Draft Coastal Management Plan
Shire of Greenough

Department of Conservation and Environment,
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Draft Coastal Management Plan

Shire of Greenough

Prepared by

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for the Shire of Greenough

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Tony Berman and Brian Stewart prepared the report for publication, and Margaret Parkinson and Tracy Neath completed the word processing.

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COASTAL PLANNING IN WESTERN AUSTRALIA

In 1982 the Western Australian Government established a Coastal Management Co-ordinating Committee (CMCC) comprising representatives from a number of State authorities to:

- advise government about coastal management policies, legislation and administrative arrangements;

- co-ordinate departmental activities on the coast through the exchange of information and views, and review expenditure programmes and priorities;

- overview the preparation and implementation of coastal management plans at regional and local levels for various locations on the coast of W.A.

SUMMARY: DRAFT COASTAL MANAGEMENT PLAN - SHIRE OF GREENOUGH

Section 1 of this report introduces coastal planning and management in the Greenough Shire by establishing the background, scope and aims of the report.

Section 2 identifies and describes the natural and human resources of the Greenough coastline, including aspects of the physical environment, climate, coastal processes, flora and fauna, marine life, human occupance and man-made facilities. This section ends with a summary of the resources and constraints of the Greenough environment.

Section 3 outlines the various ways that these resources are currently used or may be used in the future.

Existing tenure, zoning and management of the study area is outlined briefly in section 4, and this is followed by a review of the general principles of coastal management and their significance to the Greenough coastline, in section 5 of the report. The study area is broken down into landscape systems which allows a more detailed description of the characteristics and limitations of the coastline. Section 5 also recommends policies and objectives for the coast to:

- limit use of coastal areas to activities requiring coastal locations;

- encourage and plan for appropriate uses of the coastal zone;

- protect natural systems and cultural assets.

Specific coastal management issues are then discussed in section 6 and these are accompanied by recommendations where appropriate. Finally, section 7 describes how the plan may be implemented, identifying possible sources of funding, approaches to land vesting and tenure, methods of policing, the need for public education and involvement, and government agencies which may provide assistance.

1. INTRODUCTION

1.1 LOCATION

The Shire of Greenough surrounds the Town of Geraldton which is a major port some 420 km north of Perth on the central west coast of Western Australia (Map 1).

1.2 BACKGROUND

The Shire of Greenough has been actively involved in the management of its coastline over a number of years. It became apparent, however, that coastal management could be carried out most effectively in the context of a long term Management Plan. For this reason, the Shire took steps to employ a consultant for a period of six months, to undertake the preparation of a plan in close liaison with the Department of Conservation and Environment.

Work on this Draft Coastal Management Plan commenced in November 1984.

1.3 EXTENT AND PRESENT STATUS OF THE STUDY AREA

The study area, for the purpose of this Draft Management Plan, is bounded to the north and south by the Greenough Shire boundaries, located at latitudes $28^{o}41$'s and $29^{o}04$'s respectively, and extends to the North West Coastal Highway and the Brand Highway in the east (Map 1). The western boundary is defined by the low-water mark on the Western Australian coastline but the study will also deal with aspects of the adjacent offshore waters.

The study region contains areas of Freehold land, vacant Crown land, and Crown and Freehold reserves, as shown in Table 1. Shire of Greenough Town Planning Schemes Nos 4 and 1A outline the land use and zoning of the region.

1.4 PURPOSE AND AIMS OF THE PLAN

Past decisions regarding the development and use of coastal resources in Western Australia have tended to be made without consideration to their long term effects or the integrated development of the coastal belt as a whole. This trend is now being reversed as people become aware of the dynamic and fragile nature of the coastal environment and the need for more effective management. This Draft Plan deals specifically with management of the coastline within the Greenough Shire. The aim of the plan is to:

- guide long term development, conservation and management of the coastal zone;

- advise on the suitability of coastal sites for particular uses or levels of use;

- identify possible land use conflicts within the coastal zone;

- identify potential environmental problems and recommend management strategies;

- identify relevant authorities or people that should participate in the planning process or may be able to provide a management input into the area;

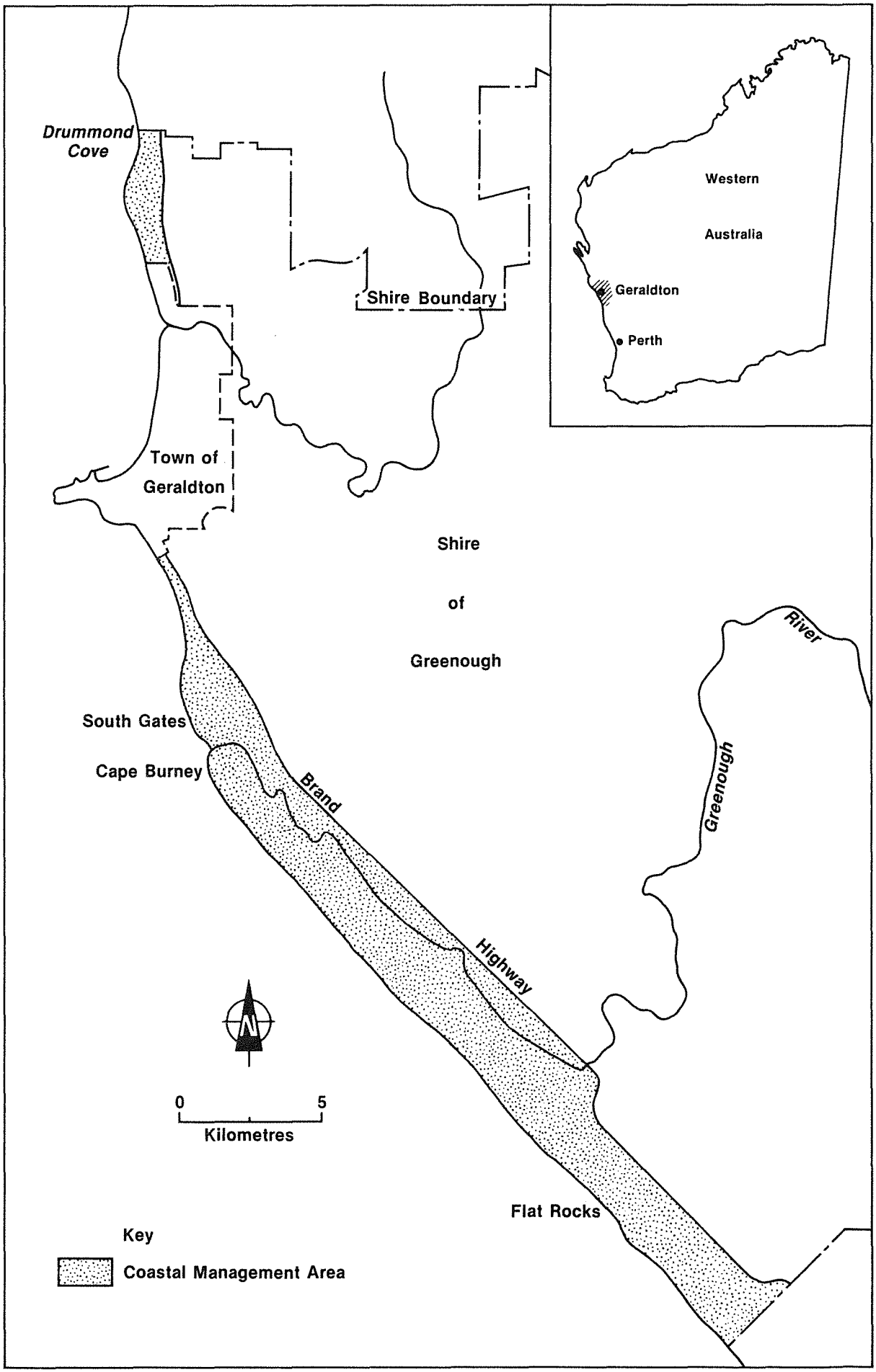
- identify possible sources of financial assistance.

The appropriate siting of coastal activities will ensure that the environment is not significantly degraded and, in the long term, minimise costly management works. If this approach is not taken it will result in a decrease in the amenity value of coastal resources as well as higher management costs to maintain these resources.

TABLE 1 Crown and Freehold Reserves in Study Area

Reserve No	Area	Vested	Purpose
24738	23.0165	Shire of Greenough	Beach Camp Resort (with power to lease 21 years)
891	2.0234	Leased to tenders	Public Utility
34973	2.9730	Shire of Greenough	Public Recreation
35927*	0.1470	Shire of Greenough	Drainage
35488	2.6567	Shire of Greenough	Public Recreation
35357	0.5470	Shire of Greenough	Public Recreation
37728	12.4703	Minister for Water Resources	Wastewater Treatment Plant
37344	0.2583	Shire of Greenough	Public Recreation
35935	11.3525	Shire of Greenough	Public Recreation
35936	2.6261	Shire of Greenough	Public Recreation
35937	2.3897	Shire of Greenough	Public Recreation
20995	6.0703	Shire of Greenough	Recreation
24420	15.2997	Shire of Greenough	Camping & Recreation
28653	2.3320	Shire of Greenough	Recreation and Beach Cottages (with power to lease 21 years)
A7276	351.8129	Shire of Greenough	Parklands
309*	80.9371	In Trust	Methodist Church and Glebe
1088	7.4665	Shire of Greenough	Water
37333	27.8200	Leased to Commonwealth of Australia yearly	Rifle Range
A8613	33.3236	Shire of Greenough	Park
7298	1.4367	Shire of Greenough	Camping

*Denotes freehold reserve



Map 1 Coastal Management Area

2. THE GREENOUGH ENVIRONMENT

2.1 PHYSICAL ENVIRONMENT

2.1.1 Geology

The Shire of Greenough lies in the northern part of the Perth Basin. The area is underlain by Tamala Limestone which outcrops extensively inland from the coastal strip but may also be found outcropping in the form of ridges or topographic highs along the coastline and offshore. Dunes of the Quindalup Dune System (Safety Bay Sand) are present along the coastal zone with an average east-west extent of one kilometre.

The Tamala Limestone was laid down during late Pleistocene times in the form of a series of massive shore parallel dune ridges and swales. These dunes subsequently underwent cementation resulting in the limestone that is observed today.

The Safety Bay Sand was deposited as a result of rising sea level during the Holocene Period about 6000 years ago. Dune building occurred as submarine sand bodies were swept onshore following the sea level rise. The rate of deposition of Holocene sand has slowed with the passage of time with the effect that most sandy shorelines are now relatively stable or eroding slowly.

2.1.2 Geomorphology

Coastal landforms are the result of a complex interaction between geology, offshore coastal features, and the prevailing wind and wave conditions. The geomorphology of the coastline between Green Head and Dongara has been described and mapped by Hesp and Gozzard (1983). To the north, the Greenough coastline exhibits similar surface features and the scheme used by Hesp and Gozzard has also been employed in this work.

Mapping was carried out through interpretation of 1:25 000 scale colour aerial photography flown in 1978. It should be noted that regional mapping of this kind is no substitute for detailed landform interpretation at particular sites.

The geomorphic or landform units of the region are displayed on Map 2. These units are described by Hesp and Gozzard and it is not proposed to reproduce that work here, however a brief review of their characteristics is in order.

Pleistocene dune complex - These landform units represent Tamala Limestone either near the surface and outcropping extensively (stipled) or covered by residual sand (unstipled). Areas of Pleistocene dune complex that are found within the Quindalup Dunes represent Tamala Limestone overlain by a veneer of Holocene sand.

In the offshore zone the Pleistocene dune complex is present in the form of a series of emergent to degraded submarine reef chains.

Alluvial flats - The alluvial flats are low lying areas generally coinciding with the valley of the Greenough River. An area of alluvium east of Drummond Cove represents the outflow of Dolbys Gully.

Parabolic dunes - The parabolic dune unit represents transgressive Holocene sand sheets that have been transported by wind action and deposited on top of the Pleistocene dune complex. Parabolic dunes are nested overlapping

Map 2 (1) Landforms

Map 2
Index

(1)

(2)

(3)

(4)

(5)

0 1
Kilometre

Drummond Cove

24738

891

Highway

Coastal

West

North

Key

- Railway
- Roads
- Rivers
- Geomorphic (Landform) Boundaries
- Shire Boundaries
- Geraldton Townsite Boundary
- Crown Reserves
- Pleistocene Dune Complex
- Pleistocene Dune Complex
- Alluvial Flats
- Deflation Basins
- Parabolic Dunes
- Foredunes
- Active Parabolic Dune Lobes and Blowouts
- Beach

Map 2 (2) Landforms

Champion Bay

Map 2
Index

(1)

(2)

(3)

(4)

(5)

Town of Geraldton

Port Grey

0 1
Kilometre

34973

Tarcoola

35488

South Gates

Key

- Railway
- Roads
- Rivers
- Geomorphic (Landform) Boundaries
- Shire Boundaries
- Geraldton Townsite Boundary
- Crown Reserves
- Pleistocene Dune Complex
- Pleistocene Dune Complex
- Alluvial Flats
- Deflation Basins
- Parabolic Dunes
- Foredunes
- Active Parabolic Dune Lobes and Blowouts
- Beach

Map 2 (3) Landforms

Cape Burney

20995

37728

35935

35937

35936

24420

28653

7276

7276

309

7276

1088

Brand Highway

Jandanol Road

Map 2
Index

(1)

(2)

(3)

(4)

(5)

0 1
Kilometre

Key

Railway

Roads

Rivers

Geomorphic (Landform) Boundaries

Shire Boundaries

Geraldton Townsite Boundary

Crown Reserves

Pleistocene Dune Complex

Pleistocene Dune Complex

Alluvial Flats

Deflation Basins

Parabolic Dunes

Foredunes

Active Parabolic Dune Lobes and Blowouts

Beach

Map 2 (4) Landforms

Georgina Road

Brand Highway

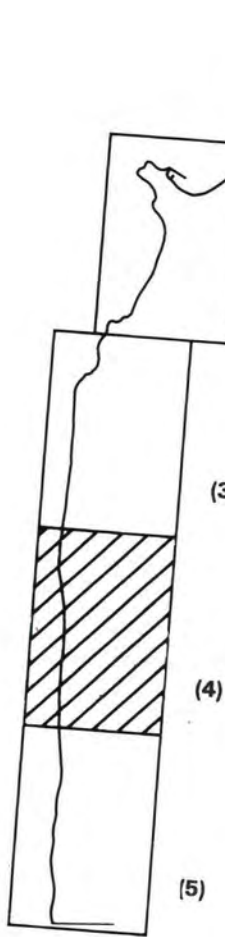
Company Road

Brand Highway

37333

8613

Map 2
Index



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Kilometre

Key

- Railway
- Roads
- Rivers
- Geomorphic (Landform) Boundaries
- Shire Boundaries
- Geraldton Townsite Boundary
- Crown Reserves
- Pleistocene Dune Complex
- Pleistocene Dune Complex
- Alluvial Flats
- Deflation Basins
- Parabolic Dunes
- Foredunes
- Active Parabolic Dune Lobes and Blowouts
- Beach

Map 2 (5) Landforms

Crampton Road

Flat Rocks Road

Duncan Road

Brand Highway

7298

Map 2

Index

(1)

(2)

(3)

(4)

(5)

0 1

Kilometre

Key

- Railway
- Roads
- Rivers
- Geomorphic (Landform) Boundaries
- Shire Boundaries
- Geraldton Townsite Boundary
- Crown Reserves
- Pleistocene Dune Complex
- Pleistocene Dune Complex
- Alluvial Flats
- Deflation Basins
- Parabolic Dunes
- Foredunes
- Active Parabolic Dune Lobes and Blowouts
- Beach

vegetated dune ridges and troughs. They are oriented north-south parallel with the dominant wind direction.

Deflation basins - These areas are flat lying, vegetated to semi-vegetated erosion plains bounded by both active and inactive Holocene parabolic dunes.

Foredunes - This unit is made up of prograded, shore parallel, vegetated to semi-vegetated relict foredunes or beach ridges.

Active parabolic dunes and blowouts - Active parabolic dunes are large scale U-shaped, unvegetated transgressive lobes. The largest of these are the South Gates and Cape Burney drifts. Blowouts are U-shaped erosional troughs with attached depositional lobes.

Beach - These represent modern day beach deposits. Coastlines within the Shire of Greenough can be classified into sandy and rocky beaches. Representative cross-sections of these two beach types are shown in Figure 1 and their distribution along the Shire coastline is illustrated in Map 3.

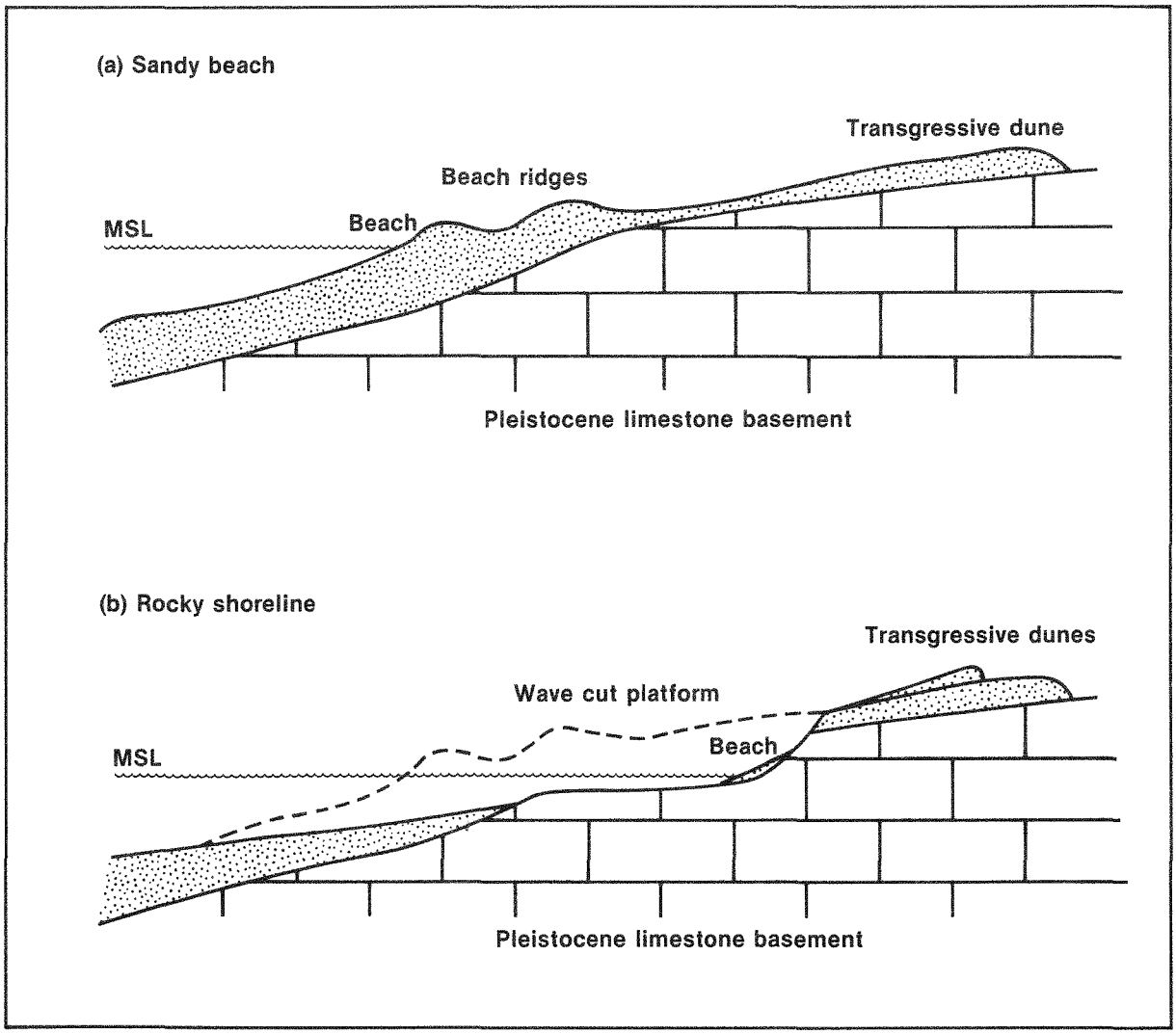

Figure 1 Typical cross sections of sandy and rocky coastlines.

Sandy beach coastlines (Figure 1a) typically comprise a relatively wide beach zone backed by relict foredunes (beach ridges) and transgressive parabolic dunes. In some cases beach ridges are absent or limited to a single foredune. This is the result of recent transgressive sand sheet activity.

Rocky shorelines (Figure 1b) are made up of exposed coastal limestone country rock with a thin veneer of sand. In many cases prolonged wave action has resulted in the formation of "wave cut platforms" which are flat rocky shelves usually exposed only at low tide. Rocky shorelines are typically backed by a variably developed rocky cliff, and transgressive parabolic dunes.

2.1.3 Soils

The coastal belt is characterised by loose, sandy calcareous soils which are susceptible to wind erosion particularly if the vegetation cover is removed.

2.2 CLIMATE AND OCEANOGRAPHY

2.2.1 Climate

The Greenough region experiences a temperate climate with mild, wet winters and hot, dry summers.

2.2.2 Winds

The windiest month is December when winds exceed 10 kph on 99% of days. July is the least windy month with winds exceeding 10 kph on 75% of days.

During summer the winds are usually southerly to southeasterly in the morning shifting south to southwest in the afternoon. Winter mornings bring winds from the northeast while in the afternoon westerly winds are prevalent.

Winter gales initially bring winds from a westerly direction, shifting south as the storm passes. Tropical cyclones can affect the coast during summer bringing winds from any direction.

The strongest winds blow during the summer months at 20-30kph from a south to southwesterly direction.

2.2.3 Rainfall and temperature

The region experiences an average annual rainfall of about 475 mm, 85% of which falls between the months of May and October. On average there are 89 rainy days per year.

The average summer temperature range at Geraldton is from an 18.2^{o}C minimum to a 31.2^{o}C maximum while during winter it is from 9.7^{o}C to 19.9^{o}C.

2.2.4 Cyclones and storms

Tropical cyclones can affect the Greenough coastline between the months of November and April. Though rare, tropical cyclones can produce a catastrophic combination of hurricane force winds, storm surge and very rough seas, which has a profound effect on the coastal strip. The area is also subject to mid-latitude storms during the winter months which bring gale force winds and heavy rainfall.

2.2.5 Seas (waves and swell)

The prevailing swell is generated in the southern latitudes and arrives from the southwest. Swell waves are refracted as they pass over the continental shelf, and reflected and diffracted as they interact with offshore reefs.

Map 3 (1) Zoning and Facilities

0 1 Km

Adapted from Dept. of Lands and Surveys
1:25000 series Cadastral Maps
and 1978 Aerial Photography.

Drummond Cove

24736

Dolbys Gully

891

Coastal Highway

North West

Indian Ocean

Bluff Point

Map 3
Index

(1)

(2)

(3)

(4)

(5)

Key

- Surveyed Roads
- Surveyed Boundaries
- Shire Boundaries
- Geraldton Townsite Boundary
- Rivers
- Tracks
- Crown Reserves
- 1 Historic Places
- Carparks
- Boat Launching Facilities
- Toilet Facilities
- Four Wheel Drive Beach Access
- Safe Boat Moorings
- Sandy Beaches
- Rocky Shorelines

Zoning

- Residential, Residential Development, Resort Development, Commercial
- General Farming
- Recreation, Public Use Special Use
- Dune Preservation

Zoning interpreted from Scheme Maps,
Shire of Greenough Town Planning Schemes
Number 4 and Number 1A (in preparation).

Map 3 (2) Zoning and Facilities

Point Moore

Champion Bay

Separation Point

Town of Geraldton

Indian Ocean

Port Grey

Tarcoola

34973

35927

35357

35488

South Gates

Map 3
Index

(1)

(2)

(3)

(4)

(5)

0 1Km

Adapted from Dept. of Lands and Surveys
1:25000 series Cadastral Maps
and 1978 Aerial Photography.

Key

- Surveyed Roads
- Surveyed Boundaries
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- Crown Reserves
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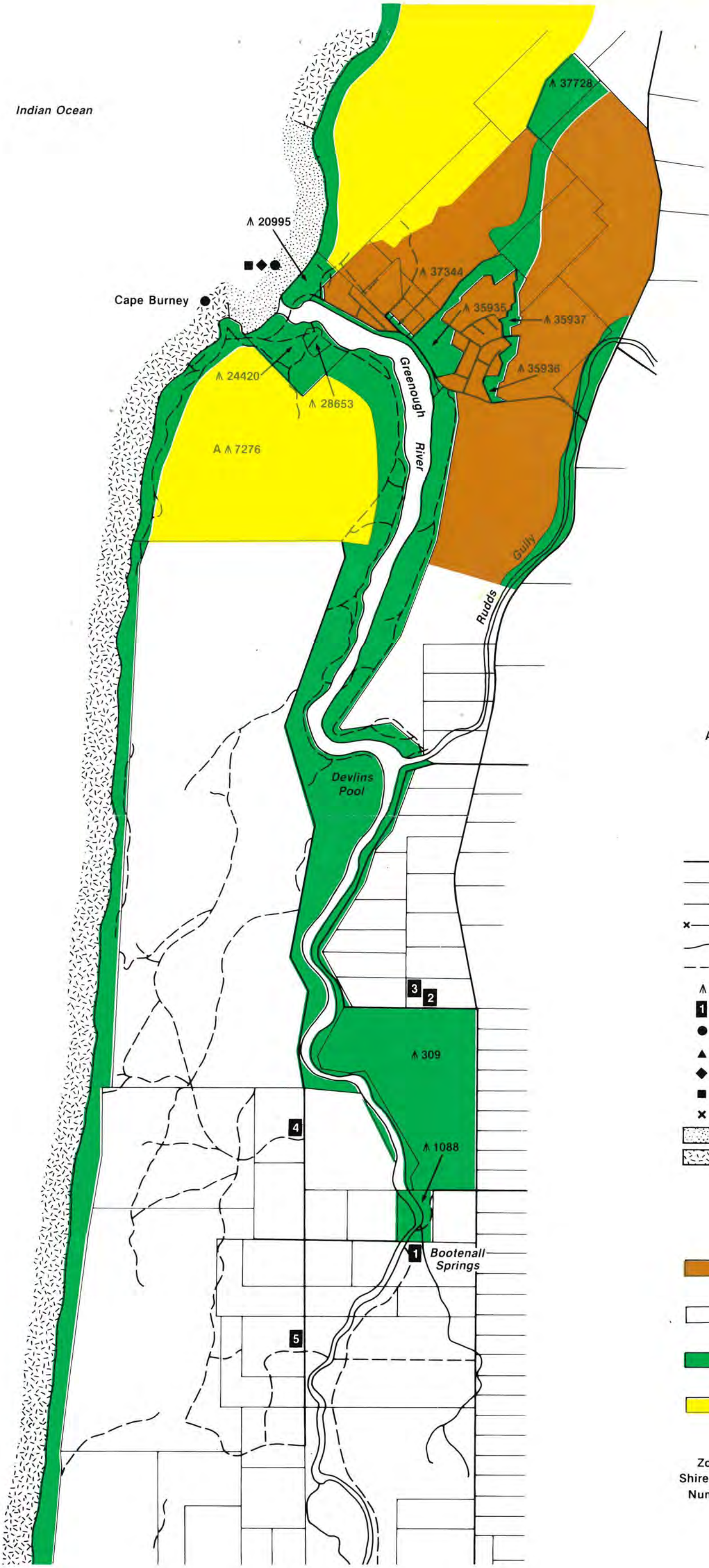
- Carparks
- Boat Launching Facilities
- Toilet Facilities
- Four Wheel Drive Beach Access
- Safe Boat Moorings
- Sandy Beaches
- Rocky Shorelines

Zoning

- Residential, Residential Development, Resort Development, Commercial
- General Farming
- Recreation, Public Use, Special Use
- Dune Preservation

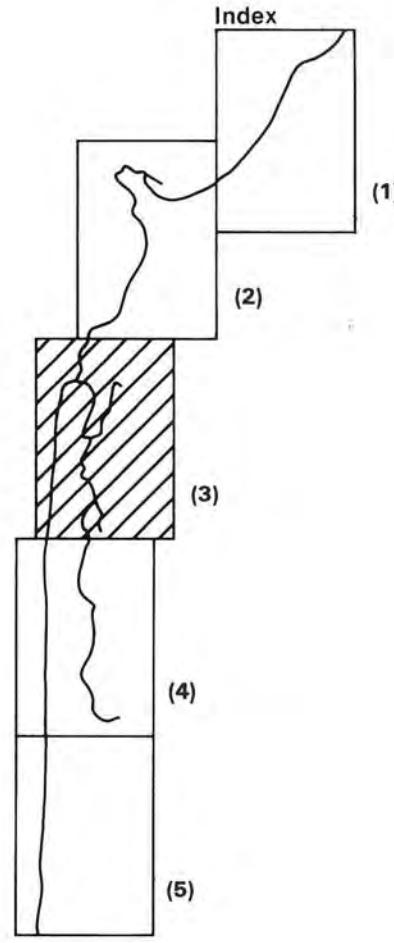
Zoning interpreted from Scheme Maps,
Shire of Greenough Town Planning Schemes
Number 4 and Number 1A (in preparation).

Map 3 (3) Zoning and Facilities



Map 3

Index



0 1Km

Adapted from Dept. of Lands and Surveys
1:25000 series Cadastral Maps
and 1978 Aerial Photography.

Key

- Surveyed Roads
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- Shire Boundaries
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- Carparks
- Boat Launching Facilities
- Toilet Facilities
- Four Wheel Drive Beach Access
- Safe Boat Moorings
- Sandy Beaches
- Rocky Shorelines

Zoning

- Residential, Residential Development
  Resort Development, Commercial
- General Farming
- Recreation, Public Use
  Special Use
- Dune Preservation

Zoning interpreted from Scheme Maps,
Shire of Greenough Town Planning Schemes
Number 4 and Number 1A (in preparation).

Map 3 (4) Zoning and Facilities

Indian Ocean

Lucys Beach

A 37333

A A 8613

6
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14
13
12
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11
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19
20
26
22
21
27
23

Map 3

Index

(1)
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(3)
(4)
(5)

0 1 Km

Adapted from Dept. of Lands and Surveys
1:25000 series Cadastral Maps
and 1978 Aerial Photography.

Key

- Surveyed Roads
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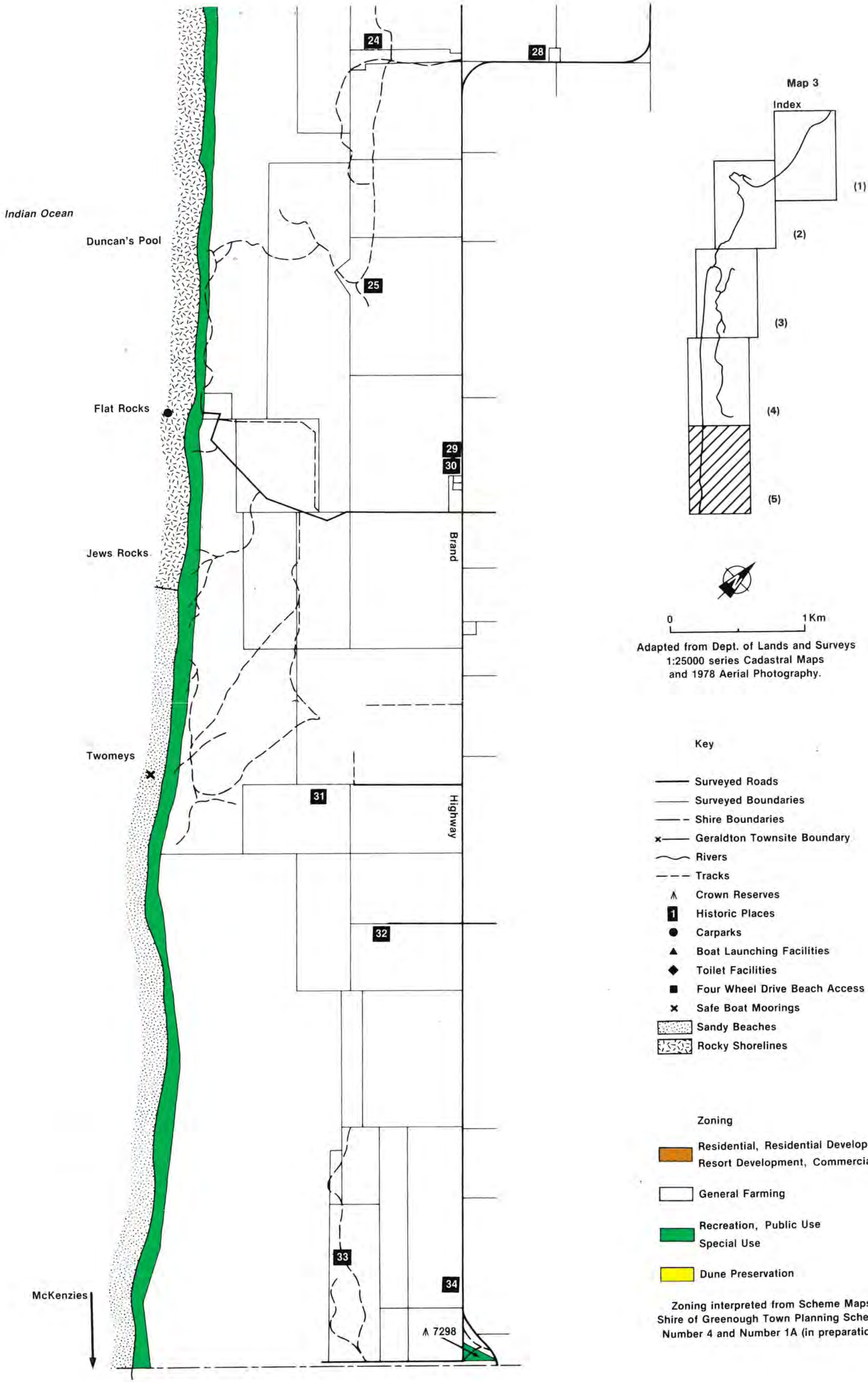
- Boat Launching Facilities
- Toilet Facilities
- Four Wheel Drive Beach Access
- Safe Boat Moorings
- Sandy Beaches
- Rocky Shorelines

Zoning

- Residential, Residential Development, Resort Development, Commercial
- General Farming
- Recreation, Public Use Special Use
- Dune Preservation

Zoning interpreted from Scheme Maps,
Shire of Greenough Town Planning Schemes
Number 4 and Number 1A (in preparation).

Map 3 (5) Zoning and Facilities



Map 3

Index

0 1 Km

Adapted from Dept. of Lands and Surveys
1:25000 series Cadastral Maps
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- Surveyed Roads
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Zoning interpreted from Scheme Maps,
Shire of Greenough Town Planning Schemes
Number 4 and Number 1A (in preparation).

Superimposed on the swell wave pattern are locally generated wind waves which can arrive from any direction.

2.2.6 Tides and currents

The tidal regime in Geraldton is predominantly diurnal with an average tidal range of 0.5 metres. Tide driven currents are of little significance.

Longshore currents generated by wind waves arriving at an angle to the shore are active in the littoral zone.

2.3 COASTAL PROCESSES

A complex of processes has acted in the past to form the coastal features that are observed today. The coastal belt is a very dynamic system often subject to rapid changes over relatively short periods of time. Natural coastal processes that have acted in the past will continue to act in the future. For this reason it is important to have an understanding of coastal processes, and the ways in which human activities may modify them.

The main coastal processes operating in Greenough are:

- breakdown of outer reefs through the action of swell waves, and onshore transport of erosion products;
- longshore transport of sand in the surf zone under the influence of swell waves;
- longshore transport of sand in the surf zone under the influence of wind waves;
- wind-driven transport of sand inland;
- seasonal offshore-onshore movement of sand in the nearshore zone.

2.3.1 Swell-induced transport

The breakdown of outer reefs through the action of swell waves has resulted in a perforate series of reef chains in the offshore zone. These offshore features in turn modify incoming swell waves by diffracting and reflecting wave energy. The resulting patterns of divergence and interference determine sites of deposition and erosion in the nearshore zone. Swell waves striking sandy beaches at an angle results in longshore transport of sediment. In the long term, this process has produced sandy shores parallel to the incoming diffracted swell patterns.

2.3.2 Wave-induced transport

Superimposed on the swell-induced transport regime is sediment movement (littoral drift) generated by local wind waves. These littoral currents drive sediment to the north during summer and to the south during winter. Northward littoral drift is dominant so there is a net movement of sand in this direction along the coast.

2.3.3 Wind transport

Inland transport of sand from the beach zone has been responsible for the formation of transgressive parabolic dunes which are generally oriented north-south parallel with the dominant wind direction. Sand arriving on

beaches is subject to inland transport by onshore winds unless trapped by vegetation to form a foredune.

2.3.4 Beach sand cycle

The seasonal nature of the wind wave and swell regime causes sand to be eroded from sandy beaches and dunes during winter and stored in the form of an offshore bar. During summer, the sand on the bar is transported onshore to reform the beach and dune system. Dune vegetation plays a vital role in the trapping and holding of sand to form a foredune, so that a balanced beach sand cycle is maintained (see Photograph 1).

Photo 1: Tarcoola - Foredune Vegetation

2.3.5 Coastal sediment budget

If there is a net loss of sediment from the beach zone, for example through the action of inland wind transport, then the shoreline will retreat unless sand is being supplied from another source. Eroding or eroded sandy beach coastlines are typified by such features as narrow beaches, the absence of a foredune, cliffed or steeply sloping seaward facing dunes and exposed limestone country rock (Photograph 2).

Conversely if there is a net gain of sediment to the beach zone then the shoreline will advance resulting in beach ridge formation as sand is trapped by vegetation behind the beach. In the long term this process has lead to the growth of beach ridge plains such as Point Moore in Geraldton.

There is currently no significant input of sand from offshore entering the nearshore coastal sediment system. This means that most sandy beaches within the Greenough Shire are relatively stable or eroding slowly. There is potential for long term erosion at sites where sediment is being lost. Human activities can modify natural coastal processes and produce changes in the patterns of erosion and deposition on sandy beaches.

Photo 2: Lucys Beach

2.4 TERRESTRIAL BIOTA

2.4.1 Vegetation

Vegetation within the study area is part of the Greenough system which is associated with the coastal limestone between Kalbarri and Dongara. The system forms part of the Irwin Botanical District within the Southwestern Botanical Province described by Beard (1976).

Vegetation within the coastal region is broadly associated with the geomorphology with thickets of *Acacia rostellifera* and *Melaleuca cardiophylla* on rocky ridges, *Acacia-Banksia* scrub on sand covered limestone and *Acacia rostellifera* low forest on the alluvial flats.

The coastal sand dunes within the study area support dune species typical of the Greenough System, with *Spinifex longifolius, Atriplex isatidea* and *Olearia axillaris* commonly occupying the seaward side of active foredunes. *Cackile maritima* and *Salsola kali* are often found on incipent foredunes. *Olearia axillaris* and *Scaevola crassifolia* typically form an open scrub on inner dunes, generally accompanied by scattered shrubs of *Acacia rostellifera* low forest, associated with which are a variety of understorey species. Common understorey species include *Rhagodia baccata* and *Acanthocarpus preisii* whilst *Euphorbia terracina* is frequently found in disturbed areas.

There is some local variation in this general sequence and four vegetation transects from sites along the coastline are included to illustrate this (Figure 2).

2.4.2 Mammals and birds

The study area supports a comparatively limited mammalian community with only seven species being recorded by the Western Australian Museum. This apparent paucity is supported by recent work in the study area and adjacent reserves (McMillan and Foulds, 1980; Chapman et al, 1977; Crook et al, 1984) which also reported a very limited mammalian diversity. Overall, nine species have been

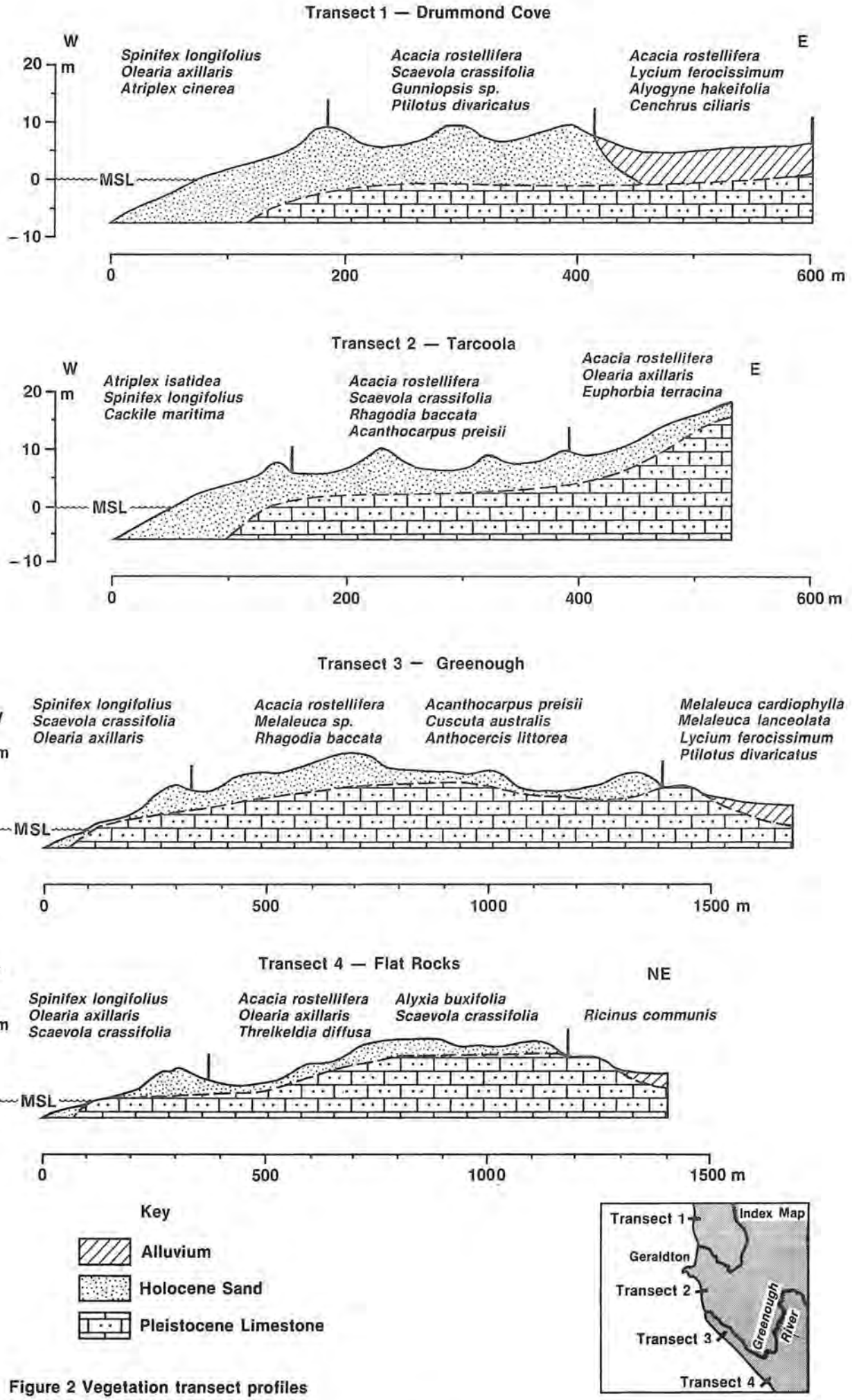


Figure 2 Vegetation transect profiles

observed but a further thirteen species, including five species of bats, are thought likely to extend their range into this area. A schedule of mammals is included in Appendix 2.

In contrast to the mammalian community, the study area is comparatively rich in birdlife with sixty-four species recorded during the survey by McMillan and Foulds. Similar diversity was also found during studies by Chapman and by Crook, suggesting an extensive avian community in this region. Records at the Western Australian Museum indicate no endemic species in the area but the passerine birds Calamanthus *(Sericornis fuliginosus)* and the White-browed Scrub-wren *(Sericornis frontalis)* are regionally confined. The Samphire flats, adjacent to Devlins Pool on the Greenough River, provide nesting sites for both the White-Headed Stilt and White-fronted Chat as well as a haven for a number of species of wading birds.

2.4.3 Reptiles and amphibia

The reptilia and amphibia (herpetofauna) of the Greenough coastal region were recently surveyed as part of a larger study of the coastal area between Balline and Green Head. The study area extended some 30-50 kms inland and 50-70 kms offshore to include the Houtman Abrolhos islands. A report of this study was published in the Records of the Western Australian Museum (Storr et al, 1983).

Ninety-six species and subspecies were recorded during this study, twenty-six of which were either observed specifically within the coastal zone of the Greenough Shire or are considered to inhabit a range extending into that area. Further studies (Chapman et al, 1977; McMillan and Foulds, 1980) have confirmed many of the observations mentioned above, indicating that the study area supports a relatively diverse herpetofaunal community.

Many of the observed species are considered rare or uncommon in the region but not to the point where their status is seen as endangered. Present knowledge of the herpetofauna indicates no endemic species on the coastal strip but certain specimens including the agamid lizards *Amphibolurus minor minor* and *Lophognathus longirostris* and the skinks *Egernia kingii, Lerista distinguenda* and *Morethia lineoocellata* are considered regionally confined to this area.

A schedule of species observed or likely to be found in the study area is included in Appendix 3.

2.5 MARINE BIOTA

2.5.1 Fish

The waters adjacent to the Greenough coastline are partially protected by an extensive reef which extends discontinuously from the northern to the southern limits of the study area. Between the shoreline and the reef, seagrass meadows of *Amphibolis antarctica* support a rich and diverse community of fish species whilst meadows of Ecklonia are found near African Reef and off Cape Burney. Much of the information regarding this region has been obtained from local fishermen but this has recently been extensively supplemented by a study of South-Western Australian fishes conducted by the Western Australian Museum (Hutchins and Thompson, 1983).

Among the more common species caught by amateur fishermen is Tailor *(Pomatomus saltator)* which is relatively abundant along the entire coastline but particularly common in the vicinity of Flat Rocks. Good catches of Whiting and Mulloway may be obtained at Drummond Cove with the latter being also found off Cape Burney. African Reef is a popular locality for anglers seeking Jewfish,

Coral Trout (Harlequin Fish) and Baldchin Groper with Coral Trout, Baldchin Groper and Pink Snapper commonly reported by fishing boats up to 6 km offshore. Amateur fishing catches may also include a number of minor species including Silver Bream, Australian Herring, Flathead, Samson Fish, Skipjack Trevally and Cobbler. This list is by no means exhaustive but illustrates the rich variety of species inhabiting the nearshore waters. A region within the reef extending from Cape Burney to approximately 2 kms south of Port Grey is regarded as an important fish nursery for many of the species referred to above and a further breeding ground for a number of species is located in the Greenough River estuary.

Catches by commercial fishing vessels are dominated by Snapper and Westralian Jewfish, with minor catches including various species of Cod, Shark, and Parrot Fish. A list of the more common fish species inhabiting these waters is included in Appendix 4.

2.5.2 Invertebrate wildlife

The coastal waters adjacent to the study area support an extremely rich and diverse invertebrate community, many of which are associated closely with the seagrass beds growing in this area.

Commercial interest is centred on the Western Rock Lobster *(Panulirus longipes)* which inhabits limestone and coral reefs out to the edge of the continental shelf, and commercial exploitation of this crustacean is a significant regional industry. Other invertebrates of commercial interest include the Saucer Scallop *(Amusium balloti)* and a species of Abalone *(Haliotis roei)*.

Although no exhaustive documentation of invertebrates has been carried out, studies in the area (Joll, 1984; Joll and Phillips, 1984; Slack-Smith, pers. comm.) reveal an extremely rich variety of invertebrates, including species of polychaete worms, bivalve molluscs and gastropods. Many small crustaceans such as isopods, amphipods and crabs (particularly *Halicarcinus* sp.) are also found, as well as echinoderms and a number of sponges.

Most of the organisms referred to above form part of the diet of the Western Rock Lobster and are thus an integral factor in the continued viability of this important industry.

2.6 CULTURE AND HERITAGE

2.6.1 Aboriginal sites

In his study of Aboriginal tribes in Australia, Tindale (1974) records the presence of one tribe in the study area, the Amangu, which ranged from the Chapman River area in the north to Hill River in the south and extended eastwards to the vicinity of Mullewa, Morawa and Carnamah.

Historical evidence of Aboriginal settlement or occupation can take many forms, but Aboriginal sites may be broadly classified into one (or both) of two overlapping divisions - ethnographic or archaeological. Ethnographic sites are those for which first-hand Aboriginal comment is available and include sites which are recalled by people today or have been documented in conjunction with people in the past. Archaeological sites contain physical evidence of Aboriginal occupation, examples of which are burial sites containing skeletal material, engravings or paintings in the open or in rockshelters, ceremonial sites of mythological significance, artifacts associated with day-to-day living, and shell middens. Middens being

stratified mounds of shell fragments, ashes, hearth stones and other debris which, when excavated, are a valuable source of information on Aboriginal settlement.

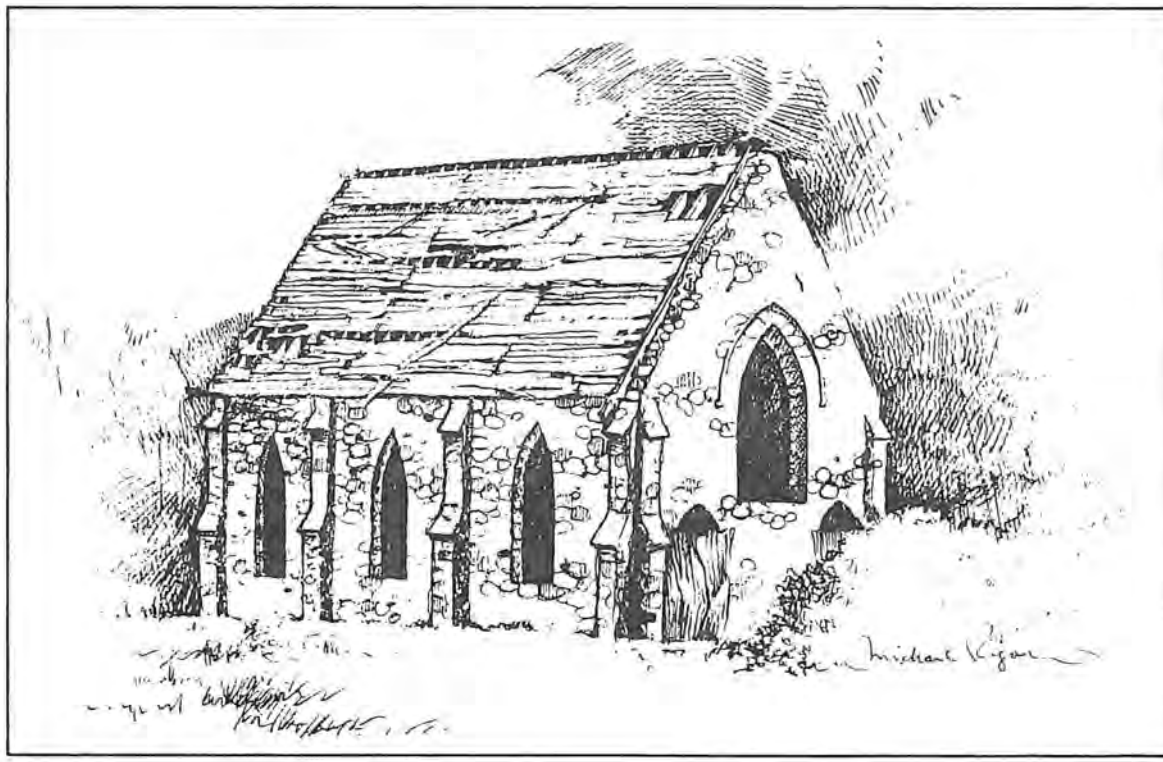
Whilst little ethnographic or archaeological work has been carried out in the study area, a number of Aboriginal sites have nevertheless been registered by the Western Australian Museum's Department of Aboriginal Sites. Among these are burial sites containing skeletal material, artifact material and shell middens.

The presence of water and the adjacent coast suggest that the Greenough River alluvial flats were a favourable environment for early Aboriginal occupation. A recent transect survey (Veth and Quartermaine, 1984) suggests considerable prehistoric habitation by Aborigines in this area and it is felt that excavations of these old alluvial soils could reveal stratified archaeological material. Some support for this view is provided by Pearce (1982) in which a survey at Oakagee River, approximately 25 kms north of Geraldton, revealed fifteen archaeological sites along the coastal portion of the river. Such intensive occupation may well be typical of the major drainage systems of this region and there is little doubt that further work within the study area will reveal many additional sites of cultural and scientific significance.

2.6.2 Historic sites - non Aboriginal

The Greenough district derives its name from the Greenough River, discovered by Lieutenant George Grey in 1839 during a forced march from the Murchison River to Perth. In the 1840's, a systematic exploration of the district was made by the brothers A.C. and H.C. Gregory, and a small number of settlers took up land on the Greenough Flats during the following decade. The rich alluvial flats surrounding the Greenough River proved to be extremely fertile and the region rapidly became an important grain producing area.

The Greenough Front Flats contain a rich legacy of historic buildings which serve as reminders of those pioneer days (see Sketch 1). The Greenough



Historic Hamlet, although located outside the study area, is an important focal point of cultural preservation and successfully preserves the atmosphere and character of the early settlement. Numerous other buildings of historic interest are located within the Greenough Flats region of the study area and their locations are indicated on Map 3. A schedule of historic places is indicated in Appendix 5.

2.6.3 Landscape

In 1977 Margaret A. Feilman and Partners, Architects and Town Planners prepared a report entitled "An Historical Survey of the Front Flats, Greenough W.A. for The Shire of Greenough", with funds provided by the National Estate. The report identifies the value of the Greenough district's landscape and recommends the creation of a landscape protection area as follows:

> *The particular character of the Front Flats extends to include the whole of the landscape from the shore line of the Indian Ocean, across the dunes to the rich agricultural flats with the Greenough River winding northwards to the sea, and up the rise on the eastern edge to a limestone ridge, uncultivated, which separates the Front Flats from the Back Flats.*
>
> *The Landscape Protection Area will extend from the shore line on the west to include the top of the ridge on the east, and from the boundary of the Shire in the south to the point of entry of the Greenough River into the sea in the north.*
>
> *The objective of such a proclamation is:*
>
> *(a) to preserve the existing character of the dunes, the limestone ridge and the Greenough River particularly between the Bootenall spring and the sea.*
>
> *(b) to retain the agricultural character of the cultivated or humanised area of the Flats, and*
>
> *(c) to conserve, ie. preserve, restore and rehabilitate, the buildings that remain from the first days of settlement on the flats, but in such a way that new buildings or alterations to the existing buildings are permissible provided the new development respects and reinforces the visual character of the old.*

There can be no objective definition of landscape quality, however there are some general principles which can be applied. Variety or contrast, and harmony are both important elements of landscape appreciation (Seddon, 1974).

The impact of natural forces is apparent along the entire Greenough coast. These forces have moulded the rivercourses, coastline and dunes of the Greenough district.

The physical diversity of the region is complemented by a cultural landscape of some richness. The historic settlement and buildings demonstrate the long occupation of this area. One is acutely aware that pioneers once lived and worked here.

2.7 EXISTING FACILITIES

A number of facilities have been developed in the study area to provide services for local residents, tourists, and the farming and commercial community.

2.7.1 Roads

Much of the study area is serviced by roads, streets and unsealed tracks which provide access to large areas of the coast. Existing roads, streets and tracks, as interpreted from 1978 aerial photography, are shown on Map 3. Numerous other informal tracks used by pedestrians and off-road vehicles, exist in the coastal dunes. Most of these were either not identifiable from aerial photography, or were constructed since the 1978 photographs were taken.

2.7.2 Car parking

Car parking is available at several locations along the foreshore and parking facilities are maintained and progressively upgraded by the Shire Council. Existing parking areas are shown on Map 3.

2.7.3 Boat launching facilities

At present three informal boat launching areas exist at Drummond Cove, the locations of which are shown on Map 3. In addition to these designated areas, informal boat launching currently takes place at the southern end of Tarcoola beach and at the mouth of the Greenough River, where beach access is provided for four-wheel drive vehicles.

2.7.4 Beach access

A number of formal pedestrian access paths are provided at various locations along the coastal strip and these are maintained and progressively upgraded by Council. There is, however, considerable uncontrolled beach access and numerous informal tracks exist across the coastal dunes.

Controlled beach access for vehicles is provided at Drummond Cove, Tarcoola beach and the mouth of the Greenough River. As with pedestrian tracks, a proliferation of informal vehicle tracks radiate out from established access points, particularly in the parabolic dunes south of the Greenough River mouth.

Vehicle access points and tracks are shown on Map 3.

2.7.5 Toilet facilities

Public toilet facilities have been constructed in association with car parks at three locations within the study area:-

. Park Place, Drummond Cove

. Glendinning Park, Tarcoola

. the Greenough River mouth

The location of these facilities is shown on Map 3.

2.7.6 Tourist accommodation

Some tourist facilities exist within the Shire of Greenough, however most accommodation in the district is located in the Town of Geraldton. Facilities within the Greenough Shire include the Greenough Resort Hotel on Greenough River Road and two caravan parks; the Greenough River Mouth Caravan Park on the Greenough River, and the S-Bend Caravan Park located on Brand Highway some 5 km south of the Greenough Historic Hamlet. These, together with 21 hotels, motels and caravan parks in the Geraldton township, provide a considerable resource for tourism within the region.

In addition there are two Crown reserves vested in the Shire of Greenough for the purpose of camping (reserves 24420 and 7298).

2.8 OPPORTUNITIES AND CONSTRAINTS

Recognising both opportunities (resources) and constraints is vital for an integrated and effective approach to resource management. Resources offer opportunities to provide for human needs while the nature of the environment constrains the level of use that can safely occur without loss of environmental quality.

The exploitation of natural coastal resources in the Greenough Shire is increasing. This management plan will assist in guiding future development and use of these resources.

2.8.1 Resources

The study area has the following significant resources:

- a productive economy based on agriculture, commercial fishing and tourism;
- a management infrastructure based on the Shire of Greenough, and various State and Commonwealth authorities;
- sites of cultural and historical interest;
- proximity to the Geraldton regional centre;
- a well-developed system of roads and an airport that provide access from the rest of the State;
- safe moorings for small boats;
- attractive natural coastal landscapes that exhibit a variety of sandy and rocky shorelines;
- a natural ecosystem comprising semi-arid coastal dune vegetation and important fish and wildlife resources;
- a major river (the Greenough) that provides impressive stretches of sheltered water.

2.8.2 Constraints

Use constraints which influence planning and management in the Greenough area include:

- existing use patterns and planning procedures;
- conflicting land uses within the coastal zone;
- a harsh summer wind regime and climate that makes establishment of vegetation difficult;
- Holocene dunes that rely on vegetation cover for their stability;
- a coastline subject to local variations in shoreline position over time;
- limited development and management funding.

3. RESOURCE USE

The Shire of Greenough exhibits extensive and often spectacular stretches of coastline which attract a wide range of recreational and commercial uses. The coastal zone is popular for such activities as surfing, swimming, sightseeing, fishing and off-road vehicle use. The waters off the Greenough coastline support a thriving rock lobster industry. It is important to understand existing and projected use patterns in order to provide effectively for these demands in the future.

3.1 RESIDENTIAL DEVELOPMENT

Demand for residential development in the Greenough Shire is growing, with the recent development of Tarcoola and proposed developments at the mouth of the Greenough River and along the northern coastline between Geraldton and Drummond Cove. This demand for new coastal subdivisions is largely in response to expansion of the Geraldton township.

3.2 TOURISM

Tourism makes a significant contribution to the economy of the region. In 1983 for example the total number of arrivals at hotels, motels, guest houses and caravan parks in Geraldton and the Greenough Shire numbered 113 800 persons. Tourism also places a high recreational demand on the coastal belt since the majority of tourist-related activities revolve around the use of coastal resources.

A publication by the Western Australian Tourism Commission entitled Domestic Travel in Western Australia July 1982 - June 1983 indicates the pattern of tourist use in the area. The Greenough Shire is part of the Mid West tourism region which was the destination for 343 000 trips or 8.3% of total domestic trips in Western Australia during the study period. January is the most popular time of the year for stays in the Mid West region, largely reflecting the influence of school holidays. September/October is also popular.

3.3 HOLIDAY ACCOMMODATION

At the time of drafting there were 17 hotels, motels and guest houses and seven caravan parks in Geraldton and the Greenough Shire. This represents a potential accommodation capacity of about 2000 persons however average annual occupancy rates are significantly less than 50%.

Other popular forms of accommodation include staying with friends or relatives and private or rented holiday houses and units.

3.4 ACCESS

Demand for greater access along the coastline has led to a proliferation of vehicle tracks and pedestrian paths radiating from established access points. The popularity of off-road vehicles has been a major contributing factor towards this situation.

3.5 HERITAGE TRAILS

Heritage Trails funded by the Bicentennial Authority have been proposed for a number of locations throughout the state including the mouth of the Greenough River. The nature of the proposed trail on the Greenough River mouth has not yet been finalised however it will probably be in the form of a walking and/or riding trail taking in features of the natural environment along the banks of

the Greenough River. A Heritage Trail will attract more people to the area and possibly provide better access to sites of recreational and aesthetic interest. There is potential, however, for a heritage trail to be misused, for example by trail bike riders.

3.6 SMALL BOAT LAUNCHING

Areas for small boat launching are maintained at Drummond Cove (Photograph 3). Informal boat launching also takes place along other parts of the coastline including the mouth of the Greenough River and along the beach between Tarcoola and South Gates (see Photograph 4). There are plans to upgrade existing facilities at Drummond Cove in the near future.

Photo 3: Drummond Cove - Boat Launching

Photo 4: South Gates

3.7 COMMERCIAL FISHING

The most important commercially exploited marine species in the Greenough district is the Western Rock Lobster. During the 1982-83 season the total catch taken by the 360 boats working out of Geraldton and the Greenough area amounted to 930 tonnes out of a Western Australian total of about 12 500 tonnes.

The region also supports an active wet line commercial fishing industry. Snapper and Westralian Jewfish are the main exploited species, however numerous other fish species are also taken.

3.8 MINING AND QUARRYING

Removal of sand, limestone and lime sand for building and road construction has taken place at various sites along the coastline. At present these activities only occur on a small scale.

There are no current mineral tenements in the area.

3.9 MARINAS AND HARBOURS

A number of possible sites have been considered for development of marina or harbour facilities along the Greenough coastline. These include a harbour at South Gates and a marina at the Greenough River mouth.

3.10 RUBBISH DUMPING AND LITTERING

Rubbish dumping and littering on the coastline is highly undesirable because of associated health risks, unsightliness and loss of beach amenity value. Fortunately this is not a widespread problem in the Shire at this stage.

3.11 SHACK CONSTRUCTION AND ILLEGAL CAMPING

Many people prefer the solitude and convenience of shacks and campsites on the coastline or may not be prepared to pay for established accommodation.

The settlement on Drummond Cove originated as a group of informal shacks and this area is now a Crown Reserve vested in the Shire of Greenough for the purpose of a beach camp resort. The only other shacks built on Crown Land within the study area are two shacks on the coastline south of Flat Rocks (see Photograph 5).

Bush camping is illegal within a 16 km radius of established caravan parks. The recreation survey discussed in section 3.14 below, however, reveals that a number of people camp at sites along the coastal belt.

3.12 AGRICULTURAL DEVELOPMENT

Existing agricultural land abuts the coastal zone mainly on the Greenough Flats to the south of Geraldton. The poorer land in the parabolic dune unit has discouraged most farmers from opening up this area for intensive grazing and cropping. It is known however that farmers occasionally run their sheep in the dunes.

3.13 POPULATION GROWTH

The permanent population of the Greenough Shire in June 1983 was estimated to be 4 810. At the same time the Town of Geraldton was estimated to have a population of 19 610. Both areas are experiencing steady population growth in

Photo 5: Shack on Crown Land

the order of 1-2%. As the population of the region increases there will be an associated increase in demand for recreation and accommodation along the coastal strip.

3.14 RECREATION SURVEY

A recreation survey of the Greenough coastline was carried out over the Australia Day weekend (January 26, 27 and 28) in 1985. The recreation survey was comprised of two parts - a survey questionnaire, and a vehicle count by aerial survey. A sample of the survey questionnaire is contained in Appendix 6, and a description of the methods and results of the recreation survey is contained in Appendices 7 and 8. The main conclusions are outlined below:

- a significant proportion of beach users are residents of the Town of Geraldton;

- many people appreciate the beaches along the Greenough coastline because of their remoteness and undeveloped nature, however there is demand for better facilities in some areas;

- commonly suggested improvements at particular locations include; clearing the weed at Drummond Cove; provision of beach shelters and toilet facilities at Tarcoola; closer shopping facilities and better access across the sand bar at the Greenough River mouth; and better access to the main fishing spot and unrestricted camping at Flat Rocks.

4. EXISTING PLANNING AND MANAGEMENT CONTROLS

For the purposes of this plan it is necessary to examine not only land and water along the coastline but adjacent lands whose future use and management may affect the stability as well as the environmental and aesthetic quality of the coast.

4.1 EXISTING TENURE

The study area is comprised of Freehold land, urban subdivisions, and unvested, vested and leasehold Crown Land (Map 3).

4.2 EXISTING ZONING

Land in the study area has been assigned a land use zone in accordance with Shire of Greenough Town Planning Schemes Nos 4 and 1A as shown on Map 3.

The majority of the study area is zoned for General Farming. There are also large areas set aside for urban development immediately north and south of the Town of Geraldton, and at the Greenough River mouth. Areas of land along the coastline and river have been allocated for recreation purposes, while land on and around the South Gates and Cape Burney drifts is zoned for Dune Preservation in recognition of the fact that these areas require special treatment.

4.3 EXISTING MANAGEMENT

The use of Freehold land within the coastal zone is controlled by the Greenough Shire Council through Town Planning Schemes Nos 4 and 1A. Also within the study area are a number of Crown and Freehold reserves which are vested in various authorities which care for, and use them, under specified conditions.

Council is directly involved in the management of foreshore reserves and Crown land, vested in the Shire, along the Greenough coastline. Council currently has three honorary rangers, based at Drummond Cove, the Greenough River mouth and Geraldton, who have the power to enforce Council By-laws.

5. PLANNING OBJECTIVES

The aim of coastal management is to facilitate the various uses associated with the coastal zone while ensuring that environmental quality is maintained. This can best be achieved through consideration of an area's natural attributes and its capacity to support certain uses, while taking into account the potential impact of natural forces and man-made developments. Effective management planning involves the allocation of appropriate uses to areas capable of sustaining these uses without significant environmental degradation.

5.1 POLICIES

The coastal belt needs to be regarded as a natural resource that can be used or abused depending on the attitudes that are adopted towards it. An important aspect of optimising the use of coastal resources is ensuring that elements of the natural environment are protected from unnecessary degradation. In this regard, Council should adopt the following policies:

- the coastal ecosystem will be maintained in as near to natural condition as possible;

- only uses that require a coastal location shall be permitted in the coastal zone.

5.2 OBJECTIVES

In line with the above policies, a number of broad objectives of coastal management can be identified. These objectives are:

- to facilitate appropriate developments in the coastal zone while maintaining the natural environment in an undisturbed state wherever possible;

- to stabilise and rehabilitate degraded areas;

- to minimise land use conflicts in the coastal zone.

This management plan outlines the principles of planning and management for the Greenough coastline at a regional scale. Comprehensive landscape designs at a project scale, which can be viewed by interested parties prior to approval, are also necessary for a rational and integrated approach to coastal management.

5.3 STRATEGIES

There are three principles which should be considered when planning for the Greenough coast:

1. Any developments should be considered in the context of the coastline as a whole.

2. The balance between natural forces and the human landscape should be maintained. People can be reminded of the power of natural forces by standing on long stretches of wild coastline, but this experience can easily be lost as a result of thoughtless man-made introductions, particularly buildings, roads, and motor vehicles. These introductions, must be limited to a few appropriate locations.

3. As outlined by Feilman and Partners (1977), every effort should be made to protect the existing character of the agricultural areas and dune systems, and their relationships must be preserved. New developments, such as houses, signs and tourist accommodation must be located and designed to retain existing landscape character.

5.3.1 Landscape systems

The study area can be conveniently subdivided into six landscape systems which are described in terms of their landforms, soils, vegetation, land use, accessibility and use constraints, in Table 2. This allows a more detailed treatment of landscape character and the activities which may degrade it. The systems include the urban, agricultural, stable dune, mobile dune, river and beach landscapes.

5.3.2 Resource allocation

The allocation of resources in the coastal zone is an important aspect of coastal management. Decisions should be based on the information outlined in Table 2, which includes aspects of the existing landscape character as well as the ability of an area to support certain uses. Conflicting or incompatible land uses can be separated by allocating areas for specific uses.

Priorities for allocation of land uses and financial resources should be based on long term planning as opposed to ad hoc responses to development applications.

TABLE 2 Landscape system characteristics

Landscape System	Landform	Soil	Vegetation
Urban	Beach ridges which result in a gently undulating topography, with some areas of parabolic dunes which are steeper.	Over drained sands which show some accumulation of organic matter.	Various introduced plants and remnant *Acacia* woodland.
Agricultural	Broad flat valleys comprised of alluvium and Pleistocene dune complex, with some areas of vertical relief.	Deep terra rossa soils.	Agricultural crops and pasture with occasional remnant trees.
Stable dune	Comprised of parabolic dunes, beach ridges, deflation basins and Pleistocene dune complex, this system has a varied and often prominent appearance.	Over drained sands usually with little or no soil profile development.	Primary and secondary dune species with some wooded areas. Height varies from a few centimetres to 10 metres.
Mobile dune	Active parabolic dunes and blowouts often resulting in features of considerable relief. Topography is determined by rates of erosion deposition.	Unconsolidated drift sands with a high calcium carbonate content.	Limited to isolated clumps of dune species.
River	Mainly Pleistocene dune complex and alluvium forming low undulating hills which are dissected by the river to form steep banks.	Over drained sands or alluvium.	Degraded *Acacia*, *Eucalypt* and *Casuarina* associations. In places agricultural grasses dominate as pasture or weeds.
Beach	Pleistocene dune complex basement or reefs, and Holocene beach sand.	Beach sand	Primary dune colonisers.

Land Use	Access	Constraints
Predominantly residential subdivisions.	Car, foot and possibly boat are all appropriate means of experiencing the landscape.	Parabolic dunes may be prone to soil erosion as a result of intensive development. Unnecessary clearing should be avoided.
Agricultural with a few residences.	This landscape system is best experienced by car.	The existing landscape character may suffer as a result of inappropriate developments.
Beach access, occasional grazing and cropping, and a few residences.	Car, off-road vehicle, and to a lesser extent foot, are all useful ways of viewing this landscape system.	Soils are dependent on vegetation cover for their stability. Roads and tracks should be carefully sited. Residential development is undesirable in some areas particularly the parabolic dunes where development should be restricted to hollows and gullies.
Some recreation, mainly off-road vehicles.	Mainly by off-road vehicle.	Unsuitable for development unless preceded by extensive stabilisation and soil conservation works.
Recreational (boating, waterskiing, fishing and picnicking) with some residential development at the river mouth.	Cars are an effective means of viewing this landscape system.	Agricultural expansion, poorly planned residential subdivisions or an increase in the number of unplanned tracks will intrude on this landscape.
Supports a wide variety of recreational uses.	Foot, off-road vehicle and boat are appropriate for experiencing this landscape.	Intolerant of most development. Spectacular views along the coastline should be preserved.

6. MANAGEMENT ISSUES AND RECOMMENDATIONS

6.1 LANDSCAPE MANAGEMENT

Council should undertake a management programme aimed at maintaining or improving existing landscape character. Appropriate management practices are outlined below. Specific site recommendations should be viewed as guidelines only, since alternative approaches may also exist.

It would be desirable for Shire to prepare a five year development plan outlining proposed projects to be undertaken in the coastal zone, and their objectives, priorities, staff requirements and cost estimates.

6.1.1 Access

Reasonable vehicle access is required at sites along the coastline to facilitate the various uses associated with the coastal zone. The number of vehicle access tracks to an area should be minimised, however, to lessen the impact on the coastal landscape and environment. Haphazard siting of tracks should be avoided.

There are several specific areas within the Shire of Greenough where issues relating to access need to be resolved. These are discussed below.

Tarcoola - There is currently conflict between the use of off-road vehicles and other beach activities, along the southern section of Tarcoola beach. The use of motorbikes, trailbikes, buggies and four-wheel drive vehicles has many antisocial aspects including excess noise and potential risks to other beach users and the coastal ecosystem.

The four-wheel drive access from Buchanan Place (Photograph 6) is used by amateur and professional fishermen as well as recreational off-road vehicle users to gain access to South Gates. This site is the only appropriate area where easy access to the beach can be obtained.

Photo 6: Tarcoola - Four Wheel Drive Access

Access from the car park south of Glendinning Road is difficult because of the high foredune along this section of the beach. It would be costly to keep a four-wheel drive access open because of drifting sands which would need to be periodically removed. Access south of the Tarcoola subdivision is complicated by the fact that this area is Freehold land over which Council has no jurisdiction.

Recommendations

The owners of Subdivided Victoria Locations 1945 and 5843 should be approached to investigate the possibility of using this land as an access to South Gates for fishermen and recreational off-road vehicle users and, subject to agreement, all vehicle access along Tarcoola beach should be prohibited.

. The four-wheel drive access from Buchanan Place should be retained to allow small boat launching at this site, however the access should be widened, where it enters Glendinning Road, to improve visibility.

. If access to South Gates across Freehold land cannot be arranged then Council should take action to have the whole of Tarcoola beach declared a prohibited area under the Control of Vehicles (Off-Road Areas) Act 1978 with exception for all licensed fishermen who would still be permitted access along the beach south of Buchanan Place.

. Access routes to the South Gates drift, other than along Tarcoola beach, should be adequately signposted and publicised. Care should be taken that recreational off-road vehicles are directed away from sensitive areas on the South Gates drift that are revegetating naturally.

Greenough River mouth There is a proliferation of four-wheel drive vehicle tracks along the stretch of coastline immediately south of Cape Burney. These are mainly used by fishermen to gain access to sites along the coastline. Access to this area is gained across the bar at the Greenough River mouth.

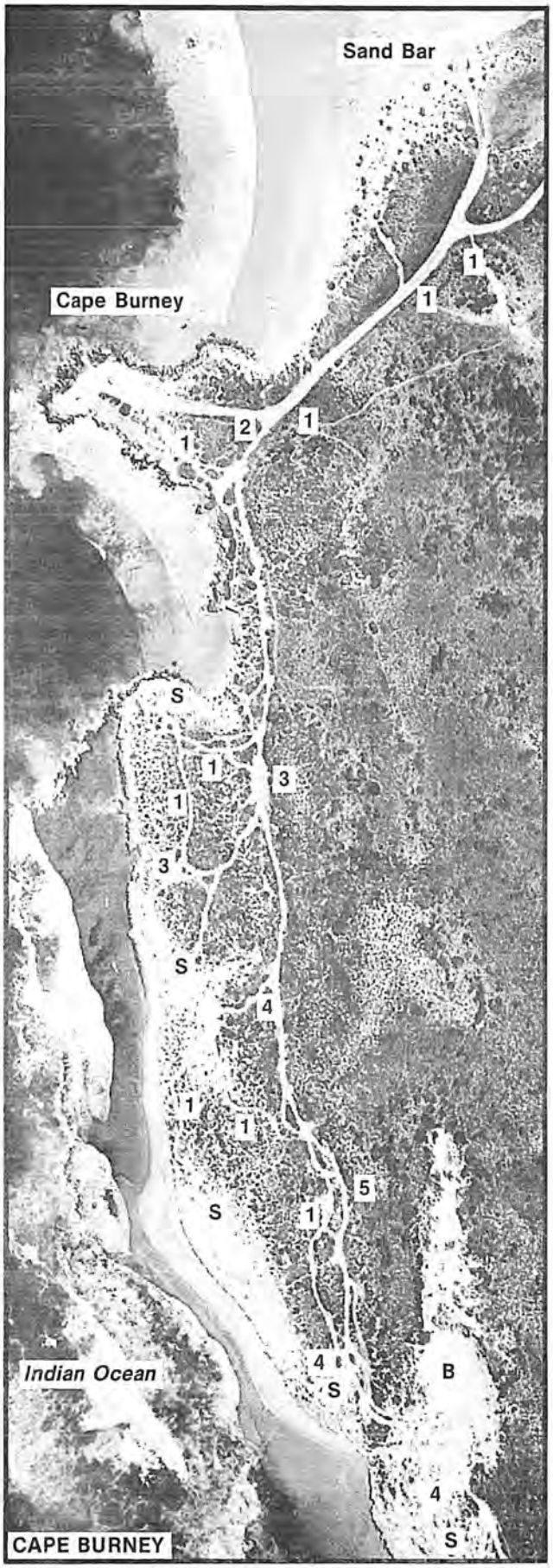
Access along this stretch of coastline needs to be critically reviewed. A main access route south from Cape Burney should be identified and improved to encourage its use. Alternative routes should be closed off by dumping sand, and signs should be erected, for example "Please Use Track".

Points where access is required to the beach should be identified. In many cases vehicle access at these points could be maintained, however, in other cases pedestrian access to the beach is more appropriate. Where a spur road off the main track gives vehicle access to the beach this should be signposted, for example, "Access to Beach". Pedestrian access paths should also be signposted, for example "Preserve Dune Vegetation - Please Use Paths". There should be small car parks constructed where pedestrian access paths are provided.

Recommendations

. Four wheel-drive access across the sandbar at the Greenough River mouth should be maintained. Laying of limestone rubble along parts of the access tracks may occasionally be required.

. Action should be taken to reduce the number of vehicle access tracks south of Cape Burney (Map 4) after consultation with the Lands and Surveys Department.



Map 4 Management Recommendations — Cape Burney

Key

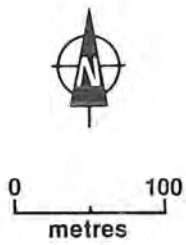
S Sandpatch

B Blowout

Management Recommendations

1. Desirable track closures.
2. Widen intersection.
3. Potential site for carpark and pedestrian access to beach.
4. Erect sign "Access to Beach".
5. Upgrade track to encourage use.

NB: Recommendations should be confirmed by detailed ground survey at relevant sites.



Greenough River There are also large numbers of tracks east of the Cape Burney drift which provide access to the west bank of the Greenough River. Many of these tracks are unnecessary and detract from the character of the natural landscape.

The number of access tracks can be reduced by closing off selected tracks and improving the standard of an appropriate access route. Access to locations off the main access track should be in the form of spurs, which do not provide through access, rather than branching access tracks.

Tracks can be closed by dumping of sand while regeneration of natural vegetation on closed tracks can be encouraged by laying of brush. Decisions regarding which tracks should be closed should be based on detailed ground survey and local knowledge.

Recommendation

. Council should adopt long term strategies aimed at reducing the number of vehicle access tracks along the banks of the Greenough River.

Flat Rocks area The rocky coastline south of the Greenough River mouth is popular for fishing and, to a lesser extent, surfing (see Photograph 7). This stretch of coastline is appreciated because of its peaceful and isolated nature.

Photo 7: Flat Rocks

Access to popular sites along the coastline should be managed and maintained in such a way that the environment and landscape of the area is not adversely affected.

Recommendations

. The level of access to sites along the coastline south of the Greenough River mouth should not be upgraded in the short term, except at locations which are actively managed to minimise the effect of human use pressure. This will ensure that the need for management of these areas is minimised.

. Access to the main fishing spot at Flat Rocks should be upgraded to facilitate use by conventional cars, since there is already considerable

demand for access to this site. This could be achieved by either improving the existing track which runs north along the coastline, or constructing a bypass about 250 m inland which would cross the dune ridge further north.

- The two access points where the old car park was located at Lucys Beach should be closed with boulders, and signs should be erected - "Road Closed - no entry to vehicles" (Map 5).

- Council should consider prohibiting vehicle access to blown out areas along the coastline between Flat Rocks and Jews Rocks, since alternative access already exists further inland.

6.1.2 Car parks

For an integrated approach to planning, it is essential that the provision of car parking is co-ordinated with the planning of vehicle access systems. Car parks should be located where vehicle access is provided to the beach.

People desire parking that is conveniently located close to the beach (see Photograph 8). It is more environmentally sound, however, to locate car parks behind a vegetated foredune and provide pedestrian access to beach areas.

Recommendations

- Formal car parking should be provided at sites along the coastline immediately south of Cape Burney (Map 4).

- There should be areas of car parking provided where there is formal access to off-road vehicle recreation areas at South Gates and Cape Burney. People could then use trailers to bring their trail bikes and buggies to these areas.

- Car parking should be provided in association with any picnic areas that are constructed (see Section 6.1.5).

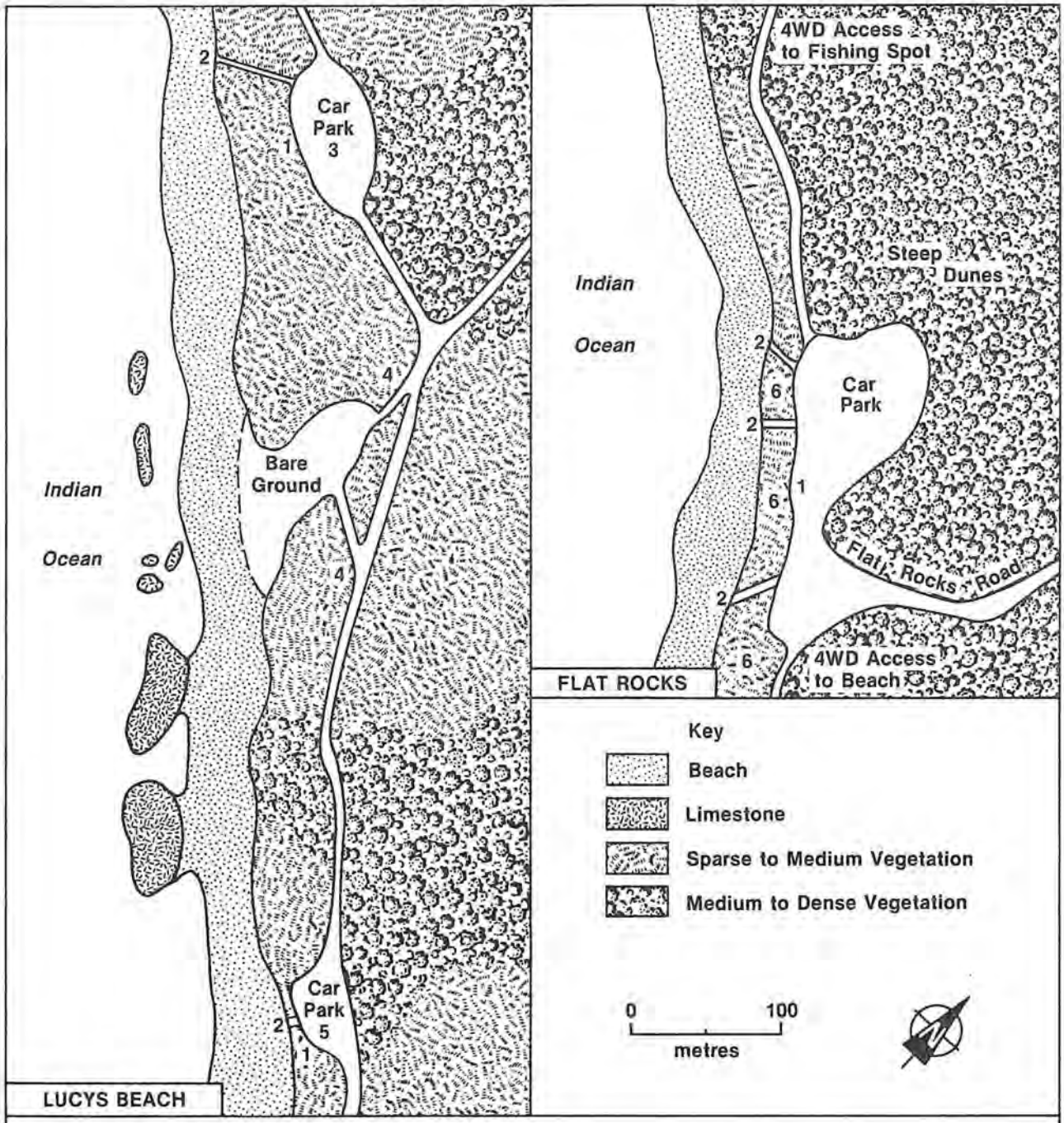
- Better car parking should be provided near the main fishing spot at Flat Rocks.

- The northern car park area at Lucys Beach should be upgraded (Map 5).

6.1.3 Pedestrian access

Pedestrian access paths to the beach protect dune vegetation from trampling and ensure that the coastal dune system is retained. Formal pedestrian access is particularly important at sites that experience the heaviest use. Pedestrian access systems at Drummond Cove, Tarcoola beach and the Greenough River mouth are adequate, however pedestrian access south of the Greenough River mouth, at Flat Rocks (see Photograph 9) and Lucys Beach, needs to be upgraded as levels of use increase.

The foredune area in front of the car park at Flat Rocks is already showing signs of degradation. Several post-and-rail access paths from the car park to the beach would relieve pressure on the dune vegetation at this site. This could be combined with brushing and planting to rehabilitate the foredune area. The existing log and boulder barrier could also be replaced by post-and-rail fencing to discourage access across the dunes. Signs should be erected that direct beach users to pedestrian paths, for example "Preserve Dune Vegetation - Please Use Paths".



Management Recommendations

1. Install post-and-rail fencing on seaward side of carpark.
2. Install beach access paths of gravel bounded by post-and-rail fencing, and erect signs "Preserve Dune Vegetation — Please use path".
3. Grade carpark area.
4. Close two access tracks with boulders and erect sign "Road closed — No entry to vehicles".
5. Provide a rubbish bin.
6. Brush and plant foredune area.

Map 5 Management Recommendations — Lucys Beach and Flat Rocks.

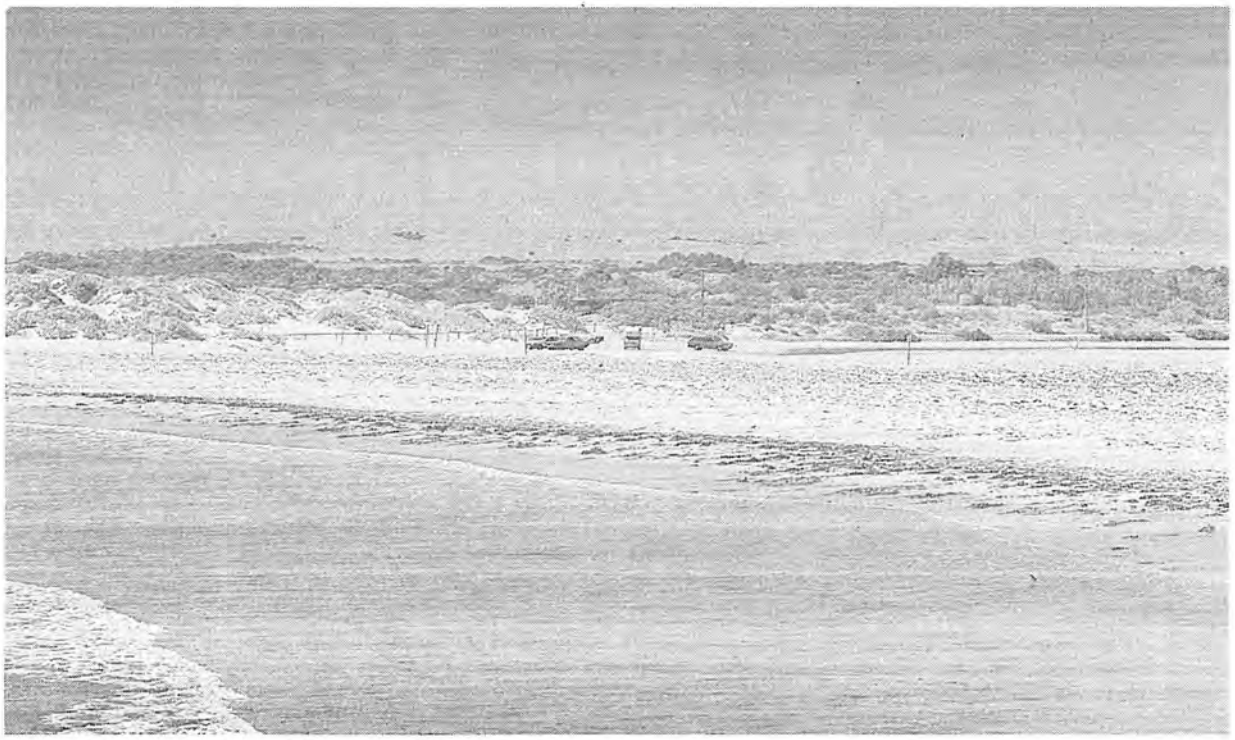


Photo 8: Greenough River Mouth - Informal Parking

Photo 9: Flat Rocks - Existing Management

Vehicle access to Lucys Beach has only recently been upgraded, and this site does not yet experience the same use pressures as Flat Rocks. Management practices similar to those outlined for Flat Rocks, (ie. post-and-rail fencing, erect signs, etc.) could be implemented at Lucys Beach to prevent trampling of the coastal dune vegetation. Pedestrian access paths at Lucys Beach would require steps down to the beach zone because of the steep foredune at this site.

Recommendations

. Pedestrian access systems at Drummond Cove, Tarcoola beach and the Greenough River mouth should be maintained.

. Formal pedestrian access to beaches at Flat Rocks and Lucys Beach (Map 5) should be provided as the necessary resources become available. Priority should be given to Flat Rocks.

6.1.4 Launching facilities

Existing provision for "low key" launching of small boats is adequate for the present. The close proximity of Geraldton probably precludes the development of launching facilities for commercial fishing boats, within the Shire.

If major development proceeds at the Greenough River mouth, then constructed boat launching facilities will be required at this site. There will also be pressure for the upgrading of access and launching facilities at Drummond Cove as accommodation in the area increases. The long term development plans for an area should be considered when deciding the location and design of boat launching facilities.

Recommendations

. Four-wheel drive access to the beach should be maintained at sites where informal small boat launching currently takes place.

. Boat launching facilities should be upgraded at particular sites as the demand for these facilities increases in the future.

6.1.5 Picnic areas

Picnic and/or barbecue facilities should be provided at sites of scenic or recreational significance within the Shire. Picnic areas should be adequately signposted and should include car parking, rubbish bins, tables and benches, and possibly barbeques at appropriate locations. Where barbecues are provided a wood supply needs to be maintained and signs should be erected - "No Fires Except in Fireplaces Provided". Where no barbecues are provided there should be signs - "Lighting of Fires Prohibited".

Picnic areas should preferably be located in sheltered and shaded areas. Planting of trees could be undertaken at appropriate sites to provide natural shading and shelter. Constructed shelters that blend into the existing landscape should be considered at exposed sites near the coastline.

A well-planned picnic area on the river foreshore at the Greenough River mouth would be an attraction to this area. In addition there are several cleared sites where Devlins Pool Road runs parallel to the Greenough River that could be upgraded and developed as scenic picnic areas (see Photograph 10). Beach shelters at Drummond Cove, Tarcoola beach and the Greenough River mouth may be appropriate.

Recommendation

Council should investigate the possibility of developing picnic areas on the Greenough River at sites along Devlins Pool Road.

Photo 10: Greenough River - Potential Picnic Site

6.1.6 Bush camping

The recreation survey in section 3.14 indicates that bush camping already takes place along the coastline within the Greenough Shire. It is desirable to limit bush camping to certain landscaped and managed locations in order to control waste disposal and potential soil erosion problems. The coastline around Flat Rocks appears to be the most popular area for bush camping, including sites at Duncans Pool, Flat Rocks and Twomeys. Areas at Lucys Beach and the Greenough River mouth may also be suitable for bush camping.

Recommendations

- That Council approach the Under Secretary for Lands regarding the possibility of creating a number of reserves, vested in the Shire of Greenough, for the purpose of Camping and Recreation.

- No informal bush camping should be allowed except within reserves specifically for that purpose.

6.1.7 Shack construction

In general, low-key beach shack construction does not pose a significant risk to the coastal environment provided that shacks are suitably sited and managed. The major problems with haphazard shack construction in the coastal zone are the lack of sanitation and waste disposal facilities and the risk of dune erosion.

Recommendation

- No further beach shack construction on Crown land should be permitted along the coastal strip except on reserves vested for that purpose.

6.1.8 Waste disposal

Rubbish bins are already provided at most sites of heavy use along the Greenough coastline. They should also be provided in association with any car parks, picnic areas and camp sites that are developed in the future.

Rubbish bins should be cleared regularly during the holiday season, and as required at other times of the year.

Recommendations

- A rubbish bin should be provided at the small southern car park at Lucys Beach (Map 5).
- Rubbish bins should be provided above the high water mark at South Gates for use by professional fishermen.

6.2 URBAN DEVELOPMENT

It is possible that inappropriate siting and design of new subdivisions in the coastal belt may incur high management costs. For this reason, controls should be placed on new development at the subdivision stage to ensure that degradation of the coastal environment is minimised.

Urban development in the coastal zone should be seen in the context of the long term evolution of the coastline as a whole. Proposals that consider the development or maintenance of environmental quality should be favoured. Ideally, developments should be compatible with the existing character of the coastal environment.

Areas of blowout activity (see Photograph 11) are particularly sensitive to human use pressure. Map 2 indicates the prevalence of small scale active parabolic dunes and blowouts along the coastline south of the Greenough River mouth. Subdivision or development along these sections of the coast is highly undesirable because of the fragile nature of these areas.

Photo 11: Blowout Activity South of the Greenough River Mouth

Recommendations

. It is recommended that Council require that any plans for urban development in the coastal zone contain a detailed environmental evaluation including such factors as site stability and projected levels of use, and a rationalisation of public open space and vehicle and pedestrian access systems.

. It is further recommended that council seek advice directly from the Department of Conservation and Environment before finally approving any plans for urban subdivision within the coastal belt.

. Development or subdivision along the coastline south of the Greenough River should not be permitted in the short term.

. Strict controls should be placed on development in potentially unstable areas, particularly south of the Greenough River mouth. Any development that is permitted in the future should be concentrated in highly managed 'development nodes', and it should be acknowledged that maintenance costs in these areas may be high.

6.3 TOURISM

Tourism should be provided for in a manner that avoids both environmental degradation and conflict with residents. Tourism can be encouraged by ensuring that existing services are properly managed (eg. litter control, access, shade, tables, chairs, etc.) and upgraded as necessary.

6.3.1 Accommodation

It is difficult to predict increases in demand for tourist accommodation in the region. A significant proportion of tourists using facilities and beaches within the Shire of Greenough are accommodated in Geraldton, however there is still scope for holiday and resort development in the Shire.

The two existing caravan parks are conveniently located near attractive coastal areas, and represent important tourist accommodation facilities. Development of suitably located, designed and managed chalets and flats in the coastal strip may also be appropriate.

6.3.2 Siting and design of tourist facilities

Wherever possible tourist accommodation and facilities should be in attractive locations, with ready access to a safe swimming beach or pleasant views. Development should be centralised in order to reduce the impact on the natural amenity of more remote areas. Development proposals should consider sand dune stability, aesthetics, wildlife and vegetation, beach quality and the location of existing improvements.

Ideally, tourist development nodes near the beach should include:

- an area for appropriate holiday accommodation;

- a public access system comprising roads, car parks and properly fenced paths to the beach;

- a foreshore reserve which will protect the beach and any associated sand dune systems and enable natural coastal processes to occur without threatening developments;

- an area of public parkland which can be improved as the need arises.

The mouth of the Greenough River currently shows the greatest potential for development as a tourist node.

Recommendation

The development of tourist accommodation and facilities should be encouraged at appropriate sites.

6.4 INDUSTRIAL AND COMMERCIAL USE

In many coastal areas industrial and commercial activities are an important aspect of resource use, however these activities should not be overemphasised. The Geraldton foreshore is an example of an area which historically had great potential for recreational development but where industrial and commercial uses were allowed to predominate to the exclusion of many other activities.

Recommendations

Industrial and commercial uses of the coastal environment should not be permitted except where it can be demonstrated that an activity requires a coastal location, and that the impact on the coastal landscape will be minimised.

Where industrial and commercial developments are allowed to take place, these should be concentrated in nodes rather than be allowed to develop as ribbons along the coastline.

6.5 MARINAS AND HARBOURS

The economic benefits of marina or harbour facilities to the region are obvious. Such a feature would act as a focal point for a wide range of commercial and recreational activities, and could form the basis of a well planned resort-style development.

Unfortunately, structures such as marinas and harbours interfere with natural littoral drift patterns along the coastline causing accretion of sandy beaches on the updrift (southern) side of the structure and erosion on the downdrift (northern) side. This process may result in long term changes in shoreline position not just in the immediate managed environment of the marina or harbour but also along more remote stretches of coastline.

The financial and environmental costs of marina or harbour construction need to be weighed against the economic benefits that would accrue from such a project. It is beyond the scope of this study, however, to evaluate the suitability of sites at South Gates and the Greenough River mouth for harbour or marina facilities, or the long term effect such features would have on adjacent areas of coastline.

The preparation of a concept plan for the long term development of land owned around the Greenough River mouth would provide a useful basis for planning in this area. Studies into the feasibility of marina and harbour facilities at the proposed sites would be required, as well as projected effects on the physical and biological processes in the Greenough River and along the coastline. This should include the effects, for example on flooding, fisheries and fauna, of opening the Greenough River to the sea. Detailed research into the dynamics and potential for stabilisation (see Section 6.7) of the South Gates and Cape Burney drifts would also be required.

Recommendations

- Any proposed marina or harbour developments should be preceded by adequate planning and an evaluation of their effect on the coastal environment.

- It is recommended that a special report be initiated on the development potential and constraints of the area around the Greenough River mouth. This work could be carried out by consultants and/or appropriate government departments.

6.6 COASTAL PROCESSES

As already mentioned, sandy beaches within the Shire are generally relatively stable or eroding slowly. The only exception appears to be the beach between South Gates and Tarcoola. This beach has been prograding steadily in recent years as a result of sand from the South Gates drift being transported northwards in the surf zone to be deposited on sandy beaches (Maps 6a and 6b).

Sandy beaches may be subject to rapid changes in shoreline position over time as a result of variations in sediment supply. These changes are usually cyclical but may represent long term shifts in shoreline position. Any developments sited behind sandy beaches should allow for the dynamic and often unpredictable nature of sandy beach coastlines. A coastal buffer zone made up of a well-vegetated dune system should be maintained between the beach and any new developments. The width of this buffer strip is dependent on the nature and stability of particular sandy beaches. Areas with a potential for shoreline recession would require the largest buffer width.

Rocky coastlines generally represent sandy beaches that have eroded back to the point where coastal limestone has been exposed. Rocky coastlines are not subject to the erosion rates that can affect sandy beaches since coastal limestone is comparatively resistant to erosion. Thus rocky coasts are relatively stable. In some cases, however, the dune system is established on a rocky base which may not fully protect the beach. These rocky coastlines may be vulnerable to erosion particularly during episodic cyclones or storm events.

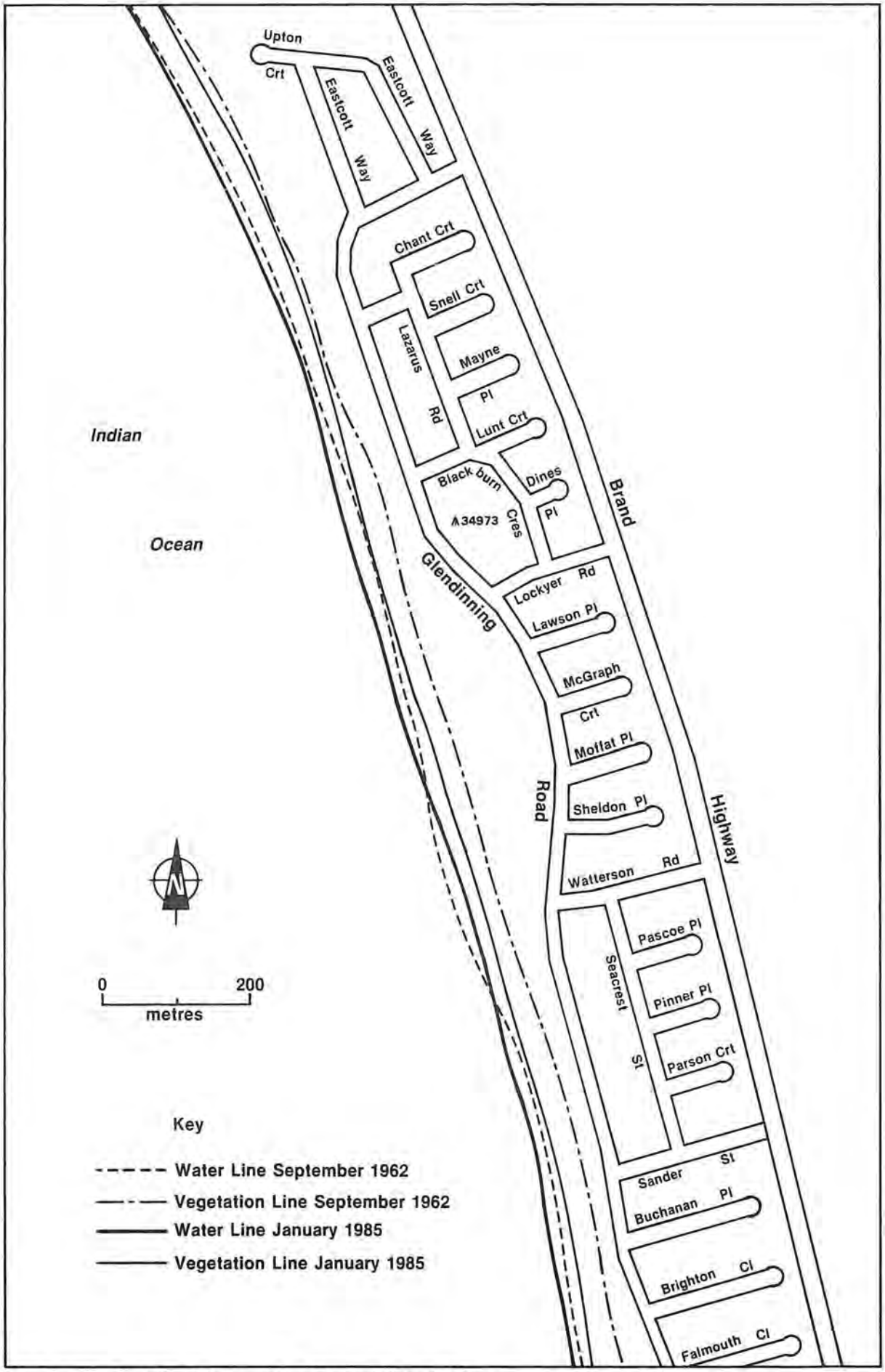
Recommendation

It is recommended that a minimum buffer zone width of 100±10 metres be set aside between any new subdivisions and the high water mark on sandy beaches. This coastal buffer strip may need to be wider if a beach is prone to shoreline attack. On rocky coasts where the possibility of shoreline retreat is remote, sufficient foreshore reserve should be set aside for public recreation purposes.

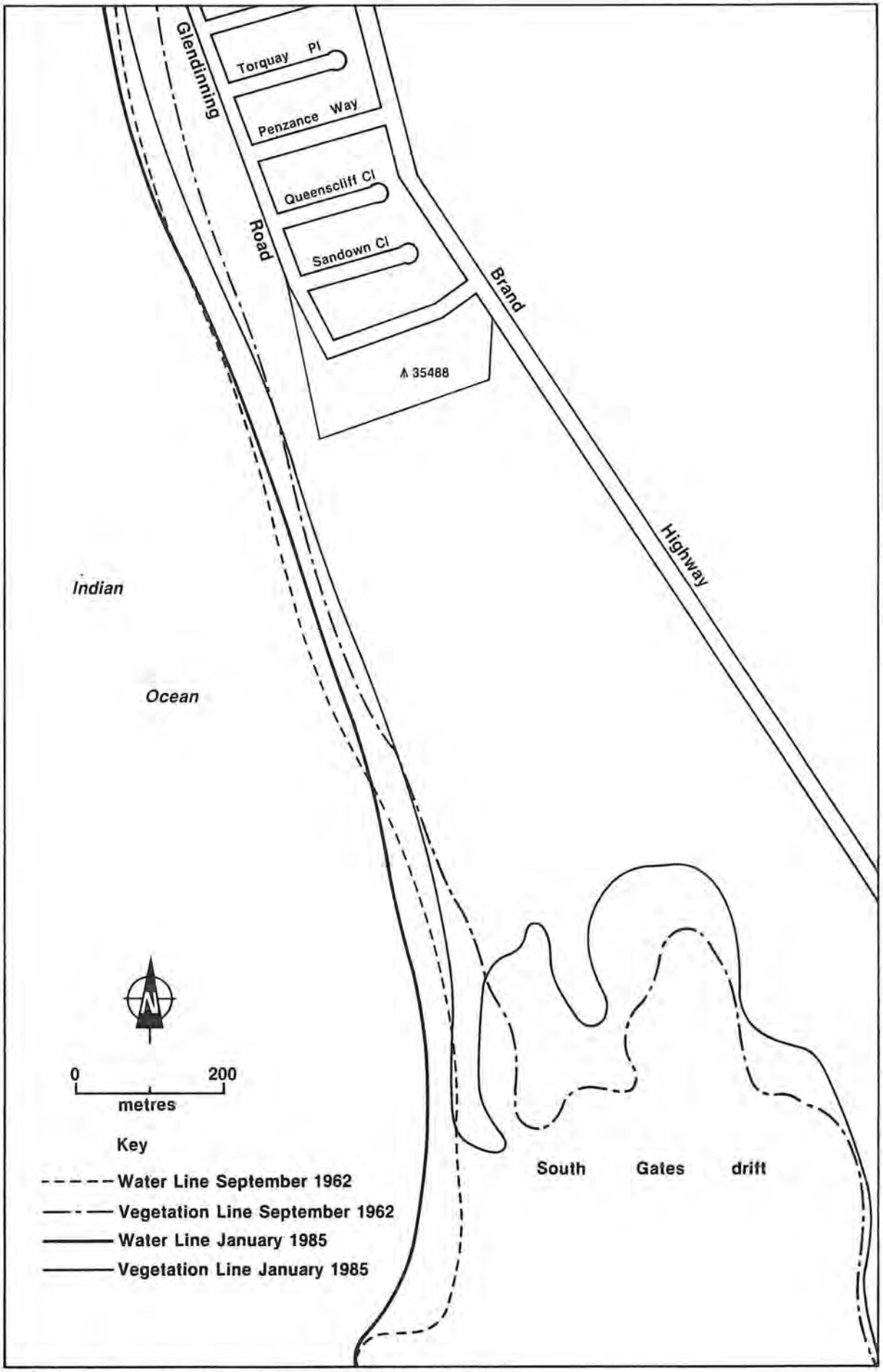
6.7 SAND SHEETS, STABILISATION AND USE

Drift sands are a major management issue within the Greenough Shire. The largest existing sand sheets are the South Gates (Photograph 12) and Cape Burney drifts, however there are numerous smaller scale active parabolic dunes and blowouts within the Shire. Stabilisation practices are expensive and involve large scale recontouring, loaming, brushing and/or revegetating the sand sheet.

In general, sand sheets are initiated by blowout formation in the vegetated foredune and parabolic dune system. A parabolic dune forms as the blowout expands and additional vegetation is inundated.



Map 6a **Shoreline Movement — Tarcoola/South Gates.**



Map 6b **Shoreline Movement — Tarcoola/South Gates.**

Photo 12: South Gates Drift

Sand sheets are characterised by an upwind erosional basin or trough, and a downwind migrating depositional lobe. The South Gates drift is a larger scale and more complex feature. It exhibits a deflation or erosion basin, and a mobile sand sheet made up of a series of well developed advancing transverse dunes and slip faces.

It has been hypothesised that the South Gates drift is episodically supplied with sediment following flooding events in the Greenough River, and that this may have been a factor in its genesis (Wood and Grieve, 1978). Pulses of sand moving out to sea through the river mouth may have been transported onshore along the southern margin of South Gates, and could then have been transported inland, as a result of wind action, to form a sand sheet. This idea could be tested by comparing the type of sediment carried out to sea when the sandbar breaks with the material on the South Gates drift. If this hypothesis is true then it is possible that a similar event may occur in the future. Therefore the success of any long term management plan for this area may rely on being able to hold or stabilise the large volumes of sand that would arrive along the southern margin of the drift following such an event.

It is also possible that the South Gates drift formed 'in situ' and was not supplied with significant quantities of sediment from other sources. This could be tested by surveying the volume of sand contained in the South Gates drift and, by reconstruction, postulating as to the nature of the original dune field and thus the volume of sand that was supplied from other sources.

6.7.1 Rate of advance

Dune sheets and active parabolic dunes in the Greenough Shire are advancing northwards under the influence of the prevailing south to southwesterly winds. Figures supplied by the Department of Agriculture for the rate of advance of the South Gates and Cape Burney drifts are shown in Table 3. These figures

TABLE 3 Sand dune movements based on aerial photograph measurements (Source: Dept. of Agriculture)

SOUTHGATES DUNE

period	m/year
1942 to 1956	11.9
1956 to 1962	10.7
1962 to 1968	8.6
1942 to 1968 (average)	10.4

GREENOUGH DUNE

period	m/year
1942 to 1956	16.4 (east point)
	3.0 (west point)
1956 to 1970	7.1 (east point)
	7.1 (west point)

agree reasonably well with an estimate by Wood and Grieve (1978) that the South Gates drift was growing northwards at approximately 4-10 metres per year. The advance of dune crests on the South Gates drift between 1978 and 1985 (Map 7) reflects the same pattern.

The migration of sand sheets is of concern because of the threat to roads, urban subdivisions and agricultural land in the path of these drifts. Based on an average rate of advance of 10 metres per year, the South Gates drift will begin encroaching on existing urban subdivisions at Tarcoola in about 80 years, and could reach the Brand Highway by about 35 years from now.

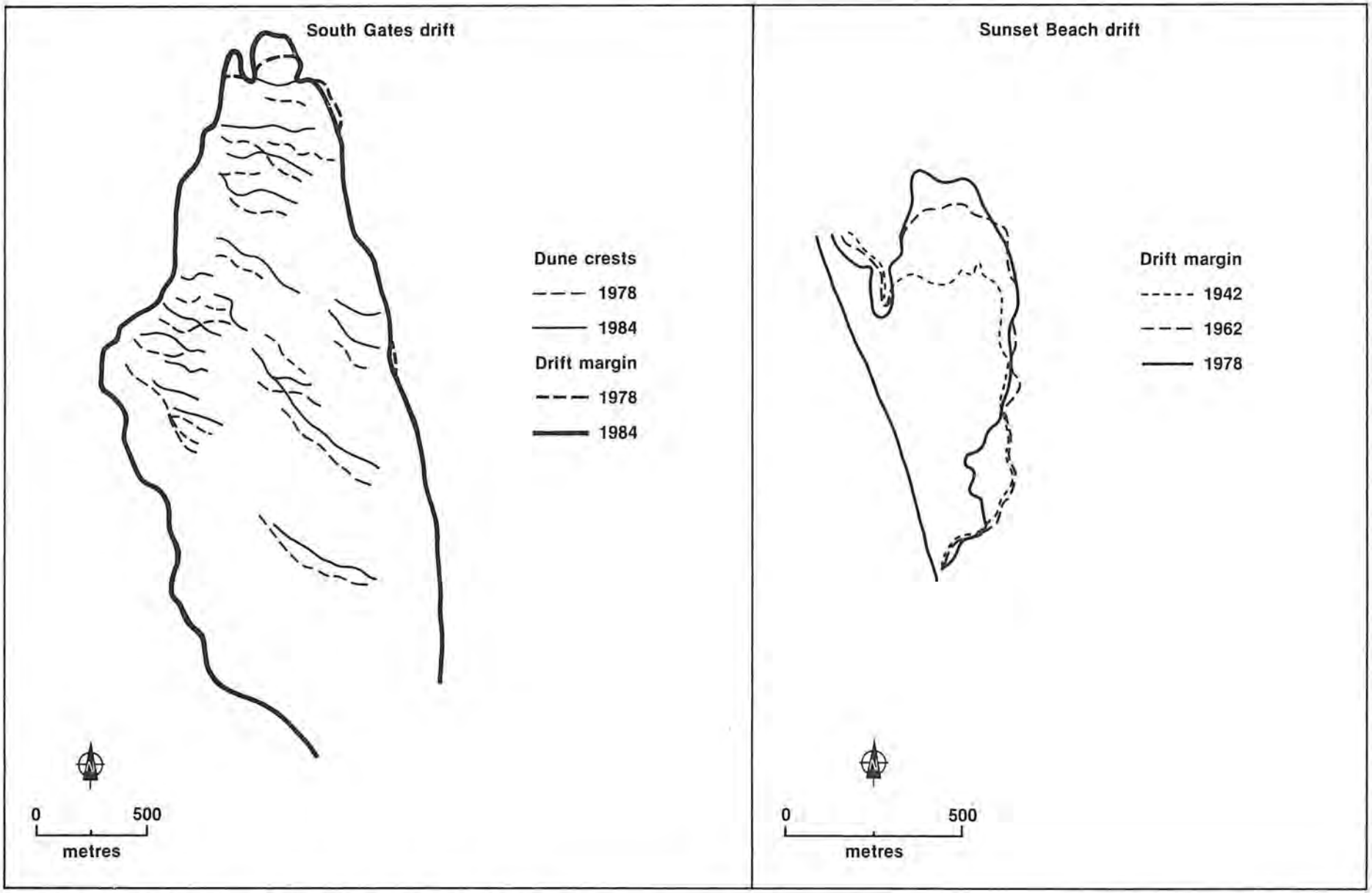
The Cape Burney drift is also of concern because it is advancing towards the Greenough River. Based on an average rate of advance of 7 metres per year, the Cape Burney drift should reach the Greenough River in about 65 years. This could lead to silting of the river resulting in flooding further upstream and possibly altering the course of the river.

The South Gates drift has reached the shoreline along part of its advancing margin and is now supplying sediment to the littoral drift system and feeding beaches to the north. The result of this additional sediment supply is that beaches between South Gates and Tarcoola have been accreting steadily in recent times.

A smaller parabolic dune in the north of the Shire (see Map 2) was initiated as a blowout near Sunset Beach in the Town of Geraldton and subsequently advanced across the shire boundary (see Map 7). It would be desirable for the Shire of Greenough and the Town of Geraldton to adopt a co-operative approach towards bringing this area of drifting sand under control.

Recommendations

- No further subdivision or development should be permitted within 1000 m of advancing sand sheets, except in the case of the Cape Burney drift where the Greenough River represents a natural barrier.



Map 7 Sand sheet advance — South Gates and Sunset Beach.

- The possibility of using the South Gates drift as a commercial sand supply for the Town of Geraldton should be investigated. Sand for this purpose should be removed from the advancing tongue of the drift.

- Potential stabilisation methods and their feasibility (section 6.7.4) should be investigated even if they are not implemented immediately.

- The effect on the coastal sediment budget along beaches to the north should be considered before undertaking stabilisation of the South Gates drift.

6.7.2 Vegetation changes

Significant natural revegetation of both the South Gates and Cape Burney drifts is occurring, however vegetated areas north of the drifts are continuing to be inundated by the migrating sand of their depositional lobes. A study of vegetation changes on active sand sheets and sand patches in the Dongara-Geraldton region was recently carried out by Patrick Hesp (unpublished data). This study included work on the South Gates and Cape Burney drifts as well as selected blowouts and sand patches along the coast to the south. In all cases, vegetation changes were interpreted through comparison of 1978 aerial photography with aerial photographs run in the 1940's. Map 8 summarises the vegetation changes that took place on the South Gates and Cape Burney drifts from 1942 to 1978.

It is evident that there has been extensive revegetation on the southern parts of the Cape Burney drift mainly by regrowth of *Acacia* spp. (Hesp, unpublished data). Significant devegetation has occurred to the north where the depositional lobe of the drift has overwhelmed vegetation.

Full revegetation of the South Gates drift, by *Acacia* spp. and *Anglanthus cunninghamii*, was limited to the deflation basin in the southwest corner of the drift however there were considerable areas of partial revegetation which are not shown on Map 8. The northwards advance of the South Gates drift, represented by areas of partial and full devegetation in Map 8, was pronounced.

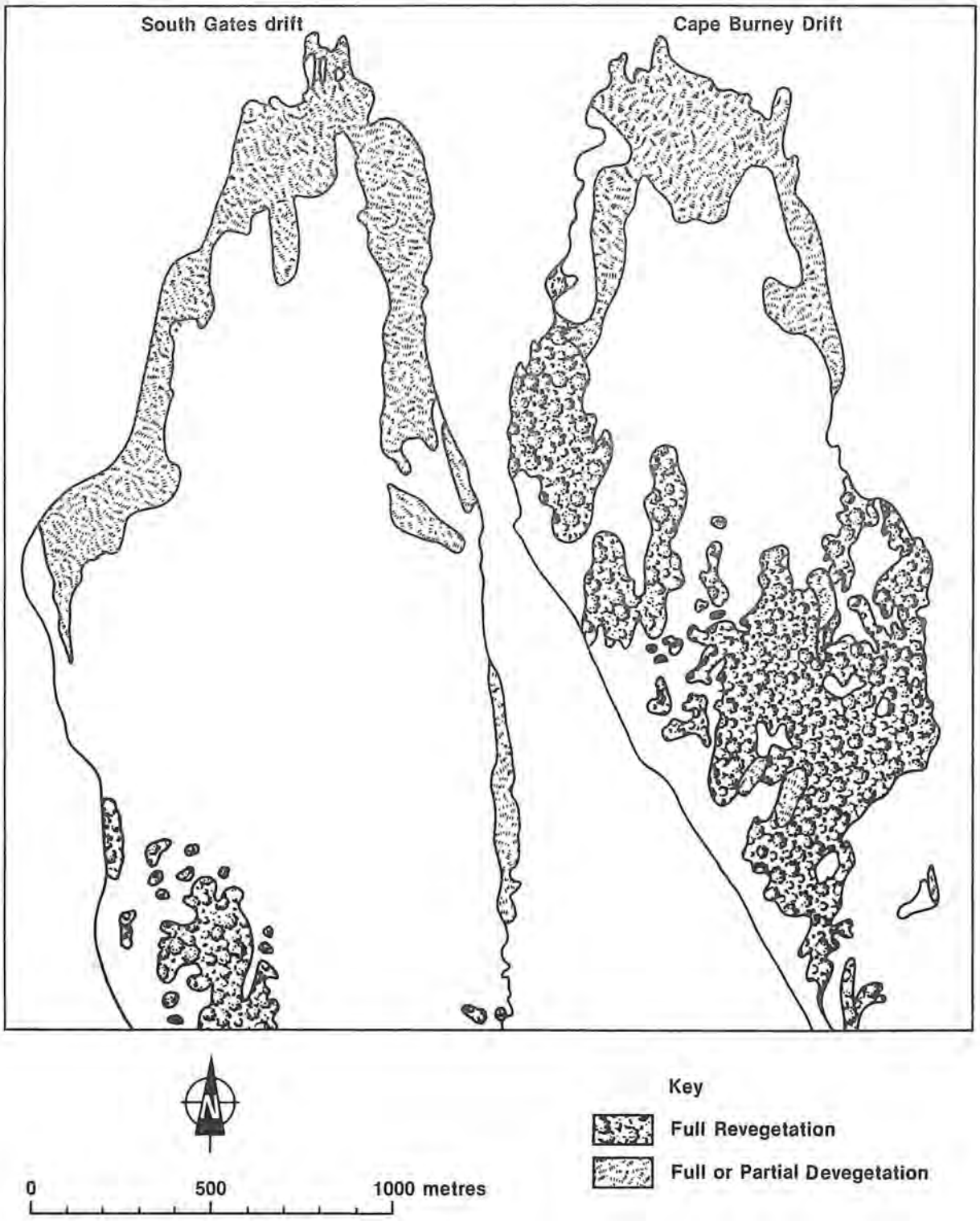
Recommendation

- Areas that are revegetating naturally on the South Gates and Cape Burney drifts should be protected from human use pressure, particularly in the form of off-road vehicle use. This will avoid unnecessary damage to the vegetation. Signs and fencing should be erected to discourage off-road vehicle use in these areas.

6.7.3 Experimental plantings

Records of trial plantings on the South Gates drift are kept by the Department of Lands and Surveys. The following paragraphs are based on these records as well as personal communications with staff from the Department of Agriculture.

The Department of Agriculture in Geraldton carried out experimental plantings on the South Gates drift over a period of more than 20 years starting in 1950. A number of dune plants were tried at various times and at various sites on the drift, including Marram grass *(Ammophila arenaria)*, Sea Wheat *(Agropyron distichum)*, Pyp grass *(Ehrharta villosa)*, Cereal rye *Secale cereale)*, *Spinifex longifolius*, *Acacia cyclops*, *Acacia cyanophylla* Creeping groundsel *(Senecio lautens)*, *Tetragonia* sp., American beachgrass *(Ammophila* spp.), Pigface *(Carpobrotus* sp.), *Atriplex* spp., and Tamarisk. The success of several of these species is discussed below.



Map 8 Vegetation changes on South Gates and Cape Burney drifts, 1942-1978. (adapted from Hesp, unpublished data)

Marram grass Marram was the major dune colonising species employed by the Department of Agriculture in their trial plantings. During the 1960's about 200 acres (81 hectares) of the South Gates drift was planted to Marram grass using a mechanical planter. It was found that a good strike rate could be achieved with Marram, however there was significant losses during the course of the first season.

The success of Marram grass was found to be largely dependent on site characteristics. Growth of Marram grass was most rapid at sites of slow sand accumulation. If accumulation is too rapid then burial takes place, while if sand is being excavated the roots become exposed resulting in the death of the plant.

Unfortunately, Marram was not found to be as suitable as was first thought. Geraldton probably represents the northern limit of the range for Marram grass, since it does not set viable seed at Geraldton nor does it grow as prolifically as along the south coast where Marram is favoured by the higher rainfall, longer growing season and milder climate generally.

Sea wheat Sea wheat is a primary dune coloniser that was imported from the Cape Province in South Africa. Early results with Sea wheat were encouraging however it had to be eradicated from the Geraldton district when it was found to be an oversummering host for wheat rust *(Puccinia tritici)*.

Sea wheat that survived along the coast near Lancelin has been remarkably successful. If it can be proven that Sea wheat does not pose a threat to the wheat industry then it should be considered in any stabilisation programme on the South Gates drift.

Pyp grass Pyp is a secondary dune coloniser originally brought from South Africa. Pyp grass was not used as extensively as Marram in trial plantings on the South Gates drift. Unlike Marram, Pyp grass was not successfully planted using mechanical methods however it was found that a 90% strike rate could be achieved using hand planting techniques in moderately sheltered areas (see Photograph 13).

Photo 13: South Gates Drift - Pyp Grass at the Southern End

Pyp grass spreads vegetatively but apparently does not set viable seed as far north as Geraldton. A characteristic of its growth is that Pyp grass generally takes several years to become established and to begin spreading.

Pyp grass probably represents a better stabilising species than Marram, on the South Gates drift. The main difficulty with the widespread use of Pyp as a dune stabiliser is the need to employ labour intensive hand planting techniques for it to be successful.

Cereal rye Cereal rye was planted over extensive areas of the South Gates drift using mechanical planting techniques. Cereal rye is an annual which does not set viable seed as far north as Geraldton, and for this reason it is only an effective stabiliser for one season. In addition, plantings with Cereal rye needed to be accompanied by the application of fertilisers.

Spinifex longifolius This species was not successfully established from cuttings during trials on the South Gates drift. It is possible, however, that *Spinifex longifolius* germinated from seed could be successfully used as a stabilising agent.

Some of the problems encountered by the Department of Agriculture during their plantings were:

- lack of sufficient planting material;
- the time taken for some species to become established;
- the failure of some species to become established through mechanical planting techniques;
- the inability of some species to set viable seed;
- the harshness of the wind regime and climate generally;
- variability in the direction of wind attack;
- variability in the sites of erosion and deposition on the drift;
- the steepness of some dune faces;
- difficulty with access to certain areas.

The main difficulty, however, seems to have been the lack of basic knowledge relating to vegetation and their growth forms, and how these respond to wind velocities, sand movement and climatic conditions. It should be stressed that research into this area will greatly enhance the success of any future stabilisation efforts.

6.7.4 Stabilisation

In the long term, the stabilisation of the South Gates and Cape Burney drifts is highly desirable, particularly considering the threat posed by the South Gates drift to developments to the north. Unfortunately, any stabilisation programme will be costly and there can be no guarantee of success.

A requirement of successful stabilisation is the control of sand movement over large areas. It is the opinion of John Grasby, who was involved in trial plantings on South Gates, that a piece meal approach towards stabilisation has a high probability of failure due to edge effects (the effect of sand movements outside the planted area), and that large areas would have to be planted at one time.

Winter is the most favourable time to undertake stabilisation of drift sands because the sand contains some moisture which lends it some stability as well as providing a good growing medium. Areas undergoing stabilisation would have to be protected from human use pressures such as off-road vehicle use. This could be achieved by fencing the stabilising area. A number of possible strategies which may be successful in achieving the stabilisation of large areas of drift sand, in particular the South Gates drift, are presented below.

Option 1 Levelling or recontouring the drift followed by loaming to a minimum depth of 150 mm. Limestone rubble could be used as an alternative to loam. Immediately following loaming, the former drift area should be planted out, using suitable initial stabilising vegetation, beginning around the sides and edges of the drift and working into the centre. The whole exercise of loaming and planting should be carried out in as short a time period as possible, and could be accompanied by hydromulching in some areas. Any damage to the stabilising agent, whether loam or vegetation, may lead to failure and should be repaired immediately by reloaming, replanting and brushing as necessary. Secondary planting of indigenous plants and bushes should be carried out during the following season.

Option 2 Vegetative stabilisation using a combination of Marram grass, Pyp grass, Tamarisk and possibly Sea wheat and Bamboo. This should be carried out once over the whole area of the drift. Each season thereafter, the drift would need to be replanted over extensive areas (possibly 50% of the area planted in the previous season), and this maintenance would probably have to continue until secondary native dune species could be established on the drift.

Option 3 Aerial seeding of the drift with Sea wheat *(Agropyron distichum)* The possibility of using this method, however, depends on Sea wheat being proven safe with regard to wheat rust and the threat to the wheat industry. This method would be considerably less expensive than Options 1 or 2, but would probably also be less effective.

Option 4 Stabilisation of dune ridges by planting with *Spinifex longifolius*, Pyp grass, Marram grass and possibly Sea wheat and Bamboo, accompanied by brushing. In theory this method should be effective since dune ridges are areas of significant sand movement. Sand trapping dune plants along the southern margin of dune ridges would hold wind-blown sand, and brushing would lend stability to the sand surface and also fulfill a trapping function. In the long term this process should result in a series of high stabilised dune ridges with intervening stable eroded swales. If this could be achieved then the swales could be progressively colonised with secondary dune species. In practice the effectiveness of this method should be proven through extensive trial plantings before being implemented as a large scale stabilisation strategy.

The high cost of stabilisation, particularly associated with options 1 and 2, may necessitate progressive freeholding of part or all of the stabilised land to cover these costs. There are two problems associated with subdivision following stabilisation. Firstly the poverty of the drift sands (low nutrient status, low organic matter content and low water holding capacity), covered by a thin layer of loam, may initially make cultivation of suburban gardens very difficult. Secondly, with regard to the South Gates drift, the conditions that produced the drift may still be operating. If it was a discrete event that takes place again in the future then there is the question of who accepts the responsibility for subdivided land and property that could be placed at risk. This problem could largely be overcome by setting aside a wide buffer strip between the southern shoreline of the South Gates drift and any land that is freeholded, so that bodies of sand coming onshore could be brought under control.

Recommendations

- Council should support, at least in principle, any plan to stabilise the South Gates or Cape Burney drifts.

- Council should approach the Department of Lands and Surveys regarding funding of any proposed stabilisation programme and the terms under which such a programme should be undertaken.

- Council should approach the Soil Conservation Service of the Department of Agriculture for technical assistance with any stabilisation programme.

6.8 SOIL CONSERVATION

The coastal belt is dominated by unconsolidated and relatively unstable Holocene sands. The vegetation cover plays an important role in stabilising these soils. If the vegetation is removed or disturbed as a result of recreation, development or agricultural practices, the sand may become mobilised forming blowouts and creating severe management problems. In addition when sand is lost from the beach zone it alters the coastal sediment budget increasing the risk of shoreline retreat.

The Commissioner of Soil Conservation has a responsibility to prevent clearing where there is a significant risk that soil erosion will result.

Recommendations

- Council should adopt a long term programme aimed at stabilising eroding areas and reducing activities that contribute to erosion.

- Council's existing programme of dune stabilisation and beach access works should be extended as the necessary resources become available. Priority should be given to those areas that experience the highest levels of use. The maintenance of existing beach access facilities such as those at Drummond Cove, Tarcoola and the Greenough River mouth should also be given a high priority. This work could be funded by the Community Employment Programme.

- Off-road vehicle recreation areas should be set aside at locations where there is a low risk of environmental degradation, or where degradation has already occurred. 'Safe' locations include parts of the South Gates and Cape Burney drifts, and the beach zone. Signs should be erected that direct off-road vehicles to these areas. Designation of off-road vehicle recreation areas should be decided in consultation with interested parties. To be effective, restrictions on the use of off-road vehicles need to be backed up by strong and committed enforcement.

- Council should request that the Ministerial Advisory Committee on Off-Road Vehicles declare all land west of the Brand Highway a prohibited area, under the Control of Vehicles (Off-Road Areas) Act 1978, with the exception of designated roads, tracks and parking areas, as well as areas of the beach and the South Gates and Cape Burney drifts designated by Council for the use of off-road vehicles.

- Off-road vehicle use in the sand dune system should be prevented through placement of appropriate signs and fencing at selected points along beaches where vehicles are permitted.

- When vegetation is removed to allow development, areas of bare soil should be surfaced with gravel or revegetated.

- Development or subdivision should be prevented where there is a significant risk that this will result in soil erosion. This can be achieved through the Town Planning and Development Act.

- Clearing should be prevented where there is a significant risk that this will result in soil erosion. This can be achieved by requesting that the Commissioner of Soil Conservation use the Soil Conservation Act for that purpose.

- The impact of grazing and cropping in the parabolic dune unit between the Greenough River mouth and the southern boundary of the Shire should be monitored. If severe soil erosion problems develop then Council should approach the Commissioner of Soil Conservation for advice.

- It is recommended that Council employ a ranger to monitor beach use, assist beach users and be responsible for maintenance of facilities. This work could initially be part-time, but eventually a full-time ranger may be required specifically for this purpose.

6.9 FIRE MANAGEMENT

Many dune plants are succulents and have a relatively high moisture content, thus reducing slightly the risk of fire. The highest fire danger results from a combination of high temperatures and easterly to northeasterly winds. The coastal ecosystem is vulnerable to fire. Dune vegetation destroyed by fire is slow to recover, and there is a risk of soil erosion while the vegetation cover is absent.

A number of Council employees are trained in firefighting techniques and they are supported by an organisation of volunteer firefighters. Council currently has three firefighting tenders, two large tenders and one smaller cruiser, however only the cruiser is suitable for work in dune areas. Landowners are encouraged to reduce the risk of fire by carrying out fuel reduction, through clearing of dead timber, in preference to establishing firebreaks. No controlled burns are undertaken by Council.

Recommendations

- Lighting of fires should be prohibited except in properly constructed fireplaces.

- The risks and effects of fire in dune areas should be integrated into a public education programme (see section 7.2).

- The best location for firebreaks should be a factor when siting new roads, since roads may serve as effective firebreaks.

- Council's existing fire control programme should be continued.

- The possibility of fuel reduction through conrolled burns should be considered in high fire risk areas.

- Landowners should be enouraged to reduce the fuel load around historic buildings.

6.10 CONSERVATION AND WILDLIFE MANAGEMENT

As outlined in section 2, reptiles and amphibia comprise much of the terrestrial vertebrate fauna in the study area, associated with which is a small number of indigenous and exotic mammal species. The coastal region also supports a rich community of birdlife, including a number of migratory waders, and offshore waters contain significant stocks of fish, crustaceans and molluscs which are exploited by commercial and amateur fishermen.

Much of the coastal region, particularly the parabolic dunes south of the Greenough River mouth, is undeveloped Freehold land and represents a relatively undisturbed natural habitat for many terrestrial faunal species. The area is considered sufficiently extensive to obviate the need for specific conservation measures.

The natural habitat of a number of wading birds is considerably more restricted and is generally confined to the lower reaches of the Greenough River and the marsh area known as Rudds Gully (Photograph 14). Populations of migratory wading birds can be protected by minimising disturbances to their seasonal habitats, and similar care should be taken to minimise disruption of the habitats of resident non-migrating species.

Photo 14: Rudds Gully

With respect to the marine biota, it is considered that sufficient management controls exist within the crayfishing industry to safeguard existing populations and no further measures are considered necessary. Concern has been expressed, however, regarding the depletion of shellfish stocks along parts of the Greenough coastline, but further research is required to accurately determine the severity and consequences of this depletion. It is probable that only localised depletion has taken place, and that shellfish breeding stocks are not under threat. Reef closures at Drummonds Cove and the Greenough river mouth are currently being considered by the Department of Fisheries and Wildlife in Geraldton.

Terrestrial vegetation within the study area is an important component of the natural environment, contributing not only to the stability of coastal landforms but also to the maintenance of faunal habitats. Every effort should be made to retain natural vegetation where possible and particular emphasis should be placed on the preservation of the Dongara - Mallee stand (*Eucalyptus loxophleba - Eucalyptus oraria* association) on the beach ridge unit south of Tarcoola which is unique within the Greenough Shire. Ideally, this site should be incorporated into a recreation reserve.

Another area of natural vegetation at Dolbys Gully, east of Drummond Cove, is also considered to be significant within the region. This site is low lying

and subject to flooding during winter. In addition there are signs that the soil is salt affected. Part or all of this land could be maintained under its natural vegetation of *Casuarina obesa* and *Eucalyptus camaldulensis,* and developed as a parkland for public recreation.

The preservation of the Bootenall Spring (reserve 1088) on the Greenough River is also important. This treed area, limited in extent, provides visual relief from the surrounding farmland, and may represent a sanctuary for a number of bird species (see Photograph 15).

Photo 15: Bootenall Spring

Recommendations

- Areas of the native flora and fauna should be preserved and conserved in their natural state for their environmental, scientific, commercial or recreational values.

- Council should ensure that natural vegetation along the banks of the Greenough River is retained, particularly between the river mouth and the area known as Devlins Pool, in order to protect the natural habitats of wader populations.

- No roadworks should be undertaken on the Brand Highway east of Devlins Pool, by the Main Roads Department, without consultation with the Department of Conservation and Environment. This will ensure minimal disruption to the marsh area and watercourse at Rudds Gully which provides food and shelter for a number of migratory wading birds as well as nesting sites for the White Headed Stilt and White Fronted Chat.

6.11 CULTURE AND HERITAGE

The majority of the cultural assets within the Shire of Greenough are to be found on the Front Flats, in the area designated as a Landscape Protection Area. Within the Landscape Protection Area, the National Trust has declared a Conservation Area which includes the Historic Hamlet. Many places of historical interest are on Freehold land.

Detailed recommendations for areas of cultural significance within the Landscape Protection Area are contained in "An Historical Survey of the Front Flats, Greenough, W.A. for The Shire of Greenough" by Margaret Feilman and Partners (1977).

Recommendations

- The heritage and existing landscape character of the Greenough Front Flats should be preserved and conserved.

- In line with recommendations by Feilman and Partners (1977), Council should ensure that valuable scenic, tourist and natural resources are not downgraded by inappropriate development.

- The principle of a Heritage Trail (see Section 3.5) located within the Landscape Protection Area should be approved by Council, provided that the siting and design of such a trail is environmentally sound and that no other difficulties are foreseen.

6.12 ABORIGINAL SITES

All sites of importance to Aboriginal people are protected under the Aboriginal Heritage Act, 1972-1980. The Act makes provision for the preservation of places and objects customarily used by, or traditional to, Aborigines. Any development within the coastal zone of the Greenough Shire which is likely to disturb these sites will necessitate an application in writing to the Trustees of the W.A. Museum.

It is often difficult for a developer to know whether an area of land contains significant Aboriginal sites but recent surveys suggest that this region, and in particular the alluvial flats surrounding the Greenough River is potentially rich in archaeological material. Accordingly, developers should ensure that the relevant notification is made to the W.A. Museum well in advance of any work being carried out in this region.

Recommendations

- That Council should consult with local Aboriginal communities and the Registrar of Aboriginal Sites at the W.A. Museum before undertaking any developmental or excavation work within the coastal zone.

- That upon receiving notification of any development on Freehold land, Council should ensure tht the owner or developer is made aware of the requirements of the Aboriginal Heritage Act, 1972-1980. Guidelines for developers are available from the W.A. Museum in cases where any doubt exists concerning the appropriate action which should be taken.

7. IMPLEMENTATION

The implementation of this Management Plan is primarily the responsibility of the Greenough Shire Council. The first step in implementation is to consider this Draft Plan. The second is to process comments from Council, residents and other interested bodies involved in planning and management at Greenough, so that a final Management Plan can be prepared. The third step is to adopt the final Coastal Management Plan and any recommendations and proposals it may contain.

7.1 PLANNING FRAMEWORK

7.1.1 Funding

Finance is required to implement management works and currently most of this is being borne by the Shire, with occasional assistance from State government departments. The Coastal Management Co-ordinating Committee should be able to co-ordinate applications for finance through various government departments so that adequate and long term funding can be ensured.

Recommendations that require only administrative changes can be addressed immediately. As for proposals that do require funding, the existing system of Shire Council management funding, supplemented by grants from appropriate government departments, should prove sufficient to initiate management and development proposals for areas under most pressure.

In the present climate of tourist promotion and unemployment relief, the two bodies that should be approached immediately are the State Tourism Commission and the Commonwealth Department of Labour and Industry. Other State government departments that do provide grants include:

- The Department for Youth, Sport and Recreation (community sport and recreation facilities fund)
- Main Roads Department (tourist road grants)
- DCE (beach management grants)
- Department of Agriculture (soil conservation grants)
- PWD (foreshore and erosion repair grants)

Past experience indicates that applications for funding are likely to be more successful if presented in the context of a long-term management plan. The fact that a Coastal Management Plan has been prepared and accepted by Council should assist these agencies in making funds available.

7.1.2 Supervision and policing

Council should continue its system of appointing honorary rangers to report on management requirements in areas vested in Council and other areas in the coastal zone. Council should also consider employing a professional ranger to investigate and report on management issues and enforce regulations when appropriate. Several of the recommendations contained in this report would require a ranger for them to be adequately implemented and enforced.

APPENDIX 1 List of plants common to the Greenough Coastal District

Landform	Growth Form	Species
Active foredunes	Grass	*Spinifex longifolius*
	Annual	*Cackile maritima*
		Salsola kali
	Succulent	*Carpobrotus* sp.
		Tetragonia decumbens
	Shrub	*Acacia rostellifera*
		Angianthus cunninghamii
		Atriplex cinerea
		Atriplex isatidea
		Gunniopsis sp.
		Myoporum insulare
		Olearia axillaris
		Scaevola crassifolia
Parabolic dunes	Grass	*Spinifex longifolius*
	Succulent	*Tetragonia decumbens*
		Threlkeldia diffusa
	Herb	*Cuscuta australis*
		Euphorbia terracina
	Shrub	*Acacia cyclops*
		Acanthocarpus preisii
		Anthocercis littorea
		Alyxia buxifolia
		Atriplex isatidea
		Lycium ferocissimum
		Olearia axillaris
		Santalum acuminatum
		Rhagodia baccata
		Scaevola crassifolia
	Tree	*Stylobasium spathulatum*
		Acacia ligulata
		Acacia rostellifera
		Melaleuca sp.
Alluvial flats	Herb	*Cuscuta australis*
	Shrub	*Lycium ferocissimum*
	Tree	*Acacia rostellifera*
		Algoanthus sp.
		Alyogyne hakeifolia
		Casuarina obesa
		Eucalyptus camaldulensis
		Eucalyptus rudis X
Beach ridges	Grass	*Cenchrus ciliaris*
		Spinifex longifolius
	Herb	*Cuscuta australis*
	Succulent	*Carpobrotus* sp.
		Threlkedia diffusa

Landform	Growth Form	Species
	Shrub	*Acanthocarpus preisii*
		Euphorbia terracina
		Kennedia prostrata
		Myoporum insulare
		Olearia axillaris
		Ptilotus divaricatus
		Rhagodia baccata
		Scaevola crassifolia
		Stylobasium spathulatum
	Tree	*Acacia rostellifera*
		Eucalyptus loxophleba
		Eucalyptus oraria
		Melaleuca cardiophylla
		Melaleuca huegelii
		Hibiscus huegelii
Deflation basins	Shrub	*Acacia cyclops*
		Acacia rostellifera
		Angianthus cunninghamii
		Olearia axillaris
		Scaevola crassifolia
Pleistocene dune complex	Grass	Introduced grass sp.
	Shrub	*Lycium ferocissimum*
		Ricinus communis
		Ptilotus divaricatus
	Tree	*Melaleuca cardiophylla*
		Melaleuca lanceolata
		Hibiscus huegelii
South Gates	Grass	*Spinifex longifolius*
		Ehrharta villosa
		Ammophila arenaria
	Herb	*Oenothera drummondii*
	Shrub	*Acacia cyclops*
		Atriplex isatidea
		Olearia axillaris
		Scaevola crassifolia

7.1.3 Land use zoning

Land use within the coastal strip should be zoned to avoid conflict between incompatible uses. Basically the zoning presented in Greenough Town Planning Schemes Nos 4 and 1A is endorsed except that along some parts of the coastline the area set aside for foreshore recreation is inadequate.

7.1.4 Land tenure

The implementation of this plan may require changes to the vesting or tenure of several areas of land within the Greenough Shire. Following the preparation of a final report, Council should approach the Under Secretary for Lands seeking appropriate alterations.

7.1.5 Public education

The co-operation of beach users is an important part of successful coastal management. There is little point in providing beach access paths and other facilities if the public do not use these. The use of appropriate signs is an important vehicle for promoting public awareness of issues relating to the coastline.

Major projects undertaken by Shire should be adequately publicised through local newspaper and radio. Any tourist facilities, picnic sites and camping areas should be adequately signposted, and marked on appropriate Shire maps. Information about the proper use of vehicles and boats along the Greenough coastline should also be publicised.

7.2 ROLE OF THE STATE GOVERNMENT

The State Government is committed to sound planning and management of the Western Australian coastline. The Coastal Management Co-ordinating Committee represents an important vehicle for local authorities to make submission on their own coastal management needs and in turn receive co-ordinated advice from State government departments.

Various government authorities can provide advice and financial assistance for management of the coast.

7.3 ROLE OF LOCAL GOVERNMENT

Councils can fulfil an important role in the management of the coast particularly if they are given technical and financial assistance. One of the important aims of this Management Plan has been to recommend management strategies in the coastal zone so that the Greenough Shire Council can become more involved in management of lands under its jurisdiction.

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APPENDIX 2 Schedule of Mammals

Western Grey Kangaroo	-	*Macropus fuliginosus*
Fat-tailed Dunnart	-	*Sminthopsis crassicaudata*
Echidna	-	*Tachyglossus aculeatus*
Euro	-	*Macropus robustus*
Feral Cat	-	*Felis catus*
House Mouse	-	*Mus musculus*
Black Rat	-	*Rattus rattus*
Rabbit	-	*Oryctolagus cuniculus*
Fox	-	*Vulpes vulpes*

Additional species which probably occur are:

Western Brush Wallaby	-	*Macropus irma*
Honey Possum	-	*Tarsipes rostratus*
Dunnart	-	*Sminthopsis griseoventer*
White-tailed Dunnart	-	*Sminthopsis granulipes*
Southern Bush Rat	-	*Rattus fuscipes*
Mitchell's Hopping Mouse	-	*Notomys mitchelli*
Ashey-grey Mouse	-	*Pseudomys albocinereus*
Gould's Wattled Bat	-	*Chalinolobus gouldii*
Chocolate Bat	-	*Chalinolobus morio*
Little Bat	-	*Eptesicus pumilus*
Lesser Long-eared Bat	-	*Nyctophilus geoffroyi*
White striped Mastiff Bat	-	*Tadarida australis*
Australian Sea Lion	-	*Neaphoca cinerea*

APPENDIX 3 Herpetofaunal species observed or considered common

LEPTODACTYLIDAE (Frogs)	
Heleioporus albopunctatus	
Heleioporus eyrei	Moaning Frog
Neobatrachus sp.	
GEKKONIDAE (Geckos)	
Diplodactylus ornatus	
Diplodactylus spinigerus	Soft-spined Gecko
Gehyra variegata	
Heteronotia binoei	Bynoe's Gecko
Phyllurus milii	
PYGOPODIDAE (Snake Lizards & Worm Lizards)	
Lialis burtonis	Common Snake Lizard
AGAMIDAE (Dragon Lizards)	
Amphibolurus maculatus maculatus	Spotted Dragon
Amphibolurus minor minor	
Lophognathus longirostris	
SCINCIDAE (Skinks)	
Ctenotus fallens	
Ctenotus lesueurii	
Egernia Kingii	King's Skink
Lerista distinguenda	
Lerista lineopunctulata	
Morethia lineoocellata	
Tiliquia occipitalis	Western Blue Tongue Lizard
Tiliquia rugosa rugosa	
TYPHLOPIDAE (Blind or Worm Snakes)	
Ramphotyphlops hamatus	
Ramphotyphlops waitii	
ELAPSIDAE (Front-fanged Snakes)	
Demansia reticulata reticulata	Whip Snake
Pseudonaja nuchalis	Gwardar
Vermicella littoralis	
Vermicella semifasciata semifasciata	

APPENDIX 4 Common species of fish in coastal waters off the Shire of Greenough

Tailor	-	*Pomatomus saltator*
Mulloway	-	*Argyrosomus hololepidotus*
Silver Bream	-	*Rhabdosargus sarba*
Australian Herring	-	*Arripis georgianus*
Yelloweye Mullet	-	*Aldrichetta forsteri*
Sea Mullet	-	*Mugil cephalus*
Flat-tailed Mullet	-	*Liza argenita*
Westralian Jewfish	-	*Glaucosoma hebraicum*
Samson Fish	-	*Seriola hippos*
Coral Trout (Harlequin Fish)	-	*Othos dentex*
Baldchin Groper	-	*Choerodon rubescens*
Pink snapper	-	*Chrysophrys auratus*
Skipjack Trevally	-	*Pseudocaranx dentex*
Cobbler	-	*Cnidoglanis macrocephalus*
Black Bream	-	*Acanthopagrus butcheri*
Yellowtail Trumpeter	-	*Amniataba caudavittatus*
Giant Herring	-	*Elops machnata*
Perth Herring	-	*Nematelosa vlaminghi*

Also common are a number of species of Whiting, Flathead, Cod, Shark and Parrot Fish although individual species are not known.

APPENDIX 5 Shire of Greenough - Schedule of Historic Places in Study Area (Adapted from Feilman and Partners, 1977)

Number	Name of Place	Location	Description
1.	Greenough River and Bootenall Spring	Victoria Location 107	The river discovered by George Grey in 1839 A freshwater spring
2.	Pensioner Kelly Cottage	Victoria Location X14	Stone-walled cottage
3.	Barn	Victoria Location X14	Stone-walled barn
4.	Farm site	Victoria Location 246	Site of former farmhouse and outbuildings
5.	"Ironbarks" farmhouse and outbuildings	Victoria Location 239	Stone-walled farmhouse
6.	Anderson cottage and outbuildings	Victoria Location 23	Small farmhouse with outbuildings
7.	Pioneer Museum, former "Home Cottage" and outbuildings	Victoria	Single-storeyed house and outbuildings
8.	Maley's Mill and outbuildings	Victoria Location 142	Stone-walled flour mill
9.	Harrison Cottage and outbuildings	Victoria Location 23	Stone-walled cottage and outbuildings
10.	"Rose Cottage"	Victoria Location 229	Stone-walled farmhouse
11.	Barn Cottage, former Coles Cottage	Pt. Victoria Location 85	Brick house
12.	Stone Barn	Pt. Victoria Location 85	Stone barn
13.	Wesley Church	Pt. Victoria Location 85	Gothic form stone-walled building
14.	Gray's Store	Pt. Victoria Location 77	Stone-walled building
15.	Lodge Ruin	Pt. Victoria Location 77	Stone walls only
16.	Maley's Bridge	Over Greenough River at McCartney Road	Stone abutments and piers with timber superstructure

17.	Ahern Cottage	Victoria Location 160	Stone-walled cottage
18.	Bridgeman's Cottage Ruin	Victoria Location 1106	Ruins of stone cottage
19.	Rectory Ruin	Victoria Location 174	Ruins of stone house
20.	Rock's House Ruin and outbuildings	Victoria Location 443	Ruins of stone cottage
21.	Former "Hampton Arms Hotel" and outbuildings	Victoria Location 66	Stone building
22.	Backshall's House Ruin	Victoria Location 444	Ruins of house
23.	Smith Cottage Ruin	Victoria Location 727	Ruins of house
24.	Three Bottle Farm House and outbuildings	Victoria Location 463	Stone cottage and farm buildings
25.	Bell Cottage and outbuildings	Victoria Location 720	Brick and stone building with outbuildings
26.	Leverman Cottage	Victoria Location 168	Stone-walled cottage
27.	"Old Walkaway" Cottage	Victoria Location 22	Stone-walled cottage
28.	Cottage and outbuildings	Victoria Location 251	Stone-walled house
29.	St James's Church	Victoria Location 703	Stone-walled building
30.	Schoolhouse Ruin	Victoria Location 11071	Stone ruins of school
31.	Cottage	Victoria Location 1032	Stone-walled cottage
32.	Cottage	Victoria Location 1050	Stone-walled cottage
33.	Cottage	Victoria Location 1486	Stone-walled house
34.	Cottage	Victoria Location 895	Stone-walled cottage

APPENDIX 6 RECREATION SURVEY QUESTIONNNAIRE

LOCATION .....

1. How many people in your group? .....

2. How many vehicles in your group? .....

3. Do you use 2WD or 4WD vehicles? ___ 4WD ___ 2WD

4. Are you a ___ Resident

___ Visitor, to the district?

5. (If resident) which locality are you from? .....

6. (If visitor) (a) How long are you staying in the district?

___ Day trip ___ Less than a week

___ More than a week

(b) Where are you staying?

___ Caravan Park ___ Hotel, Motel, Guest House

___ Private Accommodation

7. How often do you come to this location

___ First visit ___ More than once a month

___ Less than once a month ___ More than once a week

8. What activities do you take part in at this location?

___ Beach fishing ___ Swimming ___ Boating

___ Exploring ___ River fishing ___ Sailing

___ Picnic ___ Ocean fishing ___ Diving

___ Trail Bikes/Buggies ___ Surfing ___ Other .....

9. What do you like about this location? .....

10. What improvements would you like to see? .....

.....

APPENDIX 7 Recreation Survey Questionnaire - Methods and Results

Questionnaires were filled by personal interview (94%) and distribution to the S-bend Caravan Park (6%). Personal interviews were carried out at five sites along the coastline - Drummond Cove, Tarcoola/South Gates, the Greenough River mouth, Lucys Beach, and Flat Rocks. The results, based on 88 completed questionnaires, are presented in the following paragraphs.

Data from question 1 is illustrated in the graph of number of persons per group against percentage frequency (Figure 7.1). The mean number of people per groups was 3.9 and the mode was 2. Information on the number of vehicles per group (question 2) is contained in Table 7.1. The majority of groups (62.5%) had only one vehicle. Several groups (12.5%) had no vehicle, evidently visiting the beach on foot or by some other means of transport. Question 3 revealed that a significant proportion of vehicles were four-wheel drive (36.5%) with the remainder (63.5%) being two wheel drive.

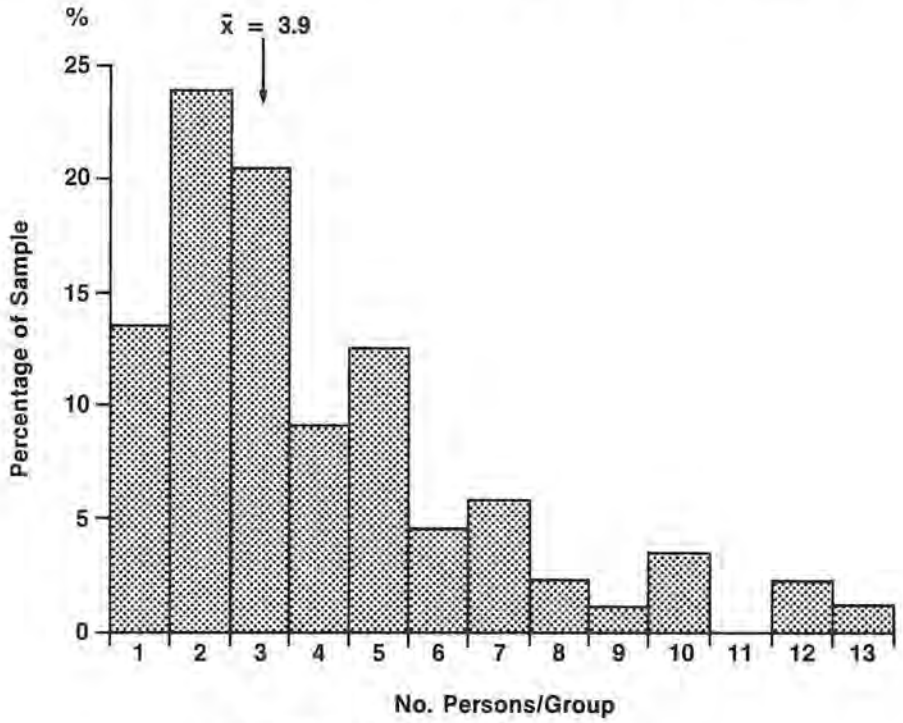

Figure 7.1 Number of people per group

No. of Vehicles in Group	No.	%
0	11	12.5
1	55	62.5
2	18	20.5
3	3	3.4
4	1	1.1
	88	100.0

Table 7.1 Number of vehicles per group

Interestingly, the majority of beach users (question 4) were residents of the district (61.5%) with only 38.5% being visitors. Of the residents, about 68% were from the Town of Geraldton and about 30% were from the Shire of Greenough, with one respondant being from the Shire of Chapman Valley. Information from question 6 regarding visitors' accommodation type and length of stay are presented in Tables 7.2 and 7.3. It can be seen that the largest number of visitors were staying in the district for less than a week, possibly reflecting the long weekend holiday. Caravan parks were the most common form of accommodation.

Length of stay	No.	%
day	3	8.6
< wk	23	65.7
> wk	9	25.7
	35	100.0

Table 7.2 Length of stay

Accommodation	No.	%
Caravan Park	20	58.8
Hotel, Motel, Guest House	1	2.9
Private Accommodation	9	26.5
Camping	4	11.8
	34	100.0

Table 7.3 Accommodation facility

Information on activities, attractions and suggested inprovements (Questions 8, 9, and 10) is presented in the form of three graphs (Figures 7.2-7.4). It can be seen that beach fishing, swimming, picnicking, exploring and surfing were the five activities most commonly listed by people during the survey. Recreation activities included in the 'other' category are sunbathing, photography, rabbit shooting, water skiing, social sport and drinking. The main attractions of the Greenough coastline currently seem to be the activities (eg. fishing, surfing) that can be carried out, the peaceful nature and remoteness of the coast, and the good facilities and pleasant environment of the beaches. When asked about suggested improvements, almost 50% of respondants thought that existing facilities were adequate.

The main activities, main attractions and suggested improvements have also been listed by location in Table 7.4.

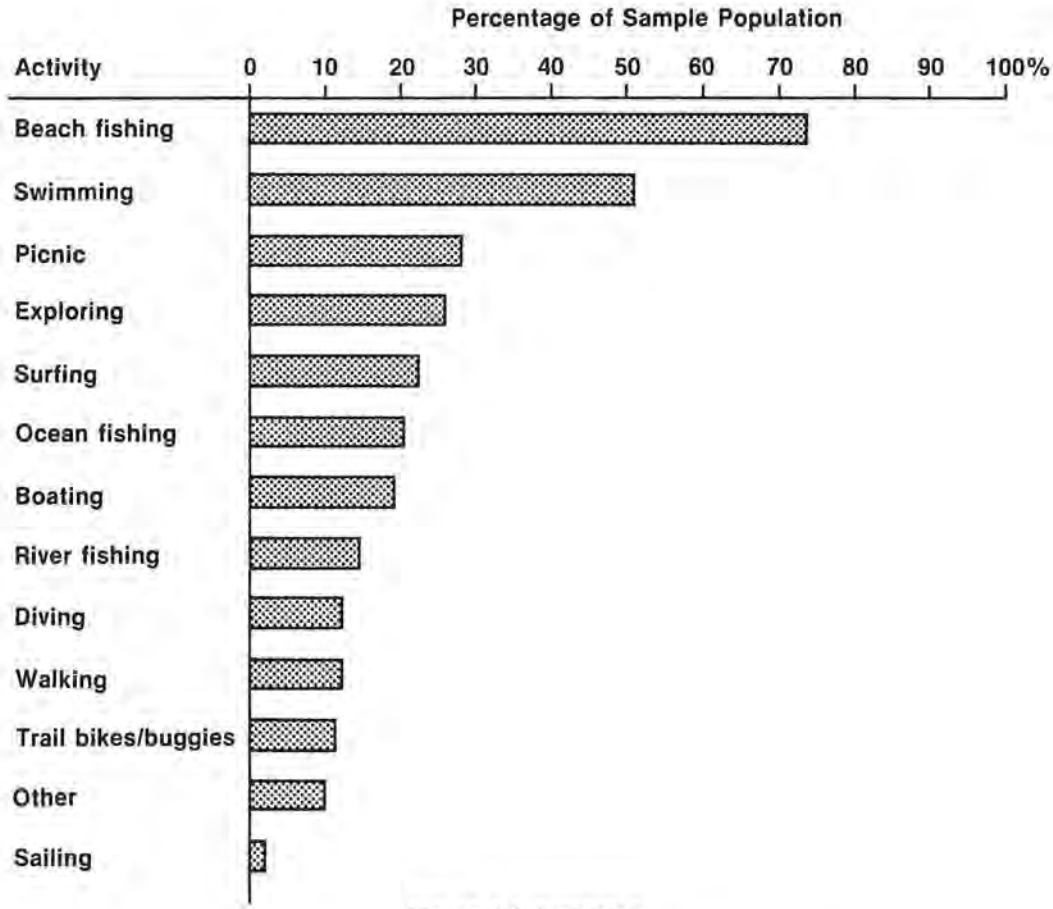

Figure 7.2 Activities

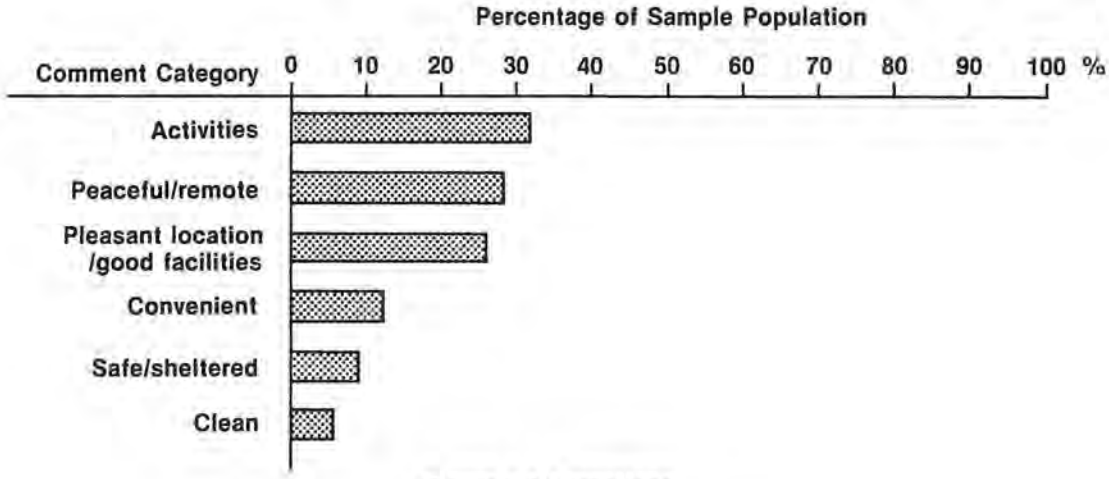

Figure 7.3 Attractions

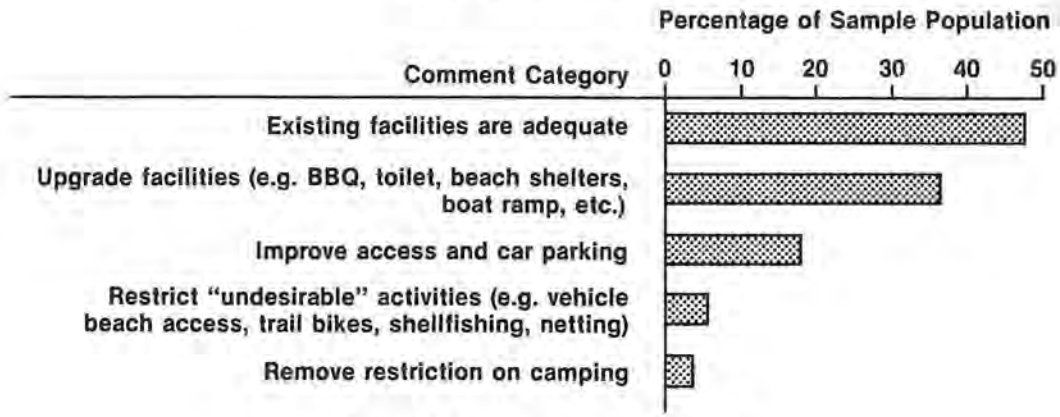

Figure 7.4 Suggested Improvements

TABLE 7.4 Survey results by location.

LOCATION	MAIN ACTIVITIES	ATTRACTIONS	*SUGGESTED IMPROVEMENTS
Drummond Cove	Beach fishing Swimming Boating Ocean fishing	Activities (eg. fishing) Peaceful/remote	Clear weed off the beach (6) Provide toilet facilities (2) Beach shelters (1) BBQ facilities(1) Shops and surfcat hire (1) Improve boat launching (1) Jetty (1)
Tarcoola	Swimming Beach fishing Exploring Walking	Pleasant location/good facilities Convenient	Beach shelters (2) Toilets (2) Launching ramp at South Gates (2) Provide rubbish bin for crayfishermen (1) Restrict vehicles/trail-bikes (1) Restrict net fishing (1)
Greenough River mouth	Beach fishing Swimming River fishing Picnic Surfing Exploring	Peaceful/remote Pleasant location Activities	Closer shopping facilities(5) Better access across sandbar (5) Car parking closer to beach (3) BBQ/picnic facilities (2) Beach shelters (2) Clean changerooms (1) Boat ramp (1) Develop facilities generally (1) Warning signs for rips and reef (1) Hire bikes/buggies (1) Restrict motorbikes/trail-bikes (1)
Flat Rocks	Beach fishing	Activities Peaceful/remote Pleasant location/ good facilities	Remove restriction on camping (3) Improve access/parking at fishing spot (1) Provide beach shelters (1) Provide BBQ area (1)

*Number in brackets refers to number of respondents that suggested this improvement.

APPENDIX 8 – Vehicle count from aerial survey
Sunday, 27 January 1985
10.00 am to 11.30 am

Location	Vehicles
Drummond Cove	12
COASTLINE - Drummond Cove to northern townsite boundary	1
Tarcoola	5
South Gates	9
Greenough River mouth	21
COASTLINE - Cape Burney to Flat Rocks	11
Flat Rocks	8
COASTLINE - Flat Rocks to southern shire boundary	0