PORT MANDURAH
STAGE 2

# PUBLIC ENVIRONMENTAL REVIEW

IANDURAH) PTY LTD

# PUBLIC ENVIRONMENTAL REVIEW

## PORT MANDURAH CANAL ESTATE STAGE 2

**Prepared for:**
**Esplanade (Mandurah) Pty Ltd**
C/- Cedar Woods Properties Limited
25th Floor, Exchange Plaza
2 The Esplanade
PERTH WA 6000

**Prepared by:**
**Bowman Bishaw Gorham**
1298 Hay Street
WEST PERTH WA 6005
Telephone: (09) 481 8588
Facsimile: (09) 481 8338

Report No: RI4240
April, 1995

# INVITATION

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

The Public Environmental Review (PER) proposes the development of Stage 2 of the Port Mandurah Canal Estate project in the City of Mandurah. In accordance with the Environmental Protection Act, a (PER) has been prepared which describes this proposal and its likely effects on the environment. The PER is available for a public review period of 8 weeks from 10rd April 1995 closing on 2nd June 1995.

Comments from government agencies and from the public will assist the EPA to prepare an assessment report in which it will make recommendations to government.

## 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 document unless specifically marked confidential, and may be quoted in full or in part of 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 10 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 PER 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 PER:

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

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 issues raised are clear. A summary of your submission is helpful;

- refer each point to the appropriate section, chapter or recommendation in the PER;

- if you discuss different sections of the PER, keep them distinct and separate, so there is no confusion as to which section you are considering;

- attach any factual information you may wish to provide and give details of the source. Make sure your information is accurate.

Remember to include:

- your name,
- address,
- data; and
- whether you want your submission to be confidential.

The closing date for submissions is: **2nd June 1995**

Submissions should be addressed to:

Environmental Protection Authority
Westralia Square
141 St George's Terrace
PERTH WA 6000

Attention: Mr Colin Murray

## SUMMARY

Esplanade (Mandurah) Pty Ltd (EMPL) proposes to develop Stage 2 of the Port Mandurah Canal Estate, located on the western side of the Mandurah Channel in the City of Mandurah.

The Stage 2 proposal will be an extension of the Port Mandurah Stage 1 project (Figure A) which was granted environmental approval in 1989, with construction of the canals and lots completed in 1990. The planning and engineering design of the first stage allowed for future extension of the canal system to the south. It is proposed to connect the Stage 2 canals to both the Mandurah Inlet and the canals in Stage 1, to allow for enhanced flushing of the waterways.

A referendum conducted by the City of Mandurah in 1991 endorsed community support for Stage 2 of the project. The Shire of Mandurah has resolved to amend the current Town Planning Scheme accordingly, subject to environmental approval for the project.

Stage 1 of the project has been highly successful in terms of design and environmental compliance. Port Mandurah Stage 2 will apply the same environmental design criteria as Stage 1, subject to minor modification where experience has shown to be appropriate in order to improve performance.

The Stage 2 project encompasses approximately 92ha, and will include 501 single residential waterfront allotments, two areas of waterfront communal housing with approximately 110 residences and approximately 33ha of canal waterways. Development will proceed in four to six stages each approximately 100 to 120 lots, shown in Figure B as Stage 2A, Stage 2B Phase 1, Stage 2B Phase 2 and Stage 2B Phase 3. The expected duration of development is from five to eight years.

Development of the canal estate is planned over land which is currently and extensively used for grazing and agistment of livestock. Land within the immediate vicinity of the development is used for a variety of purposes, including canal development, residential subdivision and recreation. Re-development of the Mandurah Marina, located immediately north of the site, has recently been approved.

The existing vegetation of the site consists of cleared pasture in Stage 2B, with the Stage 2A area consisting mainly of low-lying, seasonally inundated areas which have been significantly disturbed by grazing sheep and horses. The surface soils and drainage of portions of these areas have been altered by shallow excavations from past marl mining and constructed levee banks to prevent salt water inundation during peak floods. These low lying areas are significant areas for mosquito breeding, including *Aedes camptorhyncus* and *Aedes vigilax*, both of which are major vectors of epidemic polyarthritis (Ross River virus).

The terrestrial environment provides limited habitat for fauna and has low to moderate conservation value. The most important areas from a conservation perspective are the estuarine foreshore, samphire flats and tidal wading zones of an adjacent System 6 area (C50), which is part of a wider area recognised as having international significance as a waterbird habitat under the RAMSAR Convention. Protection and enhancement of this area has been a principle focus of planning design and the environmental management prescriptions for the project. Elements of the proposal which will ensure appropriate protection of waterbird habitat include the following:

1. Waterbird habitat values within and adjacent to the project area were assessed by specialist zoological consultants at the outset of planning design, to identify areas requiring conservation. The proposed development plan is fully consistent with the results of these studies, including provision for the appropriate conservation of samphire and other habitats having high value to waterbirds.

2. A boundary canal will be created along the eastern edge of the canal estate, to provide a buffer to minimise disturbance of the recognised waterbird habitat and to create a linear "conservation island" adjacent to the site. The protection of the significant waterbird habitat as an island will augment its existing habitat value by protecting it from animal and human access, thereby ensuring the continuance of its ecological function adjacent to residential development.

3. A 25-50m wide buffer zone between the eastern edge of the boundary canal and the waterbird habitat conservation areas will be developed to create additional valuable waterbird feeding and perching habitat, thereby providing an ecologically functional and aesthetically pleasing interface between the development and the estuarine fringe.

4. Protection and enhancement of the waterbird habitat values within the foreshore reserve and the adjacent estuarine shallows is also proposed through the location and design of the protective rock walling for the entrance channel and the eastern edge of the boundary canal, to create further additional feeding and perching habitat.

5. In total, the development proposal includes a 50-100m foreshore reserve. This proposed reserve includes all areas recognised as having high to very high waterbird habitat values. It also includes an additional 0.8ha of low to moderate waterbird habitat, which will be modified to create high value habitat. Active management measures that are proposed will ensure that the conservation values recognised by the development will be optimised. These include:

    - The provision of a conservation interpretation centre with facilities for enhancing public awareness and appreciation of waterbirds.
    - The provision of a vermin-proof fence.
    - The eventual gazettal of the Reserve as an "A" Class Reserve for the Conservation of Fauna.
    - The provision of a Conservation and Foreshore Management Plan including a Waterbird Monitoring Program which will be prepared prior to construction and implemented by the proponent until the Reserve is gazetted.

Areas within the project site are also recognised as having social heritage value. These include Aboriginal archaeological and ethnographic sites and sites of European historical significance. The areas of Aboriginal Heritage significance will be retained in Public Open Space, while the Sutton Homestead buildings of local and State heritage significance will be protected within a 'heritage precinct'. The proposal includes the active restoration of the buildings and their promotion through educational displays and facilities.

The history of canal development at Mandurah has enabled the impacts of canal construction and operation on the natural and social environment to be confidently predicted. The majority of construction impacts are addressed by standard engineering procedures defined within various statutory guidelines and policies for canal

construction, which have standardised environmental management prescriptions. These controls and management are an integral component of this proposal.

The canal estate design will ensure minimal entry of nutrients and other contaminants to the canal and adjacent estuarine waterways. Assessment of the water flushing mechanisms that will operate in the canals show that the canals will fully flush on a daily cycle. It is therefore considered most unlikely that water quality in the canals will ever deteriorate, nor will it cause any deterioration of water quality in the adjacent Mandurah Channel.

A Water and Sediment Quality Monitoring Program for the canals will be prepared and implemented.

Based upon the evaluation of the existing environment and with regard to the management proposals detailed within the PER, the potential impacts and management measure proposed for the Stage 2 Port Mandurah Project are summarised in Table A.

The proponent has made 28 Commitments which summarise the design parameters and environmental management procedures which are integral to this proposal. Compliance with these commitments will ensure that this proposal is able to be satisfactorily managed to prevent significant environmental impacts.

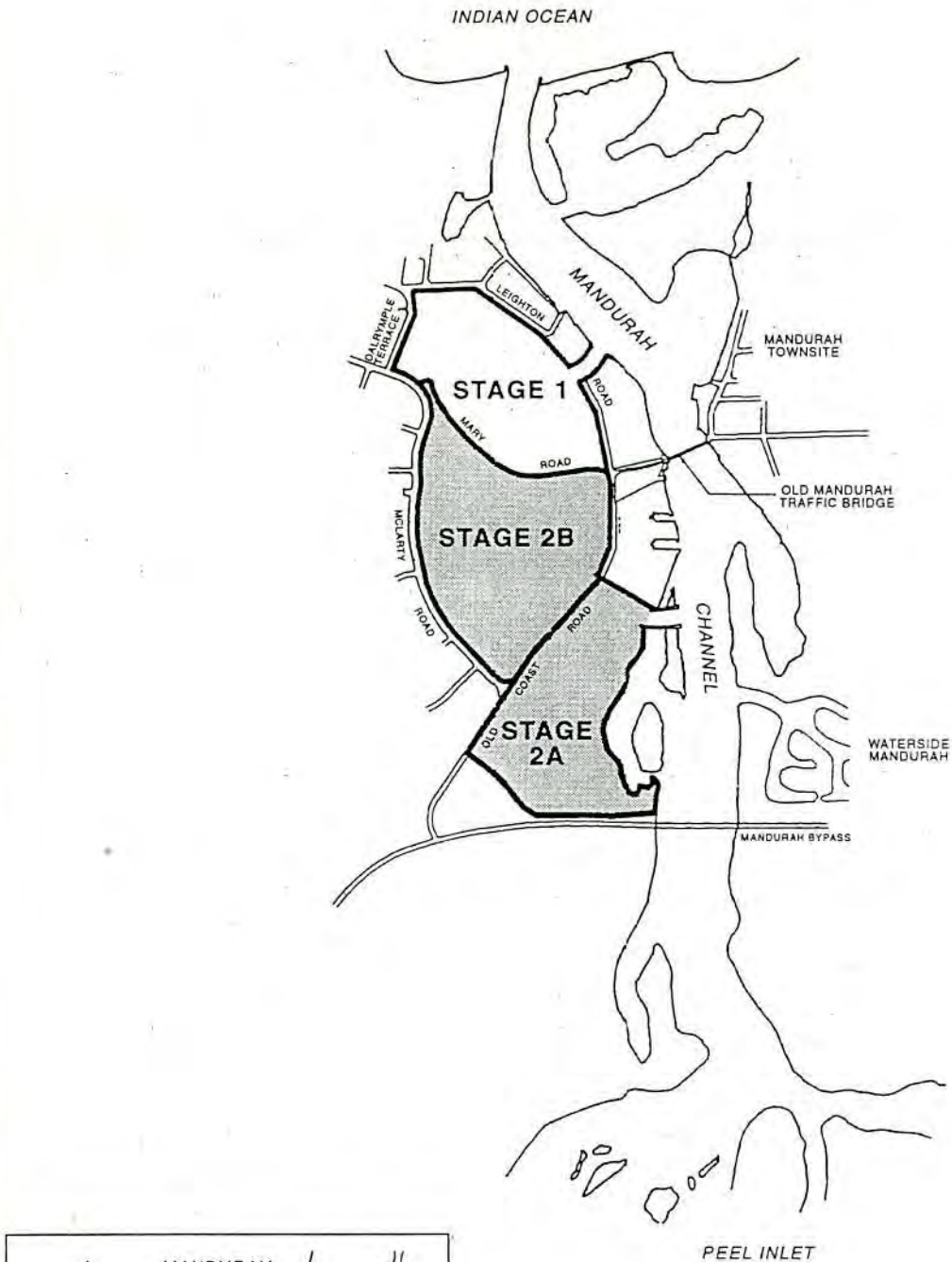
## Table A

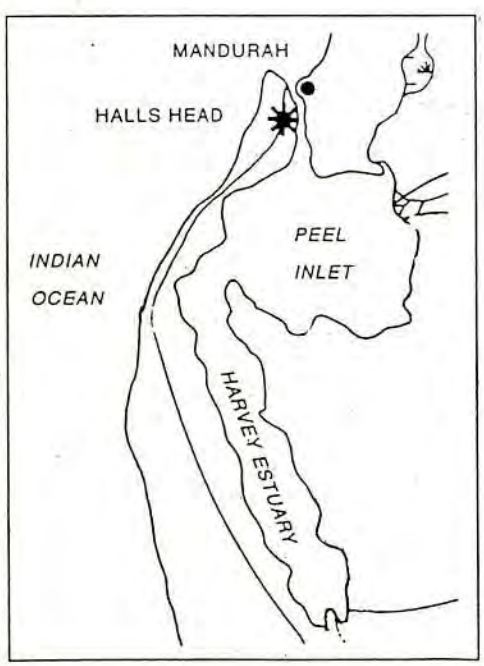
## Summary of Impacts and Management - Port Mandurah Stage 2

| PREDICTED IMPACT | PROPOSED MANAGEMENT |
|---|---|
| **Construction Phase** | |
| Impacts to waterbird habitat | - The proposal will conserve all areas having high waterbird habitat value and all areas of samphire with moderate habitat value. The project design will create new waterbird habitat which is expected to increase the total number of waterbirds using the site. The proponent will prepare and implement a Conservation and Foreshore Management Plan. The Conservation and Foreshore Reserve will be ceded to the NPNCA for vesting as an "A" Class Reserve. |
| Loss of vegetation and habitat | |
| - Loss of sedgeland which is possibly of moderate significance to a limited number of waterbird species but is a potential highly significant seasonal mosquito breeding habitat | - Removal of significant mosquito breeding area and replacement of sedge habitat in proposed Conservation and Foreshore reserve. |
| - Loss of degraded dry land samphire which is of very low significance to waterbirds and of very high, year-round significance for mosquito breeding | - Removal of highly significant mosquito breeding area and enhancement of other habitats of higher waterbird usage. |
| - Loss of some tree overstorey which has low to moderate value for bushbirds and waterbird roosting. | - Retention of the majority of the tree overstorey habitat in POS |
| Localised temporary drawdown of shallow aquifer during dewatering | |
| - Temporary impacts to a limited number of domestic bores | - Conduct most dewatering in winter to minimise impact. Pay for affected owners to connect to mains water supply. |
| - Potential stress to phreatophytic vegetation and heritage trees. | - Conduct most dewatering in winter to minimise impact. Monitor trees on site and irrigate if required. |
| Discharge of dewatering fluids into the estuary. | - Discharge procedures to follow PIMA Dewatering Policy WS 4.2, including use of stilling basin and appropriate detention time to allow turbidity in the water to settle prior to discharge of clear water to the estuary. |
| Dredging of the entrance channel | |
| - Potential for increased turbidity in Mandurah Channel | - Dredging procedures to follow PIMA Dredging Policy WS 4.1. Turbidity from dredging will be short term and be unlikely to exceed naturally occurring fluctuations. |
| - Dissection of the northernmost end of the tidal shoal | - Loss of habitat will be small and mitigated by the creation of new tidal flats within the proposed Conservation and Foreshore Reserve. |
| - Possible temporary disturbance to waterbird activities. | - Disturbance, if any, will be minimal and short-term, and will not impact longer-term use of the habitat. No management required. |
| Potential disturbance to waterbirds habitat and other conservation areas during construction | - Preparation of Conservation and Foreshore Management Plan prior to construction.<br>- Environmental specifications in construction contract to protect waterbird habitat and other conservation areas. |
| Low level noise during construction | - Construction activities confined to daylight hours. Noise expected to be masked by background traffic noise. |
| Residual dust problems during estate construction. | - Construction will mostly be conducted during winter. Dust levels will be monitored and dust-suppression procedures applied if required. |

**Table A**
**(Cont'd)**

| PREDICTED IMPACT | PROPOSED MANAGEMENT |
|---|---|
| **Operations Phase** | |
| Disruption of traffic during bridge construction. | - Bridge construction will be undertaken in "the dry" to minimise construction time. Traffic will be diverted by temporary detours constructed on land owned by the proponent to a standard acceptable to the City of Mandurah. |
| Canal and estuarine water and sediment quality impacts | |
| - Potential deterioration of water quality due to inadequate flushing | - Canal design is based on Port Mandurah Stage 1, which has a high level of flushing performance. This will be enhanced by water through flow following connection with Stage 1. |
| - Contaminant inputs from residential land use | - Nutrient and drainage management design, including spoon drains, soakwells and silt and grease traps, will ensure that nutrients and other contaminant inputs will be minimal. The proponent will provide an environmental awareness brochure which will include ways to minimise fertiliser application and encourage the use of suitable native plant species for gardens. |
| - Contaminant inputs from vessels | - Use of tributyl tin oxide (TBT) antifouling on vessels less than 25m is prohibited in WA. Discharge of sewage, hydrocarbons and litter from vessels into public waterways is also illegal.<br>- Preparation and implementation of Water and Sediment Quality Monitoring Program to the satisfaction of PIMA |
| Potential interference with hydrodynamic processes | |
| - Impacts upon shoreline stability. | - The development is not expected to influence shoreline stability. The entrance channel will be rock-walled to prevent boat wash and sediment disturbance. Design of boundary canal revetment in the proposed Conservation and Foreshore Reserve will minimise any risk of erosion from the Reserve. |
| - Potential for sediment scour from tidal currents through the canal waterways following connection of Stage 2 with Stage 1. | - Provision of adequate scour protection. |
| Movement of the saltwater interface to the west, with a potential to impact a small number of domestic bores. | - Abstraction management advice and/or compensation for affected bore owners |
| Restriction of public access to existing foreshore reserve. | - Proposal to specifically exclude public to the majority of the proposed Conservation and Foreshore Reserve, however public access controlled to allow enhanced appreciation of waterbird habitat by the provision of environmental education facilities and viewing platforms.<br>- Vessel access into the Reserve from the estuary will be specifically discouraged by the placing of limestone boulders in the tidal channel between the offshore samphire flat and the sub-tidal shoal. |
| Increased population and recreation pressure | |
| - Additional pressure on commercial fishing | - Regional impact of increased tourism and recreation. managed under the Fisheries Act |
| - Waterbird disturbance by boating activity | - Previous data indicates that high boat activity causes very little disturbance to waterbirds. managed by PIMA, CALM and Department of Transport. |




N

0 1.5km

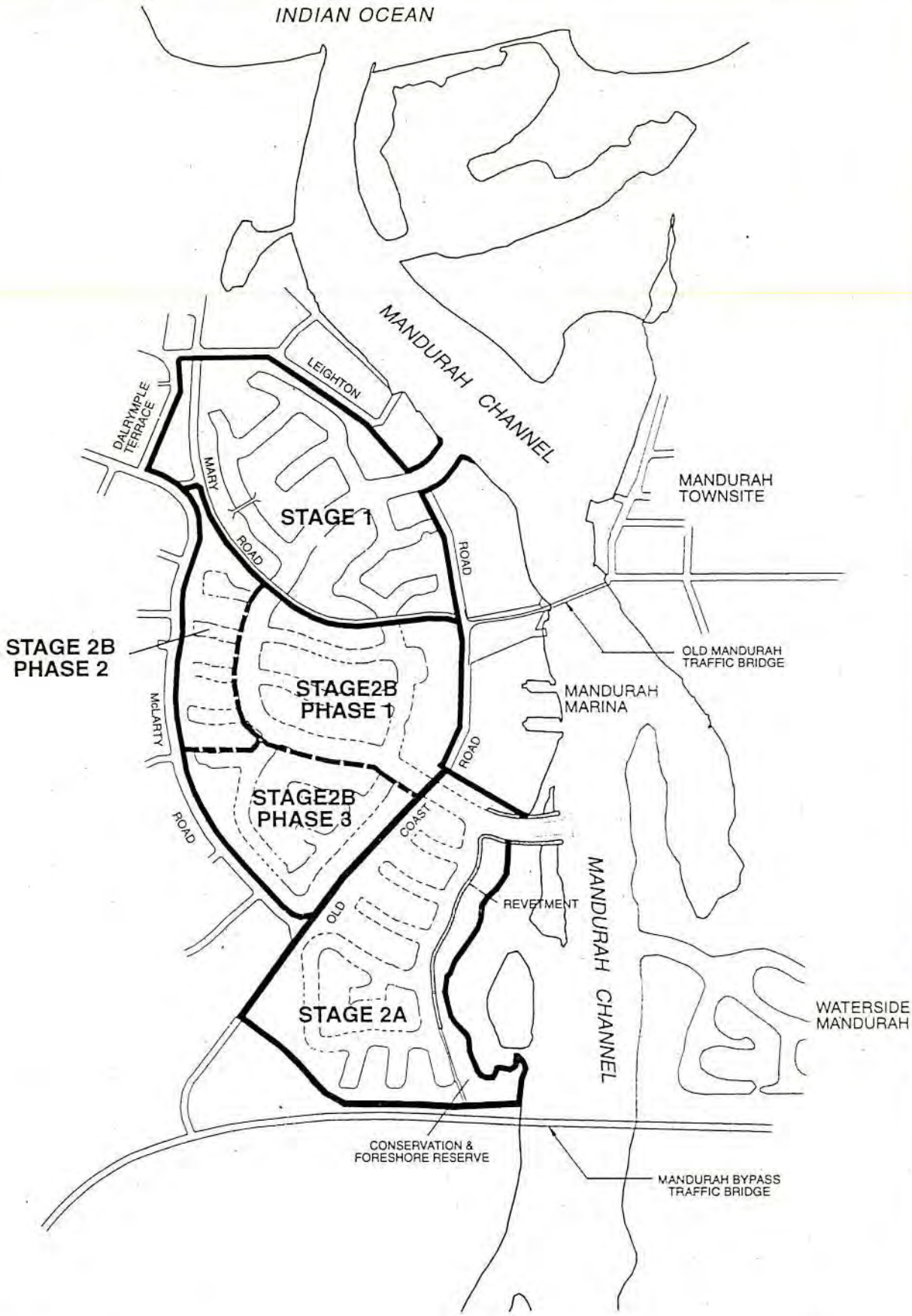
**PORT MANDURAH STAGE 2**

## LOCATION DIAGRAM

Figure A

BOWMAN BISHAW GORHAM

ENVIRONMENTAL MANAGEMENT CONSULTANTS




**PORT MANDURAH STAGE 2**

## CANAL LAYOUT AND STAGES

Figure **B**

Source : Port & Harbours, 1995

BOWMAN BISHAW GORHAM
ENVIRONMENTAL MANAGEMENT CONSULTANTS

# PUBLIC ENVIRONMENTAL REVIEW
# PORT MANDURAH CANAL ESTATE STAGE 2

## TABLE OF CONTENTS


| | | Page No. |
|---|---|---|
| SUMMARY | | i-v |
| 1.0 | INTRODUCTION | 1 |
| 1.1 | Summary of the Proposal | 1 |
| 1.2 | The Proponent | 3 |
| 1.3 | The Statutory Environmental Approvals Process | 4 |
| 1.4 | Timing and Schedules | 5 |
| 1.5 | Purpose and Structure of the Public Environmental Review (PER) | 5 |
| 2.0 | PROJECT RATIONALE | 7 |
| 2.1 | Background to the Proposal | 7 |
| 2.2 | Justification for the Development | 8 |
| 2.3 | Existing Policies and Guidelines | 10 |
| 2.3.1 | Existing Zoning - City of Mandurah TPS No.1A | 10 |
| 2.3.2 | Proposed Zoning - City of Mandurah TPS No.3 | 10 |
| 2.3.3 | State Planning Commission Policy DC1.8 | 11 |
| 2.3.4 | City of Mandurah - Draft Waterways Management Policy | 12 |
| 2.3.5 | Peel Inlet Management Programme | 13 |
| 2.3.6 | PIMA Dredging Policy WS 4.1 | 13 |
| 2.3.7 | PIMA Dewatering Policy WS 4.2 | 13 |
| 2.3.8 | System 6 ("Red Book"). | 13 |
| 2.3.9 | International Conventions | 13 |
| 2.3.10 | Peel Regional Park Study | 14 |
| 2.3.11 | Peel Regional Strategy | 14 |
| 2.4 | Benefits of the Project | 15 |
| 2.5 | Evaluation of Alternatives | 16 |
| 2.5.1 | Urban Subdivision and Conservation Area | 16 |
| 2.5.2 | Rural Use | 17 |

# TABLE OF CONTENTS
# (CONT'D)


| | | Page No. |
|---|---|---|
| **2.5** | **Evaluation of Alternatives (Cont'd)** | |
| 2.5.3 | "Do Nothing" | 17 |
| 2.5.4 | Other Sites for Canal Estate Development | 18 |
| **3.0** | **DESCRIPTION OF THE EXISTING ENVIRONMENT** | **19** |
| **3.1** | **Physical Environment** | **19** |
| 3.1.1 | Topography | 19 |
| 3.1.2 | Geomorphology and Soils | 20 |
| 3.1.3 | Surface Drainage | 21 |
| 3.1.4 | Groundwater Hydrology | 21 |
| 3.1.5 | Estuarine Hydrodynamics | 22 |
| 3.1.6 | Flood Levels | 26 |
| 3.1.7 | Water Quality | 28 |
| 3.1.8 | Shoreline Stability | 28 |
| **3.2** | **Terrestrial Biological Environment** | **30** |
| 3.2.1 | Vegetation and Flora | 30 |
| 3.2.2 | Fauna | 32 |
| **3.3** | **Estuarine Biological Environment** | **34** |
| 3.3.1 | General | 34 |
| 3.3.2 | Water Birds | 35 |
| **3.4** | **Mosquito Breeding Habitat** | **40** |
| **3.5** | **Social Environment** | **41** |
| 3.5.1 | Landscape | 41 |
| 3.5.2 | Land Uses | 42 |
| 3.5.3 | Public Foreshore Reserves | 42 |
| 3.5.4 | Nature Conservation Zones | 43 |
| **3.6** | **Aboriginal Heritage** | **43** |
| 3.6.1 | Archaeology | 44 |
| 3.6.2 | Ethnography | 44 |
| **3.7** | **European Heritage** | **45** |
| 3.7.1 | Historical Background | 45 |
| 3.7.2 | Sutton Farm | 46 |

# TABLE OF CONTENTS
## (CONT'D)


| | | Page No. |
|---|---|---|
| **4.0** | **DESCRIPTION OF THE PROPOSAL** | **49** |
| **4.1** | **Overview** | **49** |
| **4.2** | **Project Design** | **50** |
| 4.2.1 | Conservation and Foreshore Reserve | 50 |
| 4.2.2 | Heritage Reserves | 53 |
| 4.2.3 | Public Open Space | 54 |
| 4.2.4 | Urban Subdivision Layout | 55 |
| 4.2.5 | Waterways Layout | 56 |
| **4.3** | **Estate Design** | **56** |
| 4.3.1 | Minimum Building Levels | 56 |
| 4.3.2 | Canal Depths | 57 |
| 4.3.3 | Typical Canal Cross-Sections | 57 |
| 4.3.4 | Typical Block Profile | 57 |
| 4.3.5 | Canal Walls | 58 |
| 4.3.6 | Earthworks Balance | 59 |
| **4.4** | **Earthworks and Construction** | **59** |
| 4.4.1 | Required depth of fill | 59 |
| 4.4.2 | Dewatering | 60 |
| 4.4.3 | Wall Construction | 60 |
| 4.4.4 | Entrance Channel Dredging | 61 |
| 4.4.5 | Noise and Dust Control | 61 |
| 4.4.6 | Public Safety | 62 |
| **4.5** | **Drainage and Nutrient Management** | **62** |
| 4.5.1 | General | 62 |
| 4.5.2 | Road Drainage | 62 |
| 4.5.3 | Front of Block Drainage | 63 |
| 4.5.4 | Roof Drainage | 63 |
| 4.5.5 | Lower Garden/Landscaped Area/Walkway | 63 |
| **4.6** | **Services** | **64** |
| 4.6.1 | Roads | 64 |
| 4.6.2 | Bridges | 64 |

# TABLE OF CONTENTS
# (CONT'D)


| | | Page No. |
|---|---|---|
| **4.6** | **Services (Cont'd)** | **64** |
| 4.6.3 | Pedestrian/Bicycle System | 66 |
| 4.6.4 | Sewage Disposal | 66 |
| 4.6.5 | Power Supply | 67 |
| 4.6.6 | Water Supply | 67 |
| **4.7** | **Project Agreement and Management Programme** | **68** |
| **5.0** | **CONSTRUCTION PHASE ENVIRONMENTAL IMPACTS** | **71** |
| **5.1** | **Summary of Construction Impacts** | **71** |
| **5.2** | **Loss of Vegetation and Fauna Habitat** | **72** |
| **5.3** | **Impacts of Dewatering** | **73** |
| 5.3.1 | Temporary Drawdown of Domestic bores | 73 |
| 5.3.2 | Phreatophytic Vegetation and Heritage Trees | 73 |
| 5.3.3 | Discharge of Dewatering Fluids | 74 |
| **5.4** | **Impacts of Dredging** | **74** |
| 5.4.1 | Water quality | 74 |
| 5.4.2 | Cut through Tidal Shoal and System 6 area | 75 |
| **5.5** | **Noise** | **75** |
| **5.6** | **Dust** | **75** |
| **5.7** | **Traffic** | **76** |
| **6.0** | **OPERATIONAL STAGE ENVIRONMENTAL IMPACTS** | **77** |
| **6.1** | **Summary of Impacts** | **77** |
| **6.2** | **Canal and Estuarine Water and Sediment Quality** | **78** |
| 6.2.1 | Introduction | 78 |
| 6.2.2 | Tidal Regime | 78 |
| 6.2.3 | Through Flow | 79 |
| 6.2.4 | Other Flushing Mechanisms | 80 |
| 6.2.5 | Potential Contaminant Inputs | 82 |
| 6.2.6 | Potential Water Quality Effects | 83 |

# TABLE OF CONTENTS
## (CONT'D)


| | | Page No. |
|---|---|---|
| **6.3** | **Shoreline Processes** | **83** |
| **6.4** | **Hydrodynamic Processes** | **84** |
| **6.5** | **Groundwater Protection** | **85** |
| **6.6** | **Public Access** | **85** |
| **6.7** | **Effects on Waterbird Habitat** | **86** |
| **6.8** | **Population Pressure** | **87** |
| 6.8.1 | Fishing | 87 |
| 6.8.2 | Boat Use | 87 |
| **7.0** | **MANAGEMENT AND MONITORING** | **89** |
| **7.1** | **Introduction** | **89** |
| **7.2** | **Pre-construction Management** | **90** |
| 7.2.1 | Conservation and Foreshore Reserve Management | 90 |
| 7.2.2 | Canal scour protection | 90 |
| 7.2.3 | Waterway Management Agreement | 91 |
| **7.3** | **Construction Management** | **91** |
| 7.3.1 | Protection of Waterbird Habitat and other Conservation Areas | 91 |
| 7.3.2 | Noise and Dust Management | 92 |
| 7.3.3 | Control of Turbid Water Discharges | 92 |
| 7.3.4 | Groundwater Management | 92 |
| **7.4** | **Operational Management** | **92** |
| 7.4.1 | Conservation and Foreshore Reserve Management | 92 |
| 7.4.2 | Groundwater Management | 93 |
| 7.4.3 | Nutrient Management | 93 |
| 7.4.4 | Canal Maintenance | 93 |
| 7.4.5 | Foreshore Stability | 94 |
| 7.4.6 | Mosquito Control | 94 |
| 7.4.7 | Recreation Management | 94 |
| **7.5** | **Environmental Monitoring Programmes** | **95** |
| 7.5.1 | Waterbirds | 95 |
| 7.5.2 | Water and Sediment Quality | 95 |

# TABLE OF CONTENTS
# (CONT'D)


| | | Page No. |
|---|---|---|
| **8.0** | **SUMMARY OF COMMITMENTS** | **97** |
| **9.0** | **REFERENCES** | **103** |


**APPENDICES (Under separate volume, available on request)**


| | |
|---|---|
| APPENDIX A | Guidelines for the Preparation of the PER. Department of Environmental Protection, 1994 |
| APPENDIX B | Environmental Conditions and Commitments for Port Mandurah Stage 1. Minister for the Environment, 1989 |
| APPENDIX C | Rate Payer Referendum. City of Mandurah, 1990 |
| APPENDIX D | Report on Groundwater Aspects for Public Environmental Review. Port Mandurah Stage 2. Dames & Moore, February 1995 |
| APPENDIX E | Marine Engineering Aspects. Port Mandurah Stage 2 PER. Port & Harbours, February 1995. |
| APPENDIX F | Waterbird Conservation within the Port Mandurah Stage 2 Project Area. Ninox Wildlife Consulting, E. Goble-Garratt and Associates, MJ and AR Bamford, January 1995. |
| APPENDIX G | Report of an Aboriginal Heritage Survey for the Proposed Port Mandurah Housing Development Project, Halls Head. McDonald Hales & Associates, Jan. 1995. |
| APPENDIX H | Heritage Conservation Report. Sutton Farm Heritage Precinct, Mandurah. Palassis Architects, January 1995. |
| APPENDIX I | Summary of Environmental Conditions and Commitments for Port Mandurah Stage 1 and their Application to Stage 2. |

# LIST OF TABLES


| | | Page No. |
|---|---|---|
| Table 1 | Tidal Levels at Mandurah (Fisherman's Jetty) | 25 |
| Table 2 | Modelled Extreme Flood Events | 27 |
| Table 3 | List of waterbirds and associated species recorded at Peel Inlet, showing the species already recorded or expected to occur within the Port Mandurah Stage 2 Project area | 37 |
| Table 4 | The Structure and Landscape elements identified at the Sutton Farm Heritage Precinct and General levels of Conservation Significance | 47 |
| Table 5 | Management Responsibilities and Means of Funding of Canal Estate Developments as outlined by the City of Mandurah's Draft Waterways Management Guidelines | 69 |
| Table 6 | Water through flow rates and velocities predicted for the canals during average and extreme events | 81 |

## LIST OF FIGURES


| | |
|---|---|
| Figure 1 | Location |
| Figure 2 | Geomorphology |
| Figure 3 | Geological Cross Section |
| Figure 4 | Water levels, August 1994 |
| Figure 5 | Water levels, January 1995 |
| Figure 6 | Salinity Profile |
| Figure 7 | Vegetation Map |
| Figure 8 | Waterbird habitat values |
| Figure 9 | Species Richness at Port Mandurah Stage 2 compared to other sites on the northern Peel Inlet |
| Figure 10 | Waterbird abundance at Port Mandurah Stage 2 compared to other sites on the northern Peel Inlet |
| Figure 11 | Waterbird seasonality at Port Mandurah Stage 2 |
| Figure 12 | Waterbird habitat usage at Port Mandurah Stage 2. |
| Figure 13 | Location of Aboriginal Heritage Areas and Sutton Farm Precinct. |
| Figure 14 | Outline Development Plan |
| Figure 15 | Stages of Development |
| Figure 16 | Area proposed for Conservation and Foreshore Reserve |
| Figure 17 | Typical Canal Cross Section |
| Figure 18 | Typical Section through Block and Adjacent Canal |
| Figure 19 | Proposed Front of Block Drainage |

# 1.0 INTRODUCTION

## 1.1 Summary of the Proposal

Esplanade (Mandurah) Pty Ltd (EMPL) proposes to develop Stage 2 of the Port Mandurah Canal Estate Project.

The Stage 2 proposal is an extension of the Port Mandurah Stage 1 project, located adjacent to the Mandurah Channel opposite the Mandurah town centre, 70km south of Perth (Figure 1). The Port Mandurah Stage 1 project was granted environmental approval in 1989, with construction of the canals and approximately 200 residential lots completed in 1990. The planning and engineering design of the first stage allowed for future extensions of the canal system to the south. The current proposal will connect the Stage 2 canals to both the Mandurah Inlet and the Stage 1 canals to the north, to allow for completion of the integrated canal estate and secure enhanced flushing of the waterways.

The Stage 2 proposal is for development of approximately 92ha, comprising 501 residential allotments (37ha), two areas of communal housing with approximately 110 residences and approximately 33ha of canal waterways. Development will proceed in approximately 100 lot stages, with the expected duration of development being from five to eight years.

The project site is located adjacent to an area of the Mandurah Channel which is designated as a System 6 (C50) conservation area and an internationally significant waterbird habitat under the Ramsar Convention. The proposed development recognises that it is critical to protect and manage this area, with a principal focus of canal estate design being the creation, integration and ongoing protection of a Conservation and Foreshore Reserve.

The development proposal also includes the management and protection of significant Aboriginal and European heritage sites, as well as the provision of public environmental education facilities.

In addition, the proposal will maintain the high standards of water circulation experienced in Port Mandurah Stage 1. The Stage 2 proposal will apply the same environmental design criteria to the canal and residential development as Stage 1, subject to modification

where experience has shown to be appropriate in order to secure improved environmental performance.

Specific environmental issues related to the Port Mandurah Stage 2 and addressed within this PER include:

- Expected impacts of the Dawesville Channel
- Canal design (in relation to existing guidelines, flushing performance and enhancement of waterbird habitat)
- Methods and impacts of canal construction and operation
    - Impacts of dewatering
    - Estuarine water quality
    - Canal sediment quality
    - Noise and dust
    - Traffic
- Drainage and nutrient management
- Protection of heritage areas
- Management of waterbird habitat
- Public access to foreshore reserve and provision of facilities for public environmental education and awareness
- Mosquito control
- Monitoring and management programmes
- Waterways management

In summary, the key features of the proposal are:

- It is an extension to an existing canal estate which has demonstrated compliance with the conditions of environmental approval and which has shown to have minimal impact on the environment.

- It is based on previous experience in the development of canal estates and understanding of ecological issues associated with the Peel-Harvey estuarine system.

- It is a development fully approved by a majority vote in favour of the proposal by a referendum held by the City of Mandurah.

- It will apply the most recently amended guidelines and parameters for the design and construction of canal waterways.
- It will incorporate the City of Mandurah's recently formulated draft policy for Waterways Management Agreements.
- Water quality of the waterways should be improved by the anticipated benefits of the Dawesville Channel in long-term reduction of algal blooms.
- Significant social heritage features will be protected, restored and will act to improve the tourism potential for the area.
- Innovative project design and management has been applied to provide for the conservation and ongoing management of internationally significant waterbird habitat, through the provision of a Conservation and Foreshore Reserve, public access to the Reserve and facilities for environmental education and appreciation of the waterbird habitat.

## 1.2 The Proponent

The proponent for Stage 2 of the Port Mandurah Canal Estate is Esplanade (Mandurah) Pty Ltd (EMPL). The Port Mandurah project is 100% owned by EMPL, which is a wholly owned subsidiary of Cedar Woods Properties Ltd.

The subject land presently comprises six separate lots, as follows:

- Murray Location 2, Part Lot 1;
- Murray Locations 58, Lots 2 and 6, Part Lots 5 and 58;
- Murray Location 5, Lot 3; and
- Road Closure fronting Lot 2.

EMPL currently own each of these properties except Lot 2 (3.8ha) and the adjoining Road Closure land (0.9ha), which are owned/controlled by the City of Mandurah.

EMPL has the resources and capacity to both develop and manage Stage 2 of the Port Mandurah Canal Estate in an orderly and proper manner, in accordance with government

requirements for appropriate management of the adjacent marine and terrestrial environments.

Most importantly, EMPL is committed to achieving an outstanding development which, as demonstrated by the environmental performance of Stage 1 of the Port Mandurah project, is able to achieve all objectives, conditions and commitments towards protecting the environmental quality of the proposed estate and the adjacent estuarine environment. In addition, the development will contribute to the PIMA objectives of reservation, protection, enhancement and management of the valuable foreshore areas and adjacent waterbird habitat. The provision of public facilities for environmental education and appreciation is a feature of the proposal.

## 1.3 The Statutory Environmental Approvals Process

A number of Government Authorities will be involved in the decision making process in the course of approving this proposal. These include:

- The City of Mandurah
- The Peel Inlet Management Authority (PIMA) and the Waterways Commission
- The State Planning Commission and the Department of Planning and Urban Development (DPUD)
- The Department of Environmental Protection (DEP)
- The Environmental Protection Authority (EPA)
- The Department of Conservation and Land Management (CALM)
- The Water Authority of Western Australia
- The Department of Transport (Marine & Harbours)
- The Western Australian Museum (Aboriginal Affairs Department).

The *Environmental Protection Act, 1986 (as amended)* requires that any development which has the potential to affect the environment must be assessed by the EPA. One of four levels of assessment may be assigned to a proposal by the EPA. These are:

- Informal Review with Public Advice
- Consultative Environmental Review (CER)
- Public Environmental Review (PER)
- Environmental Review and Management Program (ERMP)

This proposal has been assigned a Public Environmental Review by the EPA, which is the second highest level of formal assessment. This PER is made available for public review and comment for a period of eight weeks during which submissions may be made regarding the proposal. At the conclusion of the public comment period the EPA will consider the proposal together with any public submissions. Public submissions are confidential, however the proponent will be asked to comment on any issues which are raised by the public, and summarised by the DEP.

When the assessment is completed, the EPA will prepare a report (Bulletin) which will summarise the issues and state whether the project is environmentally acceptable and under what conditions. Anyone can appeal against the recommendations of an EPA assessment report for a two week period.

Before a project may proceed, the Minister for Environment must give approval and will set conditions which must be met by the proponent. Only the proponent can appeal against Ministerial conditions which, when set, are legally binding.

## 1.4 Timing and Schedules

This PER was released on 10th April, 1995 and will be available for public comment for an eight week period, closing 2nd June, 1995. Details on how to make a submission are included at the front of this document.

## 1.5 Purpose and Structure of the Public Environmental Review (PER

This PER has been structured in accordance with DEP Guidelines for the project (Appendix A).

This document has the purpose of describing the proposal, detailing the existing environmental characteristics of the site and surrounding area and any anticipated environmental impacts, and proposing environmental design and management strategies which will be required to mitigate any potential environmental impacts. The environmental commitments proposed by the proponent are listed in Section 8.0.

The Appendices, which are the basis for summarised information in the PER in relevant sections, are presented in full under separate volume. The Appendices are available upon request (at additional $10.00 cost to the PER).

The document therefore brings together the information required to assist in the environmental assessment process.

# 2.0 PROJECT RATIONALE

## 2.1 Background to the Proposal

Stages 1 and 2 of the Port Mandurah Canal Estate project were initially assessed together as the Halls Head Waterways Project within an Environmental Review and Management Programme (ERMP) in December, 1981 (Feilman Planning Consultants, 1981). The EPA issued a report and recommendations for the project (Bulletin 129) in December, 1982, and supported development of the area on a staged basis subject to compliance with 33 recommendations. In May, 1985, the Minister for Planning granted approval to rezone the northern portion of the project to Canal Zone, subject to compliance with the above recommendations.

In 1989, the project was re-named the Port Mandurah Canal Estate Project following a revision of the development plans for the northern portion of the project (Stage 1). The EPA indicated that the changes proposed were sufficient to warrant re-assessment under a Notice of Intent (NOI), with the NOI (Rule Group Ltd, 1989) considered as supplementary to the original ERMP. The changes resulting from the design modifications included the following

- Changes to the canal layout to allow for waterfront residential allotments with a reduction in the number of small islands. The new canal orientation was designed to enhance the effect of wind induced currents (easterly). Measurements taken on site between August, 1986 and September, 1987 indicated that the measured winds were stronger than those recorded in the ERMP;
- Changes to the dewatering concept being used for construction purposes;
- Changes to the minimum block levels from 1.9m AHD to 2.2m AHD as a result of a (then) recent study of the potential greenhouse effect;
- Changes to the block profiles so that the blocks will generally slope towards the canal edge;
- Changes to the drainage design to prevent stormwater passing directly into the canals;

- Changes to the canal cross-sections, width between edge walls and width of navigable waterways, to be in accordance with the (then) current Canal Guidelines;

- Changes to the canal edge walling, with the bulk of the estate containing walls based at shallow depth rather than full depth walls.

Following public review and assessment by the EPA (Bulletin 378), Stage 1 of the Port Mandurah project was granted environmental approval in 1989 subject to 13 Ministerial Conditions and 46 Commitments made by the proponent. A copy of the environmental conditions and commitments for the Stage 1 project is presented as Appendix B.

## 2.2 Justification for the Development

The initial planning proposal for the Port Mandurah Canal Estate was for staged development of the entire site. A staged development was supported by the EPA.

At the request of statutory authorities, the planning and engineering design of the Port Mandurah Stage 1 development allowed for future extensions of the canal system to the south. Ministerial Condition 13 for Stage 1 acknowledges the proponent's intention to develop the balance of the Port Mandurah Project (Stages 2 and 3) in the future.

A requirement of the (draft) City of Mandurah Waterways Management Guidelines is for a rate payer referendum to occur, if Council desires, prior to substantive support for any canal proposal. A referendum for the proposal took place in 1990, with the outcome confirming majority elector support for proceeding with the balance of the Port Mandurah development (Appendix C).

The success of the Port Mandurah Stage 1 development is reflected by the high demand for residential lots. This demand for canal lots has occurred since the inception of canal estates within the City of Mandurah and Shire of Murray fifteen years ago. Currently there are no major, centrally located areas where demand can be fulfilled and as such, a number of lifestyle preferences cannot be pursued.

At present, the City of Mandurah and the surrounding region is experiencing relatively significant residential growth. Principally, the growth is being contained within the

eastern and southern corridors of the City Centre, with residents of the growth areas presently shopping within the south-east Forum precinct of the City. This re-direction of "shopping dollars" from the City Centre to the Forum precinct has resulted in increased floorspace being developed away from the Mandurah Terrace precinct and has subsequently reduced the importance of the City Centre. A significant impact of the project would be the influx of dollars back into the City Centre commercial precinct, contributing to the re-vitalisation of the Centre.

The project area east of Old Coast Road (Stage 2A) contains large expanses of degraded, low-lying samphire flats and is a designated mosquito breeding area. This presents significant concerns for public health with regard to Ross River virus, however continued chemical treatment of this area which is adjacent to an important waterbird habitat is not seen as a desirable management option. The proposed canal development will remove the high level mosquito breeding areas, whilst retaining quality inter-tidal samphire flats which only support intermittent mosquito breeding. Habitat of higher significance to waterbirds (ie tidal flats and perching areas) which does not support larvae development, will be constructed to replace the habitat removed by the proposal.

The foreshores of the project area are not contained within any designated reserve and are not actively managed. The Peel Inlet Management Plan (Waterways Commission, 1992), identified the need to acquire areas of the subject land for the purpose of foreshore reserve. The development proposal includes the ceding of 4.8ha of land to the Crown for Foreshore Reserve, the development of public facilities for the purposes of environmental recreation and education whereby the public can view and appreciate the flora and fauna present within the Reserve, and the development and implementation of a Conservation and Foreshore Management Plan for the protection of these areas. The layout of the canals and the engineering structures proposed have been specifically designed for the protection and enhancement of the System 6 waterbird habitat.

The project area west of Old Coast Road (Stage 2B) contains the historic Sutton Homestead buildings, together with a historical graveyard. Both of these have been researched by the Mandurah Historical Society and are considered to be of heritage significance. The planned development proposes to retain the Sutton Homestead within a 'heritage precinct', to actively restore the appearance of the buildings, and to promote the history of the site through educational displays and facilities. The graveyard will also be restored and maintained.

Following a site survey and discussions with Aboriginal representatives, two sites of Aboriginal ethnographic significance have also been identified on the site. These areas will be retained within Public Open Space, and, at the request of the Aboriginal spokesperson, a plaque identifying the significance of the location will be erected at each site.

## 2.3 Existing Policies and Guidelines

The history of canal estate developments in the Mandurah area has seen the development and maturation of detailed design and management requirements to ensure ongoing environmental performance and to avoid unacceptable impacts upon the beneficial uses of the Peel-Harvey Estuarine system and its environs. The majority of these requirements have now been incorporated into engineering and planning design guidelines, formulated by DPUD in consultation with PIMA, DEP, the Department of Transport and the City of Mandurah. The current policies and guidelines controlling canal estate development and/or development within the Peel Inlet are as follows.

### 2.3.1 Existing Zoning - City of Mandurah Town Planning Scheme No. 1A

Development within the local authority is presently controlled by the provisions of the City of Mandurah Town Planning Scheme No. 1A (operational District Planning Scheme). Under the Scheme, the subject land is included within the following zones:

- 'Tourist and Municipal Purpose' zone (Stage 2A - east of Old Coast Road)
- 'Residential 1' zone (Stage 2B - west of Old Coast Road)

Stage 1 of the existing Port Mandurah Estate is included within 'Canal' zone. Significant areas of 'Residential 1' zoned land are located to the west (Halls Head).

### 2.3.2 Proposed Zoning - City of Mandurah Town Planning Scheme No.3

In accordance with the provisions of the *Town Planning and Development Act 1928* (as amended), the City of Mandurah is presently undertaking a review of the existing Town Planning Scheme. Under the proposed Scheme (Town Planning Scheme No.3), the

subject land will be consolidated within a 'Canal' zone, with a 'Tourist' zone to accommodate the Sutton heritage precinct.

Under the revised scheme, the zoning to 'Canal' estate will provide for a range of new controls relating to canal development, including the requirement for an Outline Development Plan (ODP) to be prepared over new Canal Estates prior to rezoning. The purpose of the ODP is to co-ordinate development over larger parcels of land. In addition to planning considerations such as housing densities, servicing and community facilities the ODP is required to address environmental characteristics, land uses, Aboriginal and European Heritage sites and areas of natural conservation significance. Minimum development standards associated with the zone, including setbacks and car parking, are also stipulated within the Scheme.

Given that the finalisation of the new Scheme is unlikely to occur within the next eighteen months, the City of Mandurah will consider the current proposal as an amendment to the existing Town Planning Scheme 1A, to allow Stage 2 of the Port Mandurah Canal Estate to proceed while the new scheme is being finalised. The amendment will be in accordance with the proposed new Scheme 3 guidelines. Accordingly, an Outline Development Plan for the proposal was submitted to the Council in January, 1995 (BSD, 1995).

### 2.3.3 State Planning Commission Policy DC1.8

The SPC's Policy DC 1.8 - Procedures for Approval of Artificial Waterways and Canal Estates, was formally adopted by the Commission in December, 1991. The Policy prescribes the "general principles and procedures which should be observed and followed by those proposing to undertake projects involving artificial waterways and canal estates".

In particular, the Policy sets out the minimum provisions relating to the following:

- Canal Management
- General feasibility of proposals
- Referral Authorities
- Seeking and securing approvals
- Town Planning Scheme requirements
- The design of canal estates
- Water quality
- A model 'canal' zone for insertion within Local Authority Schemes.

The Policy stipulates that determination of a canal estate proposal should involve initial referral to a number of Authorities to establish whether there are any fundamental grounds on which the proposal should not progress. Referral to determine this must be made to the following Authorities:

- Department of Transport (formerly Marine and Harbours)
- Local Authority
- DEP and the EPA
- State Planning Commission
- Other agencies (eg Waterways Commission and PIMA)
- Minister for Planning

Upon securing endorsement for the development, proponents should then seek to rezone the relevant site through a Scheme Amendment. Any conditions required by the referral authorities should be imposed as 'deemed-to-comply' conditions of the Amendment. Re-zoning of the site has been applied for as per Section 2.3.2 above. On March 7 1995, the Council resolved to amend the Town Planning Scheme accordingly, subject to environmental approval and conditions applied by the Council.

The SPC Policy DC1.8 also sets out the minimum design standards for canal design. Whilst the standards are not for minimum construction details, the Policy does stipulate design widths, mooring spaces and canal depths based on a 'design vessel'. The 'design vessel' represents the anticipated vessel type that would use the canals.

### 2.3.4 City of Mandurah - Draft Waterways Management Policy

The City of Mandurah has recently prepared 'Waterways Management Guidelines' to control future and existing canal development within the city. Although these guidelines are presently in draft, they will be used by the Council as a planning tool for assessing any current proposal for canal estate development.

Within these guidelines, Council indicates its preparedness to accept responsibility for ongoing management of the canals as the Waterways Manager after handover of the project from the developer. Details of the responsibilities of the Waterways Manager are contained in Section 4.7 of this PER.

### 2.3.5 Peel Inlet Management Programme

In 1992, PIMA and the Waterways Commission released a management plan for the Peel Inlet and Harvey Estuary which presents recommendations for the management of particular areas throughout the estuarine system. The Plan acknowledges the development of canal estates in the area and recommends: the need to manage mosquito breeding areas; the acquisition of foreshore reserves as a condition of rezoning or subdivision; the requirement of the developer to prepare a Foreshore Management Plan to protect and rehabilitate samphire marshlands; the need to protect wildlife and landscape values; and the need to provide future public access. Section 4.2.1 outlines how the proposal conforms with these planning considerations.

### 2.3.6 PIMA Dredging Policy WS 4.1

PIMA released a Policy Statement in September, 1994 for the dredging of riverine and estuarine waterbodies. The canals for the present proposal will be excavated "in the dry" rather than dredged and only the entrance connection to Mandurah Channel will require dredging. This limited dredging will conform with the requirements of this Policy, as well as the PIMA Draft Guidelines for the Preparation of Dredge Spoil Disposal Management Plans - Guidelines for Proponents.

### 2.3.7 PIMA Dewatering Policy WS 4.2

Dewatering and the release of dewatering fluids into the estuary will follow the PIMA Dewatering Policy guidelines.

### 2.3.8 Conservation Reserves for Western Australia - System 6 ("Red Book")

The estuarine environment immediately adjacent to the project area is designated within the System 6 (C50) area of high conservation significance for waterbird habitat and recreation uses. Sections 4.2.1 and 7.4.1 explain how the proposal addresses the recommendations for C50.

### 2.3.9 International Conventions

Australia is a signatory of the Ramsar *Convention on Wetlands of International Importance Especially as Waterfowl Habitat* (Ramsar Convention, 1971), the *Agreement between the Government of Australia and the Government of Japan for the Protection of Migratory*

*Birds and Birds in Danger of Extinction and their Environment* (JAMBA, 1981) and the *Agreement Between the Government of the Peoples Republic of China for the Protection of Migratory Birds and their Environment* (CAMBA, 1988). Each of these agreements was ratified under the Commonwealth *National Parks and Wildlife Conservation Act, 1975*.

Implicit in these agreements is the obligation for Australia to preserve important waterbird habitats.

The Peel-Harvey Estuary is one of 40 Australian wetlands specified in the Ramsar convention, although areas of private ownership are not included. Thirty four species of waterbirds listed under the CAMBA and/or JAMBA treaties have been recorded from the Peel-Harvey Estuary (ANCA, 1993). The implications of the proposal on these agreements with relation to impacts, protection and management of waterbird habitat are addressed in Sections 3.3.2, 4.2.1, 5.2, 5.4.2, 6.7, 7.2.1, 7.3.1, 7.4.1 and 7.5.1.

### 2.3.10 Peel Regional Park Study

The 1993 draft Peel Regional Park Study by DPUD outlines a proposal for the establishment of a regional park through the provision of guidelines for the administration, land use and management of proposed parks and reserves in the Peel-Harvey region.

The Port Mandurah Stage 2 project contributes to the proposal for the establishment of a Peel Regional Park by the allocation of land as a Conservation and Foreshore Reserve which is proposed to be gazetted as an "A" Class Reserve for the Conservation of Fauna.

### 2.3.11 Peel Regional Strategy

The Peel Regional Strategy was released by DPUD in September, 1994 and provides a strategic policy statement and land-use plan for the Peel-Harvey region.

The Port Mandurah Stage 2 proposal conforms with environmental, economic, social, urban development and infrastructure, and water resources objectives within the urban and regional open space land-use as proposed within the Strategy.

## 2.4 Benefits of the Project

The benefits of developing the proposed residential canal estate include:

- Productive use of land which is currently under-utilised for rural or urban purposes.
- Maximising development within close proximity to the Mandurah City Centre.
- Meeting the strong demand for canal estate lots.
- Establishing a high standard residential development.
- Reducing vehicle movements and traffic density from the site, as compared with a capacity (1100 lot) dry lot subdivision.
- Increasing the amenity of Mandurah Channel and Peel-Harvey estuary by establishing close links between the water and the population.
- Converting rural land use to residential canal development, which will result in a net reduction in nutrient inputs to the estuary (EPA Bulletin 374).
- Removing an area of significant mosquito breeding habitat.
- Creating a continuous foreshore reserve, consistent with the objectives of PIMA for conservation protection of the estuarine boundaries.
- Providing for an enhanced waterbird habitat and an ecologically functional interface between the canal estate and the Foreshore Reserve, through provision of an additional 25m buffer zone along the eastern development boundary.
- Reducing ongoing impact upon valuable waterbird habitat within the proposed Conservation and Foreshore Reserve due to human activity and feral and domestic animals, by having a canal as a boundary to the Foreshore Reserve and the System 6 area and by installing a vermin proof fence elsewhere along the Reserve boundary.
- Facilitating the appropriate ongoing environmental management of the Conservation and Foreshore Reserve.

- Providing public facilities relating to environmental education and appreciation of the waterbirds and their habitat.
- Providing protection, management and restoration of European heritage sites.
- Providing protection and opportunities for appreciation of Aboriginal heritage values.

## 2.5 Evaluation of Alternatives

### 2.5.1 Urban Subdivision and Conservation Area

An urban subdivision and conservation area option would propose to develop a conventional residential estate on the subject land. Areas beyond the limit of the development boundary would be incorporated within a Conservation Area abutting the Mandurah Channel.

There are a limited number of benefits associated with a conventional urban subdivision on the subject land, most of which would also be achieved through development of a canal estate. These benefits can be identified as:

1. The development of under-utilised land.
2. Increasing economic benefits to the Mandurah City Centre.
3. Making efficient use of existing infrastructure, services and facilities within close proximity to the City of Mandurah.

Capacity development for a conventional subdivision would be approximately 1100 lots, in contrast to the 501 residential allotments proposed for the canal estate. In comparison with canal estate development, the development of the site for conventional residential use would place much greater demand on the use of existing infrastructure, services and facilities, and would cause markedly greater impact upon amenity, environment and heritage values.

Amenity

The amenity of the area would be more adversely affected in the short-term if conventional residential development occurred. Residential canal estate makes use of the material

excavated during the construction of the canals. In contrast for conventional residential subdivision, imported fill would be required to raise the height of the land above the 1 in 100 year flood level. The filling activities would require significant heavy vehicle movements which would adversely increase the impact on the amenity of surrounding residential properties throughout the construction period.

Environment

The Peel Regional Strategy has proposed the development of the area for urban land-use. The principal environmental concern resulting from a conventional subdivision would arise from the application of nutrients or fertilisers to the lawned/garden areas, which would further exacerbate nutrient problems already experienced in the estuary. In comparison, the proposed canal estate development will result in a significantly reduced area of lawn and gardens (approximately 50%) so will be much less harmful to the water quality of the Estuary.

Traffic

Capacity development for a conventional subdivision at approximately 1100 lots would effectively double the vehicle trips associated with the proposed Port Mandurah Canals Estate. This would significantly impact on the residents of adjoining roads, particularly McLarty Road and Mary Street, in the long term.

### 2.5.2 Rural Use

The development of the land for rural use would require an intensification of its existing use. It would have no significant benefits, would be economically marginal, and would be an under-utilisation of land within close proximity to the Mandurah City Centre.

Intensification of animal grazing would result in further disturbance to the seasonally inundated areas of the site, with a potentially significant increase in mosquito breeding habitat due to additional micro-depressions formed from hoof-prints. Intensified rural landuse would also considerably increase the nutrient load from the land to the Mandurah Channel.

### 2.5.3 "Do Nothing"

The "do nothing" alternative simply concludes that the status quo of activities will continue on-site.

As with intensified rural landuse, the continuance of the current landuse would result in continued foreshore and waterbird habitat disturbance, relatively high nutrient loadings to the estuary and the maintenance of current areas of low-lying land as mosquito breeding habitat. The "do nothing" alternative would prevent the acquisition of foreshore land and the establishment of a Conservation and Foreshore Reserve, hence precluding its specifically financed and immediate protection and management within the proposed Peel Regional Park as a System 6 conservation area of international significance. In addition, the option would not secure the conservation and restoration of the Sutton Homestead buildings which are of heritage significance, nor would it secure the recognition and protection of the Aboriginal sites.

### 2.5.4 Other Sites for Canal Estate Development

The current demand for a canal estate lifestyle in the Mandurah region is high and is likely to exceed the supply of available lots in the not-too-distant future, due to the limited availability of land suitable for this type of development. Land which is appropriate for canal estate development in the Peel-Harvey estuary has the following preferred characteristics:

- adjacent to the foreshore;
- degraded or with low conservation significance;
- in private ownership;
- strongly influenced by tidal exchange, ie: as close as possible to the ocean; and
- close to an existing or proposed population centre.

Limited areas of foreshore land in the Peel-Harvey estuarine system are in private ownership and suitable for canal development. The Port Mandurah Stage 2 site is ideally located, being a continuation of an existing canal estate landscape, close to the City Centre and occurs on degraded land with relatively low conservation significance. The close proximity of the site to the ocean is of benefit to the canal estate boat owners, while the strong influence of tidal exchange will assist in maintaining high water quality within the canals.

# 3.0 DESCRIPTION OF THE EXISTING ENVIRONMENT

## 3.1 Physical Environment

### 3.1.1 Topography

The proposed development site occupies low-lying ground on the western side of the Mandurah Channel (Figure 1).

The Stage 2A area, east of Old Coast Road, mostly varies between an elevation of approximately 0.2m AHD in the northern and eastern parts and 0.7m AHD in the southern central part. There are two areas of higher ground, one to 1.5m AHD in the south-eastern corner and the other rising to 3.5m AHD at the south-western corner (near the corner of Leisure Way and Old Coast Road). Stage 2A also includes areas of shallow scrapes and marl excavations, together with levee banks which were historically constructed to restrict salt-water intrusion during flooding.

The Stage 2B area, west of Old Coast Road, is also very flat. There are two low-lying areas (0.5m - 0.8m AHD), one at the north-eastern corner near the junction of Mary Street and Old Coast Road, and the other near Mary Street at the north-western corner. Elsewhere within the Stage 2B area is within the range 1.2m - 1.4m AHD.

The topography west of the Stage 2B boundary rises to the ridge of the Halls Head peninsula, which has a maximum elevation of 25m AHD.

The Mandurah Channel along the eastern site boundary has a wide (100-350m) area of shallows with less than 0.5m water depth at mean water level, then a rapid drop-off to the main channel, to a depth of -4.8m AHD. The shallows include three principal topographic elements:

- An intertidal samphire foreshore at approximately +0.15m AHD (mean high high water level) extends along all but the northern-most shoreline and is up to 50m wide.

- An elongate shoal extends parallel to the tidal flow along the offshore fringe. This shoal comprises a samphire flat at approximately +0.15m AHD in the

southern part, a shallow tidal channel at approximately -0.40m AHD in the central part and a subtidal shoal at approximately -0.25m AHD in the northern part. (Mean low low water is -0.14m AHD).

- A shallow protected lagoon, varying between -0.35m and -0.55m AHD, occurs inshore of the offshore shoal area.

### 3.1.2 Geomorphology and Soils

The geomorphology and soils of the project area have been formed primarily from estuarine/marine deposits, overlying the Leederville Formation. The project area has been classified within the geomorphology of the Peel - Harvey estuarine system as a relic or stranded channel shoal complex (Semeniuk & Semeniuk, 1990) (Figure 2) which is described as an undulating terrain of very low relief sand ridges and hummocks with intervening shallow depressions. Soils comprise a modern veneer of shelly sand overlying muddy sand or sand with underlying limestone at varying depths.

An east-west cross-section across the development site is presented in Figure 3. The estuarine/marine sediments over the development site are generally 4-5m thick, but may be up to 10m thick in places towards the Mandurah Channel. They form a complex sequence of organic clay, silt, grey fossiliferous limestone, sand and clayey sand, which wedges out against the ridge on the west side of the site. The principal elements are:

- Calcarenite, which is widespread under the surface soil and is occasionally exposed at the surface.
- Fluvial and aeolian deposits of shelly sand and silty sand extending beneath the calcarenite to a depth of approximately 5 metres below Australian Height Datum (AHD).
- Coastal (Tamala) limestone which occurs below the estuarine deposits and is present to a depth of -10mAHD. The Tamala Limestone consists of calcareous sand with irregular patches, layers and lenses of calcarenite and sand. The top of the limestone is indurated in places, forming a hard caprock with a pinnacled upper surface.

The Leederville Formation unconformably underlies the Tamala Limestone; the contact is uneven, but is generally at about 8-9m below AHD. The Leederville Formation consists

of siltstone and shale, which forms an impermeable substrate to the superficial formations. It extends to approximately 250m below sea level where it unconformably overlies the Yarragadee Formation.

### 3.1.3 Surface Drainage

There is no defined surface drainage on the development site. The high ridge to the west of the development site is covered with permeable sand which allows percolation of all incident rainfall, so that runoff to the development site is negligible. The only exception to this is road runoff from nearby streets in the Halls Head residential estate, which is piped under Old Coast Road at the junction of McLarty Road.

The surface of the development site itself is less permeable and some local ponding and flooding may occur after heavy rains.

In particular, the surface drainage within the Stage 2A area has been extensively modified by the construction of levee banks to restrict salt water incursion and by the presence of shallow depressions formed by past marl excavations. No defined drainage channels are evident, with ponded water either evaporating or percolating to the shallow water table. Water unable to infiltrate on the higher ground to the south of the site may runoff to the fringing sedgeland and samphire flats of the estuarine foreshore.

### 3.1.4 Groundwater Hydrology

The groundwater regime of the site has been assessed within an independent study (Dames & Moore, 1995) which is provided as Appendix D and summarised below.

Superficial groundwater flow beneath the site is currently towards the Stage 1 canals in the northeast. This appears to have varied from the more easterly flow direction (ie towards Mandurah Channel) originally reported for the site in the Halls Head Waterways ERMP (Feilman Group, 1981), indicating that the flow direction has been locally modified by the construction of the Stage 1 canals.

The watertable below the site ranges from 0m to 0.9m AHD, generally 1-2m below ground level. Near the estuary, the groundwater levels are affected by tidal influence and may sometimes be up to 0.4m below AHD.

The superficial groundwater beneath the site is mostly brackish to saline. To the west of the site, a lens of fresh groundwater several metres thick overlies brackish groundwater at depth. A small number of domestic bores tap this fresh groundwater for garden use.

Seasonal variations in water level are generally about 0.5m, reaching a maximum in August - September after recharge from winter rainfall and a minimum in April - May at the end of summer (Figures 4 and 5).

Groundwater in the superficial deposits is recharged from rainfall. Studies from the 1981 ERMP (Feilman Group, 1981) demonstrated that the top of the groundwater mound beneath the Halls Head peninsula was not far to the west of McLarty Road. The groundwater below most of the peninsula therefore flows westwards to the Indian Ocean, taking the preferred flowpath through the greater thickness of Tamala Limestone to the west. The less permeable marine-estuarine sediments restrict the potential for easterly flow.

Recharge from rainwater onto the ridge of Tamala Limestone would be expected to be in the range 10-20 percent of annual rainfall, which averages 880mm. It is likely to be considerably less on the development site because of the lower permeability of the estuarine/marine sediments.

The present position of the saltwater interface is about 150m east of McLarty Road (Figure 6). The interface is a broad zone of diffusion rather than a sharp boundary and is maintained in its present position by the fresh groundwater lens in the Tamala limestone on the western boundary of the site.

The deeper Leederville Formation is a regionally important artesian aquifer which is confined by an upper sequence of siltstones and shales in the vicinity of Mandurah. In the Mandurah area the upper part of the Leederville Formation contains only brackish to saline groundwater, with fresh groundwater occurring only at depths of greater than 100m.

### 3.1.5 Estuarine Hydrodynamics

The Mandurah Channel connects the Peel Inlet to the ocean. The Channel is approximately 5km long and varies in width from 120m at its mouth to approximately 250m in the vicinity of the project site. Prior to the recent opening of the Dawesville Channel, the Mandurah Channel was the sole connection between the Peel-Harvey Estuary

and the ocean.

The hydrodynamics of the Mandurah Channel are the product of the interaction between the estuary and the ocean. The major hydrodynamic processes are:

- Tidal water movements, both diurnal and longer term variations (barometric, shelf waves, etc) providing exchange of estuary and ocean waters and generating tidal currents.
- Wind stress forces generating wind waves and surface currents and promoting vertical and horizontal water exchange.
- Periodic fresh-water flushing and seasonal salinity changes due to river flooding.
- Seasonal salinity elevation due to summer evaporation which may produce localised hyper-salinities within the Peel Inlet and the Harvey Estuary.

The Mandurah Channel is a tidally dominated environment. Ocean wave action penetrates a very limited distance into the channel and marine sedimentation does not extend south of the traffic bridge (LeProvost, 1981). Hydrodynamic processes in the vicinity of the development can be summarised as follows:

- Tidal - Astronomic tides are diurnal and microtidal with a mean tidal range of approximately 0.3m (Table 1). Previous analysis (Riedel and Byrne, 1990) determined that the daily contribution to average daily water level variations by the astronomic tide at Mandurah is 0.4m. The channel has a damping effect on tides, with the range at Chimney Spit being about 85% of that at the Old Traffic Bridge.

  Longer period variations in water levels in the Mandurah Channel are associated with barometric changes, shelf and storm waves and large scale ocean currents. These variations can be as great as diurnal tidal variations with the changes occurring over several days or weeks (BSD, 1992).

- Wind Stress - Winds impart momentum to surface waters through horizontal shear stress forces. These generate surface currents of between 2-5% of wind speed. The strength of the current decreases with water depth. In areas of sufficient fetch, wind waves may also occur which agitate the water column and promote vertical mixing.

- Density Gradients - Variations in salinity and temperature associated with mixing of inlet and ocean waters in the Mandurah Channel can produce horizontal or vertical water column stratification. The resulting differences in density between different levels generate density currents.

Flushing studies undertaken for the various canal and marina developments at Mandurah have shown that each of the above forces are important for water turnover rates. Generally, as wind stress forces increase, there is a concomitant breakdown in stratification and a reduced relative influence of density currents. Conversely, density currents assume greater importance during periods of light winds.

The Dawesville Channel was opened between the northern Harvey Estuary and the ocean in April, 1994. The new channel has significant effects on the tidal range and flushing dynamics of the Peel-Harvey estuary, as discussed in Kinhill (1988) and more recently by the Department of Transport with the benefit of real input data (Department of Marine & Harbours, 1993a; b).

A detailed discussion of pre- and post-Dawesville Channel hydrodynamic conditions within the Peel-Harvey system is not required for this PER because the Port Mandurah Stage 2 Canal Estate is now subject to post-Dawesville channel tidal levels and flow conditions, however the predicted changes to the hydrodynamic conditions in Mandurah Channel due to the Dawesville Channel are minor. The Department of Transport is continuing to record tidal variations at the Mandurah Fisherman's Jetty and will analyse the data after twelve months of records are on hand (April, 1995). Informal advice from the Department of Transport is that only small variations in tidal levels are expected due to the proximity of the ocean at the mouth of Mandurah Channel.

With respect to tidal flows in the Mandurah Channel, the Department of Transport modelling indicates that, post-Dawesville Channel, the average (29 days) maximum flood and ebb flow velocities are 1.1 and 1.2 knots respectively with a maximum modelled flood and ebb flow of 2.1 and 1.9 knots respectively.

The Dawesville Channel is the dominant channel with respect to tidal prisms entering the Peel-Harvey system. For example the Department of Transport modelling shows that for an average 0.4m ocean tide range, the tidal prisms entering the system from the Mandurah and Dawesville Channels are 5,500,000$m^3$ and 17,500,000$m^3$ respectively.

## Table 1

## Tidal Levels at Mandurah (Fisherman's Jetty)

| Level | Height (m AHD) |
|---|---|
| Highest Astronomical Tide | 0.50 |
| Mean High High Water* | 0.15 |
| Mean Low High Water* | 0.03 |
| Mean Sea Level | 0.01 |
| Mean High Low Water* | - 0.06 |
| Mean Low Low Water* | - 0.14 |
| Lowest Astronomical Tide | - 0.41 |

* Mean tide levels include meteorological influences although tides may be up to 0.2 - 0.3m higher.

Source: Department of Marine and Harbours, 1992.

### 3.1.6 Flood Levels

Extreme events influencing water levels within the Peel-Harvey system, and thus the Mandurah Channel, include river floods and tropical cyclone induced ocean storm surge.

These events have been recently modelled by both the Department of Transport (Department of Marine and Harbours, 1994) and the Water Authority of WA (1994) to examine the effects of the Dawesville Channel. The modelling approach followed in each study is different, with the Department of Transport considering various flood hydrographs and ocean tide records (including storm surge) as the detailed forcing functions (15 minute timestep) of a simplified model, representing the system as interconnected basins with dual connections to the ocean. Relationships such as basin volumes at differing stages and channel flow characteristics were included within the model. Averaged conditions only such as typical basin water level and uniform channel flows are available from the published results.

The Water Authority modelling involved a more rigorous hydraulic analysis with surveyed basin and channel cross sections incorporated into the model (IRWASP). Again various flood hydrographic and ocean tidal records (including storm surge), were the forcing functions (6 hourly timestep). For the purposes of this PER the Water Authority re-activated the model to output detailed water surface and flow rates along the Mandurah Channel in order to aid investigations into through flow currents in the interconnecting canals between Stages 1 and 2 of the Port Mandurah Project.

The results of these models are shown in Table 2. In the case of the 100 year flood, a reasonable match can be seen between the two models.

The net result of this work is that the design peak water level within the Peel Inlet is +1.6m AHD (+1.15m AHD 100 year storm surge plus 0.45m wind set-up). This peak level is unchanged from pre-Dawesville conditions, though due to storm surge, rather than flooding as previously was the case.

Along the Mandurah Channel, the Water Authority advise that the published 100 year flood levels (Public Works Department, 1984) remain current as they are based upon the +1.6m AHD peak water level within the Peel Inlet as discussed above. Adjacent to the Port Mandurah Stage 2 project site the published 100 year flood level is +1.32m AHD.

## Table 2

## Modelled Extreme Flood Events

| EVENT | LOCATION | EXTREME LEVELS (m AHD)[1] | |
|---|---|---|---|
| | | DOT/DMH | WAWA |
| 25 year flood | Peel Inlet | 0.75 | |
| | Harvey Estuary | 0.70 | |
| 100 year flood | Peel Inlet | 1.15 | 1.02 |
| | Harvey Estuary | 1.00 | |
| | Project Site | | |
| | North Entrance | | 0.95 |
| | South Entrance | | 0.95 |
| T.C. Alby (Storm surge) | Ocean | 1.10 | |
| | Peel Inlet | 0.70 | |
| | Harvey Estuary | 0.70 | |
| 100 year Storm Surge | Ocean | | 1.40 |
| | Peel Inlet | | 1.15[2] |
| | Harvey Estuary | | |
| | Project Site | | |
| | North Entrance | | 1.31 |
| | South Entrance | | 1.15 |

Note: 1. All levels exclude allowances for wind and wave setup. During T.C. Alby extreme water level differences of between 0.91 - 1.18m were recorded across Peel Inlet (DMH, 1993b).

2. WAWA recommended an additional allowance of 0.45m for wind setup.

### 3.1.7 Water Quality

Water quality in the Mandurah Channel is variable, being influenced by conditions in both the Peel Inlet and the open ocean. Generally the channel is well flushed through tidal exchange with the ocean and exhibits superior water quality to the inlet/estuary system further upstream. Water quality within the channel tends to improve towards the entrance.

Conditions in the Peel-Harvey estuary system are eutrophic (nutrient enriched) and periodically are extremely poor due to algal booms. These blooms result primarily from excessive phosphorous loadings in the system, exacerbated by limited oceanic exchange. The algal bloom cycle has been widely described elsewhere (Gorham *et al*, 1988; Kinhill, 1988; EPA, 1984; 1989).

Phytoplankton blooms common in the inlet/estuary do not develop in the channel but are occasionally present during ebb tides when parts of upstream blooms are flushed out to sea.

Dredging of the Mandurah Channel in 1988 resulted in improved water quality in the Peel Inlet and the channel (EPA, 1989). It is envisaged the increased exchange of oceanic water via the Dawesville Channel will further alleviate water quality problems associated with the algal bloom cycle. If these expectations are realised, the improved water quality of the inlet/estuary will result in even higher water quality within the Mandurah Channel.

The existing environment of the Mandurah Channel now includes several canal/marina developments. Flushing efficiency studies have suggested that the water quality of these water bodies would be dependent on conditions in the channel and this has largely been confirmed by subsequent monitoring programs for Stage 1 of the project (LeProvost Environmental Consultants, 1991a; b; BSD, 1994). There is no evidence of these canals having an adverse effect on the water quality of the channel (Hobbs *et al*, 1993; BSD, 1994).

### 3.1.8 Shoreline Stability

The geomorphology of the region was studied in detail at the time of preparation of the original ERMP for the Halls Head Waterways project (The Feilman Group, 1981). At that time predictions of the stability of the northern entrance canal (for the existing Stage 1 canal estate) indicated an allowance for removal of up to 2000$m^3$/year of sand from the

entrance due to the migration of the Fainbridge Road sandbar. These predictions have been proven by monitoring surveys, with 5100$m^3$ having accumulated over five years, reflecting on average accretion of 1000$m^3$ per year. Small dredging works are imminent to remove this material that has accumulated over the past five years.

At the same time the shoreline area near the proposed southern entrance was concluded to be stable with negligible sediment erosion or accretion. These conclusions, based upon review of aerial photography, site and diving inspections, have been rechecked for this PER with the aid of more recent aerial photographs, hydrographic survey and examination of siltation records from the Waterside Canal Estate opposite. The results are described in Appendix E and are as follows.

Aerial Photographs

Aerial photographs between 1961 and 1991 show that the western shore of the Mandurah Channel, between the Old Mandurah Traffic Bridge and the Bypass Bridge has a varied history. The shoreline north of the proposed southern entrance was, in 1961, an area of concentrated boat moorings (approximately 12 jetties) with little onshore development. By 1981 most of these moorings had been removed and replaced by two excavated basins in the area known as the Mandurah Marina. Development of this site included raising of the land and slight filling across the shoreline into the channel.

Between 1981 and 1991 the shoreline in this region appears stable.

South of the Mandurah Marina and offshore from the Port Mandurah Stage 2 site, the edge of the Mandurah Channel is defined by a subaqueous shoal. The exact limits of this shoal are difficult to accurately define from the aerial photography, however its overall extent from its northern, southern and eastern edges appears to be the same between 1961 and 1991. At intermediate times, the extent of vegetation on the shoal appears to vary markedly with coverage of the southern end fluctuating between 1981 and 1991.

Generally and within the accuracy of the aerial photographs and this method, the shoreline and the subaqueous shoal adjacent to the proposed development appear to be stable. The vegetation line along the shore appears to have retreated by between 5 and 10 metres while the bare shoreline has increased in width. The reason for this is unknown.

Hydrographic Survey

Surveys of this region of the Mandurah Channel, including the subaqueous shoal, are available between 1982 (Public Works Department, WA) and 1995 (McMullen Nolan and Partners). A difference in accuracy of the surveys (the earlier survey reported depths below 0.0m AHD to nearest 0.1m only) limits conclusions that can be drawn due to the flat seabed in the area, however it is clear that again the offshore edge of the subaqueous shoal has been stable over this period. The height of the shoal appears stable, are around -0.25 to -0.3m AHD in its highest areas. Very minor erosion appears to have occurred on its southern edge while varying minimal erosion and siltation in lower areas between the shoal and the shoreline of up to 0.1m were measured. A net total accretion of around $2000m^3$ is therefore evident over the period, equating to less than $200m^3/a$.

The mechanism causing this action is unclear, however the yearly volume is insignificant.

Waterside Mandurah

Hydrographic survey monitoring of the entrance canal and adjacent Mandurah Channel was undertaken for this development between 1986 and 1990. The surveys, at typically 10 to 20m intervals across the entrance channel, extended up to 150m into the Mandurah Channel.

A review of these surveys reveals a widespread short term siltation within the canals and the immediate adjacent Mandurah Channel (where dredged) of between 0.1 to 0.2m between 1986 - 1987. This could be due to immediate post-construction effects such as the settlement of fines etc. However since 1987 and with the adoption of more accurate measurement and reporting of the depths, no trend for either siltation or erosion is evident with depths fluctuating from year to year by amounts consistent within survey accuracy.

## 3.2 Terrestrial Biological Environment

### 3.2.1 Vegetation and Flora

The vegetation distribution over the site is shown in Figure 7.

The vegetation of the project site has been severely impacted due to past and current land

uses. The Stage 2B area (west of Old Coast Road) consists of cleared pasture containing a mixture of exotic and perennial grasses under scattered Flooded Gum (*Eucalyptus rudis*). Most of the Stage 2A area (east of Old Coast Road) is low-lying and seasonally inundated and has been significantly disturbed by grazing sheep and horses, vehicle use, weed invasion, shallow excavations from past marl mining activities and the construction of levee banks to limit the extent of salt water intrusion during peak floods.

Higher areas of land within Stage 2A support *Casuarina obesa* (Salt She-oak), or Flooded Gum (*Eucalyptus rudis*) and occasional Marri (*E. calophylla*) over pasture grass, with a small area near the centre of the Stage 2A site which has been protected from grazing containing the understorey species *Melaleuca hamulosa, M. viminae, Jacksonia sericea* and *Acacia saligna* .

Depressions within the upland area in the south of the Stage 2A area contain either pasture grasses and weeds or low sedgeland. The sedgeland appears to have two components: vegetation associated with seasonal, brackish water (saltwater paperbark (*M. cuticularis*) thickets and *Juncus krausii*) as well as vegetation associated with seasonal fresh water (*M. raphiophylla* and *Gahnia trifida*). These components are mixed in places, with the sedge *J. krausii* covering the largest areas. A narrow fringe of *J. krausii* occurs between the upland area and the foreshore samphire at the most extreme south of the site.

In the north of the Stage 2A area, land which is not protected by constructed levees is seasonally inundated by saline water during winter floods and contains a disturbed and sparse open cover of samphire species (*Halosarcia halocnemoides / Sarcicornia quinqueflora / H. syncarpa* association; or *H. indica ssp biden / Suaeda australis / Threlkeldia diffusa* association on the inland margins).

The tidal shoal and foreshore fringes of the tidal lagoon along the eastern boundary support a dense to fairly open, regularly inundated samphire community between 0.3m and 0.5m high. *Sarcicornia quinqueflora* occurs closest to the shore line and is joined in increasing abundance by *Halosarcia halocnemoides* (two forms) and *H. indica ssp bidens* further inland. *Suaeda australis, Frankenia pauciflora* and *Muellerolimon salicorniaceum.* are scattered throughout the flats, but are more common on the inland margin of the project site.

There are no rare or priority flora present on the site.

### 3.2.2 Fauna

The value of the project site and the adjacent estuarine environment was assessed for its significance as fauna habitat, particularly waterbirds, by Ninox Wildlife Consultants and E.M. Goble-Garratt and Associates, with further fauna investigations conducted by M.J. and A.R. Bamford and Ninox Wildlife Consulting (Appendix F). Figure 8 shows the distribution of fauna habitat values identified by the study. The determination of significance as waterbird habitat was based on recorded usage.

The most significant waterbird habitats are located within the estuarine environment, outside of the project area, and are discussed further in Section 3.3.2.

The terrestrial environment provides limited habitat for fauna and has very low to moderate conservation value. Five habitat types were identified for the land component of the site, namely:

- Habitat 7: Regularly Inundated Samphire (SW). In addition to occurring on the offshore samphire flat (Section 3.3.2), this habitat occurs as a narrow band along the foreshore edge of the project site. This area is mainly in good condition but has localised degradation from vehicles and stock animals. This habitat has **moderate** significance to waterbirds.

- Habitat 8: Rarely Inundated Samphire (SD). This habitat is located in the northern central portion of Stage 2A in the vicinity of abandoned marl excavations, and is rarely inundated except during floods and very extreme tides. The habitat is highly degraded by stock animals, tracks, marl excavations, weed invasion and dry algal mats, with the samphire dead or dying and covered by algal mats in some lower lying locations. The habitat has **very low** significance to waterbirds.

- Habitat 9: Open Woodland (WO). This habitat consists of parkland cleared patches of remnant woodland and shrubland on higher ground, with degradation from stock, vehicle tracks and weed invasion. The overstorey trees have value as nesting and perching sites for passerine birds, including the Splendid Wren (*Malurus splendens*). The habitat of this species is becoming increasingly rare in the metropolitan area. A list of bird species recorded in this habitat is provided in Appendix F. This area has **low** significance to waterbirds.

- Habitat 10: Seasonal Swamp (SS). A low-lying depression in the central southern limits of the Stage 2A project area is a relatively large area subject to winter inundation. The depression currently supports dense sedgeland and is fringed by shrubby salt-water paperbark. There are indications that this depression is an abandoned marl excavation and that the current sedgeland habitat has been enhanced by constructed stormwater drainage from adjacent roads in the Halls Head residential development over the past six to seven years, which has been diverted into the depression via a culvert under Old Coast Road.

  While the sedgeland will not support large concentrations of waterbirds in winter because of the limited amount of open water, the dense vegetation cover is suitable for duck breeding and/or breeding/refuge by secretive waterbird species such as the Australian Crake and the Spotless Crake. Grazing sheep enter the sedgeland, however the degree to which this affects waterbird use is unknown. In the absence of waterbird observations in this area and for the purposes of this assessment, it is proposed that this habitat has **moderate** significance to waterbirds.

  The sedgeland also appears to attract foraging Grey Kangaroos (*Macropus fuliginosus*). Kangaroos are generally not visible on the site during the day and are more likely to be resident in bushland to the south-west of the site and the nearby Erskine Conservation Park. Some restricted diggings of the Southern Brown Bandicoot (*Isoodon obesulus*) were observed in a disturbed area of the site, however a more intensive survey (Bamford *et al*, 1995) revealed that these diggings were isolated, old, and consistent with the foraging activity of a single animal that has moved through the site and is no longer present.

  Although the Stage 2A area was the location of a study transect during a classification of the coastal landforms and peripheral wetlands of the Peel-Harvey estuarine system (Semeniuk and Semeniuk, 1990), the sedgeland was not classified as a wetland by the V & C Semeniuk Research Group during the Wetland and Natural Resource Mapping conducted for the Water Authority and the EPA in 1989/90.

- Habitat 11: Cleared Pastureland (CP). The entire Stage 2B area consists of this habitat, which has **very low** significance to waterbirds.

## 3.3 Estuarine Biological Environment

### 3.3.1 General

The diversity of the biological community of the Peel-Harvey estuary system is constrained by the highly variable water salinities and the relatively homogeneous sand and mud habitats. The Peel - Harvey estuarine system supports a lower diversity of plant and animal life than other south-western estuaries such as the Swan River (Kinhill, 1988). Species that have adapted to the extreme and variable salinities generally encounter less competition than in more diverse communities and consequently tend to exhibit large and rapid fluctuations in population size.

The Mandurah Channel supports a varied biota. Areas toward the entrance of the channel are essentially a marine habitat while further south the habitat types become more estuarine. Invertebrate fauna found in the channel would principally include foraminifera, polychaetes, molluscs, amphipods, the Blue manna crab (*Portunus pelagicus*) and the King (*Penaeus latisulcatus*) and River (*Metapeneas dalli*) prawns (Wells *et al*, 1980; Chalmer and Scott, 1984).

Based on studies conducted in other areas of the Peel-Harvey Estuary (Kinhill, 1988; LeProvost, 1981) and with regard to proximity to the ocean, the shallow subtidal and intertidal shoal and the lagoonal sediments bordering the southern two-thirds of the proposed development site would probably contain abundant and diverse infauna. These are important as a food source for the waterbirds which frequent the area.

Fish of commercial importance and the larger crustaceans (crabs, prawns) utilise the channel as a migratory pathway and an opportunistic feeding ground. Potter *et al* (1983) and Chalmer and Scott (1984) list twenty six species of fish found in the Mandurah Channel, of which fifteen were relatively abundant and five were commonly caught commercial species. The W.A. Museum (1986) subsequently increased the record of probable fish to seventy six species, however most of the additional species would be only very occasional visitors from the ocean.

### 3.3.2 Water Birds

Regional

The Peel-Harvey Estuary is recognised as the most important habitat in south-western Australia for waterbirds. The area has been designated a wetland of international significance under the Ramsar convention and is visited by at least 34 species cited in Japan/Australia (JAMBA) and China/Australia (CAMBA) Migratory Birds Agreements (ANCA, 1993). A significant portion of the estuary is contained within a System 6 area (C50) which is recommended for reservation for, *inter alia*, waterbird protection.

Eighty three waterbird and associated species have been recorded at the estuary and within the wetlands located along its eastern margin (Ninox, 1990). Surveys by the Waterways Commission (1990) and the RAOU (Jaensch *et al*, 1988) have recorded over 100,000 individual waterbirds using the estuary during a single month. Seven species have been recorded breeding in the estuary, including black swans, grey teals, black ducks and Australian Shelduck (Ninox, 1990). These waterfowl predominantly utilise the shallows of the eastern and southern shores of Peel Inlet and southern Harvey Estuary. Wading birds use these areas and the shallows of the northern shore of the estuary as feeding grounds.

The estuary is also important as a refuge area during dry or drought conditions when inland wetlands dry out. Particularly high concentrations of wading birds, such as the banded stilt, have been recorded at the estuary during such conditions.

Local

*Species Diversity and Abundance*

Previous reports have identified the project area as having high conservation significance to waterbirds (Kirke, 1986; Waterways Commission 1990). The study area for these reports incorporated the project site with the adjacent System 6 area, with the resultant conclusions reflecting the high waterbird usage of the off-shore area. No analysis was made during these studies of the relative waterbird usage of the respective habitats over both areas.

For this reason, field surveys for this PER were undertaken in late 1994 and early 1995 by

Ninox Wildlife Consulting as part of a study to assess the significance of the project site and adjacent estuarine environment to waterbirds (Appendix F). The results of these surveys were combined with those undertaken in 1988-1989 by the Waterways Commission (1990), which together indicated the following observations:

A total of 36 species of waterbirds have been recorded in the vicinity of the subject land, representing 48% of all species known from the Peel Inlet (Table 3). Fourteen of these species are cited within the JAMBA and CAMBA Migratory Bird Agreements, including the Grey-tailed Tattler and Whimbrel which have been reported as being present in less than five south-western wetland reserves (Jaensch *et al*, 1988). None of the six rare species recorded from the estuary (ANCA, 1993) have been observed in the vicinity of the development site (Ninox, 1995).

The project area is equal highest in species richness with two other sites in the northern Peel Inlet (Figure 9), although the waterbird abundance at Port Mandurah Stage 2 compared to other sites on the northern Peel Inlet is in the middle range of site productivity (Figure 10). Studies undertaken by CALM (Lane, unpub. data) indicate that habitats of the Mandurah Channel tidal delta (including the Channel and Creery Islands wetlands) may only support 13-28% of the total Peel-Harvey waterbird population, due to these local habitats not being sufficiently extensive to support large numbers of feeding birds (Ninox, 1995).

*Waterbird seasonality*

Based on data collected between November, 1988 and December, 1989, waterbird populations at the project site are at their lowest between March and September. Highest usage is in late spring and early summer when trans-migratory shorebirds congregate at the Inlet and in the vicinity of the project area (Figure 11).

*Habitat values*

The study conducted by Ninox Wildlife Consultants, in common with other surveys, found that the most significant habitats for waterbirds were in close proximity to the estuary waters. Accordingly, the majority of birds observed were in habitats situated in the offshore area which is outside the eastern boundary of the proposed development site. The seven habitat types identified within the estuarine environment and shown in Figure 8 are summarised below:

## Table 3

**List of waterbirds and associated species recorded at Peel Inlet, showing the species already recorded or expected to occur within the Port Mandurah Stage 2 Project area.**

(Waterbird species protected by the Japan/Australia (JAMBA) and China/Australia (CAMBA) treaties as shown).

| Peel Inlet Species List (Excluding Vagrants) | JAMBA CAMBA | Recorded on Site 1988-89 | Recorded on Site Dec. 1994 | Not Recorded but Expected |
|---|---|---|---|---|
| Great Crested Grebe | | | | |
| Hoary-headed Grebe | | | | X |
| Australasian Grebe | | | | X |
| Australian Pelican | | X | X | |
| Darter | | X | X | |
| Great Cormorant | | X | X | |
| Pied Cormorant | | X | X | |
| Little Black Cormorant | | X | X | |
| Little Pied Cormorant | | X | X | |
| White-faced Heron | | X | X | |
| Great Egret | X | X | X | |
| Little Egret | | X | X | |
| Rufous Night Heron | | | | X |
| Glossy Ibis | | | | X |
| Sacred Ibis | | X | | |
| Straw-necked Ibis | | | | X |
| Royal Spoonbill | | | | X |
| Yellow-billed Spoonbill | | X | | |
| Black Swan | | | X | |
| Australian Shelduck | | X | X | |
| Pacific Black Duck | | X | X | |
| Grey Teal | | X | X | |
| Chestnut Teal | | | | |
| Australasian Shoveler | | | | |
| Pink-eared Duck | | | | |
| Hardhead | | | | |
| Maned Duck | | | | X |
| Blue-billed Duck | | | | |
| Musk Duck | | | | X |
| Osprey | | X | | |
| White-bellied Sea-Eagle | X | | | X |
| Marsh Harrier | | | | X |
| Australian Crake | | | | X |
| Spotless Crake | | | | X |
| Dusky Moorhen | | | | X |
| Eurasian Coot | | | X | |
| Pied Oystercatcher | | | | X |

**Table 3**
**(Cont'd)**

| Peel Inlet Species List (Excluding Vagrants) | JAMBA CAMBA | Recorded on Site 1988-89 | Recorded on Site Dec. 1994 | Not Recorded but Expected |
|---|---|---|---|---|
| Grey Plover | X | X | X | |
| Lesser Golden Plover | X | | | |
| Red-kneed Dotterel | | | | |
| Large Sand Plover | X | | | |
| Red-capped Plover | | | | X |
| Black-fronted Plover | | | | |
| Black-winged Stilt | | X | X | |
| Banded Stilt | | | X | |
| Red-necked Avocet | | X | X | |
| Ruddy Turnstone | X | | | X |
| Eastern Curlew | X | X | | |
| Whimbrel | X | X | | |
| Grey-tailed Tattler | X | X | | |
| Common Sandpiper | X | X | X | |
| Greenshank | X | X | X | |
| Redshank | X | | | |
| Marsh Sandpiper | X | X | | |
| Terek Sandpiper | X | | | |
| Black-tailed Godwit | X | | | |
| Bar-tailed Godwit | X | X | | |
| Red Knot | X | | | |
| Great Knot | X | X | | |
| Sharp-tailed Sandpiper | X | X | | |
| Pectoral Sandpiper | X | | | |
| Red-necked Stint | X | X | | |
| Curlew Sandpiper | X | X | | |
| Sanderling | X | | | |
| Broad-billed Sandpiper | X | | | |
| Ruff | X | | | |
| Silver Gull | | X | X | |
| Whiskered Tern | | | | |
| White-winged Tern | X | | | |
| Gull-billed Tern | | | | |
| Caspian Tern | X | X | | |
| Fairy Tern | | X | | |
| Crested Tern | | X | | |
| Little Grassbird | | | | X |
| Australian Magpie-lark | | | | X |
| 75 | 27 | 33 | 21 | 18 |

- Habitat 1: Deep Open Water (OW). The deep open waters of the Mandurah Channel are used as a feeding area by diving species such as cormorants, darters, pelicans, terns and gulls and are important resting and refuge area for coots, grebes, swans and ducks. This habitat has **high** significance to waterbirds.

- Habitat 2: Open Shallows (OS). The open shallows fringing the Mandurah Channel are an important feeding area used by a wide range of long legged wading birds. These include herons, egrets, ibis, stilts and migratory shorebirds. Pelicans, terns, gulls, coots, grebes, swans and ducks also use this habitat as an important resting, feeding and refuge area. This habitat has **high** significance to waterbirds.

- Habitat 3: Tidal Flats (TF). The offshore, regularly exposed tidal flat has **very high** significance to waterbirds as an important feeding area for a wide range of migratory shorebirds when covered by shallow water. Pelicans, cormorants, darters, terns, gulls, swans and ducks also use this area as a roost during low tide.

- Habitat 4: Bare Shorelines (BS). This habitat occurs as a narrow band along the length of the eastern side of the offshore samphire flat (Figure 8). It has **high** significance to waterbirds as a feeding area for a wide range of migratory shorebirds when submerged by shallow water. Pelicans, cormorants, darters, terns, gulls, swans and ducks also use this area as a refuge during low tide.

- Habitat 5: Perches (PE). Perching habitat in the vicinity of the proposed development is limited to a few small (less than 50cm high) limestone rocks located offshore from the central northern shore. Perching habitat is poorly represented in Peel Inlet and Mandurah Channel and has **high** significance to waterbirds.

- Habitat 6: Tidal Lagoon (TL). The sheltered tidal lagoon is an important feeding area used by a wide range of long legged wading birds. These include herons, egrets, ibis, stilts and migratory shorebirds. Pelicans, terns, gulls, coots, grebes, swans and ducks also use this habitat as an important resting, feeding and refuge area. This habitat has **very high** significance to waterbirds.

- Habitat 7: Regularly Inundated Samphire (SW). This habitat is represented adjacent to the project site by both the offshore samphire flat and the foreshore

samphire flat. Wet samphire flats support abundant invertebrate fauna and are a feeding ground for waterbirds. Good quality wet samphire flats have **moderate** significance to waterbirds.

Based on an analysis of survey data compiled for the site, a graph of waterbird usage (Figure 12) within the eleven habitats identified for the site indicates that the most productive habitats lie outside the project area and are (in order of decreasing significance), Tidal Lagoon (Habitat 6) and Tidal Flats (Habitat 3); Open Shallows (Habitat 2), Bare Shores (Habitat 4) and Perching Areas (Habitat 5); Regularly Inundated Samphire (Habitat 7) and Open Water (Habitat 1). Unlike the 'wet' samphire (Habitat 7), rarely inundated 'dry' samphire (Habitat 8) supports very few waterbirds.

## 3.4 Mosquito Breeding Habitat

The Port Mandurah Stage 2A project area features a prominent mosquito breeding area (Wright, 1988; Waterways Commission 1990).

Twenty two species of mosquito breed in the region, with two species of biting mosquitos (*Aedes camptorhyncus* and *Aedes vigilax*), causing the greatest nuisance. *Aedes vigilax* breeds in saltmarshes, with breeding limited by low temperatures and confined to the period November to April. *Aedes camptorhyncus* breeds all year round in saline, brackish or fresh water. Both species are major vectors of epidemic polyarthritis (Ross River virus). Both species lay desiccation-resistant eggs in dry saltmarsh wetlands which can lie dormant for indefinite periods until temporary stagnant pools are formed by tidal inundation. The eggs hatch within one to two days after inundation and larval development commences. The rate of hatching and larval development is largely dependent upon temperature: the life cycle from egg to adult may be completed within approximately one week in summer, but may take three times longer in winter.

One of the critical conditions for mosquito development is the presence of shallow stagnant pools that persist for longer than 7-10 days in summer and from three to four weeks in winter.

The low-lying 'dry' samphire flats (Habitat 8) (Figure 7) within the development site east of Old Coast Road (Stage 2A) are important mosquito breeding areas for *Aedes* mosquitoes (Sites 61, 62 and 95 - Wright, 1988), with breeding throughout the year at

low, moderate and high densities depending on the extent of inundation of the high tide and the persistence of the ponded water on the site. The low impermeability of the soils promotes water ponding which is exacerbated by altered drainage due to constructed levee banks and the diversion of storm water drainage into the site which contains shallow excavations from past marl mining, micro-depressions formed by stock prints, and ruts formed by vehicle tracks. These conditions contribute to the formation of shallow stagnant pools which are ideal breeding conditions for the mosquitoes.

The sedgeland (Figure 7) is also likely to encourage high levels of mosquito breeding during winter, particularly since the diversion of stormwater runoff into the depression six to seven years ago.

The areas of 'wet' samphire are less likely to support mosquito breeding, due to regular tidal flushing.

The City of Mandurah and the WA Health Department currently monitor the project site on a fortnightly basis and conduct aerial spraying using ABATE larvicide in the event that high larvae numbers are recorded. The area is also a current study site for a WA Health Department funded project by Murdoch University.

## 3.5 Social Environment

### 3.5.1 Landscape

The majority of the development is situated on cleared agricultural land and the landscape is predominantly pastoral.

The historic Sutton Homestead and associated farm buildings are among the dominant landscape features in Stage 2B. A tall Norfolk Island pine on the western side of the homestead and a row of Mission Olive trees of similar age also form a significant part of the landscape. There are occasional shade-trees (mostly Flooded Gum) over the property, particularly along fence lines and boundaries.

East of the Old Coast Road in the Stage 2A site, there are small elevated areas of open woodland on the south-western and south-eastern sectors of the project area and an intervening low-lying area which may flood during winter. The remaining area is a highly

degraded landscape dominated by areas of abandoned marl excavations, open areas of dry algal mat and open sparse samphire in poor to moderate condition. All of this area has been disturbed by stock animals and vehicle tracks. Low levees have been formed in places to reduce the extent of salt-water intrusion during peak floods.

The dense wet samphire flats of the tidal lagoon and associated shoals along the eastern foreshore of the site create a visually lush foreground to the aesthetic views of Mandurah Channel that are available from the eastern part of the Stage 2A area.

### 3.5.2 Land Uses

Past Land Uses

The cleared Stage 2B land west of Old Coast Road and most of the Stage 2A land east of Old Coast Road has been used for agriculture since the early 1840's and possibly the 1830's. The Sutton family leased or owned the land for almost all of this period, cropping the better parts and grazing stock on the remainder (A. Sutton pers. comm.). An inn (the 'Wayside') was once located on the site at the corner of Old Coast Road and Mary Street which is now occupied by a service station.

The Sutton family sold the property in 1977.

Present Land Uses

Most of the land immediately adjacent to the proposed development is now residential. The Port Mandurah Stage 1 Canal Estate and Mandurah Marina occur to the north. To the south-west of the site is an amusement park (Castle Fun Park) and the Mandurah Bypass Road runs along the site's southern boundary . The site of the proposed development is presently vacant, and is used for sheep and horse agistment.

### 3.5.3 Public Foreshore Reserves

There are presently six Foreshore Reserves along the western bank of the Mandurah Channel (Waterways Commission, 1992). There are also several associated with the township on the opposite bank.

Five of the Foreshore Reserves are gazetted for recreational or estuary access purposes, with the sixth, currently a caravan park, proposed to be changed to that purpose. The

Reserves on the eastern bank of the channel tend to be more popular with day visitors and holidaymakers due to their proximity to the town shopping area and facilities.

### 3.5.4 Nature Conservation Zones

The high usage of the Peel-Harvey estuary by waterbirds is the highest conservation value of the area with the protection of waterbird habitat from potentially conflicting uses being a primary aim of both the Peel Inlet Management Plan (Waterways Commission, 1992) and the Peel Regional Park Strategy (DPUD, 1993).

The Peel - Harvey Estuary is included on the Register of the National Estate (Australian Heritage Commission, 1995; ANCA, 1993). The area listed includes all of the estuary to high water mark, including the system 6 Area C50.

There are no existing nature reserves in the proposed development area. Consistent with PIMA's desire to acquire significant lengths of foreshore within the Peel/Harvey Estuary, the Peel Inlet Management Plan has specifically recommended acquisition of the foreshore areas of the Mandurah Channel south from Mandurah Marina for reservation as a nature and recreation reserve. The EPA has recently recommended a foreshore width of 50m at the adjacent Mandurah Marina development (EPA Bulletin 692).

PIMA has acknowledged that the acquisition of the foreshore areas of the site is dependent upon its re-zoning and development and that the foreshore reserve width should be based on ecological boundaries.

## 3.6 Aboriginal Heritage

Although ethnohistorical information indicates considerable movement of coastal Nyungar groups, the area south of Rockingham is thought to have been the territory of the *Banyowla* Aboriginals of the *Pinjarup* tribe (McDonald, Hales & Associates 1994).

The Murray River Aboriginals were decimated by disease and conflicts following European settlement of the area. The infamous 'Battle of Pinjarra', which resulted in heavy Aboriginal casualties, took place on the banks of the Murray River in 1834.

The mythology of the region is strongly associated with Wagyl, the Dreaming ancestor. Wagyl, usually manifested as a water serpent, created the Murray and Serpentine River systems and retains a presence in some deep pools of the area.

An archaeological and ethnographic survey of the proposed development area was undertaken in December, 1994 (Appendix G). The results are summarised as follows.

### 3.6.1 Archaeology

Following an initial inspection of the area and consultation with Mr Frank Nannup, an archaeological survey of the proposed development area was conducted with emphasis on areas of concern highlighted by Mr Nannup.

With the exception of a single scarred tree, no archaeological material was discovered during the survey. The scarred tree was located opposite the entrance of the Castle Fun Park, towards the southern boundary of the subject land.

The archaeological consultants recommended the tree not be disturbed. It was considered this could most satisfactorily be achieved by incorporating the tree and a buffer zone within a parkland reserve.

### 3.6.2 Ethnography

Two sites of ethnographical significance were located during the survey. These are:

- Winjan's Camp, which extends approximately 70m south from the corner of Glencoe Parade and McLarty Road and 25m east of McLarty Road, being located mostly within the McLarty Road reserve. This site was occupied by George Winjan Jnr until 1913 and has been previously recorded as a site of ethnographic significance (SO2224).
- A 'camp' located at the corner of Old Coast Road and Leisure Way, near a waterhole and a scarred tree.

The location of the sites is presented in Figure 13. The ethnographic consultants recommended that Winjan's Camp be incorporated into Public Open Space and that a plaque be erected outlining the historical and cultural significance of the site. Although the

consultant expressed reservations regarding the ethnographical significance of the second site, it was also recommended that the area be incorporated into Public Open Space.

Approval to protect and manage the sites as proposed in this PER has been granted under Section 18 of the *Aboriginal Heritage Act 1972-80.*

## 3.7 European Heritage

### 3.7.1 Historical Background

Following widespread sickness and death at the settlement of Clarence, Thomas Peel moved the people in his service to the mouth of the Murray River near the present City of Mandurah, where he established a settlement in 1830.

Henry Hall arrived in the area shortly after and took up several parcels of land, including 200 acres on the western bank of the inlet, opposite Peel town. Financial difficulties forced Hall to leave the area and move to Perth in 1836.

In 1839, John Sutton and his family arrived in Western Australia in the service of James Tate, who purchased 3,000 acres of land from Peel. Sutton leased Hall's cottage and surrounding land and by 1849 had built an inn (the 'Wayside Inn'), and begun operating a ferry service across the Mandurah Channel.

In 1871, the Sutton family purchased Hall's cottage and the surrounding 200 acres and soon commenced construction of the farm buildings that remain to this day. Up until the turn of the century the Sutton Farm, shingle splitting and fish canneries were the only industry in Mandurah.

The economy of Mandurah remained based on fishing and holiday activities until the 1960's when it became popular as a retirement centre. More recent times have seen extensive residential and industrial development, with Mandurah achieving City status in 1991.

### 3.7.2 Sutton Farm

An independent report on the heritage significance and conservation values of the Sutton Farm was undertaken by Palassis Architects (Palassis, 1995 - Appendix H), to determine requirements for protection of the Sutton Farm buildings. The study included discussions and interviews with the City of Mandurah Historical Society and with Mr Hal Sutton, a direct descendant of the original occupants of the Farm.

The location of the Sutton farm buildings is provided in Figure 13. The report outlines the history of the Sutton Farm and determined that the Sutton Farm buildings have significant cultural heritage value based on the following reasons:

- the buildings and landscape are fine examples of a Nineteenth Century farm, one of the first built by European settlers in the Shire of Murray;
- the buildings and landscape are integral with the settlement and development of Mandurah;
- the buildings and landscape are valued by the local community for their historic, cultural and aesthetic contributions
- the place contributes to the understanding of occupation of Western Australia; and
- the place is closely associated with the Sutton family, who have been instrumental in the development of Mandurah since the 1840's.

The report defined each structure within the Sutton Farm precinct and assessed the rarity, representativeness, condition and integrity of the separate elements to determine their cultural value. The report identifies eight elements and their significance, as described below and summarised in Table 4.

**Rarity** - Sutton Farm contains an uncommon group of farm buildings and is an intact example of land use on the Murray Region.

**Representativeness** - Sutton Farm is significant in demonstrating principle characteristics of land use, human occupation and particular way of life in the State.

**Condition** - The Sutton farm buildings require repair and maintenance, but are generally in sound structural condition. There is some damage to the homestead caused by damp.

## Table 4

## The Structure and Landscape elements identified at the Sutton Farm Heritage Precinct and General levels of Conservation Significance

| Structure / Landscape | Level of Significance | Cultural Heritage Value |
|---|---|---|
| Main Barn | Considerable | Aesthetic, Historical, Scientific, Social |
| Men's Sleeping Quarters | Considerable | Aesthetic, Historical, Scientific, Social |
| Homestead | Considerable | Historical, Social |
| Old Milking Shed | Some | Historical, Scientific |
| New Milking Shed | Little | Association |
| Graveyard | Considerable | Aesthetic, Historical, Social |
| Norfolk Island Pine | Some | Aesthetic (landmark) |
| Mission Olive Trees | Some | Aesthetic (landscape) |
| Combined Group and Immediate Surroundings | Considerable | Aesthetic, Historical, Scientific, Social |

A grading of 'considerable' significance indicates that the element should not be removed/demolished, and requires conservation to retard deterioration and support future use. A grading of 'some' significance indicates that the element should not be removed and requires maintenance and conservation because of its close association with elements of 'considerable ' significance. An element of 'little' significance may be removed if it is considered to diminish the significance of adjacent elements.

The roof cladding to the main barn and men's sleeping quarters requires replacement. Some glazing and floorboards in the men's sleeping quarters also require replacement. The old milking shed and graveyard are in poor condition and are referred to as 'ruins', however their condition is not deteriorating at an excessive rate. The locations of the headstones from the graveyard have been mapped prior to removal and storage by Mr Hal Sutton, pending replacement on the site following canal construction.

**Integrity** - Apart from the roof cladding, the main barn and men's sleeping quarters retain the majority of their original fabric, but have lost most of their original function (a lessee farmer continues to use the main barn for storage, but the buildings have no other present use).

The original fabric of the homestead has been greatly altered, however the alterations are not irreversible. Much of the fabric of the old milking shed and graveyard has been lost. The new milking shed remains largely original and intact.

All of the buildings are essentially vacant and have lost their original function.

# 4.0 DESCRIPTION OF THE PROPOSAL

## 4.1 Overview

The proposal is directed towards providing a high class, attractive residential development of waterfront lots which will integrate with the conservation and management of valued cultural and natural features that occur within and adjacent to the project area. The overall development proposal is shown in Figure 14 and will include the following components:

- Approximately 23.9ha of Conservation and Foreshore Reserve, (incorporating 14.9ha of area designated as System 6) bordering the eastern edge of the development, comprising the following:
  - 5.2ha of low-lying land contained within the property which will be ceded for conservation and management of waterbird habitat.
  - 0.84ha of elevated woodland contained within the property which will be established as public open space and ceded as part of an Interpretive Facility for public access and appreciation of waterbird habitat within the Conservation and Foreshore Reserve.
  - 16.92ha of intertidal and shallow subtidal land which is contiguous with the property and which will be integrated within the Conservation and Foreshore Reserve for conservation and management of waterbirds.
  - 0.94ha of elevated woodland which is contiguous with the property and will be integrated within the proposed Interpretive Facility.

The proposed Conservation and Foreshore Reserve includes a minimum 50m wide Foreshore Reserve along the entire site boundary. The proposed Foreshore Reserve is mostly 75 - 100m wide.

- Approximately 33ha of canal waterway, with a linkage beneath Mary Street to integrate with the existing Port Mandurah Stage 1 canals and with a second entrance to Mandurah Channel.
- Approximately 500 single residential waterside lots, varying from 600m$^2$ to 750m$^2$.

- Two areas of communal housing development, covering approximately 2.7ha and including approximately 110 residences, one with a small private boat haven and mooring jetties.
- A heritage conservation precinct of 1.4ha containing the Old Sutton Farm buildings and associated features of heritage significance.
- A total of 5.2ha of Public Open Space. Proposed areas of Public Open Space will include the historic graveyard and two areas identified as having Aboriginal cultural heritage, appropriately developed and managed to preserve their heritage significance.
- The local road system, incorporating two bridges (possibly three; refer Section 4.6.2) over main canals where they pass under Old Coast Road and Mary Street, together with four bridges connecting islands created within the estate.

The Port Mandurah Canal Estate Stage 2 will be developed in approximately 100 lot stages over a period of five to eight years. It is proposed that the Conservation and Foreshore Reserve and Stage 2A (east of Old Coast Road) will be developed as a single initial stage, with three subsequent phases of development within Stage 2B (Figure 15).

## 4.2 Project Design

### 4.2.1 Conservation and Foreshore Reserve

The ecological importance to waterbirds of the existing foreshore reserve and the adjacent samphire flats, shoals and shorelines has been recognised and accommodated within the project layout and design. As described in Sections 3.3.1 and 3.3.2, the importance of the site to waterbirds was independently assessed by Mr Ken Youngson of Ninox Wildlife Consulting, who is a respected authority in waterbird ecology in Western Australia.

Based on the Ninox assessment (Appendix F) and prior to initiation of the canal estate design, Bowman Bishaw Gorham developed a concept plan for the layout and design of a proposed Conservation and Foreshore Reserve to ensure appropriate protection and management of significant waterbird habitat areas. The concept plan was refined through consultation with other biological subconsultants to the project and with relevant personnel from PIMA, DEP and CALM.

The area proposed for the Conservation and Foreshore Reserve is shown in Figure 16. Important elements of the proposal include the following:

- All areas identified as having high or very high waterbird habitat value, and all areas of samphire with moderate waterbird habitat value, are contained within the proposed Reserve.

- The areas of existing high habitat value contained within the proposed Conservation and Foreshore Reserve will be strictly protected from possible impact during project construction, then will be designated and managed as a waterbird conservation area.

- The Conservation and Foreshore Reserve will be buffered from the proposed development by a boundary canal along the eastern edge of development.

- An additional 25m wide buffer zone will be included within the proposed Reserve to enable a sensitive and natural interface between the waterbird habitat and the boundary canal. This interface will be developed as high usage waterbird habitat, thereby mitigating the loss of less valuable habitat elsewhere in the development area.

- The 25m interface area will be landscaped with a mix of the following landforms, to replicate specific waterbird habitat types:

    - Over most of its length, the interface area will be formed to create a gently shelving (approximate slope = 1:80) intertidal flat between the existing samphire flat (at approximately mean high high water) and the edge of the boundary canal (at mean low low water). This feature will replicate waterbird habitat types 3 (Tidal Flat), 4 (Bare Shoreline), and 7 (Regularly Inundated Samphire).

    - A central upland sector containing *Casuarina obesa* trees will be retained and planted with *Juncus krausii* to create a supratidal island which will function as a refuge for secretive species and a roosting area for other waterbirds during flood tides - Habitat Types 9 (Open Woodland) and 10 (Seasonal Swamp / sedgeland).

- Scattered, emergent limestone boulders will be incorporated into the design, to provide roosting habitat and refuge during flood tides - Habitat Type 5 (Perches).

- The proposed Reserve includes a minimum 50m wide Foreshore Reserve along the entire site boundary. The proposed Foreshore Reserve is mostly 75 - 100m wide, which represents a substantial increase to the current 50m foreshore reserve width recommended by PIMA and recently endorsed by the EPA for the adjacent Mandurah Marina re-development proposal (EPA Bulletin 692)

- Foreshore protection design specifications to be incorporated into the 25m interface area will be determined in consultation with CALM, PIMA and DEP so as to maintain the Reserve's natural attractiveness and enhance its ecological function, whilst also securing adequate foreshore stability and discouraging vessel encroachment upon waterbird habitat. The preliminary concept design for protection along the created Reserve foreshore adjacent to the boundary canal includes the following:

  - A low profile, permeable bund of limestone boulders to the level of the highest astronomical tide (0.5mAHD), bedded upon a limestone core-stone foundation below lowest astronomical tide levels (-0.14mAHD). The rock bund would allow free flowing water exchange so that water levels between the intertidal flat and the boundary canal remain equal, but would be an effective barrier to boat wash from the canal and prevent sediment loss from the interface area into the canals.

  - Shoreline vegetation combined as appropriate with low profile post and log walling will be used to protect the foreshore of the proposed supratidal island.

- Randomly placed larger limestone boulders which will be exposed at peak tidal levels will be placed along the top of the bund and elsewhere within the interface area to detract from the unavoidable visual linearity of the protective limestone bund. This feature will attract significant numbers of roosting waterbirds during high water conditions.

- Limestone boulders will also be placed within the shallow tidal channel between the offshore samphire flat and the subtidal shoal (Figure 16). This will also

replicate waterbird perching habitat, whilst discouraging the entry of small craft from the Mandurah Channel into the Conservation and Foreshore Reserve.

- The upland area of existing foreshore reserve and the proposed contiguous area of Public Open Space in the south-eastern corner of the project area will be developed by EMPL as an Interpretive Facility for public education and appreciation of the proposed Conservation and Foreshore Reserve. Several viewing platforms with information on the flora and fauna of the Reserve will be connected by pedestrian walkway, to encourage research and passive wildlife observation. A small public carpark will be provided.

- A vermin proof fence will be provided around the southern boundary of the proposed Conservation and Foreshore Reserve to exclude pets, feral cats and other predatory animal pests. The fence will have a single turnstyle gateway which will serve to control public access to the proposed pedestrian walkway, with appropriate signage prohibiting pets and requesting users to remain within the Interpretive Facility (ie out of the waterbird habitat). The boundary to the Conservation and Foreshore Reserve elsewhere will be protected by the eastern canal waterway (50m wide).

The intention of the proposed Conservation and Foreshore Reserve is to provide for the protection and management of valuable waterbird habitat. Public must enter the reserve through a gate in the vermin - proof fence. Human access for environmental education and appreciation will be encouraged only within the upland area that is proposed for the Interpretive Facility, and will be strongly discouraged by barrier walling and appropriate signage throughout the remainder of the Reserve.

Following approval of the proposed canal estate development and prior to its construction, EMPL will prepare a Conservation and Foreshore Reserve Management Plan to the satisfaction of the Minister for the Environment upon advice from CALM, PIMA and DEP. As detailed in Section 7.0, this Plan will provide detailed design and management prescriptions for the boundary canal revetment and the proposed Reserve.

### 4.2.2 Heritage Reserves

A Heritage Conservation Reserve of approximately 1.4ha is proposed to preserve the existing Sutton Homestead and ancillary farm buildings. Where practicable, this

conservation area encompasses the primary exclusion zone recommended by the heritage conservation consultants to the project, Palassis Architects (Appendix H). Viewsheds into the heritage precinct from Old Coast Road will be widened and improved to increase appeal.

The Sutton Heritage Precinct will be developed and managed to preserve and enhance the recognised heritage values. The heritage buildings will be restored[1], reconstructed[2] or adapted[3] (depending on compatible use[4]) in accordance with the recommendations of the Heritage Report. This work will be undertaken in consultation with the Sutton family, the City of Mandurah, the Mandurah Historical Society and the Heritage Council of WA.

The proposed ongoing use of the site will include conservation interpretation signage for public education of the historical values of the site. Possible uses which could fund the restoration of the buildings include high standard short-stay accommodation with possible office accommodation, and tearooms. Development and management of the site for an integrated tourist facility will be planned in consultation with the City of Mandurah and the Heritage Council of WA.

### 4.2.3 Public Open Space

In total, seven areas of Public Open Space (POS) have been provided within the Canal Estate totalling 10% of the subdivisible land. In part, these POS locations have been chosen to protect significant Aboriginal heritage areas within Stage 2B. A further POS area is provided within the northern part of Stage 2B to protect the heritage graveyard site.

Where possible, each of the distinct canal cells has been provided with an area of POS which is easily accessible to the residents within those cells.

---

[1] Returning the EXISTING physical material of a place to a known earlier state by removing accretions or by reassembling existing components without the introduction of new materials.

[2] Returning a place as near as possible to a known earlier state and is distinguished by the introduction of materials (new or old) into the existing material.

[3] Modifying a place to suit proposed compatible uses.

[4] A use which involves no change to the culturally significant fabric, changes which are substantially reversible, or changes which require minimal impact.

The two areas of POS containing sites of Aboriginal heritage significance and the POS containing the graveyard site of European heritage significance will be accessible to local and tourist visitors. Appropriate landscaping and information plaques will be provided.

POS located to augment the existing foreshore reserve in the southeast corner of the site will contain Conservation Interpretive Facilities. The POS extends northwards through higher woodland adjacent to the estuary, thereby providing an excellent natural viewing point for public appreciation of the high diversity of waterbird species and habitats..

### 4.2.4 Urban Subdivision Layout

The proposal seeks to create six distinct canal cells within the project area, with land for residential purposes comprising only 38% of the site . The lot sizes proposed will be smaller than those of previous canal estates, with 2.2% of the total area being for medium density housing.

Approximately 500 single residential waterside lots and 110 communal waterside lots will be created within the Estate. Lots located in the extremities of the site will generally be based on R20 coding and will be approximately 600$m^2$. Larger lots (approximately 720$m^2$) will be located in the extremities of the site, where R15 coding will apply.

There will be two R40 sites for the development of high quality terrace and town houses. It is proposed for the R40 site within the north-eastern corner of the site to accommodate a private mooring and jetty area.

The design concept for the proposed Estate does not seek to achieve the highest possible lot yield, but rather, endeavours to strike a balance between economic feasibility and high residential amenity.

The general orientation of lots has been provided in accordance with those principles set out within the Australian Model Code of Residential Development (AMCORD). In achieving these principles, the general lot orientation is north-south (or within 20 degrees thereof) which will ensure that maximum solar orientation and solar penetration to proposed dwellings will be achieved.

### 4.2.5 Waterways Layout

The design of the Stage 2 canals has been in accordance with the provisions for canal design in State Planning Commission Policy DC1.8.

The proposed canal waterways encompass approximately 30% of the site, and comprises a main trunk canal, secondary canals and minor feeder canals.

The main trunk canal will connect Stage 1 of the Port Mandurah project to the Mandurah Channel. The width of the main trunk canal (60m) has been based on a design vessel of 10m which reflects the various types of boating and water vessels expected to run through this canal (Appendix E).

The rest of the Estate is made up of a number of canal pods and canal peninsulas (fingers) within six distinct cell precincts within the canal estate. The majority of these cells are made up of feeder canals which generally have a width of 40m, which includes provision for a navigable channel and mooring areas for each of the residential lots. A series of secondary canals, generally with a width of 50m, surround each of these canal cells.

The short non-connective canals mostly have an easterly orientation, which will encourage water-borne debris to collect at their western ends (propelled by easterlies), thereby enabling easy maintenance (collection and clearing).

The main purpose of the main trunk and secondary canal systems will be to provide proper and orderly boating manoeuvrability, as well as to flush canals with clean water (estuarine and ocean water). The flow rates to these canals will generally be governed by tidal currents, salinity density currents and wind driven currents.

## 4.3 Estate Design

### 4.3.1 Minimum Building Levels

The minimum building levels recommended in an assessment of extreme flood levels by Port and Harbour Consultants (Appendix E), the marine engineering consultants to the project, are +1.92m AHD for fill and +2.17m AHD for floors. The rationale for the proposed minimum levels is described in Appendix E. These minimum levels draw upon

the most recent revised estimates of mean sea level rise associated with the Greenhouse effect to the year 2050, consideration of the effects of the Dawesville Channel and published Water Authority 100 year flood levels, together with recommended fill and floor level freeboards.

The minimum building block level proposed for the development is 2.3m AHD.

### 4.3.2 Canal Depths

The canal depth within the Port Mandurah Stage 1 is -2.7m AHD. It is proposed to maintain this depth within the Stage 2A canals. Within Stage 2B it is proposed that, subject to further geotechnical investigations, earthworks balance calculations and marketing considerations, the side canals have the option of being reduced to -2.1m AHD (thus catering for only design vessel powerboats or small yachts). The main interconnecting 60m wide canal between the Mary Street and Old Coast Road Bridges would be maintained at -2.7m AHD to allow a limited number of design vessel yacht mooring locations and better hydraulic flushing of the canal estate. Details of the canal depth calculations are given in Appendix E.

### 4.3.3 Typical Canal Cross-Sections

The canal width from wall to wall will be 40m, 50m or 60m depending upon the particular waterway hierarchy. The main canal passing under the traffic bridge on Mary Street will be 60m wide in its entire length.

A typical canal cross-section is indicated in Figure 17. This figure shows alternative deep and shallow walls as discussed in Section 4.3.5.

The proposed variety of canal widths and section details that will apply to the other canals are described in Appendix E.

### 4.3.4 Typical Block Profile

A typical block profile is indicated in Figure 18.

It is proposed that the top of the canal edge walls shall be RL +0.9 AHD. Immediately at the back of the wall will be a 1m wide paved area which will be graded away from the

canal as described in Section 4.5. The block fill will then rise at a slope of 1 vertical to 5 horizontal until a minimum block level of RL 2.3 is reached. From this minimum level the block will rise at a varying grade, depending upon the location of the building block, to a peak level approximately 7m inside the front verge level which will approximate to the building set back line. The block will then slope at 2% to the road verge and the road verge will then slope at 2% towards the edge of kerb of the access road.

The block profile as described above will facilitate the separation of stormwater drainage into its various components, as described in Section 4.5. It will also provide for the maximum block elevation which can be achieved within the restrictions of availability of fill material.

The typical block profiles for the Stage 2 estate will be the same as for Stage 1.

### 4.3.5 Canal Walls

The wall details will be subject to final structural engineering design, but will be of similar form to that included in the Stage 1 development, being reinforced concrete panels designed for a minimum 50 year wall life.

It is likely that at least two types of concrete wall panel would be utilised in the project.

a) Shallow Walls. The generally preferred wall shape will be as indicated on the walls shown on the right in Figure 17 which indicates that the top of the wall will be at RL 0.9 AHD and the base of the canal where it abuts the wall will be at RL -0.5 AHD, giving 0.5m of water depth at the face of the wall when the water is at mean sea level. This depth of wall is very safe from the point of view of children's safety since even a small child can stand in the water at the canal wall face.

   However this water depth does pose some problems for navigation in that it limits the width of the navigable waterway within the canal. Therefore, some of the narrower canals will be provided with deeper wall sections.

b) Deep Walls. The deep wall will have its top at the same level as the shallow walls, that is, RL 0.9 AHD. However the deep wall will have approximately 1.4m of water at the wall face when the water level is at mean sea level. This will require a considerably higher wall panel than for the shallow walls but it will

increase the width of navigable waterways within the development, as indicated on the wall shown on the left in Figure 17.

At regular intervals throughout the canal system step rungs will be provided to enable climbing access out of the canal as a safety feature.

The walls to the new entrance channel to the Mandurah Estuary will be inclined limestone rip-rapped walls in a similar manner to the entrance to the estuary for the Stage 1 development.

Limestone rock walling is also proposed within the preliminary concept design for foreshore protection between the eastern boundary canal in Stage 2A and the Conservation and Foreshore Reserve. This element will be determined in consultation with CALM and PIMA, as discussed in Section 5.4.2.1.

#### 4.3.6 Earthworks Balance

An approximate earthworks balance carried out for the Stage 2 development has indicated a possible small deficiency in block fill required for the Stage 2A development and a small excess of material available for the Stage 2B development. These figures will be subject to verification during detailed design work.

Therefore it is possible that some small amount of future canal excavation could be required within the Stage 2B area during the construction of the Stage 2A. Should this be the case, the borrow area temporarily opened up will be kept to a shallow depth and will be fully restored and hydromulched at the completion of Stage 2A construction work.

## 4.4 Earthworks and Construction

#### 4.4.1 Required depth of fill

The depth of filling that will be generally required will be between 2m and 3m. The preliminary geotechnical investigation indicates that the majority of the area excavated consists either of silty sand or underlying limestone material which, with careful treatment, will be suitable as a building subgrade for subsequent building construction. The imported material will be thoroughly compacted to minimise any future settlement to the

building blocks. All material excavated from the site will be utilised within the development, with any material not suitable for house construction being selectively deposited in non-construction areas.

### 4.4.2 Dewatering

It is anticipated that the development will be dewatered to enable canal excavation in the dry using conventional earthmoving machinery consisting of scrapers, dozers and excavators.

The discharge of dewatering fluids will be in accordance with PIMA's requirements, including Dewatering Policy WS4.2.

Subsoil water entering the canal system as it is being excavated will be drained in a longitudinal manner to a suitable location, probably near the future entrance to the estuary where it will be pumped via large capacity centrifugal dewatering pumps into a high level and large capacity stilling basin immediately inside the future canal entrance.

It is proposed that the stilling basin will have capacity to provide an adequate detention time for any turbidity in the water to settle out prior to discharge of the clear water to the estuary.

This method was successfully utilised during the construction of Stage 1 of the Port Mandurah Development and resulted in full acceptance at the time from both the City of Mandurah and PIMA. The quality of ground water discharged during the Stage 1 Development operation was excellent and did not raise any problems to other users of the Mandurah Estuary.

### 4.4.3 Wall Construction

It is anticipated that precast concrete wall panels will be used for the bulk of the canal edge walls. They will be placed by mechanical equipment on prepared bedding material which will be accurately surveyed for compaction and level.

The joints between all panels will be protected by a tough flexible membrane to prevent potential damage to the joints caused by vandals. A complete coverage of filter cloth at the

rear of the walls will be provided from the level of the paved area at the top of the wall to a level close to the base of the wall.

A subsoil drain will extend over the length of the wall along its rear face to control the rise of groundwater at the back of the wall and will be relieved by seepage out of suitably located weepholes.

### 4.4.4 Entrance Channel Dredging

The mouth of the entrance channel will be excavated using a cutter suction dredge when the inland excavation of the Stage 2A canals is complete and will be conducted in accordance with PIMA guidelines. The timing of the final connection to Mandurah Channel will be controlled in consultation with PIMA in recognition of the need to manage turbid water escape to the estuary. Water quality in the constructed canals and tide, channel flow and weather conditions will be the primary factors in the scheduling of this work.

The spoil from the entrance channel dredging will be used for land fill on the site. The slurry water will be directed to a large capacity stilling basin to allow settlement of solids prior to discharge to the estuary, to the satisfaction of PIMA.

### 4.4.5 Noise and Dust Control

Project construction will entail extensive site works and the potential for nuisance noise and dust during site development will be carefully managed to minimise the impact on the surrounding community. Noise levels will comply with the most recent EPA Guidelines. The operation of heavy equipment will be restricted to daylight hours with all vehicles to be fitted with noise suppressing devices and comply with current vehicle emission and noise regulations.

Dust levels will be managed and monitored in compliance with the EPA's "Guidelines for Assessment and Control of Dust and Windborne Material for Land Development Sites". The guidelines provide a procedure by which to prevent and/or suppress excessive dust volumes leaving the site during and after the construction of the works.

The existing EPA limit for the maximum allowable level of dust concentration in the atmosphere is 1000 mg/m$^3$ measured at the boundary of the site. If this level is exceeded, further on-site dust controls must be implemented.

### 4.4.6 Public Safety

In the interests of public safety, access to the development site during the construction phase will be restricted and appropriate warning signs will be erected.

## 4.5 Drainage and Nutrient Management

### 4.5.1 General

The control and management of stormwater runoff from the proposed development is an essential part of the environmental adequacy of the project. Stormwater runoff can easily be segregated into the following different categories, each of which will have different methods of control.

a) Road and road reserve verge runoff.
b) Front garden and driveway runoff from properties.
c) Roof runoff from roofed areas.
d) Lower garden and landscaped areas adjacent to the canal wall.
e) The walkway adjacent to the canal wall.

### 4.5.2 Road Drainage

Stormwater runoff from the roads will be collected by grated or side entry gully pits in accordance with the requirements of the City of Mandurah. Each gully and in the case of a pair of gullies, the downstream gully, will be provided with an approved trapping device to prevent solids being washed into the drainage system and to limit the passage of any soil and soil-sorbed contaminant into the drainage system.

These gullies will then be connected to a drainage pipe and manhole system and will be discharged at certain strategically located exit points to the canal system. The downstream manhole in each system (the last manhole in the system prior to discharge to the canal) will also be provided with a baffle which will further trap any contaminants which survive trapping via the upstream road gullies. Thus, possible contaminants to the stormwater

runoff from the roads will be trapped by either road gullies or trapped manholes and prevented from entering the waterway system.

The road drainage management system will encompass all road surfaces within the Canal Estate, together with road runoff from the adjacent Halls Head estate which is currently collected at the junction of Old Coast Road and McLarty Road and discharged to the site.

### 4.5.3 Front of Block Drainage

All blocks will be graded so that the 7m of block adjacent to the road reserve boundary will slope at a minimum grade of 2% towards the road reserve (Figure 19). Stormwater drainage from this area, including driveways and garden areas, will be drained to soak wells within the property.

### 4.5.4 Roof Drainage

All roof drainage will be combined together down one side of the property and will be discharged directly to the canal system via PVC drainage pipes (Figure 19). The outlet through the canal wall will be provided by the proponent for uniformity and the outlet will be at an invert level of approximately RL 0.0 AHD to reduce its visibility from the waterway side.

### 4.5.5 Lower Garden/Landscaped Area/Walkway

It is proposed that the landscaped area between the houses and the canal wall will be drained via a spoon drain to a soak well to be located just clear of the proposed walkway (Figure 19). The walkway will be drained to the low point and a spoon drain incorporated at the rear edge of this walkway will direct stormwater discharge from this area into the soak well. It is anticipated that once the lots are developed and landscaped in this area, there will be very little runoff occurring from this portion of the lot.

Access to the soak well can be maintained by suitably raising the cover or access manhole of the soak well to suit individual landscaping requirements by the block purchasers. Maintenance of this system will be easy and will eliminate some of the maintenance problems which were associated with the cleaning of the porous concrete spoon drains in Port Mandurah Stage 1 development.

## 4.6 Services

### 4.6.1 Roads

All roads will be fully kerbed and sealed to the requirements of the City of Mandurah. In general, they will match the standard of roadworks achieved in the Stage 1 development, with strategically placed round-abouts and areas of brick paving included to make the road system functional and aesthetically pleasing.

The road hierarchy has been planned to limit the points of access to the relatively busy perimeter roads of Old Coast Road, McLarty Road and Mary Street. "T" junctions of road intersections will be preferred and where four way intersections are unavoidable they will be treated by the inclusion of a round-about to provide the necessary traffic separation. Road reserve widths, road pavement widths and road geometry will be to the requirements of the City of Mandurah.

Roads will be drained as previously described in Section 4.5.

### 4.6.2 Bridges

The development of Stage 2 will require the construction of two, possibly three, road bridges over the future canals, with a further bridge providing access to the various islands.

The first bridge will be that constructed on Old Coast Road over the main entry canal immediately south of the Mandurah Marina Site. This bridge will be designed to Austroads/MRWA standards and to the approval of Main Roads Western Australia and will basically stretch the full width of the 60m wide canal except that it will contain intermediate piers within the canal for support to the bridge deck beams. It is proposed that the bridge will have the following geometric characteristics:

| | |
|---|---|
| Total length | 60m plus |
| Width | 2 x 3.7m wide carriageways, a 1.2m wide walkway and a 2.5m wide dual use path. |

Clearance Clearance under the navigation spans will be similar to that under the Old Traffic Bridge across the Mandurah Estuary, (4.8m at Highest Astronomical Tide (HAT)).

The provision of this bridge would entail the reconstruction of portion of Old Coast Road, for approximately 130m on either side of the proposed canal crossing. Embankment approaches to this bridge will be required at an approach grade of between 3 and 4% and will be determined during final design. Access to the nine R20 lots east of the bridge and abutting the Mandurah Marina Site will be by access road under the northern bridge abutment.

The second traffic bridge will be on Mary Street approximately 550m west of the intersection of Mary Street with Old Coast Road. This bridge will have similar characteristics to the proposed bridge on Old Coast Road.

The existing road profile along this section of Mary Street has already been constructed at a suitable elevation so that the profile of the bridge will fit the existing profile of Mary Street. The bridge will be constructed utilising the existing embankment as temporary support and when the bridge is finished, the existing embankment will be excavated. All the existing services passing over this Mary Street embankment will be picked up by the new bridge structure and supported across the future canal to the approval of the relevant authorities.

The dimensions and the clearance under this bridge will be similar to the bridge on Old Coast Road, as previously described.

The initial concept plans for the project proposed that Stage 2 would be connected to Stage 1 via two canals, therefore requiring two traffic bridges over Mary Street. However preliminary hydrodynamic studies indicate that only one major canal connection is required for flushing purposes, which would also reduce throughflow rate and the extent of scouring and scour maintenance requirements.

Detailed modelling studies will be undertaken in order to determine the need for the additional bridge. This bridge will be similar to the previously described bridge on Mary Street as far as width, construction methods and support of existing services is concerned, but the clearance under the deck structure will be reduced to approximately 3.0m from HAT.

The requirement for an additional bridge will also take into account any existing expectations of residents of Stage 1 for a bridge to be built, as well as the perceived viewshed amenity of a bridge over waterways.

Should the third traffic bridge not be built, then the 'connecting' canal finger abutting Stage 1 will be in-filled. The existing dual use path along Mary Street will be continued over the bridge.

The inter-canal road bridges will consist of small span access bridges to the various islands. As with the previously mentioned road bridges, these bridges will be designed to Austroads/MRWA standards for geometry and load carrying capacity and will contain the following characteristics:

- Single span bridges with a free span in the order of 12m. This will be adequate for the passage of small boats and will enable free water circulation within the canal system albeit with a small hydraulic restriction at each bridge location.
- The carriageway width will be adequate for two lanes of traffic together with a dual use path and will carry services as required to each island.
- It is anticipated that the clearance between the underside of the bridge structure and HAT will be approximately 3.0m.

The proposed bridges on each of the existing local roads of Mary Street and Old Coast Road will be constructed "in the dry" to minimise construction time. During bridge construction traffic will be diverted by temporary detours constructed on land owned by the proponent, to a standard acceptable to the Local Authority.

### 4.6.3 Pedestrian/Bicycle System

The nature of the Estate utilises a series of Peninsulas and Pods which are not conducive to an effective pedestrian/bicycle network. However, it is proposed to create a number of dual-use paths on the entry and access place roads within the Estate.

### 4.6.4 Sewage Disposal

The subdivision will be fully serviced with a vacuum sewerage scheme. The heart of the vacuum sewerage scheme will be the existing vacuum pumping station which was

constructed during the Stage I development of Port Mandurah on Mary Street, near its intersection with McLarty Road. This pumping station was originally designed to have sufficient basic capacity to cater for the requirements of not only the full development of Stage 2 of the Port Mandurah development but also additional infill sewerage work by the Water Authority to the north and south of this development. As the contribution from the vacuum sewerage catchment area gradually increases, some minor upgrading of the pumping station equipment will be necessary and this work will be carried out by the Water Authority. The existing vacuum sewerage reticulation has been designed to be extended to pick up the new development.

Vacuum sewerage of this type was installed in a residential subdivision for the first time in Western Australia in the Stage I development of Port Mandurah and after five years of operation the Water Authority is fully satisfied with its performance. The installation has been the forerunner of a number of vacuum sewerage schemes now being included in the Infill Sewerage Programme to the Perth Metropolitan Region.

### 4.6.5 Power Supply

The entire development will be provided with underground power reticulation and street lighting to the requirements of Western Power and the City of Mandurah. It is proposed that street lighting poles will be upgraded to a style and standard superior to those existing in the Port Mandurah Stage 1 development.

### 4.6.6 Water Supply

Water supply reticulation will be provided to each lot in the normal residential manner. Provision has been made during the design of the Stage 1 development for the extension of water supply mains into the Stage 2 development area.

As previously mentioned the bridges will be used to support all services including water supply reticulation lines across the waterways. These services will be supported in a manner which generally hides them from view and potential damage. Where some visibility is essential they will be supported in an aesthetically pleasing fashion to the approval of the relevant Authority.

## 4.7 Project Agreement and Management Programme

The City of Mandurah has recently prepared 'Waterways Management' guidelines to control future and existing canal development.

Management for Port Mandurah Stage 2 will be consistent with these guidelines and with the conditions imposed on the proposal following the recent resolution by Council to approve the re-zoning amendment. The 'Waterways Management' guidelines state that the responsibility of various management aspects should be as outlined in Table 5.

The guidelines direct that the Council's management responsibilities shall be funded by an up-front 'headworks' cost (dollars per lot) based on a calculation of the design life of the estate. The contribution will be payable at subdivision stage and secured by bank guarantee at rezoning stage. Estate owners can be individually levied under Section 548(4) of the Local Government Act for additional funds after the initial five year management requirement has been fulfilled by the proponent.

Residents outside the individual canal estates will not be exposed to management costs.

An initial five year management period will be the responsibility of the developer. After the five year period, the Council shall be responsible for:

(a) sea walls abutting public land
(b) silting of canals and the entrance channel
(c) water quality within canals
(d) monitoring jetties and document transfer

The guidelines stipulate that the Council may require that a referendum be held for public artificial waterways. This requirement has been satisfied by the referendum already conducted which expressed substantial support for the balance of the Port Mandurah project (Appendix C). On March 7, 1995 and following submission of an Outline Development Plan as stipulated in Section 2.3.2, the Council resolved to amend the current Town Planning Scheme in accordance with the proposal, subject to environmental approval.

## Table 5

## Management Responsibilities and Means of Funding of Canal Estate Developments as outlined by the City of Mandurah's Draft Waterways Management Guidelines

| Management Responsibilities | Responsible Organisation | Means of Funding |
|---|---|---|
| Walls | | |
| i. within privately owned land | Land Owner | Owner to fund |
| ii. abutting POS, roads etc | City of Mandurah | Developer contribution and general rating |
| Silting | | |
| i. In canal/marinas | City of Mandurah | Developer contribution and general rating |
| ii. In entrance channel | City of Mandurah | Developer contribution and general rating |
| Water Quality (litter, spills, algae etc) | | |
| i. In canals/marinas | City of Mandurah | Developer contribution and general rating |
| ii. In source body | PIMA | PIMA to fund |
| Jetties | City of Mandurah and Department of Transport | Licence fee from owners |
| Speed Limits | Department of Transport | Department of Transport |
| Canal Signage (Navigation) | Department of Transport | Department of Transport |

# 5.0 CONSTRUCTION PHASE ENVIRONMENTAL IMPACTS

## 5.1 Summary of Construction Impacts

The history of canal development at Mandurah has enabled the impacts of canal construction and operation on the natural and social environment to be confidently predicted and well understood. The majority of construction impacts are now addressed by standard engineering procedures defined within various statutory guidelines and policies for canal construction, which have standardised management prescriptions to mitigate environmental and social impacts to minimal levels. As discussed in Section 4.0, these controls and management are an integral component of this proposal.

Based upon the evaluation of the existing environment as described in Section 3.0 and with regard to the management proposals detailed in Section 4.0, the potential impacts of canal construction for the Stage 2 Port Mandurah Project are summarised as:

- Loss of vegetation and fauna habitat, namely:
  - loss of sedgeland which is possibly of moderate significance to a limited number of waterbird species but is a highly significant seasonal mosquito breeding habitat;
  - loss of degraded dry land samphire which is of very low significance to waterbirds and of very high, year-round significance for mosquito breeding; and
  - loss of some tree overstorey which has low to moderate value for bushbirds and waterbird roosting.

- Localised temporary drawdown of the shallow aquifer during dewatering operations which will:
  - cause temporary impacts to a limited number of domestic bores; and
  - cause potential stress to phreatophytic vegetation.

- Discharge of dewatering fluids into the estuary.

- Dredging of the entrance channel which will result in:

- potential dispersion of residual sediment into the Mandurah Channel;
- the dissection of the northernmost end of the tidal shoal; and
- possible temporary disturbance to waterbird activities.

- Low level noise during construction which may impact residents on the western-most boundary of the site.
- Residual dust problems during estate construction.
- Disruption of traffic during bridge construction.

These impacts are discussed in detail below.

## 5.2 Loss of Vegetation and Fauna Habitat

Construction for canal estate development will remove the pastured land in Stage 2B, as well as the degraded and limited remnant vegetation which occurs over most of the Stage 2A site. All of the dry samphire, sedgeland and *Melaleuca cuticularis* overstorey will be removed. Some *Casuarina obesa* trees will be retained within an upland 'island' in the proposed Conservation and Foreshore Reserve, whilst the majority of large Flooded Gums and Marri on the upland areas to the south-west and south-east corners of the site will be conserved within POS. All areas of wet samphire will be protected and conserved.

Most of the vegetation of the site is in poor condition and is of low and very low significance to waterbirds. The dryland samphire habitat on the project site is rarely used by waterbirds, and significantly contributes to mosquito breeding habitat in the Mandurah area. Removal of this habitat will be a positive impact of the proposal from a public health perspective.

Loss of the sedgeland habitat which is a likely mosquito breeding area may have moderate local impact for a small number of secretive waterbird species. This habitat occurs elsewhere along the Peel-Harvey estuary foreshore (eg Falcon).

Loss of some bushbird tree overstorey habitat will occur through the removal of some of the larger *Eucalyptus* species and the *Melaleuca cuticularis* thicket, although the number of trees on the project area is minimal in comparison to nearby bushland.

## 5.3 Impacts of Dewatering

### 5.3.1 Temporary Drawdown of Domestic Bores

Dewatering of canal excavations will induce a temporary lowering of water levels in the vicinity, which may affect a limited number of domestic bores to the west and south-west of the site.

The magnitude of this drawdown effect has been simulated using a simple computer model, as discussed in Appendix D. The estimated drawdown after a period of 120 days indicates that a drawdown of about 1m will be induced at a distance of 100m from a dewatered excavation, with 0.4m drawdown at 200m distance.

If dewatering is carried out in summer, drawdown of water levels will probably affect domestic bores, particularly within 100m of a dewatering cell. The impacts would occur in both water quantity, by lowering the available watertable, and quality, by reducing the thickness of the freshwater layer above the underlying brackish water. If the dewatering is carried out in winter, there would be no significant effect on domestic bores.

An estimated 10-12 domestic bores occur within the total radius of dewatering influence (Appendix D). Dewatering is proposed to generally occur in winter and in small cells over the 5-8 years life of the project, so any impacts are expected to be minimal, temporary and readily manageable by compensating the bore owner to use scheme water for the period of effect (Section 7.4.2).

### 5.3.2 Phreatophytic Vegetation and Heritage Trees

If dewatering occurs in summer, trees which depend on a superficial layer of fresh/brackish water overlying the generally saline groundwater may be affected by temporary lowering of the watertable.

As described above, the areas with the highest potential to be affected are those within 100m of dewatering operations. Vegetation located within this radius includes the Flooded Gums and Marri trees on the upland areas of the site which are to be retained in POS. Other areas include a stand of trees located within the Castle Fun Park just outside the southwest boundary of the development site, together with bushland to the southwest of the site. Of importance will be the impact on heritage trees, namely the Norfolk Island

pine and Mission Olive trees associated with the Sutton Farmstead, and the scarred tree of archaeological significance near Winjan's Camp.

Bushland to the southwest of the site is understood to be scheduled for re-development and will be cleared of trees in the near future.

Impacts upon phreatophytic vegetation are not expected if dewatering operations occur during the winter months, due to the recharge of the superficial aquifer by rainfall. Monitoring and contingency management measures are discussed in Section 7.0.

### 5.3.3 Discharge of Dewatering Fluids

As described in Section 4.4.2, discharge of dewatering fluids will be accordance with PIMA's requirements, including Dewatering Policy WS 4.2. The dewatering fluids will be held in stilling basins of large enough capacity to provide an adequate detention time for any turbidity in the water to settle out prior to discharge of the clear water to the estuary.

This method was successfully used during the construction of Stage 1 of the Port Mandurah Development and was supported by both the City of Mandurah and PIMA. The discharged groundwater during the Stage 1 development operation was of high water quality and did not raise any problems for other users of the Mandurah Estuary.

Discharge will be directly to the main channel via a gravity pipe crossing through the conservation area, and is expected to have little or no impact on the water quality of the Estuary.

## 5.4 Impacts of Dredging

### 5.4.1 Water quality

As discussed in Section 4.4.4, dredging operations will be limited to the opening of the canals with the estuary and the formation of the entrance channel through the northernmost point of the tidal shoal. Dredging operations will be managed in consultation with PIMA and will conform to the PIMA Dredging Policy WS 4.1. Dredge spoil will be used for landfill on the site and the slurry water discharge will be managed to minimise turbid water outflow.

The short term contribution to water turbidity associated with the operation of the cutter suction dredge is not expected to cause discernible impact upon the biota within Mandurah Channel. The estuarine ecosystem is highly dynamic and the composition and abundance of the resident fauna varies greatly on a seasonable basis and from year to year, partly because of variable water quality conditions. The turbidity in the Mandurah Channel can vary markedly in response to tidal and river flow conditions. Turbidity from dredging the entrance to the canals will be short term and would be unlikely to exceed naturally occurring fluctuations.

### 5.4.2 Cut through Tidal Shoal and System 6 area

The dredging of the entrance channel will dissect the northernmost area of the System 6 area and the sub-tidal shoal, which is one of the waterbird habitats of high conservation significance. Loss of habitat area will be relatively small and will be mitigated by the creation of new tidal flats within the boundary canal / Conservation and Foreshore Reserve interface.

## 5.5 Noise

Continual noise from earthmoving machinery has the potential to impact nearby residents when construction occurs adjacent to the western and northern boundaries of the site.

As described in Section 4.4.5, construction activities will be confined to daylight hours, so noise emissions will be partially masked by the background traffic noise from the Mandurah Bypass during construction in Stage 2A and from the Mandurah Bridge and Mary Street during construction in Stage 2B.

Noise levels monitored during the Stage 1 construction phase indicated that little noise impact was experienced by residents.

## 5.6 Dust

The conduct of the majority of earthworks will occur in winter which will reduce the dust hazard of the site during construction. As described in Section 4.4.5, the application of standard dust control procedures will occur in accordance with EPA guidelines.

The impacts of dust on the nearby residents is therefore likely to be small, however the possibility of residual dust is recognised and is addressed within the Monitoring and Management component of the proposal (Section 7.0).

## 5.7 Traffic

As described in Section 4.6.2, the proposed bridges on the existing local roads of Mary Street and Old Coast Road will be constructed "in the dry" to minimise construction time. During this period traffic will be diverted by temporary detours constructed on land owned by the proponent to a standard acceptable to the Local Authority.

Due to the presence of the Mandurah Bypass, these roads are currently used as local distributors only, hence traffic disruption will be relatively small.

# 6.0 OPERATIONAL STAGE ENVIRONMENTAL IMPACTS

## 6.1 Summary of Impacts

The potential operational impacts of the Stage 2 Port Mandurah Project are summarised as:

- Canal and estuarine water and sediment quality impacts, associated with:
  - potential deterioration of water quality due to inadequate flushing;
  - contaminant inputs from residential land use; and
  - contaminant inputs from vessels.
- Potential interference with hydrodynamic processes and resultant impacts upon shoreline stability, including potential impacts on the stability of the existing foreshore vegetation.
- Potential for sediment scour from tidal currents through the canal waterways following connection of Stage 2 with Stage 1.
- Movement of the saltwater interface within the superficial watertable to the west, with a potential to permanently impact a small number of domestic bores.
- Restriction of public access to existing foreshore reserve.
- Impacts to waterbird habitat
- Increased population and recreation pressure, which may result in:
  - additional pressure on commercial fishing; and
  - waterbird disturbance.

These potential operational impacts are discussed in detail in this section.

## 6.2 Canal and Estuarine Water and Sediment Quality

### 6.2.1 Introduction

The concept of canal flushing and water quality within canal developments has the underlying benchmark that developments such as these can only achieve water quality as good as that of the estuarine source water. Designs proposed in Appendix E will therefore be carried out to achieve maximum flushing. The efforts of Government in implementing the Dawesville Channel will assist to improve source water quality. Using our current high level of understanding of the Port Mandurah Stage 1 monitoring data together with those influences should ensure the development meets water quality standards.

The existing Stage 1 Port Mandurah canals have been the subject of extensive water quality monitoring since construction (Riedel and Byrne Consulting Engineers, 1990; BSD Consultants, 1994) which has improved the knowledge available for predicting the water quality in canal estates. The monitoring has shown that the canals are well flushed, even in periods of adverse weather conditions, due to the mechanisms of:

- tidal exchange
- wind driven currents
- density driven currents

The previously documented (Riedel and Byrne Consulting Engineers, 1990) flushing mechanisms at Port Mandurah will continue to operating in the Stage 2A and 2B canal estate. However due to the second connection of the canal estate to the Mandurah Channel a new significant flushing mechanism, through flow, will control the water quality within the estate. This through flow is generated by the hydraulic gradient in the Mandurah Channel between the northern and southern entrances to the canal estate, under daily tidal flow conditions.

### 6.2.2 Tidal Regime

The tidal levels at Mandurah (Fisherman's Jetty) are shown in Table 1. These levels are based upon recorded data prior to the Dawesville Channel, however given their similarity to ocean tides, noticeable changes due to the Dawesville Channel are not expected.

Previous analysis (Riedel and Byrne Consulting Engineers, 1990) has determined that the daily contribution to average daily water level variations by the astronomical tide is 0.4 metres at Mandurah. Other astronomic and atmospheric conditions contribute to water level variations, however their influence on water quality are minimal in the longer term.

The tidal conditions at the Port Mandurah site are nearly identical to Indian Ocean tides due to its closeness to the ocean entrance of the Mandurah Channel. The Dawesville Channel has significant effects on the tidal range within the Peel/Harvey System but minimal effect in Mandurah Channel.

The existing tidal regime is discussed in detail in Appendix E and summarised in Section 3.1.5.

Considering the whole of Port Mandurah; Stages 1, 2A and 2B; the daily tidal variation will introduce approximately 18.5% of the water volume in the estate.

$$\text{Tidal Exchange} = \frac{\text{Estate Surface Area x Tidal Variation}}{\text{Estate Volume}}$$

The resulting mixing and flushing of water in the canals during the tidal cycle relies on achieving efficient mixing of the introduced waters with the canal waterbody. This is achieved by enhancing the use of winds in canal alignment design. Extensive previous work carried out in this area (Port and Harbour Consultants, 1990) shows the mixing of introduced waters to take place in a time frame significantly less than the daily tidal cycle, for even the 25 percentile wind condition. Positive contributions to flushing by this process can therefore be relied upon to operate efficiently in the proposed design.

### 6.2.3 Through Flow

Also associated with tidal exchange is the through flow generated in the canal estate by the hydraulic gradient in the Mandurah Channel across the two canal estate entrances, during both flood and ebb tides.

Calculation of these flow conditions (and those under extreme flood and storm surge events) have been carried out as part of the Port & Harbour Consultants study (Appendix E). The calculations estimate the water through flow that will occur within the Mandurah Channel, the main 60m wide canal and the three other loop canals in Stages 1, 2B Phase 1 and 2B Phase 3.

Table 6 shows the calculated through flow rates and velocities in the canal estate for the average tidal conditions (as well as for extreme conditions). These tidal through flow rates and velocities as modelled by Port and Harbour Consultants are based upon boundary conditions derived from previous modelling work (Department of Marine and Harbours, 1993 (b) ) and are the 29 day average maximum tidal flows.

With respect to water quality and after allowing for a variation in flow velocity throughout a 12 hour tidal cycle, the average quantity of through flow is approximately 5 times the average tidal prism of the canal estate and equal to the total volume of the canal estate waters. This through flow, working in conjunction with density driven exchange mechanisms and tidal exchange mechanisms between branch canals, will ensure that the canals will flush effectively.

Monitoring of the Stage 1 canals has confirmed that flushing occurs on a daily cycle. Flushing of the combined Stage 1 and 2 canals will be at least as efficient as currently occurs in Stage 1.

### 6.2.4 Other Flushing Mechanisms

Previously referenced studies and field measurements have proven the ability of wind driven and density current driven water exchange within the Port Mandurah Stage 1 canal estate. These mechanisms will continue to operate within the canal estate, following completion of Stages 2A and 2B. Due to the magnitude of the tidal through flow, they need only operate within Stage 2A and the secondary canals of the existing Stage 1 and new Stage 2B, to compliment the maximum throughflow generated by increased tidal circulation.

The general alignment of these canals has been selected to take advantage of the predominant winds from the easterly through southerly directions, to enhance the wind driven flushing mechanism. The previously documented density currents will operate on each individual secondary canal, due to the through flow providing a similar regime of driving water densities (salinity and temperature) to that which currently exists for the Port Mandurah Stage 1 Canal Estate in relation to the Mandurah Channel.

Within Stage 2A, the water exchange due to density currents has been calculated to be the same as that within the existing Stage 1 canal estate. This indicates that, with respect to phased construction, Stage 2A can be developed first (without the Main Canal in Stage

## Table 6

### Water through flow rates and velocities predicted for the canals during average and extreme events

| CHANNEL | AVERAGE TIDE | | STORM SURGE | | FLOOD FLOW | |
|---|---|---|---|---|---|---|
| | RATE ($m^3/s$) | VELOCITY (m/s) | RATE ($m^3/s$) | VELOCITY (m/s) | RATE ($m^3/s$) | VELOCITY (m/s) |
| **Mandurah Channel:** | | | | | | |
| - Up/Downstream | 286 | 0.33 | 910 | 0.76 | 570 | - |
| - Adjacent | 250 | 0.29 | 760 | 0.64 | 475 | 0.53 |
| **Main Canal:** | | | | | | |
| - Maximum | 35 | 0.26 | 150 | 0.71 | 95 | 0.56 |
| - Minimum | 22 | 0.16 | 102 | 0.49 | 63 | 0.37 |
| **Loop Canals** | | | | | | |
| - Stage 1 | 4 | 0.04 | 14 | 0.08 | 10 | 0.07 |
| - Stage 2B Phase 1 | 9 | 0.08 | 31 | 0.18 | 21 | 0.16 |
| - Stage 2B Phase 3 | 5 | 0.05 | 16 | 0.11 | 11 | 0.10 |

Source: Port and Harbour Consultants (Appendix E).

2B) and still be assured of good water quality, equivalent to that presently observed in Stage 1.

Subsequent development within Stage 2B has been planned such that at a suitable time in the staging, either a loop canal or the main canal will be constructed within Stage 2B Phase 1, to initiate the contribution of the through flow to the flushing of the Canal Estate waters.

### 6.2.5 Potential Contaminant Inputs

The proposed nutrient and drainage management design (Section 4.5) provides for segregation of irrigation and stormwater runoff and seepage to the canals into the following elements:

- Rainwater runoff from the roof will discharge directly into the canals.
- Rainwater and irrigation water from landscaped and paved areas within residential blocks will be directed to soakwells and will only enter the canals by subsurface seepage and soil adsorption of nutrients.
- Road drainage will be directed to the canals via silt trapping and grease baffle devices to minimise the discharge of soil sorbed contaminants.

These design precautions will ensure that the entry of nutrients and other contaminants to the canals and adjacent estuary will be minimal. Provision is also made for the removal of litter, accumulation and floating debris.

The use of antifoulants containing tributyl tin oxide (TBT) on vessels less than 25m and on marine structures is prohibited in Western Australia. The discharge to public waterways of sewerage, hydrocarbons and litter from vessels is also illegal.

Monitoring data from the Port Mandurah Stage 1 canals and the nearby Waterside Mandurah canals have shown that appropriate canal estate design and management can minimise the risk of significant contaminant inputs to the canals. However, it is possible that low level inputs of heavy metals, petroleum hydrocarbons and nutrients may accumulate in the canal sediments over the long term. It is not possible to accurately predict rates of accumulation of any of these potential contaminants and appropriate monitoring is proposed to determine the possible need for ameliorative measures (Section 7.0).

### 6.2.6 Potential Water Quality Effects

With regard to the minimal input of nutrients and other contaminants and to the very high rate of flushing, it is expected that water quality throughout the canal estate will closely approximate that in the Mandurah Channel. It is considered most unlikely that water quality in the canals will deteriorate, nor will it cause deterioration in water quality within the adjacent Mandurah Channel.

It is anticipated that, similar to the Stage 1 canals, the Stage 2 canals will act biologically as a natural extension of the Mandurah Channel and will be inhabited by similar biota as occur in the adjacent channel. Algal growth in the canals, as in the adjacent channel, will be limited by light penetration and is extremely unlikely to occur to nuisance levels.

## 6.3 Shoreline Processes

As discussed in Section 3.1.8, the shoreline and nearshore shoal in the vicinity of the Stage 2 entrance channel appear to be stable. The entrance canal to the Port Mandurah Stage 2 Estate will cut through the Conservation and Foreshore Reserve near the northern tip of the subtidal shoal. In order to preserve the hydrodynamic characteristics of this area whilst stabilising it from erosion due to boat wash, it is proposed to construct low profile, permeable revetments along the edges of the entrance (on both the northern and southern sides) until the Mandurah Channel is reached. Foreshore protection will continue from the southern revetment along the western boundary of the Reserve (Section 4.2.1).

The construction of a canal on the landward side of the existing samphire foreshore will effectively create an isthmus which may experience increased water movement over the existing flats and constructed interface area, particularly during outgoing high tides due to the connection of the estuary and the boundary canal during these conditions. Although the vegetation currently experiences these high extreme tide levels and conditions, there may be a potential for erosion of the vegetation and resultant transport of sediment if outgoing currents are stronger than those which presently occur.

This potential impact has been considered in view of the altered hydrodynamic processes predicted for the canal and estuary (Section 6.4). Conservative calculations of water flow across the Reserve under high tidal conditions show that it will be less than 0.05m/s or 20% of the main channel velocity, at worst. Given the preliminary design height for the

protective boundary canal revetment at Highest Astronomical Tide (Appendix E), this will not cause erosion of the Reserve. This height allows for a 0.9 -1.25m height above the samphire flats during stormsurge conditions (ie 100 year flood levels). The influence of tidal levels less than HAT will be severely restricted by the presence of the revetment and will result in negligible impact. However, due to the need to balance aesthetic and natural habitat considerations with engineering structural specifications, the final design of the revetment will be addressed in detail within the Conservation and Foreshore Management Plan. This will be prepared prior to construction, to the satisfaction of PIMA, CALM and the DEP.

It is anticipated that the project will cause minimal interference with the hydrodynamic processes responsible for the existing foreshore stability, however this is best handled by continued monitoring. With the southern entrance channel and associated revetments cutting through the shoal area, a nominal allowance will be made for sediment trapping and remedial works (excavation or dredging) should siltation occur within the channel. The overall scale of this will be much smaller than is presently allowed for at the northern entrance channel of Stage 1.

Over time, Mandurah Channel has been disturbed by human use, at its northern end by training walls and dredging works, and at its southern end by the dredging of Sticks Channel to improve the flushing of the Peel Inlet.

## 6.4 Hydrodynamic Processes

Construction of Stages 2A and 2B of Port Mandurah will, due to the double connection of the canal estate to the Mandurah Channel, most likely slightly increase the flow capacity of the Mandurah Channel over the limited distance (approximately 1300m) between the entrances. However given that the scale of the Mandurah Channel is some 5000m in length from the ocean to the Peel Inlet, this increase in flow capacity is not expected to have a measurable effect on the estuarine hydrodynamics.

The benefit of the through flow to maintaining water quality in the canals has been discussed in Section 6.2. However during extreme events, river flood flows and ocean storm surges, the greater flow in the Mandurah Channel results in a greater driving head available to increase the through flow rates and velocities. This may result in scour affecting the canal batters.

Extreme event flow data has been calculated using the method described in Appendix E, with revised channel flow cross-sections and hydraulic data to account for the increased water levels. The results of the calculations are shown in Table 6.

The through flow rate predicted in the proposed canals during extreme events is approximately 15% of the Mandurah Channel flow, while the velocities are around 10% slower within the canal estate. Depth averaged velocities within the main 60m wide channel are as high as 0.5 - 0.7m/s near the entrances and 0.35 - 0.5m/s within the Canal Estate. The velocities within the loop canal are much less, at between 0.1 - 0.2m/s.

During the detailed design phase of the project, further calculations will be made to determine the extent and design of any scour protection required on the canal batters.

The extreme flow velocities are not expected to cause any significant problems with respect to the mooring of boats, especially compared with extreme wind loadings and wind driven currents, provided the moorings are adequately designed for these loadings.

## 6.5 Groundwater Protection

The introduction of seawater into the completed canals will induce a progressive westward migration of the saltwater interface, which is at present located about 150m west of McLarty Road. The interface is a broad zone of diffusion, rather than a sharp boundary, and is maintained in its present position by the fresh groundwater lens in the Tamala Limestone on the western boundary of the site.

The canals will introduce saltwater to a distance of about 50m from the boundaries of existing properties along the west side of McLarty Road, and is estimated to impact approximately 10-12 domestic bores.

## 6.6 Public Access

Due to the high conservation value of the adjacent System 6 area and the additional foreshore reserve included as a component of the proposal, the highest priority 'beneficial use' of the foreshore reserve is for waterbird protection. For this reason, the proposal has

been specifically designed to exclude public access to the majority of the proposed foreshore reserve.

Access to the existing foreshore reserve, whilst restricted, will be enhanced by the adjacent location of Public Open Space and the provision of facilities for conservation appreciation to compliment the educational value of the proposed Conservation and Foreshore Reserve.

Vessel access into the Reserve from the estuary will be discouraged by the proposed placement of limestone boulders in the tidal channel between the offshore samphire flat and the sub-tidal shoal.

## 6.7 Effects on Waterbird Habitat

As discussed in Section 5.2, the proposed Canal Estate will not remove valued existing waterbird habitat. To the contrary, the project will provide for the conservation and management of existing waterbird habitat values, which together with the development of additional waterbird habitat, is likely to increase the total numbers of waterbirds using the site.

Based on records of waterbird usage of the Peel-Harvey estuary and from more specific data collected from the site (Appendix F), the new habitats provided and their expected significance to waterbirds are as follows:

- 'Wet' samphire (Regularly Inundated Samphire): The estuary edge of the 25m interface will colonise with samphire and augment Habitat Type 7, which is of moderate significance to waterbirds but of importance as a feeding area, one of the limited habitats of the site.

- Tidal flats: This habitat (Habitat Type 3) will be formed over most of the length of the interface area between the existing samphire flat (at approximately mean high high water) and the edge of the boundary canal (at mean low low water). This habitat has very high significance to waterbirds.

- The central upland sector of the interface area presently contains *Casuarina obesa* trees which will be retained and planted with *Juncus krausii* to create a supratidal island. This will function as a refuge for secretive bird species and a roosting area for other waterbirds during flood tides - Habitat Types 9 (Open Woodland)

and 10 (Seasonal Swamp / sedgeland), which are of moderate significance to waterbirds.

- Perching habitat (Habitat Type 5), which has very high waterbird significance as roosting habitat and refuge during flood tides, will be provided by emergent limestone boulders which will be incorporated into the design of the interface / canal boundary revetment, as well as being placed in the intertidal channel between the samphire flat and the intertidal shoal to discourage boat entry into the Reserve.

## 6.8 Population Pressures

### 6.8.1 Fishing

Additional recreation use of the estuary will inevitably place pressure on the fishery resources of the area. This is a regional impact of increased tourism and recreation in the area which is appropriately managed by the Department of Fisheries.

### 6.8.2 Boat Use

Additional boating use of the estuary and the waterways has the potential to impact the waterbirds in the proposed Conservation and Foreshore Reserve. However, a survey by Ninox Wildlife Consulting undertaken at Soldier's Cove shallows during the 1991 Kanyana Festival indicated that high boat activity caused very little disturbance to normal waterbird activity. Current boating within Mandurah Channel regularly occurs within 20m of waterbirds roosting and feeding on the subtidal flat, with no obvious disturbance.

# 7.0 MANAGEMENT AND MONITORING

## 7.1 Introduction

The discussion presented in Sections 5.0 and 6.0 demonstrate that, with appropriate management, the proposed Port Mandurah Stage 2 development will cause minimal adverse impact upon the environment. This section outlines the management program designed to minimise the environmental impacts during construction and operation of the project.

Elements of the proposed development requiring environmental management include the following:

- Pre-construction
  - Preparation of the Conservation and Foreshore Reserve Management Plan, including design of structures and facilities and prescriptions for ongoing management.
  - Determination of the requirements for and design of any scour protection required for the canal batters.
  - Formulation of a legal agreement with the City of Mandurah for the future management of the Estate.

- Construction
  - Protection of waterbird habitat
  - Noise and dust management
  - Control of turbid water discharges
  - Watertable drawdown.

- Operation
  - Conservation and Foreshore Reserve management
  - Groundwater protection
  - Fertiliser management
  - Maintenance of flushing performance
  - Shoreline stability
  - Mosquito control
  - Recreation impacts.

An environmental monitoring strategy is integral to the environmental management program, to provide feedback upon the predictions made in this PER, to ascertain the success of ongoing management programs and to identify possible requirements for additional environmental management necessary to achieve acceptable environmental performance.

## 7.2 Pre-construction Management

### 7.2.1 Conservation and Foreshore Reserve Management

As outlined in Section 4.2.1, prior to the commencement of construction, EMPL will prepare a Conservation and Foreshore Reserve Management Plan in consultation with CALM and PIMA. The Plan will include:

- methods and design of foreshore protection;
- landscape and rehabilitation design and implementation;
- public access and information facilities;
- waterbird monitoring;
- mosquito management; and
- management responsibility.

The Plan should be integrated with the Foreshore Management Plan being prepared for the adjacent Mandurah Marina Project. It is anticipated that the Reserve will eventually be vested in the NPNCA and managed by CALM.

### 7.2.2 Canal scour protection

As outlined in Section 6.4, water velocities through the main canal of the Stages 1 and 2 Estate during extreme storm surges or floods may result in scouring of the canal batters. During detailed project design and prior to canal construction, EMPL will undertake additional investigations and determine appropriate ameliorative design specifications in order to satisfy this concern, to the satisfaction of the City of Mandurah on advice from the Department of Transport.

### 7.2.3 Waterway Management Agreement

Prior to the commencement of construction, EMPL will secure legal agreement with the City of Mandurah whereby the City will accept the future responsibilities as the Waterways Manager and otherwise, as defined in SPC Policy DC1.8. It is anticipated that EMPL will be responsible for all elements of Estate management for the first five years, with the City of Mandurah accepting ongoing responsibilities as outlined in Section 4.7. To assist in financing future work requirements associated with these responsibilities, it is anticipated that EMPL will contribute "seed" funding then the City will impose a "specified area" rating upon landholders. This will be accomplished so that there will be no impact on the existing ratepayers in the City of Mandurah.

The Council has agreed in principle to accept this arrangement through the resolution to proceed with the Town Planning Scheme Amendment, following submission of the Outline Development Plan in February, 1995.

## 7.3 Construction Management

### 7.3.1 Protection of Waterbird Habitat and other Conservation Areas

Waterbird habitat and all proposed conservation areas will be protected during site preparation and other construction works through the inclusion of a comprehensive set of environmental specifications into the construction contracts. These specifications will be designed to protect the conservation areas and water quality of the estuary from any potential impacts resulting from construction activities.

The specifications will include the demarcation of conservation areas, particularly the foreshore reserve, with temporary fencing prior to construction works. Other conditions of contract will include:

- induction of all employees prior to commencement of works;
- responsibilities pertaining to a possible oil spillage from construction machinery;
- contractors penalties for damages; and
- dismissal of employees for non-compliance with specifications.

### 7.3.2 Noise and Dust Management

As described in Section 4.4.5, construction activities will be confined to daylight hours and all vehicles will be fitted with noise suppressing devices and comply with standard vehicle emission and noise regulations. Dust emissions will be managed and monitored in compliance with EPA's "Guidelines for Assessment and Control of Dust and Windblown Material from land Development Sites".

### 7.3.3 Control of Turbid Water Discharges

As described in Section 4.4.2, the discharge of dewatering and dredge spoil water will be in accordance with PIMA's requirements and published policies. Large capacity stilling basins will be used to allow settlement of suspended material prior to discharge to the estuary.

### 7.3.4 Groundwater Management

The extent of watertable drawdown from dewatering during construction upon nearby domestic bores will be monitored. In the event that the bores become temporarily unsuitable for garden irrigation, EMPL will pay the affected bore owner to use scheme water for the period of effect.

The possible effects of dewatering operations upon trees which are proposed to be retained in upland areas of the Stage 2A estate and the adjacent Castle Fun Park will be monitored. Trees will be watered if necessary to maintain their viability during the period of water table drawdown.

## 7.4 Operational Management

### 7.4.1 Conservation and Foreshore Reserve Management

EMPL will implement the Conservation and Foreshore Reserve Management Plan (as described in Section 7.2.1) until vesting of the Reserve, expected to be with the NPNCA.

### 7.4.2 Groundwater Management

EMPL will monitor the impact of the Canal Estate upon groundwater quality, including the quality of borewater abstracted from properties in nearby residences to the west of the project area. In the event that the westerly relocation of the saline/fresh water interface associated with the Canal Estate causes any reduction in the quality or quantity of groundwater available to local bore owners, EMPL would pay the bore owner to adjust the depth of the bore to remedy such a problem, or would compensate the bore owner for changing to scheme water supply insofar as is required to allow the bore water quality to return to a standard appropriate for watering gardens.

EMPL would aim for possible arrangements for compensation to bore owners to be determined by private treaty, utilising the experience and expertise of EMPL's groundwater consultants and a local bore and irrigation contractor.

Where trees are likely to be influenced by the movement of the saltwater interface, salt-resistant tree seedlings will be planted in the immediate vicinity of each tree during the construction period.

### 7.4.3 Nutrient Management

The minimisation of nutrient application within future residential gardens and the preferential use of slow release fertilisers and native plant species will be encouraged by providing each land purchaser with a detailed booklet, prepared by EMPL's landscape architects, recommending coastal plant species requiring minimal fertiliser.

### 7.4.4 Canal Maintenance

The Waterways Manager (EMPL for the initial five years, then the City of Mandurah subject to agreement) will maintain the canals and entrance channel depth to ensure adequate flushing and safe navigable depths. Depths will be monitored annually for the first five years, then as considered appropriate by the City of Mandurah in consultation with PIMA. When dredging is required, the Waterways Manager will submit plans for dredging and disposal of dredged material to PIMA for approval prior to their implementation.

### 7.4.5 Foreshore Stability

The Waterways Manager in consultation with CALM and PIMA will monitor the shoreline and nearshore shoal in the vicinity of the Stage 2 entrance channel. In the unlikely event that sediment erosion or accretion associated with the development causes significant adverse impact upon valued waterbird habitat or otherwise requires remedying, then the Waterways Manager would prepare and implement a management response to the satisfaction of DEP upon advice from CALM and PIMA.

The foreshore and nearshore shoal monitoring program will be conducted on an annual basis for the initial five years following development of the Stage 2A canals, whereupon the program and monitoring frequency will be reviewed to the satisfaction of the DEP upon advice from CALM and PIMA.

In the event that extreme storms or floods cause significant damage which may reduce waterbird habitat values in the Conservation and Foreshore Reserve, the Waterways Manager would undertake an additional survey to assess the damage then would rectify the damage as soon as possible, to the satisfaction of CALM.

### 7.4.6 Mosquito Control

As outlined in Section 7.2.1, the management of mosquito breeding habitat will be addressed within the proposed Conservation and Foreshore Management Plan, and will incorporate the results of ongoing research of the site by the WA Health Department and Murdoch University. Mosquito control will continue to be the responsibility of the WA Health Department and the City of Mandurah, in consultation with CALM and PIMA.

### 7.4.7 Recreation Management

Control of public access within and adjacent to the proposed Conservation and Foreshore Reserve will be addressed within the Conservation and Foreshore Reserve Management Plan, and will include fencing, signage and barriers to demark no-access areas.

The management of increased fishing pressure due to the additional fishers who will be attracted to the Canal Estate is appropriately the responsibility of the Department of Fisheries.

## 7.5 Environmental Monitoring Programmes

### 7.5.1 Waterbirds

A Waterbird Monitoring Programme (WMP) will be prepared in consultation with PIMA and CALM and implemented by EMPL. Monitoring will commence prior to construction, and continue through the construction and operation phases of Stage 2A to determine the impacts of the project on waterbird usage of the proposed Conservation and Foreshore Reserve. Waterbird usage is anticipated to increase as a consequence of the project.

Incorporated within the WMP will be the development of a field proforma for opportunistic bird observations to be supplied to visitors to the Conservation Interpretation Facility. Whilst these proforma are mainly for the purpose of environmental education, data supplied may also supplement the formal monitoring of the site.

Monitoring will continue for five years following the completion of Stage 2A of the project, at which time the monitoring program will be reviewed in consultation with the DEP. Annual reports detailing the results of the monitoring shall be submitted to DEP, PIMA, CALM and the City of Mandurah.

### 7.5.2 Water and Sediment Quality

A Water and Sediment Quality Monitoring Program (WSQMP) will be implemented by the Waterways Manager in accordance with the requirements of the DEP and PIMA.

The objective of the WSQMP will be to assess the effectiveness of the management strategies outlined in this PER and to ensure the maintenance of a high quality waterway environment commensurate with the Estate. The data obtained will provide feedback to the environmental management program and may lead to alteration of the ongoing management strategies.

The monitoring program will measure water quality and sediment quality parameters which are commonly recognised as being indicators of environmental quality in canal waterways constructed in Western Australian estuarine environments (eg nutrients, phytoplankton, heavy metals, dissolved oxygen, water clarity, water column stratification). The sampling periods and intensity of testing will be designed to allow a statistical comparison of test results between each sampling period. The timing of

sampling periods will take into account antecedent meteorological and limnological conditions.

The monitoring program will commence immediately following completion of the Stage 2A Canal Estate and will run for a five year period, at which time the monitoring program will be reviewed in consultation with the DEP for handover of monitoring responsibility to the City of Mandurah. Annual reports detailing the results of the monitoring shall be submitted to DEP and the City of Mandurah.

## 8.0 SUMMARY OF COMMITMENTS

The principal project design and environmental management commitments given by Esplanade (Mandurah) Pty Ltd in this PER are as follows:

General

1. The Canal Estate will comply with the provisions of the State Planning Commission's Policy DC1.8, Procedures for Approval of Artificial Waterways and Canal Estates, to the satisfaction of DPUD on advice from DEP, PIMA, the Department of Transport and the City of Mandurah.

2. The design, construction and management of the Canal Estate will be in accordance with the requirements for "canal zoning" defined by the proposed City of Mandurah Town Planning Scheme No. 3, and with the City of Mandurah's Draft Waterways Management Policy, to the satisfaction of the City of Mandurah.

Project Design

Project design commitments to be satisfied prior to the commencement of project construction include the following:

3. The project design will incorporate the provision and establishment of a Conservation and Foreshore Reserve meeting the objectives and specifications outlined in Section 4.2.1 of the PER, including a minimum Foreshore Reserve width of 50m and an additional 25m buffer zone, so as to provide for conservation management of all areas identified in the PER as having high or very high waterbird habitat and all areas of wet samphire with moderate waterbird habitat value. This commitment will be accomplished to the satisfaction of the EPA upon advice from DEP, CALM and PIMA.

4. The proposed Conservation and Foreshore Reserve will be buffered from the proposed development by a 50m wide boundary canal.

5. The Stage 2A proposal will include an area of Public Open Space located in the south eastern corner of the project area, to augment the existing Foreshore

Reserve and to be developed and managed for conservation interpretation and public appreciation of waterbird species and habitats. This commitment is to be accomplished to the satisfaction of the EPA upon advice from DEP, CALM and PIMA.

6. A Conservation and Foreshore Reserve Management Plan defining the detailed design and management prescriptions for the Reserve will be prepared by EMPL in consultation with DEP, CALM and PIMA, to the satisfaction of the Minister for the Environment. The Plan will be consistent with the objectives proposed for the Reserve in this PER and will include arrangements whereby EMPL will construct and establish the Reserve facilities during construction of the Stage 2A Canal Estate then shall cede its property within the Reserve for ongoing management by CALM.

7. The Stage 2B proposal will include a Heritage Conservation Area of approximately 1.4ha to preserve the existing Sutton Homestead and ancillary farm buildings, to the satisfaction of the City of Mandurah.

8. The Stage 2B proposal will include an area of Public Open Space at the heritage graveyard site, to enable its appropriate conservation and management. This commitment is to be accomplished to the satisfaction of the City of Mandurah.

9. The Stage 2B proposal will include two areas of Public Open Space at the two identified Aboriginal heritage areas, to the satisfaction of the City of Mandurah upon advice from the Department of Aboriginal Affairs.

10. The Port Mandurah Stage 2 canals will be connected to both the Mandurah Inlet and the Stage 1 canals, to provide an integrated canal estate and to secure enhanced flushing of the waterways.

11. The Stage 2 proposal will apply the same high standards of environmental design criteria as Stage 1, subject to minor modifications as described in the PER where experience has shown to be appropriate to secure improved environmental performance. This commitment will be implemented to the satisfaction of the DEP upon advice from the Department of Transport, PIMA and the City of Mandurah.

12. EMPL will enter into an agreement with the City of Mandurah which clearly delineates responsibilities for the physical maintenance and waterways management of the Canal Estate and the entrance channel. This agreement is to be to the satisfaction of the Minister for the Environment on advice from the DEP.

13. EMPL will prepare a water and sediment quality monitoring program for the canals to the satisfaction of the DEP on advice from PIMA.

14. EMPL will prepare a waterbird monitoring program for the Conservation and Foreshore Reserve, to the satisfaction of the DEP on advice from CALM and PIMA.

15. EMPL will undertake additional investigations and provide detailed design specifications to ensure that the through flow of water in the integrated Stage 1 and 2 canals will not result in unacceptable scouring of the canal batters. This will be accomplished to the satisfaction of the City of Mandurah upon advice from the Department of Transport.

Project Construction

Project construction commitments, to be satisfied prior to final subdivisional approval of the relevant stage of development, include the following:

16. EMPL will incorporate environmental conditions including those outlined in Section 7.3.1 into the Construction Contracts to provide for protection of the conservation areas, to the satisfaction of the DEP. In particular, EMPL will ensure that, during construction of Stage 2A, construction contractors do not encroach upon any areas of the Conservation and Foreshore Reserve which are recognised as important waterbird habitat.

17. During construction of Stage 2A, EMPL will develop the Conservation and Foreshore Reserve and Conservation Interpretation Facility consistent with the objectives and scope of the Conservation and Foreshore Reserve Management Plan, and will enter into an agreement with CALM for vesting and ongoing management of the Reserve. This commitment will be accomplished to the satisfaction of the Minister for the Environment upon advice from DEP, CALM and PIMA.

18. Dust emissions from the project area during construction activities will be managed and monitored in compliance with the EPA's Guidelines for Assessment and Control of Dust and Windborne Material from Land Development Sites", to the satisfaction of the City of Mandurah.

19. Construction activities will be restricted to daylight hours. Appropriate techniques will be employed to suppress any noise nuisance to nearby residents, to the satisfaction of the City of Mandurah.

20. The effects of dewatering operations during project construction upon nearby domestic bores will be monitored by EMPL and, in the event that the bores become unsuitable for garden irrigation, EMPL will pay the affected bore owner to use scheme water for the period of effect. This commitment will be fulfilled to the satisfaction of the City of Mandurah.

21. The effects of dewatering operations upon trees on the upland areas of the Stage 2A site, those within the adjacent Castle Fun Park, and the trees of heritage significance, will be monitored by EMPL and watered if necessary to maintain their viability during the period of temporary water table drawdown. This commitment will be fulfilled to the satisfaction of the DEP.

22. The proposed canals will be excavated in a land-locked basin; with dredging being required only for opening the entrance channel to Mandurah Channel. The discharge of dewatering and dredge spoil water will incorporate large capacity stilling basins to allow settlement of suspended material prior to discharge to the estuary and will be in accordance with PIMA's requirements and published policies.

23. The proposed canals will be constructed to a high standard to the satisfaction of the City of Mandurah and EPA upon advice from PIMA and the Department of Transport.

Ongoing Management and Monitoring

Upon completion of each stage of the proposed development, EMPL will fulfill the following commitments:

24. The canal waterways will be ceded free of cost to the Crown, for vesting with the City of Mandurah.

25. EMPL will monitor the impact of the canals upon groundwater abstracted at nearby residential properties. In the event that the canals cause any reduction in the quality or quantity of groundwater available to local bore owners, then EMPL would pay the bore owner to modify the bore or would compensate him/her for changing to scheme water, to the satisfaction of the City of Mandurah.

26. For the initial five years following construction then subject to the agreement with the City of Mandurah, EMPL will annually monitor the depths of the canals and the entrance channel to ensure the maintenance of adequate flushing and safe navigable depths, to the satisfaction of the EPA and Department of Transport. If and when required by the Department of Transport or PIMA, EMPL (or the City of Mandurah subject to agreement) will submit plans for dredging and disposal of dredged material to PIMA for approval prior to their implementation.

27. For the initial five years following construction of Stage 2A then subject to the agreement with the City of Mandurah, EMPL will annually monitor the shoreline and nearshore shoal in the vicinity of the Stage 2 entrance channel, to the satisfaction of the DEP on advice from CALM and PIMA. In the unlikely event that sediment erosion or accretion associated with the development causes significant adverse impact upon the Conservation and Foreshore Reserve, then the Waterways Manager will prepare and implement a management response to the satisfaction of EPA upon advice from CALM and PIMA.

28. For the initial five years following construction and then subject to agreement with the City of Mandurah, EMPL will implement the water and sediment quality monitoring program for the canals, to the satisfaction of the DEP upon advice from the Department of Transport and PIMA.

A summary of the Environmental Conditions and Commitments for Port Mandurah Stage 1 in relation to the above commitments is provided as Appendix I.

## 9.0 REFERENCES

ANCA, 1993. A Directory of Important Wetlands in Australia. Australian Nature Conservation Agency.

Bamford, M.J., Bamford, A.R. and Ninox Wildlife Consulting, 1995. Bandicoot Numbers within the Port Mandurah Stage 2 Project Area. Prepared for Bowman Bishaw Gorham, January, 1995.

BSD Consultants Pty Ltd, 1992. Amendment No. 183, City of Mandurah, District Zoning Scheme No. 1A, Harbour City Canal Estate, with supporting Planning and Environmental Reports. Esplanade (Mandurah) Pty Ltd.

BSD Consultants, 1994. Port Mandurah Environmental Monitoring Programme Water Quality Survey. Prepared for Cedar Woods Limited, February, 1994.

BSD Consultants, 1995. Outline Development Plan. Submission to the City of Mandurah. Prepared for Esplanade (Mandurah) Pty Ltd., February, 1995 (unpub.).

CAMBA, 1988. *Agreement Between the Government of the Peoples Republic of China for the Protection of Migratory Birds and their Environment* .

Chalmer, P.N. and Scott, J.K., 1984. Fish and Benthic Faunal Surveys of the Leschenault and Peel-Harvey Estuarine Systems of South-Western Australia in December 1974. DCE Bulletin No. 149 (April, 1984).

City of Mandurah, 1985. Town Planning Scheme No.1A.

City of Mandurah, 1994. Draft Waterways Management Policy.

City of Mandurah (*In prep*). Town Planning Scheme No.3.

CSIRO, 1994. The Greenhouse Effect - Regional Implications for Western Australia - Final Report 1992-93. Division of Atmosphere Research, Climate Impact Group.

Dames and Moore, 1995. Report on Groundwater Aspects for Public Environmental Review. Port Mandurah Stage 2. Prepared for Cedar Woods Limited, February, 1995.

Department of Conservation and Environment (DCE), 1980. The Peel-Harvey Estuarine System Study (1976-1980). Department of Conversation and Environment, Report No.9.

Department of Conservation and Environment (DCE), 1984 Management of Peel Inlet and Harvey Estuary. Department of Conservation and Environment Bulletin 170, May, 1984.

Department of Conservation and Environment (DCE), 1983. Conservation Reserves for Western Australia as recommended by the Environmental Protection Authority: The Darling System - System 6. Department of Conservation and Environment Report 13, October, 1983.

Department of Marine and Harbours, 1992. Mandurah, Fishermans Service Jetty Submergence Curve.

Department of Marine and Harbours, 1993 (a). Impact of the Dawesville Channel on water levels in the Peel-Harvey Estuarine System. Coastal Management Issue 1.

Department of Marine and Harbours, 1993 (b). Water Levels in Peel Inlet and Harvey Estuary Before and After Dawesville Channel. DHM D10/92.

Department of Planning and Urban Development (DPUD), 1993. Peel Regional Park Study. January, 1993.

Department of Planning and Urban Development (DPUD), 1994. Peel Regional Strategy September, 1994.

Environmental Protection Authority (EPA), 1982. Halls Head Waterways Project. Parrys Esplanade Ltd. Report and Recommendations of the Environmental Protection Authority. Bulletin 129.

Environmental Protection Authority (EPA), 1988. The Peel Inlet and Harvey Estuary Management Strategy, Stage 2, Report and Recommendations of the Environmental Protection Authority. Bulletin No. 363.

Environmental Protection Authority (EPA), 1989. Port Mandurah Stage 1. Rule Group Ltd. Report and Recommendations of the Environmental Protection Authority. Bulletin 378.

Environmental Protection Authority (EPA), 1993. Redevelopment of Mandurah Marina. Lot 11 Old Coast Road Mandurah. Norman Hope Nominees Pty Ltd. Report and Recommendations of the Environmental Protection Authority. Bulletin 692.

The Feilman Group, 1981. Environmental Review and Management Programme (ERMP) Halls Head Waterways Project. Prepared for Parrys Esplanade Ltd.

Feilman Planning Consultants, 1989. Notice of Intent, Port Mandurah Development. Esplanade (Mandurah) Pty Ltd, February. Supplementary to The Feilman Group, 1981.

Gorham, R.A., Humphries, R., Yeates, J.S., Puglisi, G.R. and Robinson, S.J. 1988. The Peel Inlet and Harvey Estuary Management Strategy. Journal of the Australian Water and Wastewater Association; Volume 15, No. 3, pp 39-45.

Halpern Glick Maunsell (HGM) and The Planning Group, 1992. Redevelopment of Mandurah Marina, Lot 11 Old Coast Road, Mandurah. Consultative Environmental Review. Prepared for Norman Hope Nominees Pty Ltd.

Hobbs, V., Saunders, A. and Bailey, J. 1990. Environmental Auditing: Case Studies of Artificial Waterway Developments in Western Australia. Environmental Science Discussion Paper 1/90. Murdoch University, Western Australia.

The Institution of Engineers, Australia, 1991. Guidelines for Responding to the Effects of Climatic Change in Coastal Engineering Design. National Committee on Coastal and Ocean Engineering.

Jaensch, R.P., Vervest, R.M. and Hewish, M.J., 1988. Waterbirds in Nature Reserves of South-Western Australia 1981-1985: Reserve Accounts. Royal Australian Ornithologists Union. Report No. 30.

JAMBA, 1981. *Agreement between the Government of Australia and the Government of Japan for the Protection of Migratory Birds and Birds in Danger of Extinction and their Environment*

Kay, R., Eliot, I. and Klem, G., 1992. Analysis of the Intergovernmental Panel on Climate Change Sea Level Rise Vulnerability Assessment Methodology using Geographic Bay, SW Western Australia, as a Case Study. DASET, Canberra, 24pp.

Kinhill Engineers, 1988 Peel Inlet and Harvey Estuary Management Strategy. Environmental Review and Management Programme - Stage 2. Prepared for Department of Agriculture and Department of Marine and Harbours, May 1988.

Kirke, A., 1986. A Study of the Conservation Value of Three Foreshore Areas of the Peel Inlet-Harvey Estuary. Prepared for the Peel-Harvey Conservation and Development Committee, July, 1986.

Lane J, unpub. data. Department of Conservation and Land Management (CALM), 1979.

LeProvost Semeniuk and Chalmer, 1981. Environmental Considerations, Waterways Project - Halls Head Mandurah (included in The Feilman Group, 1981). Port and Harbour Consultants.

LeProvost Environmental Consultants (LEC), 1991 (a). Waterside Mandurah Environmental Monitoring Programme, Fifth Annual Report and Quinquennial Review, November, 1985 to June, 1991. Prepared for John Holland Pty Ltd.

LeProvost Environmental Consultants (LEC), 1991 (b) Port Mandurah Environmental Monitoring Programme, First Annual Report, July, 1990 to June, 1991. Prepared for Esplanade (Mandurah) Pty Ltd, September, 1991.

McMullen Nolan and Partners, 1995. Port Mandurah, Natural Surface Survey - Drawings 91084-2. Cedar Woods Pty Ltd.

Ninox Wildlife Consulting and E.M. Goble Garratt and Associates, 1995. Waterbird Conservation within the Port Mandurah Stage 2 Project Area. Prepared for Bowman Bishaw Gorham, January 1995.

Peel Inlet Management Authority (PIMA), 1994. Draft Dredge Spoil Disposal Policy WS 4.2.

Peel Inlet Management Authority (PIMA), 1994. Dredging Policy Statement WS 4.1

Port and Harbour Consultants, 1990. Mandurah Quay, Water Quality and Flushing Study. D and M. Drainage.

Port and Harbour Consultants, 1995. Marine Engineering Aspects. Port Mandurah Stage 2 PER. Appendix E.

Potter, I.D., Loneragan, N.R., Lenanton, R.C.J. Crystal, P.J. and Grant, C.J., 1983. Abundance, Distribution and Age Structure of Fish Populations in a Western Australian Estuary. *J. Zool. Lond.*, **200**:21-50.

Public Works Department, WA, 1984. Peel Inlet Entrance Channel, Flood Investigations. Charts 52725 - 6 - 1, - 2, 52725 - 3 - 1.

Ramsar Convention, 1971. Ramsar *Convention on Wetlands of International Importance Especially as Waterfowl Habitat.*

Reidel and Byrne, 1981. Hydraulic Aspects. Prepared for Parry Esplanade Ltd, In Halls Head ERMP (Appendix 3).

Reidel and Byrne Consulting Engineers, 1985 (a). Dredge Depths and Wall Heights, Port Mandurah. Halls Head Estates, R129.

Reidel and Byrne Consulting Engineers, 1985 (b). Preliminary Design Report, Port Mandurah. Halls Head Estates, R150.

Reidel and Byrne Consulting Engineers, 1990. Canal Flushing Study, Port Mandurah. Esplanade (Mandurah) Pty Ltd.

Reidel and Byrne Consulting Engineers, 1992. Marine and Water Quality Aspects, Harbour City Canal Estate, Mandurah. Esplanade (Mandurah) Pty Ltd (included in BSD Consultants Pty Ltd 1992).

Rule Group Ltd, 1989. Notice of Intent (NOI). Port Mandurah Stage 1.

Semeniuk, C.A. and Semeniuk, V. 1990 The coastal landforms and peripheral wetlands of the Peel-Harvey estuarine system. *J. Roy. Soc. of WA*, **73**(1):9-21.

State Planning Commission, 1991. Procedures for Approval of Artificial Waterways and Canal Estates. Policy DC 1.8, Department of Planning and Urban Development.

Waterways Commission, 1990. The significance of Mosquito Breeding Areas to the Waterbirds of Peel Inlet, Western Australia. Waterways Commission Report No. 20, June, 1990.

Waterways Commission, 1992. Peel Inlet Management Programme. Waterways Commission Report No. 27, January, 1992.

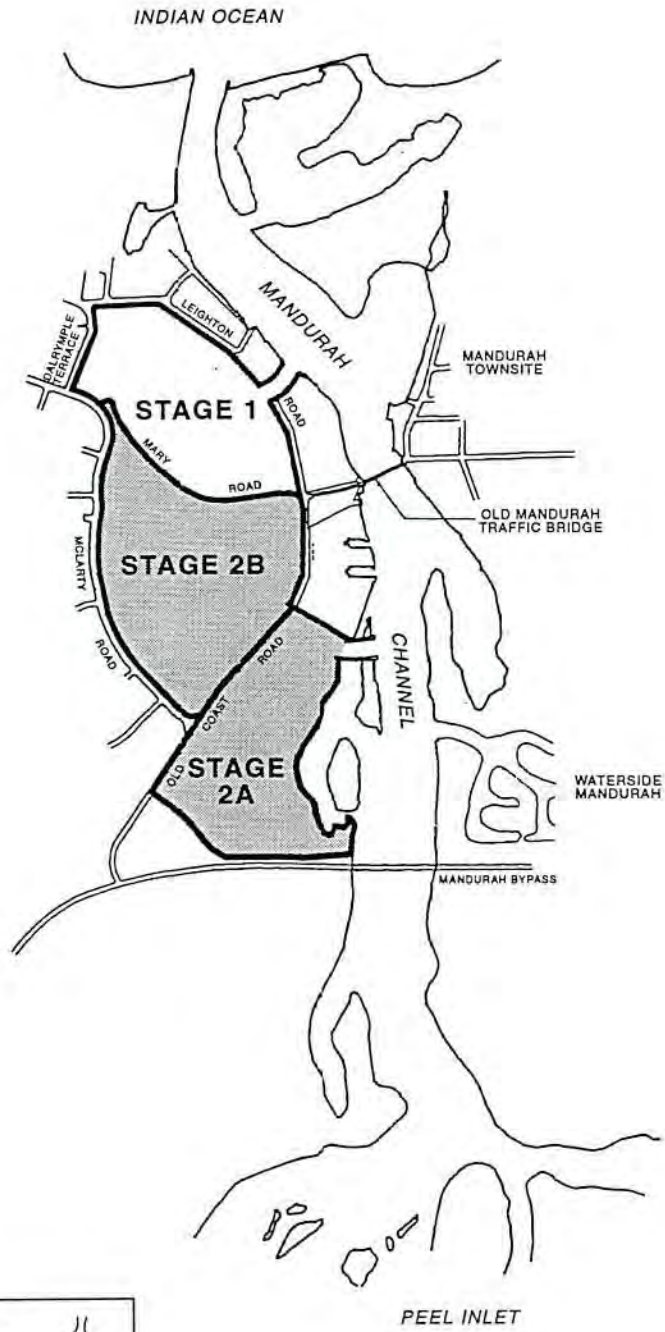
Wells, F.E., Threlfall, T.J. and Wilson, B.R., 1980. Aspects of the Biology of Molluscs in the Peel-Harvey Estuarine System, Western Australia. DCE Bulletin No. 97 (June 1980).

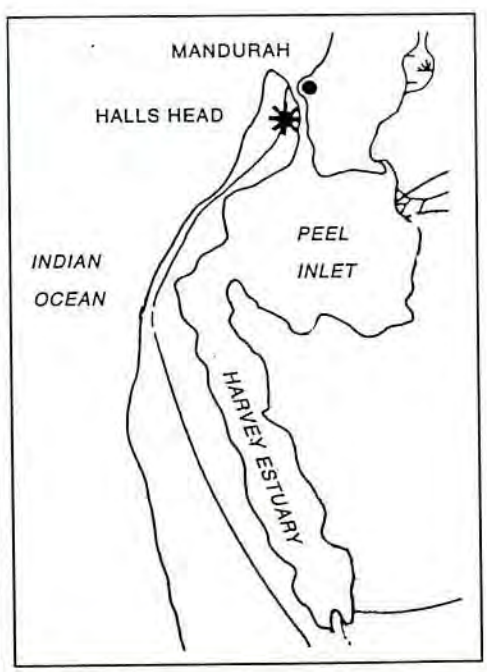
Western Australian Museum, 1986. List of Current Records in Collection of Mammals, Reptiles, and Fish from the Peel-Harvey District. Unpublished data.

Wigley, T.M.L. and Raper, S.C.B, 1992. Implications for climate and sea level of revised IPCC emissions scenarios. Nature, **357**:293 - 300, 28th May 1992.

Wright, A.E., 1988. Report on the mosquito eradication campaign. Survey of Mosquitoes in the Mandurah Region. Health Department of Western Australia.

# FIGURES





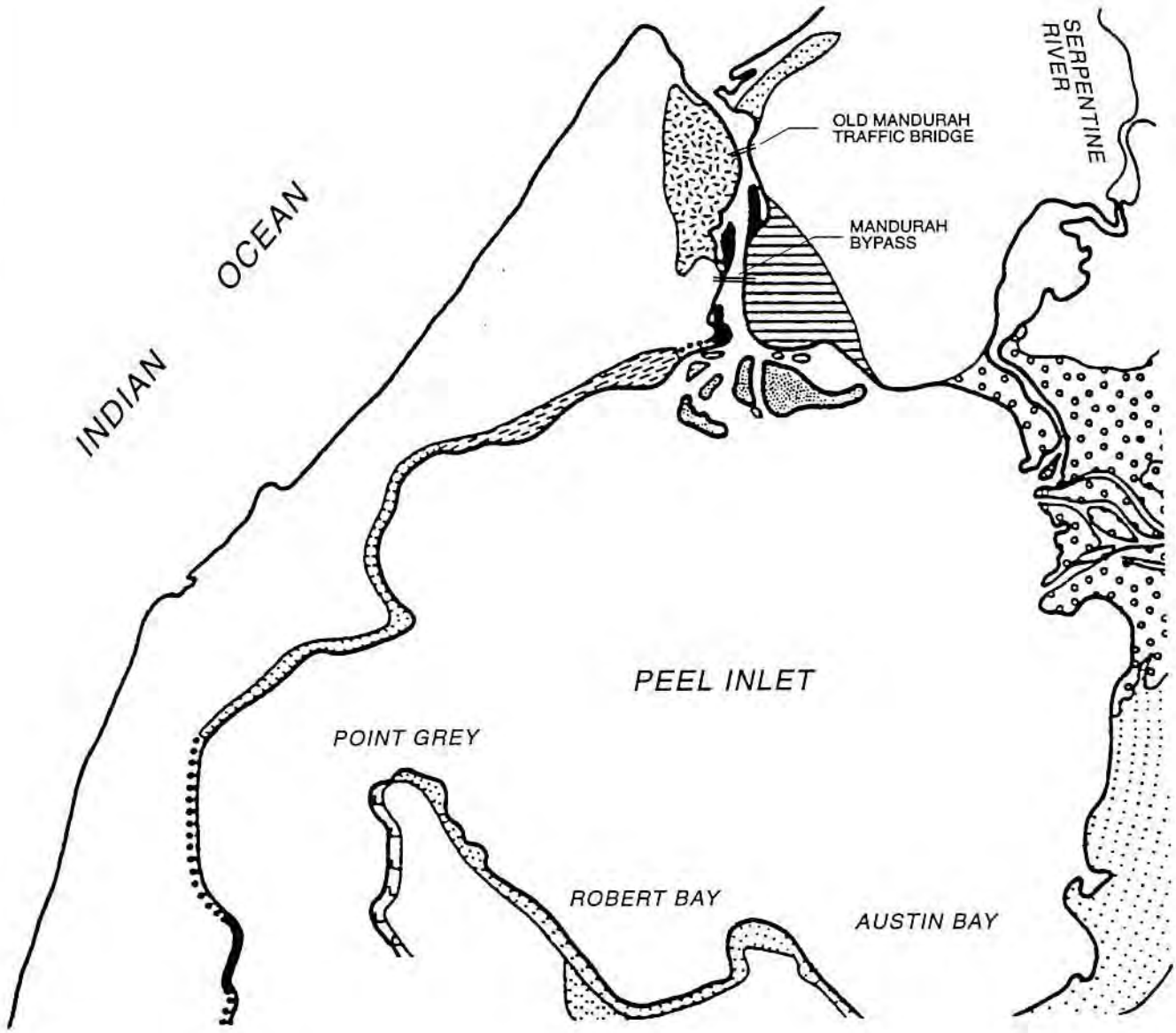

**PORT MANDURAH STAGE 2**

## LOCATION DIAGRAM

Figure 1

BOWMAN BISHAW GORHAM

ENVIRONMENTAL MANAGEMENT CONSULTANTS




## Key

- Tidal shoal
- Active tidal delta
- Stranded channel shoal complex
- Relic tidal delta
- Stranded estuarine embayment
- Spit-lagoon complex
- Beach ridge complex
- Marginal platforms
- Erosional sandy shore
- Limestone cliff-pocket beach shore
- Lobate fluvial delta complex
- Elongate fluvial delta complex

N

0 5km

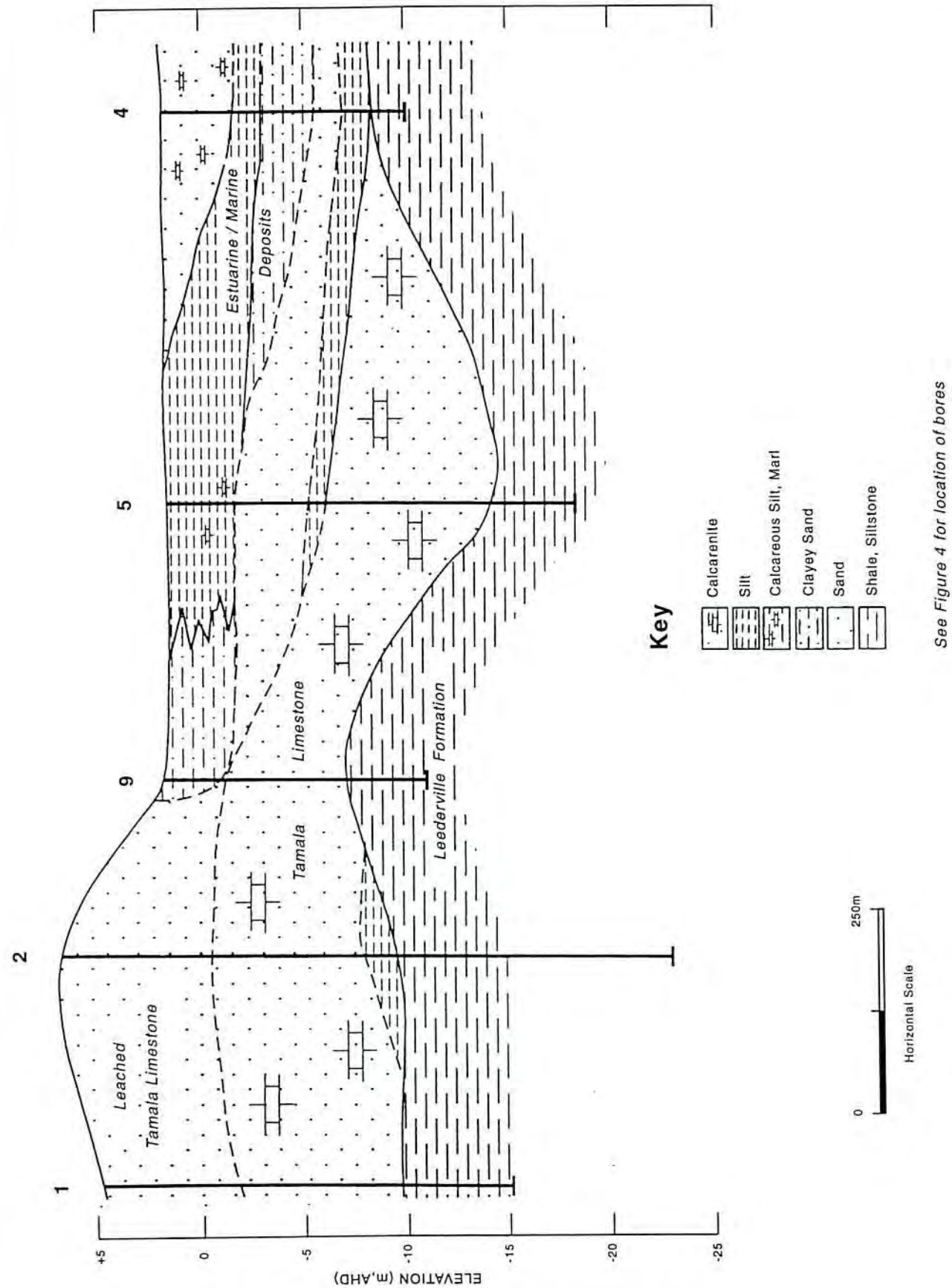
**PORT MANDURAH STAGE 2**

**ESTUARINE GEOMORPHOLOGY**

Figure 2

Source : Semeniuk & Semeniuk 1990

BOWMAN BISHAW GORHAM
ENVIRONMENTAL MANAGEMENT CONSULTANTS



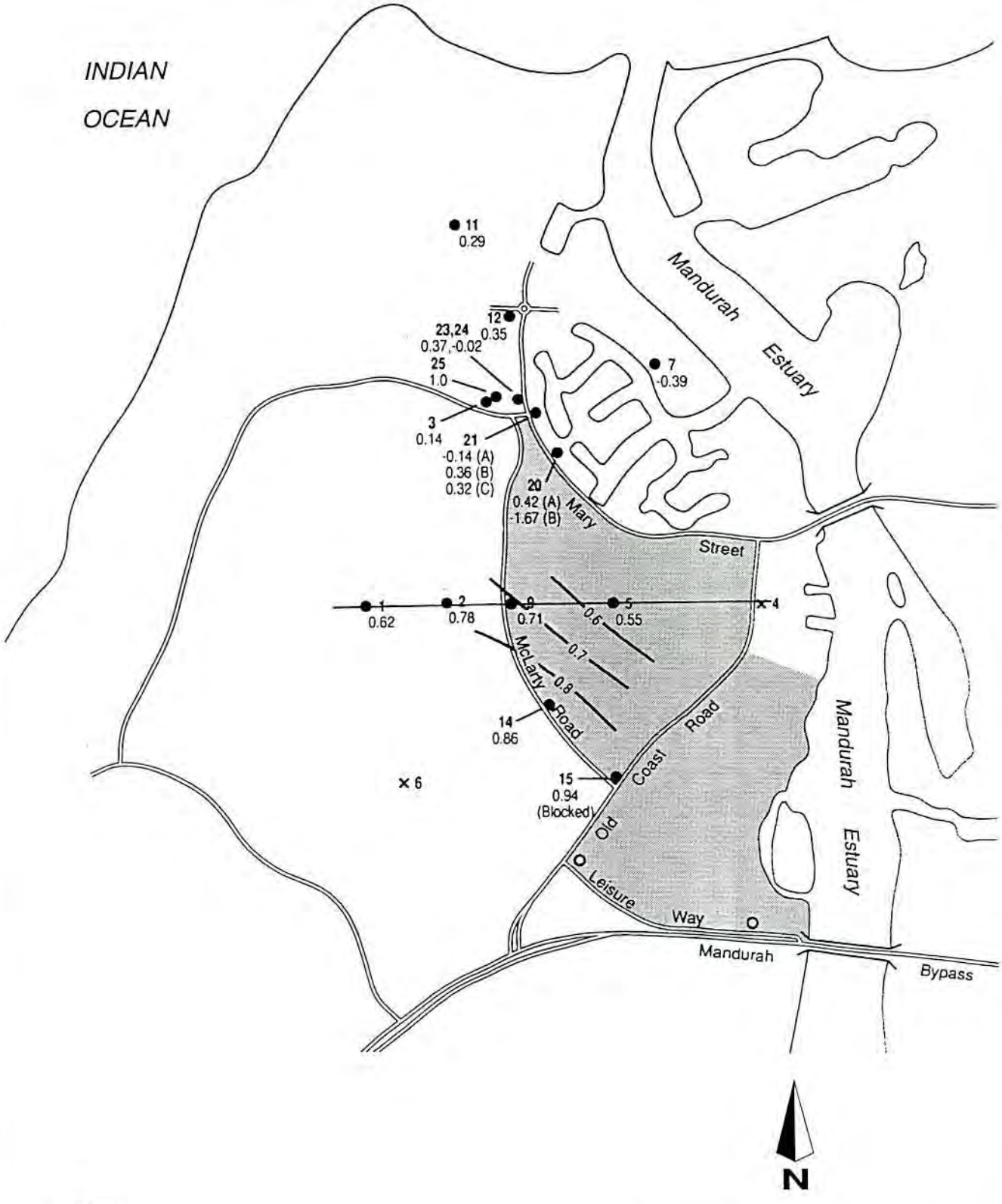

**PORT MANDURAH STAGE 2**

## GEOLOGICAL CROSS SECTION

Figure 3

Source : Dames & Moore 1995

BOWMAN BISHAW GORHAM
ENVIRONMENTAL MANAGEMENT CONSULTANTS




## Key

- ● Monitor Bore
- × Monitor Bore, Destroyed
- O Recommended Additional Monitoring Site
- 0.28 Water-Level (m,AHD)
- —0.1— Water Level Contour

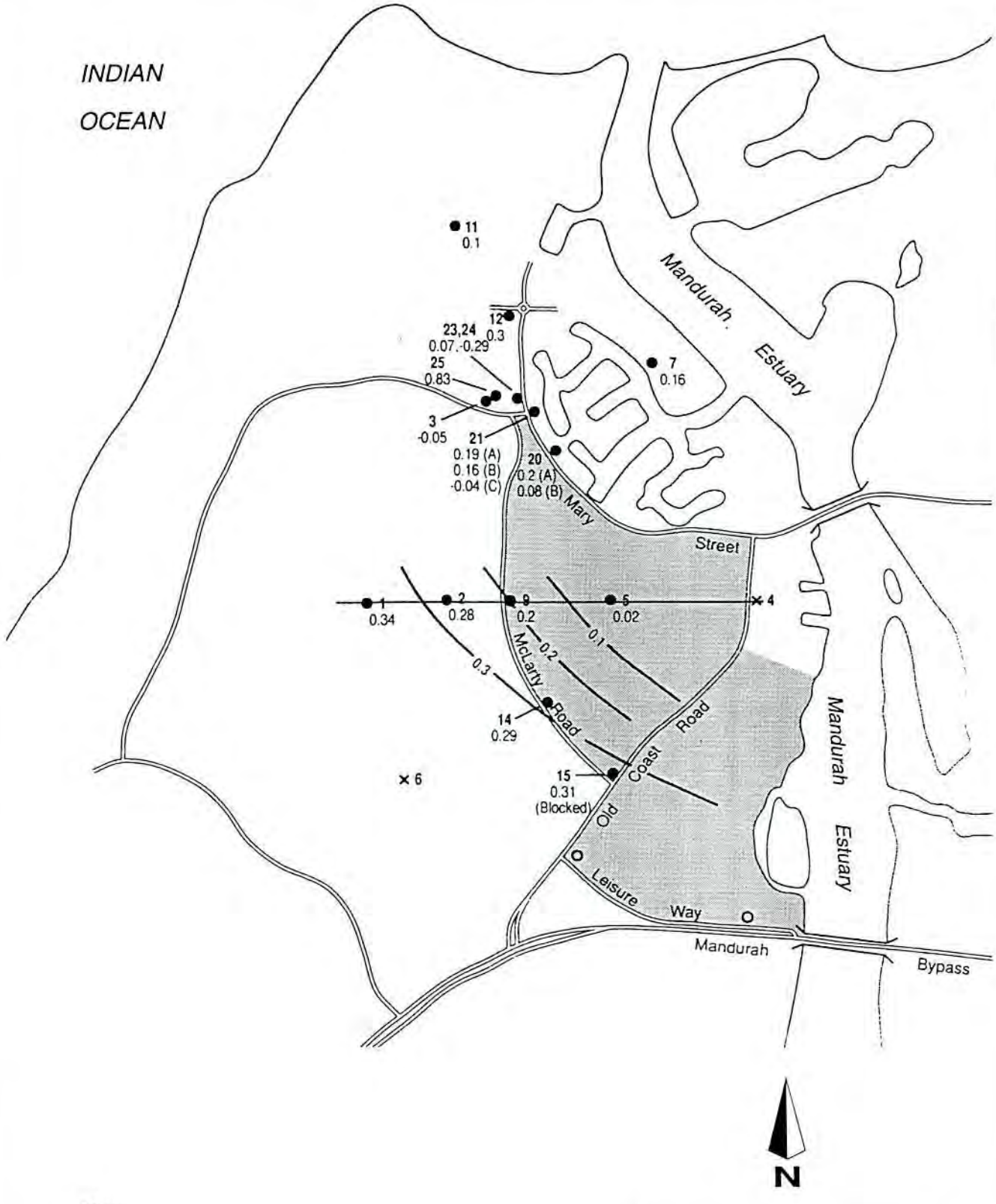
**PORT MANDURAH STAGE 2**

**WATER LEVELS AUGUST 1994**

Figure 4

Source : Dames & Moore 1995

BOWMAN BISHAW GORHAM
ENVIRONMENTAL MANAGEMENT CONSULTANTS




## Key

- ● Monitor Bore
- × Monitor Bore, Destroyed
- O Recommended Additional Monitoring Site
- 0.28 Water-Level (m,AHD)
- —0.1— Water Level Contour

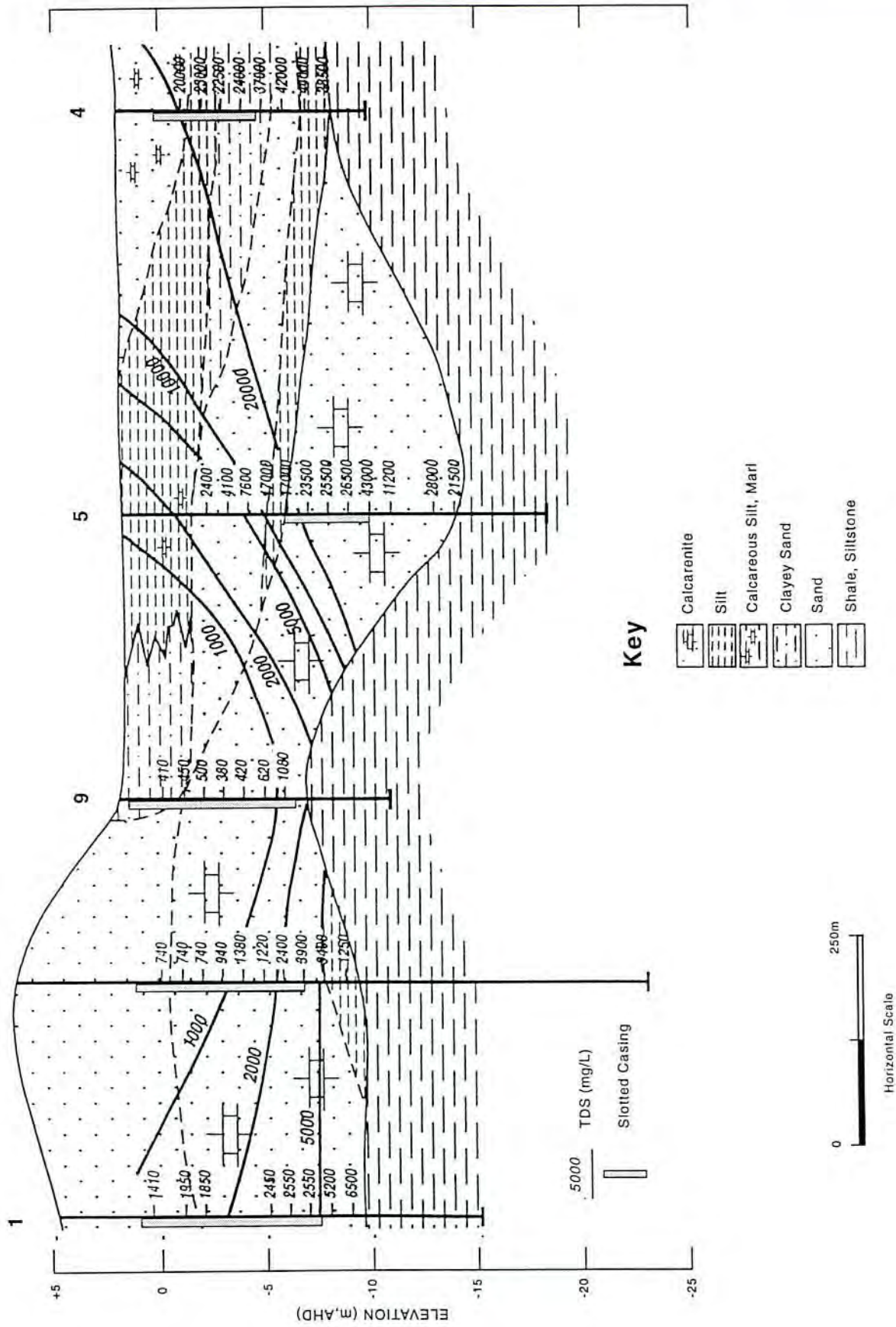
**PORT MANDURAH STAGE 2**

**WATER LEVELS JANUARY 1995**

Figure 5

Source : Dames & Moore 1995

BOWMAN BISHAW GORHAM
ENVIRONMENTAL MANAGEMENT CONSULTANTS




**PORT MANDURAH STAGE 2**

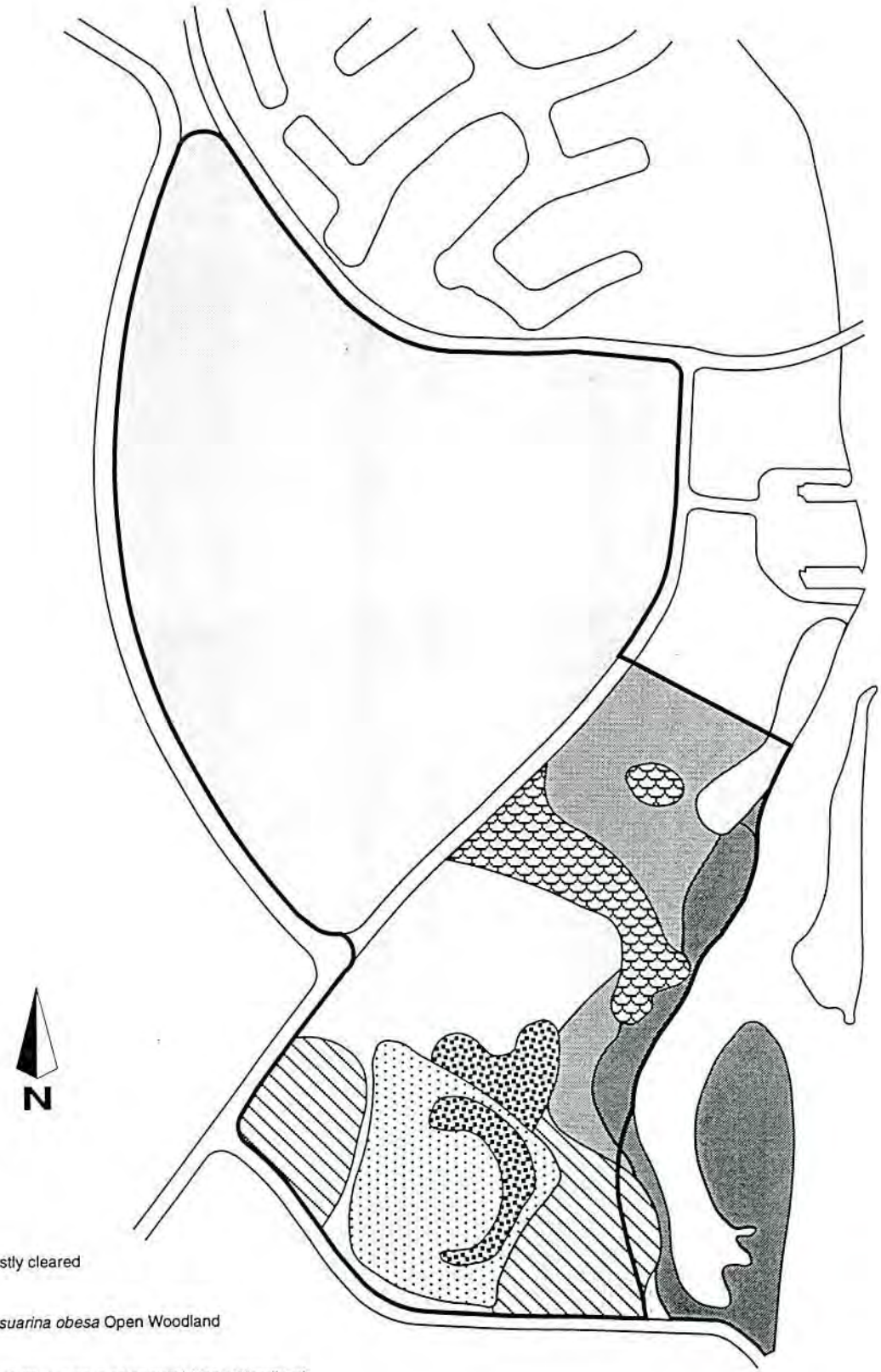
**SALINITY PROFILE**

Figure 6

Source : Dames & Moore 1995

BOWMAN BISHAW GORHAM

ENVIRONMENTAL MANAGEMENT CONSULTANTS




**PORT MANDURAH STAGE 2**

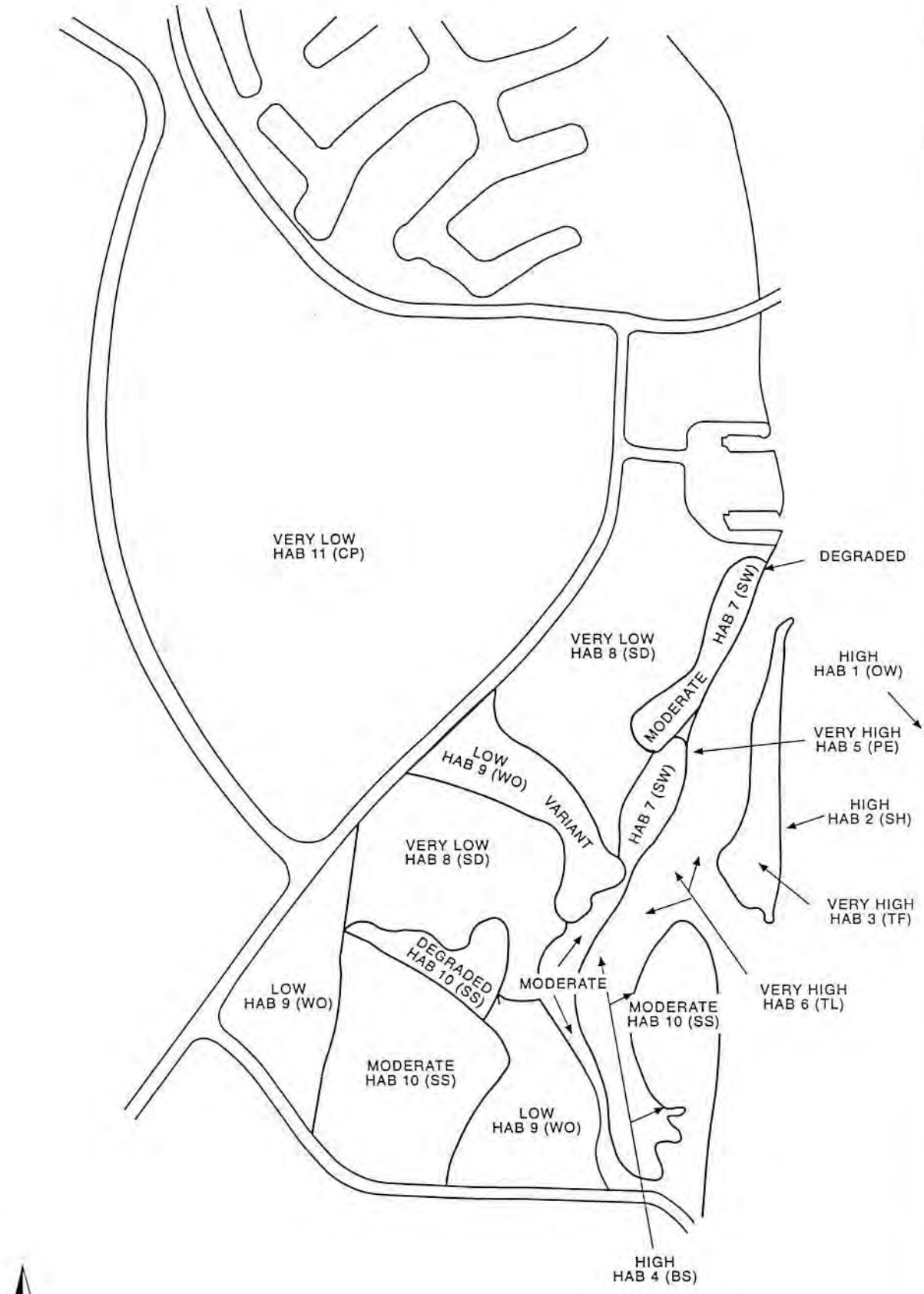
**VEGETATION**

Figure 7

Source : Ninox, 1995

BOWMAN BISHAW GORHAM

ENVIRONMENTAL MANAGEMENT CONSULTANTS




**PORT MANDURAH STAGE 2**

## WATERBIRD HABITAT VALUES

Figure 8

Source : Ninox, 1995

BOWMAN BISHAW GORHAM
ENVIRONMENTAL MANAGEMENT CONSULTANTS

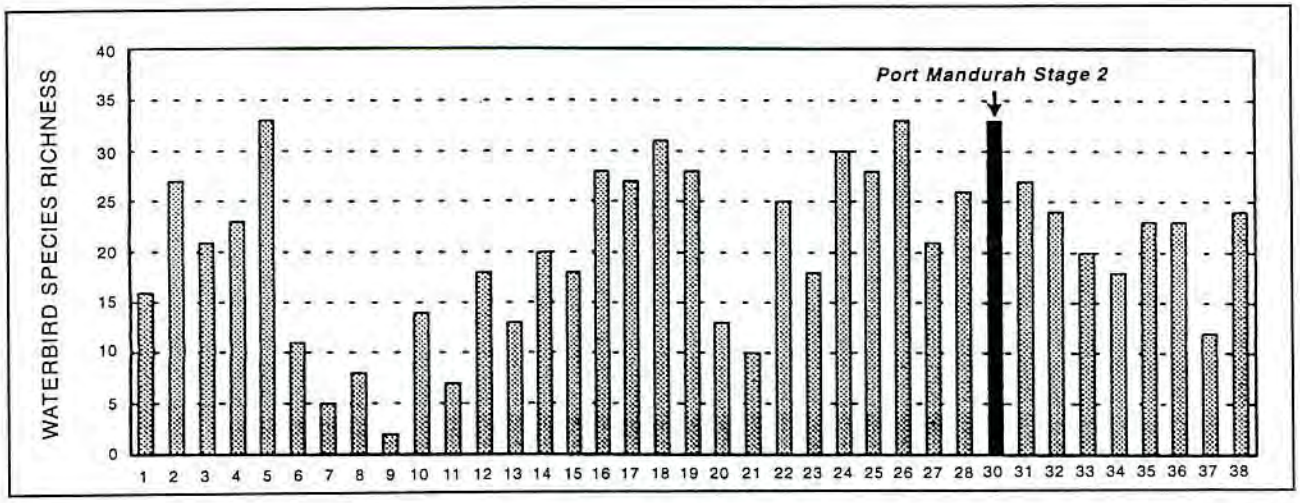



Figure 9

**Species richness at Port Mandurah Stage 2 compared to other sites on northern Peel Inlet**

**( November 1988 to December 1989 )**

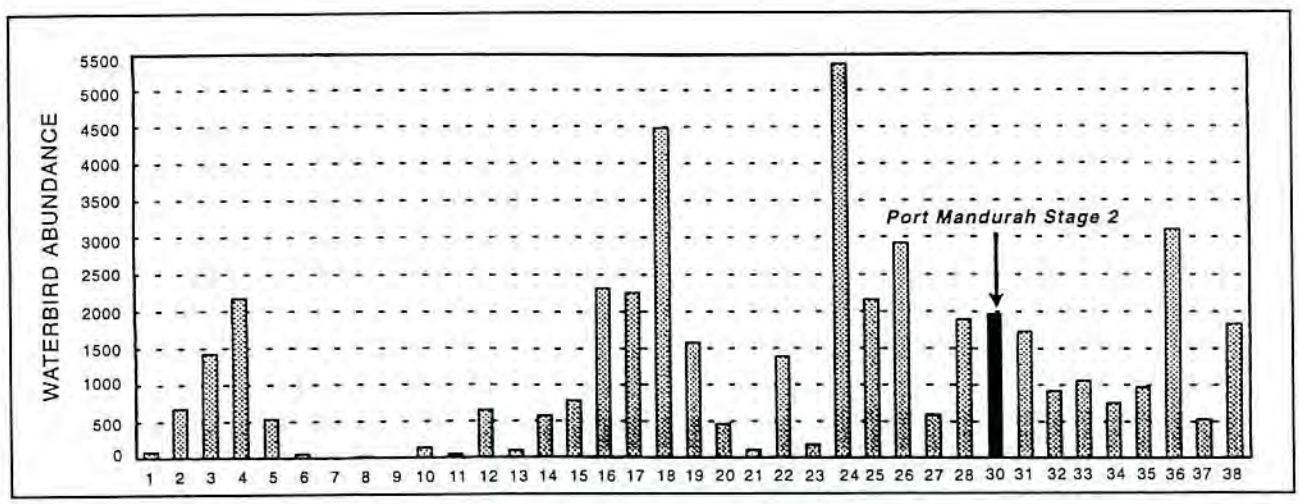



Figure 10

**Waterbird abundance at Port Mandurah Stage 2 compared to other sites on northern Peel Inlet**

**( November 1988 to December 1989 )**

*Note : Site locations as Waterways Commission 1990*

Source : Ninox, 1995

**PORT MANDURAH STAGE 2**

**SPECIES RICHNESS AND ABUNDANCE OF WATERBIRDS**

Figures 9 & 10

BOWMAN BISHAW GORHAM

ENVIRONMENTAL MANAGEMENT CONSULTANTS

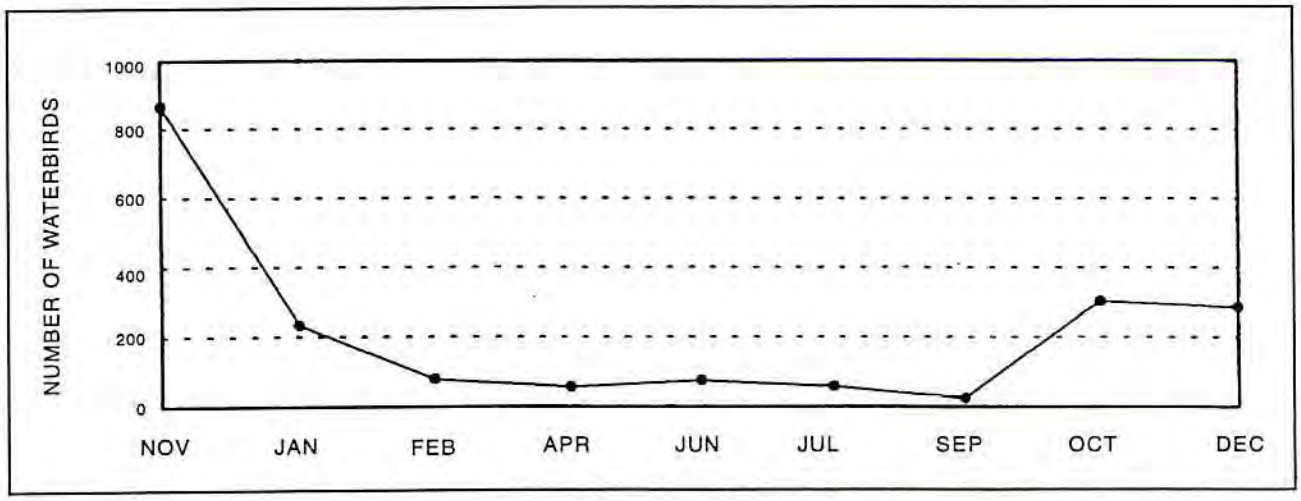



Figure 11

**Waterbird seasonality at Port Mandurah Stage 2**

**( November 1988 to December 1989 )**

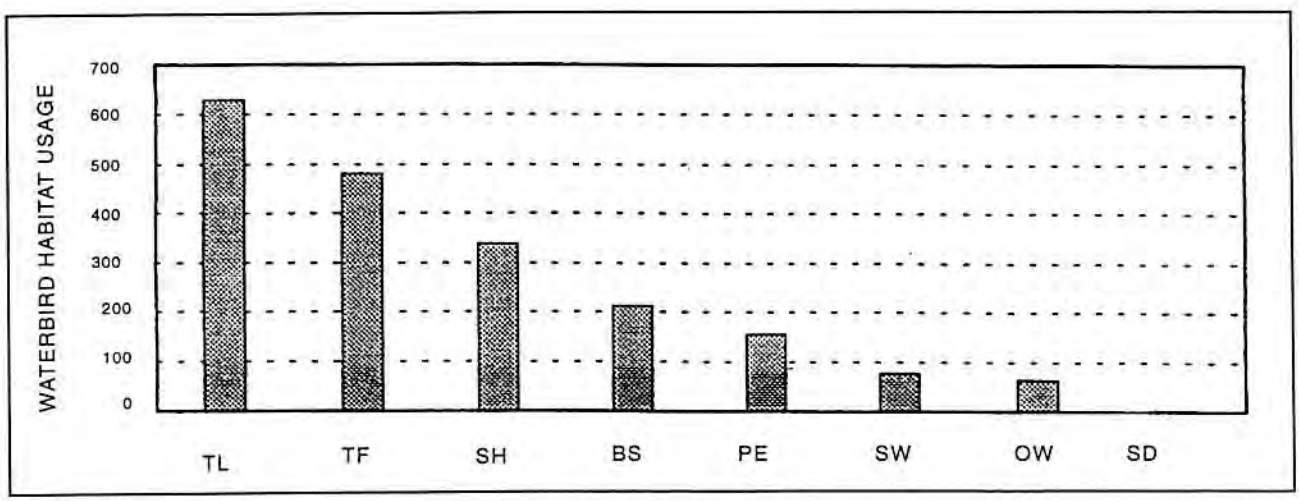



Figure 12

**Waterbird habitat usage at Port Mandurah Stage 2**

**( November 1988 to December 1989 )**

## Key

| | |
|---|---|
| TL | Tidal lagoon between samphire peninsula and tidal flats and to minor extent, seasonal pools. |
| TF | Exposed tidal flats east of the proposed deveolpment. |
| SH | Shallows of the inlet east of the proposed development. |
| BS | Bare shorelines of the inlet, the samphire peninsula and the lagoon. |
| PE | Perches - primary concentrations of limestone rocks on and adjacent to central eastern shoreline. |
| SW | Samphire inundated at the time of sampling on the peninsula, the littoral zone and sub-littoral zone. |
| OW | Open water of the inlet immediately adjacent to site. |
| SD | Samphire not inundated at the time of sampling. |

Source : Ninox, 1995

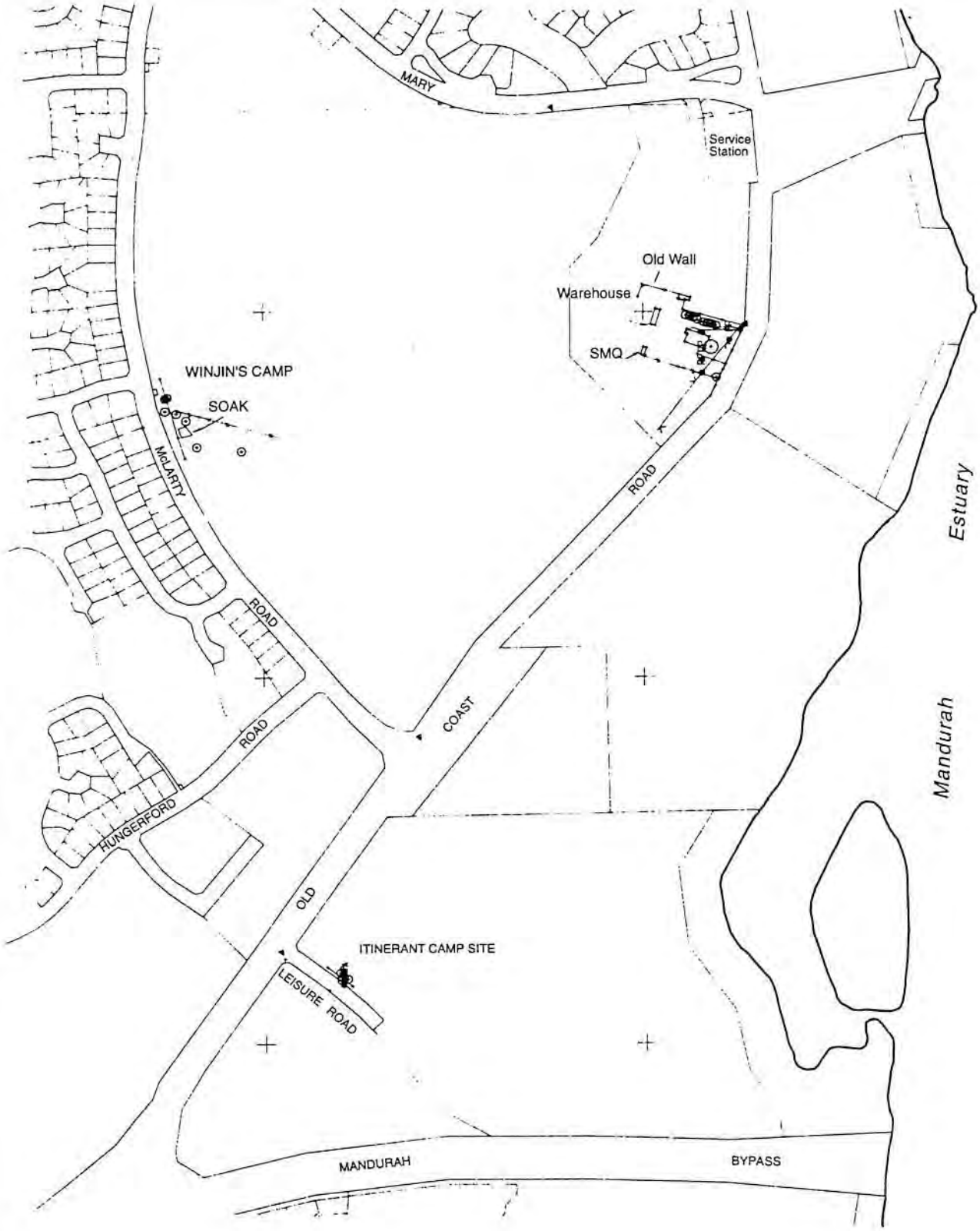
**PORT MANDURAH STAGE 2**

**WATERBIRD SEASONALITY AND HABITAT USAGE**

Figures 11 & 12

BOWMAN BISHAW GORHAM

ENVIRONMENTAL MANAGEMENT CONSULTANTS




**PORT MANDURAH STAGE 2**

**LOCATION OF ABORIGINAL HERITAGE AREAS AND SUTTON FARM PRECINCT**

Figure 13

Source : McMullen Nolan & Partners 1995

BOWMAN BISHAW GORHAM

ENVIRONMENTAL MANAGEMENT CONSULTANTS


| LOT YIELD | SINGLE RES. | R40 (D.U.'s) |
|---|---|---|
| STAGE 2 TOTAL | 500 | 110 |

N

0 150km

Source : BSD, 1995

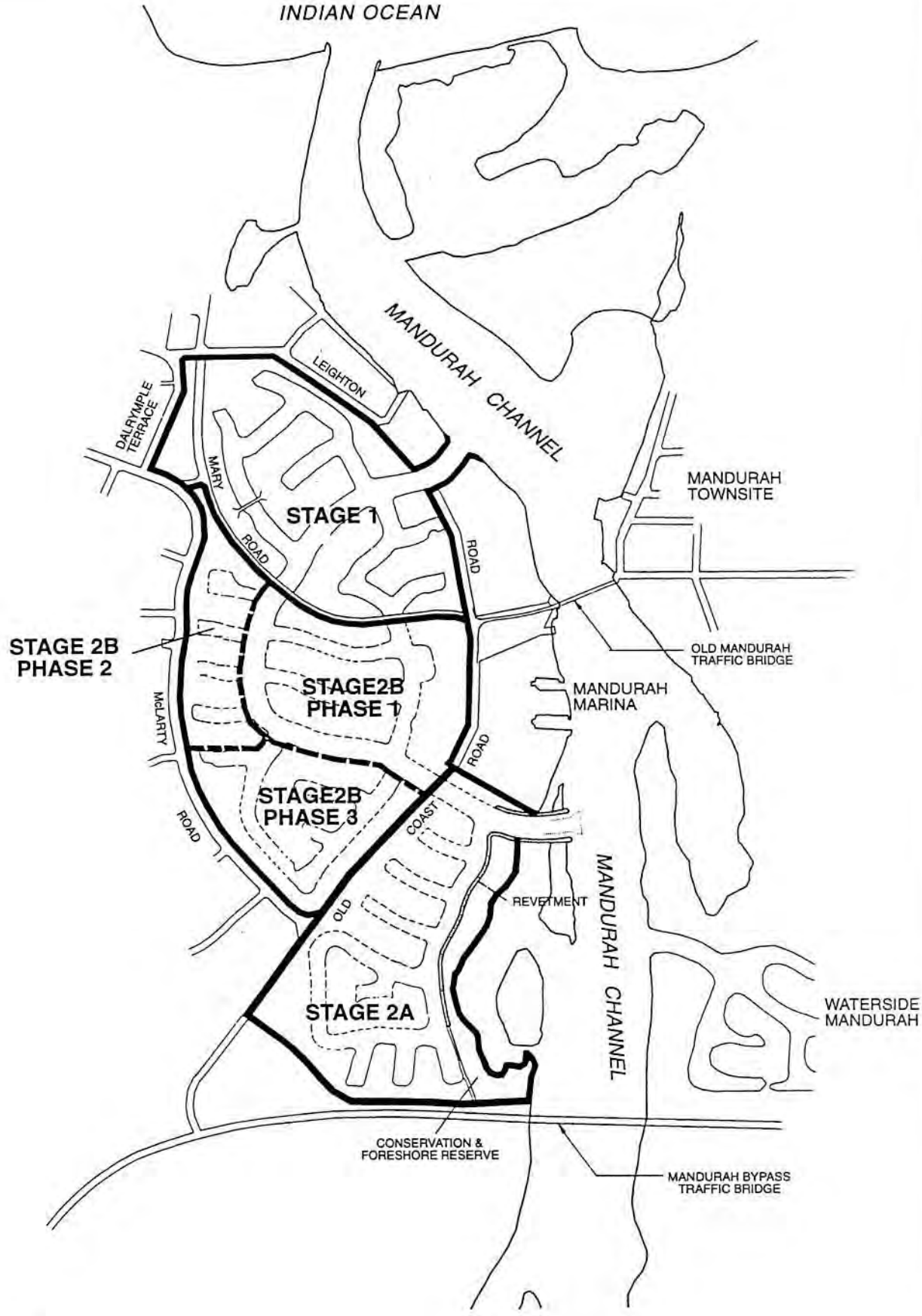
# PORT MANDURAH STAGE 2

## OUTLINE DEVELOPMENT PLAN

Figure 14

BOWMAN BISHAW GORHAM

ENVIRONMENTAL MANAGEMENT CONSULTANTS



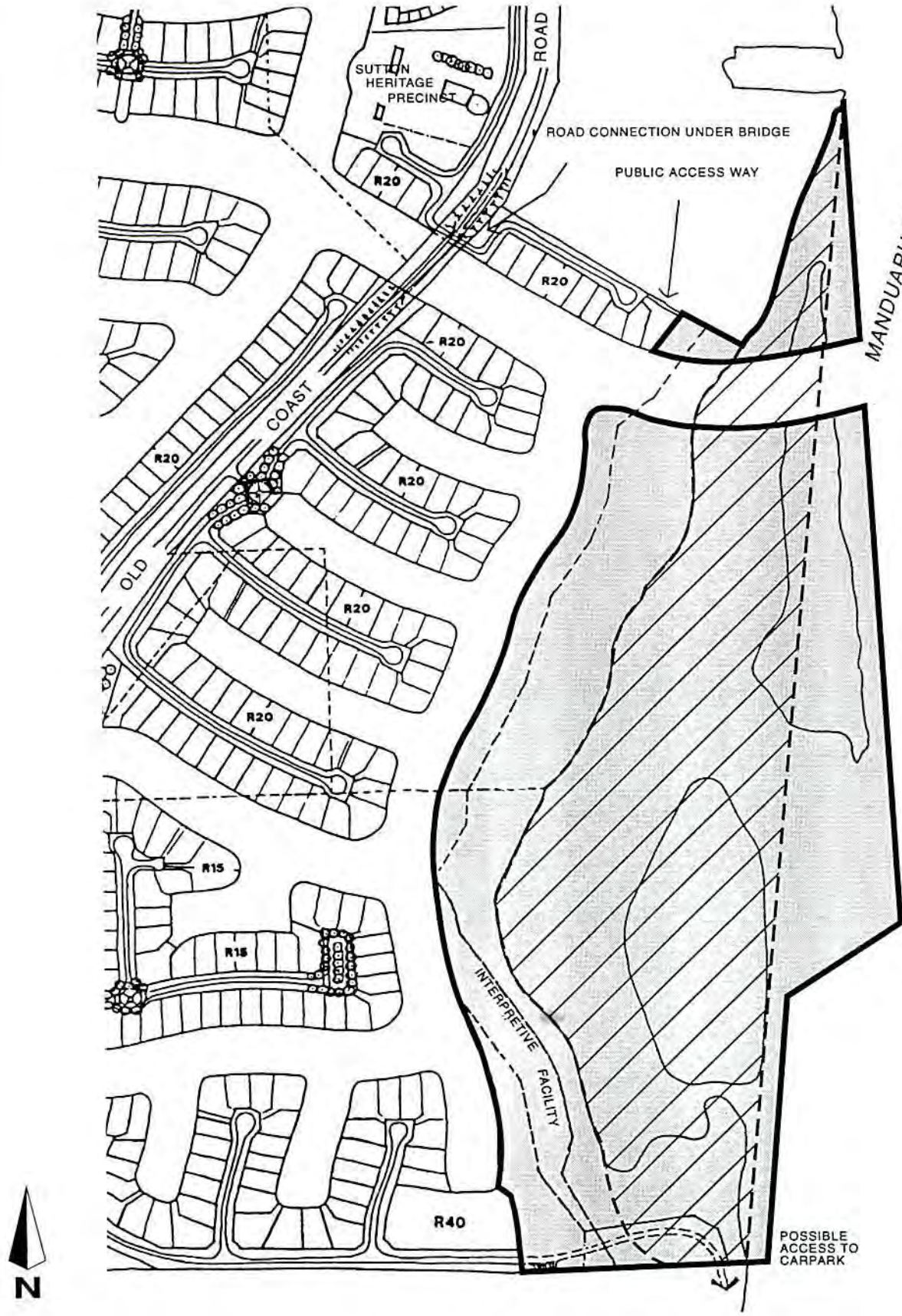

**PORT MANDURAH STAGE 2**

## CANAL LAYOUT AND STAGES

Figure 15

Source : Port & Harbours, 1995

BOWMAN BISHAW GORHAM
ENVIRONMENTAL MANAGEMENT CONSULTANTS




**Key**

Conservation & Foreshore Reserve - 23.9ha

System 6 (C50) - 14.9ha

Source : BSD, 1995

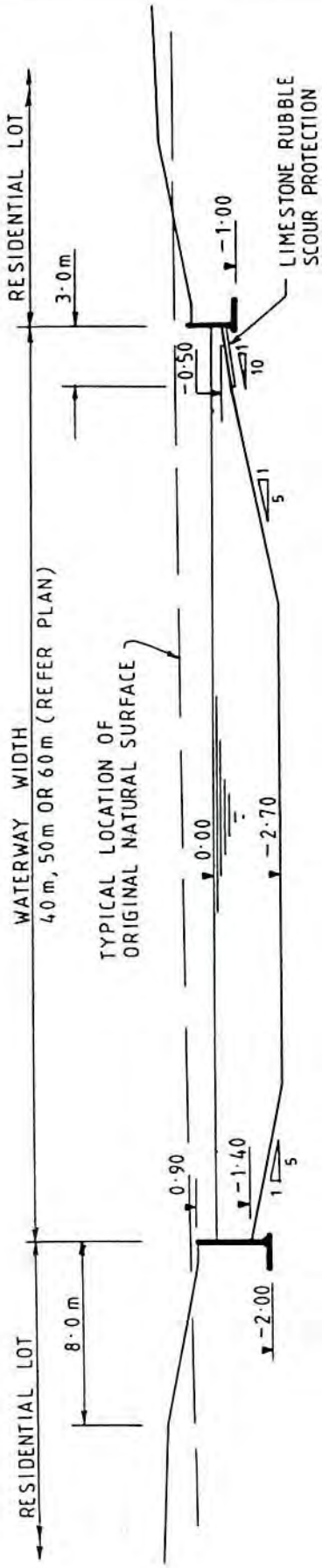
**PORT MANDURAH STAGE 2**

## CONSERVATION AND FORESHORE RESERVE

Figure 16

BOWMAN BISHAW GORHAM

ENVIRONMENTAL MANAGEMENT CONSULTANTS



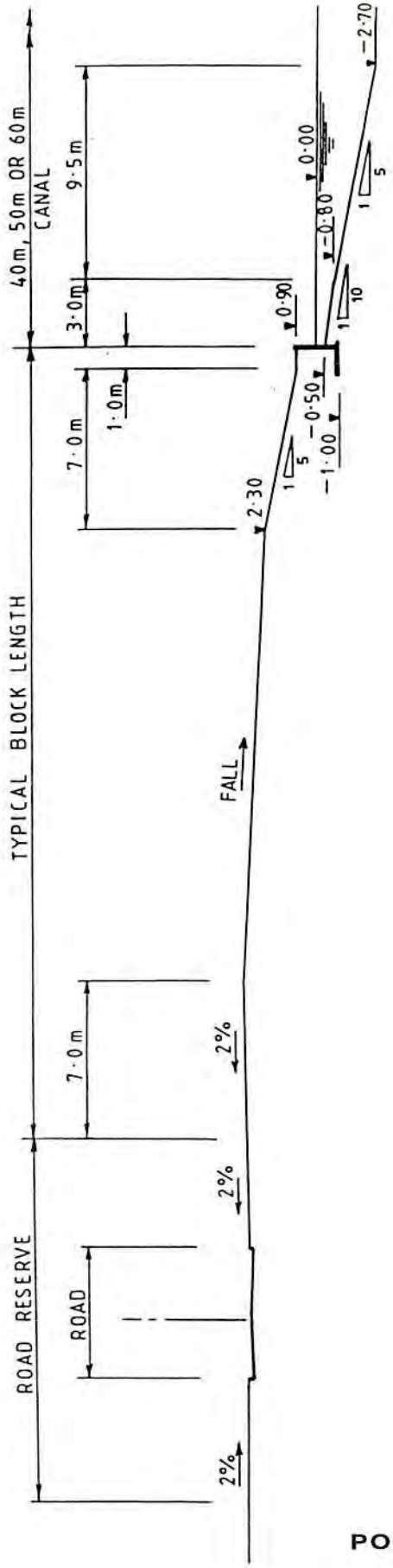

**PORT MANDURAH STAGE 2**

## TYPICAL CANAL SECTION

Figure 17

Source : Airey Ryan and Hill

BOWMAN BISHAW GORHAM
ENVIRONMENTAL MANAGEMENT CONSULTANTS




**PORT MANDURAH STAGE 2**

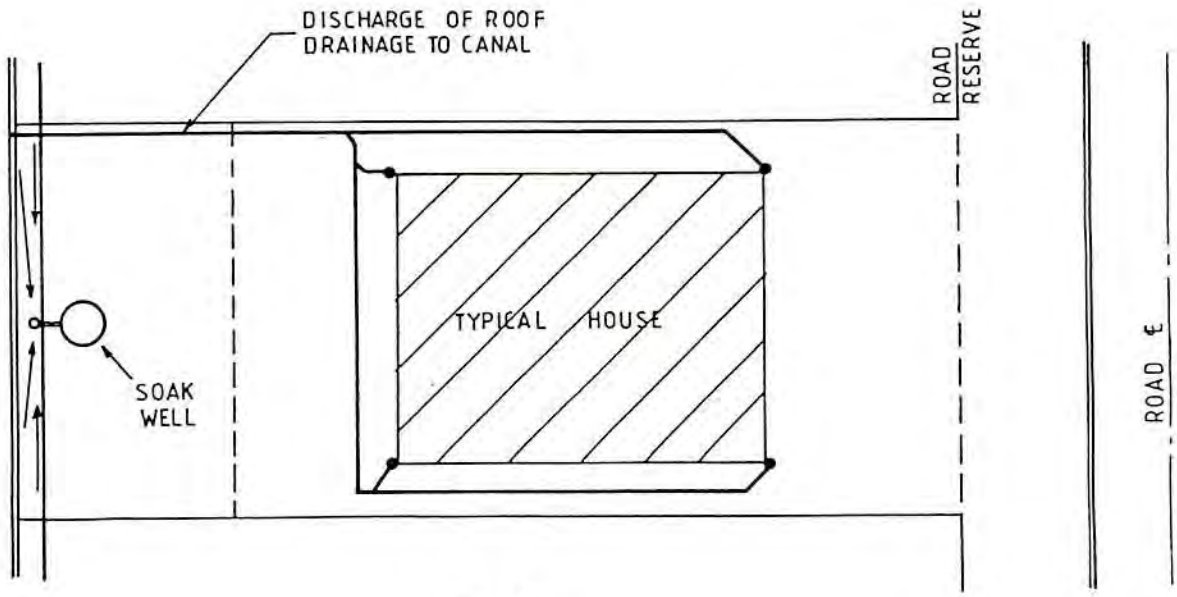
**TYPICAL SECTION THROUGH BLOCK AND ADJACENT CANAL**

Figure 18

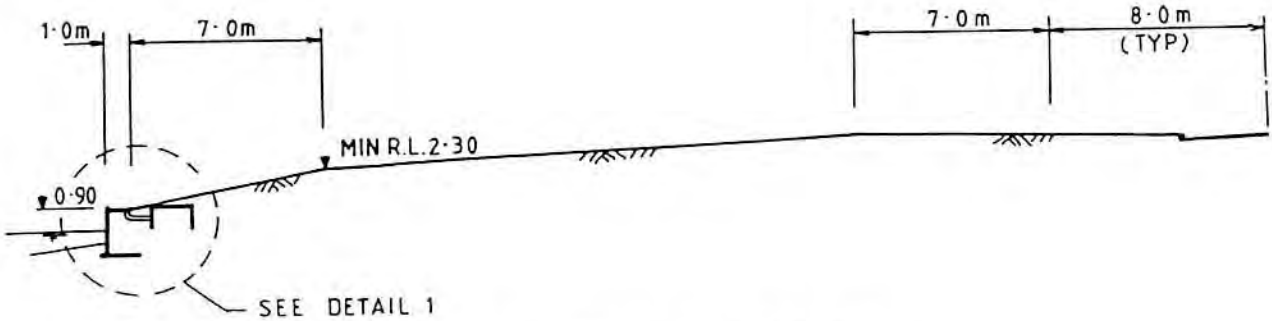
Source : Airey Ryan and Hill

BOWMAN BISHAW GORHAM

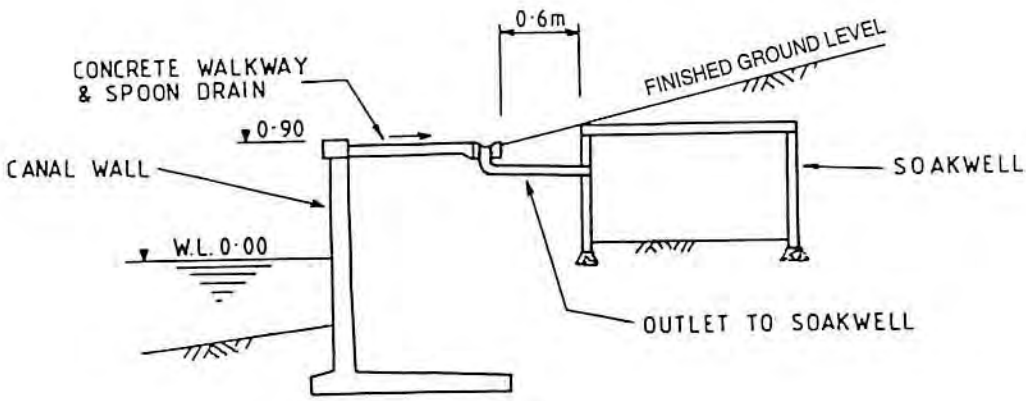
ENVIRONMENTAL MANAGEMENT CONSULTANTS




PLAN




SECTIONAL ELEVATION




DETAIL 1

**PORT MANDURAH STAGE 2**

**PROPOSED FRONT OF BLOCK DRAINAGE**

Figure 19

Source : Airey Ryan and Hill