REVISED
PUBLIC ENVIRONMENTAL REVIEW*

EXTENSION TO YUNDERUP CANAL ESTATE

November, 1990

* This document is a revision of a Public Environmental Review which has been previously released for public review.

Report No. RI0156

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INVITATION

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

The Public Environmental Review (PER) is a revision of an earlier PER that was released for public review in 1986. The revised PER proposes two new canals and approximately 160 serviced residential lots, together with works to improve water quality in the existing canals, at Yunderup Canal Estate. The report has been prepared by Peel Waterways Pty Ltd in accordance with Western Australian Government procedures and will be available for comment until 11 January 1991.

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

Why write a submission?

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

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

Why not join a group?

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

Developing a submission

You may agree or disagree with, or comment on, the general issues discussed in the revised 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 revised 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 the issues raised are clear. A summary of your submission is helpful.
- Refer each point to the appropriate section, chapter or recommendation in the revised PER.
- If you discuss different sections of the revised PER, keep them distinct and seperate, so there is no confusion as to which section you are considering.
- Attach any factual information you wish to provide and give details of the source. Make sure your information is accurate.

Remember to include:

- your name
- address
- date.

THE CLOSING DATE FOR SUBMISSION IS 11 JANUARY 1991.

Submissions should be addressed to:

The Chairman
Environmental Protection Authority
1 Mount Street
PERTH W.A. 6000

Attention: Ms Jackie Boyer

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2. The development proposal will include the following components:

- Two new canals will be constructed, as follows:

  - the eastern canal (area 6.0 ha) will comprise a linear waterway that is aligned north-south in Lots 5, 6, 7 and 8, Kiap Road. This canal will be connected to the existing canals by a navigable waterway in the north and a culvert beneath Kiap Road in the south.

  - the western canal (area 1.4 ha) will comprise an obloid waterway located in Lot 18, Warma Way. This canal will be connected to the existing entrance channel by a navigable channel, and to the existing northern canal by a pipe or culvert..

- Remedial works will be undertaken to alleviate previously poor water quality in the canal estate. These will include:

  - dredging of a shallow sill within the entrance channel to the canal estate. This work has been recently completed by the Department of Marine and Harbours with funding from Peel Waterways.

  - partial filling of deep water areas at the closed ends of the existing northern and eastern canals, which are currently prone to water column stratification leading to deoxygenation.

  - the existing northern canal will be connected, via the proposed western canal, to the entrance channel.

  - the existing culvert through the bund to Wellya Lagoon will be relocated to Peel Inlet, so that it no longer contributes dense saline water to the canals.

- Approximately 160 serviced residential lots, each at least 750m^2 in area will be

provided. There will be approximately 114 lots bordering the eastern canal and a further 24 lots bordering the western canal. The western development site will also contain 22 lots adjacent to the southern shoreline of the Murray River (Minjoogup Branch). All lots will be deep sewered.

- A homestore with a petrol outlet will be provided for at the north-eastern corner of the estate.

- The local road system will require minor modification to accommodate the development.

3. The proposed design of the canal extensions and the proposed works to remedy design anomalies in the existing canals fully accord with recommendations from the Centre for Water Research, University of Western Australia (CWR). These recommendations were based on detailed monitoring and assessment of the hydrodynamic performance and water quality of the canal system by the CWR.

4. The design of the proposed canal estate also accords fully with the recommended specifications for canal developments described in the Canal Guidelines (Waterways Commission, 1982).

5. On the basis of the monitoring and assessment studies undertaken by the CWR, the proposed development will ensure the maintenance of greatly improved water quality throughout the extended canal system.

6. The proposed extension to Yunderup Canal Estate will provide affordable holiday and residential properties oriented towards recreational enjoyment of Peel Inlet. The commercial opportunity to extend the canal estate will enable the proponent to undertake the substantial capital works that are proposed to remedy previous water quality concerns in the existing canal estate, which are inherent in the present canal configuration. In combination, the development of new waterfront housing allotments and the alleviation of previous water quality concerns will provide existing and future residents with a highly desirable residential estate.

7. The project will not cause any major adverse impact upon the environment. The development areas were substantially degraded by earthworks during construction of the existing canal estate in 1971-72, and are generally derelict. In its present condition it has no conservation value.

8. It is concluded that the proposed extension to Yunderup Canal Estate can be accommodated within the existing natural and social environment to considerable benefit and without any significant adverse impacts.

1.0 INTRODUCTION

1.1 The Proposal

Peel Waterways Pty Limited propose to extend the existing Yunderup Canal Estate, located immediately to the south of the mouth of the Murray River and adjacent to Peel Inlet (Figure 1).

The proposed extension will include two additional canals:

- one located to the east of the existing development and aligned north-south; and
- the second located to the north of the entrance to the existing development and aligned northeast-southwest.

The land areas proposed for development and their relationship to the existing canal estate are shown on Figure 2. The proposed development sites are identified as:

- The eastern site, comprising Lots 5, 6, 7 and 8 Kiap Road (17.2 hectares); and
- The western site, comprising Lot 18 Warma Way (5.7 hectares).

The proposed development will include:

- 7.4 ha of new canal waterway;
- 160 residential lots;
- a local store with a petrol outlet;
- public open space to the satisfaction of the Shire of Murray (preferred arrangement still to be finalised); and
- local roads and pedestrian access ways.

Figure 3 depicts the overall plan of the development and the proposed linkages with the existing canal estate.

The land has been nominated by the landowner of Yunderup Canal Estate for the purpose

of future canal extensions since 1979. Preliminary earthworks were undertaken at the time of development of the existing canals, however the land has otherwise remained undeveloped.

Since the purchase of their interest in the Yunderup Canal Estate in 1979, Peel Waterways have had protracted negotiations regarding both the proposed development and the existing canals with the Shire of Murray and State Government authorities. The existing Yunderup Canal Estate was developed in 1971-72, prior to any requirement for detailed environmental assessment. Design deficiencies, notably the existence of dredged basins that are deeper than the entrance channel and the consequential low rate of flushing of bottom water from some areas of the canals, have resulted in a propensity for the canals to experience reduced water quality. Peel Waterways have undertaken a number of studies to define the associated concern, and to assist in developing appropriate environmental management strategies. They recently funded dredging of the canal entrance as a major initiative to improve canal hydrodynamics.

The proposed canal extension will provide for additional remedial works to assure that water quality in the canals, both the existing and the proposed, is appropriately maintained.

1.2 The Proponent

The proponent for the canal extension project is Peel Waterways Pty Ltd, who have freehold ownership of Lots 5, 6, 7 and 8 Kiap Road and Lot 18 Warma Way. Peel Waterways also retains a number of vacant blocks in the existing canal estate, which were purchased from the original developer in 1979. The company's legal interest in the existing development is merely as an owner of individual blocks of land, and includes no rights or obligations beyond those that attach to each of the other landholders in the estate.

1.3 Site Zoning

Lot 18, Warma Way is currently zoned for Tourism, and Lots 5, 6, 7 and 8, Kiap Way are currently zoned as rural under the Shire of Murray's Town Planning Scheme. The area including the proposed canal extension is designated under the Scheme as a Policy A area. Policy A areas are areas identified by Council as flood prone land or land with significant

drainage problems. In view of the inherent constraints of the land to traditional subdivision and development, approval will be sought for the rezoning of this land to Canal Zone. In effect, this proposal simply represents an extension of the existing residential canal estate, which has been demonstrated to be a viable land use for this Policy A area. The site rezoning will be sought in accordance with the Canal Guidelines (Waterways Commission, 1982).

1.4 Project Timing

It is proposed that construction of the eastern and western canal extensions will be initiated within 12 months of approval. Construction of the new canals and development of the residential subdivision will take approximately 12 months, and it is anticipated that the new lots will be introduced onto the market beginning in early 1993.

1.5 Responsible Authorities and Required Approvals

Approval for the proposal will be sought from the Government of Western Australia and the Shire of Murray following advice from relevant authorities. The statutory procedures that must be followed in order to proceed with the development are as follows:

1. Submission of the Public Environmental Review (PER) to the Environmental Protection Authority (EPA) for public review and comment;

2. EPA assessment of the PER, together with public submissions and advice from other relevant authorities;

3. EPA recommendation to the Western Australian Government (Minister for the Environment) that the project is environmentally acceptable, and the Governments acceptance of this recommendation;

4. Application to the Shire of Murray to effect rezoning of the site to Canal Estate;

5. Application to the Department of Planning and Urban Development (DPUD) for approval to proceed. Consideration of the project by DPUD, involving advice from other authorities in specialized areas; and

6. Application to the EPA and other relevant Government authorities for Works Approvals to proceed with construction of the Development.

Authorities consulted during the planning and design stage of the project include:

- Shire of Murray
- Environmental Protection Authority
- Department of Planning and Urban Development
- Peel Inlet Management Authority
- Waterways Commission
- Department of Marine and Harbours
- Water Authority of Western Australia
- Department of Conservation and Land Management

The development of the proposed canal residential extension would be consistent with all relevant Acts and Regulations.

1.6 Scope and Structure of the PER

This PER is a revision of an earlier PER for the proposed extension to Yunderup Canal Estate that was submitted to the EPA for assessment in 1986 (Chappel et al., 1986). The EPA's assessment of the 1986 PER was postponed following public review after the EPA requested the proponent to provide a more detailed analysis of the circulation and flushing dynamics of the canal system. As discussed in Section 2.2, Peel Waterways then commissioned further studies of the proposed canal extension and, as a result of those studies, together with advice from the EPA and comments from the public and relevant authorities on the 1986 submission, substantially revised their proposal. Therefore, the EPA's assessment of the proposed development is a continuation of the assessment process initiated in 1986 rather than a new assessment. However, the proposal has been significantly modified to achieve improved environmental performance.

This PER describes the revised development proposal and the environmental resources that would be affected by it, assesses the potential impacts of the proposal, and defines the environmental management program that will be instituted to minimize potentially adverse environmental effects.

This PER has been prepared to enable the EPA's continued assessment of the proposal upon advice from the public and other government authorities. The document presents the following information:

- a brief description of the proposal, identification of the proponents description of site zoning and approval requirements (Section 1);
- an outline of the history of the project (Section 2);
- an outline of the need for the canal extensions and the benefits of the proposed development (Section 3);
- a description of the development proposal, including development design, earthworks and construction, provision of infrastructure and public utilities and ongoing management (Section 4);
- a description of the existing physical, biological and human environment of the site and adjacent areas (Section 5);
- an evaluation of potential environmental impacts (Section 6);
- a program of environmental management that will be implemented to ensure impacts are minimized (Section 7); and
- conclusions and a summary of the commitments to ensure environmental acceptability of the canal extensions (Sections 8 and 9).

2.0 BACKGROUND

Peel Waterways Pty Ltd first initiated a proposal to extend the Yunderup Canals Estate in late 1980. Since that time the Company has made a number of submissions for development to Government. Protracted negotiations with Government authorities and extensive monitoring and assessment studies have been associated with these submissions. In order to bring the current proposal into context, it is appropriate to briefly outline the history of canal estate developments in Western Australia and the history of the currently proposed project.

2.1 History of Canal Developments in Western Australia

The existing Yunderup Canals Estate was constructed in 1971-72 and was the first canal estate constructed in W.A. Subsequently, there were a number of proposals for similar canal estates elsewhere adjacent to Peel Inlet. However, increasing concern regarding the water quality and algal problem of Peel Inlet, and especially the implication of the canals as a possible causative agent, prompted the State Government to proclaim a moratorium on all forms of canal development. A committee was established to develop a set of guidelines for future canal estates, and a study on the Peel-Harvey estuarine system was initiated.

The Peel-Harvey Estuarine System Study report, released by the Department of Conservation and Environment in 1980, found that excessive algal growth in Peel Inlet and Harvey Estuary was largely attributable to artificial nutrient enrichment, primarily due to excessive use of fertilisers on agricultural land in the catchment areas (Hodgkin *et al.*, 1980). Yunderup Canals were absolved as a cause of degradation of the Inlet waters.

In 1981, the Waterways Commission published their "Recommendations for the Development of Canal Estates", providing guidelines for the design, construction and management of canal waterways. The moratorium on canal developments was lifted in 1981 and a number of canal estates in the area have been subsequently proposed and constructed. There are presently five canal developments adjacent to the Peel Inlet waterway, as follows:

- Yunderup Canals;
- Murray Waters (Windslee) and Murray Lakes, adjacent to the lower estuarine reaches of the Murray River; and

- Waterside Mandurah and Port Mandurah, located adjacent to the Peel Inlet Entrance Channel.

2.2 History of Yunderup Canals Extension Proposal

Yunderup Canals have been the subject of numerous studies and reports during the last eight years. These have been undertaken to improve understanding of issues concerning water quality and the hydrodynamics of the canals, and as submissions to assist with the assessment of proposals for further development of the canal estate. The principal reports are described in the following:

- T.D. Meagher and Associates. 1982. Water Quality Characteristics of Yunderup Canals.

This report was commissioned by Peel Waterways and described the first detailed study of water quality in Yunderup Canals. It showed, inter alia, that wind driven water currents and gravitational currents along density gradients, rather than tidal forces, were the principal mechanisms for water exchange between Yunderup Canals and Peel Inlet.

- T.D. Meagher and Associates. 1982. Development of Lot 18 - Extension to Existing Canals at South Yunderup, Notice of Intent.

This was the first formal submission to the EPA proposing the extension of the canal estate to the western site.

- Brindley R.F. 1984. Physical Water Quality Data in Yunderup Canals.

This report of the Peel Inlet Management Authority (PIMA) analysed and assessed 2.5 years of regular monitoring data for Yunderup Canals. It showed that the water quality in the canals was, in some respects, less than in the adjacent Peel Inlet. In particular, dissolved oxygen levels in the bottom waters of the canals were regularly less than the applicable recommended water quality criterion.

- Klem V.V. and H. Hosja. Undated. An Evaluation of Water Quality in Yunderup Canals.

This draft report of the Waterways Commission described the results of investigations of physical water quality, nutrient status and algal levels in Yunderup Canals during the period 1983 to 1985. The data available suggested that the water quality in the canals was poor, frequently showing anoxic conditions, low light penetration, high biochemical oxygen demand, high nutrient availability, high chlorophyll 'a' concentrations and high phytoplankton cell counts. The report concluded that the manifestation of these water quality conditions would probably be only coloured water with poor light penetration together with occasional odours and a slimey feel. However concern was expressed that the continuation of these conditions would likely increase the organic sludge layer on the sediment, which would increase the nutrient bank and possibly support larger and more frequent algal blooms in the future.

In response to the expanded data base of water quality characteristics, Peel Waterways proposed an alternative development design to accommodate the documented concern for poor water quality in the existing canals. Formal submissions to the EPA describing this proposal were provided in:

- P. Chappel, Australian Groundwater Consultants Pty Ltd and Wood & Grieve Pty Ltd 1985. Yunderup Canals - Stage 2. Notice of Intent.

- P. Chappel et al. 1986. Yunderup Canals - Stage 2. Public Environmental Report.

The proposal involved extending the existing canals eastwards into Lots 5, 6, 7 and 8 Kiap Road, with a second channel connecting the canals to Peel Inlet through Crown Land to the south of the canal estate.

The PER was partially processed by the EPA who sought public review and comment from relevant Government authorities. However, prior to conducting their environmental assessment of the proposal, the EPA requested the proponent to prepare a report on the circulation and flushing dynamics of the canal system to demonstrate that the proposed extensions would successfully improve the exchange of water between the canals and the Inlet.

Peel Waterways commissioned the Environmental Dynamics Section at the Centre for Water Research, University of Western Australia (CWR) to carry out an independent assessment of the proposal. This study was:

- Van Senden D. 1986. The Proposed Extension to Yunderup Canals Estate. Assessment of its Impact on Flushing and Suggested Design Modifications to Enhance Circulation.

The assessment concluded that the second entrance channel to the Inlet would possibly assist the canal flushing, but that the most important determinant of water quality in the canals was the residence time of the dense, saline bottom water. Because parts of the canals were deeper than the entrance channel, there was a low rate of flushing of bottom water. This resulted in reduced water quality and occasional anoxic conditions in the bottom waters. It was recommended that the exchange of bottom water between the canal system and Peel Inlet needed to be improved to reduce this deep water residence time, and to achieve this, the existing entrance channel needed to be dredged to a depth of at least 2 metres. Modification of the canal configuration to reduce the number of dead end canals was also recommended. The existing canal water quality subsequently became the subject of lengthy negotiations between the proponents, EPA, Shire of Murray, PIMA and Department of Marine and Harbours.

Peel Waterways re-examined their proposal and modified it on the basis of advice from relevant authorities. A redrafted PER describing the revised proposal was submitted to the EPA in 1989 but was not released for public review. The EPA decided to proceed with the assessment process subject to the proponents acquiring additional water quality and sediment quality data and confirmatory information that the modified proposal would remedy previous water quality concerns. Peel Waterways subsequently funded dredging of the entrance channel to the canals to remove the constricting entrance sill. Bowman Bishaw Gorham were commissioned to undertake baseline monitoring of water quality and sediment quality in the pre-dredged canals, as described in Appendix A. The proponent also engaged the CWR to ascertain that the dredging resulted in improved flushing of the canal system, and to define any additional recommendations relating to project design to ensure adequate water quality. The CWR report is entitled:

- Brown S., L. Chedzey and D.P. Lewis 1990. Yunderup Canals Flushing Study.

The report is provided as Appendix B to this PER. It documents a very substantial improvement in water exchange as a result of the entrance channel dredging. A number of recommendations are made regarding design of the proposed canal extension and further remedial works in the existing canals, to ensure the maintenance of adequate water quality. The proposal described in this PER incorporates all of the CWR's recommendations.

2.3 Submissions Upon the 1986 PER

The public submissions that resulted from the release of the 1986 PER (Chappel et al., 1986) have been mostly accommodated by the revised proposal. These submissions and Peel Waterways' response are summarized in the following.

Comment: *Concern was expressed by Government regarding the availability of the land for a second entry to the canals that was proposed to pass through WAWA controlled land to the south of the existing canals.*
Concern was expressed regarding the construction of a navigable channel and bridge associated with the second entry.

Response: The second entry referred to is no longer proposed.

Comment: *There was a lack of adequate soil sampling and insufficient information regarding disposal of spoil and source of proposed fill.*

Response: Soil investigations described in Appendix D, together with previous information derived from the excavation of the existing canals, are adequate for engineering design requirements. The present proposal has been designed to achieve a balance of cut and fill and, except for the importation of relatively small quantities of topsoil for garden areas, there will be no requirement to import or export fill material.

Comment: *Lack of flushing details.*
Lack of adequate water quality details/circulation information.

Response: This has been addressed through theoretical and field research conducted by the CWR and described in Appendix B to this CER.

Comment: *Lack of construction program and engineering details.*

Response: Detailed engineering design and scheduling will be prepared following rezoning of the development area, to the satisfaction of the Shire of Murray and the Department of Marine and Harbours.

Comment: *Lack of understanding of nutrient/algal relationships.*

Response: This is addressed in Section 5.2 of this PER.

Comment: *Lack of detail regarding ongoing management and monitoring.*

Response: This is addressed in Section 7.3.2 of this PER.

Comment: *Acknowledgement of road closures.*

Response: The proposed modifications to the local roads to accommodate the development are described in Section 4.1 of this PER.

Comment: *Shortfall of Public Open Space.*

Response: The proposed provision of Public Open Space is addressed in Section 4.3 of this PER.

3.0 NEED FOR THE PROPOSAL

The proposed extension of Yunderup Canal Estate will service a growing demand for affordable waterfront homes in the Yunderup area. There has recently been a considerable increase in new home construction within the existing Yunderup Canal Estate. The proposed residential lots, similar to those in the existing estate, will be offered for holiday homes, retirement homes and as permanent family residences.

Since the initial development of Yunderup Canals, four other canal estates have been developed adjacent to the Murray River/Peel Inlet waterway. These have mostly catered for more expensive residences than Yunderup Canals, but have confirmed a continuing and growing demand for water-oriented holiday and permanent dwellings. In particular, the completion of Murray Waters and Murray Lakes Canal Estates have brought increased interest for lots at Yunderup Canals. The supply of affordable land offering a water-oriented lifestyle adjacent to Peel Inlet is considered to be substantially less than the potential demand, and the proponent is confident of the proposal's commercial viability.

The proposed extension to the existing canals will involve approximately 30% additional lots within Yunderup Canal Estate. The commercial opportunity to develop these lots has provided the financial justification for the proponent agreeing to fund the recent entrance channel dredging, and also the additional remedial works for the existing canals that are included within this proposal. These capital works have, and will, ensure substantially improved water quality within the canals, so will increase the attractiveness of Yunderup Canal Estate as a place to live.

The perceived benefits of the proposed extension to Yunderup Canal Estate are as follows:

- The development will assist to meet the demand for additional canal lots at an affordable price for people desiring a water oriented lifestyle.

- The long standing environmental management concerns associated with Yunderup Canals will be resolved. The proposed canal extension includes substantial undertakings for remedial works to improve the hydrodynamic operation of the canal estate. Ongoing responsibilities for environmental management are also defined.

- The project will develop disused areas of land that are currently degraded.

- The development of Lots 5, 6, 7 and 8 Kiap Way will remove an extensive breeding ground for mosquitoes and thereby reduce public nuisance and health concerns associated with mosquito plagues at South Yunderup.

- The project will provide an important stimulus for the construction industry in the region, with considerable employment opportunities during the construction stage. Indirect employment opportunities will be created in the longer term through the demand for goods and services by future residents in the estate.

The Shire of Murray and the South Yunderup Canals Rate Payers and Residents Association have both indicated their support for the development.

4.0 PROJECT DESCRIPTION

4.1 Introduction

The proposal development is directed towards providing an attractive, affordable residential area with waterfront lots. The development proposal is shown in Figure 3, and will include the following components:

- Two new canals will be constructed, as follows:

  - the eastern canal (area 6.0 ha) will comprise a linear waterway that is aligned north-south in Lots 5, 6, 7 and 8, Kiap Road. This canal will be connected to the existing canals by a navigable waterway in the north and a box culvert beneath Kiap Road in the south.

  - the western canal (area 1.4 ha) will comprise an obloid waterway located in Lot 18, Warma Way. This canal will be connected to the existing entrance channel by a navigable channel, and to the existing northern canal (canal F, Figure 2) by a pipe or culvert..

- Approximately 160 serviced residential lots, each at least 750m^2 in area will be provided. There will be approximately 114 lots bordering the eastern canal and a further 24 lots bordering the western canal. The western development site will also contain 22 lots adjacent to the southern shoreline of the Murray River (Minjoogup Branch).

- A homestore with a petrol outlet will be provided for at the north-eastern corner of the estate.

- The local road system will be modified to accommodate the development. Changes to the existing roads will include:

  - construction of a new access road along the eastern estate boundary, with closure of the northern section of Kiap Road that coincides with the proposed entrance to the eastern canal.

- the diversion of Warma Way around the northern side of the western canal, with closure of the section that coincides with the proposed canal entrance.

- closure of the western section of the existing road reserve that crosses the proposed eastern canal.

- Remedial works will be undertaken to ameliorate previous concerns regarding poor water quality in the canal estate. These will include:

  - dredging of a shallow sill within the entrance channel to the canal estate. This work has been recently completed by the Department of Marine and Harbours with funding from Peel Waterways.

  - partial filling of deep water areas at the extremeties of canals E and F, which are currently prone to water column stratification leading to deoxygenation.

  - canal F will be connected, via the proposed western canal, to the entrance channel.

  - the culvert through the bund to Wellya Lagoon will be relocated to Peel Inlet, so that it no longer contributes dense saline water to the canals.

4.2 Canal Design

Figure 3 shows the proposed layout of the canal estate, and a typical canal cross section is shown in Figure 4. The design configuration of the proposed canals is in accordance with the Canal Guidelines (Waterways Commission, 1982) and has been determined on advice from the Centre for Water Research, University of Western Australia.

Comparison of the proposed design specifications with specifications described in the Canal Guidelines are as follows:

- The Canal Guidelines recommend a navigable width of not less than 15m and a width across water between property boundaries of not less than 30m. The proposed canals will exceed this requirement, and are generally 60-80m in width, with a minimum navigable channel of 20m.

- The Canal Guidelines recommend a canal channel depth that is in excess of 1m at all times of the year but is less than the depth of the entrance channel. The recent dredging of the entrance channel to the canals was to -2.2mAHD. The proposed extension canals will be excavated to -1.5mAHD. The existing canals are generally at -2.0mAHD, except for deeper basins at the extremeties of canals E and F, which are presently to -2.5mAHD. These basins will be filled to -2.0mAHD during excavation of the proposed extension canals, using the excavated material.

The canals will be excavated using land based excavation equipment, such as hydraulic excavators or a dragline. The excavation will occur in a land-locked basin, with the equipment operating from the edge of the canal and working progressively along the face. This wet excavation technique avoids any requirement for dewatering.

A licence will be required from PIMA prior to excavation of the canals, and a detailed description of the proposed technique will accompany the licence application. The use of bunds and settling ponds will be incorporated into the construction design to prevent turbid water from flowing into the existing canals.

Culvert connections between the proposed extension canals and existing canals E (southern end) and F (western end) will be installed to provide a continuous waterway. The base of the culverts will be at -1.5mAHD, to facilitate exchange of bottom water. The culvert specifications will be defined during detailed engineering studies for the project, and will be submitted to PIMA with the required licence application.

As shown in Figure 4, the new canals will have soft edges, a low level retaining wall set back from the water's edge to prevent material from the adjoining blocks from washing into the canals. The foreshore design specifications will be determined in consultation with PIMA and the Department of Marine and Harbours, and to the satisfaction of the Shire of Murray.

4.3 Subdivision Design

The proposed subdivision will include approximately 160 residential allotments of at least 750m^2. The proposed arrangement of the allotments is shown in Figure 3. Approximately 138 lots will have canal frontage, whilst the remaining 22 lots will overlook the Murray River (Minjoogup Branch).

The Homestore and petrol outlet will be located in the north-eastern corner of the subdivision, at the junction of Yunderup road and the proposed new eastern road to the estate (Figure 3). Shire access to the canals will be provided at this site to allow removal of occasional quantities of weed that are blown into the canals from Peel Inlet.

Properties on the canals will have a private water frontage. There will be a minimum building setback of 6m from the canal frontage, and building floor levels will be a minimum of 2.0mAHD.

Negotiations between the proponent and the Shire of Murray are continuing regarding the provision of public open space (POS) within the subdivision. It is proposed that either land adjacent to the eastern boundary of the development (i.e. within Lots 3 or 4, refer Figure 2) will be purchased by the proponent and vested with the Shire, or a cash payment in lieu of POS will be made to the Shire.

4.4. Flood Considerations

The proposed development sites are not within the designated floodways required to allow the dissipation of floodwaters from the Murray River (Public Works Department, 1984; Figure 5).

The Public Works Department (1984) Murray River Flood Study determined the 1:100 year flood level for Peel Inlet at Yunderup at +1.6mAHD. Upstream in the Murray River near to the eastern boundary of the site, the 1:100 year flood level is as high as 2.06mAHD (Figure 5).

With the possible exception of the north-eastern corner of the proposed eastern site, the relevant flood level for defining appropriate building levels is Peel Inlet (1.6mAHD). Building levels may require an appropriate safety factor to allow for wave run-up during peak water levels, however this would be small due to the protection afforded to the canals by their setback from the foreshore.

There is now sufficient evidence to accept that the continued increase of "Greenhouse" gases in the atmosphere will cause significant climatic changes during the next fifty years. A consequence of this may be that sea levels will rise. Although predictions of the scale and rate of changes are still only approximate, the scenario currently considered to be most likely is that sea levels will increase by up to 1.0 cm per annum during the next fifty years. Extreme storm events would also increase in frequency. Based on this scenario, the design peak water level may increase by 0.3m by the year 2040.

Measured sea level changes have not supported the predicted trend towards increasing sea levels. During the last 100 years the mean sea level along the Australian coast appears to have risen at a fairly constant rate of 1.3mm per annum, and there has been no significant increase in this rate during the last 20 years (Wallace, 1988). The "Greenhouse Theory" suggests that the trend towards increasing mean sea level should have been detected, and it is possible that the ocean's capacity as a heat sink is greater than anticipated. Nevertheless, the proponent recognizes the necessity for planning for the predicted sea level rise.

Construction of the proposed Dawesville Channel will increase the rate of flood dissipation from Peel Inlet, so will reduce the risk that coastal developments within the inlet would be inundated during periods of peak river flow. Construction of the proposed dam on the North Dandalup River would reduce any risk of flooding from the Murray River.

The minimum building level for the canal allotments is proposed at 2.0mAHD. This is considered to allow a suitable safety margin over 1:100 year flood level projections to assure an acceptably low risk of flooding. Ongoing engineering design for the subdivision will confirm the appropriate building levels and other aspects of flood mitigation. It is possible that the road elevation in the north eastern corner of the estate may need to be increased to preclude potential flood risk from the Murray River.

4.5 Landscaping

The project has been designed to have a balance of cut and fill. The majority of the required fill will be placed directly within the subdivision during excavation of the adjacent canal. Trucking of minor quantities of material will be required to fill Lots 5,6,7 and 8 using material excavated from Lot 18. Transfer of material within the two subdivision sites will be accomplished using conventional earthmoving machinery.

Soil testing has confirmed the suitability of the excavated material for residential fill. However its high salt content will affect its suitability as garden soils, and suitable top soils will be brought into the site and applied to the ground surface outside of the defined building envelopes. Surface soils from the excavated areas will be stockpiled during the initial excavation, to also be used to landscape future residential garden areas.

A detailed landscaping plan will be prepared and submitted with application for final subdivisional approval. The proponent recognizes that difficulties in establishing vegetation

upon the freshly excavated soil significantly affected the aesthetic appeal of the existing Yunderup Canal Estate during the initial years following its development. Landscaping for the proposed development will include appropriate placement of topsoil and the widespread establishment of salt tolerant tree species (e.g. *Eucalyptus camaldulensis, Melaleuca cuticularis*). Tree plantings will be primarily in areas adjacent to roadways and the canals so as not to interfere with subsequent house construction.

The minimisation of nutrient application within future residential gardens and the preferential use of slow release fertilisers and native plant species will be encouraged as follows:

- An information brochure describing the use of slow release fertiliser and suitable native plants for residential gardens will be issued to all purchasers of lots.

- With the purchase of each residential lot the proponent will supply, free of charge, sufficient slow release fertiliser to establish a native garden. This will be achieved by the issue of a voucher which will be negotiable at nominated local hardwater suppliers for specific slow release fertilisers only.

4.6 Services

The land proposed for the canal extensions adjoins the existing canal area that has an established service infrastructure capable of being expanded. Therefore, mains water supply, electrical power and telephone services will be easily provided to the development.

4.6.1 Stormwater Drainage

Stormwater runoff will be collected from the roads via gullies and a piped drainage system that will discharge into the canals at various locations. Traps will be installed in all gullies to prevent sand and debris from entering the drainage system. These traps also tend to contain any oil residues which may wash off the roads. In addition to the gully traps, the manhole immediately upstream of each discharge point will be trapped. This will reduce the flow speed, and any debris which has been carried through with the stormwater will settle.

4.6.2 Sewer Reticulation

The development will be deep sewered. In the eastern extension, the existing sewer reticulation

will be directed away from the existing temporary pump station in Kiap Road, and across the proposed eastern canal to a new permanent pump station in the new entrance road. A rising main will connect to the existing sewer in Yunderup Road.

In the western canal extension the existing sewer will be diverted around the proposed canal where Warma Way is closed. The existing pump station at Moyup Road was originally designed to accommodate sewer reticulation for the proposed canal extension.

The Water Authority has been consulted regarding the design and routing of the proposed sewerage system. Planning and construction of the sewerage system will be to the satisfaction of the Water Authority, which will be responsible for operating and maintaining the system in the future.

4.7 Public Access

Public access along the Murray River (Minjoogup Branch) foreshore, adjacent to the northern boundary of the western development site, will be preserved. The proponent will construct a concrete walkway in the foreshore reserve to accommodate pedestrian use and to delineate the boundary between private residential landholdings and the foreshore reserve.

Public access to the foreshore of Peel Inlet will also be preserved. The proposed entrance channel to the western canal will interrupt existing pedestrian and vehicle access to the boat ramp and adjacent foreshore, however alternate access to this area will be provided around the northern side of the canal (Figure 3).

As with the existing Yunderup Canal Estate, the foreshore to the canals will be privately owned, however the canal waterways will be public areas.

4.8 Land Tenure

Land tenure arrangements are proposed as follows:

- The residential allotments and the homestore allotment will be sold as freehold.
- Road reserves, pedestrian walkways and POS will be vested with the Shire of Murray.

- The canal waterways will be ceded to the Crown and vested with the Shire of Murray.

4.9 Ongoing Management

Following development of the canal estate, ongoing maintenance would be the responsibility of the Shire of Murray, who would act as the "Waterways Manager" as defined in the Canal Guidelines (Waterways Commission, 1982). Correspondence from the Shire accepting this responsibility as Waterway Manager is included as Appendix C.

An environmental monitoring program determined in consultation with PIMA and to the satisfaction of the EPA will be implemented following completion of canal construction (Section 7.3.2). Responsibility for conducting the monitoring will initially lie with Peel Waterways then will pass to the Shire of Murray. Arrangements regarding the transfer of this responsibility to the Shire of Murray remain subject to further discussions between the proponent and the Shire.

Responsibility for the maintenance of roadways, pedestrian paths, POS and the foreshore reserves would also rest with the Shire of Murray.

The proposed residential lots in the canal estate, together with the homestore, will be privately owned, and responsibilities for the maintenance of the foreshores and retaining walls will lie with the individual landholders.

5.0 THE EXISTING ENVIRONMENT

Yunderup Canal Estate is located in the southern bank region of the Murray River delta to Peel Inlet. Kinhill (1986) and Waterways Commission (1990) include detailed descriptions of the existing environment of Peel Inlet and it's catchment from a regional perspective. This section describes the existing physical, biological and social environment within and immediately adjacent to the proposed development.

5.1 The Terrestrial Environment

5.1.1 Landform

The deltaic landforms within and surrounding the site have been formed by the deposition of sediments carried down to Peel Inlet by the Murray River. The resulting topography is relatively flat and comprises shallow river channels, floodways and low banks. Various earthworks to manage flooding of land areas adjacent to the Murray River have modified the natural landform in the locality.

The landform of the two sites addressed in this proposal has been altered significantly from their original state. During construction of the existing canals in 1971-72, soil was removed from Lots 5, 6, 7 and 8 to elevate the residential allotments in the existing canal estate. These excavations were permitted on the basis that the site would subsequently be developed as an extension to the canals. Parts of this site are now permanently inundated with water to depths of up to 1 m.

Also at the time of the original construction, spoil dredged from the entrance channel was placed on Lot 18, which now has a profile up to 1m higher than in its natural state.

5.1.2 Geomorphology and Soils

The Murray River delta is a classic example of a delta influenced by relatively strong wind and tidal forces, with several distributory channels between central and distal islands. Accordingly, the sediments comprise variable lensitic formations of marine sediments, including poorly sorted sands, shell and organic detritus, together with fluvial clays, silts and sands.

Soil profiles from the proposed eastern canal site are described in Appendix D. The sediment cores indicated that poorly sorted sands predominate, with occasional thin layers (0.1m thick and separated by at least 1m) of medium to fine sand containing small amounts of organic material. Only small amounts of clay were encountered.

5.1.3 Groundwater

Hydrological studies of the site by Australian Groundwater Consultants (1985) are described in Appendix D. They showed that the site has shallow surficial groundwater with direct hydraulic connection to the existing canals and Peel Inlet. The slope of the watertable indicated gradual flow through the site to the west-southwest. The assessment concluded that groundwater would contribute less than 3% of the canal volume over an entire year.

5.1.4. Vegetation

The natural vegetation of Yunderup is identified according to Beard (1981) as Vasse complex. The well drained upland sites support an open forest of *Eucalyptus marginata*, *E. calophylla* and *E. gomphocephala*, with *Kingia australis*, *Xanthorrhea preissii*, *Banksia grandis* and *Nutsia floribunda*. An *E.redunca - E. rudis* woodland occurs on upland areas with poorer drainage.

Seasonally flooded areas support a variety of paperbark species (*Melaleuca raphiophylla*, *M. hamulosa*, *M. cuticularis*, *M. incana*), together with associated sedges, particularly *Gahnia trifida* and *Lepidosperma effusum*.

The Murray River foreshore is vegetated by a mixture of *E. rudis*, *M. raphiophylla* and *Casuarina obesa*, and there is a narrow fringe of *Juncus kraussi* along the river bank.

The fringing plant community on the eastern shore of Peel Inlet consists of marsh vegetation with *Sarcocornia blackiana*, *Sualda australis*, *Atriplex paludosa*, *Arthrochnemum halocnemoides*, *Holcus lanatus*, *Juncus kraussii* and *Scirpus maritimus*.

Vegetation within Yunderup Canal Estate was cleared during construction in 1971-72 and little of the present vegetation in the area is indigenous to the site. The two

proposed canal development sites were also fully disturbed by earthworks in 1971-72, and now contain few remnants of the original vegetation. Regrowth in Lot 18 is dominated by introduced grasses. Lots 5, 6, 7 and 8 have been partially colonised by sedges and marsh vegetation, and there are isolated remnant Melaleuca thickets.

Plates 1 and 2 indicate the present degraded condition of the two proposed development sites, neither of which contains significant vegetation requiring conservation.

The vegetation within the river foreshore reserve adjacent to Lot 18 is mostly in good condition, although it has been invaded by introduced grasses.

5.1.5 Reserves

There are several reserves within the Murray River delta that are near to Yunderup Canal Estate, as follows:

Reserve Number	Purpose	Area (Ha)	Authority
20215	National Park	78.5	Murray Shire
4990	Conservation of Flora and Fauna	139.2	W.A. Wildlife Authority
5621	Recreation/Parklands	1.3	Not vested
5622	Public Utility	0.2	Not vested
5625	Recreation	1.2	Not vested
32034	Recreation (Canal Waterway)	10.0	Murray Shire
39985	Public Recreation	0.1	Not vested.

The locations of these reserves are shown in Figure 6.

The National Park (Reserve 20215) includes most of the islands in the river delta, which are recognised as providing important and diverse habitats for birds, especially waterbirds that use Peel Inlet for feeding.

Reserve 39985 is the foreshore reserve between the northern boundary to Lot 18 and the Murray River (Minjoogup Branch).

5.1.6 The Social Environment

Until fairly recently, the vast majority of dwellings at South Yunderup were holiday homes. However the permanent resident population in the area has now increased significantly, comprising both retired people and younger families employed in the Mandurah-Pinjarra region.

Lots in the existing Yunderup Canal Estate have similarly been purchased for holiday homes, retirement homes and permanent family residences. The development has attracted people looking for relatively low cost waterfront homes in the area.

Recreational opportunities in the Yunderup area focus mainly upon the adjacent Peel Inlet and Murray River waterways, which offer substantial recreational and leisure resources. Kinhill (1988) provides a general review of recreational use of Peel Inlet.

Nuisance from mosquito and midge plagues is popularly considered by the residents to be the major detraction to living at Yunderup. Odour associated with decomposing algae in Peel Inlet also causes concern, although it does not appear to rate as highly as mosquitoes. The Canal Estate residents generally perceive the canals as offering high amenity, notwithstanding the concerns that attach to the eutrophication problems in adjacent Peel Inlet.

5.2 The Marine Environment

5.2.1. Peel Inlet

The Peel Inlet-Harvey Estuary system is a broad, shallow coastal lagoon of approximately 133km^2. The expansive and bountiful waterway is popularly recognised as an invaluable ecological and recreational asset, and is accordingly listed on the Register of the National Estate.

Peel Inlet is a shallow basin about 10km in diameter with a central basin about 2m deep. The margins are shallow and dry out at extreme low tides.

The eastern area of Peel Inlet includes expansive shallows with very high biological productivity. These shallows, together with the tidal flats and shallows around the

entrance to the Mandurah Channel, are recognized as the most important waterbird habitat within the Inlet. The area is also believed to provide an important nursery area for fish species.

The Peel Inlet Harvey Estuary system is currently experiencing severe water quality problems associated with nutrient enrichment, derived mainly from agricultural sources in the catchment. The estuary is predisposed to eutrophication due to its shallow depth, its strong seasonal riverine inflows and its very limited oceanic exchange. High phosphorus enrichment has promoted excessive growth of algae in the water, and the accumulation and decomposition of the algae, particularly on the shores of the estuary, cause considerable public nuisance. It is also symptomatic of severe environmental deterioration.

Kinhill (1988) and EPA (1988) provide detailed descriptions of the estuary's eutrophication and the management responses proposed by Government.

5.2.2 Yunderup Canals

As discussed in Section 2, Yunderup canals have been the focus of numerous monitoring and assessment studies since they were constructed some twenty years ago. The emphasis of most of these studies has related to concerns regarding poor water quality in the canals. These concerns, which are directly related to the concerns associated with eutrophication of Peel Inlet and Harvey Estuary, are that the poor quality of the canals' source water should deteriorate further during its residence in the canals, to cause significant biological impact and/or public nuisance.

The source water for Yunderup Canals is (almost exclusively) from Peel Inlet. To this extent, Yunderup Canals are eutrophic, and phytoplankton concentrations in the canals are of similar magnitude to those in Peel Inlet. However the high nutrient concentrations in the canals has not been manifested by the nuisance conditions that occur in Peel Inlet, and has not reduced the amenity value to the residents beyond those experienced generally around the foreshores of Peel Inlet.

Senescent weed blown in from Peel Inlet does cause occasional local nuisance within Yunderup canals, especially in the north-eastern corner of the canal estate where much of the weed accumulates under prevailing wind conditions. As long as the problem continues in Peel Inlet, some management of detritus will be necessary to minimise this nuisance in the canals.

There have been ocassional fish kills within Yunderup canals, apparently due to the occasional prolonged occurrence of deoxygenated conditions in the bottom water. However the canals usually support abundant fish and crab populations, and water birds frequently use the area in large numbers. The general perception of the residents of Yunderup Canal Estate is that, notwithstanding the problems of Peel Inlet, the canal development continues after twenty years of existence to provide a biologically healthy system offering high amenity value to its residents.

The evidence is fairly clear that Yunderup canals have suffered little of the overt consequences of eutrophication that have been manifested in the adjacent Peel Inlet. Nevertheless, scientific monitoring and assessment studies have also clearly documented water quality concerns in the canals. In the face of twenty years of evidence of relative biological health, scientific concern for reduced water quality may seem largely irrelevant, except that it is believed to be symptomatic of the canal system's reduced ecological resilience. Ongoing ecological health problems in Peel Inlet involve a risk that similar problems may become manifest in the canals.

The relative lack of existing ecological or public nuisance in Yunderup canals would indicate that the canals enjoy greater resilience to the impacts of eutrophication than the adjacent Peel Inlet. The reasons for this are not clear but are probably related to the depth of light penetration relative to the water column depth, which is less in the canals than in Peel Inlet.

Importantly, the occasional deterioration of water quality within the canals, which is associated with prolonged water residence time, is inherent in the waterway's design characteristics and is amenable to remediation. Opportunities have been identified for remedial works to ensure that the canal water quality remains no worse that its source water. If this is achieved, the clear evidence of the canal system's relative resilience to the consequences of eutrophication supports confidence that concerns related to canal water quality can be overcome. The following discussion of water quality in the canals therefore focuses on this aspect.

Past Water Quality

Previous monitoring of the canals has shown the regular occurrence of vertical salinity stratification of the water column, where relatively fresh water having a lower density overlies a distinct bottom layer of more saline water with higher density. The

concern with the high propensity for the water column in the canals to stratify is that the bottom water, after a prolonged period without overturn, will become low in dissolved oxygen. The reason that this occurs is as follows:

- The transparency of water in Yunderup canals is relatively low, and there is usually insufficient light below a depth of approximately 1m for aquatic plants to photosynthesis. Oxygen is a product of photosynthesis.

- Below the compensation depth, (i.e. the depth at which oxygen production through photosynthesis is equal to the consumption of oxygen through respiration) respiration by biota reduces the oxygen supply of the bottom water.

- Dissolved oxygen within bottom waters can only be replenished by downwards circulation of oxygenated surface waters. This cannot occur if there is a density cline below the depth of compensation.

- The consumption of oxygen in bottom waters of a eutrophic waterbody tends to be rapid, due to the bacterial decomposition of the high amounts of organic material.

Van Senden (1986) reviewed 2.5 years of monitoring data for Yunderup canals and the adjacent Peel Inlet. The data showed that the depth averaged dissolved oxygen (D.O.) level was low (below 5mg/L) in Yunderup canals for 25% of the time, compared with 15% of the same period in Peel Inlet. D.O. levels in the bottom water of the canals was low for 75% of the time.

The reduction of D.O. has two important potential effects on the health of a waterbody:

- Suffocation of fauna. Most species occuring in Peel Inlet are adapted to periods of low dissolved oxygen levels, but cannot withstand prolonged deoxygenation over extensive areas.

- Enhanced algal nuisance. Deoxygenation at the sediment surface can induce the chemical release of phosphorus from the sediments which can, during optimal water temperature and light conditions, promote increased growth of nuisance algae.

Water Exchange

Water column stratification and the consequent reduced water quality are each interdependent with the flushing regime for the canals. Water is exchanged between the canals and Peel Inlet (and ultimately the ocean) by longitudinal mixing and advection. The generally good quality of the surface waters in Yunderup canals, as indicated by high D.O. levels, suggests that the time scale for flushing of surface waters is significantly shorter than for the bottom water, which is usually low in D.O.

Van Senden (1986) considered that the long residence time of trapped bottom water in the canals prior to the recent entrance channel dredging, which he estimated to be in the order of months, was responsible for the inferior water quality of the canals compared to Peel Inlet. The surface waters in the canals were flushed more readily, due to wind effects, although they still suffered more periods of reduced water quality than the surface waters of Peel Inlet.

Van Senden (1986) concluded that there were two basic problems with the design of the canals:

1. The bathymetry. Prior to the recent dredging of the entrance channel, the canals were an average 1m deeper than the entrance channel. Basins at the extremities of canals F and E were almost 1.5m deeper than the entrance channel. This resulted in the entrapment and extended residence of dense saline bottom water within the canals, which was the primary cause of poor water quality.

2. That a single entrance channel fed a series of dead end canals.

To alleviate these problems, Van Senden (1986) proposed two design criteria:

1. The dense bottom water must be able to drain out of the canals.

2. The distance a fluid parcel must travel to escape from the canals (the number of dead ends) should be minimized.

Present and Future Water Quality

The entrance channel to the canals was dredged to 2.2m AHD in January - March,

1990. Peel Waterways commissioned the Centre for Water Research (CWR) to monitor the effect of the dredging upon flushing of the canals, in order to confirm that the anticipated benefits to water quality were realized and that they would extend to the proposed canal extensions.

The CWR undertook pre- and post-dredging surveys of the canals, which included:

- dye flushing experiments to determine the rate of flushing of the canal waters;
- dissolved oxygen measurements recorded over a complete diurnal cycle;
- salinity and temperature profiling at selected locations in the canal and Inlet.

The CWR report is provided as Appendix B to this PER. The results clearly demonstrated a dramatic improvement in the flushing of Yunderup canals as a result of the entrance dredging. Specific findings included the following

- The dye experiments indicated that the average flushing time for the canals decreased from 5.4 days prior to dredging to 2.3 days following dredging.
- The dissolved oxygen measurements confirmed the improved exchange subsequent to the dredging. Anoxic bed conditions were observed near the closed ends of the canals in the pre-dredged survey, consistent with the trapping of dense saline water. Anoxia was not detected at any location in the post-dredged survey.
- The salinity-temperature profiling, in combination with the other results, showed that the driving mechanism for water exchange is a density gradient between the canals and the Inlet, resulting in gravitational exchange.

The CWR concluded that the observed dramatic improvement in flushing of the canals will be maintained over time and will also apply to the proposed canal extensions. This is because the improvement is not dependent upon the specific conditions at the time of each survey. Gravitational exchange of water masses along density gradients will, in most instances, flush the canal waters most quickly. Given the nature of Peel Inlet, with its expansive shallows and ocean and river inputs, density gradients are likely to exist at all times. However even in the absence of such

gradients, wind and tidal driven exchange between the canals and the Inlet will be enhanced by the dredging of the sill.

Importantly, CWR also concluded that the mechanisms and results defined by their study applied to the canal system in both its present form and in the proposed extension. On the basis of the canal design proposed herein, and provided the deeper basins near the ends of the existing canals are partially filled, the CWR concluded that the improvement in flushing would extend throughout the expanded canal system. A second entrance channel to the eastern end of the canals, as had been previously proposed in the 1986 PER, was considered unnecessary to assure adequate water quality. The proposed development now includes a connection from the end of the existing northern canal, via the proposed western canal, to the entrance channel.

6.0 ASSESSMENT OF ENVIRONMENTAL IMPACTS

This section reviews and assesses the impacts of the proposed canal extensions upon the environment at Yunderup, demonstrating that, with appropriate management, potential adverse impacts will be minimal.

6.1 Landform Modification

The existing topography of the development site will be modified as a result of excavation for the waterways and earthworks to raise the levels of the lots above flood levels. The proposed modifications will not markedly alter the present landscape aesthetics, which are presently dominated by the existing canal development. In addition, previous earthworks have already modified the sites of both the eastern and western extensions.

6.2 Flood Levels

The majority of land in the South Yunderup area is subject to periodic inundation. Landfill operations to create built-up residential areas on the downstream end of an alluvial plain may have an effect on upstream flood levels. The Public Works Department (1984) indicated in the Murray River Flood Study that some form of future flood mitigation may be necessary in response to continued residential and canal developments on the Murray River delta.

However, the proposed development, will not affect upstream flood levels. Lots 5, 6, 7 and 8 are north of the major floodway (Figure 5), and Lot 18, which has been elevated above the 1:100 year flood level for 20 years, was taken into account in the PWD study.

6.3 Drainage

Stormwater runoff will be directed to the canals,via silt traps. The quality of the discharged water should be better or equal to that of the surface freshwater flow to Peel Inlet from the Murray River, which will occur at the same time.

6.4 Shoreline Stability

The proposed development will not encroach upon the adjacent foreshore reserves of the Murray River and Peel Inlet, except at the entrance for the western canal.

Increased use of the foreshore by future residents will place additional pressures on the shoreline, particularly along the Murray River adjacent to Lot 18. Management of the foreshore reserves is the responsibility of the Murray Shire. During the construction phase of the project, the proponent will assist the Shire where practicable to ensure the ongoing protection of the foreshore in its present condition.

The existing foreshore reserve should provide a very ample buffer between the shore and the development.

6.5 Vegetation

The existing vegetation in the two proposed development sites is substantially degraded, having been mostly removed during earthworks for the construction of the existing canal estate in 1971. There are remnant Melaleuca thickets in the eastern development area that will be removed, however these are relatively sparse and offer very little conservation value.

6.6 Canal Water Quality

As described in Appendix B and summarized in Section 5.2.2, the proposal will result in substantial improvement in the water quality of the canals. This improvement will extend to the proposed canal extensions as well as the existing canals. Considerable improvement in canal water quality has already been achieved as a result of recent dredging of the entrance channel to the canals, funded by Peel Waterways.

The proposal will also encourage the formalisation of arrangements between the Shire of Murray and the State Government for ongoing maintenance of the canal waterway, which have not previously been satisfactorily ascertained.

6.7 Social Impacts

Local residents at South Yunderup may be inconvenienced during construction of the development by noise and dust from excavation and earthmoving operations. This nuisance will be temporary, and appropriate onsite management will ensure that it is minimized. Construction activities will be restricted to normal daylight hours and, if found to be necessary, appropriate dust supression techniques will be employed.

The development will involve minor changes to the existing local road system. These will mostly benefit existing residents by reducing traffic volumes on the roads that are affected.

The development of 160 new residences will marginally increase traffic movements along Yunderup Road, however total traffic volumes should remain sufficiently low that negligible nuisance would result.

Public access along the Peel Inlet foreshore will be interrupted by the proposed entrance to the western canal. The foreshore reserves bordering the development site will otherwise be unaffected.

The development of Lots 5, 6, 7 and 8 will remove a significant mosquito breeding site, so should assist to reduce the intensity and frequency of mosquito nuisance near this locality. Mosquito breeding sites also occur through extensive areas peripheral to the development site that are outside of the influence or control of the proponent. An integrated regional mosquito control strategy has been recently implemented by State and Local Authorities to try to reduce this problem.

7.0 ENVIRONMENTAL MANAGEMENT

The discussion presented in Section 6 demonstrates that, with appropriate management, the proposed extensions to the canal estate will cause considerable benefit and negligible adverse impact upon the environment. This section outlines the management programme designed to minimise the identified potential environmental impacts during the construction and operational phases of the development.

7.1 Elements Requiring Management

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

- Construction phase
  - incursion upon the foreshore reserve
  - dust and noise suppression
  - turbid runoff
  - landscaping

- Operational phase
  - nutrient management
  - canal waterway maintenance
  - foreshore management
  - environmental monitoring

7.2 Management Responsibilities

The proponent will be responsible for all aspects of environmental management during the construction phase.

Following completion of their construction, the canal waterways will be vested with the Shire of Murray who will be responsible for their ongoing management and maintenance. To assist in financing work requirements associated with these responsibilities, the Shire anticipates the imposition of a "specified area" rate on the land owners abutting the canals.

Correspondence from the Shire confirming their responsibility to manage the canal waterway is included as Appendix C.

The Shire of Murray would also be responsible for the maintenance of POS, roadways and other public facilities within the estate.

7.3 Management Program

7.3.1 Construction Phase

Earthworks on Lot 18 will be managed to avoid any incursion of machinery into the Murray River foreshore reserve. Temporary fencing will be constructed to clearly mark this boundary.

Possible nuisance from construction noise will be reduced through working normal daylight hours. Dust levels will be suppressed, if necessary, by watering.

During canal excavation, bunds and settling ponds will be managed to prevent turbid water from entering adjacent waterways. The canal waterways will be excavated prior to their opening to the existing canals. The final opening of connecting links will be controlled to prevent scour during the initial inflow of water.

Landscaping of the development to be undertaken by Peel Waterways will include appropriate use and placement of topsoil and the widespread establishment of salt tolerant tree species adjacent to roads and the canals.

7.3.2 Operational Phase

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 as follows:

- An information brochure describing the use of slow release fertiliser and suitable native plants for residential gardens will be issued to all purchasers of lots.

- With the purchase of each residential lot the proponent will supply, free of charge,

sufficient slow release fertiliser to establish a native garden. This will be achieved by the issue of a voucher which will be negotiable at nominated local hardware suppliers for specific slow release fertilisers only.

Canal Maintenance

The ongoing maintenance of the canal waterways will be undertaken by the Shire of Murray, in consultation with PIMA, and which will be done to the satisfaction of the EPA.

It is anticipated that seagrass wrack will collect in the north-east corner of the canal estate. Access to the canals at this point (adjacent to the homestore) will be provided to allow Shire vehicles to remove the wrack.

The canals and entrance channel depth will be maintained to ensure adequate flushing of the water system. Depths will be monitored by the Shire to determine the need for dredging. When required, the Shire will submit plans for dredging and disposal of dredged material to PIMA for approval prior to their implementation. Spoil disposal site options being considered include:

- pumping to the south of the bund wall to create a reserve for recreational purposes;
- removal from the immediate vicinity to a disposal site to be determined; or
- pumping to the Wellya Lagoon, inside the bund area.

Foreshore Management

Management of the foreshore reserve adjacent to the canal estate will remain the responsibility of the Shire of Murray. The proponent will construct a concrete footpath along the Murray River foreshore reserve adjacent to Lot 18, which will encourage continued and controlled public enjoyment of the reserve and assist to prevent the encroachment of exotic plants from the adjacent residences.

During construction of the development, the proponent will assist the Shire where practicable to ensure the ongoing protection of the foreshore in its present condition.

Environmental Monitoring

An environmental monitoring program will be implemented following completion of canal construction and the proposed remedial works to confirm the predictions made in the PER regarding the maintenance of improved water quality in the canals. The design of the monitoring program will be determined in consultation with PIMA and to the satisfaction of the EPA, and will include the following:

- Monthly monitoring of water quality at three sites within Yunderup Canal Estate and at a control station in nearby Peel Inlet. This will involve water column profile measurements of salinity, temperature, pH and dissolved oxygen, and sampling of the surface and bottom water for analysis of total phosphorus, phosphate, total nitrogen and chlorophyll 'a'.

- Annual sampling of the sediments from the above sites for analysis of total phosphorus and bicarbonate extractable phosphorus.

It is proposed that the monitoring program will be conducted for two years, following which the results will be formally reported to the EPA and the requirement for continued monitoring will be reviewed. Peel Waterways will initially be responsible for undertaking the monitoring, however responsibility will subsequently pass to the Shire of Murray. Arrangements regarding the transfer of this responsibility are subject to continuing discussions between the proponent and the Shire.

8.0 CONCLUSIONS

The proposed extension to Yunderup Canal Estate will provide affordable holiday and residential properties oriented towards recreational enjoyment of Peel Inlet. The commercial opportunity to extend the canal estate will enable the proponent to undertake substantial capital works to remedy previous water quality problems in the existing canal estate, which are inherent in the present canal configuration.

In combination, the development of new waterfront housing allotments and the alleviation of previous water quality concerns will provide existing and future residents with a highly desirable residential estate.

The project will not cause any major adverse impact upon the environment. The development area was substantially degraded by earthworks during construction of the existing canal estate in 1971-72, and is generally derelict. In its present condition it has not conservation value.

The development will remedy previous water quality concerns in the canal estate. Detailed monitoring and assessment studies by CWR have confirmed that, subject to recommendations regarding canal design and remediation of design anomalies in the existing canals, efficient water exchange with Peel Inlet will be maintained over time. All of the CWR recommendations to achieve this objective have been incorporated in the present proposal.

It is concluded that, with appropriate environmental management, the proposed extensions to Yunderup Canal Estate can be accommodated within the existing natural and social environment to considerable benefit and without any significant adverse impacts.

9.0 SUMMARY OF COMMITMENTS

Project design and environmental management commitments given by Peel Waterways Pty Ltd include the following.

Canal Design

1. The proposed canal estate will incorporate, to the satisfaction of the EPA in consultation with the Shire of Murray and PIMA, all of the Centre for Water Research (CWR) recommendations to ensure the maintenance of adequate water quality. Specifically, the CWR recommendations are as follows:

   1.1 The proposed eastern canal to have a depth no greater than -1.9mAHD. (The proposed depth is -1.5mAHD).

   1.2 Connections to be installed between the proposed eastern canal and the existing eastern canal (Canal E) at both the northern and southern ends.

   1.3 The connection where Kiap Road crosses the southern link to the proposed eastern canal to include full depth box culverts.

   1.4 The proposed western canal to have a depth no greater than -2.0mAHD. (The proposed depth is -1.5mAHD).

   1.5 A bottom pipe or culvert connection to be installed between the western end of the existing northern canal (Canal F) and the proposed western canal.

   1.6 The deepest parts of the existing canals, near the closed ends of Canal F and Canal E, to be filled to a depth consistent with the remainder of each canal (-2.0mAHD).

   1.7 The depth of the entrance sill to be maintained. (Note: This will be accomplished through an agreement that is currently being negotiated between the Shire of Murray and the Minister for Transport, described in Appendix C to this PER).

1.8 The culvert connection between Wellya Lagoon and the entrance channel to the canal estate to be closed and relocated to the western side of the lagoon.

2. The design of the proposed canals will accord with the recommended specifications described in the Canal Guidelines (Waterways Commission, 1982), in consultation with PIMA and to the satisfaction of the EPA.

3. Shire access to the north-eastern corner of the canals will be provided to the Shire's requirements to allow removal of occasional quantities of weed and other debris that will accumulate at this location.

Subdivision Design

4. Design building levels for the proposed allotments will be above the 1:100 year flood level, as required by the Shire of Murray.

5. The development will be deep sewered.

6. Stormwater drainage will include a suitable arrangement of silt traps to ensure that any water discharged to the canals is of adequate quality, in consultation with PIMA and to the satisfaction of the EPA.

7. Public access to all areas of foreshore reserve adjacent to the estate will be preserved, save at the entrance channel to the western canal. Alternate vehicle and pedestrian access to the boat ramp and foreshore reserve near the western canal will be provided around the northern side of the canal, to the satisfaction of the Shire of Murray.

8. Landscaping of the development to be undertaken by Peel Waterways prior to the sale of the blocks will include appropriate use and placement of topsoil and the widespread establishment of salt tolerant tree species adjacent to roads and the canals, to the satisfaction of the Shire of Murray.

9. The minimisation of nutrient application within future residential gardens and the preferential use of slow release fertilisers and native plant species will be encouraged as follows:

9.1 An information brochure describing the use of slow release fertiliser and

suitable native plants for residential gardens will be issued at the time of sale to all purchasers of lots.

9.2 With the purchase of each residential lot the proponent will supply, free of charge, sufficient slow release fertiliser to establish a native garden. This will be achieved by the issue of a voucher which will be negotiable at nominated local hardwater suppliers for specific slow release fertilisers only.

Project Construction

10. The proponent will ensure to the Shire of Murray's satisfaction that construction contractors do not encroach upon the adjacent foreshore reserves.

11. During construction of the project, the proponent will assist the Shire of Murray where practicable to ensure the ongoing protection of the foreshore reserve. To assist this objective and to encourage continued public use, the proponent will construct a concrete footpath along the Murray River foreshore reserve adjacent to the western site (Lot 18).

12. The proposed canals will be excavated in a land-locked basin. Bunds and settling basins will be used to prevent the flow of turbid water into the existing canals, in consultation with PIMA and to the satisfaction of the EPA. The final opening of the connecting links will be controlled to prevent scour during the initial inflow of water.

13. The proposed canals will be constructed, and the remedial works proposed for the existing canals undertaken, to the satisfaction of the Shire of Murray and EPA upon advice from PIMA and the Department of Marine and Harbours.

14. Construction activities will be restricted to normal daylight hours. If found to be necessary, appropriate techniques will be employed to suppress any noise or dust nuisance to nearby residents, to the satisfaction of the Shire of Murray.

Ongoing Management

15. Upon completion of development of the canal estate, the canal waterways will be ceded to the Crown for vesting with the Shire of Murray. The Shire will accept responsibility to ongoing maintenance of the canal waterways, which will be

undertaken in consultation with PIMA and which will be done to the satisfaction of the EPA. The Shire will impose a differential rating scheme upon Yunderup Canal Estate to provide specific funding for this purpose.

16. Following construction of the canals and the proposed remedial works, the proponent will implement an environmental monitoring program as described in Section 7.3.2 of the PER, designed in consultation with PIMA, to the satisfaction of the EPA.

10.0 REFERENCES

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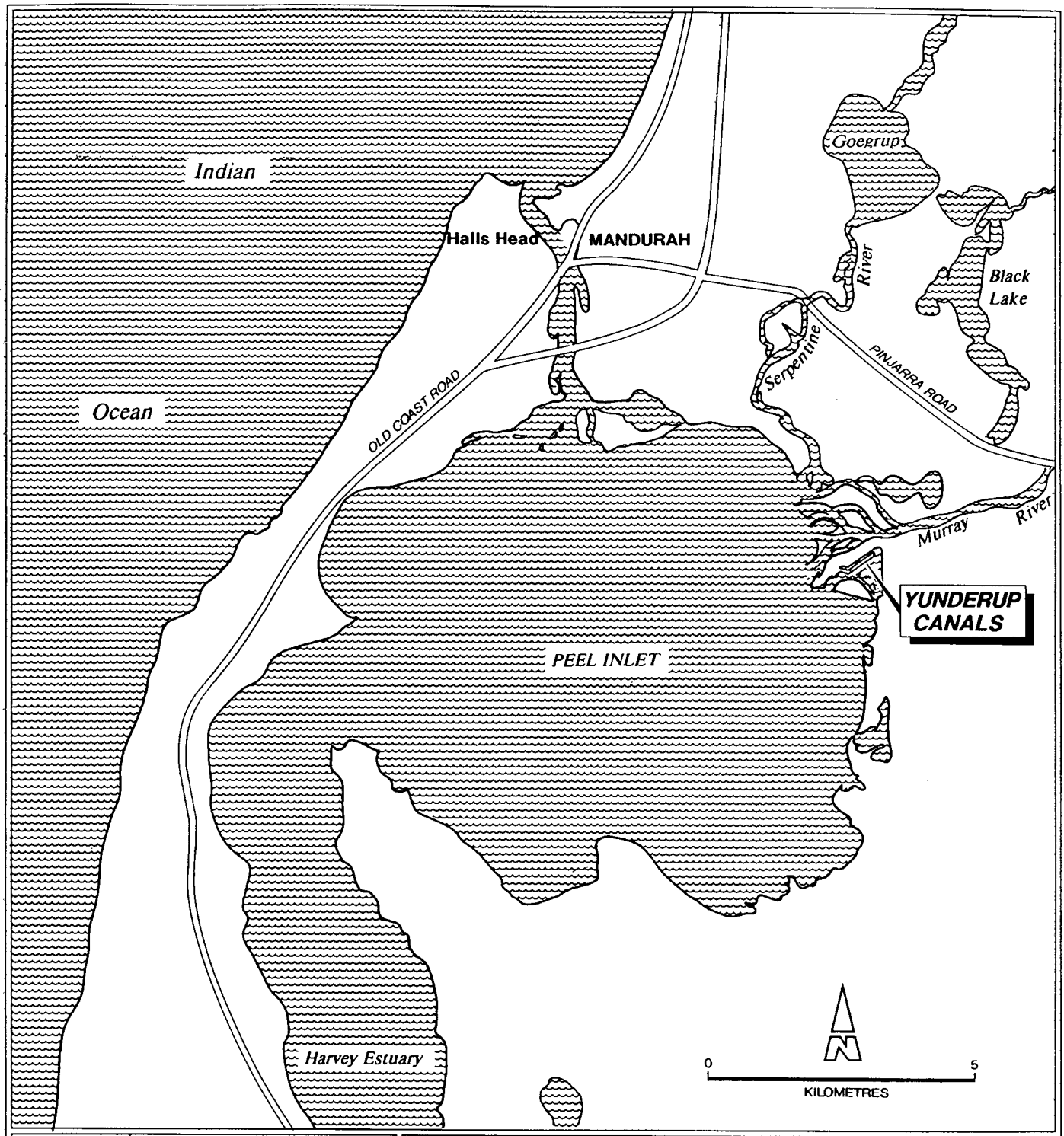
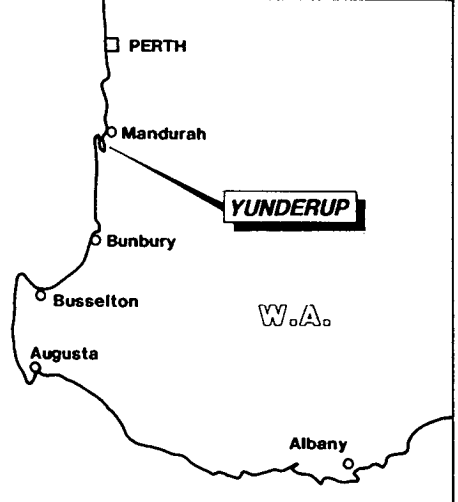
PLATES AND FIGURES

Plate 1 View across Lot 18 looking west from Moyap Way.

Plate 2 View across Lots 6 and 7 looking east from Kiap Road.



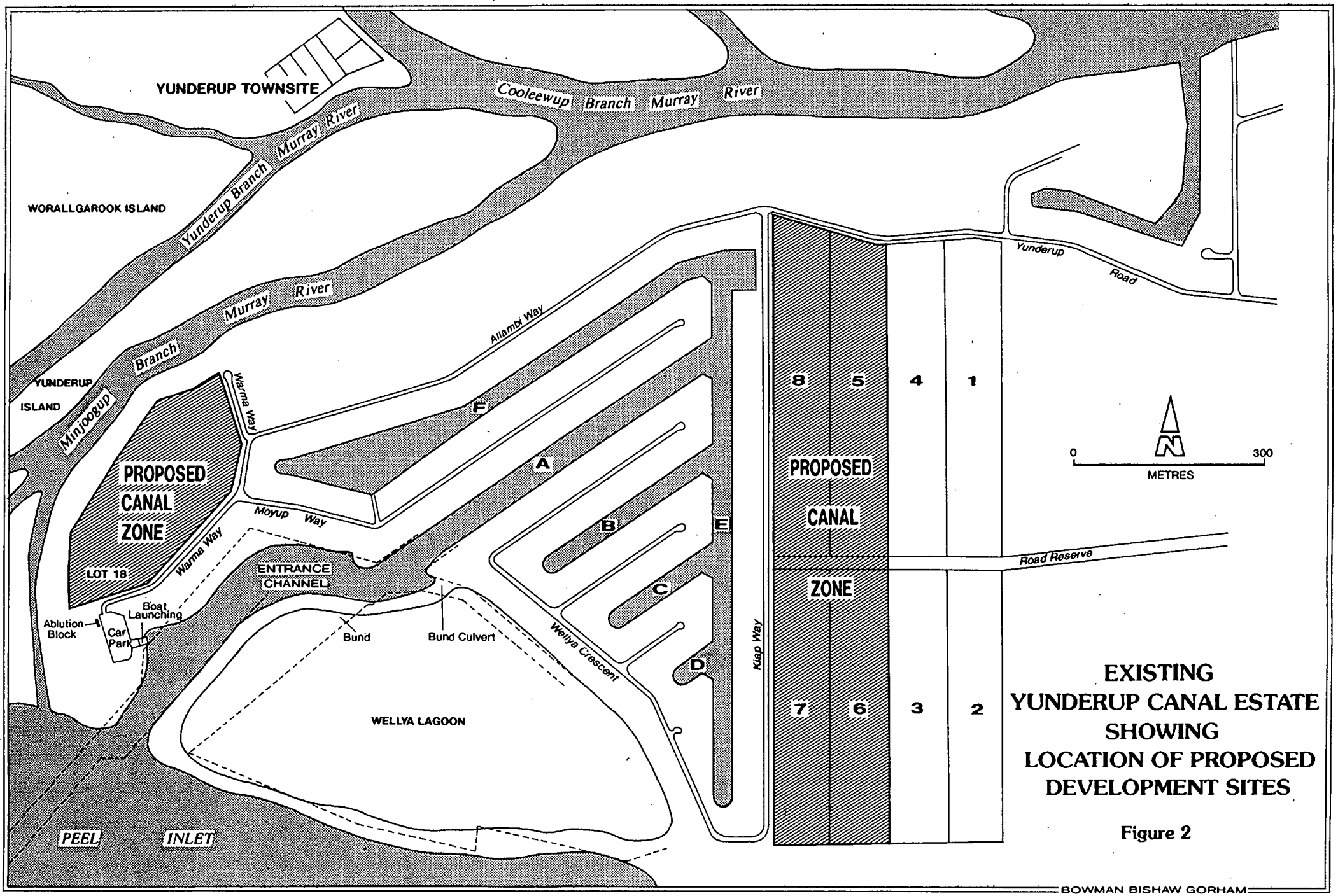


LOCALITY

LOCATION MAP

Figure 1

BOWMAN BISHAW GORHAM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Murray River
Yunderup Branch
WORALLGAROOK ISLAND
Murray River
Branch
YUNDERUP ISLAND
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Allambi Way
Warma Way
PROPOSED CANAL ZONE
LOT 18
Warma Way
Moyup Way
ENTRANCE CHANNEL
Boat Launching
Ablution Block
Car Park
Bund
Bund Culvert
Wellya Crescent
WELLYA LAGOON
PEEL INLET
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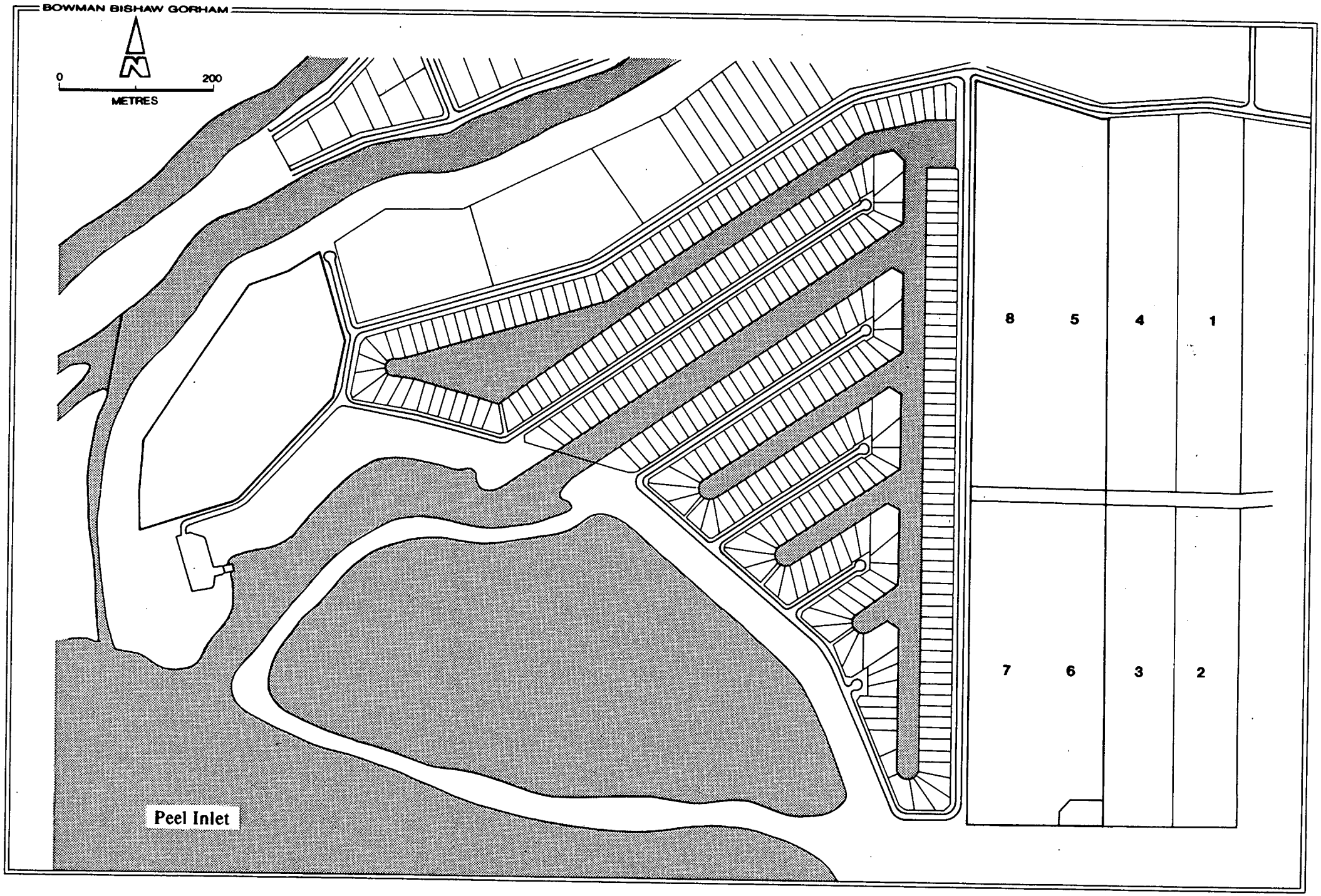
EXISTING YUNDERUP CANAL ESTATE SHOWING LOCATION OF PROPOSED DEVELOPMENT SITES
Figure 2
BOWMAN BISHAW GORHAM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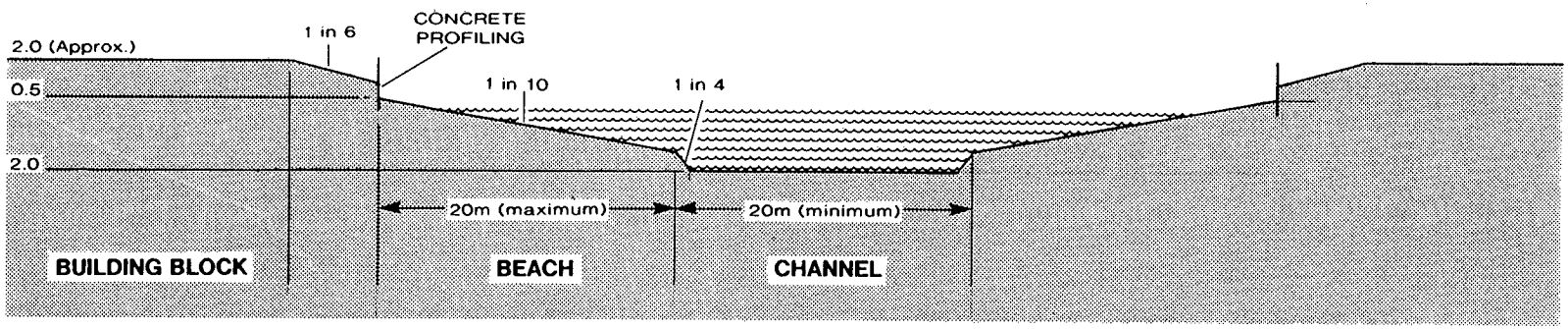

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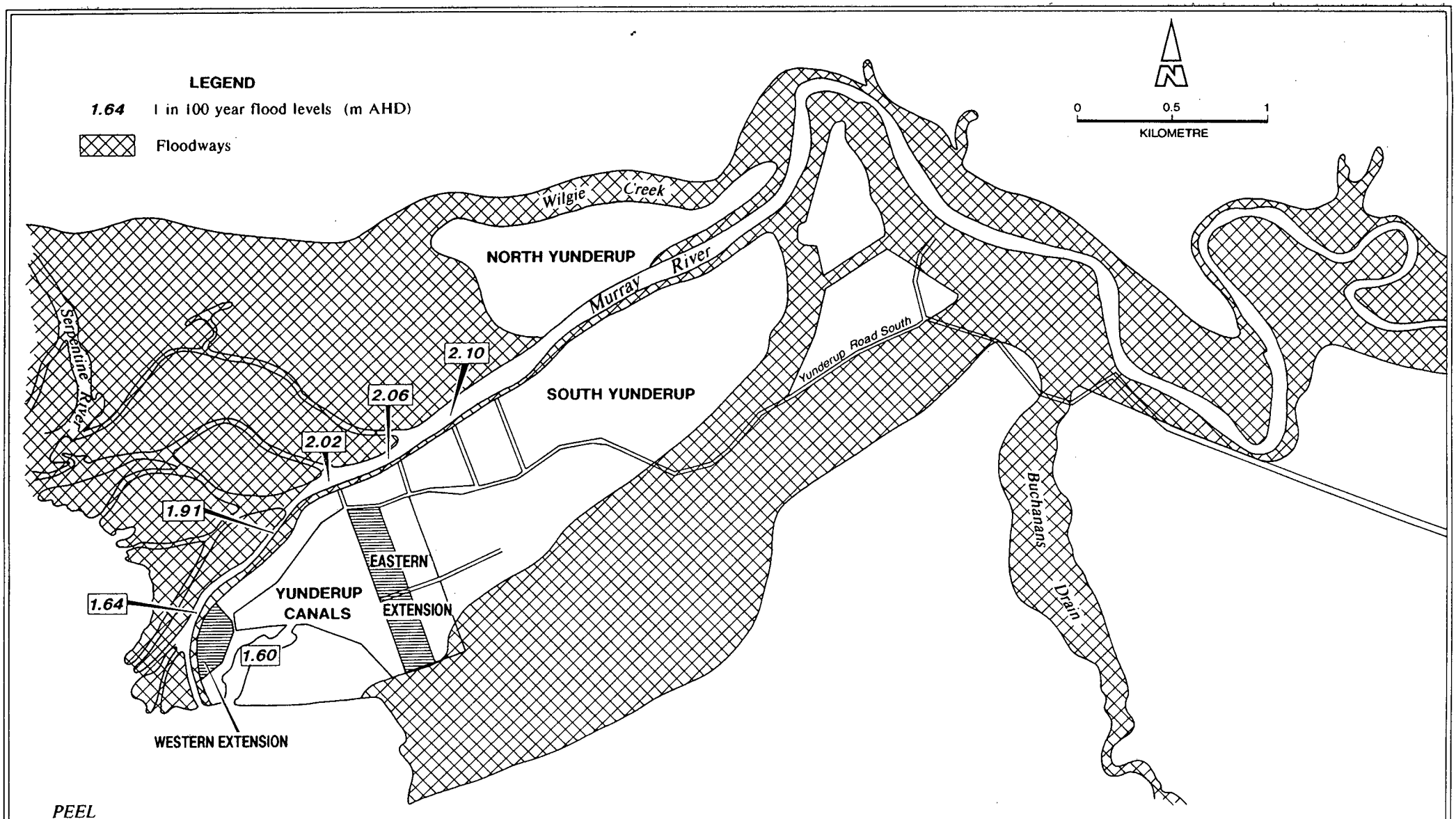
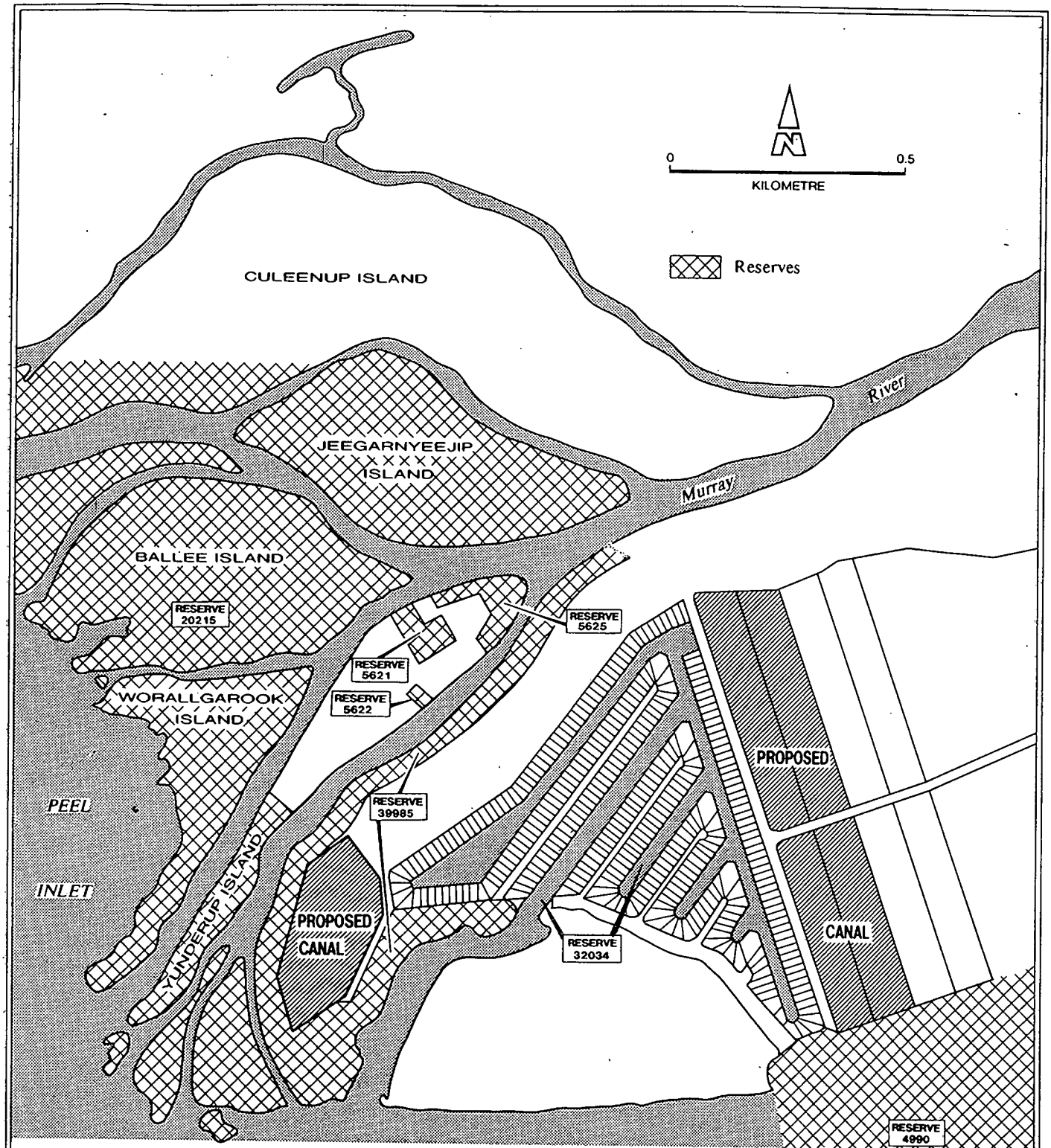
CROSS SECTION OF PROPOSED CANAL EXTENSION

Figure 4



FLOOD MANAGEMENT AT YUNDERUP

Figure 5



LOCATION OF CONSERVATION AND RECREATION RESERVES AT YUNDERUP

Figure 6

APPENDIX A

Baseline Water Quality and Sediment Monitoring Results

BOWMAN BISHAW GORHAM
ENVIRONMENTAL MANAGEMENT CONSULTANTS

Martin P. Bowman B.Sc. (Hons)
Michael Bishaw B.Sc. (Hons)
Richard A. Gorham LL.B., M.Sc.

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Subiaco 6008
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Telephone (09) 388 1859
Facsimile (09) 381 7362

Our Reference: RI9163

9 April 1990

Mr Colin E. Day
Peel Waterways Pty Ltd
Apartment 11, 16 Mill Point Road
SOUTH PERTH WA 6151

Dear Colin,

Yunderup Canals - Water Quality and Sediment Results

During the last nine months Bowman Bishaw Gorham have conducted three field surveys at Yunderup Canals to sample the water quality and sediments. I am pleased to provide herein a record of the results obtained from these surveys.

The survey dates, samples collected, parameters analysed and the analytical results are as follows. Figure 1 shows the location of each of the sampling sites.

Survey 1 21-22 July, 1989

a) Water

Surface and bottom water samples were collected from Sites PN, PS, PC and A2. Sites PN, PS and PC are located in Peel Inlet as follows:

- Site PN is within the dredged entrance channel to Yunderup Canals, adjacent to the navigation marker where the channel takes the initial "dog-leg" (to the north) outside of the canals.

- Site PS is adjacent to Site PN but on the shallow bank to the south of the dredged channel.

Site PC is adjacent to the final navigational beacon at the northern end of the dredged entrance channel to Yunderup Canals. This station coincides with a permanent station that is routinely monitored by the Waterways Commission.

The samples were analysed by the W.A. Chemistry Centre for nitrate-nitrogen, ammonia-nitrogen, total persulphate nitrogen, orthophosphate and total phosphorus. The results are described in Table 1.

b) Sediment

A sediment sample (surface 2cm) was collected from mid channel at Site A3, and analysed for total nitrogen, total phosphorus, phosphorus extracted in 0.5m sodium bicarbonate (as per Colwell, 1963) and organic carbon (as per Walkley and Black, 1934). The results are described in Table 2.

Survey 2 20 October, 1989

a) Water

Surface and bottom water samples were collected at Sites PN, PS and A2, and analysed for the same parameters as the first survey samples. The results are described in Table 1.

b) Sediment

A sediment sample (surface 2cm) was collected from mid-channel at Site A2, and analysed for the same parameters as the sediment sample collected during Survey 1. The results are described in Table 2.

Survey 3 9 January, 1990

a) Water

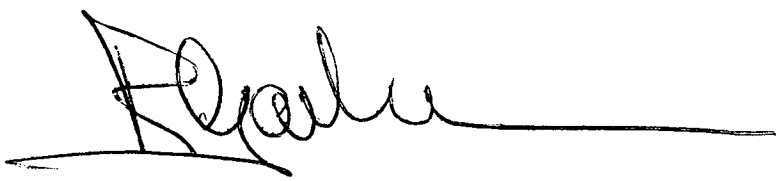
Surface and bottom water samples were collected from Sites PN, PS, BR, A2, A3, AE, CE, E1, F2 and F1. The samples were analysed by the Centre for Water Research, Murdoch University for orthophosphate, organic phosphorus, total phosphorus, ammonia-nitrogen, nitrate and nitrite nitrogen, organic nitrogen, total nitrogen, chlorophyll a and phaeophytin. The results are described in Table 3.

b) Sediment

Sediment samples (surface 2cm) were collected from Sites PN, PS, A3 and F1, and were analysed for total nitrogen, non-apatite phosphorus, apatite phosphorus, organic phosphorus, total phosphorus, organic matter and biological oxygen demand (5 day). The results are described in Table 4. The BOD analyses were undertaken in duplicate and the data describes the average and standard deviation of the results obtained.

The results described should fulfill the specified EPA requirements for baseline water quality and sediment chemistry data. Bowman Bishaw Gorham would be pleased to assist Peel Waterways Pty Limited further should you require interpretation of the data and look forward to receiving your instructions.

Yours faithfully,



RICHARD A. GORHAM

cc Mr Don Lewis
University of Western Australia

Table 1

Water Quality Results, Surveys 1 and 2

Date	Location	Surface (S) Bottom (B)	Nitrate Nitrogen (mg/L)	Ammonia Nitrogen (mg/L)	Total Pers Nitrogen (mg/L)	Ortho Phosphate (mg/L)	Total Phosphorus (mg/L)
21-Jul-89	Control 1	S	0.31	0.06	1.3	0.02	0.11
21-Jul-89	Control 1	B	0.12	0.11	0.76	0.01	0.04
21-Jul-89	Control 2	S	0.19	0.05	1.3	<0.01	0.07
21-Jul-89	Control 2	B	0.07	0.02	1.7	0.01	0.24
21-Jul-89	Control 3	S	0.05	<0.02	0.87	<0.01	0.04
21-Jul-89	Control 3	B	0.13	0.09	0.89	<0.01	0.05
21-Jul-89	Site A2	S	0.10	0.18	1.1	0.01	0.04
21-Jul-89	Site A2	B	0.11	0.35	1.6	0.01	0.16
22-Jul-89	Control 1	S	0.77	0.21	2.4	<0.01	0.30
22-Jul-89	Control 1	B	0.07	0.33	0.79	0.01	0.07
22-Jul-89	Control 2	S	0.14	0.10	1.2	0.06	0.11
22-Jul-89	Control 2	B	0.05	0.07	0.98	<0.01	0.05
22-Jul-89	Control 3	S	0.15	0.18	1.4	0.07	0.14
22-Jul-89	Control 3	B	0.04	0.44	0.85	<0.01	0.03
22-Jul-89	Site A2	S	0.39	0.07	1.2	0.01	0.05
22-Jul-89	Site A2	B	0.07	0.40	0.99	0.03	0.09
20-Oct-89	Site A2	S	<0.02	0.37	2.0	0.14	0.25
20-Oct-89	Site A2	B	0.02	0.23	0.77	0.05	0.14
20-Oct-89	Site PS	S	0.02	0.02	0.97	0.01	0.05
20-Oct-89	Site PS	B	0.07	0.07	1.5	0.03	0.27
20-Oct-89	Site PN	S	0.05	0.03	1.0	0.01	0.10
20-Oct-89	Site PN	B	0.02	0.36	1.9	0.05	0.43

Table 2

Sediment Results, Surveys 1 and 2

Survey Date	Sample	Total Nitrogen (%)	Total Phosphorus (ppm)	HCO_{-3} Extractable Phosphorus (ppm)	Organic Carbon (%)
22.7.89	Site A3	0.31	360	38	3.4
20.10.89	Site A2	0.38	380	53	4.0

Table 3

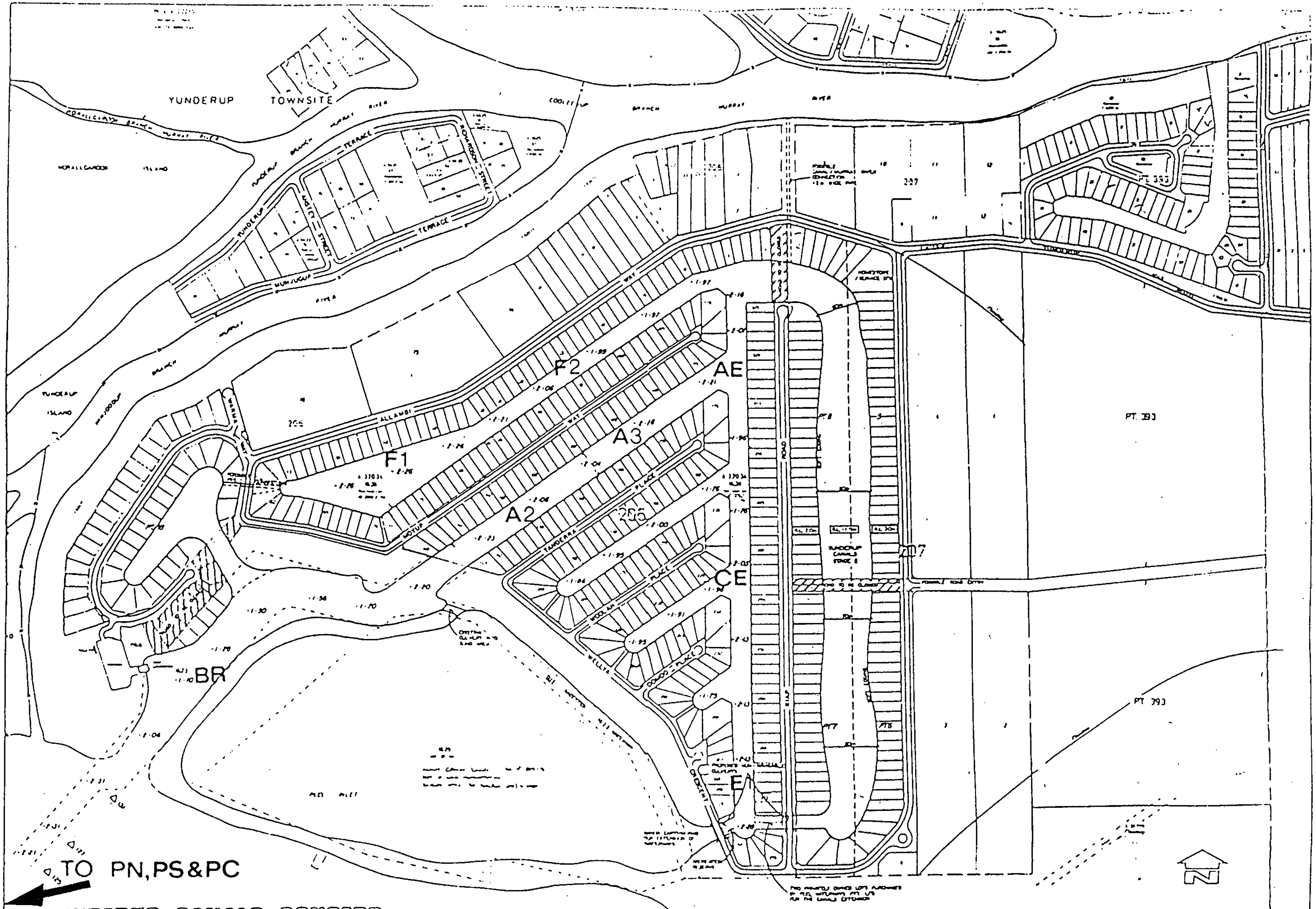
Water Quality Results, Survey 3

Sample Location	Surface (S) or Bottom (B)	Ortho-phosphate (µg/L)	Ogranic Phosphorus µg/L)	Total Phosphorus (µg/L)	Ammonia Nitrogen (µg/L)	Nitrate-Nitrite Nitrogen (µg/L)	Organic Nitrogen (µg/L)	Total Nitrogen (µg/L)	Chlorophyll A (µg/L)	Phaeophytin (µg/L)
Site A2	S	11	164	175	103	6	2261	2370	10.52	5.26
Site A2	B	12	107	119	194	4	2397	2595	10.99	8.44
Site A3	S	11	147	158	83	6	2337	2426	18.36	3.55
Site A3	B	12	148	160	60	3	2247	2310	9.79	14.24
Site AE	S	15	145	160	57	3	2221	2281	11.44	6.29
Site AE	B	13	189	202	43	2	2548	2593	14.64	7.32
Site BR	S	30	154	184	223	4	2027	2254	6.94	3.87
Site BR	B	26	156	182	193	4	1972	2169	5.34	2.67
Site CE	S	7	164	171	40	3	2295	2338	16.78	2.67
Site CE	B	16	207	223	43	3	2548	2594	21.36	0.01
Site E1	S	13	171	184	12	3	2437	2452	15.26	0.01
Site E1	B	7	196	203	144	3	3667	3814	18.95	2.37
Site F1	S	2	210	212	6	2	3237	3245	32.04	0.01
Site F1	B	11	199	210	412	4	3427	3843	31.15	0.01
Site F2	S	3	176	179	9	2	2496	2507	30.26	0.01
Site F2	B	9	166	175	19	2	3054	3075	29.37	0.01
Site PN	S	1	100	101	13	1	1386	1400	11.13	0.01
Site PN	B	21	136	157	200	2	1766	1968	6.94	2.67
Site PS	S	1	111	112	19	1	1295	1315	7.63	1.81

Table 4

Sediment Results, Survey 3

Sample Location	Organic Matter (%)	Total Phosphorus (µg/g)	Organic Phosphorus (µg/g)	Apatite Phosphorus (µg/g)	Non-Apatite Phosphorus (µg/g)	Total Nitrogen (µg/g)	BOD (mg/L)
Site A3	15.8	625	132	121	392	634	527 ± 159
Site F1	16.5	494	79	99	313	560	296 ± 72
Site PN	23.5	1097	95	153	633	1142	386 ± 136
Site PS	4.1	254	56	38	201	248	193 ± 92



YUNDERUP CANALS CONCEPT - CANAL DEPTHS SOUNDINGS

prepared for PEEL WATERWAYS PTY LTD

APPENDIX B

Yunderup Canals Flushing Study

This appendix provides the "Summary and Recommendations" of the Centre for Water Research Report to Peel Waterways. Copies of the full report are available for inspection at the Environmental Protection Authority, the Shire of Murray and PIMA and can be purchased for $5.00 from Bowman Bishaw Gorham.

YUNDERUP CANALS FLUSHING STUDY

FINAL REPORT

PRE-DREDGED INVESTIGATION : 5-19 JANUARY 1990

POST-DREDGED INVESTIGATION : 6-25 APRIL 1990

REPORT TO PEEL WATERWAYS PTY LTD

JUNE 1990

S. BROWN, L. CHEDZEY AND D.P. LEWIS

COASTAL AND HYDRAULIC ENGINEERING LABORATORY
CENTRE FOR WATER RESEARCH
UNIVERSITY OF WESTERN AUSTRALIA
NEDLANDS WA 6009

Reference WP 453 SB

SUMMARY AND RECOMMENDATIONS

In order to continue the assessment process for the proposed extension of the Yunderup Canal Estate, a three stage program was proposed to assess the impact of previously recommended modifications to the canal system. These stages were :

(1) dredging of the entrance channel to a depth of at least 1.5 metres below datum,

(2) monitoring of the canal before and after the dredging to identify the impact of the deepening on the flushing of the existing canal waters and the likely flushing of the proposed extension,

(3) assess the benefits of dredging a second entrance to the canals and proceed only if warranted.

This report sets out the results of the pre- and post-dredged monitoring program leading to a number of recommendations for the future development of the canals to ensure acceptable flushing of the canal waters.

Dredging of the entrance channel commenced in January 1990 and was completed in March 1990. The pre-dredged field trip was carried out between 5 and 19 January 1990 and the post-dredged survey completed between 6 and 25 April 1990. The surveys included :

- dye flushing experiments to determine the rate of flushing of the canal waters,
- dissolved oxygen measurements recorded over a complete diurnal cycle,
- conductivity and temperature profiling at selected locations in the canal and Inlet.

The dye experiments showed that the flushing time was substantially reduced between the pre- and post-dredged surveys with the average flushing rate dropping from 5.4 days to 2.3 days. The data obtained in both dye experiments, however, did not show any substantial variation in the rate of flushing with depth. This was not expected to be the case in the pre-dredged survey where a large volume of dense, saline water was found to be trapped in the deep closed-ends of the canals. It was concluded that either the dye dosing or the sampling did not adequately penetrate these deep sections thereby not identifying the most slowly flushed water.

The dissolved oxygen measurements confirmed the improved exchange of the canal waters with the Inlet subsequent to the entrance dredging. Anoxic bed conditions were observed near the closed-ends of the canals in the pre-dredged survey, consistent with the trapping of dense saline water. Anoxia was not detected at any location in the post-dredged survey supporting the evidence of increased flushing as demonstrated by the dye experiments.

It was important, however, to identify the dominant flushing mechanism so that the observed improvement in flushing could be confidently expected to be maintained over time. Fine scale conductivity and temperature profiling was used to isolate the dominant exchange mechanism with both the pre- and post-dredged data characterised by strong salinity and density stratification.

The pre-dredged survey identified dense saline water trapped in the deep closed-ends of the canals. The source of this saline water was most likely the lagoon located adjacent to the canal and the Inlet. To alleviate this problem it is recommended that the culvert connection between the canals and the lagoon be relocated to the western (Inlet) side of the lagoon. The pre-dredged data also showed a strong baroclinic front moving into the canals on the incoming tide. This front established a density gradient between the canals and the Inlet apparently driving a gravitational exchange. The shear induced by this flow, and that generated by surface winds, was not sufficient to mix and flush the trapped saline water in the deeper parts of the canals.

The post-dredged survey showed a stable surface layer of fresher water overlaying more saline water in both the canals and the Inlet. In itself this data did not identify the flushing mechanism but, given the presence of large volumes of both fresh and salty waters and the very rapid flushing of the canals, as evidenced by the dye and dissolved oxygen experiments, gravitational exchange was the obvious driving force.

The effectiveness of exchange between the canals and the Inlet was shown to be controlled by the depth of the entrance sill and the magnitude of the density gradient between the two systems. The sill depth sets the vertical dimension over which effective exchange can occur with this depth increasing from around 1.25 metres to 1.75 metres between the pre- and post-dredged survey. The sill depth also controls the volume of dense water that can be trapped in the canal system.

The improved exchange observed as a result of the dredging program will then be maintained in both the existing and proposed canal systems provided that the present sill depth is maintained. Given the nature of Peel Inlet, with its large expanses of drying tidal beds and the inputs of both the ocean and various rivers, some density gradient between the canals and the Inlet is likely to exist at all times. Exchange driven by such gradients will propagate throughout the proposed extension to the canals provided that sufficient connections between the existing and new canals are provided.

The results of the monitoring program are then clear. Dredging of the entrance sill has significantly reduced the flushing time of the canals with gravitational exchange identified as the dominant flushing mechanism. This improvement in flushing will be maintained and its benefit applied to the proposed extension provided the following recommendations are incorporated into the development plan :

(1) the proposed north-south canal (stage 2) must be a depth no greater than 1.5 metres below datum,

(2) connections must be installed between the proposed and existing north-south canals at both the northern and southern ends of the canals (in accordance with the appended Chappell and Lambert Concept Plan dated 20 June 1990),

(3) the connection where Kiap Road crosses the southern link to the proposed north-south canal must include full depth box culverts (in accordance with the appended Wood and Grieve Culvert Detail Plan dated 20 March 1989),

(4) the proposed canal near the entrance to the Estate (stage 3) must be a depth no greater than 1.6 metres below datum,

(5) a bottom pipe or culvert connection must be installed between the western end of the existing northern canal and the proposed canal near the entrance to the Estate, when Part Lot No. 18 is developed for a canal,

(6) the deepest parts of the canals, near the closed-ends of the existing northern and north-south canals, must be filled to a depth consistent with the remainder of each canal (in accordance with the appended Plan No. 1),

(7) the depth of the entrance sill must be maintained at its present depth to minimise trapping of dense water in the canal system,

(8) the culvert connection between the lagoon and the entrance channel to the Estate must be closed and relocated to the western (Inlet) side of the lagoon (in accordance with the appended Plan No. 1).

Given the above recommendations, the field investigation indicates that dredging of the entrance sill has sufficiently improved the flushing of Yunderup Canals so that a second entrance to the canal system, as originally proposed, is not warranted.

APPENDIX C

Correspondence from Shire of Murray

SHIRE OF MURRAY

PINJARRA ROAD, PINJARRA, W.A., 6208. TELEPHONES: 531 1755, 531 1068
FACSIMILE: 531 1981

All Communications to the Shire Clerk, P.O. Box 21, Pinjarra, 6208

Office Hours: Monday to Friday
8.30 a.m. to 4.30 p.m.

Your Ref:

Our Ref: 5.6.1.1 BB

If telephoning or calling with reference to this letter please ask for

Mr. McClements

17th August 1990

Mr Colin E Day
Peel Waterways Pty Ltd
Unit 11 Millpoint
16 Mill Point Road
SOUTH PERTH W A 6151

Dear Mr. Day,

FUTURE DREDGING OF YUNDERUP CANALS ENTRANCE CHANNEL

In response to your request for information relating to Council's proposals for future dredging of the Yunderup Canals entrance channel, I advise that negotiations have been taking place with the Minister for Transport regarding the setting up of an agreement to provide funds for the dredging to be carried out in later years.

The basis of the negotiations has been that the State Government agreed to dredge the entrance channel and would provide $60,000 as the foundation for a reserve fund. Council, for its part, has agreed to contribute $10,000 per annum to the reserve fund. When dredging work is required, a contract will be arranged through the Department of Marine and Harbours, with funds being provided from the reserve fund.

Some documentation has been prepared but agreement has not been reached, due to issues relating to the demarcation of responsibilities between the Department of Marine and Harbours and Council. Council's method of providing 50% of its annual contribution to the fund has also run into some technical delays, but it is expected that the way will be cleared for this to happen within the next 12 months.

Yours sincerely,

D.A. McCLEMENTS
Shire Clerk

SHIRE OF MURRAY

PINJARRA ROAD, PINJARRA, W.A., 6208. TELEPHONES: 531 1755, 531 1088
FACSIMILE: 531 1981

All Communications to the Shire Clerk, P.O. Box 21, Pinjarra, 6208

Office Hours, Monday to Friday
8.30 a.m. to 4.30 p.m.

Your Ref:

Our Ref: 5.6.1.6 DAMcC:BB

If telephoning or calling with reference to this letter please ask for

Mr. McClements

22nd October 1990

Mr Colin Day
Peel Waterways Ltd
Unit 11
16 Mill Point Road
SOUTH PERTH W A 6151

Dear Mr. Day,

MANAGEMENT OF YUNDERUP CANALS WATERWAYS

In response to your request, I confirm that Council is responsible for maintaining and managing the present Yunderup Canals waterways. Council is also negotiating with the Minister for Transport regarding the future maintenance of the Yunderup Canals entrance channel.

With reference to the extensions to the Canals proposed by your company, it is anticipated that the canal waterways will be vested in Council as part of the subdivision process and Council will therefore be responsible for future maintenance involving the normal clearing of weed and dredging to maintain the required depth.

To assist in the financing of these operations it is envisaged that Council will impose a "specified area" rate on the land owners abutting the canals. The funds raised by this method will be placed in a specific reserve fund each year and drawn upon as required.

Yours sincerely,

D.A. McCLEMENTS
Shire Clerk

APPENDIX D

Results of Soil and Groundwater Investigations, Yunderup Canal Extension. (Compiled from Chappell et al., 1986)

Soil samples and groundwater levels were taken in October 1985. Holes could not be augered underwater therefore the test sites were limited to dry areas on blocks 6 and 7. Five sites were selected, as far apart as practicable. (Figure 4).

A hole was drilled by hand auger and sampled at each site. Piezometer tubes were installed in each hole to monitor the groundwater level. All holes collapsed once the depth reached about a metre below the water-table. The deepest bore reached -1.1m AHD. An engine-driven auger was sent to the site to try to reach -3m AHD, but the attempt failed because the rig could not get into the swampy site. It seems that the depth requirement can only economically be met in summer when the water-table is lower and the site is dry.

SUBSURFACE ENVIRONMENT - SOIL AND GROUNDWATER RESULTS

A description of the soil samples obtained from the hand-augered holes is given in Appendix 1. The deepest bore was at Site # 2, where a depth of approximately -1.1m AHD was reached.

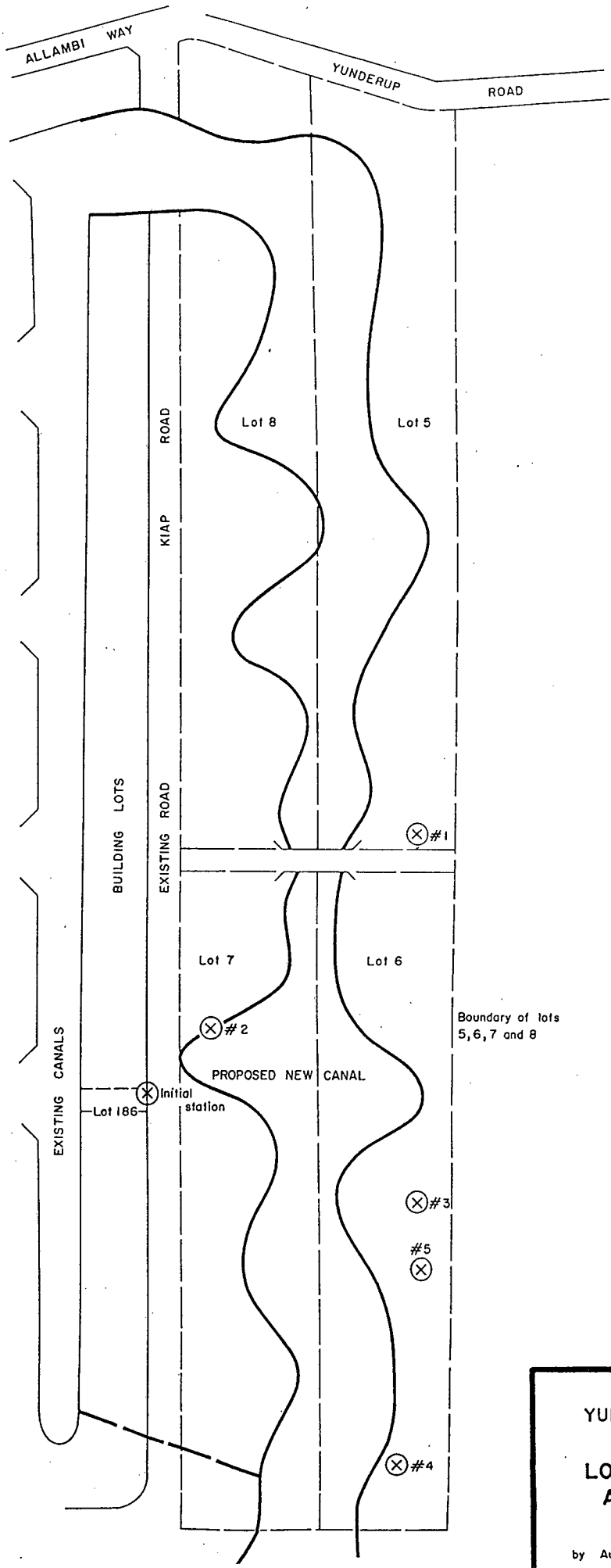
The soil sampling indicates that poorly sorted sands underlie the site, at least to a depth of -1.1m. The sands vary in colour from white through orange to brown.

There are thin layers of medium to fine, dark grey sand in the area which contain small amounts of organic material. These layers are less than 0.1m thick and they are commonly separated by at least 1m of poorly sorted sands.

A few centimetres of clay were encountered on the surface of the highest site, Site # 5. No other clay soils were encountered. A few sand samples contained a trace of clay. Samples from the thin bands at Site # 2 contained small amounts of clay which caused the sand to have slight plasticity.

Groundwater levels were measured on 8 October 1985, which was the day after the piezometers were installed. Some of the levels were measured again eight days later. The greatest variation between successive readings was 0.11m. These readings are given in Appendix B.

Groundwater contours are approximated in Figure 5 using the data collected on 8 October 1985. These contours indicate that groundwater flows approximately West-South-West. Groundwater in the shaded area in Figure 5 will flow into Peel Inlet. Groundwater from the rest of the development site will flow towards the existing canals.



PEEL WATERWAYS PTY. LTD.

YUNDERUP CANALS EXTENSION

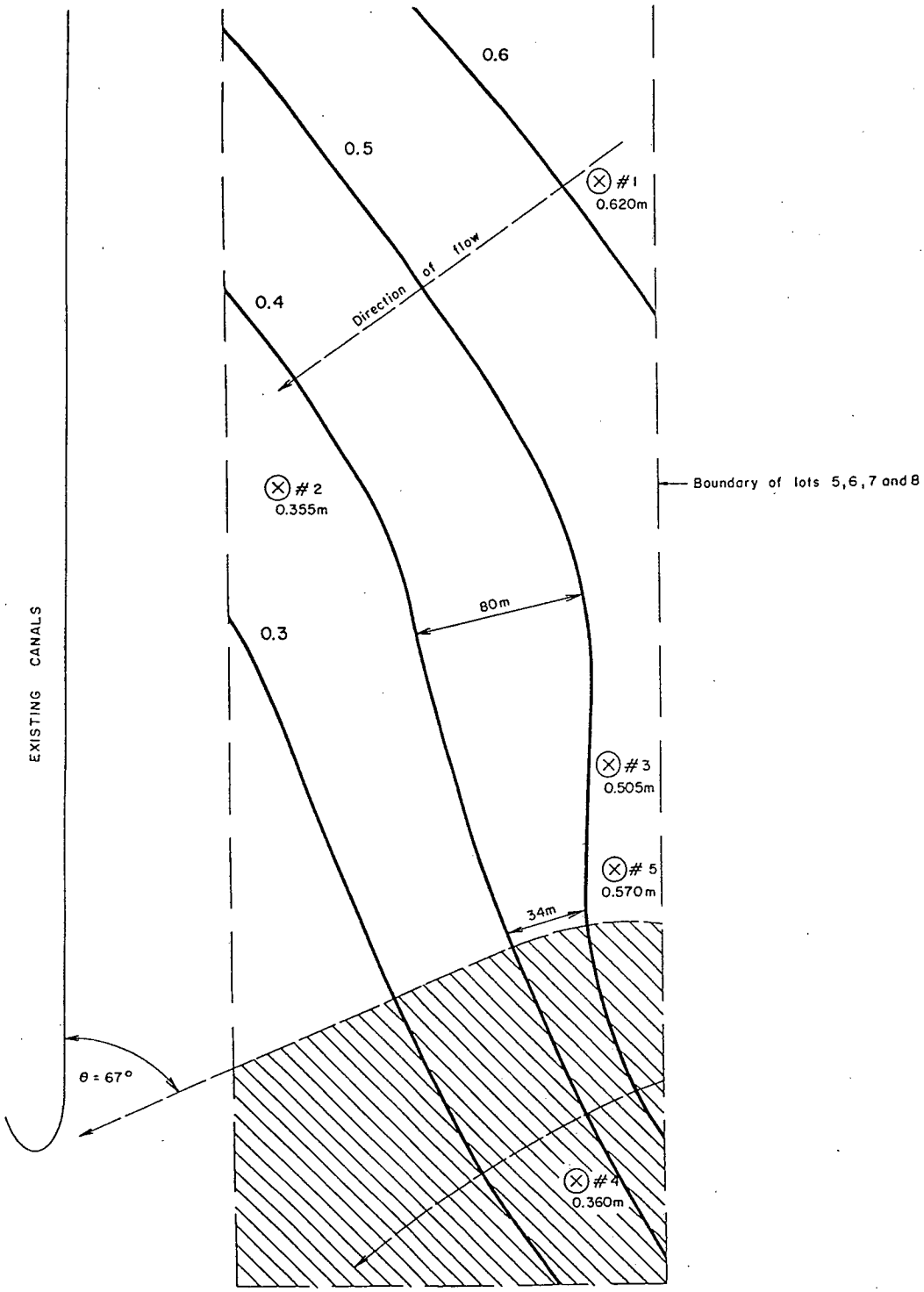
LOCATION OF SOIL SAMPLE AND PIEZOMETER SITES

by Australian Groundwater Consultants Pty. Ltd.

FIG. 4

Dwg. No. 1236 - 1

Date October 1985



PEEL WATERWAYS PTY. LTD.

YUNDERUP CANALS EXTENSION

GROUNDWATER CONTOURS AT SOUTH YUNDERUP ON 8TH OCTOBER, 1985

by Australian Groundwater Consultants Pty. Ltd.

FIG. 5 Dwg. No. 1236-2

Date October 1985

The slope of the groundwater table in the unshaded area varies from 0.0013 to 0.0029. An average value of the hydraulic gradient is 0.002. If it is assumed that this figure is representative of the development site, then a rough calculation of the groundwater flow into the canals can be made by use of the Darcy Equation:

$$Q = KibW$$

where Q = Flow rate (m^3/day)

K = Hydraulic Conductivity (m/day)

i = Hydraulic gradient

b = Thickness of aquifer which contributes to the canals (m).

W = Width of flow path (m).

Black and Rosher (1980) estimated the hydraulic conductivity of the superficial sediments east of Peel Inlet as 5 m/day.

Although the aquifer thickness is not known it is reasonable to assume that the layered nature of the deposits will restrict vertical permeability and therefore in the estimate 2.5m has been adopted as the effective aquifer thickness. The width of flow path is approximately 850m (approaching the canal obliquely). Use of the Darcy Equation indicates an average flow rate of about 20 m^3/day.

$$[Q = 5 \text{ m/d} \times 0.002 \times 2.5\text{m} \times 850\text{m}]$$

Meagher and Associates (1982a) noted that the groundwater flow dropped to negligible rates by December. If the value obtained in October is representative of five months over winter and spring, then the annual groundwater contribution to the canals would be about 3000 m^3.

The total volume of the existing canals is about 126 500m^3 and groundwater would contribute less than 3% of the canal volume over an entire year. Further monitoring of the piezometers would be required to confirm this estimate since the levels recorded on one occasion may not have been typical of the entire winter. It is also important to remember that the inferred contours were drawn somewhat subjectively.

Nevertheless, it is apparent that the groundwater contribution to the canals is relatively small and the canal water is as a result essentially Peel Inlet water. Furthermore water quality data suggest that the canal water is exchanged with Peel Inlet many times throughout the year so that the canal water cannot be considered to be isolated from the main body of Peel Inlet.

SOIL DESCRIPTIONS

Reduced levels are relative to the initial position on the road boundary of Lot 286 which is taken as 2.18m.

Site # 1 - On higher ground on the eastern side of the proposed development (+ 0.830m R.L.)

Surface to 0.3m	Coarse orange sand
0.3m to 0.4m	Dark grey, poorly sorted sand with some organic material. Smells of H_2S.
0.4m to 0.65m	Orange/grey, poorly sorted sand HOLE COLLAPSING AT 0.65m

Site # 2 - on low moist ground near the road. Many small wild-flowers (+ 0.635m R.L.)

Surface to 0.3m	Medium to fine grained, grey sand
0.3m to 0.7m	Coarse, orange sand
0.7m to 0.8m	Fine, grey sand with a trace of clay
0.8m to 1.1m	Poorly graded orange and grey sands
1.1m to 1.2m	Dark grey, fine sand with some clay
1.2m to 1.5m	Poorly graded, orange and grey sands
1.5m to 1.6m	Dark grey, fine sand with some clay
1.6m to 1.75m	Poorly graded, orange with grey sands HOLE COLLAPSED AT 1.75m

Site # 3 - on low ground adjacent to surface water (+ 0.630m R.L.)

Surface to 0.9m	Poorly sorted, grey sand HOLE COLLAPSED AT 0.9m

Site # 4 - within 10m of Lot 9 contains elevated water tanks (+ 0.425m R.L.)

Surface to 0.4m	Brown, poorly graded sand with a trace of clay
0.4m to 0.6m	Poorly graded, orange and white sands with a trace of clay
0.6m to 1m	Poorly graded yellow/orange sand with a trace of clay HOLE COLLAPSED AT 1m

Site # 5 - on the highest ground in the blocks, between # 3 and # 4 (+ 2.275m R.L.)

Surface to 0.05m	Grey and red/brown clay
0.05m to 0.6m	Brown, poorly sorted sand
0.6m to 0.9m	Orange, poorly sorted sand
0.9m to 1.1m	Brown, poorly sorted sand
1.1m to 1.3m	Orange and brown, poorly sorted sands

1.3m to 1.4m	Orange and black sand with some organic material, poorly sorted
1.4m to 1.6m	White, poorly sorted sand
1.6m to 2.0m	Orange, poorly sorted sand
	HOLE COLLAPSED AT 2.0m

GROUNDWATER LEVELS

Reduced levels are relative to the initial survey station on the road boundary of Lot 286 which is taken as 2.18m (interpolated from benchmarks on Kiap Road).

Site	Level on 8/10/85 (m)	Level on 16/10/85 (m)
# 1	0.620	0.590
# 2	0.355	0.245
# 3	0.505	0.500
# 4	0.360	Not available
# 5	0.570	Not available