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DRAFT COASTAL MANAGEMENT PLAN SHIRE OF COOROW



Department of Conservation and Environment
Perth, Western Australia

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DRAFT COASTAL MANAGEMENT PLAN

SHIRE OF COOROW

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with a contribution
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Department of Conservation and Environment
Perth, Western Australia

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CONTENTS

	<u>Page</u>
(i) Abstract	viii
(ii) Acknowledgements	ix
(iii) List of Figures	iv
(iv) List of Tables	v
(v) List of Plates	vi
(vi) List of Appendices	vii
1. <u>INTRODUCTION</u>	1
1.1 LOCATION OF SHIRE AND DELINEATION OF PROJECT AREA AND MANAGEMENT UNITS	1
1.2 CONTEXT OF THE PROJECT AREA	1
1.3 AIMS AND OBJECTIVES OF THE COASTAL MANAGEMENT PLAN	4
1.4 CHAPTER OUTLINE	5
<u>DESCRIPTION OF THE PROJECT AREA</u>	
2. <u>PHYSICAL ENVIRONMENT</u>	6
2.1 GEOLOGY	6
2.2 SOILS	6
2.3 VEGETATION	6
2.4 CLIMATE	7
2.5 COASTAL PROCESSES	9
2.5.1 Introduction	9
2.5.2 Winds	9
2.5.3 Waves	9
2.5.4 Tides	9
2.5.5 Sediment Budget	9
2.5.6 Shoreline Stability and Coastal Erosion	11
2.6 GEOMORPHOLOGY	13
2.7 TERRESTRIAL FAUNA	15
2.7.1 Mammals and Birds	15
2.7.2 Reptiles and Amphibians	16
2.8 AQUATIC FAUNA	16
2.8.1 Fish	16
2.8.2 Other Invertebrates	16
3. <u>HUMAN ENVIRONMENT</u>	17
3.1 CULTURE AND HERITAGE	17
3.2 POPULATION GROWTH	18
3.3 FACILITIES	18
3.3.1 Roads	18
3.3.2 Carparks	19
3.3.3 Beach Access: Vehicular and Pedestrian	19

	<u>CONTENTS</u> (contd)	Page
3.3.4	Toilet and Picnic Facilities	21
3.3.5	Boat Ramps and Mooring Facilities	21
3.3.6	Tourism Accommodation	23
3.4	LAND USE IN THE PROJECT AREA	23
3.4.1	Tourism	23
3.4.2	Recreational Activity	24
3.4.3	Commercial Fishing	24
3.4.4	Mining Exploration and Quarrying	25
3.4.5	Apiarists	26
3.4.6	Residential Development	26
3.4.7	Industrial and Commercial Development	26
3.4.8	Squatter Settlements	26
3.4.9	Flora and Fauna Reserves	27
4.	<u>SUMMARY OF ATTRIBUTES AND CONSTRAINTS IN PROJECT AREA</u>	30
5.	<u>MANAGEMENT ISSUES AND RECOMMENDATIONS</u>	36
5.1	CULTURE AND HERITAGE	36
5.2	FACILITIES	36
5.2.1	Roads	36
5.2.2	Carparks	37
5.2.3	Beach Access: Vehicular and Pedestrian	37
5.2.4	Toilet and Picnic Facilities	39
5.2.5	Boat Ramps and Mooring Facilities	45
5.2.6	Tourist Accommodation	46
5.2.7	Rubbish Disposal	47
5.3	LAND USE IN PROJECT AREA	48
5.3.1	Tourism	48
5.3.2	Recreational Activity	49
5.3.3	Commercial Fishing	50
5.3.4	Mining Exploration and Quarrying	51
5.3.5	Apiarists	51
5.3.6	Wildlife Management	51
5.3.7	Residential Development	51
5.3.8	Squatter Settlements and Camping	53
5.3.9	Industrial and Commercial Development	55
5.4	DUNE STABILISATION	55
5.4.1	Importance of Natural Vegetation in Dune Stability	55
5.4.2	Use of Soil Conservation and Fire Management in Dune Stabilisation	60
5.4.3	Methods of Dune Stabilisation	61
5.4.4	Areas Recommended for Dune Restoration	64
6.	<u>IMPLEMENTATION OF MANAGEMENT RECOMMENDATIONS</u>	66
6.1	MANAGEMENT PRIORITIES	66

	<u>CONTENTS</u> (contd)	Page
6.2	ROLE OF STATE AND LOCAL GOVERNMENT	66
6.2.1	Public Education	66
6.2.2	Crown Land Vesting and Management	75
6.2.3	Funding - Cost of Dune Rehabilitation	76
6.2.4	Surveillance and Policing	77
7.	<u>CONCLUDING REMARKS</u>	82
	<u>BIBLIOGRAPHY</u>	83

<u>List of Figures</u>	<u>Page</u>
FIGURE 1 : <u>Location of Project Area</u>	3
FIGURE 2 : <u>Components of the Coastal Sediment Budget</u>	10
FIGURE 3 : <u>Beach Sand Cycle</u>	12
FIGURE 4 : <u>Geomorphology of the Project Area</u>	14
FIGURE 5 : <u>Beekeepers Reserve and Stockyard Gully</u>	28
FIGURE 6 : <u>Mt Lesueur Reserve</u>	29
FIGURE 7 : <u>Management Area 1: Green Head Townsite</u>	31
FIGURE 8 : <u>Management Area 2: Squatter Settlement 1</u>	32
FIGURE 9 : <u>Management Area 3: Squatter Settlement 2</u>	33
FIGURE 10: <u>Management Area 4: Squatter Settlement 3</u>	34
FIGURE 11: <u>Management Area 5: Leeman Townsite</u>	35
FIGURE 12: <u>Management Recommendations for Green Head Townsite</u>	40
FIGURE 13: <u>Management Recommendations for Squatter Settlement 1</u>	41
FIGURE 14: <u>Management Recommendations for Squatter Settlement 2</u>	42
FIGURE 15: <u>Management Recommendations for Squatter Settlement 3</u>	43
FIGURE 16: <u>Management Recommendations for Leeman Townsite</u>	44

List of Tables

	Page
TABLE 1 : <u>The Principal Reserves of the Project Area</u>	2
TABLE 2 : <u>Climatic Data of the Project Area</u>	8
TABLE 3 : <u>Visitors to the Shire of Coorow</u>	24
TABLE 4 : <u>The Pros and Cons of Reserve 22522 and 22521 for Camping</u>	56
TABLE 5 : <u>List of Coastal plants commonly found in Management Areas</u>	57
TABLE 6 : <u>Management Priorities for Management Area 1: Green Head Townsite</u>	67
TABLE 7 : <u>Management Priorities for Management Area 2: Squatter Settlement 1</u>	69
TABLE 8 : <u>Management Priorities for Management Area 3: Squatter Settlement 2</u>	70
TABLE 9 : <u>Management Priorities for Management Area 4: Squatter Settlement 3</u>	71
TABLE 10 : <u>Management Priorities for Management Area 5: Leeman Townsite</u>	72
TABLE 11 : <u>Responsibility of Government Authorities in regard to Coastal Management in the Shire of Coorow</u>	74
TABLE 12 : <u>Cost of Dune Rehabilitation at Cottlesloe by Woods (1984)</u>	78
TABLE 13 : <u>Cost of Dune Rehabilitation at Halls Head by Ewing (1981)</u>	79
TABLE 14 : <u>Cost of Dune Rehabilitation at Wanneroo by Scott and Furphy (1979)</u>	80
TABLE 15 : <u>Cost of Dune Rehabilitation at Port Hedland by Chalmers (1984)</u>	81

List of Plates

Page

PLATE 1	: Degradation of vegetation along a pedestrian track at Dynamite Bay, Green Head. The eroded face is a metre high.	19
PLATE 2a	: Blowouts at Leeman, opposite the Leeman-Shag Island Caravan park. <u>Tetragonia decumbens</u> in mid-ground is forming an incipient foredune. The blowouts are partially vegetated by Pyp grass.	20
PLATE 2b	: Blowouts north of Leeman Jetty. Exposed bench mark in mid-ground.	20
PLATE 3	: Exposed vegetation root system at blowout area opposite the Leeman-Shag Island Caravan Park. The eroded face is just over a metre.	21
PLATE 4	: Toilet, changeroom and shower facilities at the Leeman Jetty.	22
PLATE 5	: Leeman Jetty. In the left-hand background, is a distant view of the eroded Leeman cliff head.	22
PLATE 6a	: The carpark at Dynamite Bay, which has been extended seaward 14 metres. In the background, excessive tracking has resulted in dune vegetation degradation.	38
PLATE 6b	: The carpark is already experiencing erosion in the form of gullying. There is also no formal access to the beach.	38
PLATE 7	: Dumping of household refuse which is associated with the squatter settlements.	48
PLATE 8	: Seaweed accumulation near the jetty at Green Head. This is a common sight on all the beaches in the area during winter and spring.	50
PLATE 9	: "older" eroded dunes. Vegetation has revegetated the dune face and there is a humus layer at the crest of the dune. a) North of Green Head Jetty b) At squatter settlement 1	54
PLATE 10	: Lower or non-existent foredunes typical of squatter settlements 2 and 3. Seaweed accumulation on the beach. <u>Salsola kali</u> is the main vegetation species.	55
PLATE 11a	: Excessive tracking resulting in loss of vegetation and amenity value. The southern cliff area of Dynamite Bay, Green Head.	59
PLATE 11b	: A closer look at cliff degradation south of the Leeman Jetty.	59

List of Appendices

	Page
APPENDIX 1 : <u>Mammals and Birds in the Project Area</u>	87
APPENDIX 2 : <u>Reptiles in the Project Area</u>	90
APPENDIX 3 : <u>Questionnaire Sheet used and Questionnaire results obtained from a Recreational Survey conducted at Green Head and Leeman during the 4th and 5th of September, 1985</u>	92

ABSTRACT

The main purpose of this report is to contribute towards the long term management of the Western Australian coastline as well as fulfil the Shire of Coorow's objectives for a more co-ordinated and comprehensive approach to coastal management along its shoreline. The report describes the physical and human environment of the area which is full of opportunities which lie within a complex and fragile environment. Certain management issues emerge such as squatter settlements, excessive tracking, damage of dune vegetation by off-road vehicles and inappropriate siting of developments. These management issues as well as others are exacerbating existing coastal management problems such as dune erosion and loss of coastal vegetation. Recommendations were suggested for each management issue. The majority of the recommendations deal with controlling access and development. The report also suggests methods of avoiding dune instability or restoring the dune system to a stable state. This can be achieved by formalising access, closing of tracks, carrying out dune restoration programmes and preventing development in the coastal buffer zone. All the management issues come to one conclusion which is if one wants to "develop" the coastline to its full potential it will be necessary to conserve and preserve the coastal environment. Lastly the report deals with the implementation of the management recommendations. Implementation involves accessibility to funds and expertise as well as an appreciation of the responsibilities and functions of each government department.

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INTRODUCTION

1.1 LOCATION OF SHIRE AND DELINEATION OF PROJECT AREA AND MANAGEMENT UNITS

The Shire of Coorow is situated in the region of Western Australia known as the North Midlands. The Coastal Management Plan (C.M.P.) concentrates on a 16 kilometre coastal strip which is located between the two coastal towns of Green Head and Leeman. However, the immediate and more distant hinterlands will affect this section of coastline. Green Head is 288 km north of Perth and 38 km west of the Brand Highway while Leeman is only 14 km north of Green Head. The Shire of Coorow is bordered to the north by the Shire of Carnamah and to the south by the Shire of Dandaragan. The two nearest coastal towns of major significance are Dongara and Jurien Bay.

The project area, for the purpose of this Draft Coastal Management Plan, is bounded to the north and south by the Coorow Shire boundaries located at the latitudes of 29° 53's and 30° 05's respectively and extends eastwards to the Cockleshell Gully road which passes through the Mt Lesueur and Beekeepers Reserve. The eastern boundary was chosen to include the major geomorphic units of the coastal region, and the users of the coastal environment. However, users such as tourists and squatters invariably come from areas outside the project area. The low water mark has been used to define the western boundary of the project area. Nevertheless, the C.M.P. will also deal with aspects of the adjacent off-shore waters.

The study region contains areas of freehold land, vacant crown land, crown reserves and freehold reserves, as shown in TABLE 1.

The project area has been divided into five management areas. In reality these units would be interactive and interdependent upon each other and not viewed as discrete entities. However, for convenience and efficiency the above perspective will have to suffice.

The five management areas are (FIGURE 1):

- (1) Green Head Townsite (includes Dynamite Bay and South Bay)
- (2) Squatter Settlement 1 (3 kms north of Green Head and opposite the turnoff to the Brand Highway)
- (3) Squatter Settlement 2
- (4) Squatter Settlement 3 (the squatter settlement closest to Leeman)
- (5) Leeman Townsite

1.2 CONTEXT OF THE PROJECT AREA

In the past coastal management has been "ad hoc" and unco-ordinated. In an attempt to have more comprehensive coastal management the Department of Conservation and Environment is producing a series of Coastal Management Plans (C.M.P.'s) which will cover most of the Western Australian coastline.

TABLE 1 : The Principal Reserves of the Project Area

<u>Reserve Number</u>	<u>Purpose</u>
24496	Protection of Flora
22521	Camping and Water
22522	Camping and Water
38041	Navigation Beacon
38042	Navigation Beacon
38043	Navigation Beacon
38044	Navigation Beacon
15018	Horse Breeding
29259	Harbour Purposes (Green Head)
38735	Harbour Purposes (Leeman)
34516	Fishing Industry
31682	Recreation (Leeman)
32639	Recreation (Leeman)
81229	Parking and Recreation (Green Head)
*31159, 34437, 38589	Rubbish and Sanitary Depot (Leeman)
*31230	Rubbish Depot and Sanitary Disposal (Green Head)
29259	Conservation of Flora and Fauna (Lipfert, Milligan, Shag Island, Webb Islet, Drummon and Orton Rocks Nature Reserves)
29257	Conservation of Flora and Fauna - Fisherman Islands Nature Reserve
1223	Water and Stopping
19219	Stock Route Reserve
38461	Quarry Reserve

* There will soon be a new Rubbish Disposal Area which will replace these sites.

Source: Taylor and Burrell Pty Ltd, 1985 (Unpublished)

The "Coastal Planning and Management in Western Australia - A Government Position Paper" (Coastal Management Co-ordinating Committee, 1983) also outlines the policies of the Western Australian Government towards coastal planning and management which serves as a guideline to all government departments.

Some of the main policies are:

1. "The Government recognises that the coast is a dynamic environment which requires specialised planning and management".
2. "Before coastal land is allocated for a particular use the physical capability of the land to support that development should be carefully considered".
3. "Public access to the coast should be controlled in such a way as to permit its use as a resource and yet minimise costly environmental damage".

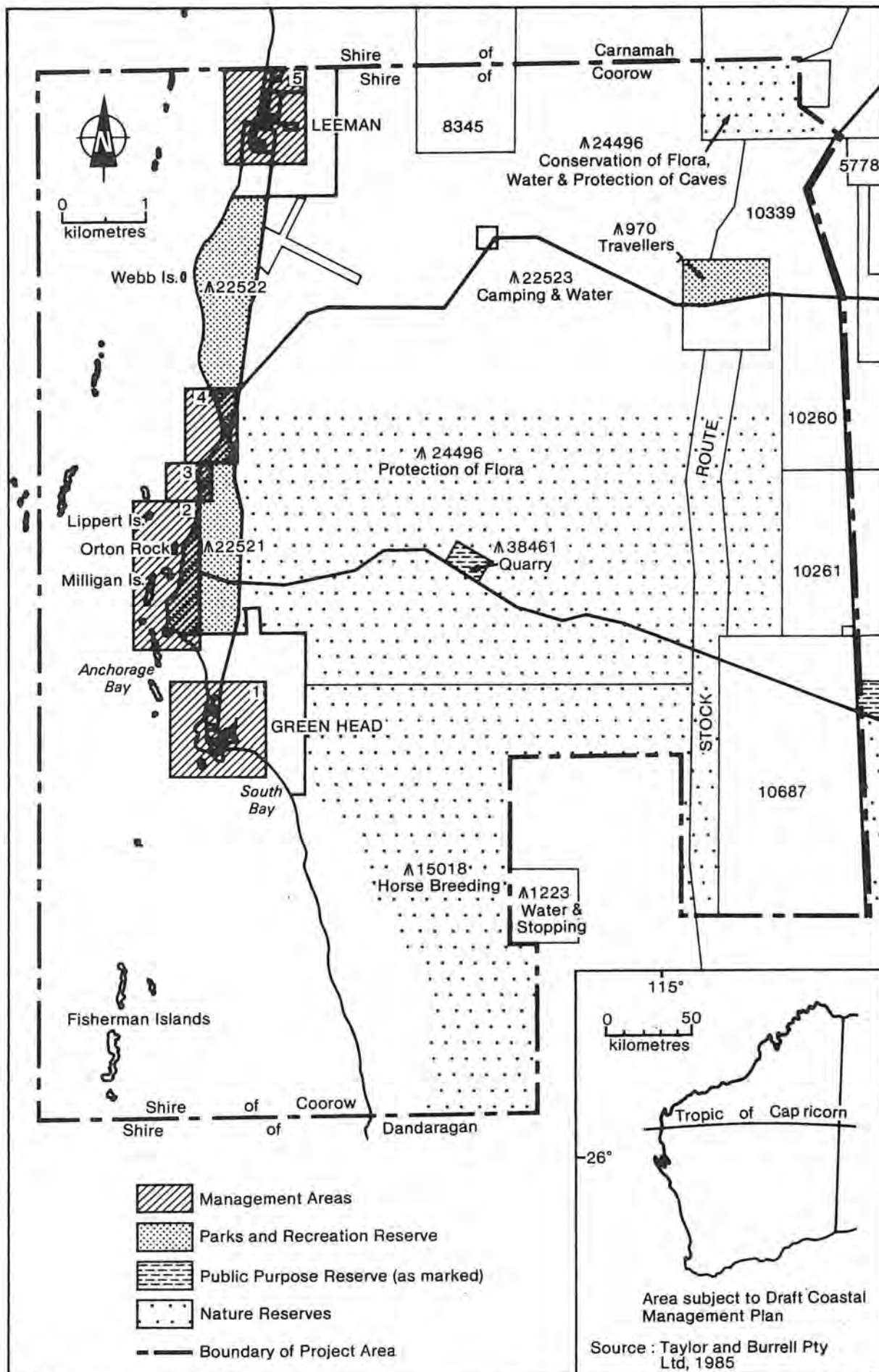


FIGURE 1 : Location of the Project Area

4. "The coast is a visual resource which should be carefully managed. Development which is in harmony with the sensitive nature of the coast should be encouraged".
5. "Haphazard squatter shack settlements are unacceptable...".
6. "Places of unique landscape, scientific and cultural significance should be conserved and managed, including geomorphological, ecological, anthropological and historic sites".
7. "The West Australian coast exhibits a rich and varied range of resources. Coastal problems arise from the inherent fragility and sensitivity of the coastal environment and general lack of understanding of coastal processes (author's underlining)..."

The aim of coastal management is to ensure that the physical and human components of the environment can compatibly coexist in the coastal zone, to maintain coastal stability and to minimise impact of or degradation by natural forces or man-made developments. To achieve this goal forward thinking, interactive and comprehensive land management is required. There should be an overall co-ordination of coastal management issues to involve all interested parties and prevent "ad hoc" decision-making.

1.3 AIMS AND OBJECTIVES OF THE COASTAL MANAGEMENT PLAN

The following objectives summarise the main areas of investigation to be examined in this Draft Coastal Management Plan.

- . Identify potential and existing management problems and recommend strategies to prevent or resolve them.
- . Advise the Shire on the suitability of coastal sites for specific uses and levels of activity.
- . Identify possible land use conflicts within the coastal zone.
- . Formulate a long-term development, conservation and management guide for the coastal area being studied.
- . Identify participants in the planning process or who have management input in the area.
- . Identify possible sources of financial assistance for management proposals.

The ultimate purpose of the Coastal Management Plan is to integrate and harmonise the development of the coastal environment with its conservation.

It is widely known that the coastal zone is a dynamic and fragile system which in the past has been subjected to "ad hoc" decision making. The appropriate siting and management of coastal activities will ensure that the environment is protected and that costly management techniques can be avoided. The advantage of such a perspective is that the amenity value of the coastal environment is preserved.

1.4 CHAPTER OUTLINE

Chapter One briefly outlines the aims and objectives of the Coastal Management Plan (C.M.P.) and summarises the main policies within which the context of the C.M.P. is set. This chapter also defines the project area and delineates the smaller management units.

Chapter Two and Three describe the physical and human environment of the project area. Chapter Two describes aspects of the physical environment such as geology, soils, vegetation, climate, coastal processes, geomorphology, terrestrial and aquatic fauna. Chapter Three describes the human environment of the area and concentrates on the facilities and land use in the project area.

Chapter Four summarises the main physical and human attributes as well as constraints of the project area.

Chapter Five deals with the major management issues of the area such as beach access, squatter settlement and dune stabilisation. For each management issue recommendations are made or possible courses of action available to remedy or avoid the situation.

Chapter Six then examines the implementation of the management recommendations by suggesting management priorities, possible sources of funding and education, land-use zoning, crown land vesting and management as well as surveillance and policing.

Finally, Chapter Seven summarises the main findings of the report.

DESCRIPTION OF THE PROJECT AREA

PHYSICAL ENVIRONMENT

2.1 GEOLOGY

The Shire of Coorow has been mapped geologically in detail and published as part of Dongara and Hill River Sheet by Lowry (1974). The western sector of the project area mainly consists of recent (Holocene) deposits of Safety Bay Sand (part of the Quindalup Dune System) which in the southern region has formed mobile dunes. Along the coast there is a thin strip of coastal limestone (more commonly referred to as Tamala limestone) which is dissected by sandy bays. The Tamala limestone was previously sand dunes which have become lithified. The eastern sector is dominated by Tamala limestone with a lagoon system separating the two sectors. The Tamala limestone originates from the Pleistocene period. During the Pleistocene, sea level varied repeatedly, falling to low levels during glacial periods and rising to present day levels or higher during interglacials. Changes in sea level result in periods of erosion and deposition along the coast.

The project area (part of the Perth Basin) was submerged and accumulating sediments throughout the Palaeozoic and Mesozoic areas when the sea level was at a higher level than at present. However sedimentation ceased at the end of the Cretaceous period. Since the Cretaceous period the area has been continually above the sea and subject to weathering and denudation.

Lagoonal deposits are found near the coast (<1 km) between and within dune systems. They are filled with gypsiferous, calcareous, saline clay a few metres thick.

2.2 SOILS

Soils in the coastal region coincide with the Holocene sand dune and Pleistocene limestone formations. All the soils of the project area are depauperate and have a neutral to alkaline soil reaction. They have a sandy texture and minimal to non-existent horizonation. The soils on the coastal dunes are chiefly calcareous (Uc 1.1) (Northcote *et al.*, 1967). Further inland the soils become more siliceous (Uc 1.2) and are associated with smaller areas of brown sands (Uc 4.22) and leached sands (Uc 2.21) in the wetter sites. The soils are very friable and have low cohesion, making them extremely vulnerable to wind erosion, especially if the vegetation cover is removed.

2.3 VEGETATION

The vegetation of the project area is described by Beard (1976, 1979). It is part of the Irwin Botanical District and more specifically the Cliff Head System. The Cliff Head System occupies a narrow belt along the coast south of Port Denison, 1 kilometre by 5 kilometres wide. The geomorphic units - parabolic dune, blowout, foredune, deflation basin, limestone platform and lagoon system (comprised of salt lakes and adjacent swamps) all have distinct vegetation formations which are described briefly below. For more detail on coastal vegetation refer to TABLE 5 in section 5.4.1.

Dunes (specifically parabolic ridges)

The dunes are dominated by dense thickets of Acacia rostellifera, A. xanthia, Casuarina baxteriana, Melaleuca cardiophylla and M. huegelli.

Foredune

On the foredunes the component species are Spinifex longifolia, S. hirsutus, Atriplex isatidea, Carpobrotus aequilaterus, Scaevola crassifolia, Olearia axillaris, Myoporum insulare, Salsola kali and Tetragonia decumbens.

Lagoon System

The salt lakes are surrounded by samphire while the adjacent swampy areas are thickets of Teatree and scattered Sheoak. The main species of Teatree are Melaleuca huegelli, M. thyoides and M. lanceolata with a sedge as the ground layer and Sheoak tree (Casuarina obesa) scattered singularly or in groves.

Blowouts

The blowouts are largely unvegetated except for the margins.

Limestone Platform (Tamala limestone)

The limestone headlands and coastline are covered with a low heath vegetation of small shrubs (30-60 cm in height), with small patches of Acacia and mallee thickets. The principal species in the heath are Acacia lasiocarpa and Melaleuca acerosa but frequently Scaevola sp. is dominant. Other species noted include Hemiandra pungens, Adriana quadripartita, Scaevola thesioides, Canostylis sp., Podolepis canescens and some very small Santalum acuminatum. The vine Cuscuta australis can be very common. Further inland, on the eastern side of the Lagoon system, the scrub heath is comprised of larger shrubs interspersed with patches of Eucalyptus erythrocorys F. Muell. (Illyarri).

The lateritic mesas of the Gairdner Range including Mt Lesueur and Mt Peron carry a distinctive flora with a high degree of endemism (Gardner, 1942).

2.4 CLIMATE

The area of investigation has no meteorological stations within its boundaries. Therefore, to analyse the climatic characteristics of the project area data was obtained from the nearest coastal stations in Dongara and Jurien Bay as well as the inland station in Eneabba. The climatic characteristics examined for this report are rainfall, temperature, winds and thunderstorms.

The typical climatic regime of the area is hot, dry summers and cool, wet winters which typifies a dry, warm mediterranean climate. For instance, the annual rainfall for Jurien Bay is 558 mm of which 78% falls in winter, leaving a long dry spell of 7 months.

The seasonal distribution of rainfall and fluctuation in temperature from January to December, 1984 for the three stations

is shown in TABLE 2. The Leeman-Green Head area has an average annual rainfall of 600 mm and it decreases progressively inland to 400 mm (average annual rainfall) at the town of Coorow.

The highest temperature occurs in January and February with temperatures approximately 30°C (Jurien Bay figures) while the minimum temperature occurs during the winter months (approximately 12°C).

Thunderstorms are most frequent in the summer months and the average annual number of thunder days is about ten. Nevertheless thunderstorms also occur in winter. Tropical cyclones may affect the coastline between January and March.

TABLE 2: Climatic Data on the Project Area

Average Monthly Rainfall

1984													<u>mm</u>		
	J	F	M	A	M	J	J	A	S	O	N	D	TOTAL	S	W
Dongara	-	52	36	68	158	26	74	51	41	17	30	5	558	58	151
Jurien Bay	0.2	13	32	44	174	54	65	73	52	25	33	12	557.2	25.2	192
Eneabba	-	40	40	36	160	34	66	67	59	30	55	9	596	49	167

S - Summer W - Winter

Average Max Temperature

1984													<u>°C</u>
	J	F	M	A	M	J	J	A	S	O	N	D	
Eneabba	36.2	37.3	30.7	29.2	21.3	20.5	18	19.4	22.5	25.5	28.5	30.8	
Jurien Bay	30.7	32	27.8	27.7	22	21.2	18.9	19.5	22.1	24	25.4	25	

Average Min Temperature

1984													<u>°C</u>
	J	F	M	A	M	J	J	A	S	O	N	D	
Eneabba	19.0	20.6	17.9	17.1	12.8	10.1	9.2	8.0	9.7	1.0	13.7	13.6	
Jurien Bay	16.6	18.1	14.8	14.8	13.7	9.4	8.2	9.1	9.3	1.9	13.3	13.7	

Average annual minimum and maximum temperature for:

Eneabba: 37.3°C 8.2°C
 Jurien Bay: 30.7°C 8.0°C

Source: Bureau of Meteorology, (1984)

2.5 COASTAL PROCESSES

2.5.1 Introduction

For any firm conclusions to be made on coastal processes one would need quantitative data on wind, wave and tide regimes, beach near-shore morphology, and the sediment budget for each bay. However, the above data are not available for the project area. The following techniques were the only ones available which could be used to deduct coastal processes. The techniques are aerial photographic interpretation, qualitative observation, extension of studies completed in adjacent areas and the educated opinion of resident coastal geomorphologists.

2.5.2 Winds

Summer winds are generally easterlies in the morning and become south-south westerlies in the afternoon. The dominant winds are south westerlies which blow mostly between 11 kph and 30 kph. It is believed that wind speeds greater than 10 kph are responsible for sand movement (Wood and Grieve, 1978). In winter, wind direction may vary from the north west through to the south. The Bureau of Meteorology wind records indicate the main direction and speed of the winds at Jurien Bay (the closest meteorological station to the project area).

During the passage of a tropical cyclone the wind direction may vary but usually they are north to north westerlies.

2.5.3 Waves

The coastline is dominated by two major wave forms -swell and wind waves. Swell waves are generally propagated from the south-west but their direction may be altered, as they approach the coast, by offshore features such as reefs and islands or due to extensions of the shoreline by using structures such as jetties. The swell waves are diffracted and reflected and break on the beach parallel to the shoreline. Waves refract and bend towards the headlands because of the offshore shoal area associated with the headland. The wave energy is therefore concentrated on the headland, and the wave heights there may be several times as large as in the adjacent embayments.

2.5.4 Tides

The project area on a world scale consists of a mixed tidal regime that is predominantly either diurnal or semi-diurnal (Davies, 1980). In the mixed tidal regime there are two highs and two lows per day which are not of the same magnitude. The tidal range is low and at the spring tides the tidal range is approximately less than 2 m. Since the tidal range is low in the project area the influence of tide-induced currents is limited to constrictions between islands and around headlands.

2.5.5 Sediment Budget

There are various inputs and outputs in the sediment budget. The inputs consist of littoral drift in, onshore transport, and cliff erosion, while the outputs are littoral drift out, offshore transport and dune migration. Each of the above components will briefly be discussed (FIGURE 2).

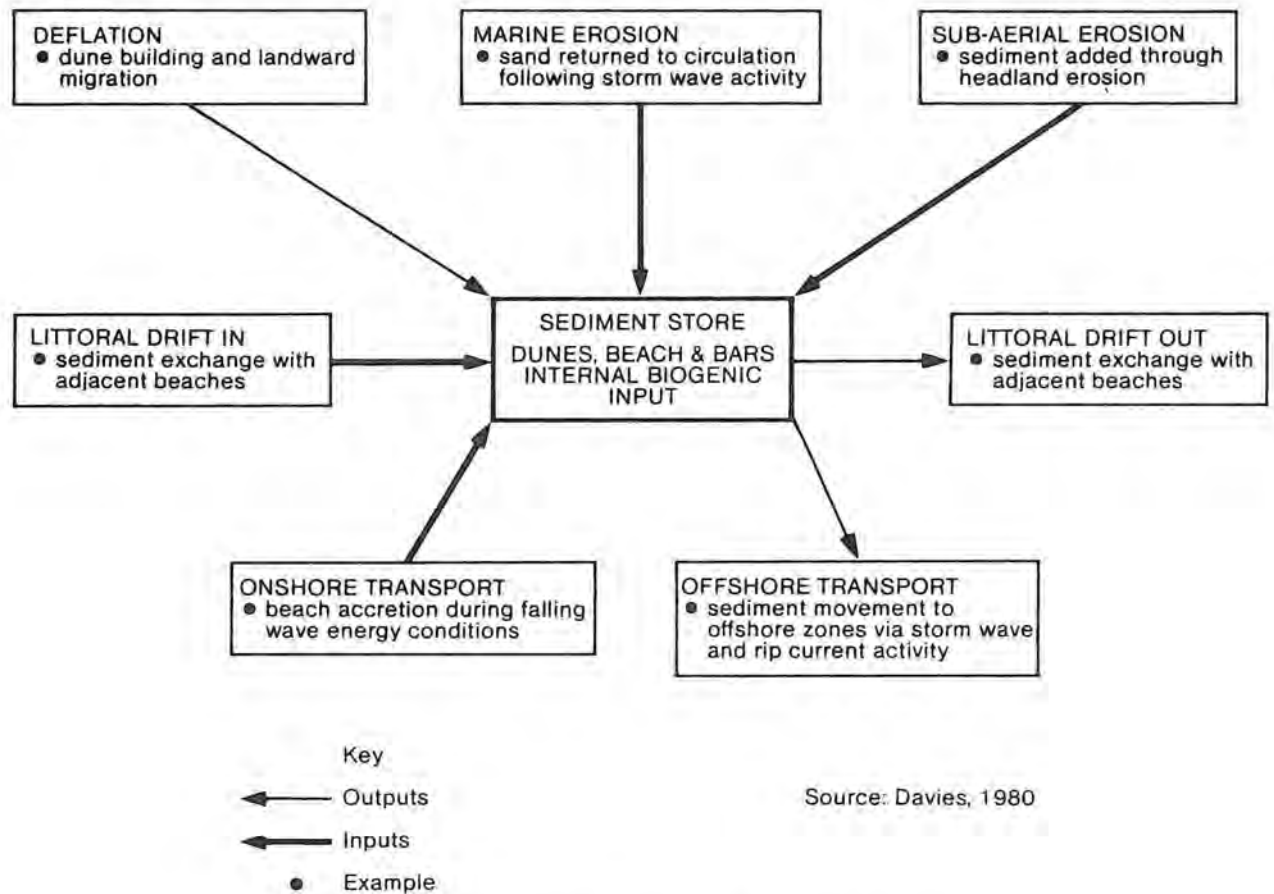


FIGURE 2 : Components of the Coastal Sediment Budget

The term "sink" is used to cover all those processes whereby sediment is lost to the coastal system. The first sink is represented by the migration of dunes inland where they can no longer be acted on by waves at times of storm activity and the second by transport offshore onto the seafloor.

Parabolic dunes seem to develop when the dune is no longer receiving new sand and begins to wander inland. As the dune travels, the sand body at the head is progressively exhausted and the two trailing edges develop into long slightly converging ridges. The development of such a sequence requires not only time but the frequent occurrence of high velocity winds from one major direction. In the project area the wind transport is mainly from the south-south west so that the parabolic dunes are orientated in a north-south direction. The natural development of dunes depends on a fortuitous sequence of events and circumstances.

Transport of sediment occurs in conjunction with nearshore cell circulation and littoral drift. The nearshore cell circulation consists of rip currents and feeding longshore currents and is normally generated by variations in the wave breaker height along the length of the beach. The longshore variations in wave height may be produced either by wave refraction causing divergence and convergence of the wave rays or by edge waves trapped in the nearshore interacting with normal swell waves. Alternative explanations for nearshore circulation have been developed by Hino (1975) and Sonu (1972). Longshore currents may also be produced by waves breaking at an angle to the shoreline. Exactly what processes cause longshore currents in the project area can not be ascertained.

However, longshore movement of sediment at any beach is the sum of transport under all the individual wave trains arriving at the shore from numerous wave generation areas. The beaches in the project area have north-south orientations and during summer sand may move northward for a time due to waves arriving from the south to south-west and then later move to the south in winter under waves coming from the north.

The result of north and south longshore drift is a net dominance of the northward transport system. Thus a small amount of sediment is continually being moved to the north. This phenomenon is responsible for the asymmetric growth of beach ridge plains and erosion on their southern flanks.

2.5.6 Shoreline Stability and Coastal Erosion

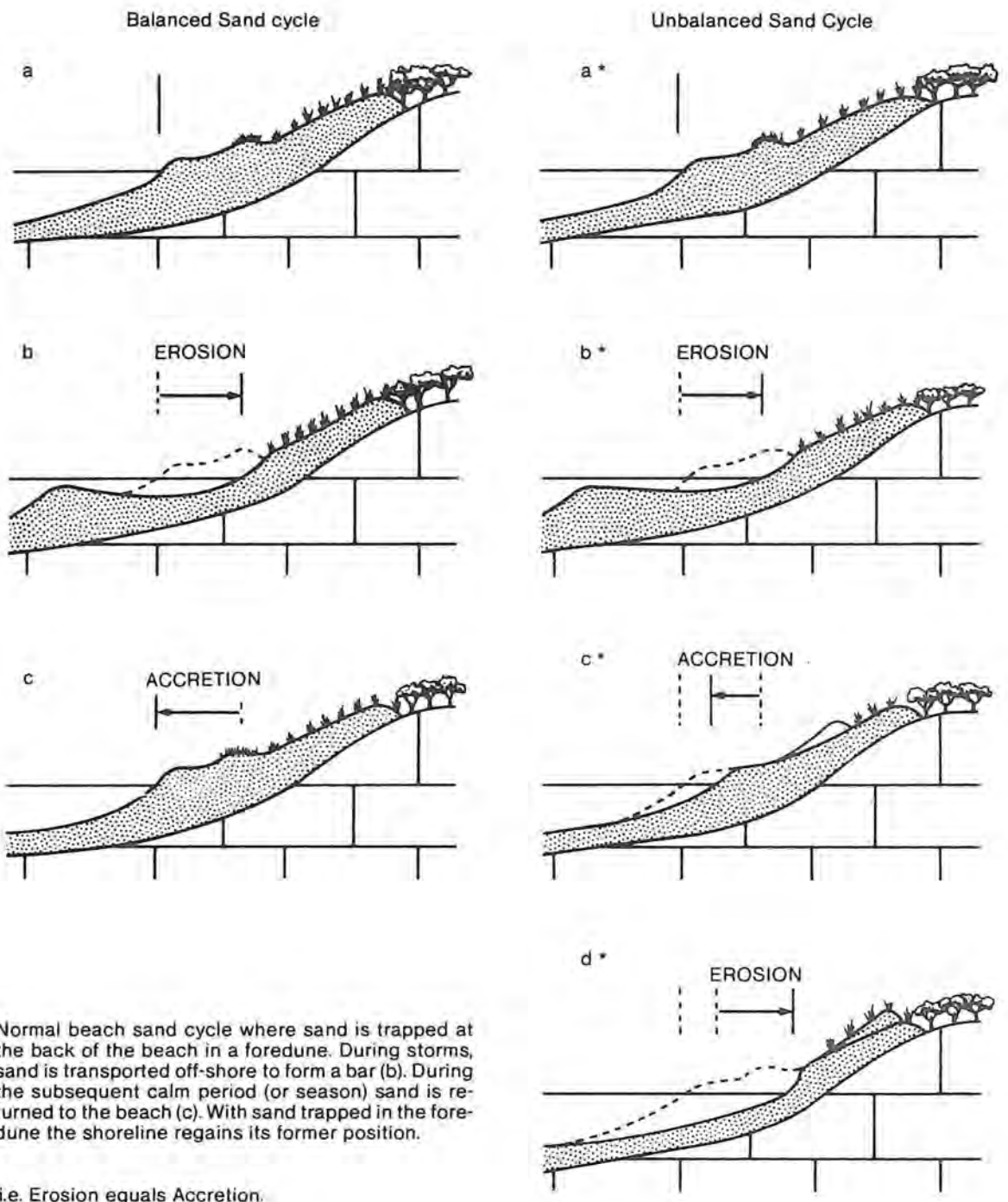
The recession hazard can be categorised into two main types which pose significantly different problems to the coastal planner - the beach sand cycle and secular recession.

Beach Sand Cycle

The commonly perceived definition of the beach is the interface between the ocean and the land at a particular instant. In reality, this zone is not static but varies within a definable zone depending on the existing weather conditions. During storm events the back beach escarpment will move landward as sand is moved offshore to form storm bars which dissipate the wave energy. In contrast, during periods of calm weather the sand gradually moves back onshore from the bar, rebuilding the beach and an incipient foredune. The term used to describe the area which encompasses the accreted and storm profile is the dynamic swept prism (Chapman and Smith, 1980). This situation does not involve any nett loss of sediment from the beach system. However, if development is allowed within this dynamic swept prism it may be threatened or lost during a severe event (FIGURE 3).

Secular Recession

Secular recession is an ongoing landward movement of the erosion escarpment associated with an average sediment loss from the coastal compartment. Therefore to assess or predict shoreline stability various techniques could be used (May *et al.*, 1983). However, sediment budgets are generally used to assess the medium term stability of the shoreline. No such investigations have been completed for the area. From preliminary investigation (29-31 May) of the project area the northern ends of the crescentic, sandy bays appear to have wider beach widths and are backed by a series of beach ridges. Thus, one could assume that the northern ends of the bays are prograding or at least have been prograding in the past. However, these areas also have consolidated parabolic dunes indicating periods of high sand influx and instability. Hence, shoreline instability results from an imbalance between sediment removal and sediment supply to the coast. The natural beach exhibits short-term fluctuations which are in dynamic equilibrium while over a greater period of time it may be prograding or receding.



Normal beach sand cycle where sand is trapped at the back of the beach in a foredune. During storms, sand is transported off-shore to form a bar (b). During the subsequent calm period (or season) sand is returned to the beach (c). With sand trapped in the foredune the shoreline regains its former position.

i.e. Erosion equals Accretion.

Unbalanced sand cycle where sand is not trapped in the foredune following a storm allowing sand to be lost from the active beach zone (c)*. As a result the shore will not regain its former position. During the next storm the dune will be attacked leading to formation of a dune cliff (d)*.

i.e. Erosion greater than Accretion.

FIGURE 3 : Beach Sand Cycle

Source : Woods, 1984

Beach Erosion

Woods (1984) placed the project area into Region 5 (Kalbarri to Cape Naturaliste). This section of coastline is characterised by long, sandy beaches and rocky limestone headlands, reefs and islands. The sandy bays are crescent-shaped and are orientated towards the north.

The modal form of the beaches in the project area is extremely low energy due to the presence of offshore islands and reefs. However, the area does experience high energy conditions with the passage of extra-tropical cyclones across the coastline. During the field trip (29-31 May) minor erosion was observed. For example scarping or cliffing along the foredune South of Leeman, erosional cusping along the summer berm at South Bay and vast accumulations of seaweed. Erosion was more prominent along the southern and central portions of the sandy bays. The beaches at South Bay, Squatter Settlement 1, south of and including Dynamite Bay, north of Leeman and Green Head jetty are showing evidence of erosion. Old dunes are progressively being cut back, bench marks have been exposed and there is scarping as well as erosional cusping along the sandy bays. At Squatter Settlement 1 (closest to Green Head) and north of Green Head jetty the erosional events are not as recent as vegetation has recolonised the dune system and there is a layer of humus underlaying the vegetation. In contrast, where the foredunes are low or non existent the beaches are more stable and are probably prograding. Most of the erosional activity is associated with activities such as tracking, off road vehicles, and squatter settlement.

2.6 GEOMORPHOLOGY

Hesp and Gozzard (1983) have included the project area within a description and land use capability study of coastal lands from Dongara to Green Head. They identified seven geomorphic units within the area. The units are Pleistocene Barrier complex, Deflation basins, Parabolic dunes, Active parabolic dunes and blowouts, foredunes and beach. These geomorphic units are the result of a complex interaction between geology, climate, vegetation, soils and coastal processes.

The geomorphology of the area was mapped by aerial photographic interpretation at 1:25 000 scale using 1978 aerial photographs. To check the reliability of the aerial photographic interpretation a field reconnaissance of the area was conducted by Hesp and Gozzard (1983). The main characteristic of each geomorphic unit is outlined below (FIGURE 4).

Pleistocene Barrier Complex

This geomorphic unit is equivalent to Tamala limestone which outcrops extensively to form rocky headlands and pools as well as submarine shelf chains and islands. The barrier complex consists of cemented aeolian calcarenite (limestone) and is often covered by a veneer of Safety Bay Sand.

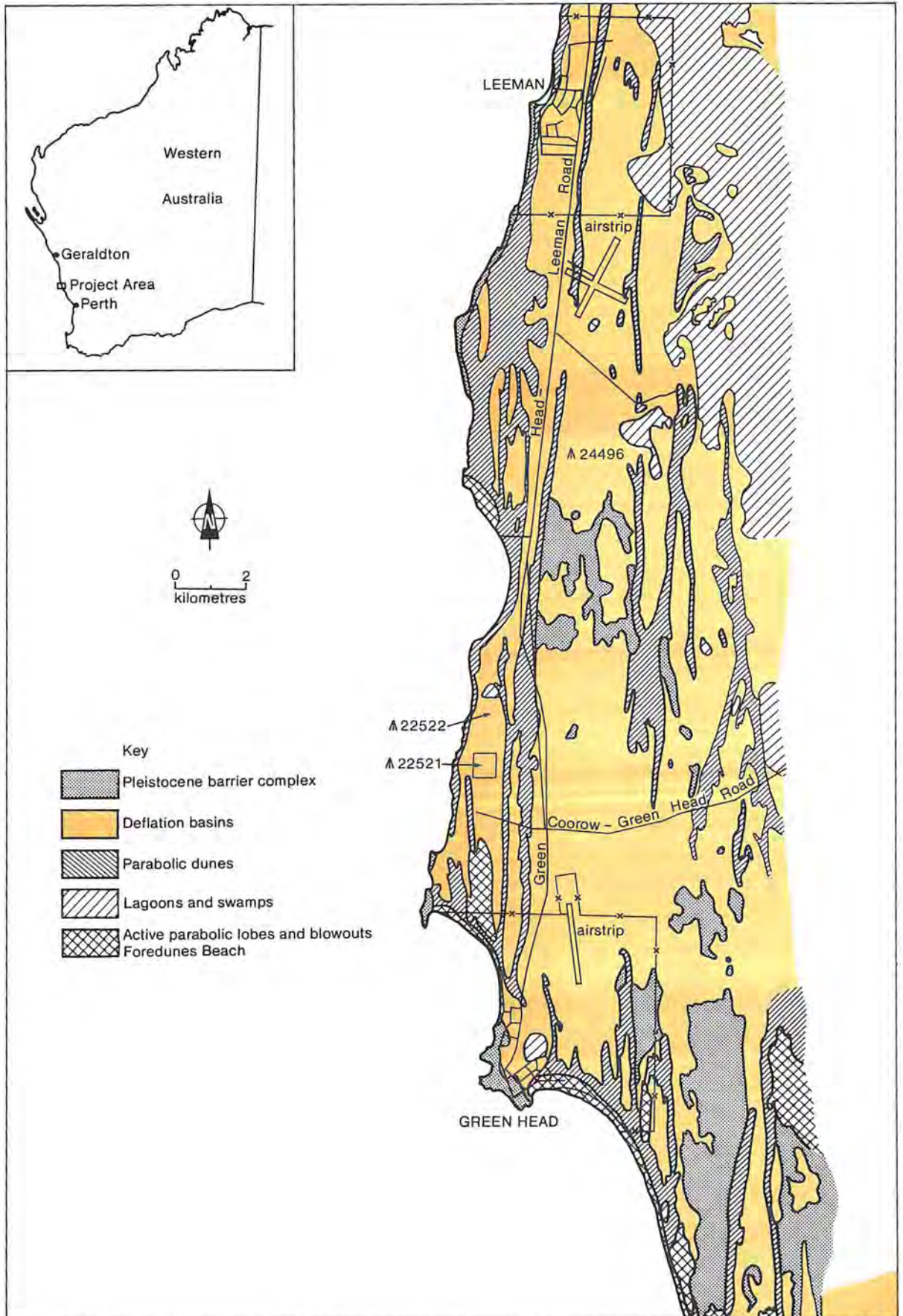


FIGURE 4 : Geomorphology of the Project Area

Source: Hesp and Gozzard, 1983

Parabolic Dunes

The geological equivalent of the parabolic dunes is the Quindalup dune system. The parabolic dune system represents more recent (Holocene) activity which has camouflaged the Pleistocene dune ridge complex. They are orientated in a north-south direction (parallel to the coast) which is the dominant wind direction. Active Parabolic Dune lobes and blowouts are at South Bay and north of Green Head. They are usually formed during periods of high sand influx and are later cutoff by vegetation recolonisation when the sand supply decreases. The active parabolic dune lobes continue to advance (approximately 1-9 m/yr) in a northern direction.

Deflation Basins

These areas are the flat and gently undulating erosion plains which are bounded by the active and inactive parabolic dunes.

Foredune

This unit may be made up of active and relic beach ridges. The ridges are asymmetric and can be vegetated or semi-vegetated. The geological equivalent is Safety Bay Sand and in some sections Quindalup Sand.

Beach

The beach is the active surf/swash zone and is a highly dynamic process area.

2.7 TERRESTRIAL FAUNA

2.7.1 Mammals and Birds

Chapman *et al.* (1977) completed a case study of the Cockleshell Gully Reserve which is included in the project area. Chapman and Kitchener (1977) found thirteen native mammals and six exotic mammals. An annotated list of mammals is included in APPENDIX 1. With the exception of Sminthopsis granulipes all mammal species recorded in this survey were previously known to inhabit the west coastal sand heaths between Moore and Murchison Rivers.

In contrast to the mammalian community the birdlife of the area is rich and diverse. There have been a total of 146 species of birds recorded from the area.

The Cockleshell Gully area is relatively undisturbed by clearing or mining and therefore it is of considerable importance in maintaining large breeding populations of birds. Thus, the area is viewed as "the most important portion of the southwest for conserving coastal passerine birds" (Dell and Johnstone, 1977).

The area is very rich in heath-dwelling species. The genus Malurus is represented by four species, and the genera Stipiturus, Sericornis, Calamanthus and Acanthiza are present. Similarly, the islands of the area, especially the Fishermen Islands, are important breeding grounds for nine species of sea birds and waders. The Pied Cormorant (Phalacrocorax varius), Roseate Tern (Sterna dougallii), Bridled Tern (Sterna anaethetus) and White-faced Storm Petrel (Pelagodroma marina) are the most important, each having fairly large breeding populations.

The project area has a variety of habitats such as beaches, salt lakes, fresh water springs and islands which offer important resting areas, summer refuges, feeding areas and breeding for avian fauna. The annotated list of bird species is in APPENDIX 1.

2.7.2 Reptiles and Amphibians

Seven species of frog and forty species of reptiles were collected on Cockleshell Gully Reserve. The reptiles on Cockleshell Gully Reserve include nine taxa which we have not recorded on any wheatbelt reserve. These are Diplodactylus alboquattatus, Aclys concinna, Amphibolurus adelaidensis adelaidensis, Ctenotus lesueurii, C. fallens, Lerista elegans, L. planiventralis decora, Liasis childreni and Vermicella littoralis. In addition it includes the sandplain species Morethia lineocellata. Amphibian and reptilian species richness depends on different soil types. For instance, the colluvial sands on the western slopes of the Gairdner Range are particularly rich with 28 species. Next in species richness are the Spearwood Dunes with 23 species and the Gairdner Range with 20 species. Safety Bay Sands (which cover the project area) are very depauperate with only 6 species. One of these six, Egneria kingii, probably occurs on coastal limestone exposures. Two of the reptile species - Vermicella calonotus (Bandy-Bandy Snake) and Lerista christinae (Lizard) are on the list of rare and protected fauna. For the complete annotated list of reptiles and amphibians refer to APPENDIX 2.

2.8. AQUATIC FAUNA

2.8.1 Fish

The coastal waters are partially protected by an extensive reef system which extends discontinuously from one end of the project area to the other. A rich and diverse community of fish species is supported by meadows of Amphibolis antarctica and Ecklonia. For the project area there exists very little information on the diversity and distribution of fishes. However, in a general capacity the book by Hutchins and Thompson (1983) describes the distribution of many South Western Australian fishes. Common species to the area are Tailor, Mulloway, Silver Bream, Australian Herring, Yelloweye Mullet, Westralian Jewfish, Samson Fish, Coral Trout, Pink Snapper, Cobbler, Skipjack Trevally, Giant and Perth Herring.

2.8.2 Other Invertebrates

The coastal waters of Leeman and Green Head form part of the habitat for the Western Rock Lobster (Panulirus cygnus). It inhabits limestone and coral reefs out to the edge of the continental shelf. Other invertebrates worthy of mention are the Saucer Scallop (Amusium balloti) and a species of Abalone (Haliotis roei). The project area lacks extensive listing of crustacea in the area. However, from the few studies which have been carried out (Joll, 1984; Joll and Phillips, 1984) in the vicinity of the project area they reveal a rich variety of invertebrates, including species of polychaete worms, bivalve molluscs and gastropods. There are also many small crustaceans such as isopods, amphipods and crabs as well as echinoderms and a selection of sponges. Thus, the project area forms part of a rich and diverse invertebrate community.

HUMAN ENVIRONMENT

3.1 CULTURE AND HERITAGE

Aborigines

Aboriginal people are thought to have lived in Australia for the last 40 000 years. During this time, they have coped with changes in both climate and sea levels (the present sea level was reached 6 000 years ago) and consequent changes to the animal and plant communities upon which they were dependent for food.

In response to the changing environment, Aboriginal people developed a nomadic lifestyle based on "hunting and gathering". This involved the systematic exploitation of available food resources such as marine and freshwater animals, marine shell species, terrestrial plants (herbs, rushes, seeds fruits, and nuts), nectar, and terrestrial animals (birds, mammals, reptiles).

Patterns of land and resource use and associated trade networks are reflected in both ethnographic and archaeological sites. Archaeological sites usually contain the physical remains of Aboriginal culture both before and after European colonisation and include shelters, stone arrangements, camping sites, paintings, engravings and marked trees. Ethnographic sites are those where first hand Aboriginal comment is or has been available for example places for current ritual or ceremony, or sites with mythical associations. Ethnographic sites are often also archaeological sites such as fish traps, burials, stone quarries.

Aboriginal Occupation

Traditional Aboriginal culture disappeared from the south west coast of Western Australia in the mid 19th century. At that time the "Amangu" tribe was known to occupy this section of coastline (Tindale, 1974). Although few ethnographic or archaeological data exist for this area it is assumed that their economy was based on exploitation of resources available to them from both the coastal plain and inland areas, as has been documented for regions further south.

Archaeological Sites

Archaeological sites are usually associated with fresh water sources. Although there are no freshwater streams or lakes occurring naturally in this area, freshwater soaks are found in the swales between the foredunes and secondary dunes parallel with the coast. Sites located in this area include:

SHELL MIDDENS - These can be described as "accumulations of humanly transported mollusc shells of selected food species in situ (that is undisturbed in their original position), associated with other archaeological material including stone artefacts, beach pebbles, charcoal, and vertebrate faunal remains" (Dortch et al., 1984).

A midden site has been found at Greenhead, on a rocky platform overlooking a beach where many marine shells can easily be collected. The deposit includes numerous marine shells such

as limpet, turban, whelk, abalone, and chiton) in association with calcrete and other stone artefacts on a sandy soil (Dortch et al., 1984). The deposit has been almost completely destroyed by sand quarrying, but the remaining number of artefacts indicate the site to have been originally quite dense. Radio carbon dates approximately 5 260 years old.

This site is significant in terms of West Australian prehistory as it indicates that marine molluscs were included as a natural food resource in traditional Aboriginal economy. Only a few middens have been located on the south west coast of Western Australia to date, but they have disproved the theory held until quite recently that mollusc species were not part of the traditional diet as indicated in ethnographic sources.

OCCUPATION SITES - An occupation/camping site has been found behind the foredune system near a freshwater soak. Artefacts found include a piece of grindstone which indicates that food preparation had taken place there.

BURIALS - Coastal dunes were used for Aboriginal burials throughout the West Australian coast. Human skeletal material has been exposed by dune blowouts in the area.

3.2 POPULATION GROWTH

The two major concentrations of population are at Green Head (165 people and 85 dwellings) and Leeman (460 people and 176 dwellings), (Shire of Coorow, 1985). The likely future population of Green Head or Leeman is difficult to project. The major industry of the area is commercial rock lobster fishing. The industry is not expected to increase dramatically considering the restrictions on the industry and the more favourably located fishing industry at Jurien Bay. The most likely cause of future population growth (especially in Green Head) will be the increased popularity of the area as a holiday/tourism centre. Leeman was originally a small fishing village which developed when selected as the residential setting for Western Titanium mineral sands venture at Eneabba.

3.3 FACILITIES

The project area is served by a number of facilities. The facilities of concern are those which affect the coastal area and serve the local residents, squatters and tourists.

3.3.1 Roads

At the present time there is a sealed road and a number of tracks which connect Leeman and Green Head. In most places the main road (connecting the two towns) is set far enough inland (1km) to avoid the management problems which are inherent with roads built too close to the coastline. However, the network of tracks which proliferate the coast is an obvious management problem. The growth and use of tracks is uncontrolled and in most instances they are on the coastal dune system. PLATE 1 illustrates the erosional problems involved with uncontrolled tracking. The old tracks have been abandoned and new ones developed leaving the old tracks to form gullies.



PLATE 1 : Degradation of vegetation along a pedestrian track at Dynamite Bay, Green Head. The eroded face is a metre high.

There is also a proposal concerning the alignment, dedication and construction of a coastal road system through the Shires of Gingin Dandaragan, Coorow and Carnamah. One segment of the coastal road link will join Green Head to Jurien Bay. In the long term the road will connect Cervantes to Geraldton. The new coastal road will supposedly increase tourist flow through the area as well as allowing fishermen the greater convenience of fish processing facilities at Jurien Bay and Cervantes (McCulloch, pers. comm.).

3.3.2 Carparks

In most cases the parking areas are located at jetties, boat ramps and popular beach spots such as Dynamite Bay at Green Head. The parking facilities are usually constructed of blue metal or gravel or compacted limestone. In general, the areas are unfenced and in close proximity to the foreshore. For instance, the parking facilities at Leeman are 10 metres from the waterline.

3.3.3 Beach Access: Vehicular and Pedestrian

Beach access is largely uncontrolled and criss crosses the dune system. The tracks follow the edge of the rocky headlands and seem to be causing erosional problems. Vegetation has been denuded along the tracks and in some places, (especially south of Leeman) blow-outs have formed (PLATE 2a and b). The tracks have also contributed to gully-type erosion, exposing the vegetation's root system (PLATE 3). The vegetation of the coastal dune system may be able to withstand dehydration, salt and wind but it is extremely vulnerable to man's activities. Areas of extreme tracking are indicated in FIGURES 7 to 11. South of Leeman (between the boat ramp opposite the caravan park and cliff head) some attempt has been made to control off-road vehicle activity by closing down the tracks which run parallel to the coastline. A track running parallel to the



PLATE 2a : Blowouts at Leeman, opposite the Leeman-Shag Island Caravan park. Tetragonia decumbens in mid-ground is forming an incipient foredune. The blowouts are partially vegetated by Pyp grass.



PLATE 2b : Blowouts north of Leeman Jetty. Exposed bench mark in mid-ground.



PLATE 3 : Exposed vegetation root system at blowout area opposite the Leeman-Shag Island Caravan Park. The eroded face is just over a metre.

coastline towards Dynamite Bay has also been closed down. These examples are the only known cases where people and vehicle movement are being controlled.

3.3.4 Toilet and Picnic Facilities

Toilet and showering/change room facilities exist in association with parking and barbecue facilities at Leeman jetty and Dynamite Bay in Green Head. The toilets at Dynamite Bay are not camouflaged and are visible from most vantage points. To a lesser extent this is true for the facilities at Leeman. Both of the conveniences are constructed of brown brick with tin roofs which are too stark and austere (PLATE 4).

Located inland from the jetties, at Leeman and Green Head, adjacent to the parking areas is grassed parkland. At Leeman there is also a children's playground.

3.3.5 Boat Ramps and Mooring Facilities

In Leeman there exists a number of disused boat ramps which appear to have been abandoned due to erosion. The main boat ramp is slightly north of the Leeman jetty and there is a pseudo-boat ramp opposite the caravan park. Green Head has only one boat ramp at South Bay which is more suitable for launching boats if one has a Four Wheel Drive.

Both the townsites offer excellent mooring facilities since the bays are sheltered from high energy wave conditions by offshore reefs and islands (PLATE 5). Mooring facilities are available at both jetties and South Bay. Adequate mooring space exists for



PLATE 4: Toilet, changeroom and shower facilities at the Leeman jetty.



PLATE 5 : Leeman Jetty. In the left-hand background, is a distant view of the eroded Leeman cliff head.

current recreational usage at both these sites, however, in neither case is there room for expansion.

3.3.6 Tourist Accommodation

The project area has two aesthetically pleasing caravan parks at Leeman and Green Head. The Leeman Caravan Park has a capacity of 100 bays while the Green Head Caravan park has a capacity of 67 bays. Both caravan parks have on-site caravans and chalets. There are no hotels within the project area but 58 kilometres, south of Green Head, at Jurien Bay, there is a hotel/motel.

In the findings of the "Caravan Park Study of Northern Western Australia" (W.A. Dept of Tourism, 1982) it suggested that Kalbarri was the only location with potential site shortage and concluded that "elsewhere in the region no supply problem is evident - in fact existing capacity was well able to accommodate the ... growth in the 1982 tourist season". However, this study was primarily concerned with the Kimberley and Pilbara regions but did include Dongara which is north of the project area.

The caravan parks are used sporadically with the busiest influxes being the Christmas and New Year period, long weekends such as the Australia Day long weekend, and Easter. The proprietor of the Green Head Caravan Park commented that they were booked out for Easter 1986 already (May, 1985). The second busiest times are school holidays and the wildflower season. The Leeman-Snag Island Caravan Park also has occupants from the Eneabba Allied Mining Company and crayfishermen. Both caravan parks have only a few permanent residents. The Leeman-Snag Island Caravan park has 10-12 permanent residents while the smaller Green Head Caravan Park has two permanent residents. Most of the visitors are holiday makers originating from Perth with the occasional Eastern States visitor.

There are two camping reserves (22521, 22522) in the project area which were recommended by the Conservation Through Reserves Committee (C.T.R.C.) in 1972 and as yet are not vested. Besides the legitimate accommodation offered by caravan parks there are the squatter settlements north of Green Head. These settlements offer low cost accommodation for mainly, Perth residents and farmers from surrounding agricultural districts.

3.4 LAND USE IN THE PROJECT AREA

3.4.1 Tourism

The project area has definite seasons - when it is extremely popular for tourists. The peak periods coincide with long weekends such as Australia Day long weekend, Easter Holidays and the Christmas - New Year Break. The Leeman - Green Head area is a popular tourism resort for people from Perth, the surrounding wheatbelt farming districts and interstate. One of the major attractions of the area is the low energy beaches which offer safe, swimming conditions and surf fishing. Nearby, national parks provides an impetus for people interested in the flora and fauna of the northern sand plain especially during the wildflower season. There are also caves to explore in the area. The Australian Bureau of Statistics (A.B.S.) has collected data on tourist arrivals to the Shire of Coorow (TABLE 3). In 1984 there were 7537 arrivals.

TABLE 3 : Visitors to the Shire of Coorow

<u>Period</u>	<u>Number of Visitors</u>
January - March	1 605
April - June	2 065
July - September	2 085
October - December	1 773
TOTAL	7 528

Source: A.B.S., 1984

3.4.2 Recreational Activity

A recreational survey was carried out at the Leeman-Shag Island and Green Head Caravan Park on the 4th and 5th of September 1985. The survey aims to ascertain the characteristics of the recreating populations, where and when they are recreating, what type of recreation they are participating in, where the recreators come from and improvements they perceive a need for in the area. The information from the survey will enable identification of "popular" beaches, the main type of beach users, the recreational activities they are involved in and improvements for the beach in terms of recreation.

Likely, recreational activities are fishing, snorkeling and scuba diving, swimming, sunbathing and sailing. However, new recreational possibilities will emerge as the towns grow. For instance, at Green Head they are proposing to build a golf course. Recreation is centred on water-based activities. The results of the recreational survey are described and discussed in section 5.3.2. and APPENDIX 3 contains the questionnaire sheet and results.

3.4.3 Commercial Fishing

In Western Australian waters the most important commercial, crustacean species is the Western Rock Lobster (Panulirus cygnus). Green Head and Leeman are two of the principal localities for the industry. The industry is protected from overfishing by the declaration of fishing seasons (15th of November to the 30th of June for the Leeman area) and the proclamation of fishing zones. In 1984, the total fish catch for the coast between Leeman and Green Head was 506 tonnes of which rock lobster comprised 449 tonnes (88.6%), Westralian Jewfish 20.5 tonnes (4.0%) and miscellaneous fish species 36.5 tonnes (7.4%).

A variety of fishes are caught in the area such as Shark Bronze Whaler, Baldchin Groper, Wobbegong Shark, Skates, Rays, Cod, Black Kingfish, Yellowtail Kingfish, Monwong, Mullet, Mulloway, Queen Snapper, Sweep and Western Sand Whiting.

Most of the rock lobster catch is exported to the United States, Japan and Europe.

3.4.4 Mining Exploration and Quarrying

Mining Tenement

C.R.A. Exploration holds Coal Mining Leases for the project area which has moderate to high coal deposits. There are mineral claims within the area which occupy crown land (24496) and private property.

Potential Mineral Resources

There are potentially significant economic deposits of limestone, limesand, heavy mineral sands, construction sand, and guano.

Limestone

Extensive deposits of Tamala limestone occur widely along the coast. No analyses are available but undoubtedly limestone deposits, ranging in suitability from road base to industrial grade limestone, occur. There are a number of small quarries established within this unit throughout the area. Presumably most of the material excavated is being used for road base.

Limesand

Limesand deposits occur along the coast within the Safety Bay sand and Quindalup sand units.

Heavy Mineral Sands

Heavy mineral deposits along the modern shoreline have been reported at Snag Island, near Leeman and at Green Head. These deposits are small and are restricted to the beach and therefore have no economic importance.

Construction Sand

Deposits of yellow, residual, quartz sand (derived from weathering of the Tamala limestone) form a variable, thick veneer on the limestone throughout the area. However, the deposits occur principally north of Dongara and near Illawong.

Guano

A few tonnes of phosphatic material (guano) have been mined for fertilisers from some of the limestone caves south of Green Head. The guano was formed by the reaction of bat excreta of calcareous cave debris.

Petroleum Potential

Outside the project area is the Beagle Ridge which as a whole does not have a great potential for hydrocarbons.

Groundwater Resources

Tamala limestone is widespread throughout the project area and is up to a 100 m thick and extends 25 m below sea level, but the saturated thickness is confined to the basal 20-30 m above.

3.4.5 Apiarists

One of the resource users of the area are the bee keepers. "Their" reserve is located north of Jurien Bay and is vitally important to apiarists in the spring period. The management and conservation of these areas is important to the livelihood of the apiarists as clearing, mining and detrimental fire management have diminished the existing locations available to bee keepers.

To this end Beekeepers Reserve is perhaps one of the important areas for apiarists.

3.4.6 Residential Development

Allen (1983) has developed a development plan for Green Head. Future residential settlement is proposed for areas east of South Bay and north along Green Head road. At this point in the report the suitability of the above mentioned areas for residential development will rely on future population growth (Section 3.2).

Residential development in Green Head is concentrated in and around the headland area in a north-south and east-west orientation.

Similarly, in the Leeman area residential development is contained within the existing road network. In future, residential development would be allowed to develop north and south of existing residential areas. The project area is also part of a larger Town Planning Scheme being produced for the Shire of Coorow by Taylor and Burrell Pty Ltd, Town Planning consultants.

3.4.7 Industrial and Commercial Development

In Leeman, the commercial facilities are confined to one local store and two fast-food outlets between Spencer Street and Acacia Way. Commercial facilities at Green Head are confined to one small store providing essential day-to-day items. However, the store is planning to expand.

Most purchases of higher order goods have to be made from Leeman or the larger centres such as Jurien Bay or Geraldton.

The facilities at Leeman serve the residents of Leeman, and Green Head and the transient tourist and crayfishing population who visit the coastal towns.

Industrial activity is non-existent in Leeman and Green Head. However, provision has been made on the western edge of the township for industrial purposes. The industrial area will also accommodate the demand for industrial land arising in Green Head.

3.4.8 Squatter Settlements

The West Midlands Coastal Townsites Committee and The West Coast Working Group have both examined the squatter settlement issue. Their recommendations consist of various alternatives which the Shire of Coorow could employ to control or eradicate squatter settlement. An overview of the situation is given below.

In the project area there are 75 shacks north of Green Head. Forty of the shacks are located in a bay which is referred to as Billy

Goat Bay and has Milligan Islet, Orton Rock and Lipfert Islet offshore (Squatter Settlement 1). The other bay which is slightly north has 17 shacks (Squatter Settlement 2). While the one further north - Little Anchorage - has 28 shacks (Squatter Settlement 3). The majority of the shacks are located on the foredune system. During the first field trip (29th-31st May, 1985) which coincided with the May school holidays only three families were observed at each settlement. On the second field trip (3rd-6th of September) again coinciding with the school holidays only about 6 family groups were sighted. At the present moment only two permanent residents live in the squatter settlements. The main users of the shacks are Perth residents and farmers. Thus, the user population of the shacks is transitory and does not have any bias towards fishermen. The local residents of Green Head and Leeman, expressed concern and disapproval of the squatter settlements. The major argument against the squatters was that they paid no rates to the Shire but used the amenities offered by the Shire. For example, they use the Green Head Caravan Park's facilities and "steal" water from the premises. The proprietor's water bill had tripled compared to his last bill yet he had not had an increase in caravan park patronage. Therefore one can only presume that squatters were the cause of the increase in water charges. Other local residents feel angered by the squatter settlements because they are investing their capital in the townsite while the squatters are degrading the Shire's beaches. The shacks are unsightly, aggravate dune erosion and are health hazards, because they lack sanitation and waste disposal facilities. A recent incident highlights the danger of squatter settlements. The incident involved a gas bottle exploding (at Sandy Cape near Jurien Bay) which killed one man and injured eleven others.

The attraction of squatter settlements is naturally their low cost and upkeep (although it was mentioned that one shack was resold for 2 000 dollars) but also the freedom of doing their "own thing". In the Shire of Dandaragan shacks are "changing hands" at up to 20 000 dollars each, and on average, one more is being built every week.

The squatter issue must be dealt with effectively and affirmatively. The Shire has been unable to evict the squatters because of inadequate laws and the necessary funds are unavailable. Such delays only lead to a further erosion of the Council's credibility and let the squatters believe they are "legitimately" residing on the beach and accepted by the town's people.

3.4.9 Flora and Fauna Reserves

A report of the Conservation Through Reserves Committee (C.T.R.C., 1974) to the Environmental Protection Authority, concluded that the reserves in the region were considered adequate for the conservation of representative flora and fauna and growing recreational usage.

The most urgent needs identified were for the re-classification of some C Class reserves to A Class reserves, the redesignation of the purpose of others, and adequate management.

Beekeepers Reserve

The committee recommends that the purpose of those parts of reserve 24496 (Protection of Flora) and Reserve 19219 (Stock Route) (FIGURE

5) be changed to "Apiculture and Conservation of Flora". The reserve should be C Class and vested in the Minister for Agriculture.

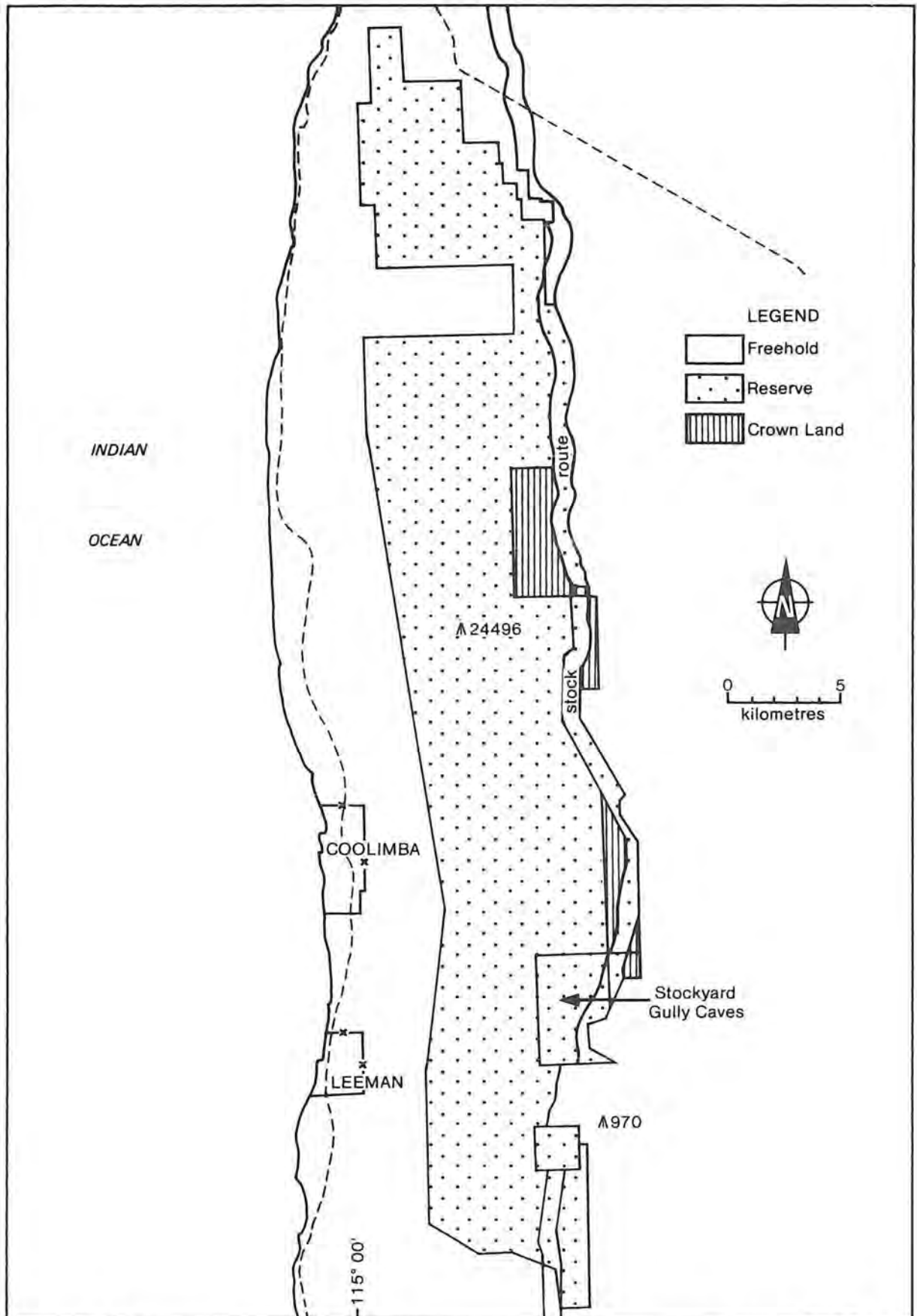


FIGURE 5 : Beekeepers Reserve and Stockyard Gully

Source : C.T.R.C., 1974

Stockyard Gully

The committee recommends that part of Stock Route Reserve 19219 and the Beekeepers Reserve 24496 be cancelled and incorporated in a new reserve (FIGURE 5). The reserve should be designated as an A class reserve for the "Protection of Caves and Conservation of Flora". The reserve should be placed under the control of The Department of Conservation and Land Management.

Mt Lesueur Reserve

The area shown in FIGURE 6 should be consolidated and declared an "A" Class reserve for the "Conservation of Flora and Fauna". The reserve should be vested in the Western Australian Wildlife Authority.

The grazing lease 667/14A should be cancelled and Victoria Locations 1433 and 1730 be purchased and added to the reserve.

The western boundary of the Mt Lesueur reserve will undoubtedly become the road proposed to join Jurien Bay to Green Head.

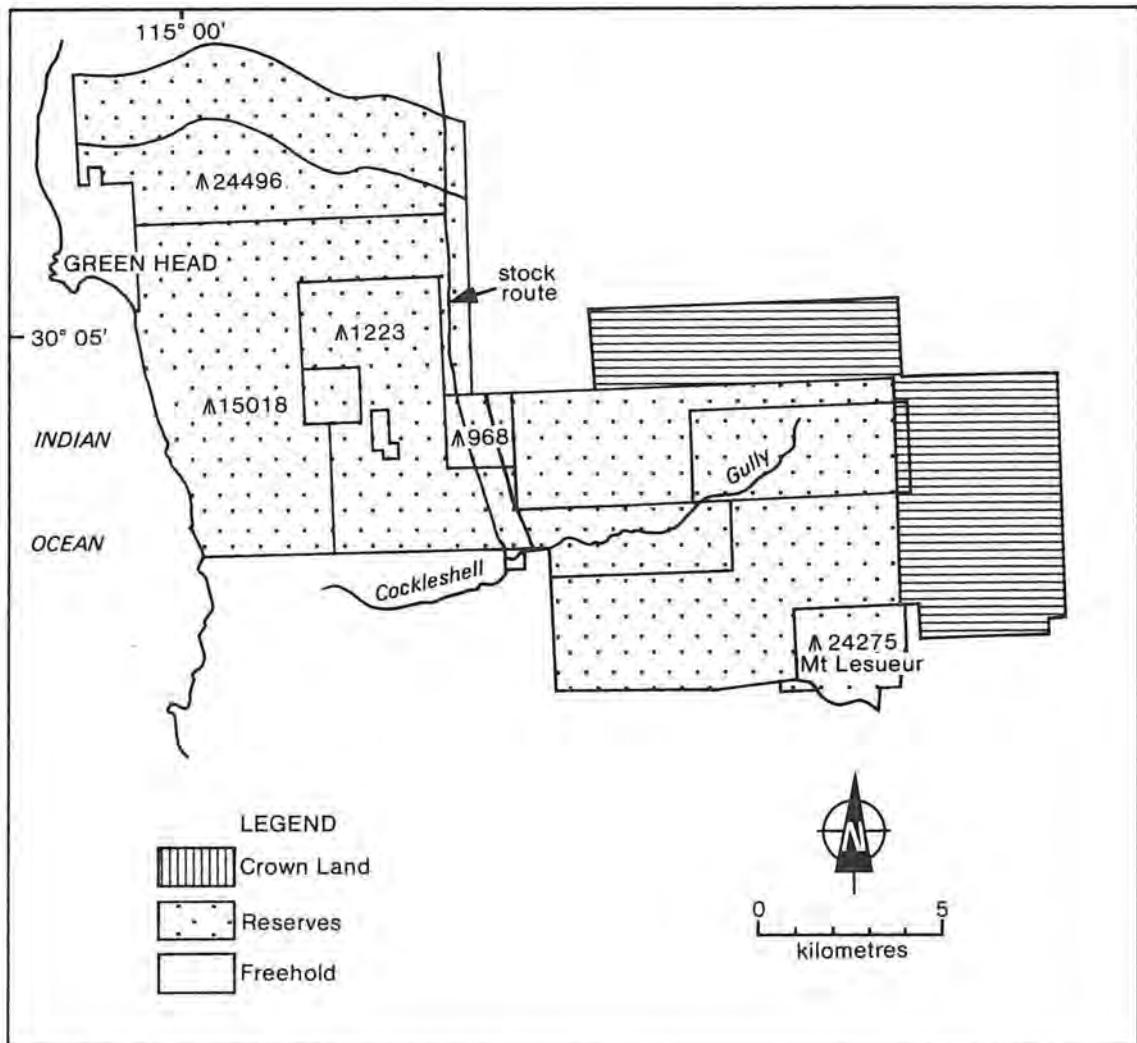


FIGURE 6 : Mt Lesueur Reserve

Source : C.T.R.C., 1974

4.

SUMMARY OF ATTRIBUTES AND CONSTRAINTS IN PROJECT AREA

To set the management plan into a framework or context the major attributes and constraints of the project area will be briefly described.

The major attributes of the area are:

1. a diverse floristic community;
2. a rich diversity of avian fauna who rely on offshore islands and nature reserves in the project area for summer refuges, breeding, feeding and resting areas;
3. an attractive, relatively undisturbed coastal landscape which exhibits a variety of rocky and sandy shorelines;
4. a low energy coastal environment which provides local residents and tourists with safe, swimming areas. The area also offers a variety of water-based recreational activities;
5. an existing infrastructure of roads, airports, boat moorings, jetties, boat ramps, tourist accommodation and beach amenities which sufficiently provide for the needs of residents and tourists in the project area;
6. a productive economy based on commercial fishing and tourism.

The major constraints of the area are:

1. the degradation of sand-dune vegetation by uncontrolled tracking, use of off-road vehicles and squatter settlements;
2. the aggravation of dune instability, reduction of beach amenity, littering and health risk problems posed by squatter settlement;
3. a shoreline which in places, is eroding and possibly receding;
4. a limited input of funding towards coastal management in areas such as shack removal and dune revegetation;
5. the existing land use patterns and planning procedures which will affect the future development of townsites;
6. the conflicting interests of the coastal land users over priority for instance the squatter settlements.

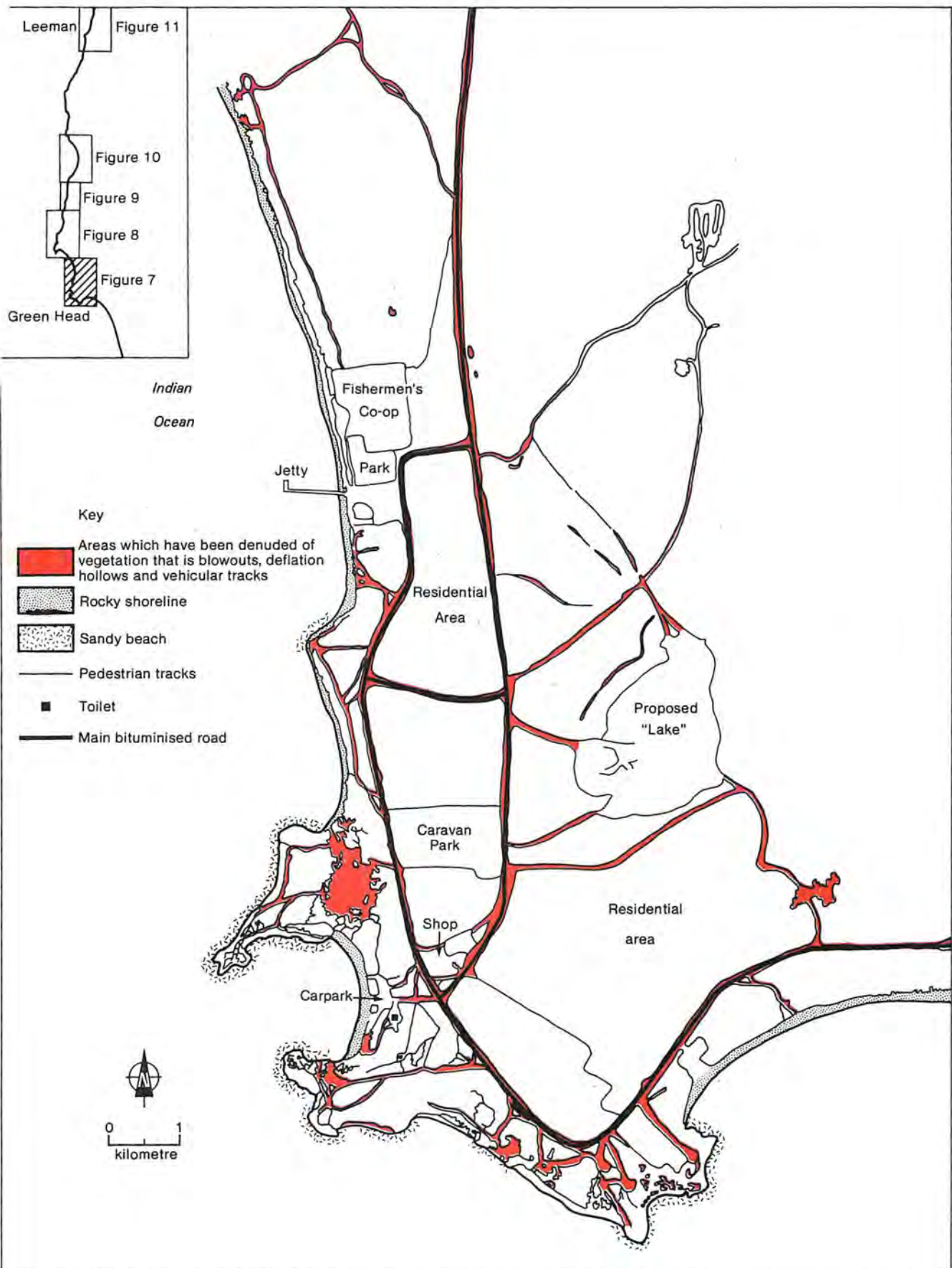


FIGURE 7 : Management Area 1 : Green Head Townsite

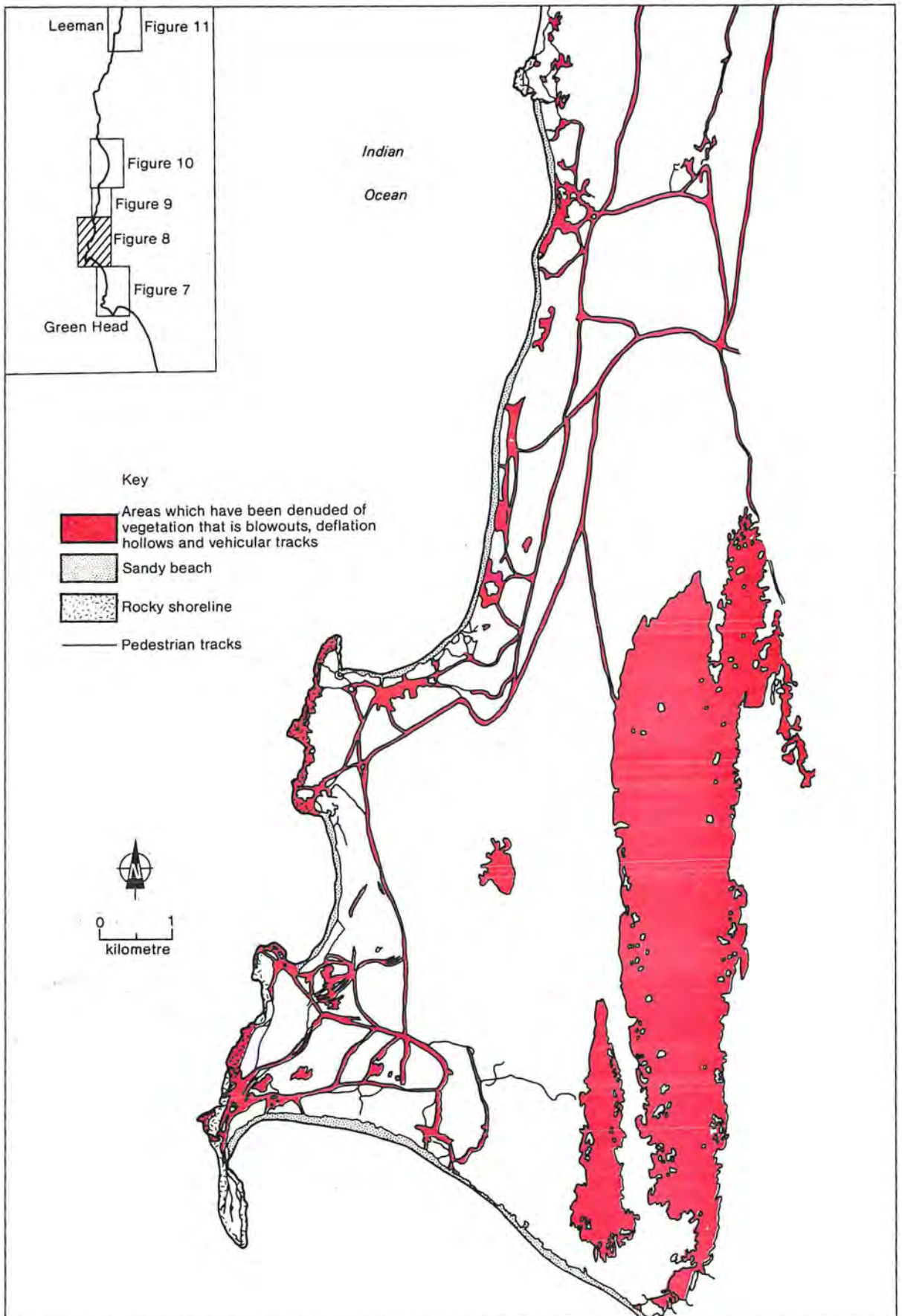


FIGURE 8 : Management Area 2 : Squatter Settlement 1.

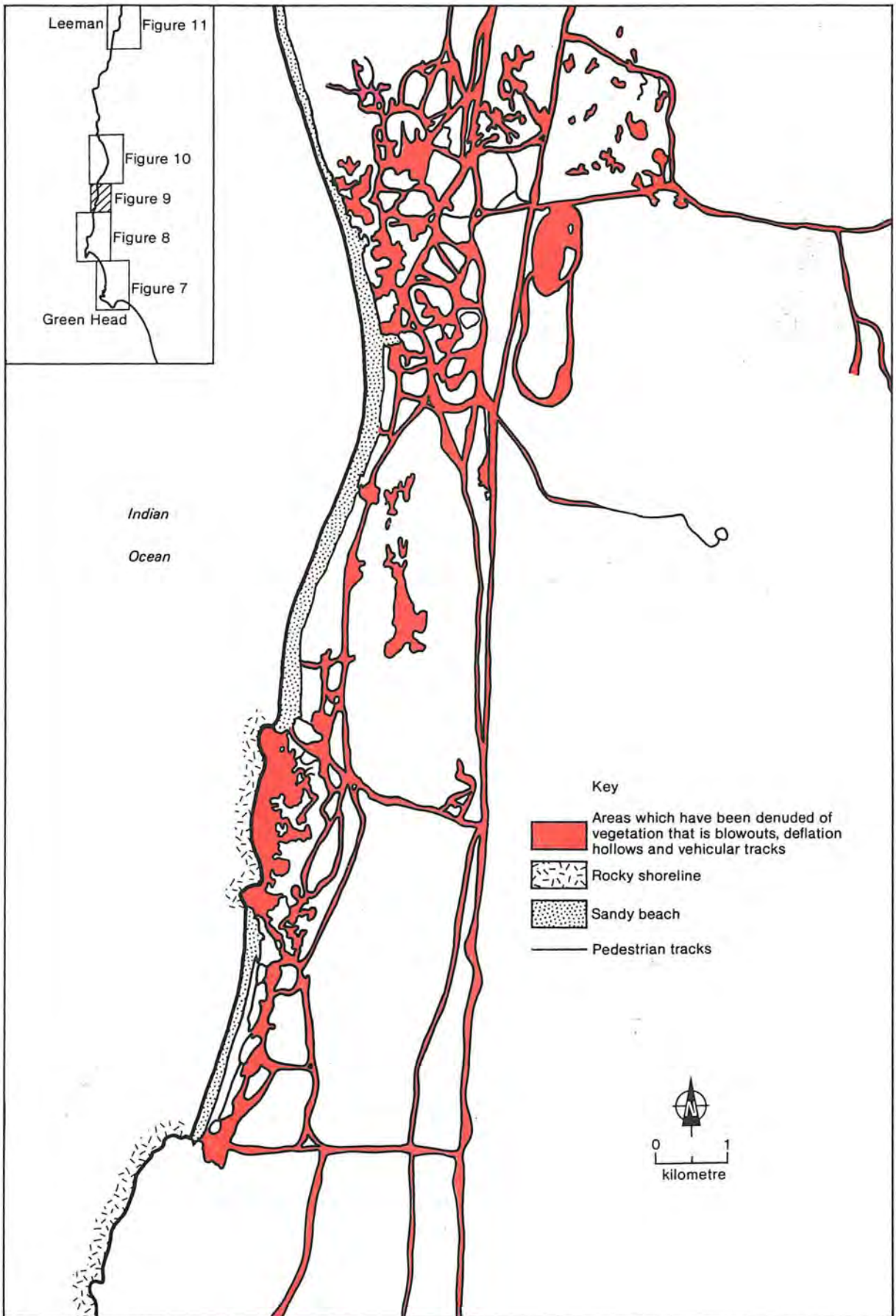


FIGURE 9 : Management Area 3 : Squatter Settlement 2.

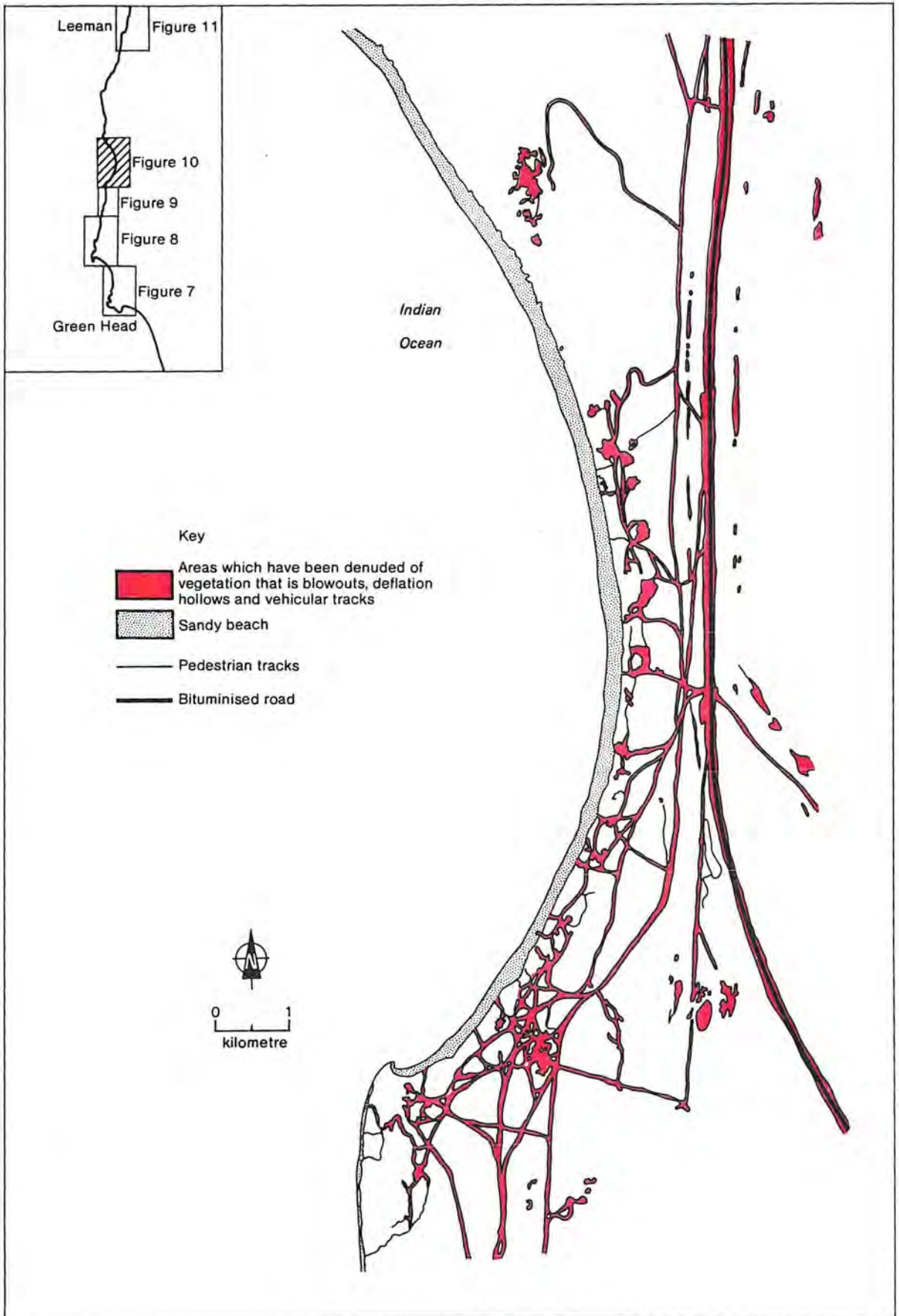


FIGURE 10 : Management Area 4 : Squatter Settlement 3.

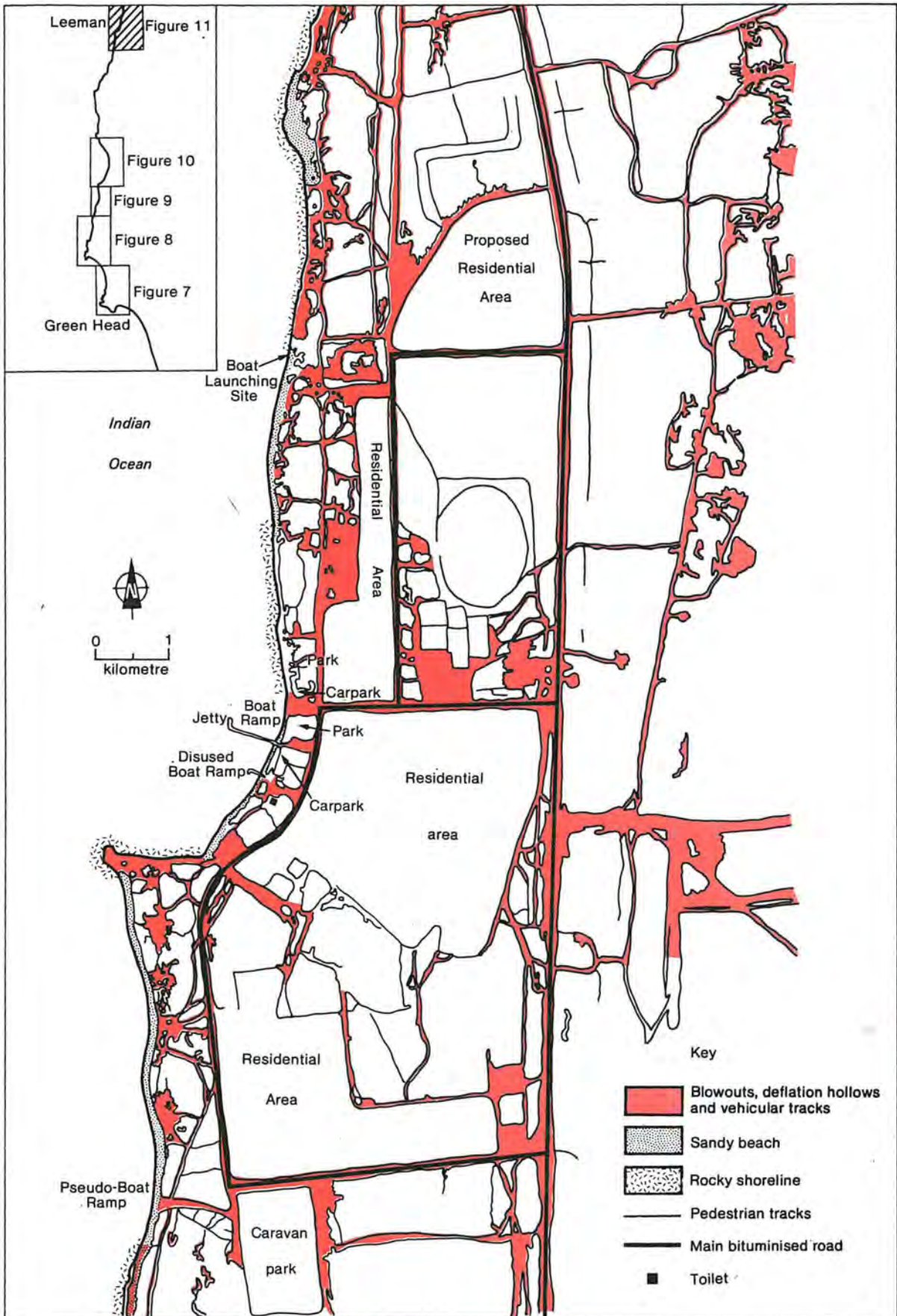


FIGURE 11 : Management Area 5 : Leeman Townsite.

MANAGEMENT ISSUES AND RECOMMENDATIONS

5.1 CULTURE AND HERITAGE

The archaeological evidence outlined in Section 3.1 is invaluable in understanding traditional Aboriginal land and resource use in the south-west of Australia, as well as in terms of Australian prehistory. While only a few sites have been recorded in the area, more are presumed to be present but are as yet unlocated. Any developments in the Coorow area will have to consider the impact on Aboriginal sites and local Aboriginal communities.

The recording and protection of Aboriginal sites in Western Australia is the responsibility of the Department of Aboriginal Sites, Western Australian Museum, under the Aboriginal Heritage Act (1972-1980).

5.2 FACILITIES

5.2.1 Roads

The area's road system is set back, in most cases, a sufficient distance from the beach. The proposed Jurien Bay - Green Head road link will not cause significant management problems until the rest of the Cervantes - Geraldton Coastal road is complete. Once the coastal road is complete it will certainly mean increased tourist flow through the area and possible management problems for the coastal area.

Recommendations

- . The design and siting of the coastal road is imperative to ensure preservation of the fragile coastal environment.

Features of design and siting to be taken into consideration are:

- . The road should be no closer than 1 km from the beach. People are more likely to stop and walk 700 metres to look at a beach if they only get glimpses of the ocean as they drive along. However, if people have an unobstructed, continuous view of the ocean they are more likely to pass through. Therefore, if one is interested in developing tourism in the area, the road should be located inland (1 km).
- . A reasonable distance should be selected which allows for the natural beach sand cycle or secular recession to continue without damaging the road or causing sand drift problems. Roadways should be sited sufficiently landward of the existing dune line to permit natural sand movement. A sufficient setback is also required to prevent encroachment onto the dunes by development attracted to the area by the newly created road access.
- . In no case should a frontal dune be altered or crossed.
- . The coastal road should have subsidiary roads which link the coastal towns to the main road instead of having the coastal road pass through the town.

5.2.2 Carparks

There are carparks at the boat ramps and jetties of each town as well as Dynamite Bay. The existing carparks are in most cases only 10-15 metres (occasionally 30 m such as the South Bay carpark) from the waterline. Although, the beaches are normally in a state of low energy the passage of a high energy storm event over the coast would cause structural damage to many of the carparks or sand drift onto the carparks.

None of the carparks are fenced off and therefore they encourage access onto the beach by off-road vehicles or allow people to haphazardly obtain access to the beach by any pathway. Hence, there are a number of unnecessary tracks radiating from the carparks to the beaches. Recently, the carpark at Green Head's Dynamite Bay has been extended seaward 14 m (flattening foredune vegetation in the process). Already the carpark has small gullies developing (PLATE 6a and b).

Recommendations

- . The carparks should be surrounded by post and rail fencing to confine the motorists to the assigned area and prevent the indiscriminate use of any track to obtain access to the beach.
- . At the present moment existing carparks seem to be coping and it does not seem necessary for more carparks to be constructed.
- . Any maintenance work due to sand drift or gullying requires financial support which is often difficult to obtain. Thus, in the future, it is recommended that any proposed carpark be sited further from the foreshore to avoid the cost of maintenance work after a storm event.
- . In some instances the Agriculture Department of Western Australia has found that the pine rail fencing does not effectively deter people from crossing the dunes. Therefore they advise (Broun, pers. comm.) the use of barbed wire fencing. The W.A. Agriculture Department found this to be very effective. However, it will always be necessary to check the fencing as vandalism and destruction by storm events is a possibility.

5.2.3 Beach Access: Vehicular and Pedestrian

In the project area proliferation of tracks is a severe problem. The unnecessary number of tracks (both vehicular and pedestrian) is largely due to squatter settlements or people obtaining access to secluded beaches. Particularly bad areas for tracking is on the rocky headlands and adjacent dune systems at: Leeman (south of the jetty), Squatter Settlement 1, 2 and 3, Dynamite Bay and South Bay. The tracks are causing gully erosion, denudation of vegetation, cliff erosion and loss of beach amenity.

Recommendations

- . Any type of access should be controlled to prevent unnecessary replication of function. Tracks (vehicular and pedestrian)



PLATE 6a : The carpark at Dynamite Bay, which has been extended seaward 14 metres. In the background, excessive tracking has resulted in dune vegetation degradation.



PLATE 6b : The carpark is already experiencing erosion in the form of gullying. There is also no formal access to the beach.

should be sited and designed so as to minimise disturbance of the coastal environment yet still be of maximum efficiency to the user(s).

- . All unnecessary tracks should be sealed off by dumping sand at the entrance or in some instances barring the road with signs which read "track closed - vehicular access prohibited".
- . Tracks that are recommended for removal and those which should remain for each management area are illustrated in FIGURES 12 to 16.
- . New tracks should be controlled by fencing so that the existing situation does not redevelop.
- . New tracks should be positioned so that minimum disturbance of the sand dune vegetation occurs.
- . Pedestrian tracks down to the beach should be fenced on either side by post and rail fencing or barbed wire fencing to discourage people from creating new tracks. Logically, one would think that if the tracks are positioned properly then there would be little reason for people to develop new tracks.

Access over a vegetated frontal dune system, to be effective, must comply with specific requirements. These requirements are outlined below:

- . Access tracks should be located over existing dunes and not through them. Location in this manner with help to prevent the formation of blowouts along the track, or the excessive accumulation of sand.
- . Access tracks should be straight, if practicable, narrow (1.5 to 2.5 metres) and fenced off so where considerable usage is anticipated the vegetated areas will be protected.
- . To encourage use of the access, suitably worded and prominently placed signs will often help (Barr and Watt, 1969).
- . Off-road vehicles can be constrained by various regulations or laws [Control of Vehicles (off-road areas) Act, 1978]. The Act can control access and restrict off-road vehicles from traversing foredunes where vegetation can be destroyed and dune restoration projects jeopardised.
- . The pathway can be stabilised by gravel, bitumen, board and chain walkways and steps (preferably wood and not cement).

5.2.4 Toilet and Picnic Facilities

The beach amenities (toilets, shower, change rooms and barbecue facilities) also seem to be adequately catering for the needs of beach users in the area.

The prediction of future tourists' and local residents' demands for accommodation and beach facilities is difficult to project as there is virtually no information on the subject.

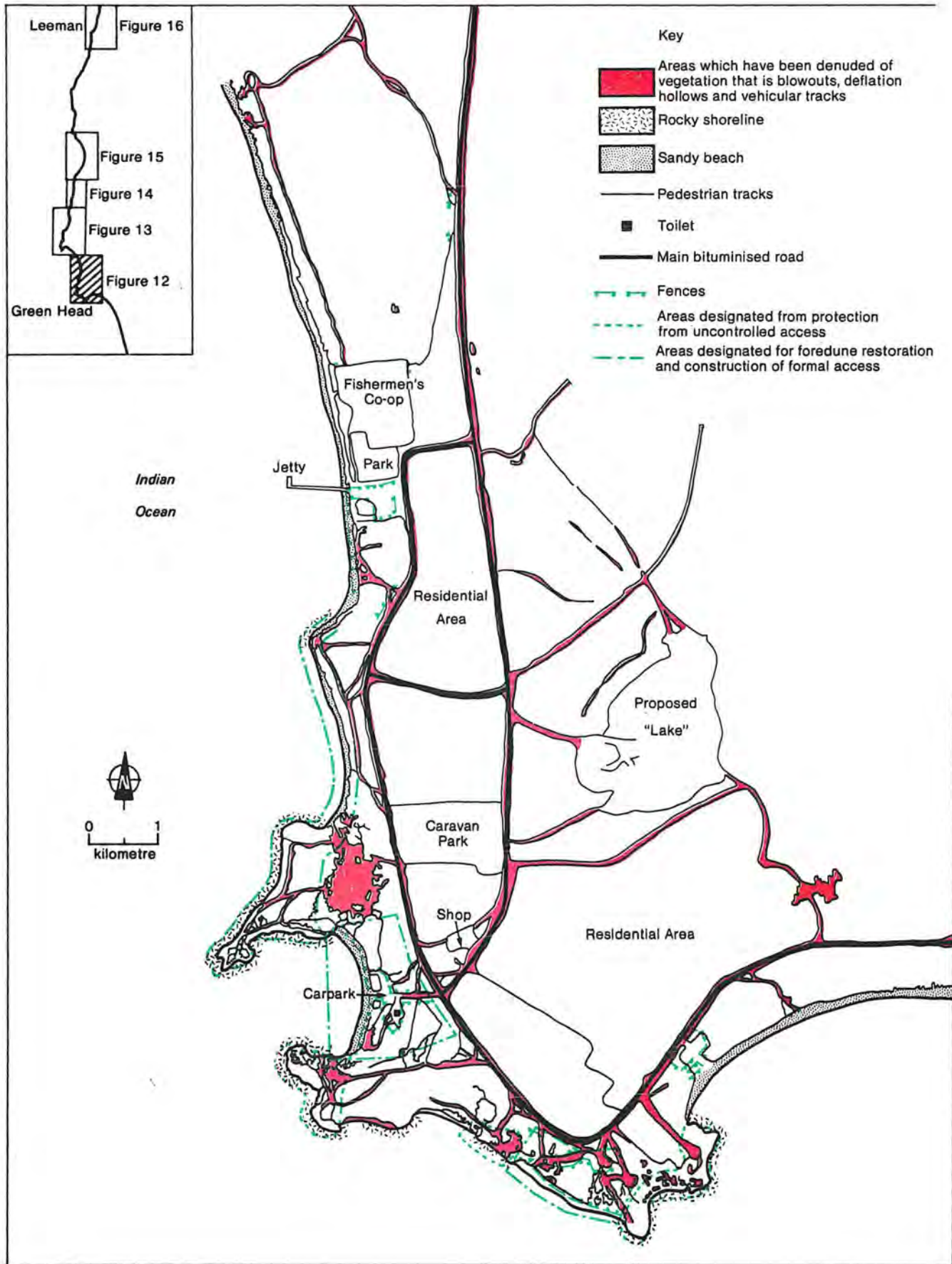


FIGURE 12 : Management Recommendations for Green Head Townsite.

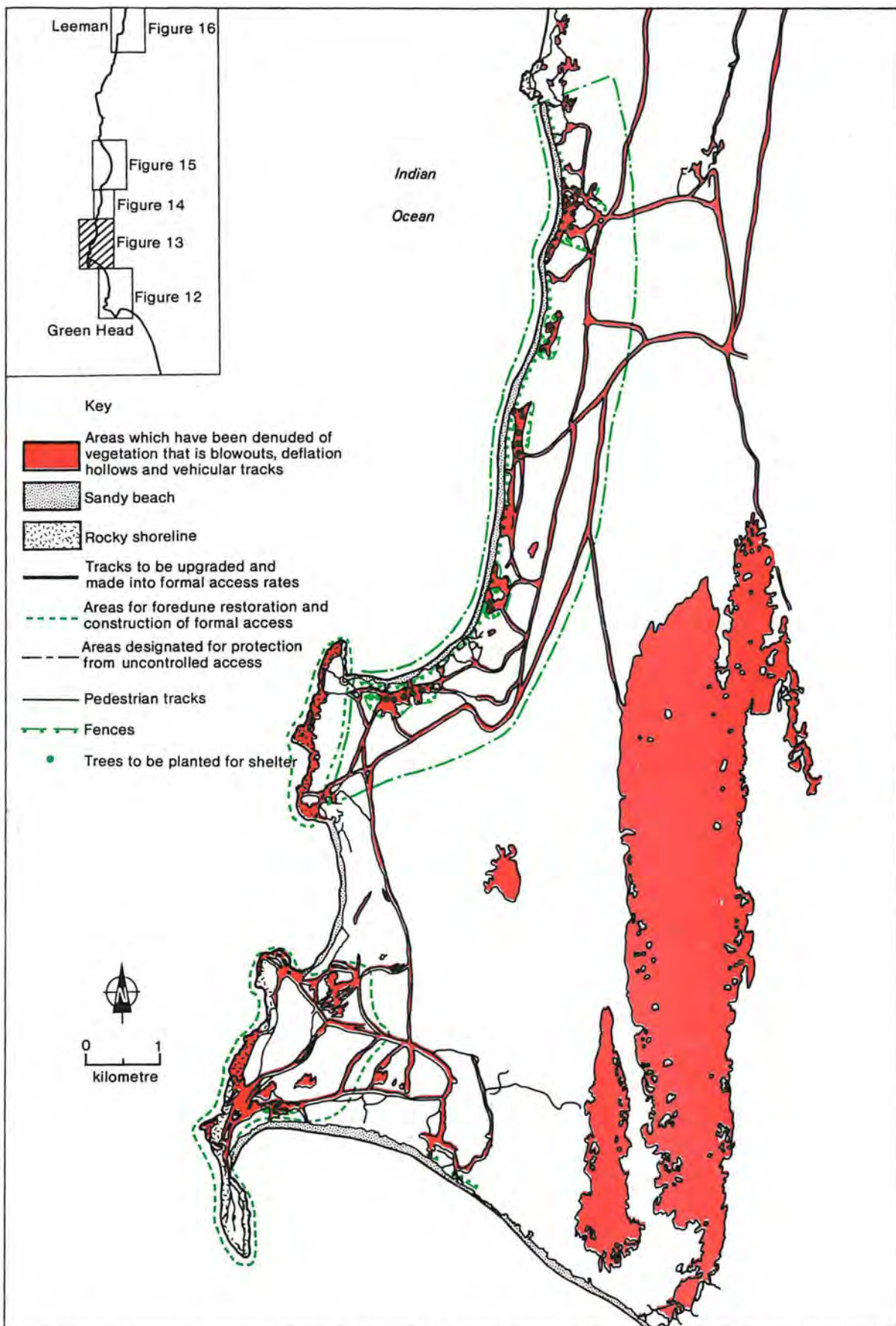


FIGURE 13 : Management Recommendations for Squatter Settlement 1.

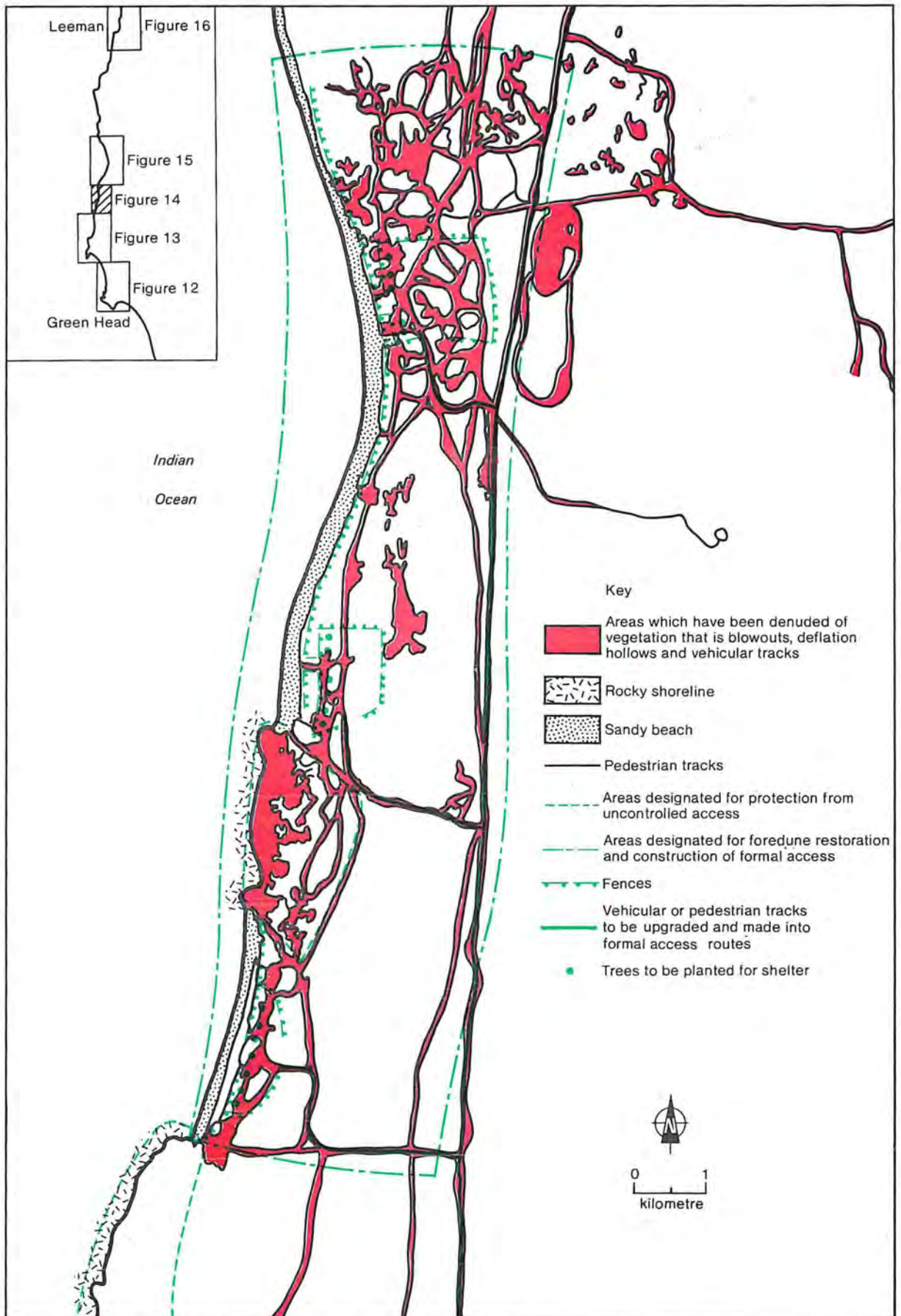


FIGURE 14 : Management Recommendations for Squatter Settlement 2.

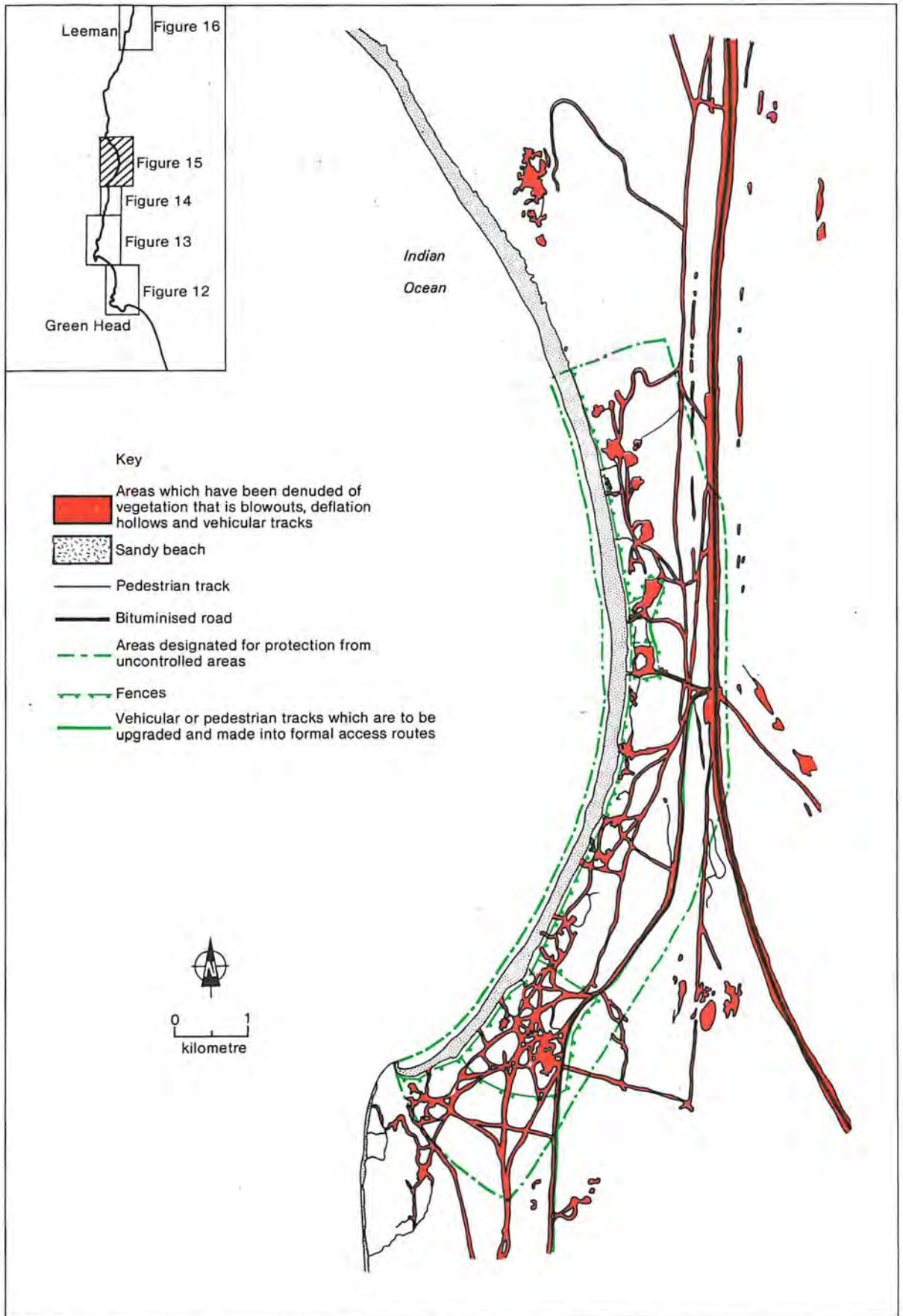


FIGURE 15 : Management Recommendations for Squatter Settlement 3.

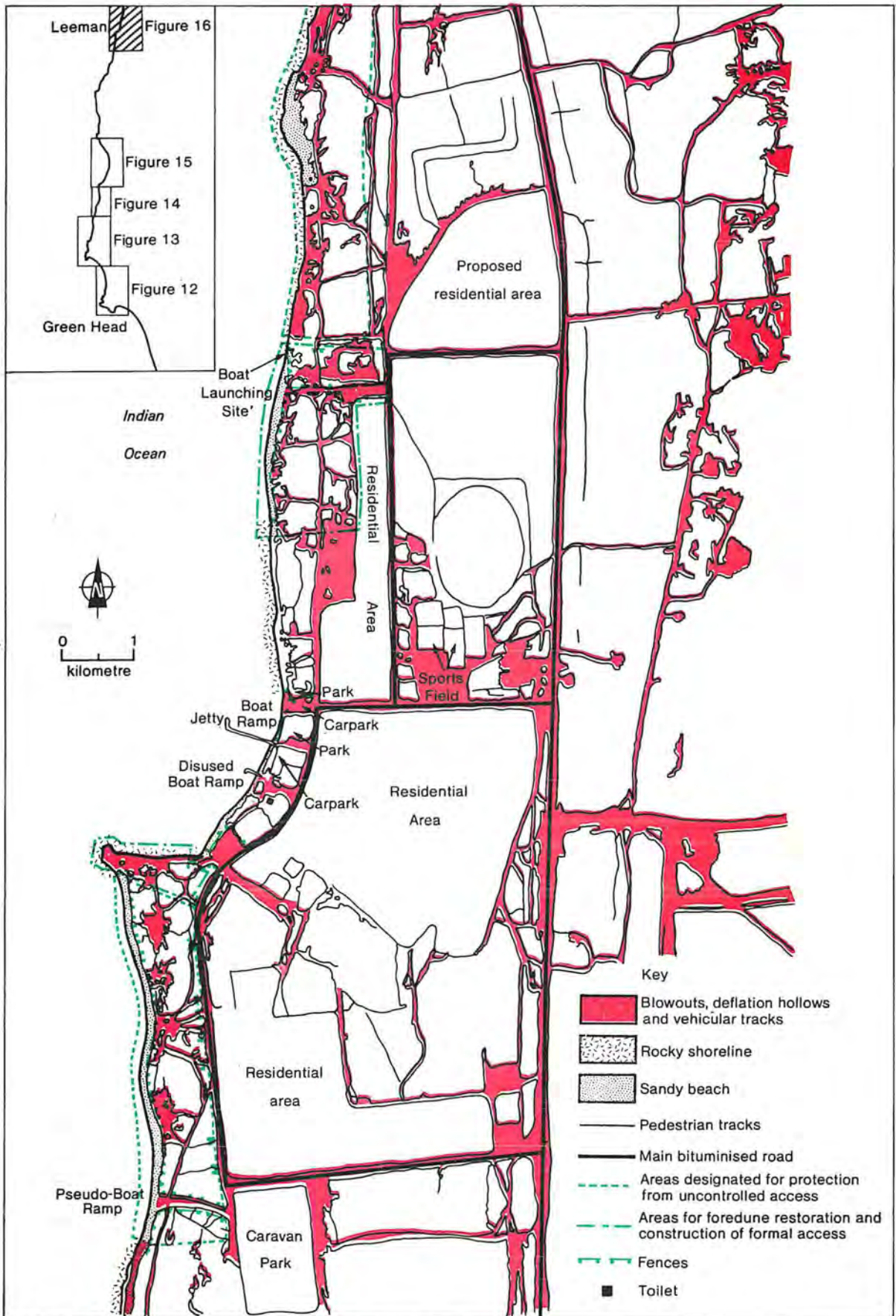


FIGURE 16 : Management Recommendations for Leeman Townsite.

Recommendations

- . In future when new toilet facilities are constructed it would be preferable if they were built of lighter coloured materials. Lighter coloured materials blend in better with the surrounding scenery compared to darker colours which look harsh and austere. Also, light colours reflect the heat.

5.2.5 Boat Ramps and Mooring Facilities

The Personnel Administration Pty Ltd (1981) placed the project area within the Geraldton to Cervantes sector for boating facilities. This sector includes the Shires of Greenough, Irwin, Carnamah and Dandaragan as well as Coorow.

The Geraldton-Cervantes sector caters mainly for boaters from the central and metropolitan areas.

At Green Head the boat ramp is constructed of natural sand. The launching area is in a sheltered position but suffers from lack of parking (six vehicles). The Leeman boat ramp is also protected from rough wind or ocean conditions and constructed of cement. Parking adjacent to the ramp is limited to four vehicles and this area is insufficient in peak holiday periods. In Leeman there exist a number of disused boat ramps which appear to have been abandoned due to erosion. The excessive number of boat ramps in Leeman is causing secondary management problems such as tracking and informalised carparks. Location of boat ramps is indicated in FIGURES 7 and 11. Department of Marine and Harbours (M. & H.) have no plans to construct a marina or harbour in the Green Head and Leeman area. At the present moment an inland harbour is being constructed at Jurien Bay. This harbour will cater for the needs of Jurien Bay as well as the surrounding hinterland. Both the townsites offer excellent mooring facilities at South Bay and at each jetty since the bays are sheltered from high energy wave conditions by offshore reefs and islands.

There will be increasing pressure from ratepayers to connect Jurien Bay to the Shire of Coorow by a bitumenised road (section 5.2.1), once the Jurien Bay Harbour is complete. Therefore, the only developments likely to occur in the foreseeable future is the upgrading of the South Bay boat ramp at Green Head and the upgrading of the jetty reserve surrounding the Green Head jetty. Adequate mooring space exists for current recreational usage at both these sites, however in neither case is there room for expansion.

Marine and Harbours is willing to contribute funds to upgrade the jetty reserve at Green Head. Funds could also be made available for enlarging the facilities at Green Head boat ramp.

- . The parking facilities at the South Bay boat ramp should be enlarged or the option for enlargement should be kept open.

The area west of the existing carpark is proposed as a barbecue/picnic area while the area east of the existing carpark will be for carpark extensions. For the relevant recommendations on car park facilities refer to section 5.2.2. fluctuation of the shoreline will degrade the boat ramp and it will involve costly maintenance.

- . Marines and Harbours would request that the access tracks to the navigation aids be maintained. They are located at Leeman, Green Head and at the northern tip of Anchorage Bay.
- . Marines and Harbours recommend that any fish processing works be located in the Jetty reserve.

All the fish processing companies can be located in the one building by subdividing the building into sections. This option prevents the "ad hoc" development of land by fish processing companies which can result in each company occupying quarter acre blocks with only a tin shed on it. Not only is this type of uncontrolled or "ad hoc" development wasteful of land but is also unsightly.

- . The first option contains development and keeps the fish processing plants in one location.
- . The location of the Sea Rescue Club would best be located in close proximity to the navigation aids north of the Leeman jetty.
- . There needs to be a rationalisation of the number of boat ramps in Leeman to a reasonable number.
- . A setback for boat ramps is not possible. Therefore, a sheltered position should be chosen for the boat ramps which "rarely" experiences storm events. Since, there is no record of storminess for the project area it is not possible to recommend specific areas. However, in general boat ramps should be located on the northern extremity of crescentic bays which seems to be more stable than the southern ends and orientated towards the south to avoid tropical cyclones from the north-west.
- . There are three options for the future use of the boat ramp opposite the Leeman-Shag Island Caravan Park. One option is to leave the areas as it is. The second option would be to upgrade the area by improving car parking facilities and fencing off the area. The third option would be to downgrade the area, prevent boat launching from this site and concentrate boat launching facilities at the boat ramp closest to the Leeman jetty. The last option is probably the most advisable, since, leaving the area as it is would only lead to further deterioration of the site and upgrading the area would increase pressure on the nearby dune system which is already eroding.

5.2.6 Tourism Accommodation

The area offers sufficient potential for "low-key" holiday accommodation. At Green Head and Leeman there are excellent facilities for caravan travellers. The caravan parks also offer chalets at reasonable prices. However, the area does not have the more luxurious-style of accommodation of - hotel/motel. The nearest hotel/ motel is at Jurien Bay, 58 kilometres from Green Head. It is not likely that tourism flow into the area will dramatically

increase in the next decade or so, unless the proposed coastal road from the Shire of Gin Gin to Geraldton becomes an eventuality. At the moment, it is not necessary to construct more holiday facilities, since the present facilities are coping adequately with the tourist flow except at peak periods such as the Easter holiday period. At Green Head, Dynamite Bay, the council has proposed to build a hotel/motel complex.

Recommendations

- . Any type of tourism accommodation development should not proceed before a detailed evaluation of the site's potential and alternative proposals have been examined.
- . The Shire of Coorow should seek advice from the relevant authorities before proceeding with any tourism development.
- . As with any other type of development such as roads, carparks and houses they should be located outside the coastal buffer zone, away from areas of dune instability and shoreline recession.
- . Any tourism accommodation should compliment the "low key" character of the area. For instance, the proposed hotel/motel complex should be no taller than two storeys and be constructed of light coloured materials such as sandstone or sandstoned coloured brick ensuring that it blends in with the natural scenery. A good example of such accommodation is the facilities at Rottneest Island.

A coastal buffer zone is an area of land which allows for fluctuation in shoreline. The coastal buffer zone allows the coastal processes to go on unimpeded. Hence, if any form of development such as housing is developed in the buffer zone it could severely disrupt the coastal processes such as the beach sand cycle.

5.2.7 Rubbish Disposal

For the foreshore locations there are only a few rubbish bins at the Green Head and Leeman jetties and at Dynamite Bay.

At the squatter settlement closest to the Green Head to Leeman Road there was a severe rubbish problem. There were rusty car bodies, disused fridges, articles of old clothing, and household refuse strewn amongst the dune vegetation (PLATE 7). The dumping of rubbish is unsightly, a health risk and detracts from the natural beauty of the area. In the centre of Green Head there is a "lake" which at the moment is an untidy receptacle for rubbish. Part of the Allen's (1983) recommendations was to beautify the "lake" and surround it by parkland. This recommendation is already in progress.

Recommendations

If new areas are to be set up for camping and picnic areas there should be an adequate number of rubbish bins. Convenient but not unsightly positions should be chosen for the rubbish bins. For instance, they could be located at the entrance of paths leading to



PLATE 7 : Dumping of household refuse which is associated with the squatter settlements.

the beach so that people can drop off their rubbish as they leave from or arrive at the beach area.

5.3 LAND USE IN THE PROJECT AREA

5.3.1 Tourism

Tourism in the area will increase in the future. However, the rate of increase in tourist flow cannot be estimated. The area serves principally as a "low-key" tourist resort and the coastline provides the main potential for tourism.

At the present moment facilities in the area are coping adequately with the tourist flow except in peak periods. During, peak periods there is a shortage in tourist accommodation and the pressure on facilities such as boat ramps is at its maximum. The lack of tourist accommodation is expressed in the prevalence of squatter shacks along the coastline. Whilst tourism is an important economic activity in the area, it can also have a significant effect on the coastal environment and its residents.

Recommendations

- . Therefore the main recommendation in relation to tourism is to keep it as "low-key" as possible. To improve the commercial and other facilities within the towns so that during peak holiday periods they are not under pressure.
- . To provide sufficient accommodation for tourists so that the squatter shack does not become a viable alternative for accommodation.

- . To protect the coastal environment from increased tourist pressure which will spoil the natural amenity of the area, recommendations on dune stabilisation, access and recreational activity should be enforced.

5.3.2 Recreational Activity

A recreational survey was carried out during a field trip from the 3rd to the 6th September. As part of the survey 22 people were interviewed from a population of 79. For the results of the questionnaire and the questionnaire sheet refer to APPENDIX 3.

The following comments outline the main results of the survey. Everyone interviewed was married. They usually had two or three children and only three couples did not have children or children with them. Just over half the population is comprised of adults (the rest being children) who are mostly between the ages of 35-44, 45-54 or 25-34. The children's ages range from 1 to 15 years of age. In general, the female member of the family group was interviewed instead of the male. The high incidence of families travelling into the area could be due to their stay coinciding with the September school holidays.

Nearly all the tourists (19 out of 22) came from the Perth metropolitan area. The other three families originated from different country areas.

The majority of the families intend to stay for one or two weeks. This length of stay coincides with the school holiday break. Seven of the people interviewed had been to the area before. In one instance, the person visited the area every six weeks and another had just decided to permanently live in the area.

The most popular reason for visiting the area is the peace and quiet as well as the fishing. The next most attractive characteristic of the area to visitors is the beaches.

Most of the tourists (18) had either visited all the beaches at Greenhead (11) or all the beaches at Leeman (7). Only two of the family groups (who were interviewed) had visited the squatter settlements. The most popular, individual beach in the area is Dynamite Bay.

The most popular beach activities are swimming (18 out of 22), beaching-combing/exploring (15 out of 22), ocean fishing (14 out of 22) and sunbathing (13 out of 22). The second most popular activities are beach fishing (12 out of 22), picnicking (11 out of 22) and power boating (6 out of 22). All the activities are orientated around the beach and rocky headlands. It will be difficult to discourage people from walking on and around the rocky headlands since beach combing and exploring is one of the main recreational activities of the area.

In reply to Question 11, half the interviewees wanted the area to be left "as it is" or "no" changes or improvements to take place. The remaining eleven interviewees suggested a variety of improvements (11). In relation, to coastal management the most important suggestions for improvement were the upgrading of the boat ramp facilities at South Bay and the provision of more activities. The type of alternative activities were not suggested

by any of the interviewees except by one interviewee who suggested a boat or bicycle hireservice could be made available. Four of the interviewees complained about the presence of seaweed on the beaches. Seaweed accumulation will cease to be a problem in the summer months. However, during the winter and autumn months it invariably gets washed up on the beaches during storm activity. It would not be advisable to remove the seaweed from the beaches as it acts as a buffer against coastal erosion. Nevertheless it incurs costly maintenance costs when seaweed has to be removed from the boat ramp (PLATE 8).



PLATE 8 : Seaweed accumulation near the jetty at Green Head. This is a common sight on all the beaches in the area during winter and spring.

Recommendations

- . It should be of utmost priority for the Shire to preserve the natural attributes of the area (Chapter 4), since, most of the recreational activities are water-based and rely on an aesthetically pleasing environs.
- . To preserve the natural attributes of the area and hence enhance the recreational potential of the area the recommendations in section 5.2, 5.3 and 5.4 should be examined and implemented as soon as possible.

5.3.3 Commercial Fishing

Commercial fishing is by far the biggest employer in the area and the industry is of great importance to the livelihood of local residents. Therefore it must be protected.

Recommendations

The most relevant recommendations in regard to the fishing industry would be in section 5.2.5 on boat ramps and mooring facilities.

5.3.4 Mining Exploration and Quarrying

There is a small quarry reserve (38461) on the Coorow-Green Head road. This is the only mining activity in the area.

Recommendation

It is recommended that no mining or even exploration activity be conducted in the coastal buffer zone since this area is sensitive to perturbations. Even further inland such activities could spoil the scenic value of the area.

5.3.5 Apiarists

To ensure the continuation of the apiarist's livelihood it is of vital importance to preserve and properly manage reserves. Therefore, the recommendations in section 5.3.6 and the information in section 6.2.2 is of the greatest interest to apiarists.

5.3.6 Flora and Fauna Reserves - Wildlife Management

The area supports a rich diversity of birdlife as well as reptiles and amphibians. There is also a rich community of marine life to be found in the area. The diversity of birdlife and other forms of fauna is supported by various vegetation formations. The vegetation is a very important component of the environment especially in maintenance of habitats for fauna. For instance, birdlife in the region relies on the various vegetation formations for breeding, feeding and resting grounds. The vegetation formations are being conserved in a number of reserves, the largest being the Mt Lesueur Reserve (unvested).

Recommendations

The project area has vast areas of relatively undisturbed vegetation which should be protected. These areas serve as faunal habitats and contribute to the stability of coastal landforms. They also provide areas for scientific, commercial (bee keeping) and recreational (bushwalking) activities to be pursued.

5.3.7 Residential Development

Areas of residential development occur only at Green Head and Leeman. Settlement at Green Head is confined within the existing road system. All residential development has been kept within 90 metres of the beach and in some cases even further (210 to 360 metres). However, west of South Bay the houses are less than 90 metres from the beach. Nevertheless, the houses are located on a rocky headland which is fairly stable. The settlement at Leeman is less confined and sprawls along the coast. Most of the Leeman houses (along the coastal road) are only 60 to 90 metres from the beach.

Recommendations

Residential development should be discouraged from areas which have active sand dunes, are subject to secular or seasonal erosion (such as foredunes) or would be susceptible to degradation if residential development proceeded. Therefore, urban subdivisions can incur unnecessary management costs if inappropriately designed or sited. Hence, top priority should be allocated to investigations into coastal processes which affect shoreline stability.

For the project area conceptual or descriptive models were applied as well as field observation. The shoreline stability of the area is described in section 2.5.6.

- . In general, residential development should not proceed before detailed evaluation of the site's potential and alternative proposals for urban development have been examined.
- . The Shire of Coorow should seek advice from the relevant authorities before proceeding with any type of development. For instance, the appropriate authorities could be the Department of Conservation and Environment or the Town Planning Department.
- . More specifically, at GREEN HEAD residential development should be contained within the existing road structure and not allowed to develop outside it. For instance, no development should be allowed south of Ocean View Drive along South Bay nor any further east of existing residential areas. The rationale behind the above recommendations is that elicit parabolic dunes east of Ocean View Drive (the section which runs along South Bay) could be re-activated by urban development and cause undesirable sand drift.

Residential development south of Ocean View Drive could be detrimental since it is probably an area of flux from stability (progradation) to instability (recession and/or mobile sand dunes). Examination of aerial photographs in the area indicate the above situation may be likely. At the present moment the area is exhibiting evidence of minor erosion.

- . In LEEMAN residential development should be encouraged to development north and south of existing residential areas. No development should be allowed on or in the vicinity of the western sand-dune system. The dunes are already degraded and development would only worsen the situation.
- . SQUATTER SETTLEMENTS (1,2,3) should have a total restriction on urban development. The area should be rehabilitated back to their "original" state and be areas of passive recreation and/or camping. All the squatter settlements have areas of dune instability which is being aggravated by tracking, off-road vehicles and the squatters' shacks.
- . A coastal buffer zone of 1km should be designated in which no development is allowed.

5.3.8 Squatter Settlements and Camping

Shack construction is associated with several management problems such as littering, tracks and dune erosion (Section 5.2.7, 5.2.3 and 5.4). In general, the shacks are inappropriately sited on the foredune.

At squatter settlement 1 (S.S.1.) the majority of shacks are located on a receding foredune. However, the rate of dune recession is not rapid since there is a layer of humus forming under the vegetation on the crest of the dune and vegetation is recolonising the eroded dune face (PLATE 9a and b). Nevertheless, it would be unwise to construct shacks in such a perilous position. Those shacks which are threatened by dune recession have attempted to prevent the inevitable by dumping gravel and compacting it in front of the shack.

At squatter settlement 3 (S.S.3) and squatter settlement 2 (S.S.2) the beach has lower frontal dunes in comparison with S.S.1. Along the southern extremity of the bay at S.S.3. the shacks are set further inland compared with the shacks constructed in the middle of the bay (PLATE10).

Recommendations

Controlling shack development will only lead to pseudo-residential areas which still require services and amenities. The squatter areas would be more suitable as camping or passive recreation areas. A possible alternative for the permanent residents of the squatter settlements would be to offer them subsidised caravan lots till they decide their future arrangements.

Dune rehabilitation programmes will have to begin once the shacks are removed since in and around shacks vegetation has been denuded.

It is proposed that future option for the squatter settlements is to re-develop them into passive recreation and tourism areas. The option is illustrated in FIGURES 13, 14 and 15. The concept can be achieved by utilising already developed areas and converting them into segregated nodes. Each area is defined by fencing. Trees can be planted, especially along the area facing the beach. Amenities such as barbecues, tables and chairs may gradually be included in the areas as demand and funds increase.

Camping

Before one decides on suitable sites for camping it must be established whether the area is suitable for camping and if it is feasible to establish camping grounds.

Two of the areas which have been suggested as camping areas are in close proximity to squatter settlement 1 and 3. The areas are as yet unvested and are Camping and Water reserves 22522 (near to squatter settlement 1) and 22521 (near to squatter settlement 3).

The disadvantages and advantages of each area for camping grounds is outlined in TABLE 4.



PLATE 9 : "older" eroded dunes. Vegetation has revegetated the dune face and there is a humus layer at the crest of the dune.

a) North of Green Head Jetty

b) At squatter settlement 1



PLATE 10 : Lower or non-existent foredunes typical of squatter settlements 2 and 3. Seaweed accumulation on the beach. Salsola kali is the main vegetation species.

The advantages and disadvantages of each area for camping should be considered and evaluated before a final decision is made concerning the location of the proposed camping reserves. The establishment of the areas will involve rehabilitation of the squatter settlements, establishment of facilities and the appointment of a part-time ranger to patrol and manage the area.

5.3.9 Industrial and Commercial Development

The town of Leeman is to be developed as the centre of public and community services while Green Head is to be orientated towards tourism. Therefore each townsite will have a dominant role to play, Leeman as the main service and community centre and Green Head as a holiday centre. This designation of priority for each town will prevent costly duplication of services. An example, of the above recommendation in practice, is the location of the new rubbish dump. The rubbish disposal area will be located halfway between the two settlements and the existing rubbish dumps at each town will be rehabilitated. Therefore preventing a duplication of services.

5.4 DUNE STABILISATION

5.4.1 Importance of Natural Vegetation in Dune Stability

TABLE 5 indicates the type of coastal vegetation found in the area. The list of species of vegetation is in no way complete but a brief expose of the main species. Section 2.3 also outlined the major floristic components of the various geomorphic regions. The dune vegetation of the region is severely denuded in several areas along the coast. Major areas where vegetation has been degraded are shown in FIGURES 7 to 11. The most vulnerable areas are around the squatter's shacks and on the foredune area where the shacks are

TABLE 4: The Pros and Cons of Reserve 22522 and 22521 for Camping

Reserve 22522

Advantages

(1) Able to establish camping areas further inland and away from the fragile dune system in comparison with S.S.3.

(2) The area offers three alternative swimming areas - one at the northern extremity of S.S.1. Also there is a swimming area between the two, called Harrop Inlet. All beaches are safe and sheltered areas for swimming.

(3) In the vicinity of the shacks at S.S.1. there are less tracks to alleviate and the littering problem is not as severe compared with S.S.3.

Disadvantages

(1) Formal access still has to be provided to and from the beach as well as car parking facilities.

(2) The mobile sand dune to the south of S.S.1. will in the long term migrate north-wards and cross access tracks to the beach.

(3) The cliff head area is badly degraded by tracks and should be protected if camping is allowed in the area.

(4) In the "past" the foredune areas have experienced high energy storm events which have left the dunes in an eroded form. They would be further degraded by "people pressure" especially by tracking. Therefore it would be necessary to define access to and from the beach.

(5) The area has more squatters' shacks than S.S.3. The removal of the squatters' shacks will be a difficult task but is completely necessary if the area is to become a camping reserve.

(6) The southern end of the bay at S.S.1 has a large accumulation of seaweed on its shore which might be aesthetically displeasing to some people.

Reserve 22521

Advantages

(1) There is a greater number of established trees in comparison to Reserve 22522.

(2) The establishment of the area as a camping reserve may provide the council with the initiative to restore the area to its "undisturbed" state.

(3) The foredune system appears to be more stable at S.S.3. than the foreshore at S.S.1.

Disadvantages

(1) Tracking and littering is a severe management problem in the area. It may be worsened by increased "people pressure" if the area is designated for camping.

(2) The unvested camping area is probably too close to the coast. The campers may have to be located slightly south of the bay.

(3) There are two islets - Milligan and Lipfert - as well as Orton Rock. The areas should be protected from human influence.

(4) Formal access still has to be provided to and from the beach as well as car parking facilities.

(5) The squatters' shacks will have to be removed before any restoration work can begin.

TABLE 5: List of Coastal plants commonly found in Management Areas

Alphabetic listing of species	Location in the Dune system	Notes
<u>Acacia lasiocarpa</u>	stable dune (S.D.)	This species dominates the well established low closed heath community.
<u>Acacia rostellifera</u>	S.D.	
<u>Acacia truncata</u>	S.D.	
<u>Acanthocarpus preissii</u>	S.D., Foredune (F.D.)	
<u>Acanthocarpus littorea</u>	S.D.	
<u>Allocasuarina lehmanniana</u>		
<u>Atriplex isatidea</u>	F.D., Mobile dune (M.D.)	
<u>Cakile maritima</u>	F.D.	Pioneer species
<u>Carpobrotus aequilaterus</u>	M.D., S.D., Limestone Cliff (L.C.)	
<u>Hardenbergia comptoniana</u>	S.D.	
<u>Hemiandra pungens</u>		
<u>Leptocarpus</u> sp.		
<u>Leucopogon ovalifolius</u>	S.D.	
<u>Melaleuca acerosa</u>	S.D.	This species dominates the well established low closed heath community.
<u>Melaleuca huegelii</u>	S.D., Limestone ridges of dune (L.R.)	Found in lowlying swamp areas
<u>Myoporum adscendens</u>		

TABLE 5: List of Coastal plants commonly found in Management Areas(contd)

Alphabetic listing of species	Location in the Dune system	Notes
<u>Myoporum insulare</u>	F.D., M.D., S.D.	Sheltered rear slopes of coastal dunes
<u>Myrtaceae</u> sp		
<u>Nitraria billardieri</u>		
<u>Olearia axillaris</u>	M.D., S.D., L.C.	Usually dominate in rapidly accreting zones
<u>Rhagudia baccata</u>	S.D.	Often found in the lee of an eroding beach ridge or just back from an escarpment in a protect pocket.
<u>Salsola kali</u>	I.D.(Incipient dune), F.D.	Sheltered beaches - features early in succession on dune lands which have been levelled or disturbed.
<u>Santalum acuminatum</u>		
<u>Scaevola crassifolia</u>	M.D., S.D., L.R., L.C.	Secondary coloniser
<u>Scirpus nodosus</u>	F.D., M.D., S.D., Wetland littoral (W.L.)	
<u>Spinifex hirsutus</u>	F.D.	pioneer species
<u>Spinifex longifolius</u>	I.D., F.D., M.D.	pioneer species
<u>Spyridium globulosum</u>	F.D.	dominate secondary species
<u>Tamarix</u> sp.		
<u>Templetonia retusa</u>	S.D, L.R.	
<u>Tetragonia decumbens</u>	I.D., F.D., M.D.	Especially prevalent in areas of drifting sand.
<u>Threlkeldia axillaris</u>	L.C., S.D., Salt Marsh (S.M.)	

located. South of and north of Leeman jetty is also severely denuded of dune vegetation. Other major areas of dune vegetation degradation are around the cliff heads: south of squatter settlement 1, Green Head and south of Leeman jetty (PLATE 11 a&b).



PLATE 11a: Excessive tracking resulting in loss of vegetation and amenity value. The southern cliff area of Dynamite Bay, Green Head.



PLATE 11b: A closer look at cliff degradation south of the Leeman Jetty.

Recommendation

The presence of vegetation stabilises the foredune and prevents sand being blown inland, thereby ensuring that sand is available during the erosion phase of the beach sand cycle. Hence, the protection of dune vegetation is extremely important in avoiding sand drift or dune erosion:

- . Therefore, recreational activities such as off-road vehicles, pedestrian traffic, grazing by cattle and fire management must be controlled in order to preserve and maintain the foredune vegetation.
- . Fencing is a major method of controlling access to the beach-dune system by people and off-road vehicles. Fences are usually constructed of pine and fabricated wire (optional). Another technique used in controlling movement of people is to concentrate them in certain areas by using carparks, pathways and signs. This management technique defines access to the beach and prevents indiscriminate walking over the foredune. For an expansion on management of access refer to section 5.2.3.

5.4.2 Use of Soil Conservation and Fire Management in Dune Stabilisation

Soil Conservation

The coastal belt is dominated by unconsolidated and relatively unstable Holocene sands. As already mentioned vegetation plays an important role in stabilising these soils.

Soil conservation is the responsibility of the West Australian Agriculture Department's Soil Conservation Service (S.C.S.). The S.C.S. uses the powers vested in them by the Soil Conservation Act (1942-1982) to initiate soil conservation projects and other aspects of soil conservation. Part of the Soil Conservation Act (1942-1982) offers several mechanisms for dune management. The mechanisms are outlined by Grasby and Sansom (1983).

Recommendations

Typical soil conservation techniques which could be employed through the Soil Conservation Act (1942-1982) which have not already been discussed are:

- . Prevent clearing where there is a significant risk that there is a potential for soil erosion.
- . Declare an area a Soil Conservation District and plan soil conservation projects. Once an area is declared a Soil Conservation District it is possible to prohibit or restrict any activity which might cause soil erosion and order remedial works to be done. These could include regulation of changes in land use and requirements for management programmes. Thus, the Soil Conservation Act (1942-82) could lend valuable support to town planning controls in sensitive coastal areas.
- . Land can also be acquired and managed as a Soil Conservation Reserve, within which soil conservation works and research projects may be carried out.

- . The Commissioner, subject to the agreement of the Soil Conservation Advisory Committee, is able to issue soil conservation orders requiring land owners to prevent, control or restore erosion damage. This power may not be useful in the project area since the vast majority of coastal land is vested in the crown.

Fire Management

Fire management in the area is the responsibility of voluntary fire brigade organisations set up at each townsite.

Recommendations

The Bush Fire Controls board advises that access tracks running east-west be maintained to act as firebreaks for fires moving north. The bitumen road which connects Green Head to Leeman can protect the coastal vegetation from bush fires travelling west by serving as a firebreak.

- . To protect the area against accidental bush fires specific areas should be set aside for camp fires and barbecues. Better still, the designated areas for fires can have barbecue facilities or fireplaces already constructed to contain the fire and avoid bush fires.

5.4.3 Methods of Dune Stabilisation

There are four major mobile or active sand dunes (parabolic) - two at the most southern part of South Bay and two south of Squatter Settlement 1. However, there are numerous smaller scale active parabolic dunes and blowouts within the project area. North and south of the Leeman jetty (within the townsite's boundaries) sand dune destabilisation is particularly serious. Sand dune erosion is also prominent at the Squatter Settlements (1,2 and 3), Dynamite Bay and the beach in between South Bay and Dynamite Bay. The location of sand dune instability is shown in FIGURES 7 to 11.

Active parabolic dunes are advancing north under the influence of south westerly winds. Estimating the rate of advance of dunes cannot be determined since no studies have been completed for the area.

There are smaller active parabolic dunes and blowouts which are developing in a east - west direction.

The major areas of sand dune instability are most likely natural. However, the smaller areas of active sand dunes are probably due to "people pressure" such as tracking (pedestrian and vehicular), shack development and off-road vehicles. Some of the sand dune drift problems are in locations which will have little effect on people while others may affect property, man-made structures, people's activities or their convenience. The problem of sand dune destabilisation has the potential to increase as urban subdivision, leisure and recreation activities and general use of the coast become more popular.

Recommendations

Techniques on sand dune stabilisation are outlined in Bastin *et al.*, (1981), Seeliger (1975) and Woodhouse (1978). Some of the main methods of sand dune stabilisation and the pros and cons of each technique will be described.

Mats, netting, brush, mulches and stones

(a) Mats and Netting

Bare surface sands can be quickly protected by matting and nets. They protect the sand surface but they collect little sand. All nets and matting are subject to traffic damage and require protection.

(b) Brush

Brush is an effective temporary stabiliser. This method has a high labour requirement and it interferes with subsequent planting. Use should be limited to small blowout areas.

(c) Mulches

Mulches of straw or wood fibre are difficult to anchor to dune surfaces.

(d) Crushed Stone

A cover of crushed stone or clay will provide immediate protection to the dune surfaces. However it is expensive and usually can be confined to small parts of the dune. Unless the surrounding areas are stabilised, the material may become buried and lost.

Asphalt, Latex and Chemicals

Another method of rapid stabilisation of sand is to apply binding agents to the surface layer. Asphalt emulsions and latex compounds are useful temporary stabilisers during the establishment of vegetation. As with netting and mulches, the edges must be protected from undermining, and the surface protected from traffic. Adriani and Terwindt (1974) and Zak and Bredakis (1963) found this method of stabilisation of little value.

Fences

A system of sand fences may effectively stabilise an area of blowing sand for 1 or 2 years, but dune protection with fences usually becomes a continuing process. Most fences tend to deteriorate because of corrosion or decay as well as from storm damage or vandalism. Without continuing maintenance and repair, the fences eventually fail and release the accumulating sand. However, fences are more durable than most netting and mats. Once a fence system is filled, it stops catching sand; the installation of additional fence is necessary. Consequently, a sand fence is a temporary dune stabiliser which must be supplemented or followed by longer dune restoration works such as planting.

Fences have two distinct advantages over planting vegetation. One, they may be installed at any season (vegetation usually must be planted in cooler and wetter seasons of spring and winter) and, secondly, they are fully effective as soon as installed. Unlike fencing, vegetation has to grow for trapping capacity to develop. The volume of sand moved by strong winds may be too large to permit the establishment of vegetation. Thus, temporary protection by low fences is a possible solution. The design of fence systems to stabilise areas of blowing sand should consider the characteristics of the particular site, including wind patterns and the ultimate configuration desired.

Vegetation

Vegetation is the only long-term stabiliser suitable for general use on sand dunes. It is the only stabilisation technique with self-healing capability and the ability to grow and change with the dune. Four important areas of consideration are plant selections, preparation of site, planting procedures and maintenance of dune restoration projects. Bastin *et al.*, (1981) goes into greater detail on the above aspects of dune stabilisation. In general, the following points are useful to remember.

(a) Selection of Plant Species

The first colonisers of mobile sands are Cakile edentula (Sea Rocket), Ammophila arenaria (Marram grass) and Spinifex hirsutus (Spiny Rolling grass). These species are particularly tolerant of sandblast, wind, wind-borne salt and hot, dry, infertile soils. They, also have an ability to accumulate sand around themselves and grow up through the accumulating sand.

Clayton (1985) outlines the various dune species used by the S.C.S. of the Agriculture Department and the Department of Lands and Surveys and summarises the results of experimental plantings of marram grass (Ammophila arenaria), Sea Wheat (Agropyron distichum), Pyp grass (Ehrharta villosa), Cereal rye (Secale cereale), Spinifex longifolius, Acacia cyclops, Acacia cyanophylla, Creeping grounself (Senecio lautens), Tetragonia spp., American beachgrass (Ammophila breviligulata), Pigface (Carpobrotus aequilaterns), Atriplex spp. and Tamarisk sp.

(b) Preparation of Site

The soils of the project area have a sandy texture. Therefore, the sites chosen for rehabilitation should be sown with Cereal rye at 32 kg/ha to prevent further degradation of the areas. Fencing may also be established to build up the dune's sand store.

(c) Planting Procedure

May to July is the best period to plant trees and shrubs but ground cover species should go in during April or September.

There are various damaging influences against which plants may need protection. Where wind, sand and salt blast are

particularly severe and there is no vegetation cover, plastic mesh or brushwood which reduce soil velocity by about 50%.

Spacing requirements vary with plant species and site exposure. Plant spacing should be less on exposed sites such as dune crests. Planting should begin on the windward side and extend over the entire sand mass. If the restoration area is large, establishment of vegetative cover will be difficult, particularly under high energy conditions.

Fertiliser should be added when establishing the vegetative cover and is best applied beneath each seedling at planting. The addition of complete fertiliser mixtures will increase vigour and growth rates.

5.4.4 Areas Recommended for Dune Restoration

Before one can recommend areas for dune restoration the following questions must be resolved:

- (i) If the sand dune is left as it is or continues to deteriorate will it have any detrimental effect on the beach amenity, beach facilities or recreational value of the area?
- (ii) If deterioration of the sand dune is causing loss of beach amenity, destruction to beach facilities, and a decrease in the recreational value of the beach, is the rehabilitation of the dune system a viable proposition - economically and environmentally?
- (iii) If the rehabilitation of the dune system is a viable proposition who finances, manages and executes the programme? (Section 6.2)

Once the above questions are resolved then one can decide in which order or priority, areas will be stabilised.

Identification of areas requiring dune stabilisation are shown in FIGURES 12 to 16.

Area 1 South of Leeman Jetty and directly seaward from the Leeman-Shag Island Caravan Park

Area 1 should be fenced off to rebuild the foredune and then replanted with one or more of the suggested pioneer dune species as well as brushing. Later on, when the pioneer dune species have established themselves secondary colonisers can be planted.

Area 2 North of Leeman Jetty

Similarly, Area 2 needs to be fenced off and access controlled. Preliminary stabilisation could be achieved by laying down brush on mobile areas. Later on the dunes should be revegetated.

Area 3 The cliff head south of Leeman Jetty

It is impractical to exclude the public from using this headland as a scenic lookout and access to the southern beach. Therefore, the provision of one walking track which caters for both demands may solve the problem. Sections of the path should be fenced to discourage people from criss crossing the foredune and trampling more vegetation. The temporary laying of brush will discourage people from using eroded areas. However, there should be signs which inform people of the foredune restoration project and request that they always use the paths. The front of the foredune should be fenced off to prevent people wandering haphazardly through the dunes.

Areas 4, 5 and 6, The areas surrounding the squatter settlements (especially the tracks)

Selected tracks need to be cordoned off, shacks removed and vegetation allowed to regenerate or assisted by a planting programme. If vegetation is to be planted over the tracks then the tracks will have to be deep ripped to assist vegetation growth because the soil will have been compacted by traffic flow.

Area 7 Dynamite Bay

All the tracks need to be closed off and revegetated. Those tracks which are left should be fenced on either side.

Area 8 Cliff head west of South Bay

The sandy beach south of Dynamite Bay needs treatment similar to Area 1. It also has active blowouts. The limestone cliff headlands should be protected from further denudation by fencing. If people still want to use the area as a lookout trail walks should be defined and pedestrian movement restricted to them.

For more specific advice on sand dune rehabilitation officers from the Soil Conservation Service of the West Australian Agriculture Department should be contacted.

IMPLEMENTATION OF MANAGEMENT RECOMMENDATIONS

6.1 MANAGEMENT PRIORITIES

TABLES 6 to 10 indicate more specific areas within management areas which require attention. The tables summarise the vegetation condition, dune stability, shoreline stability, land based development, facilities, usage and finally management priorities for each management unit.

Unless mentioned otherwise, the management objectives are listed in order of decreasing priority. To properly manage the areas the activities listed in the management objectives need to be undertaken. A timetable for the implementation of the management priorities is not feasible since there is no knowledge of the amount of funds available to the council. However, if any dune stabilisation programmes are to commence then the most suitable time is in the cooler, wetter months of June to September (early). For the other management objectives there are no time restrictions.

6.2 ROLE OF STATE AND LOCAL GOVERNMENT

The Government Position Paper on "Coastal Planning and Management in Western Australia" (Coastal Management Co-ordinating Committee, 1983) outlines the Government's role in coastal management. The responsibility of safe guarding the coastal zone is held by a number of Government departments and the functions of the various government authorities (relevant to this coastal area) are outlined in TABLE 11.

6.2.1 Public Education

The Public Education Programme should be part of the tourism package for the area. The programme would aim: to direct people to "key" areas for recreation and tourism; to divert people away from environmentally sensitive areas; to help people understand the reasons why environmentally sensitive areas have to be protected and to give them a better appreciation of the processes which occur in a coastal environment.

The above objectives can be achieved by providing them with information (attractively presented) on the facilities in the area such as boat launching and accommodation, recreational possibilities and locations such as popular fishing spots, beaches and picnic areas. In this way people's movements can be subtly guided and environmentally sensitive areas can be protected.

The information bulletins should also contain information on the proper use of off-road vehicles and boats in the area.

To guide people's movements signs can also be used as long as they are well designed and located in appropriate places. On the aspect of increasing people's understanding of the environment part of the information bulletin could contain a brief explanation of the physical environment and interconnections between all the elements - revegetation, soils, climate, geology and geomorphology - to conclude with the remark that all the elements create the unique coastal environment of the Green Head - Leeman area. The bulletin

TABLE 6: Management Priorities for Management Area 1: Green Head Townsite

Beach	Vegetation	Dune Stability	Recent Shoreline Changes	Land Based Development	Access	Facilities	Usage	Management Objectives
Management Area 1								
Anchorage Bay: Green Head Jetty	low to moderate vegetation cover	low to non-existent foredune	Seaweed deposition on the beach	Residential	Carpark constructed of gravel and bitumenised roads	Grassed area for picnics or recreation	Boat launching	<ul style="list-style-type: none"> * Enclose the car-parks by post and rail fencing * If the construction of alternative toilet facilities becomes necessary in the future this site would be the likely location
North of Green Head Jetty	Vegetation degraded along dune face. Vegetation cover is low to non-existent in blowout areas	Eroded foredune	Seaweed deposition and recession of shoreline in the "past" since the dune face is revegetated	Residential	Pedestrian tracks	None	Swimming	<ul style="list-style-type: none"> * Closure of unnecessary tracks * Fencing off the foredune area to prevent uncontrolled access NB Both management objectives are of equal importance
Dynamite Bay	Vegetation severely denuded along tracks. Root systems are exposed.	Eroded foredune and erosion of tracks into gullies	Scarping of deposition and recession of shoreline in the "past" since the dune face is revegetated	Residential	Pedestrian tracks and a limestone carpark	Toilet, shower and changeroom facilities. Barbecue area	Swimming SCUBA-diving	<ul style="list-style-type: none"> * Fencing off the foredune area to prevent uncontrolled access * Closure and rehabilitation of unnecessary tracks and planting of trees * Enclosure of carpark by pine railing

TABLE 6: Management Priorities for Management Area 1: Green Head Townsite(contd)

Beach	Vegetation	Dune Stability	Recent Shoreline Changes	Land Based Development	Access	Facilities	Usage	Management Objectives
The beach between Dynamite Bay and South Bay	Vegetation in and around blowout. In contrast the northern end of the beach has a denser cover of vegetation.	Blowouts at southern extremity of the sandy beach. The dune is greater than 20 m in height	Scarping of summer berm which is more prominent at the southern end of the beach	Residential	Pedestrian tracks	None	Swimming	<ul style="list-style-type: none"> * Fence the rehabilitation area * Rehabilitation of blow out area, firstly by trapping sand using fences and secondly by replanting * Define formal access to the beach
Green Head Cliff Head	Vegetation severely denuded along the tracks		Relatively stable	Residential	Carpark Pedestrian tracks	None	Scenic	<ul style="list-style-type: none"> * Closure of area to prevent tracking. However if the area is still to be used as a scenic lookout then access will have to be defined and pedestrian access restricted to one path
South Bay	Vegetation cover is moderate to dense	The dunes are experiencing some recession. There is scarping along the foredune and erosional cusping on the summer berms	The shoreline is showing evidence of recession. At this point in time the scale of erosion is only small. The form of erosion is small scale blowouts and a collapsing of the fore-dune	Residential	A couple of informal tracks which run along the beach. A bitumenised road which extends eastwards in an unsealed form.	A limestone carpark A formalised boat ramp	Boat Launching Sun-bathing Swimming Surf Fishing	<ul style="list-style-type: none"> * Enclose the carpark by post and rail fencing * Closure of unnecessary tracks * Fencing off of the foredune area to prevent uncontrolled access

TABLE 7: Management Priority for Management Area 2: Squatter Settlement 1

Beach	Vegetation	Dune Stability	Recent Shoreline Change	Land Based Development	Access	Facilities	Usage	Management Priorities
Management Area 2: Squatter Settlement 1	Vegetation cover is low around the shacks and non-existent on the tracks to and from the shacks. In all other areas vegetation cover is moderate to high	The dunes are either very low (less than 1 m) or reasonably high (3 m). The dune faces have been eroded by storm activity and tracking.	A series of summer berms have been re-worked by storm activity. The berms have been eroded by a cusping action. The foredunes exhibit evidence of "past" erosion events since vegetation has recolonised the dune face and there is a layer of darkened sand underlying the vegetation on the crest of the dune. Despite the fact that the erosion event is important in showing that the normally low energy coastline can be afflicted by high energy storm events.	There are no land based developments in the area unless one considers the squatters' "development"	Tracks (unsealed) for pedestrians and vehicles. There is also a bitumenised road which connects Green Head to Leeman.	There are no facilities in the area except for the home-made toilets, power and water amenities of the squatters.	Squatters' shacks for holiday homes. NO.:38	<ul style="list-style-type: none"> * Remove all the shacks. * Close down all the unnecessary tracks * Rehabilitate the dune area where the shacks were located * The rehabilitated areas should be fenced off * Formal access to the beach should be created * Establish rubbish bins at convenient and easily sighted points along the foreshore and carparks

TABLE 8: Management Priorities for Management Area 3: Squatter Settlement 2

Beach	Vegetation	Dune Stability	Recent Shoreline Changes	Land Based Development	Access	Facilities	Usage	Management Priorities
Management Area 3: Squatter Settlement 2	Vegetation is relatively dense along the foredune. The foredune consists mainly of <u>Spinifex hirsutus</u> , <u>Salsoli kali</u> and <u>Olearia axillaris</u> . The vegetation cover is low around the shacks and non-existent along the tracks	There is a low frontal foredune. The dune system appears to be relatively stable	There is a build up of seaweed along the beach	None	Tracks (unsealed) both for vehicles & pedestrians	There are no facilities in the area	Squatter shacks for holiday homes NO: 7	<ul style="list-style-type: none"> *Remove all the shacks *Close down all unnecessary tracks *Rehabilitate the dune area where the shacks are located *Before any rehabilitation begins the areas should be fenced off *Formal access to the beach should be created *Establish rubbish bins at convenient and easily sighted points along the foreshore and carparks *Construct carparks set-back from the beach and enclosed by pine railing *Establish sheltered barbecue and playground areas *Finally, appoint a part-time ranger who will patrol and maintain all camping areas

TABLE 9: Management Priorities for Management Area 4: Squatter Settlement 3

Beach	Vegetation	Dune Stability	Recent Shoreline Changes	Land Based Development	Access	Facilities	Usage	Management Priorities
Management Area 4: Squatter Settlement 3	Vegetation is relatively dense along the foredune. The foredune consists mostly of <u>Spinifex hirsutus</u> and <u>S. longifolius</u> . The southern extremity of the bay has <u>Melaleuca</u> sp. growing in groves. The vegetation cover is low around the shacks and non-existent along the tracks.	There is a frontal foredune. The dune system appears to be relatively stable.	There is a build up of seaweed along the southern sections of the sandy bay. The northern section of the bay had two summer berms. The berms had been eroded by cusping action. The cusps were larger at the northern extremity of the bay.	There is no land based development in the area unless one considers the squatter settlements as "development". However there is a proposed rubbish dump located east of the bitumen road. Another proposal is to remove the squatter settlements and redevelop the area into a camping area	Tracks (unsealed) both for vehicles and pedestrians. Road that is bitumenised and connects Leeman to Green Head.	There are no facilities in the area unless the home-made water tanks, gas cylinders for power and holes in the ground for toilets are considered as facilities.	Squatters' shacks for holiday homes. No.: 27	<ul style="list-style-type: none"> *Remove all the shacks *Close down all unnecessary tracks *Rehabilitate the dune area where the shacks were located *The rehabilitated areas should be fenced off before any rehabilitation begins *Formal access to the beach should be created *Establish rubbish bins at convenient and easily sighted points along the foreshore and carparks *Construct toilet, shower and changeroom facilities for the proposed camping area *Establish sheltered barbecue and playground areas *Construct carparks set-back from the beach and enclosed by pine railing *Finally, appoint a part-time ranger who will patrol and maintain all camping areas

TABLE 10: Management Priorities for Management Area 5: Green Head Townsite

Beach	Vegetation	Dune Stability	Recent Shoreline Changes	Land Based Development	Access	Facilities	Usage	Management Priorities
Management Area 5: Leeman Jetty	The area is sparsely vegetated. Areas around the jetty have been removed of native vegetation and planted with lawn	There is no frontal dune	There is no evidence of erosion except the deposition of a large amount of seaweed	Residential and sport recreational facilities are the only land based developments	There are two limestone carparks and one gravel carpark	Toilet block which contains changerooms, showers and toilets Boat ramp Barbecues Children's playground	Boat launching Picnicking	*Close down all unnecessary tracks *Formally enclose the carpark *Planting of trees in and around picnic area and children's play-ground for shelter and aesthetic quality
South of Leeman Jetty	There is a low cover of vegetation along the frontal dune due to uncontrolled access to and from the beach. The back beach has moderate to high vegetation cover	A series of blowouts along the southern beach. The most visible blowout area just north of pseudo-carpark	Minor scarping along the summer berm. The scarping was less than 75 cms.	Residential and Caravan Park	Limestone carpark Uncontrolled tracking to and from the beach as well as over and around the cliff-head	Boat ramp (pseudo)	Boat launching Swimming	*Close down all unnecessary tracks *Fence off the frontal dune to prevent uncontrolled access *Provide formal access to prevent dune deterioration *Commence dune stabilisation programmes *Enclose carpark area and either upgrade or close down pseudo boat ramp

TABLE 10: Management Priorities for Management Area 5: Green Head Townsite(contd)

Beach	Vegetation	Dune Stability	Recent Shoreline Changes	Land Based Development	Access	Facilities	Usage	Management Priorities
North of Leeman Jetty		A series of blowouts at the northern extremities of the area are the most obvious	Minor scarping of the summer berm Erosion of the foredune appears to be recent as vegetation has not recolonised and root systems are exposed	Residential	Uncontrolled pedestrian tracking to and from the beach as well as vehicle tracks			*Close down all unnecessary tracks *Fence off the frontal dune to prevent uncontrollable access to avoid further dune deterioration Commence dune stabilisation
cliff head at Leeman	Vegetation cover is especially low at the point of the Cliff Head	Erosion caused by tracking		Residential and Commercial	Uncontrolled pedestrian traffic		Scenic lookout access to southern beach	* Control access

TABLE 11: Responsibility of Government Authorities in regard to Coastal Management in the Shire of Coorow

AUTHORITY	FUNCTION
Agricultural Department of W.A. - Soil Conservation Service (S.C.S.)	Western Australian Agricultural advising Local Government Authorities on dune reclamation projects. They will also provide estimates on costs and supervise any dune conservation work. The S.C.S. has powers to enforce soil conservation measures under the Soil Conservation Act (1942-1982).
Department of Conservation and Environment (D.C.E.)	The Department of Conservation and Environment is responsible for advice and possibly funding to Local Government Authorities on beach management and usage. They also produce Coastal Management Plans.
Department of Resource Development (D.R.D.)	Planning of ports associated with major resource projects.
Department of Youth, Sport and Recreation (D.Y.S.R.)	The Department of Youth, Sport and Recreation deals with research and policy on recreation; supplies funds for recreational officers for Local Government Authorities and subsidises projects through Community Sporting and Recreation Facilities Fund.
Environmental Protection Authority (E.P.A.)	The Environmental Protection Authority has the role of reviewing major development projects.
Conservation and Land Management (C.A.L.M.) (Fisheries and Wildlife, National Parks Authority)	Fisheries and Wildlife: C.A.L.M. has the responsibility of regulating all aspects of professional and amateur fishing set under the Fisheries Act. <i>No</i> National Parks Authority: Under the National Parks Act C.A.L.M. prepares management plans of reserves.
Geological Survey	The Geological Survey assesses mineral resources and supervises exploration activity.
Lands and Surveys	The Department of Lands and Surveys administers the Land Act and Park and Reserves Act. It controls vesting and leasing of reserves, and pastoral leases. Lands and Surveys is responsible for vacant crown land but has very limited management resources.
Local Government Authority	The local authority is involved in: <ul style="list-style-type: none"> . the preparation and implementation of Town Planning Schemes . development control under Town Planning schemes by implementing building by-laws and regulations

- . the management of vested crown land and reserves created in new subdivisions
- . foreshore management
- . maintenance of secondary, local and tourist roads
- . local recreation reserves and facilities
- . local protection works and boating facilities

Local Government Dept.	L.G. Dept administers Control of Vehicles (off-road areas) Act (1978). Marine and Harbours is involved in navigation and safety aspects of aquatic recreation.
Marine and Harbours (Public Works Department)	The Public Works Department is involved in dune stabilisation associated with coastal engineering works. The P.W.D. is also involved in coastal investigations and erosion control.
Town Planning Department (T.P.D.)	The T.P.D. approves or rejects all subdivision. In areas of coastal subdivision it is advised by the Coastal Development Committee.
Tourism Department	The Tourism Department is responsible for policy, planning and promotion. It also subsidises regional committees and development projects.
Western Australian Wildlife Authority (W.A.W.A.)	The W.A.W.A. is responsible for preparing management plans under the Wildlife Conservation Act.

Source: Coastal Planning Steering Committee, 1981

should stress that if any of these linkages are disturbed then the coastal environment will suffer.

6.2.2 Crown Land Vesting and Management

The management of conservation reserves is of special importance when considering the preservation of ecosystems and species diversity. Many reserves including the ones in the project area are exhibiting signs of degradation due to recurrent burning, invasion of introduced plants such as veldt grass (Ehrharta calycina), indiscriminate mining for gravel or sand, spread of Phytophthora cinnamoni (Dieback disease) and uncontrolled use of off-road vehicles.

Significant allocation of staff and resources to reserve management has occurred over the past decade and especially in recent times with the formation of the new Department of Conservation and Land Management. This department comprises three departments - The Department of Fisheries and Wildlife, National Parks Authority and the Forestry Department. The reserves are managed by country-based operational personnel supported by centralised planning and

administrative staff. There are also community groups which have formed "friends in parks" associations and offer volunteer labour to assist with management projects (Hopper and Muir, 1984).

It has been proposed that the Beekeepers Reserve (24496) and Mt Lesueur Reserve have their classification altered.

For the Mt Lesueur Reserve will comprise Class C reserves 485 (Public purposes, unvested), 1223 (Water and Stopping Place, Shire of Dandaragan), 15018 (Horse Breeding, not vested), part of 19219 (Stock Route, not vested), 24275 (Educational purposes, University of Western Australia, not vested), Shire of Dandaragan 24437 (Water and Camping, not vested) and 24496 (Protection of Flora, not vested) as shown in FIGURE 6 be consolidated and declared Class A reserve for Conservation of Flora and Fauna.

The western boundary of the Mt Lesueur Reserve will be the proposed road from Jurien to Green Head. Therefore, there will be a section of Crown Land between the Low Water Mark and the new road. To prevent uncontrolled, indiscriminate growth of any kind the area should be vested in the council as Recreation and Foreshore Protection.

Beekeepers Reserve is to become a reserve for the Apiculture and Conservation of Flora, vested in the Department of Agriculture by combining parts of Class C reserve 24496 (Protection of Flora, not vested) and Class C reserve 19219 (Stock Route, not vested) (FIGURE 5).

Part of the Class C reserve 19219 (Stock Route, not vested) and part of Class C reserve 24496 (Protection of Flora, not vested) be cancelled and incorporated into a Class A reserve for the Conservation of Flora, Water and the Protection of Caves (36419). Vested in the National Parks Authority, with boundaries shown as in FIGURE 6.

Therefore the bulk of the project area will be vested as reserves under the control of various government authorities. The rest of the land is either crown or freehold land. All the freehold land and urban subdivisions are in the townsites of Leeman and Green Head.

Management of coastal lands is vested in the authorities which care for them such as Conservation and Land Management for the Mt Lesueur reserve. The council is also forming a Town Planning Scheme No. 1 which will control the use of freehold land and land vested in the council.

6.2.3 Funding - Cost of Dune Rehabilitation

Funding is required to implement management works and is currently being borne by the shire, with occasional assistance from State Government Departments. To ensure sufficient, long term funding the council should refer its applications to the Coastal Management Co-ordinating Committee (C.M.C.C.).

For areas which require prompt attention and implementation of management proposals the council can apply for grants provided from the Department of Youth, Sport and Recreation (D.Y.S.R.) for work on community and recreation facilities; Main Roads Department

(M.R.D.) for tourist road grants; Department of Agriculture (Dept of Agr.) for soil conservation works, Public Works Department (P.W.D.) for foreshore restoration and control of erosion; and Department of Conservation and Environment (D.C.E.) for beach management programmes.

These programmes operate without apparent reference to each other, application procedures may vary, and different levels of subsidy are paid.

Community Employment Programme (C.E.P.) could be utilised to provide funding and manpower for the necessary dune stabilisation works. To be eligible for a C.E.P. grant:

- (i) The community must provide at least 20% of the grant money including cash component of 10%.
- (ii) At least 65% of the Commonwealth grant must be paid in wages and allowances to the "target" group.

One of the difficulties for the Shire of Coorow is that unemployment in the district is low. Therefore eligible, unemployed people would have to be brought in from other areas where unemployment is higher. The other difficulty is the provision of suitable living accommodation for the workers.

The C.E.P. project would also have to be supervised to ensure efficient and correct use of materials and equipment.

There is a dearth of information on costing of dune restoration due to the fact that not many records have been kept. However, people are becoming increasingly aware of the importance of keeping records of their expenditure for future reference and planning.

To enable the Council to comprehend the costs involved in dune restoration projects the following estimates are provided.

- (i) Cottesloe, (Woods, 1979), (TABLE 12).
- (ii) Halls Head, (Ewing, 1981), (TABLE 13).
- (iii) Wanneroo, (Scott and Furphy, 1979), (TABLE 14).
- (iv) Port Hedland, (Chalmers, 1984), (TABLE 15).

The disadvantage of using these estimates of dune restoration as a guide is that they are four to six years old except for the figures given by Chalmers (1984). There would be a considerable increase in cost of materials and labour due to inflation. Labour is the most expensive outlay in any dune restoration project.

6.2.4 Surveillance and Policing

If camping areas and the like are to be established then the dune environment has to be protected from off-road vehicles and pedestrian traffic by surveillance and policing. The council has several options available to them:

TABLE 12: Cost of Dune Rehabilitation at Cottesloe by Woods (1984)

Section	Cost (dollars)
1. Cottesloe Groyne to Grant St	33 750
2. Beach St to Jarrad St	26 000

These costs include the cost of materials, labour and maintenance. 60 to 70% of the costs goes to wages.

Materials	Cost (dollars)
1. Pine log railings (3m horizontal and 1.6m vertical)	4 p.m
2. Paving - concrete slabs, (1.5m wide)	17 p.m
- laid concrete (1.5m wide)	11 p.m
3. Signs	50
4. Pine brush	50-60c p.m ²
5. Marram grass	1 p.m ²

Source: Woods, 1979

- (i) The first option is to employ a part-time ranger who will patrol the coastline in between Green Head and Leeman and ensure that no illegal camping or off-road vehicle activity occurs. This option would be an expensive alternative for the council to choose. Since it would involve allocating funds for accommodation, transportation and wages of the ranger.
- (ii) Option number two (like number one) assumes that camping will be allowed in rehabilitated squatter settlements. There are already two caravan park proprietors in the area and they may be interested in supervising the camping areas. The proposed camping areas could be leased to the caravan park managers and a camping fee charged for using the premises and facilities. This option ensures that the council is not involved in managing the area and keeps the costs of managing the area at a minimum.

TABLE 13: Cost of Dune Rehabilitation at Halls Head by Ewing (1981)

Labour costs involved in planting, collecting, loading, carting and cutting of brush for foredune and secondary dunes.

Section	Cost
<u>Foredune Area</u> (520m x 52m = 27040m ²)	
1. Planting of Marram grass, <u>Spinifex hirsutus</u> and <u>S. longifolius</u> seeds, <u>S. hirsutus</u> runners and spreading Acacia brush.	
5 to 10 hrs @ \$4.50	2 430
2. Collecting, loading and carting of Acacia brush	
368 hrs @ \$4.50	1 650
3. Chainsawing of Acacia brush	
278 hrs @ \$7.00	1 946
TOTAL	6 032

Days : 147.80

Source: Ewing, 1981

Secondary Area (520 m x 30 m = 15 600 m²)

1. Planting of propagated secondary dunes species from tubes (7000), Pelargonium runners, and spreading Acacia brush.	
192.25 hrs @ \$4.50	865.12
2. Collecting, loading and cutting Acacia brush	
122.5 hrs @ \$4.50	551.25
3. Chainsawing of Acacia brush	
93 hrs @ \$7.00	651.00
TOTAL	8 099.37

This is because in an eight hour day 1 man would take 199.25 days.

Maintenance to Dune Stabilisation.

Storm (21st - 22nd July, 1981)	
59.75 hrs @ \$4.50	268.90
Storm (24th August, 1981)	
42 hrs @ \$4.50	189.00

TABLE 14: Cost of Dune Rehabilitation at Wanneroo by Scott and Furphy (1979)

Concept 4 - Preferred Development

<u>Item</u>	<u>Cost(000 dollars)</u>
1. Carparks (paved)	750
2. Two-way access roads	120
3. Multi-purpose tracks (sealed) 2.2 m wide	240
4. Earthworks and Clearing	70
5. *Fencing (18 km)	110
6. Secondary pedestrian tracks	5.5
7. Nature trails	10
8. *Trickle irrigation (20 km)	10
9. *Foredune access	16
10. *Foredune restoration (20.5 ha)	123
12. General landscaping	170

*Items related to dune management

Source: Scott and Furphy, 1979

(iii) Option three makes use of existing council manpower in the area, by combining the duties they already have with , surveillance and policing of the camping areas.

To control off-road vehicles The Control of Vehicles (Off-Road Areas) Act (1978) can be used.

TABLE 15: Cost of Dune Rehabilitation at Port Hedland by Chalmers (1984)

<u>Cost of Dune Rehabilitation</u>	<u>Area 1</u>	<u>Area 2</u>	<u>Cost</u> (Areas 1 + 2)
Area of Operation			
Post and Rail fencing (km)	1.8	1.8	\$12 816
Post and Wire fencing (km) (preferred option)	2.7	1.8	\$ 5 980
Paths (km)	1.0	0.7	\$12 104
Walkways (m)	100	100	\$ 2 200
Rehabilitation works (ha)	2	1	\$12 000

Materials' Cost Breakdown:

Post and Rail fencing

Treated Pine Posts

1.8 x 0.75-1 m = \$ 2.10

1.8 x 1-1.25 m = \$ 3.40

3.6 x 1-1.25 m = \$10.10

To construct 3.6 kilometres of post and rail fencing it would require 280 rails and 280 posts and 240 bolts at \$170/100 in total \$4 188. 15% is deducted for discounts bringing the cost of fencing to \$3 560.

Post and Plastic Wire fencing

COST

Posts 280 at \$2.10	\$ 588
Wire (p.c.) 8 at \$75.00	600
Staples	20
Strainers 10 at \$70.00	70
Stays 5 at \$10.00	51
	<hr/>
	\$1 329 - 15% = \$1 130

Rehabilitation Works

Straw - 1 000 bales at \$3.00	\$3 000
Bitumen emulsion	500
Seed	500
	<hr/>
	\$4 000

Board and Chain Walkways (per metre)

Chain (6 mm gal at \$129/60 metre drum)	\$2
Half round posts 3 at \$2.00 each	\$6
6 bolts 75 mm x 10 mm at \$50/100	\$3
	<hr/>
therefore	\$11

Source: Chalmers, 1984

7. CONCLUDING REMARKS

The overall aim of the Draft Coastal Management Plan is to supply the decision maker with the information necessary to:

- . plan a long term strategy for conserving and protecting the coastal environment.
- . prevent "ad hoc" planning and management and enable the decision maker to make more co-ordinated decisions.
- . resolve land-use conflicts.
- . avoid and alleviate coastal management problems.

To achieve this aim the components of the physical and human environment were described. From this setting emerged the following management problems.

There is uncontrolled access all along the coast which has resulted in several coastal management problems such as squatter settlements, off-road vehicles and tracking. These problems have in turn exacerbated existing dune erosion or actually were instrumental in its existence. Dune instability as well as other problems (such as littering and shack development) will ultimately affect the natural beauty and stability of the area. The coastline will eventually become degraded and lose its potential for tourism and residential development unless proper action is taken.

Such action requires expertise, funds, manpower and long term planning. One major recommendation would be to control the movement of people and the growth of developments. Since, incorrect siting and design of any development invariably results in further management problems.

Therefore to avoid unnecessary costs major attempts have to be made at controlling access, rehabilitation of eroded dune areas and keeping development out of the fragile coastal buffer zone.

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APPENDIX 1: Mammals and Birds in the Project Area

MAMMALS

<u>Cercartetus concinunus</u>	-	Western Pygmy Possum
<u>Vulpes vulpes</u>	-	Fox
<u>Sminthopsis grassicaudata</u>	-	Fat tailed Dunnart
<u>Sminthopsis granulipes</u>	-	White tailed Dunnart
<u>Sminthopsis griseoventer</u>	-	Dunnart
<u>Sminthopsis murina</u>	-	Common Dunnart
<u>Felis catus</u>	-	Feral Cat
<u>Macropus fuliginosus</u>	-	Western Grey Kangaroo
<u>Macropus irma</u>	-	Western Bush Wallaby
<u>Mus musculus</u>	-	House Mouse
<u>Pseudomys albocinereus</u>	-	Ash-Grey Mouse
<u>Rattus fuscipes</u>	-	Bush Rat
<u>Neophoca cinerea</u>	-	Australian Sea Lion
<u>Tarsipes rostratus</u>	-	Honey Possum
<u>Chalinolobus gouldii</u>	-	Gould's Wattled Bat
<u>Chalinolobus morio</u>	-	Chocolate Bat
<u>Eptesicus regulus</u>	-	Common Bat
<u>Nyctophilus geoffroyi</u>	-	Lesser Long-eared Bat

BIRDS

<u>Dromaius novaehollandiae</u>	-	Emu
<u>Podiceps sp.</u>	-	Grebe
<u>Eudyptula minor</u>	-	Little Penguin
<u>Puffinus pacificus</u>	-	Wedge-tailed Shearwater
<u>P. assimilis</u>	-	Little Shearwater
<u>Oceanites marinus</u>	-	White-faced Storm Petrel
<u>O. oceanicus</u>	-	Wilson's Storm Petrel
<u>Phalacrocorax sulcirostris</u>	-	Little Black Cormorant
<u>P. carbo</u>	-	Black Cormorant
<u>P. melaneoleucos</u>	-	Little Pied Cormorant
<u>P. varius</u>	-	Pied Cormorant
<u>Sula bassana</u>	-	Australian Gannet
<u>Phaethon rubricauda</u>	-	Red-tailed Tropic Bird
<u>Pelecanus conspicillatus</u>	-	Australian Pelican
<u>Ardea novaehollandiae</u>	-	White-faced Heron
<u>Egretta sacra</u>	-	Reef Heron
<u>Cygnus atratus</u>	-	Black Swan
<u>Tadorna tadornoides</u>	-	Mountain Duck
<u>Anas superciliosa</u>	-	Black Duck
<u>A. gibberifrons</u>	-	Grey Teal
<u>Chenonetta jubata</u>	-	Wood Duck
<u>Elanus notatus</u>	-	Black-shouldered Kite
<u>Haliastur sphenurus</u>	-	Whistling Kite
<u>Accipiter fasciatus</u>	-	Brown Goshawk
<u>A. cirrocephalus</u>	-	Collared Sparrow Hawk
<u>Aquila morphnoides</u>	-	Australian Little Eagle
<u>A. audax</u>	-	Wedge-tailed Eagle
<u>Haliaeetus leucogaster</u>	-	White-breasted Sea Eagle
<u>Circus assimilis</u>	-	Spotted Harrier
<u>Pandion haliaetus</u>	-	Osprey
<u>Falco longipennis</u>	-	Little Falcon
<u>F. peregrinus</u>	-	Peregrine Falcon
<u>F. berigora</u>	-	Brown Falcon

<u>F. cenchroides</u>	-	Kestrel
<u>Leipoa ocellata</u>	-	Mallee Fowl
<u>Coturnix novaezelandiae</u>	-	Stubble Quail
<u>Gallirallus philippensis</u>	-	Banded Landrail
<u>Porzana tabuensis</u>	-	Spotless Crake
<u>P. fluminea</u>	-	Spotted Crake
<u>Otis australis</u>	-	Australian Bustard
<u>Haematopus ostralegus</u>	-	Pied Oyster catcher
<u>H. fuliginosus</u>	-	Sooty Oyster catcher
<u>Vanellus tricolor</u>	-	Banded Plover
<u>Pluvialis squatarola</u>	-	Grey Plover
<u>Charadrius ruficapillus</u>	-	Red-capped Dotterel
<u>C. cucullatus</u>	-	Hooded Dotterel
<u>C. bicinctus</u>	-	Double-banded Dotterel
<u>C. melanops</u>	-	Black-fronted Dotterel
<u>Numenius phaeopus</u>	-	Whimbrel
<u>Limosa lapponica</u>	-	Bar-tailed Godivit
<u>Tringa nebularia</u>	-	Greenshank
<u>T. brevipes</u>	-	Grey-tailed tattler
<u>T. hypoleucos</u>	-	Common Sandpiper
<u>Arenaria interpres</u>	-	Turnstone
<u>Calidris canutus</u>	-	Knot
<u>C. alba</u>	-	Sanderling
<u>C. ruficollis</u>	-	Red-necked stint
<u>C. acuminata</u>	-	Sharp-tailed sandpiper
<u>C. ferruginea</u>	-	Curlew Sandpiper
<u>Himantopus himantopus</u>	-	White-headed Stilt
<u>Cladorhynchus leucocephalus</u>	-	Banded Stilt
<u>Larus novaehollandiae</u>	-	Silver Gull
<u>L. pacificus</u>	-	Pacific Gull
<u>Anous tenuirostris</u>	-	Lesser Noddy
<u>Sterna caspia</u>	-	Caspian Tern
<u>S. bergii</u>	-	Crested Tern
<u>S. nilotica</u>	-	Gull-billed Tern
<u>S. hybrida</u>	-	Marron Tern
<u>S. dougallii</u>	-	Roseate Tern
<u>S. macrura</u>	-	Artic Tern
<u>S. nereis</u>	-	Fairy Tern
<u>S. anaethetus</u>	-	Bridled Tern
<u>S. fuscata</u>	-	Sooty Tern
<u>Phaps chalcoptera</u>	-	Common Bronzewing
<u>Ocyphaps lophotes</u>	-	Crested Pigeon
<u>Calyptorhynchus baudinii</u>	-	White-tailed Cockatoo
<u>Cacatua sanguinea</u>	-	Corella
<u>C. roseicapilla</u>	-	Galah
<u>Nymphicus hollandicus</u>	-	Cockatiel
<u>Polytelis anthopeplus</u>	-	Smoker Parrot
<u>Platycercus zonarius</u>	-	Port Lincoln Parrot
<u>Neophema petrophila</u>	-	Rock Parrot
<u>Cuculus pallidus</u>	-	Pallid Cuckoo
<u>Chrysococcyx basalis</u>	-	Horsfield Bronze Cuckoo
<u>C. lucidus</u>	-	Golden Bronze Cuckoo
<u>Tyto alba</u>	-	Barn Owl
<u>Ninox novaeseelandiae</u>	-	Boobook Owl
<u>Aegotheles cristatus</u>	-	Crested Owlet-Nightjar
<u>Caprimulgus guttatus</u>	-	Spotted Nightjar
<u>Podargus strigoides</u>	-	Tawny Frogmouth
<u>Dacelo gigas</u>	-	Laughing Kookaburra
<u>Halcyon sancta</u>	-	Scared Kingfisher

<u>Apus pacificus</u>	-	Fork-tailed Swift
<u>Merops ornatus</u>	-	Black-tailed Bee-eater
<u>Cheramoeca leucosternum</u>	-	White-backed Swallow
<u>Hirundo neoxena</u>	-	Welcome Swallow
<u>H. nigricans</u>	-	Tree Martin
<u>Anthus novaeseelandiae</u>	-	Australian Pipit
<u>Coracina novaehollandiae</u>	-	Black-faced Cuckoo-shrike
<u>Pomatostomus superciliosus</u>	-	White-browed Babbler
<u>Megalurus gramineus</u>	-	Little Grassbird
<u>Cinclorhamphus cruralis</u>	-	Brown Songlark
<u>Malurus splendens</u>	-	Splendid Blue Wren
<u>M. leucopterus</u>	-	White-winged Wren
<u>M. lamberti</u>	-	Variiegated Wren
<u>M. pulcherrimus</u>	-	Blue Breasted Wren
<u>Stipiturus malachurus</u>	-	Southern Emu-Wren
<u>Gerygone fusca</u>	-	Western Warbler
<u>Acanthiza pusilla apicalis</u>	-	Broad tailed Thornbill
<u>A. inornata</u>	-	Western Thornbill
<u>A. chrysorrhoa</u>	-	Yellow-tailed Thornbill
<u>Sericornis maculatus</u>	-	Spotted Scrub-Wren
<u>Smicrornis brevirostris</u>	-	Weebill
<u>Calamanthus fuliginosus</u>	-	Field Wren
<u>Epthianura albifrons</u>	-	White-fronted Chat
<u>Petroica multicolor</u>	-	Scarlet Robin
<u>P. goodenovii</u>	-	Red-capped Robin
<u>P. cucullata</u>	-	Hooded Robin
<u>Eopsaltria georgiana</u>	-	White-breasted Robin
<u>Rhipidura fuliginosa</u>	-	Grey Fantail
<u>R. leucophrys</u>	-	Willie Wagtail
<u>Pachycephala pectoralis</u>	-	Golden Whistler
<u>P. rufiventris</u>	-	Rufous Whistler
<u>Colluricincla rufiventris</u>	-	Western Strike Thrush
<u>Dicaeum hirundinaceum</u>	-	Mistletoe-Bird
<u>Pardalotus striatus</u>	-	Red-tipped Pardaloti
<u>substriatus</u>	-	
<u>Zosterops lateralis gouldii</u>	-	Western Silvereye
<u>Meliphaga virescens</u>	-	Singing Honeyeater
<u>Melithreptus brevirostris</u>	-	Brown-headed Honeyeater
<u>Acanthorhynchus superciliosus</u>	-	Western Spinebill
<u>Phylidonyris melanops</u>	-	Tawny-crowned Honeyeater
<u>P. niger</u>	-	White-cheeked Honeyeater
<u>Anthochaera carunculata</u>	-	Red Wattle-Bird
<u>A. chrysoptera</u>	-	Little Wattle-Bird
<u>Acanthagenys rufogularis</u>	-	Spiny-cheeked Honeyeater
<u>Manorina flavigula</u>	-	Yellow-throated Minor
<u>Grallina cyanoleuca</u>	-	Magpie-Lark
<u>Artamus cyanopterus</u>	-	Dusky Wood-Swallow
<u>A. cinereus</u>	-	Black-faced Wood-Swallow
<u>Strepera versicolor</u>	-	Grey Currawong
<u>Cracticus torquatus</u>	-	Grey Butcher-Bird
<u>C. nigrogularis</u>	-	Pied Butcher-Bird
<u>C. tibicen dorsalis</u>	-	Western Magpie
<u>Corvus coronoides</u>	-	Australian Raven
<u>C. bennetti</u>	-	Little Crow
<u>Lichmera indistincta</u>	-	Brown Honeyeater

Source: Dell, J. and Johnstone, R.E., (1977), Birds of Cockleshell Gully reserve and Adjacent Areas, In Lovell A.F., (Ed), A Vertebrate Survey of Cockleshell Gully Reserve, Western Australia. W.A. Museum Supplement 4: 37-75.

APPENDIX 2: Reptiles in the Project Area

REPTILES

<u>Ctenophorus maculatus</u>	-	Dragon Lizards
<u>Pogona minor minor</u>	-	Dragon Lizards
<u>Tympanocryptis adelaidensis</u>	-	Dragon Lizards
<u>adelaidensis</u>	-	Dragon Lizards
<u>Liasis stimsoni stimsoni</u>	-	Python
<u>Demansia reticulata</u>	-	Whip Snake, Coppertail
<u>Notechis curtus</u>	-	Tiger snake
<u>Pseudechis australis</u>	-	King Brown Snake
<u>Pseudonaja nuchalis</u>	-	Western Brown Snake, Gwarden
<u>Rhinoplocephalus gouldii</u>	-	Snake
<u>Vermicella bertholdi</u>	-	Bandy Bandy Snake
<u>Vermicella bimaculata</u>	-	Bandy Bandy Snake
<u>Vermicella calonotos</u>	-	Bandy Bandy Snake
<u>Vermicella fasciolata</u>	-	Bandy Bandy Snake
<u>fasciolata</u>	-	Bandy Bandy Snake
<u>Vermicella littoralis</u>	-	Bandy Bandy Snake
<u>Crenadactylus ocellatus</u>	-	Clawless Gecko
<u>Crenadactylus ocellatus</u>	-	Clawless Gecko
<u>ocellatus</u>	-	Clawless Gecko
<u>Diplodactylus alboguttatus</u>	-	Lizard
<u>Diplodactylus granariensis</u>	-	Lizard
<u>Diplodactylus oranatus</u>	-	Lizard
<u>Diplodactylus polyophthalmus</u>	-	Lizard
<u>Diplodactylus spinigerus</u>	-	Western Spiny Tailed Gecko
<u>Gehyra variegata</u>	-	Three Dtella
<u>Phyllodactylus marmoratus</u>	-	Marbled Gecko
<u>Phyllurus milii</u>	-	Lizard
<u>Litoria moorei</u>	-	Western Green and Golden
		Bullfrog
<u>Heleioporus albopunctatus</u>	-	Frog
<u>Heleioporus eyrei</u>	-	Moaning Frog
<u>Limnodynastes dorsalis</u>	-	Western Banjo Frog
<u>Neobatrachus pelobatoides</u> or	-	
<u>Pseudophryne guentheri</u>	-	Guenther's toadlet
<u>Ranidella insignifera</u>	-	Frog
<u>Ranidella pseudinsignifera</u>	-	Frog
<u>Aclys concinna</u>	-	Lizard
<u>Pygopus lepidopodus</u>	-	Common Scaly-Foot
<u>Cryptoblepharus plagiocephalus</u>	-	Lizard
<u>Ctenotus fallens</u>	-	Lizard
<u>Ctenotus impar</u>	-	Lizard
<u>Ctenotus lesuerii</u>	-	Lizard
<u>Ctenotus pantherinus ocellifer</u>	-	Lizard
<u>Ctenotus pantherinus</u>	-	
<u>pantherinus</u>	-	
<u>Ctenotus schomburgkii</u>	-	Lizard
<u>Egernia multiscutata bos</u>	-	Skink
<u>Egernia napoleonis</u>	-	Napoleon's Skink
<u>Hemiergis quadrilineata</u>	-	Lizard
<u>Lerista christinae</u>	-	Lizard
<u>Lerista elegans</u>	-	Lizard
<u>Lerista lineopunctulata</u>	-	Lizard
<u>Lerista planiventralis decora</u>	-	Lizard
<u>Lerista praepedita</u>	-	Lizard

<u>Menetia greyii</u>	-	Lizard
<u>Morethia lineocellata</u>	-	Lizard
<u>Morethia obscura</u>	-	Lizard
<u>Omolepida branchialis</u>	-	Lizard
<u>Tiliqua occipitalis</u>	-	Western Blue-tongued Lizard
<u>Tiliqua rugosa rugosa</u>	-	Lizard, shingle back
<u>Ramphotyplops australis</u>	-	
<u>Varanus gouldii</u>	-	Lizard
<u>Varanus tristis tristis</u>	-	Lizard

Source: W.A. Museum

APPENDIX 3: Questionnaire sheet used and Questionnaire results obtained from a Recreational Survey conducted at Green Head and Leeman during the 4th and 5th of September, 1985

INTERVIEWER'S INITIALS _____

DATE _____

COASTAL MANAGEMENT PLAN
SHIRE OF COOROW

QUESTIONNAIRE FOR RECREATIONAL ACTIVITIES IN THE PROJECT AREA

NOTE: PLEASE TICK THE APPROPRIATE BOXES OR WRITE IN THE SPACE PROVIDED

1. Please tick the box appropriate for your age group.

15 - 24

25 - 34

35 - 44

45 - 54

55 - 64

65 - 74

75 +

2. Sex : Male
Female

3. Marital status: Married
Single

4. Number of children

5. Where have you travelled from? _____

6(a) How long are you planning to stay in the area? _____

(b) Have you been to the area before - Yes No How often?

7. What do you like about the area? _____

SUMMARY OF RECREATIONAL SURVEY
RESULTS

QUESTION ONE : Age of the interviewee

15 - 24 : 1
25 - 34 : 4
35 - 44 : 9
45 - 54 : 4
55 - 64 : 4
Total : 22

QUESTION TWO : Sex of the interviewee

Female : 14
Male : 8
Total : 22

QUESTION THREE : Marital status of the interviewee

Married : 22
Single : 0
Total : 22

QUESTION FOUR : Number of children in the family

Number of children 0 : 3
1 : 2
2 : 5
3 : 5
4 : 2
Total : 37

QUESTION FIVE : Where have you travelled from?

Perth (Metropolitan Area) : 19
Dalwallinu : 1
Mt Barker : 1
Mandurah : 1

QUESTION SIX : How long are you planning to stay in the area?

2 days : 1
3 days : 2
4 days : 1
1 week : 5
2 weeks : 8
3 weeks : 2
2 - 3 years : 1
permanently : 2
Total : 22

QUESTION SEVEN : What do you like about the area?

Peaceful : 6
Restful : 5
Quiet : 9
Walks : 1
Fishing : 8

Friendly people	: 2
Short journey from Perth	: 1
Beach	: 5
Freedom	: 1
Weather	: 2
Natural environment	: <u>3</u>
Total	: 43

QUESTION NINE (a) : When visiting the area which beach/es do or will you visit?

Leeman (All)	: 11
Green Head (All)	: 7
Squatter Settlements	: 2
Dynamite Bay	: 4
All the beaches in the project area	: 3
South Bay	: 1

QUESTION NINE (b) : When visiting these beaches what activities do you take part in?

Beach fishing	: 12
Swimming	: 18
Surfing	: 2
Picnicking	: 11
Beachcombing/exploring	: 15
Sunbathing	: 13
Scuba diving	: 2
Ocean fishing	: 14
Power boating	: 6
Sailing	: 1
Trail bikes/dune buggies	: 1
Skiing	: 1
Cycling	: 1
Sightseeing	: 1

QUESTION ELEVEN : Are there any improvements you would like to see in the area?

Beaches free of seaweed	: 4
More activities	: 2
None	: 8
Keep it as it is	: 3
Boats/bicycles for hire	: 1
More barbecue facilities	: 1
Childrens' playground	: 1
Removal of squatters' shacks	: 1
Green Head - public telephone and letter box	: 1
More flexible shopping hours	: 1
Full-time doctor	: 1
Improvement of boat ramp at South Bay	: 3