YANCHEP SUN CITY

ST ANDREWS DISTRICT STRUCTURE PLAN ENVIRONMENTAL ASSESSMENT

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ATA Environmental
environmental scientists

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1. INTRODUCTION

1.1 Location, Background and Purpose

Yanchep Sun City is currently undertaking structure planning at a district level in the Yanchep to Two Rocks area. The area is referred to as St Andrews and encompasses both the Tokyu landholding and other landholdings within the Yanchep to Two Rocks area.

ATA Environmental has been engaged to provide environmental consultancy services to assist a multi-disciplinary project team in the development of a District Structure Plan (DSP) for the St Andrews area. The provision of environmental advice to assist the development of a District Structure Plan has been based on a review of previous detailed investigations of the Yanchep to Two Rocks area and more recent assessments specific to the requirements of district structure planning for St Andrews. Environmental investigations conducted to date that are relevant to this study include:

- The Shire of Wanneroo Town Planning Scheme No. 1 Amendment 787, Yanchep – Two Rocks Environmental Review prepared by Alan Tingay & Associates in 1999; including background studies to assist the development of the Environmental Review (ER):

  - Yanchep Vertebrate Fauna Survey (Alan Tingay & Associates, 1991);
  - Yanchep Physical Environment (Alan Tingay & Associates, 1992);
  - Yanchep Flora and Vegetation Report (Alan Tingay & Associates, 1992);
  - Yanchep Coastal Planning Strategy (Alan Tingay & Associates, 1993);
  - Yanchep Structure Plan Hydrogeology and Water Resource Development (Alan Tingay & Associates and Peck (1991);
  - Report on a Survey for Aboriginal Sites (MacIntyre, K. and Dobson, B. (1991); and
  - Report on an Archaeological Survey for Aboriginal Sites (Quartermaine, G. (1991).

- Yanchep Southern Project – Flora and Vegetation Assessment (ATA Environmental, 2001) including a spring survey of the Yanchep Southern Project landholding;

- St Andrews Estate Structure Plan Environmental Assessment (ATA Environmental, 2003). Now renamed as the Capricorn Village development; and

- Two Rocks Structure Plan – Flora and Vegetation Assessment (ATA Environmental, 2001).

This environmental assessment reviews the findings of previous investigations and summarises further investigations of the DSP area including:

- A desktop flora and vegetation assessment updating previous vegetation analyses;

- Supplementary vegetation assessment of the Tokyu landholding to assist in updating vegetation association types and to identify any likely Threatened Ecological Communities (TECs);

- A review of the Aboriginal heritage database to identify sites of significance not previously recorded.

Information in this report is intended to provide guidance on environmental aspects for the preparation of the St Andrews DSP. This report does not describe the environmental attributes of Bush Forever Sites or Lot 202 Breakwater Drive in the north-east of the DSP area.

A district level site assessment of karst is currently in preparation and will be submitted following the submission of the DSP. It is intended that the karst assessment will be submitted as a separate report.

1.2 Yanchep Structure Plan

Work done for the initial Yanchep Structure Plan (Feilman Planning Consultants, 1992; Jones Lang Wootton, 1992) provided the basis for the majority of previous environmental studies for the Yanchep to Two Rocks area.

The environmental assessments identified significant issues in relation to flora, vegetation and fauna and resulted in the creation of two areas of Parks and Recreation Reserve within the Metropolitan Region Scheme. These areas were set aside for the protection of the environmental attributes of the area.

1.3 Environmental Review

The Yanchep - Two Rocks area was the subject of the City of Wanneroo Town Planning Scheme (TPS) No. 1 Amendment 787 which required the preparation of an Environmental Review (ER) by ATA Environmental (Alan Tingay & Associates, 1999). The ER addressed the potential impacts of the rezoning on a number of issues and identified appropriate management measures to be implemented at various stages of the planning process. Issues addressed in the ER included:

- Biophysical
  - Vegetation Communities;
  - Declared Rare & Priority Flora;
  - Terrestrial Fauna;
  - Specially Protected (Threatened) Fauna;
  - Subterranean Fauna;
  - Groundwater Quantity; and
  - Karstic Landform.
- Pollution
  - Air;
  - Groundwater Quality;
  - Solid and Liquid Waste; and
  - Public Safety.
- Social
  - Unexploded Ordnance (UXO);
  - Aboriginal Culture and Heritage.

The TPS Amendment 787 and Environmental Review were formally assessed by the Environmental Protection Authority (EPA) under Section 48 of the Environmental Protection Act, 1986. The EPA recommended that the rezoning be gazetted subject to a number of environmental conditions.

The DSP area also includes land in the north-east corner that was rezoned under the TPS Amendment 837. This amendment was subject to an Environmental Review under Section 48 of the Environmental Protection Act, 1986. This land was reserved for Special Rural Purposes.

1.4 Environmental Conditions and Statement

The following conditions of Amendment 787 to the City of Wanneroo TPS requested by the Minister of Environment are required to be implemented to ensure that the future development of Yanchep-Two Rocks is undertaken in accordance with the principles of sound environmental management.

TABLE 1
ENVIRONMENTAL MANAGEMENT PROVISIONS

Item	Environmental Issue	Environmental Condition	Status
2.2-1	Environmental Management Plans	The following Environmental Management Plans shall be prepared in accordance with the specifications set out in Attachment 1 of the Minister for the Environment's Statement that a scheme may be implemented: ▪ Stygofauna and/or Troglobitic fauna Management Plan; ▪ Drainage, Nutrient and Water Management Plan; ▪ Karst Management Strategy; ▪ Solid and Liquid Waste Management Plan; and ▪ Aboriginal Culture and Heritage Management Plan. The environmental management plans shall be prepared and implemented in accordance with the provisions of the plans, to the requirements of the responsible authority.	Refer to items below.
2.3-1	Vegetation and Fauna Management	Regionally significant vegetation (draft Perth's Bushplan sites) which surrounds the amendment area shall be protected from indirect and direct impacts associated with the development of the amendment area by the following: ▪ Clear delineation of regionally significant areas of vegetation from the amendment area through the use of dual use paths, roads, public open space area and the like; ▪ Control of off-road vehicle use and dumping of rubbish; ▪ Fire Management; and ▪ Promotion of community awareness and bushland protection.	A portion of Bush Forever Site 288 Yanchep National Park and Adjacent Bushland is within the central eastern portion of the Study Area. Bush Forever Site 397 Coastal Strip from Wilbinga to Mindarie forms part of the coastal foreshore reserve. No other bushland identified as regionally significant occurs within the study area. Treatment of regionally significant bushland will be determined at the District Structure Planning stage. Management plans for any areas identified as being regionally significant will be prepared at the Local Structure Planning stage.
3.4-1	Stygofauna and Troglobitic Fauna Management	If studies in relation to Karst and hydrology indicate the likelihood of significant stygofauna and/or troglobitic fauna assemblages being present in or immediately adjacent to the Amendment Area, the landowner shall undertake a survey (at the LSP stage) to assess the nature and extent of any population/s. The survey shall be completed prior to finalisation of the	Assessment for Karst Landforms is to be undertaken prior to finalisation of the District Structure Plan. If the karst assessment indicates that stygofauna and/or troglobitic fauna assemblages are likely to be present further surveys will be

Item	Environmental Issue	Environmental Condition	Status
		LSP and to the requirements of the responsible authority on advice from CALM and UWA (Department of Zoology).	undertaken to assess the nature and extent of any populations at the LSP stage.
2.5-1	Assessment of Karst	At the DSP and LSP stage, the landowner shall review existing geotechnical information and undertake further site investigations to confirm the nature and extent of karst landform within the amendment area. This review shall be completed prior to the finalisation of the DSP and LSP and to the requirements of the responsible authority on advice from the DEP.	An assessment of karst landform will be undertaken for Stage 1 – 3 of the DSP prior to the DSP being finalised. Prior to the preparation of Local Structure Plans for land identified within Stages 4 – 5 of the St Andrews District Structure Plan, a karst investigation will be undertaken to ascertain the likelihood of karstic formations and the impact of these formations on landuse distribution within the District Structure Plan.
2.6-1	Solid and Liquid Waste Management	The landowner shall ensure that lots within the industrial zone are connected to the deep sewerage system for the disposal of appropriate liquid waste as approved by the relevant Government agencies. The landowner shall prepare a Solid and Liquid Waste MP at the LSP stage to the requirements on the responsible authority on the advice of the DEP. This plan shall include: ▪ The identification of the environmental outcome to be achieved through the implementation of this plan; and ▪ Options for recycling, and appropriate storage and disposal options for liquid and solid wastes from industry.	To be addressed at the Local Structure Planning stage.
2-1	Drainage, Nutrient and Water Management Plan	At the LSP stage, the landowner shall prepare a Drainage, Nutrient and Water Management Plan (DNWMP) to ensure that surface and groundwater are managed to the minimum requirements of the responsible authority on the advice of the WRC and the Water Corporation. This plan shall include: ▪ Identify the environmental outcome (including sustainability indicators) to be achieved through the implementation of this Plan; ▪ Include provisions for the connection of all areas of development to the deep sewerage; ▪ Demonstrate that best practice WSUD principles are incorporated to maximise on-site water infiltration generally;. ▪ Provide details of reporting mechanisms to demonstrate compliance with performance criteria specified in the Plan; and Provide details of contingency plans in the event that the performance criteria specified in the Plan are not achieved.	The preparation of Drainage, Nutrient and Water Management Plans will be addressed at the Local Structure Planning Stage.
5-1	Aboriginal Culture and Heritage Management Plan	The landowner shall prepare an Aboriginal Culture and Heritage Management Plan at the LSP stage to the requirements of the responsible authority with the concurrence of the Aboriginal Affairs Department. This plan shall include:	An assessment of Aboriginal culture and Heritage has been undertaken. Aboriginal Culture and Heritage Management Plans will be prepared as necessary

Item	Environmental Issue	Environmental Condition	Status
		▪ The identification of the environmental outcome to be achieved through the implementation of this plan; ▪ Management Strategies for the archaeological site (if it becomes necessary to disturb the site, the subdivider shall obtain the necessary clearances under the Aboriginal Heritage Act, 1972; ▪ Management strategies to ensure that employees and workers involved in construction activities in the vicinity of the site receive training regarding protection of its values; and ▪ Management strategies to ensure that prior to commencement of site works, staff undergo a briefing on Aboriginal Heritage issues, to enable staff to recognise materials that may constitute an Aboriginal site. During earthworks, all contractors shall be supervised by a site manager, who shall seek specialist advice to confirm the identification of any suspected sites.	during the Local Structure Planning stage.
Other Issues:			
-	Coastal Management	'Other reports to be prepared'.	Foreshore Management Plans and Implementation Strategies (FMP) will be prepared for the foreshore area adjacent to the study area during the Local Structure Planning stage.

1.5 Location and Land Use

The St Andrews DSP area is located approximately 50km north of Perth city centre and occupies roughly 7580ha. The regional location is shown in Figure 1 while the study area boundary is shown in Figure 2. The study area is bounded by the Indian Ocean to the west, Eglinton to the south, privately owned land and Yanchep National Park to the east and extends to the boundary of the Metropolitan Region in the north, approximately 3km north of Two Rocks town site.

The area comprises cleared land and areas of remnant vegetation and includes the town sites of Yanchep and Two Rocks, and Sun City Country Club and golf course. The proposed District Structure Plan is shown in Figure 3.

Land adjoining the DSP area predominantly supports remnant vegetation. Bush Forever Site 406 Wilbinga-Caraban Bushland is located adjacent to the northern boundary of the study area and Bush Forever site 288 Yanchep National Park and Adjacent Bushland is located adjacent to the majority of the eastern boundary of the study area. Bush Forever Site 284 South-West Link from Wilbinga to Yanchep National Park and part of Bush Forever Site 288 Yanchep National Park and Adjacent Bushland are located within the St Andrews DSP landholding.

Bush Forever Site 284 South-West link from Wilbinga to Yanchep National Park is reserved in the Metropolitan Region Scheme (MRS) as Parks and Recreation and is proposed for inclusion in Yanchep National Park. Land vested with, or managed by, the Department of Conservation and Land Management (State Forest) occupies much of the area further east. Bush Forever Site 289 Ningana Bushland, Yanchep/ Eglington straddles the southern DSP boundary. This area is reserved as Parks and Recreation in the MRS. Bush Forever Site 397 Coastal Strip from Wilbinga

to Mindarie comprises part of the foreshore reserve within the study area. This area is also a Parks and Recreation reserve.

2. STUDY AREA DESCRIPTION

2.1 Climate

2.1.1 Rainfall and Evaporation

The study area experiences a Mediterranean climatic regime similar to that of Perth. Most rain falls during the winter months (May to October), with monthly totals often exceeding 100mm. Monthly rainfall of up to 50mm may occur in the remaining months (Bureau of Meteorology, 2006).

The annual pan evaporation for the Yanchep area is estimated from the Bureau of Meteorology evaporation map as approximately 1990mm (Alan Tingay & Associates and Dr Adrian Peck, 1991).

2.1.2 Wind

Wind patterns over southern parts of Western Australia are controlled by the position of the belt of anticyclonic systems that move eastward over the coast from the west. During summer, these systems are centred over the Southern Ocean to the south of the state, whilst in winter they are located over the northern half of Australia (Alan Tingay and Associates, 1992[a]).

The result of this latitudinal migration of pressure systems is that during summer winds blow from the east to southeast in the morning and from the southwest in the afternoon due to the local sea breeze. During winter the northerly locations of the anticyclone systems result in a passage of low pressure systems over the south western portion of the state. The resultant storm winds bring wet weather interspersed with calmer periods.

Tropical cyclones may occasionally migrate further southward than usual in the summer to autumn period bringing gale force winds and heavy rains.

2.1.3 Temperature

The Yanchep area experiences air temperatures similar to those of Perth with mean daily maximum temperatures varying from 31.8C in summer to 17.8C in winter. Mean daily minimum temperatures vary from 17.4C in summer to 8.0C in winter (Bureau of Meteorology, 2006).

2.2 Geology and Landform

2.2.1 Overview

The study area is located in the Perth Basin, a geological formation containing Phanerozoic rocks of sedimentary origin up to approximately 10km thick (Alan Tingay & Associates and Dr Adrian Peck, 1991). Three major geological units occur within the study area; Tamala Limestone, the Leederville Formation, and the Yarragadee Formation. The Pleistocene to early Holocene Tamala Limestone forms the major shallow unconfined aquifer underlying the study area, whilst the Cretaceous Leederville Formation and the Jurassic Yarragadee Formation constitute the main confined aquifers.

The surface geology of the study area is dominated by Tamala Limestone and Holocene Safety Bay sand. The Safety Bay sand unit adjoins and overlies the Tamala Limestone.

Isolated outcrops of Tamala Limestone appear throughout the site, particularly in the eastern parts (Alan Tingay & Associates and Dr Adrian Peck, 1991).

A number of conspicuous landforms are present within the study area including rocky limestone outcrops and reefs, various dune formations and isolated conical hills.

2.2.2 Safety Bay Sand

Safety Bay sand is composed of coastal dune sands and shallow marine sands, most of which are eolian. The unit comprises generally unlithified sand composed of shell fragments (mainly formaniferal and molluscan skeleton fragments), variable quantities of quartz and minor feldspar. Its distribution coincides with that of the Quindalup Dune System (Alan Tingay & Associates, 1992[b]).

The Safety Bay unit forms Holocene coastal sand dunes and shallow marine to littoral sands that occupy most of the near coastal zone in the study area. Portions of the unit are also present in eastern parts of the study area where they form shore-transverse arms and faces of probable amalgamated elongated parabolic dunes. In some localities, particularly on inland older dunes, the sand has become weakly lithified, marking the first stage in conversion to eolianite.

Safety Bay sand varies in thickness over the western portion of the site from 0m to about 50m (Alan Tingay & Associates and Dr Adrian Peck, 1991). Deposition continues today with active accumulation along the coast and inland migration of dunes.

2.2.3 Tamala Limestone

Tamala Limestone formed as a result of the induration of coastal paleodune structures which are aligned sub parallel to the present coastline, during the Pleistocene and early Holocene. Tamala Limestone is a unit of friable to hard, medium grained, eolian calcarenite composed of wind-blown shell fragments (mainly foraminiferal and molluscan skeleton fragments) with variable amounts of quartz sand. The unit also contains interbedded coarse quartz sand and is characterised by large scale crossbedding marking successive dune slopes (Alan Tingay & Associates and Dr Adrian Peck, 1991). Soil horizons and calcified root structures are also common.

The Tamala Limestone unit forms several lines of offshore reefs in the area and extends to approximately 30m below sea level (Alan Tingay & Associates and Dr Adrian Peck, 1991). On land the Tamala Limestone unit forms some of the highest landform features rising to approximately 50mAHD.

2.2.4 Leederville Formation

The Leederville Formation is the most important confined hydrogeological unit underlying the area. The formation is an interbedded sequence of sandstone, shale, siltstone, claystone and minor conglomerate. Lenticular beds of sand, which hold the majority of the water in the formation, usually do not exceed a thickness of 10m and do not persist over large areas.

Data from deep wells drilled within the study area indicate that the Leederville formation conformably overlies the South Perth Shale (Alan Tingay & Associates and Dr Adrian Peck, 1991).

2.2.5 Yarragadee Formation

The Jurassic Yarragadee Formation is a light to dark grey or white to brown, interbedded sequence of sandstone, siltstone and shale that contains minor claystone and conglomerate

horizons. Sandstone beds within the formation are up to 30m thick and usually consist of medium to very coarse subangular, weakly cemented feldspathic sand. Bedding is commonly ill-defined and the formation contains thick pyritic and micaceous siltstone together with thin, alternating sandstone and siltstone horizons (Alan Tingay & Associates and Dr Adrian Peck, 1991).

The Yarragadee Formation is one of the most widespread units in the Perth Basin, being exposed discontinuously in the north and occurring in the subsurface throughout most of the central and south coast plain. The maximum thickness of the unit exceeds 3000m (Alan Tingay & Associates and Dr Adrian Peck, 1991).

2.3 Geomorphology and Soils

2.3.1 Overview

The study area occupies a coastal section of the Swan Coastal Plain. The Swan Coastal Plain is an undulating lowland separated from dissected uplands by the wave-cut Darling-Gingin Scarp. Broad physiographic areas of the plain are referred to as the Quindalup and Spearwood Dune Systems, Bassendean Dunes, Pinjarra Plain, and Ridge Hill Shelf. In the study area only the Holocene Quindalup and the Pleistocene to Holocene Spearwood Dune Systems are represented.

2.3.2 Quindalup Dune System

The Quindalup Dune System extends along the modern shoreline of the Swan Coastal Plain, from Geographe Bay in the south to Dongara in the north. This dune system is the geomorphologic expression of the Safety Bay Sand geological unit. In the study area it borders the present coastline as a series of fretted parabolic dunes and chaots. Close to the coast there is a 100m wide section of low shore-parallel beach ridges that have been deposited on a recently accreting shoreline. The Quindalup Dunes extend inland in a series of large-scale, elongated and coalescent parabolic dunes, whose arms and faces measure several kilometres in length. It is the youngest of the dune systems in the area and consequently abuts or rests on the Spearwood Dune System (Alan Tingay & Associates and Dr Adrian Peck, 1991).

2.3.3 Spearwood Dune System

The Spearwood Dune System is the geomorphic expression of the Tamala Limestone geological unit. In the study area it lies landward of the Quindalup System, extending from about 1km of the coast to beyond the eastern margin of the site. The dunes rise from a maximum elevation of about 30m in western parts, to over 60m in the east.

Originally the material comprising the dunes was calcareous throughout, but leaching has removed carbonate from upper horizons to be precipitated below, forming a hard calcretised cap (Alan Tingay & Associates and Dr Adrian Peck, 1991). Material remaining in upper horizons is mainly brown to yellow sand and this covers much of the limestone within the study area, to depths often greater than 1m. However, eolianite comprising the core of many dunes has been extensively exposed by wind action, particularly in areas in the northwestern portion of the site.

The topography of the study area is shown in Figure 2.

2.3.4 Karstic Landform

On a regional basis within the Swan Coastal Plain, the intensity and nature of karstification is variable, with limestone in some districts being massive, with no cavern development or comprising only a minor feature of the geology below residual sandy soils. The reasons for this variability are related to the heterogenous composition of the limestone, the area of influence of groundwater on the limestone formation over time and critically, the chemical characteristics of the groundwater.

The term "karst" has a range of definitions that vary depending on the author and their scientific background. Often the term is used to describe landscapes that are commonly characterised by closed depression (sinkholes), subterranean drainage and both horizontal and vertical caves. However, numerous authors use the term to describe any surficial or subterranean features that are formed by dissolution of limestone or other soluble rocks. The scale of these features can vary from millimetres to hundreds of metres or more and can include small underground voids or cavities, caves, dolines, collapsed caves and sculpting of limestone surfaces.

Karst features such as solution sculpting are common on the surfaces of the coastal limestone of the Perth region, including the Two Rocks area. Solution sculpting is produced by dissolution at the surface of the limestone either from direct rainfall or by water percolating through the soil profile to a point where it intersects the limestone. Carbon dioxide in the atmosphere and from pore spaces in the soil profile (and to a lesser extent organic acids from within the soil profile) acidify the meteoric waters (rainfall and water percolating down through the soil profile), thus aiding dissolution of the limestone.

Larger karst features such as caves, collapsed caves, and subsurface cavities are less common in the coastal limestone and, in the northern part of the Perth region, have generally been thought to be restricted to a linear zone which roughly corresponds with the Wanneroo wetlands chain including Loch McNess. The karst features in this zone are formed by groundwater from the Gnangara Mound dissolving the limestone as it migrates towards the coast. The groundwater initially passes through quartz sands (and thus is undersaturated with respect to carbonate) before intersecting the limestone along a linear front where it begins the dissolution process. The width of the zone of potential karst phenomenon varies depending on a range of factors including water quality, transmissivity and the degree to which the limestone is cemented. Where voids have formed at the water table, they may expand by the collapse of overlying limestone. Once the migrating groundwater has become saturated with dissolved carbonate, further dissolution of limestone at the watertable is limited.

The size of potential karst features within the zone and thus their significance in terms of constraints to development varies according to a variety of factors including water chemistry, the degree to which the limestone is cemented, and depth to groundwater from the surface.

The results of an ongoing karst assessment undertaken for Lot 202, to the east of the study area, have recently become available. This assessment was undertaken as part of the requirements for the Local Structure Planning process for Lot 202 and established that the process of karstification on Lot 202 (which lies directly in the linear zone described above) has largely concluded, except in western portions of the lot where groundwater still intersects the calcarenite (limestone) which underlies the site.

It is therefore highly likely that phreatic karstification is, at a minimum, currently active within the reserve land on the eastern boundary of the study area in the north, and on eastern parts of the study area in the south (this is west of the previously recognised zone). However, the extent to which this may impact further to the west is unknown. The impact this current process may have on any older karst features, produced earlier in geological time (in the last 100,000-150,000 years before present) is also unknown.

The study area comprises a mature dune landscape with calcarenite covered by a layer of residual soil (quartz sand) about 5m thick, which is occasionally overlain by younger, approximately 10m-high parabolic dunes and metre-thick dune sheets composed of calcareous sand, particularly towards the coast. Within the study area there are a number of hectometre- to kilometre-scale, sub-circular, closed basins with floors some 10m to 15m below the general level. These basins are suspected to be cover-collapse or cover-subsidence sinkholes reflecting the presence, or past presence, of caverns and/or solution basins in the underlying calcarenite. They occupy about 6% of the study area (mainly in eastern parts) and require further assessment to determine if karst features are present.

2.4 Coastal Processes

2.4.1 Overview

A Coastal Planning Strategy was prepared for the Yanchep to Two Rocks area by Alan Tingay and Associates in 1993 as part of the MRS Amendment process. The principal objective of the Strategy was to describe coastal process occurring and to identify management considerations for the coastal area in the context of future development.

Coastal processes are dominated by wind and tidal action, which distribute sediment by seasonal onshore and offshore migration, and longshore transport. The magnitude of these processes is dependant on climatic conditions.

A primary factor influencing these processes in the Yanchep to Two Rocks area is the prevailing south westerly swell. This has eroded the outer reefs, caused onshore sediment transport, and continues to produce longshore currents that mobilise sand in the surf zone (Alan Tingay and Associates, 1993).

Diffraction of the swell waves as they pass through the inner chain of reefs produces local longshore currents in the surf zone that flow in various directions, depending on the complex patterns of divergence and convergence produced during diffraction. Wind generated waves have a significant effect in this near shore environment because they overprint local currents to produce a sustained unidirectional longshore current. Such sustained currents generally move sediment northward during summer and southward during winter in response to prevailing seasonal winds. As the summer wind, swell and wave regime is dominant, there is a slight northerly bias to net sediment transport (Alan Tingay and Associates, 1993).

The banks of offshore reefs and seagrass meadows that are generally adjacent to the coast significantly attenuate the offshore wave climate and reduce wave heights, resulting in a considerably milder sediment transport regime along much of the coast between Yanchep to Two Rocks than might be expected on an open coast.

During winter, steep wind generated waves contribute to coastal processes by combining with surges during storm events, to attack high parts of the beach normally isolated from wave action. This type of wave attack erodes the beach and foredunes and produces an offshore bar. During summer, sediment from the bar and sediment generated by erosion of pre-existing geomorphic features, such as reefs and the sea floor, is returned to the beach by prevailing south-west swell and wind waves (Alan Tingay and Associates, 1993).

The Coastal Planning Strategy prepared by Alan Tingay and Associates (1993) divided the Yanchep-Two Rocks area into five sectors as follows:

- Sector 1 Southern Boundary to Yanchep Lagoon;
- Sector 2 Yanchep Lagoon to Club Capricorn Groyne;

- Sector 3 Club Capricorn Groyne to south of "The Spot" Headland;
- Sector 4 "The Spot" Headland to Two Rocks Marina; and
- Sector 5 Two Rocks Marina to Northern Boundary.

The sectors identified in the 1993 study by Alan Tingay and Associates are described below.

2.4.2 Sector 1: Southern Boundary to Yanchep Lagoon

The coast from the southern boundary of the study area to Yanchep Lagoon is characterised by a sandy beach ranging from 15 to 30m in width. This beach stretches unbroken from the boundary for approximately 2km before terminating against a limestone headland that extends seaward to form an intertidal platform. Winter conditions expose extensive beach rock in the swash zone, and there is extensive seaweed offshore at the northern end of the sector fronting Yanchep townsite.

Cemented limestone occurs at elevations ranging from 2m to 6.5m above sea level. This limestone slopes seaward and outcrop as a reef formation immediately off the beach.

The primary dunes in this sector are well vegetated except in areas where pedestrian access and off road vehicle use have destabilised the vegetation. The foredunes are vegetated with *Spinifex hirsutus*, and marram grass (*Ammophila arenaria*) is apparent where foredunes are building seaward.

2.4.3 Sector 2: Yanchep Lagoon to Club Capricorn Groyne

Yanchep Lagoon is defined by a shallow limestone reef which extends in a northerly direction from the intersection with the beach. The reef is approximately 700m long and 50m wide and it defines a shallow lagoon which is approximately 300m wide and 50m wide. The limestone enclosing the lagoon outcrops over about 200m and is up to 3m high. Yanchep lagoon is a popular recreational swimming and fishing area.

From Yanchep Lagoon to Club Capricorn Groyne, the coast consists of a single beach approximately 1200m long. The beach gradually widens northward from about 20m in the vicinity of the lagoon, to approximately 80m immediately south of the groyne. Shoreline movement plans from the Department of Marine and Harbours indicate that this sector has been accreting since the 1940's.

The sandy beach is backed by a series of low broad dunes that rise into steep primary dunes about 75m from the beach. This beach is prograding, with marram grass colonising new foredunes seaward of more established vegetation.

2.4.4 Sector 3: Club Capricorn Groyne to South of "The Spot" Headland

The beach to the north of Club Capricorn Groyne is relatively narrow (10 – 15m wide) and backed by low foredunes colonised by marram grass. This section of beach is affected by sediment interruption resulting from construction of the groyne. Seaweed was observed offshore at the end of the groyne but did not appear to interfere with beach or swimming conditions onshore.

2.4.5 Sector 4: "The Spot" to Two Rocks Marina

The section of the coast from "The Spot" to Two Rocks Marina is approximately 3km long and consists of a gently curved beach which is evidently accreting. "The Spot" is a large rocky headland composed of Tamala Limestone which is 200m long and up to 5m high. This headland is possibly part of an extensive Tamala Limestone ridge that roughly parallels the

coast, but is mostly covered by Quindalup Dunes. “The Spot” is a popular place for surfing and a small car park and toilets are provided adjacent to the beach.

Exposed limestone at “The Spot” acts to retard longshore drift and aids beach accretion to the south, where the beach is relatively wide. Immediately north of “The Spot” the beach is narrow due to interruption of sand movement by the rocky headland. However, the influence of the headland diminishes northward, and approximately 100m north of the headland the beach attains widths of up to 80m.

In the south of this sector, the beach is backed by low broad foredunes colonised by marram grass. The central part of the sector displays some limestone exposures within the dunes and beach rock in the near shore area is exposed during winter.

Wreck point is a less elevated limestone headland just south of the Two Rocks Marina that extends into the ocean as a littorial platform. It serves as a natural barrier to longshore sand drift. As a result, this area of beach is accreting to form a tombolo. The beach to the north of Wreck Point is not as narrow as might be expected since the Two Rocks Marina also acts to retard near shore littorial drift and has caused continued sand deposition to maintain the beach. Seaweed builds up during summer at this location.

From “The Spot” to the middle of this sector, limestone cliffs are exposed at various points. The remainder of the sector is accreting, due to the combined effect of Wreck Point and the marina structure encouraging sand deposition in the area. The sediment build up is being stabilised by primary colonisers (particularly marram grass) which are building seawards.

2.4.6 Sector 5: Two Rocks Marina to the Northern Boundary

The coast from Two Rocks Marina to the northern boundary is characterised by narrow, eroding beaches that have steep profiles. The beaches are generally 15m to 20m wide and are characteristically backed by high cliffed dunes. Local onshore reefs may act to increase the width of adjoining (southern) beaches.

Weathered Tamala Limestone between 2m to 6m high backs part of the shore towards the northern boundary and influences the shape and width of the beaches. The extent of Tamala Limestone along the coast is indicated by its exposure at the base of blowouts within cliffed dunes. Littorial platforms composed of Tamala Limestone and beach rock extend from the base of beaches further north, contributing to the rugged appearance of this section of the coast.

The beaches typically lack foredunes, or the foredunes show evidence of wave erosion. However, in a number of places, the vegetation is recovering and there is some evidence of incipient dune development.

In winter, almost the entire sector exhibits exposed beach rock in the near shore and swash zones. The northern end of the property has extensive seaweed beds offshore.

2.5 Marine Environment

2.5.1 Offshore Habitat

The marine environment in the Yanchep to Two Rocks area contains no marine protected areas under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). State marine conservation reserves are managed and protected under

Conservation and Land Management (CALM) Act 1984. There are no marine conservation reserves near the St Andrews District Structure Plan area.

Discussions with the Fisheries Department indicate that there are no Fish Habitat Protection Areas in the Yanchep to Two Rocks area. Fish Habitat Protection Areas are protected under the *Fish Resources Management Act 1994* (FRMA).

No biological survey data is available for the Yanchep to Two Rocks area.

2.6 Hydrogeology

2.6.1 Tamala Limestone

The Tamala Limestone is the shallowest and most productive aquifer in the area. It is overlain in western parts by calcareous dunal sands, but is exposed in eastern areas as dune sands and solid limestone outcrop. Water in this superficial aquifer is derived from direct recharge by winter rainfall. The Gnangara Mound is a large mound of groundwater underlying the Swan Coastal Plain to the east of the study area. The Mound lies between 20m to 50m above the level of the water table in the Tamala Limestone Aquifer (Alan Tingay & Associates and Dr Adrian Peck, 1991).

Through flow of groundwater to the coast in the Tamala Limestone is conservatively estimated to be 365ML/yr/km. The hardness of water in this aquifer is about 220mg/L, and the salinity is about 400mg/L. Salt water from the ocean intrudes into parts of the aquifer near the coast (Alan Tingay & Associates and Dr Adrian Peck, 1991).

2.6.2 Leederville Formation

The Leederville formation is the most important confined hydrogeological unit underlying the study area (Alan Tingay and Associates, 1991). Most of the water in the formation is held in discontinuous lenticular bands of sand that are generally less than 10m thick. These lenticular sand beds comprise about half the formation and vary considerably in sorting, grain size, and clay content. Through flow to the coast is about 180ML/yr/km and the water has a salinity of about 350mg/L. (Alan Tingay & Associates and Dr Adrian Peck, 1991).

Recharge to the aquifer is from the overlying unconfined aquifer to the north of the study area (near Gingin), where intervening formations are absent or sandy. Recharge may also occur by upward leakage of groundwater from the Yarragadee Formation, also where intervening formations are absent.

2.6.3 Yarragadee Formation

The Yarragadee formation is a massive confined aquifer that underlies much of the Swan Coastal Plain. The Yarragadee Formation is a Jurassic fluviatile deposit with minor shallow-marine and continental components. It consists of an interbedded sequence of sandstone, siltstone and shale that contains minor claystone and conglomerate horizons. Most of the water in the aquifer is held in sandstone beds composed of medium to very coarse, subangular, weakly-cemented, feldspathic sand that are up to 30m thick. Through flow to the coast is estimated at about 90ML/yr/km, and the water has a salinity of about 1800mg/L (Alan Tingay & Associates and Dr Adrian Peck, 1991).

Recharge to the Yarragadee formation occurs by downward leakage from the Leederville Formation and superficial aquifer, in areas where intervening sediments are absent.

2.7 Vegetation and Flora

2.7.1 Background

A detailed flora and vegetation survey of the Yanchep area (Tokyu Corporation landholding of 7000ha) was conducted between September and November 1991. The south eastern section was extensively and severely burnt by a fire in January 1991 and therefore was not sampled in detail. Portions of this area was surveyed by ATA Environmental in 2001, 2005 and 2006 to update previous investigations.

Further investigations were undertaken by ATA Environmental in 2003 and 2005 to determine the extent of *Melaleuca huegelii* and *Melaleuca cardiophylla* populations with the Yanchep area. In order to update original mapping of vegetation associations within the DSP area an additional site visit was undertaken in January 2006.

2.7.2 Methodology

During the 1991 survey, the vegetation description of the property was based on sampling over a number of sites. These sites were selected by placing a 500m x 500m scale grid over a 1:20,000 composite aerial photograph. Intersections of the grid intercepted sample sites but only those sites which coincided with natural vegetation were actually sampled. The description of each site included the topography, soil type, and degree of disturbance, vegetation type, dominant species and other species within a 10m x 10m quadrat. The description of vegetation associations was based on the system devised by Specht (1981) which classifies vegetation on the basis of height and cover of the tallest stratum (e.g. Low Woodland). Individual plant associations are then named according to the dominant species (e.g. *Banksia attenuata* Low Woodland).
The quadrat data were analysed using a computer classification technique that groups areas of similar floristic composition together. Using this technique a number of broad vegetation groupings were identified. These groupings, or Alliances, included the following:

- Young Quindalup Dune Heath;
- Old Quindalup Dune Heath;
- Limestone Heath; and
- Sand over Limestone Vegetation.

This analysis and the use of the Alliance as a descriptive tool predates the current use of Floristic Community Types used on the southern Swan Coastal Plain (see section 2.6.6).

A list of the native species of the area was compiled from observations and collections made along a series of foot and vehicle traverses conducted during this period. These traverses covered the entire property with the exception of the south eastern burnt section. It is considered that the original vegetation survey methodology complies with the requirements of the Environmental Protection Authority as indicated in *Guidance Statement No. 51: Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia.*

A survey of the previously burnt south-eastern portion of the DSP area was undertaken by ATA Environmental in 2001. In addition, follow up surveys undertaken in 2003, 2005, and 2006 included targeted assessment of *Melaleuca cardiophylla* vegetation and ground truthing existing 1991 mapping to map the vegetation at a finer scale than the original Alliance concept and to determine if any vegetation associations may be Threatened Ecological Communities. The Bush Forever Sites, Special Rural area and Freeway Reserve were not included in these following surveys as no changes to these areas are proposed within the DSP.

2.7.3 Vegetation Complexes

Vegetation Complexes are a broad level of vegetation description which is based on the underlying geomorphology and rainfall (Heddle *et a*l., 1980).

At this level, the majority of the vegetation within the St Andrews Structure Plan area is classified as being in the Quindalup Complex. Small portions of the eastern extent of the study area comprise the Cottesloe Complex – North.

The Quindalup Complex extends in an almost continuous thin strip along the coast from Dongara in the north to Busselton in the south. There is considerable variation in the vegetation that comprises the Quindalup Complex both at the local and regional level. The Cottesloe Complex – North adjoins the Quindalup Complex at its eastern extent and extends south towards the Perth Metropolitan area where a transition occurs to Cottesloe Complex – Central and South.

The vegetation complexes present within the St Andrews Structure Plan area are described as follows (Heddle *et a*l., 1980):

- Quindalup Complex – Coastal dune complex consisting mainly of two alliances – the strand and foredune alliance and the mobiles and stable dune alliance. Local variations include the low closed forest of *M. lanceolata – Callitris preissii* and the closed scrub of *Acacia rostellifera*; and

- Cottesloe Complex - North – Predominantly low open forest and low woodland of *Banksia attenuata – B. menziesii – E. todtiana*; closed heath on the Limestone outcrops.

2.7.4 Vegetation Associations

The vegetation associations mapped within the DSP area are shown in Figure 6 and described below. This description does not cover the Bush Forever Sites, the Special Rural area or the freeway

QUINDALUP VEGETATION COMPLEX

Young Quindalup Dune Heath

- ***Acacia rostellifera* (Ar) Closed Heath and *Acacia rostellifera Spyridium globulosum* Closed Heath (ArSg)**

The Ar vegetation association is located inland from the youngest dunes in places where weak cementation of the sand and the development of an organic layer at the surface have occurred. The vegetation on the crests and slopes of the dunes usually contains a mixture of vegetation, while the swale usually contains a *Lepidosperma gladiatum* sedgeland. This vegetation association occurs in patches between the Yanchep and Two Rocks town sites and also in the north-western corner of the DSP area to the north of Two Rocks. In some patches *Spyridium globulosum* is present to form the ArSg vegetation association, which occurs within the Ar association.

- ***Spinifex hirsutus* (Sh) on Foredunes and *Ammophila arenaria* (Aa) Grassland (Marram)**

These vegetation units are typical of accreting shorelines, generally being the first species to colonise the primary dune. Marram Grass is a non-native species introduced to stabilise

foredune areas in selected parts of the coast. Where it has been successfully introduced it has formed low dunes about 1m high and from 4m to 8m wide, parallel to the coast. Other strand species, such as *Spinifex hirsutus, S. longifolius, Cakile maritima* and *Trachyandra divaricata,* have also colonised the dunes. This vegetation association is generally found in the southernmost section of coast within the DSP area.

- ***Olearia axillaris* and *Scaevola crassifolia* (OaSc) Shrubland**

The windward slope and crest of the primary dune supports an *Olearia axillaris* and *Scaevola crassifolia* (OaSc) Shrubland. Other species found within this association include *Carpobrotus virescens, Senecio lautus, Trachyandra divaricata* and *Leucophyta brownii*. *Lepidosperma gladiatum* is dominant in patches.

- ***Olearia axillaris* and *Spyridium globulosum* Heath (OaSg) and *Olearia axillaris, Spyridium globulosum* and *Acacia rostellifera* Heath (OaSgAr)**

These associations are the dominant associations on young Quindalup dunes to the east of colonising species on the foredunes. The width of these associations varies considerably according to the inland extent of the young Quindalup dunes. The OaSg association extends from Yanchep to Two Rocks to the west of Two Rocks Road while the OaSgAr variation generally occurs close to the Ar association. The OaSgAr association occurs in the coastal zone near Yanchep and in the northernmost coastal section of the DSP area. Other species commonly found in this association include *Acanthocarpus preissii, Rhagodia baccata, Conostylis candicans* and *Poa drummondiana*.

Old Quindalup Dune Heath

- ***Acacia rostellifera* Closed Heath with scattered *Dryandra sessilis* (ArDs)**

The vegetation association occurs in patches in the central southern portion of the District Structure Plan area and generally occurs near the Ar and Ds vegetation associations.

- ***Acacia saligna* (As) Open Scrub to Tall Shrubland**

On some dune slopes, flat areas and swales of the older dunes the *Melaleuca systena* (Ms) association is covered by a sparse to dense cover of *Acacia saligna* with *Xanthorrhoea preissii* also common up to 2.5m tall. The soil type is generally dark brown sand and probably indicates the proximity of the Tamala Limestone to the surface. Common species within the As and AsXp unit are similar to that of the Ms association, with *Conostylis candicans, Diplopeltis huegelii* and *Melaleuca systena.* The As and Xp associations differ slightly from the Mn assocation with the inclusion of the two dominant species *Acacia saligna* and *Xanthorrhoea preissii,* as well as the inclusion of *Lepidosperma angustatum* and *Rhagodia baccata*. These areas appear to have a higher number of introduced species due to either the increased nutrients of the soil type, higher moisture availability or increased grazing pressure.

- ***Acacia saligna* and *Xanthorrhoea preissii* Tall Shrubland (AsXp)**

This vegetation association occurs in the swales of Quindalup dunes predominantly in the northern portion of the DSP area, although pockets also occur in the central portion where intact vegetation remains. The dark soil type probably indicates the proximity of Tamala Limestone to the surface. Common species are similar to the Ms vegetation association and include *Conostylis candicans, Diplopeltis huegelii* and *Melaleuca systena.* The AsXp association differs with the inclusion of the two dominant species; *Acacia saligna* and *Xanthorrhoea preissii,* as well as the inclusion of *Lepidosperma angustatum* and *Rhagodia*

baccata. An Xp variation lacking *Acacia saligna* as a dominant occurs in proximity to the AsXp vegetation association.

- ***Melaleuca systena* Closed Heath (Ms)**

The Ms vegetation association occurs on the flanks and crests older Quindalup dunes close to the coast which have a more developed soil profile with an accumulation of organic matter in the topsoil and moderate cementation of the subsoil. This soil type occurs on rolling parabolic dunes generally with convex slopes. The Ms association is dominated by *Melaleuca systena* and also commonly includes *Conostylis candicans, Hibbertia racemosa, Diplopeltis huegelii, Phyllanthus calycinus* and *Gastrolobium reticulatum*.

Limestone Heath Types

- ***Dryandra sessilis* Heath to Closed Heath (Ds), *Dryandra sessilis* and *Calothamnus quadrifidus* Heath to Closed Heath (DsCq and CqDa) and *Calothamnus quadrifidus* Closed Heath (Cq)**

The limestone heaths dominated by *Dryandra sessilis* (Ds)are by far the most widespread heath vegetation throughout the area. *Dryandra sesslis* can be the sole dominant species or can be found associated with other dominants including *Hibbertia hypericoides*, *Acacia pulchella*, *Hakea trifurcata*, *Calothamnus quadrifidus* (DsCq, and CqDs) and mixtures of these co-dominants. In some places *Calothmnus quadrifidus* (Cq) can be found in isolation. These associations tend to occur mainly on the lower, mid and upper slopes of limestone rises and hills. Where the limestone abuts areas of deeper sand, occasional emergent *Banksia* and Tuart trees occur. However, the transition from Ds to *Banksia* Woodland is usually abrupt.

Common understorey species include *Melaleuca systena, Mesomelaena pseudostygia, Hibbertia hypericoides, Xanthorrhoea preissii, Desmocladus flexuosus, Conostylis candicans* and *Hybanthus calycinus.*

- ***Melaleuca huegelii* Open Heath to Heath (Mh)**

The Mh association occurs in a few small areas adjacent to Breakwater Drive near Two Rocks and an area along Yanchep Beach Road. The association occurs on the top of limestone hill areas and the soil type typically contains abundant limestone with very little sand present. The exposed limestone is more weathered than that exposed in the Ds Heath. *Melaleuca huegelii* occurs in association with *Melaleuca systena, Dryandra sessilis, Spyridium globulosum, Scaevola nitida* and *Acacia cyclops* and to a lesser extent *Templetonia retusa, Leucopogon parviflorus, Desmocladus flexuosus, Austrostipa flavescens, Lepidosperma angustatum* and *Rhagodia baccata*.

- ***Melaleuca cardiophylla* Closed Scrub (Mc)**

This association occurs as isolated patches in the western region of the study area. The association occurs mostly on bare limestone, but unlike the Mh association (which occurs on heavily fractured limestone on hilltops) the Mc association occurs on solid smooth limestone on flat valley terrain. The *Melaleuca* shrubs can attain a height of up to 3m with a dense canopy inhibiting the development of a dense understorey. *Melaleuca huegelii* and *Templetonia retusa* are common shrub species in the understorey. The association appears to be the main habitat of two *Thomasia* species, *T. cognata* and *T. triphylla*, and the creeper *Billardiera erubescens*.

Sand over Limestone Vegetation

- ***Banksia attenuata* Low Open Forest (Ba)**

The Banksia vegetation type includes a variety of different associations based mainly on the dominance of four low tree species: *Banksia attenuata, B. menziesii, Eucalyptus todtiana* and *Allocasuarina fraseriana* with a range of understorey shrubs.

Banksia associations are distributed mainly in the eastern half of the study area. They occur as large areas such as in the central and northern region of the site or intermixed with limestone vegetation or occasionally as small stands throughout valleys in the older Quindalup Dunes. The understorey vegetation is usually dominated by *Hibbertia hypericoides* with *Mesomelaena pseudostygia, Xanthorrhoea preissii, Macrozamia fraseri* and *Sowerbaea laxiflora*.

- ***Eucalyptus gomphocephala* Woodland to Open Forest (Eg)**

Tuart trees occur on a wide range of soil types, but in the study area naturally occurring populations are restricted to deep brown / yellow sand over limestone. The Tuart Woodlands were recorded from a number of locations in the study area, generally in the central and eastern portions of the DSP area. Common understorey species include *X. preissii, Desmocladus flexuosus, Dryandra lindleyana, Hakea prostrata* and *Rhagodia baccata*. The creeper *Hardenbergia comptoniana* is frequent among the trees and large shrubs.

- ***Eucalyptus marginata* Woodland (Em)**

Eucalyptus marginata (Jarrah) Woodland (Em) generally occurs in small remnant pockets in the central and eastern portions of the study area. The Jarrah trees attain a height of 15-18m over a low shrub understorey. Occasionally *Banksia menziesii* is also present as a mid-canopy strata. Some common *Banksia* Woodland species are in the understorey including *X. preissii, Macrozamia fraseri* and *Mesomelaena psuedostygia*, while other *Banksia* Woodland indicators are notably absent, including *Sowerbaea laxiflora* and *Caladenia flava*. Three species which appeared to be confined to this association are *Eremaea beaufortioides, Eremaea* sp. A and *Acacia stenoptera.* Other commonly occurring species are *Stirlinga latifolia, Patersonia ocidentalis, Petrophile macrostachya* and *Bossiaea eriocarpa*.

2.7.5 Vegetation Condition

The condition of the vegetation was assessed according to the system devised by Keighery and described in *Bush Forever* (2000a). Keighery's condition rating scale ranges from Pristine (where the vegetation exhibits no visible signs of disturbance) to Completely Degraded (where the vegetation structure in no longer intact and without native plant species). Vegetation condition for the St Andrews DSP area is mapped in Figure 7 and ranges from Excellent to Completely Degraded.

The majority of the study area has been historically used for farming, which has adversely affected areas of native vegetation through grazing, trampling, introducing and spreading weeds, and nutrient enrichment. Intact areas of remnant vegetation remain throughout the study area although larger pockets of better quality vegetation are generally confined to the northern potion of the study area.

A description of the vegetation condition ratings in *Bush Forever* (2000a) are outlined in Table 2.

TABLE 2
VEGETATION CONDITION RATING SCALE

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 disturbance. 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 are often described as 'parkland cleared' with the flora comprising weed or crop species with isolated native trees or shrubs.

Source: Government of Western Australia, 2000.

2.7.6 Floristic community Types

The vegetation associations identified in the DSP area can be related to Floristic Community Types (FCTs) as described by Gibson *et al*., (1994). A study initiated by the City of Wanneroo to investigate the conservation values of remnant vegetation in the region provides further information regarding the FCTs present in the study area (Trudgen, 1996). The FCTs identified in the study area include the following:

24 Northern Spearwood shrublands and woodlands

28 Spearwood *Banksia attenuata* or *Banksia attenuata-Eucalyptus* Woodlands

29a Coastal Shrublands on shallow sands

29b *Acacia* Shrublands on taller dunes

S7, S11, S13, S14 (the strand) and S15 – recent Quindalup divisions

Gibson (*et al*., 1994) provides the following description of the Floristic Community Types found in the study area.

FCT 24 and 28 are restricted to the Spearwood Dune system. FCT 24 includes heaths or heaths with scattered Tuart (*Eucalyptus gomphocephala*) occurring on the deeper soils north from Woodman Point. Within the study area FCT 24 corresponds to the vegetation associations dominated by *Melaleuca huegelii, M. systena* or *Dryandra sessilis* on the skeletal soil on ridge slopes and ridge tops. FCT 28 is largely made up of the *Banksia* woodlands and has been recorded from Thompson's Lake north to Seabird.

FCT 29 is largely restricted to the Quindalup System and contains two distinct subgroups. FCT 29a comprises mostly heaths on shallow sands over limestone close to the coast. These communities do not have a single dominant but important species include, *Spyridium globulosum, Rhagodia baccata* and *Olearia axillaris*. This community occurs between Seabird and Garden Island. FCT 29b is dominated by *Acacia* Shrublands or mixed heaths of the larger dunes and ranges from Seabird to south of Mandurah. There is no consistent dominant in FCT 29b, however species such as *Acacia rostellifera, Acacia lasiocarpa* and *Melaleuca systena* are important.

The Mc vegetation association also corresponds to FCT 29b. Although it occurs on limestone there is sufficient Quindalup dune species in this unit to classify the Mc unit with the Quindalup vegetation types rather than the Spearwood types.

2.7.7 Flora

A flora survey of the St Andrews DSP and adjacent areas was conducted during September to November 1991. The flora list was compiled from observations and collections that were made along a series of traverses by vehicle and on foot and by sampling 10m x 10m quadrats. The traverses encompassed the entire property however; the southern area was severely burnt in January 1991 and was therefore not surveyed in as much detail as other areas. As part of the survey, a specialist botanist, Peter Grayling, was engaged to search for rare or endangered *Eucalyptus* species that may occur on the property.

The flora survey conducted in 1991 identified a total 248 native species (Alan Tingay & Associates, 1992a). This total of 248 native species is comparable with other areas of similar size in the region. For example, at the time of the survey 221 native species had been recorded from Wilbinga and Caraban MPA (10,000ha) and 166 native species were known from Breton Bay (7,000ha) (Alan Tingay and Associates, 1992[c]).

The 2001 assessment of the southeastern portion of the DSP area recorded a total of 111 species of flora, including 86 native and 25 introduced flora.

The flora list compiled in 1991 includes one Declared Rare Flora species, *Euca1yptus argutifolia*. *Eucalyptus argutifolia* is protected under the provisions of the Wildlife Conservation Act, 1950. Two discrete populations of *Eucalyptus argutifolia* occur within an area which is now part of Bush Forever Site 284 South-West link from Wilbinga to Yanchep National Park. The largest population consists of about 45 trees up to 4m tall. The second population supports about 19 trees to 1.5m tall and occurs on the slope of a limestone hill. This species is typically associated with, and generally restricted to, areas of limestone.

Two other species which are not listed as Rare or Priority Flora but are considered significant have been recorded within the Yanchep to Two Rocks area;

- ***Goodenia berardiana*** **(Goodeniaceae)**

This species is not recorded in the Perth Flora or any other coastal area species lists. It is known to occur from Carnarvon to Southern Cross and on the south coast near Esperance. The closest known population to the study site is located in Nambung National Park. In the Yanchep to Two Rocks area it was found in *Melaleuca cardiophylla* Scrub.

- ***Thomasia triphylla*** **(Sterculiaceae)**

Restricted to coastal limestone between Breton Bay and Augusta. It is at its northerly extent in the Yanchep area and was only found in association with *Melaleuca cardiophylla* on limestone.

No Declared Rare Flora (DRF) or Priority Flora were recorded in the study area during the 1991 and 2001 surveys.

2.7.8 Conservation Significance of Vegetation and Flora

Bush Forever

The identification and delineation of Regional Open Space within the Yanchep-Two Rocks area is based primarily on the recommendations of The System 6 Study Report (EPA, 1983) and more recently, Bush Forever (Government of WA, 2000).
The System 6 study identified three areas of regionally significant bushland within the Yanchep to Two Rocks area. Area M1 encompasses an area of bushland immediately south of Wilbinga and Caraban MPA, Area M2 comprises the coastal area from Two Rocks to Burns Beach and Area M3 comprises the westward extension of the Yanchep National Park.

Bush Forever has been prepared jointly by the Ministry for Planning (MFP), Department of Environmental Protection (DEP), Department of Conservation and Land Management (CALM) and the Water & Rivers Commission. It builds on the System 6 Update and the findings of the Perth Environment Project and identifies areas of regional significance worthy of protection to conserve the biodiversity of the vegetation on the Swan Coastal Plain portion of the Perth Metropolitan Region. The principal objective of Bush Forever is to protect at least 10% or 400ha, whichever is the largest, of each vegetation complex in at least five separate areas in the Perth Metropolitan Region. Other key criteria for the identification of regionally significant areas include the protection of threatened ecological communities, floristic communities and verified conservation category wetlands associated with bushland. In addition, elements such as size, vegetation condition, relationship with other areas and land use zoning constraints were also considered during the selection process.

Bush Forever Sites in the Yanchep to Two Rocks region are shown in Figure 8 and described below.

Bush Forever Site 406 Wilbinga Caraban Bushland

Bush Forever Site 406 is located directly to the north of the DSP area. The site is currently State Forest but is proposed as a Conservation Park.

BF Site 397 Coastal Strip from Wilbinga to Mindarie

Bush Forever 397 corresponds to the existing coastal foreshore reserve between Mindarie and Wilbinga and is therefore identified in Bush Forever as a 'Site with some Existing Protection'. The foreshore reserve boundary was determined in 1996 as part of MRS Amendment 975/33 and is based on the Coastal Planning Strategy prepared for the Yanchep-Two Rocks area (Alan Tingay & Associates, 1993).

BF Site 284 South-West Link from Wilbinga to Yanchep National Park

Bush Forever Site 284 is located to the east of the northern portion of the DSP area and provides a Link from Bush Forever Site 406 Wilbinga Caraban Bushland through to Bush Forever Site 288 Yanchep National Park and Adjacent Bushland. The Site is reserved in the MRS as Parks and Recreation and is proposed for inclusion in Yanchep National Park.

BF Site 288 Yanchep National Park and Adjacent Bushland

Yanchep National Park – is located to the east of the Structure Plan area and is separated from the DSP area by the future Mitchell Freeway alignment.

BF Site 289 Ningana Bushland, Yanchep/Eglington

The 'Ningana' ROS provides a corridor of green space between the coast at Eglinton and Yanchep National Park. Part of Bush Forever Site 289 is located within the southern portion of the DSP.

Vegetation Complexes

The flora and vegetation assessment conducted in 1991 provided recommendations relating to the protection of vegetation complexes at the regional level. In particular, the study recommended adequate protection of the Quindalup Dune System beyond the foreshore reserve to provide for the protection of the vegetation of the older Quindalup Dunes. This is in accordance with the initiatives of Bush Forever which aims to increase the reservation of the Quindalup Complex to include 20% of the original distribution of this complex in the conservation estate.

The 1991 assessment identified that the vegetation of the Spearwood Dune System is adequately represented in reserves in comparison to the Quindalup Dune System. Representation of Spearwood Dune vegetation typical of the study area (i.e. Cottesloe Complex-North) are found in existing bushland reserves such as Yalgorup National Park, Nambung National Park, Neerabup National Park, Yanchep National Park and several smaller recreation reserves, including Kings Park, Bold Park and Star Swamp north of Perth. As a result, approximately 64% of the original extent of the Cottesloe Complex – North is protected in conservation estate.

Vegetation Associations

The 1991 assessment identified that the majority of vegetation associations present in the Yanchep area are common in the south-west of Western Australia and extend throughout the coastal area from north of Lancelin to south of Bunbury. While these broad types are common, specific associations may be uncommon or poorly represented in National Parks and conservation reserves.

The *Melaleuca cardiophylla* (Mc) vegetation association is considered locally significant as it has limited protection in existing conservation reserves and is not common close to the coast outside in the Yanchep to Two Rocks area in the Perth Metropolitan Region. The Mc association is generally restricted to small parcels located near Two Rocks townsite and on the coast near 'The Spot'. Areas of *Melaleuca cardiophylla* dominated vegetation are shown in Figure 8.

A review of the distribution of the *Melaleuca cardiophylla* vegetation associations in the Yanchep to Two Rocks area was undertaken by ATA Environmental in 2005. The review indicated that although some stands of *Melaleuca cardiophylla* vegetation were afforded protection in existing reserves (including the foreshore reserve) there is the potential for conservation of additional stands in areas of Public Open Space within proposed future development. It was recommended that this be addressed during the district and local structure planning stages for the area.

Floristic Community Types

The vegetation surveys undertaken in 1991, 2001 and 2003 suggest no Floristic Community Types (FCTs) listed as Threatened Ecological Communities (TEC) occur in the study area (English and Blyth, 1997). The study area however, does support two communities recommended for listing as Threatened. These comprise FCTs 29a and 29b, as shown in

Table 3. These communities occur as large parcels in the study area and therefore present opportunities to be protected in local open space, including foreshore reserve.

Site investigations were undertaken in March 2003 to determine whether a stand of *Melaleuca huegelii* Open Heath to Heath (Mh) close to the coast, near Capricorn Village, corresponds to FCT 24, 26a or 29. FCT 26a is listed as a TEC while FCTs 24 and 29 are not listed as TECs. Releve data collected revealed that the stand of *Melaleuca huegelii*, corresponds to FCT 24 or 29 rather than 26a. This is due to the absence of typical species usually recorded from FCT 26a and the presence of some species commonly associated with Quindalup Dune FCTs such as FCT 29. This finding was confirmed by botanist Greg Keighery from CALM during a site investigation in June 2003. Other strands of *Melaleuca huegelii* vegetation close to the coast are also considered to be FCT 24 or 29. A more inland stand of *Melaleuca huegelii* located on a tall hill within the Freeway Reserve will need further assessment by Main Roads Western Australia when approval to construct the Freeway is sought.

TABLE 3
CONSERVATION STATUS OF FLORISTIC COMMUNITY TYPES RECORDED IN THE STUDY AREA

Floristic Community Type		Reservation Status	Conservation Status
24	Northern Spearwood Shrublands and Woodlands	Well Reserved	Susceptible
28	Spearwood *Banksia attenuata* or *Banksia attenuata -Eucalyptus* Woodlands	Well Reserve	Low Risk
29a	Coastal Shrublands on shallow sands	Poorly Reserved	Susceptible
29b	*Acacia* Shrublands on taller dunes	Poorly Reserved	Susceptible

Significant Flora

The Yanchep-Two Rocks area has particular conservation value for two species of flora; *Goodenia berardiana* and *Thomasia triphylla* as they are outside or at the edge of their normal range.

Species conservation is most readily achieved by conserving the habitats in which they occur. By carefully selecting areas of bushland in good or very good condition in which these species occur, the potential viability of the population in enhanced. The conservation of the *Melaleuca cardiophylla* (Mc) Closed Scrub in areas of local open space will enable the protection of *Goodenia berardiana* and *Thomasia triphylla*.

2.8 Fauna

2.8.1 Background

A vertebrate fauna survey of the Yanchep-Two Rocks area was conducted in 1991. The survey results, together with survey information from surrounding areas and an assessment of the regional significance of the fauna present in the area, are detailed in a report prepared by Alan Tingay & Associates in 1991.

Further assessment of the southern portion of the DSP area was conducted by ATA Environmental in 2005. The assessment included the area surrounding the existing golf course in the south-eastern portion of the DPS area. Information from this assessment relevant to the

DSP stage is included in this report. A summary of the results from both the 1991 and 2005 surveys is provided in the following sections.

2.8.2 Methodology

The 1991 survey involved an intensive and systematic trapping program, transect surveys, active searching, night spotlighting and opportunistic observations. Bird surveys were carried out over a four day period in winter and spring. Night spotlighting was conducted over ten nights during September and October. Opportunistic results were recorded throughout the survey periods. The trapping program included the use of Elliott, pitfall and cage traps and equipment for trapping bats. Traps were operated for four nights in September and five nights in October 1991. Weather conditions during the trapping period were generally fine and sunny with clear nights, except for one day when rain was recorded.

The 1991 survey identified four sampling localities which were considered representative of the remaining native vegetation in the study area, and included part of Bush Forever Site 284 South-West link from Wilbinga to Yanchep National Park and Bush Forever Site 289 Ningana Bushland Yanchep/ Eglinton. Seven sites were selected within these sampling localities for intensive and systematic trapping.

The 2005 southern sector survey involved an intensive trapping program, combined with avifauna surveys, spotlighting and opportunistic sighting. The 2005 survey was undertaken in accordance with the EPA *Guidance for Assessment of Environmental Factors: Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia, No. 56* (EPA, 2004).

As part of the 2005 survey, a search of the Department of Conservation and Land Management's Threatened Fauna database was undertaken to identify potential scheduled and threatened species in the region. A search of the Commonwealth *Environment Protection and Biodiversity Conservation (EPBC) Act 1999* online database was also undertaken for the area 32^{o} 00' to 32^{o} 30'S, and longitude 115^{o} 30' to 115^{o} 50'E to identify species of conservation interest to the Commonwealth Government. This information was compiled to produce a list of species recorded or potentially occurring in the vicinity of the Yanchep to Two Rocks area.

2.8.3 Species Found Within the Study Area

The 1991 survey revealed a relatively diverse, but generally typical vertebrate fauna for the region. A total of three amphibians, 24 reptiles, 63 native and three introduced birds, and six native and five introduced mammals were recorded during the survey. The reptile assemblage comprised three species of gecko, five species of legless lizard, two species of dragon, 12 species of skinks and two snake species.

The 2005 survey recorded two amphibians, 27 reptiles, 59 birds and six mammals. Although the survey conducted in 2005 was confined to a portion of the St Andrews DSP area, it would be expected that similar species would be found in other portions of the DSP area within the same vegetation types.

Avifauna

A list of 100 bird species that may potentially occur within the south eastern portion of the DSP area was compiled during the 2005 survey using previous studies, reports and current databases, including *FaunaBase*. Not all of these species are expected to be observed, forage or nest in the general area. Of these 100 species, 59 species and 2096 individuals were observed in the vicinity of the south eastern portion of the DSP area. A number of bird species have been reported in the general region that were not recorded in *FaunaBase* for the

search area. This is to be expected as species lists for the region are compiled over many years and many of the species listed have seasonal shifts in foraging and breeding sites.

Table 4 shows the most probable habitat in which each of these species is likely to be recorded within the south-eastern portion of the DSP area. It is expected that the assessment of probable habitat is relevant for the whole of the DSP area given the similarity between vegetation and landform types in the south-eastern portion and the remainder of the study area. Habitat data for each species comes from Storr and Johnstone (1988) and Johnstone and Storr (1998, 2004). Information contained within Table 4 refers only to the data compiled during the 2005 survey for the south-eastern portion of the DSP area.

TABLE 4
BIRD SPECIES LIKELY TO BE FOUND IN THE STUDY AREA WITH COMMENT ON HABITAT PREFERENCE, DIET AND MOVEMENT PATTERNS

Species		Number recorded in systematic surveys on site	Suitable habitat type *	Comments on habitat+, diet and movement patterns*
Acanthizidae (Thornbills, Flycatchers, Gerygones)				Some occupy tree-tops others are found mostly in the undergrowth and heathlands. Most are vagrants and migratory. Most are insectivorous.
Acanthiza apicalis	Inland Thornbill	8	2, 3, 4, 6, 7	Thickets and scrub, tall heathlands
Smicrornis brevirostris	Weebill	11	7, 8	Open Eucalypt forests, woodlands and scrub
Acanthiza chrysorrhoa	Yellow-rumped Thornbill	9	1, 3, 4, 5, 6, 8, 10	Open woodlands, near dense shrubs, forages on the ground in open spaces
Acanthiza inornata	Western Thornbill	28	3, 5, 6, 7, 8	Jarrah, marri, melaleuca woodlands, scrub
Gerygone fusca	Western Gerygone	35	7, 8	Eucalypt forests, melaleuca woodlands, migratory
Sericornis frontalis maculatus	White-browed Scrubwren	13	3, 6, 7	Thickets
Accipitridae (Kites and Eagles)				Diurnal birds of prey normally with large home ranges, feeding on lizards, rodents, birds and carrion.
Accipiter cirrocephalus	Collared Sparrowhawk	1	5, 6, 7, 8	Well-wooded areas normally around water, partly migratory
Accipiter fasciatus fasciatus	Brown Goshawk	2	5, 6, 7, 8	Well-wooded areas, forests, thickets, migratory
Aquila audax	Wedge-tailed Eagle		1, 5, 7, 10	Lighted wooded areas and farmland, feeds on carrion, reptiles, mammals, sedentary, high nest fidelity
Aquila morphnoides morphnoides	Little Eagle	3	all sites	Tuarts, vicinity of rivers and lakes, feeds on lizards and mammals
Circus assimilis	Spotted Harrier		1, 5, 8, 10	Lighted wooded areas, feeds on lizards and rodents
Circus approximans	Swamp Harrier	3	1, 5, 8, 9, 10	Lighted wooded areas, swamps and woodlands
Elanus caeruleus	Black-shouldered Kite	4	1, 3, 5, 10	Open or lightly wooded areas, farmlands, migratory, feeds on lizards and mammals
Haliastur sphenurus	Whistling Kite	2	9, 10 but any areas	Wetlands and wet farm lands, feeds on carrion and birds, is

Species		Number recorded in systematic surveys on site	Suitable habitat type *	Comments on habitat+, diet and movement patterns*
				mostly migratory
Hamirostra isura	Square-tailed Kite		3, 5, 8	Eucalypt woodlands, scrub and forests, feeds on birds and bird eggs, migratory breeding visitor to south-west
Haliaeetus leucogaster	White-bellied Sea-Eagle		any area along the coast	Coastal areas and estuaries, feeds on fish and birds, territorial
Pandion haliaetus cristatus	Osprey		any area along the coast	Coastal areas, seldom inland, feeds on fish. Migratory but will return to the same nest to breed
Aegothelidae (Owlet-Nightjar)				
Aegotheles cristatus cristatus	Australian Owlet-nightjar		5, 6, 7, 8	Well-wooded areas, insectivorous
Apodidae (Swifts)				Insectivorous, prey captured in the air.
Apus pacificus	Fork-tailed Swift		over all areas	Migratory
Artamidae (Woodswallows)				Insectivorous, prey captured in the air
Artamus cinereus	Black-faced Woodswallow	2	5, 8	Sparsely wooded areas, partly migratory
Artamus cyanopterus	Dusky Woodswallow		5, 6, 7, 8	Eucalypt forest and woodlands, partly migratory
Artamus personatus	Masked Woodswallow		3, 5, 8	Mainly in open and lightly wooded areas, nomadic
Campephagidae (Cuckoo-shrikes)				Feed on insects and are mostly migratory.
Coracina novaehollandiae	Black-faced Cuckoo-shrike	12	3, 5, 6, 7, 8	Eucalypt forests, woodland and scrubs, feeds on insects, migratory
Lalage tricolor	White-winged Triller		3, 5, 8	Lightly wooded areas, dunes, insectivorous, nomad and migratory
Caprimulgidae (Nightjar)				Nocturnal insect eaters.
Eurostopodus argus	Spotted Nightjar		5, 8	Sparsely wooded area

Species		Number recorded in systematic surveys on site	Suitable habitat type *	Comments on habitat+, diet and movement patterns*
Casuariidae (Emu)				
Dromaius novaehollandiae	Emu	9	1, 3, 5, 8, 10	Shrubland, Banksia, heathlands, feeds on seeds and fruits
Columbidae (Pigeons and Doves)				Feed on vegetable matter, seeds, fruits and flowers
Columba livia	Rock Dove (Domestic Pigeon)		10	Buildings and wheat silos, exotic, seed eater
Ocyphaps lophotes	Crested Pigeon	15	1, 5, 8, 10	Lightly wooded area
Phaps chalcoptera	Common Bronzewing	14	1, 3, 5, 8, 10	Lightly and moderately wooded areas, mobile
Phaps elegans	Brush Bronzewing		3	Dense shrubland
Streptopelia chinensis tigrina	Spotted Turtle-Dove		1, 3, 5, 8, 10	Well-wooded areas, suburbs, exotic, feeds on seeds
Streptopelia senegalensis	Laughing Turtle-Dove	2	1, 3, 5, 8, 10	Lighted wooded areas, suburbs, exotic, feeds on seeds
Corvidae (Crows and Ravens)				Omnivorous, some are scavengers.
Corvus coronoides	Australian Raven	34	all areas	Suburbs, farmland, lightly wooded areas, scavenger, also feeds on insects and carrion
Cracticidae (Butcherbirds and Magpie)				Feed on lizards, small birds and insects
Cracticus tibicen	Australian Magpie	74	3, 5, 8, 10	Lightly wooded areas, feeds on insects
Cracticus torquatus	Grey Butcherbird	4	2, 5, 6, 7, 8	Scrub, thickest and woodlands, feeds on small birds, insects and lizards
Strepera versicolor	Grey Currawong		1, 2, 3, 5, 6, 7, 8	Eucalypt forests and woodlands, coastal heath, feeds on insects, snails, fruit and berries
Cuculidae (Cuckoos)				Feed on invertebrates, invertebrate larvae, most are migratory.
Cacomantis flabelliformis	Fan-tailed Cuckoo		5, 6, 7, 8	Well-wooded areas from karri to Acacia, eats earthworms and caterpillars, migratory

Species		Number recorded in systematic surveys on site	Suitable habitat type *	Comments on habitat+, diet and movement patterns*
Cuculus pallidus	Pallid Cuckoo		3, 5, 6, 10	Woodlands, shrublands and farmland, migratory
Chrysococcyx basalis	Horsfield's Bronze Cuckoo	1	3, 5, 6	Woodlands and shrublands, migratory
Chrysococcyx lucidus plagosus	Shining Bronze Cuckoo		5, 6, 7, 8	Well-wooded areas, feeds on caterpillars and beetles, migratory
Dicruridae (Fantails and Flycatchers)				Feed on insects, can be both sedentary and migratory
Grallina cyanoleuca	Magpie-lark	2	1, 3, 5, 8, 10	Lakes, swamps, sparsely vegetated areas, feeds on insects
Myiagra inquieta	Restless Flycatcher		5, 8, 10	Open forests, woodlands near waterways, feeds on insects
Rhipidura fuliginosa	Grey Fantail	34	3, 5, 6, 7, 8	Edges of dense shrublands, resident and migratory
Rhipidura leucophrys	Willie Wagtail	11	5, 8, 10	Lightly wooded areas, urban area, feeds on insects, is sedentary and migratory
Falconidae (Falcons)				Most are carnivorous, some are vagrants, and others are migratory.
Falco berigora	Brown Falcon	2	3, 5-8	Lighted wooded areas, feeds on insects, reptiles and birds, partly migratory
Falco cenchroides	Australian Kestrel	1	3, 5-8	Open and sparsely wooded areas, feeds on insects, lizards and birds, migratory
Falco longipennis	Australian Hobby	1	3, 5-8	Lightly wooded areas, feeds on small birds, resident and migratory
Falco peregrinus	Peregrine Falcon		all areas	Cliffs along the coast, rivers and ranges, feeds on birds
Alcedinidae (Kookaburras and Kingfishes)				Carnivorous, either territorial or migratory.
Dacelo novaeguineae	Laughing Kookaburra	9	5-8	Well-wooded areas, feeds on insects and reptiles, exotic
Todiramphus sanctus sanctus	Sacred Kingfisher	1	5-9	Wooded areas near water courses, feeds on reptiles, fish, migratory

Species		Number recorded in systematic surveys on site	Suitable habitat type *	Comments on habitat+, diet and movement patterns*
Hirundinidae (Swallows)				Feed on aerial insects, most are migratory.
Cheramoeca leucosternus	White-backed Swallow	3	5, 8, forage over all areas	Open and sparsely wooded areas, inland coastal dunes, partly migratory
Hirundo neoxena	Welcome Swallow	20	5, 8, forage over all areas	Open and sparsely wooded areas, buildings, migratory
Hirundo nigricans	Tree Martin		5, 8, forage over all areas	Wooded areas, near water, migratory
Laridae (Gulls and terns)				Sea-birds, some of which have adapted to human habitation and scavenging.
Larus novaehollandiae novaehollandiae	Silver Gull		coastal areas	Everywhere there is food on the coastal plain, sedentary unless breeding
Maluridae (Fairy-wrens, Grasswrens)				Insectivorous, live on ground, shrubs and long grass
Malurus lamberti	Variegated Fairy-wren	24	2, 3, 4	Coastal scrub, feeds on insects
Malurus leucopterus	White-winged Fairy-wren	23	1, 2, 3, 4, 5	Open scrub land, lightly wooded areas, feeds on insects and seeds
Malurus splendens	Splendid Fairy-wren	204	2, 3, 4, 6, 7	Coastal scrub and thickets, feeds on insects
Stipiturus malachurus westernensis	Southern Emu-wren		2, 3, 6	Low dense scrub land, heathlands, feeds on insects, spiders
Meliphagidae (Honey eaters)				Feed on nectar in flowering trees and shrubs and insects, both migratory and sedentary.
Acanthorhynchus superciliosus	Western Spinebill	4	1, 2, 3, 5, 6	Woodlands, shrublands, urban areas, feeds on nectars and insects, sedentary
Anthochaera carunculata	Red Wattlebird	36	5, 8	Open Eucalypt and forests, feeds on nectar and insects, partly migratory
Anthochaera lunulata	Western Wattlebird		3, 5-8	Tall shrublands, Eucalypt forests, heath and Banksia, feeds on nectar and insects, nomadic feeds on insects and nectar

Species		Number recorded in systematic surveys on site	Suitable habitat type *	Comments on habitat+, diet and movement patterns*
Epthianura albifrons	White-fronted Chat	15	1, 3, 4, 10	Open areas, farmlands, waterside areas
Lichenostomus ornatus	Yellow-plumed Honeyeater		1, 3, 5	Forests and woodlands, Eucalypts, feeds on insects and nectar
Lichenostomus virescens	Singing Honeyeater	10	2, 3, 5, 6	Edges of thickets, open scrub, urban areas, feeds on insects and nectar
Lichmera indistincta indistincta	Brown Honeyeater	193	2, 3, 5, 6	Shrublands, suburbs, woodlands, feeds on nectar and insects
Manorina flavigula	Yellow-throated Miner		1, 3, 5, 10	Open scrub and Eucalypt and Banksia woodlands, feeds on insects, nectar, fruit
Phylidonyris melanops	Tawny-crowned Honeyeater	9	1, 2, 3, 5	Heathlands and low shrubs, feeds on nectar, flowers and insects, nomadic
Phylidonyris nigra gouldii	White-cheeked Honeyeater	109	1, 2, 3, 5-8	Proteaceae, coastal heath, scrubs and thickets, Banksia woodlands, feeds on nectar and insects
Phylidonyris novaehollandiae	New Holland Honeyeater	152	1, 3, 5, 6, 8	Flowering shrubs, urban areas, near water, feeds on nectar, fruit, seeds and sap, is mostly sedentary
Meropidae (Rainbow Bee-eater)				Migratory, insectivorous.
Merops ornatus	Rainbow Bee-eater	26	1, 3, 10	Lightly wooded areas, insectivorous, migratory
Motacillidae (Pipit)				
Anthus australis	Australian Pipit	31	1, 3, 10	Coastal beaches and dunes, heathlands, sparsely vegetated areas feeds on insects, vagrant and sedentary
Neosittidae (Stittella)				Search bark of trees for insects and spiders, probably sedentary.
Daphoenositta chrysoptera	Varied Sittella		5, 8	Open forests and woodlands, feeds on insects and spiders
Pachycephalidae (Whistlers and Shrike-thrush)				Insectivorous, mostly searching branches and stems, non-migratory.

Species		Number recorded in systematic surveys on site	Suitable habitat type *	Comments on habitat+, diet and movement patterns*
Colluricincla harmonica rufiventris	Grey Shrike-thrush	1	3, 5, 8	Open forests, woodlands, thickets, feeds on insects
Pachycephala pectoralis fuliginosa	Golden Whistler		3, 5-8	Thickets and shrubs of Acacia, Melaleuca, Eucalypt woodlands
Pachycephala rufiventris rufiventris	Rufous Whistler	19	5-8	Woodlands, thickets, feeds on insects
Pardalotidae (Pardalotes)				Insectivorous and mostly migratory.
Pardalotus punctatus punctatus	Spotted Pardalote		7, 8	Eucalypt woodland and forests, feeds on insects in the mid and upper canopy of forests, migratory
Pardalotus striatus	Striated Pardalote	4	7, 8	Eucalypt woodlands and forests, feeds on insects, forages in the canopy foliage, migratory
Petroicidae (Australian Robins and Flycatchers)				Feed on insects in flight and on stems of trees and shrubs.
Eopsaltria australis griseogularis	Yellow Robin		3, 5-8	Well-wooded areas, thickets, shrubs, Eucalypt understorey
Petroica cucullata	Hooded Robin		3, 5-8	Lightly wooded areas, edges of thickets
Petroica goodenovii	Red-capped Robin		3, 5-8	Mainly in tea-tree, plantations of tuart, migratory
Petroica multicolor campbelli	Scarlet Robin	3	5-8	Banksia and Eucalypt woodlands, sedentary
Phasianidae (Quail and Pheasant)				Feed on seeds and berries.
Coturnix novaezelandiae	Stubble Quail	7	1, 2, 3, 5, 8, 10	Swamp margins, sparsely wooded coastal areas, nomadic.
Podargidae (Tawny Frogmouth)				Nocturnal, insectivorous, sedentary.
Podargus strigoides	Tawny Frogmouth	1	5-8	Well-wooded areas
Psittacidae (Parrots and Cockatoos)				Feed on seeds, nectar, fruit and flowers
Cacatua roseicapilla	Galah	116	5, 8, 10	Lightly wooded areas, farmland, suburbs, feeds on seeds of a wide range of plants
Cacatua sanguinea	Little Corella	14	5, 8, 10	Lightly wooded areas, farmland, suburbs, feeds on seeds of a

Species		Number recorded in systematic surveys on site	Suitable habitat type *	Comments on habitat+, diet and movement patterns*
				wide range of plants
Calyptorhynchus latirostris	Carnaby's Black Cockatoo	240	5-8	Eucalypt woodlands and forests, feeds on proteaceous shrubs – including in heath and shrubland habitats, migratory
Neophema elegans	Elegant Parrot		5-8, 10	Cleared farmlands, lakes and swamps, sedentary, feeds on seeds or grasses and shrubs
Neophema petrophila	Rock Parrot		coastal dunes, 1, 2	Coastal area, beaches and dunes, feeds on seeds and fruits on beach and samphire areas
Platycercus spurius	Red-capped Parrot		5-8	Eucalypt forests, feeds on seeding marri and other Eucalypts.
Platycercus zonarius	Australian Ringneck Parrot	67	5-8	Woodlands, suburbs, forests, feeds on Eucalypt, Banksia, Grevillea and other seeds and flowers
Polytelis anthopeplus	Regent Parrot		5, 8, 10	Farmlands, lighted treed areas, feeds on Acacia seed and germinating wheat and ripening orchard fruit
Trichoglossus haematodus	Rainbow Lorikeet		5-8	Treed areas, exotic, feeds on pollen and nectar
Strigidae (Hawk Owls)				Nocturnal, feeds on birds, mammals, reptiles
Ninox novaeseelandiae	Southern Boobook		5-8, 10	Well-wooded areas, feeds on small rodents, insects, migratory
Sylviidae (Songlarks and Reed-warblers)				
Cincloramphus mathewsi	Rufous Songlark		3, 5	Lightly wooded areas with good grass cover, feeds on insects, migratory
Threskiornithidae (Ibises and Spoonbills)				
Threskiornis spinicollis	Straw-necked Ibis	92	5, 8, 9, 10	
Threskiornis molucca	Australian White Ibis		5, 8, 9, 10	Open areas
Turnicidae (Button quail)				Feed on seeds and insects

Species		Number recorded in systematic surveys on site	Suitable habitat type *	Comments on habitat+, diet and movement patterns*
Turnix varia	Painted Button-Quail		3, 5-8	Well-wooded tuart forests, scrubs, thickets, non-migratory
Tytonidae (Owls)				Nocturnal, feeders on birds and mammals
Tyto alba	Barn Owl	2	5, 8, 10	Lightly wooded area, migratory
Zosteropidae (Silvereye)				
Zosterops lateralis gouldi	Silvereye	321	All areas	Thickets and scrub, urban areas, feeds on insects and spiders, migratory and resident

+ Habitat types, diet and movement patterns are mostly taken from Johnstone and Storr (1998; 2004)
* Individual species accounts need to be read in conjunction with comments for the family

*** Habitat types**

1. Low open heath
2. Low closed heath
3. Shrublands
4. Sedges/herbs
5. Low open woodlands with a limited understorey
6. Low closed woodlands with a dense understorey
7. Forest with dense understorey
8. Forest with limited understorey
9. Wetland
10. Cleared

Reptiles and Amphibians

Reptile species caught at Yanchep during the 2005 survey are listed in Table 5. 27 species of reptiles were caught during the field survey.

The frog species detected within the DSP area during the 1991 survey are considered common and widespread throughout much of the south west region of Western Australia. In general the study area provides only limited value for most frogs because of their requirement for surface water for breeding. Most reptiles detected during the 1991 survey were recorded in low numbers. This may be partly as a result of the relatively cool weather experienced during the 1991 survey period.

Amphibian species caught at Yanchep during the 2005 survey are listed in Table 5. Two species of amphibians (*Heleiporus eyrei* and *Limnodynastes dorsalis*) were caught during the field survey.

TABLE 5
SPECIES CAUGHT DURING TRAPPING - SOUTH EASTERN AREA 2005

Reptiles
Agamidae (Dragons)
Pogona minor
Rankinia adelaidensis
Elapidae (Front fanged Snakes)
Brachyurophis semifasciatus
Demansia psammophis
Echiopsis curta
Neelaps bimaculatus
Neelaps calonotos
Parasuta gouldii
Pseudonaja affinis
Simoselaps bertholdi
Gekkonidae (Geckoes)
Strophurus spinigerus
Scincidae (Skinks)
Cryptoblepharus plagiocephalus
Ctenotus australis
Ctenotus fallens
Cyclodomorphus celatus
Egernia napoleonis
Hemiergis initialis
Hemiergis quadrilineata
Lerista elegans
Menetia greyii
Morethia lineocelata
Tiliqua occipitalis
Tiliqua rugosa
Typhlopidae (Blind snakes)
Ramphotyphlops australis
Pygopodidae (Legless Lizards)
Aprasia repens

Delma fraseri
Lialis burtonis
Mammals
Mus musculus
Tarsipes rostratus
Amphibians
Helioporous eyrei
Limnodynastys dorsalis

Mammals

Larger mammal species (e.g. kangaroos and rabbits) are unlikely to be caught in pit, funnel, Elliott or cage traps, but their scratchings, burrows and scats provide evidence of their presence in an area. Spot-lighting at night is also a useful method of detecting the presence of many of these species. Mammals caught during the 2005 survey are shown in Table 5. Two species of mammals were caught; House Mice (*Mus musculus*) and Honey Possums (*Tarsipes rostratus*). Numerous rabbits, two foxes and three cats were sighted in the night searches. In addition to the nocturnal observations, one Western Brush Wallaby (*Macropus irma*) was observed. This is an important observation as few Western Brush Wallabies are observed on the Swan Coastal Plain.

ATA Environmental recorded no bats during the 2005 survey of the south-eastern portion of the DSP area. However, bat activity is influenced by ambient conditions including light pollution.

During the wider study conducted in 1991 by Alan Tingay and Associates it was concluded that all of the native mammals recorded on the Yanchep property appeared to occur in relatively small numbers at the time of the survey, except the Western Grey Kangaroo which was more abundant. Single individuals of the Honey Possum and Common Dunnart were recorded at one sampling location near the northern boundary of the study area where it adjoins Bush Forever Site 406 Wilbinga-Caraban Bushland. The Western Brush Wallaby was seen infrequently in the same area, and to the east of the study area near Yanchep National Park.

2.7.4 Species Potentially Occurring Within the Project Areas Identified as Being of National Environmental Significance under the EPBC Act 1999

Numerous species of birds identified during work undertaken for the 2005 survey as having national environmental significance under the *EPBC Act* 1999 could potentially occur within the south-eastern portion of the DSP area. However, as the vast majority of these are marine or coastal species that are likely to inhabit the marine environment, they were not considered during the 2005 survey. The remaining species are listed in Table 6.

It should be noted that according to some interpretations of the *EPBC Act* 1999, any member of the Accipitridae (Eagles, Kites, Hawks and Bustards), Anatidae (Ducks, Geese and Swans), Charadriidae (Plovers, Dotterels, Lapwings), Falconidae (Kestrels, Falcons, Hobbys), Muscicapidae (Flycatchers), Recurvirostridae (Avocets, Stilts), Scolopacidae (Sandpipers, Turnstones Snipes, Curlews) and Grus (Cranes) families are listed as Migratory Species. It is ATA Environmental's understanding that the Department of Environment and Heritage accepts this as an ambiguity in the wording. These family groups are therefore not necessarily intended to be listed as Migratory Species and thereby afforded special protection under the *EPBC Act* 1999. Should a literal interpretation of the Act be adopted, they must be considered to be listed species under the Act and therefore approval is required before any disturbance occurs.

2.7.5 Significant Fauna under the WA Wildlife Conservation Act 1950-1979

In Western Australia, all native fauna species are protected under the *Wildlife Conservation Act 1950-1979*. Fauna species that are considered rare, threatened with extinction or have a high conservation value are specially protected under the Act. In addition, some species of fauna are covered under the 1991 ANZECC convention, while certain birds are listed under the Japan and Australian Migratory Bird Agreement (JAMBA) and the China and Australian Migratory Bird Agreement (CAMBA). In addition to the above classification, CALM also classifies fauna under five different Priority codes and rare and endangered fauna are classified under the *Wildlife Conservation (Specially Protected Fauna) Notice 2005* into four schedules of taxa. These are:

Schedule 1 – Fauna which are rare or likely to become extinct and are declared to be fauna in need of special protection.

Schedule 2 – Fauna which are presumed to be extinct and are declared to be fauna in need of special protection.

Schedule 3 – Birds which are subject to an agreement between the governments of Australia and Japan relating to the protection of migratory birds and birds in danger of extinction which are declared to be fauna in need of special protection.

Schedule 4 – Fauna that are in need of special protection, otherwise than for the reasons mentioned in Schedule 1, 2 or 3.

In addition to the above classification, CALM also classifies fauna under five different priority codes:

Priority 1 – *Taxa with few, poorly known populations on threatened lands.* Taxa which are known from few specimens or sight records from one of a few localities on lands not managed for conservation. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened species.

Priority 2 – *Taxa with few, poorly known populations on conservation lands, or taxa with several, poorly known populations not on conservation lands.* Taxa which are known from few specimens or sight records from one or a few localities on lands not under immediate threat of habitat destruction or degradation. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.

Priority 3 – *Taxa with several, poorly known populations, some on conservation lands.* Taxa which are known from few specimens or sight records from several localities, some of which are on lands not under immediate threat of habitat destruction or degradation. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.

Priority 4 and 5 – Taxa in need of monitoring. Taxa which are considered to have been adequately surveyed or for which sufficient knowledge is available and which are considered not currently threatened or in need of special protection, but could if present circumstances change. These taxa are usually represented on conservation lands. Taxa which are declining significantly but are not yet threatened.

Threatened and Priority species listed under the *Wildlife Conservation Act* or CALM's database that may potentially occur at Yanchep are listed in Table 6. Included are two Schedule 1 species, and two Schedule 4 species. Four species with a priority listing with CALM have also been predicted or recorded in the general area. Table 6 does not include marine or coastal species as they were considered unlikely to breed or forage within the area covered by the 2005 survey.

TABLE 6
SPECIES LISTED AS BEING SIGNIFICANT VERTEBRATE FAUNA BY THE COMMONWEALTH OR STATE GOVERNMENTS AND PREDICTED TO OCCUR IN THE YANCHEP AREA

Species	Status under Wildlife Conservation Act Schedule (S) / Priority (P)	Status under Commonwealth *Environment Protection and Biodiversity Act*	Potential to be found within the District Structure Plan area
Calyptorhynchus latirostris (Carnaby's Cockatoo)	Schedule 1	Endangered	*Recorded* during 1991 and 2005 surveys
Dasyurus geoffroii (Chuditch)	Schedule 1	Vulnerable	*Recorded* in region
Falco peregrinus (Peregrine Falcon)	Schedule 4		*Recorded* during 1991 survey
Morelia spilota imbricata (Carpet Python)	Schedule 4		*Recorded* in region
Phascogale tapoatafa tapoatafa, (Southern Brush-tailed Phascogale)	Priority 3		*Recorded* in region
Neelaps calonotos (Black-striped Snake)	Priority 3		*Recorded* during 2005 survey
Macropus irma (Western Brush Wallaby)	Priority 4		*Recorded* during 2005 survey
Isoodon obesulus fusciventer (Southern Brown Bandicoot)	Priority 5		*Recorded* in region
Merops ornatus (Rainbow Bee-eater)		Migratory	*Recorded* during 2005 survey

Note: excludes marine and coastal species as these were not included within the 2005 survey

Two species listed under provision of the Wildlife Conservation Act, 1950 were recorded during the 1991 survey. These comprise the Short-Billed Black Cockatoo (or Carnaby's Cockatoo) (Schedule 1) and the Peregrine Falcon (Schedule 4).

Of the species listed under Commonwealth and State government legislation requiring special protection due to their vulnerability, Carnaby's Black Cockatoo, Carpet Python, Black-striped Snake, Western Brush Wallaby, Southern Brown Bandicoot and Rainbow Bee-eater were recorded on or adjacent to the south eastern portion of the DSP area during the 2005 survey undertaken by ATA Environmental.

2.7.6 Ecological Function at Ecosystem Level

The EPA's Position Statement No 3, *Terrestrial Biological Surveys as an Element of Biodiversity Protection* and Guidance Statement No. 56, *Guidance for the Assessment of Environmental Factors; Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia* indicate that field survey data should be used to assess the impact of the development on species and ecosystems.

The number of reptile individuals caught at Yanchep was typical of the assemblage expected in the region. There are no characteristics of the reptile assemblage or the species recorded on site to indicate that the assemblage has particular conservation significance in the region. The collection of *Neelaps calonotos* (Black-striped Snake) is an important record for the area, given the development pressure in the region.

Although low, the species richness for small mammals at Yanchep is typical of what would be found on coastal habitats in WA.

There were a number of cats and foxes present in the area. This was expected as they are present in similar habitats elsewhere on the northern Swan Coastal Plain. Other than the presence of Western Brush Wallaby, Honey Possum and the Southern Brown Bandicoot, there are no characteristics of the mammal assemblage or the species recorded on site to indicate that the mammal assemblage has particular conservation significance in the region.

It is particularly difficult to quantify bird assemblages at a site as there are appreciable temporal variations driven by seasonal effects, specific rain events, droughts, etc. The bird assemblage recorded at Yanchep was typical of other surveys conducted in the region and desktop predictions from known distributions. The site is used by breeding Rainbow Bee-eaters, and Peregrine Falcons have been recorded in the region. A large number of Carnaby's Cockatoos were recorded feeding in the Dryandra shrublands and Banksia woodlands most days during the 2005 survey. These habitat types are important feeding grounds for this species. No trees suitable for breeding were located although anecdotal reports of breeding have been made east of the site at Yanchep National Park.

2.7.7 Biodiversity Value

The EPA *Position Statement No. 3* indicates an ecological assessment of a site must consider its biodiversity value at the genetic, species and ecosystem levels; and its ecological functional value at the ecosystem level (EPA 2002).

Based on the surveys conducted in 1991 and in 2005, it is ATA Environmental's view that species of mammals, reptiles, birds and amphibians present or likely to visit the study area would also be present or visit other similarly vegetated areas in the region.

A comparison of the fauna present within the major habitats indicates that the woodland habitats generally supported a larger number of species and populations than heathlands. The composition of the fauna in the woodland and the heaths, overlapped to some extent, but was noticeably distinctive (Alan Tingay and Associates, 1991).

The diversity recorded is related to the range of different habitats that remain in the area despite use of much of the land for agricultural purposes. The main habitats are the tracts of remnant vegetation and remaining stands of Tuart trees on pastureland. This vegetation is restricted particularly to the near coastal zone and small portions of the north-eastern sector within the St Andrews DSP area. Habitat areas containing taller vegetation is also present to the east of the DSP area adjacent to Yanchep National Park. This area is contained within Bush Forever Site 284 South-West Link from Wilbinga to Yanchep National Park and Bush Forever Site 288 Yanchep National Park and Adjacent Bushland and provides a wide range of the locally important fauna habitats.

In a regional context, the vertebrate fauna in the Yanchep-Two Rocks study area is similar to that found elsewhere in the region within National Parks and Conservation Reserves, particularly Yanchep National Park. This park supports a range of terrestrial fauna habitats of high quality which host a diversity of animal species. Equivalent, but more extensive and considerably less disturbed near coastal habitats also occur at Wilbinga, immediately north of

the Yanchep-Two Rocks study area. The vertebrate fauna that occurs in coastal and inland heath at Yanchep-Two Rocks is likely to be present at Wilbinga and almost certainly in larger numbers.

The presence of the Western Brush Wallaby, Carnaby's Cockatoo, Black-striped Snake, Rainbow Bee-eaters and possibly the Southern Brown Bandicoot is an important consideration for the proposed DSP and any potential impacts to these species should be minimised.

It is not possible to assess the biodiversity value at a genetic level based on the information available.

2.7.8 Subterranean Fauna

Karstic terrain is often host to subterranean fauna including terrestrial and aquatic species restricted to these habitats. Troglobitic fauna are fauna restricted to living in a cave environment. Stygofauna is a sub-set of troglobitic fauna and refers to aquatic troglobytes. These fauna are highly specialised to living in subterranean conditions. Most stygal and troglobitic species in Western Australia are invertebrates, although stygal fish and troglobitic snakes do occur in subterranean caves. Crustaceans form the richest group of stygofaunal invertebrates, with the greatest biogeographic significance (Alan Tingay and Associates, 1999).

Stygofauna occur at a variety of depths, with some species being found in surface waters as well as deep aquifers. As a general rule, the greater the distance between a groundwater habitat and surface water, the stronger the groundwater affinity of the fauna. The distribution of fauna will also be affected by the physical characteristics of the aquifer, such as its salinity and dissolved oxygen levels (EPA, 2003).

Troglofaunal invertebrates include spiders, scorpions, centipedes, millipedes, insects and crustaceans. Troglofauna are sometimes easily observed and are readily sampled, but more commonly they occur under rocks and in crevices and small cavities in the cave systems. Extrapolation from the study of surface waters suggests that stygofauna have important ecosystem service functions, such as the maintenance of water quality in groundwater aquifers. Much of Western Australia's water supply, especially in the arid zone, is drawn from groundwater.

Stygofauna in the Yanchep region have generally only been found where a substantial root mat exists within the karst. Such mats provide a constant and abundant primary food source for the micro ecosystems and generally occur only where Tuart Woodlands coincide with karstic formations.

Jasinska (1997) identified five factors that control the development of tree root mats:

- Presence of trees above caves. Root mats in Australia are related to a number of species of trees, including *Eucalyptus gomphocephala*, *Casuarina* spp., *Corymbia calophylla*, *Agonis flexuosa* and *Ficus* spp.

- Cavernous rock with fissures or solution channels, i.e. rock penetrable by roots.

- Depth to cave waters of <30m, reflecting the limit to which tree roots can penetrate substrates.

- Arid conditions in the cave atmosphere and soil above the cave for extended periods of the year.

- Permanent streams or pools in caves.

An assessment of the subterranean fauna of Lots 201 and 202 Breakwater Drive, which lie to the east of Bush Forever Site 284 was undertaken by Alan Tingay & Associates with assistance from Dr Brenton Knott (UWA Department of Zoology). The findings of this assessment have been published in a separate Environmental Review for Lots 201 and 202 Breakwater Drive (Alan Tingay & Associates, 1999[b]). Lots 201 and 202 had been partially cleared at the time of the survey, although good stands of Tuarts remained. Some karstic features including caves are present below these lots.

Investigations undertaken for Lots 201 and 202 indicated the water table is quite deep (greater than 10m over the majority of the site) and there is no evidence to support the presence of subterranean streams or pools. Investigation within one of the caves to which access was possible indicated few roots with none extending near to the bottom of the cave and no root mats. Given the conditions, limited subterranean fauna would be expected in the caves. The study failed to locate any root mat habitat within Lots 201 and 202.

A sampling program of subterranean water, both on and surrounding Lots 201 and 202 was undertaken. A limited drilling program undertaken to sample for stygofauna was abandoned due to the ground conditions encountered. The water sampling program demonstrated that stygofauna in the area were in low number and of low diversity. The study detected the presence of two species of stygofauna in the area. The stygofauna detected appeared not to be restricted to root mat habitats.

Based on the results of the studies on Lots 201 and 202 Breakwater Drive and the work by Jasinska (1997 in Alan Tingay and Associates, 1999), it is unlikely that stygofauna are present within the study area. This is due to the absence of Tuart Woodland over the majority of the study area and the low likelihood of karst features being present within the study area. If stygofauna were present, they are likely to be of restricted assemblage and not confined to root mats or associated with subterranean streams or pools.

2.9 Aboriginal Heritage

Surveys for archaeological and ethnographic sites within the Yanchep-Two Rocks area were undertaken by Quartermaine (1991) and MacIntyre and Dobson (1991). These surveys involved an investigation of previous research in the area, a systematic field survey of the area, and recording of any archaeological material located. During the survey one archaeological site was located approximately 1km northeast of the current Yanchep townsite, and one isolated find comprising a quartz flake was located within a deflated sand area near a windmill.

The archaeological site is located on the eroding crest of an older Quindalup Dune sequence and consists of up to 40 artefacts dominated by quartz. It includes one fossiliferous chert flake and one quartzite backed blade. This site is considered to be important as it represents one of few sites recorded on the Quindalup Dune System.

The ethnographic survey comprised a thorough review of the existing information, consultation with relevant Aboriginal persons and long term residents of the area, and site inspections. The survey revealed no recorded information of Aboriginal habitation or ceremonial activities within the Yanchep-Two Rocks area. A cave located within the north-east sector of the study area, adjacent to, but outside, the DSP area, is considered a mythological site within the meaning of the Aboriginal Heritage Act, 1972. No other sites of Aboriginal significance were identified within the survey area by the Aboriginal consultants.

An additional ethnographic study was conducted for the southwestern portion of the DSP area. The study was conducted by MacIntyre Dobson & Associates to update previous work done in the area. Discussions with local Aboriginal groups identified the presence of a Waugal Dreaming track along coastal sand dunes that stretches from Two Rocks to Augusta (MacIntyre Dobson & Associates, 2005). Although the Waugal Dreaming Track was mentioned by local Aboriginal groups, discussions concluded that there were no newly recorded sites of Aboriginal significance within the area covered by the study and no additions to the Sites Register were made (MacIntyre Dobson & Associates, 2005).

A search of the Department of Indigenous Affiars Sites Register in February 2006 revealed three registered sites of significance to Aboriginal people within the St Andrews DSP area, including two mythological sites and one site comprising artefacts. Two mythological sites are located at the coast adjacent to Yanchep Beach and are identified on the sites register as Yanchep Beach (Site 17599) and Limestone Reef (Site 17596). The site containing artefacts has been described by Quartermaine (1991) and Macintyre and Dobson (1991). The largest site of mythological and ceremonial significance to Aboriginal people in the Yanchep to Two Rocks region is located to the east of the St Andrews DPS area and encompasses Loch McNess (Wagardu Spring).

A search of the Register of Native Title Claims (February 2006) identified the existence of four applications relevant to the study area, including WC03/6 (registered), WC03/5 (unregistered), WC99/6 (registered) and WC95/86 (unregistered). These Native Title claims are four distinct applications relating to the future use of land located within approximately a 150km radius of Perth.

2.10 European Heritage

A report on shipwrecks in the Yanchep area was prepared by Alan Kendrick in 1991 as part of the preparation of the original Yanchep Structure Plan. The report identified four shipwrecks in the surrounding area with two wrecks being near the St Andrews District Structure Plan area.

The *Emily*, a schooner built in 1868 was wrecked in the same year on rocks near Two Rocks Marina and lay on the beach just south of what later came to be known as wreck point. The exact position of the wreck of the Emily is now not known and if not broken up or dispersed by waves, may now lie buried beneath the beach or foredunes.

The *Alex T. Brown*, a 180ft four masted American Schooner struck rocks in gale force winds in May 1917. The Maritime Archaeological Association of WA surveyed the site in 1988 and found it to consist of the ships keelsons and floor timbers scattered in a 50m area. The remains can still be seen today with keel ribs and planking visible.

The significance of the *Emily* lies in its close association with the colonial community while the Alex T Brown is considered important as the only example of its class to be wrecked on the Western Australian coast (Kendrick, 1991). The Maritime Archaeology Act (1973) provides automatic protection for the wreck of the *Emily* even though its exact location remains unknown. Shipwreck legislation does not currently protect the *Alex T. Brown* although protection is favoured by the WA Museum and may be possible under the WA Heritage Act (1991).

The report by Kenrick (1991) recommended that the *Emily* be located using a magnetometer survey and then once located the wreck should be recorded and remain buried to enhance preservation. The *Alex T. Brown* has considerable tourist potential and an information plaque has been erected on the shore adjacent to the wreck. The *Alex T. Brown* is also used as a

teaching aid by Curtin University. It is recommended that steps be taken to protect the wreck legally.

3. OPPORTUNITIES AND CONSTRAINTS

3.1 Karst

The requirements for karst investigations in the study area are detailed in EPA Bulletin 959, Ministerial Conditions 2.5-1. These studies are to be undertaken as part of the district and local structure planning process.

Preliminary site investigations have identified a number of basins that are suspected to be cover-collapse or cover-subsidence sinkholes reflecting the presence, or past presence, of caverns and/or solution basins in the underlying calcarenite. They occupy about 6% of the property (mainly in eastern parts) and represent prime targets for examination.

A karst assessment will be required prior to the finalisation of the DSP. Due to the lengthy timeframe of the development (approximately 60 years) it is proposed that a staged approach to the assessment of karst be adopted. It is proposed that a framework for the assessment of karst be outlined within the DSP document and discussed in terms of the staging of the development.

An assessment of karst landform will be undertaken prior to the plan being finalised and will be submitted as an additional assessment report following the lodgement of the DSP. If district level karst assessment indicates that karst is present within the study area, further assessment and the preparation of a Karst Management Plan will be required at the LSP stage.

3.2 Coastal Foreshore Management

3.2.1 Foreshore Reserve Delineation

Coastal planning investigations conducted by ATA Environmental in 1993 formed the basis for the delineation of a foreshore reserve boundary in the Yanchep to Two Rocks area. The determination of the foreshore boundary was influenced by the existing Yanchep townsite, existing reserves and the existence of houses and private lots in proximity to the coast. In addition, the delineation of the reserve considered relevant environmental parameters including the nature of the coastal dunes and presence of Tamala Limestone, beach characteristics, topographic features, coastal processes, coastal stability and sea level change, existing and future recreation potential, and suitability for development of recreational facilities and amenities. The investigation identified a foreshore reserve of varying widths, with portions of the reserve reaching widths of up to 250m.

This is consistent with Statement of Planning Policy No. 2.6 – State Coastal Planning Policy (WAPC, 2003) which as a general guide requires a total setback in the order of 100 metres from the horizontal setback datum (HSD). According to the policy, the setback can be reduced, however to not less than 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.

3.2.2 District and Local Beaches

To achieve the balance between conservation and recreation, recreational activities within the DSP area will be focused on both existing nodes, including Yanchep Lagoon and Two Rocks Marina and on future proposed nodes. Development adjacent to these locations will provide recreational opportunities within the reserve to residents from within and outside the district.

The location of these nodes and the provision of facilities and amenities will be determined at the LSP stage. The recreation nodes will cater for specific activities which attract beach users and will include amenities such as cafes/kiosks, tables and seating, water supplies, BBQs, bins, change rooms and toilets.

Access to and linkages between coastal recreational nodes will include facilities such as car parking, dual use paths (DUPs) and lookout points. The placement of these facilities will be determined at the LSP stage.

The Ministerial Conditions for MRS Amendment 787 requires the preparation of a Foreshore Management Plan (FMP) to be undertaken during the local structure planning stages. The objective of the FMP is to ensure that development adjacent to the coast provides a balance between protection of the environment and sustainable development of both recreational facilities within and immediately adjacent to the foreshore reserve.

The following principles and components will apply to the development of the foreshore reserve and will be incorporated into the FMP:

- Preservation of existing recreational areas;
- Controlled access through the provision of DUPs and beach access paths;
- Utilisation of car parking within the development area rather than the creation of parking within the foreshore reserve;
- Incorporation of a highly scenic cycle route along the edge of, or within, the foreshore reserve as part of a regional system;
- Structures such as lookout points/gazebos which enhance beach access yet offer vital foreshore protection;
- Use of fencing and signage as integral methods of access control; and
- Coastal rehabilitation/stabilisation and revegetation undertaken for degraded areas and areas disturbed by existing development.

A FMP has already been prepared for an area in Sector 3 of the Yanchep – Two Rocks coast for Capricorn Coastal Village (ATA Environmental, 2004). A FMP has also been prepared for a portion of the coast to the north of Two Rocks marina (ATA Environmental, 2004).

3.3 Groundwater

Groundwater under the Swan Coastal Plain is vulnerable to contamination due to the unconfined, sand aquifer which allows rapid infiltration of surface runoff. A number of potential sources of contamination are associated with urban development. Examples include fertiliser application, pesticide use, septic tank leachate, leakage of fuel and other stored chemicals, spills of transported hazardous materials, leachate from waste disposal sites, leakage from sewers, and road runoff. Any adverse impacts on water quality could impact on areas of high conservation significance, existing and potential public water supply and private groundwater use.

The St Andrews DSP area is within a Priority 3 groundwater source protection area (Department of Environment, 2005). The Water Corporation currently draws water from the superficial aquifer for public supply and proposes to continue this practice.

Priority 3 areas are declared over land where water supply sources need to co-exist with other land uses such as residential, commercial and light industrial developments. Protection of Priority 3 areas is achieved through management guidelines rather than restrictions on land use. If water source does become contaminated, then water supplied may need to be treated or an alternative water source found. The following are the minimum requirements for development occurring in Priority 3 areas:

- Installation of reticulated sewerage in new urban centres with appropriate disposal of waste water effluent, preferably off catchment;
- Ensure that septic tank densities and location in non-urban area complies with Water Corporation or Department of Water recommendations;
- Observe restrictions on development of industries handling or processing noxious or polluting substances;
- Commercial areas are designed to prevent catchment contamination through stormwater run off or discharge of wastes;
- Observe restrictions on intensive agricultural development; and
- Restriction of disposal sites for polluting wastes (sites with suitable location, construction, and management to ensure no significant pollution can occur may be acceptable).

The proposed future development of the St Andrews DSP area will be required to comply with the minimum requirements of protection for a Priority 3 Groundwater Source Protection Area. Deep sewerage will be incorporated into urban development at an early stage in the planning process to minimise the risk of groundwater contamination. Stormwater will be treated with a storage oriented approach in accordance with principles outlined in the Department of Environment's Stormwater Management Manual for Western Australia. Broad principles will be developed at the DSP level. Major locational and design features are to be identified at the LSP level. Detailed Drainage and Nutrient Management Plans for the area will be prepared at the LSP level.

Individual proposals for industrial development within the industrial zone will be assessed during later stages of planning and regulated by relevant authorities as part of the approval process for the proposal. This will ensure proposals are compatible with the zoning and that drainage and waste disposal issues are managed to prevent adverse impacts on water quality.

The chemical composition of water from existing production bores meets guidelines for drinking water quality, as published by the National Health and Medical Research Centre (Alan Tingay and Associates, 1999[a]). The hardness of the water, expressed as $CaCO_3$, is about 200mg/L indicating that the water may need to be treated before use for certain purposes.

3.4 Remnant Vegetation

3.4.1 Vegetation

Regionally significant vegetation in the Yanchep to Two Rocks area has already been identified and protected in Parks and Recreation Reservations. The rare plant species *Eucalyptus argutifolia* is protected within Bush Forever Site 284 South-West link from

Wilbinga to Yanchep National Park. Some remaining vegetation outside these reservations may have local significance.

Stands of Tuart trees are present within the District Structure Plan area with the large majority being planted approximately 10-15 years ago. Consideration should be given to retaining some stands of Tuarts for aesthetic and habitat reasons.

Areas of Banksia woodland and Dryandra shrublands that have high fauna habitat value are present within the DSP area. Although large areas of vegetation containing *Dryandra sessilis* and *Banksia attenuata* dominated vegetation are conserved within Parks and Recreation Reservations adjacent to the DSP area, it is recommended that additional areas be incorporated into POS within the DSP where possible.

Stands of *Melaleuca cardiophylla* vegetation have been identified as being locally significant. The Melaleuca cardiophylla vegetation association also contains the unusual plant species *Goodenia berardiana* and *Thomasia triphylla.* Approximately 16% of the remnant *Melaleuca cardiophylla* vegetation association within the DSP area has been recommended for retention as indicated in Table 7.

The maintenance of linkages between vegetated areas is necessary to retain the ecological viability of areas vegetation retained for conservation purposes. Linkage corridors are critical to provide for species movement and the continuation of viable populations. Vegetated connections between larger areas of habitat enable migration, colonisation and interbreeding of plants and animals. It is recommended that vegetated linkage corridors be maintained within the DSP area to provide linkage between Bush Forever Sites to the north and east of the DSP and the Foreshore Reserve (Bush Forever Site 397 Coastal Strip from Wilbinga to Mindarie).

TABLE 7
AREAS OF MELALEUCA CARDIOPHYLLA WITHIN THE DISTRICT STRUCTURE PLAN AREA

MELALEUCA CARDIOPHYLLA WITHIN ST ANDREWS

REF	AREA (m2)	CONDITION	ZONING	CONNECTIVITY	RETAIN	COMMENTS
1	6474.5	VG	Urban	N	N	Too small to retain value and in urban zoned land near proposed coastal node
2	10857.4	VG	Urban	N	N	Too small to retain value and in urban zoned land near proposed coastal node
3	8945.9	D	50% Urban, 50% P&R	Y	Y (50%)	50% in Foreshore Reserve - will be retained, extend Foreshore Reserve to include whole stand
4	4817.5	VG	Urban	N	N	Too small to retain value
5	7216.7	VG	Urban	N	N	Too small and isolated
6	32785.3	VG	Urban	N	N	Current zoning too dense to retain bushland
7	1720.5	VG	?	N	N	Too small
8	10822.3	E-VG	?	N	Y (50%)	Partially contained within POS, very small isolated stand
9	1678.5	G	Urban	N	N	Too small and isolated.
10	45540.2	E-VG	Urban	N	N	Current zoning too dense to retain bushland
11	32658.3	E-VG	Urban	N	N	Current zoning too dense to retain bushland
12	16379.5	VG-G	Urban	N	N	Urban zoning, irregular shape
13	23677.7	VG-G	Urban	N	N	Urban zoning, irregular shape
14	24031.3	VG-E	Urban	N	Y (if possible)	Potential area for retention is quite large and of Excellent –Very Good quality
15	31465.1	VG-E	?	N	Y (if possible)	Potential area for retention is quite large and of Excellent –Very Good quality
16	15766.9	VG-E	Urban	Y	N	Existing Structure Plan, Urban zone, adjacent to Foreshore Reserve
17	27842.5	VG-G	Urban	N	N	In Lot 501
18	5503	G-VG	P&R	Y	Y	In Foreshore Reserve
19	2645.7	VG	Urban	Y	N	Mostly in Urban, nearby stand 18 is in Foreshore Reserve
20	34079.3	E-VG	Urban	Y	Some	Near Foreshore Reserve, retain part in a widened Foreshore Reserve
21	2815.6	E-VG	Urban	N	N	Too small and isolated.
22	14179.6	E-VG	Urban	Y	Some	Near Foreshore Reserve (the Spot), retain part in widened Foreshore Reserve
23	15815.7	E-VG	50% Urban, 50% POS	Y	Y (50%)	Partly within POS, expand POS to retain a larger proportion
24	29540.8	G (burnt)	Urban	Y	Some	Keep part, next to POS
25	20267.8	G-D (partially burnt)	Urban	N	N	Condition is Good to Degraded
26	8574.1	G-D (partially burnt)	Urban	N	N	Condition is Good to Degraded area not big enough

MELALEUCA CARDIOPHYLLA WITHIN ST ANDREWS						
REF	**AREA (m2)**	**CONDITION**	**ZONING**	**CONNECTIVITY**	**RETAIN**	**COMMENTS**
Total Area of Melaleuca cardiophylla			**436101.7**			
Total Area Retained In P&R Reserve			**9975.95**			
Percentage of Total			**2.30%**			
Total Area Retained in POS			**5490.94**			
Percentage of Total			**1.26%**			
Total Recommended For Retention			**70963.29**	(includes areas to be retained in P&R Reserve and POS and total areas for stands 14 and 15, does not include stands 20, 21 or 24)		
Percentage of Total			**16.27%**			

3.4.2 Flora

A regional comparison of flora undertaken by Alan Tingay and Associates (1992a) indicates that there is a difference in the species composition in the vegetation of the Quindalup and Spearwood dunes between central (Wilbinga) and southern (Yalgorup) coastal locations. This demonstrates that areas need to be set aside at intervals along the coast if there is to be adequate conservation of these flora groups.

Bush Forever Site 406 Wilbinga-Caraban Bushland contains a significant area of Quindalup and Spearwood dune vegetation that has been set aside for conservation. In addition Bush Forever Sites 284 South-west link from Wilbinga to Yanchep National Park and Bush Forever Site 288 Yanchep National Park and Adjacent Bushland contain vegetation of excellent quality that is set aside for conservation purposes. Bush Forever Sites 289 and 387 also contain Quindalup vegetation that has been set aside for conservation.

The results of the survey undertaken by Alan Tingay and Associates (1992[c]) indicates that although there are not comprehensive flora lists for the conservation reserves surrounding the St Andrews DSP area, many of the plant species found within the DSP area can be expected to occur within adjacent reserve boundaries.

In order to conserve the greatest diversity of flora species possible, the following are recommended;

- Areas to be set aside for the retention of natural vegetation should contain as many vegetation associations as possible. This will lead to a diverse flora assemblage being retained within the DSP area;

- Green belts and areas of Public Open Space to be retained as natural vegetation should be determined at the Structure Planning Stage; and

- The management of vegetation remnants should be determined at the local structure planning stage.

3.5 Significant Fauna

3.5.1 Terrestrial Fauna

Large sections of the site are significantly weed infested or degraded, with areas containing rubbish and car bodies. The increased amounts of grass and weed species have resulted in a low fauna habitat value for these areas. In comparison, there are areas of Banksia woodland and Dryandra shrublands that have high fauna habitat value representative of the region. Clearing of these high quality fauna habitats would significantly impact on fauna (including conservation significant fauna) on site.

It is appreciated that the proposed urban development will inevitably result in the loss of some fauna habitat. It is recommended that where possible, the clearing of vegetation is restricted to those areas that are already degraded and disturbed, and where possible areas of high quality fauna habitat should be left intact. Adoption of this recommendation will minimise the developments impact on fauna assemblages and species of conservation significant.

The Ministerial Conditions for MRS Amendment 787 require that the fauna values of vegetation be considered during the district and local structure planning stages. The following recommendations are made with respect to Structure Planning for the area;

- In accordance with DEC's current policy, an effort will need to be made to protect habitat that are important for the Western Brush Wallaby and the Southern Brown Bandicoot in the planning and clearing of the project area. Where this is not possible, a trapping program may need to be implemented to relocate animals during the LSP Stage;

- Areas of vegetation containing *Dryandra sessilis* and *Banksia attenuata* dominated vegetation should be conserved where possible;

- A Fauna Management Plan detailing techniques to minimise the impacts on fauna species of National and State significance and is recommended to be undertaken at the LSP stage;

- If high quality fauna habitat is to be cleared, then ATA Environmental recommends that the following be undertaken during the LSP stage;

    - A fauna relocation and management plan is prepared;

    - A trapping program is put in place to capture and relocate Quenda;

    - If it is likely that the Western Brush Wallabies in the area will not be able to readily move to adjacent areas during the development, then a capture and relocation program should be implemented;

    - Areas that are disturbed but remain after the proposed development has been completed, should be rehabilitated with local Banksia or Dryandra to provide supplementary feeding habitat for Carnaby's Cockatoo; and

    - Areas of remnant vegetation left in the development site should be few in number and as large as possible with high connectivity.

3.5.2 Subterranean Fauna

As indicated in Section 2.7.8 it is unlikely that stygofauna (subterranean fauna) are present within the study area. However, if karstic features are identified under the small areas of Tuart woodland during the district level karst assessment, the presence of stygofauna may need to be reviewed.

If it was determined during assessment of karst that the presence of stygofauna is likely, a subterranean fauna assessment would be required at the LSP level for those areas where stygofauna were likely to be present.

3.6 Aboriginal Heritage

Three registered Aboriginal sites have been recorded within the St Andrews DSP area. The approximate locations of the registered sites are shown in Figure 8. The requirement to appropriately manage these sites was included in the Ministerial Conditions for Amendment 787 to the City of Wanneroo Town Planning Scheme (outlined in Section 1.3).

The Environmental Conditions included in the EPA recommendations for Amendment 787 require the preparation of Aboriginal Culture and Heritage Management Plans to be undertaken during the LSP stage.

Although four Native Title claims are registered over Vacant Crown Land in the Yanchep area, no further consultation on the basis of Native Title claimants is required for the St Andrews DSP. As the DSP area is freehold land, there is no requirement under the Commonwealth *Native Title Act 1993* to undertake any further consultation in regards to Native Title claims.

Protection and suitable management of any Aboriginal sites of significance is required under the *Aboriginal Heritage Act 1972*.

4. ENVIRONMENTAL FEATURES INCORPORATED INTO THE DISTRICT STRUCTURE PLAN

4.1 District Structure Plan

The St Andrews area will house 150,000 residents in 55,000 households at full development. It is proposed to be the economic anchor for the north-west corridor, providing employment and high-level economic activity not viable in other parts of the city (Advanced Land Resources, 2005).

The primary land use components within the DSP are:

- Mixed Use Activity Centres;
- Residential Neighbourhoods;
- Mixed Use Transit Corridor;
- District Employment Areas; and
- Existing Urbanized Areas.

The proposed DSP includes provision for local and regional open space area including areas to be retained for conservation purposes. The planning process for the St Andrews DSP has also taken into account the environmental conditions of Amendment 787 to the City of Wanneroo Town Planning Scheme as indicated in Section 1.3 of this report. Environmental features incorporated into the DSP are outlined below.

4.2 Environmental Features

4.2.1 Coastal Areas

Foreshore Management Plans and Implementation Strategies will be prepared for the foreshore reserve along the Yanchep to Two Rocks coast. Plan preparation will be undertaken at the LSP stage with implementation at the subdivision stage.

The following principles and components will apply to the development of the foreshore reserve and will be incorporated into the FMPs:

- all access formalised by construction of roads, paths and car parks;
- fenced dual use paths and pedestrian accessways;
- incorporation of a highly scenic cycle route along edge of, or within, the foreshore reserve as part of a regional system;
- structures such as pavilions and boardwalks to be provided as public facilities to enhance beach access yet offer vital foreshore protection;
- use of fencing and signage as integral methods of access control; and
- coastal rehabilitation/stabilisation and revegetation undertaken for degraded areas, and all other areas disturbed by development.

Management works and improvements to the foreshore reserve and foreshore management initially will be the responsibility of the landowners but this responsibility will be transferred to the City of Wanneroo over time.

4.2.2 Groundwater Management

The DSP contains the following commitments with respect to groundwater management:

- The proposed future development of the St Andrews DSP area will comply with the minimum requirements of protection for a Priority 3 Groundwater Source Protection Area;
- Development on the study area will be connected to the deep sewerage system in accordance with State Government policy;
- The potential impact of proposals for industrial development on groundwater resources will be assessed during the local stages of planning and regulated by relevant authorities as part of the approval process for the proposal; and
- Management of drainage and stormwater will be addressed at LSP level with advice to be sought from the regulatory authorities, including the City of Wanneroo and Department of Water and any requirements recommended by the regulatory authorities will be adhered to. Drainage and stormwater management will incorporate the principles and best management practices detailed in *Planning and Management Guidelines for Water Sensitive Urban Design* and *Stormwater Management Manual for Western Australia*;

4.2.3 Remnant Vegetation

General Recommendations

The DSP has incorporated the following initiatives with respect to remnant vegetation:

Preservation of Vegetation

- Stands of *Melaleuca cardiophylla, Dryandra sessilis* and *Banksia attenuata* vegetation have been included in viable POS areas;
- Vegetated linkage corridors have been established to link large areas of remnant vegetation in the north and east with vegetation retained within the DSP area and with vegetation retained within the foreshore reserve;
- Remnant trees scattered through the pasture cleared areas will be retained and incorporated into POS areas where possible; and
- Rehabilitation and landscaping will be undertaken using native species where appropriate.

Clearing of Vegetation

- The location and limit of clearing of vegetation within all work areas will be clearly identified on site and delineated on appropriate plans. These will be supplied to contractors and personnel prior to commencement of works;

- Native vegetation to be cleared will be removed in a systematic manner and stockpiled where appropriate for later use in rehabilitation and landscaping works;
- The stockpiling of cleared vegetation of a poor quality will be separate to that of good quality to minimise the spread of weeds. Only the good quality vegetation will be used for mulch and rehabilitation; and
- No burning of cleared vegetation will be permitted during any stage of construction.

Open Space Areas

It is proposed that Management Plans and Implementation Strategies be prepared for open Space within the DSP area. Plans are to be prepared at the LSP stage, and implemented at subdivision stage.

Detailed management issues which will be addressed at the LSP stage, as part of a Management Plan and Implementation Strategy will include:

- The delineation and treatment of boundaries between the Urban and Parks and Recreation areas;
- Treatment of the immediate interface to Parks and Recreation reservations (delineation of a clear boundary, installation of access control measures, etc);
- Management of bushland during infrastructure works in open space areas;
- Provision of recreation opportunities;
- Access control;
- Exclusion of domestic cats and feral animals;
- Fire management;
- Restricting and controlling the invasion of weeds; and
- Rehabilitation procedures to be used for areas that have been degraded.

In addition, the Plan will specify monitoring requirements to ensure the recommendations and outcomes of the Plan are adhered to.

Provision of the plan will be at the LSP stage which will enable the appropriate agencies, landowners or non-government groups to have input to future planning decisions which may impact on the areas for which they will be responsible.

4.2.4 Significant Fauna

General Recommendations

The DSP incorporates the following initiatives with respect to significant fauna:

Preservation of habitat

- Areas of good or better quality vegetation dominated by *Dryandra sessilis* and *Banksia attenuata* have been retained in POS where possible for conservation to provide habitat for the Carnaby's Cockatoo; and

- Vegetated links have been created to provide access corridors and habitat linkage between coastal areas, vegetation retained within the DSP area and large vegetated areas to the north and east.

Clearing of habitat

- A Vegetation, Flora and Fauna Management Plan will be prepared at the LSP stage;

- Any clearing of native vegetation will be conducted in stages;

- A 'fauna friendly' clearing protocol will be used as part of any clearing operations. All tree hollows, nests and vegetated debris should be inspected for fauna prior to clearing; and

- All hollow logs and branches will be returned to other remnant vegetation areas as part of the rehabilitation works.

4.3 Aboriginal Heritage

The following commitments are made with respect to Aboriginal heritage:

- Appropriate site protocol will be followed during construction works to ensure that any potential Aboriginal sites discovered during the works process are appropriately managed. An appropriate site protocol to manage Aboriginal Heritage will be developed prior to site works commencing and all site managers and staff will be inducted prior to commencing earthworks.

REFERENCES

Advanced Land Resources (2005). *Saint Andrews Concept Plan – Advertised Version.* Prepared for Yanchep Sun City Pty Ltd. July 2005.

Alan Tingay & Associates (1991). *Yanchep Structure Plan Vertebrate Fauna Survey.* Prepared on behalf of Tokyu Corporation.

Alan Tingay & Associates and Dr Adrian Peck (1991). *Yanchep Structure Plan – Hydrology and Water Resource Development*. Prepared for Tokyu Corporation, October 1991.

Alan Tingay and Associates (1992[a]). *Yanchep Structure Plan – Physical Environment.* Report no. 92/5 February 1992).

Alan Tingay & Associates (1992[b]). Yanchep *Structure Plan – Physical Environment.* Response to the Draft North-West Corridor Structure Plan Department of Planning and Urban Development (February 1991). Report prepared for Tokyu Corporation.

Alan Tingay & Associates (1992[c]). Yanchep *Structure Plan – Flora and Vegetation Report*. Response to the Draft North-West Corridor Structure Plan Department of Planning and Urban Development (February 1991). Report prepared for Tokyu Corporation.

Alan Tingay & Associates (1993). *Metropolitan Region Scheme – Yanchep Area Amendment – Yanchep Coastal Planning Strategy*. Report prepared for Tokyu Corporation.

Alan Tingay & Associates (1999[a]). Shire *of Wanneroo Town Planning Scheme No. 1 Amendment 787, Yanchep – Two Rocks Environmental Review*. Prepared on behalf of the Shire of Wanneroo.

Alan Tingay & Associates (1999[b]). *Shire of Wanneroo Town Planning Scheme No. 1 Amendment 837 - Yanchep/Two Rocks Environmental Review*. Prepared on behalf of the Shire of Wanneroo.

ATA Environmental (2001). *Yanchep Southern Project – Flora and Vegetation Assessment*. Prepared for Masterplan Consultants December 2001.

ATA Environmental (2004). *Capricorn Coastal Village Structure Plan – Foreshore Management Plan.* Prepared for Yanchep Sun City, January 2004).

ATA Environmental (2004). *Two Rocks Superlot Subdivision Coastal Foreshore Management Plan.* November 2004. Report 2002/14

Bureau of Meteorology (2006). Website: http://www.bom.gov.au

Department of Environment (2005). *Perth Coastal and Gnangara UWPCA Map.* Department of Environment Resource Management Division. May 2005.

(EPA) Environmental Protection Authority (1983). *Conservation Reserves for Western Australia: As Recommended by the Environmental Protection Authority1983: The Darling System, System6.* Parts 1 and 2. Department of Conservation and Environment, Perth, WA.

(EPA) Environmental Protection Authority (1999). *City of Wanneroo Town Planning Scheme No. 1, Amendment 787 – Primarily to Rezone the Yanchep/Two Rocks area from "Rural" & "Residential Development" to "Urban Development Zone", "Centre Zone" and "Industrial Development Zone"*. Report and recommendations of the Environmental Protection Authority. November 1999.

(EPA) Environmental Protection Authority (1999). *City of Wanneroo Town Planning Scheme No. 1, Amendment 837 – Rezone from "Rural" to "Rural Community", Lots 201 and 202 Breakwater Drive, Two Rocks.* Report and recommendations of the Environmental Protection Authority. November 1999.

(EPA) Environmental Protection Authority (2002). *Terrestrial Biological Surveys as an Element of Biodiversity Protection: Position Statement No. 3.* Environment Protection Authority, Perth, WA.

(EPA) Environmental Protection Authority (2003). *Consideration of Subterranean Fauna in Groundwater and Caves during Environmental Impact Assessment in Western Australia.* Guidance Statement No. 54. December, 2003.

(EPA) Environmental Protection Authority, (2004a). *Guidance Statement No. 51: Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia,* Perth, Western Australia. June, 2004.

(EPA) Environmental Protection Authority (2004b). *Guidance for the Assessment of Environmental Factors. Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia No. 56.* Environmental Protection Authority, Perth.

Feilman Planning Consultants (1992). *Yanchep Structure Plan Report.* Response to the Draft North-West Corridor Structure Plan. Department of Planning and Urban Development. February 1991.

Gibson, N., Keighery, B., Keighery, G., Burbidge, A. and Lyons, M. (1994). *A Floristic Survey of the Southern Swan Coastal Plain*. Report prepared by CALM and the WA Conservation Council for the Australian Heritage Commission.

Government of Western Australia, (2000a). *Bush Forever - Keeping the Bush in the City. Volume 1: Policies Principles and Processes,* Western Australian Planning Commission, Perth.

Government of Western Australia, (2000b). *Bush Forever - Keeping the Bush in the City. Volume 2: Directory of Bush Forever Sites,* Western Australian Planning Commission, Perth.

Johnstone, R.E. and Storr, G.M. (1998). *Handbook of Western Australian Birds: Volume 1 – Non-Passerines (Emu to Dollarbird).* W.A. Museum, Perth.

Johnstone, R.E. and Storr, G.M., (2004). *Handbook of Western Australian Birds: Volume 2 – Passerines (Blue-winged Pitta to Goldfinch).* W.A. Museum, Perth.

Jones Lang Wootton (1992). *Yanchep Structure Plan.* Prepared for the Tokyo Corporation July 1992.

Kenrick, A. (1991). Shipwreck ref

MacIntyre, K. and Dobson, B. (1991). *Yanchep Structure Plan Report on a Survey for Aboriginal Sites*. Prepared on behalf of Tokyu Corporation.

Quartermaine, G. (1991). *Yanchep Structure Plan - Report on an Archaeological Survey for Aboriginal Sites.* Prepared on behalf of Tokyu Corporation.

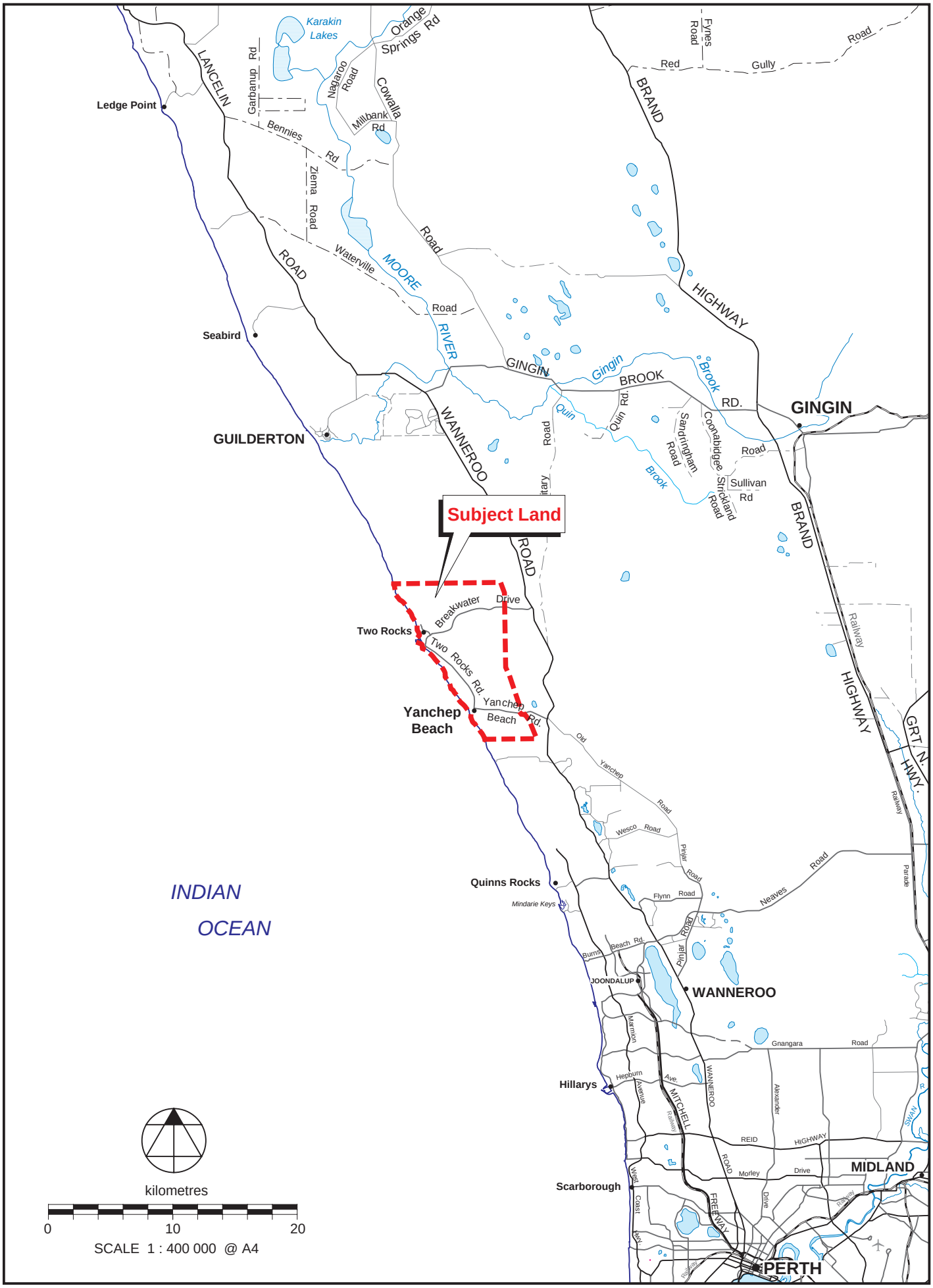
Storr, G.M. and Johnstone R.E. (1988). *Birds of the Swan Coastal Plain and Adjacent Seas and Islands*. Records of the Western Australian Museum, Supplement, No 28.

Trudgen, M. (1996). *An Assessment of the Conservation Values of the Remnant Vegetation in the City of Wanneroo with Recommendations for Appropriate Reserves for the City*. Prepared for the City of Wanneroo by Malcolm Trudgen, September 1996.

Western Australian Planning Commission (2005). *A Sustainability Checklist – A further step towards putting sustainability into practice in planning, development and building in WA*. WAPC March 2005.

Western Australian Planning Commission (2003). *Statement of Planning Policy No. 2.6 - State Coastal Planning Policy*. WAPC June 2003.

FIGURES



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ST ANDREWS DISTRICT STRUCTURE PLAN

REGIONAL LOCATION

FIGURE 1

kilometres

0 0.5 1 1.5 2

SCALE 1 : 50 000

LEGEND

- Study Area Boundary
- Cadastral Boundary
- Topographic Contour (5m interval, m AHD)

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ST ANDREWS DISTRICT STRUCTURE PLAN

STUDY AREA

FIGURE 2

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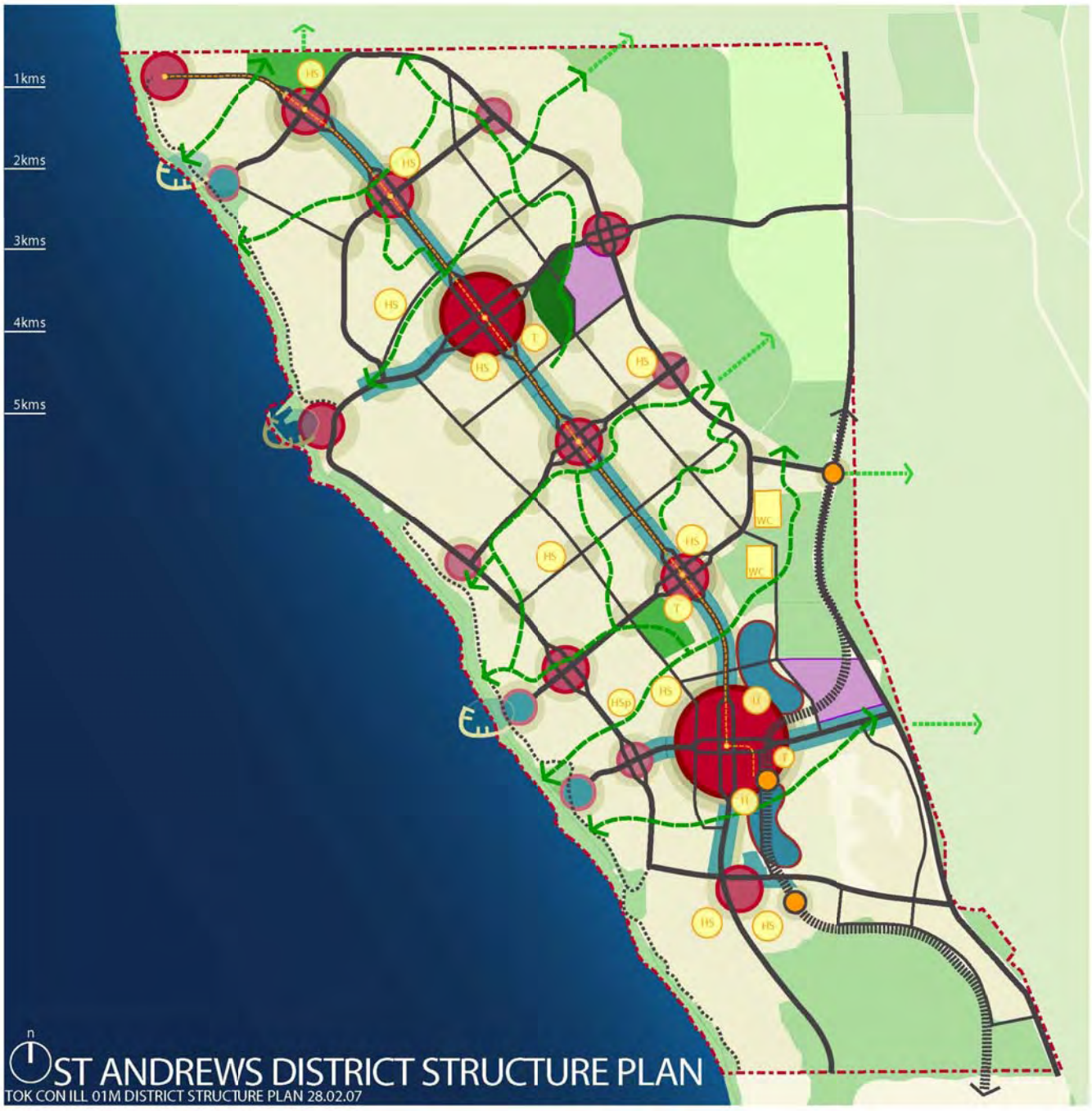

SOURCE: Roberts Day Town Planning + Design, Ref TOK CON ILL 01M, 28-02-07.

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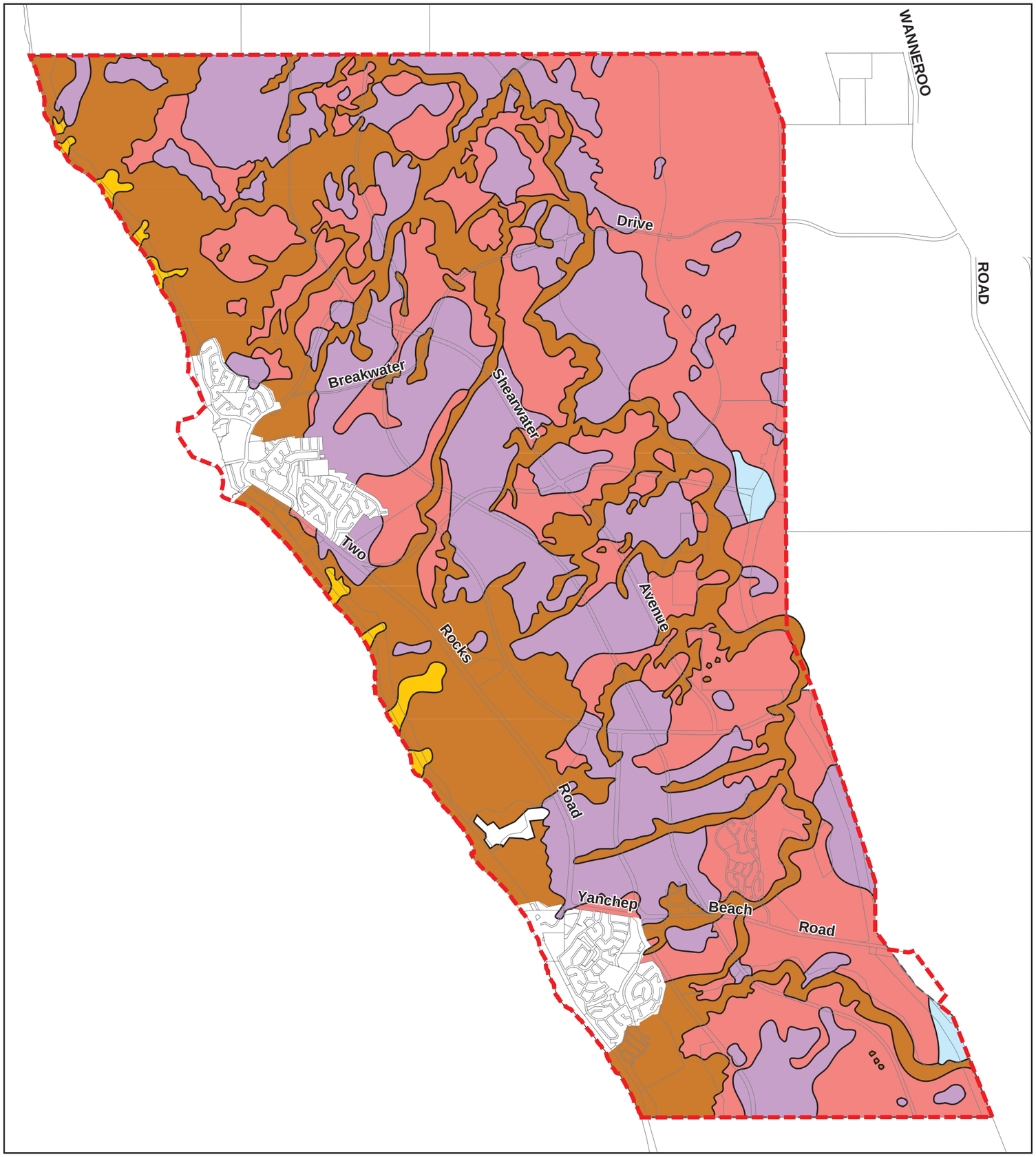
ST ANDREWS DISTRICT STRUCTURE PLAN

PROPOSED ST ANDREWS DISTRICT STRUCTURE PLAN

FIGURE 3



kilometres

0 0.5 1 1.5 2

SCALE 1 : 50 000

LEGEND

- Study Area Boundary
- Cadastral Boundary
- Topographic Contour (5m interval, m AHD)

GEOLOGY LEGEND

	CALCAREOUS SAND - white, fine grained sub-rounded quartz and shell debris.	*Safety Bay Sand (mobile dunes)*
	CALCAREOUS SAND - weakly cemented in places, of eolian origin.	*Safety Bay Sand*
	QUARTZ SAND - pale and olive yellow, medium to coarse grained, moderately sorted.	*Sand derived from Tamala Limestone*
	LIMESTONE - pale yellowish brown, weakly cemented, friable, medium grained, sub-rounded quartz and shell debris, of eolian origin.	*Tamala Limestone*
	LIMESTONE - as above, abundant karstic phenomena.	*Tamala Limestone*

HOLOCENE

PLEISTOCENE

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ST ANDREWS DISTRICT STRUCTURE PLAN

GEOLOGY

FIGURE 4

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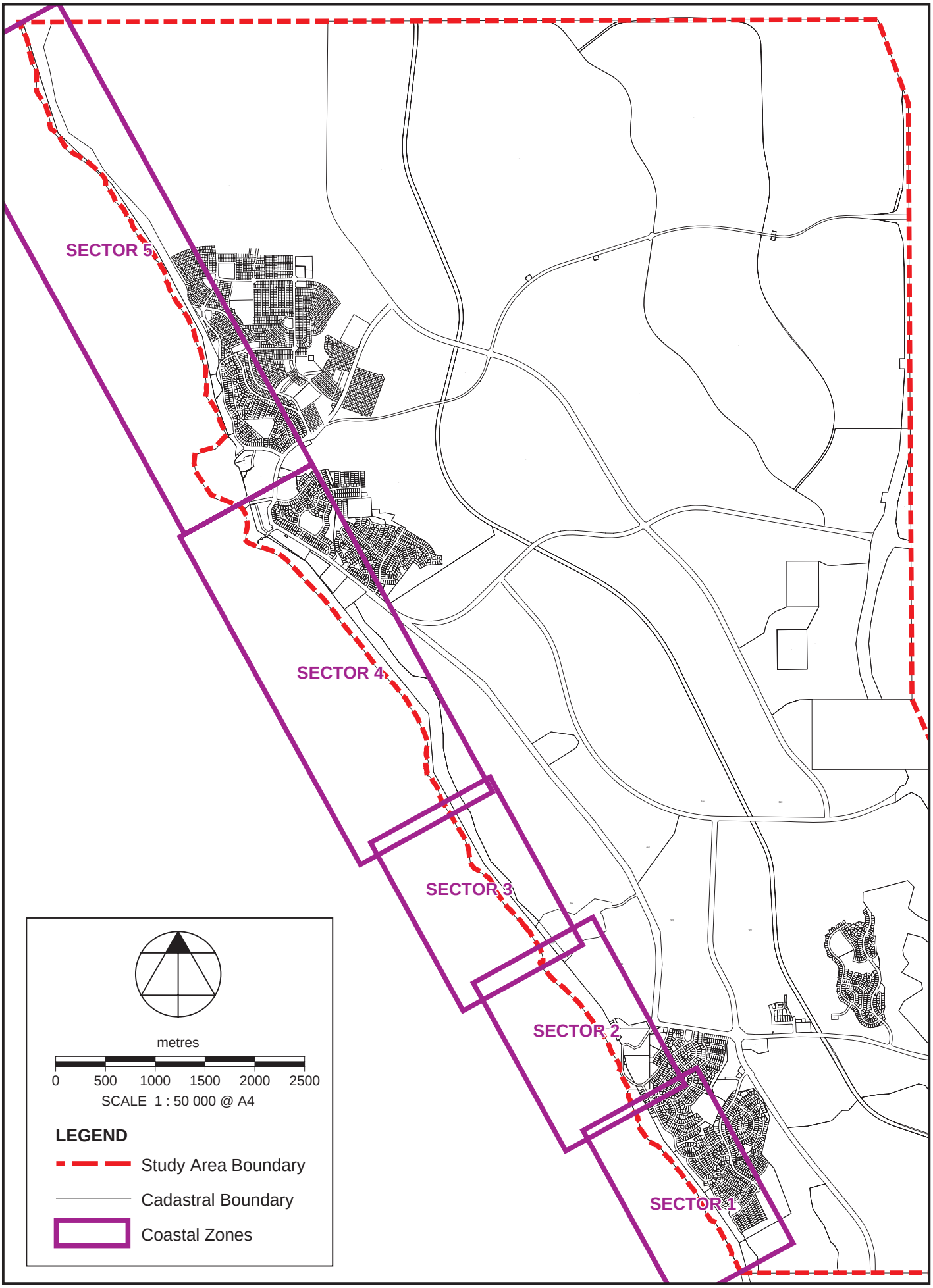

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ST ANDREWS DISTRICT STRUCTURE PLAN

LOCATION OF COASTAL SECTORS

FIGURE 5

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metres

0 200 400 600 800 1000

SCALE 1 : 20 000 @ A3

LEGEND

- Study Area Boundary
- Cadastral Boundary
- Vegetation Association Boundary
- Ba Vegetation Association

See Figure 6c for Vegetation Associations Legend

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ST ANDREWS DISTRICT STRUCTURE PLAN

VEGETATION ASSOCIATIONS

FIGURE 6a

PRINTED: Tue 06 Mar 07

YSC-2005-007/DSP/26_061f06b.dgn DATUM: PCG94 DRAWN BY: EDS 15-08-06 CHECKED BY: EO 15-08-06

metres

0 200 400 600 800 1000

SCALE 1 : 20 000 @ A3

LEGEND

- Study Area Boundary
- Cadastral Boundary
- Vegetation Association Boundary
- Ba — Vegetation Association

See Figure 6c for Vegetation Associations Legend

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ST ANDREWS DISTRICT STRUCTURE PLAN

VEGETATION ASSOCIATIONS

FIGURE 6b

PRINTED: Tue 15 Aug

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DATUM: PCG94

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VEGETATION ASSOCIATIONS LEGEND

QUINDALUP VEGETATION COMPLEX

Young Quindalup Dune Heath

Ar	*Acacia rostellifera* Closed Heath
Aa	*Ammophila arenaria* Grassland
Sh	*Spinifex hirsutus* on Foredunes
OaSg	*Olearia axillaris* and *Spyridium globulosum* Heath
OaSgAr	*Olearia axillaris, Spyridium globulosum* and *Acacia rostellifera* Closed Heath
SgAr	*Spyridium globulosum* and *Acacia rostellifera* Closed Heath

Old Quindalup Dune Heath

ArDs	*Acacia rostellifera* Closed Heath with scattered *Dryandra sessilis*
As	*Acacia saligna* Open Scrub to Shrubland
AsXp	*Acacia saligna* and *Xanthorrhoea preissii* Tall Shrubland
Nf	*Nuytsia floribunda* stand
Ms	*Melaleuca systena* Closed Heath

COTTESLOE - NORTH VEGETATION COMPLEX

Limestone Heath Types

Ds	*Dryandra sessilis* Heath to Closed Heath
DsCq	*Dryandra sessilis* and *Calothamnus quadrifidus* Heath to Closed Heath
CqDs	*Dryandra sessilis* and *Calothamnus quadrifidus* Heath to Closed Heath
Cq	*Calothamnus quadrifidus* Closed Heath
DsMh	*Dryandra sessilis*
Mh	*Melaleuca huegelii* Open Heath to Heath
Mc	*Melaleuca cardiophylla* Closed Scrub

Sand over Limestone

Ba	*Banksia attenuata* Low Open Forest
Eg	*Eucalyptus gomphocephala* Woodland to Open Forest
Em	*Eucalyptus marginata* Woodland
Et	*Eucalyptus todtiana* Woodland

Pl Denotes plantation predominantly *Eucalyptus gomphocephala* and *Agonis flexuosa*

metres

0 200 400 600 800 1000

SCALE 1 : 20 000 @ A3

LEGEND

- Study Area Boundary
- Cadastral Boundary
- Vegetation Association Boundary
- Ba — Vegetation Association

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ST ANDREWS DISTRICT STRUCTURE PLAN

VEGETATION ASSOCIATIONS

FIGURE 6c

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DATUM: PCG94

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metres

0 200 400 600 800 1000

SCALE 1 : 20 000 @ A3

LEGEND

- Study Area Boundary
- Cadastral Boundary
- Vegetation Condition Boundary
- CD — Vegetation Condition

See Figure 7c for Vegetation Condition Legend

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ST ANDREWS DISTRICT STRUCTURE PLAN

VEGETATION CONDITION

FIGURE 7a

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metres

0 200 400 600 800 1000

SCALE 1 : 20 000 @ A3

LEGEND

- Study Area Boundary
- Cadastral Boundary
- Vegetation Condition Boundary
- CD Vegetation Condition

See Figure 7c for Vegetation Condition Legend

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ST ANDREWS DISTRICT STRUCTURE PLAN

VEGETATION CONDITION

FIGURE 7b

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VEGETATION CONDITION LEGEND
(SOURCE: BUSH FOREVER Govt. of W.A., 2000)

P **Pristine**
Pristine or nearly so, no obvious signs of disturbance.

E **Excellent**
Vegetation structure intact, disturbance affecting individual species and weeds are non aggressive species.

VG **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.

G **Good**
Vegetation structure significantly altered by very obvious signs of multiple disturbance. 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.

Deg **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.

CD **Completely Degraded**
The structure of the vegetation is no longer intact and the areas is completely or almost completely without native species. These areas are often described as 'parkland cleared' with the flora composing weed or crop species with isolated native trees or shrubs.

metres
0 200 400 600 800 1000
SCALE 1 : 20 000 @ A3

LEGEND
- Study Area Boundary
- Cadastral Boundary
- Vegetation Condition Boundary
- CD Vegetation Condition

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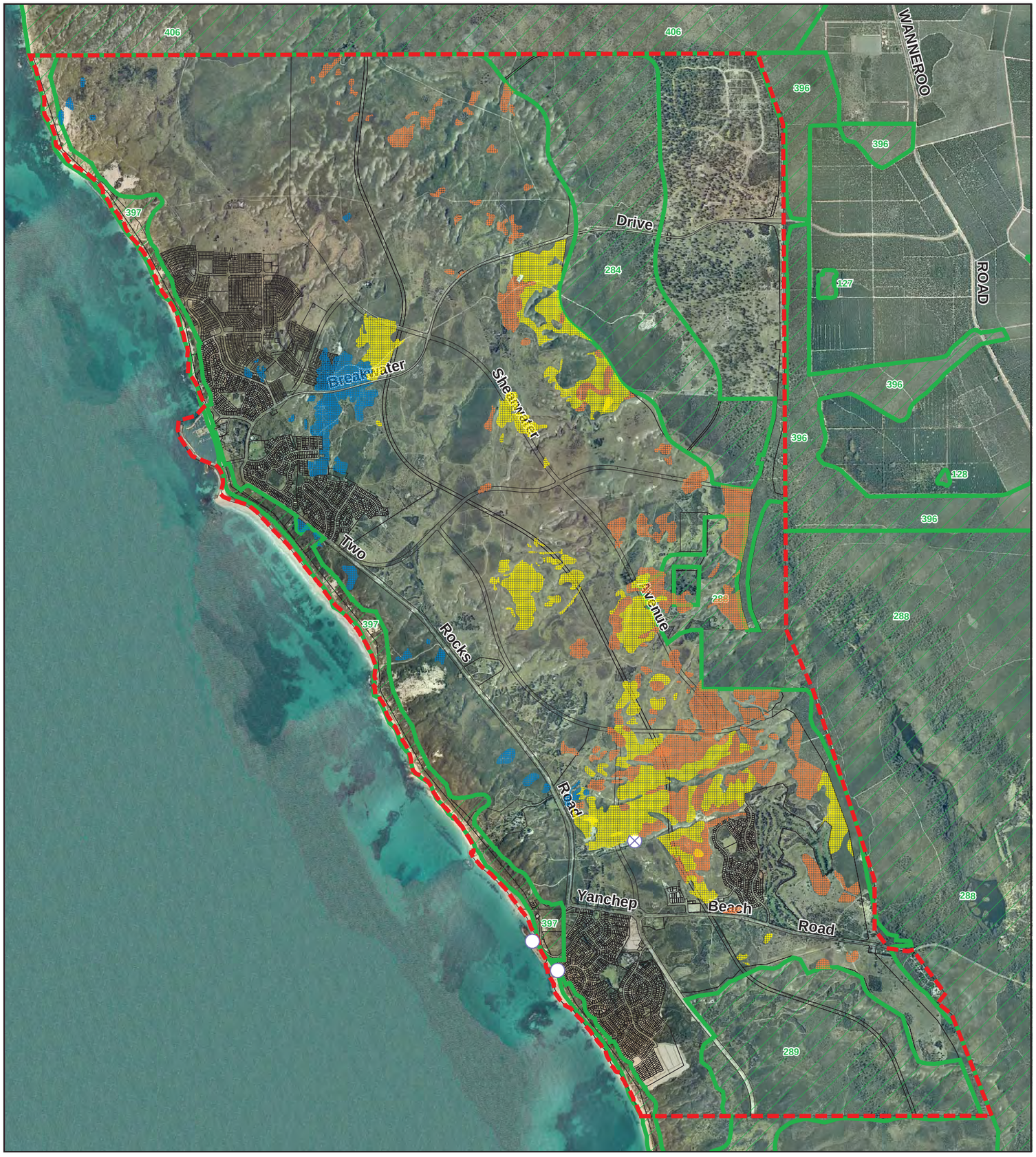
ST ANDREWS DISTRICT STRUCTURE PLAN
VEGETATION CONDITION
FIGURE 7c



kilometres

0 0.5 1 1.5 2

SCALE 1 : 50 000

LEGEND

- Study Area Boundary
- Cadastral Boundary
- Bush Forever Site Boundary
- Aboriginal Mythological Site
- Aboriginal Artefacts/Scatter Site
- *Melaleuca cardiophylla*
- *Dryandra sessilis*
- *Banksia attenuata*

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ST ANDREWS DISTRICT STRUCTURE PLAN

LOCAL ENVIRONMENTAL ISSUES FOR PLANNING CONSIDERATION IN THE ST ANDREWS AREA

FIGURE 8

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