the Foreshore Management Plan and Public Open Space by the Proponent is to be determined at the Subdivision stage or through a Development Deed between the proponent and the Shire in a manner that reflects progressive development of the project and progressive demand for additional facilities.

The ocean foreshore reserve and adjacent public open space is able to be used for drainage works or functions pursuant to an approved Stormwater and Drainage Management Plan as required by Planning Policy Statement 13, including subsurface stormwater drainage and absorption structures, which do not materially diminish the capacity of the area for public use.

7. Fire Management Plan

A fire management plan must be prepared and implemented to the satisfaction of the Shire of Gingin and the Department of Fire and Emergency Services.

Goonmarra Rd will be required to be constructed for emergency public access to the satisfaction of the Shire.

Development must be undertaken in compliance with:

- Part 3.7.4 (Bushfire Areas) of the Building Code of Australia
- The WAPC Planning for Bushfire Protection Guidelines; and Australian Standard 3959.

A memorial is to be placed on the Certificate of Title for those lots affected by the fire the requirement to comply with the approved fire management plan and the ownermanagement plan advising of's responsibility to maintain fire protection measures and emergency access to an appropriate standard.

8. Community Facilities

Local Community Facilities will be provided for through a Deed of Agreement between the Shire of Gingin and the Moore River Company. If for any reason, the Deed of Agreement is not executed the Shire will progress Developer Contribution Plans under the provisions of its Local Planning Scheme.

A small multipurpose community facility shall be provided as part of the first stage of development of the ODP area.

9. Local Water Management Strategy

A Local Water Management Strategy shall be approved by the relevant agencies prior to the approval of the first stage of subdivision.

10. Dust Management

A dust management plan is to be:

- Submitted to and, if acceptable, approved by the Shire; and
- Implemented at each and every stage of development to the satisfaction of the Shire.

11. Landscape Strategy

A landscape strategy plan for the road reserves including the primary access road from Indian Ocean Drive and public open space areas shall be prepared, which:

- Indicates the location and species of all trees to be removed and/or retained;
- Indicates the location and type of fencing to be installed;
- Indicates the location and type of reticulation to be installed;
- Indicates the location and type of paving to be installed; and
- Includes a plant schedule nominating each species, the spacing of species, the numbers of plants required, and the size of each plant to be used at the time of planting and the anticipated height of each plant at maturity.

The landscape strategy plan shall:

- be submitted to and, if acceptable, approved by the Shire;
- be the subject of a management agreement between the owner and the Shire;
- include provisions for the specific approval of the Shire for any proposals to remove Tuart trees; and
- implemented to the satisfaction of the Shire.

12. Construction Management Plan

Any Construction Management Plan required to be prepared at the subdivision or development stage shall include the technical, physical and contractual measures to minimise environmental impacts during construction and post-construction. Such plan to address Acid Sulphate Soils in accordance with the guidelines of the Department of Environment and Conservation.

A plan addressing cut/fill and retaining requirements (i.e. bulk earthworks plan) shall be prepared and submitted to the Shire of Gingin prior to or concurrent with the subdivision application process.

13. Stormwater and drainage

A stormwater and drainage management plan shall be:

- Prepared, which identifies the locations and dimensions of all proposed pump stations, infiltration basins and sumps;
- Submitted to and, if acceptable, approved by the Shire and the Department of Water; and
- Implemented to the satisfaction of the Shire.

The design objectives of the stormwater and drainage management plan will be to optimise the infiltration of stormwater at source and the reuse of water.

14. Utilities and Services

All development is to be connected to underground power, telecommunications and reticulated water and sewage services.

The design of utilities and services will be aimed at the maximum feasible use of technology capable of capture of energy from wind and solar sources and the reuse of wastewater so as to minimise the demands of the new development for importation of energy and water.

All utilities and services are to be contained within the ODP area or where outside the ODP area within a public road reserve, Shire managed reserves or easements specifically created for that purpose.

These connections are to occur at the first stage of development at the full cost to the owner/developer and to the satisfaction of the Shire and, in relation to water and sewage, the Water Corporation.

15. Traffic Management and Parking

- A traffic and parking strategy shall be prepared by a suitably qualified traffic engineer, which:
- Shows the required upgrading works for the local road system, including the intersection of the primary access road and Indian Ocean Drive;
- Shows the staging of these works relative to the staging of the development;
- Assesses the future public, private residential and tourist car park requirements generated by the development proposed in the ODP area;
- Able to demonstrate that sufficient foreshore parking or alternative access is provided for tourist and residential development as well as the demands of visitors and the general public.
- Include a noise impact assessment undertaken for Barragoon Road adjoining Woodridge Estate so as to demonstrate the need for any noise attenuating requirements as part of the road upgrading work
- Submitted to the Shire and, if acceptable, approved by the Shire and Main Roads WA; and

The strategy shall be implemented to the satisfaction of the Shire prior to the Shire's clearance of any condition of any approval granted for the subdivision or strata subdivision of land within the ODP area. All residential lots are to contain on-site car parking in accordance with the Residential Design Codes.

16. Further Subdivision

Subdivision of the residential areas depicted on the ODP will only be permitted in accordance with the Residential Design Codes.

17. Special Land Use Controls

The following special land use exemptions will apply to development in the ODP area:

- For the purposes of facilitating provision of community facilities in the initial stages of development land identified as being within the 'Residential zone on the ODP map may be developed for the purposes of 'educational establishment', 'medical centre', 'shop', 'civic use' and/or 'office' as defined under the Shire of Gingin Town Planning Scheme No. 9 (TPS 9) and on the basis of being an 'SA' use for the purposes of Table 1 - Zoning Table in the scheme;
- Civic use' and 'educational establishment' are deemed to be 'AA' uses in the Town Centre zone under TPS 9; and
- Land in the area shown as 'Mixed Business R5' on the ODP map may be developed for a 'Single House' in conjunction with any mixed business use subject to the application processes and considerations that apply according to a dwelling under the R5 coding under the Residential Design Codes (as amended from time to time).
- The land shown as 'Caravan Park' on the ODP is restricted to that land use as defined in TPS 9, including all associated land uses that are ordinarily ancillary, subsidiary and incidental to the primary use of a caravan park.

ADOPTION SIGNATURE

This Outline Development Plan was endorsed by the council of the Shier of Gingin pursuant to clause 5.7.5 of the Shire of Gingin Town Planning Scheme No. 9

on 17 day of Sept 2013

Chief Executive Officer

and

Endorsed by the Western Australian Planing Commission

on 30 day of October 2013

WAPC Chairman

Signed by an officer duly authorised by the Western Australian Planning Commission pursuant to section 24 of the *Planning and Development Act 2005*

SHEET 2 OF 2 SHEETS FIGURE 7

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REVISED OUTLINE DEVELOPMENT PLAN
MOORE RIVER SOUTH
SHIRE OF GINGIN

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SHIRE OF GINGIN
PROJECT-PHASE-PLAN NUMBER REVISION
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7.2 Revised Outline Development Plan Design Principles

The overarching design principles for the development of Moore River South are as follows:

- Create a revised ODP which meet the Minister for Planning's criteria for a reduced scale of development to provide for a sustainable community of up to 2,000 dwellings;
- Incorporate the twelve principal aims of the WAPC's Liveable Neighbourhoods policy;
- Provide a high quality living environment within the Shire of Gingin;
- Provide a range of compatible and environmentally sustainable uses that will cater for both the needs of the future community as well as the needs of surrounding existing local communities;
- Provide a design which responds to the natural topography with the retention of extensive areas for conservation purposes;
- Provide a design to accommodate wide road reserves and other design elements aimed at maximising the opportunity for capture of drainage at source and minimising impacts on groundwater;
- Provide significantly increased foreshore and other reserves to the Indian Ocean and the Moore River, to protect appropriate environmental features and provide for managed public access.
- Create Neighbourhoods which are compact and have a local shop and/or community facility in a central and walkable location.
- Ensure that adequate land is identified, in appropriate locations, for social, community and recreation purposes, and to foster early introduction of community facilities and services;
- Provide a variety of lot sizes and residential densities to accommodate the anticipated range of housing preferences;
- Provide sites for integrated tourist resorts to help meet the tourist demands of the region both now and in the future;
- Acknowledge the playground setting of the site and reflect a leisure/holiday theme within the design; and
- Generally reflect a more sympathetic response to site attributes within a contemporary design response.

7.3 Revised Outline Development Plan Design Overview

The revised ODP has been designed with the Minister for Planning's requirements for the future development of the site a key consideration. The design principles of the approved ODP have been adapted to reflect these requirements and to respond to issues that have arisen in light of additional technical studies required to be undertaken, particularly in relation to environmental issues.

Significant design changes between the approved 2000 ODP and the revised ODP include:

- Significantly reduced scale of development;
- Significantly increased setbacks from the Indian Ocean to allow for:
    - The physical processes setback (PPS) identified in the updated Costal Assessment report (**Appendix I**);
    - Retention of the sites natural topography, particularly in relation to the coastal dunal system;
    - Provision of natural drainage areas; and
    - Retention of important flora and vegetation communities.
- Exclusion of tourism uses adjacent to Moore River;
- Generous allocation of public open space to ensure retention of remnant vegetation;
- Protection of key physical environmental attributes;
- Increased road widths to maximise the opportunity for capture of drainage at source; and
- Creation of an extensive area of foreshore reserve to be ceded free of cost to the Shire of Gingin and/or the State for the purpose of recreation and conservation.

The design of revised ODP is based on a framework provided under the Western Australian Planning Commission's (WAPC) strategic policy document Liveable Neighbourhoods. The design reflects the 12 principle aims of Liveable Neighbourhoods as set out below and as considered under each element of the design in the following section of the report.

1. To provide for an urban structure of walkable neighbourhoods clustering to form towns of compatible mixed uses in order to reduce car dependence for access to employment, retail and community facilities.
2. To ensure that walkable neighbourhoods and access to services and facilities are designed for all users, including those with disabilities.
3. To foster a sense of community and strong local identity and sense of place in neighbourhoods and towns.
4. To provide for access generally by way of an interconnected network of streets which facilitate safe, efficient and pleasant walking, cycling and driving.
5. To ensure active street-land use interfaces, with building frontages to streets to improve personal safety through increased surveillance and activity.
6. To facilitate new development which supports the efficiency of public transport systems where available, and provides safe, direct access to the system for residents.
7. To facilitate mixed use urban development which provides for a wide range of living, employment and leisure opportunities, capable of adapting over time as the community changes and which reflects appropriate community standards of health, safety and amenity.
8. To provide a variety of lot sizes and housing types to cater for the diverse housing needs of the community at a density that can ultimately support the provision of local services.
9. To ensure the avoidance of key environmental areas and the incorporation of significant cultural and environmental features of a site into the design of an area.
10. To provide for a more integrated approach to the design of open space and urban water management.
11. To ensure cost-effective and resource-efficient development to promote affordable housing.
12. To maximise land efficiency wherever possible.

7.3.1 Community Design

In accordance with the principles of Liveable Neighbourhoods the revised ODP is predicated on the creation of a community structure with two clearly defined activity centres based on 400m walkable catchments and well defined edges.

The design allows for a transition from the rural land surrounding the revised ODP area to the denser mixed use urban cores of the activity centres. Moving outwards from the activity centres it is anticipated that residential densities would decrease from small cottage lots to fully detached houses.

An important component in the overall design has been the desire to retain the natural topography of the site and protect and enhance important environmental attributes wherever possible. In this regard, urban land uses have generally been proposed on those areas that have been subject to extensive past grazing and clearing. The natural topography of the site, including the coastal dunal system, has been retained where possible as either foreshore reserve or areas of public open space and areas identified of having important environmental habitat have been retained within the open space system.

7.3.2 Movement Network

The movement network within the revised ODP has been designed with an emphasis on connectivity, amenity, and integration to achieve safe, efficient and attractive street networks that not only cater for vehicles and public transport but also aims to attract pedestrians and cyclists.

In accordance with Liveable Neighbourhoods the revised ODP incorporates the following key design principles within the movement network:

- The street system is highly interconnected, aimed at reducing travel distances;
- Integrator arterial routes form the core of the revised ODP area;
- Street layout designed to maximise walk-ability - through a structure of local neighbourhoods based on 400m walkable catchments;
- Street widths maximised to ensure adequate and safe vehicle, pedestrian and cyclist interaction and to provide an integral part of the sustainable urban water management system proposed for the revised ODP area;
- Parkland areas within the revised ODP area to be fronted by streets;
- Use of four-way junctions to facilitate pedestrian and cycle movement and to encourage efficient lot configuration; and
- Within the proposed activity centres, integrator arterial routes are supported by parallel routes to serve local traffic and reduce pressure on arterial intersections.

A traffic assessment was undertaken as part of the 2000 approved ODP, which addressed road hierarchy, network analysis, traffic analysis, road and intersection requirements, public transport, river crossings and pedestrian and cyclist movement. An updated transport assessment (**Appendix D**) has been undertaken by Cardno in support of the revised ODP, as considered in the previous Section 6 of this report.

7.3.3 Residential - Lot Layout

The revised ODP allows for a mixture of lot sizes to provide housing choice to meet the housing requirements of retirees, weekenders, permanent residents and tourists. The purpose of the revised ODP is to provide a guiding framework for development. In regard to proposed residential densities it is intended that the revised ODP provides an indicative outline for future densities, retaining the flexibility for final definition to be determined at subdivision stage.

The general densities promoted generally range from R20 to R40. The recommended densities for various components of the revised ODP are as follows:-

- Residential Neighbourhoods - broad range including R20 and for medium density housing, R40.

The average and minimum property sizes for each of the specified codes is as follows:

- R5 - (2000m^2)
- R20 - (500m²/450m²);
- R40 - (250m²/220m²);
- R50 - (200m²/180m²)
- R60 - (180m²/160m²)
- R80 - (125m²)

The majority of the neighbourhoods have a density coding of R20, which it is anticipated will allow for a wide range of lot sizes and housing types, ranging from conventional larger lots with views to more medium density housing located close to parkland and other high amenity areas, such as the proposed activity centres and public transport stops, which will help support these facilities.

The revised ODP will allow for a future population of 5,000 residents through the provision of 2,000 residential lots. Given the rural nature of the area and the steep topography of much of the site, it is anticipated that the majority of lots outside of the neighbourhood centres will be developed greater than to minimum standards. Based on this assumption a 30% addition has been applied to average lot sizes (i.e. R20 - 600m² and R40 - 300m²) for the purpose of calculating the overall yield. The revised ODP is a broadbrush plan and detailed lot layout, design and yields will be considered further through the subdivision of each stage of development including consideration of dwelling occupancy rates..

Detailed Design and Settlement Guidelines (DSG) included within the revised ODP's Statements of Planning Policy (Section 9) sets appropriate standards for design of dwellings to meet sustainability criteria, building location and orientation, built form, building heights, scale and roof pitch, external colours and materials, curtilage and landscaping, vehicle parking and access and fencing, to the satisfactory of the Shire of Gingin.

7.3.4 Public Parkland

The WAPC requires that a minimum contribution of 10 per cent of the gross subdivisible area (GSA) of a new development must be given up free of cost by the subdivider for the purpose of Public Open Space (POS). Liveable Neighbourhoods requires that a minimum of 8 per cent be provided by active and passive recreational purposes ('unrestricted' POS). The remaining 2 per cent can comprise 'restricted' use POS, such as natural areas, urban water management measures such as swales and/or detention areas and artificial lakes/permanent drainage ponds.

Based on the area figures provided on the Open Space Plan (**Appendix A**) and the drainage figures provided in Tables 6 and 7 of the supporting Local Water Management Strategy (LWMS) (**Appendix H**) a POS Schedule (**Figure 8**) has been prepared in accordance with the provisions of Liveable Neighbourhoods.

Public Open Space (POS) Schedule - Moore River South - Revised Outline Development Plan (in hectares)			
Revised ODP Area			**460.07**
Less:			
Foreshore Reserve to be Ceded	**46.45**		
***Drainage Basins with Parkland Areas 3-13 (more frequent than 1 in 1 yr rainfall) (LNR33)**	**0.94**		
Total		**47.39**	
Net Site Area			**412.68**
Deductions:			
Primary School	**4.74**		
Council and Emergency Services	**1.36**		
Tourist Sites 1-3	**35.66**		
Mixed Business R5	**24.27**		
Community Site Areas 1 & 2	**1.27**		
Neighbourhood Commercial Area 1-8	**8.09**		
POS (Restricted and Unrestricted)	**64.04**		
Area Subject To Future Structure Plan	**96.57**		
Total		**2236.00**	
Gross Subdivisible Area			**176.68**

POS Required			**17.67**
POS Contribution			
May Comprise:			
Minimum 80% Unrestricted POS			**14.14**
Maximum 20% Restricted POS			**3.53**
Unrestricted POS Sites:			
Parkland 2 (Buffer to Crown Reserve)	**12.57**		
Parklands 3 - 12 (includes drainage basins 1 in 5 to 1 in 100 yr / excludes drainage basins 1 in 1 to 1 in 5 yr and more frequent than 1 in 1 yr rainfall) (LNR25)	**12.38**		
Total Creditable Unrestricted POS			**24.95**
Restricted POS Sites:			
Parkland 1 (Coastal Dunal System)	**25.51**		
Restricted Drainage Basins (1 in 1 to 1 in 5yr rainfall) (LNR33)	**2.85**		
Total Restricted POS		**28.36**	
Total Creditable Restricted POS			**3.53**
Total Creditable (Unrestricted & Restricted) POS Provision			**28.48**
Total % POS Provision			**16.1%**

Drainage basin locations within the revised ODP area are depicted on Figure 10 and the rainfall events and required storage areas shown in Tables 6 and 7 of the supporting Local Water Management Strategy (*Appendix H***).*

NB: It should be noted that if Liveable Neighbourhoods provision LNR43 is applied and the restricted public open space in excess of the 2 per cent of the 10 per cent minimum (i.e. 37.12 ha) is deducted from the overall site area the total POS provision increases to 17.82%%.

Whilst the creditable provision of POS is slightly in excess of 16 per cent, the actual amount of open space provided within the revised ODP area (346.3575ha) as both public open space (64.9794ha) and other reserve areas (21.9702ha) is actually in excess of 25%.

The revised ODP has been designed in accordance with Liveable Neighbourhoods incorporating the following principles into parkland design:

- Provide for a balance between conservation and active and passive recreational use in district, neighbourhood and local open space;
- Incorporate natural features;
- Provide for parks in a safe walking distance from all dwellings;
- Allow for parkland frontage and surveillance - through the provision of perimeter roads around parkland areas;
- Incorporate drainage wherever practicable using contemporary urban water management principles;
- Accommodate water-sensitive urban design in parkland areas where usability for recreation purposes has not been compromised or where conservation values are enhanced; and
- Adopt a conservative design approach to provide more open space than is technically required.

The design and layout of the parkland areas has been considered in conjunction with the preparation of the supporting Local Water Management Strategy (LWMS) (**Appendix H**). **Figure 11** of the LWMS

indicates the location of the required areas of drainage, including natural drainage basins within the troughs of the coastal dunal system, swales and bio-pockets within the proposed road reserves, and vegetated basins within the formal parkland areas. Where a drainage function (i.e. for events more frequent than 1 in 5yr rainfall) is provided within formal parkland the affected area is considered as 'restricted' POS (pursuant to the provisions of Liveable Neighbourhoods) for the purpose of calculating the overall POS provision. Tables 6 and 7 of the supporting LWMS include the required storage area sizes which have been included within the POS Schedule (**Figure 8**).

The revised ODP includes two large areas of public open space: Parkland 1 (34.27ha) between the coastal foreshore reserve and the development; and, Parkland 2 (13.39ha) between the crown reserve and the development to the north.

Parkland 1 retains the coastal dunal system and provides for natural areas of drainage and habitat protection. The parkland will allow for low key passive recreation, with strategic access to the beach. Given that the area will include areas for drainage Parkland 1 is considered as 'restricted' POS for the purpose of calculating the overall POS provision.

Parkland 2 provides a buffer between the development and the Crown Reserve to the north and will allow for the protection of important flora and vegetation communities. Parkland 2 will also be considered for low key passive recreation purposes with a series of walk trails, viewing locations and interpretive stops and providing access to the Crown Reserve to the north and the coast to the west. As there are no urban water management features Parkland 2 is considered as 'unrestricted' POS.

Parkland areas 3-13 as shown on the POS Plan (**Figure 9**) are located internally within the revised ODP area. These formal areas of POS range in size from 5089m² to 6.12ha and provide for a varied provision of parkland areas that will allow for a balance between neighbourhood parks, local parks and district playing fields. The detailed design of these parkland areas will be considered and assessed at subdivision stage. In accordance with the provisions of Liveable Neighbourhoods, all parts of the revised ODP area are within at least 400m of a formal parkland area.

In accordance with recommendations from Cardno's Environmental Assessment, various parcels of good quality remnant vegetation are recommended for protection within public parklands. A further detailed consideration of the significant environmental issues that have influenced the revised ODP design is considered in Section 4.14 of this report.

State Planning Policy 2.6 - State Coastal Planning Policy requires that, where a subdivision abuts the coast, that any foreshore be ceded free of cost without payment of compensation by the Crown and will be in addition to the 10 per cent public open space contribution. The revised ODP includes a significantly increased coastal foreshore setback (compared to both policy requirements and the approved 2000 ODP) based on the physical processes setback identified within the updated Coastal Assessment Setback Assessment (**Appendix I**), which together with the foreshore adjacent to the Moore River, will be given up as part of subdivision approval.



FIGURE 9

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PUBLIC OPEN SPACE PLAN
MOORE RIVER SOUTH OUTLINE DEVELOPMENT PLAN
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7.3.5 Activity Centres and Employment

The revised ODP design adopts a main street mixed activity centre approach with two neighbourhood commercial centres located centrally and within a 400 to 500m radius of all surrounding neighbourhoods. In accordance with the principles of Liveable Neighbourhoods it is the intention that these centres, through the provision of high quality mixed use development, will encourage local employment provision, higher density housing in the surrounding area, higher amenity environments, and modes of transport other than the private car.

The approved 2000 ODP was designed to cater for a total of 15,000 people and a district centre design approach was proposed to cater for the needs of the community. The revised ODP has been reduced considerably to cater for a total population of 5,000 and therefore the facilities and services that will be required will be better provided through a neighbourhood centre approach. These centres will be able to service the whole of the revised ODP area being within convenient walkable catchments of 400 to 500m and therefore removing the need for other smaller supporting centres.

To encourage successful neighbourhood commercial centres the revised ODP has been designed to take account of the following factors, as set out in Liveable Neighbourhoods:

- A required minimum local residential population of approximately 2,000 people - the ultimate population of the revised ODP will be for 5,000 people serviced by two neighbourhood centres;
- Central location in good walkable catchments for local residents - being located within 400 to 500m of all neighbourhoods;
- Location on a busy main street with good traffic levels - the northern centre being located on a Neighbourhood Connector A and the southern centre on the Integrator B (Main St);
- Good on street parking in front and across the street - accommodated through the wider than average road reserves proposed;
- Preferably a two-storey building design - to be considered at the later stages of planning; and
- Slight under-provision (rather than overprovision) of retail to maximise vitality - 500m² retail floor space cap to be integrated with the caravan park and tourist site components of the revised ODP and provide for local convenience shopping and services in the first stages of the overall development.

The proposed neighbourhood commercial centres will allow for high quality mixed use development and this is advocated through the Shire of Gingin Local Planning Scheme No. 9 (LPS9) which allows for a mix of uses within 'Town Centre' zoned land. Uses appropriate to the neighbourhood centres and allowed pursuant to LPS 9 include: various types of holiday accommodation; home business; medical centres; consulting rooms; motels; offices; service stations and shop/retail.

Whilst the two neighbourhood centres are comparable in size, the centre to the north is proposed to be included within the first stage of development, along with the primary school, community facilities site, and caravan park, which are adjacent to and form part of this centre. The inclusion of this mix of uses will service the future needs of the area, but importantly, will also provide much needed facilities and services to the surrounding townsites of Guilderton to the north and Woodridge to the east.

7.3.5.1 Mixed Business Area

A 22 ha area is provided to the western extremity of the revised ODP area to provide for an area of Mixed Business Lots. It is envisaged that these Mixed Business lots will be developed for the purpose of light / service industry and to support home based business.

Larger lot sizes of 3000m² will allow for residential use in the interim but will provide for an efficient lot layout and access for rear parking, together with large front setbacks that will enable a business to be constructed in front of a dwelling at a later stage. The final layout of this area, the apportionment of areas for residential and business use on one lot, will be controlled by a Detailed Area Plan to be formulated and approved at subdivision stage.

It is the intent of the Mixed Business Lots to provide for appropriate local businesses and other employment generating activities in order to encourage as many locally based jobs as possible.

7.3.6 Community Facilities

The identification of the types and ranges of community facilities required to sustain an ultimate population of 5000 people and ensuring land is provided for these facilities is an integral part of the revised ODP design.

7.3.6.1 Primary School

The revised ODP identifies a site for a Government Primary School, which is proposed to be granted free of cost. The Education Department requires one Primary School for every 1,800 dwelling units.

The Primary School is located centrally to facilitate convenient access. It is located in close proximity to the neighbourhood commercial centre and adjacent to the Community Sites, site to enable joint use of these facilities. The school has been strategically located to ensure that all school children within the revised ODP area will live generally within a 1km to 1.5 km radius of a school.

The approved 2000 ODP identified that approximately 80 children from Woodridge and 20 children for Guilderton travel to Gingin daily for their schooling. The Education Department acknowledges that those student numbers alone generate the need for a local school. The revised ODP is considered to be the ideal location for a new school site. As such, to meet not only the needs of the future population of the revised ODP area, but to also meet the needs of the surrounding areas of Guilderton and Woodridge, the primary school site is included within the first stage of development.

7.3.6.2 Public Use Community Facilities

The revised ODP area will likely generate the need for a community hall, senior citizens centre, infant health clinic, library and in the future a Shire of Gingin local office.

In accordance with the principles of Liveable Neighbourhoods, the community sites are located centrally within the revised ODP area adjacent to the primary school site and in close proximity to the neighbourhood commercial area to the north.

7.3.6.3 Medical Centres

The revised ODP area will ultimately accommodate a medical centre(s) comprising doctors, dentists, other specialists and pharmacies. No land provision is required for these centres as they are usually located adjacent to commercial centres. Additionally, pursuant to the Shire of Gingin Local Planning Scheme No. 9, consulting rooms are permitted on residential land with Council approval, subject to public advertising.

To ensure community development is adequately provided the revised ODP includes Planning Policy Statement No. 8 (Section 9) to require a comprehensive community facilities infrastructure contribution plan to be:

- Prepared, identifying the basis for determination of contributions to be made to fund community facilities and infrastructure within the locality required as a direct result of the development of the land;
- Submitted to, and approved by, the Shire prior to the lodgement of an application for planning approval or building licence and prior to the clearance of any subdivision of the land; and
- Implemented to the satisfaction of the Shire.

The proponent has undertaken to sponsor the provision of floor space in the first stage of development to facilitate the earliest possible availability of medical and other services to the new and existing communities. In this regard, the Planning Policy Statement also requires that a general purpose community purpose facility shall be provided as part of the first stage of development. It is anticipated that this facility will initially be in the form of an open plan dwelling or similar structure for temporary use pending the development of purpose built structures once the community reaches sufficient critical mass to require and sustain specified services.

7.3.7 Tourist Resorts

Three tourist resort sites are identified within the revised ODP area as 'Tourism' sites, all of which are adjacent to the coastal foreshore with direct pedestrian access to the coast via proposed strategic beach access points. The tourist site that was proposed adjacent to Moore River on the approved ODP has been omitted from this revised ODP.

The largest Tourism site to the north of the revised ODP area recognises the particular attractiveness of the coastline, the prominent and protected Crown Reserve and the site identified as suitable for a possible boat launching facility, and its proximity to the river. The Environmental Assessment (refer Section 4) carried out by Cardno as part of this revised ODP has identified important flora and vegetation communities within this site. Any development within this site will require consideration to the retention of vegetation and be designed sympathetically to the vegetation and topography of the area. Where possible the Tourism Sites will be designed to create a feature of the protected areas within the resort. Further consideration will be given to this at the detailed design stage. Associated facilities intended for the resort include cabins, conference facilities, and resort accommodation at a density consistent with site attributes.

The second largest Tourist Site is proposed as a Caravan Park to provide for chalets, tents, caravans and a general store. In recognition of the high demand for this type of accommodation in the area, particularly during peak holiday seasons, the proposed Caravan Park has been included within the first stage of development. The revised ODP includes Planning Policy Statement No. 2 (refer Section 9), which requires that a maximum of 500 m² of retail floor space shall be integrated with the caravan park and tourist site components of the ODP and provide for local convenience shopping and services in the first stages of the overall development. The Caravan Park will be required to make specific provision for short term (overnight) stays by the travelling public, tow-in caravans and 'grey nomads'.

The smaller Tourist Site is located at the southern extremity of the revised ODP area. There is no proposal for the use of this site given that it is identified within the last stage of development. It is envisaged that this site will be developed in accordance with the tourist zoning provisions of an approved Town Planning Scheme. Pursuant to LPS9 the following uses are permissible within the 'Tourism zone': bed and breakfast; cabin; caravan park; chalet; guest house; holiday house; holiday house (large); hotel; motel; resort, restaurant; and serviced apartment.

As a guide, density of development on Tourist sites could be expected to range from R30 for apartment style accommodation to R80 for hotel suites subject site conditions and environmental constraints. Development of these sites will be guided by LPS 9.

8 Viewshed Analysis

Riverine, coastal and estuary landscapes are highly valued by the community and it is important that any development of the ODP area is cognisant of this. Additionally, the visual impact of any new development adjacent to an existing townsite (Guilderton) needs to ensure that development is consistent with the existing landscape values of the environment and the surrounding developed area.

Visual impact was raised as a key community concern during community consultation for the 2000 ODP and in response to this issue a viewshed analysis of the revised ODP area from Guilderton was undertaken.

Key viewing locations of the revised ODP area from Guilderton were identified including:

- *Site 1* - Intersection of Gordon Street and Mullins Street, Guilderton;
- *Site 2* - Guilderton lookout; and
- *Site 3* - Guilderton foreshore and picnic area (northern side of Moore River riverbank).

From these locations a 'seen area analysis was conducted, to determine the area of a two-storey (9m) hypothetical development that would be visible from these locations. The two-storey scenario allows for a worst case scenario, although it is considered that the majority of future development will be single storey. This analysis was based on existing contours and assumed no vegetation cover or built structures.

A combined viewshed analysis, which overlays the visible area of a hypothetical two-storey development from all three locations is shown in **Figure 10** overleaf.



FIGURE 10

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VIEWSHED ANALYSIS

MOORE RIVER SOUTH OUTLINE DEVELOPMENT PLAN

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The viewshed analysis demonstrates that only a small portion of the revised ODP area is visible from Guilderton. The greatest visibility of the revised ODP area is from the intersection of Gordon Street and Mullins Street (Site 2), which is not a significant viewing location for Guilderton. Viewers in this location would commonly be in cars and would not be stopping to observe any views.

The more significant viewing locations for the revised ODP area are the foreshore (Site 3) and the lookout (Site 1) as people in these location are likely to be looking out towards the revised ODP area. From both sites there are restricted views of the revised ODP area, only visible from over one kilometre away, when any development would occupy only a small portion of the observer's field of vision. The revised ODP area will also be obscured by vegetation over the area, which is not considered in the 'seen area analysis'.

The viewshed analysis demonstrates there are minimal visual impacts of the development of the revised ODP area from Guilderton. The use of a two storey analysis provides a worst-case scenario for the development, as the majority of dwellings are likely to be single storey over the revised ODP area. In addition, it is likely that the finalised construction levels be smoothed to achieve development and hence structures will be lower than presented in the analysis.

In identified areas, which may be visible, additional visual management measures will be incorporated into future design and planning of the revised ODP area through the implementation of mandatory Design and Settlement Guidelines (DSG) as per Planning Policy Statement 3. These DSG's may incorporate measures to reduce visual impacts including:

- Use of non-reflective materials, particularly on roofs;
- Use of eaves on windows to shade from glare and reduce the reflection of glass;
- Use of colours that blend into the current landscape (neutral colours) and consistent colour schemes across the development; and
- Use of natural building materials, such as local soil or rock.

Incorporating these measures into the built form of the proposed development would help blend the development into the existing landscape.

9 Planning Policy Statements

The revised ODP, once approved, supersedes any previously approved ODP for the subject land. The implementation of the revised ODP will be facilitated through the subdivision and development approvals process, which pursuant to Town Planning Scheme 9 will be required to generally conform with the approved ODP. Future applications will be required to demonstrate compliance with the following key Planning Policy Statements:

1. **Subdivision and Development**

- The development of the subject land shall be undertaken generally in accordance with the endorsed Outline Development Plan (ODP). Subdivision of the ODP area requires approval from the Western Australian Planning Commission (WAPC) and shall be undertaken generally in accordance with the ODP.
- Development Applications and Detailed Area Plans will be required for all development generally excluding residential land use being R20-R40 which will be guided by the Residential Density Codes and Design and Settlement Guidelines if appropriate.
- The ODP map is the authoritive document in relation to prosed land uses and conditions attached to subdivision and development. In the event of an inconsistency between the ODP map and any other map contained in the ODP documentation the ODP map prevails to the extent of that inconsistency.

2. **Retail Floor Space**

A maximum of 500 m² of retail floor space shall be integrated with the caravan park and tourist site components of the ODP and provide for local convenience shopping and services in the first stages of the overall development.

3. **Design and Settlement Guidelines**

Detailed Design and Settlement Guidelines (DSG) will be prepared and implemented by the proponent to guide the form and nature of buildings and structures in the ODP area. The DSG:

- Will set appropriate standards for design of dwellings and commercial and tourist development to meet sustainability criteria, building location and orientation, built form, building heights, scale and roof pitch, external colours and materials, curtilage and landscaping, vehicle parking and access and fencing.
- Will promote and encourage the installation of water tanks, water efficient taps and appliances and solar energy harnessing devices in every dwelling.
- Will require that any development in the northern tourism resort site will require consideration to the retention of vegetation and be designed sympathetically to the vegetation and topography of the site.
- May include special provisions for the 'Mixed Business' precinct shown on the ODP map to set standards for lot sizes, separation of uses and setbacks in addition to the matters outlined in above.
- Can be undertaken for the tourism sites independently from the residential and commercial sites.

The DSG is intended to supplement the Residential Design Codes and TPS 9. In the event of a contradiction or inconsistency between the DSG and the Residential Design Codes and/or TPS 9 the Residential Design Codes and TPS 9 will prevail.

The WAPC and the Local Government may require Detailed Area Plan(s) prior to subdivision of a tourism site and/or as a condition of subdivision approval for the Mixed Business and/or Residential Lots.

4. **Staging of Subdivision and Development**

The progressive subdivision and development of land identified for residential lots (both green title and strata) on the ODP shall proceed on the basis of a staging plan approved by the Shire and the West Australian Planning Commission that has regard for the necessity for the introduction of reticulated water and sewerage facilities to the ODP area and the early establishment of foreshore improvement works.

5. **Tourist Units**

The strata subdivision and/or development of any land identified on the ODP for tourist accommodation shall include common management arrangements to ensure the tourist units and any associated facilities are available at all times for tourists, visitors and travellers. These arrangements are not intended to preclude owner use of tourist accommodation for holiday purposes.

6. **Foreshore Reserves**

A foreshore management plan shall be prepared under clause 5.1(x) and (xi) of State Planning Policy No. 2.6: State Coastal Planning Policy prior to the first stage of subdivision.

The foreshore management plan must:

- Include the foreshore reserves for both the ocean and Moore River frontages of the development identified on the ODP and the adjacent Crown Reserve abutting the mouth of the Moore River ;
- Contain a schedule of works, public facilities, infrastructure and amenities provision and implementation schedule;
- Consider and respond to costal processes, biophysical characteristics and any access requirements, both pedestrian and vehicle access, between the residential development front and Moore River;
- Include a strategy for the investigation of the feasibility and provisions of a low key boat launching facility;
- Define and implement an appropriate foreshore reserve width along Moore River having regard to the above factors and specifically in response to SPP 2.6;
- Identify those with responsibility for implementation of the plan and management of the reserves thereafter;
- Be subject of its own public consultation process;
- Be approved, if acceptable, by the Shire of Gingin; and
- Identify required works to be fully implemented prior to the Shire's clearance of the conditions of any subdivision approval granted for the ODP area.

Inclusion of the whole of the land area between the residential development front and the Moore River is intended to allow consideration and a response to relevant issues. Any land use proposals beyond the proposed foreshore reserve do not fall within the scope of the foreshore management plan and would be subject to a separate future Structure Plan.

The staged construction of the Foreshore Management Plan and Public Open Space by the Proponent is to be determined at the Subdivision stage or through a Development Deed between the proponent and the Shire in a manner that reflects progressive development of the project and progressive demand for additional facilities.

The ocean foreshore reserve and adjacent public open space is able to be used for drainage works or functions pursuant to an approved Stormwater and Drainage Management Plan as required by Planning Policy Statement 13, including subsurface stormwater drainage and absorption structures, which do not materially diminish the capacity of the area for public use.

7. **Fire Management Plan**

A fire management plan must be prepared and implemented to the satisfaction of the Shire of Gingin and the Department of Fire and Emergency Services.

Goonmarra Rd will be required to be constructed for emergency public access to the satisfaction of the Shire.

Development must be undertaken in compliance with:

- Part 3.7.4 (Bushfire Areas) of the Building Code of Australia
- The WAPC Planning for Bushfire Protection Guidelines; and
- Australian Standard 3959.

A memorial is to be placed on the Certificate of Title for those lots affected by the fire management plan advising of the requirement to comply with the approved fire management plan and the owner's responsibility to maintain fire protection measures and emergency access to an appropriate standard.

8. **Community Facilities**

Local Community Facilities will be provided for through a Deed of Agreement between the Shire of Gingin and the Moore River Company. If for any reason, the Deed of Agreement is not executed the Shire will progress Developer Contribution Plans under the provisions of its Local Planning Scheme.

A small multipurpose community facility shall be provided as part of the first stage of development of the ODP area.

9. **Local Water Management Strategy**

A Local Water Management Strategy shall be approved by the relevant agencies prior to the approval of the first stage of subdivision.

10. **Dust Management**

A dust management plan is to be:

- Submitted to and, if acceptable, approved by the Shire; and
- Implemented at each and every stage of development to the satisfaction of the Shire.

11. **Landscape Strategy**

A landscape strategy plan for the road reserves including the primary access road from Indian Ocean Drive and public open space areas shall be prepared, which:

- Indicates the location and species of all trees to be removed and/or retained;
- Indicates the location and type of fencing to be installed;
- Indicates the location and type of reticulation to be installed;
- Indicates the location and type of paving to be installed; and
- Includes a plant schedule nominating each species, the spacing of species, the numbers of plants required, and the size of each plant to be used at the time of planting and the anticipated height of each plant at maturity.

The landscape strategy plan shall:

- be submitted to and, if acceptable, approved by the Shire;
- be the subject of a management agreement between the owner and the Shire; and
- implemented to the satisfaction of the Shire.

12. **Construction Management Plan**

Any Construction Management Plan required to be prepared at the subdivision or development stage shall include the technical, physical and contractual measures to minimise environmental impacts during construction and post-construction. Such plan to address Acid Sulphate Soils in accordance with the guidelines of the Department of Environment and Conservation.

A plan addressing cut/fill and retaining requirements (i.e bulk earthworks plan) shall be prepared and submitted to the Shire of Gingin prior to or concurrent with the subdivision application process.

13. **Stormwater and drainage**

A stormwater and drainage management plan shall be:

- Prepared, which identifies the locations and dimensions of all proposed pump stations, infiltration basins and sumps;
- Submitted to and, if acceptable, approved by the Shire and the Department of Water; and
- Implemented to the satisfaction of the Shire.

The design objectives of the stormwater and drainage management plan will be to optimise the infiltration of stormwater at source and the reuse of water.

14. **Utilities and Services**

All development is to be connected to underground power, telecommunications and reticulated water and sewage services.

The design of utilities and services will be aimed at the maximum feasible use of technology capable of capture of energy from wind and solar sources and the reuse of wastewater so as to minimise the demands of the new development for importation of energy and water.

All utilities and services are to be contained within the ODP area or where outside the ODP area within a public road reserve, Shire managed reserves or easements specifically created for that purpose.

These connections are to occur at the first stage of development at the full cost to the owner/developer and to the satisfaction of the Shire and, in relation to water and sewage, the Water Corporation or other licenced service provider.

15. **Traffic Management and Parking**

A traffic and parking strategy shall be prepared by a suitably qualified traffic engineer, which:

- Shows the required upgrading works for the local road system, including the intersection of the primary access road and Indian Ocean Drive;
- Shows the staging of these works relative to the staging of the development;
- Assesses the future public, private residential and tourist car park requirements generated by the development proposed in the ODP area;
- Able to demonstrate that sufficient foreshore parking or alternative access is provided for tourist and residential development as well as the demands of visitors and the general public;
- Include a noise impact assessment undertaken for Barragoon Road adjoining Woodridge Estate so as to demonstrate the need for any noise attenuating requirements as part of the road upgrading work; and
- Submitted to the Shire and, if acceptable, approved by the Shire and Main Roads WA.
  The strategy shall be implemented to the satisfaction of the Shire prior to the Shire's clearance of any condition of any approval granted for the subdivision or strata subdivision of land within the ODP area.

All residential lots are to contain on-site car parking in accordance with the Residential Design Codes.

16. **Further Subdivision**

Subdivision of the residential areas depicted on the ODP will only be permitted in accordance with the Residential Design Codes.

17. **Special Land Use Controls**

- Where this plan imposes a classification on the land included in it by reference to reserves, zones, or Residential Design Codes then the provisions in TPS 9 applicable to land in those classifications under the Scheme apply to the structure plan area except that tThe following special land use exemptions will apply to development in the ODP area:For the purposes of facilitating provision of community facilities in the initial stages of development land identified as being within the 'Residential zone on the ODP map may be developed for the purposes of 'educational establishment', 'medical centre', 'civic use' and/or 'office' as defined under the Shire of Gingin Town Planning Scheme No. 9 (TPS 9) and on the basis of being an 'A' use for the purposes of Table 1 – Zoning Table in the scheme;
- 'Civic use' and 'educational establishment' are deemed to be 'D' uses in the Town Centre zone under TPS 9; and
- Land in the area shown as 'Mixed Business R5 on the ODP map may be developed for a 'Single House' in conjunction with any mixed business uses subject to the application processes and considerations that apply according to a dwelling under the R5 coding under the Residential Design Codes (as amended from time to time).
- The land shown as 'Caravan Park' on the ODP is restricted to that land use as defined in TPS9, including all associated land uses that are ordinarily ancillary, subsidiary and incidental to the primary use of a caravan park.

10 Population and Employment Opportunities

10.1 Population and Growth

The approved 2000 ODP envisaged an ultimate population of 13,500 residing in 5,269 dwellings. An assumption of 2.8 persons per residential dwelling was made. In the formative years lower than average household sizes were anticipated - particularly through the likely greater presence of retirees and 'empty nesters'.

In response to the State Cabinet's acknowledgement that, subject to a reduction in the scale of development, the existing Future Development zone could accommodate a sustainable community, the revised ODP has been designed to reflect a total population of 5,000 residents. This figure is based on the States assumption of an occupancy rate of 2.5 persons per dwelling.

In determining the actual likely occupancy rate of the revised ODP area a comparison was made with the neighbouring coastal towns of Yanchep to the south, Lancelin to the north and the existing adjacent townsites of Guilderton and Woodridge, based on the 2006 Census details (http:www.censusdata.abs.gov.au) in relation to population and housing, as set out in the table below.

Table 2 Australian Bureau of Statistics Data (2006)

	Yanchep	Guilderton	Lancelin	Woodridge
Population	2,482	146	666	565
Dwellings	1,194	432	878	266
Occupancy Rate	2.1	0.3	0.8	2.1

For the purpose of considering servicing requirements based on the occupancy rates above a conservative rate of 1.8 persons per dwelling was considered.

The timeframe envisaged for the revised ODP to achieve full development is approximately 25 to 30 years. Even then, it can be expected that approximately 15% of the area will be undeveloped, consistent with the established patterns of development for similar communities throughout Australia. At the time of full development, the population characteristics will very likely reflect those of Mandurah - a mix of permanent residents (families and retirees) and weekenders/holiday makers/tourists. There is no accurate means of predicting how and when the resident mix will change. It is acknowledged however that families with children will be more attracted to the area when particular facilities are provided, e.g. schools.

10.1.1 Employment Opportunities

The revised ODP area is intended to attract the full cross section of the community - retirees, empty nesters, families, investors, weekenders, tourists, etc.

The site's locational attributes and attractions are those of a holiday town and not of an expanding Perth suburb. It is expected that the minimal employment opportunities in the early years of development will attract people of similar characteristics to those occupying the existing Guilderton townsite, i.e. retirees and weekenders. Retirees are not seeking employment and the weekenders are generally employed in the city, which is their permanent residential address.

This revised ODP ensures that employment opportunities are provided through the allocation of land for, commercial, tourist, light industrial uses, and other uses. The revised ODP also acknowledges that employment follows residential expansion. Employment opportunities will be progressively

provided via the following land uses shown on the revised ODP - neighbourhood shopping centres, mixed business and service industry (Mixed Business Lots), a school, community facilities, medical centres and three tourist sites.

The proposed Mixed Business Lots are a specific component of the revised ODP, introduced to stimulate early development of small business.

The anticipated employment opportunities within the revised ODP area, at ultimate development, are shown on the following table:

Table 3 Estimated Employment Opportunities in Revised ODP Area

	Activity	Estimated Employees / ha or Employment Estimate	Total Area (ha)	Employment Opportunities
Retail	Neighbourhood Commercial	30 / ha	5.3	159
	Mixed Business Areas	5 / ha	22.9	114
	Primary School	30 / school	4.7	30
	Community Facilities	15 / ha	1.2	18
Tourist	Tourism	5 / ha	30.4	152
	Caravan Park	5 / ha	6	30
			TOTAL	503

*Please note that the figures above exclude construction workers.

10.2 Staging

A Staging Plan is included, which shows the future development of the revised ODP area split into 6 distinct stages. It is anticipated that each stage will be developed within a 3-5 year timeframe.

The State Cabinet acknowledges that the existing Urban Development zone that had been in place since 1995 and that this zoning, subject to a reduction in the scale of the development, will provide the township of Guilderton and surrounding rural estates with a primary school, shopping and community facilities, and servicing infrastructure, which will result in the creation of a sustainable community catering for a population of up to 5,000 residents.

The revised ODP includes within the first stage of development, a neighbourhood centre, primary school, a community facilities site and a caravan park. The first stage (1A) of development is also linked to stage 1B on the western extremity of the revised ODP area at the point of entry. This will allow some light service (Mixed Business lots) industry and residential display homes to be incorporated within the first stage of development. A FMP plan is required to be prepared and approved prior to the first stage of subdivision approval. Key infrastructure provision will also be required to be provided as part of the first stage.

Staging the development is entirely dependent on economic conditions and so can only be taken as indicative at this point in the approval process. **Figure 11** on the overleaf is a Staging Plan for the revised ODP area.

MOORE RIVER

CROWN RESERVE
(Recreation and Landscape Protection Reserve)

Moore River Foreshore Reserve
To be ceded to the State and subject to a Foreshore Management Plan

20m wide road reserve and possible river crossing subject to detailed design of alignment and Developer Contribution Plan by Shire

Coastal development setback.

HOLIDAY RESORT
Cabins
Conference Facilities
Resort
Accommodation and Facilities

CARAVAN PARK
Chalets, Tents, Caravans and short stay / Overnight Accommodation.
General Store

PRIMARY SCHOOL

Alternate emergency egress road.

Development of this area is subject to a Fire Management Plan and/or redesign to address exposure to fire risk from the adjoining vegetated land to the north.

TOURIST RESORT

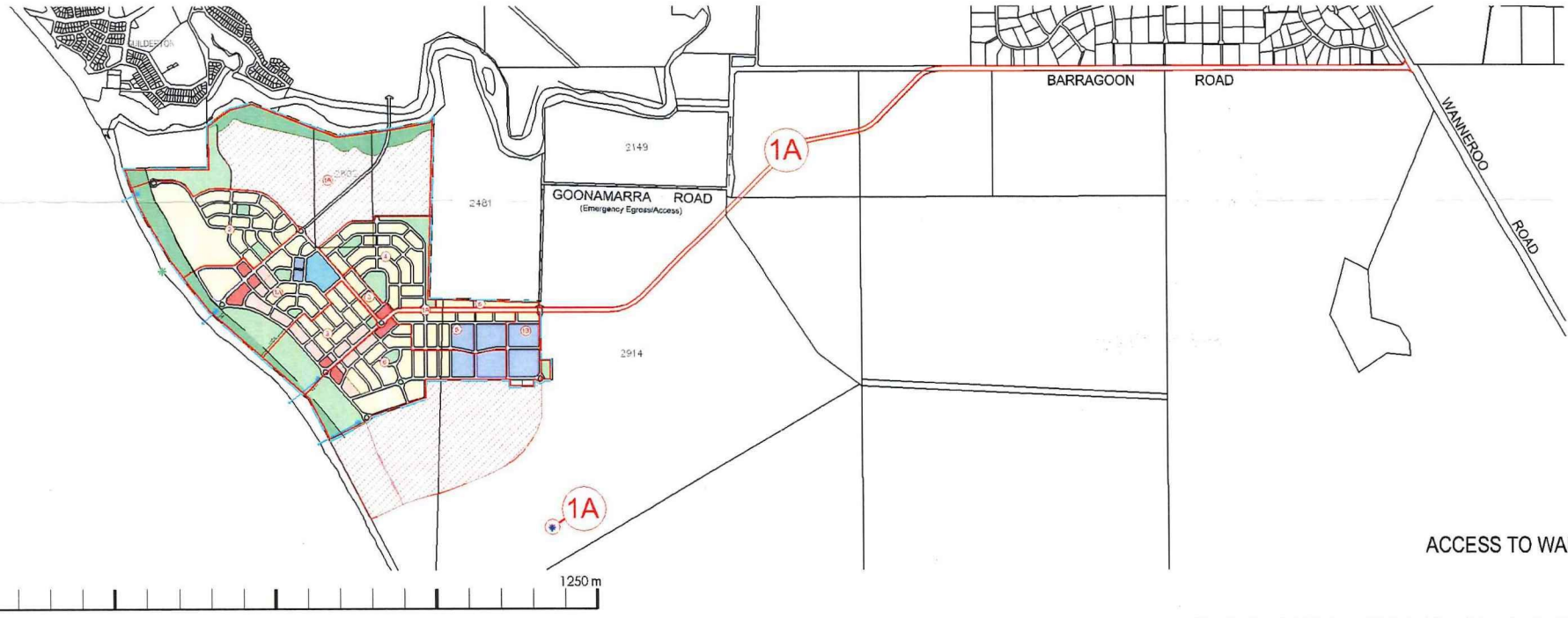
Southern interface of ODP area with Future Development Zone to be addressed at subdivision stage.

1A 1B 2 3 4 5 6

LEGEND

ZONES
- RESIDENTIAL LOW DENSITY R20
- RESIDENTIAL MEDIUM DENSITY R40
- TOWN CENTRE
- TOURISM
- MIXED BUSINESS R5
- FUTURE DEVELOPMENT ZONE
  SUBJECT TO FUTURE STRUCTURE PLANNING

RESERVES
- PUBLIC USE PRIMARY SCHOOL
- PUBLIC USE COMMUNITY FACILITIES
- PARKS AND RECREATION
  PUBLIC OPEN SPACE
- PARKS AND RECREATION
  FORESHORE RESERVE
- COUNCIL DEPOT
- EMERGENCY SERVICES
- ODP BOUNDARY
- STAGING BOUNDARY
- COASTAL DEVELOPMENT SETBACK
- POSSIBLE BOAT LAUNCH FACILITY
- POTENTIAL SEWERAGE TREATMENT PLANT SITE
  (Indicative Only)
- STRATEGIC BEACH ACCESS



ACCESS TO WANNEROO ROAD

FIGURE 11

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STAGING PLAN (INDICATIVE)
MOORE RIVER SOUTH OUTLINE DEVELOPMENT PLAN
MOORE RIVER SOUTH, SHIRE OF GINGIN

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SHIRE OF GINGIN
PROJECT-PHASE-PLAN NUMBER REVISION
P7026 CON 006 A

11 Changing Role of Guilderton

Guilderton was first developed in the 1940's when farmers from the broader Gingin hinterland constructed beach shacks for holiday use. The land released for housing development is Crown Land administered by the Department of Land Administration (DOLA). DOLA progressively created and released residential lots until approximately 1984 when waste from residential septic tanks was found in the Moore River. The Water Corporation advised DOLA (which was clearing future road reserves between the townsite and lighthouse for a new land release at that time) that all future land development must be deep sewered. DOLA abandoned its subdivision plans and has not created any further lots for the past fifteen years.

Over the past twenty years or more, Perth residents have acquired most of the existing properties for holiday purposes. As at the 1996 Census, conducted in August, there were 411 houses and a permanent population of 178 people in Guilderton. At the same time (1996) Woodridge had a population of 485 people and 205 dwellings. Google Earth Aerial Photography as at 5 September 2006 details approximately 312 houses in Guilderton and according to the 2006 Census, a permanent population of 93 people. At the same time (2006) Woodridge had a population of 565 people and 193 dwellings.

Local real estate agents confirm that one significant reason for (older) permanent residents selling their properties is that they require proximity to health facilities which are not available in Guilderton. The small permanent population would not warrant the provision of such facilities.

11.1 Shire Intentions for Guilderton

The land surrounding the Guilderton townsite is owned by only two institutional owners – DOLA and the Catholic Church. Both appear to have no immediate plans for the area.

The Shire of Gingin identified land suitable for urban development in the Guilderton area in its (1992) Development Strategy and Structure Plan for the Gingin Coastal and Structure Plan for the Gingin Coastal Region. At that time the development option adopted by Council was for Guilderton to become a town of 30,000 people – with 15,000 residents each on both sides of the river.

More recently, in 2003, the Shire prepared a draft Local Planning Strategy, which also recognises that the then Urban Development zoning of the revised Outline Development Plan (ODP) area, in the medium to long-term, is anticipated to provide for a resident population of some 13,500 persons. However, the Strategy states that prior to actual urban development occurring on the south side of the Moore River, there will be a need for further detailed planning, and in particular some key issues including coastal management, river management and integration with the existing Guilderton townsite, will need to be addressed.

Under the provisions of LPS9, the revised ODP area is zoned Future Development. The purpose of the Future Development zone is to ensure that subdivision and development of land should only take place after the completion of a comprehensive Structure Plan.

11.2 Western Australian Planning Commission Intentions for Guilderton

The announcement by the Minister for Planning of the support of State Cabinet for development at Moore River in a manner that that will provide the township of Guilderton and surrounding rural estates with a primary school, shopping and community facilities catering for a population of up to 5,000 residents followed consultation with the Western Australian Planning Commission (WAPC).

Pre-lodgement consultation with relevant Government Agencies has been facilitated by the WAPC / Department of Planning.

11.3 Existing Guilderton Townsite

The future of the existing Guilderton townsite will essentially be guided by the two major landowners, together with the WAPC and the Shire of Gingin. The Moore River Company has no direct involvement in the direction or extent of urban growth. The role of Guilderton however, will change over the next decade or two for a variety of reasons.

Over the past twenty years or more, Guilderton has become an attractive holiday home location for residents of Perth. Being the first 'coastal' settlement north of the Perth metropolitan area, and more significantly, only an hour away from the CBD, it is perceived by the holiday home market as a very attractive and convenient location. Most certainly, it will continue to be a desirable holiday home or retirement home location in the short, mid and long term. In the midterm, as more social, community, recreational, education and commercial facilities are provided, it will become more attractive to permanent residents. The employment opportunities created by the increasing facilities and services, together with the provision of retail, mixed business, local industry and local tourism opportunities, will further attract permanent residents.

Section 10.1 Population and Growth, addresses demographic characteristics and anticipated growth rates. These projections envisage a thirty year time frame and population characteristics similar to those of Mandurah at the present time i.e. a mix of permanent residents (comprising families and retirees) and weekenders/holiday makers/tourists. The actual rate of change of resident mix over the next thirty years is difficult to predict. It is likely that the introduction of a primary school will be the most significant factor influencing young families to reside in the area.

11.4 Accessibility of Facilities in Revised Outline Development Plan Area

The State Cabinet, when acknowledging the Urban Development zone of the site and considering a reduced proposal, acknowledged the opportunity to provide the township of Guilderton and surrounding rural estates with a primary school, shopping and community facilities, and servicing facilities.

As a direct response to these criteria the revised ODP has been designed to incorporate a neighbourhood centre, primary school, community facilities and a caravan park within the first stage of development.

The Woodridge community will have convenient direct access to these facilities by way of a 5 km car trip. The Guilderton community will have little requirement for the early shopping/café/restaurant/fuel supply facilities as these are all available in the townsite presently.

Access from Guilderton to the possible boat launching facility and later school and health facilities will be via Indian Ocean Drive unless it is considered feasible to construct a bridge across the Moore River. The location of this bridge (and its funding and timing of construction) will be considered in more detail at the later planning stages of development.

11.5 Existing Social and Community Infrastructure (Guilderton and Woodridge)

The Guilderton townsite comprises of approximately 312 dwellings (Obtained from Google Earth Aerial Photography as at 5 September 2006), of which approximately 20% are occupied by permanent residents. Facilities and services presently available to residents (and visitors) include:

- Combined service station/newsagent;
- Take away food outlet;
- Small supermarket near the golf course;
- Supermarket; and
- Delicatessen, restaurant and café near the river mouth.

Although Woodridge has a permanent population approximating 565 persons, the Shire of Gingin has been reluctant to formalise this mature rural residential estate as a townsite. As such, facilities are restricted to a community hall, tennis/netball courts and a child care centre.

There are no full time medical or health care services, nor any other professional or educational services or facilities in either Guilderton or Woodridge, with the exception of occasional services offered by local residents. All residents are required to go east to Gingin or south to Two Rocks, Wanneroo or Joondalup for basic services such as general shopping, education, medical and health care.

According to the Public Transport Authority of Western Australia, approximately 80 children from Woodridge and Guilderton currently travel to Gingin daily for their schooling. The Education Department acknowledges that those student numbers almost generate the need for a local school presently. The revised ODP is considered to be the ideal location for the new school site (particularly the Primary School located near the first development node).

The revised ODP area is located 4 km west of Woodridge and is directly accessible via Barragoon Road and the proposed arterial entry road. The Guilderton townsite is on the opposite side of the Moore River, and is approximately 20 kms by car to the site.

11.6 Revised Outline Development Plan Site – Social and Community Infrastructure Provision

The revised ODP site is 346 hectares in area and is planned to ultimately accommodate 5000 people in approximately 2000 dwellings. The following social and community facility sites are proposed for the area, generally in accordance with the revised ODP plan.

- Primary School
- Public Use Community Facilities:
  - Medical Centre; and
  - Community Centre.
- Playgrounds, playing facilities, coastal parks and facilities.

These facilities will be available to the revised ODP area residents and Guilderton and Woodridge residents alike. The delivery of these facilities relates directly to the timing of development. The Staging Plan (**Figure 11** - Section 10.3) identifies six likely phases of development.

The provision of health and medical services will evolve over the early years of development. It is anticipated that over the first five years of development, doctors, dentists, chiropractors and

physiotherapists, in particular, will locate in residences – similar to their location in the metropolitan area. It is likely that after the first five years growth, those activities and facilities will be formalised in professional suites or medical centres. The introduction of these services relates to (i) the population in the Guilderton/Woodridge/Moore River South catchment and (ii) the attractiveness of the area as a permanent residential location and (iii) accessibility to the area for part-time servicing.

Moore River Company is confident that the area's idyllic setting and accessibility will attract residents and visitors in suitable numbers to allow the smooth progressive development of the site. It is envisaged that at the commencement of the project arrangements will be made for the provision of basic social/community/recreational infrastructure up-front to ensure new residents, be they permanent or part time, will be more comfortable.

Assuming a suitable lot sales (and house construction) rate and considering the number of new permanent residents, the next range of facilities desired would include bank (ATM), access to some level of health and medical services, improved general store, community centre and (interim) primary school.

Moore River Company has committed to the provision of suitable floor space (both interim and long term) and other measures to provide incentives and facilitate the early availability of basic retail, medical, dental and childcare services to the community.

12 Infrastructure Contributions

As part of the development of the revised Outline Development Plan (ODP) area the proponent will provide a range of services and facilities for the community and visitors to the locality. A matrix of community facilities and infrastructure provision and contributions Plan has been agreed between the proponent and the Shire and are proposed to be subject of a voluntary agreement prepared in accordance with Planning Policy Statement No 8. (refer Section 9). The commitments will be provided either as part of the development of the site, the implementation of the Foreshore Management Plans for the foreshore abutting the site or in addition to these matters.

Commitments

1. Provide a new coastal promenade and provide parking bays, viewing areas, lighting, beach access and landscape improvements in this area
2. Provide a new primary school site in the first stage of development.
3. Installation of state of the art water and sewerage infrastructure, accompanied by mandatory requirements for water reuse and water and energy efficient appliances in all dwellings.
4. Cede a community purposes site comprising approximately 1.3ha in the first stage of development.
5. Ceding of an expansive network of new coastal and river foreshore reserves as shown on the ODP map.
6. Contribute to local FESA facilities and support creation of a new or enlarged local bush fire brigade.
7. Sponsor/subsidise a new local store, community meeting space and floorspace for visiting medical and dental services in the first stage of development.
8. Contribute to a boat launch facility on the basis that the funding, design and ongoing management issues can be resolved to the satisfaction of all stakeholders.
9. Assist the creation of a small business incubator to facilitate early introduction of employment generating activities in the ODP area and at Guilderton.
10. Contribute to a tourism promotion campaign for the region and the locality.
11. Management and maintenance of all new open spaces for a period of 3 years.
12. Provision of low key active and passive recreation facilities (including play equipment, seating, barbecues, public art and similar facilities) and landscaping/embellishment of selected Public Open Spaces.
13. Landscaping and rehabilitation of foreshore areas in accordance with approved Foreshore Management Plans.
14. Provision of a pedestrian trail network throughout the development.

15. Contribute proportionately to the funding of a pedestrian bridge connecting to Guilderton on the basis that the funding, design, ongoing management and other relevant issues can be resolved to the satisfaction of all stakeholders.

16. Development of a minimum 250m² multipurpose community purposes facility for management under a peppercorn lease by a community based management committee, including provision of temporary floorspace in first stage of development pending completion of the purpose built facility.

17. Upgrading of Indian Ocean Drive, intersections and connector roads to Moore River.

18. Ceding of approximately 86.9ha of land for Public Open Space and new coastal and river foreshore reserves, equivalent to 25.1 percent of the ODP area.

19. Contribution to provision and/or augmentation of district community facilities by the Shire (for example: district library, sporting complexes and the like) and required as a consequence of the development.

20. Contribute to the employment of a Community Development Officer by the Shire for the first 5 years of the development program

The above list is a broad outline of the scope of the proponent's commitments. The detail, quantification, staging and tenure details of each commitment will be addressed in later documentation between the Shire and proponent.

Moore River South

Revised Outline Development Plan

Cardno
Shaping the Future

Prepared for Moore River Company Pty Ltd
October 2011
Job Number P7026

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Executive Summary

The Moore River South revised Outline Development Plan (ODP) has been prepared by Cardno (WA) Pty Ltd (Cardno), on behalf of the Moore River Company, as a revision to the Outline Development Plan prepared by Masterplan Consultants W.A. Pty Ltd (Masterplan) and approved by the Western Australian Planning Commission in January 2000.

The revised ODP has been prepared in response to the acknowledgement by State Cabinet that the existing Urban Development zone within the Shire of Gingin Town Planning Scheme No. 8 has been in place since 1995 and that this zoning, subject to a reduction in the scale of the development, will provide the township of Guilderton and surrounding rural estates with a primary school, shopping and community facilities, and servicing infrastructure, which will result in the creation of a sustainable community catering for a population of up to 5,000 residents.

The Minister for Planning required that development under the revised ODP be in accordance with State Government environmental regulations and prepared such as to allow the Shire of Gingin to finalise Town Planning Scheme No. 9 and update it's draft Local Planning Strategy, which have been held in abeyance since 2006.

The Minister also acknowledged that the Shire of Gingin and the Department of Planning will work closely with the Moore River Company to progress the revised ODP, which will be publicly advertised through the Shire's statutory process. Whilst the revised ODP will have to undergo the required public consultation process the Minister has emphasised the issue of whether the land should be developed or not is no longer open to debate and that the Government supports development in this area.

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1 Introduction and Objectives

1.1 Introduction

The proposed Moore River South revised Outline Development Plan (ODP) has been prepared by Cardno (WA) Pty Ltd (Cardno), on behalf of the Moore River Development Company, as a revision to the Outline Development Plan prepared by Masterplan Consultants W.A. Pty Ltd (Masterplan) and approved by the Western Australian Planning Commission (WAPC) in January 2000.

The revised ODP has been prepared in response to the acknowledgement by State Cabinet that the existing Urban Development zone within the Shire of Gingin Town Planning Scheme No. 8 has been in place since 1995 and that this zoning, subject to a reduction in the scale of the development, will provide the township of Guilderton and surrounding rural estates with a primary school, shopping and community facilities, and servicing infrastructure, which will result in the creation of a sustainable community catering for a population of up to 5,000 residents.

The revised ODP has been reduced by approximately 211ha from 557ha covered by the currently endorsed ODP to 346ha. It includes the addition of several supporting technical studies that have been required as a result of changing legislation, with the recommendations of these reports informing the revised design.

In summary, the main changes to the revised ODP include:

- Significantly reduced scale of development;
- Significantly increased setbacks from the Indian Ocean to allow for:
    - The physical processes setback (PPS) identified in the updated Coastal Assessment report (**Appendix I**);
    - Retention of the sites natural topography, particularly in relation to the coastal dunal system;
    - Acknowledgement and preservation of natural drainage areas; and
    - Retention of important flora and vegetation communities.
- Exclusion of land uses adjacent to Moore River, specifically the proposed tourist resort;
- Generous allocation of public open space to ensure retention of remnant vegetation;
- Protection of key physical environmental attributes;
- Increased road widths to maximise the opportunity for capture of drainage at source; and
- Creation of an extensive area of foreshore reserve to be ceded free of cost to the Shire of Gingin and/or the State for the purpose of recreation and conservation.

1.2 Objectives of Revised Outline Development Plan

The key objectives of the revised ODP are to:-

- Provide a significantly reduced scale of development;
- Provide the township of Guilderton and surrounding rural estates with a primary school site, shopping and community facilities, and servicing infrastructure, which will result in the creation of a sustainable community catering for a population of up to 5,000 residents;
- Provide an adequate physical process setback from the coast to safeguard future development from coastal processes.
- Protect the Moore River from development through the provision of new foreshore reserves;
- Ensure the impacts of climate change are adequately considered;
- Provide extensive additional areas of foreshore reserve and adequate public open space;
- Retain, where possible, the natural topography of the subject site;
- Ensure the visual impact of the development from Guilderton is minimised;

- Concentrate development on areas that have been substantially cleared / degraded in the past;
- Retain remnant vegetation (including “Excellent” and “Pristine-Excellent” condition vegetation and Priority Flora populations), habitat trees and wildlife corridors;
- Minimise the disturbance of key physical environmental attributes;
- Prepare a Local Water Management Strategy with the emphasis on water sensitive urban design;
- Provide state of the art wastewater and water re-use technologies and demonstrate viable options for the management of these systems;
- Provide for a variety of housing densities and lot layouts;
- Cater for the tourist demands of the region both now and in the future;
- Encourage a less transient more permanent population in the longer term through the provision of locally based employment;
- Provide managed public access to and along the coast;
- Create a permeable road and pedestrian system;
- Encourage modes of transport other than the private car;
- Maximise road widths to encourage drainage within the road reserves;
- Prepare a framework for sustainable development; and
- Generally reflect a more sympathetic response to site attributes within a contemporary design response.

1.3 Site Location and Description

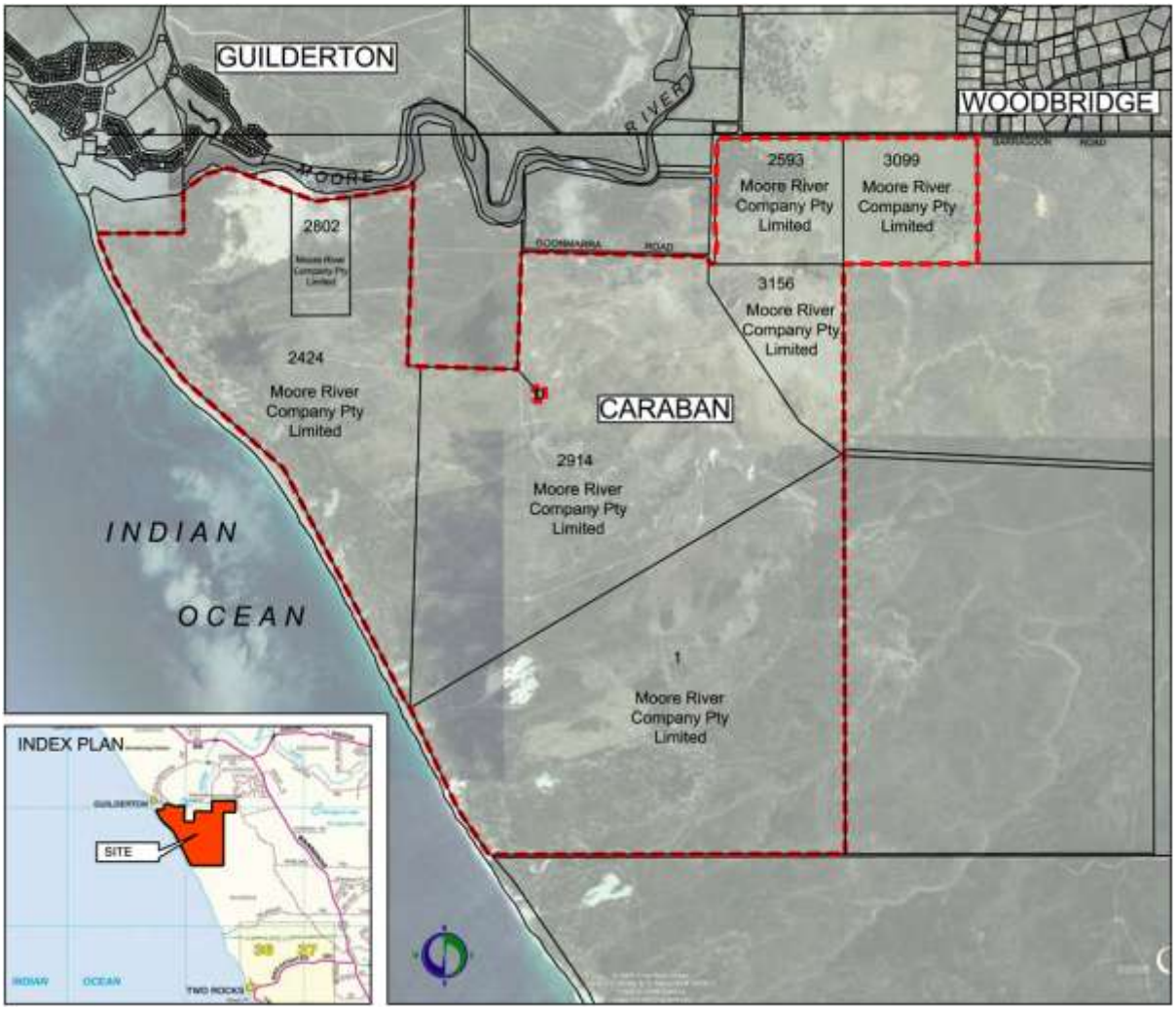
The revised ODP area is located on the south side of the Moore River, opposite the Guilderton townsite, and is located approximately 75 kilometres north of the Perth Central Business District. The revised ODP area is part of the Moore River Company's 2000 hectare property which has direct frontage and access to Barragoon Road and is connected to Wanneroo Road via Link Road and King Drive, Woodridge.

The revised ODP area rises steeply from the Indian Ocean, with a coastal dunal system attaining heights of 10m Australian Height Datum (AHD) and up to 30m AHD further inland. The site rises steeply from Moore River up to a dune crest along the shore which is up to 50m AHD.

The revised ODP area comprises Swan Location 2802 and portions of Swan Locations 2424 and 2914 as shown on Figure 1 - Land Ownership Plan. There is a frontage of approximately 2.6 kms to the Indian Ocean. The site is separated from the rivermouth of the Moore River by a Crown Reserve No. 17949 (Loc. 3049), comprising of 19 hectares. The south eastern boundary of the revised ODP area accords with the Amendment No. 22 boundary and is subject to survey.

The Moore River Company's property has for many years and continues to be used for farming and grazing purposes and, as a result, much of the land has been cleared and converted to pasture.

Figure 1 - *Land Ownership Plan*



1.4 Planning History

The subject site has undergone extensive planning over the last 15 years, from the initial rezoning of the land in 1995 to allow for urban development to the lodgement of this current revised ODP in 2010.

1.4.1 Amendment No. 22 (1995)

On March 3 1995, 557 hectares of the Moore River Company land was rezoned from 'Rural' to 'Urban Development' under the Shire of Gingin Town Planning Scheme No. 8 (TPS8) (refer **Figure** 3). The purpose and intent of this zone was to ensure that the district will derive the maximum possible benefit from the design, layout and provision of works and services for urban development. Council requires the preparation of an ODP prior to supporting or approving any proposal for subdivision or development of the land. The numerous issues to be addressed in the revised ODP are articulated in Clause 5.5.1 of Town Planning Scheme No. 8.

1.4.2 Outline Development Plan (2000)

An Outline Development Plan was prepared on behalf of the Moore River Company by Masterplan Consultants, and was adopted by the Western Australian Planning Commission (WAPC) on 17

January 2000. The 2000 ODP incorporated the whole 557 ha of the Urban Development zone with an envisaged ultimate population of 13,500 residents in 5,269 dwellings.

The approved 2000 ODP included: six residential precincts; two primary schools and one high school; community facilities; a district hospital site; three medical centres; three tourist sites; and commercial centres, including a district centre, neighbourhood centres and local shops.

1.4.3 Subdivision Application (2003)

On 27 October 2003 an application for subdivision was submitted to the WAPC by Masterplan Town Planning Consultants (Masterplan) for approval of 661 residential lots, 8 areas of public open space, a central retail area and roads, generally in accordance Stage 1 of the 2000 approved ODP. On 21 September 2004 the WAPC refused the subdivision application on the basis that the proposal was contrary to the current strategic planning for the Gingin coast area and the then State Governments expectations for the area.

The Moore River Company sought a review of the decision in the Town Planning Appeal Tribunal in November 2004 the then Minister for Planning and Infrastructure 'called in' the appeal and instructed the Tribunal to make a recommendation on the matter to hand. Following a hearing the Tribunal reached the view that it should recommend against approval. The matter remained in dispute until the recent decision of State Cabinet which gave rise to the preparation of the revised ODP.

1.5 Regional Setting

The Department of Planning and the Shire of Gingin have undertaken various studies which considered the future of the Guilderton/Moore River area in the context of its regional setting. The revised ODP area is located on the south side of the Moore River opposite the Guilderton townsite and will be the first settlement located north of the metropolitan region as identified on the Metropolitan Region Scheme. Its locational characteristics, relative to Perth, are not dissimilar to those of Mandurah in the south - as can be seen on **Figure 2** - Regional Location. Descriptions of the various regional studies and strategies prepared by the Department of Planning and the Shire of Gingin are found in Section 2.0 - Planning Context.

Figure 2 - *Regional Context Plan*



2 Planning Context

2.1 Department of Planning / Western Australian Planning Commission

The Department of Planning (DoP) is the State planning authority and is concerned with all regional planning matters. In this instance, the DoP will make a recommendation to the Western Australian Planning Commission (WAPC) on the endorsement of this revised Outline Development Plan (ODP), but only after the matter has been advertised for public comment and the Shire of Gingin has made its own recommendation as to whether the revised ODP ought to be endorsed and any conditions that should be affected to that endorsement.

2.1.1 State Planning Strategy

The WAPC prepared and adopted the State Planning Strategy in 1997. The Strategy provides the overall vision of the State and will be further articulated and applied by policies and plans dealing with particular planning issues or regions of the State.

The State Planning Strategy states that the primary aim of planning is to provide for the sustainable use and development of land. The Strategy identifies the five key principles (Environment; Community; Economy; Infrastructure and Regional Development), which further define this primary aim and describe the considerations which influence good decision-making in land use planning and development.

The State Planning Strategy aims to guide the sustainable development of Western Australia to 2029. In accordance with the principles of the Strategy the revised ODP has been designed to incorporate sustainable design principles as considered further in Section 4.12 of this report

2.1.2 Statements of Planning Policy

2.1.2.1 State Planning Policy 1 - State Planning Framework

The State Planning Framework unites existing State and regional policies, strategies and guidelines within a central framework which provides a context for decision-making on land use and development in Western Australia. It also restates and expands upon the key principles of the State Planning Strategy in planning for sustainable land use and development.

The policy was initially gazetted on 22 December 1998 as Statement of Planning Policy No. 8. Subsequently, a variation to the policy, Statement of Planning Policy No 1 (Variation No 1) State Planning Framework Policy, was gazetted on 30 May 2000.

The Statement of Planning Policy has now been further updated to include additional regional strategies, regional and sub-regional structure plans, strategic policies and operational policies that have been endorsed by the WAPC since May 2000. This Statement of Planning Policy, which does not introduce new policies but simply brings together existing policies, strategies and plans approved by the WAPC, will continue to assist local governments in preparing schemes and will also clarify the State and regional policies that apply to a particular locality.

2.1.2.2 Statement of Planning Policy No. 2.6 – State Coastal Planning Policy

This policy, prepared in 2003 and updated in 2006, addresses land use planning and development issues specifically as they relate to the protection and management of the coast. The policy requires

strategic plans to guide local planning, development setbacks for protection against coastal processes such as erosion and storms, and the provision of coastal foreshore reserves.

Guidance is provided on determining coastal setbacks. The preparation of coastal planning strategies or coastal foreshore management plans in partnership with the broader community is also strongly advocated.

The policy provides high order guidance for decision-making on coastal planning matters and applies statewide. Implementation will be through local government town planning schemes, and regional and local strategies.

The objectives of this policy are to:

- Protect, conserve and enhance coastal values, particularly in areas of landscape, nature conservation, indigenous and cultural significance;
- Provide for public foreshore areas and access to these on the coast;
- Ensure the identification of appropriate areas for the sustainable use of the coast for housing, tourism, recreation, ocean access, maritime industry, commercial and other activities; and
- Ensure that the location of coastal facilities and development takes into account coastal processes including erosion, accretion, storm surge, tides, wave conditions, sea level change and biophysical criteria.

To comply with the provisions of SPP 2.6 the Moore River Development Company have engaged M P Rogers and Associates to provide a Coastal Setback Assessment as part of the original ODP. As part of the revised ODP M P Rogers have again been engaged to provide an updated Coastal Setback Assessment, which is included as **Appendix I**. The report concludes that the coastal dunal system at the development frontage are stable and accordingly recommends a physical processes setback of between 75 and 105m, which is incorporated, as a minimum, within the revised ODP design.

2.1.2.3 Statement of Planning Policy No. 3 – Urban Growth and Settlement

This policy sets out the principles and considerations which apply to planning for urban growth and settlements in Western Australia. The objectives of this policy are:

- To promote a sustainable and well planned pattern of settlement across the State, with sufficient and suitable land to provide for a wide variety of housing, employment, recreation facilities and open space.
- To build on existing communities with established local and regional economies, concentrate investment in the improvement of services and infrastructure and enhance the quality of life in those communities.
- To manage the growth and development of urban areas in response to the social and economic needs of the community and in recognition of relevant climatic, environmental, heritage and community values and constraints.
- To promote the development of a sustainable and liveable neighbourhood form which reduces energy, water and travel demand while ensuring safe and convenient access to employment and services by all modes, provides choice and affordability of housing and creates an identifiable sense of place for each community.
- To coordinate new development with the efficient, economic and timely provision of infrastructure and services.

Achieving sustainable forms of development is key to this policy and central to the planning system in Western Australia. It is the intention of the revised ODP to create a sustainable community and place to live that provides for an appropriately high level of local employment and economic growth, and to

create a strong, vibrant and socially inclusive community, whilst preserving the coastal and estuarine environments of the locality.

2.1.2.4 Statement of Planning Policy 3.1 - Residential Design Codes (Variation 1)

The purpose of the Residential Design Codes (R-Codes) is to provide a comprehensive basis for the control, through local government, of residential development throughout Western Australia. They are intended to cover all requirements for planning control purposes and to minimise the need for councils to introduce separate planning policies or variations to these matters.

The main objectives of the R-Codes are:

- To provide for a full range of housing types and densities that meet the needs of all people;
- To provide for local variations in neighbourhood character;
- To ensure appropriate standards of amenity for all dwellings;
- To protect the amenity of adjoining residential properties; and,
- To encourage environmentally sensitive design.

Whilst the R-Codes are generally used during the later stages of the planning process in the assessment and determination of applications for residential development the density controls set out in the policy are relevant in the consideration of the design of the revised Outline Development Plan.

The R-Codes set out a range of density codes from low density R2 (with a minimum site area of 5000m²) to high density R160 with a minimum site area of 62.5m². In accordance with the objectives of this policy and the objectives of Liveable Neighbourhoods to provide for a range of housing types and densities the revised ODP proposes a mix of residential density codes from R20 (500m² average) to R40 (220m² average).

2.1.2.5 Draft Statement of Planning Policy No. 3.6 – Development Contributions for Infrastructure

This draft policy sets out the principles and considerations that apply to development contributions for the provision of infrastructure in new and established urban areas, and the form, content and process to be followed.

In summary, the objectives of this draft policy are:

- To promote the efficient provision of public infrastructure and facilities to meet the demands arising from new growth and development;
- To ensure that development contributions are necessary and relevant to the development to be permitted and are charged equitably among those benefiting from the infrastructure and facilities to be provided; and
- To ensure consistency and transparency in the system for apportioning, collecting and spending development contributions.

In the absence of relevant provisions within the Shire of Gingin TPS8, this policy sets out the format for developer contributions and provides a template for the form, content and process to be followed in the provision of infrastructure contributions for new development. Developer contributions are considered in Section 12 of this report.

2.1.3 Regional Strategies

Regional Strategies cover a region or sub-region and interpret the Sate Planning Strategy at that level, providing a basis for cooperative action to be taken by State and local government on land use and development.

2.1.3.1 Central Coast Regional Strategy

The Central Coast Regional Strategy was endorsed by the WAPC in June 1994. The strategy addresses the future of the coastal area between Wilbinga (south of Moore River and immediately north of the Metropolitan Region Scheme boundary) and Dongara in the north. The strategy identifies urban growth areas and conservation areas, amongst other things. The WAPC has identified the subject site as an urban growth area of major local centre status. The revised ODP area, which is zoned 'Urban Development, is consistent with this regional strategy.

2.1.4 Regional and Sub-regional Structure Plans

Regional and sub-regional structure plans provide for the comprehensive planning of regions, sub-regions or particular locations to guide change in the short to medium term.

2.1.4.1 Development Strategy and Structure Plan for the Gingin Coastal Region (Shire of Gingin 1992)

This Development Strategy and Structure Plan were prepared in 1992 to determine a direction for growth for the coastal region of the Shire of Gingin which stretches from the northern boundary of the Metropolitan Region Scheme for 70 kms to the Lancelin Naval Firing Range. This coastal strip comprises four main settlements, being Guilderton, Seabird, Ledge Point and Lancelin. The purpose of the study was to review the region's past and existing characteristics, examine key issues and trends and evaluate alternative planning strategies for future development. The four main issues addressed in this study were as follows:

1. Rapid northward direction of metropolitan region. The report states, in its executive summary, that "these processes are likely to increase pressures for large-scale urban development in the Coastal Region."
2. The economic potential of the region, particularly for tourism and emerging horticultural development.
3. The perceived threat to the fishing industry and quality of life in the four nominated towns from the pressures for urban and industrial development.
4. The capability of the region's coastal environment to accommodate development.

The development strategy adopted by the Gingin Shire Council earmarks Guilderton as a town of approximately 30,000 people with approximately 15,000 residents north of the river and 15,000 residents south of the river. The revised ODP area comprises 346 ha and will accommodate approximately 5,000 residents, and is therefore consistent with Council's Coastal Region Structure Plan.

2.1.4.2 North West Corridor Structure Plan

The North West Corridor Structure Plan was endorsed by the Minister for Planning in 1994 and established a growth framework for land north of Hepburn Avenue and extending to the northern boundary of the Metropolitan Region Scheme (approximately 4 kms north of the Two Rocks townsite). The significance of the Structure Plan to this project is that the Minister had determined there will be a large open space between the Metropolitan Area and the Moore River Company's land holding. This green area is generally known as Wilbinga Open Space and is approximately 8000 hectares in area or twenty times larger than Kings Park. In general terms, Wilbinga measures approximately 10 kms east-west by 8 kms north-south. This open space is consistent with the conservation strategy determined in the Central Coast Regional Strategy.

2.1.4.3 Gingin Coast Structure Plan

In December 2003 the Minister for Planning approved the WAPC's release of the draft Gingin Coast Structure Plan. The public submissions received during the advertising period were collated and the responses evaluated by the Department of Planning in consultation with the community advisory group and steering committee. A key change to the structure plan following advertising related to the proposed change of land use of the area to the south of Moore River, being the site of this revised ODP.

The Gingin Coast Structure Plan designates the area south of Moore River as a 'Recreational and Tourist Node Investigation Area'. The structure plan report states that this type of settlement will be in response to the demand for tourist/visitor accommodation driven by tourist attractions and/or recreation-based activities in the locality and will be subject to planning, infrastructure, environmental and social considerations.

The Gingin Coast Structure Plan is a non-statutory document not endorsed by the Shire of Gingin and components of which, involving Moore River, do not have the support of the State Government.

The recommendations of the Gingin Coast Structure Plan in relation to the use of land south of Moore River as a Recreational and Tourist Node Investigation Area are contrary to the provisions of TPS8, the statutory land use planning control for the Shire, as well as the draft Town Planning Scheme No. 9 (TPS9) and the draft Local Planning Strategy. The revised ODP has been designed to reflect the current TPS8 and proposed TPS9 'Urban Development' zoning of the land.

2.1.5 Strategic Policies

Strategic policy statements deal with particular strategic planning issues, and in some cases refine and expand upon aspects of a regional strategy. Of particular relevance to the revised ODP is the WAPC's Liveable Neighbourhoods policy document.

2.1.5.1 Liveable Neighbourhoods

Liveable Neighbourhoods is a strategic operational policy for the design and assessment of structure plans (region, district and local) and subdivision for new urban (predominantly residential) areas in the metropolitan area and country centres.

In general, Liveable Neighbourhoods replaces the current WAPC development control policies. Where there is conflict with existing policies, Liveable Neighbourhoods will prevail unless it can be demonstrated why it cannot or should not apply.

Liveable Neighbourhoods has been prepared to implement the objectives of the State Planning Strategy which aims to guide the sustainable development of Western Australia to 2029.

In summary, the 12 principal aims of Liveable Neighbourhoods are:

1. To provide for an urban structure of walkable neighbourhoods, clustering to form towns of compatible mixed uses in order to reduce car dependence for access to employment, retail and community facilities;
2. To ensure that walkable neighbourhoods and access to services and facilities are designed for all users, including those with disabilities;
3. To foster a sense of community and strong local identity and sense of place in neighbourhoods and towns;
4. To provide for access generally by way of an interconnected network of streets which facilitate safe, efficient and pleasant walking, cycling and driving;

5. To ensure active street-land use interfaces, with building frontages to streets to improve personal safety through increased surveillance and activity;
6. To facilitate new development which supports the efficiency of public transport systems where available, and provides safe, direct access to the system for residents;
7. To facilitate mixed use urban development which provides for a wide range of living, employment and leisure opportunities, capable of adapting over time as the community changes and which reflects appropriate community standards of health, safety and amenity;
8. To provide a variety of lot sizes and housing types to cater for the diverse housing needs of the community at a density that can ultimately support the provision of local services;
9. To ensure the avoidance of key environmental areas and the incorporation of significant cultural and environmental features of a site into the design of an area;
10. To provide for a more integrated approach to the design of open space and urban water management;
11. To ensure cost-effective and resource-efficient development to promote affordable housing; and
12. To maximise land efficiency wherever possible.

The revised ODP has been designed in accordance with the principles of Liveable Neighbourhoods, which are fundamental to the design philosophy. Key principles include the provision of walkable neighbourhoods, through an interconnected network of streets that provide convenient access to a mix of facilities and services that will meet the needs of both the new population and the existing population of the Guilderton and Woodridge townsites.

Importantly, the revised ODP proposes much wider streets and significantly more public open space than is required by Liveable Neighbourhoods. This has been done to achieve a greater level of site responsiveness and to create a 'point of difference'.

2.2 Shire of Gingin

The revised ODP area lies within the Shire of Gingin and is therefore required to comply with the Shire of Gingin Town Planning Scheme No. 8, the current statutory land-use planning control, as well as other relevant Council policies and strategy plans.

The Council of the Shire of Gingin and the WAPC adopted Amendment No. 22, under which 557 hectares of the Moore River Development Company land was rezoned from “Rural” to “Urban Development”, as the proposal was consistent with the various Shire and WAPC strategies and structure plans identified in the preceding sub-section. The 'Urban Development' zone identifies land suitable for urban development. An ODP is required to be prepared and endorsed to ensure that the area will derive the maximum possible benefit from the design, layout and provision of works and services. Subdivision and development will thereafter be approved in general conformity with the adopted ODP.

2.2.1 Shire of Gingin Town Planning Scheme No. 8

The revised ODP complies with all Shire requirements and in particular the requirements of Clause 5.4 of TPS8.

Pursuant to TPS 8 any proposal for development of land within the Urban Development zone requires the preparation of an ODP that shall include sufficient detail to show the following:

- Topography of the area;
- Natural vegetation of the area;
- The existing major road systems;
- The location and width of proposed roads and non-vehicular movement systems;

- The appropriate location and quantity of commercial, civic and public facilities proposed;
- The approximate location of recreation and open space areas proposed, the open space where appropriate to be related to creek lines, native vegetation and other natural landscape features;
- The population, residential densities and generalised subdivision layout and development standards proposed, including the spatial location of proposed Residential Planning Code densities;
- The distribution of any other proposed land uses;
- Servicing arrangements and schematic layouts, including reticulated sewerage, water and drainage provision;
- The proposed staging of subdivision and development; and
- Such other information as may be required by Council.

The revised ODP has been prepared in accordance with the provisions of TPS8. All of the detail requested to be provided is included within this ODP report and plan as well as the supporting technical reports included as appendices.

Figure 3 - *Shire of Gingin Town Planning Scheme No.8*



2.2.2 Shire of Gingin Town Planning Scheme No. 9

The draft Shire of Gingin Town Planning Scheme No. 9 (TPS9) was prepared in September 2003 and has been held in abeyance since 2006. TPS9 proposes that the revised ODP area and the whole of the Urban Development zone identified pursuant to TPS8 become Special Control Area No. 2 - Development Areas (SCA2).

The purpose of SCA2 is to ensure that subdivision and development of land should only take place after comprehensive planning has ensured high design standards and cost effective servicing which is sensitive to the environment.

The provisions of SCA2 require that the subdivision and development of land within the Development Area is to be generally in accordance with an approved Structure Plan. Details to be included within a Structure Plan include:

- A site analysis map showing the characteristics of the site;
- A context analysis map of the immediate surrounds
- Map showing:
    - Neighbourhoods around proposed neighbourhoods;
    - Existing and proposed commercial centres;
    - Natural features to be retained;
    - Street block layouts;
    - The street network including street types;
    - Transportation corridors;
    - Land uses including residential densities;
    - Schools and community facilities;
    - Public parklands; and
    - Urban water management areas.
- A written report to explain the mapping and to address:
    - The planning framework for the structure plan
    - The site analysis
    - The context analysis
    - How planning is to be integrated with the surrounding land;
    - The design rationale for the proposed pattern of subdivision, land use and development;
    - Traffic management and safety;
    - Parkland provision and management;
    - Urban water management;
    - Proposal for public utilities; and
    - The proposed method of implementation.

Whilst the revised ODP is currently controlled by TPS8 the provisions of TPS9 in relation to SCA2 are considered relevant as a 'seriously entertained proposal'. TPS9 and the Shires draft Local Planning Strategy have been held in abeyance since 2006 but it is understood that the Shire and the WAPC are working collaboratively to finalise both documents. The revised ODP has therefore been prepared with the provisions of TPS9 in mind.

2.2.3 Shire of Gingin Draft Local Planning Strategy

The Shire of Gingin's draft Local Planning Strategy (the Strategy) was prepared in September 2003 and has been held in abeyance along with Town Planning Scheme No. 9 since 2006. The Strategy is a planning tool that enables Council to set out its vision for the municipality, and the longer term directions for land use and development. The Strategy establishes a basic structure of population and employment, and outlines the broad strategies for housing, industry, shopping and business activities, and proposals for transport, open space and other public uses.

The Strategy recognises the Urban Development zoning of the revised ODP area and acknowledges that in the medium to long-term the area is anticipated to provide for a resident population of some 13,500 persons. However, the Strategy states that prior to actual urban development occurring on the south side of the Moore River, there will be a need for further detailed planning, and in particular addressing some key issues including coastal management, river management and integration with the existing Guilderton townsite.

The relevant objectives of the Strategy in relation to the revised ODP area are:

- To promote and support new urban expansion around the existing Guilderton townsite;
- To facilitate a high quality, environmentally sensitive and integrated form of urban expansion south of Moore River as part of the Guilderton townsite expansion plan;

- To increase local employment opportunities and local expenditure by increasing the level and diversity of business prospects both within and adjacent to the townsite;
- To promote increased level of community facilities within or adjacent to the Guilderton townsite; and
- To maintain the attraction and importance of Guilderton as a tourist destination, and recognise its popularity for non-permanent residents.

A number of strategies are identified to meet these objectives, including:

- Utilise rationalisation of zones and zoning controls to encourage the establishment of a greater mix of urban land uses, such as home offices, home based business, cottage industries and the like;
- Preparation and adoption of structure plans for identified expansion area incorporation the existing Outline Development Plan for south of Moore River, to ensure that subdivision and development of urban land only proceeds after comprehensive planning to ensure design standards, cost effective servicing sensitive to the environment and adequate level of community facility provision; and
- Promote, facilitate and undertake the preparation and implementation of localised coastal management plans which recognise the importance and attraction of the coast for urban townsite and nodal development, whilst simultaneously ensuring the reinstatement and ongoing protection of coastal systems in the context of urban townsite growth and activities.

The revised ODP reflects the provisions of the draft Strategy by facilitating the future development south of Moore River and providing the necessary technical and management plans to support the proposal and protect the coastal and estuarine environments.

2.2.4 Shire of Gingin Town Planning Policies

A provision within the Shire of Gingin TPS8 allows Council to make Town Planning Scheme Policies in relation to parts or all of the Scheme Area and in relation to one of more aspects of the control of development and land use.

A Town Planning Scheme Policy shall not bind the Council in respect of any application for Planning Consent but Council shall take into account the aims and provisions of the policy when making its decision. Policies relevant to the revised ODP are considered in the following section of this report:

2.2.4.1 Town Planning Policy No. 1.2 – Foreshore Protection Areas

Town Planning Policy 1.2 applies to the area depicted on the various Strategy Maps labelled as Foreshore Protection Areas and applies to the revised ODP area. The objective of the policy is to provide general development guidelines including setbacks, building height, pedestrian access and parking in areas where development is permitted in the foreshore area.

The revised ODP has been designed to ensure that the environmental attributes of the Foreshore Protection Area are preserved through the provision of increased setbacks to both the river and ocean and through the retention of the coastal dunal system, whilst maximising pedestrian access through strategic beach access points. Environmental protection measures will be set out in a Foreshore Management Plan, as required by the revised ODP's Statements of Planning Policy, included as Section 9 of this report.

The Guilderton Townsite Strategic Map which is contained within Section 4.0 of the Shire of Gingin Draft Local Planning Strategy requires that a coastal management plan be prepared for the subject site. Planning Policy Statement No. 6 (refer Section 9) states that a foreshore management plan shall

be prepared under clause 5.1(x) and (xi) of State Planning Policy No. 2.6: State Coastal Planning Policy, at the subdivision stage.

2.2.4.2 Town Planning Policy No. 7.1 – Guilderton Foreshore Protection Area

This policy applies to areas depicted on the Guilderton Strategy Map as Foreshore Protection Areas. The objective of the policy is to provide for the improvement of river water quality to allow for recreational purposes and ensure that any development in or adjacent to the Foreshore Protection Area has minimal detrimental effect on the quality of the local environment over the long term.

The revised ODP responds to this policy by proposed expansion of the foreshore reserve system and precluding any development within the direct catchment of the Moore River.

2.2.4.3 Town Planning Policy No. 7.2 – Guilderton Expansion Area

Town Planning Policy No. 7.2 applies to the land south of Moore River and therefore specifically relates to the revised ODP area. The objective of the policy is to provide a comprehensive structure plan for large scale urban development in the area. The policy requires that structure plans should indicate urban cells, retail centres, schools, public open space, and the main infrastructure for the area. The policy also requires that urban cells to the south of Moore River will not be supported unless a trafficable bridge is provided to connect the existing townsite.

2.3 Environmental Protection Agency

In determining an informal level of assessment with public review for Amendment No. 22, the Environmental Protection Agency was aware of a commitment made by the proponent that the following four matters would be addressed in the preparation of an ODP:

- Preparation of a river foreshore management plan;
- Preparation of an ocean foreshore management plan;
- Preparation of a drainage management plan; and
- The development would be sewered.

During the advertising period of Amendment No. 22, the Minister for the Environment determined an informal level of (environmental) assessment where public review would apply. This decision was advertised and appeals were lodged in regard to the level of assessment.

In August 1994 the Minister for Environment advised Moore River Company that he had dismissed all appeals against the informal level of assessment of Amendment No. 22. It was considered there were no significant environmental concerns which would prevent urban development providing there was no direct drainage discharge to the river or ocean, the development was sewered and management plans were prepared for the coastal and river foreshore areas.

The revised ODP is of significantly lesser scale than that anticipated by Amendment 22 and the currently approved ODP for the site. The area of new reserves has increased enormously, and the proposal responds to all contemporary environmental criteria. It is considered that the revised ODP will not have a 'significant effect on the environment' for the purposes of the Environmental Protection Act.

3 Community Consultation

A comprehensive community consultation process was carried out as part of the approved 2000 Outline Development Plan (ODP). In accordance with an agreement between the then Department of Planning and the Shire of Gingin, three community workshops were held under the direction of an independent chairman - Dr Geoff Syme from the C.S.I.R.O. The main purpose of these workshops was to provide information to the public so that they could suggest principles and basis for guidelines for the ODP. Additionally, the following extract from the summary of the workshops identified the objectives for the workshops as being:

- To develop planning principles for the Outline Development Plan;
- To provide the reasoning or basis on which guidelines can be derived; and
- To ensure that the greatest breadth of input and ideas are gained from which the planners can work.

Key issues that arose from the workshops included:

- Retention or stabilisation of the 'desert';
- Requirement for adequate coastal and river foreshore setbacks;
- River not to be dredged and rivermouth bar to remain;
- Retention of the site as a conservation reserve;
- Provision of adequate employment;
- No discharge of stormwater into the river or ocean;
- Managed public access along river and coastal foreshore;
- Need for safe ocean boat launching facility;
- Provision of adequate servicing - power, water, sewer;
- Provision of adequate community facilities;
- Requirement for a bridge crossing; and
- Provision of a well balanced community.

The 2000 approved ODP was designed to reflect the outcomes of the workshop where possible. The workshops provided a breadth of input and ideas (principles and guidelines). Although the principles and guidelines established did not override the relevant planning principles at the time they were taken into account in the consideration and assessment of the approved 2000 ODP, by the proponent, the Shire, the WAPC and relevant Government agencies.

3.1 Revised Outline Development Plan

The revised ODP is essentially a revision to the approved 2000 ODP, which has been amended to reflect the Minister of Planning's acknowledgement of the Urban Development zoning of the land and its suitability to accommodate a reduced scale of development. Preparation of the revised ODP has considered the issues arising from consultation in relation to the approved 2000 ODP and the Gingin Coast Structure Plan. The most significant design response has been the proposed reduction of the scale of development and the incorporation of significant additional reserves and open space in response to expressed community opinion.

The revised ODP area has been reduced from 557ha to 346ha with a reduction in the envisaged total population from 13,500 to 5,000 residents. The overall impact on the environment has also been significantly reduced with additional setbacks provided to the coast and the previously proposed tourist development omitted from adjacent to the Moore River. Additional supporting technical studies have also been provided to address the amended design and reflect changes in legislation.

The revised ODP will undergo formal consultation pursuant to the Shire of Gingin Town Planning Scheme No. 8 (TPS8), which requires that once an ODP has been prepared to the satisfaction of Council, the Council shall advertise, including notifying in writing, to all owners considered likely to be affected by the ODP, and inviting each owner to make a submission regarding any aspect of the Plan of interest to or affecting the landowner. TPS8 specifies a minimum time period of 28 day for submissions to be received. The revised ODP will be advertised for public comment in the early stages of assessment to allow for refinement according to issues that might arise from community input. The Moore River Company will work together with the Shire, Department of Planning and other Government Agencies in this regard.

A full copy of the revised ODP is attached at the end of this report.

4 Environmental Assessment

In 1992 the Moore River Company engaged Alan Tingay and Associates, Environmental Consultants, to undertake an environmental assessment of a study area slightly in excess of the approved 2000 ODP area. The purpose of the study was to provide an assessment of environmental opportunities and constraints to urbanisation of the area. In the following years to 1996 further environmental studies were carried out to identify coastal stability and mobile dune stability, as well as additional management plans for the river foreshore reserve and the ocean foreshore reserve, which were used as supporting technical reports to the approved 2000 ODP.

Cardno, on behalf of the Moore River Company, have undertaken a new scope of work to re-evaluate the environmental issues, constraints and opportunities to assess the environmental impact of the revised Outline Development Plan (ODP) and to update the understanding of environmental values in line with current regulatory requirements.

The environmental consultancy services included a number of site specific environmental investigations including:

- Flora and vegetation assessment - Level 2 (Cardno 2010);
- Fauna assessment (Harewood 2010); and
- Ongoing ground water monitoring (Cardno October 2009 to July 2010 and ongoing).

A summary of these investigations along with a review and synthesis of other previously existing environmental information for the subject site is provided in the following section of this report. The key environmental features of the subject site include:

- Suitable habitat for both Carnaby's Black Cockatoo and the Graceful Sun Moth;
- Areas of remnant vegetation, including vegetation in "Excellent" and "Pristine-Excellent" condition;
- The coastal setting of the site; and
- Significant Flora species.

This information was incorporated into a comprehensive, collaborative and multi-disciplinary design for the revised ODP. Key environmental design features incorporated into the revised ODP design include:

- A generous and strategic allocation of Public Open Space (POS);
- A design that accommodates the retention of topography and landscape; and
- Protection of key physical environmental attributes such as habitat trees.

A key objective of the revised ODP is to retain the existing environmental character of the subject site wherever possible.

4.1 Site Topography, Geology, Landform and Soils

The revised ODP area is located within the Swan Coastal Plain, which is on the central portion of Perth Basin. The Perth Basin extends from the Darling fault in the east to the continental slope west of Rottnest Island, from the Murchison River in the north and the Southern Ocean in the south. The Perth Basin is sedimentary in origin.

The Swan Coastal Plain is comprised of a number of geomorphic entities running parallel to the coastline. From west to east, these include the Quindalup Dunes, Spearwood Dunes, Bassendean Dunes and the Pinjarra Plain. According to landform and soil mapping (Churchward and McArthur 1980), the subject site is comprised of the Quindalup dunes, which is described as unconsolidated

sand and shell fragments with some organic matter darkening the surface of the sand. The Quindalup dune system is described as a Holocene landform.

The topography of the subject site is undulating with the natural surface height ranging from 6m Australian Height Datum (mAHD) along the coast to 50 mAHD further inland. The subject site is characterised by a number of irregular dunes, which rise steeply away from the beach and Moore River, to a series of high dunes and valleys, and range from approximately 10 mAHD on the coast to 40 mAHD a short distance inland.

4.2 Geoheritage

Geoheritage is a complex expression of the geological and geographical landforms and the historical development of all ecological systems upon them. Geoheritage is the historical record of the processes that have produced the geology and landform in an area.

Based on the broad description of the landform and geology above and the Department of Agriculture online mapping, the majority of the subject site appears to be composed of the Quindalup Dunes. These can be associated with forms of geoheritage where unusual landforms occur, such as the record of Holocene dune building found at Port Kennedy.

From the available information, the revised ODP area does not contain any landforms of geoheritage which are currently targeted for protection. Additionally, none of the previous studies or planning for the site has noted the occurrence of significant or unusual geoheritage features.

4.3 Hydrology

4.3.1 Surface Water

The revised ODP area is located directly to the south of the mouth of Moore River. The Moore River catchment receives variable rainfall and as a result the river has only seasonal contact with the sea, when the volume of water flowing through it is sufficient to break through the sandbar across its mouth or when anthropogenic forces have opened the bar. Apart from Moore River to the north of the subject site, there are no known or mapped waterways.

4.3.2 Groundwater

4.3.2.1 Review of Existing Information

The revised ODP area represents the north-west portion of the Gnangara Mound groundwater system. This system extends from Moore River in the north, to the Swan River in the south, the Indian Ocean to the west and Ellen Brook to the east. The Gnangara Mound is a superficial aquifer which contains predominantly unconfined groundwater, which overlays the deeper and impermeable Osborne Formation and Lancelin Beds (Coolyena Group), which are approximately 500m deep (GSS 2009). The surface sediments that form these formations are broadly consistent with the soil characteristics discussed above and vary vertically and laterally with interweaving layers of sand, limestone, silt and clay.

The groundwater in the region is likely to be directly recharged by rainfall, which percolates into and moves slowly through the superficial formations.

4.3.2.2 Groundwater Site Investigations

Currently, site specific groundwater investigations are being undertaken across the revised ODP area to support the future planning process. However, from regional information and previous investigations, the majority of the groundwater is likely to flow in a westerly direction with groundwater discharging over a saline wedge to the ocean. This occurs both in the vicinity of the Seabird town site, approximately 10 kilometres to the north, and in the Wilbinga area, which is located directly to the south of the Moore River Company's wider landholdings. In the northern portion of the subject site, groundwater is likely to flow in a north, north-westerly direction, towards Moore River.

Ten shallow groundwater bores have been installed within the revised ODP area at locations shown in **Figure 6** of the supporting Environmental Assessment and Justification Report (**Appendix E**), which will provide the best representation of anticipated groundwater systems and an accurate dissemination of data throughout the site. These locations were selected to allow for the identification of potential nutrient hotspots and development of underlying groundwater contours.

Groundwater levels have been measured on a monthly basis since October 2009 on all installed bores. These bores are measured using an audible dip meter to record standing water levels. The groundwater contours over the site identified during preliminary investigations indicate a westerly groundwater flow direction.

Groundwater quality sampling has been conducted in November 2009 and February 2010. Initial analysis (November 2009) was conducted for a full range of parameters including nutrients, nutrient species, metals, pesticides and hydrocarbons. The second round of groundwater quality analysis (February 2010) was conducted for nutrients and nutrient species. It has been agreed with the relevant Government Agencies that the monitoring carried out to date is sufficient to inform the preparation of the revised ODP. A detailed monitoring report providing analysis of the results will be presented upon completion of the groundwater sampling program.

4.3.3 Wetlands

Based on the mapping maintained by the DEC, the *Geomorphic Wetlands of the Swan Coastal Plain* dataset (Hill *et al*. 1996) and an environmental audit conducted by Tinley (1992), no wetlands are present within the subject site.

The wetlands in the vicinity of the revised ODP area are located in the coastal back-plain zone, found to the east of the subject site. From the site specific investigations as part of the Flora and Vegetation Survey (Cardno 2010), there was no evidence of wetland systems or wetland dependant vegetation.

4.3.4 Public Drinking Water Source Area

Public Drinking Water Source Areas (PDWSAs) are gazetted by the Department of Water (DoW) to protect the water quality of identified drinking water sources, which can be surface water or groundwater (DoW 2009). PDWSAs provide the community of Western Australia with the majority of its drinking water supplies and can be vulnerable to contamination by a range of land uses and water based activities.

According to the DoW *Geographic Atlas* (online) (2009) there are no declared Public Drinking Water Source Areas (PDWSAs) located within the subject site. However, a Priority 2 PDWSA is located approximately one kilometre to the north of the subject site. Development of the revised ODP area is unlikely to impact on this PDWSA as Moore River acts as a barrier to groundwater flow to the north. This PDWSA was proclaimed with the intention to provide the town of Guilderton with a safe drinking water supply.

4.4 Flora and Vegetation

Broad regional information indicates that the revised ODP area is located within the Swan Coastal Plain Subregion Drummond Botanical Subdistrict. The vegetation is broadly categorised as Banksia low woodland on leached sands with Melaleuca swamps on ill-drained soils and woodlands of Tuart (*Eucalyptus gomphocephala*), Jarrah (*Eucalyptus marginata*) and Marri (*Corymbia calophylla*) on less leached soils (Beard, 1990).

Regional vegetation complex mapping undertaken by Heddle *et. al*. 1986 for parts of Western Australia indicates that the subject site is primarily within the Quindalup Complex (refer **Figure 7**, **Appendix E**). The description given for the Quindalup Complex is:

> "Coastal dune complex consisting mainly of two alliances, the strand and fore dune alliance and the mobile and stable dune alliance. Local variations include low closed forest of *Melaleuca lanceolata – Collistris preissii* and closed scrub of *Acacia rostellifera*"

Previously, a flora and vegetation survey of the site was conducted by Alan Tingay and Associates in November 1992 (Alan Tingay and Associates 1993). This survey did not reveal any significant or protected flora or vegetation, however suggested that "significant stands of *Allocasurina lehmanniana* could be protected as much as possible within open space along the top of the Moore River Southern riverbank". In addition, the survey noted a feature could be made of some or all of the Tuart grove which also has an understorey of *A. lehmanniana*.

To update the flora and vegetation data, Cardno (2010), on behalf of the Moore River Company, conducted a detailed spring flora and vegetation in accordance with the Environmental Protection Authority's (EPA) *Guidance Statement No.51 Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia* (EPA 2004a) across the subject site. This included three separate visits, two in October and once in September by a team of experienced botanists to identify the presence of Declared Rare Flora (DRF), Priority Flora (PF) and/or Threatened Ecological Communities (TEC). The survey also identified the flora species present within the survey area and the condition of the vegetation.

4.4.1 Plant Communities

Eight broad plant communities have been described for the revised ODP area, which are:

*OaSc - Low Scrub B of Olearia axillaris and Scaevola crassifolia over Open Herbs of *Trachyandra divaricata *Tetragonia decumbens, *Cakile maritima, *Pelargonium capitatum, Hardenbergia comptoniana and Conostylis candicans on foredunes with Spinifex longifolius and Ficinia nodosa;*

*ArAp - Dense Thicket to Thicket of Acacia rostellifera over Low Scrub B of Acanthocarpus preissii over Open Low Grass of *Bromus diandrus, *Lolium rigidum and Poa porphyroclados, Open Herbs of Calandrinia sp. Southwest Coast, *Dischisma arenarium, Carpobrotus virescens, and *Tetragonia decumbens on lower slopes and within swales;*

*AlEg - Scrub of Allocasuarina lehmanniana subsp. lehmanniana, Spyridium globulosum and Myoporum insulare with emergent pockets of Low woodland A to Open Low Woodland A of Eucalyptus gomphocephala over Low Scrub B of Acacia lasiocarpa, Olearia axillaris and Leucopogon parviflorus over Low Open Sedges of Lepidosperma gladiatum with *Bromus diandrus and Austrostipa flavescens, Parietaria debilis, Senecio pinnatifolius, *Trachyandra divaricata, Daucus glochidiatus, *Crassula glomerata and Trachymene pilosa;*

MsAlSg - Heath A to Dwarf Scrub C of Melaleuca systena, Acacia lasiocarpa, Spyridium globulosum and Calothamnus quadrifidus with occasional pockets of Low Woodland A of Eucalyptus gomphocephala and Low Woodland B of Banksia attenuata over Open Herbs of Lomandra maritima, Parietaria debilis, Phyllanthus calycinus, Poranthera microphylla, Senecio pinnatifolius and Trachymene pilosa;

*MsAlAp - Low Heath B of Melaleuca systena, Acacia lasiocarpa, Acanthocarpus preissii and Calothamnus quadrifidus with occasional pockets of Low Woodland B of Banksia attenuata or Thicket to Scrub of Acacia rostellifera in the swales over Open Herbs of Conostylis candicans, Desmocladus asper and Heliophila pusilla, Lepidosperma pubisquameum, *Bromus diandrus and Poa porphyroclados on cream-grey shallow sands over limestone;*

*McSg - Thicket of Melaleuca cardiophylla, Spyridium globulosum, Leucopogon insularis and Acanthocarpus preissii over Low Grasses *Bromus diandrus, *Lolium rigidum and *Ehrharta longiflora with Desmocladus asper, Calandrinia sp. Southwest Coast, Stylidium maritimum (P3), Hibbertia spicata subsp. leptotheca (P3) and Beyeria cinerea subsp. cinerea (P3) on grey-brown shallow sands over limestone. This plant community was recorded along the southern bank of Moore River to the east of the large blow-out;*

*MsMhBs - Heath A to Dwarf Scrub C of Melaleuca systena/Melaleuca huegelii, Banksia sessilis, Spyridium globulosum, Templetonia retusa, Acacia truncata and Hakea lissocarpha over Open Herbs of Calandrinia brevipedata, Podotheca gnaphalioides and Trachymene coerulea subsp. coerulea with Austrostipa flavescens, Poa porphyroclados, *Bromus diandrus and Ehrharta villosa on dark grey-brown sand over limestone; and*

*MhMtMs - Low Heath C recently burnt (3-5 years) of Melaleuca huegelii/Acacia truncata, Melaleuca systena and Banksia sessilis, over Very Open Herbs of Desmocladus asper, Stylidium junceum, Calandrinia sp. Two-rocks, Carpobrotus virescens, *Crassula glomerata, and Gompholobium tomentosum with *Bromus diandrus and Poa porphyroclados on grey-brown shallow sands over limestone.*

* Refers to species that are known weeds.

The spatial distribution of these communities is shown in **Figure 8** of the supporting Environmental Assessment and Justification Report (**Appendix E**)**.**

4.4.2 Vegetation Condition

The condition of the vegetation was assessed to assist in determining the conservation values of the site. The vegetation condition was rated according to Keighery (1994), a vegetation condition scale commonly used in the Perth Metropolitan Region, which is also appropriate for use in other urbanised and agricultural areas. The categories are listed and defined in Table 2 of the supporting Environmental Assessment and Justification Report (**Appendix E**)**.**

Vegetation condition across the site ranged from 'Completely Degraded' to 'Pristine-Excellent', with the largest portions of vegetation being in a 'Completely Degraded' condition.

Areas of 'Completely Degraded' condition consisted of cleared paddock and tracks in the centre of the revised ODP area. The coastal foreshore reserve and adjacent eastern coastal dune is in an 'Excellent' to 'Pristine-Excellent' condition. The river foreshore area is in a 'Good' to 'Very Good' condition. Remaining patches of remnant vegetation east of the foreshore reserve were in a 'Degraded' to 'Very Good' condition.

4.4.3 Significant Flora

Species of flora are prescribed as "Declared Rare" or "Priority" conservation status where populations are restricted geographically or threatened by local processes. The DEC recognises these threats and subsequently applies regulations towards population protection and species conservation. The DEC enforces regulations under the Wildlife *Conservation Act 1950* to conserve Declared Rare Flora (DRF) and protect significant populations. Priority flora (PF) species are potentially rare or threatened and are classified in order of threat.

A search was conducted of the DEC's databases for DRF and priority floras that occur within the wider local area and the results are listed in Table 3 of the supporting Environmental Assessment and Justification Report (**Appendix E**). Twenty seven DRF and PF species have been identified as occurring in close proximity to the revised ODP area. Of these species, four are classified as DRF species. The flora survey undertaken by ATA Environmental in 1993 did not identify any listed DRF or PF species.

4.4.3.1 Flora Survey Results

During Cardno's 2010 survey no DRF species were recorded within the revised ODP area, however three PF species were recorded, these being:

- *Stylidium maritimum (P3);*
- *Hibbertia spicata subsp. leptotheca (P3); and*
- *Beyeria cinerea subsp. cinerea (P3).*

A number of species were identified in the 1993 report that were considered to have poor representation or uncommon distributions. These species were Allocasuarina lehmanniana, Billardieria erubescens and Thomasia triphylla.

4.4.4 Threatened Ecological Communities

In Western Australia, 'Threatened Ecological Communities' (TECs) are defined by the Western Australian TEC Scientific Advisory Committee (within the DEC) and are assigned to category of Priority 1 to Priority 5. While they are not afforded direct statutory protection at a State level (unlike DRF under the Wildlife Conservation Act 1950) their significance is acknowledged through other State environmental approval processes (i.e. Environmental Impact Assessment pursuant to Part IV of the Environmental Protection Act 1986).

Selected TECs are also afforded statutory protection at a Federal level pursuant to the Environmental Protection and Biodiversity Conservation Act 1999 (EPBC Act). The EPBC Act provides for the strong protection of TECs, which are listed under section 181 of the Act, and are defined as "Critically Endangered", "Endangered" or "Vulnerable" under Section 182.

A search was conducted of the DEC's TEC database and no known occurrences of TECs were recorded within the boundary of the revised ODP area.

In addition to listing as a TEC, a community may be listed as a Priority Ecological Community (PEC). An ecological community that is under consideration for listing as a TEC, but does not yet meet survey criteria or has not been adequately defined, is placed on the list of PECs in either Category 1, 2 or 3. Ecological communities that are adequately known and are rare but not threatened, or meet criteria for Near Threatened, or that have been recently removed from the threatened list, are placed in Priority 4. These ecological communities require regular monitoring. Conservation Dependent ecological communities are placed in Priority 5 (DEC 2007).

No PECs have been recorded by the DEC within the revised ODP area.

4.4.5 Environmentally Sensitive Areas

Environmentally Sensitive Areas (ESAs) are areas prescribed under the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004*. As a result ESAs are only considered when a clearing permit is required under these regulations. ESAs have been identified to protect the native vegetation values of areas surrounding significant, threatened or scheduled ecosystems and communities.

A search of the Department of Environment Conservation (DEC) Native Vegetation Mapping database revealed that no ESAs are mapped over the subject site.

4.5 Terrestrial Fauna

As part of the overall assessment of the fauna and fauna habitat values within the revised ODP area, a review of existing available information was undertaken in addition to a site specific fauna survey. The comprehensive documentation of this is contained within the supporting report prepared by Greg Harewood (**Appendix G**).

A fauna survey was conducted across the subject site in November 1997 (ATA 1998). This survey found that the original ODP area supported a range of habitat types. During the fauna survey a number of species were recorded as being present including: two amphibian species; 18 reptile species; 69 bird species and eight mammal species (four of which were introduced species). Of the species found or determined to be likely found given the habitat and known range, a number of these were considered to be of conservation significance.

The fauna survey carried out in October 2009, in support of the revised ODP, and in accordance with EPA Guidance Statement No 56 Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia (EPA 2004b), found that 192 species could potentially utilise the site, although the number is likely to be significantly lower. A total of 38 native fauna species were observed (or positively identified from foraging evidence, scats, tracks skeletons or calls) within the subject site during the three day survey in October 2009. Three vertebrate fauna species of conservation significance were positively identified as utilising the revised ODP area, including:

- *Calyptorhynchus latirostris Carnaby's Black Cockatoo;*
- *Ardea alba Great Egret;*
- *Sunemon gratiosa Graceful Sun Moth; and*
- *Pandian haliaetus Osprey.*

Ten additional species of conservation significance were also identified as potentially using the site for some purposes at times, although their presence could not be confirmed. Additionally, given the varied habitat over the site, these species may only visit the area for short periods or as rare/uncommon vagrants. The additional conservation species are identified in Table 7 of the supporting Environmental Assessment and Justification Report (**Appendix E**).

The supporting fauna survey also recorded the location of significant habitat trees, which were defined as "native trees of the Eucalyptus or Corymbia genera having a diameter at breast height (DBH) greater than 500mm". The trees provide habitat for vulnerable and endangered Black Cockatoo species. The survey revealed 17 significant trees within the study area, all of which were tuart. These trees are generally in two distinct clusters over the site, in association with tuart woodlands mapped over the site.

The Environmental Issues, Opportunities and Constraints Plan (**Figure 5**) identifies the location of the significant habitat trees. The revised ODP has been designed to retain significant habitat trees within foreshore and parkland areas wherever possible. The large cluster of trees to the north of the site adjacent to Moore River are proposed to be retained within the foreshore reserve with smaller clusters to the south retained within areas of public open space.

A survey undertaken during March 2010 positively identified the Graceful Sun Moth at the site. The survey was undertaken in accordance with the DEC guidelines. In total 21 Graceful Sun Moths were sited over a period of 4 surveys throughout March. The Graceful Sun Moth inhabits coastal dune systems vegetated with Lomandra species. Current Graceful Sun Moth habitat is shown in **Figure 11** of the supporting Environmental Assessment and Justification Report (**Appendix E**).

4.6 Indigenous Heritage

An online search of relevant Aboriginal heritage information was undertaken using the Department of Indigenous Affairs (DIA) Aboriginal Inquiry System (DIA, 2010) that incorporates both the heritage site register and the heritage survey database. A number of sites were listed as occurring within the revised ODP area, which are illustrated in **Figure 12** of the supporting Environmental Assessment and Justification Report (**Appendix E)**

The majority of these sites are associated with the Moore River. An archaeological and ethnographic survey was completed for the subject site in December 1993 (Bavin 1993 and Tamora Pty Ltd 1993). These surveys reported that no additional archaeological sites were found within the revised ODP area and the three archaeological sites that were already been registered were not able to be relocated. The ethnographic survey revealed:

"There were no ethnographic sites of significance in the survey area. However the Moore River was formed during the Waugal journey (the Waugal is a creature from the dreamtime and created the waterways and landforms around the Perth region) and there should be a 30m zone between the banks of the river and the development" (Bavin 1993). This 30m buffer is accommodated within the foreshore reserves proposed within the revised ODP design.

There have been no site specific indigenous heritage investigations undertaken as part of the revised ODP design process as the previous site investigations were deemed sufficient.

4.7 Non-Indigenous Heritage

In order to determine the actual or potential presence of sites or features of non-indigenous heritage significance within the revised ODP area, a review of readily available information was undertaken to determine if there were any of the following within the subject site:

- World heritage sites;
- National heritage sites;
- Commonwealth heritage sites;
- Sites listed on the Register of the National Estate; and/or
- Heritage Council of WA sites.

Based on examination of the Shire of Gingin's Heritage Register there are no known heritage sites located within the revised ODP area, however the Moore River estuary adjacent to the site contains high heritage value.

To date there have been no site specific non-indigenous heritage investigations undertaken as part of the revised ODP design process. Given the nature of the site and the lack of identified heritage

values it is considered unlikely that non-indigenous heritage values will be revealed at any stage of future planning and development.

4.8 Site Contamination

The Contaminated Sites Act 2003 and the associated Contaminated Sites Regulations 2006 took effect on 1 December 2006. The Act provides a legal framework for the management of contaminated sites in Western Australia, and requires owners, occupiers and polluters to report known or suspected contaminated sites to the DEC.

There are no identified contaminated sites found within the revised ODP area recorded on the DEC's Contaminated Sites database. This database does not include sites that have not yet been classified or sites that are classified as possibly contaminated - investigation required, contaminated - restricted use or remediated for restricted use.

Based on a review of the historical aerial photography for the revised ODP area and a number of onsite inspections it is considered unlikely that any of the observed existing or historical land uses would have caused significant soil or groundwater contamination within the subject site.

4.9 Acid Sulfate Soils

Acid Sulfate Soil (ASS) is a naturally occurring soil or sediment that contains iron sulphide (iron pyrite) minerals. In their natural state ASS are present in waterlogged anoxic conditions and do not present a risk to the environment. They become an issue when oxidised, producing sulphuric acid, which can convey a range of impacts on the surrounding environment, infrastructure and human health.

Mapping prepared by the Department of Planning (DoP) to support the WAPC's Planning Bulletin 64: Acid Sulfate Soils (WAPC 2009) does not cover the revised ODP area. The ASS Planning Guidelines (WAPC 2009) indicate that only the areas in Western Australia currently considered to be most at risk of disturbance of ASS soils are depicted in the mapping. ASS are commonly recorded from natural wetland and mangrove coastal areas, which is not consistent with the conditions over the subject site. The adjacent Moore River contains ASS but is beyond the revised ODP boundary and therefore does not affect the site.

4.10 Urban Water Management

There are no waterways or wetlands within the revised ODP area. The area represents the extreme north west corner of the Gnangara ground water mound. The groundwater generally slopes downward to the west to sea level near the coast but would also have some outlet to north into the Moore River. Recharge of the groundwater occurs through rainfall infiltration through the porous soil. Water table levels fluctuate minimally throughout the year - between 10cm and 30cm. Sandy ground conditions ensure the proposed development would be well drained.

The development of a Local Water Management Strategy (LWMS) is the appropriate mechanism to establish broad-level designs and management measures for flood mitigation and effective stormwater management at structure planning stage. To support the revised ODP, a LWMS (refer **Appendix H**) has been prepared by Cardno on behalf of the Moore River Company. This document provides the detail of a LWMS document and covers the scope of a District Water Management Strategy (DWMS).

The development of the LWMS has been undertaken with the intention of providing a structure within which subsequent development can occur consistent with a 'total water cycle management' approach described in the document. It is also intended to provide overall guidance to the general stormwater

management principles for the area and to guide future Urban Water Management Plans (UWMPs) that will support subdivision approval.

The LWMS for the revised ODP has been developed to:

- Provide a broad level stormwater management framework to support future urban development;
- Incorporate appropriate best management practices into the drainage systems that address the environmental and stormwater management issues identified;
- Minimise development construction costs, which will result in reduced land costs for future home owners;
- Minimise ongoing operation and maintenance costs for the land owners and Shire of Gingin;
- Develop a water conservation strategy for the area that will accommodate existing groundwater allocation constraints for the area; and
- Gain support from the Department of Water and Shire of Gingin for the proposed method to manage stormwater within Lot 27 and Lot 201 and potential impacts on downstream areas.

A number of broad level studies that include the revised ODP area provide a regional environmental context for the LWMS. These have been reviewed in order to provide suitable background information for Lot 27 and Lot 201 and also to provide an indication of the issues requiring further investigation. Further, a number of site-specific investigations into various aspects of Lot 27 and Lot 201 have recently been conducted as a part of the revised ODP process. In summary, the investigations conducted to date indicate that:

- The revised ODP area is situated within a sand and limestone dune, with the topography within the residential/commercial area ranging from 10 to 50mAHD.
- The Maximum Recorded Groundwater Levels (MGL) where observed in October 2009 ranging between 0.25mAHD and 0.49mAHD. The depth to groundwater for the residential/commercial areas is between 10 to 40mAHD. All locations within the development boundary have a separation distance between the existing topography and the MGL of at least 1.2m;
- Groundwater quality results are generally within or slightly above the default trigger values. The TN and NOX concentrations vary across the revised ODP area and were recorded up to 5 and 40 times the default trigger values respectively;
- All runoff is to be retained and infiltrated on site resulting in no discharge from the revised ODP area;
- No streamlines or surface water channels exist within the revised ODP area and hence no surface water quality data is available;
- The revised ODP area has been historically cleared and used for sheep and cattle grazing; and

The LWMS document outlines the proposed groundwater management strategy, surface water management strategy, water supply and conservation strategy, and a monitoring strategy. These strategies have been determined based on the physical constraints of the site, as well as to achieve the requirements of government authorities.

Due to the significant depth to groundwater across the site, no management of groundwater levels is required. The groundwater nutrient concentrations are generally moderate compared to default trigger values. As the water does not intersect the surface at any location no treatment of the groundwater will be conducted. Monitoring of groundwater quality will be implemented to ensure that the nutrient concentrations within the underlying are not significantly increased due to the development.

The principle behind the stormwater management strategy is to retain and infiltrate all runoff (as occurs in the pre-development environment) within the revised ODP area, with treatment of minor rainfall events within vegetated treatment areas. The strategy will utilise bio-pockets, swales, vegetated infiltration areas, constructed infiltration basins and natural depression infiltration areas.

The development is situated in an area that has no scheme water network. Water Corporation will potentially be able to supply a significant portion of the water required for the development. Given that the relevant aquifer is fully allocated, acquisition of an adequate groundwater allocation from an existing groundwater licence holder to facilitate the remainder of the development might be required. The proponent proposes implementation of a new public drinking water supply from a source closer to Guilderton and the development site that will meet the needs of the new development and also provide an improved quality and quantity of potable water to Guilderton.

All waste water from the development will be treated and used to irrigate POS and School Ovals. Excess water produced during winter (due to reduce irrigation requirements) will be infiltrated into the underlying aquifer. This strategy will achieve the sewerage requirements of the development and reduce the total water consumption of the development. At a lot scale, households will be required to implement water saving strategies including rainwater tanks, water efficient appliances and water efficient gardens.

A summary of how the design criteria will be achieved and the proposed management strategy implemented (as presented within this LWMS document) is provided within Table 1 of the supporting Environmental Assessment and Justification Report, included as **Appendix E**.

The Moore River LWMS provides a framework that future landowners can follow to assist in establishing stormwater management methods that have been based upon site-specific investigations, are consistent with relevant State and Local Government policies and have been endorsed by the Shire of Gingin. The responsibility for working within the framework established within the LWMS rests with the individual landowners, although it is anticipated that future UWMPs will be developed in consultation with the Shire of Gingin, Department of Water and in consideration of other relevant policies and documents as well as the LWMS.

4.11 Coastal Assessment

Coastal areas represent the interface between the land and the sea and are recognised as sensitive and dynamic environments. The subject site is located within a coastal area and a foreshore reserve has been allocated to the west of the development. The foreshore is reserved for “Parks and Recreation” and is currently Unallocated Crown Land (UCL).

In 1994 M P Rogers and Associates, Consulting Engineers specialising in coastal, ocean and marine projects, was engaged by the Moore River Company to:

- Examine the stability of the coastline;
- Make recommendations on the appropriate setback from a coastal stability point of view; and
- Identify a site for a possible small boat launching facility which had the potential to accommodate a marina in the long term should such a facility be considered economically feasible.

This report was produced in November 1994 and revised in March 1996 and was included as a supporting technical report to the approved ODP.

To support the revised ODP, M P Rogers have been engaged to update their coastal setback assessment and to include an assessment of the physical processes setback to development with the most recent available data so as to provide an adequate level of protection to development from coastal erosion in the coming 100 years.

The WAPC Statement of Planning Policy No. 2.6 - State Coastal Planning Policy (SCPP) provides guidance on the siting of development on the Western Australian coastline. For new development on

an undeveloped sandy shoreline, such as the shoreline adjacent to the revised ODP area, the SCPP recommends the following criteria to be used to calculate an appropriate coastal setback:

- S1 - Allowance for acute short term erosion caused by a series of severe storms, with elevated water levels and an Average Recurrence Interval (ARI) of approximately 100 years. The Department of Transport (DoT) suggests the use of the SBEACH model using three repeats of the severe storm experienced in July 1996 to conservatively represent the 100 year ARI storm with respect to coastal erosion;
- S2 - Allowance for chronic long-term trends caused by local coastal dynamics. This needs to provide a buffer for the coming 100 years. The policy recommends the use of 100 times the long-term average rate of recession or 20m, whichever is greater; and
- S3 - Possible long term erosion trends caused by Climate Change and associated sea level rise anticipated in the coming 100 years. The policy recommends the allowance of a 0.38m rise in the general sea level and the assumption that this may cause 38m recession of shoreline.

To determine the severe storm sequence allowance, SBEACH modelling was completed for three locations on the shoreline at Moore River South. The modelling was shown to result in unrealistic inshore water levels when input using the method requested by DOT. The storm was also therefore modelled to match the measured inshore water levels during the July 1996 event. The storm sequence is believed to represent the 100 year ARI event at Moore River South in relation to beach erosion.

The SBEACH results indicate that the vegetation line would recede approximately 17 m following the severe storm sequence. This was used as the S1 factor in determining the appropriate PPS.

Shoreline movement analysis was updated for the Moore River South coastline to examine shoreline movements over the past 40 years at intervals of approximately every 5 years. The analysis showed that the majority of the site has experienced long-term accretion, with rates of movement of the coastal vegetation line ranging from 0.1 to 0.9 m/yr. The 20 m safety allowance was included as the S2 component for the majority of the site. In the north of the site there has been some recent erosion up to 0.5 m/yr. A 50 m allowance for S2 in the northern section of the site was therefore included.

The recommended allowance of 38 m was included as the S3 component, based on the mean of the IPCC's median model estimate of sea level rise, and the Bruun Rule.

The recommended physical processes setback (PPS) was therefore between 75 and 105m. This is presented in the setback plan, included as part of M P Rogers - Updated Coastal Setback Assessment, included as **Appendix I**. The PPS is measured from the Horizontal Setback Datum (HSD). For the accreting sandy coast of Moore River South, the HSD is taken as the seaward limit of coastal vegetation.

The revised ODP has been designed to reflect the required PPS, which is incorporated within the proposed foreshore reserve. In accordance with the WAPC's Liveable Neighbourhoods policy the foreshore (i.e. the area seaward of the PPS) will be ceded free of cost to the Crown, without payment of compensation by the Crown, and will be in addition to the 10 per cent public open space contribution.

4.11.1 Boat Launching Facility

The revised ODP identifies a possible low key boat launching facility adjacent to the proposed Holiday Resort to the north west of the revised ODP area. The boat launching facility is not a formal component of the revised ODP but has been examined in response to an expression of community desire for such a facility in the area and that the development might present an opportunity for it to be

provided. The impact of coastal processes on the proposed boat launching facility is considered in the supporting M P Rogers - Updated Coastal Setback Assessment (**Appendix I**).

Australian Standard AS3962 Guidelines for design of marinas outlines the requirements for the location and alignment of boat launching ramps. In summary, the location must:

- Be aligned to the dominant waves from swell, sea and boat wash;
- Be sheltered from waves larger than 0.2m;
- Have sufficient land approaches to permit queuing without blocking other traffic; and
- Have water approaches of sufficient area to allow queuing and low speed manoeuvres without blocking fairways and channels.

The Coastal Setback Assessment identifies that commonly occurring wave conditions at Moore River South would result in wave heights much greater than 0.2m and protective breakwaters would therefore be required to provide shelter to the facility. These breakwaters would have to be designed to sufficiently reduce the wave height for boat launching. The protective breakwaters would interrupt the longshore sand transport along the cost. If left unmanaged this could cause significant accretion of sediment on the up drift side of the facility, eventually impeding navigation into the facility, and erosion on the down drift side.

The assessment recommends that these effects would therefore have to be managed to minimise adverse effects on the surrounding coastline. This could be completed by sand bypassing, where sand is mechanically moved by one side of the facility to the other. Therefore, questions arise about who will be able to manage such a facility in perpetuity. Moore River Company has committed to making a contribution to a boat launch facility on the basis that the funding, design and ongoing management issues can be resolved to the satisfaction of all stakeholders.

4.11.2 Climate Change

The Intergovernmental Panel on Climate Change (IPCC) has presented various scenarios of possible climate change and the resultant sea level rise in the coming century (IPCC 2001). There is still some uncertainty as to which of these scenarios will occur. For example it is not known whether greenhouse gas emissions will fall, stay steady or increase in the coming decades and century, nor are the likely sea level changes well understood. In addition recent evidence suggests climate change is worse than predicted in IPCC 2001.

The atmospheric and oceanographic processes involved in climate modelling are complex, and numerical modelling of these processes is far from perfect. Due to these uncertainties, there are a wide range of predictions for global sea level rise. In 2007 the IPCC released findings conducted since the release of the IPCC in 2001. In 2007 further findings were released by the IPCC. The sea level rise predictions made in 2007 are essentially the same as those provided in 2007. These figures range from around 0.1 to 0.9m.

The WAPC Statement of Planning Policy No. 2.6 - State Coastal Planning Policy (SCPP) recommends estimating sea level rise based on the mean of the median model of the IPCC scenarios. This gives approximately 0.38m sea level rise in the coming century. The SCPP recommends that for sandy coasts the recession be taken as 100 times the estimated rise in sea level. This would be around 38m in the coming 100 years and is used in M P Rogers coastal assessment of the physical processes setback (PPS), which as stated above, recommends a total setback of between 75 and 105m.

The issue of climate change and an assessment of the PPS is considered further in the M P Rogers Updated Coastal Setback Assessment, included as **Appendix I**.

4.12 Sustainable Development

The primary aim of planning, as set out in the WAPC's Statement of Planning Policy No. 1 - State Planning Framework Policy (February 2006), is to provide for the sustainable use and development of land. The State Planning Strategy identifies the five key principles which further define this primary aim and describe the considerations which influence good decision-making in land use planning and development. Planning should take account of and give effect to, these principles and related policies to ensure integrated decision-making throughout government.

Environment:

To protect and enhance the key natural and cultural assets of the State and deliver to all West Australians a high quality of life which is based on environmentally sustainable principles.

Community:

To respond to social changes and facilitate the creation of vibrant, safe and self-reliant communities.

Economy:

To actively assist in the creation of regional wealth, support the development of new industries and encourage economic activity in accordance with sustainable development principles.

Infrastructure:

To facilitate strategic development by making provision for efficient and equitable transport and public utilities.

Regional Development:

To assist the development of regional Western Australia by taking account of the special assets and accommodating the individual requirements of each region.

The revised ODP has been formulated in a manner that facilitates achievement of the sustainable design objectives at the detailed subdivision stage. These include solar orientation, permeable layouts to encourage walking and cycling, application of Water Sensitive Urban Design guidelines, consideration of grey water recycling onto recreation reserves and development of management guidelines to foreshore reserves. The proponent will consider methods of encouraging sustainable building techniques relating to solar efficiency, appropriate building techniques and materials, garden design and efficient water usage.

4.13 Assessment of Issues, Opportunities and Constraints

As part of the revised ODP design process, the environmental attributes and values of the subject site have been assessed and the key aspects translated into spatial issues, opportunities and constraints in terms of possible design responses. These were then used to inform the type of design response so that the attributes and values were not significantly compromised.

Constraints were defined as attributes and values where there were clear government policies identifying significant environmental features and there is a clear presumption against impacts on these features. No constraints were identified within the revised ODP area.

Issues were defined as environmental features where there was no specific government policy which indicates there is a presumption against impacts on these environmental features. Issues are generally broader features, with no discrete boundaries; however, these features need consideration due to the potential environmental impacts and should be considered to demonstrate best practice environmental planning. The issues within the subject site included the presence of Carnaby's Black Cockatoo habitat, Graceful Sun Moth habitat, vegetation in "Excellent" and "Pristine-Excellent" condition and a required foreshore setback.

Opportunities were defined as areas where the environmental attributes and values are such that they are supportive of development. The opportunities within the subject site included the large areas of "Degraded" and "Completely Degraded" condition vegetation, the blow outs found on site and the depth of the groundwater.

The summarised environmental issues, opportunities and constraints of the subject side are shown in **Figure 5** below.

4.14 Environmental Design Considerations

The environmental issues, opportunities and constraints identified in this section of the report has informed the design of the revised ODP. This reiterative process allowed for the design to recognise the environmental features of the revised ODP area. The findings of the Environmental Assessment and Justification Report concluded that the development would have no significant environmental impact on Moore River.

The key environmental features of the revised ODP area include:

- Suitable habitat for both Carnaby's Black Cockatoo and the Graceful Sun Moth;
- The coastal setting of the revised ODP area;
- Areas of remnant vegetation, including vegetation in "Excellent" and "Pristine-Excellent" condition; and
- Significant Flora species.

Each of these environmental features has been considered in the revised ODP design process. In particular the most significant design responses to environmental features of the revised ODP are set out in the following section of this report:

4.14.1 The Generous and Strategic Allocation of Public Open Space

Public Open Space (POS) has been strategically allocated throughout the revised ODP area to retain remnant vegetation (including "Excellent" and "Pristine-Excellent" condition vegetation and Priority Flora populations), habitat trees and wildlife corridors. The allocated POS is in addition to the required foreshore reserve that will be ceded to the Crown. It is envisaged that the areas of POS will maintain and enhance the environmental integrity of the revised ODP area and provide opportunities for recreation and community interaction.

4.14.2 Retention of Topography and Landscape

The design of the revised ODP has taken into account the subject site's topography and landscape. The design aims to minimise modifications to the topography and landscape wherever possible, which

will help facilitate vegetation retention, reduce risks of erosion and sand mobilisation and minimise the need for fill.

A key element of the design has been the retention of the coastal dunal system, which was seen as the main topographical feature of the site. This dunal system was also identified as containing important vegetation and flora communities worthy of retention. Another important function was the location of natural drainage basins within the lower troughs of the dunes, which would minimise the need for additional drainage basins to be provided within formal areas of public open space.

4.14.3 Protection of Key Physical Environmental Attributes

The revised ODP design aims to minimise the disturbance of key physical environmental attributes. This includes Carnaby's Black Cockatoo habitat trees and Indigenous Heritage sites. These physical environmental attributes have been addressed in a series of management plans.

In addition to the above features of the revised ODP, a future management framework will be put in place during the future planning and development process for the long term protection of the environmental features within the revised ODP area. This is likely to be based on additional site investigations and the preparation of various management plans and strategies to protect and maintain environmental features. These can be undertaken/prepared during future stages of development and are likely to include the following:

- Future detailed site investigations;
- Plan and Strategy Preparation;
- Foreshore Management Plan including the foreshore reserve and POS;
- Management Plans for Carnaby's Black Cockatoo and the Graceful Sun Moth;
- Dieback Hygiene Management Plan;
- Fire Management Plan;
- Revegetation, Rehabilitation and Landscaping Plan;
- Dust Management Plan;
- Landscape Strategy;
- Construction Management Plan;
- Stormwater and Drainage Management Plan;
- Traffic and Parking Strategy;
- Development and land ownership controls;
- Design guidelines; and
- Management frameworks.

Given the planning and development framework in Western Australia, and the specific details provided above (which are in no manner exhaustive), Cardno, on behalf of the Moore River Company, is confident that the environmental features of the subject site can be retained and managed in the long term.

4.15 Preparation of Foreshore Management Plan

As a condition of future subdivision the Western Australian Planning Commission (WAPC), pursuant to State Planning Policy No. 2.6 – State Coastal Planning Policy, will require the preparation of a Foreshore Management Plan (FMP). The proposed FMP will provide a guiding framework for the restoration and protection of the coastal landforms and vegetation, as well as the management and integration of the coastal frontage and foreshore reserve. The proposed FMP will set out the standards for management of the foreshore and will describe the community facilities to be provided for visitors to the foreshore and beach including the path network which will link the future development with the beach. The following sketch plan identifies the type of community facilities that

will be provided, as a minimum, at each of the four strategic beach access locations identified on the revised Outline Development Plan (ODP).

Figure 4 - *Beach Access Nodes Concept Plan*

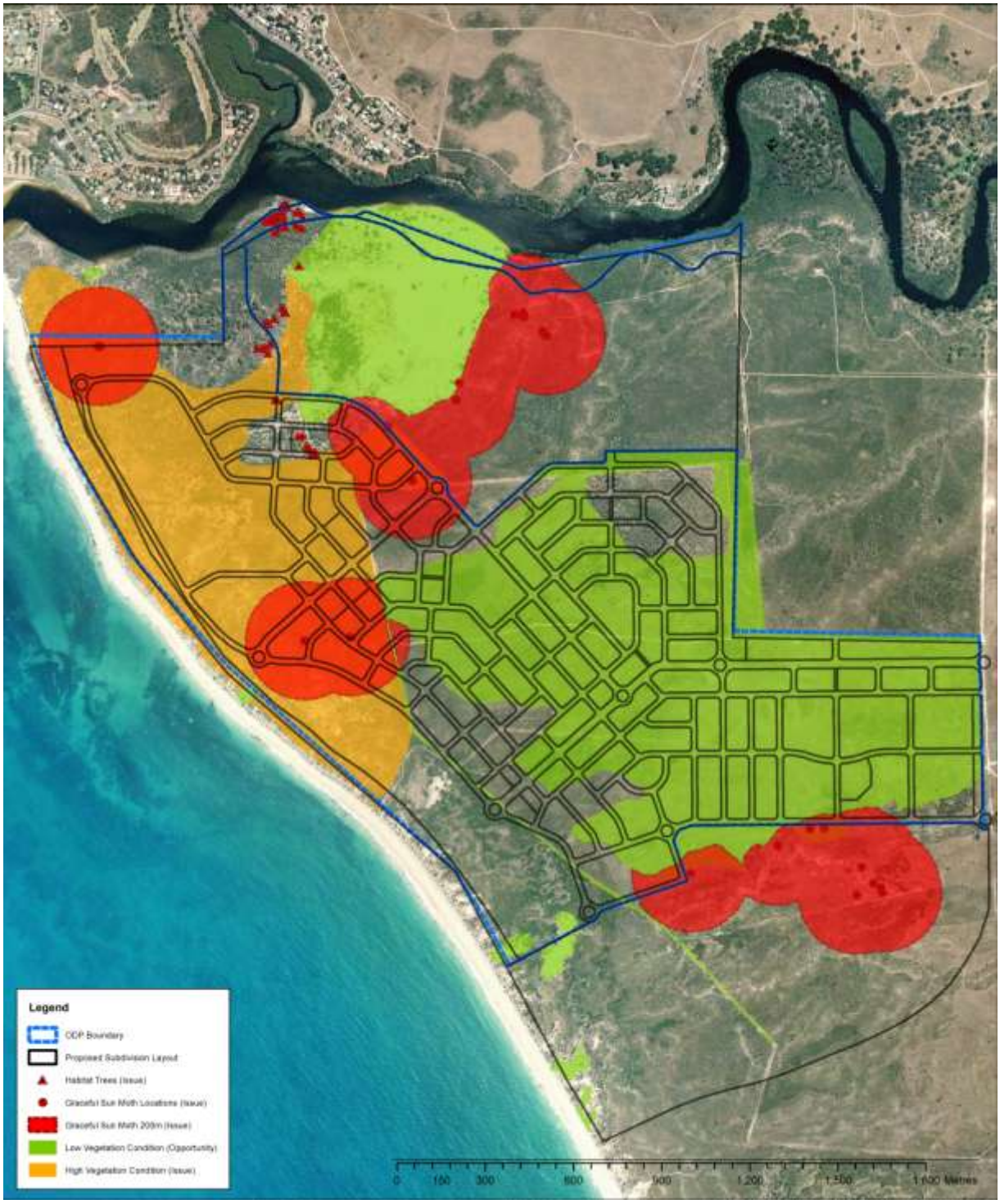


The proposed FMP will include a review of the existing legislation and policy context as well as an assessment of the existing environmental conditions of the site, utilising the comprehensive coastal and environmental reports that have been prepared in support of this revised ODP. This assessment will identify the environmental issues, opportunities and constraints associated with the foreshore, which will enable the development of a series of management principles to provide a guiding framework for the protection, future management and integration of the foreshore with the proposed future development.

A key attribute of the revised ODP is the significant portion of reserved that is proposed to be ceded free of cost. These reserves include the Crown Reserve to the north, the coastal foreshore and the river foreshore. It is anticipated at this stage that all reserves will be ceded to the State but the actual tenure of the reserves will be a matter for resolution with the proposed FMP.

The proposed FMP will be subject to public consultation with stakeholders within the local community. Active involvement with the community will help foster community identity within the Moore River South development and help the conservation and future protection of the foreshore environment.

Figure 5 - *Environmental Issues, Opportunities and Constraints Plan*



(A full copy of this plan is included as **Figure 13** *within the supporting Environmental Assessment Justification Report (***Appendix E***))*

5 Services Infrastructure

This section provides a summary of the servicing report prepared by Cardno in March 2010 in support of the revised Outline Development Plan (ODP), attached as **Appendix C**. The report updates the previous reports prepared in support of the approved 2000 ODP and investigates both availability as well as security of supply and emergency provisions for water, wastewater, power and telecommunications required for the revised ODP proposal.

The report reinvestigates the base or options available with consideration for alternative systems. The terminology of 'no risk' is used by the Water Corporation for their water and wastewater system in which there is a secure system for the use of water supply and, in the case of wastewater, a suitable treatment method together with a disposal solution for effluent.

The purpose of the engineering inputs to the revised ODP is to assess the extent and nature of the above facilities and to confirm, where possible, the feasibility of the various concepts for their implementation.

5.1 Physical Capacity of Land for Development

In general the ground conditions within the revised ODP area comprise sand overlying, to varying depths, Tamala limestone. In some locations the limestone outcrops at the surface as capstone. These conditions are well suited to urban development and would provide well drained and stable foundations for associated building.

Site ground conditions vary from alluvium and peaty sands along the Moore River to unstable dunes fringing the coast. These portions of the site are to be incorporated into foreshore reserves and therefore would not affect development proposals.

Maximum recorded groundwater levels within the area are typically less than 3m A.H.D. which is generally well below the minimum ground surface levels within the revised ODP area.

Surface slopes within the area are typically less than 10 percent and well suited therefore to urban development. In the parts of the site where slopes are steeper, in very undulating terrain, development would require the land to be earthworked to suit road and services requirements and to create suitable sites for building development.

Overall, therefore, it is considered that the siteworks, which would be necessary for the urban development proposals within the revised ODP area, would be feasible in line with both the planning and environmental objectives for the site.

5.2 Drainage Management

The sandy ground conditions within the revised ODP area would ensure that the proposed development would be well drained. There are no low lying areas where the groundwater table is so high that any development would be flooded during wet weather.

It is proposed that all stormwater run-off be contained and disposed of on-site with no direct discharges to either the ocean or the Moore River. This would ensure that any nutrients in the stormwater would be sufficiently filtered out before it enters the groundwater system, below the revised ODP area, and would ensure, therefore, that the risk of any pollution of the receiving waters would be minimised.

Within the site, stormwater disposal would be via infiltration basins and swales located within road reserves and areas of open space. These could be shallow sided, landscaped areas which could be utilised as areas of passive open space during periods of dry weather. Temporary drainage basins have been included within the natural low lying troughs of the coastal dunal system that is being retained as a key topographical feature of the site.

A water sensitive design approach would be adopted for the design of the drainage system. This could include the incorporation of swales and basins within road verges to dissipate flows and maximise the recharge of the groundwater system.

5.3 Water Supply

The servicing report proposes a 'no risk' water supply option sourcing water through groundwater. The revised ODP area falls under the Gingin Groundwater Area (GGA), whereby all water is currently sourced through groundwater and the Water Corporation has a license agreement with the Officer of Water Regulation for Guilderton. Within this licence area the Water Corporation have allocation for three bores.

It is proposed that the water supply be derived from bores as being the “no risk” option, however, the current bores owned by the Water Corporation are not enough to cater for the full future development water consumption. As it currently stands the existing bores have enough water available for local townships together with stages 1, 2 and 3 of the revised ODP proposal (refer Staging Plan - Section 10.3), after which additional water will be required, but there are concerns with the quality of the water available from the current supply point for the purposes of servicing both existing consumers and future requirements. To achieve a “no risk” scheme water system it will be necessary for the proponent and/or the Water Corporation to acquire additional bore water allocation either by direct purchase and/or water trading and investigations are currently ongoing in this regard.

During the State Administrative Tribunal's consideration of the appeal in relation to the 2003 subdivision application, the Western Australian Planning Commission (WAPC) accepted, based on evidence provided by Water Corp, that there was a reasonable degree of certainty that the provision of a reticulated water supply would be feasible and that the approvals required for the provision of this services could be obtained, and that this issue was not grounds for refusal of the subdivision application.

The proponent therefore seeks to work with government on a proposal to increase the security, reserves and quality of the public drinking water for the broader locality, probably sourced from a location closer to Guilderton and the development site than is the current Water Corporation bore field. In this regard an approach has been made to the WAPC Infrastructure Coordinating Committee with the intent that details of the final proposal being available to approval agencies concurrent with consideration of the revised ODP.

The demand for water will be significantly reduced form 'normal' due to the proposed re-use of treated effluent for non-potable purposes and at the requirement that new dwellings include water efficiency measures.

5.4 Sewerage

Based on the recommendations of the servicing report it is not considered that the collection and treatment of the wastewater will be problematic and during the summer months the final effluent, being class A+, will be disposed of by Public Open Space (POS) irrigation. During the winter months however, disposal by Managed Aquifer Recharge (MAR) is required which would assist in reducing existing salt and nitrate levels in the aquifer.

A centralised treatment plant is the preferred option for treatment with disposal by irrigation within the town site and possibly to agriculture. Given the "no risk" option being the preferred option for scheme water and a centralised treatment plant it would be expected, upon completion by the proponent, that the Water Corporation of Western Australia WCWA would become the licensed operator.

Disposal of treated wastewater to marine outfall is not an option for Moore River. For most of the year all the treated wastewater generated can be disposed of either by recycling to the surrounding rural lots for irrigation or by irrigation of POS. Climatic data shows that traditionally Moore River has a block of four months in winter when rainfall is high and exceeds evaporation. During this period irrigation would not be necessary and MAR would be the preferred option for disposal.

There are many potential uses for Class A+ recycled water. The most reliable at this stage is irrigation to the POS and is clearly possible for this scheme. During negotiation for the additional water allocation it is expected that a priority for use of the wastewater will emerge that represents a more beneficial use of this valuable resource.

The actual solution/technology is dependent on who the service provider will finally be and the economics of that selection. Detailed engineering will be necessary, in conjunction with the service provider, to ascertain the most economic solution.

5.5 Power and Telecommunications

The servicing report shows that sufficient power generating capacity and distribution is available in the area to cater for the revised ODP proposal and associated services.

The report shows that the existing telephone exchanges at Guilderton has sufficient capacity to serve the revised ODP proposal. The existing exchange will not be able to provide more advanced services such as high speed broadband but these services are available via mobile phone networks such as Next G and 4G. Mobile phone service coverage is provided from Telstra with mobile phone towers located at Moore River and on the Brand Highway between Gingin and Beermullah.

Currently, there is uncertainty if Telstra will provide underground infrastructure to service the revised ODP area, but if this service is not provided Telstra will provide home telephone communications via their mobile phone system at home phone rates.

5.6 Fire Management

The document 'Planning for Bushfire' is the key guidance for design of new development areas and has been used in the preparation of the revised ODP.

The new development will introduce scheme water and state of the art hydrant systems to Moore River. All bushfire protection and hazard perimeter criteria will able to be that and dual emergency access/egress routes will be available at all locations. Whilst the primary access road to the new development will be via Barragoon Road a system of unsealed but constructed alternative access routes will connect from the north east of the revised ODP area to Woodridge to provide an alternate emergency egress route. A detailed Fire Management Plan will be submitted at subdivision stage in accordance with usual practices.

6 Traffic and Transport

6.1 Background

A traffic assessment was undertaken as part of the 2000 approved Outline Development Plan (ODP), which addressed road hierarchy, network analysis, traffic analysis, road and intersection requirements, public transport, river crossings and pedestrian and cyclist movement. The assessment nominated Barragoon Road as the principal access road.

6.2 River Crossing Options

In accordance with Clause 5.5.1 of the Shire's Town Planning Scheme No. 8 Scheme Text, the approved ODP examined river crossing options to connect the serviced ODP area with Guilderton. An examination of options was undertaken by all consultants engaged in the project, identifying a possible river crossing corridor within which crossing options could be considered. The revised ODP has identified a location (within the possible river crossing corridor) for a possible river crossing, which is subject to change following further more detailed investigation.

Investigations have cast doubt over the feasibility, necessity and desirability for a vehicle bridge over the Moore River. However, the Shire of Gingin wants to preserve this option in accordance with the existing approved ODP and has resolved that the revised ODP retain the river crossing corridor on the basis that the Shire itself will investigate the matter within a Developer Contribution Plan (DCP) to be prepared by the Shire at a later date and subject to Guilderton Townsite Expansion Plans having been prepared. Therefore the road reserve shown on the revised ODP is notional and the final alignment will be determined in the Foreshore Management Plan and DCP processes and will be influenced by the final decision of the Shire with respect to a vehicular bridge.

The cost benefit of a pedestrian bridge is also doubtful at this stage. Notwithstanding, Moore River Company has made a commitment to proportionate funding of the pedestrian facility on the basis that funding, design and ongoing management issues can be resolved to the satisfaction of all stakeholders. Preliminary analysis indicates the pedestrian bridge would cost >$3M.

The detail of the possible construction of a river crossing will be the subject of input at the community consultation phase of the revised ODP and further discussions between the proponent, the Shire of Gingin, the WAPC and any other relevant State government agency.

6.3 Traffic Assessment

An updated transport assessment (**Appendix D**) has been undertaken by Cardno Eppell Olsen in support of the revised ODP. This additional assessment was required pursuant to the Western Australian Planning Commission's: Structure Plans - Guidelines for Transport Assessments, 2006.

As part of the assessment a forecasting of future traffic volumes was undertaken using the Cube transport planning software package. As part of this the following sub-tasks were undertaken:

- A trip generation exercise was undertaken to assess the quantum of traffic likely to be generated by each landuse and the entire development. This was assessed to be around 30,000 vehicles per day (vpd).
- A distribution exercise was undertaken using a simple gravity model to determine the volume of flows between internal landuses and the external road network. Based upon this exercise it was assessed that 16,000vpd would come from / leave to the external road network

- A traffic assignment exercise was used to assign traffic to the road network, allowing the prediction of traffic volumes on roads throughout the structure plan. Most roads are expected to have less than 3000vpd, whilst the main spine road coming into the development is expected to have 16,000vpd.

(*The above estimates are based on full development and will therefore not be experienced within a 20 year horizon)*

Following this an examination of the preferred bus and pedestrian routes was undertaken based upon the traffic volume and the spatial location of landuses such as schools, retail and commercial areas. This information, with the addition of proposed drainage information, then informed the development of a road hierarchy and recommended road cross sections.

The highest order road (The road entering from Wanneroo Road to the development) would be classified as an integrator A, and is recommended to be between 23 – 27m in width, with a 4m median and a 4m pavement in each direction with a cycle lane of 1.5m. Within the town centre areas, the assessment recommends that this be downgraded to an Integrator B Main Street, which would consist of a 25m road reserve with 2m median and 3.5m pavement, with a 1.5m cycle lane and 2.5m parking. It is recommended that other roads would consist generally of 3.5m road lanes, except Industrial neighbourhood connectors which would have 4m road lanes.

All road reserves in the revised ODP area have been designed to exceed the above recommended widths, for example the Integrator A and B roads are both 30m wide.

The revised ODP also proposes access to the site from Wanneroo Road via Barragoon Road. This route is currently an unsealed road between Link Road and Wanneroo Road that would need upgrading in the first stage of development so that there is limited impact on the Woodbridge residential area to the east of the site.

An additional assessment of sightline and basic geometric requirements for the access onto Wanneroo Road was undertaken. The recommendations from this were that:

- The operating speed along Wanneroo Road around the Wanneroo Road / Barragoon Road access be reduced from 110km/h to 90km/h so that safe sight distance requirements could be met. It is emphasized that such a reduction in operating speed to 90km/h is consistent with other treatments observed along Wanneroo Road as well as with the expected traffic volume entering/exiting the site (i.e. ultimately approximately 16,000vpd). Additionally, it is also logical that creating a 90km/h zone be around this access and the King Drive Access to the Woodbridge area to the north would improve safety along this section of road.
- A SIDRA assessment at the access suggests that to allow the right turn movement from Barragoon Road to clear effectively in both the AM and PM Peak Hours, a staged right turn crossing (IE. A short painted median in each direction) would be required, a 30m right turn in pocket would be needed along the Wanneroo Road North Approach to store queuing vehicles; and a left turn out short pocket that can store a single vehicle (IE. 30m) is needed at the Barragoon Road Approach.

The conclusion of the assessment is that the proposed transport network for the revised ODP proposal would operate acceptably under the network recommendations set out in the report.

7 Revised Outline Development Plan

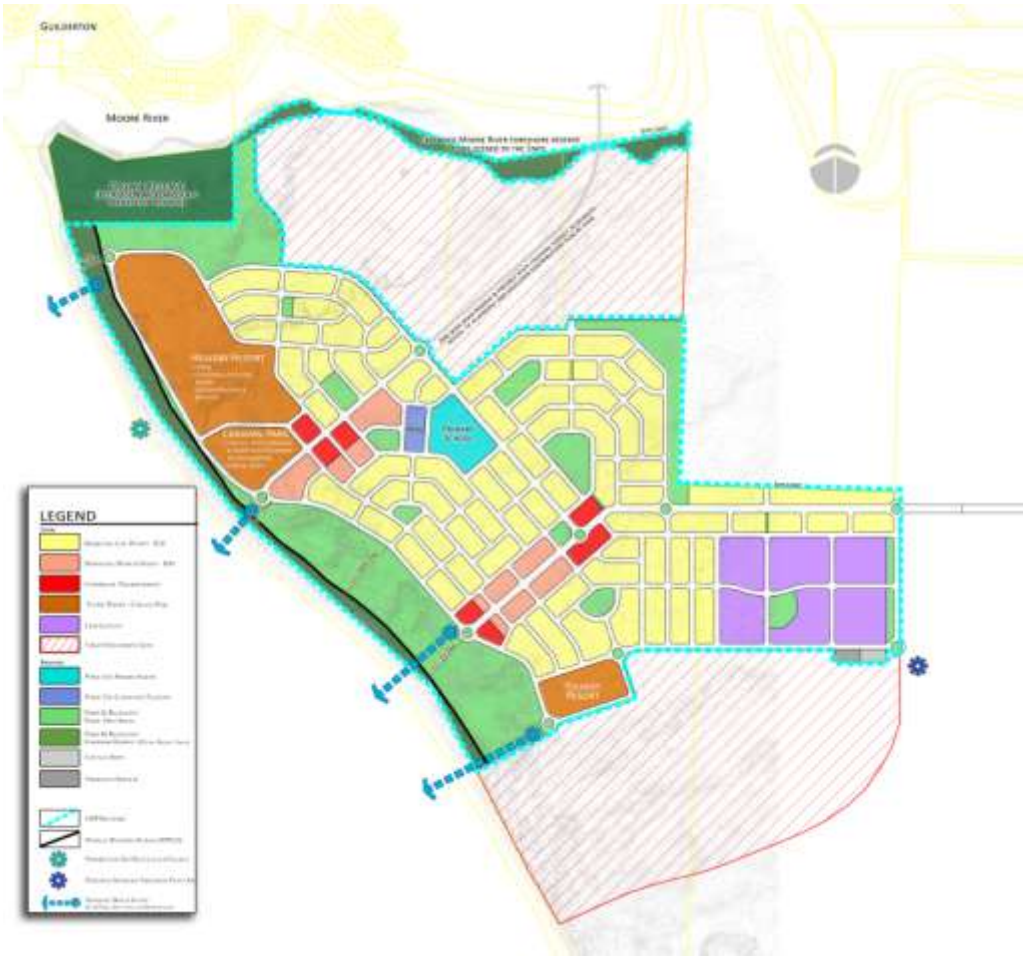
7.1 Project Summary

The proponent, the Moore River Company, has commissioned the preparation of this revised Outline Development Plan (ODP) for land south of Moore River following the Minister for Planning's recognition that the area, with a reduction in the scale of development, can accommodate a sustainable community catering for a population of up to 5,000 residents.

In response to the criteria set by the Minister for Planning the revised ODP area has been reduced from 557ha to 346ha, which will leave a 211ha area of the Urban Development zoned land unaffected by the proposal. The number of residential lots has been reduced from 5,000 to 2,000, which will see a reduction in the overall estimated population by approximately 8,500.

The area of land unaffected by the proposal will remain in the Urban Development zone. This land will be unable to support development without a further structure planning approval process at some time in the future. Any future structure plan would need to assess the site in detail in accordance with the special control area provisions of the Shire of Gingin Town Planning Scheme No. 8 as outlined in Section 2.2.2 of this report.

Figure 6 - *Revised Outline Development Plan*



(A full version of the revised Outline Development Plan is attached at the end of this report)

7.2 Revised Outline Development Plan Design Principles

The overarching design principles for the development of Moore River South are as follows:

- Create a revised ODP which meet the Minister for Planning's criteria for a reduced scale of development to provide for a sustainable community of up to 2,000 dwellings;
- Incorporate the twelve principal aims of the WAPC's Liveable Neighbourhoods policy;
- Provide a high quality living environment within the Shire of Gingin;
- Provide a range of compatible and environmentally sustainable uses that will cater for both the needs of the future community as well as the needs of surrounding existing local communities;
- Provide a design which responds to the natural topography with the retention of extensive areas for conservation purposes;
- Provide a design to accommodate wide road reserves and other design elements aimed at maximising the opportunity for capture of drainage at source and minimising impacts on groundwater;
- Provide significantly increased foreshore and other reserves to the Indian Ocean and the Moore River, to protect appropriate environmental features and provide for managed public access.
- Create Neighbourhoods which are compact and have a local shop and/or community facility in a central and walkable location.
- Ensure that adequate land is identified, in appropriate locations, for social, community and recreation purposes, and to foster early introduction of community facilities and services;
- Provide a variety of lot sizes and residential densities to accommodate the anticipated range of housing preferences;
- Provide sites for integrated tourist resorts to help meet the tourist demands of the region both now and in the future;
- Acknowledge the playground setting of the site and reflect a leisure/holiday theme within the design; and
- Generally reflect a more sympathetic response to site attributes within a contemporary design response.

7.3 Revised Outline Development Plan Design Overview

The revised ODP has been designed with the Minister for Planning's requirements for the future development of the site a key consideration. The design principles of the approved ODP have been adapted to reflect these requirements and to respond to issues that have arisen in light of additional technical studies required to be undertaken, particularly in relation to environmental issues.

Significant design changes between the approved 2000 ODP and the revised ODP include:

- Significantly reduced scale of development;
- Significantly increased setbacks from the Indian Ocean to allow for:
    - The physical processes setback (PPS) identified in the updated Costal Assessment report (**Appendix I**);
    - Retention of the sites natural topography, particularly in relation to the coastal dunal system;
    - Provision of natural drainage areas; and
    - Retention of important flora and vegetation communities.
- Exclusion of tourism uses adjacent to Moore River;
- Generous allocation of public open space to ensure retention of remnant vegetation;
- Protection of key physical environmental attributes;
- Increased road widths to maximise the opportunity for capture of drainage at source; and
- Creation of an extensive area of foreshore reserve to be ceded free of cost to the Shire of Gingin and/or the State for the purpose of recreation and conservation.

The design of revised ODP is based on a framework provided under the Western Australian Planning Commission's (WAPC) strategic policy document Liveable Neighbourhoods. The design reflects the 12 principle aims of Liveable Neighbourhoods as set out below and as considered under each element of the design in the following section of the report.

1. To provide for an urban structure of walkable neighbourhoods clustering to form towns of compatible mixed uses in order to reduce car dependence for access to employment, retail and community facilities.
2. To ensure that walkable neighbourhoods and access to services and facilities are designed for all users, including those with disabilities.
3. To foster a sense of community and strong local identity and sense of place in neighbourhoods and towns.
4. To provide for access generally by way of an interconnected network of streets which facilitate safe, efficient and pleasant walking, cycling and driving.
5. To ensure active street-land use interfaces, with building frontages to streets to improve personal safety through increased surveillance and activity.
6. To facilitate new development which supports the efficiency of public transport systems where available, and provides safe, direct access to the system for residents.
7. To facilitate mixed use urban development which provides for a wide range of living, employment and leisure opportunities, capable of adapting over time as the community changes and which reflects appropriate community standards of health, safety and amenity.
8. To provide a variety of lot sizes and housing types to cater for the diverse housing needs of the community at a density that can ultimately support the provision of local services.
9. To ensure the avoidance of key environmental areas and the incorporation of significant cultural and environmental features of a site into the design of an area.
10. To provide for a more integrated approach to the design of open space and urban water management.
11. To ensure cost-effective and resource-efficient development to promote affordable housing.
12. To maximise land efficiency wherever possible.

7.3.1 Community Design

In accordance with the principles of Liveable Neighbourhoods the revised ODP is predicated on the creation of a community structure with two clearly defined activity centres based on 400m walkable catchments and well defined edges.

The design allows for a transition from the rural land surrounding the revised ODP area to the denser mixed use urban cores of the activity centres. Moving outwards from the activity centres it is anticipated that residential densities would decrease from small cottage lots to fully detached houses.

An important component in the overall design has been the desire to retain the natural topography of the site and protect and enhance important environmental attributes wherever possible. In this regard, urban land uses have generally been proposed on those areas that have been subject to extensive past grazing and clearing. The natural topography of the site, including the coastal dunal system, has been retained where possible as either foreshore reserve or areas of public open space and areas identified of having important environmental habitat have been retained within the open space system.

7.3.2 Movement Network

The movement network within the revised ODP has been designed with an emphasis on connectivity, amenity, and integration to achieve safe, efficient and attractive street networks that not only cater for vehicles and public transport but also aims to attract pedestrians and cyclists.

In accordance with Liveable Neighbourhoods the revised ODP incorporates the following key design principles within the movement network:

- The street system is highly interconnected, aimed at reducing travel distances;
- Integrator arterial routes form the core of the revised ODP area;
- Street layout designed to maximise walk-ability - through a structure of local neighbourhoods based on 400m walkable catchments;
- Street widths maximised to ensure adequate and safe vehicle, pedestrian and cyclist interaction and to provide an integral part of the sustainable urban water management system proposed for the revised ODP area;
- Parkland areas within the revised ODP area to be fronted by streets;
- Use of four-way junctions to facilitate pedestrian and cycle movement and to encourage efficient lot configuration; and
- Within the proposed activity centres, integrator arterial routes are supported by parallel routes to serve local traffic and reduce pressure on arterial intersections.

A traffic assessment was undertaken as part of the 2000 approved ODP, which addressed road hierarchy, network analysis, traffic analysis, road and intersection requirements, public transport, river crossings and pedestrian and cyclist movement. An updated transport assessment (**Appendix D**) has been undertaken by Cardno in support of the revised ODP, as considered in the previous Section 6 of this report.

7.3.3 Residential - Lot Layout

The revised ODP allows for a mixture of lot sizes to provide housing choice to meet the housing requirements of retirees, weekenders, permanent residents and tourists. The purpose of the revised ODP is to provide a guiding framework for development. In regard to proposed residential densities it is intended that the revised ODP provides an indicative outline for future densities, retaining the flexibility for final definition to be determined at subdivision stage.

The general densities promoted generally range from R20 to R40. The recommended densities for various components of the revised ODP are as follows:-

- Residential Neighbourhoods - broad range including R20 and for medium density housing, R40;
- Tourist Resort Precinct - R30, R40, R60 and R80.

The average and minimum property sizes for each of the specified codes is as follows:

- R20 - (500m²/450m²);
- R40 - (250m²/220m²);
- R50 - (200m²/180m²)
- R60 - (180m²/160m²)
- R80 - (125m²)

The majority of the neighbourhoods have a density coding of R20, which it is anticipated will allow for a wide range of lot sizes and housing types, ranging from conventional larger lots with views to more medium density housing located close to parkland and other high amenity areas, such as the proposed activity centres and public transport stops, which will help support these facilities.

The revised ODP will allow for a future population of 5,000 residents through the provision of 2,000 residential lots. A total area of 111ha is allocated for R20 coded land and11ha for land coded R40. Given the rural nature of the area and the steep topography of much of the site, it is anticipated that the majority of lots outside of the neighbourhood centres will be developed greater than to minimum standards. Based on this assumption a 30% addition has been applied to average lot sizes (i.e. R20 - 600m² and R40 - 300m²) for the purpose of calculating the overall yield. In this regard the revised ODP can accommodate up to 1,720 R20 lots and 370 R40 lots yielding a total maximum of 2,090 residential lots. The revised ODP is a broadbrush plan and detailed lot layout, design and yields will be considered further through the subdivision of each stage of development.

Detailed Design and Settlement Guidelines (DSG) included within the revised ODP's Statements of Planning Policy (Section 9) sets appropriate standards for design of dwellings to meet sustainability criteria, building location and orientation, built form, building heights, scale and roof pitch, external colours and materials, curtilage and landscaping, vehicle parking and access and fencing, to the satisfactory of the Shire of Gingin.

7.3.4 Public Parkland

The WAPC requires that a minimum contribution of 10 per cent of the gross subdivisible area (GSA) of a new development must be given up free of cost by the subdivider for the purpose of Public Open Space (POS). Liveable Neighbourhoods requires that a minimum of 8 per cent be provided by active and passive recreational purposes ('unrestricted' POS). The remaining 2 per cent can comprise 'restricted' use POS, such as natural areas, urban water management measures such as swales and/or detention areas and artificial lakes/permanent drainage ponds.

Based on the area figures provided on the Open Space Plan (**Appendix A**) and the drainage figures provided in Tables 6 and 7 of the supporting Local Water Management Strategy (LWMS) (**Appendix H**) a POS Schedule (**Figure 7**) has been prepared in accordance with the provisions of Liveable Neighbourhoods.

The POS Schedule identifies a total 'creditable' POS provision of 12.6518 per cent of the GSA of the revised ODP area. However, should Liveable Neighbourhoods provision LNR43 be applied, and the restricted public open space in excess of the 2 per cent of the 10 per cent minimum is deducted from the overall site area, the actual total POS provision increases to 14.4904%.

Whilst the creditable provision of POS is slightly in excess of 12 per cent, the actual amount of open space provided within the revised ODP area (346.3575ha) as both public open space (64.9794ha) and other reserve areas (21.9702ha) is actually in excess of 25%.

Figure 7 - *Open Space Schedule*

Public Open Space (POS) Schedule - Moore River South - Revised Outline Development Plan			
Revised ODP Area			**346.3575**
Less:			
Foreshore Reserve to be Ceded	**21.9702**		
***Drainage Basins with Parkland Areas 3-13 (more frequent than 1 in 1 yr rainfall) (LNR33)**	**0.9435**		
Total		**22.9137**	
Net Site Area			**325.4438**
Deductions:			
Primary School	**4.7370**		
Tourist Sites 1-3	**36.4009**		
Lifestyle Property Areas 1-6	**22.9925**		
Community Site Areas 1 & 2	**1.2620**		
Neighbourhood Commercial Area 1-7	**5.3448**		
Total		**70.7372**	
Gross Subdivisible Area			**252.7066**
POS Required			**25.2707**
POS Contribution			
May Comprise:			
Minimum 80% Unrestricted POS			**20.2166**
Maximum 20% Restricted POS			**5.0541**
Unrestricted POS Sites:			
Parkland 2 (Buffer to Crown Reserve)	**13.3941**		
Parklands 3 - 14 (includes drainage basins 1 in 5 to 1 in 100 yr / excludes drainage basins 1 in 1 to 1 in 5 yr and more frequent than 1 in 1 yr rainfall) (LNR25)	**13.5238**		
Total Creditable Unrestricted POS			**26.9179**
Restricted POS Sites:			
Parkland 1 (Coastal Dunal System)	**34.2695**		
Restricted Drainage Basins (1 in 1 to 1 in 5yr rainfall) (LNR33)	**2.8485**		
Total Restricted POS		**37.1180**	
Total Creditable Restricted POS			**5.0541**
Total Creditable (Unrestricted & Restricted) POS Provision			**31.9720**
Total % POS Provision			**12.6518%**

Drainage basin locations within the revised ODP area are depicted on Figure 10 and the rainfall events and required storage areas shown in Tables 6 and 7 of the supporting Local Water Management Strategy (*Appendix H***).*

NB: It should be noted that if Liveable Neighbourhoods provision LNR43 is applied and the restricted public open space in excess of the 2 per cent of the 10 per cent minimum (i.e. 32.0639 ha) is deducted from the overall site area the total POS provision increases to 14.4904%.

The revised ODP has been designed in accordance with Liveable Neighbourhoods incorporating the following principles into parkland design:

- Provide for a balance between conservation and active and passive recreational use in district, neighbourhood and local open space;
- Incorporate natural features;
- Provide for parks in a safe walking distance from all dwellings;
- Allow for parkland frontage and surveillance - through the provision of perimeter roads around parkland areas;
- Incorporate drainage wherever practicable using contemporary urban water management principles;
- Accommodate water-sensitive urban design in parkland areas where usability for recreation purposes has not been compromised or where conservation values are enhanced; and
- Adopt a conservative design approach to provide more open space than is technically required.

The design and layout of the parkland areas has been considered in conjunction with the preparation of the supporting Local Water Management Strategy (LWMS) (**Appendix H**). **Figure 11** of the LWMS indicates the location of the required areas of drainage, including natural drainage basins within the troughs of the coastal dunal system, swales and bio-pockets within the proposed road reserves, and vegetated basins within the formal parkland areas. Where a drainage function (i.e. for events more frequent than 1 in 5yr rainfall) is provided within formal parkland the affected area is considered as 'restricted' POS (pursuant to the provisions of Liveable Neighbourhoods) for the purpose of calculating the overall POS provision. Tables 6 and 7 of the supporting LWMS include the required storage area sizes which have been included within the POS Schedule (**Figure 7**).

The revised ODP includes two large areas of public open space: Parkland 1 (34ha) between the coastal foreshore reserve and the development; and, Parkland 2 (13ha) between the crown reserve and the development to the north.

Parkland 1 retains the coastal dunal system and provides for natural areas of drainage and habitat protection. The parkland will allow for low key passive recreation, with strategic access to the beach. Given that the area will include areas for drainage Parkland 1 is considered as 'restricted' POS for the purpose of calculating the overall POS provision.

Parkland 2 provides a buffer between the development and the Crown Reserve to the north and will allow for the protection of important flora and vegetation communities. Parkland 2 will also be considered for low key passive recreation purposes with a series of walk trails, viewing locations and interpretive stops and providing access to the Crown Reserve to the north and the coast to the west. As there are no urban water management features Parkland 2 is considered as 'unrestricted' POS.

Parkland areas 3-13 as shown on the POS Plan (**Figure 8**) are located internally within the revised ODP area. These formal areas of POS range in size from 3000m² to 6ha and provide for a varied provision of parkland areas that will allow for a balance between neighbourhood parks, local parks and district playing fields. The detailed design of these parkland areas will be considered and assessed at subdivision stage. In accordance with the provisions of Liveable Neighbourhoods, all parts of the revised ODP area are within at least 400m of a formal parkland area.

In accordance with recommendations from Cardno's Environmental Assessment, various parcels of good quality remnant vegetation are recommended for protection within public parklands. A further detailed consideration of the significant environmental issues that have influenced the revised ODP design is considered in Section 4.14 of this report.

State Planning Policy 2.6 - State Coastal Planning Policy requires that, where a subdivision abuts the coast, that any foreshore be ceded free of cost without payment of compensation by the Crown and

will be in addition to the 10 per cent public open space contribution. The revised ODP includes a significantly increased coastal foreshore setback (compared to both policy requirements and the approved 2000 ODP) based on the physical processes setback identified within the updated Coastal Assessment Setback Assessment (**Appendix I**), which together with the foreshore adjacent to the Moore River, will be given up as part of subdivision approval.

Figure 8- *Open Space Plan*



(A full version of the Open Space Plan is included as **Appendix A***)*

7.3.5 Activity Centres and Employment

The revised ODP design adopts a main street mixed activity centre approach with two neighbourhood commercial centres located centrally and within a 400 to 500m radius of all surrounding neighbourhoods. In accordance with the principles of Liveable Neighbourhoods it is the intention that these centres, through the provision of high quality mixed use development, will encourage local employment provision, higher density housing in the surrounding area, higher amenity environments, and modes of transport other than the private car.

The approved 2000 ODP was designed to cater for a total of 13,500 people and a district centre design approach was proposed to cater for the needs of the community. The revised ODP has been reduced considerably to cater for a total population of 5,000 and therefore the facilities and services that will be required will be better provided through a neighbourhood centre approach. These centres will be able to service the whole of the revised ODP area being within convenient walkable catchments of 400 to 500m and therefore removing the need for other smaller supporting centres.

To encourage successful neighbourhood commercial centres the revised ODP has been designed to take account of the following factors, as set out in Liveable Neighbourhoods:

- A required minimum local residential population of approximately 2,000 people - the ultimate population of the revised ODP will be for 5,000 people serviced by two neighbourhood centres;
- Central location in good walkable catchments for local residents - being located within 400 to 500m of all neighbourhoods;
- Location on a busy main street with good traffic levels - the northern centre being located on a Neighbourhood Connector A and the southern centre on the Integrator B (Main St);
- Good on street parking in front and across the street - accommodated through the wider than average road reserves proposed;
- Preferably a two-storey building design - to be considered at the later stages of planning; and
- Slight under-provision (rather than overprovision) of retail to maximise vitality - 500m² retail floor space cap to be integrated with the caravan park and tourist resort components of the revised ODP and provide for local convenience shopping and services in the first stages of the overall development.

The proposed neighbourhood commercial centres will allow for high quality mixed use development and this is advocated through both the Shire of Gingin Town Planning Scheme No. 8 (TPS8) and the draft Town Planning Scheme No. 9, which allow for a mix of uses within 'Commercial' zoned land. Uses appropriate to the neighbourhood centres and allowed pursuant to TPS 8 include: holiday accommodation; home business; medical centres; consulting rooms; motels; offices; service stations and shop/retail.

Whilst the two neighbourhood centres are comparable in size, the centre to the north is proposed to be included within the first stage of development, along with the primary school, community facilities site, and caravan park, which are adjacent to and form part of this centre. The inclusion of this mix of uses will service the future needs of the area, but importantly, will also provide much needed facilities and services to the surrounding townsites of Guilderton to the north and Woodridge to the east.

7.3.5.1 Lifestyle Property Area

A 22 ha area is provided to the western extremity of the revised ODP area to provide for an area of Lifestyle Properties. It is envisaged that these Lifestyle lots will be developed for the purpose of light / service industry and to support home based business.

Larger lot sizes of 3000m² will allow for residential use in the interim but will provide for an efficient lot layout and access for rear parking, together with large front setbacks that will enable a business to be constructed in front of a dwelling at a later stage. The final layout of this area, the apportionment of areas for residential and business use on one lot, will be controlled by a Detailed Area Plan to be formulated and approved at subdivision stage.

It is the intent of the Lifestyle Lots to provide for appropriate local businesses and other employment generating activities in order to encourage as many locally based jobs as possible.

7.3.6 Community Facilities

The identification of the types and ranges of community facilities required to sustain an ultimate population of 5000 people and ensuring land is provided for these facilities is an integral part of the revised ODP design.

7.3.6.1 Primary School

The revised ODP identifies a site for a Government Primary School, which is proposed to be granted free of cost. The Education Department requires one Primary School for every 1,800 dwelling units.

The Primary School is located centrally to facilitate convenient access. It is located in close proximity to the neighbourhood commercial centre and adjacent to the Community Sites, site to enable joint use of these facilities. The school has been strategically located to ensure that all school children within the revised ODP area will live generally within a 1km to 1.5 km radius of a school.

The approved 2000 ODP identified that approximately 80 children from Woodridge and 20 children for Guilderton travel to Gingin daily for their schooling. The Education Department acknowledges that those student numbers alone generate the need for a local school. The revised ODP is considered to be the ideal location for a new school site. As such, to meet not only the needs of the future population of the revised ODP area, but to also meet the needs of the surrounding areas of Guilderton and Woodridge, the primary school site is included within the first stage of development.

7.3.6.2 Public Use Community Facilities

The revised ODP area will likely generate the need for a community hall, senior citizens centre, infant health clinic, library and in the future a Shire of Gingin local office.

In accordance with the principles of Liveable Neighbourhoods, the community sites are located centrally within the revised ODP area adjacent to the primary school site and in close proximity to the neighbourhood commercial area to the north.

7.3.6.3 Medical Centres

The revised ODP area will ultimately accommodate a medical centre(s) comprising doctors, dentists, other specialists and pharmacies. No land provision is required for these centres as they are usually located adjacent to commercial centres. Additionally, pursuant to the Shire of Gingin Town Planning Scheme No. 8, consulting rooms are permitted on residential land with Council approval.

To ensure community development is adequately provided the revised ODP includes Planning Policy Statement No. 8 (Section 9) to require a comprehensive community facilities infrastructure contribution plan to be:

- Prepared, identifying the basis for determination of contributions to be made to fund community facilities and infrastructure within the locality required as a direct result of the development of the land;
- Submitted to, and approved by, the Shire prior to the lodgement of an application for planning approval or building licence and prior to the clearance of any subdivision of the land; and
- Implemented to the satisfaction of the Shire.

The proponent has undertaken to sponsor the provision of floor space in the first stage of development to facilitate the earliest possible availability of medical and other services to the new and existing communities. In this regard, the Planning Policy Statement also requires that a general purpose community purpose facility shall be provided as part of the first stage of development. It is

anticipated that this facility will initially be in the form of an open plan dwelling or similar structure for temporary use pending the development of purpose built structures once the community reaches sufficient critical mass to require and sustain specified services.

7.3.7 Tourist Resorts

Three tourist resort sites are identified within the revised ODP area, all adjacent to the coastal foreshore with direct pedestrian access to the coast via proposed strategic beach access points. The tourist resort that was proposed adjacent to Moore River on the approved ODP has been omitted from this revised ODP.

The largest (25 ha) Holiday Resort to the north of the revised ODP area recognises the particular attractiveness of the coastline, the prominent and protected Crown Reserve and the site identified as suitable for a possible boat launching facility, and its proximity to the river. The Environmental Assessment (refer Section 4) carried out by Cardno as part of this revised ODP has identified important flora and vegetation communities within this site and it is anticipated that proposed Holiday Resort will be designed to retain these communities where possible and make a feature of the protected areas within the resort. Further consideration will be given to this at the detailed design stage. Associated facilities intended for the resort include cabins, conference facilities, and resort accommodation at a density consistent with site attributes.

The second largest tourist resort (6 ha) is proposed as a Caravan Park to provide for chalets, tents, caravans and a general store. In recognition of the high demand for this type of accommodation in the area, particularly during peak holiday seasons, the proposed Caravan Park has been included within the first stage of development. The revised ODP includes Planning Policy Statement No. 2 (refer Section 9), which requires that a maximum of 500 m² of retail floor space shall be integrated with the caravan park and tourist resort components of the ODP and provide for local convenience shopping and services in the first stages of the overall development. The Caravan Park will be required to make specific provision for short term (overnight) stays by the travelling public, tow-in caravans and ‘grey nomads’.

The smaller (5 ha) Tourist Resort is located at the southern extremity of the revised ODP area. There is no proposal for the use of this site given that it is identified within the last stage of development. It is envisaged that this site will be developed in accordance with the tourist zoning provisions of an approved Town Planning Scheme. Pursuant to TPS8 the following uses are permissible within the 'Tourist zone': aquaculture; bed and breakfast; caravan park; child minding facilities; dwellings, health studio; holiday accommodation; home business; licensed premises; medical centre; motel; office; public amusement; service station; shop; and, vehicle sales and hire.

8 Viewshed Analysis

Riverine, coastal and estuary landscapes are highly valued by the community and it is important that any development of the ODP area is cognisant of this. Additionally, the visual impact of any new development adjacent to an existing townsite (Guilderton) needs to ensure that development is consistent with the existing landscape values of the environment and the surrounding developed area.

Visual impact was raised as a key community concern during community consultation for the 2000 ODP and in response to this issue a viewshed analysis of the revised ODP area from Guilderton was undertaken.

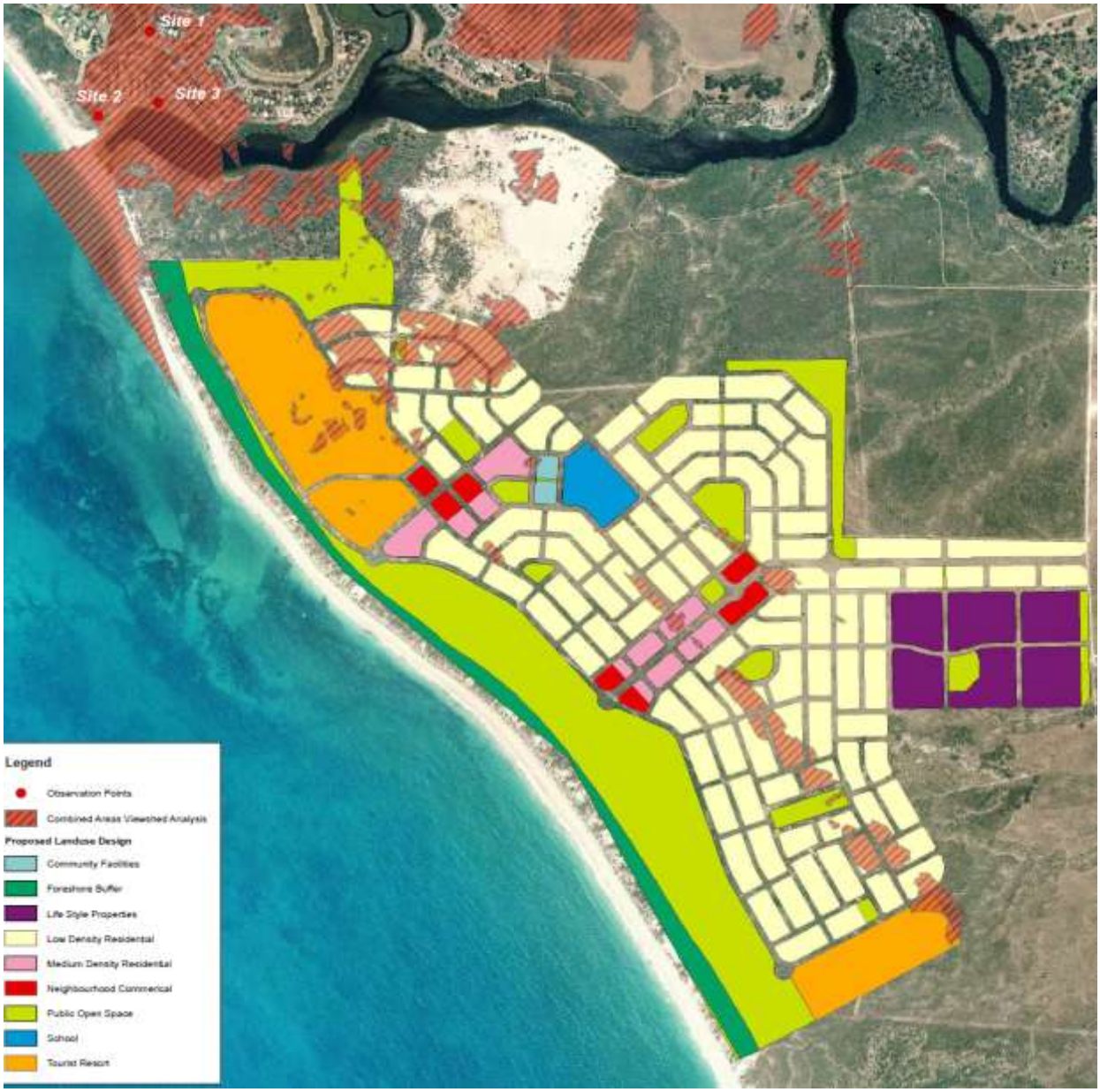
Key viewing locations of the revised ODP area from Guilderton were identified including:

- *Site 1* - Intersection of Gordon Street and Mullins Street, Guilderton;
- *Site 2* - Guilderton lookout; and
- *Site 3* - Guilderton foreshore and picnic area (northern side of Moore River riverbank).

From these locations a 'seen area analysis was conducted, to determine the area of a two-storey (9m) hypothetical development that would be visible from these locations. The two-storey scenario allows for a worst case scenario, although it is considered that the majority of future development will be single storey. This analysis was based on existing contours and assumed no vegetation cover or built structures.

A combined viewshed analysis, which overlays the visible area of a hypothetical two-storey development from all three locations is shown in **Figure 9** overleaf.

Figure 9 - *Viewshed Analysis*



The viewshed analysis demonstrates that only a small portion of the revised ODP area is visible from Guilderton. The greatest visibility of the revised ODP area is from the intersection of Gordon Street and Mullins Street (Site 2), which is not a significant viewing location for Guilderton. Viewers in this location would commonly be in cars and would not be stopping to observe any views.

The more significant viewing locations for the revised ODP area are the foreshore (Site 3) and the lookout (Site 1) as people in these location are likely to be looking out towards the revised ODP area. From both sites there are restricted views of the revised ODP area, only visible from over one kilometre away, when any development would occupy only a small portion of the observer's field of vision. The revised ODP area will also be obscured by vegetation over the area, which is not considered in the 'seen area analysis'.

The viewshed analysis demonstrates there are minimal visual impacts of the development of the revised ODP area from Guilderton. The use of a two storey analysis provides a worst-case scenario for the development, as the majority of dwellings are likely to be single storey over the revised ODP

area. In addition, it is likely that the finalised construction levels be smoothed to achieve development and hence structures will be lower than presented in the analysis.

In identified areas, which may be visible, additional visual management measures can be incorporated into future design and planning of the revised ODP area. For example, design guidelines may incorporate measures to reduce visual impacts including:

- Use of non-reflective materials, particularly on roofs;
- Use of eaves on windows to shade from glare and reduce the reflection of glass;
- Use of colours that blend into the current landscape (neutral colours) and consistent colour schemes across the development; and
- Use of natural building materials, such as local soil or rock.

Incorporating these measures into the built form of the proposed development would help blend the development into the existing landscape.

9 Implementation of Revised Outline Development Plan - Planning Policy Statements

The implementation of the revised Outline Development Plan (ODP) once approved will be facilitated through the subdivision and development approvals process, which pursuant to Town Planning Scheme 8 will be required to generally conform with the approved ODP. Future applications will be required to demonstrate compliance with the following key Planning Policy Statements:

1. **Subdivision and Development**

The development of the subject land shall be undertaken generally in accordance with the endorsed Outline Development Plan (ODP). Subdivision of the ODP area requires approval from the Western Australian Planning Commission (WAPC) and shall be undertaken generally in accordance with the ODP.

2. **Retail Floor Space**

A maximum of 500 m² of retail floor space shall be integrated with the caravan park and tourist resort components of the ODP and provide for local convenience shopping and services in the first stages of the overall development.

3. **Design and Settlement Guidelines**

Detailed Design and Settlement Guidelines (DSG) will be prepared and implemented by the proponent to guide the form and nature of buildings and structures in the ODP area. The DSG will set appropriate standards for design of dwellings and commercial and tourist development to meet sustainability criteria, building location and orientation, built form, building heights, scale and roof pitch, external colours and materials, curtilage and landscaping, vehicle parking and access and fencing.

The DSG will promote and encourage the installation of water tanks, water efficient taps and appliances and solar energy harnessing devices in every dwelling.

The Design and Settlement Guidelines may include special provisions for the 'Lifestyle Lots' precinct shown on the ODP map to set standards for lot sizes, separation of uses and setbacks in addition to the matters outlined in 3 and 4 above.

The DSG is intended to supplement the Residential Design Codes. In the event of a contradiction or inconsistency between the DSG and the Residential Design Codes the Residential Design Codes will prevail.

4. **Staging of Subdivision and Development**

The progressive subdivision and development of land identified for residential lots (both green title and strata) on the ODP shall proceed on the basis of a staging plan approved by the Shire and the West Australian Planning Commission that has regard for the necessity for the introduction of reticulated water and sewerage facilities to the ODP area and the early establishment of foreshore improvement works.

5. **Tourist Units**

The strata subdivision and/or development of any land identified on the ODP for tourist accommodation shall include common management arrangements to ensure the tourist units and any associated facilities are available at all times for tourists, visitors and travellers. These arrangements are not intended to preclude owner use of tourist accommodation for holiday purposes.

6. **Foreshore Reserves**

A foreshore management plan shall be prepared under clause 5.1(x) and (xi) of State Planning Policy No. 2.6: State Coastal Planning Policy.

The foreshore management plan must:

- Include the foreshore reserves for both the ocean and Moore River frontages of the development identified on the ODP and the adjacent Crown Reserve abutting the mouth of the Moore River ;
- Contain a schedule of works, public facilities, infrastructure and amenities provision and implementation schedule;
- Identify those with responsibility for implementation of the plan and management of the reserves thereafter;
- Be subject of its own public consultation process;
- Be approved, if acceptable, by the Shire of Gingin; and
- Identify required works to be fully implemented prior to the Shire's clearance of the conditions of any subdivision approval granted for the ODP area.

The staged construction of the Foreshore Management Plan and Public Open Space by the Proponent is to be determined at the Subdivision stage or through a Development Deed between the proponent and the Shire in a manner that reflects progressive development of the project and progressive demand for additional facilities.

The ocean foreshore reserve and adjacent public open space is able to be used for drainage works or functions, including subsurface stormwater drainage and absorption structures, which do not materially diminish the capacity of the area for public use.

7. **Fire Management Plan**

A fire management plan must be prepared and implemented to the satisfaction of the Shire of Gingin and the Fire and Emergency Services Authority.

Development must be undertaken in compliance with:

- Part 3.7.4 (Bushfire Areas) of the Building Code of Australia; and
- Australian Standard 3959.

A memorial is to be placed on the Certificate of Title for those lots affected by the fire management plan advising of the requirement to comply with the approved fire management plan and the owner's responsibility to maintain fire protection measures and emergency access to an appropriate standard.

8. **Community Facilities**

A comprehensive Community Facilities Infrastructure Contribution Plan shall be:

- Prepared, which identifies the basis for determination of the nature and extent of community facilities and infrastructure within the development area required to be provided by the developer as a direct result of the development of the land;
- Submitted to, and approved by, the Shire prior to the lodgement of an application for planning approval or building licence and prior to the clearance of any subdivision of the land; and
- Implemented to the satisfaction of the Shire.

A small multipurpose community facility shall be provided as part of the first stage of development of the ODP area.

9. **Revegetation, Rehabilitation and Landscaping**

A revegetation, rehabilitation and landscaping plan shall be:

- Prepared and submitted to the Shire for approval as part of any application for planning consent; and
- Implemented to the satisfaction of the Shire.

10. **Dust Management**

A dust management plan is to be:

- Submitted to and, if acceptable, approved by the Shire; and
- Implemented at each and every stage of development to the satisfaction of the Shire.

11. **Landscape Strategy**

A landscape strategy plan for the road reserves including the primary access road from Wanneroo Road and public open space areas shall be prepared, which:

- Indicates the location and species of all trees to be removed and/or retained;
- Indicates the location and type of fencing to be installed;
- Indicates the location and type of reticulation to be installed;
- Indicates the location and type of paving to be installed; and
- Includes a plant schedule nominating each species, the spacing of species, the numbers of plants required, and the size of each plant to be used at the time of planting and the anticipated height of each plant at maturity.

The landscape strategy plan shall be:

- Submitted to and, if acceptable, approved by the Shire;
- The subject of a management agreement between the owner and the Shire; and
- Implemented to the satisfaction of the Shire.

12. **Construction Management Plan**

Any Construction Management Plan required to be prepared at the subdivision or development stage shall include the technical, physical and contractual measures to minimise environmental impacts during construction and post-construction.

13. **Stormwater and drainage**

A stormwater and drainage management plan shall be:

- Prepared, which identifies the locations and dimensions of all proposed pump stations, infiltration basins and sumps;
- Submitted to and, if acceptable, approved by the Shire and the Department of Water; and
- Implemented to the satisfaction of the Shire.

The design objectives of the stormwater and drainage management plan will be to optimise the infiltration of stormwater at source and the reuse of water.

14. **Utilities and Services**

All development is to be connected to underground power, telecommunications and reticulated water and sewage services.

The design of utilities and services will be aimed at the maximum feasible use of technology capable of capture of energy from wind and solar sources and the reuse of wastewater so as to minimise the demands of the new development for importation of energy and water.

All utilities and services are to be contained within the ODP area or where outside the ODP area within a public road reserve, Shire managed reserves or easements specifically created for that purpose.

These connections are to occur at the first stage of development at the full cost to the owner/developer and to the satisfaction of the Shire and, in relation to water and sewage, the Water Corporation.

15. **Traffic Management and Parking**

A traffic and parking strategy shall be:

- Prepared by a suitably qualified traffic engineer, which:
- Shows the required upgrading works for the local road system, including the intersection of the primary access road and Wanneroo Road;
- Shows the staging of these works relative to the staging of the development;
- Assesses the future public, private residential and tourist car park requirements generated by the development proposed in the ODP area; and
- Able to demonstrate that sufficient foreshore parking or alternative access is provided for tourist and residential development as well as the demands of visitors and the general public.
- Submitted to the Shire and, if acceptable, approved by the Shire and Main Roads WA; and
- Implemented to the satisfaction of the Shire prior to the Shire's clearance of any condition of any approval granted for the subdivision or strata subdivision of land within the ODP area.

All residential lots are to contain on-site car parking in accordance with the Residential Design Codes.

16. **Further Subdivision**

Subdivision of the residential areas depicted on the ODP will only be permitted in accordance with the Residential Design Codes.

17. **Special Land Use Controls**

The following special land use exemptions will apply to development in the ODP area:

- For the purposes of facilitating provision of community facilities in the initial stages of development land identified as being within the 'Residential zone on the ODP map may be developed for the purposes of 'educational establishment', 'medical centre', 'shop', 'civic use' and/or 'office' as defined under the Shire of Gingin Town Planning Scheme No. 8 (TPS 8) and on the basis of being an 'SA' use for the purposes of Table 1 – Zoning Table in the scheme;
- 'Civic use' and 'educational establishment' are deemed to be 'AA' uses in the Commercial zone under TPS 8; and
- Land in the area shown as 'Lifestyle Lots' on the ODP map may be developed for all land uses marked as 'P', 'IP' and/or 'AA' opposite the Residential and Industrial zones in Table 1 – Zoning Table in TPS 8 subject to the application processes and considerations that apply according to each land use pursuant to Table 1 and Clause 3.2 of TPS 8.

10 Population and Employment Opportunities

10.1 Population and Growth

The approved 2000 ODP envisaged an ultimate population of 13,500 residing in 5,269 dwellings. An assumption of 2.8 persons per residential dwelling was made. In the formative years lower than average household sizes were anticipated - particularly through the likely greater presence of retirees and 'empty nesters'.

In response to the State Cabinet's acknowledgement that, subject to a reduction in the scale of development, the existing Urban Development zone could accommodate a sustainable community, the revised ODP has been designed to reflect a total population of 5,000 residents. This figure is based on the States assumption of an occupancy rate of 2.5 persons per dwelling.

In determining the actual likely occupancy rate of the revised ODP area a comparison was made with the neighbouring coastal towns of Yanchep to the south, Lancelin to the north and the existing adjacent townsites of Guilderton and Woodridge, based on the 2006 Census details (http:www.censusdata.abs.gov.au) in relation to population and housing, as set out in the table below.

Table 1: Australian Bureau of Statistics Data (2006)

	Yanchep	Guilderton	Lancelin	Woodridge
Population	2,482	146	666	565
Dwellings	1,194	432	878	266
Occupancy Rate	2.1	0.3	0.8	2.1

For the purpose of considering servicing requirements based on the occupancy rates above a conservative rate of 1.8 persons per dwelling was considered.

The timeframe envisaged for the revised ODP to achieve full development is approximately 25 to 30 years. Even then, it can be expected that approximately 15% of the area will be undeveloped, consistent with the established patterns of development for similar communities throughout Australia. At the time of full development, the population characteristics will very likely reflect those of Mandurah - a mix of permanent residents (families and retirees) and weekenders/holiday makers/tourists. There is no accurate means of predicting how and when the resident mix will change. It is acknowledged however that families with children will be more attracted to the area when particular facilities are provided, e.g. schools.

10.1.1 Employment Opportunities

The revised ODP area is intended to attract the full cross section of the community - retirees, empty nesters, families, investors, weekenders, tourists, etc.

The site's locational attributes and attractions are those of a holiday town and not of an expanding Perth suburb. It is expected that the minimal employment opportunities in the early years of development will attract people of similar characteristics to those occupying the existing Guilderton townsite, i.e. retirees and weekenders. Retirees are not seeking employment and the weekenders are generally employed in the city, which is their permanent residential address.

This revised ODP ensures that employment opportunities are provided through the allocation of land for, commercial, tourist, light industrial uses, and other uses. The revised ODP also acknowledges that employment follows residential expansion. Employment opportunities will be progressively

provided via the following land uses shown on the revised ODP - neighbourhood shopping centres, mixed business and service industry (Lifestyle Lots), a school, community facilities, medical centres and three tourist resorts.

The proposed Lifestyle Lots are a specific component of the revised ODP, introduced to stimulate early development of small business.

The anticipated employment opportunities within the revised ODP area, at ultimate development, are shown on the following table:

Table 2: Estimated Employment Opportunities in Revised ODP Area

	Activity	Estimated Employees / ha or Employment Estimate	Total Area	Employment Opportunities
Retail	Neighbourhood Commercial	40 / ha	5.3	212
	Lifestyle Areas	5 / ha	22.9	114
	Primary School	30 / school	4.7	30
	Community Facilities	40 / ha	1.2	48
Tourist	Holiday Resort	15 / ha	25.4	381
	Caravan Park	15 / ha	6	90
	Tourist Resort	15 / ha	5	75
			TOTAL	950

10.2 Overall Land Use Data

The following table identifies the allocation of the various land uses:

Table 3: Land Use Summary

TOTAL SITE AREA (HA)	346
RESIDENTIAL POPULATION	5000 (inhabitants)
RESIDENTIAL LOTS / DWELLINGS	2000 (dwellings)
Residential Area	119
COMMERCIAL	
Commercial Neighbourhood	5.3
Lifestyle Lots	23
TOURIST RESORTS	
Holiday Resort	25
Caravan Park	6
Tourist Resort	5
COMMUNITY	
Primary School	4.7
Community Sites	1.3
RECREATION	
Foreshore Reserves	19
Public Open Space	105
Road Network	32.7

10.3 Staging

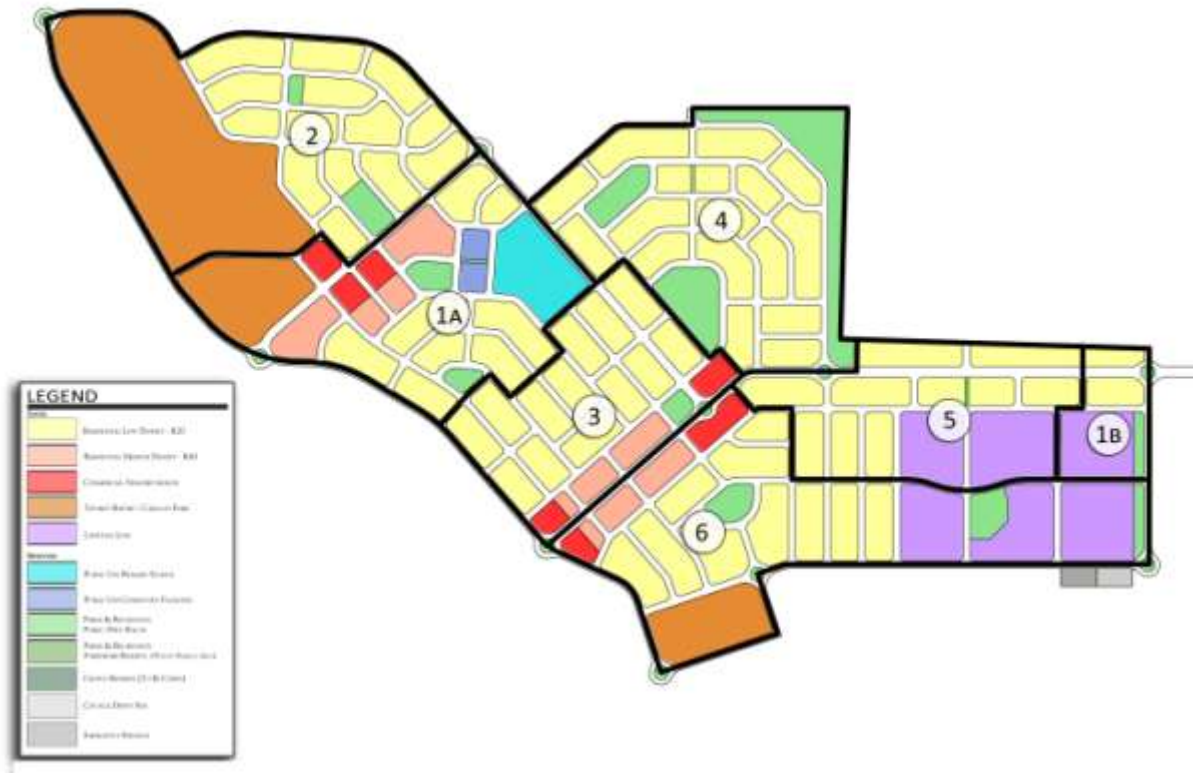
A Staging Plan is included, which shows the future development of the revised ODP area split into 6 distinct stages. It is anticipated that each stage will be developed within a 3-5 year timeframe.

The State Cabinet acknowledges that the existing Urban Development zone within the Shire of Gingin Town Planning Scheme No. 8 has been in place since 1995 and that this zoning, subject to a reduction in the scale of the development, will provide the township of Guilderton and surrounding rural estates with a primary school, shopping and community facilities, and servicing infrastructure, which will result in the creation of a sustainable community catering for a population of up to 5,000 residents.

The revised ODP includes within the first stage of development, a neighbourhood centre, primary school, a community facilities site and a caravan park. The first stage (1A) of development is also linked to stage 1B on the western extremity of the revised ODP area at the point of entry. This will allow some light service (lifestyle lots) industry and residential display homes to be incorporated within the first stage of development.

Staging the development is entirely dependent on economic conditions and so can only be taken as indicative at this point in the approval process.

Figure 10 - *Staging Plan*



(A full version of the Staging Plan is included as **Appendix B***)*

11 Changing Role of Guilderton

Guilderton was first developed in the 1940's when farmers from the broader Gingin hinterland constructed beach shacks for holiday use. The land released for housing development is Crown Land administered by the Department of Land Administration (DOLA). DOLA progressively created and released residential lots until approximately 1984 when waste from residential septic tanks was found in the Moore River. The Water Corporation advised DOLA (which was clearing future road reserves between the townsite and lighthouse for a new land release at that time) that all future land development must be deep sewered. DOLA abandoned its subdivision plans and has not created any further lots for the past fifteen years.

Over the past twenty years or more, Perth residents have acquired most of the existing properties for holiday purposes. As at the 1996 Census, conducted in August, there were 411 houses and a permanent population of 178 people in Guilderton. At the same time (1996) Woodridge had a population of 485 people and 205 dwellings. Google Earth Aerial Photography as at 5 September 2006 details approximately 312 houses in Guilderton and according to the 2006 Census, a permanent population of 93 people. At the same time (2006) Woodridge had a population of 565 people and 193 dwellings.

Local real estate agents confirm that one significant reason for (older) permanent residents selling their properties is that they require proximity to health facilities which are not available in Guilderton. The small permanent population would not warrant the provision of such facilities.

11.1 Shire Intentions for Guilderton

The land surrounding the Guilderton townsite is owned by only two institutional owners – DOLA and the Catholic Church. Both appear to have no immediate plans for the area.

The Shire of Gingin identified land suitable for urban development in the Guilderton area in its (1992) Development Strategy and Structure Plan for the Gingin Coastal and Structure Plan for the Gingin Coastal Region. At that time the development option adopted by Council was for Guilderton to become a town of 30,000 people – with 15,000 residents each on both sides of the river.

More recently, in 2003, the Shire prepared a draft Local Planning Strategy, which also recognises that the Urban Development zoning of the revised Outline Development Plan (ODP) area, in the medium to long-term, is anticipated to provide for a resident population of some 13,500 persons. However, the Strategy states that prior to actual urban development occurring on the south side of the Moore River, there will be a need for further detailed planning, and in particular some key issues including coastal management, river management and integration with the existing Guilderton townsite, will need to be addressed.

Town Planning Scheme No. 9 (TPS9) was prepared in September 2003 and has been held in abeyance since 2006. TPS9 proposes that the revised ODP area and the whole of the Urban Development zone identified pursuant to Town Planning Scheme No. 8 (TPS8) become Special Control Area No. 2 - Development Areas (SCA2).

The purpose of SCA2 is to ensure that subdivision and development of land should only take place after comprehensive planning has ensured high design standards and cost effective servicing which is sensitive to the environment.

11.2 Western Australian Planning Commission Intentions for Guilderton

The announcement by the Minister for Planning of the support of State Cabinet for development at Moore River in a manner that that will provide the township of Guilderton and surrounding rural estates with a primary school, shopping and community facilities catering for a population of up to 5,000 residents followed consultation with the Western Australian Planning Commission (WAPC).

Pre-lodgement consultation with relevant Government Agencies has been facilitated by the WAPC / Department of Planning.

11.3 Existing Guilderton Townsite

The future of the existing Guilderton townsite will essentially be guided by the two major landowners, together with the WAPC and the Shire of Gingin. The Moore River Company has no direct involvement in the direction or extent of urban growth. The role of Guilderton however, will change over the next decade or two for a variety of reasons.

Over the past twenty years or more, Guilderton has become an attractive holiday home location for residents of Perth. Being the first 'coastal' settlement north of the Perth metropolitan area, and more significantly, only an hour away from the CBD, it is perceived by the holiday home market as a very attractive and convenient location. Most certainly, it will continue to be a desirable holiday home or retirement home location in the short, mid and long term. In the midterm, as more social, community, recreational, education and commercial facilities are provided, it will become more attractive to permanent residents. The employment opportunities created by the increasing facilities and services, together with the provision of retail, mixed business, local industry and local tourism opportunities, will further attract permanent residents.

Section 10.1 Population and Growth, addresses demographic characteristics and anticipated growth rates. These projections envisage a thirty year time frame and population characteristics similar to those of Mandurah at the present time i.e. a mix of permanent residents (comprising families and retirees) and weekenders/holiday makers/tourists. The actual rate of change of resident mix over the next thirty years is difficult to predict. It is likely that the introduction of a primary school will be the most significant factor influencing young families to reside in the area.

11.4 Accessibility of Facilities in Revised Outline Development Plan Area

The State Cabinet, when acknowledging the Urban Development zone of the site and considering a reduced proposal, acknowledged the opportunity to provide the township of Guilderton and surrounding rural estates with a primary school, shopping and community facilities, and servicing facilities.

As a direct response to these criteria the revised ODP has been designed to incorporate a neighbourhood centre, primary school, community facilities and a caravan park within the first stage of development.

The Woodridge community will have convenient direct access to these facilities by way of a 5 km car trip. The Guilderton community will have little requirement for the early shopping/café/restaurant/fuel supply facilities as these are all available in the townsite presently.

Access from Guilderton to the possible boat launching facility and later school and health facilities will be via Wanneroo Road unless it is considered feasible to construct a bridge across the Moore River.

The location of this bridge (and its funding and timing of construction) will be considered in more detail at the later planning stages of development.

11.5 Existing Social and Community Infrastructure (Guilderton and Woodridge)

The Guilderton townsite comprises of approximately 312 dwellings (Obtained from Google Earth Aerial Photography as at 5 September 2006), of which approximately 20% are occupied by permanent residents. Facilities and services presently available to residents (and visitors) include:

- Combined service station/newsagent;
- Take away food outlet;
- Small supermarket near the golf course;
- Supermarket; and
- Delicatessen, restaurant and café near the river mouth.

Although Woodridge has a permanent population approximating 565 persons, the Shire of Gingin has been reluctant to formalise this mature rural residential estate as a townsite. As such, facilities are restricted to a community hall, tennis/netball courts and a child care centre.

There are no full time medical or health care services, nor any other professional or educational services or facilities in either Guilderton or Woodridge, with the exception of occasional services offered by local residents. All residents are required to go east to Gingin or south to Two Rocks, Wanneroo or Joondalup for basic services such as general shopping, education, medical and health care.

According to the Public Transport Authority of Western Australia, approximately 80 children from Woodridge and Guilderton currently travel to Gingin daily for their schooling. The Education Department acknowledges that those student numbers almost generate the need for a local school presently. The revised ODP is considered to be the ideal location for the new school site (particularly the Primary School located near the first development node).

The revised ODP area is located 4 km west of Woodridge and is directly accessible via Barragoon Road and the proposed arterial entry road. The Guilderton townsite is on the opposite side of the Moore River, and is approximately 20 kms by car to the site.

11.6 Revised Outline Development Plan Site – Social and Community Infrastructure Provision

The revised ODP site is 346 hectares in area and is planned to ultimately accommodate 5000 people in approximately 2000 dwellings. The following social and community facility sites are proposed for the area, generally in accordance with the revised ODP plan.

- Primary School
- Public Use Community Facilities:
  - Medical Centre; and
  - Community Centre.
- Playgrounds, playing facilities, coastal parks and facilities.

These facilities will be available to the revised ODP area residents and Guilderton and Woodridge residents alike. The delivery of these facilities relates directly to the timing of development. The Staging Plan (**Figure 10** - Section 10.3) identifies six likely phases of development.

The provision of health and medical services will evolve over the early years of development. It is anticipated that over the first five years of development, doctors, dentists, chiropractors and physiotherapists, in particular, will locate in residences – similar to their location in the metropolitan area. It is likely that after the first five years growth, those activities and facilities will be formalised in professional suites or medical centres. The introduction of these services relates to (i) the population in the Guilderton/Woodridge/Moore River South catchment and (ii) the attractiveness of the area as a permanent residential location and (iii) accessibility to the area for part-time servicing.

Moore River Company is confident that the area's idyllic setting and accessibility will attract residents and visitors in suitable numbers to allow the smooth progressive development of the site. It is envisaged that at the commencement of the project arrangements will be made for the provision of basic social/community/recreational infrastructure up-front to ensure new residents, be they permanent or part time, will be more comfortable.

Assuming a suitable lot sales (and house construction) rate and considering the number of new permanent residents, the next range of facilities desired would include bank (ATM), access to some level of health and medical services, improved general store, community centre and (interim) primary school.

Moore River Company has committed to the provision of suitable floor space (both interim and long term) and other measures to provide incentives and facilitate the early availability of basic retail, medical, dental and childcare services to the community.

12 Infrastructure Contributions

As part of the development of the revised Outline Development Plan (ODP) area the proponent will provide a range of services and facilities for the community and visitors to the locality. A detailed Community Facilities Infrastructure Contributions Plan will be prepared in accordance with Planning Policy Statement No 20. (refer Section 9). The commitments will be provided either as part of the development of the site, the implementation of the Foreshore Management Plans for the foreshore abutting the site or in addition to these matters.

Commitments

1. Provide a new coastal promenade and provide parking bays, viewing areas, lighting, beach access and landscape improvements in this area

2. Provide a new primary school site in the first stage of development.

3. Installation of state of the art water and sewerage infrastructure, accompanied by mandatory requirements for water reuse and water and energy efficient appliances in all dwellings.

4. Cede a community purposes site comprising approximately 1.3ha in the first stage of development.

5. Ceding of an expansive network of new coastal and river foreshore reserves as shown on the ODP map.

6. Contribute to local FESA facilities and support creation of a new or enlarged local bush fire brigade.

7. Sponsor/subsidise a new local store, community meeting space and floorspace for visiting medical and dental services in the first stage of development.

8. Contribute to a boat launch facility on the basis that the funding, design and ongoing management issues can be resolved to the satisfaction of all stakeholders.

9. Assist the creation of a small business incubator to facilitate early introduction of employment generating activities in the ODP area and at Guilderton.

10. Contribute to a tourism promotion campaign for the region and the locality.

11. Management and maintenance of all new open spaces for a period of 3 years.

12. Provision of low key active and passive recreation facilities (including play equipment, seating, barbecues, public art and similar facilities) and landscaping/embellishment of selected Public Open Spaces.

13. Landscaping and rehabilitation of foreshore areas in accordance with approved Foreshore Management Plans.

14. Provision of a pedestrian trail network throughout the development.

15. Contribute proportionately to the funding of a pedestrian bridge connecting to Guilderton on the basis that the funding, design, ongoing management and other relevant issues can be resolved to the satisfaction of all stakeholders.

16. Development of a minimum 250m² multipurpose community purposes facility for management under a peppercorn lease by a community based management committee, including provision of temporary floorspace in first stage of development pending completion of the purpose built facility.

17. Upgrading of Wanneroo Road, intersections and connector roads to Moore River on a proportionate basis.

18. Ceding of approximately 86.9ha of land for Public Open Space and new coastal and river foreshore reserves, equivalent to 25.1 percent of the ODP area.

19. Contribution to provision and/or augmentation of district community facilities by the Shire (for example: district library, sporting complexes and the like) and required as a consequence of the development.

20. The above list is a broad outline of the scope of the proponent's commitments. The detail, quantification, staging and tenure details of each commitment will be addressed in the Community Facilities Infrastructure Contributions Plan.

Contributions, Calculation and Management Principles

1. Each of the individual components of the contributions inventory, excluding civil engineering works (e.g. roads and services) and/or contributions of land, will be allocated a maximum value to be agreed between the proponent and the Shire.

2. This total value of the inventory (minus the works-in-kind components) will be divided across all residential lots and tourist precincts on a per lot and per hectare basis respectively.\

3. The pro-rata contributions calculated will be paid into a trust fund prior to the clearance of each respective lot/stage of development. The trust fund to be managed by the Shire as a "Restricted Asset Account" and held specific to the Moore River Project with the release of monies to be agreed by both Council and Moore River Company.

4. The individual components will be allocated against nominated stages of the development by agreement between the proponent and the Shire.

5. The developer will submit designs for the individual components of the inventory within the agreed maximum values and at an appropriate time for the approval of the Shire. On receipt of that approval the developer will construct the works and will receive reimbursement from the trust fund for the work.

6. The above process will be managed, insofar as is practical, to keep the trust fund "in the black" during the staging process.

7. Delays in the approval of designs submitted by the developer (for e.g. due to consultation with community groups etc) will not be a basis for the withholding of clearances for any given stage of development.

8. The developer acknowledges and agrees with the principle of the Shire establishing a Specified Area Rate to apply to the ODP area for the purposes of achieving equitable ratepayer

contributions to new facilities and maintaining to a high level the comparatively superior facilities and landscaped environment that will be available to landowners and residents.

9. If approved works are completed by the proponent during the subdivision and prior to seeking the subdivision clearance, then the value of these works will be deducted from the per lot contributions payable for that stage.

Moore River South

Revised Outline Development Plan

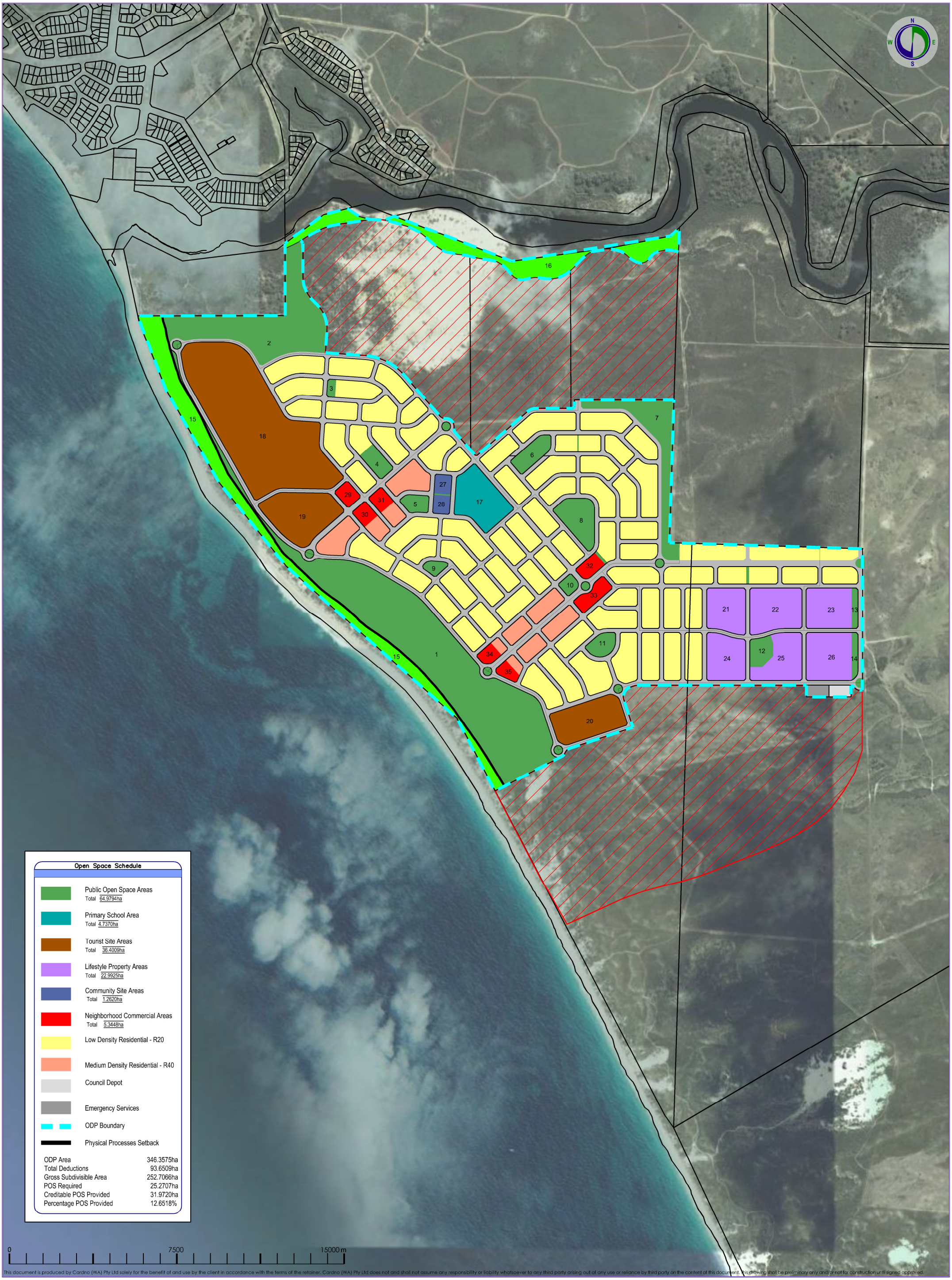
Appendices A-G

Cardno
Shaping the Future

Prepared for Moore River Company Pty Ltd
October 2011
Job Number P7026

Appendix A
Open Space Plan

Cardno
Shaping the Future



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APPENDIX A - PUBLIC OPEN SPACE PLAN

MOORE RIVER SOUTH

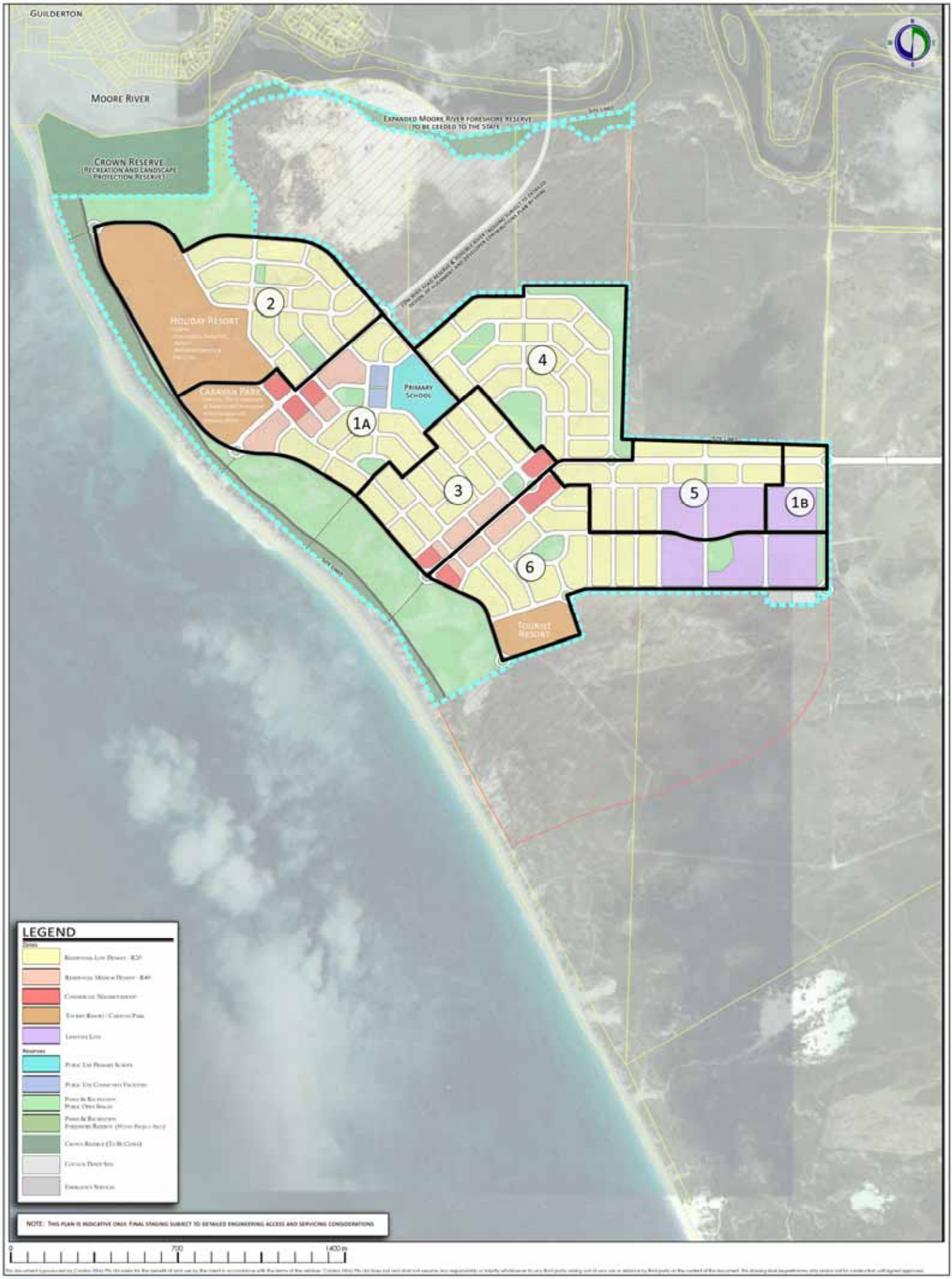
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PROJECT-PHASE-PLAN NUMBER REVISION
P07026 - SK16 A

Appendix B
Staging Plan

Cardno
Shaping the Future



APPENDIX B - STAGING PLAN

MOORE RIVER SOUTH

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APPENDIX C
SERVICING REPORT

Cardno
Shaping the Future

Moore River Outline Development Plan

Servicing Feasibility Study

Prepared for Moore River Company Pty Ltd

July 2010

Project Number E09013-002

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EXECUTIVE SUMMARY

The Civil Infrastructure Department of Cardno WA has been engaged by the Moore River Company to prepare supporting documentation to this revised ODP in the form of a Servicing Feasibility Study.

This study updates the previous reports and investigates both availability as well as security of supply and emergency provisions for water, wastewater, power and telecommunications required for the MRS Development.

In preparing this study previous reports have been considered:

- Water Authority of Western Australia October 1993: Gingin Groundwater Area Management Plan
- Cossill & Webley's April 1996 Report on Engineering Aspects
- Sinclair Knights Merz November 1995 report on – Guilderton South ODP Sewage Treatment and Disposal Strategy - Final Report
- Sinclair Knights Merz November 1996 report on - Moore River South ODP Sewage Treatment and Disposal Strategy Final Report (Rev D)
- Outline Development Plan number Number (P7026 - SK10).

This study reinvestigates the base or options available with consideration for alternative systems. The terminology of "no risk" is used by the Water Corporation for their water and wastewater systems in which there is a secure system for the use of water supply or in the case of the wastewater, a suitable treatment method together with a disposal solution for final effluent.

The water supply for instance is derived from bores as being the "no risk" option, however, the current bores owned by the Water Corporation is not enough to cater for the full future development water consumption. As it currently stands the existing bores have enough water available for local townships together with stages 1, 2 and 3 of the MRS Development, after which additional water will be required. To achieve a "no risk" scheme water system it will be necessary for the proponent and/or the Water Corporation to acquire additional bore water allocation either by direct purchase and/or water trading and investigations are currently ongoing in this regard.

The water re-use and efficiency measures built into the revised ODP will significantly reduce the demand for water, compared to "normal" standards, for potable use and should eliminate any requirement to outsource for non-potable use.

The collection and treatment of the wastewater is no problem and during the summer months the final effluent, being class A+, will be disposed of by Public Open Space (POS) irrigation. During the winter months however, disposal by Managed Aquifer Recharge (MAR) is required which should assist in reducing existing salt and Nitrate levels in the aquifer.

Both power and telecommunication will not be a problem to the site and is just a matter of determining the best option available.

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APPENDIX A Bore Hole Allocation

1 "NO RISK" WATER

1.1 Water Supply Demand

The ODP has provided a preliminary design of the development where the average water demand is calculated based on the average occupancy as follows:

Number of Lot	2,000 (from Approval)
Average number of residents per lot	1.8 (this is a conservative estimation based on the current residents per lot for Guilderton being 0.5 per resident. It has been anticipated that this will increase during the summer months to cater for the holiday period, hence the 1.8 figure used. Note that buffering through tanks will be required in order to cater for peak flows)
Average number of residents	2,000 x 1.8 = 3,600 persons
Average flow per resident	280 litres/person
Average flow per lot	280 x 1.8 x 365 = 184 kL/lot/year
Average flow for overall development	2,000 x 183.96 = 368,000 kL/development/year

Seasonal Peaks - The above is for the average flow. Seasonal peaks will occur, which will coincide with the dry season. To cater for these peaks the supply system and pipework system will be sized appropriately. Buffering / storage facilities will have to be constructed to accommodate the additional holiday population.

Irrigation of POS –Is required for this development and is based on the ODP:

Total POS area	11.2 ha
Irrigation rate	7,500 kL/ha/year
Irrigation requirement for POS	84,000 kL/year.

(Based on 80% turfed, and, 20% low water gardens and arterial road verges only).

Total School area	4.7 ha
% of area irrigated	52 %
Irrigated area	2.466 ha
Irrigation rate	7,500 kL/ha/year
The school irrigation	18,500 kL/year.
Total development water reuse	102,500 kL/year

Note that the POS irrigation demand is met with water reclaimed from the Wastewater Treatment Plant, therefore, this is not an additional amount to the net 368,000 kL/development/year demand estimate.

1.1.1 Staging Requirements

The ODP has provided a preliminary design of the development where approximate zoning codes and staging of the development have been determined. The expected flows from the development area have been presented in Table 1 below. The values in this table have been calculated on the basis of 1.1 above.

Table 1: Expected Water Supply Demand per Stage

Stage	Number of lots	Potable water (Per lot)	Potable water (kL/year)
1	362	184	66,608
2	287	184	52,808
3	309	184	56,856
4	352	184	64,768
5	300	184	55,200
6	390	184	71,760
Total	**2,000**		**368,000**

The water requirement would be designed in stages to meet the ODP.

1.2 WATER CORPORATION OF WESTERN AUSTRALIA (WCWA) SUPPLY

1.2.1 WCWA Current Allocation

The proposed MRS development falls under the Gingin Groundwater Area (GGA). The GGA was proclaimed on 26 September 1975 under the Rights in Water and Irrigation Act (1914) (RIWIA). All water is currently sourced through groundwater and the WCWA has a license agreement with the Officer of Water Regulation for Guilderton. Within this licence area the WCWA have allocations for 3 bores namely:

Table 2: Current WCWA Bore Allocation for Area

Inst Number	Allocation	Issue Date
69108	170,000 kL/yr	18/01/2004
65342	100,000 kL/yr	11/07/2008
160674	130,000 kL/yr	25/05/2008
Current total allocation	**400,000 kL/yr**	

The Total Catchment (Maximum Allowance) is estimated as follows

Table 3: Total Catchment (Maximum Allowance) Estimate

Area	Maximum lots	Maximum required consumption
Guilderton	400 (Existing)	73,600 kL/yr
MRS	2000	368,000 kL/yr
Woodridge	500 (Existing)	92,000 kL/yr
Total catchment		**533,600 kL/yr**

Based on average flow per lot – 184 kL/lot/year

Although not currently utilised this water requirement means there is a shortfall in the Guilderton area of:

Total catchment – Current total allocation = 533,600 – 400,000 kL/yr
=133,600 kL/yr.

When studying the bore allowance for the South Guilderton area we note that there are 3 bores of the required magnitude that could provide this shortfall.

To achieve a “no risk” scheme water system it will be necessary for the proponent and/or the Water Corporation to acquire additional bore water allocation either by direct purchase and/or water trading and investigations are currently ongoing in this regard. Assuming the additional water is acquired by water trading the developer must agree to supply treated wastewater to the farmer to supplement the loss of borewater.

Potable/scheme water SURPLUS can be calculated as follows depending on which bore is purchased / traded;

Table 4: Examples of bores in area that can supplement the surplus demand

Case	Shortfall	Bore Allowance	Surplus
Bore 151892	133,600 kL/y	930,000 kL/yr	796,400 kL/yr
Bore 155088	133,600 kL/y	494,000 kL/yr	360,400 kL/yr
Bore 155452	133,600 kL/y	406,200 kL/yr	272,600 kL/yr

Note from the calculations the Guilderton, Woodridge and MRS development stages 1, 2 and 3 could be supplied with scheme water from the current WCWA allocation without the requirements for the purchase of bores or water trading. In order for the stage 4 to commence the bore must be purchased or traded.

Table 5: Demand which can be met under WCWA current bore allocation

Area	Maximum lots	Maximum required consumption
Guilderton	400 (Existing)	73,600 kL/yr
MRS	Stage 1 2 &3	176,272 kL/yr
Woodridge	500 (Existing)	92,000 kL/yr
Stage catchment		341,872 kL/yr

Based on average flow per lot – 184 kL/lot/year

Surplus in the Guilderton area when MRS Stages 1, 2 and 3 is completed is

Stage catchment – Current total allocation = 341,872 – 400,000 kL/yr
=58,128 kL/yr.

1.2.2 Additional Aquifer Water Allocations

Attached in Appendix A, are the bore hole allocations for the study area, which verify the above and indicate the owners of the 3 bore allowances meet the volume criteria. The other allowances are not of significant magnitude or they may be too far from the MRS area to be note worthy.

1.2.3 Current Bore Water Quality

Cardno are currently sampling water from the superficial aquifer for MRS, samples indicate that currently in the Guilderton, Moore River development area the water is within drinking water standards. I.e. groundwater salinity in the area is considered fresh (<1000mg/L).

1.2.4 Possible Future Bore Water Quality

WCWA have experienced a build-up of nitrates and salt in the superficial aquifer in the Guilderton area to levels, which it is anticipated that they may exceed drinking water standards in the near future. Membrane technologies, ion exchange and thermal desalination treatment are all successful in removing both nitrates and salt to potable water standard levels, while nitrates alone can be treated biologically.

Other systems such as Managed Aquifer Recharge and irrigation of the land could be a preventative measure to reduce levels of nitrates and salt to negate the need for treatment.

1.2.5 Potable Water Buffer Tank

When optimising the water balance to take into account seasonal occupancy it may be found that the size of the treatment plant/pumps may be reduced by strategically installing buffer tanks to cater for the peak demand. These buffer tanks would have an allowance for other services such as fire fighting and would be of standard WC design.

1.2.6 Other Options

Other more economically viable and environmentally sustainable solutions are available that may be attractive to WCWA upon further investigation.

These alternative solutions could include combinations of:

- Rain water harvesting could significantly reduce the water demand to a point where the purchase or trading of additional water will not be required
- Utilisation of the Wastewater Treatment Plant's final effluent for toilet flushing and washing machines.

The water re-use and efficiency measures built into the revised ODP will significantly reduce the demand for water, compared to "normal" standards, for potable use and should eliminate any requirement to outsource for non-potable use.

2 "NO RISK" WASTEWATER

There is no overall wastewater system in the Gingin coastal area. Wastewater collection and treatment facilities are generally community based and at present only exist at Lancelin and Ledge Point. Seabird, Guilderton and the rural residential settlement are un-sewered.

The Water Corporation has a sewerage services license agreement, with the Officer of Water Regulation for Lancelin and Ledge Point but not for the Guilderton South area.

The Water Corporation has identified an area between Lancelin and Guilderton for the construction of a future wastewater treatment plant to serve the communities in this area. Construction of this facility however is not programmed in the foreseeable future.

2.1 LOADING ESTIMATES

To cater for the needs of MRS an infill sewer system, consisting of conventional gravity sewers connected with a series of pumping stations and a single centralized Wastewater Treatment Plant (WwTP) will be required.

Using the WCWA's Wastewater Manual (vol 1) the required flow per lot is:

- 630 litres/lot/day(based on a peak demand of 3.5 residents per lot x 180 litres per resident which is taken from the WCWA Wastewater Manual for dry or well drained ground)

The planned development of 2000 lots means the final WwTP design capacity would be:

Design capacity = 2,000 X 0.63 X 365
=459,900 kL/year

The wastewater treatment plant would be designed in stages to meet the development's staging plan as follows.

Table 6 Wastewater Treatment Plant Staging

WwTP Stage	Development Stage	No of lots	Flow per lot (dry)	Total Treatment flow (kL/yr)	WwTP construction (KL/yr)
1	1 , 2	649	630 L/lot	149,239	153,000
2	3, 4	661	630 L/lot	151,996	153,000
3	5, 6	690	630 L/lot	158,665	153,900
	Total	**2,000**	**630 L/lot**	**459,900 kL/yr**	**459,900 kL/yr**

2.2 CONVENTIONAL WASTEWATER TREATMENT

There is a range of conventional wastewater treatment technologies available, which comply with the WCWA standard designs and are suitable for this modular application. Modern treatment plants use variations on the one type of process, with different configurations, depending on influent quality and required final effluent quality.

Conventional Activates Sludge, Sequence Batch Reactors and Membrane Bioreactors are all acceptable technologies which can be used for this application.

Detailed investigations into these variants should be done at a later date. At this stage it is sufficient to say that at least three technologies are accepted by WCWA. Each can produce the effluent standard required for sustainable disposal.

2.2.1 Treatment Standards

Western Australia has introduced an initiative called the State Water Strategy. This strategy recognises the need to conserve water. It focuses on the management and monitoring of agricultural irrigation schemes to reduce the demand on potable water.

To ascertain the standards of treatment the disposal route must be finalised. For MRC there is no chance for marine discharge so other long-term solutions must be utilised. These could include:

- Water Reuse (for toilet flushing and residential irrigation);
- Irrigation of public open spaces;
- Managed aquifer recharge (for winter flows).

Where the reuse water is being supplied through a pipeline system to users, such as for urban, domestic, commercial or industrial use, or in agricultural areas where there is also a reticulated potable water supply, the recycled supply system is usually described as a third-pipe system. This usually comprises piped recycled water, a piped potable supply and a piped sewage disposal [sewerage] system. It may also be described as a component of a dual reticulation system.

The following standards and general criteria are:

2.2.1.1 Class A

Class A water is produced by tertiary treatment or other advanced processes to ensure a minimum log 7 removal of pathogens through the process. Both Class A and A+ quality waters require disinfection (the destruction, inactivation or removal of pathogenic micro-organisms). Following disinfection, Class A water may be used for:

- Urban non-drinking water use with uncontrolled public access;
- Agricultural production, e.g. food crops which are consumed raw; and
- Industrial applications with the potential for worker exposure.

2.2.1.2 Class A+

Class A+ water is produced by the same process as Class A water, with the addition of an advanced treatment stage. Advanced treatment processes include chemical clarification, carbon absorption, reverse osmosis and other membrane processes, air stripping, ultra-filtration, and ion exchange.

2.2.2 Location

Based on the project staging, sewerage arrangement, and the capacity of the WwTP to provide reuse water to the development, the location of the WwTP should be located at the eastern boundary as indicated below. Allowance for access and buffering have been taken into account.

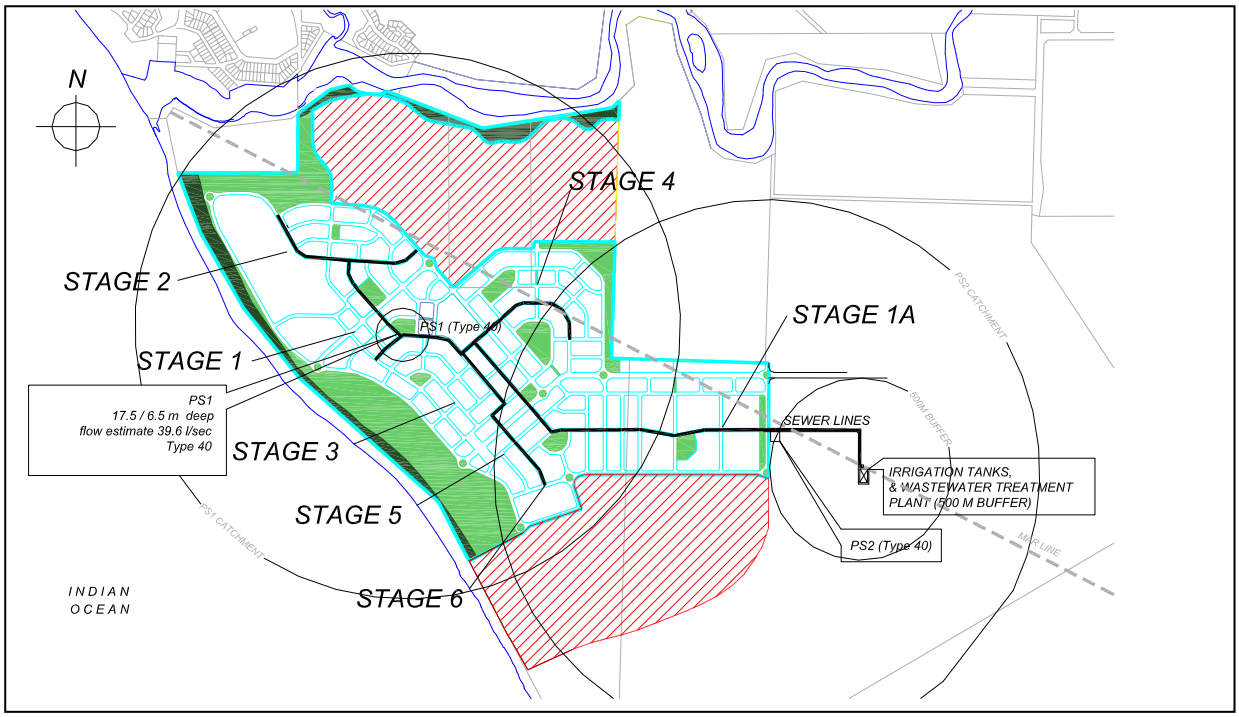


Figure 1 Wastewater Treatment Plant - Location with 500m Buffer

2.2.3 Odour and Noise Buffer

An Odour & noise buffer is necessary and has been allowed for in selection of the location (see above). Further surveys are required to undertake modelling of odour and noise behaviour for the WwTP locations. It should be noted that for Alkmos WwTP the EPA applied a 500m no risk, low noise buffer for the project. For planning purposes we have allowed a 500m buffer as indicated on the below sketch, although we believe that this buffer can be reduced to <300m by using best technology. This includes:

- Reducing odour generation by reducing retention time in the sewer and appropriate design of sewer transitions;
- Appropriate proven biological technology to reduce odour generation; and
- Appropriate treatment technology to treat an odour.

2.2.4 ALTERNATIVE WASTEWATER CONFIGURATIONS

The “no risk” option is to agree with the WCWA to take over the water and wastewater facilities and operate it under their current operations licence.

The developer may wish to investigate the possibility of a private company undertaking the works, under a Build and Operate agreement or similar financial agreement.

This could pose difficulties in obtain an operating license for any future Private Enterprise and careful consideration has to be made with any future agreements to consider the fees charged to the residents. The benefit for the WCWA is that this model will not affect their budget when the MRS development progresses and could be a way to improve the salt and nitrates levels within the area which will assist the WCWA in improving the water supply for the area.

3 POWER

The study area is served by the existing South-West Transmission Network. The major generating plant adjacent to the study area includes the gas turbine stations at Pinjar, Mungarra and Geraldton.

- Pinjar is a gas turbine station of installed capacity of 580MW;
- Mungarra is a gas turbine station of installed capacity of 110MW;
- Geraldton is a gas turbine station of installed capacity of 20MW.

A 132kv transmission line extends from the Pinjar Gas Turbine Station to the west of Gingin town along the Brand Highway to Geraldton via Reagan's Ford, Cataby, Eneabba and Three Springs. A new 132kV zone substation has been constructed at Reagan's Ford just north of Cataby, which will supply the Shire of Gingin. The study area is served using a 22kV distribution system and a separate 33kV distribution system. The southern section is supplied from two 22kV feeders. A single 33kV feeder supplies the northern section. This load will eventually be transferred to the new Reagan's Ford zone substation. The system has been designed to supply the existing rural and coastal communities.

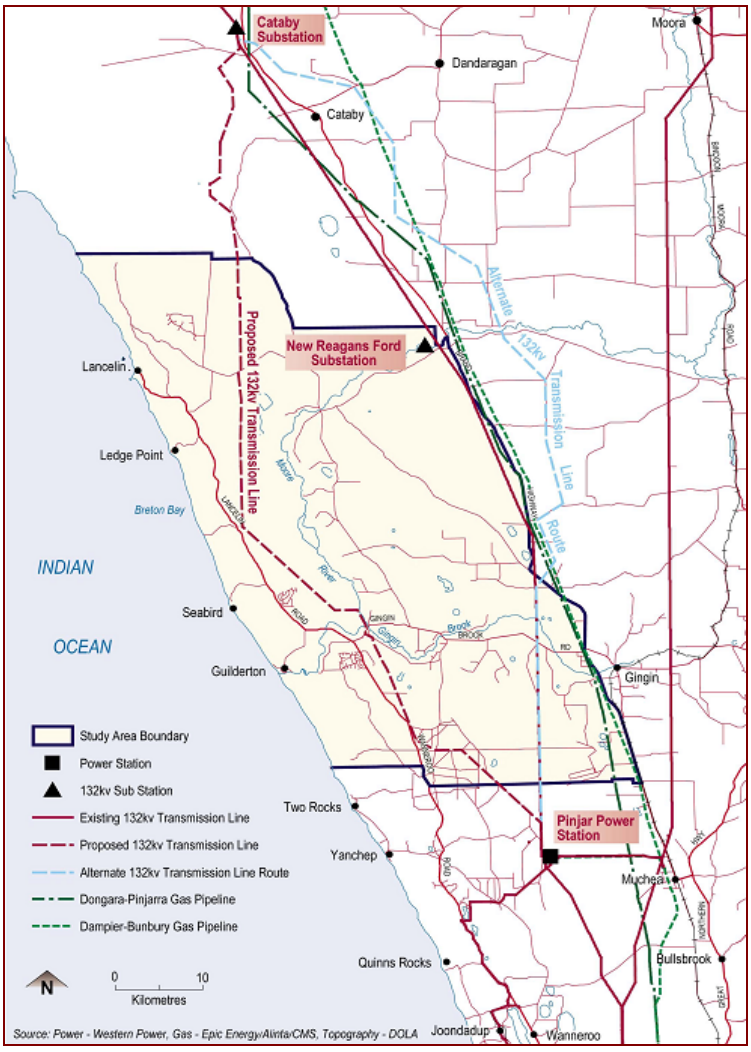


Figure 2 Existing and Proposed Power Network

Western Power Corporation (WPC) proposes to reinforce the existing network with a twin circuit 132kV overhead power transmission line from Pinjar to Cataby. Two alternative alignments are proposed as shown in Figure 2. One alignment is along a coastal route and the other following a more easterly route along the Brand Highway.

3.1.1 AVAILABLE SUPPLY

WPC are currently negotiating the route for the new transmission line. Of the two routes being reviewed by Western Power the coastal route would better serve the MRS development.

If the easterly route is chosen then additional lines may need to be erected to supply the MRC development.

Either alternative ensures that the MRS development can be supplied with sufficient power.

4 COMMUNICATIONS

4.1.1 STANDARD TELSTRA EXCHANGE

The area is currently served with telephone and data communication systems as shown in the figure below

Telephone exchanges exist at Guilderton. The existing trunk routes have capacity for 10,000 to 20,000 lines with an upgrading of exchange equipment.

Feb, 2009 Telstra announced that they have changed their policy regarding the installation of telecommunications network infrastructure in green field developments. For projects where the developer has not made arrangements to have FTTP infrastructure installed, Telstra will no longer deploy copper cable. Additionally, Telstra may require a developer to pay a contribution towards the cost of the installation of any telecommunications infrastructure in green field developments, including fibre.

Telstra will continue to meet their Universal Service Obligation (USO) which requires Telstra to provide reasonable access to a Standard Telephone Service on request from and end customer. Telstra will "determine the most appropriate service on the request from and end customer." The USO arrangements allow Telstra to deploy wireless technologies to fulfil its obligations as a temporary measure - this potentially means the issuing of mobile phones at local call rates. The existing communications infrastructure is shown in

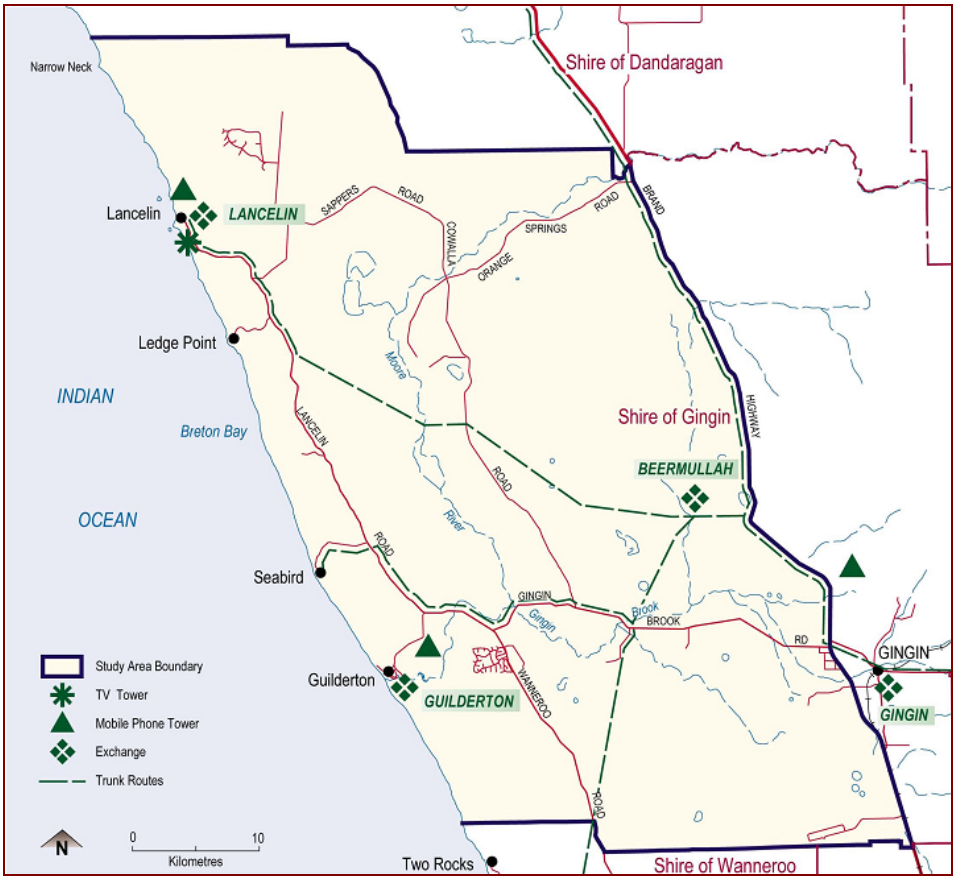


Figure 3 Existing Communication Infrastructure.

It is expected that for MRS the telephone lines could be expanded from the existing Guilderton exchange with the footbridge over the Moore River being utilised for access. This network would not support fast Internet services.

4.1.2 TELSTRA NEXT G

Telstra in meeting their USO arrangements may mean the issuing of mobile phones at local call rates. Hose phones are available that can connect to mobile phone services.

Mobile phone service coverage is provided from Telstra with mobile phone towers are located at Moore River and a tower on the Brand Highway between Gingin and Beermullah. This system supports Next G and could provide house telephones, mobile coverage and fast internet services without the costs of telephone lines and ground works/maintenance.

4.1.3 FUTURE UPGRADE TO WIMAX / 4G

It is expected that in the next 10 years Wimax and/or 4G technology will replace Next G. This system will provide a much wider bandwidth, cheaper call rates allowing for faster internet as well as television and data transfer on demand.

Developers have continued to express concern about the lack of clarity surrounding the implementation of the national broadband network and we must assume that the national broadband network will not extend to MRS in the foreseeable future. Thus Next G/ Wimax or 4G will provide fast broadband service to the MRS.

5 CONCLUSION

This Report concludes that conventional application of wastewater, power, and telephone services are suitable for the MRS Development.

Scheme Water - Studies have shown that current scheme water is not sufficient for the area and the new development. To achieve a “no risk” scheme water system it will be necessary for the Developer to acquire additional bore water allocation either by direct purchase and/or water trading.

Wastewater Treatment - A centralised treatment plant is the preferred option for treatment with disposal by irrigation within the town site and possibly to agriculture.

Given the “no risk” option being the preferred option for scheme water and a centralised treatment plant we would expect, upon completion by the developer, that the Water Corporation of Western Australia WCWA would become the licensed operator.

Treated Wastewater Disposal - Disposal of treated wastewater to marine outfall is not an option for Moore River. For most of the year all the treated wastewater generated can be disposed of either by recycling to the surrounding rural lots for irrigation or by irrigation of POS. Climatic data shows that traditionally Moore River has a block of four months in winter when rainfall is high and exceeds evaporation. During this period irrigation would not be necessary and Managed Aquifer Discharge MAR would be the preferred option for disposal. This would also have the advantage of improving the aquifer water quality by dilution and reduction of nitrates and salt intrusion.

There are many potential uses for Class A+ recycled water. The most reliable at this stage is irrigation to the public open space and is clearly possible for this scheme. During negotiation for the additional water allocation it is expected that a priority for use of the wastewater will emerge that represents a more beneficial use of this valuable resource.

The actual solution/technology is dependent on who the service provider will finally be and the economics of that selection. Detailed engineering will be necessary , in conjunction with the service provider , to ascertain the most economic solution.

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APPENDIX A

Bore Hole Allocation

RE I ER EX RAC IN ORMA ION

No compensation is payable in respect of anything done or omitted to be done in good faith by the Department in the performance or purported performance of any duty, or the exercise or purported exercise of any power, in relation to this register, including its accuracy and the notification of people with a registered interest

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Inforce licen e it in m radiu of co-ordinate provided a re ue ted

Information e tracted from t e Department databa e a at 10 00 r - 29 April 2009

GW Area	GW Subarea	Aquifer Name	Instrument Number	Total Alloc inc Reserve	Licensee Full Name	Issue Date	Expiry date	Description or Address
Gingin	Guilderton North	Perth - Superficial Swan	41422	1,000.00	Onus ML & DL	29/06/1992		Lot 82 Walebing Way, Guilderton
			53078	1,000.00	Hucker CJ & EC	29/03/1995		Lot 185 Brandis Street Guilderton
			57870	7,500.00	Shire of Gingin	22/09/2006	6/10/2016	1 DEWAR ST GUILDERTON
			69106	170,000.00	Mr Water Corporation	16/01/2004	31/12/2008	
								11772 GABBADAH
								367 GUILDERTON
	Guilderton South	Perth - Superficial Swan	33952	1,500.00	Peach EB & MR	15/10/1990		Lot 144 Tranmore Place, Woodridge
			42041	1,000.00	Barnard RJ & SD	8/09/1992		Lot 155 Parkland Way, Woodridge Estate, Guilderton
			42301	1,000.00	Wallinger E	2/12/1992		Lot 9 Fairway Court Woodridge
			42334	1,000.00	Grunt JO	18/11/1992		Lot 54 Nicklaus Ave Woodridge
			42914	1,000.00	Robinson P	30/11/1992		Lot 141 King Drive Woodridge
			43269	1,500.00	Jones EW	13/01/1993		Lot 163 Parkland Way Woodridge
			43271	1,500.00	Galloway J	14/01/1993		Lot 160 Chipping Court Woodridge
			43647	1,000.00	Roe KW	24/02/1993		Lot 103 King Drive Woodridge
			44323	1,000.00	Tomlinson JF & JA	7/04/1993		Lot 244 Birdwood Drive Woodridge
			44996	1,500.00	Jory PA & SJ	29/06/1993		Lot 188 Cnr Nicklaus/Hillcrest Ridge Woodridge
			45071	1,500.00	Di Falco D & I	6/07/1993		Lot 129 King Drive Woodridge Guilderton
			45075	1,500.00	Farmer SL & Skyes BL	6/07/1993		Lots 909,787,925,M1332 Caraban Road Guilderton
			47479	1,500.00	Ornsby WA & M	21/12/1993		Lot 150 King Drive Woodridge
			48068	1,500.00	R B Turner	17/02/1994		Lot 118 King Drive Woodridge
			48136	1,500.00	Husten S & Atkinson JD	28/02/1994		Lot 58 Nicklaus Avenue Woodridge
			48617	1,500.00	Bus B	15/04/1994		Lot 166 King Drive Woodridge
			48618	1,500.00	Wegner HJ & PI	15/04/1994		Lot 107 King Drive Woodridge
			48620	1,500.00	Woodruff RE	15/04/1994		Lot 115 Fieldgate Place Woodridge
			48622	1,500.00	Morris PK & SC	15/04/1994		Lot 116 Fieldgate Place Woodridge
			48918	1,500.00	Cebis P & PA	30/05/1994		Lot 191 Hillcrest Ridge Woodridge
			49258	1,500.00	O'Loghlen MJ	10/06/1994		Lot 240 Birdwood Drive Woodridge
			49847	1,500.00	Donovan MB	22/07/1994		Lot 182 Hilltop Rise Woodridge
			50398	1,500.00	Hellewell DE & SA	1/09/1994		Lot 265 King Drive Woodridge
			50400	1,500.00	Warby WA	1/09/1994		Lot 266 King Drive Woodridge
			51771	1,500.00	Arnold G	5/12/1994		Lot 43 King Drive Woodridge
			52268	1,500.00	Gordon G & J	22/03/1995		Lot 152 King Drive Woodridge
			52274	1,500.00	Hill WE & MT	22/03/1995		Lot 65 Banksia Court Woodridge
			52728	1,500.00	Kirk Jennifer	3/03/1995		Lot 77 Hilltop Rise Woodridge
			52947	1,500.00	King MA & BA	15/03/1995		Lot 94 Nicklaus Avenue Woodridge
			52998	1,500.00	Wisse MJ & PJ	22/03/1995		Lot 24 Marsh Court Woodridge
			53001	1,500.00	Neave CF	22/03/1995		Lot 23 Marsh Court Woodridge
			53076	1,500.00	Snowball LW	29/03/1995		Lot 35 Dawson Court Woodridge
			53138	1,500.00	Martin D	31/03/1995		Lot 203 Birdwood Drive Woodridge
			54518	1,500.00	Holmes Maureen	2/08/1995		Lot 364 Wooly Bush Loop Woodridge
			54531	1,500.00	Stewart J	2/08/1995		Lot 235 Wayeela Place Woodridge
			54532	1,500.00	Brenkman WJ & J	2/08/1995		Lot 195 Hillcrest Ridge Woodridge
			54562	1,500.00	Schwanitz	7/08/1995		Lot 243 Birdwood Drive Woodridge
			54691	1,500.00	Hodgson D	23/08/1995		Lot 55 Nicklaus Avenue Woodridge
			54693	1,500.00	Wilkes JD	23/08/1995		Lot 15 St Andrews Court, Woodridge Estate
			54808	1,500.00	Shelton W	12/09/1995		Lot 177 King Drive Woodridge
			54897	1,500.00	McCrea G & S	14/09/1995		Lot 215 Acacia Court Woodridge
			55330	1,000.00	Demarz H	1/11/1995		Lot 80 Hilltop Rise Woodridge
			55938	1,500.00	Shelton AT	13/12/1995		Lot 183 King Drive Woodridge
			56033	1,500.00	Mcgary B	8/01/1996		Lot 175 King Drive Woodridge
			56436	1,000.00	Willey E & C	20/03/1996		Lot 89 Hilltop Rise Woodridge
			57160	1,500.00	Fisher E	13/06/1996		Lot 96 Nicklaus Avenue Woodridge
			57169	8,836.00	Mr R T Andrews	21/06/2007	21/06/2017	84 BLACKBOY CT WOODRIDGE
			59147	1,500.00	Dooley LD	18/03/1997		Lot 239 Birdwood Drive Woodridge
			59770	1,500.00	Valli JE	8/05/1997		Lot 210 Valley Road Woodridge
			59913	1,500.00	Crooks JT	22/05/1997		Lot 100 Nicklaus Avenue Woodridge
			61637	1,500.00	J Meek	7/11/1997		Lot 128 King Drive Woodridge
			62221	1,500.00	Schulze JA	9/02/1998		Lot 123 King Drive Woodridge
			62432	1,500.00	Chittock TM BM	27/02/1998		Lot 126 King Drive, Woodridge
			63123	1,500.00	McClure S & C	4/06/1998		Lot 254 Birdwood Drive Woodridge
			64240	1,500.00	Clancy RM & F	15/10/1998		Lot 252 Birdwood Drive, Woodridge
			64293	1,500.00	Kirk JJ	14/10/1998		Lot 241 Birdwood Drive Woodridge
			64457	1,500.00	S Winter-Pike	11/11/1998		Lot 85 Nicklaus Avenue Woodridge
			65342	100,000.00	Mr Water Corporation	11/07/2008	11/07/2009	10449 NICKLAUS AV WOODRIDGE
			70468	1,500.00	Bail JWJ & MV	25/06/1999		Lot 14 Saint Andrews Court Woodridge, Guilderton
			76817	37,000.00	R A & V L Atyeo	24/08/1999	24/08/2009	Lot 56 Nicklaus Avenue Woodridge
			95092	1,500.00	Colyer, VM	8/02/2000		Lot 193 Hillcrest Ridge Woodridge
			95807	45,750.00	Guilderton Golf Club	20/03/2000	14/03/2010	Lot 232 Reserve 27949 Guilderton Road, Guilderton
			97142	1,500.00	Williams RF	19/05/2000		Lot 162 Parkland Way, Woodridge Estate, Guilderton
			97406	1,500.00	Horton K.W	4/05/2000		Lot 12 St Andrews Court, Woodridge.
			100169	1,500.00	Roland Meili	4/10/2000		Lot 32 King Drive Woodridge
			101436	8,000.00	Mr & Mrs C & R M Chiera	18/11/2004	17/11/2014	201 CARABAN
			104196	1,500.00	Moore TA & Duckworth HM	22/02/2001		Lot 242 Birdwood Drive Woodridge
			104913	4,900.00	Mr S C Noonan	8/04/2003	8/04/2013	Lot 145 Tranmore Place, Woodridge Estate, Guilderton145 Tranmore Place Woodridge Estate
			109235	1,000.00	Shalders L	18/09/2001		Lot 108 King Drive Woodridge Estate
			109872	1,000.00	Knowles T	11/10/2001		Lot 98 Nicklaus Road Woodridge
			151892	930,300.00	Do, Phung Tran	17/05/2007	8/10/2008	203 CARABAN
					Huyhn, Tuyet Chau	17/05/2007	8/10/2008	203 CARABAN
			154088	494,000.00	M I Michael	9/12/2003	27/11/2013	Lot 202 Caraban Road Guilderton202 Caraban Caraban
			155452	406,200.00	Mr M D Grubisa	21/01/2009	1/09/2009	202 CARABAN
			155837	10,150.00	Mrs B Pittams	28/05/2004	27/05/2014	104 KING DR WOODRIDGE
			158421	155,150.00	Mr F Silvestro	19/04/2007	25/04/2009	2149 GOONMARRA RD CARABAN
					Mr SL Silvestro	19/04/2007	25/04/2009	2149 GOONMARRA RD CARABAN
					Mrs K Silvestro	19/04/2007	25/04/2009	2149 GOONMARRA RD CARABAN
					Mrs T Silvestro	19/04/2007	25/04/2009	2149 GOONMARRA RD CARABAN
					Ms T Crookes	19/04/2007	25/04/2009	2149 GOONMARRA RD CARABAN
			163243	2,500.00		5/12/2007	5/12/2017	18 ST ANDREWS CT WOODRIDGE
	SA 3 South	Perth - Leederville.	160674	130,000.00	Mr Water Corporation	25/05/2006	30/09/2010	10449 NICKLAUS AV WOODRIDGE

2,293,786.00

Appendix D

Transport Assessment

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Shaping the Future

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Moore River South Transport Assessment – Final Report (Version 3)

Moore River Development Company

August 2010

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Document Control Moore River South Transport Assessment					
Version	**Date**	**Author**		**Reviewer**	
		Name	**Initials**	**Name**	**Initials**
Final – Version 3	2/8/10	Richard Isted		Ray Cook	

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EXECUTIVE SUMMARY

A transport assessment has been undertaken for the Moore River South. This assessment has been undertaken to meet the requirements as set out in Part 3: Structure Plans - Guidelines for Transport Assessments, West Australian Planning Commission (WAPC), 2006.

As part of this a forecasting of future traffic volumes within the revised ODP area using the Cube transport planning software package. As part of this the following sub-tasks were undertaken:

- A trip generation exercise was undertaken to assess the quantum of traffic likely to be generated by each land use and the entire development. This was assessed for the around 30,000 vehicles per day (vpd).
- A distribution exercise was undertaken using a simple gravity model to determine the volume of flows between internal land uses and the external road network. Based upon this exercise it was assessed that 16,000vpd would come from / leave to the external road network at 100% full build out. It should be also noted that this is considered a conservative estimate, as it has been based upon the assumption of 2.5 persons per household, whereas the predicted occupancy is forecast to be less than 1.8 persons per household.
- A traffic assignment exercise was used to assign traffic to the road network, allowing the prediction of traffic volumes on roads throughout the structure plan. Most roads are expected to have less than 3000vpd, whilst the main spine road coming into the development is expected to have 16,000vpd under the scenario above.

Following this an examination of the preferred bus and pedestrian routes was undertaken based upon the traffic volume and the spatial location of land uses such as schools, retail and commercial areas. This information, with the additional of proposed drainage information, then informed the development of a road hierarchy and recommended road cross sections.

- The highest order road (The road entering from Wanneroo Road to the development) would be classified as an integrator B, and is recommended to be between 23 – 27m in width, with a 4 metre median and a 4 metre pavement in each direction (Larger than the 3.5m recommended in Liveable Neighbourhoods) with a cycle lane of 1.5m. Within the town centre areas, this would be downgraded to an Integrator B Main Street, which would consist of a 25m road reserve with 2 metre median and 3.5m pavement, with a 1.5m cycle lane and 2.5m parking; and
- Other roads would consist generally of 3.5m road lanes, except Industrial neighbourhood connectors which would have 4m road lanes. It should be noted that the total road widths are also wider than the typical minimums recommended under livable Neighbourhood standards (E.g. 2.5m parking lanes, rather than 2.1m).

Under the existing road network, it is expected that the travel time between Moore River South and the Guilderton Town centre would be around 20 minutes. This might in the future (Once the development becomes populated) spark debate about bridging Moore River in some manner for economic and/or social reasons (E.g. Allow better accessibility for students in Guilderton to attend school in the Moore River South development).

There are several forms this bridge could take; these are:

- Pedestrian Bridge;
- A "Green" (Limited to only Public Transport and Pedestrians) Bridge; and
- A Full Vehicle Access Bridge.

It is concluded that the bridge will never be needed from a road capacity perspective, and whilst it could improve travel times slightly for some groups, it is recommended that a pedestrian bridge or a green bridge, if considered feasible, could address all accessibility issues.

An additional assessment of sightline and basic geometric requirements for the access onto Wanneroo Road was undertaken and is attached in Appendix B. The recommendations from this were that:

- The operating speed along Wanneroo Road around the Wanneroo Road / Barragoon Road access be reduced from 110km/h to 90km/h so that safe sight distance requirements could be met. It is emphasized that such a reduction in operating speed to 90km/h is consistent with other treatments observed along Wanneroo Road as well as with the expected traffic volume entering/exiting the site (IE. Around 16,000vpd). Additionally, it is also logical that creating a 90km/h zone be around this access and the King Drive Access to the Woodbridge area to the north would improve safety along this section of road.
- A SIDRA assessment at the access suggests that to allow the right turn movement from Barragoon Road to clear effectively in both the AM and PM Peak Hours, a staged right turn crossing (IE. A short painted median in each direction) would be required, a 30m right turn in pocket would be needed along the Wanneroo Road North Approach to store queuing vehicles; and a left turn out short pocket that can store a single vehicle (IE. 30m) is needed at the Barragoon Road Approach.

This assessment report is based on an earlier draft design layout for the revised ODP area, which was for a large development concept, and therefore the assessment is conservative. Similarly, references to the 'Potential Sewerage Treatment Site' and the 'Rural Holiday Resort' are now redundant, having been altered in the final revised ODP.

1.0 INTRODUCTION

The Moore River South site is located to the south of the existing Guilderton town site in the Shire of Gingin on the opposite side of the Moore River. The general area is a popular holiday destination for locals, and is only slightly over an hours' drive from Perth.

An Outline Development Plan (ODP) was prepared by Richard Pawluk and Associates for the Moore River Company in 1996 for a greenfields site along the southern side of Moore River. A revised ODP has since developed by Cardno in 2010, with a substantial reduction in the quantum of housing from the original plan. This ODP is shown in Appendix A.

This transport assessment of the revised 2010 Moore River South ODP has been prepared by Cardno Eppell Olsen (Cardno) for the Moore River Company. The assessment has been undertaken in accordance with the Part 3: Structure Plans, Transport Assessments for Developments, WAPC, 2006. This includes an assessment of the following elements:

- Traffic Modelling (Trip Generation, Distribution and Assignment);
- Road Hierarchy and Road Cross Sections;
- Public Transport; and
- Pedestrians and Cycling.

2.0 TRAFFIC MODELLING

2.1 Background Data and Assumptions

A daily volume traffic model was developed for the ultimate development of the revised ODP area using the transport modelling software package Cube. The model would be typically described as a three step model (I.e. Trip Generation, Distribution and Assignment), and revises the modelling undertaken in *Moore River South ODP Transportation Study, 1996* In light of a revised ODP. Each of the components is discussed in the following sections.

In undertaking modelling for the development, a number of assumptions were made with regard to the likely demographic information relating to the ultimate development. These are:

- Assumed that there are 2.5 persons per households; and
- Student population for the primary school of around 500.

In addition to this the quantum and distribution of employee opportunities was estimated based upon the size and spatial location of commercial land uses shown in the ODP. The ODP was broken down into a series of zones for the purpose of the traffic modelling; this zone system in shown in the following figure.

2.2 Trip Generation

The Trip Generation model estimates the number of trips generated from within each zone. The trip generation used in the current modelling has used the same model structure (IE. Linear regression equations) and coefficients as the modelling undertaken as in the *Moore River South ODP Transportation Study, 1996.* The unfamiliar reader should be aware that the linear regression equations used have been developed from those derived as part of the *Road Reserve Review, Department for Transport, 1987*. The adjustment to those documented in the Road Reserve Review is primarily because it is assumed that 20% of the housing stock within the Moore River East ODP would operate as holiday houses, and that this would decrease the work and education trip generation rates accordingly.

The model divides trips up into three different purposes, these being Work, Education and Other and two trip end types, being productions (A trip starting or ending at a dwelling) and attractions (A trip starting or ending at something that is not a dwelling). The linear regression equations for each category are highlighted below:

It should be noted that the assessments in this report are based on layout plans of a larger development concept and therefore the assessments are conservative.

Table 2.1 ***Summary of Trip End Assumptions***

Type	Linear Regression Equation
Work Production	0.6 x Population
Education Production	0.124 x Population
Other Production	1.82 x Population
Work Attraction	1.5 x Employment
Education Attraction	0.8 x Student Enrolment
Other Attraction	1.138 x No# of Dwellings + 0.8 x Retail NLA + 0.77 x School Enrolment + 1.006 x Employment

The final trip generation per purpose is summarised in Table 3.1:

Table 2.2 ***Summary of Trip Generation***

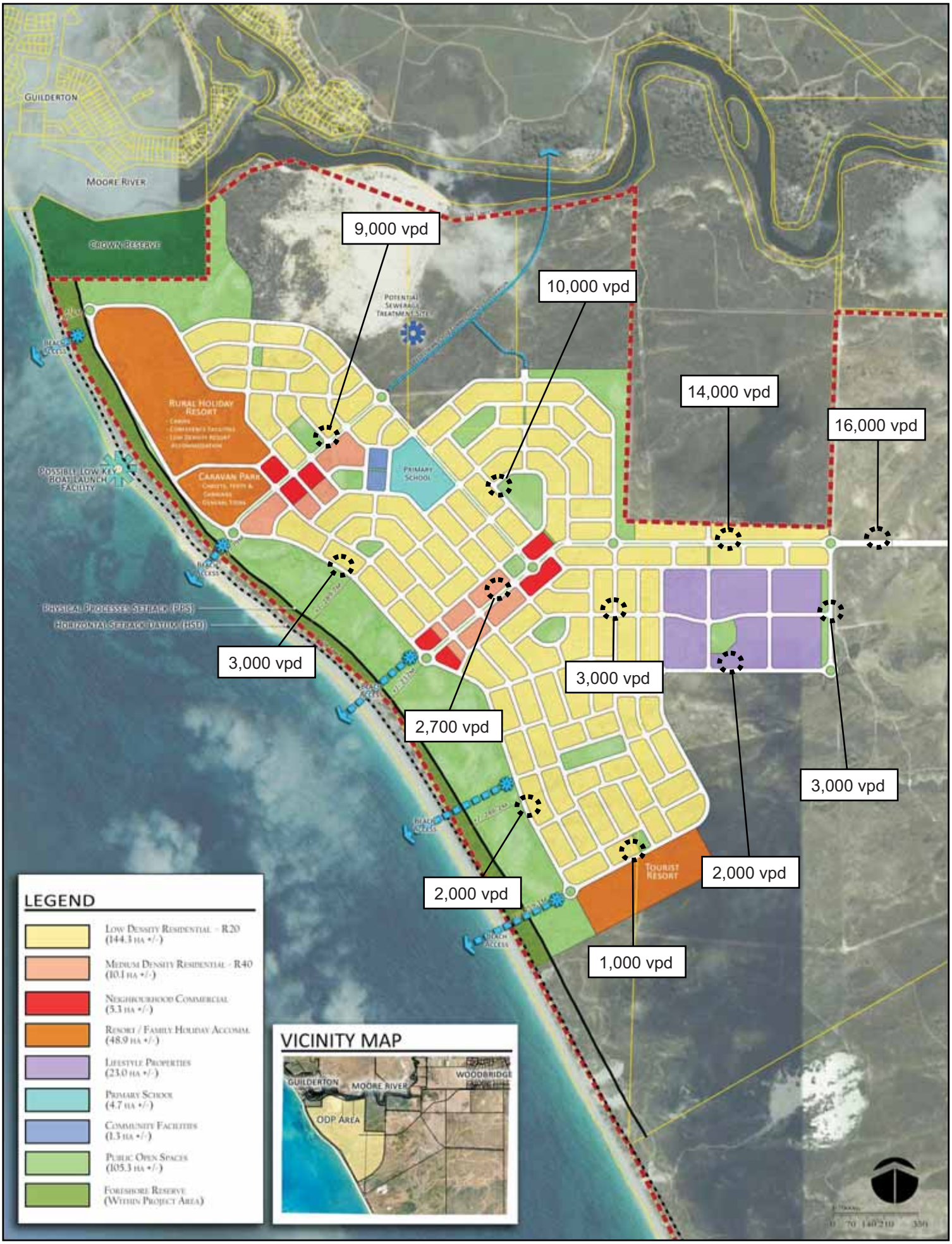
Activity Purpose	Work	Education	Other	Total
Trips Internal to the Development	870	360	12,301	13,531
Trips To/From the development to external areas	6,210	1,103	9,175	16,488
Total	7,080	1,463	21,476	3,0019

In total it is estimated that the fully developed ODP would generate around 30,000 vehicle trips per day (vpd), of which approximately 16,000 vpd would be released onto the external road network.

2.2 Traffic Distribution and Assignment

Traffic was distributed between origins and destinations for each trip purpose using a simple gravity model (I.e. Singly constrained and a unity matrix for frictional values). Traffic was then assigned to the road network using Cube using the “All or Nothing” Assignment method. This differs slightly from the original equilibrium assignment method detailed in the previous traffic study in that traffic only takes the fastest free flow path, and any reductions in speed due to any slight congestion does not cause re-routing of trips. This is a reasonable method for assigning daily traffic on a rural, low congested environment.

The forecasted traffic volumes expected at the completion of the development are shown in Figure 1.



Cardno Eppell Olsen
Shaping the Future

Forecast Traffic Volumes at Development Build Out

Figure 1 | Job Number: CEP02015

09 | 02 |2010

Traffic\2009\CEP02015 Figure 1.ka.cdr

3.0 NETWORK ASSESSMENT

3.1 Introduction

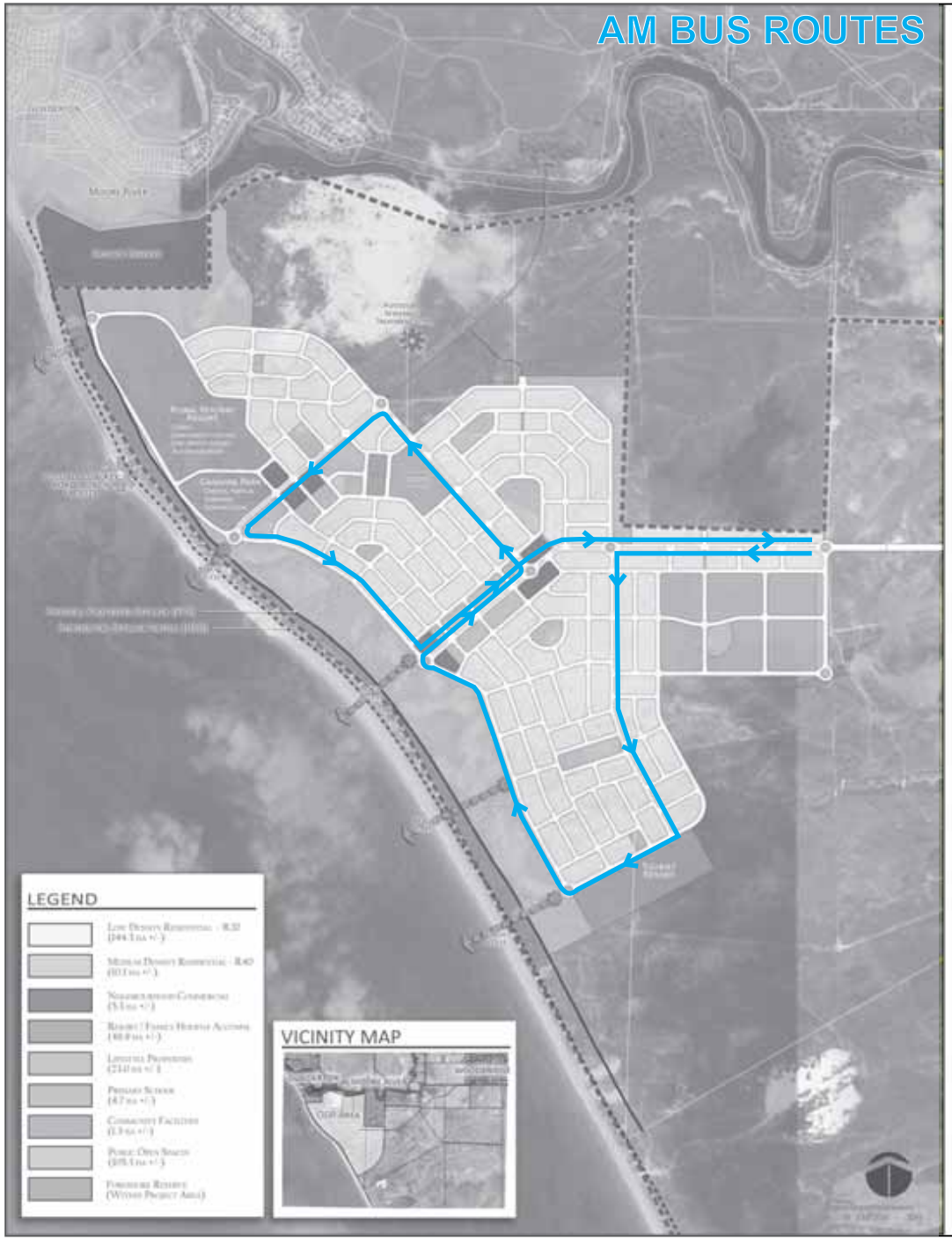
The focus of this assessment has been undertaken to:

- Ensure that the road design supports safe pedestrian and bicycle links throughout the precinct;
- Ensure that the needs of school buses are accounted for;
- Provide safe and adequate driving conditions.

This assessment method is somewhat different from standard procedures in that it focuses on accommodating walking, cycling and public transport routes before concluding on what road forms should be developed.

3.2 Public Transport

It is expected that in the future, a school bus service could be provided by TRANSWA to provide public transport to the proposed school and to a regional high school outside of the structure plan area. The majority of houses should have reasonable access to bus stops on major roads. Generally speaking walkers would be expected to travel up to a maximum of 50 metres to catch a school bus. Based upon trying to provide maximum catchment coverage whilst minimizing the number of stops, a bus plan has been put together – this is shown in Figure 2. These roads need the correct design to accommodate bus movements, including 3.5m or greater road lanes and a preference for give-way intersections. It should be noted that it is assumed that the school would have frontage onto the road adjacent to its North Eastern boundary, as the path has been chosen so that the bus would be picking up on its left.





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Recommended Bus Routes

Figure 2 | Job Number: CEP02015

9 | 02 | 2010

Traffic 2009/CEP02015 Figure 2.ai.cdr

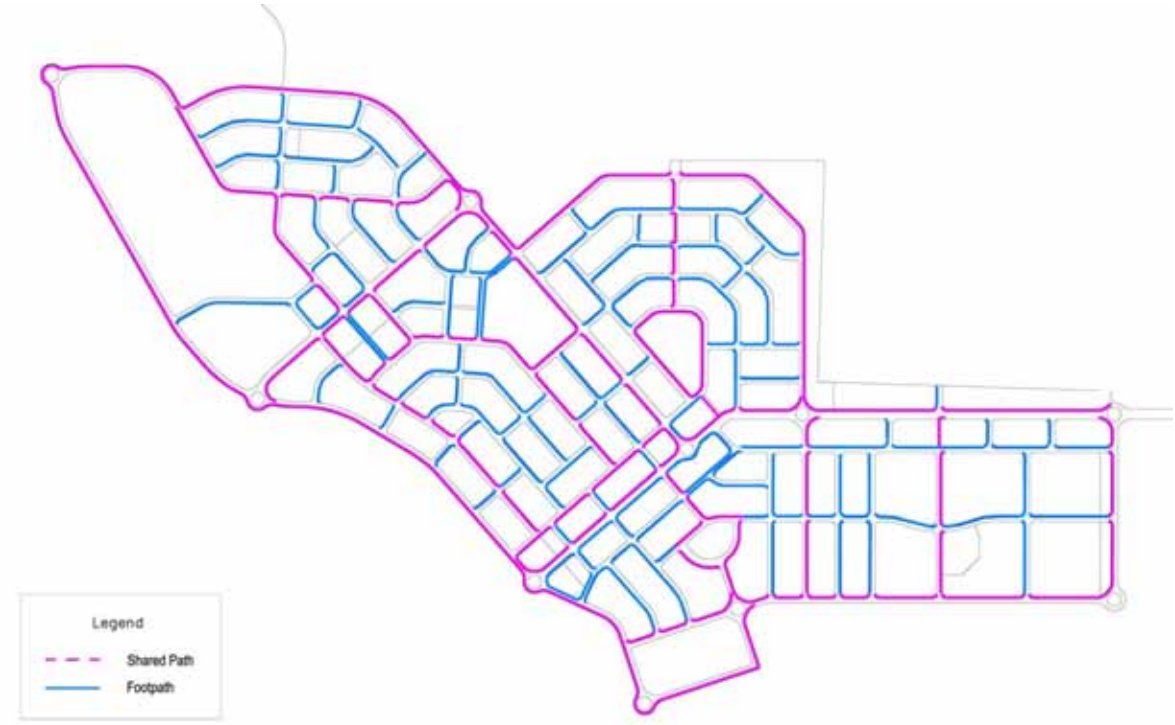
3.3 Walking and Cycling

Cycling and walking are a great alternative to car driving as they have a significantly less impact on the environment and also contribute to the aggregate health of the community. Good design of the pedestrian network and end of trip facilities is essential to encouraging the use of these modes of travel.

In consideration, large amount of this kind of travel would be undertaken by education and other trip purposes, especially holiday makers travelling to and from the beach. The other major pedestrian movements are expected to be between the commercial areas.

Given both these desire lines and the need to provide safe access to school bus stops, the recommended path network and crossing treatments are shown in Figure 3.

Figure 3



3.4 Road Hierarchy and Intersection Configurations

Liveable Neighbourhoods Guidelines, WAPC, 2006 provides guidance in terms of what classification roads should be given based upon traffic volume and other characteristics. Based upon the forecasted volumes and the requirements identified for cycling and walking infrastructure, the recommended road hierarchy is shown in Figure 4. Recommended cross sections are shown in Figure 5.

3.5 Bridge Crossings

Under the existing road network, it is expected that the travel time between Moore River South and the Guilderton Town centre would be around 20 minutes. This might in the future (Once the development becomes populated) spark debate about bridging Moore River in some manner for economic and/or social reasons (E.g. Allow better accessibility for students in Guilderton to attend school in the Moore River South development).

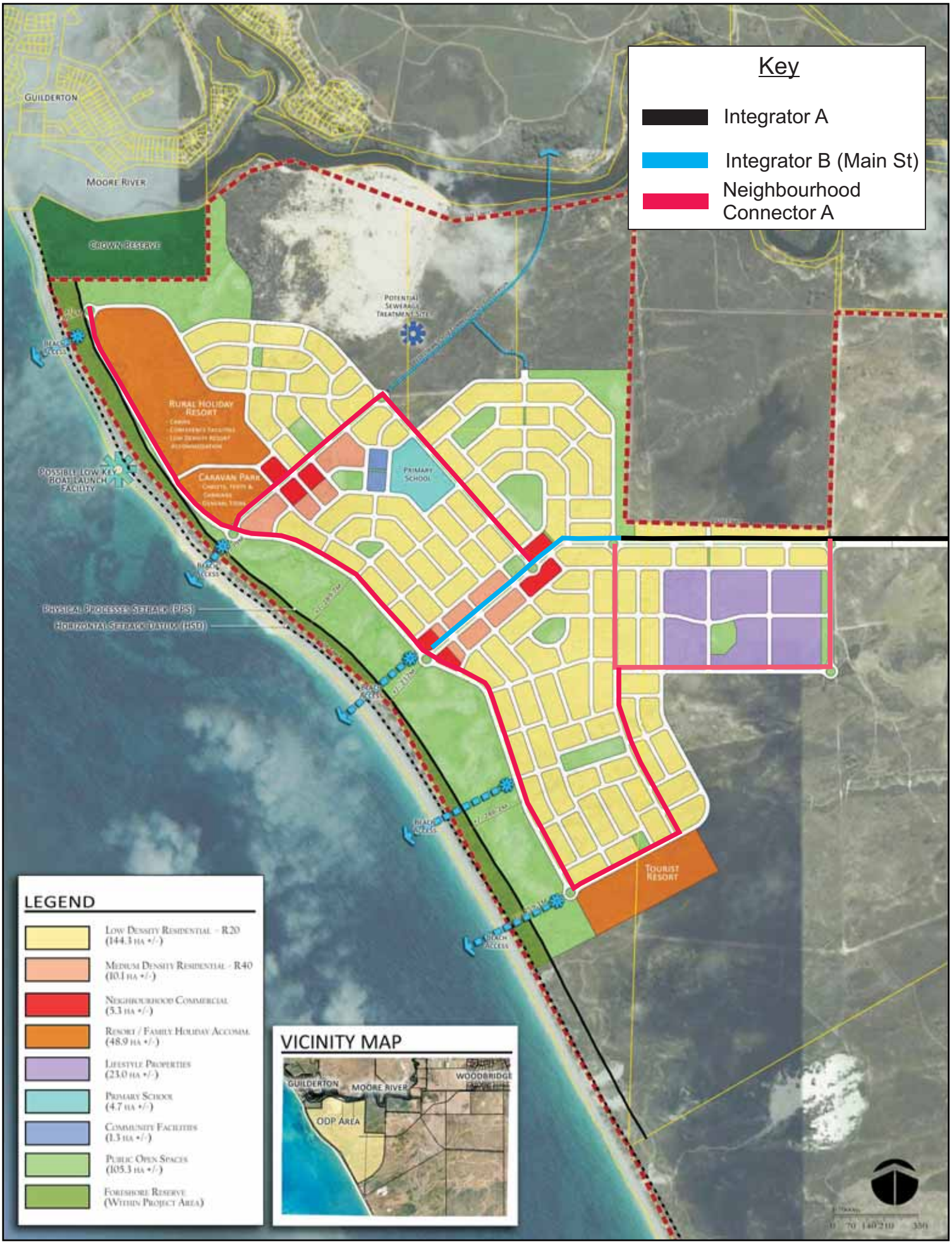
There are several forms this bridge could take; these are:

- Pedestrian Bridge;
- A “Green” (Limited to only Public Transport and Pedestrians) Bridge; and
- A Full Vehicle Access Bridge.

It is concluded that the bridge will never be needed from a road capacity perspective, and whilst it could improve travel times slightly for some groups, it is recommended that, if considered feasible, a pedestrian bridge or a green bridge could address all accessibility issues.

Preliminary investigations have also cast doubt over the feasibility, necessity and desirability for the vehicle bridge over the Moore River. Therefore, the revised ODP shows a pedestrian connection option at this stage, and the proponent has committed to proportionate funding on the facility on the basis that funding, design and ongoing management issues can be resolved to the satisfaction of all stakeholders.

The detail of the possible construction of a river crossing will be the subject of input at the community consultation phase of the revised ODP and further discussions between the proponent, the Shire of Gingin, the WAPC and any other relevant State government agency.



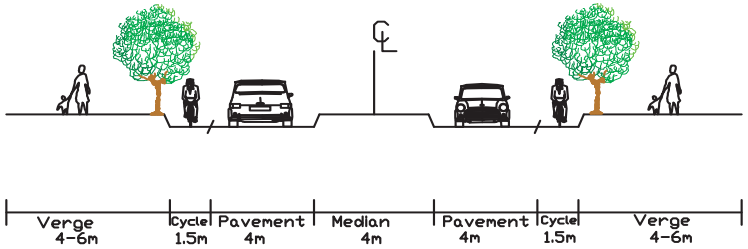
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Road Hierarchy

Figure 4 | Job Number: CEP02015 | 09 | 02 |2010

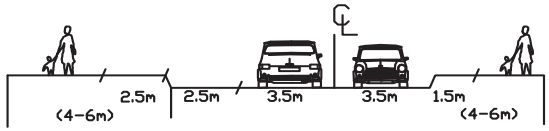
Traffic\2009\CEP02015 Figure 4.ka.cdr

Integrated Arterial B



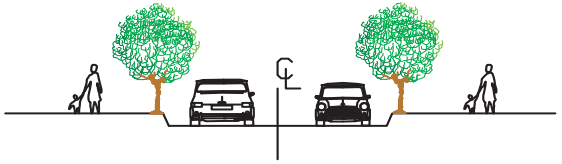
23-27m

Neighbourhood Connector A (adjacent to open space)



17.5-19.5m

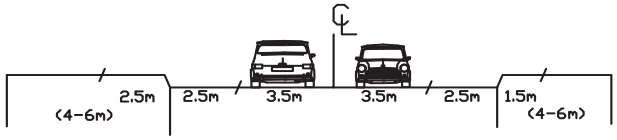
Neighbourhood Connector (Industrial)



16-20m

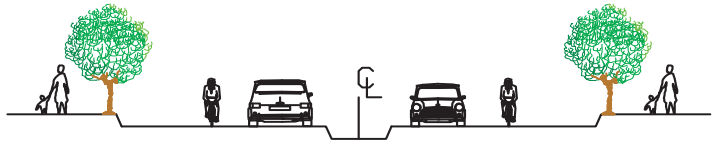


Neighbourhood Connector A

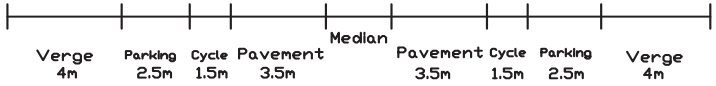


20-24m

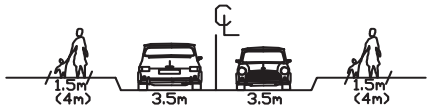
Integrated Arterial B (Main St)



25m



Access Road



15m

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Recommended Road Cross Sections

Figure 5 | Job Number: CEP02015

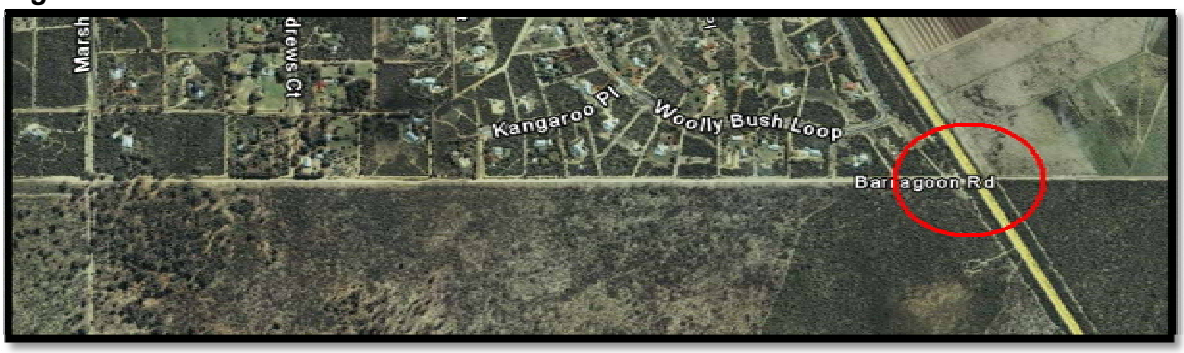
09 | 02 | 2010

Traffic:\2009\CEP02015 Figure 5.ka.cdr

3.6 Access to External Road Network

Access to the site would be provided from Wanneroo Road via Barragoon Road as shown in Figure 6 below. This route is currently an unsealed road between Link Road and Wanneroo Road that would need upgrading before work on this development could begin so that there is limited impact on the Woodbridge residential area to the east of the site.

Figure 6



Wanneroo Road / Barragoon Road Locality

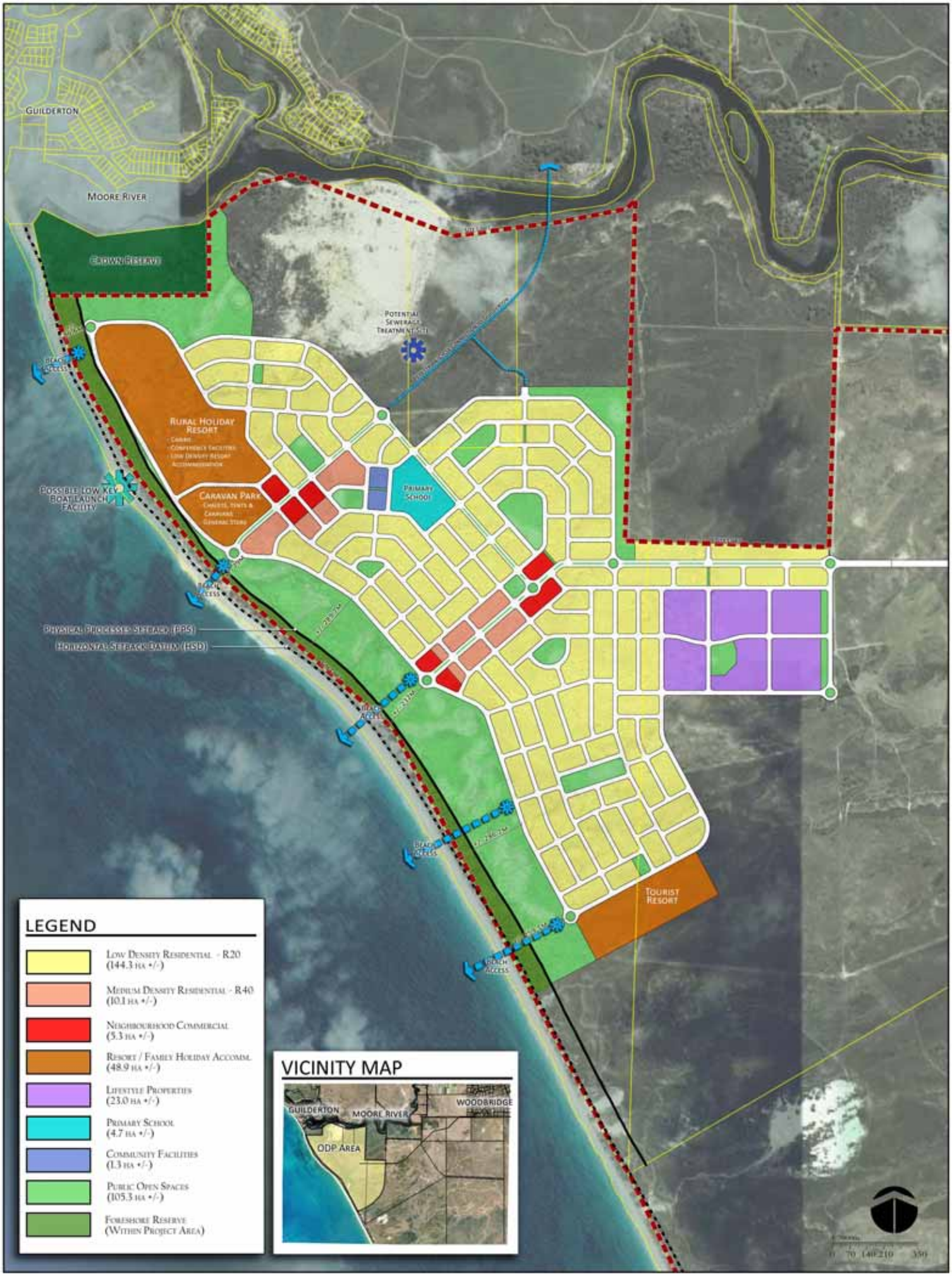
4.0 CONCLUSIONS

Cardno have undertaken this transport assessment for the revised Moore River South Outline Development Plan. As part of this exercise we constructed a Cube traffic model for the area which was then used to assess the likely traffic volumes on the various roads. An assessment was then undertaken for likely bus and pedestrian movements, and a road hierarchy allocated and road cross sections indicated.

The conclusion of the assessment is that the proposed transport network for the revised Moore River South ODP would operate acceptably under the network recommendations set out in this document.

Appendix A

Outline Development Plan



PROJECT: MOORE RIVER

TITLE: REVISED OUTLINE DEVELOPMENT PLAN

PREPARED: MOORE RIVER COMPANY PTY LTD

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DRAWN: RG | APPROVED:
LOCAL AUTHORITY: | SHEET: 1 OF 1

SHIRE OF GINGIN
PROJECT - PHASE - PLAN NUMBER: P07026 - SK10
REVISION: V

ORIGINAL: A1

Appendix B

Wanneroo Road / Barragoon Road Access Assessment

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Our Ref: CEP02015

Date: 8 March 2010

DESIGN NOTE

SIGHT DISTANCE AND GENERAL DESIGN ADVICE FOR WANNEROO ROAD / BARRAGOON ROAD INTERSECTION

Introduction

This brief technical note details an additional investigation with regards to the requirements for the intersection treatment for Wanneroo Road / Barragoon Road under the proposed traffic demand expected to be generated by the Moore River South Structure Plan.

Sight Distance Assessment

A site visit was undertaken on Monday the 8th of March 2009 between 9.30 and 10am. The following photos outline the general visibility in each direction along Wanneroo Road:

Figure 1 ***Wanneroo Road Looking Northbound from Barragoon Road***



Figure 2 ***Wanneroo Road Looking Southbound from Barragoon Road***



Maximum sightlines in each direction from the proposed intersection of Wanneroo Road / Barragoon Road were observed to be:

- The maximum available sight of a car stationed at the Barragoon Road access from Wanneroo Road to the South was 230 metres; and
- The maximum available sight of a car stationed at the Barragoon Road access from Wanneroo Road to the North was in excess of 330 metres.

From a safety perspective, minimum Approach Sight distance (ASD – in this case accommodating trucks using Wanneroo Road with a -2/+2% grade) and Safe Intersection Sight Distance (SISD) must be provided for vehicles travelling from either direction. The minimum values based upon different operating speeds stipulated in *Guide to Road Design, Austroads (2009)* are highlighted in the following table:

Table 1 ***Requirements for Sight Distances***

Operating Speed	Approach Stopping Distance (m)	Safe Intersection Sight Distance (m)
90km/h	178m	207m
100km/h	213m	246m
110km/h	252m	289m

The operating speed observed on the site visit was 110km/h. This speed would need to be reduced around the location of the access so that the sight distance requirements could be met. It is emphasized that such a reduction in operating speed to 90km/h is consistent with other treatments observed along Wanneroo Road as well as with the expected traffic volume entering/exiting the site (IE. Around 16,000vpd). Additionally, it is also logical that creating a 90km/h zone be around this access

and the King Drive Access to the Woodbridge area to the north would improve safety along this section of road.

Turning Volumes and Warrants for Additional Lanes

2005 data from Main Roads Western Australia suggests that Wanneroo Road has around combined directions 300vph during its peak hours, with less than 3000vpd. If we assume a split of 50% North 50% South, then this is 150vpd in each direction. Based upon the daily volumes, likely peak and directional distributions, the following volumes at the intersection have been estimated for the Wanneroo Road / Barragoon Road Intersection.

Table 2 ***Estimated Traffic Volumes – Wanneroo Road / Barragoon Road***

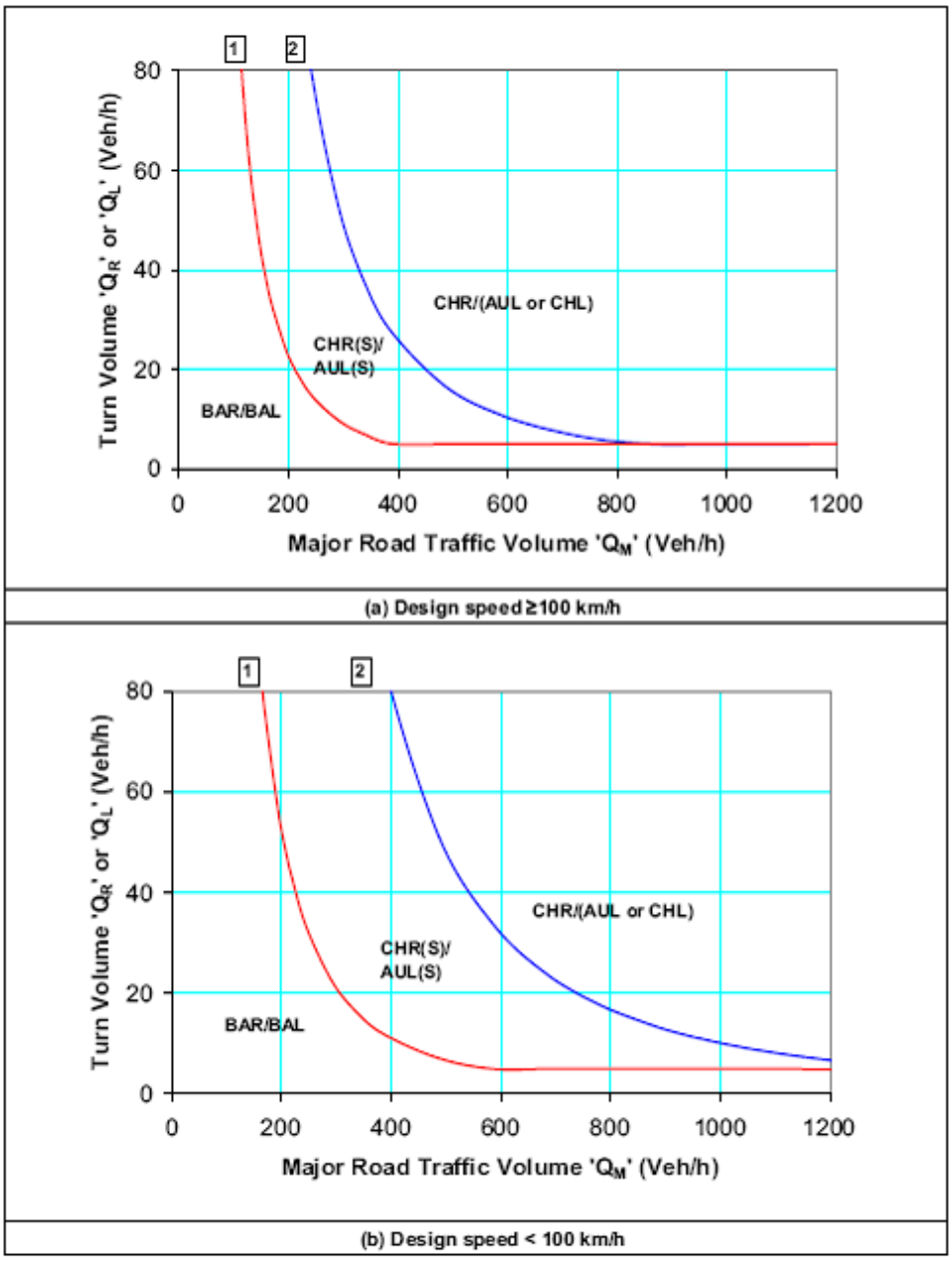
Approach	Movement	Expected AM Peak Hour Volume	Expected PM Peak Hour Volume
Wanneroo Road South	Left	432	1008
	Through	150	150
Wanneroo Road North	Through	150	150
	Right	48	112
Barragoon Road	Left	112	48
	Right	1008	432

Based upon these volumes, an iterative SIDRA assessment was undertaken for the peak hours until a reasonable intersection Level of Service was achieved (Movement summary tables are attached to this document). From a geometric perspective, the analysis suggests that:

- To allow the right turn movement from Barragoon Road to clear effectively in both the AM and PM Peak Hours, a staged right turn crossing (IE. A short painted median in each direction) would be required;
- A 30m right turn in pocket would be needed along the Wanneroo Road North Approach to store queuing vehicles; and
- A left turn out short pocket that can store a single vehicle (IE. 30m) is needed at the Barragoon Road Approach.

The warrants for particular unsignalised intersection treatments are shown in Figure 3 from *Part 4A – Unsignalised and Signalised Intersections, Guide to Road Design, Austroads, 2009*. With respect to estimated volumes, the treatment recommendations are consistent with the conclusions from the SIDRA assessment.

Figure 3 ***Warrants for Unsignalised Intersection Treatments***



Source: Arndt and Troutbeck (2008)

Figure 4.9: Warrants for turn treatments on the major road at unsignalised intersections

SIDRA - Movement Summary

Wanneroo Road / Barragoon Road

AM Peak Hour
Two-way stop

Vehicle Movements

Mov ID	Turn	Dem Flow (veh/h)	%HV	Deg Satn (v/c)	f Aver Delay (sec)	Level Of Service	95% Back of Queue (m)	Prop. Queued	Eff. Rate	Stop	Aver Speed (km/h)
Wanneroo Road South											
1	L	455	0.0	0.326	8.2	LOS A	0	0.00	0.67		49.0
2	T	158	0.0	0.326	0.0	LOS A	0	0.00	0.00		60.0
Approach		**613**	**0.0**	**0.326**	**6.1**	**LOS A**		**0.00**	**0.50**		**51.4**
Wanneroo Road North											
8	T	158	0.0	0.081	0.0	LOS A	0	0.00	0.00		60.0
9	R	51	0.0	0.073	11.9	LOS B	2	0.55	0.81		45.2
Approach		**209**	**0.0**	**0.081**	**2.9**	**LOS A**	**2**	**0.14**	**0.20**		**55.6**
Barragoon Road											
10	L	118	0.0	0.153	13.1	LOS B	5	0.47	0.94		44.9
12	R	1061	0.0	0.385	11.2	LOS B	18	0.42	0.89		46.5
Approach		**1179**	**0.0**	**0.385**	**11.4**	**LOS B**	**18**	**0.43**	**0.89**		**46.3**
All Vehicles		**2001**	**0.0**	**0.385**	**8.9**	**Not Applicable**	**18**	**0.26**	**0.70**		**48.6**

Symbols which may appear in this table:

Following Degree of Saturation
x = 1.00 for Short Lane with resulting Excess Flow
* x = 1.00 due to minimum capacity

Following LOS
- Based on density for continuous movements

Following Queue
- Density for continuous movement

SIDRA Movement Summary

Wanneroo Road / Barragoon Road

PM Peak Hour
Two-way stop

Vehicle Movements

Mov ID	Turn	Dem Flow (veh/h)	%HV	Deg Satn (v/c)	Aver Delay (sec)	Level of Service	95% Back of Queue (m)	Prop. Queued	Eff. Rate	Stop	Aver Speed (km/h)
Wanneroo Road South											
1	L	1061	0.0	0.653	8.2	LOS A	0	0.00	0.67		49.0
2	T	158	0.0	0.653	0.0	LOS A	0	0.00	0.00		60.0
Approach		**1219**	**0.0**	**0.652**	**7.1**	**LOS A**		**0.00**	**0.58**		**50.2**
Wanneroo Road North											
8	T	158	0.0	0.081	0.0	LOS A	0	0.00	0.00		60.0
9	R	118	0.0	0.686	45.5	LOS E	25	0.96	1.14		26.6
Approach		**276**	**0.0**	**0.684**	**19.4**	**LOS C**	**25**	**0.41**	**0.49**		**39.1**
Barragoon Road											
10	L	51	0.0	0.108	16.5	LOS C	3	0.63	1.00		42.3
12	R	455	0.0	0.200	11.5	LOS B	8	0.51	0.91		46.4
Approach		**506**	**0.0**	**0.200**	**12.0**	**LOS B**	**8**	**0.52**	**0.92**		**46.0**
All Vehicles		**2001**	**0.0**	**0.686**	**10.1**	**Not Applicable**	**25**	**0.19**	**0.65**		**47.2**

Symbols which may appear in this table:

Following Degree of Saturation
x = 1.00 for Short Lane with resulting Excess Flow
* x = 1.00 due to minimum capacity

Following LOS
- Based on density for continuous movements

Following Queue
- Density for continuous movement

Appendix E

Environmental Justification and Assessment

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Moore River South

Environmental Assessment and Justification Report

Prepared for Moore River Company Pty Ltd

May 2010

Project Number V9070-7

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Executive Summary

Cardno Pty Ltd (Cardno) was engaged by Moore River Company Pty Ltd (MRC) to provide environmental consultancy services associated with the formulation of the revised Outline Development Plan (ODP) for MRC landholdings. MRC landholdings are adjacent to the southern shore of Moore River just south to the existing Guilderton town site. The development area is referred to within this report as the 'subject site'.

Initially the ODP design process was conducted following the modification of the Shire of Gingin Town Planning Scheme No. 8 in 1995. The ODP was originally submitted to the Shire of Gingin in 1996 and was approved subject to alterations in 1998. The ODP was submitted to the Western Australian Planning Commission (WAPC) in 1998, modified in 1999 in accordance with WAPC's requests and approved in 2000. The WAPC refused the subdivision application in 2004. MRC have engaged Cardno to prepare the revised ODP and to re-evaluate the environmental issues, constraints and opportunities in line with the changes in legislation and modifications in environmental conditions at the subject site.

The revised ODP has been prepared in response to the Minister of Planning's acknowledgement that the existing Urban Development zone within the Shire of Gingin Town Planning Scheme No. 8 has been in place since 1995 and that this zoning, subject to a reduction in the scale of the development, will provide the township of Guilderton and surrounding rural estates with a primary school, shopping and community facilities, and servicing infrastructure, which will result in the creation of a sustainable community catering for a population of up to 5,000 residents. The area of land unaffected by the proposal will remain zoned as Urban Development, which will be unable to support development without the required structure planning approval at some time in the future.

The environmental consultancy services included a number of site specific environmental investigations including:

- Flora and vegetation assessment - Level 2 (Cardno 2010);
- Fauna Assessment (Harewood 2010); and
- Ongoing ground water monitoring (Cardno October 2009 to March 2010).

A summary of these investigations and a review and synthesis of other previously existing environmental information for the subject site is provided in this report. The key environmental features of the subject site include:

- Suitable habitat for both Carnaby's Black Cockatoo and the Graceful Sun-Moth;
- Indigenous heritage sites;
- Significant areas of remnant vegetation, including vegetation in "Excellent" and "Pristine-Excellent" condition;
- The coastal setting of the subject site; and
- Significant Flora species.

This information was incorporated into a comprehensive, collaborative and multi-disciplinary design for the revised ODP. Key environmental design features incorporated into the revised ODP design include:

- A generous and strategic allocation of Public Open Space (POS);
- A design that accommodates the retention of topography and landscape; and
- Protection of key physical environmental attributes such as habitat trees.

The overall objective of the revised ODP is to retain the existing environmental character of the subject site as much as possible. In addition to the design features above further environmental investigations and management measures will be incorporated at future stages of planning and development process to achieve this objective. These are likely to include (but are not limited to):

- Plan and Strategy Preparation
  - Foreshore Management Plan including the increased foreshore reserve and POS
  - Management Plans for Carnaby's Black Cockatoo and the Graceful Sun-Moth
  - Fire Management Plan
  - Revegetation, Rehabilitation and Landscaping Plan
  - Dust Management Plan
  - Landscape Strategy
  - Construction Management Plan
  - Stormwater and Drainage Management Plan
  - Traffic and Parking Strategy
- Development and land ownership controls
  - Design guidelines
  - Management frameworks

In conclusion, through applying the collaborative design process, the revised ODP is responsive to the significant environmental features of the subject site. By integrating the findings from the environmental investigations into the design process for the revised ODP, the design has managed to encapsulate the environmental character of the subject site and ensure that the majority of the development occurs in lower condition vegetation. Future management frameworks to retain, protect and manage these environmental features will provide for their long term management and protection.

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1 Introduction

1.1 Background

Moore River Company Pty Ltd (MRC) is the owner of a parcel of land (Swan Location 2802 and portions of Swan Location 2424 and 2914) on the coast, immediately south of Moore River near Guilderton. This area is referred to within this report as the 'subject site' (**Figure 1**). This parcel of land forms part of a larger piece of land, which is zoned "Urban Development" under the Shire of Gingin Town Planning Scheme (TPS) No. 8. The entire MRC landholding occupies approximately 2000 hectares, however only 557 hectares are incorporated into the Urban Development Zone within the Gingin TPS No. 8. The revised ODP area is roughly 346 hectares. A coastal foreshore reserve abuts the western boundary of the subject site.

The draft Local Planning Strategy supports the new urban expansion south of Moore River and aims to facilitate a high quality, environmentally sensitive and integrated urban development. It is envisaged that the future urban development will support a range of residential and accommodation options to contribute towards a sustainable community for the broader region. The State Government has indicated support for the urban development (subject to further detailed planning) of the subject site with the future urban development to support a medium to long-term population of approximately 5,000 people, consistent with the draft Local Planning Strategy.

1.2 Purpose of this report

This report provides a synthesis of information from a range of sources regarding the environmental attributes and values of the subject site, including existing information and site specific assessments that have been undertaken for the subject site. Collectively this information has been used to inform the revised ODP design process, which involved collaboration from many technical disciplines, together with planning consultants.

Initially the ODP design process was conducted following the modification of the Shire of Gingin Town Planning Scheme No. 8 in 1995. The ODP was originally submitted to the Shire of Gingin in 1996 and was approved subject to alterations in 1998. The ODP was submitted to the WAPC in 1998, modified in 1999 in accordance with WAPC's requests and approved in 2000. The WAPC refused the subdivision application in 2004. MRC have engaged Cardno to prepare the revised ODP and to re-evaluate the environmental issues, constraints and opportunities in line with the changes in legislation and modifications in environmental conditions at the subject site.

The revised ODP has been prepared in response to the Minister of Planning's acknowledgement that the existing Urban Development zone within the Shire of Gingin Town Planning Scheme No. 8 has been in place since 1995 and that this zoning, subject to a reduction in the scale of the development, will provide the township of Guilderton and surrounding rural estates with a primary school, shopping and community facilities, and servicing infrastructure, which will result in the creation of a sustainable community catering for a population of up to 5,000 residents. The area of land unaffected by the proposal will remain zoned as Urban Development, which will be unable to support development without the required structure planning approval.

The primary purpose of this report is to present the information that was used to inform the development of the revised ODP, assess the potential environmental impacts that could potentially arise from the implementation of the revised ODP, and finally provide recommendations as to the

future environmental management requirements for the future planning and development phases of the revised ODP.

1.3 Scope of work undertaken

Cardno was engaged to conduct a number of site specific environmental investigations covering the subject site and prepare an Environmental Assessment and Justification Report, which defined the environmental features of the subject site and how these would be treated by the revised ODP. This report details and assesses the site specific environmental issues, constraints and opportunities and justifies the methods undertaken by the revised ODP to minimise any negative impact on the environment.

The environmental investigations were conducted over a broad area in order to refine the revised ODP boundary. These investigations include the following:

- Flora and vegetation assessment - Level 2 (Cardno 2010);
- Fauna Assessment (Harewood 2010); and
- Ongoing ground water monitoring (Cardno October 2009).

The document provides a summary of these environmental investigations. In addition to the site specific environmental investigations, this document provides analysis of other environmental features present within the subject site including:

- Existing, historic and surrounding land uses;
- Potential soil and groundwater contamination;
- Aboriginal and European heritage;
- Coastal processes; and
- Recreational and aesthetic values.

Following an assessment of the existing environmental attributes of the subject site, the revised ODP was prepared to address these attributes and values. This collaborative, multi-disciplinary and iterative process has resulted in a revised ODP design which has been fully informed by and responds to the environmental values of the subject site. The document also details how the various environmental aspects need to be addressed in the ongoing planning and development process to achieve the necessary environmental outcomes.

2 Existing Environment and Site Specific Investigations

2.1 The local context

The subject site is located within the Shire of Gingin and is located approximately 75 kilometres north west of the Perth central business district, just south of the Guilderton town site (**Figure 1**). This site is bound by the Indian Ocean to the west, Moore River to the north and pastoral and uncleared land to the east and south.

The Shire of Gingin is one of the fast growing regions in Western Australia. At present the Perth metropolitan region is incurring significant population growth which is resulting in a high demand for residential development. The Shire of Gingin is likely to experience significant growth and change in the future as the Perth metropolitan region expands to the north along the coastal growth corridor. The development at Moore River South aims to provide a residential development that contributes to the sustainable growth of the region.

2.2 Land Uses

2.2.1 Previous and Current Land Uses

The subject site is currently zoned "Urban Development" under the Shire of Gingin TPS No. 8. Historically, the subject site was utilised for grazing and pastoral purposes, with the MRC landholdings still being utilised for these purposes. At present the majority of land along the foreshore is only used for the occasional beach access by either foot or vehicles. The foreshore is often subject to trespassing by four wheel drive vehicles from Wilbinga Road.

2.2.2 Surrounding Land Uses

The subject site is surrounded by “Rural” zoned land which is used for grazing and pastoral land uses. Several parcels of the adjacent “Rural” zoned land also contain remnant vegetation. There are no high intensity industrial or agricultural uses surrounding the subject site (**Figure 2**).

The subject site is directly south of the existing Guilderton townsite, separated by the Moore River. Guilderton has been a popular camping and recreation spot since 1905 and the area was declared as a recreation area in 1907.

Guilderton is still a popular tourist destination and is known for its water based activities, including surfing, fishing, kayaking and boating. Due to its proximity to Perth, the population of Guilderton increases significantly in the summer months and over long weekends.

The townsite currently supports a population of approximately 150 people (ABS 2006), however the Gingin Coast Structure Plan (WAPC 2006) predicts a population of 200 – 5000 people in the next 20 years. This population growth includes the endorsed development of the subject site.

Directly to the west of the subject site is a foreshore reserve, reserved for “Parks and Recreation” under TPS 8. To the north west of the subject site is an additional coastal reserve, reserved for “Parks and Recreation” under TPS 8. The subject site is less than 1 kilometre south of existing housing in Whitfield St, Guilderton.

2.3 Climate and Weather

Guilderton is located within the South West of Western Australia, which experiences a Mediterranean climate of mild wet winters and hot dry summers. There is no weather information available on the Bureau of Meteorology website for the Guilderton area and the nearest weather stations are Lancelin approximately 40 kilometres to the north and Pearce 60 kilometres to the south east.

Climatic data obtained from the closest coastal monitoring station (Lancelin) provides average temperature and rainfall statistics. The temperature, calculated from data collected from 1965 to 2009, shows a mean maximum range of 29.7℃ in February to 19.1℃ in July and a mean minimum range from 18℃ in February to 9.2℃ in August. The mean maximum rainfall occurs in July with 127.2 mm and the mean minimum rainfall occurs in December with 7.4 mm.

The Pearce and Lancelin weather stations show that in the morning, the wind typically blows from the east, while in the afternoon the wind is typically from the south and south west (See Diagrams 1 and 2). Overall, the sea breeze (from the west) is stronger at Lancelin, which is typical for a coastal site.

Diagram 1 Wind Roses for Pearce, 9 am (left) and 3 pm (right) based upon observations from 1940 to 2008 (Commonwealth of Australia 2008).

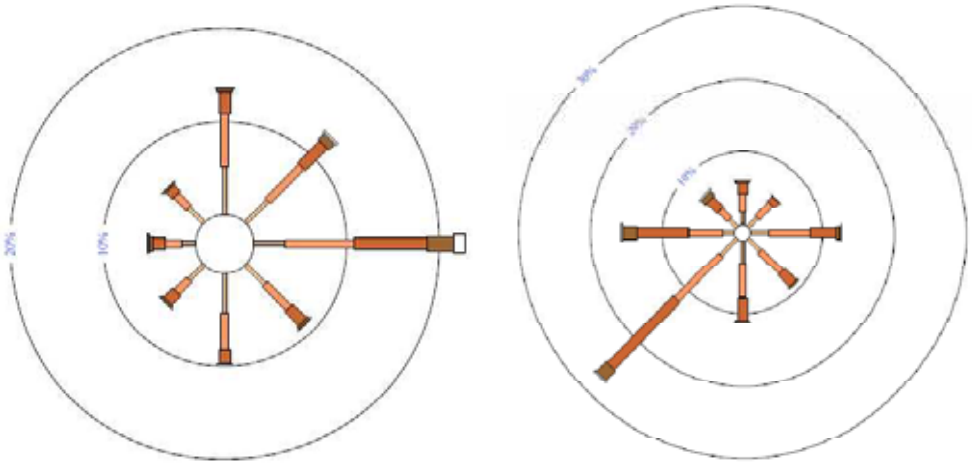
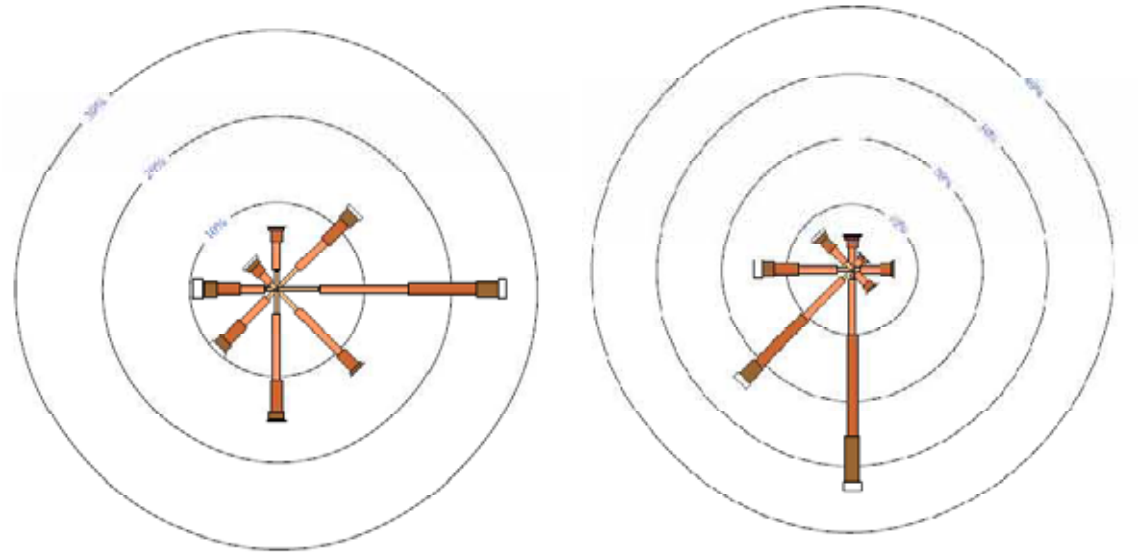


Diagram 2 Wind Roses for Lancelin, 9 am (left) and 3 pm (right) based upon observations from 1965 to 2008 (Commonwealth of Australia 2008).



2.4 Subject Site Topography, Geology, Landform and Soils

The subject site is located within the Swan Coastal Plain, which is on the central portion of Perth Basin. The Perth Basin extends from the Darling fault in the east to the continental slope west of Rottnest Island, from the Murchison River in the north and the Southern Ocean in the south. The Perth Basin is sedimentary in origin.

The Swan Coastal Plain is comprised of a number of geomorphic entities running parallel to the coastline. From west to east, these include the Quindalup Dunes, Spearwood Dunes, Bassendean Dunes and the Pinjarra Plain. According to landform and soil mapping (Churchward and McArthur 1980), the subject site is comprised of the Quindalup dunes, which is described as unconsolidated sand and shell fragments with some organic matter darkening the surface of the sand. The Quindalup dune system is described as a Holocene landform.

The Department of Agriculture and Food (DAF) provides mapping of the region, detailing the likely soil units. The soil units described as occurring across the subject site are detailed in **Table 1**.

Table 1: Soil landform units of the subject site (Churchward and McArthur, 1978)

Soil Unit	Land Unit	Description
Quindalup Coastal dunes, of the Swan Coastal Plain, with calcareous deep sands and yellow sands. Coastal scrub.	Qp	Quindalup South Deep Sand Flat - Undulating landscapes with deep calcareous sands overlaying limestone.
	Qu	Quindalup South Unstable Sand - unstable, calcareous sands.
	Q_2	Quindalup South Second Phase - a complex pattern of dunes with moderate relief, calcareous sands with some organic staining to about 20 centimetres
	Q_3	Quindalup South - irregular dunes with high relief, slopes up to 20 per cent, loose calcareous sand with little surface organic staining.

Soil Unit	Land Unit	Description
	Q_4	Quindalup South Youngest Dune - irregular dunes with slopes up to 20 per cent, loose pale brown calcareous sands.
Karrakatta Undulating landscape with deep yellow sands over limestone	Ky	Karrakatta Sand Yellow Phase - low hilly to gently undulating terrain, yellow sand over limestone at 1 to 2 metres.
	Kls	Karrakatta Shallow Sands - low hills and ridges, bare limestone or shallow siliceous or calcareous sand over limestone.

These soil units are shown in **Figure 3**.

The topography of the subject site is undulating with the natural surface height ranging from 6 metres Australian Height Datum (mAHD) along the coast to 50 mAHD further inland (**Figure 4**). The subject site is characterised by a number of irregular dunes, which rise steeply away from the beach and south of Moore River, to a series of high dunes and valleys, and range from approximately 10 mAHD on the coast to 40 mAHD a short distance inland (refer to Slope Analysis, **Figure 5**).

2.5 Geoheritage

Geoheritage is a complex expression of the geological and geographical landforms and the historical development of all ecological systems upon them. Geoheritage is the historical record of the processes that have produced the geology and landform in an area.

Based on the broad description of the landform and geology above and the Department of Agriculture online mapping, the majority of the subject site appears to be composed of the Quindalup Dunes. These can be associated with forms of geoheritage where unusual landforms occur, such as the record of Holocene dune building found at Port Kennedy.

From the available information, the subject site does not contain forms of geoheritage, which are currently targeted for protection. Additionally, none of the previous studies or planning for the subject site has noted the occurrence of significant or unusual geoheritage features.

2.6 Hydrology

2.6.1 Surface Water

The subject site is located directly to the south of the mouth of Moore River. The Moore River catchment receives variable rainfall and as a result the river has only seasonal contact with the sea, when the volume of water flowing through it is sufficient to break through the sandbar across its mouth or when anthropogenic forces have opened the bar. Apart from Moore River to the north of the subject site, there are no known or mapped waterways.

2.6.2 Groundwater

2.6.2.1 Review of existing information

The subject site represents the north-west portion of the Gnangara Mound groundwater system. This system extends from Moore River in the north, to the Swan River in the south, the Indian Ocean to the west and Ellen Brook to the east. The Gnangara Mound is a superficial aquifer which contains

predominantly unconfined groundwater, which overlays the deeper and impermeable Osborne Formation and Lancelin Beds (Coolyena Group), which are approximately 500 metres deep (GSS 2009). The surface sediments that form these formations are broadly consistent with the soil characteristics discussed above in **Section 2.3** and vary vertically and laterally with interweaving layers of sand, limestone, silt and clay.

The groundwater in the region is likely to be directly recharged by rainfall, which percolates into and moves slowly through the superficial formations.

2.6.2.2 Groundwater site investigations

Currently, site specific groundwater investigations are being undertaken across the subject site to support the future planning process. However, from regional information and previous investigations, the majority of the groundwater is likely to flow in a westerly direction with groundwater discharging over a saline wedge to the ocean. This occurs both in the vicinity of the Seabird town site, approximately 10 kilometres to the north, and in the Wilbinga area, which is located directly to the south of the MRC's wider landholdings. To the northern portion of the subject site, groundwater is likely to flow in north, north-westerly direction, towards Moore River.

Ten shallow groundwater bores have been installed within the Moore River South subject site at locations which will provide the best representation of anticipated groundwater systems and an accurate dissemination of data throughout the subject site. The locations of these groundwater bores are shown in **Figure 6**. These locations were selected to allow for the identification of potential nutrient hotspots and development of underlying groundwater contours.

Groundwater levels have been measured on a monthly basis since October 2009 on all installed bores. These bores are measured using an audible dip meter to record standing water levels. The groundwater contours over the subject site are shown in **Figure 6** and preliminary investigations indicate a westerly groundwater flow direction.

Groundwater quality sampling has been conducted in November 2009 and February 2010. Initial analysis (November 2009) was conducted for a full range of parameters including nutrients, nutrient species, metals, pesticides and hydrocarbons. The second round of groundwater quality analysis (February 2010) was conducted for nutrients and nutrient species. A detailed monitoring report providing analysis of the results will be presented upon completion of the groundwater sampling program in mid 2010. This will be presented in a Local Water Management Strategy.

2.6.3 Wetlands

Based on the mapping maintained by the DEC, the *Geomorphic Wetlands of the Swan Coastal Plain* dataset (Hill *et al*. 1996) and an environmental audit conducted by Tinley (1992), no wetlands are present within the subject site.

The wetlands in the vicinity of the subject site are located in the coastal back-plain zone, found to the east of the subject site. From the site specific investigations as part of the Flora and Vegetation Survey (Cardno 2010), there was no evidence of wetland systems or wetland dependant vegetation.

2.6.4 Public Drinking Water Source Area

Public Drinking Water Source Areas (PDWSAs) are gazetted by the Department of Water (DoW) to protect the water quality of identified drinking water sources, which can be surface water or groundwater (DoW 2009). PDWSAs provide the community of Western Australia with the majority of

its drinking water supplies and can be vulnerable to contamination by a range of land uses and water based activities.

According to the DoW *Geographic Atlas* (online) (2009) there are no declared Public Drinking Water Source Areas (PDWSAs) located within the subject site. However, a Priority 2 PDWSA is located approximately one kilometre to the north of the subject site. Development of the subject site is unlikely to impact on this PDWSA as Moore River acts as a barrier to groundwater flow to the north. This PDWSA was proclaimed with the intention to provide the town of Guilderton with a safe drinking water supply.

2.7 Flora and vegetation

Broad regional information indicates that the subject site is located within the Swan Coastal Plain Subregion Drummond Botanical Subdistrict. The vegetation is broadly categorised as Banksia low woodland on leached sands with Melaleuca swamps on ill-drained soils and woodlands of Tuart (*Eucalyptus gomphocephala*), Jarrah (*Eucalyptus marginata*) and Marri (*Corymbia calophylla*) on less leached soils (Beard, 1990).

Regional vegetation complex mapping undertaken by Heddle *et. al*. 1986 for parts of Western Australia indicates that the subject site is primarily within the Quindalup Complex (**Figure 7**). The description given for the Quindalup Complex is:

"Coastal dune complex consisting mainly of two alliances, the strand and fore dune alliance and the mobile and stable dune alliance. Local variations include low closed forest of *Melaleuca lanceolata – Collistris preissii* and closed scrub of *Acacia rostellifera*"

Previously, a flora and vegetation survey of the subject site was conducted by Alan Tingay and Associates in November 1992 (Alan Tingay and Associates 1993). This survey did not reveal any significant or protected flora or vegetation, however suggested that "significant stands of *Allocasurina lehmanniana* could be protected as much as possible within open space along the top of the Moore River Southern riverbank". In addition, the survey noted a feature could be made of some or all of the Tuart grove which also has an understorey of *A. lehmanniana*.

To update the flora and vegetation data, Cardno (2010) conducted a detailed spring flora and vegetation in accordance with the Environmental Protection Authority's (EPA) *Guidance Statement No.51 Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia* (EPA 2004a) across the subject site. This included three separate visits, two in October and once in September by a team of experienced botanists to identify the presence of Declared Rare Flora (DRF), Priority Flora (PF) and/or Threatened Ecological Communities (TEC). The survey also identified the flora species present within the survey area and the condition of the vegetation. An additional Lomandra density survey was conducted in March 2010 in accordance with DEC Graceful Sun-Moth Guidelines.

2.7.1 Plant Communities

Eight broad plant communities have been described for the subject site, which are:

- **OaSc** - Low Scrub B of *Olearia axillaris* and *Scaevola crassifolia* over Open Herbs of **Trachyandra divaricata* **Tetragonia decumbens*, **Cakile maritima*, **Pelargonium capitatum, Hardenbergia comptoniana* and *Conostylis candicans* on foredunes with *Spinifex longifolius* and *Ficinia nodosa;*

- **ArAp** - Dense Thicket to Thicket of *Acacia rostellifera* over Low Scrub B of *Acanthocarpus preissii* over Open Low Grass of **Bromus diandrus, *Lolium rigidum* and *Poa porphyroclados*, Open Herbs of *Calandrinia sp. Southwest Coast*, **Dischisma arenarium, Carpobrotus virescens*, and **Tetragonia decumbens* on lower slopes and within swales;

- **AlEg** - Scrub of *Allocasuarina lehmanniana* subsp. *lehmanniana, Spyridium globulosum* and *Myoporum insulare* with emergent pockets of Low woodland A to Open Low Woodland A of *Eucalyptus gomphocephala* over Low Scrub B of *Acacia lasiocarpa, Olearia axillaris* and *Leucopogon parviflorus* over Low Open Sedges of *Lepidosperma gladiatum* with **Bromus diandrus* and *Austrostipa flavescens*, *Parietaria debilis, Senecio pinnatifolius, *Trachyandra divaricata, Daucus glochidiatus, *Crassula glomerata* and *Trachymene pilosa;*

- **MsAlSg** - Heath A to Dwarf Scrub C of *Melaleuca systena, Acacia lasiocarpa, Spyridium globulosum* and *Calothamnus quadrifidus* with occasional pockets of Low Woodland A of *Eucalyptus gomphocephala* and Low Woodland B of *Banksia attenuata* over Open Herbs of *Lomandra maritima, Parietaria debilis, Phyllanthus calycinus, Poranthera microphylla, Senecio pinnatifolius* and *Trachymene pilosa;*

- **MsAlAp** - Low Heath B of *Melaleuca systena, Acacia lasiocarpa, Acanthocarpus preissii* and *Calothamnus quadrifidus* with occasional pockets of Low Woodland B of *Banksia attenuata* or Thicket to Scrub of *Acacia rostellifera* in the swales over Open Herbs of *Conostylis candicans, Desmocladus asper* and *Heliophila pusilla*, *Lepidosperma pubisquameum*, **Bromus diandrus* and *Poa porphyroclados* on cream-grey shallow sands over limestone;

- **McSg** - Thicket of *Melaleuca cardiophylla, Spyridium globulosum, Leucopogon insularis* and *Acanthocarpus preissii* over Low Grasses **Bromus diandrus, *Lolium rigidum* and **Ehrharta longiflora* with *Desmocladus asper, Calandrinia sp. Southwest Coast*, *Stylidium maritimum* (P3), *Hibbertia spicata* subsp. *leptotheca* (P3) and *Beyeria cinerea* subsp. *cinerea* (P3) on grey-brown shallow sands over limestone. This plant community was recorded along the southern bank of Moore River to the east of the large blow-out;

- **MsMhBs** - Heath A to Dwarf Scrub C of *Melaleuca systena/Melaleuca huegelii, Banksia sessilis, Spyridium globulosum, Templetonia retusa, Acacia truncata* and *Hakea lissocarpha* over Open Herbs of *Calandrinia brevipedata, Podotheca gnaphalioides* and *Trachymene coerulea* subsp. *coerulea* with *Austrostipa flavescens, Poa porphyroclados, *Bromus diandrus* and *Ehrharta villosa* on dark grey-brown sand over limestone; and

- **MhMtMs** - Low Heath C recently burnt (3-5 years) of *Melaleuca huegelii/Acacia truncata, Melaleuca systena* and *Banksia sessilis*, over Very Open Herbs of *Desmocladus asper, Stylidium junceum, Calandrinia* sp. Two-rocks, *Carpobrotus virescens, *Crassula glomerata*, and *Gompholobium tomentosum* with **Bromus diandrus* and *Poa porphyroclados* on grey-brown shallow sands over limestone.

  * Refers to species that are known weeds.

The spatial distribution of these communities is shown in **Figure 8.** Whilst the mapping does not cover the entire eastern area within the revised ODP boundary, field observations and observations of the aerial imagery indicate that the plant communities are comparable to those mapped. Most of the additional area unmapped is largely devoid of native vegetation and consistent mainly of areas of completed degraded paddocks (**Pd**).

2.7.2 Vegetation Condition

The condition of the vegetation was assessed to assist in determining the conservation values of the subject site. The vegetation condition was rated according to Keighery (1994), a vegetation condition scale commonly used in the Perth Metropolitan Region, which is also appropriate for other urbanised and agricultural areas. The categories are listed and defined in **Table 2.**

Table 2: Vegetation Condition Scale (Keighery 1994)

Vegetation Condition	Definition
Pristine	Pristine or nearly so, no obvious signs of disturbance.
Excellent	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species.
Very Good	Vegetation structure altered, obvious signs of disturbance. For example, disturbance to vegetation structure caused by repeated fires, the presence of some more aggressive weeds, dieback, logging and grazing
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate it. For example, disturbance to vegetation structure caused by very frequent fires, the presence of some very aggressive weeds at high density, partial clearing, dieback and grazing.
Degraded	Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management. For example, disturbance to vegetation structure caused by very frequent fires, the presence of very aggressive weeds, partial clearing, dieback and grazing.
Completely Degraded	The structure of the vegetation is no longer intact and the area is completely or almost completely without native species. These areas are often described as 'parkland cleared' with the flora comprising weed or crop species with isolated native trees or shrubs.

Vegetation condition across the subject site ranged from 'Completely Degraded' to 'Pristine-Excellent', with the largest portions of vegetation within the revised ODP area mapped as 'Completely Degraded' and 'Pristine-Excellent' condition (see **Figure 9**). The revised ODP has aimed to respond to the varying conditions of the vegetation across MRC landholdings and has aimed to preserve, where possible, areas of 'Pristine-Excellent' condition vegetation.

Areas of 'Completely Degraded' condition consisted of cleared paddock and tracks in the centre of the subject site. The coastal foreshore reserve and adjacent eastern coastal dune is in an 'Excellent' to 'Pristine-Excellent' condition. The southern river foreshore area is in a 'Good' to 'Very Good' condition. Remaining patches of remnant vegetation east of the foreshore reserve were in a 'Degraded' to 'Very Good' condition.

Whilst the mapping does not cover the entire eastern area within the revised ODP boundary, field observations and observations of the aerial imagery indicate that the vegetation condition is comparable to those mapped. Most of the additional area unmapped is largely devoid of native vegetation and consistent mainly of areas of completed degraded paddocks (**Pd**)**.** This lower condition vegetation is mapped as an opportunity for development within **Figure 13**.



Image 01: 'Excellent' condition vegetation



Image 02: Foreground shows 'Very Good' condition vegetation with 'Completely Degraded' vegetation condition

2.7.3 Significant Flora

2.7.3.1 Background and Desktop information

Species of flora are prescribed as "Declared Rare" or "Priority" conservation status where populations are restricted geographically or threatened by local processes. The DEC recognises these threats and subsequently applies regulations towards population protection and species conservation. The DEC enforces regulations under the *Wildlife Conservation Act 1950* to conserve Declared Rare Flora (DRF) and protect significant populations. Priority flora species are potentially rare or threatened and are classified in order of threat.

A search was conducted of the DEC's databases for DRF and priority floras that occur within the wider local area and the results are listed in **Table 3**.

Table 3: DRF and PF identified as occurring in close proximity to the subject site

Species	Conservation Code	Life Strategy	Flowering Period
Acacia horridula	3	P	May-Aug
Banksia dallanneyi subsp. pollosta	3	P	Aug
Banksia sclerophylla	4	P	Sept-Oct
Caladenia speciosa	4	Pg	Sept-Oct
Calytrix sylvana	4	P	Aug-Sept
Chamelaucium sp. Wongan Hills	3	P	
Chorizema varium	R	P	Jun/Sept-Oct
Conostylis bracteata	3	P	Jul-Aug
Conostylis pauciflora subsp. euryrhipis	4	P	July
Cyathochaeta teretifolia	3	P	Dec
Eucalyptus argutifolia	R	P	Mar-April
Eucalyptus mundijongensis	1	P	
Georgeantha hexandra	4	P	May-Nov
Grevillea thelemanniana	4	P	May-Nov
Hibbertia spicata subsp. leptotheca	3	P	Jul-Oct
Hypocalymma sp. Cataby (aff tetrapterum)	1	P	Aug-Sept
Leucopogon sp. Perth Coastal		P	Mar-Jun
Leucopogon sp. Yanchep	3	P	Apr-Jun, Sept
Marianthus paralius	R	P	Sept-Nov
Melaleuca clavifolia	1	P	Oct-Dec
Paracaleana dixonii	R	Pg	Nov
Sarcozona bicarinata	3	P	Aug
Scaevola paludosa	2	P	Sept-Oct
Stylidium maritimum	3	P	Sept-Nov

Species	Conservation Code	Life Strategy	Flowering Period
Stylidium nonscandens	3	P	Sept-Nov
Verticordia lindleyi subsp. lindleyi	4	P	Nov-Jan
Verticordia paludosa	4	P	Jan

Twenty seven DRF and PF species have been identified as occurring in close proximity to the subject site. Of these species, four are classified as DRF species. The flora survey undertaken by ATA Environmental in 1993 did not identify any listed DRF or PF species.

2.7.3.2 Flora survey results

During Cardno's 2010 survey no DRF species were recorded within the subject site, however three PF were recorded, these being:

- *Stylidium maritimum* (P3);
- *Hibbertia spicata subsp. leptotheca* (P3); and
- *Beyeria cinerea subsp. cinerea* (P3).

All three species collected were found at Site 212, which occurred on outcropping limestone to the north of the subject site outside the ODP area. For each species, less than 20 individuals were recorded as being present.

A number of species were identified in the 1993 report that were considered to have poor representation or uncommon distributions. These species were *Allocasuarina lehmanniana, Billardieria erubescens* and *Thomasia triphylla*.

Allocasuarina lehmanniana (now recognised as *Allocasuarina lehmanniana* subsp. *lehmanniana*) is not an uncommon species, however, is uncommon on the Swan Coastal Plain, occurring mainly in one Reserve (Trigg Bushland Reserve) and at Wilbinga (Alan Tingay and Associates 1993). *Allocasuarina lehmanniana* subsp. *lehmanniana* is found from Perth to north of Geraldton and also in a disjunct population in the south-west, inland from Albany. Therefore, the Moore River South population can be considered to be significant for the Swan Coastal Plain, as it is outside of the known populations.

Billardieria erubescens, now known as *Marianthus erubescens*, has been recorded inland from Albany up to Geraldton, however is known from mostly inland sites. At Two Rocks and the subject site, the species was known to occur in the exposed limestone vegetation close to the coast. *Thomasia triphylla* is near its northerly extent in the subject site, and occurs on exposed limestone close to the coast. Both *Marianthus erubescens* and *Thomasia triphylla* are not uncommon species but represent unusual distributions or extent of ranges.

2.7.4 Threatened Ecological Communities

2.7.4.1 Background and Desktop information

In Western Australia, 'Threatened Ecological Communities' (TECs) are defined by the Western Australian TEC Scientific Advisory Committee (within the DEC) and are assigned to category of Priority 1 to Priority 5. While they are not afforded direct statutory protection at a State level (unlike DRF under the Wildlife Conservation Act 1950) their significance is acknowledged through other State

environmental approval processes (i.e. Environmental Impact Assessment pursuant to Part IV of the Environmental Protection Act 1986).

Selected TECs are also afforded statutory protection at a Federal level pursuant to the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The EPBC Act provides for the strong protection of TECs, which are listed under section 181 of the Act, and are defined as "Critically Endangered", "Endangered" or "Vulnerable" under Section 182.

A search was conducted of the DEC's TEC database and no known occurrences of TECs were recorded within the boundary of the subject site, however, within approximately 6 km of the subject site the following TEC has been recorded:

- 'Endangered' TEC – 'Melaleuca huegelii - Melaleuca acerosa (currently M. systena) shrublands on limestone ridges (Gibson et al. 1994 FCT 26a).

This TEC is not listed at a Federal level pursuant to the EPBC Act.

In addition to listing as a TEC, a community may be listed as a Priority Ecological Community (PEC). An ecological community that is under consideration for listing as a TEC, but does not yet meet survey criteria or has not been adequately defined, is placed on the list of PECs in either Category 1, 2 or 3. Ecological communities that are adequately known and are rare but not threatened, or meet criteria for Near Threatened, or that have been recently removed from the threatened list, are placed in Priority 4. These ecological communities require regular monitoring. Conservation Dependent ecological communities are placed in Priority 5 (DEC 2007).

No PECs have been recorded by the DEC within the subject site, however within approximately 6km the PEC Acacia shrublands on taller dunes (FCT 29b) has been recorded.

2.7.4.2 Flora survey results

Plant communities **OaSc, ArAp, AlEg** and **MhAtMs** were all determined to be FCT 29a – Coastal shrublands on shallow sands, with the remaining plant communities **MsAlSg, MsAlAp, McSg** and **MsMhBs** were all determined to be FCT 29b – Acacia shrublands on taller dunes. Both of these FCTs are classified as Priority 3 Ecological Communities due to their 'Poorly Reserved' reservation status and 'Susceptible' conservation status (Gibson et al. 1994). These Priority Flora communities are reserved in the Moore River South increased foreshore reserve allocated as POS.

2.7.5 Environmentally Sensitive Areas

Environmentally Sensitive Areas (ESAs) are areas prescribed under the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004*. As a result ESAs are only considered when a clearing permit is required under these regulations. ESAs have been identified to protect the native vegetation values of areas surrounding significant, threatened or scheduled ecosystems and communities. ESAs generally occur over or in association with:

- a declared World Heritage property;
- an area that is registered on the Register of the National Estate, because of its natural values;
- a defined wetland and the area within 50 m of the wetland;
- the area covered by vegetation within 50 m of rare flora, to the extent to which the vegetation is continuous with the vegetation in which the rare flora is located;
- the area covered by a threatened ecological community;
- in the metropolitan region in a Bush Forever site listed in "Bush Forever" Volumes 1 and 2 (2000), published by the WAPC;

- the areas covered by the following policies —
    - the *Environmental Protection (Gnangara Mound Crown Land) Policy 1992*;
    - the *Environmental Protection (Western Swamp Tortoise) Policy 2002*;
- the areas covered by the lakes to which the *Environmental Protection (Swan Coastal Plain Lakes) Policy 1992* applies;
- protected wetlands as defined in the *Environmental Protection (South West Agricultural Zone Wetlands) Policy 1998*;
- areas of fringing native vegetation in the policy area as defined in the *Environmental Protection (Swan and Canning Rivers) Policy 1998*.

A search of the Department of Environment Conservation (DEC) Native Vegetation Mapping database revealed that no ESAs are mapped over the subject site.

2.7.6 Lomandra Density Survey

As a requirement of the DEC Graceful Sun-Moth Survey Guidelines (Bishop *et al.* 2009) a *Lomandra* density survey was undertaken within the subject site. The Graceful Sun-Moth's larva is known to feed and live only on *Lomandra maritima* and *Lomandra hermaphrodita*, two species of the *Lomandra* mat-rushes. Within the study area only the coastal *Lomandra* species, *Lomandra* maritima was recorded. *Lomandra maritima* is known to occur between Carnarvon and Bunbury and grows only in coastal regions within sandy soils, being particularly common on the foredune (Western Australian Herbarium 2010).

A *Lomandra* density survey was undertaken across the subject site, to determine the distribution and density of *Lomandra maritima* (**Figure 11**). The survey was conducted on the 29th, 30th and 31st of February and 23rd of April 2010 in accordance with guidelines provided by Bishop *et al.* (2009).

Twenty transects were established within the subject site with $2m^2$ quadrats spaced at 50m intervals along each transect. The length of each transect ranged from 300m to 850m depending on vegetation extent. Each transect started from a central point and radiated outward across the site at equal angles as described in Bishop *et al.* (2009). The position of each quadrat was recorded with a hand-held GPS unit.

Environmental data recorded from each quadrat included the Foliage Projective Cover (FPC) of *Lomandra maritima*, the FPC of dominant species, topographic position, aspect, slope, bare ground, position in the landscape, surface and sub-surface soil description, vegetation structure and vegetation condition.

Lomandra maritima was recorded at 146 of the 238 quadrats surveyed (61.3%). The FPC of *Lomandra maritima* ranged from 1 to 80 % with an average cover of 24.9 % (±1.4) across the entire subject site. The soil type most highly associated with *Lomandra maritima* is grey sand overlying a brown loam. The vegetation condition predominately associated with *Lomandra maritima* was "Very Good", however it was recorded in both "Excellent" and "Good" vegetation conditions also. Areas with a moderate incline (~10˚) in combination with a north, northwest or west aspect was most highly attributed to *Lomandra maritima* populations.

Figure 11 illustrates that the majority of *Lomandra maritima* was recorded in Plant Community 4.

2.8 Terrestrial Fauna

As part of the overall assessment of the fauna and fauna habitat values on the subject site, a review of existing available information was undertaken in addition to a site specific fauna survey. The comprehensive documentation of this is contained within the report prepared by Greg Harewood (Harewood 2010); however the key elements of this are outlined below.

2.8.1 Review of existing fauna information

The conservation of threatened fauna species in Western Australia is legislated by Western Australian *Wildlife Conservation Act 1950* (WAWC Act) and administered by DEC. The WAWC Act utilises a set of schedules which are described below in **Table 4**.

Table 4: Categories of WAWC Act Threatened Fauna

Scientific Name	Code	Description
Schedule 1	S1	Fauna which is rare of likely to become extinct
Schedule 2	S2	Fauna which is presumed extinct
Schedule 3	S3	Birds which are subject to an agreement between the governments of Australian and Japan (JAMBA) relating to the protection of migratory birds and birds in danger of extinction
Schedule 4	S4	Fauna that is otherwise in need of special protection

In addition to this, the DEC also produces a list of 'Priority Species', which while not considered threatened under the WAWC Act, are of concern in relation to their long-term survival. The Priority Fauna species categories are described below in **Table 5.**

Table 5: DEC Priority Fauna Categories

Scientific Name	Code	Description
Priority 1	P1	Taxa with few, poorly known populations on threatened lands.
Priority 2	P2	Taxa with few, poorly known populations on conservation lands
Priority 3	P3	Taxa with several, poorly known populations, some on conservation lands
Priority 4	P4	Taxa in need of monitoring (Not currently threatened or in need of special protection but could be if present circumstances change)
Priority 5	P5	Taxa in need of monitoring (Not considered threatened by are subject to specific conservation programs, the cessation of which would result in the species becoming threatened within five years)

The Commonwealth *Environment Protection and Biodiversity Conservation Act* (EPBC Act) also allows for the protection of fauna at a species level. Conservation codes under the EPBC Act include:

- Critically Endangered;
- Endangered;
- Vulnerable;
- Migratory (Terrestrial, Marine and Wetland).

Each of the categories listed above are considered triggers for environmental impact assessment, as a matter of National Environmental Significance (NES). Any actions that have, or are likely to have, a

significant impact on a matter of NES requires approval from the Australian Government Minister for the Environment, Heritage and the Arts.

A fauna survey was conducted across the subject site in November 1997 (ATA 1998). This survey found that the subject site supported a range of habitat types. During the fauna survey a number of species were recorded as being present including: two amphibian species; 18 reptile species; 69 bird species and eight mammal species (four of which were introduced species). Of the species found or determined to be likely found given the habitat and known range, a number of these are considered to be of conservation significance and are listed below in Table 6.

Table 6: Fauna of Conservation Significance (ATA 1998)

Scientific Name	Common Name	Level of Significance	
		Western Australia	Commonwealth
Calyptorhynchus latirostris	Carnaby's Cockatoo	Schedule 1	Endangered
Lophoictinia isura	Square-tailed Kite		-
Morelua spilota	Carpet Python	Schedule 4	-
Falco peregrinus	Peregrine Falcon	Schedule 4	-
Pletholax gracilis	Legless Lizard	Priority 3	-
Neelaps calonotus	Black-striped Snake	Priority 4	-
Marcopus irma	Western Brush Wallaby	Priority 4	-

2.8.2 Site specific fauna investigations

A more recent survey, conducted in October 2009 (Harewood 2010) in accordance with EPA Guidance Statement No 56 Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia (EPA 2004b) found that 192 species could potentially utilise the subject site, although the number is likely to be significantly lower. A total of 38 native fauna species were observed (or positively identified from foraging evidence, scats, tracks skeletons or calls) within the subject site during the three day survey in October 2009. Three vertebrate fauna species of conservation significance were positively identified as utilising the subject site, including:

- *Calyptorhynchus latirostris* Carnaby's Black Cockatoo;
- *Ardea alba* Great Egret; and
- *Pandian haliaetus* Osprey.

Ten additional species of conservation significance were also identified as potentially using the subject site for some purposes at times, although their presence could not be confirmed. Additionally, given the varied habitat over the subject site, these species may only visit the area for short periods or as rare/uncommon vagrants. The additional conservation species identified in Harewood 2010 are identified in Table 7.

Table 7 Additional Fauna of Conservation Significance as identified by Harewood 2010.

Scientific Name	Common Name	Level of Significance	
		Western Australia	Commonwealth
Ctenotus gemmula	Jewelled Ctenotus	P3	-
Neelaps calonotos	Black-striped Snake	P3	-
Morelia spilota imbricate	Southern Carpet Python	S4	-

Scientific Name	Common Name	Level of Significance	
		Western Australia	Commonwealth
		P4	
Merops ornatus	Rainbow Bee-eater	-	Migratory
Ardea ibis	Cattle Egret	-	Migratory
Apus pacificus	Fork-tailed Swift	-	Migratory
Haliaeetus leucogaster	White-bellied Sea-Eagle	-	Migratory
Falco peregrines	Peregrine Falcon	S4	-
Isoodon obessulus fusciventer	Southern Brown Bandicoot	P5	-
Macropus Irma	Western Brush Wallaby	P4	-
Synemon gratiosa	Graceful Sun-Moth	S1	Endangered
Ardeotis australis	Australian Bustard	P4	-

2.8.2.1 Black Cockatoo species

As a part of the recent fauna survey (Harewood 2010) the location of significant habitat trees were recorded. Significant habitat trees were defined as “native trees of the Eucalyptus or Corymbia generally having a diameter at breast height (DBH) greater than 500 mm”. These types of trees have been identified as providing habitat for the ‘Vulnerable’ and ‘Endangered’ Black Cockatoo species, as listed under the EPBC Act. The survey revealed 17 significant trees within the subject site, all of which were Tuart species (**Figure 10**). These trees are generally in two distinct clusters over the subject site, in association with tuart woodlands mapped over the subject site.

2.8.2.2 Graceful Sun-Moth

In addition, habitat for the *Synemon gratiosa* - Graceful Sun-Moth was identified within the subject site and due to the potential presence of the species a Graceful Sun-Moth survey was undertaken in March 2010. As listed above, Graceful Sun-Moth is a federally listed 'Endangered' species under the EPBC Act and is endemic to south-west Western Australia. It is a small day-flying moth that has black-brown forewings and bright orange hind wings. The Graceful Sun-Moth’s larva is known feed and live only on *Lomandra maritima* and *Lomandra hermaphrodita*, two species of the *Lomandra* mat-rushes.

There is limited knowledge with regards to the location, occurrence and lifecycle of the Graceful Sun-Moth. A number of surveys have been undertaken by the DEC during March 2010, with the intention to gain a better understanding of the distribution of Graceful Sun-Moth and likely habitat of the species. The results of these surveys are still being correlated, but the known distribution of the Graceful Sun-Moth has now extended from the northern suburbs of Perth to an area encompassing Jurien Bay in the north to Binningup in the south (DEC *pers. comms.* April 2010).

The Graceful Sun-Moth survey was undertaken in accordance with the DEC guidelines (Bishop *et al* 2009) and included a *Lomandra* density survey and a Graceful Sun-Moth survey. The Graceful Sun-Moth survey involved 4 individual days of survey in which relatively open areas and tracks were walked by two observers. In total 22 Graceful Sun-Moth’s were sited over the 4 surveys throughout March. The location of the Graceful Sun-Moth’s found during the survey period and density of *Lomandra* is shown in **Figure 11**. The outcomes of this survey are further discussed in Section 4.8.

2.9 Coastal Processes and Management

Coastal areas represent the interface between the land and the sea and are recognised as sensitive and dynamic environments. The subject site is located within a coastal area and a increased foreshore reserve has been allocated to the west of the development. The foreshore is reserved for "Parks and Recreation" and is currently Unallocated Crown Land (UCL).

Rogers (2010) provides an assessment of coastal processes and a report on the appropriate coastal setback to development at Moore River South (Moore River South Updated Coastal Setback Assessment). Assessment of the physical processes setback was based on the requirements of Schedule One of the State Coastal Planning Policy (SPP 2.6) for an undeveloped sandy shoreline. The setback was measured from the seaward limit of coastal vegetation.

Modelling of a severe storm sequence indicated that approximately 17 m erosion may occur following a severe storm. Shoreline movement analysis showed the majority of the subject site has experienced long-term accretion with some erosion occurring between 2002 and 2008 in the northern area close to the mouth of Moore River.

The various setback allowances calculated and the total physical processes setback required by SPP 2.6 are presented in Table 8 below.

Table 8: Coastal Processes Setback (Rogers 2010)

Factor	Distance (m)
S1: Severe storm	17
S2: Historic trend	20 - 50
S3: Sea Level rise	38
Total setback	75 - 105

It should be noted that this total setback is based on a sandy shoreline however there is some evidence of rock outcropping along the coast south of Moore River (Coffey Partners 1996).

2.9.1 Boat Launching Facility

In response to existing and future growth in recreational boating around Moore River, it is understood the Shire of Gingin has been seeking a suitable coastal site for safer boat launching. Rogers (2010) provides an assessment of a proposed site to meet this need and concludes that a safe boat launching ramp would need protective breakwaters to shelter from waves and ongoing coastal management. This would possibly include sand bypassing, due to the interruption of longshore sand transport by the breakwaters.

2.10 Subject site Contamination

2.10.1 Review of existing contamination information

The *Contaminated Sites Act 2003* and the associated Contaminated Sites Regulations 2006 took effect on 1 December 2006. The Act provides a legal framework for the management of contaminated sites in Western Australia, and requires owners, occupiers and polluters to report known or suspected contaminated sites to the DEC.

There are no identified contaminated sites found on the subject site recorded on the DEC's Contaminated Sites database. This database does not include sites that have not yet been classified or sites that are classified as possibly contaminated - investigation required, contaminated - restricted use or remediated for restricted use.

2.10.2 Site specific contamination investigations

Based on a review of the historical aerial photography for the subject site and a number of onsite inspections it is considered unlikely that any of the observed existing or historical land uses would have caused significant soil or groundwater contamination within the subject site.

2.11 Acid Sulphate Soils

2.11.1 Review of existing Acid Sulphate Soils information

Acid Sulphate Soil (ASS) is a naturally occurring soil or sediment that contains iron sulphide (iron pyrite) minerals. In their natural state ASS are present in waterlogged anoxic conditions and do not present a risk to the environment. They become an issue when oxidised, producing sulphuric acid, which can convey a range of impacts on the surrounding environment, infrastructure and human health.

The DEC guidelines Identification and Assessment of Acid Sulphate Soils (DEC 2009) list the following environmental features as locations where ASS is known to have developed or has appropriate combination of environmental factors to promote the development of ASS:

- Areas depicted on geology and/or geomorphologic maps as geologically recent (Holocene) such as; shallow tidal flats or tidal lakes, shallow estuarine or shallow marine deposits, stranded beach ridges and adjacent swales, interdunal swales or coastal sand dunes, coastal alluvial valleys, wetlands, floodplain, waterlogged areas, scalded areas, marshes and swamps.
- Areas depicted in vegetation mapping as mangroves, wetland dependant vegetation such as reeds and paperbarks (Melaleuca spp.), areas where the dominant vegetation is tolerant of salt, acid and/or waterlogging conditions e.g. mangroves, salt couch, swamp-tolerant reeds, rushes, paperbarks and swamp oak (Casuarina spp.);
- Areas depicted in geological descriptions or in maps as bearing sulphide minerals, former marine or estuarine shales and sediments, coal deposits and mineral sand deposits;
- Areas known to contain peat or a build up of organic material;
- Areas where the highest known watertable is within 3.0 metres of the surface;
- Land with elevation less than 5.0metres AHD; and
- Any areas in Western Australia (including inland areas) where organic matter, iron minerals, waterlogged conditions or a high watertable, sulphidic minerals and deep estuarine sediments below ground exist in combination.

The above features have been attributed to the presence or formation of ASS and can therefore be used during a preliminary or desktop assessment of a site to identify the areas where the formation of ASS is probably/possible. Subsequently, a detailed investigation can target these areas to identify the nature and extent of ASS that will be potentially affected by any endorsed development.

Mapping prepared by the Department for Planning (DP) to support the WAPC's Planning Bulletin 64: Acid Sulphate Soils (WAPC 2009) does not cover the subject site. The Acid Sulphate Soil Planning Guidelines (WAPC 2009) indicate that only the areas in Western Australia currently considered to be most at risk of disturbance of acid sulphate soils are depicted in the mapping. Acid Sulphate soils are

commonly recorded from natural wetland and mangrove coastal areas, which is not consistent with the conditions over the subject site. The adjacent Moore River contains ASS but is beyond the ODP boundary and therefore does not affect the subject site.

2.11.2 Site specific investigations for Acid Sulphate Soils

The desktop review of existing information determined conclusively that Acid Sulphate Soils would not be found within the subject site. Site specific investigations were not required.

2.12 Heritage

2.12.1 Indigenous Heritage

2.12.1.1 Review of existing heritage information

An online search of relevant Aboriginal heritage information was undertaken using the Department of Indigenous Affairs (DIA) Aboriginal Inquiry System (DIA, 2010) that incorporates both the heritage site register and the heritage survey database. A number of sites were listed as occurring within the subject site, these included:

- DIA 3357 - Guilderton South, artefact/scatter
- DIA 3358 - Moore River South 1 - 5, artefact/scatter
- DIA 3653 - Moore River, artefact/scatter
- DIA 19138 - Wetlands and Watercourses Moore River to Bullsbrook, mythological
- DIA 19183 - Red Gully Creek, mythological
- DIA 20008 - Gingin Brook Waggyl site, mythological
- DIA 20650 - Lennard Brook, mythological
- DIA 20749 - Moore River Waugal, mythological
- DIA 21616 - Boonanarring Brook, mythological
- DIA 21617 - Wallering Brook, mythological
- DIA 21618 - Nullilla Brook, mythological

These sites are illustrated in **Figure 12**.

The majority of these sites are associated with the southern bank of Moore River. An archaeological and ethnographic survey was completed for the subject site in December 1993 (Bavin 1993 and Tamora Pty Ltd 1993). These surveys reported that no additional archaeological sites were found within the subject site and the three archaeological sites that were already been registered were not able to be relocated. The ethnographic survey revealed:

“There were no ethnographic sites of significance in the survey area. However the Moore River was formed during the Waugal journey and there should be a thirty metre zone between the banks of the river and the development” (Bavin 1993).

The Waugal is a creature from the dreamtime and created the waterways and landforms around the Perth region.

2.12.1.2 Site specific indigenous heritage investigations

There have been no site specific indigenous heritage investigations undertaken as part of the revised ODP design process as the previous site investigations were deemed sufficient.

2.12.2 Non-Indigenous Heritage

2.12.2.1 Review of existing non-indigenous heritage information

In order to determine the actual or potential presence of sites or features of non-indigenous heritage significance within the subject site, a review of readily available information was undertaken to determine if there were any of the following within the subject site:

- World heritage sites;
- National heritage sites;
- Commonwealth heritage sites;
- Sites listed on the Register of the National Estate; and/or
- Heritage Council of WA sites.

Based on examination of the Shire of Gingin's Heritage Register there are no known heritage sites located within the subject site, however the Moore River estuary adjacent to the north of the subject site contains high heritage value.

2.12.2.2 Site specific non-indigenous heritage investigations

To date there have been no site specific non-indigenous heritage investigations undertaken as part of the revised ODP design process. Give the nature of the subject site and the lack of identified heritage values it is considered unlikely that non-indigenous heritage values will be revealed at any stage of future planning and development.

2.13 Recreation and Aesthetic Values

The subject site, which is in private property, is not currently used for recreation. However, the Guilderton area has a high recreation value and the increased foreshore reserve to the north and west is frequently used for bushwalking and to access the Moore River southern foreshore and beach areas. It is anticipated that the beachside setting and coastal aesthetics should be maintained in the development.

3 The Revised Outline Development Plan

3.1 The Revised Outline Development Plan Design Process

In addition to the environmental consultancy services provided by Cardno, MRC have commissioned Cardno to prepare a revised ODP for the subject site.

The revised ODP has responded to the feedback provided by the WAPC by reducing the number of lots in the subject site and revising the coastal setback. The current design for the revised ODP has recognised the location, natural character and physical attributes of the subject site. The need for environmental investigations was identified as part of the ODP revision process to address areas of uncertainty in regards to the environmental attributes and values of the subject site.

Refer to the revised ODP report for the overarching design principles for the revised ODP of Moore River South.

3.2 Assessment of constraints, issues and opportunities

As part of the revised ODP design process, the environmental attributes and values of the subject site were assessed and the key aspects were translated into spatial issues, opportunities and constraints in terms of possible design responses.

Constraints were defined as attributes and values where there were clear government policies identifying significant environmental features and there is a clear presumption against impacts on these features. No constraints were identified on the subject site.

Issues were defined as environmental features where there was no specific government policy which indicates there is a presumption against impacts on these environmental features. Issues are generally broader features, with no discrete boundaries; however, these features need consideration due to the potential environmental impacts and should be considered to demonstrate best practice environmental planning. The issues within the subject site included the presence of Carnaby's Black Cockatoo habitat, Graceful Sun-Moth habitat, vegetation in "Excellent" and "Pristine-Excellent" condition and a required foreshore setback.

Opportunities were defined as areas where the environmental attributes and values are such that they are supportive of development. The opportunities within the subject site included the large areas of "Degraded" and "Completely Degraded" condition vegetation, the blow outs found on subject site and the depth of the groundwater.

The summarised issues, constraints and opportunities of the subject side are shown in **Figure 13**.

3.3 The Revised Outline Development Plan

The revised ODP provides an opportunity for sustainable neighbourhood living in a beach side setting. The revised ODP is shown in **Figure 14**. The plan has allocated land for a primary school, a neighbourhood commercial centre, community areas, tourism, parks and POS. The majority of the

foreshore has been protected in the increased foreshore reserve and areas of POS. The residential areas within the subject site will include densities of R20[1] to R40.

The ODP design has been revised to more holistically account for the environmental considerations of the subject site. In particular the revised design provides a wide area retained as POS and increased foreshore reserve. The clearing of vegetation has been minimised in areas of high environmental value including areas of significant topographical features, endangered fauna habitat, high condition vegetation and significant flora species.

The relevant aspects of the revised ODP in relation to the environmental features of the subject site are discussed in the following section of this report.

3.4 Future Planning and Approvals Process

Following the completion of the revised ODP, the subdivision of the ODP area will require approval from the WAPC. Once the revised ODP has been endorsed and a subdivision application submitted, the WAPC have a statutory 90 day timeframe to determine the application. Following subdivision approval the development of land identified for residential lots will be constructed in line with a staging plan approved by the Shire and WAPC. Staging will reflect requirements for infrastructure, revegetation and management of the foreshore and commercially viable development sequencing. Further planning initiatives will include (but are not limited to):

- Design and Settlement Guidelines
- Foreshore Management Plan including the increased foreshore reserve and POS
- Management plan for Carnaby's Black Cockatoo and the Graceful Sun-Moth
- Fire Management Plan
- Revegetation, Rehabilitation and Landscaping Plan
- Dust Management Plan
- Landscape Strategy
- Construction Management Plan
- Stormwater and Drainage Management Plan
- Traffic and Parking Strategy.

[1] Residential Design Codes (eg. R20) refer to the number of housings within one hectare. For example R20 generally indicates that there will be 20 dwelling units within one hectare.

4 Assessment of Environmental Impacts and Future Management

This section is structured to identify the key environment values and attributes of the subject site, specify what the required environmental outcome would be in relation to the value and/or attribute, summarise the revised ODP design considerations that have been made to accommodate the necessary outcomes, and then provide a summary of the likely future environmental management framework.

The structure above is addressed for each of the elements of the existing environment as outlined earlier in this document.

4.1 The Local Context

The endorsed development at Moore River South will contribute to the sustainable growth of the region. The inclusion of a new residential development within the Shire of Gingin will address the demand for suitable housing as well as celebrating the coastal character of Moore River South. Provision of tourism resorts will accommodate the growing numbers of tourists in the region.

4.2 Land Uses

4.2.1 Previous and Current Land Uses

The majority of the development has been located in cleared areas that are currently or have been previously grazed. It is anticipated that neither the previous nor current land uses will have an impact on the development.

4.2.2 Surrounding Land Uses

Given that the surrounding land uses consists of “Rural” zoned land, it is expected that the development will have minimal effect on the surrounding land uses nor will the surrounding land uses have any impact on the development.

4.3 Climate and weather

The climate of the subject site is conducive to a residential coastal development particularly within the Perth basin. The Mediterranean climate provides ideal conditions for residential development. Construction of the subject site may be inhibited by wet weather during winter however it is anticipated that this will be addressed in the Construction Management Plan.

4.4 Subject site topography, geology, landform and soils

The key topographical and landform features of the ODP area include:

- The irregular nature of the dunes, which rise steeply away from the beach and the southern bank of Moore River and form a series of high dunes and valleys.
- Stability of the dunal systems

The steep slopes present within the subject site further exacerbate the risk of erosion and landslides. This is a key issue that the revised ODP design (and future planning and development) need to respond to.

The revised ODP has been designed to be responsive to the topography and landforms within the development area. The revised ODP design aims to minimise the disruption to landform and retain as much existing vegetation as possible. This was achieved by designing the development to strategically respond to the dune formation. This subject site responsive design is particularly evident in the foreshore setback, which mimics the dunal system along the foreshore in order to conserve the prominent dunal ridge and prevent sand blowing into developed areas.

Stability has also been addressed through the management of the development with coastal dunes that are not proposed for development as well as revegetation to assist with the stabilisation of the dunes.

4.5 Geoheritage

Given there is no evidence of geoheritage at the subject site it is anticipated that there is no requirement for further management.

4.6 Hydrology

Within Western Australia there is a framework for addressing urban water management, which requires differing levels of water planning in conjunction with the various stages of the planning hierarchy. This water management framework is ultimately managed by the Department of Water, who require the preparation of plans and strategies in conjunction with planning approvals managed by Department of Planning and the Western Australian Planning Commission. The *Planning Bulletin 92 Urban Water Management* (WAPC 2008) provides the state government policy in relation to this urban water management framework and explains the level of detail required during various phases of planning for a site.

4.6.1 Surface Water

Given the absence of surface water over the subject site, surface water is not expected to impact the development. Drainage will need to be managed in accordance with relevant state government policy, including *Better Urban Water Management* (WAPC 2008a).

4.6.2 Groundwater

At this stage only preliminary results are available for groundwater monitoring, however the results do not reveal any significant concerns associated with groundwater.

4.6.3 Wetlands

Given there were no wetlands observed over the subject site, wetlands are not expected to be a concern for the endorsed development.

4.6.4 Public Drinking Water Source Area

Given that the subject site is not within a Public Drinking Water Source Area, this is not expected to be a concern for the development.

4.7 Flora and vegetation

The key flora and vegetation values of the subject site include:

- Areas of "Pristine-Excellent" and "Excellent" condition vegetation;
- Significant flora species
- Priority Ecological Communities

The overall management objective for flora and vegetation in the development area is to maximise the retention of these key flora and vegetation values and future management as planning and development proceeds.

4.7.1 Vegetation Condition

Design of the revised ODP has responded to the varying conditions of the vegetation across MRC landholdings, aiming to preserve, where possible, areas of 'Pristine-Excellent' condition vegetation. The native vegetation within the revised ODP boundary is in varied condition, ranging from "Completely Degraded" to "Pristine-Excellent".

Given the previous and current grazing land use of the subject site, a number of areas of the subject site particularly toward the eastern edge of the endorsed development have little native vegetation remaining. These areas present an opportunity for development which will have very minimal impact on any flora and vegetation of significance. The revised ODP boundary includes 96.3% of the mapped 'Completely Degraded' condition vegetation (**Figure 9**) as well as roughly 36ha of unmapped degraded vegetation within the revised ODP boundary. The areas of degraded vegetation have been mapped as an opportunity for development in **Figure 13**.

The majority of the western portion of the subject site contains vegetation in either "Excellent" or "Pristine-Excellent" condition. Within the revised ODP a large area of POS and increased foreshore reserve has been located to retain the higher value vegetation condition along the foreshore. It is anticipated that more detailed design of both the Holiday Resort and Tourist Resort may present an opportunity for retention of appropriate pockets of vegetation in order to further secure the integrity of the vegetation (**Figure 15**). Approximately 17ha of 'Pristine-Excellent' condition vegetation has been retained outside the revised ODP boundary.

4.7.2 Priority Flora

Given there were no Priority Flora species observed within the subject site, it is expected that there will not be any future management requirements.

4.7.3 Significant Flora

The significant flora found on the subject site includes *Allocasuarinia lehmanniana* subsp. *Lehmanniana, Marianthus erubescens* and *Thomasia triphylla* are found over a number of plant communities including **MsAlSg, MsAlAp, AlEg, McSg** and **MsMtBs** (**Figure 8**). This flora species have at present not been specifically mapped over the subject site. The majority of these vegetation communities have been retained within the increased foreshore reserve as well as areas of POS. In particular large tracts of **MsAlSg, AlEg, McSg** have been retained. While the retention of these flora species is not required by the Wildlife Conservation Act 1950, MRC have endeavoured to maximise the retention of significant flora species.

4.7.4 Priority Ecological Communities

The PEC's within the subject site have been retained where possible in the increased foreshore reserve and POS. No further management measures are required.

4.7.5 Threatened Ecological Communities

Given there were no TEC's observed within the subject site, it is expected that there will not be any future management requirements.

4.7.6 Environmentally Sensitive Areas

Given there were no ESA's observed within the subject site, it is expected that there will not be any future management requirements.

4.7.7 Lomandra Density Survey

The results from the Lomandra Density Survey will inform the appropriate management of the Graceful Sun-Moth.

4.8 Terrestrial Fauna

The development area is likely to play an important function as both a local wildlife corridor and fauna habitat for a number of native fauna species, which are rare or in need of special protection (ie. listed in Schedule 1 to 4 of the *Wildlife Conservation Act 1954* or Endangered or Vulnerable under the EPBC Act).

While all native vegetation provides some form of fauna habitat function, the key fauna values of the subject site include:

- Habitat trees and foraging habitat for Carnaby's Black Cockatoo;
- Habitat for the Graceful Sun-Moth; and
- Remnant vegetation in "Excellent" and "Pristine-Excellent" condition.

As discussed in **Section 4.7.1**, vegetation within the development area will be retained in areas of POS and within both the coastal and riverine foreshore reserve.

The retention of vegetation, particularly in areas of high quality ("Excellent" or "Pristine-Excellent") vegetation will allow for the future, long-term retention and management of the vegetation and habitat values in most of these areas. In addition the inclusion of significant fauna habitat such as habitat trees within areas of POS as well as both foreshore reserves will also allow for the long term retention and management of these important wildlife habitat and corridor values. There are also opportunities to improve the condition of fauna habitat in POS areas through revegetation, discussed further below.

The retention of vegetation along both foreshore reserves will reduce the overall fragmentation of the vegetation and fauna habitat. The wide corridor along the coastal foreshore includes the increased foreshore reserve (which will be ceded to the Crown) as well as a large area of POS. This corridor aims to allow fauna movement from North to South.

While the design of the revised ODP has considered fauna habitat values and wildlife corridors, to ensure the security and management of these features are addressed in the longer term it is expected

that future stages of the planning and development process will involve various mechanisms to retain these fauna values and wildlife corridors. These are likely to include:

- Management plans to address the retention and enhancement of fauna habitat within foreshore and POS areas;
- Building envelopes to protect remnant vegetation and habitat trees within private lots; and
- Landscaping management plans to ensure that locally occurring native species are used as much as possible within road reserves and parkland areas.

4.8.1 Carnaby's Black Cockatoo

The most significant fauna issue for future management that was identified by the fauna survey is clearing of potential Carnaby's Black Cockatoo habitat. This includes both foraging and breeding habitat, as identified by Harewood 2010 and shown in **Figure 10**. In general, the clearing of potential foraging and breeding habitat should be limited, where possible.

The clearing of potential Carnaby's Black Cockatoo habitat may require a referral under the EPBC Act. Recent informal advice from the Department of Environment, Water, Heritage and the Arts (DEWHA) suggests that clearing of more than one hectare of potential habitat or more than a few potential breeding trees for Carnaby's Black Cockatoo species may require referral under the EPBC Act. This includes habitat such as Banksia woodland or heath, which has been found over several areas of the subject site. Foraging species have been found in the following plant communities **AIEg**, **MsAlSg**, **MsAlAp**, **MsMhBs** and **MhAtMs** (**Figure 10**).

The detailed design of the development at Structure Planning stage should be undertaken with regard for the requirement for referral of any clearing greater than the current informal threshold values advised under the EPBC Act. In that design process the main mechanisms to conserve the population of Carnaby's Black Cockatoo would include:

- Retention of habitat trees;
- Use of building envelopes to protect remnant vegetation and habitat trees within private lots; and
- Landscaping management plans to ensure that suitable foraging species are used as much as possible within road reserves and parkland areas.

It is envisaged that these actions will ensure the development has no negative impacts on the population of Carnaby's Black Cockatoos.

4.8.2 Graceful Sun-Moth

A federally listed 'Endangered' moth species, the Graceful Sun-Moth, listed under the EPBC Act is known to inhabit coastal dune systems vegetated with *Lomandra* species (in particular *Lomandra maritima* and *Lomandra hermaphrodita*). A survey undertaken in March 2010 to determine the presence of Graceful Sun-Moth found that the species occurred within the development area, predominantly in the north-west portion.

Figure 11 shows the location of Graceful Sun-Moth observed within and outside the development area in comparison to the *Lomandra* densities recorded. Thirteen (13) of the Graceful Sun-Moth observed were outside the development area, with six (6) along the interface with the development area and three (3) found within. Based on the outcomes shown in **Figure 11**, Graceful Sun-Moth appears to occur in areas where *Lomandra* species was recorded in densities of 1 – 40 per cent, with some occurring in areas where no *Lomandra* was recorded. These observations where most closely associated with the vegetation communities **MgAlAp** and **MgAlSg**. However, this comparison is

limited as the *Lomandra* density survey did not cover all the areas in which Graceful Sun-Moth was observed. Furthermore, other factors such as openness of the vegetation, incidence of sunlight and location of suitable habitat along ridges may influence the occurrence of Graceful Sun- Moth.

As discussed in **Section 2.8.2.2** there is limited knowledge with regards to the location, occurrence and lifecycle of the Graceful Sun-Moth. The current known distribution is from Jurien Bay in the north to Binningup in the south (DEC *pers. comms.* April 2010). At present there is very limited information on the preservation actions required for Graceful Sun-Moth. Recent informal advice from the DEC suggests that there may be an opportunity to relocate the host *Lomandra* species, however this is largely untested. There is also likely to be a requirement to retain habitat for this species, especially since Graceful Sun-Moth has been observed within the development area. The clearing of Graceful Sun-Moth habitat may require a referral under the EPBC Act.

Therefore the main mechanisms used to conserve the population of the Graceful Sun-Moth within the development area include:

- Where possible, the retention of the identified habitat for Graceful Sun-Moth (*Lomandra* species) in areas of POS;
- Translocation of *Lomandra* species to POS to be considered as a part of the landscaping design, in collaboration with the DEC;
- Use of landscaping management plans to ensure that *Lomandra* species, particularly *Lomandra maritima* are utilised where possible within road reserves and parkland areas.
- Future monitoring of the Graceful Sun-Moth population following development;
- Minimising construction, fire management and use of tracks during March (when the moth is active); and
- Where possible, use of building envelopes to protect remnant vegetation within private lots.

4.9 Coastal Processes and Management

The coastal processes affecting the subject site have both influenced the design of the revised ODP and the future management and planning. The key considerations for coastal setbacks to development include erosion, accretion, storm surge, tides, wave conditions, sea level changes and biophysical criteria. The primary management objectives of the revised ODP for coastal processes include:

- Uphold the objectives of SPP 2.6 by taking into account coastal processes and providing a Foreshore Management Plan that includes management objectives of the foreshore regarding access, retention of vegetation, management of fauna, revegetation, rehabilitation, and dune stabilisation;
- Maintain a coastal setback to development of 75-105 metres in line with the assessment of coastal processes in Rogers (2010);
- Minimise the need for future coastal protection works by limiting development in the foreshore; and
- Protect and rehabilitate coastal areas within the POS and increased foreshore reserve.

4.9.1 Boat Launching Facility

Further studies would be required to determine whether a boat launching facility at the subject site is economically or environmentally feasible. The report prepared by Rogers (2010) highlights that wave heights are often too high for launching off the beach. Protective breakwaters would be required for safe launching. The inclusion of a boat launching facility is likely to incur a significant cost, require an approval by the Department of Infrastructure and require ongoing maintenance by shire. In addition,

construction of such a facility is likely to trigger a number of environmental issues including (but not limited to) beach access, erosion, induced changes in wave conditions and sea level, storm surges, and tides.

4.10 Subject site Contamination

Given there were no contaminated areas identified within the subject site, it is expected that there will not be any design or future management requirements.

4.11 Acid Sulphate Soils

The sandy conditions of the subject site are not conducive to the presence of Acid Sulphate Soils. Given there were no areas of Acid Sulphate Soils identified within the subject site, it is expected that there will not be any design or future management requirements.

4.12 Heritage

4.12.1 Indigenous Heritage

It is unlikely that the development will impact upon any Aboriginal heritage sites due to the uncertainty of the location of sites. There are a number of Aboriginal heritage sites which may be impacted by the further development of the subject site, however the Aboriginal heritage sites identified by the DIA register were not found during the Ethnographic Survey. Should any disturbance to Aboriginal sites occur, consent under the *Aboriginal Heritage Act 1972* will be required. Additional archaeological and ethnographic investigations may be required to support a Section 18 Application.

4.12.2 Non-Indigenous Heritage

There are no known non-indigenous heritage site over the subject site, it is expected that there will not be any design or future management requirements.

4.13 Recreation and Aesthetic Values

It is anticipated that the development will increase and enhance the recreational and aesthetic values of the development area. The revised ODP has incorporated various recreational attributes within the design of the development. In particular the development design aims to:

- Prioritise community access at appropriate locations across the foreshore, providing an area of public space that encourages outdoor activity along the beach and foreshore;
- Prioritise the value of the natural environment through incorporating native vegetation in landscaping and revegetation management plans as well as maximising the retention of the existing native vegetation;
- Mimic the existing land formation for both environmental and aesthetical reasons. The POS incorporates and reflects the existing dune formation, minimising the impact on the natural environment and maintain the natural character of the foreshore;
- Retain the coastal character in line with the objectives of the *Visual Landscape Planning in Western Australia* (WAPC 2007) through applying the following visual landscape management principles:
    - The revised ODP has located, sited and designed built elements near the coast in a way that minimises their visual dominances and acknowledges their coastal setting;

  - The revised ODP has retained a green belts along the foreshore that incorporates coastal landscape features such as dune systems and remnant coastal vegetation;
  - The general contours of the landscape have been retained where feasible; and
  - Plant communities or individual plants of ecological, visual or cultural significance have been retained where feasible (eg. retention of habitat trees);
- Ensure that the Tourism areas of the revised ODP are designed in accordance with the guidelines from the *Visual Landscape Planning in Western Australia* (WAPC 2007) including:
  - Placement and sizing of tourism buildings to reduce the visibility from important recreation areas such as beaches;
  - Incorporating local natural building materials and colours that reflect the local landscape at Moore River South;
  - Reduction of the mass and scale of buildings by developing a number of smaller buildings instead of a single larger one;
  - Using local vegetation where possible to screen the tourism area; and
  - Use setbacks and buffer strips along roads utilising the native vegetation as a buffer.

5 Conclusions

Cardno have provided a range of environmental consultancy services to support the revision of the Moore River South ODP. This has involved several site specific technical studies and the collation and synthesis of a body of existing environmental information.

This environmental information had informed the revision of the ODP. This reiterative process allowed for the design to recognise the environmental features of the subject site. The findings concluded that the development would have no significant environmental impact on Moore River South. The key environmental features of the subject site include:

- Suitable habitat for both Carnaby's Black Cockatoo and the Graceful Sun-Moth;
- Indigenous heritage sites;
- The coastal setting of the subject site;
- Significant areas of remnant vegetation, including vegetation in "Excellent" and "Pristine-Excellent" condition; and
- Significant Flora species.

Each of these environmental features has been considered in the revised ODP design process. In particular the most significant environmental design features of the revised ODP include:

The Generous and Strategic Allocation of POS

POS has been strategically allocated throughout the revised ODP to retain remnant vegetation (including "Excellent" and "Pristine-Excellent" condition vegetation and Priority Flora populations), habitat trees and wildlife corridors. The allocated POS is in addition to the require increased foreshore reserve that will be ceded to the Crown. It is envisaged that the areas of POS will maintain and enhance the environmental integrity of the subject site and provide opportunities for recreation and community interaction.

Retention of Topography and Landscape

The design of revised ODP has taken into account the subject site's topography and landscape. The design aims to minimise modifications to the topography and landscape which will help facilitate vegetation retention, reduce risks of erosion and sand mobilisation and minimise the need for fill. In addition it will assist in retaining the existing visual landscape character of the area and reduce visual impacts.

Protection of key physical environmental attributes

The revised ODP design has aimed to minimise the disturbance of key physical environmental attributes. This includes Carnaby's Black Cockatoo habitat trees and Indigenous Heritage sites. These physical environmental attributes have been addressed in a series of management plans.

In addition to the above revised ODP design features, a suite of future management activities have been considered. These can be put in place during the future planning and development process for the long term protection of the environmental features within the revised ODP are and/or to minimise the impacts of development. This is likely to include additional site investigations and the preparation of various management plans and strategies to protect and maintain environmental features. These can be undertaken/prepared during future stages of development and are likely to include the following:

- Future investigations
  - Indigenous heritage investigations should any sites be uncovered during construction
- Plan and Strategy Preparation
  - Foreshore Management Plan including the increased foreshore reserve and POS
  - Management Plans for Carnaby's Black Cockatoo and the Graceful Sun-Moth
  - Fire Management Plan
  - Revegetation, Rehabilitation and Landscaping Plan
  - Dust Management Plan
  - Landscape Strategy
  - Construction Management Plan
  - Stormwater and Drainage Management Plan
  - Traffic and Parking Strategy
- Development and land ownership controls
  - Design guidelines
  - Management frameworks

Given the planning and development framework in Western Australia, and the specific details provided above, Cardno is confident that the environmental features of the subject site can be retained and managed in the long term. The first step in this process, the revision of the ODP, will provide clear guidance for future planning that can fed into scheme amendment processes and local structure planning.

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Figure 1: Locality Plan

Figure 2: Town Planning Scheme

Figure 3: Soil and Landform Units

Figure 4: Topography and Aerial Photography

Figure 5: Slope Analysis

Figure 6: Groundwater Information

Figure 7: Regional Vegetation Mapping

Figure 8: Plant Communities

Figure 9: Vegetation Condition

Figure 10: Carnaby's Black Cockatoo potential foraging habitat and habitat trees

Figure 11: Graceful Sun-Moth habitat

Figure 12: Aboriginal Heritage Sites

Figure 13: Issues, Constraints and Opportunities

Figure 14: Details of land uses under the proposed Outline Development Plan

Figure 15: Vegetation condition within the Outline Development Plan

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PROJECT Moore River South - Environmental Assessment & Justification Report

DRAWING TITLE FIGURE 1 : Locality Plan

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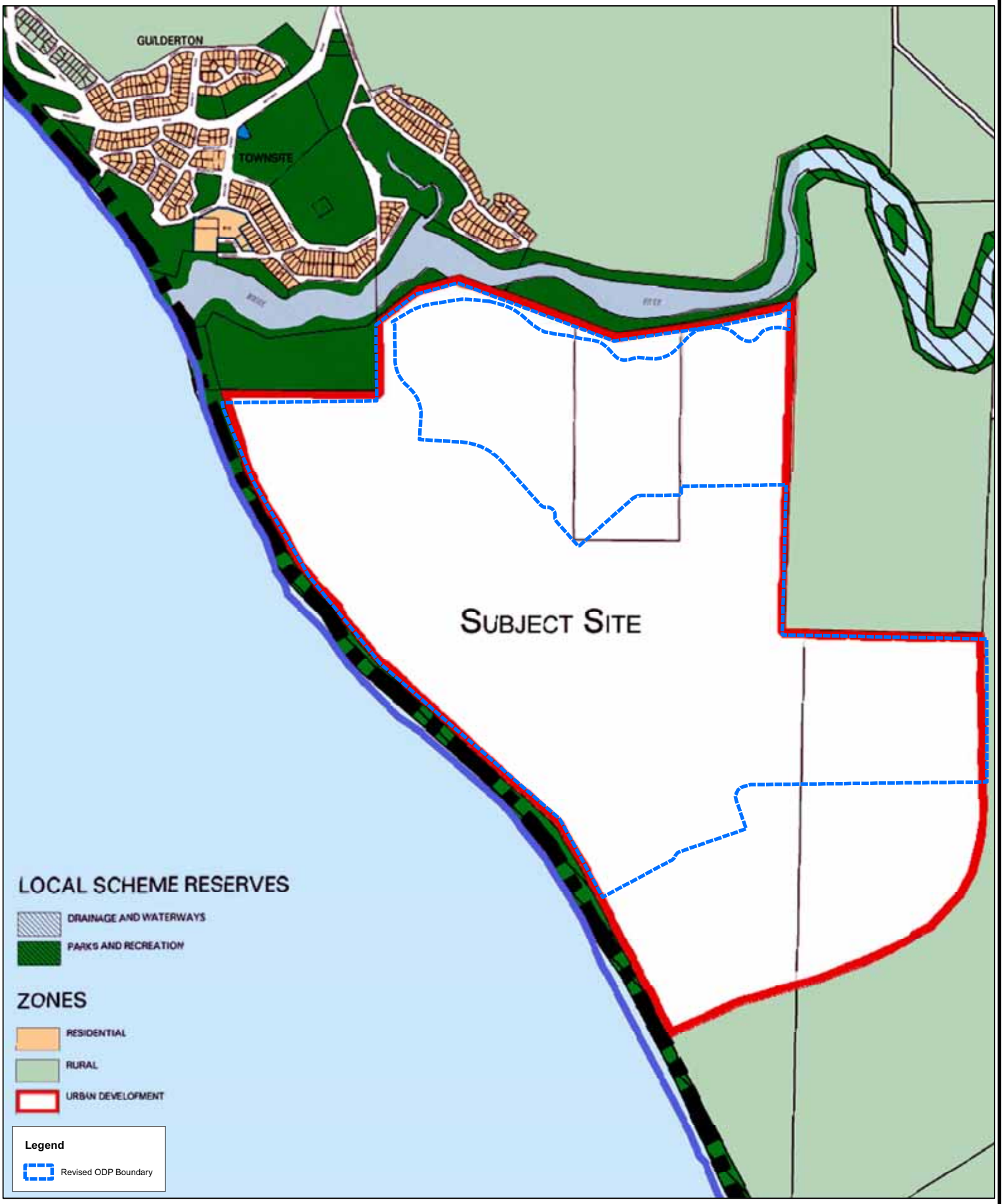
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DRAWING TITLE **FIGURE 2: Town Planning Scheme**

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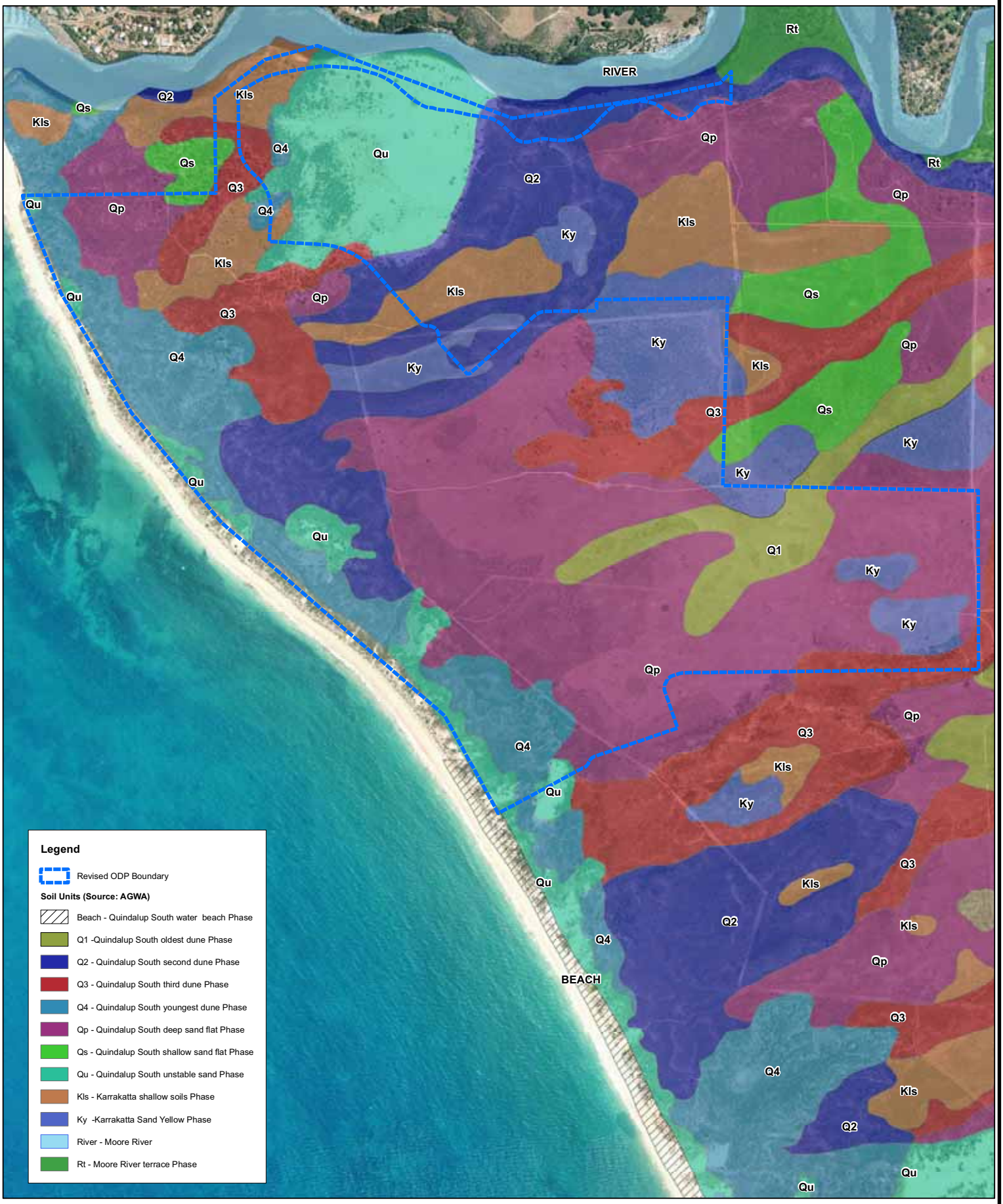
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DRAWING TITLE **FIGURE 3 : Soil Units & Landform Units**

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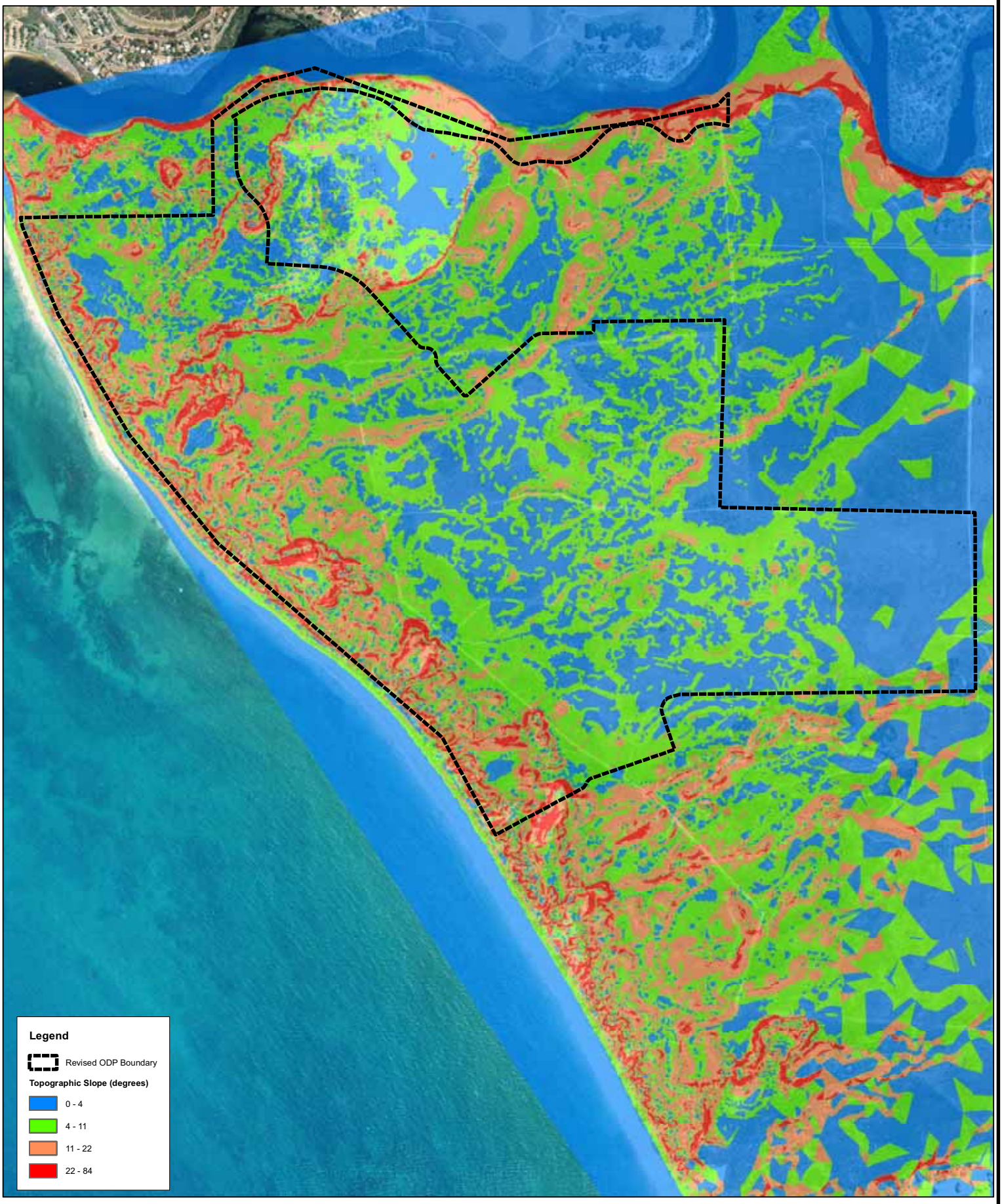
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DRAWING TITLE **FIGURE 5: Slope Analysis**

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PROJECT **Moore River South - Environmental Assessment & Justification Report**

DRAWING TITLE **FIGURE 6: Groundwater Information**

PRINCIPAL **Moore River Company Pty Ltd**

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Project Number **V9070**

Original **A3**

Drawing Number **SK48**

Revision **00**

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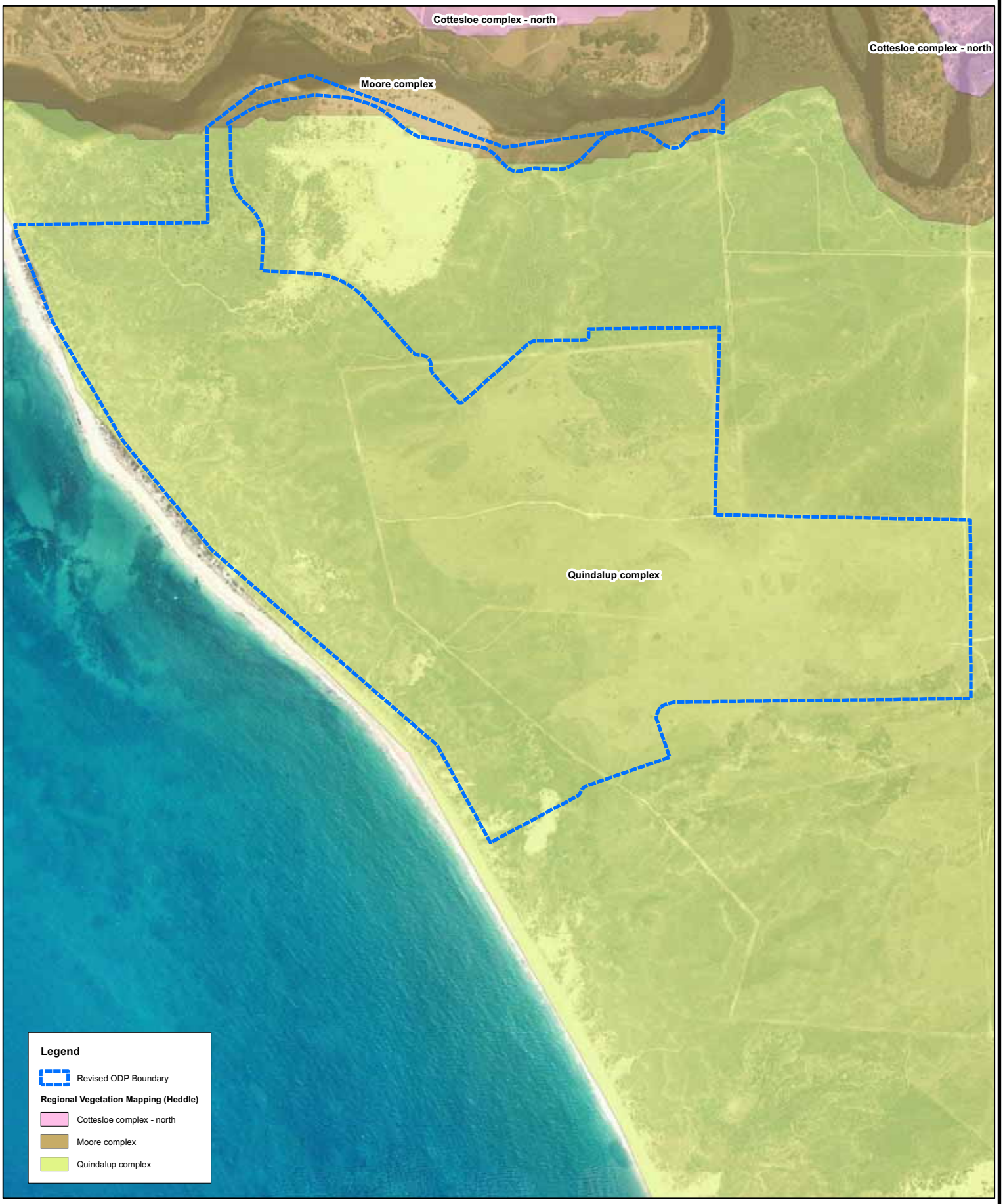
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PROJECT **Moore River South - Environmental Assessment & Justification Report**

DRAWING TITLE **FIGURE 7: Regional Vegetation Mapping**

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Revision **00**

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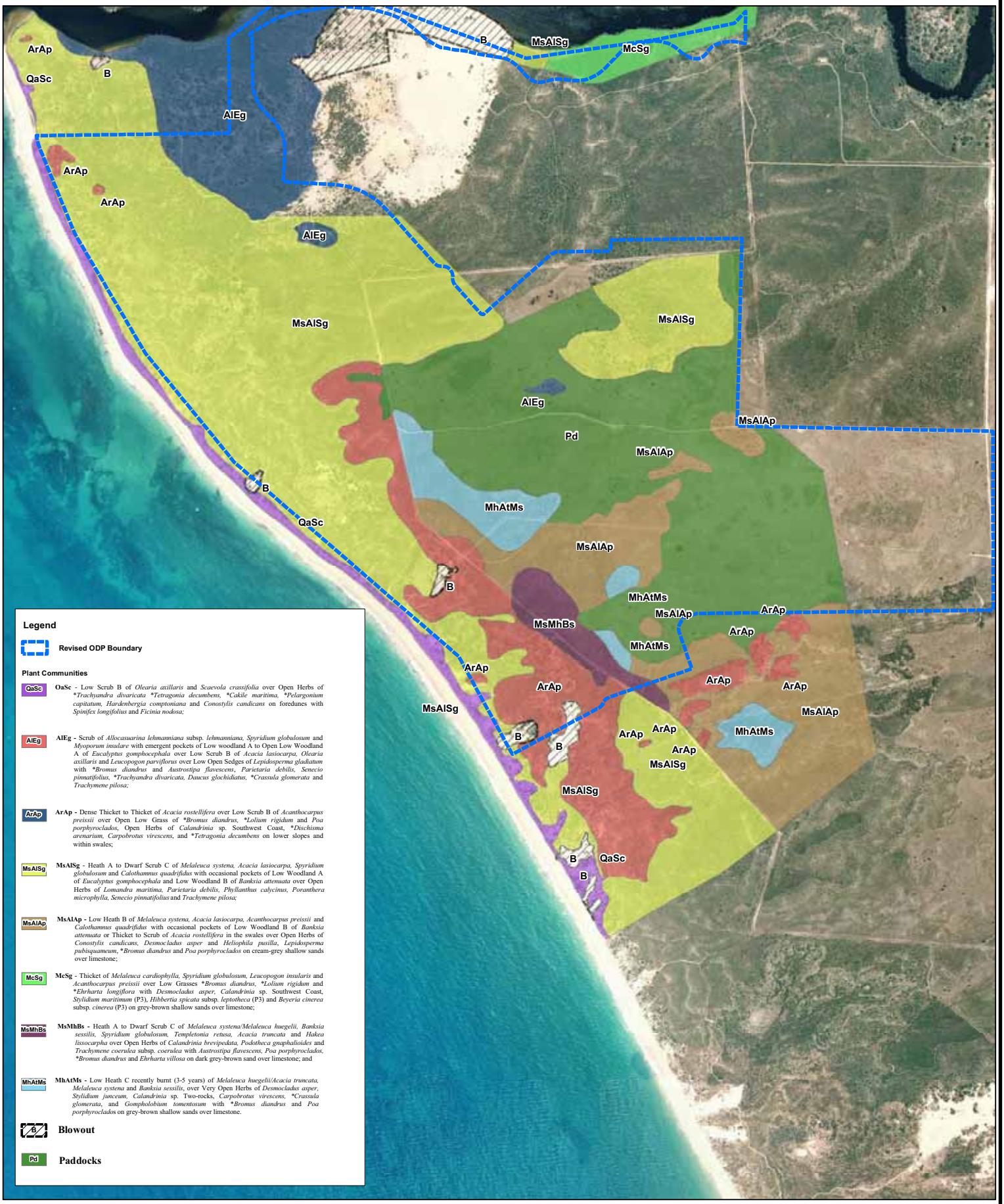
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Date 12/04/10



Legend

Revised ODP Boundary

Plant Communities

QaSc - Low Scrub B of *Olearia axillaris* and *Scaevola crassifolia* over Open Herbs of **Trachyandra divaricata* **Tetragonia decumbens*, **Cakile maritima*, **Pelargonium capitatum*, *Hardenbergia comptoniana* and *Conostylis candicans* on foredunes with *Spinifex longifolius* and *Ficinia nodosa;*

AlEg - Scrub of *Allocasuarina lehmanniana* subsp. *lehmanniana, Spyridium globulosum* and *Myoporum insulare* with emergent pockets of Low woodland A to Open Low Woodland A of *Eucalyptus gomphocephala* over Low Scrub B of *Acacia lasiocarpa, Olearia axillaris* and *Leucopogon parviflorus* over Low Open Sedges of *Lepidosperma gladiatum* with **Bromus diandrus* and *Austrostipa flavescens*, *Parietaria debilis, Senecio pinnatifolius*, **Trachyandra divaricata, Daucus glochidiatus*, **Crassula glomerata* and *Trachymene pilosa;*

ArAp - Dense Thicket to Thicket of *Acacia rostellifera* over Low Scrub B of *Acanthocarpus preissii* over Open Low Grass of **Bromus diandrus*, **Lolium rigidum* and *Poa porphyroclados*, Open Herbs of *Calandrinia* sp. Southwest Coast, **Dischisma arenarium, Carpobrotus virescens*, and **Tetragonia decumbens* on lower slopes and within swales;

MsAlSg - Heath A to Dwarf Scrub C of *Melaleuca systena, Acacia lasiocarpa, Spyridium globulosum* and *Calothamnus quadrifidus* with occasional pockets of Low Woodland A of *Eucalyptus gomphocephala* and Low Woodland B of *Banksia attenuata* over Open Herbs of *Lomandra maritima, Parietaria debilis, Phyllanthus calycinus, Poranthera microphylla, Senecio pinnatifolius* and *Trachymene pilosa;*

MsAlAp - Low Heath B of *Melaleuca systena, Acacia lasiocarpa, Acanthocarpus preissii* and *Calothamnus quadrifidus* with occasional pockets of Low Woodland B of *Banksia attenuata* or Thicket to Scrub of *Acacia rostellifera* in the swales over Open Herbs of *Conostylis candicans, Desmocladus asper* and *Heliophila pusilla, Lepidosperma pubisquameum*, **Bromus diandrus* and *Poa porphyroclados* on cream-grey shallow sands over limestone;

McSg - Thicket of *Melaleuca cardiophylla, Spyridium globulosum, Leucopogon insularis* and *Acanthocarpus preissii* over Low Grasses **Bromus diandrus, *Lolium rigidum* and **Ehrharta longiflora* with *Desmocladus asper, Calandrinia* sp. Southwest Coast, *Stylidium maritimum* (P3), *Hibbertia spicata* subsp. *leptotheca* (P3) and *Beyeria cinerea* subsp. *cinerea* (P3) on grey-brown shallow sands over limestone;

MsMhBs - Heath A to Dwarf Scrub C of *Melaleuca systena/Melaleuca huegelii, Banksia sessilis, Spyridium globulosum, Templetonia retusa, Acacia truncata* and *Hakea lissocarpha* over Open Herbs of *Calandrinia brevipedata, Podotheca gnaphalioides* and *Trachymene coerulea* subsp. *coerulea* with *Austrostipa flavescens, Poa porphyroclados, *Bromus diandrus* and *Ehrharta villosa* on dark grey-brown sand over limestone; and

MhAtMs - Low Heath C recently burnt (3-5 years) of *Melaleuca huegelii/Acacia truncata, Melaleuca systena* and *Banksia sessilis*, over Very Open Herbs of *Desmocladus asper, Stylidium junceum, Calandrinia* sp. Two-rocks, *Carpobrotus virescens, *Crassula glomerata*, and *Gompholobium tomentosum* with **Bromus diandrus* and *Poa porphyroclados* on grey-brown shallow sands over limestone.

Blowout

Paddocks

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PROJECT **Moore River South - Environmental Assessment & Justification Report**

DRAWING TITLE **FIGURE 8: Plant Communities**

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Original **A3**

Drawing Number **SK50**

Revision **01**

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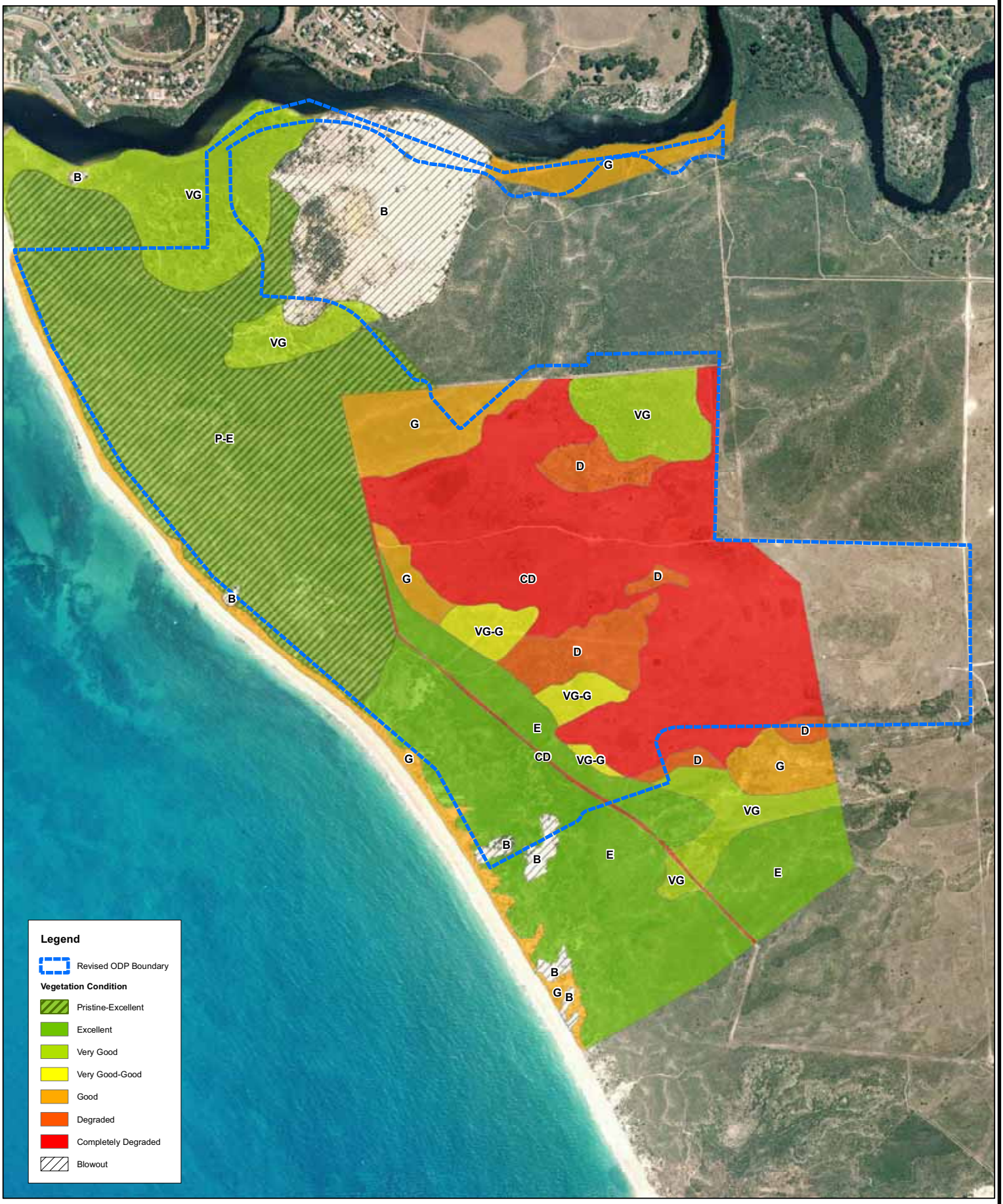
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PROJECT **Moore River South - Environmental Assessment & Justification Report**

DRAWING TITLE **FIGURE 9: Vegetation Condition**

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Drawing Number **SK49**

Revision **01**

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PROJECT **Moore River South - Environmental Assessment & Justification Report**

DRAWING TITLE **FIGURE 10 : Carnaby Black Cockatoos Potential Foraging Habitat & Habitat Trees**

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Original **A3**

Drawing Number **SK55**

Revision **00**

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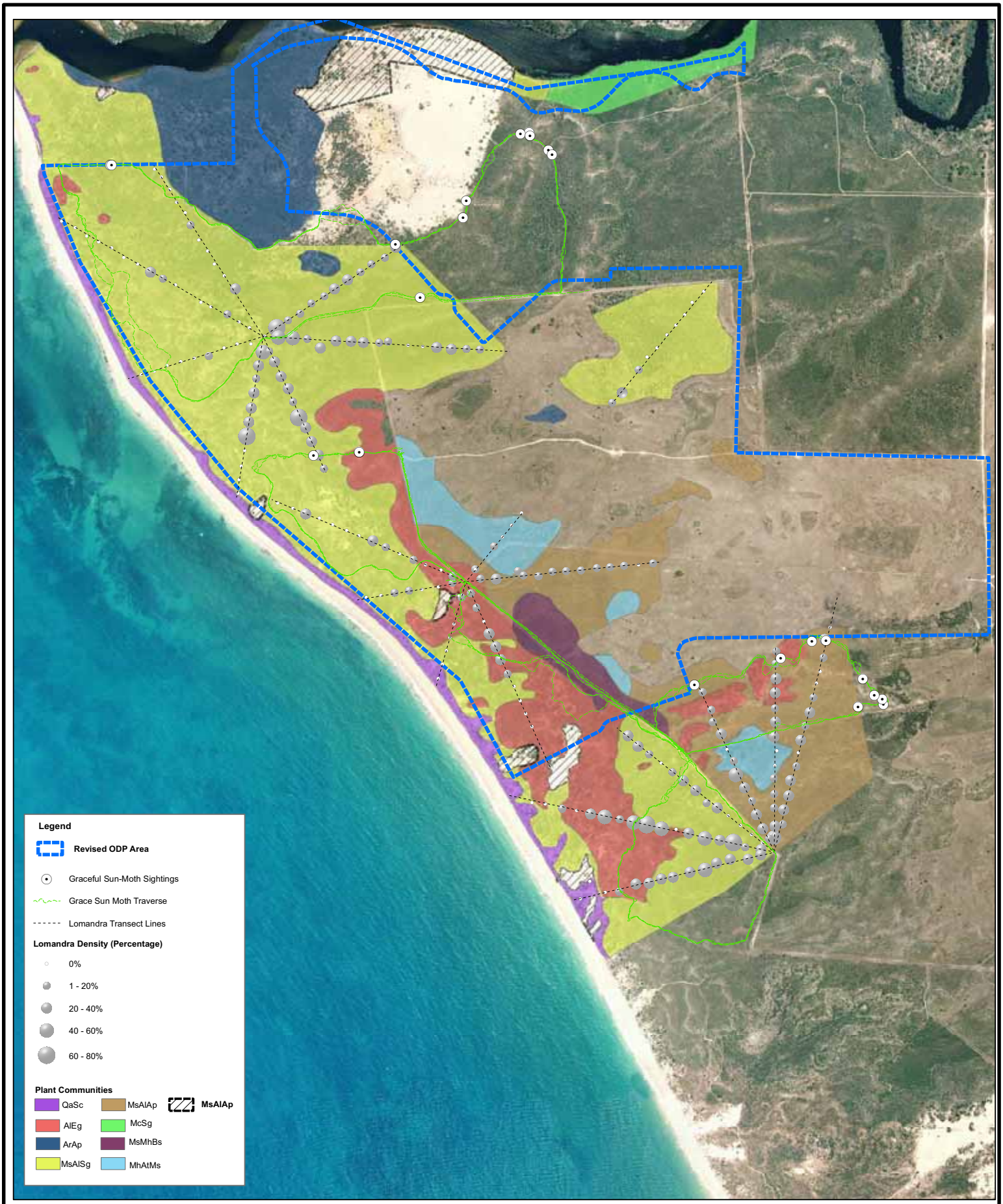
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PROJECT **Moore River South - Environmental Assessment & Justification Report**

DRAWING TITLE **FIGURE 11: Graceful Sun Moth Locations, Lomandra Densities Data and Plant Communities**

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Drawing Number **SK75**

Revision **00**

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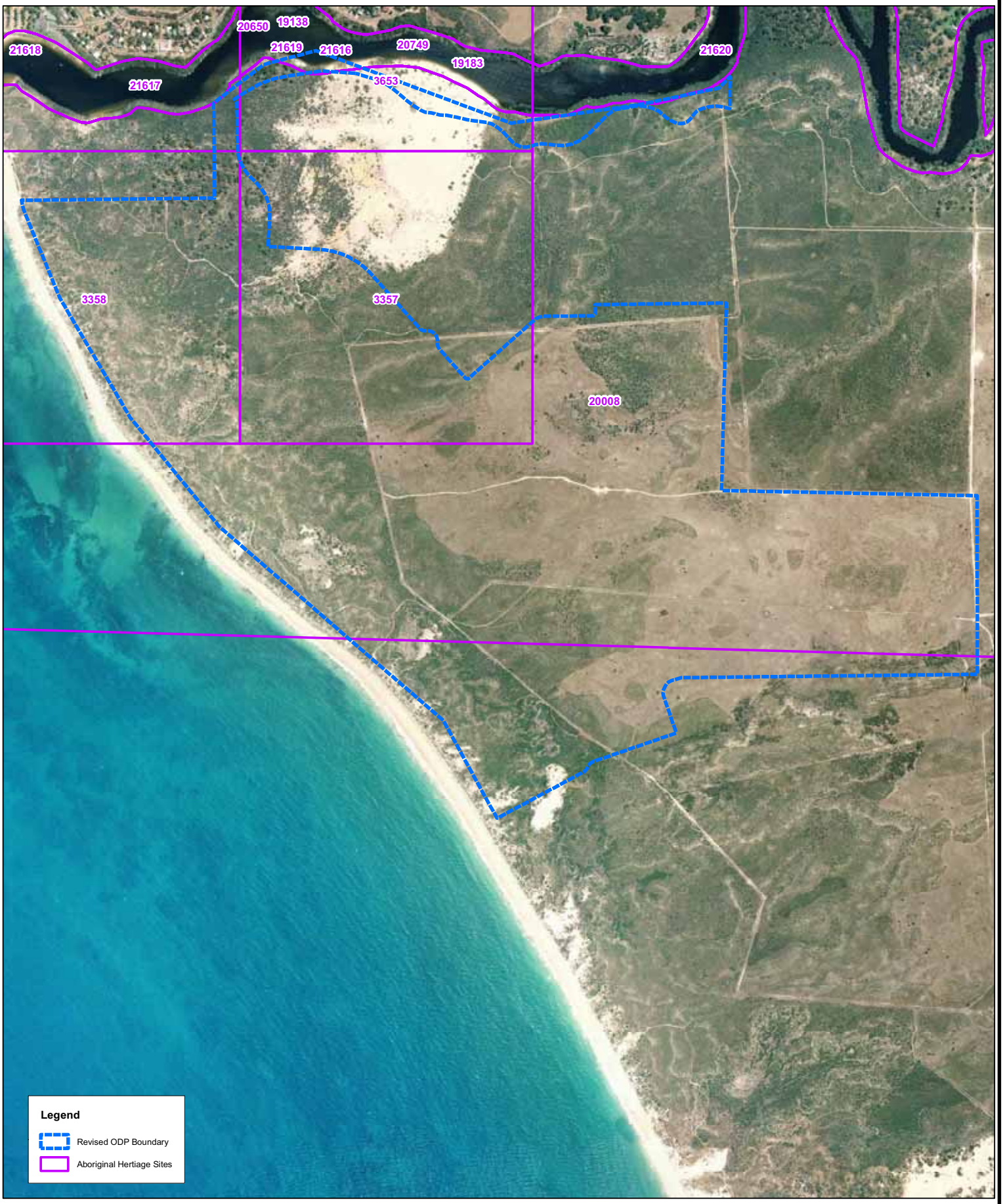
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PROJECT **Moore River South - Environmental Assessment & Justification Report**

DRAWING TITLE **FIGURE 12: Registered Aboringinal Heritage Sites**

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Drawing Number **SK52**

Revision **01**

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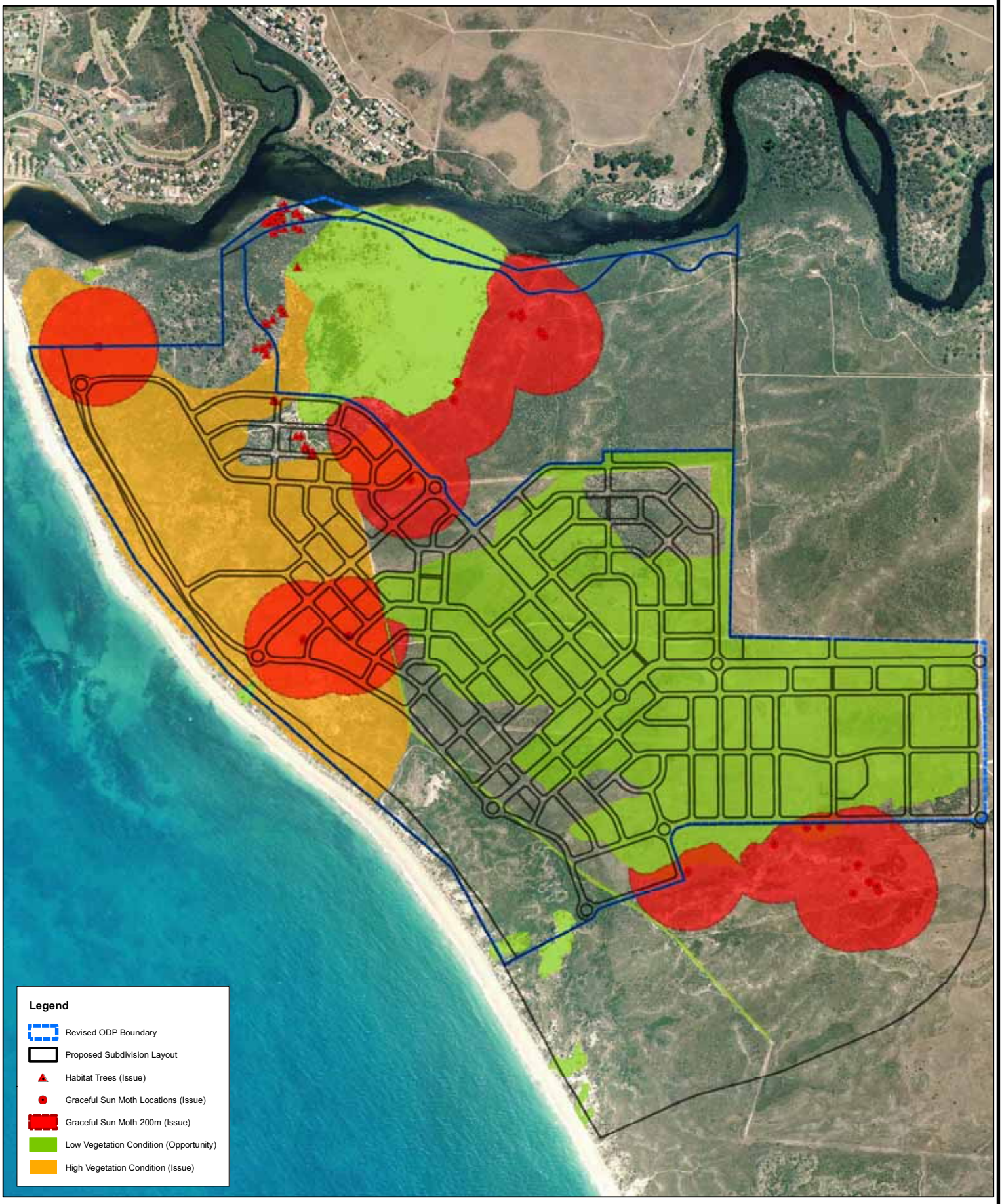
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PROJECT **Moore River South - Environmental Assessment & Justification Report**

DRAWING TITLE **FIGURE 13 : Issuses, Constraints & Opportunities**

PRINCIPAL **Moore River Company Pty Ltd**

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Project Number **V9070**

Original **A3**

Drawing Number **SK58**

Revision **00**

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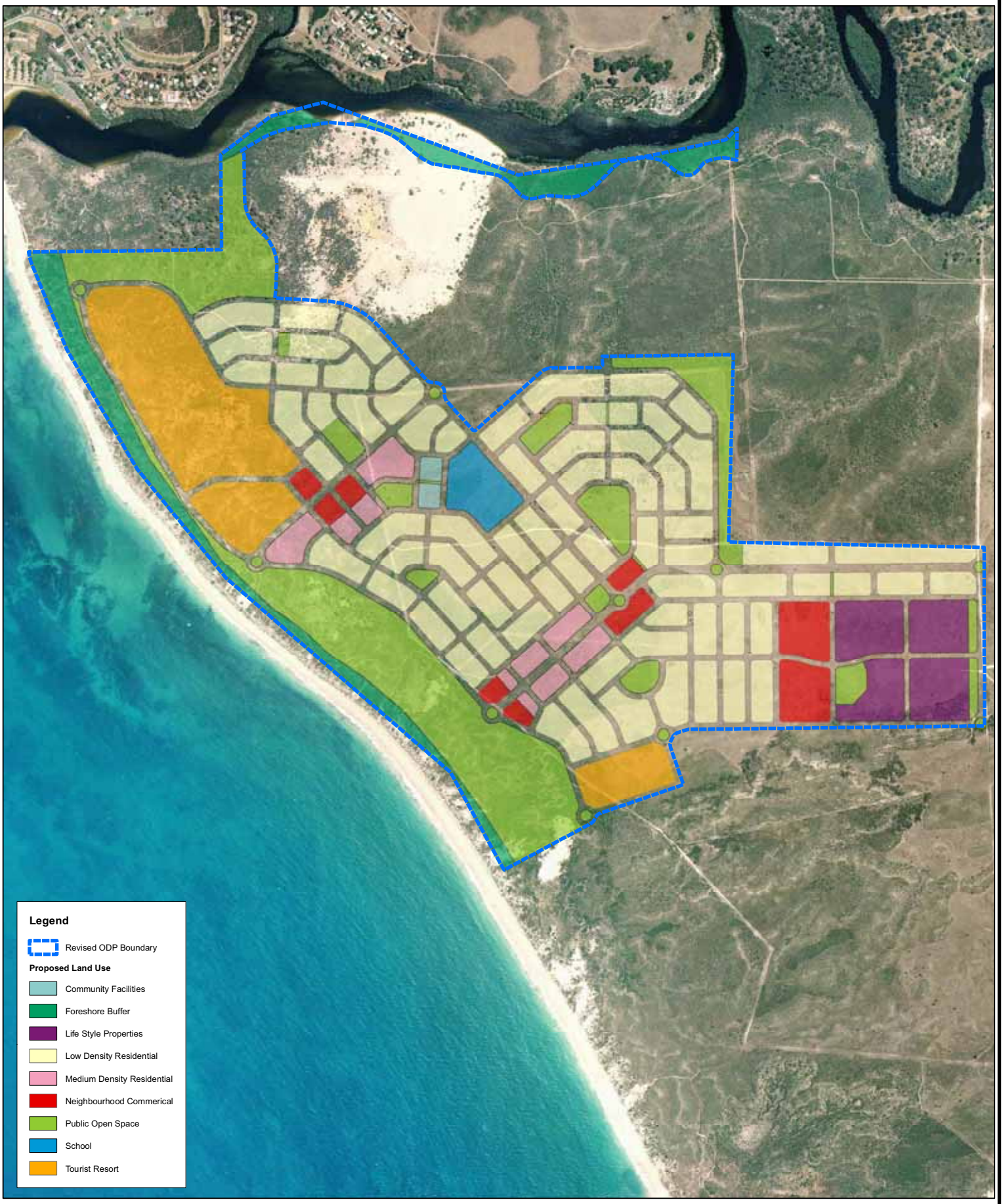
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PROJECT **Moore River South - Environmental Assessment & Justification Report**

DRAWING TITLE **FIGURE 14 : Details of Land Uses Under Proposed Outline Development Plan**

PRINCIPAL **Moore River Company Pty Ltd**

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Project Number **V9070**

Original **A3**

Drawing Number **SK57**

Revision **00**

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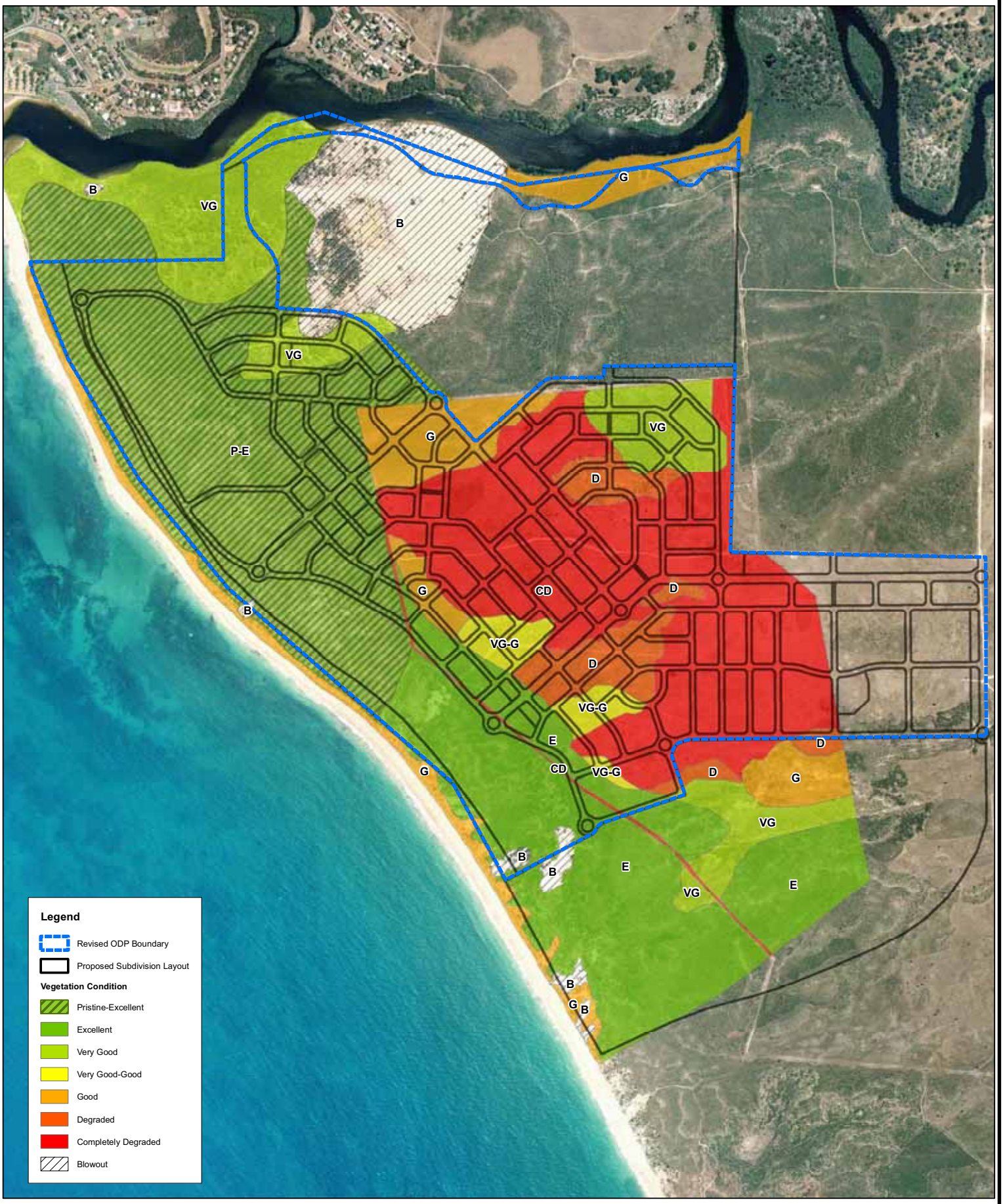
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PROJECT **Moore River South - Environmental Assessment & Justification Report**

DRAWING TITLE **FIGURE 15: Vegetation Condition within the Revised ODP Area**

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Drawing Number **SK59**

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Sheet 1 of 1

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Appendix F
Flora Study

Cardno
Shaping the Future

Cardno
Shaping the Future



Moore River South

Flora and Vegetation Assessment

Prepared for Moore River Company Pty Ltd
April 2010
Project Number V9070

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Document Control

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Version 1	March 2010	Gillian Turner	GFT	Shane Chalwell	SC
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Version 3	June 2010	Gillian Turner	GFT	Barbara Pedersen	BP
Filename	V9070-GFT100002.30-BP.Docx				

Author: Gillian Turner
Position Title: Botanist

Reviewer: Barbara Pedersen
Position Title: Section Leader Environmental Planning

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Executive Summary

Cardno (WA) Pty Ltd (Cardno) was engaged by the Moore River Company (MRC) in September 2009 to undertake a range of environmental consultancy services required to support the lodgement of a revised Outline Development Plan (ODP) for the Moore River South proposed development, herein referred to as the 'subject site'. The ODP design process reflects the information provided on the flora and vegetation values documented within this report.

This report addresses the flora and vegetation component of the environmental services required. A previous flora and vegetation assessment was undertaken for the subject site in 1993 by Alan Tingay and Associates (now Coffey Environments) to support the original ODP. As the ODP is being revised, an update to the 1993 survey is required to be undertaken as the conditions within the subject site may have changed such as vegetation condition, or size and extent of local populations of flora. In addition, the way threatened or significant flora and fauna species are classified and their protection mechanisms have also changed over time. Therefore, the purpose of this flora and vegetation assessment is to update the original survey undertaken by Alan Tingay and Associates in 1993 and to support the lodgement of a revised ODP for the subject site.

The subject site was visited by botanists from Cardno in October and November 2009 and a field survey, conducted in accordance with EPA Guidance Statement No. 51 – *Terrestrial flora and vegetation survey environmental impact assessment in Western Australia* (2004) was undertaken to the level of a detailed survey. A separate visit was also made to the site in April 2010 to map *Lomandra maritima* density for the purpose of a Graceful Sun Moth assessment (see Cardno 2010, Graceful Sun-Moth Survey). The vegetation was assessed at 32 survey locations, selected to adequately sample each plant community observed within the subject site. At each site, a species list including an estimate of Foliage Projective Cover (FPC) percentage was recorded. In addition environmental site data was recorded including topographic position, aspect, slope, soil colour and texture class, rock outcropping, litter cover as well as the degree of disturbance and an estimate of the time since the last fire event. The condition of the vegetation was assessed to assist in determining the conservation values of the site. The vegetation was rated according to Keighery (1994), a vegetation scale commonly used in the Perth Metropolitan Region, but which is also appropriate for other urbanised and agricultural areas.

Across the visits, 138 native and 36 introduced flora species were recorded comprising 54 families and 118 genera. No DRF species were recorded; however three Priority Three Flora *Stylidium maritimum, Hibbertia spicata* subsp. *leptotheca* and *Beyeria cinerea* subsp. *cinerea* were recorded at Site 212. A number of significant flora have also been recorded, these being *Allocasuarina lehmanniana*, *Marianthus erubescens* and *Thomasia triphylla*. These species are not uncommon species; however they do represent extensions of ranges or unusual coastal occurrences.

Eight broad plant communities have been described for the subject site, which are:

1. **OaSc** - Low Scrub B of *Olearia axillaris* and *Scaevola crassifolia* over Open Herbs of **Trachyandra divaricata* **Tetragonia decumbens*, **Cakile maritima*, **Pelargonium capitatum, Hardenbergia comptoniana* and *Conostylis candicans* on foredunes with *Spinifex longifolius* and *Ficinia nodosa;*

2. **ArAp** - Dense Thicket to Thicket of *Acacia rostellifera* over Low Scrub B of *Acanthocarpus preissii* over Open Low Grass of **Bromus diandrus*, **Lolium rigidum* and *Poa porphyroclados*, Open Herbs of *Calandrinia sp. Southwest Coast*, **Dischisma arenarium, Carpobrotus virescens*, and **Tetragonia decumbens* on lower slopes and within swales;

3. **AlEg** - Scrub of *Allocasuarina lehmanniana* subsp. *lehmanniana, Spyridium globulosum* and *Myoporum insulare* with emergent pockets of Low woodland A to Open Low Woodland A of *Eucalyptus gomphocephala* over Low Scrub B of *Acacia lasiocarpa, Olearia axillaris* and *Leucopogon parviflorus* over Low Open Sedges of *Lepidosperma gladiatum* with **Bromus diandrus* and *Austrostipa flavescens*, *Parietaria debilis, Senecio pinnatifolius, *Trachyandra divaricata, Daucus glochidiatus, *Crassula glomerata* and *Trachymene pilosa;*

4. **MsAlSg** - Heath A to Dwarf Scrub C of *Melaleuca systena, Acacia lasiocarpa, Spyridium globulosum* and *Calothamnus quadrifidus* with occasional pockets of Low Woodland A of *Eucalyptus gomphocephala* and Low Woodland B of *Banksia attenuata* over Open Herbs of *Lomandra maritima, Parietaria debilis, Phyllanthus calycinus, Poranthera microphylla, Senecio pinnatifolius* and *Trachymene pilosa;*

5. **MsAlAp** - Low Heath B of *Melaleuca systena, Acacia lasiocarpa, Acanthocarpus preissii* and *Calothamnus quadrifidus* with occasional pockets of Low Woodland B of *Banksia attenuata* or Thicket to Scrub of *Acacia rostellifera* in the swales over Open Herbs of *Conostylis candicans, Desmocladus asper* and *Heliophila pusilla*, *Lepidosperma pubisquameum*, **Bromus diandrus* and *Poa porphyroclados* on cream-grey shallow sands over limestone;

6. **McSg** - Thicket of *Melaleuca cardiophylla, Spyridium globulosum, Leucopogon insularis* and *Acanthocarpus preissii* over Low Grasses **Bromus diandrus, *Lolium rigidum* and **Ehrharta longiflora* with *Desmocladus asper, Calandrinia sp. Southwest Coast*, *Stylidium maritimum* (P3), *Hibbertia spicata* subsp*. leptotheca* (P3) and *Beyeria cinerea* subsp. *cinerea* (P3) on grey-brown shallow sands over limestone. This plant community was recorded along the Moore Rivers southern bank to the east of the large blow-out;

7. **MsMhBs** - Heath A to Dwarf Scrub C of *Melaleuca systena/Melaleuca huegelii, Banksia sessilis, Spyridium globulosum, Templetonia retusa, Acacia truncata* and *Hakea lissocarpha* over Open Herbs of *Calandrinia brevipedata, Podotheca gnaphalioides* and *Trachymene coerulea* subsp. *coerulea* with *Austrostipa flavescens, Poa porphyroclados, *Bromus diandrus* and *Ehrharta villosa* on dark grey-brown sand over limestone; and

8. **MhMtMs** - Low Heath C recently burnt (3-5 years) of *Melaleuca huegelii/Acacia truncata, Melaleuca systena* and *Banksia sessilis*, over Very Open Herbs of *Desmocladus asper, Stylidium junceum, Calandrinia* sp. Two-rocks, *Carpobrotus virescens, *Crassula glomerata*, and *Gompholobium tomentosum* with **Bromus diandrus* and *Poa porphyroclado*s on grey-brown shallow sands over limestone.

Whilst the mapping does not cover the entire eastern area within the revised ODP boundary, field observations and observations of the aerial imagery indicate that the plant communities are comparable to those mapped. Most of the additional area unmapped is largely devoid of native vegetation and consistent mainly of areas of completed degraded paddocks (**Pd**)**.**

Of the plant communities described, **OaSc, ArAp** and **AlEg** have been determined to be FCT 29a and plant community **MsAlSp, MsAlAp, McSp, MsMhBs** and **MhMtMs** have been determined to be FCT 29b. Both of these FCTs are classified as Priority 3 Ecological Communities. A number of supplementary FCTs have been added to the Gibson *et al*. 1994 FCT dataset following 1994, which identified additional FCTs for the Swan Coastal Plain. This information is not readily available and could not be included within the FCT analysis, however the supplementary community type FCT S11 – Northern *Acacia rostellifera – Melaleuca systena* shrublands was inferred from the 1993 Alan Tingay and Associates study. The DEC will need to confirm the FCTs of the plant communities within the subject site.

The vegetation ranged from 'Completely Degraded' to 'Pristine-Excellent' condition with a majority of the vegetation in either a 'Completely Degraded' or 'Pristine-Excellent' condition. Whilst the mapping does not cover the entire eastern area within the revised ODP boundary, field observations and observations of the aerial imagery indicate that the vegetation condition is comparable to those mapped and largely represent 'Completely Degraded' condition vegetation. The revised ODP has aimed to respond to the varying conditions of the vegetation across MRC landholdings and has aimed to preserve, where possible, areas of 'Pristine-Excellent' condition vegetation. The revised ODP boundary includes 96.3% of the mapped 'Completely Degraded' condition vegetation as well as roughly 36ha of unmapped degraded vegetation within the revised ODP boundary.

After undertaking the investigations a number of conservation features were identified that will need to be considered. These are:

- The presence of three Priority Three species *Stylidium maritimum, Hibbertia spicata* subsp. *leptotheca* and *Beyeria cinerea* subsp. *cinerea* within plant community **McSg** – *Melaleuca cardiophylla* thicket on limestone;
- Significant local flora *Allocasuarina lehmanniana* subsp. *lehmanniana*, *Marianthus erubescens* and *Thomasia triphylla,* which are not uncommon species, but represent the extent of their ranges or unusual coastal distributions;
- The eight plant communities within the subject site have been determined to be FCT 29a and 29b which are Priority Three Ecological Communities, however this will need to be confirmed by the DEC; and
- Vegetation of the fenced foreshore reserve is currently in an 'Excellent' to 'Pristine-Excellent' condition.

Therefore Cardno recommends that vegetation clearing be minimised wherever possible. No specific plant community can be recommended for retention as all plant communities have been determined to be Priority 3 Ecological Communities, therefore all represent the same conservation significance. The DEC will be required to confirm the FCTs within the subject site.

Priorities for vegetation retention should be based on vegetation condition and the presence of locally significant species including the P3 species (*Stylidium maritimum, Hibbertia spicata* subsp. *leptotheca* and *Beyeria cinerea* subsp. *cinerea*) and the species that represent the extent of their ranges (e.g. *Allocasuarina lehmanniana*) or unusual coastal distributions (e.g. *Marianthus erubescens, Thomasia triphylla*).

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1 Introduction

1.1 Background

Cardno (WA) Pty Ltd (Cardno) was engaged by the Moore River Company Pty Ltd (MRC) in September 2009 to undertake a range of environmental consultancy services required to support the lodgement of a revised Outline Development Plan (ODP) for the Moore River South development (herein referred to as the "subject site" see **Figure 1** and **Figure 2**). The subject site is located on the south side of the Moore River, opposite the Guilderton town site, 75 km north of Perth. The subject site is part of a 2000 ha pastoral property that has been owned by the MRC for more than 40 years.

Alan Tingay and Associates (now Coffey Environments) undertook a flora and vegetation assessment for the subject site in 1993 to support the original ODP. This assessment was updated in 2003 by ATA Environmental (now Coffey Environments) as part of the *Moore River South Environmental Report Update*. Botanical field work was only undertaken for the 1993 assessment and therefore the onsite flora data is now greater than 15 years old. As the ODP is being revised, it is required that an update to the 1993 flora and vegetation survey be undertaken as conditions within the subject site are likely to have changed, including vegetation condition and the size and extent of local populations of flora. In addition to onsite conditions, increased survey effort and research into many flora in Western Australia have significantly increased the pool of information available about their distribution and conservation status. The classification and protection mechanisms of significant floras and communities have also changed in the intervening period.

1.2 Purpose of Report

The purpose of this flora and vegetation assessment is to update the original survey undertaken by Alan Tingay and Associates in 1993 to support the lodgement of a revised ODP for the subject site. The design process for revision of the ODP has been undertaken to reflect the information provided within this technical report.

The report will document the botanical values of the site including:

- A desktop study of publicly available, relevant background material, including previous flora surveys of the subject site and relevant policies and legislation;
- A search of the Department of Environment and Conservation's (DEC's) Declared Rare Flora (DRF) and Priority Flora (PF) Datasets and Threatened and Priority Ecological Community (TEC/PEC) datasets;
- The results of a detailed flora survey conducted in spring (October and November) 2009;
- A discussion of the conservation significance of the vegetation encountered across the subject site; and
- Conclusions and recommendations about the future constraints and protection issues that may arise through the development of the subject site.

2 Regional Geomorphology, Soils, Climate and Vegetation

2.1 Geomorphology and Soils

Guilderton occurs on the north western edge of the Swan Coastal Plain, which is the surface expression of a small part of the Perth Basin, and characterises the Perth region and surrounds (Seddon 2004). It is a geomorphologic unit approximately 20 – 30 km wide consisting of two sedimentary belts of different origin. On the eastern side of the Swan Coastal Plain, the Pinjarra Plain has been formed from the deposition of alluvial material whilst the three dune systems (Quindalup, Spearwood and Bassendean) that form the western part of the Swan Coastal Plain are of Aeolian origin (Seddon 2004). The subject site contains two of the main geomorphic features; the Quindalup Dune System and the Spearwood Dune System.

The Quindalup Dune system is of Holocene origin and extends along the coast from Geographe Bay to Dongara. The Quindalup Dunes are composed of calcareous sand of Holocene origin (known as the Safety Bay Sands) and are characterised by a series of parabolic dunes, shore-parallel ridges, choats, conical hill residuals as well as small beach ridges and blowouts (Lemmon *et al*. 1979). Underlying the Safety Bay Sands is a limestone rock known as Tamala Limestone (Playford *et al*. 1976). The Tamala Limestone is part of the Spearwood Dune System and is of late Pleistocene origin. The Spearwood Dune System comprises a series of shore parallel limestone ridges originally deposited as coastal sand dunes. They extend from several kilometres inland to offshore submerged reefs and islands (Playford *et al.* 1976). Near the coastline the Spearwood dunes are mostly overlain by the Quindalup Dune System (ATA Environmental 2003).

The soils of the study area consist of Safety Bay Sands (Quindalup Dune System) and Tamala Limestone (Spearwood Dune System). The Safety Bay Sand is composed of pale cream coloured calcareous sands. Soil development is poor ranging from no development on the youngest and mobile dunes to up to 50 cm thick on the older dunes. Where the soil profile has been developed the topsoil consists of an organic layer over pale brown soils to 50cm depth. The older dunes may have weakly cemented subsurface layers which occasionally outcrop on the sides of tall dunes. The Tamala limestone soils of the study area belong to the Cottesloe Association which are defined as consisting of exposed limestone which weathers to siliceous brown sand. The Tamala limestone within the subject site is mainly expressed at the surface as limestone rock with only a shallow sand cover in places (ATA Environmental 2003)

2.2 Climate

The climate of the Moore River area can be described as warm Mediterranean with mild wet winters and hot dry summers, with 5-6 dry months per year (Beard 1990). Climatic data from the closest climatic station (Lancelin), utilising data from 1965 to 2010, provides an annual rainfall average of 609.5 mm. July has the highest mean rainfall, with 127.2 mm, and December has the lowest with 7.4 mm. The mean maximum temperature ranges from 29.7^{o}C in February to 19.1^{o}C in July, and the mean minimum temperature ranges from 18^{o}C in February to 9.9^{o}C in August (Bureau of Meteorology 2010).

2.3 Vegetation Description and Soil and Vegetation Relationships

The subject site lies within the Swan Coastal Plain Interim Biogeographic Regionalisation for Australia (IBRA) region (Thackway and Cresswell 1995). The Swan Coastal Plain IBRA Region is broadly compatible with the Swan Coastal Plain (Drummond Botanical Subdistrict) Phytogeographical Subregion as described by Beard (1990). This region is characterised by *Banksia* low woodlands on

leached sands, woodlands of tuart (*Eucalyptus gomphocephala*), jarrah (*Eucalyptus marginata*) and marri (*Eucalyptus calophylla*) on less leached soils and *Melaleuca* swamps.

Beard (1980) describes the first stable vegetation on a foredune as consisting of **Cakile maritima* and **Arctotheca calendula*, *Spinifex longifolius, Spinifex hirsutus, *Tetragonia decumbens* and **Ammophila arenaria*. In the area on the peak and behind foredunes, species such as **Tetragonia decumbens*, *Ficinia nodosa, Scaevola crassifolia, Lepidosperma gladiatum* and *Olearia axillaris* occur.

The vegetation of the foreshore has been described by Alan Tingay and Associates (1993). The strand vegetation has been described as **Ammophila arenaria* Grassland and *Olearia axillaris* Open Shrubland over *Spinifex longifolius* Grassland with *Olearia axillaris/Scaevola crassifolia* Shrubland on Q4 sand and *Acacia rostellifera/Spyridium globulosum* Scrub on Q3 sand. Further east, described as the Older Quindalup Dune Heath, on Q2 sand consist mainly of *Melaleuca systena* heath or shrublands with associated species. On limestone outcrops *Banksia sessilis* and *Melaleuca huegelli* heaths occur and on sand over limestone, *Banksia attenuata* and *Eucalyptus gomphocephala* woodlands were recorded.

Vegetation complex mapping undertaken by Heddle *et al.* (1980) indicates the basic relationship between vegetation, soils and rainfall. Two vegetation complexes have been mapped for the subject site, which are the Quindalup Complex and adjacent to the Moore River, the Moore Complex. These complexes are described below:

- Quindalup Complex – Coastal dune complex consisting of mainly two alliances – the strand and foredune alliance and the mobile and stable alliance. Local variations include the low closed forest of *Melaleuca lanceolata – Callitris preissii* and the closed scrub of *Acacia rostellifera*; and
- Moore Complex – Fringing woodland of *Eucalyptus rudis* and *Melaleuca rhaphiophylla*.

The vegetation complexes, Quindalup Complex and Moore Complex, have 47.1% and 29.7% of their pre-European extent remaining respectively (EPA 2006). This number however was determined in 1997/1998 and is most likely less than this percentage now. Just 5.2% of the Quindalup Complex and 0.2% of the Moore Complex was determined to be in secure tenure in 2002 (EPA 2006).

2.4 Bush Forever and Surrounding Remnant Vegetation

Significant remnant vegetation within the Perth Metropolitan area has been recognised by the State Government in the System 6 (Department of Conservation and Environment), Greenways (Alan Tingay and Associates) and Bush Forever (Government of Western Australia 2000) studies. The Bush Forever initiative aims to conserve regionally significant bushland and associated wetland areas on the Swan Coastal Plain. The Bush Forever Policy aims to protect 10% of each vegetation complex as defined by Heddle *et al.* (1980).

The extent of Bush Forever area does not reach as far north as the subject site, however 2.3 km to the south and 2.5 km to the east of the subject site is Bush Forever Site No. 406, Wilbinga-Caraban Reserve which covers 9158.3 ha of Spearwood and Quindalup Dune vegetation. The vegetation condition of the reserve is >70% in Excellent to Pristine condition, <30% in Very Good to Good, with small areas of localised disturbance. This reserve was identified and protected due to high conservation significance.

South of Wilbinga-Caraban Reserve is BF Site No. 397 – Coastal Strip from Wilbinga to Mindarie, which includes the coastal reserve. To the north of the subject site, the main areas of reserved remnant vegetation consist of small portions of the Moore River foreshore reserve and the coastal reserve along the coast. The remaining native vegetation occurs within private property.

2.5 Declared Rare and Priority Flora

Species of flora acquire "Declared Rare" or "Priority" conservation status where populations are restricted geographically or threatened by local processes. The DEC recognises these threats and subsequently applies regulations towards population protection and species conservation. The DEC enforces regulations under the *Wildlife Conservation Act 1950* to conserve Declared Rare Flora (DRF) and protect significant populations. Priority flora species are potentially rare or threatened and are classified in order of threat. DRF and priority flora category definitions are listed in **Table 1.**

DRF are gazetted under subsection 2 of section 23F of the *Wildlife Conservation Act 1950* and therefore it is an offence to "take" or damage rare flora without Ministerial approval. Section 23F of the Act defines "to take" as "… to gather, pluck, cut, pull up, destroy, dig up, remove or injure the flora to cause or permit the same to be done by any means". Species of flora may also be listed as "Threatened" pursuant to Schedule 1 of the *Environment Protection and Biodiversity Conservation Act* (1999) (EPBC Act). Any action likely to have a significant impact on a species listed under the EPBC Act requires approval from the Commonwealth Minister for Environment, Water, Heritage and the Arts.

Table 1: Definition of Rare and Priority Flora (Atkins 2008)

Conservation Code	Category
R	**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, and have been gazetted as such.
X	**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, and have been gazetted as such.
P1	**Priority One – Poorly Known Taxa** Taxa which are known from one or a few (generally <5) populations which are under threat, either due to small population size, or being on lands under immediate threat eg road verges, urban areas, farmland, active mineral leases etc, or the plants are under threat, eg from disease, grazing by feral animals etc. May include taxa with threatened populations on protected lands. Such taxa are under consideration for declaration as 'rare flora', but are in urgent need of further survey.
P2	**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 (i.e. not currently endangered). Such taxa are under consideration for declaration as 'rare flora', but urgently need further survey.
P3	**Priority Three – Poorly Known Taxa** Taxa which are known from several populations, and the taxa are not believed to be under immediate threat (i.e. not currently endangered), either due to the number of known populations (generally >5), or known populations being large, and either widespread or protected. Such taxa are under consideration for declaration as 'rare flora' but need further survey.
P4	**Priority Four – Rare Taxa** Taxa which are considered to have been adequately surveyed and which, whilst being rare (in Australia), are not currently threatened by any identifiable factors. These taxa require monitoring every 5-10 years.

A search was conducted of the DEC's databases for DRF and Priority Flora that occur within the wider local area and the results are listed in **Table 2**.

Table 2: DRF and PF identified as occurring in close proximity to the subject site

Species	Conservation Code	Life Strategy	Flowering Period
Acacia horridula	3	P	May-Aug
Banksia dallanneyi subsp. *pollosta*	3	P	Aug
Banksia sclerophylla	4	P	Sept-Oct
Caladenia speciosa	4	Pg	Sept-Oct
Calytrix sylvana	4	P	Aug-Sept
Chamelaucium sp. Wongan Hills	3	P	
Chorizema varium	R	P	Jun/Sept-Oct
Conostylis bracteata	3	P	Jul-Aug
Conostylis pauciflora subsp. *euryrhipis*	4	P	July
Cyathochaeta teretifolia	3	P	Dec
Eucalyptus argutifolia	R	P	Mar-April
Eucalyptus mundijongensis	1	P	
Georgeantha hexandra	4	P	May-Nov
Grevillea thelemanniana	4	P	May-Nov
Hibbertia spicata subsp. *leptotheca*	3	P	Jul-Oct
Hypocalymma sp. Cataby (aff tetrapterum)	1	P	Aug-Sept
Leucopogon sp. Perth Coastal		P	Mar-Jun
Leucopogon sp. Yanchep	3	P	Apr-Jun, Sept
Marianthus paralius	R	P	Sept-Nov
Melaleuca clavifolia	1	P	Oct-Dec
Paracaleana dixonii	R	Pg	Nov
Sarcozona bicarinata	3	P	Aug
Scaevola paludosa	2	P	Sept-Oct
Stylidium maritimum	3	P	Sept-Nov
Stylidium nonscandens	3	P	Sept-Nov
Verticordia lindleyi subsp. *lindleyi*	4	P	Nov-Jan
Verticordia paludosa	4	P	Jan

Twenty seven DRF and PF species have been identified as occurring in close proximity to the subject site. Of these species, 4 are classified as DRF species. The flora survey undertaken by ATA Environmental in 1993 did not record any DRF or PF species in the subject site.

2.6 Threatened Ecological Communities

In Western Australia, 'Threatened Ecological Communities' (TECs) are defined by the Western Australian TEC Scientific Advisory Committee (within the DEC) and are assigned to one of the categories outlined below in **Table 3**. While they are not afforded direct statutory protection at a State

level (unlike DRF under the *Wildlife Conservation Act 1950*) their significance is acknowledged through other State environmental approval processes (i.e. Environmental Impact Assessment pursuant to Part IV of the Environmental Protection Act 1986).

Selected TECs are also afforded statutory protection at a Federal level pursuant to the EPBC Act. The EPBC Act provides for the strong protection of TECs, which are listed under section 181 of the Act, and are defined as "Critically Endangered", "Endangered" or "Vulnerable" under Section 182.

Table 3: Categories of DEC Threatened Ecological Communities (English and Blyth 1997)

Conservation Category	Description
PD	**Presumably Totally Destroyed** An ecological community that has been adequately searched for but for which no representative occurrences have been located.
CE	**Critically Endangered** An ecological community that has been adequately surveyed and is found to be facing an extremely high risk of total destruction in the immediate future.
E	**Endangered** An ecological community that has been adequately surveyed and is not critically endangered but is facing a very high risk of total destruction in the near future.
V	**Vulnerable** An ecological community that has been adequately surveyed and is not critically endangered or endangered but is facing a high risk of total destruction or significant modification in the medium to long-term future.

A search was conducted of the DEC's TEC database and no known occurrences of TECs were recorded within the boundary of the subject site, however, within approximately 6 km of the subject site the following TEC has been recorded:

- The 'Endangered' TEC – '*Melaleuca huegelii - Melaleuca acerosa* (currently *M. systena*) shrublands on limestone ridges (Gibson et al. 1994 FCT 26a).

This TEC is not listed at a Federal level pursuant to the EPBC Act 1999.

In addition to listing as a TEC, a community may be listed as a Priority Ecological Community (PEC). An ecological community that is under consideration for listing as a TEC, but does not yet meet survey criteria or has not been adequately defined, is placed on the list of PECs in either Category 1, 2 or 3 (**Table 4**). Ecological communities that are adequately known and are rare but not threatened, or meet criteria for Near Threatened, or that have been recently removed from the threatened list, are placed in Priority 4. These ecological communities require regular monitoring. Conservation Dependent ecological communities are placed in Priority 5 (DEC 2009).

No PECs have been recorded within the subject site, however within approximately 6km the PEC FCT 29b - *Acacia shrublands* on taller dunes, has been recorded.

The 1993 flora and vegetation report inferred FCTs for the plant associations described within the subject site. The inferred FCT's were FCT S11, FCT 24 or FCT 29a and FCT 28. FCT 29a is now considered to be a Priority 3 PEC. FCT S11 represents a supplementary community type added after the initial Gibson *et al*.(1994) dataset was released.

Table 4: Categories of Priority Ecological Communities

Priority Categories	Description
Priority 1	Ecological communities with apparently few, small occurrences, all or most not actively managed for conservation (e.g. within agricultural or pastoral lands, urban areas, active mineral leases) and for which current threats exist. Communities may be included if they are comparatively well-known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under immediate threat from known threatening processes across their range.
Priority 2	Communities that are known from few small occurrences, all or most of which are actively managed for conservation (e.g. within national parks, conservation parks, nature reserves, State forest, unallocated Crown land, water reserves, etc.) and not under imminent threat of destruction or degradation. Communities may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under threat from known threatening processes.
Priority 3	Communities that are known from several to many occurrences, a significant number or area of which are not under threat of habitat destruction or degradation or: (ii) communities known from a few widespread occurrences, which are either large or within significant remaining areas of habitat in which other occurrences may occur, much of it not under imminent threat, or; (iii) communities made up of large, and/or widespread occurrences, that may or not be represented in the reserve system, but are under threat of modification across much of their range from processes such as grazing by domestic and/or feral stock, and inappropriate fire regimes. Communities may be included if they are comparatively well known from several localities but do not meet adequacy of survey requirements and/or are not well defined, and known threatening processes exist that could affect them.
Priority 4	Ecological communities that are adequately known, rare but not threatened or meet criteria for Near Threatened, or that have been recently removed from the threatened list. These communities require regular monitoring.
Priority 5	Ecological communities that are not threatened but are subject to a specific conservation program, the cessation of which would result in the community becoming threatened within five years.

2.7 Local and Regional Significance

Apart from being listed as either DRF or priority flora, plant taxa may be significant for a number of other reasons. The EPA in Guidance Statement No. 51 – *Terrestrial flora and vegetation surveys for environmental impact assessment in Western Australia* (2004) stated that significant flora may include taxa that have:

- "a keystone role in a particular habitat for threatened species, or supporting large populations representing a significant proportion of the local regional population of a species;
- relic status;
- anomalous features that indicate a potential new discovery;
- being representative of the range of a species (particularly, at the extremes of range, recently discovered range extensions, or isolated outliers of the main range);
- the presence of restricted subspecies, varieties or naturally occurring hybrids;
- local endemism/a restricted distribution; or
- being poorly reserved."

Similarly, plant communities or vegetation may be significant for reasons other than a listing as a TEC. The EPA (2004) stated that these reasons include:

- "scarcity;
- unusual species;
- novel combinations of species;
- a role as a refuge;
- a role as a key habitat for threatened species or large populations representing a significant proportion of the local to regional total population of a species;
- being representative of the range of a unit (particularly, a good local and/or regional example of a unit in 'prime' habitat, at the extremes of range, recently discovered range extensions, or isolated outliers of the main range); or
- a restricted distribution. "

A number of species were identified in the 1993 report that was considered to have poor representation or uncommon distributions. These species were *Allocasuarina lehmanniana, Billardieria erubescens* and *Thomasia triphylla*.

Allocasuarina lehmanniana (now recognised as *Allocasuarina lehmanniana* subsp. *lehmanniana*) is not an uncommon species, however, is uncommon on the Swan Coastal Plain, occurring mainly in one Reserve (Trigg Bushland Reserve) and at Wilbinga (Alan Tingay and Associates 1993). *Allocasuarina lehmanniana* subsp. *lehmanniana* is found from Perth to North of Geraldton and also a disjunct population in the south-west, inland from Albany. Therefore, the Moore River population can be considered to be significant for the Swan Coastal Plain.

Billardieria erubescens, now known as *Marianthus erubescens,* has been recorded inland from Albany up to Geraldton, however is known from mostly inland sites. At Two Rocks and the subject site, this species was known from the exposed limestone vegetation close to the coast. *Thomasia triphylla* is near its northerly extent in the subject site, and occurs on exposed limestone close to the coast. Both *Marianthus erubescens* and *Thomasia triphylla* are not uncommon species but represent unusual distributions or extent of ranges.

3 Methods

3.1 Field Survey

Botanists from Cardno visited the site on three occasions in 2009 (twice in October and once in November) and undertook field surveys, conducted in accordance with EPA Guidance Statement No. 51 – *Terrestrial flora and vegetation survey environmental impact assessment in Western Australia* (2004) to the level of a detailed survey. In addition to this survey, the site was also visited in April 2010 to map the density of *Lomandra maritima* for the purpose of a Graceful Sun Moth assessment (see Cardno 2010, Graceful Sun-Moth Survey). The subject site was traversed on foot and the vegetation assessed at 32 survey locations, selected to adequately sample each plant community observed within the subject site. The position of each survey location was recorded with a hand-held GPS unit and all vascular plant species were recorded within a radius of at least 15 metres from that point. In addition, opportunistic plant taxa that were observed, but not located at a particular survey location, were also recorded through the course of the survey. An estimate of the Foliage Projective Cover (FPC) percentage was made for each species at each survey location.

The field surveys undertaken in 2009 were inclusive of the area within former ODP boundary. Whilst the mapping foes not cover the entire eastern area within the revised ODP boundary, field observations from the 2010 *Lomandra* density mapping and observations of the aerial imagery indicate that the vegetation condition and plant communities are comparable to those mapped. Most of the additional area unmapped is devoid of native vegetation and consistent mainly of areas of completely degraded paddocks east of the fenced foreshore reserve.

Environmental data recorded from each site included topographic position, aspect, slope, soil colour and texture class, rock outcropping, litter cover as well as the degree of disturbance and an estimate of the time since the last fire event. The condition of the vegetation was assessed to assist in determining the conservation values of the site. The vegetation condition was rated according to Keighery (1994), a vegetation condition scale commonly used in the Perth Metropolitan Region, but which is also appropriate for other urbanised and agricultural areas. The categories are listed and defined in **Table 5**.

All plant specimens collected during the field survey were dried, pressed and then sorted in accordance with requirements of the Western Australian Herbarium. Identification of specimens occurred through comparison with named material and through the use of taxonomic keys.

Table 5: Vegetation Condition Scale (Keighery 1994)

Vegetation Condition	Definition
Pristine (1)	Pristine or nearly so, no obvious signs of disturbance.
Excellent (2)	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species.
Very Good	Vegetation structure altered, obvious signs of disturbance. For example, disturbance to vegetation structure caused by repeated fires, the presence of some more aggressive weeds, dieback, logging and grazing
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate it. For example, disturbance to vegetation structure caused by very frequent fires, the presence of some very aggressive weeds at high density, partial clearing, dieback and grazing.

Vegetation Condition	Definition
Degraded	Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management. For example, disturbance to vegetation structure caused by very frequent fires, the presence of very aggressive weeds, partial clearing, dieback and grazing.
Completely Degraded	The structure of the vegetation is no longer intact and the area is completely or almost completely without native species. These areas are often described as 'parkland cleared' with the flora comprising weed or crop species with isolated native trees or shrubs.

3.2 Mapping and Analysis

A cluster analysis was performed on the 32 sites by converting FPC at each site to a 'Domin value' (Kent and Coker 1992). Classification was undertaken using hierarchical clustering within the analysis package PC-ORD (McCune and Mefford 2006). Groups were defined using the Relative Euclidean distance measure with the Ward's linkage method (beta level -0.25). The dendrogram was trimmed at an appropriate scale for the communities observed onsite (46% of information remaining), which is illustrated as **Appendix D**. These communities were then described according to the dominant species present and the structural vegetation classification follows that of Muir (1977).

The identified plant communities were then mapped on aerial photography (1:4000) extrapolated from the survey sites and utilising community boundaries mapped while in the field.

Once all the plant communities were described and mapped, each community was assigned a FCT using presence/absence species data so that a comparison could be made against the DEC's TEC database. The site data was reconciled with the SCP dataset of Gibson *et al*. (1994) by standardising the names of taxa with those used in the earlier study. This was necessary due to changes in nomenclature in the intervening period. Taxa that were only identified to genus level were excluded while some infraspecies that have been identified since 1994 were reduced to species level. The combined dataset was then classified into groups using a Bray-Curtis Association and a UPGMA fusion (beta level = -0.1) within the analysis package PATN (Belbin 2006).

3.3 Considerations of the Assessment

There is a variability in "life strategy" of many plant species in the south-west of Western Australia, which means that some species, especially herbaceous species, spend part of their life-cycle as either underground storage organs (such as corms or rhizomes) or as seed. This is an adaptation to unfavourable environmental conditions such as excessive heat or drought. These species, also known as "Geophytes" or "Annuals", will re-sprout or germinate during favourable conditions such as after rainfall. Most species re-emerge during winter and are most visible during their flowering period, which is spring for a majority of the plant species in the south-west of Western Australia. For this reason, surveys should be timed to coincide with these most favourable conditions so that a comprehensive survey of an area's plant species can be achieved.

The assessment was conducted in spring and followed the field methods within EPA Guidance Statement No. 51 (EPA 2004) to the level of a detailed survey. A detailed survey indicates that multiple visits were made in the main flowering period (spring) and replication of sites was undertaken within vegetation units. From such a survey design, the number of species recorded within an area is maximised.

The adequacy of the sampling was tested using a species-area curve generated from the data collected, also known as a "species effort curve" (Angermeier and Smogor 1995). As shown within the

curve (See **Appendix D**), 25 plots yielded an average of 166 species with the remaining 7 plots yielding only 10 additional species and increasing in small increments. A first-order 'Jack-knife' method (Palmer 1990) estimated the total species richness to be 228.5 species, which indicates 76% of the species expected to occur within the subject site were recorded. The estimated total species for the subject site would be expected to be much less if the analysis was undertaken separately on each plant community or by grouping the limestone and dune communities together, as the Jack-knife method is sensitive to heterogeneity in the data. By including all sites within the analysis, the variability amongst plots is high and therefore the estimate of total species richness is also high. In addition, the Jack-knife estimate method has limitations and usually overestimates the total number of species occurring within an area, especially if a high number of species are rare species (e.g. occurring only once or twice in the dataset). Therefore it is expected that the total percentage of species recorded is in excess of 76%.

The method of combining data from this survey to the regional Floristic Survey of the southern Swan Coastal Plain dataset (Gibson *et al.* 1994) needs to be considerate of a number of factors. The main objective of a flora survey is the compilation of a comprehensive species list, which is best obtained by using larger relevés. This study used large relevés compared to the Gibson *et al.* (1994) study which used 10 x 10 metre quadrats. This will introduces a degree of incompatibility with the SCP regional study. Also, the original SCP survey was a regional survey whilst a localised flora survey such as the one at Moore River will add a number of spatially correlated sites to the dataset. Such sites are often grouped in any combined analysis and the original classification is often disrupted by the addition of new data (E.A. Griffin & Associates 2005). Hence, care should be exercised when interpreting the results of any combined analysis.

4 Results

4.1 Site Observations

The subject site can be described in terms of three areas: 1) the fenced coastal foreshore reserve which consists of the relatively undisturbed foredunes and secondary dune system; 2) cleared paddocks and patches of remnant vegetation to the east of the fenced foreshore reserve that are actively grazed and maintained and 3) the river foreshore reserve which adjoins to the coastal reserve to the south.

From initial observations, the coastal foreshore reserve seems relatively undisturbed, due to its isolation from public access areas. A number of cleared tracks and non-invasive weed species were present within the foreshore, however, on the whole the foreshore was relatively undisturbed. To the east of the foreshore reserve much of the area is cleared for agricultural purposes. Patches of remnant vegetation have been retained but are disturbed through regular burning practices. Each patch of remnant vegetation is in a different state of regeneration depending on the time since the last burning event. The river foreshore reserve, which adjoins the coastal foreshore reserve, is used to a greater extent for recreational purposes, due to its proximity to the Guilderton townsite and location along the Moore River. The condition of the vegetation is more degraded than the coastal foreshore reserve and a number of weed species including **Acacia longiflora* subsp. *longiflora* were recorded and tracks were observed.

4.2 Flora

A total of 174 flora species were recorded within the survey comprising 54 families and 118 genera. Of this total, 36 were identified as introduced (weed) taxa, leaving 138 species being native species. The dominant native families were Fabaceae (14 native taxa, 1 introduced taxon), Proteaceae (9 native taxa), Asteraceae (13 native taxa, 2 introduced taxa) and Myrtaceae (7 native taxa). The dominant introduced families were Poaceae (9 introduced taxa, 9 native taxa), Brassicaceae (3 introduced taxa, 2 native taxa), Orobanchaceae (2 introduced taxa) and Aizoaceae (2 introduced taxa, 1 native taxon). For a complete species list and environmental site data see **Appendix A** and **C** respectively. **Appendix A** also provides plant taxa recorded in 1993 by Alan Tingay and Associates. A number of differences occur between the two lists that should be noted; these being the 1993 survey only list native species, and covers a larger area than the area surveyed in 2009. In addition, some taxa have had name changes since 1993 and these have been amended in the species list.

4.3 DRF, PF and Significant Species

No DRF species were recorded within the subject site, however three PF were recorded, these being *Stylidium maritimum* (P3), *Hibbertia spicata* subsp. *leptotheca* (P3) and *Beyeria cinerea* subsp. *cinerea* (P3). All three species were recorded at Site 212 (MGA GDA '94 – 0359476mE/6530325mN), which occurred on outcropping limestone adjacent to the Moore River. Fewer than 20 individuals of each species were recorded.

As mentioned in **Section 2.7**, *Allocasuarina lehmanniana* subsp. *lehmanniana* is not an uncommon species but is uncommon for the Swan Coastal Plain, with the main populations occurring at Trigg Bushland Reserve and Wilbinga Reserve. Both *Marianthus erubescens* and *Thomasia triphylla* are also not uncommon species but represent unusual coastal distributions and extents of their ranges.

4.4 Plant Communities

The floristic composition of the vegetation was compared using the statistical program, PC-ORD. Within this program a hierarchical cluster analysis was performed using both native and weed species. The results are presented in the dendrogram and statistical summary in **Appendix D**. From this analysis, eight groups were determined.

The plant community analysis dendrogram, scaled with 46% and information remaining and 5.45% chaining, provided eight community types, which are described below and illustrated on **Figure 3**. Whilst the mapping does not cover the entire eastern area within the revised ODP boundary, field observations and observations of the aerial imagery indicate that the plant communities are comparable to those mapped. Most of the additional area unmapped is largely devoid of native vegetation and consistent mainly of areas of completed degraded paddocks (**Pd**).

Plant Community OaSc

Plant Community OaSc consists of Low Scrub B of *Olearia axillaris* and *Scaevola crassifolia* over Open Herbs of **Trachyandra divaricata* **Tetragonia decumbens, *Cakile maritima, *Pelargonium capitatum, Hardenbergia comptoniana* and *Conostylis candicans* on foredunes with *Spinifex longifolius* and *Ficinia nodosa.* This plant community occupies the foredunes and the peak of the foredunes and represents the first succession of vegetation along the coast. **Plate 1** illustrates this community.

Plant Community ArAp

Plant Community ArAp consists of dense Thicket to Thicket of *Acacia rostellifera* over Low Scrub B of *Acanthocarpus preissii* over Open Low Grass of **Bromus diandrus, *Lolium rigidum* and *Poa porphyroclados*, Open Herbs of *Calandrinia sp. Southwest Coast*, **Dischisma arenarium, Carpobrotus virescens*, and **Tetragonia decumbens* on lower slopes and within swales. Plant community ArAp occurs within the foreshore reserve within the interdunal swales on the more stable Quindalup dunes. A representation of this community is illustrated in **Plate 2**.

Plant Community AlEg

Plant Community AlEg consists of Scrub of *Allocasuarina lehmanniana* subsp. *lehmanniana, Spyridium globulosum* and *Myoporum insulare* with emergent pockets of Low woodland A to Open Low Woodland A of *Eucalyptus gomphocephala* over Low Scrub B of *Acacia lasiocarpa, Olearia axillaris* and *Leucopogon parviflorus* over Low Open Sedges of *Lepidosperma gladiatum* with **Bromus diandrus* and *Austrostipa flavescens*, *Parietaria debilis, Senecio pinnatifolius, *Trachyandra divaricata, Daucus glochidiatus, *Crassula glomerata* and *Trachymene pilosa.* This plant community occurs in the large valley to the east of the coastal dunes and along the Moore River to the west of the large blow-out.

Plant Community MsAlSg

Plant Community MsAlSg consists of Heath A to Dwarf Scrub C of *Melaleuca systena, Acacia lasiocarpa, Spyridium globulosum* and *Calothamnus quadrifidus* with occasional pockets of Low Woodland A of *Eucalyptus gomphocephala* and Low Woodland B of *Banksia attenuata* over Open Herbs of *Lomandra maritima, Parietaria debilis, Phyllanthus calycinus, Poranthera microphylla, Senecio pinnatifolius* and *Trachymene pilosa.* This community occurs immediately inland from the OaSc vegetation occurring on the more stable Quindalup dunes with the beginning of a soil profile. As this plant community proceeds inland *Calothamnus quadrifidus* and *Chamelaucium uncinatum* co-dominate in many areas. A representation of this community is illustrated in **Plate 3**.

Plant Community MsAlAp

Plant Community MsAlAp consists of Low Heath B of *Melaleuca systena, Acacia lasiocarpa, Acanthocarpus preissii* and *Calothamnus quadrifidus* with occasional pockets of Low Woodland B of *Banksia attenuata* or Thicket to Scrub of *Acacia rostellifera* in the swales over Open Herbs of *Conostylis candicans, Desmocladus asper* and *Heliophila pusilla*, *Lepidosperma pubisquameum*, **Bromus diandrus* and *Poa porphyroclados* on cream-grey shallow sands over limestone. This community occurs to the east of the fenced foreshore reserve and is illustrated on **Plate 4**.

Plant Community McSg

Plant Community McSg consists of Thicket of *Melaleuca cardiophylla, Spyridium globulosum, Leucopogon insularis* and *Acanthocarpus preissii* over Low Grasses **Bromus diandrus, *Lolium rigidum* and **Ehrharta longiflora* with *Desmocladus asper, Calandrinia sp. Southwest Coast*, *Stylidium maritimum* (P3), *Hibbertia spicata* subsp. *leptotheca* (P3) and *Beyeria cinerea* subsp. *cinerea* (P3) on grey-brown shallow sands over limestone. This plant community was recorded along the Moore Rivers southern bank to the east of the large blow-out. It's the only community that recorded *Melaleuca cardiophylla* within the subject site and recorded the only Priority Flora. **Plate 5** illustrates this community.

Plant Community MsMhBs

Plant Community MsMhBs consists of Heath A to Dwarf Scrub C of *Melaleuca systena/Melaleuca huegelii, Banksia sessilis, Spyridium globulosum, Templetonia retusa, Acacia truncata* and *Hakea lissocarpha* over Open Herbs of *Calandrinia brevipedata, Podotheca gnaphalioides* and *Trachymene coerulea* subsp. *coerulea* with *Austrostipa flavescens, Poa porphyroclados, *Bromus diandrus* and *Ehrharta villosa* on dark grey-brown sand over limestone. This community also occurs to the east of the fenced foreshore reserve over limestone (**Plate 6**).

Plant Community MhAtMs

Plant Community MhMtMs consists of Low Heath C recently burnt (3-5 years) of *Melaleuca huegelii/Acacia truncata, Melaleuca systena* and *Banksia sessilis*, over Very Open Herbs of *Desmocladus asper, Stylidium junceum, Calandrinia* sp. Two-rocks, *Carpobrotus virescens, *Crassula glomerata*, and *Gompholobium tomentosum* with **Bromus diandrus* and *Poa porphyroclado*s on grey-brown shallow sands over limestone. This community occurs to the east of the fence foreshore reserve and has a higher presence of *Acacia truncata* (**Plate 7**).

4.5 Status of Plant Communities

The eight plant communities were compared to the Gibson *et al*. (1994) dataset using the analysis package PATN. Each plant community was assigned a Floristic Community Type (FCT) which is described below. The resulting dendrograms from all of the analysis are not shown, as the best results are obtained by adding no more than two local sites to the Gibson *et al.* (1994) dataset at a time. Therefore the number of dendrograms produced would be high. However we have included a number of the dendrograms produced from the analysis as examples of each plant community in **Appendix D**.

Plant communities **OaSc, ArAp**, **AlEg** and **MhAtMs** were all determined to be FCT 29a – Coastal shrublands on shallow sands, with the remaining plant communities **MsAlSg, MsAlAp, McSg and MsMhBs** were all determined to be FCT 29b – *Acacia* shrublands on taller dunes. Both of these FCTs are classified as Priority 3 Ecological Communities due to their 'Poorly Reserved' reservation status and 'Susceptible' conservation status (Gibson *et al*. 1994).

4.6 Vegetation Condition

Vegetation condition ranged from 'Completely Degraded' to 'Pristine-Excellent', with the largest portions of vegetation being in a 'Completely Degraded' and 'Excellent' to 'Pristine-Excellent' condition (see **Figure 4**). Whilst the mapping foes not cover the entire eastern area within the revised ODP boundary, field observations and observations of the aerial imagery indicate that the vegetation condition is comparable to those mapped and largely represent 'Completely Degraded' condition vegetation.

Areas of 'Completely Degraded' condition consisted of cleared paddock and tracks east of the foreshore reserve. The coastal foreshore reserve is in an 'Excellent' to 'Pristine-Excellent' condition. The river foreshore area is in a 'Good' to 'Very Good' condition. Remaining patches of remnant vegetation east of the foreshore reserve were in a 'Degraded' to 'Very Good' condition.

5 Discussion

The vegetation observed onsite is consistent with the regional vegetation complexes, Quindalup and Moore Complex described by Heddle *et al.* (1980). At this broad vegetation complex level the vegetation is well represented, with the Quindalup complex having 47.1% of its pre-European distribution remaining. The Moore Complex is not as well represented with only 29.7% of its pre-European extent remaining; however this complex is required to be retained within a foreshore reserve.

5.1 Flora

The total number of flora species recorded for the subject site in 2009 was 138 native species and 36 weed species. In 1993, 117 native species were recorded over a larger area (due to differences in the ODP design). **Appendix A** provides a comparison between species lists.

No DRF or PF species were recorded in 1993, however Cardno recorded three Priority Flora species in the 2009 survey. These species were *Stylidium maritimum* (P3), *Hibbertia spicata* subsp. *leptotheca* (P3) and *Beyeria cinerea* subsp, *cinerea* (P3). These three species were localised within plant community **McSg**, which represents a *Melaleuca cardiophylla* and *Spyridium globulosum* Thicket community on limestone along the foreshore of the Moore River.

5.2 Plant Communities

Original mapping undertaken in 1993 utilised vegetation descriptions proposed by Alan Tingay and Associates (1992) for the Yanchep area. The 'plant associations' described for the 1993 report are on the same scale as the 'plant community' descriptions used within the 2009 report. The structural descriptions used in this report use the classification system of Muir (1977). The plant community and plant association boundaries are roughly comparable, with eight communities being described for both the 1993 and 2009 reports. The precise boundaries of these communities differ due to the scale at which vegetation mapping occurs and the ecotonal complexity of plant communities.

A couple of differences occur between the two maps, these being:

The B1 vegetation *Melaleuca acerosa* (now *Melaleuca systena*)/*Acacia lasiocarpa* vegetation on old Quindalup Dunes along the southern boundary mapped in 1993 is not separated from the northern occurrences of *Melaleuca systena* vegetation. The 2009 mapping distinguishes the southern occurrence as **MsAlAp** – *Melaleuca systena/Melaleuca lasiocarpa* heath over limestone, from the northern occurrences of **MsAlSg** – *Melaleuca systena/Melaleuca lasiocarpa* and *Spyridium globulosum* Heath to Scrub which does not occur over limestone, but is on the more stable Quindalup dunes. A number of sites were surveyed in the **MsAlAp** vegetation in 2009 and the cluster analysis separated it from the northern vegetation **MsAlSg**. The southern *Melaleuca systena* heath was also determined to be a separate FCT to the northern *Melaleuca systena* vegetation.

The C3 vegetation – *Melaleuca huegelii* vegetation on limestone outcrops in the 1993 report, has been described in the 2009 report as three separate plant communities, **MsAlAp, MsMhBs** and **MhMtMs**. These plant communities are considered to be a similar association, however have been separated by the cluster analysis potentially due to the fire disturbance history. Plant communities **MsAlAp, MsMhBs** and **MhMtMs** were all determined to be the same FCT, FCT 29b and can be described as *Melaleuca huegelii/Melaleuca systena* heath on limestone. Previous fire events are likely to have altered the plant species composition in the intervening periods.

A number of small mapping differences were also recorded within the northern portion of the study area. The 1993 mapping has identified the patch of *Eucalyptus gomphocephala* vegetation as a different community to the surrounding *Allocasuarina lehmanniana* Scrub, while in the 2009 mapping this emergent *Eucalyptus gomphocephala* is determined to be part of the same community within the cluster analysis. *Eucalyptus gomphocephala* is determined to be an emergent species in this plant community, not a separate community. Also, the extent of the *Melaleuca cardiophylla* community, (**McSg** in the 2009 report and *Melaleuca cardiophylla* closed scrub in the 1993 report), was found to be more extensive along the Moore River than depicted in the original mapping. Within this plant community the three P3 species *Stylidium maritimum, Hibbertia spicata* subsp. *leptotheca* and *Beyeria cinerea* subsp. *cinerea* were recorded, which were not identified in 1993.

5.3 Conservation Significance of Flora and Vegetation

Only PF species were recorded within the subject site, which are not statutorily protected under the *Wildlife Conservation Act* (1950), unlike DRF species. PF species can potentially become DRF species if their range or total population size is further reduced; therefore large population need to be high priority for retention. Within the subject site, fewer than 20 individuals were recorded of each species; therefore a significant population is not represented in the subject site. These three priority flora species all occur at one survey site within plant community **McSg**, which occurs along the Moore River. Due to requirements to retain a foreshore reserve, this plant community including the PF will most likely be retained within the foreshore reserve.

Species that are not DRF or PF but have been identified as 'significant' are *Allocasuarina lehmanniana* subsp. *lehmanniana*, *Marianthus erubescens* and *Thomasia triphylla*. These species are not uncommon, however are considered to represent extents of ranges or unusual coastal distributions. There is no statutory requirement to retain these species. The most extensive of these is *Allocasuarina lehmanniana* subsp. *lehmanniana* and should be considered for retention in any Reserve or Public Open Space.

The FCTs inferred from the 1993 report indicated FCT S11, FCT 24 and FCT 29b potentially occur within the subject site. In 2009, two FCTs were determined (by undertaking a PATN analysis) which were FCT 29a and FCT 29b. Both FCT 29a and 29b are Priority 3 Ecological Communities and are considered to be susceptible in terms of conservation status as they are coastal vegetation types that are subjected to high levels of development. The vegetation is typically only represented in narrow coastal strips which are designed to conserve the beaches not the vegetation of the coastal dunes (Keighery *et al.* 1997).

FCT S11 – Northern *Acacia rostellifera – Melaleuca systena* shrublands, which was identified in the 1993 report as an inferred community type is not included in the original Gibson *et al.* (1994) dataset and represents a supplementary community type. This supplementary community type could potentially represent a number of the plant communities within the subject site, mainly **OaSc, ArAp, AlEg** and **MsAlSp**. However the supplementary FCT data is not formally available and therefore was not considered in the FCT analysis. The FCT for each plant community will need to be confirmed by the DEC.

6 Conclusions and Recommendations

After undertaking the flora and vegetation survey in October and November 2009, a total of 138 native and 36 weed species were recorded, comprising 54 families and 118 genera. No DRF species were recorded, however three Priority 3 species, *Stylidium maritimum, Hibbertia spicata* subsp. *leptotheca* and *Beyeria cinerea* subsp. *cinerea* were indentified at Site 212. A number of significant flora have also been recorded, these being *Allocasuarina lehmanniana* subsp*. lehmanniana*, *Marianthus erubescens* and *Thomasia triphylla*. These species are not uncommon species, however do represent extents of ranges or unusual coastal occurrences.

Eight broad plant communities have been described within the subject site, which can generally be described as **OaSc** –*Olearia axillaris, Scaevola crassifolia* and *Spinifex longifolius* on foredunes, **ArAp** – *Acacia rostellifera* thicket on slopes and within swales of more stable Quindalup dunes, **AlEg** – Scrub of *Allocasuarina lehmanniana* subsp. *lehmanniana* with emergent *Eucalyptus gomphocephala*, **MsAlSp** – Heath to Scrub of *Melaleuca systena* and *Spyridium globulosum* on more stable Quindalup dunes, **MsAlAp** – Low Heath of *Melaleuca systena* over limestone, **McSg** – *Melaleuca cardiophylla* thicket, **MsMhBs** – *Melaleuca systena/Melaleuca huegelii* heath on limestone and **MhMtMs** – *Melaleuca huegelii/Acacia truncata* recently burnt Heath on limestone. The remainder of the site can be described as paddocks and blow-outs.

Of the plant communities described, **OaSc, ArAp** and **AlEg** have been determined to be FCT 29a and plant community **MsAlSp, MsAlAp, McSp, MsMhBs** and **MhMtMs** have been determined to be FCT 29b. Both of these FCTs are classified as Priority 3 Ecological Communities. A number of supplementary FCTs have been described following the Gibson *et al*. 1994 FCT dataset, which identified additional FCTs for the Swan Coastal Plain. The 1993 report inferred that a number of plant communities within the subject site could potentially be the supplementary community type S11 – Northern *Acacia rostellifera – Melaleuca systena* shrublands. This information is not readily available was not included in the FCT analysis. The FCTs for each plant community within the subject site should be confirmed by the DEC.

Vegetation within the revised ODP boundary ranged from 'Completely Degraded' to 'Pristine-Excellent' with a majority of the vegetation in either a 'Completely Degraded' or 'Pristine-Excellent' condition. The revised ODP has aimed to respond to the varying conditions of the vegetation across MRC landholdings and has aimed to preserve, where possible, areas of 'Pristine-Excellent' condition vegetation. The revised ODP boundary includes 96.3% of the mapped 'Completely Degraded' condition vegetation as well as roughly 36ha of unmapped degraded vegetation within the revised ODP boundary.

Therefore after undertaking the site investigations a number of conservation features were identified that will need to be considered. These are:

- The presence of three Priority Three species *Stylidium maritimum, Hibbertia spicata* subsp. *leptotheca* and *Beyeria cinerea* subsp. *cinerea* within plant community **McSg** – *Melaleuca cardiophylla* thicket on limestone;
- Significant flora *Allocasuarina lehmanniana* subsp. *lehmanniana*, *Marianthus erubescens* and *Thomasia triphylla,* which are not uncommon species but represent the extents of their ranges or unusual coastal distributions;
- All plant communities within the subject site have been identified to be Priority Three Ecological Communities (FCT 29a and FCT 29b). This will need to be confirmed by the DEC; and
- Vegetation of the fenced foreshore reserve is currently in an 'Excellent' to 'Pristine-Excellent' condition.

Therefore Cardno recommends that vegetation clearing be minimised wherever possible. No particular plant community can be recommended for retention as all plant communities have been determined to be Priority 3 Ecological Communities, therefore they all represent the same conservation significance. The DEC will be required to confirm the FCTs within the subject site.

Priorities for vegetation retention should be based on vegetation condition and the presence of locally significant species including the P3 species (*Stylidium maritimum, Hibbertia spicata* subsp. *leptotheca* and *Beyeria cinerea* subsp. *cinerea*) and the species that represent the extent of their ranges (e.g. *Allocasuarina lehmanniana*) or unusual coastal distributions (e.g. *Marianthus erubescens, Thomasia triphylla*).

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Plates



Plate 1: Plant Community OaSc (direction west) – *Olearia axillaris* and *Scaevola crassifolia* over *Spinifex longifolius* on foredunes



Plate 2: Plant Community ArAp – *Acacia rostellifera* over *Acanthocarpus preissii* over **Bromus diandrus* and **Trachyandra divaricata* on lower slopes and within swales



Plate 3: Plant Community AlEg (direction west) – *Allocasuarina lehmanniana* and *Spyridium globulosum* with emergent *Eucalyptus gomphocephala* over *Olearia axillaris* and *Leucopogon parviflorus*



Plate 4: Plant Community MsAlSg (direction west) – *Melaleuca systena, Acacia lasiocarpa* and *Spyridium globulosum* heath on Quindalup dunes



Plate 5: Plant Community MsAlAp (direction north-west) – Low Heath of *Melaleuca systena, Acacia lasiocarpa*, *Acanthocarpus preissii* and *Banksia sessilis* on limestone



Plate 6: Plant Community McSg – Thicket of *Melaleuca cardiophylla*, *Spyridium globulosum* and *Leucopogon insularis* over **Bromus diandrus, Desmocladus asper* and *Calandrinia* sp. SW Coastal on limestone

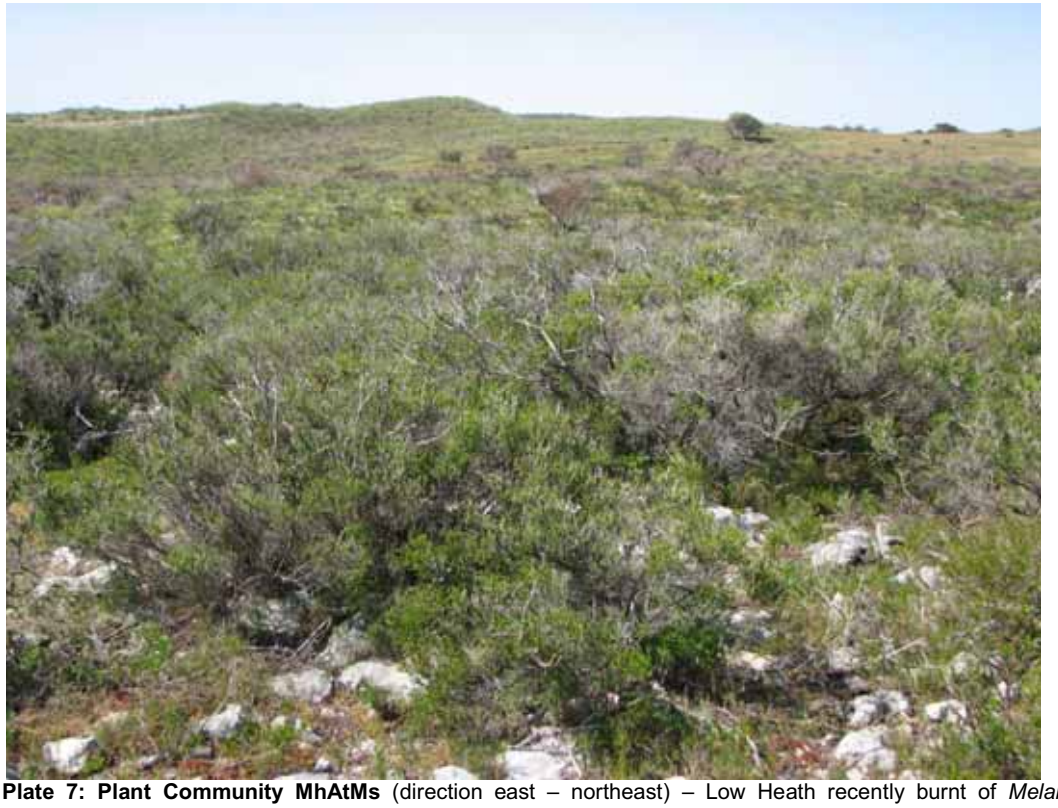
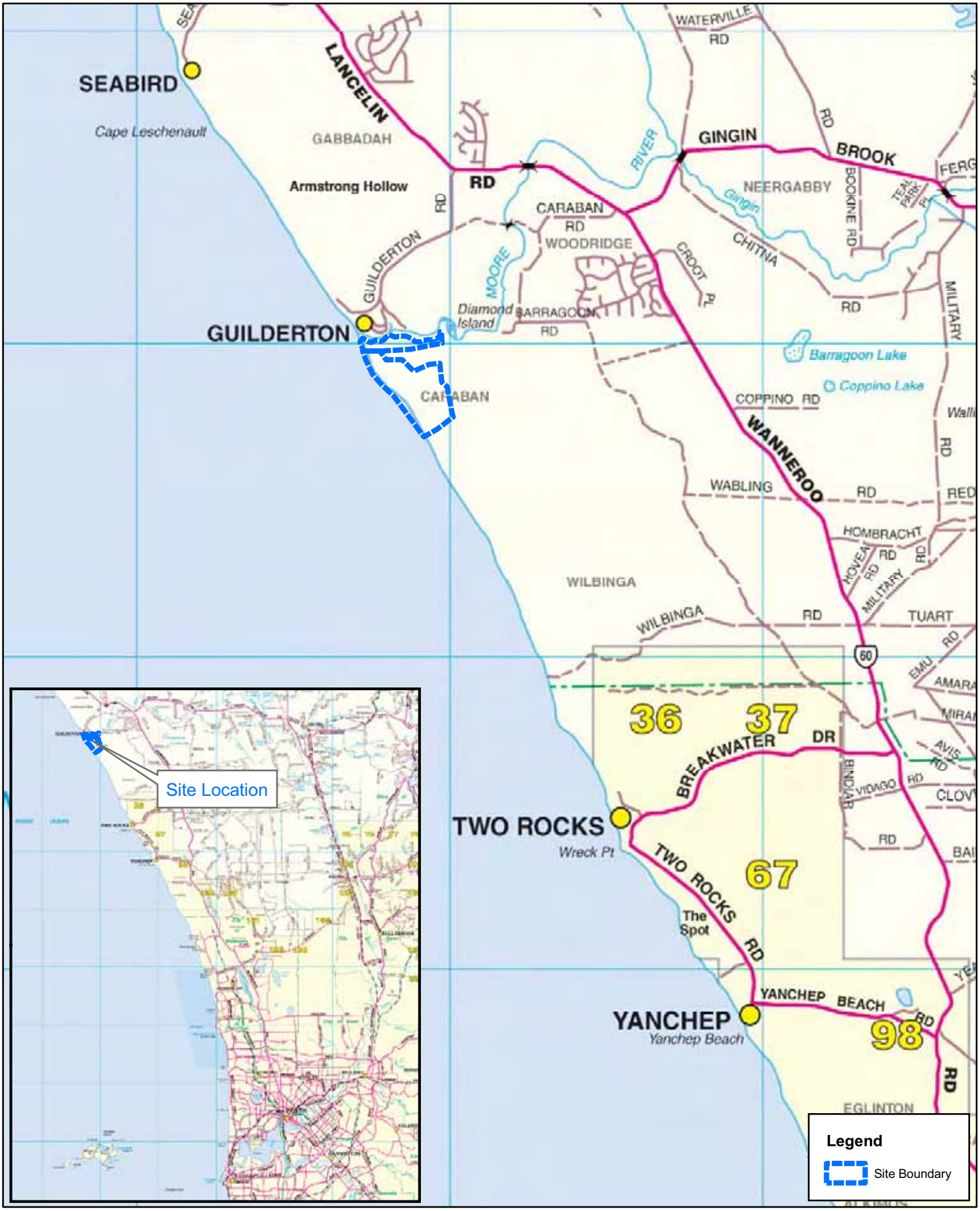


Plate 7: Plant Community MhAtMs (direction east – northeast) – Low Heath recently burnt of *Melaleuca huegelii/Acacia truncata* and *Banksia sessilis* over limestone

Figures



DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD

DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD

Cardno

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Scale: 1:160,000

0 2,500 5,000 10,000 15,000 Metres

PROJECT Moore River Flora & Vegetation Survey

DRAWING TITLE FIGURE 1 : Locality Plan

PRINCIPAL Moore River Company Pty Ltd

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Project Number V9070
Original A4
Drawing Number SK23
Revision 00
Designed GT
Checked GT
Drawn MGW
Approved SH
Local Authority Shire of Gingin
Sheet 1 of 1
Date 8/03/10



DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD
10/05/10	01	Revised OPD Boundary Change	BP	SB	BP	BP

DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD

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Scale: **1:20,000**

0 250 500 1,000 1,500 Metres

PROJECT **Moore River Flora & Vegetation Survey**

DRAWING TITLE **FIGURE 2 : Extent of Subject Site**

PRINCIPAL **Moore River Company Pty Ltd**

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Project Number **V9070**

Original **A4**

Drawing Number **SK24**

Revision **01**

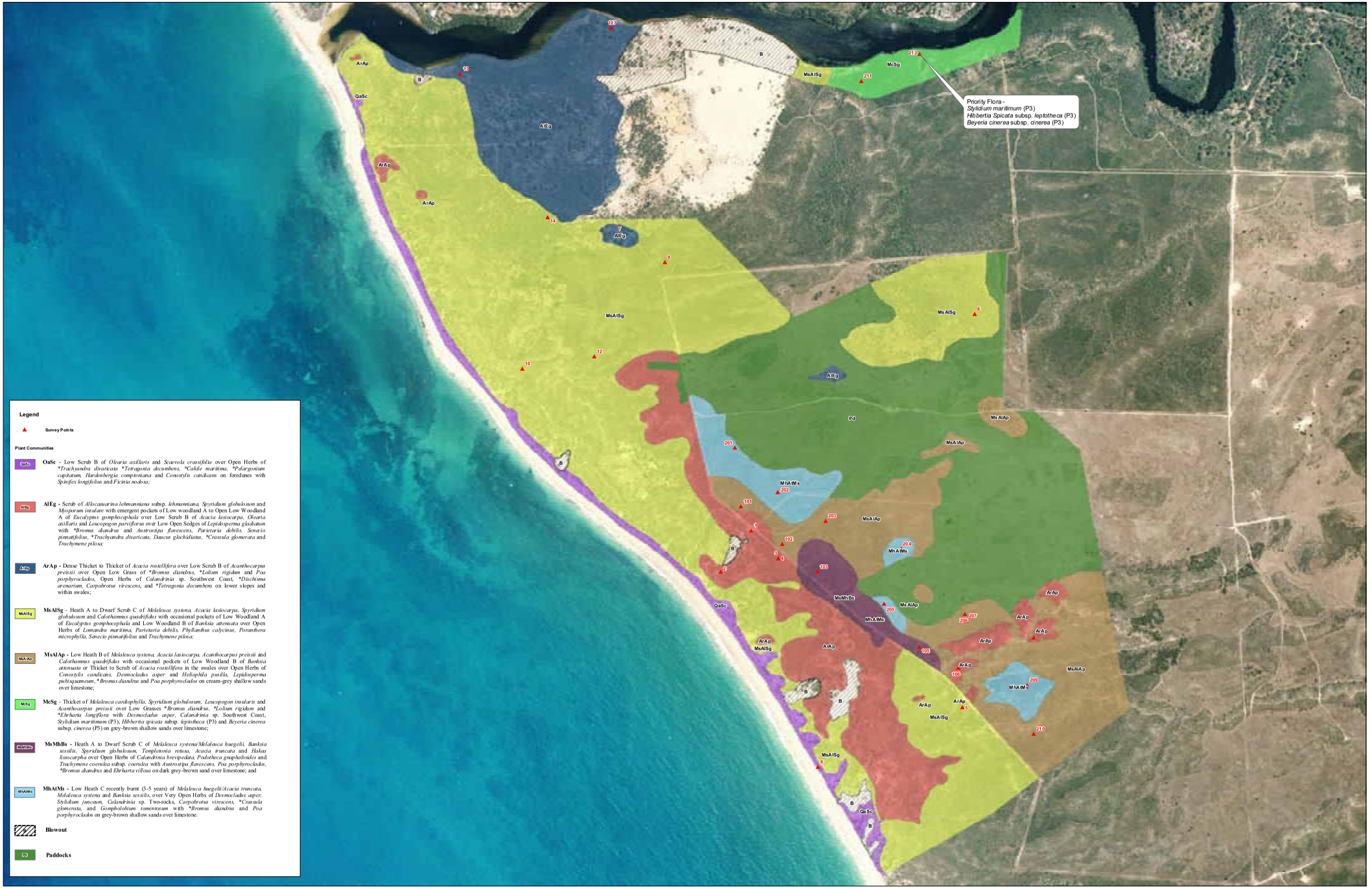
Designed GT | Checked GT

Drawn MGW | Approved BP

Local Authority Shire of Gingin

Sheet 1 of 1

Date 10/05/10



DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHKD	APPD
10/09/10	01	Revisions as per client feedback	BP	SB	BP	BP

PROJECT: **Moore River - Flora & Vegetation Survey**

DRAWING TITLE: **FIGURE 3 : Plant Communities**

PRINCIPAL: **Moore River Company Pty Ltd**

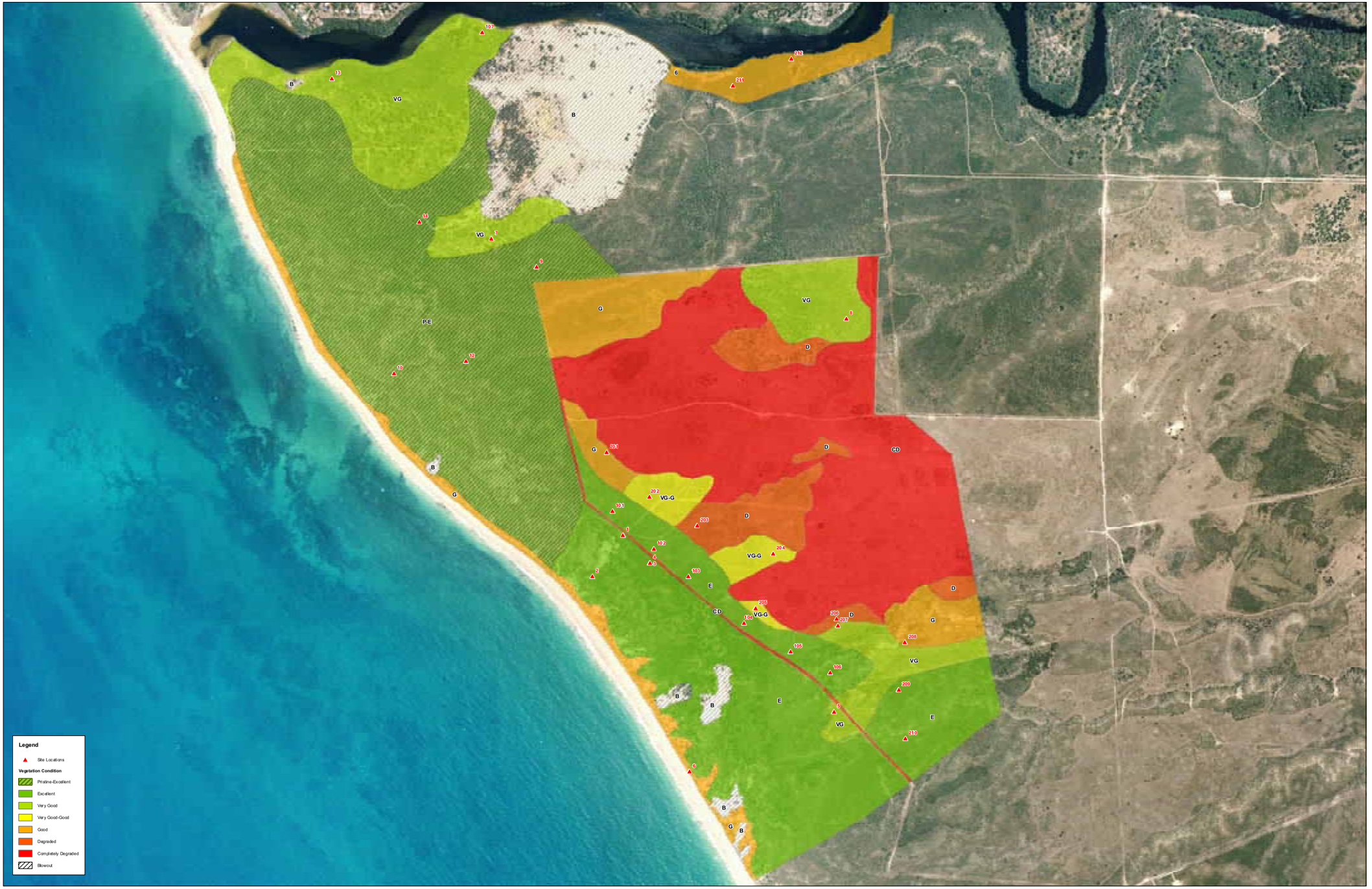
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Scale: **1:6,500** 0 100 200 400 600 800 1,000 1,200 Metres

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Project Number	Drawing Number	Revision	Original
V9070	SK21	00	A1

Designed BP | Checked GT | Date 10/09/10
Drawn SB | Approved SH | Sheet 1 of 1
Local Authority SHIRE OF GINGIN



DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHKD	APPD
10/05/10	01	Revisions as per client feedback	BP	SB	BP	SB

PROJECT: **Moore River Flora & Vegetation Survey**

DRAWING TITLE: **FIGURE 4 : Vegetation Condition**

PRINCIPAL: **Moore River Company Pty Ltd**

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Scale: **1:6,500** 0 100 200 400 600 800 1,000 1,200 Metres

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Project Number	Drawing Number		Revision / Original
V9070	SK22		01 / A1
Designed BP		Checked BP	Date 10/05/10
Drawn SB		Approved BP	Sheet 1 of 1
Local Authority SHIRE OF GINGIN			

Appendix A

Species Recorded in 1993 and 2009

Appendix A: Flora Species Recorded within Moore River South in 1993 (Alan Tingay and Associates) and 2009 (Cardno)

	Species	Alan Tingay and Associates (1993)	Cardno (2009)
	Acacia cochlearis	X	X
	Acacia cyclops	X	
	Acacia lasiocarpa var. *lasiocarpa*	X	X
*	*Acacia longifolia* subsp. *longifolia*		X
	Acacia pulchella	X	X
	Acacia rostellifera	X	X
	Acacia saligna	X	X
	Acacia truncata	X	X
	Acanthocarpus preissii	X	X
	Acrotriche cordata	X	X
	Allocasuarina campestris		X
	Allocasuarina humilis	X	X
	Allocasuarina lehmanniana subsp. *lehmanniana*	X	X
	Alyxia buxifolia	X	
*	*Anagallis arvensis*		X
*	*Anagallis arvensis* var. *caerulea*		X
	Anigozanthos humilis	X	
	Anigozanthos manglesii	X	
	Anthocercis ilicifolia	X	X
	Anthocercis littorea	X	X
	Asteridea pulverulenta		X
	Austrodanthonia occidentalis		X
	Austrostipa compressa		X
	Austrostipa elegantissima		X
	Austrostipa flavescens	X	X
	Austrostipa hemipogon		X
*	*Avena barbata*		X
	Banksia attenuata	X	X
	Banksia dallanneyi		X
	Banksia menziesii	X	
	Banksia nivea	X	X
	Banksia prionotes	X	
	Banksia sessilis	X	X
	Baumea juncea		X
	Beyeria cinerea subsp. *cinerea* (P3)		X
	Boronia crenulata subsp. ?*viminea*		X
	Brachyscome bellidioides		X
*	*Brassica tournefortii*		X
*	*Bromus diandrus*		X
*	*Cakile maritima*		X
	Calandrinia sp. Two Rocks		X
	Calandrinia brevipedata		X

Appendix A: Flora Species Recorded within Moore River South in 1993 (Alan Tingay and Associates) and 2009 (Cardno)

	Species	Alan Tingay and Associates (1993)	Cardno (2009)
	Calandrinia liniflora	X	
	Calandrinia sp. SW Coastal		X
	Calocephalus brownii	X	
	Calothamnus quadrifidus	X	X
*	*Carpobrotus edulis*		X
	Carpobrotus virescens	X	X
	Cassytha aurea var. *hirta*		X
	Cassytha racemosa	X	
*	*Cerastium glomeratum*		X
	Chamelaucium uncinatum	X	X
	Comesperma confertum	X	X
	Comesperma integerrimum	X	
	Conospermum stoechadis	X	X
	Conostylis candicans	X	X
	Conostylis candicans subsp. *calcicola*		X
	Conostylis serrulata		X
	Cotula cotuloides		X
*	*Crassula alata*		X
	Crassula colorata		X
	Crassula colorata var. *acuminata*		X
*	*Crassula glomerata*		X
	Cryptandra mutila	X	X
*	*Cuscuta epithymum*		X
	Daucus glochidiatus		X
	Daviesia divaricata	X	
	Daviesia triflora	X	
	Desmocladus asper		X
	Desmocladus flexuosus		X
	Dianella revoluta	X	X
	Diplolaena drummondii	X	
*	*Disa bracteata*		X
*	*Dischisma arenarium*		X
	Drosera macrantha subsp. *macrantha*		X
*	*Ehrharta brevifolia*		X
*	*Ehrharta calycina*		X
*	*Ehrharta longiflora*		X
*	*Ehrharta villosa*		X
	Eremophila glabra	X	
	Erodium cicutarium		X
	Eucalyptus gomphocephala	X	X
*	*Euphorbia peplus*		X
	Exocarpos sparteus		X

Appendix A: Flora Species Recorded within Moore River South in 1993 (Alan Tingay and Associates) and 2009 (Cardno)

	Species	Alan Tingay and Associates (1993)	Cardno (2009)
	Ficinia nodosa	X	X
	Gastrolobium capitatum	X	X
	Gastrolobium nervosum		X
	Gompholobium tomentosum	X	X
	Grevillea thelmanniana	X	
	Haemodorum spicatum	X	
	Hakea costata	X	
	Hakea lissocarpha	X	X
	Hakea prostrata	X	X
	Hakea trifurcata	X	X
	Hardenbergia comptoniana	X	X
*	*Heliophila pusilla*		X
	Hemiandra pungens	X	X
	Hibbertia cuneiformis	X	
	Hibbertia hypericoides	X	
	Hibbertia racemosa	X	X
	Hibbertia spicata subsp. *leptotheca* (P3)		X
	Hibbertia subvaginata		X
	Hyalosperma cotula	X	
	Hybanthus calycinus	X	X
	Hydrocotyle pilifera var. *glabrata*		X
*	*Hypochaeris glabra*		X
*	*Isolepis marginata*		X
	Isotoma hypocrateriformis	X	X
	Jacksonia stricta	X	
	Kennedia prostrata	X	X
*	*Lagurus ovatus*		X
	Lechenaultia floribunda	X	
	Lechenaultia linarioides	X	X
	Lepidium rotundum		X
	Lepidosperma angustatum	X	
	Lepidosperma gladiatum	X	X
	Lepidosperma pubisquameum		X
	Leptomeria empetriformis		X
	Leptomeria preissiana	X	X
	Leptorhynchos scaber		X
	Leucopogon australis		X
	Leucopogon insularis	X	X
	Leucopogon nutans		X
	Leucopogon parviflorus	X	X
	Lobelia tenuior	X	X
	Logania vaginalis	X	X

Appendix A: Flora Species Recorded within Moore River South in 1993 (Alan Tingay and Associates) and 2009 (Cardno)

	Species	Alan Tingay and Associates (1993)	Cardno (2009)
*	*Lolium rigidum*		X
	Lomandra maritima	X	X
	Loxocarya flexuosa	X	
	Lysinema ciliatum	X	X
	Marianthus erubescens	X	X
	Melaleuca acerosa	X	
	Melaleuca cardiophylla	X	X
	Melaleuca huegelii subsp. *huegelii*	X	X
	Melaleuca systena		X
*	*Melilotus indicus*		X
	Mesomelaena pseudostygia	X	
	Microtis alba		X
	Millotia tenuifolia var. *tenuifolia*		X
	Myoporum insulare	X	X
	Nuytsia floribunda	X	X
	Olearia axillaris	X	X
	Olearia rudis	X	X
*	*Opercularia vaginata*	X	X
*	*Orobanche minor*		X
	Ozothamnus cordatus	X	X
*	*Parentucellia latifolia*		X
	Parietaria debilis		X
	Patersonia occidentalis	X	
*	*Pelargonium capitatum*		X
	Pelargonium littorale		X
	Petrophile serruriae	X	X
*	*Petrorhagia dubia*		X
	Phyllanthus calycinus	X	X
	Pimelea angustifolia		X
	Pimelea calcicola		X
	Pimelea ferruginea	X	X
	Pimelea sp.	X	
	Poa drummondiana	X	X
	Poa porphyroclados		X
	Podolepis gracilis		X
	Podotheca angustifolia	X	X
	Podotheca gnaphalioides		X
	Polypogon tenellus		X
	Poranthera microphylla		X
	Ptilotus polystachyus	X	X
	Ptilotus stirlingii var. *stirlingii*		X
	Rhagodia baccata	X	X

Appendix A: Flora Species Recorded within Moore River South in 1993 (Alan Tingay and Associates) and 2009 (Cardno)

	Species	Alan Tingay and Associates (1993)	Cardno (2009)
	Rhodanthe citrina		X
	Santalum acuminatum	X	X
	Scaevola crassifolia	X	X
	Scaevola nitida	X	X
	Scaevola paludosa	X	
	Scaevola thesioides subsp. *thesioides*	X	X
	Schoenus grandiflorus	X	X
	Schoenus lanatus		X
	Senecio pinnatifolius	X	X
	Senecio sp.	X	
	Senecio quadridentatus	X	
*	*Solanum nigrum*		X
*	*Sonchus oleraceus*		X
	Sphaerolobium medium		X
	Spinifex hirsutus	X	
	Spinifex longifolius	X	X
	Spyridium globulosum	X	X
	Stackhousia pubescens	X	
	Stenopetalum robustum		X
	Stylidium brunonianum	X	
	Stylidium junceum	X	X
	Stylidium maritimum (P3)		X
	Templetonia retusa	X	X
	Tersonia cyathiflora	X	X
*	*Tetragonia decumbens*		X
	Tetraria octandra		X
	Thomasia triphylla	X	X
	Threlkeldia diffusa	X	X
	Thysanotus arenarius		X
	Thysanotus manglesianus		X
	Thysanotus patersonii		X
	Thysanotus sparteus	X	
*	*Trachyandra divaricata*		X
	Trachymene coerulea var. *coerulea*		X
	Trachymene pilosa	X	X
	Tricoryne elatior	X	
*	*Trifolium arvense*		X
	Triglochin sp. a flora of australia G.J. Keighery 2477		X
	Tripterococcus brunonis	X	
	Trymalium ledifolium var. *ledifolium*	X	X
*	*Vulpia myuros* forma *myuros*		X
	Waitzia acuminata	X	

Appendix A: Flora Species Recorded within Moore River South in 1993 (Alan Tingay and Associates) and 2009 (Cardno)

Species	Alan Tingay and Associates (1993)	Cardno (2009)
Zygophyllum fruticulosum	X	X

Appendix B

Species Composition and Frequency within each Plant Community

Appendix B: Species Composition and Frequency within each Plant Community. Species that only occur at one site within plant communities are represented by an X (to indicate presence), while species that occur at greater than 1 site are displayed as a percent frequency

Species Name	Plant Community							
	OaSc	ArAp	AlEg	MsAlSg	MsAlAp	McSg	MsMhBs	MhMtMs
Acacia cochlearis				25				
Acacia lasiocarpa var. *lasiocarpa*	x	x	66.6	100	85.7	x	x	
Acacia longifolia subsp. *longifolia*					x	100		
Acacia pulchella				x				
Acacia rostellifera		100	x	x	28.5		x	
Acacia saligna			x					
Acacia truncata				x	57.1		100	80
Acanthocarpus preissii	x	100	100	62.5	85.7	100	100	x
Acrotriche cordata			x					
Allocasuarina campestris			x					
Allocasuarina humilis				x				
Allocasuarina lehmanniana subsp. *lehmanniana*			66.6	25		x		
Anagallis arvensis		x	66.6					
Anagallis arvensis var. *caerulea*			66.6		x			40
Anthocercis ilicifolia				x	42.8		66.6	
Asteridea pulverulenta							x	
Austrodanthonia occidentalis				37.5				
Austrostipa compressa					28.5			40
Austrostipa elegantissima			x					
Austrostipa flavescens	x	x	66.6	25	57.1	x	100	x
Austrostipa hemipogon			x	62.5				
Avena barbata			x	37.5	57.1			40
Banksia attenuata				x	x			
Banksia dallanneyi				x	x		100	x
Banksia nivea				x	28.5			x
Banksia sessilis				x	42.8		100	80
Beyeria cinerea subsp. *cinerea* (P3)						x		
Boronia crenulata subsp. ?*viminea*					x			
Brachyscome bellidioides				37.5	x			

Species Name	Plant Community							
	OaSc	ArAp	AlEg	MsAlSg	MsAlAp	McSg	MsMhBs	MhMtMs
Brassica tournefortii								x
Bromus diandrus	x	100	100	50	100	100	100	80
Cakile maritima	x							
Calandrinia sp. Two Rocks				37.5	57.1	x	x	100
Calandrinia brevipedata			66.6		28.5		100	
Calandrinia sp. SW Coastal		100		50	42.8	100		x
Calothamnus quadrifidus		x	x	80	85.7		x	
Carpobrotus edulis					57.1		x	
Carpobrotus virescens	100	x	x	80	57.1	x	x	100
Cassytha aurea var. *hirta*	100	x	66.6	80	42.8			80
Cerastium glomeratum			x		28.5			x
Chamelaucium uncinatum			x	x		x		
Comesperma confertum				x				
Conospermum stoechadis					x		x	
Conostylis candicans	100	100	x	37.5	100	x	100	40
Conostylis candicans subsp. *calcicola*				50				
Conostylis serrulata			x					
Cotula cotuloides								x
Crassula alata				x				
Crassula colorata								40
Crassula colorata var. *acuminata*			x	x	x			
Crassula glomerata	100	x	100	100	100		100	100
Cryptandra mutila				25	28.5			
Cuscuta epithymum	x		66.6					
Daucus glochidiatus		x	66.6	25	42.8	x	100	x
Desmocladus asper		x		x	100	100	66.6	80
Desmocladus flexuosus				100				
Dianella revoluta			x					
Disa bracteata				x				
Dischisma arenarium	x	100	66.6	75	100	100	100	40
Ehrharta brevifolia	x	x						
Ehrharta calycina	x		66.6					

Species Name	Plant Community							
	OaSc	ArAp	AlEg	MsAlSg	MsAlAp	McSg	MsMhBs	MhMtMs
Ehrharta longiflora			x	x		100		
Ehrharta villosa					x		100	
Erodium cicutarium					x		x	
Eucalyptus gomphocephala			66.6	25				
Euphorbia peplus	x							
Exocarpos sparteus					28.5			x
Ficinia nodosa	100	x	x					
Gastrolobium capitatum				x	28.5			
Gastrolobium nervosum	x							
Gompholobium tomentosum				25	42.8	x	66.6	60
Hakea lissocarpha					42.8		100	40
Hakea prostrata					3		66.6	
Hakea trifurcata					x			
Hardenbergia comptoniana	100	x	x	80	100		100	60
Heliophila pusilla	x	x	66.6	37.5	100	100	100	80
Hemiandra pungens	x	x	x	37.5	42.8			
Hibbertia racemosa				x			66.6	
Hibbertia spicata subsp. *leptotheca* (P3)						x		
Hibbertia subvaginata					28.5			x
Hybanthus calycinus					28.5			
Hydrocotyle pilifera var. *glabrata*				x				
Hypochaeris glabra						x		x
Isolepis marginata			x		x		x	x
Isotoma hypocrateriformis				50	x		x	
Kennedia prostrata				x	x			
Lagurus ovatus				x				
Lechenaultia linarioides				37.5				
Lepidium rotundum				37.5	x			
Lepidosperma gladiatum	100	x	100	25				
Lepidosperma pubisquameum				75	85.7		66.6	60
Leptomeria empetriformis				x				
Leptomeria preissiana	x	x	66.6	x				

Species Name	Plant Community							
	OaSc	ArAp	AlEg	MsAlSg	MsAlAp	McSg	MsMhBs	MhMtMs
Leptorhynchos scaber				25	85.7	x	x	x
Leucopogon australis				x				
Leucopogon insularis				x		100		
Leucopogon nutans				50				
Leucopogon parviflorus		x	100	x	42.8	x	66.6	40
Lobelia tenuior				62.5	71	x	66.6	60
Logania vaginalis						x		
Lolium rigidum	100	x		25	100	x	100	x
Lomandra maritima	x		x	100	85.7	x	66.6	40
Lysinema ciliatum				25	x		x	60
Marianthus erubescens			x					
Melaleuca cardiophylla					x	100		
Melaleuca huegelii					x		100	80
Melaleuca huegelii subsp. huegelii				x				
Melaleuca systena		x		100	100		100	60
Melilotus indicus			x		x			40
Microtis alba					x			
Millotia tenuifolia var. *tenuifolia*					57.1		66.6	60
Myoporum insulare			100	x				
Nuytsia floribunda			x					
Olearia axillaris	100	x	66.6	50				x
Olearia rudis					42.8			
Opercularia vaginata				50	71.4		x	60
Orobanche minor					28.5		x	
Ozothamnus cordatus	100						x	
Parentucellia latifolia								40
Parietaria debilis		100	100	87.5	28.5	x	2	
Pelargonium capitatum	100		66.6	x	57.1		x	x
Pelargonium littorale							x	x
Petrophile serruriae				x			x	x
Petrorhagia dubia								40
Phyllanthus calycinus		x	x	87.5	100		66.6	

Species Name	Plant Community							
	OaSc	ArAp	AlEg	MsAlSg	MsAlAp	McSg	MsMhBs	MhMtMs
Pimelea angustifolia								x
Pimelea calcicola				25			x	x
Pimelea ferruginea					x			
Poa drummondiana				75			x	
Poa porphyroclados	x	100		62.5	100	100	100	80
Podolepis gracilis				x				
Podotheca angustifolia			x	x				
Podotheca gnaphalioides				87.5	100	x	100	40
Polypogon tenellus							x	
Poranthera microphylla			x	75	71.4		100	x
Ptilotus polystachyus					x		x	x
Ptilotus stirlingii subsp. *stirlingii*				x				
Rhagodia baccata	100	x	100	87.5	42.8	100	66.6	80
Rhodanthe citrina			x	37.5	x	x	x	
Santalum acuminatum	x							
Santalum spicatum				x				
Scaevola crassifolia	2	x	x					x
Scaevola nitida			x	x				
Scaevola thesioides subsp. *thesioides*				37.5	71.4		66.6	40
Schoenus grandiflorus				62.5	28.5		100	
Schoenus lanatus				25			x	x
Senecio pinnatifolius	100	x	100	87.5	100		100	60
Solanum nigrum			x					
Sonchus oleraceus			x		42.8	x		x
Sphaerolobium medium								x
Spinifex longifolius	100							
Spyridium globulosum	x	100	100	87.5	57.1	100	100	40
Stenopetalum robustum			x	25	85.7		66.6	40
Stylidium junceum				37.5	57.1		66.6	80
Stylidium maritimum (P3)						x		
Templetonia retusa			x	25	28.5	x	100	40
Tersonia cyathiflora				x	x			

Species Name	Plant Community							
	OaSc	ArAp	AlEg	MsAlSg	MsAlAp	McSg	MsMhBs	MhMtMs
Tetragonia decumbens	x	x	x	25	57.1	x	66.6	
Tetraria octandra		x			57.1			40
Thomasia triphylla				x	x			x
Threlkeldia diffusa	x	x	x					
Thysanotus arenarius		x		25	28.5			
Thysanotus manglesianus					28.5			
Thysanotus patersonii			x	37.5				
Trachyandra divaricata	100	100	100	62.5	71.4		x	40
Trachymene coerulea subsp. *coerulea*					x		100	
Trachymene pilosa			66.6	87.5	100	x	100	60
Trifolium arvense								x
Triglochin sp. a flora of australia G.J. Keighery 2477							66.6	
Trymalium ledifolium var. *ledifolium*				x				x
Vulpia myuros forma *myuros*			x					
Zygophyllum fruticulosum		x		x				

Appendix C

Environmental Site Data

APPENDIX C: Environmental Site Data 2009

Date:	15.10.09	Site:	1	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	gda94	50	358844	6528537

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	S	White		

Geomorphology:	Topography	Aspect	Slope (°)
	Swale/VF	W	>5

Litter:	Logs	Twigs	Leaves	Bare Ground (%)
	2	5	2	35

Disturbance:	Time Since Fire	Level of Human Impact	Condition
	>5 yrs	Low	E

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)			1.2
	% Cover			65

Observations	

Field description of vegetation	*Spyridium globulosum* and *Olearia axillaris* over *Conostylis candicans* and *Acacia lasiocarpa*

Species	Foliage Projective Cover
Olearia axillaris	10
Spyridium globulosum	7
Conostylis candicans	7
Leptomeria preissiana	7
Acacia lasiocarpa var. *lasiocarpa*	5
Gastrolobium nervosum	1
Scaevola crassifolia	1
Bromus diandrus	1
Crassula glomerata	abundant
Dischisma arenarium	abundant
Senecio pinnatifolius	many
Poa porphyroclados	many
Hardenbergia comptoniana	few
Lolium rigidum	few
Rhagodia baccata	few
Heliophila pusilla	few
Cassytha aurea var. *hirta*	few
Ficinia nodosa	few
Ehrharta brevifolia	few
Pelargonium capitatum	few
Acanthocarpus preissii	few
Carpobrotus virescens	few

Santalum acuminatum	few
Lepidosperma gladiatum	few
Spinifex longifolius	few
Hemiandra pungens	few
Trachyandra divaricata	few
Ozothamnus cordatus	few
Cuscuta epithymum	few
Austrostipa flavescens	few
Lolium rigidum	
Lomandra maritima	

APPENDIX C: Environmental Site Data 2009

Date:	15.10.09	Site:	2	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA94	50	358729	6528382

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	S	White		

Geomorphology:	Topography	Aspect	Slope (°)
	Swale	S	5 to 15

Litter:	Logs	Twigs	Leaves	Bare Ground (%)
	10 to 15	10	20	1

Disturbance:	Time Since Fire	Level of Human Impact	Condition
	>5 yrs	Low	E

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)			1.5 to 2
	% Cover			95

Observations	

Field description of vegetation	

Species	Foliage Projective Cover
Acacia rostellifera	40
Lepidosperma gladiatum	7
Scaevola crassifolia	3
Acanthocarpus preissii	2
Bromus diandrus	2
Spyridium globulosum	1
Crassula glomerata	many
Dischisma arenarium	many
Ehrharta brevifolia	many
Olearia axillaris	few
Cassytha aurea var. *hirta*	few
Hardenbergia comptoniana	few
Senecio pinnatifolius	few
Trachyandra divaricata	few
Rhagodia baccata	few
Threlkeldia diffusa	few
Calandrinia sp. Swan Coastal Plain	few
Poa porphyroclados	few
Leptomeria preissiana	few
Carpobrotus virescens	few
Ficinia nodosa	few
Conostylis candicans	few

Tetragonia decumbens
Parietaria debilis
Zygophyllum fruticulosum

APPENDIX C: Environmental Site Data 2009

Date:	15.10.09	Site:	3	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA94	50	358945	6528433

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	S	White	Limestone	

Geomorphology:	Topography	Aspect	Slope (°)
	Breakaway	W	5 to 15

Litter:	Logs	Twigs	Leaves	Bare Ground (%)
		2	2	5

Disturbance:	Time Since Fire	Level of Human Impact	Condition
	>5 yrs	Low	P

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)			0.7
	% Cover			80

Observations	Limestone outcrop

Field description of vegetation	*Melaleuca huegelii* subsp. *huegelii* and *Acacia truncata* over *Thomasia triphylla* over herbs on limestone

Species	Foliage Projective Cover
Melaleuca huegelii subsp. *huegelii*	40
Thomasia triphylla	10
Melaleuca systena	10
Spyridium globulosum	7
Acacia truncata	5
Desmocladus flexuosus	3
Schoenus lanatus	2
Schoenus lanatus	2
Desmocladus asper	2
Crassula glomerata	1
Lomandra maritima	1
Acacia lasiocarpa	1
Lepidosperma pubisquameum	1
Trachymene pilosa	abundant
Heliophila pusilla	abundant
Leptorhynchos scaber	abundant
Gompholobium tomentosum	many
Scaevola thesioides subsp. *thesioides*	many
Austrostipa flavescens	many
Poa drummondiana	many
Calandrinia sp. Swan Coastal Plain	few
Stylidium junceum	few

Poa drummondiana	few
Lysinema sp.	few
Podotheca gnaphalioides	few
Poranthera microphylla	few
Leucopogon parviflorus	few
Acacia rostellifera	few
Conostylis candicans	few
Lobelia tenuior	few
Leptomeria empetriformis	few
Stylidium junceum	few
Lysinema ciliatum	few
Podotheca gnaphalioides	few
Poranthera microphylla	few
Isotoma hypocrateriformis	few
Pimelea calcicola	few
Cryptandra mutila	few
Rhodanthe citrina	few
Thysanotus patersonii	few
Hibbertia racemosa	few
Stylidium junceum	few
Trymalium ledifolium var. *ledifolium*	few
Daucus glochidiatus	few
Crassula colorata var. *acuminata*	few
Carpobrotus virescens	few
Phyllanthus calycinus	few
Crassula alata	few
Rhagodia baccata	few
Cassytha aurea var. hirta	few
Olearia axillaris	few
Gastrolobium capitatum	few
Lagurus ovatus	few
Comesperma confertum	few
Lepidium rotundum	few
Gompholobium tomentosum	few
Hydrocotyle pilifera var. *glabrata*	few
Opercularia vaginata	few

APPENDIX C: Environmental Site Data 2009

Date:	15.10.09	Site:	4	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA94	50	358945	6528433

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	LS	Cream to brown		

Geomorphology:	Topography	Aspect	Slope (°)
	US	E	5 to 15

Litter:	Logs	Twigs	Leaves	Bare Ground (%)
		1	2	5

Disturbance:	Time Since Fire	Level of Human Impact	Condition
	>5 yrs	Low	E

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	6 to 7		0.7
	% Cover	5 to 10		70

Observations	Adjacent to Tuart patch

Field description of vegetation	*Calothamnus quadrifidus, Melaleuca systena* over *Conostylis candicans* subsp. *calcicola* and *Acacia lasiocarpa* var. *lasiocarpa*

Species	Foliage Projective Cover
Calothamnus quadrifidus	20
Eucalyptus gomphocephala	10
Melaleuca systena	10
Lomandra maritima	10
Scaevola thesioides subsp. *thesioides*	10
Desmocladus flexuosus	5
Acacia lasiocarpa var. *lasiocarpa*	1
Acacia cochlearis	1
Acanthocarpus preissii	1
Opercularia vaginata	1
Conostylis candicans subsp. *calcicola*	1
Spyridium globulosum	1
Hardenbergia comptoniana	1
Heliophila pusilla	1
Cryptandra mutila	many
Trachymene pilosa	many
Dischisma arenarium	many
Austrostipa flavescens	many
Senecio pinnatifolius	many
Leptorhynchos scaber	many
Avena barbata	many
Crassula glomerata	many

Poranthera microphylla	many
Brachyscome bellidioides	many
Calandrinia aff. sp. Blackberry	many
Podotheca angustifolia	many
Schoenus grandiflorus	many
Brachyscome bellidioides	many
Poa drummondiana	few
Lepidosperma pubisquameum	few
Schoenus grandiflorus	few
Cassytha aurea var. *hirta*	few
Heliophila pusilla	few
Carpobrotus virescens	few
Rhodanthe citrina	few
Lobelia tenuior	few
Rhagodia baccata	few
Acacia pulchella	few
Leucopogon insularis	few
Hemiandra pungens	few
Thysanotus patersonii	few
Olearia axillaris	few
Trachyandra divaricata	few
Lolium rigidum	few
Banksia dallanneyi	few
Petrophile serruriae	few
Calandrinia ?aff sp. Blackberry	few
Myoporum insulare	few
Parietaria debilis	few
Lechenaultia linarioides	few
Tetragonia decumbens	few
Brachyscome bellidioides	few
Thysanotus arenarius	few
Stenopetalum robustum	few
Phyllanthus calycinus	few
Isotoma hypocrateriformis	few
Podotheca gnaphalioides	few
Templetonia retusa	few
Allocasuarina lehmanniana subsp. lehmanniana	opportunistic

APPENDIX C: Environmental Site Data 2009

Date:	16.10.09	Site:	5	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA94	50	359636	6527874

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	S	Grey		Dry soil

Geomorphology:	Topography	Aspect	Slope (°)
	Swale		

Litter:	Logs	Twigs	Leaves	Bare Ground (%)
		5	2	2

Disturbance:	Time Since Fire	Level of Human Impact	Condition
	>10 yrs	Low	VG

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)		2	0.5
	% Cover		60	50

Observations	

Field description of vegetation	*Spyridium globulosum* and *Calothamnus quadrifidus* shrubland over *Lepidosperma gladiatum* and *Melaleuca systena*

Species	Foliage Projective Cover
Spyridium globulosum	40
Lepidosperma gladiatum	40
Calothamnus quadrifidus	15
Melaleuca systena	15
Acacia lasiocarpa	5
Lomandra maritima	5
Acanthocarpus preissii	2
Rhagodia baccata	2
Conostylis candicans	1
Opercularia vaginata	1
Trachymene pilosa	1
Cassytha aurea var. *hirta*	1
Lolium rigidum	abundant
Crassula glomerata	abundant
Schoenus grandiflorus	many
Trachyandra divaricata	many
Desmocladus flexuosus	many
Parietaria debilis	many
Avena barbata	many
Avena barbata	many
Lechenaultia linarioides	few
Lepidium rotundum	few

Phyllanthus calycinus	few
Calandrinia aff. sp. Blackberry	few
Thysanotus arenarius	few
Senecio sp. 1	few
Carpobrotus virescens	few
Scaevola thesioides subsp. *thesioides*	few
Poa porphyroclados	few
Poa porphyroclados	few

APPENDIX C: Environmental Site Data 2009

Date:	16.10.09	Site:	6	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA94	50	359093	6527650

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	S	White		Beach sand

Geomorphology:	Topography	Aspect	Slope (°)
	foredune	W	

Litter:	Logs	Twigs	Leaves	Bare Ground (%)
		2	1	60 to 70

Disturbance:	Time Since Fire	Level of Human Impact	Condition
	10 yrs	Low	G

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)			1.2
	% Cover			30

Observations	

Field description of vegetation	*Scaevola crassifolia* and *Olearia axillaris* foredune shrubland

Species	Foliage Projective Cover
Scaevola crassifolia	10
Olearia axillaris	7
Spinifex longifolius	2
Tetragonia decumbens	2
Cakile maritima	2
Pelargonium capitatum	2
Ficinia nodosa	1
Trachyandra divaricata	1
Euphorbia peplus	1
Hardenbergia comptoniana	1
Crassula glomerata	abundant
Crassula glomerata	abundant
Cassytha aurea var. *hirta*	many
Ehrharta calycina	many
Conostylis candicans	few
Carpobrotus virescens	few
Senecio sp. 2	few
Threlkeldia diffusa	few
Lepidosperma gladiatum	few
Ozothamnus cordatus	few
Rhagodia baccata	few

APPENDIX C: Environmental Site Data 2009

Date:	16.10.09	Site:	7	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA94	50	358350	6529650

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	S	White		

Geomorphology:	Topography	Aspect	Slope (°)
	Swale	Flat	

Litter:	Logs	Twigs	Leaves	Bare Ground (%)
		20	10	10

Disturbance:	Time Since Fire	Level of Human Impact	Condition
	>10 yrs	Medium	G

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	10	4	1.5
	% Cover	30	5	45

Observations	

Field description of vegetation	

Species	Foliage Projective Cover
Eucalyptus gomphocephala	30
Acacia lasiocarpa	10
Spyridium globulosum	10
Trachyandra divaricata	10
Leucopogon parviflorus	8
Allocasuarina lehmanniana subsp. lehmanniana	5
Rhagodia baccata	5
Phyllanthus calycinus	5
Acanthocarpus preissii	5
Lepidosperma gladiatum	5
Acrotriche cordata	5
Avena barbata	2
Conostylis candicans	1
Lomandra maritima	1
Acacia saligna	1
Myoporum insulare	1
Heliophila pusilla	1
Chamelaucium uncinatum	1
Crassula glomerata	abundant
Trachymene pilosa	abundant
Ehrharta calycina	many
Parietaria debilis	many

Hemiandra pungens	few
Leptomeria preissiana	few
Senecio sp. 3	few
Podotheca angustifolia	few
Anagallis arvensis	few
Solanum nigrum	few
Calandrinia brevipedata	few
Carpobrotus virescens	few
Cassytha aurea var. *hirta*	few
Conostylis serrulata	few
Austrostipa flavescens	few
Scaevola crassifolia	few
Stenopetalum robustum	few
Cuscuta epithymum	few

APPENDIX C: Environmental Site Data 2009

Date:	24.11.09	Site:	8	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA	50	359683	6529350

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	LS	grey	NA	

Geomorphology:	Topography	Aspect	Slope (°)
	undulating sar	w	<5

Litter:	Logs	Twigs	Leaves	Bare Ground (%)
	1	2	5	40

Disturbance:	Time Since Fire	Level of Human Impact	Condition
	3 to 5 yrs	Med	VG

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	3.5	1	0.4
	% Cover	10	30	30

Observations	

Field description of vegetation	*Banksia attenuata* over *Melaleuca systena* over *Acanthocarpus preissii and Conostylis candicans* subsp. c*alcicola* on grey sand

Species	Foliage Projective Cover
Melaleuca systena	20
Banksia attenuata	10
Carpobrotus virescens	8
Acacia lasiocarpa	5
Dischisma arenarium	5
Acanthocarpus preissii	4
Phyllanthus calycinus	2
Desmocladus flexuosus	2
Lomandra maritima	2
Lechenaultia linarioides	2
Hemiandra pungens	1
Conostylis candicans subsp. *calcicola*	1
Senecio pinnatifolius	1
Pelargonium capitatum	1
Calothamnus quadrifidus	1
Lepidosperma pubisquameum	1
Crassula glomerata	abundant
Poranthera microphylla	abundant
Austrostipa hemipogon	abundant
Schoenus grandiflorus	many
Austrodanthonia occidentalis	many
Banksia nivea	many

Ptilotus stirlingii subsp. *stirlingii*	few
Lobelia tenuior	few
Calandrinia sp. Swan Coastal Plain	few
Bromus diandrus	few
Parietaria debilis	few
Trachyandra divaricata	few
Poa porphyroclados	few
Tetragonia decumbens	few
Anthocercis ilicifolia	few
Tersonia cyathiflora	few
Banksia sessilis	few
Rhagodia baccata	few
Poa drummondiana	few
Kennedia prostrata	few
Trachymene pilosa	few
Disa bracteata	few
Hardenbergia comptoniana	few

APPENDIX C: Environmental Site Data 2009

Date:	24.11.09	Site:	9	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA	50	358519	6529544

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	LS	Grey	NA	

Geomorphology:	Topography	Aspect	Slope (°)
	MS	SW	<5

Litter:	Logs	Twigs	Leaves	Bare Ground (%)
		1	2	20

Disturbance:	Time Since Fire	Level of Human Impact	Condition
	>5yrs	Low	P-E

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)		0.2	0.03
	% Cover		50	60

Observations	

Field description of vegetation	*Spyridium globulosum* and *Chamelaucium uncinatum* over *Melalaleuca systena* over *Lomandra maritima* and *Desmocladus flexuosus*

Species	Foliage Projective Cover
Spyridium globulosum	20
Melaleuca systena	20
Lomandra maritima	20
Chamelaucium uncinatum	10
Desmocladus flexuosus	10
Acacia lasiocarpa	7
Dischisma arenarium	2
Parietaria debilis	2
Phyllanthus calycinus	1
Bromus diandrus	1
Podotheca gnaphalioides	abundant
Lobelia tenuior	many
Rhagodia baccata	many
Austrostipa hemipogon	many
Austrodanthonia occidentalis	few
Senecio pinnatifolius	few
Cassytha aurea var. *hirta*	few
Hardenbergia comptoniana	few
Crassula glomerata	few
Poranthera microphylla	few
Calothamnus quadrifidus	few
Poa porphyroclados	few

Lepidosperma pubisquameum	few
Conostylis candicans subsp. *calcicola*	few
Leucopogon nutans	few
Lepidium rotundum	opportunistic

APPENDIX C: Environmental Site Data 2009

Date:	24.11.09	Site:	10	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA	50	357984	6529144

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	LS-S	grey	NA	

Geomorphology:	Topography	Aspect	Slope (°)
	MS, dunes	-	<5

Litter:	Logs	Twigs	Leaves	Bare Ground (%)
		2	2	10

Disturbance:	Time Since Fire	Level of Human Impact	Condition
	>5yrs	Low	P-E

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)			0.15
	% Cover			90

Observations	Primary dunes

Field description of vegetation	Low dune heath of *Melaleuca systena, Acanthocarpus preissii, Spyridium globulosum, Olearia axillaris* over *Lomandra maritima*

Species	Foliage Projective Cover
Melaleuca systena	20
Acanthocarpus preissii	20
Lomandra maritima	20
Spyridium globulosum	10
Olearia axillaris	8
Acacia lasiocarpa	5
Austrostipa hemipogon	2
Cassytha aurea var. *hirta*	2
Rhagodia baccata	2
Senecio pinnatifolius	1
Dischisma arenarium	1
Zygophyllum fruticulosum	1
Desmocladus flexuosus	1
Crassula glomerata	many
Poranthera microphylla	many
Podotheca gnaphalioides	many
Bromus diandrus	many
Parietaria debilis	many
Trachyandra divaricata	few
Phyllanthus calycinus	few
Trachymene pilosa	few
Rhodanthe citrina	few
Schoenus grandiflorus	few
Poa drummondiana	few
Lepidosperma pubisquameum	few
Scaevola nitida	few

Calothamnus quadrifidus	few
Carpobrotus virescens	few
Conostylis candicans subsp. *calcicola*	few
Lepidosperma gladiatum	few
Leucopogon nutans	few
Calandrinia sp. Swan Coastal Plain	few
Opercularia vaginata	few
Poa porphyroclados	few
Hardenbergia comptoniana	few
Thysanotus patersonii	few
Allocasuarina humilis	few
Santalum acuminatum	few

APPENDIX C: Environmental Site Data 2009

Date:	24.11.09	Site:	12	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA	50	358254	6529190

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	LS	grey	NA	

Geomorphology:	Topography	Aspect	Slope (°)
	US/ridge	NE	<5

Litter:	Logs	Twigs	Leaves	Bare Ground (%)
		1	2	10

Disturbance:	Time Since Fire	Level of Human Impact	Condition
	>5yrs	Low	P-E

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)			1.5
	% Cover			90

Observations	

Field description of vegetation	Low coastal heathland of *Calothamnus quadrifidus* and *Acacia cochlearis* and *Melaleuca systena* and *Acacia lasiocarpa* over *Desmocladus flexuosus* and *Lomandra maritima*

Species	Foliage Projective Cover
Calothamnus quadrifidus	15
Acacia cochlearis	15
Melaleuca systena	15
Acacia lasiocarpa	10
Lomandra maritima	8
Dischisma arenarium	8
Desmocladus flexuosus	5
Austrostipa hemipogon	3
Carpobrotus virescens	2
Lepidosperma pubisquameum	1
Olearia axillaris	1
Rhagodia baccata	1
Parietaria debilis	many
Podotheca gnaphalioides	many
Conostylis candicans	many
Senecio pinnatifolius	many
Austrodanthonia occidentalis	many
Hemiandra pungens	many
Crassula glomerata	many
Lobelia tenuior	few
Phyllanthus calycinus	few
Bromus diandrus	few

Trachymene pilosa	few
Stenopetalum robustum	few
Hardenbergia comptoniana	few
Isotoma hypocrateriformis	few
Daucus glochidiatus	few
Templetonia retusa	few
Spyridium globulosum	few
Trachyandra divaricata	few
Ehrharta sp. 1	few
Leucopogon nutans	few
Podolepis gracilis	few

APPENDIX C: Environmental Site Data 2009

Date:	24.11.09	Site:	13	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA	50	357751	6430251

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	LS-S	grey	NA	

Geomorphology:	Topography	Aspect	Slope (°)
	MS	NW	<5

Litter:	Logs	Twigs	Leaves	Bare Ground (%)
	2	1	3	20

Disturbance:	Time Since Fire	Level of Human Impact	Condition
	>5yrs	Low	VG

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	5	3	0.07
	% Cover	5	30	70

Observations	

Field description of vegetation	*Nuytsia floribunda* over *Allocasuarina lehmanniana* subsp. *lehmanniana* and *Acacia rostellifera* and *Spyridium globulosum* over *Acanthocarpos preissii, Rhagodia baccata and Senecio pinnatifolius*

Species	Foliage Projective Cover
Acanthocarpus preissii	30
Acacia rostellifera	10
Spyridium globulosum	10
Rhagodia baccata	10
Allocasuarina lehmanniana subsp. *lehmanniana*	7
Senecio pinnatifolius	5
Nuytsia floribunda	5
Myoporum insulare	3
Parietaria debilis	2
Calothamnus quadrifidus	2
Lepidosperma gladiatum	2
Ficinia nodosa	2
Trachyandra divaricata	1
Olearia axillaris	1
Scaevola nitida	1
Daucus glochidiatus	abundant
Dischisma arenarium	abundant
Crassula glomerata	many
Cuscuta epithymum	many
Ehrharta calycina	many
Anagallis arvensis	many
Melilotus indicus	many

Tetragonia decumbens	few
Templetonia retusa	few
Austrostipa hemipogon	few
Leucopogon parviflorus	few
Marianthus erubescens	few
Austrostipa elegantissima	few
Bromus diandrus	few
Pelargonium capitatum	few

APPENDIX C: Environmental Site Data 2009

Date:	24.11.09	Site:	14	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA	50	358079	6529713

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	LS-S	grey	NA	

Geomorphology:	Topography	Aspect	Slope (°)
	US		<5

Litter:	Logs	Twigs	Leaves	Bare Ground (%)
		2	5	

Disturbance:	Time Since Fire	Level of Human Impact	Condition
	>5yrs	low	P-E

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	5	0.25	0.07
	% Cover	5	40	60

Observations	

Field description of vegetation	*Eucalyptus gomphocephala* over *Allocasuarina lehmanniana* subsp. *lehmanniana*, *Spyridium globulosum over Melaleuca systena* and *Acanthocarpus preissii*

Species	Foliage Projective Cover
Spyridium globulosum	30
Melaleuca systena	20
Acanthocarpus preissii	15
Allocasuarina lehmanniana subsp. *lehmanniana*	10
Desmocladus flexuosus	10
Eucalyptus gomphocephala	5
Acacia lasiocarpa	5
Leucopogon nutans	2
Leucopogon australis	1
Parietaria debilis	1
Podotheca gnaphalioides	1
Leptomeria preissiana	1
Trachymene pilosa	many
Cassytha aurea var. *hirta*	many
Austrostipa hemipogon	many
Crassula glomerata	many
Dischisma arenarium	many
Lomandra maritima	few
Poa drummondiana	few
Hardenbergia comptoniana	few
Pimelea calcicola	few
Senecio pinnatifolius	few

Calandrinia sp. Swan Coastal Plain	few
Isotoma hypocrateriformis	few

APPENDIX C: Environmental Site Data 2009

Date:	15.10.09	Site:	101	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA94	50	358805	6528627

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	S	grey-brown	few, limestone	Limestone

Geomorphology:	Topography	Aspect	Slope (°)
	LS	W	<5

Litter:	Logs	Twigs	Leaves	Bare Ground (%)
		2	4 to 5	2 to 5

Disturbance:	Time Since Fire	Level of Human Impact	Condition
	1-2 yrs	Low	E

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	1.6	0.6	0.3-0.4
	% Cover	10 to 15	25 to 30	90 to 95

Observations	

Field description of vegetation	Coastal closed heath on leeward side of second degree dunes. *Acacia rostellifera* open shrubland over *Melaleuca systena* low open shrubland over mixed species closed herbland

Species	Foliage Projective Cover
Melaleuca systena	20
Acacia rostellifera	10 to 15
Poranthera microphylla	3 to 5
Dischisma arenarium	3 to 5
Lomandra maritima	3 to 4
Phyllanthus calycinus	2 to 3
Podotheca gnaphalioides	2 to 3
Leptorhynchos scaber	2 to 3
Acacia longifolia subsp. *longifolia*	2 to 3
Tetragonia decumbens	1 to 2
Lobelia tenuior	1 to 2
Acacia lasiocarpa	1 to 2
Heliophila pusilla	1
Senecio pinnatifolius	1
Austrostipa flavescens	1
Poa porphyroclados	1
Desmocladus asper	1
Gompholobium tomentosum	1
Conostylis candicans	1
Cryptandra mutila	1
Schoenus grandiflorus	1
Stenopetalum robustum	abundant
Crassula glomerata	abundant
Bromus diandrus	abundant
Acanthocarpus preissii	abundant
Trachymene pilosa	many

Brachyscome bellidioides	many
Avena barbata	many
Kennedia prostrata	many
Lolium rigidum	many
Hakea prostrata	many
Pimelea ferruginea	few
Orobanche minor	few
Hardenbergia comptoniana	few
Rhagodia baccata	few
Isolepis marginata	few
Ptilotus polystachyus	few
Anthocercis ilicifolia	few
Olearia rudis	few
Carpobrotus virescens	few
Trachyandra divaricata	few
Thysanotus arenarius	few
Poa porphyroclados	few
Anagallis arvensis var. *caerulea*	few
Lepidium rotundum	few
Calandrinia brevipedata	few
Microtis alba	few
Stylidium junceum	few
Opercularia vaginata	few
Isotoma hypocrateriformis	few
Pelargonium capitatum	few
Spyridium globulosum	few
Carpobrotus edulis	few
Dryandra lindleyana	few
Scaevola thesioides subsp. *thesioides*	few
Erodium cicutarium	few
Olearia rudis	few
Acacia truncata	few

APPENDIX C: Environmental Site Data 2009

Date:	15.10.09	Site:	102	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA94	50	358960	6528486

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	Soil texture	grey	numerous, li	

Geomorphology:	Topography	Aspect	Slope (°)
	MS	NW	<5

Litter:	Logs	Twigs	Leaves	Bare Ground (%)
		2 to 3	5	20 to 25

Disturbance:	Time Since Fire	Level of Human Impact	Condition
	1 yr	Low	E

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	1.3		0.3 to 0.4
	% Cover	30 to 40		70 to 75

Observations	

Field description of vegetation	Burnt *Melaleuca cardiophylla* low shrubland over low resprouting *Melaleuca systena* open shrubland over mixed species closed herbland

Species	Foliage Projective Cover	
Melaleuca cardiophylla	30 to 35	juvenile
Dischisma arenarium	10	
Calandrinia sp. Swan Coastal Plain	5 to 8	
Austrostipa flavescens	5 to 8	
Melaleuca systena	5	
Lomandra maritima	3 to 4	
Leptorhynchos scaber	3 to 4	
Podotheca gnaphalioides	2 to 3	
Heliophila pusilla	1 to 2	
Trachymene pilosa	1 to 2	
Poranthera microphylla	1 to 2	
Desmocladus asper	1 to 2	
Senecio pinnatifolius	1	
Poa porphyroclados	1	
Crassula colorata var. *acuminata*	many	
Crassula glomerata	many	
Conostylis candicans	many	
Scaevola thesioides subsp. *thesioides*	many	juvenile
Bromus diandrus	many	
Leucopogon parviflorus	few	juvenile
Trachymene coerulea subsp. coerulea	few	juvenile
Hardenbergia comptoniana	few	

Trachyandra divaricata	few
Stenopetalum robustum	few
Boronia crenulata subsp. ?*viminea*	few
Rhodanthe citrina	few
Tetragonia decumbens	few
Cryptandra mutila	few
Lolium rigidum	few
Phyllanthus calycinus	few
Carpobrotus virescens	few juvenile
Sonchus oleraceus	few
Pelargonium capitatum	few
Anthocercis ilicifolia	few
Lobelia tenuior	few
Lepidosperma pubisquameum	few
Acacia truncata	few
Hakea prostrata	few
Thomasia triphylla	few
Hakea lissocarpha	few juvenile

APPENDIX C: Environmental Site Data 2009

Date:	15.10.09	Site:	103	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	gda94	50	359090	6528382

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	S	Dark grey-brow	Moderate	Limestone

Geomorphology:	Topography	Aspect	Slope (°)
	MS	W	<5

Litter:	Logs	Twigs	Leaves	Bare Ground (%)
		2 to 3	2 to 3	15 to 20

Disturbance:	Time Since Fire	Level of Human Impact	Condition
	1 yr	Low	E

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	1.7		0.5
	% Cover	660		80

Observations	

Field description of vegetation	*Dryandra sessilis* and *Melaleuca huegelii* shrubland over mixed species closed herbland

Species	Foliage Projective Cover
Melaleuca huegelii	30 to 35
Dryandra sessilis	25
Austrostipa flavescens	5
Dischisma arenarium	4 to 5
Senecio pinnatifolius	3 to 4
Calandrinia brevipedata	2 to 3
Melaleuca systena	2 to 3
Melaleuca systena	2 to 3
Trachymene pilosa	1 to 2
Tetragonia decumbens	1 to 2
Lobelia tenuior	2
Hardenbergia comptoniana	1
Schoenus grandiflorus	1
Heliophila pusilla	1
Hakea prostrata	1
Podotheca gnaphalioides	abundant
Poa porphyroclados	abundant
Bromus diandrus	abundant
Dryandra lindleyana	many
Carpobrotus edulis	many
Conostylis candicans	many
Poranthera microphylla	many

Lolium rigidum	many
Scaevola thesioides subsp. *thesioides*	many
Rhodanthe citrina	few
Ehrharta villosa	few
Parietaria debilis	few
Acacia truncata	few
Acanthocarpus preissii	few
Millotia tenuifolia var. *tenuifolia*	few
Pelargonium littorale	few
Trachymene coerulea subsp. *coerulea*	few
Daucus glochidiatus	few
Crassula glomerata	few
Anthocercis ilicifolia	few
Asteridea pulverulenta	few
Ozothamnus cordatus	few
Rhagodia baccata	few
Templetonia retusa	few
Trachyandra divaricata	few
Hakea lissocarpha	few
Orobanche minor	few
Poa porphyroclados	few
Spyridium globulosum	few
Stenopetalum robustum	few
Phyllanthus calycinus	few
Isolepis marginata	few

APPENDIX C: Environmental Site Data 2009

Date:	15.10.09	Site:	104	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA94	50	359299	6528207

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	Soil texture	Grey	Moderate	Limestone

Geomorphology:	Topography	Aspect	Slope (°)
	MS	NW	<5

Litter:	Logs	Twigs	Leaves	Bare Ground (%)
		1 to 2	1 to 2	3 to 5

Disturbance:	Time Since Fire	Level of Human Impact	Condition
	3 to 5 yrs	Low	E

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	1.6	0.5 to 0.6	0.3 to 0.4
	% Cover	10 to 15	50 to 60	25 to 35

Observations	unburnt *Melaleuca huegelii* and *Dryandra sessilis* site, on a sandy low rise with outcropping limestone
Field description of vegetation	*Melaleuca huegelii* and *Dryandra sessilis* shrubland over *Melaleuca systena* and *Acacia truncata* low open shrubland over mixed species herbland

Species	Foliage Projective Cover
Melaleuca huegelii	50
Dryandra sessilis	15
Templetonia retusa	2
Lomandra maritima	2
Acacia truncata	1 to 2
Scaevola thesioides subsp. *thesioides*	1 to 2
Lysinema ciliatum	1 to 2
Gompholobium tomentosum	1 to 2
Melaleuca systena	1
Calandrinia brevipedata	1
Desmocladus asper	1
Austrostipa flavescens	1
Hakea lissocarpha	1
Spyridium globulosum	1
Trachymene pilosa	abundant
Poa porphyroclados	abundant
Senecio pinnatifolius	abundant
Heliophila pusilla	abundant
Dischisma arenarium	abundant
Calandrinia brevipedata	abundant
Stylidium junceum	many
Pimelea calcicola	many

Opercularia vaginata	many
Crassula glomerata	many
Schoenus lanatus	many
Leptorhynchos scaber	many
Calothamnus quadrifidus	many
Podotheca gnaphalioides	many
Lepidosperma pubisquameum	many
Petrophile serruriae	few
Polypogon tenellus	few
Millotia tenuifolia var. *tenuifolia*	few
Hardenbergia comptoniana	few
Bromus diandrus	few
Isotoma hypocrateriformis	few
Carpobrotus virescens	few
Acacia lasiocarpa	few
Acanthocarpus preissii	few
Schoenus grandiflorus	few
Leucopogon parviflorus	few
Daucus glochidiatus	few
Ehrharta villosa	few
Lolium rigidum	few
Hibbertia racemosa	few
Calandrinia aff. sp. Blackberry	few
Triglochin sp. a flora of australia G.J. Keighery 2477	few
Stenopetalum robustum	few
Trachymene coerulea subsp. *coerulea*	few
Ptilotus polystachyus	few
Bromus diandrus	few
Conostylis candicans	few
Dryandra lindleyana	few
Poranthera microphylla	few

APPENDIX C: Environmental Site Data 2009

Date:	16.10.09	Site:	105	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA94	50	359473	6528100

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	S	Pale brown - gr	Few	Limestone

Geomorphology:	Topography	Aspect	Slope (°)
	MS	NW	<5

Litter:	Logs	Twigs	Leaves	Bare Ground (%)
		2 to 3	5	10 to 15

Disturbance:	Time Since Fire	Level of Human Impact	Condition
	2 to 3 yrs	Low	E

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	3	1.7	0.4
	% Cover	40	65	60 to 70

Observations	

Field description of vegetation	*Acacia rostellifera* tall shrubland over *Dryandra sessilis, Melaleuca systena* and *Melaleuca huegelii* shrubland over mixed species open herbland

Species	Foliage Projective Cover
Acacia rostellifera	40
Melaleuca huegelii	20
Melaleuca systena	10 to 15
Banksia sessilis	10
Spyridium globulosum	5
Acacia truncata	5
Gompholobium tomentosum	4 to 5
Templetonia retusa	3 to 4
Phyllanthus calycinus	2 to 3
Austrostipa flavescens	2
Dischisma arenarium	2
Parietaria debilis	1 to 2
Senecio pinnatifolius	1 to 2
Trachymene pilosa	1 to 2
Calandrinia brevipedata	1 to 2
Hakea lissocarpha	1 to 2
Lobelia tenuior	1
Poa porphyroclados	1
Desmocladus asper	1
Conostylis candicans	many
Schoenus grandiflorus	many
Bromus diandrus	many

Lolium rigidum	many
Rhagodia baccata	many
Heliophila pusilla	many
Lomandra maritima	many
Hakea prostrata	many
Podotheca gnaphalioides	many
Acanthocarpus preissii	many
Crassula glomerata	many
Pelargonium capitatum	few
Lepidosperma pubisquameum	few
Poranthera microphylla	few
Anthocercis ilicifolia	few
Trachymene coerulea subsp. *coerulea*	few
Hardenbergia comptoniana	few
Tetragonia decumbens	few
Stylidium junceum	few
Conospermum stoechadis	few
Leucopogon parviflorus	few
Banksia dallaneyi	few
Podotheca gnaphalioides	few
Erodium cicutarium	few
Poa drummondiana	few
Daucus glochidiatus	few
Triglochin sp. a flora of australia G.J. Keighery 2477	few
Ehrharta villosa	few
Hibbertia racemosa	few

APPENDIX C: Environmental Site Data 2009

Date:	16.10.09	Site:	106	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA94	50	359622	6528021

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	S	Grey	Few	Limestone

Geomorphology:	Topography	Aspect	Slope (°)
	MS	NW	<5

Litter:	Logs	Twigs	Leaves	Bare Ground (%)
		3 to 4	1 to 2	3 to 5

Disturbance:	Time Since Fire	Level of Human Impact	Condition
	3 to 4 yrs	Low	E

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	2.3	1.3	0.3
	% Cover	50 to 60	50	35 to 40

Observations	

Field description of vegetation	Lower dune slope grading into a swale area. *Acacia rostellifera* tall shrubland over *Calothamnus quadrifidus* and *Melaleuca systena* low shrubland to shrubland over mixed species open herbland to herbland.

Species	Foliage Projective Cover
Acacia rostellifera	50 to 60
Calothamnus quadrifidus	15 to 20
Melaleuca systena	10 to 15
Scaevola thesioides subsp. *thesioides*	3 to 5
Acacia lasiocarpa	3 to 4
Desmocladus asper	2 to 3
Dischisma arenarium	2 to 3
Phyllanthus calycinus	1 to 2
Acanthocarpus preissii	1 to 2
Parietaria debilis	1 to 2
Trachymene pilosa	1 to 2
Lomandra maritima	1 to 2
Conostylis candicans	1 to 2
Bromus diandrus	1 to 2
Spyridium globulosum	2
Bromus diandrus	2
Senecio pinnatifolius	1
Austrostipa flavescens	1
Calandrinia aff. sp. Blackberry	1
Poa porphyroclados	1
Calandrinia brevipedata	abundant
Poranthera microphylla	many

Lolium rigidum	many
Poa porphyroclados	many
Heliophila pusilla	many
Schoenus grandiflorus	many
Thysanotus arenarius	few
Daucus glochidiatus	few
Leptorhynchos scaber	few
Exocarpos sparteus	few
Tetragonia decumbens	few
Lepidosperma pubisquameum	few
Pelargonium capitatum	few
Hardenbergia comptoniana	few
Ehrharta villosa	few
Podotheca gnaphalioides	few

APPENDIX C: Environmental Site Data 2009

Date:	16.10.09	Site:	107	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA94	50	358315	6530424

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	S	Pale grey	None	

Geomorphology:	Topography	Aspect	Slope (°)
	MS	NE	<5

Litter:	Logs	Twigs	Leaves	Bare Ground (%)
	2 to 3	5 to 8	5 to 6	

Disturbance:	Time Since Fire	Level of Human Impact	Condition
	>5 yrs	Low	VG

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	12	2.8	0.6
	% Cover	40 to 45	50 to 60	80

Observations	River foreshore management area. Many annual weed species patches in understorey stratum
Field description of vegetation	*Eucalyptus gomphocephalus* tall woodland over Rh*agodia baccata* , *Olearia exillaris* and *Acanthocarpus preissii* shrubland over mixed species herbland and annual grasses

Species	Foliage Projective Cover
Eucalyptus gomphocephala	40
Acanthocarpus preissii	20
Olearia axillaris	10 to 15
Rhagodia baccata	10 to 15
Spyridium globulosum	5
Leucopogon parviflorus	2 to 3
Allocasuarina lehmanniana subsp. lehmanniana	2 to 3
Myoporum insulare	2 to 3
Hardenbergia comptoniana	1 to 2
Poranthera microphylla	1 to 2
Daucus glochidiatus	1 to 2
Parietaria debilis	1 to 2
Leptomeria preissiana	1 to 2
Acacia lasiocarpa	1 to 2
Trachymene pilosa	1
Calandrinia brevipedata	1
Dischisma arenarium	1
Anagallis arvensis var. caerulea	1
Heliophila pusilla	abundant
Austrostipa flavescens	many
Bromus diandrus	many
Bromus diandrus	many

Ehrharta longiflora	many
Cerastium glomeratum	many
Crassula glomerata	many
Senecio pinnatifolius	few
Threlkeldia diffusa	few
Dianella revoluta	few
Trachyandra divaricata	few
Vulpia myuros forma myuros	few
Rhodanthe citrina	few
Pelargonium capitatum	few
Sonchus oleraceus	few
Lepidosperma gladiatum	few
Crassula colorata var. acuminata	few
Isolepis marginata	few
Thysanotus patersonii	few
Cassytha aurea var. hirta	few

e	n
358252	6530440

** at above GPS veg comm is same as at site 107 (tuart woodland over shrubland and weedy understorey stratum)

APPENDIX C: Environmental Site Data 2009

Date:	15.10.09	Site:	201	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA	50	358783	6528848

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	LS	Grey-Brown	Numerous	Limestone

Geomorphology:	Topography	Aspect	Slope (°)
	R	N/A	<5

Litter:	Logs	Twigs	Leaves	Bare Ground (%)
		5	5	40

Disturbance:	Time Since Fire	Level of Human Impact	Condition
	>3	Medium	G

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)			1
	% Cover			50

Observations	grazing, burning (recent) around site, site mostly unburnt

Field description of vegetation	Low heath of *Melaleuca huegelii* and *Spyridium globulosum* and *Carpobrotus virescens*

Species	Foliage Projective Cover
Avena barbata	10
Melaleuca huegelii	5
Spyridium globulosum	3
Carpobrotus virescens	3
Crassula glomerata	3
Senecio pinnatifolius	2
Stylidium junceum	2
Exocarpos sparteus	2
Desmocladus asper	2
Trachyandra divaricata	1
Bromus diandrus	1
Rhagodia baccata	1
Austrostipa compressa	1
Melilotus indicus	1
Poa porphyroclados	1
Trachymene pilosa	abundant
Calandrinia aff. sp. Blackberry	abundant
Anagallis arvensis var. *caerulea*	many
Dischisma arenarium	many
Pelargonium littorale	many
Scaevola thesioides subsp. *thesioides*	many
Millotia tenuifolia var. tenuifolia	many

Parentucellia latifolia		many	
Crassula colorata		many	
Conostylis candicans		few	
Banksia sessilis		few	
Hardenbergia comptoniana		few	
Scaevola crassifolia		few	
Heliophila pusilla		few	
Carpobrotus virescens		few	
Olearia axillaris		few	
Lysinema ciliatum		few	
Sonchus oleraceus		few	
Pelargonium capitatum		few	
Acacia littorea		few	
Banksia dallanneyi		few	
Cerastium glomeratum		few	
Petrorhagia dubia		few	
Gompholobium tomentosum		few	
Isolepis marginata		few	
Lobelia tenuior		few	
Calandrinia aff. sp. Blackberry		few	
Opercularia vaginata		few	
Cassytha aurea var. hirta		few	
Stenopetalum robustum	few		opportunistic
Pimelea calcicola	few		opportunistic

APPENDIX C: Environmental Site Data 2009

Date:	15.10.09	Site:	202	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA94	50	358944	6528681

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	LS	grey-brown	numerous	Limestone

Geomorphology:	Topography	Aspect	Slope (°)
	R		<5

Litter:	Logs	Twigs	Leaves	Bare Ground (%)
		10	5	20

Disturbance:	Time Since Fire	Level of Human Impact	Condition
	1-3 yrs	Medium	VG-G

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)			1
	% Cover			75

Observations	Grazing

Field description of vegetation	Low heath of *Spyridium globulosum* and *Banksia sessilis* and *Melaleuca huegelii* with *Phyllanthus calycinus* and *Carpobrotus virescens*

Species	**Foliage Projective Cover**
Melaleuca huegelii	25
Banksia sessilis	20
Spyridium globulosum	7
Austrostipa compressa	5
Senecio pinnatifolius	3
Carpobrotus edulis	3
Calothamnus quadrifidus	2
Conostylis candicans	2
Rhagodia baccata	2
Trachymene pilosa	1
Desmocladus asper	1
Phyllanthus calycinus	1
Tetraria octandra	1
Bromus diandrus	1
Melaleuca systena	1
Crassula glomerata	abundant
Dischisma arenarium	abundant
Lobelia tenuior	many
Opercularia vaginata	many
Poa porphyroclados	many
Millotia tenuifolia var. tenuifolia	many
Heliophila pusilla	many

Avena barbata	many
Hardenbergia comptoniana	few
Scaevola thesioides subsp. *thesioides*	few
Pelargonium capitatum	few
Gompholobium tomentosum	few
Stylidium junceum	few
Lolium rigidum	few
Acacia littorea	few
Cassytha aurea var. hirta	few
Leucopogon parviflorus	few
Orobanche minor	few
Acacia lasiocarpa	few
Hibbertia subvaginata	few
Calandrinia sp. Swan Coastal Plain	few
Exocarpos sparteus	few
Lomandra maritima	few
Stenopetalum robustum	few
Podotheca gnaphalioides	few
Calandrinia aff. sp. Blackberry	few
Trachyandra divaricata	few
Anthocercis ilicifolia	few
Lepidosperma pubisquameum	few
Gastrolobium capitatum	few
Lysinema ciliatum	few

APPENDIX C: Environmental Site Data 2009

Date:	15.10.09	Site:	203	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA94	50	359122	6528573

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	S	cream		

Geomorphology:	Topography	Aspect	Slope (°)
	LS	S	5 to 15

Litter:	Logs	Twigs	Leaves	Bare Ground (%)
		5	5	20

Disturbance:	Time Since Fire	Level of Human Impact	Condition
	<1	High	D

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	3		1
	% Cover	10		70

Observations	Burnt recently

Field description of vegetation	*Banksia attenuata* over *Melaleuca systena* and *Acanthocarpus pressii* with grasses

Species	Foliage Projective Cover
Melaleuca systena	15
Banksia attenuata	10
Senecio pinnatifolius	10
Avena barbata	10
Austrostipa compressa	10
Trachyandra divaricata	5
Bromus diandrus	5
Melilotus indicus	5
Lolium rigidum	3
Acanthocarpus preissii	3
Calothamnus quadrifidus	3
Tetraria octandra	2
Phyllanthus calycinus	1
Hakea lissocarpha	1
Desmocladus asper	1
Dischisma arenarium	abundant
Millotia tenuifolia var. *tenuifolia*	many
Lobelia tenuior	many
Heliophila pusilla	many
Crassula glomerata	many
Trachymene pilosa	many
Podotheca gnaphalioides	many

Cerastium glomeratum	many
Stenopetalum robustum	few
Conostylis candicans	few
Tetragonia decumbens	few
Sonchus oleraceus	few
Banksia nivea	few
Hardenbergia comptoniana	few
Poranthera microphylla	few

APPENDIX C: Environmental Site Data 2009

Date:	15.10.09	Site:	204	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA94	50	359408	6528468

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	LS	grey-brown	numerous	Limestone

Geomorphology:	Topography	Aspect	Slope (°)
	R		<5

Litter:	Logs	Twigs	Leaves	Bare Ground (%)
		5	5	15

Disturbance:	Time Since Fire	Level of Human Impact	Condition
	1-3 yrs	medium	VG-G

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)			1
	% Cover			85

Observations	Unburnt. Surrounds recently burnt

Field description of vegetation	*Melaleuca huegelii* heath over *Carpobrotus virescens* and herbs

Species	Foliage Projective Cover
Melaleuca huegelii	50
Desmocladus asper	10
Templetonia retusa	5
Senecio pinnatifolius	5
Crassula glomerata	4
Carpobrotus virescens	4
Banksia sessilis	2
Rhagodia baccata	1
Melaleuca systena	1
Lolium rigidum	1
Poa porphyroclados	many
Podotheca gnaphalioides	many
Calandrinia sp. Swan Coastal Plain	many
Crassula colorata	many
Heliophila pusilla	many
Opercularia vaginata	many
Millotia tenuifolia itenuifolia	many
Leptorhynchos scaber	many
Acacia littorea	few
Avena barbata	few
Trachyandra divaricata	few
Lepidosperma pubisquameum	few

Lysinema ciliatum	few
Cassytha aurea var. *hirta*	few
Leucopogon parviflorus	few
Banksia nivea	few
Stylidium junceum	few
Hakea lissocarpha	few
Gompholobium tomentosum	few
Poranthera microphylla	few
Trifolium arvense	few
Lobelia tenuior	few
Trymalium ledifolium var. *ledifolium*	few
Schoenus lanatus	few

APPENDIX C: Environmental Site Data 2009

Date:	15.10.09	Site:	205	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA95	50	359341	6528263

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	LS	grey-brown	numerous	Limestone

Geomorphology:	Topography	Aspect	Slope (°)
	R		<5

Litter:	Logs	Twigs	Leaves	Bare Ground (%)
		3	5	20

Disturbance:	Time Since Fire	Level of Human Impact	Condition
	1-3 yrs	Medium	VG-G

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)			1
	% Cover			80

Observations	

Field description of vegetation	*Melaleuca huegelii* with *Templetonia retusa* and *Banksia sessilis*

Species	Foliage Projective Cover
Melaleuca huegelii	55
Templetonia retusa	10
Desmocladus asper	10
Banksia sessilis	3
Crassula glomerata	2
Melaleuca systena	2
Carpobrotus virescens	1
Senecio pinnatifolius	1
Rhagodia baccata	1
Carpobrotus virescens	1
Poa porphyroclados	many
Trachymene pilosa	many
Dischisma arenarium	many
Austrostipa compressa	many
Bromus diandrus	many
Millotia tenuifolia var. *tenuifolia*	many
Heliophila pusilla	many
Lomandra maritima	few
Lobelia tenuior	few
Podotheca gnaphalioides	few
Calandrinia aff. sp. Blackberry	few
Brassica tournefortii	few

Cassytha aurea var. *hirta*	few
Hakea lissocarpha	few
Acacia littorea	few
Gompholobium tomentosum	few
Tetraria octandra	few
Stylidium junceum	few
Hardenbergia comptoniana	few
Lepidosperma pubisquameum	few
Conostylis candicans	few
Sphaerolobium medium	few
Petrophile serruriae	few

APPENDIX C: Environmental Site Data 2009

Date:	15.10.09	Site:	206	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA94	50	359646	6528223

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	S	cream	few	limestone

Geomorphology:	Topography	Aspect	Slope (°)
	US	N	5 to 15

Litter:	Logs	Twigs	Leaves	Bare Ground (%)
		2	3	10

Disturbance:	Time Since Fire	Level of Human Impact	Condition
	2-5 yrs	Medium	D

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)			1
	% Cover			90

Observations	

Field description of vegetation	*Banksia sessilis* heath over *Desmocladus asper* and grasses

Species	Foliage Projective Cover
Banksia sessilis	70
Desmocladus asper	15
Melaleuca systena	5
Templetonia retusa	3
Senecio pinnatifolius	3
Stylidium junceum	3
Acacia lasiocarpa	2
Acacia littorea	1
Phyllanthus calycinus	1
Bromus diandrus	1
Hakea trifurcata	1
Conostylis candicans	1
Dischisma arenarium	abundant
Trachymene pilosa	abundant
Heliophila pusilla	many
Crassula glomerata	many
poa porphyroclados	many
Daucus glochidiatus	many
Millotia tenuifolia var. *tenuifolia*	many
Lolium rigidum	few
Avena barbata	few
Lobelia tenuior	few

Hardenbergia comptoniana	few
Gompholobium tomentosum	few
Gastrolobium capitatum	few
Acanthocarpus preissii	few
Sonchus oleraceus	few
Carpobrotus edulis	few
Hybanthus calycinus	few
Leptorhynchos scaber	few
Lepidosperma pubisquameum	few
Calothamnus quadrifidus	few
Opercularia vaginata	few
Hakea lissocarpha	few
Olearia rudis	few

APPENDIX C: Environmental Site Data 2009

Date:	16.10.09	Site:	207	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA94	50	359651	6528198

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	S	Cream		

Geomorphology:	Topography	Aspect	Slope (°)
	R		

Litter:	Logs	Twigs	Leaves	Bare Ground (%)
		2	2	25

Disturbance:	Time Since Fire	Level of Human Impact	Condition
	1 to 3 yrs	Low	VG

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)			1
	% Cover			80

Observations	

Field description of vegetation	Low heath of *Acacia lasiocarpa, Lomandra maritima* and *Calothamnus quadrifidus*

Species	Foliage Projective Cover
Lomandra maritima	50
Acacia lasiocarpa	20
Calothamnus quadrifidus	10
Bromus diandrus	5
Crassula glomerata	3
Phyllanthus calycinus	3
Acanthocarpus preissii	2
Desmocladus asper	1
Dischisma arenarium	abundant
Trachymene pilosa	abundant
Heliophila pusilla	abundant
Conostylis candicans	many
Millotia tenuifolia var. tenuifolia	many
poa porphyroclados	many
Cerastium glomeratum	many
Hybanthus calycinus	many
Hardenbergia comptoniana	few
Banksia nivea	few
Cassytha aurea var. hirta	few
Calandrinia aff. sp. Blackberry	few
Opercularia vaginata	few
Melaleuca systena	few

Lepidosperma pubisquameum	few
Carpobrotus edulis	few
Stenopetalum robustum	few
Rhagodia baccata	few
Senecio pinnatifolius	few
Hemiandra pungens	few
Tetraria octandra	few
Trachyandra divaricata	few
Carpobrotus virescens	few
Thysanotus manglesianus	few
Leptorhynchos scaber	few
Podotheca gnaphalioides	few
Conospermum stoechadis	few
Tersonia cyathiflora	few
Hemiandra pungens	few
Calandrinia aff. sp. Blackberry	few

APPENDIX C: Environmental Site Data 2009

Date:	16.10.09	Site:	208	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA94	50	359903	6528135

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	S	Cream		

Geomorphology:	Topography	Aspect	Slope (°)
	LS	SE	<5

Litter:	Logs	Twigs	Leaves	Bare Ground (%)
		5	10	20

Disturbance:	Time Since Fire	Level of Human Impact	Condition
	1 to 3 yrs	Medium	G

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)		250	70
	% Cover		50	80

Observations	

Field description of vegetation	

Species	Foliage Projective Cover
Acacia rostellifera	50
Lolium rigidum	25
Calandrinia sp. Swan Coastal Plain	20
Bromus diandrus	15
Spyridium globulosum	5
Phyllanthus calycinus	3
Austrostipa flavescens	2
Acanthocarpus preissii	2
Conostylis candicans	1
Melaleuca systena	1
Tetraria octandra	1
Dischisma arenarium	abundant
Heliophila pusilla	abundant
Poa porphyroclados	many
Daucus glochidiatus	many
Acacia lasiocarpa	few
Desmocladus asper	few
Thysanotus arenarius	few
Parietaria debilis	few
Hemiandra pungens	few
Leucopogon parviflorus	few
Calothamnus quadrifidus	few
Anagallis arvensis	few
Trachyandra divaricata	few
Poa porphyroclados	few

APPENDIX C: Environmental Site Data 2009

Date:	16.10.09	Site:	209	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA94	50	359879	6527957

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	LS	Brown	Numerous	Limestone

Geomorphology:	Topography	Aspect	Slope (°)
	MS	N	5 to 15

Litter:	Logs	Twigs	Leaves	Bare Ground (%)
		10	10	25

Disturbance:	Time Since Fire	Level of Human Impact	Condition
	>3 yrs	Low	E

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)			1.5
	% Cover			80

Observations	

Field description of vegetation	*Melaleuca huegelii* heath with *Banksia sessilis, Acacia littorea* and Sp*yridium globulosum*

Species	Foliage Projective Cover
Melaleuca huegelii	35
Banksia sessilis	15
Desmocladus asper	10
Acacia littorea	5
Leucopogon parviflorus	5
Spyridium globulosum	3
Calandrinia aff. sp. Blackberry	3
Melaleuca systena	2
Bromus diandrus	2
Crassula glomerata	abundant
Anagallis arvensis var. *caerulea*	abundant
Hypochaeris glabra	abundant
Crassula glomerata	abundant
Trachymene pilosa	abundant
Daucus glochidiatus	abundant
Heliophila pusilla	many
Melilotus indicus	many
Petrorhagia dubia	many
Thomasia triphylla	few
Hardenbergia comptoniana	few
Cassytha aurea var. hirta	few
Lomandra maritima	few

Lepidosperma pubisquameum	few
Carpobrotus virescens	few
Lysinema ciliatum	few
Opercularia vaginata	few
Stylidium junceum	few
Scaevola thesioides subsp. *thesioides*	few
Hibbertia subvaginata	few
Rhagodia baccata	few
Tetraria octandra	few
Austrostipa flavescens	few
Calandrinia aff. sp. Blackberry	few
poa porphyroclados	few
Acanthocarpus preissii	few
Stenopetalum robustum	few
Parentucellia latifolia	few
Pimelea angustifolia	few
Cotula cotuloides	few
Bromus diandrus	few
Ptilotus polystachyus	few

APPENDIX C: Environmental Site Data 2009

Date:	16.10.09	Site:	210	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA94	50	359905	6527774

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	LS	Cream		

Geomorphology:	Topography	Aspect	Slope (°)
	MS	S	5 to 15

Litter:	Logs	Twigs	Leaves	Bare Ground (%)
		2	5	15

Disturbance:	Time Since Fire	Level of Human Impact	Condition
	>3 yrs	Low	E

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)			1
	% Cover			90

Observations	

Field description of vegetation	*Acacia lasiocarpa* heath with P*hyllanthus calycinus, Melaleuca systena, Templetonia retusa, Banksia sessilis* and *Scaevola thesioides subsp. thesioides*

Species	Foliage Projective Cover
Acacia lasiocarpa	35
Melaleuca systena	30
Phyllanthus calycinus	7
Scaevola thesioides subsp. *thesioides*	5
Desmocladus asper	5
Austrostipa flavescens	4
Templetonia retusa	3
Banksia sessilis	2
Calandrinia sp. Swan Coastal Plain	2
Leucopogon parviflorus	2
Bromus diandrus	2
Acanthocarpus preissii	1
Calothamnus quadrifidus	1
Lomandra maritima	1
Spyridium globulosum	1
poa porphyroclados	1
Bromus diandrus	1
Lolium rigidum	1
Heliophila pusilla	abundant
Crassula glomerata	abundant
Dischisma arenarium	abundant
Trachymene pilosa	abundant

Conostylis candicans	many
Opercularia vaginata	many
Daucus glochidiatus	many
Parietaria debilis	few
Hemiandra pungens	few
Podotheca gnaphalioides	few
Hibbertia subvaginata	few
Stenopetalum robustum	few
Tetraria octandra	few
Hakea prostrata	few
Carpobrotus virescens	few
Leptorhynchos scaber	few
Hardenbergia comptoniana	few
poa porphyroclados	few
Lepidosperma pubisquameum	few
Stylidium junceum	few
Cassytha aurea var. *hirta*	few
Poranthera microphylla	few
Thysanotus manglesianus	few

APPENDIX C: Environmental Site Data 2009

Date:	16.10.09	Site:	211	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA94	50	359256	6530224

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	LS	Grey-brown		

Geomorphology:	Topography	Aspect	Slope (°)
	LS	N	5 to 15

Litter:	Logs	Twigs	Leaves	Bare Ground (%)
		5	10	15

Disturbance:	Time Since Fire	Level of Human Impact	Condition
	>3 yrs	Medium	D-G

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)		3.5	1
	% Cover		75	80

Observations	

Field description of vegetation	*Melaleuca cardiophylla* thicket over grasses

Species	Foliage Projective Cover
Melaleuca cardiophylla	75
Bromus diandrus	40
Ehrharta longiflora	35
Calandrinia sp. Swan Coastal Plain	10
Lolium rigidum	10
Acanthocarpus preissii	8
Spyridium globulosum	5
Chamelaucium uncinatum	5
Desmocladus asper	3
Parietaria debilis	2
Templetonia retusa	2
Daucus glochidiatus	abundant
Heliophila pusilla	many
Lobelia tenuior	many
Acacia longifolia subsp. *longifolia*	few
Tetragonia decumbens	few
Sonchus oleraceus	few
Hypochaeris glabra	few
Acacia lasiocarpa	few
Rhagodia baccata	few
poa porphyroclados	few
Dischisma arenarium	few

Logania vaginalis	few

APPENDIX C: Environmental Site Data 2009

Date:	16.10.09	Site:	212	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA94	50	359476	6530325

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	LS	Grey-brown	Moderate	Limestone

Geomorphology:	Topography	Aspect	Slope (°)
	US	N	>15

Litter:	Logs	Twigs	Leaves	Bare Ground (%)
		10	5	30

Disturbance:	Time Since Fire	Level of Human Impact	Condition
	>3 yrs	Medium	G

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)		3.5	1
	% Cover		50	60

Observations	

Field description of vegetation	*Melaleuca cardiophylla* shrubland over *Acacia lasiocarpa, Acanthocarpus preissii, Lomandra maritima* and *Desmocladus asper*

Species	Foliage Projective Cover
Melaleuca cardiophylla	50
Desmocladus asper	30
Lomandra maritima	25
Allocasuarina lehmanniana subsp. *lehmanniana*	3
Acanthocarpus preissii	2
Gompholobium tomentosum	2
Spyridium globulosum	1
Calandrinia sp. Swan Coastal Plain	1
Bromus diandrus	1
Ehrharta longiflora	1
Heliophila pusilla	abundant
Trachymene pilosa	abundant
Dischisma arenarium	many
Calandrinia aff. sp. Blackberry	many
Podotheca gnaphalioides	many
Leptorhynchos scaber	few
Austrostipa flavescens	few
Stylidium maritimum (P3)	few
Poa porphyroclados	few
Leucopogon insularis	few
Leucopogon insularis	few
Rhodanthe citrina	few
Carpobrotus virescens	few
Hibbertia spicata subsp. *leptotheca* (P3)	few
Rhagodia baccata	few
Beyeria cinerea subsp. *cinerea* (P3)	few

Leucopogon parviflorus	few
Acacia longifolia subsp. *longifolia*	few
Conostylis candicans	few

APPENDIX C: Individual sampling unit data

Date:		Site:		Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA94	50		

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments

Geomorphology:	Topography	Aspect	Slope (°)

Litter:	Logs	Twigs	Leaves	Bare Ground (%)

Disturbance:	Time Since Fire	Level of Human Impact	Condition

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)			
	% Cover			

Observations	

Field description of vegetation	

Species **Foliage Projective Cover**

Appendix D

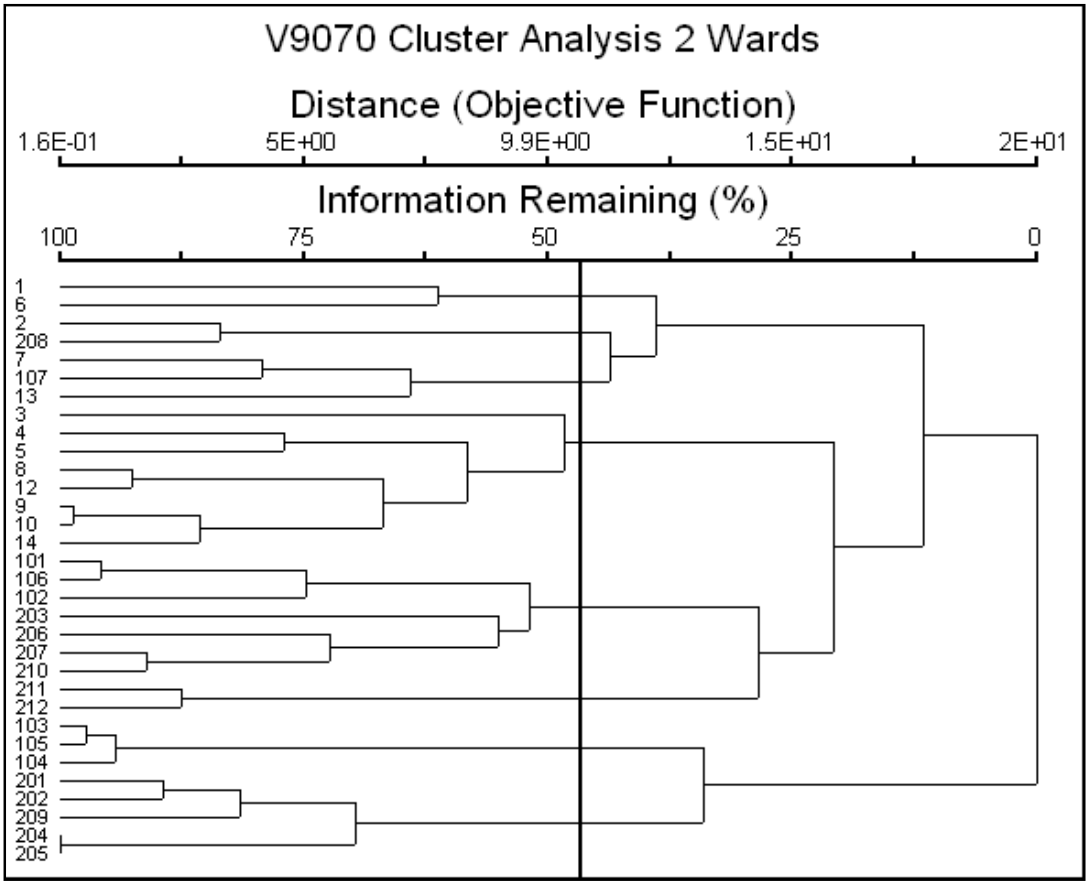
Plant Community Dendrogram, Species Area Curve and FCT Dendrograms

********** Hierarchical Cluster Analysis **********
PC-ORD, 5.18
18 Feb 2010, 13:58

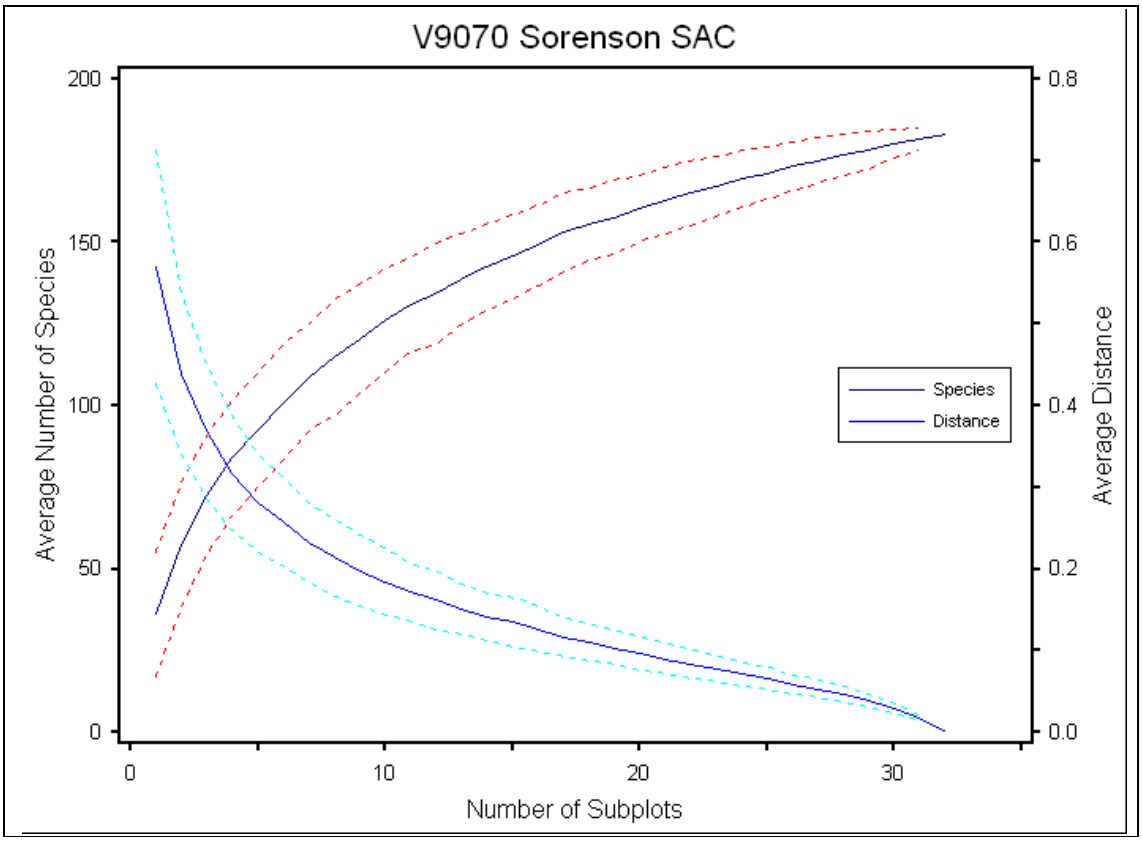
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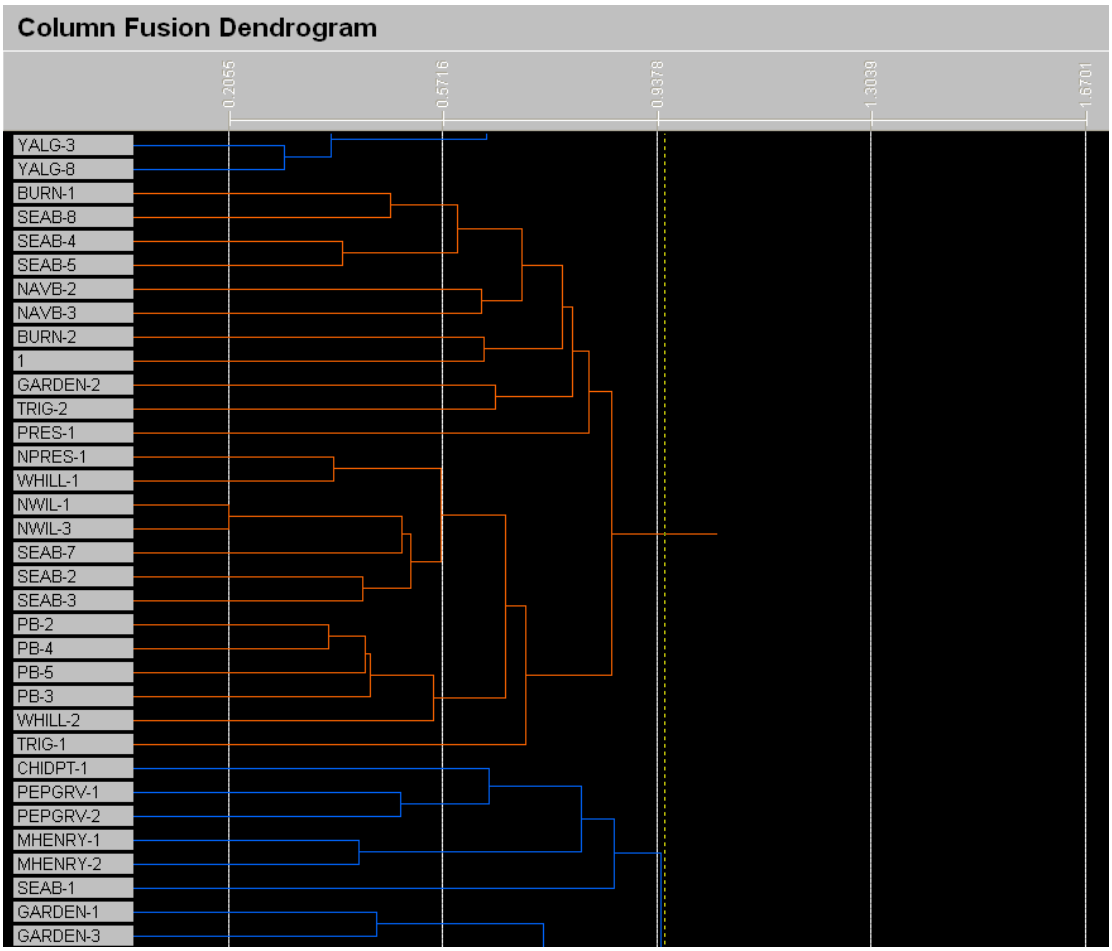
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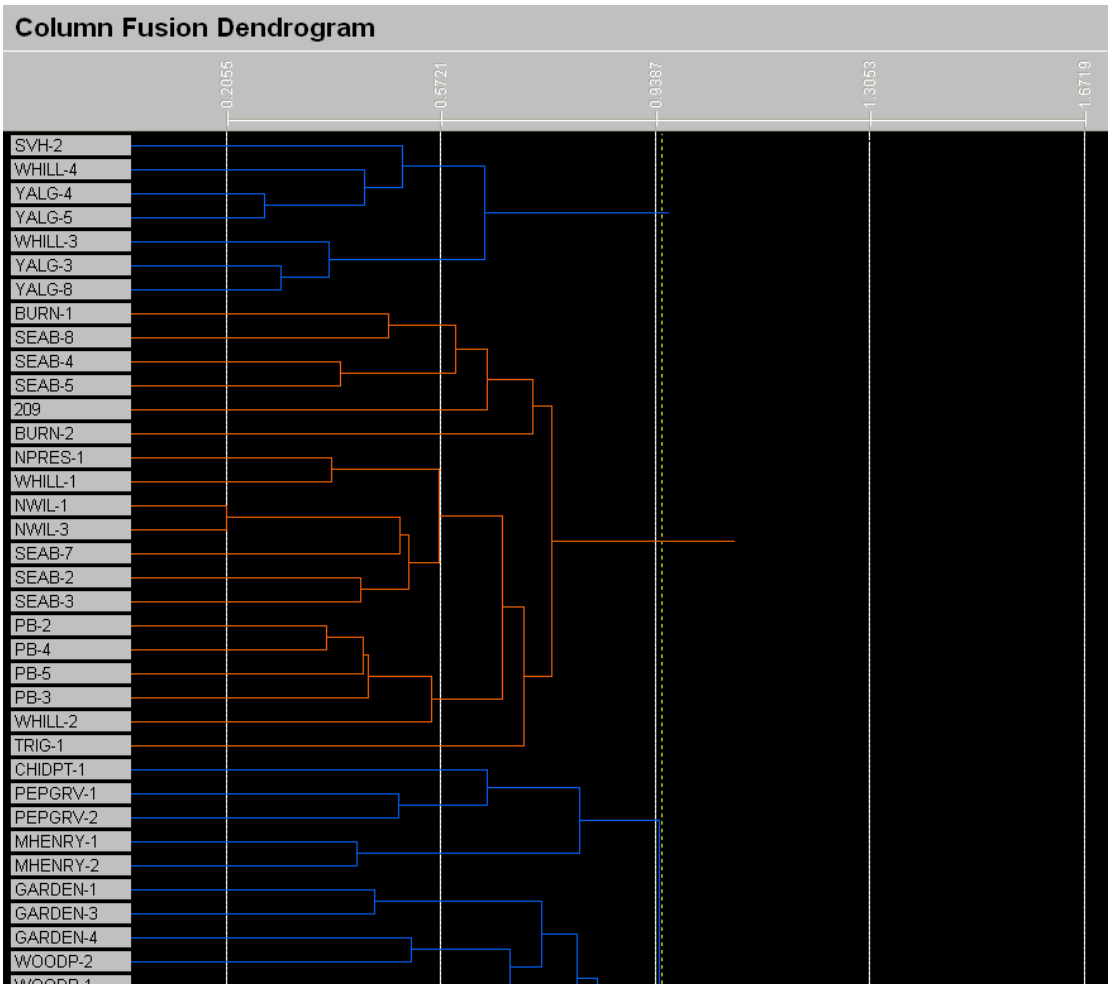
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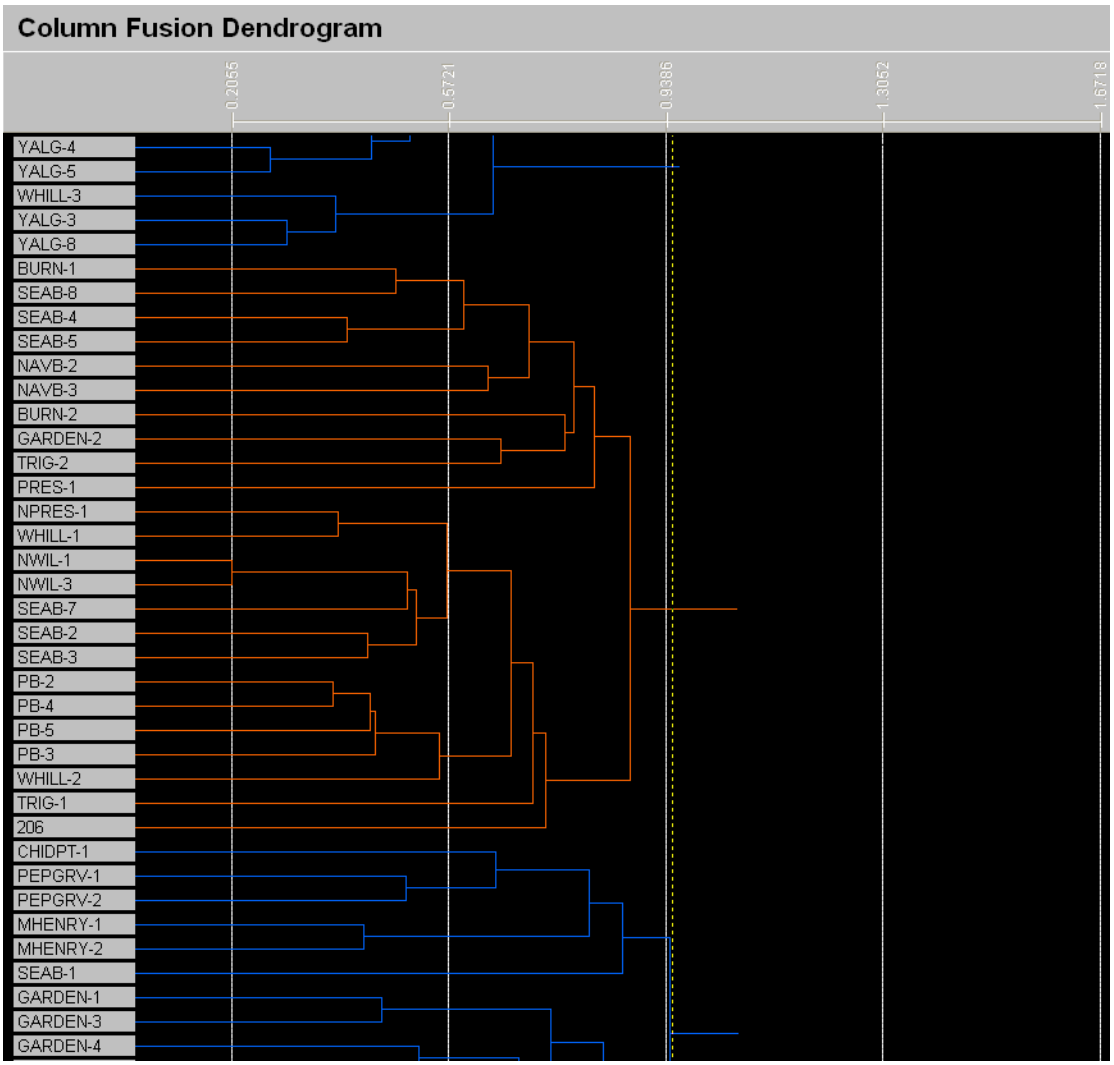
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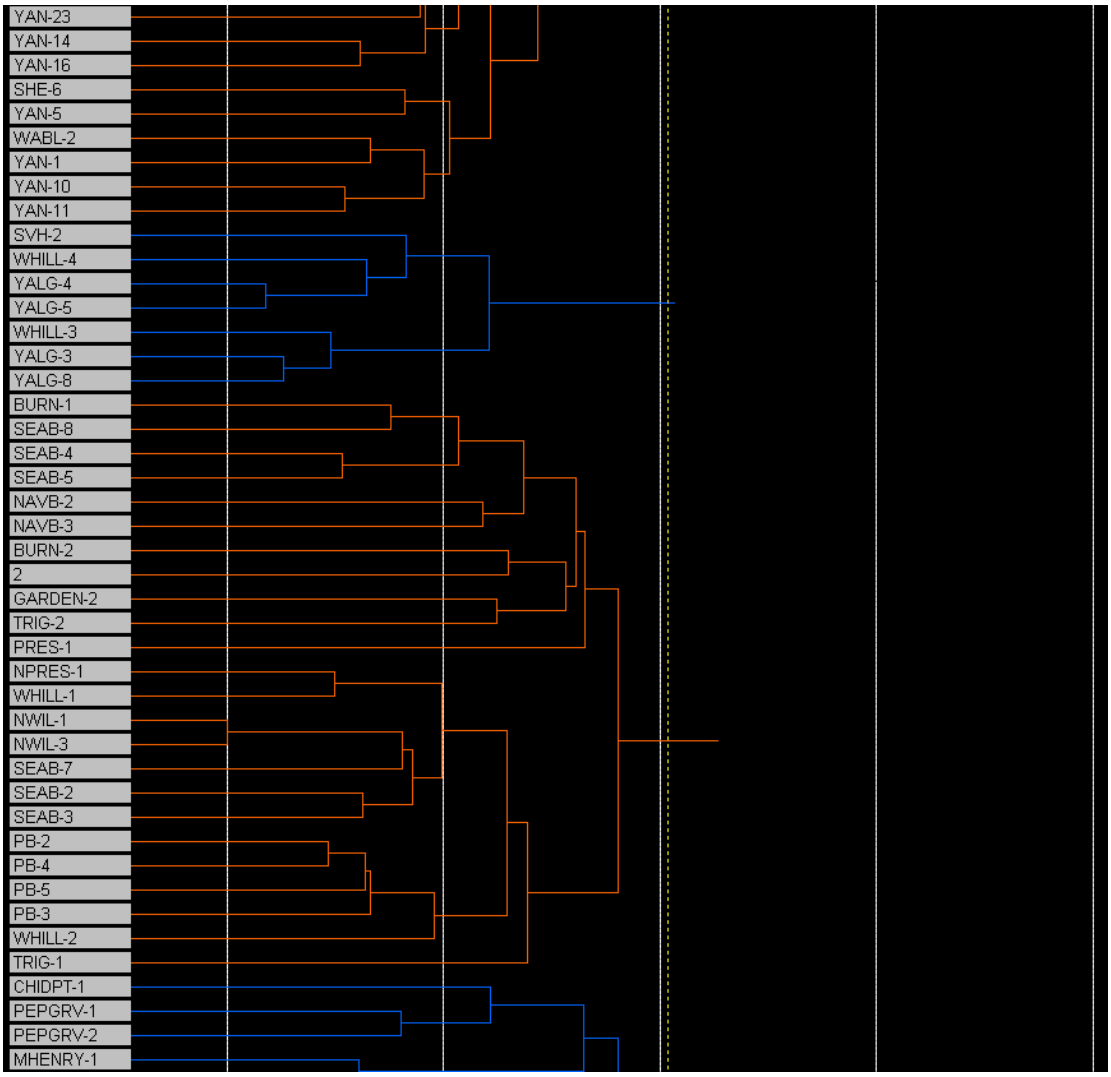
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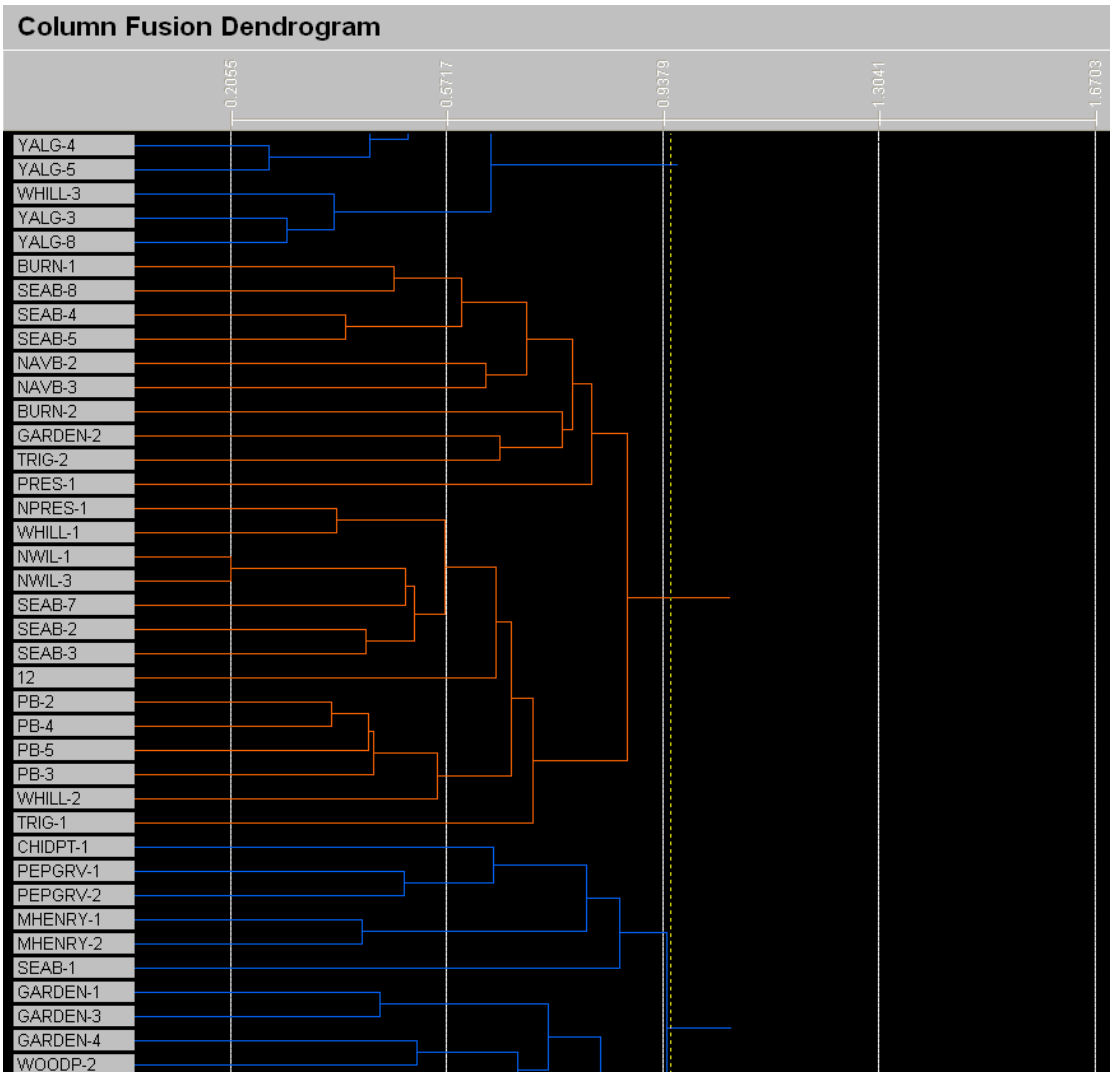
FCT Analysis – Site 206



FCT Analysis – Site 2



FCT Analysis – Site 12



Appendix E

Environmental Assessment 2003

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MOORE RIVER COMPANY PTY LTD

MOORE RIVER SOUTH ENVIRONMENTAL REPORT UPDATE

VERSION 5

OCTOBER 2003

REPORT NO: 2003/57

ATA Environmental

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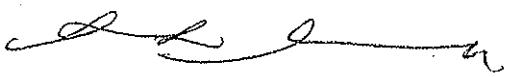
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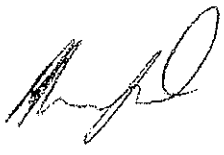
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Checked by: Signed: 

Name: Sarah Maxwell Date: 21 October 2003

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1. INTRODUCTION

1.1 Purpose and Scope

The Moore River Company Pty Ltd owns a large area of coastal land between Moore River and southwards to Wilbinga. The north-west portion of this land has been considered for urban development by the Shire of Gingin as part of the 1992 Development Strategy and Structure Plan for the Gingin Coastal Region. Subsequently, the Moore River Company lodged an Outline Development Plan (ODP) which was adopted by the Shire of Gingin in July 1998 and by the Western Australian Planning Commission in 2000.

In accordance with the regional and local structure planning the Moore River Company propose to lodge a subdivision application for the first cell of the landholding adjacent to the coast.

Environmental assessments of the landholding were undertaken by Alan Tingay & Associates (now ATA Environmental) between 1993 and 1998. The purpose of this report is to provide an updated assessment of the environmental characteristics of the landholding and the potential environmental impacts specific to the proposed subdivision.

1.2 Study Area

The Moore River Company (MRC) landholding is located in the Shire of Gingin and is bounded by the Indian Ocean to the west, the Moore River estuary to the north and pastoral and uncleared land of the same Locations to the east and south, as shown in Figure 1.

The entire landholding occupies approximately 2000ha comprising Swan Location 2802, 2424, 2914, 3156, 2593 and 3099. The area of land subject to the ODP area is situated in the north western portion of the landholding and covers an area of 557ha, consisting of Swan Location 2802 and portions of Swan Location 2424 and 2914 and is bounded by property owned by Moore River Company which extends to the east and south, and other privately owned lots.

The landholding is separated from the mouth of the Moore River by Reserve 17949 which is vested with the Shire of Gingin and covers approximately 19ha. The landholding is further separated from the river to the east of the ODP area by Swan Locations 2481 and 2149 which are not owned by Moore River Company.

The landholding is bounded by Wilbinga to the south and properties largely supporting native vegetation to the east. The existing Woodridge development adjoins the northeastern corner of the site. Guilderton townsite is situated to the north of the landholding, adjacent to the north side of the Moore River mouth.

The area of land subject to the subdivision application, herein referred to as the study area, encompasses 60ha and is located immediately adjacent to the coast. The study

area in relation to the MRC landholding and area subject to the Outline Development Plan is shown in Figure 2.

1.3 Land Use

The landholding has for many years and continues to be extensively used for various farming and grazing purposes. Consequently much of the landholding, particularly the eastern section, has been cleared and converted to pasture or is relatively degraded as a result of grazing activities. Remnant vegetation occurs along the river and coastal sections and in isolated and disturbed patches throughout the landholding.

The Reserve and private property separating the landholding from the Moore River have not been subjected to the same level of grazing and clearing and support representative vegetation.

1.4 Previous Relevant Studies

ATA Environmental (formerly Alan Tingay & Associates) has undertaken several environmental studies to assist the preparation of the various planning submissions, including the ODP for a portion of the landholding, as listed below:

- South Guilderton Environmental Assessment (Alan Tingay & Associates, 1993).

  This study was undertaken to assess the environmental opportunities and constraints to urbanisation of the landholding with a particular review of flora and vegetation issues and coastal stability.

- Management Plan for the Southern Foreshore of the Moore River Estuary (Alan Tingay & Associates, 1994).

  As part of the approval to rezoning the MRC landholding from Rural to Urban, the MRC made a commitment to prepare a Foreshore Management Plan (FMP) for those parts of the landholding that abut the Moore River. The 1994 Management Plan describes the physical and botanical features of the study area and existing and proposed land uses and management strategies. The management strategies provide for access, recreation and conservation needs and also specify a recommended treatment for a large sand drift which occupies a major part of the northern portion of the area. The main objectives of the FMP were to define a development setback from the river, and outline management strategies designed to preserve the natural environment of the river frontage (including the river itself) while accommodating the recreational needs of future local inhabitants.

- Moore River South Coastal Foreshore Management Plan and Strategy (Alan Tingay & Associates, 1996).

  This report describes a planning strategy for the coastal sector of the MRC landholding. The report defines a Foreshore Reserve based on physical environmental features and coastal recreation potential, particularly information in previous regional studies, aerial photography, topographic plans and site assessments of the coastal area. The study also defines requirements for management of recreational demands including potential locations for access, recreation facilities and amenities and rehabilitation requirements.

- Moore River South Coastal Engineering Study (MP Rogers & Associates, 1994).

  This study was undertaken by MP Rogers to assist the preparation of the Coastal Strategy and Management Plan by ATA in 1994. The MP Rogers study examined the stability of the coastline adjacent to the MRC landholding and provided recommendations on the appropriate setback to development from a coastal stability point of view. Concept planning for a small boat launching facility and possible marina were also investigated as part of the study.

- Reserve 17949, Moore River Management Plan (ATA Environmental, 1998).

  This Management Plan was prepared on behalf of the Moore River Company (MRC) at the direct request of the Shire of Gingin. The principal objectives of the Plan included developing strategies to preserve the natural environment of the Reserve while accommodating the recreational needs of future residents and visitors and identifying a suitable linkage between the Moore River foreshore and the coastal reserve.

- Moore River South Vertebrate Fauna Survey November 1997 (ATA Environmental, 1998).

  This report presents the results of a survey undertaken by Alan Tingay & Associates in association with John Dell of the Western Australian Museum on 4 November 1997. The survey encompassed the entire MRC landholding with particular reference to the area referred to as Moore River South which is zoned "Urban Development" and is subject to an Outline Development Plan (ODP). The survey area included land in the eastern portion of the landholding and a Reserve vested with the Shire of Gingin which adjoins the ODP area at the mouth of the Moore River.

The above reports have been reviewed and information extracted and updated which is relevant to the proposed first stage of subdivision to form the basis of this document.

1.5 Environmental Approvals

A proposal to rezone the MRC landholding from Rural to Urban Development was referred to the EPA on 11 February 1994 and identified a number of commitments by the MRC to manage to proposed development, including:

- preparation of a Coastal Foreshore Management Plan to the satisfaction of the Department for Planning and Infrastructure (DPI) and Shire of Gingin prior to the approval of the ODP;
- preparation of a River Foreshore Management Plan to the satisfaction of the Department of Environmental Protection, DPI and Shire prior to approval of the ODP;
- ensure that the residential development will be deep sewered; and
- preparation of a Drainage and Nutrient Management Plan.

An informal level of assessment was set by the EPA on 25 February 1994. The DEP then provided advice to DPI on the proposal in September 1994 to draw attention to a number of issues including rare and unusual flora, the foreshore reserve of the Moore River, and water quality in the Moore River estuary.

The Minister for the Environment dismissed all appeals relating to the level of assessment following a thorough examination of the site by the Appeals Convenor. Subsequently, Amendment 22 to the Shire of Gingin Town Planning Scheme No. 8 was gazetted in March 1995.

In July 1998 the Shire of Gingin adopted the Moore River South ODP which was accompanied by several specialist studies mostly relating to environmental matters and prepared to fulfil the commitments of the MRC. Prior to adopting the ODP, the Shire liaised directly with the DEP and WRC regarding foreshore setbacks, vegetation and other environmental issues. In addition, the WAPC/DPI liaised with the DEP and WRC in arriving at its endorsement of the ODP in January 2000.

2. PHYSICAL ENVIRONMENT

2.1 Topography

The MRC landholding rises steeply away from both the beach and Moore River to a series of high dunes, dune ridges and valleys. Steep slopes occur from the Moore River up to the dune crests (up to 50m AHD) along the shore.

The coastal dunes attain heights of 10m AHD near the coast and up to 30m AHD a short distance inland. In the northern section of the coast there is a large valley behind the dunes which has a low point of less than 5m AHD.

Further inland the landholding lies between the 10 and 60m AHD levels with several small sandy knolls or chaots rising above the general surface level. A major dune ridge extends inland from the coast near the southern part of the study area and achieves elevations of 50 - 60m AHD.

The topography of the study area and wider MRC landholding is shown in Figure 2.

2.2 Geomorphology

The MRC landholding lies on the western extent of the Swan Coastal Plain which is an undulating lowland bounded to the east by the Darling and Dandaragan Plateaus and to the west by the Indian Ocean. The landholding contains two of the main geomorphic features of the Swan Coastal Plain; the Quindalup Dune System and Spearwood Dune System.

The Quindalup Dune System is a Holocene landform which extends along the coast from Geographe Bay to Dongara. Within the Quindalup Dune system there is a variety of aeolian landforms developed by climatic, geomorphic and sedimentology factors as well as coastal processes, distance from strandline and vegetative cover. Large to medium scale geomorphic units which occur within the Quindalup Dune System include parabolic dunes, chaots, shore-parallel ridges, shore-transverse ridges, blowouts, undulating plains, flats and conical hill residuals. The Quindalup Dunes extend along the whole coastline of the MRC landholding in a series of fretted parabolic dunes, chaots, a few small conical hill residuals and a large shore transverse ridge (remnant of a large parabolic dune). The inland Quindalup dunes which extend to the eastern boundary of the landholding are part of a large system up to 6km inland starting at the northern end of Wilbinga up to the Moore River. The coastal dunes in places are still active with blowouts and mobile crests moving gradually inland.

The dune system fronting the sandy beach in the northern part of the landholding does not have any small foredunes. Instead there is a steep rise to the crest of the first dune up to 10m above the sand below. Further south a vegetated foredune has developed with a height of 2m and up to 10m wide. Immediately inland from the narrow low foredune zone the dunes again rise steeply to tall secondary dunes except in places where blowouts have proceeded inland and have broken through the shore-parallel dunes.

The Spearwood Dune System is a series of shore parallel ridges which are older (Pleistocene) than the Quindalup Dune System (Holocene). The Spearwood Dune System has a similar distribution along the coastline as the Quindalup Dune System but is more extensive laterally from several kilometres inland to sub-marine expressions and coastal islands off-shore. Near the coastline the Spearwood Dunes are mostly overlain by the Quindalup Dunes System.

The Spearwood Dunes in the MRC landholding are mainly overprinted by shallow to deep Quindalup dunes. There are no surface expressions of the Spearwood Dunes within 300m of the coast. Further inland the Spearwood Dunes are exposed immediately east of the tall chaotic dune system in the southern and central portions of the landholding and in the northern section between ridges of parabolic dunes.

The Spearwood Dunes are mainly flat to gently undulating landforms with no major ridge systems on the landholding.

2.3 Soils

The soils of the MRC landholding consist of Safety Bay Sand (Quindalup Dune System) and Tamala Limestone (Spearwood Dune System).

The Safety Bay Sand is composed of pale cream coloured calcareous sands. Soil development is very poor ranging from no development on the youngest dunes and mobile dunes up to 50cm thick on older dunes.

Where the soil profile has been developed the topsoil consists of an organic layer over pale brown soils to 50cm depth. The older dunes may also have weakly cemented subsurface layers which occasionally outcrop on the sides of tall dunes.

The Tamala Limestone soils in the landholding belong to the Cottesloe Association which are defined as consisting of exposed limestone which weathers to a siliceous brown sand. Outside the study area the sand can be up to 5m deep over the limestone but within the study area the Tamala Limestone is mainly expressed at the surface as limestone rock with only a shallow sand cover in places.

2.4 River and Coastal Processes

2.4.1 Moore River Estuary Foreshore

The MRC landholding includes land with direct frontage to the Moore River. The landholding is located adjacent to approximately 2.5km of river or estuary foreshore between Reserve 17949 located at the river mouth to the west and Swan Location 2481 to the east. The northern boundary of the study area is located approximately 650m from the Moore River.

A Foreshore Management Plan was prepared for the length of river foreshore abutting the development area by ATA Environmental in 1994. The principal objective of the FMP was to define a development setback from the river, and propose management strategies

to preserve the natural environment of the river frontage (including the river itself) while accommodating the recreational needs of future local inhabitants.

2.4.2 Coastal Foreshore

The Moore River South Coastal Management Plan and Strategy prepared by Alan Tingay & Associates in 1996 provided a description of the coastal foreshore from the mouth of the Moore River to the southern boundary of the landholding. The following section provides a description of the foreshore subject to the subdivision application.

Description

The northern end of the foreshore in the study area consists of a narrow (10m wide) beach with a moderate to steep slope, backed by low (0.5m to 1m) foredunes colonised with marram grass.

The remainder of the foreshore consists of low foredunes backed by large blowout features. Primary dunes are set back beyond a comparatively broad swale and exhibit wind eroded seaward slopes. The steep berm has a storm cut cliff which allows for protection of foredunes from wave activity. The upper berm and foredunes are revegetating with marram grass.

The dunes are predominantly degraded through wind erosion causing successive blowout features with occasional vegetated remnants or conical hill residuals remaining. Dune heights range from an average 5m at the foredune up to a maximum of 18m. The average height of the remnant dune crests is approximately 13m. A large bowl at the southern end of the sector has a bottom elevation of 2m AHD and a ridge up to 30m in height in the arm of the larger parabolic dune feature.

Coastal Stability

An assessment of long term stability of the coastal foreshore of the MRC landholding was conducted by MP Roger & Associates in 1994 to assist in determining a foreshore reserve boundary as part of the Moore River South Coastal Foreshore Management Plan and Strategy (Alan Tingay & Associates, 1996).

Review of aerial photography between 1985 and 1992 demonstrated that the South Guilderton coastal vegetation line has remained stable or accreted between 5m and 15m during this period. The exception is the 400m of coast directly south of the river mouth, comprising Crown Reserve ↑17949, which has receded since 1985.

In addition to the recent trend, high water mark surveys from 1910 were obtained, covering 1.5km of coast south of the Moore River. Comparison of the 1910 survey data and 1994 survey plans indicates there has been little coastal movement during this time.

The conclusion of the coastal engineering study for South Guilderton is that longshore and cross-shore processes are in balance, resulting in a stable coastline adjacent to the landholding (MP Rogers & Associates, 1994). The study recommended that any proposed development adjacent to the coast incorporate provision for a 100m setback

from the existing coastal vegetation line to ensure protection from storm erosion and the effects of possible climate change.

This is consistent with the Statement of Planning Policy No. 2.6 – State Coastal Planning Policy (WAPC, 2002) which as a general guide requires a total setback in the order of 100 metres from the horizontal setback datum (HSD). This can be reduced however to at least 78m on an undeveloped sandy shore with an established historical rate of chronic accretion and 98m on an undeveloped sandy shore with no clearly defined historical evidence of chronic erosion.

2.5 Hydrology

The MRC landholding represents the extreme north-west corner of the Gnangara groundwater mound. The groundwater generally slopes downward to the west to sea level near the coast but would also have some outlet to the north into the Moore River. Groundwater flow is estimated to be about 2400m^3/day per kilometre of coastline.

Recharge of the groundwater occurs through rainfall infiltration through the porous soil. Annual recharge over the site is estimated to be about 30% of rainfall. Water table levels fluctuate only a small amount during the year, about 10 to 30cm. A freshwater/saltwater interface occurs at the coast where seawater underlies the fresh groundwater.

The deeper Leederville Formation extends to 200 and 700m below sea level and contains fresh groundwater which is recharged in the vicinity of the Gingin Scarp. A thick 100 to 200m impermeable strata prevents groundwater flow between the Tamala Limestone aquifer and the Leederville Formation.

3. BIOLOGICAL ENVIRONMENT

3.1 Vegetation and Flora

3.1.1 Vegetation Types

The vegetation of coastal areas between Perth and Lancelin is strongly determined by the Quindalup and Spearwood Dune soil types as well as geomorphic features and proximity to the coast.

The vegetation of the MRC landholding was surveyed by Alan Tingay & Associates in November 1992 (Alan Tingay & Associates, 1993) and described according the main vegetation associations, types and alliances, as listed below. A vegetation map of the entire landholding is shown in Figure 3.

An attempt to standardise vegetation descriptions in coastal environments north of Perth was proposed for the Yanchep area. This classification system forms the basis of the descriptions and mapping prepared by Alan Tingay & Associates in 1993. Accordingly, the most basic unit for describing vegetation is the Association which is a recognisable unit of component species with particular dominants after which the association is named. The Yanchep classification system groups associations which are floristically similar into Types which can be further grouped into Alliances.

Alliance A	Young Quindalup Dune Heath.	
Type A1	Strand Vegetation	
Associations	Aa	*Ammophila arenaria* Grassland (Marram).
	OaSI	*Olearia axillaris* Open Shrubland over *Spinifex longifolius* Grassland.
Type A2	Olearia axillaris on Q4 Sand.	
Associations	OaSc	*Olearia axillaris/Scaevola crassifolia* Shrubland.
Type A3	*Acacia rostellifera/Spyridium globulosum* on Q3 sand.	
Associations	AleSg	*Allocasuarina lehmanniana/Spyridium globulosum* Scrub.
Alliance B	Old Quindalup Dune Heath	
Type B1	*Melaleuca acerosa* (now *M. systena*)/*Acacia lasiocarpa* on Q2 Dunes.	
Associations	MaA1	*Melaleuca acerosa/Acacia lasiocarpa* Low Open Heath
	MaA1Cu	*Melaleuca acerosa/Acacia lasiocarpa/Chamelaucium uncinatum* Low Open Heath
	MaCu	*Melaleuca acerosa/Chamelaucium uncinatum* Low Open Heath
	MaCq	*Melaleuca acerosa/Calothamnus quadrifidus* Closed Heath
	MaOa	*Melaleuca acerosa/Olearia axillaris* Shrubland
	AleMa	*Allocasuarina lehmanniana/Melaleuca acerosa* Shrubland
	ArMa	*Acacia rostellifera/Melaleuca acerosa* Closed Heath
	Ar	*Acacia rostellifera* Closed Heath
	SgMa	*Spyridium globulosum/Melaleuca acerosa* Shrubland

Alliance C	Limestone Heath Types	
Type C1	*Dryandra sessilis* on Limestone Outcrops	
Associations	Ds	*Dryandra sessilis* Heath to Closed Heath
Type C3	*Melaleuca huegelii* on Limestone Outcrops	
Associations	Mh	*Melaleuca huegelii* Low Open Heath
	DsMh	*Dryandra sessilis/Melaleuca huegelii* Open Heath
	AtMh	*Acacia truncata/Melaleuca huegelii* Heath
	Mc	*Melaleuca cardiophylla* Closed Scrub
Alliance D	Sand Over Limestone Vegetation	
Type D1	*Banksia attenuata* Vegetation	
Assocations	Ba	*Banksia attenuata* Low Woodland
	BaBp	*Banksia attenuata/B.prionotes* Low Woodland
Type D3	*Eucalyptus gomphocephala* (Tuart) Vegetation	
Association	EgAle	*Eucalyptus gomphocephala* Woodland over *Allocasuarina lehmanniana* Shrubland

The vegetation types relevant to the subdivision application study area are described below and mapped in Figure 3.

The strand vegetation is the first vegetation encountered along the coast and is quite limited in extent in the study area and wider landholding. Where low foredunes have developed these are covered mainly in Marram Grass (*Ammophila arenaria*). Between these foredunes and the large secondary dunes a narrow section of *Olearia axillaris* Shrubland with some *Spinifex longifolius* occurs. Where there is no foredune the vegetation at the base of the first secondary dune consists mainly of *Cakile maritima*.

The seaward face and crests of the first tall secondary dune typically contain an *Olearia axillaris/Scaevola crassifolia* (OaSc) Shrubland. A narrow zone of this vegetation association occurs along the length of the coastal dunes.

Immediately inland from this OaSc vegetation these is a variety of vegetation associations belonging to the *Melaleuca acerosa (*now *M. systena)/Acacia lasiocarpa* (MaAl) Type which occur typically on more stable Quindalup dunes with the beginnings of a soil profile. In the coastal areas other shrubs which can dominate with the vegetation type include *Acacia rostellifera, Olearia axillaris* and *Spyridium globulosum*. Rarely does the vegetation achieve any substantial height, being mostly a heath formation less than 2m tall.

Towards the northern portion of the study area, an isolated patch of *Allocasuarina lehmanniana* occurs in large dense Scrub formations. This stand of *A. lehmanniana* is dissected from the balance of this vegetation type by a large sand sheet extending from the Moore River foreshore.

The inland Quindalup dunes extend to the eastern region of the study area and are generally dominated by MaA1 Low Open Heaths with *Calothamnus quadrifidus* and *Chamelaucium uncinatum* co-dominant in many areas.

Dryandra sessilis and *Melaleuca huegelii* vegetation types occur in the central and north eastern region of the study area where limestone soils outcrop. The *Melaleuca huegelii* type, often with *Acacia truncata*, occupies a more westerly distribution than the *Dryandra sessilis* Heaths.

A *Eucalyptus gomphocephala* (Tuart) Woodland occurs at the northern boundary of the study area with trees up to 20m tall. The understorey of the Tuart Woodland consists mainly of an *Allocasuarina lehmanniana* Shrubland.

3.1.2 Floristic Community Types

The area subject to the subdivision application comprises up to four different floristic community types (FCTs) as inferred from information collected during the November 1992 flora survey and other surveys conducted in the region. All of these FCTs are found in Super Group 4 which is typical of the Spearwood and Quindalup Dunes. FCT 24 and 28 typically occur in the Spearwood Dunes while FCT 29a and S11 typically occur in the Quindalup Dunes.

According to Gibson *et al.* (1994) FCT 24 and 28 are well reserved, being found in at least one Nature Reserve or National Park on the southern Swan Coastal Plain and are generally well distributed along the coast (Keighery *et al.*, 1997). However, FCT 29a is currently considered to be susceptible in terms of its conservation status as in most cases vegetation typical of this FCT is generally represented in narrow coastal strips which are designed to conserve the beaches not the vegetation of the coastal dunes (Keighery, *et al.* 1997). The conservation status of FCT S11 is currently undetermined.

TABLE 1
VEGETATION TYPES RECORDED IN THE STUDY AREA AND INFERRED FLORISTIC COMMUNITY TYPES

Association	Vegetation Type		Floristic Community Type
Alliance A - Young Quindalup Dune Heath			
Type A2 - Olearia axillaris on Q4 sand	OaSc	*Olearia axillaris/Scaevola crassifolia* Shrubland	S11
Type A3 - *Acacia rostelliferal/Spyridium globulosum* on Q3 sand.	AleSg	*Allocasuarina lehmanniana/Spyridium globulosum* Scrub	S11
Alliance B – Old Quindalup Dune Heath			
Type B1 – *Melaleuca acerosa* (now *M. systena)/Acacia lasiocarpa* on Q2 Dunes	MaA1	*Melaleuca acerosa/Acacia lasiocarpa* Low Open Heath	S11
	MaOa	*Melaleuca acerosa/Olearia axillaris* Shrubland	S11
	AleMa	*Allocasuarina lehmanniana/Melaleuca acerosa* Shrubland	S11
Alliance C - Limestone Heath Types			
Type C1 – *Dryandra sessilis* on Limestone Outcrops	Ds	*Dryandra sessilis* Heath to Closed Heath	24 or 29a
Type C3 – *Melaleuca huegelii* on Limestone Outcrops	Mh	*Melaleuca huegelii* Low Open Heath	24 or 29a
	Mc	*Melaleuca cardiophylla* Closed Scrub	24 or 29a
Alliance D – Sand Over Limestone Vegetation			
Type D1 – *Banksia attenuata* Vegetation	Ba	*Banksia attenuata* Low Woodland	28
	BaBp	*Banksia attenuata/B.prionotes* Low Woodland	28
Type D3 – *Eucalyptus gomphocephala* (Tuart) Vegetation	EgAle	*Eucalyptus gomphocephala* Woodland over *Allocasuarina lehmanniana* Shrubland	28

3.1.3 Vegetation Condition

The condition of the vegetation was assessed during the 1992 survey (Alan Tingay & Associates, 1993) with an emphasis on the degree of disturbance and extent of weed invasion. The condition of the native vegetation in the MRC landholding ranged from degraded areas cleared for pasture to Excellent. The areas of vegetation in best condition were coastal sections west of the main fence line and track. These areas contain few weeds and very few tracks. Vegetation parallel to the southern Moore River riverbanks is also in Very Good condition with small areas comprising tracks and non-invasive weed species.

The inland areas have largely been cleared for agriculture while islands of remnant native vegetation range from Very Good to Degraded due to the effects of grazing and prevalence of invasive weeds.

3.1.4 Flora

A flora survey of the MRC landholding was undertaken by ATA Environmental in early November 1992. A total of 117 native species were recorded from the landholding. The list of flora recorded in the landholding is contained in 'South Guilderton Environmental Assessment (Alan Tingay & Associates, 1993)'. The most represented families include Cyperaceae (5 species), Poaceae (4) and Haemodoraceae (4) for the Monocotyledons and the Proteaceae (12), Asteraceae (10) and Papilionaceae (9) for the Dicotyledons. There was an absence of orchid species from the list due to the timing of the survey when most orchid, and other ephemeral species, would have died back to their underground components.

The species list probably represents about 90% of the total native species present in the MRC landholding.

3.1.5 Significant Flora

Prior to the November 1992 survey, CALM was consulted to obtain a list of significant flora which have been recorded at or in the near vicinity of the landholding. This list obtained in 1992 has been updated for this report to include updated changes to the conservation codes of the flora according to the current CALM list (CALM, 2003). Accordingly, two Declared Rare Flora species and seven species of Priority Flora were listed by CALM as occurring in the general district but not necessarily on the landholding, as shown in the following table.

TABLE 2
SIGNIFICANT FLORA RECORDED IN THE VICINITY OF THE MRC LANDHOLDING

Species	Conservation Code
Chamelaucium conostigmum ms	3
Chorizema varium	R
Dryandra sclerophylla	4
Eucalyptus argutifolia	R
Eucalyptus foecunda ssp. Coolimba sp.	3

Species	Conservation Code
Olax scalariformis	3
Stylidium maritimum	3
Tetratheca pilifera	3
Verticordia paludosa	4

The flora survey of the MRC landholding did not identify any species listed by CALM as Declared Rare or Priority. However, three species are worthy of mention due to their poor representation in reserves or uncommon distribution. These species are as follows:

- *Allocasuarina lehmanniana*
  This species occurs on Quindalup Dunes and shallow sand over limestone and is uncommon on the Swan Coastal Plain occurring in only one reserve (Trigg Bushland Reserve). It also occurs south of Yanchep and at Wilbinga. This species occurs in large stands in the northern section of the ODP area.

- *Marianthus erubescens* (previously *Billardiera erubescens*)
  This species is known from the south coast up to Wongan Hills but mainly on inland sites. It has only been recorded in the Perth coastal area near Two Rocks. At both Two Rocks and the study site this species occurs infrequently on exposed limestone vegetation (*Melaleuca huegelii* Type) close to the coast in the northern section.

- *Thomasia triphylla*
  Restricted to coastal limestone between Breton Bay and Augusta. It is near its northerly extent in the study area, where it occurs on exposed limestone (*Melaleuca huegelii* Type) close to the coast in the central portion.

While the flora survey was not able to identify some ephemeral species due to the late Spring timing of the survey, no Declared Rare or Priority Flora species of ephemeral habit have been recorded in the vicinity of the landholding. Therefore the timing of the survey is highly unlikely to have led to any significant flora species being missed.

3.1.6 Conservation Value of the Flora and Vegetation

Flora

No Declared Rare or Priority Flora species were recorded on the landholding in general or in the subdivision area specifically. However, three unusual species, *Allocasuarina lehmanniana, Marianthus erubescens* (previously *Billardiera erubescens*) and *Thomasia triphylla*, were recorded in the landholding. Within the subdivision area, *Marianthus erubescens* and *Thomasia triphylla* potentially occur in the *Melaleuca huegelii* (Mh) vegetation type which is found in the southeast region of the study area. *Allocasuarina lehmanniana* occurs in small stand in the northern most point of the subdivision area.

Consideration has been given to protecting these species as part of the subdivision design. In particular, the small stand of *Allocasuarina lehmanniana* located at the northern boundary of the study area has been protected in open space. This stand of *Allocasuarina lehmanniana* vegetation is located adjacent to a Tuart grove which has also been retained in open space.

Floristic Community Types

The vegetation survey undertaken in 1992 suggests no FCTs listed as Threatened Ecological Communities (TEC) at either the state level or Commonwealth level (English and Blyth, 1997 and CALM 2002) occur in the study area. The study area however, does support FCT 29a which is recommended for listing as a Threatened Ecological Community. The vegetation types which represent this FCT is dominant over most of the study area and will have representative areas protected in local open space including the foreshore reserve.

FCT 24 and 28 occur as smaller parcels in the eastern region of the site and to the south of the river mouth. These FCTs are currently well reserved in terms of reservation status and low risk (FCT 28) and Susceptible (FCT 24) in terms of their conservation status.

TABLE 3
CONSERVATION STATUS OF FLORISTIC COMMUNITY TYPES RECORDED IN THE STUDY AREA

Floristic Community Type		Reservation Status	Conservation Status
S11		Has not been determined	
24	Northern Spearwood Shrublands and Woodlands	Well Reserved	Susceptible
28	Spearwood *Banksia attenuata* or *Banksia attenuata* - *Eucalyptus* Woodlands	Well Reserved	Low Risk
29a	Coastal Shrublands on shallow sands	Poorly Reserved	Susceptible

Vegetation Types

The MRC landholding and study area has a wide range of vegetation associations and types. Most of these types are common on Quindalup and Spearwood Dune Systems on the Swan Coastal Plain. While the broad types may be common, specific associations may be uncommon or poorly represented in conservation reserves. The vegetation of the Quindalup Dune System is poorly conserved between Mandurah and Lancelin except for a narrow band of the youngest Quindalup Dune types which occur within the Foreshore Reserve areas. The Spearwood Dune vegetation is better conserved in large reserves including Yanchep and Neerabup National Parks.

Investigations in 1991 for potential sites for the Heavy Industry Site north of Perth identified the Wilbinga area to the south of the MRC landholding as containing vegetation with very high conservation values. Recent discussions between relevant Government agencies have resulted in the likelihood of retaining the Wilbinga property as a nature reserve. Wilbinga contains nearly all of the vegetation associations and types that occur within the landholding.

Particular vegetation associations which have been identified elsewhere as having a high priority for conservation is *Melaleuca cardiophylla* Scrub which is close to its southern limit of distribution and is poorly represented in conservation reserves. There is only one small stand of this association in the landholding, however this is located outside the study area adjacent to the Moore River foreshore.

The Tuart Woodlands are considered unusual so close to the coast north of Perth. A small pocket of Tuart grove is located at the northern boundary of the study area and is proposed to be protected in open space.

The vegetation types dominated by *Allocasuarina lehmanniana* are very unusual on the Swan Coastal Plain, being found in only one reserve, the Trigg Bushland Reserve. A large area of this vegetation type is currently protected immediately to the north of the study area in Reserve 17949. A smaller pocket occurs in the northern region of the study area of which a portion is proposed for protection in open space.

3.2 Fauna

A vertebrate fauna survey of the MRC landholding was undertaken in November 1997 to identify the distribution of the vertebrate fauna across the major habitat types available within the landholding, determine the presence or otherwise of any rare or unusual species that may require special conservation measures, and to identify the regional significance of the vertebrate fauna recorded at the site. The survey involved a trapping program, bird survey, active searching, opportunistic observations and review of relevant literature.

A total of 97 species of vertebrate fauna were recorded during the November 1997 survey. This included species which were detected within similar habitats on the landholding and on adjacent properties and are expected to inhabit or utilise habitats within the landholding. All of these species detected, have widespread distributions in the coastal and south-west regions of Western Australia. None is restricted to the habitat types found on the landholding. In summary, the vertebrate fauna of the landholding comprises:

- Amphibians 2 Species
- Reptiles 18 Species
- Birds 69 Species
- Mammals 8 Species (4 introduced)

One of the species detected during the survey is classified threatened and is protected under provisions of the *Wildlife Conservation Act 1950*. Another of the species recorded is included on the current Department of Conservation and Land Management's (CALM) Priority Fauna list (November, 1996).

3.2.1 Amphibians

Two species of frog were recorded during the survey. The Slender Tree Frog (*Litoria adelaidensis*) and Western Green Tree Frog (*Litoria moorei*) were heard calling along the Moore River. These species have widespread distributions on the Swan Coastal Plain and throughout the wetter regions of the south-west.

3.2.2 Reptiles

The survey identified 18 reptile species including 1 turtle, 2 geckos, 3 legless lizards, 1 dragon, 7 skinks and 4 snakes.

All of these species have a wide distribution on the Swan Coastal Plain or central coast and most have wide distributions in the southwest forested regions and the wheatbelt of Western Australia (Chapman and Dell, 1984). Few are habitat specific and most occur in a wide range of habitat types across the Coastal Plain (How and Dell, 1994). Only the legless lizard, *Aclys concinna* is likely to be restricted to the Quindalup and Spearwood dune systems (Storr *et al.*, 1990; How and Dell 1994).

3.2.3 Birds

Sixty-nine species of bird were recorded during the survey, comprising 37 passerines and 32 non-passerines. Generally, the avifauna recorded is typical of the region and the habitats available. Most of the bird species recorded are within their documented distribution and are not considered unusual in the region.

The Short-billed Black-Cockatoo (*Calyptorhynchus latirostris*) was recorded during the survey and is listed on Schedule 1 of the *Wildlife Conservation Act_1950*. A large flock of about 150 Short-billed Black-Cockatoos was observed in *Banksia* and Tuart Woodland.

The subspecies of Western Corella (*Cacatua pastinator*) occurring in the area is Butler's Corella which is not a gazetted rare species (Mawson and Johnstone 1997).

The record of the White-breasted Robin is of interest as it represents a possible extension of the widely accepted distribution of this species. The species is endemic to the south west region and has a distribution from Geraldton to the south coast with approximately a 100km gap around the Perth area. The Robin has also been recorded at Breton Bay to the north of the survey area. Prior to this, the southern limit of the isolated north coastal population which inhabits dense, tall *Acacia rostellifera* thickets, was reported to be just south of Lancelin. During the survey the White-breasted Robin was detected along the river and in Tuart Woodland.

3.2.4 Mammals

Eight species of mammal including four introduced species were recorded during the survey. All of the native mammals recorded have widespread distributions throughout south-west or southern Australia.

The Honey Possum (*Tarsipes rostratus*) was captured on two occasions, once in *Banksia* woodland and once in Limestone Heath. The Honey Possum is widespread in coastal and sandplain heaths of south-west Western Australia particularly those rich in Proteaceae and Myrtaceae plant species.

The Western Grey Kangaroo (*Macropus fuliginosus*) was detected in all major habitats of remnant vegetation and also pasture within the landholding boundaries.

Two Ash-grey Mouse (*Pseudomys albocinereus*) individuals were caught in pitfall traps within Limestone Heath only. The Southern Bush Rat *(Rattus fuscipes)* appeared more common with individuals caught in Tuarts and several juveniles and adults recorded in Limestone Heath.

The Honey Possum, Ash-grey Mouse and Bush Rat have all suffered range and population reductions on the Swan Coastal Plain. All of these species are however, common throughout the south-west and none is listed as threatened fauna.

The House Mouse (*Mus musculus*) was captured within *Banksia* and Tuart woodlands, Old Quindalup Heath and along the river. Evidence of the fox and rabbit occurred throughout the landholding. The cat was detected or observed within the Old Quindalup Heath, Tuarts and farmland.

3.2.5 Distribution

A summary of the distribution of native species recorded in the landholding during the November 1997 survey is presented in the following table.

TABLE 4
NUMBER OF FAUNA SPECIES RECORDED WITHIN EACH OF THE HABITAT TYPES

	HABITAT TYPE					
	Old Quindalup Heath	Limestone Heath	Banksia Woodland	Tuarts	Moore River	Farming Land
Amphibians	-	-	-	-	2	-
Reptiles	10	8	12	12	2	2
Birds	18	17	26	30	29	31
Mammals*	1	4	2	2	1	1
TOTAL	29	29	40	44	34	34

* native species only

According to the survey results the richest assemblage of vertebrate fauna is supported in Tuart Woodland (44 species) and *Banksia* Woodland (40 species). The number of species detected within the Tuart Woodland habitat type however, includes 15 species which were only detected at one site which lies outside of the Moore River South ODP area. The Old Quindalup Heath and Limestone Heath recorded the same level of species diversity with 29 species recorded within each. The higher species diversity within woodland sites may be attributable to the greater vertical complexity within these sites. Both the river foreshore and the farming land recorded relatively diverse fauna, particularly avifauna.

A fairly similar diversity of herpetofauna was recorded between habitat types. The woodlands once again supported the greater diversity with 12 species recorded in the *Banksia* and Tuarts. Old Quindalup Heath supports 10 species and 8 species were recorded in the Limestone Heath. Amphibians were only detected at the river survey site.

The richest habitat types for birds were the Tuart Woodlands and the Moore River. Thirty and twenty-nine species were identified in these areas respectively. The *Banksia*

woodlands also support a diverse array of bird species with 26 species recorded at these sites. Old Quindalup Heath and Limestone Heath sites were the least rich in avifauna. The farming land recorded a high diversity of birds largely because the cleared areas included remnants of various vegetation types.

The Limestone Heath recorded the greater number of mammal species with four species detected. The diversity of mammals was low at all other sites surveyed. Two species were located within both the *Banksia* and Tuart Woodland, while only one species, the Western Grey Kangaroo, occurred within the other habitats.

The species diversity recorded within each habitat type is not strictly comparable however, as trapping intensity and methods varied between sites. In particular, three Tuart woodland sites were selected, traps were set in only one Limestone Heath site, and no trapping was undertaken along the River or in farmland areas.

4. DEVELOPMENT CONSIDERATIONS

4.1 Foreshore Reserve Boundaries

4.1.1 Moore River

The Management Plan for the Moore River Estuary defines the setback to development as varying between 50 and 115m from the vegetation line (identified as coinciding with the High Water Mark in the Management Plan) (ATA Environmental, 1994). This is in accordance with the recommendations of the Department of Planning and Infrastructure that an estuarine setback of 50m is required from mean water level to conform with the Country Coastal Planning Policy (Section 3.6.4). However, this setback may vary depending on the topography and special circumstances of the particular site. This setback was determine after extensive consultation with the Department of Environmental Protection, Water and Rivers Commission and the WA Planning Commission.

The proposed foreshore reserve boundary along the Moore River is widest in the central part of the study area across the sand drift where the boundary corresponds with the landholding. The reserve then narrows east and west to be 50m wide.

The area of land subject to the proposed subdivision application is not located adjacent to the Moore River foreshore, however access to this area and use of facilities are likely to be management issues in the future.

The potential environmental impacts of development on the Moore River and foreshore have been addressed in the Management Plan for the Estuary prepared by Alan Tingay & Associates in 1994. The Plan discusses the issues and presents strategies that will enable the main objectives to be achieved, including, providing for the protection of the foreshore and estuary, and sustainable development of recreation facilities within the foreshore reserve and other land uses immediately adjacent to the reserve.

4.1.2 Coastal Foreshore

The Coastal Foreshore Reserve was delineated on the basis of coastal engineering studies undertaken by MP Rogers & Associates (1994) and the Coastal Foreshore Management Plan and Strategy prepared by Alan Tingay & Associates (1996).

The coastal foreshore reserve boundary fronting the proposed development area currently allows for a setback varying from 100m to 110m from the line of permanent vegetation.

The Foreshore Reserve boundary generally follows contour alignments contracting to a minimum width of 100m in the central region of the subdivision area.

The recommended setbacks to development are consistent with the Statement of Planning Policy No. 2.6 – State Coastal Planning Policy (WAPC, 2002) which as a general guide requires a total setback in the order of 100 metres from the horizontal setback datum (HSD). This can be reduced however to at least 78m on an undeveloped sandy shore with an established historical rate of chronic accretion and 98m on an undeveloped sandy shore with no clearly defined historical evidence of chronic erosion.

The coastal foreshore reserve boundary for the study area as defined in the Coastal Foreshore Management Plan and Strategy (Alan Tingay & Associates, 1996) is shown in Figure 4.

4.2 Management Recommendations for the Coastal Foreshore

The Coastal Foreshore Management Plan and Strategy recommended various management strategies for the foreshore area adjacent to the proposed subdivision area, described as follows and shown in Figure 4.

A dual use path is proposed within the Foreshore Reserve with four access routes identified for paths leading to local beach areas. Where possible the dual use path is aligned in response to topographic considerations (ie. along lines of least topographic variation). A car park and associated picnic area is also proposed for a topographic low within the Foreshore Reserve. As the beach areas within this sector will be ultimately suited to local use, the car park caters for a maximum of 25 vehicles.

It is recommended that a more detailed Foreshore Management Plan (FMP) be prepared for the part of the foreshore fronting the proposed subdivision area, to define the specific management proposals for the foreshore area. The FMP would typically and appropriately be required as a condition of subdivision approval.

4.3 Flora and Vegetation

Development of the subdivision area for residential purposes is not constrained by the presence of Declared Rare or Priority Flora as currently listed by CALM (2003).

The subdivision area and wider landholding comprise one floristic community, FCT 29a, which is currently recommended by CALM for listing as a Threatened Ecological Community (TEC). FCT 29a is currently protected in Reserve 17949 which is located immediately to the north of the subdivision area. In addition, protection of this community type will occur within POS located within the subdivision area.

In terms of vegetation associations, surveys of the landholding have determined that most of the vegetation types present in the area are common on the Quindalup and Spearwood Dune Systems. However, three main vegetation types were identified during the survey as being important, including *Melaleuca cardiophylla* Scrub, Tuart Woodland and *Allocasuarina lehmanniana* Scrub. The *Melaleuca cardiophylla* Scrub is considered important as it is close to its southern limit of distribution and is poorly represented in conservation reserves; the Tuart Woodland found in the landholding is an isolated pocket of Tuarts which is unusual so close to the coast north of Perth; and the Scrub dominated by *Allocasuarina lehmanniana* are very unusual on the Swan Coastal Plain, being found in only one reserve, the Trigg Bushland Reserve.

The *Melaleuca cardiophylla* Scrub is located outside the subdivision area adjacent to the northern boundary of the landholding. In addition, a small stand of Tuart Woodland is located immediately adjacent to an isolated area of *Allocasuarina lehmanniana* Scrub. These vegetation types are proposed to be protected in open space.

4.4 Drainage Management

Water sensitive urban design principles and techniques for the management of stormwater are to be implemented in the proposed subdivision area, in accordance with the Water and Rivers Commission's 'A manual for managing urban stormwater quality in Western Australia':

- using the natural contours to incorporate and enhance functions of the natural stormwater system;
- maximising local onsite storage;
- utilisation of vegetation, particularly native vegetation, in stormwater management to promote filtering and slowing of runoff to maximise the settling of particulate-bound pollutants;
- recognition of the natural drainage system by appropriately locating the open space system; and
- employment of water sensitive design approach to road layout, lot layout and streetscape.

5. SUMMARY AND CONCLUSIONS

This report has highlighted the following environmental opportunities and constraints for the subdivision application area:

- The area of land subject to the proposed subdivision application is not located adjacent to the Moore River foreshore, however access to this area and use of facilities are likely to be management issues in the future. The Management Plan for the Moore River Estuary prepared in 1994 addresses these issues.

- The coastal foreshore reserve boundary fronting the proposed development area currently allows for a setback varying from 100m to 110m. The setbacks are in accordance with the Draft Statement of Planning Policy No. 2.6 – State Coastal Planning Policy (WAPC, 2002).

- Review and update the Foreshore Management Plan and Strategy, prepared by Alan Tingay & Associates in 1996, to identify specific management proposals for the foreshore area fronting the proposed subdivision area.

- No Declared Rare or Priority Flora occur in the subdivision area.

- FCT 29a, recommended for listing as a TEC, is currently protected in Reserve 17949 which is located immediately to the north of the subdivision area. In addition, protection of this community type will occur within POS located within the subdivision area.

- Locally significant vegetation identified in the landholding, including a small stand of Tuart Woodland and *Allocasuarina lehmanniana* Scrub will be protected in open space. Other significant vegetation, *Melaleuca cardiophylla* Scrub, is located outside the subdivision area.

- Drainage design within the subdivision area will incorporate the principles of water sensitive urban design.

- The subdivision area will be deep sewered.

This report concludes on the basis of the issues identified above that the 60ha subdivision for the study area will not have a detrimental impact on any significant environmental features and is therefore considered environmentally acceptable.

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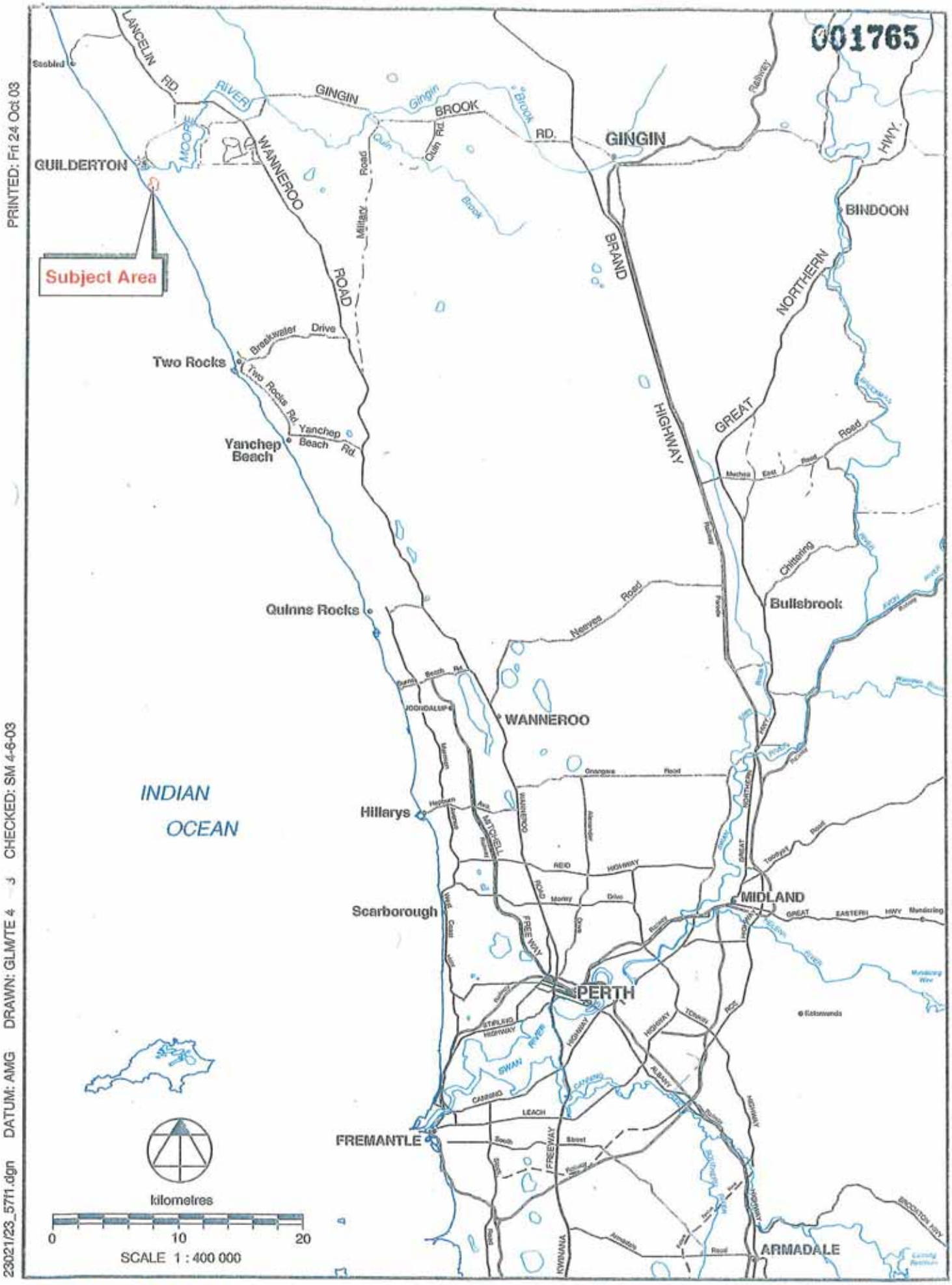
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FIGURES

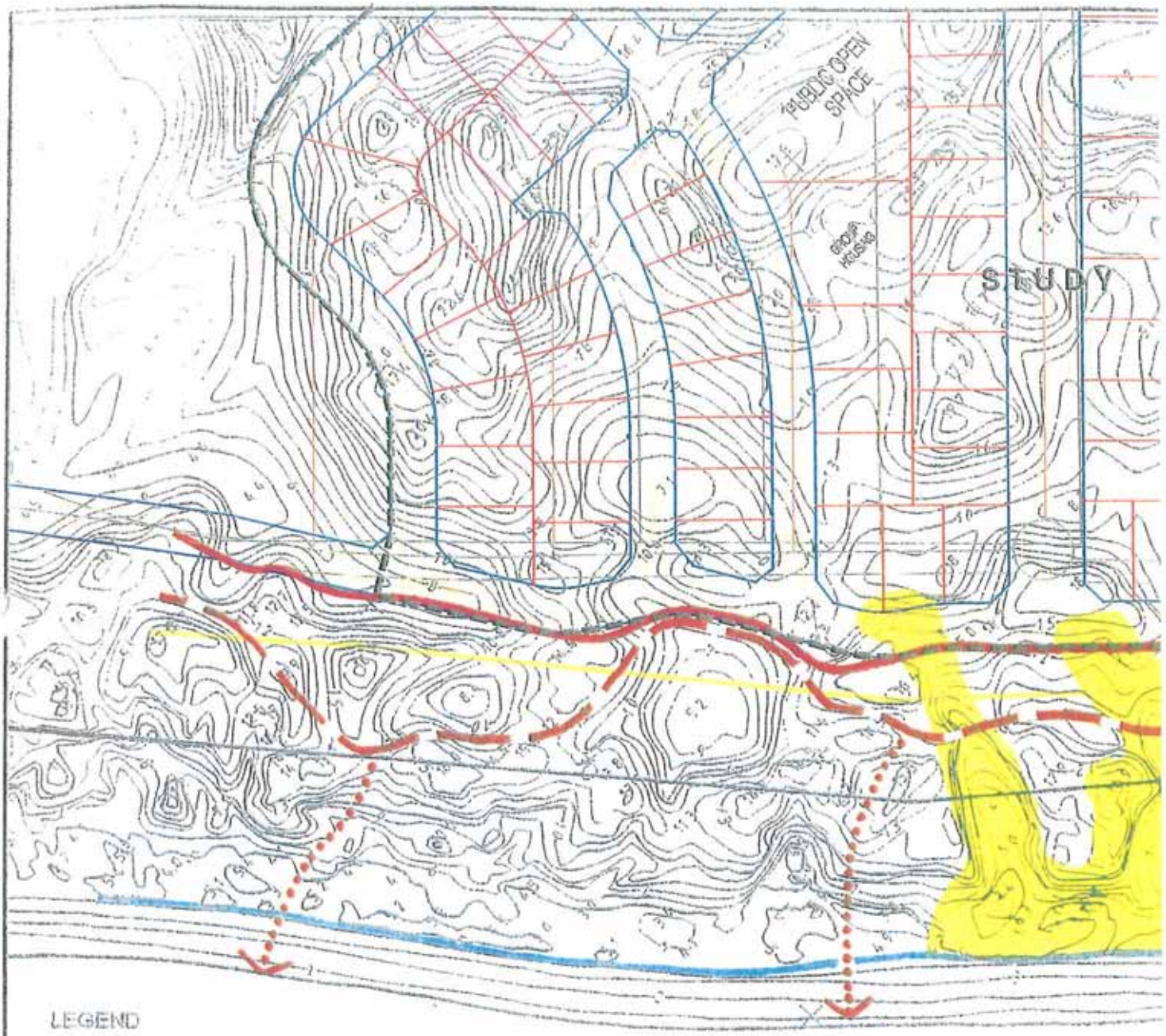


ATA Environmental
environmental scientists

MOORE RIVER SOUTH - ENVIRONMENTAL REPORT UPDATE

REGIONAL LOCATION

FIGURE 1

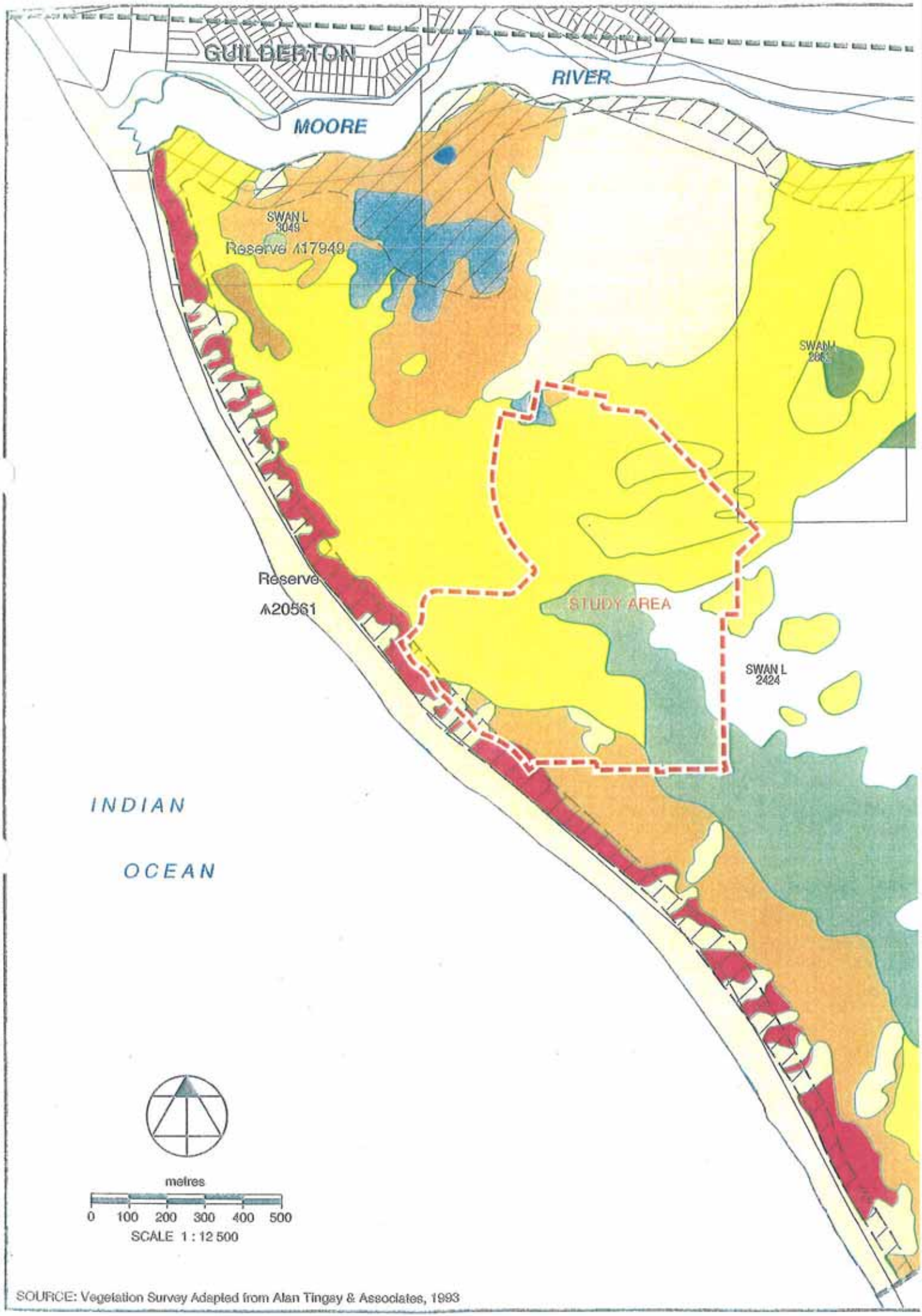


LEGEND

- Proposed Foreshore Reserve Boundary
- Cadastral Boundary
- Vegetation Line
- 100m Setback Line
- Integrated Tourist Resort Zone
- Parking
- Lawn/Picnic Area
- Dual Use Path
- Beach Access Path
- Major Blowout
- Study Area Boundary

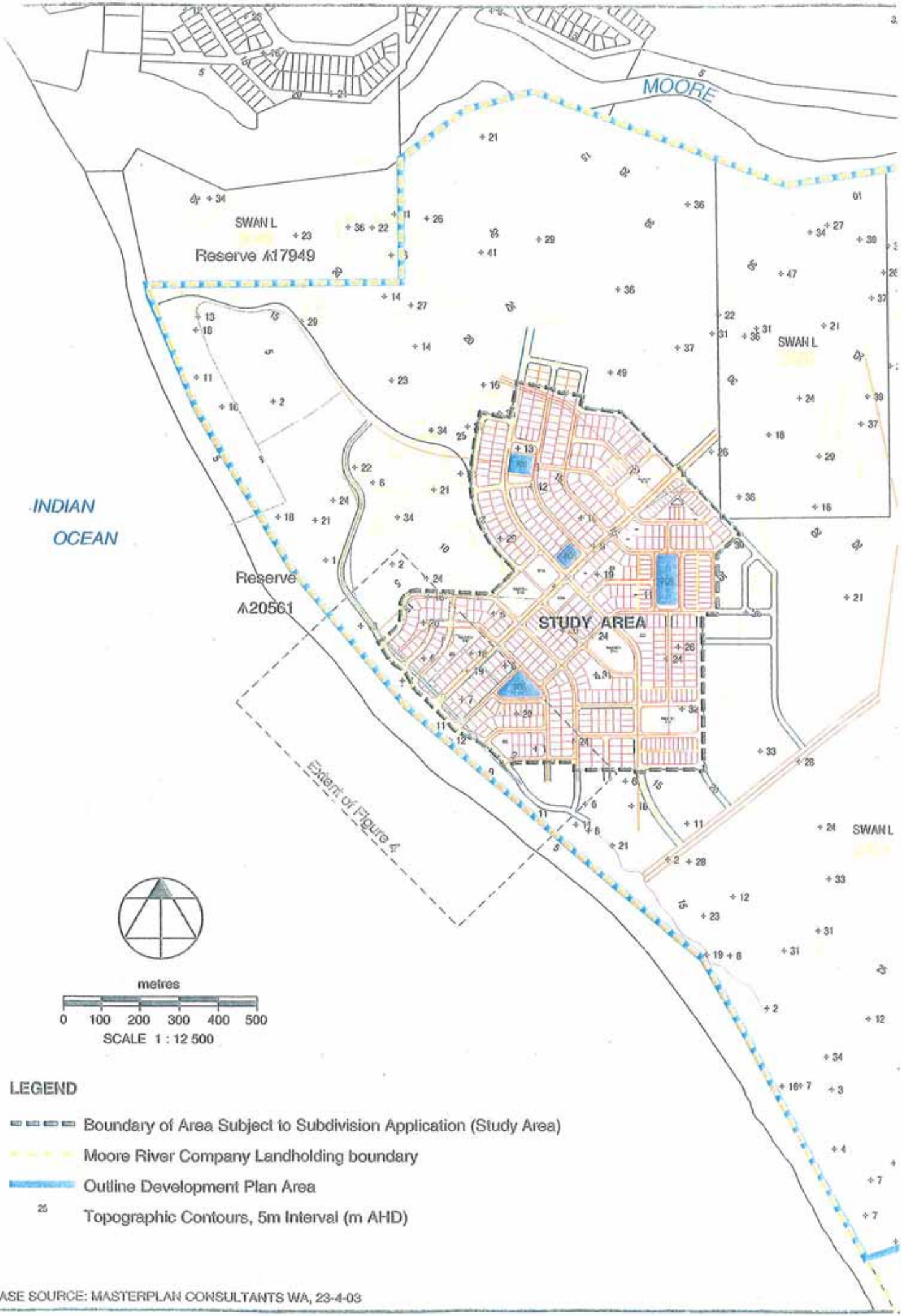
SOURCES: TOPOGRAPHY & MANAGEMENT RECOMMENDATIONS - Alan Tingay & Associates, 1996
: SUBDIVISION - Masterplan Consultants WA , 23-4-03

PRINTED: Fri 24 Oct 03
CHECKED BY: SM 13-5-03
DRAWN BY: GLM 6-5-03
DATUM: MGA
23021/29_5714.dgn



SOURCE: Vegetation Survey Adapted from Alan Tingay & Associates, 1993

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DATUM: MGA
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Appendix G
Fauna Study

Cardno
Shaping the Future

Fauna Habitat
Impact Assessment

Proposed Subdivision

Moore River South

July 2010
Version 4

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PLATE 1: *Olearia axillaris* Shrubland

PLATE 2: *Allocasuarina lehmanniana* Scrub

PLATE 3: *Melaleuca acerosa* /*Olearia axillaris* Shrubland

PLATE 4: *Allocasuarina lehmanniana*/*Melaleuca acerosa* Scrub

PLATE 5: *Melaleuca acerosa*/*Acacia lasiocarpa* Low Open Heath

PLATE 6: *Banksia sessilis* Heath on Limestone

PLATE 7: *Melaleuca huegelii* Low Open Heath on Limestone

PLATE 8: *Banksia attenuata*/*prionotes* Low Woodland

PLATE 9: Tuart Woodland over *Allocasuarina lehmanniana* Shrubland

PLATE 10: Bare Sand/Blow Outs

PLATE 11: Cleared/Totally Degraded

APPENDICES

APPENDIX A: Conservation Categories

APPENDIX B: Carnaby's Black Cockatoo Food Plants

APPENDIX C: Significant Tree Details

APPENDIX D: Fauna Observed or Potentially in Study Area

APPENDIX E: EPBC Database Search Results

APPENDIX F: Details of Significant Species

DISCLAIMER

This fauna assessment report ("the report") has been prepared in accordance with the scope of services set out in the contract, or as otherwise agreed, between the Client and Greg Harewood ("the Author"). In some circumstances the scope of services may have been limited by a range of factors such as time, budget, access and/or site disturbance constraints. In accordance with the scope of services, the Author has relied upon the data and has conducted environmental field monitoring and/or testing in the preparation of the report. The nature and extent of monitoring and/or testing conducted is described in the report.

The conclusions are based upon field data and the environmental monitoring and/or testing carried out over a limited period of time and are therefore merely indicative of the environmental condition of the site at the time of preparing the report. Also it should be recognised that site conditions, can change with time.

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

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

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EXECUTIVE SUMMARY

This report details the results of a fauna habitat impact assessment of an area of land referred to as Moore River South (the study area). The site is located on the southern side of the Moore River at Guilderton in Western Australia. It is about 73 km north of the Perth CBD and covers an area of about 346 ha (Figure 1).

The currently proposed outline development plan (ODP) is shown as Figure 2. In this figure the proposed development is shown as consisting of a mosaic of low to medium density residential, neighbourhood commercial, resort/family holiday accommodation, primary school and community facilities, lifestyle properties, public open space and foreshore reserves in addition to associated roads and walkways.

The main aim of the survey work is to provide information that will allow an assessment of the likely impact of the proposal on the identified species of conservation significance and in particular those listed as threatened under the *Environment Protection and Biodiversity Conservation Act 1999* (*EPBC Act*). The specific objectives of the survey work were therefore:

- document the potential use of the survey site by Carnaby's Black Cockatoo as a feeding, roosting and/or breeding location;
- report on the evidence found of feeding and roosting by Carnaby's Black Cockatoo species within the study area;
- document the potential use of the survey site by the Graceful Sun-Moth;
- based on observations made during a site survey and a review of other available survey information consider the potential for other conservation significant fauna species to utilise the site;
- document any opportunistic records of fauna observed whilst on site;
- provide a risk assessment of the likely impact on all species of conservation significant potentially present in the area; and
- provide recommendations to minimise impacts to fauna.

Field survey work was carried out in two stages. The initial reconnaissance survey was carried out by Greg Harewood (B.Sc. Zoology) on the 23rd, 24th and 25th October, 2009. Graceful Sun–Moth surveys were carried out on the 11th, 16th, 24th and 25th March, 2010 by the Author and several Cardno (WA) Pty Ltd personnel (Jessica Lisle, Kirsten Knox, Chrystal King and Vyvyan Summers).

Fauna surveys, assessments and reviews have been undertaken in nearby areas in the past. The most significant of these were used as the primary reference material for

compiling the potential fauna assemblage for the region. The following environment assessments of the Moore River South area have previously been carried out:

Alan Tingay & Associates (1993). South Guilderton Environmental Assessment, Report No. 92/34, Prepared for Moore River Company Pty Ltd.

Alan Tingay & Associates (1998). Moore River South Vertebrate Fauna Survey November 1997, Report No. 97/05, Prepared for Moore River Company Pty Ltd.

The extent of the broadly defined fauna habitats within the study area, based on vegetation mapping by Cardno (WA) Pty Ltd (2010), are shown in Figure 4 with a description of each given below. Additional information of the vegetation units present within the study area can be found in the flora and vegetation survey report (Cardno (WA) Pty Ltd 2010).

1. **OaSc** - Low Scrub of *Olearia axillaris* and *Scaevola crassifolia* over Open Herbs of **Trachyandra divaricata* **Tetragonia decumbens*, **Cakile maritima, *Pelargonium capitatum, Hardenbergia comptoniana* and *Conostylis candicans* on foredunes with *Spinifex longifolius and Ficinia nodosa.*

2. **AlEg** - Scrub of *Allocasuarina lehmanniana, Spyridium globulosum* and *Myoporum insulare* with emergent pockets of Low woodland to Open Low Woodland of *Eucalyptus gomphocephala* over Low Scrub of *Acacia lasiocarpa, Olearia axillaris and Leucopogon parviflorus* over Low Open Sedges of *Lepidosperma gladiatum* with **Bromus diandrus* and *Austrostipa flavescens, Parietaria debilis, Senecio pinnatifolius, *Trachyandra divaricata, Daucus glochidiatus, *Crassula glomerata* and *Trachymene pilosa*

3. **ArAp** - Dense Thicket to Thicket of *Acacia rostellifera* over Low Scrub of *Acanthocarpus preissii* over Open Low Grass of **Bromus diandrus, *Lolium rigidum and Poa porphyroclados,* Open Herbs of *Calandrinia sp. Southwest Coast, *Dischisma arenarium, Carpobrotus virescens,* and **Tetragonia decumbens* on lower slopes and within swales*;*

4. **MsAlSg** - Heath to Dwarf Scrub of *Melaleuca systena, Acacia lasiocarpa, Spyridium globulosum* and *Calothamnus quadrifidus* with occasional pockets of Low Woodland of *Eucalyptus gomphocephala* and Low Woodland of *Banksia attenuata* over Open Herbs of *Lomandra maritima, Parietaria debilis, Phyllanthus calycinus, Poranthera microphylla, Senecio pinnatifolius* and *Trachymene pilosa;*

5. **MsAlAp** - Low Heath of *Melaleuca systena, Acacia lasiocarpa, Acanthocarpus preissii and Calothamnus quadrifidus* with occasional pockets of Low Woodland of *Banksia attenuata* or Thicket to Scrub of *Acacia rostellifera* in the swales over Open Herbs of *Conostylis candicans, Desmocladus asper* and *Heliophila pusilla, Lepidosperma pubisquameum,*

**Bromus diandrus* and *Poa porphyroclados* on cream-grey shallow sands over limestone.

6. **McSg -** Thicket of *Melaleuca cardiophylla, Spyridium globulosum, Leucopogon insularis* and *Acanthocarpus preissii* over Low Grasses **Bromus diandrus, *Lolium rigidum* and **Ehrharta longiflora* with *Desmocladus asper, Calandrinia sp. Southwest Coast, Stylidium maritimum (P3), Hibbertia spicata subsp. leptotheca (P3)* and *Beyeria cinerea subsp. cinerea (P3)* on grey-brown shallow sands over limestone*;*

7. **MsMhBs -** Heath to Dwarf Scrub of *Melaleuca systena/Melaleuca huegelii, Banksia sessilis, Spyridium globulosum, Templetonia retusa, Acacia truncata* and *Hakea lissocarpha* over Open Herbs of *Calandrinia brevipedata, Podotheca gnaphalioides and Trachymene coerulea subsp. coerulea* with *Austrostipa flavescens, Poa porphyroclados, *Bromus diandrus and Ehrharta villosa* on dark grey-brown sand over limestone*;*

8. **MhAtMs** - Low Heath recently burnt (3-5 years) *of Melaleuca huegelii/Acacia truncata, Melaleuca systena* and *Banksia sessilis,* over Very Open Herbs of *Desmocladus asper, Stylidium junceum, Calandrinia sp. Two-rocks, Carpobrotus virescens, *Crassula glomerata,* and *Gompholobium tomentosum* with **Bromus diandrus and Poa porphyroclados* on grey-brown shallow sands over limestone.

9. **Bare Sand/Blow Outs**; and

10. **Paddocks** - Cleared/Totally Degraded**.**

Plates 1 to 11 illustrate the nature of fauna habitats existing within the study area.

Evidence of foraging within the study area by Carnaby's Black Cockatoos was observed during the survey period. The evidence observed was confined to the areas of Banksia Low woodland in and outside of the ODP area and was in the form of broken Banksia cones (mainly *Banksia attenuata* and to a lesser extent *B. prionotes*) indicating black cockatoos feeding on grubs and/or seeds. No evidence of foraging on other tree or shrub species (e.g. Tuart, *B. sessilis*) was observed.

Irrespective of the amount of actual foraging evidence observed, any area of vegetation onsite containing documented food species of black cockatoos can be considered potential black cockatoo foraging habitat. A full list of documented Carnaby's Black Cockatoo foraging species is held in Appendix B.

Using the abovementioned list and vegetation mapping from Cardno (2010) (see Figure 4) the following units onsite can be regarded as representing potential Carnaby's Black Cockatoo foraging habitat to some degree.

1. **AlEg** - Scrub of *Allocasuarina lehmanniana, Spyridium globulosum* and *Myoporum insulare* with emergent pockets of Low woodland to Open Low Woodland of *Eucalyptus gomphocephala* over Low Scrub.

   Tuart is a documented food plant for Carnaby's Black Cockatoo and they will also forage on the seeds of a range of *Allocasuarina* species. No specific species are documented so it must be assumed that *Allocasuarina lehmanniana* is a potential foraging species. No actual foraging evidence observed.

2. **MsAlSg** - Heath to Dwarf Scrub of *Melaleuca systena, Acacia lasiocarpa, Spyridium globulosum* and *Calothamnus quadrifidus* with occasional pockets of Low Woodland of *Eucalyptus gomphocephala* and Low Woodland of *Banksia attenuata;*

   Contains documented Carnaby's Black Cockatoo foraging species, namely Tuart, *Banksia attenuata* and *Banksia prionotes*. Actual foraging evidence on *Banksia* observed.

3. **MsAlAp** - Low Heath of *Melaleuca systena, Acacia lasiocarpa, Acanthocarpus preissii and Calothamnus quadrifidus* with occasional pockets of Low Woodland of *Banksia attenuata.*

   Contains documented Carnaby's Black Cockatoo foraging species, namely *Banksia attenuata* and *Banksia prionotes*. Actual foraging evidence on *Banksia* observed.

4. **MsMhBs -** Heath to Dwarf Scrub of *Melaleuca systena/Melaleuca huegelii, Banksia sessilis, Spyridium globulosum, Templetonia retusa, Acacia truncata* and *Hakea lissocarpha* over Open Herbs.

   Contains documented Carnaby's Black Cockatoo foraging species, namely *Banksia sessilis* and *Hakea lissocarpha*. No actual foraging evidence observed.

5. **MhAtMs -** Low Heath recently burnt (3-5 years) of *Melaleuca huegelii/Acacia truncata, Melaleuca systena and Banksia sessilis, over Very Open Herbs***.**

   Contains documented Carnaby's Black Cockatoo foraging species, namely *Banksia sessilis*. No actual foraging evidence observed.

Clearly some vegetation on site represents potential black cockatoo foraging habitat in a broad sense. It is however difficult to define exact areas and relative foraging values due to the complex variation in plant species composition and densities that occur

throughout each unit. For example some sections of the mapped units contain sparsely vegetated areas and/or the boundary of the unit is open to interpretation (gradational or inferred from an air photo). The degree to which black cockatoos utilise the various plant species as food also varies considerably but is not documented in any literature.

Where possible, retention of some vegetation within POS/reserves and landscaping areas in the construction phase of the development will assist in the retention of suitable habitat for many fauna species including potential black cockatoo foraging habitat. It should also be noted that substantial areas of native vegetation are being retained in areas beyond the revised ODP boundary. The adjustment to the ODP area has in particular resulted in the retention of areas of *Banskia attenuata*, *B. Sessilis* and *Allocasuarina lehmanniana* scrub outside the area proposed for development, and design of the ODP retains areas of *Tuart woodland* and *Allocasuarina lehmanniana* scrub in POS.

The tree assessment identified a total of 29 “significant” trees within the study area (i.e. native/endemic Eucalypt/Corymbia tree species with DBH >50cm) (Figure 5). An additional 15 trees were observed outside of the ODP area. The majority (37) of the significant trees were not observed to contain hollows of any size. Eight trees were observed to contain one or more small (~<12cm diameter) hollows determined not to be suitable for black cockatoos to use for nesting purposes. No tree within the ODP area was observed to contained hollows with large entrances (>~12cm diameter) that appeared big enough to possibly allow the entry of a black cockatoo. All of the significant trees were Tuart. Details of the significant trees identified are held in Appendix C.

A single dusk “observation” survey was carried out to allow the recording of roosting activity on site. Evidence of past use as a roosting site (significant concentrations of feathers and droppings) was also searched for during the day time field surveys.

No black cockatoos were observed roosting within the site during the survey period which extended from late afternoon to early dusk on the 24th October 2009. No evidence of previous roosting on site was observed during the day time surveys of the site. No black cockatoos were observed in the site during any stage of the survey work though several flocks were observed near Woodridge during the March 2010 survey period.

A series of Graceful Sun Moth (GSM) surveys were undertaken at Moore River south site in March 2010. In total 23 individual GSMs were observed. Only four of the sightings were within the proposed ODP area though it is difficult to draw more definitive conclusions regarding the potential distribution of GSM in development areas until the GSM observations are correlated with the *Lomandra* density survey also carried out (Cardno 2010, Moore River South: Graceful Sun Moth Survey, in preparation). The majority of the sightings were within the *Melaleuca acerosa*/*Acacia lasiocarpa* Low Open Heath (as mapped by ATA 1993).

An assessment of the likely impact of the proposal on Carnaby's Black Cockatoos using DEWHA's current Significant Impact Guidelines suggests that the development would be unlikely to trigger any defined criteria and therefore "significant" impact on Carnaby's Black Cockatoo, is considered unlikely to occur.

The potential impacts on several migratory species possibly present in the area are not considered to be significant using DEWHA criteria.

With respect to native vertebrate fauna in general, 18 mammals (includes 7 bats species), 115 bird, eight frog and 51 reptile species have previously been recorded in the general area, some of which have the potential to occur in or utilise at times sections of the study area.

Of the 192 native animals that are listed as potentially occurring in the area, four are considered to be endangered/vulnerable or in need of special protection under state and/or federal law. In addition six migratory species may frequent the site at times and four DEC priority species were identified as possibly present. With respect to fauna in general (i.e. species not listed as threatened) no significant impacts are expected. A substantial proportion of the study area is already cleared or highly degraded and the development is unlikely to have any substantial impact on the status of the more common fauna species most likely to be currently using these areas.

The proposed development will necessarily require the clearing of some existing fauna habitat. A series of recommendations are provided that aim to minimise impact of development at the site on fauna. These should be incorporated into relevant management plans, where considered reasonable and practical.

The revised ODP design has been based on the need to retain suitable habitat for GSM and Carnaby's Black Cockatoo. Notwithstanding this there may still be a requirement to refer a subsequent action(s) pursuant to the EPBC Act. However in the absence of a formalised Commonwealth policy that actual requirement is yet to be determined.

1. INTRODUCTION

This report details the results of a fauna habitat impact assessment of an area of land referred to as Moore River South (ODP) (the study area). The site is located on the southern side of the Moore River at Guilderton in Western Australia and is about 73 km north of the Perth CBD. The study area is centred at approximately 31.365199°S and 115.517600°E (Figures 1, 2 & 3) and covers an area of about 346 ha.

2. DEVELOPMENT PROPOSAL

The currently proposed outline development plan (ODP) is shown as Figure 2. In this figure the proposed development is shown as consisting of a mosaic of low to medium density residential, neighbourhood commercial, resort/family holiday accommodation, primary school and community facilities, lifestyle properties, public open space and foreshore reserves in addition to associated roads and walkways.

A significant proportion of ODP area falls within existing cleared land but the removal of existing native vegetation will be required in other areas. The information obtained as part of the fauna habitat assessment reported on here will be used, in conjunction with other environmental investigations, to enable regulatory authorities to assess the potential impact of the proposal and allow for its modification if required. The information will also enable the formulation of management plans aimed at minimising potential environmental impacts if the proposal is granted approval and proceeds.

3. SCOPE OF WORKS

The main aim of the proposed survey work is to provide information that will allow an assessment of the likely impact of the proposal on the identified species of conservation significance and in particular those listed as threatened under the *Environment Protection and Biodiversity Conservation Act 1999* (*EPBC Act*). The specific objectives of the proposed work are therefore:

- document the potential use of the survey site by Carnaby's Black Cockatoo as a feeding, roosting and/or breeding location;
- report on the evidence found of feeding and roosting by Carnaby's Black Cockatoo species within the study area;
- document the potential use of the survey site by the Graceful Sun-Moth;

- based on observations made during a site survey and a review of other available survey information consider the potential for other conservation significant fauna species to utilise the site;
- document any opportunistic records of fauna observed whilst on site;
- provide a risk assessment of the likely impact on all species of conservation significant potentially present in the area; and
- provide recommendations to minimise impacts to fauna.

4. PREVIOUS VERTEBRATE FAUNA SURVEYS

Fauna surveys, assessments and reviews have been undertaken in nearby areas in the past. The most significant of these were used as the primary reference material for compiling the potential fauna assemblage for the region. Those reports referred to included, but were not limited to:

Ninox Wildlife Consulting (1991a), Eglinton Beach Resort, An Appraisal of the Vertebrate Fauna, In Le Provost Environmental Consultants, Eglinton Resort Development Pty Ltd, Eglinton Resort Public Environmental Review, Volume 2 of 2 Technical.

Ninox Wildlife Consulting (1991b), The Wilbinga and Breton Bay Sites – A Comparative Appraisal of their Vertebrate Fauna, Prepared for Halpern Glick Maunsell.

Alan Tingay & Associates (1993). South Guilderton Environmental Assessment, Report No. 92/34, Prepared for Moore River Company Pty Ltd.

Alan Tingay & Associates (1997). Alkimos-Eglinton Vertebrate Fauna Survey October 1996, Report No. 97/05, Prepared for LandCorp and Eglinton Estates Pty Ltd.

Alan Tingay & Associates (1998). Moore River South Vertebrate Fauna Survey November 1997, Report No. 97/05, Prepared for Moore River Company Pty Ltd.

Bamford M.J., & Davis R.A. (2005). Alkimos Proposed Wastewater Treatment Plant: Fauna Assessment, January 2005. Unpublished Report for the Water Corporation

Johnstone RE & C (2008). Distribution, Status & Movements of Carnaby's Cockatoo in Lancelin Region. Appendix G in ENV Australia (2008). Nilgen Wind Farm Fauna Assessment. Unpublished report for Pacific Hydro

5. METHODOLOGY

5.1 CARNABY'S BLACK COCKATOO ASSESSMENT

5.1.1 Foraging Habitat

An assessment of the sites value as foraging habitat for Carnaby's Black Cockatoos was made during two six hour daytime surveys of the site. Traverses were carried out across the entire study area (ODP specifically with some adjoining areas also looked at) with the main aim of searching for direct or indirect evidence of foraging by Carnaby's Black Cockatoo. The locations of observations made were recorded with a GPS.

5.1.2 Potential Breeding Habitat

During the course of the opportunist and habitat assessment observations of "significant" trees were recorded using a GPS. The main aim of this component of the survey was to document the presence of trees having a diameter at breast height (DBH) >50cm which are considered as potential black cockatoo breeding trees (pers. comm. Environment Assessment Branch, DEWHA – September 2009).

All suitable trees within the ODP area (but not all those in proposed reserves or POS) were assessed for potential to contain or develop suitable hollows for Carnaby's Black Cockatoos. (Note: the ODP area was changed after the initial survey and so some trees now inside the ODP area (but not previously) were not assessed. This has not affected the result as the areas included fall inside proposed reserves/POS and therefore these trees will not require removal in any event).

Target tree species were Tuart, Jarrah, Marri or any other *Corymbia/Eucalyptus* species documented as being used by cockatoos for breeding. Banksia trees, for example, were not assessed as they typically do not develop hollows suitable for use by black cockatoos.

Characteristics of each tree recorded with a DBH of >50cm included an estimate of the number, type and size of hollows present and if a hollow was observed, an assessment of their potential to represent a potential black cockatoo nest hollow.

For the purposes of this study a potential cockatoo nest hollow has been defined as:

Generally any tree which is alive or dead that contains one or more visible hollows (cavities within the trunk or branches) suitable for occupation by Carnaby's Black Cockatoo species for the purpose of nesting/breeding.

Hollows that had an entrance greater than about 12cm in diameter and would allow the entry of a cockatoo into a suitably sized branch or trunk were recorded as a "potential nest hollow".

It should be noted that the assessment of hollows from ground level using this method is likely to result in an over estimation of the number of hollows that would be suitable for use by black cockatoos as the full characteristic of the hollow cannot be made. The method does however provide an idea of the relative abundance of hollows compared to other areas if similar methods are employed.

5.1.3 Roosting Habitat

A dusk survey in the area of Tuarts on site was carried out to determine if there is any roosting activity on site. Evidence of past use as a roosting site (significant concentrations of feathers and droppings) was also searched for during the day time field surveys.

5.1.4 Opportunistic Observations

Opportunistic observations of fauna species in general was made during the daytime surveys of the site. This included a series of close spaced transects across the site while searching under logs, rocks and leaf litter, observations of bird species with binoculars.

5.2 GRACEFUL SUN-MOTH SURVEY

Methods detailed in the GSM – Information Kit and Survey Methods (Bishop, Williams & Gamblin 2009) were followed.

To comply with DEC requirements four repeat surveys of the site were carried out. All surveys were completed within the first 3.5 weeks of March 2010, between 10am and 3pm and at least 4 days apart. Windy (>18km/h) periods were avoided where possible.

A series of predefined transects totally ~14km, following existing firebreaks and within some sparsely vegetated areas were walked at a steady pace by two groups of two observers (~7km each group) and any GSMs seen within 5m to each side and ahead were be recorded. Any GSM seen outside of this corridor, or detected at the site during other activities, were recorded as an 'incidental' observation. At the DEC's request several GSM specimens were captured and passed on to Andrew Williams at the Wildlife Research Centre, Woodvale.

(Note: the required *Lomandra* density survey was carried out independently and will be reported on separately).

5.3 RISK ASSESSMENT

An assessment of the likely impact of the proposal on *EPBC Act* listed threatened species potentially utilising the site is provided using DEWHA's significant impact guidelines (DEH 2006) in addition to other proposed guidelines made available by the DEWHA that are applicable. Conclusions have been based on observations made on site and on other available documented information including species habitat preferences, distribution and abundance in the area.

5.4 FAUNA INVENTORY

5.4.1 Potential Fauna

A list of all vertebrate fauna potentially occurring within the study area was compiled from searches the Department of Environment and Conservation's (DEC's) Threatened Fauna and 'NatureMap" database (joint DEC and Western Australian Museum (WAM) data), the Department of the Environment, Water, Heritage and the Arts (DEWHA) Commonwealth Environment Protection and Biodiversity Conservation database, Birds Australia's 'Birdata" database, published and unpublished reports and specialist books detailing fauna of the general area.

Taxonomy and nomenclature for fauna species used in this report generally follow Aplin and Smith (2001) for amphibians and reptiles, How *et al*. (2001) for mammals and Johnstone (2001) for birds. Some names, including common names recommended for national and international use by Christidis and Boles (1994) for birds, are also used. Common names for reptiles and amphibians come from a variety of sources and are not necessarily generally accepted. Sources include Van Dyck & Strahan (2008), Bush *et al* (2007), Wilson and Swan (2008), Bush *et al* (2002), Tyler *et al.* (2000) and Glauret (1961).

5.4.2 Fauna of Conservation Significance

The conservation significance of fauna species has been assessed using data from the following sources:

- *Environment Protection and Biodiversity Conservation Act 1999* (*EPBC Act*). Administered by the Australian Government Department of the Environment, Water, Heritage and the Arts (DEWHA);
- *Wildlife Conservation Act 1950 (WC Act).* Administered by the Western Australian Department of Environment and Conservation (DEC);
- The Red List produced by the Species Survival Commission (SSC) of the World Conservation Union (also known as the IUCN Red List - the acronym derived from its former name of the International Union for

Conservation of Nature and Natural Resources). The Red List has no legislative power in Australia but is used as a framework for State and Commonwealth categories and criteria; and the

- DEC Priority Fauna list. A non-legislative list maintained by the DEC for management purposes.

The *EPBC Act* also requires the compilation of a list of migratory species that are recognised under international treaties including the:

- Japan Australia Migratory Bird Agreement 1981 (JAMBA);
- China Australia Migratory Bird Agreement 1998 (CAMBA);
- Republic of Korea-Australia Migratory Bird Agreement 2007 (ROKAMBA); and
- Bonn Convention 1979 (The Convention on the Conservation of Migratory Species of Wild Animals).

(Note - Species listed under JAMBA are also protected under Schedule 3 of the *WC Act*).

All migratory bird species listed in the annexes to these bilateral agreements are protected in Australia as matters of national environmental significance under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*.

The conservation status of all the vertebrate fauna species listed as occurring or possibly occurring in the vicinity of the study area has been assessed using the most recent lists published in accordance with the above-mentioned Acts, International Agreements and DEC's priority fauna list. The status of each species as defined in the above mentioned acts is indicated in the fauna listings of this report. A full listing of conservation codes are held in Appendix A.

5.4.3 Other Species of Significance

A number of other species not listed in official lists can also be considered of regional conservation significance. These include species that have a restricted range, those that occur in breeding colonies and those at the limit of their range.

While not classified as rare, threatened or vulnerable under any State or Commonwealth legislation, a number of bird species have been listed as of significance on the Swan Coastal portion of the Perth Metropolitan Region (Bush Forever - Government of Western Australia 1998 and 2000). The bird species are often referred to as Bush Forever Decreaser Species. The three categories used for birds within the Bush Forever documents are:

- Habitat specialists with reduced distribution on the Swan Coastal Plain (code Bh)
- Wide ranging Species with reduced population's on the Swan Coastal Plain. (code Bp)
- Extinct in the Perth region (code Be)

The presence of Bush Forever species should be taken into consideration when determining an areas fauna values. Bush Forever decreaser species are indicated as such within the species list held in Appendix D.

6. SURVEY CONSTRAINTS

The assessment reported on here has included a desktop analysis and a site reconnaissance survey that included opportunistic fauna observations over a total of about twelve hours. No seasonal sampling has been conducted.

Fauna species are indicated as potentially present within this report based on there being suitable (quality and extent) habitat within the study area. With respect to opportunistic observations, the possibility exists that certain species may not have been detected during field investigations due to:

- seasonal inactivity during field survey;
- species present within micro habitats not surveyed;
- cryptic species able to avoid detection;
- transient wide-ranging species not present during survey period.

The lack of observational data on some species should therefore not be taken as necessarily indicating that a species is absent from the site.

In recognition of survey limitations a precautionary approach has been adopted for this assessment. Any fauna species that would possibly occur within the study area as identified through ecological databases, publications, discussions with local experts/residents and the habitat knowledge of the Author has been assumed to potentially occur in the study area.

With respect to the significant tree survey some trees containing hollows, generally of smaller sizes may not have been detected.

Field survey work was carried out by Greg Harewood (B.Sc. Zoology) on the 23rd, 24th and 25th October, 2009. Graceful Sun–Moth surveys were carried out on the 11th, 16th, 24th and 25th March, 2010 by the Author and several Cardno

(WA) Pty Ltd personnel (Jessica Lisle, Kirsten Knox, Chrystal King and Vyvyan Summers).

7. RESULTS

7.1 REGIONAL BIOLOGICAL CONTEXT

The project area is situated within the wester margin of the Swan Coastal Plain. The Swan Coastal Plain Bioregion (SWA) is classified as part of the Interim Biogeographical Regionalisation for Australia. The SWA bioregion is described as being a:

"Low lying coastal plain mainly covered with Woodlands. It is dominated by Banksia or Tuart on sandy soils, Casuarina obesa on outwash plains, and paperbark in swampy areas. In the east, the plain rises to duricrusted Mesozoic sediments dominated by Jarrah Woodland. Warm Mediterranean. Three phases of marine sand dune development provide relief.

The outwash plains, once dominated by Casuarina obesa – Marri Woodlands and Melaleuca shrublands, are extensive only in the south." (Thackway and Cresswell, 1996; IBRA, 2000).

Vegetation complexes were defined in relation to landform and soil units for the Swan Coastal Plain by Heddle *et al*. (1980). Of these the Quindalup Complex and the Cottesloe Complex (North) are mapped as originally comprising the vegetation units present within or near the study area.

The Quindalup Complex is described as being a coastal dune complex consisting of mainly two alliances – the strand and foredune alliance and the mobile and stable dune alliance. Local variations include closed *Melaleuca – Callitris* forest and *Acacia rostellifera* scrub.

The Cottesloe Complex (North) is described as being predominately composed of a low open forest/low woodland of *Banksia attenuata – B. menziesii – Eucalyptus todtiana* and closed heath on limestone outcrops (Heddle *et al*. 1980).

7.2 FAUNA HABITAT ASSESSMENT

7.2.1 Fauna Habitats

The broad scale fauna habitats within the study area are based on vegetation structure. The study area has been subject to a significant amount of historical disturbance such as clearing, construction of fire breaks, access tracks and livestock grazing. These impacts have reduced the sites overall value to fauna

by reducing or altering habitat quality and biodiversity values to various degrees.

The extent of the broadly defined fauna habitats within the study area, based on vegetation mapping by Cardno (WA) Pty Ltd (2010), are shown in Figure 4 with a description of each given below. Additional information of the vegetation units present within the study area can be found in the flora and vegetation survey report (Cardno (WA) Pty Ltd 2010).

1. **OaSc** - Low Scrub of *Olearia axillaris* and *Scaevola crassifolia* over Open Herbs of **Trachyandra divaricata* **Tetragonia decumbens*, **Cakile maritima, *Pelargonium capitatum, Hardenbergia comptoniana* and *Conostylis candicans* on foredunes with *Spinifex longifolius and Ficinia nodosa.*

2. **AlEg** - Scrub of *Allocasuarina lehmanniana, Spyridium globulosum* and *Myoporum insulare* with emergent pockets of Low woodland to Open Low Woodland of *Eucalyptus gomphocephala* over Low Scrub of *Acacia lasiocarpa, Olearia axillaris and Leucopogon parviflorus* over Low Open Sedges of *Lepidosperma gladiatum* with **Bromus diandrus* and *Austrostipa flavescens, Parietaria debilis, Senecio pinnatifolius, *Trachyandra divaricata, Daucus glochidiatus, *Crassula glomerata* and *Trachymene pilosa*

3. **ArAp** - Dense Thicket to Thicket of *Acacia rostellifera* over Low Scrub of *Acanthocarpus preissii* over Open Low Grass of **Bromus diandrus, *Lolium rigidum and Poa porphyroclados,* Open Herbs of *Calandrinia sp. Southwest Coast, *Dischisma arenarium, Carpobrotus virescens,* and **Tetragonia decumbens* on lower slopes and within swales*;*

4. **MsAlSg** - Heath to Dwarf Scrub of *Melaleuca systena, Acacia lasiocarpa, Spyridium globulosum* and *Calothamnus quadrifidus* with occasional pockets of Low Woodland of *Eucalyptus gomphocephala* and Low Woodland of *Banksia attenuata* over Open Herbs of *Lomandra maritima, Parietaria debilis, Phyllanthus calycinus, Poranthera microphylla, Senecio pinnatifolius* and *Trachymene pilosa;*

5. **MsAlAp** - Low Heath of *Melaleuca systena, Acacia lasiocarpa, Acanthocarpus preissii and Calothamnus quadrifidus* with occasional pockets of Low Woodland of *Banksia attenuata* or Thicket to Scrub of *Acacia rostellifera* in the swales over Open Herbs of *Conostylis candicans, Desmocladus asper* and *Heliophila pusilla, Lepidosperma pubisquameum, *Bromus diandrus* and *Poa porphyroclados* on cream-grey shallow sands over limestone.

6. **McSg -** Thicket of *Melaleuca cardiophylla, Spyridium globulosum, Leucopogon insularis* and *Acanthocarpus preissii* over Low Grasses **Bromus diandrus, *Lolium rigidum* and **Ehrharta longiflora* with *Desmocladus asper, Calandrinia sp. Southwest Coast, Stylidium maritimum (P3), Hibbertia spicata subsp. leptotheca (P3)* and *Beyeria cinerea subsp. cinerea (P3)* on grey-brown shallow sands over limestone*;*

7. **MsMhBs -** Heath to Dwarf Scrub of *Melaleuca systena/Melaleuca huegelii, Banksia sessilis, Spyridium globulosum, Templetonia retusa, Acacia truncata* and *Hakea lissocarpha* over Open Herbs of *Calandrinia brevipedata, Podotheca gnaphalioides and Trachymene coerulea subsp. coerulea* with *Austrostipa flavescens, Poa porphyroclados, *Bromus diandrus and Ehrharta villosa* on dark grey-brown sand over limestone*;*

8. **MhAtMs** - Low Heath recently burnt (3-5 years) *of Melaleuca huegelii/Acacia truncata, Melaleuca systena* and *Banksia sessilis,* over Very Open Herbs of *Desmocladus asper, Stylidium junceum, Calandrinia sp. Two-rocks, Carpobrotus virescens, *Crassula glomerata,* and *Gompholobium tomentosum* with **Bromus diandrus and Poa porphyroclados* on grey-brown shallow sands over limestone.

9. **Bare Sand/Blow Outs**; and

10. **Paddocks** - Cleared/Totally Degraded**.**

Plates 1 to 11 illustrate the nature of fauna habitats existing within the study area.

7.3 CARNABY'S BLACK COCKATOO ASSESSMENT

7.3.1 Foraging Habitat

Evidence of foraging within the study area by Carnaby's Black Cockatoos was observed during the survey period. The evidence observed was confined to the areas of Banksia Low woodland in and outside of the ODP area and was in the form of broken Banksia cones (mainly *Banksia attenuata* and to a lesser extent *B. prionotes*) indicating black cockatoos feeding on grubs and/or seeds. No evidence of foraging on other tree or shrub species (e.g. Tuart, *B. sessilis*) was observed.

Irrespective of the amount of actual foraging evidence observed, any area of vegetation onsite containing documented food species of black cockatoos can be considered potential black cockatoo foraging habitat. A full list of documented Carnaby's Black Cockatoo foraging species is held in Appendix B.

Using the abovementioned list and vegetation mapping from Cardno (2010) (see Figure 4) the following units onsite can be regarded as representing potential Carnaby's Black Cockatoo foraging habitat to some degree

1. **AlEg** - Scrub of *Allocasuarina lehmanniana, Spyridium globulosum* and *Myoporum insulare* with emergent pockets of Low woodland to Open Low Woodland of *Eucalyptus gomphocephala* over Low Scrub.

   Tuart is a documented food plant for Carnaby's Black Cockatoo and they will also forage on the seeds of a range of *Allocasuarina* species. No specific species are documented so it must be assumed that *Allocasuarina lehmanniana* is a potential foraging species. No actual foraging evidence observed.

2. **MsAlSg** - Heath to Dwarf Scrub of *Melaleuca systena, Acacia lasiocarpa, Spyridium globulosum* and *Calothamnus quadrifidus* with occasional pockets of Low Woodland of *Eucalyptus gomphocephala* and Low Woodland of *Banksia attenuata;*

   Contains documented Carnaby's Black Cockatoo foraging species, namely Tuart, *Banksia attenuata* and *Banksia prionotes*. Actual foraging evidence on *Banksia* observed.

3. **MsAlAp** - Low Heath of *Melaleuca systena, Acacia lasiocarpa, Acanthocarpus preissii and Calothamnus quadrifidus* with occasional pockets of Low Woodland of *Banksia attenuata.*

   Contains documented Carnaby's Black Cockatoo foraging species, namely *Banksia attenuata* and *Banksia prionotes*. Actual foraging evidence on *Banksia* observed.

4. **MsMhBs -** Heath to Dwarf Scrub of *Melaleuca systena/Melaleuca huegelii, Banksia sessilis, Spyridium globulosum, Templetonia retusa, Acacia truncata* and *Hakea lissocarpha* over Open Herbs.

   Contains documented Carnaby's Black Cockatoo foraging species, namely *Banksia sessilis* and *Hakea lissocarpha*. No actual foraging evidence observed.

5. **MhAtMs -** Low Heath recently burnt (3-5 years) of *Melaleuca huegelii/Acacia truncata, Melaleuca systena and Banksia sessilis, over Very Open Herbs***.**

Contains documented Carnaby's Black Cockatoo foraging species, namely *Banksia sessilis*. No actual foraging evidence observed.

Clearly some vegetation on site represents potential black cockatoo foraging habitat in a broad sense. It is however difficult to define exact areas and relative foraging values due to the complex variation in plant species composition and densities that occur throughout each unit. For example some sections of the mapped units contain sparsely vegetated areas and/or the boundary of the unit is open to interpretation (gradational or inferred from an air photo). The degree to which black cockatoos utilise the various plant species as food also varies considerably but is not documented.

Where possible, retention of some vegetation within POS/reserves and landscaping areas in the construction phase of the development will assist in the retention of suitable habitat for many fauna species including potential black cockatoo foraging habitat. It should also be noted that substantial areas of native vegetation are being retained in areas beyond the revised ODP boundary. The adjustment to the ODP area has in particular resulted in the retention of areas of *Banskia attenuata*, *B. Sessilis* and *Allocasuarina lehmanniana* scrub outside the area proposed for development, and design of the ODP retains areas of *Tuart woodland* and *Allocasuarina lehmanniana* scrub in POS.

7.3.2 Potential Breeding Habitat

The tree assessment identified a total of 29 "significant" trees within the study area (i.e. native/endemic Eucalypt/Corymbia tree species with DBH >50cm) (Figure 5). An additional 15 trees were observed outside of the ODP area. The majority (37) of the significant trees were not observed to contain hollows of any size. Eight trees were observed to contain one or more small (~<12cm diameter) hollows determined not to be suitable for black cockatoos to use for nesting purposes. No tree within the ODP area was observed to contained hollows with large entrances (>~12cm diameter) that appeared big enough to possibly allow the entry of a black cockatoo. All of the significant trees were Tuart.

Details of the significant trees identified are held in Appendix C.

Note: the ODP area was changed after the initial survey and so some trees now inside the ODP area (but not previously) were not assessed. This has not affected the result as the areas included fall inside proposed reserves/POS and therefore none of the unsurveyed areas will be affected by the development.

7.3.3 Roosting Habitat

A single dusk "observation" survey was carried out to allow the recording of roosting activity on site. Observations were carried out in a central location within the main groves of Tuarts at the northern end of the study site. Evidence of past use as a roosting site (significant concentrations of feathers and droppings) was also searched for during the day time field surveys.

No black cockatoos were observed roosting within the site during the survey period which extended from late afternoon to early dusk on the 24th October 2009. No evidence of previous roosting on site was observed during the day time surveys of the site.

No actual Black Cockatoos were observed in or near the site during any stage of the October 2009 survey work. It should however be noted that the survey was undertaken at a time of the year when Carnaby's Black Cockatoo are least likely to be present in the area. The vast majority of Carnaby's leave the Lancelin/Yanchep area in July-August to their main breeding sites (this being the northern and midland regions of the wheatbelt for birds in this area). Most breeding is completed by the end of January to early February and family groups then begin to move west to the coast with the largest flocks being observed in February-April in the Lancelin Yanchep region (Johnstone 2008). Several flocks of Carnaby's Black Cockatoos were observed near Woodridge during the March 2010 GSM surveys.

7.4 GRACEFUL SUN-MOTH SURVEY

Table 1 summarises the details of the four surveys carried out at the Moore River study area. The survey route taken and the location of all GSM observations made during each survey are shown combined in Figure 6.

Table 1: Summary of GSM Survey Results

Survey Number	Date	Number of GSMs Observed
1	11/03/2010	8
2	16/03/2010	13
3	24/03/2010	1
4	29/03/2010	1

In total 23 individual GSMs were observed. Only four of the sightings were within the proposed ODP area, though it is difficult to draw more definitive

conclusions regarding the potential distribution of GSM in development areas until the GSM observations are correlated with the *Lomandra* density survey also carried out (Cardno 2010, Moore River South: Graceful Sun Moth Survey, in preparation).

7.5 FAUNA INVENTORY

7.5.1 Opportunistic Fauna Surveys

The results of the opportunistic fauna survey are summarised in Table 2 and listed in Appendix D. A total of 39 native fauna species were observed (or positively identified from foraging evidence, scats, tracks, skeletons or calls) within the study area during the reconnaissance survey. Evidence of three introduce species were also found.

Evidence of two listed threatened species was observed (Carnaby's Black Cockatoo – foraging evidence, Graceful Sun-Moth – a number of individuals observed). Two migratory bird species were sighted (Osprey and Great Egret). A single DEC priority species was observed (Australian Bustard). In addition to Carnaby's Black Cockatoo, evidence of another nine bush forever decreaser bird species was observed.

7.5.2 Potential Fauna

Table 2 summarises the numbers of potential species based on vertebrate class considered likely to be present or utilise at times the study area. A complete list of vertebrate fauna possibly inhabiting or frequenting the study area is held in Appendix D. The results of a DEC Threatened fauna database search and the *EPBC Act* database are held in Appendix E.

Details on specially protected and priority species expected and/or listed as potentially occurring in the general area are given in Table 3 and Appendix F.

Not all species listed in existing databases and publications as potentially occurring within the study area (i.e. *EPBC Act's* Threatened Fauna and Migratory species lists, DEC's Threatened Fauna Database and various publications) are shown in the expected listing in Appendix D. Some species have been excluded from this list based largely on the lack of suitable habitat at the study site and in the general area. They are however discussed and the reasons for their omission from the potential listing detailed (see Table 3 and Appendix F).

Despite the omission of some species it should be noted that the list provided is still very likely an over estimation of the fauna species utilising the site (either on a regular of infrequent basis) as a result of the precautionary approach adopted for the assessment.

Table 2: Summary of Potential Terrestrial Fauna Species (As listed in Appendix D)

Group	Total number of potential species	Potential number of specially protected species	Potential number of migratory species	Potential number of priority species	Number of species observed October 09
Amphibians	8	0	0	0	0
Reptiles	51	1	0	2	4
Birds	119[4]	2	6	0	34
Non-Volant Mammals	18[7]	0	0	2	4[3]
Volant Mammals (Bats)	7	0	0	0	0
Total	203[11]	3	6	4	42[3]

Superscript = number of introduced species included in total.

7.5.3 Fauna of Conservation Significance

A review of EPBC Act's threatened fauna list, DEC's Threatened Fauna Database and Priority List and scientific publications identified about 17 specially protected, priority or migratory fauna species as potentially occurring in the general vicinity of the study area. Some of those species that have no potential whatsoever, under normal circumstances, to utilise the site for any purpose are not listed or discussed despite appearing in the DEC or *EPBC Act* database searches (e.g. offshore seabirds) (Appendix E).

Species have been omitted from the potential list (Appendix D) for the site principally due to lack of suitable habitat on site or known local extinction. A brief account of these species with details on their distribution and habitat preference and potential impact are shown in Table 3. Additional details on significant species that potentially utilise the study site are given in Appendix F.

In summary, four vertebrate and one invertebrate fauna species of conservation significance (listed on state or federal threatened species lists, migratory or DEC priority species) were positively identified as utilising the study area for some purpose during the Level 1 reconnaissance survey/GSM survey, these being:



- *Synemon gratiosa* Graceful Sun-Moth – S1 (*WC Act*), Endangered (*EPBC Act*)
  Twenty three specimens collected in or near the ODP area during the GSM survey. The current known distribution is from Jurien Bay in the north to Binningup in the south (DEC *pers. comms.* April 2010).

- *Calyptorhynchus latirostris* Carnaby`s Cockatoo – S1 (*WC Act*), Endangered (*EPBC Act*)
  Foraging evidence attributed to this species observed during site survey. This species may occasionally roost onsite though no evidence of this observed. No hollows potentially suitable for nesting appear to be present.

- *Ardea alba* Great Egret – S3 (WC Act), Migratory (*EPBC Act*)
  Observed foraging along the Moore River. Listed as a potential species as it may roost within in trees in or near the boundary of the proposed development. No suitable breeding habitat.

- *Pandion haliaetus* Osprey – Migratory (*EPBC Act*)
  Observed flying overhead during the survey period. Potential for larger trees to be used for nesting though probability of this occurring is low. No existing nest sites observed.

- *Ardeotis australis* Australian Bustard - P4 *(*DEC Priority Species)
  A single individual of this species was observed during the March 2010 GSM surveys. Despite this observation the species is only likely to be a rare vagrant to the area.

Ten additional species of conservation significance may possibly utilise the study area for some purpose at times but their current status on site and/or in the general area is difficult to determine because they were not sighted during the survey period or evidence of use of the study area was not found. Note: Habitat for some species onsite, while considered possibly suitable, may be marginal in extent/quality and species listed below may only visit the area for short periods or as rare/uncommon vagrants. For example habitat within significant portion of the site (e.g. cleared areas) can be considered totally unsuitable for some of the species listed:

- *Ctenotus gemmula* Jewelled Ctenotus – P3 (DEC Priority species)
  The study area appears to be within this species documented range though no specimens have been reported in any of the previous survey reports examined. May utilise Banksia woodland areas.

- *Neelaps calonotos* Black-striped Snake – P3 (DEC Priority species)
  DEC record from general area. May utilise coastal dunes and banksia woodland as habitat.

- *Morelia spilota imbricata* Southern Carpet Python - S4 (WC Act), P4 (DEC Priority species)
  DEC record from general area. Potentially present in low numbers within any of the densely vegetated areas.

- *Merops ornatus* Rainbow Bee-eater – S3 (WC Act), Migratory (*EPBC Act*)
  Common seasonal visitor to south west. Likely to forage and roost in the study area at times. Potentially breeds on site where soil conditions allow.

- *Ardea ibis* Cattle Egret – S3 (WC Act), Migratory (*EPBC Act*)
  May infrequently visit cleared paddock areas at times, most likely when cattle present. No suitable breeding habitat.

- *Apus pacificus* Fork-tailed Swift – S3 (WC Act), Migratory (*EPBC Act*)
  Rare seasonal visitor. May forage in area but very unlikely to roost.

- *Haliaeetus leucogaster* White-bellied Sea-Eagle – S3 (WC Act), Migratory (*EPBC Act*)
  May fly over occasionally given proximity to ocean and river. Potential for larger trees to be used for nesting though probability of this occurring is very low. No existing nest sites observed.

- *Falco peregrinus* Peregrine Falcon - S4
  Uncommon so unlikely to be resident in the actual study site but area may form part of larger home range. No potential nest sites observed.

- *Isoodon obesulus fusciventer* Quenda – P5 (DEC Priority Species)
  May frequent areas with dense ground cover though not captured during the detailed fauna survey on the site previously or in other nearby surveys.

- *Macropus irma* Western Brush Wallaby – P4 (DEC Priority Species)
  Status in the area is uncertain. Limited area of potential habitat but may move through the area on occasions.

Species of conservation significance that, while possibly present in the general area (e.g. larger public and private nature reserves in the general area), are not listed as potential species due to known localised extinction (and no subsequent recruitment from adjoining areas) and/or lack of suitable habitat and/or the presence of feral predators:

- *Calyptorhynchus baudinii* Baudin`s Cockatoo - S1 (*WC Act*), Vulnerable (*EPBC Act*)
  Study area is outside the documented range of this species and it is unlikely to frequent the area.

- *Calyptorhynchus banksii naso* Forest Red-tailed Black Cockatoo – S1 (*WC Act*), Vulnerable (*EPBC Act*)
  Study area is outside the documented range of this species and it is unlikely to frequent the area.



- *Dasyurus geoffroii* Chuditch - S1 (*WC Act*), Vulnerable (*EPBC Act*)
  Rarely recorded on the coastal plain. Not recorded during any of the detailed surveys carried out in the area in the past. This species is very unlikely to be present.

7.5.4 Other Species of Significance

Fourty two of the bird species that potentially frequent or occur in the study area are noted as Bush Forever Decreaser Species in the Perth metropolitan region (ten species were sighted/identified as having used the site during the site survey). Decreaser species are a significant issue in biodiversity conservation in the Perth section of the Coastal Plain as there have been marked reductions in range and population levels of many sedentary bird species as a consequence of disturbance and land clearing (Dell & Hyder-Griffiths 2002).

8. COMMONWEALTH ENVIRONMENT PROTECTION & BIODIVERSITY CONSERVATION ACT 1999

A number of fauna species known to or potentially present within the study area are listed under the federal *Environment Protection and Biodiversity Conservation Act* (*EPBC Act, 1999*). The objective of the *EPBC Act* is to provide for the protection of the environment, especially those aspects that are of national significance, promote ecologically sustainable development, the conservation of biodiversity and a cooperative approach to the protection and management of the environment.

Development proposals ("actions") that are likely to have a significant impact on any listed species should be referred to the Department of Environment, Water, Heritage and Arts (DEWHA) for assessment. The aim of a referral is to provide certainty about whether a proposal does or doesn't need approval under the *EPBC Act*. The proposed action should be considered at its broadest possible scope. This includes all stages and components of the action, all related activities, and all related infrastructure such as roads and powerlines, if applicable.

It is the proponent's responsibility to determine if their proposed action (e.g. clearing and development of an area of native bushland) requires referral. To aid in determining if a proposal is likely to have a significant impact DEWHA provide a series of Significant Impact Guidelines (DEH 2006). These guidelines outline a 'self-assessment' process, including detailed criteria, to assist persons in deciding whether or not referral may be required.

The criteria are intended to provide general guidance on the types of actions that will require approval and the types of actions that will not require approval. The criteria are not intended to be exhaustive or definitive. If a proponent is

Table 3: Listed Threatened, Migratory and Priority Fauna Species Potentially Occurring in Study Area.

Common Name/Species	Conservation Code				Actual Records or Listed as Potentially in General Area				Threatening Processes	Habitat Requirements	Habitat in Project Area/Quality	Potential Impact on Habitat
	EPBC Act Status	WAWC Act Status	ICUN Status	DEC Priority Status	EPBC Act Database	DEC Databases	Birds Aust. Data Base	Other Records				
Graceful Sun Moth *Synemon gratiosa*	EN	S1	EN	-	Yes	-	-	Yes	Land clearing/changing fire regimes/recreational use of cleared tracks	Low open woodlands or low open forest dominated by Banksia and Eucalyptus nas coastal shrubland/heaths. The Graceful Sun Moth is thought to breed exclusively on *Lomandra* species.	Yes	Loss of an area of potential habitat
Jewelled Ctenotus *Ctenotus gemmula*	-	-	-	P3	-	-	-	-	Land clearing	Prefers pale sandplains supporting either banksia or mallee with heath. Seeks shelter beneath leaf litter, in abandoned stick-ant nest and burrows at the base of trees and shrubs	Yes Marginal	Loss of small area of potential habitat
Black-striped Snake *Neelaps calonotos*	-	-	-	P3	-	Yes	-	-	Land clearing	This species of snake favours sandy soils supporting heath and banksia/eucalypt woodland	Yes Marginal	Loss of an area of potential habitat
Southern Carpet Python *Morelia spilota impricata*	-	S4	LR/NT	P4	-	Yes	-	-	Fox predation.	This species has been recorded from semi-arid coastal and inland habitats, Banksia woodland, Eucalypt woodlands, and grasslands. Often arboreal but will utilise hollows and the burrows of other animals for shelter.	Yes	Loss of an area of potential habitat
Australian Bustard *Ardeotis australis*	-	-	NT	P4	-	-	-	Yes	Fox predation, hunting, intensive agriculture, invasion of pastoral land by woody weeds, changes to fire regimes	Grasslands, especially tussock grasses, like speargrass, Mitchell grass, spinifex; arid scrub with saltbush, bluebush; open dry woodland of mulga, mallee and heath.	Yes Marginal	None
Great Egret *Ardea alba*	Migratory (CAMBA, JAMBA)	S3	LC	-	Yes	-	Yes	Yes	Loss of breeding habitat and declines in water quality.	Wetlands, flooded pasture, dams, estuarine mudflats, mangroves and reefs	Yes Marginal	None
Cattle Egret *Ardea ibis*	Migratory (CAMBA, JAMBA)	S3	LC	-	Yes	-	-	-	Loss of breeding habitat and declines in water quality	Moist pastures with tall grasses, shallow open wetlands and margins, mudflats.	Yes Marginal	None
White-bellied Sea Eagle *Haliaeetus leucogaster*	Migratory (CAMBA)	S3	LC	-	-	-	Yes	-	Loss of breeding habitat and declines in water quality	Nests and forages near the coast over islands, reefs, headlands, beaches, bays, estuaries, mangroves, but will also live near seasonally flooded inland swamps, lagoons and floodplains, often far inland on large pools of major rivers. Established pairs usually sedentary, immatures dispersive. Builds a large stick nest, which is used for many seasons in succession.	Yes Marginal	None Likely
Osprey *Pandion haliaetus*	Migratory (Bonn)		LC				Yes	Yes	Loss of breeding habitat and declines in water quality	Coasts, estuaries, bays, inlets, islands, and surrounding waters, coral atolls, reefs, lagoons, rock cliffs and stacks. Ascends larger rivers. Construct nests on prominent headland, large trees communication towers	Yes Marginal	None Likely
Peregrine Falcon *Falco peregrinis*	-	S4	LC	-	-	Yes	Yes	Yes	Loss of breeding habitat	Diverse from rainforest to arid shrublands, from coastal heath to alpine. Mainly about cliffs along coasts, rivers and ranges and about wooded watercourses and lakes. The species utilises the ledges, cliff faces and large hollows/broken spouts of trees for nesting. It will also occasionally use the abandoned nests of other birds of prey.	Yes	None Likely
Forest Red-tailed Black Cockatoo *Calyptorhynchus banksii naso*	VU	S1	LC	-	Yes	-	-	-	Land clearing and logging.	This subspecies of the Red-tailed Black Cockatoo is restricted to the forests of the south-west. It requires tree hollows to nest and breed and is totally dependent on jarrah-marri forest.	No	None
Baudin's Black-Cockatoo *Calyptorhynchus baudinii*	VU	S1	EN	-	Yes	-	-	-	Land clearing and illegal shooting	Heavily forested areas of the south-west, where it feeds on the seeds of' eucalypts and various proteaceous species. Mainly a migrant moving from the deep south-west to the central and northern Darling Range between March and September. Nests in tree hollows (primarily Marri).	No	None
Carnaby's Black-Cockatoo *Calyptorhynchus latirostris*	EN	S1	EN	-	Yes	Yes	Yes	Yes	Land clearing and illegal shooting	This species moves around in seasonal flocks to feeding areas in proteaceous scrubs and heaths and eucalypt woodlands as well as pine plantations. Breeding occurs in winter/spring mainly in eastern forest and wheatbelt where they can find mature hollow bearing trees to nest in though it appears this species is currently expanding its breeding range westward and south into the Jarrah – Marri forest of the Darling Scarp and into the Tuart forests of the Swan Coastal Plain including the region between Mandurah and Bunbury.	Yes	Loss of a small area of foraging and potential breeding habitat

Common Name/Species	Conservation Code				Actual Records or Listed as Potentially in General Area				Threatening Processes	Habitat Requirements	Habitat in Project Area/Quality	Potential Impact on Habitat
	EPBC Act Status	WAWC Act Status	ICUN Status	DEC Priority Status	EPBC Act Database	DEC Databases	Birds Aust. Data Base	Other Records				
Fork-tailed Swift *Apus pacificus*	Migratory (CAMBA, JAMBA)	S3	LC	-	Yes	-	Yes	-	None identified	Low to very high airspace over varied habitat from rainforest to semi desert.	Yes	None
Rainbow Bee-eater *Merops ornatus*	Migratory (JAMBA)	S3	LC	-	Yes	-	Yes	Yes	Loss of roosting and breeding sites	Open Country, of woodlands, open forest, semi arid scrub, grasslands, clearings in heavier forest, farmlands. Common as a regular summer migrant to southern Australia (September to April) and breeds underground during this period in areas of suitable soft soil firm enough to support tunnel building.	Yes	None
Chuditch *Dasyurus geoffroii*	VU	S1	VU	-	Yes	-	-	-	Competition from and predation by foxes and cats, land clearing, habitat alteration through removal of suitable den logs, poisoning, illegal shooting and road traffic.	This carnivorous marsupial occupies large home ranges, is highly mobile and appears to utilise bush remnant and corridors. Requires a medium sized hollow at or near ground level or will dig burrow under log or stump. Chuditch occur in a wide range of habitats but are more commonly found in woodland, forest and riparian vegetation.	No Locally Extinct	None
Quenda *Isoodon obesulus fusciventer*	-	-	LC	P5	-	Yes	-	-	Fox predation and land clearing	This species prefers areas with dense understorey vegetation, particular around swamps and along watercourses that provide ample protection from predators.	Yes	Loss of an area of potential habitat
Western Brush Wallaby *Macropus irma*	-	-	LC	P4	-	-	Yes	Yes	Fox predation.	The western brush wallaby prefers areas of forest and woodland supporting a dense shrub layer adjacent to small open areas.	Yes	Loss of a small area of potential habitat

unsure whether their proposed action is likely to have a significant impact on a matter of national environmental significance it should be referred to the DEWHA for a binding decision on whether approval is required (DEH 2006).

The revised ODP design has been based on the need to retain suitable habitat for GSM and Carnaby's Black Cockatoo. Notwithstanding this there may still be a requirement to refer a subsequent action(s) pursuant to the EPBC Act. However in the absence of a formalised Commonwealth policy that actual requirement is yet to be determined.

8.1 LISTED THREATENED SPECIES

Two *EPBC Act* listed threatened fauna species were identified as being present in the area of the development site at times, these being:

- *Calyptorhynchus latirostris* Carnaby's Black Cockatoo – Endangered
- *Synemon gratiosa* Graceful Sun-Moth – Endangered

The significant impact criteria for endangered species are defined in the Significant Impact Guidelines (DEH 2006) as:

An action is likely to have a significant impact on an endangered species (e.g. Carnaby's Black Cockatoo and the Graceful Sun-Moth) if there is a real chance or possibility that it will:

- lead to a long-term decrease in the size of a population; or
- reduce the area of occupancy of the species, or
- fragment an existing population into two or more populations, or
- adversely affect habitat critical to the survival of a species, or
- disrupt the breeding cycle of a population, or
- modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline, or
- result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species´ habitat; or
- introduce disease that may cause the species to decline; or

- interfere with the recovery of the species.

To have a significant impact on an endangered species as defined under the DEWHA Significant Impact Guidelines (DEH 2006), any proposed development would need to trigger at least one of the abovementioned significant impact criteria thresholds. Each of these is briefly assessed below.

Note: Potential implications of the project on the Graceful Sun-Moth are not discussed as the analyses of survey results are not complete at this stage. GSM will be the subject of a separate report when details are finalised (Cardno 2010, Moore River South: Graceful Sun Moth Survey, in preparation).

Lead to a long-term decrease in the size of a population

The study area contains foraging habitat for Carnaby's Black Cockatoos but the extent of the proposed clearing is relatively small. The removal of this area of vegetation is very unlikely to lead to a long term decrease in the size of the Carnaby's Black Cockatoo population. The closest known breeding population of Carnaby's Black Cockatoo is centred in Yanchep National Park and consists of about 8-10 pairs (Ron Johnstone pers. comms.). This breeding area is however over 20km from the study site, a distance that exceeds the distance travelled by breeding birds in search of food for hatchlings (Saunders 1980). No evidence has been gathered that suggests that the proposed development of the land would lead to a decrease in the size of the Carnaby's Black Cockatoo population.

It is very unlikely that this criteria will be compromised by the development proceeding.

Reduce the area of occupancy of the species

The extent of the proposed clearing is relatively small and significant areas of similar habitat are present in adjoining areas. Carnaby's Black Cockatoo will also use residential areas where suitable plant species are present. It can therefore be expected that the species will continue to utilise the general area as they do now despite the proposal proceeding. There is no evidence to suggest that the proposed development of the land at the study site would lead to a significant reduction in the area of occupancy by the species.

This criteria will not be compromised by the development proceeding.

Fragment an existing population into two or more populations

The extent of clearing required is small and will not fragment any potential habitat to the extent that it would represent a barrier to Carnaby's Black Cockatoo movement therefore development of the site to any degree will not

fragment any existing black cockatoo populations. Cockatoos will continue to utilise the wider area as they do now despite any development of the site.

This criteria will not be compromised by the development proceeding.

Adversely affect habitat critical to the survival of a species

It is extremely unlikely at the vegetation onsite identified as potential foraging/breeding habitat is "critical" for the survival of Carnaby's Black Cockatoo. The closest known breeding population of Carnaby's Black Cockatoo is centred in Yanchep National Park (Ron Johnstone pers. comms.). This breeding area is however over 20km from the study site, a distance that exceeds the documented distance travelled by breeding birds in search of food for hatchlings (Saunders 1980).

This criteria will therefore not be compromised by the development proceeding.

Disrupt the breeding cycle of a population

No trees were identified onsite as containing hollows suitable for Carnaby's Black Cockatoo to use for breeding. While it is possible that some trees onsite may in the future develop suitable hollows, the probability of any one tree developing a hollow and then it being used by a cockatoo is extremely low. The closest known breeding population of Carnaby's Black Cockatoo is centred in Yanchep National Park (Ron Johnstone pers. comms.). This breeding area is however over 20km from the study site, a distance that exceeds the documented distance travelled by breeding birds in search of food for hatchlings (Saunders 1980).

It is very unlikely that this criteria will be compromised by the development proceeding.

Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

The study area contains foraging habitat for Carnaby's Black Cockatoos but the extent of the proposed clearing is relatively small. The removal of this area of vegetation is very unlikely have a significant impact on overall population levels. The closest known breeding population of Carnaby's Black Cockatoo is centred in Yanchep National Park and consists of about 8-10 pairs (Ron Johnstone pers. comms.). This breeding area is however over 20km from the study site, a distance that exceeds the distance travelled by breeding birds in search of food for hatchlings (Saunders 1980). There is no evidence to suggest that the proposed development of the land at the study site would modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that would cause the Carnaby's Black Cockatoo population numbers to decline.



It is unlikely that this criteria will be compromised by the development proceeding.

Result in invasive species that are harmful to endangered becoming established in the endangered species' habitat

It is extremely unlikely that the proposed development of the land would result in an invasive species harmful to Carnaby's Black Cockatoo, becoming established on the site or in the vicinity.

This criteria will not be compromised by the development proceeding.

Introduce disease that may cause the species to decline;

It is extremely unlikely that the proposed development of the land would result in the introduction of a disease that would cause Carnaby's Black Cockatoo to decline.

This criteria will therefore not be compromised by the development proceeding.

Interfere with the recovery of the species

The population growth of the Carnaby's Black-Cockatoo is primarily limited by factors associated with breeding, and consequently priority areas for the recovery of the species are currently focused on known breeding sites (Cale 2003). No trees within the study area were found to contain hollows suitable for breeding and as far as the Author is aware the study area is not in or near other known breeding sites. The closest known breeding area, used by an estimated 8-10 pairs (Ron Johnstone pers. comms.) is located over 20km away. The study site is therefore very unlikely to be used by breeding birds for any purpose. There is no evidence to suggest that the proposed development of the land would interfere with the recovery of Carnaby's Black Cockatoo.

This criteria will therefore not be compromised by the development proceeding.

In all cases it is considered unlikely that the impact caused by development at the site would trigger any of the abovementioned criteria and therefore "significant" impact on Carnaby's Black Cockatoo, as currently defined by the DEWHA is considered unlikely to occur.

As previously mentioned the revised ODP design has been based on the need to retain suitable habitat for GSM and Carnaby's Black Cockatoo. Notwithstanding this there may still be a requirement to refer a subsequent action(s) pursuant to the EPBC Act. However in the absence of a formalised Commonwealth policy that actual requirement is yet to be determined.

It should also be noted that the DEWHA are in the process of formulating new guidelines relating to impacts on black cockatoos and any actual development of the site may exceed thresholds relating to likely significant impacts (under the *EPBC Act*) as defined in this new document.

While not officially released it is understood that DEWHA will consider clearing of an area of foraging habitat over 1.0 ha to constitute a significant impact. Clearance of more than a few (three) breeding trees (defined as any tree with a diameter at breast height of 50cm or more) in a woodland stand of greater than 0.5 ha in size or any existing breeding trees would also be considered to be significant (pers. comm. Environment Assessment Branch, DEWHA – December 2009).

While not fully discussed it is also possible that DEWHA will consider the project likely to have a significant impact on the endangered Graceful Sun Moth given they are present in some areas of the ODP area. It is unclear at this stage what offsets/management actions the DEWHA would consider appropriate for GSMs.

8.2 LISTED MIGRATORY SPECIES

EPBC Act listed migratory fauna species identified as being present in the general area of the development site at times were:

- *Ardea alba* Great Egret – Migratory
- *Ardea ibis* Cattle Egret – Migratory
- *Apus pacificus* Fork-tailed Swift – Migratory
- *Merops ornatus* Rainbow Bee-eater – Migratory
- *Pandion haliaetus* Osprey – Migratory
- *Haliaeetus leucogaster* White-bellied Sea-Eagle – Migratory

An action has, will have, or is likely to have a significant impact on migratory species if it does, will, or is likely to:

- substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat of the migratory species; or
- result in invasive species that is harmful to the migratory species becoming established in an area of important habitat of the migratory species; or



- seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of the species.

An area of important habitat is:

- habitat utilised by a migratory species occasionally or periodically within a region that supports an ecologically significant proportion of the population of the species;
- habitat that is of critical importance to the species at particular life-cycle stages;
- habitat utilised by a migratory species which is at the limit of the species range; or
- habitat within an area where the species is declining.

To have a significant impact on a migratory species as defined under the DEWHA Significant Impact Guidelines (DEH 2006), any proposed development would need to trigger at least one of the abovementioned significant impact criteria thresholds. Each of these is briefly assessed below.

Substantially modify, destroy or isolate an area of important habitat of the migratory species

The study are does not represent important habitat for any of the migratory species listed as potentially utilising the site. The study site contains only very marginal habitat for the Great Egret and Cattle Egret. They would not breed on site.

The Fork-tailed swift is a widespread, uncommon species that is almost totally aerial and rarely roosts. This species would not be specifically attracted to the area and would only visit the site temporarily, on very rare occasions.

Rainbow Bee-eaters are seasonally widespread and common in the south west and utilise both natural and totally degraded habitats. This species may forage and roost onsite and possibly breeds in some areas but the number of individuals present at any one time would not represent an "ecologically significant proportion of the population" and therefore impacts, if any on this species could not be regarded as "significant".

Both the White-bellied Sea Eagle and the Osprey may fly over the site at times but only when traversing to the ocean or river. There is some potential for trees onsite to be used for nesting but most are not ideally located and/or are too small. No existing nest sites are present.

The area would not support a substantial number of any of the species in question at any time.

This criteria will not be compromised by the development proceeding.

Result in invasive species that is harmful to the migratory species becoming established in an area of important habitat of the migratory species

The study are does not represent important habitat of any of the migratory species listed as potentially utilising the site. It is extremely unlikely that the proposed development of the land would result in an invasive species that is harmful to migratory species becoming established on the site or in the vicinity.

This criteria will not be compromised by the development proceeding.

Seriously disrupt the lifecycle of an ecologically significant proportion of the population of the species.

The study are does not represent important habitat for any of the migratory species listed as potentially utilising the site. The proposal area or adjoining areas do not support, at any time of the year, a significant proportion of the population of any migratory species.

This criteria will not be compromised by the development proceeding.

In all cases it is considered unlikely that the impact caused by development at the site would trigger any of the abovementioned criteria.

8.3 MINIMISING AND OFFSETTING IMPACTS

The following recommendations are provided for guidance for the formulation of management plans that should aim to reduce the impact on fauna and fauna habitat as much as reasonable and practicable. This listing is not exhaustive final plans may need to be finalised after liaison with relevant regulatory authorities (e.g. DEC and DEWHA). It should be acknowledge that planning for the development has up to this point already aimed to retain suitable GSM and Carnaby's Black Cockatoo habitat where possible.

It is recommended that:

- Any proposed landscape plantings should utilise local seed stock that includes cockatoo food plants, specifically *Eucalyptus*, *Banksia, Hakea*, and *Allocasuarina*. The final selection of suitable species should be carried out after liaison with appropriate experts or local land care groups to ascertain which species are most suitable for the area.

- A Graceful Sun-Moth management plan will need to be formulated. This species is present with some of the proposed POS and foreshore reserve areas and the management plans for these areas will need to incorporate measures that enable the species to continue to persist in these areas in the long term.

- During site works areas requiring clearing should be clearly marked and access to other areas restricted to prevent accidental clearing of areas to be retained.

- No dead, standing or fallen timber should be removed unnecessarily. Logs (hollow or not) and other debris resulting from land clearing should be used to enhance fauna habitat in untouched and rehabilitated areas if possible.

- A Construction and Operations Fire Management Plan should be prepared to reduce the risk of unplanned fires and provide contingency measures to minimise any associated impacts. The plan will include a contingency and response plan in the event of any bushfires that commence as a result of the works on site.

- All staff working on site should be made aware that native fauna is protected. Personnel working on the project should not be allowed to bring firearms, other weapons or pets onsite.

- During clearing operations a suitably experienced “fauna spotter” should be employed to inspect logs and hollow trees (where possible) before clearing to reduce likelihood of injury to fauna. If feasible any fauna encountered should be relocated to suitable retained habitat nearby.

- Native fauna injured during clearing or normal site operations should be taken to a designated veterinary clinic or a DEC nominated wildlife carer.

- Fuel storage facilities should be bunded.

- Any trenching required for services should be kept open for only as long as necessary and suitable escape ramps and bridging provided if the site is to be left unattended for extended periods. Significant sized trenches should be inspected for fauna immediately prior to filling.

9. CONCLUSION

The fauna habitat assessment at Moore River South was undertaken for the primary purpose of documenting the potential use of the site by Carnaby’s Black Cockatoo as a feeding, roosting and/or breeding location and other species of

national environmental significance such as the Graceful Sun-Moth. The results of the assessment have been used to provide a risk assessment of the likely impact on the identified species of conservation significant potentially present in the area.

The proposed development areas were found to contain areas of potential black cockatoo foraging and breeding habitat in addition to habitat of the Graceful Sun-Moth. Revised plans for the development have aimed to retain suitable GSM and Carnaby's Black Cockatoo habitat where possible.

With respect to native vertebrate fauna in general, 18 mammals (includes 7 bats species), 115 bird, eight frog and 51 reptile species have previously been recorded in the general area, some of which have the potential to occur in or utilise at times sections of the study area.

Of the 192 native animals that are listed as potentially occurring in the area, four are considered to be endangered/vulnerable or in need of special protection under state and/or federal law. In addition six migratory species may frequent the site at times and four DEC priority species were identified as possibly present. With respect to fauna in general (i.e. species not listed as threatened) no significant impacts are expected. A substantial proportion of the study area is already cleared or highly degraded and the development is unlikely to have any substantial impact on the status of the more common fauna species most likely to be currently using the area.

The proposed development will necessarily require the clearing of some existing fauna habitat. A series of recommendations are provided that aim to minimise impact of development at the site on fauna. These should be incorporated into relevant management plans, where considered reasonable and practical.

The revised ODP design has been based on the need to retain suitable habitat for GSM and Carnaby's Black Cockatoo. Notwithstanding this there may still be a requirement to refer a subsequent action(s) pursuant to the EPBC Act. However in the absence of a formalised Commonwealth policy that actual requirement is yet to be determined.

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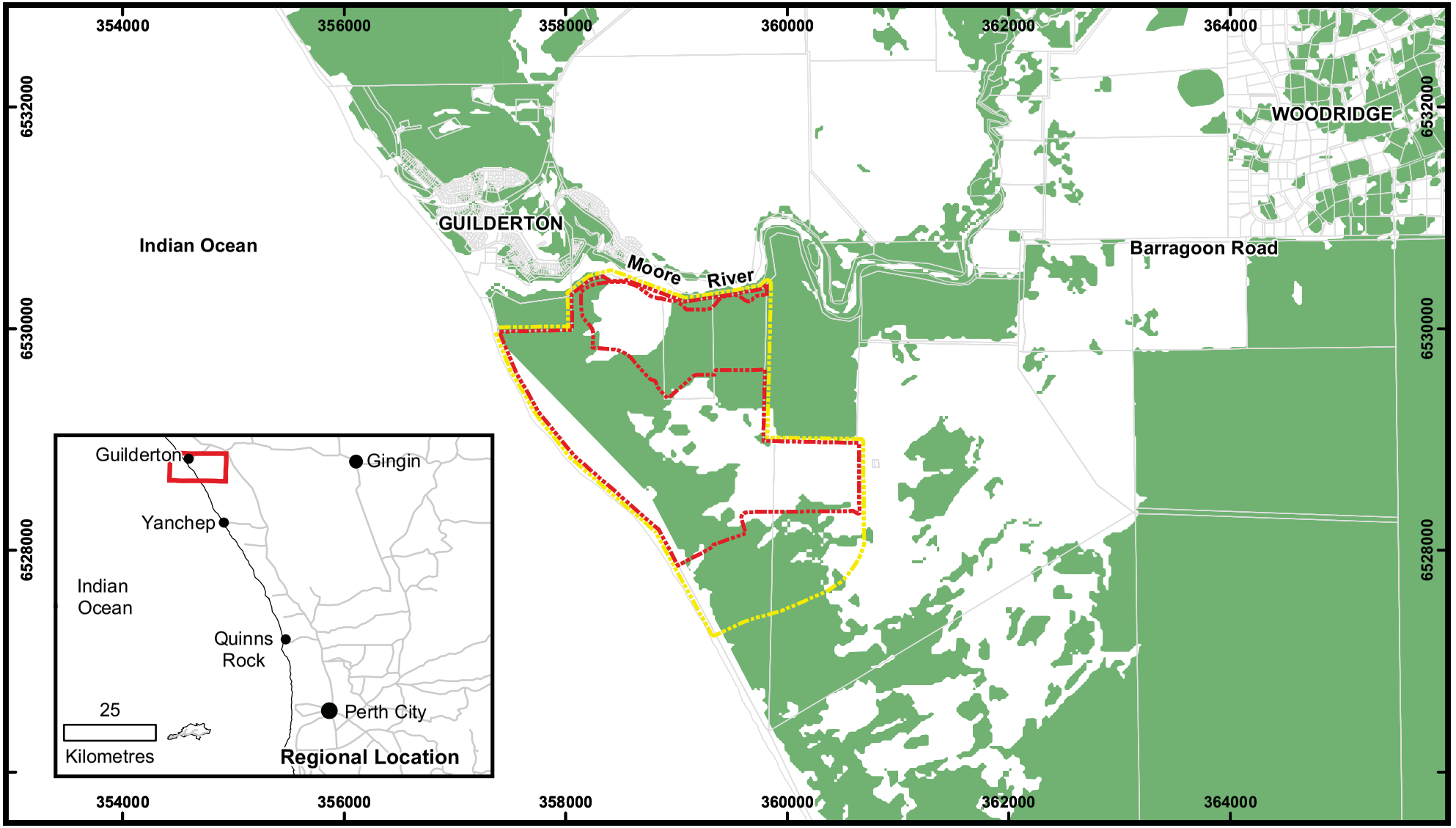
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FIGURES



Legend

- Cadastral Boundaries (Existing)
- Remnant Vegetation
- Urban Development Zone Boundary (Approx)
- Outline Development Plan Boundary (Approx)

N

0 0.5 1 1.5 2

Kilometres

MGA Zone 50

Fauna Survey

DRAWN:G Harewood

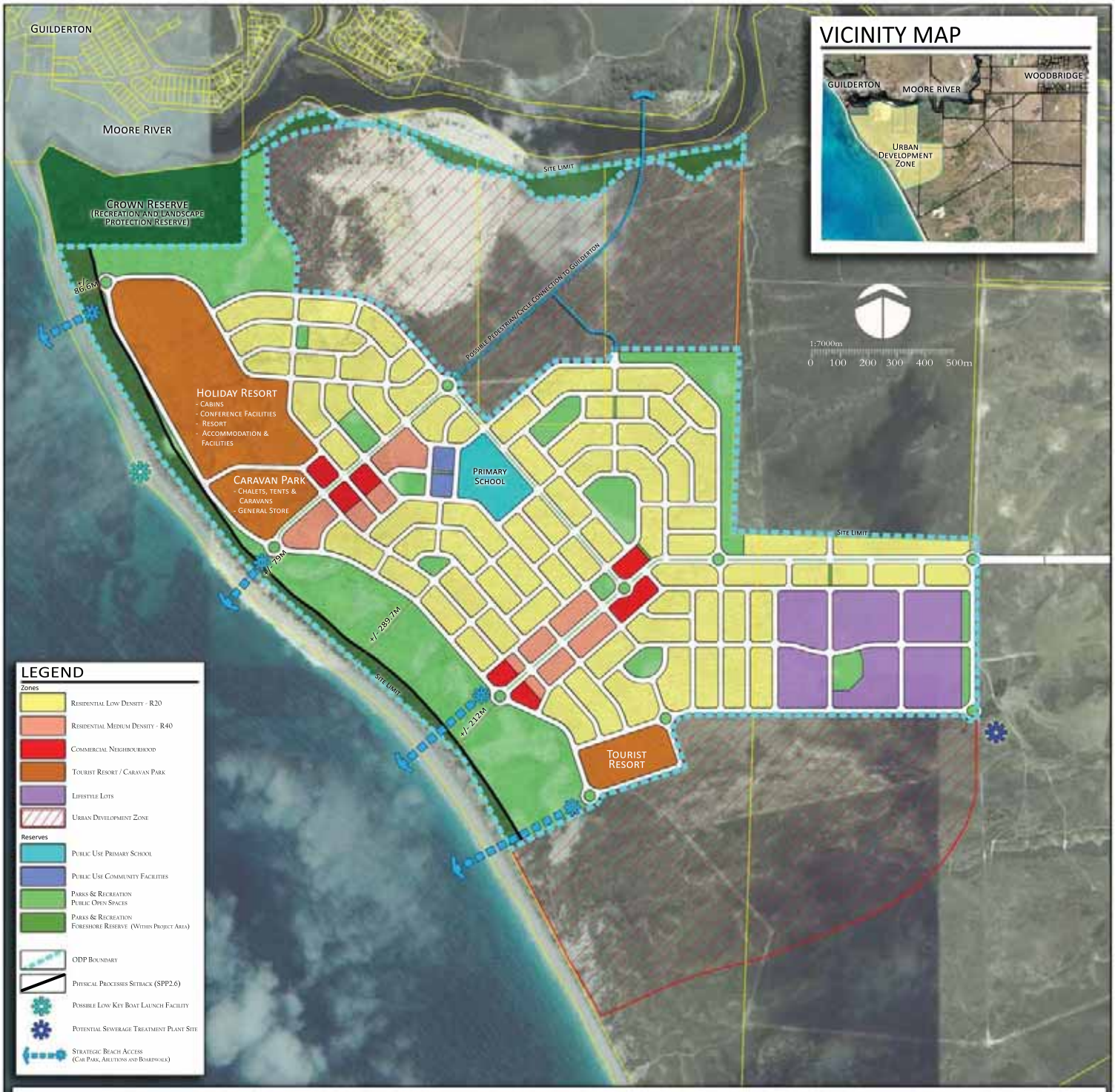
DATE : Apr 2010

SCALE: 1: 50,000

Moore River

Study Area and Surrounds

Figure: 1



VICINITY MAP

LEGEND

Zones

- Residential Low Density - R20
- Residential Medium Density - R40
- Commercial Neighbourhood
- Tourist Resort / Caravan Park
- Lifestyle Lots
- Urban Development Zone

Reserves

- Public Use Primary School
- Public Use Community Facilities
- Parks & Recreation Public Open Spaces
- Parks & Recreation Foreshore Reserve (Within Project Area)

- ODP Boundary
- Physical Processes Setback (SPP2.6)
- Possible Low Key Boat Launch Facility
- Potential Sewerage Treatment Plant Site
- Strategic Beach Access (Car Park, Ablutions and Boardwalk)

PLANNING POLICY STATEMENTS

Subdivision and Development

1. The development of the subject land shall be undertaken generally in accordance with the endorsed Outline Development Plan (ODP). Subdivision of the ODP area requires approval from the Western Australian Planning Commission (WAPC) and shall be undertaken generally in accordance with the ODP.

Retail Floor Space

2. A maximum of 500 m2 of retail floor space shall be integrated with the caravan park and tourist resort components of the ODP and provide for local convenience shopping and services in the first stages of the overall development.

Design and Settlement Guidelines

3. Detailed Design and Settlement Guidelines (DSG) for any building or structure in the ODP area must be lodged with and, if acceptable, be approved by the Shire of Gingin (the Shire). The DSG must set appropriate standards for design of dwellings to meet sustainability criteria, building location and orientation, built form, building heights, scale and roof pitch, external colours and materials, curtilage and landscaping, vehicle parking and access and fencing.
4. The DSG must mandate the installation of water tanks, water efficient taps and appliances and solar and wind energy harnessing devices in every dwelling;
5. The Design and Settlement Guidelines must include special provisions for the 'Lifestyle Lots' precinct shown on the ODP map to set standards for lot sizes, separation of uses and setbacks in addition to the matters outlined in 3 and 4 above.
6. All development in the ODP area must conform to the DSG.
7. The height of buildings must not exceed the applicable height limits in the DSG.

Staging of Subdivision and Development

8. The progressive subdivision and development of land identified for residential lots (both green title and strata) on the ODP shall proceed on the basis of a staging plan approved by the Shire and the West Australian Planning Commission that has regard for the necessity for the introduction of reticulated water and sewerage facilities to the ODP area, the early establishment of foreshore improvement works and for the subdivision and development to be carried out on a commercially viable basis.

Tourist Units

9. The strata subdivision and/or development of any land identified on the ODP for tourist accommodation shall include common management arrangements to ensure the tourist units and any associated facilities are available at all times for tourists, visitors and travellers. These arrangements are not intended to preclude owner use of tourist accommodation for holiday purposes.

Foreshore Reserves

10. A foreshore management plan shall be prepared under clause 5.1(x) and (xi) of State Planning Policy No. 2.6: State Coastal Planning Policy.
11. The foreshore management plan must:
(a) include the foreshore reserves for both the ocean and Moore River frontages of the development identified on the ODP and the adjacent Crown Reserve abutting the mouth of the Moore River ;
(b) contain a schedule of works, public facilities, infrastructure and amenities provision and implementation schedule;
(c) identify those with responsibility for implementation of the plan;
(d) be approved, if acceptable, by the Shire of Gingin; and
(e) identify required works to be fully implemented prior to the Shire's clearance of the conditions of any subdivision approval granted for the ODP area.
12. The staged construction of the Foreshore Management Plan and Public Open Space by the Proponent is to be determined at the Subdivision stage on through a Development Deed between the Proponent and the Shire in a manner that reflects progressive development of the project and progressive demand for additional facilities.
13. The ocean foreshore reserve and adjacent public open space is able to be used for drainage works or functions, including subsurface stormwater drainage and absorption structures, that do not diminish the capacity of the area for public use .

Management Plan – Carnaby's Black Cockatoo

14. Prior to the commencement of any works associated with the implementation of any approved development, subdivision or strata-subdivision, a management plan for Carnaby's Black Cockatoo shall:
(a) be prepared and submitted to the Department of Environment and Conservation for approval prior to implementation of the plan; and
(b) once approved, be implemented to the satisfaction of the Department of Environment and Conservation.

Dieback Hygiene Management Plan

15. A dieback hygiene management plan shall be prepared and submitted for approval by the Shire, which:
(a) proposes measures to ensure that dieback disease is not spread from, or to, the ODP area during those works or the transportation of vegetation or other materials as part of those works; and
(b) conforms with the Department of Environment and Conservation's publication entitled: "Best Practice Guidelines for the Management of Phytophthora cinnamomi".
16. Work associated with the implementation of any approved development, subdivision or strata-subdivision must not commence until the dieback hygiene management plan is approved by the Shire.

Fire Management Plan

17. A fire management plan must be prepared and implemented to the satisfaction of the Shire of Gingin and the Fire and Emergency Services Authority.
18. Development must be undertaken in compliance with:
(a) Part 3.7.4 (Bushfire Areas) of the Building Code of Australia; and
(b) Australian Standard 3959.
19. A memorial is to be placed on the certificate of Title for those lots affected by the fire management plan advising of the requirement to comply with the approved fire management plan and the owner's responsibility to maintain fire protection measures and emergency access to an appropriate standard.

Community Facilities

20. A comprehensive community facilities infrastructure contribution plan shall be:
(a) prepared, which identifies the basis for determination of contributions to be made to fund community facilities and infrastructure within the locality required as a direct result of the development of the land;
(b) submitted to, and approved by, the Shire prior to the lodgement of an application for planning approval or building licence and prior to the clearance of any subdivision of the land; and
(c) implemented to the satisfaction of the Shire.
21. A community purpose facility with a minimum floor area (GFA) of 200 m2 shall be provided as part of the first stage of development of the ODP area .

Revegetation, Rehabilitation and Landscaping

22. A revegetation, rehabilitation and landscaping plan shall be:
(a) prepared and submitted to the Shire for approval as part of any application for planning consent; and
(b) implemented to the satisfaction of the Shire.

Dust Management

23. A dust management plan is to be:
(a) submitted to and, if acceptable, approved by the Shire;
(b) implemented at each and every stage of development to the satisfaction of the Shire.

Landscape Strategy

24. A landscape strategy plan for the road reserves including the primary access road from Wanneroo Road and public open space areas shall be prepared, which:
(a) indicates the location and species of all trees to be removed and/or retained;
(b) indicates the location and type of fencing to be installed;
(c) indicates the location and type of reticulation to be installed;
(d) indicates the location and type of paving to be installed; and
(e) includes a plant schedule nominating each species, the spacing of species, the numbers of plants required, the size of each plant to be used at the time of planting and the anticipated height of each plant at maturity.
25. The landscape strategy plan shall:
(a) be submitted to and, if acceptable, approved by the Shire;
(b) the subject of a management agreement between the owner and the Shire; and
(c) implemented to the satisfaction of the Shire.

Construction Management Plan

26. A construction management plan shall be:
(a) prepared, which details the technical, physical and contractual measures to minimise environmental impacts during construction and post-construction phases of subdivision and development;
(b) submitted to and, if acceptable, approved by the Shire; and
(c) implemented to the satisfaction of the Shire.

Stormwater and Drainage

27. A stormwater and drainage management plan shall be:
(a) prepared, which identifies the locations and dimensions of all proposed pump stations, infiltration basins and sumps;
(b) submitted to and, if acceptable, approved by the Shire and the Department of Water; and
(c) implemented to the satisfaction of the Shire.
28. The design objectives of the stormwater and drainage management plan will be to optimise the infiltration of stormwater at source and the reuse of water.

Utilities and Services

29. All development is to be connected to underground power, telecommunications and reticulated water and sewage services.
30. The design of utilities and services will be aimed at the use of technology capable of capture of energy from wind and solar sources and the reuse of wastewater so as to minimise the demands of the new development for importation of energy and water.
31. All utilities and services are to be contained within the ODP area or where outside the ODP area within a public road reserve, Shire managed reserves or easements specifically created for that purpose.
32. These connections are to occur at the first stage of development at the full cost to the owner/developer and to the satisfaction of the Shire and, in relation to water and sewage, the Water Corporation.

Traffic Management and Parking

33. A traffic and parking strategy shall be:
(a) prepared by a suitably qualified traffic engineer, which:
(i) shows the required upgrading works for the local road system, including the intersection of the primary access road and Wanneroo Road;
(ii) shows the staging of these works relative to the staging of the development;
(iii) assesses the future public, private residential and tourist car park requirements generated by the development proposed in the ODP area; and
(iv) demonstrates that sufficient foreshore parking or alternative access is provided for tourist and residential development as well as the demands of visitors and the general public.
(b) submitted to the Shire and, if acceptable, approved by the Shire and Main Roads WA; and
(c) implemented to the satisfaction of the Shire prior to the Shire's clearance of any condition of any approval granted for the subdivision or strata subdivision of land within the ODP area.
34. All residential lots are to contain on-site car parking in accordance with the Residential Design Codes.

Further Subdivision

35. Subdivision of the residential areas depicted on the ODP will only be permitted in accordance with the Residential Design Codes.

Special Land Use Controls

36. The following special land use exemptions will apply to development in the ODP area:
(a) For the purposes of facilitating provision of community facilities in the initial stages of development land identified as being within the 'Residential zone on the ODP map may be developed for the purposes of 'medical centre', 'shop', 'civic use' and/or 'office' as defined under the Shire of Gingin Town Planning Scheme No. 8 (TPS 8) and on the basis of being an 'SA' use for the purposes of Table 1 – Zoning Table in the scheme;
(b) 'Civic use' is deemed to be an 'AA' use in the Commercial zone under TPS 8; and
(c) Land in the area shown as 'Lifestyle Lots' on the ODP map may be developed for all land uses marked as 'P', 'IP' and/or 'AA' opposite the Residential and Industrial zones in Table 1 – Zoning Table in TPS 8 subject to the application processes and considerations that apply according to each land use pursuant to Table 1 and Clause 3.2 of TPS 8.

Adoption Signature

This Outline Development Plan was endorsed by the Council of the Shire of Gingin pursuant to Clause 5.6.3 of the Shire of Gingin Town Planning Scheme No. 8 on _____ day of _____ 2010

_____
Chief Executive Officer

and

Endorsed by the Western Australian Planning Commission on _____ day of _____ 2010

_____
WAPC Chairman

Project: Moore River

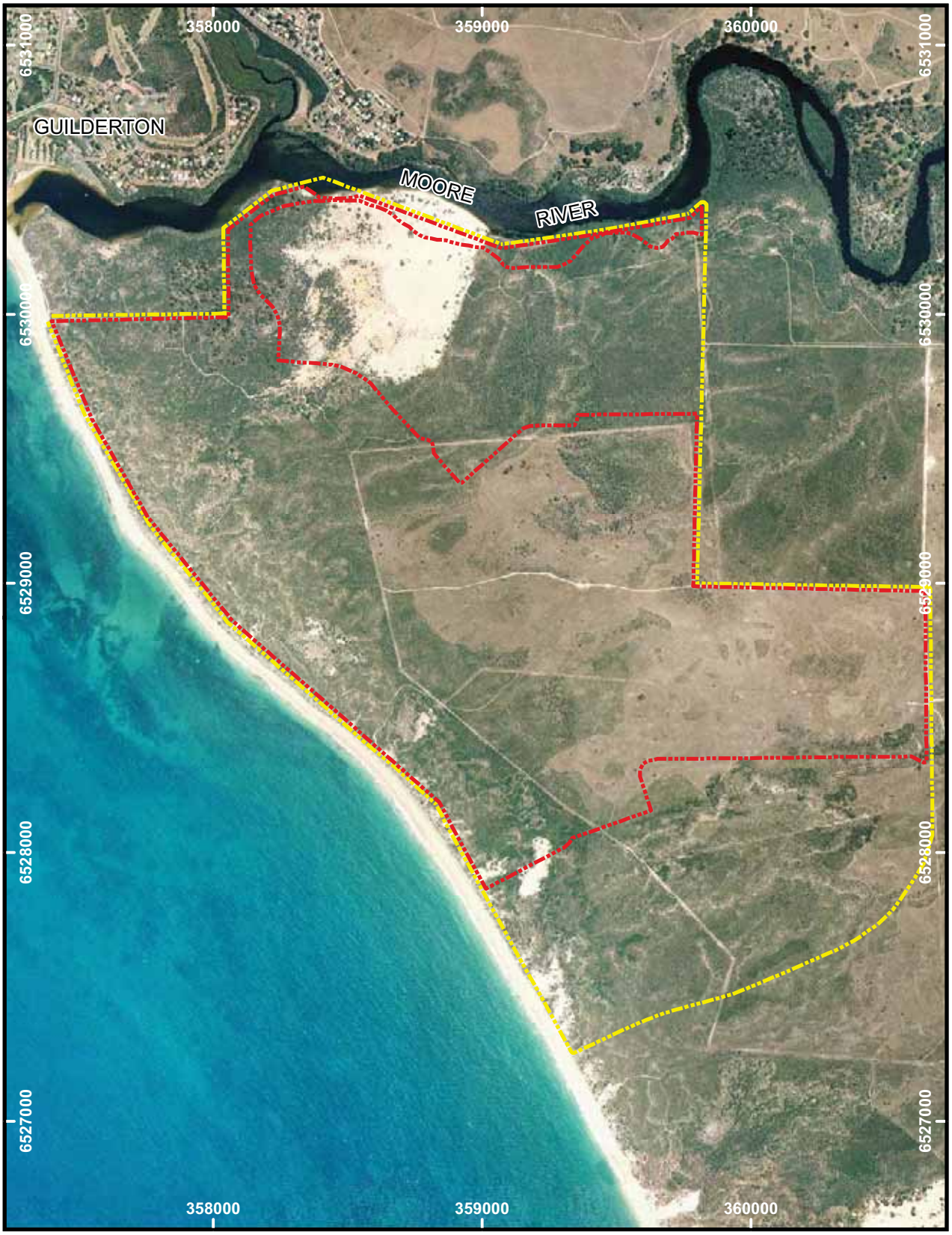
Title: Revised Outline Development Plan

Principal: Moore River Company Pty Ltd

Cardno (WA) Pty Ltd
Cardno Centre
2 Bagot Road
P.O. Box 155 Subiaco
Western Australia 6904
Telephone (08) 9273 3888
Fax (08 9388 3831

Date: 07 April 2010	Scale: 1:7000m
Designed: RG	Checked:
Drawn: RG	Approved:
Local Authority: Shire of Gingin	Sheet 1 of 1
Project - Phase - Plan Number P07026 - SK10	Revision X

Original: A1



Legend

Outline Development Plan Boundary (Approx)

Urban Development Zone Boundary (Approx)

N

0 250 500 750 1,000

Meters

MGA Zone 50

Fauna Survey

DRAWN: G Harewood

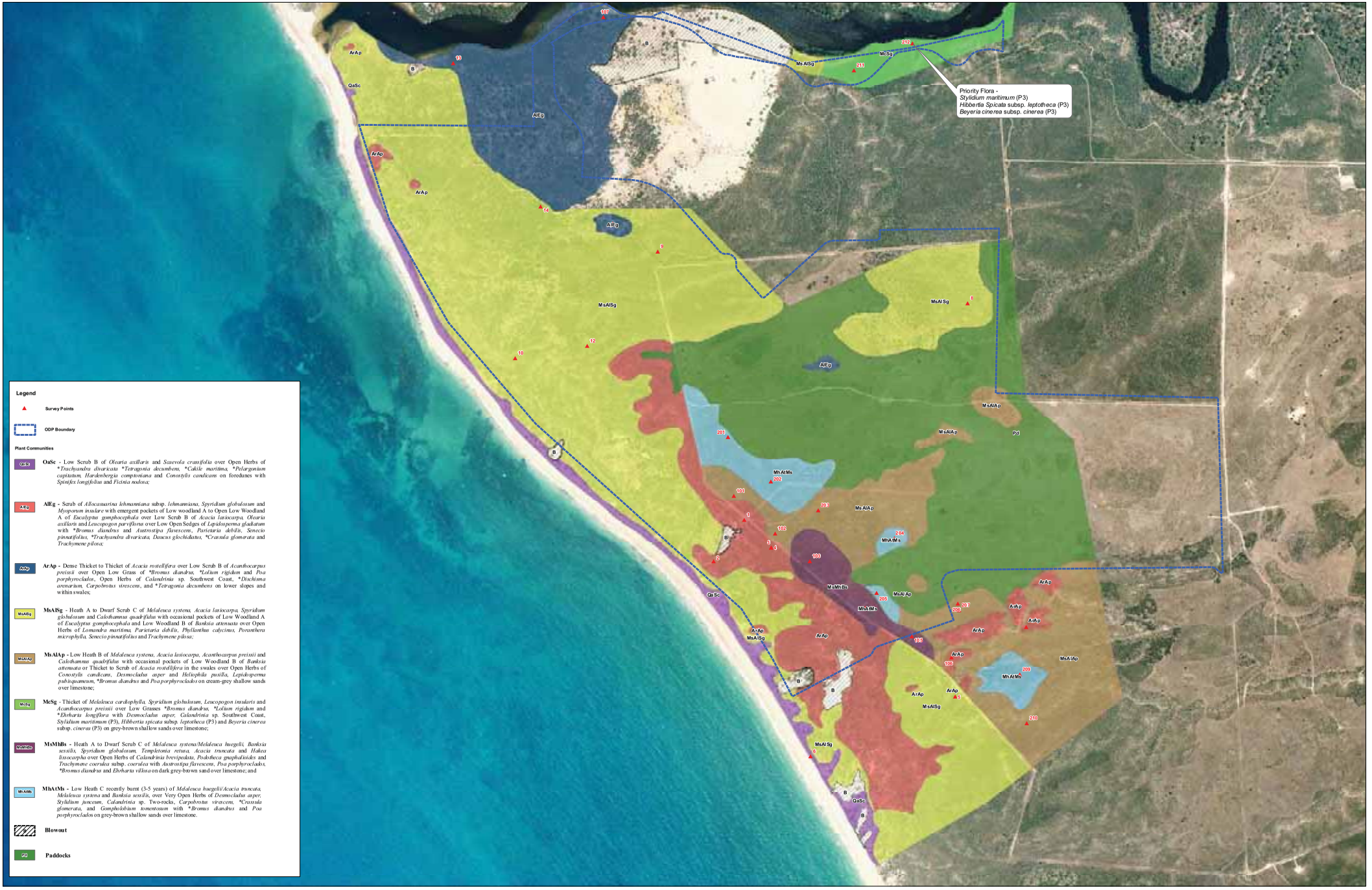
DATE : Apr 2010

SCALE: 1: 21 000

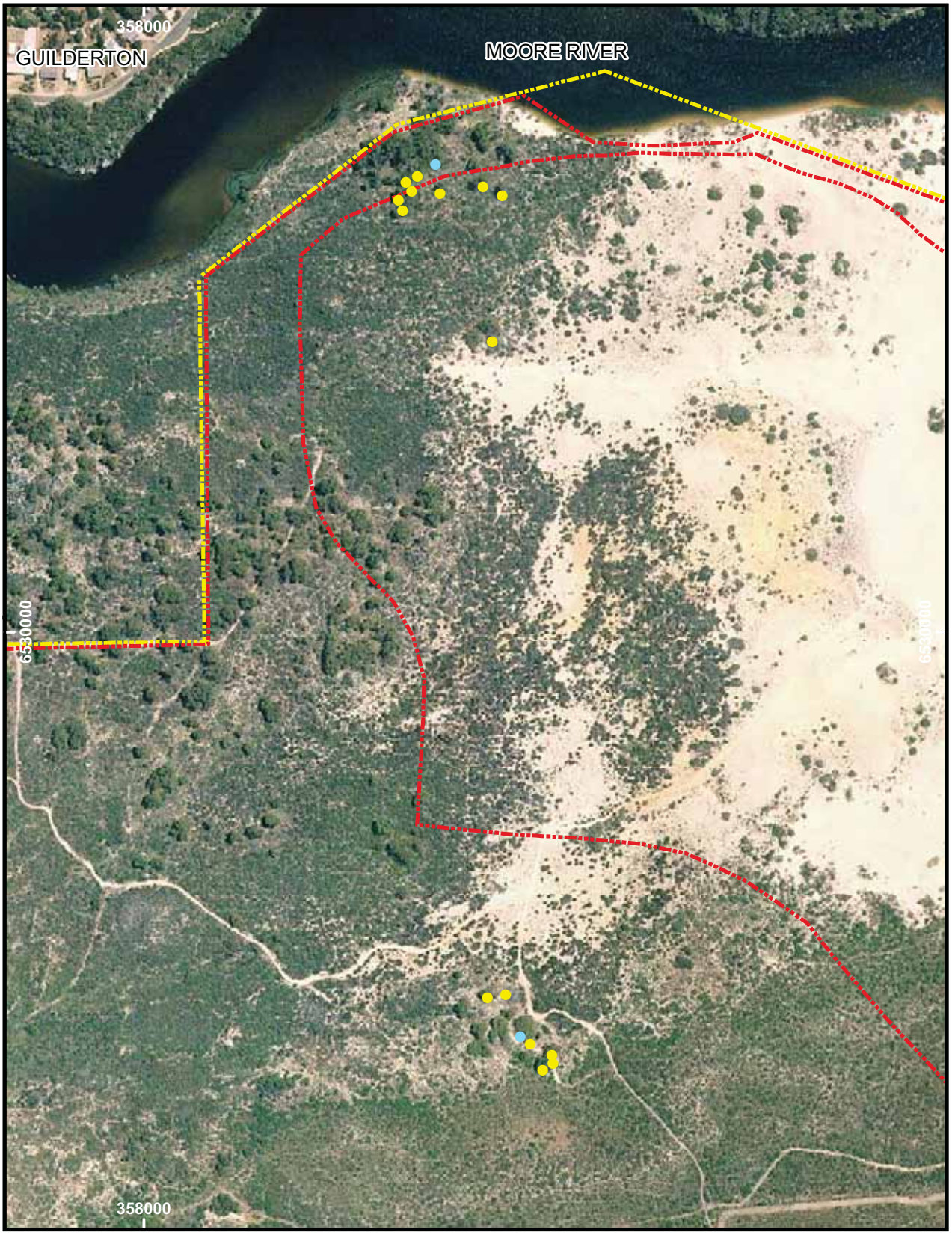
Moore River

Air Photo

Figure: 3



This drawing has been prepared in accordance to Cardno Quality Management System & remains the property of Cardno WA Pty Ltd, and shall not be used without permission. The drawing shall be preliminary only and/or not for construction until signed approved.



Legend

- Outline Development Plan Boundary (Approx)
- Urban Development Zone Boundary (Approx)
- >50cm DBH, no hollows
- >50cm DBH, 1 or more small hollows

0 50 100 150 200 250
Meters

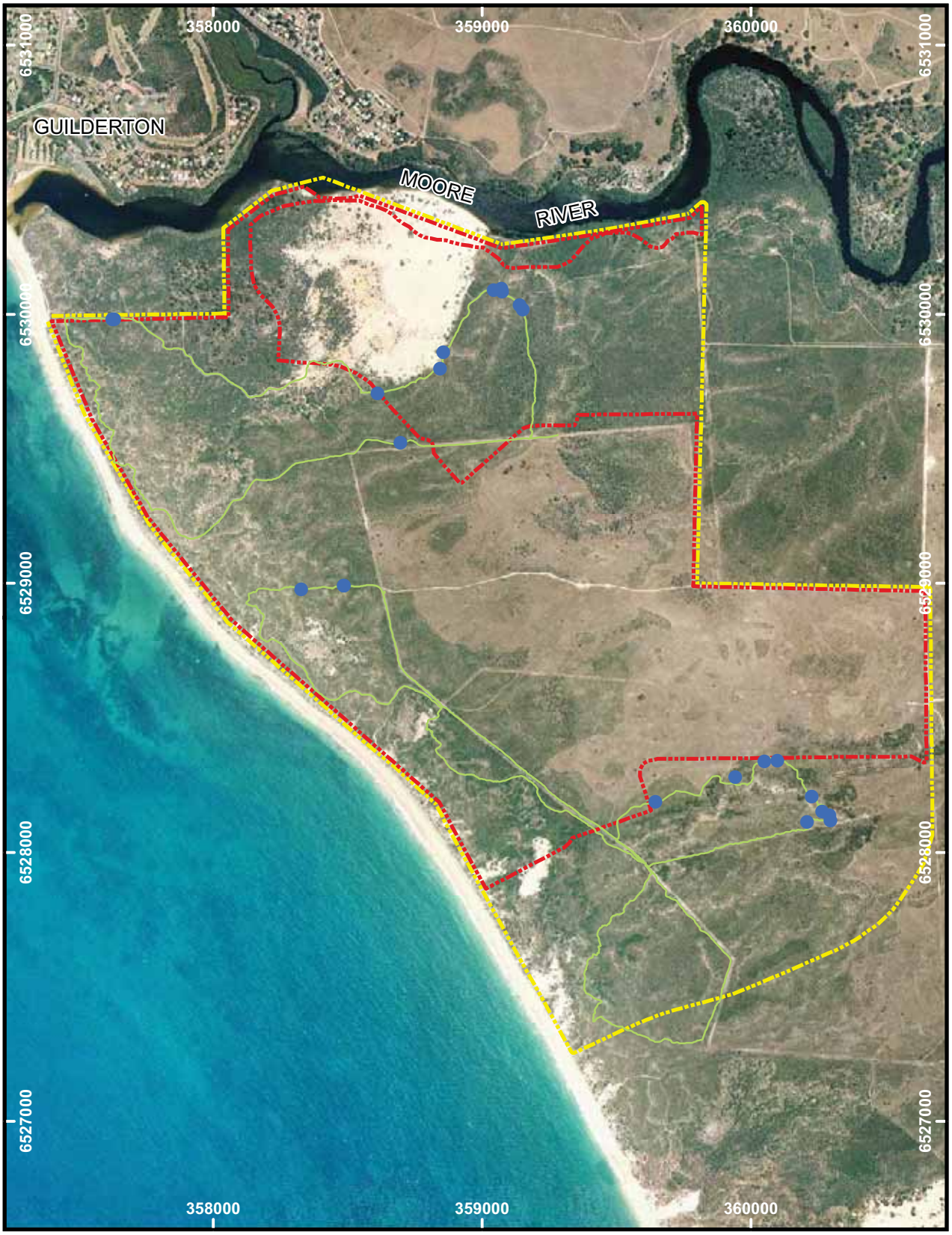


DRAWN: G Harewood
DATE : Apr 2010
SCALE: 1: 5 000
MGA Zone 50

Moore River

Signifciant Trees

Figure: 5



Legend

- Outline Development Plan Boundary (Approx)
- Urban Development Zone Boundary (Approx)
- GSM Survey Route
- Combined GSM Sightings March 2010

0 250 500 750 1,000
Meters



DRAWN: G Harewood
DATE : Apr 2010
SCALE: 1: 21 000
MGA Zone 50

Moore River

Combined Graceful Sun-Moth Observations

Figure: 6

PLATES



Plate 1: *Olearia axillaris* Shrubland.



Plate 2: *Allocasuarina lehmanniana* Scrub.



Plate 3: *Melaleuca acerosa* /*Olearia axillaris* Shrubland.



Plate 4: *Allocasuarina lehmanniana*/*Melaleuca acerosa* Scrub



Plate 5: *Melaleuca acerosa*/*Acacia lasiocarpa* Low Open Heath



Plate 6: *Banksia sessilis* Heath on Limestone



Plate 7: *Melaleuca huegelii* Low Open Heath on Limestone



Plate 8: *Banksia attenuata*/*prionotes* Low Woodland



Plate 9: Tuart (*E. gomphocephala*) Woodland over *Allocasuarina lehmanniana* Shrubland



Plate 10: Bare Sand/Blow Outs



Plate 11: Cleared/Totally Degraded

APPENDIX A

CONSERVATION CATEGORIES

EPBC Act (1999) Threatened Fauna Categories

Category	Code	Description
Extinct	E	There is no reasonable doubt that the last member of the species has died.
*Extinct in the wild	EW	A species (a) is known only to survive in cultivation, in captivity or as a naturalised population well outside its past range; or (b) has not been recorded in its known and/or expected habitat, at appropriate seasons, anywhere in its past range, despite exhaustive surveys over a time frame appropriate to its life cycle and form.
*Critically endangered	CE	A species is facing an extremely high risk of extinction in the wild in the immediate future.
*Endangered	EN	A species: (a) is not critically endangered; and (b) is facing a very high risk of extinction in the wild in the near future.
*Vulnerable	VU	A species (a) is not critically endangered or endangered; and (b) is facing a high risk of extinction in the wild in the medium-term future.
Conservation dependent	CD	A species is the focus of a specific conservation program the cessation of which would result in the species becoming vulnerable, endangered or critically endangered
*Migratory	Migratory	(a) all migratory species that are: (i) native species; and (ii) from time to time included in the appendices to the Bonn Convention; and (b) all migratory species from time to time included in annexes established under JAMBA, CAMBA and ROKAMBA; and (c) all native species from time to time identified in a list established under, or an instrument made under, an international agreement approved by the Minister.
Marine	Ma	Species in the list established under s248 of the EPBC Act

Note: Only species in those categories marked with an asterix are matters of national environmental significance under the EPBC Act.

Western Australian Wildlife Conservation Act (1950) Threatened Fauna Categories

Category	Code	Description
Schedule 1	S1	Fauna which is rare or likely to become extinct
Schedule 2	S2	Fauna which is presumed extinct
Schedule 3	S3	Birds which are subject to an agreement between the governments of Australia and Japan (JAMBA) relating to the protection of migratory birds and birds in danger of extinction
Schedule 4	S4	Fauna that is otherwise in need of special protection

Note: The *WAWC Act* also uses the categories defined by the *EPBC Act* to further define the status of species in the S1 category.

Western Australian DEC Priority Fauna Categories

Category	Code	Description
Priority 1	P1	Taxa with few, poorly known populations on threatened lands.
Priority 2	P2	Taxa with few, poorly known populations on conservation lands.
Priority 3	P3	Taxa with several, poorly known populations, some on conservation lands.
Priority 4	P4	Taxa in need of monitoring (Not currently threatened or in need of special protection, but could be if present circumstances change)
Priority 5	P5	Taxa in need of monitoring (Not considered threatened but are subject to a specific conservation program, the cessation of which would result in the species becoming threatened within five years)

IUCN Red List Threatened Species Categories

Category	Code	Description
Extinct	EX	Taxa for which there is no reasonable doubt that the last individual has died.
Extinct in the Wild	EW	Taxa which is known only to survive in cultivation, in captivity or and as a naturalised population well outside its past range and it has not been recorded in known or expected habitat despite exhaustive survey over a time frame appropriate to its life cycle and form.
Critically Endangered	CR	Taxa facing an extremely high risk of extinction in the wild.
Endangered	EN	Taxa facing a very high risk of extinction in the wild.
Vulnerable	VU	Taxa facing a high risk of extinction in the wild.
Near Threatened	NT	Taxa which has been evaluated but does not qualify for CR, EN or VU now but is close to qualifying or likely to qualify in the near future.
Least Concern	LC	Taxa which has been evaluated but does not qualify for CR, EN, VU, or NT but is likely to qualify for NT in the near future.
Data Deficient	DD	Taxa for which there is inadequate information to make a direct or indirect assessment of its risk of extinction based on its distribution and/or population status.

A full list of categories and their meanings are available at:

http://www.iucnredlist.org/info/categories_criteria2001#categories

APPENDIX B

CARNABY'S BLACK COCKATOO FOOD PLANTS

Genus	Species	Common name	Part Eaten
Acacia	saligna	Orange Wattle	fresh bark
Agonis	flexuosa	Peppermint	bark, grubs
Allocasuarina	spp	Sheoak	seeds
Banksia	affincircioides		seeds
Banksia	ashbyi	Ashby's Banksia	flowers, seeds
Banksia	attenuata	Slender Banksia	flowers, seeds
Banksia	ericifolia	Coastal Heath Banksia	flowers, seeds
Banksia	fraseri		flowers, seeds
Banksia	grandis	Bull Banksia	flowers, seeds
Banksia	ilicifolia	Holly Banksia	flowers, seeds
Banksia	littoralis	Swamp Banksia	flowers, seeds
Banksia	longifolia	Tree Banksia	flowers, seeds
Banksia	menziesii	Firewood or Menzies Banksia	flowers, seeds
Banksia	nivea	Couch Honeypot	flowers, seeds
Banksia	nobilis	Golden Dryandra	seeds
Banksia	praemorsa	Urchin or Cut-leaf Dryandra	flowers, seeds
Banksia	prionotes	Acorn Banksia	flowers, seeds
Banksia	sessilis	Parrot bush	flowers, seeds
Banksia	speciosa	Shaggy Dryandra	flowers, seeds
Banksia	tricuspis	Lesueur Banksia	flowers, seeds
Banksia	verticillata	Granite Banksia	flowers, seeds
Callistemon	viminalis	Bottlebrush	nectar
Corymbia	colophylla	Marri or redgum	flowers, seeds, nectar
Corymbia	ficifolia	Red Flowering Gum	flowers, seeds, nectar
Eucalyptus	citriodora	lemon-scented Gum	flowers, seeds, nectar
Eucalyptus	gomphocephalla	Tuart	flowers, seeds, nectar
Eucalyptus	marginata	Jarrah	seeds
Eucalyptus	salmonophloia	Salmon Gum	seeds
Eucalyptus	todtiana	Coastal Blackbutt, Prickly Bark	seeds
Eucalyptus	wandoo	Wandoo	flowers
Grevillea	apiciloba		flowers, seeds
Grevillea	armigera	Prickly Toothbrush	flowers, seeds
Grevillea	hookerana	Black Toothbrush	seeds
Grevillea	paniculata	Kerosene Bush	seeds
Grevillea	paradoxa	Bottlebrush Grevillea	seeds
Grevillea	petrophiloides	Pink Poker	seeds
Hakea	auriculata		seeds
Hakea	circumalata		seeds
Hakea	conchifolia	Shell-leaved Hakia	seeds
Hakea	crassifolia		seeds
Hakea	cyclocarpa		seeds
Hakea	falcata		seeds
Hakea	gilbertii		seeds
Hakea	incrassata	Golfball or Marble Hakea	seeds
Hakea	laurina	Pin-cushion Hakea	flowers, seeds
Hakea	lissocarpha	Honeybush	seeds
Hakea	multilineata	Grass leaf Hakea	seeds
Hakea	obliqua	Needles and Corks	seeds
Hakea	prostrata	Harsh Hakea	seeds
Hakea	ruscifolia	Candle Hakea	seeds
Hakea	scoparia		seeds
Hakea	sulcata	Furrowed Hakea	seeds
Hakea	trifurcata	Two-leaved Hakea	seeds
Hakea	undulata	Wavy-leaved Hakea	seeds
Hakea	varia	Variable-leaved Hakea	seeds
Isopogon	scabriuscula		seeds
Lambertia	multiflora	Many flowered honeysuckle	flowers, seeds
Xanthorrhoea	preissii	Grass tree	flowers, seeds
*Emex	australis	Doublegee	seeds
*Erodium	spp		seeds
*Ficus	spp	Fig Tree	Fruit
*Helianthus	spp	Sunflower	seeds
*Hibiscus	spp	Hibiscus (garden variety)	flowers
*Jacaranda	mimosifolia	Jacaranda tree	seeds
*Lupinus	spp	Lupin	seeds
*Macadamia	integrifolia	Macadamia nut tree	nuts
*Pinus	spp	Pine tree	seeds
*Prunus	amygdalus	Almond tree	nuts

References

Birds Australia (WA), http://www.birdswa.com.au/projects/carnaby/Recovery_project.html

Saunders, D.A. (1980). Food and movements of the short-billed form of the white-tailed black cockatoo. Australian Wildlife Research, 7, 257-269.

Shah, B (2006) Conservation of Carnaby's Black Cockatoo on the Swan Coastal Plain, Western Australia, Birds Australia WA.

APPENDIX C

SIGNIFICANT TREE DETAILS

Waypoint Number	Zone	mE	mN	Tree Species	DBH (cm)	Tree Height (m)	Number of Hollows	Hollow Height (m)	Hollow Type 1	Hollow Size 1 (cm)	Occupancy	Chew Marks	Potential Cockatoo Nest Hollow
WP1	50J	358196	6530412	Tuart	>50	15-20	0				No signs	No signs	No
WP2	50J	358209	6530415	Tuart	>50	15-20	1	10-15	Branch	5-10	No signs	Galahs	No
WP3	50J	358214	6530418	Tuart	>50	15-20	0				No signs	No signs	No
WP4	50J	358206	6530407	Tuart	>50	15-20	0				No signs	No signs	No
WP5	50J	358224	6530427	Tuart	>50	10-15	0				No signs	No signs	No
WP6	50J	358231	6530420	Tuart	>50	10-15	0				No signs	No signs	No
WP7	50J	358242	6530403	Tuart	>50	15-20	0				No signs	No signs	No
WP8	50J	358232	6530398	Tuart	>50	10-15	0				No signs	No signs	No
WP9	50J	358237	6530390	Tuart	>50	10-15	0				No signs	No signs	No
WP10	50J	358225	6530382	Tuart	>50	10-15	0				No signs	No signs	No
WP11	50J	358229	6530373	Tuart	>50	10-15	0				No signs	No signs	No
WP12	50J	358262	6530388	Tuart	>50	10-15	0				No signs	No signs	No
WP13	50J	358258	6530414	Tuart	>50	10-15	1	0-5	Branch	<5	No signs	No signs	No
WP14	50J	358250	6530436	Tuart	>50	10-15	0				No signs	No signs	No
WP15	50J	358248	6530446	Tuart	>50	10-15	1	5-10	Knot Hole	<5	No signs	No signs	No
WP16	50J	358246	6530449	Tuart	>50	10-15	0				No signs	No signs	No
WP17	50J	358249	6530457	Tuart	>50	10-15	0				No signs	No signs	No
WP18	50J	358253	6530460	Tuart	>50	10-15	0				No signs	No signs	No
WP19	50J	358263	6530471	Tuart	>50	10-15	0				No signs	No signs	No
WP20	50J	358271	6530458	Tuart	>50	15-20	0				No signs	No signs	No
WP21	50J	358302	6530440	Tuart	>50	15-20	0				No signs	No signs	No
WP22	50J	358309	6530440	Tuart	>50	10-15	0				No signs	No signs	No
WP23	50J	358322	6530424	Tuart	>50	15-20	1	0-5	Branch	<5	No signs	No signs	No
WP24	50J	358300	6530394	Tuart	>50	10-15	0				No signs	No signs	No
WP25	50J	358317	6530386	Tuart	>50	10-15	0				No signs	No signs	No
WP26	50J	358308	6530257	Tuart	>50	5-10	0				No signs	No signs	No
WP27	50J	358261	6530099	Tuart	>50	10-15	0				No signs	No signs	No
WP28	50J	358259	6530101	Tuart	>50	10-15	0				No signs	No signs	No
WP29	50J	358252	6530115	Tuart	>50	15-20	0				No signs	No signs	No
WP30	50J	358203	6530062	Tuart	>50	5-10	1	0-5	Branch	<5	No signs	No signs	No
WP31	50J	358224	6530077	Tuart	>50	10-15	0				No signs	No signs	No
WP32	50J	358194	6530063	Tuart	>50	10-15	0				No signs	No signs	No
WP33	50J	358211	6529993	Tuart	>50	10-15	1	0-5	Knot Hole	<5	No signs	No signs	No
WP34	50J	358196	6529974	Tuart	>50	5-10	0				No signs	No signs	No

Waypoint Number	Zone	mE	mN	Tree Species	DBH (cm)	Tree Height (m)	Number of Hollows	Hollow Height (m)	Hollow Type 1	Hollow Size 1 (cm)	Occupancy	Chew Marks	Potential Cockatoo Nest Hollow
WP35	50J	358187	6529978	Tuart	>50	15-20	1	0-5	Knot Hole	<5	No signs	No signs	No
WP36	50J	358166	6529977	Tuart	>50	10-15	0				No signs	No signs	No
WP37	50J	358201	6529958	Tuart	>50	5-10	1	5-10	Branch	5-10	No signs	No signs	No
WP38	50J	358233	6529800	Tuart	>50	10-15	0				No signs	No signs	No
WP39	50J	358227	6529802	Tuart	>50	10-15	0				No signs	No signs	No
WP40	50J	358320	6529679	Tuart	>50	10-15	0				No signs	No signs	No
WP41	50J	358304	6529676	Tuart	>50	5-10	0				No signs	No signs	No
WP42	50J	358333	6529642	Tuart	>50	5-10	1	0-5	Branch	<5	No signs	No signs	No
WP43	50J	358342	6529635	Tuart	>50	5-10	0				No signs	No signs	No
WP44	50J	358353	6529612	Tuart	>50	5-10	0				No signs	No signs	No
WP45	50J	358362	6529618	Tuart	>50	5-10	0				No signs	No signs	No
WP46	50J	358361	6529625	Tuart	>50	5-10	0				No signs	No signs	No

APPENDIX D

FAUNA OBSERVED OR POTENTIALLY IN STUDY AREA

Fauna Observed or Potentially in Study Area

Moore River South

Approximate Centroid: 31.365199°S and 115.517600°E

Compiled by Greg Harewood - October 2009

Sighted/Heard/Signs = X

A = Harewood (2010) - This report

B = ATA (1998). Moore River South Vertebrate Fauan Survey November 1997. Unpublished report for Moore River Company Pty Ltd

C = ATA (1997). Alkimos-Eglinton Vertebrate Fauna Survey October 1996 and Ninox Wildlife Consulting (1991a) Eglington Beach Resort. An Appraisal of the Vertebrate Fauna. Unpubished reports.

D = ATA (1991), Yanchep Structure Plan, Vertebrate Fauna Survey, Prepared for Tokyu Corporation

E/F = Ninox Wildlife Consulting (l991b), The Wilbinga and Breton Bay Sites - A Comparative Appraisal of their Vertebrate Fauna, Prepared for Halpern Glick Maunsell.

G = DEC Threatened Fauna NatureMap Database, H = Birds Australia Database

Class **Family** *Species*	Common Name	Conservation Status	A	B	C	D	E	F	G	H
Amphibians										
Myobatrachidae Ground or Burrowing Frogs										
Crinia insignifera	Squelching Froglet	LC								
Heleioporus albopunctatus	Western Spotted Frog	LC								
Heleioporus eyrei	Moaning Frog	LC				X				
Limnodynastes dorsalis	Banjo Frog	LC			X	X				
Myobatrachus gouldii	Turtle Frog	LC				X				

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Class **Family** *Species*	Common Name	Conservation Status	A	B	C	D	E	F	G	H
Pseudophryne guentheri	Güenther`s Toadlet	LC								
Hylidae Tree Frogs										
Litoria adelaidensis	Slender Tree Frog	LC		X						
Litoria moorei	Motorbike Frog	LC		X					X	

Reptiles

Chelidae Side-necked Tortoises										
Chelodina oblonga	Long-necked Tortoise	LR/LC	X	X					X	

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Class **Family** *Species*	Common Name	Conservation Status	A	B	C	D	E	F	G	H
Gekkonidae Geckoes										
Christinus marmoratus	Marbled Gecko		X	X		X		X		
Crenadactylus ocellatus	White-spotted Gecko					X				
Diplodactylus alboguttatus	White-spotted Ground Gecko									
Diplodactylus polyophthalmus	Speckled Stone Gecko									
Gehyra variegata	Variegated Dtella									
Strophurus spinigerus	South-western Spiny-tailed Gecko			X		X			X	
Underwoodisaurus milii	Barking Gecko							X		

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Class **Family** *Species*	Common Name	Conservation Status	A	B	C	D	E	F	G	H
Pygopodidae Legless Lizards										
Aprasia repens	Sand-plain Worm Lizard					X		X		
Delma concinna	West Coast Javelin Delma			X					X	
Delma fraseri	Fraser's Scale-footed Lizard				X	X				
Delma grayii	Gray's Legless Lizard					X			X	
Lialis burtonis	Common Snake Lizard			X	X	X			X	
Pletholax gracilis gracilis	Slender Snake Lizard				X	X				
Pygopus lepidopodus	Common Scaleyfoot			X				X		
Agamidae Dragon Lizards										
Pogona minor	Dwarf Bearded Dragon				X	X	X	X		
Rankinia adelaidensis	Western Heath Dragon		X	X		X	X	X		

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Class **Family** *Species*	Common Name	Conservation Status	A	B	C	D	E	F	G	H
Varanidae Monitor's or Goanna's										
Varanus gouldii	Gould's Sand Monitor								x	
Varanus tristis	Black-headed Monitor									

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Class **Family** *Species*	Common Name	Conservation Status	A	B	C	D	E	F	G	H
Scincidae Skinks										
Acritoscincus trilineatum	South-west Cool Skink									
Cryptoblepharus buchananii	Fence Skink				X	X		X	X	
Ctenotus australis	Western Limestone Ctenotus					X				
Ctenotus fallens	West Coast Ctenotus			X	X	X	X		X	
Ctenotus gemmula	Jewelled Ctenotus (Swan CP)	P3								
Ctenotus impar	South-western Odd-striped Ctenotus									
Cyclodomorphus celatus	Western Slender Blue-tongue			X	X		X	X	X	
Egernia kingii	King's Skink		X			X			X	
Egernia napoleonis	Salmon-bellied Skink							X	X	
Hemiergis quadrilineata	Two-toed Earless Skink			X	X	X	X	X		

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Lerista elegans	West Coast Four-toed Lerista			X	X	X	X	X	X	
Lerista lineopunctulata	West Coast Line-spotted Lerista				X		X	X	X	
Lerista praepedita	Worm Lerista			X		X	X	X	X	
Menetia greyii	Dwarf Skink			X	X	X		X		
Morethia lineoocellata	Western Pale-flecked Morethia					X	X			
Morethia obscura	Dusky Morethia					X		X		
Tiliqua occipitalis	Western Blue Tongue Lizard				X	X				
Tiliqua rugosa	Western Bobtail		X	X	X	X	X	X	X	
Typhlopidae Blind Snakes										
Ramphotyphlops australis	Southern Blind Snake			X	X		X		X	

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Class **Family** *Species*	Common Name	Conservation Status	A	B	C	D	E	F	G	H
Boidae Pythons, Boas										
Morelia spilota imbricata	Southern Carpet Python	S4 P4 LR/NT							X	

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Class **Family** *Species*	Common Name	Conservation Status	A	B	C	D	E	F	G	H
Elapidae Elapid Snakes										
Brachyurophis fasciolata	Narrow-banded Shovel-nosed Snake									
Brachyurophis semifasciata	Southern Shovel-nosed Snake			X				X	X	
Demansia psammophis	Yellow-faced Whipsnake			X	X					
Echiopsis curta	Bardick				X		X		X	
Neelaps bimaculatus	Black-naped Snake					X				
Neelaps calonotos	Black-striped Snake	P3							X	
Notechis scutatus	Tiger Snake									
Parasuta gouldii	Gould's Snake						X			
Pseudonaja affinis	Dugite		X		X	X			X	
Pseudonaja modesta	Ringed Brown Snake									

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Pseudonaja nuchalis	Gwardar									
Simoselaps bertholdi	Jan`s Banded Snake			X				X	X	

Birds

Casuariidae
Emus, Cassowarries

Dromaius novaehollandiae	Emu	Bp LC	X	X	X	X	X	X		

Phasianidae
Quails, Pheasants

Coturnix pectoralis	Stubble Quail	LC	X							X

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Anatidae Geese, Swans, Ducks										
Anas gracilis	Grey Teal	LC		X						X
Anas rhynchotis	Australasian Shoveler	Bh LC			X					
Anas superciliosa	Pacific Black Duck	LC	X	X	X					X
Aythya australis	Hardhead	Bh LC								
Chenonetta jubata	Australian Wood Duck	LC								X
Tadorna tadornoides	Australian Shelduck	LC		X			X			X
Anhingidae Darters										
Anhinga melanogaster	Darter	NT								X

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Phalacrocoracidae Cormorants										
Phalacrocorax carbo	Great Cormorant	LC								X
Phalacrocorax melanoleucos	Little Pied Cormorant	LC		X						X
Phalacrocorax sulcirostris	Little Black Cormorant	LC	X	X	X					X
Phalacrocorax varius	Pied Cormorant	LC	X				X			X
Ardeidae Herons, Egrets, Bitterns										
Ardea alba	Great Egret	Migratory CA JA	X							X
Ardea ibis	Cattle Egret	Migratory CA JA								
Ardea pacifica	White-necked Heron	LC								X
Egretta novaehollandiae	White-faced Heron	LC	X	X	X					X
Nycticorax caledonicus	Rufous Night Heron	Bp LC								X

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Threskiornithidae Ibises, Spoonbills										
Platalea flavipes	Yellow-billed Spoonbill	LC								X
Platalea regia	Royal Spoonbill	LC		X						
Threskiornis molucca	Australian White Ibis	LC								X
Threskiornis spinicollis	Straw-necked Ibis	LC		X						X

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Accipitridae Kites, Goshawks, Eagles, Harriers										
Accipiter cirrocephalus	Collared Sparrowhawk	Bp LC	X	X						X
Accipiter fasciatus	Brown Goshawk	Bp LC		X	X			X		X
Aquila audax	Wedge-tailed Eagle	Bp LC		X	X	X	X	X		X
Aquila morphnoides	Little Eagle	Bp		X	X	X	X	X		X
Circus approximans	Swamp Harrier	LC					X			
Circus assimilis	Spotted Harrier	LC			X					
Elanus caeruleus	Black-shouldered Kite	LC		X		X		X		X
Haliaeetus leucogaster	White-bellied Sea-Eagle	Migratory CA LC								X
Haliastur sphenurus	Whistling Kite	Bp LC	X	X						X
Hamirostra isura	Square-tailed Kite	Bp		X		X				

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Pandion haliaetus	Osprey	Migratory LC	X							X
Falconidae Falcons										
Falco berigora	Brown Falcon	Bp LC		X	X		X	X		X
Falco cenchroides	Australian Kestrel	LC	X	X	X	X	X	X		X
Falco longipennis	Australian Hobby	LC	X	X		X				X
Falco peregrinus	Peregrine Falcon	S4 Bp LC			X	X			X	X
Otididae Bustards										
Ardeotis australis	Australian Bustard	P4 Bp NT	X			X				
Turnicidae Button-quails										
Turnix varia	Painted Button-quail	Bp					X			

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Laridae Gulls, Terns										
Larus novaehollandiae	Silver Gull	LC	X	X		X	X			X
Sterna caspia	Caspian Tern	LC					X			X
Columbidae Pigeons, Doves										
Columba livia	Domestic Pigeon	Introduced				X				X
Ocyphaps lophotes	Crested Pigeon	LC		X	X		X			X
Phaps chalcoptera	Common Bronzewing	Bh LC			X	X	X			X
Phaps elegans	Brush Bronzewing	Bh LC								X
Streptopelia chinensis	Spotted Turtle Dove	Introduced				X				
Streptopelia senegalensis	Laughing Turtle-Dove	Introduced			X	X				X

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Cacatuidae Cockatoos, Corellas										
Cacatua pastinator butleri	Western Long-billed Corella	LC								X
Cacatua sanguinea	Little Corella	LC				X				X
Calyptorhynchus latirostris	Carnaby`s Cockatoo	S1 EN Bp EN A2bcd+3bcd	X	X	X	X		X	X	X
Eolophus roseicapilla	Galah	LC	X	X	X	X	X	X		X
Psittacidae Parrots										
Neophema elegans	Elegant Parrot	LC				X				
Platycercus icterotis icterotis	Western Rosella (Western ssp)	Bp LC								
Platycercus spurius	Red-capped Parrot	LC								X
Platycercus zonarius	Australian Ringneck Parrot	LC	X	X	X	X	X	X		X

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Cuculidae Parasitic Cuckoos										
Cacomantis flabelliformis	Fan-tailed Cuckoo	LC			X	X		X		X
Chrysococcyx basalis	Horsfield`s Bronze Cuckoo	LC		X		X	X	X		X
Chrysococcyx lucidus	Shining Bronze Cuckoo	LC			X	X	X	X		X
Cuculus pallidus	Pallid Cuckoo	LC		X		X		X		X
Strigidae Hawk Owls										
Ninox novaeseelandiae	Boobook Owl	LC	X			X				X
Tytonidae Barn Owls										
Tyto alba	Barn Owl	LC								X
Podargidae Frogmouths										
Podargus strigoides	Tawny Frogmouth	LC		X		X				X

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Aegothelidae Owlet-nightjars										
Aegotheles cristatus	Australian Owlet-nightjar	LC			X					
Apodidae Swifts, Swiftlets										
Apus pacificus	Fork-tailed Swift	Migratory CA JA LC								X
Halcyonidae Tree Kingfishers										
Dacelo novaeguineae	Laughing Kookaburra	Introduced		X	X	X		X		X
Todiramphus sanctus	Sacred Kingfisher	LC		X	X	X				X
Meropidae Bee-eaters										
Merops ornatus	Rainbow Bee-eater	Migratory JA LC		X	X	X		X		X

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Maluridae Fairy Wrens, GrassWrens										
Malurus lamberti	Variegated Fairy-wren	Bh LC	X	X	X		X		X	X
Malurus leucopterus	White-winged Fairy-wren	Bh LC	X	X	X	X	X	X		X
Malurus splendens	Splendid Fairy-wren	Bh LC	X	X	X	X	X	X		X
Stipiturus malachurus	Southern Emu-wren	Bh LC		X						

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Class **Family** *Species*	Common Name	Conservation Status	A	B	C	D	E	F	G	H
Pardalotidae Pardalotes, Bristlebirds, Scrubwrens, Gerygones, Thornbills										
Acanthiza apicalis	Broad-tailed Thornbill	Bh LC		X	X	X	X	X		X
Acanthiza chrysorrhoa	Yellow-rumped Thornbill	Bh LC		X	X	X		X		X
Acanthiza inornata	Western Thornbill	Bh LC		X		X		X		X
Gerygone fusca	Western Gerygone	LC	X	X	X	X	X	X		X
Pardalotus punctatus	Spotted Pardalote	LC				X	X			X
Pardalotus striatus	Striated Pardalote	LC	X	X	X	X		X		X
Sericornis frontalis	White-browed Scrubwren	Bh LC	X	X	X	X	X			X
Smicrornis brevirostris	Weebill	Bh LC	X	X		X		X		X

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Meliphagidae Honeyeaters, Chats										
Acanthorhynchus superciliosus	Western Spinebill	LC		X		X	X	X		X
Anthochaera carunculata	Red Wattlebird	LC	X	X	X	X	X	X		X
Anthochaera lunulata	Western Little Wattlebird	Bp		X	X	X	X		X	X
Epthianura albifrons	White-fronted Chat	LC		X						X
Lichenostomus ornatus	Yellow-plumed Honeyeater	Bh LC				X				
Lichenostomus virescens	Singing Honeyeater	LC	X	X	X	X	X	X		X
Lichmera indistincta	Brown Honeyeater	LC	X	X	X	X	X	X	X	X
Manorina flavigula	Yellow-throated Miner	Bp LC					X	X		
Melithreptus lunatus	White-naped Honeyeater	Bp LC				X				
Phylidonyris melanops	Tawny-crowned Honeyeater	Bp LC		X		X	X	X		

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Phylidonyris nigra	White-cheeked Honeyeater	Bp	X	X		X	X			X
Phylidonyris novaehollandiae	New Holland Honeyeater	Bp LC	X	X	X	X		X		X
Petroicidae Australian Robins										
Eopsaltria georgiana	White-breasted Robin	Bh LC		X			X			X
Petroica cucullata	Hooded Robin	Bh				X				
Petroica goodenovii	Red-capped Robin	LC								X
Petroica multicolor	Scarlet Robin	Bh LC			X	X		X		X
Neosittidae Sitellas										
Daphoenositta chrysoptera	Varied Sittella	Bh LC								X

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Pachycephalidae Crested Shrike-tit, Crested Bellbird, Shrike Thrushes, Whistlers										
Colluricincla harmonica	Grey Shrike-thrush	Bh LC			X	X	X	X		X
Pachycephala pectoralis	Golden Whistler	Bh LC			X					X
Pachycephala rufiventris	Rufous Whistler	LC		X		X	X	X		X
Dicruridae Monarchs, Magpie Lark, Flycatchers, Fantails, Drongo										
Grallina cyanoleuca	Magpie-lark	LC		X	X	X	X			X
Rhipidura fuliginosa	Grey Fantail	LC		X	X	X	X	X		X
Rhipidura leucophrys	Willie Wagtail	LC		X	X	X	X	X		X
Campephagidae Cuckoo-shrikes, Trillers										
Coracina maxima	Ground Cuckoo-shrike	LC								
Coracina novaehollandiae	Black-faced Cuckoo-shrike	LC		X	X	X	X	X		X
Lalage sueurii	White-winged Triller	LC			X					

WC Act Status - S1 to S4, EPBC Act Status - EN = Endangered, VU = Vulnerable, EX = Extinct, DEC Priority Status - P1 to P5, Int. Agmts - CA = CAMBA, JA = JAMBA, Bush Forever Decreaser Species - Bh = habitat specialists, Bp = wide ranging species, Be = extinct in Perth Coastal Plain Region. IUCN Red List Category Definitions see: www.iucnredlist.org/info/categories_criteria2001#categories.

Class **Family** *Species*	Common Name	Conservation Status	A	B	C	D	E	F	G	H
Artamidae Woodswallows, Butcherbirds, Currawongs										
Artamus cinereus	Black-faced Woodswallow	Bp LC		X	X	X	X			X
Artamus cyanopterus	Dusky Woodswallow	Bp LC								X
Cracticus nigrogularis	Pied Butcherbird	LC						X		
Cracticus tibicen	Australian Magpie	LC	X	X	X	X	X	X		X
Cracticus torquatus	Grey Butcherbird	LC	X	X	X	X	X	X		X
Corvidae Ravens, Crows										
Corvus bennetti	Little Crow	LC		X						
Corvus coronoides	Australian Raven	LC	X	X	X	X	X	X		X
Motacillidae Old World Pipits, Wagtails										
Anthus novaeseelandiae	Australian Pipit	LC		X	X	X	X	X	X	X

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Class **Family** *Species*	Common Name	Conservation Status	A	B	C	D	E	F	G	H
Dicaeidae Flowerpeckers										
Dicaeum hirundinaceum	Mistletoebird	LC		X						X
Hirundinidae Swallows, Martins										
Cheramoeca leucosternus	White-backed Swallow	LC		X	X	X	X	X		X
Hirundo neoxena	Welcome Swallow	LC	X	X	X	X	X	X		X
Hirundo nigricans	Tree Martin	LC	X	X	X	X				X
Sylviidae Old World Warblers										
Cincloramphus cruralis	Brown Songlark	LC					X			X
Cincloramphus mathewsi	Rufous Songlark	LC								
Zosteropidae White-eyes										
Zosterops lateralis	Grey-breasted White-eye	LC	X	X	X	X	X	X		X

WC Act Status - S1 to S4, EPBC Act Status - EN = Endangered, VU = Vulnerable, EX = Extinct, DEC Priority Status - P1 to P5, Int. Agmts - CA = CAMBA, JA = JAMBA, Bush Forever Decreaser Species - Bh = habitat specialists, Bp = wide ranging species, Be = extinct in Perth Coastal Plain Region. IUCN Red List Category Definitions see: www.iucnredlist.org/info/categories_criteria2001#categories.

Class **Family** *Species*	Common Name	Conservation Status	A	B	C	D	E	F	G	H
Mammals										
Tachyglossidae Echidnas										
Tachyglossus aculeatus	Echidna	LR/LC								
Dasyuridae Carnivorous Marsupials										
Sminthopsis dolichura	Little Long-tailed Dunnart	LR/LC								
Sminthopsis griseoventer	Grey-bellied Dunnart	LR/LC				X				
Peramelidae Bandicoots										
Isoodon obesulus fusciventer	Southern Brown Bandicoot	P5							X	
Phalangeridae Brushtail Possums, Cuscuses										
Trichosurus vulpecula	Common Brushtail Possum	LR/LC								
Burramyidae Pygmy Possums										
Cercartetus concinnus	Western Pygmy-possum	LR/LC								

WC Act Status - S1 to S4, EPBC Act Status - EN = Endangered, VU = Vulnerable, EX = Extinct, DEC Priority Status - P1 to P5, Int. Agmts - CA = CAMBA, JA = JAMBA, Bush Forever Decreaser Species - Bh = habitat specialists, Bp = wide ranging species, Be = extinct in Perth Coastal Plain Region. IUCN Red List Category Definitions see: www.iucnredlist.org/info/categories_criteria2001#categories.

Class **Family** *Species*	Common Name	Conservation Status	A	B	C	D	E	F	G	H
Tarsipedidae Honey Possum										
Tarsipes rostratus	Honey Possum	LR/LC		X		X			X	
Macropodidae Kangaroos, Wallabies										
Macropus fuliginosus	Western Grey Kangaroo	LR/LC	X	X	X	X	X	X		
Macropus irma	Western Brush Wallaby	P4 LR/NT				X			X	
Molossidae Freetail Bats										
Mormopterus planiceps	Western Freetail Bat	LR/LC								
Tadarida australis	White-striped Freetail-bat	LR/LC								

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Class **Family** *Species*	Common Name	Conservation Status	A	B	C	D	E	F	G	H
Vespertilionidae Ordinary Bats										
Chalinolobus gouldii	Gould`s Wattled Bat	LR/LC							X	
Chalinolobus morio	Chocolate Wattled Bat	LR/LC			X					
Nyctophilus geoffroyi	Lesser Long-eared Bat	LR/LC								
Nyctophilus timoriensis	Greater Long-eared Bat	DD								
Vespadelus regulus	Southern Forest Bat	LR/LC				X				
Muridae Rats, Mice										
Mus musculus	House Mouse	Introduced		X	X	X				
Pseudomys albocinereus	Ash-grey Mouse	LR/LC		X						
Rattus fuscipes	Western Bush Rat	LR/LC		X	X	X				
Rattus rattus	Black Rat	Introduced				X				

WC Act Status - S1 to S4, EPBC Act Status - EN = Endangered, VU = Vulnerable, EX = Extinct, DEC Priority Status - P1 to P5, Int. Agmts - CA = CAMBA, JA = JAMBA, Bush Forever Decreaser Species - Bh = habitat specialists, Bp = wide ranging species, Be = extinct in Perth Coastal Plain Region. IUCN Red List Category Definitions see: www.iucnredlist.org/info/categories_criteria2001#categories.

Class **Family** *Species*	Common Name	Conservation Status	A	B	C	D	E	F	G	H
Canidae Dogs, Foxes										
Vulpes vulpes	Red Fox	Introduced	X	X	X	X	X	X		
Felidae Cats										
Felis catus	Cat	Introduced	X	X		X				
Bovidae Horned Ruminants										
Bos taurus	European Cattle	Introduced								
Capra hircus	Goat	Introduced					X			
Leporidae Rabbits, Hares										
Oryctolagus cuniculus	Rabbit	Introduced	X	X	X	X	X	X		

WC Act Status - S1 to S4, EPBC Act Status - EN = Endangered, VU = Vulnerable, EX = Extinct, DEC Priority Status - P1 to P5, Int. Agmts - CA = CAMBA, JA = JAMBA, Bush Forever Decreaser Species - Bh = habitat specialists, Bp = wide ranging species, Be = extinct in Perth Coastal Plain Region. IUCN Red List Category Definitions see: www.iucnredlist.org/info/categories_criteria2001#categories.

APPENDIX E

EPBC DATABASE SEARCH RESULTS

Protected Matters Search Tool

You are here: Environment Home > EPBC Act > Search

14 August 2009 17:09

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected. Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

You may wish to print this report for reference before moving to other pages or websites.

The Australian Natural Resources Atlas at http://www.environment.gov.au/atlas may provide further environmental information relevant to your selected area. Information about the EPBC Act including significance guidelines, forms and application process details can be found at http://www.environment.gov.au/epbc/assessmentsapprovals/index.html

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Search Type: Point

Buffer: 5 km

Coordinates: -31.35639,115.50804



Report Contents:

Summary
Details
- Matters of NES
- Other matters protected by the EPBC Act
- Extra Information

Caveat
Acknowledgments



This map may contain data which are
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Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance - see http://www.environment.gov.au/epbc/assessmentsapprovals/guidelines/index.html.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Significance: (Ramsar Sites)	None

Commonwealth Marine Areas:	None
Threatened Ecological Communities:	None
Threatened Species:	30
Migratory Species:	29

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place and the heritage values of a place on the Register of the National Estate. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage/index.html.

Please note that the current dataset on Commonwealth land is not complete. Further information on Commonwealth land would need to be obtained from relevant sources including Commonwealth agencies, local agencies, and land tenure maps.

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species. Information on EPBC Act permit requirements and application forms can be found at http://www.environment.gov.au/epbc/permits/index.html.

Commonwealth Lands:	None
Commonwealth Heritage Places:	None
Places on the RNE:	None
Listed Marine Species:	47
Whales and Other Cetaceans:	13
Critical Habitats:	None
Commonwealth Reserves:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	None
Other Commonwealth Reserves:	None
Regional Forest Agreements:	None

Details

Matters of National Environmental Significance

Threatened Species [Dataset Information]	Status	Type of Presence
Birds		
Anous tenuirostris melanops Australian Lesser Noddy	Vulnerable	Species or species habitat may occur within area

Calyptorhynchus banksii naso Forest Red-tailed Black-Cockatoo	Vulnerable	Species or species habitat may occur within area
Calyptorhynchus baudinii Baudin's Black-Cockatoo, Long-billed Black-Cockatoo	Vulnerable	Species or species habitat likely to occur within area
Calyptorhynchus latirostris Carnaby's Black-Cockatoo, Short-billed Black-Cockatoo	Endangered	Species or species habitat likely to occur within area
Diomedea exulans (sensu lato) Wandering Albatross	Vulnerable	Species or species habitat may occur within area
Diomedea exulans amsterdamensis Amsterdam Albatross	Endangered	Species or species habitat may occur within area
Diomedea exulans exulans Tristan Albatross	Endangered	Foraging, feeding or related behaviour may occur within area
Diomedea exulans gibsoni Gibson's Albatross	Vulnerable	Species or species habitat may occur within area
Halobaena caerulea Blue Petrel	Vulnerable	Species or species habitat may occur within area
Macronectes giganteus Southern Giant-Petrel	Endangered	Species or species habitat may occur within area
Macronectes halli Northern Giant-Petrel	Vulnerable	Species or species habitat may occur within area
Pterodroma mollis Soft-plumaged Petrel	Vulnerable	Species or species habitat may occur within area
Thalassarche carteri Indian Yellow-nosed Albatross	Vulnerable	Foraging, feeding or related behaviour may occur within area
Thalassarche cauta cauta Shy Albatross, Tasmanian Shy Albatross	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris Black-browed Albatross	Vulnerable	Species or species habitat may occur within area
Mammals		
Balaenoptera musculus Blue Whale	Endangered	Species or species habitat may occur within area
Dasyurus geoffroii Chuditch, Western Quoll	Vulnerable	Species or species habitat likely to occur within area
Eubalaena australis Southern Right Whale	Endangered	Species or species habitat likely to occur within area
Megaptera novaeangliae Humpback Whale	Vulnerable	Species or species habitat known to occur within area
Neophoca cinerea Australian Sea-lion	Vulnerable	Species or species habitat may occur within area
Reptiles		
Caretta caretta Loggerhead Turtle	Endangered	Species or species habitat may occur within area
Chelonia mydas Green Turtle	Vulnerable	Foraging, feeding or related behaviour may occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth	Endangered	Species or species habitat may occur within area
Sharks		
Carcharias taurus (west coast population) Grey Nurse Shark (west coast population)	Vulnerable	Species or species habitat may occur within area
Carcharodon carcharias Great White Shark	Vulnerable	Species or species habitat may occur within area

Rhincodon typus Whale Shark	Vulnerable	Species or species habitat may occur within area
Plants		
Eucalyptus argutifolia Yanchep Mallee, Wabling Hill Mallee	Vulnerable	Species or species habitat likely to occur within area
Grevillea curviloba subsp. incurva Narrow curved-leaf Grevillea	Endangered	Species or species habitat likely to occur within area
Hemigenia ramosissima	Critically Endangered	Species or species habitat may occur within area
Lepidosperma rostratum Beaked Lepidosperma	Endangered	Species or species habitat likely to occur within area
Migratory Species [Dataset Information]	Status	Type of Presence
Migratory Terrestrial Species		
Birds		
Haliaeetus leucogaster White-bellied Sea-Eagle	Migratory	Species or species habitat likely to occur within area
Merops ornatus Rainbow Bee-eater	Migratory	Species or species habitat may occur within area
Migratory Wetland Species		
Birds		
Ardea alba Great Egret, White Egret	Migratory	Species or species habitat may occur within area
Ardea ibis Cattle Egret	Migratory	Species or species habitat may occur within area
Migratory Marine Birds		
Apus pacificus Fork-tailed Swift	Migratory	Species or species habitat may occur within area
Ardea alba Great Egret, White Egret	Migratory	Species or species habitat may occur within area
Ardea ibis Cattle Egret	Migratory	Species or species habitat may occur within area
Diomedea amsterdamensis Amsterdam Albatross	Migratory	Species or species habitat may occur within area
Diomedea dabbenena Tristan Albatross	Migratory	Foraging, feeding or related behaviour may occur within area
Diomedea exulans (sensu lato) Wandering Albatross	Migratory	Species or species habitat may occur within area
Diomedea gibsoni Gibson's Albatross	Migratory	Species or species habitat may occur within area
Macronectes giganteus Southern Giant-Petrel	Migratory	Species or species habitat may occur within area
Macronectes halli Northern Giant-Petrel	Migratory	Species or species habitat may occur within area
Thalassarche carteri Indian Yellow-nosed Albatross	Migratory	Foraging, feeding or related behaviour may occur within area
Thalassarche cauta (sensu stricto) Shy Albatross, Tasmanian Shy Albatross	Migratory	Species or species habitat may occur within area
Thalassarche chlororhynchos Yellow-nosed Albatross, Atlantic Yellow-nosed Albatross	Migratory	Species or species habitat may occur within area

Thalassarche melanophris Black-browed Albatross	Migratory	Species or species habitat may occur within area
Migratory Marine Species		
Mammals		
Balaenoptera edeni Bryde's Whale	Migratory	Species or species habitat may occur within area
Balaenoptera musculus Blue Whale	Migratory	Species or species habitat may occur within area
Caperea marginata Pygmy Right Whale	Migratory	Species or species habitat may occur within area
Eubalaena australis Southern Right Whale	Migratory	Species or species habitat likely to occur within area
Lagenorhynchus obscurus Dusky Dolphin	Migratory	Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale	Migratory	Species or species habitat known to occur within area
Orcinus orca Killer Whale, Orca	Migratory	Species or species habitat may occur within area
Reptiles		
Caretta caretta Loggerhead Turtle	Migratory	Species or species habitat may occur within area
Chelonia mydas Green Turtle	Migratory	Foraging, feeding or related behaviour may occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth	Migratory	Species or species habitat may occur within area
Sharks		
Carcharodon carcharias Great White Shark	Migratory	Species or species habitat may occur within area
Rhincodon typus Whale Shark	Migratory	Species or species habitat may occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species [Dataset Information]	Status	Type of Presence
Birds		
Anous tenuirostris melanops Australian Lesser Noddy	Listed	Species or species habitat may occur within area
Apus pacificus Fork-tailed Swift	Listed - overfly marine area	Species or species habitat may occur within area
Ardea alba Great Egret, White Egret	Listed - overfly marine area	Species or species habitat may occur within area
Ardea ibis Cattle Egret	Listed - overfly marine area	Species or species habitat may occur within area
Catharacta skua Great Skua	Listed	Species or species habitat may occur within area
Diomedea amsterdamensis Amsterdam Albatross	Listed	Species or species habitat may occur within area

Diomedea dabbenena Tristan Albatross	Listed	Foraging, feeding or related behaviour may occur within area
Diomedea exulans (sensu lato) Wandering Albatross	Listed	Species or species habitat may occur within area
Diomedea gibsoni Gibson's Albatross	Listed	Species or species habitat may occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle	Listed	Species or species habitat likely to occur within area
Halobaena caerulea Blue Petrel	Listed	Species or species habitat may occur within area
Macronectes giganteus Southern Giant-Petrel	Listed	Species or species habitat may occur within area
Macronectes halli Northern Giant-Petrel	Listed	Species or species habitat may occur within area
Merops ornatus Rainbow Bee-eater	Listed - overfly marine area	Species or species habitat may occur within area
Pterodroma mollis Soft-plumaged Petrel	Listed	Species or species habitat may occur within area
Thalassarche carteri Indian Yellow-nosed Albatross	Listed	Foraging, feeding or related behaviour may occur within area
Thalassarche cauta (sensu stricto) Shy Albatross, Tasmanian Shy Albatross	Listed	Species or species habitat may occur within area
Thalassarche chlororhynchos Yellow-nosed Albatross, Atlantic Yellow-nosed Albatross	Listed	Species or species habitat may occur within area
Thalassarche melanophris Black-browed Albatross	Listed	Species or species habitat may occur within area
Mammals		
Arctocephalus forsteri New Zealand Fur-seal	Listed	Species or species habitat may occur within area
Neophoca cinerea Australian Sea-lion	Listed	Species or species habitat may occur within area
Ray-finned fishes		
Acentronura australe Southern Pygmy Pipehorse	Listed	Species or species habitat may occur within area
Campichthys galei Gale's Pipefish	Listed	Species or species habitat may occur within area
Choeroichthys suillus Pig-snouted Pipefish	Listed	Species or species habitat may occur within area
Halicampus brocki Brock's Pipefish	Listed	Species or species habitat may occur within area
Hippocampus angustus Western Spiny Seahorse, Narrow-bellied Seahorse	Listed	Species or species habitat may occur within area
Hippocampus breviceps Short-head Seahorse, Short-snouted Seahorse	Listed	Species or species habitat may occur within area
Hippocampus subelongatus West Australian Seahorse	Listed	Species or species habitat may occur within area
Lissocampus fatiloquus Prophet's Pipefish	Listed	Species or species habitat may occur within area
Maroubra perserrata Sawtooth Pipefish	Listed	Species or species habitat may occur within area

Mitotichthys meraculus Western Crested Pipefish	Listed	Species or species habitat may occur within area
Nannocampus subosseus Bony-headed Pipefish	Listed	Species or species habitat may occur within area
Phycodurus eques Leafy Seadragon	Listed	Species or species habitat may occur within area
Phyllopteryx taeniolatus Weedy Seadragon, Common Seadragon	Listed	Species or species habitat may occur within area
Pugnaso curtirostris Pug-nosed Pipefish	Listed	Species or species habitat may occur within area
Solegnathus lettiensis Indonesian Pipefish, Gunther's Pipehorse	Listed	Species or species habitat may occur within area
Stigmatopora argus Spotted Pipefish	Listed	Species or species habitat may occur within area
Stigmatopora nigra Wide-bodied Pipefish, Black Pipefish	Listed	Species or species habitat may occur within area
Syngnathoides biaculeatus Double-ended Pipehorse, Alligator Pipefish	Listed	Species or species habitat may occur within area
Urocampus carinirostris Hairy Pipefish	Listed	Species or species habitat may occur within area
Vanacampus margaritifer Mother-of-pearl Pipefish	Listed	Species or species habitat may occur within area
Reptiles		
Aipysurus pooleorum Shark Bay Seasnake	Listed	Species or species habitat may occur within area
Caretta caretta Loggerhead Turtle	Listed	Species or species habitat may occur within area
Chelonia mydas Green Turtle	Listed	Foraging, feeding or related behaviour may occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth	Listed	Species or species habitat may occur within area
Disteira kingii Spectacled Seasnake	Listed	Species or species habitat may occur within area
Pelamis platurus Yellow-bellied Seasnake	Listed	Species or species habitat may occur within area
Whales and Other Cetaceans [Dataset Information]	Status	Type of Presence
Balaenoptera acutorostrata Minke Whale	Cetacean	Species or species habitat may occur within area
Balaenoptera edeni Bryde's Whale	Cetacean	Species or species habitat may occur within area
Balaenoptera musculus Blue Whale	Cetacean	Species or species habitat may occur within area
Caperea marginata Pygmy Right Whale	Cetacean	Species or species habitat may occur within area
Delphinus delphis Common Dophin, Short-beaked Common Dolphin	Cetacean	Species or species habitat may occur within area
Eubalaena australis Southern Right Whale	Cetacean	Species or species habitat likely to occur within area
Grampus griseus Risso's Dolphin, Grampus	Cetacean	Species or species habitat may occur within area

Lagenorhynchus obscurus Dusky Dolphin	Cetacean	Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale	Cetacean	Species or species habitat known to occur within area
Orcinus orca Killer Whale, Orca	Cetacean	Species or species habitat may occur within area
Stenella attenuata Spotted Dolphin, Pantropical Spotted Dolphin	Cetacean	Species or species habitat may occur within area
Tursiops aduncus Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin	Cetacean	Species or species habitat likely to occur within area
Tursiops truncatus s. str. Bottlenose Dolphin	Cetacean	Species or species habitat may occur within area

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the *Environment Protection and Biodiversity Conservation Act 1999*. It holds mapped locations of World Heritage and Register of National Estate properties, Wetlands of International Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

For species where the distributions are well known, maps are digitised from sources such as recovery plans and detailed habitat studies. Where appropriate, core breeding, foraging and roosting areas are indicated under "type of presence". For species whose distributions are less well known, point locations are collated from government wildlife authorities, museums, and non-government organisations; bioclimatic distribution models are generated and these validated by experts. In some cases, the distribution maps are based solely on expert knowledge.

Only selected species covered by the migratory and marine provisions of the Act have been mapped.

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers.

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites;
- seals which have only been mapped for breeding sites near the Australian continent.

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Acknowledgments

This database has been compiled from a range of data sources. The Department acknowledges the following custodians who have contributed valuable data and advice:

- New South Wales National Parks and Wildlife Service
- Department of Sustainability and Environment, Victoria
- Department of Primary Industries, Water and Environment, Tasmania
- Department of Environment and Heritage, South Australia Planning SA
- Parks and Wildlife Commission of the Northern Territory
- Environmental Protection Agency, Queensland
- Birds Australia
- Australian Bird and Bat Banding Scheme
- Australian National Wildlife Collection
- Natural history museums of Australia
- Queensland Herbarium
- National Herbarium of NSW
- Royal Botanic Gardens and National Herbarium of Victoria
- Tasmanian Herbarium
- State Herbarium of South Australia
- Northern Territory Herbarium
- Western Australian Herbarium
- Australian National Herbarium, Atherton and Canberra
- University of New England
- Other groups and individuals

ANUCliM Version 1.8, Centre for Resource and Environmental Studies, Australian National University was used extensively for the production of draft maps of species distribution. Environment Australia is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

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APPENDIX F

DETAILS OF SIGNIFICANT SPECIES

Graceful Sun-Moth *Synemon gratiosa*

Status and Distribution: The Graceful Sun-Moth is listed as Scheduled 1 under the *WC Act* and as Endangered under the *EPBC Act*. It is also ranked as endangered under the IUCN (2001) criteria.

The Graceful Sun-Moth was once relatively widespread in the Swan Coastal Plain (DEWHA 2009) and up until recently was thought to be confined to a small number of bush reserves in the northern suburbs of Perth. Targeted survey work in February and April of 2010 by a number of consultants and the DEC have now extended the known range of the species north to Jurien Bay and south as far as Binningup (DEC pers. coms. April 2010).

Previous to this the ten known extant subpopulations of Graceful Sun-Moth were all located in Perth's northern metropolitan area. Two of these subpopulations are distinct fragments within Warwick Conservation Reserve, and another seven sub-populations occur in *Banksia* woodland in very small areas in Koondoola Bushland, Errina Road Bushland, Marangaroo Bushland, Landsdale Road Bushland, Gumblossom Reserve, Shenton Bushland and Whiteman Park (DEWHA 2009). All of these sites (except Shenton Bushland), are within 4 km of each other. Two other sub-populations occur in coastal heath/shrubland vegetation at Sorrento (DEC 2008) and Ocean Reef (SMEC 2009). Areas at which the species has recently found are located in coastal locations at Jurien Bay, Guilderton, Wilbinga, Rockingham, Yalgorup National Park and Binningup though site specific details are not as yet available.

Habitat: Up until recently (late 2008) the Graceful Sun-Moth was only known from open areas amongst Banksia woodland/woolly bush *(Adenanthos cygnorum)* over *Lomandra* on deep sands. A significant proportion of the recently discovered populations have however been located within coastal heath/shrubland vegetation all typically having extensive areas of *Lomandra maritima* suggesting a wider habitat reference than previously documented.

Male moths first appear in late February and females in early March. Mating occurs during March and females lay eggs during March and early April, then all adult moths die off. The larvae (caterpillars) take 11 months to fully develop and then emerge as adult moths the following year (Willers, 2009; DEWHA, 2009 cited from WA CALM 2005). The larvae are thought to feed exclusively on *Lomandra* sp. To date the species has been recorded in association with *Lomandra hermaphrodita* and *Lomandra maritima* (DEWHA 2009, SMEC 2009). Hence, the presence of *Lomandra* species provides a good indication of prospective habitat, however, sufficient numbers and densities of these plants

are thought to be necessary to sustain a viable breeding colony of Graceful Sun-Moths (DEWHA 2009). The larvae of other species of sun moths, apart from feeding on *Lomandra* spp have also been reported to utilise *Lepidosperma* spp. (Common 1990; Nielsen et al. 1996).

Adult Graceful Sun-Moths emerge during hot weather in bright sunshine. Graceful Sun-Moth males are sedentary, but the extent to which females disperse is unknown. It is believed that females disperse less than 1 km from their colony of birth and are unlikely to cross unsuitable habitat (DEWHA 2009). Despite being able to fly, most species of butterflies and day-flying moths will not disperse across unsuitable habitat, and do not disperse far during their lifetime (DEWHA 2009). Due to the limited dispersal ability of the Graceful Sun Moth, recolonisation at locally extinct sites is unlikely (TSSC 2008aei).

Likely presence in study area: Targeted surveys for this species in March 2010 confirmed the existence of this species within sections of the study area. The species distribution across the site appears to be related to the presence of *Lomandra maritima* though it was not found in some areas where this plant was present in reasonable densities suggesting other factors affect its presence/absence at any one location.

Potential impact of proposed development: The majority of the observations made of the GSM were outside of the currently proposed development footprint though the loss and/or modification of some existing/potential habitat will occur.

The potential presence of this species in proposed reserves (POS and Foreshore reserves) will need to be taken into account during the formulation of management plans to ensure the species long term survival in the area.

Jewelled Ctenotus *Ctenotus gemmula*

Status and Distribution: Listed as Priority 3 by DEC. In the west at Cataby and from Wanneroo south to Medina. In the southern interior and along the south coast from Rocky Gully inland to Lake Magenta and east to Toolina Cove (Storr *et al*, 1999).

Habitat: Prefers pale sandplains supporting either *Banksia* or mallee with heath. Seeks shelter beneath leaf litter, in abandoned stick-ant nest and burrows at the base of trees and shrubs (Bush et al 2002).

Likely presence in study area: Current status onsite uncertain. The study area appears to be within this species documented range though no specimens have been collected despite numerous surveys. May utilise Banksia woodland areas.

Potential impact of proposed development: Loss and/or modification of some potential habitat, though most within the propose works footprint is already degraded by grazing and frequent fire.

Black-striped Snake *Neelaps calonotos*

Status and Distribution: Listed as Priority 3 by DEC. Found in the lower west coast from Lancelin to Mandurah. It is locally abundant but is under threat due to land clearing (Storr *et al*, 1999).

Habitat: This species of snake favours sandy soils supporting heath and banksia/eucalypt woodland (Nevill 2005).

Likely presence in study area: DEC record from general area, though other surveys have not detected this species. Current status onsite uncertain. May utilise coastal dunes and Banksia woodland as habitat.

Potential impact of proposed development: Loss and/or modification of some potential habitat.

Southern Carpet Python *Morelia spilota impricata*

Status and Distribution: The south western population is classified as Priority 4 by DEC and is also listed in Schedule 4 under the *WC Act*. This sub species has wide distribution within the south west but is uncommon. Occurs north to Geraldton and Yalgoo and east to Pinjin, Kalgoorlie, Fraser Range and Eyre (Storr *et al*, 2002).

Habitat: This species has been recorded from semi-arid coastal and inland habitats, Banksia woodland, Eucalypt woodlands, and grasslands. Most often found utilising hollow logs in addition the burrows of other animals for shelter. Often arboreal and will also use tree hollows for refuge.

Likely presence in study area: DEC record from the general area. Status onsite uncertain. Maybe present in low densities within the most densely vegetated areas.

Potential impact of development: Loss and/or modification of some potential habitat.

Australian Bustard *Ardeotis australis*

Status and Distribution: This species is listed as Priority 4 by DEC. A nomadic species that is common away from settled areas over much of Australia (Morcombe, 2003).

Habitat: Grasslands, especially tussock grasses, like speargrass, Mitchell grass, spinifex; arid scrub with saltbush, bluebush; open dry woodland of mulga, mallee and, heath (Morcombe, 2003).

Likely presence in study area: A single individual of this species was observed during the March 2010 GSM surveys. Despite this observation the species is only likely to be a rare vagrant to the area.

Potential impact of development: Loss of an area of potential habitat though no significant impact on this species is anticipated as it is likely to be present only rarely.

Great Egret *Ardea alba*

Status and Distribution: This species of egret is listed as migratory under the *EPBC Act* and under international agreements to which Australia is a signatory. The Great Egret is common and very widespread in any suitable permanent or temporary habitat (Morcombe 2003).

Species or species habitat listed as likely to occur in general area within EPBC database search.

Habitat: Wetlands, flooded pasture, dams, estuarine mudflats, mangroves and reefs (Morcombe 2003).

Likely presence in study area: Observed foraging along the Moore River. Listed as a potential species as it may roost within in trees in or near the boundary of the proposed development. No suitable breeding habitat.

Potential impact of proposed development: No impact on this species is anticipated.

Cattle Egret *Ardea ibis*

Status and Distribution: This species of egret is listed as migratory under the *EPBC Act* and under international agreements to which Australia is a signatory. The Cattle Egret is common in the north sections of its range but is an irregular

visitor to the better watered parts of the state (Johnstone and Storr 1998). The population is expanding (Morcombe 2003).

Species or species habitat listed as likely to occur in general area within EPBC database search.

Habitat: Moist pastures with tall grasses, shallow open wetlands and margins, mudflats (Morcombe 2003).

Likely presence in study area: May infrequently visit cleared paddock areas at times especially when cattle present. No suitable breeding habitat.

Potential impact of proposed development: No impact on this species is anticipated.

Osprey *Pandion haliaetus*

Status and Distribution: This species is listed as migratory under the *EPBC Act (1999)* and under international agreements to which Australia is a signatory. Moderately common to very common in sheltered seas around the north and west coast islands south to 31°S; uncommon to common on mainland coasts, estuaries and large rivers north of tropic, rare to uncommon elsewhere (Johnstone and Storr 1998).

Habitat: Coasts, estuaries, bays, inlets, islands, and surrounding waters, coral atolls, reefs, lagoons, rock cliffs and stacks. Ascends larger rivers (Pizzey & Knight 2007). Construct nests on prominent headland, large trees communication towers (Simposn and Day 2004).

Likely presence in study area: Observed flying overhead during the survey period. Potential for larger trees to be used for nesting though probability of this occurring is low. No existing nest sites observed.

Potential impact of proposed development: No impact on this species is anticipated.

White-bellied Sea Eagle *Haliaeetus leucogaster*

Status and Distribution: This species is listed as migratory under the *EPBC Act (1999)* and under international agreements to which Australia is a signatory. White-bellied sea eagles are moderately common to common on Kimberley and Pilbara islands, coasts and estuaries, on Bernier, Dorre and Dirk Hartog Is., in Houtman Abrolhos and in the Archipelago of the Recherche; rare to uncommon elsewhere (Johnstone and Storr 1998). Also found in New Guinea, Indonesia,

China, southeast Asia and India. Scarce near major coastal cities (Morcombe 2003).

Species or species habitat listed as likely to occur in general area within EPBC database search.

Habitat: They nest and forage usually near the coast over islands, reefs, headlands, beaches, bays, estuaries, mangroves, but will also live near seasonally flooded inland swamps, lagoons and floodplains, often far inland on large pools of major rivers. Established pairs usually sedentary, immatures dispersive (Morcombe 2003). White-bellied Sea-Eagles build a large stick nest, which is used for many seasons in succession.

Likely presence in study area: May fly over occasionally given proximity to ocean and river. Potential for larger trees to be used for nesting though probability of this occurring is very low. No existing nest sites observed.

Potential impact of proposed development: No impact on this species is anticipated.

Peregrine Falcon *Falco perigrinus*

Status and Distribution: This species is listed as Schedule 4 under the *WC Act*. Individuals of this species are uncommon/rare but wide ranging across Australia. Moderately common at higher levels of the Stirling Range, uncommon in hilly, north west Kimberley, Hamersley and Darling Ranges; rare or scarce elsewhere (Johnstone and Storr 1998).

Habitat: Diverse from rainforest to arid shrublands, from coastal heath to alpine (Morcombe 2003). Mainly about cliffs along coasts, rivers and ranges and about wooded watercourses and lakes (Johnstone and Storr 1998). The species utilises the ledges, cliff faces and large hollows/broken spouts of trees for nesting. It will also occasionally use the abandoned nests of other birds of prey.

Likely presence in study area: The species potentially utilises some sections of the study area as part of a much larger home range. No potential nest sites observed.

Potential impact of proposed development: No impact anticipated.

Forest Red-tailed Black Cockatoo *Calyptorhynchus banksii naso*

Status and Distribution: Listed as Scheduled 1 under the *WC Act* and as Vulnerable under the *EPBC Act*. Found in the humid and subhumid south west,

mainly hilly interior, north to Gingin and east to Mt Helena, Christmas Tree Well, North Bannister, Mt Saddleback, Rock Gully and the upper King River (Johnstone and Storr 1998).

Habitat: Eucalypt forests, feeds on Marri, Jarrah, Blackbutt, Karri, Sheoak and Snottygobble. The Forest Red-tailed Black Cockatoo nests in the large hollows of Marri, Jarrah and Karri (Johnstone and Kirkby 1999). In Marri, the nest hollows of the Forest Red-tailed Black Cockatoo range from 8-14m above ground, the entrance is 12 – 41cm in diameter and the depth is one to five metres (Johnstone and Storr 1998).

Breeding commences in winter/spring. There are few records of breeding in the Forest Red-tailed Black Cockatoo (Johnstone and Storr 1998), but eggs are laid in October and November (Johnstone 1997; Johnstone and Storr 1998). Recent data however indicates that breeding in all months of the year occurs with peaks in spring and autumn–winter (Ron Johnstone pers comms). Incubation period 29 – 31 days. Young fledge at 8 to 9 weeks (Simpson and Day 2004).

J	F	M	A	M	J	J	A	S	O	N	D

Period in which breeding is most likely to commence
Period in which fledging could extend through

Likely presence in study area: The study area is outside the documented range of this species and it is very unlikely to frequent the area.

Potential impact of development: No impact on this species will occur.

Baudin's Black- Cockatoo *Calyptorhynchus baudinii*

Status and Distribution: Listed as Scheduled 1 under the *WC Act* and as Vulnerable under the *EPBC Act*. Confined to the south-west of Western Australia, north to Gidgegannup, east to Mt Helena, Wandering, Quindanning, Kojonup, Frankland and King River and west to the eastern strip of the Swan Coastal Plain including West Midland, Byford, Nth Dandalup, Yarloop, Wokalup and Bunbury (Johnstone and Storr 1998). On the southern Swan Coastal Plain this cockatoo is in some areas resident but mainly a migrant moving from the deep south-west to the central and northern Darling Range. Between March and September most flocks move north and are concentrated in the northern parts of the Darling Range. During this period birds forage well out onto the southern Swan Coastal Plain to areas such as Harvey, Myalup, Bunbury, Capel, Dunsborough and Meelup. While generally more common in the Darling Range this species can also be common on parts of the southern Swan Coastal Plain

especially in mid-August – September when flocks begin to return to their breeding quarters (Johnstone 2008).

Habitat: Mainly eucalypt forests where it feeds primarily on the Marri seeds, (Morcombe, 2003), Banksia, Hakeas and *Erodium* sp. Also strips bark from trees in search of beetle larvae (Johnstone and Storr 1998). This species of cockatoo nests in large tree hollows, 30–40 cm in diameter and more than 30 cm deep (Saunders 1974).

Baudin's Black-Cockatoo breeds in late winter and spring, from August to November or December (Gould 1972; Johnstone 1997; Saunders 1974; Saunders *et al*. 1985). Eggs laid in October (Johnstone and Storr 1998). Based on observations at currently known nest sites breeding mainly occurs within the October-December period (Ron Johnstone pers comms). Incubation is 28 – 30 days. Young fledge at 8 to 9 weeks (Simpson and Day 2004).

J	F	M	A	M	J	J	A	S	O	N	D

Period in which breeding is most likely to commence
Period in which fledging could extend througho

Likely presence in study area: The study area is outside the documented range of this species and it is very unlikely to frequent the area.

Potential impact of development: No impact on this species will occur.

Carnaby's Black- Cockatoo *Calyptorhynchus latirostris*

Status and Distribution: Carnaby's Black Cockatoo is listed as Scheduled 1 under the *WC Act* and as Endangered under the *EPBC Act*. Confined to the south-west of Western Australia, north to the lower Murchison River and east to Nabawa, Wilroy, Waddi Forest, Nugadong, Manmanning, Durokoppin, Noongar (Moorine Rock), Lake Cronin, Ravensthorpe Range, head of Oldfield River, 20 km ESE of Condingup and Cape Arid; also casual on Rottnest Island (Johnstone and Storr 1998).

Habitat: Forests, woodlands, heathlands, farms; feeds on Banksia, Hakeas and Marri. Carnaby's Cockatoo has specific nesting site requirements. Nests are mostly in smoothed-barked eucalypts with the nest hollows ranging from 2.5 to 12m above the ground, an entrance from 23-30cm diameter and a depth of 0.1-2.5m (Johnstone and Storr, 1998).

Breeding occurs in winter/spring mainly in eastern forest and wheatbelt where they can find mature hollow bearing trees to nest in (Morcombe, 2003). Judging from breeding records in the Storr – Johnstone Bird Data Bank, this species is currently expanding its breeding range westward and south into the Jarrah – Marri forests of the Darling Scarp and into the Tuart forests of the Swan Coastal Plain including Yanchep, Lake Clifton and near Bunbury and possibly also in the Lancelin region. The closest known breeding population of Carnaby's Cockatoo to the study area is centred in Yanchep National Park. This population is thought to consist of about 8-10 pairs. Carnaby's Black Cockatoo have also been known to breed close to the town of Mandurah, as well as at Dawesville, Lake Clifton and Baldivis (pers. comm., Ron Johnstone, WA Museum) and there are small resident populations on the southern Swan Coastal Plain near Mandurah, Lake Clifton and near Bunbury. At each of these sites the birds forage in remnant vegetation and adjacent pine plantations (Johnstone 2008).

Carnaby's Black-Cockatoo lays eggs from July or August to October or November, with most clutches being laid in August and September (Saunders 1986). Most of the breeding is in September through to December (Ron Johnstone pers comms). Birds in inland regions may begin laying up to three weeks earlier than those in coastal areas (Saunders 1977). The female incubates the eggs over a period of 28-29 days. The young depart the nest 10–12 weeks after hatching (Saunders 1977; Smith & Saunders 1986).

J	F	M	A	M	J	J	A	S	O	N	D

Period in which breeding is most likely to commence
Period in which fledging could extend through

Likely presence in study area: Foraging evidence attributed to this species was observed during site survey and several flocks of birds were observed nearby during the March 2010 GSM survey. This species may occasionally roost onsite though no evidence of this observed. No hollows potentially suitable for nesting appear to be present and it is very unlikely to breed within the study area.

Potential impact of development: Potential for the loss of some foraging habitat.

Fork-tailed Swift *Apus pacificus*

Status and Distribution: The Fork-tailed Swift is listed as migratory under the *EPBC Act* and under international agreements to which Australia is a signatory. It is a summer migrant (Oct-Apr) to Australia (Morcombe 2003).

Habitat: Low to very high airspace over varied habitat from rainforest to semi desert (Morcombe 2003).

Likely presence in study area: It is potentially an occasional summer visitor to the study area but is entirely aerial and largely independent of terrestrial habitats.

Potential impact of development: No impact on this species is anticipated.

Rainbow Bee-eater *Merops ornatus*

Status and Distribution: This species is listed as migratory under the *EPBC Act* and under international agreements to which Australia is a signatory. The Rainbow Bee-eater is a common summer migrant to southern Australia but in the north they are resident (Morcombe 2003).

Habitat: Open Country, of woodlands, open forest, semi arid scrub, grasslands, clearings in heavier forest, farmlands (Morcombe 2003). Breeds underground in areas of suitable soft soil firm enough to support tunnel building.

Likely presence in study area: Common seasonal visitor to south west. Likely to forage and roost in the study area at times. Potentially breeds on site where soil conditions allow.

Potential impact of development: No significant impact on this species is anticipated as only a small number of individuals have the potential to be directly affected. The species will continue to utilise the area, as it does now, despite any future development.

Chuditch *Dasyurus geoffroii*

Status and Distribution: Listed as Scheduled 1 under the *WC Act* and as Vulnerable under the *EPBC Act.* Formerly occurred over nearly 70 per cent of Australia. The Chuditch now has a patchy distribution throughout the Jarrah forest and mixed Karri/Marri/Jarrah forest of southwest Western Australia. Also occurs in very low numbers in the Midwest, Wheatbelt and South Coast Regions with records from Moora to the north, Yellowdine to the east and south to Hopetoun.

Habitat: Chuditch are known to have occupied a wide range of habitats from woodlands, dry sclerophyll (leafy) forests, riparian vegetation, beaches and deserts. Riparian vegetation appears to support higher densities of Chuditch, possibly because food supply is better or more reliable and better cover is offered by dense vegetation. Chuditch appear to utilise native vegetation along road

sides in the wheatbelt (CALM 1994). The estimated home range of a male Chuditch is over 15 km^2 whilst that for females is 3-4 km^2 (Sorena and Soderquist 1995).

Likely presence in study area: Rarely recorded on the coast plain. Not recorded during any of the detailed surveys carried out in the area in the past. This species is very unlikely to be present

Potential impact of development: No impact on this species will occur.

Quenda *Isoodon obesulus fusciventer*

Status and Distribution: Listed as Priority 5 by DEC. Widely distributed in the south west from near Cervantes north of Perth to east of Esperance, patchy distribution through the Jarrah and Karri forest and on the Swan Coastal Plain, and inland as far as Hyden. Has been translocated to Julimar State Forest, Hills Forest Mundaring, Tutanning Nature Reserve, Boyagin Nature Reserve, Dongolocking Nature Reserve, Leschenault Conservation Park, and Karakamia and Paruna Sanctuaries (DEC information pamphlet) and Nambung National Park (DEC pers. coms.)

Habitat: Dense scrubby, often swampy, vegetation with dense cover up to one metre high, often feeds in adjacent forest and woodland that is burnt on a regular basis and in areas of pasture and cropland lying close to dense cover. Populations inhabiting Jarrah and Wandoo forests are usually associated with watercourses. Quendas can thrive in more open habitat subject to exotic predator control (DEC information pamphlet).

Likely presence in study area: Status onsite uncertain. May frequent areas with dense ground cover though not captured during the detailed fauna survey on the site previously or in other nearby surveys.

Potential impact of development: Loss of some potential habitat.

Western Brush Wallaby *Macropus irma*

Status and Distribution: Listed as Priority 4 by DEC. The Western Brush Wallaby is distributed across the south-west of Western Australia from north of Kalbarri to Cape Arid (DEC information pamphlet).

Habitat: The species optimum habitat is open forest or woodland, particularly favouring open, seasonally wet flats with low grasses and open scrubby thickets.

It is also found in some areas of mallee and heathland, and is uncommon in karri forest (DEC information pamphlet).

Likely presence in study area: Status in the area is uncertain. Limited area of potential habitat but may move through the area on occasions.

Potential impact of development: No significant impact on this species is anticipated.

Moore River South

Revised Outline Development Plan

Appendices H-J

Cardno
Shaping the Future

Prepared for Moore River Company Pty Ltd
October 2011
Job Number P7026

Appendix H

District / Local Water Management Strategy

Cardno

Shaping the Future

Cardno
Shaping the Future



Moore River

District and Local Water Management Strategy

Prepared for Moore River Company Pty Ltd

March 2011

Project Number V9070

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Executive Summary

Moore River Company Pty Ltd has a revision of commenced structure planning for the Moore River development situated in Caraban, within the Shire of Gingin (Swan Location 2802 and portions of Swan Location 2424 and 2914). The development of a Local Water Management Strategy (LWMS) is the appropriate mechanism to establish broad-level designs and management measures for flood mitigation and effective stormwater management at the structure planning stage. This document provides the detail of a LWMS document and covers the scope of a District Water Management Strategy (DWMS).

The LWMS is a key supportive document for the revised Outline Development Plan (ODP). The development of the LWMS has been undertaken with the intention of providing a structure within which subsequent development can occur consistent with a 'total water cycle management' approach described in the document. It is also intended to provide overall guidance to the general stormwater management principles for the area and to guide future Urban Water Management Plans (UWMPs) that will support subdivision approval.

This LWMS for the ODP has been developed to:

- Provide a broad level stormwater management framework to support future urban development.
- Incorporate appropriate BMPs into the drainage systems that address the environmental and stormwater management issues identified.
- Minimise development construction costs, which will result in reduced land costs for future home owners.
- Minimise ongoing operation and maintenance costs for the land owners and Shire of Gingin.
- Develop a water conservation strategy for the area that will accommodate existing groundwater allocation constraints for the area.
- Gain support from the Department of Water and Shire of Gingin for the proposed method to manage stormwater within Lot 27 and Lot 201 and potential impacts on downstream areas.

A number of broad level studies that include the ODP area provide a regional environmental context for the LWMS. These have been reviewed in order to provide suitable background information for Lot 27 and Lot 201 and also to provide an indication of the issues requiring further investigation. Further, a number of site-specific investigations into various aspects of Lot 27 and Lot 201 have recently been conducted as a part of the LSP preparation process. In summary, the investigations conducted to date indicate that:

- The ODP area is situated within a sand and limestone dune, with the topography within the residential/commercial area ranging from 10 to 50mAHD.
- ASS risk mapping does not extend over the study area. Site characteristics indicate that there is the potential for ASS to occur at depth, however these are significantly lower than the likely excavation depths and therefore not considered of concern.
- No Declared Rare Flora species were recorded; however three Priority Three Flora species were recorded within the study area.
- Three species identified as endangered/vulnerable or in need of special protection are listed as potential occurring within the area.
- Monitoring has recently been conducted for a six month period. The Maximum Recorded Groundwater Levels (MGL) where observed in October 2009 ranging between 0.25mAHD and 0.49mAHD. The depth to groundwater for the residential/commercial areas is between 10 to 40mAHD. All locations within the development boundary have a separation distance between the existing topography and the MGL of at least 1.2m.
- Groundwater quality results are generally within or slightly above the default trigger values. The TN and NO_X concentrations vary across the ODP area and were recorded up to 5 and 40 times the default trigger values respectively.
- All runoff is retained and infiltrated on site resulting in no discharge from the ODP area.

- No streamlines or surface water channels exist within the ODP area and hence no surface water quality data is available.
- The ODP area has been historically cleared and used for sheep and cattle grazing.

The LWMS document outlines the proposed groundwater management strategy, surface water management strategy, water supply and conservation strategy, and a monitoring strategy. These strategies have been determined based on the physical constraints of the site, as well as to achieve the requirements of government authorities.

Due to the significant depth to groundwater across the site, no management of groundwater levels is required. The groundwater nutrient concentrations are generally moderate compared to default trigger values. As the water does not intersect the surface at any location no treatment of the groundwater will be required. Monitoring of groundwater quality will be implemented to ensure that the nutrient concentrations within the underlying are not significantly increased due to the development.

The principle behind the stormwater management strategy is to retain and infiltrate all runoff (as occurs in the pre-development environment) within the ODP area, with treatment of minor rainfall events within vegetated treatment areas. The strategy will utilise bio-pockets, swales, vegetated infiltration areas, constructed infiltration basins and natural depression infiltration areas.

Water Corporation will potentially be able to supply a portion of the water required for the development. Given that the relevant aquifer is fully allocated, aquisition of an adequate groundwater allocation from an existing groundwater licence holder to facilitate the remainder of the development will be required. It is anticipated that confirmation that adequate water allocations have been secured will be provided in the future UWMP documents. A water treatment facility will treat the groundwater prior to it being supplied to the development for potable uses. This facility will ultimately be managed by the Water Corporation.

All waste water from the development will be treated and used to irrigate POS and School Ovals. The predicted treated water supply will meet with demands for these irrigation uses. Excess water produced during winter (due to reduce irrigation requirements) will be infiltrated into the underlying aquifer. This strategy will achieve the sewerage requirements of the development and reduce the total water consumption. At a lot scale, households will be required to implement water saving strategies including rainwater tanks, water efficient appliances and water efficient gardens.

A summary of how the design criteria will be achieved and the proposed management strategy implemented (as presented within this LWMS document is provided within **Table 1**.

The Moore River DWMS/LWMS provides a framework that future landowners can follow to assist in establishing stormwater management methods that have been based upon site-specific investigations, are consistent with relevant State and Local Government policies and have been endorsed by the Shire of Gingin. The responsibility for working within the framework established within the LWMS rests with the individual landowners, although it is anticipated that future UWMPs will be developed in consultation with the Shire of Gingin, Department of Water and in consideration of other relevant policies and documents as well as this LWMS.

Table 1 Design Elements and Compliance

Key Element	Design Objectives and Criteria	Compliance
Surface Water Quantity	Retain the 1 year - 1 hour duration ARI rainfall event on site.	Runoff will be retained within each drainage catchment. Lot rainwater tanks and soakwells will be used to retain the 1 year - 1 hour ARI storm event from roof areas. For the remainder of the development, the runoff from this event will be retained within vegetated retention areas. Larger runoff events will also flow into these vegetated retention areas and overtop into the larger infiltration basin/depressions (**Section 7.1**).
	Vegetated treatment systems should be sized to accommodate at least 2% of the connected impervious area.	This will be provided by bio-pockets, swales and other vegetated treatment areas.
	Piped road network design based on the 5 year ARI rainfall event.	The development will have a mixture of pathways for conveying rainfall runoff events to the downstream infiltration areas; these include swales, road pavement and concrete piped network. The concrete piped network will be sized for the 5 year ARI rainfall event.
	Ensure that the 100 year ARI rainfall event conveyance can be contained within the road reserve.	With the combination of at-source storage within lot soakwells and rainwater tanks, infiltration within vegetated retention systems and the use of a piped network to convey the 5 year ARI rainfall event, the 100 year ARI event conveyance will be contained within the road reserve.
	Ensure that properties have a finished floor level of 500mm above the 100 year flood level within the adjacent basins.	The major event retention storage will be within infiltration basins/depressions. The 100 year ARI water levels in these areas are provided in **Table 8**.
	Lots must have clearance of 300mm to the 100 year ARI flow level within road reserves.	The majority of lots will be elevated 300mm above the 100 year ARI level within the road reserve; however, due to the requirement to maintain the existing topography in the post-development environment, some lots will be have a lower elevation than the road network. To ensure lots are not flooded, measures must be implement to prevent unexpected flooding in road areas flowing into these lots (**Section 7**).
Surface Water Quality	Maintain or improve the surface and groundwater quality within the development relative to pre-development conditions.	The Moore River development will achieve this objective by implementing treatment within vegetated retention areas. The retention of the 1 year - 1 hour ARI storm event and the provision of a minimum bio-retention area of 2% connected impervious area will ensure the surface and groundwater quality is maintained (**Section 7.3**).
	Maintaining the total water cycle balance within the development relative to the pre-development conditions.	The post-development environment will retain all runoff within the ODP boundary as occurs in the pre-development environment.
	Maximising the reuse of stormwater.	Stormwater and excess treated waste water will be infiltrated onsite. This infiltrated water will enter the groundwater and will be reused by the natural environment and also redrawn during

		summer to be treated and supplied to the development (**Section 5**).
Groundwater Quantity	Lots should have a separation distance to the maximum groundwater level (MGL) of at least 1.2m.	The depth to groundwater across the development area is significantly greater than 1.2m (**Figure 7**)
Groundwater Quality	Minimise the risk of nutrient enrichment of downstream receiving surface water bodies from groundwater sources.	The Moore River development reduces the risk of nutrient enrichment and transportation by using a treatment train approach and ensuring nutrient uptake in the vegetated retention areas.
	Minimise the risk of nutrient enrichment of groundwater	The groundwater currently has moderate nutrient concentrations. The development will minimise additional nutrient loading of the groundwater through management strategies. The retention of the 1 year - 1 hour ARI storm event and the provision of a minimum vegetated retention areas sized to be 2% of the connected impervious area will ensure the infiltration of nutrient rich surface water to groundwater is minimised; thus improving the groundwater quality exiting the ODP area (**Section 7.3**).
Water Conservation	Ensure the efficient use of all water within the development	Remnant vegetation will be maintained within proposed POS areas. This will reduce the water requirements to establish vegetation. Low water requiring plant species (such as native species) will be utilised and turfed areas minimised. Where turf is to be used, a low nutrient and water requiring species should be utilised.
	Use water efficiently.	Water conservation devices and practises are proposed to be implemented within the development (**Section 5.3**).
	A target for domestic scheme water use of 100kL/year per person and an aspirational target of 60kl/year a person.	The 100kL/person/year target can be achieved in the development with the implementation of water conservation devices and practises such as rainwater tanks, water efficient gardens and water efficient appliances (**Section 5.4**).

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1 Introduction

1.1 Background

Moore River Company Pty Ltd is revising structure planning to support development of a parcel of land (Swan Location 2802 and portions of Swan Location 2424 and 2914) immediately south of Moore River, near Guilderton, (henceforth referred to as the study area). This parcel of land forms part of a larger piece of land, which is zoned "Urban Development" under the Shire of Gingin (SoG, 2009) *Town Planning Scheme* (TPS) No. 8. The location of the study area (Outline Development Plan) is shown in **Figure 1**.

The proposed future urban development has recently been endorsed by the State government, with the future urban development to support a population of approximately 5,000 people, consistent with the *Gingin Coast Structure Plan* (Western Australian Planning Commission (WAPC) 2006). It is envisaged that the future urban development will support a range of residential and accommodation options to contribute towards a sustainable community for the broader region. The boundary of the revised Outline Development Plan (ODP) and proposed development area is shown in **Figure 2** and **Figure 3**.

1.2 Policy Framework

There are a number of State Government policies relevant to Moore River. These policies include:

- *State Water Strategy* (Government of WA, 2003).
- *State Planning Policy 2.9 Water Resources* (Government of WA, 2006).
- *Draft Perth Coastal Planning Strategy* (WAPC, 2008).
- *Australian Runoff Quality* (Engineers Australia, 2006).
- *Draft Guidance Statement No. 33: Environmental Guidance for Planning and Development* (EPA, 2005).
- *Liveable Neighbourhoods Edition 4* (WAPC, 2007).
- *Planning Bulletin No. 64: Acid Sulfate Soils* (WAPC, 2007).

In addition to the above policies, there are a number of published guidelines and standards available that provide direction regarding the water discharge characteristics that urban developments should aim to achieve. These are key inputs that relate either directly or indirectly to the site and include:

- *Better Urban Water Management* (WAPC, 2008).
- *Decision Process for Stormwater Management in Western Australia* (DoW, 2009).
- *Stormwater Management Manual for Western Australia* (DoW, 2007).
- *National Water Quality Management Strategy* (ANZECC, 2000).
- *Development of Sampling and Analysis Programs* (DoE, 2001).

The *Decision Process for Stormwater Management in WA* (DoW, 2009) provides a decision framework for the planning and design of stormwater management systems. Effectively, the document provides guidance as to how urban developments can achieve compliance with the objectives, principles and delivery approach outlined in the Stormwater *Management Manual for WA (DoW, 2007)*.

The essence of the recommended approach is to address water quality concerns for minor events (up to a 1 year – 1 hour ARI event) at source, or as close as possible to source. Following this and where appropriate, water quality should also be addressed through a 'treatment train' approach, such that the combined effect meets the water quality management objectives specified in relevant regional

water management targets. Conveyance of flows up to the 5 year ARI event should be accommodated within the minor system (i.e. pipes and swales), while flows up to the 100 year ARI event should be catered for by overland flow paths. The *Decision Process* indicates that stormwater quantity should be managed to preserve pre-development peak flow rates. This should be achieved by providing adequate storage within the site boundaries.

The guidance documents listed were reviewed to determine the likely data requirements for the area within the proponent's landholdings, which are proposed for future urban development. These documents point to the need for accurate baseline data prior to urban development. Comprehensive baseline data ensures that any future development is able to fulfil the stormwater management requirements of DoW and engineering standards specified by the SoG, but will also ensure that realistic water quality criteria that are practically achievable are adopted.

1.3 Moore River LWMS Objectives

The LWMS for the Moore River ODP has been developed to meet the following major objectives:

- Incorporate appropriate Best Management Practises (BMPs) into the drainage systems that address the environmental and stormwater management issues identified.
- Minimise development construction costs, which will result in reduced land costs for future home owners.
- Minimise ongoing operation and maintenance costs for the land owners and SoG.
- Develop a water conservation strategy for the area that will accommodate existing groundwater allocation constraints for the area.
- Gain support from the DoW and SoG for the proposed method to manage stormwater within the study area and potential impacts on downstream areas.

The Moor River Structure Plan is shown in **Figure 3**.

2 Proposed Development

The proposed Moore River Development will have 2000 residential lots of mixed density. The highest density lots will be located near POS areas and commercial nodes. These higher density lots will be approximately 350m^2. Approximately 75% of the lots will be medium density with an average size of 700m^2. A small proportion of the lots will be large 'Lifestyle' lots with an average size of 3000m^2. These lifestyle lots are located near the entrance to the development (See **Figure 3** for location of structure plan and lot densities).

The study site is located (northwards) outside of the Perth Metropolitan Area in a relatively untouched environment. The development proposes to minimise the impact on the natural environment wherever possible via methods such as:

- The lots are setback up to 300m from the coastline to protect the delicate ecosystem of the dune system.
- Natural vegetation is retained where possible.
- The development site ground surface levels are largely unaltered to retain the natural undulating topography.
- Existing depression areas will continue to be used as flood storage areas in the post-development environment.
- Road reserve widths are maximised to allow for more verge areas which can include natural vegetation.
- The road reserves will be used for at-source retention and treatment of stormwater runoff.
- Waste water will be treated and reused to reduce the water consumption footprint of the development.
- Alternative electricity supply will be encouraged at a lot scale by the developer.

The development is situated in an area that is frequented by holiday makers. Due to the Holiday Resort, Caravan Park and Tourist Resort the Moore River Development is likely to have a highly transient population. However, the development is large enough to support a moderately sized permanent population and a school has been provided to encourage these residents.

3 Pre-Development Environment

3.1 Sources of Information

The following sources of information were used to provide a broad provide a broad regional environmental context to the site:

- *National Water Quality Management Strategy* (ANZECC, 2000).
- *Water Quality Sampling Standards*. AS/NZS 5667:1:1998 & 5667:2:1998 (AS/NZS, 1998).
- *Aboriginal Heritage Inquiry Search Database* (DIA, 2009).
- *WA Atlas* (Landgate, 2009).

In addition to the above information, site-specific investigations have been conducted. These have been aimed at providing more detail to the existing regional information. These site-specific investigations include:

- *Moore River South: Flora and Vegetation Assessment* (Cardno, 2010a).
- *Fauna Habitat Impact Assessment: Proposed Subdivision Moore River South* (Harewood, 2010).
- *Moore River: Environmental Constraints, Issues and Opportunities* (Cardno, 2010b).
- *Hydrological Monitoring* (Cardno, 2010c).

The above studies have been consulted to determine any potential capacity limitations of local surface water flow paths and existing surface and groundwater levels. This is important, as both can have implications for the stormwater management measures and the extent of earthworks that may be required to facilitate subdivision.

3.2 Geotechnical Conditions

3.2.1 Topography

The topography of the study area rises steeply away from the beach and Moore River to a series of high dunes, dune ridges and valleys. The slopes from the Moore River up to the dune crests (50m AHD) are steep. The coastal dunes attain heights of 10m AHD near the coast and up to 30m AHD a short distance inland. In the northern section of the coast there is a large valley behind the dunes which has a low point of less than 5m AHD.

Further inland the study area lies between 10 and 60m AHD with several small sandy knolls or chaots rising above the surface level. A major dune ridge extends inland from the coast near the southern part of the study area and achieves elevations of 50 to 60m AHD. The topography contours of the study area are shown in **Figure 4**.

3.2.2 Geomorphology

The study area lies on the western extent of the Swan Coastal Plain. The study area contains two of the main geomorphic features of the Swan Coastal Plain; the Quindalup Dune System and Spearwood Dune System.

The Quindalup Dune System is a Holocene landform which extends along the coast from Geographe Bay to Dongara. A variety of Aeolian landforms exist in the Quindalup Dune System which have been developed by climatic, geomorphic, sedimentology, coastal and vegetation factors and processes. The Quindalup Dunes extend along the whole coastline of the study area in a series of fretted parabolic dunes, chaots, a few small conical hill residuals and a large shore transverse ridge (remnant

of a large parabolic dune). The Quindalup dunes extend toward the eastern boundary of the study area. The coastal dunes in places are still active with blowouts and mobile crests moving gradually inland.

The dune system fronting the sandy beach in the northern part of the study area does not have any small foredunes. Immediately inland from the narrow low foredune zone the dunes again rise steeply to tall secondary dunes except in places where blowouts have proceeded inland and broken through shore-parallel dunes.

The Spearwood Dune System is a series of shore parallel ridges which are older (Pleistocene) than the Quindalup Dune System (Holocene). The Spearwood Dune System has a similar distribution along the coastline as the Quindalup System but is more extensive laterally from several kilometres inland to sub-marine expressions and coastal islands off-shore. Near the coastline the Spearwood Dunes are mostly overlain by the Quindalup Dune System. There are no surface expressions of the Spearwood Dunes within 300m of the coast. Further inland the Spearwood Dunes are exposed immediately east of the tall chaotic dune system in the southern and central portions of the landholding and in the northern section between ridges of parabolic dunes. The Spearwood Dunes are mainly flat to gently undulating landforms with no major ridge systems on the landholding.

3.2.3 Soils

The soils of the study area consist of Safety Bay Sand (Quindalup Dune System) and Tamala Limestone (Spearwood Dune System). The Safety Bay Sand is composed of calcareous sands with high permeability and low slope stability. The Tamala Limestone belongs to the Cottesloe Association which is defined as consisting of exposed limestone which can weather to siliceous brown sand. Within the study area the Tamala Limestone is mainly expressed at the surface as limestone rock with only shallow sand cover in places. The soil types underlying and surrounding the site are shown in **Figure 5**. While future geotechnical investigations can be expected to further clarify the underlying infiltration rates, for the current investigation a conservative infiltration rate of $2.5x10^{-5}$m/s has been adopted.

3.2.4 Acid Sulfate Soils

The development site is within an area not classified by The WA Atlas (Landgate, 2009) Acid Sulfate Soils (ASS) risk mapping.

The DEC guideline '*Identification and Assessment of Acid Sulfate Soils and Acidic Landscapes*' (DEC 2009) lists the following environmental features as locations where ASS is known to have developed or have the appropriate combination of environmental factors to promote the development of ASS:

- Areas depicted on geology and/or geomorphological maps as geologically recent (Holocene) such as - shallow tidal flats or tidal lakes, shallow estuarine or shallow marine deposits, stranded beach ridges and adjacent swales, interdunal swales or coastal sand dunes, coastal alluvial valleys, wetlands, floodplains, waterlogged areas, scalded areas, marshes or swamps.
- Areas depicted in vegetation mapping as – mangroves, wetland dependant vegetation such as reeds and paperbarks (*Melaleuca spp*.), or areas where the dominant vegetation is tolerant of salt, acid and/or waterlogging conditions e.g. mangroves, salt couch, swamp-tolerant reeds, rushes, paperbarks and swamp oak (*Casuarina spp.*).
- Areas depicted in geological descriptions or in maps as – bearing sulfide minerals, former marine or estuarine shales and sediments, coal deposits or mineral sand deposits.
- Areas known to contain peat or a build up of organic material.
- Areas where the highest known watertable is within 3.0 m of the surface.
- Land with elevation less than 5.0 mAHD.

- Any areas in Western Australia (including inland areas) where a combination of all of the following pre-disposing factors exist – organic matter, iron minerals, waterlogged conditions or a high watertable, sulfidic minerals or deep estuarine sediments below ground.

The site contains several of the features described above, and it is therefore possible that ASS are present at some point within the soil column. Any future investigations should target these areas to determine the nature and extent of ASS that could be potentially affected by the proposed works.

3.3 Environmental Assets

A search of the Swan Coastal Plain Wetlands, Bush Forever 2007 and Environmentally Sensitive Areas databases on the WA Atlas (Landgate, 2009) indicated that the subject site does not contact any of these environmental assets.

3.3.1 Flora

The study area was visited by botanists in October and November 2009 and a field survey, conducted in accordance with EPA *Guidance Statement No. 51 – Terrestrial flora and vegetation survey environmental impact assessment in Western Australia* (2004) was undertaken to the level of a detailed survey.

Across the visits, 138 native and 36 introduced flora species were recorded comprising 54 families and 118 genera. No "Declared Rare Flora" (DRF) species were recorded; however three Priority Three Flora *Stylidium maritimum*, *Hibbertia spicata* subsp*. leptotheca* and *Beyeria cinerea* subsp. *cinerea* were recorded at Site 212. A number of significant flora have also been recorded, these being *Allocasuarina lehmanniana*, *Marianthus erubescens*, *Calandrinia* aff. sp. Blackberry and *Thomasia triphylla*. These species are not uncommon species, however do represent extents of ranges or unusual coastal occurrences.

Eight broad plant communities have been described for the subject site, which are:

1. **OaSc** - Low Scrub B of *Olearia axillaris* and *Scaevola crassifolia* over Open Hummock Grass of *Spinifex longifolius*, Very Open Low Sedges of *Ficinia nodosa* and Open Herbs of **Trachyandra divaricata* **Tetragonia decumbens, *Cakile maritima, *Pelargonium capitatum, Hardenbergia comptoniana* and *Conostylis candicans* on foredunes.
2. **ArAp** - Dense Thicket to Thicket of *Acacia rostellifera* over Low Scrub B of *Acanthocarpus preissii* over Open Low Grass of **Bromus diandrus, *Lolium rigidum* and *Poa porphyroclados*, Open Herbs of *Calandrinia* sp. Swan Coastal Plain, **Dischisma arenarium*, *Carpobrotus virescens*, and **Tetragona decumbens* on lower slopes and within swales.
3. **AlEg** - Scrub of *Allocasuarina lehmanniana* subsp. *lehmanniana*, *Spyridium globulosum* and *Myoporum insulare* with emergent pockets of Low woodland A to Open Low Woodland A of *Eucalyptus gomphocephala* over Low Scrub B of *Acacia lasiocarpa*, *Olearia axillaris* and *Leucopogon parviflorus* over Low Open Sedges of *Lepidosperma gladiatum*, Open Low Grasses of **Bromus diandrus* and *Austrostipa flavescens* and Open Herbs of Parietaria debilis, Senecio pinnatifolius, *Trachyandra divaricata, Daucus glochidiatus, *Crassula glomerata and *Trachymene pilosa*.
4. **MsAlSg** - Heath A to Dwarf Scrub C of *Melaleuca systena, Acacia lasiocarpa, Spyridium globulosum* and *Calothamnus quadrifidus* with occasional pockets of Low Woodland A of *Eucalyptus gomphocephala* and Low Woodland B of *Banksia attenuata* over Open Herbs of *Lomandra maritima*, *Parietaria debilis, Phyllanthus calycinus, Poranthera microphylla, Senecio pinnatifolius* and *Trachymene pilosa*.

5. **MsAlAp** - Low Heath B of *Melaleuca systena, Acacia lasiocarpa, Acanthocarpus preissii* and *Calothamnus quadrifidus* with occasional pockets of Low Woodland B of *Banksia attenuata* or Thicket to Scrub of *Acacia rostellifera* in the swales over Open Herbs of *Conostylis candicans*, *Desmocladus asper* and Heliophila pusilla, Very Open Low Sedges of *Lepidosperma pubisquameum* and Open Low Grass of **Bromus diandrus* and *Poa porphyroclados* on sand over limestone.
6. **McSg** - Thicket of *Melaleuca cardiophylla*, *Spyridium globulosum, Leucopogon insularis* and *Acanthocarpus preissii* over Low Grasses *Bromus diandrus, *Lolium rigidum and **Ehrharta longiflora* and Herbs *Desmocladus asper*, *Calandrinia* sp. Swan Coastal Plain, *Stylidium maritimum* (P3), *Hibbertia spicata* subsp. *leptotheca* (P3) and *Beyeria cinerea* subsp. *cinerea* (P3) on grey-brown sands over limestone.
7. **MsMhBs** - Heath A to Dwarf Scrub C of Melaleuca systena/Melaleuca huegelii, *Banksia sessilis, Spyridium globulosum, Templetonia retusa, Acacia truncata* and *Hakea lissocarpha* over Open Herbs of *Calandrinia brevipedata*, *Podotheca gnaphalioides* and *Trachymene coerulea* subsp. *coerulea* and Very Open Low Grasses of Austrostipa flavescens, Poa porphyroclados, **Bromus diandrus* and *Ehrharta villosa* on dark grey-brown sand over limestone.
8. **MhAtMs** - Low Heath C recently burnt (3-5 years) of *Melaleuca huegelii/Acacia truncata, Melaleuca systena* and Banksia sessilis, over Very Open Herbs of Desmocladus asper, *Stylidium junceum, Calandrinia* aff. sp. Blackberry, *Carpobrotus virescens*, **Crassula glomerata*, and *Gompholobium tomentosum* and Very Open Low grasses of *Bromus diandrus and *Poa porphyroclados* on grey-brown sand over limestone.

Of the plant communities described, **OaSc**, **ArAp** and **AlEg** have been determined to be "Floristic Community Type" (FCT) 29a and plant community **MsAlSp**, **MsAlAp**, **McSp**, **MsMhBs** and **MhMtMs** have been determined to be FCT 29b. Both of these FCTs are classified as Priority 3 Ecological Communities. A number of supplementary FCTs have been added to the Gibson *et al*. (1994) FCT dataset following 1994, which identified additional FCTs for the Swan Coastal Plain, focusing within the northern portion of the Swan Coastal Plain. This information is not readily available and could not be included within the FCT analysis, however the supplementary community type FCT S11 – Northern *Acacia rostellifera* – *Melaleuca systena* shrublands could be inferred for the study area and could potentially represent **OaSc**, **ArAp**, **AlEg** and **MsAlSp**. FCT S11 is not classified as either a "Priority Ecological Community" (PEC) or a "Threatened Ecological Community" (TEC). Additional information will be required to be obtained from the EPA to better determine the FCTs.

The vegetation ranged from ‘Completely Degraded’ to ‘Pristine-Excellent’ condition with a majority of the vegetation in either a ‘Completely Degraded’ or ‘Excellent’ to ‘Pristine-Excellent’ condition, in particular within the fenced foreshore reserve. Detailed mapping of the above areas is available within the Flora and Vegetation Assessment (Cardno, 2010a).

3.3.2 Fauna

Fauna survey work was conducted by a qualified zoologist between 23-25 October 2009. Evidence of foraging within the study area by Carnaby's Black Cockatoo was observed during the survey period. No black cockatoos were observed in or near the site during any stage of the survey work. It should however be noted that the survey was undertaken at a time of the year when Carnaby’s Black Cockatoo were least likely to be present in the area.

With respect to native vertebrate fauna in general, 18 mammals (includes 7 bats species), 115 bird, eight frog and 51 reptile species have previously been recorded in the general area, some of which have the potential to occur in or utilise at times sections of the study area.

Of the 192 native animals that are listed as potentially occurring in the area, three are considered to be endangered/vulnerable or in need of special protection under state and/or federal law, these being: *Calyptorhynchus latirostris* Carnaby`s Cockatoo, *Ardea alba* Great Egret and *Pandion haliaetus* Osprey. The Great Egret and the Osprey were both sighted within the study area during the survey period.

In addition six migratory species may frequent the site at times and four DEC priority species were identified as possibly present; however neither where observed during the survey period. With respect to fauna in general no significant impacts are expected. A significant proportion of the study area is already cleared or highly degraded and the development is unlikely to have any substantial impact on the status the fauna species most likely to be currently using the area.

3.4 Hydrology

3.4.1 Groundwater Levels

Groundwater quality was measured at 10 groundwater bores within the study area over a six month period. The maximum observed groundwater levels across the study area were recorded in October 2009 and ranged between 0.25mAHD and 0.49mAHD (as shown in **Table 2**). The location of the groundwater bores and the groundwater contours are presented within **Figure 6**. The groundwater contours indicate that the groundwater flow direction is perpendicular to the coast line.

Table 2 Groundwater Levels (mAHD)

Bore ID	Oct-09	Nov-09	Dec-09	Jan-10	Feb-10
MR1	0.28	0.20	0.10	0.10	-0.67
MR2	0.33	0.25	0.26	0.21	0.21
MR3	0.42	0.41	0.36	0.35	0.33
MR4	0.22	0.23	0.03	-0.04	0.00
MR5	0.33	0.37	0.30	0.25	0.24
MR6	0.48	0.39	0.36	0.32	0.36
MR7	0.25	0.22	0.20	0.11	0.08
MR8	0.49	0.45	0.38	0.34	0.32
MR9	0.27	0.18	0.09	0.10	0.09
MR10	0.27	0.26	0.13	0.16	0.10

Given that the site is so close to the coast, underlain by highly permeable soil profiles and has the further control on groundwater provided by the Moore River, it is not anticipated that there would be significant fluctuations in maximum groundwater levels from year to year. Therefore, the groundwater levels measured in October 2009 are considered to provide adequate representation of the annual Maximum Groundwater Levels (MGLs) underlying the site.

The significant depth to the MGL across the site (10-40m for the residential lots) is presented within **Figure 7**. Detail of the post-development groundwater management strategy is provided within **Section 6**.

3.4.2 Groundwater Quality

Along with levels, groundwater quality was measured at the 10 groundwater bores within the study area. Samples were taken and tested at a NATA accredited laboratory for nutrients and nutrient

species. In situ field parameters were also recorded and are presented in **Table 3**. Nutrient concentrations have been compared to default trigger values from the National Water Quality Management Strategy (ANZECC, 2000), which are intended for surface water. Therefore, where there are apparent exceedences of these levels this is not necessarily a cause for concern; rather it provides an indication of the relative concentrations of nutrients across the site.

The results for total phosphorous (TP), ortho-phosphorous (ORP), ammonium (NH_4), dissolved oxygen (DO), pH and salinity are within or slightly higher than the default trigger values. The total nitrogen (TN) concentrations varied across the study area increasing to five times the default values in groundwater bore MR9. The nitrate and nitrite nutrient species (NO_X) were recorded at values up to 40 times the default trigger values.

The exceedence of the default trigger values groundwater quality are not considered to be of concern, as the trigger values are intended to be applied to surface water, not groundwater. Further, given the significant depth to groundwater across the site, it is not anticipated that the development of the site would involve disturbance of the underlying groundwater.

Table 3 Groundwater Quality

	Trigger Values	MR1	MR2	MR3	MR4	MR5	MR6	MR7	MR8	MR9	MR10
Laboratory Analytes											
TN (µg/L)	1,200	1,000	3,400	3,800	1,100	4,600	3,200	5,100	-	6,800	2,200
TP (µg/L)	65	290	20	130	50	20	20	120	-	50	110
ORP (µg/L)	40	10	10	10	50	10	10	10	-	10	10
NH_4 (µg/L)	80	20	10	30	10	50	30	10	-	20	10
NO_X (µg/L)	150	990	3,390	3,830	800	4,200	2,980	4,300	-	6,820	2,250
TKN (µg/L)	-	100	200	200	300	400	300	800	-	500	200
Field Parameters											
Temp (°C)	-	21.0 (0.4)	21.2 (1.2)	21.7 (0.9)	20.7 (2.1)	21.4 (1.3)	22.3 (1.7)	21.6 (1.5)	22.8 (-)	21.0 (1.2)	21.3 (0.8)
Cond (mS/cm)	-	0.8 (0.5)	0.7 (0.0)	0.8 (0.0)	1.6 (0.2)	0.8 (0.1)	0.7 (0.0)	1.2 (0.0)	0.8 (-)	0.8 (0.2)	0.9 (0.3)
DO (mg/L)	-	4.5 (3.6)	8.5 (0.1)	8.3 (0.6)	2.8 (1.5)	6.5 (0.7)	7.3 (0.6)	7.5 (0.4)	5.0 (-)	8.2 (0.1)	7.4 (0.2)
DO (%)	80-120	85 (6.4)	96 0.7)	83 (7.0)	31 (17.3)	74 (5.7)	85 (4.7)	86 (2.4)	58 (-)	93 (2.4)	86 (0.4)
pH	6.5-8.0	7.6 (0.3)	7.6 (0.1)	7.6 (0.3)	7.6 (0.4)	7.7 (0.3)	7.8 (0.5)	7.6 (0.4)	8.0 (-)	7.6 (0.1)	6.9 (0.2)
Salinity (ppt)	0.12-0.3	0.4 (0.2)	0.3 (0.0)	0.4 (0.0)	0.8 (0.1)	0.4 (0.1)	0.4 (0.0)	0.6 (0.0)	0.4 (-)	0.4 (0.0)	0.4 (0.1)
Redox (mV)	-	70 (31.1)	77 (28.3)	75 (41.7)	66 (52.3)	70 (43.1)	64 (55.9)	73 (53.0)	-15 (-)	84 (47.4)	109 (61.5)

Note: the above statistics are 'average'/'standard deviation'. Trigger values are for slightly Disturbed Ecosystems in South Western Australia for lowland rivers, as classified by ANZEEC (2000). This data includes two sampling occasions for the laboratory analytes and field chemistry parameters.

Analysis of dissolved metals, hydrocarbons and OC/OP Pesticides was also conducted. All OC/ OP pesticide concentrations were below the Limit of Reporting (LOR). All dissolved metal concentrations were below ANZECC guideline values. The C29 – C36 Total Petroleum Hydrocarbon fraction was recorded above the LOR at Bore MR5. It should be noted that no trigger value has been assigned for total petroleum hydrocarbon fractions and the concentration was only moderately above the LOR.

Further detailed descriptions of the monitoring results are provided within the Monitoring Report in **Appendix C**.

3.4.3 Surface Water

The existing environment of the proposed development area can be described as undulating sand dunes with low lying vegetation. Sand dunes have very small surface runoff catchments, with any runoff being retained within the troughs formed between the peaks of the dunes. This runoff is quickly infiltrated due to the high infiltrating coarse sands. Therefore there are no drainage paths through the development site.

The pre-development LSP area was delineated into 27 surface runoff sub-catchments, which are presented in **Figure 8**. A surface water runoff model (such as XPSWMM) can be used to calculate the runoff rates and volumes for each of the catchments within a development area. This is typically performed for proposed development sites to determine the most appropriate locations for stormwater infrastructure (i.e. not within the floodplain), and to determine the runoff into or from the site boundary so that the hydrologic regime can be maintained in the post-development environment.

For the Moore River development area, the size and shape of the catchments will be modified but these will generally be consistent with the pre-development hydrology and retain all runoff within infiltration basins or natural depression areas located adjacent to the development area. Therefore, detailed modelling of the pre-development environment to obtain discharge rates and volumes will not provide further information to the structure plan design and therefore pre-development modelling has not been undertaken.

Some of the catchments are across the development boundary and thus there is technically some discharge from the portion of the site proposed for development. These discharges as still retained within the subject site and are therefore not considered to be of concern. Since all of the runoff is retained within catchments in the existing environment, the design criteria for the post-development environment will also be to retain all runoff on site or adjacent to the site boundary.

While predevelopment modelling has not been undertaken for the entire site, modelling of the undeveloped catchments adjacent to the structure plan was performed during the post-development modelling. This was performed to determine the flooding extent in basins and natural depression areas adjacent to the site and to ensure that the earthworks levels were sufficient to prevent surface runoff from these undeveloped areas flowing into the development area. Further detail on the post-development modelling and stormwater management strategy is presented in **Section 7,** and the design criteria are presented within **Section 4.3**. The modelling assumptions and parameters used in the modelling are presented in **Appendix A**.

3.4.4 Surface Water Quality

No streamline or surface water channels are located within the study area and therefore no surface water quality data exists.

3.5 Historical and Current Land Use

The study area has been historically cleared and used for sheep and cattle grazing. No buildings or permanent infrastructure have been constructed within the area proposed for development.

3.6 Summary of Existing Environment

In summary, the environmental investigations conducted to date indicate that:

- The topography of the study area rises steeply away from the beach and Moore River to a series of high dunes, dune ridges and valleys. The study area lies between 10 and 60m AHD with several small sandy knolls or chaots rising above the surface level.
- The study area lies on the western extent of the Swan Coastal Plain and contains two of the main geomorphic features of the Swan Coastal Plain: the Quindalup Dune System and Spearwood Dune System.
- The soils of the study area consist of Safety Bay Sand (Quindalup Dune System) and Tamala Limestone (Spearwood Dune System).
- ASS risk mapping does not extend over the study area. Site characteristics indicate that there is the potential for ASS to occur at depth, however these are significantly lower than the likely excavation depths and therefore not considered of concern.
- No DRF species were recorded; however three Priority Three Flora species were recorded within the study area.
- Three species identified as endangered/vulnerable or in need of special protection are listed as potential occurring within the area.
- The MGL where observed in October 2009 ranging between 0.25mAHD and 0.49mAHD. The depth to groundwater is significantly greater than 1.2m across the entire study area.
- Groundwater quality results are generally within or slightly above the default trigger values. The TN and NO_X concentrations vary across the study area and were recorded up to 5 and 40 times the default trigger values respectively.
- All runoff is retain and infiltrated on site resulting in no discharge from the ODP area.
- No streamlines or surface water channels exist within the study area and hence no surface water quality data is available.
- The study area has been historically cleared and used for sheep and cattle grazing.

4 Design Objectives and Criteria

This section outlines the objectives and design criteria that this LWMS and future UWMPs must achieve. The objectives and design criteria are both general water management philosophies that reflect state-wide principles and site specific characteristics (taking into account the local environment). The water management strategy covers all aspects of water use, including stormwater, groundwater and water consumption.

4.1 Total Water Cycle Management

Total water cycle management recognises the finite limit to a region's water resources, and the inter-relationships between the uses of water and its role in the natural environment. The State Water Strategy (Government of WA, 2003) endorses the promotion of total water cycle management and application of WSUD principles to provide improvements in the management of stormwater, and to increase the efficient use of other existing water supplies. Total water cycle management addresses not only physical and environmental aspects of water resource use and planning, but also integrates other social and economic concerns. Stormwater management design objectives should therefore seek to deliver better outcomes in terms of:

- Potable water consumption.
- Stormwater quality management.
- Shallow groundwater management.
- Flood mitigation.

A fundamental first step in applying total water cycle management in urban catchments is to establish agreed environmental values for receiving waters and their ecosystems. Guidance regarding environmental values and criteria is provided by a number of National and State policies and guidelines and site specific studies undertaken in and around the Moore River area. These are discussed in **Section 1.2**.

The overall objective for preparing total water cycle management plans for proposed residential developments is to minimise pollution and maintain an appropriate water balance. This objective is central to the Moore River LWMS.

4.2 Water Conservation

It is widely thought that the local climate is undergoing a drying trend and that as the Shire's population grows and demands for potable water sources increase, significant attention should be focused on the manner in which the resources currently available are utilised. This consideration is acknowledged and therefore use of water within the subdivision will be minimised wherever possible.

The design objectives for water conservation management at a development scale within the study area will be:

- Minimise water requirements for establishment of POS.
- Minimise water requirements for POS maintenance.
- Minimise net use of water by maximising surface aquifer recharge.

The largest proportion of water consumed in the development will be from consumption at the lot scale. Improving the water conservation at a lot scale can therefore dramatically reduce the total water consumed for the development. Developers can provide information to aid householders to implementing water conservation methods; however, ultimate responsibility for these decisions rests

with the home owners. The at-lot scale measures that will be encouraged by the proponent to conserve potable water are provided in **Section 5.2**.

The design objectives for water conservation management at a lot scale within the study area will be:

- A maximum domestic water consumption of 100kL/year per person.
- An aspirational target of 40-60kL/person/year.

The above at lot water consumption target has been set in the *State Water Plan* (Government of WA, 2007).

4.3 Stormwater Management

The overall guiding document for development of stormwater management strategies within urban areas is the *Stormwater Management Manual for Western Australia* (DOW, 2007); with the *Decision Process for Stormwater Management in WA* (DOW, 2009) providing guidance as to how urban developments can achieve compliance with the objective, principles and delivery approach outlined in the *Stormwater Management Manual for WA*.

Through the above guiding documents and environmental constraints of the site, the proposed stormwater management design criteria are:

- Retain the 1 year - 1 hour duration ARI rainfall event on site as close to source as practicable.
- The 100 year ARI event must be retained within an infiltration basin or natural depression area.
- Properties must have a finished floor level of 500mm above the 100 year ARI flood level within the adjacent basin or natural depression area (where used for infiltration).
- Lots must have a clearance of 300mm to the 100 year ARI level within road reserves.
- Ensure that the pipe networked is designed to convey the 5 year ARI rainfall event.
- Ensure that the road networked designed to convey the 100 year ARI rainfall event.
- No runoff from adjacent undeveloped catchments should flow onto lots or the road network.

Due to the steep grade of some localised parts of the development and the intention to retain the natural landform as much as possible, not all lots will be elevated above the 100 year ARI level within the road reserve and thus measures are required (such as raised driveways or retaining walls) to prevent runoff from the road entering the lot. These lots will not be able to discharge the excess runoff from the lot onto the road network; therefore lot owners must determine lot-scale strategies to retain the 100 year ARI event within the lot boundary.

Better Urban Water Management (WAPC, 2008) advocates a water quality management approach that establishes pre-development water quality standards and then sets targets for post-development scenarios that reflect the pre-development water quality parameters. The stated principle is that existing surface and groundwater quality should be maintained as a minimum, and preferably improved prior to discharge from the development area. Further detail on the water quality and quantity monitoring is provided within **Section 9**.

The water quality treatment design criteria for the development that will achieve an improvement in the existing water quality that infiltrates to groundwater include:

- Size bio-retention areas to be (at least) 2% of the connected impervious area.
- Apply appropriate structural and non-structural measures to reduce applied nutrient loads.

The following further design criteria are proposed for the vegetated retention areas:

- A maximum depth of 0.5m to facilitate incorporation into the surrounding development (however, this depth can be altered provided that it can be adequately justified).
- There must be a minimum depth of 0.5m of high infiltration sand under the vegetated retention area to encourage infiltration. Where possible this should have an appropriate Phosphorus Retention Index (PRI).
- The invert of vegetated retention area must be 0.5m above the MGL.
- Stormwater is infiltrated within 96 hours after the storm event has ended.
- Storage areas in POS and road verges will have minimum side slopes of 1:6.

4.4 Groundwater Management

As a general approach, any proposed manipulation of groundwater levels during construction should be approached in a manner that adequately considers nearby wetland water dependant ecosystems, elevated nutrient concentrations within superficial aquifers and ASS potential across the site, and should be fully rationalised within the future UWMP.

Given that urban development for residential purposes can have implications for the types and quantity of pollutants released to the local surface water and groundwater, and that the work undertaken to develop the land has the potential to mobilise nutrients introduced by former land uses, it is important that groundwater is adequately managed to minimise the risk to downstream receiving environments. The significant depth to groundwater underlying the ODP area eliminates the need for active groundwater level management at the site.

The design objectives for groundwater management within the Moore River Development are to:

- Minimise changes to the underlying groundwater levels as a result of development.
- Minimise the risk of nutrient enrichment of groundwater.
- Ensure that finished lot levels have a minimum clearance of 1.2m from the underlying Maximum Groundwater Level (MGL).
- Ensure flood storage areas have a minimum of 0.5m above the MGL.
- Protect vegetation onsite that is dependent on the underlying groundwater.
- Protect the adjacent coastal and riverine environment from nutrient enrichment.

Within the ODP area there are minimal locations with low clearance to groundwater and there is no underlying clay layer. The design criteria provided within the following sections is based on the significant depth to groundwater observed across the site. Notwithstanding the significant depth to groundwater, the design criteria must be adhered to when setting final earthworks levels.

It is not proposed that a computer modelling tool would be used to demonstrate nutrient reduction in groundwater, as the groundwater will not be intersected nor groundwater levels controlled in any portion of the development.

5 Water Source Allocation, Infrastructure and Fit for Purpose

5.1 Water Supply

The development site is located in an area that currently is not connected to the Perth Scheme water network. The neighbouring towns of Guilderton and Woodridge receive the majority of their water from treated groundwater, supplied by the Water Corporation (WC). Ultimately, the Moore River development will also receive the majority of its water through a similar strategy with the WC. However, the WC does not currently hold enough groundwater allocation to service the entire Moore River Development. Thus, for the 5000 person Moore River Development to proceed, groundwater allocations for the remainder of the development must be secured.

Through consultation with the WC, it is a requirement that the Moore River development implements the WC "No Risk" water supply and treatment strategy. The No Risk approach requires that water is only supplied by a Scheme Water network i.e. water cannot be solely sourced from rainwater, treated recycled water or desalination; and the waste water must be treated to a class and method consistent with that approved by the WC (as the WC will ultimately be responsible for the infrastructure).

The Guilderton South Perth Superficial Aquifer, which the development site is located within, is currently 102% allocated (as of November 2009). The aquifer has an allocation limit of 11,000ML. The substantial aquifer is 84% allocated to 10 licenses, which are likely to all be for turf farms (DoW, 2009). These combined 10 licenses have a total allocation of 9,228ML; this could potential supply water to approximately 92,300 people (based on a conservative water consumption rate of 100kl/person/year).

The groundwater licenses are distributed on a 'first come, first served' basis and it is unlikely that any of the licensees will be forfeiting their licenses. Therefore, groundwater licenses to cater for both the Moore River Development and the future growth of Guilderton will need to be secured through purchase and/or water trading[1] or by a fresh public water drinking supply allocation. These allocations would only be required for the ultimate development size and therefore they will be obtained if and when required. Investigations are currently ongoing via the Western Australian Planning Commission's Infrastructure Coordinating Committee.

To determine the amount of water required for the development (that will need to be sourced from groundwater), a water balance was created. The description and results of the water balance are presented within **Sections 5.2**, **5.3** and **5.4**.

5.2 Water Conservation Strategy

Water is a valuable resource that must be managed sustainably. Conservation of water through fit-for-purpose use and best management practices is encouraged so that water is not wasted. The term fit-for-purpose describes the use of water that is of a quality suitable for the required use of the water[2]. Fit-for-purpose principles have been utilised in the water conservation strategy for the Moore River ODP Site.

[1] The development could trade the treated waste water to the groundwater license holder in exchange for groundwater. This would satisfy the WC requirement that the development is supplied with groundwater.
[2] For example the quality of the water used in a toilet does not require the same quality as the water required for a kitchen tap, as the kitchen tap water may be consumed. The water quality standards for potable drinking water are stricter than that for non-potable water.

A water balance study was conducted to determine the development water uses for two residential water use options:

- Option 1 – Business as Usual (BAU)
- Option 2 – Water Efficient Appliances (WEA), Water Efficient Gardens (WEG) and Rainwater Tanks (RWT) and Recycled Treated Wastewater (RWW)

The results of the water balance analysis are presented in **Section 5.4**.

The State Water Plan has set a target for domestic water use of 100kL/year per person with an aspiration target of no more than 40 to 60kL/person/year from scheme water. This is adopted as the water conservation design criterion for the Moore River ODP Site.

5.3 Water Conservation Measures

5.3.1 Rainwater Tanks

Collection of rainwater from roof surfaces can be undertaken, with this water stored within rainwater tanks for later use. This water is of high quality; however, in urban environments it is advised that this water is considered non-potable. In Perth, 90% of the rainfall occurs in the seven month period from April to October. The remainder of the year has little rainfall but collection is still possible. Thus, collected rainwater is not available for irrigation in summer but is available to supplement irrigation requirements in spring and autumn (irrigation not required in winter). The Moore River Development water efficiency strategy proposes that rainwater is mainly used to supplement internal building non-potable uses, e.g. used in washing machines, toilets and hot water systems.

Due to the potable water requirements of the lots and the available space for rainwater tanks, the optimal rainwater tank size proposed is 3000 litres per lot. A storage of this size can significantly reduce the total water consumption of the lot. Therefore, rainwater tanks will be mandated in the development. The use of rainwater tanks can be mandated by the local council through the building licence. Information can be provided to the lot purchaser by the developer at point-of-sale.

5.3.2 Water Efficient Appliances

Significant reduction in in-house water uses can be achieved with the use of water efficient appliances (WEA). The following **Table 4** gives an example of the water uses of typical appliances verses WEA. These water use rates in **Table 4** have been used in the water balance investigation.

Table 4 Water Efficient Appliances

Appliance	Water use	
	Standard Device	Water Saving Device
Toilet	12 Litres/Flush	4 Litres/Flush
Washing Machine	130 Litres/Wash	40 Litres/Wash
Shower Head	15-25 Litres/Minute	6-7 Litres/Minute
Taps	15-18 Litres/Minute	5-6 Litres/Minute

(Australian Government, 2009 & Melbourne Water, 2009)

The water conservation strategy proposes that all dwellings use water efficient appliances. This can be encouraged by state and local government rebates, as well as education and additional incentives from the developers.

5.3.3 Water Efficient Gardens

Studies by the Water Corporation (WC, 2003) have found that for a typical dwelling, 56% of the water consumed by the lot is used on the gardens. Therefore, reductions in water irrigation by employing Water Efficiency Garden (WEG) measures can significantly reduce the total water usage of the lot. The following water efficiency measures should be used on lot gardens:

- Where required, soil shall be improved with soil conditioner certified to Australian Standard AS4454 to a minimum depth of 150mm where turf is to be planted and a minimum depth of 300mm for garden beds.
- Garden beds to be mulched to 75mm with a product certified to Australian Standard AS4454.
- Installing adequate irrigation control systems to ensure that water can be applied selectively.
- The irrigation system shall be designed and installed according to best water efficient practices. The controller must be able to irrigate different zones with different irrigation rates. Emitters must disperse coarse droplets or be subterranean.
- Utilise sub-surface irrigation where appropriate.
- Limiting the amount of turfed areas.
- The turf species used should be a genotype endorsed by the UWA Turf Industries Research Steering Committee (e.g. Couch grass – *Cynodon dactylon*).

Water conservation can also be reduced on a development scale within POS areas. As well as using the lot scale garden measures on POS gardens, the following additions measures should be utilised:

- Encouraging at-source surface aquifer recharge where possible. This can be achieved via soakwells, vegetated retention basins and swales.
- Retention of remnant native vegetation within POS areas where possible. This will provide shade and reduce the water demands of POS areas.
- Minimal proportion of the POS areas will be turfed. Instead the POS will be largely vegetated with local native species to enhance the environmental values of the POS areas.
- Entry statements should include a 1:1 mix of hardstand areas to turfed areas and garden beds;
- Turf species will be low water and nutrient requiring.
- The adoption of Xeriscaped POS gardens, where garden beds within POS and community areas are landscaped using ‘waterwise plants’, which are local native species from regions with similar climates that require less water inputs than exotic species.
- Managing irrigation practises within POS areas to minimise losses to evaporation (e.g. amount applied is not excessive, timing irrigation to avoid wastage, etc.).
- Provision of some smaller lot sizes that will require less landscaping and thus lower water demand.

It is proposed that POS areas will be irrigated with treated recycled waste water. This will reduce the total required water for the development, which would otherwise need to be provided by groundwater. Through this strategy, the amount of groundwater allocation that needs to be secured is reduced.

5.3.4 Waste Water Reuse

Waste water can be recycled and used as potable or non-potable water (depending on the quality of the treatment). It is proposed that waste water from the development will treated, via a method approved by the Water Corporation, and used to irrigate the POS areas and School Ovals. A 15,000kl tank is required to ensure there is sufficient storage of water to irrigate throughout summer. During winter, the excess treated waste water will be directed to the underlying aquifer (via methods such as infiltration or pumping).

5.4 Water Balance

The water balance analysis has been based on the rates and calculation methodology presented in the Water Corporation Spreadsheet *AltWaterSupply_Water_Use_Model.xls*. This spreadsheet has been adapted to model the effects of using water efficient appliances and gardens. The water balance analysis has assumed that there would be on average 2.5 people per dwelling. The water balance has also been calculated for the various lots densities and contemporary dwelling sizes. These contemporary lots typically have smaller garden areas when compared to traditional lots and therefore the lot water consumption rates (due to garden watering) are lower than those reported for traditions lots (WC, 2003).

The lot scale water consumption for the two water conservation strategies are presented in **Table 5**.

Table 5 Lot Water Consumption

	Option 1 BAU	Option 2 WEA, WEG, RWT1, RWW
Total Scheme Water Required (ML/year)	654	269
Scheme Water Required per Capita (kL/year/person)	131	54

The results of the water balance indicate that on average in the development, a dwelling not using any water conservation strategies will exceed the 100kl/year/person water consumption target.

The comparison of the consumption rates used by the Moore River Development, using the proposed water conservation strategy, shows that the development will achieve the aspirational water consumption target of between 40 to 60kL/year/person of Scheme Water and achieve the State Water Plan target of 100kl/y per person. Further details on the calculations and assumptions are provided within **Appendix B**.

The development has 12.6ha of POS. It is conservatively assumed at the DWMS/LWMS stage that 100% of this area will be turfed; therefore this area would require approximately 94ML/year of water for irrigation (assuming irrigation rate of 7,500kl/ha). The water required for irrigation of POS areas should (where possible) use non-potable water, leaving higher quality water for internal dwelling uses. The Moore River Development will treat and recycled the waste water to be used for irrigation of the POS. Therefore, irrigation of POS will use non-potable water.

The development will have a primary school situated on a 4.7ha lot. This will approximately require a total of 22.1ML/year; of which, 17.8ML/year will be required for irrigation. It is proposed (Option 2) that the irrigation requirements of the school will also be achieved through treated recycled waste water.

There is approximately 6.3ha of commercial area within the development. This will require approximately 70ML of potable water. There is the potential for commercial lots to reduce their water consumption through water efficient practices and fit-for-purpose use; however, no measures have been included in these conservative water consumption calculations for the commercial lots as the types of commercial activities is currently not known.

The total scheme water required and waste water produced in the development is presented in **Table 6**.

Table 6 Development Scheme Water Required and Waste Water Produced

	Option 1 BAU	Option 2 WEA, WEG, RWT1, RWW
Total Development Scheme Water Required (ML/year)	840	344
Total Development Waste Water Produced (ML/year)	347	191

The total waste water produced for the proposed water conservation strategy (Option 2) is 191ML/year. The total irrigation requirements for the School and the POS area is 112ML/year. There is enough treated recycled for irrigation; however, the irrigation rate requirements throughout the year are not consistent with the temporal availability of recycled waste water. During winter, the POS area requires little to no irrigation and during summer the POS areas requires irrigation every second day. In order for there to be water for irrigation throughout summer, water must be stored in other periods of the year. The water balance has calculated that a 15,000kl storage volume is required to supply uninterrupted water for irrigation of the POS areas and the primary school oval.

During winter, the 15,000kl storage will be exceeded. This excess water will be disposed of via discharge to the underlying aquifer. This can be achieved via infiltration through the highly permeable sandy soils within a dedicated infiltration area. The water balance has calculated that a total of 79ML/year will be returned to the aquifer.

A water balance schematic of the proposed water conservation strategy and BAU Option is presented within **Appendix B**; this provides a visual presentation of where water will be used and saved within the development.

6 Groundwater Management Strategy

6.1 Groundwater Level Management

As shown in **Figure 7**, the clearance to the MGL is significantly greater than 1.2m across the entire site and the residential lots have a clearance of 10-40m to the underlying MGL. Therefore groundwater levels will not influence the design of the development layout. However, the Holiday Resort (Catchment A) is within an area with relatively low clearance to groundwater. The areas with low clearance also correspond with the depression areas that would be used for storage of runoff from extreme rainfall events. It is therefore recommended that these low lying areas are not used for construction of buildings unless a detailed water management plan is developed specifically for the lot which demonstrates that adequate clearance to the MGL can be maintained.

Should sand fill be required for anywhere in the site (after the final earthworks have been created), this could readily be sourced from within the ODP area. The soil mapping and bore logs indicate that the soil is sand and thus potentially suitable for sand fill. The preliminary earthworks strategy, indicating likely cut and fill areas within the site is shown in **Appendix D**. The preliminary earthworks strategy has been based on the following principles:

- Maintaining pre-development catchment boundaries as far as possible.
- Provision of infiltration basins in the lowest point of each catchment.
- Grading of roads to direct stormwater flows to the lowest point in each catchment.
- Maintain the existing undulation of the site with minor amounts of cut to fill to ensure road grades do not exceed a 10% grade.

It is expected that the final earthworks levels for the site will be finalised during the detailed design stage and these should be presented with detailed drainage designs at UWMP stage.

It is not proposed that subsoil drainage will be required for the Moore River ODP as the soils are course sands and will have high infiltration, and there is adequate clearance to groundwater. Stormwater will be encouraged to infiltrate at source as high up in the catchment as practicably possible to be consistent with the existing environmental regime.

6.2 Groundwater Quality Management

The main objective of the management of the groundwater quality is to maintain or improve the existing groundwater quality. This can be achieved by either reducing the total nutrient load into the groundwater that originates from the development or by improving the groundwater via treatment of the surface runoff prior to infiltrating to the groundwater.

The reduction of nutrient load to the groundwater should be achieved in the development by:

- Minimising the use of fertilisers to establish and maintain vegetation within POS areas and road verges.
- Selection of drought tolerant turf species that require minimal water and nutrients;
- Use of roll-on turf within the POS areas and road verges, to prevent the high nutrient input requirement during establishment of the turf.
- Direct stormwater to vegetated (with native wetland species) treatment areas including swales, bio-pockets and vegetation retention areas. These treatment areas will improve the quality of the water prior to it infiltrating into the underlying groundwater.
- Garden beds should not be located immediately adjacent to the infiltration or vegetated retention areas to reduce nutrient transportation into these areas.

7 Stormwater Management Strategy

Surface water runoff will be managed both on a development scale and at a lot scale. The principles behind the stormwater management strategy are to maintain the existing hydrology by retaining or detaining surface flows, prevent flooding of lots and to infiltrate the stormwater runoff as close to source as possible. The development drainage system has been designed to achieve the objectives and criteria stated in **Section 4**.

7.1 Development Drainage System

The preliminary Earthworks Strategy (**Appendix D**) indicates that there are 11 post-development catchments. Of these catchments, four discharge the surface runoff to a trapped low point within the development area (and to infiltration basins located within POS areas); whereas the remaining catchments discharge to natural depressions immediately adjacent to the development boundary. The natural depressions will also facilitate infiltration, which will assist in maintaining the existing hydrology. These natural depressions are henceforth referred to as an 'infiltration depression'. These infiltration depressions will not be modified and the existing vegetation will be maintained (and potentially rehabilitated if required). Due to the sometimes steep topography and inundation depths greater than 1.2m, the use of infiltration depressions may require these areas to be fenced for safety reasons or the landform re-engineered to conform with appropriate safety standards.

The infiltration depressions will receive runoff from the development area and from existing undeveloped catchments located outside the development area. Where upstream catchments would otherwise sheet flow into the development during major or intense rainfall events, these flows will be diverted to the nearest downstream infiltration depression. In some locations (Catchments A, B, C, D, E, G and I) the infiltration depressions are immediately adjacent to the road network or lots. It will be necessary to determine the flood elevation within these depressions to ensure there is adequate clearance to prevent flooding of lots within the development.

Stormwater runoff from the 1 year - 1 hour ARI rainfall event will be retained as close to source as practicably possible; only rainfall events greater than this event will be conveyed beyond source. The retention storage for the 1 year – 1 hour ARI rainfall event will be provided through a multiple of strategies including bio-pockets, swales and vegetated retention areas (see **Section 7.1.1** for further description). The vegetation and the infiltration process within the soil column will remove a large portion of the contaminants (nutrients, gross pollutants, suspended sediments, etc) within the stormwater runoff. Rainfall events greater than the 1 year - 1 hour ARI event will be conveyed by overland flow or pipe network to a catchment scale infiltration basin/depression. The infiltration basin/depression will retain the large event runoff entirely and there will be no discharge from the site, which is consistent with the pre-development scenario. The size of major event retention storages will be minimised due to the retention storage provided higher up in the catchment from both road reserves and lots. The stormwater drainage system for the development (including swales, bio-pockets and infiltration basins/depressions) is shown conceptually in **Figure 9**.

7.1.1 Vegetated Retention Areas

As indicated the 1 year - 1 hour ARI rainfall event will be retained at source, or as close to source as possible. This will primarily be achieved by using vegetated retention areas to capture runoff from roads and driveways; these may have the form of a bio-pockets (within road reserves), swales (within road reserves) or undefined vegetated retention area (located within POS or undeveloped areas). In some catchments, the use of either swales, bio-pockets or other retention area has not been specified in the XPSWMM modelling. For these areas the important concept is that the 1 year - 1 hour event

for the contributing catchment is retained. It is acceptable for these areas specified as having swales or bio-pockets, to be modified to final form at Urban Water Management Plan stage. This is to allow flexibility with the detailed design of the contributing catchment stormwater management system. The sizes of the vegetated retention areas are summarised in **Table 7** and locations presented in **Figure 9**.

7.1.1.1 Swales

Swales can provide both conveyance of stormwater and retention/detention storage. It is proposed to utilise central median swales and swales alongside the road adjacent to POS areas. Stormwater will be directed into the swales via flush kerbing or via the pipe network. The swales will be approximately 0.3m deep and 3-5m wide (to be finalised at UWMP stage). The swale will provide a large surface area for the stormwater to infiltrate into the underlying sand soil (high infiltration rate will be achieved due to the large separation distance to groundwater and the highly permeable sand soils). This swale will assist in achieving retention of the 1 year - 1 hour ARI rainfall as close to source as practicable. For larger rainfall events, the swale will discharge into the downstream infiltration basin/depression for that catchment.

The central median swales located in Catchments J and K, will be within the central verge area separating the two traffic lanes. These swales will be positioned on roads that are on a slope; thus in order to provide storage, mortared rock pitched riffles (or similar) will need to be used to hold back the stormwater and provide the retention storage. At intersections, flows will be collected in side entry pits or gully pits, piped and bubbled out on the opposite downstream side (or directly into an infiltration basin/depression) to ensure intersections are free from overland flows up to the 5 year ARI event.

For Catchment K, swales will be used along side of the road to prevent surface runoff from the existing undeveloped adjacent catchment flowing into the development road network. These swales will direct the runoff to an infiltration depression (see **Figure 12**).

The combined vegetated surface area of the swales and bio-pockets will need to be consistent with at least 2% of the connected impervious area to achieve the design criteria proposed in **Section 4**. Where the combined surface area provided by swales and bio-pockets exceeds 2% for each sub-catchment these areas need not be vegetated, and may be developed as either turfed or paved infiltration swales

7.1.1.2 Bio-pockets

Stormwater can be retained in vegetated 'bio-pockets' within the road verges. The location of a bio-pocket is optimally suited to the side of corner lots (i.e. lots with dual frontage) so that they do not interfere with driveways, services and lot landscaping. Bio-pockets are proposed on the corner lots within Catchments D, F, G and K. As indicated in **Section 7.1.1.1**, where the surface area of the bio-pockets, swales and vegetated retention area combined exceeds 2% of the connected impervious area, the bio-pocket/swale/vegetated area can be either turfed or treated with alternative measures such as permeable paving.

7.1.2 Infiltration Areas- Basins & Depressions

Infiltration areas are the created basins (within POS) and natural vegetated depressions (adjacent to the development area) that will be utilised to retain major event flows that exceed the capacity of the bio-pockets, swales and other vegetated retention areas (i.e. flows exceeding the 1 year - 1 hour ARI rainfall event). Minor event storage will be kept separate from the infiltration area. Unlike a wetland, the infiltration basins/depressions are not designed to be permanently wet. Instead, the stormwater will infiltrate into the soil. Infiltration basins will be located entirely within the Moore River

development boundary, while the infiltration depressions are located immediately adjacent to the proposed development boundary (however, still within the ODP boundary). These infiltration depressions are generally not proposed to be shaped or landscaped; rather, they will retain the existing topography and native vegetation. The exception to this is where the native vegetation or landform has low value, and where safety considerations dictate a shallow storage area. These are proposed for runoff from Catchments A, B, C, E, H, I and J. Due to the previous rural uses of the site, it is possible that some of the infiltration depressions may be devoid of vegetation. In these instances the infiltration depression will be appropriately shaped and landscaped.

Those Catchments (D, F, G and K) within the development which do not discharge to infiltration depressions, will discharge to an infiltration basin located within the relevant POS area and these will be landscaped appropriately. The infiltration basins should be located at the low point of the POS area, nominally have a maximum depth of 1.5m and maximum side slopes of 1:6.

All finished lot floor levels must be 500mm above the adjacent 100 year flood level in the infiltration basin/depression. This design criterion reduces the risk of unexpected flooding causing damage to properties. The road surface will be utilised to convey the 100 year ARI event surface runoff; therefore it is also required to provide a 300mm clearance above the 100 year ARI level within the road surface network to the lot, to prevent flooding of the lot.

The infiltration depressions will receive runoff from the development and from the external undeveloped portions of the catchment. These infiltration depressions would in the existing environment fill to a significant depth and it may be possible that these infiltration depressions also fill to a significant depth in the post-development environment. **Figure 12** indicates the location and depth of water during the 100 year ARI event in all infiltration areas. For the infiltration depressions with significant depth, and if the infiltration depression does not contain significant flora, it could be earth worked to provide the flood storage at a more acceptable depth and slope. Alternatively, fencing may be required to protect the public from entering the deep water body. These depth requirements and infiltration depression detail drawing designs should be determined and presented at UWMP stage.

7.2 Lot Drainage System

Rainfall on the front and backyards of lots (garden areas) will either infiltrate directly at-source or, in large rainfall events, a portion of the runoff may discharge to the road network. The runoff from roof areas will be directed to 3000L rainwater tanks with excess runoff to soakwells, which will infiltrate into the sandy soil and ultimately the groundwater. The assumption regarding soakwells is that every residence would provide 2650L of storage within soakwells. For commercial lots the assumption has been that for every 250m^2 of roof surface there will be 2650L of storage.

For the purposes of stormwater detention modelling, it has been assumed that each lot will have a 3000L rainwater tank, and that these would provide 1500L of storage during a storm event. The water balance analysis (**Section 5.4**) has determined that the rainwater tanks are on average 50% empty due to water consumption of the lots; therefore, the rainwater tanks can provide some measure of retention storage for the rainfall event.

For rainfall events where the runoff from roof areas cannot be retained within the rainwater tanks and soakwell, the excess runoff will overflow onto the lot (e.g. garden). During extreme rainfall events, this excess runoff will flow off the lot and onto the road drainage network. However, in some locations the lots are elevated below the road surface. This is due to the approach of retaining the natural landform as far as possible, which results in some parallel roads having a significant elevation difference. For some of these lots, runoff will not discharge to the road drainage network where it is

uphill. Where this occurs additional storage may need to be provided within the lot boundaries by the lot owner to ensure that the downhill lot does not become inundated from lot runoff. In addition, the road network will need to be designed in a manner which ensures that runoff from the road pavement does not enter the lot and cause additional flooding.

7.3 Post-development Surface Runoff Modelling

The total volume of runoff from a site is determined by the amount of rainfall less the losses (due largely to infiltration). The rate of runoff is determined by the slope and roughness (Manning's n) of the surface. An "initial loss – continuing loss" infiltration modelling method was adopted for the sub-catchments, with loss values chosen based on Cardno's experience (see **Appendix A** for further details on modelling parameters and assumptions).

The hydraulic and hydrologic XPSWMM modelling software was used to calculate the volume of runoff for the 1 year – 1 hour, 5 year and 100 year ARI critical duration events. As described in **Section 7.1** and **7.2**, the Moore River development will utilise vegetated retention areas, infiltration areas, soakwells and rainwater tank storage within the surface water management strategy to achieve the design criteria in **Section 4.3**. This section of the report presents the results from the modelling which proves that the stormwater management strategy can achieve the design criteria.

The results of the 1 year – 1 hour ARI rainfall event modelling is presented with **Table 7**.

Table 7 1 year – 1 hour ARI Rainfall Event Modelling Results

Sub-catchment	Total Runoff Volume (m^3)	Storage Volume Provided (m^3)			Storage Area Provided (m^2)		
		Swale	Bio-pockets	Vegetated Retention Area	Swale	Bio-pockets	Vegetated Retention Area
A.a	185	-	-	150	-	-	405
A.b	70	-	-	50	-	-	170
A.c	45	-	-	35	-	-	120
A.d	55	-	-	35	-	-	130
B	360	-	-	265	-	-	675
C.a	235	-	-	180	-	-	475
D.a	1080	-	220	600	-	730	1415
E.a	305	-	-	265	-	-	675
E.b	215	-	-	180	-	-	475
F	1265	-	290	575	-	975	1355
G.a	1045	-	235	1140	-	775	2575
H	705	-	-	600	-	-	1415
I	1105	-	-	870	-	-	2000
J.a	775	-	-	600	-	-	1415
J.b	115	125	-	-	540	-	-
K.a	2345	-	175	870	-	575	2000
K.b	325	315	-	-	1040	-	-
K.d	2085	400	-	1405	1340	-	3135

L	195	-	-	135	-	-	370
Total	12510	840	920	7955	2920	3055	18805

Through the at-source retention storage provided by the swales and bio-pockets, the development has 8.4% of treatment area to the connected impervious area. This exceeds the 2% connected impervious area design criteria. Therefore, the Moore River LWMS will exceed the water quality design criteria if all of the swales and bio-pockets were to be planted with nutrient removal vegetation. It is considered acceptable if the criterion is exceeded, or as an alternative the bio-pocket/swale areas that exceed the 2% criteria could be developed as infiltration areas. These could receive a variety of treatments, such as turf or permeable pavement. The type of treatment utilised is not critical to water quality control, provided the 1 year - 1 hour ARI rainfall event is retained at source or as close to source as possible.

The XPSWMM model was used to calculate the surface runoff for the 5 year and 100 year ARI rainfall events. The inundated area within the Moore River development for the various rainfall events are shown in **Figure 10** (1 year – 1 hour inundation), **Figure 11** (5 year inundation) and **Figure 12** (100 year inundation).

The primary criterion that the Moore River stormwater management strategy must achieve is to retain and infiltrate the 100 year ARI event. This is to be achieved through the use of vegetated retention areas, soakwells, rainwater tanks and ultimately within infiltration areas. The runoff modelling results for the extreme rainfall events is presented in **Table 8** and the infiltration areas characteristics required to achieve the criterion are presented in **Table 9**.

Table 8 Extreme Rainfall Event Modelling Results

Sub-catchment	Total Runoff Volume (m^3)		Peak Stored Volume (m^3)		Peak Flood Area (m^2)		Peak Flood Depth (m)	
	5y ARI	100y ARI	5y ARI	100y ARI	5y ARI	100y ARI	5y ARI	100y ARI
A.a	365	915	105	815	2460	5825	0.06	0.16
A.b	150	330						
A.c	20	85						
A.d	0	210						
A.e	105	420	45	245	170	685	0.47	1.02
A.f	70	265	45	185	130	365	0.42	0.91
A.g	45	175	25	110	80	165	0.46	1.15
A.h	555	2180	265	1420	735	1610	0.44	1.46
B	1975	7500	755	4990	1810	4340	0.45	1.82
C.a	485	1190	195	665	2005	2475	0.11	0.31
C.b	1290	5050	605	3465	1690	3420	0.43	1.36
C.c	30	115	15	65	75	145	0.21	0.51
D.a	2350	7770	1240	5060	4630	5825	0.27	0.96
D.b	200	770	80	405	435	930	0.22	0.64
E.a	615	2360	385	1625	1215	1900	0.41	1.21
E.b	475	1850	380	1530	270	795	1.27	3.15
F	2820	9160	1400	6005	5445	5895	0.26	0.97
G.a	1890	10475	530	6580	7045	8595	0.07	0.80
G.b	1920	7775	870	4755	1200	4870	1.06	2.33
H	1410	6050	1005	4410	1595	3270	1.10	2.38
I	2555	9000	865	8150	1265	1410	2.07	2.27
J.a, Jb	1660	5865	910	3390	3400	4645	0.33	0.80
K.a, Kb	3980	16855	1300	9740	8820	10740	0.14	0.95
K.c	0	465	0	215	0	1180	0	0.22
K.d	4710	13490	3480	17770	7100	14255	0.55	1.80
K.e	3490	14215						
L	910	5225	365	4285	880	3100	0.61	2.06
Total	34075	129760	14865	85880	52455	86440	na	na

Table 9 Infiltration Basin Characteristics

Sub-catchment	Basin Invert (mAHD)	Clearance to MGL (m)	Basin Bottom Area (m^2)	Basin Top Area (m^2)
A.a	3.0	2.7	2555	5825
A.b				
A.c				
A.d				
A.e	7.0	6.7	90	685
A.f	4.0	3.7	80	365
A.g	6.0	5.7	40	165
A.h	8.0	7.7	445	1610
B	16.0	15.7	1435	4340
C.a	2.0	1.7	1670	2475
C.b	3.0	2.7	880	3420
C.c	10.0	9.7	60	145
D.a	8.2	7.9	4200	5825
D.b	24.0	23.7	225	930
E.a	10.0	9.7	790	1900
E.b	9.0	8.7	200	795
F	14.1	13.8	5000	6775
G.a	14.1	13.8	6900	8595
G.b	26.0	25.7	480	4870
H	7.0	6.7	360	3270
I	11.0	10.7	50	1410
J.a	25.0	24.7	1785	4645
K.a	25.9	25.6	8500	10740
K.c	32.0	31.7	760	1180
K.d	34.0	33.7	4870	14255
K.e				
L	12.0	11.7	275	3100
Total	na	na	41650	87320

The peak water depth within the infiltration areas is presented in **Table 8**. This elevation has also been presented within **Figure 12**. The road elevations in Appendix D can be compared with **Figure 12** to demonstrate that there is the required clearance from the road level to the 100 year ARI flood level within the infiltration areas. The inundation and road levels may be modified during detail design at UWMP stage.

The natural topography immediately adjacent to the eastern portion of sub-catchments K.c and K.d are elevated above the road elevation; therefore, runoff from this natural topography could flow into the road drainage network. To prevent this, a roadside swale/drain is required to collect the runoff and direct it south to the natural depression area as presented in **Figure 12**. This is required to

achieve the design criteria presented in **Section 4**. It should be noted that such measures will be subject to review once the final earthworks strategy has been undertaken, and the results of such review should be detailed within the relevant UWMP.

Detailed modelling of the pipe drainage network or water levels on the road surface has not been completed as part of this LWMS. This modelling is properly carried out when until detailed designs are prepared, and it is anticipated that this would be included with future UWMP documents.

7.4 Surface Water Quality Management

The purpose of this section is to describe the management methods that are proposed to manage the surface water quality. The principle methodology is to retain minor events within treatment areas prior to infiltrating into the groundwater.

7.4.1 Development Drainage System

To achieve water quality design criteria, all of the runoff from the 1 year -1 hour ARI rainfall event will be retained onsite within either roadside/median swales, bio-pockets or alternative format vegetation area. The vegetation and soils will provide nutrient uptake and reduce the nutrient load to the underlying aquifer. Where possible, the soils beneath these retention areas should have a high infiltration rate and high a PRI. As indicated, where the 1year 1 hour storage areas exceed the 2% requirement for each catchment, it is acceptable that the vegetated surface area is reduced to achieve the 2%, with the remaining 1 year 1 hour storage provided as infiltration storage.

The vegetated retention areas should be vegetated with native vegetation species selected for their ability to uptake nutrients. Where possible, retention of existing native vegetation is recommended unless the landform is to be re-worked for public safety reasons. It is envisaged that given the high infiltration rates of the post-development underlying soils, the vegetated retention areas will remain dry for the majority of the year. Therefore, the species used within these areas and within the surrounding POS areas should be selected to be able to tolerate extended dry periods or seasonally fluctuating groundwater levels, such as species typically found in 'dampland' areas. An example of possible suitable species is provided within **Table 10**.

Table 10 Potential Vegetation Species List

Species	Common Name
Baumea articulate	Jointed Twig Rush
Baumea juncea	Bare Twig Rush
Baumea vaginalis	Sheath Twig Rush
Bolboschoenus caldwellii	Marsh Club Rush
Gahnia trifida	Coast Saw Sedge
Juncus kraussii	Sea Rush
Juncus subsecundus	Finger Rush
Juncus pallidus	Pale Rush
Casuarina obese	Swamp Sheoak
Melaleuca rhaphiophylla	Swamp Paperbark
Ficinia nodosa	Knotted Club Rush

While the recommended species are provided in **Table 10**, it is considered acceptable that these could be varied at the subdivision stage, provided that they fulfil the criteria of being native, provenance correct and appropriate for the intended uses (i.e. nutrient uptake and visual amenity). A detailed list of vegetation species should be provided within a landscaping document and presented at UWMP Stage.

For the natural depression areas, it is not proposed that the vegetation and topography will be altered unless some minor revegetation is required.

It is recommended that Silt Traps (STs) be utilised to remove fine pollutants prior to runoff discharging into vegetated retention areas (i.e. bio-pockets and swales) or infiltration depressions. Although there will be maintenance requirements for the STs and vegetated retention areas, the maintenance is concentrated at defined locations. Gross Pollutant Traps (GPTs) will remove large pollutants prior to runoff discharging to infiltration basins within the four internal POS area. It is recommended that GPTs also be used in catchments with high density resort accommodation and commercial properties. These areas are likely to receive higher load of gross pollutants and thus GPTs would reduce the maintenance requirements for the vegetated retention areas.

Additional non-structural measures to reduce nutrient loads are provided in the groundwater quality management **Section 6.2**.

7.4.2 Lot Drainage System

The principle surface water quality management methodology, at a lot scale, is to encourage onsite infiltration which will facilitate natural nutrient stripping processes that occur within the soil profile. This minimises nutrients being transported through the catchment via surface runoff and into downstream infiltration basins. The developers will encourage the use of low nutrient and water requiring plants (i.e. native species), nutrient absorbing soils and design of landscaping to ensure that the nutrient inputs from the gardens are minimised. Further details regarding lot-scale nutrient reduction and water quality treatment should be provided at UWMP Stage.

8 Subdivision and Urban Water Management Plans

The requirement to undertake preparation of more detailed water management plans to support subdivision is generally imposed as a condition of subdivision. The development of the UWMP should follow the guidance provided in *Urban Water Management Plans: Guidelines for Preparing Plans and for Complying with Subdivision Conditions* (DoW, 2008b).

While strategies have been provided within this LWMS that address planning for water management within the study area, it is a logical progression that future subdivision designs and supportive UWMP will clarify details not provided within the LWMS. The main areas that will require further clarification within future UWMPs include:

- Water allocation and supply servicing.
- Modelling of local road drainage network.
- Earthworks strategy and lot scale storage.
- ASS investigations.
- Infiltration area configurations and outlet structures.
- Geotechnical investigation.
- Groundwater abstraction capacity modelling.
- Details of wastewater treatment facility.
- Implementation of water conservation strategies.
- Non-structural water quality improvement measures.
- Sensitive Flora and Fauna conservation measures.
- Construction period management strategy.
- Management and maintenance requirements.
- Monitoring and evaluation program.

These are further detailed in the following sections. As stated above, ongoing monitoring of groundwater will be detailed in the UWMP. However, an overview is provided in **Section 9** of this LWMS.

8.1 Water Allocation and Supply

While it is proposed that the first three stages of the Moore River South development could be serviced by Water Corporation scheme water supplies (in turn sourced from groundwater allocation), at this stage the remaining required allocation is yet to be secured/traded with private holders of groundwater allocations within the same groundwater management area. It is expected that these would be resolved and reported on in future UWMP documents, which will confirm that adequate water is available to supply the development with both potable and non-potable needs.

8.2 Modelling of Local Road Drainage Network

It is acknowledged that the drainage strategies documented in this LWMS are based upon broad-scale assumptions and regional data. These assumptions are considered adequate for development of the proposed basin sizes and of an appropriate level of detail; however verification of proposed subdivision drainage designs within the LSP area should be undertaken by modelling the piped drainage network. Such modelling will allow verification that the development undertaken within the LSP area is consistent with this LWMS. The design of the drainage system to date has been undertaken at an appropriate level for local structure planning and runoff-routing computer modelling of the stormwater drainage system should be reviewed once detailed drainage design has

commenced for the area. It is anticipated that this will occur during the subdivision stage and detailed within the future UWMPs.

8.3 Earthworks Strategy

Due to the proposed earthwork levels (which retain as much of the existing site undulation as possible) some parallel roads have (in places) up to 10 metres variation in elevation. Therefore, some lots will have significant grade (10-13%). For these locations, some measure of retaining walls and possible lot grades are likely. Where the localised topography is such that the runoff from the driveways cannot discharge to the development scale stormwater network these lots will require additional onsite storage (e.g. within soakwells, rainwater tanks bio-pockets etc). This should be clarified once the final earthworks strategy has been completed and at the time of detailed design. It is expected that any variation to lot scale storage would be further detailed in the future UWMP documents.

8.4 Acid Sulfate Soil Investigations

At this stage it is not expected that the development would intersect groundwater, even with the deepest of servicing trenches. On this basis ASS is not considered to be of concern or require identification or any specific management approach. However, once the final earthworks strategy has been completed an assessment should be undertaken as to whether an ASS investigation is warranted. Should this be the case, it is expected that this would be reported on in an UWMP document.

8.5 Flood Storage Area Configurations and Outlet Structures

While the LSP area drainage catchments have been defined based on the existing topography and the current LSP, it is possible that these could undergo some change to accommodate stakeholder feedback prior to final subdivision design. The exact location and shape of the infiltration basins will still need to be specified and presented within the future UWMPs.

In order to review the final infiltration basin configurations and depth of water within the infiltration depressions, the hydrological model that has been developed to support this LWMS may need to be refined in light of stakeholder feedback. It is expected that the infiltration basins will be designed to a level that provides detailed cross-sections, sizes of storage areas, pipe sizes, inverts, etc. The ultimate aim of revising the hydrological model will be to minimise the sizes of the infiltration basins within POS areas, and ensuring that they will fully retain the 100 year event from the contributing catchment.

8.6 Geotechnical Investigation

A geotechnical investigation will need to be conducted to confirm the regional geological mapping discussed in this LWMS. A number of test pits will be required to be installed at depths just below the ground surface to determine the soil characteristics and how this could impact on the proposed development. The investigation should include infiltration tests, soil types, suitability of soils for development and if treatment is required, settlement tests, bearing ratios and the hydraulic conductivity, which governs the infiltration rates (as discussed in **Appendix A**).

8.7 Groundwater Abstraction Capacity Modelling

Due to the proximity to the coast and small head difference between the groundwater and the coast, there is a significant risk of saltwater intrusion caused from abstraction of groundwater from the

shallow superficial aquifer. It is possible that the groundwater abstraction required for the development can be spread over several bores located along the 2km length of the site boundary and prevent saltwater intrusion, or that alternatively the abstraction could occur further inland but within the same groundwater management sub-area. Dependant on the exact source (i.e. aquifer) and location of abstraction, detailed groundwater modelling may be required. If it is determined that this will be required, it is expected that the modelling would be summarised in the UWMP to demonstrate that the proposed water source is viable.

8.8 Water Treatment Facility

The development site will need to treat all waste water prior to it being recycled for irrigation or infiltration into the underlying aquifer. The treatment facility will ultimately be operated by the Water Corporation and thus the methodology, location and configuration must be approved by the Water Corporation. Detailed designs for the facility and agreement of the design by WC should be confirmed prior to completion of an UWMP document.

8.9 Implementation of Water Conservation Strategies

A number of potential measures to conserve water have been presented within this LWMS. These water conservation management strategies should be incorporated into the design and the ongoing maintenance of all POS areas. Landscape design measures that will be incorporated into the water conservation strategy should be further detailed within the future UWMPs produced for the development.

The manner in which the developer intends to promote water conservation measures discussed in this LWMS to future lot owners should be discussed within the future UWMPs.

8.10 Non-Structural Water Quality Improvement Measures

Guidance for the development and implementation of non-structural water quality improvement measures is provided within the *Stormwater Management Manual for Western Australia* (DoW 2007). Some measures will be more appropriately implemented at a local government level, such as street sweeping, however many can be implemented relatively easily within the design and maintenance of subdivisions and the POS areas. It is expected that the future UWMPs will provide reference to measures such as public education (through measures such as signage that may be implemented to raise awareness).

8.11 Management and Maintenance Requirements

The management measures to be implemented to address surface water quality, such as the use of vegetation within bio-pockets and infiltration areas will require ongoing maintenance. It is therefore expected that the future UWMPs will provide detailed management and maintenance plans that will set out maintenance actions (e.g. gross pollutant removal), timing (e.g. how often it will occur), locations (e.g. exactly where it will occur) and responsibilities (e.g. who will be responsible for carrying out the actions). Given that approval from the Shire and DoW will be sought for the proposed measures, it is anticipated that consultation with these agencies will be undertaken and referral to guiding policies and documents will be made.

8.12 Construction Period Management Strategy

It is anticipated that the construction stage may require some management of various aspects (e.g. dust, surface runoff, noise, traffic etc.). In particular, dust generation has the potential to cause significant public disturbance during construction works. Given the sandy nature of the soils underlying the study area, it is anticipated that some dust suppression will be required during the subdivision stage with the implementation of the appropriate management measures, such as:

- Not undertaking earthworks during dry, windy conditions where practicable;
- Watering down cleared areas will occur as necessary during dry dusty periods;
- Covering materials during construction to reduce dust emissions where practicable; and
- Undertaking revegetation as soon as practicably possible to ensure that soils are protected from wind erosion.

8.13 Monitoring and Evaluation Program

It will be necessary to confirm that the management measures that are implemented are able to fulfil their intended management purpose, and are in a satisfactory condition at a point of management hand-over to the Shire. A monitoring program should be developed to provide this confirmation, and it should include details of objectives of monitoring, relevant issues and information, proposed methodology, monitoring frequency and reporting obligations. These monitoring programs will be further detailed at the UWMP stage.

9 Monitoring

The aim of this section is to outline the pre-development monitoring currently being undertaken and make recommendations regarding future post-development monitoring. It is anticipated that the post-development monitoring would be consistent with the pre-development monitoring of hydrological conditions (as documented in earlier sections), with the addition that the BMPs should also be monitored to ensure their continued effectiveness. It will be necessary to confirm that the structural management measures that are implemented are able to fulfil their intended management purpose and are in a satisfactory condition at a point of management hand-over to the Shire. These monitoring programs will be further detailed at the UWMP stage.

The pre-development Sampling and Analysis Plan (SAP) of surface water quality, groundwater levels and groundwater quality conditions was concluded in March 2010. The results of this monitoring provide baseline data that enable verification of future detailed designs at the subdivision stage. The results of the SAP are summarised in **Section 3** of this LWMS and can be found in more detail in the monitoring report (Cardno, 2010).

The groundwater monitoring was conducted at ten locations (Cardno, 2010c). The collected data included groundwater levels, sampling of physio-chemical parameters *in situ* and laboratory analysis of nutrients.

9.1 Recommended Program for UWMP

The post-development environment requires monitoring of both quantity and quality. Since there is no discharging or standing water within either the pre-development or post-development, no surface water monitoring is possible or required. However, since all surface runoff will infiltrate to the underlying aquifer, monitoring the groundwater will provide an indication as to the effect of the surface water quality management measures.

The post-development groundwater monitoring should aim to measure changes in groundwater quality. Where possible and if necessary, measures could be implemented on a development and lot scale to rectify the changes.

Bores 1, 4, 5, 7, 8 and 9 are not located within lots or roads and thus should be retained for post-development monitoring. An additional six bores are proposed, as shown in **Figure 13**, so that upstream and downstream water quality can be determined. This will indicate if the practices within POS and lots are affecting the groundwater quality. Due to the significant separation between the surface and the groundwater (up to 40m), it may take a long period of time before any effects are measurable within the groundwater. Additionally, due to the significant separation distance to groundwater, it is not possible to accurately determine the location of the nutrient source, thus the bores are not located immediately upstream and downstream of POS areas and instead are located upstream and downstream of the development (i.e. the monitoring will be on a broader scale). If the nutrient concentrations are found to have significantly increased post-development, the contingency action plan should be implemented to facilitate POS management and lot scale gardening practices which minimise fertiliser inputs to the underlying superficial aquifer.

The existing groundwater bores should be maintained post-development where possible. Where this is not possible, bores should be re-installed, post-development, at locations that can provide comparable results.

Table 11 Post-Development Monitoring Program Summary

Monitoring Type	Locations	Frequency	Parameters
Groundwater	Network of monitoring bores providing a suitable spatial representation of the study area.	Quarterly (typically Jan, April, July, Oct).	In situ pH, EC, dissolved oxygen, temperature. Sample pH, TSS, TN, TKN, NH4, NOx, TP, ORP.

9.2 Contingency Action Plan

A Contingency Action Plan (CAP) should be detailed and implemented as a part of each UWMP. The CAP is effectively a plan of steps that will be undertaken should certain water quality criteria be reached.

9.2.1 Trigger Criteria

The surface water trigger values are to be derived from surface water monitoring conducted in the Moore River ODP and in consideration of the *National Water Quality Management Strategy (ANZECC, 2000).* As discussed in **Section 9.1**, there are two separate groundwater monitoring regions (east and west) and as such two separate sets of trigger value criteria will be used to assess the impact of an urban post-development environment on the local groundwater. The trigger criteria were derived from a combination of temporal median values from the site specific data and the ANZECC (2000) default trigger values. The post-development trigger criteria are shown **Table 12**.

Table 12 Post-Development Trigger Values

Groundwater Area	TN (µg/L)	TP (µg/L)	ORP (µg/L)	NH_4 (µg/L)	NO_X (µg/L)	TKN (µg/L)	pH	EC (mS/cm)
East	1,600	65	40	200	150	1,700	6.0-8.0	120-300
West	5,500	1,500	1,200	220	300	2,500	6.0-8.0	120-300

9.2.2 Contingency Actions

If the results from the initial monitoring occasion and successive follow-up monitoring indicate that action is required to address the issue, a number of contingency measures may be employed. The first action that should be undertaken if groundwater trigger criteria is exceeded is to conduct a site-specific comparison of long term background data with the collected data from the SAP. There is some amount of variability (both spatially and temporally) in nutrient concentrations experienced across the Moore River ODP area and the trigger values may need to be modified to accommodate background levels. This information should then be used as a management tool in consultation with DoW to determine if the trigger values should be revised.

If the trigger values are deemed to be appropriate the following actions should be undertaken in relation to nutrients if the groundwater trigger criteria are exceeded:

- Re-sample to verify results.
- Identify source if possible.
- Remove source if possible (e.g. fertiliser input, etc.).

- Remove sediment-bound nutrients by removing basin sediments.
- Review implementation of open space management practices and street sweeping.
- Manual removal of plant material from bio-pockets, swales and vegetated retention areas to facilitate further nutrient uptake.
- Education of lot owners to minimise fertiliser application rates, and provide information on alternative low nutrient requiring vegetation.

The need for fertiliser application will be determined through periodic leaf and tissue analysis of plants within the POS areas. Additional measures in response to other parameters will be assessed on a case-by-case basis and it is anticipated that this would be undertaken in conjunction with the Shire.

9.3 Reporting

The post-development monitoring should be conducted for 3 years after 80% of the lots within the sub-division have been completed. On this basis three annual monitoring reports would be presented to the DoW and Shire of Gingin. It is expected that the monitoring and subsequent reporting would be further detailed in the UWMP documents.

10 Implementation

The LWMS is a key supportive document for the Moore River ODP. The development of the LWMS has been undertaken with the intention of providing a structure within which subsequent development can occur consistent with the total water cycle management approach described in the document. It is also intended to provide overall guidance to the general stormwater management principles for the area and to guide the development of the future UWMPs.

10.1 Roles and Responsibility

The LWMS provides a framework that the proponent can utilise to assist in establishing stormwater management methods that have been based upon site-specific investigations, are consistent with relevant State and Local Government policies and have been endorsed by the Shire. The responsibility for working within the framework established within the LWMS rests with the subdivider, although it is anticipated that future UWMP documents will be developed in consultation with the Shire and DoW and in consideration of other relevant policies and documents.

Due to the size of the Moore River ODP area, it is most likely that the area will not be developed as a single parcel. Staged development will therefore be required. It will be the responsibility of the developer to prepare detailed subdivision designs and supportive UWMPs at the appropriate time (i.e. at subdivision stage). It is also the responsibility of the developer to demonstrate that the proposed subdivision designs and supportive UWMPs not only comply with the objectives and management approaches provided in this LWMS, but that they can also achieve the water quantity and quality objectives and criteria set by this LWMS.

The Moore River development will utilise water efficient appliances to conserve the use of water. This is a requirement under the Department of Housing and Works “5 Star Plus” Building Regulations (gazetted 21 August 2007). The developer will supply information to the lot purchaser at point of sale. This LWMS mandates the use of rainwater tanks on all dwellings. The mechanism for mandating rainwater tanks is through issue of building licence by SoG.

10.2 Funding

As the Moore River ODP area constitutes a single landholding, the management strategies outlined in this LWMS will be borne solely by the proponent. The Shire has not advised of any funding contributions required for the development to discharge to the existing regional stormwater network. However, it is anticipated that the proponent will work with the Shire to reach a mutually agreeable outcome where required.

10.3 Review

It is not proposed that this LWMS will be reviewed, unless the ODP changes significantly, or the proposed approach to water supply and wastewater treatment are to vary from the approach proposed in this document.

The next stages of water management are anticipated to be lot planning through subdivision. Subdivision approvals should be supported by a UWMP. The UWMP is largely an extension of the LWMS, as it should provide detail to the designs proposed within this LWMS. In addition to the issues detailed in **Section 8**, the UWMPs should address:

- Compliance with design objectives within the LWMS;
- Detailed stormwater management design;

- Specific structural and non-structural methods to be implemented and their manner of implementation; and
- Details of proposed roles and responsibilities for the above measures.

The next stage of development following the UWMP is single lot or multiple dwelling developments. It is recognised that certain elements of the LWMS and the UWMP will not be implemented until this late stage, and that there is little or no statutory control that can be applied to ensure the implementation of any remaining measures. While the remaining measures are unlikely to be enforced at this stage, their implementation could be encouraged by the Shire through policy (or modification of these where necessary) or awareness programs (such as the Water Corporation's Waterwise program).

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Figures



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PROJECT Moore River District & Local Water Management Strategy

DRAWING TITLE FIGURE 1 : Locality Plan

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DRAWING TITLE **FIGURE 2 : Outline Development Boundary**

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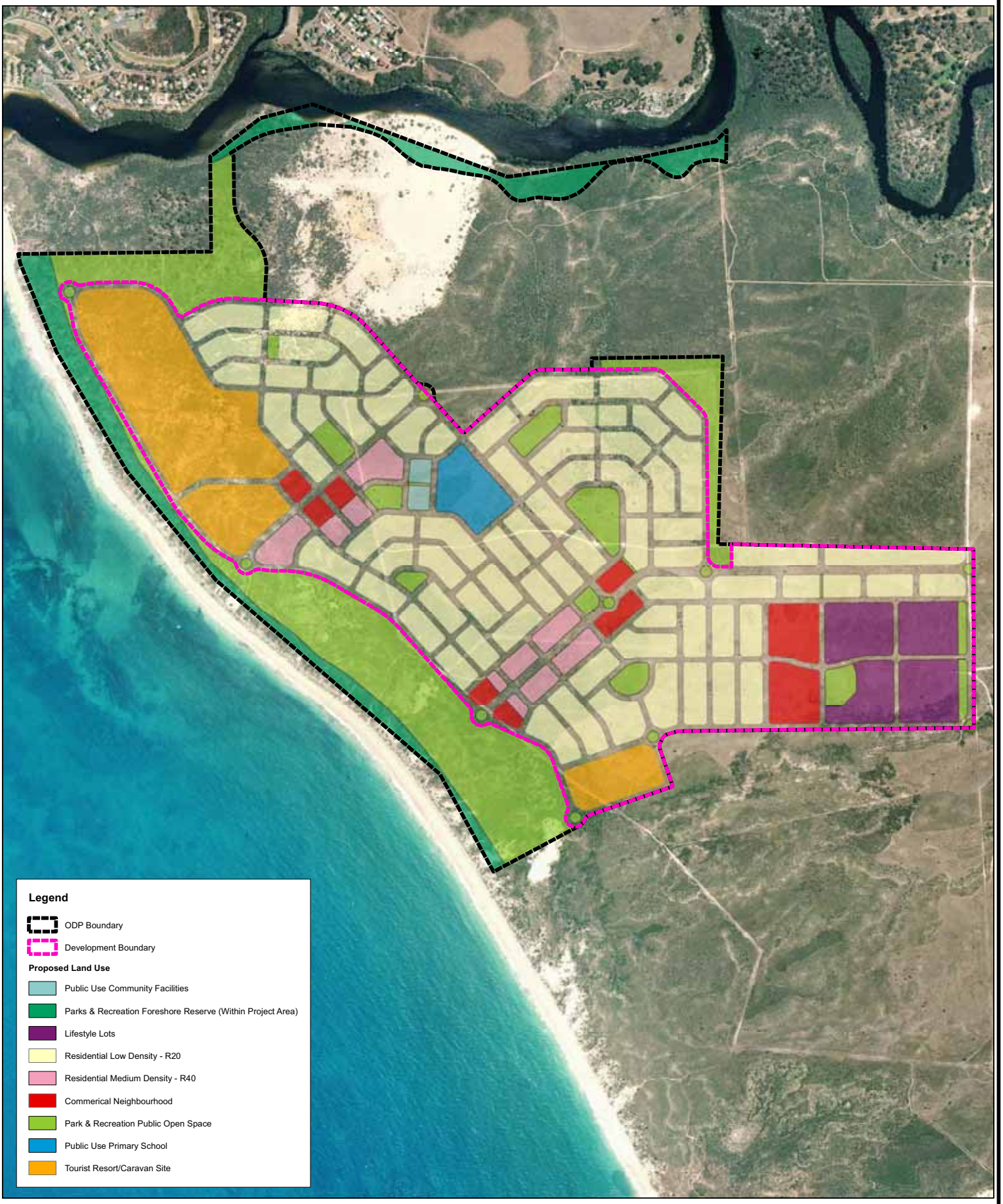
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DRAWING TITLE **FIGURE 3: Local Structure Plan**

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Revision **00**

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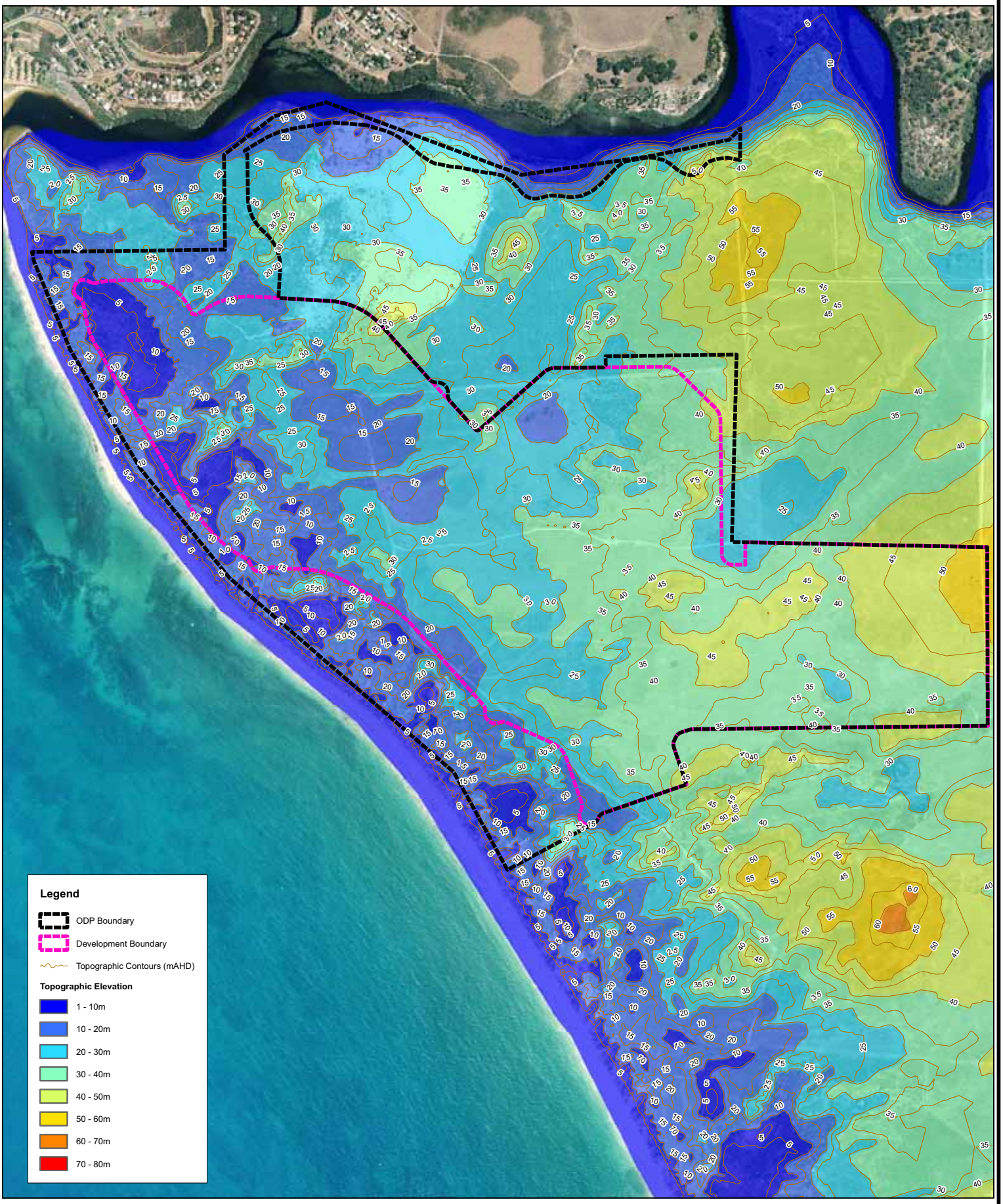
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DRAWING TITLE **FIGURE 4 : Topography**

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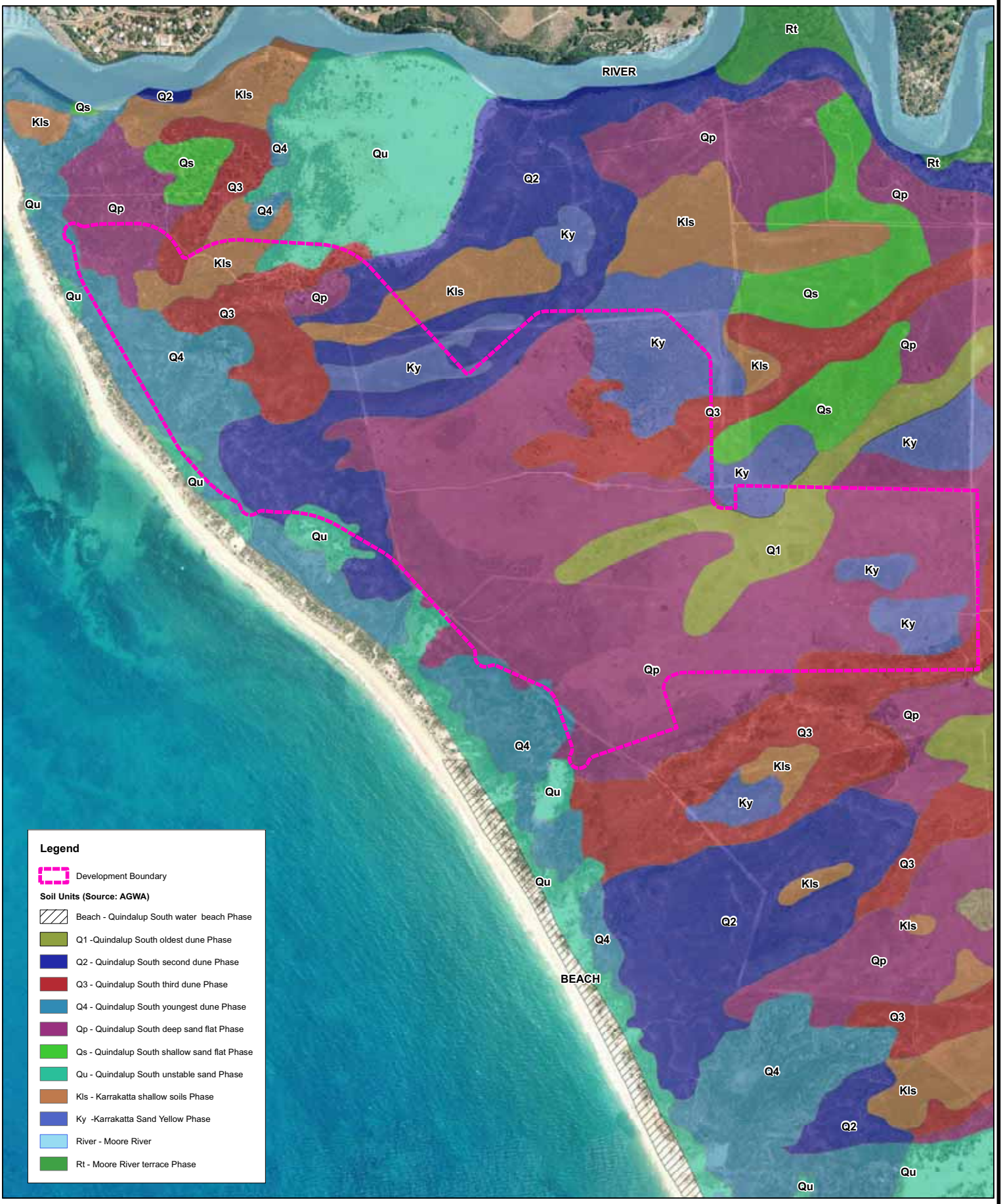
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DRAWING TITLE **FIGURE 5 : Soil Types**

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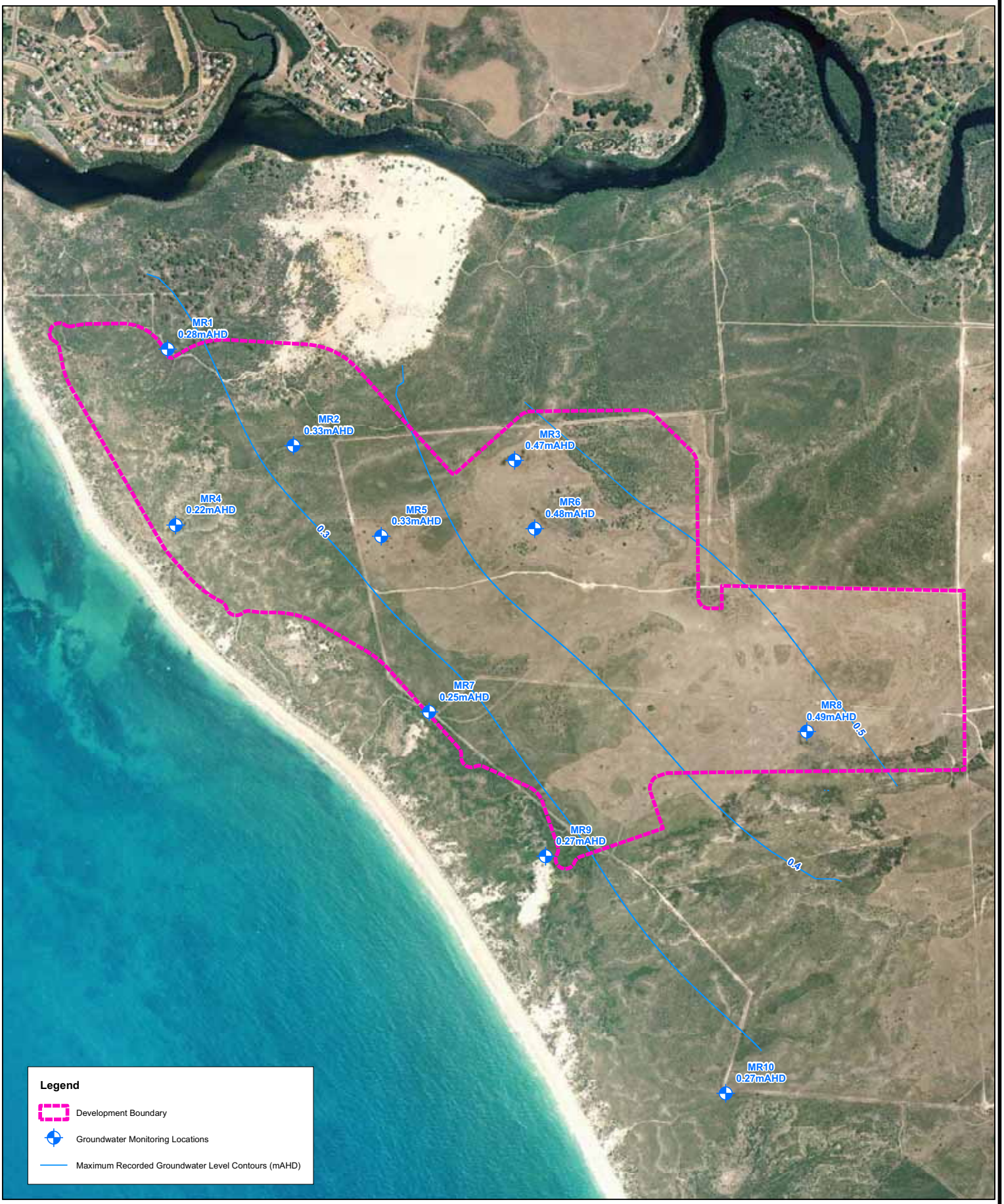
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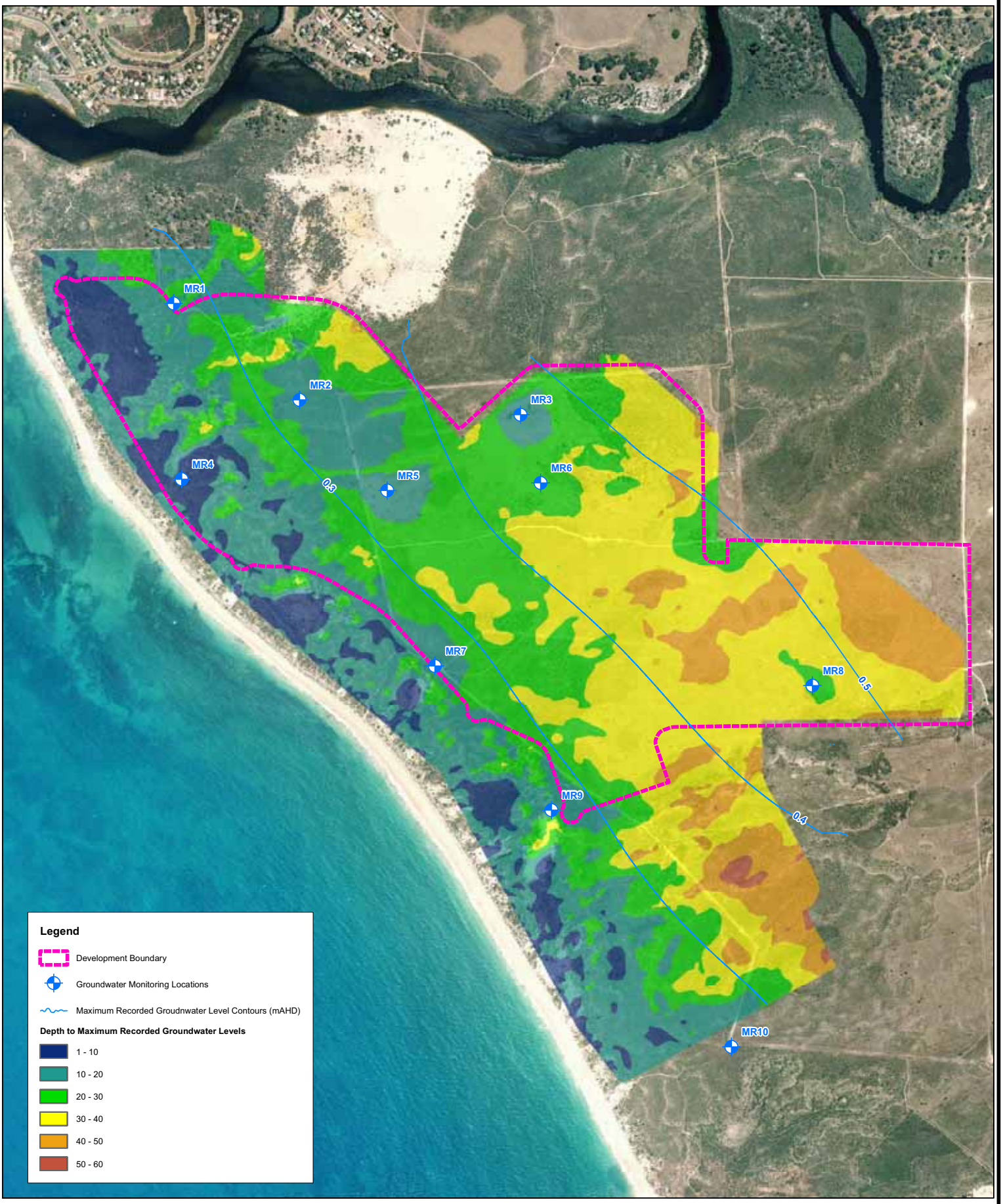
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DRAWING TITLE **FIGURE 6: Maximum Recorded Groundwater Levels**

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DRAWING TITLE **FIGURE 7: Depth to Maximum Recorded Groundwater Levels**

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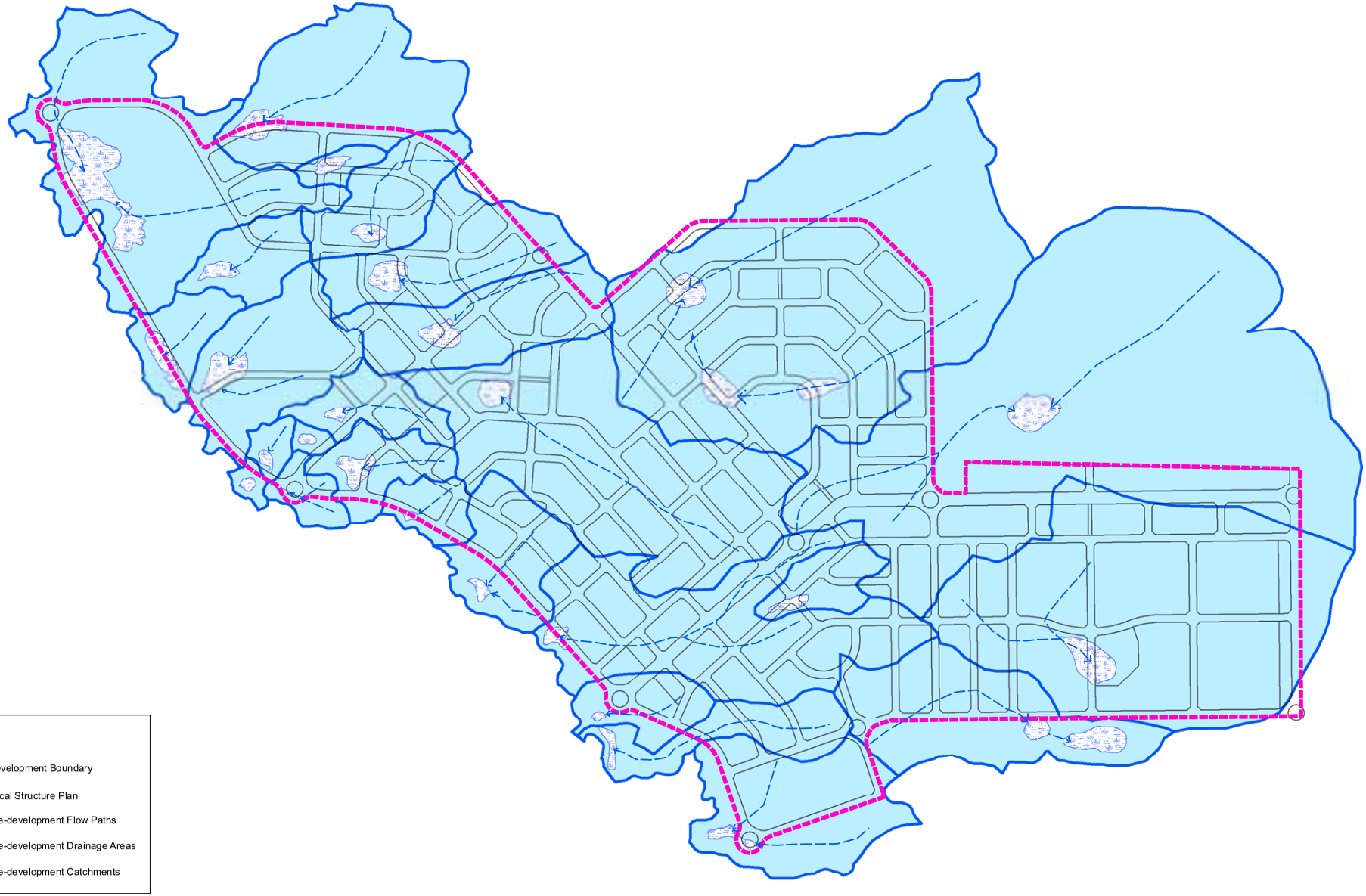
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DRAWING TITLE **FIGURE 8 : Pre-development Surface Runoff Catchments**

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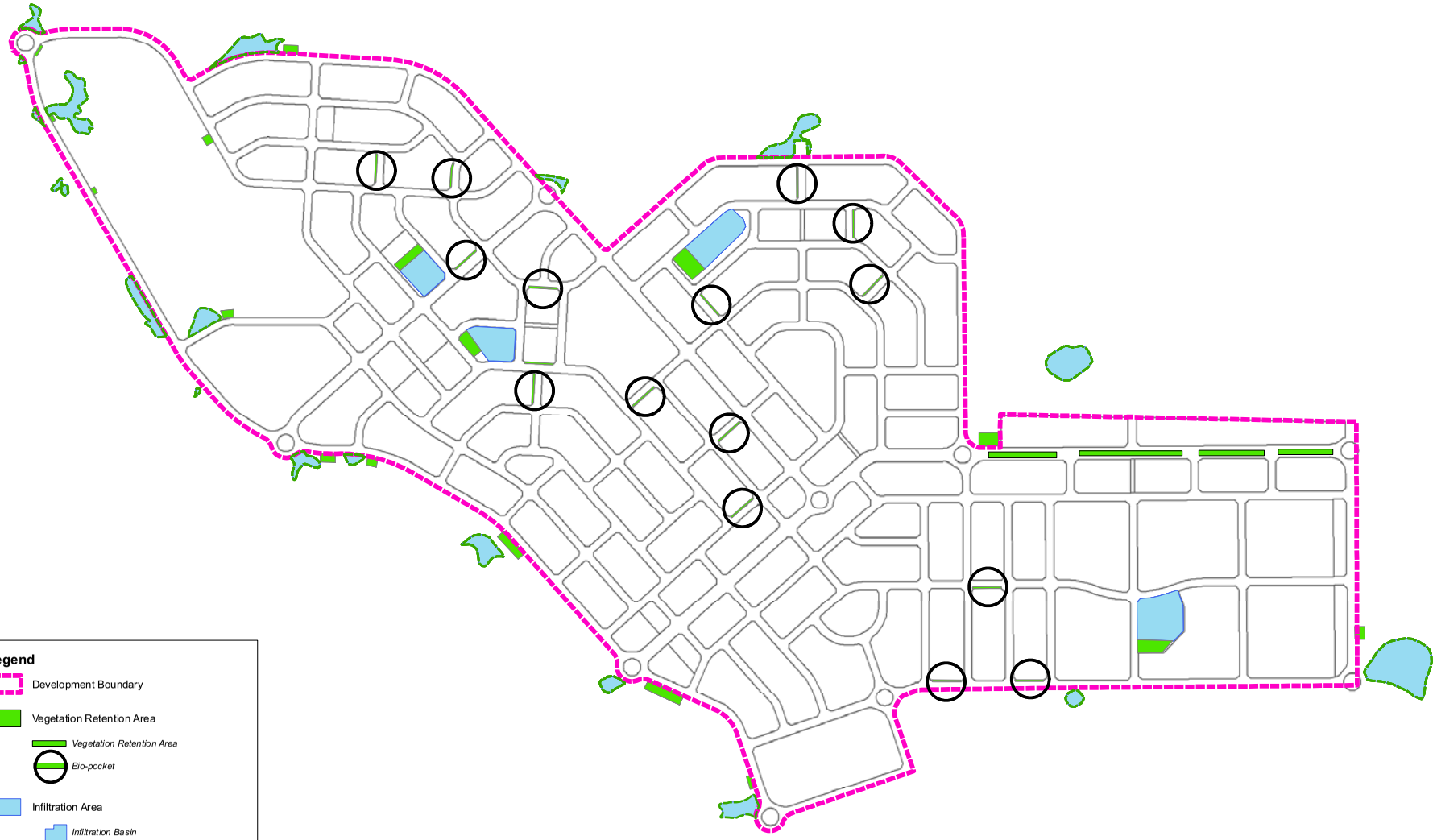
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PROJECT **Moore River District & Local Water Management Strategy**

DRAWING TITLE **FIGURE 9: Location of WSUD Measures**

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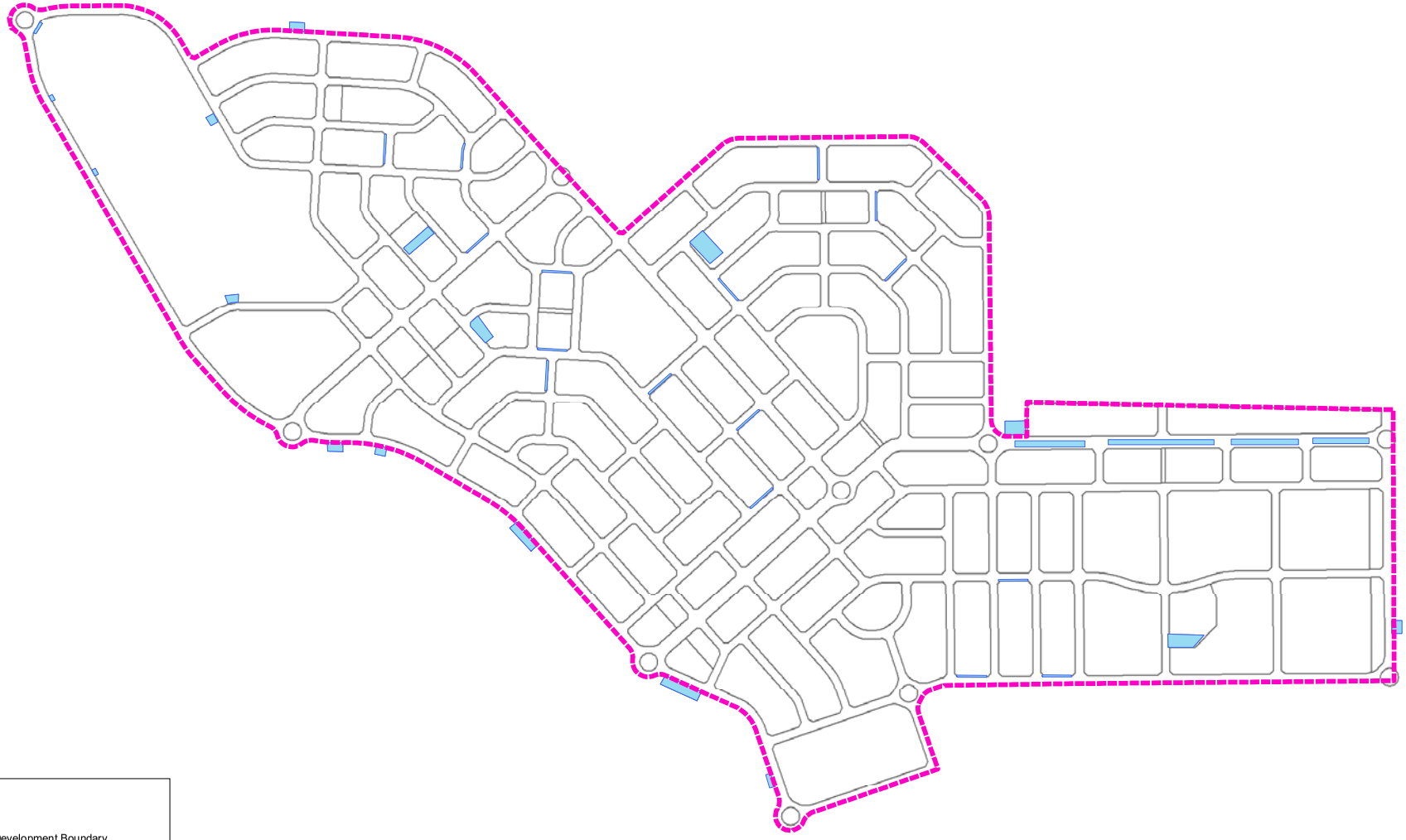
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PROJECT **Moore River District & Local Water Management Strategy**

DRAWING TITLE **FIGURE 10 : 1 Year - 1 Hour Inundation Areas**

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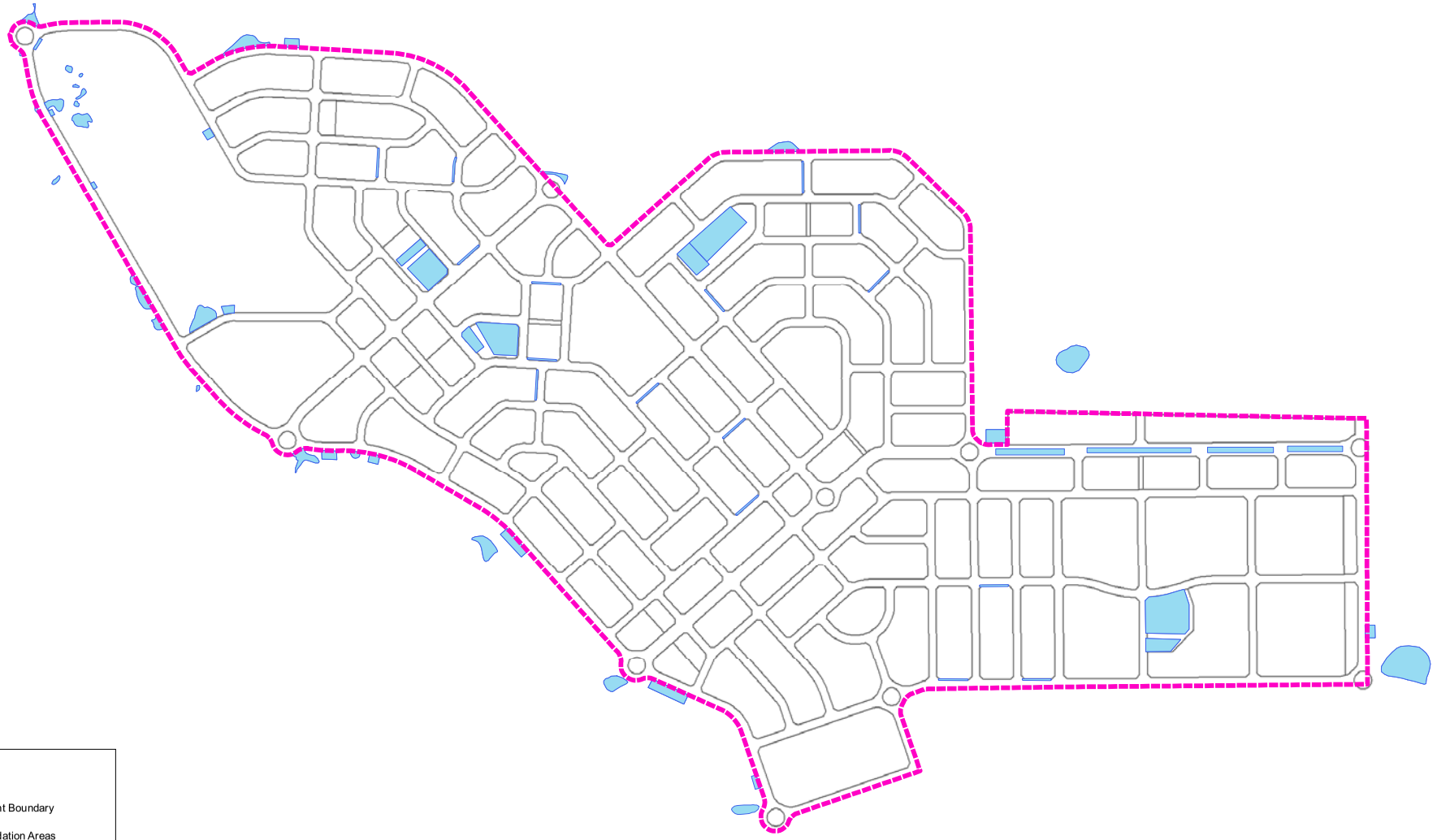
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PROJECT **Moore River District & Local Water Management Strategy**

DRAWING TITLE **FIGURE 11 : 5 Year Inundation Areas**

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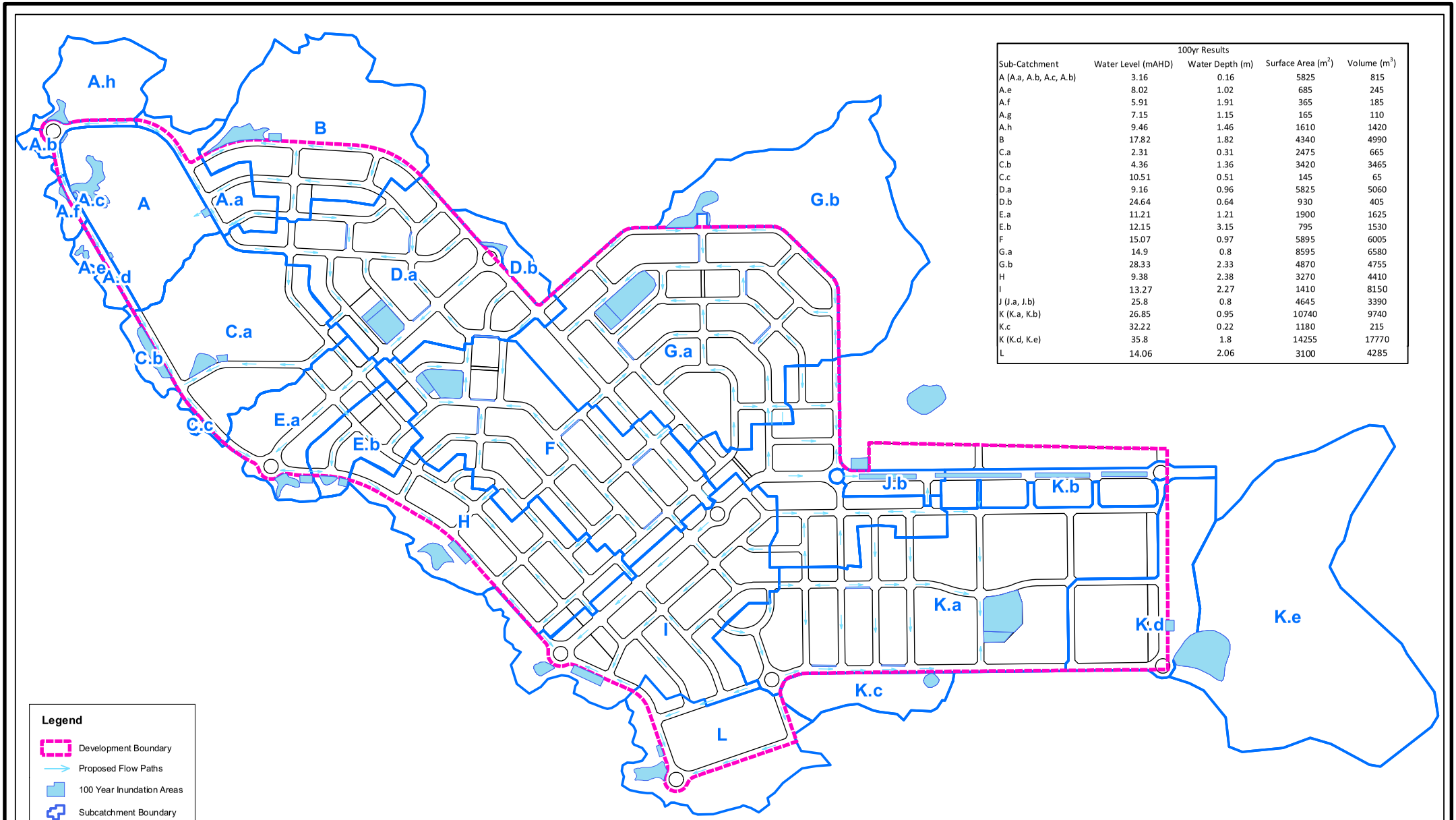
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V9070	SK70	00	A3

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100yr Results

Sub-Catchment	Water Level (mAHD)	Water Depth (m)	Surface Area (m^2)	Volume (m^3)
A (A.a, A.b, A.c, A.b)	3.16	0.16	5825	815
A.e	8.02	1.02	685	245
A.f	5.91	1.91	365	185
A.g	7.15	1.15	165	110
A.h	9.46	1.46	1610	1420
B	17.82	1.82	4340	4990
C.a	2.31	0.31	2475	665
C.b	4.36	1.36	3420	3465
C.c	10.51	0.51	145	65
D.a	9.16	0.96	5825	5060
D.b	24.64	0.64	930	405
E.a	11.21	1.21	1900	1625
E.b	12.15	3.15	795	1530
F	15.07	0.97	5895	6005
G.a	14.9	0.8	8595	6580
G.b	28.33	2.33	4870	4755
H	9.38	2.38	3270	4410
I	13.27	2.27	1410	8150
J (J.a, J.b)	25.8	0.8	4645	3390
K (K.a, K.b)	26.85	0.95	10740	9740
K.c	32.22	0.22	1180	215
K (K.d, K.e)	35.8	1.8	14255	17770
L	14.06	2.06	3100	4285

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PROJECT: **Moore River District & Local Water Management Strategy**

DRAWING TITLE: **FIGURE 12 : 100 Year Inundation Areas**

PRINCIPAL: **Silverlake Investments Pty Ltd**

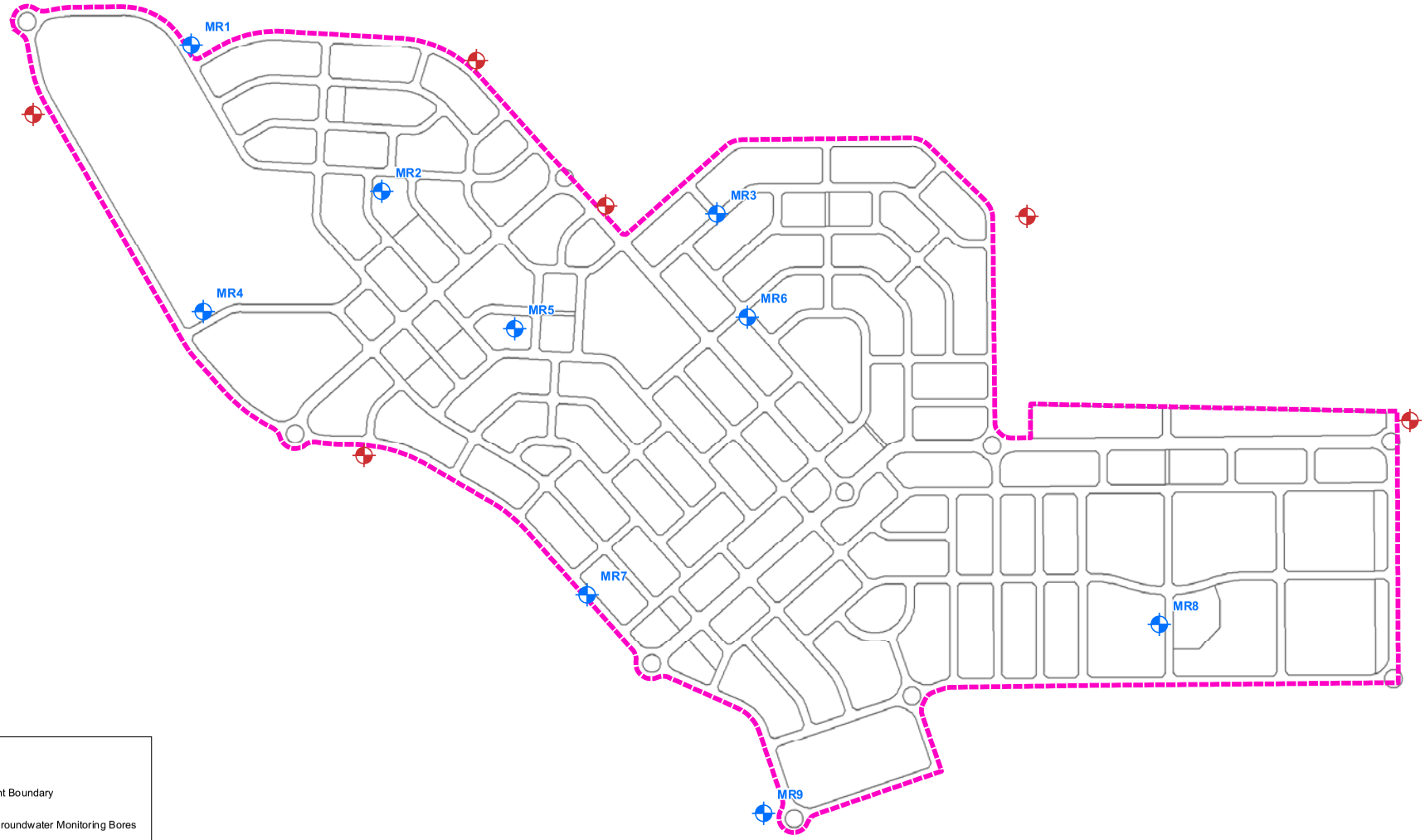
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DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD

PROJECT **Moore River District & Local Water Management Strategy**

DRAWING TITLE **FIGURE 13 : Post-development Monitoring Locations**

PRINCIPAL **Silverlake Investments Pty Ltd**

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Appendix A

Modelling Methodology

A1 Surface Water Modelling Assumptions and Parameters

Surface runoff from rainfall events can be estimated using relationships between the surface slope, area, roughness, infiltration and rainfall. The interaction of runoff from areas with different characteristics and the routing of this runoff through a catchment can be very complex; it is for these reasons that computational models are used to ensure the accuracy and speed of the calculations.

For the calculation of the existing surface runoff from the Moore River development site, the hydrologic and hydraulic model XPSWMM was used. The hydrologic component of the software uses the Laurenson non-linear runoff-routing method to simulate runoff from design storm events. The Laurenson runoff-routing method assumes that runoff is proportional to slope, area, infiltration and percentage of imperviousness of a catchment. Catchment area and slope are determined from topographical data. The infiltration rate and percentage imperviousness can be determined from field experiments or experience with model preparation with similar soil conditions. The runoff from each sub-catchment is routed though the catchment drainage network using the hydraulic component of XPSWMM.

A1.2 Modelling Assumptions and Parameters

The total volume of runoff from a site is determined by the amount of rainfall less the losses, due largely to infiltration. The rate of runoff is determined by the slope and roughness (Manning's n) of the surface.

An "initial loss – continuing loss and proportional loss" infiltration model was adopted for the catchments, with loss values chosen based on Cardno's experience with similar soil types and catchments. The infiltration losses for the land types within the pre-development and post-development model are summarised in **Table A1**.

Table A1 Initial and Continuing Loss Parameters for Hydrological Modelling

Infiltration Land Type	Initial Loss (mm)	Continuing Loss (mm)
Sandy Sparse Vegetation	30.0	3.00
Roof	7.0	0.10
Impervious (e.g. Road etc)	1.0	0.10
Verge	9.0	2.00
Basin, Bio-Pockets	15.0	0.00
POS	15.0	2.50
Lot Garden	25.0	3.00

The post-development loss rates for residential areas, POS areas and verges were influenced by the existing loss rates used for the pre-development environment and by Cardno experience with other residential development modelling. Specifically the post-development loss rates were determined by comparing the characteristics of the post-development land type compared to the pre-development land type. For example:

- POS - These areas will be turfed, have imported sand topsoil, relatively flat and moderately compacted. Compared to the pre-development environment of sandy soils, significant clearance to groundwater, moderate to steep slope and little vegetation, the POS areas will have lower

Initial Loss (storage) and slightly lower overall infiltration rate (Continuing Loss or Proportional Loss);

- Verge – The road verge will be similar to POS areas, except that it will also have a footpath. The footpath will reduce the overall loss rates of the verge area as shown in **Table A1**;
- Basin – The basins will be constructed with highly permeable sands and contain vegetation; therefore, these basin areas will have a high Initial Loss. These areas have not been modelled using a continuing loss parameter in the hydrology calculations. Instead, these have been modelled in the hydraulic calculations with an infiltration rate of $2.5x10^{-5}$m/s.
- Impervious areas – The loss rates on the impervious Road, Lot-paved and Lot-roof area will be minor. Therefore, an initial loss of 1mm and a continual loss of 0.1mm/h has been used;
- Lot-Garden – These areas will have high infiltration rates as it is likely that sand or mulch will be used, the majority of lots will have little slope (flat) and pockets of storage are likely. Therefore the Initial Loss and Continuing Loss will be higher than POS areas but less than the pre-development environment.

Appendix B

Water Conservation Modelling Assumptions and Parameters

B1 Water Conservation Assumptions and Parameters

Table B.1 Water Efficient Appliances - Water Use Rates

Appliance	Water use	
	Standard Device	Water Saving Device
Toilet	12 Litres/Flush	4.5 Litres/Flush
Washing Machine	130 Litres/Wash	40 Litres/Wash
Shower Head	15 Litres/Minute	8 Litres/Minute
Taps	20 Litres/Minute	10 Litres/Minute
Dishwasher	50 Litres/ Wash	25 Litres/ Wash

(Australian Government, 2009 & Melbourne Water, 2009)

Table B.2 Water Efficient Gardens - Water Use Rates

Lot	Composition of Garden Area				Irrigation Rates (kL/ha)	
	Non Water Efficient Garden		Water Efficient Garden		Turf	Garden Beds
	Turf	Garden Beds	Turf	Garden Beds		
Cottage Lot	84%	16%	20%	80%	7,500	1,000
Standard Lot	84%	16%	50%	50%	7,500	1,000
Rural Lot	50%	50%	30%	70%	7,500	1,000

(Assumed Rural Lots have a maximum of 400m^2 of combined garden area)

Table B.3 Watering Days and Rainfall

Month	Average Rainfall (mm)	Average Rainfall Days	Water Frequency
January	8	0.7	Every 2 days
February	12.5	1.1	Every 2 days
March	14.8	1.6	Every 3 days
April	35.4	3.5	Every 5 days
May	86.8	6.4	No Watering
June	138.5	9	No Watering
July	137.4	9.9	No Watering
August	105.2	8.9	Every 14 days
September	69.5	6.8	Every 7 days
October	37.1	4.4	Every 4 days
November	23.5	2.9	Every 3 days
December	9.1	1.2	Every 2 days
Total	692.8	56.4	

(BoM, 2007)

Table B.4 Rainwater Tank Parameters

Variable	Parameter
Rainwater Tank Size	3000L
Connect Roof Area	250m^2 (100% of roof area)
Initial Loss of Each Rainfall Event	1mm
Total Rainfall	612mm/year
Water Use	Toilets and Hot Water System
Percentage of all Water used in Dwelling being Hot Water	40%

Table B.5 Miscellaneous Parameters

Variable	Parameter
Percentage of Waste Water produced from Scheme Water (remainder lost to leaks or consumption)	95%
Waste Water Tank Size	30,000kL
Areas Using Recycled Waste Water	Lot Gardens and POS areas

Appendix C

Groundwater Monitoring Report

Cardno
Shaping the Future



Moore River

Groundwater Monitoring Report

Prepared for Moore River Company Pty Ltd
May 2010
Project Number V9070

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Executive Summary

The Moore River study area is comprised of a parcel of land (Swan Location 2802 and portions of Swan Location 2424 and 2914) immediately south of Moore River, near Guilderton. This parcel of land forms part of a larger piece of land, which is zoned "Urban Development" under the Shire of Gingin (SoG) *Town Planning Scheme* (TPS) No. 8. The proposed future urban development has recently been endorsed by the State Government, with the future urban development to support a population of approximately 5000 people, consistent with the *Gingin Coast Structure Plan* (Western Australian Planning Commission (WAPC) 2006).

Cardno has been engaged to gather baseline data within the Moore River study area prior to development. Cardno developed the Sampling and Analysis Plan (SAP) detailed within this report to characterise the pre-development hydrological environment. The SAP was able to capture groundwater levels from October 2009 to March 2010 and groundwater quality for November 2009 and February 2010.

Ten shallow groundwater bores were installed within the study area at locations which would provide the best representation of anticipated shallow groundwater systems. These bores were measured for groundwater levels each month for the monitoring period. Analysis of the groundwater depths of the ten installed bores indicates that the study area has a significant surface to groundwater separation distance to the east of the dune system. A minimum surface to groundwater separation distance of 1.27m was recorded at Bore MR4 in October 2009. It is possible that the groundwater may intersect with the surface at more than one location along the primary dune swale during peak groundwater levels (typically in October). If they are proposed to be developed, areas in the primary dune swale may require fill or other methods to achieve appropriate separation to groundwater. Salinity contours indicate the groundwater within the study area is potentially susceptible to salt water intrusion, particularly within 500m of the coastline. Analysis of groundwater contours indicate that the ground water flow is in a westerly direction.

Groundwater quality was measured *in situ* and samples were also collected and submitted for laboratory analysis. TN concentrations were generally 'moderate' throughout the site with 'low' concentrations in the north west corner. TP concentrations exceeded the guideline value at the majority of sampling locations and are at their highest in the eastern portion of the study area, decreasing toward the western boundary.

All OC/ OP pesticide concentrations were below the Limit of Reporting (LOR). All dissolved metal concentrations were below ANZECC guideline values. The C29 – C36 Total Petroleum Hydrocarbon fraction was recorded above the LOR at Bore MR5. It should be noted that no trigger value has been assigned for total petroleum hydrocarbon fractions in the *National Water Quality Management Strategy* and the concentration was only moderately above the LOR.

This report concludes the scope of work in regard to groundwater monitoring of the study area. The groundwater monitoring results provide a snapshot of baseline conditions over a six month period which can be used as a guide to establish trigger values in the Water Management Strategy.

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Appendix B Laboratory Certificates of Analysis and Chain of Custody Forms

1 Introduction

1.1 Project Background

The Moore River study area (hereafter referred to as the study area) is comprised of a parcel of land (Swan Location 2802 and portions of Swan Location 2424 and 2914) immediately south of Moore River, near Guilderton. This parcel of land forms part of a larger piece of land, which is zoned "Urban Development" under the Shire of Gingin (SoG) *Town Planning Scheme* (TPS) No. 8. The location of the study area is shown in **Figure 1**.

The proposed future urban development has recently been endorsed by the State Government, with the future urban development to support a population of approximately 5000 people, consistent with the *Gingin Coast Structure Plan* (Western Australian Planning Commission (WAPC) 2006). The boundary of the study area is shown in **Figure 2**. The study area is predominately cleared farmland used for the farming of livestock with some coastal dune vegetation providing an (approximate) 2km buffer from the shoreline. It is envisaged that the future urban development will support a range of residential and accommodation options. Such a land use change can have implications for the types and quantity of pollutants released to local surface water and groundwater, which can in turn affect the ecological health of downstream receiving environments.

1.2 Monitoring Objective

Cardno has been engaged to gather baseline data within the study area prior to development. The objective of collecting this data is to characterise the pre-development hydrological environment of the study area. To achieve this objective, Cardno has developed a Sampling and Analysis Plan (SAP). It was determined that in order to achieve the project objective, the SAP would need to:

- Identify and quantify nutrient hotspots so that appropriate management measures can be implemented to avoid exacerbating the current situation;
- Determine groundwater quality to provide baseline data against which the effectiveness of future urban stormwater management and development impacts can be compared; and
- Understand the groundwater levels within the study area to determine if fill is required to achieve satisfactory separation distance.

Baseline data will be used to inform the future design process and will ensure that any future development is able to fulfil the stormwater management requirements of the Department of Water (DoW).

1.3 Purpose of this Report

This report documents the results of the groundwater quality and groundwater level monitoring that was undertaken between October 2009 and March 2010

2 Sampling and Analysis Plan Rationale

2.1 Key Documents and Inputs

There are a number of published guidelines and standards available which provide direction regarding the discharge characteristics that residential developments should aim to achieve. These were key inputs utilised for development of the SAP, and include:

- *National Water Quality Management Strategy* (ANZECC 2000);
- *Stormwater Management Manual for Western Australia* (DOW 2007);
- *Development of Sampling and Analysis Programs* (DOE 2001); and
- *Better Urban Water Management* (WAPC 2008).

The guidance documents detailed above were reviewed to determine the likely data requirements for the study area. These documents point to the need for accurate baseline data prior to development. Additionally, existing groundwater levels have potential implications for the stormwater management measures that will be required and the extent of earthworks that will be required to facilitate development.

2.2 Groundwater Methodology

Ten shallow groundwater bores were installed within the study site at locations which would provide the best representation of anticipated shallow groundwater systems. The locations of these groundwater bores are shown in **Figure 2**. These locations allow for the identification of nutrient hotspots and underlying groundwater contours.

The groundwater bores were constructed of 50mm threaded PVC slotted screen and blank casing sections. A 3m screened section was installed in each of the bores to approximately bisect the observed groundwater level. Graded gravel pack was placed around the screened section extending at least 0.5m above the top of the screened section. A bentonite seal was placed above the gravel pack and the bore annulus was backfilled with any available cuttings and concrete to the surface. Each bore was completed with approximately 0.5m of PVC casing extending above the ground surface and a protective steel casing. All bores were logged for hydro-geological parameters on installation. Bore completion log sheets are contained in **Appendix A.**

2.2.1 Groundwater Levels

Groundwater levels were measured on a monthly basis for 6 months on all installed bores. These bores are measured using an audible dip meter to record standing water levels. All bores have been surveyed to provide an accurate elevation, thereby allowing accurate water elevation characterisation.

2.2.2 Groundwater Quality

A clear understanding of the existing groundwater quality is important to determine whether the quality of water in the superficial aquifer is slowly improving with time or at least not degrading as a result of development. Groundwater quality sampling was conducted quarterly for a period of 6 months (i.e. two occasions) following installation of the monitoring bores.

Bores were purged using an electric pump prior to sampling. A Hydrolab Quanta water quality meter is used to collect field chemical data. Purging of the well was continued for approximately five minutes before samples were collected for *in situ* physiochemical and laboratory analysis. Physiochemical parameters measured *in situ* include:

- pH;
- Temperature;
- Salinity;
- Electrical Conductivity (EC); and
- Oxidation-Reduction Potential (Eh).

Upon collection, groundwater samples were placed directly into laboratory prepared and supplied containers. The samples are then placed on ice immediately following collection and transported to the laboratory under standard Chain of Custody procedures. Samples are submitted to a National Association of Testing Authority (NATA) accredited laboratory for analysis. The parameters selected for groundwater analysis include:

- Total Nitrogen (TN);
- Total Phosphorous (TP);
- Ortho-Phosphorous (Ortho P);
- Oxides of Nitrogen (NO_x);
- Total Kjeldahl Nitrogen (TKN);
- Ammonium (NH_4);
- Metals (arsenic, aluminium, copper, cadmium, iron, lead, chromium, nickel, mercury, zinc);
- Pesticides; and
- Hydrocarbons.

Initial analysis was undertaken for the full range of parameters. Ongoing monitoring was conducted for nutrients and nutrient species (TN, TP, Ortho P, NO_x, TKN & NH_4) as no other analytes were found to have a significant level upon receiving the initial results.

2.2.2.1 Chain of Custody

Standard Chain of Custody forms are completed for all samples transferred to the laboratory, detailing the sample identification, collection date and the requested analysis. Upon receipt of the samples the laboratory completes the Chain of Custody forms and provides a copy to Cardno for confirmation. Completed Chain of Custody forms for sampling undertaken are provided in **Appendix B.**

2.2.2.2 Laboratory Analysis

The laboratory used for this investigation was the ALS Laboratory Group. ALS is a National Association of Testing Authorities (NATA) accredited laboratory (NATA Accreditation No. 825) and is accredited for compliance with ISO/IEC 17025. All primary and QA/QC samples were submitted to ALS for analysis. Laboratory certificates of analysis are included in **Appendix B**.

3 Assessment Criteria

In order to provide an indication of the relative concentration of nutrient levels and physiochemical parameters within both surface and groundwater, comparison with the 'default trigger values for slightly disturbed ecosystems (lowland river) in South Western Australia' (ANZECC 2000) is made in the following sections. While the default trigger values are applicable to nutrient concentrations within surface water features, they are not specifically intended for application to groundwater nutrient concentrations. However, as there are no nationally published trigger values available for groundwater quality, a comparison of nutrient concentrations and some field chemistry parameters are made to the 'default trigger values' to provide some context to the measured concentrations. As such, the 'default trigger values' are hereafter referred to as the 'guideline values'. These guideline values are shown in **Table 3.1**.

Table 3.1 ANZECC Guideline Values

TN (µg/L)	TP (µg/L)	Ortho P (µg/L)	NH_4 (µg/L)	NO_x (µg/L)	DO (% Sat)	pH	Salinity (mS/cm)
1200	65	40	80	150	80-120	6.5-8.0	0.12-0.3

Discussion of nutrient concentrations in the following sections refers to their relative concentration compared to the guideline values. The terms 'low', 'moderate', high' and 'very high' are used in the following manner:

- 'Low' – nutrient concentration below, equal to or marginally above default trigger value;
- 'Moderate' – nutrient concentration up to five times the default trigger value;
- 'High' – nutrient concentration between five and 10 times the default trigger value; and
- 'Very High' – nutrient concentrations more than 10 times the default trigger value.

Principally, comparison is made for the TN and TP concentrations. However, some comment is also provided for nutrient species (Ortho P, NH_4, NO_X) where these form a substantial portion of the overall nutrient concentrations.

In addition to the analysis of nutrient concentrations and physiochemical parameters, a comprehensive assessment of metals, organochlorine (OC) and organophosphate (OP) pesticides, and hydrocarbons was undertaken. These parameters were assessed against ANZECC guidelines for slightly disturbed ecosystems (90% level of protection). The 90% protection level relates to the percentage of species protection. The 90% level of protection was assigned as the catchment is predominately cleared farmland used for the farming of livestock with some coastal dune vegetation providing an (approximate) 2km buffer from the shoreline.

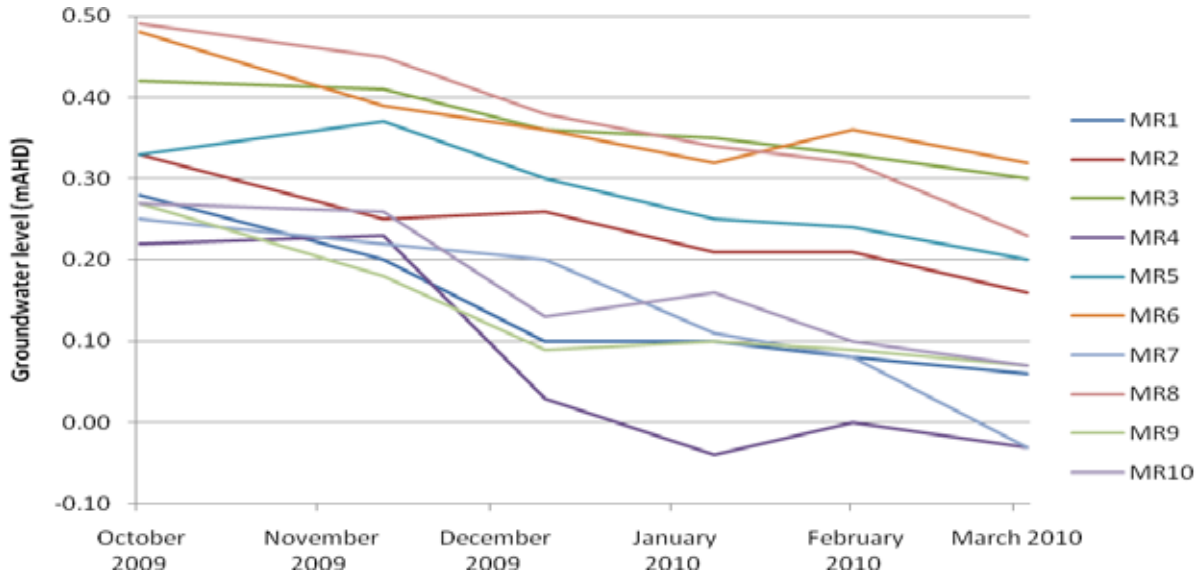
4 Monitoring Results

4.1 Groundwater Levels

Depth to groundwater for the ten bores was measured monthly from October 2009 to March 2010. Depth to groundwater results are attached in **Appendix B**. Depth to groundwater ranged from 1.27mBGS (Bore MR4, October 2009) to 28.03mBGS (Bore MR8, March 2010).

Analysis of DoW groundwater bore level data across Perth and in a 10km radius of the study area indicate that groundwater levels are typically at their lowest in April and at their highest in October, with seasonal fluctuations of approximately up to 2m. Notwithstanding, the study area is immediately adjacent to the coast and groundwater levels would be affected by long term sea levels. A hydrograph of the groundwater levels for the ten bores is shown in **Figure 4.1**.

Figure 4.1 Moore River Hydrograph



As shown in **Figure 4.1** maximum groundwater levels were generally observed in October. The hydrograph indicates the water level in each of the bores followed a similar pattern and groundwater depth generally decreased over the monitoring period.

Groundwater contours have been generated using the October 2009 groundwater level data as the majority of maximum groundwater levels were recorded on this occasion. These contours are shown in **Figure 2**. Analysis of the groundwater contours produced indicates that the ground water flow is in a westerly direction. The groundwater levels (m AHD), and survey data for each bore are shown in **Appendix B**. Salinity contours have been generated from the February 2010 data. These contours are shown in **Figure 3**.

4.2 Groundwater Quality

Groundwater quality was measured *in situ* on 19th November 2009 and 2nd February 2010. Groundwater samples were also collected and submitted for laboratory analysis. Results of the metals, OC/OP pesticides and hydrocarbon analysis is attached in **Appendix B**. Results of the laboratory analysed nutrient concentrations and the *in situ* physiochemical parameters for 19th November 2009 are shown in **Table 4.2.A**. Bore MR8 was unable to be sampled due to equipment malfunction on this occasion.

Table 4.2.A *In situ* Physiochemical Parameters and Laboratory Analysed Nutrient Concentrations for 19th November 2009

	Physiochemical Parameters					Nutrients (µg/l)					
Bore ID	Temp (°C)	Salinity (mS/cm)	pH	DO (%)	Redox (mV)	TN	TP	Ortho-P	NH4	N0x	TKN
MR1	20.68	1.107	7.43	89.6	92	1000	290	<10	20	990	<100
MR2	20.29	0.672	7.54	95.9	97	3400	<20	<10	10	3390	<200
MR3	21.04	0.801	7.39	78.4	104	3800	130	<10	30	3830	<200
MR4	19.20	1.77	7.35	43.6	103	1100	50	50	10	800	300
MR5	20.47	0.793	7.45	78.4	100	4600	<20	<10	50	4200	400
MR6	21.09	0.716	7.43	88.7	103	3200	<20	10	30	2980	300
MR7	20.52	1.17	7.34	87.6	110	5100	120	10	10	4300	800
MR8	No data										
MR9	20.12	0.585	7.48	91.6	117	6800	<50	<10	20	6820	<500
MR10	20.70	0.667	7.01	86	152	2200	110	10	10	2250	<200

As shown in **Table 4.2.A**, comparison of the physiochemical parameters and nutrient concentrations with the ANZECC guideline values indicate:

- 'Low' to 'high' TN concentrations;
- 'Low' to 'moderate' TP concentrations;
- 'High' to 'very high' NO_x concentrations;
- Generally 'low' Ortho P concentrations with one 'moderate' reading at Bore MR4;
- Salinity values that exceed the default trigger range at some locations; and
- pH values within the guideline range;

All OC/ OP pesticide concentrations were below the Limit of Reporting (LOR). All dissolved metal concentrations were below ANZECC guideline values. The C29 – C36 Total Petroleum Hydrocarbon fraction was recorded above the LOR at Bore MR5. It should be noted that no trigger value has been assigned for total petroleum hydrocarbon fractions and the concentration was only moderately above the LOR.

Results of the laboratory analysed nutrient concentrations and the *in situ* physiochemical parameters for 2nd February 2010 are shown in **Table 4.2.B**.

Table 4.2.B *In situ* Physiochemical Parameters and Laboratory Analysed Nutrient Concentrations for 2nd February 2010

	Physiochemical Parameters					Nutrients (µg/l)					
Bore ID	Temp (°C)	Salinity (uS/cm)	pH	DO (%)	Redox (mV)	TN	TP	Ortho-P	NH4	N0x	TKN
MR1	21.26	0.402	7.82	80.6	48	1100	80	<10	20	880	200
MR2	22.02	0.644	7.69	96.9	57	2700	100	<10	10	2560	100
MR3	22.32	0.856	7.79	88.3	45	4400	180	<10	10	4450	<200
MR4	22.13	1.491	7.93	19.2	29	600	70	40	20	350	300
MR5	22.37	0.871	7.9	70.3	39	5300	430	<10	10	4410	900
MR6	23.45	0.766	8.19	82.1	24	3400	780	<10	20	2720	700
MR7	22.65	1.201	7.91	84.2	35	5000	910	<10	10	4850	200
MR8	22.84	0.771	7.95	58	-15	5700	5860	<10	40	3850	1900
MR9	21.85	0.932	7.69	95	50	4600	150	10	<10	4610	<500
MR10	21.85	1.044	6.74	85.5	65	4700	20	<10	10	3130	1600

As shown in **Table 4.2.A**, comparison of the physiochemical parameters and nutrient concentrations with the ANZECC guideline values indicate:

- 'Low' to 'Moderate' TN concentrations;
- 'Low' to 'very high' TP concentrations;
- 'Moderate' to 'very high' NO_x concentrations;
- Salinity values that exceed the guideline range; and
- pH values generally within the guideline range with one reading at Bore MR6 marginally above the guideline range.

5 Discussion

The SAP was able to capture groundwater levels from October 2009 to March 2010 and groundwater quality for November 2009 and February 2010. A minimum surface to groundwater separation distance of 1.27m was recorded at Bore MR4 in October 2009. This relatively high range is due to variable topography of the study area with the bores located outside of the dune swales recording the highest depths to groundwater. Bore MR4 is located in the swale behind the primary dune, in an area that is currently proposed to be developed as a Holiday Resort. Bore MR4 is the closest bore to the ocean and displayed the highest EC concentrations on both sampling occasions, indicating this area may be affected by long term sea levels. Salinity contours indicate that the bores closest to the ocean have the highest EC concentrations suggesting some level of conductivity between sea levels and groundwater levels in the coastal zone.

Analysis of the groundwater depths of the ten installed bores indicates that the study area has a significant surface to groundwater separation distance to the east of the dune system. It is possible that the groundwater may intersect with the surface at more than one location along the primary dune swale during peak groundwater levels (typically in October). If they are proposed to be developed, these areas may require fill or other methods to achieve appropriate separation to groundwater prior to development.

The groundwater quality parameters are consistent with a predominantly agricultural region and show elevated levels of some nutrients. Over the two groundwater quality monitoring occasions TN concentrations were generally 'moderate'. TP concentrations were generally higher during the February monitoring occasion with three 'very high' readings recorded. TN and TP concentrations have been mapped using the February data in **Figure 4** and **Figure 5** respectively. The February data was used as all bores were able to be sampled on this occasion.

Figure 4 indicates TN concentrations were generally 'moderate' throughout the site with 'low' concentrations in the north west corner. The TN concentrations were primarily comprised of NO_x throughout the study area. NO_x comprises the oxides of nitrogen, nitrite (NO^2) and nitrate (NO^3). NO_x concentrations were generally 'very high' throughout the study area. Elevated NO_x concentrations are potentially a concern as NO_x is known to have a correlation with accelerated algal growth, and because NO_2 is toxic to some aquatic species.

Figure 5 indicates TP concentrations are at their highest in the eastern portion of the study area and decrease toward the western boundary. Comparison of the TP concentrations and the groundwater contours in **Figure 2** suggests the TP concentrations are decreasing within the study area as the groundwater flows to the west. It should be noted that Ortho P concentrations (the biologically available form of phosphorous) were consistently 'low' during February. The bores which showed 'very high' TP readings had a significant surface to groundwater separation distance (>13m).

The OC/ OP pesticide concentrations, hydrocarbon concentrations and dissolved metal concentrations did not point to any major concerns or groundwater quality contamination issues. All OC/ OP pesticide concentrations were below the LOR. All dissolved metal concentrations were below ANZECC guideline values. The C29 – C36 Total Petroleum Hydrocarbon fraction was recorded marginally above the LOR at Bore MR5. It should be noted that there is no guideline value

for hydrocarbon fractions in the *National Water Quality Management Strategy* and no other hydrocarbon values were recorded above the LOR.

6 Conclusion and Recommendations

This report is a standalone document that may be used for future detailed design stages and other management documents that may be required in the Structure Planning process. The groundwater monitoring results provide a snapshot of baseline conditions over a six month period which can be used as a guide to establish trigger values in the Water Management Strategy.

Overall, the main concern in regard to groundwater quality within the study area relates to TP and NO_x concentrations. The data presented in this report suggests these concentrations are part of a regional problem and groundwater quality may actually be improving within the study area. Further post construction monitoring of nutrients and nutrient species is recommended to ensure the development is not exacerbating the current situation.

In summary Cardno recommends:

- Undertaking post construction monitoring of nutrients and nutrient species.

References

Australian and New Zealand Environment and Conservation Council (ANZECC), 2000, *National Water Quality Management Strategy,* Australian and New Zealand Guidelines for Fresh and Marine Water Quality.

Department of Environment (DOE), 2001, *Development of Sampling and Analysis Programs*, State Government of Western Australia, Perth.

Department of Water (DOW), 2007, *Stormwater Management Manual for Western Australia*, State Government of Western Australia, Perth.

Western Australian Planning Commission (WAPC), 2006, *Gingin Coast Structure Plan,* State of Western Australia, Perth.

Western Australian Planning Commission (WAPC), 2008, *Better Urban Water Management*, WAPC, Perth.

Figures

Figure 1 Locality Plan
Figure 2 Groundwater Contours and Monitoring Locations
Figure 3 Salinity Contours
Figure 4 TN Mapping
Figure 5 TP Mapping



DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD

DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD

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Scale: 1:160,000

0 2,500 5,000 10,000 15,000 Metres

PROJECT Moore River - Groundwater Monitoring

DRAWING TITLE FIGURE 1 : Locality Plan

PRINCIPAL Moore River Company Pty Ltd

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Project Number V9070
Original A4
Drawing Number SK44
Revision 00
Designed JN
Checked DPC
Drawn MGW
Approved DPC
Local Authority Shire of Gingin
Sheet 1 of 1
Date 12/04/10



DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD

DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD

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Scale: 1:12,000

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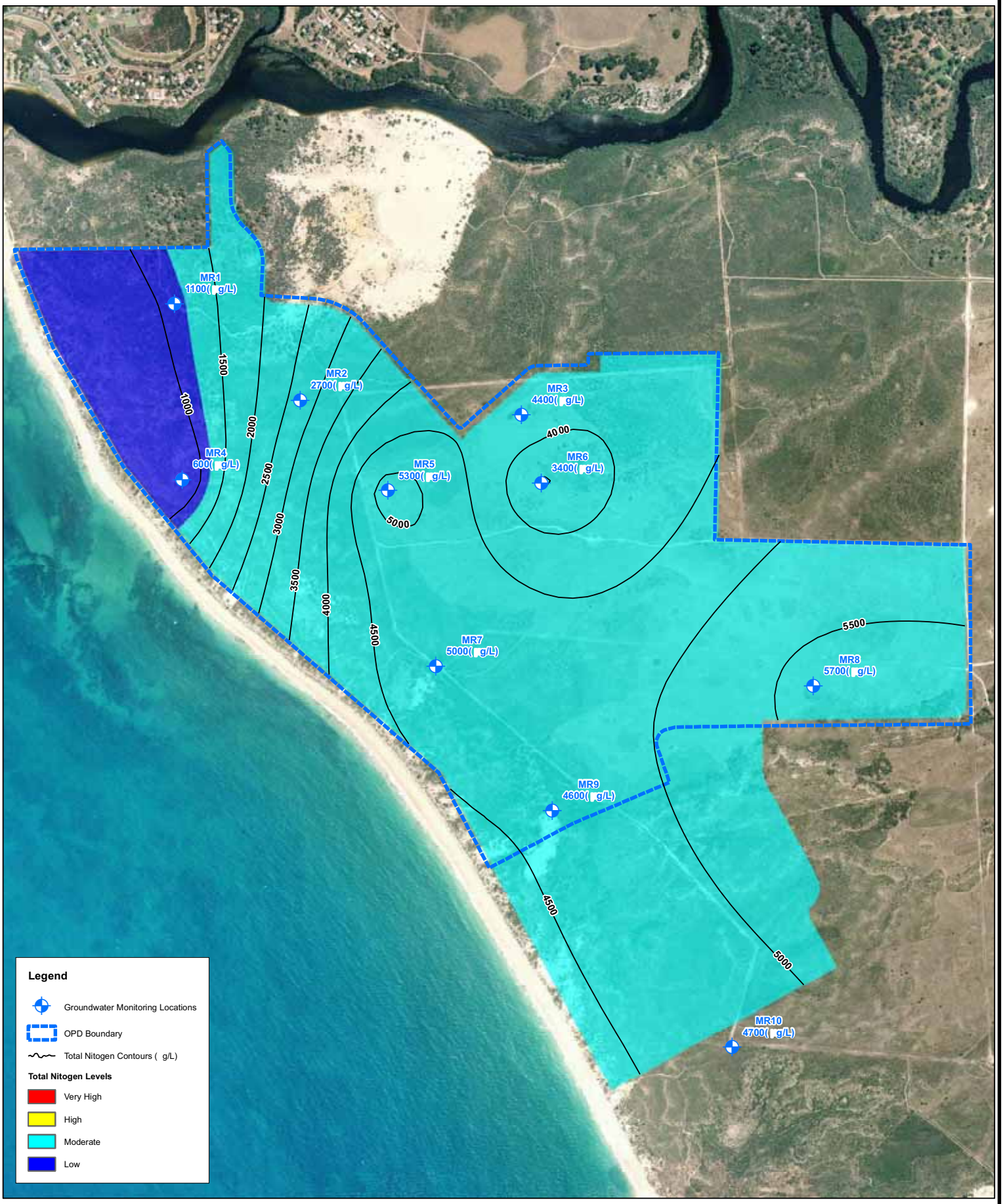
PROJECT: Moore River - Groundwater Monitoring

DRAWING TITLE: FIGURE 3: Salinity Contours

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Original: A3
Drawing Number: SK40
Revision: 00
Designed: JN
Checked: DPC
Drawn: MGW
Approved: DPC
Local Authority: Shire of Gingin
Sheet 1 of 1
Date: 12/04/10



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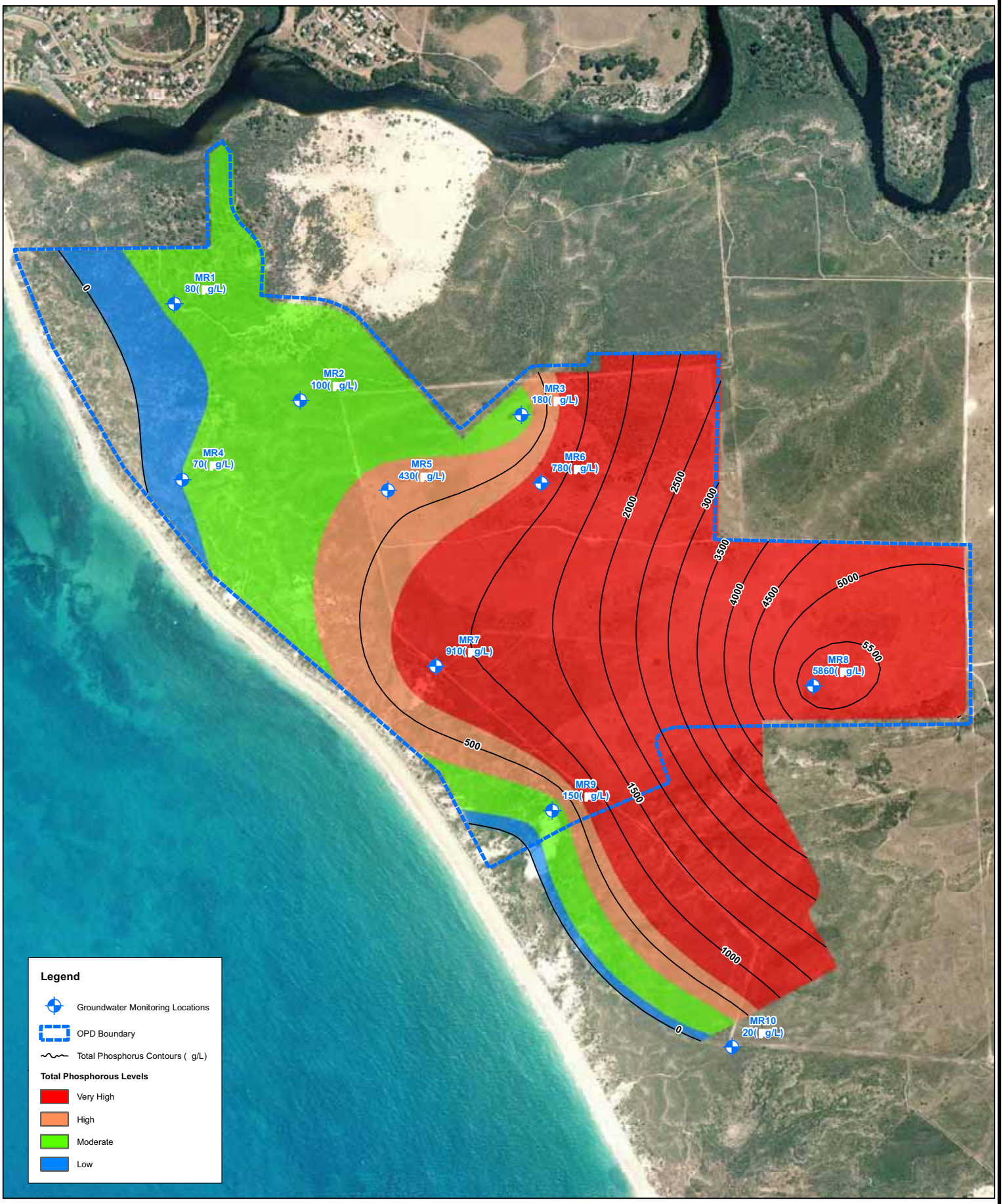
PROJECT: Moore River - Groundwater Monitoring

DRAWING TITLE: FIGURE 4: Total Nitogen Mapping

PRINCIPAL: Moore River Company Pty Ltd

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Project Number: V9070
Original: A3
Drawing Number: SK41
Revision: 00
Designed JN
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Drawn MGW
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Scale: 1:12,000

0 150 300 600 900 1,200 1,500 1,800 Metres

PROJECT **Moore River - Groundwater Monitoring**

DRAWING TITLE **FIGURE 5: Total Phosphorus Mapping**

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Project Number **V9070**

Original **A3**

Drawing Number **SK42**

Revision **00**

Designed JN

Checked DPC

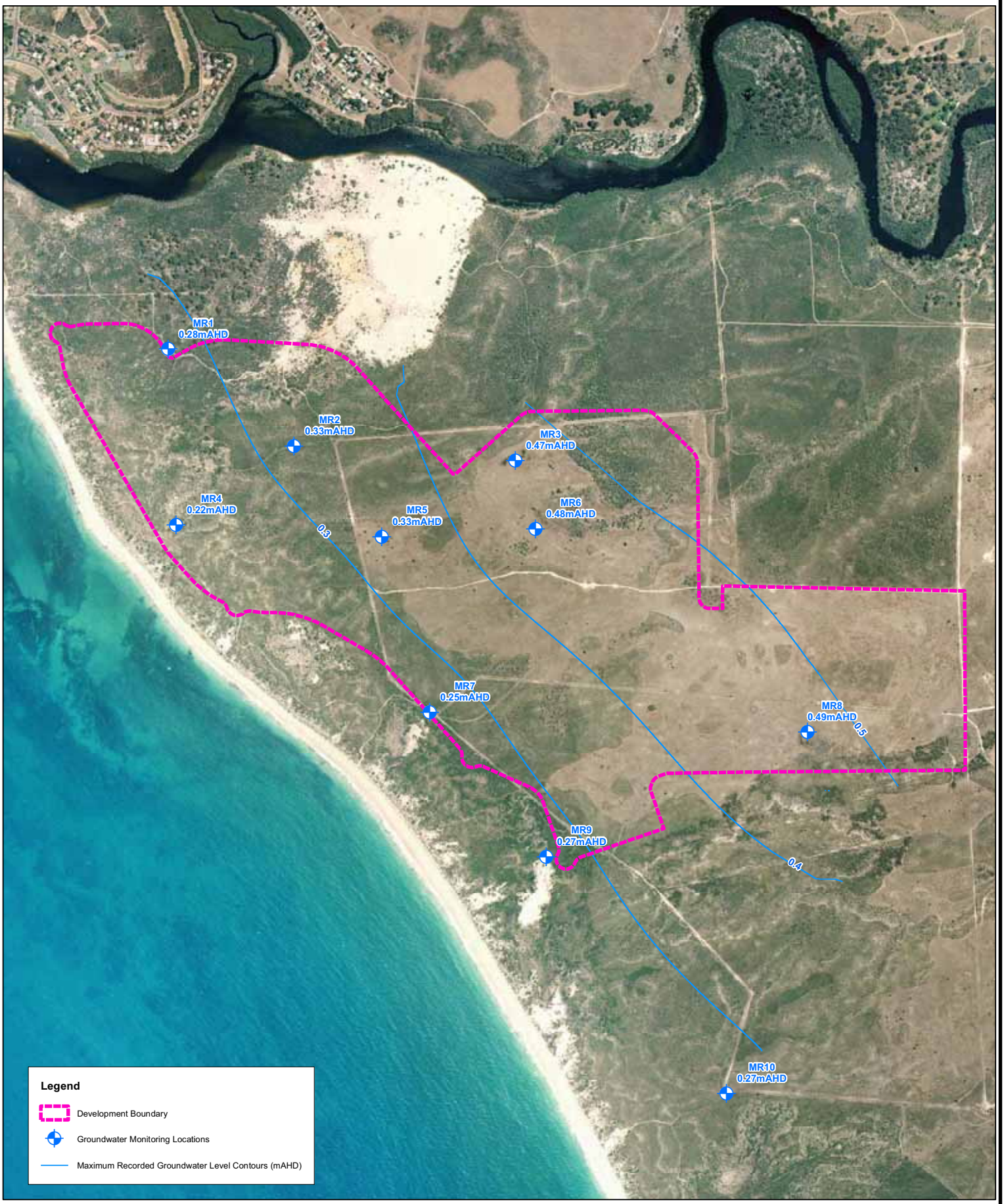
Drawn MGW

Approved DPC

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Sheet 1 of 1

Date 12/04/10



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DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD

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Scale: 1:12,000

0 150 300 600 900 1,200 1,500 1,800 Metres

PROJECT **Moore River - Groundwater Monitoring**

DRAWING TITLE **FIGURE 2: Bore Locations and Groundwater Contours**

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Project Number **V9070**

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Revision **00**

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Sheet 1 of 1

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Appendix A

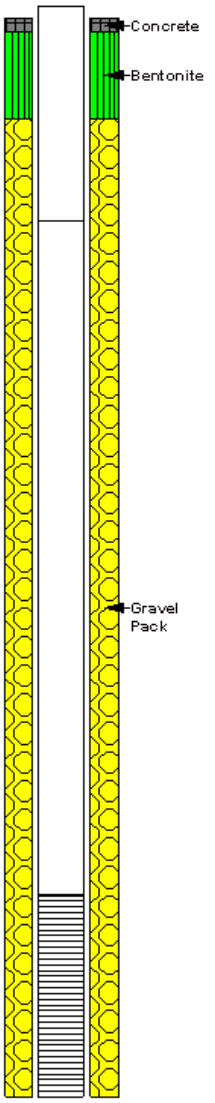
Bore Logs

MONITORING WELL LOG & CONSTRUCTION DESCRIPTIONS

PROJECT: Moore River
BORE NAME: MR9
BORE LOCATION: 359085 6528147
DATUM: GDA94
DRILLING METHOD: Sonic
CASING DIAMETER: 5cm

JOB NUMBER: V9070
DATE: 9/10/09
TOTAL DEPTH: 16
RL TOP OF CASING: 12.71
RL NATURAL SURFACE: 12.21
LOGGED BY: JLN

DEPTH mBGS	DEPTH mAHD	SOIL PROFILE	SOIL DESCRIPTION	MOISTURE CONTENT	DTW
0	0		Fine to coarse grey sands with some organics and some quartz fragments	moist	
1	-1				
2	-2		Medium yellow sands with traces of grey sands and some quartz fragments		
3	-3		Fine to medium orange sands		
4	-4		Tamala Limestone: Pale grey, calcareous, well cemented, lenses of medium grained quartz sand, sub angular to sub rounded in a carbonate cement.		
5	-5				
6	-6				
7	-7				
8	-8				
9	-9		Medium brown sands with some quartz fragments		
10	-10				
11	-11		Fine to medium red sands with traces of brown sands		
12	-12		Tamala Limestone: Pale grey, calcareous, well cemented, lenses of medium grained quartz sand, sub angular to sub rounded in a carbonate cement.		
13	-13			wet	▼
14	-14				
15	-15				
16	-16				



NOTES:

MONITORING WELL LOG & CONSTRUCTION DESCRIPTIONS

PROJECT: Moore River
BORE NAME: MR8
BORE LOCATION: 360115 6528486
DATUM: GDA94
DRILLING METHOD: Sonic
CASING DIAMETER: 5cm

JOB NUMBER: V9070
DATE: 9/10/09
TOTAL DEPTH: 34
RL TOP OF CASING: 28.85
RL NATURAL SURFACE: 28.26
LOGGED BY: JLN

DEPTH mBGS	DEPTH mAHD	SOIL PROFILE	SOIL DESCRIPTION	MOISTURE CONTENT	DTW	WELL CONSTRUCTION	WELL DESCRIPTION
0–12	0 to -12		Fine to coarse black sands with some organics and some quartz fragments; Fine to coarse grey sands with traces of white sands and some organics and some quartz fragments; Tamala Limestone: Pale grey, calcareous, well cemented, lenses of medium grained quartz sand, sub angular to sub rounded in a carbonate cement.	dry		Concrete; Bentonite	
12–13	-12 to -13		Fine to coarse white sands with some quartz fragments and some medium to coarse yellow sands	moist			
13–34	-13 to -34		Tamala Limestone: Pale grey, calcareous, well cemented, lenses of medium grained quartz sand, sub angular to sub rounded in a carbonate cement.	wet	▼	Gravel Pack	

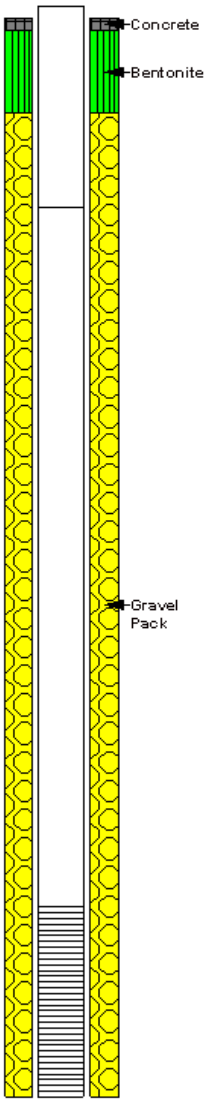
NOTES:

MONITORING WELL LOG & CONSTRUCTION DESCRIPTIONS

PROJECT: Moore River
BORE NAME: MR7
BORE LOCATION: 358845 6528550
DATUM: GDA94
DRILLING METHOD: Sonic
CASING DIAMETER: 5cm

JOB NUMBER: V9070
DATE: 9/10/09
TOTAL DEPTH: 17
RL TOP OF CASING: 14.65
RL NATURAL SURFACE: 13.9
LOGGED BY: JLN

DEPTH mBGS	DEPTH mAHD	SOIL PROFILE	SOIL DESCRIPTION	MOISTURE CONTENT	DTW
0	0				
1	-1		Fine to coarse grey sands with some organics and some quartz fragments	dry	
2	-2		Tamala Limestone: Pale grey, calcareous, well cemented, lenses of medium grained quartz sand, sub angular to sub rounded in a carbonate cement.	dry	
3	-3				
4	-4				
5	-5				
6	-6				
7	-7				
8	-8				
9	-9				
10	-10				
11	-11				
12	-12				
13	-13				
14	-14				
15	-15		Fine to coarse white sands with some quartz fragments and some medium to coarse yellow sands	wet	
16	-16				▼
17	-17				



NOTES:

MONITORING WELL LOG & CONSTRUCTION DESCRIPTIONS

PROJECT: Moore River
BORE NAME: MR6
BORE LOCATION: 358737 6529162
DATUM: GDA94
DRILLING METHOD: Sonic
CASING DIAMETER: 5cm

JOB NUMBER: V9070
DATE: 9/10/09
TOTAL DEPTH: 25m
RL TOP OF CASING: 22.2
RL NATURAL SURFACE: 21.51
LOGGED BY: JLN

DEPTH mBGS	DEPTH mAHD	SOIL PROFILE	SOIL DESCRIPTION	MOISTURE CONTENT	DTW	WELL CONSTRUCTION	WELL DESCRIPTION
0	0		Fine to coarse white sands with traces of grey sands and some organics and quartz fragments	dry		Concrete	
1	-1		Fine to medium grey sands with some quartz fragments	dry		Bentonite	
6	-6		Medium to coarse yellow sands with some quartz fragments	dry			
10	-10		Tamala Limestone: Pale grey, calcareous, well cemented, lenses of medium grained quartz sand, sub angular to sub rounded in a carbonate cement.	dry			
21	-21			wet	▼	Gravel Pack	
25	-25						

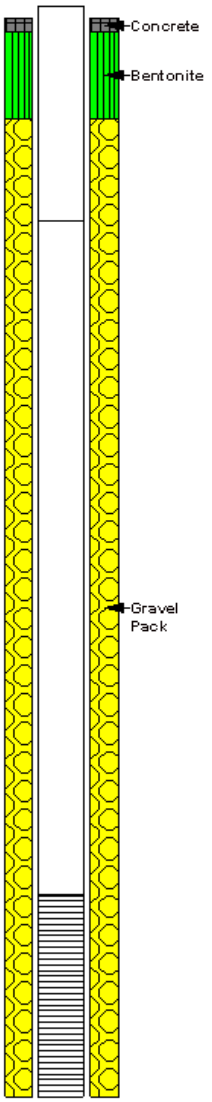
NOTES:

MONITORING WELL LOG & CONSTRUCTION DESCRIPTIONS

PROJECT: V9070
BORE NAME: MR5
BORE LOCATION: 358677 6529157
DATUM: GDA94
DRILLING METHOD: Sonic
CASING DIAMETER: 5cm

JOB NUMBER: V9070
DATE: 8/10/09
TOTAL DEPTH: 16
RL TOP OF CASING: 13.28
RL NATURAL SURFACE: 12.63
LOGGED BY: JLN

DEPTH mBGS	DEPTH mAHD	SOIL PROFILE	SOIL DESCRIPTION	MOISTURE CONTENT	DTW
0	0		Fine to coarse grey sands with some organics and some quartz fragments	moist	
1	-1		Medium to coarse yellow sands with some quartz fragments	dry	
7	-7		Tamala Limestone: Pale grey, calcareous, well cemented, lenses of medium grained quartz sand, sub angular to sub rounded in a carbonate cement.		
9	-9		Medium to coarse orange sands with some quartz fragments		
11	-11		Tamala Limestone: Pale grey, calcareous, well cemented, lenses of medium grained quartz sand, sub angular to sub rounded in a carbonate cement.	wet	▼
16	-16				



WELL CONSTRUCTION

WELL DESCRIPTION

NOTES:

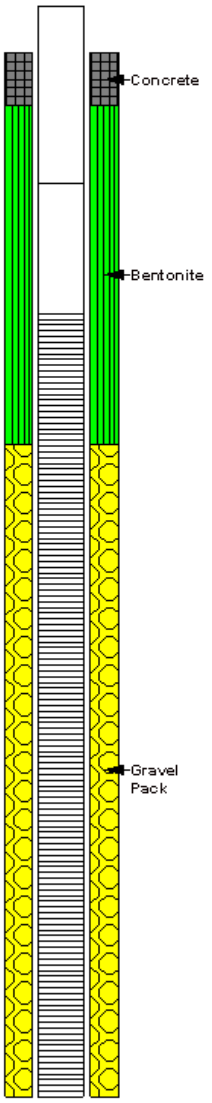
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PROJECT: V9070
BORE NAME: MR4
BORE LOCATION: 357972 6529190
DATUM: GDA94
DRILLING METHOD: Sonic
CASING DIAMETER: 5cm

JOB NUMBER: V9070
DATE: 7/10/09
TOTAL DEPTH: 4m
RL TOP OF CASING: 2.18
RL NATURAL SURFACE: 1.49
LOGGED BY: JLN

DEPTH mBGS	DEPTH mAHD	SOIL PROFILE	SOIL DESCRIPTION	MOISTURE CONTENT
0	0		Fine to medium grey sands with some medium white sands and some organics	moist
1	-1		Fine to medium grey sands with some orange sands and some quartz fragments	moist
2	-2		Fine to medium grey sands with some white sands and some quartz fragments	wet
3	-3			
4	-4			

DTW



NOTES:

MONITORING WELL LOG & CONSTRUCTION DESCRIPTIONS

PROJECT: Moore River
BORE NAME: MR3
BORE LOCATION: 359110 6529450
DATUM: GDA94
DRILLING METHOD: Sonic
CASING DIAMETER: 5cm

JOB NUMBER: V9070
DATE: 8/10/09
TOTAL DEPTH: 15.5
RL TOP OF CASING: 14.12
RL NATURAL SURFACE: 13.5
LOGGED BY: JLN

DEPTH mBGS	DEPTH mAHD	SOIL PROFILE	SOIL DESCRIPTION	MOISTURE CONTENT	DTW	WELL CONSTRUCTION	WELL DESCRIPTION
0	0		Medium to coarse black sands with some medium quartz fragments	dry			
1	-1		Medium to coarse yellow sands with traces of black sands and some medium quartz fragments	moist			
8	-8		Medium to coarse yellow sands with traces of medium white sands and some medium quartz fragments	moist			
10	-10		Tamala Limestone: Pale grey, calcareous, well cemented, lenses of medium grained quartz sand, sub angular to sub rounded in a carbonate cement.	moist	▼	Concrete Bentonite Gravel Pack	
19	-19						

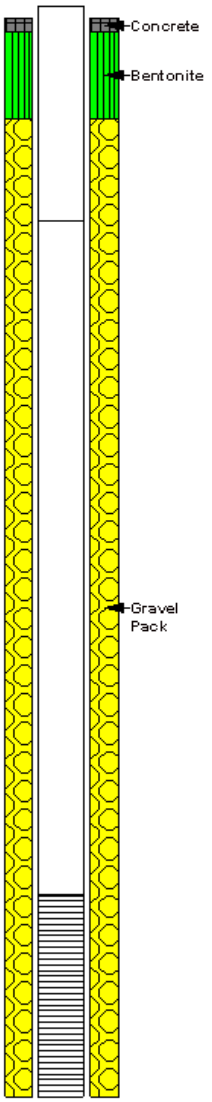
NOTES:

MONITORING WELL LOG & CONSTRUCTION DESCRIPTIONS

PROJECT: Moore River
BORE NAME: MR2
BORE LOCATION: 358360 6429472
DATUM: GDA94
DRILLING METHOD: Sonic
CASING DIAMETER: 5cm

JOB NUMBER: V9070
DATE: 8/10/09
TOTAL DEPTH: 16m
RL TOP OF CASING: 14.12
RL NATURAL SURFACE: 13.5
LOGGED BY: JLN

DEPTH mBGS	DEPTH mAHD	SOIL PROFILE	SOIL DESCRIPTION	MOISTURE CONTENT	DTW
0	0		Fine to coarse grey sands with some organics and some quartz fragments	dry	
1	-1		Medium to coarse yellow sands with some coarse limestone fragments		
2	-2		Medium to coarse white sands with some quartz fragments and some medium to coarse yellow sands		
3	-3		Medium to coarse brown sands with some orange sands and some quartz fragments		
4	-4				
5	-5				
6	-6		Fine to medium yellow sands		
7	-7				
8	-8		Tamala Limestone: Pale grey, calcareous, well cemented, lenses of medium grained quartz sand, sub angular to sub rounded in a carbonate cement.	moist	
9	-9				
10	-10				
11	-11				
12	-12			wet	
13	-13		Fine to coarse yellow sands with some medium to coarse quartz fragments		▼
14	-14				
15	-15				
16	-16				



WELL CONSTRUCTION

WELL DESCRIPTION

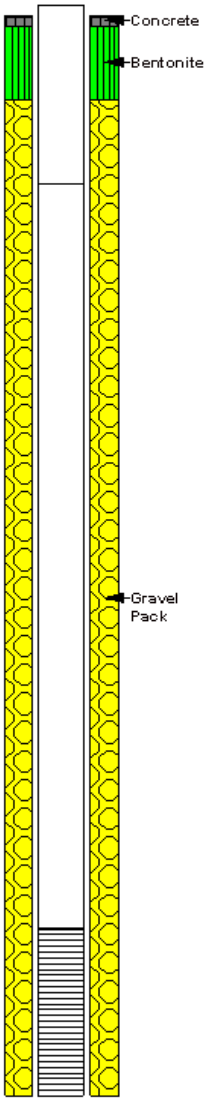
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MONITORING WELL LOG & CONSTRUCTION DESCRIPTIONS

PROJECT: Moore River
BORE NAME: MR1
BORE LOCATION: 357910 6529806
DATUM: GDA94
DRILLING METHOD: Sonic
CASING DIAMETER: 5cm

JOB NUMBER: V9070
DATE: 8/10/09
TOTAL DEPTH: 19.3
RL TOP OF CASING: 18.27
RL NATURAL SURFACE: 17.76
LOGGED BY: JLN

DEPTH mBGS	DEPTH mAHD	SOIL PROFILE	SOIL DESCRIPTION	MOISTURE CONTENT	DTW
0	0		Fine to coarse grey sands with some organics and some quartz fragments	moist	
1	-1		Medium to coarse yellow sands with some coarse limestone fragments	moist	
2	-2		Medium to coarse white sands with some coarse limestone fragments and some medium quartz fragments	moist	
3	-3				
4	-4				
5	-5				
6	-6				
7	-7				
8	-8		Fine to coarse white sands with some yellow sands and some coarse limestone fragments	dry	
9	-9				
10	-10				
11	-11				
12	-12		Tamala Limestone: Pale grey, calcareous, well cemented, lenses of medium grained quartz sand, sub angular to sub rounded in a carbonate cement.	dry	
13	-13				
14	-14				
15	-15				
16	-16				
17	-17			wet	
18	-18				
19	-19				



WELL CONSTRUCTION

WELL DESCRIPTION

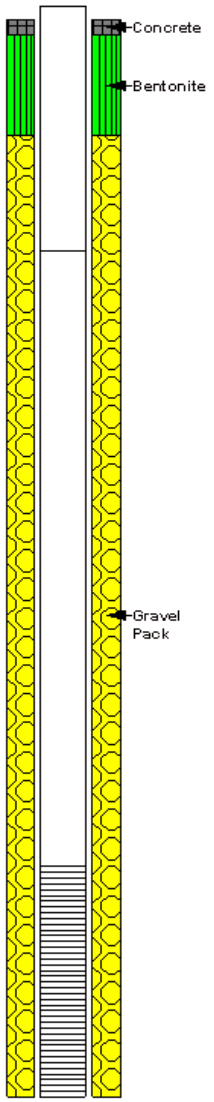
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MONITORING WELL LOG & CONSTRUCTION DESCRIPTIONS

PROJECT: Moore River
BORE NAME: MR10
BORE LOCATION: 359841 6527252
DATUM: GDA94
DRILLING METHOD: Sonic
CASING DIAMETER: 5cm

JOB NUMBER: V9070
DATE: 9/10/09
TOTAL DEPTH: 14
RL TOP OF CASING: 10.56
RL NATURAL SURFACE: 10.01
LOGGED BY: JLN

DEPTH mBGS	DEPTH mAHD	SOIL PROFILE	SOIL DESCRIPTION	MOISTURE CONTENT	DTW
0	0				
1	-1		Fine to medium grey sands with some yellow sands and some quartz fragments	moist	
2	-2				
3	-3		Tamala Limestone: Pale grey, calcareous, well cemented, lenses of medium grained quartz sand, sub angular to sub rounded in a carbonate cement.	dry	
4	-4				
5	-5				
6	-6				
7	-7		Medium brown sands with traces of grey sands	moist	
8	-8		Medium orange sands with traces of brown sands		
9	-9				
10	-10				
11	-11		Tamala Limestone: Pale grey, calcareous, well cemented, lenses of medium grained quartz sand, sub angular to sub rounded in a carbonate cement.	dry	
12	-12			wet	▼
13	-13				
14	-14				



NOTES:

Appendix B

Laboratory Certificates of Analysis and Chain of Custody Forms

CHAIN OF CUSTODY DOCUMENTATION

ALS Laboratory Group

CLIENT: Cardno	SAMPLER: JLN
ADDRESS / OFFICE: 2 Bagot Rd, Subiaco	MOBILE:
PROJECT MANAGER (PM): Dave Coremans	PHONE:
PROJECT ID: V9070	EMAIL REPORT TO: jorma.nolan@cardno.com.au
SITE: Moore River P.O. NO.:	EMAIL INVOICE TO: (if different to report)
RESULTS REQUIRED (**Date**): ASAP QUOTE NO.: EP/379/09	*

FOR LABORATORY USE ONLY
COOLER SEAL (circle appropriate)
Intact: Yes No N/A
SAMPLE TEMPERATURE
CHILLED: Yes No

COMMENTS / SPECIAL HANDLING / STORAGE OR DISPOSAL:

SAMPLE INFORMATION (note: S = Soil, W=Water) | CONTAINER INFORMATION

ALS ID	SAMPLE ID	MATRIX	DATE	Time	Type / Code	Total bottles	suite 2	Notes:
1	MR1		19/11/2009			7	X	unfiltered
2	MR2		19/11/2009			7	X	unfiltered
3	MR3		19/11/2009			7	X	unfiltered
4	MR4		19/11/2009			7	X	unfiltered
5	MR5		19/11/2009			7	X	unfiltered
6	MR6		19/11/2009			7	X	unfiltered
7	MR7		19/11/2009			7	X	unfiltered
8	QA		19/11/2009			7	X	unfiltered
9	MR9		↓				X	As per Jorma N 20/11 @ 1622
10	MR10		↓				X	

Environmental Division
Perth
Work Order
EP0906735
Telephone : +61-8-9209 7655

RELINQUISHED BY:		RECEIVED BY		METHOD OF SHIPMENT
Name: Jorma Nolan	Date:20/11/09	Name: Linda.W	Date: 20-11	Con' Note No:
Of: Cardno	Time: 0945	Of: ALS	Time: 1030	
Name:	Date:	Name:	Date:	Transport Co:
Of:	Time:	Of:	Time:	

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; V = VOA Vial HCl Preserved; VS = VOA Vial Sulphuric Preserved; SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass; Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag.

ALS LABORATORY GROUP

ENFM (204/5)

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES

Environmental Division

CERTIFICATE OF ANALYSIS

Work Order	: **EP0906735**	Page	: 1 of 10
Client	: **CARDNO (WA) PTY LTD**	Laboratory	: Environmental Division Perth
Contact	: MR JORMA NOLAN	Contact	: Michael Sharp
Address	: PO BOX 155 SUBIACO WA, AUSTRALIA 6904	Address	: 10 Hod Way Malaga WA Australia 6090
E-mail	: jorma.nolan@cardno.com.au	E-mail	: michael.sharp@alsenviro.com
Telephone	: +61 08 9273 3888	Telephone	: +61-8-9209 7655
Facsimile	: +61 08 9388 3831	Facsimile	: +61-8-9209 7600
Project	: V9070	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: ----		
C-O-C number	: ----	Date Samples Received	: 20-NOV-2009
Sampler	: JLN	Issue Date	: 27-NOV-2009
Site	: Moore River		
		No. of samples received	: 10
Quote number	: EP-379-09	No. of samples analysed	: 10

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits

NATA Accredited Laboratory 825

This document is issued in accordance with NATA accreditation requirements.

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Rassem Ayoubi	Organic Chemist	Perth Organics
Scott James	Assistant Laboratory Manager	Perth Inorganics
Todd Lee	Senior Organic Chemist	Perth Inorganics
Todd Lee	Senior Organic Chemist	Perth Organics

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insuffient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When date(s) and/or time(s) are shown bracketed, these have been assumed by the laboratory for processing purposes. If the sampling time is displayed as 0:00 the information was not provided by client.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting

- **EK061G/EK067G: LOR raised for TKN/TP on various samples due to matrix effect.**

Analytical Results

Sub-Matrix: **WATER**

Compound	CAS Number	LOR	Unit	Client sample ID: MR1	MR2	MR3	MR4	MR5
				Client sampling date / time: 19-NOV-2009 15:00	19-NOV-2009 15:00	19-NOV-2009 15:00	19-NOV-2009 15:00	19-NOV-2009 15:00
				EP0906735-001	EP0906735-002	EP0906735-003	EP0906735-004	EP0906735-005
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Arsenic	7440-38-2	0.001	mg/L	<0.001	<0.001	<0.001	**0.002**	**0.001**
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	**0.0003**	<0.0001	<0.0001
Chromium	7440-47-3	0.001	mg/L	<0.001	**0.003**	**0.002**	<0.001	**0.001**
Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	**0.004**	<0.001	<0.001
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	**0.004**	<0.001	<0.001
Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	<0.001	**0.001**	<0.001
Zinc	7440-66-6	0.005	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005
Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
EG020T: Total Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	**0.16**	**0.06**	**1.58**	<0.01	**0.16**
Arsenic	7440-38-2	0.001	mg/L	**0.002**	<0.001	**0.002**	**0.002**	**0.002**
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	**0.0002**
Chromium	7440-47-3	0.001	mg/L	<0.001	**0.003**	**0.010**	<0.001	**0.003**
Copper	7440-50-8	0.001	mg/L	**0.002**	<0.001	**0.006**	<0.001	<0.001
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	**0.001**	<0.001	<0.001
Nickel	7440-02-0	0.001	mg/L	<0.001	**0.001**	<0.001	<0.001	<0.001
Zinc	7440-66-6	0.005	mg/L	<0.005	<0.005	**0.010**	<0.005	<0.005
Iron	7439-89-6	0.05	mg/L	**0.41**	**0.09**	**1.69**	<0.05	**0.20**
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EG035T: Total Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EK055G: Ammonia as N by Discrete Analyser								
Ammonia as N	7664-41-7	0.01	mg/L	**0.02**	**0.01**	**0.03**	**0.01**	**0.05**
EK059G: NOX as N by Discrete Analyser								
Nitrite + Nitrate as N	----	0.01	mg/L	**0.99**	**3.39**	**3.83**	**0.80**	**4.20**
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	0.1	mg/L	<0.1	<0.2	<0.2	**0.3**	**0.4**
EK062G: Total Nitrogen AsN By Discrete Analyset								
^ Total Nitrogen as N	----	0.1	mg/L	**1.0**	**3.4**	**3.8**	**1.1**	**4.6**
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	0.01	mg/L	**0.29**	<0.02	**0.13**	**0.05**	<0.02
EK071G: Reactive Phosphorus as P by discrete analyser								
Reactive Phosphorus as P	----	0.01	mg/L	<0.01	<0.01	<0.01	**0.05**	<0.01
EP068A: Organochlorine Pesticides (OC)								

Analytical Results

Sub-Matrix: **WATER**

Compound	CAS Number	LOR	Unit	Client sample ID: MR1	MR2	MR3	MR4	MR5
				Client sampling date / time: 19-NOV-2009 15:00	19-NOV-2009 15:00	19-NOV-2009 15:00	19-NOV-2009 15:00	19-NOV-2009 15:00
				EP0906735-001	EP0906735-002	EP0906735-003	EP0906735-004	EP0906735-005
EP068A: Organochlorine Pesticides (OC) - Continued								
alpha-BHC	319-84-6	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Hexachlorobenzene (HCB)	118-74-1	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
beta-BHC	319-85-7	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
gamma-BHC	58-89-9	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
delta-BHC	319-86-8	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Heptachlor	76-44-8	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Aldrin	309-00-2	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Heptachlor epoxide	1024-57-3	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
trans-Chlordane	5103-74-2	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
alpha-Endosulfan	959-98-8	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
cis-Chlordane	5103-71-9	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Dieldrin	60-57-1	0.5	µg/L	<0.6	<0.6	<0.6	<0.6	<0.6
4.4`-DDE	72-55-9	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Endrin	72-20-8	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
beta-Endosulfan	33213-65-9	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
4.4`-DDD	72-54-8	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Endrin aldehyde	7421-93-4	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Endosulfan sulfate	1031-07-8	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
4.4`-DDT	50-29-3	2	µg/L	<2	<2	<2	<2	<2
Endrin ketone	53494-70-5	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Methoxychlor	72-43-5	2	µg/L	<2	<2	<2	<2	<2
EP068B: Organophosphorus Pesticides (OP)								
Dichlorvos	62-73-7	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Demeton-S-methyl	919-86-8	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Monocrotophos	6923-22-4	2	µg/L	<2	<2	<2	<2	<2
Dimethoate	60-51-5	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Diazinon	333-41-5	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Chlorpyrifos-methyl	5598-13-0	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Parathion-methyl	298-00-0	2	µg/L	<2	<2	<2	<2	<2
Malathion	121-75-5	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Fenthion	55-38-9	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Chlorpyrifos	2921-88-2	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Parathion	56-38-2	2	µg/L	<2	<2	<2	<2	<2
Pirimphos-ethyl	23505-41-1	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Chlorfenvinphos	470-90-6	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Bromophos-ethyl	4824-78-6	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Fenamiphos	22224-92-6	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Prothiofos	34643-46-4	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5

Analytical Results

Sub-Matrix: WATER				Client sample ID	MR1	MR2	MR3	MR4	MR5
				Client sampling date / time	19-NOV-2009 15:00	19-NOV-2009 15:00	19-NOV-2009 15:00	19-NOV-2009 15:00	19-NOV-2009 15:00
Compound	CAS Number	LOR	Unit		EP0906735-001	EP0906735-002	EP0906735-003	EP0906735-004	EP0906735-005
EP068B: Organophosphorus Pesticides (OP) - Continued									
Ethion	563-12-2	0.5	µg/L		<0.5	<0.5	<0.5	<0.5	<0.5
Carbophenothion	786-19-6	0.5	µg/L		<0.5	<0.5	<0.5	<0.5	<0.5
Azinphos Methyl	---	0.5	µg/L		<0.5	<0.5	<0.5	<0.5	<0.5
EP071/080: Total Petroleum Hydrocarbons									
C6 - C9 Fraction	---	20	µg/L		<20	<20	<20	<20	<20
C10 - C14 Fraction	---	50	µg/L		<50	<50	<50	<50	<50
C15 - C28 Fraction	---	100	µg/L		<100	<100	<100	<100	<100
C29 - C36 Fraction	---	50	µg/L		<50	<50	<50	<50	70
EP080/071: Total Petroleum Hydrocarbons									
^ C10 - C36 Fraction (sum)	---	50	µg/L		<50	<50	<50	<50	70
EP068S: Organochlorine Pesticide Surrogate									
Dibromo-DDE	21655-73-2	0.1	%		103	102	98.2	95.6	99.6
EP068T: Organophosphorus Pesticide Surrogate									
DEF	78-48-8	0.1	%		58.5	88.4	98.8	93.3	110
EP080S: TPH(V)/BTEX Surrogates									
1.2-Dichloroethane-D4	17060-07-0	0.1	%		81.2	74.8	74.8	74.4	75.1
Toluene-D8	2037-26-5	0.1	%		87.7	86.1	84.9	85.7	83.5
4-Bromofluorobenzene	460-00-4	0.1	%		83.5	84.5	82.5	84.2	83.9

Analytical Results

Sub-Matrix: **WATER**

Compound	CAS Number	LOR	Unit	Client sample ID: MR6	MR7	QA	MR9	MR10
				Client sampling date / time: 19-NOV-2009 15:00	19-NOV-2009 15:00	19-NOV-2009 15:00	19-NOV-2009 15:00	19-NOV-2009 15:00
				EP0906735-006	EP0906735-007	EP0906735-008	EP0906735-009	EP0906735-010
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Arsenic	7440-38-2	0.001	mg/L	<0.001	**0.001**	**0.001**	**0.002**	**0.001**
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	**0.0003**
Chromium	7440-47-3	0.001	mg/L	**0.001**	**0.003**	**0.002**	**0.003**	**0.003**
Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Lead	7439-92-1	0.001	mg/L	**0.001**	<0.001	<0.001	<0.001	<0.001
Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	**0.001**	<0.001	<0.001
Zinc	7440-66-6	0.005	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005
Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
EG020T: Total Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	**0.05**	**0.20**	**0.16**	**0.23**	**0.39**
Arsenic	7440-38-2	0.001	mg/L	<0.001	**0.004**	**0.002**	**0.003**	**0.004**
Cadmium	7440-43-9	0.0001	mg/L	**0.0002**	**0.0002**	**0.0007**	**0.0002**	**0.0002**
Chromium	7440-47-3	0.001	mg/L	**0.004**	**0.010**	**0.003**	**0.006**	**0.010**
Copper	7440-50-8	0.001	mg/L	<0.001	**0.002**	<0.001	<0.001	<0.001
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Nickel	7440-02-0	0.001	mg/L	**0.002**	<0.001	<0.001	<0.001	<0.001
Zinc	7440-66-6	0.005	mg/L	<0.005	**0.006**	<0.005	<0.005	**0.006**
Iron	7439-89-6	0.05	mg/L	**0.17**	**0.72**	**0.16**	**0.24**	**0.59**
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EG035T: Total Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EK055G: Ammonia as N by Discrete Analyser								
Ammonia as N	7664-41-7	0.01	mg/L	**0.03**	**0.01**	**0.05**	**0.02**	**0.01**
EK059G: NOX as N by Discrete Analyser								
Nitrite + Nitrate as N	----	0.01	mg/L	**2.98**	**4.30**	**3.87**	**6.82**	**2.25**
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	0.1	mg/L	**0.3**	**0.8**	<0.2	<0.5	<0.2
EK062G: Total Nitrogen AsN By Discrete Analyset								
^ Total Nitrogen as N	----	0.1	mg/L	**3.2**	**5.1**	**3.9**	**6.8**	**2.2**
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	0.01	mg/L	<0.02	**0.12**	<0.02	<0.05	**0.11**
EK071G: Reactive Phosphorus as P by discrete analyser								
Reactive Phosphorus as P	----	0.01	mg/L	**0.01**	**0.01**	<0.01	<0.01	**0.01**
EP068A: Organochlorine Pesticides (OC)								

Analytical Results

Sub-Matrix: **WATER**

Compound	CAS Number	LOR	Unit	Client sample ID: MR6	MR7	QA	MR9	MR10
				Client sampling date / time: 19-NOV-2009 15:00	19-NOV-2009 15:00	19-NOV-2009 15:00	19-NOV-2009 15:00	19-NOV-2009 15:00
				EP0906735-006	EP0906735-007	EP0906735-008	EP0906735-009	EP0906735-010
EP068A: Organochlorine Pesticides (OC) - Continued								
alpha-BHC	319-84-6	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Hexachlorobenzene (HCB)	118-74-1	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
beta-BHC	319-85-7	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
gamma-BHC	58-89-9	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
delta-BHC	319-86-8	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Heptachlor	76-44-8	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Aldrin	309-00-2	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Heptachlor epoxide	1024-57-3	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
trans-Chlordane	5103-74-2	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
alpha-Endosulfan	959-98-8	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
cis-Chlordane	5103-71-9	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Dieldrin	60-57-1	0.5	µg/L	<0.6	<0.6	<0.6	<0.6	<0.6
4.4`-DDE	72-55-9	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Endrin	72-20-8	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
beta-Endosulfan	33213-65-9	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
4.4`-DDD	72-54-8	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Endrin aldehyde	7421-93-4	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Endosulfan sulfate	1031-07-8	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
4.4`-DDT	50-29-3	2	µg/L	<2	<2	<2	<2	<2
Endrin ketone	53494-70-5	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Methoxychlor	72-43-5	2	µg/L	<2	<2	<2	<2	<2
EP068B: Organophosphorus Pesticides (OP)								
Dichlorvos	62-73-7	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Demeton-S-methyl	919-86-8	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Monocrotophos	6923-22-4	2	µg/L	<2	<2	<2	<2	<2
Dimethoate	60-51-5	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Diazinon	333-41-5	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Chlorpyrifos-methyl	5598-13-0	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Parathion-methyl	298-00-0	2	µg/L	<2	<2	<2	<2	<2
Malathion	121-75-5	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Fenthion	55-38-9	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Chlorpyrifos	2921-88-2	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Parathion	56-38-2	2	µg/L	<2	<2	<2	<2	<2
Pirimphos-ethyl	23505-41-1	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Chlorfenvinphos	470-90-6	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Bromophos-ethyl	4824-78-6	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Fenamiphos	22224-92-6	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Prothiofos	34643-46-4	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5

Analytical Results

Sub-Matrix: WATER				Client sample ID	MR6	MR7	QA	MR9	MR10
				Client sampling date / time	19-NOV-2009 15:00	19-NOV-2009 15:00	19-NOV-2009 15:00	19-NOV-2009 15:00	19-NOV-2009 15:00
Compound	CAS Number	LOR	Unit		EP0906735-006	EP0906735-007	EP0906735-008	EP0906735-009	EP0906735-010
EP068B: Organophosphorus Pesticides (OP) - Continued									
Ethion	563-12-2	0.5	µg/L		<0.5	<0.5	<0.5	<0.5	<0.5
Carbophenothion	786-19-6	0.5	µg/L		<0.5	<0.5	<0.5	<0.5	<0.5
Azinphos Methyl	---	0.5	µg/L		<0.5	<0.5	<0.5	<0.5	<0.5
EP071/080: Total Petroleum Hydrocarbons									
C6 - C9 Fraction	---	20	µg/L		<20	<20	<20	<20	<20
C10 - C14 Fraction	---	50	µg/L		<50	<50	<50	<50	<50
C15 - C28 Fraction	---	100	µg/L		<100	<100	<100	<100	<100
C29 - C36 Fraction	---	50	µg/L		<50	<50	**90**	<50	<50
EP080/071: Total Petroleum Hydrocarbons									
^ C10 - C36 Fraction (sum)	---	50	µg/L		<50	<50	**90**	<50	<50
EP068S: Organochlorine Pesticide Surrogate									
Dibromo-DDE	21655-73-2	0.1	%		**114**	**108**	**122**	**123**	**94.8**
EP068T: Organophosphorus Pesticide Surrogate									
DEF	78-48-8	0.1	%		**108**	**108**	**99.3**	**114**	**99.4**
EP080S: TPH(V)/BTEX Surrogates									
1.2-Dichloroethane-D4	17060-07-0	0.1	%		**79.0**	**78.1**	**85.1**	**82.3**	**85.6**
Toluene-D8	2037-26-5	0.1	%		**87.4**	**83.6**	**83.0**	**83.2**	**83.2**
4-Bromofluorobenzene	460-00-4	0.1	%		**84.0**	**82.8**	**81.2**	**78.8**	**82.0**

Surrogate Control Limits

Sub-Matrix: **WATER**		Recovery Limits (%)	
Compound	*CAS Number*	*Low*	*High*
EP068S: Organochlorine Pesticide Surrogate			
Dibromo-DDE	21655-73-2	10.0	136
EP068T: Organophosphorus Pesticide Surrogate			
DEF	78-48-8	10.0	136
EP080S: TPH(V)/BTEX Surrogates			
1.2-Dichloroethane-D4	17060-07-0	70.0	130
Toluene-D8	2037-26-5	70.0	130
4-Bromofluorobenzene	460-00-4	70.0	130

CHAIN OF CUSTODY DOCUMENTATION

ALS Laboratory Group

CLIENT: Cardno	SAMPLER: JLN
ADDRESS / OFFICE: 2 Bagot Rd, Subiaco	MOBILE:
PROJECT MANAGER (PM): Dave Coremans	PHONE:
PROJECT ID: V9070	EMAIL REPORT TO: jorma.nolan@cardno.com.au
SITE: Moore River P.O. NO.:	EMAIL INVOICE TO: (if different to report)
RESULTS REQUIRED (Date): ASAP QUOTE NO.: EP/379/09	*

FOR LABORATORY USE ONLY
COOLER SEAL (circle appropriate)
Intact: Yes No N/A
SAMPLE TEMPERATURE
CHILLED: Yes No

COMMENTS / SPECIAL HANDLING / STORAGE OR DISPOSAL:

SAMPLE INFORMATION (note: S = Soil, W=Water)					CONTAINER INFORMATION		suite 1	Notes:
ALS ID	SAMPLE ID	MATRIX	DATE	Time	Type / Code	Total bottles		
1	MR1	W	8/02/2010		P,HCl	2	X	unfiltered
2	MR2	W	8/02/2010		P,HCl	2	X	unfiltered
3	MR3	W	8/02/2010		P,HCl	2	X	unfiltered
4	MR4	W	8/02/2010		P,HCl	2	X	unfiltered
5	MR5	W	8/02/2010		P,HCl	2	X	unfiltered
6	MR6	W	8/02/2010		P,HCl	2	X	unfiltered
7	MR7	W	8/02/2010		P,HCl	2	X	unfiltered
8	MR8	W	8/02/2010		P,HCl	2	X	unfiltered
9	MR9	W	8/02/2010		P,HCl	2	X	unfiltered
10	MR10	W	8/02/2010		P,HCl	2	X	unfiltered
11	QA	W	8/02/2010		P,HCl	2	X	unfiltered

Environmental Division
Perth
Work Order
EP1000762



Telephone : +61-8-9209 7655

RELINQUISHED BY:		RECEIVED BY		METHOD OF SHIPMENT
Name: Jorma Nolan	Date: 10/02/10	Name: Shuk	Date: 10.02.10	Con' Note No:
Of: Cardno	Time: 1515	Of: ALSE	Time: 16:44	
Name:	Date:	Name:	Date:	Transport Co:
Of:	Time:	Of:	Time:	

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; V = VOA Vial HCl Preserved; VS = VOA Vial Sulphuric Preserved; SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass; Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag.

Analytical Charges

Suite 1

Parameter	ALS Method/ Package Code	Technique/ Method Reference	Limit of Reporting (mg/L) (or as indicated)	Price per Sample ($)
Nitrogen - Ammonia as N	EK055G	APHA 4500-NH_3-H	0.01	20.00
Total Nitrogen *(incl TKN + NO_x)* + Total Phosphorus	**NT-11**	EK062, EK061, EK057, EK058, EK067	0.01 (TN, TKN - 0.1)	50.00
Phosphorus – Reactive	EK071G	APHA 4500-P G	0.01	12.00
TOTAL SUITE COST FOR WATER SAMPLES:				**82.00**

Please note: *to receive analysis at the above cost, the ALS quotation number must be referenced on the COC.*

Suite 2

Parameter	ALS Method/ Package Code	Technique/ Method Reference	Limit of Reporting (mg/L) (or as indicated)	Price per Sample ($)
Nitrogen - Ammonia as N	EK055G	APHA 4500-NH_3-H	0.01	20.00
Total Nitrogen *(incl TKN + NO_x)* + Total Phosphorus	**NT-11**	EK062, EK061, EK057, EK058, EK067	0.01 (TN, TKN - 0.1)	50.00
Phosphorus – Reactive	EK071G	APHA 4500-P G	0.01	12.00
Dissolved Metals by ICPMS – As, Cd, Cr, Cu, Pb, Ni, Zn, Al, Fe	EG020F	USEPA 6020 ICPMS	0.0001 - 0.01	22.00
Total Recoverable Metals by ICPMS (incl digest) – As, Cd, Cr, Cu, Pb, Ni, Zn, Al, Fe	EG020T	USEPA 6020 ICPMS	0.0001 - 0.01	28.00
Mercury – **Dissolved**	EG035F	APHA 3112 Hg-B CV/FIMS	0.0001	10.00
Mercury - **Total Recoverable**	EG035T	APHA 3112 Hg-B CV/FIMS	0.0001	10.00
TPH (C6-C36) [19]	EP080/ EP071	USEPA 5030/8260 USEPA 3510/8015 P&T-GC/MS/FID	20-100 µg/L	49.00
OC/OP Pesticides	**W-12**	GC/ECD/FPD-MS	0.5-2 µg/L	65.00
TOTAL SUITE COST FOR WATER SAMPLES:				**266.00**

Please note: *to receive analysis at the above cost, the ALS quotation number must be referenced on the COC.*

Where metals suites are stipulated '**T**' denotes Total metals analysis (eg. W-2 T = 8 Total Metals). Where no '**T**' is present in the suite code, this denotes dissolved/filtered metals.

For metals in waters, field filtration status must be clearly indicated on the bottle label (via tick) indicating whether total or dissolved metals are required.

Package Prices apply only when specific ALS Group Codes ('W' & 'NT' suites) are selected on COCs. Standard LORs apply for suites.

Administration Charges

An administration fee of $30.00 is applicable to each submission of samples submitted regardless of the size of the submission.

Sample Container Requirements

ALS provides pre-treated and labelled sample containers, for all analytical work to be conducted at the laboratory. Samples for analysis should be chilled whilst en route to the laboratory. **Please contact the laboratory to organise bottle delivery via email address bottles.perth@alsenviro.com.**

Suite 1

Test Parameter	Label Colour	Container Type (*Preservation*)
INORGANICS		
FRP	Green	1 x **250ml** Green (*none*)
Ammonia, TN, NOx, TKN, TP	Purple	1 x **125ml** plastic (*Sulphuric acid*)

Suite 2

Test Parameter	Label Colour	Container Type (*Preservation*)
INORGANICS		
FRP	Green	1 x **250ml** Green (*none*)
Ammonia, TN, NOx, TKN, TP	Purple	1 x **125ml** plastic (*Sulphuric acid*)
METALS		
Total Heavy Metals	Red & Green Stripe	1 x **60ml** plastic (*none*) **AIRFREIGHT OPTION**
Dissolved Heavy Metals **(Field Filtered)**	Red & Green Stripe	1 x **60ml** plastic (*none*) **AIRFREIGHT OPTION**
ORGANICS		
TPH(C_6-C_9)	Maroon *	2 x **40ml** Amber vials (*Hydrochloric Acid*)
TPH (C_{10}-C_{36})	Orange *	1 x **500ml** Amber glass (*none*) for primary analysis. 2 x additional **500ml** Amber glass (*none*) for laboratory duplicates and matrix spikes.

Important Notes:

- All bottles for organics analysis (where appropriate) are provided with Teflon lined lids. These are marked in the above tables with the following symbol *.
- For general semi-volatile organics or LC/MS analysis in orange labelled Amber bottles, ALS is working to reduce the total volume of sample required. This provides considerable benefits with respect to sampling, OH&S and the environment. CURRENT orange labels may indicate larger sample volumes are required however in many cases where differences are observed between orange or orange and white stripe labels and the above tables, the tables should be followed.

Environmental Division

CERTIFICATE OF ANALYSIS

Work Order	: **EP1000762**	Page	: 1 of 5
Client	: **CARDNO (WA) PTY LTD**	Laboratory	: Environmental Division Perth
Contact	: MR JORMA NOLAN	Contact	: Scott James
Address	: PO BOX 155 SUBIACO WA, AUSTRALIA 6904	Address	: 10 Hod Way Malaga WA Australia 6090
E-mail	: jorma.nolan@cardno.com.au	E-mail	: scott.james@alsenviro.com
Telephone	: +61 08 9273 3888	Telephone	: +61-8-9209 7655
Facsimile	: +61 08 9388 3831	Facsimile	: +61-8-9209 7600
Project	: V9070	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: ----		
C-O-C number	: ----	Date Samples Received	: 10-FEB-2010
Sampler	: JLN	Issue Date	: 16-FEB-2010
Site	: Moore River		
		No. of samples received	: 11
Quote number	: EP-379-09	No. of samples analysed	: 11

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

NATA Accredited Laboratory 825

This document is issued in accordance with NATA accreditation requirements.

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ankit Joshi	Inorganic Chemist	Perth Inorganics

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insuffient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When date(s) and/or time(s) are shown bracketed, these have been assumed by the laboratory for processing purposes. If the sampling time is displayed as 0:00 the information was not provided by client.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting

- **LOR raised for TKN on certain samples due to matrix effects.**

Analytical Results

Sub-Matrix: **WATER**

Compound	CAS Number	LOR	Unit	Client sample ID: MR1	MR2	MR3	MR4	MR5
				Client sampling date / time: 08-FEB-2010 15:00	08-FEB-2010 15:00	08-FEB-2010 15:00	08-FEB-2010 15:00	08-FEB-2010 15:00
				EP1000762-001	EP1000762-002	EP1000762-003	EP1000762-004	EP1000762-005
EK055G: Ammonia as N by Discrete Analyser								
Ammonia as N	7664-41-7	0.01	mg/L	**0.02**	<0.01	**0.01**	**0.02**	**0.01**
EK059G: NOX as N by Discrete Analyser								
Nitrite + Nitrate as N	----	0.01	mg/L	**0.88**	**2.56**	**4.45**	**0.35**	**4.41**
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	0.1	mg/L	**0.2**	**0.1**	<0.2	**0.3**	**0.9**
EK062: Total Nitrogen as N (TKN + NOx)								
^ Total Nitrogen as N	----	0.1	mg/L	**1.1**	**2.7**	**4.4**	**0.6**	**5.3**
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	0.01	mg/L	**0.08**	**0.10**	**0.18**	**0.07**	**0.43**
EK071G: Reactive Phosphorus as P by discrete analyser								
Reactive Phosphorus as P	----	0.01	mg/L	<0.01	<0.01	<0.01	**0.04**	<0.01

Analytical Results

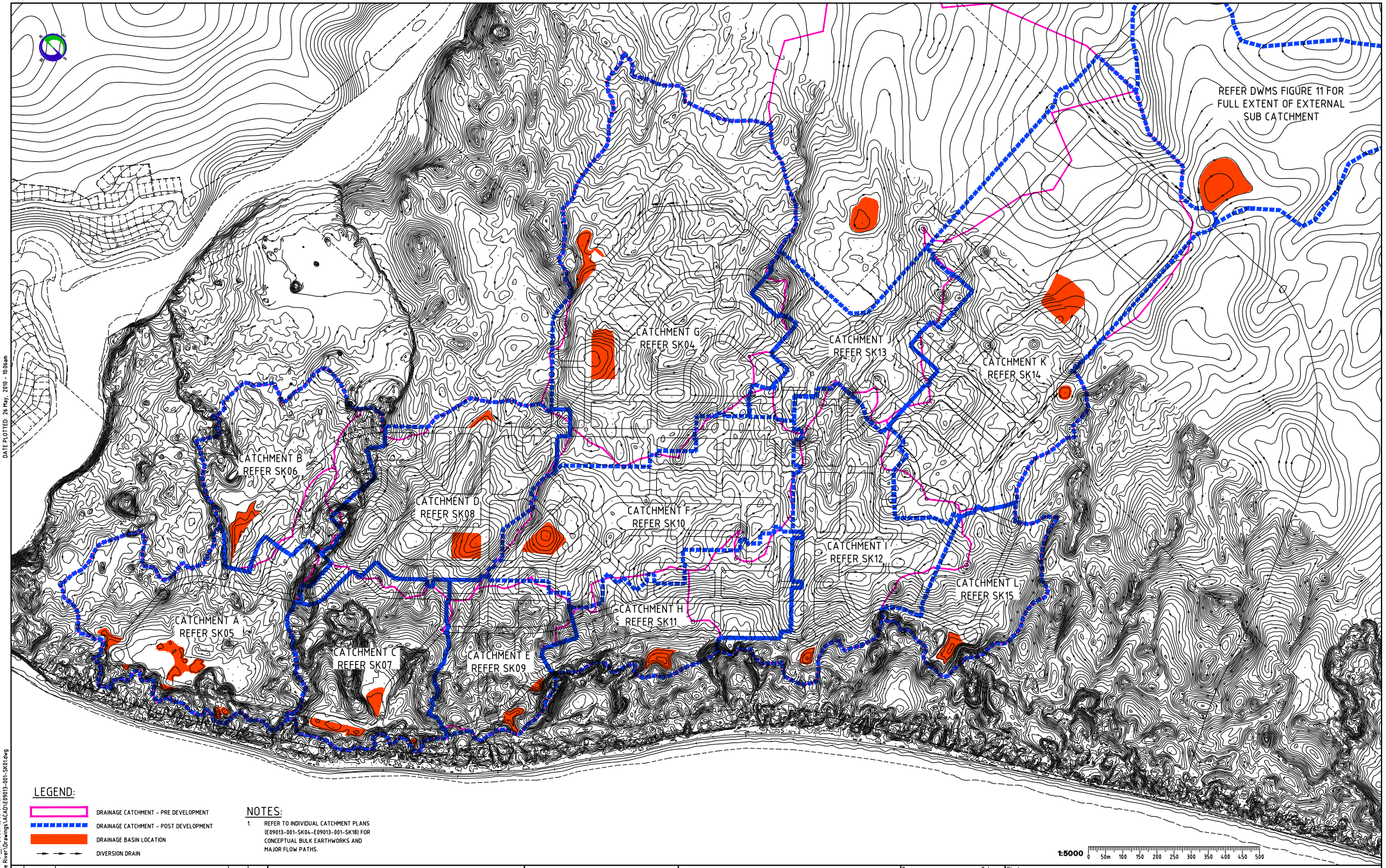
Sub-Matrix: WATER			Client sample ID	MR6	MR7	MR8	MR9	MR10
			Client sampling date / time	08-FEB-2010 15:00	08-FEB-2010 15:00	08-FEB-2010 15:00	08-FEB-2010 15:00	08-FEB-2010 15:00
Compound	CAS Number	LOR	Unit	EP1000762-006	EP1000762-007	EP1000762-008	EP1000762-009	EP1000762-010
EK055G: Ammonia as N by Discrete Analyser								
Ammonia as N	7664-41-7	0.01	mg/L	0.02	0.01	0.04	<0.01	0.01
EK059G: NOX as N by Discrete Analyser								
Nitrite + Nitrate as N	----	0.01	mg/L	2.72	4.85	3.85	4.61	3.13
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	0.1	mg/L	0.7	0.2	1.9	<0.5	1.6
EK062: Total Nitrogen as N (TKN + NOx)								
^ Total Nitrogen as N	----	0.1	mg/L	3.4	5.0	5.7	4.6	4.7
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	0.01	mg/L	0.78	0.91	5.86	0.15	0.02
EK071G: Reactive Phosphorus as P by discrete analyser								
Reactive Phosphorus as P	----	0.01	mg/L	<0.01	<0.01	<0.01	0.01	<0.01

Analytical Results

Sub-Matrix: **WATER**				Client sample ID	QA	----	----	----	----
				Client sampling date / time	08-FEB-2010 15:00	----	----	----	----
Compound	*CAS Number*	*LOR*	*Unit*		**EP1000762-011**	**----**	**----**	**----**	**----**
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L		<0.01	----	----	----	----
EK059G: NOX as N by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		**2.89**	----	----	----	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L		**0.8**	----	----	----	----
EK062: Total Nitrogen as N (TKN + NOx)									
^ Total Nitrogen as N	----	0.1	mg/L		**3.7**	----	----	----	----
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		**0.46**	----	----	----	----
EK071G: Reactive Phosphorus as P by discrete analyser									
Reactive Phosphorus as P	----	0.01	mg/L		**0.01**	----	----	----	----

Appendix D

Preliminary Earthworks Plans



LEGEND:

- DRAINAGE CATCHMENT – PRE DEVELOPMENT
- DRAINAGE CATCHMENT – POST DEVELOPMENT
- DRAINAGE BASIN LOCATION
- DIVERSION DRAIN

NOTES:

1. REFER TO INDIVIDUAL CATCHMENT PLANS (E09013-001-SK04–E09013-001-SK18) FOR CONCEPTUAL BULK EARTHWORKS AND MAJOR FLOW PATHS.

1:5000 0 50m 100 150 200 250 300 350 400 450 500

Rev	Date	Description	Drawn	Appr.
F	12.05.10	AMENDMENTS TO CATCHMENTS/BASIN LOCATIONS TO MATCH DWMS MODELING	CTB	PSN
E	16.03.10	ADDITIONAL SURVEY ADDED	CTB	PSN
D	22.02.10	REVISED LOCAL STRUCTURE PLAN INCORPORATED	CTB	PSN
C	18.12.09	CATCHMENTS I AND L AMENDED	CTB	PSN
B	08.12.09	REVISED LOCAL STRUCTURE PLAN INCORPORATED	CTB	PSN
A	03.12.09	ISSUED FOR INFORMATION	CTB	PSN

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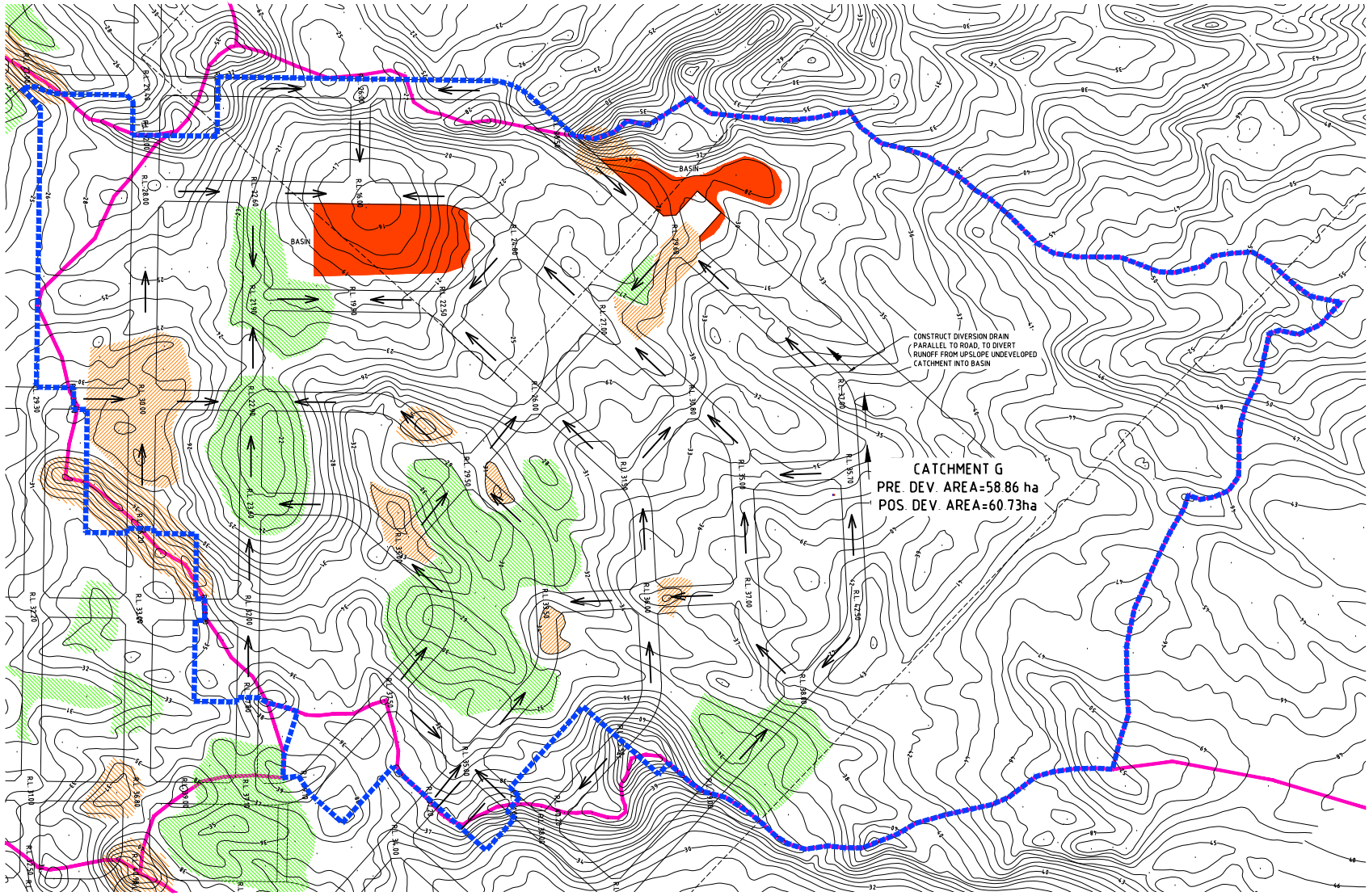
Cardno
Cardno (WA) Pty Ltd
Cardno Centre, 2 Bagot Road, P.O. Box 155
Subiaco Western Australia 6904
Phone (08) 9273 3888 Fax (08) 9388 3831
South West Regional Office, Units 2-4, 89 Duchess Street,
P.O. Box 713, Busselton Western Australia 6280
Phone (08) 9754 2397 Fax (08) 9752 2471
Quality Endorsed Company
AS/NZS ISO 9001:2008 Standards Australia

Drawn	CTB	Date 03.12.09
Designed	LW	Date 03.12.09
Checked	LW	Date 03.12.09
Reviewed	PSN	Date 03.12.09
Approved	PSN	Date 03.12.09

Client: MOORE RIVER COMPANY PTY LTD
Project: MOORE RIVER
Status:
Title: OUTLINE DEVELOPMENT PLAN DRAINAGE MASTER PLAN
Date: 03-12-2009 | Datum: AHD | Scale: 1:5000 | Size: A1
Drawing Number: E09013-001-SK01 | Revision: F

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150mm ON A1 ORIGINAL

DATE PLOTTED: 26 May, 2010 - 10:06am
XREFs: Xref_Existing Contours, Xref_DA basins catchments
CAD FILE: L:\2009\E09013 - Moore River\Drawings\ACAD\E09013-001-SK01.dwg



NOTES:

1. MINIMUM ROAD DESIGN GRADE TO BE 0.7% AND MAXIMUM TO BE 10% FOR DESIGN PURPOSES.
2. AREAS OF CUT/FILL HAVE BEEN SHOWN INDICATIVELY PENDING DETAILED DESIGN.
3. BASIN EXTENT AND STAGE-STORAGE RELATIONSHIP NOTIONAL ONLY, BASED ON EXISTING TOPOGRAPHY.
4. NATURAL LANDFORM TO BE MODIFIED AND BASIN LAYOUT RECONFIGURED AT DETAILED DESIGN STAGE TO CONFORM WITH APPROPRIATE SAFETY STANDARDS, VIZ:
   - MAXIMUM 100-YEAR DEPTH OF 1.2m (ARR BOOK VIII, S.1.10.4)
   - 1 IN 6 SIDE SLOPES (IPWEA, S.4.3.3.6).

LEGEND:

- DRAINAGE CATCHMENT - PRE DEVELOPMENT
- DRAINAGE CATCHMENT - POST DEVELOPMENT
- DRAINAGE BASIN LOCATION
- PROPOSED MAJOR FLOWS DIRECTION
- INDICATIVE AREAS OF CUT TO ACHIEVE DESIRED ROAD GRADINGS
- INDICATIVE AREAS OF FILL TO ACHIEVE DESIRED ROAD GRADINGS
- RL 21.30 PRELIMINARY ROAD DESIGN LEVELS

1:2000 0 20m 40 60 80 100 120 140 160 180 200

DATE PLOTTED: 26 May, 2010 - 10:07am

XREFs: Xref_Existing Contours; Xref_DA_basins; rd design levels; catchments
CAD FILE: L:\2009\E09013 - Moore River\Drawings\ACAD\E09013-001-SK04.dwg

Rev	Date	Description	Drawn	Appr.
C	12.05.10	MINOR AMENDMENTS TO ROAD LEVELS / DWMS MODELING	CTB	PSN
B	22.02.10	REVISED LOCAL STRUCTURE PLAN INCORPORATED	CTB	PSN
A	03.12.09	ISSUED FOR INFORMATION	CTB	PSN

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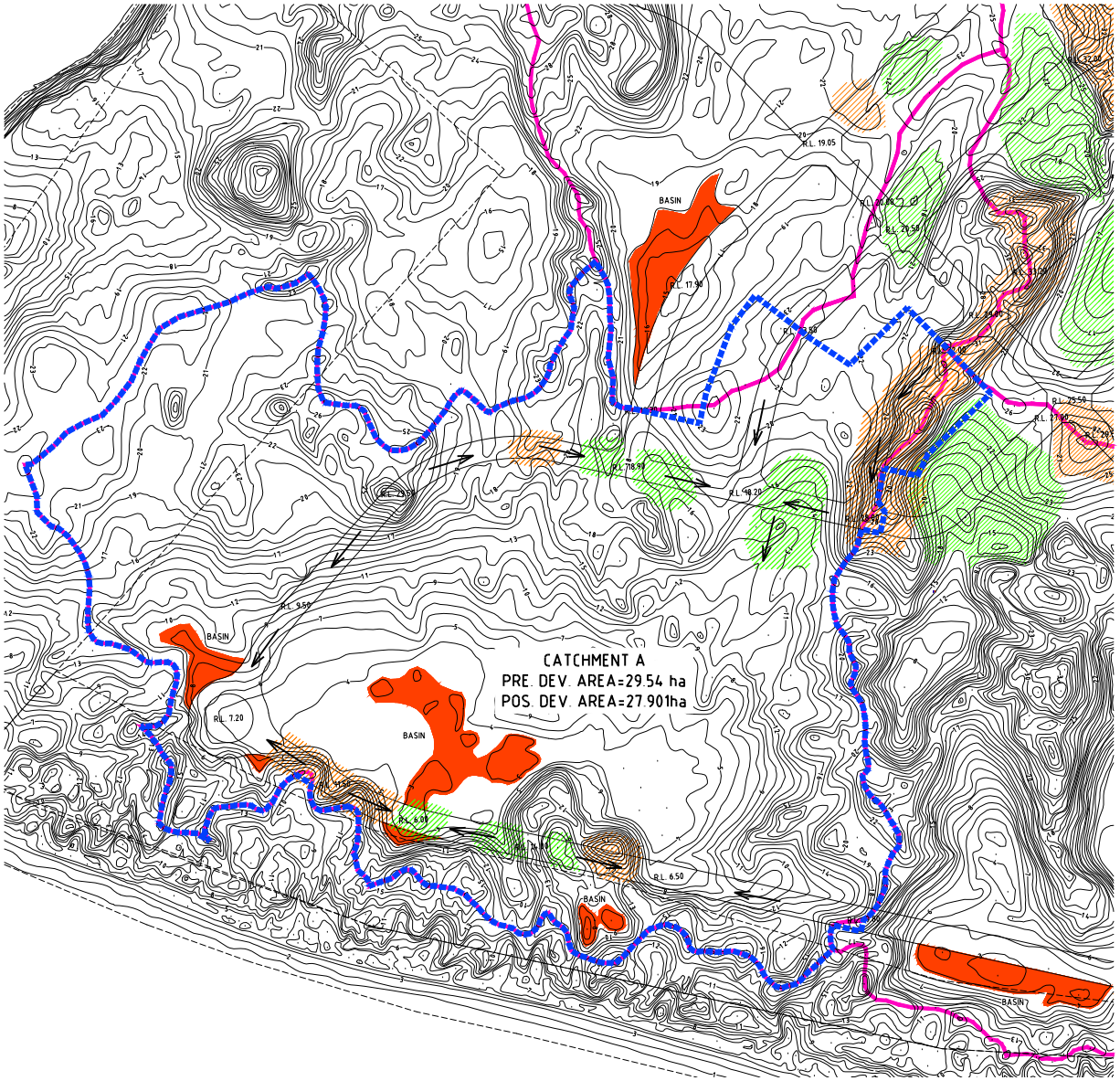
Drawn	CTB	Date 03.12.09
Designed	LW	Date 03.12.09
Checked	LW	Date 03.12.09
Reviewed	PSN	Date 03.12.09
Approved	PSN	Date 03.12.09

Client: MOORE RIVER COMPANY PTY LTD
Project: MOORE RIVER
Status: PRELIMINARY ISSUE
Title: OUTLINE DEVELOPMENT PLAN
CONCEPTUAL EARTHWORKS STRATEGY
CATCHMENT G

Date	Datum	Scale	Size
03-12-2009	AHD	1:2000	A1

Drawing Number: E09013-001-SK04
Revision: C

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150mm ON A1 ORIGINAL



NOTES:

1. MINIMUM ROAD DESIGN GRADE TO BE 0.7% AND MAXIMUM TO BE 10% FOR DESIGN PURPOSES.
2. AREAS OF CUT/FILL HAVE BEEN SHOWN INDICATIVELY PENDING DETAILED DESIGN.
3. BASIN EXTENT AND STAGE-STORAGE RELATIONSHIP NOTIONAL ONLY, BASED ON EXISTING TOPOGRAPHY.
4. NATURAL LANDFORM TO BE MODIFIED AND BASIN LAYOUT RECONFIGURED AT DETAILED DESIGN STAGE TO CONFORM WITH APPROPRIATE SAFETY STANDARDS, VIZ:
   - MAXIMUM 100-YEAR DEPTH OF 1.2m (ARR BOOK VIII, S.1.10.4)
   - 1 IN 6 SIDE SLOPES (IPWEA, S.4.3.3.6).

LEGEND:

- DRAINAGE CATCHMENT - PRE DEVELOPMENT
- DRAINAGE CATCHMENT - POST DEVELOPMENT
- DRAINAGE BASIN LOCATION
- PROPOSED MAJOR FLOWS DIRECTION
- INDICATIVE AREAS OF CUT TO ACHIEVE DESIRED ROAD GRADINGS
- INDICATIVE AREAS OF FILL TO ACHIEVE DESIRED ROAD GRADINGS
- RL 21.30 PRELIMINARY ROAD DESIGN LEVELS

1:2000 0 20m 40 60 80 100 120 140 160 180 200

DATE PLOTTED: 26 May, 2010 - 10:09am

XREFs: Xref_Existing Contours; Xref_DA basins; rd design levels; Flood Areas and Catchments; catchments
CAD FILE: L:\2009\E09013 - Moore River\Drawings\ACAD\E09013-001-SK05.dwg

Rev	Date	Description	Drawn	Appr.
C	12.05.10	MINOR AMENDMENTS TO ROAD LEVELS / DWMS MODELING	CTB	PSN
B	22.02.10	REVISED LOCAL STRUCTURE PLAN INCORPORATED	CTB	PSN
A	08.12.09	ISSUED FOR INFORMATION	CTB	PSN

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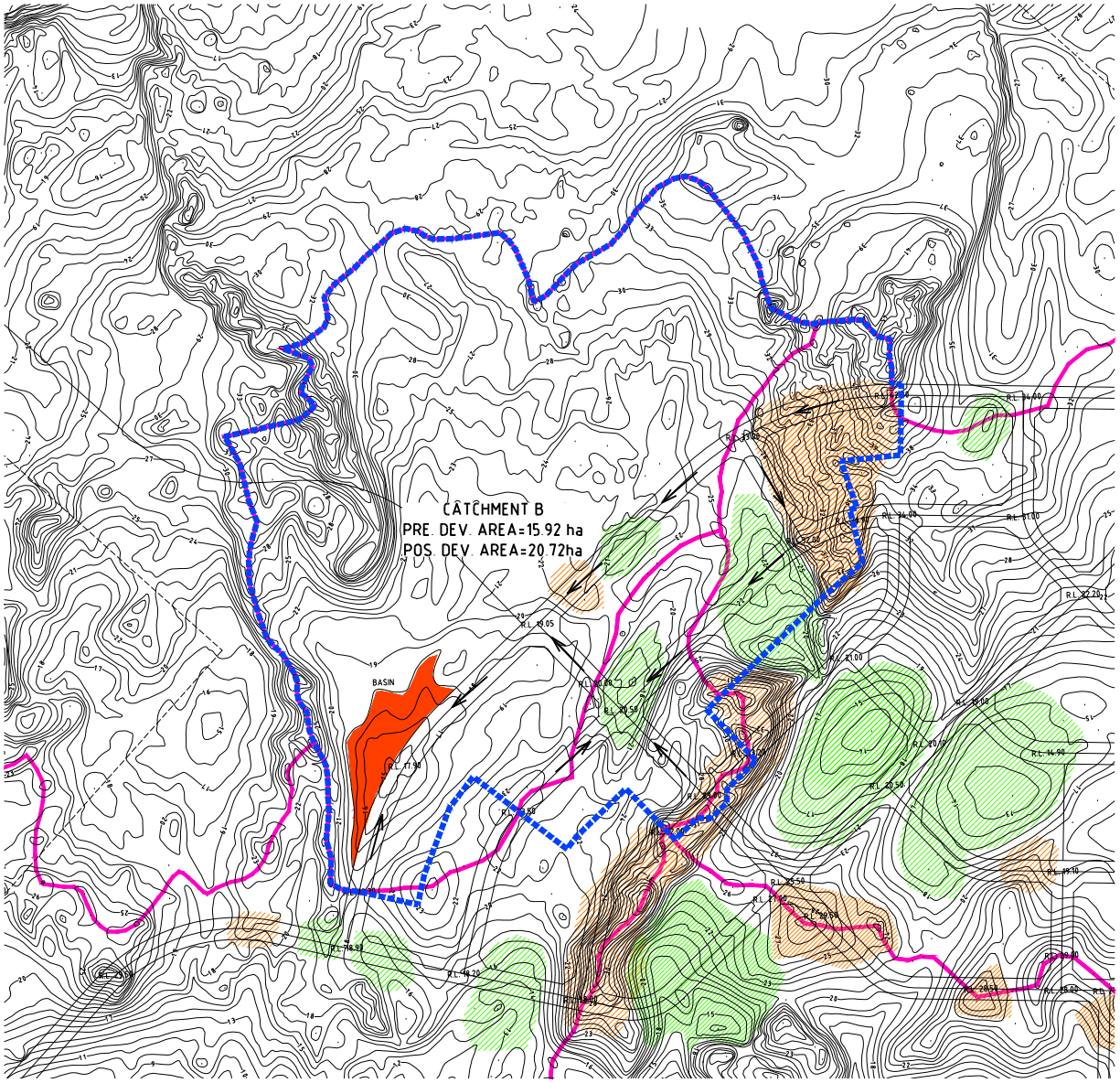
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Quality Endorsed Company
AS 9001:Lic.9960 Standards Australia

Drawn	CTB	Date 03.12.09
Designed	LW	Date 03.12.09
Checked	LW	Date 03.12.09
Reviewed	PSN	Date 03.12.09
Approved	PSN	Date 03.12.09

Client: MOORE RIVER COMPANY PTY LTD
Project: MOORE RIVER
Status: PRELIMINARY ISSUE
Date: 03-12-2009 | Datum: AHD | Scale: 1:2000 | Size: A1
Title: OUTLINE DEVELOPMENT PLAN
CONCEPTUAL EARTHWORKS STRATEGY
CATCHMENT A
Drawing Number: E09013-001-SK05 | Revision: C

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150mm ON A1 ORIGINAL



NOTES:

1. MINIMUM ROAD DESIGN GRADE TO BE 0.7% AND MAXIMUM TO BE 10% FOR DESIGN PURPOSES.
2. AREAS OF CUT/FILL HAVE BEEN SHOWN INDICATIVELY PENDING DETAILED DESIGN.
3. BASIN EXTENT AND STAGE-STORAGE RELATIONSHIP NOTIONAL ONLY, BASED ON EXISTING TOPOGRAPHY.
4. NATURAL LANDFORM TO BE MODIFIED AND BASIN LAYOUT RECONFIGURED AT DETAILED DESIGN STAGE TO CONFORM WITH APPROPRIATE SAFETY STANDARDS, VIZ.
   - MAXIMUM 100-YEAR DEPTH OF 1.2m (ARR BOOK VIII, S.1.10.4)
   - 1 IN 6 SIDE SLOPES (IPWEA, S.4.3.3.6).

LEGEND:

- DRAINAGE CATCHMENT - PRE DEVELOPMENT
- DRAINAGE CATCHMENT - POST DEVELOPMENT
- DRAINAGE BASIN LOCATION
- PROPOSED MAJOR FLOWS DIRECTION
- INDICATIVE AREAS OF CUT TO ACHIEVE DESIRED ROAD GRADINGS
- INDICATIVE AREAS OF FILL TO ACHIEVE DESIRED ROAD GRADINGS
- RL 21.30 PRELIMINARY ROAD DESIGN LEVELS

1:2000 0 20m 40 60 80 100 120 140 160 180 200

DATE PLOTTED: 26 May, 2010 - 10:09am

XREFs: Xref_Existing Contours; Xref_OA_basins; rd design levels; catchments
CAD FILE: L:\2009\E09013 - Moore River\Drawings\ACAD\E09013-001-SK06.dwg

Rev	Date	Description	Drawn	Appr.
C	12.05.10	MINOR AMENDMENTS TO ROAD LEVELS / DWMS MODELING	CTB	PSN
B	22.02.10	REVISED LOCAL STRUCTURE PLAN INCORPORATED	CTB	PSN
A	08.12.09	ISSUED FOR INFORMATION	CTB	PSN

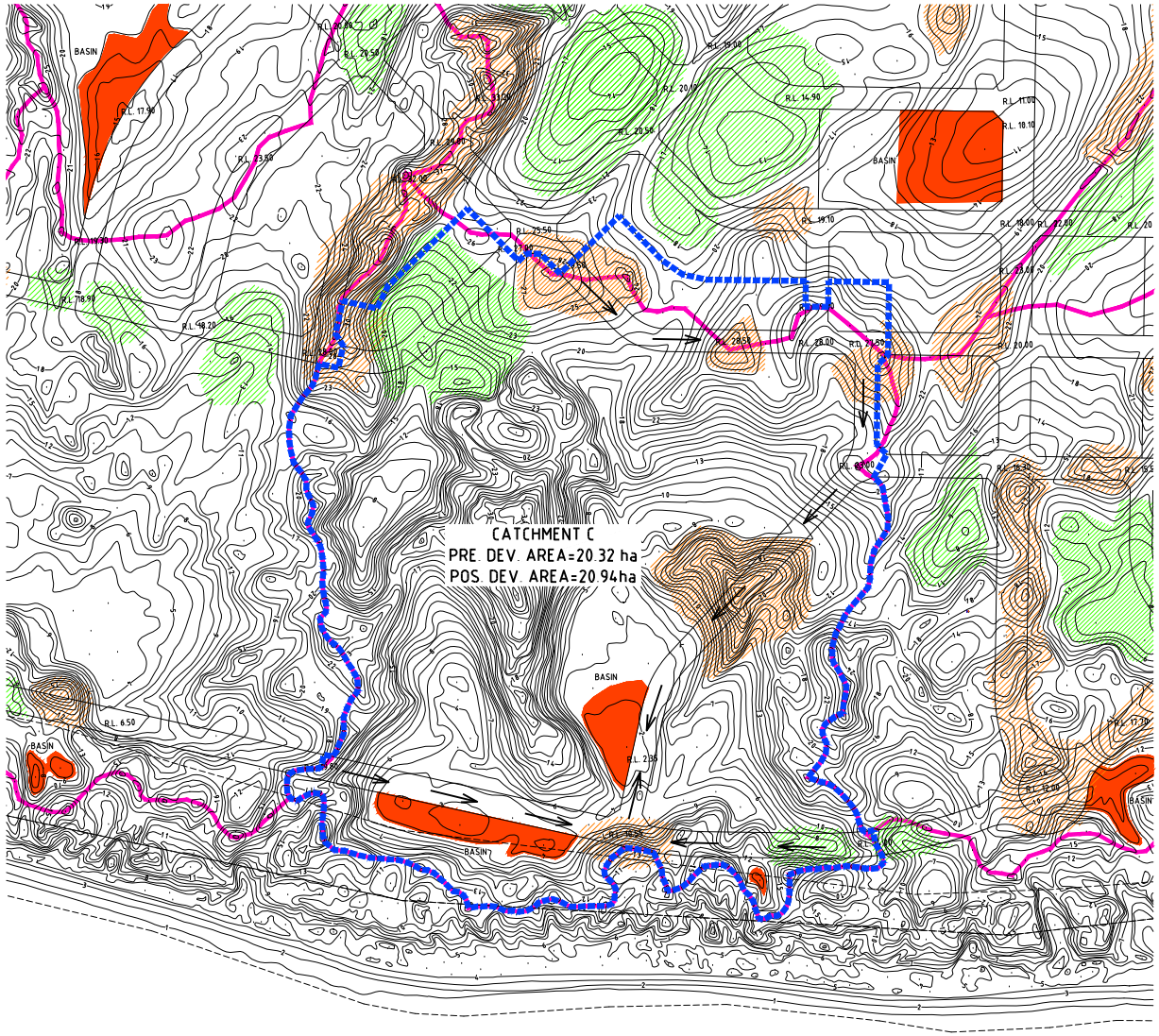
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Drawn	CTB	Date 03.12.09
Designed	LW	Date 03.12.09
Checked	LW	Date 03.12.09
Reviewed	PSN	Date 03.12.09
Approved	PSN	Date 03.12.09

Client: MOORE RIVER COMPANY PTY LTD
Project: MOORE RIVER
Status: PRELIMINARY ISSUE
Date: 03-12-2009 | Datum: AHD | Scale: 1:2000 | Size: A1
Title: OUTLINE DEVELOPMENT PLAN
CONCEPTUAL EARTHWORKS STRATEGY
CATCHMENT B
Drawing Number: E09013-001-SK06 | Revision: C

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150mm ON A1 ORIGINAL



NOTES:

1. MINIMUM ROAD DESIGN GRADE TO BE 0.7% AND MAXIMUM TO BE 10% FOR DESIGN PURPOSES.
2. AREAS OF CUT/FILL HAVE BEEN SHOWN INDICATIVELY PENDING DETAILED DESIGN.
3. BASIN EXTENT AND STAGE-STORAGE RELATIONSHIP NOTIONAL ONLY, BASED ON EXISTING TOPOGRAPHY.
4. NATURAL LANDFORM TO BE MODIFIED AND BASIN LAYOUT RECONFIGURED AT DETAILED DESIGN STAGE TO CONFORM WITH APPROPRIATE SAFETY STANDARDS, VIZ.
   - MAXIMUM 100-YEAR DEPTH OF 1.2m (ARR BOOK VIII, S.1.10.4)
   - 1 IN 6 SIDE SLOPES (IPWEA, S.4.3.3.6).

LEGEND:

- DRAINAGE CATCHMENT - PRE DEVELOPMENT
- DRAINAGE CATCHMENT - POST DEVELOPMENT
- DRAINAGE BASIN LOCATION
- PROPOSED MAJOR FLOWS DIRECTION
- INDICATIVE AREAS OF CUT TO ACHIEVE DESIRED ROAD GRADINGS
- INDICATIVE AREAS OF FILL TO ACHIEVE DESIRED ROAD GRADINGS
- RL 21.30 PRELIMINARY ROAD DESIGN LEVELS

1:2000 0 20m 40 60 80 100 120 140 160 180 200

DATE PLOTTED: 26 May, 2010 - 11:18am

XREFs: Xref_Existing Contours, Xref_DA, basins, rd design levels, catchments
CAD FILE: L:\2009\E09013 - Moore River\Drawings\ACAD\E09013-001-SK07.dwg

Rev	Date	Description	Drawn	Appr.
C	12.05.10	MINOR AMENDMENTS TO ROAD LEVELS / DWMS MODELING	CTB	PSN
B	22.02.10	REVISED LOCAL STRUCTURE PLAN INCORPORATED	CTB	PSN
A	08.12.09	ISSUED FOR INFORMATION	CTB	PSN

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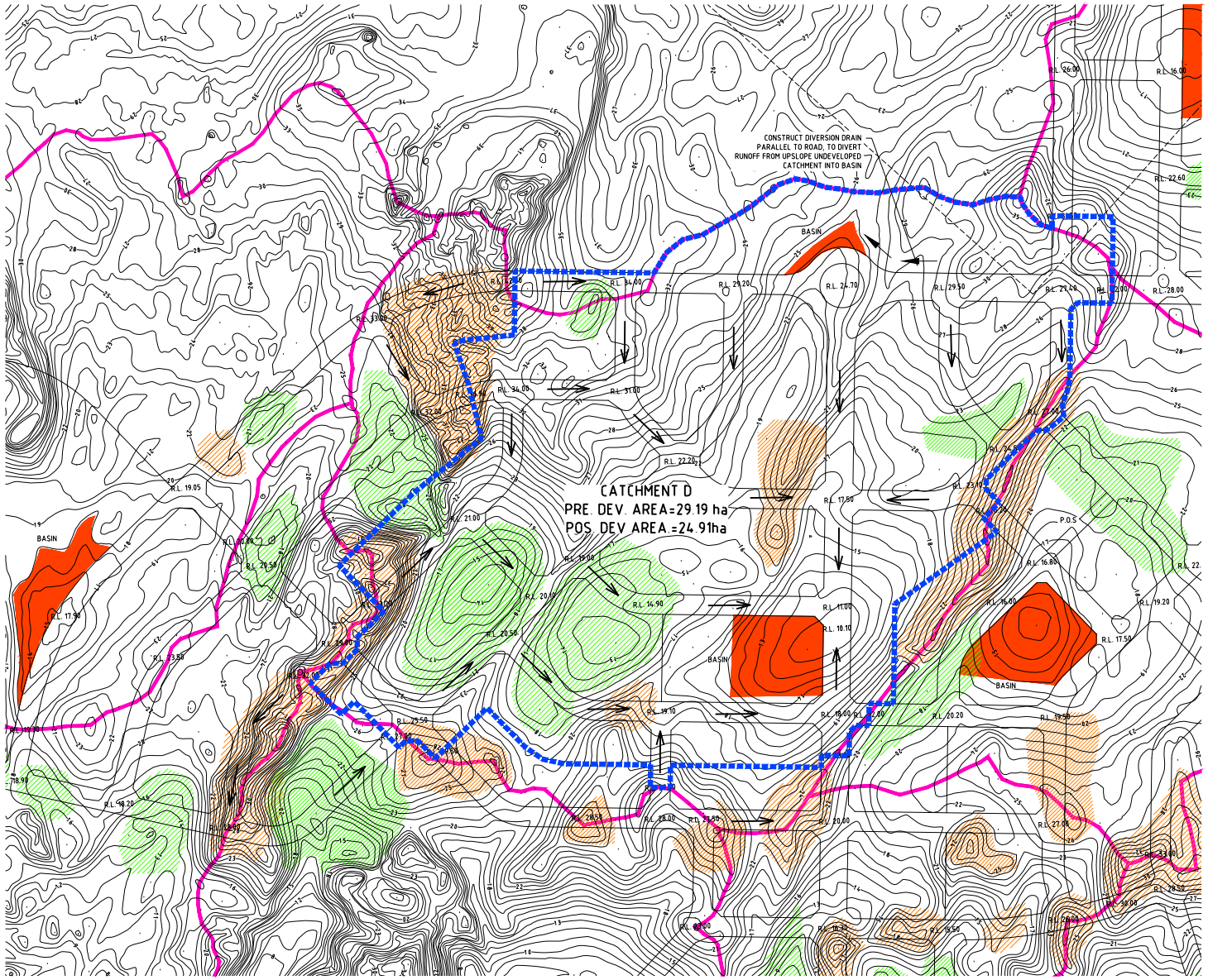
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Drawn	CTB	Date 03.12.09
Designed	LW	Date 03.12.09
Checked	LW	Date 03.12.09
Reviewed	PSN	Date 03.12.09
Approved	PSN	Date 03.12.09

Client: MOORE RIVER COMPANY PTY LTD
Project: MOORE RIVER
Status: PRELIMINARY ISSUE
Date: 03-12-2009 | Datum: AHD | Scale: 1:2000 | Size: A1
Title: OUTLINE DEVELOPMENT PLAN
CONCEPTUAL EARTHWORKS STRATEGY
CATCHMENT C
Drawing Number: E09013-001-SK07 | Revision: C

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150mm ON A1 ORIGINAL



NOTES:

1. MINIMUM ROAD DESIGN GRADE TO BE 0.7% AND MAXIMUM TO BE 10% FOR DESIGN PURPOSES.
2. AREAS OF CUT/FILL HAVE BEEN SHOWN INDICATIVELY PENDING DETAILED DESIGN.
3. BASIN EXTENT AND STAGE-STORAGE RELATIONSHIP NOTIONAL ONLY, BASED ON EXISTING TOPOGRAPHY.
4. NATURAL LANDFORM TO BE MODIFIED AND BASIN LAYOUT RECONFIGURED AT DETAILED DESIGN STAGE TO CONFORM WITH APPROPRIATE SAFETY STANDARDS, VIZ.
   - MAXIMUM 100-YEAR DEPTH OF 1.2m (ARR BOOK VIII, S.1.10.4)
   - 1 IN 6 SIDE SLOPES (IPWEA, S.4.3.3.6).

LEGEND:

- DRAINAGE CATCHMENT - PRE DEVELOPMENT
- DRAINAGE CATCHMENT - POST DEVELOPMENT
- DRAINAGE BASIN LOCATION
- PROPOSED MAJOR FLOWS DIRECTION
- INDICATIVE AREAS OF CUT TO ACHIEVE DESIRED ROAD GRADINGS
- INDICATIVE AREAS OF FILL TO ACHIEVE DESIRED ROAD GRADINGS
- RL 21.30 PRELIMINARY ROAD DESIGN LEVELS

1:2000 0 20m 40 60 80 100 120 140 160 180 200

DATE PLOTTED: 26 May, 2010 - 10:11am

XREFs: Xref_Existing Contours, Xref_DA, basins, rd design levels, catchments
CAD FILE: L:\2009\E09013 - Moore River\Drawings\ACAD\E09013-001-SK08.dwg

Rev	Date	Description	Drawn	Appr.
C	12.05.10	MINOR AMENDMENTS TO ROAD LEVELS / DWMS MODELING	CTB	PSN
B	22.02.10	REVISED LOCAL STRUCTURE PLAN INCORPORATED	CTB	PSN
A	08.12.09	ISSUED FOR INFORMATION	CTB	PSN

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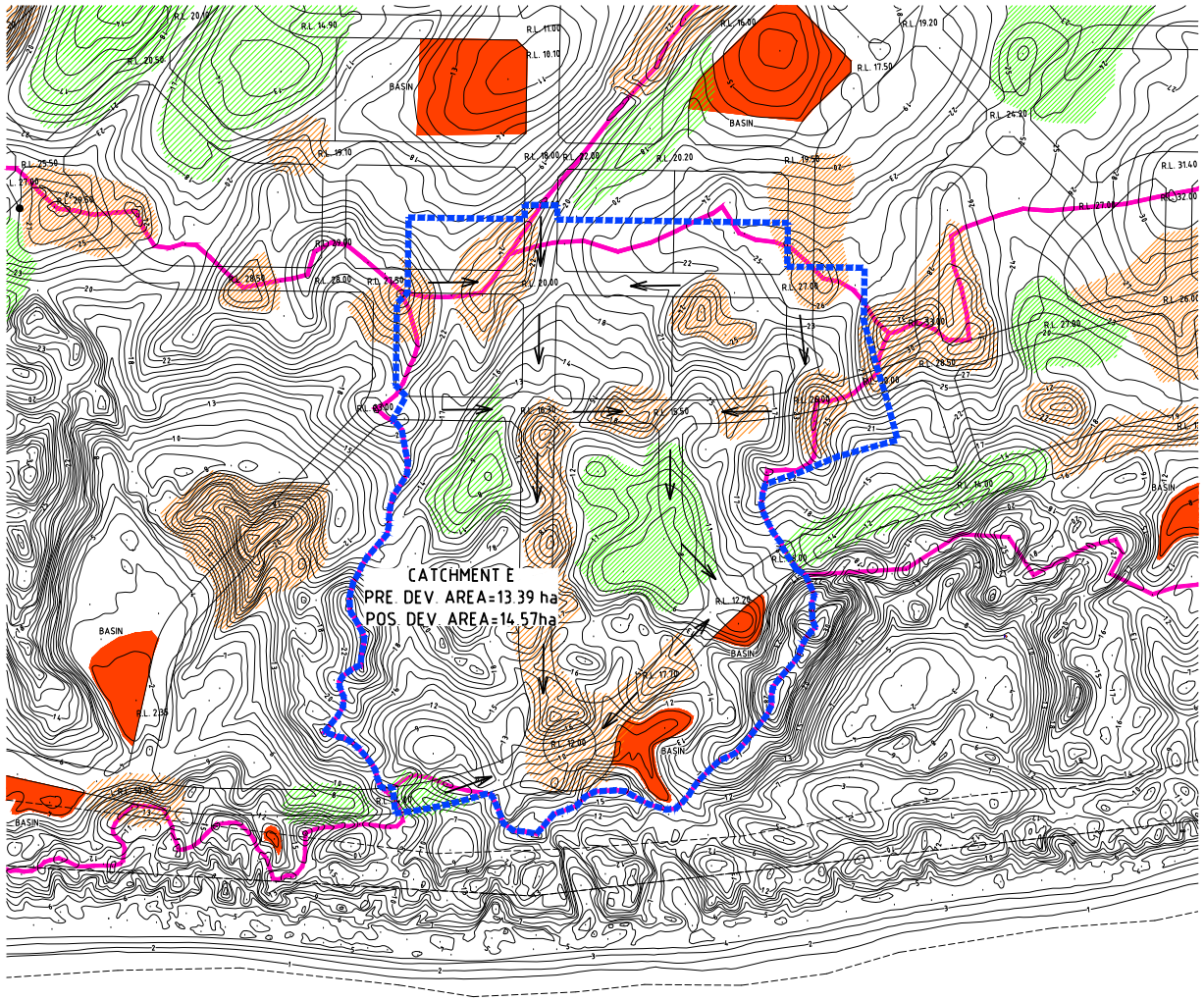
Drawn	CTB	Date 03.12.09
Designed	LW	Date 03.12.09
Checked	LW	Date 03.12.09
Reviewed	PSN	Date 03.12.09
Approved	PSN	Date 03.12.09

Client: MOORE RIVER COMPANY PTY LTD
Project: MOORE RIVER
Status: PRELIMINARY ISSUE
Title: OUTLINE DEVELOPMENT PLAN
CONCEPTUAL EARTHWORKS STRATEGY
CATCHMENT D

Date	Datum	Scale	Size
03-12-2009	AHD	1:2000	A1

Drawing Number: E09013-001-SK08
Revision: C

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150mm ON A1 ORIGINAL



NOTES:

1. MINIMUM ROAD DESIGN GRADE TO BE 0.7% AND MAXIMUM TO BE 10% FOR DESIGN PURPOSES.
2. AREAS OF CUT/FILL HAVE BEEN SHOWN INDICATIVELY PENDING DETAILED DESIGN.
3. BASIN EXTENT AND STAGE-STORAGE RELATIONSHIP NOTIONAL ONLY, BASED ON EXISTING TOPOGRAPHY.
4. NATURAL LANDFORM TO BE MODIFIED AND BASIN LAYOUT RECONFIGURED AT DETAILED DESIGN STAGE TO CONFORM WITH APPROPRIATE SAFETY STANDARDS, VIZ.
   - MAXIMUM 100-YEAR DEPTH OF 1.2m (ARR BOOK VIII, S.1.10.4)
   - 1 IN 6 SIDE SLOPES (IPWEA, S.4.3.3.6).

LEGEND:

- DRAINAGE CATCHMENT - PRE DEVELOPMENT
- DRAINAGE CATCHMENT - POST DEVELOPMENT
- DRAINAGE BASIN LOCATION
- PROPOSED MAJOR FLOWS DIRECTION
- INDICATIVE AREAS OF CUT TO ACHIEVE DESIRED ROAD GRADINGS
- INDICATIVE AREAS OF FILL TO ACHIEVE DESIRED ROAD GRADINGS
- RL 21.30 PRELIMINARY ROAD DESIGN LEVELS

1:2000 0 20m 40 60 80 100 120 140 160 180 200

DATE PLOTTED: 26 May, 2010 - 10:11am

XREFs: Xref_Existing Contours; Xref_DA basins; rd design levels; catchments
CAD FILE: L:\2009\E09013 - Moore River\Drawings\ACAD\E09013-001-SK09.dwg

Rev	Date	Description	Drawn	Appr.
C	12.05.10	MINOR AMENDMENTS TO ROAD LEVELS / DWMS MODELING	CTB	PSN
B	22.02.10	REVISED LOCAL STRUCTURE PLAN INCORPORATED	CTB	PSN
A	08.12.09	ISSUED FOR INFORMATION	CTB	PSN

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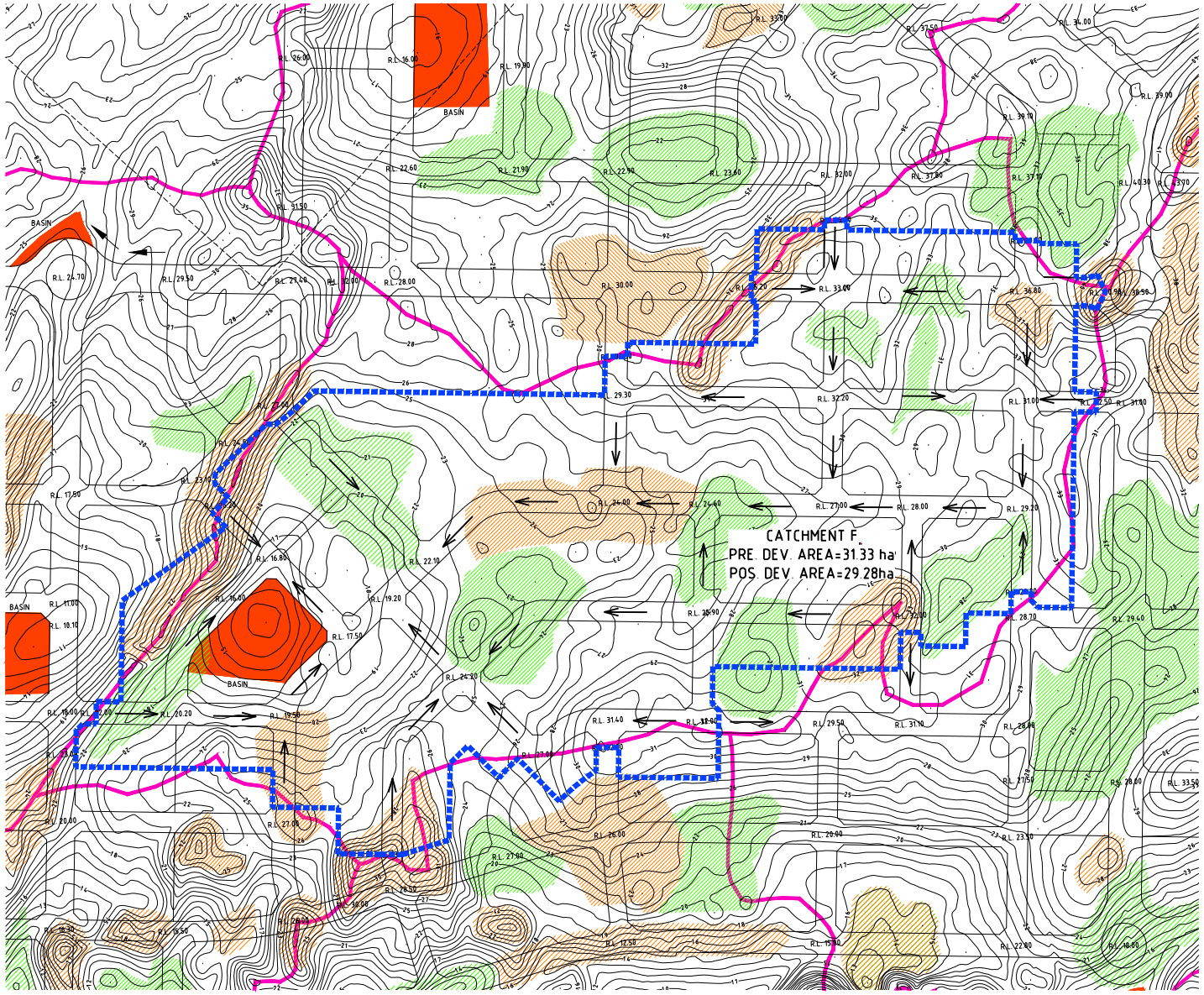
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Drawn	CTB	Date 03.12.09
Designed	LW	Date 03.12.09
Checked	LW	Date 03.12.09
Reviewed	PSN	Date 03.12.09
Approved	PSN	Date 03.12.09

Client: MOORE RIVER COMPANY PTY LTD
Project: MOORE RIVER
Status: PRELIMINARY ISSUE
Date: 03-12-2009 | Datum: AHD | Scale: 1:2000 | Size: A1
Title: OUTLINE DEVELOPMENT PLAN
CONCEPTUAL EARTHWORKS STRATEGY
CATCHMENT E
Drawing Number: E09013-001-SK09 | Revision: C

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150mm ON A1 ORIGINAL



NOTES:

1. MINIMUM ROAD DESIGN GRADE TO BE 0.7% AND MAXIMUM TO BE 10% FOR DESIGN PURPOSES.
2. AREAS OF CUT/FILL HAVE BEEN SHOWN INDICATIVELY PENDING DETAILED DESIGN.
3. BASIN EXTENT AND STAGE-STORAGE RELATIONSHIP NOTIONAL ONLY, BASED ON EXISTING TOPOGRAPHY.
4. NATURAL LANDFORM TO BE MODIFIED AND BASIN LAYOUT RECONFIGURED AT DETAILED DESIGN STAGE TO CONFORM WITH APPROPRIATE SAFETY STANDARDS, VIZ:
   - MAXIMUM 100-YEAR DEPTH OF 1.2m (ARR BOOK VIII, S.1.10.4)
   - 1 IN 6 SIDE SLOPES (IPWEA, S.4.3.3.6).

LEGEND:

- DRAINAGE CATCHMENT - PRE DEVELOPMENT
- DRAINAGE CATCHMENT - POST DEVELOPMENT
- DRAINAGE BASIN LOCATION
- PROPOSED MAJOR FLOWS DIRECTION
- INDICATIVE AREAS OF CUT TO ACHIEVE DESIRED ROAD GRADINGS
- INDICATIVE AREAS OF FILL TO ACHIEVE DESIRED ROAD GRADINGS
- RL 21.30 PRELIMINARY ROAD DESIGN LEVELS

1:2000 0 20m 40 60 80 100 120 140 160 180 200

DATE PLOTTED: 26 May, 2010 - 10:12am

XREFs: Xref_Existing Contours; Xref_DA basins; rd design levels; catchments
CAD FILE: L:\2009\E09013 - Moore River\Drawings\ACAD\E09013-001-SK10.dwg

Rev	Date	Description	Drawn	Appr.
C	12.05.10	MINOR AMENDMENTS TO ROAD LEVELS / DWMS MODELING	CTB	PSN
B	22.02.10	REVISED LOCAL STRUCTURE PLAN INCORPORATED	CTB	PSN
A	08.12.09	ISSUED FOR INFORMATION	CTB	PSN

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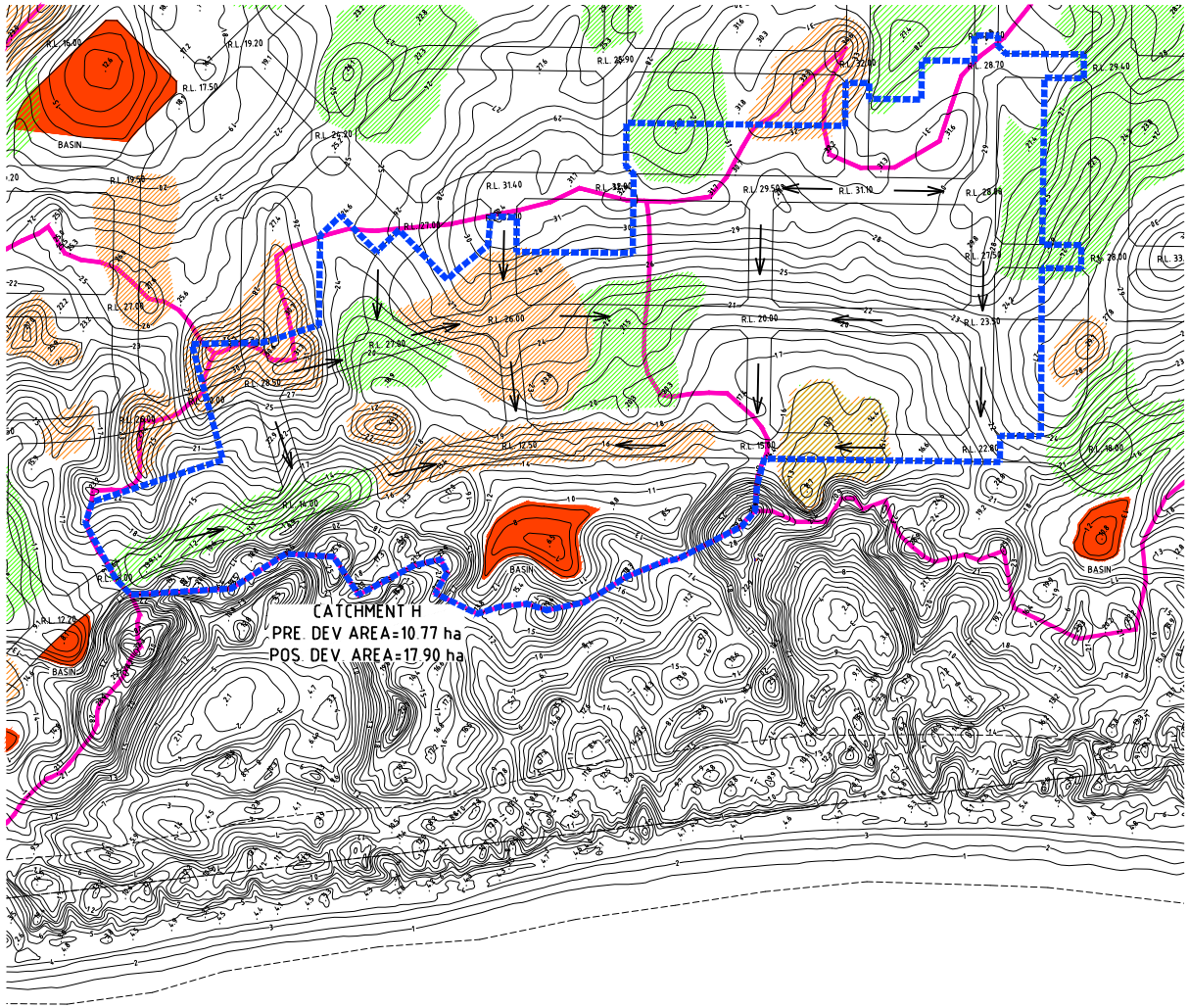
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Drawn	CTB	Date 03.12.09
Designed	LW	Date 03.12.09
Checked	LW	Date 03.12.09
Reviewed	PSN	Date 03.12.09
Approved	PSN	Date 03.12.09

Client: MOORE RIVER COMPANY PTY LTD
Project: MOORE RIVER
Status: PRELIMINARY ISSUE
Date: 03-12-2009 | Datum: AHD | Scale: 1:2000 | Size: A1
Title: OUTLINE DEVELOPMENT PLAN
CONCEPTUAL EARTHWORKS STRATEGY
CATCHMENT F
Drawing Number: E09013-001-SK10 | Revision: C

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150mm ON A1 ORIGINAL



NOTES:

1. MINIMUM ROAD DESIGN GRADE TO BE 0.7% AND MAXIMUM TO BE 10% FOR DESIGN PURPOSES.
2. AREAS OF CUT/FILL HAVE BEEN SHOWN INDICATIVELY PENDING DETAILED DESIGN.
3. BASIN EXTENT AND STAGE-STORAGE RELATIONSHIP NOTIONAL ONLY, BASED ON EXISTING TOPOGRAPHY.
4. NATURAL LANDFORM TO BE MODIFIED AND BASIN LAYOUT RECONFIGURED AT DETAILED DESIGN STAGE TO CONFORM WITH APPROPRIATE SAFETY STANDARDS, VIZ:
   - MAXIMUM 100-YEAR DEPTH OF 1.2m (ARR BOOK VIII, S.1.10.4)
   - 1 IN 6 SIDE SLOPES (IPWEA, S.4.3.3.6).

LEGEND:

- DRAINAGE CATCHMENT - PRE DEVELOPMENT
- DRAINAGE CATCHMENT - POST DEVELOPMENT
- DRAINAGE BASIN LOCATION
- PROPOSED MAJOR FLOWS DIRECTION
- INDICATIVE AREAS OF CUT TO ACHIEVE DESIRED ROAD GRADINGS
- INDICATIVE AREAS OF FILL TO ACHIEVE DESIRED ROAD GRADINGS
- RL 21.30 PRELIMINARY ROAD DESIGN LEVELS

1:2000 0 20m 40 60 80 100 120 140 160 180 200

DATE PLOTTED: 26 May, 2010 - 10:12am

XREFs: Xref_Existing Contours; Xref_DA basins; rd design levels; catchments
CAD FILE: L:\2009\E09013 - Moore River\Drawings\ACAD\E09013-001-SK11.dwg

Rev	Date	Description	Drawn	Appr.
C	12.05.10	MINOR AMENDMENTS TO ROAD LEVELS / DWMS MODELING	CTB	PSN
B	22.02.10	REVISED LOCAL STRUCTURE PLAN INCORPORATED	CTB	PSN
A	08.12.09	ISSUED FOR INFORMATION	CTB	PSN

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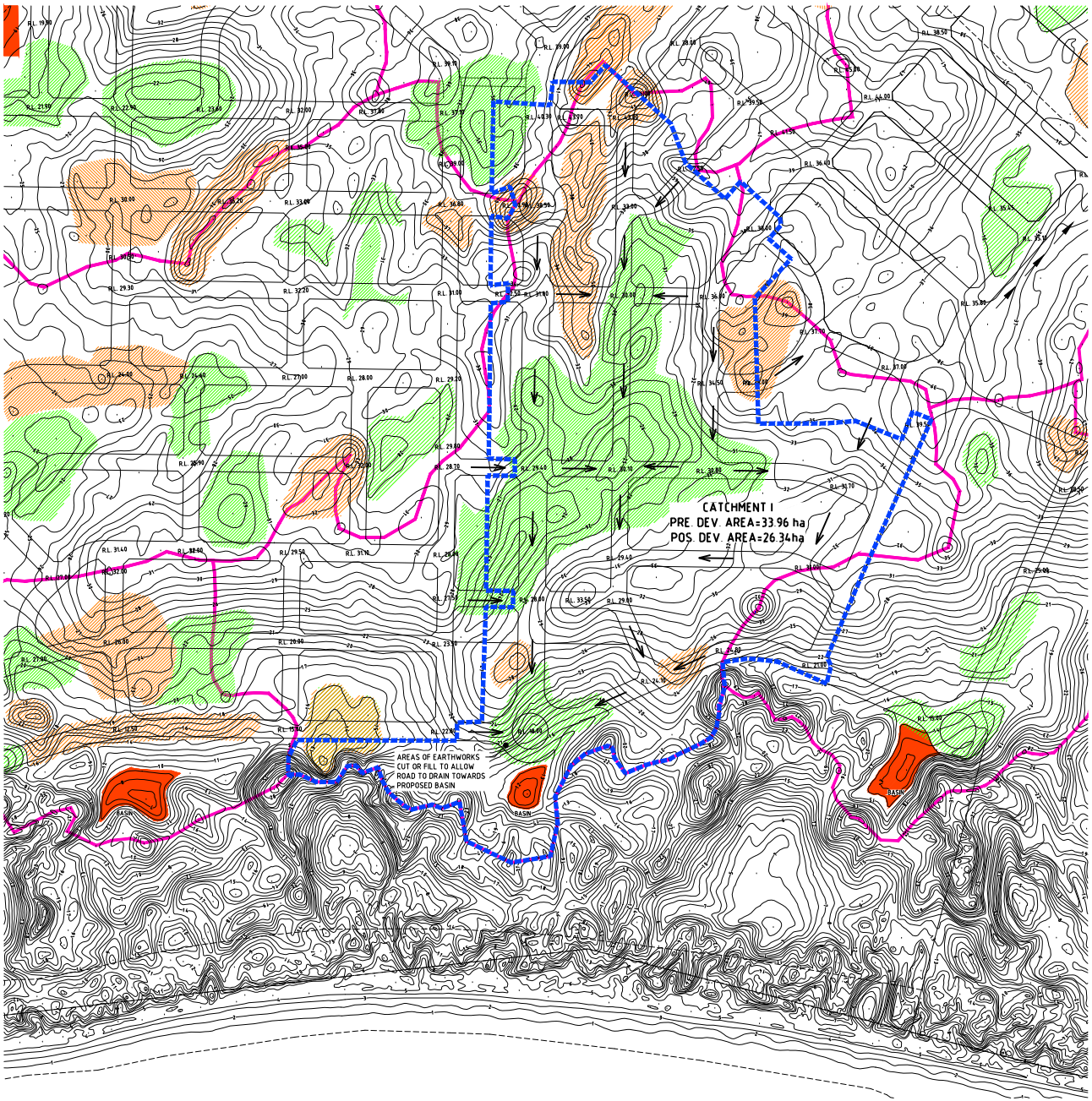
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CATCHMENT H
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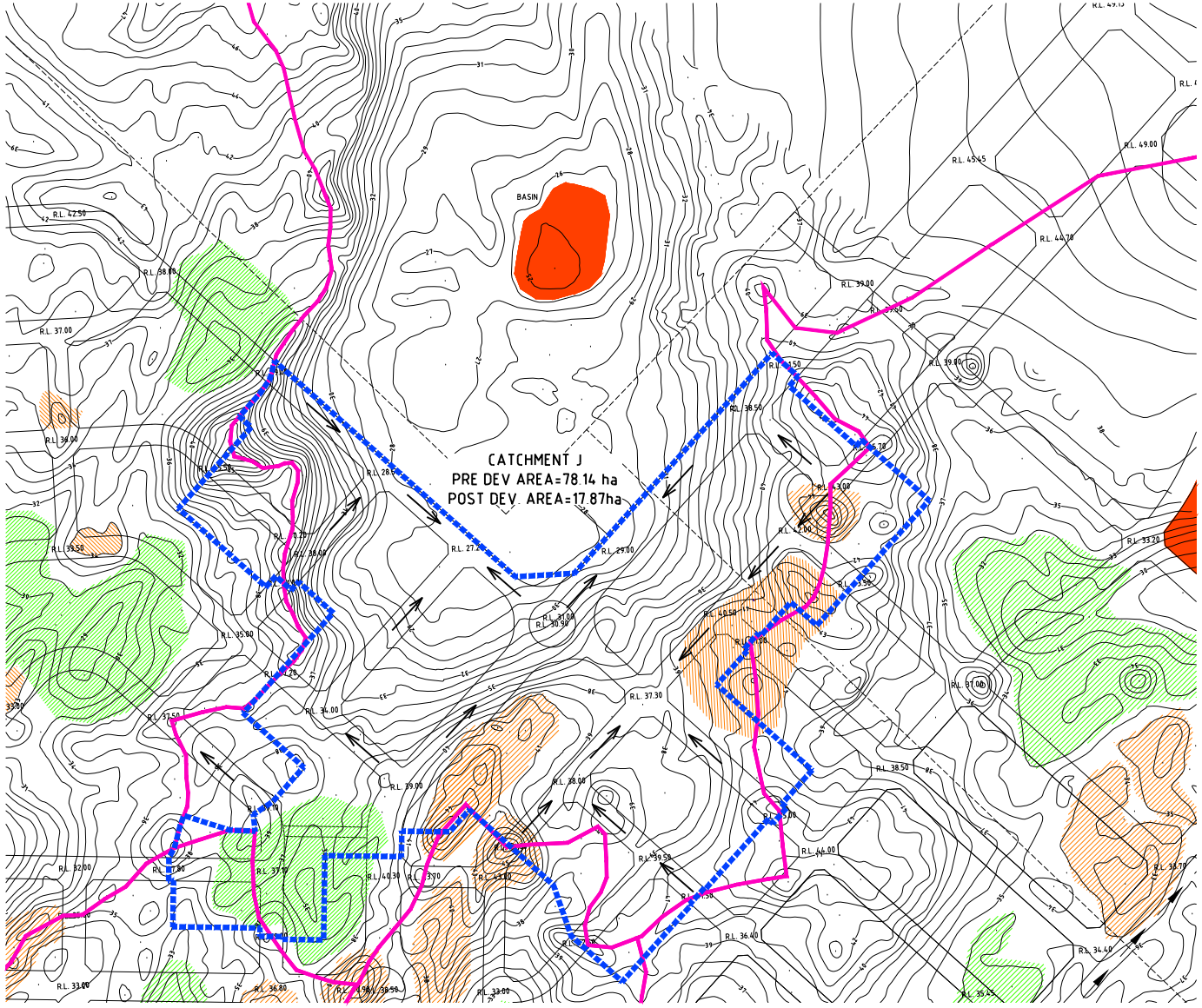
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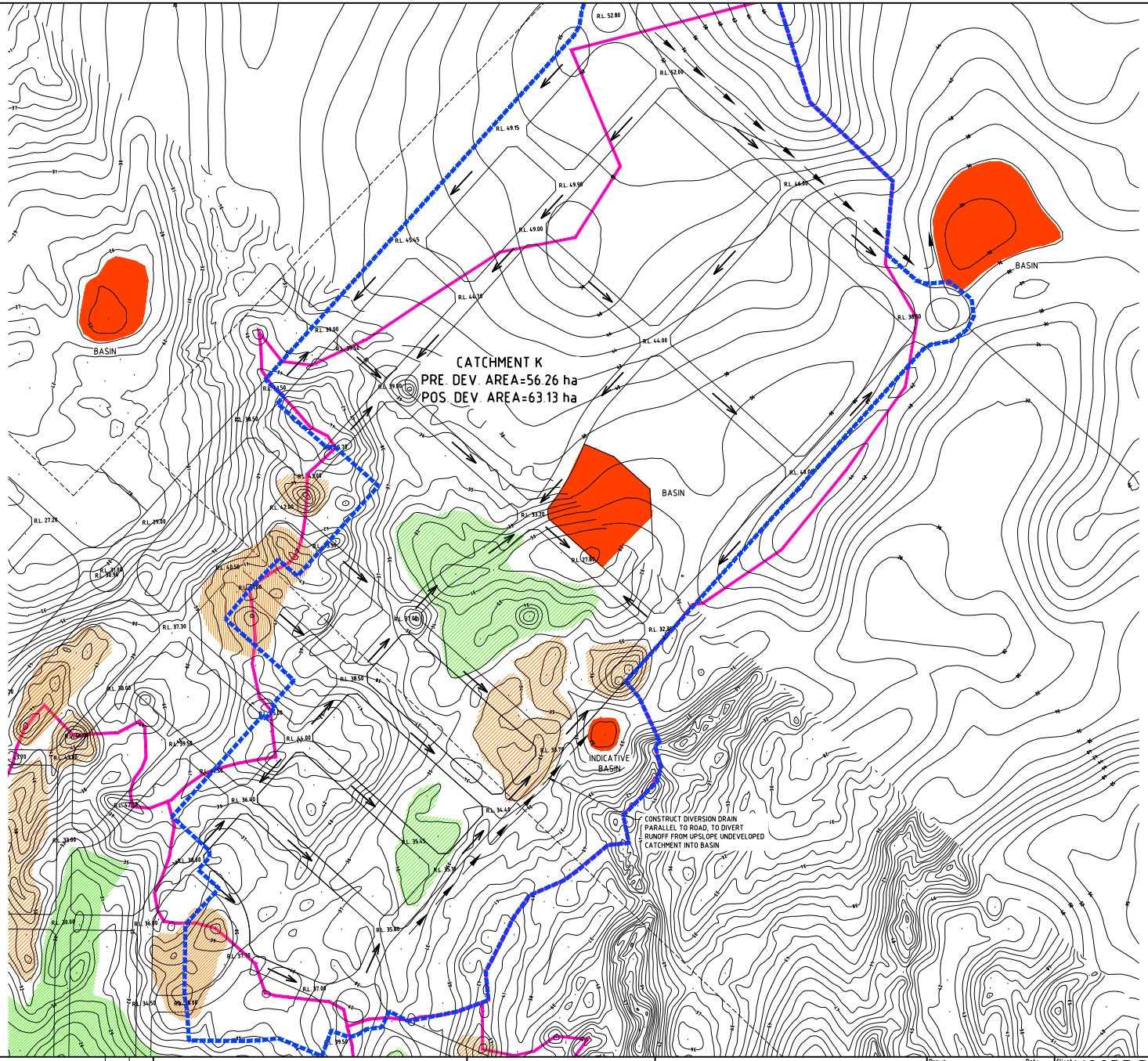
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CATCHMENT J

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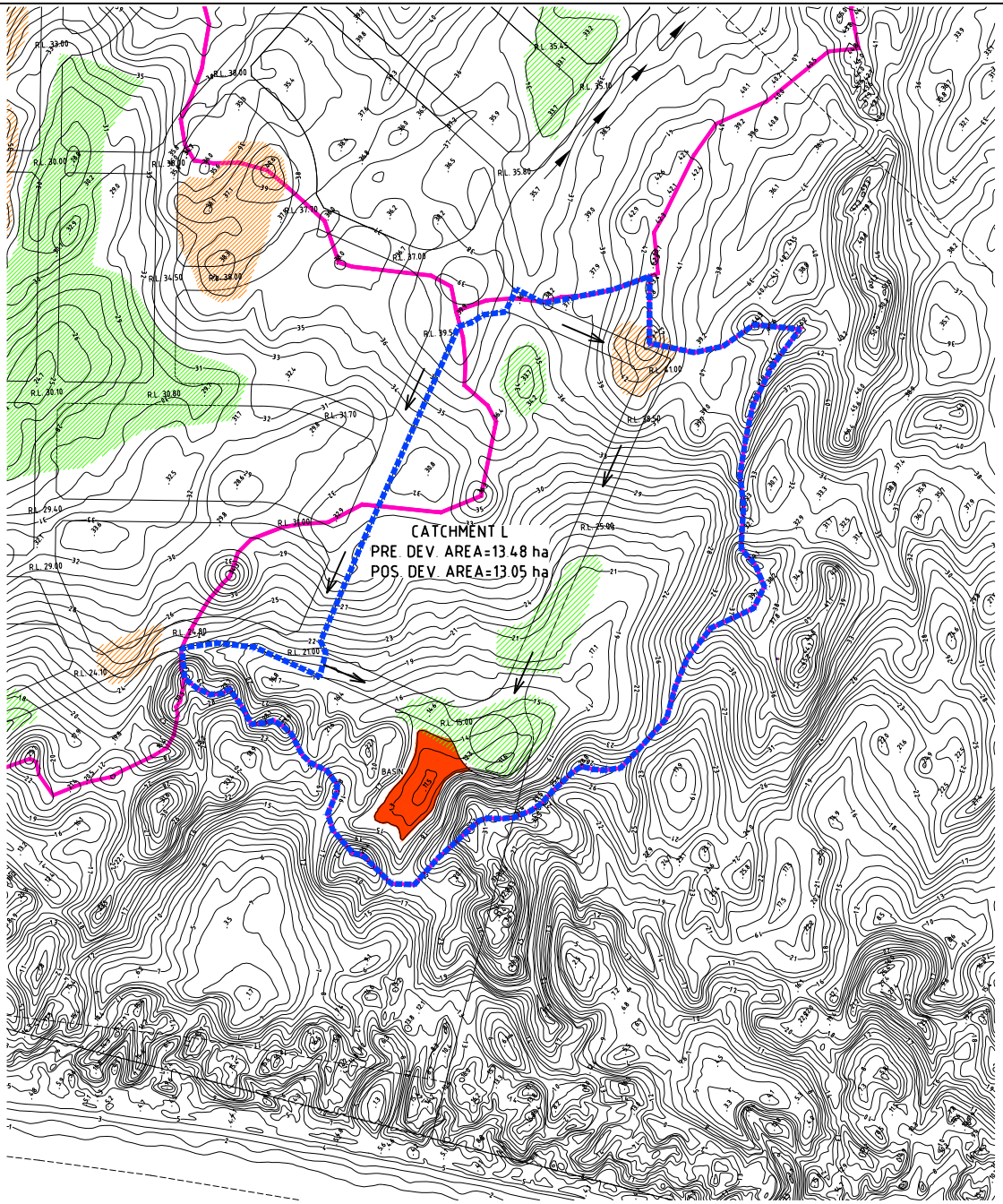
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Appendix I

Updated Coastal Assessment

Cardno

Shaping the Future

R254 Rev 1

July 2010

Moore River Company Pty Ltd

Moore River South
Updated Coastal Setback Assessment

m p rogers & associates pl
marinas boat harbours canals breakwaters jetties submarine pipelines seawalls dredging reclamation

Job J801, Report R254 Rev 1

R254 Rev 1

July 2010

Moore River Company Pty Ltd

Moore River South
Updated Coastal Setback Assessment

Job J801, Report R254 Rev 1
Record of Document Revisions

Rev	Purpose of Document	Prepared	Reviewed	Approved	Date
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1	Updated ODP added	T Hunt	C Doak	T Hunt	29/07/2010

Form 035 12/02/07

m p rogers & associates pl
waves currents tides flood levels water quality siltation erosion rivers beaches estuaries climate change

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Executive Summary

Locations 2424, 2802 and 2914 Barrogoon Road, Gingin, are located on coastal land south of the Moore River, Western Australia. The subject Lots are referred to as Moore River South.

The Moore River Company Pty Ltd engaged M P Rogers & Associates Pty Ltd (MRA) to update previous assessments of the physical processes setback to development with the most recent available data. This will provide an adequate level of protection to development from coastal erosion in the coming 100 years.

For new development on an undeveloped sandy shoreline such as Moore River South, the SCPP recommends the following criteria be used to calculate an appropriate coastal setback:

- S1 = Allowance for acute short term erosion caused by a series of severe storms, with elevated water levels and an Average Recurrence Interval (ARI) of approximately 100 years. The Department of Transport (DOT) suggests the use of the SBEACH model using three repeats of the severe storm experienced in July 1996 to conservatively represent the 100 year ARI storm with respect to coastal erosion.

- S2 = Allowance for chronic long-term trends caused by local coastal dynamics. This needs to provide a buffer for the coming 100 years. The policy recommends the use of 100 times the long-term average rate of recession or 20 m, whichever is greater.

- S3 = Possible long term erosion trends caused by Climate Change and associated sea level rise anticipated in the coming 100 years. The policy recommends the allowance of a 0.38 m rise in the general sea level and the assumption that this may cause 38 m recession of the shoreline.

To determine the severe storm sequence allowance, SBEACH modelling was completed for three locations on the shoreline at Moore River South. The modelling was shown to result in unrealistic inshore water levels when input using the method requested by DOT. The storm was also therefore modelled to match the measured inshore water levels during the July 1996 event. The storm sequence is believed to represent the 100 year ARI event at Moore River South in relation to beach erosion.

The SBEACH results indicate that the vegetation line would recede approximately 17 m following the severe storm sequence. This was used as the S1 factor in determining the appropriate PPS.

Shoreline movement analysis was updated for the Moore River South coastline to include lines approximately every 5 years. The analysis showed that the majority of the site has experienced long-term accretion, with rates of movement of the coastal vegetation line ranging from 0.1 to 0.9 m/yr. The 20 m safety allowance was included as the S2 component for the majority of the site. In the north of the site there has been some recent erosion up to 0.5 m/yr. A 50 m allowance for S2 in the northern section of the site was therefore included.

The recommended allowance of 38 m was included as the S3 component, based on the mean of the IPCC's median model estimate of sea level rise, and the Bruun Rule.

The recommended physical processes setback was therefore between 75 and 105 m. This is presented in the setback plan, included as an Appendix to this report.

The required minimum setback distances are to be measured from the Horizontal Setback Datum (HSD). For the accreting sandy coast of Moore River South, the HSD is taken as the seaward limit of coastal vegetation.

The recommended setback calculated in this study is greater than the setback in Cardno's original Outline Development Plan (dated March 2009) for the northern 1,000 m of the site. The setback in this area was therefore revised.

The final revised ODP (dated April 2010) includes reduced shoreline development and increased setbacks. Previous references to "Potential Sewerage Treatment Site and 'Rural Holiday Resort' have been amended in the final revised ODP. The revised ODP meets the requirements of this coastal setback assessment.

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1. Introduction

The land referred to as Moore River South lies south of Guilderton and the Moore River, covering lots 2424, 2802 and 2914 Barrogoon Rd Gingin. The Moore River Company Pty Ltd owns this land and is seeking approval for an amended Outline Development Plan.

M P Rogers & Associates Pty Ltd (MRA) have previously completed coastal engineering and setback assessments for the land at Moore River South (MRA 1994, 2005). The previous development plans have now been updated and MRA were engaged to update their coastal setback assessment with the most recent available data and for the new ODP. The location of the site is shown in Figure 1.1.



Figure 1.1 – Location Diagram

The final revised ODP (dated 7 April 2010) is included in Appendix A. This report presents the data, methods and findings of the investigations.

2. State Coastal Planning Policy

The State Coastal Planning Policy provides guidance on the siting of development on the Western Australian coastline. Schedule One of the SCPP outlines the recommended criteria for use in determining an appropriate coastal setback to development to provide adequate protection from physical coastal processes in the coming 100 years. This is referred to as the Physical Processes Setback (PPS) and will be assessed in the report.

For the general case of development on an undeveloped sandy shoreline such as Moore River South, the SCPP recommends using the following criteria to calculate the appropriate PPS:

- S1 = Acute short term erosion caused by a series of severe storms with elevated water levels. The Department of Transport (DOT) suggests the use of the SBEACH model using three repeats of the severe storm experienced in Perth in July 1996 to conservatively represent the 100 year ARI storm with respect to coastal erosion. Statistically there is a 63% chance of experiencing a 100 year ARI event or greater in the coming 100 years. The policy recommends taking the S1 factor as the total recession of the mean sea level contour as estimated using SBEACH and three repeats of the July 1996 storm. MRA does not believe that the recession of the mean sea level contour is the best measure of the impacts of storm erosion. The erosion behind the coastal vegetation line provides a better parameter and will be used in this assessment.

- S2 = Chronic long-term trends caused by the local coastal dynamics. This needs to provide a buffer for the coming 100 years. The policy recommends the use of 100 times the long-term average rate of recession or 20 metres, whichever is greater.

- S3 = Possible long term erosion trends caused by Climate Change and associated sea level rise anticipated in the coming 100 years. The policy recommends the allowance of a 0.38 metre rise in the general sea level and the assumption that this may cause 38 metres recession of the shoreline.

The calculated PPS is measured from the Horizontal Setback Datum (HSD). On a sandy coast such as at Moore River South the HSD is taken as the seaward limit of ephemeral coastal vegetation.

The SCPP also considers factors such as public beach access and ecological values. The scope of this report does not include consideration of these factors, but only the requirements to protect development from physical coastal processes. The PPS should therefore be considered a minimum.

3. Severe Storm Erosion Allowance (S1)

To determine the allowance for severe storm erosion, the SCPP recommends using a computer model such as SBEACH with three repeats of the storm experienced in Fremantle in July 1996. This is believed to conservatively represent the 100 year ARI event in relation to coastal erosion. The duration of the storm with elevated water levels and high waves is important in determining the severe storm erosion.

The SBEACH computer model was developed by the Coastal Engineering Research Centre to simulate beach profile evolution in response to storm events. It is described in detail by Larson & Kraus (1989). Since this time the model has been further developed, updated and verified based on field measurements (Wise et al 1996). Primary input to the model include time histories of wave height, period, water elevation, pre-storm beach profile and median sediment grain size (Wise et al 1996). The SBEACH model has also been locally validated by MRA, with results outlined in Rogers et al (2005). This local validation showed that SBEACH can provide useful predictions of the storm induced erosion provided the inputs to SBEACH are correctly applied and care is taken to ensure that the model is accurately reproducing measured nearshore water levels and wave conditions.

DOT have provided MRA with the appropriate measured data from the July 1996 event for use in the SBEACH modelling. The peak wave height (Hs) in 48 m of water was 7.8 m and the peak water level, measured in approximately 5 m of water, was 0.99 mAHD. Care needs to be taken to ensure that SBEACH reproduces the measured conditions at locations comparable to the measurement locations.

In recent years DOT have requested that the July 1996 storm be input into the SBEACH model in 48 m of water. In an area such as at Moore River South which is protected by shallow offshore reefs, this is likely to greatly overestimate inshore waves and water levels. In many cases these conditions are unrealistic.

MRA do not believe it is appropriate to model unrealistic conditions and as well as modelling the storm using DOT's recommended method have modelled the storm to match modelled nearshore waves and measured inshore water levels.

MRA has completed wave modelling work near Two Rocks, located approximately 15 km south of the study site. A comparison of the offshore wave heights measured at south-west Rottnest and the modelled nearshore wave heights at Two Rocks is presented in Figure 3.1. The nearshore wave heights at Two Rocks are in approximately 11 m of water.

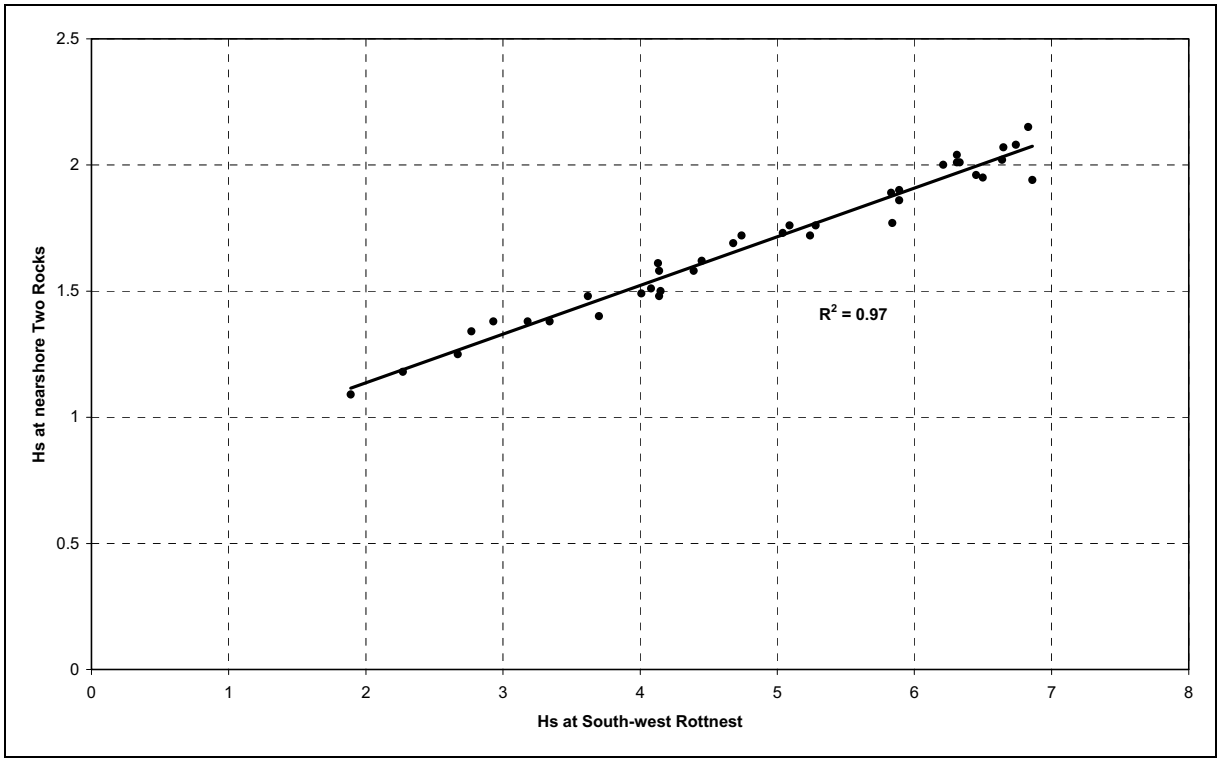


Figure 3.1 – Comparison of Offshore and Nearshore Wave Heights

The figure shows a strong relationship between the offshore and nearshore wave heights.

Comparison of the bathymetry and reef systems at Two Rocks and Moore River South suggest they would experience similar nearshore wave conditions. The relationship between wave heights at south-west Rottnest and Two Rocks shown in Figure 3.1 was therefore used to estimate the nearshore wave heights at Moore River South during the July 1996 event. These wave heights were input to the SBEACH model in approximately 11 m of water.

The water levels for the duration of the July 1996 storm were recorded by the DOT in the Fremantle Fishing Boat Harbour and represent nearshore waters of approximately 5 metres depth. Worley (2002) estimated the 100 year ARI water levels at Two Rocks, approximately 15 km south of the study area. The 100 year ARI water level was estimated to be 1.22 mAHD at Two Rocks, in approximately 5 metres of water. This value is similar to the estimated 100 year ARI water level of 1.19 mAHD at Fremantle (MRA 2009, Department for Planning & Infrastructure 2004).

In addition, the submergence curves prepared by the DOT at Two Rocks and Fremantle both show highest recorded water levels of 1.98 mCD (= 1.22 mAHD), on 16 May 2003.

Due to the similar extreme water level conditions at Two Rocks and Fremantle, the water levels during the July 1996 storm are assumed to be similar at Fremantle and Moore River South. The water levels recorded in Fremantle during the event were therefore used as input to the SBEACH model.

Sediment samples were taken from the site by MRA and analysed for the representative grain size. Samples were taken from the waterline, the beach berm and the dunes and a composite sample of the three was taken to represent the grain size. The d50 of the composite sample was approximately 0.33 mm and this value was used in all SBEACH model runs.

To account for any differences in topography and bathymetry across the site, three profiles were compiled and modelled. The approximate locations of the profiles and the local bathymetry are shown in Figure 3.2.

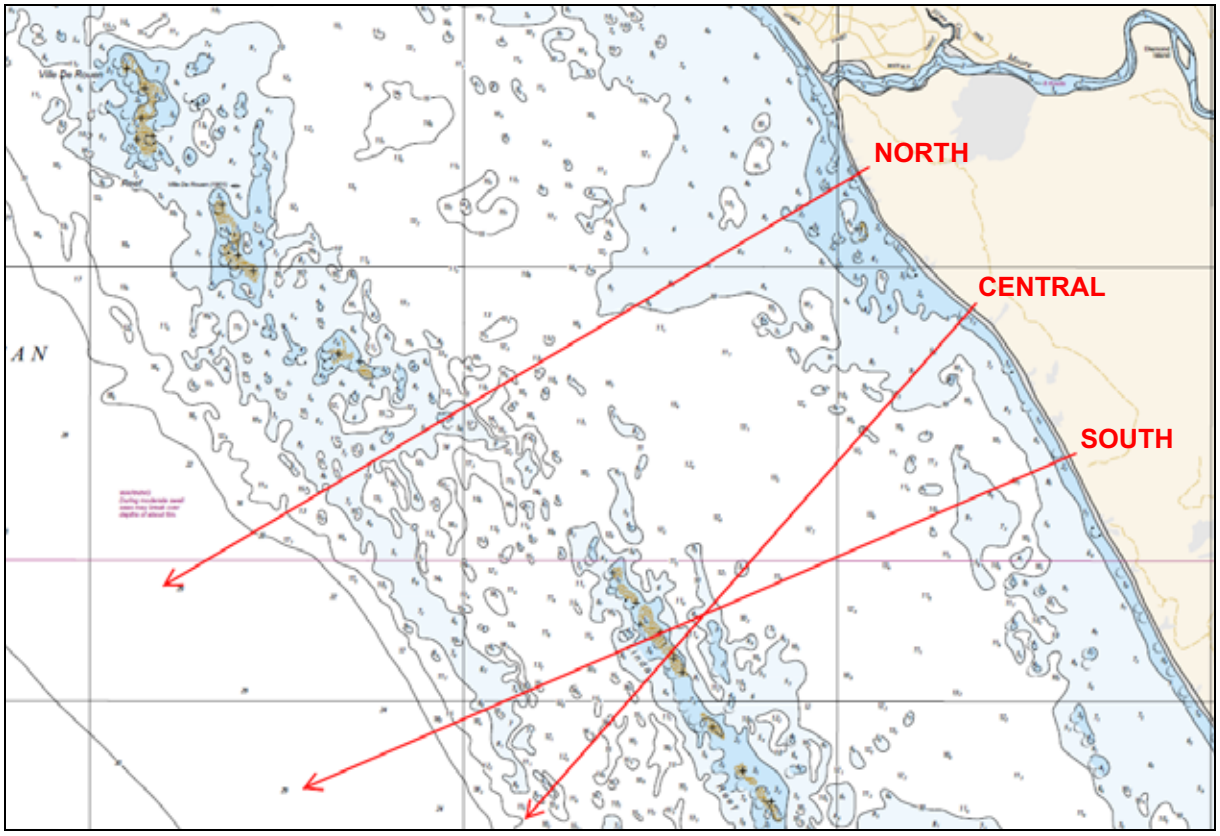


Figure 3.2 – SBEACH Profile Locations

The profiles were compiled from topographical data for the site supplied by the Client, public nautical charts for the area (WA 1110 and AUS 754) and measurements of the beach and nearshore zone taken by MRA. The profiles can be seen to extend over shallow reefs offshore. At these locations 'hard bottom profiles' were used in the SBEACH model.

The position of the HSD was estimated from the topographical data for the site and found to be generally between +3.0 and 3.5 mAHD. As a reference for estimating the potential storm erosion, +3.0 mAHD will be used.

The results from the northern profile for the DOT method and MRA method are presented in Figure 3.3. The top figure, using the DOT method, results in a nearshore water level of +1.65 mAHD. This is 0.65 m higher than recorded during the July 1996 event and 0.43 m higher than the highest recorded water level in this region. This is therefore considered unrealistic and should not be used in any analysis.

The bottom plot in Figure 3.3 shows that the SBEACH model is reproducing the measured conditions in a comparable depth of water. This is a realistic representation of the conditions and will be used in the assessment of an appropriate setback.

Similar plots for the central and southern profiles are presented in Figures 3.4 and 3.5. In all cases, using the DOT method can be seen to give unrealistic water levels and these cases should not be used for any purpose.

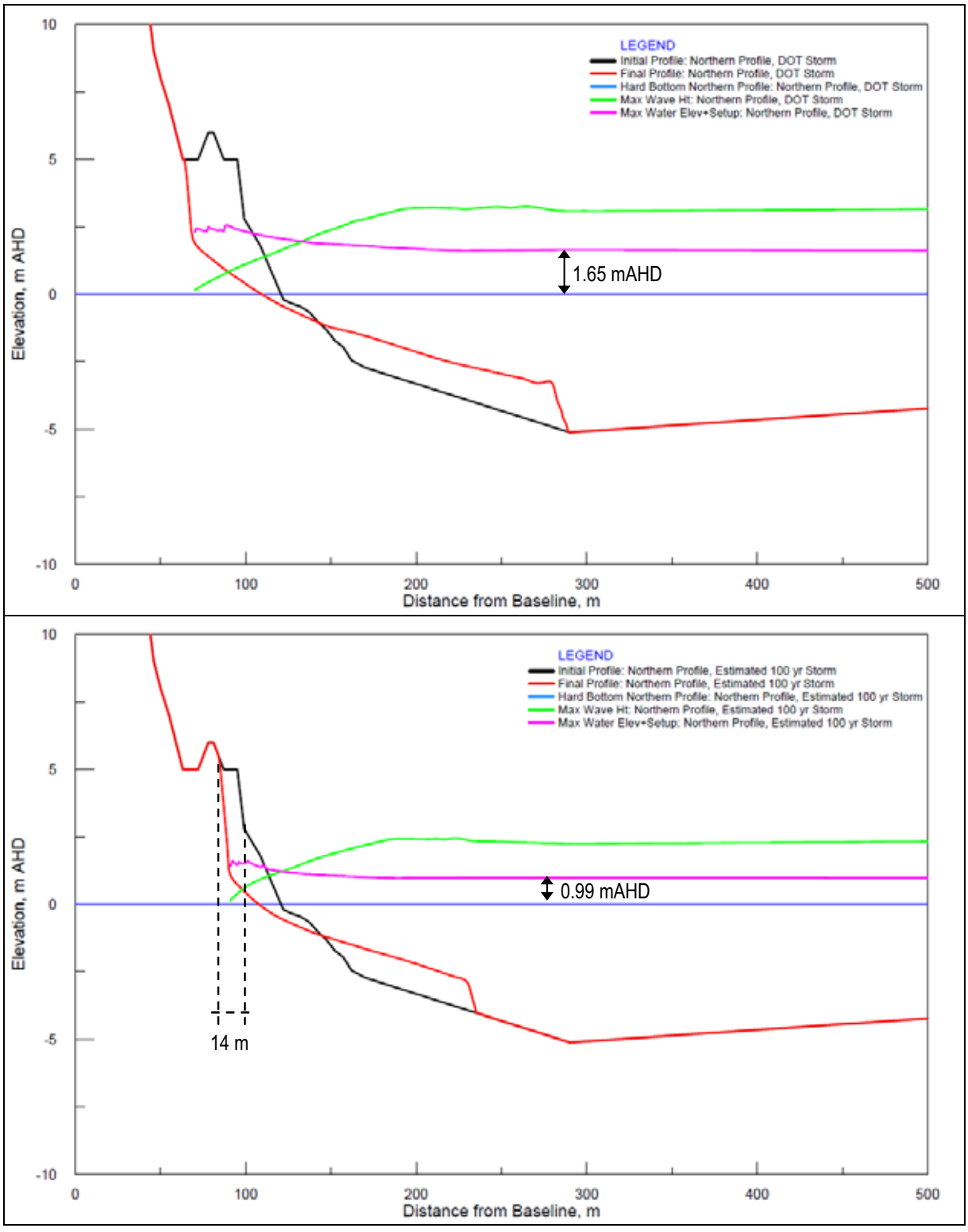


Figure 3.3 – Northern Profile Modelled Using DOT (top) and MRA (bottom) Methods

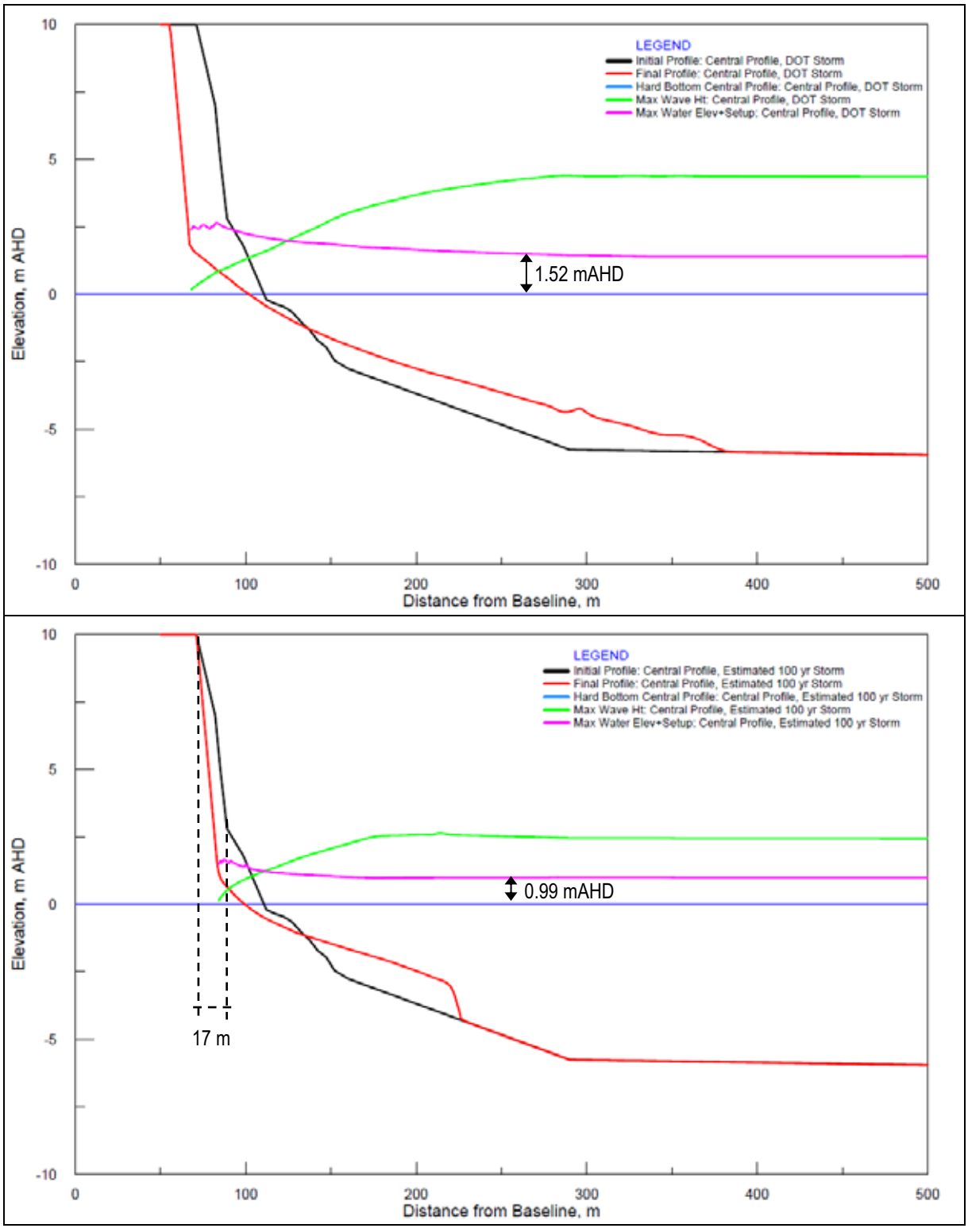


Figure 3.4 – Central Profile Modelled Using DOT (top) and MRA (bottom) Methods

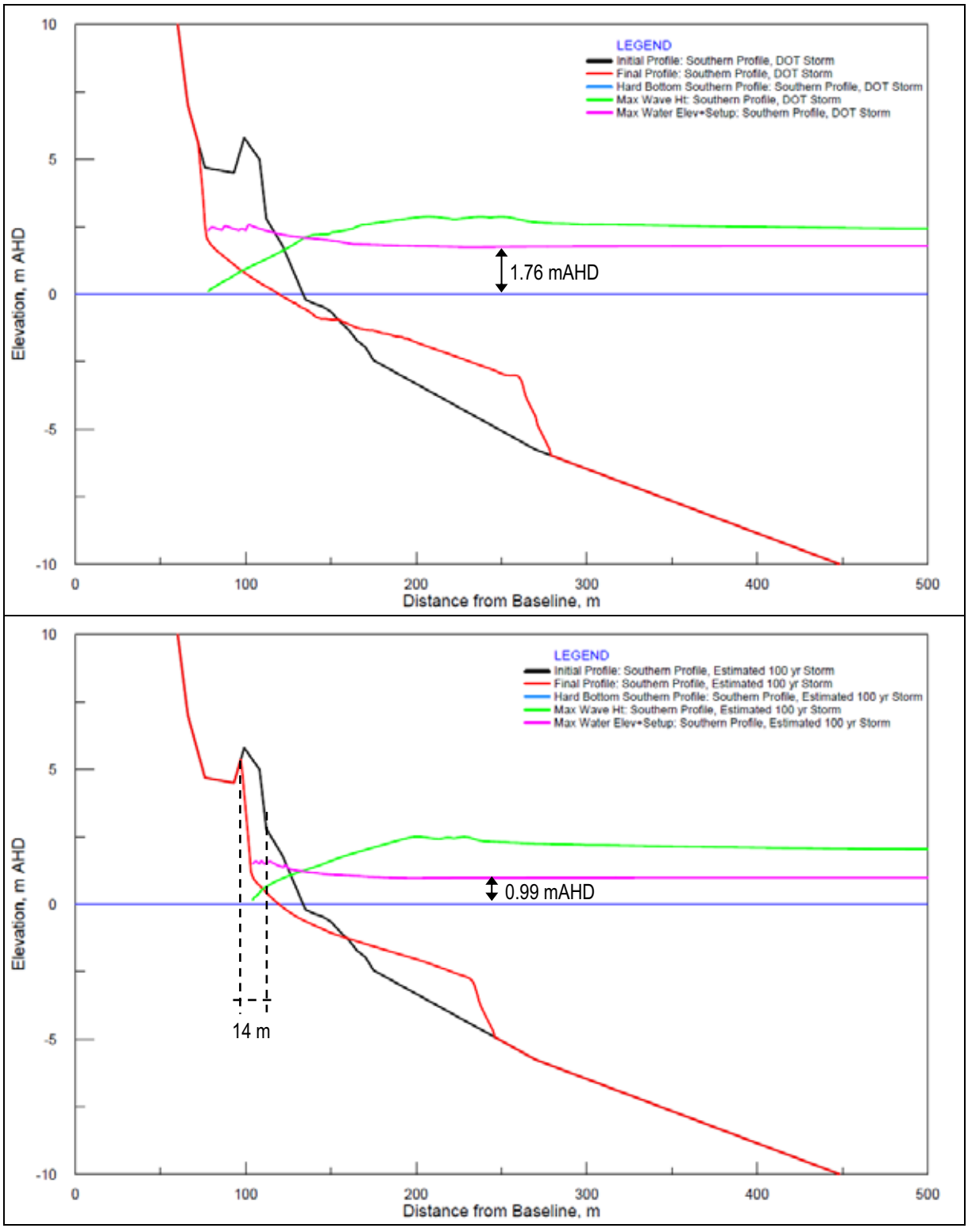


Figure 3.5 – Southern Profile Modelled Using DOT (top) and MRA (bottom) Methods

Figures 3.3 to 3.5 show that as well as resulting in unrealistic water levels, the DOT method results in very high inshore wave heights. The central profile (Figure 3.4) shows a modelled wave height over 4 m in around 5 to 10 m of water. This is in an area that is directly behind shallow reef and not believed to be representative of the severe storm sequence experienced in July 1996.

The above clearly show that using the DOT method results in unrealistic water levels in the inshore area, with waves and water levels not representing the July 1996 storm requested in the policy. Using unrealistic waves and water levels can only result in unrealistic results and the output from the model runs using the DOT method should not be used.

The results from the model runs using the MRA method are presented in Table 3.1. Both the erosion behind the HSD and the recession of the mean sea level are presented.

Table 3.1 Modelled Erosion

Profile	Erosion Behind HSD	Recession of MSL contour
Northern	14	13
Central	17	12
Southern	14	14

The modelling reports for each of these SBEACH runs are included in Appendix 2.

MRA recommend that the erosion behind the HSD is taken as the S1 allowance. The greatest erosion was seen at the central profile and this should be applied for the whole site. The S1 allowance will therefore be taken as 17 m.

It should be noted that limestone outcrops have been seen in the dunes at Moore River South. These have not been included in the storm erosion modelling as the extent of limestone is not known. However, any durable rock present in the coastal dunes may offer additional protection from storm erosion.

4. Historic Shoreline Movement Allowance (S2)

To estimate the appropriate S2 allowance, shoreline movement analysis was completed for the coastline near the study site. This plots the historical position of the coastal vegetation line, an indicator of shoreline position, over a number of years.

MRA commissioned Whelans to undertake the photogrammetry, plotting the position of the coastal vegetation lines in line with the DOT's *Coastal Demarcation Lines* methodology (DOT, 2009). This extended analysis from MRA (2005) to include lines approximately every 5 years. Vegetation lines from the following years were included in the analysis:

- 1965;
- 1969;
- 1974;
- 1980;
- 1986;
- 1990;
- 1994;
- 2002; and
- 2008.

The relative movement of the coastal vegetation line was therefore determined over a 43 year period. The accuracy of the plotted coastal vegetation lines is believed to be approximately ± 5 metres in the horizontal plane. The shoreline movement plans are included in Appendix B.

In general the plans indicate that the vegetation line has been moving forward since 1965 and a number of the blowouts indicated in earlier photographs lines have been stabilising and filling in.

From the shoreline movement plans, the relative movement of the coastal vegetation line from 1965 was estimated at 100 metre intervals along the site. This is presented in Figure 4.1.

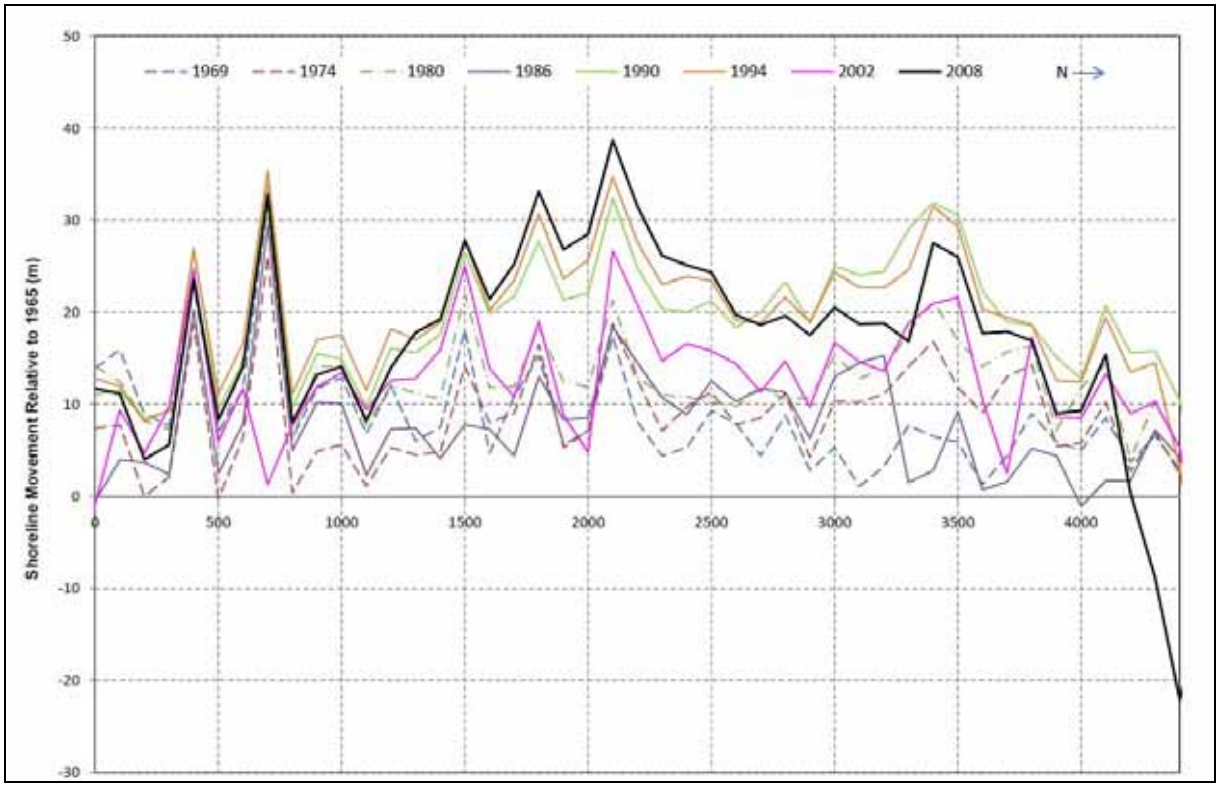


Figure 4.1 – Shoreline Movement Relative to 1965

The following can be seen from Figure 4.1:

- Between chainage 0 and 2,500 m there was a generally consistent accretion trend between 1965 and 2008.
- Between chainage 2,500 and 4,100 m there was erosion between 1994 and 2002, then accretion since 2002. The general trend over the measurement period was accretion.
- North of chainage 4,100 m there has been recent erosion. This area is close to the mouth of the Moore River.

Time history plots of shoreline position at chainages 1,500, 3,000 and 4,300 m are presented in Figure 4.2 to 4.4.

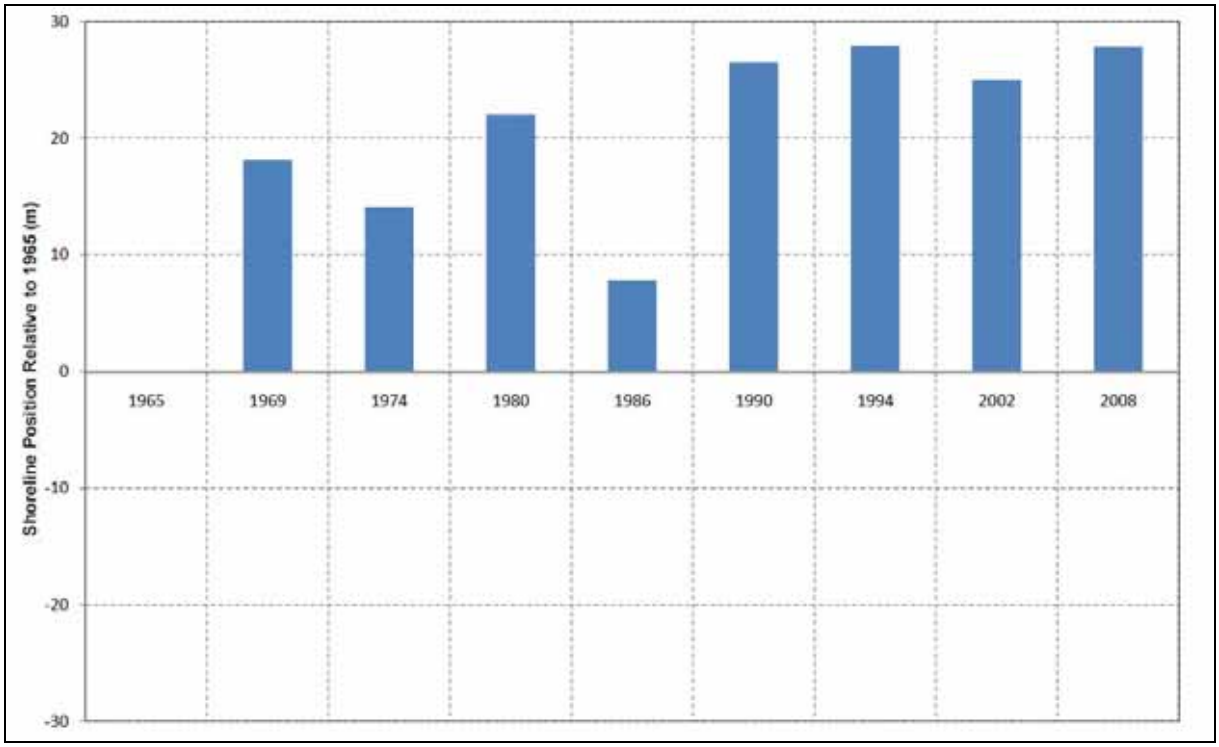


Figure 4.2 – Time History of Shoreline Position at Ch 1,500 m

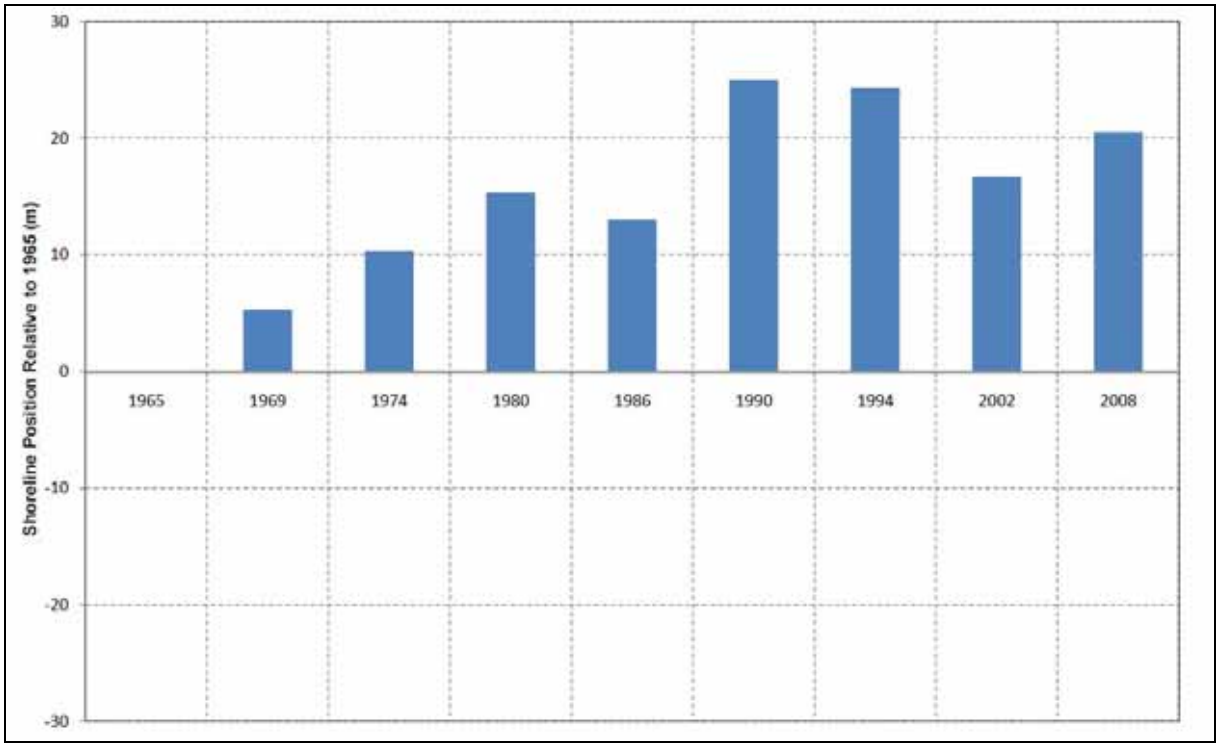


Figure 4.3 – Time History of Shoreline Position at Ch 3,000 m

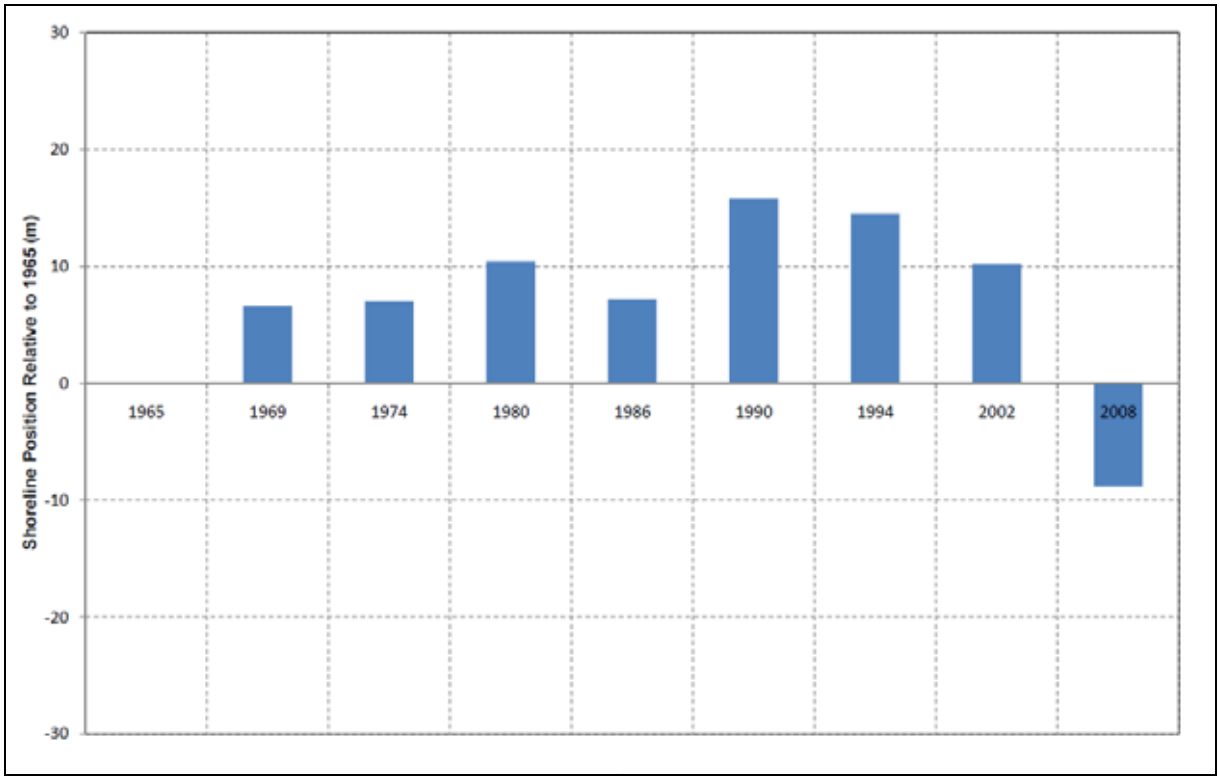


Figure 4.4 – Time History of Shoreline Position at Ch 4,300 m

The time histories at chainages 1,500 and 3,000 m both show fluctuations of up to 15 m in the position of the vegetation line, with a continuing long-term accretion trend. The time history at 4,300 m shows erosion between 2002 and 2008. This leads to a long-term erosion trend at this site.

The rate of shoreline movement between 1965 and 2002 is presented in Figure 4.5. The SCPP states that if the long-term rate of accretion on the shoreline is less than 0.2 m/yr, a 20 metre "safety" allowance should be used. The 0.2 m/yr rate is also shown on the figure as a solid line.

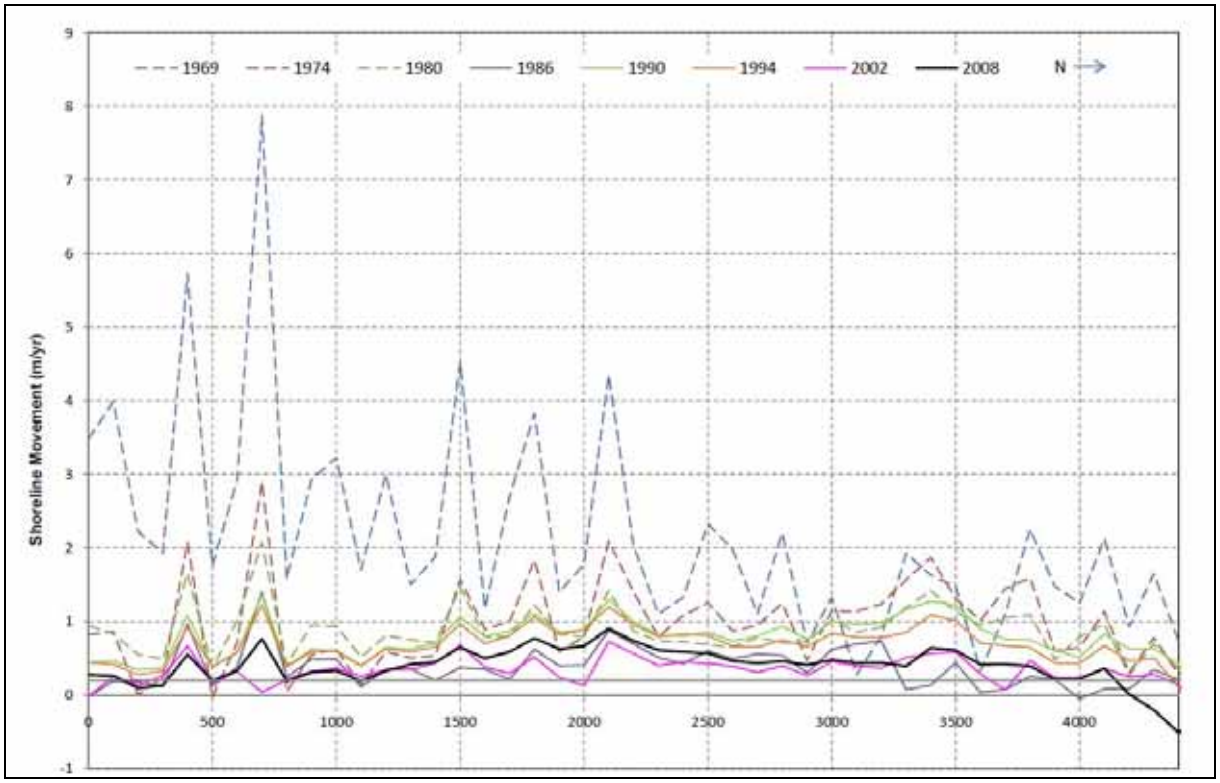


Figure 4.5 – Rate of Shoreline Movement from 1965

The figure shows that between 1965 and 2008 most of the shoreline (between chainages 1,100 and 4,100 m) accreted at a rate greater than 0.2 m/yr. In places south of chainage 1,100 m and north of chainage 4,100 m the rate falls below 0.2 m/yr. The greatest rate of erosion measured in this area is approximately 0.5 m/yr.

Although the rate of accretion for a large part of the site was greater than 0.2 m/yr in the long-term, it is recommended that the 'safety' allowance of 20 m is included. This is due to the fluctuations in shoreline position shown in the time histories of Figures 4.2 and 4.3.

In the north of the site where there has been some recent erosion the largest erosion rate is recommended to be applied to the whole section. This will provide additional allowance if this erosion extends further from the Moore River.

The rates of change and recommended S2 allowances are summarised in Table 4.1.

Table 4.1 Recommended S2 Allowances

Shoreline Section	Rate of Movement (m/yr)	S2 Allowance (m)
0 – 3,800 m	0.1 to 0.9	20
3,800 – 4,400 m	-0.5 to 0.4	50

The recommended S2 allowances above should be used in calculation of the total PPS.

5. Sea Level Rise Allowance (S3)

The Intergovernmental Panel on Climate Change (IPCC) has presented various scenarios of possible climate change and the resultant sea level rise in the coming century (IPCC 2001). There is still some uncertainty as to which of these scenarios will occur. For example it is not known whether greenhouse gas emissions will fall, stay steady or increase in the coming decades and century.

The atmospheric and oceanographic processes involved in climate modelling are complex, and numerical modelling of these processes is far from perfect. Due to these uncertainties, there are a wide range of predictions for global sea level rise in the coming century.

In 2007 the IPCC released the findings of research conducted since the release of IPCC (2001). This is presented in the revised *Summary for Policymakers* (IPCC 2007). Table SPM 3 contained in IPCC (2007) presents projected sea level rise scenarios to 2099. The predictions made in IPCC (2007) are essentially the same as those provided in IPCC (2001). These predictions are shown in Figure 5.1 and range from around 0.1 to 0.9 m.

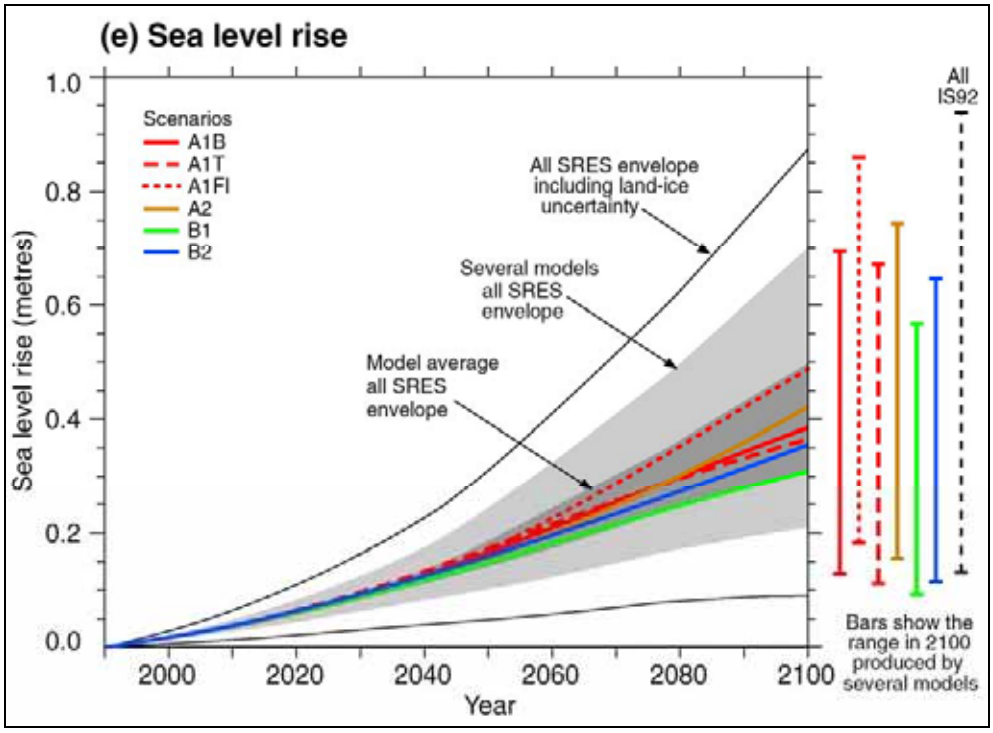


Figure 5.1 - IPCC Scenarios for Sea Level Rise

The SCPP recommends estimating sea level rise based on the mean of the median model of these scenarios. This gives approximately 0.38 m sea level rise in the coming century.

The effect of sea level rise on the coast is difficult to predict. Komar (1998) provides a reasonable treatment for sandy shores, including examination of the Bruun Rule (Bruun 1962). The Bruun Rule relates the recession of the shoreline to the sea level rise and slope of the nearshore sediment bed:

$$R = \frac{1}{\tan(\theta)} S$$

where: R = recession of the shore;

θ = average slope of the nearshore sediment bed; and

S = sea level rise.

Komar suggests that the general range for a sandy shore is R = 50S – 100S. However, the Bruun Rule does not account for possible changes in the longshore transport of sediment as a result of changes in the directionality or frequencies of meteorological events. Should changes in these meteorological events occur the effect of climate change could be markedly different. No information currently exists in this regard, so for this investigation it is assumed that these factors would remain constant.

The SCPP recommends that for sandy coasts the recession be taken as 100 times the estimated rise in sea level. This would be around 38 m in the coming 100 years and will be used in the assessment of the PPS.

It was noted previously that limestone outcrops have been seen in the coastal dunes on the site. The extent of any limestone is unclear and it has therefore not been included in the assessment of erosion due to sea level rise. However, any durable rock in the coastal dunes may provide additional protection to the development.

6. Assessment of PPS

The following assessment of the appropriate PPS at Moore River South has been made based on the criteria outlined in previous sections and in Schedule One of the SCPP.

The various setback allowances calculated in previous sections as well as the total recommended physical processes setback are presented in Table 6.1.

Table 6.1 Calculation of Appropriate PPS

Factor	Allowance (m)
S1 – Severe Storm Erosion	17
S2 – Historic Shoreline Movement	20-50
S3 – Sea Level Rise	38
Total Recommended PPS	**75-105**

The PPS is to be measured from the HSD. The total coastal setback to development should also allow for factors such as public beach access, ecological and landform values.

The PPS should transition from the recommended 105 m in the north of the site to 75 m over approximately 500 m.

The recommended PPS above has increased from MRA (2005) especially in the north of the site. This is primarily due to the updated shoreline movement plans showing some recent erosion in the north of the site.

The recommended PPS across the site is presented in D801-01-01A, included in Appendix D. Review of the Cardno ODP dated March 2009 indicated the setback was insufficient in the northern 1,000 m of the Lot. The recommended PPS shown in D801-01-01A should be used in determining the setback to development.

The final revised ODP (dated 7 April 2010) is presented in Appendix A. This plan shows increased setbacks and a reduced development area. The final revised ODP is consistent with this assessment of coastal setbacks.

7. Boat Launching Facility

The ODP for the Moore River South development shows a boat launching facility towards the north of the site. MRA previously provided concept sketches of a boat launching facility approximately 1.2 km south of the Moore River (MRA 1994). It is assumed the facility would consist of a boat ramp and associated infrastructure.

Australian Standard AS3962 *Guidelines for design of marinas* outlines the requirements for the location and alignment of boat launching ramps. The location must:

- be aligned to the dominant waves from swell, sea and boat wash;
- be sheltered from waves larger than 0.2 m;
- have sufficient land approaches to permit queuing without blocking other traffic; and
- have water approaches of sufficient area to allow queuing and low speed manoeuvres without blocking fairways and channels.

Commonly occurring wave conditions at Moore River South would result in wave heights much greater than 0.2 m and protective breakwaters would therefore be required to provide shelter to the facility. These breakwaters would have to be designed to sufficiently reduce the wave height for boat launching.

The protective breakwaters would interrupt the longshore sand transport along the coast. If left unmanaged this could cause significant accretion of sediment on the updrift side of the facility, eventually impeding navigation into the facility, and erosion on the downdrift side.

These effects would therefore have to be managed to minimise adverse effects on the surrounding coastline. This could be completed by sand bypassing, where sand is mechanically moved by one side of the facility to the other. Similar sand bypassing and maintenance operations are carried out at a number of small craft facilities in Western Australia. Costs to complete sand bypassing operations depend on the quantities of sand moved, but can cost in the order of $100,000 annually.

8. Summary & Conclusions

The assessment of an appropriate setback at Moore River South has been made in line with the recommendations and intent of Schedule One of the State Coastal Planning Policy.

The following findigs and recommendations have been made from this study.

- The severe storm sequence may result in approximately 17 m erosion behind the coastal vegetation line.

- Shoreline movement plans for the site have been prepared and analysed. These indicate that the majority of the site has experienced a long-term accretion trend, although the position of the vegetation line has fluctuated at times. For the majority of the site the 20 m 'safety' allowance is therefore recommended. In the north of the site where there has been some recent erosion an S2 allowance of 50 m is recommended.

- A minimum setback to development of between 75 and 105 m is recommended. The final revised ODP included revised setbacks and is consistent with this assessment.

- A boat launching facility would require protective breakwaters and coastal management. Concept plans have previously been sketched for a site in the north of the Lot.

9. References

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10. Appendices

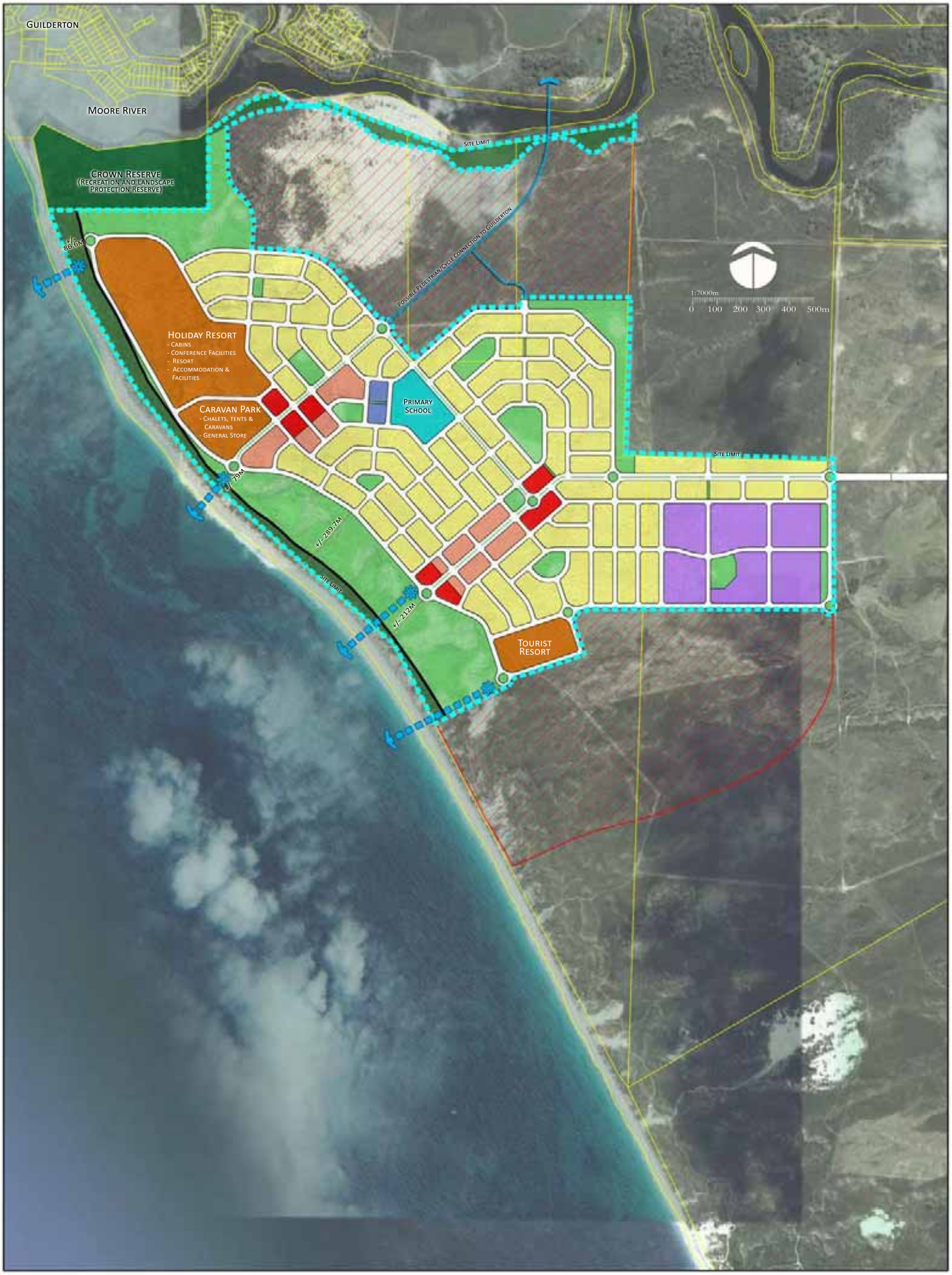
Appendix A **Outline Development Plan (7 April 2010)**

Appendix B **SBEACH Modelling Reports**

Appendix C **Shoreline Movement Plans**

Appendix D **Setback Plan**

Appendix A Outline Development Plan (7 April 2010)



PROJECT: MOORE RIVER SOUTH

TITLE: APPENDIX A - REVISED OUTLINE DEVELOPMENT PLAN

PRINCIPAL: MOORE RIVER COMPANY PTY LTD

Cardno (WA) Pty Ltd
Cardno Centre
2 Baggot Road
P.O. Box 155 Subiaco
Western Australia 6904
Telephone (08) 9273 3888
Fax (08 9388 3831

DATE: 07 APRIL 2010		SCALE:	1:7000M
DESIGNED: RG		CHECKED:	AKT
DRAWN: RG		APPROVED:	JA
LOCAL AUTHORITY:		SHEET	OF
SHIRE OF GINGIN		1	1
PROJECT - PHASE - PLAN NUMBER			REVISION
P07026 - SK10			X

ORIGINAL: A1

Appendix B SBEACH Modelling Reports

Reach: Northern Profile Storm: Estimated 100 yr Storm

Report

Project:

Reach: Northern Profile

Storm: Estimated 100 yr Storm

MODEL CONFIGURATION

INPUT UNITS (SI=1, AMERICAN CUST.=2): 1
NUMBER OF CALCULATION CELLS: 1000
GRID TYPE (CONSTANT=0, VARIABLE=1): 1
NUMBER OF GRID CELL REGIONS: 3
NUMBER CELLS AND CELL WIDTH IN REGION 1: 300, 1.0
NUMBER CELLS AND CELL WIDTH IN REGION 2: 200, 5.0
NUMBER CELLS AND CELL WIDTH IN REGION 3: 500, 65.0
NUMBER OF TIME STEPS AND VALUE OF TIME STEP IN MINUTES: 4008, 5.0
TIME STEP(S) OF INTERMEDIATE OUTPUT 1: 200
TIME STEP(S) OF INTERMEDIATE OUTPUT 2: 400
NO COMPARSION WITH MEASURED PROFILE.
PROFILE ELEVATION CONTOUR 1: 2.00
PROFILE ELEVATION CONTOUR 2: 0.00
PROFILE ELEVATION CONTOUR 3: -2.00
PROFILE EROSION DEPTH 1: 0.01
PROFILE EROSION DEPTH 2: 0.01
PROFILE EROSION DEPTH 3: 0.05
REFERENCE ELEVATION: 3.00
TRANSPORT RATE COEFFICIENT (m^4/N): 1.75E-6
COEFFICIENT FOR SLOPE DEPENDENT TERM (m^2/s): 0.0020
TRANSPORT RATE DECAY COEFFICIENT MULTIPLIER: 0.50
WATER TEMPERATURE IN DEGREES C : 16.0

WAVE TYPE (MONOCHROMATIC=1, IRREGULAR=2): 2
WAVE HEIGHT AND PERIOD INPUT (CONSTANT=0, VARIABLE=1): 1
TIME STEP OF VARIABLE WAVE HEIGHT AND PERIOD INPUT IN MINUTES: 120.0
WAVE ANGLE INPUT (CONSTANT=0, VARIABLE=1): 0
CONSTANT WAVE ANGLE: 0.0
WATER DEPTH OF INPUT WAVES (DEEP WATER = 0.0): 10.0
SEED VALUE FOR WAVE HEIGHT RANDOMIZER AND % VARIABILITY: 4567, 20.0
TOTAL WATER ELEVATION INPUT (CONSTANT=0, VARIABLE=1): 1
TIME STEP OF VARIABLE TOTAL WATER ELEVATION INPUT IN MINUTES: 120.0
WIND SPEED AND ANGLE INPUT (CONSTANT=0, VARIABLE=1): 0
CONSTANT WIND SPEED AND ANGLE: 20.0, 0.0

TYPE OF INPUT PROFILE (ARBITRARY=1, SCHEMATIZED=2): 1
DEPTH CORRESPONDING TO LANDWARD END OF SURF ZONE: 0.30
EFFECTIVE GRAIN SIZE DIAMETER IN MILLIMETERS: 0.33
MAXIMUM PROFILE SLOPE PRIOR TO AVALANCHING IN DEGREES: 45.0

NO BEACH FILL IS PRESENT.

NO SEAWALL IS PRESENT.

HARD BOTTOM IS PRESENT.

COMPUTED RESULTS

DIFFERENCE IN TOTAL VOLUME BETWEEN FINAL AND INITIAL PROFILES:
0.0 m^3/m

MAXIMUM VALUE OF WATER ELEVATION + SETUP FOR SIMULATION
1.62 m

Reach: Northern Profile Storm: Estimated 100 yr Storm

TIME STEP AND POSITION ON PROFILE AT WHICH MAXIMUM VALUE
OF WATER ELEVATION + SETUP OCCURRED
460, 101.0 m
MAXIMUM ESTIMATED RUNUP ELEVATION: 3.15 m
(REFERENCED TO VERTICAL DATUM)

POSITION OF LANDWARD MOST OCCURRENCE OF A 0.01 m EROSION DEPTH:
85.0 m

DISTANCE FROM POSITION OF REFERENCE ELEVATION ON INITIAL PROFILE
TO POSITION OF LANDWARD MOST OCCURRENCE OF A 0.01 m EROSION DEPTH:
13.6 m

POSITION OF LANDWARD MOST OCCURRENCE OF A 0.01 m EROSION DEPTH:
85.0 m

DISTANCE FROM POSITION OF REFERENCE ELEVATION ON INITIAL PROFILE
TO POSITION OF LANDWARD MOST OCCURRENCE OF A 0.01 m EROSION DEPTH:
13.6 m

POSITION OF LANDWARD MOST OCCURRENCE OF A 0.05 m EROSION DEPTH:
85.0 m

DISTANCE FROM POSITION OF REFERENCE ELEVATION ON INITIAL PROFILE
TO POSITION OF LANDWARD MOST OCCURRENCE OF A 0.05 m EROSION DEPTH:
13.6 m

MAXIMUM RECESSION OF THE 2.00 m ELEVATION CONTOUR:
17.79 m

MAXIMUM RECESSION OF THE 0.00 m ELEVATION CONTOUR:
12.99 m

MAXIMUM RECESSION OF THE -2.00 m ELEVATION CONTOUR:
0.00 m

Reach: Central Profile Storm: Estimated 100 yr Storm

Report

Project:

Reach: Central Profile

Storm: Estimated 100 yr Storm

MODEL CONFIGURATION

INPUT UNITS (SI=1, AMERICAN CUST.=2): 1
NUMBER OF CALCULATION CELLS: 1000
GRID TYPE (CONSTANT=0, VARIABLE=1): 1
NUMBER OF GRID CELL REGIONS: 3
NUMBER CELLS AND CELL WIDTH IN REGION 1: 300, 1.0
NUMBER CELLS AND CELL WIDTH IN REGION 2: 200, 5.0
NUMBER CELLS AND CELL WIDTH IN REGION 3: 500, 75.0
NUMBER OF TIME STEPS AND VALUE OF TIME STEP IN MINUTES: 4008, 5.0
TIME STEP(S) OF INTERMEDIATE OUTPUT 1: 200
TIME STEP(S) OF INTERMEDIATE OUTPUT 2: 400
NO COMPARSION WITH MEASURED PROFILE.
PROFILE ELEVATION CONTOUR 1: 2.00
PROFILE ELEVATION CONTOUR 2: 0.00
PROFILE ELEVATION CONTOUR 3: -20.00
PROFILE EROSION DEPTH 1: 0.01
PROFILE EROSION DEPTH 2: 0.01
PROFILE EROSION DEPTH 3: 0.05
REFERENCE ELEVATION: 3.00
TRANSPORT RATE COEFFICIENT (m^4/N): 1.75E-6
COEFFICIENT FOR SLOPE DEPENDENT TERM (m^2/s): 0.0020
TRANSPORT RATE DECAY COEFFICIENT MULTIPLIER: 0.50
WATER TEMPERATURE IN DEGREES C : 16.0

WAVE TYPE (MONOCHROMATIC=1, IRREGULAR=2): 2
WAVE HEIGHT AND PERIOD INPUT (CONSTANT=0, VARIABLE=1): 1
TIME STEP OF VARIABLE WAVE HEIGHT AND PERIOD INPUT IN MINUTES: 120.0
WAVE ANGLE INPUT (CONSTANT=0, VARIABLE=1): 0
CONSTANT WAVE ANGLE: 0.0
WATER DEPTH OF INPUT WAVES (DEEP WATER = 0.0): 10.0
SEED VALUE FOR WAVE HEIGHT RANDOMIZER AND % VARIABILITY: 4567, 20.0
TOTAL WATER ELEVATION INPUT (CONSTANT=0, VARIABLE=1): 1
TIME STEP OF VARIABLE TOTAL WATER ELEVATION INPUT IN MINUTES: 120.0
WIND SPEED AND ANGLE INPUT (CONSTANT=0, VARIABLE=1): 0
CONSTANT WIND SPEED AND ANGLE: 20.0, 0.0

TYPE OF INPUT PROFILE (ARBITRARY=1, SCHEMATIZED=2): 1
DEPTH CORRESPONDING TO LANDWARD END OF SURF ZONE: 0.30
EFFECTIVE GRAIN SIZE DIAMETER IN MILLIMETERS: 0.33
MAXIMUM PROFILE SLOPE PRIOR TO AVALANCHING IN DEGREES: 45.0

NO BEACH FILL IS PRESENT.

NO SEAWALL IS PRESENT.

HARD BOTTOM IS PRESENT.

COMPUTED RESULTS

DIFFERENCE IN TOTAL VOLUME BETWEEN FINAL AND INITIAL PROFILES:
0.0 m^3/m

MAXIMUM VALUE OF WATER ELEVATION + SETUP FOR SIMULATION
1.67 m

Reach: Central Profile Storm: Estimated 100 yr Storm

TIME STEP AND POSITION ON PROFILE AT WHICH MAXIMUM VALUE
OF WATER ELEVATION + SETUP OCCURRED
1783, 87.0 m
MAXIMUM ESTIMATED RUNUP ELEVATION: 3.47 m
(REFERENCED TO VERTICAL DATUM)

POSITION OF LANDWARD MOST OCCURRENCE OF A 0.01 m EROSION DEPTH:
72.0 m

DISTANCE FROM POSITION OF REFERENCE ELEVATION ON INITIAL PROFILE
TO POSITION OF LANDWARD MOST OCCURRENCE OF A 0.01 m EROSION DEPTH:
16.6 m

POSITION OF LANDWARD MOST OCCURRENCE OF A 0.01 m EROSION DEPTH:
72.0 m

DISTANCE FROM POSITION OF REFERENCE ELEVATION ON INITIAL PROFILE
TO POSITION OF LANDWARD MOST OCCURRENCE OF A 0.01 m EROSION DEPTH:
16.6 m

POSITION OF LANDWARD MOST OCCURRENCE OF A 0.05 m EROSION DEPTH:
72.0 m

DISTANCE FROM POSITION OF REFERENCE ELEVATION ON INITIAL PROFILE
TO POSITION OF LANDWARD MOST OCCURRENCE OF A 0.05 m EROSION DEPTH:
16.6 m

MAXIMUM RECESSION OF THE 2.00 m ELEVATION CONTOUR:
14.72 m

MAXIMUM RECESSION OF THE 0.00 m ELEVATION CONTOUR:
11.81 m

THE -20.00 m CONTOUR DID NOT RECEDE

Reach: Southern Profile Storm: Estimated 100 yr Storm

Report

Project:

Reach: Southern Profile

Storm: Estimated 100 yr Storm

MODEL CONFIGURATION

INPUT UNITS (SI=1, AMERICAN CUST.=2): 1
NUMBER OF CALCULATION CELLS: 1000
GRID TYPE (CONSTANT=0, VARIABLE=1): 1
NUMBER OF GRID CELL REGIONS: 3
NUMBER CELLS AND CELL WIDTH IN REGION 1: 300, 1.0
NUMBER CELLS AND CELL WIDTH IN REGION 2: 200, 5.0
NUMBER CELLS AND CELL WIDTH IN REGION 3: 500, 72.0
NUMBER OF TIME STEPS AND VALUE OF TIME STEP IN MINUTES: 4008, 5.0
TIME STEP(S) OF INTERMEDIATE OUTPUT 1: 200
TIME STEP(S) OF INTERMEDIATE OUTPUT 2: 400
NO COMPARSION WITH MEASURED PROFILE.
PROFILE ELEVATION CONTOUR 1: 2.00
PROFILE ELEVATION CONTOUR 2: 0.00
PROFILE ELEVATION CONTOUR 3: -2.00
PROFILE EROSION DEPTH 1: 0.01
PROFILE EROSION DEPTH 2: 0.01
PROFILE EROSION DEPTH 3: 0.05
REFERENCE ELEVATION: 3.00
TRANSPORT RATE COEFFICIENT (m^4/N): 1.75E-6
COEFFICIENT FOR SLOPE DEPENDENT TERM (m^2/s): 0.0020
TRANSPORT RATE DECAY COEFFICIENT MULTIPLIER: 0.50
WATER TEMPERATURE IN DEGREES C : 16.0

WAVE TYPE (MONOCHROMATIC=1, IRREGULAR=2): 2
WAVE HEIGHT AND PERIOD INPUT (CONSTANT=0, VARIABLE=1): 1
TIME STEP OF VARIABLE WAVE HEIGHT AND PERIOD INPUT IN MINUTES: 120.0
WAVE ANGLE INPUT (CONSTANT=0, VARIABLE=1): 0
CONSTANT WAVE ANGLE: 0.0
WATER DEPTH OF INPUT WAVES (DEEP WATER = 0.0): 10.0
SEED VALUE FOR WAVE HEIGHT RANDOMIZER AND % VARIABILITY: 4567, 20.0
TOTAL WATER ELEVATION INPUT (CONSTANT=0, VARIABLE=1): 1
TIME STEP OF VARIABLE TOTAL WATER ELEVATION INPUT IN MINUTES: 120.0
WIND SPEED AND ANGLE INPUT (CONSTANT=0, VARIABLE=1): 0
CONSTANT WIND SPEED AND ANGLE: 20.0, 0.0

TYPE OF INPUT PROFILE (ARBITRARY=1, SCHEMATIZED=2): 1
DEPTH CORRESPONDING TO LANDWARD END OF SURF ZONE: 0.30
EFFECTIVE GRAIN SIZE DIAMETER IN MILLIMETERS: 0.33
MAXIMUM PROFILE SLOPE PRIOR TO AVALANCHING IN DEGREES: 45.0

NO BEACH FILL IS PRESENT.

NO SEAWALL IS PRESENT.

HARD BOTTOM IS PRESENT.

COMPUTED RESULTS

DIFFERENCE IN TOTAL VOLUME BETWEEN FINAL AND INITIAL PROFILES:
0.0 m^3/m

MAXIMUM VALUE OF WATER ELEVATION + SETUP FOR SIMULATION
1.61 m

Reach: Southern Profile Storm: Estimated 100 yr Storm

TIME STEP AND POSITION ON PROFILE AT WHICH MAXIMUM VALUE
OF WATER ELEVATION + SETUP OCCURRED
1790, 109.0 m
MAXIMUM ESTIMATED RUNUP ELEVATION: 3.44 m
(REFERENCED TO VERTICAL DATUM)

POSITION OF LANDWARD MOST OCCURRENCE OF A 0.01 m EROSION DEPTH:
98.0 m

DISTANCE FROM POSITION OF REFERENCE ELEVATION ON INITIAL PROFILE
TO POSITION OF LANDWARD MOST OCCURRENCE OF A 0.01 m EROSION DEPTH:
13.6 m

POSITION OF LANDWARD MOST OCCURRENCE OF A 0.01 m EROSION DEPTH:
98.0 m

DISTANCE FROM POSITION OF REFERENCE ELEVATION ON INITIAL PROFILE
TO POSITION OF LANDWARD MOST OCCURRENCE OF A 0.01 m EROSION DEPTH:
13.6 m

POSITION OF LANDWARD MOST OCCURRENCE OF A 0.05 m EROSION DEPTH:
98.0 m

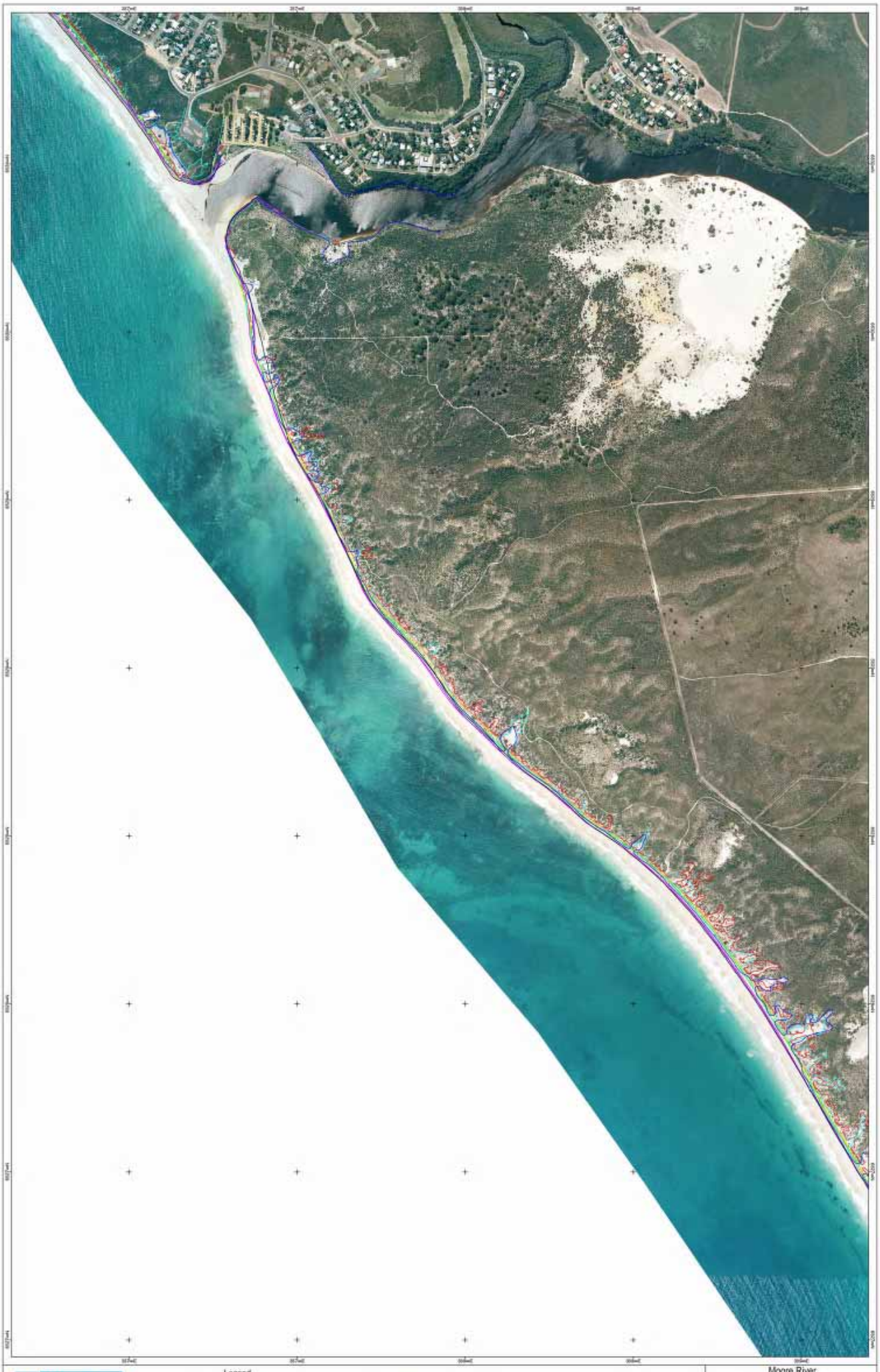
DISTANCE FROM POSITION OF REFERENCE ELEVATION ON INITIAL PROFILE
TO POSITION OF LANDWARD MOST OCCURRENCE OF A 0.05 m EROSION DEPTH:
13.6 m

MAXIMUM RECESSION OF THE 2.00 m ELEVATION CONTOUR:
17.81 m

MAXIMUM RECESSION OF THE 0.00 m ELEVATION CONTOUR:
14.19 m

MAXIMUM RECESSION OF THE -2.00 m ELEVATION CONTOUR:
0.00 m

Appendix C Shoreline Movement Plans



whelans

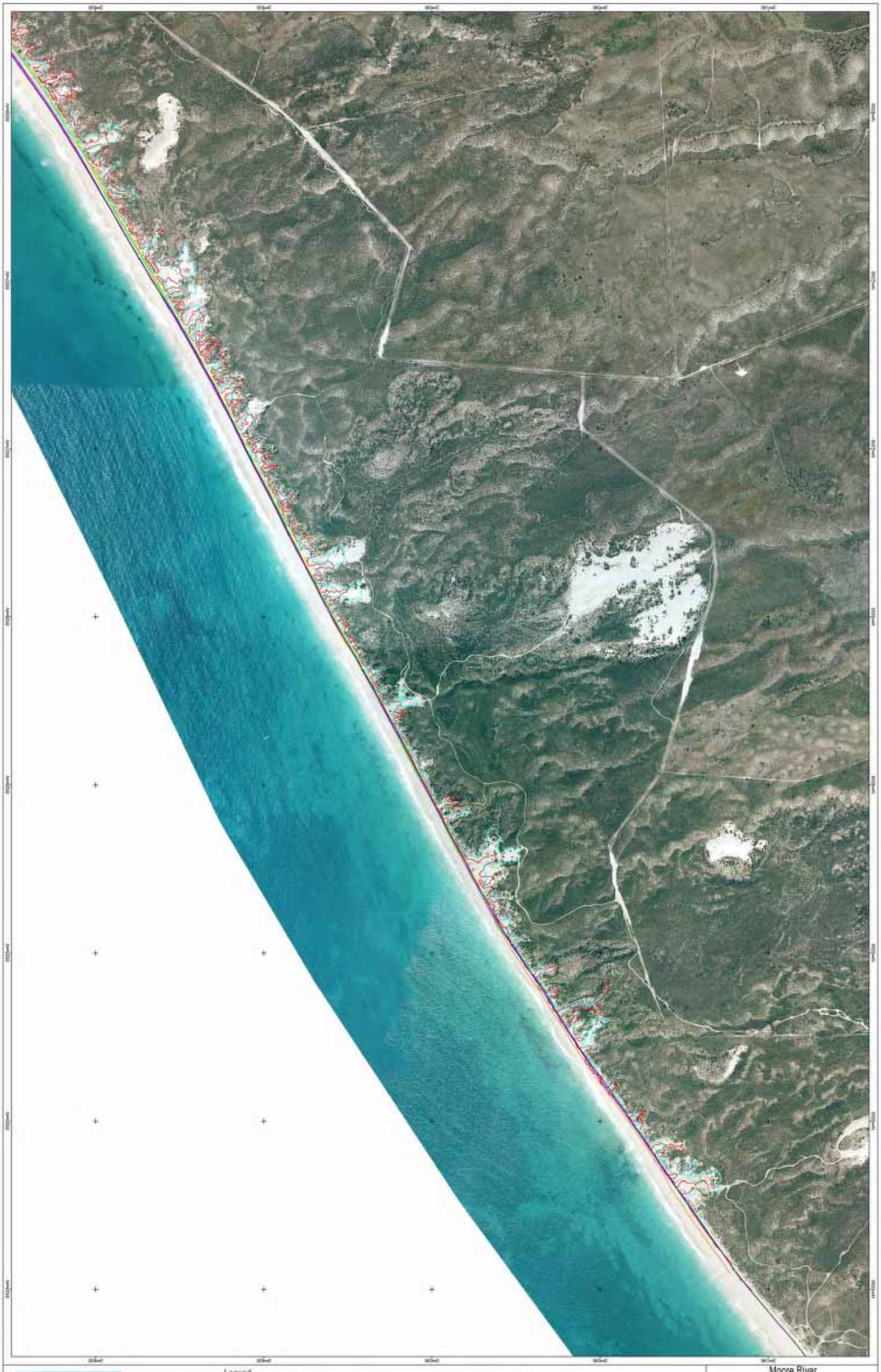
Legend

- 1965 Vegetation line from Digital Imagery
- 1969 October Vegetation line from Digital Imagery
- 1974 October Vegetation line from Digital Imagery
- 1980 December Vegetation line from Digital Imagery
- 1985 Vegetation line from Digital Imagery
- 1990 November Vegetation line from Digital Imagery
- 1994 October Vegetation line from Digital Imagery
- 2002 Vegetation line from Digital Imagery
- 2008 September Vegetation Line from Digital Imagery

Moore River
Shoreline Movement Survey

m. p. rogers and associates

Plan Scale: 1:8000	Plan Date: 19 Nov 2008	Plan No: 30668-0001
Base Imagery date: September 2008		Datum: GDA94 (50)



whelans

Legend

- 1965 Vegetation line from Digital Imagery
- 1969 October Vegetation line from Digital Imagery
- 1974 October Vegetation line from Digital Imagery
- 1980 December Vegetation line from Digital Imagery
- 1985 Vegetation line from Digital Imagery
- 1990 November Vegetation line from Digital Imagery
- 1994 October Vegetation line from Digital Imagery
- 2002 Vegetation line from Digital Imagery
- 2008 September Vegetation Line from Digital Imagery

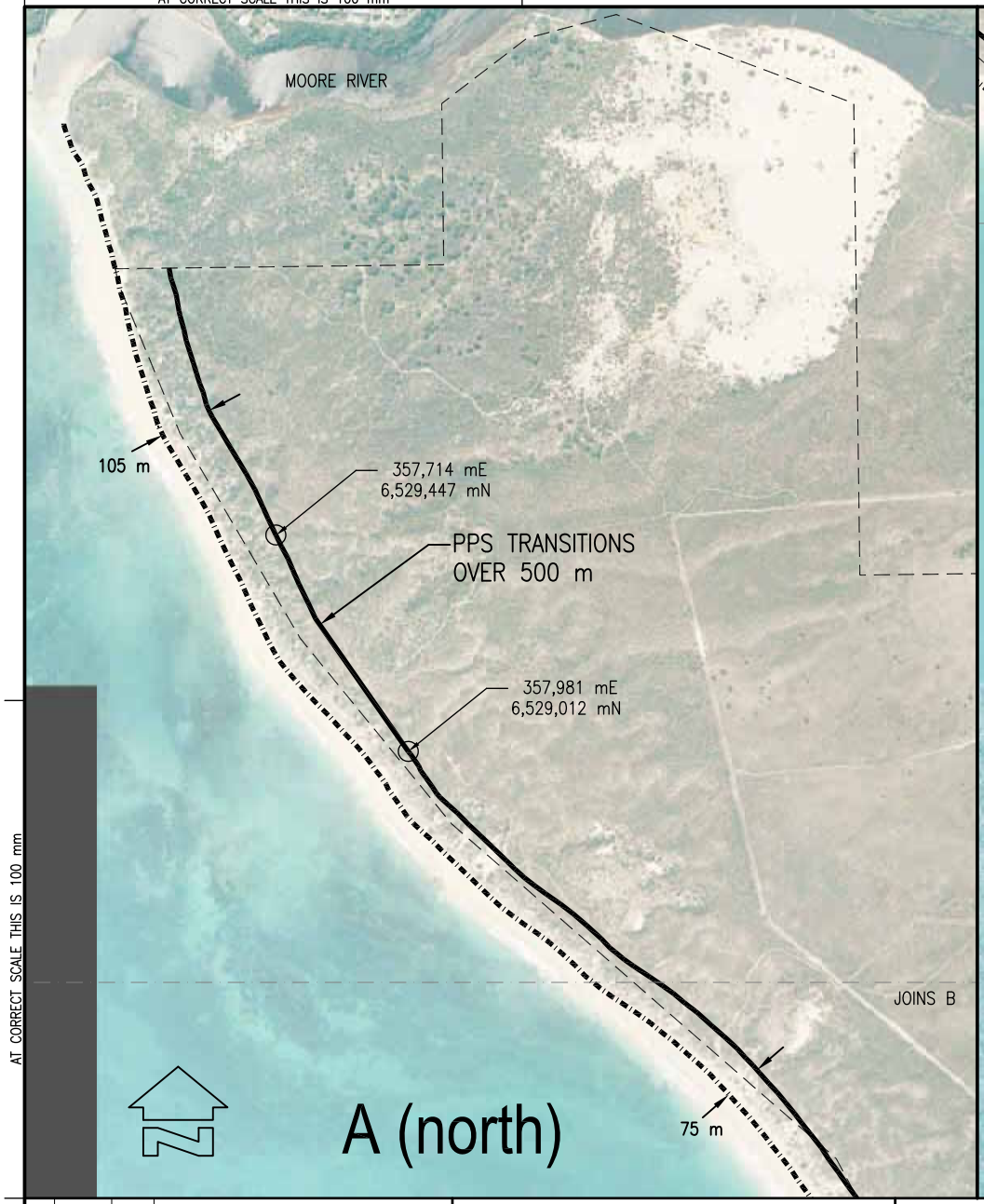
Moore River
Shoreline Movement Survey

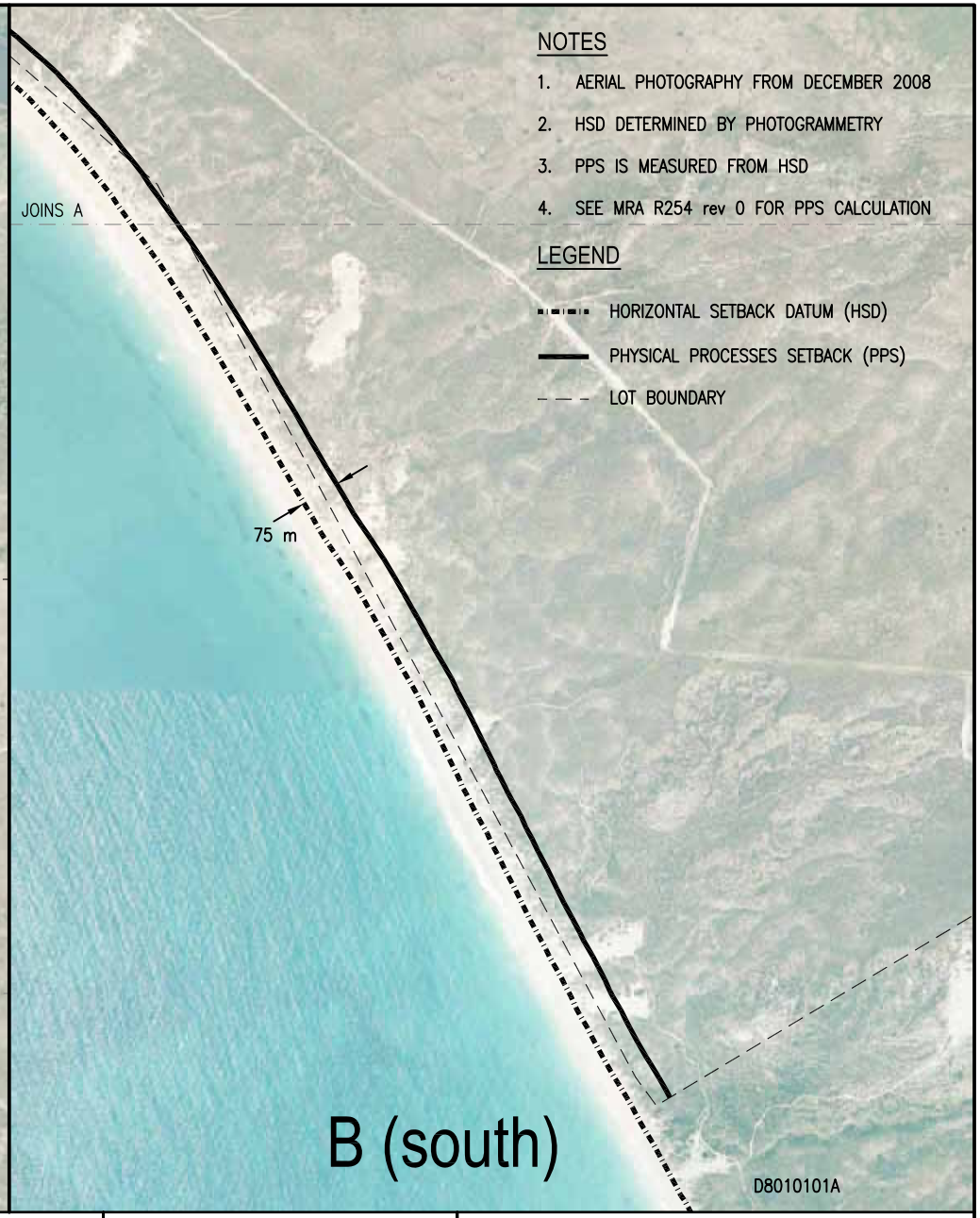
m. p. rogers and associates

Plan Scale: 1:5000	Plan Date: 19 Nov 2009	Plan No: 30669-2002
Base imagery date: September 2008		Datum: GDA94 Z50

Appendix D Setback Plan

AT CORRECT SCALE THIS IS 100 mm





NOTES

1. AERIAL PHOTOGRAPHY FROM DECEMBER 2008
2. HSD DETERMINED BY PHOTOGRAMMETRY
3. PPS IS MEASURED FROM HSD
4. SEE MRA R254 rev 0 FOR PPS CALCULATION

LEGEND

- HORIZONTAL SETBACK DATUM (HSD)
- PHYSICAL PROCESSES SETBACK (PPS)
- LOT BOUNDARY

AT CORRECT SCALE THIS IS 100 mm

REV	DATE	APP'D	DESCRIPTION
A	21.12.09		ISSUED FOR REPORT

CLIENT: MOORE RIVER COMPANY PTY LTD

DESIGNED	CHECKED	APPROVED
T HUNT		
DRAWN: T HUNT	CHECKED: T VAN BEEM	

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PROJECT: MOORE RIVER SOUTH

TITLE: PHYSICAL PROCESSES SETBACK PLAN

SCALE AT A3	DRAWING NUMBER	REV
1:10,000	D801-01-01	A

Appendix J

Graceful Sun-Moth Survey

Cardno

Shaping the Future

Cardno
Shaping the Future



Moore River South

Graceful Sun-Moth Survey

Prepared for Moore River Company Pty Ltd
June 2010
Project Number V9070-006

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Author: Full Name
Position Title:

Reviewer: Full Name
Position Title:

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Executive Summary

The Moore River Company Pty Ltd (MRC) have commissioned environmental investigations to support the revised Outline Development Plan (ODP) of Swan Location 2802 and portions of Swan Location 2424 and 2914, immediately south of Moore River near Guilderton. The subject site is located approximately 75 kilometres north of Perth central business district. It is within the local government area of the Shire of Gingin and is bound to the north by Moore River, to the west by the Indian Ocean and to the south and east by rural areas.

A survey for the Graceful Sun-Moth (GSM) – *Synemon gratiosa* was undertaken to determine whether the species was present within the subject site. The GSM is a federally listed 'Endangered' species under the *Environment Protection and Biodiversity Conservation* Act 1999 (EPBC Act) that is endemic to south-west Western Australia. The presence of the GSM may potentially require a referral under the EPBC Act.

The GSM is a small day-flying moth that has black-brown forewings and bright orange hind wings. Its' larva is known to feed and live exclusively on *Lomandra maritima* and *Lomandra hermaphrodita*, two species of the *Lomandra* mat-rushes.

The *Lomandra* species are broadly described as a grass-like perennial herb, with different species growing in regions all over Australia. *Lomandra maritima* and *Lomandra hermaphrodita* are both found in the south-west of Western Australia. *Lomandra maritima* is known to occur between Carnarvon and Bunbury and grows only in coastal regions with sandy soils. *Lomandra hermaphrodita* is known to occur from Geraldton and Albany and has a more widespread distribution, growing on sandy soils on the coastal plain and lateritic soils throughout the Darling Range.

Cardno was engaged by MRC to undertake a GSM Survey over the subject site. The GSM survey was undertaken in accordance with the Department of Environment and Conservation (DEC) guidelines *Graceful Sun Moth Information Kit and Survey Methods* (Bishop *et al* 2009) and consisted of two parts:

- A *Lomandra* density survey to be conducted prior to a GSM Survey; and
- A GSM survey based on the results of the *Lomandra* density survey.

The *Lomandra* density survey showed that the *Lomandra* species *Lomandra maritima* were found growing over different areas within the subject site, with the density varying from 1 to 80% coverage where it was found. The density survey also found that there were areas of the subject site that contained no *Lomandra* species.

On four separate days the subject site was walked by two observers to determine if GSM were present. A total of 22 GSM individuals were recorded within the subject site over the survey period, however the majority of the individuals were found beyond the revised ODP boundary.

No statistical analysis was undertaken in comparing the *Lomandra* density and the GSM locations however a comparison of these results was undertaken. It was difficult to determine if there was a correlation between the observations of GSM and the density of *Lomandra*, as GSMs were found in areas where the density of *Lomandra* was higher, but the opposite was also true in that no GSM were observed in some areas of higher *Lomandra* density and that GSMs were found in areas that appeared to contain no *Lomandra.*

An observation made during the GSM survey was that the GSM appeared to occur in areas of *Lomandra* and/or bushland in which there was a high incidence of sunlight i.e. limited over storey

species present, or open road and firebreaks. Another observation was that the area of the subject site where the greatest numbers of GSM were observed appears to correspond with a local high topographical point. These observations appear to support the information currently provided by the DEC, in that the GSM are only active in warm sunny weather and bright sunshine and the male GSMs prefer open areas, such as tracks and ridges.

From this survey it can be determined that GSM are located within the subject site. Due to the relatively small population size of this species it is likely vulnerable to localised extinction due a number of factors, including habitat loss and fragmentation.

Cardno recommend that MRC retain where possible areas of vegetation where the GSM were observed. Guidance should be sought from the DEC on viable management actions for such a conservation area, particularly on the requirements for retention. It is recommended that the main mechanisms used to conserve the populations of the Graceful Sun-Moth within the development area include:

- Where possible, the retention of the identified habitat for Graceful Sun-Moth (*Lomandra* species) in areas of POS;
- Translocation of *Lomandra* species to POS to be considered as a part of the landscaping design, in collaboration with the DEC;
- Use of landscaping management plans to ensure that *Lomandra* species, particularly *Lomandra maritima* are utilised where possible within road reserves and parkland areas;
- Future monitoring of the Graceful Sun-Moth population following development;
- Minimising construction, fire management and use of tracks during March (when the moth is active); and
- Where possible, use of building envelopes to protect remnant vegetation within private lots.

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Appendices

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Appendix B Graceful Sun-Moth Species Profile

Appendix C *Lomandra* Density Survey Raw Data

Appendix D GSM Transect Details

1 Introduction

The MRC is the owner of a parcel of land (Swan Location 2802 and portions of Swan Location 2424 and 2914) on the coast, immediately south of Moore River near Guilderton, which is approximately 75 kilometres north of Perth central business district. The MRC has commissioned environmental investigations to support the development and lodgement of a revised ODP. The revised ODP has been developed to facilitate "Urban Development" under the Shire of Gingin Town Planning Scheme (TPS) No. 8. The revised ODP covers an area approximately 346 hectares in size and is referred to as the 'subject site' within this report, as shown in **Figure 1**.

In particular, as a part of the investigations is it was identified that a referral for the proposed development pursuant to the federal *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) may be required due to the potential presence of a Matter of National Environmental Significance (MNES) - the Graceful Sun-Moth (GSM) - *Synemon gratiosa.* GSM has been recently listed under the EPBC Act as 'Endangered' and is known to occur in small reserves in the northern suburbs of the Perth metropolitan region, in vegetation communities found within the subject site (see **Section 2.1**).

1.1 Purpose of this Report

Cardno was engaged by MRC to undertake a GSM Survey, to be carried out in accordance with the Western Australian Department of Environment and Conservation (DEC) guidelines on how to conduct a GSM Survey (*Graceful Sun Moth Information Kit and Survey Methods*, Bishop *et al* 2009). A GSM survey consists of two parts:

- A *Lomandra* density survey to be conducted prior to the GSM Survey; and
- A GSM survey based on the results of the *Lomandra* density survey.

The purpose of this report is to document the outcomes of both the *Lomandra* density survey and the GSM Survey, providing comment on the likely occurrence of GSM within the subject site and likely management requirements should the species be present. This report will also support the referral pursuant to the federal EPBC Act.

1.2 Scope of Survey

This report presents a synthesis of the *Lomandra* density survey and the GSM survey, undertaken in accordance with the DEC guidelines. This report includes:

- An outline of the known information regarding GSM;
- Survey methodology for both the *Lomandra* density survey and GSM survey;
- Results of these surveys; and
- A discussion of the above results in relation to likely distribution of GSM within the subject site, with consideration of future management.

Cardno would like to acknowledge that this GSM survey and report was undertaken in collaboration with Greg Harewood (B.Sc). In particular Greg's expertise and experience were utilised in understanding the distribution and habits of the GSM as well as guiding the survey methodology and undertaking the survey.

2 Background

2.1 Graceful Sun Moth

2.1.1 Distribution

At present there is limited knowledge related to the population distribution of the GSM. Up until recently GSM were thought to be confined to a small number of bush reserves in the northern suburbs of Perth. Targeted survey work in February and April of 2010 by a number of consultants and the DEC have now extended the known range of the GSM north to Jurien Bay and south as far as Binningup (DEC *pers. comms.* April 2010).

As a significant number of the known GSM populations are located in small isolated bushland remnants, they are subject to a high risk of local extinction. It is anticipated that by identifying the key habitat for the GSM, suitable conservation sites for this species can be identified and protected.

2.1.2 Conservation Status

The GSM (*Synemon gratiosa*) is listed as 'Endangered' under the EPBC Act and in 'Schedule 1' under the Western Australian *Wildlife Conservation Act 1950* (WC Act). The DEC is currently undertaking a conservation project to conserve the GSM on the Swan Coastal Plain, including the 2010 survey program mentioned above. Cardno anticipate that the GSM survey of the subject site will contribute to the conservation efforts for the GSM.

2.1.3 Taxonomy

The GSM is brightly coloured and is often mistaken for a butterfly. GSM have black-brown forewings and bright orange hind wings, see **Plate 1** below. Their wingspan is between 25-30 mm. The female of the GSM is generally slightly larger than the male.



Plate 1: Graceful Sun Moth as found within subject site

2.1.4 Life Cycle

At present the exact life cycle of the GSM is not well known and is assumed to be between 1-3 years. The eggs are laid at the base of *Lomandra* mat-rushes, the known food source for the larvae of the GSM. The larvae then either live entirely within or alongside the underground part of the host

Lomandra until adulthood, feeding on the underground culms, roots or rhizomes of the *Lomandra* host. It is thought that larvae take between one or two years to reach maturity, however this is largely unknown. Male moths first appear in late February and females in early March. Mating occurs during March and females lay eggs during March and early April, after which all adult moths die off usually after a brief 2 to 10 day lifespan.

2.1.5 Behaviour

Adult GSMs are distinctively diurnal (active during the day). They prefer sunny conditions and are usually most active in the hottest part of the day (~10am to 3pm). They prefer conditions where there is little to no wind and typically do not fly more than a few metres above the ground.

Male GSMs are very territorial and prefer open areas such as tracks or firebreaks. Their territories are about 20 square metres in extent. Males are also known to seek out hilltops or dune ridgelines. Females are not as active as the males and prefer less open areas. GSM males are sedentary, but the extent to which females disperse is unknown. It is believed that females disperse less than 1 km from their colony of birth and are unlikely to cross unsuitable habitat (DEWHA 2009).

2.2 Lomandra

Lomandra hermaphrodita and *Lomandra maritima* are currently the only known food source for the GSM larvae (Bishop *et al*. 2009).

2.2.1 Morphology

Lomandra hermaphrodita and *Lomandra maritima* are two closely related and morphologically similar looking species of the *Lomandra* "mat-rushes". *Lomandra* species are broadly described as a grass-like perennial herb, with different species growing in different regions all over Australia. The genus comes in a variety of forms, but predominantly has long strap-like leaves. Generally *Lomandra* species are dioecious plants with male and female flowers occurring on different plants.

Lomandra maritima grows in clumps to 0.3 metres wide and 0.2 metres high, flowering from August to November (Western Australian Herbarium 2010), see **Plate 2**. *Lomandra hermaphrodita* grows in clumps to 0.2 metres wide and 0.2 metres high and flowers from April to June (Western Australian Herbarium 2010).



Plate 2: *Lomandra maritima* (courtesy of Florabase)

2.2.2 Distribution

Both *Lomandra maritima* and *Lomandra hermaphrodita* are endemic to Western Australia.

Lomandra maritima is known to occur between Carnarvon and Bunbury and grows only in coastal regions within sandy soils, being particularly common on the foredune (Western Australian Herbarium 2010). *Lomandra hermaphrodita* is known to occur from Geraldton to Albany and has a more widespread distribution, growing on sandy soils on the coastal plain and lateritic soils throughout the Darling Range of Western Australia.

3 Methodology

3.1 Lomandra Survey

In order to describe the distribution of GSM populations in any one area, the density and distribution of these two *Lomandra* species within the area need to be investigated and mapped. A *Lomandra* density survey was therefore undertaken across the subject site, to determine the presence of *Lomandra maritima* and *Lomandra hermaphrodita*.

A botanist and two environmental scientists from Cardno visited the subject site on the 29th, 30th and 31st of March and again on the 23rd of April 2010 to complete a *Lomandra* density survey undertaken in accordance with the methods described in Bishop *et al.* (2009).

Twenty transects were established within the subject site with 2 metre by 2 metre quadrats spaced at 50 metre intervals along each transect, shown in **Figure 2**. The length of each transect ranged from 300 to 850 metres depending on vegetation extent. Each transect started from a central point and radiated outward across the subject site at equal angles as described in Bishop *et al.* (2009). The position of each of the 238 quadrats was recorded with a hand-held GPS unit.

Environmental data recorded from each quadrat included the Foliage Projective Cover (FPC) of *Lomandra maritima*, the FPC of dominant species, topographic position, aspect, slope, bare ground, position in the landscape, surface and sub-surface soil description, vegetation structure and vegetation condition. The condition of the vegetation was assessed to assist in determining the conservation values of the subject site. The vegetation condition was rated according to Keighery (1994), the vegetation condition scale commonly used in the Perth Metropolitan region. The categories are shown below in **Table 1**.

Table 1: Vegetation Condition Scale (Keighery 1994)

Condition	Description
Excellent	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species.
Very Good	Vegetation structure altered, obvious signs of disturbance. For example, disturbance to vegetation structure caused by repeated fires, the presence of some more aggressive weeds, dieback, logging and grazing.
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate it. For example, disturbance to vegetation structure caused by very frequent fires, the presence of some very aggressive weeds at high density, partial clearing, dieback and grazing.
Degraded	Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management. For example, disturbance to vegetation structure caused by very frequent fires, the presence of very aggressive weeds, partial clearing, dieback and grazing.
Completely Degraded	The structure of the vegetation is no longer intact and the area is completely or almost completely without native species. These areas are often described as 'parkland cleared' with the flora comprising weed or crop species with isolated native trees or shrubs.

3.2 Graceful Sun Moth Survey

The targeted GSM survey was conducted with advice from the botanists, with the survey targeting those areas in which *Lomandra* coverage appeared densest (*Lomandra* survey was completed post the GSM survey) and on the general characterisation of vegetation condition. The GSM survey was undertaken in accordance with Bishop *et al* (2009). Prior to undertaking the survey the following actions were taken:

- Completion of an EPBC Act Protected Matters Search of the area (**Appendix A**);
- Review of the Department of the Environment, Water, Heritage and the Arts Species Profile for the GSM (**Appendix B**);
- Training from the Department of Environment and Conservation (DEC) on appropriate methods for undertaking GSM surveys; and
- Review of existing research undertaken by the DEC including the *Graceful Sun Moth Information Kit and Survey Methods*.

To comply with DEC requirements, four repeat surveys of the subject site were carried out. All surveys were completed within March 2010, between 10am and 3pm and were at least 4 days apart. Where possible windy (>18km/h) periods were avoided.

A predefined 14 kilometre transect, following existing roads and firebreaks and within some sparsely vegetated areas was walked at a steady pace by four observers. Any GSMs observed 5 metres either side of the transect and 5 metres ahead were recorded with a hand-held GPS providing accurate record of the location. Any GSM seen outside of this corridor, or detected at the subject site during other activities, were recorded as an 'incidental' observation.

At the DEC's request several GSM specimens were captured and passed on to Andrew Williams at the Wildlife Research Centre, Woodvale.

The "standard details" for transects were recorded as outlined in Appendix 1 of the Information Kit document (Bishop *et al* 2009).

4 Results

4.1 Lomandra

4.1.1 Lomandra Density

One species of *Lomandra* was recorded in the density survey, *Lomandra maritima*, with this species identified as significant habitat for the GSM (Bishop *et al*, 2009). *Lomandra maritima* was recorded at 146 of the 238 quadrats surveyed (61.3% of the quadrats). The FPC of the *Lomandra maritima* recorded varied across the subject site, ranging between 1 to 80 % with an average cover of 24.9 % (±1.4) across the entire subject site.

A Level 2 Flora and Vegetation Survey was previously completed by Cardno, in support of the proposed development (Cardno 2009). **Figure 3** illustrates that the majority of *Lomandra maritima* was recorded in the plant community MsAlSg. *Lomandra maritima* was also prominent in plant communities MsAlAp, MhAtMs and AlEg. *Lomandra maritima* was not recorded in the coastal plant community OaSc (>75m shoreline) nor was it recorded in communities ArAp, McSg or MsMhBs respectively. A description of these plant communities is provided in **Table 2** below.

Table 2: Plant Communities described within the subject site (Cardno 2009)

Plant Community	Description
OaSc	Low Scrub B of *Olearia axillaris* and *Scaevola crassifolia* over Open Herbs of **Trachyandra divaricata* **Tetragonia decumbens*, **Cakile maritima*, **Pelargonium capitatum*, *Hardenbergia comptoniana* and *Conostylis candicans* on foredunes with *Spinifex longifolius* and *Ficinia nodosa*.
AlEg	Scrub of *Allocasuarina lehmanniana subsp. lehmanniana*, *Spyridium globulosum* and *Myoporum insulare* with emergent pockets of Low woodland A to Open Low Woodland A of *Eucalyptus gomphocephala* over Low Scrub B of *Acacia lasiocarpa*, *Olearia axillaris* and *Leucopogon parviflorus* over Low Open Sedges of *Lepidosperma gladiatum* with **Bromus diandrus* and *Austrostipa flavescens*, *Parietaria debilis*, *Senecio pinnatifolius*, **Trachyandra divaricata, Daucus glochidiatus*, **Crassula glomerata* and *Trachymene pilosa*.
ArAp	Dense Thicket to Thicket of *Acacia rostellifera* over Low Scrub B of *Acanthocarpus preissii* over Open Low Grass of **Bromus diandrus*, **Lolium rigidum* and *Poa porphyroclados*, Open Herbs of *Calandrinia sp. Southwest Coast*, **Dischisma arenarium*, *Carpobrotus virescens*, and **Tetragonia decumbens* on lower slopes and within swales.
MsAlSg	Heath A to Dwarf Scrub C of *Melaleuca systena*, *Acacia lasiocarpa*, *Spyridium globulosum* and *Calothamnus quadrifidus* with occasional pockets of Low Woodland A of *Eucalyptus gomphocephala* and Low Woodland B of *Banksia attenuata* over Open Herbs of *Lomandra maritima*, *Parietaria debilis*, *Phyllanthus calycinus*, *Poranthera microphylla*, *Senecio pinnatifolius* and *Trachymene pilosa*.
MsAlAp	Low Heath B of *Melaleuca systena*, *Acacia lasiocarpa*, *Acanthocarpus preissii* and *Calothamnus quadrifidus* with occasional pockets of Low Woodland B of *Banksia attenuata* or Thicket to Scrub of *Acacia rostellifera* in the swales over Open Herbs of *Conostylis candicans*, *Desmocladus asper* and *Heliophila pusilla*, *Lepidosperma pubisquameum*, **Bromus diandrus* and *Poa porphyroclados* on cream-grey shallow sands over limestone.
McSg	Thicket of *Melaleuca cardiophylla*, *Spyridium globulosum*, *Leucopogon insularis* and *Acanthocarpus preissii* over Low Grasses **Bromus diandrus*, **Lolium rigidum* and **Ehrharta longiflora* with *Desmocladus asper*, *Calandrinia sp. Southwest Coast*, *Stylidium maritimum* (P3), *Hibbertia spicata subsp. leptotheca* (P3) and *Beyeria cinerea subsp. cinerea* (P3) on grey-brown shallow sands over limestone.
MsMhBs	Heath A to Dwarf Scrub C of *Melaleuca systena/Melaleuca huegelii*, *Banksia sessilis*, *Spyridium globulosum*, *Templetonia retusa*, *Acacia truncata* and *Hakea lissocarpha* over

	Open Herbs of *Calandrinia brevipedata*, *Podotheca gnaphalioides* and *Trachymene coerulea subsp. coerulea* with *Austrostipa flavescens*, *Poa porphyroclados*, **Bromus diandrus* and *Ehrharta villosa* on dark grey-brown sand over limestone.
MhAtMs	Low Heath C recently burnt (3-5 years) of *Melaleuca huegelii/Acacia truncata*, *Melaleuca systena* and *Banksia sessilis*, over Very Open Herbs of *Desmocladus asper*, *Stylidium junceum*, *Calandrinia sp. Two-rocks*, *Carpobrotus virescens*, **Crassula glomerata*, and *Gompholobium tomentosum* with **Bromus diandrus* and *Poa porphyroclados* on grey-brown shallow sands over limestone.

The vegetation condition predominately associated with *Lomandra maritima* was "Very Good", however it was also recorded in both "Excellent" and "Good" condition vegetation. Areas with a moderate incline (~10˚) in combination with a north, northwest or west aspects were most highly attributed to *Lomandra maritima* populations.

The soil type most highly associated with *Lomandra maritima* is grey sand overlying a brown loam.

The raw data collected as a part of the *Lomandra* Density Survey is presented in **Appendix D**.

4.2 Graceful Sun Moth

The transect path for the GSM survey totalled about 14 kilometres and was comprised of 58 "sections", the details of which are held in **Appendix E**.

4.2.1 Number of Moths Observed

A total of 22 GSMs were found within the subject site. The GSMs were recorded throughout the subject site in a variety of locations.

Table 3 summarises the results of the four surveys carried out over the subject site. The location and extent of the GSM transects and location of the GSM observations made during each survey is shown in **Figure 4**. Additional details on each survey and the specimens observed/collected are in **Appendix D.**

Table 3: Summary of GSM Survey Results

Survey Number	Survey Date	Number of GSMs Observed
1	11/03/2010	8
2	16/03/2010	12
3	24/03/2010	1
4	29/03/2010	1
TOTAL		**22**

5 Discussion

A total of 22 GSM were recorded as being present on the subject site in March 2010. The majority of the GSM found were beyond the revised ODP boundary with a few found in the northern coastal strip of the revised ODP area.

The *Lomandra* density survey indicates that the *Lomandra maritima* was found across the entire subject site and was predominantly associated with Plant Community MsAlSg, see **Figure 3**. Where *Lomndra maritima* was recorded the density of the *Lomandra* present ranged between 1 and 80%, with the highest density of 80% recorded at a number of locations across the subject site, see **Figure 2**.

No statistical analysis has been undertaken for the results of this survey, however when compaing the results of the *Lomandra* density survey and the GSM survey there appears to be some correlation between the location of *Lomandra* and the observation of GSM; GSMs were observed in locations which the higher densities of *Lomandra* were observed, see **Figure 5**.

However, while there appears to be some correlation between the density of *Lomandra maritima* recorded and observations of GSM, it is also difficult, based on these results, to determine if GSM occur at all locations in which *Lomandra* is observed. This is because some GSM observations were recorded at relatively low *Lomandra* densities (ie. the GSM observed on the north east boundary of the revised ODP boundary recorded a 20-40% *Lomandra* density). However, in similar areas throughout the subject site in which densities from 1-80% were recorded, no GSM were observed. In some instances GSM occurred in areas where little or no *Lomandra* were recorded.

These results suggest that there are other factors which may influence the presence of GSM in addition to the presence of *Lomandra*.

During the GSM survey, observations of the GSM were recorded in locations that were open, with limited over storey and a high incidence of sunlight of the ground. This is in line with general knowledge of the species, recorded in *Graceful Sun Moth Information Kit and Survey Methods Version 1.0.* (Bishop 2009). The two areas in which the most GSM were recorded, just beyond the revised ODP boundary to the north and south, were relatively open, being a vehicle track and the vegetation was predominantly understorey in structure.

The inference, that GSM are found in open, sunlight dominated areas is based on observations made in the field, and would need further correlation with the results of other surveys to determine if this is a factor in the record of GSM distribution. Also, the GSM observed in the survey were found at local high topographical points when compared with the topography for the subject site.

There is limited knowledge with regards to the location, occurrence and lifecycle of the GSM. The purpose of the recent surveys (March 2010) undertaken by the DEC was to grain a better understanding of the distribution of GSM and likely habitat of the species. The results of these surveys are still being correlated, but the known distribution of the GSM has now been extended. As this information has not been reported in detail, it is difficult to draw conclusions with regards to the observations make during this GSM survey in comparison to broader population trends. The results so far suggest that the number of GSM found in each location is relatively small, thus populations of GSM are likely to be vulnerable to threatening process, discussed below, and a result population decline is a continuing concern.

The key threatening processes likely to impact on GSM include:

- Habitat fragmentation and loss: There is limited remnant vegetation remaining upon the Swan Coastal Plain, the primary area in which the GSM appears to occur. The Swan Coastal Plain currently faces broader development pressures, which are likely to result in the fragmentation and loss of vegetation. As GSM appears to be limited to a specific habitat, utilising *Lomandra* species for food and shelter and requiring warm sunny conditions for mating, this threat increases the vulnerability of GSM.
- Limited knowledge on the lifecycle of the GSM: The lifecycle of the GSM is relatively unknown, with the DEC currently completing a three year study to determine the habitat, lifecycle and distribution of the GSM. The lack of information means that there is the potential to impact on the habitat and lifecycle of the GSM without realising, particularly with regards to the type of habitat the GSM prefers and the protection of this habitat. This makes the conservation of the species difficult, as limited knowledge means the impact of different actions in unknown. A precautionary approach should be applied in the protection of this species, until further information regarding the lifecycle of the species has been determined.

6 Conclusions and Recommendations

Cardno was engaged by MRC to undertake a GSM survey over Swan Location 2802 and portions of Swan Location 2424 and 2914 on the coast, immediately south of Moore River. GSM is a federally listed 'Endangered' species under the EPBC Act and is endemic to south-west Western Australia. It is a small day-flying moth that has black-brown forewings and bright orange hind wings. The GSMs larva is known to feed and live only on *Lomandra maritima* and *Lomandra hermaphrodita*, two species of the *Lomandra* mat-rushes.

The survey was to be undertaken in accordance with the DEC guidelines *Graceful Sun Moth Information Kit and Survey Methods* (Bishop *et al* 2009). The GSM survey consisted of two parts:

- A *Lomandra* density survey to be conducted prior to the GSM Survey; and
- A GSM survey based on the results of the *Lomandra* density survey.

The *Lomandra* density survey showed that one of the *Lomandra* habitat species, *Lomandra maritima,* was located across the entire subject site, with the density varying from 1 to 80% when it was found. The density survey found that there were areas of the subject site that contained no *Lomandra*. *Lomandra* were predominantly recorded in plant community MsAlSg, see **Figure 3**.

There were 22 GSM individuals recorded within the subject site over the survey period, however the majority of individuals observed were located beyond the revised ODP boundary. The GSM were recorded in predominately within plant communities MsAlSg and MsAlAg and within areas cleared for access roads and pathways.

No statistical analysis was undertaken in comparing the *Lomandra* density and the GSM locations however a comparison of these results was undertaken. It was difficult to determine if there was a correlation between the observations of GSM and the density of *Lomandra*, as GSMs were found in areas where the density of *Lomandra* was higher, but the opposite was also true in that no GSM were observed in some areas of higher *Lomandra* density and that GSMs were found in areas that appeared to contain no *Lomandra.*

An observation made during the GSM survey was that the GSM appeared to occur in areas of *Lomandra* and/or bushland in which there was a high incidence of sunlight i.e. limited over storey species present, or open road and firebreaks. Another observation was that the area of the subject site which the greatest numbers of GSM were observed appears to correspond with a local high topographical point. These observations support the information currently provided by the DEC, in that the GSM are only active in warm sunny weather and bright sunshine and the male GSMs prefer open areas, such as tracks and ridges.

As a result of this GSM survey, a population of GSM is known to occur within the subject site. Due to the relatively small known population and limited distribution of this species as well as its vulnerability to localised extinction from primarily habitat fragmentation and loss, Cardno recommend that the MRC retain where possible all areas of vegetation(ie. plant community MsAlSg and MsAlAg) where the GSM were observed. This is shown within **Figure 3** and in particular refers to the GSM observed just north and south of the revised ODP boundary. Guidance should be sought from the DEC on viable management actions for such a conservation area, particularly on the requirements for retention.

It is recommended that the main mechanisms used to conserve the populations of the Graceful Sun-Moth within the development area include:

- Where possible, the retention of the identified habitat for Graceful Sun-Moth (*Lomandra* species) in areas of POS;

- Translocation of *Lomandra* species to POS to be considered as a part of the landscaping design, in collaboration with the DEC;
- Use of landscaping management plans to ensure that *Lomandra* species, particularly *Lomandra maritima* are utilised where possible within road reserves and parkland areas;
- Future monitoring of the Graceful Sun-Moth population following development;
- Minimising construction, fire management and use of tracks during March (when the moth is active); and
- Where possible, use of building envelopes to protect remnant vegetation within private lots.

The apparent small population size of the GSM and the limited knowledge regarding this species mean that it is important, where possible, to conserve the areas of vegetation in which the GSM is found.

7 References

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Keighery, BJ. 1994. *Bushland plant survey: A guide to plant community survey for the community*, Nedlands: Wildflower Society of WA (Inc).

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Figure 1: Locality Plan

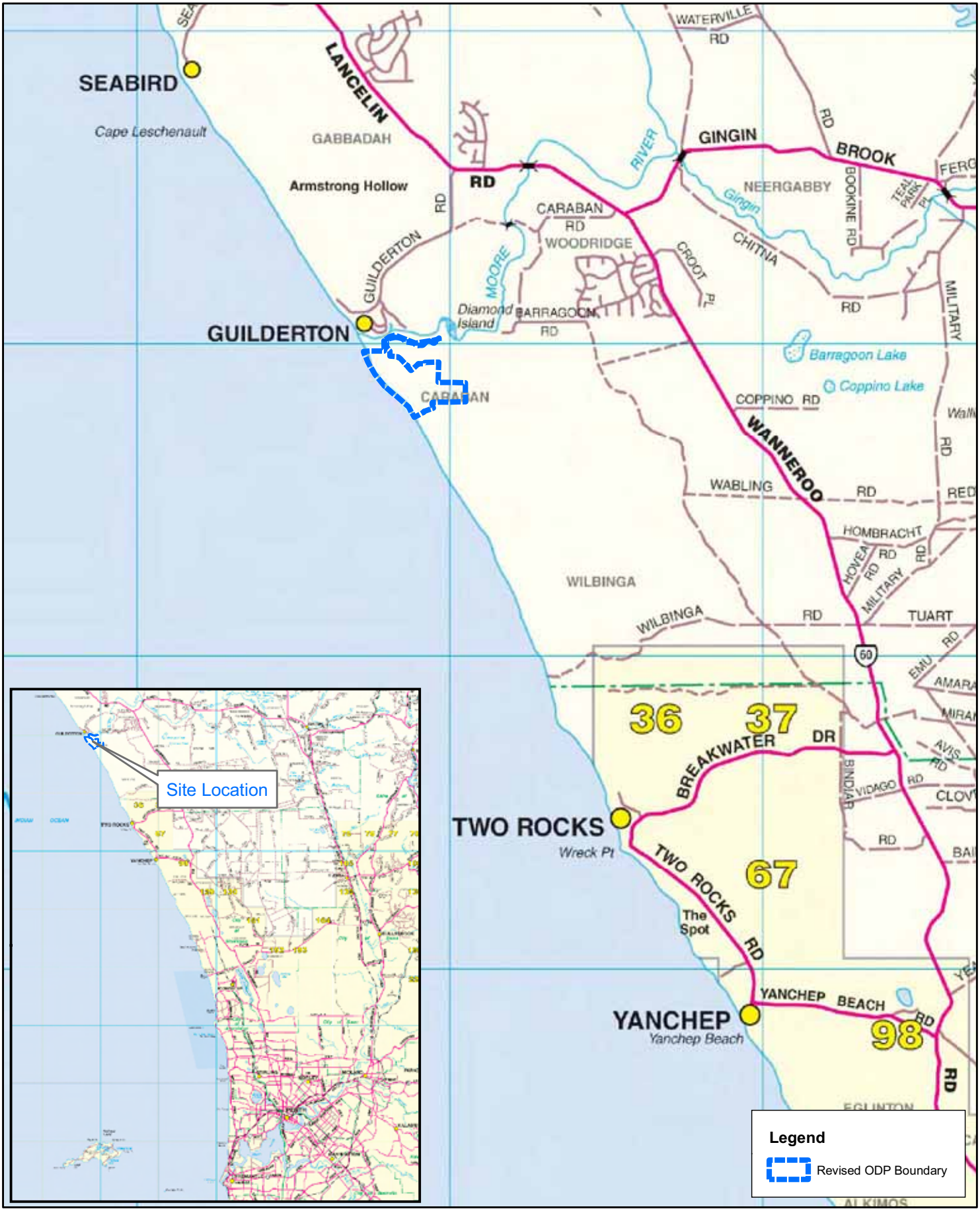
Figure 2: Lomandra Densities

Figure 3: Lomandra Densities and Plant Communities

Figure 4: Location of Graceful Sun-Moth Transects and Observation

Figure 5: Lomandra Densities and Graceful Sun-Moth Locations

Figures



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PROJECT Moore River South - Graceful Sun-Moth Survey

DRAWING TITLE FIGURE 1 : Locality Plan

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Drawing Number SK76

Revision 00

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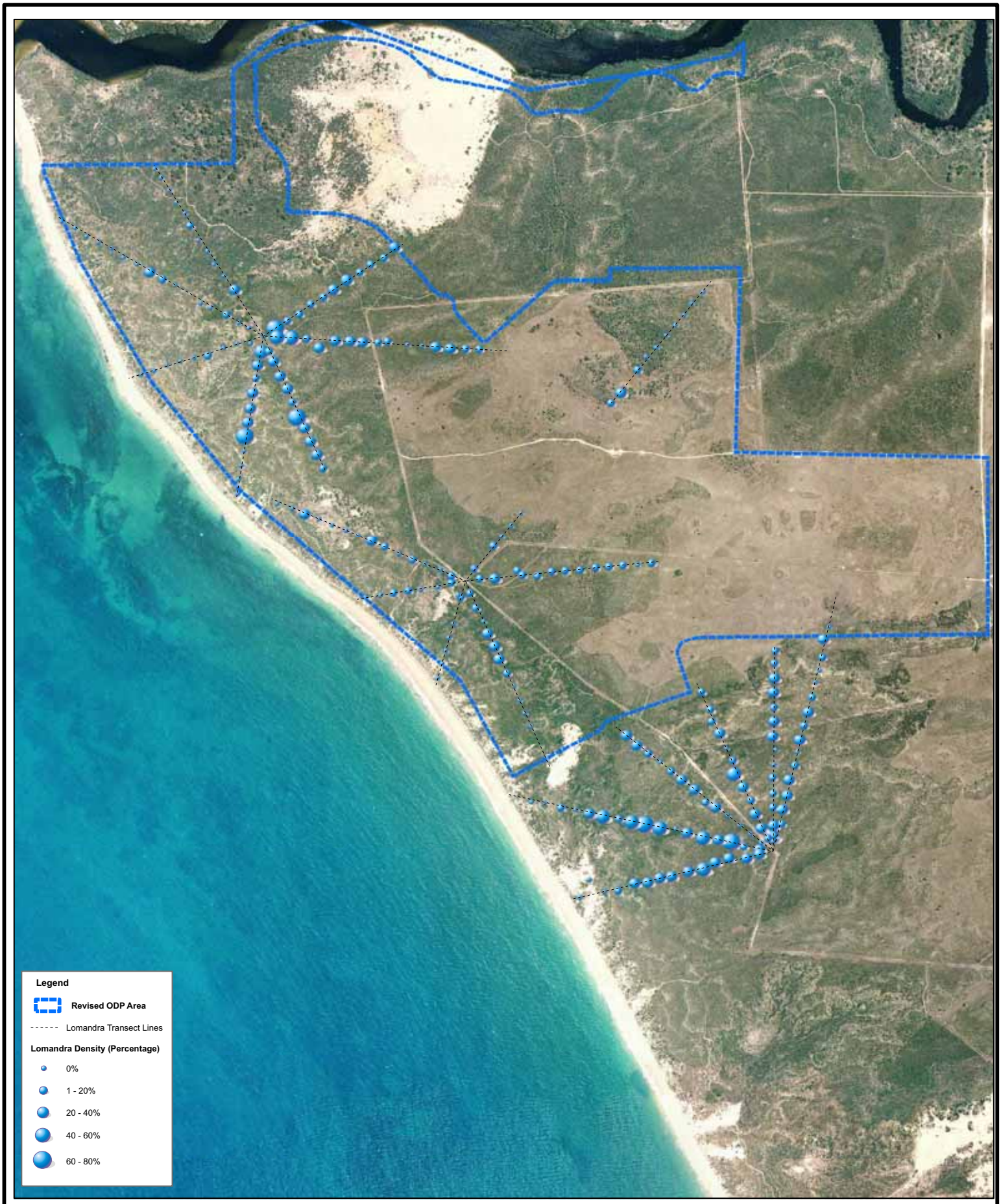
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PROJECT **Moore River South - Graceful Sun-Moth Survey**

DRAWING TITLE **FIGURE 2: Lomandra Densities**

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Original **A3**

Drawing Number **SK77**

Revision **00**

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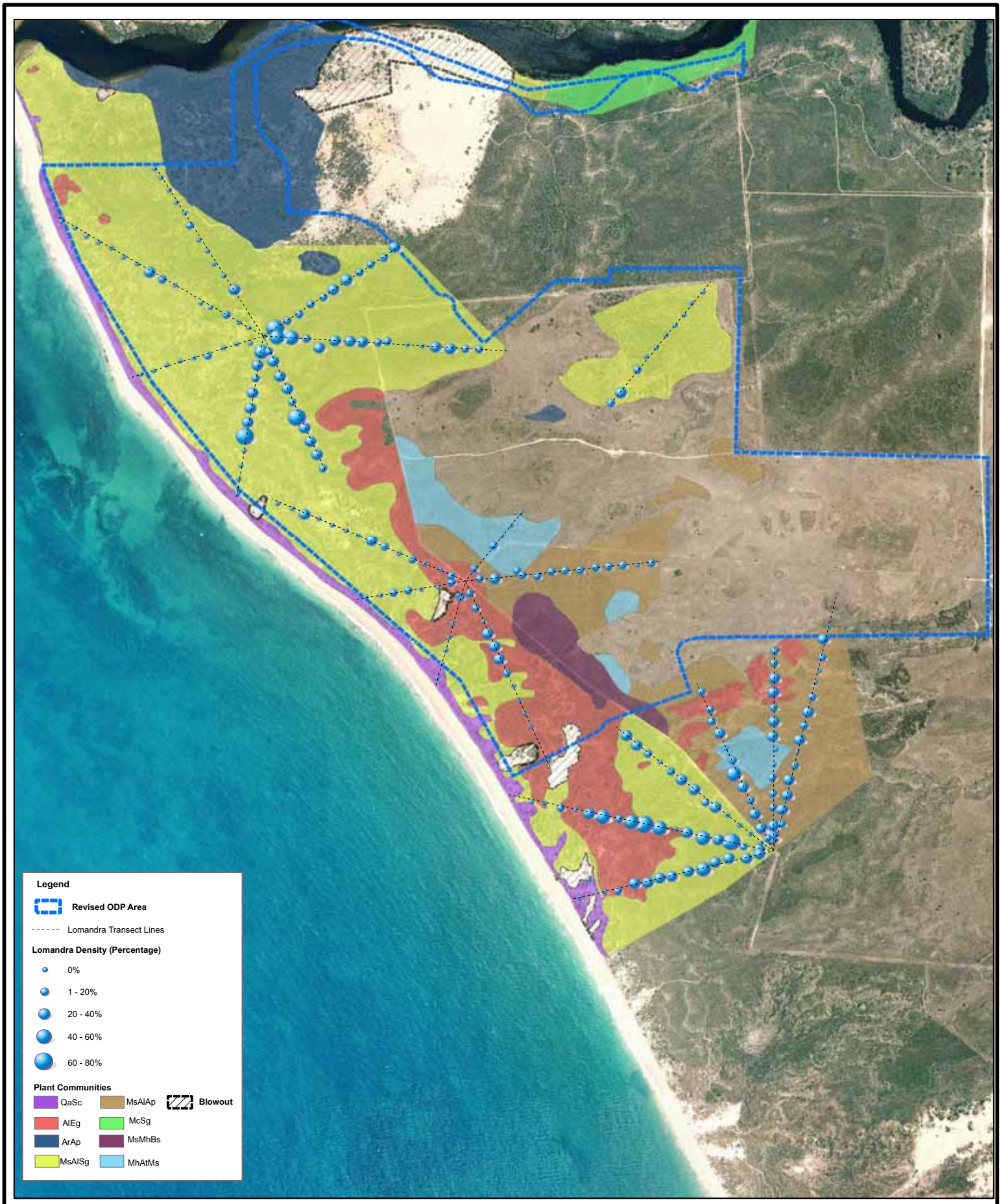
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PROJECT **Moore River South - Graceful Sun-Moth Survey**

DRAWING TITLE **FIGURE 3: Lomandra Densities and Plant Communities**

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Drawing Number **SK78**

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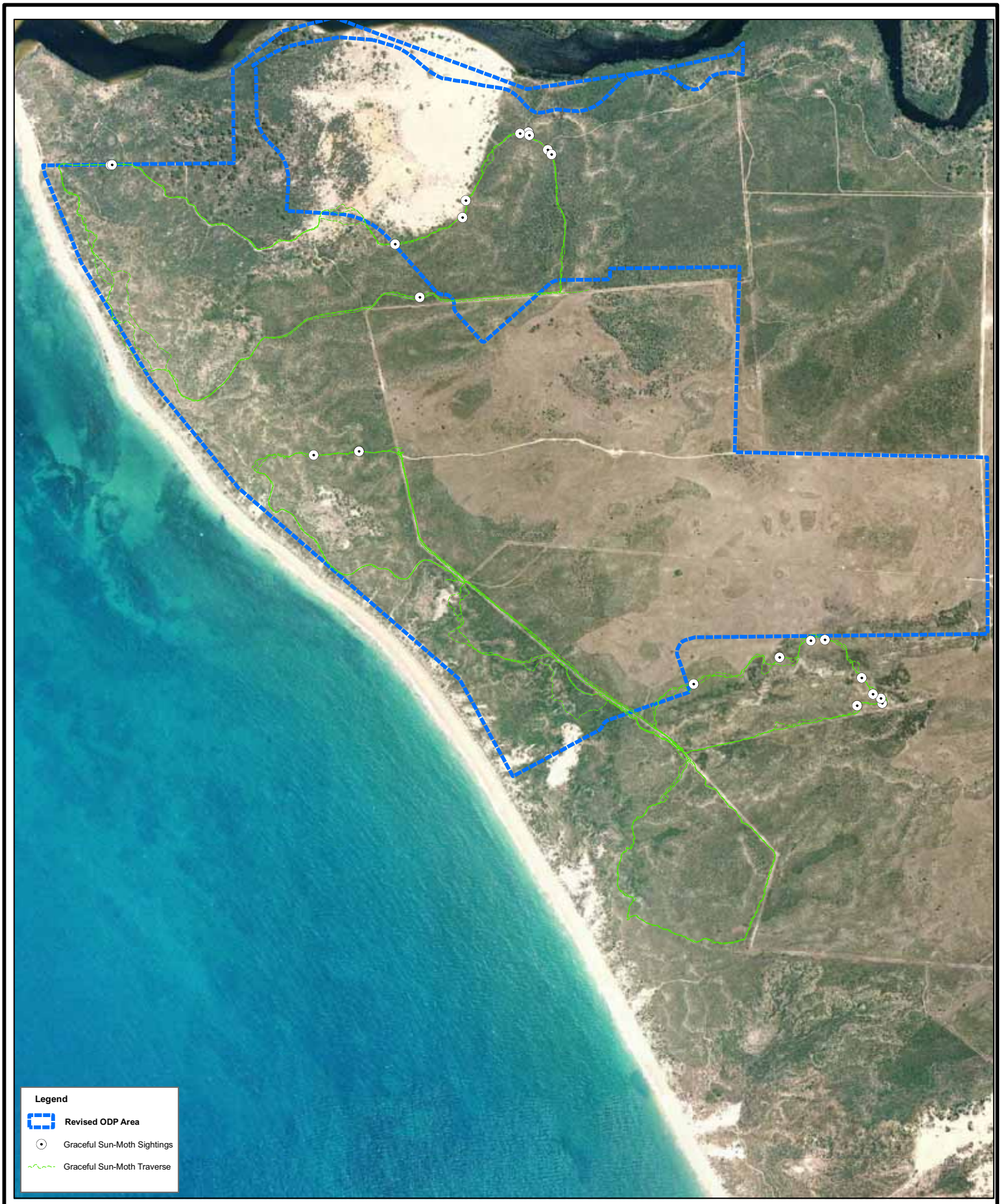
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PROJECT **Moore River South - Graceful Sun-Moth Survey**

DRAWING TITLE **FIGURE 4: Location of Graceful Sun-Moth Transects and Observations**

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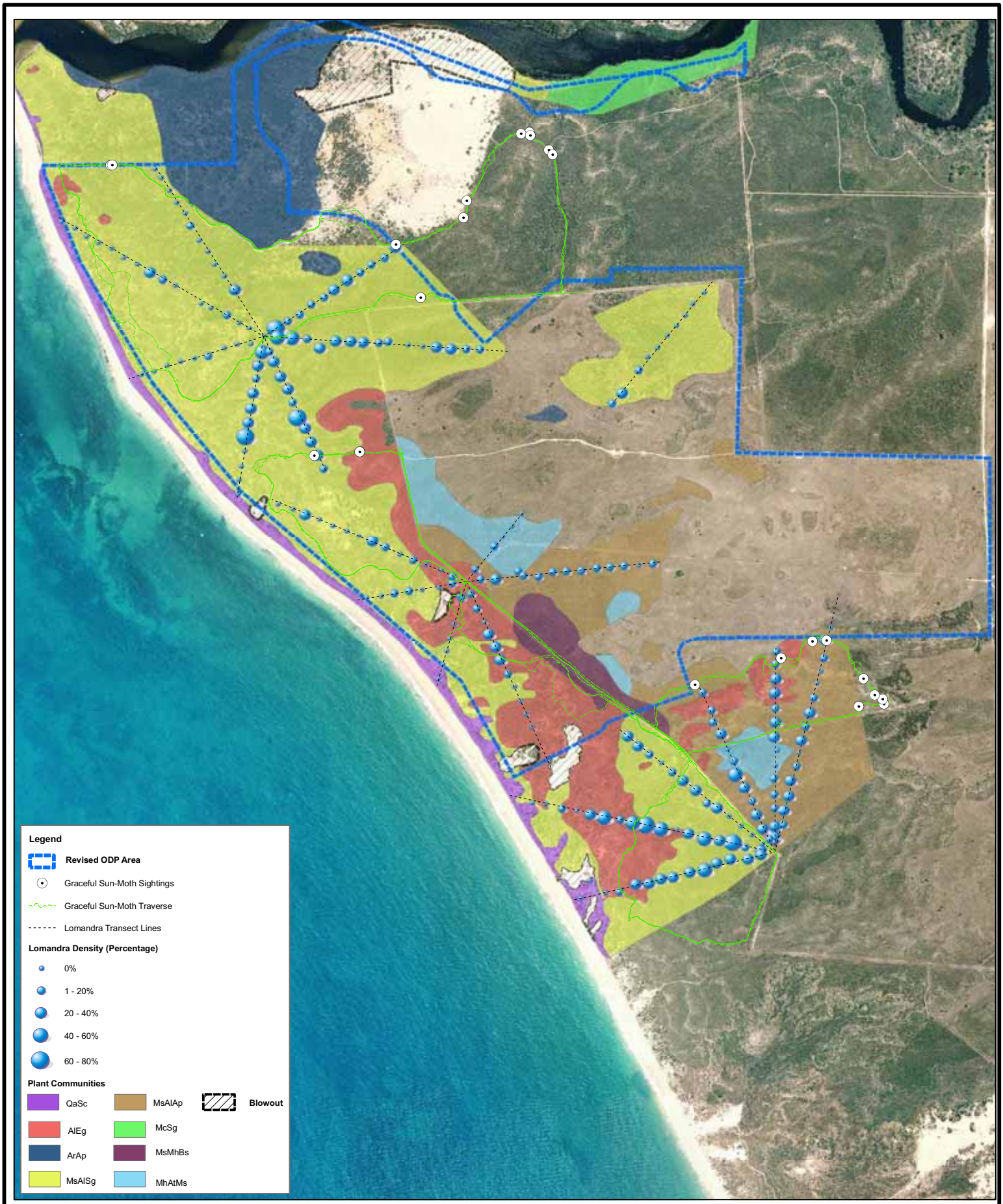
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PROJECT **Moore River South - Graceful Sun-Moth Survey**

DRAWING TITLE **FIGURE 5: Lomandra Densities and Graceful Sun-Moth Locations**

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Appendix A

EPBC Act Protected Matters Search

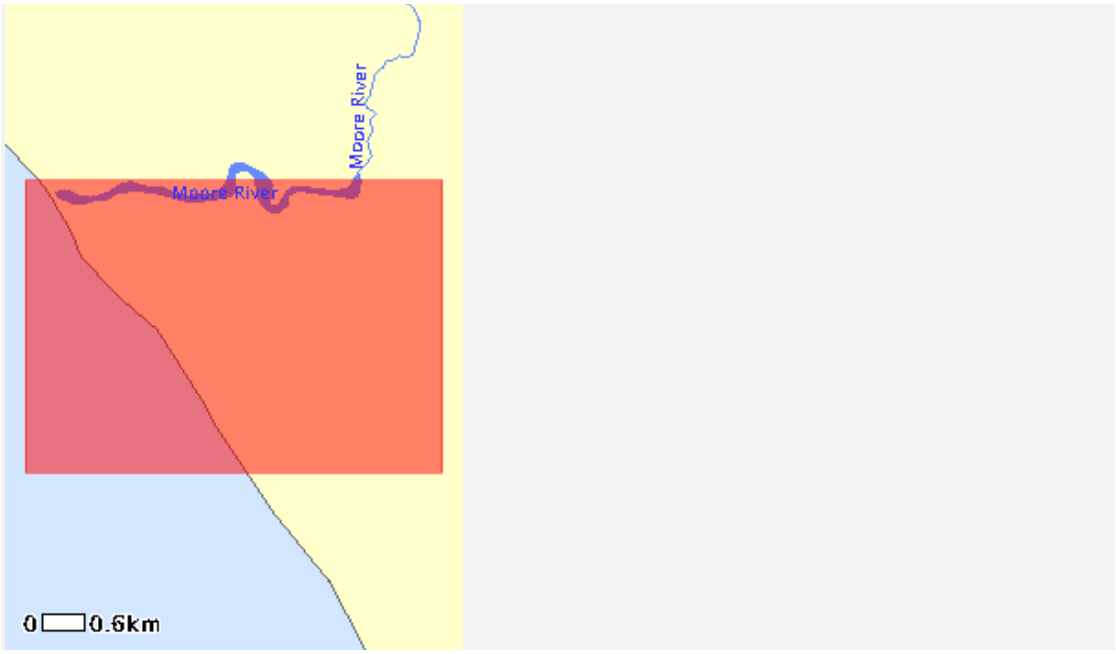
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EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected. Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

You may wish to print this report for reference before moving to other pages or websites.

The Australian Natural Resources Atlas at http://www.environment.gov.au/atlas may provide further environmental information relevant to your selected area. Information about the EPBC Act including significance guidelines, forms and application process details can be found at http://www.environment.gov.au/epbc/assessmentsapprovals/index.html



This map may contain data which are
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Search Type: Area

Buffer: 0 km

Coordinates: -31.34944,115.49441, -31.39426,115.49441, -31.39426,115.55832, -31.34944,115.55832



Report Contents: Summary
Details

- Matters of NES
- Other matters protected by the EPBC Act
- Extra Information

Caveat
Acknowledgments

Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance - see http://www.environment.gov.au/epbc/assessmentsapprovals/guidelines/index.html.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Significance: (Ramsar Sites)	None
Commonwealth Marine Areas:	None
Threatened Ecological Communities:	None
Threatened Species:	28
Migratory Species:	29

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place and the heritage values of a place on the Register of the National Estate. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage/index.html.

Please note that the current dataset on Commonwealth land is not complete. Further information on Commonwealth land would need to be obtained from relevant sources including Commonwealth agencies, local agencies, and land tenure maps.

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species. Information on EPBC Act permit requirements and application forms can be found athttp://www.environment.gov.au/epbc/permits/index.html.

Commonwealth Lands:	None
Commonwealth Heritage Places:	None
Places on the RNE:	None
Listed Marine Species:	47
Whales and Other Cetaceans:	13
Critical Habitats:	None
Commonwealth Reserves:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	None
Other Commonwealth Reserves:	None
Regional Forest Agreements:	None

Details

Matters of National Environmental Significance

Threatened Species [Dataset Information]	Status	Type of Presence
Birds		
Anous tenuirostris melanops Australian Lesser Noddy	Vulnerable	Species or species habitat may occur within area
Calyptorhynchus banksii naso Forest Red-tailed Black-Cockatoo	Vulnerable	Species or species habitat may occur within area
Calyptorhynchus latirostris Carnaby's Black-Cockatoo, Short-billed Black-Cockatoo	Endangered	Species or species habitat likely to occur within area
Diomedea exulans (sensu lato) Wandering Albatross	Vulnerable	Species or species habitat may occur within area
Diomedea exulans amsterdamensis Amsterdam Albatross	Endangered	Species or species habitat may occur within area
Diomedea exulans exulans Tristan Albatross	Endangered	Foraging, feeding or related behaviour may occur within area
Diomedea exulans gibsoni Gibson's Albatross	Vulnerable	Species or species habitat may occur within area
Halobaena caerulea Blue Petrel	Vulnerable	Species or species habitat may occur within area
Macronectes giganteus Southern Giant-Petrel	Endangered	Species or species habitat may occur within area
Macronectes halli Northern Giant-Petrel	Vulnerable	Species or species habitat may occur within area

Pterodroma mollis Soft-plumaged Petrel	Vulnerable	Species or species habitat may occur within area
Thalassarche carteri Indian Yellow-nosed Albatross	Vulnerable	Foraging, feeding or related behaviour may occur within area
Thalassarche cauta cauta Shy Albatross, Tasmanian Shy Albatross	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris Black-browed Albatross	Vulnerable	Species or species habitat may occur within area

Mammals

Balaenoptera musculus Blue Whale	Endangered	Species or species habitat may occur within area
Dasyurus geoffroii Chuditch, Western Quoll	Vulnerable	Species or species habitat likely to occur within area
Eubalaena australis Southern Right Whale	Endangered	Species or species habitat likely to occur within area
Megaptera novaeangliae Humpback Whale	Vulnerable	Species or species habitat known to occur within area
Neophoca cinerea Australian Sea-lion	Vulnerable	Species or species habitat may occur within area

Reptiles

Caretta caretta Loggerhead Turtle	Endangered	Species or species habitat likely to occur within area
Chelonia mydas	Vulnerable	Species or species habitat likely to

Green Turtle		occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth	Endangered	Species or species habitat may occur within area
Sharks		
Carcharias taurus (west coast population) Grey Nurse Shark (west coast population)	Vulnerable	Species or species habitat may occur within area
Carcharodon carcharias Great White Shark	Vulnerable	Species or species habitat may occur within area
Rhincodon typus Whale Shark	Vulnerable	Species or species habitat may occur within area
Plants		
Eucalyptus argutifolia Yanchep Mallee, Wabling Hill Mallee	Vulnerable	Species or species habitat likely to occur within area
Grevillea curviloba subsp. incurva Narrow curved-leaf Grevillea	Endangered	Species or species habitat likely to occur within area
Lepidosperma rostratum Beaked Lepidosperma	Endangered	Species or species habitat likely to occur within area
Migratory Species [Dataset Information]	Status	Type of Presence
Migratory Terrestrial Species		
Birds		
Haliaeetus leucogaster White-bellied Sea-Eagle	Migratory	Species or species habitat likely to occur within area

Merops ornatus Rainbow Bee-eater	Migratory	Species or species habitat may occur within area

Migratory Wetland Species

Birds

Ardea alba Great Egret, White Egret	Migratory	Species or species habitat may occur within area
Ardea ibis Cattle Egret	Migratory	Species or species habitat may occur within area

Migratory Marine Birds

Apus pacificus Fork-tailed Swift	Migratory	Species or species habitat may occur within area
Ardea alba Great Egret, White Egret	Migratory	Species or species habitat may occur within area
Ardea ibis Cattle Egret	Migratory	Species or species habitat may occur within area
Diomedea amsterdamensis Amsterdam Albatross	Migratory	Species or species habitat may occur within area
Diomedea dabbenena Tristan Albatross	Migratory	Foraging, feeding or related behaviour may occur within area
Diomedea exulans (sensu lato) Wandering Albatross	Migratory	Species or species habitat may occur within area
Diomedea gibsoni Gibson's Albatross	Migratory	Species or species habitat may occur within area

Macronectes giganteus Southern Giant-Petrel	Migratory	Species or species habitat may occur within area
Macronectes halli Northern Giant-Petrel	Migratory	Species or species habitat may occur within area
Thalassarche carteri Indian Yellow-nosed Albatross	Migratory	Foraging, feeding or related behaviour may occur within area
Thalassarche cauta (sensu stricto) Shy Albatross, Tasmanian Shy Albatross	Migratory	Species or species habitat may occur within area
Thalassarche chlororhynchos Yellow-nosed Albatross, Atlantic Yellow-nosed Albatross, Indian Yellow-nosed Albatross	Migratory	Species or species habitat may occur within area
Thalassarche melanophris Black-browed Albatross	Migratory	Species or species habitat may occur within area

Migratory Marine Species

Mammals

Balaenoptera edeni Bryde's Whale	Migratory	Species or species habitat may occur within area
Balaenoptera musculus Blue Whale	Migratory	Species or species habitat may occur within area
Caperea marginata Pygmy Right Whale	Migratory	Species or species habitat may occur within area
Eubalaena australis Southern Right Whale	Migratory	Species or species habitat likely to occur within area

Lagenorhynchus obscurus Dusky Dolphin	Migratory	Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale	Migratory	Species or species habitat known to occur within area
Orcinus orca Killer Whale, Orca	Migratory	Species or species habitat may occur within area

Reptiles

Caretta caretta Loggerhead Turtle	Migratory	Species or species habitat likely to occur within area
Chelonia mydas Green Turtle	Migratory	Species or species habitat likely to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth	Migratory	Species or species habitat may occur within area

Sharks

Carcharodon carcharias Great White Shark	Migratory	Species or species habitat may occur within area
Rhincodon typus Whale Shark	Migratory	Species or species habitat may occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species [Dataset Information]	Status	Type of Presence

Birds

Anous tenuirostris melanops Australian Lesser Noddy	Listed	Species or species habitat may occur within area

Apus pacificus Fork-tailed Swift	Listed - overfly marine area	Species or species habitat may occur within area
Ardea alba Great Egret, White Egret	Listed - overfly marine area	Species or species habitat may occur within area
Ardea ibis Cattle Egret	Listed - overfly marine area	Species or species habitat may occur within area
Catharacta skua Great Skua	Listed	Species or species habitat may occur within area
Diomedea amsterdamensis Amsterdam Albatross	Listed	Species or species habitat may occur within area
Diomedea dabbenena Tristan Albatross	Listed	Foraging, feeding or related behaviour may occur within area
Diomedea exulans (sensu lato) Wandering Albatross	Listed	Species or species habitat may occur within area
Diomedea gibsoni Gibson's Albatross	Listed	Species or species habitat may occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle	Listed	Species or species habitat likely to occur within area
Halobaena caerulea Blue Petrel	Listed	Species or species habitat may occur within area
Macronectes giganteus Southern Giant-Petrel	Listed	Species or species habitat may occur within area

Macronectes halli Northern Giant-Petrel	Listed	Species or species habitat may occur within area
Merops ornatus Rainbow Bee-eater	Listed - overfly marine area	Species or species habitat may occur within area
Pterodroma mollis Soft-plumaged Petrel	Listed	Species or species habitat may occur within area
Thalassarche carteri Indian Yellow-nosed Albatross	Listed	Foraging, feeding or related behaviour may occur within area
Thalassarche cauta (sensu stricto) Shy Albatross, Tasmanian Shy Albatross	Listed	Species or species habitat may occur within area
Thalassarche chlororhynchos Yellow-nosed Albatross, Atlantic Yellow-nosed Albatross, Indian Yellow-nosed Albatross	Listed	Species or species habitat may occur within area
Thalassarche melanophris Black-browed Albatross	Listed	Species or species habitat may occur within area
Mammals		
Arctocephalus forsteri New Zealand Fur-seal	Listed	Species or species habitat may occur within area
Neophoca cinerea Australian Sea-lion	Listed	Species or species habitat may occur within area
Ray-finned fishes		
Acentronura australe	Listed	Species or species habitat may

Southern Pygmy Pipehorse		occur within area
Campichthys galei Gale's Pipefish	Listed	Species or species habitat may occur within area
Choeroichthys suillus Pig-snouted Pipefish	Listed	Species or species habitat may occur within area
Halicampus brocki Brock's Pipefish	Listed	Species or species habitat may occur within area
Hippocampus angustus Western Spiny Seahorse, Narrow-bellied Seahorse	Listed	Species or species habitat may occur within area
Hippocampus breviceps Short-head Seahorse, Short-snouted Seahorse	Listed	Species or species habitat may occur within area
Hippocampus subelongatus West Australian Seahorse	Listed	Species or species habitat may occur within area
Lissocampus fatiloquus Prophet's Pipefish	Listed	Species or species habitat may occur within area
Maroubra perserrata Sawtooth Pipefish	Listed	Species or species habitat may occur within area
Mitotichthys meraculus Western Crested Pipefish	Listed	Species or species habitat may occur within area
Nannocampus subosseus Bonyhead Pipefish, Bony-headed Pipefish	Listed	Species or species habitat may occur within area
Phycodurus eques Leafy Seadragon	Listed	Species or species habitat may occur within area

Phyllopteryx taeniolatus Common Seadragon, Weedy Seadragon	Listed	Species or species habitat may occur within area
Pugnaso curtirostris Pugnose Pipefish, Pug-nosed Pipefish	Listed	Species or species habitat may occur within area
Solegnathus lettiensis Gunther's Pipehorse, Indonesian Pipefish	Listed	Species or species habitat may occur within area
Stigmatopora argus Spotted Pipefish, Gulf Pipefish	Listed	Species or species habitat may occur within area
Stigmatopora nigra Widebody Pipefish, Wide-bodied Pipefish, Black Pipefish	Listed	Species or species habitat may occur within area
Syngnathoides biaculeatus Double-end Pipehorse, Double-ended Pipehorse, Alligator Pipefish	Listed	Species or species habitat may occur within area
Urocampus carinirostris Hairy Pipefish	Listed	Species or species habitat may occur within area
Vanacampus margaritifer Mother-of-pearl Pipefish	Listed	Species or species habitat may occur within area

Reptiles

Aipysurus pooleorum Shark Bay Seasnake	Listed	Species or species habitat may occur within area
Caretta caretta Loggerhead Turtle	Listed	Species or species habitat likely to occur within area
Chelonia mydas Green Turtle	Listed	Species or species habitat likely to occur within area

Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth	Listed	Species or species habitat may occur within area
Disteira kingii Spectacled Seasnake	Listed	Species or species habitat may occur within area
Pelamis platurus Yellow-bellied Seasnake	Listed	Species or species habitat may occur within area
Whales and Other Cetaceans [Dataset Information]	Status	Type of Presence
Balaenoptera acutorostrata Minke Whale	Cetacean	Species or species habitat may occur within area
Balaenoptera edeni Bryde's Whale	Cetacean	Species or species habitat may occur within area
Balaenoptera musculus Blue Whale	Cetacean	Species or species habitat may occur within area
Caperea marginata Pygmy Right Whale	Cetacean	Species or species habitat may occur within area
Delphinus delphis Common Dophin, Short-beaked Common Dolphin	Cetacean	Species or species habitat may occur within area
Eubalaena australis Southern Right Whale	Cetacean	Species or species habitat likely to occur within area
Grampus griseus Risso's Dolphin, Grampus	Cetacean	Species or species habitat may occur within area
Lagenorhynchus obscurus Dusky Dolphin	Cetacean	Species or species habitat may occur within area

Megaptera novaeangliae Humpback Whale	Cetacean	Species or species habitat known to occur within area
Orcinus orca Killer Whale, Orca	Cetacean	Species or species habitat may occur within area
Stenella attenuata Spotted Dolphin, Pantropical Spotted Dolphin	Cetacean	Species or species habitat may occur within area
Tursiops aduncus Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin	Cetacean	Species or species habitat likely to occur within area
Tursiops truncatus s. str. Bottlenose Dolphin	Cetacean	Species or species habitat may occur within area

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the *Environment Protection and Biodiversity Conservation Act 1999*. It holds mapped locations of World Heritage and Register of National Estate properties, Wetlands of International Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

For species where the distributions are well known, maps are digitised from sources such as recovery plans and detailed habitat studies. Where appropriate, core breeding, foraging and roosting areas are indicated under "type of presence". For species whose distributions are less well known, point locations are collated from government wildlife authorities, museums, and non-government organisations; bioclimatic distribution models are generated and these validated by experts. In some cases, the distribution maps are based solely on expert knowledge.

Only selected species covered by the migratory and marine provisions of the Act have been mapped.

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers.

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites;
- seals which have only been mapped for breeding sites near the Australian continent.

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Acknowledgments

This database has been compiled from a range of data sources. The Department acknowledges the following custodians who have contributed valuable data and advice:

- New South Wales National Parks and Wildlife Service
- Department of Sustainability and Environment, Victoria
- Department of Primary Industries, Water and Environment, Tasmania
- Department of Environment and Heritage, South Australia Planning SA
- Parks and Wildlife Commission of the Northern Territory
- Environmental Protection Agency, Queensland
- Birds Australia
- Australian Bird and Bat Banding Scheme
- Australian National Wildlife Collection
- Natural history museums of Australia
- Queensland Herbarium
- National Herbarium of NSW
- Royal Botanic Gardens and National Herbarium of Victoria
- Tasmanian Herbarium
- State Herbarium of South Australia
- Northern Territory Herbarium
- Western Australian Herbarium
- Australian National Herbarium, Atherton and Canberra
- University of New England
- Other groups and individuals

ANUCliM Version 1.8, Centre for Resource and Environmental Studies, Australian National University was used extensively for the production of draft maps of species distribution. Environment Australia is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Appendix B

Graceful Sun-Moth Species Profile

Australian Government
Department of the Environment, Water, Heritage and the Arts

Biodiversity

Species Profile and Threats Database

Glossary

Synemon gratiosa — Graceful Sun Moth

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EPBC Act Status and Documents

EPBC Act Listing Status	**Listed as Endangered**
Listed Critical Habitat	
Listing & Conservation Advice	Threatened Species Scientific Committee (TSSC) (2008aed). *Commonwealth Conservation Advice on* Synemon gratiosa. [Online]. Department of the Environment, Water, Heritage and the Arts. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/66757-conservation-advice.pdf.
	Threatened Species Scientific Committee (TSSC) (2008aei). *Commonwealth Listing Advice on* Synemon gratiosa. [Online]. Department of the Environment, Water, Heritage and the Arts. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/66757-listing-advice.pdf.
EPBC Act Plans	
Public Guidelines	
Info Sheets	
State Government Documents & Websites	Bishop, C., M. Williams & T. Gamblin (2009). *Graceful Sun-Moth Info Kit and Survey Methods*. [Online]. Perth, Western Australia: Department of Environment and Conservation. Available from: http://www.dec.wa.gov.au/index2.php?option=com_docman&task=doc_view&gid=3976&Itemid=99999999.

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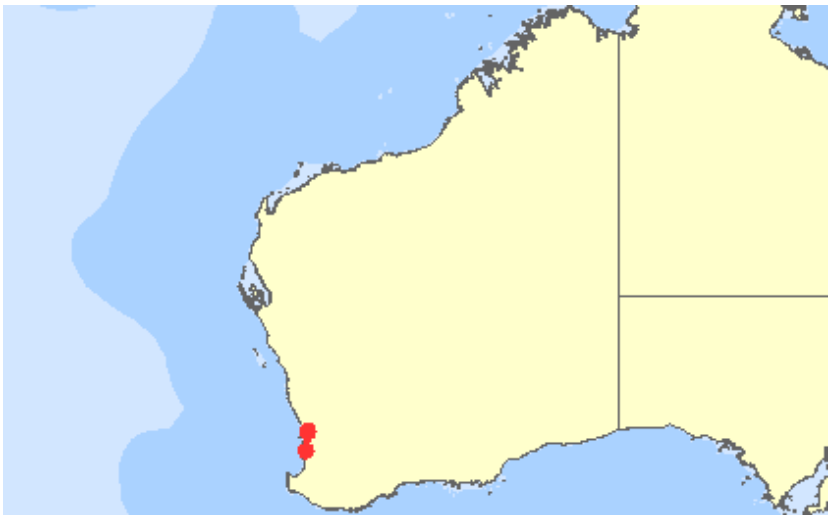
Naming

Scientific name	*Synemon gratiosa* [66757]
Family	Castniidae:Lepidoptera:Insecta:Arthropoda:Animalia (Other animals)
Species author	
Infraspecies author	
Reference	ANZECC Threatened Fauna List May 2000

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Distribution Map

Distribution map



This is an indicative distribution map of the present distribution of the species based on best available knowledge. See map caveat for more information.

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Illustrations

Illustrations Google Images

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Legal Status

The current conservation status of the Graceful Sun Moth, *Synemon gratiosa*, under Australian and State Government legislation, is as follows:

National: Listed as Endangered under the *Environment Protection and Biodiversity Conservation Act 1999*.

Western Australia: Listed as fauna that is rare or likely to become extinct under the *Wildlife Conservation Act 1950*.

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Taxonomy

Scientific name: *Synemon gratiosa*

Common name: Graceful Sun Moth

The genus *Synemon* is well researched and there are 45 identified Australian species (24 from south-west Western Australia), 160 from Central and South America and two from Asia (Edwards 1997; WAISS 1993).

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Description

The Graceful Sun Moth is a medium sized diurnal flying sun moth that is similar in appearance to a butterfly (WAISS 1993). It has brightly coloured orange hind-wings (Common 1990; Nielsen et al. 1996). Adults are active only in autumn, predominantly in March. The larvae are white and hairless (WAISS 1993).

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Australian Distribution

The Graceful Sun Moth occurs over a restricted range, confined to the Swan Coastal Plain between the Wanneroo area in northern Perth, south to Mandurah (approximately 60 km south of Perth). It occurs within the Swan and South West Natural Resource Management Regions.

The Graceful Sun Moth occurs in at least nine subpopulations. Two of these subpopulations are distinct fragments within Warwick Conservation Reserve, sufficiently separated to probably be beyond the dispersal capabilities of this species. The numbers of the species are low and are restricted to very small areas in Koondoola Bushland, Errina Road Bushland, Marangaroo Bushland, Landsdale Road Bushland, Gumblossom Reserve, Shenton Bushland and Whiteman Park (WAISS 1997b; WA CALM 2005a).

Systematic transect surveys for butterflies and day-flying moths were undertaken at 40 bushland remnants, predominantly Bush Forever sites, on the Swan Coastal Plain in 2003–4 and 2004–5 (M. Williams in prep.). All of these sites are within the known range of the Graceful Sun Moth, between Rockingham and Wanneroo. The species was recorded at five sites, three of which are new records. These sites (and the number of individual specimens observed at each) are:

- Koondoola Bushland, Bush Forever site 201 (5)
- Errina Road Bushland, Bush Forever site 493 (1)
- Marangaroo (Decourcey Way) Bushland, Bush Forever site 328 (3)
- Shenton Bushland, Bush Forever site 218 (1)
- Warwick Bushland, Bush Forever site 202 (26).

All of these sites, other than Shenton Bushland, are within 4 km of each other. The Graceful Sun Moth was not recorded at any of the 25 sites south of the Swan River that were surveyed. The viability of the populations at all sites, other than Warwick Bushland and perhaps Koondoola Bushland, requires further investigation. The Neerabup population is presumed extinct, due to habitat destruction.

A number of sites have not been re-located, in some instances this is the result of habitat clearance (WA CALM 2005a). Similarly, a location where collections were made in 1996 has since been cleared for urban development (TSSC 2008aed). These extinct populations are evidence of a decline in the known range of the Graceful Sun Moth, however, it is difficult to determine the effects of particular threats or the impact on the population size (TSSC 2008aei). Presumed extinct locations include (WAISS 1997a, 1997b):

- Mandurah in 1984 and 1985
- Sorrento in 1971
- Jandakot in 1969
- Applecross in 1951
- Crawley, Kings Park and Fremantle in 1935
- Swanbourne, date unknown
- Swan River, date unknown.

Extent of occurrence
The extent of occurrence for the Graceful Sun Moth is approximately 234.05 km². This was calculated using the Western Australia Department of Conservation and Land Management Threatened Fauna Database, based on sightings from 1995 to 2006. This species has declined in extent of occurrence from approximately 516.21 km²

(calculated using records from 1935 to 2006). Although the Graceful Sun Moth has not been recently recorded from some locations, future collections cannot be ruled out.

Area of occupancy
The area of occupancy for the Graceful Sun Moth is < 18 km² (the sum of the area of all reserves in which this species has been recorded in recent times) and has probably declined in recent years.

Fragmentation
The Graceful Sun Moth appears to be highly fragmented. All of the subpopulations are disjunct and are sufficiently separate to be beyond the dispersal capabilities of this species (WA CALM 2005a).

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Surveys Conducted

Staff from the Western Australia Department of Conservation and Land Management (currently known as the Department of Environment and Conservation) have conducted systematic transect surveys for butterflies and day-flying moths at over 40 sites on the Swan Coastal Plain (Pollard & Yates 1993; Williams, in prep.). At each site, a fixed-route transect between 1 and 6 km in length is walked every 2 weeks during the flight period, and all butterflies and day-flying moths within 5 m of the observer are identified and tallied.

Due to the level of surveying in the expected range, it is likely that the current known distribution corresponds to the actual distribution. However, more systematic surveys outside of the current known limits of the range are needed to confirm this assertion.

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Population Information

There is insufficient data to estimate the size of all known subpopulations of the Graceful Sun Moth, and there is insufficient information to calculate a reliable estimate of the total number of mature individuals. However, the limited data available records consistently low numbers of individuals at known sites (TSSC 2008aei). Current threats will impact on the population of this species, but the magnitude and rate of decline is unknown (TSSC 2008aei).

Based on comparisons between transect counts and mark-recapture estimates of butterflies (Pollard & Yates 1993), population sizes of the Graceful Sun Moth are typically one order of magnitude larger than transect counts on a given day. The greatest number observed in one day was 12, at Warwick Bushland. The greatest number seen in one day elsewhere was three, at Koondoola Bushland. Therefore it is possible that the population of the Graceful Sun Moth at Warwick Bushland is in the order of approximately 120 individuals.

Trends
The population trend of the Graceful Sun Moth has probably declined in recent years due to the inability to find specimens at historical locations. The Neerabup subpopulation is presumed extinct due to habitat destruction for urban development (WAISS 1995). The rate and magnitude of past population decline is unknown and difficult to predict (TSSC 2008aei).

Fluctuations
There is no evidence to suggest that the Graceful Sun Moth undergoes any natural changes in extent of occurrence or area of occupancy. Limited information on annual fluctuations in population numbers show no evidence of extreme fluctuations. Transect surveys conducted over three consecutive years at Warwick Bushland (2003–2005) and at Koondoola Bushland (2002–2004), have recorded consistently low numbers of individuals. At Warwick Bushland, numbers observed in the three years during the main flight period (two surveys each year) were 12, 12 and 4. At Koondoola Bushland, numbers observed in the three years during the main flight period (2 surveys each year) were 3, 1 and 1 (WA CALM 2005a).

Generation length
The generation length of the Graceful Sun Moth is unknown, however this species breeds only once each year, between February and April (WA CALM 2005a).

Imporant populations
All known sites of the Graceful Sun Moth are in formally reserved areas or included as 'Bushland Forever' sites, which are vested with local shires or private landholders (TSSC 2008aei). Howver, it is highly likely that populations occur in suitable habitat on unreserved land. Most previous surveys are likely to have previously targeted reserved

areas during monitoring programs.

The largest subpopulation of the Graceful Sun Moth, in the Warwick Conservation Reserve, is of high importance for the long-term survival and recovery of the species. The subpopulations at Koondoola Regional Bushland Reserve and Whiteman Park are in fragmented habitat and are important to maintain the current level of genetic diversity (WA CALM 2005a).

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Populations in Reserves

The Graceful Sun Moth has been found in the last decade in eight reserves on the Swan Coastal Plain: Koondoola Regional Bushland Reserve, Warwick Conservation Reserve, Errina Road Bushland, Marangaroo Bushland, Landsdale Road Bushland, Gumblossom Reserve, Shenton Bushland and Whiteman Park. Errina Road Bushland is unfenced and subject to severe local disturbance including frequent fires (arson) and four-wheel-driving due to the reserve not being fenced, The remaining reserves are managed for conservation generally, but not specifically for this species.

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Habitat

Australian species of Castniid moth tend to breed on grasses, sedges and rushes (WAISS 1991), and the juvenile stages exist underground (Edwards 1997). The Graceful Sun Moth has been observed to oviposit on a *Lomandra* species, which may prove to be the foodplant.
Koondoola Regional Bushland (120 ha), Errina Road Bushland (8 ha), Marangaroo Bushland (33 ha), Landsdale Park (16 ha), Shenton Bushland (20 ha) and Warwick Conservation Area (58 ha) are all located on Spearwood dune soils, with low open woodlands or low open forest dominated by *Banksia* and *Eucalyptus.* Warwick Conservation Area is divided into three major fragments by a road, high school and playing fields, and has been subject to greater disturbance from fire and weed invasion; only two of the fragments are currently occupied by the Graceful Sun Moth (Williams 2003). Gumblossom Reserve (2 ha) is located on Quindalup dune soils, with open shrubland dominated by *Dryandra*, *Melaleuca* and *Acacia* and open *Banksia* woodlands. Whiteman Park (1548 ha) is located on Bassandean dune soils and is dominated by low open *Banksia* woodlands.

The Graceful Sun Moth is thought to breed exclusively on *Lomandra* species, probably *L. hermaphrodita*. Sufficient numbers and densities of this plant are probably necessary to sustain a viable breeding colony (WA CALM 2005a). Koondoola Bushland, Marangaroo Bushland, Landsdale Bushland and Errina Road Bushland are within the Swan Coastal Plain threatened ecological community '20a - *Banksia attenuata* woodland over species-rich dense shrublands' listed as endangered in Western Australia.

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Life Cycle

The Graceful Sun Moth is univoltine. Adults breed only once, in February–April each year, and have a short flight period of approximately one month (WA CALM 2005a). The species may have a two-year or longer larval cycle (McNamara 2009).
Graceful Sun Moth males establish small territories in open areas and often employ tracks or firebreaks for this purpose; this behaviour markedly increases their detectability. In contrast, females are thought to practice male avoidance after mating, as this is a common behavior in species with a similar breeding strategy. This contrasting detectability is reflected in the observed sex-ratio: approximately 90% of all individuals detected in track-based surveys are males (WA CALM 2005a).

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Feeding

Some adult Castniids feed on nectar but other species have atrophied mouth parts (WAISS 1993). Two known food plants for the Graceful Sun Moth are *Lomandra hermaphrodita* and *L. maritima* (McNamara 2009).

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Movement Patterns

Adults of the Castniidae are diurnal (Common 1990), emerging during hot weather in bright sunshine during summer and autumn (Chapman 2002), predominantly March.
Graceful Sun Moth males are sedentary, but the extent to which females disperse is unknown. Based on mark-recapture studies of butterflies with similar social organization in the same habitat, it is thought that females disperse less than 1 km from their colony of birth and are unlikely to cross unsuitable habitat (WA CALM 2005a).

Despite being able to fly, most species of butterflies and day-flying moths that have been studied, both in south-west Australia and elsewhere in the world, will not disperse across unsuitable habitat, rarely dispersing "more than a few hundred metres (if that) during their lifetime" (Williams 2003).

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Survey Guidelines

A standard technique for surveys of butterflies and day-flying moths was described by Williams (2003; in prep.), and included: using tracks and firebreaks, transects of 1–5 km in length, at air temperatures of between 20–32 °C, conducted between 10 am and 2.30 pm. The Graceful Sun Moth is active in hot weather in summer and autumn (particularly March; Chapman 2002; WAISS 1997b). They may be caught by hand netting.

The *Graceful Sun-Moth Info Kit and Survey Methods* (Bishop et al. 2009) provides guidance for the surveying methods of the species.

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Threats

Urban development
Urban development was a major threat to the Graceful Sun Moth in the past. For example, the Neerabup site where this species was found in 1995 was largely bulldozed for industrial development and housing (WAISS 1995). Many species of sun moth have declined in distribution and abundance due to the loss of habitat containing their larval food plants (Nielsen et al. 1996; O'Dwyer et al. 1998)

Current known subpopulations of the Graceful Sun Moth are likely to be protected from urban development because they are within areas recognized as being reserved for conservation, either as formal reserves or as Bush Forever sites. However, Bush Forever sites are vested with local shires or private landowners and are not included in the formal reserve system. In future, these sites may be acquired for conservation purposes, however until this occurs these areas are not as secure as those within the formal conservation system.

Public access and track maintenence
Males use sandy tracks in March during which time they establish small territories in open areas (for example tracks or firebreaks). Thus, vehicles using these tracks during this period may kill individuals. In particular, the recreational use of four-wheel drive vehicles at some sites, in reserves, may be having an adverse impact (TSSC 2008aed). Also, management of tracks within the reserve system, such as grading of tracks and spraying for weeds, may adversely effect the species (WA CALM 2005a).

Fire
The early stages of butterflies (and day-flying moths) are highly vulnerable to fire, even those that live underground, which may lose their food supply soon after fire events, rendering reserve populations at risk of extinction due to lack of dispersal from unaffected areas (Williams 2003).

Localised extinction
Due to the limited dispersal ability of the Graceful Sun Moth, recolonisation at locally extinct sites is unlikely (TSSC 2008aei).

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Threat Abatement and Recovery

Minister's reasons to approve the development of a recovery plan
The biology of the Graceful Sun Moth renders it vulnerable to threats from track maintenance and use. Males establish territories in open spaces (including tracks) during the breeding season. These threats can be better managed with a recovery plan in place.

Recovery actions

Recovery actions outlined by the Threatened Species Scientific Committee (TSSC 2008aed) include:

- protect areas of native vegetation that contain, or potentially contain, subpopulations
- develop and implement a suitable fire management strategy
- increase community awareness
- investigate formal conservation arrangements
- investigate options for establishing additional subpopulations
- minimize the use and maintenance of fire trails in March, when males have established their territories
- undertake monitoring of known sites
- fence known sites to prevent public access.

Chapman (2002) provided a list of aims for the conservation of the Graceful Sun Moth on the Swan Coastal Plain in an unsubmitted draft grant application, and included:

- research history and ecology
- collate historical distribution on the Swan Coastal Plain
- increase public awareness of this species and the importance of remnant urban bushland on the Swan Coastal Plain
- survey locations where this species may occur to establish current distribution, abundance and habitat requirements.

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Management Documentation

Priority recovery actions are outlined in the *Commonwealth Conservation Advice on* Synemon gratios (TSSC 2008aed).

The *Graceful Sun-Moth Info Kit and Survey Methods* (Bishop et al. 2009) provides guidance for the surveying methods of the species.

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Caveat

This database is designed to provide statutory, biological and ecological information on species and ecological communities, migratory species, marine species, and species and species products subject to international trade and commercial use protected under the *Environment Protection and Biodiversity Conservation Act 1999* (the EPBC Act). It has been compiled from a range of sources including listing advice, recovery plans, published literature and individual experts. While reasonable efforts have been made to ensure the accuracy of the information, no guarantee is given, nor responsibility taken, by the Commonwealth for its accuracy, currency or completeness. The Commonwealth does not accept any responsibility for any loss or damage that may be occasioned directly or indirectly through the use of, or reliance on, the information contained in this database. The information contained in this database does not necessarily represent the views of the Commonwealth. This database is not intended to be a complete source of information on the matters it deals with. Individuals and organisations should consider all the available information, including that available from other sources, in deciding whether there is a need to make a referral or apply for a permit or exemption under the EPBC Act.

Citation: Department of the Environment, Water, Heritage and the Arts (2010). *Synemon gratiosa* in Species Profile and Threats Database, Department of the Environment, Water, Heritage and the Arts, Canberra. Available from: http://www.environment.gov.au/sprat. Accessed Thu, 10 Jun 2010 13:01:24 +1000.

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Appendix C

Lomandra Density Survey Raw Data

Lomandra Survey

Site Name: Moore River	Observer: gt
Date: 30.3.10	quadrat no. 1
Easting: 359948	Aspect: south
Northing: 6527706	% bare ground: 50
Elevation: 43.1	Slope: gently inclined
Transect No.	Position: lower slope
Surface Soil: grey sand loam	
Sub-surface Soil: grey sand loam	
Vegetation Condition: vg	

Vegetation Description: low open heath of *acacia lasiocarpa* and *melaleuca systena* and *lomandra maritima*

Species	Cover/Count
acacia lasiocarpa	30
melaleuca systena	10
lomandra maritima	15

Lomandra Survey

Site Name: Moore River	Observer: gt
Date: 30.3.10	Quadrat No. 2
Easting: 359951	Aspect: south
Northing: 6527755	% Bare ground:30
Elevation: 47.6	Slope: gently inclined
Transect No.	Position: mid slope
Surface Soil: grey sand loam	
Sub-surface Soil: grey sand loam	
Vegetation Condition: vg	

Vegetation Description:low open heath of *acacia lasiocarpa* and *melaleuca systena* over *lomandra maritima*

Species	Cover/Count
acacia lasiocarpa	35
melaleuca systena	20
lomandra maritima	30

Lomandra Survey

Site Name:Moore River	Observer: gt
Date: 30.3.10	Quadrat No. 3
Easting: 359968	Aspect: south
Northing: 6527804	% bare ground: 20
Elevation: 48.8	Slope: moderately inclined
Transect No.	Position: mid slope
Surface Soil: grey sand loam	
Sub-surface Soil: grey sand loam	
Vegetation Condition: vg	

Vegetation Description: low open heath of *acacia lasiocarpa* and *melaleuca systena* over *lomandra maritima*

Species	Cover/Count
acacia lasiocarpa	45
melaleuca systena	5
lomandra maritima	35

Lomandra Survey

Site Name: Moore River	Observer: gt
Date: 30.3.10	Quadrat No. 4
Easting: 359974	Aspect: ne
Northing: 6527857	% bare ground: 40
Elevation: 46.4	Slope: gently inclined
Transect No.	Position: upper slope
Surface Soil: grey sand loam	
Sub-surface Soil: grey sand loam	
Vegetation Condition: vg	

Vegetation Description: low open heath of *acacia lasiocarpa* and *melaleuca systena* over *lomandra maritima*

Species	Cover/Count
acacia lasiocarpa	50
melaleuca systena	5
lomandra maritima	30

Lomandra Survey

Site Name: Moore River	Observer: gt
Date: 30.3.10	Quadrat No. 5
Easting: 359994	Aspect: ne
Northing: 6527906	% bare ground: 50
Elevation: 42.5	Slope: gently inclined
Transect No.	Position: mid slope
Surface Soil: grey sand loam	
Sub-surface Soil: grey sand loam	
Vegetation Condition: vg	

Vegetation Description: low open heath of *acacia lasiocarpa* and *melaleuca systena* over *lomandra maritima*

Species	Cover/Count
acacia lasiocarpa	40
melaleuca systena	10
lomandra maritima	10

Lomandra Survey

Site Name: Moore River	Observer: GT
Date: 30.3.10	Quadrat No. 6
Easting: 360001	Aspect: ne
Northing: 6527953	% bare ground: 40
Elevation: 42.4	Slope: moderately inclined
Transect No.	Position: mid slope
Surface Soil: thin grey sand loam over limestone	
Sub-surface Soil: limestone	
Vegetation Condition: vg	

Vegetation Description:low open heath of *melaleuca heugelii* and *leucopogon parviflorus*

Species	Cover/Count
melaleuca heugelii	30
leucopogon parviflorus	30

Lomandra Survey

Site Name: Moore River	Observer: gt
Date: 30.3.10	Quadrat No.7
Easting: 360010	Aspect: ne
Northing: 6527996	% bare ground: 40
Elevation: 40.4	Slope: moderately inclined
Transect No.	Position: mid slope
Surface Soil: grey sand loam	
Sub-surface Soil: grey sand loam	
Vegetation Condition: vg	

Vegetation Description: low open heath of *acacia lasiocarpa* and *leucopogon parviflorus* over *lomandra maritima*

Species	Cover/Count
acacia lasiocarpa	30
leucopogon parviflorus	15
acacia truncata	15
lomandra maritima	35

Lomandra Survey

Site Name: Moore River	Observer: gt
Date: 30.3.10	Quadrat No. 8
Easting: 360025	Aspect: ne
Northing: 6528045	% bare ground: 50
Elevation: 35.2	Slope: gently inclined
Transect No.	Position: lower slope
Surface Soil: grey sand loam	
Sub-surface Soil: grey sand loam	
Vegetation Condition: good	

Vegetation Description: open heath of *acacia lasiocarpa* and *melaleuca systena* over *carpobrotus edulis*

Species	Cover/Count
melaleuca systena	30
acacia lasiocarpa	30
lomandra maritima	10

Lomandra Survey

Site Name: Moore River	Observer: gt
Date: 30.3.10	Quadrat No. 9
Easting: 360041	Aspect: East
Northing: 6528092	% bare ground: 30
Elevation: 29.9	Slope: gently inclined
Transect No.	Position: lower slope
Surface Soil: grey sand loam	
Sub-surface Soil: grey sand loam	
Vegetation Condition: vg	

Vegetation Description: low open heath of *melaleuca systena* and *acacia lasiocarpa* over *lomandra maritima*

Species	Cover/Count
melaleuca systena	25
acacia lasiocarpa	20
lomandra maritima	35

Lomandra Survey

Site Name: Moore River	Observer: GT
Date: 30.3.10	Quadrat No. 10
Easting: 360053	Aspect: SW
Northing: 6528144	% bare ground: 40
Elevation: 31.3	Slope: slightly inclined
Transect No.	Position: lower slope
Surface Soil: grey sand loam	
Sub-surface Soil: grey sand loam	
Vegetation Condition: vg	

Vegetation Description: low open heath of *acacia lasiocarpa* and *melaleuca systena* over *gahnia trifida*

Species	Cover/Count
acacia lasiocarpa	40
melaleuca systena	10
gahnia trifida	7
lomandra maritima	5

Appendix D

GSM Transect Details

Date	Traverse Number	Start Time	Finish Time	Temp	Wind (max recorded)	Wind Direction
11/03/2010	1	10:15am	1:00pm	30 - 32	~3km/hr	Nth Westerly
	2	10:30am	11:45am			
	3	1:30pm	2:30pm			
	4	12:00pm	1:05pm			
	5	1:30pm	2:38pm			
16/03/2010	1	10:10am	12:50pm	28-30	~16km/hr	Sth Westerly
	2	10:20am	11:25am			
	3	1:30pm	2:20pm			
	4	11:44pm	12:52pm			
	5	1:23pm	2:15pm			
24/03/2010	1	10:15am	12:10pm	30 to 32	~5km/hr	Sth Westerly
	2	10:20am	11:10am			
	3	12:50pm	1:37pm			
	4	11:24pm	12:42pm			
	5	12:50pm	1:35pm			
29/03/2010	1	10:12am	12:09pm	29 - 31	~10km/hr	Easterly
	2	10:19am	11:06am			
	3	12:20pm	1:31pm			
	4	11:20pm	12:10pm			
	5	12:46pm	1:28pm			

Sightings

		MGA			
Date	Id	Zone	mE	mN	Vouchered
11/03/2010	1	50J	359074	6530084	
11/03/2010	2	50J	358854	6529858	Voucher to DEC
11/03/2010	3	50J	358328	6528979	Voucher to DEC
11/03/2010	4	50J	360208	6528112	Voucher to DEC
11/03/2010	5	50J	360290	6528137	Voucher to DEC
11/03/2010	6	50J	360263	6528152	
11/03/2010	7	50J	360096	6528340	
11/03/2010	8	50J	360048	6528337	
16/03/2010	9	50J	359151	6530018	
16/03/2010	10	50J	359071	6530095	Voucher to DEC ?
16/03/2010	11	50J	359071	6530095	
16/03/2010	12	50J	359042	6530090	
16/03/2010	13	50J	358843	6529800	
16/03/2010	14	50J	358610	6529708	
16/03/2010	15	50J	357631	6529982	
16/03/2010	16	50J	358695	6529524	
16/03/2010	17	50J	358484	6528992	
16/03/2010	18	50J	358484	6528992	
16/03/2010	19	50J	360295	6528120	
16/03/2010	20	50J	360224	6528208	
16/03/2010	21	50J	359940	6528279	Voucher to DEC
16/03/2010	22	50J	359643	6528187	
24/03/2010	23	50J	357625	6529982	
29/03/2010	24	50J	359138	6530034	

	Australian Geocentric 1994
Datum	(GDA94)