PORT MANDURAH
STAGE 2

PUBLIC ENVIRONMENTAL REVIEW

APPENDICES

MANDURAH) PTY LTD

APPENDICES

Port Mandurah Stage 2
Public Environmental Review (PER)

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APPENDIX A

Guidelines for the Preparation of the PER

Department of Environmental Protection, 1994

GUIDELINES FOR THE CONSULTATIVE ENVIRONMENTAL REVIEW FOR THE PROPOSED PORT MANDURAH STAGE 2 CANAL ESTATE, MANDURAH

Overview

In Western Australia, all environmental reviews are about protecting the environment, which for this proposal means that the environmental values associated with the land west of the new Mandurah traffic bridge is protected.

These Guidelines have been prepared in response to a proposal forwarded to the Authority by Esplanade (Mandurah) Pty Ltd to construct a new canal estate in the City of Mandurah, adjacent to the Mandurah Inlet Channel. The primary purpose of the Public Environmental Review (PER) is to provide information on the proposal to the Environmental Protection Authority within a local framework. The Authority will assess this information and then provide advice to the Government on protecting the environment. An additional function is to communicate clearly with the public so that the Authority can obtain informed public comment. As such, environmental impact assessment is quite deliberately a public process. It also seeks to inform decision makers, to identify risks and minimise adverse environmental impacts, to achieve environmentally sound proposals through research, management and monitoring, and to manage conflict through the provision of the means for effective public participation.

It is the responsibility of the proponent to design and implement a proposal which protects the environment (ecological and social), and to present this proposal for review. The proponent should describe what is proposed, discuss the potential environmental impacts of the proposal, and then describe how these environmental impacts are going to be managed so that the environment is protected.

These Guidelines have been prepared to assist the proponent in identifying issues which should be addressed within the PER. They are not intended to be exhaustive, and the proponent may consider that other issues should also be considered within the document.

The discussion in the PER should be concise, accurate, and easily understood. Specialist information should be included where it assists in the understanding of technical aspects of the proposal. A copy of these Guidelines should be included in the PER.

Objectives of the PER

The PER should have the following objectives :

- to place this proposal in the context of the local environment;
- to explain the issues and decisions which led to the choice of this proposal at this place at this time;
- to set out the environmental impacts that the proposal may have; and
- for each impact, to describe any environmental management steps the proponent believes would avoid, mitigate or ameliorate that impact.

The PER should focus on the major issues for the area and anticipate the questions that members of the public may raise. Data describing the environment should be directly related to the discussion of the potential impacts of the proposal. Both should then relate directly to the actions proposed to manage those impacts.

Key Issues

Key issues include :

1. Justification

• an evaluation of alternative locations and scales, including discussion alternative options, and constraints associated with other potential sites;
• justification of preferred site, including scale; and
• anticipated use of site and perceived need for a development proposal of this type at this location.

2. Proposal

This should include a discussion of the following points:

• background of proposal (i.e.previously proposed Halls Head Stage 2 Canal Development in 1981);
• precise location;
• size / area of canal estate and associated components (i.e. waterways, foreshore reserve, urban subdivision, marina);
• details of proposed services (roads, sewage disposal);
• source of fill for proposed reclamation of any low lying land;
• construction method of canals (such as use of bund walls to provide barrier between estuary and excavation of canals);
• anticipated construction timetable, including details of proposed staging of development; and
• final proposed land use layout and when this is expected to be achieved in view of proposed staging of development.

3. Existing Environment

• Soils;
• geology;
• groundwater;
• hydrological characteristics of adjacent water body;
• estuarine flora / fauna. This should include a species list and measurements per unit area;
• land use, including past land uses and current reservation ;
• local and regional significance of the land, including recreation, landscape and visual amenity. The proposal needs to be viewed in the context of other similar existing and approved proposed developments in the near vicinity; and
• historical, archaeological and ethnographic sites;

4. Environmental Impacts and Management

The following impacts should be addressed :

• impact of development on estuary foreshore;
• impact on System 6 Recommendation area C. 50 and proposed management of potential impacts associated with adjacent urban development;

• water quality within proposed canals and anticipated flushing characteristics. Reference should also be made to Department of Planning and Urban Development Policy DC 1.8, i.e. details regarding first five years of water quality monitoring (to be prepared in consultation with officers of the Peel Inlet Management Authority), and post five years waterway management responsibilities;
• details of proposed join between existing Stage 1 waterbody and proposed Stage 2 canal waterbody, and associated implications on flushing characteristics;
• effect on water quality within adjacent Mandurah Inlet Channel during construction;
• construction of associated services (roads, power etc.);
• management of adjacent land with established conservation value (System 6 area C.50) in view of staged construction timetable;
• control of traffic and noise associated with construction; and
• construction and operational work-force.

5. Public Participation and Consultation

A description should be provided of the public participation and consultation activities proposed to be undertaken by the proponent following preparation of the PER.

Cross reference should be made with the description of the environmental management for the proposal which should clearly indicate how potential community concerns may be addressed. Where these concerns are dealt with via other departments or procedures outside the Environmental Protection Authority process, these can be noted and referenced here.

6. Detailed list of environmental commitments

The commitments made by the proponent to protect the environment should be clearly defined and separately listed. Where an environmental problem has the potential to occur, there should be a commitment to rectify it. They should be numbered and take the form of:

(a). who will do the work;

(b). what the work is;

(c). when the work will be undertaken; and

(d). to whose satisfaction the work will be carried out.

All actionable and auditable commitments made in the body of the document should be numbered and summarised in this list. For auditing purposes, the commitments should be grouped together in order of timing, i.e.

• pre - construction;
• during construction; and
• post - construction.

APPENDIX B

Environmental Conditions and Commitments for Port Mandurah Stage 1

Minister for the Environment, 1989

Ass # 213

Bull # 378

State # 072

WESTERN AUSTRALIA

MINISTER FOR ENVIRONMENT

STATEMENT THAT A PROPOSAL MAY BE IMPLEMENTED (PURSUANT TO THE PROVISIONS OF THE ENVIRONMENTAL PROTECTION ACT 1986)

PORT MANDURAH CANAL DEVELOPMENT, HALLS HEAD

ESPLANADE (MANDURAH) PTY LTD

This proposal may be implemented subject to the following conditions:

1. The proponent shall adhere to the proposal as assessed by the Environmental Protection Authority and shall fulfil the commitments made and published in Appendix 3 of EPA Bulletin 378 and as subsequently revised (copy of revised commitments attached).

2. The proponent shall design this project to standards (including water quality) which are not less than those contained in "Recommendations for the development of Canal Estates" (June 1984).

3. The proponent shall not cause any unacceptable impacts to occur outside the project site as a result of undertaking dewatering operations for the construction of the proposal. The proponent shall be liable for any such impacts should they occur together with any required remedial action. Additionally, prior to construction, the proponent shall prepare and implement a groundwater monitoring programme of five years' duration, to the satisfaction of the Minister for Environment on advice of the Water Authority of Western Australia. The proponent shall institute remedial action to the satisfaction of the Minister for Environment on the advice of the Water Authority of Western Australia, in the event that monitoring results indicate an adverse effect of dewatering on the environment.

4. The proponent shall connect the public boat wastewater facility to a reticulated sewage system.

Published on 16 AUG 1989

18th FLOOR, ALLENDALE SQUARE, 77 ST GEORGE'S TERRACE, PERTH, W.A. 6000 TELEPHONE 325 8422 FAX 325 5621

5. Prior to construction, the proponent shall prepare contingency plans for the prevention of pollution of the canals in the event of failure of the sewage disposal system, to the satisfaction of the Minister for Environment.

6. Prior to construction, the proponent shall prepare contingency plans for the construction of a hydraulic link to the Mandurah Inlet Channel via Paul Street, to the satisfaction of the Minister for Environment on the advice of the Town of Mandurah as canal estate manager and the Peel Inlet Management Authority. If in the opinion of the Minister for Environment, on the advice of the Town of Mandurah as canal estate manager and the Peel Inlet Management Authority, water quality monitoring results indicate unacceptable water quality in the northern part of the canal development, the proponent shall construct the hydraulic link.

7. If in the opinion of the Minister for Environment, on the advice of the Town of Mandurah as canal estate manager and the Peel Inlet Management Authority, there is inadequate flushing of the canals, resulting in unacceptable water quality, the proponent shall construct an additional canal entrance channel in the south-east of the canal estate to increase flushing rates.

8. Prior to construction, the proponent shall prepare and implement a detailed monitoring and management programme to the satisfaction of the Minister for Environment, on the advice of the Town of Mandurah and the Peel Inlet Management Authority.

   This programme shall include, but shall not be limited to, the following:

   (1) water quality monitoring;

   (2) monitoring of phosphorus and heavy metals in sediments, including release rates;

   (3) observation of fish movements within the canal waterways, undertaken for one year, and subject to review at the end of that year; and

   (4) results of survey and assessment of maintenance dredging works.

   Reports shall be submitted annually, with a comprehensive final report immediately following the termination of the proponent's five year period of management responsibility.

9. The proponent shall employ earth moving methods which minimise noise and dust, and shall stabilise soils during and after earth moving operations associated with the proposed development, and shall undertake rehabilitation and stabilisation of the project site following completion of earthworks.

10. The proponent shall ensure that the floodways and foreshore areas are protected from adverse effects during the construction stage.

11. The proponent shall conduct a survey of the depths of the canals, the entrance channel(s), and the adjacent Mandurah Inlet Channel to the satisfaction of the Peel Inlet Management Authority, on advice of the Town of Mandurah as canal estate manager and the Department of Marine and Harbours within one month of the completion of the canal construction, and shall repeat the survey of required sections annually for five years.

    Additionally, the proponent shall, during the five-year period of responsibility, carry out any maintenance dredging of the canals and entrance channel(s), to the satisfaction of the Minister for Environment on the advice of the Town of Mandurah as canal estate manager, the Peel Inlet Management Authority and the Department of Marine and Harbours. The proponent shall include the results of the survey and an assessment of maintenance dredging works in the annual monitoring report (see Condition 8).

12. The proponent shall, during the five-year period of responsibility, maintain sections of the adjacent Mandurah Inlet Channel that are affected by the canal development, to the satisfaction of the Minister for Environment, on the advice of the Peel Inlet Management Authority and the Department of Marine and Harbours.

13. No transfer of ownership, control or management of the project which would give rise to a need for the replacement of the proponent shall take place until the Minister has advised the proponent that approval has been given for the nomination of a replacement proponent. Any request for the exercise of that power of the Minister shall be accompanied by a copy of this statement endorsed with an undertaking by the proposed replacement proponent to carry out the project in accordance with the conditions and procedures set out in the statement.

Bob Pearce, MLA
MINISTER FOR ENVIRONMENT

15 AUG 1989

PORT MANDURAH PROJECT

SUMMARY OF UNDERTAKINGS MADE BY

ESPLANADE (MANDURAH) PTY LTD

IN ENVIRONMENTAL REPORT & MANAGEMENT PROGRAMME

AND IN NOTICE OF INTENT

THAT ARE RELEVANT TO STAGE 1 OF DEVELOPMENT

1. UNDERTAKINGS RELATING TO WATER QUALITY

1.1. If at any time before the Date of Handover the Water Quality Test indicates that a deterioration in the quality of water in the Canals has occurred or is likely to occur so that the quality of water in the Canals is or is likely to be significantly less than that existing in the Mandurah Estuary in the vicinity of the Canals, but at points beyond the significant influence of the Canals selected by the Town of Mandurah, and in the opinion of the Town of Mandurah remedial action is or may be necessary, then within seven (7) days of the receipt of written notice from the Town of Mandurah of that opinion the Developer will initiate a study to determine the cause of the deterioration in water quality and within thirty (30) days of receipt of the written notice submit a written report to the Town of Mandurah outlining the cause or causes of deterioration in water quality and a recommended course of action to improve the quality of water in the Canals. If following consideration of this report the Town of Mandurah considers action is needed to improve the water quality in the Canals then within seven (7) days of receiving written notice from the Town of Mandurah specifying the works required the Developer shall commence to carry out the works specified in the notice and shall complete these works within a reasonable period of time specified in the notice. [DWIM 3.1]

1.2 If the works or other action referred to in Clause 3.1 do not improve the water quality in the Canals to the levels specified in the Management and Monitoring Programme the Town of Mandurah may by a further notice in writing to the Developer require the Developer within the period stipulated in that notice (not being less than thirty (30) days after receipt by the Developer of that notice) commence to construct a through canal beneath the Bypass Road shown on the Concept Development Plan connecting with the Mandurah Estuary at the location specified in the notice and the Developer shall comply with and observe the requirements of the notice within the period stipulated in it. [DWIM 3.2]

1.3 The Developer shall prior to seeking clearances of survey documents for Stage 1 of the Project lodge with the Town of Mandurah a Bank Guarantee in favour of the Town of Mandurah to secure the due and punctual performance and observances by the Developer of the obligations contained in Clauses 3.1 and 3.2 and the Bank Guarantee shall be for an amount of TWO HUNDRED THOUSAND DOLLARS ($200,000.00) subject to the provisions of Clause 7 hereof. [DWIM 3.3]

2. UNDERTAKINGS RELATING TO SEDIMENTATION

2.1 The proponent undertakes to carry out a long term sediment sampling programme, as detailed in the proposed Environmental Monitoring Programme (Appendix A (ii), NOI)

This sediment monitoring programme will be aimed at documenting nutrient and metal characteristics of sediment in the canals;

An additional survey line will be added to the sediment monitoring programme, as requested by the Department of Marine & Harbours.

2.2 If at any time before the Date of Handover the Town of Mandurah is of the opinion that the Project has caused an undesirable impact on sediment transport within the Mandurah Estuary which can be reasonably considered to have been caused by or to be attributable to the Project or any stage of it or the construction of the Project or any stage of it the Developer shall within seven (7) days of the date of receipt of written notice from the Town of Mandurah of its opinion in that behalf initiate a study to determine the cause of the undesirable impact on sediment transport within the Mandurah Estuary and within thirty (30) days of receipt of the written notice submit a written report to the Town of Mandurah outlining the causes of any undesirable impact on sediment transport within the Mandurah Estuary caused in the manner mentioned above and a recommended course of action to improve the quality of the same.

If following consideration of the report mentioned in this clause the Town of Mandurah considers action is needed to improve the sediment transport within the Mandurah Estuary where it has been considered to have been affected by or attributable to the Project or any stage of it or the construction of the Project or any stage of it then within seven (7) days of receiving written notice from the Town of Mandurah the Developer shall commence to carry out the works specified in the notice and shall complete the same within a reasonable period of time specified in the notice. [DWIM 4.3]

3.5 It is planned to conduct the bulk of the excavation during the winter months thereby minimizing dust and the effect of any dewatering operations on the shallow reticulation bores of neighbouring residences. [NOI 9.1.1]

3.6 [RESPONSES TO SUBMISSIONS]
The proponent undertakes to construct a deep cut off barrier around the perimeter of Mary Street near the proposed public open space to help contain the freshwater mount to the west of the barrier. Accordingly, excavation for the sewer reticulation will extend to a depth of 4.7 to 6.0m AHD.

As soon as the line has been laid and tested an impermeable PVC membrane will be draped over the side of the excavation and the trench back-filled with at least 600mm thickness of clay immediately inside the membrane, to further ensure that an effective and permanent water barrier is constructed.

It is proposed that the abovementioned sewerage reticulation and barrier be constructed as soon as possible after construction on site commences. If the Water Authority approves the use of a vacuum sewerage system in lieu of a deep sewerage system an alternative cut off barrier will be constructed in accordance with plans and specifications approved by the Water Authority and the Environmental Protection Authority.

If necessary, remedial action approved by the Water Authority and the Environmental Protection Authority will be instituted to ensure that the location of the fresh/salt water interface is maintained at an acceptable distance from the closest property boundary. [NOI 2.3]

5.7 The proponent undertakes to make allowance for maintenance dredging of the canals every 15 to 20 years. As stated in the proposed Monitoring and Management Programme (Appendix A, NOI)

5.8 The proposed waterway system will be ceded free of cost to the Crown. [NOI 4.1.4]

6.9 The Developer shall repair or cause to be repaired all Canal wall structures and Culverts to a standard commensurate with the Specifications and Drawings until the Date of Handover but nothing contained in this sub-clause obliges the Developer to undertake any repairs to Canal wall structures or Culverts which are directly attributable to Lot owners, boat owners, vandals or any other person or corporation not being an employee, agent, contractor or sub-contractor of the Developer and which cannot be directly attributed to any fault in workmanship or design of the walls or culverts. [DWIM 4.4]

6.10 Monitoring of the condition of the vertical rock sea walls adjacent to the entrance channel will be carried out on an annual basis to identify and record any scour occurring at the base of the vertical and rock sea walls, as stated in the proposed Monitoring and Management Programme (Appendix A, NOI)

Further a monitoring procedure will be carried out to confirm that the design and construction of the walls and scour protection material is satisfactory. [M&MP 2.1.2]

The Monitoring will include diving inspections.

6.11 Vertical and Sea Walls will be, where required, provided with scour protection material at their toe and will be designed such that minimal maintenance through scour action is anticipated over the next thirty to fifty years. [M&MP 3.2.3]

8. UNDERTAKINGS RELATING TO NAVIGATION AIDS

8.1 Navigation aids as required by the Department of Marine & Harbours will be provided by the proponent prior to the opening of the canals for boat traffic. [ERMP 4.3.3]

8.2 Once constructed and accepted by the Department of Marine and Harbours, servicing and maintenance of Navigation Aids will be the responsibility of that Authority. The design and construction of Navigation Aids will be required to be carried out in accordance with standards set by the Department of Marine and Harbours. [M&MP 3.2.5]

8.3 The proponent undertakes to ensure that the proposed channel beacons comply with Department of Marine & Harbour standards. The beacons will then be maintained by that Department. [M&MP 4.3]

10. UNDERTAKINGS RELATING TO MONITORING FOR FISHERY IMPACT

10.1 The proponent undertakes to carry out monitoring of impact on fisheries as detailed in the proposed Environmental Monitoring Programme. [Appendix A(ii) NOI]

12. PLANNING UNDERTAKINGS

12.1 The proponent undertakes to ensure that within the project area the number of residential units shall not exceed 12.5 units per gross hectare. (The gross area being defined as the total land area included within the project development). [ERMP 4.1.7]

13.4 In carrying out the Project and each stage thereof and all works in connection therewith respectively the Developer shall comply with and observe -

(a) the provisions and requirements of the Town of Mandurah Town Planning Scheme No 1A, the Local Government Act 1960, the Health Act 1911, the Waterways Conservation Act 1976 and all other relevant statutes, regulations, by-laws and orders;

(b) all conditions imposed by the Town of Mandurah in granting its development consent prior to the Date of Practical Completion except to the extent that any condition imposes continuing obligations. [M&MP 2.2]

14.7 The unsightliness of the earthworks during the construction phase will be minimized through proper control and the placement and shape of excavated material and by reducing the time taken for the construction stages through efficient planning and management.

Where the general public may be at risk because of construction work acceptable safety systems will be adopted. (Fencing, signage, lighting etc). [ERMP 5.2.9]

14.8 A dust suppressing media will be utilized during all operations as necessary, to prevent dust being a nuisance to the public. [NOI 2.6]

14.9 Extreme care will be taken to ensure that there is no nuisance caused to neighbouring residences due to dust. Water carts for watering all internal haul roads together with the progressive use of a dust suppressing agent will ensure that any effect on neighbouring residences is kept to an absolute minimum. At the completion of each section of earthworks the exposed areas will be seeded with suitable grass seed and coated with either a papermache mulch or biodegradable dust suppressing agent so that as soon as possible adequate ground cover is established to provide a permanent safeguard against wind borne dust. As services are progressively constructed on the completion of major earthworks all areas effected by these services will be made good. [NOI 9.1.2]

14.10 The vibration effects of construction plant on the surrounding properties will be monitored during construction and methods of operation and plant usage will be adjusted if necessary to ensure minimum inconvenience to neighbouring properties. [NOI 2.6]

14.11 The contractor for both the earthworks phase and the subsequent road construction phase of the project will be required to conduct a survey of all adjacent residences particularly those on McLarty Road and Leighton Road prior to any compaction work commencing. This survey will include photographic records as appropriate so that should a dispute arise with any of the residents in regard to vibration caused damage, the matter will be more easily resolved. [NOI 9.1.4.]

14.15 UNDERTAKING IN RELATION TO STATUTORY APPROVALS

The proponent undertakes that the design and documentation of all services and structures associated with the development will be submitted to the relevant Authorities and all necessary approvals and licenses will be obtained prior to any construction work commencing on site.

16. UNDERTAKINGS RELATING TO EXCESS SPOIL FROM EXCAVATION

16.1 Excess spoil resulting from the development of Stage 1 will be disposed of to:

a) Town of Mandurah for building up the adjacent parks.

b) Town and Country for top dressing areas of their land covered with surface rock.

c) To adjacent land owners requiring fill.

d) Any surplus spoil will be stored on the areas set aside for future development and will be stabilized to the satisfaction of the relevant Authorities. [ERMP 4.1.13]

18. UNDERTAKINGS RELATING TO BRIDGES

18.1 The bridge as proposed in the Notice of Intent will be built in accordance with plans and specifications approved by the relevant Authorities. [ERMP 4.1.9]

20. UNDERTAKINGS RELATING TO DRAINAGE

20.1 The proponent undertakes to adopt measures to ensure that there will be minimal detrimental effect to the environment through changes to the drainage pattern of the area and the new drainage systems proposed. [ERMP 5.1.1]

20.2 The design and construction of stormwater runoff and drainage will ensure that drainage and erosion will not be a problem. [ERMP 6.2.5]

20.3 A covenant will be placed on all lots ensuring that all canal frontages are grassed or otherwise landscaped to ensure soil stability during a rare flooding. [NOI 4.2.1]

20.4 Road drainage will be constructed in accordance with plans and specifications approved by the relevant Authorities including the Town of Mandurah. [ERMP 4.1.10]

20.5 Runoff generated from the development proposed will be disposed of primarily by means of absorption through properly designed sumps, soakwells and leach drain systems fitted with appropriate traps and separators. The designs will ensure that direct runoff into the waterway system will be absolutely minimal and where it is permitted the water disposed of will not contain harmful pollutants. [ERMP 5.1.1]

20.6 The proponent will place a covenant on each lot title requiring the owner of the lot to dispose of normal stormwater drainage from the dwelling via soakwells and/or leach drains into the sub soil. [NOI 2.5]

20.7 The drainage from typical lots will be split into several sections as follows:

(a) The roof of the house will be drained into standard soakwells and/or leach drains with any overflow running into the street drainage system.

(b) The front portion of the block will drain directly to the road reserve and then to the roadway from whence it will discharge to the normal trapped street gullies and then via trapped manholes to the waterway system.

(c) The remainder of the block will drain to the walkway which in turn will drain via "no fines" concrete spoon drains. [NOI 7.3]

20.11 Maintenance of Drainage Walkways

During the maintenance period the proponent will periodically inspect the drainage walkways behind the canal walls to ensure that the lot owners are keeping them free of silt. Such inspections will be relatively frequent up to the time houses are established on lots and gardens have been established on the steep slope situated between the walkway and the rear building line. After the slope has been stabilised with landscaping the need for maintenance will be infrequent. The need to clean the spoon drains when they become blocked will be obvious to property owners as irrigation water, or light rainfall would cause the walkway to have puddles of water which would hinder the use of the walkway for access to jetties. Furthermore,as the walkways would be continuous and only separated by fences constructed over them, excess water would flow into neighbouring properties whose owners would obviously complain to the offender. [M&MP 3.2.7]

20.12 The proponent, as part of its maintenance obligations, will check that porous spoon drains have not been blocked by silt. [NOI 7.3]

22. UNDERTAKINGS RELATING TO RUBBISH REMOVAL

22.1 The cost of rubbish removal from canals will form part of the annual management cost levied on an annual basis on the property owners within Stage 1 by the Waterways Manager.

22.2 The proponent undertakes to carry out rubbish removal from the canals as described in the Monitoring and Management Programme [Appendix A, NOI]

23.3 The Parkway Road linking Mary Street to Old Coast Road discussed this section has already been constructed. The proponent undertakes to landscape this parkway with irrigated grass and an avenue of trees on each side and to provide a pedestrian and cycleway system through the parkway during the first stage of development. [ERMP 5.2.8]

23.4 The land to be vested under Section 20A of the Town Planning & Development Act for public recreation purposes is to be landscaped by the company in accordance with a landscaped plan prepared by the company in liaison with the council. [ERMP 6.2.2]

23.5 The proponent undertakes to have cuttings taken of the saltwater paperbarks situated in the north western corner of the development area and have them propagated by a competent nursery, so that clones of the existing plants can be used for landscaping throughout this development.

24.5 A pedestrian/bicycle facility will be provided as part of the development. The facility will link the development to the Village Centre, the Inlet Foreshore, bridge approaches to the Mandurah Town Centre and the existing Halls Head Settlement. [ERMP 4.2.1]

24.6 Historical Place lots will be created as separate lots and transferred to the National Trust or the Crown (or the Mandurah Historical Society under current proposals). The proponent has already agreed to pass ownership of Halls Cottage to the Mandurah Historical Society by a Deed of Gift once the cottage has been subdivided onto a separate lot. In the meantime, the cottage is being leased by the Historical Society on a peppercorn rental basis. [ERMP 4.2.5]

The results of monitoring which will be reflected in Annual Reports may lead to modifications to ongoing monitoring programmes or to detailed designs for future stages of development. [M&MP 1.0]

Should assessment of monitoring reveal the need for management programmes to be implemented then at that time programmes will be developed in close liaison with the Environmental Protection Authority. Management provisions must be made flexible in terms of man power and funding to allow management efforts to be concentrated on each problem as it arises. [ERMP 2.6]

25.2 A simple monitoring programme will be conducted on an annual basis to monitor the:

* Condition of the vertical and rock sea walls;
* Scour at walls;

and

* Sedimentation in the canal estate and at the Northern Entrance.

Sedimentation would be monitored by surveying with level and staff where possible and by echo sounder or lead line in deeper areas.

Survey cross sections would be run in the same locations each year, as indicated on Plan No. 3 in the Monitoring and Management Programme. [Appendix A, NOI]

Monitoring of the conditions of moorings, vertical walls, and rock sea walls would include diving inspections. The results of the monitoring would be used to decide on design parameters for later stages in the development. Where possible photography would be used to keep a record of structure performance.

25.3 Monitoring programmes will be undertaken by the company, primarily as a check on design and construction methods.

Assessment of monitoring results and subsequent periodic reporting to the Environmental Protection Authority will be undertaken. [ERMP 6.1]

25.10 The proponent agrees to the Date of Handover to the Waterways Manager being five (5) years after the Date of Practical Completion of the Canals. [DWIM 10.0]

25.11 The proponent undertakes to conform with these undertakings or any modification to the monitoring and management programme required by the responsible Authority and/or the Environmental Protection Authority. It also undertakes not to vary the Monitoring and Management Programme without the prior approval of the relevant Authority and the Environmental Protection Authority.

APPENDIX C

Rate Payer Referendum

City of Mandurah, 1990

CITY OF MANDURAH

MEDIA RELEASE

14th November, 1990.

RESULTS of the Port Mandurah Canal Referendum, commissioned by the Mandurah City Council in November of last year, were today released by the City's Acting Mayor, Joy Carter.

"Council is extremely pleased with the level of reponse to the referendum, which leaves no doubt that Mandurah's electors are in favour of proceeding with stage two of the Port Mandurah development," Cr Carter said.

"It is also encouraging to note that those who stood to be most affected, the Town Ward electors, have voted in favour of the the development," Cr Carter explained.

Town Ward electors produced "the most favourable response towards the canal development proceeding", according to the final report compiled and supplied to Council by the Marketing Centre.

The combined results of the two phases of the survey showed that 62.3 per cent of the Town Ward electors returned a 'Yes' vote.

A 53.42 percent 'Yes' vote was returned by Coastal Ward electors, while the Outer Ward showed that 54.15 were in favour.

"The referendum was undertaken in two phases during the months of September and October.

"Phase one was a personal survey of electors and phase two was a postal survey of the remaining electors," Acting Mayor Carter explained.

The households at which personal interviews were conducted were selected by computer from existing electoral rolls, with 400 such households being selected as 'starting points'. From these points, four adjoining households were also surveyed, resulting in a sample of 3,436 electors being personally interviewed.

Two follow-up calls were made to homes where electors had not been available at the initial approach and in instances where the registered electors were not available following these three calls, a postal ballot was then sent to that household.

Replacement personal interviews were then obtained from the next adjoining household.

All enrolled electors, whether living in Mandurah or elsewhere, who had not participated in the personal survey, were mailed a response form.

"In determining the methodology proposed for the survey, Council agreed that the outcome would be determined by comparing only the YES and NO responses from both personal and postal surveys.

"Neutral responses in both phases were removed for the purpose of determining the results", Cr Carter explained.

A notable feature of the postal survey was that 10,377 response forms were returned from the 26,588 electors who were not interviewed in the personal survey.

This represented a significant 39 per cent response rate.

"In determining the guidelines under which this referendum was to be conducted, Council was well aware that postal surveys can be biased, in that they attract responses largely from extreme views and the silent majority who fail to respond," Cr Carter said.

"This is where the results of the personal surveys proved invaluable as they provided an accurate basis of information upon which to assess the extent of any bias in the postal survey responses," Cr Carter said.

Applying this method, 57.1 per cent of electors showed approval for the next stage of the Port Mandurah development. Breaking this down even further, each of the three Wards within the Municipality all individually show support for the project.

"The survey has been conducted under the most rigorous approaches and approved by the Australian Bureau of Statistics.

"Results show a clear majority of electors are in favour of the project and have provided a firm basis which will enable Council to determine the rezoning issue and it is at this point that the public still have the right to make submissions on the zonings which are proposed.

"Development is then another matter, and Council will deal with zoning amendments and plans as they are submitted by the developer, at which time it will then be appropriate for Council to impose conditions under which development approval may be granted," Cr Carter said.

.....ENDS.

APPENDIX D

Evaluation of Groundwater Conditions Near Port Mandurah Canal Estate Stage 2

Dames & Moore, 1995

REPORT ON

GROUNDWATER ASPECTS FOR

PUBLIC ENVIRONMENTAL REVIEW

PORT MANDURAH CANAL ESTATE STAGE 2

for

Cedar Woods Properties Limited

DAMES & MOORE

February 1995

DK:178-8457/PER

Job No. 23917-012-366 Revision 2

4 April 1995

Bowman Bishaw Gorham
1298 Hay Street
WEST PERTH WA 6005

Attention: Ms Beverley Walker

Dear Ms Walker

REPORT ON
GROUNDWATER ASPECTS FOR
PUBLIC ENVIRONMENTAL REVIEW
PORT MANDURAH CANAL ESTATE STAGE 2

We enclose one unbound copy of the above report, revised as requested.

Yours sincerely
DAMES & MOORE

R.J. McGowan
Consultant-in-Charge
Water & Waste Management

JCB:sor/23917-012-366/DK:178-8457/PER

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REPORT ON
GROUNDWATER ASPECTS FOR
PUBLIC ENVIRONMENTAL REVIEW
PORT MANDURAH CANAL ESTATE STAGE 2

1.0 INTRODUCTION

1.1 GENERAL

The second stage of the Port Mandurah canal estate is proposed for the eastern side of the Halls Head peninsula, alongside the Mandurah Estuary. This stage of the development will cover about 95ha and represents the southward extension of the existing Port Mandurah canal estate (Stage 1). The walls of the canals will be permeable, and will not form a barrier to groundwater movement; the maximum depth of the canals is to be 2.7m below AHD. The development is being undertaken by Cedar Woods Properties Limited.

Dames and Moore have been commissioned by Cedar Woods Properties Limited to report on groundwater aspects of the development, as part of a Public Environmental Review document being prepared by Bowman Bishaw Gorham.

The scope of this report comprises a description of the existing groundwater regime, and a discussion of the predicted effects of the development on that regime, both during and after construction. Recommendations are made for monitoring and management of the predicted effects.

1.2 DATA BASE

Data relevant to the existing groundwater regime have been obtained from hydrogeological and environmental studies prepared for previous Environmental Review and Management Programmes and Notices of Intent in the region, and from reports, maps and borehole information held by the Geological Survey Division of the Department of Minerals and Energy. Electric friction cone penetrometer test data for the development area have also been examined.

A census of domestic bores has been carried out immediately to the west of the proposed development, in the area where the groundwater regime might be affected by canal construction.

Water-level and water quality data is available from 1987-1988 and 1991 (Rockwater, 1989, 1992) and 1993 (Dames & Moore, 1994), from 25 monitoring bore sites. More recent monitoring carried out by Dames & Moore since 1993 is also incorporated in this report. Monitoring bores ED1-ED18 were constructed in 1981, bores ED19-25 in early 1987.

1.3 TOPOGRAPHY AND SURFACE DRAINAGE

The development site occupies low-lying ground on the western side of the Mandurah Estuary, and is bounded by Mary Street to the north, McLarty Road and a section of the Old Coast Road between McLarty Road and Leisure Road to the west and by Leisure Road to the south. The site has a general elevation of 0.3 - 0.6m AHD east of the Old Coast Road and 1.0 - 1.5m AHD west of the Old Coast Road. The site is bounded on the west by the ridge of the Halls Head peninsula, which rises to a maximum elevation of about 25m AHD about 1km to the west of the site.

There is no defined surface drainage on the development site. The ridge to the west is covered with permeable sand which allows percolation of all incident rainfall, so that runoff to the development site is negligible. The surface of the development site itself is less permeable, so that local ponding may occur after heavy rains, but no defined drainage channels are evident. The ponded water either evaporates or percolates to the shallow water table. Stormwater drainage from the Halls Head residential development has been diverted onto the site since 1987, via a culvert under the Old Coast Road.

The natural drainage of the area east of the Old Coast Road has been modified by the construction of levee banks to reduce salt water flooding, and by excavations for marl pits.

2.0 GEOLOGICAL SETTING

The development site is underlain by superficial formations which in turn overlie the Leederville Formation. The superficial formations consist of estuarine and marine sediments overlying the Tamala Limestone. An east-west geological cross-section across the site is given in Figure 1.

The estuarine/marine sediments are generally 4-5m thick over the development site, but may be up to 10m thick in places towards the Mandurah Estuary. They consist of a complex sequence of organic clay, silt, grey fossiliferous limestone, sand and clayey sand, which wedges out against the ridge on the west side of the site. Figure 1 indicates a thickening of the marine/estuarine sediments towards the Mandurah Estuary, cutting out the Tamala Limestone completely on the east; it is not known whether this is a local occurrence, or whether it represents a general deepening of these sediments towards the estuary.

Electric friction - cone probes encountered refusal at shallow depth (1.9 - 2.8m) on the eastern side of the old Coast Road, within the development site. This may represent either fossiliferous limestone within the estuarine/marine deposits, or an area of shallow Tamala Limestone.

The Tamala Limestone consists of calcareous sand with irregular patches, layers and lenses of calcarenite and sand. On the ridge to the west of the development site the upper part of the Tamala Limestone has been leached of calcium carbonate, to form an upper layer of quartz sand some 5-8m thick. The top of the limestone, beneath the quartz sand and the marine/estuarine deposits, is indurated in places, forming a hard caprock with a pinnacled upper surface. Hard limestone was encountered on the site during drilling at 11.8m in Bore ED5, and at 6.0m in ED9.

The Tamala Limestone unconformably overlies the Leederville Formation; the contact is uneven, but is generally at about 8-9m below AHD. The Leederville Formation consists of siltstone and shale, which forms an impermeable substrate to the superficial formations.

3.0 HYDROGEOLOGICAL ENVIRONMENT

3.1 GENERAL

Groundwater occurs in both the superficial formations, and in the Leederville Formation.

Groundwater flow in the superficial formations is towards the Stage 1 canals in the northeast, from a groundwater divide to the west of McLarty Road. The flow direction was originally reported (Halls Head Waterways ERMP, 1981) to be towards the east, so that the flow direction has apparently been modified by the construction of the Stage 1 canals. The canals would have provided a closer zone of discharge and a shorter flowpath through the estuarine/marine deposits than was available under the previous groundwater regime.

The water-table below the development site is at shallow depth, 1-2m below ground level, and the groundwater is generally brackish to saline. To the west of the site, below the ridge of Tamala Limestone, a lens of fresh groundwater, several metres thick, overlies brackish groundwater at depth. A small number of domestic bores tap this fresh groundwater for garden use.

The Leederville Formation is a regionally important artesian aquifer, which is confined by an upper sequence of siltstones and shales in the vicinity of Mandurah. In the Mandurah area the upper part of the Leederville Formation contains only brackish to saline groundwater, with fresh groundwater at a depth of over 100m. The potentiometric head in the Leederville Formation is about 6-7m above AHD, so that groundwater in a bore drilled into the formation will naturally rise to that level.

The Leederville Formation will not be affected by the development, and is not considered further in this report.

3.2 SUPERFICIAL DEPOSITS

3.2.1 Water - Levels and Seasonal Variations

Water-levels beneath the development site are within 2m of the ground-surface, ranging from 0 to 0.9m AHD. Near the estuary the levels are affected by tidal influence, and may sometimes be down to 0.4m below AHD.

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

3.2.2 Recharge and Water-Table Configuration

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

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

3.2.3 Water Quality

The original water salinities, recorded during drilling of monitor bores ED1-ED10 in 1981, showed that the groundwater was generally saline beneath the development site, except for a lenticular body of fresh water at the western side, centred on Bore ED9. This freshwater lens is underlain by brackish water towards the base of the Tamala Limestone (Figure 2).

Recent monitoring results, shown as profiles of electrical conductivity in Appendix A, confirm the regional pattern shown by the original drilling. Seasonal fluctuations in electrical conductivity (EC) by a factor of 2-3 reflect recharge from winter rainfall. EC measurements in microsiemens/cm can be converted to approximate salinity in mg/L Total Dissolved Solids, by multiplying EC by 0.65.

Private bores, tapping the fresh water in the upper part of the Tamala Limestone, show a similar seasonal fluctuation (Appendix A).

Nutrient levels in groundwater in the vicinity of the development site, namely nitrate and phosphate, are generally low, as shown in Table 1. Elevated phosphate levels were recorded in samples taken in 1981 from Bores ED3 and ED4. ED3 is located in Joseph Cooper Park and ED4 on a previously farmed property, so that leaching of phosphate fertiliser almost certainly accounts for these elevated levels.

TABLE 1

ANALYSES OF NUTRIENTS IN GROUNDWATER

Parameter	Date	Bore									
		ED2	ED3	ED4	ED5	ED6	8 Arundel	4 Carina	11 Carina	22 McLarty	1 Tallwood
N	June 1981	0.39	0.70	0.78	0.31	0.31					
NO_3	19.6.90								5.1		3.7
	17.12.90						24.9		0.9	0.1	2.2
	3.5.91						16.8		4.1	0.2	2.4
	23.4.93						15	10			
	21.12.93						0.5	8.0			
	3.8.94						13	9.3			
	16.1.95							8.5			
P	June 1981	0.08	1.38	4.65	0.08	0.08					
PO_4	19.6.90								<0.1		<0.1
	17.12.90						<0.1		<0.1	<0.1	<0.1
	3.5.91						<0.1		<0.1	<0.1	<0.1
	23.4.93						<0.05	<0.05			
	21.12.93						<0.05	<0.05			
	3.8.94						<0.05	<0.05			
	16.1.95							<0.05			

3.2.4 Hydraulic Parameters

Pumping tests were carried out in connection with the 1989 Notice of Intent for the Port Mandurah Development, at sites ED21 and ED22. The results indicated hydraulic conductivity of 3.5m/day for the upper part of the Tamala Limestone, and 90m/day for the lower part. Specific yield values of 0.11 and 0.19 were obtained for the Tamala Limestone from two observation bores at Site ED22.

The hydraulic conductivity of the estuarine/marine deposits is unknown, but would be expected to range from less than 1m/day for the silt and clayey sand, up to about 10m/day for the sand and calcarenite, with an average for the whole sequence of about 5m/day.

3.2.5 Throughflow

Throughflow can be estimated by means of the formula:

$$Q = Kbil$$

where: Q = throughflow (m^3/day)
K = hydraulic conductivity (m/day)
b = aquifer thickness (m)
i = hydraulic gradient (dimensionless)
l = length of cross-section (m)

The most recent water levels, for August 1994 and January 1995, indicate a hydraulic gradient averaging about 7×10^{-4} in the vicinity of McLarty Road.

Throughflow into the section northwest of the Old Coast Road will be by way of the Tamala Limestone, along about 1,000m of cross-section at right angles to the flow-direction, giving an estimated throughflow, for an average Tamala Limestone thickness of 9m, of 315m^3/day. An average hydraulic conductivity of 50m/day is assumed for the Tamala Limestone.

Throughflow into the section southeast of the Old Coast Road will be by way of the more permeable lower part of the Tamala Limestone and through estuarine/marine deposits, along a 800m length of section. Assuming an average of 4m of limestone with hydraulic conductivity of 90m/day, and 5m of estuarine/marine deposits with hydraulic conductivity of 5m/day, the estimated throughflow for this section is 215m^3/day.

Total throughflow for the entire site is therefore estimated at 530m^2/day.

3.2.6 Saltwater Interface

The present position of the saltwater interface is about 150m east of McLarty Road (Figure 2). The interface is a broad zone of diffusion, rather than a sharp boundary, and is maintained in its present position by the fresh groundwater lens in the Tamala Limestone on the western boundary of the site.

3.2.7 Domestic Usage

A census of domestic bores to the west of the development site, within 200m of McLarty Road, was undertaken on 8-9 February 1995, in the area south of Arundel Drive.

Of a total 113 properties surveyed, the following results were obtained:

No bore	-	75 properties
Unknown (not at home)	-	30 properties
Bore confirmed	-	5 properties
Bore reported (by neighbour)	-	3 properties

Full details of the census are given in Appendix B.

Assuming the same proportion of bores for the unknown properties, a total of 11 bores would be expected. In addition, there are 9 bores known from a previous census in the area north of Arundel Road, which might be affected by the Stage 2 development. A total of 20 domestic bores is therefore known to exist within the potential radius of influence of the development.

3.2.8 Groundwater-dependent Vegetation

There are stands of trees within the Castle Fun Park, just outside the southwest boundary of the proposed development site, and also in the southeast corner of the site itself. These trees probably depend on a thin layer of fresh-brackish groundwater overlying generally saline groundwater, and may therefore be affected by canal construction.

The Castle Fun Park is understood to be scheduled for redevelopment, and will be cleared of trees in the near future. The trees in the southeast may have to be maintained by watering during any summer period when canals are being constructed, as may the Norfolk Island Pines near Sutton Farm.

4.0 EFFECTS OF CONSTRUCTION PHASE ON GROUNDWATER REGIME

4.1 EFFECT ON WATER RESOURCES

The groundwater beneath the development site is generally brackish to saline, so that no significant groundwater resources will be affected by canal construction.

Dewatering of canal excavations will induce a temporary lowering of water levels in the vicinity, which may affect the few domestic bores to the west of the site. This is discussed in more detail in Section 4.3 below.

4.2 POSITION OF SALTWATER INTERFACE

The introduction of seawater into the completed canals will induce a progressive westward migration of the saltwater interface, which is at present located about 150m west of McLarty Road. The modified position of the interface, following construction of the canals, is given in Section 5.2. During the construction phase itself, the westward movement of the interface will be delayed by the effects of dewatering.

4.3 RADIUS OF DEWATERING EFFECT ON DOMESTIC BORES

Dewatering of the canal excavations will cause a lowering of water levels in the general vicinity. The magnitude of this drawdown effect has been simulated using a simple computer model (Walton B8, single-layer aquifer, uniform properties). The radial effect of lowering water levels by 3m at a series of point-sinks, 10m apart, has been assessed, to simulate dewatering of the canal excavations to 2.7m below AHD by means of sumps along the base of the excavations.

A transmissivity value of $15m^2$/day has been used in the model, corresponding to 3m thickness of estuarine/marine sediments with average hydraulic conductivity of 5m/day. A value of 0.1 has been used for specific yield.

The estimated drawdown after a period of 120 days is given on Figure 5, which shows that a drawdown of about 1m will be induced at a distance of 100m from a dewatered excavation, and drawdown of about 0.4m at 200m distance. Such drawdowns may affect domestic bores, particularly within 100m, in both quantity, by reducing the available drawdown, and quality, by reducing the thickness of the freshwater layer above the underlying brackish water. If the dewatering is carried out in winter there would be no significant effect on domestic bores, as groundwater availability would be greater because of recharge from winter rainfall, and the amount of abstraction for garden use would be at a minimum.

Water levels in domestic bores were not recorded prior to construction of the Stage 1 canals in April 1989-May 1990. During the dewatering for Stage 1, levels in the monitor bores dropped by as much as 2.2m in the immediate vicinity of the canals (ED21, ED23) and up to 0.9m within

200m (ED3, ED25). A decline in levels was noted as far as 500m to the south, in the Stage 2 area (ED9). Levels largely recovered during the following winter, and had recovered completely by winter 1991 (Rockwater, 1992).

4.4 GROUNDWATER INFLOW TO DEWATERING EXCAVATIONS

The amount of groundwater inflow to the canal excavations can be estimated from the formula for non-steady flow to a finite line-sink:

$$Q = swS\sqrt{\frac{4Tt}{\Pi S} \times \frac{L}{t}}$$

where: Q = inflow (m^3/day)
sw = drawdown (m)
S = specific yield (dimensionless)
T = transmissivity (m^2/day)
L = length of excavation (m)
t = time (days)

Using the hydraulic parameters given in Section 4.3, the inflows to a 1,000m long excavation, 2.7m deep, would be as follows:

30 days	-	680m^3/day
60 days	-	480m^3/day
90 days	-	390m^3/day
120 days	-	340m^3/day

Should any shallow areas of Tamala Limestone be encountered during excavation, the amount of inflow could be much greater. For example, a 1m thickness of limestone, with hydraulic conductivity of 90m/day and specific yield of 0.2, exposed along a 100m length of excavation, would contribute an inflow of 260m^3/day at 30 days.

5.0 LONG-TERM EFFECTS OF DEVELOPMENT ON GROUNDWATER REGIME

5.1 EFFECT ON WATER RESOURCES

The only long-term effect on water resources would be related to the westward movement of the saltwater interface from its present location about 150m east of McLarty Road, which may affect a few domestic bores.

The only surviving monitor bores in the vicinity of Stage 1 for which pre-construction salinity profiles are recorded, namely EB20A and EB20B (Rockwater, 1989), show no evidence of a net inland movement of the interface as a consequence of the Stage 1 development (Appendix A).

This is discussed in more detail in Section 5.2 below. The freshwater lens beneath the Halls Head peninsula is not considered to be a significant water resource and is already subject to overpumping (EPA, 1989).

5.2 POSITION OF SALTWATER INTERFACE

The canals will introduce saltwater to a distance of about 50m from the boundaries of existing properties along the west side of McLarty Road. This will cause the saltwater interface to migrate westwards from its present position.

The resultant position of the interface can be estimated from Glovers Equation:

$$Z^2 = \frac{2\rho q x}{\Delta\rho K} + \left(\frac{\rho q}{\Delta\rho K}\right)^2$$

where: Z = aquifer thickness (m)

x = distance from shoreline (m)

ρ = density of fresh water (1gm/cm^3)

$\Delta\rho$ = density difference between saltwater and freshwater (~0.025gm/cm^3)

q = unit groundwater inflow (m^3/day)

K = hydraulic conductivity (m/day)

An average hydraulic conductivity of 50m/day is adopted for the Tamala Limestone, with average thickness of 9m, and a unit groundwater inflow of 0.315m^3/day, derived from the amount of throughflow calculated in Section 3.2.5. Solving Glover's Equation for x, the estimated position of the interface at the base of the aquifer is 160m from the shoreline of the canal.

Any domestic bore within 100m of McLarty Road may therefore be affected by rising groundwater salinity. This may amount to 10-12 domestic bores. Experience with other canal developments in the region indicates that any effect on domestic bores will be short-lived. Following dewatering for canal excavations on Port Mandurah, Stage I, over the period April 1989 to May 1990, a few domestic bores had to be supplemented with scheme water for garden watering until May 1993, by which time all the bores had recovered in yield and quality so that no further supplementation was required. At Waterside Mandurah, a canal estate occupying a similar hydrogeological environment on the opposite side of the Mandurah Estuary, monitoring of domestic bores following canal construction in 1985-1986 showed that there was no detectable decline in quality due to dewatering or canal construction, and that water levels had largely recovered by the end of the following winter.

5.3 NUTRIENT INPUT TO CANALS

Nitrate values recorded in bores on the upgradient side of the development range from 0.1-24.9mg/L, with an average of less than 10mg/L. The estimated natural groundwater throughflow of 530m^3/day, with an assumed loading of 10mg/L, would therefore contribute about 5kg of nitrate to the canals per day.

Phosphate values in domestic bores have been consistently below detection levels in all analyses, so that any phosphate contribution to the canals from groundwater throughflow will be negligible.

5.4 GROUNDWATER-DEPENDENT VEGETATION

The area of trees in the southeast of the development site is unlikely to be affected by the canals in the long-term, as a thin layer of fresh groundwater should be re-established and maintained by recharge from winter rainfall.

The only surviving monitor bore within the Stage 1 area, EB7, has maintained a fresh to slightly brackish (1500-3000uS/cm) layer, about 2m thick, since the canals were constructed.

5.5 EFFECTS OF URBANISATION ON WATER LEVELS WITHIN DEVELOPMENT

A number of previous studies in the Perth area (e.g. McFarlane, 1981) have demonstrated that groundwater levels rise following urbanisation, because of decreased evapotranspiration by exotic plants as compared to native vegetation, importing of mains water, and enhanced recharge from shedding areas (e.g. roads and roofs).

Thin lenses of fresh groundwater are therefore expected to form beneath islands and spurs within the canal estate, but these will be too small to form any significant water resource, although they may assist in supporting garden vegetation. Any rise in water level will be readily dissipated by discharge into the canals, and no significant rise is likely within the estate.

7.0 CONCLUSIONS

1. The Port Mandurah Stage 2 development site is underlain mainly by brackish and saline groundwater, so that no significant groundwater resource will be affected by the development.

2. Dewatering of excavations during canal construction is predicted to cause lowering of water levels amounting to 1m at 100m distance, and 0.4m at 200m distance.

   This may temporarily affect the quantity and quality of groundwater obtained from a small number (estimated at about 12) of domestic bores, used principally for garden watering, within 100m of the west side of McLarty Road.

   Groundwater-dependent trees on the southeast of the development site may have to be maintained by watering during the construction period.

   No noticeable effect would be expected if the dewatering were to be carried out in winter.

3. Groundwater inflows to a dewatered canal excavation, 1,000m long, are estimated at 680m^3/day after 30 days, declining to 340m^3/day after 120 days. Additional inflows, of the order of several hundred cubic metres per day, may result if shallow areas of Tamala Limestone are encountered during excavation.

4. The existence of the canals will result in the westward migration of the saltwater interface which is currently located about 150m east of McLarty Road. The interface will re-establish itself about 100m to the west of McLarty Road, and may affect the salinity of domestic bores within that area, although any such effect is likely to be short-lived.

5. Background nutrient input to the canals from groundwater throughflow is estimated at about 5kg of nitrate per day; contribution of phosphate will be negligible.

8.0 RECOMMENDATIONS

1. The effects of dewatering may be minimised in the following ways:

   - undertaking dewatering during winter;
   - carrying out dewatering in sections, rather than over the entire area; and
   - keeping the duration of dewatering to a minimum.

2. Existing ED Monitor Bore Nos. 1, 2, 5, 9, 14 and 15 should be cleaned out to their original construction depths.

3. Two additional monitoring sites should be established on the south side of the development. At each site two piezometers should be installed, one in the Tamala Limestone and one in the overlying estuarine/marine sediments. Anticipated piezometer depths are about 6m and 12m.

4. The monitoring frequency should be increased to monthly during the canal construction period, from the present frequency of every six months.

   Following construction, monitoring should be continued at three monthly intervals for two years, and six monthly intervals for a further three years.

   Water level and profiles of electrical conductivity should be measured in each piezometer during each monitoring run.

   Pumped samples should be taken annually from each piezometer and analysed for Total Dissolved Solids, Electrical Conductivity, pH, nitrate and phosphate.

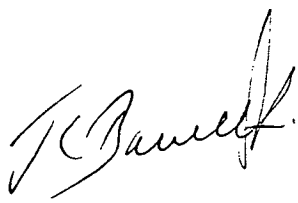
5. An additional four domestic bores should be added to the monitoring schedule, on the west side of McLarty Road.

The most suitably sited bores, subject to permission from their owners, would be:

- 18 McLarty Road;
- 74 McLarty Road;
- 14 Sandalwood Parade; and
- 5 McMahon Court.

* * *

Respectfully submitted
DAMES & MOORE



J.C. Barnett
Consultant Hydrogeologist

REFERENCES

Commander, D.P., 1975. Hydrogeology of the Mandurah-Pinjarra Area, Perth Basin, W.A. Geological Survey of Western Australia Record No. 1975/3.

Environmental Protection Authority, 1989. Port Mandurah Development, Report and Recommendations of the Environmental Protection Authority. Bulletin 378.

Dames & Moore, 1994. Port Mandurah Groundwater Monitoring - 1993. Report for Cedar Woods Properties Limited.

Geological Survey of Western Australia, 1977. Mandurah, 2032 IV 1:50 000 Urban Geology Map Series.

McFarlane, D.J., 1981. The effects of Urbanisation on Groundwater Levels and Chemistry in Perth, Western Australia. Proceedings of Symposium on Groundwater Resources of the Swan Coastal Plain.

Rockwater, 1989. Results of Groundwater Monitoring, December 1987-December 1988. Report to Esplanade (Mandurah) Pty Ltd.

Rockwater, 1992. Port Mandurah Groundwater Monitoring, 1991 Annual Report. Report to Cedar Woods Ltd.

Rule Group, 1989. Port Mandurah Development, Notice of Intent.

The Feilman Group, 1981. Halls Head Waterways, Environmental Review and Management Programme. Report for Parrys Esplanade Limited.

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Figures

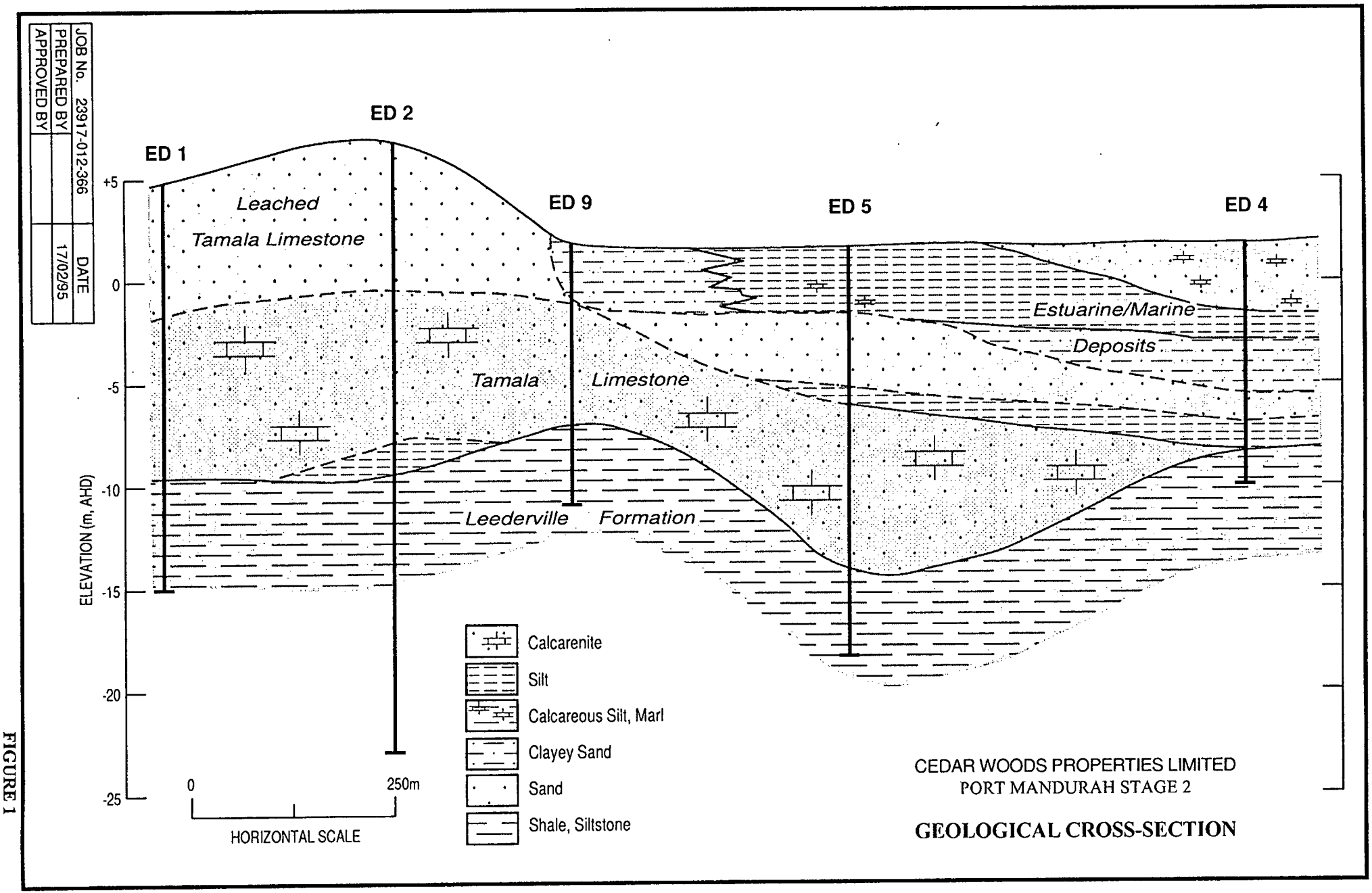


FIGURE 1
DAMES & MOORE

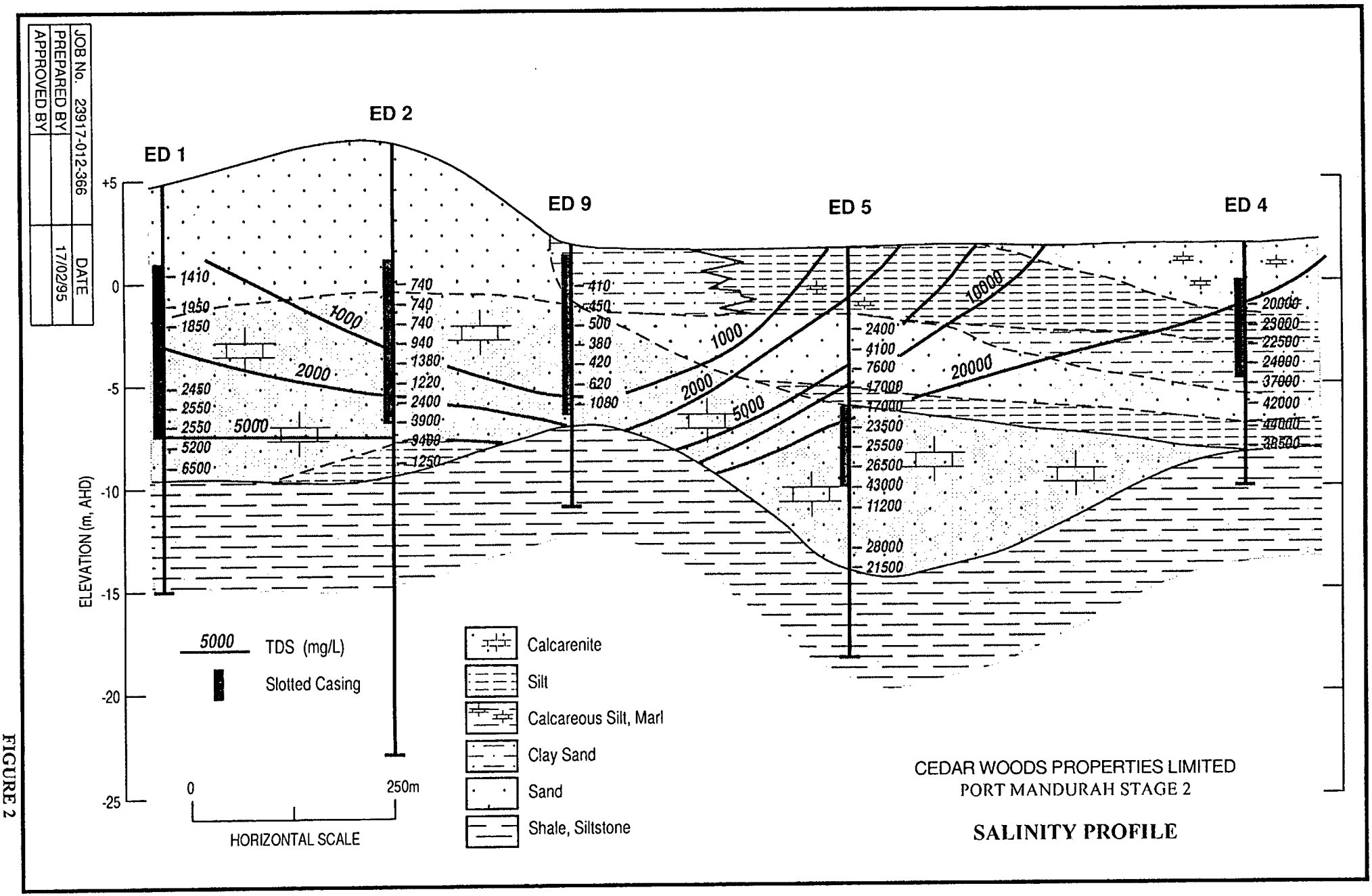
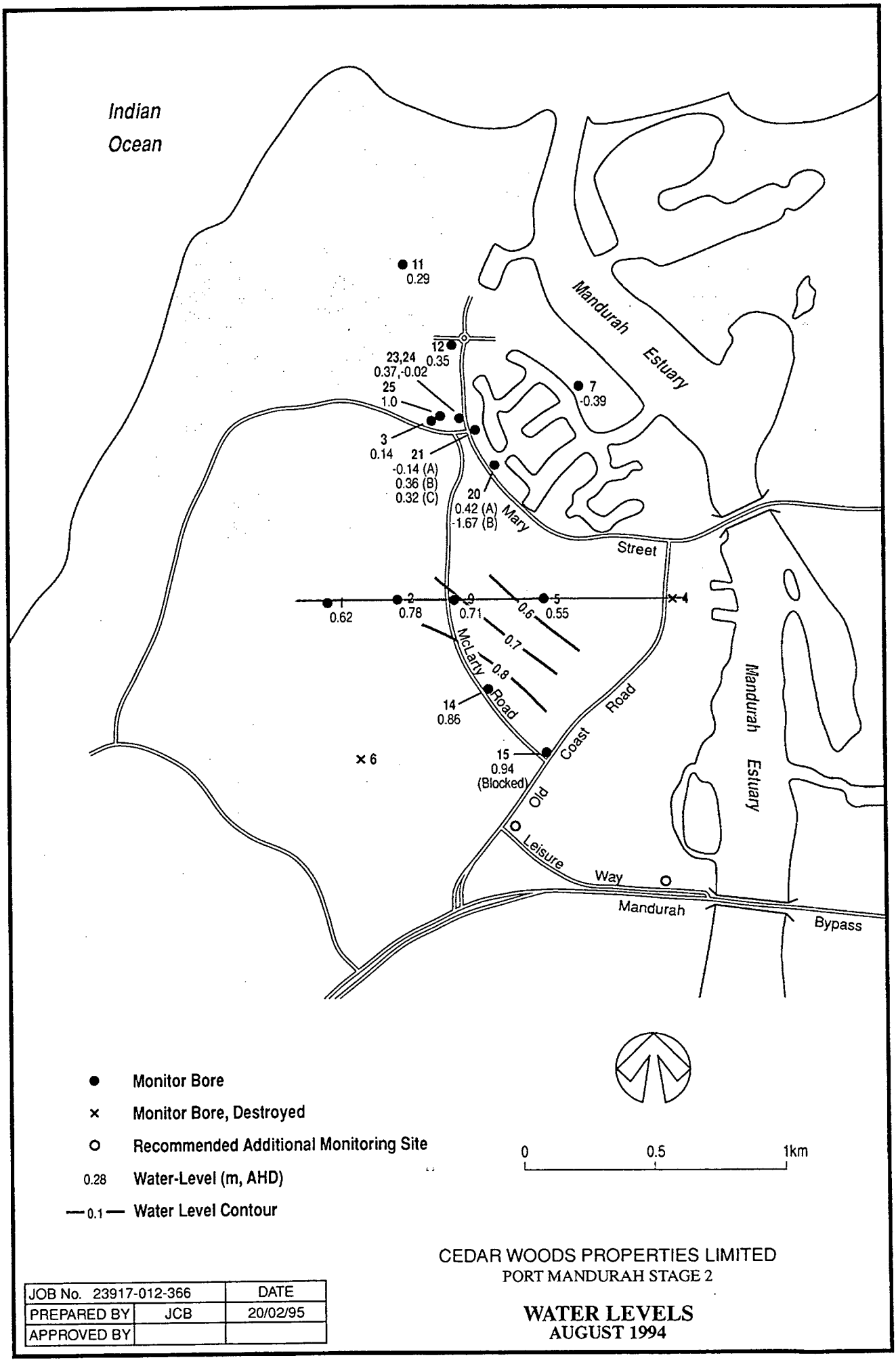


FIGURE 2
DAMES & MOORE

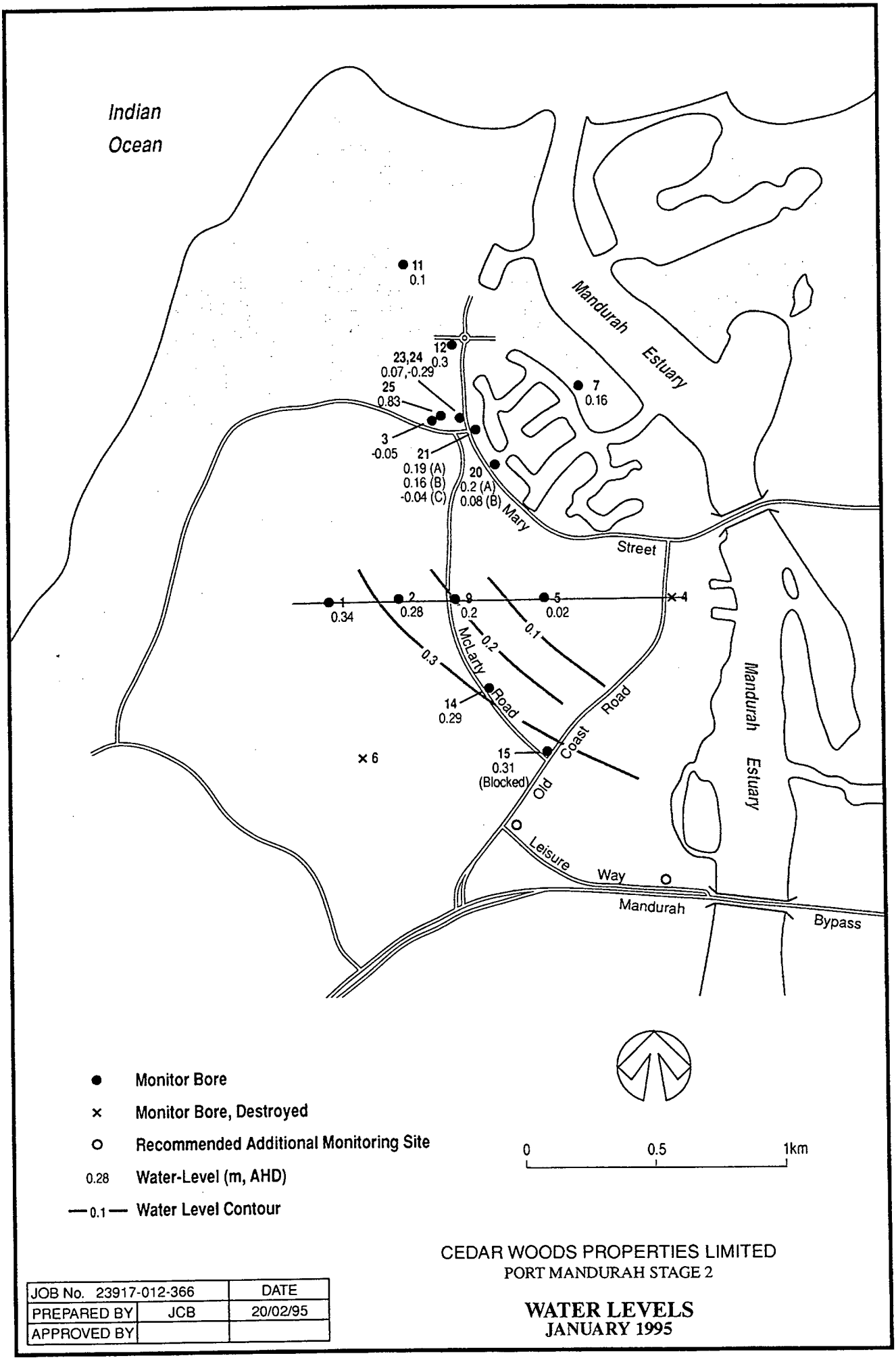


CEDAR WOODS PROPERTIES LIMITED
PORT MANDURAH STAGE 2

WATER LEVELS
AUGUST 1994

JOB No. 23917-012-366		DATE
PREPARED BY	JCB	20/02/95
APPROVED BY		

FIGURE 3
DAMES & MOORE

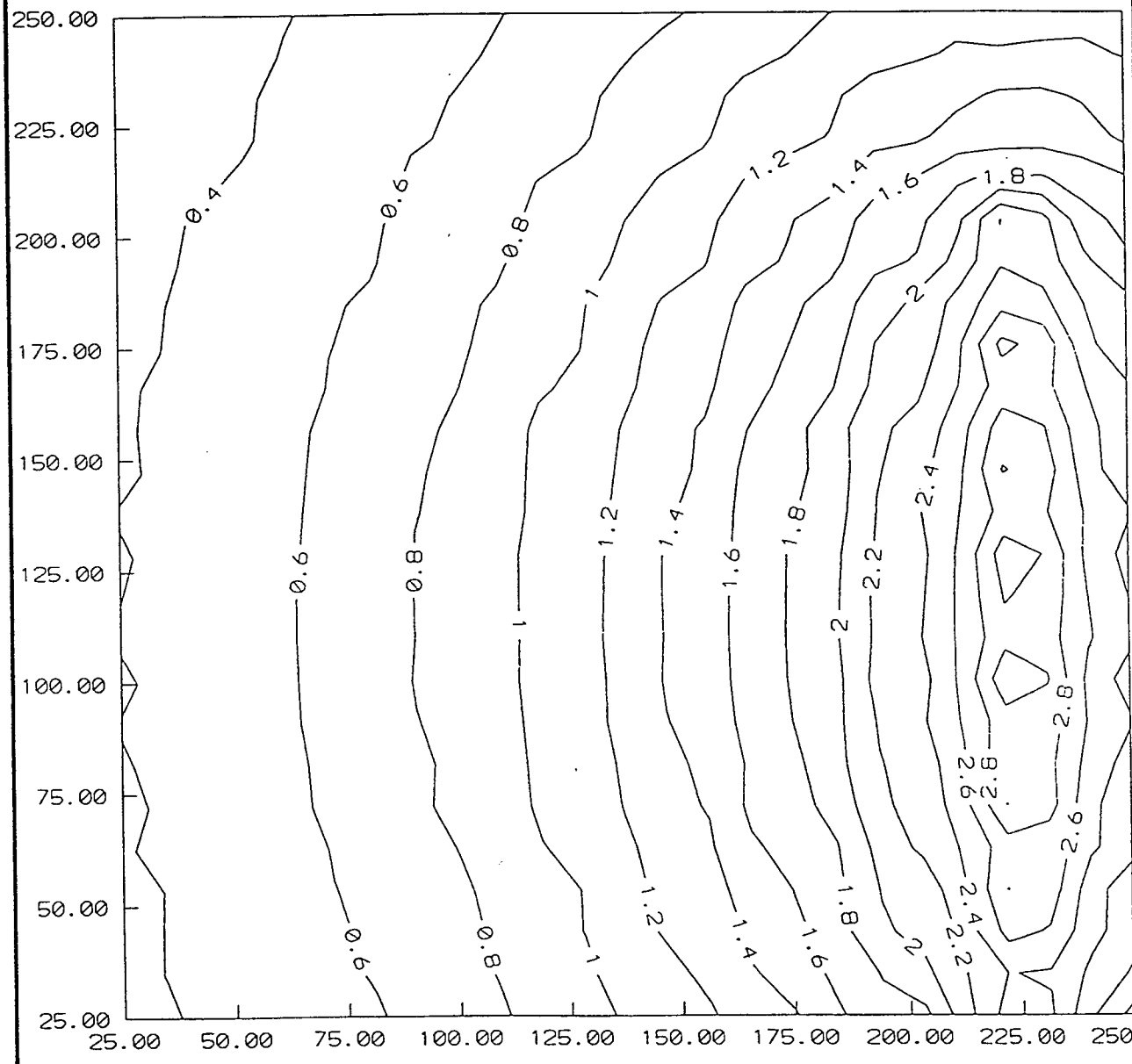


CEDAR WOODS PROPERTIES LIMITED
PORT MANDURAH STAGE 2

WATER LEVELS
JANUARY 1995

JOB No. 23917-012-366		DATE
PREPARED BY	JCB	20/02/95
APPROVED BY		

FIGURE 4
DAMES & MOORE



CEDAR WOODS PROPERTIES LIMITED
PORT MANDURAH STAGE 2

JOB No. 23917-012-366		DATE
PREPARED BY	JCB	21/02/95
APPROVED BY	JCB	21/2/95

CONCEPTUAL CANAL DEWATERING EXCAVATION
PREDICTED DRAWDOWN 120 DAYS
(Transmissivity 15m²/day, Specific Yield 0.1)

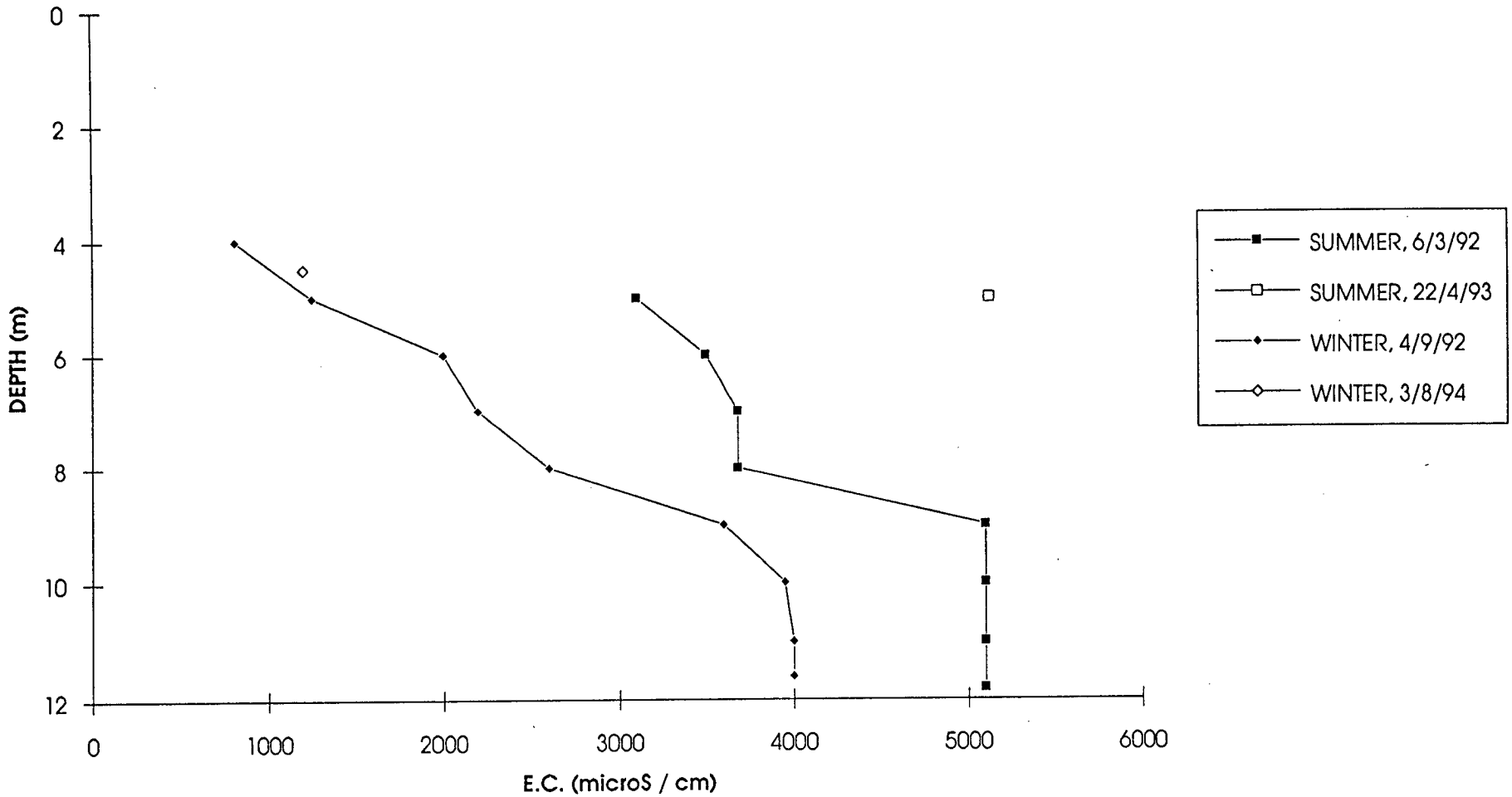
FIGURE 5
DAMES & MOORE

Appendix A

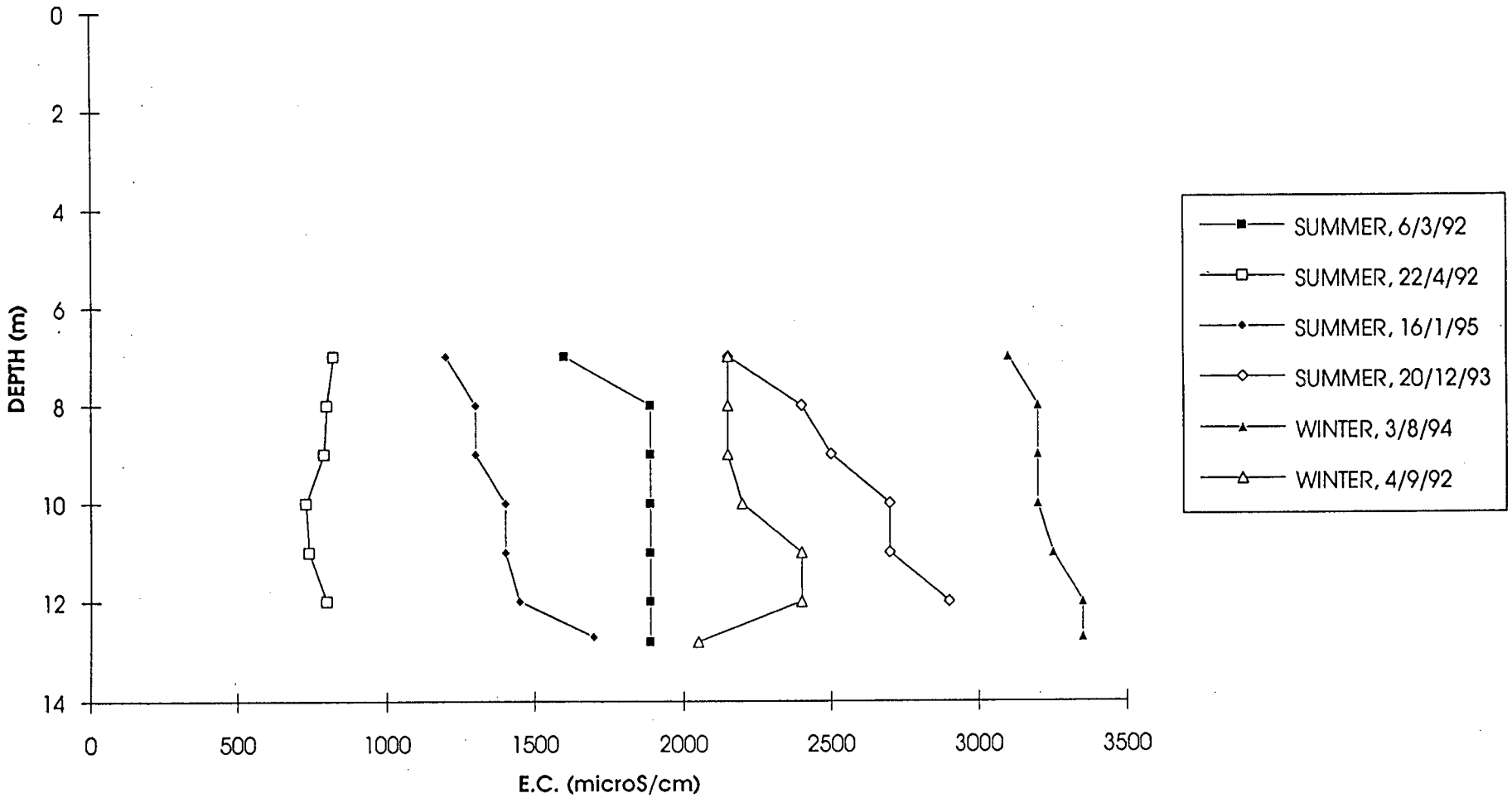
APPENDIX A

ELECTRICAL CONDUCTIVITY PROFILES AND WATER-LEVELS

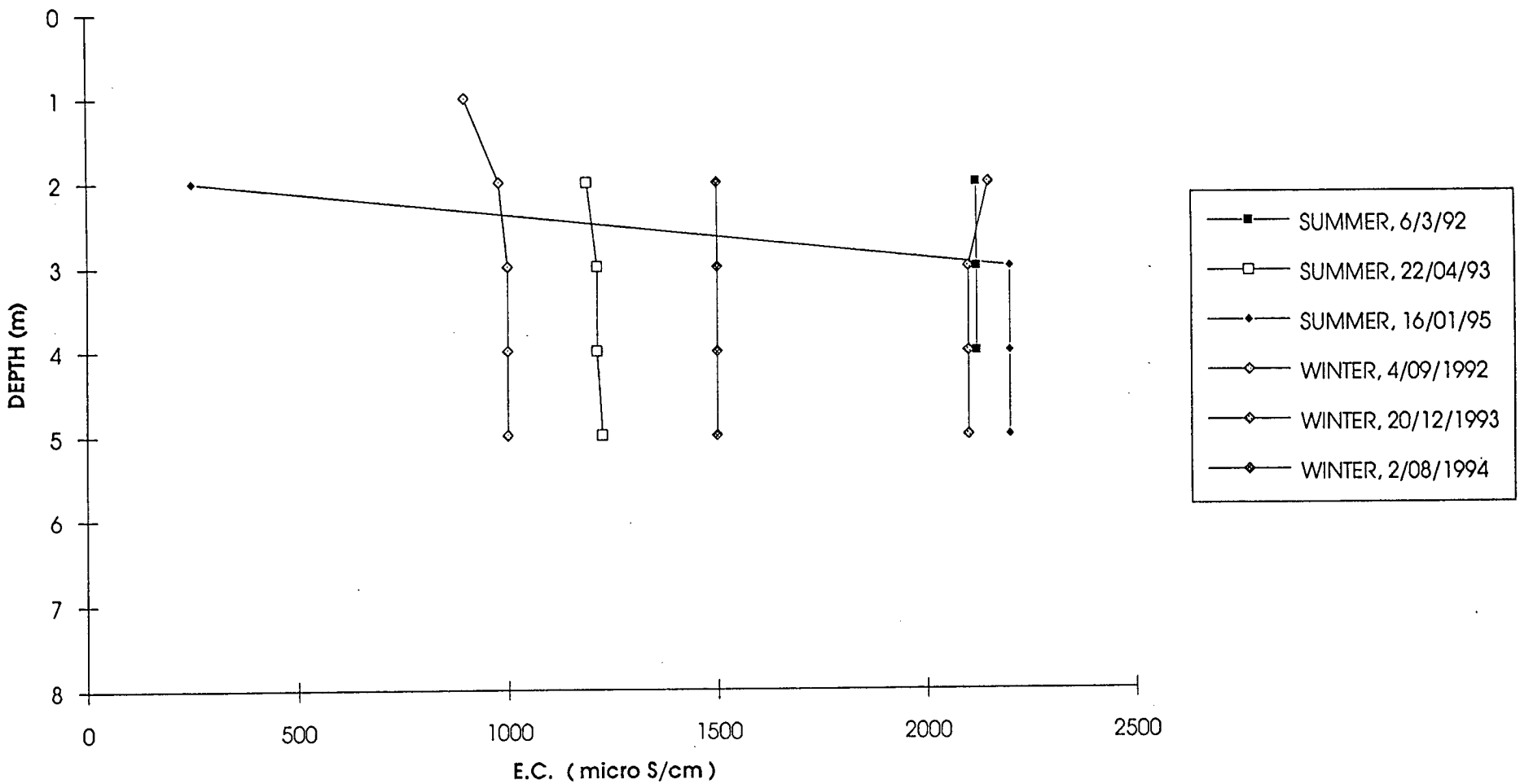
BOREHOLE ED-1, E.C. READINGS



BOREHOLE ED-2



BOREHOLE ED-5, E.C. READINGS



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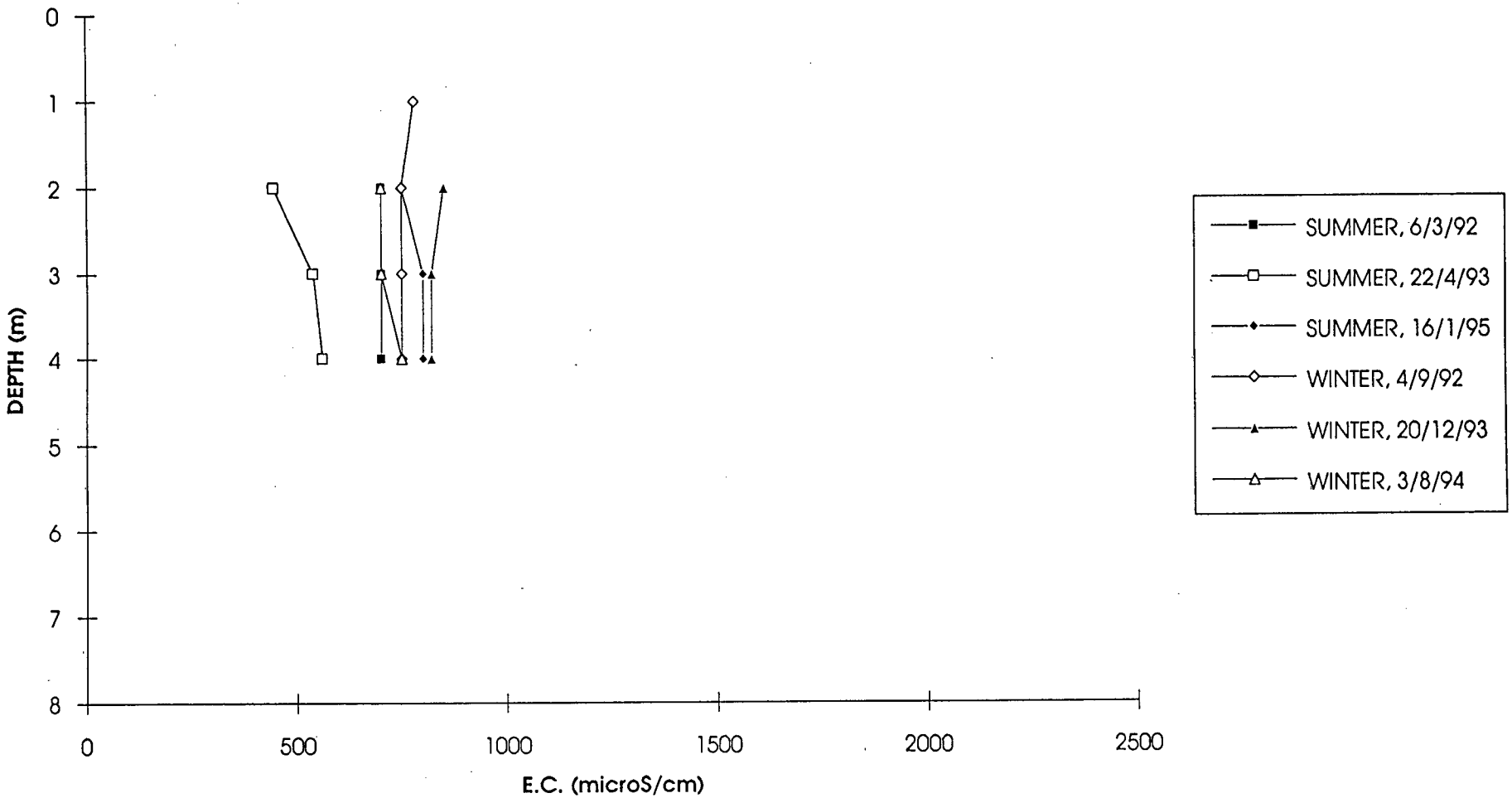

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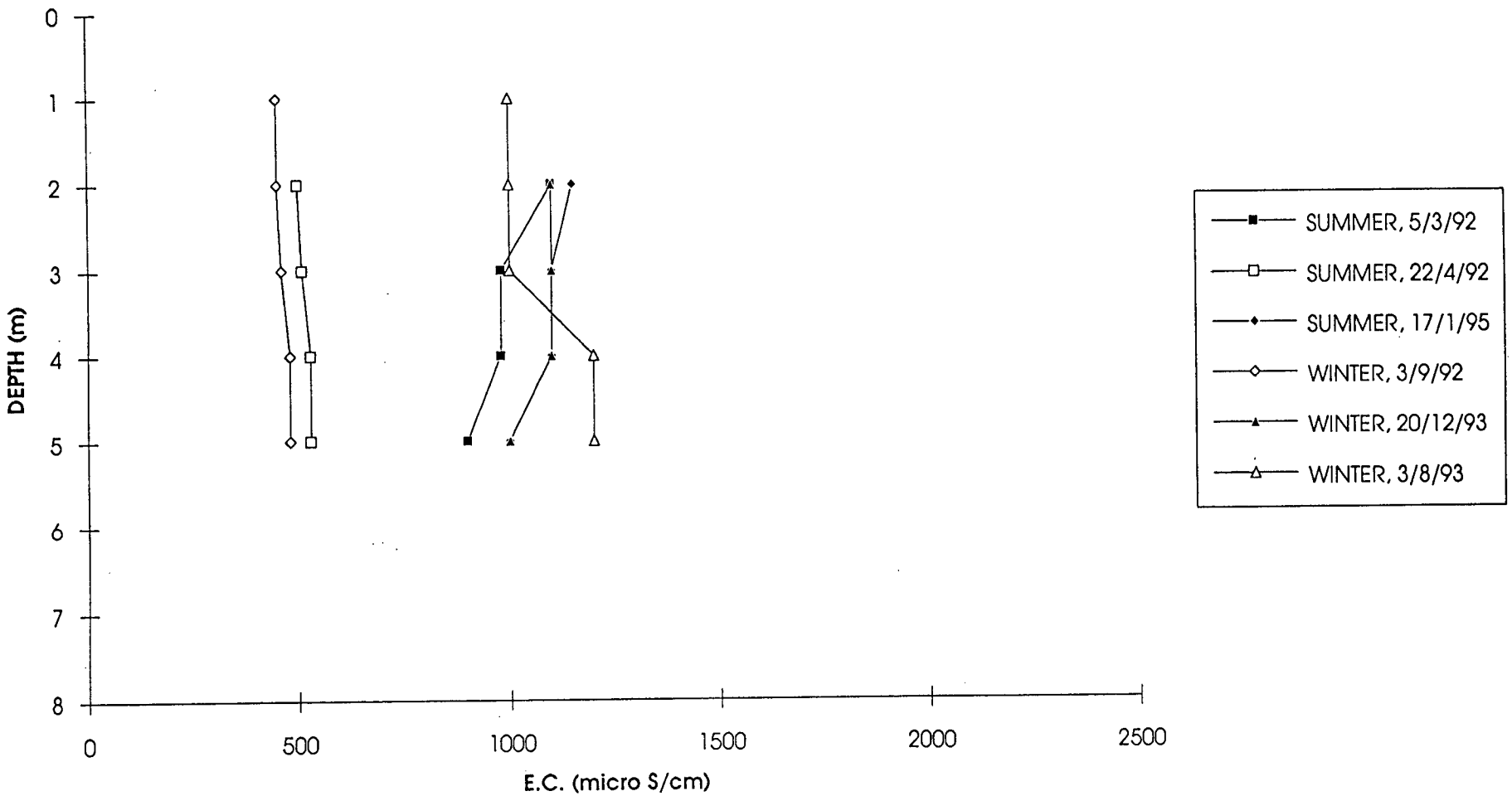
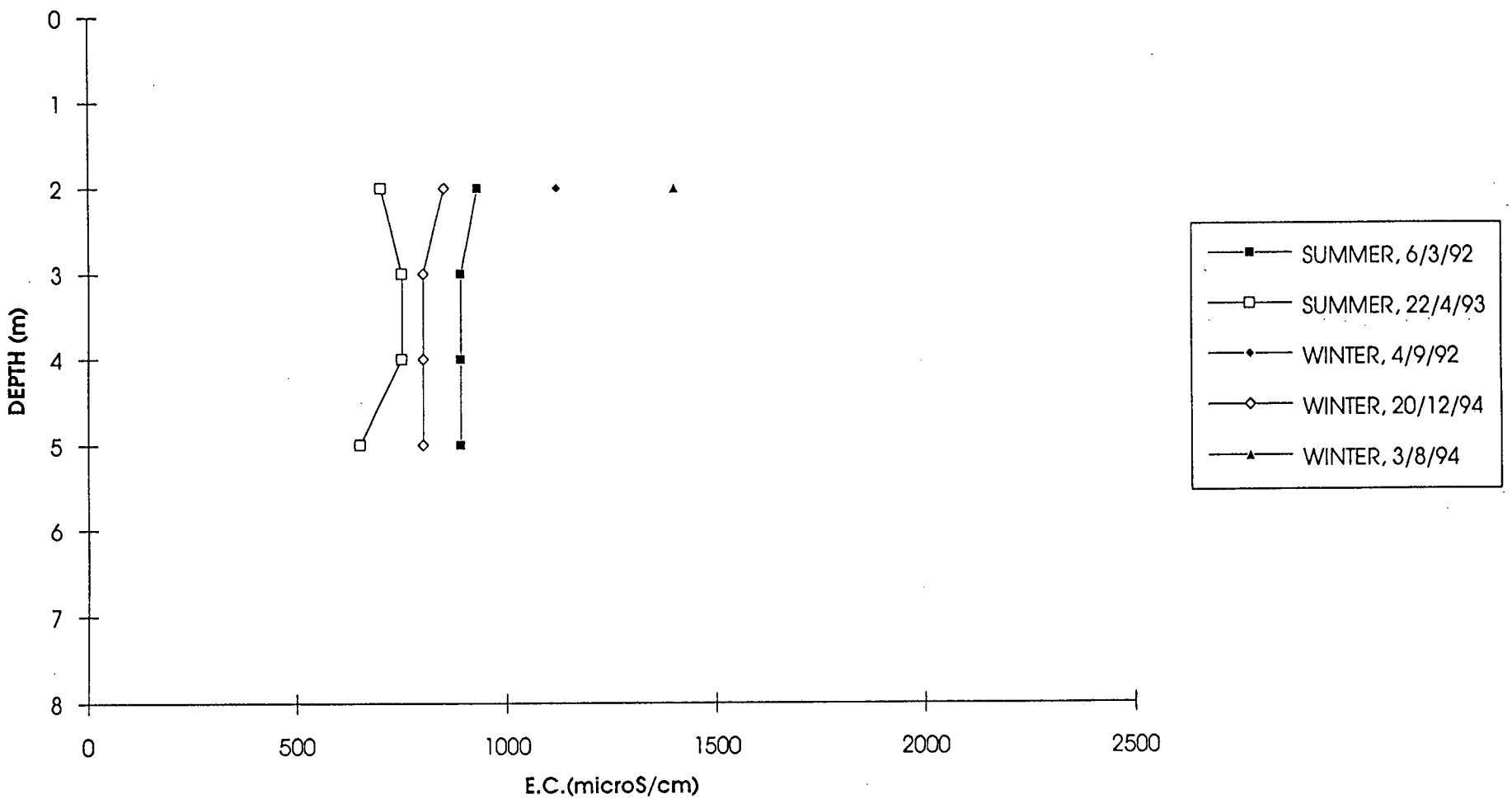
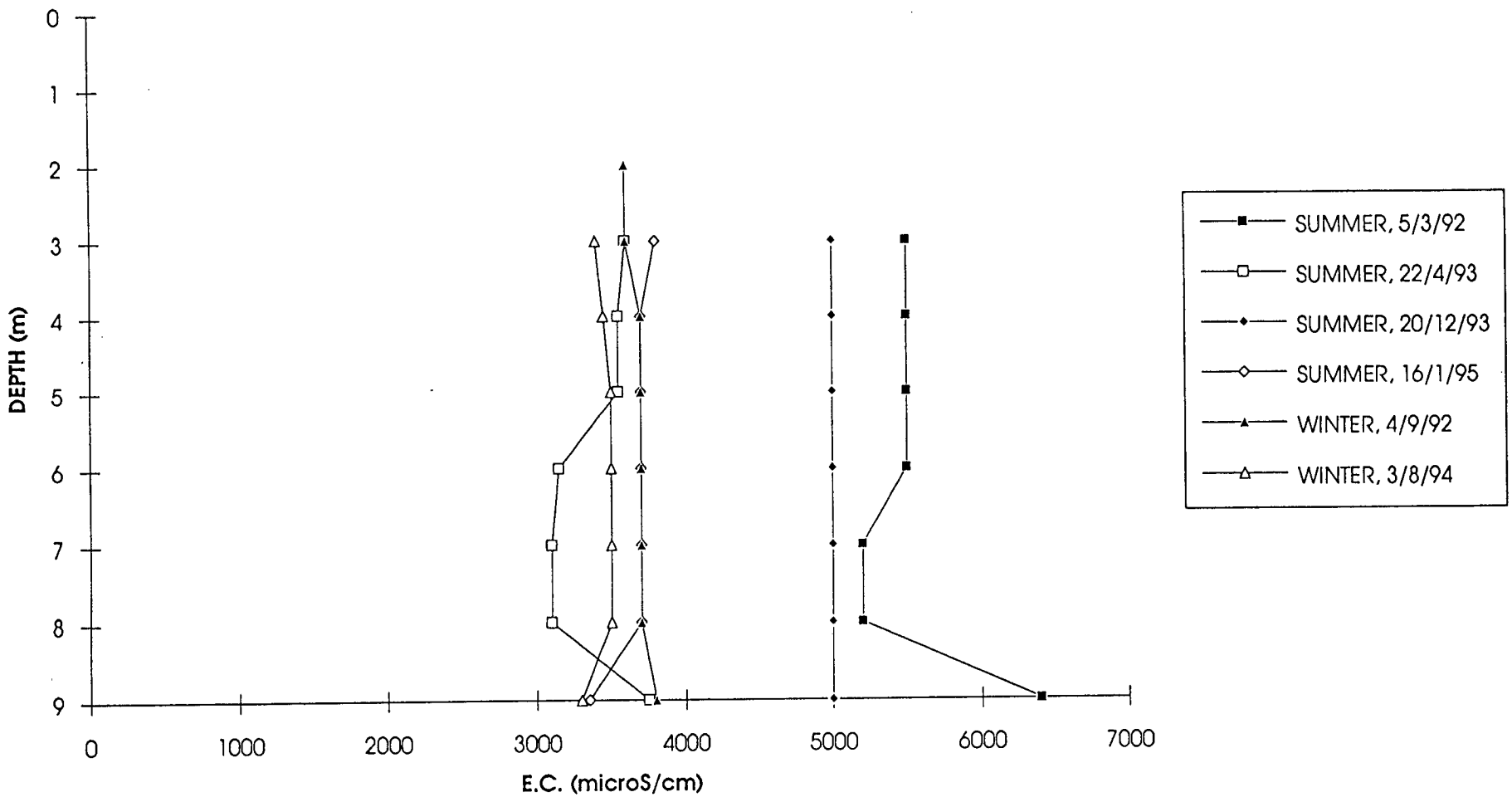


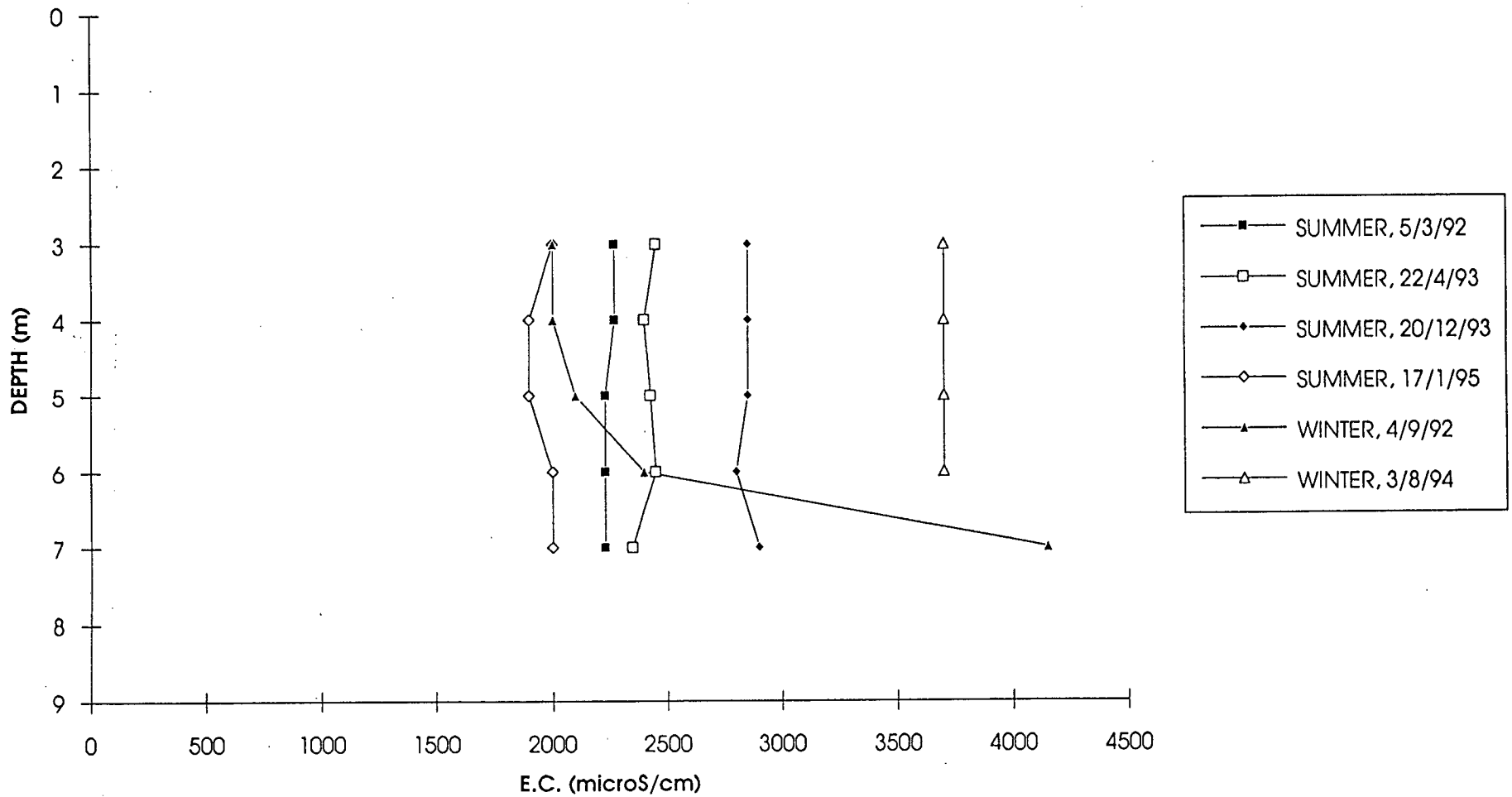
BOREHOLE ED-15



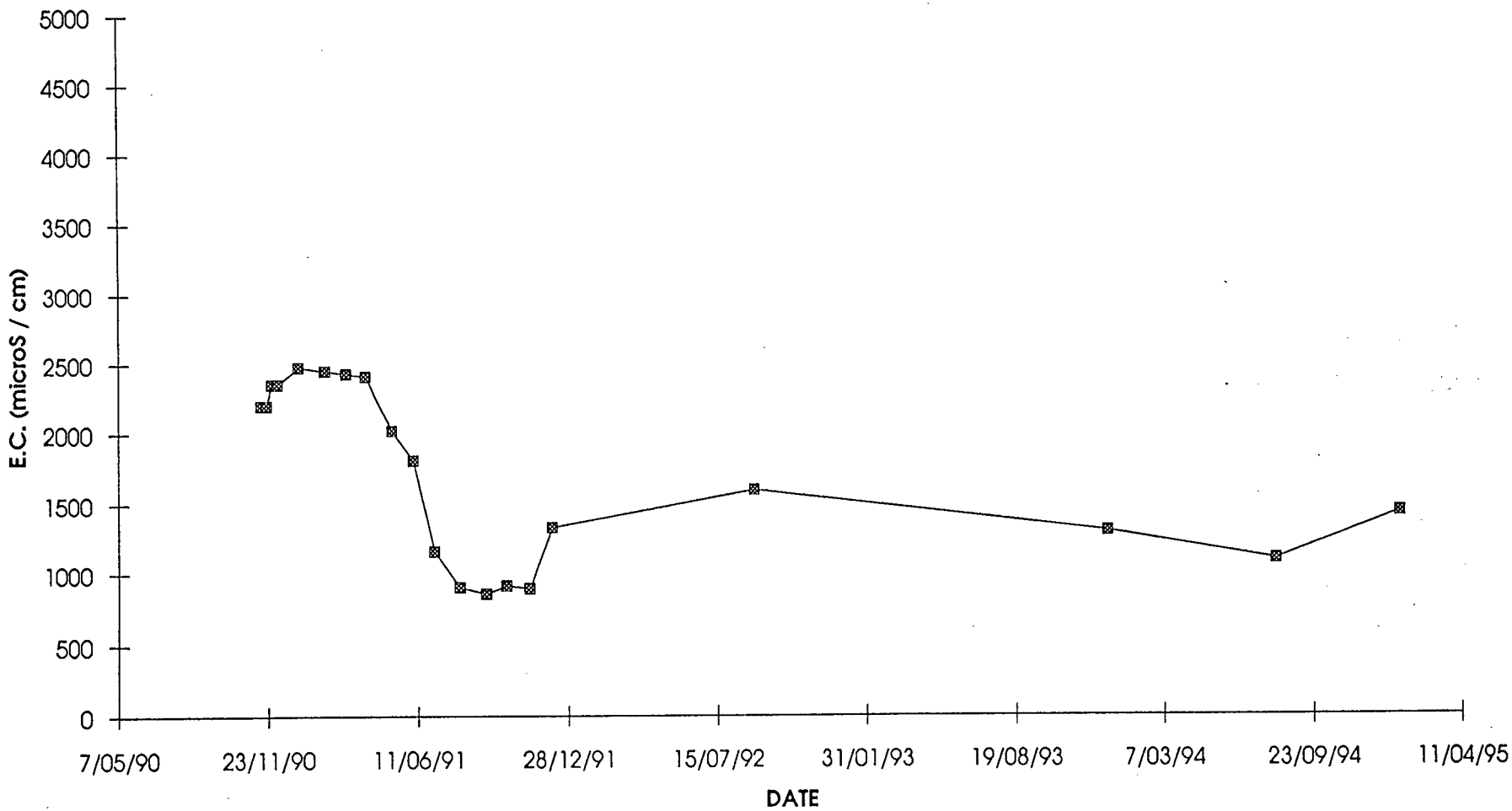
BOREHOLE ED-20A, E.C. READINGS



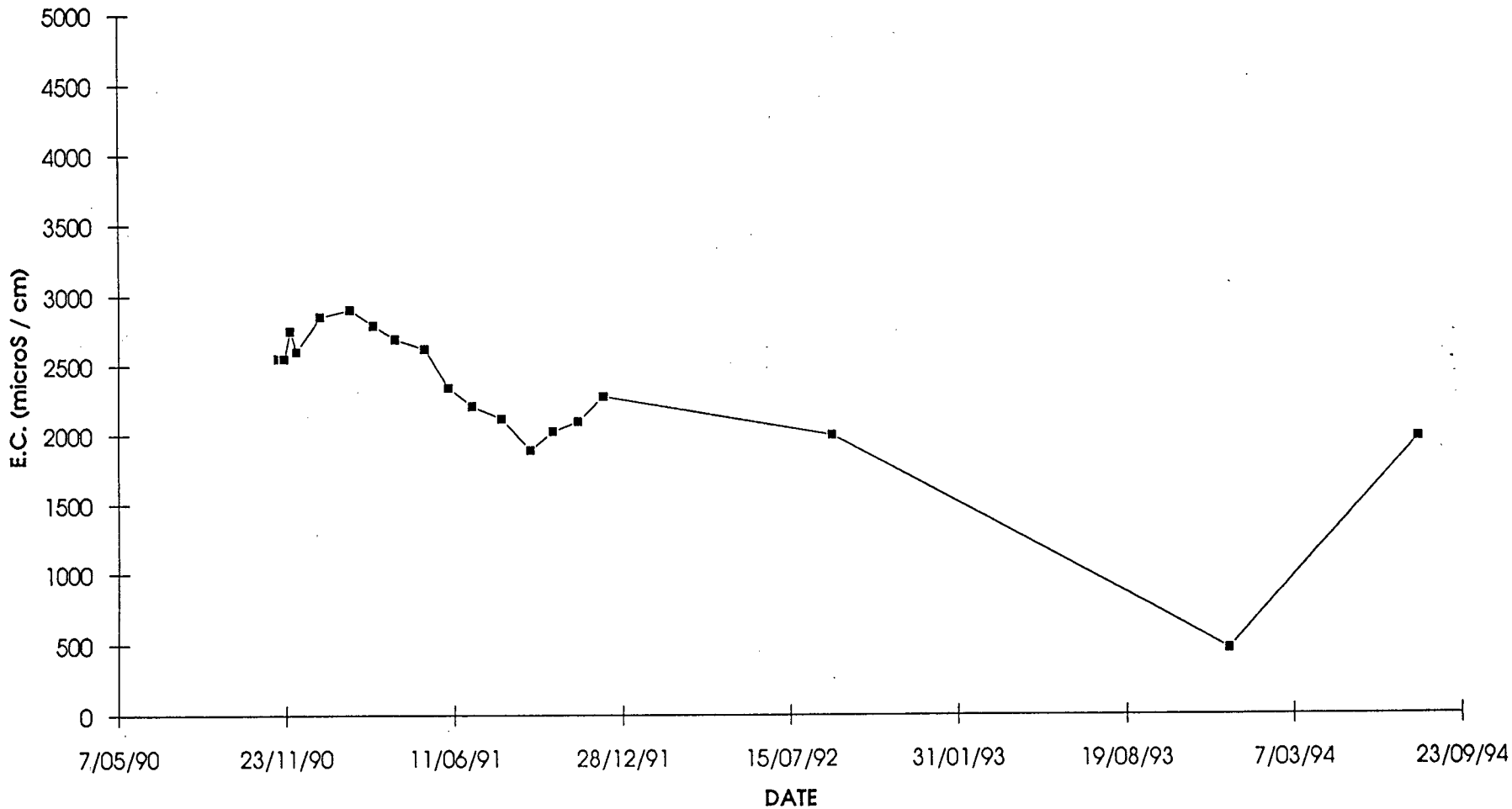
BOREHOLE ED-20B, E.C. READINGS

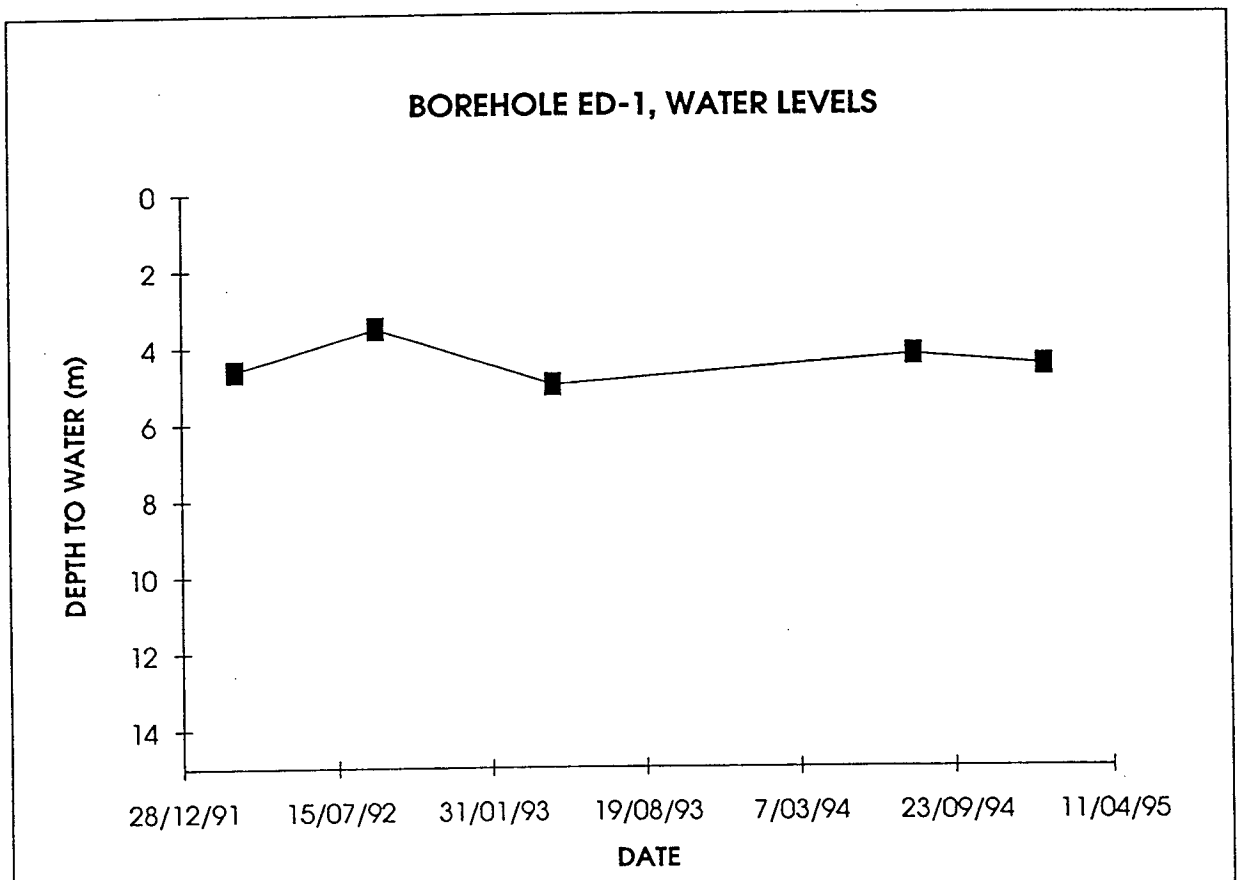


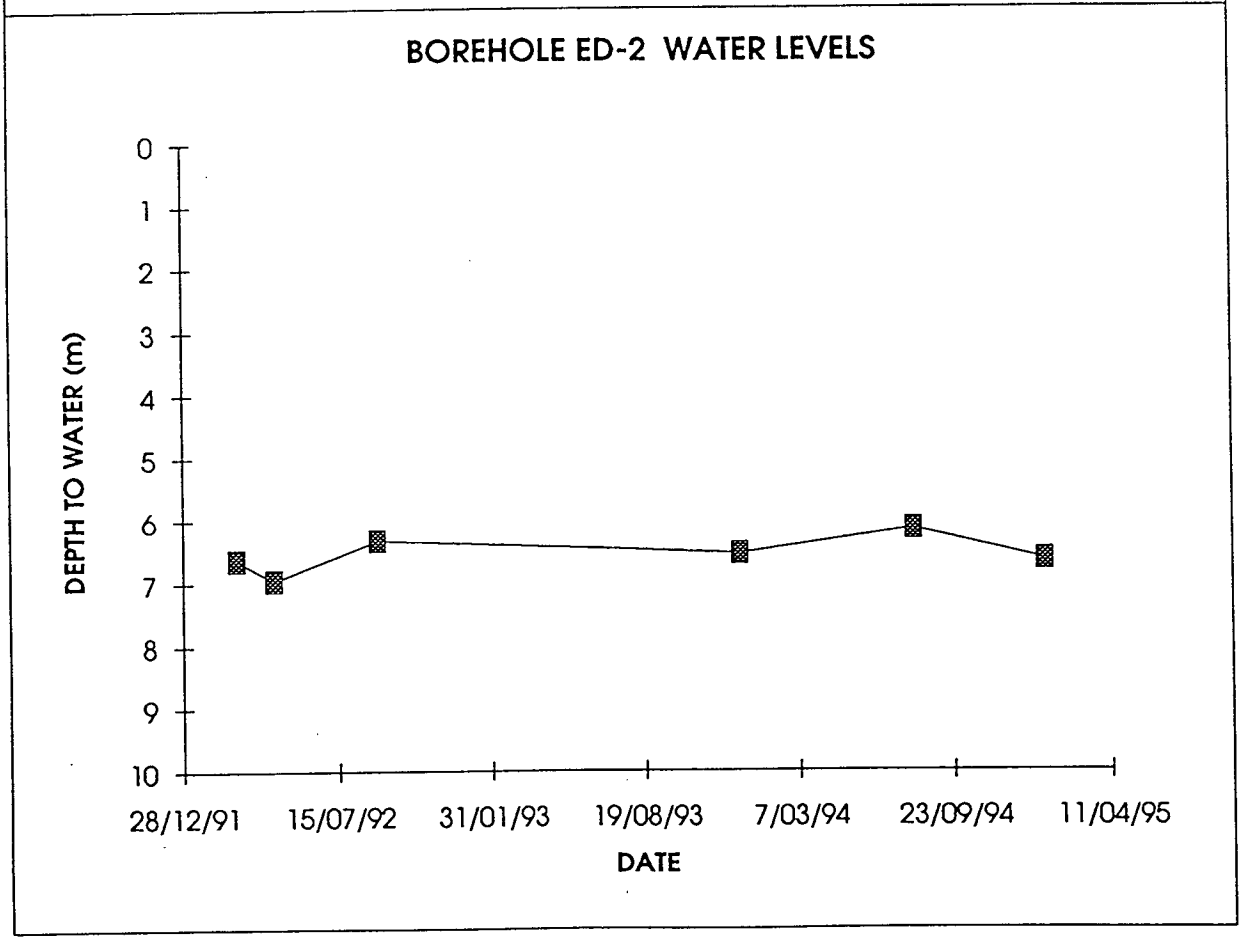
4 CARINA CLOSE, BOREHOLE E.C. READINGS



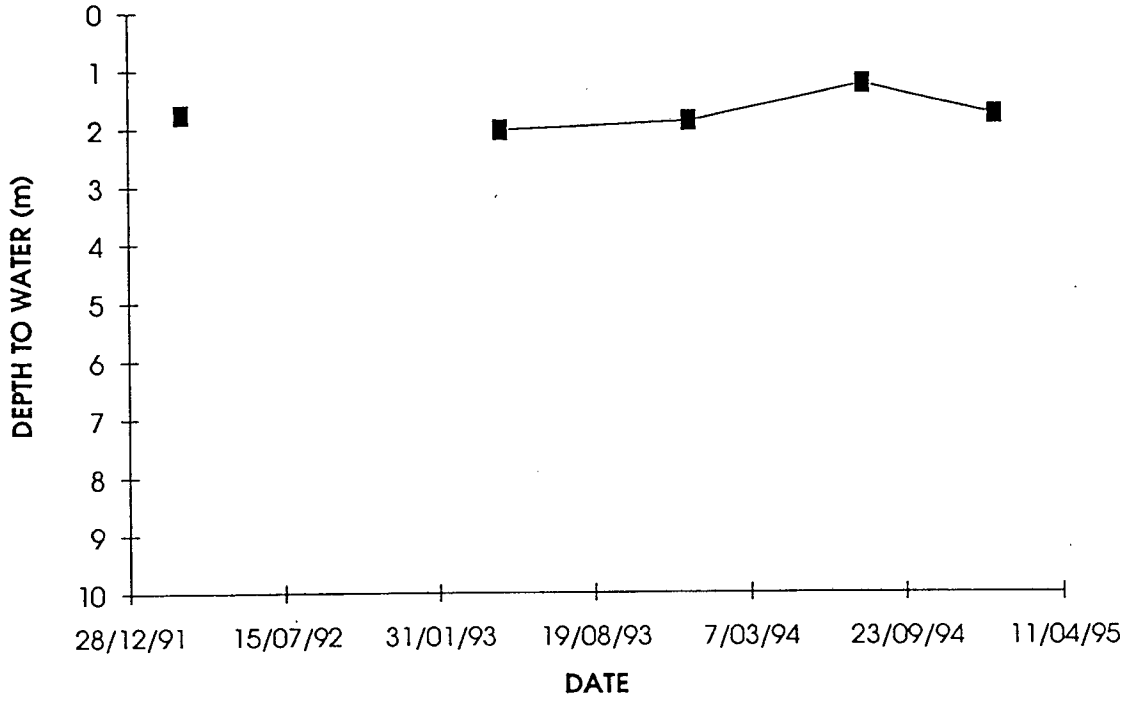
8 ARUNDEL DRIVE, BOREHOLE E.C. READINGS



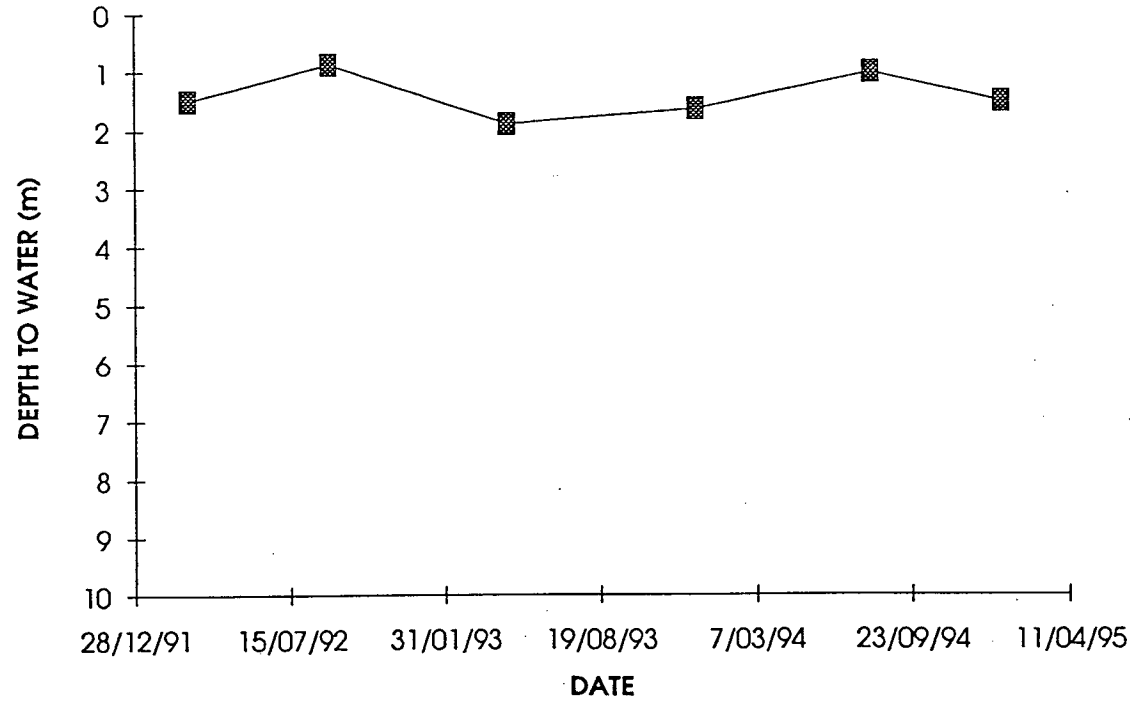

BOREHOLE ED-1, WATER LEVELS
DEPTH TO WATER (m)
0
2
4
6
8
10
12
14
28/12/91
15/07/92
31/01/93
19/08/93
7/03/94
23/09/94
11/04/95
DATE


BOREHOLE ED-2 WATER LEVELS
DEPTH TO WATER (m)
0
1
2
3
4
5
6
7
8
9
10
28/12/91
15/07/92
31/01/93
19/08/93
7/03/94
23/09/94
11/04/95
DATE

BOREHOLE ED-5 WATER LEVELS



BOREHOLE ED-9 WATER LEVELS



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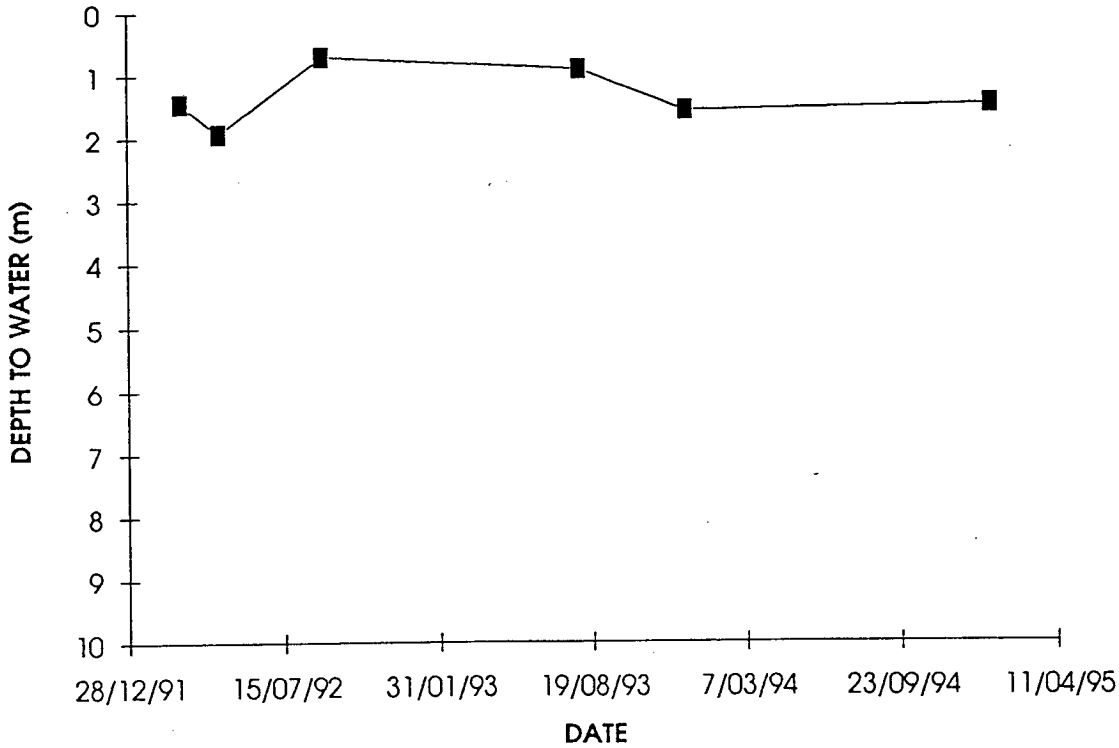
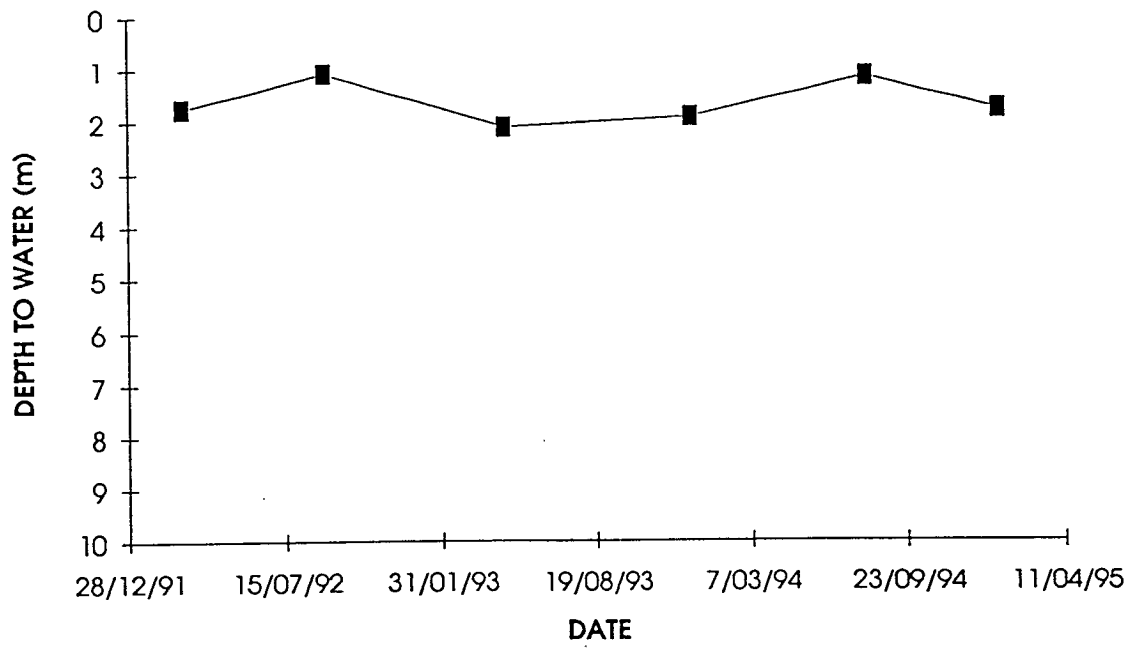
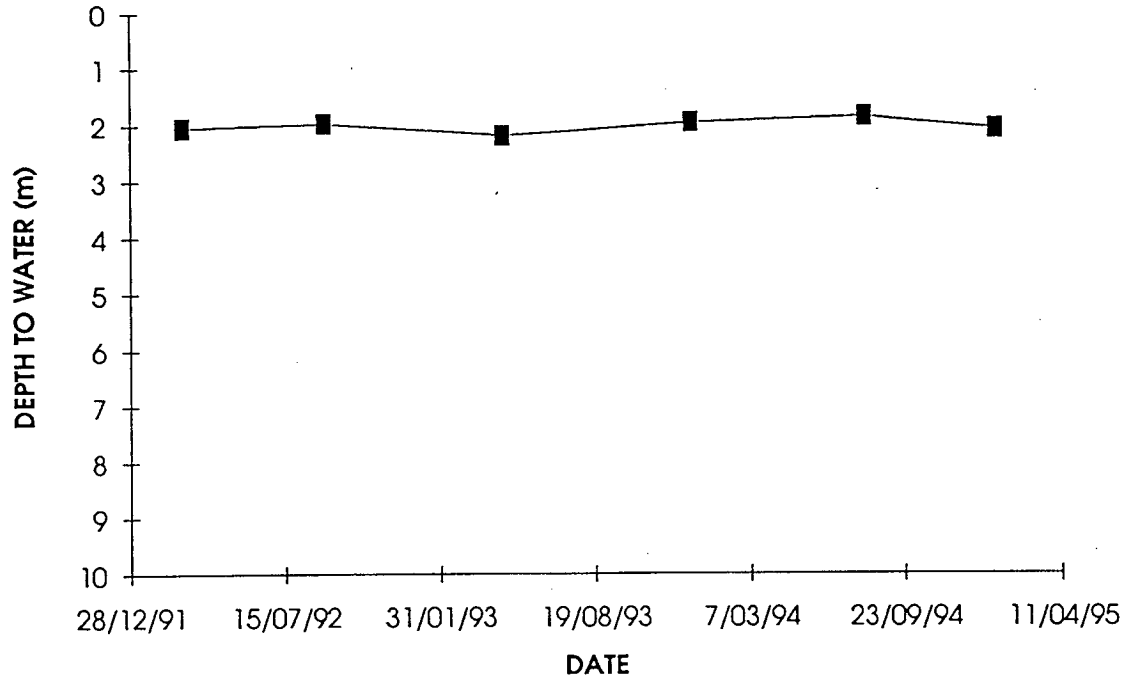


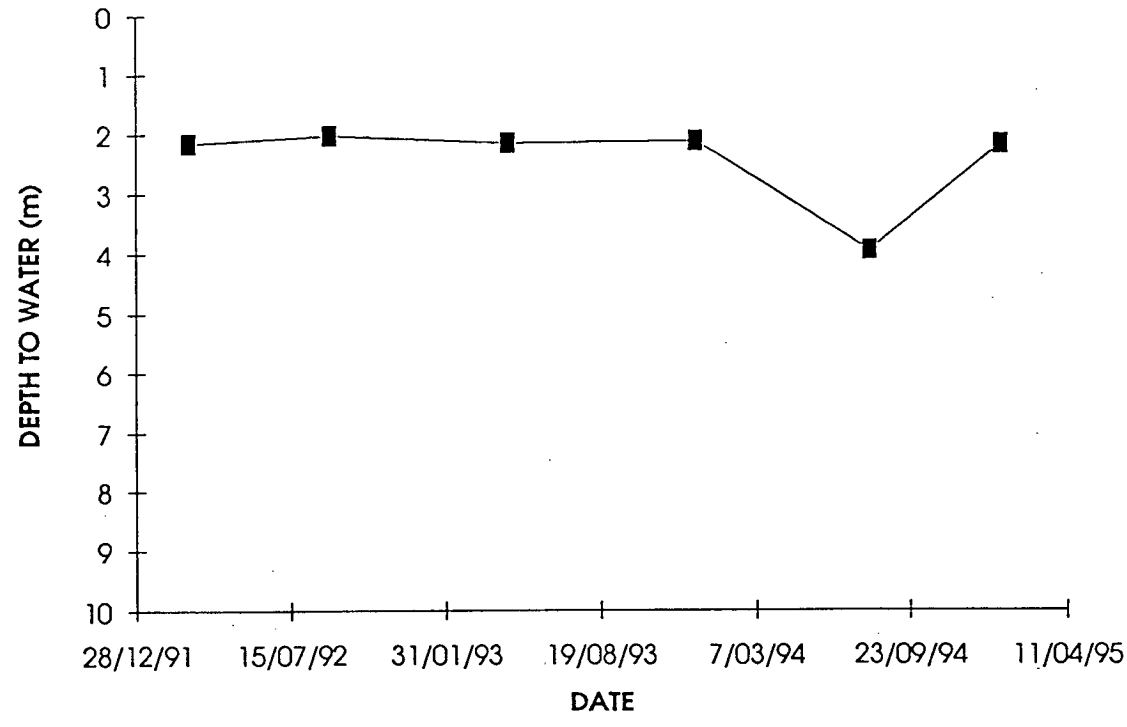
BOREHOLE ED-15 WATER LEVELS



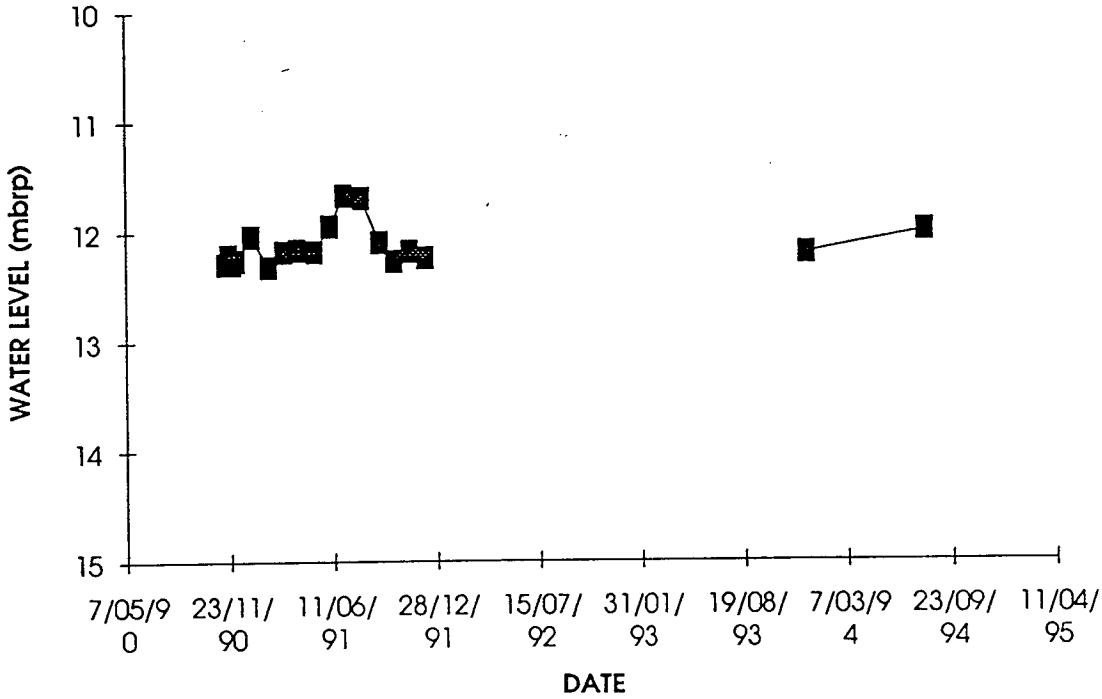
BOREHOLE ED-20A WATER LEVELS



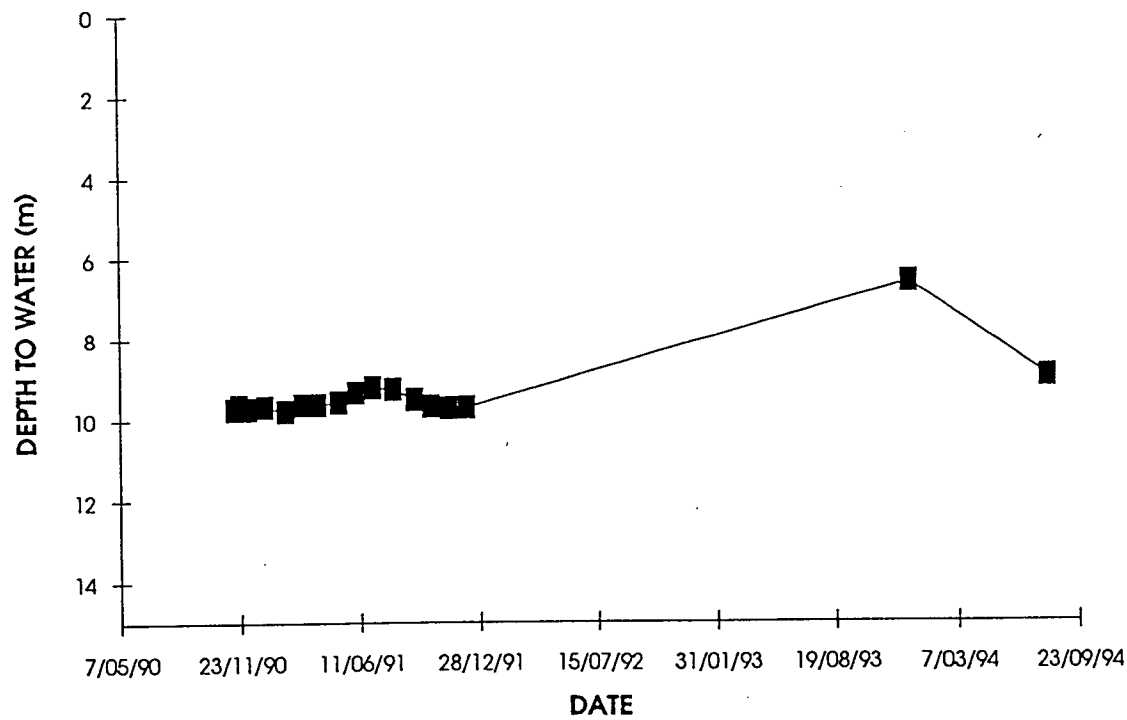
BOREHOLE ED-20B WATER LEVELS



4 CARINA CLOSE, BORE WATER LEVELS



8 ARUNDEL DRIVE, BOREHOLE WATER LEVELS



Appendix B

APPENDIX B

RESULTS OF DOMESTIC BORE CENSUS

PORT MANDURAH GROUNDWATER CENSUS 8/2/95 TO 9/2/95

PRIORITY AREA

McLarty Road

Deli	No bore.
52	No bore.
50 (Childcare Centre)	No bore.
48	No bore.
46	Neighbours say has bore. No one at home.
44	No one at home.
42	Vacant lot.
40	No bore.
38	No bore.
36	No bore.
34	No bore.
32	No bore.
30	No bore.
28	No one at home.
26	No one at home.
24	No bore.
22	Neighbours says has bore. No one at home.
20	No bore.
18	Has bore. - 55 feet deep, 30 feet to water level, unable to get probe down hole. - 12 months old. - Used for garden, fish pond, top up pool.

- pH	Cond. (uS/cm)
1. 7.0	2400
2. 8.3	2600
3. 8.4	2600

16 (Mandurah Nursing Home) No bore.

Sandalwood Parade

28	No bore.
26	No bore.
24	No bore.
22	Vacant lot.

20	No bore.
18	No bore.
16	No one at home. Likely to have indicated by rust staining on verge.
14	Has bore. - Put down two bores in the last month. - One got stuck while drilling 30 feet, has water level of 5m. The other down to 25 feet with water level of 5.21m. - Used for garden. - pH Cond. (uS/cm) 1. 7.5 780 2. 7.3 790 3. 7.4 680
12	No bore.
10	No bore.
8	No bore.
6	No one at home. Neighbours say has no bore.
4	No bore.
2	No bore.

Enfield Street

Land being built with houses, no bores.

Glencoe Parade

2	No bore.
4	No one at home.

NORTH OF PRIORITY AREA

Glencoe Parade

1	No one at home.
3	No bore.
5	No one at home.
7	No bore.

Leyburn Drive

40	No bore.
38	No bore.
36	No bore.

34	No one at home.
32	No one at home.
28	No bore.
26	No bore.
24	Has bore.

- 36 to 40 feet deep and water level of 5.85m.
- 12 months old and used for garden.

-	pH	Cond. (uS/cm)
1.	8.3	1370
2.	8.3	1440
3.	8.4	1460

20	No bore.
18	No one at home.

Haddon Place (Residents say no bores in street)

1	No bore.
2	No one at home.
3	No bore.
4	No bore.
5	No one at home.
6	No one at home.
7	No one at home.

Agnew Place

1	No bore.
2	No bore.
3	No bore.
4	No bore.
5	No one at home.
6	No one at home.

McMahon Court

1	No bore.
2	No bore.
3	No bore.
4	No bore.

5 Has bore.

- Just moved in to house, does not know depth of bore.
- Could not get a water level.

-	pH	Cond. (uS/cm)
1.	8.4	910
2.	8.4	960
3.	8.4	1000

McLarty Road

74 Has bore.

- 25 feet deep with a water level of 2.28m.
- Water quality or supply has not deteriorated over summer or over the years.

-	pH	Cond. (uS/cm)
1.	8.3	960
2.	8.3	940
3.	8.2	970

72 No bore.

70 No bore.

68 No one at home.

66 No one at home.

64 No one at home.

62 Neighbours say has no bore.

60 No bore.

58 No bore.

SOUTH OF PRIORITY AREA

McLarty Road

Halls Head Retirement Village — Has no bore at present, but had test drilling conducted recently by Michael Leighton of Leighton Drilling, Mandurah.

WEST OF PRIORITY AREA

Sandalwood Parade

19 No one at home.

17 No one at home.

15 No one at home.

13	No one at home.
11	No one at home.
9	No one at home.
7	No one at home.
5	No bore.
3	No bore.
1	No bore.

Glencoe Parade

6	No bore.
8	No bore.
10	No bore.

Brigadoon Close

1	No one at home.
2	No bore.
3	Neighbours say has bore, no one home.
4	No bore.
5	No one home.
6	No bore.
7	No bore.
8	No bore.
9	No one at home.
10	No bore.
11	No bore.
15	No one at home.

Talbot Close

1	No bore.
2	No bore.
3	No bore.
4	No bore.
5	No bore.
6	No bore.
7	No bore.
8	No bore.
9	No one at home.
10	No bore.

APPENDIX E

Marine Engineering Aspects
Port Mandurah Stage 2 PER

Port & Harbours, 1995

PORT & HARBOUR CONSULTANTS

CEDAR WOODS PROPERTIES LTD

PORT MANDURAH STAGE 2

PUBLIC ENVIRONMENTAL REPORT

MARINE ENGINEERING ASPECTS

Rev	Date	Description	Prepared By	Reviewed By	Approved By
O	28/2/95	Issued to Client	D. Todd	J. Schepis	D. Todd

Prepared by

PORT AND HARBOUR CONSULTANTS

Document no: 032/07031/1

REVISIONS

Rev	Date	Description	Prepared By	Reviewed By	Approved By
A	20/2/95	Issued for Internal Review	D. Todd	J. Schepis	D. Todd
B	24/2/95	Issued for Project Team Review	D. Todd	J. Schepis	D. Todd
O	28/2/95	Issued to Client	D. Todd	J. Schepis	D. Todd

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LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

The Port Mandurah Stage 1 Canal Estate was completed in 1990. The project has been a success from both developmental and environmental view points with a history of strong property sales and housing construction, while on-going monitoring has confirmed that the performance of the canals with respect to water quality has exceeded expectations.

Cedar Woods Properties Limited (CWPL), who are responsible for the on-going management and monitoring of Port Mandurah Stage 1 canals, are now proceeding with the planning for the Stages 2A and 2B canals. This further development is significantly larger than the existing Stage 1 canals and will provide a second connection of the Canal Estate with the Mandurah Channel.

Port and Harbour Consultants (PHC) have been appointed to the Project Team to investigate the Marine Engineering Aspects of the proposed development.

The results of these investigations, which have been tailored specifically for the purpose of providing input to the Public Environmental Report, are presented this report.

Associated with gaining approvals for the Port Mandurah Stage 1 canal estate, a large number of reports have been prepared detailing various environmental, planning and engineering aspects of the overall project. Further details of these reports are listed in Section 8.0 - References. In this report PHC will reference wherever possible, this existing work.

Previously determined environmental impacts and engineering designs will either be confirmed with respect to applicability for these later stages of development or modified with the benefit of recently available data, observations or calculations.

2. PROJECT AREA

The Port Mandurah Stage 1 canal estate is located north of Mary Street and south of Leighton Road with a channel connection to the Mandurah Channel north of Halls Park.

It is proposed that the Stages 2A and 2B of the canal estate extend south of Mary Street with Stage 2A between the Conservation and Foreshore Reserve adjacent to the Mandurah Channel and the Old Coast Road. Stage 2B is thus bordered by Mary Street, McLarty Road and Old Coast Road.

The proposed layout of the completed Canal Estate is shown in Figure 2.1.

3. CANAL GEOMETRY

In this Section PHC will describe the basis of the principal dimensions selected for use in the Stage 2A and 2B canals and provide typical canal sections through the project area. Where appropriate, reference will be made to the existing Stage 1 canals to illustrate the desired uniformity of appearance. In general it is proposed to maintain a mixture of 40, 50 and 60m wide canals as used in Stage 1.

3.1 Design Vessel

The design vessel previously used in the Stage 1 canals was 10m long. It is proposed to maintain this design vessel size for Stages 2A and 2B as vessels moored in these new stages will at times travel though the existing Stage 1 canals. The principal dimensions of this design vessel are listed in Table 3.1.

Access to the Stage 2A canals will require navigation under the Old Mandurah Traffic Bridge, which has a maximum clearance (at low tide) of 5.60m (Department of Transport, 1995). Further access into the Stage 2B canals will require passage under either the new Mary Street or Old Coast Road Traffic Bridges. It is proposed that these are constructed with a clearance of 5.5m above Mean Sea Level. Discussions with various boat manufacturers and brokers indicates that these clearances will be adequate for powerboats up to the design vessel length, including allowances for flybridges, canopies and radar masts. Yachts will be able to pass under these bridges by lowering their masts, a practice frequently seen at the Fremantle Road and Rail Bridges in Perth. However this is expected to reduce the number of yachts wishing to moor within Stages 2A and 2B, compared to the presently available full height access to Stage 1.

3.2 Canal Depths

The canal depth within the Stage 1 canals is -2.7m AHD (Feilman Planning Consultants, 1989). It is proposed to maintain this depth within the Stage 2A canals. Within Stage 2B it is proposed that, subject to further geotechnical investigations, earthworks balance calculations and marketing considerations, the side canals have the option of being reduced to -2.1m AHD (thus catering for only design vessel powerboats or small yachts). The main interconnecting 60m wide canal between the Mary Street and Old Coast Road Bridges would be maintained at -2.7m AHD to allow a limited number of design vessel yacht mooring locations and better hydraulic flushing of the canal estate. Details of these canal depth calculations are given in Table 3.2 Canal Depth Basis.

3.3 Typical Canal Sections

It is planned that a variety of canal widths and section details are used within the Stage 2A and 2B canals.

The three basic canal widths, measured from opposite canal wall faces, are 40, 50 and 60 metres. Details of these are shown in Figures 3.1 and 3.2.

A variety of mooring configurations and wall toe depths are available, consistent with that used in the Stage 1 canals, that provide more than the required minimum navigable widths. For the 60m wide main canal, the navigable width is around three times the design vessel length, based upon the options of parallel moorings against shallow toe depth walls or end-on moorings to deep toe depth walls.

Within the 40m wide canals, which are only proposed for use where there is no through traffic and limited upstream moorings, the navigable width provided remains at or slightly greater than the minimum requirements (Department of Planning and Urban Development, 1991) for the above shallow and deep toe depth wall options.

3.3 Typical Canal Sections (Cont'd)

In areas with increased numbers of upstream moorings a 50m canal width is proposed which further increases the navigable width to around 30 metres.

It is proposed that fixed jetty moorings are used in the canal estate, as is the case in the Stage 1 canals, to accurately position the vessels within their mooring envelopes.

Along the eastern edge of the canal estate in Stage 2A, at the Conservation and Foreshore Reserve boundary, a special revetment treatment is proposed as shown in Figure 3.3. The typical details shown have been selected to provide protection to the Reserve from boat wash, while allowing the tidal interchange of water through the porous revetment into the intertidal area. The crest height has been selected to be at H.A.T. level, during detailed design and in liason with the relevant authorities appropriate navigational safety requiremetns will be agreed.

To achieve a visually pleasing edge treatment it is proposed that the revetment crest height and level be varied along its length to create a natural appearance, consistent with good engineering design, while taking into account the above features.

Additional further refinement of the internal geometry of the 40, 50 and 60m wide canals will occur during detailed design of the project to take into consideration factors such as canal wall height and depth, batter slopes, depths and scour, mooring configurations and envelopes, and geotechnical conditions on site.

4. CANAL FLUSHING

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

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

- tidal exchange
- wind driven currents
- density driven currents

These mechanisms will be discussed in the following sections with respect to the Stage 2A and 2B canal estate, together with the new additional mechanism of through flow due to the creation of a second entrance into the Mandurah Channel.

4.1 Canal Layout

The canal layout for the existing Stage 1 and proposed Stage 2A and 2B canals is shown in Figure 4.1, Canal Layout. The basic data relating to the canal estates layout, such as water surface area and volume are given in Table 4.1, Canal Layout Data. The data indicate that together, Stages 2A and 2B are slightly more than double the existing Stage 1 canal estate.

The canal alignments have been selected to enhance the flushing of the canals due to wind driven currents while providing points of concentration and easy collection of surface driven flotsam. The multiple loop canal system, off the main 60m wide canal, enhances the flushing of the canal estate. These aspects will be discussed further in the Section 4.2 of this report.

Within Stages 2A and 2B, which are delimited by the major roads in the area, smaller parcels of blocks may be developed and released on a staged basis to suit market conditions. Typical examples of this are shown as Stage 2B Phase 1, Phase 2 and Phase 3. During Detailed Design the exact extent of these sub-parcels will be determined for both Stages 2A and 2B.

4.2 Flushing and Water Quality

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

4.2.1 Tidal Regime

The tidal levels at Mandurah (Fishermans Jetty) are shown in Table 4.2. As will be discussed further in Section 6.3 these levels are based upon recorded data prior to the Dawesville Channel, however given their similarity to Ocean tides, noticeable changes due to the Dawesville Channel are not expected.

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

4.2.1 Tidal Regime (Cont'd)

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

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

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

4.2.2 Through Flow

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

Calculation of these flow conditions (and those under extreme flood and storm surge events) have been carried out as part of this study. The ambient conditions providing assessment of effective flushing conditions and the extremes providing the design conditions for scour and walling stability.

By considering the Mandurah Channel, the main 60m wide canal and the three other loop canals in Stages 1, 2B Phase 1 and 2B Phase 3, a set of nine simultaneous equations was developed using networked channel flow and considering conservation of energy around each flow loop and conservation of flow at each node point. By its nature this analysis assumes that the flow along the Mandurah Channel, upstream and downstream of the canal estate, is unchanged, and that the flow in the Mandurah Channel adjacent to the canal estate is reduced by the amount of the through flow. These assumptions are valid providing the volume of the through flow is small compared to the Mandurah Channel and considering the overall quality of the driving data (modelled flows rather than measured) available at this stage of the project as discussed further in Section 6.3.

Table 4.3 shows the calculated through flow rates and velocities in the canal estate for the tidal conditions (as well as for extreme conditions). These tidal through flow rates, and velocities as modelled by Port and Harbour Consultants are based upon boundary conditions derived from previous modelling work (Department of Marine and Harbours, 1993 (b)) and are the 29 day average maximum tidal flows.

4.2.2 Through Flow (Cont'd)

With respect to water quality, and after allowing for a variation in flow velocity throughout a 12 hour tidal cycle, the average quantity of through flow is approximately 5 times the average tidal prism of the canal estate and equal to the total volume of the canal estate waters. This through flow, working in conjunction with density driven exchange mechanisms and tidal exchange mechanisms between branch canals will ensure those will flush effectively. This is discussed further under Section 4.2.3.

4.2.3 Other Flushing Mechanisms

Previously referenced studies and field measurements have proven the ability of wind driven and density current driven water exchange within the Port Mandurah Stage 1 canal estate. It is expected that these mechanisms will continue to operate within the canal estate, following completion of Stages 2A and 2B, though due to the magnitude of the tidal through flow, they need only operate within Stage 2A and the smaller dead end canals of the existing Stage 1 and new Stage 2B.

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

Within Stage 2A the water exchange due to density currents has been calculated to be the same as that within the existing Stage 1 canal estate and can be confirmed by comparison of each Stages surface area (and thus canal length) and volume data given in Table 4.1. This indicates that, with respect to Phased Construction, Stage 2A can be developed first (without the Main Canal in Stage 2B) and still be assured of good water quality, equivalent to that presently observed in Stage 1.

Subsequent development within Stage 2B has been planned such that at a suitable time in the staging either a loop canal or the main canal are developed with Stage 2B Phase 1 to initiate the contribution of the through flow to the flushing of the canal estate waters.

4.3 Extreme Events

The benefit of the through flow to maintaining water quality has been discussed in Section 4.2. During extreme events, river flood flows and ocean storm surges, the greater flow in the Mandurah Channel results in a greater driving head available to increase the through flow rates and velocities.

The resultant flow data has been calculated using the method described in Section 4.2.2, with revised channel flow cross-sections and hydraulic data to account for the different increased water levels relating to these two types of extreme events. Further details of these extreme events (typically 100 year return period) are given in Section 6.3.3 while the results of the calculations are shown in Table 4.3.

The through flow rate during extreme events is approximately 15% of the Mandurah Channel flow while the velocities are around 10% slower within the canal estate. Depth averaged velocities within the main 60m wide channel are as high as 0.5 - 0.7m/s near the entrances and 0.35 - 0.5m/s within the canal estate. The velocities within the loop canal are much less at between 0.1 - 0.2 m/s. During the detailed design phase of the project further calculations will be made to determine the extent and design of any scour protection required on the canal batters.

These velocities are not expected to cause any significant problems with respect to the mooring of boats, especially compared to extreme wind loadings and wind driven currents, provided the moorings are adequately designed for these loadings. However, within the main canal it would be preferable to have parallel moorings to reduce this portion of the loading.

5. ADJACENT SHORELINE AREAS

The geomorphology of the region was studied in detail at the time of preparation of the original ERMP for the Halls Head Waterways project (The Feilman Group, 1981). At that time predictions of the stability of the northern entrance canal (for the existing Stage 1 canal estate) indicated an allowance for removal of up to 2000m^3/year of sand from the entrance due to the migration of the Fainbridge Road sandbar. These predictions have been proven by monitoring surveys and small dredging works are imminent to remove this material that has accumulated over the past 5 years.

At the same time the stability of the proposed southern entrance was concluded to be satisfactory with no expected significant siltation problems. These conclusions, based upon review of aerial photography, site and diving inspections, have been rechecked for this PER with the aid of more recent aerial photographs, hydrographic survey and examination of siltation records from the Waterside Canal Estate opposite.

5.1 Aerial Photographs

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

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

South of the Mandurah Marina, in the region where the southern entrance cuts across the Conservation and Foreshore Reserve (see Figure 4.1), the edge of the Mandurah Channel is defined by a subaqueous shoal. The exact limits of this shoal are difficult to accurately define from the aerial photography, however its overall extent from its northern, southern and eastern edges appears to be the same between 1961 and 1991. At intermediate times, the extent of vegetation on the shoal appears to vary markedly with coverage of the southern end fluctuating between 1981 and 1991.

The Reserve vegetation line west of the shoal appears to have retreated by between 5 and 10 metres while the beach has increased in width. Generally and within the accuracy of the aerial photographs and this method, the shoreline and the subaqueous shoal appear to be stable, and as discussed further in Section 5.2, significant coastal processes cannot be found.

5.2 Hydrographic Survey

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

The mechanism causing this action is unclear, however the yearly volume is insignificant and is best handled by continued monitoring. With the southern entrance channel and associated revetments cutting through this shoal area a nominal allowance should be made for sediment trapping and remedial works (excavation or dredging) should this siltation occur within the channel. The overall scale of this would be much smaller than that presently allowed for at the northern entrance channel.

5.3 Waterside Mandurah

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

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

Given that the Waterside Mandurah entrance canal is on the opposite side and only some 300m south along the Mandurah Channel from the proposed southern entrance of Port Mandurah Stages 2A and 2B canal estate, it is reasonable to assume that the performance of that entrance is a valid guide to this proposed entrance. Thus siltation is not expected to be a problem within the Port Mandurah southern entrance canal and its dredged opening into the Mandurah Channel.

5.4 Southern Entrance Canal

The southern entrance canal cuts through the conservation and foreshore reserve at the northern tip of the subaqueous shoal. In order to preserve the current water quality and flushing characteristics of this area, as well as stabilising it from erosion due to boat wash, it is proposed to continue the permeable revetment (as shown previously in Figure 3.3) from the western edge of the Reserve along the canal edge alignment (on both the northern and southern sides) until the Mandurah Channel is reached.

In this region the Mandurah Channel is deep and wide with side batters of 1:15 between -0.5m and -4.0m AHD and maximum depths of -4.8m AHD. It is proposed that the revetments be terminated in the vicinity of the -0.5 to -1.0m AHD contour and be identified with appropriate navigational markers. The entrance canal, with a dredged depth of -2.7m AHD, will be carried into the Mandurah Channel approximately 30 metres beyond the revetments with the approach area widened into a small "fan" shape, as has been done for the northern entrance canal.

6. BUILDING LEVELS

The selection of building levels depend upon several factors relating to extreme flood and storm surge events, possible greenhouse effects and freeboard allowances. The existing criteria established for Port Mandurah Stage 1 will be discussed below together with recent developments with respect to revised greenhouse effect predictions and the Dawesville Cut.

6.1 Stage 1 Building Levels

The minimum building floor levels within the Stage 1 canals are at +2.2m AHD (Feilman Planning Consultants, 1989). This was based upon an allowance of 0.3m for Greenhouse Sea Level rise (over the next 50 years) on top of the approved Shire of Mandurah minimum building levels of +1.9m AHD. This intum was based upon Public Works Department Flood plans showing an extreme storm surge water level of +1.5m AHD and a freeboard allowance of 0.4m.

6.2 Greenhouse Allowances

As discussed in Section 6.1 an allowance for sea level rise, one of the Greenhouse effects, has been made in the Port Mandurah Stage 1 canal estate. Similar allowances have also been proposed for other developments in the Mandurah region, such as the Harbour City Canal Estate (Riedel and Bryne Consulting Engineers, 1992).

Guidelines for the design of Coastal Engineering Projects with respect to Greenhouse effects (The Institution of Engineers, Australia, 1991) identify the key variables listed in Table 6.1 for consideration.

With respect to building levels, the important variable is Mean Sea Level. This is also the only variable for which quantitative scenarios are available. These scenarios indicate a best estimate of sea level rise of +0.18 and +0.30m for the years 2030 and 2050 respectively. This data was drawn from the work of the United Nations Intergovernmental Panel on Climate Change (IPCC), Response Strategies Working Group, 1990.

It is noted that other variables, such as wind climate (altered numbers, intensity and location of Tropical Cyclones) and rainfall (altered flood events) may also effect building levels, however the development of quantitative scenarios at that time required more detailed modelling work.

In recent years (since 1990) further modelling has been undertaken with more detailed global circulation models, refined greenhouse gas emissions data and an examination of regional implications to Western Australia. This work is report in Wigley and Raper (1992) and CSIRO (1994). With respect to Mean Sea Level, Wigley and Raper provide revised best guess scenarios indicating a rise of +0.14 and +0.22m for the years 2030 and 2050 respectively. Around these estimates considerable variability still exists due to differing estimates of aerosol forcing possibilities giving a maximum possible range, at year 2050, of between +0.06m and +0.42m for sea level rise on the best guess basis of CO_2 fertilisation and ozone-depletion feedback. CSIRO reference directly the Wigley and Raper work with respect to Mean sea Level change and note again the complex interactions of temperature change, sea level rise, tropical cyclone or other extreme event characteristics, storm surges and wind and wave climates to coastal impacts due to Green house effects.

They recommend further research into the reformulation of tropical cyclone prediction parameters (and indeed the basic understanding of tropical cyclones themselves) and more detailed modelling to simulate cyclones.

6.2 Greenhouse Allowances (Cont'd)

Further quantification of these effects is some time away and clearly beyond the scope of this PER.

Allowances for Greenhouse effects will be made within the development by the application of a possible rise in Mean Sea Level as discussed above.

6.3 Effect of the Dawesville Channel

The Dawesville Channel was opened, between the Peel/Harvey System and the Indian Ocean, in April 1994. Possible impacts of the Dawesville Channel, with respect to building levels, are related to extreme events. Other impacts of the Channel with respect to tidal conditions and the Peel/Harvey System water quality will also be discussed below.

6.3.1 Peel/Harvey System Water Quality

The Dawesville Channel was constructed as part of the overall strategy to overcome algae related problems within the Peel/Harvey System. Full details of this strategy are given in the Environmental Review and Management Programme (ERMP) for the project (Kinhill Engineers Pty Ltd, 1988). The environmental effects of the project impact upon the physical, biological and human environments of the region, with the aim of reversing the deterioration of the system that has occurred over the last thirty to forty years. With a second connection to the sea it will provide a more marine like environment within the Peel/Harvey System and a more resilient ecosystem into the future.

With respect to the Port Mandurah Project, the net effect of these impacts is predicted to be, in the long term, an improvement in the water quality (salinity, dissolved oxygen, turbidity, nutrients and algae) of the source water body.

The water quality within the Port Mandurah Canal Estate can never be higher than that of the source water body, thus the Dawesville Channel is deemed to have a positive impact on this project.

6.3.2 Tidal Conditions

The tidal conditions at the Port Mandurah site are nearly identical to Indian Ocean Tides due to its closeness to the ocean entrance of the Mandurah Channel. The Dawesville Channel has significant effects on the tidal range within the Peel/Harvey System and these were discussed in the ERMP for the project and more recently re-examined by the Department of Transport (Department of Marine and Harbours, 1993(a), 1993(b)), with the benefit of better input data.

A detailed discussion of pre and post Dawesville Channel conditions within the Peel/Harvey System is not required in this PER as the Port Mandurah Stage 2A and 2B Canal Estate is now subject to post Dawesville Channel tidal level and flow conditions, however suffice to say that predicted changes in tidal levels and flows are minor with respect to this project.

6.3.2 Tidal Conditions (Cont'd)

The Department of Transport currently operate a tidal gauge at the Mandurah Fishermans Jetty. An analysis of this data will be available after 12 months of records are on hand (after April 1995). Informal advice received from the Department of Transport is that only small variations in tidal levels are expected, due to the existing close match to ocean levels.

With respect to tidal flows in the Mandurah Channel, the Department of Transport modelling indicates that, Post-Dawesville Channel, the average (29 day) maximum flood and ebb flow velocities are 1.1 and 1.2 knots respectively with a maximum modelled flood and ebb flow of 2.1 and 1.9 knots respectively. Average channel dimensions of 170m width and 2.8 depth (at MSL, 0.0m AHD) were adopted for this work. The average flows are nearly identical to pre-Dawesville Channel, while the maximum flows are slightly reduced.

The Department of Transport have recently collected tidal flow data from within the Mandurah Channel over the Periods of April-May and October-November 1994, however, at the time of writing, this data was unprocessed and not available as a check upon the model tidal flow predictions.

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

6.3.3 Extreme Conditions

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

The above extreme event types have been recently modelled by both the Department and Transport (Department of Marine and Harbours (1993(b)) and the Water Authority of WA (1994) to examine the effects of the Dawesville Channel. The modelling approach followed in each study is different.

The Department of Transport (DOT) considered various flood hydrographs and ocean tidal records (including storm surge) as the detailed forcing functions (15 minute timestep) in a simplified model. The DOT model represented the system as interconnected basins with dual connections to the ocean. Relationships such as basin volumes at differing stages and channel flow characteristics were parameterised within the model. Averaged conditions only are available from the published results such as typical basin water level and uniform channel flows.

6.3.3 Extreme Conditions (Cont'd)

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

The results of these models are shown in Table 6.2. In the case of the 100 year flood, a reasonable match can be seen between the two models.

The net result of this work, as detailed by the Water Authority in their letter to the City of Mandurah (WAWA, 1994) is that the design peak water level within the Peel Inlet is +1.6m AHD (+1.15m AHD 100 year storm surge plus 0.45m wind set-up). This is unchanged from pre-Dawesville conditions, though now due to storm surge, rather than flooding as previously was the case.

Along the Mandurah Channel, the Water Authority advise that the published 100 year flood levels (PWD, WA (1984)), remain current as they are based upon the +1.60m AHD peak water level within the Peel Inlet as discussed above. Along the Port Mandurah Stages 1, 2A and 2B project site these published levels vary between +1.44 and +1.32m AHD at the Northern and Southern entrance canals respectively.

6.4 Stage 2 and 3 Building Levels

It is proposed that the building levels detailed in Table 6.3, more specifically the fill levels and floor levels, are adopted for Stages 2A and 2B of the Port Mandurah Canal Estate. These levels draw upon the revised estimates of Mean Sea Level rise associated with the Greenhouse effect to the year 2050, consideration of the effects of the Dawesville Channel and published Water Authority 100 year flood levels and recommended fill and floor level freeboards.

7. IMPACT OF THE DEVELOPMENT

With respect to Marine Engineering and Water Quality issues, analysis adopted in this work has shown the development is not expected to have any detrimental impacts on these aspects of the existing environment. This is due to its limited impact on the hydraulics of the Mandurah Channel, an already vastly man controlled channel, and the use of appropriate canal edge details along the Conservation and Foreshore Reserve Boundary. These points will be discussed further in the following sections.

7.1 Estuary Hydrodynamics

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

Now most recently the Dawesville Channel has been constructed, although its effect on the Mandurah Channel has been shown to be limited compared to its effect on water levels within the Peel/Harvey System. Modelling (Department of Marine and Harbours 1993 (b)) has shown that the tidal prisms flowing through the Mandurah Channel reduced from 8.8 x 10^6 m^3 to 8.0 x 10^6 m^3 for a 0.6m ocean tide range. Construction of Stages 2A and 2B of Port Mandurah will, due to the double connection of the canal estate to the Mandurah Channel, most likely slightly increase the flow capacity of the Mandurah Channel over the limited distance (approximately 1300m) between the entrances. However given that the scale of the Mandurah Channel is some 5000m in length, from the Ocean to the Peel Inlet, this increase in flow capacity is not expected to have a measurable effect on the estuarine hydrodynamics.

7.2 Conservation and Foreshore Reserve

A Reserve will be created between the existing shoreline (0.0m AHD) and the Stage 2A Canal Estate. The reserve is variable in width, but is mostly 75m wide and is level with its western most edge at +0.3 to +0.4m AHD adjacent to the southern entrance channel and as low as +0.15m AHD on its way to higher land greater than +1.0m AHD at its southern end.

By reference to Table 4.2 - Tidal Levels, it can be seen that most of this land (except the southern most portions) is inundated under Highest Astronomical Tide conditions (+0.5m AHD) with large areas inundated on a daily and weekly basis.

For environmental reasons it is proposed to form a 25m wide transition zone across the western most edge of this reserve with a fall in levels down to Low Water Level towards the canal estate. To allow a free flowing exchange of water into this zone and to equalise water levels across the top of the Reserve a permeable limestone bund is proposed along the eastern side of the canal. A typical section of this bund is shown in Figure 3.3.

During times of high tides or extreme events the bund will slow down water flow across the Reserve (whether entering or leaving the canal estate) while providing an effective barrier to prevent boat wash from the adjacent canal damaging the Reserve. It is anticipated that during the detailed design phase of the project discussions will be held with the Department of Transport to determine their requirements with respect to this bund (ie crest height and navigational marker requirements).

8. REFERENCES

- BSD Consultants Pty Ltd, 1992

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

- BSD Consultants Pty Ltd, 1994

  "Water Quality Survey, January 1994,
  Environmental Monitoring Programme, Port Mandurah"
  Cedar Woods Limited, February

- CSIRO, 1994

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

- Department of Planning and Urban Development, 1991

  "Policy DC 1.8, Artificial Waterways and Canal Estates",
  Dated 10th December 1991

- Department of Marine and Harbours, 1993 (a)

  "Impact of the Dawesville Channel on water levels in the
  Peel/Harvey Estuarine System", Coastal Management Issue 1

- Department of Marine and Harbours, 1993 (b)

  "Water Levels in Peel Inlet and Harvey Estuary Before and After
  Dawesville Channel", DHM D10/92, September

- Department of Marine and Harbours, 1992

  "Mandurah, Fishermans Service Jetty Submergence Curve"

- Department of Transport, 1995

  "Swan River, Tidal Information and Bridge Clearances",
  Marine Emergency Operations Centre, Pers. Comm.

- The Feilman Group, 1981

  "Environmental Review and Management Programme,
  Halls Head Waterways", Parrys Esplanade Limited,
  Volumes 1 - Text and 2 - Appendices, December

8. REFERENCES (Cont'd)

- Feilman Planning Consultants, 1989

  "Notice of Intent, Port Mandurah Development",
  Esplanade (Mandurah Pty Ltd, February
  (Supplementary to The Feilman Group, 1981)

- The Institution of Engineers, Australia, 1991

  "Guidelines for Responding to the Effects of Climatic
  Change in Coastal Engineering Design",
  National Committee on Coastal and Ocean Engineering

- Kay, R,Eliot, I and Klem, G, 1992.

  "Analysis of the Intergovernmental Panel on Climate Change
  Sea Level Rise Vulnerability Assessment Methodology using
  Geographic Bay, SW Western Australia, as a Case Study"
  DASET, Canberra, 24pp.

- Kinhill Engineers Pty Ltd, 1988

  "Peel Inlet and Harvey Estuary Management Strategy"
  Environmental Review and Management Program - Stage 2,
  Department of Agriculture and Department of Marine and Harbours,
  May

- LeProvost Semeniuk and Chalmer, 1981

  "Environmental Considerations, Waterways Project -
  Halls Head Mandurah", (included in The Feilman Group, 1981),
  December, Port and Harbour Consultants

- McMullen Nolan and Partners, 1995

  "Port Mandurah, Natural Surface Survey", Drawings
  91084-2, Cedar Woods Pty Ltd

- Port and Harbour Consultants, 1990

  "Mandurah Quay, Water Quality and Flushing Study",
  D. M. Drainage

- Public Works Department, WA, 1984

  "Peel Inlet Entrance Channel, Flood Investigations",
  Charts 52725 - 6 - 1,2
  52725 - 3 - 1

8. REFERENCES (Cont'd)

- Riedel and Byrne Consulting Engineers, 1985 (a)

  "Dredge Depths and Wall Heights, Port Mandurah"
  Halls Head Estates, R129, March

- Riedel and Byrne Consulting Engineers, 1985 (b)

  "Preliminary Design Report, Port Mandurah"
  Halls Head Estates, R150, July

- Riedel and Byrne Consulting Engineers, 1981

  "Hydraulic Aspects, Halls Head Waterways Project, Mandurah",
  Parry Esplanade Ltd. (included in The Feilman Group, 1987),
  November

- Riedel and Byrne Consulting Engineers, 1990

  "Canal Flushing Study, Port Mandurah",
  Esplanade (Mandurah) Pty Ltd, October

- Riedel and Byrne Consulting Engineers, 1992

  "Marine and Water Quality Aspects, Harbour City
  Canal Estate, Mandurah", Esplanade (Mandurah) Pty Ltd
  (included in BSD Consultants Pty Ltd 1992), April

- Standards Australia, 1991

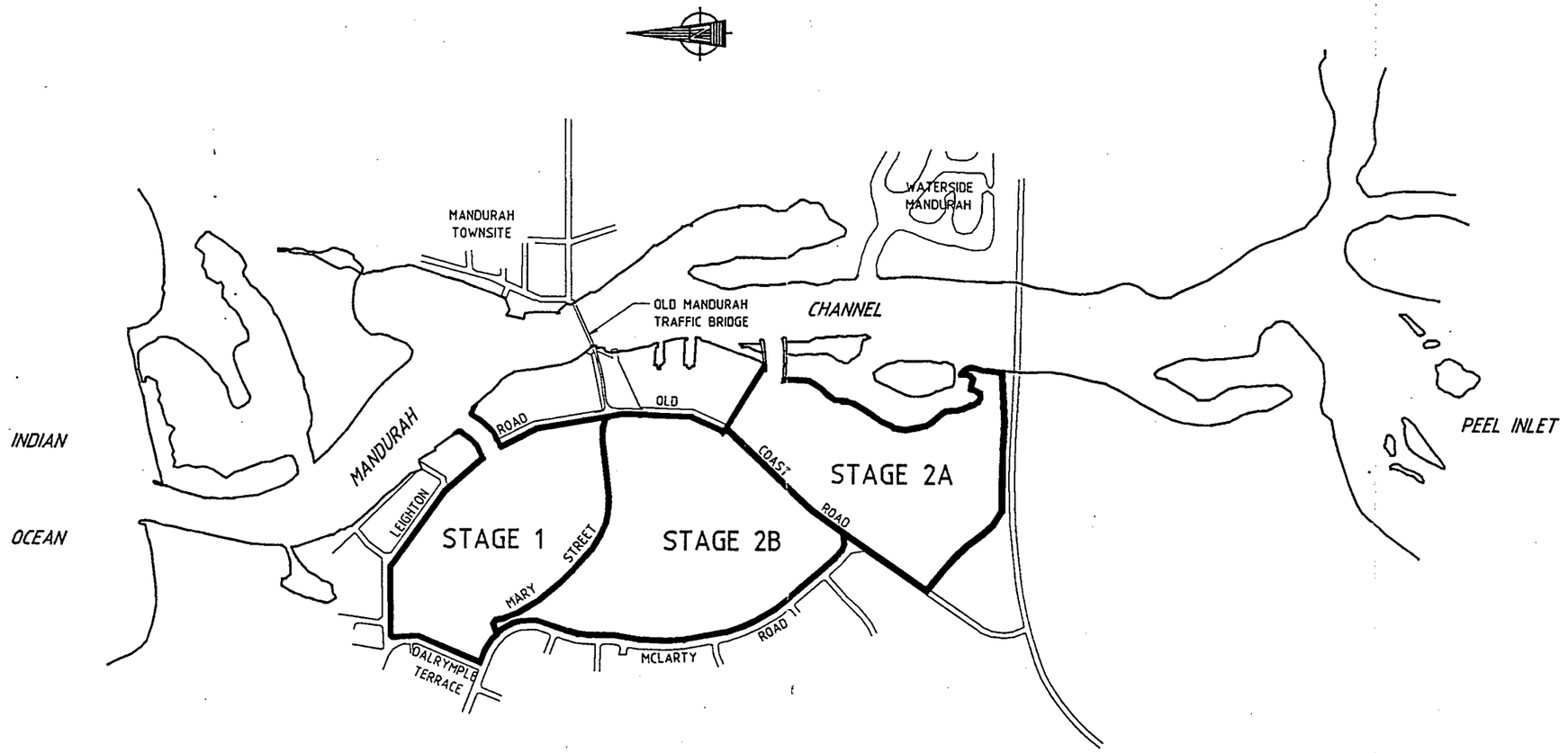
  "AS 3962-1991, Guidelines for Design of Marines"

- Water Authority of WA, 1994

  "Dawesville Channel" Letter to City of Mandurah,
  Ref: G 02712, 21st July 1994

- Wigley T.M.L. and Raper, S.C.B, 1992

  "Implications for climate and sea level of revised
  IPCC emissions scenarios", Nature, Volume 357,
  Page 293 - 300, 28th May 1992



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24.02.95	ISSUED FOR PROJECT TEAM REVIEW	B.G.C.	D.T.	
22.02.95	ISSUED FOR INTERNAL REVIEW	B.G.C.	D.T.	

DRG No | REFERENCE DRAWINGS

PORT MANDURAH STAGE 2
SITE PLAN

CLIENT
CEDAR WOODS PROPERTIES LTD.

PORT & HARBOUR CONSULTANTS
FRASER-WHOLOHAN GRILL PTY LTD ACN 049 313 068
CONSULTING ENGINEERS
LEVEL 16, QV1, 250 ST. GEORGE'S TERRACE, PERTH, 6000, WESTERN AUSTRALIA.
Tel (09) 278 8333 Fax (09) 278 8110

DES	D.T.
DRN	B.G.C.
CHD	
SCALE 1:20000 AT A3	DATUM AHD
APPROVED PROJECT MGR.	DATE
DRG NO FIGURE 2.1	REV 0

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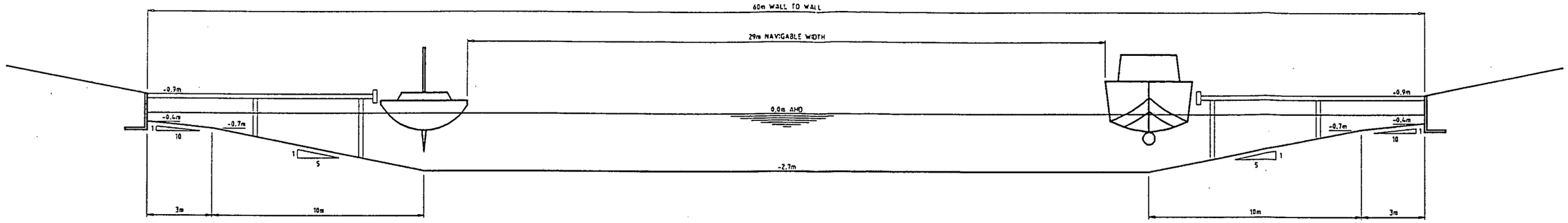

SHALLOW WALL

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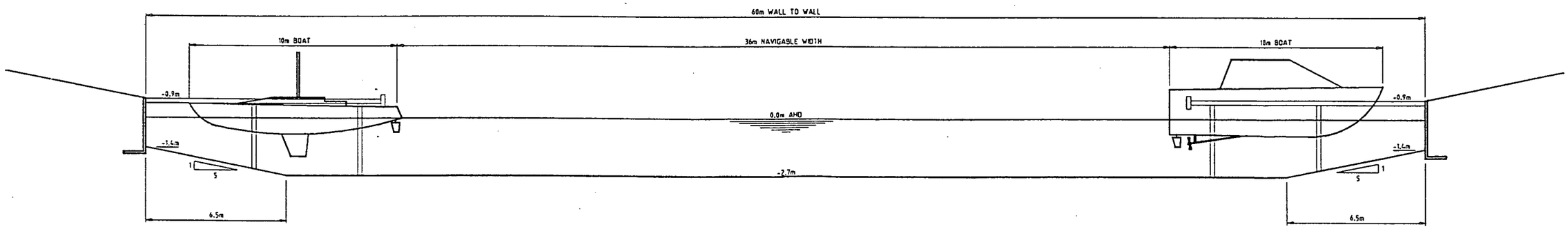

DEEP WALL

SCALE 1:200 AT A3

NOTES

WALL AND TOE GEOMETRY AS USED FOR EXISTING STAGE 1

DATE	REVISION RECORD	ORN	REC	APP
28.12.95	ISSUED TO CLIENT	B.G.C.	D.T.	
24.12.95	ISSUED FOR PROJECT TEAM REVIEW	B.G.C.	D.T.	
20.12.95	ISSUED FOR INTERNAL REVIEW	B.G.C.	D.T.	

DWG No | REFERENCE DRAWINGS

PORT MANDURAH STAGE 2
TYPICAL CANAL SECTION
60m WIDE

CLIENT
CEDAR WOODS PROPERTIES LTD.

PORT & HARBOUR CONSULTANTS
FRASER-WHOLOHAN GRILL PTY LTD ACN 009 213 004
CONSULTING ENGINEERS
LEVEL 14, QVI, 250 ST. GEORGE'S TERRACE,
PERTH, 6000, WESTERN AUSTRALIA.
Tel (09) 278 8333 Fax (09) 278 8310

DES D.T.
DRN B.G.C.
CHD
DATE

SCALE AS SHOWN | DATUM AHD | APPROVED PROJECT MGR. | DATE

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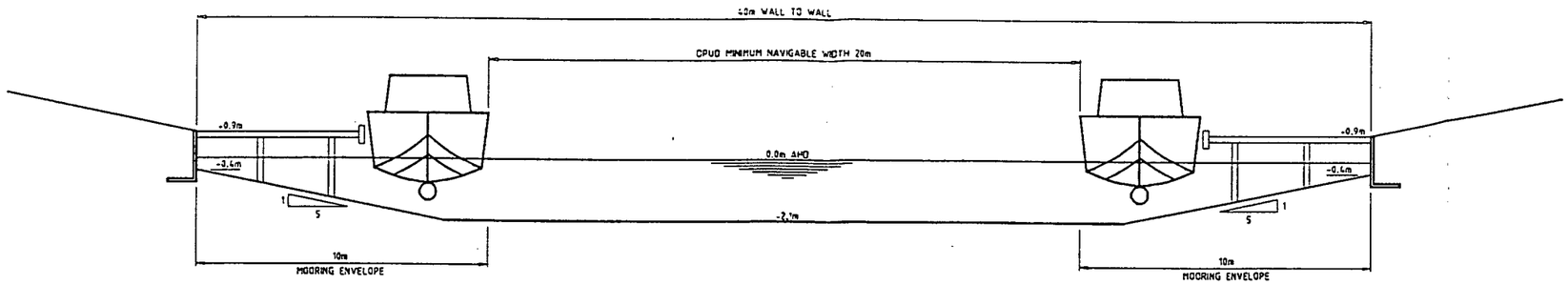
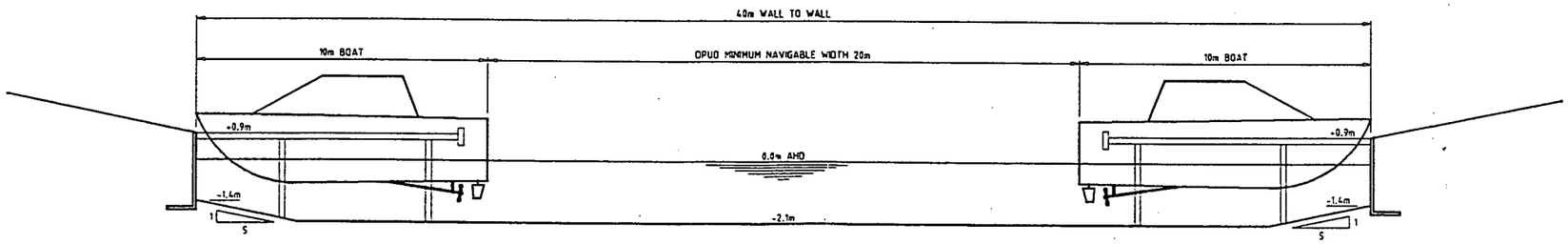


SHALLOW WALL

SCALE 1:200 AT A3



DEEP WALL

SCALE 1:200 AT A3

NOTES

WALL AND TOE GEOMETRY AS USED FOR EXISTING STAGE 1

DATE	REVISION RECORD	DRN	REC	APP
28.02.95	ISSUED TO CLIENT	B.G.C.	O.T.	
24.02.95	ISSUED FOR PROJECT TEAM REVIEW	B.G.C.	O.T.	
20.02.95	ISSUED FOR INTERNAL REVIEW	B.G.C.	O.T.	

ORG No

REFERENCE DRAWINGS

PORT MANDURAH STAGE 2

TYPICAL CANAL SECTION

40m WIDE

CLIENT

CEDAR WOODS PROPERTIES LTD.

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PERTH, 6000. WESTERN AUSTRALIA.
Tel (09) 278 8333 Fax (09) 278 8110

DES O.T.
DRN B.G.C.
CHD
DATE

SCALE AS SHOWN
DATUM AHD
APPROVED PROJECT MGR.

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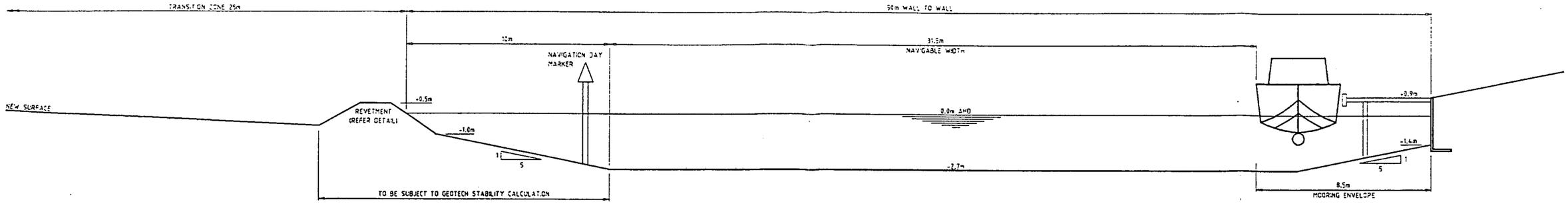
DRG NO FIGURE 3.2

REV 0



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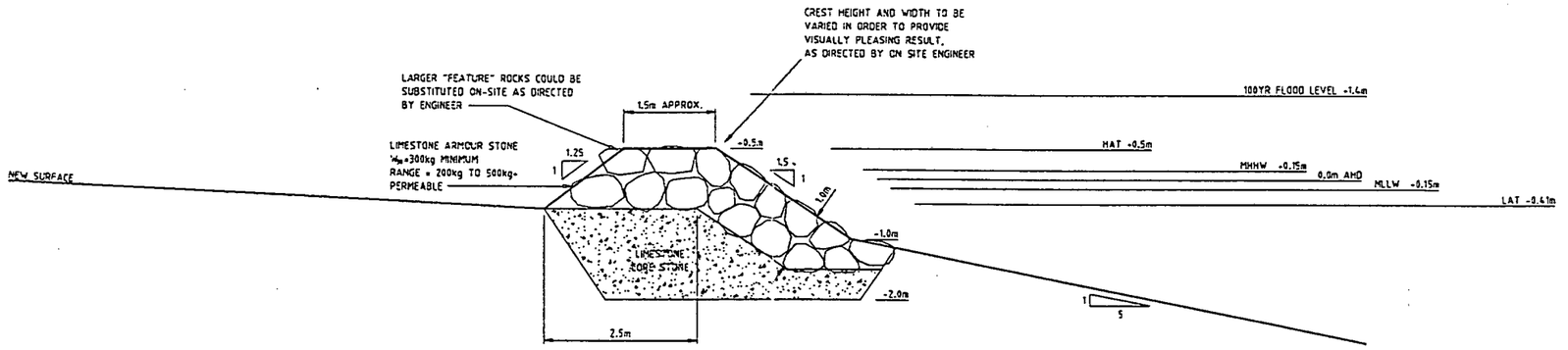

REVETMENT DETAIL 'TYPICAL)

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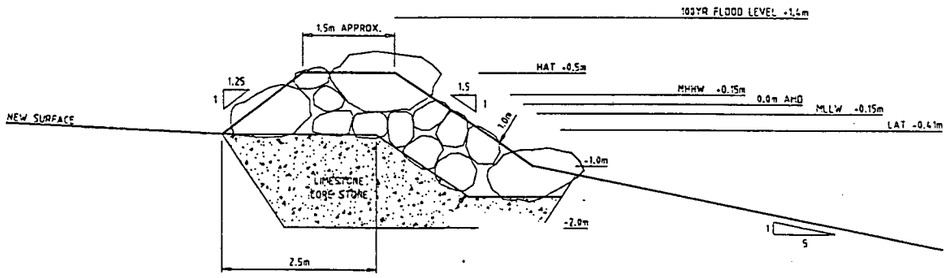

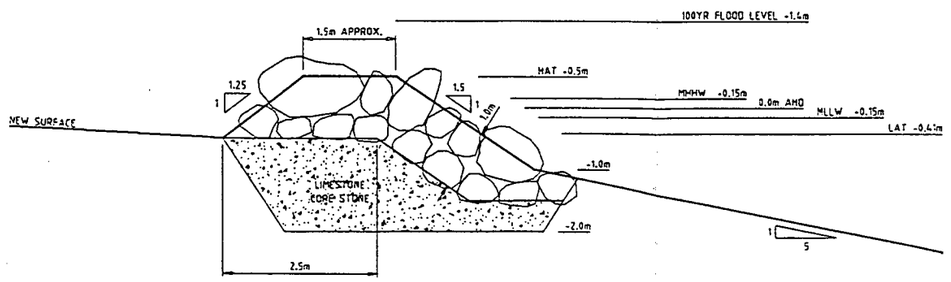

ALTERNATE VARIED REVETMENT DETAIL (TYPICAL)

SCALE 1 : 100 AT A3

NOTES

WALL AND TOE GEOMETRY AS USED FOR EXISTING STAGE 1

DATE	REVISION RECORD	DRN	REC	APP
28.02.95	ISSUED TO CLIENT	B.G.C.	D.T.	
23.02.95	ISSUED FOR PROJECT TEAM REVIEW	B.G.C.	D.T.	
20.02.95	ISSUED FOR INTERNAL REVIEW	B.G.C.	D.T.	

DRG No	REFERENCE DRAWINGS

PORT MANDURAH STAGE 2

TYPICAL CANAL SECTION

CONSERVATION AND FORESHORE RESERVE BOUNDARY

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Tel (09) 278 8333 Fax (09) 278 5110

DES	D.T.
DRN	B.G.C.
CHD	
SCALE	AS SHOWN
DATUM	AHD
APPROVED PROJECT MGR.	
DATE	

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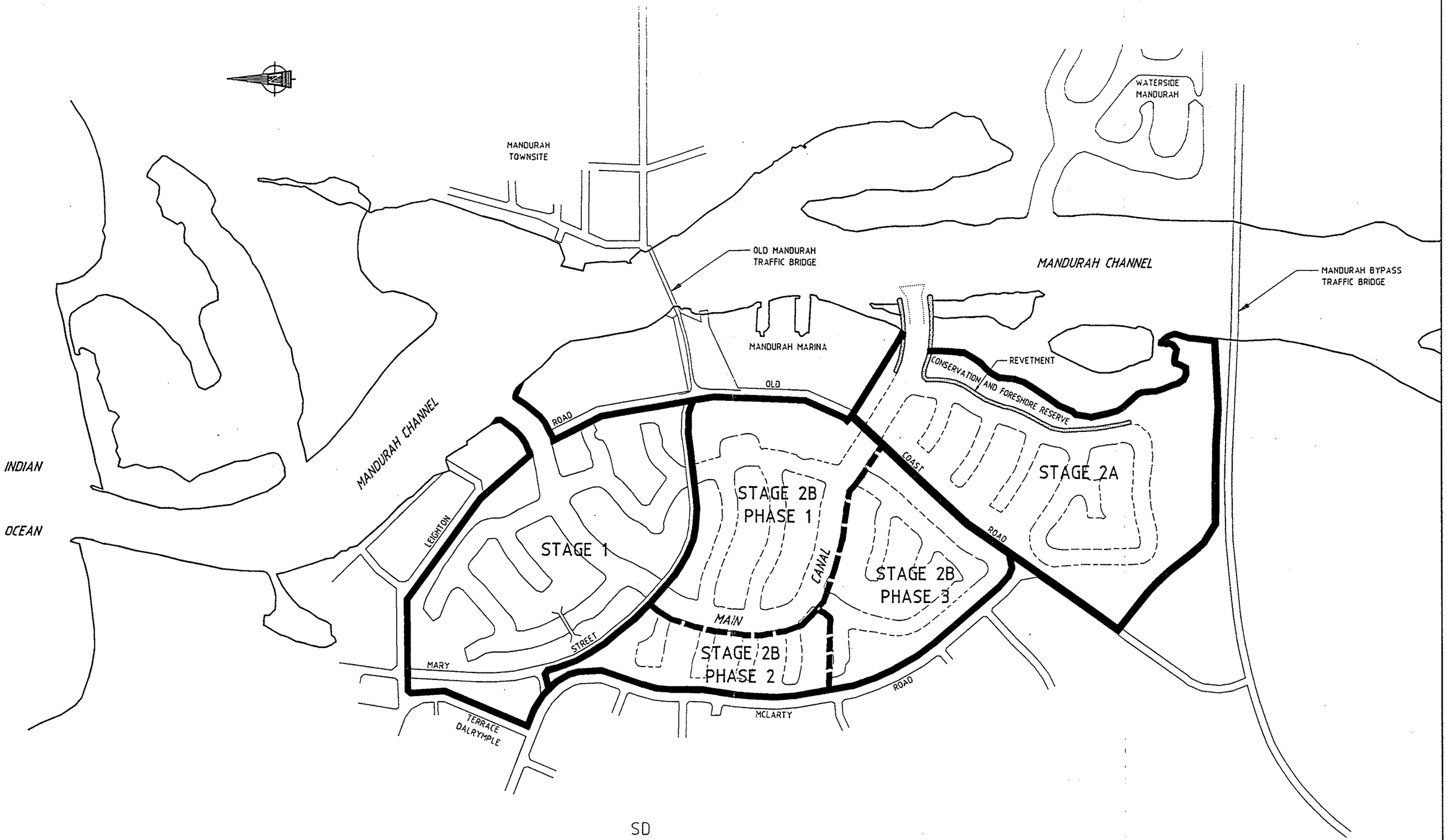
DRG NO FIGURE 3.3

REV 0



SD
SD

28.02.95	ISSUED TO CLIENT	B.G.C.	D.T.				
24.02.95	ISSUED FOR PROJECT TEAM REVIEW	B.G.C.	D.T.				
22.02.95	ISSUED FOR INTERNAL REVIEW	B.G.C.	D.T.				
DATE	REVISION RECORD	DRN	REC	APP	ORIG No	REFERENCE DRAWINGS	

PORT MANDURAH STAGE 2
CANNAL LAYOUT AND STAGES

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DES	D.T.
DRN	B.G.C.
CHD	

SCALE 1:10000 AT A3	DATUM AHD	APPROVED PROJECT MGR.	DATE

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DRG NO FIGURE 4.1 REV 0

TABLE 3.1 DESIGN VESSEL DIMENSIONS (m)

DIMENSION	YACHT	POWER BOAT
Length	10	10
Beam	3.4	4.0
Draft	1.8	1.2

Sources: Riedel and Byrne Consulting Engineers, 1985 (a)
Standards Australia, 1991
Department of Planning and Urban Development, 1991

TABLE 3.2 CANAL DEPTH BASIS

ITEM	DESIGN VESSEL	
	YACHT	POWER BOAT
Tide (98% exceedance)	-0.4m AHD	-0.4m AHD
Draft	1.8m	1.2m
Combined Underkeel Clearance (Waves, clearance, siltation allowance)	0.5m	0.5m
Canal Depth	-2.7m AHD	-2.1m AHD

TABLE 4.1 CANAL LAYOUT DATA[1]

	AT MEAN SEA LEVEL	
STAGE	SURFACE AREA (m^2)	VOLUME $(M^3)^2$
1	138,700	303,100
2	127,000	274,400
3A	108,000	234,700
B	29,800	60,800
C	53,900	114,100
Sub Total	**318,700**	**684,000**
TOTAL	**457,400m^2**	**987,100m^3**

Notes: 1. All data approximate only.

2. Based upon -2.7m AHD canal depth throughout.

TABLE 4.2 TIDAL LEVELS

LEVEL	CHART DATUM (m)	AUSTRALIAN HEIGHT DATUM (m)
Highest Astronomical Tide	1.26	0.50
Mean High High Water	0.91	0.15
Mean Low High Water	0.79	0.03
Mean Sea Level	0.77	0.01
Mean High Low Water	0.70	-0.06
Mean Low Low Water	0.62	-0.14
Lowest Astronomical Tide	0.35	-0.41

Source: Department of Marine and Harbours, 1992.

TABLE 4.3 THROUGH FLOW RATES AND VELOCITITES[1]

	CONDITIONS[2]					
	Average Tide		Storm Surge		Flood Flow	
Channel	Rate (m^3/s)	Velocity (m/s)	Rate (m^3/s)	Velocity (m/s)	Rate (m^3/s)	Velocity (m/s)
Mandurah Channel:						
- Up/Downstream	286	0.33	910	0.76	570	-
- Adjacent	250	0.29	760	0.64	475	0.53
Main Canal:						
- Maximum	35	0.26	150	0.71	95	0.56
- Minimum	22	0.16	102	0.49	63	0.37
Loop Canals through:						
- Stage 1	4	0.04	14	0.08	10	0.07
- Stage 3A	9	0.08	31	0.18	21	0.16
- Stage 3C	5	0.05	16	0.11	11	0.10

Notes: 1. Depth average velocities at average water surface levels for the event.

2. Assumed mannings n = 0.025 (Department of Transport, 1993).

TABLE 6.1 GREENHOUSE EFFECTS, KEY VARIABLES

VARIABLE NAME
Mean Sea Level
Wind Climate
Wave Climate
Rainfall
Ocean Current
Water Temperature
Air Temperature

TABLE 6.2 MODELLED EXTREME EVENTS

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

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

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

TABLE 6.3 STAGE 2 AND 3 BUILDING LEVELS

ITEM	VALUE
Average 100 year flood level (WAWA)	+1.40m AHD
Greenhouse Effect (Year 2050)	+0.22m
Freeboards (WAWA)	0.3m Fill, 0.55m Floor
Minimum Building Levels	+1.92m Fill, +2.17m Floor

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Fraser-Wholohan Grill Pty Ltd
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16TH FLOOR, QV1, 250 ST GEORGES TERRACE, PERTH, WESTERN AUSTRALIA, 6000
TEL: + 61 9 278 8300 FAX: + 61 9 278 8110

COMPANY	:	BBG	FAX NO	:	481 8338
ATTN	:	B. Walker	OUR REF	:	032/07031/A06/DJT/jb /24423
FAX CC	:	Cedar Woods	FAX NO	:	421 1867
ATTN	:	N. Perrignon	OUR REF	:	032/07031/A06/DJT/jb
FROM	:	David Todd	DATE	:	4 April 1995
COPIES TO	:	N/A	FILE	:	032/07031.1
SUBJECT	:	PT Mandurah Stage 2 PER	STATUS	:	URGENT

Bev,

Our comments on the two points in the PER as previously discussed follows:

1) *Flow across the Conservation Reserve*

We have undertaken some basic conservative calculations into the flow across the reserve under high tidal conditions and believe it should be less than 0.05 m/s in velocity or 20% of the Main Channel velocity, at worst.

Considering this low velocity and providing that the region is revegetated and smoothly graded to prevent flow concentration, it should not result in significant scour of the reserve.

2) *Eastern Mary Street Bridge*

We have also briefly examined the hydraulics and water quality/flushing issues associated with the non-construction of this bridge and believe that it would be possible to omit it. This would result in acceptable water quality, better than that at present in Stage 1, but not quite as good as what it could be with the bridge constructed. In light of this finding you should write the following into the PER:

"that detailed design will confirm, with respect to water quality and flushing, but we may wish to remove the eastern Mary Street Bridge from the proposed works".

Further details on both of these points will be sent to Nick Perrignon separately. Please call me if you have any questions or require any further information on the above project.

Regards

David Todd
Project Manager

If you have any problems with this transmission, please telephone the above number

G:\032PHC\ADM\07031\07031A06.FAX

APPENDIX F

Waterbird Conservation and Bandicoot Numbers within the Port Mandurah Stage 2 Project Area

Ninox Wildlife Consulting
E. Goble - Garrett & Associates
MJ and AR Bamford, 1995

FAUNA REPORT

WATERBIRD CONSERVATION WITHIN THE PORT MANDURAH STAGE 2 PROJECT AREA

Prepared for: Bowman Bishaw Gorham

By: Ninox Wildlife Consulting
and
E. Goble-Garratt and Associates

January 1995

SUMMARY

The current conservation status of waterbird habitats within and immediately adjacent to the proposed Port Mandurah Stage 2 Project Area is explored and is based on two short surveys in December 1994 and January 1995. Eleven waterbird habitats were identified and described. The Project Area was regularly surveyed for waterbirds by the Waterways Commission in 1988 and 1989 and with the addition of recent data the total number of known species for the Project Area is 36. This represents 48% of all species known from Peel Inlet, excluding vagrants. A further 16 species are expected to occur given long-term sampling.

Fourteen species of waterbirds covered by the Japan/Australia and China/Australia Treaties for the Protection of Migratory Birds and their Environment have been recorded in the Project Area and two more protected species are expected to occur. This is a large number of such species and reflects the complexity of the site. However, very few of these will venture much beyond the intertidal zone on the eastern edge of the Project Area.

This assessment and earlier surveys have shown that most habitats of significance to waterbirds within the Project Area are situated in close proximity to the estuary itself, rather than within the main body of the proposed development area. The only possible exception being the seasonal swamp in the extreme southern limits of the Project Area. Although these significant habitats are essentially a continuum, in order of precedence they are:

- *the tidal lagoon situated along the entire eastern edge of the Project Area;*
- *the large tidal flat north-east of the samphire peninsula;*
- *all bare shorelines subject to tidal inundation. The role played by regularly inundated samphire situated immediately behind these shorelines is not fully understood, and while bird activity in this habitat is limited, it should be viewed as a component of shorelines;*
- *the limestone outcrops used as perches situated in the central eastern section of the Project Area.*

the Project Area (specifically its eastern edge and to a lesser degree a semi-pristine seasonal swamp within its confines) is of high local significance in the context of northern Peel Inlet. Regionally it is considered to be of moderate significance.

TABLE OF CONTENTS

1.0 INTRODUCTION AND METHODS

The following report represents an investigation of the current conservation status of waterbird habitats within and immediately adjacent to the proposed Port Mandurah Stage 2 Project Area. It is based on a site appraisal carried out on December 30, 1994 by two field personnel experienced in the habitats and waterbirds of Peel Inlet. Both personnel were involved in an earlier, intensive survey of the northern section of the inlet (Waterways Commission 1990) and one of them was involved in surveying each of 37 sites for waterbirds on nine occasions between November 1988 and December 1989 for the above Waterways Commission study. Two of these sites were situated within the proposed Port Mandurah Stage 2 Project Area.

All resulting waterbird information from these earlier surveys is held, updated and maintained in a comprehensive database by Ninox Wildlife Consulting, and permission was earlier granted by the Waterways Commission to use the database in various projects which may have some bearing on the conservation status of Peel Inlet. This database has been used to provide detailed and site-specific background information on the Project Area.

A further short site visit was undertaken on January 9, 1995 in association with a Bowman Bishaw Gorham staff member to further clarify waterbird habitat buffer zones and discuss conservation issues. The results of an additional field survey conducted on January 25, 1995 to investigate the site's potential for Southern Brown Bandicoot *Isoodon obesulus* habitat are presented in Appendix 1.

1.1 OBJECTIVES

The objectives of the report are to:

- identify and map the range of waterbird habitats within the Project Area;
- itemise the species recorded during the site assessment, compile a list of known species and a provisional list of those likely to occur;
- comment on the condition of each habitat and discuss the implications of any observed degradation on waterbird usage;
- comment on the regional significance of the site and the percentage of waterbird habitat it contains in relation to the Peel-Harvey Estuarine System as a whole;
- comment on the adequacy of the foreshore protection zone as designated within the Peel Inlet Management Plan (Waterways Commission 1992);
- provide management recommendations for enhancing existing waterbird habitats and, detail any further recommendations such as monitoring;
- comment on the existing terrestrial vertebrate fauna of the site.

2.0 RESULTS AND DISCUSSION

2.1 Waterbirds Recorded

Twenty-one waterbird species were observed during the December site assessment; three of which were not recorded in the Waterways Commission surveys, bringing the total number of known species for the Project Area to 36. This represents 48% of all species known from Peel Inlet, excluding vagrants (Table 1). A further 16 species are expected to occur in the Project Area given long-term sampling.

Table 1 ***List of waterbirds and associated species recorded at Peel Inlet, showing the species already recorded or expected to occur within the Port Mandurah Stage 2 Project Area. Waterbird species protected by the Japan/Australia (JAMBA) and China/Australia (CAMBA) treaties are shown.***

PEEL INLET SPECIES LIST (EXCLUDING VAGRANTS)	JAMBA CAMBA	RECORDED ON SITE 1988-89	RECORDED ON SITE DEC. 1994	NOT RECORDED BUT EXPECTED
Great Crested Grebe				
Hoary-headed Grebe				X
Australasian Grebe				X
Australian Pelican		X	X	
Darter		X	X	
Great Cormorant		X	X	
Pied Cormorant		X	X	
Little Black Cormorant		X	X	
Little Pied Cormorant		X	X	
White-faced Heron		X	X	
Great Egret	X	X	X	
Little Egret		X	X	
Rufous Night Heron				X
Glossy Ibis				X
Sacred Ibis		X		
Straw-necked Ibis				X
Royal Spoonbill				X
Yellow-billed Spoonbill		X		
Black Swan			X	
Australian Shelduck		X	X	
Pacific Black Duck		X	X	
Grey Teal		X	X	
Chestnut Teal				
Australasian Shoveler				
Pink-eared Duck				
Hardhead				
Maned Duck				X
Blue-billed Duck				

PEEL INLET SPECIES LIST (EXCLUDING VAGRANTS)	JAMBA CAMBA	RECORDED ON SITE 1988-89	RECORDED ON SITE DEC. 1994	NOT RECORDED BUT EXPECTED
Musk Duck				X
Osprey		X		
White-bellied Sea-Eagle	X			X
Marsh Harrier				X
Australian Crake				X
Spotless Crake				X
Dusky Moorhen				X
Eurasian Coot			X	
Pied Oystercatcher				X
Grey Plover	X	X	X	
Lesser Golden Plover	X			
Red-kneed Dotterel				
Large Sand Plover	X			
Red-capped Plover				X
Black-fronted Plover				
Black-winged Stilt		X	X	
Banded Stilt			X	
Red-necked Avocet		X	X	
Ruddy Turnstone	X			X
Eastern Curlew	X	X		
Whimbrel	X	X		
Grey-tailed Tattler	X	X		
Common Sandpiper	X	X	X	
Greenshank	X	X	X	
Redshank	X			
Marsh Sandpiper	X	X		
Terek Sandpiper	X			
Black-tailed Godwit	X			
Bar-tailed Godwit	X	X		
Red Knot	X			
Great Knot	X	X		
Sharp-tailed Sandpiper	X	X		
Pectoral Sandpiper	X			
Red-necked Stint	X	X		
Curlew Sandpiper	X	X		
Sanderling	X			
Broad-billed Sandpiper	X			
Ruff	X			
Silver Gull		X	X	
Whiskered Tern				
White-winged Tern	X			
Gull-billed Tern				

PEEL INLET SPECIES LIST (EXCLUDING VAGRANTS)	JAMBA CAMBA	RECORDED ON SITE 1988-89	RECORDED ON SITE DEC. 1994	NOT RECORDED BUT EXPECTED
Caspian Tern	X	X		
Fairy Tern		X		
Crested Tern		X		
Little Grassbird				X
Australian Magpie-lark				X
75	**27**	**33**	**21**	**18**

2.2 Habitat Units

One of the major problems in defining distinct waterbird habitats in a large estuarine system is that an artificial categorisation is set up, even though there are major structural and species differences between, for example, bare shorelines, samphire flats and lagoons. Similarly, areas of dry samphire supporting few waterbirds can attract larger numbers of birds when this effectively dryland habitat is inundated by high tides or rain. Swampy depressions may be very unproductive in summer but operate as rich waterbird breeding areas in winter and spring. Estuarine surrounds are therefore a variable continuum and are used as such by waterbirds, even to the extent that limestone ridges supporting Tuart trees distant from the shoreline are an integral part of this system; the hollow trunks of mature Tuarts are an important nesting resource for a number of ducks.

The result of this is that altering a part of the continuum can have an effect on the whole. The impact of a development can therefore potentially extend beyond its boundaries. For this reason the "project area" in this report is defined by a line extending 50 metres east into the main body of the inlet, north to Mary Street, west to McLarty Road/Old Coast Road and south to the Mandurah Bypass. Within these constraints, 11 habitats were recognised in the Project Area. Starting from the open water of the inlet and moving landward, these habitats are described below with notes on their significance to waterbirds. One of these - limestone rocks near the inlet shoreline - is not strictly a habitat but is of significance to a large number of birds as a roosting and refuge area during low tide.

HABITAT 1 - DEEP OPEN WATER (OW)

Location: adjacent to the entire length of the eastern side of the Project Area.

Description: relatively deep, exposed section of the estuary immediately adjacent to the Project Area.

Vegetation: aquatic species including algae.

Degradation: No obvious degradation.

Usage: used as a feeding area by diving species such as cormorants, darters, pelicans, terns and gulls. Also an important resting and refuge area for coots, grebes, swans and ducks.

Significance to Waterbirds: high.

System Representation: well represented.

Project Impact on System: very low.

Local Project Impact : minimal.

HABITAT 2 - OPEN SHALLOWS (SH)

Location: adjacent to the entire length of the extreme eastern side of the Project Area.

Description: shallow exposed expanse of the estuary immediately adjacent to shoreline.

Vegetation: aquatic species including algae. No obvious degradation.

Degradation: No obvious degradation.

Usage: used as an important feeding area by a wide range of wading birds with longer legs. These include herons, egrets, ibis, stilts and migratory shorebirds. Pelicans, terns, gulls, coots, grebes, swans and ducks also use this habitat as an important resting, feeding and refuge area.

Significance to Waterbirds: high.

System Representation: well represented.

Project Impact on System: cumulative but low, depending on protection zone width.

Local Project Impact: moderate to low, depending on protection zone width.

HABITAT 3 - TIDAL FLATS (TF)

Location: situated in the north eastern to central eastern section of the Project Area immediately north of the samphire peninsula and forming part of the shoreline of the lagoon.

Description: large, regularly exposed expanse of tidal flats.

Vegetation: none.

Degradation: No obvious degradation.

Usage: used as an important feeding area by a wide range of migratory shorebirds when covered with shallow water. Pelicans, cormorants, darters, terns, gulls, swans and ducks also use this habitat as an important resting and refuge area when exposed.

Significance to Waterbirds: very high.

System Representation: moderately well represented.

Project Impact on System: cumulative but low.

Local Project Impact: moderate to low depending on whether silt depositional patterns are altered by the development or whether the area is channelled.

HABITAT 4 - BARE SHORELINES (BS)

Location: adjacent to the entire length of the eastern side of the samphire peninsula, throughout the internal perimeter of the adjacent lagoon and extending along the extreme north-eastern shoreline of the Project Area.

Description: narrow, regularly inundated intertidal zone.

Vegetation: none.

Degradation: localised minor degradation by vehicles.

Usage: used as an important feeding area by a wide range of migratory shorebirds when covered with shallow water. Pelicans, cormorants, darters, terns, gulls, swans and ducks also use this habitat as an important resting and refuge area when bare ground is exposed.

Significance to Waterbirds: high.

System Representation: moderately well represented.

Project Impact on System: cumulative but low.

Local Project Impact: high to moderate depending on protection zone width.

HABITAT 5 - PERCHES (PE)

Location: apart from occasional trees near the shoreline, the main expression of this habitat extends from the central northern shoreline of the Project Area east towards the large tidal flat to the east.

Description: regularly inundated intertidal zone typified by a large number of small limestone/sandstone outcrops less than 50 cm high.

Vegetation: none.

Degradation: no obvious degradation.

Usage: the limestone rocks are used as an extremely important roosting area by pelicans, cormorants, darters, terns, gulls, swans and ducks mainly during low tide.

Significance to Waterbirds: very high.

System Representation: very poorly represented.

Project Impact on System: moderate but cumulative.

Local Project Impact: high to moderate depending on protection zone width and potential channelling for the project entry or exit points.

HABITAT 6 - TIDAL LAGOON (TL)

Location: adjacent to the Project Area, situated between the samphire peninsula and the large tidal flat.

Description: a large, sheltered and shallow lagoon varying in depth depending on tidal influences. Sections may operate as tidal flats.

Vegetation: aquatic species including algae.

Degradation: no obvious degradation.

Usage: used as an important feeding area by a wide range of wading birds with longer legs. These include herons, egrets, ibis, stilts and migratory shorebirds. Pelicans, terns, gulls, coots, grebes, swans and ducks also use this habitat as an important resting, feeding and refuge area.

Significance to Waterbirds: very high.

System Representation: poorly represented.

Project Impact on System: moderate but cumulative.

Local Project Impact: potentially high to moderate depending on protection zone width and potential channelling for the project entry or exit points.

HABITAT 7 - REGULARLY INUNDATED SAMPHIRE (SW)

Location: the entire samphire peninsula and the narrow band running along the eastern edge of the Project Area between the peninsula and the large tidal flat.

Description: dense areas of samphire within the intertidal zone regularly inundated by moderate to high tides.

Vegetation: dense to fairly open samphire community between 0.3 and 0.5m high. *Sarcocornia quinqueflora* occurs closest to the shoreline in almost monospecific stands. This is joined in increasing abundance as one moves inland by *Halosarcia halocnemoides* (two forms) and *Halosarcia indica* ssp. *bidens*. This latter species is the predominant samphire along the border between the samphire flats and the adjacent woodland. Also scattered throughout the flats, but more common on the inland margins are *Suaeda australis* and *Frankenia pauciflora*.

Degradation: no obvious degradation within the samphire peninsula, but the narrow fringing areas along the eastern edge of the Project Area show localised degradation by stock animals and vehicular traffic.

Usage: used by relatively few species of waterbirds but provides a sheltered area for those that do. Some feeding on terrestrial and benthic invertebrates may take place.

Significance to Waterbirds: moderate.

System Representation: the Peel/Harvey System has only three extensive areas of fringing vegetation: near the southern end of the Mandurah channel, eastern Peel Inlet and southern Harvey Estuary (DCE 1986). The first of these takes in the Project Area.

Project Impact on System: potentially high to moderate and cumulative if the samphire peninsula is affected by potential channelling for the project entry or exit points.

Local Project Impact: potentially high to moderate depending on protection zone width and potential channelling for the project entry or exit points.

HABITAT 8 - RARELY INUNDATED SAMPHIRE (SD)

Location: the northern central portion of the Project Area in the vicinity of the abandoned marl excavations.

Description: areas of samphire which are rarely inundated except by unusually high tides.

Vegetation: a mixture of *Halosarcia halocnemoides* (mostly) and *Sarcocornia quinqueflora.* These areas are much more open in structure than the wetter samphire communities. Some of this community may be the result of post-disturbance, secondary colonisation. Weedy species are mainly annual grasses.

Degradation: highly degraded by stock animals, tracks, marl excavations, weed invasion and dry algal mats. The samphire is dead or dying in some lower-lying locations where algal mats have covered it. This may be a product of the higher tides resulting from the Dawesville Cut.

Usage: used by very few species of waterbirds, and only on rare occasions when either very high tides or heavy rain create temporary pools.

Significance to Waterbirds: very low.

System Representation: the Peel/Harvey System has only three extensive areas of fringing vegetation: near the southern end of the Mandurah channel, eastern Peel Inlet and southern Harvey Estuary (DCE 1986). The first of these takes in the Project Area.

Project Impact on System: with or without the development, this habitat will continue to degrade unless extreme and expensive conservation measures are taken.

Local Project Impact: low.

HABITAT 9 - OPEN WOODLAND (WO)

Location: the south-eastern and south-western limits of the Project Area adjacent to Leisure Way and the Mandurah Bypass traffic bridge.

Description: patches of remnant woodland and shrubland on higher ground.

Vegetation: the canopy consists of Flooded Gum *Eucalyptus rudis* which is joined along the boundary with the samphire flats by *Casuarina obesa.* Remaining native understorey species tend to be more common along the samphire flat margins where they have been protected from grazing by a fenceline. These species include *Melaleuca hamulosa, Melaleuca viminea, Jacksonia furcellata, Jacksonia sericea, Acacia saligna* and *Gahnia trifida.* This latter sedge

species also occurs in clumps along the boundary between the woodland/shrubland areas and the samphire flats, and is an indicator of freshwater seepage.

Degradation: both areas are parkland cleared and show degradation from stock, vehicle tracks and weed invasion.

Usage: used by very few species of waterbirds. Limited duck breeding may take place in the occasional mature Flooded Gum or in patches of particularly dense sedge. Grazing species such as the Maned Duck and Australian Shelduck may occasionally feed on winter grasses.

Significance to Waterbirds: low.

System Representation: well represented in and beyond the system.

Project Impact on System: with or without the development, this habitat will continue to degrade unless conservation measures are taken.

Local Project Impact: low.

HABITAT 10 - SEASONAL SWAMP (SS)

Location: the central southern limits of the Project Area adjacent to Leisure way and the Mandurah Bypass traffic bridge.

Description: relatively mature Paperbark trees indicate that this area has always been a dampland, but over the last 6-7 years it has received stormwater via a culvert under the Old Coast Road from the Hall's Head residential development.

Vegetation: the vegetation in this area is a closed sedgeland dominated by *Juncus krausii*, with some *Gahnia trifida*. Dense, shrubby *Melaleuca cuticularis* occurs as an emergent in varying densities over much of the area.

Degradation: probably because of its density and seasonal waterlogging, damage by stock animals is relatively low in this swamp. It is in surprisingly good condition considering its proximity to developed areas.

Usage: the swamp will not support large concentrations of waterbirds in winter because of the limited amount of open water. However, some duck breeding may take place and secretive species such as the Australian Crake and Spotless Crake almost certainly breed or take refuge in this site. Egrets, night herons, Ibis and cormorants may also roost here at times. Scattered diggings of the declared rare Southern Brown Bandicoot were found during the January 1995 visit and appeared to be confined to lower-lying damper areas where *Melaleuca cuticularis* was present. Further investigations by M. J. Bamford (Appendix 1)

indicated that the Bandicoot diggings were not common and most likely represented signs of a single animal passing through the site.

Significance to Waterbirds: potentially moderate.

System Representation: moderately well represented.

Project Impact on System: low to moderate.

Local Project Impact: high.

HABITAT 11 - CLEARED PASTURELAND (CP)

Location: east of the Old Coast Road and west of the Halls Head Development.

Description: a large area of cleared land currently grazed by stock.

Vegetation: a few remnant Flooded Gums *Eucalyptus rudis* occur along fencelines and are scattered through the paddocks. The paddocks are vegetated with a mixture of exotic annual and perennial grasses. Watsonia *Cynodon bulbillifera* and Cape Tulips *Homeria* spp. also probably occur.

Degradation: highly degraded.

Usage: used by very few species of waterbirds. Grazing species such as the Maned Duck and Australian Shelduck may occasionally feed on winter grasses and there are likely to be concentrations of Straw-necked Ibis from time to time.

Significance to Waterbirds: very low.

System Representation: well represented in and beyond the system.

Project Impact on System: minimal.

Local Project Impact: minimal.

2.3 Waterbird Utilisation of the Project Area

While the recent survey recorded approximately 75% of the waterbird species known to occur in the Project Area, the objective was to undertake a habitat assessment rather than a waterbird census. While some waterbird counts were made, these were not of long enough duration to provide reliable comparisons between habitats. For this reason the 1988-89 survey database (Waterways Commission 1990) has been used to provide a perspective on the area and the way it is used by waterbirds. Because this earlier survey mainly concentrated on known mosquito breeding sites and their immediate environs, some habitats within the Project Area were not covered. Specific among these were cleared pastureland, woodland communities and the seasonal swamp near the southern limits of the area. However, enough data were gathered to provide a reliable perspective on the Project Area as a whole, its significance in terms of northern Peel Inlet and the way that most waterbirds use its habitat sub-units.

2.3.1 Species Richness

Figure 1 shows that the Project Area is equal highest in species richness with the two most species diverse locations in northern Peel Inlet. The site has a wide range of habitat types and water depths and therefore caters to a large number of species with differing requirements.

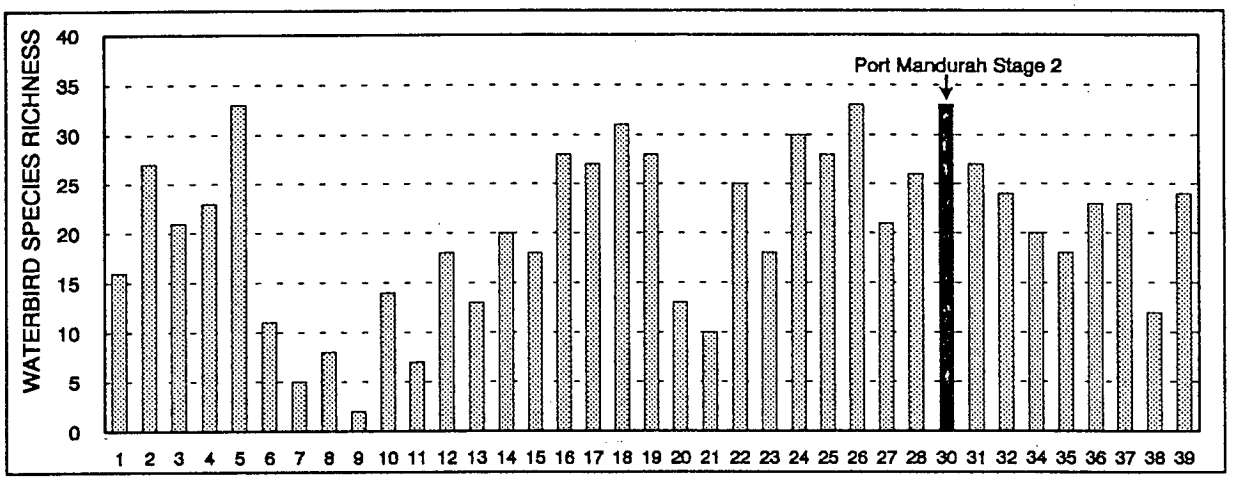


Figure 1 Species richness at Port Mandurah Stage 2 compared to other sites on northern Peel Inlet (November 1988 to December 1989).

2.3.2 Waterbird Abundance

While the Project Area is rich in waterbird species, in terms of abundance it lies in the middle range of site productivity for northern Peel Inlet (Figure 2). The main reason for this is that the habitats where birds tend to congregate, although diverse, are relatively small in area and cannot support large feeding parties.

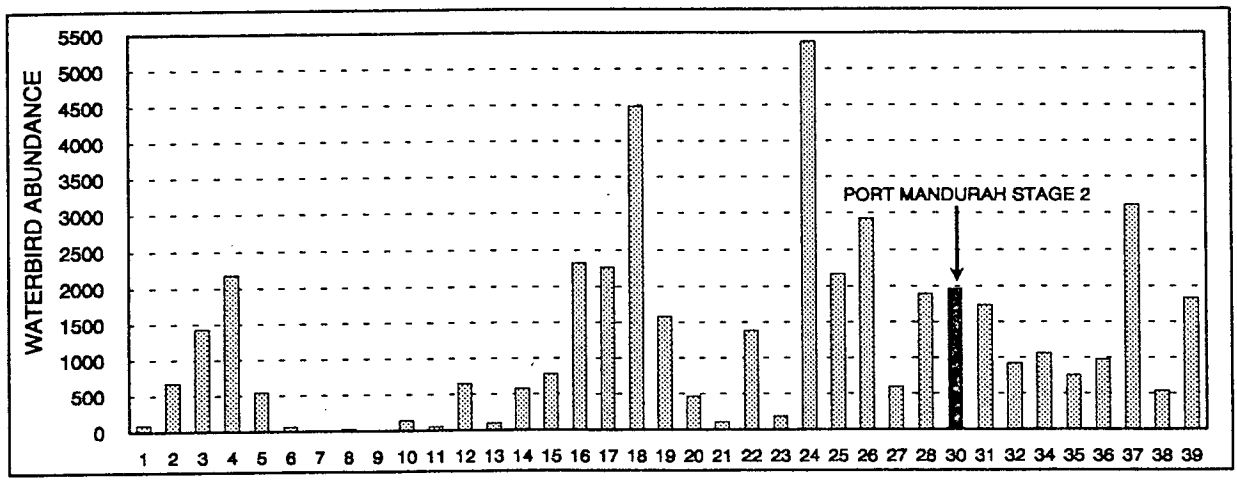
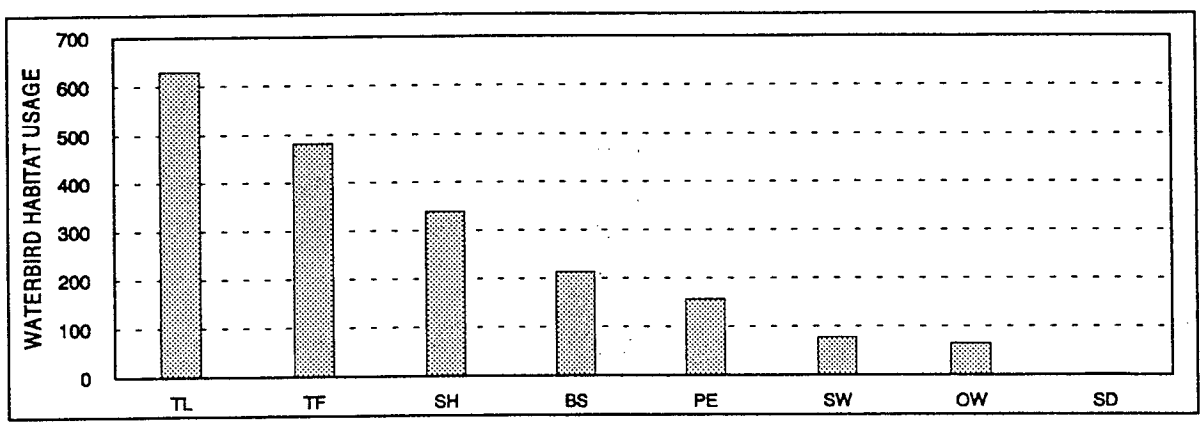


Figure 2 Waterbird abundance at Port Mandurah Stage 2 compared to other sites on northern Peel Inlet (November 1988 to December 1989).

2.3.3 Waterbird Habitat Usage

In Figure 3 habitat usage by waterbirds has been ranked to show where birds tend to congregate in the Project Area. It is immediately apparent that the tidal lagoon, tidal flats and inlet shallows, all of which lie to the east of the proposed development area are the most productive habitats for waterbirds.



KEY

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

Figure 3 Waterbird habitat usage at Port Mandurah Stage 2 (November 1988 to December 1989).

2.3.4 Waterbird Seasonality

The number of waterbirds using the Project Area between November 1988 and December 1989 has been graphed in Figure 4 and shows that populations are at their lowest between March and September. Poor weather conditions (high tides, high winds) resulted in few waterbird observations for the final survey which should have shown a peak similar to the first survey.

This pattern has implications for construction in that late spring and early summer is the time when trans-equatorial migratory shorebirds protected by international treaties congregate at the inlet and the Project Area. Disturbance to these birds could be minimised if construction was scheduled outside this period.

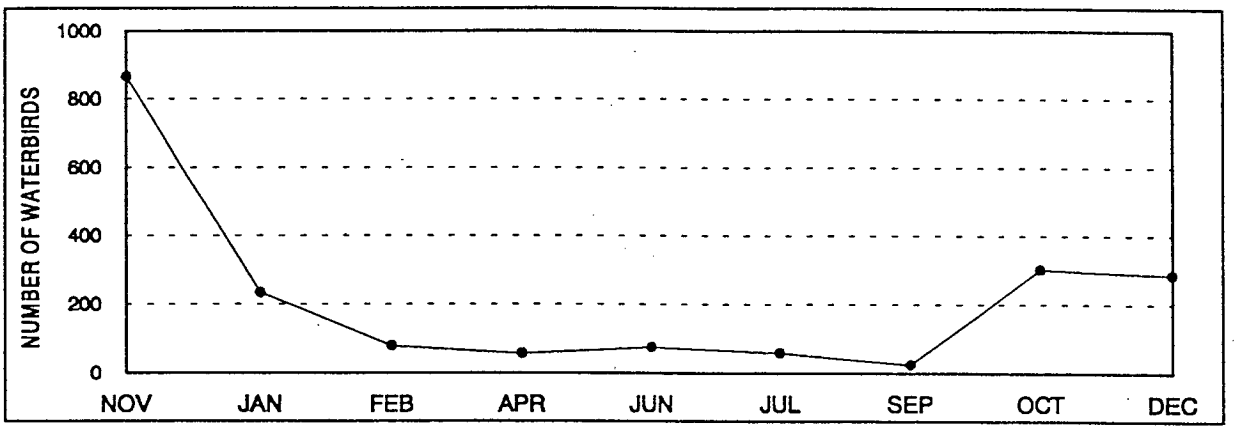


Figure 4 Waterbird seasonality at Port Mandurah Stage 2 (November 1988 to December 1989).

3.0 CONCLUSIONS

3.1 Local Significance of the Project Area

Because of the complexity of its habitats, the number of species it supports (Figure 1) and the prevalence of waterbird species protected by international agreements, the Project Area (specifically its eastern edge and to a lesser degree the semi-pristine seasonal swamp) is of high local significance in the context of northern Peel Inlet.

3.2 Regional Significance of the Project Area

Peel Inlet as a whole is considered to be of very high regional significance and each location along its shoreline contributes to this, not the least being the Project Area. As development proceeds along the northern portion of the inlet, with inevitable disturbance in varying degrees to waterbirds, each remaining area takes on a higher significance. The Project Area is not the most productive area on the northern inlet (Figure 2) but on a significance scale

consisting of: very low; low; moderate; high; very high, it is judged to be of moderate regional significance.

3.3 Habitats of Significance

This assessment and earlier surveys have shown that most habitats of significance to waterbirds within the Project Area are situated in close proximity to the estuary itself, rather than within the main body of the proposed development area. The only possible exception being the seasonal swamp in the extreme southern limits of the Project Area adjacent to Leisure Way. Although these significant habitats are essentially a continuum, in order of precedence with reference to Figure 4 they are:

- the tidal lagoon (TL) situated along the entire eastern edge of the Project Area;
- the large tidal flat (TF) north-east of the samphire peninsula;
- all bare shorelines (BS) subject to tidal inundation. The role played by regularly inundated samphire (SW) situated immediately behind these shorelines is not fully understood, and while bird activity in this habitat is limited (Figure 4), it should be viewed as a component of shorelines;
- the limestone outcrops (PE) situated in the central eastern section of the Project Area are also significant and while the number of birds recorded here was lower than the preceding habitats, virtually every outcrop had a roosting bird at the time of the December 30, 1994 survey. Activity was lower during the higher tide of the January 9, 1995 visit.

3.4 Degraded Habitats

Virtually all of the woodland, shrubland and rarely inundated samphire communities north of the seasonal swamp and east of the Old Coast Road are highly degraded, particularly in the vicinity of the abandoned marl excavation. This is not to suggest that they are of no value to fauna. The lower lying areas of samphire will maintain some seasonal usage by waterbirds and areas of Flooded Gum and Swamp Sheok showed fairly high bushbird activity during the recent survey.

3.5 Species of Significance

Fourteen species of waterbirds covered by the Japan/Australia and China/Australia Treaties for the Protection of Migratory Birds and their Environment have been recorded in the Project Area. Two more protected species are expected to occur (Table 1). This is a large number of such species and reflects the complexity of the Project Area. However, very few of these will venture much beyond the intertidal zone on the eastern edge of the Project Area.

3.6 Foreshore Protection Zone

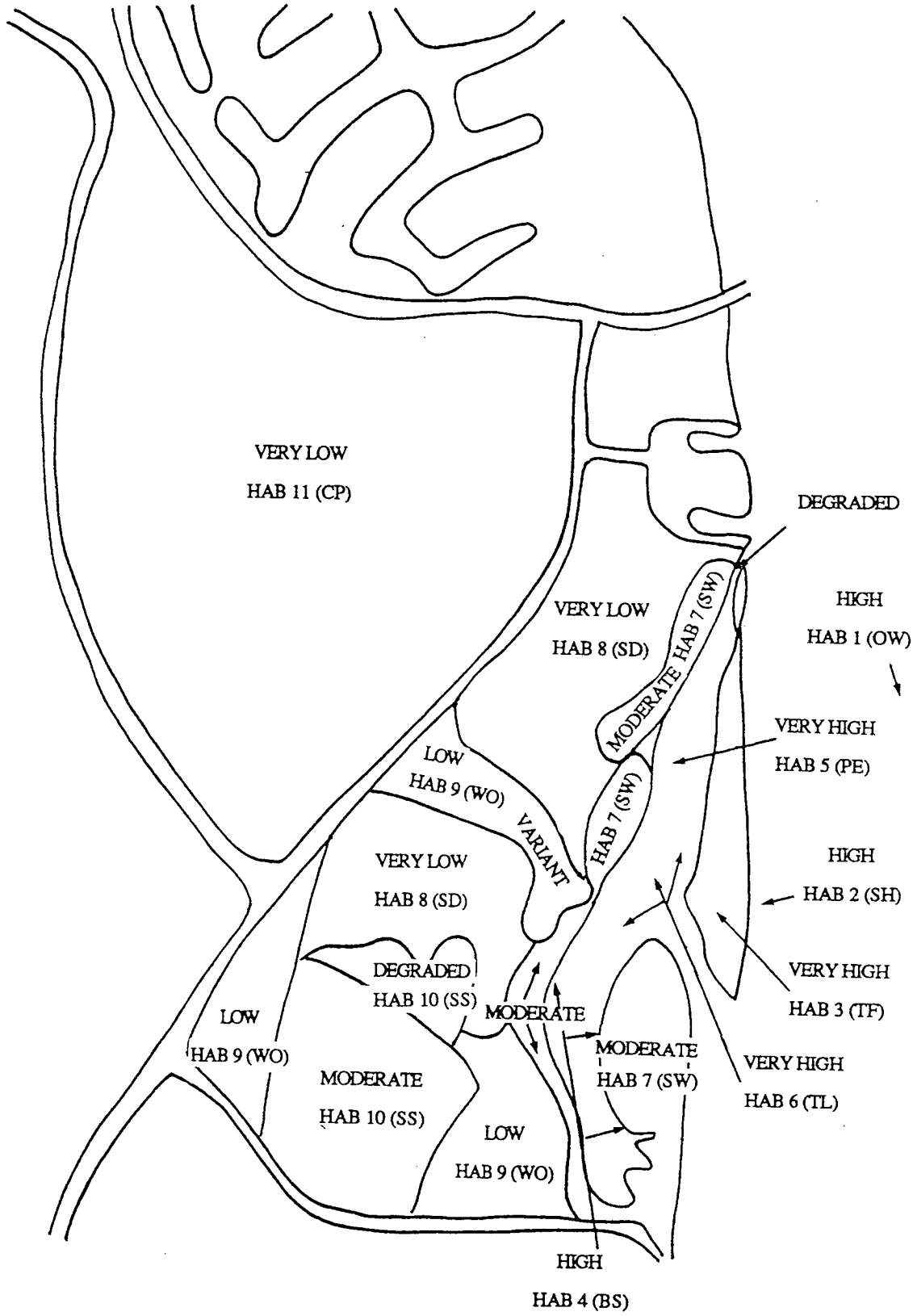
The Peel Inlet Management Plan (Waterways Commission 1992) gives guidelines for foreshore protection at Peel Inlet, but the diagram accompanying this document is of too small a scale to accurately assess protection zones in specific localities. The suggested protection zone for the Project Area appears to be in the region of 100 metres from the main inlet shoreline and takes in the entire samphire peninsula. Recent recommendations from the Environmental Protection Authority for the adjacent Mandurah Marina require a foreshore reserve of 50 metres.

The south-eastern portion of the development boundary as it stands gives good protection to the samphire peninsula, but in other areas it runs along the high water mark therefore providing little or no buffer zone.

Dept of Conservation and Environment (1986). *The Peel-Harvey System. Proposals for management.* Report 14 : Appendix 2 The response of the biota to the proposed management measures. Bulletin 242.

Waterways Commission (1990). *The significance of mosquito breeding areas to the waterbirds of Peel Inlet, Western Australia.* Report No. 20.

Waterways Commission (1992). *The Peel Inlet Management Plan.* Report No. 27.


VERY LOW
HAB 11 (CP)
DEGRADED
HIGH
HAB 1 (OW)
VERY LOW
HAB 8 (SD)
MODERATE HAB 7 (SW)
VERY HIGH
HAB 5 (PE)
LOW
HAB 9 (WO)
VARIANT
HAB 7 (SW)
VERY LOW
HAB 8 (SD)
HIGH
HAB 2 (SH)
DEGRADED
HAB 10 (SS)
VERY HIGH
HAB 3 (TF)
LOW
HAB 9 (WO)
MODERATE
MODERATE
HAB 7 (SW)
MODERATE
HAB 10 (SS)
VERY HIGH
HAB 6 (TL)
LOW
HAB 9 (WO)
HIGH
HAB 4 (BS)

Appendix 1: Bandicoot numbers within the Port Mandurah Stage 2 Project Area.
(Prepared by M.J & A.R. Bamford and Ninox Wildlife Consulting)

BACKGROUND

Port Mandurah Stage 2 is a proposed extension of an existing canal estate on the west side of the Mandurah Estuary, north of the Mandurah bypass bridge. While much of the property is degraded farmland, the site includes some natural habitats along and adjacent to the estuary. The significance of these habitats for waterbirds has already been assessed by Ninox Wildlife Consulting. M.J. and A.R. Bamford have been requested by Bowman Bishaw Gorham to provide additional comments with particular emphasis on the value of the site for the Quenda or Southern Brown Bandicoot *Isoodon obesulus*. This species is declared "rare and likely to become extinct". Some of its characteristic conical diggings were noted in January 1995 during an inspection of the southern end of the site by Ninox Wildlife Consulting.

METHODS

The site was visited on 25 January 1995 by Dr. M. J. Bamford who is experienced in Bandicoot surveys, including estimating population size from the number of diggings recorded. Habitats in the area where Quenda diggings were reported by Ninox Wildlife Consulting were examined in detail. In addition to searching intensively for Quenda diggings, some general notes on wildlife and the significance of the site were made.

The following section is divided into observations on the Quenda and observations on the conservation value of some of the habitats of the Project Area.

OBSERVATIONS

Quendas

Quenda diggings were located in a thicket of *Melaleuca cuticularis* over *Gahnia trifida*, but all diggings found were at least several weeks old. The density of diggings could not be adequately quantified as only about 10 diggings in an area of a few square metres were found. This is insufficient to calculate a meaningful density per hectare. Bamford and Bamford (1994) considered a mean density of 1.4 diggings/m^2 to be moderately high and this was associated with a population density of at least 1.6 animals per hectare.

The patch of old diggings found in the Project Area is consistent with the foraging activity of a single animal that has moved through the site and is no longer present. Quendas possibly occur in the Project area as transient individuals moving from locations such as the nearby

Erskine Conservation Park. The status of Quendas in this park is unknown, but it contains a large area of the dense, low vegetation known to be favoured by Quendas.

Habitats

Woodlands on the site, as noted by Ninox Wildlife Consulting, are substantially degraded with a depauperate and weed-infested understorey. Despite this, some species of birds were recorded in them. These are listed below:

White-faced Heron	*Egretta novaehollandiae*
Laughing Turtle-Dove *	*Streptopelia senegalensis*
Striated Pardalote	*Pardalotus striatus*
Western Thornbill	*Acanthiza inornata*
Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*
Red Wattlebird	*Anthochaera carunculata*
Grey Fantail	*Rhipidura fuliginosa*

(* = introduced species)

All these species are widespread in the region but the presence of the White-faced Heron suggests that this waterbird may breed in the tall eucalypt woodland. Waterbird breeding in this habitat was predicted by Ninox Wildlife Consulting. Of perhaps highest significance is the patch of tall woodland closest to the bridge and the estuary. The retention of this patch of trees for waterbird breeding would be compatible with use of the area as public open space and would preserve one of the few patches of tall trees close to the Peel Inlet.

The seasonal swamp habitat described by Ninox Wildlife Consulting appears to have two components: vegetation associated with seasonal, brackish water (*Melaleuca cuticularis* thickets and *Juncus krausii* sedgelands) and vegetation associated with seasonal fresh water (*Melaleuca rhaphiophylla* and *Gahnia trifida*). These components are mixed in places, such as where *M. cuticularis* grows over *G. trifida*. The sedge *J. krausii* covers the largest area. The significance of the seasonal swamp vegetation is that it suggests that freshwater pools are seasonally present. These may be the focus of breeding by some waterbirds. Fauna observed in the seasonal swamp included the Grey Kangaroo *Macropus fuliginosus* and Splendid Fairy-wren *Malurus splendens*. The latter species is of some interest because, while widespread and generally common, it declines in developed areas through loss and fragmentation of habitat.

APPENDIX G

Aboriginal Heritage Survey

McDonald Hales & Associates, 1995

REPORT OF AN ABORIGINAL HERITAGE SURVEY FOR THE PROPOSED PORT MANDURAH HOUSING DEVELOPMENT PROJECT, HALLS HEAD

for

CEDAR WOODS PROPERTIES LIMITED

by

M. Hammond BSc. Hons, S. O'Reilly BSc. Grad.Dip
and A. Walster BA. Hons

January 1995

McDonald Hales and Associates
1170 Hay Street West Perth 6005

Summary and Recommendations.

In November 1994 McDonald, Hales and Associates were commissioned by Cedar Woods Properties Limited to conduct an archaeological and ethnographic survey of a proposed housing development area in the Halls Head district.

A total of two sites were recorded during this Heritage survey.

Two ethnographic sites of significance were located within the PDA. The first site has been recorded previously as 'Winjan's Camp' (S0224). **It was recommended** by Informant #1 to both survey teams that this site not be disturbed. The informants requested that a plaque be erected in the vicinity of the camp which indicates its significance to the Aboriginal people of Mandurah.

The second site recorded as a 'camp' during the ethnographic survey is that recorded as a scarred tree during the archaeological survey. Although Informants brought this site to the attention of the the ethnographer, it **does not necessarily** fall within the definition of an **ethnographic site** (see appendix I). It is without a doubt significant to the informants but **in the opinion of the consultant** its significance falls within the realm of **archaeological significance** This opinion is based on the following;

1. The informants did not know of the site's presence prior to the survey.
2. The informants were unable to identify any person, alive or dead, who had camped in the area.
3. The area was not considered of sacred or ceremonial importance.

The ethnographer recommends, however, that given the site's perceived significance to the informants, that the area be included within the public open space allotment of the proposed development.

The Aboriginal people of the Mandurah area should be informed of the recommendations and actions taken to preserve the sites. After due consultation at all stages the Aboriginal informants have requested that their community be involved in

the conservation of wild life and vegetation in the area as well as promoting the recreational value of the sites. It was suggested by the informants that the proponents help in the facilitation of this request. The proponent has agreed to the protection of both of the above mentioned sites (See Appendix 2).

The archaeological survey revealed the presence of one scarred tree.

It is recommended that the development may proceed;

It is recommended that this scarred tree represents an impediment to the proposed development.

It is recommended that the development proceed if the scarred tree is located within an appropriate reserve or buffer zone.

It is recommended that the site at 'Winjan's Camp' (S0224) not be disturbed and that this site be protected as part of the development.

It is recommended that continued use by Aboriginal people of the sites should not be discouraged on any grounds by any official body or element in the community.

It is recommended that there be further consultation with Aboriginal people before and during the development process.

It is recommended that consideration be given to the request that a plaque be erected in the vicinity of the camp which indicates its significance to the Aboriginal people of Mandurah.

The proponents have agreed, where necessary, to prepare plaques outlining Aboriginal connections/associations with the PDA. The wording of the plaques will be prepared under the guidance of McDonald, Hales and Associates with Informant #1.

CONTENTS

Consultancy Brief

In November 1994 McDonald, Hales and Associates was commissioned by Cedar Woods Properties Limited to conduct an archaeological and ethnographic survey of a proposed housing development in the Halls Head district, W.A. The archaeological survey was undertaken by S. O'Reilly and A. Walster and the ethnographic research was conducted by M. Hammond.

The site proposed for the construction of the Port Mandurah housing estate consists of some 3km^2. The study area of the proposed development area (PDA) is bounded by Mary Street in the north. Its western boundary is McLarty Road and in the south Leisure Way. The eastern boundary of the development is on the Mandurah Estuary. The best access is from the Mary street entrance to Memorial Park, from McLarty Street (opposite Arundel Drive), at the intersection of Old Coast Road and McLarty Street and off Leisure Way (opposite 'Castle Fun Park'). Much of the PDA has been extensively modified by human activities such as agricultural development, construction of an airstrip, municipal activities such as sewage installation, and the use of some areas for dirt tracks for bikes and horses.

Local physical environment and land integrity.

Climate.

The south west has been divided up into four major climatic types, all known as Mediterranean but classified according to the number of dry months experienced each year (Beard 1990). The proposed development area is located within the Dry Mediterranean climatic zone and has between five and six dry months per year. The area lies within the 1000mm isohyet and average annual precipitation regularly approaches this level. There are great differences between the rainfall figures for summer and winter months, respectively 10mm in January and 194mm in June (Bureau of Meteorology) resulting in seasonal water shortages throughout this region. The average maximum and minimum temperatures for summer and winter in the area are as follows; summer 29 °C and 18.2 °C , winter 17.4 °C and 9.8 °C. As a result of the warm summers and cool, wet winters experienced, this area enjoys an extended growing season and has thus tended to be utilised for forestry, the dairy industry and fruit growing (Beard 1990).

Vegetation.

The following information is taken from Beard (1990): The PDA is located within the Drummond Botanical Sub-district of the Darling Botanical District on the Swan Coastal Plain. Within the PDA, what remains of the natural flora consists almost exclusively of sedgeland. This is a broad general term for the vegetation typical of periodically inundated lands which may not consist exclusively of sedges (e.g. *Cypera spp.*) but also representatives of other species of reed-like plants, including *Typha*, *Juncus* and *Baumea*. Indeed, *Juncus* marsh may replace the sedges along the open water borders of tidal estuaries. A distinct vegetation type, consisting of hydrophyllic species, is confined to the margins of permanently or seasonally swampy areas within the above complexes. Around fresh water this association consists of sedges *Melaleuca raphiophylla, M preissiana* (both paperbarks) and/or *Banksia littoralis* with Samphires (*Arthrocnemum* spp) the dominant species where conditions are saline.

Leached sands support a low woodland composed mainly of *Banksia.* Ill-drained areas support *Melaleuca* swamps (Beard 19 90). Within the eucalypt woodland on less leached soils tuart (*Eucalyptus gomphocephala*) is dominant overall. This is clear on the western slopes of the dune system where few other eucalypts are found and where limestone outcrops or is close to the surface. Jarrah (*E. marginata*) assumes co-dominance to the east. Tuart is most abundant on the ridges while Jarrah assumes dominance in depressions. On better drained soils typical tall wetland vegetation occurs, composed mainly of *Melaleuca spp* (Paperbarks), occasional Flooded Gums (*Eucalyptas rudis*) and sedgeland continuing as an understorey. There are minor communities of *Dryandra-Calothammus* heath and *Agonis flexuosa* (Peppermint).

Introduced plant species are also present and include Buffalo and Veldt grasses which occur discontinuously throughout the entire PDA.

Geology.

The southwest has been divided into physiographic units, one of which is the Perth region. This region takes in a group of geomorphological systems, including the Swan Coastal Plain on which the PDA is situated. The PDA is wholly contained within the Spearwood Dune sub-unit of the Swan Coastal Plain (Beard 1990). This consists of sand dunes which have been lithified to limestone, forming ridges (up to 150m high) and troughs roughly parallel to the present coast. Within and especially along its eastern edge are permanent lakes, occurring in chains parallel to the present coast. These may represent old lagoons cut off by beach deposits formed after a drop in sea level and are variably saline, brackish or completely fresh .

Yellow quartz sands make up the dune deposits with some areas of heavy mineralisation within them. Underlying the sands are aeoleanite rocks, wind blown deposits which have become consolidated, known as Tamala limestone. This basal sediment extends far beyond the Spearwood Dune system, both to east and west, outcropping on offshore islands and appearing as "floaters" within the more landward Bassendean Dune system.

Results of the Archaeological Field Survey.

Archaeological Background

There are three previously recorded archaeological sites registered at the Aboriginal Affairs Department which are within ten kilometres of the proposed development area (PDA). None of these sites was within the PDA and so will not be directly impacted upon by the proposed development.

All of these previously recorded sites consist of small artefactual scatters. This closely reflects the patterning observed in the wider region, where stone artefact assemblages recorded are typical of the Swan Coastal Plain in that they have a high proportion of quartz and waste flakes and have a small formal tool component. Other lithic materials, such as fossiliferous chert and dolerite were used to a much lesser extent. Most of the sites belong to Hallam's late phase. However, the presence of fossiliferous chert and artefacts typical of the "Australian Small Tool Tradition" (Gould 1969) at some sites (Early and Middle phase respectively) suggests that the area supported a fairly continuous Aboriginal occupation spanning the last several millennia.

The high proportion of waste flakes and chips present in some assemblages indicates that primary stone working activities and implement maintenance were probably being undertaken (Sullivan and Rosen 1985). The occasional presence of percussion-stone fragments and adzes further suggests that food processing and woodworking activities were being carried out (Gould, Koster & Sontz 1971; Lantzke 1991). Those sites with a diverse artefact inventory, wide range of lithic materials, a formal tool component and large quantities of waste flakes may be indicative of more permanent and/or more frequent camping sites (Anderson 1984).

The geographical distribution of artefact lithologies, with fossiliferous chert-rich early assemblages, concentrated in the west on the older Spearwood Dunes, with quartz dominated material more common at sites situated on the Bassendean Sands to the east of the Inlet-Estuary, would apparently lend support to the theory about the contraction of tribal areas owing to the post-glacial rise in sea level and gradual movement of inhabitants of the receding coastal plain towards the Darling Ranges. The number of sites previously recorded in the area strongly suggests that parts of the region supported a large Aboriginal population. The distribution of a large number of sites in general association with coastal and wetland resources on the Spearwood Dunes and Bassendean Sands systems is consistent with the predictions made by Anderson (1984).

However, it is important that these associations be regarded as tentative owing to the fact that the patterning of Aboriginal site distribution has been clearly skewed by survey and research bias. The majority of sites have been recorded along the western margin of Peel Inlet/Harvey Estuary, with a high proportion of these located along the course of the Old Coast Road. This probably stems from the relatively large area exposed by the road cutting in an area of comparatively steep topography. The remaining sites were disturbed from contexts such as sand-pits, road cuttings and soil build-ups around the base of dams. Many isolated artefacts were exposed by firebreaks and other access ways.

The area along the coastal strip to the west of the Peel Inlet/Harvey Estuary system has been subject to a degree of survey and research, particularly in and around residential areas and transport corridors. The majority of sites located in this area have been discovered as the result of disturbance which has raised the visibility of sites. The largely fortuitous nature of site location, and a comparison with the high density of sites recorded in similar geomorphic zones elsewhere in the Perth Metropolitan Area (Hallam 1987; Strawbridge 1988), strongly suggests that there yet remains a high potential for site discovery.

Survey Methods

The archaeological survey for the Port Mandurah proposed development area (PDA) was conducted between December 8-14, 1994, by S. O'Reilly and A. Walster. Following an initial consultation with Informant #1, a survey method that covered the PDA and allowed areas of concern highlighted by Informant #1 to be examined as followed.

Within the Port Mandurah PDA Informant #1 expressed concern regarding Winjan's Camp and an area with possible marked trees near Castle Fun Park. These areas were noted and examined thoroughly within a survey strategy that covered the whole PDA. The PDA includes areas that are currently used as pasture as well as an area that is on the shore of the estuary that has some remnant vegetation. The pasture land has extensive grass cover and where exposures exist is heavily disturbed, this includes the area identified as Winjan's Camp.

The survey methodology was to walk evenly spaces transects that covered the PDA, in addition, each area highlighted by Informant #1 was examined separately. The results of the survey are given below.

Survey Results.

As a result of the archaeological survey one scarred tree was located. This scarred tree was located on the southern boundary of the PDA, approximately ten metres from the road opposite the entrance to the castle Fun Park, this was within the area highlighted by Informant #1.

The surface around the soak identified as Winjan's Camp was examined thoroughly, but no artefacts were located. It is possible that the construction of McLarty Road within 10m of the soak at Winjan's camp may have disturbed the area.

With the exception of the scarred tree, no artefactual material was located. Details of the relevant attributes of the scarred tree are given below.

Tree

Type:	large Tuart (*Eucalyptus gomphocephala*)
Height:	approximately 20m
Diameter at scar:	87cm
Circumference at scar :	276cm

Scar

Height:	58cm
Width:	26cm
Depth:	7cm
Height from ground:	48cm

The scar has only bark removed. There is no evidence of a branch having broken, the grain of the wood within the scar is almost straight without knotting. There is no perceptible bulge on the scar margin, however regrowth over the margin is extensive and so there are no visible marks of the method of bark removal or the type of implement used.

Discussion and Recommendations.

The Peel Harvey estuary is known to be rich in archaeological material, as outlined above in the archaeological background. Thus the PDA can be seen to have high archaeological potential. The negative result of the present survey in locating stone artefacts can be argued to be the result of the high level of disturbance that has previously affected the area. This is compounded by site detection limiting factors such as poor visibility due to dense vegetation cover.

The scarred tree located during this survey is evidence of the presence of Aboriginal people in the area in the past. The scarred tree has limited potential to address regional research questions about patterns of occupation and resource exploitation. The significance of the scarred tree lies in both its rarity and representativeness. No similar site is recorded near the proposed development. **The scarred tree located during this survey represents an impediment to the development and should not be disturbed.** Disturbance may best be avoided if the scarred tree and a buffer around it are included within any nature reserve or parkland within the development. When consulted about this scarred tree Informant #1 expressed his concern that the tree should not be disturbed and felt that its inclusion in a reserve or buffer zone would provide appropriate protection. He also felt that it would be appropriate to provide a sign that outlined the significance of this scarred tree as evidence of his peoples presence in the area in the past.

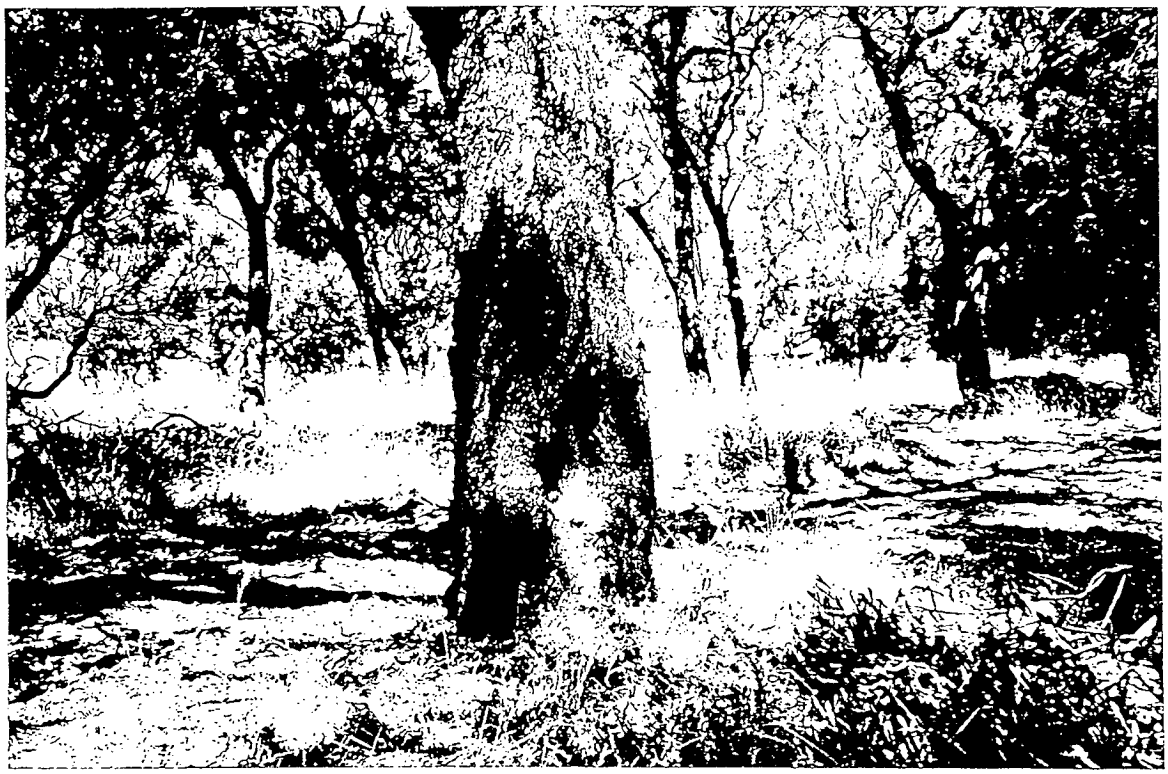
Recommendations

- **It is recommended** that the scarred tree represents an impediment to the proposed development.

- **It is recommended** that the development proceed if the scarred tree is included within an appropriate reserve or buffer zone.

The developer's attention is drawn to their obligations under Section 17 of the *Aboriginal Heritage Act* (1972-1980) to report any archaeological material discovered during the course of the development.

PORT MANDURAH, SCARRED TREE.



Ethnographic Survey.

Ethnographic Background.

Ethnohistorical reconstructions based on archaeological and ethnographic data suggest that prior to the start of European colonisation in 1829, the southwest of Western Australia was occupied by thirteen socio-dialectical groups (known colloquially and anthropologically as tribes), which formed a distinct socio-cultural bloc (Tindale 1974; Berndt 1979). This cultural bloc has been given the label 'Nyungar' (Nyungah or Noongah) which translates as 'man' or 'person' in the language identified by the same name - Nyungar. Thus the term "Nyungar', refers to the language as well as the people.

The area in which the Nyungar language was spoken extends from the coast south of Geraldton in an arc south-eastwards, ending in the Great Australian Bight east of Esperance (Tilbrook 1983:3). Apart from language division, the Nyungars can be separated from their northern and eastern neighbours in that they did not practice subincision or circumcision as a part of the male initiation ceremony. However, Hammond (1933:63) reported that there was a place near Albany where a modified version of circumcision was conducted until the 1870's but this circumstance should be considered an exception to the rule.

Various estimates have been made about the size of the Nyungar population at the time of colonisation. Berndt (1979) estimates that there were approximately 6 000 people in the southwest in 1829. This total contrasts with an earlier estimate made by Radcliffe-Brown (1930) which was in the vicinity of 25 000. The general consensus among anthropologists and archaeologists is that Berndt's estimate is more accurate. The population density would not have been uniform. The coastal and estuarine ecosystems would have been densely populated vis-a-vis the drier inland areas which would be unable to support large numbers of people. The area in and around the Peel Region would have been one of the more densely populated areas given the richness of the environment.

The basic unit of traditional Nyungar social organisation was the family. The family, consisting of 2 to 10 individuals, was the primary economic unit. The band or horde, which consisted of a number of family units, was the basic unit of social interaction. The band usually consisted of approximately 40 individuals and occupied a specific area of land. The boundaries of this 'territory' were probably initially ecologically determined but later came to be associated with spiritual and sacred affiliations.

Prior to colonisation the Peel Region was occupied by the *Pindjarup* people. The northern 'boundary' of this socio-dialect group was reportedly a line through Mangles Bay (Rockingham), Jarrahdale and Mt Cook (see Berndt 1979). The social organisation of the *Pindjarup* included matrilineal moieties, with at least two exogamous clans. The names of these clans had totemic affiliations. The moieties were named *Manitchmat* (white cockatoo) and *Wardungmat* (crow). The four key matrilineal clans were *Ballarok, Naganok, Tondarup* and *Ngotak*. Thus each individual was assigned a moiety, a totemic clan and often an individual totem such as *Weijing* (emu), *Merritt* (tree) et cetera, depending on a particular event at conception, birth or during early childhood.

All of this was to change with the arrival of the British in 1829 and the subsequent establishment of the Swan River Colony. Upon arrival the British colonisers declared the Nyungars to be British subjects with all the associated rights and privileges. This was not an altruistic action, it was hoped the Aborigines would provide a handy source of labour for the expanding colony (Tilbrook 1983:11). The nature of work available was seasonal in response to the agricultural nature of settlement. During the 'off-season' the Aborigines were expected to fend for themselves using traditional means. This was not always possible because the best hunting and gathering land was usually the land most suited to agriculture. The inevitable consequence of this circumstance was conflict and, for the Nyungars, dependence on the agricultural resources of the colony.

One of the most notorious battles or massacres in the Peel Region was the 'Battle of Pinjarra'. The battle took place on October 28, 1834 on the bank of the Murray River just south of the settlement of Pinjarra. It is reported that Stirling and his party of soldiers and police officers came upon a group of Nyungar people camping near the river just after dawn. After killing a few of the older people who were unable to run they drove the rest of the group into the Murray River where many of the younger

children and women were drowned. Those who attempted to climb the bank and escape were killed. Official reports estimate that 15 Nyungars were killed. The contemporary Nyungar population of the Pinjarra/Mandurah area maintains that over 150 people were massacred. Regardless of the 'correct' number, the result of this attack and subsequent epidemics of measles meant the decimation of the *Pindjarup* people.

Prior to 1898, the welfare of Aboriginal people was in the hands of the British Colonial Office in London. The 'problem' of Aboriginal people hanging around the newly formed colony and their general state of degradation forced the Colonial office to launch a Royal Commission into the welfare of the Aborigines. The consequence of this Royal Commission was the implementation of the Aborigines Act of 1905. The '1905 Act' was enacted for the good of all Aboriginal people however the indirect result was the almost complete nihilation of Nyungar culture. Under the 1905 act the chief protector of Aborigines was the legal guardian of all Aboriginal children, Aboriginal people could be ordered out of town, moved off their campsites and directed to live on reserves set aside for the purpose (Tilbrook 1983:5).

The remnants of Nyungar culture left in the wake of the 1905 Act have remarkably served to strengthen Nyungar solidarity and identity. New links to the country in historical and biographical terms have served to fortify the fabric of Nyungar associations to land.

In brief contemporary Nyungar associations to land can be categorised as;

1. Esoteric - including sacred, mythological, ceremonial, ritual and
2. Historical - including biographical and social associations.

The 'esoteric' category relates to traditional religious beliefs and practices as dictated by the Dreaming. The Dreaming is central to the life of Aboriginal people as it guides, protects and sustains them and the world they live in. In popular culture the Dreaming is recognised as representing the period when the world was created by mythic beings which were in spirit half man/woman, half animal. But the Dreaming is much more than that to Aboriginal people. The concept of past time is absent from Dreaming stories and concepts thus there is no association between the actions of the Dreaming spirits and the past. In a sense the creator spirits exist in 'the now'. For example, the Waugal is the central creator spirit for the Nyungar people. The Waugal created and is still

present in all sources of fresh water in the south-west. The Waugal did not just create the Murray and Serpentine Rivers and then move on. The very fact that these rivers flow is a sign that the Waugal is still there creating the water. In traditional times the Nyungar people would have felt obliged to perform various religious ceremonies to maintain the presence of the Waugal and thus their own survival.

The historical category of association is not just one of sentiment. An individuals or groups associations to the land and specific sites can be spiritual and based on links which may have evolved through;

1. Habitation; regular camping and utilisation of bush resources, work on particular properties, etc.;

2. Biographical categorisation; places associated with an individual's life either through personal experience or through the experiences of family members and;

3. Historical; where specific events of historic importance to an individual/ group/ family may have occurred.

There is no doubt that the strength of attachment to a particular place varies between individuals and families. However there is overall, a recognition that these differing levels of association are crucial elements of contemporary Nyungar society.

Survey Methodology

McDonald Hales & Associates have conducted a number of previous surveys in the Peel Region (for example; McDonald Hales & Associates 1989 & 1992; Locke & Murphy 1991; Locke, Murphy & Jarvis 1992). These studies have provided a broad understanding of the Aboriginal heritage values in the area and of the key Aboriginal people who have associations with the sites.

The survey involved the following methods;

1. Archival research;
2. Site inspection and interviews with Aboriginal and non-Aboriginal consultants/informants;
3. Consultation with community organisations and groups.

Community organisations were initially canvassed to ascertain the identity of possible informants. As a result of discussions three key informants were identified and interviewed for the ethnographic survey.

Informant Biographies

Informant #1 is an Aboriginal man in his late fifties who has lived in the Pinjarra/Mandurah area all of his life. His family was one of the first to move back into the Mandurah area after a measles epidemic killed a sizeable portion of the Nyungar population in 1865. He is currently fighting for the recognition of his peoples cultural heritage in Mandurah. He is the chairperson of the Winjan Aboriginal Corporation and is considered by that community to be an appropriate person to speak for the area of the PDA.

Informant #2 is a generational brother of Informant #1. Informant #2 spent most of his youth travelling with his family, who were timber cutters and fencers, throughout the Peel Inlet area. During this time he learned to live off the land and identify a myriad of bush foods and medicines which he is now cataloguing for a soon to be published book. His knowledge of the cultural significance of the land in and around Mandurah is invaluable. This informant is a representative of the Winjan Aboriginal Corporation and was selected by Informant #1 to participate in the survey because of his extensive knowledge of the PDA.

Informant #3 is a non-Aboriginal man and he was born in Mandurah in 1916. He previously owned the PDA. His family was the first to farm in the Halls Head area, establishing their farm in the 1830's. The family of Informant #3 had close contact with the local Aboriginal people - close enough for certain words of the *Pindjarup* dialect to enter into the daily discourse of his family. Informant #3 has a keen interest in the local history of Mandurah and his intimate knowledge of the PDA made him a good person to consult.

Survey Results

Two sites were located by the informants within the PDA, one of which "Winjan's Camp" (S0224) has been listed previously at the Department of Aboriginal Sites.

The first site, identified as 'Winjan's Camp', was occupied by George Winjan in the nineteen thirties. The informants were unable to ascertain if the camp was occupied by George Winjan, who was one of the few Nyungars to escape the Pinjarra Massacre of October 28 1834, or his son - George Winjan Jnr. However it is unlikely that the principal occupant of the site was George Winjan, or 'King' Winjan as he was known by the local white population, beyond the 1880's as he maintained a camp at Perth at the corner of Hay and George Streets at this time. He was living at this Perth camp when he took ill in the early 1880's and was carried by stretcher to Mandurah where he subsequently died (Horton 1994:1189). After George Winjan's death his third son, *Yabburgurt* or George, became the 'leader' of the *Pindjarup* people of the Mandurah/Pinjarra area and probably the principal occupant of the site identified as 'Winjan's Camp'. The boundary of this site, as identified by Informants #1 and #2, extends south from the corner of Glencoe Parade and McLarty Road, Halls Head, for a distance of approximately 70 metres along McLarty Road. The eastern boundary of the site is approximately 25 metres from McLarty Road. The boundaries of the site identified by Informant #3 are inclusive within these parameters, although he feels that the majority of the camp lay outside the current fenceline, ie, in the road reserve.

The second site identified by the informants as a 'Camp' is located at the corner of Old Coast Road and Leisure Way, Halls Head. The identification of this site was facilitated through the discovery a scarred tree (see Archaeological survey results) adjacent to Leisure Way, Halls Head. Informant #2 located a waterhole close to the trees which then convinced both informants that it was highly probable that the area was used as a camp. The informants were unable to provide the names of the likely occupants of the camp. The second site is located on the farming property once owned by Informant #3 who has no recollection of Aboriginal people camping in the area identified by Informants #1 and #2. Although he did state that Aboriginal people "passed through" the area.

Conclusions and Recommendations

As stated in section 2, sites of significance were located within the PDA. The first site has been recorded previously as 'Winjan's Camp' (S0224). **It was recommended** by Informant #1 to both survey teams that this site not be disturbed. The informants requested that a plaque be erected in the vicinity of the camp which indicates its significance to the Aboriginal people of Mandurah.

The second site **does not necessarily** fall within the definition of an **ethnographic site** (see appendix I). It is without a doubt significant to the informants but **in the opinion of the consultant** its significance falls within the realm of **archaeological significance**. This opinion is based on the following;

1. The informants did not know of the site's presence prior to the survey.
2. The informants were unable to identify any person, alive or dead, who had camped in the area.
3. The area was not considered of sacred or ceremonial importance.

It is recommended, however, that the area be included within the public open space allotment of the proposed development because of the attribution of significance to the place as a camping area by the informants. The proponent has agreed to include the scarred tree and an area around it in the public open space allotment of the proposed development.

The Aboriginal people of the Mandurah area should be informed of the recommendations and actions taken to preserve the sites. After due consultation at all stages the Aboriginal informants have requested that their community be involved in the conservation of wild life and vegetation in the area as well as promoting the recreational value of the sites. **It is** suggested by the informants that the proponents help in the facilitation of this request. The proponent has agreed to the protection of both these areas (see Appendix 2).

It is recommended that the development may proceed;

It is recommended that the site at 'Winjan's Camp' (S0224) not be disturbed and that this site be protected as part of the development.

It is recommended that continued use by Aboriginal people of the sites should not be discouraged on any grounds by any official body or element in the community.

It is recommended that there be further consultation with Aboriginal people before and during the development process.

It is recommended that consideration be given to the request that a plaque be erected in the vicinity of the camp which indicates its significance to the Aboriginal people of Mandurah.

References Cited

Anderson, J.F. 1984. Between Plateau and Plain: flexible responses to varied environments in south-western Australia. Occasional Papers in Prehistory 4. Research School of Pacific Studies, ANU: Canberra

Beard, J.S. 1990. Plant Life of Western Australia, Kangaroo Press, NSW.

Berndt., R. 1979 Aborigines of the South-west in Berndt, R. and Berndt, C.H. Aborigines of the West. Nedlands. UWA Press.

Gould, R.A. 1969 Puntutjarpa rockshelter. Archaeology and Physical Anthropology in Oceania 4:229-37.

Gould, R.A., Koster, D.A.,and Sontz, A.H.L. 1971. The lithic assemblage of the Western Desert Aborigines of Australia. American Antiquity 36:149-169.

Hallam, S.J. 1987. Coastal does not equate littoral. Australian Archaeology 25:10-29

Hammond, J.E. 1933. Winjans People. Imperial Printing, Perth.

Horton, D. 1994. The Encyclopaedia of Aboriginal Australia, Institute of Aboriginal and Torres Strait Islander Studies, Canberra.

Lantzke, D.L. 1991. Grindstones: analysis, classification and distribution in the Shark Bay and adjoining regions, Western Australia. Unpublished B. Sc. (Hons) Thesis, Department of Archaeology, UWA.

Locke, R., Murphy, A. and Jarvis, P. 1992. Report of an archaeological and ethnographic survey for Aboriginal Sites, Ravenswood Structure Plan, Ravenswood. Unpublished report for the Department of Aboriginal Sites, Perth WA.

Locke,R. and Murphy, A. 1991a. Report of an archaeological and ethnographic survey for Aboriginal Sites, Lot 1 Tim's Thicket Road, Dawseville. For Koltasz, Smith and Partners. Unpublished report, Department of Aboriginal Sites: Perth.

McDonald Hales & Associates 1989. A report of an ethnographic survey of the proposed Dawesville Channel alignment and fill area. For the Department of Archaeology, UWA. Unpublished report, Department of Aboriginal Sites: Perth.

McDonald Hales & Associates 1992. Peel Region Park Study. Unpublished report for the Department of Planning and Urban Development, Perth, WA.

Radcliffe -Brown, A. 1930. The Social Organisation of Australian Tribes in Oceania 1:34-63.

Strawbridge, L. 1988. Aboriginal Sites in the Perth Metropolitan area: A Management Schema (Revised Edition) Unpublished report to the Department of Aboriginal Sites; Perth.

Sullivan, A.P. and Rosen, K.C. 1985. Debitage analysis and archaeological interpretation. Americal Antiquity 50:755-79

Tilbrook, L. 1983. Nyungar Tradition , UWA Press, Nedlands.

Tindale, N. 1974. Aboriginal Tribes of Australia. Berkeley University of California Press.

Appendix I

The Aboriginal Heritage Act 1972-80

The Aboriginal Heritage Act was implemented to;

> "...make provision for the preservation on behalf of the community of places and objects customarily used by or traditional to the original inhabitants of Australia or their descendants, or associated therewith, and for other purposes incidental thereto." [A.H.A. 1972-80:1].

Under the Act all places or objects which are considered of significance to Aboriginal people are protected. This protection applies to;

> a) any place of importance and significance where persons of Aboriginal descent have, or appear to have, left any object, natural or artificial, used for, or made or adapted for use for, any purpose connected with the traditional cultural life of the Aboriginal people, past or present;
>
> b) any sacred, ritual or ceremonial site which is of importance and special significance to persons of Aboriginal descent;
>
> c) any place which, in the opinion of the Trustees (of the Museum), is or was associated with the Aboriginal people and which is of historical, anthropological, archaeological or ethnographical interest and should be preserved because of its importance and significance to the cultural heritage of the state;
>
> d) any place where objects to which this Act applies are traditionally stored, or to which, under the provision of this Act, such objects have been taken or removed.
>
> [A.H.A. 1972-80 Sect. 5]

Disturbance of a site without permission will result in prosecution under section 17 of the Act. Permission to disturb or destroy a site must be gained through a section 16 (disturbance) or section 18 (destruction) application to the Minister of Aboriginal Affairs via the Aboriginal Cultural Materials Committee.

Appendix II

On December 16, 1994 the ethnographer was present at a meeting between Mr Frank Nannup of Winjan Aboriginal corporation and Mr Nick Perrignon of Cedar Woods P/L. The future of Aboriginal sites on the Port Mandurah property was discussed. The following terms and conditions were agreed upon;

1. The site identified as Winjan's Camp will be preserved in its current state. The site will be incorporated into the public open space allotment of the development. Mr Perrignon agreed to erect a plaque near the camp outlining the significance of the site to the Aboriginal people of the Mandurah area.
2. The site adjacent to Castle Fun Park will be preserved in its current state. A plaque will be erected outlining the significance of the site to the Aboriginal people of the Mandurah area.
3. Mr Perrignon has agreed to discuss the possibility of Aboriginal involvement in the preservation of the sites after the area has been developed.

A Note on Winjan's Camp

The information supplied to the anthropologist by Informants #1, #2 and #3 about Winjan's camp conflicts with that recorded in the Aboriginal site archives of the Heritage and Culture Division of the Aboriginal Affairs Department. The information contained within the Port Mandurah report is a faithful reproduction of the information supplied by the informants.

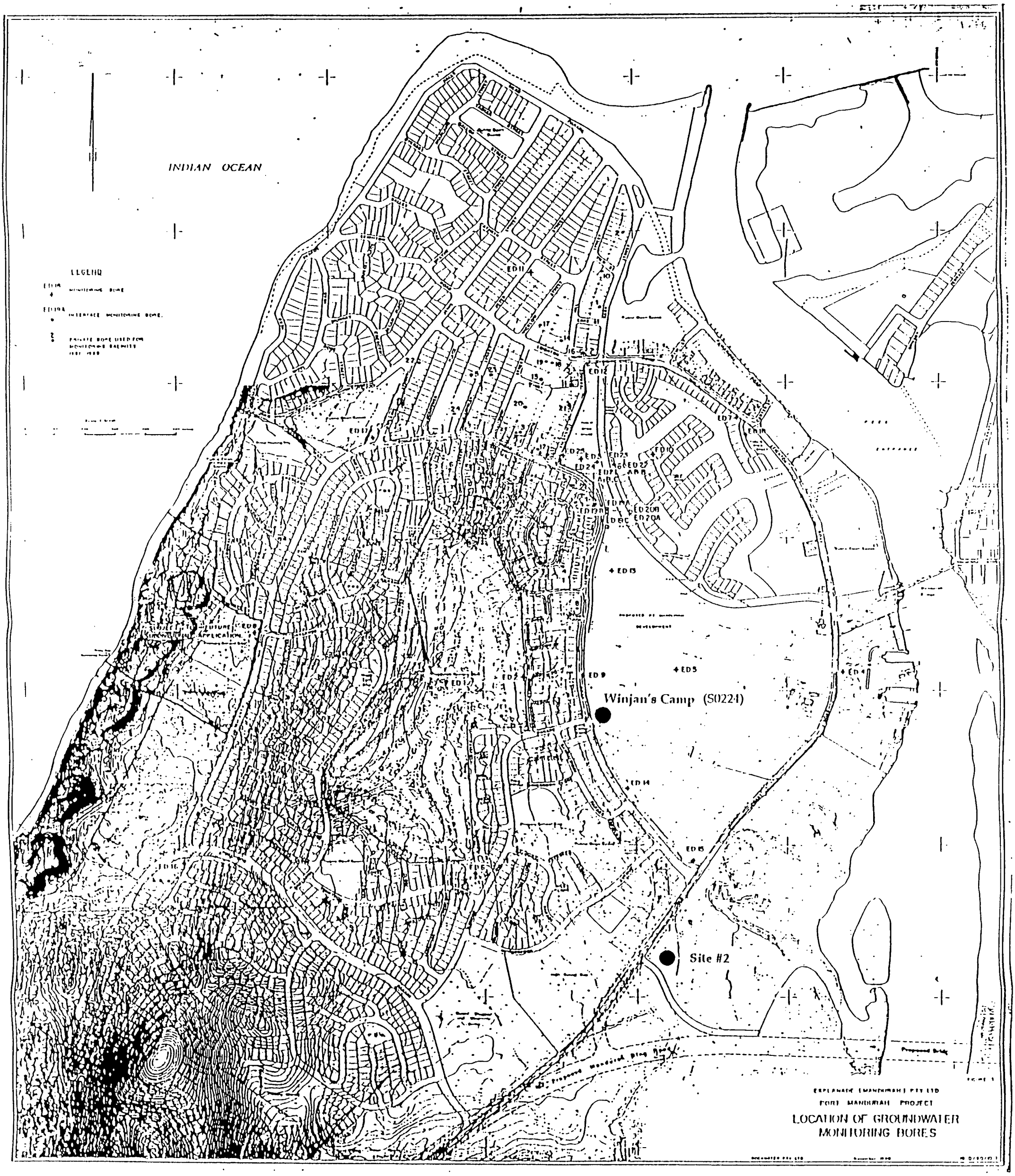
According to Informants #1 and #2 90% of Winjan's Camp is contained within the bounds of the proposed development area (see map of site). This information contradicts that supplied by Informant #3 who maintains that the majority of Winjan's Camp lies underneath McClarty Road.

Both of these accounts conflict with the dimensions and position outlined in O'Connor et al 1985 which states that;

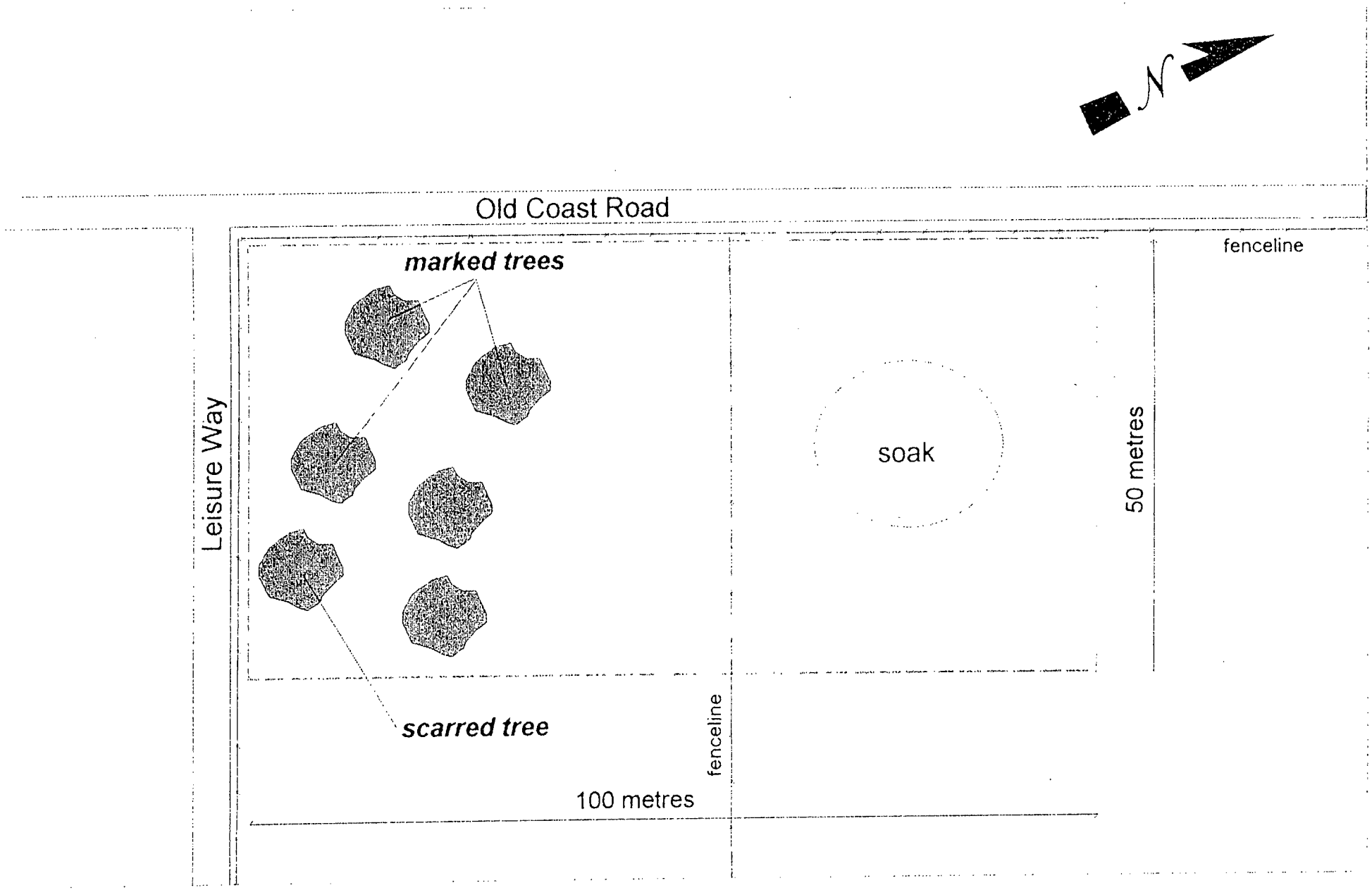
> 200 metres West of Sandalwood Parade junction with McClarty Road, a low depression on the Southern side of the road marks Winjan's camp and waterhole (O'Connor, Bodney and Little 1985:111).

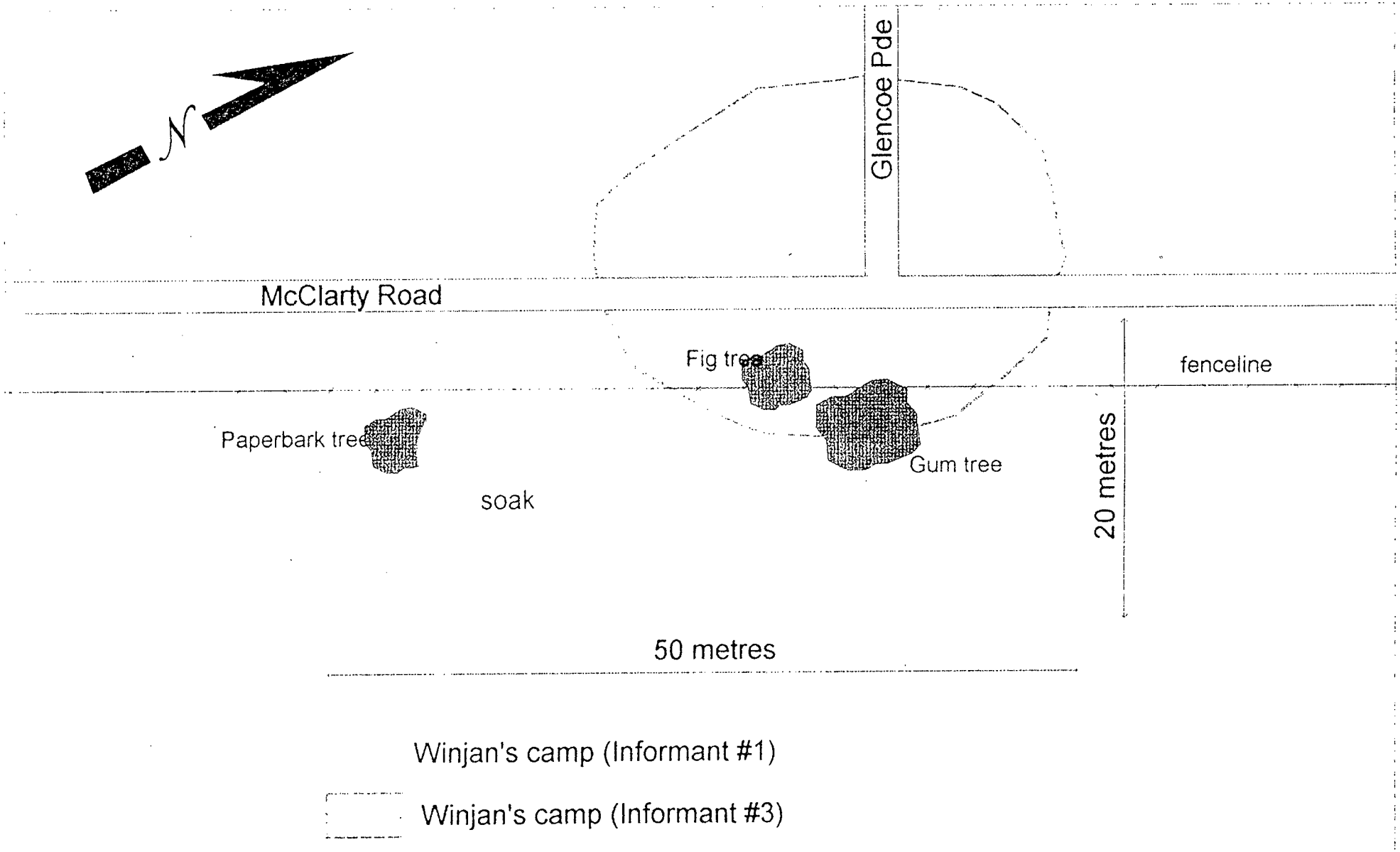
This account situates Winjan's camp on the grounds of the Glencoe Primary School. The report of Winjan's camp in O'Connor et al 1985 differs considerably of McDonald Hales and Associates. However, the photo of Winjan's camp contained within the O'Conner report resembles the area where McDonald Hales and Associates has located the camp. It appears that in both cases the anthropologists have faithfully recorded the information provided to them by the informants, the analysis of this information from a macroscopic perspective may have to be done by the Aboriginal Affairs Department in order to explain the apparent discrepancies from an objective perspective.

PORT MANDURAH ABORIGINAL SITE LOCATIONS*



*Site dimensions contained in report


N
Old Coast Road
fenceline
marked trees
Leisure Way
soak
50 metres
scarred tree
fenceline
100 metres


N
Glencoe Pde
McClarty Road
Fig tree
fenceline
Paperbark tree
Gum tree
soak
20 metres
50 metres
Winjan's camp (Informant #1)
Winjan's camp (Informant #3)

APPENDIX H

Heritage Conservation Report
Sutton Farm Precinct

Palassis Architects, 1995

PALASSIS ARCHITECTS
Kevin

ARCHITECTURE
INTERIORS
CONSERVATION
URBAN DESIGN

HERITAGE CONSERVATION REPORT

SUTTON FARM HERITAGE PRECINCT

Old Coast Road, Mandurah

Prepared for
BOWMAN BISHAW GORHAM
ENVIRONMENTAL MANAGEMENT CONSULTANTS
on behalf of
CEDAR WOODS PTY LTD

January 1995

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Kevin Palassis A.R.A.I.A.
Brian Wright F.R.A.I.A.

INDEX

1.0 INTRODUCTION

Name : **Sutton Farm**

Location : Loc 58 Pt 5, Old Coast Road, Mandurah

Local Government Area: City of Mandurah

Owner : Cedar Woods Pty Ltd.

Heritage Listings :

- National Trust of Australia (WA) : Not Classified; Dec 1994.
- Heritage Council of Western Australia : Listed on data base, but no formal status; Dec 1994.
- City of Mandurah : Municipal Heritage Inventory not yet completed (Jan 1995) however City of Mandurah advises that it is highly likely that the Men's Sleeping Quarters and Main Barn will be included on the inventory.

1.1 Brief

This report has been prepared at the request of Bowman Bishaw Gorham, Environmental Management Consultants, acting for Cedar Woods Pty Ltd.

The main objective of this report is to identify the boundaries of the Sutton Farm Heritage Precinct. Documentary and Physical Evidence is presented, in addition to an Assessment of the Cultural Heritage Significance of the place, to enable the sound identification of the boundaries.

This report also forms a basis for a full Conservation Plan, should one be prepared in the future.

1.2 Brief Description of Place

Loc 58, Pt 5, henceforth referred to as **Sutton Farm**, consists of approximately 52 hectares of land, principally used for the grazing of livestock.

Buildings on the site include the **Main Barn** (c1873), the **Men's Sleeping Quarters** (c1873), the **Homestead** (c1881), the ruins of the **Original Milking Shed** (c1885), the **New Milking Shed** (c1950) and the private **Graveyard** of the Sutton Family containing the graves of John Sutton (d.1857), his wife Eleanor (d.1868), and their son Henry (d.1861) who arrived in Western Australia in 1839 and settled on the present site of **Sutton Farm** in the 1840s.

A substantial Norfolk Pine Tree, planted c1890, grows on the western side of the homestead. A row of Mission Olive Trees, planted at approximately the same time, lines the northern side of the driveway.

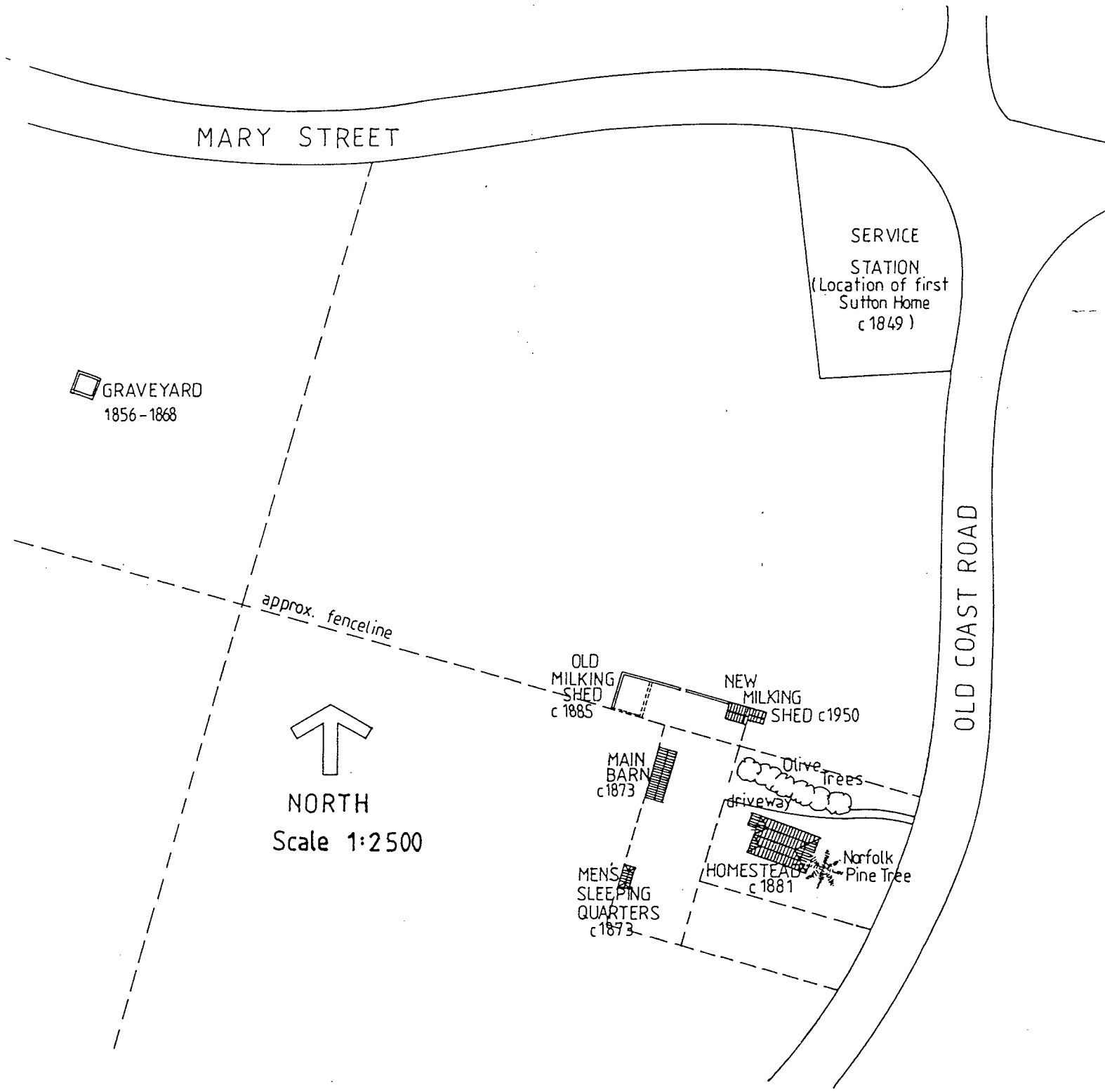

FIGURE N° 1 Location of Buildings, Sutton Farm

1.3 Sources of Study Information

The information in this report has been researched from a variety of sources including:

- On site investigation
- Verbal information from Hal Sutton, past resident
- J S Battye Library of Western Australia
- Mandurah Historical Society
- Client Advice

1.4 Structure of Report

This report follows the general structure of the *Documentation of Places for Entry into the Register of Heritage Places*, provided by the Heritage Council of Western Australia; and the guidelines of *The Australia ICOMOS Charter for the Conservation of Places of Cultural Significance (The Burra Charter).*

1.5 Definitions

The following terms where used in this report have the definition given to them in the International Council on Monuments and Sites document *The Australia ICOMOS Charter for the Conservation of Places of Cultural Significance (The Burra Charter).*

1.5.1 *Place* means site, area, building or other work, group of buildings or other works together with associated contents and surroundings.

1.5.2 *Cultural Significance* means aesthetic, historic, scientific or social value for past, present or future generations.

1.5.3 *Fabric* means all the physical material of the *place.*

1.5.4 *Conservation* means all the processes of looking after a *place* as to retain its *cultural significance.* It includes *maintenance* and may according to circumstance include *preservation, restoration, reconstruction* and *adaptation* and will be commonly a combination of more than one of these.

1.5.5 *Maintenance* means the continuous protective care of the *fabric,* contents and setting of a *place,* and is to be distinguished from repair. Repair involves *restoration* or *reconstruction* and it should be treated accordingly.

1.5.6 *Preservation* means maintaining the *fabric* of a *place* in its existing state and retarding deterioration.

1.5.7 *Restoration* means returning the EXISTING *fabric* of a *place* to a known earlier state by removing accretions or by reassembling existing components without the introduction of new material.

1.5.8 *Reconstruction* means returning a *place* as nearly as possible to a known earlier state and is distinguished by the introduction of materials (new or old) into the *fabric.* This is not to be confused with either re-creation or conjectural reconstruction which are outside the scope of this Charter.

1.5.9 *Adaptation* means modifying a *place* to suit proposed compatible uses.

1.5.10 *Compatible use* means a use which involves no change to the culturally significant fabric, changes which are substantially reversible, or changes which require a minimal impact.

1.6 Authors

This document has been prepared by:

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Christopher Paterson, B.Sc., B.Arch(Hons), R.I.B.A.

1.7 Acknowledgments

The authors wish to thank the following individuals and organisations who assisted in the preparation of this report:

Mr Hal Sutton
Mrs Beryl Slade
Mandurah Historical Society
City of Mandurah
Heritage Council of Western Australia
National Trust of Australia (WA)
J S Battye Library of Western Australia

2.0 DOCUMENTARY EVIDENCE

Thomas Peel arrived in Western Australia in late 1829 with the intention of introducing an ambitious investment scheme south of Perth, based on the land grant principle of the Colonial Office. Peel was granted 250,000 acres of land from Cockburn Sound south to Peel Inlet in return for money spent in endeavouring to settle and populate the area.[1]

Upon arrival, Peel set up a settlement at Clarence. Widespread illness and fatalities in the winter of 1830 precipitated the abandonment of the settlement. Peel moved the people who remained in his service to the mouth of the Murray River, close to the present site of Mandurah.[2]

By the end of 1830, over 50 people resided in Peel's Murray Settlement, including 14 soldiers, stationed at the settlement because of the threat of attack by aborigines. Some land was cultivated and houses built, however Peel was so disliked that the majority of workmen left his service. By 1837, the total population of the district was reduced to 22.[3]

John Sutton, his wife Eleanor and son Henry arrived in Western Australia on the "Hindoo" from Ireland in 1839. Sutton was a servant of James Tate, who in partnership with Messrs Creery and Montgomery, bought 3000 acres in the Murray District from Thomas Peel.[4]

It is unknown when Sutton left the employ of Tate, however in September 1843, the Rev. J R Wollaston passed through Mandurah and stayed 'at a hut kept by a poor man of the name of Sutton.' In October 1843, Sutton requested exclusive right from the government to provide a ferry service crossing the Mandurah Estuary. Sutton also applied for a free publican's licence for 'a house of entertainment.'[5]

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1 *The Cyclopaedia of Western Australia,* edited by J S Battye, Hussey and Gillingham Ltd, Adelaide, 1913. Volume 2. p.410.
L Russell, *Kwinana. Third Time Lucky,* 1979.p.10.
2 R Richards, *The Murray District of Western Australia,* Shire of Murray. 1978.p.12
3 R Richards, *Murray and Mandurah - A Sequel History of the Old Murray District of Western Australia,* Shire of Murray and City of Mandurah, 1993. p.8.
4 Ibid. p.11.
5 R Richards, *The Murray District of Western Australia.* p.182.

Evidence suggests that Sutton was leasing and occupying Hall's Cottage and 200 surrounding acres on the west bank of the Mandurah Estuary from Henry Hall. Sutton provided a ferry service in competition with Thomas Watson (Sutton's ferry was owned by Thomas Peel) and offered accommodation for travellers.

Between 1848 and 1849, John Sutton contracted out the building of an inn on the present site of the Shell Service Station, on the corner of Old Coast Road and Mary Street. The building, also known as 'The Wayside Inn', had six to eight rooms, was built of jarrah slabs and had a thatched roof.[6]

In 1853, the Rev. J R Wollaston once again stayed with John Sutton and commented "Sutton, mine host ..... has crept on to be a substantial monied man."[7] In 1854, Sutton did not take out a Publican's License.[8] However, it is assumed that his family continued to provide the ferry service and accommodation as well as farm the land they leased from Hall. John Sutton died in 1857 at the age of 57.[9]

In 1861, Henry Sutton died. His mother Eleanor wrote home to Ireland and a nephew, also named Henry Sutton, was sent out to help run the farm.[10]

In 1866, Henry Sutton married Jane McLarty. They had three sons and seven daughters.[11] The family acquired more land between Point Robert and the mouth of the Harvey River. They cropped the better parts of their substantial acreage and grazed stock on the remaining land.[12]

The Sutton family continued to reside on the land John Sutton originally leased from Henry Hall on the west bank of the Mandurah Estuary. In 1871 Henry Sutton purchased the land, referred to in this report as **Sutton Farm**, comprising 200 acres, from Henry Hastings Hall.[13]

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6 Ibid pp 185-6.
7 J R Wollaston, *Wollaston's Albany Journals (1848-1856)*, edited by Rev. Canon A Burton, Perth, 1945.p.189.
8 *The Inquirer*, March 1854.
9 J Burgess, *Mandurah - Water Under the Bridge*, Town of Mandurah, 1988.p.9
10 R Richards, *The Murray District of Western Australia*, p.292.
11 R Richards, *Murray and Mandurah*, p.496.
12 R Richards, *The Murray District of Western Australia*. p.293.
13 Ibid p.334.

In c1873, the still extant **Main Barn** and **Men's Sleeping Quarters** at **Sutton Farm** were built. The **Homestead** was built c1881.[14] Henry Sutton's prominence in the local community at this time was evidenced by his election to the Murray Board of Education in the 1870's.[15] The **Original Milking Shed**, now in ruins, was built c1885.[16]

In the 1880s and 1890s, there were approximately 24 houses in Mandurah and 12 families. The town also boasted a church and state school. Apart from **Sutton Farm,** the only other industry in Mandurah before the turn of the century was shingle splitting and fish canneries.[17]

In 1897, Henry Sutton read the speech of welcome to Governor Smith on an official visit to Mandurah. Sutton was described as one of the "leading men of Mandurah."[18]

Sutton was a member of the first Anglican synod in Perth and took church services in Christ Church, Mandurah for more than forty years after its consecration in 1871.[19] Henry Sutton was also a founding member of the Murray Road Board.[20] Henry Sutton died in 1921. In 1924, **Sutton Farm** was sold to Joseph Cooper. Tony Sutton, Henry Sutton's grandson, bought back **Sutton Farm** in 1949 and formed a partnership with his brother Hal soon afterwards.[21]

Tony and Hal Sutton built the **New Milking Shed** c1950 and made extensive alterations to the **Homestead** c1955. The **Homestead** was re-roofed, the verandahs were re-built, the external walls were rendered, some windows were replaced and internal changes were made to ceilings and fireplaces.[22]

Members of the Sutton Family continued to reside in the Homestead and run the farm until it was sold for residential development in 1977.[23]

14 Verbal Information from Hal Sutton, December 1994.
15 R Richards, *The Murray District of Western Australia.* p.384.
16 Verbal Information from Hal Sutton, December 1994.
17 R Richards, *Murray and Mandurah.* p.63.
18 *Western Mail,* 22 October 1897.p.12.
19 R Richards, *Murray and Mandurah.* p.496
20 Ibid.p.227.
21 Verbal Information from Hal Sutton, December 1994.
22 Ibid
23 Ibid

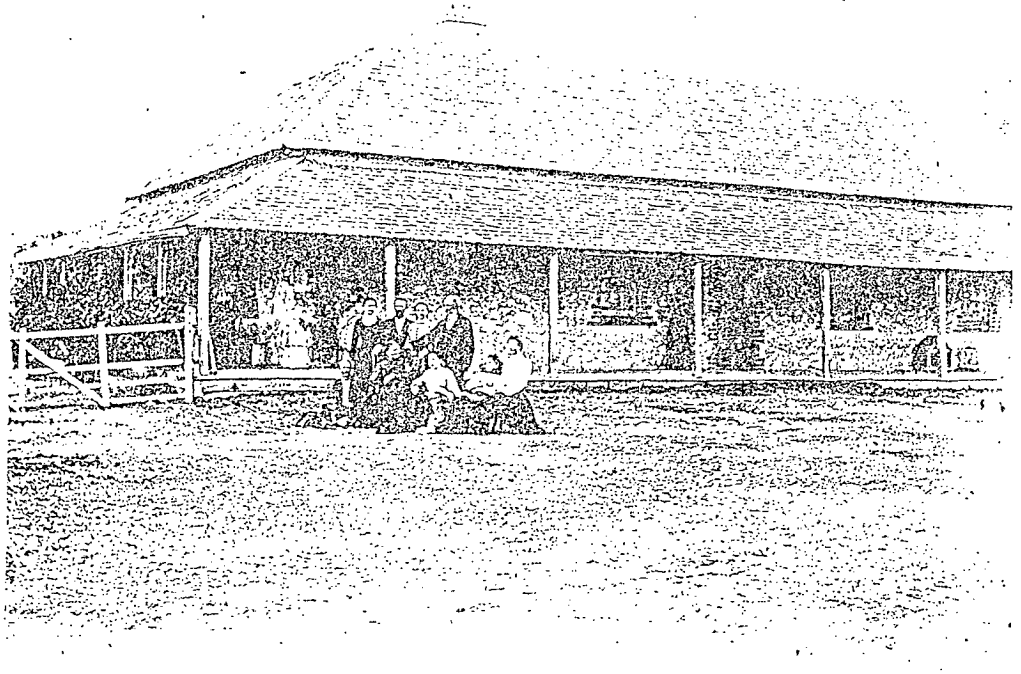

FIGURE N° 2 Henry Sutton and Family and the Old Mandurah Homestead.
Battye Library BA 779/1.

FIGURE N° 3 Sutton Home, Old Coast Road Mandurah. Henry Sutton with his three daughters: Lillian, Marion and May.
Courtesy Mandurah Historical Society.

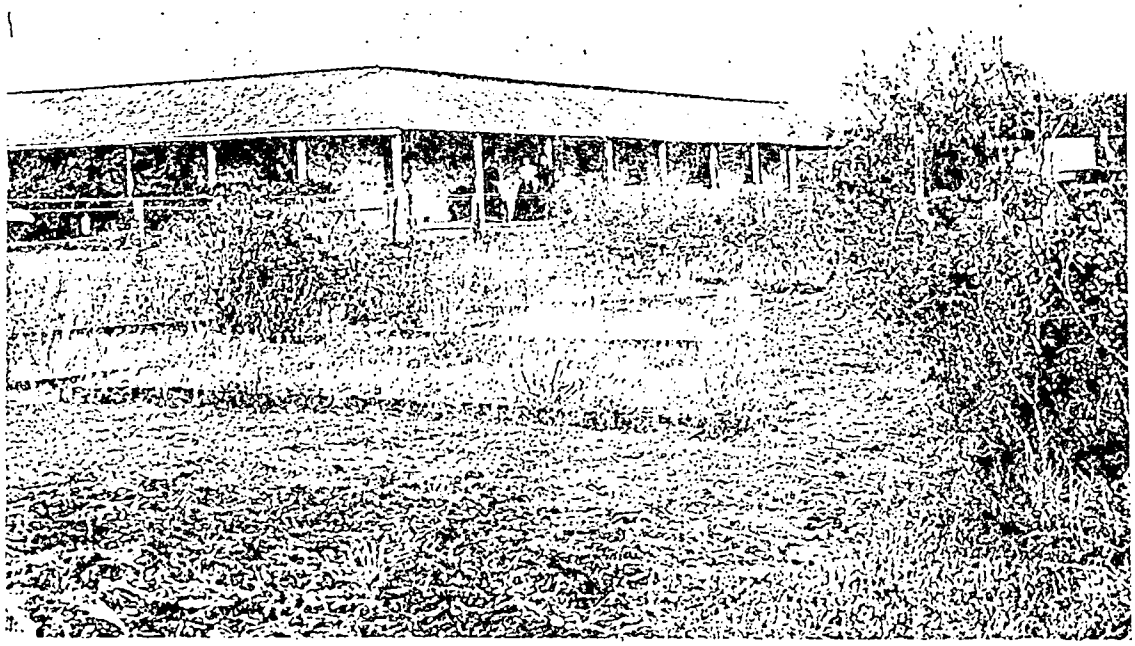

FIGURE N° 4 The Old Sutton Homestead, Mandurah.
Battye Library BA779/4.

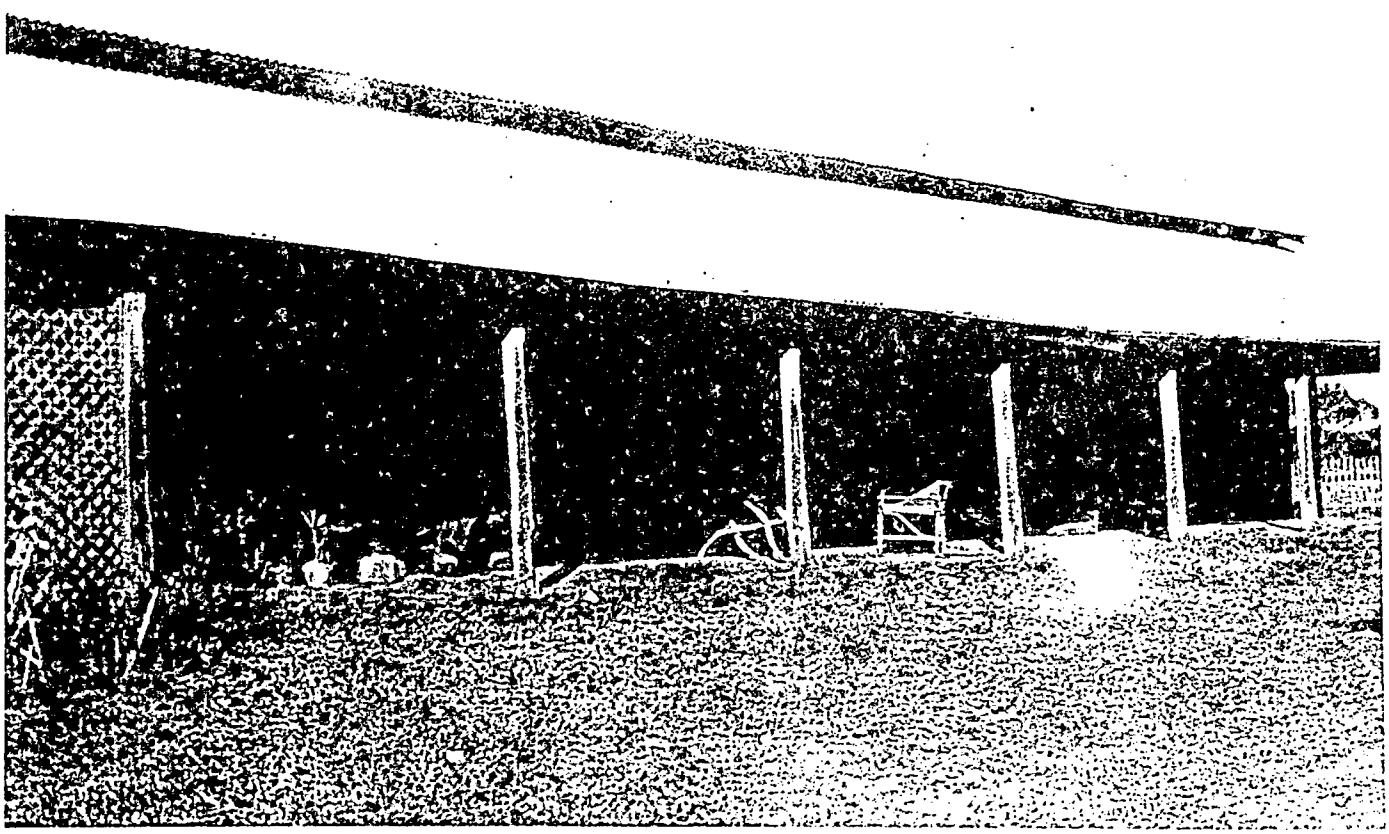

FIGURE N° 5 Untitled and undated photograph of Sutton Homestead.
Courtesy Mandurah Historical Society.

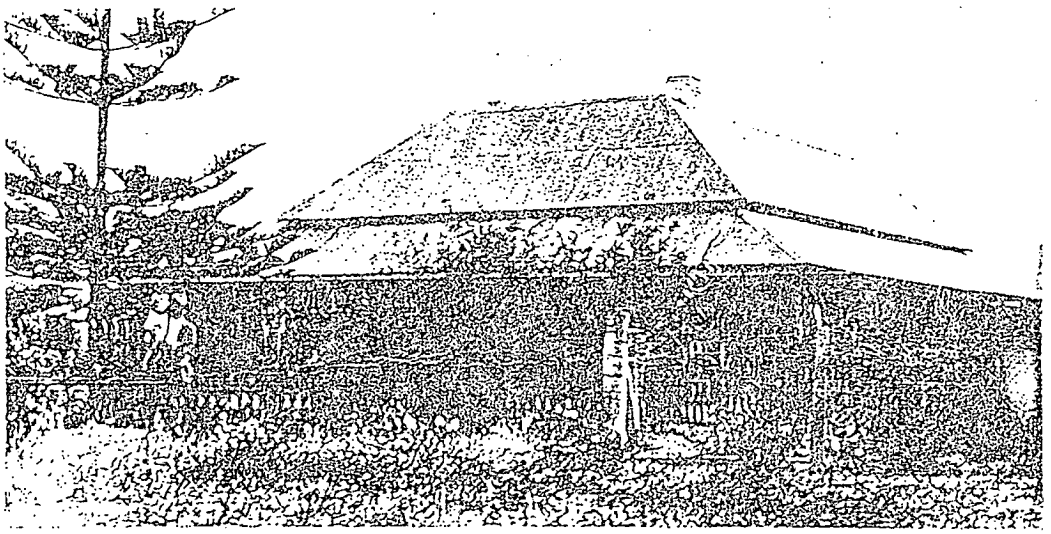

FIGURE N° 6 Sutton's second Home, Leighton House. c1910
(Courtesy Mrs Violet Sutton).
From R Richards, *Murray and Mandurah,* 1993.

FIGURE N° 7 The graves of Henry Sutton and his family in a private graveyard at Sutton's Farm.
(Photo: courtesy Mandurah Camera Club.)
From J. Burgess, *Mandurah-Water Under the Bridge*, 1988. p.30

3.0 PHYSICAL EVIDENCE

The **Sutton Farm** buildings, comprising the **Main Barn**, the **Men's Sleeping Quarters**, the **Homestead**, the ruins of the **Original Milking Shed** and the **New Milking Shed**, are sited on the western side of Old Coast Road, near its junction with Mary Street on the western side of the Mandurah Estuary.

3.1 Main Barn (c1873)

The **Main Barn** is located approximately 40 metres west of the homestead and approximately 100 metres west of Old Coast Road. The building is approximately 20 metres long and 5 metres wide. The structure is split into two sections. The largest portion of the building on the southern end of the barn has two large openings on the east and west sides allowing passage in and out for horses and wagons. The doors to these openings are missing, however the western opening has been boarded up with a timber frame and corrugated iron.

The northern end of the **Main Barn** is referred to as the stable and contains 6 stalls with a loft above. The still extant managers and stall dividers are constructed of jarrah. The floor of the stalls is flagstone and the loft floor is timber. A single limestone wall divides the northern and southern ends of the barn.

The random rubble limestone construction of the walls and pitched roof are typical of similar structures built in the Pinjarra - Mandurah area in the second half of the nineteenth century.[24]

The roof structure is constructed of jarrah and contains evenly spaced collar ties. The close proximity of the battens substantiates the verbal evidence of Hal Sutton, confirming that the roof was originally timber shingles. The roof is presently clad with corrugated iron. There are no fascias, barge boards or gutters.

The timber lintels and frames to window-type openings in the northern and southern ends of the building are set into the stonework. A small window on the eastern side of the stable still contains its original timber louvres.

There is a steel framed lean-to structure built on to the eastern side of the **Main Barn**. It is clad and roofed with corrugated iron. Physical evidence and verbal collaboration with Hal Sutton confirms that this addition was made in the 1950s.

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24 I Molyneux and J White, "Farmhouses". *Western Towns and Buildings*, edited by M. Pitt Morison and J White. University of Western Australia Press, 1979.p.183.

3.2 Men's Sleeping Quarters (c1873)

The **Men's Sleeping Quarters** is a two room cottage located approximately 45 metres west of the **Homestead** and approximately 30 metres south of the **Main Barn.** The building is approximately 10 metres long and 4 metres wide. A verandah runs along the eastern side of the building. Corner stones projecting from the northern end of the building suggest that the original builder anticipated future additions.

The construction of the **Men's Sleeping Quarters** is very similar to the **Main Barn**. This is not surprising considering their proximity and dates of construction. The floor is jarrah boards running longitudinally. The walls are random rubble limestone and have been plastered internally.

The roof is hipped and is presently clad with corrugated iron. The corrugated iron is not original. The condition of the rafters and battens suggest that the roof structure was replaced at the same time the corrugated iron was laid. Shingles were commonly used in the Pinjarra - Mandurah area in the 19th Century; combined with the fact that the **Main Barn** was shingled, it is probable that the roof of the **Men's Sleeping Quarters** was also shingled.

The verandah has a skillion roof, also clad with corrugated iron, that has the same pitch as the main roof, but the two are not connected. The verandah has simple timber posts and floor boards.

The southern room of the **Men's Sleeping Quarters** contains a fireplace, centrally located on the wall dividing the two rooms. The chimney is constructed of clay bricks and the fireplace has been plastered in a similar fashion to the walls.

Each of the rooms have a door and a window fronting the verandah. The timber lintels and sills are set into the stonework. The ledged doors are timber and appear original. The windows are side hung and contain two narrow sashes, side by side. Each sash contains eight panes of glass.

3.3 Homestead (c1881)

The **Homestead** is sited in front of the associated farm buildings, approximately 35 metres west of Old Coast Road. The building is single storey and relatively large for a homestead of the period in the Pinjarra-Mandurah area, measuring approximately 30 metres by 15 metres.[25]

Alterations to the **Homestead,** c1955, have substantially changed the original fabric of the place, but not the general form. Major alterations include re-roofing, the rendering of external walls and the re-building of the verandah.

Old Photographs of the place (Figure N°s 2,3 & 4), clearly show the roof as shingled. A photograph dated c1910 (Figure N° 6) shows that the roof was re-clad with corrugated iron. The roof is currently tiled, however it has retained its original pitched form, with an 'M' roof development at the rear.

The originally 8 foot wide verandah of timber boards and posts was pulled down c1955 and replaced with a 10 foot wide verandah.[26] The existing verandah has a concrete floor, preventing ventilation underneath the building and causing damp problems.

Like the **Men's Sleeping Quarters,** the verandah of the **Homestead** originally had a skillion roof, with the same pitch as the main roof, but not connected to it. The new verandah roof is now connected to the main roof, but at a different pitch. The outer edge of the verandah has been largely bricked-in to balustrade height. Louvred windows and concrete columns virtually enclose the space.

Old Photographs (Figure N°s 2,4 & 5) show that the external walls of the homestead were constructed of random rubble limestone with quoin bricks surrounding window and door openings. The external walls have now been rendered with a textured finish. Several of the windows have been replaced.

Internal changes to the **Homestead** include the replacement of original ceilings and fireplaces.

25 Comparison with Hall's Cottage, Old Blythewood, Pinjarra Park and Edenvale.
26 Verbal Information from Hal Sutton, December 1994.

3.4 Original Milking Shed (c1885)

The ruins of the **Original Milking Shed** are located approximately 25 metres north west of the **Main Barn.** The ruins essentially consist of two walls.

The short wall, running north-south, is constructed of random rubble limestone and is heavily buttressed on the western side. On the eastern side of this wall, the timber frame of a roof structure and the jarrah mangers from the stalls, still exist.

The long wall, enclosing the northern end of **Original Milking Shed,** extends approximately 50 metres to the east and links with the **New Milking Shed.** The wall is approximately 2 metres high and 300mm thick. There is an opening and timber gate approximately halfway along its length.

Both walls have been extensively repaired with concrete at a later date. A grapevine and timber trellis exist in the north west corner of the enclosed space created by the ruins of the **Original Milking Shed.**

3.5 New Milking Shed (c1950)

The **New Milking Shed** is located approximately 25 metres north-east of the **Main Barn.** It is built of textured concrete blocks and has a pitched corrugated iron roof. The floor is concrete.

The building contains a storage room and milking machinery. Three loose boxes are located at the western end of the building. The dividers of the loose boxes are constructed of timber boards. The roof over the loose boxes is of a lower pitch than the eastern end of the building.

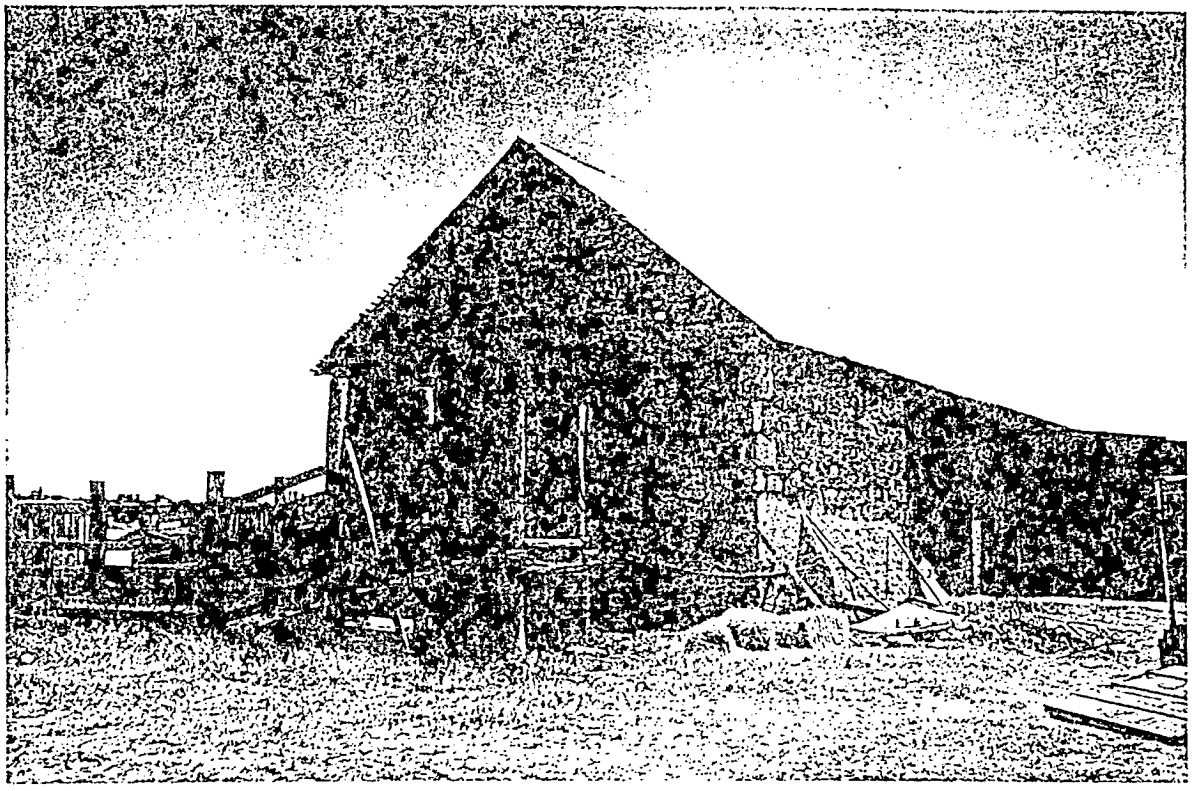
3.6 Graveyard (1857 - 1868)

The **Graveyard** is located approximately 400 metres west-north-west of the **Homestead.** It is located closer to Mary Street than Old Coast Road.

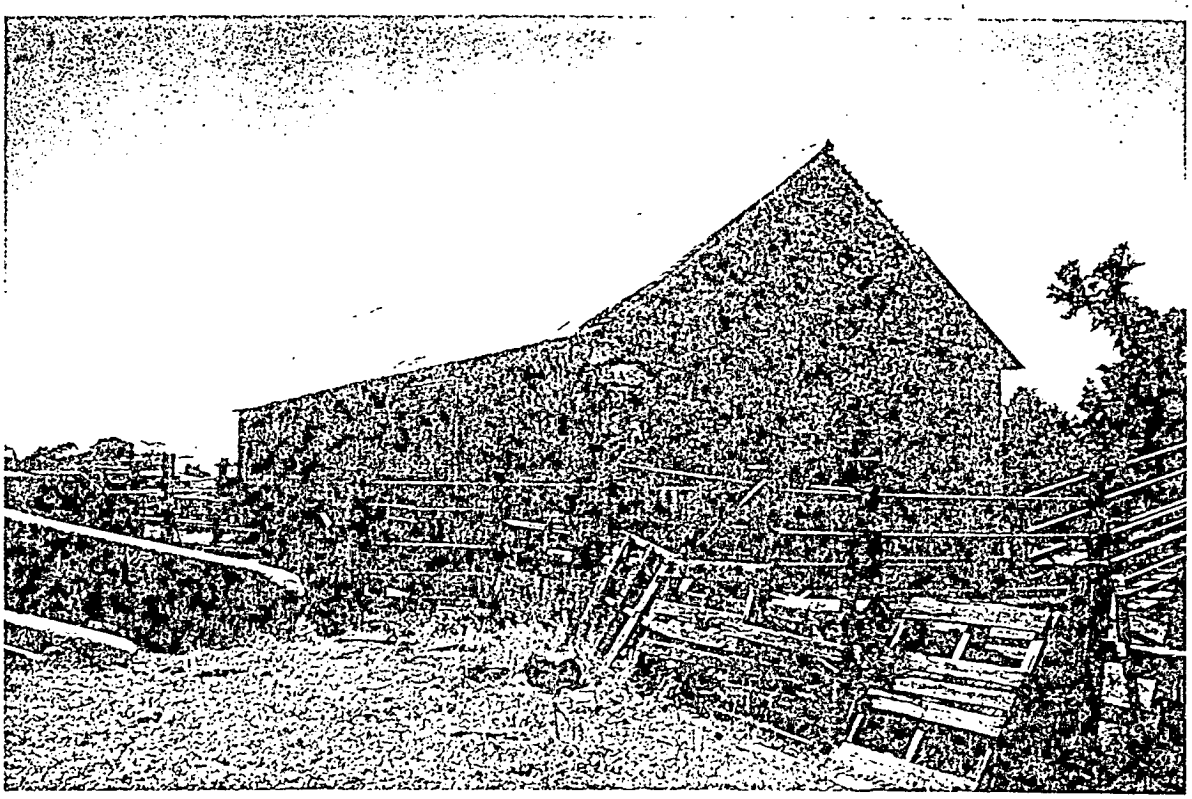
The **Graveyard** contains the graves of John Sutton (deceased 1856), his son Henry Sutton (deceased 1861) and his wife Eleanor Sutton (deceased 1868). The tombstones have been removed and are in the custody of their descendent Hal Sutton.

The **Graveyard** is surrounded by a random rubble limestone wall approximately 6 metres square, 1.2 metres high and 300mm thick. There is a gateway through the northern side of the wall. The limestone footings of an inner wall, approximately 3 metres square, exist within the main wall. A timber picket fence once existed above the limestone footings.[27]

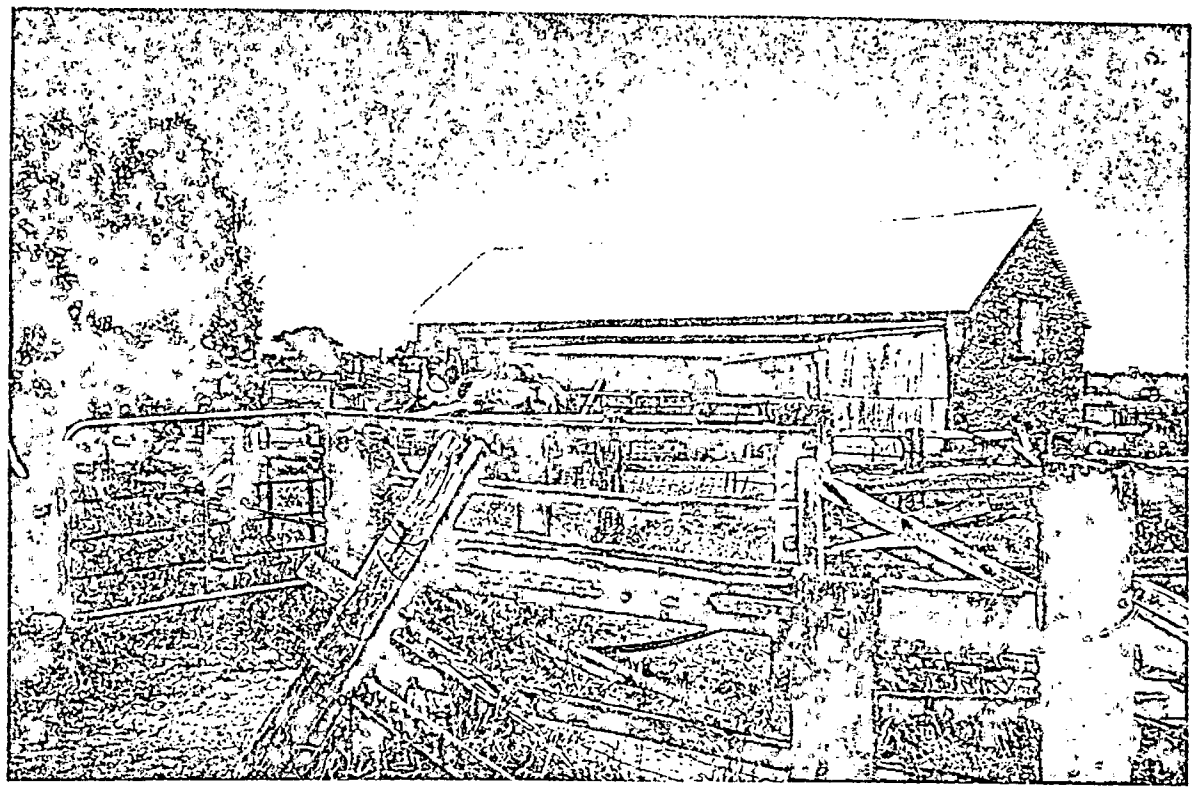
27 Verbal Information from Hal Sutton, December 1994.



PHOTOGRAPH N° 1 Eastern side of the Main Barn, viewed from the South

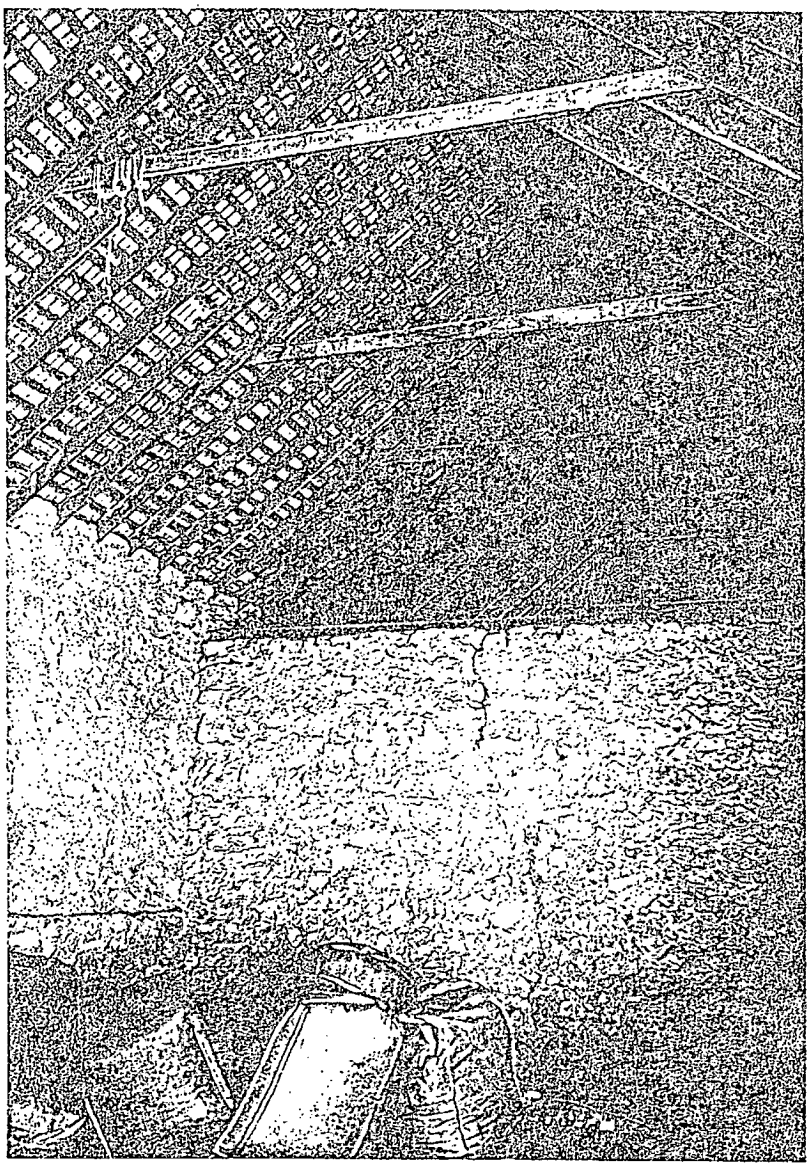


PHOTOGRAPH N° 2 Western side of the Main Barn, viewed from the South

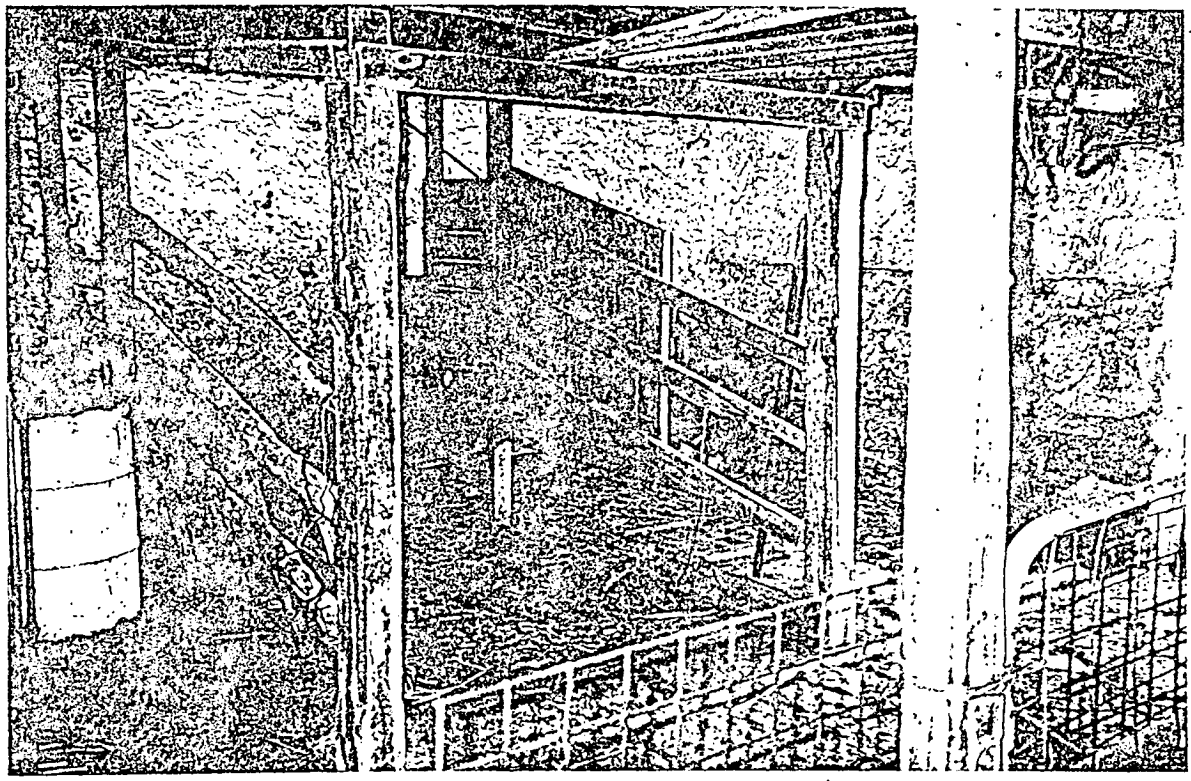


PHOTOGRAPH N° 3 Eastern side of the Main Barn and lean to addition.

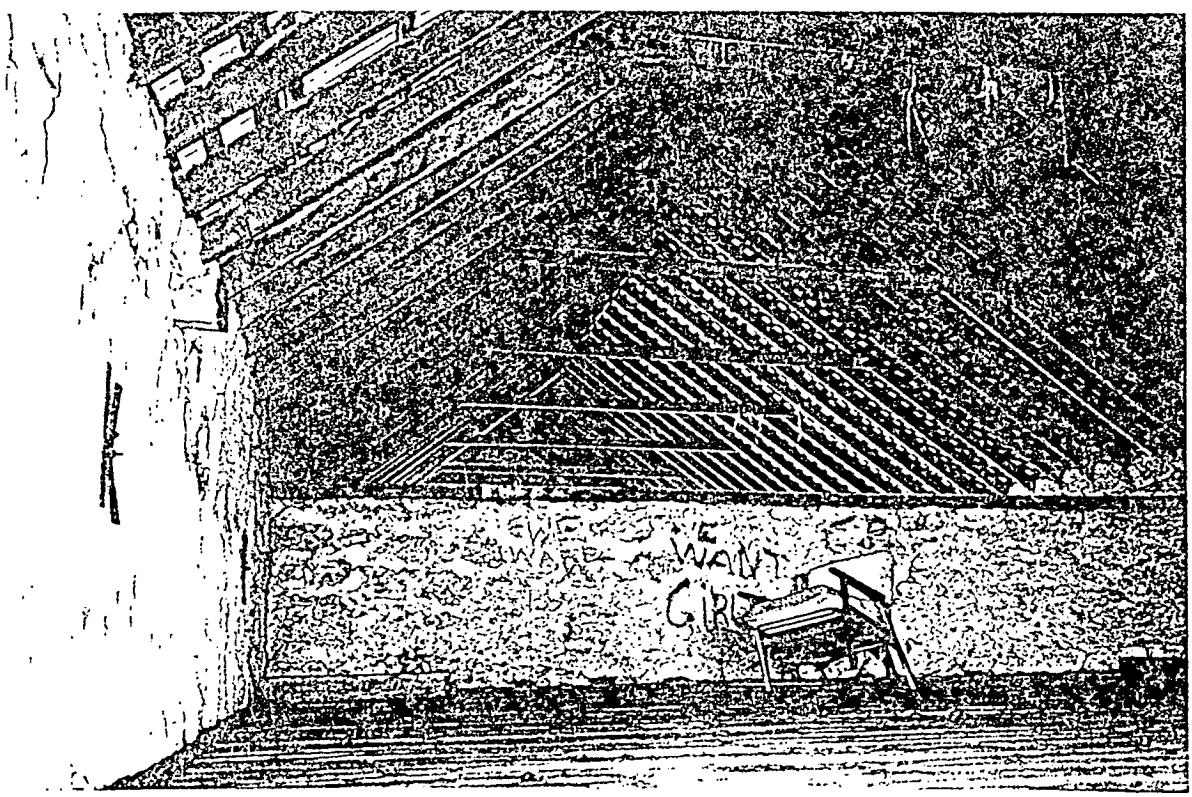
PHOTOGRAPH N° 4 Entry to the stalls, eastern side of the Main Barn.



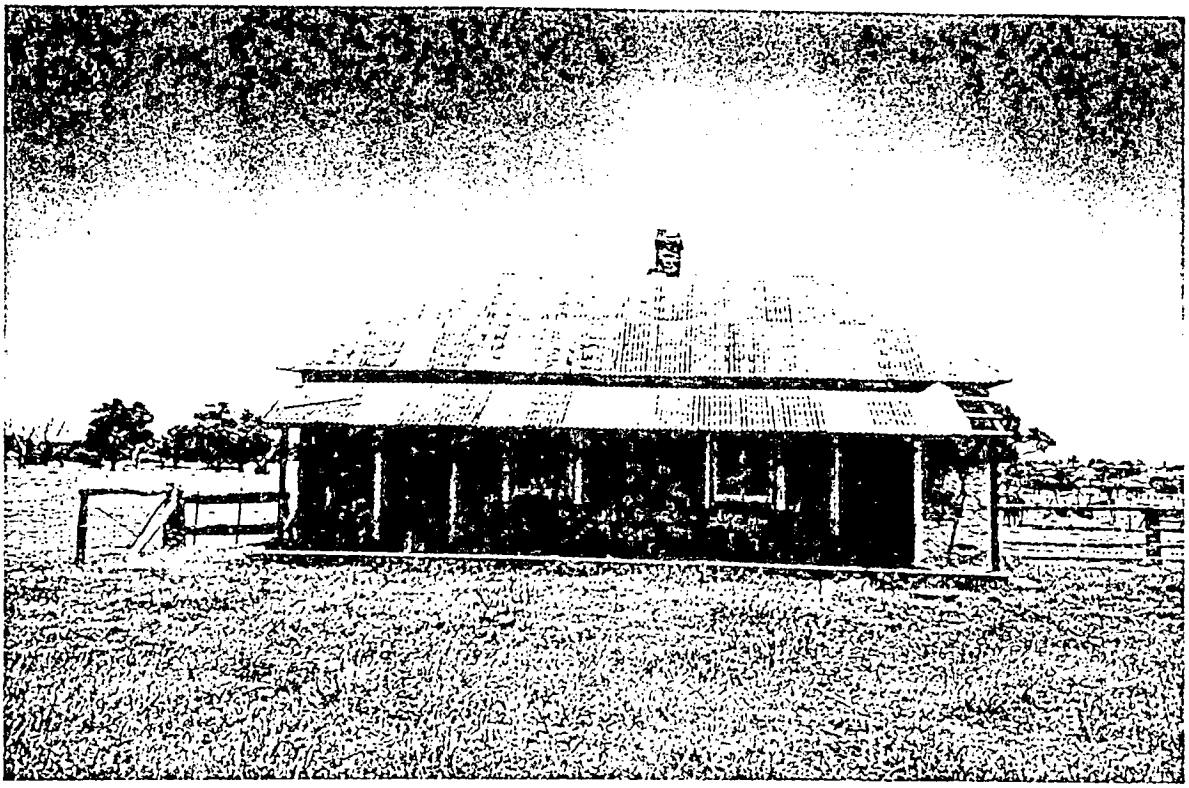
PHOTOGRAPH N° 5 Interior of the southern end of the Main Barn, showing dividing wall between stalls and south end.



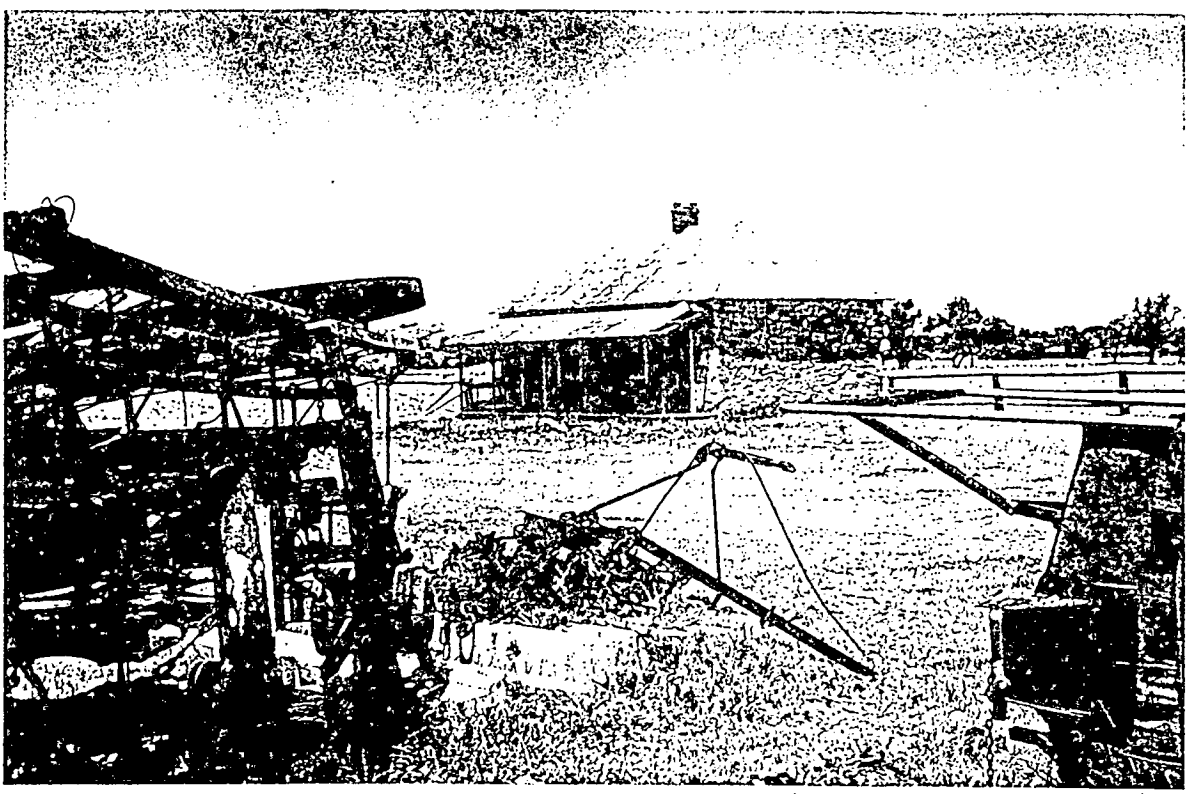
PHOTOGRAPH N° 6 Stalls in the Main Barn, flagstone floor and jarrah stall dividers and mangers.



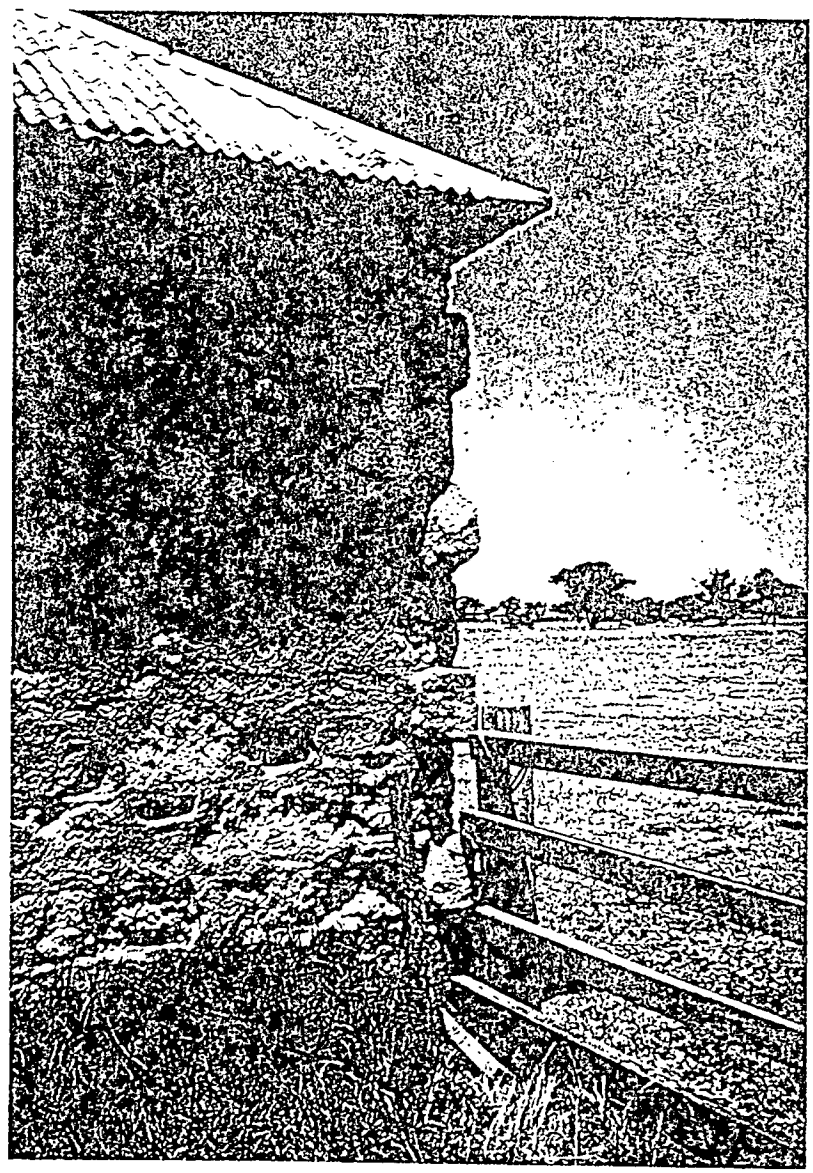
PHOTOGRAPH N° 7 Loft and roof structure of the Main Barn.



PHOTOGRAPH N° 8 Eastern side of the Men's Sleeping Quarters.

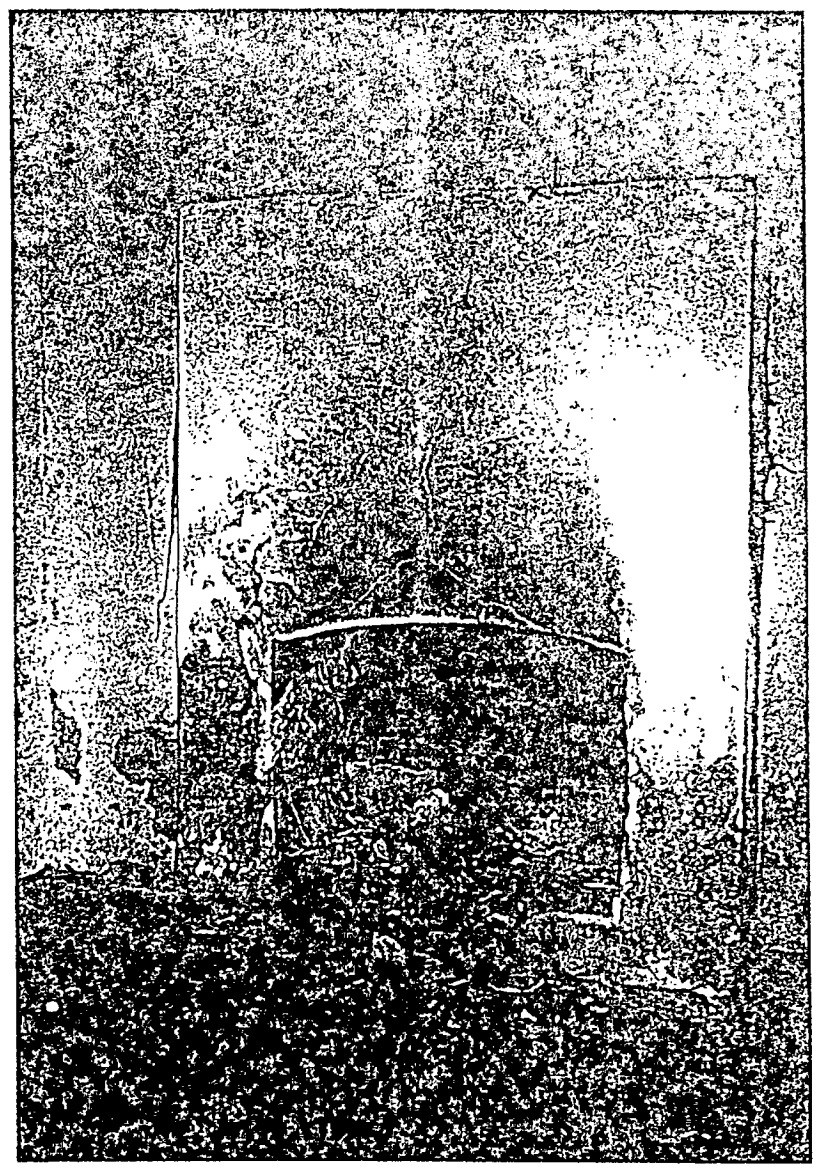


PHOTOGRAPH N° 9 Men's Sleeping Quarters and old farm machinery.



PHOTOGRAPH N° 10 Northern end of the Men's Sleeping Quarters, showing projecting corner stones for future extensions.

PHOTOGRAPH N° 11 Door on the eastern side of the Men's Sleeping Quarters.

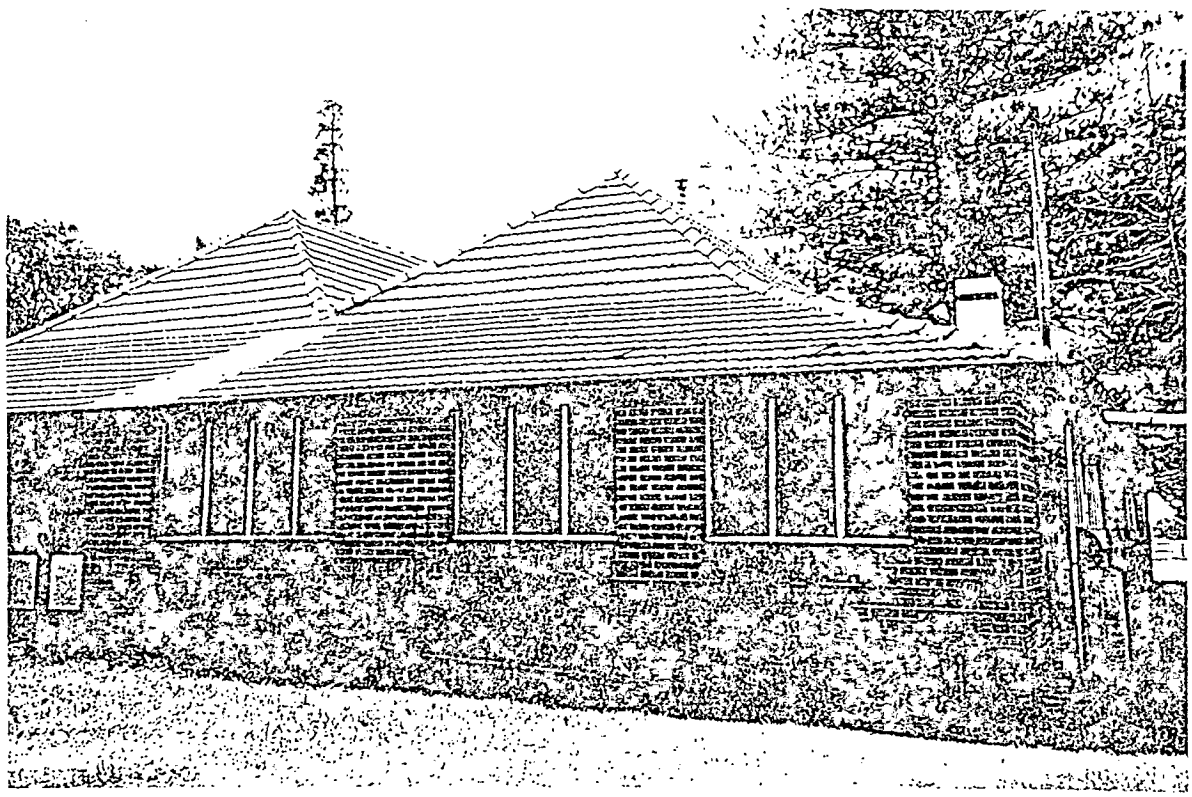


PHOTOGRAPH N° 12 Fire Place in the Men's Sleeping Quarters.

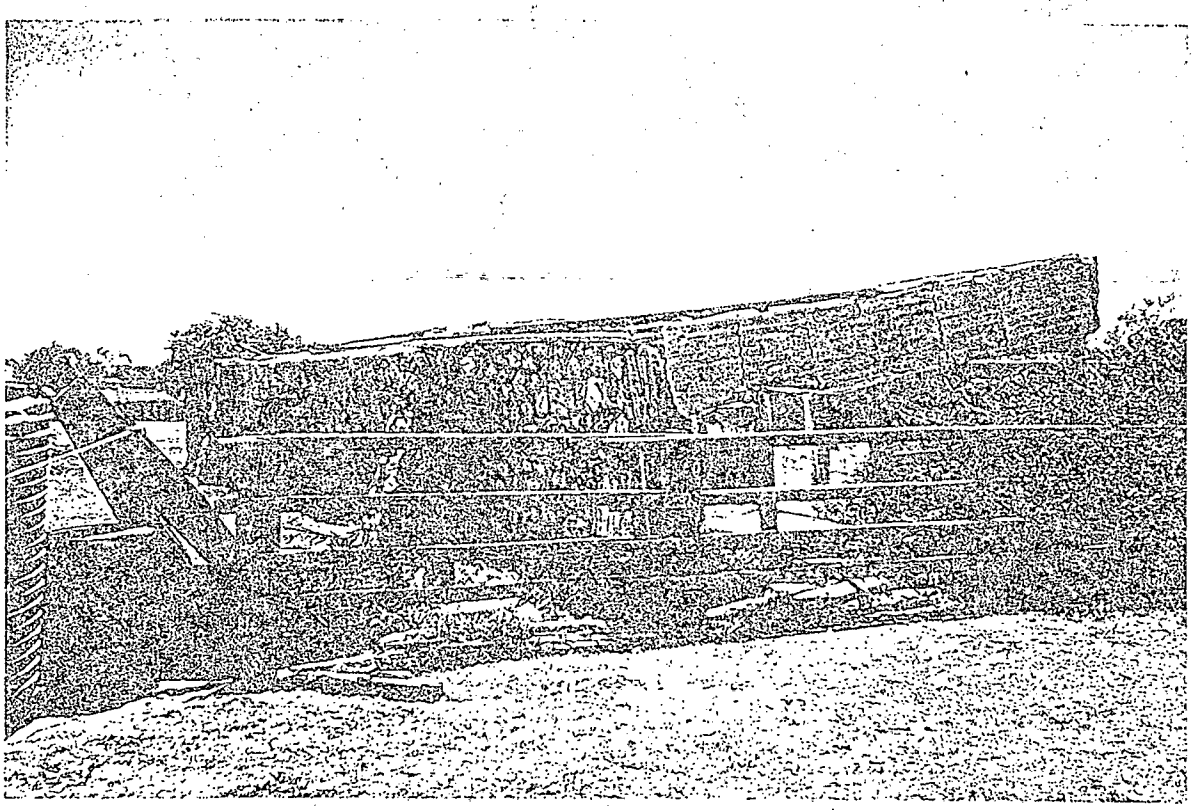
PHOTOGRAPH N° 13 Homestead viewed from Old Coast Road.

PHOTOGRAPH N° 14 Eastern side of the Homestead

PHOTOGRAPH N° 15 Eastern and northern sides of the Homestead

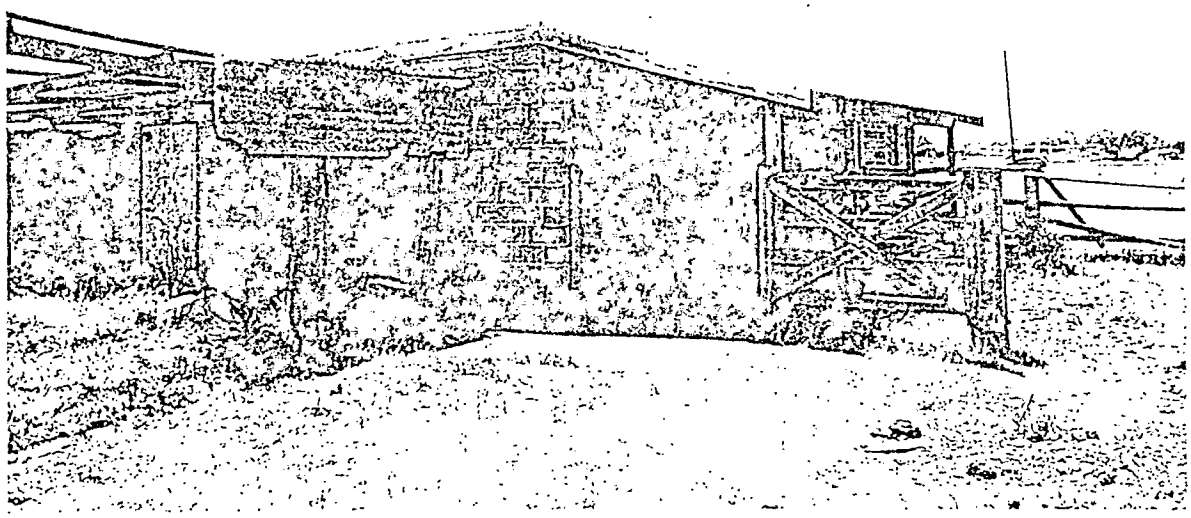


PHOTOGRAPH N° 16 'M' roof development at the rear of the Homestead

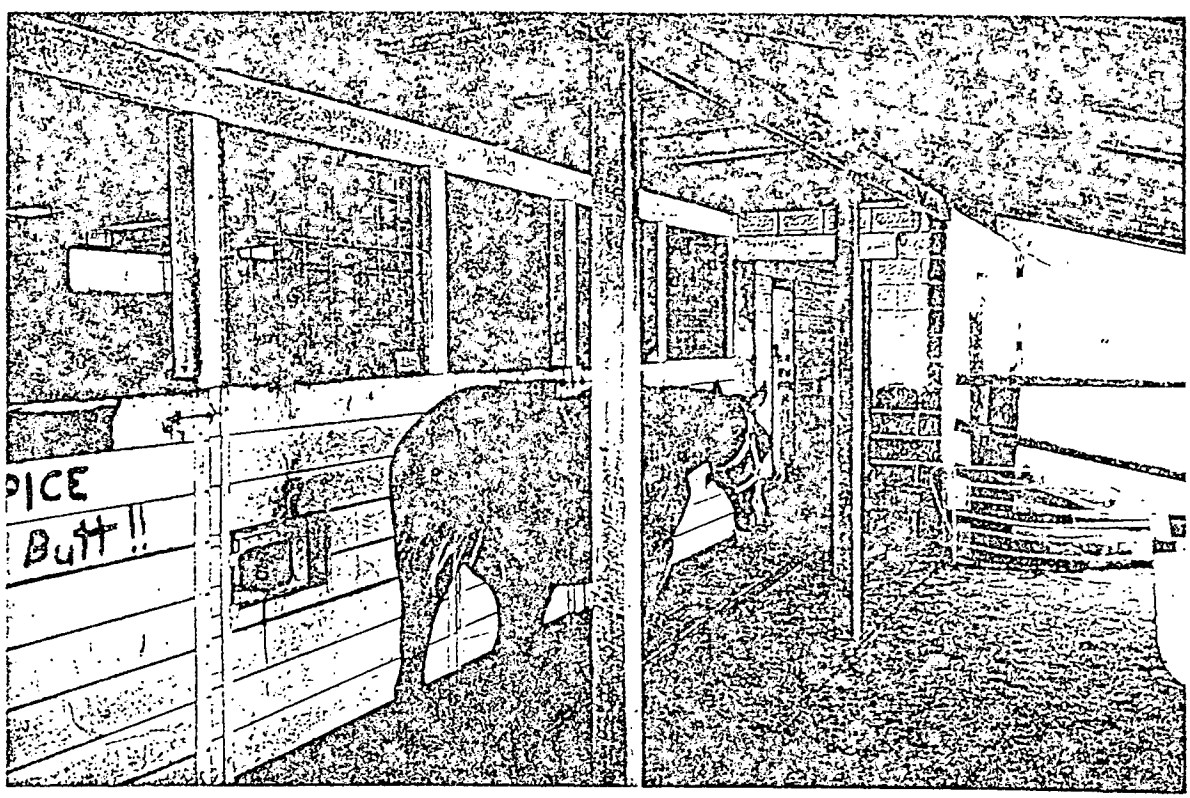


PHOTOGRAPH N° 17 Ruins of the Old Milking Shed with limestone buttresses

PHOTOGRAPH N° 18 Remnants of mangers in the Old Milking Shed

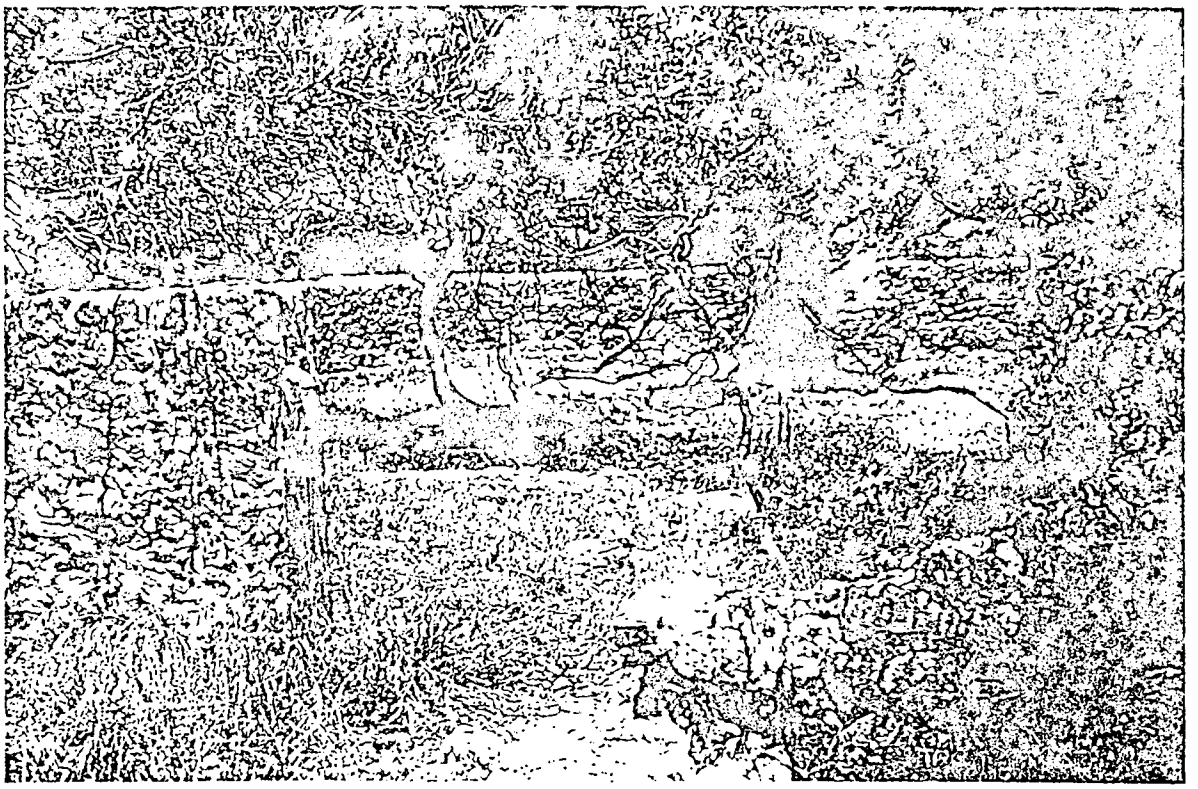


PHOTOGRAPH N° 19 The New Milking Shed, viewed from the west

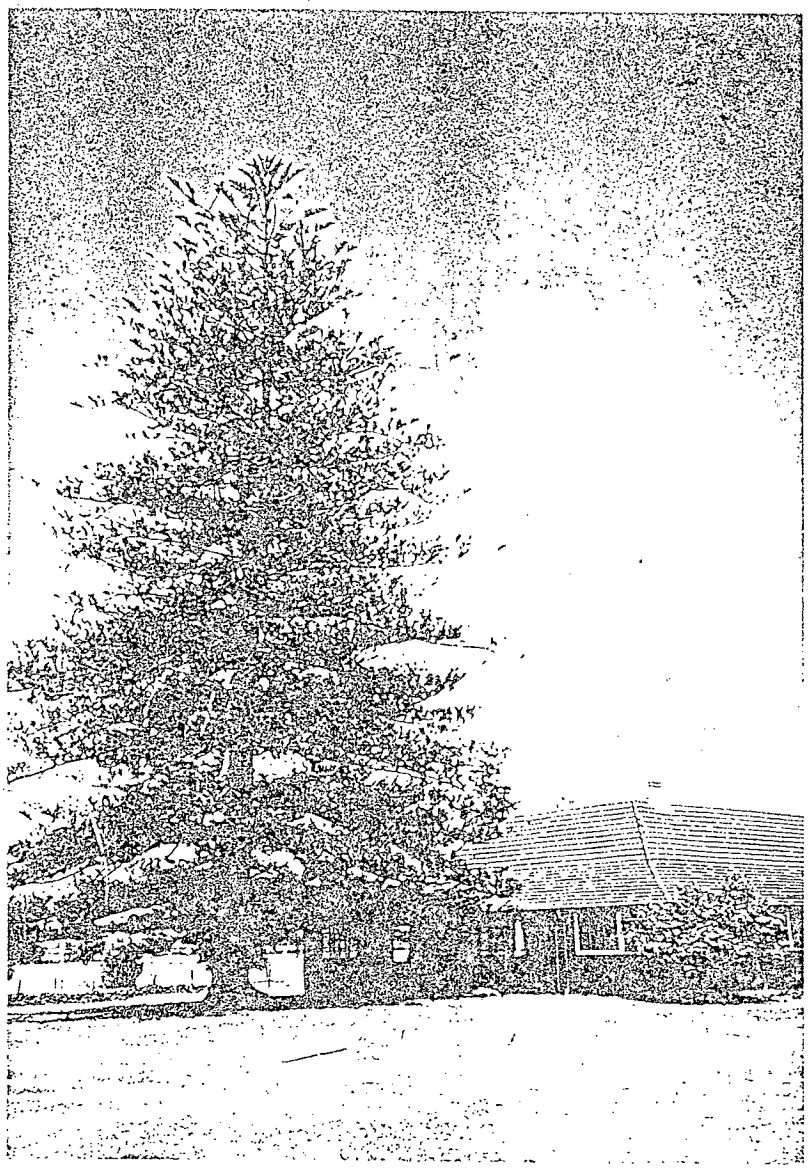


PHOTOGRAPH N° 20 Loose boxes in the New Milking Shed

PHOTOGRAPH N° 21 Sutton Graveyard



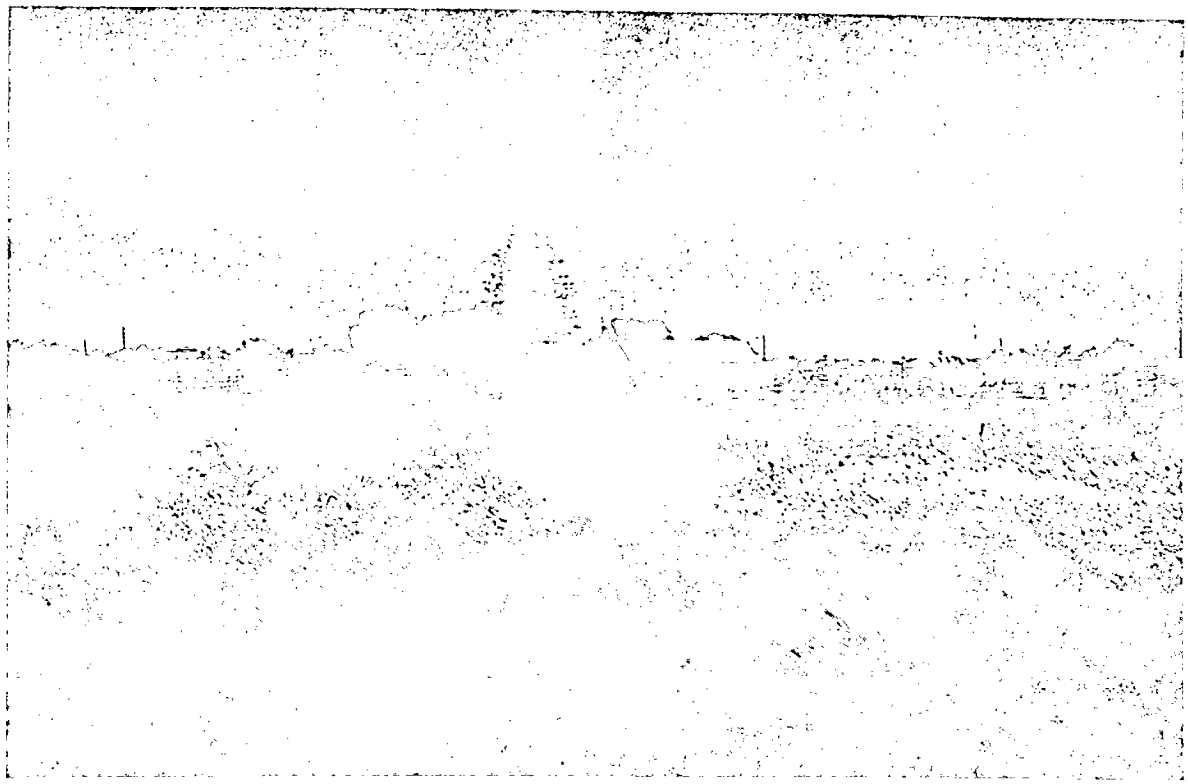
PHOTOGRAPH N° 22 Gateway into the Graveyard



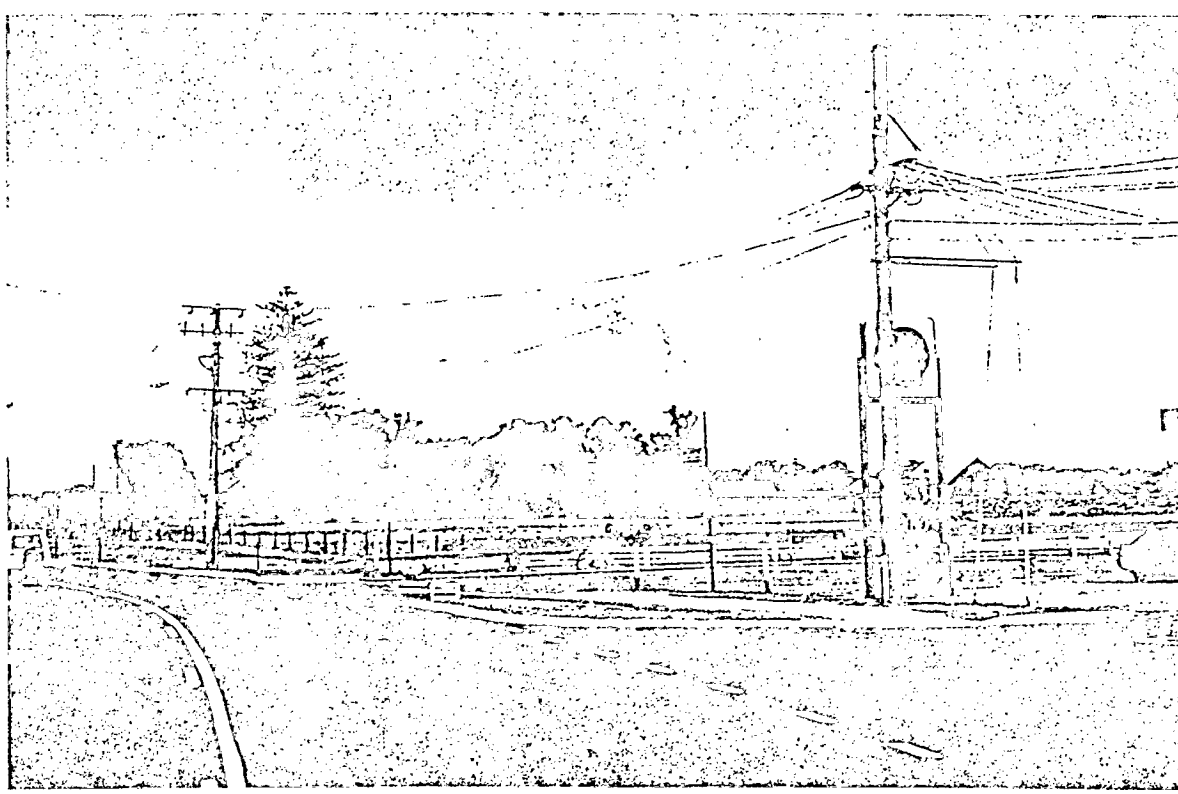
PHOTOGRAPH N° 23 Norfolk Pine Tree in front of the Homestead

PHOTOGRAPH N° 24 Cattle run and Mission Olive Trees

PHOTOGRAPH N° 25 Wagon and farm machinery behind the Homestead



PHOTOGRAPH N° 26 View of Sutton Farm from the Graveyard.



PHOTOGRAPH N° 27 View of Sutton Farm from the corner of Old Coast Road and Mary Street.

4.0 ASSESSMENT OF CULTURAL HERITAGE SIGNIFICANCE

The criteria adopted by the Heritage Council of Western Australia in September, 1991 have been used to determine the cultural heritage significance of the place.

4.1 Aesthetic Value

The **Main Barn, Men's Sleeping Quarters** and **Homestead,** exhibit aesthetic characteristics of style and construction that are typical of significant 19th Century buildings in the Pinjarra - Mandurah area. (Criterion 1.1)

The **Sutton Farm** buildings, as a group, contribute to the aesthetic qualities of the landscape surrounding the Mandurah Estuary and are identified as a landmark, visible from several vantage points, by local residents. (Criterion 1.3)

The **Sutton Farm** buildings, located within close proximity of each other, collectively form a significant cultural environment, representative of a regional 19th Century farm. (Criterion 1.4)

4.2 Historic Value

Sutton Farm is significant in the evolution of the history of the Murray Region for its demonstration of human occupation, design and usage in the development of the local area. (Criterion 2.1)

Sutton Farm has a close association with the Sutton Family who have been instrumental in the development of Mandurah since the 1840s. (Criterion 2.3)

4.3 Scientific Value

Sutton Farm possesses demonstrable potential as a research site to yield information that will contribute to an understanding of the cultural history of Western Australia. (Criterion 3.1)

Sutton Farm contributes to an understanding of the human occupation of the Murray Region. (Criterion 3.2)

4.4 Social Value

Sutton Farm is highly valued by the local Mandurah community for its cultural and aesthetic associations. (Criterion 4.1)

Sutton Farm contributes to the local community's sense of place as a reminder of Mandurah's past and an example of its development. (Criterion 4.2)

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5.0 DEGREE OF SIGNIFICANCE

5.1 Rarity

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

5.2 Representativeness

Sutton Farm is significant in demonstrating principal characteristics of land use, human occupation and a particular way of life in the State.

5.3 Condition

The **Sutton Farm** buildings require some repairs and maintenance, however they are generally in a sound structural condition. There is some damage to the **Homestead**, caused by damp. The roof cladding to the **Main Barn** and **Men's Sleeping Quarters** requires replacement. Some glazing and floor boards in the **Men's Sleeping Quarters** also require replacement. The **Old Milking Shed** and **Graveyard** are in poor condition and referred to as 'ruins', however their condition is not deteriorating at an excessive rate.

5.4 Integrity

Apart from the roof cladding, the **Main Barn** and **Men's Sleeping Quarters** retain the majority of their original fabric, but have lost most of their original function (a lessee farmer continues to use portions of the **Main Barn** for storage, but the buildings have no other use at present).

The original fabric of the **Homestead** has been greatly altered, however the alterations are not irreversible. Much of the fabric of the **Old Milking Shed** and **Graveyard** has been lost. The **New Milking Shed** remains largely original and intact.

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

6.0 GENERAL LEVELS OF SIGNIFICANCE

The levels of cultural significance of the separate elements of **Sutton Farm** have been identified to support the Statement of Cultural Heritage Significance and aid future conservation.

The rarity, representativeness, condition and integrity of each of the elements has been considered in the determination of these levels. The cultural heritage values possessed by each element has also been recorded to emphasise what is significant about each element.

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

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

7.0 STATEMENT OF CULTURAL HERITAGE SIGNIFICANCE

Sutton Farm has cultural heritage significance for the following reasons:

the buildings and landscape are a fine example of a Nineteenth Century Farm, one of the first built by European settlers in the Shire of Murray;

the buildings and landscape are integral with the settlement and development of Mandurah;

the buildings are valued by the local community for their historic, cultural and aesthetic associations;

the place contributes to an understanding of the human occupation of Western Australia; and,

the place is closely associated with the Sutton Family, who have been instrumental in the development of Mandurah since the 1840s.

8.0 DEFINITION OF PRECINCT BOUNDARIES

The intention of creating the **Sutton Farm Heritage Precinct** is to preserve and enhance the cultural heritage significance of the place as previously identified in this report.

Primary and Secondary boundaries have been defined in Figure N° 8. The Primary Boundary defines the area referred to as the **Sutton Farm Heritage Precinct.**

The Primary Boundaries of the precinct have been located with the following objectives:

- to protect structures and landscapes of cultural heritage significance.
- to allow the structures and landscapes to be readily seen from old Coast Road.
- to retain the immediate spatial qualities surrounding the buildings, appropriate to the original scale of the farm.

Three principles have been determined to ensure that what happens within the Primary Boundary, will not endanger the cultural heritage significance of the **Sutton Farm Heritage Precinct:**

Principle 1 CONSERVATION. All buildings, ruins and landscapes identified as possessing considerable or some significance should be conserved according to *The Australia ICOMOS Charter for the Conservation of Places of Cultural Significance (The Burra Charter).*

Principle 2 NEW STRUCTURES. New structures should only be located within the precinct if they are essential to the conservation and re-use of the place. For example, toilet facilities, additional accommodation or storage.

Principle 3 DESIGN OF NEW STRUCTURES. The scale, materials and aesthetics of new structures should respect, but not imitate, existing structures. The design of new structures should be identifiable as belonging to the era in which they are built and should not mislead the general public into believing that they were built many years earlier. New buildings should maintain existing physical themes of the precinct, such as height, rhythm of fenestration and roof pitch.

The Secondary Boundaries have been located with the following objectives:

- to ensure that surrounding developments do not detract from the cultural heritage significance of the **Sutton Farm Heritage Precinct.**

- to retain partial views of the **Sutton Farm** Buildings, as they are currently seen when travelling along Old Coast Road and Mary Street.

Two principles are recommended to restrict the height and density of new developments within the Secondary Boundaries, to ensure that the above objectives are met.

Principle 1 The DENSITY of new developments should not exceed residential code R40 (medium density).

Principle 2 The HEIGHT of new developments should be predominantly one and two stories high. Three stories should be the maximum height of new developments.

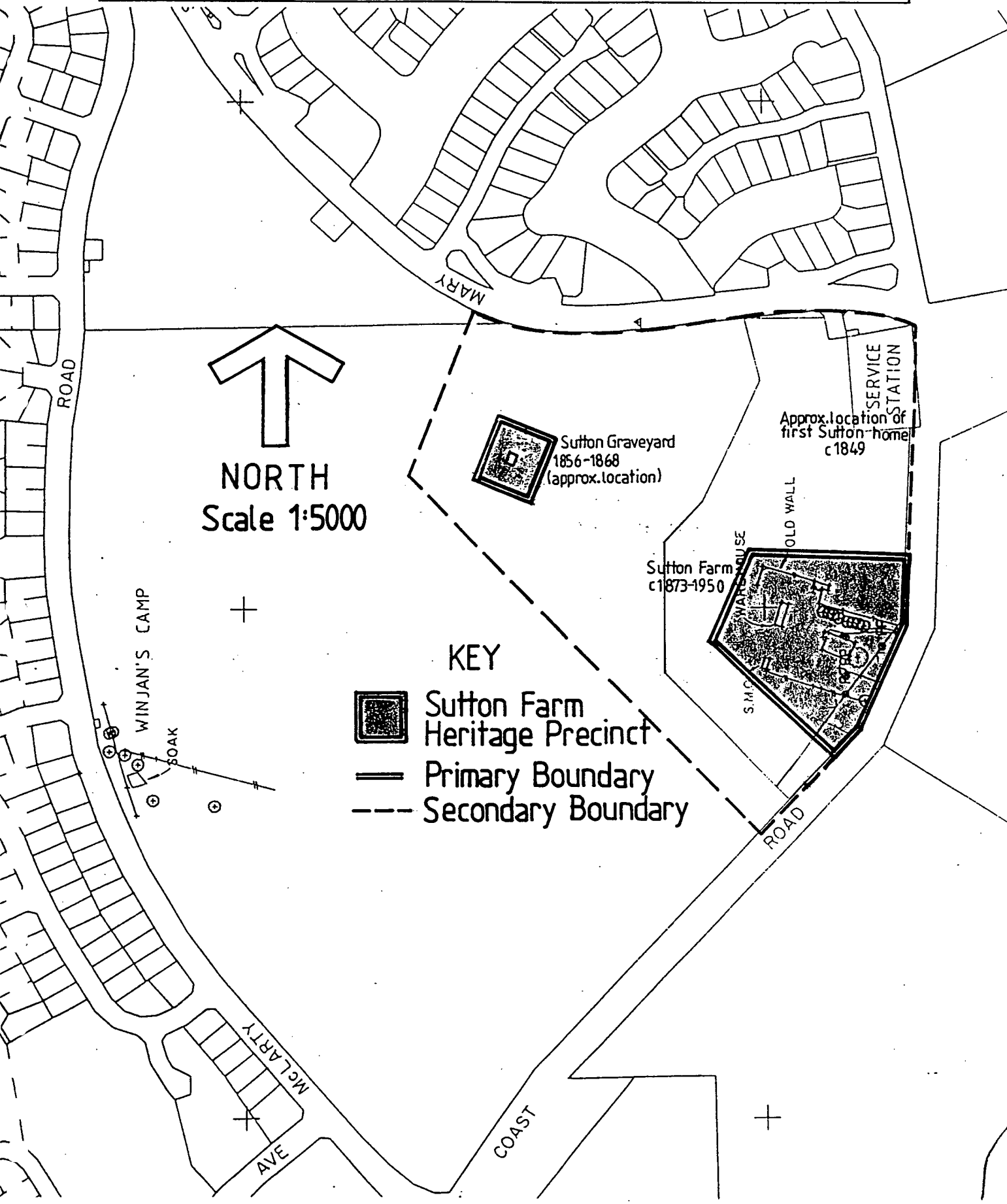

FIGURE N° 8 Sutton Farm Heritage Precinct Boundaries

9.0 STRATEGY FOR FUTURE CONSERVATION

The following strategy has been determined after due consideration of the documentary evidence, physical evidence and cultural heritage significance of the Sutton Farm Heritage Precinct. It is recommended that the actions be carried out chronologically in the order they are listed.

9.1 Prepare and adopt a full CONSERVATION PLAN for the Sutton Farm Heritage Precinct. The preparation of a Conservation Plan before carrying out any built conservation work is considered sound practice by all heritage bodies, and in many cases is a pre-requisite for receiving heritage grants. The Conservation Plan should include options for the interpretation and re-use of the place.

9.2 Implement a HERITAGE AGREEMENT to protect the identified cultural heritage significance of the place if it is sold or leased.

9.3 Recommend the Sutton Farm Heritage Precinct to the HERITAGE COUNCIL OF WESTERN AUSTRALIA for listing on the Register of the National Estate.

9.4 Recommend the Sutton Farm Heritage Precinct to the NATIONAL TRUST OF AUSTRALIA (WA) for classification.

9.5 Prepare a FEASIBILITY STUDY for the specific future use of the precinct to determine the economic viability of intended uses.

9.6 Prior to any built or site works, prepare a PHOTOGRAPHIC AND WRITTEN RECORD of all structures (including fences, cattle runs etc.), artefacts (such as farming implements) and the landscape within the boundaries of the defined precinct. This investigation should be carried out by a suitably qualified heritage professional.

9.7 REMOVE the **New Milking Shed** and that section of the old wall that is not determined to be integral with the ruins of the **Old Milking Shed,** to enhance the vistas of the precinct, as seen from Old Coast Road.

9.8 CONSERVE the **Main Barn, Men's Sleeping Quarters** and **Homestead.** Conservation should include restoration, reconstruction, adaptation and maintenance (see Section 1.5 for the applicable definitions of these terms). The services of a suitably qualified conservation architect should be appointed to ensure that work is carried out with due care and reference to *The Australia ICOMOS Charter for the Conservation of Places of Cultural Significance (the Burra Charter)* and the Conservation Plan.

9.9 PRESERVE the ruins of the **Old Milking Shed** or adapt the building fabric, in situ, for compatible re-use.

9.10 CONSERVE and adapt the outdoor areas of the precinct to support and enhance the new use of the place. A suitable qualified landscape architect with expertise in the conservation of significant heritage landscapes, should be appointed to design and conserve the landscape within the precinct boundaries and select appropriate plants.

9.11 Implement a MAINTENANCE SCHEDULE of monthly, quarterly and annual inspections to ensure the proper and on-going conservation of the building fabric. Timely attention to defects shall be financially economical in the medium to long term.

APPENDIX

The Australia ICOMOS Charter for the Conservation of Places of Cultural Significance (The Burra Charter).

THE AUSTRALIA ICOMOS CHARTER FOR THE CONSERVATION OF PLACES OF CULTURAL SIGNIFICANCE (THE BURRA CHARTER)

Preamble

Having regard to the International Charter for the Conservation and Restoration of Monuments and Sites (Venice 1966), and the Resolutions of the 5th General Assembly of the International Council on Monuments and Sites (ICOMOS) (Moscow 1978), the following Charter was adopted by Australia ICOMOS on 19th August 1979 at Burra Burra. Revisions were adopted on 23rd February 1981 and on 23 April 1988.

Definitions

ARTICLE 1. For the purpose of this Charter:

1.1 *Place* means site, area, building or other work, group of buildings or other works together with associated contents and surrounds.

1.2 *Cultural significance* means aesthetic, historic, scientific or social value for past, present or future generations.

1.3 *Fabric* means all the physical material of the *place*.

1.4 *Conservation* means all the processes of looking after a place so as to retain its *cultural significance*. It includes maintenance and may according to circumstance include *preservation*, *restoration*, *reconstruction* and *adaptation* and will be commonly a combination of more than one of these.

1.5 *Maintenance* means the continuous protective care of the *fabric*, contents and setting of a *place*, and is to be distinguished from repair. Repair involves *restoration* or *reconstruction* and it should be treated accordingly.

1.6 *Preservation* means maintaining the *fabric* of a *place* in its existing state and retarding deterioration.

1.7 *Restoration* means returning the EXISTING *fabric* of a *place* to a known earlier state by removing accretions or by reassembling existing components without the introduction of new material.

1.8 *Reconstruction* means returning a *place* as nearly as possible to a known earlier state and is distinguished by the introduction of materials (new or old) into the *fabric*. This is not to be confused with either recreation or conjectural reconstruction which are outside the scope of this Charter.

1.9 *Adaptation* means modifying a *place* to suit proposed compatible uses.

1.10 *Compatible use* means a use which involves no change to the culturally significant fabric, changes which are substantially reversible, or changes which require a minimal impact.

Conservation Principles

ARTICLE 2. The aim of *conservation* is to retain the *cultural significance* of a *place* and must include provision for its security, its *maintenance* and its future.

ARTICLE 3. *Conservation* is based on a respect for the existing *fabric* and should involve the least possible physical intervention. It should not distort the evidence provided by the *fabric*.

ARTICLE 4. *Conservation* should make use of all the disciplines which can contribute to the study and safeguarding of a *place*. Techniques employed should be traditional but in some circumstances they may be modern ones for which a firm scientific basis exists and which have been supported by a body of experience.

ARTICLE 5. *Conservation* of a *place* should take into consideration all aspects of its *cultural significance* without unwarranted emphasis on any one aspect at the expense of others.

ARTICLE 6. The conservation policy appropriate to a *place* must first be determined by an understanding of its *cultural significance*.

ARTICLE 7. The conservation policy will determine which uses are compatible.

ARTICLE 8. *Conservation* requires the maintenance of an appropriate visual setting: e.g., form, scale, colour, texture and materials. No new construction, demolition or modification which would adversely affect the setting should be allowed. Environmental intrusions which adversely affect appreciation or enjoyment of the *place* should be excluded.

ARTICLE 9. A building or work should remain in its historical location. The moving of all or part of a building or work is unacceptable unless this is the sole means of ensuring its survival.

ARTICLE 10. The removal of contents which form part of the *cultural significance* of the *place* is unacceptable unless it is the sole means of ensuring their security and *preservation*. Such contents must be returned should changed circumstances make this practicable.

Conservation Processes

Preservation

ARTICLE 11. *Preservation* is appropriate where the existing state of the *fabric* itself constitutes evidence of specific *cultural significance*, or where insufficient evidence is available to allow other conservation processes to be carried out.

ARTICLE 12. *Preservation* is limited to the protection, *maintenance* and, where necessary, the stabilisation of the existing *fabric* but without the distortion of its *cultural significance*.

Restoration

ARTICLE 13. *Restoration* is appropriate only if there is sufficient evidence of an earlier state of the *fabric* and only if returning the *fabric* to that state reveals the *cultural significance* of the *place*.

ARTICLE 14. *Restoration* should reveal anew culturally significant aspects of the *place*. It is based on respect for all the physical, documentary and other evidence and stops at the point where conjecture begins.

ARTICLE 15. *Restoration* is limited to the reassembling of displaced components or removal of accretions in accordance with Article 16.

ARTICLE 16. The contributions of all periods to the place must be respected. If a *place* includes the *fabric* of different periods, revealing the *fabric* of one period at the expense of another can only be justified when what is removed is of slight *cultural significance* and the *fabric* which is to be revealed is of much greater *cultural significance*.

Reconstruction

ARTICLE 17. *Reconstruction* is appropriate only where a *place* is incomplete through damage or alteration and where it is necessary for its survival, or where it reveals the *cultural significance* of the *place* as a whole.

ARTICLE 18. *Reconstruction* is limited to the completion of a depleted entity and should not constitute the majority of the *fabric* of the *place*.

ARTICLE 19. *Reconstruction* is limited to the reproduction of *fabric*, the form of which is known from physical and/or documentary evidence. It should be identifiable on close inspection as being new work.

Adaptation

ARTICLE 20. *Adaptation* is acceptable where the *conservation* of the *place* cannot otherwise be achieved, and where the *adaptation* does not substantially detract from its *cultural significance*.

ARTICLE 21. *Adaptation* must be limited to that which is essential to a use for the *place* determined in accordance with Articles 6 and 7.

ARTICLE 22. *Fabric* of *cultural significance* unavoidably removed in the process of *adaptation* must be kept safely to enable its future reinstatement.

Conservation Practice

ARTICLE 23. Work on a *place* must be preceded by professionally prepared studies of the physical, documentary and other evidence, and the existing *fabric* recorded before any intervention in the *place*.

ARTICLE 24. Study of a *place* by any disturbance of the *fabric* or by archaeological excavation should be undertaken where necessary to provide data essential for decisions on the *conservation* of the *place* and/or to secure evidence about to be lost or made inaccessible through necessary *conservation* or other unavoidable action. Investigation of a *place* for any other reason which requires physical disturbance and which adds substantially to a scientific body of knowledge may be permitted, provided that it is consistent with the conservation policy for the *place*.

ARTICLE 25. A written statement of conservation policy must be professionally prepared setting out the *cultural significance* and proposed *conservation* procedure together with justification and supporting evidence, including photographs, drawings and all appropriate samples.

ARTICLE 26. The organisation and individuals responsible for policy decisions must be named and specific responsibility taken for each such decision.

ARTICLE 27. Appropriate professional direction and supervision must be maintained at all stages of the work and a log kept of new evidence and additional decisions recorded as in Article 25 above.

ARTICLE 28. The records required by Articles 23, 25, 26 and 27 should be placed in a permanent archive and made publicly available.

ARTICLE 29. The items referred to in Articles 10 and 22 should be professionally catalogued and protected.

Words in italics are defined in Article 1.

APPENDIX I

Summary of Environmental Conditions and Commitments for Port Mandurah Stage 1 and their Relationship to the Commitments for Port Mandurah Stage 2.

Appendix I

Environmental Commitments for Port Mandurah Stage 1 and their Application to Commitments for Stage 2

Commitment Stage 1	Application to Stage 2 (Commitment No.)
Water Quality	
1.1	12, 13, 28
1.2	12, 13, 28
1.3	12, 13, 28
Sedimentation	
2.1	13
2.2	12, 27
Dust and Dewatering	
3.5	18 and as per proposal
3.6	25
Management of Waterways	
5.7	12
5.8	24
6.9	12
6.10	12
6.11	2, 11, 15, 23
Navigation Aids	
8.1	2, 23
8.2	2, 23
8.3	2, 23
Monitoring for Fishery Impact	
10.1	No impact predicted
Planning Considerations	
12.1	1, 2, 11
13.4	1, 2, 11
14.7	1, 2, 11, 19
14.8	1, 2, 11, 18
14.9	1, 2, 11, 18
14.10	1, 2
14.11	1, 2
Statutory Approvals	
14.15	1, 2
Dredge Spoil Disposal	
16.1	1, 2, 22, 23
Bridges	
18.1	11, 23
Drainage	
20.1	1, 2, 11
20.2	1, 2, 11
20.3	1, 2, 11
20.4	1, 2, 11
20.5	1, 2, 11
20.6	1, 2, 11
20.7	1, 2, 11
20.11	1, 2, 11
20.12	1, 2, 11

Appendix I
(CONT'D)

Commitment Stage 1	Application to Stage 2 (Commitment No.)
Rubbish Disposal	
22.1	1, 2
22.2	1, 2
Public Open Space and Conservation Areas	
23.3	6, 7, 8, 9
23.4	6, 7, 8, 9
23.5	N/A
24.5	1, 2, 6 and as per proposal
24.6	7, 8, 9
Monitoring	
25.1	12, 13, 14, 25, 26, 27, 28
25.2	12, 15, 25, 26, 27, 28
25.3	12, 15, 25, 26, 27, 28
25.10	12, 25, 26, 27, 28
25.11	12, 25, 26, 27, 28