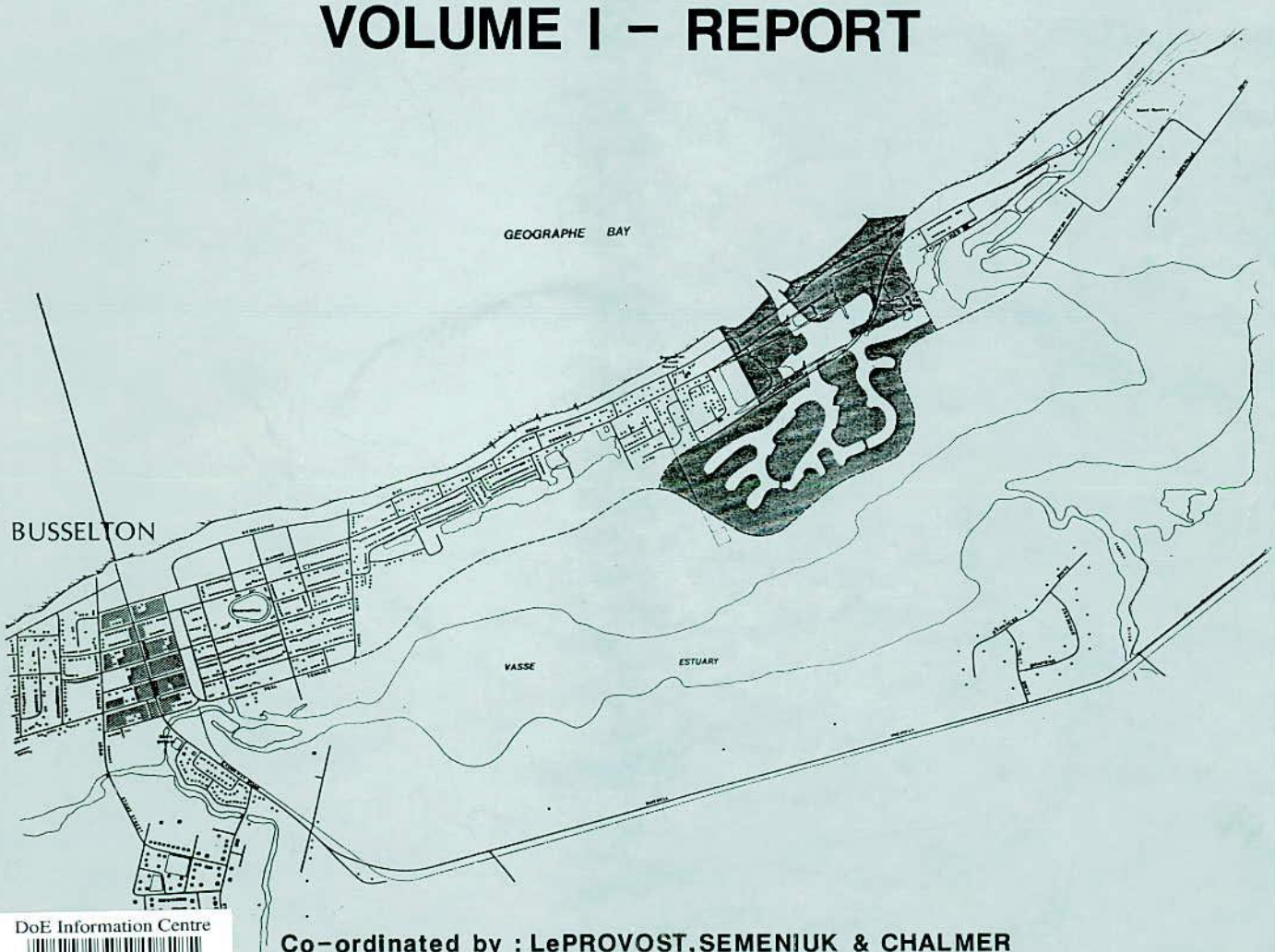
INTERSTRUCT PTY.LTD.
NATURALISTE DEVELOPMENTS PTY.LTD.

PORT GEOGRAPHE

ENVIRONMENTAL REVIEW AND MANAGEMENT PROGRAMME

VOLUME I - REPORT



Co-ordinated by : LePROVOST, SEMENIUK & CHALMER
Environmental Consultants

INVITATION

The Environmental Protection Authority (EPA) invites people to make a submission on this proposal.

The Environmental Review and Management Programme (ERMP) has been prepared in accordance with Western Australia Government procedures. The ERMP proposes the development of part of the Vasse Wonnerup Area. The report will be available for comment until 9 December 1988.

Following receipt of comments from government agencies and the public, the EPA will prepare an assessment report with recommendations to government, taking into account issues raised in public submissions.

Why write a submission?

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

All submissions received by the EPA will be acknowledged. Submissions will be treated as public documents unless confidentiality is requested, and may be quoted either in full or in part in each report.

Why not join a group?

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

Developing a submission

You may agree or disagree with, or comment on, the general issues discussed in the ERMP or the specific proposals. It helps if you give reasons for your conclusions, supported by relevant data. You may make an important contribution by suggesting ways to make the proposal environmentally more acceptable.

When making comments on specific proposals in the ERMP:

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

21.09.88

Points to keep in mind

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

- attempt to list points so that the issues raised are clear. A summary of your submission is helpful;
- refer each point to the appropriate section, chapter or recommendation in the ERMP;
- if you discuss different sections of the ERMP, keep them distinct and separate, so there is no confusion as to which section you are considering;
- attach any factual information you wish to provide and give details of the source. Make sure your information is accurate.

Remember to include:

- your name
- address
- date

The closing date for submissions is:

9 December 1988

Submissions should be addressed to:

The Chairman
Environmental Protection Authority
1 Mount Street
PERTH WA 6000

Attention: Mr Jim Singleton

21.09.88

PORT GEOGRAPHE

ENVIRONMENTAL REVIEW AND MANAGEMENT PROGRAMME

REPORT

21.09.88

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PORT GEOGRAPHE

ENVIRONMENTAL REVIEW AND MANAGEMENT PROGRAMME

1.0 INTRODUCTION

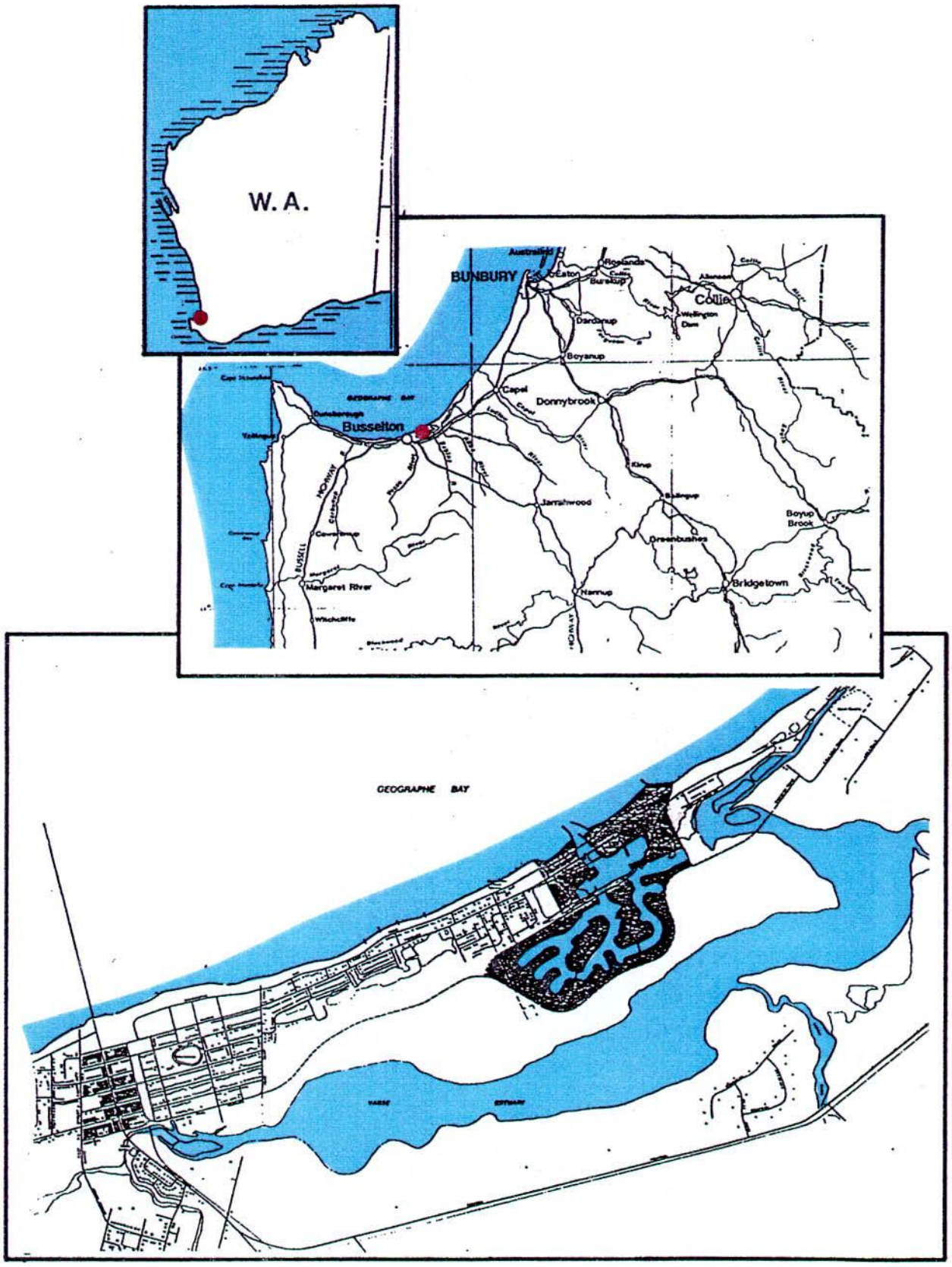
1.1 THIS DOCUMENT

This document is an Environmental Review and Management Programme (ERMP) which has been prepared by Interstruct Pty Ltd, and Naturaliste Developments Pty Ltd for their proposed Port Geographe Development - a harbour and residential waterway complex located on Geographe Bay some 4 km east of Busselton, Western Australia (Figure 1.1). The purpose of the document is to seek environmental approval for the proposed project to proceed.

The ERMP has been prepared in response to the requirements of the Environmental Protection Authority (EPA) following their review of a detailed Notice of Intent (NOI) submitted by the John Holland Group and Naturaliste Developments Pty Ltd for a previous design concept in 1985.

This document presents the current development proposal which has been revised from the 1985 proposal on the basis of the response to the NOI by the EPA and other relevant authorities, and of the results of further studies carried out since presentation of the NOI.

One of these studies the Leeuwin-Naturaliste Region Plan (State Planning Commission [SPC], 1987) has provided much of the stimulus and the design background for the project. The proposed development has been designed to be compatible with the objectives of the region plan.



PROJECT LOCATION

FIG. 1.1

Guidelines for the ERMP have been provided by the EPA and are presented in Section 9. The structure of the ERMP broadly follows the structure outlined in those guidelines. The ERMP is presented in three parts:

- Volume 1 ERMP Report
- Volume II Technical Appendices
- Summary Document

Section 1 of the ERMP Report provides details of the Proponents of the project, describes the proposed project, and places the project into an overall concept plan for future stages of development fringing the Vasse-Wonnerup estuarine system. This section also describes the relevant statutory requirements and approval procedures. The study team is identified and the assistance of various government officers is acknowledged.

Section 2 outlines the history of the project and evaluates the potential alternatives to the proposed development.

Section 3 describes the project in detail, including construction, servicing and operation. Since the environmental acceptability of this project depends to a large extent on the implementation of a range of management programmes, and these programmes are inseparable from the operation of the project, they are outlined in this section. Administrative details of the management programme are outlined in Section 6.

Section 4 describes the existing physical, biological and human environment at a regional and local scale to place the development into perspective within the Shire of Busselton.

Section 5 assesses the effects of the proposed project and its associated management programmes on the physical, biological and human environment of the region.

Section 6 provides the administrative details of management plans and programmes to be implemented by the Proponent in order to overcome or minimise any adverse effects which were identified in Section 5.

Section 7 provides an assessment of the acceptability of the project, based on a balance of the benefits of the project as opposed to the adverse impacts and the ongoing cost of managing those impacts.

Section 8 provides references.

Section 9 presents the EPA guidelines for the Port Geographe ERMP.

Volume 2 of the ERMP contains the technical appendices which support the conclusions drawn about the effects of this proposal on the environment and may be consulted by readers requiring more specific technical information on the investigations conducted. The contents of Volume 2 are as follows:-

Appendix	1	Sea Level Rise - Riedel & Byrne
	2	Stratigraphy and Hydrogeology of Project Site - LSC
	3	Sewerage Investigations - Airey Ryan and Hill
	4	Waterfowl Surveys - Ninox
	5	Flushing Characteristics of Port Geographe - Riedel & Byrne
	6	Hydrogeological Assessment - Rockwater
	7	Resolution of Waterfowl Issues - LSC
	8	Traffic Study - Airey Ryan and Hill

1.2. THE PROPONENT

The Proponent for the project is a Joint Venture between Interstruct Pty Ltd and Naturaliste Developments Pty Ltd.

Interstruct Pty Ltd is a privately-owned Western Australian Builder/Developer with its head office on the 4th Floor of 190 St George's Terrace, Perth. Major projects undertaken in Western Australia include Princess Margaret Hospital, Customs House (Fremantle) and East Perth Government Offices.

Naturaliste Developments Pty Ltd is a privately-owned Busselton company operating in land developments throughout the Busselton region with its office at 55 Queen Street, Busselton. Major local projects include the Busselton Beach Resort, the Bayside Residential Subdivision and the Town Court Retail and Office Complex in Busselton.

The Proponent's objectives are:

a To develop a large parcel of land located on the eastern outskirts of Busselton. The land is currently owned jointly by Interstruct and Naturaliste Developments and zoned part residential and part rural (Figure 2.1).

b To develop this land in a way that will benefit both the Proponent and the local community and at the same time maintain and enhance where possible the natural values of the area.

The proposed development has been designed to be compatible with the stated objectives of the State Government's Leeuwin-Naturaliste Region Plan.

Specifically, the aim of the project is to:

i provide much-needed boating facilities for recreational and professional fishermen;

ii enhance year-round tourism in the Busselton region through the provision of tourist attractions such as a marina village and a Waterfowl Conservation Park;

iii provide new recreational and residential opportunities for people of Busselton and southwest Australia;

iv provide for waterfowl conservation and improved public access to the estuary;

v promote conservation and education values of the Vasse Estuary.

vi stabilize an eroding section of Geographe Bay coastline.

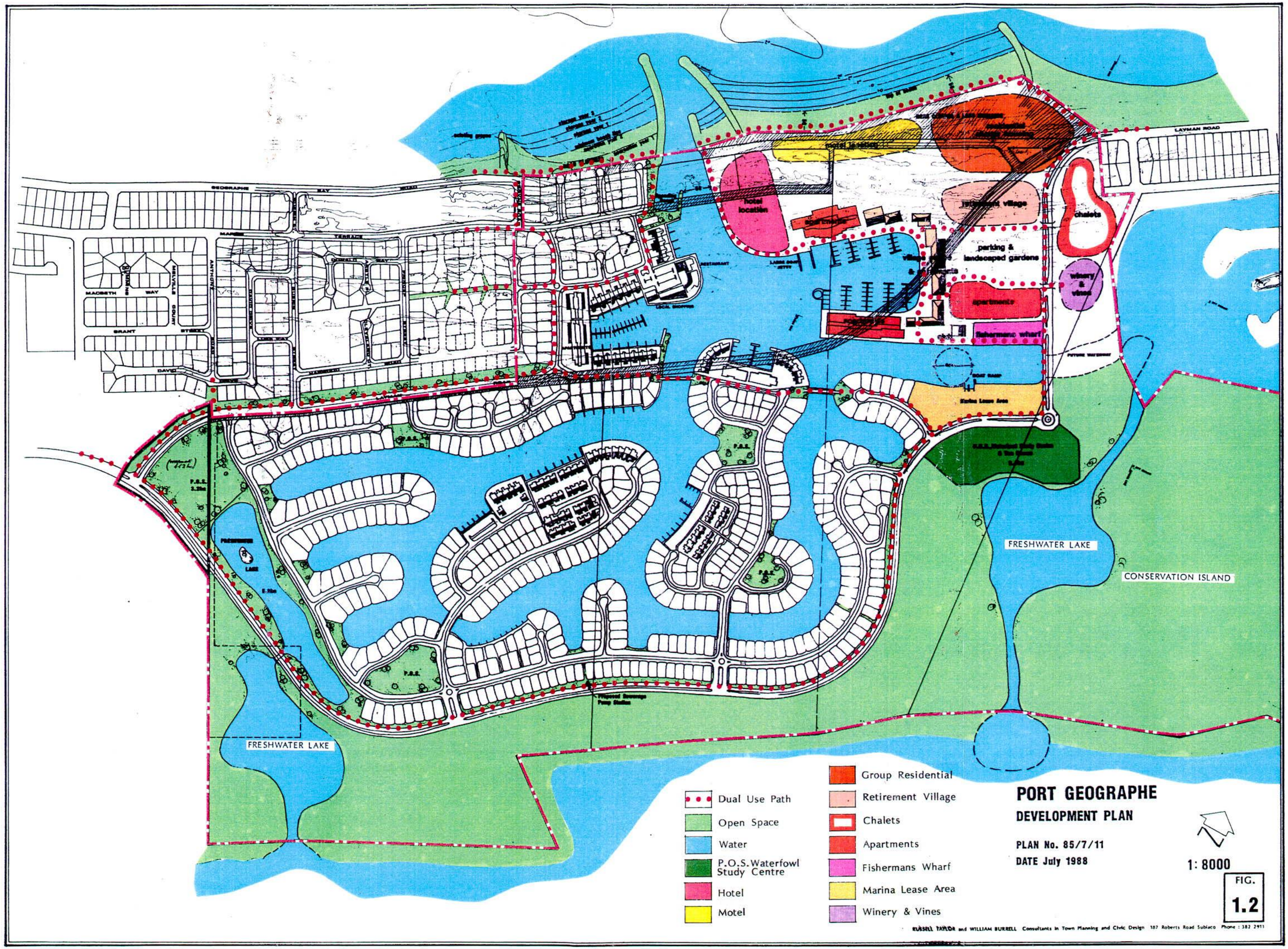
1.3 THE PROPOSED PROJECT - PORT GEOGRAPHE

The proposed project (Figure 1.2) will satisfy the above objectives by providing the following facilities;

- a safe inland harbour for local and visiting craft, including fishing boats, with mooring facilities for approximately 500 craft and two public boat ramps;
- residential waterways for canal lots, group marina lots and apartments with water views and boating facilities;
- a village centre for local residents and tourists;
- a beach hotel and medium-standard motel;
- retirement and rental chalets with communal jetty;
- a waterfowl conservation park on the Vasse Estuary incorporating a tourist and education centre.

In addition, the project will contribute to a much-needed estuary management programme by:

- conducting investigations into selected ecological aspects of the estuary related to the project;
- contributing funds towards a larger-scale study of the estuary's hydrodynamics, water quality and ecology;


GEOGRAPHE BAY ROAD
MACBETH WAY
MELVILLE COURT
ANTHONY STREET
GRANT STREET
DAVIES
MARINE TERRACE
DONNELLY WAY
LOCAL SHOPPING
RESTAURANT
hotel location
LAYMAN ROAD
chalets
parking & landscaped gardens
winery & vines
apartments
fishermans wharf
Marina Lease Area
P.O.S.
FRESHWATER LAKE
CONSERVATION ISLAND
Proposed Sewerage Pump Station
Group Residential
Retirement Village
Chalets
Apartments
Fishermans Wharf
Marina Lease Area
Winery & Vines
Dual Use Path
Open Space
Water
P.O.S. Waterfowl Study Centre
Hotel
Motel
PORT GEOGRAPHE
DEVELOPMENT PLAN
PLAN No. 85/7/11
DATE July 1988
1: 8000
FIG. 1.2
RUSSELL TAYLOR and WILLIAM BURRELL Consultants in Town Planning and Civic Design 187 Roberts Road Subiaco Phone : 382 2911

1.4 FUTURE STAGES OF DEVELOPMENT

The current Port Geographe project, for which this document seeks environmental approval to proceed is economically viable.

However, Port Geographe could also be the first stage of a larger development incorporating both the Vasse and the Wonnerup Estuaries. This larger development proposal is purely conceptual at present and it is recognised that an estuary management programme would need to be devised and shown to be practicable prior to seeking further environmental approvals for subsequent stages of development.

The overall concept for the region has been termed the Vasse-Wonnerup Conservation Park. The total concept is also compatible with the objectives of the Leeuwin-Naturaliste Region Plan and would provide the following additional benefits to the Busselton community:

- o the re-opening of the Vasse Estuary and the relocation and redesign of the tide flood gates to provide better flushing of the estuary, better flood control, inland navigable waterways and increased estuarine fish nursery habitat;
- o more waterfowl conservation reserves along the western edge of the Wonnerup Estuary and Malbup Creek;
- o more tourist-orientated facilities including an international-standard golf course and resort complex;
- o more boat mooring facilities;
- o more water-based residential opportunities.

The overall concept is shown in Figure 1.3. There are four major components within the Vasse-Wonnerup Conservation Park. These are:

- o Stage 1: Port Geographe (as described above);
- o Stage 2: the Vasse Waterways providing:
  - a range of water- based residential opportunities,
  - a permanent opening to the Vasse-Wonnerup Estuary,
  - a new tide/flood gate located sufficiently upstream to allow Port Geographe to link into the lower Vasse Estuary, thereby providing an inland navigable waterway;

LEGEND

- Conservation Area existing or proposed
- Conservation Area subject to further study
- Village Centre, Hotel, Motel, Shops, Fishermans Wharf & Winery
- L — Proposed Locks
- Alternative Layman Rd alignment
- Concept Plan Study Area

Wonnerup Estate-Golf Course Village

The Entrance-Marina Village

Vasse Waterways-Canal Estate

INDIAN OCEAN

Port Geographe-Village & Waterways

BAY

GEOGRAPHE

VASSE

ESTUARY

Loc 1440
81.90ha

A40250

VASSE/WONNERUP CONSERVATION PARK

CONCEPT PLAN

SCALE 1:30,000

FIG 1.3

- Stage 3: The Entrance providing:
  - a tourist and holiday resort facility,
  - an additional marina complex,
  - a new tide/flood gate located further upstream on the Wonnerup Inlet to provide navigable access to the resort complex and to Stage 4;
- Stage 4: The Wonnerup Estate providing:
  - an international-standard golf course,
  - rural residential opportunities in a parkland setting.

All four components will feature major conservation initiatives.

The more important wetlands will be vested in the crown for conservation as the development proceeds. The estuarine conservation park has two distinct features - freshwater areas set aside for waterfowl and other birdlife, and saltwater nursery areas for marine fish. The main features of the park and its management are envisaged as follows:

- protection of estuary foreshores and wetland habitats;
- flood control;
- management to control disturbance to waterfowl;
- provision of freshwater drought refuges;
- waterfowl study and observation centre;
- controlled public access;
- education and research;
- extension of fish nursery areas.

The philosophy adopted for the overall development is one of co-operation with the various government departments and the Busselton Shire Council to ensure that estuary and wetlands management is soundly based, and to enhance both the conservation areas and the human settlements in a way which could not otherwise be achieved.

This philosophy of ENHANCEMENT through MANAGEMENT can reach fulfilment through co-operation between the private and public participants and the unification of land ownership under a single proponent.

Approvals will be sought through a process of STAGED ASSESSMENT AND MANAGEMENT.

1.5 TIMING

It is anticipated that approvals, rezoning and finalisation of an appropriate agreement between the State Government, Busselton Shire Council, and the Proponent for Stage I (Port Geographe) would be put in place progressively from December 1988 to early 1989. This would allow detailed design and documentation to proceed early in 1989 and construction of breakwaters and the start of civil works for Port Geographe to proceed by June 1989.

The current anticipated rate of sales for Stage 1 indicates a five-year construction programme.

Subsequent stages of development will require further environmental research and monitoring work to achieve approvals and rezoning. This work will be undertaken progressively using knowledge gained during, and funded by, Stage I.

If further environmental approvals are obtained, it is expected that development of the overall concept could continue over a period extending to the year 2010 - a 15- to 20-year construction programme.

1.6 RELEVANT STATUTORY REQUIREMENTS - APPROVAL PROCEDURE

Approval for the project will be sought from the State Government and the Busselton Shire Council following advice from relevant authorities.

The statutory procedures which must be followed in order to develop and operate the project are:

i Submission of the ERMP to the EPA, and 10 week period for public review and comment.

ii EPA consideration of the ERMP together with public submissions and advice from other relevant authorities.

iii EPA recommendation to Government (through the Minister for the Environment) that the project may proceed on environmental grounds, and Government acceptance of this recommendation.

iv Applications to the Shire of Busselton to effect rezoning of the project to a "Canal Zone" or "Marine Development Zone" to comply with Canal Guidelines (1981 as amended).

v Application to the SPC for approval to subdivide. SPC consideration of the project, involving advice from other authorities in specialised areas.

1.7 STUDY TEAM

A wide range of studies was undertaken for this ERMP by:

LeProvost, Semeniuk & Chalmer, Environmental Consultants,
(Environmental description and impact assessment; coastal, estuarine and conservation park management planning, design and production of ERMP)

Russell Taylor and William Burrell, Consultants in Town Planning and Civic Design,
(Project planning and design, land use study, community needs)

Philip Cox, Etherington, Coulter and Jones, Architects and Planners,
(Vasse-Wonnerup Conservation Park concept plan, architecture of Port Geographe)

Port and Harbour Consultants Pty Ltd,
(Harbour concept and coastal management)

Riedel & Byrne , Consulting Engineers Pty Ltd,
(Physical and engineering studies related to sand bypass, water quality, flood control, breakwater and wall construction and the greenhouse effect)

Janet Gilchrist Town Planner and Urban Geographer,
(Retail study, demographic study)

Airey Ryan and Hill, Consulting Civil Engineers,
(Traffic studies and services)

Ninox Wildlife Consulting,
(Waterfowl and wildlife surveys)

Allen Wilson, Town Planner,
(Project Agreement)

Rockwater, Hydrogeologists,
(Groundwater use, impact and supply studies)

Studies currently proceeding as part of the Environmental Management Programme are being conducted by:-

Tract Landscaping Consultants,
(Landscape design and costings for management of Public Open Space and construction areas)

Ninox Wildlife Consultants,
(Waterfowl use of conservation zone and management recommendations)

Tony Wright,
(Mosquito population characteristics, Vasse Estuary)

Jenny Davies,
(Midge population characteristics, Vasse Estuary)

1.8 ACKNOWLEDGEMENTS

The assistance of the following individuals and organisations is acknowledged:

Peter Driscoll, Geoff Klem and Ian Everett
(SPC)

John Clydesdale
(South West Development Authority)

Glen Bishop
(Busselton Shire Council)

Vera Novak
(Aboriginal Sites Department, Western Australian Museum)

Graeme Holt and Peter Marchesani
(West Australian Water Authority)

Garry Whisson and Jim Singleton
(Environmental Protection Authority)

Barry Wilson and John Blythe
(Conservation and Land Management)

John Jenkin and Bob Brindley
(Department of Marine and Harbours)

Peter Rogers
(Fisheries Department)

Terry Wright
(Health Department of Western Australia)

2.0 ALTERNATIVES TO THE PROPOSED DEVELOPMENT

2.1 INTRODUCTION

This section outlines the history of the project before evaluating the of potential alternative development options for the subject land with a view to justifying the preferred option which is the subject of detailed assessment in this report. The Proponent's land is situated between the Vasse Estuary (on south and eastern borders), Geographe Bay (northern border) and the eastern suburb of Busselton known as Bayside (western border). The land comprises basically four types of land unit as follows:-

- beach and foredune;
- coastal dune ridges;
- estuarine flats;
- estuary foreshore.

The location of the above units within the Proponent's land boundary is shown on Figure 2.1.

2.2 HISTORY OF THE PROJECT

In 1983, Naturaliste Developments commissioned a number of consultants to provide advice on planning, construction, coastal engineering, financial and environmental aspects of developing the site. Discussions were initiated with a number of Government Departments to identify community needs in the region and potential constraints on developing the site. As a result, in 1983, Naturaliste Developments signed an agreement with the John Holland Group to develop the site as a joint venture.

The proposal at that stage involved an ocean-front harbour with offshore groynes, as well as an inland waterway with associated residential, tourist and commercial development.

In order to determine the environmental acceptability of the project, Naturaliste Developments and the John Holland Group submitted a detailed Notice of Intent (NOI) to the Environmental Protection Authority (EPA) in March 1985. The NOI identified the potential concerns associated with the development and provided sufficient information to allow preliminary appraisal of the feasibility and desirability of proceeding with the project. The EPA obtained comment on the NOI from a wide range of appropriate government representatives and authorities and subsequently recommended that an Environmental Review and Management Programme (ERMP) should be prepared to provide additional information to enable the EPA to advise on the environmental acceptability of the project. The EPA also pointed out that the development would need to proceed in accordance with the recommendations of the Steering Committee on Canal Developments (1981), commonly known as the Canal Guidelines.

Since submission of the NOI, several events have taken place which affect the project.

These are:

a John Holland Constructions has relinquished its interest in the project to Interstruct.

b A major planning study of the region commissioned by the State Planning Commission (SPC) has identified that the Port Geographe site is suitable for a harbour facility subject to satisfactory conclusions of current environmental investigations.

c The harbour and waterway complex has been redesigned to replace the offshore breakwater with an inland harbour together with reconstituted frontal dunes and beaches (Figure 1.2). This modification has substantial benefit in reducing the potential impact of the development on the marine environment and improving sand bypass management.

d The Department of Marine and Harbours (DMH) has commissioned an investigation into coastal processes of the area. The results have confirmed earlier studies that management for the proposed harbour entrance is feasible from an engineering view point and is economically viable.

Subsequent discussions between the Proponents and various Government Departments have resulted in the following points of understanding:

i Agreement in principle has been reached between the Proponents and the Department of Marine and Harbours (DMH) for DMH to participate in the project. The DMH responsibility would be to operate and manage the waterways in conjunction with Busselton Council and to minimise the impact on the marine environment through a project funded management programme.

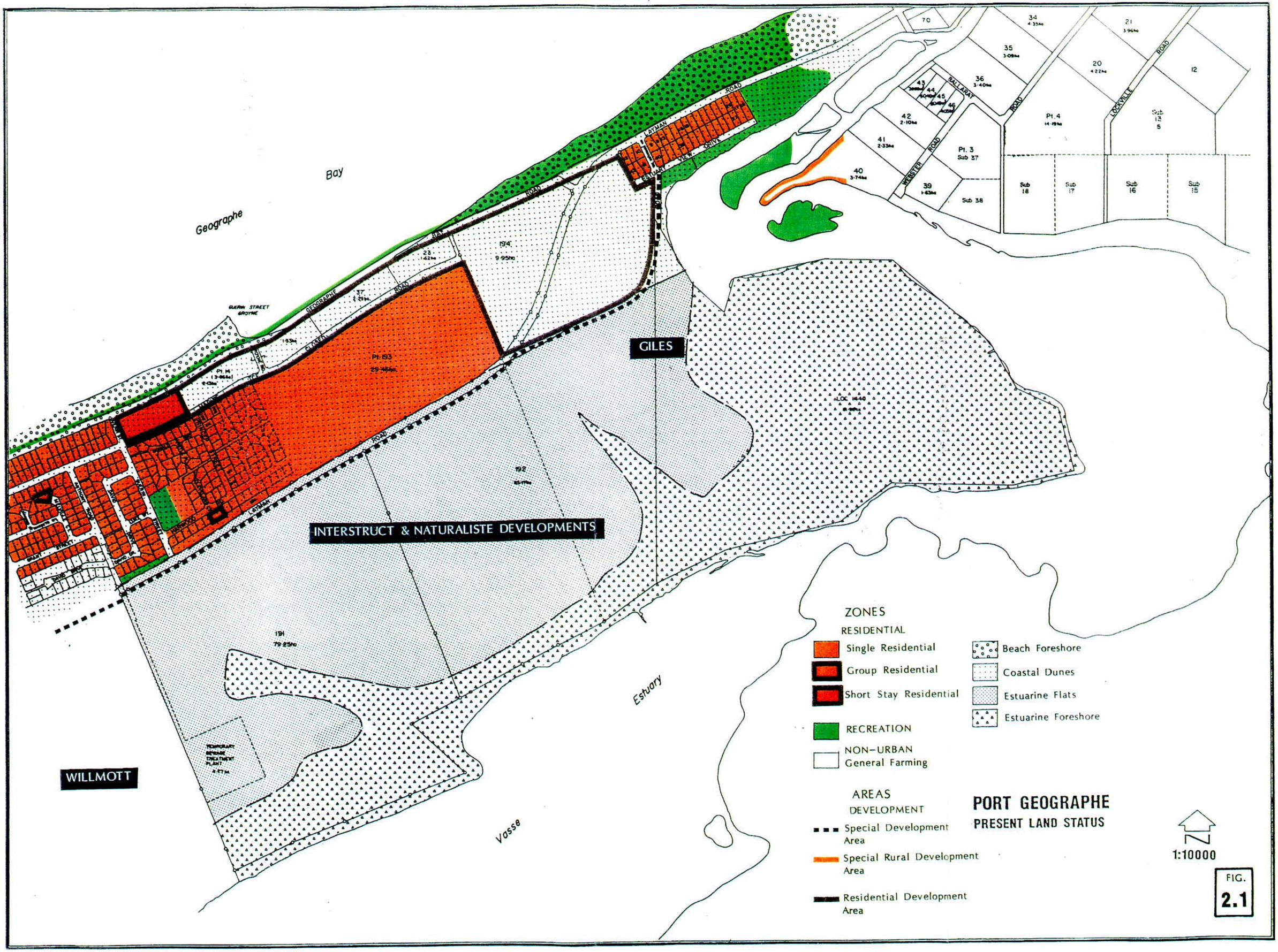
ii Discussions have been held between the Proponents and the EPA and the Department of Conservation and Land Management (CALM) with the aim of reaching an agreement whereby CALM would receive management control over the more important wetlands fringing the Vasse Estuary. Whilst no agreement has been formally defined, the component parts of any agreement have been identified.

iii The Busselton Shire Council accepts responsibility for providing all the normal services that would apply to conventional "dry" subdivision. It also accepts that monies collected by virtue of the "added value" of the waterways component of the project will be used to pay for waterways management and sand bypassing. The mechanism for collection and use of money will be covered in an Agreement to be finalised between the Proponent, the State Government and the Busselton Shire Council.

iv A draft Project Agreement has been prepared outlining the responsibilities of the various parties (Proponent, DMH, Busselton Shire Council) for funding and managing the development. This Agreement will be finalised upon receipt of environmental approval for the project to proceed. Final wording of this Agreement will be approved by each of the three parties involved.

2.3 PRESENT ZONING AND DEVELOPMENT POSSIBILITIES

The estuarine flats within the proposed development area are currently zoned rural and have been developed as a grazing property. Grazing activity ceased some years ago. (Figure 2.1)


Bay
Geographe
GUERNSEY ROAD
LAYMAN VIEW DRIVE
GEOGRAPHE ROAD
GUERN STREET GROYNE
GILES
INTERSTRUCT & NATURALISTE DEVELOPMENTS
WILLMOTT
Estuary
Vasse
ROAD
WEBSTER ROAD
BAYLARAY ROAD
LOCKVILLE ROAD
Pt. 3 Sub 37
Sub 38
Pt. 4
Sub 13
5
Sub 18
Sub 17
Sub 16
Sub 15
ZONES
RESIDENTIAL
Single Residential
Group Residential
Short Stay Residential
RECREATION
NON-URBAN
General Farming
Beach Foreshore
Coastal Dunes
Estuarine Flats
Estuarine Foreshore
AREAS
DEVELOPMENT
Special Development Area
Special Rural Development Area
Residential Development Area
PORT GEOGRAPHE
PRESENT LAND STATUS
1:10000
FIG.
2.1

The coastal dune strip forming the northern component of the development area is currently zoned residential or future residential under the Busselton Town Planning Scheme (Scheme Maps 2 and 3). Naturaliste Developments have been progressively subdividing and selling residential blocks on the coastal dune strip to the west of the Port Geographe location.

Subdivision of the coastal dune strip as a dryland subdivision represents a fall-back position for the Proponent if it should not be successful in gaining approvals for the proposed Port Geographe development. However, should this eventuate, it would be necessary to restock the estuarine flats portion of the land which would result in a return to grazing pressure to a level comparable to that applied by adjacent landholders in order to provide a reasonable financial return on the land.

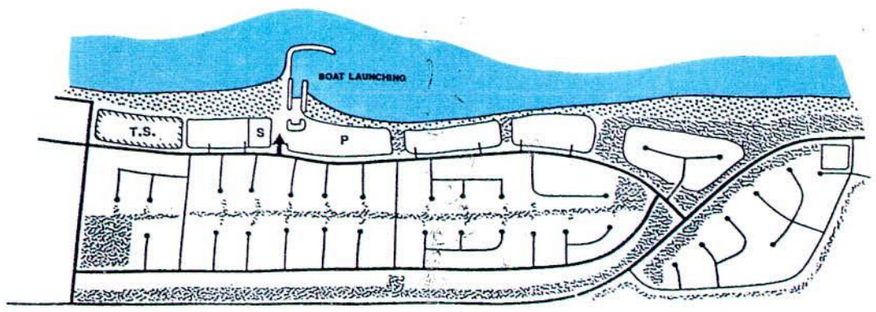
2.4 ALTERNATIVE POTENTIAL DEVELOPMENTS

2.4.1 Urban Development on Dunes plus Small Boat Launching Facility

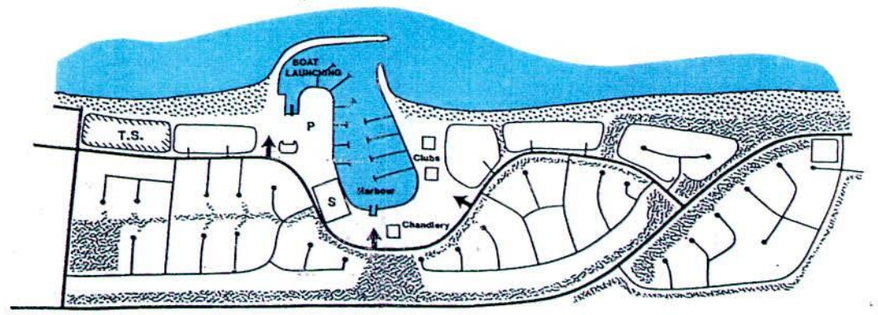
This alternative involves dryland subdivision along the coastal dune strip incorporating a small boat harbour with capacity to protect small to medium size craft during launching operations only (Figure 2.2a). The harbour might have limited facilities such as boat trailer parking and washdown area. This alternative is feasible to the extent that the land is appropriately zoned, but suffers from high management costs as outlined below and is considered not economically viable.

2.4.2 Harbour, Commercial and Residential Development on Coastal Dunes

This alternative involves residential development built around a safe harbour incorporating marina facilities and a commercial village (Figure 2.2b). The harbour in this instance might have 100 - 200 boat pens, boat ramp, sailing and offshore fishing clubs, working marina, hotel, restaurants and shopping facilities.

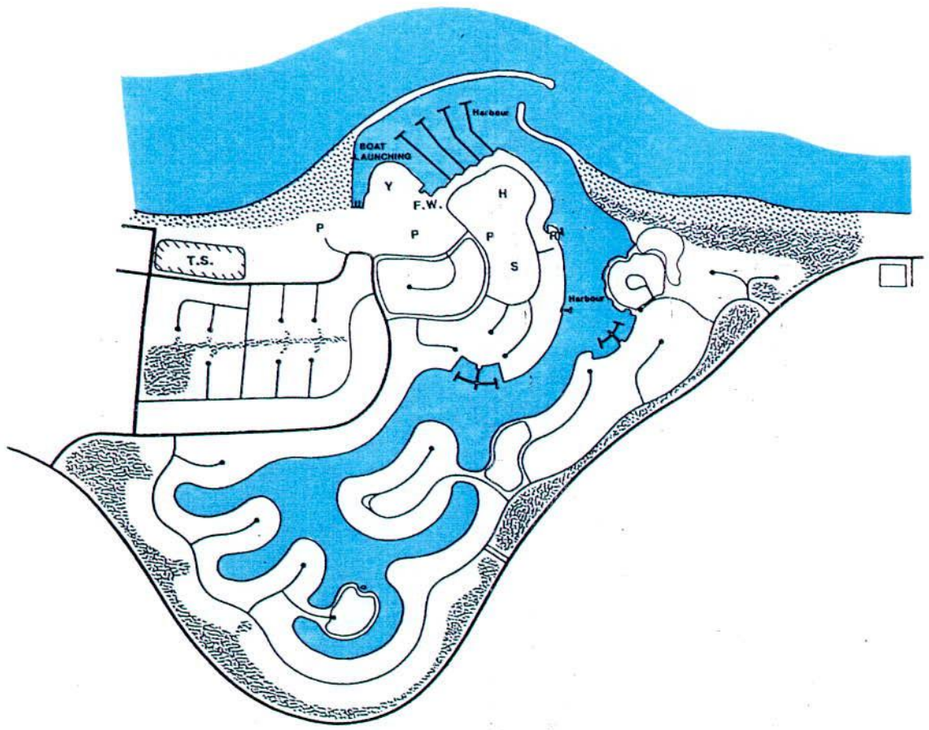


(a)

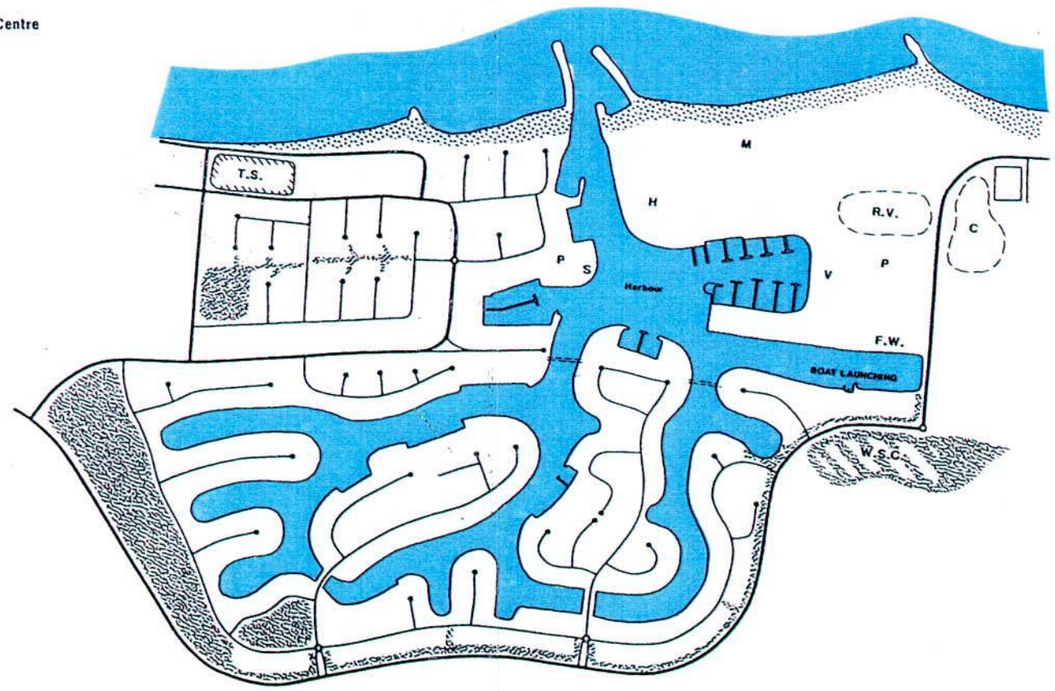


(b)

TS – Time Share
S – Shopping
P – Parking
H – Hotel
FW – Fishermans Wharf
Y – Yacht Club
R – Restaurant
M – Motel
RV – Retirement Village
C – Chalets
V – Village Centre
WSC – Waterfowl Study Centre



(c)



(d)

PORT GEOGRAPHE
DEVELOPMENT OPTIONS

FIG. **2.2**

Both this and the previous alternative (2.4.1) suffer from high capital costs of the harbour and breakwaters, sand bypass and waterway management (for the latter alternative) as well as low financial returns resulting from insufficient waterway lots to support the public equity components. The added value of residential waterway lots in large numbers is required to support these liabilities.

A project based on either of the two alternatives outlined above would not be economically viable.

2.4.3 Original John Holland Concept

The original John Holland Constructions Concept (JHC 1985) involved construction of a large outer harbour on the coast (similar to Two Rocks Marina) with a small residential waterway system encroaching onto the driest portions of the estuarine flats only. This concept (Figure 2.2c) was dropped for a number of reasons:

a Little support for the development was expressed when the project was first proposed and substantial opposition from some government departments raised what seemed to be insurmountable barriers to the development proceeding at that time;

b The "outer harbour" which formed the focal point of the John Holland concept had two fundamental problems:

- o the long breakwaters may have interfered with the offshore sand bars and seagrass beds, thus complicating sand bypass management and raising questions of coastal stability;
- o the up-front capital costs of long breakwaters enclosing a large harbour plus the need to find fill material was a significant financial burden to the project;

c The number of waterway lots located on the estuarine flats was not sufficient generate capital necessary to meet the high initial capital costs and the costs of ongoing sand bypassing and waterways management.

The project, in that form, was not economically viable and was dropped by John Holland Constructions.

2.4.4 Revised Concept (Current Proposal)

The revised concept for Port Geographe (Figure 2.2d) was developed on the basis of the information from the Leeuwin-Naturaliste Region Plan and the DMH Coastal Study. This concept moves the harbour inshore to keep well clear of the offshore sand bars and seagrass beds, thereby reducing the impact on the marine environment and improving the ease of sand bypass management. It also reduces the cost of breakwaters. The concept also allows a moratorium on sand bypassing costs for approximately five years by using the natural sand buildup from the west to replace land lost to erosion (east of Guerin Street groyne), whilst at the same time replenishing beaches to the east of the harbour progressively from sand obtained from harbour and waterways excavations.

However, bringing the harbour inland uses prime development land and this must be balanced with additional residential land to fund the project. The only land available is the adjacent estuarine flats. The low elevation above sea level renders these flats ideal for development of prime waterway residential blocks. In order to safeguard the acknowledged waterfowl conservation values of the Vasse Estuary and allow development of the flats, the Vasse Waterfowl Conservation Area has been set aside. The most valuable wetlands would be ceded to the State for management as a conservation reserve. Studies conducted by the Proponent and the RAOU have identified the most valuable wetland habitat as the sedge and samphire habitats fringing the southern border of the Proponent's land plus the large area of samphire wetland on Giles property to the east.

The need to have access to more of the estuarine flats to achieve this balance and make the Project financially viable prompted the Proponent to purchase the Giles property. Having control of this property has enabled the Proponent to make firm commitments as to what land it can cede to the State and also to define what area of estuarine flats must be developed to keep the Project viable.

Any reduction in the area of estuarine flats developed not only reduces the contribution to up front capital required to construct the project but also dilutes the residential catchment required to pay for the ongoing management costs. The development is financially viable only in the form and scale described in this ERMP.

2.4.5 The Vasse-Wonnerup Conservation Park

The proposed Vasse-Wonnerup Conservation Park (Figure 1.3) embraces the major water bodies and estuarine flats of the Vasse and Wonnerup estuary systems north of the Bussell Highway to ensure that conservation and management of the wetlands are sensitively combined with low key residential and tourist development. The concept has already been described in Section 1.0 of this document.

The stimulus for the concept arose from the recognition that there was a need for an estuary management plan as identified in the SPC (1987) Leeuwin-Naturaliste Region Plan. It is proposed that an estuary management plan could involve two basic components:

- a permanent opening to the ocean to allow tidal flushing and runoff discharge
- better tide/flood gates than presently exist to allow more flexible control of water quality and level in the estuaries.

Since the management of the estuary is obviously of benefit to the Port Geographe development, the Proponent engaged a consultant to design a long-term development concept that could fund the management and maintain the natural and conservation values of the area. Preliminary studies suggest that the concept is potentially both feasible and financially viable. However insufficient information is available about the hydrodynamics, water quality and ecology of the estuary at present to determine its environmental acceptability.

Further studies are needed before this development option can be assessed. The concept does, however indicate what might be achieved if Port Geographe is allowed to proceed and provide funds for research into estuary management.

2.5 ALTERNATIVE SITES

There is no alternative site in Geographe Bay which can be built onto the infrastructure of Busselton and provide the harbour facility needed in the region, as identified in the Leeuwin-Naturaliste Region Plan. Busselton has developed in a linear fashion along the coastal strip and harbours of the form proposed are therefore difficult to locate except at the extremities. The western extremity has multiple ownerships, lacks landform and servicing opportunities, and is constrained by Bussell Highway. The subject land at the eastern extremity of the town has all the advantages of single ownership, established breakwater, existing services, shops and school site and does not have major physical or environmental constraints that cannot be resolved by management.

The only other possible site for a harbour in Geographe Bay is that identified in the Region Plan at Curtis Bay. That site, however, is of more limited value to the Busselton community and also cannot provide the water-based residential opportunities that can be achieved at Port Geographe.

2.6 CONCLUSIONS

There are only two financially viable alternatives for development of the Proponent's land holding - the dry land subdivision outlined in Section 2.3, or the Proponent's concept (option 2.4.4). The Proponent's concept requires that use must be made of a portion of the estuarine flats for waterway development. The Project is NOT economically viable if use of the flats is reduced.

Should the proposed project not receive environmental approval, then the Proponent will revert to the dry land subdivision option. The estuarine flats will also be restocked to the level required to obtain a reasonable return on the land's value.

Should this eventuate, the Busselton community will lose its only opportunity to benefit from the facilities proposed for Port Geographe and the associated economic benefits for the region.

3.0 DESCRIPTION OF PROJECT - PORT GEOGRAPHE

3.1 INTRODUCTION

This section describes the proposed project in sufficient detail to allow comprehensive assessment of its potential impacts. The project concept and facilities are outlined first followed by an outline of the proposed arrangements for public access, land exchange and equity transfer. Construction details are outlined subsequently. These include consideration of engineering design criteria, a description of major civil works and auxiliary services. Details on operation and management of the project are presented in Section 6.0 of this ERMP.

3.2 CONCEPT AND LAYOUT

There are four physical components to the plan; the beach, the harbour, the waterways and the waterfowl conservation area.

The Port Geographe concept, as shown in the Development Plan (Figure 1.2) has evolved in response to the regional need for a safe harbour and recreational boating facilities as well as a diverse series of market requirements ranging from beach hotel/motel and shopping facilities for tourists to waterfront lots and units. The development will contribute to tourist facilities and attractions in the region but the tourist market does not dominate the concept. Tourist visits are seasonal and transient, and the concept is based on a mixture of markets and activities which, while responding to seasonal changes will be alive all year round. Port Geographe is designed to cater for permanent residents, the retired and visitors.

The capital cost of the harbour and breakwaters must be offset by securing an adequate area of saleable land with waterway frontage, or at least with access to a group marina.

The layout of the development provides the maximum waterfrontage and opportunities for water-based activity because of the fundamental requirement to satisfy the urgent need for a harbour and boating facility. Views of the water have been maximised in the design and open space has been located to give long vistas over water. Many of the dryland dwelling units within the estate will be elevated to gain views over adjacent waterfront housing.

The shape of the harbour and the orientation of the waterways have been designed to assist flushing and promote water exchange.

The border between the waterfowl conservation area and the development will be provided by relocating Layman Road (Figure 1.2). The location and siting of this road have been selected to:

a Provide a buffer zone of at least 50m width between the development and the landward edge of the valuable samphire wetland habitat which fringes the estuary foreshore. This means that the road will be at least 100m from the edge of the estuary at its closest point.

b Provide a scenic and landscaped entry to both the development and East Busselton.

c Provide adequate land area for waterways and residential lots necessary to make the project financially viable.

The location of the waterfowl study and visitor centre has been selected to provide appropriately controlled access to the portion of the conservation area which is most heavily used by waterfowl, and to provide an entry statement to the development.

3.3 PROJECT COMPONENTS

The major components of the project (Figure 1.2) are:

a Harbour entrance and beach incorporating two breakwaters adjacent to the entrance and two smaller groynes to the east for foreshore protection and sand trapping.

b Beachfront and harbour-entrance holiday accommodation, incorporating a 120-room beachfront resort and a 250-room international hotel.

c A main harbour incorporating:

- o 210 mooring pens for pleasure craft,
- o 18 mooring pens for fishing boats,
- o power and water to selected mooring pens,
- o fuelling jetty,
- o boat maintenance and repair facilities,
- o a sewered sullage-pumpout facility,
- o security fencing and lighting as necessary,
- o fire fighting facilities.

d A village centre surrounding the main harbour incorporating:

- o promenade apartments and town houses,
- o public tavern and restaurants,
- o commercial and retail complex,
- o administration and community centre,
- o yacht clubs,
- o amphitheatre and square.

e A public boat-launching facility incorporating two boat ramps and a 120-bay trailer parking area.

f Waterway residential subdivisions and islands incorporating:

- o apartment housing and associated small group marinas,
- o waterfront and ordinary residential blocks.

g Normal dry land subdivision on the west side of the harbour.

h Public open space incorporating gardens, squares and artificial wetlands plus parking areas throughout the development as required.

i Chalet and retirement village located to the east of the village centre.

The total number of dwelling units proposed is as follows:

Waterfront and land-based residential lots	538
Group dwelling units	168
Chalet and retirement units	100
Apartments	300
Total	**1106**

The total number of moorings pens proposed is as follows:

Main Harbour	210
Group dwelling marinas	198
Fishermen's wharf	18
Private jetties (assume 60% of waterfront blocks)	70
Total	**496**

3.4 PUBLIC ACCESS

3.4.1 Present Status

Geographe Bay Road which runs along the coastline, was washed out at the site boundary several years ago. A bypass road (Layman Road) was constructed inland, running through the proposed development site.

Access to the coastline in the immediate vicinity of the development site is by pedestrian access from the Guerin Street groyne to the west and from the point of the wash-away of the coast road to the east. The erosion of the coastline in this area has removed the reserve land on the north side of Geographe Bay Road and the sea has subsequently encroached onto private land.

3.4.2 Pedestrian Access

The presence of the harbour entrance channel will interrupt public access along the foreshore. The development incorporates public pedestrian thoroughfares and pedestrian bridges over the waterways which provide continuous but indirect access along the foreshore. The bridges will be elevated sufficiently to allow the passage of yachts and provide a scenic view of the development.

Public access ways and areas of Public Open Space are also incorporated throughout the residential subdivision surrounding the waterways. The beachfront will be reserved as Public Open Space and be accessible to the public. Promenades and boardwalks with strong activity themes will be a feature of the harbour and village centre.

3.4.3 External Access

The existing and proposed road system is shown on Figure 3.1. The existing system is basically linear in form and parallels the coast and the estuary. Access to the site is via Layman Road and Geographe Bay Road. The proposed Port Geographe road network integrates the existing coastal grid system and produces a sweeping collector road around the entire development. This collector road will be Layman Road realigned as shown on Figure 3.1. Lower-order roads branching from Layman Road will form the local hierarchy within the development.

Layman Road will eventually provide the main arterial link westward back to the town and Bussell Highway, as well as a scenic drive to the east returning to Bussell Highway.

The internal road system proposed for the development features collector roads providing circulation for the public activity areas together with loop roads, collector roads and cul de sacs providing access to the residential subdivisions.

GEOGRAPHE BAY

VASSE ESTUARY

GEOGRAPHE

MARINE

BAY

ROAD

TERRACE

Recreation

ROAD

FORD

PEEL

TERRACE

STREET

WEST

BAKER OFFICE

CAVES WAY ROAD

BIGGE STREET

STIRLING STREET

BUSSELL HIGHWAY

Busselton Beach Resort

ESTUARY VIEW DR

WEBSTER ROAD

BALLARAT ROAD

LOCKVILLE ROAD

LAYMAN ROAD

Sand Quarry

SARATOGA DRIVE

CRESCENT

INLET DRIVE

CHAPMAN

SABINA RIVER

PORT GEOGRAPHE

EXISTING & PROPOSED ROAD SYSTEM

PLAN No.85/7/13

DATE July 1988

SCALE 1:20000

FIG. 3.1

RUSSELL TAYLOR and WILLIAM BURRELL Consultants in Town Planning and Civic Design 187 Roberts Road Subiaco Phone : 382 2911

3.5 DEVELOPMENT SEQUENCE

The proposed sequence of development will be:

i Relocate Layman Road thereby establishing the boundary of the development and allowing the waterfowl conservation area to be established early in the programme.

ii Stabilize the coastline by construction of the groynes and breakwaters, thereby allowing the natural and constructed build-up of the beach front to take place.

iii Excavate and construct the main harbour.

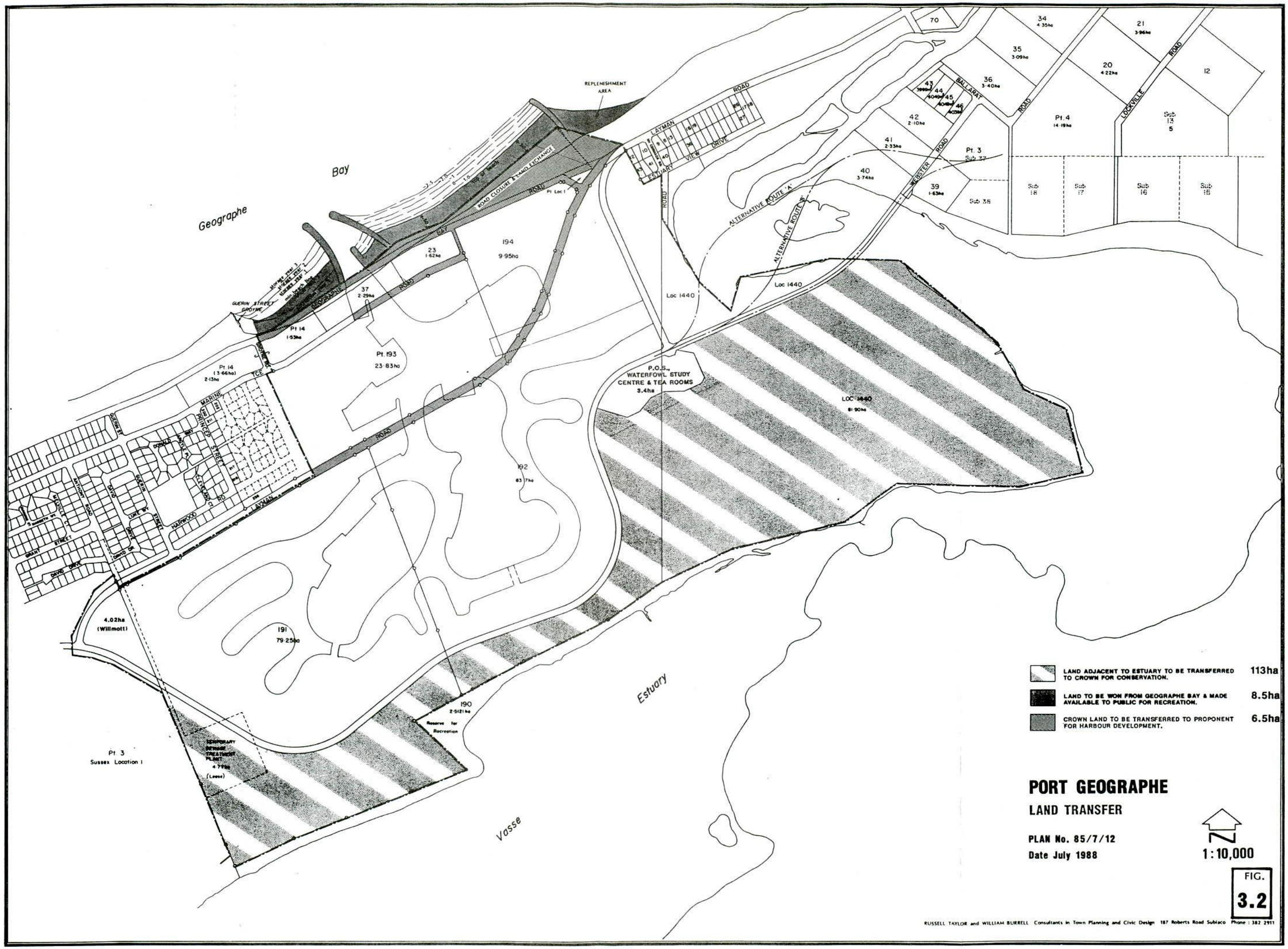
iv Progressively establish the village centre, the marina and its associated activities and the tourist resorts

v Progressively develop and service waterway residential lots to keep ahead of the demand for properties. The development of single residential and apartment properties, with and without water frontage will follow the growth of the village centre and tourist facilities. Development will spread in a well-planned orderly manner away from the harbour, progressively south and finally to the south west.

3.6 LAND EXCHANGES AND EQUITY TRANSFER

The Land Transfer Plan (Figure 3.2) shows the land to be created in Geographe Bay and those areas to be exchanged between private and public custodians.

It is intended that the harbour and waterways (44.4ha) be vested in the Crown.



PORT GEOGRAPHE

LAND TRANSFER

PLAN No. 85/7/12

Date July 1988

N

1:10,000

FIG. **3.2**

RUSSELL TAYLOR and WILLIAM BURRELL Consultants in Town Planning and Civic Design 187 Roberts Road Subiaco Phone : 382 2911

The area of beach and foreshore land to be reclaimed from the ocean has been determined by the need to guarantee a stable 50m, width foreshore which may erode under extreme conditions, but will be quickly replaced. Groynes have been designed to secure this result. The foreshore reserve which should have a minimum seasonal width of 50m has been shown on the Property Plan as 8.5ha approximately. There would be more beach out to the low-water mark and at times of seasonal accretion.

Building setbacks for the various residential (waterfront) precincts will be agreed with Council at the time of detail planning.

The waterfowl conservation area (113ha) currently owned by the Proponent will be transferred to the Crown and vested in CALM for conservation purposes.

Roads to be closed will be replaced with other public roads and have therefore been added into the project area. These, together with the key foreshore areas within the village, have been nominated for transfer to the proponent free of cost with consideration for the above lands.

The Proponent's land holding (300ha) may be broken up into a number of specific land use precincts as follows:

	Area in Hectares
PRECINCT 1 - WATER AREA	
o Harbour and marina north of the pedestrian bridges	19.1
o Waterways and canals south of the pedestrian bridges	25.2
Total Water Area	**44.4**
PRECINCT 2 - LAND AREA	
o The village centre, hotel, motel and apartments	29.1
o The chalet and retirement village east of the village centre	11.1
o Dryland subdivision and waterfront apartments on the western side of the harbour, including local open space	14.8
o The canal estate south of the existing Layman Road alignment and south of the village centre including local open space	68.7
o Conservation area	113.0
o Freshwater lake inside the estate and the alignment of new Layman Road	5.3
o Layman Road and its landscaping provision (5 metres)	9.2
o Local shopping and restaurant	1.2
o Waterfowl study centre	1.0
o Marina lease area	2.2
Total Land Area	**255.6**
TOTAL PROJECT AREA - WATER AND LAND	**300.00**
PERCENTAGE WATER	**14.8%**

3.7 CONSTRUCTION DETAILS

3.7.1 Design Criteria - Engineering Risk Assessment

3.7.1.1 Storm Surge

Cyclone Alby (April 1978) produced the highest water levels ever recorded at Busselton and Bunbury. Bunbury has good tide recordings going back over 30 years. Consequently, the water level associated with Cyclone Alby has become the accepted yardstick for design water levels associated with storm surge for any foreshore development.

The measurement of storm surge at tidal gauges normally occurs seaward of where waves break. Breaking waves tend to push water ahead of them and this causes a local increase in water level close to the shore. This is normally referred to as "wave setup". Wave setup is added to the storm surge to calculate design criteria for foreshore developments.

The maximum recorded water level at Busselton during Cyclone Alby was +1.71m AHD. The breaking wave height offshore from Port Geographe was about 3m. The water level increase due to wave setup is approximately 10% of the breaking wave height giving a wave setup of 0.3m.

The maximum water level at the shoreline would therefore be 2.0m AHD. A further allowance needs to be made for wave run-up on the beaches. This is of the order of 0.5m. This means that buildings near the shoreline need to be set at no less than 2.5m AHD.

3.7.1.2 Flood Control

The Port Geographe development is situated between the ocean waters of Geographe Bay and floodplains of the Vasse Estuary. Flooding of the site can occur from the ocean or the estuary. Flooding by the ocean is described above. The possibility of flooding from the Vasse and Wonnerup Estuary systems is discussed below.

A full description of the Vasse and Wonnerup Estuaries and their respective floodplains can be found in the Busselton Regional Flood Study carried out by the Water Authority of Western Australia (WAWA, 1987). This report describes the rather complex system of natural and artificial waterways which has evolved over the years in the Busselton region.

The computed maximum water levels in the Vasse and Wonnerup Estuaries for the 25 and 100-year floods are 1.25m AHD and 1.35m AHD respectively. Layman Road, which marks the border of the Vasse and Wonnerup Estuaries, has an average road level of about RL 1.10m AHD. The estuary system becomes a single body of water during the 25 and 100-year floods. It is believed that water in the Wonnerup Estuary would rise more quickly than water in the Vasse Estuary. Hence water from Wonnerup Estuary would flow across Layman Road during the period prior to the estuary system reaching its maximum water level.

Adequate flood protection may be afforded to the Port Geographe development by observing a minimum building floor level of RL 1.85m AHD.

In the event that either of the Vasse or Wonnerup floodgates should be blocked or closed during the one in 100-year flood, the estuarine flood level would still be only RL 1.50 metres AHD and so minimum recommended floor levels would still have 350mm clearance to the water line.

3.7.1.3 Sea Level Rise (Greenhouse Effect)

A special ministerial committee has been formed in Western Australia to develop options to deal with the greenhouse effect. A statement recently released by this committee predicts that southwest Western Australia could suffer more frequent and intense cyclones and more coastal erosion due to unusual tides and perhaps a rise in sea level.

The issue of rising sea levels is attracting increasing attention both in technical literature and more particularly in the popular press. Estimates of the magnitude and effects of any rise have ranged from alarmist to dismissive.

Considerable research is now underway to refine predictions of the relative changes that are occurring to mean sea level. However it will probably be many years before sufficient data is available to make confident predictions.

In the meantime, the issue has to be considered in the planning of all coastal projects. Appendix 1, which is based on a survey of published information on sea level rise, examines the factors involved and it summarises the present state of knowledge. The general conclusion is that there will probably be a small global rise in sea level. For any particular site, the rise will probably be less than the changes that are occurring locally as a result of tectonic movements and isostatic rebound. The best estimate is that the rise over the next forty years will be from 70mm to 180mm and from 180mm to 450mm over the next century.

Allowance for a rise of 300mm in addition to all other factors (such as storm surge and flooding) has therefore been adopted for this development.

If a higher rise were to occur, it would be possible to build up the land around the water line. If the level is made too high now, especially near berths and wharfs, they become awkward to use for the foreseeable future. An allowance of 300mm appears to be a practical compromise.

3.7.1.4 Project Levels

Port Geographe will be constructed to a floor level of +2.8m AHD. The proposed development will therefore be higher than Busselton, most of which is built on land which is only 2-2.5m AHD above present sea level.

3.7.2 Foundation and Fill Material

3.7.2.1 Soil Stratigraphy

Information on the soil stratigraphy of the project area is available from two sources. One is a study conducted by LSC in 1983 and presented as Appendix 2. The other is a survey by the Geological Survey on the radiation hazards in the vicinity of the project site.

a LSC Data

A series of 12 boreholes and some 17 shallow pits were sunk as part of the stratigraphy investigation which formed part of the Notice of Intent for the Port Geographe Development submitted by John Holland Constructions in March 1985.

A typical cross-section through the site (Figure 3.3) shows the following sequence:

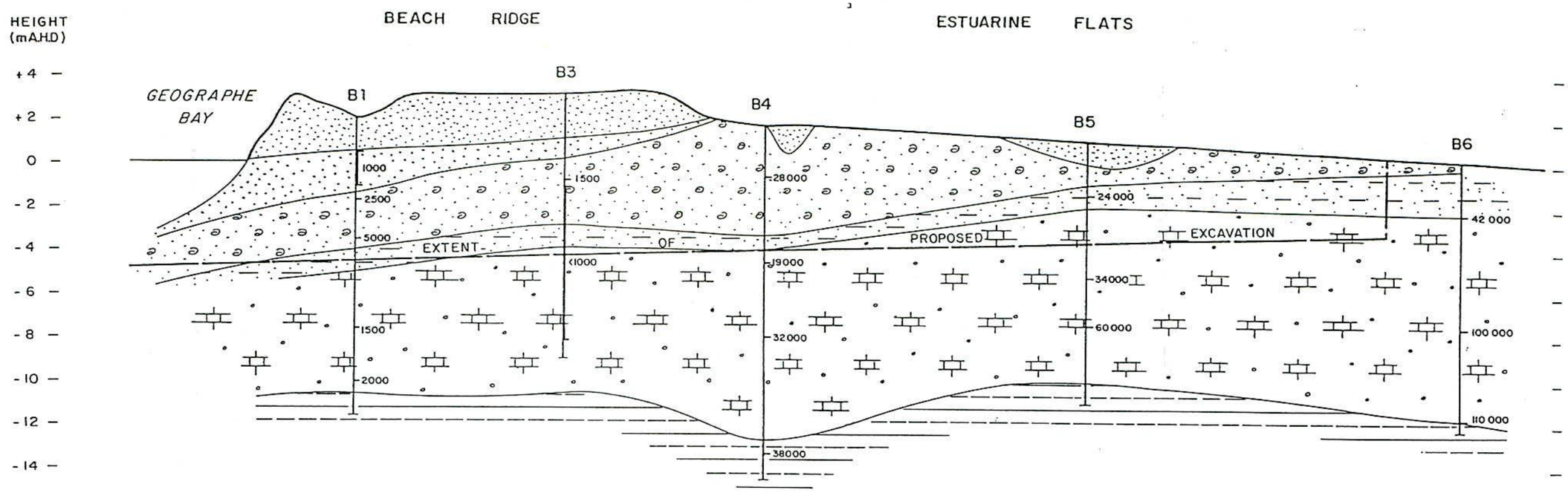
- o dune sands,
- o beach sand,
- o seagrass bank sand (Becher sand),
- o estuarine muddy sand,
- o sand with some limestone layers,
- o muddy sand.

b Geological Survey Data

In 1986, the Geological Survey prepared Environmental Review Report EV 36 which included a survey of the possible radiation hazards associated with the Port Geographe Development.

NORTH

SOUTH



LEGEND

- DUNE SANDS (Quartz sand – fine to medium grained)
- BEACH SAND (Quartz sand – medium to coarse grained)
- SEAGRASS BANK SAND (Shelly quartz sand)
- ESTUARINE MUDDY SAND (Muddy sand)
- SAND WITH SOME LIMESTONE LAYERS (Sand, coarse, irregularly cemented to limestone)
- MUDDY SAND (Mud)

42000 Approx. groundwater salinity (mg/l TDS)

0 100 200m

Horizontal scale 1:4000
(20 x vertical exaggeration)

PORT GEOGRAPHE
DIAGRAMMATIC CROSS SECTION

FIG. 3.3

As part of this investigation a series of 55 boreholes were sunk in the area of the proposed development to a depth of 9m in the dune areas and 6m on the estuarine flats. Some holes were terminated before reaching the target depths because hard limestone layers were encountered.

An inspection of the borelogs from these 55 boreholes reveals a similar pattern of stratigraphy to that reported by LSC, except that some lenses of clay and sandy clay were encountered above RL -3.0m AHD, which would be in the zone for excavation of the waterways. These small lenses of clay and silty clay are not widespread and would not cause a problem with development.

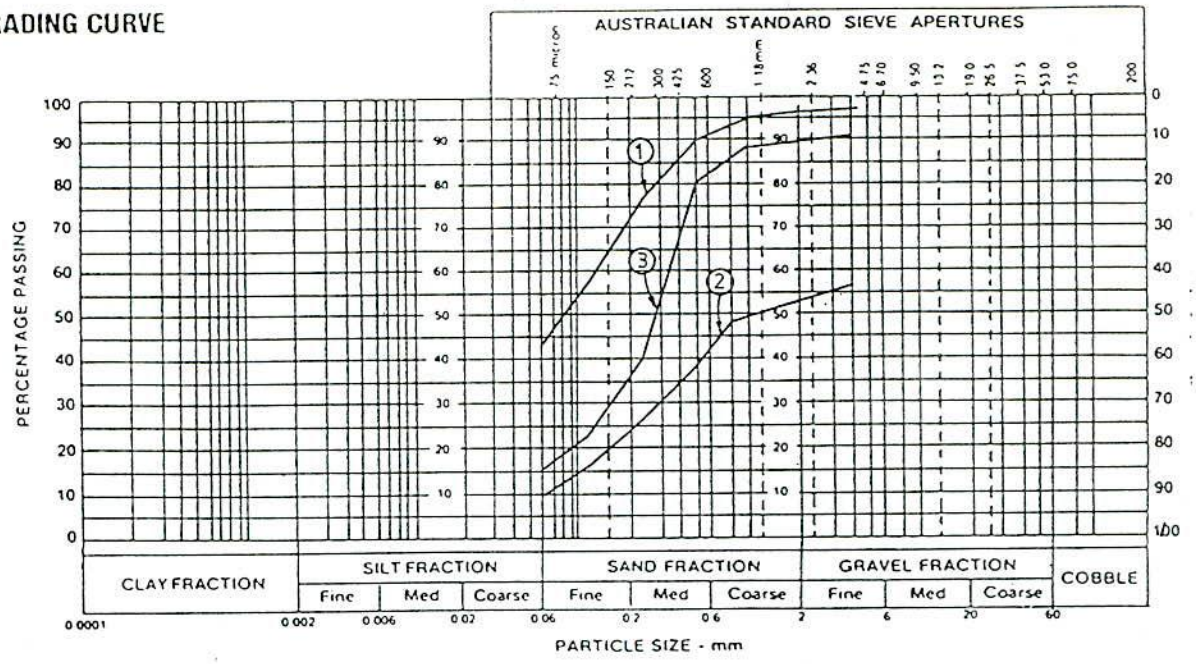
3.7.2.2 Grading Analysis

Grading analyses assessing suitability of material as fill for residential and commercial development have been performed on three samples (Figure 3.4). Two of the samples are of the most unsuitable foundation material likely to be encountered during excavations. Sample 1 was taken from a depth horizon of between 1m and 2m on LSC borehole No. 9 which had been classified as muddy sand. The grading analysis indicates that approximately 55% of the material is within the sand fraction with approximately 45% being mainly silt and possibly a small fraction of clay. The engineering classification for this material is silty sand, which is acceptable as fill.

The second sample was taken from LSC borehole No. 9 at a depth horizon of between 2m and 3m and was originally classified as sand with some limestone present and possibly some shell fragments. The grading analysis indicates that some 91% of the material is within the sand fraction and less than 9% within the coarse silt fraction and therefore the engineering classification for this material is sand. This sediment will make excellent fill material.

The third sample was taken from LSC borehole No. 10 at a depth of approximately 5m. This material was originally classified as muddy sand. The grading analysis indicates that approximately 85% of the material is within the sand fraction with less than 15% within the coarse silt fraction and hence the engineering classification for this material is sand. This material also will make excellent fill material.

GRADING CURVE



SAMPLE 1. BOREHOLE NO. 9 - DEPTH 1M TO 2M

SAMPLE 2. BOREHOLE NO. 9 - DEPTH 2M TO 3M

SAMPLE 3. BOREHOLE NO. 10 - DEPTH 5M

PORT GEOGRAPHE
GRADING ANALYSIS
MUDDY SANDS

FIG. **3.4**

3.7.2.3 Conclusions

It is expected that, in general, the soil will be perfectly amenable to excavation and filling operations and form sound foundation conditions for low-rise buildings. When lenses of silt and clay are encountered during the excavation, these will be mixed with coarser underlaying sediments to improve their suitability for use as foundation material.

There are substantial quantities of clean marine-derived sediments on the project site, particularly on the coastal dunes, which are available and ideal for use in beach replenishment areas.

It is therefore anticipated that all fill material for the project will come from the site.

3.7.3 Materials Balance

As the project is designed to have a balance of cut to fill, there will be no waste. The waterways can be excavated to acceptable deeper levels if detailed design establishes that more fill is required.

a Beach Sand

The sand required to extend the beach back to the original coastline (prior to the erosion attributed to the Guerin Street groyne) on the east side of the harbour entrance will come from the levelling of the sand dunes and excavation of the harbour and its associated waterways. This will also be the source for sand required to renourish the beaches to the east of the easternmost groyne of the project for the first five years.

b Limestone Rock

The limestone or similar rock required for the breakwaters will have to be transported to the site. Final sizes and quantities will be more clearly defined in the detailed design of the breakwaters, however there will be approximately 140,000 tonnes in total.

The source of limestone rock has not yet been finalised but discussions are proceeding with Westralian Sands at Capel.

3.7.4 Major Civil Works

3.7.4.1 Breakwaters and Groynes

The proposed development at Port Geographe includes two limestone (or similar rock) breakwaters and two limestone (or similar rock) groynes extending into Geographe Bay and one limestone (or similar) groyne within the harbour entrance (Figure 1.2).

The project will utilise the existing Guerin Street groyne as part of the overall coastal protection works. The longest of the breakwaters extends 270m into the ocean. The purpose of the breakwaters and groynes is to:

- stabilise the beaches adjacent to the development;
- provide storage as a sand trap for material which will be mechanically bypassed to the downdrift (eastern) beaches periodically;
- provide safe boating access to the harbour and waterways from the ocean;
- contain the energy-spending beaches located at the harbour entrance.

The entrance breakwaters and beach stabilisation groynes will be formed by placing some 50,000 tonnes of limestone or similar armour and 90,000 tonnes of limestone core.

The breakwaters provide both a protected entrance channel for navigation purposes and a means for trapping littoral sand drift, thereby assisting in the maintenance of navigable depths. The groynes are designed to retain an adequate beach buffer zone in front of the development.

Construction of the breakwaters and groynes can proceed in conjunction with harbour excavation works but will be substantially complete before entrance channel dredging or beach renourishment works are commenced.

The construction of breakwaters and groynes can be accomplished over a period of four to six months. In order to minimise disruption to beach users and to avoid the productive period of seagrass growth, construction will be scheduled to commence after March if possible.

3.7.4.2 Dredging/Landfill/Beach Renourishment

It is proposed to excavate the harbour and waterways to depths varying from RL -4.3m AHD at the entrance and in the harbour to RL-2.7m AHD in the secondary waterways.

Excavation of the harbour and waterways will be accomplished using conventional land-based earthmoving equipment wherever possible . The entrance channel will be excavated by floating cutter-suction dredge and this operation will not commence until such time as excavation of the harbour is complete. Excavation of the waterways will take place progressively as demand requires.

The excavation and dredging operation will generate approximately 2,600,000 cubic metres of spoil. Of this volume, 150,000 cubic metres will be placed on the beach to the east of the easternmost groyne to prevent scouring over the intervening years prior to bypass dredging. A further 500,000 cubic metres will be used to renourish the beaches between the entrance channel and the groynes to the east and west of the channel, and the balance will be used to fill and contour the entire development area. The ocean beaches will be constructed to have similar slope configuration to those naturally occurring at present.

This operation will run in conjunction with breakwater and groyne construction and with harbour wall construction. Prior to completion of the entrance channel excavation, banks around the perimeter of the harbour and waterways excavation will be constructed to a sufficient level to ensure that estuary waters are not contaminated with sea water in the event of storm surges.

Dredging and excavation operations will continue over a period of 24 months, but will not be continuous. During this period, it will at times be necessary to undertake dewatering operations when excavating using conventional land based earthmoving equipment. Dewatering would be localised to the sections being worked on to reduce the volume required. This technique is not only more economic in terms of dewatering costs but also reduces the area affected by drawdown of the water table.

3.7.4.3 Harbour Walls

Harbour and Waterway walling will be constructed using either stone pitching or flexmats on battered sideslopes in the harbour and entrance channel and precast reinforced concrete walling units in the waterways.

Tests on the sand will be undertaken to determine slope stability prior to commencement of construction and finalisation of design. The results of these tests will determine permissible sideslopes, size of stones or flexmat necessary, and height of precast concrete wall units.

Where vertical walling is not used, access to temporarily-moored craft and pedestrian access along the waters edge can still be maintained by a piled boardwalk structure over the stone pitched embankment.

More detailed site investigation is required to estimate the cost of excavation, and the optimum configuration of wall and anchors (if necessary).

3.7.4.4 Jetties and Berthing Facilities

A number of design options will be considered for jetties and berthing facilities. It is understood and accepted that all documentation associated with these structures must be approved by the Department of Marine and Harbours.

The Port Geographe development will ultimately provide berths for up to 500 vessels. Jetties and pens will be of the floating or fixed type. Floating pens will comprise Glass Reinforced Concrete (GRC) or PVC styrene-filled cell units held in place by driven piles. Guide rollers will facilitate vertical movement with the tide. Fixed jetties, pens and walkways will be constructed using either steel or precast concrete piles and timber or prestressed concrete decking. Fixed pens will also incorporate driven mooring piles. All structures will be designed and licensed in accordance with the requirements of the Department of Marine and Harbours.

It is not anticipated that all of the berths will be required from the outset. Hence provision of these facilities will be staged to meet demand.

3.7.5 Auxiliary Services

3.7.5.1 Water Supply

Discussions have taken place with the Busselton Water Board in regard to the provision of potable water supply to the development for domestic purposes.

The proposed development extends beyond the present boundaries of the Water Board's licensed area and therefore this area will require extending. The Busselton Water Board have indicated that it is technically quite feasible to supply water to the development and that they are willing to apply to the Minister for Water Resources for the appropriate extension to the current boundary.

3.7.5.2 Sewerage

The project will be deep sewered throughout. Investigations into sewerage requirements have been conducted and a report is presented in Appendix 3.

There is no impediment from the point of view of sewerage reticulation to the development of the Port Geographe project. The construction of a new sewage pumping station and rising main into central Busselton will be required. The funding of this pumping station and rising main will be a matter of negotiation between the Proponent and the Water Authority and may require some initial funding by the Proponent.

3.7.5.3 Electricity

Discussions have taken place with the State Energy Commission (SEC) at both Margaret River and Bunbury. The SEC report no problems associated with the supply of power to the Port Geographe Development providing the development takes place in a progressive, orderly fashion during the next five years, as proposed by the Proponent.

It is the intention of the Proponent to use underground power reticulation for the proposed development and therefore the Proponent will be responsible for making a contribution to the capital cost of the underground reticulation in the normal manner for residential subdivisions.

3.7.5.4 Roads

The quality of the road system will be similar to or better than normal subdivisional roads within the Busselton township. Roads generally will be constructed of flexible pavements and asphalt seal to the specification and approval of the Local Authority. Generally, all roads will be curbed with extruded concrete kerbs and road widths will be to the approval of the Local Authority.

Layman Road will be constructed as a dual 7.0m wide carriageway around the southern and western edges of the development. Elsewhere, Layman Road will be constructed as a single 9.0m wide carriageway.

3.7.5.5 Stormwater Drainage

Stormwater drainage will be collected from the road system via road gullies and a piped drainage system which will discharge to the waterway system in various locations. It is expected that there will be a number of discharge openings through the waterway walls to evenly spread the fresh water discharge from the road system to the waterway system.

Surface runoff from Layman Road will be drained back through a filter system into the waterways.

The invert of the pipe discharge points will be just below RL 0 so that there will be minimum visibility of these outlets, whilst at the same time the available grade within the pipe system will be maximised.

Two separate trapping systems will be used within the drainage system to minimise the discharge of debris and oil contamination to the waterway system.

a Gullies

The downstream gully of each pair of gullies on the roadway system will be trapped. The lighter debris together with oil slicks will rise above the level of the outlet from the gully and may be regularly cleaned especially in the initial stages of development. Debris such as sand will sink to the bottom of the gullies, and again will be removed by regular maintenance.

b Downstream Manholes

The downstream manhole on each drainage subcatchment area will also be trapped by means of a suitably placed baffle to further reduce the likelihood of any foreign materials which may have bypassed the first gully trap entering the final discharge pipe to the waterway.

Manholes and gullies will generally be of the precast-concrete pipe-section type fitted with concrete covers or trafficable cast iron covers if located within trafficable areas.

3.8 OPERATION DETAILS

The project will be operated and maintained in accordance with guidelines established by a series of Management Programmes which are detailed in Section 6 of this document.

In summary, four management programmes are proposed as follows:

- Port Geographe Management Programme aimed at ensuring acceptable water quality, serviceability of all infrastructure and facilities, and minimisation of inconvenience to residents of Busselton during construction phase;
- Coastal Management Programme aimed at ensuring local and adjacent coastal stability;
- Waterfowl Conservation Plan aimed at safeguarding the waterfowl conservation values of estuary;
- Estuary Management Programme aimed at understanding estuary hydrodynamics and, in particular, potential nuisance events such as algal blooms, insect pests, and fish kills.

4.0 EXISTING ENVIRONMENT

4.1 INTRODUCTION

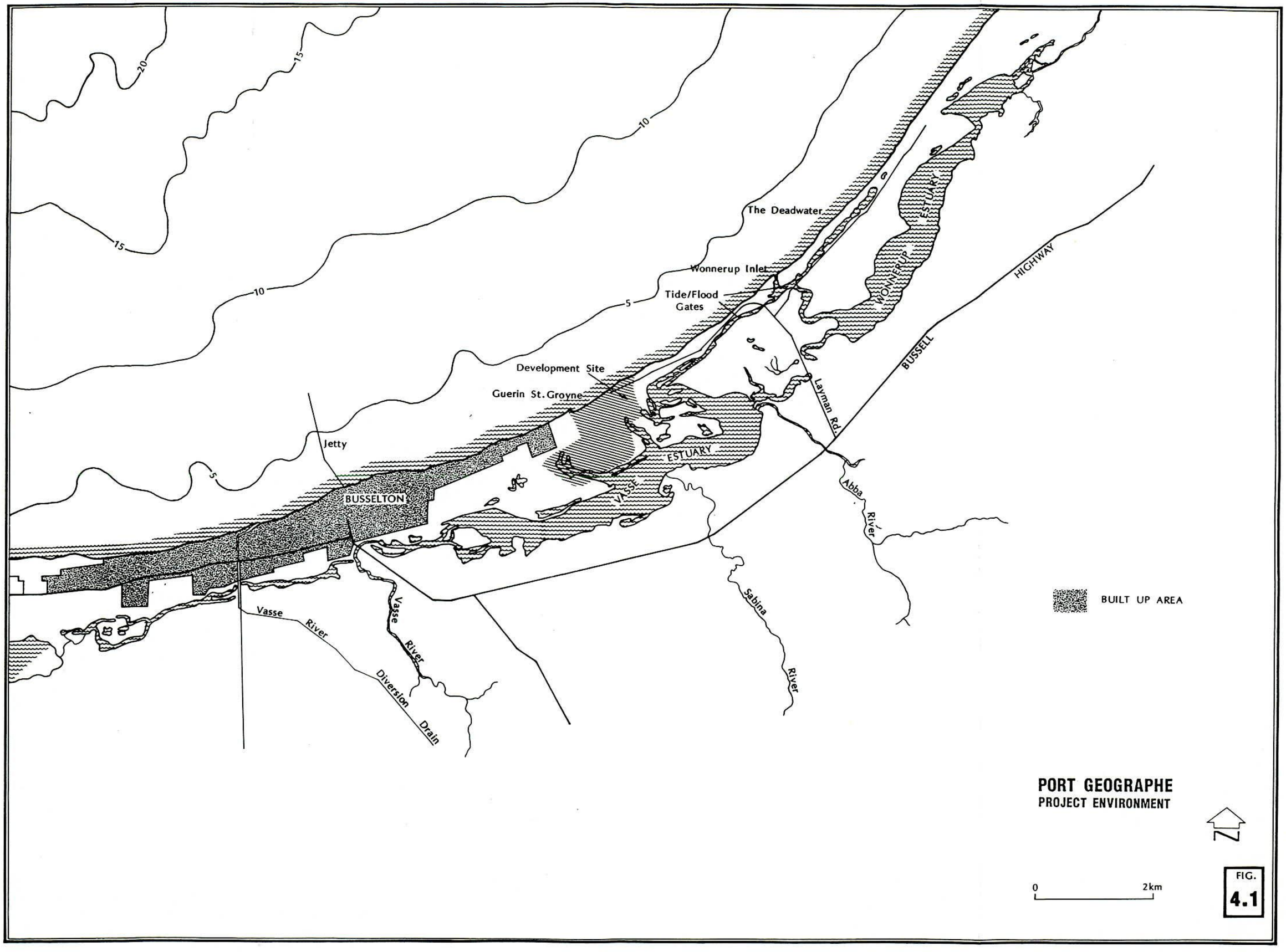
The Port Geographe development site is located on the coastline of Geographe Bay, some 4km east of Busselton (Figure 4.1). The site is bounded by Geographe Bay to the north, the Vasse Estuary and associated wetlands to the south and east, and grazing land and the residential development of Busselton to the west. At a local scale, the project therefore includes and will affect marine, terrestrial (beach and beachridge dune systems), wetland and estuarine environments.

The following description of the physical, biological and social environment details the local environment (the project site and adjacent land) and places the project in the context of the regional environment. The regional environment incorporates Geographe Bay, the beachridge dunes of the Geographe Bay coast and the Vasse-Wonnerup Estuarine system (Figure 4.1). The human environment of the development has been defined for the purposes of the ERMP, as the Vasse Region (ie Busselton and Augusta-Margaret River Shires) although it is acknowledged that visitors to the region from Perth and other areas of Western Australia, interstate and overseas will utilise the facilities. The project is, therefore, discussed on a broader (State) level when appropriate.

The following description is based largely on a review of available information. Additional field data were obtained specifically on the use of the Vasse Estuary wetlands by waterfowl in order to provide sufficient detail to allow assessment of the environmental impacts of the project.

4.2 AVAILABLE INFORMATION

A number of papers and other documents have been written on the physical environment of Geographe Bay. Searle and Semeniuk (1985), in their classification of the inner Rottnest Shelf coast, described the coastal processes and geomorphology of the bay. Searle (1977) documented the morphology and features of the embayment, and Paul and Searle (1978) further discussed the sedimentary processes occurring in the bay. DMH (1988) investigated coastal processes at the project site and placed the processes into a regional perspective. The onshore coastal stratigraphy and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15
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The Deadwater
Wonnerup Inlet
Tide/Flood Gates
WONNERUP ESTUARY
HIGHWAY
BUSSELL
Development Site
Guerin St. Groyne
Layman Rd.
Jetty
ESTUARY
VASSE
BUSSELTON
Abba River
Vasse River
Vasse River
Diversion Drain
Sabina River
BUILT UP AREA
PORT GEOGRAPHE
PROJECT ENVIRONMENT
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2km
FIG.
4.1

hydrology were documented by LSC (JHC, 1985) during the preparation of the NOI for this project (Appendix 2). The WA Department of Mines, investigated the mineral potential of the project area (Geological Survey 1986).

The biological components of the area have also been described in various papers and reports. In the marine environment, Searle (1977) documented seagrass distribution in the bay and correlated vegetative and, to a lesser extent, faunal assemblages with substrate types. Walker (1979) compiled an inventory of fish occurring in the Bunbury-Port Geographe area. Scott (1981) sampled the fish fauna associated with seagrass in Geographe Bay. Lenanton (1982) undertook a study of fish habitats of southwestern Australia and discussed the ecological significance of Geographe Bay as a fish nursery. Heald (1977) conducted a survey for Pecten scallops which involved sampling the benthic fauna, but sampling was undertaken primarily around the western end of the bay near Cape Naturaliste and in deep water.

A desk study of the marine and terrestrial fauna of the area was undertaken by Bunbury (1987) as part of the preparation of the Leeuwin-Naturaliste Region Plan. Bunbury compiled a species list of echinoderms for the area from Western Australian Museum records and summarised fish studies to date. For the terrestrial environment, Bunbury (1987) has compiled a list of species of mammals and reptiles for the region and Ninox (Appendix 4) has collected information related specifically to the study area.

The avifauna, particularly that using the Vasse-Wonnerup estuarine system, has been studied more extensively. Bunbury (1987) reported work by Jaensch (in prep) on waterbird species diversity and waterbird use of the system and on surveys conducted by the Royal Australasian Ornithologists Union (RAOU) between 1981 and 1986. A number of field surveys of waterbird usage of the project area have been conducted for this ERMP by Ninox Wildlife Consultants (Appendix 4).

Recently, a survey and mapping project (at 1:10,000 scale) was undertaken to map the flora and vegetation of the Leeuwin-Naturaliste Region (Keating and Trudgen, 1987). The EPA (is at present preparing a report on a study of the water quality of the rivers flowing into the Vasse-Wonnerup estuaries.

The social environment of the region has been described as part of the SPC's planning study of the Leeuwin-Naturaliste region (SPC, 1987). Surveys and reports by a number of Government Departments and other organisations contributed data to the study. These studies included:

- An economic profile of the region (ACIL, 1987).
- Population projections and demographic profile (SPC, 1986).
- Agricultural assessment (Agriculture Department, 1986).
- Mineral potential (Mines Department, 1986).
- Fisheries potential (Fisheries Department, 1986).
- Evaluation of harbour sites and associated facilities in Geographe Bay (DMH, 1986).

In addition, surveys have been carried out for specific purposes, largely related to tourism development and assessing the need for services and facilities in the southwest. The Western Australian Tourism Commission commissioned a Tourism Development Plan for the southwest region. Research included attitudinal surveys of Perth residents, visitors to the southwest and business operators, farmers and householders in the southwest and visitor (tourist) surveys (Western Australian Tourism Commission, 1986).

The South-West Development Authority carried out a Community Needs Study for Bunbury and the southwest region (Wilson Sayer Core, 1985) and developed a map catalogue of community resources by local authority area (Wilson Sayer Core, 1986). On a more specific level, the Busselton Shire Council has engaged a planner to assess the specific needs of elderly residents of the Busselton region and data are available from a number of community forums (D. Pilpel, pers. comm.).

The WAWA has reviewed drainage works carried out in the Busselton region as part of the Busselton Regional Flood Plain Study which has resulted in floodplain management strategies for the area (Water Authority of Western Australia, 1987).

4.3 PHYSICAL ENVIRONMENT

4.3.1 Regional Setting

4.3.1.1 Climate

The following summary of the climate of the Busselton region is extracted from the Leeuwin-Naturaliste Region Plan (SPC, 1987):

"The study area has a 'Mediterranean' climate, winters being cool and wet, and summers being hot and dry. There are some variations in climate between coastal and inland areas, coastal areas being more moderate."

In winter the, "average daily temperature is about 15^{o}C. By contrast, the average summer temperature is about 22^{o}C, and the average daily maximum in summer is about 26^{o}C, peaking at about 28^{o}C in January and February. The highest and lowest temperatures recorded at Busselton have been 41.1^{o}C and -1.0^{o}C respectively."

"Rainfall is reliable and strongly seasonal, averaging 800 - 850mm annually, of which three quarters falls between May and September. Very little rain falls between December and March. Annual rainfall has been found to vary between 505mm and 1210mm at Busselton. Rainfall is affected by topography, particularly by the Cape Naturaliste land mass."

"Winds vary both with the seasons and during the day. During summer nights and mornings, winds generally arrive from the east and south at speeds of 10 to 25 kmph. In the afternoons and evenings, winds are frequently westerly and southwesterly at speeds of 20 to 55 kmph. During winter, storms generally occur every three to five days, initially bringing winds which shift southwest and south as the system passes. Winds from the northwest and west frequently reach 35 to 45 kmph while those from the southwest and south generally reach 30 to 50 kmph. Between such events relatively light and variable winds (less than 25 kmph) predominate."

"Occasionally during January to April decaying tropical cyclones travel south along the coast. These systems weaken as they move south but can still produce high winds, which may arrive from any direction. Three examples of these, which have been responsible for strong winds and/or extreme rainfall events, are 'Mavis' 1965, 'Alby' 1978 and 'Bruno' 1982. Winds are also affected by topography, particularly by the Cape Naturaliste land mass."

4.3.1.2 Oceanography

Tidal range at Busselton is about 0.5 metre with one low and one high tide occurring each day. Tides are almost identical to Bunbury for which 30 years' data and detailed predictions exist.

Sea conditions vary seasonally in Geographe Bay. Year-round southwesterly swell waves generated far out in the Indian Ocean (Silvester, 1974) are refracted around Cape Naturaliste and impinge on the entire arcuate north-facing shore of the embayment. However in winter, westerly wind waves and northerly storm waves are superimposed on the refracted southwest swells and impinge with variable impact on the shore. In summer, winds are less strong or prolonged and hence the waves generated are less significant and generally more quiescent sea states prevail.

The most significant current system is that occurring longshore, parallel to the bathymetric contours and in depths of up to 10m. This current is the product of the westerly wave systems.

Oceanographic processes which determine the onshore morphology of Geographe Bay are described in more detail in Section 4.3.1.5.

4.3.1.3 Geology

The sedimentary and geomorphic system of Geographe Bay geologically lies in the Bunbury Trough which is a fault-bound extension of the Perth Basin, bounded by the Leeuwin Block to the west and the Darling Scarp to the east. The coast of Geographe Bay is a southern extension of the Swan Coastal Plain, and hence the embayment is defined by the Leeuwin Block in the west and the gradual northerly alignment of the coastal plain as it changes from east-west to north-south orientation.

4.3.1.4 Drainage

The Busselton area is characterised by low-lying, flat topography, low coastal sand dunes and large shallow estuaries (Vasse-Wonnerup Estuaries). Up to the turn of the century, the Buayanyup, Vasse, Sabina, Abba, Ludlow and Capel Rivers all drained into the Vasse-Wonnerup Estuaries which in turn drained into the Indian Ocean through one or more natural outlets (WAWA, 1987). Flow in all the rivers is intermittent throughout much of the year. Due to the nature of the topography, large areas of the coastal plain constituted a floodplain. Flood protection levees, river diversions and drainage control structures constructed over the past 60 years have significantly altered the drainage system and the nature of the estuaries.

Drainage works began in 1907 to drain land required for a group settlement scheme and an extensive drainage scheme was undertaken in the 1920's. The Vasse River Diversion (Figure 4.1) drains approximately 90% of the Vasse River catchment and approximately 65% of the upper catchment of the Sabina River although water may still enter the Lower Vasse River through a 900mm diameter pipe that has been installed with a control gate at the junction of the river with the Vasse River Diversion. These works and levees, which prevent inundation of low-lying farmlands by all but the more extreme floods, provide a high degree of flood protection to Busselton residents (WAWA, 1987).

The Vasse-Wonnerup Estuaries discharge into Geographe Bay through a common channel (Figure 4.1). Floodgated structures constructed on the ocean outlet channels in the 1920's enable water levels in the estuaries to be controlled and provide a barrier to seawater intrusion, protecting low-lying pastures from salt contamination. Consequently, the waterbodies which develop during periods of river flow are now also largely fresh. The Vasse Estuary, although still referred to as an estuary, therefore functions as a freshwater impoundment rather than a true estuary. This management of salinity and water levels provides a freshwater breeding habitat for waterbirds. Water levels are maintained up to 0.40 metre AHD through the breeding season (WAWA, 1987).

4.3.1.5 Geomorphology and Coastal Processes

The coast of the inner Rottnest Shelf of Western Australia has been divided into five natural sectors by Searle and Semeniuk (1985). These sectors are distinguished by a unique combination of onshore and offshore geomorphology, coastal processes and Holocene sediment accumulations. Geographe Bay itself comprises the southernmost of the five sectors and is broadly characterised by a low, gently undulating hinterland plain, a narrow ribbon of low barrier dune ridges, long sandy beaches and a broad north-facing open embayment with a simple offshore bathymetry. The main marine and shoreline units in the region (Figure 4.2) are:

- embayment floor (submarine sand sheet);
- beach ridge (coastal barrier dunes) and beach system;
- estuarine systems;
- onshore aeolian hinterland.

Four distinct wave patterns determine the nearshore and offshore morphology of the bay. Long-wavelength westerly swell waves are refracted around Cape Naturaliste, as are nearshore westerly wind waves. Southwest breezes blowing across the bay generate a third wave pattern. Infrequently, storms develop a northwesterly wind wave pattern (Searle, 1977).

The distribution of wave energy along the coast is determined by the interaction of the shoaling swell with the seagrass meadow which colonises the sand sheet, shore transverse scours and nearshore bars. The end product is a gentle sinuosity in the shoreline (Searle, 1977; Searle and Semeniuk, 1985). The shoreline sediments are dynamic, with a strong net movement to the east and north.

Offshore, the embayment floor of Geographe Bay slopes gently north reaching depths of 10m, (Figure 4.1) some 4km offshore, where it joins the inner Rottnest Shelf. The bay floor is comprised of a sand sheet, largely vegetated by seagrass meadows, which extends from the beach to a distance of approximately 4km offshore. At depths greater than 12m, the sand sheet is generally thinner with discontinuous exposures of the underlying Pleistocene limestone as 1 - 3m high shore-parallel ridges.

Approximately 70% of the embayment floor is vegetated by seagrass meadows with the remaining 30% comprised of sand-floored scours, bars and shallow subtidal sandsheet (Searle, 1977) (Figure 4.2). The scours are oriented transverse to the shore and correspond with refracted swell wave orthogonals. They extend from nearshore to the seaward edge of the embayment sand sheet where they become discontinuous. Nearshore, elongate sand bars up to 3 metres in relief occur. These are oriented at a less than transverse angle to the shore. At their nearshore extremities, the shore-transverse scours meet with the nearshore sand bars.

The onshore morphology of Geographe Bay is the product of sedimentation and oceanographic processes. Onshore sediment accretion has resulted in the seaward migration of the shoreline and the successive accretion of Quindalup Dune System beach ridges and the eventual development of a 500 metre wide low beach ridge ribbon, peripheral to the shore and behind a sandy beach. The development of successive ridges significantly impeded drainage from the hinterland, resulting in the development of estuarine lagoons behind the beach ridge dune unit.

The estuarine system comprises several open water bodies including the Vasse-Wonnerup Estuaries and the Broadwater, which are surrounded by low flatlands only marginally above sea level. In the vicinity of the development site, the estuarine system varies between 0.5km and 1.5km in width and contains a series of broad open water areas interconnected by meandering channels and connected to Geographe Bay by long narrow channels which run between parallel dune ridges.

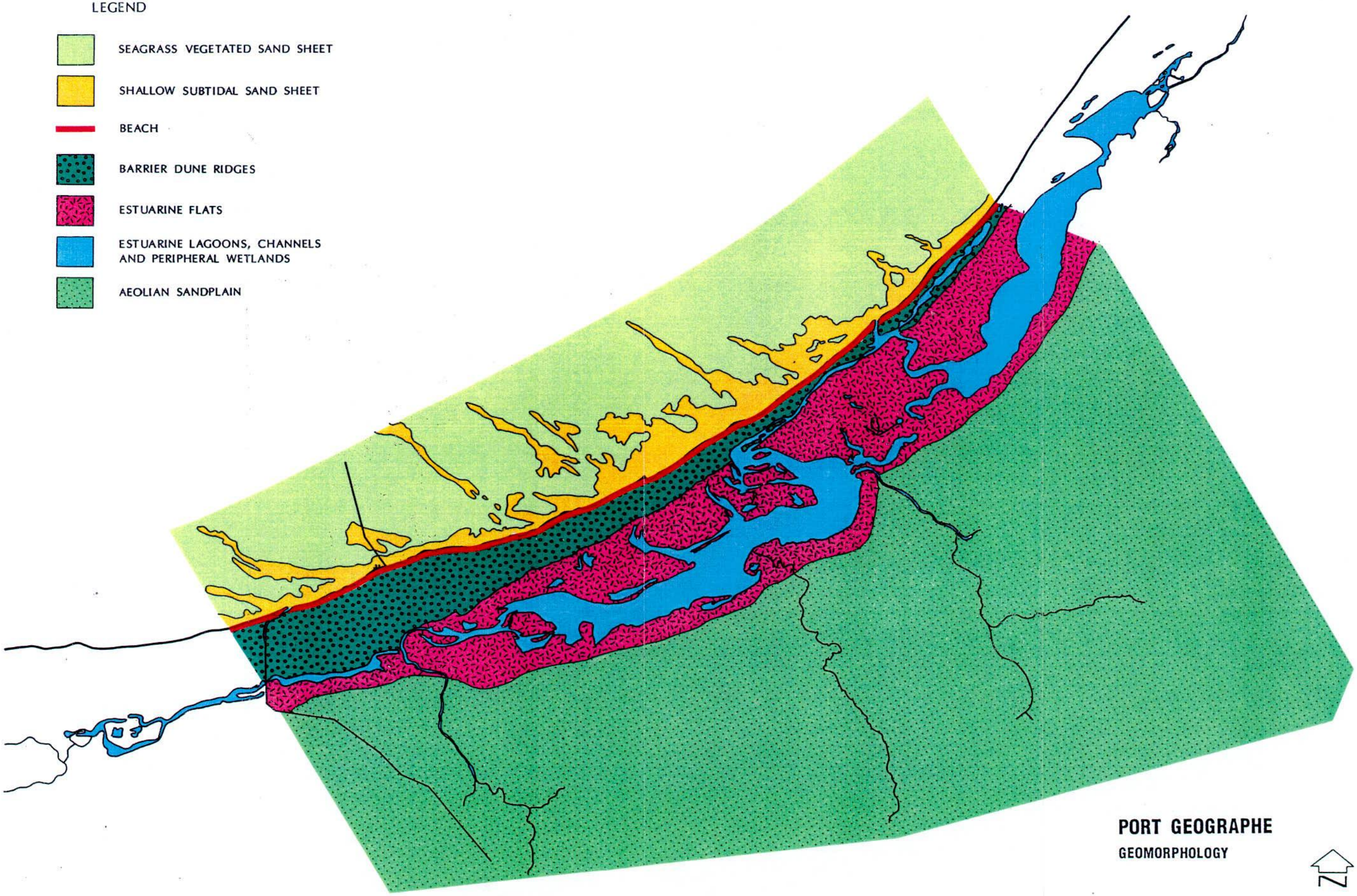
To the south, the estuarine system is bounded by the Yoongarillup Plain which, to the west of the Bussell Highway, comprises a low-lying and poorly-drained flat sand plain which is subject to seasonal inundation.

4.3.1.6 Geomorphic Units and Habitats

Within each of the regional-scale geomorphic units of the Geographe Bay coastal system (estuarine systems, beach ridge plain and submarine sand sheet), are smaller-scale geomorphic and other features which form habitats for the biological components of the environment. The smaller scale features of each of the major units are described below.

LEGEND

- SEAGRASS VEGETATED SAND SHEET
- SHALLOW SUBTIDAL SAND SHEET
- BEACH
- BARRIER DUNE RIDGES
- ESTUARINE FLATS
- ESTUARINE LAGOONS, CHANNELS AND PERIPHERAL WETLANDS
- AEOLIAN SANDPLAIN



PORT GEOGRAPHE

GEOMORPHOLOGY

N

0 2km

FIG. **4.2**

RUSSELL TAYLOR and WILLIAM BURRELL Consultants in Town Planning and Civic Design 167 Roberts Road Subiaco Phone : 382 2911

a Marine

The main nearshore geomorphic unit may be further divided into four medium-scale geomorphic units, a seagrass vegetated sand sheet, scours, nearshore sand lobes and bars, and beach unit (Searle, 1977). These are further described below:

i Seagrass Vegetated Sand Sheet

The seagrass meadow is an aquatic flora assemblage as well as a distinct geomorphic unit. The seagrass meadow develops a mat of rhizomes up to 30 cm thick in the substrate. The baffling effect of the seagrass leaves on incidental wave energy results in a micro-sedimentary sink (Searle, 1977) where the leaves create a low-energy environment in which sediment is deposited and then trapped within the rhizome mesh.

ii Scours

The shore-transverse linear scours are developed by the coalescing of adjacent small (metre scale) cuspate and linear scours. The merging of the smaller scours is due to the interaction, at different times, of wave and current action. The resultant shore-transverse scours are asymmetric in cross-section, with an undercut cliff up to 60cm high along the southwest edge and a rippled floor that slopes upwards to the northeast edge of a scour (Searle, 1977). The scours actually migrate towards the southwest by the continuous undercutting of the cliff face and re-deposition of the excavated sand on the opposite (northeast) edge of the scour (Searle, 1977). Hence, the scour environment which includes an eroding and accreting surface is relatively dynamic. The rate of migration is unknown but believed to be slow (in the order of a few metres per decade).

iii Nearshore Sand Lobes and Bars

The sand lobes develop on the accreting side of the transverse scours. Within 500m of shore and up to 2m isobath, the lobes accrete to form linear sand bars as their angle relative to the shore becomes more acute.

The bars are the nearshore expression of transverse scours (Searle, 1977). As such, they form a similar habitat type to that of the scours themselves, ie a dynamic bare-sand environment. Recent studies by DMH (1988) show that these bars are dynamic but have a relatively insignificant contribution to coastal dynamics. They do however migrate from west to east at 5-10m per year.

iv Beach

Beach profiles vary at different locations along the coast. Some sections of the shoreline of Geographe Bay, behind intact seagrass meadow, are eroding, while along other sections are accreting, primarily behind inshore bars (Searle, 1977). Where the coast is eroding, the beach slopes up to an erosional scarp, up to 1.5m high, cut into the well vegetated, older dune system. Where the coast is accreting, the beach slopes back to a shallow depression, approximately 10 - 20cm lower than the berm. Behind this depression are foredunes.

b Coastal Dunes

Behind the beach lies the undulating plain of the beach ridge dune system and locally developed foredunes. The beach ridge plain is geomorphically upgraded with ridges generally being less than 1m high but up to 5 - 6m high and 50m wide (Semeniuk, Cresswell and Wurm, 1988). Where the undulations in topography are well developed, linear wetlands or depressions develop in the swales. A shallow freshwater lens underlies the barrier dune system and is separate from the adjacent water bodies associated with the estuarine system.

The main habitat types recognised in this coastal unit are the beach ridge plain, depressions and foredune.

c Estuary and Associated Wetlands

Landward of the beach ridge barrier is the broad estuarine system. The contact between the two units is irregular as estuarine deposits have accumulated in dune swales where dune ridges have been breached and dune sediments have been reworked into the estuarine margins.

The intermittent and erratic nature of the fluvial influences on the estuary has produced an array of landform types within the system. At Wonnerup Inlet, where artificially regulated exchange with the ocean takes place, a deeper basin with permanent water occurs.

In the Vasse-Wonnerup Estuarine System there are peripheral flats, broad shallow basins which are intermittently and periodically filled with water, and systems of channels and islands. Tingay and Tingay (1980) identified the areas of regular inundation as being generally below the 1m contour and those of periodic inundation as being generally below the 2.5m contour. Where channels become isolated from the estuarine water body, wetlands develop within the peripheral flats (Figure 5.1).

The salinity of open water bodies which develop in the estuaries is fresh to brackish. However, the groundwater and surface soil water of the adjacent flats are saline, varying from 20,000 mg/L to 100,000 mg/L (Appendix 2). The contact between the two water bodies as indicated by salinity gradient, is abrupt and occurs within a distance of approximately 150m.

The main habitat types occurring within the estuarine system are the deep estuarine basins, peripheral flats, broad shallow basins, islands, channels, and cutoff channels.

4.3.1.7 Processes Maintaining Units

The marine geomorphic units are maintained largely by natural processes with the exception of the beach unit in which erosion and deposition are modified by groynes and other structures.

The seagrass meadows modify the wave climate and act as a trap for sediment eroded and transported from the rocky shoreline to the west in addition to being a major site of biogenic carbonate sediment production. Cyclic erosion and wave-generated winnowing of sediment from within the seagrass meadow results in sediment being transported toward the shoreline from where net transport is to the east until trapped at natural sites of accretion. The majority of sediment transport occurs alongshore. The volumes contributed by offshore sandbars are of minor significance in the short term.

The shoreline undergoes periods of erosion and deposition as a consequence of periodic variation in sediment supply and wave energy and has, in part, been stabilised by groynes and other structures. In its natural state, it is maintained by the supply of sediment from offshore, either directly or from longshore transport, balanced against losses to the terrestrial environment. Further detail on the coastal processes and sediment dynamics of the area is presented in the recently released Coastal Processes Study by DMH (1988).

The dune ridge system is essentially stable with minor inputs of sand, blown inland from the beaches, and riverine and estuarine sediments, deposited in the narrow entrance channels. Extreme storm events may result in erosion of the beach and shoreward edge of the dune system which is followed by accretion at a slow rate during the succeeding season(s).

The estuarine system is partly artificially maintained in that there are controls on the entry of water from the Vasse River and flood/tide gates which prevent the intrusion of salt water into the estuarine wetlands. Siltation of the wetlands by river-borne sediment is occurring at a slow but undefined rate.

4.3.2 Local Geomorphic Setting

The proposed development site spans parts of the estuarine, beach ridge, beach and nearshore embayment components of the Geographe Bay coastal system (Figure 2.1).

4.3.2.1 Seafloor of Geographe Bay

The seafloor in the vicinity of the proposed development is mainly barren, mobile sand which does not appear to support a diverse or abundant assemblage of biota. Dense seagrass meadows occur approximately 250 metres offshore from the seaward toe of the proposed harbour breakwaters.

4.3.2.2 Beach

The development site has a 1,200m frontage to Geographe Bay. The beach and shoreline in the vicinity of the development site has undergone marked fluctuations in recent years (Public Works Department, 1973) mainly as the result of groyne installation to the west (Russell Street). Since 1975, when the nearby Guerin Street Groyne was installed, the shoreline to the east has receded to the extent that the Old Coast Road into Busselton (Geographe Bay Road) has been breached, and the shoreline now lies within private property. A new road (Layman Road) has since been constructed further inland.

The beach slopes up to an erosional scarp cut into the older dune system.

4.3.2.3 Barrier Dunes

The northern portion of the development site is comprised of undulating low barrier dunes which rise to only a few metres above sea level. This unit is approximately 500m wide.

4.3.2.4 Estuarine Flats

The southern and southeastern portion of the development site consists of low-lying estuarine flats which have been altered (mainly levelled) by ploughing and cultivation over many years.

Two substantially modified freshwater soaks occur on the northern portion of the flats.

4.4 BIOLOGICAL ENVIRONMENT

4.4.1 Regional Setting

The habitats of the Geographe Bay coastal system can be broadly grouped into marine (seagrass vegetated sand sheets, unvegetated sand and waters of Geographe Bay), terrestrial (the foredune and beach ridge plain habitats of the coastal dune system) and estuarine/wetland (the basins, flats, islands and channels of the Vasse-Wonnerup Estuarine System). The biotic assemblages associated with these habitats are described below.

4.4.1.1 Marine Assemblages

Zoogeographically, Geographe Bay is located within a zone of overlap between the southern Australian region and the southern part of the northern Australian or Indo-Pacific region. Consequently, the marine fauna is composed of a complex of temperate and tropical species (Walker, 1979).

Seagrass meadows dominate the marine flora in the embayment. The predominant species is Posidonia sinuosa which forms extensive nonspecific stands (Walker et al, 1987).

From the available literature, two main benthic fauna assemblages and two nektonic fish assemblages can be identified. These are the seagrass assemblage and the unvegetated sand assemblage which both occur within the offshore sand sheet. Although it is possible to define medium-scale geomorphic units in more detail (see Section 4.3.1.6), there is insufficient information on the biota to allow determination of assemblage types beyond these two broad groups.

Assemblages are named according to the broad habitat types in which they occur, ie seagrass-vegetated sand assemblages, unvegetated sand assemblages, and planktonic and nektonic assemblages.

a Seagrass-Vegetated Sand Assemblages

The seagrass meadow occurs on sandy substrates between the 2 - 14m isobath covering approximately 70% of the offshore sand sheet. The seagrass itself is the primary determinant of this habitat type as well as being a member of the assemblage itself (Searle, 1977). The seagrass blades provide a colonising surface for many encrusting organisms, such as the algae Melobesia sp. and members of the Corallinae and epiphytes including bryozoans, serpulids and foraminifera (Searle, 1977).

The molluscs Thalotia conica, Cantharides (Phasianotrodius) isodontes and Bittium granarium occur amongst the foliage (Paul and Searle, 1978).

Museum records show that at least four species of Echinoderm are known to occur in seagrass and have been collected in Geographe Bay.

b Unvegetated Sand Assemblages

Searle (1977) described a sand assemblage occurring on sand between the beach and the 2m isobath and on patches within the seagrass itself. The assemblage consists primarily of crabs and echinoderms and, although it is described as being a less diverse assemblage than that occurring in the seagrass meadows, museum records indicate that a rich echinoderm fauna inhabits the sandy substrates.

c Planktonic and Nektonic Assemblages

Studies of fish in Geographe Bay indicate that a diverse fish fauna uses the area. Scott (1981), in a study of the seagrass fish fauna, collected a total of 19 species, one of which was a new record for Western Australia. Of the 217 inshore (less than 15m) species found by Walker (1979), 87 species were described as being inshore demersal and occurring amongst weed, 89 species as being inshore demersal and sand or mud dwelling and 41 as being inshore pelagic species.

A study by Walker (1979) indicated that Geographe Bay is a breeding ground for 10 commercially exploited fish species. Lenanton (1982) found that the inshore marine environment of Geographe Bay (particularly the inshore zone of the seagrass beds where rafts of seagrass detritus accumulate) provides a regionally-significant nursery area for some commercially and recreationally important fish species.

No study has been undertaken of the planktonic biota of Geographe Bay.

4.4.1.2 Terrestrial Assemblages

a Foredune Assemblage

The foredune assemblage is an open herbland comprised primarily of introduced species which occur commonly along the Western Australian coastline. The major species comprising the unit are Cakile maritima and Arctotheca calendula with Salsola kali ,Euphorbia paralias and Spinifex hirsutus.

b Beach Ridge Plain

Keating and Trudgen (1987) identified two vegetation units on the beach ridge plain. An open heath, up to 1.4m tall, of predominantly Acacia cochlearis, Acacia cyclops and Scaevola crassifolia, occurs intermittently along the seaward edge of some sectors of the beach ridge plain. Other floristic components of the unit include Acanthocarpus preissii, Pelargonium capitatum, Tetragonia decumbens, Spyridium globulosum and Olearia axillaris. The sedges Isolepis nodosus, Lepidospera gladiatum and the introduced species Trachyandra divaricata form an understorey. The unit occurs primarily as remnants amongst residential development.

An open scrub to low open woodland of Agonis flexuosa occurs over the remainder of the beach ridge plain on the older relatively degraded land surfaces and well developed soils. Spyridium globulosum and Acacia cochlearis are the dominant shrub species with Exocarpus sparteus, Pelargonium capitatum, Hibbertia sp. and Rhagodia baccata shrubs also occurring in the understorey. The lowest structural component includes Phyllanthus calycinus, Lepidospera gladiatum, Isolepis nodosus, Hardenbergia comptoniana and Loxocarya fascialata. Much of the unit is heavily invaded by weeds such as Trachyandra divaricata and grasses such as Lagurus ovatus, with Arum lily occurring in disturbed wetter areas. This vegetation unit also occurs as remnants amongst residential developments.

The fauna of the beach ridge plain system has been surveyed by Ninox (Appendix 4). Regionally however this has not been studied in detail. However, Bunbury (1987) noted that the Western Ringtail Possum occurs in Agonis flexuosa woodlands in the Busselton area. The range of this species has been severely contracted by the clearing of habitat and predation by feral animals. The Ninox investigation indicates that the Western Ringtail Possum is also present in the peppermint woodland of the project site.

4.4.1.3 Estuarine and Wetland Assemblages

The periphery of the estuarine system is vegetated by samphires and sedgelands (Keating and Trudgen, 1986; Tingay and Tingay, 1980). The samphires are composed of a low open heath to shrubland of Sarcocornia quinqueflora, Halosarcia indica, H. pergranulata. These species form a structural upper storey (40 - 70cm tall) below which is a herbfield of Cotula coronopifolia. A low closed heath of Halosarcia halocnemoides and Threlkeldia diffusa occurs at the front of sedgelands on the margins of coastal-linked, interdunal wetlands at the Deadwater between Busselton and Dunsborough. The sedgelands are comprised primarily of Juncus kraussii, with Isolepis nodosus and scattered Lepidospera gladiatum, Halosarcia halocnemoides or Threlkeldia diffusa. The margins of the deeper sections of the Vasse Estuary are vegetated by a tall sedgeland of Typha orientalis (an introduced species) and Juncus kraussii.

An open woodland of Melaleuca cuticularis and M. hamulosa occurs as isolated patches within the Halosarcia-Sarcocornia shrubland. These woodland units occur within the Wonnerup Estuary and the shallower sections of the Vasse Estuary. A woodland of Melaleuca cuticularis and M. hamulosa with an understory of Acacia saligna and Viminaria juncea shrubs and the sedges Typha orientalis, Juncus kraussii and J. pallidus, occurs along the margins of the deep sections of the Vasse Estuary. A low closed forest of Melaleuca cuticularis, M. rhaphiophylla and M. preissiana occurs on the margins and islands in the Vasse Estuary. Shrub species which form an understorey include Agonis flexuosa, Melaleuca hamulosa and Acacia saligna (Keating and Trudgen, 1986).

Tingay and Tingay (1980) correlated vegetation types to water level contours within the estuarine system. Sarcocornia blackiana open heath and areas of Halosarcia pergranulata open heath occur between 0 - 0.5m contours, with S. blackiana occurring at the lower edge of this range. Melaleuca rhaphiophylla occurs towards the 1m contour as a low open forest, or with M. cuticularis and M. hamulosa as a low open forest-woodland. Juncus kraussii open sedgeland occurs above the 1m contour and isolated stands of Eucalyptus rudis occur above the 1.5m contour.

The wetland vegetation fringing the Wonnerup Inlet occurs as narrower zones of Gahnia trifida and Juncus kraussii sedgelands and Sarcocornia blackiana closed heath. Melaleuca hamulosa low closed forest occurs as a stand behind the S. blackiana at the northern margin of the inlet.

The significance of the estuarine system to avifauna has been established by recent studies (Jaensch, in prep, and RAOU surveys, after Bunbury, 1987; Ninox, (Appendix 4). The Vasse-Wonnerup estuary system is a significant breeding, feeding and migratory resting site for many species of birds, some of which are rare. To date, 77 species of birds have been recorded. This number includes residents which remain in the area throughout their lifetime, Australian nomads which move into the area from other parts of Australia either on an annual or irregular basis, and trans-equatorial migrants which breed in various parts of Eurasia, Siberia and Asia during the northern hemisphere summer and migrate south during the early Australian spring.

The estuary is used by significantly large numbers of birds for both feeding and breeding. For example, 4,000 Red-necked Avocets were recorded in the system during surveys by RAOU. This represents 1% of the total Australian population and is double the maximum number recorded elsewhere. Other species which have been recorded in higher numbers than elsewhere in southwestern Australia are the Great Egret, Yellow-billed Spoonbill, Black-winged Stilt, Black-tailed Godwit, Sharp-tailed Sandpiper and Australian Pelican. Pied Cormorant, Wood Sandpiper, Greenshank, Silver Gull, Whiskered Tern, White-winged Tern, Australasian Grebe, Pacific Black Duck, Grey Teal and Long-toed Stint also occur in large numbers in comparison to most other wetlands (Ninox, Appendix 4). Long-toed Stint are uncommon migrant waders and are considered to have a stronghold in southwestern Australia.

The Wonnerup estuary is also a significant breeding area for Black Swans and particularly important as a refuge for cygnets. About 200 pairs have been recorded, representing the largest known breeding aggregation of Black Swans in Western Australia. The Vasse-Wonnerup Estuary System is used regularly by at least 10,000 ducks and swans.

Rare species, such as the Little Egret, Australasian Bittern, Glossy Ibis, Royal Spoonbill, Black-tailed Godwit, Pectoral Sandpiper, Ruff, Caspian Tern, Painted Snipe and Pin-tailed Snipe also use these wetlands (Ninox, 1987).

There is no information available on estuarine benthic fauna, ie annelids, crustacea, insects etc, occurring in the habitat units of the Vasse-Wonnerup estuarine system.

4.4.2 Local Setting

The local setting within which the project is located contains elements of marine, terrestrial and estuarine assemblages.

4.4.2.1 Marine Assemblages

The development will incorporate part of the shallow subtidal sand assemblage. Part of this area is of recent origin resulting from erosion of the beach line following coastal movement and groyne construction. The remainder consists of mobile sands within the nearshore zone. There are no attached plants, seagrass or macroalgae, within this assemblage and the fauna consisting primarily of echinoderms, crustacea, polychaete worms and molluscs has a low diversity.

4.4.2.2 Terrestrial Assemblages

a Foredune Assemblage

Recent erosion has resulted in the loss of the foredune in the development area. The present narrow beach backs on to a low scarp eroded into the nearshore beach ridges.

b Beach Ridge Plain

Within the development area the beach ridge plain is bounded by the beach line and the approximate alignment of Layman Road. The area is grazed and contains numerous introduced grasses and other pasture species but does support extensive growth, and regrowth, of the nature peppermint, Agonis Flexuosa.

4.4.2.3 Estuarine Assemblages

The area of estuarine habitat included within the development includes mostly modified estuarine flats. These areas are largely an artificial habitat generated by ploughing, the introduction of pasture species and grazing. Similarly the samphires and sedgelands, previously described in Section 4.4.1.3 are also modified as a result of grazing pressure.

4.4.3 Ecosystem Considerations

The basis of ecosystem analysis is the identification of the major physical processes and ecological relationships responsible for maintaining the existing habitats and biological assemblages.

For any given area it is therefore necessary to identify:

- the physical processes which maintain the habitats and supply the nutrients required for primary productivity (discussed previously in Section 4.3.1.7;
- the source of the nutrients;
- the location of the areas of high biological productivity.

The following conceptual ecosystem models are based on general ecological principles and available information on the ecological relationships of the major components of the study area.

In order to simplify the discussion, the marine, terrestrial and estuarine systems are discussed separately, although each system has both physical and biological links to the other systems.

a Marine Ecosystem

The major primary producers (ie organisms able to fix energy from the sun through the process of photosynthesis) in the marine environment are the seagrasses, macroalgae and phytoplankton.

The seagrasses, which are widely distributed on the sandy floor of Geographe Bay at depths of between 2-14 metres, together with their associated epiphytic algae, are the major source of primary productivity.

The macroalgae occur over a smaller area at greater depths and generally at a lower density, suggesting lower overall productivity.

There is no available information on shallow-water phytoplankton productivity in Geographe Bay. However the clarity of the water suggests that phytoplankton productivity is generally low.

The sources of nutrients which support the primary producers are in situ breakdown of organic material by detritivores and decomposers, including recycling of the nutrients from wrack previously exported from the site of production and terrestrial inputs from rivers, drains and shallow groundwater discharge. The relative contribution of nutrients from each source is unknown. However the breakdown of the seagrass wrack by detritivores is known to play an important part in the marine food chain.

Seagrass growth is seasonal with strong growth during the summer period when light, water temperature and water clarity are at their optimum, followed by a period of low growth and leaf senescence during the winter. Waves produced by winter storms break off the senescent leaves and transport them shoreward to be deposited on the shoreline as wrack. Onshore winds may result in part of the wrack being blown inland where it becomes incorporated into the terrestrial and estuarine food web.

b Terrestrial Ecosystem

The terrestrial ecosystems affected by this proposal are the foredune and beach dune ridge habitats. The food cycle within the dune system is largely self-sustaining with production, consumption and recycling of plant material taking place largely in situ. The foredune and beach dune ridge receive little direct input from either the marine or estuarine environments but are shaped physically by the deposition and erosion of sand from the beach and foredune zone and, to a minor extent, by flood deposition and watercourse changes within the estuarine system. The latter inputs have largely ceased as a result of the large scale flood control measures adopted in the region since the turn of the century.

The vegetation of the coastal zone is also shaped, both in terms of species composition and physical development, by the salt-laden onshore winds.

The terrestrial environment contributes to the marine ecosystem by providing a site for seagrass wrack decomposition from which the end products can be returned to the marine environment.

There may be some interchange of faunal populations between the terrestrial and estuarine ecosystems for breeding and feeding but the extent to which this occurs is thought to be relatively minor.

c Estuarine Ecosystem

The estuarine ecosystem is highly modified in terms of its physical and biological processes. Modifications include control over freshwater flow, management of water exchange with the marine environment, siltation, nutrient accumulation, pesticide input, clearing, grazing of native plant species, and introduction of pasture plants and feral animals.

Clearing in the catchment area, modification of land use practices and extensive use of fertilisers have resulted in altered runoff patterns, affected sedimentation rates and increased the nutrient load on the estuary. In recent years these changes, (particularly the raised nutrient levels), have tended to generate extensive phytoplankton blooms toward the end of summer. These blooms have been followed by fish kills as the result of deoxygenation of the water mass caused by the decomposition of the algal blooms.

Much of the estuary dries out at the end of the summer drought period. Water generally remains in the large bay and channel east of the Giles property.

The maintenance of fresh water in the estuarine system over the summer period provides a summer refuge and freshwater resource for many species of waterfowl including migratory and endemic species.

The estuarine fringes and flats provide a food resource and breeding area for a number of species of waterfowl including black swans and black duck. The effects of cultivation and grazing on the maintenance of the habitat value of these areas is unknown although present investigations (Ninox, Appendix 5) suggest that the cleared and grazed sections of the estuarine flats are little used by waterfowl in comparison to the use made of the rest of the estuary.

As mentioned previously the exchange of water between the estuary and the ocean is controlled by artificial means, reducing the outflow of freshwater and preventing the regular flushing of the estuary by seawater. Consequently the contribution of nutrients to the marine ecosystem from the estuary is thought to be much reduced but has yet to be quantified.

4.4.4 Present Condition of Ecosystems

Neither the proposed development site nor the surrounding environment remains in an unmodified condition. The land is highly degraded and modified, the Vasse Estuary no longer functions as a true estuary, the beach is artificially stabilised with groynes, and the nearshore seagrass beds are contracting in extent. However, in its modified state, the estuary is still regarded as an important waterfowl drought refuge because of the artificial control on water levels and salinity.

4.4.5 Conservation Significance

The major conservation significance of the development site and immediately adjacent environment is the importance of the Vasse Estuary and its associated wetlands for waterfowl conservation. None of the estuarine flora species however are considered to be rare or endangered.

The dunes at Geographe Bay constitute the most southerly occurrence of the Quindalup Dunes, and their origin and the resultant morphology of a beach ridge barrier in front of a lagoon system is unique along the Western Australian coast.

Although the coastal dune system within the development site is not a pristine habitat, the extent of clearing and disturbance and consequent loss of similar habitat elsewhere means that residual stands of vegetation, such as the peppermint woodland, become significant habitat out-liers for populations of species whose distribution is gradually contracting. For example, the Western Ringtail Possum which is now considered rare is most commonly found in peppermint woodland (Bunbury, 1987).

4.5 HUMAN ENVIRONMENT

4.5.1 Regional Values

The coastal areas of the Busselton Shire were among the first areas of Western Australia to be settled by Europeans. Settlers were attracted by the mild climate, sheltered harbours, plentiful water supplies and range of soil types offering potential grazing and cropping opportunities. These factors, together with a natural environment which offers attractive scenery and a range of recreational opportunities, have been the basis for population growth and economic expansion in the region over the last century.

Agriculture and forestry have traditionally been the mainstays of the region's economy and most of the coastal hinterland has been cleared for farming. Mineral sands and construction materials are mined and a small but significant commercial fishery operates in Geographe Bay. Tourism and providing services for the retired and elderly have increased greatly in importance over the past decade, and in recent years the Busselton Shire has become the State's most popular tourist destination after Perth (SPC, 1987). Services and infrastructure and a commercial base have developed to serve the resident and tourist populations and the town of Busselton is a major recreational, tourist and retirement centre for southwest Western Australia.

The SPC (1987) has defined the regional values of the area for different uses. It is clear from their listings of values for both general and specific uses of the area (for example by retired people, rural residents and for recreation) that many of the values are based on the natural and developed landscape and environment. For example, the sheltered, north-facing aspect and clear waters of Geographe Bay and the variety of coastal settings and natural landscapes offer a range of recreational opportunities and are basic to the attractiveness of the region for many uses. The Vasse-Wonnerup estuarine system is considered to be regionally significant for conservation (Conservation Through Reserves Committee, 1974).

Land uses and developments based on these regional values are described below from historical and present perspectives. Community needs and planning issues are identified in order to view the Port Geographe development in the context of the regional social environment.

4.5.2 Regional Development - A Historical Perspective

4.5.2.1 Aboriginal Use

Evidence found in 'Devil's Lair', a cave in aeolian limestone near Augusta, indicated human occupation in the region up to 28,000 years ago and perhaps more than 35,000 years ago (Hallam, 1981). It has been estimated that approximately 6,000 aboriginal people were living in the southwest at the time of European colonisation (SPC, 1987). A tribe known as the Wardandi were traditionally associated with the Busselton area (Tindale, 1974).

The sheltered location, availability of fresh water and proximity to Wonnerup Inlet made it a particularly attractive area in the summer, but boggy conditions in winter seasonally forced the tribes inland. Early records showed that fire was used as a management tool, especially patchy burns in late summer. After European settlement took up land in the area, tribal groups were driven away and the traditional aboriginal way of life declined.

Burial sites, campsites, shell middens, stone tools and artefact scatters have been found during excavation and development in the region (SPC, 1987). Tools and flakes found in artefact scatters have provided information on tool traditions and on occupation of the area before the sea reached present levels (Hallam, 1981).

4.5.2.2 European Use

Settlers from Augusta began moving north to the Vasse District in 1831 and the townsite of Busselton was declared in 1833 (SPC, 1987). The open pastures which resulted from aboriginal management (particularly burning) and plentiful water supplies made the area particularly attractive for settlement.

The first settlers in the area grew cereals and later produced dairy products and vegetables to supply the growing settlement and American whaling ships operating off the coast. Cattle were also bred in the district. Timber was milled and the first sawn timber was exported in 1850.

During the past century, agricultural and forestry uses have continued but the range of agricultural products has increased and more recently the tourist industry has become particularly important to the region's economy. Mineral sand mining and a small fishing industry have also developed. The present economic profile of the region is described in the following section.

4.5.3 Economic Profile

Historically, the economy of the Leeuwin-Naturaliste region has been based on agriculture and timber production. The economy is now more diverse, with major dependence on agriculture and tourism and significant contributions from mining and service industries and small timber and fishing industries (ACIL, 1987). These industries are discussed below to provide background to the impact of the Port Geographe development on the regional economy.

4.5.3.1 Agriculture

Agriculture has always been the mainstay of the region's economy and this is likely to continue as a variety of new agricultural activities (including floriculture) become established (SPC, 1987). The main activities are dairying and the grazing of sheep and beef cattle. Viticulture has become a major contributor in the past ten years (ACIL, 1987).

The value of agricultural products in the Busselton Shire in 1984-85 was estimated to be $24 million. Agriculture is a significant source of employment, employing some 600 people and contributes to the economies of local towns (SPC, 1987). For the Vasse Region, agriculture was valued at $43 million in 1984-85 (ACIL, 1987).

Viticulture and other horticultural activities are the main agricultural growth areas which will add to the gross income and employment opportunities (ACIL, 1987).

4.5.3.2 Tourism and Recreation

Tourism is fast becoming the industry which generates most income for the area, currently injecting an estimated $50 million annually into the Vasse region's economy (SPC, 1987).

The region offers a wide variety of opportunities for both land-based and aquatic recreation, including swimming, fishing, boating, scenic drives, bushwalking, horseriding and picnicking. Other activities are related to special features of the area, such as caving, excellent surfing and visits to wineries, potteries, craft centres and historic sites. Busselton is considered to be a key heritage resource centre (Western Australian Tourism Commission, 1986).

The opportunities, together with the outstanding scenery, attractive settlements and existing infrastructure to service tourism, attract both residents and visitors to the area.

In the Busselton Shire, at least 400 people are employed in tourism-oriented industries and a similar number in service industries based on the economic activity generated by visitors. Up to a half million people visited the area in 1986-87, spending about $25 million (SPC, 1987). Tourism is expected to continue to increase in importance to the region.

4.5.3.3 Forestry

The forest resources in the region provide timber for milling and for local cottage industries. Forestry has traditionally been an important part of the region's economy, but it has diminished in relative importance in recent years. Four hardwood timber mills still operate in the Busselton area (SPC, 1987). The estimated value of timber production for the Vasse Region in 1984-85 was $5.7 million and some 70 people were directly employed in the industry in 1986 (ACIL, 1987). The hardwood timber industry is expected to decline as further controls are placed on logging activities but softwood (pine) production is expected to increase (ACIL, 1987).

4.5.3.4 Mining

Mining is currently restricted to mineral sands and construction materials (limestone, granite and gneiss, lime sands and other sands). The contribution of the mineral sand and other mining activities to the economy of the Vasse Region in 1984-85 was valued at $10 million (ACIL, 1987).

There is potential for the expansion of mineral sand mining and, in the longer term, for coal mining, which would increase the contribution of mining to the regional economy (SPC, 1987).

4.5.3.5 Fishing

The diversity of marine habitats and sheltered aspect of Geographe Bay provide opportunities for local, commercial and recreational fisheries which are important to the lifestyle as well as to the economy of the region. Inshore fishing grounds between Cape Naturaliste and Bunbury provide significant commercial catches of Australian salmon, herring and sandy sprat. Offshore fishing grounds provide mainly shark, pilchard, Southern bluefin tuna and Westralian jewfish. A small number of rock lobster and abalone fishermen also operate in the area (Fisheries Department, 1986).

The economic return from the fishing industry in the waters of Geographe Bay and west of Cape Naturaliste is in the order of $1.4 million annually (Fisheries Department, 1986). ACIL (1987) estimated that the value of the commercial fishing industry to the Vasse Region would be at least $2 million. Most species fished are currently fully exploited but there is some potential for expansion of the pilchard and deep sea fisheries (SPC, 1987).

4.5.3.6 Commerce and Industry

A small number of manufacturers serve local demands, employing about 230 persons and providing about $12 million to the economy of the Busselton area (SPC, 1987). The importance of cottage industries is expected to increase.

Retail operations employed an estimated 450 persons in 1984-85 and provided about $8 million through wages, salaries and retained profits.

The retail section will expand in line with increased tourism and retirement to the region.

4.5.3.7 Construction and Residential Development

A great deal of construction has taken place in recent years, offering employment in the area (560 people in 1983-84) (SPC, 1987). The construction industry is highly variable, however, and is very dependent on other economic sectors for its growth and stability.

The SPC (1987) has identified increased demands for residential housing from:

- natural population increase;
- retirement from Perth or other areas;
- persons working in Bunbury and commuting from the Busselton area;
- new residents attracted by employment prospects in the area;
- demand for holiday homes.

Strong demand for a variety of housing is expected to continue for the foreseeable future (SPC, 1987).

4.5.4 Demographic Profile

4.5.4.1 Resident Population

Population estimates for the southwest for the period between 1961 and 1985 indicate a slow growth, with a declining share in the State population until the early 1970's, followed by a rapid growth (and an increased share of the State's non-metropolitan population) in the late 1970's and during the 1980's (SPC, 1986). Approximately 69% of the population of the Vasse Region (Busselton and Augusta-Margaret River Shires) are domiciled in the town of Busselton (1981 Census Figures, ACIL, 1987). The estimated resident population of the Busselton Shire in 1985 was 10,900 (ACIL, 1987). Busselton Shire Planners estimated the resident population at 11,500 in 1986 (ACIL, 1987). Projections of the future resident population of the Busselton Shire by extrapolation has produced estimates of 12,900 for 1991, 14,600 for 1996 and 16,400 for the year 2001 (SPC, 1986).

The 1986 Census figures (Australian Bureau of Statistics, 1986) show that Busselton has an ageing population with more than 24% over 55 years of age. This compares with 21% for the 1981 Census and percentages as low as 12% for other municipalities in the region (SPC, 1987).

The proportion of the population in the 0 - 14 and 15 - 54 year age groups are generally below those of other municipalities in the region (SPC, 1986).

The older age profile of the area, together with the relatively large proportion of widowed persons, single-person households and older families with no dependants at home, have a number of planning implications. Such areas generally require a range of health and welfare services to meet the needs of the elderly, and a range of different forms of accommodation and recreational pursuits (SPC, 1987).

The SPC has surveyed community needs in the southwest region (South West Development Authority, 1985) and the Busselton Shire Council has surveyed the specific needs of the elderly population in the Busselton area (D. Pilpel, pers. comm.).

4.5.4.2 Visitors

Although visitors are not normally included in the demographic profile of a region, visitation patterns are discussed here because large numbers of tourists and holidaymakers visit the area each year and are vital to the region's economy. Busselton has the second highest number of overnight visitors of any local authority area in the State (SPC, 1987). Unofficial estimates suggest that visitors may swell the local population fourfold during the summer season (ACIL, 1987).

Tourist accommodation surveys have shown the visitor pattern to be very seasonal in nature. The Christmas school holidays, other school holidays, Easter and long weekends are the most popular times. The seasonal pattern results in demands for accommodation and facilities during peak periods and under-utilisation of many of these facilities at other times of the year (SPC, 1987).

4.5.4.3 Non-Resident Landowners

Another relevant factor for the Busselton Shire, especially in coastal areas, is the large proportion of land owned by non-resident landowners. Overall, about 55% of lots are owned by non-residents, many of whom use the area for holidays and eventually plan to retire there (SPC, 1987).

4.5.5 Community Facilities and Services

4.5.5.1 Services

The water supply for Busselton is managed by the Busselton Water Board. The supply is drawn from the Leederville Formation confined aquifer in the Busselton-Capel Groundwater Area (SPC, 1987, Map 3). There is expected to be sufficient water for the expected requirements of industry and urban development in the region for the next twenty years (ACIL, 1987).

A reticulated sewerage scheme administered by the Water Authority of Western Australia covers part of Busselton. All new subdivisions must be sewered.

Transport is nearly all by roads, with good road links to Perth and the regional centre of Bunbury. A private airport operates in Busselton but there is no public air service. The closest rail link to Perth is Bunbury.

4.5.5.2 Recreational Facilities

The climate, scenery and variety of inland, coastal and marine environments offer a range of recreational opportunities to residents and visitors. A range of accommodation, recreational facilities, culturally-based resources and special events also attract visitors to the region (Western Australian Tourism Commission, 1986).

Accommodation offered includes hotels, motels, caravan parks, guest houses, holiday flats, cabins, chalets, cottages, hostels and campsites. The ACIL study of the economic profile of the region (ACIL, 1987) identified a limited number of opportunities to upgrade existing accommodation and build new facilities to cater for the expected demand for higher-grade accommodation by the increasing proportion of international and interstate tourists to the Vasse Region.

Cottage industries, including wineries, local arts and crafts, potteries and speciality foodmakers (eg cheese), and historical features such as museums, historic homes and the Busselton Jetty, contribute to the range of recreational opportunities.

4.5.5.3 Boat Launching and Mooring Facilities

Although there are a number of boat launching ramps along the Geographe Bay coastline, the six ramps in the Busselton-Dunsborough area are frequently unserviceable in the winter due to sand encroachment (G. Bishop, pers. comm.). Establishment of a continuously-usable launching ramp along the sandy shoreline requires regular and extensive maintenance work. On the rocky shoreline to the west, boat launching is hazardous under certain wind and wave conditions (DMH, 1986). Carparking provisions at all existing ramps are minimal and this prevents efficient use of the ramps (DMH, 1986).

4.5.5.4 Facilities for the Retired and Elderly

A district hospital, a community health and development centre and a variety of paramedical, dental, community nursing and other services serve the Busselton District. Services available specifically for the elderly include short-term care, residential care, social activities, social support services, employment services and voluntary organisations (self-help and support groups), service clubs and church activities (South West Development Authority, 1986).

4.5.6 Identified Community Needs and Attitudes

Community needs and attitudes have been identified in the Leeuwin-Naturaliste Region Plan (SPC, 1987). Aspects relevant to this project are outlined below.

4.5.6.1 Housing

The SPC (1987) has identified an increasing demand for residential housing and holiday homes in the area. The majority of the demand is for dwellings which are close to services and have good access to recreational opportunities. The SPC has therefore formulated an objective 'to provide for an increase in housing opportunities in the study area in a variety of environments for residents and holiday home owners' (Objective 5, SPC, 1987).

4.5.6.2 Tourism and Recreation

The tourist industry is vital to the economy of the region and to the growth in employment opportunities. The SPC has identified the need to 'provide for the development of tourism' (Objective 2, SPC, 1987).

There are indications of a rising demand for a broader spectrum of types of accommodation and facilities (SPC, 1987). In a visitor survey undertaken by the Western Australian Tourism Commission (Hassell Planning Consultants, 1985), 'lack of facilities' was cited as the principal 'dislike' in the southwest. An accommodation survey (Department of Conservation and Environment (DCE), 1982) indicated that visitors preferred accommodation

close to the beach in an attractive setting. Other preferences included central location, good access, good facilities and reasonable prices. In particular, there is an increasing demand for more 'up-market' accommodation for international and interstate tourists (ACIL, 1987). The Western Australian Tourism Commission (1986) considers that the main emphasis should be on holiday units and cabin/chalet accommodation. The SPC has therefore formulated a specific objective to 'provide for a variety of tourist accommodation and other facilities in keeping with the character of the area and objectives of the study'. (Objective 2 (a), SPC 1987)

The SPC has also identified the need to enhance both waterbased and land-based recreational opportunities for residents and visitors (Objective 6, SPC, 1987). In view of the seasonal visitor pattern which places existing facilities under pressure during peak holiday periods and often leaves them under-utilised at other times of the year, there is a particular need to encourage year-round tourism by developing attractions, facilities and events which will spread the visitor pattern more evenly (SPC, 1987; ACIL, 1987).

4.5.6.3 Boat Launching and Mooring Facilities

The current lack of all-weather boat launching facilities and moorings in Geographe Bay places restrictions on recreational boating in the area.

The DMH (1986) assessed that "on the limited data available, the figures indicate an immediate need for 20 mooring pens at a location in Geographe Bay and a possible short-term need of up to three times that figure", and identified an immediate need for a sheltered ocean launching site.

4.5.6.4 Boat Harbour Facilities

Existing boat facilities for commercial fishing vessels are limited to the Bunbury fishing boat harbour. There are no facilities for commercial vessels and few sheltered anchorages for commercial or recreational vessels between Bunbury and Augusta (Fisheries Department, 1986). A need has been identified for harbour facilities in Geographe Bay (SPC, 1987).

The fishing industry located in the Geographe Bay region has been requesting the construction of fishing boat harbour facilities in the area since the early 1970's (Fisheries Department, 1986). Although a harbour would not lead to substantial expansion of the fishery, provision of harbour facilities would have the following benefits (Fisheries Department, 1986):

i a centralised service centre would enable fishermen affected by recent inshore net restrictions, and local pressure to close beaches to commercial fishing use, to diversify their operations into alternative fisheries;

ii a centralised facility would make the existing fishing industry more viable by saving travel time and reducing fuel costs and helping the development of pilchard and perhaps other fisheries;

iii a harbour would offer a safe boat anchorage for both commercial fishing vessels and recreational vessels in poor weather.

A harbour would also provide a link in a recreational waterway route down the Western Australian coast. The South West Development Authority (1986) and the Western Australian Tourism Commission (1986), recognised the establishment of an oceanway between Fremantle, Rottnest, Mandurah, Bunbury and Geographe Bay as an initiative for State tourism.

4.5.6.5 Facilities for the Retired and Elderly

The Busselton Shire has a high proportion of elderly residents and the SPC has identified the need 'to provide for the special housing needs of the aged' (Objective 5(c), SPC, 1987).

The community needs study for Bunbury and the southwest region (Wilson Sayer Core, 1985) also identified services for the elderly, including accommodation and all forms of care, as among the main areas of inadequacy in current community resources and services.

4.5.7 Conservation and Landscape Values

It has already been stated that much of the attractiveness of the region to both residents and visitors lies in its scenery, landscape and conservation values.

Many of the current uses and proposed future developments in the Busselton area depend on maintaining the area's natural and built attractiveness, environmental amenity and conservation values. The SPC has recognised this in formulating their overall objective for the region, ie, 'to provide for appropriate development of the region so that its significant tourist, residential, agricultural, forestry and industrial resources can be used for the benefit of the people of the region and of the state generally, while ensuring that the attractiveness of the region upon which some of these resources depend is not impaired' (SPC, 1987).

Specific features which have been identified by the SPC (1987) as having particular conservation value are:

- unique, rare or unusual features (including caves, flora and fauna);
- the diversity of plant species and communities, especially coastal heath communities, marine fauna and habitats and wetland habitats;
- features of particular scientific interest, for example, karri at the extremity of its range at Cape Clairault, waterfowl in the Vasse-Wonnerup Estuary and the breeding ground for Great Egrets in McCarley's Swamp;
- features useful for environmental education;
- features which are valuable to the community in helping to maintain infrastructure of a resource, for example, the vegetated dune shoreline of Geographe Bay which assists shoreline stability and seagrass which helps to maintain the fisheries resource in Geographe Bay.

Conservation values of particular relevance to the area of the proposed development are the waterbird usage of the Vasse-Wonnerup Estuary system and the shoreline and seagrass beds of Geographe Bay.

4.5.7.1 Vasse-Wonnerup Estuarine System

The EPA has recognised the regional importance of the Vasse-Wonnerup Estuaries as summer drought refuges for both endemic species of waterfowl and trans-equatorial migratory waders (see Section 4.4.1.3). The estuary is considered to be a wetland of regional, national and international significance because of its large and diverse populations, its extensive feeding, breeding and refuge areas, its utilisation by rarer species and a high number (21 species) of birds covered by the Japan-Australia Migratory Birds Agreement (JAMBA) (Ninox, Appendix 5). The JAMBA treaty obligates Australia to protect the species listed. The wetland also satisfies criteria as a 'wetland of international importance especially as a waterfowl habitat' under the Ramsar Convention to which Australia is a signatory. Both the large number of birds (for example, the estuary annually supports at least 10,000 ducks and swans) and the presence of at least 1% of the known population of Long-toed Stint (Calidris subminuta) satisfy criteria for nomination (Ninox, Appendix 5).

Based on the recommendations of the Conservation Through Reserves Committee (1974), the EPA (1976) recommended that:

i the Director of Fisheries and Wildlife approaches the landholders in this area to gain their voluntary agreement to manage the appropriate areas for the protection and improvement of wetland habitats;

ii the Department of Fisheries and Wildlife provide technical advice for this purpose to the landowners and consultants advice to the EPA;

iii where conservation of wetlands can be shown to inhibit the productive potential of farmland, the Minister for Agriculture recommends to the State that it provides monetary compensation in the event of the owner entering into a legally binding agreement protecting the State's investment;

iv the Mines Department not grant any mining claims in the area without prior consultation with the EPA.

To date no agreement between authorities and local landowners has been reached.

4.5.7.2 Geographe Bay Shoreline

The vegetated dune shoreline assists in maintaining coastal stability. Offshore the seagrass beds provide shelter and 'nursery' habitat which help to maintain the fisheries resource in Geographe Bay. The coastal dune ridges support stands of peppermint which provide food and shelter for the endangered Ringtail Possum.

4.5.8 Local Land Use

4.5.8.1 Aboriginal and Historic Sites

The Aboriginal Sites Department of the Western Australian Museum has no records of any Aboriginal archaeological or ethnographic sites within the boundaries of the development project, but the area has not been examined in detail and it is possible that burial sites, campsites and stone arrangements may be present (V. Novack, pers. comm.).

No historic sites have been recorded on the Port Geographe development site, although there are a number of sites inland of the Vasse Estuary and to the east, including Wonnerup House and Chapmans Mill.

4.5.8.2 Present Land Use

The development site is currently cleared and pastured grazing land. Some natural vegetation remains on the coastal dune ridge and in samphire and mudflats on low-lying land near the Vasse Estuary.

Mineral sand mining has taken place on coastal grazing land to the east, and residential development of Busselton, including a time-share resort, extends along the coastline to the west of the development site. The Vasse Estuary forms the inland (southern) boundary of the site.

The level of use made of the beaches fronting the development site is unknown but is expected to be low in view of the difficulty of access to this area. Existing uses are expected to include swimming, sunbathing and beach fishing.

Plate 1: Shoreline of development area looking east from base of Guerin Street groyne. Note steep beach slope and presence of eroded road base material in mid ground.

Plate 2: Beachridge dune zone with Peppermint and Acacia shrubland following bushfire.

Plate 3: Estuarine flat grazing area typical of the development zone.

Plate 4: Estuarine samphire and sedge located within proposed conservation zone.

Plate 5: Estuarine flats area showing effects of different land management practices.

Plate 6: Tide/flood gate located on entrance to Vasse Estuary to prevent entry of seawater.

5.0 ENVIRONMENTAL EFFECTS

5.1 INTRODUCTION

Identification and investigation of the potential environmental effects of the Port Geographe development have been undertaken in stages. A detailed Notice of Intent was submitted to the EPA for evaluation in 1985.

On the basis of the EPA's assessment of the NOI, and later, more detailed information on the environment of the project area and on the modified project design, the following issues were identified as the major concerns to be addressed in the ERMP.

a Maintenance of coastal stability, specifically:

- impact on the sediment dynamics of Geographe Bay which involve major offshore features as well as longshore transport;
- nearshore loss of seagrass and its effect on onshore sand movement;
- the volume and direction of sand bypass and methods and costs of bypass.
- the effect of seasonal deposition and dispersion of seagrass wrack on harbour and sand bypass management.

b Maintenance of the waterfowl conservation value of the estuarine wetland. Specific concerns have been expressed regarding:

- loss of waterfowl habitat;
- disturbance to waterfowl;
- contamination of the estuary water with saline water via permeable sediments;
- setting an undesirable land-use precedent;

. the potential need for midge and mosquito control measures and their effect on food sources for waterfowl;

c The effect on Busselton's risk of flooding and storm surge inundation. Specifically, concern has centred on the need to ensure that:

. the loss of the potential flood compensation and storage value of the estuarine flats due to construction of the project does not result in flooding in Busselton;

. the waterways in the development do not allow storm surge into the estuary.

d The effect of construction and operation of the project on the adjacent community. Specific concerns are:

. the effects on groundwater usage adjacent to the development;

. construction traffic;

. traffic movements on the eastern approaches to Busselton;

. source of funds and responsibility for required remedial and management action to be identified;

. landscape impacts;

. foreshore access, treatment and management;

. potential for public health risks from mosquitos and exposure to radioactive mineral sands.

In order to address these concerns, desk studies have been undertaken to review literature on the impact of marina developments and to determine the potential effects of the Project on.

i The physical environment, including hydrogeology, coastal processes, sand bypassing, water quality, (wind data, nutrient inputs, flushing and exchange rates), floodplain and storm surge management (including a review of past rates of loss of seagrass cover and the characteristics of seagrass wrack accumulation and dispersal);

ii The biological environment, with special emphasis on the estuarine wetlands (a review of previous data on waterfowl use of the Vasse-Wonnerup Estuary was supplemented by field surveys of the Project area);

iii The human environment, including the regional and local (adjacent) communities, conservation and landscape values, aboriginal sites, traffic, foreshore access and public health.

The following sections review the available information and relevant literature and describe the potential benefits and negative impacts of the Port Geographe development on the physical, biological and human environment.

5.2 POTENTIAL IMPACTS OF MARINA CONSTRUCTION - LITERATURE REVIEW

A review of Australian and overseas literature up to 1984 was conducted as part of the review of the potential impacts of the Sorrento (now Hillarys) Marina. The review was presented in the ERMP for that project (PWD 1984).

The international (mainly American) literature identified a number of potential impacts which could arise from marina construction including:

- o alteration of existing site habitat,
- o effect on the stability of the adjacent coastline,
- o alteration of nearshore circulation patterns,
- o increased turbidity from the resuspension of sediments by boat movements,
- o sewage contamination,
- o oxygen depletion,
- o oil/petroleum spills,
- o land runoff contamination,
- o metal pollution and the accumulation of metals in the sediments, from antifouling paints.

It was, however the general conclusion of these studies that the majority of the impacts could be avoided or ameliorated by selection of appropriate sites and by appropriate design, particularly with respect to achieving proper flushing and water circulation within the harbour.

Mulvihill et. al. (1980) concluded that "the impact of any structure on the coastal environment is site specific and should be considered on a case by case basis".

In the same review, it was reported that "there is little literature available [up to 1984] on the environmental effects of small boat harbours in Australia".

However, in the four years since that report was written, investigations have been carried out on the functioning and impacts of several harbour and residential waterway developments on the coast of south western Australia.

These include:

- water quality studies in the small boat harbour at Hillarys (DMH pers. comm.);
- water quality studies in the fishing boat harbour at Fremantle (DMH pers. comm.);
- water quality and fisheries studies on Waterside Mandurah residential canal development (LSC, 1987);
- heavy metal content in boat harbour sediments (EPA unpublished information).

In general, these studies have shown that water quality within marina and waterway developments is acceptable. Water quality problems have been recorded only in the fishing boat harbour at Fremantle as a result of a major oil spill (not associated with normal harbour operation). Available data indicates that these developments flush adequately and in the case of the Waterside Mandurah project, provide nursery habitat for a range of marine organisms including prawns, crabs and yellow eye mullet.

Port Geographe would be considered similar to the Hillarys Marina in terms of its relationship to unpolluted nearshore marine waters, although the Port Geographe proposed development differs in that it contains a large residential component and has a more complex waterway arrangement. As such, it bears some similarity to Waterside Mandurah although it differs radically in terms of the quality of its source water.

As pointed out previously, the water quality of canal and other forms of waterway development is very much dependent on their location, the specific conditions which pertain to that location, and to the design of the development. Nevertheless, experience does provide some evidence about the functioning of these developments under local conditions, and this experience is considered relevant to the assessment of this project. The various specialist consultants have reviewed the published data pertaining to their specific areas of study and this information is evaluated in assessing particular impacts of the project.

5.3 IMPACT ASSESSMENT

5.3.1 Effect on the Physical Environment

5.3.1.1 Scope of Effects

The entrance to the development cuts across the coastline in an area that has been subject to recent localised erosion. This section examines the effect of the development on the coastline, particularly on sediment transport, as well as on the immediate offshore area. There will be some influence on the local superficial groundwater resources. The site itself is located partly on the floodplain adjacent the Vasse Estuary. In addition to these effects on the natural environment, an artificial waterway system will be created. The potential water quality aspects of this waterway system are discussed.

5.3.1.2 Topography and Bathymetry

The existing topography of the development site will be substantially modified by:

- excavation for the harbour and waterways,

- addition of landfill to raise the level of the estuarine flats,
- reconstruction of the beach,
- construction of two breakwaters and two groynes,
- earthmoving and levelling in the vicinity of the village centre and beach resort,
- excavation of the moat and drought refuge lakes in the waterfowl conservation area.

Detail on levels and volumes to be moved are outlined in Section 3.7.4.2. Figure 1.2 indicates the area to be topographically modified.

As a result of the modifications and construction of the village centre, the landscape will be altered from an essentially rural vista to one of urban character. The proposed architecture has been selected to blend in with the present urban character of the coastline and the development will look basically like an extension of Busselton.

5.3.1.3 Nearshore Oceanography

The breakwaters will extend only 200m offshore, some 100m farther offshore than the existing Guerin and Russell Street groynes. Studies conducted by Riedel and Byrne (DMII, 1988) indicate that nearshore current orientation and direction of flow are largely dependant on strength and direction of prevailing wind. It is likely that energy shadows will be created in the lee zone of breakwaters under some wind conditions, causing entrained material (seagrass and sediment) to drop out of suspension locally. However the proposed breakwaters are unlikely to affect regional patterns of water circulation.

5.3.1.4 Coastal Stability

The proposed project will not threaten coastal stability in the region and, in fact, will stabilise a section of coast which historically has been unstable. This stabilisation will result from breakwater construction adjacent to the development site, major beach nourishment works to

reconstruct the eroded beach, and the initiation of a coastal management programme (CMP) aimed at maintaining the stability of the coastline. The main components of the management programme will be a sand bypass operation, foreshore revegetation and protection works and controlled public access ways to the beach. Details of the CMP are presented in Section 6 of this ERMP.

The proposed sand bypass operation has been designed on the basis of results of the recently released DMH 1988 coastal process study for the Port Geographe site (DMH 1988). This study indicates that there is on average a net sediment movement of about 50,000 cubic metres per year from west to east along the coast. This could in very stormy years increase to about 80,000 cubic metres per year. During storms from the north to northeast there can be a reversal of this movement but the volume being returned is comparatively small, being of the order 6,000 - 10,000 cubic metres.

The development allows for a sand trap to the west of the entrance channel, with sufficient space to trap about five years of sediment movement. It is intended that the sediment trapped in the first two years will be left in the trap to build the coastline forward. Referring to Figure 5.2 it can be seen that the nearest seagrass is approximately 400m from the sand trap. Risk to the seagrass both offshore and down drift if negligible. The rest of the sand will be bypassed to the east as required. With this arrangement there will be a shortfall of sand supplied to the east of the development for the first five years. This sand will be made up with sand excavated from within the development. A buffer equivalent in volume to the sand trapped will be placed on the eastern side of the last groyne and this will be available for transport eastward along the coast.

During stormy periods sand is scoured from the beach and the dune system and forms a sand bar offshore. During subsequent milder weather this sand is returned to the beach and recaptured by dune vegetation. Calculations by Riedel and Byrne (A Byrne pers. comm.) indicate that during an extreme storm event up to 60 cubic metres of sand per metre length of beach could be scoured off the beach. The development allows for at least 100 cubic metres of sand per metre as a buffer in front of all permanent facilities.

Measurements of the amount of sand removed from beaches under strom attack have been undertaken in the United States and Holland. Typically it has been found that up to 80-100m cubed per metre length of beach can be desposited offshore during an extreme (say 1 in 50 year) event.

Calculations using the method of Swart, (1976) indicate that for Busselton approximately 60m cubed per metre of beach could be expected to be removed during an 8 hour storm event. These calculations are consistent with storms measured elsewhere. The slightly lower values obtained are probably explained by the relatively flat offshore seabed at Busselton. This dissipates some of the wave energy by the time it reaches the beach.

It is reocmmended the development for this project be restricted such that a buffer of at least 100 cubic metres be provided between any housing and mean sea level where wave protection is not offered by the breakwaters. This buffer should take into account the normal seasonal variations in the shape of the beach adjacent to the groyne on the eastern side of the harbour.

5.3.1.5 Flood Risk

Port Geographe will not adversely affect existing drainage or flood compensation characteristics of the Vasse Estuary. WAWA have advised that projection of the development onto the estuarine flats of the Vasse floodplain does not contribute to a flood risk to Busselton as it does not impair the drainage functions of the estuary and will have an insignificant effect on flood levels in the estuary.

Conversely, the proposed development will not cause the estuary to be flooded during extreme storm events. As discussed in Section 3.7.1.1 and 3.7.1.2, the effects of extreme events (such as Cyclone Alby) have been incorporated into calculations of extreme water levels. The level to which it is proposed to construct the development is well above anticipated maximum water levels. Flooding of the estuary via the waterways will not be possible.

5.3.1.6 Hydrology of the Vasse Estuary

The proposed project will not adversely affect either the quantity or the quality of water in Vasse Estuary as a result of subterranean connections.

During preliminary discussions in 1983, concern was expressed by officers of the EPA and CALM about possible effects of the proposed waterways on the quality and quantity of water in the Vasse Estuary due to the possibility that:

a the salt water interface will be brought closer to the estuary and may contaminate the fresh water during summer, and

b the fresh water in the estuary at the end of winter may drain out through the canals via subterranean connections.

Stratigraphic and hydrogeological studies conducted in 1983 by LSC (Appendix 2) show that neither of the above is likely to occur because:

i the freshwater in the estuary is perched above impermeable estuarine muds which effectively seal the water from the underlying strata;

ii there is no lateral movement of groundwater in the estuarine flats;

iii groundwater and surficial soil water in the estuarine flats is already highly saline, ranging from 20,000 to 100,000 mg/L. Hence any salt water intrusion will not be noticeable above background salinity;

iv the interface between the fresh to low brackish surface water in the estuary/estuarine channels and the saline groundwater of the estuarine flats is sharp and narrow (less than 150m), indicating that there is little lateral movement of groundwater, so the proposed waterways could be located as close as 150m to the estuary without adverse impact on the maintenance of the freshwater regime.

As a result, there is little likelihood that the waterways will contaminate the fresh water of the estuary, or enable the freshwater to drain out of the estuary via estuarine connections.

5.3.1.7 Groundwater Resources

The proposed development will have negligible long-term effect on the thin lens of fresh groundwater which occurs beneath the coastal dune ridge plain. However investigations by Rockwater (Appendix 6) indicate that short-term effects can be expected during the construction period as a result of dewatering activity required to allow 'dry' excavation of the harbour and waterways. The effects will comprise:

a Reduction in groundwater levels in the vicinity of the excavation. Calculations based on "worst case" aquifer characteristics indicated a water level lowering of up to 0.1m at a distance of 1km from the excavation;

b Landward migration of the salt/freshwater interface by about 50m.

However these above effects will be temporary. Once the waterways are flooded and fresh groundwater levels are restored beneath the coastal dune plain, the salt water interface will gradually regain its original position, except close to the entrance channel and the harbour. The effect of these temporary modifications to the shallow dune aquifer on the adjacent community is detailed in Section 5.3.3.2 (e) of this report.

5.3.1.8 Harbour and Waterway Quality

Local sea water quality is not expected to deteriorate as a result of the project. Localised turbidity will however occur during the construction period as a result of;

- groyne emplacement;
- harbour dredging;

o disposal of dewatering liquids.

This will be a temporary and relatively short-term event and is unlikely to adversely affect seagrass communities which are located some 100-250m offshore from the nearest groyne.

Water quality within the harbour and waterways will be much the same as that in nearshore waters of the bay. Adequate flushing will be provided by tidal and wind-induced mixing of the water mass.

Riedel and Byrne (Appendix 5) have investigated the flushing characteristics of the proposed waterways and harbour and show that the waterways will have a tidal exchange coefficient of 0.15 (ie 15% of water volume will be exchanged each tide on average). In addition, the waterways have been oriented in the direction of the predominant winds to ensure water mixing and maximise wind-assisted flushing. These two factors, plus the fact that there will be no nutrient input into the waterways from sewage (which will be piped to the Busselton treatment plant), confirm that water quality should not decrease to levels of either ecologic or public health concern and will generally be oceanic in character. The Port Geographe management programme will ensure minimal entry of nutrients and other contaminants to the waterways, and will also allow for the removal of litter and floating debris as appropriate.

5.3.2 Effect on the Biological Environment

5.3.2.1 Scope of Effects

The effects of the project on the biological environment may be divided into those effects which are a consequence of carrying out the project and are essentially permanent in nature (eg direct loss of habitat), those which relate only to the construction phase and are thus of short term duration (eg the impact on marine biota of increased water turbidity) and those which are ongoing but may be modified by various management techniques for example disturbance to waterfowl.

The major permanent impact is the loss of terrestrial habitat previously used for grazing purposes.

5.3.2.2 Marine Biota

The proposed project will not adversely affect marine resources of the region. In fact, the provision of additional nursery habitat for marine organisms will be a benefit. The diversity of organisms is also likely to increase as a result of the provision of new habitat types such as breakwaters, walls and sheltered basins.

The project impacts are confined to the loss of a small area of sandy subtidal habitat caused by reclamation of the beach area. Due to the extent of this habitat within Geographe Bay, and the fact that most of the area concerned was part of the terrestrial environment as recently as 20 years ago, this impact is not considered to be significant.

The breakwaters and groynes are unlikely to have any detectable effect on nearshore seasonal migration of important commercial or recreational fish species such as Australia salmon or herring.

The major constructional impact which will arise will be a temporary increase in turbidity of nearshore waters in the vicinity of the project site during the placement of breakwater core and armour material and sand fill for the reclaimed beach and discharge of shallow groundwater during dewatering operations.

There will be some impact on sedentary organisms in close proximity to sites of high turbidity, but as the nearest seagrass beds are more than 500m offshore the impact will be confined to the low-productivity sand habitat. Underwater observations in the vicinity of the Hillary's Boat Harbour confirm that seagrass beds immediately adjacent to breakwaters did not suffer any long-term damage as a result of construction operations.

Areas affected by increased turbidity may be temporarily avoided by fish but this will cease when construction is completed. Sedentary organisms will also readily recolonise from adjacent areas. Solid substrates (breakwaters and walls) will be colonised by a new fouling community (probably similar to that presently occurring on Busselton Jetty).

The ongoing impact of the project on water quality is expected to be undetectable outside of the harbour.

Studies at the Waterside Mandurah canals project have shown that such areas form a useful additional nursery and refuge areas (LSC, 1987).

5.3.2.3 Terrestrial Biota

The proposed project will have two adverse impacts on the terrestrial system of the region. It will remove some 75ha of coastal peppermint woodland and in doing so will reduce the habitat available for the gazetted Western Ringtail Possum and a range of bush birds.

The native peppermint is widely distributed through the southwest and its loss at this site would not threaten the survival of these species.

The peppermint in the Vasse-Wonnerup area is recognised as the preferred habitat of the Western Ringtail Possum and it is considered that further loss of this species habitat is significant. Ninox Wildlife Consulting has recently confirmed the presence of the species in the development area by locating several nests. In southern Australia up to five nests are used by a single individual indicating that the development area population is not necessarily large. Prime habitat for this species near Vasse-Wonnerup is the very dense, creeper-covered peppermint woodland along the Abba and Sabina River (W K Youngson, pers. obs.). The sparse, recently burnt woodland in the development area cannot be considered as providing optimum conditions for this animal.

The current status of the Western Ringtail Possum in the development area is under investigation and the results of this study will be available to the EPA before the conclusion of the assessment period. If, on the advice of CALM, a trapping and relocation programme is considered to be warranted, this work will be undertaken by a team experienced in handling native mammals and will take place immediately prior to the commencement of clearing. Options for relocation include Ludlow Forest, remaining areas of naturally vegetated public open space within the development area (Ringtail Possums use this type of habitat in Busselton townsite) or providing CALM or South Perth Zoo with enough animals to manage a captive breeding programme.

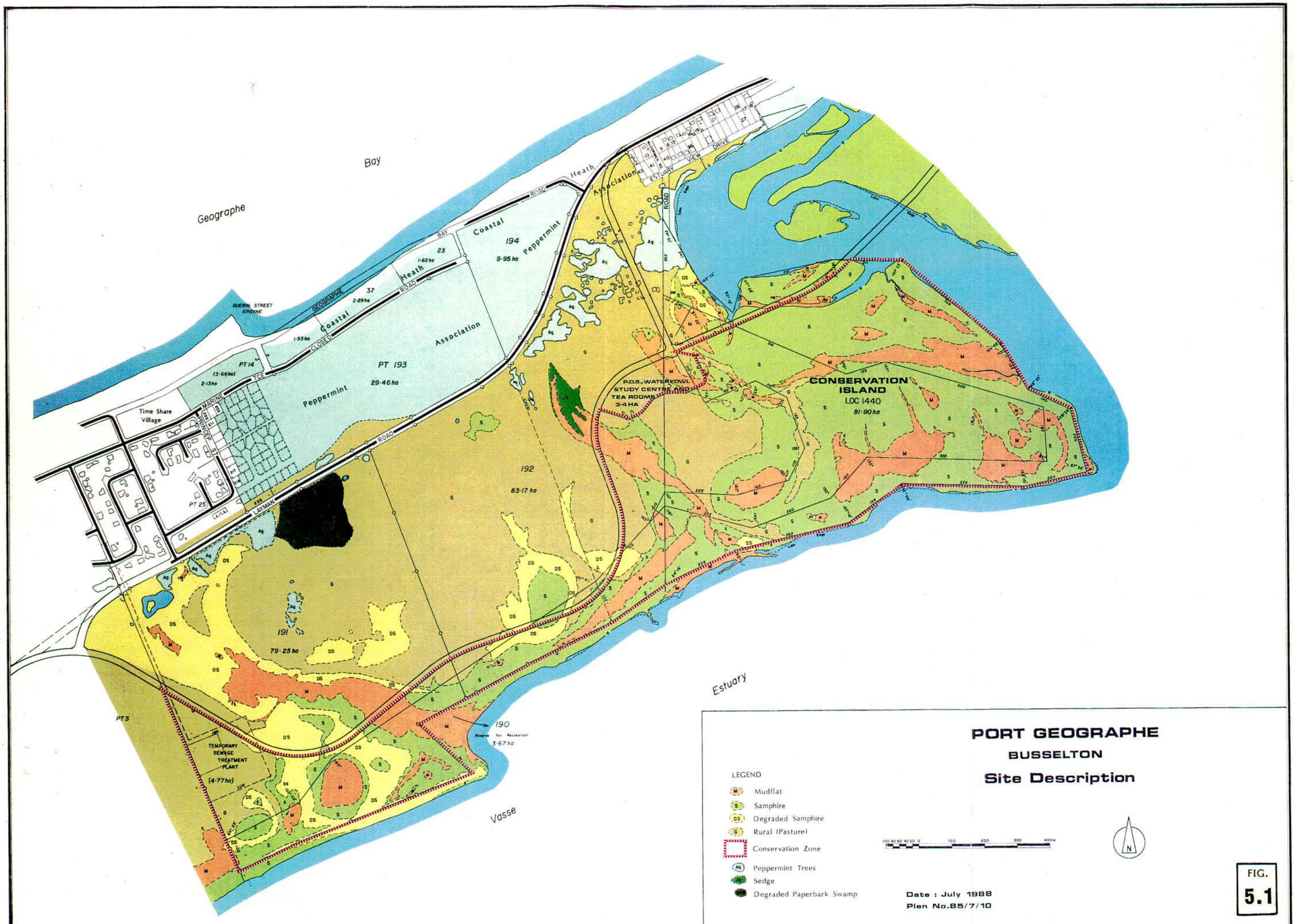
5.3.2.4 Estuarine and Wetland Biota

The proposed project is unlikely to cause a detectable reduction in the abundance of waterbirds utilising Vasse Estuary. Certain species such as the Pelican, Darter, Pied Cormorant and Silver Gull may become more common in the vicinity of the harbour since these species prefer seawater. Studies conducted for the Proponent by Ninox (Appendix 4) and LSC (Appendix 7) indicate that the bulk of the estuarine flat habitat which will be permanently alienated by the development are:

- not a significant proportion of the total area of similar habitat available in the region;
- not used intensively by a wide range of waterbirds for either feeding or breeding purposes;
- not supportive of any species of wetland birds declared "rare or otherwise in need of special protection".
- not supportive of significant numbers of birds of high local conservation status such as the Black Swan, Great Egret and Yellow-billed Spoonbill;

The development area will modify the following area of estuarine flat habitats (Figure 5.1 and 5.2):

- 108ha of grazing pasture,
- 16ha of stock affected samphire flat which is inundated in winter and early spring,
- 1ha of degraded paperbark swamp and surrounding sedgeland which is inundated during winter and early spring.



PORT GEOGRAPHE

BUSSELTON

Site Description

LEGEND

- Mudflat
- Samphire
- Degraded Samphire
- Rural (Pasture)
- Conservation Zone
- Peppermint Trees
- Sedge
- Degraded Paperbark Swamp

100 80 60 40 20 0 100 200 300 400m

N

Date : July 1988

Plan No.85/7/10

FIG. 5.1

RUSSELL TAYLOR and WILLIAM BURRELL Consultants in Town Planning and Civic Design 187 Roberts Road Subiaco Phone : 382 2911

The area of grazing pasture represents 10% of similar habitat available around the edge of the Vasse-Wonnerup Estuaries, and less than 1% of similar habitat available throughout the Busselton region.

The area of samphire which will be lost represents some 3% of similar habitat type available in the vicinity of the Vasse Estuary - studies by Ninox (Appendix 4) show that this type of habitat in the development site is primarily used in winter by a small range of species only one of which is abundant, the White-fronted Chat. Maximum breeding of this species is mainly concentrated in the inundated samphire at the southern boundary of the development site. Relatively low numbers of other species occur here but are unlikely to be affected to any great extent by a loss of a portion of this habitat. Inundated samphire is extremely well represented in the proposed Conservation Area.

The degraded paperbark swamp and its sedge margins at the northern limits of the development site showed higher densities of Pacific Black Duck than any other location (7.3 birds per 10ha, Appendix 4). Breeding also took place here. Several other poorly represented species such as the Grey Teal, Australian Shoveler and Hardhead were also present but in low numbers. None of these species are locally or regionally threatened and loss of the above site will have not detectable effect on populations. The small degraded swamp dries out in early summer when activity virtually ceases and stock use the area as an extension of grazing land.

In contract to these areas studies by Ninox (Appendix 4) and the RAOU of the abundance and distribution of waterfowl using the estuary show that the most important estuarine habitat types utilised by waterfowl are:

- the seasonally exposed mudflats and bare shorelines of the estuary;
- the open, deeper waterbody of the estuary;
- the shallows fringing the estuary;
- the samphire and sedge which fringes the estuary;
- the very low, extensive samphire patches at the extreme northern limits of Wonnerup Estuary (largest breeding aggregation of Black Swans in Western Australia);

The areas of the estuary which regularly support the greatest abundance of waterfowl are located in the vicinity of:

- o the outflow marshes at the mouth of the Abba and Sabina Rivers;
- o the complex of samphire flats and sedge, pools and islands which occur on Giles property, the importance of which have only recently been ascertained by the RAOU and Ninox;
- o areas which maintain water throughout the dry summer months and act as drought refuges;
  - the narrow, deep channel east of Giles property,
  - the large bay between the mouths of the Abba and Sabina Rivers,
  - the deep pools beyond the southern boundary of the development.

Therefore, the removal of the greatly modified estuarine flats, sections of the adjacent samphire and associated relict habitats is most unlikely to result in a detectable reduction in waterfowl abundance and diversity in the estuary. This is especially apparent when it is considered that earlier studies by Ninox show that very little activity takes place in the northern sections of the project area in summer while up to 33,000 birds can congregate in drought refuge areas on the estuary itself (RAOU data for 1986).

While habitat modification is unlikely to result in a detectable reduction in waterfowl abundance or diversity in the estuary, it is necessary to identify possible impacts resulting from normal operation of the development and the introduction of a relatively large resident population into the area. Communications with CALM have identified the following concerns regarding the operational effects of the development on the conservation value of the estuary for waterfowl:

- o disturbance of avifauna by a nearby residential population;
- o effects of insect pest control measures on waterfowl food sources which may be requested by a nearby residential community.

These concerns have been investigated by LSC (Appendix 7) and the following conclusions have been drawn.

Four potential sources of disturbance to waterbirds are likely at the proposed development site. These are:

- o noise from boats, cars and other sources within the development;
- o illumination of the shorelines and water opposite the development;
- o physical disturbance of the birds by residents intruding on feeding, breeding and refuge areas;
- o harassment and predation by dogs and cats.

Studies of the effects of noise on waterbird populations at a development site in Mandurah have indicated that noise has little effect on most waterbirds, especially if a buffer (eg trees or mudflats) is present (Appendix 7). It is therefore likely that the limited amount of noise produced by the proposed development will have little observable effect on waterbirds.

Similarly, low light intensity levels such as are likely to occur at the proposed development should cause minimal disturbance to waterfowl. Many metropolitan wetlands are subject to high light levels and breeding of waterbirds still takes place (eg Shenton Park, Monger and Hyde Park Lakes).

There is very little published information on the effects of physical disturbance to waterfowl from a nearby residential community. Much of the available information on this topic indicates that the availability and biological productivity of suitable nesting, feeding and roosting habitat is of more concern to waterbirds than the level of non-life threatening disturbances to which they are exposed. Numerous examples of this are evident throughout the metropolitan area of Perth. One of the best and most appropriate examples is provided by Alfred Cove on the Swan River. The waterfowl characteristics of this area have recently been investigated by the EPA (1987). This study showed that Alfred Cove is considered to be one of the most important waterbird habitats in southwest Australia and yet it occurs in the heart of metropolitan Perth. The cove is under substantial pressure from adjacent residential areas and yet still manages to provide breeding habitat for about 10 species of waterbird, three of which are relatively sensitive (ie Spotless Crake, Black-Winged Stilts and Buff-Banded Rail.

The wetlands adjoining the proposed development area, like most wetlands in southwestern Australia, is already under pressure from cats, foxes and stock animals. Development of the area will exclude cattle and horses and probably reduce predation by foxes. This, however, will be offset by an increase in the number of cats and dogs present in the vicinity of sensitive areas. Cats are a virtually uncontrollable factor but cannot now be considered as other than part of the Australian fauna, since they are here to stay. There is some evidence to suggest that their effect on wildlife has reached a plateau and that they are filling niches left by the now scarce marsupial predators such as the Western Quoll (Dasyurus geoffroii) (Ninox, Appendix 4).

Harassment of waterbirds by dogs can be a problem as is immediately apparent from the uncontrolled behaviour seen on the Swan and Canning Estuary foreshore and metropolitan lakes. Unlike cats, this activity can be reduced. Enforcement of the recently-revised dog laws and a resident education programme could minimise this problem.

However, to ensure that disturbance to the waterfowl using the estuary is kept to a minimum, the proponent will establish the Vasse Waterfowl Conservation Area and Management Programme. This programme will consist primarily of the following management actions:

- removal of all stock animals from the remaining grazing land;
- construction of a dog-proof fence around the estuary edge of the new Layman Road alignment;
- construction of a moat and lake to protect the most valuable wetlands on Giles land from foxes and cats.

The need for insect pest control measures which could affect waterfowl food stocks has not yet been established. The two potential nuisance organisms are mosquitos and non-biting midges. The Busselton Shire Council does not consider mosquitos or midges to be a major nuisance or public health problem in the Busselton area. Local residents (in the vicinity of the development site) also support this view, but add that both mosquitos and midges are a minor nuisance for short periods at some times of the year. Mosquitos tend to be abundant during the four or five months of winter-spring (July to November) and at nuisance levels during September-October. Midges are present only for one to two months during early summer (November - December).

The Council implements an insect pest control programme during these periods of the year. The programme mainly involves fogging residential areas with insect adulticide. Both the Council and the Health Department of Western Australia view this programme as adequate. It is likely that this programme will be extended to the new residential areas associated with the development.

The problem of midges and mosquitos is unavoidable in most residential areas adjacent to wetlands in southwestern Australia.. Despite their nuisance value, they form an integral part of the biological environment. Midge and mosquito larvae are an important food source for many vertebrates and some invertebrates in the food chain of an aquatic ecosystem and also keep the aquatic environment clean by consuming and recycling organic debris (Ali, 1980). Control measures invariably diminish the natural resource base of an area to a greater or lesser degree depending on the technique used. Chemical control measures have been shown to result in degradation of the wetland environment to a degree that can increase the insect pest problems due to loss of natural predators such as dragonflies (Davis, 1987).

It is recognised, however, that the development will place a human community close to potential mosquito and midge breeding areas and that this may result in pressure to control the insects at the larval stage rather than at the adult stage as occurs at present. Should such pressure eventuate it would be necessary to ensure that the juvenile waterfowl using the estuary for nursery purposes will not be adversely affected through the loss of invertebrate food stocks which can be decimated through inappropriate use of insect larvicides. Techniques for larval control of insect pests that are compatible with preservation of ecological values of a wetland do exist. Such techniques can be designed and based on information regarding the location of breeding sites and the population characteristics of the nuisance insect.

In order to determine whether or not a potential insect pest problem exists, and enable design of an appropriate control method if a potential problem is found to exist, the proponent has initiated field investigations into the population characteristics and breeding location of both mosquitos and midges in the Vasse Estuary. These investigations were initiated in July 1988 and preliminary reports and findings are due in December 1988. These studies form part of the proponents commitment to development of an estuary management programme.

5.3.3 Effect on the Human Environment

5.3.3.1 Scope of Effects

The Port Geographe development will affect the social environment on local (neighbouring community), regional (Busselton region) and State scales.

At the local level, residential and tourist development will involve a change in land use of the site, with consequent impacts related to construction and operation of residential, harbour and tourist facilities, road design and traffic flow and the provision of services.

The neighbouring community will benefit from increased facilities and recreational opportunities and from the regional economic growth. Issues of concern would include coastal access, traffic flows and conservation issues.

On a regional scale, the development will provide a range of residential, tourist and elderly accommodation, recreational attractions and facilities and boat launching, mooring and harbour facilities, with consequent benefits for regional employment, recreational and accommodation opportunities. The tourist industry is becoming increasingly important to the regional economy and benefits from encouraging the tourist industry will extend to the State level. The development will provide facilities for interstate and overseas visitors and the harbour facilities will provide a link in a coastal 'oceanway' between Fremantle and Busselton which is considered an initiative for State Tourism (WA Tourism Commission, 1986).

As well as economic and demographic effects, the development will take place within a region of recognised conservation and landscape value and potential impacts on the environment of Geographe Bay and the Vasse Estuary and its associated wetlands are recognised.

The following consideration of the impact of the development on the human environment therefore takes account of both regional and local impacts and identifies potential benefits to the community and possible negative impacts. The impacts on the human environment are considered in the context of the overall planning for development of the region as presented in the State Planning Commission's Leeuwin-Naturaliste Region Plan.

5.3.3.2 Local Impact

a Land-Use Changes

The most obvious local impact will be a change in land use of the development area from grazing to residential, commercial and harbour development. The site does not have soil types suitable for intensive agriculture, and is not subject to proposals for future mineral sand mining. There are no identified historic or ethnographic sites.

This change in land use is in keeping with identified needs for further housing, tourist and commercial development in the region, and does not preclude any alternative land use of recognised importance, other than the land's present value as a buffer zone to the estuary and its important fringing wetlands.

Approval of the project will define the boundary between conservation and development areas discussed, but not defined by the EPA (DCE, 1976) in their recommendations on the CRTC (1974) report.

The Proponent has put forward the proposed conservation line on the basis that it protects the most valuable wetland areas, as requested by the EPA, while providing the necessary land for development to make the project viable.

This proposal has the added advantage that the identified conservation areas will be ceded to the State free of charge to be managed in perpetuity as a waterfowl conservation reserve.

A concern expressed by CALM has been that approval of this project would constitute a precedent for further development of estuarine floodplains.

This project will not necessarily establish a precedent for development of low-lying land in the Busselton region. The Council will declare the development site as a 'harbour development zone. This is a special zoning created specifically because the Council recognises the need for a harbour in the region and that this site is the only suitable site available in the short to medium term.

b Coastal Access

The development will increase the local stability of the shoreline and provide improved road access to the coast. Currently, the erosion of Geographe Bay Road near the north eastern boundary of the property prevents all but pedestrian access to the section of coastline fronting the development site.

The harbour development and boating facilities will increase opportunities for public access to this section of coastline and to the offshore marine environment.

Pedestrian access along the length of the beach frontage will be prevented by construction of the entrance channel to the waterways, but continuity of pedestrian use will be ensured by providing a bridge over the waterways within the development. Access to the coastline for the residents of Busselton, and maintenance of the character of the coastline will be ensured by the Coastal Management Plan.

c Marine Water Uses

A potential effect of the increased population pressure will be to increase fishing pressure on local fish stocks. However this is likely to occur as a result of natural population growth whether or not this project proceeds. Increased fishing pressure will in part be compensated for by the provision of substantial additional fish and crab nursery areas within the sheltered waters of the development. No adverse impact on fish stocks can be expected to be caused solely by the development.

The development will assist nearshore based fishermen to diversify into offshore fishing activities thereby reducing competition between recreational and commercial fishermen for the same nearshore resource. Fishing pressure can be managed via regulations under the Fisheries Act if necessary.

d Traffic

Construction of the proposed development will necessitate the relocation of Layman Road further inland. The proposed treatment of Layman Road (Refer Section 3.4.2) will ensure that it can handle the volume of traffic that will be generated by the project. In addition, however, it will provide a more efficient and more scenic arterial link eastward of Busselton than is provided by the existing alignment.

Studies conducted by Airey Ryan and Hill (Appendix 9) show that the project will increase the volume of traffic using Layman Road by less that 50% above that generated by the existing development, together with the presently zoned land and tourist traffic in East Busselton. The ultimate development of the Vasse Wonnerup Conservation Park (2008) is expected to generate traffic around the site in the order of 1,090 upm or 12,120 vpd which fall well within the capacity of a single carriageway two way road of standard 7.4m width. For aesthetic reasons the Proponent is contemplating making Layman Road a dual 7m wide carriageway system which will have an even higher capacity.

The project will hasten the development of Layman Road as an arterial distributor ensuring the eastern access to Busselton, and will reduce present traffic flows along Geographe Bay Road and The Esplanade. This will be of benefit to residents of both these roads.

e Groundwater Use

A bore census conducted by Rockwater (Appendix 6) identified a considerable usage of the resource beneath the coastal dune ridge by residents of nearby areas (over 100 bores and wells). The proposed project will not adversely affect present domestic users of this resource in the long term.

Bores which occur close to the development area may be slightly affected during the construction period as a result of dewatering operations causing drawdown (reduced water levels locally) and salt water encroachment (landward migration of seawater). In order to minimise any effect, dewatering operations will be conducted in stages rather than continuously, and will be conducted during winter if possible when extraction rates are at their minimum.

Groundwater levels and quality in the vicinity of the development will be monitored and if local residents are shown to be inconvenienced they will be appropriately compensated by the Proponent.

f Construction Impacts

During construction, local residents in Eastern Busselton may be inconvenienced at times by noise associated with traffic movements and earthmoving activities on site. However, on-site management programmes will ensure that any inconvenience is restricted to the minimum practicable. It is proposed to leave the clearing of the peppermint woodland between the harbour and East Busselton until after harbour construction is completed, thereby providing a buffer to construction noise.

g Radiation Hazard

A mineral sands deposit known as the Wonnerup Beach deposit contains ilmenite, rutile, zircon and garnet and may also contain monazite. This deposit has been mined to the northeast of the development site but not on the site itself. Radioactivity from minerals such as monazite and zircon in tailings from mineral sand mining has been a problem in some areas. Concern has been expressed that excavation and subsequent seawater inundation of the canals and possible use of the excavated material as landfill could lead to health problems. However, recent investigations by the Geological Survey of Western Australia concluded that monazite was not prevalent in the vicinity of the proposed development and as a result, no radiation hazard exists.

5.3.3.3 Regional Impact

At the regional scale, the project will provide substantial economic and community benefits through the provision of:

- harbour and boating facilities;
- new residential and recreational opportunities;
- tourist accommodation and attractions;
- waterfowl conservation areas and education facilities;
- an estuary management plan;
- short and long-term employment opportunities;
- increased fish and crab nursery grounds.

A number of local industries will benefit as a result, not the least of which will be the growing tourism industry. This industry will benefit from the provision of an all-season tourist attraction in the form of both the harbour village and the Waterfowl Conservation Park. Tourist accommodation will also be increased.

The fishing and boating industry will benefit by the provision of a safe harbour and marina facilities, thereby allowing both industries to expand. The harbour will also provide increased tourism by allowing the extension of the west coast 'oceanway' which exists between Geraldton and Bunbury harbours.

The local building industry will also benefit by the provision of employment and service opportunities.

No adverse economic impacts are envisaged. The only way in which such impacts could arise is if the State or local ratepayers have to contribute financially to the management of the project, particularly its regular sand bypass costs. This will not eventuate because management of the development will be funded by the user. This will be achieved by a financial levy system applying to land within the development boundaries, and through fees raised from boat launching and mooring charges.

Construction of the Village Centre within Port Geographe has been limited so as to recognise the importance of Busselton Town Centre and the need to allow its consolidation as the dominant centre. New population attracted by the project will help this consolidation process.

The existing floor space in urban Busselton has been estimated at 27,700 square metres (Gilchrist 1988).

Port Geographe Village Centre has been assessed on the basis of catchment area, definitions, annual expenditure, floorspace productivity ratio and the distribution of floorspace between the Village Centre and other locations within the Vasse Wonnerup Conservation Park and East Busselton. The Village Centre is planned to serve only locally generated needs and tourists. Its impact on Busselton Town Centre is therefore likely to be slight. The two should complement one another.

Therefore, no major negative impacts on the social environment are likely and substantial economic and social benefits will accrue both locally and regionally.

6.0 ENVIRONMENTAL MANAGEMENT

The four management programmes proposed for ameliorating environmental impacts and their objectives have been described previously in this report. This section summarises details of management, funding and reporting commitments by the proponent and identifies the authorities responsible for ensuring the successful achievement of management objectives for each programme.

The four programmes are identified as:

- o Port Geographe Management Programme;
- o Coastal Management Programme;
- o Waterfowl Conservation and Management Programme;
- o Estuary Management Programme.

Details of each programme are provided below.

6.1 PORT GEOGRAPHE MANAGEMENT PROGRAMME

6.1.1 Objectives

The objectives of the Port Geographe Management programme are to :

i minimise inconvenience to local residents during the construction phase of the project, and

ii ensure the serviceability and integrity of all public infrastructure and facilities and maintain acceptable water quality standards within the harbour and waterways.

6.1.2 Construction Phase Management

Details of the construction works are provided in Section 3. In summary, construction of the project will require:

- relocation of Layman Road,
- relocation of the existing sewage treatment plant,
- clearing and levelling of development site,
- excavation of harbour and waterways,
- dewatering of groundwater during excavation,
- soil stabilisation,
- construction of walls and major facilities,
- construction of breakwaters and groynes.

These activities will generate construction traffic, emissions (dust and gases) and noise. Details of management activities that will be implemented to reduce inconvenience to nearby residents are outlined below.

6.1.2.1 Relocation of Layman Road

Layman Road will be reconstructed as the first phase of the development in order to provide continuity of access around the site and to define the construction area in order to prevent construction activity from overspilling into the proposed conservation zone. The existing section of Layman Road will not be closed until the alternative route is completed.

6.1.2.2 Construction Traffic

Construction traffic will have access to the site from Bussell Highway via the eastern end of Layman Road thereby minimising traffic through existing residential areas of Busselton. Limitation of working hours to between 7.00 am and 6.00 pm will help to minimise inconvenience to local residents.

6.1.2.3 Construction Noise

The majority of the construction activity will be undertaken in the central part of the site which is most distant from existing built-up areas and will therefore assist in minimising the impact of noise on adjacent residents. A buffer of trees will be left between the harbour site and nearby residents to further reduce noise levels.

6.1.2.4 Dewatering and Groundwater

There are a number of private water supply bores in the vicinity of the project which could be affected by dewatering operations. A series of monitoring piezometers will be installed and any private bore users who suffer water shortages will be compensated. However every attempt will be made to ensure this does not happen.

Management options available include:

- conducting dewatering operations during winter when groundwater extraction rates are minimal and replenishment is high;
- conduct dewatering operations in short stages.

6.1.2.5 Public Access to Site and Beach

Public access to the site will be restricted during the construction period to ensure public safety. In addition, access to the beach where breakwater construction or beach reconstruction is being undertaken will be restricted until construction works are completed.

6.1.2.6 Sand Stabilisation

Soil surfaces exposed during earthworks are expected to be moist and thus result in little dust generation. Water from dewatering operations will be available for dust suppression purposes if required. Soil surfaces will be revegetated to prevent erosion upon completion of filling and compaction.

6.1.2.7 Fertiliser Application

Land will be progressively filled during the construction phases and upon completion will be stabilized with vegetation. Fertiliser application required to promote the growth of the plant cover will be limited to the minimum application of a slow-release type fertiliser.

6.1.2.8 Waste Disposal

All excavated material will be reused on site. In the event that clay which is unsuited to use on building sites is encountered this material will be mixed with other soil and used in landscaping Public Open Space areas.

Armour and limestone core material for the breakwaters will be imported onto the site from one of the local mineral sand mining operations.

Any waste materials generated during construction (ie rubbish, waste construction materials, etc) will be disposed of at the Shire rubbish dump in accordance with council operations.

6.1.2.9 Aboriginal Sites

The Proponent is aware of the existence, and provisions of the Aboriginal Heritage Act, 1972. The appropriate authorities will be notified in the event that materials of Aboriginal origin are unearthed during the construction period.

6.1.3 Operation Phase Management

Management of the development during the operation phase will be necessary largely to ensure the efficient operation and structural integrity of public facilities, and to maintain a high standard of water quality and aesthetics for the enjoyment of both residents and visitors. The following management actions will be implemented to achieve the above objectives. Most activities are aimed at minimising the entry of nutrients and other contaminants to the waterways.

6.1.3.1 Public Open Space

Open space will be landscaped with low maintenance species, in order to minimise nutrient contribution to the waterways, before being transferred to the local authority.

6.1.3.2 Litter

Notwithstanding local authority litter regulations and policing by the harbour manager it is inevitable that litter will periodically enter the waterways. It will be the responsibility of the harbour manager to remove any floating litter from the harbour area.

6.1.3.3 Seagrass Wrack

Wrack collecting within the harbour area will be removed if necessary by the harbour manager and disposed of offsite, either by releasing it back into the ocean downdrift of the breakwaters or by using it for beach stabilisation works.

6.1.3.4 Fuel and Oil Spills

Minor fuel spills which occur during refuelling operations will be allowed to dissipate naturally. Drainage from all boat servicing areas will be passed through grease traps to prevent pollution of the harbour by oil. Management of any fuel or oil spill within the harbour will be the responsibility of the harbour manager. One of the harbour manager's responsibilities will be to develop an Emergency Procedure Manual, which will cover such matters as major oil spills and fires.

6.1.3.5 Drainage

i Drainage from all road and other paved surfaces will be passed through grease/silt traps before the water is discharged to the harbour in order to maintain water quality. Runoff from boat storage and work areas will be trapped in sumps, where material from antifouling stripping can be trapped and periodically removed.

ii Boat maintenance facilities will be incorporated in the harbour as part of the Marina. Waste disposal from maintenance will be properly disposed of, other than into the harbour.

6.1.3.6 Navigable Water Depth and Navigation Aids

Navigable water depth within the development will be maintained as long as the sand bypassing/dredging programme is adhered to. In the event of unforeseen siltation of the waterways, maintenance dredging will be undertaken in accordance with the State agreement.

Navigation aids will be provided in accordance with the requirements of the Department of Marine and Harbours.

6.1.4.7 Public Education

Residents of the development will be encouraged to minimise use of fertilisers on private gardens. Information on landscaping with native plants and use of slow-release fertilisers will be distributed to all residents.

Boat owners will be required to use sullage pumpout facilities and refrain from operating boat toilets inside the waterways. The pumpout facility will be located in the public marina.

6.1.4 Monitoring

6.1.4.1 Salinity of Estuary Water

The salinity of estuary water at a number of selected sites will be monitored both prior to, during and subsequent to completion of construction of the waterways to confirm that the waterways have not contaminated the freshwater resource utilised by the waterfowl.

6.1.4.2 Groundwater Quality and Levels in Coastal Dunes

A series of peizometers will be installed at selected locations emanating away from the development and extending into nearby residential areas. These bores will be used to monitor the effects of the dewatering operation and provide warning to construction management of potential inconvenience to domestic users of the resource.

6.1.4.3 Water Quality in the Harbour and Waterways

The proposed usage of the harbour and waterways is for navigation and boating use only (ie Beneficial Use No. 16) (DCE 1981). No provision for swimming will be made.

Water quality in the harbour and waterways will be monitored at selected sites on a semi annual basis during the first four years of operation and on a quarterly basis on the fifth year. The parameters to be monitored will include

- aesthetics (by visual observation),
- salinity (throughout water column to check for stratification),
- dissolved oxygen (surface and 0.5m from bottom of waterways),
- total suspended solids (midway between top and bottom of water),
- total nitrogen (midway between top and bottom of water),
- total phosphorus (midway between top and bottom of water),
- chlorophyll 'a' (midway between top and bottom of water).

In addition bacteria levels will be monitored five times over a 30-day period during the summer holiday period each year.

6.1.4.4 Sediment Quality in the Harbour

Contamination of the sediments by antifouling metals will be monitored once during the first year of operation and subsequently in year five to determine whether or not metal accumulation is occurring.

Nutrient concentrations will also be monitored at the same frequency to determine if accumulation of nutrients is taking place.

6.1.4.5 Metals in Harbour Biota

Concentration of antifouling metals in filter feeding organisms (mussels) within the harbour will be monitored at the same frequency as for sediments.

6.1.4.6 Navigable Depth

The harbour, waterways and entrance channel will be surveyed immediately after construction. The entrance channel will subsequently be resurveyed at appropriate intervals with a final survey being conducted prior to handover to the State after five years.

6.1.4.7 Structural Integrity of Walls

Harbour walls will be surveyed at the completion of construction. Regular surveys of the toe of the walling will be carried out to monitor for scouring and all surveys will be repeated after five years.

6.1.5 Reporting

6.1.5.1 Annual Report

An annual report containing the results of each years monitoring programme will be submitted to the EPA and other State Government agencies as specified.

6.1.5.2 Final Report

A final report presenting the results and an analysis of all monitoring undertaken will be submitted to the EPA and other State Government agencies as specified in the agreement before the hand over of management responsibility to the State.

6.1.6 Authorities Responsible for Funding

6.1.6.1 Project Agreement

An agreement will be finalised between the Proponent, the Shire Council and the State Government to define responsibilities for the management of the waterways and public facilities. Proposed responsibilities are as detailed below.

6.1.6.2 The Proponent

The Proponent will be responsible for all aspects of the development including the management programme outlined above. After five years, some management aspects, subject to detailed arrangements being finalised in the Proposed Agreement, will revert to the Local Authority and the State.

6.1.6.3 Harbour Lessee

The harbour manager will be responsible for the day-to-day management of the harbour and waterways and for the maintenance and monitoring programme. It is anticipated that Marine and Harbours will become the harbour managers and the basis of this management will be covered by the Proposed Agreement.

6.1.6.4 Shire of Busselton

Upon completion of the Project, the Shire of Busselton will be responsible for the management of public roads, Public Open Space and normal ratepayer services.

6.1.6.5 State Government

Under the terms of the proposed agreement, the responsibility for waterways management, subject to detailed arrangements being finalised in the Proposed Agreement, will revert to the State after a period of five years.

6.2 COASTAL MANAGEMENT PROGRAMME

6.2.1 Objectives and Scope

The objective of the coastal management programme is to maintain the coastline in front of the development and on adjacent sides in a state of dynamic stability. It is proposed to achieve this by:

- construction of four breakwaters and groynes to provide foreshore protection and trap sediment;
- renourish the beaches in front of the development site and to the east with sufficient volumes of sand to ensure coastal stability in front of the development and downdrift;
- undertake foredune stabilisation and protection works;
- design foreshore reserves to control public access;
- undertake ongoing sand bypass operations as required to keep the coast stable;
- monitor sediment build-up and loss to identify appropriate timing for sand bypass operations.

- monitor structural integrity of the foreshore protection works (breakwaters).

Details of some of the above management actions have already been outlined in Sections 3 and 5 (ie breakwater construction and beach nourishment proposals). Summaries are presented below. Details of management actions not yet described in this report are also provided below.

6.2.2 Foreshore Protection Works

Two breakwaters and two groynes will be constructed and located as shown in Figure 1.2. These structures have been designed to withstand a one in 25 year storm event.

6.2.3 Beach Nourishment

During the construction period the Proponent will place sufficient volumes of sand from the development site to the east of the development to ensure that no scouring of the adjacent coastline occurs in the period before sand bypassing is undertaken.

The beach to the west of the entrance channel will be allowed to build up naturally by trapping normal sand transport.

6.2.4 Foredune Stabilisation

Following reconstruction of the beaches in front of the development site, the reconstituted foredune will be stabilised with plant species appropriate for the coast and similar to species occurring in adjacent areas of coastline. Brush matting may be required for a period until the plants establish themselves. Public access to these areas will be restricted by appropriately-located fencing.

6.2.5 Public Access and Foreshore Reserve

A foreshore reserve will be designed such that public facilities and amenities are located at appropriate sites to both enable access to the beaches and protect the foredune from erosion. Pedestrians will be required to use defined public access pathways.

Public access will also be provided to the breakwaters and groynes for sightseeing and fishing.

6.2.6 Sand Bypass Operations

Subsequent to completion of beach nourishment and dune stabilisation works, there will be a need to bypass approximately 50,000 cubic metres of sand per year on average from the west side of the entrance channel to the east side of the easternmost groyne.

Sand bypass operations will be undertaken by progressive dredging as required under the terms of a contract to be reassigned on a regular basis (probably every three years). The contract would cater for emergency dredging determined by the monitoring programme.

6.2.7 Seagrass Wrack

Substantial quantities of seagrass and algal wrack are deposited on the shores of Geographe Bay each winter. It is likely that the breakwater and groynes will at times trap substantial quantities of this material.

The role performed by the wrack in the detrital food chain of the marine ecosystem is recognised. No attempt will be made to remove the wrack unless it restricts use of the beach facilities. Under these circumstances, wrack will be removed and dumped on the beaches downshore of the development site.

Investigation indicates that the accumulation of seagrass wrack will not restrict sand bypass operations. The reduced detrital material which is incorporated into beach sediments is manageable by dredge. Dredging will be undertaken during periods when wrack is not prevalent and sea conditions are most appropriate, ie late summer.

6.2.8 Monitoring

6.2.8.1 Coastal Stability

Subsequent to completion of beach nourishment works, a series of transects normal to the beach will be established to monitor beach profiles and sediment volumes accumulated or lost. The transects will be established in front of the development site and extend for 0.5km on either side. Monitoring surveys will be undertaken on a semiannual basis toward the end of summer and the end of winter each year.

Additional monitoring will be conducted after significant storm events.

6.2.8.2 Integrity of Structures

The foreshore structures will be surveyed at the completion of construction and subsequently at yearly intervals to determine their stability.

Maintenance to these structures is unlikely to be required during normal climatic conditions. However, some rebuilding of breakwater parapets or replacement of armour may be required after extreme storm events.

6.2.9 Reporting

The results and analyses of the monitoring programme will be made available to the EPA, DMH and Shire of Busselton. Reporting will be on an annual basis with a final report submitted prior to the handover of management responsibility to the State.

6.2.10 Authority Responsible and Funding

The Proponent will be responsible for initial beach nourishment and subsequently for sediment bypass for five years until responsibility, subject to detailed arrangements being finalised in the Proposed Agreement, is assumed by the Department of Marine and Harbours.

Funding will initially (five years) be the responsibility of the Proponent. Subsequently sediment bypass will be undertaken using funds generated by levy applied to the development and from harbour fees. The mechanics of achieving this will be defined by the project agreement.

6.3 WATERFOWL CONSERVATION

6.3.1 Objectives and Scope

The objective of the Waterfowl Conservation and Management Programme Plan is to safeguard the conservation value of the estuary for waterfowl. It is proposed to achieve this objective by:

i securing the conservation and education values of the estuary;

ii minimising disturbance to waterfowl utilising the estuary.

6.3.2 Securing Conservation and Education Values

The conservation value will be secured by:

- donation of prime waterfowl habitat to the State for reservation as a Waterfowl Conservation Area;

- provision of additional drought refuge areas and sources of fresh water;
- construction of a channel to form a conservation island;
- construction and donation to the State of a waterfowl study centre;

The proposed location and boundaries of the above are shown in Figure 5.1.

6.3.3 Minimising Disturbance to Waterfowl

Disturbance to the waterfowl will be minimised by:

- removing all stock animals and horses from the land donated as reserve;
- providing a buffer zone of 50m width between Layman Road and the landward edge of the wetlands fringing the edge of the estuary;
- constructing a dog-proof 1.5m high wire-link fence around the border of the Waterfowl Conservation Area and the development. The fence will basically be constructed along the southern border of the new Layman Road alignment;
- providing appropriate landscaping and revegetation of the estuary edge of Layman Road;
- controlling public access to the Waterfowl Conservation Area via defined pathways and viewing areas.

6.3.4 Responsible Authorities

6.3.4.1 The Proponent

Subsequent to receipt of works approval by EPA and the final decision to proceed, the Proponent will fund:

- construction of the waterfowl study centre to a standard similar to that of the Herdsman Lake facility and to a value of $100,000.00;
- construction of the fence;
- construction of the additional drought refuge areas and channel separating the conservation island;
- organisation of titles and land transfer to the State.

6.3.4.2 State Government

The State Government through its representative (CALM) will be responsible for management of:

- the conservation area;
- public access to conservation area;
- the waterfowl study centre.

The centre will be staffed by persons qualified in management of conservation area and management and education of the public.

6.4 ESTUARY MANAGEMENT PROGRAMME

6.4.1 Objectives

The aim of the programme is to investigate aspects of the estuary's ecology and hydrology that have particular relevance to the nearby residents of Port Geographe and that can contribute to the development of an overall management plan for future use of the estuary.

Subsequent to the decision to proceed being taken, the Proponent proposes to make an annual contribution of $40,000 for two years towards the cost of the investigation conducted for this programme. In the meantime, the Proponent has already initiated investigations into the population characteristics of potential insect pests in the estuary. This part of the study will be funded in total by the Proponent.

6.4.2 Timing and Reporting

Interim reports on the insect studies will be available in December 1988 in time for incorporation in the EPA's assessment report on the project.

6.4.3 Responsible Authorities

It is envisaged that the State Government, through the EPA, would manage the programme of future investigations through a Steering Committee constituted of representatives of the Proponent, Busselton Shire and appropriate Government Departments.

6.5 PROJECT AGREEMENT

An agreement will be finalised between the State (DMH), the Busselton Shire and the Proponent to cover waterways management and sand bypassing.

The basis of the agreement will be:

- the Proponent will accept total responsibility for waterways management and sand bypassing for a period of five years subsequent to limitation of project construction;
- revenue created from within the project will be paid into a trust fund (or similar) to pay for waterways management and sand bypassing after the five year period;
- the Proponent will provide a bank guarantee in support of the trust fund until such time that the fund has reached its operating minimum level;
- the DMH will accept, subject to detailed arrangements being finalised in the Proposed Agreement, full responsibility for waterways management and sand bypassing after the five year period.
- Busselton Shire Council will, upon completion of the project be responsible for management of all public roads, areas of public open space and foreshore reserves. The Shire will also collect a financial levy from all ratepayers within the development and hold the money in the abovementioned trust fund.

6.6 COMMITMENTS

The Proponents hereby commit themselves to abide by all commitments made in this ERMP. Specifically this refers to undertaking all management actions and funding requirements detailed in the various management programmes outlined above. These commitments will be included in the Project Agreement which is to be established between the Proponent, the State and Busselton Shire Council.

Major commitments of each of the four management programmes proposed can be summarised as follows:

6.6.1 Port Geographe Management Programme

- Working hours will be limited to 7.00 am to 6.00 pm.
- The effects of dewatering will be monitored and private bore users who suffer water shortages will be compensated.
- Water quality in the harbour and waterways will be monitored.
- The structural integrity of major civil works will be monitored.
- The Proponent will be responsible for undertaking all management actions for the first five years of development.

6.6.2 Coastal Management Programme

- The Proponent will be responsible for monitoring coastal stability in front of and on adjacent sides of the development.
- The Proponent will monitor sediment building up or loss.

6.6.3 Waterfowl Conservation and Management Programme

- Waterfowl habitat as identified on Figure 3.2 will be donated to the State.
- A waterfowl study centre to the value of $100,000 will be constructed by the Proponent and donated to the State.
- A 1.5m high dog-proof fence will be constructed around the edge of the new Layman Road alignment.

6.6.4 Estuary Management Programme

- The Proponent will complete the investigations into potential insect pest populations.

- The Proponent will contribute $40,000 per year for two years for estuary research.

7.0 CONCLUSIONS AND SYNTHESIS

The proposed development has been thoroughly researched over the past five years. It has undergone preliminary environmental scrutiny through a detailed NOI which was commented upon by appropriate Government departments in 1985. Subsequent investigations by both the Proponent and a range of Government departments have led to the refinement of the Project to produce a concept which has been designed to be environmentally manageable and responsible. Particular attention has been focused on ensuring that the Project is compatible with the stated objectives and recommendations of the Leeuwin-Naturaliste Region Plan.

Much of the projects environmental acceptability depends on the successful implementation of a number of management plans. A prime requisite for management is the provision of funds to both establish the management programmes and subsequently to support them. To achieve this funding security, it is necessary to have access to as large a catchment of user ratepayers as possible without reducing the natural environmental values and aesthetics of the area. Hence, there is a need to develop part of the estuarine flats of the Vasse Estuary.

Development of the flats is recognised as being the main potentially negative impact of the proposed development. However, it is believed that this impact will be more than compensated for by the provision of the Waterfowl Conservation Park and the estuary management plan. It should be remembered that:

- the flats are in degraded condition,
- the prime waterfowl habitats are conserved in the proposed Waterfowl Conservation Park,
- the present value of the estuary to waterfowl is largely due to human interference with the hydrology of the estuary,
- the estuary is under threat, mainly from intensification of agricultural development in the catchment,
- no management provision presently exists to safeguard the waterfowl conservation values of the estuary,
- retention of the waterfowl as a tourist attraction is a prime objective of the proponent.

The presence of development on a part of the estuarine flats will be the major cost to the community. Other impacts, such as increased traffic, greater requirement for community services, are a natural function of population growth and would apply to any development in the Busselton region. The Project will be funded on a 'user-pays' principle at no cost to the State or the local community.

In addition, the following beneficial impacts will accrue to both the local and regional community:

- the provision of a much-needed harbour and public boating facilities,
- the provision of a major year round regional tourist attraction in both the marine village and the Waterfowl Conservation Park,
- the provision of new residential and recreational opportunities,
- the provision of additional tourist accommodation,
- the provision of public access to the estuary,
- the protection of the valuable waterfowl resource,
- the initiation of a much-needed estuary management plan,
- the provision of new fish and crab nursery habitat.

These impacts will benefit the regional and local economy through the provision of long-term employment opportunities and a major boost to the tourism, fishing and construction industries of the region.

It is therefore concluded that the proposed development can be managed to minimise adverse effects on the local environment, and that the local and regional community will benefit substantially from the Project. The adoption of the management programmes outlined in this report will ensure that any adverse effects are minimised. It is therefore submitted that the proposal is environmentally acceptable.

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9.0 ENVIRONMENTAL PROTECTION AUTHORITY - GUIDELINES

PORT GEOGRAPHE DEVELOPMENT - BUSSELTON

The following guidelines have been prepared for an Environmental Review and Management Programme on the development of a harbour facility and residential canal development at a site approximately 4 km east of Busselton.

These guidelines are issued as a checklist of matters which the Environmental Protection Authority considers should be addressed in the ERMP. They are not exhaustive and other relevant issues may arise during the preparation of the document: these should also included in the ERMP.

It should also be noted that the guidelines are not intended to convey the Authority's wishes with respect to the format of the document. The format is a matter for the proponent and his consultant.

A copy of these guidelines should appear in the ERMP.

1. Summary

The ERMP should contain a brief summary of:

- salient features of the proposal;
- alternatives considered;
- description of receiving environment and analysis of potential impacts and their significance;
- environmental monitoring, management and safeguards and commitments thereto;
- conclusions.

2. Introduction

The ERMP should include an explanation of the following:

- identification of proponent and responsible authorities;
- background and objectives of the proposal;
- brief details of, and timing of the proposal;
- relevant statutory requirements and approvals;
- scope, purpose and structure of the ERMP.

3. Need for the Development

The ERMP should examine the justification for the project and projected costs and benefits (in the broad sense) at local and regional levels.

4. Evaluation of Alternatives

The evaluation of alternatives is an important part of an ERMP. A discussion of alternatives to the proposal, including alternative sites as well as the "do nothing" option, should be given. A comparison of these in the context of the stated objectives should be included as well as costs and benefits at both construction and operational stages. This discussion should also briefly consider various scales (sizes) of the project and their implications. In this way the rationale for not choosing certain alternatives should be clear as would the basis for choosing the preferred option.

5. Description of Proposal

The ERMP should include details of:

- Overall concept;
- Location and layout;
- Proposed land uses, land tenures and a clear indication between boundaries of private and public land;
- Construction schedule and methods of construction including source of materials and disposal of wastes;
- Infrastructure including boating support facilities;
- Access;
- Auxiliary services (eg power, water, sewerage);
- Control and staging of project;
- Operation during and after construction, including littoral sand management;
- Projected lifetime.

6. Existing Environment

The ERMP should provide an overall description of the environment and an appraisal of physical and ecological systems likely to be affected by it.

It should then concentrate on the significant aspects of the environment likely to be impacted by the development (ie in particular the processes sustaining the system). Only the processes, habitats, resources and potential resources which could be influenced should be defined. Detailed inventories should be placed in appendices to the ERMP.

Wherever possible in the discussion of physical and biological processes that are essential determinants in the maintenance of habitats and resources, conceptual models or diagrams should be used to illustrate and synthesize the interactions between the processes.

The following matters should be addressed:

6.1 Physical - meteorology;
- oceanography;

- offshore and onshore geology and geomorphology;
- drainage;
- onshore hydrology and hydrogeology, including water quality;
- near shore water quality;
- coastal processes;
- wetlands;

6.2 Biological - offshore and onshore biota (including wetlands) ecosystems;

6.3 Human
- land-use, including past land-uses, land tenure, zoning and reservation, conservation recreational aspects.
- road systems and traffic;
- landscape;
- public access;
- sites affected by System 1 "Red Book" recommendations;
- historical, archaeological and ethnographic sites;
- adjacent urban developments;
- use of offshore waters in vicinity of proposal;
- use of groundwater (existing and potential public and private users;
- use of adjacent wetlands.

These issues need to be discussed in both a local and regional context. In addition, the ERMP should, where appropriate, take cognisance of any other known developments proposed for the general area.

7. Environmental Impacts

This is the most important part of the ERMP and the result should show the overall effect on the total ecosystem and social surroundings of the location during and after construction.

The objective is to take an overview of the elements of the system involved and the external factors with which they interact and to present them as a synthesis or conceptual model which can be used to predict system behaviour under the stresses likely to be encountered. This should include an assessment of the resilience of the systems identified in 6 to natural and man-induced pressures. Impacts should be quantified where possible. Criteria for making assessments of their significance should be outlined. Compliance with relevant standards should be demonstrated. In some cases there will be advantage in discussing construction and operation impacts separately.

It will be necessary to determine impacts on individual components of the environment before a final overall synthesis of potential impacts is made.

The following potential environmental impacts should be included:

- oceanography;
- coastal processes (in particular sediment movements);
- offshore and onshore biota (in particular seagrass and wetland ecosystems)
- risk analysis of storm events;
- contingency planning and safety;
  drainage;
- water quality (within the proposed harbour and canals, in adjacent waters of Geographe Bay and Vasse Estuary, and groundwater;
- land stability (with particular reference to areas disturbed during construction);
- landscape;
- local and regional significance of foreshores;
- any historical, archaeological and ethnographic sites;
- the System 1 areas;
- emissions (air, water, waste disposal, noise);
- land use including conservation and recreation aspects;
- access road systems and transport;
- effect on existing community and facilities;
- services (power, water, sewerage);
- use of adjacent offshore waters;
- construction and operational workforce.
- use of wetlands by waterfowl;

The final synthesis should include an assessment of the significance and timing of the various potential impacts identified.

8. Environmental Management

An environmental management programme should be described on the basis of (and cross-referenced to) the synthesis of potential environmental impacts.

The purpose of the management programme is to demonstrate the manner in which potential environmental impacts can be ameliorated.

Authorities responsible for management should be clearly identified as should management administration, costs and funding including long-term financial contingency.

Elements of monitoring and the environmental management programme should include the impacts identified in 7.

Emphasis should be placed on the manner in which monitoring results will lead, where appropriate, to amendments to the management programme.

Environmental safeguards should be described.

Procedures for reporting the results of monitoring and management to appropriate authorities should be given.

It is important that specific commitments are given to all components and procedures of the management programme.

9. Conclusion

An assessment of the environmental acceptability of the project in terms of its overall environmental impact and in the context of the proposed management programme should be given.

10. References

Glossary (definitions of technical terms, abbreviations)

ERMP Guidelines

Appendices

NOTE: These Guidelines should be used in the context of the attached document "Notes for the preparation of an ERMP".

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