Medium-term shellsand dredging, Success Bank, Owen Anchorage

Cockburn Cement Limited

Report and recommendations
of the Environmental Protection Authority

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Summary and recommendations

Cockburn Cement Limited (Cockburn) has proposed to continue shellsand dredging of the medium-term area on Success Bank, Owen Anchorage over the period 1997 to approximately the end of 2002. Shellsand of high quality - about 92% calcium carbonate - is used by the company for the manufacture of quicklime and cement products.

This report provides the Environmental Protection Authority's (EPA's) advice and recommendations to the Minister for the Environment on the environmental factors, conditions and procedures relevant to the proposal.

Pursuant to Section 44 of the *Environmental Protection Act 1986* the EPA reports to the Minister for the Environment on the environmental factors relevant to the proposal and on the conditions and procedures to which the proposal should be subject, if implemented. Furthermore, the EPA may make recommendations as it sees fit.

Environmental Factors

The EPA has concluded that the environmental factors relevant to the proposal are:

a) Wave climate, sediment movement and shoreline stability – the effects of continued dredging on Success Bank and the coast;

b) Seagrass - distribution, abundance and diversity;

c) Transplanting of seagrasses – feasibility and success; and

d) Alternative measures and resources – beneficiation and land-based sources.

Since 1995, through a commitment to the Western Australian government, Cockburn has been conducting a multi-dimensional research programme aimed at addressing these environmental factors. Some components of the research work are complete or sufficiently advanced to provide findings applicable to the assessment of the proposal.

Conclusions

The EPA has considered the proposal by Cockburn Cement to continue Shellsand dredging on Success Bank in the area described in its medium-term environmental review document.

The EPA has concluded that its advice on acceptability of the proposal needs to consider on one hand a reduction in seagrass and seagrass habitat and on the other hand the value of the research being undertaken on wave climate on Success Bank, distribution of seagrass within Owen Anchorage, ecological significance and function of seagrasses, rehabilitation techniques for the replacement of seagrass function and beneficiation of lower grade shellsand material.

Within the Owen Anchorage area there have been gains and losses of seagrass cover between 1972 and 1995 with a net gain of 198ha. Accordingly, the seagrass habitat needs to be considered in association with actual seagrass cover. Within this context, the proposal could be regarded as not bringing about a major change in the Owen Anchorage area. However, Owen Anchorage cannot be separated from the extensive reduction in seagrass in Cockburn Sound even though the reason for that reduction had nothing to do with the activities of Cockburn Cement.

In general terms, the further loss of seagrass and the consequential reduction in a primary benthic community cannot be supported by the EPA. However, in the particular case of the Cockburn Cement proposal, the EPA has taken into account the long term environmental aspects of acquiring information about the ecological functions of seagrass and the development of techniques for seagrass rehabilitation. The research being undertaken is of world-class status and is peer reviewed by an International Peer Review Group.

The research effort has led to a number of significant findings and conclusions relevant to the medium-term proposal even though the studies are still ongoing. In addition, Cockburn Cement has developed a machine for small-scale excavation of seagrass and substrate, and the transplanting of the material in a prepared reception site away from likely development sites. The research is continuing, including the development of another more efficient machine.

The EPA holds the view that, on balance, there is an environmental benefit to be gained in having the research continue in both the biological and engineering fields vis-à-vis the environmental damage caused by the loss of seagrass in the area described in the mid-term proposal.

Accordingly, the EPA has concluded that the environmental harm resulting from the mid-term proposal by Cockburn Cement is outweighed by the environmental value of the information flowing from the research being undertaken provided the commitment to research is accompanied by a condition towards utilising the research findings for continuous improvement in the environmental performance, both during the period of the Medium-term dredging proposal and post dredging.

Other advice

The EPA is concerned at the loss of seagrass due to human-induced influences both in Owen Anchorage and within Cockburn Sound.

With regard to Owen Anchorage and Success Bank in particular, the value of seagrass as a functional biological component of the localised ecosystem is still being determined. Ecological function is one element of the suite of studies. However, the abundance of seagrass on Success Bank and hence its ecosystem role, shifts from time to time in response to natural forces.

On a regional scale, there has been past degradation through seagrass loss. The ability to restore seagrass meadows would be of ecological benefit. As there is ongoing decline in Cockburn Sound, reliance on natural regeneration appears unlikely whereas natural regeneration is still occurring in Owen Anchorage.

For Cockburn Sound, the EPA holds the opinion that development proposals should not adversely add to the gross changes that have already occurred. As seagrasses are the main biological element significantly impacted by the water quality change in Cockburn Sound it is paramount that there should not be any further losses.

The completion of the medium-term proposal will provide two direct opportunities, firstly a reason to stop the further loss of seagrass by dredging and, secondly the focus to move to other resource acquisition options. Hence, a longer-term proposal which would see the further removal of seagrass from the confines of Owen Anchorage should be recognised as environmentally unreasonable.

Recommendations

Section 44 of the Environmental Protection Act 1986 requires the EPA to report to the Minister for the Environment on the environmental factors relevant to the proposal and on the conditions and procedures to which the proposal should be subject, if implemented. In addition, the EPA may make recommendations as it sees fit.

The EPA submits the following recommendations to the Minister:

1. That the Minister considers the report on the relevant factors of wave climate, sediment movement and shoreline stability, seagrass, the transplanting of seagrasses, and alternative measures and resources;

2. That the Minister notes that the EPA has concluded that the environmental harm resulting from the mid-term proposal by Cockburn Cement is outweighed by the environmental value of the information flowing from the research being undertaken provided the commitment to research is accompanied by a condition towards utilising the research findings for continuous improvement in the environmental performance, both during the period of the Medium-term dredging proposal and post dredging;

3. That the Minister notes that the EPA has recommended that, within two years of the approval to implement the proposal, the proponent investigate and prepare a report on potential alternative sources of lime-making material (marine sources, terrestrial sources and environmental impacts of development and production), to the requirements of the Environmental Protection Authority on advice of the Department of Resources Development, the Department of Minerals and Energy and the Department of Environmental Protection. The EPA will seek public comment on the report and provide advice to the Minister for the Environment on that report.

4. That the Minister imposes the conditions and procedures consistent with Section 5 and set out in formal detail in Appendix 3 of this report; and

5. That the Minister notes that the EPA has formed the view that proposals involving the removal of seagrass and potential seagrass habitat in the long-term for shellsand should be recognised as environmentally unreasonable.

Conditions

Having considered the proponent's commitments and the information provided in this report, the EPA has developed the following set of conditions which the EPA recommends be imposed if the proposal by Cockburn Cement Limited to continue shellsand dredging of the medium-term area on Success Bank, Owen Anchorage over the period 1997 to the end of 2002, is approved for implementation.

(a) The proponent shall fulfil the commitments in the Consolidated Commitments statement set out as an attachment to the recommended conditions in Appendix 3, noting that the commitments include:

- implementing all of the programmes of scientific and technical investigation as outlined in the EMP (Cockburn Cement Limited, February 1995) and its Supplement (Cockburn Cement Limited, December 1995);
- development of a detailed audit programme for this project;
- referral of its plan for long-term resources for assessment by the EPA under Part IV of the *Environmental Protection Act* at least 15 months prior to the expected depletion of the medium-term resource; and
- implementation of a dredging programme that prioritises dredging areas, gaining access to areas of lower seagrass cover first.

(b) The proponent shall prepare a report to the EPA within two years of the approval to implement the proposal on the potential alternative sources of lime material (terrestrial and marine) for its manufacturing process such that the EPA can review, seek public comment and provide strategic environmental advice;

(c) The proponent shall prepare a post-dredging closure plan indicating how transplanting research will be applied to on-going seagrass re-establishment. This plan shall be prepared, within two years of the approval to implement the proposal, for EPA review and public comment prior to submission to the Minister for the Environment for acceptance;

(d) The proponent's Annual Report on the 'Shellsand Dredging - Environmental Management Programme' shall include a summary statement of the research results to the end of each year, and shall include the following:

- those results adopted for incorporation into the environmental management of the proposal; and
- any research results which are not adopted, or which indicate that aspects of the environment are being adversely affected, including measures or steps introduced to overcome those effects; and
- a detailed audit of both the area of seagrass affected by current and ongoing operations, and the area transplanted. That audit should also show statistics relevant to the monitoring of the performance of the transplanted material.

(e) In order to manage the relevant environmental factors and the EPA objectives contained in this bulletin, and subsequent conditions and procedures authorised by the Minister for the Environment, the proponent shall demonstrate that there is an environmental management system in place which includes the following elements:

- an environmental policy and a corporate commitment to it;
- mechanisms or processes to ensure planning of environmental requirements;
- mechanisms or processes to ensure implementation and operation of environmental requirements;
- mechanisms or processes to ensure measurement and evaluation of environmental performance; and
- a mechanism for continuous review and improvement of environmental outcomes.

Contents

Tables

Figures

Appendices

1. Introduction

Through this report the Environmental Protection Authority (EPA) provides its advice and recommendations to the Minister for the Environment on the environmental factors relevant to the proposal by Cockburn Cement Limited (Cockburn) to dredge shellsand within the medium-term area of Success Bank, north of Woodman Point, over the period 1997 to approximately the end of 2002 or to the end of the resource (known as the medium-term proposal), and to use the shellsand as feedstock for quicklime and cement manufacture. The intention to undertake the dredging for shellsand was referred to the EPA in May 1996.

The EPA resolved to assess the medium-term proposal at Consultative Environmental Review (CER) level. The document of August 1996 describing the project is referred to within this report as the CER (Cockburn Cement, 1996a).

Cockburn has been dredging shellsand on Success Bank in waters known as Owen Anchorage since 1987 under the terms of the *Cement Works (Cockburn Cement Limited) Agreement Act 1971*, as amended 1986. The area dredged on Success Bank lies within a defined 8km radius of operation available to the Company under the Agreement Act. The medium-term proposal is the continuation of a similar scheme – the short-term shellsand dredging proposal 1994-1996 – a development which already has been largely undertaken. Ministerial approval, by way of a Ministerial Statement for that proposal to be implemented, was given on 23 February 1998.

The bulk of the shellsand sediment from Success Bank averages 92% calcium carbonate, the preferred grade set by Cockburn for its quicklime manufacturing operations.

Between 1972 and 1981 Cockburn dredged shellsand from the adjacent Parmelia Bank offshore from Woodman Point. Parmelia Bank forms the northern seafloor flank of Cockburn Sound. The Fremantle Port Authority's (FPA) Shipping Channel joining Cockburn Sound and Gage Roads west of Fremantle extends north-south through Parmelia and Success Banks.

Dredging since 1981 has had the effect of establishing a second shipping channel alignment inshore (eastward) of the FPA Shipping Channel. Both the 'short-term' and the 'medium-term' proposals involve dredging to access shellsand from Success Bank between the two shipping channels.

The history of dredging on Success Bank since 1987, and the statutory approvals process relevant to that activity, is complex and unusual. The details are given in Section 3 of this report. Section 4 discusses the environmental factors relevant to the medium-term proposal and the EPA's assessment. A major factor influencing the EPA's approach to the assessment is the comprehensive five year research programme that Cockburn has commissioned which commenced in 1995, the majority of which is due for completion toward the end of 2000. The details of the programme are described in the CER and in an 'Environmental Management Programme' of February 1995 (Cockburn Cement, 1995) together with a 'Supplement' of September 1995 (incorporated within EPA Bulletin 803, 1995). The research has already provided valuable information in relation to the medium-term proposal.

Conditions and procedures to which the proposal should be subject if the Minister determines that it may be implemented are discussed in Section 5. Section 6 provides advice to the Minister on matters related to the EPA's assessment. The EPA's conclusion is in Section 7 and Section 8 presents the EPA's recommendations to the Minister for the Environment.

Ten people and organisations made submissions to the EPA on the proposal. They are listed in Appendix 1. References cited in the report are provided in Appendix 2 and recommended environmental conditions and proponent's commitments are provided in Appendix 3.

2. The proposal

The medium-term proposal involves the suction dredging over an estimated five year period of about 9.1 million tonnes (Mt) of shellsand sediment from two areas on Success Bank. For resource estimates calculations are for the period 1997 to the end of 2002. The two areas total 146ha of seafloor between the FPA Shipping Channel and a second partly constructed channel to the east (Figure 1). The Fremantle Port Authority has requested Cockburn not to dredge a 47ha area extending 100m east of the FPA Shipping Channel and parallel to it to protect the eastern edge of that channel. This buffer zone contains 3.7 million tonnes of shellsand and the resource estimate in the CER has been reduced accordingly.

As a result of the FPA Shipping Channel buffer zone being excluded, Cockburn Cement has advised that the proposal involves the dredging of 99ha of Success Bank. Dredging of this area will result in the removal of 18ha of shallow unvegetated sediment with seagrass cover less than 25%, 39ha of low density seagrass (25-50% cover), and 42ha with high density seagrass (50-100% cover).

The seafloor over the bank is at a depth of 3m to 7m which will be deepened through the dredging to between 13m and 14m below the sea surface. In places a dredging depth of 16m might be accomplished. The shellsand sediment is transferred by barge to a spoil dump adjacent to Woodman Point where it is recovered, washed and then pumped through a pipe to Cockburn's manufacturing plant at Munster. Sluice water and tailings are disposed into Owen Anchorage immediately north of Woodman Point. The proposal details are set out in the proponent's CER, and summarised in Table 1 below.

Table 1. Summary of the proposal

Proposal aspect	Description
Site location and area	• Dredging, in accordance with a 'dredging management programme' of 99ha in 2 areas on Success Bank containing approx. 9.1Mt of shellsand sediment averaging 92% calcium carbonate; • the dredged depth generally will be 13m-14m below the sea surface; • the dredging is a continuation of earlier shellsand access operations on Success Bank.
Timing	• The operation is scheduled over a period 1997 to approx. end of 2002 or to the end of the resource;
Operation	• Water-jet suction dredge acquiring sediment at the rate of 800t per hour in depths 5m-16m, operating 12 hours per day; • Dredged sediment as a slurry is transferred by barge to a spoil dump adjacent to Woodman Point; • Sediment is recovered, washed and pumped via pipeline to Cockburn's Munster manufacturing plant.
Management measures presented in the CER	• Cockburn commits to implementing all the programmes of scientific and technical investigations outlined in the EMP (Feb. 1995) & 'Supplement' (Sept. 1995). • Cockburn commits to a detailed environmental management audit (Appendix 1 of CER). • Cockburn commits to a dredging programme gaining access first to lower seagrass cover. • Plans for longer-term access will be referred to the EPA.

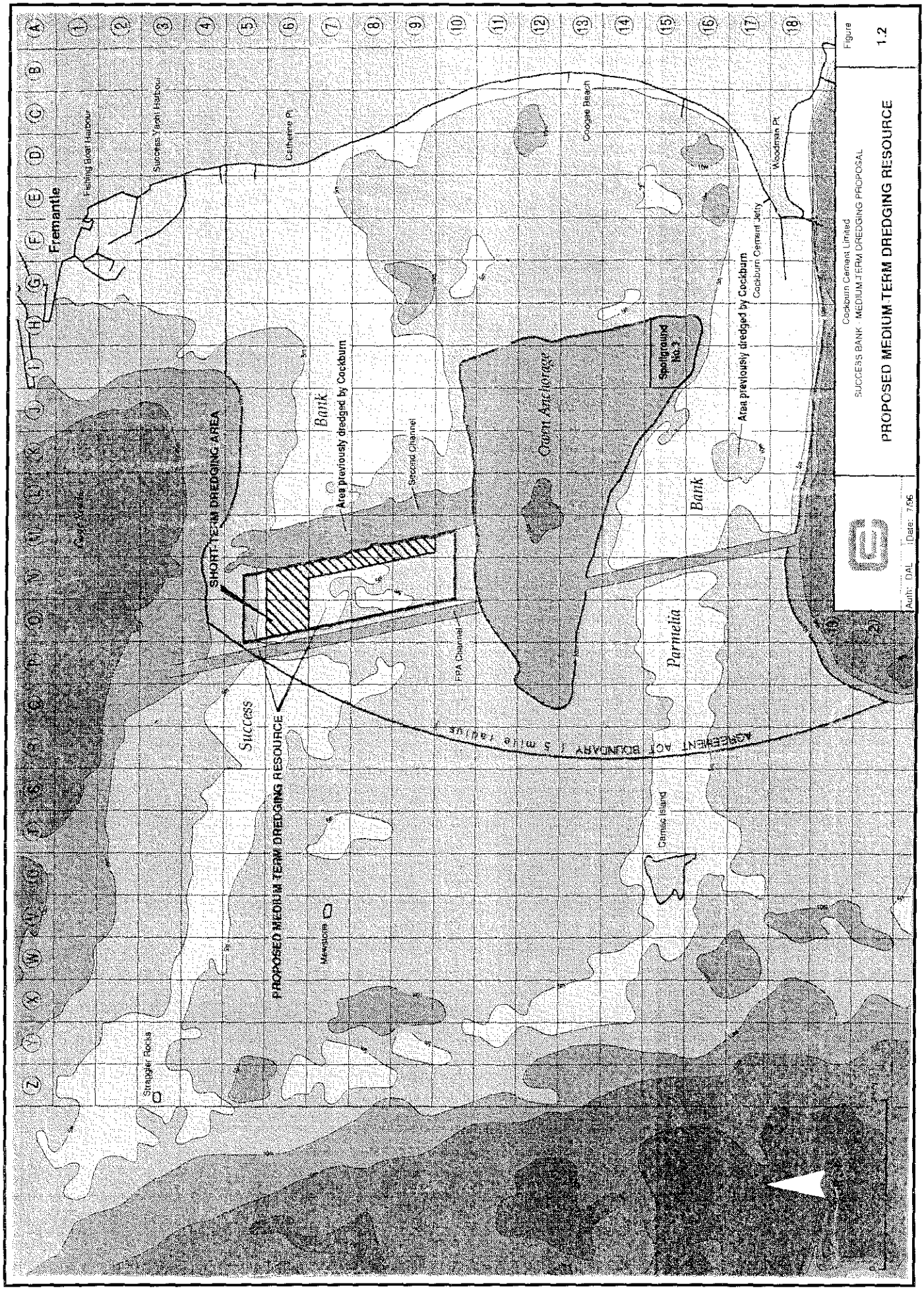

Figure 1. Location of the medium-term shellsand dredging proposal.

The CER within Section 2 sets out Cockburn's shellsand resource requirement, the availability of the material, and alternatives to the medium-term proposal. In summary the Munster plant shellsand requirement to the year 2002 is about 9.34Mt as illustrated in Table 2.

However, Cockburn's resource requirements are dictated by its clients' demand for quicklime and cement products and hence the Company's resource needs fluctuate with varying market conditions. The main product is quicklime for the mining industry, the manufacture of which requires a very high grade calcium carbonate feedstock.

Table 2. Shellsand requirements: 1996-2002

Year	SHELLSAND REQUIRED (million tonnes)		
	Estimated within the medium-term CER (Aug 1996)	**Estimated within the EMP (Feb 1995)**	**Current estimated usage (June 1998)**
1996	1.80	1.72	
1997	1.95	1.91	
1998	2.30	1.99	1.9
1999	2.40	2.02	1.75
2000	2.42	2.03	1.83
2001	2.43	2.05	1.91
2002			**1.95**
TOTAL	**13.30**	**11.72**	**9.34**

(Source: Cockburn Cement, 1996a and Cockburn Cement, pers comm 1998)

Shaded area indicates the duration of the medium-term proposal.

The shellsand resource on Success Bank in the medium-term area is estimated at 9.1Mt, sufficient to allow dredging on Success Bank until approximately the year 2002 with a contingency should the demand for raw material increase beyond forecast. At that time Cockburn anticipates accessing shellsand elsewhere on Success Bank including dredging farther offshore.

Cockburn has established a dredging plan for the medium-term proposal within which it is planned initially to dredge only seafloor areas of less than 25% seagrass cover, with operations progressing over time to areas containing seagrass densities between 25%-50% cover.

This schedule has been designed to provide maximum time for Cockburn to develop seagrass transplanting techniques appropriate to the locality as discussed in Section 4.4 below.

The edge slopes of the area dredged will be allowed to adjust to a natural, but deeper, stable configuration.

3. Background

3.1 Context to the proposal

Cockburn manufactures quicklime and cement and operates under the *Cement Works (Cockburn Cement Limited) Agreement Act 1971*. That Act was substantially amended in 1986 to require, among other matters, that the Company comply with the State's environmental laws,

and to submit a 'dredging management programme' (DMP) every two years for approval. The Minister for Resources Development has responsibility for the administration of the Agreement Act and for approving the DMPs tendered in accordance with it.

The scheme of the Agreement Act, effective to 2011 with provision for extension to 2021, entitles Cockburn to access shellsand sediment within a five mile (8km) radius of a point on Coogee Beach, north of Woodman Point. It also obliges the State to provide alternative resources should the shellsand within this area not be available.

Cockburn has been dredging shellsand in the Owen Anchorage vicinity since 1972, initially on Parmelia Bank where resource grades varied below the Company's desired 92% calcium carbonate. About 3.1Mt of shellsand was acquired from a 26ha site on this bank.

Cockburn however, has been seeking to maintain its grade specification averaging 92% calcium carbonate to facilitate quicklime manufacture and hence has progressively shifted its resource access operations to Success Bank. Over the period 1981-1994 dredging proceeded along an alignment for a possible second FPA Shipping Channel, and since 1994 operations have been located generally between the two Channels.

Cockburn submitted four DMPs up to 1992; the details are given in Section 1.3.2 of the CER.

In order to reconcile environmental issues over the impact upon the marine environment of the loss of seagrass through the dredging activity, and the physical effects to shoreline stability from changing the shape and deepening Success Bank significantly, Cockburn prepared two development proposals. Both proposals were referred to the EPA in December 1993 by the Minister for Resources Development via the Minister for the Environment.

The first proposal involved the dredging of shellsand over the period 1994-1996 from 67ha of seafloor from a battleaxe shaped segment between the two shipping channels; titled *'Proposal to continue dredging of shellsand on Success Bank (1994-1996)'* (LeProvost Dames & Moore, 1994). It became known as the short-term proposal. The EPA set a Consultative Environmental Review level of assessment which commenced in January 1994.

The EPA reported on the short-term proposal to the Minister for the Environment in May 1994 (Bulletin, 739) and subsequently a 'Ministerial Statement for the Proposal to be Implemented' was published in August 1994. That Statement also referred to development by Cockburn of a medium-term and a longer-term proposal. However, the Supreme Court in 1996 overturned Bulletin 739, and by association, the August 1994 Ministerial approval. A further report by the EPA on the short-term proposal of November 1996 (Bulletin 833) has led to a revised Ministerial Statement of 23rd February 1998.

Additionally in August 1994, following the initial 1994 Ministerial Statement and pursuant to the Agreement Act, the Minister for Resources Development approved the short-term proposal affecting Success Bank. Cockburn, acting in accordance with that approval, commenced dredging the 'short-term' area. About 62ha were dredged consuming approximately 4.3Mt of shellsand sediment before dredging was suspended following release of Bulletin 833. The dredging of shellsand currently occurs within the intended medium- term area.

Cockburn's second proposal was for a longer-term scheme of at least 15 years for access to Success Bank shellsand, the environmental effects it was suggested should be addressed through an Environmental Review and Management Programme (ERMP). However, within the August 1994 'Ministerial Statement' the notion of long-term access to shellsand was recast into separate medium-term and longer-term proposals. In response Cockburn developed the medium-term proposal, which is the subject of this environmental assessment. Moreover, some aspects of the dredging plans earlier intended to be canvassed in the ERMP, are now incorporated into the medium-term proposal. Furthermore, in February 1995, Cockburn undertook negotiations with both the Minister for the Environment and the Minister for Resources Development and with their departments, and prepared a *'Shellsand Dredging Environmental Management Programme'*. That plan was complemented by a later

'Supplement' with both documents being endorsed by the Minister for the Environment in December 1995. Within this report the two documents together are referred to as the EMP (Cockburn Cement, 1995a & b).

Cockburn Cement has examined areas of potential shellsand resource on Success Bank and has estimated the extent of seagrass cover for these areas. This information is presented in Table 3.

Table 3. Shellsand resources and seagrass cover on portions of Success Bank

	Total Area (ha)	Shellsand[1] (tonnes x 10^6)	Seagrass Cover[2]			
			<25% + unmapped	25-50%	50-75%	>75%
Short-term	66.8	6.26	61.8	4.5	0.0	0.5
Medium-term	98.9	9.08	18.0	38.8	0.9	41.2
FPA Buffer zone	46.7	3.68	31.0	9.1	0.0	6.6
FPA Shipping Channel	35.7	0.26	35.7	0.0	0.0	0.0

Note: 1. From report prepared by BHP in 1995
2. Data from LeProvost Dames & Moore (1994)

3.2 Research (studies) Programme

The EMP

The Environmental Management Programme was formulated to incorporate detailed research (studies) aimed at deriving information necessary to minimise the adverse impacts of Cockburn's continuing dredging operations on Success Bank in Owen Anchorage and to resolve the issue of long-term access to shellsand (Cockburn Cement, 1995a). There is an expectation that any proposal for long-term access to shellsand resource would be submitted to Government not less than 15 months before depletion of the medium-term resource. Cockburn intends in that context to complete most of the research by September 2000 between 15 months and 27 months prior to the projected exhaustion of the medium-term resource.

The programme consists of 12 main study components most of which include a number of inter-related elements. Some elements are complete but most are ongoing. Other aspects of the research, mainly to do with the evaluation of alternative resources to shellsand may continue beyond 2001. A summary of the timetable and the status of the various projects within the EMP as at July 1997, is outlined in Table 4.

The EMP has the objective to "provide the principles, framework and procedures that will:

(i) minimise the potential adverse environmental effects arising out of the short- and medium-term dredging operations; and

(ii) resolve the issue of long-term resource access". (Cockburn Cement, 1995a).

To meet this objective four key environmental issues relevant to the medium-term proposal have been identified, with the EMP studies being aimed specifically at addressing those issues. They are:

- to understand the effects of wave climate on Success Bank and the stability of the shoreline;

Table 4. Summary timetable and status of EMP projects: 1995-2001 (as of July 1997)

CODE	STUDY		1995	1996	1997	1998	1999	2000	2001
R1	Beneficiation	Phase 1/2, Pilot tests							
		Phase 3/4, Trials 200,000 tpa							
		Phase 5, Select Technology							
		Phase 6, Build							
R2	Alternative Resources	Phase 1, Review							
		Phase 2, Feasibility							
R3	Dredging Plan	Review							
R4	Innovative Dredging	Review							
C1	Wave Climate Study	Phase 1, Short/medium-term dredging							
		Phase 2, Long-term dredging							
C2	Shoreline Monitoring								
C3	Banks Sedimentology	Phase 1, Review							
		Phase 2, Assessment							
S1	Ecological Significance	Phase 1, Review							
	of Seagrass	Phase 2, Baseline							
		Phase 3, Monitoring							
		Phase 4, Evaluation							
S2	Seagrass Rehabilitation	Phase 1, Review							
		Phase 2, Implementation							
		Phase 3, Assessment							
S3	Seagrass Mapping	Phase 1, Seagrass Mapping 94/95							
		Phase 2, Seagrass dynamics							
		Phase 3, Seagrass mapping 98/99							
S4	Artificial Reefs	Review							
		Recommendation to take place 1st half of 97							
S5	Slope Monitoring								

Source: Cockburn Cement, 1997a

- to map the distribution of seagrass within Owen Anchorage and to understand the ecological significance and function of the major seagrasses particularly on Success Bank;

- to develop rehabilitation techniques for the replacement of seagrass function and to achieve no net loss in ecological function; and

- to determine the feasibility of beneficiation of lower grade shellsand material, and examine the prospect of alternative resources.

Cockburn has established a three level management structure for the purpose of conducting the investigations and for reviewing and interpreting the scientific outcomes. The structure comprises:

(i) A 'Study team' - to carry out scientific literature reviews and conduct field and laboratory investigative studies;

(ii) A 'Technical Advisory Group' - to coordinate and integrate study methodologies and to interpret results; and

(iii) An 'International Peer Review Group (IPRG)', and an 'Environmental Management Advisory Board for the Implementation of the EMP (EMAB)' - to review the methodologies and to interpret scientific findings within an international scientific context, and to provide Cockburn with advice on the direction and meaning of the research.

The IPRG comprises 6 scientific specialists of international repute with expertise in one or other of the fields of investigation set out in the EMP. The EMAB consists of six members, three from Cockburn and three scientifically eminent persons independent of the company.

The overall coordination of the research effort and integration between the three tiers is administered through a 'Project Manager', who is a consultant external to the company.

To date the research effort has led to a number of significant findings and conclusions relevant to the medium-term proposal even though the studies are ongoing. The salient aspects of the programme and results now coming to hand are published in four principal documents:

- *Environmental Management Programme, International Peer Review and Technical Presentations*, January 1996 (Cockburn Cement, 1996b);

- *Shellsand Dredging Environmental Management Programme, International Peer Review Report*, October 1996 (Cockburn Cement, 1996c);

- *Shellsand Dredging Environmental Management Programme, Annual Report June 1996-July 1997*, July 1997 (Cockburn Cement, 1997a);

- *Shellsand Dredging Environmental Management Programme, International Peer Review Report*, December 1997 (Cockburn Cement, 1997b).

In addition to these publications a geographic information system (GIS) Dictionary (National Geographic Information Systems, 1998) has been produced to assemble the information acquired during the course of the research programme in a form that can be stored and electronically accessed, and to enable that information to be inter-compared with other relevant data.

There have also been a number of specialist technical reports produced, the information from which is incorporated into the GIS Dictionary. Some of the technical reports provide reference material for the assessment made below.

The principal aspects of the research (not inclusive), and recent results relevant to the assessment of the medium-term proposal, are summarised below (Cockburn Cement, 1997a and b).

Effects of wave climate on sediment movement and shoreline stability

This study is a multi-component investigation aimed at understanding the ambient wind, wave and swell conditions of Owen Anchorage and farther offshore, and to establish a numerical simulation model of these characteristics. It was aimed also at determining the bathymetry of surrounding waters, the movement of entrained sediment and the shape and stability of the adjacent coast. To accompany this work the sedimentology of Success and Parmelia Banks was reviewed to determine the age and source of shellsand material.

Two additional objectives were to ensure that the dredging eastward of the FPA Shipping Channel did not compromise navigation along it, and to provide information useful in the interpretation of the ecological significance of seagrasses.

A mathematical wave climate model has been finalised and calibrated to simulate present-day wave conditions, and it has been run to predict the likely effects upon sea conditions following the short- and medium-term dredging of Success Bank (see Section 4.2 of this report).

For the coast, comparisons between historical aerial photographs have been made to indicate the dynamic shape of the shoreline, and beach profiles have been measured and routinely monitored. The data have been inter-compared with information from shoreline surveys since 1976 and earlier coastal vegetation surveys.

The main elements of this combined study are complete with shoreline monitoring continuing on a two yearly basis.

In summary the following findings relevant to this assessment (Section 4.2) are that:

- the banks are composed mainly of geologically 'Recent' calcium carbonate sediment (mostly of organic origin) derived from farther offshore and driven shoreward, with the larger volume of sediment being transported by swell waves;
- the modelling indicates the swell wave characteristics following the dredging will not be significantly different from the conditions now prevailing, thus the overall sediment contribution will be largely uninterrupted, but within the dredged basin sediment movement will be significantly less;
- the common seagrasses of the banks best adapted to moderate wave energy conditions - *Posidonia* and *Amphibolis* - have only a minor influence on sediment production and movement;
- the shoreline of Owen Anchorage is substantially modified by developments, including the WAPET Groyne extending seaward off Woodman Point;
- these developments have affected sediment movement particularly longshore drift, and to an extent the present shape of the coast which is generally accreting; and
- the proposed dredging will have little overall effect on sediment patterns on beaches.

Seagrass distribution and function

This investigation comprises a series of interdisciplinary studies to map the habitat and extent of the seagrasses of Owen Anchorage in space and time, to define their functional attributes, and to quantify the loss or replacement of their functional role, stemming from the removal of seagrasses by dredging and the relocation of some seagrasses. None of the seagrasses present

in the Owen Anchorage locality are identified as being either rare or endangered, but the seagrass meadows on Success Bank are considered to be ecologically significant.

Work has also been extended to include a quantification of the loss of functional role as a result of historical cumulative losses in Cockburn Sound and Owen Anchorage, and, in the same context, to determine how much seagrass can be lost without impairing that functional role.

Other than the seagrass mapping task, which involved sophisticated image rectification of historical and recent aerial photographs and underwater 'ground truthing', the studies are ongoing.

The mapping of areas containing seagrasses on Success and Parmelia Banks has been undertaken on two separate occasions. The initial direct comparison on the change in area covered by seagrasses between 1971 and 1995 showed 387ha more seagrass in 1995.

Subsequently, a series of aerial photographs from the years 1972, 1982 and 1995 showed 198ha more seagrass in 1995 than 1972. Both analyses demonstrated substantial increases in seagrass on Success and Parmelia Banks. The second analysis considered a smaller area of the banks, leading to reported differences in increases in seagrass cover.

In summary the findings to date relevant to this assessment (Section 4.3) are that:

- seagrass distribution and density in Owen Anchorage has changed measurably over the past 30 years and these changes are continuing;
- the changes in seagrass distribution over a wide area have been wrought by human activity (pollution and dredging), and particularly for the banks by the emplacement and winnowing of sediment under natural conditions;
- ocean swell conditions and intense storm events drive these changes, and that smothering of seagrass occurs during episodes of high energy activity while recolonisation by seagrass occurs at quiescent times;
- the combined seagrass area on Success and Parmelia Banks has increased between 1972 and 1995 by 198ha (NGIS *et al*, 1998 p 25), (or 387ha between 1971 and 1995 - LeProvost Dames & Moore, 1994);
- present bare sand on Success and Parmelia Banks has provided habitat for seagrass from time to time, and bare sand remains a substrate available for seagrass colonisation;
- the seagrasses are capable of recolonisation under natural conditions by the lateral extension of existing clumps, or through fruit settlement and seedling germination (in particular *Posidonia coriacea* is shown to propagate from seedlings, a finding regarded as a major advance in the knowledge of seagrasses in wave-dominated environments);
- seagrass wrack and associated detritus is accumulating in the dredged basin and establishing a new localised habitat for marine plants and animals; and
- seagrasses are only a minor (10%) contributor of calcium carbonate to the overall sediment store.

Transplanting of Seagrass

Studies have been initiated into two rehabilitation (restoration) techniques for seagrass affected by dredging, vis:

(1) literature and desk reviews into the feasibility of *in situ* propagation of seagrasses; and

(2) field testing the transplanting of mechanically excavated seagrass clumps, incorporating the plant canopy and sediment substrate (known as 'sods'), following the transplantation of those clumps to a reception site.

The regrowth of seagrass species including propagation studies and the transplanting of sprigs or cores containing some plants has been trialed in Australia and elsewhere with limited success. However, large scale subsurface physical excavation of seafloor substrate and associated plants and their relocation, effectively involving the transplanting of seagrass, is a new initiative. This is the direction being pursued by Cockburn.

Experiments have centred on the design and operation of a prototype harvester known as ECOSUB 1. Field trials have been underway since February 1996 and by June 1998 1000 sods (250 m^2) covering an area of 1000 m^2 of seafloor have been transplanted. The transplanted seagrass is regularly monitored.

The rate of transplanting has been influenced by the availability of seagrass clumps in the area shortly to be dredged - which is relatively sparse, and technical difficulties have occurred in operating a submerged mechanical device on an undulating seafloor. However, the transplanting trials are continuing and a second larger machine with an improved design is under construction.

In summary the findings to date relevant to this assessment (Section 4.4) are that:

- sods about one quarter of a square metre in area (50cmx50cmx40cm) containing a relatively undisturbed canopy suite of seagrass and associated animals and epiphytes, have been collected and transplanted;

- mainly *Posidonia coriacea* and some *Amphibolis* have been transplanted, but the areal extent is short of the desired target rate for transplantation; and

- the transplanted seagrass is showing continued growth and vitality although 20% of sods suffered early signs of stress, and winter storms caused some smothering of sods with sediment. Some seagrass appears to be recolonising the donor sites.

Alternative measures and resources

Investigations within the framework of the EMP have been undertaken by Cockburn into a range of measures to determine whether shellsand from the current and proposed dredging operations can be substituted from other resources. The objective is to resolve for Cockburn whether it is feasible to shift to other raw materials (such as terrestrial limesand and limestone) as feedstock for its manufacturing processes.

The work has been complemented by studies into the beneficiation of lower grade calcium carbonate shellsand. Furthermore, design and operation of Cockburn's suction dredge has been reviewed to determine whether the dredge can be operated to acquire high grade shellsand while limiting disturbance of seagrass and associated habitat.

These investigations are continuing.

In summary the findings to date relevant to this assessment (Section 4.5) are that:

- while alternative dredging areas (to the medium-term proposal area) are being evaluated the high grade calcium carbonate raw material requirement by Cockburn restricts the scope for supply from sources other than the preferred resource area on Success Bank;

- alternative land-based feedstock materials sufficient to meet the resource demand up to 2002 are considered to be unavailable although exploration continues;

- beneficiation of lower grade shellsand to achieve a grade of around 92% calcium carbonate, and beneficiation of other calcium carbonate sources is being tested but requires further development; and

- while operation of the suction dredge and the techniques employed in its use are being refined, technology is not available to markedly reduce impacts from dredging on the seagrass cover.

4. Environmental factors and assessment

4.1 Relevant environmental factors

In discharging its responsibilities under Part IV of the *Environmental Protection Act* the EPA is required to report to the Minister for the Environment on the environmental factors relevant to the proposal and on the conditions and procedures to which the proposal should be subject, if implemented.

For this proposal the EPA has identified the relevant environmental factors, firstly by referring to a preliminary list of such factors it has compiled over the years on the basis of experience in evaluating the environmental impact of various proposals, and secondly, from the proponent's CER and from public submissions. In addition, where a proposal is a continuation of an earlier and similar development, the EPA may take account of the experience and effectiveness of current environmental investigation outcomes and management procedures in determining the relevant environmental factors.

With regard to the latter, the EPA is of the opinion that the research issues identified in the EMP process constitute in large measure the principal environmental factors relevant to the proposal.

In a signed statement published in December 1997 (Cockburn Cement, 1997) the independent eminent persons on the EMAB reported among other matters that "... the scientific results of the programme have international standing. This ensures the credibility of the work undertaken and that it will provide a basis for the development of appropriate management plans".

In light of this work the EPA has concluded that with respect to the medium-term proposal a tailored approach to the assessment, taking account of the EMP research, is warranted. The EPA has considered the publicly available scientific material now to hand and has made a judgement that there is sufficient relevant information of international scientific standing to enable the EPA to derive conclusions relevant to the medium-term proposal. The EPA has made this judgement knowing that some important aspects of the research programme are ongoing and questions as to the significance and function of seagrass on Success Bank remain unresolved.

The EPA has approached this assessment by accounting for the research findings to date, and having full regard for the published opinions of both the IPRG and the eminent independent members of the EMAB.

However, the EPA is aware that a perception may arise in the community of a weighting in the interpretation of the research results toward Cockburn's advantage. This perception may come about on the one hand, because the EMP research initiative was a Cockburn strategic step, although formulated in consultation with government, and on the other, because the full cost of the work is being borne by the company itself.

The EPA is satisfied, nonetheless, both with the research programme methodologies and peer review process, and with the checks and balances in place through the decision-making steps and approval arrangements.

Thus the EPA has full confidence in the efficacy of the investigation process and in the conclusions being derived, given that the full suite of investigations is not due for completion until about 2001. Much of the information however is now available.

At times it is more meaningful within an assessment to combine inter-related factors. For example, as in this case for the physical processes affecting the coast, it is convenient to combine factors such as 'wave climate', 'sediment movement', and 'shoreline'.

The EPA has adopted the following environmental factors as pertaining to the medium-term proposal:

a) Wave climate, sediment movement and shoreline stability - the effects of continued dredging on Success Bank and the coast;

b) Seagrass - distribution, abundance and diversity;

c) Transplanting of seagrass - feasibility and success; and

d) Alternative measures and resources - beneficiation and land-based resources.

The relevant environmental factors and the assessment of each is discussed in Sections 4.2 to 4.5 of this report.

4.2 Wave climate, sediment movement and shoreline stability - the effects of continued dredging on Success Bank and the coast

Description

The factors of wave climate, sediment movement and shoreline stability have been grouped as they are consequent upon wave modification effects resulting from dredging for shellsand on Success Bank. The area subject to such wave modification is likely to be Success Bank itself westward of the FPA Shipping Channel, southerly to Parmelia Bank and shoreward to the coast. Likewise, an altered wave regime will be expected to effect sediment movement within Owen Anchorage and impact upon present coastal processes of accretion and local recession. These changed physical processes may be adverse to bank and coastal stability, and to ship navigation and under-keel clearance along the Channel.

The wave climate simulation work (Rogers *in* Cockburn Cement, 1996b; M P Rogers & Associates, 1997) suggests that the dredging of the medium-term area will result in only minor changes to present-day wave height conditions and direction.

Over the dredged basin wave height would be reduced but could increase marginally in height toward the flanks of the dredged basin. The direction of wave propagation could alter up to 13 degrees. More distinct changes would occur under a 'severe storm' scenario but both wave height (0.1-0.2m) and direction changes are not significant when contrasted against the measured intensity of wind and waves (1-2m).

In regard to the maintenance of ships' navigational integrity, the modelling also explored the probable effects of the medium-term dredging at 6 sites along the FPA Shipping Channel selected by the Fremantle Port Authority. The data indicate a wave height increase at 0.03m, with a directional change of 13 degrees.

These changes were concluded as being of little effect. The wave climate model work was extended also to predict the impact on Fremantle Harbour structures and adjacent marinas from a 'severe storm' event. Again the data suggest insignificant effects, as the harbour structures are designed to withstand wave and storm surge substantially greater than that predicted to arise from the medium-term proposal.

In relation to shoreline stability the investigative work shows that the coast is already modified by developments, and some longshore sediment movement is interrupted by the WAPET Groyne off Woodman Point. Nonetheless sediment flux to the Owen Anchorage shoreline is about 60 000 cubic metres/year (Cockburn Cement, 1997a). The sand accumulation is shown by the photography to have continued without major change since the first aerial surveys in 1942.

Shoreline surveys show in this context that the beach north of Woodman Point to the abandoned South Fremantle Power Station is accreting, and coastal vegetation has opportunistically shifted seaward. The Quarantine Station beach on the north side of Woodman Point provides a major recreational opportunity in the locality.

Assessment

The area deemed for assessment of this environmental factor is Owen Anchorage shoreward from Mewstone Rock, Parmelia Bank to the south and the coast north to Fremantle.

The EPA's objectives in relation to this environmental factor are:

(i) to maintain the integrity, function and environmental values of the foreshore area;

(ii) to maintain the stability of Success Bank.

The EPA notes that the wave climate likely to occur following completion of the proposal is predicted as unlikely to significantly impair shipping movements along the FPA Shipping Channel, or to affect the marine structures around Fremantle Harbour.

The EPA also notes comments from the IPRG which has urged the study group to utilise the wave climate model over time in helping to resolve biological questions as to the dynamics of seagrass. In particular should a sudden loss of seagrass occur the model should be run to determine the hydrodynamic factors operating at the time.

In addition, further work is recommended to understand the water circulation pattern operating in Owen Anchorage, as this information would benefit interpretation of the biological data. The EPA supports these views.

The IPRG additionally, while supporting the coastal studies and the interpretation of results from that work, also observed that the biennial beach profiling which is an ongoing management commitment, should be extended to include a profile line at the northern end of Owen Anchorage. Data from that profile would help determine whether the beaches adjacent to the Fremantle marinas were being affected by the proposal, and if they were to enable appropriate plans to be developed. The EPA supports this recommendation.

A further consideration within this environmental factor, is the question of the continued use by Cockburn of the shellsand spoil dump on the north side of Woodman Point, and the discharge of cloudy reject water from the washing plant adjacent to the southwestern extremity of Quarantine Beach. Implementation of the medium-term proposal will result in a continuation of these activities.

Both the dumping of shellsand slurry from the hopper barges that transport the material from the dredge, and the washing plant reject water, cause localised turbidity problems. The seafloor in the vicinity is degraded. This is of concern to some beach users who complain of turbid water, and gritty sands where shelly material is washed ashore. This activity is subject to pollution licensing by the Department of Environmental Protection.

Having particular regard to:

(a) the mathematical modelling which suggests that the medium-term proposal will result in only minor hydrodynamic changes from ambient conditions, under expected scenarios (ie moderate swell to severe storm); and

(b) the indication that the present sediment supply to Success Bank and to the coast will continue although modified in character;

it is the EPA's opinion that the proposal can be managed to meet the EPA's objectives.

4.3 Seagrass distribution, abundance and diversity

Description

The marine ecosystem of the Garden Island and Rottnest Shelves which includes the relatively open embayment of Owen Anchorage, is dominated by macrophytes and a range of seagrasses both meadow-forming and individual species. For this region the most common seagrasses are 3 species of *Posidonia* (*P. sinuosa, P. australis*, and *P. coriacea*), *Amphibolis griffithii* and the fringing and under-storey varieties of *Heterozostera* and *Halophila.*

On the Western Australian coast 10 genera and 25 species of seagrasses have been identified (Kirkman and Walker *in* Larkum *et al*, 1989). They exist over a vast range in the temperate waters from Eucla to north of Shark Bay. Generally, seagrasses provide habitat for diverse assemblages of small plants and animals, nursery areas for invertebrates and fish, and a means for storing and recycling nutrients (Larkum, McComb and Shepherd, 1989).

Seagrasses largely require nutrient-poor ocean water, with high clarity and relatively deep light penetration, factors which together facilitate benthic - at the seafloor - 'primary production' (Southern Metropolitan Coastal Waters Study-SMCWS, 1996 p17).

Owen Anchorage possesses these characteristics. Within its surrounds nine seagrass assemblages have been identified (CER, p 32) with *Posidonia coriacea* patches occurring dominantly on the eastern fringes of Success Bank, while *Amphibolis griffithii* accompanied by smaller patches of *Posidonia coriacea* occupy the broad central area. The understorey genera occur throughout.

The northern and western portion of Owen Anchorage including the western slope of Success Bank is subject to high wave energy conditions during storm events. The seagrasses of Success Bank are adapted to these conditions.

Within Cockburn Sound the optimal conditions for light penetration of the water have been markedly altered through water pollution caused by the interacting or cumulative effects of man-made influences and developments (SMCWS, p19). In consequence the ecosystem has significantly changed with seagrass presence severely depleted. By comparison, Warnbro Sound farther south has good water quality, high light penetration and extensive seagrass meadows.

The medium-term proposal on Success Bank is predicted to result in the removal by dredging of 18ha of shallow unvegetated sediment with seagrass cover less than 25%, 39ha of low density seagrass (25-50%) cover, and 42ha of high density seagrass (50-100% cover). A small portion of this seagrass will be relocated under the trial transplanting programme to appropriate reception sites (Section 4.4 of this report).

Hence the EPA believes that within this broad scene, the impact of the medium-term proposal on this environmental factor needs to be viewed both in its local context and against the present condition and distribution of the seagrasses in the general region.

The biological studies within the EMP framework relating to seagrass significance and function are pivotal to understanding the operation of the marine ecosystem in the Owen Anchorage and surrounding waters. Literature reviews and laboratory investigations are well advanced, but field observations are not scheduled to be completed until mid-1999. Some of the work involves investigation into the inter-relationship between seagrass as a nutrient source and store, and as a nursery area for fish. This work incorporates examination of fish gut and isotope analysis to track the food chain.

Meshed with the biological studies has been precision 'habitat' mapping over Success and Parmelia Banks to determine the distribution of seagrass cover and the changes to that cover over time.

The mapping has been largely completed and a detailed technical report prepared, vis: *Changes to seagrass coverage on Success and Parmelia Banks between 1965 and 1995*, National Geographic Information Systems (Australia), The University of Western Australia, and D.A. Lord & Associates (NGIS *et al.*, 1998). The work has utilised aerial photography taken on calm days in summer over the years 1965, 1972, 1982, 1993, and 1995, with the photographic images being rectified and enhanced to determine the spatial and temporal variability of seagrass cover.

Seagrasses with high leaf area indices which includes the meadow-forming varieties of the genera *Posidonia* and *Amphibolis* were mapped. Species such as *Posidonia coriacea* however, which occurs in patches colonising bare sand particularly in the wave dominated areas of Success Bank and is a species having a lower leaf index than the other main meadow forming varieties, appears not well represented through this kind of mapping (NGIS *et al*, 1998 p 27).

The seagrass mapping when the data are integrated with the information derived from the wave climate and sedimentological studies, shows that seagrass cover is changeable and spontaneous.

Overall between 1972 (when Cockburn commenced its shellsand dredging operation on Parmelia Bank) and 1995 (the latest available suitable aerial photography for accurate photo-interpretation), the seagrass area on Parmelia Bank has decreased, and increased over Success Bank. Over this 23 year period seagrass on the two banks has regressed in places and expanded in others, both in area covered by seagrass and in density (NGIS *et al.*, 1998 p 28). The extent of the changes are indicated in Table 5 and illustrated in Figure 2.

Table 5. Changes in seagrass area between 1972 and 1995

Area	Changes in Seagrass Coverage (1972-1995) (ha)
Success Bank - east	+141.8
Success Bank - central	-27.4
Success Bank - west	+160.9
Success Bank (total)	**+275.4**
Parmelia Bank - east	-167.4
Parmelia Bank - west	+90.0
Parmelia Bank (total)	**-77.4**

Source: Changes to seagrass coverage on Success and Parmelia Banks between 1965 and 1995, NGIS *et al.*, 1998, P 25.

Aerial photography from 1965 has also been used in the habitat mapping.

The changes between 1965 and 1995 reported by NGIS *et al.*, 1998 show that Success Bank seagrass cover expanded from 507.3ha in 1965 (or 21.2% of the available seafloor) to 1035.9ha (43.3%). For Parmelia Bank the 1965 coverage was 735.0ha (46.4%) but by 1995 contracting to 699.2ha (44.2%). The total seagrass expansion on Success Bank between 1965 and 1995 has been 528.6ha, notwithstanding the losses due to Cockburn's dredging since 1972 (NGIS *et al*, 1988).

Consequent upon these findings the IPRG has commented "that a real increase in the area of seagrass from natural causes has been conclusively demonstrated by this study" (Cockburn Cement, 1997, p8).

The main difference between the two banks in the distribution of the seagrass cover not influenced by natural causes, appears to be the eastern flank and slopes of Parmelia Bank, which have been impacted by nutrient-enriched waters both from Cockburn Sound and the former Woodman Point effluent outfall, and from earlier dredging by Cockburn (NGIS *et al*, 1988, p 25).

Many earlier studies have documented the progressive death of seagrass in Cockburn Sound, mainly from the shallower areas adjoining the industrialised western shore (eg Cambridge, 1979; Cambridge and McComb, 1984). Seagrass loss extends also to the southern fringe of Parmelia Bank. These studies have been synthesized within the SMCWS where it is reported that of the 4000ha of the predominantly *Posidonia* seagrass present in 1957 only 900ha remain (approximately 80% reduction), and that in adjacent waters where seagrass is still common, its existence is stressed by degraded water quality and further anthropogenic development. The seagrass loss is attributed to two causes, light starvation to the plants from light attenuated by nutrient-rich waters which induces a proliferation in phytoplankton, or through enhanced epiphyte growth on the plants, both having the same effect of shading leaves and reducing photosynthesis.

Moreover, within the SMCWS, as a measure to understand the conditions necessary to maintain seagrass functional vitality, indices have been developed to describe the light requirements for the meadow-forming *Posidonia sinuosa* (SMCWS, p 151). This is because to promote health, not only is it necessary to maintain sea water with a low nutrient status, but also, the depth to which the common seagrasses can grow is light limited. In this regard, *Posidonia* meadows under naturally prevailing conditions are depth restricted by their light requirements to about 12m to 15m. Thus, it is demonstrated that to maintain seagrass health light needs to be maintained below the water surface at a level of about 10% of the available photosynthetic radiation (SMCWS, p 153). This is important information in the case of the medium-term proposal because the dredging of shellsand on Success Bank will result in depths to 13m -14m, and in places deeper. This depth is regarded as being too deep for the maintenance of the main meadow seagrasses.

On the other hand, some seagrasses such as *Heterozostera* have been found to recolonise the slopes of dredged areas and the floor to a depth of 14m, with the FPA Shipping Channel being the best example (Paling *in* Cockburn Cement, 1996b). The regrowth appears progressive even in the turbulent environment of the ship channel. Additionally, the dredged area or basin accumulates seagrass wrack and detritus, the decomposition of which is providing nutrients for a modified but functional, localised ecosystem.

Further, within the SMCWS it is concluded that once lost from shallow water (<10m) seagrass, particularly the meadow-forming varieties of *Posidonia*, have little capacity to regrow over very long periods extending into decades. However, this conclusion is at variance with the recent seagrass mapping programme as detailed above. Added to these matters, as discussed earlier, the seagrasses of Success Bank have been shown not to contribute significantly to the calcium carbonate sediment load and sediment movement is not measurably baffled by the plants. The major influence upon sediment movement is the intensity of wave energy (Cockburn Cement, 1997a).

The IPRG has observed that this finding "..has lead to some major revisions in our understanding of these high-energy environments resulting from wave action" (Cockburn Cement, 1997b, piii).

From the complexity of these observations, the IPRG has itself further concluded that for Success and Parmelia Banks as colonisation by seagrasses is now demonstrated, "..in a long-term context, seagrass rehabilitation efforts may be less significant than natural variability" (Cockburn Cement, 1997b, piv).

Additionally, much of the area of the "shallow banks can be viewed as either realised or potential seagrass habitats. Thus, dredging of the banks to form deep water environments in which light penetration is insufficient to support seagrass survival (>10m) effectively removes some potential seagrass habitat. The deep water habitat accumulates seagrass detritus however, and has a unique faunal community and ecological function".

Drawing from that conclusion the IPRG has recommended that aspects of the ecological studies be refocussed to establish "the ecological interactions between shallow sand banks (with and without seagrass) and deep water habitats...". The implication from all this, is that on Success and Parmelia Banks the characteristics and operation of the ecosystem alter in response to the changing seagrass cover and density, and that these attributes of the ecosystem need to be intercompared with that developing in the deeper water through dredging.

The deeper water environment may be relatively more stable over time. Furthermore, the biological activity in the dredged area occupied by colonising seagrass and organic detritus would have an ecological function greater than that of bare sand.

The EPA in undertaking the assessment of seagrass its distribution, abundance and diversity as an environmental factor has noted the conclusions and recommendation of the IPRG and supporting comments of the independent members of the EMAB (Cockburn Cement, 1997).

The EPA also notes the context within which these views were given. That is that the principal biological studies aimed at describing the ecological significance of seagrasses and their functional attributes within the dynamic environmental relationships now revealed by the habitat mapping, are continuing.

Added to the above, the EPA's attention has been drawn to the early finding from the biological studies that shellsand substrate provides a holdfast for seagrasses into which seedlings can settle and rhizomes can extend. The chemical composition and the constituency of the shellsand are not necessarily limiting factors in this equation.

In this scenario it can be postulated that an artificial substrate might be developed as a substitute for shellsand to facilitate seedling settlement, growth and extension. Such a scheme presumably would allow for appropriate material to be disposed into a dredged area which could be rehabilitated by shallowing and reshaping. The EPA discusses this idea further in Section 4.5.

Assessment

The area considered for assessment of this environmental factor is Owen Anchorage and surrounding waters including Cockburn Sound.

In defining the area for this environmental factor, the EPA is cognisant of the written comments of the independent members of the EMAB for the implementation of the EMP studies, who cautioned that the "focus of (Cockburn's) activities and of the EMP is on Owen Anchorage and (we) consider this should be recognised in references to the programme. If Cockburn's activities are to be considered in a wider context there would be strong arguments for that context to include a wider segment of the coast".

The EPA's objectives in relation to this environmental factor are:

(i) to maintain the ecological function, abundance, species diversity and geographic distribution of seagrasses; and

(ii) to maintain the abundance, biodiversity, productivity and geographical distribution of fauna on the marine banks.

The broadscale loss of seagrass from Cockburn Sound as a result of water contamination from industrial discharges and diffuse sources, is a community-wide concern. There are also incidents of industrial emissions into Owen Anchorage causing seagrass death near-shore. The main sources were the Robb Jetty abattoir and the South Fremantle Power Station. Both facilities have ceased to operate and seagrass appears again to be extending into the formerly affected areas. These seagrass losses however, have little to do with Cockburn's shellsand operation based in Owen Anchorage.

The government has taken strategic steps through pollution control mechanisms to remove or have cleaned-up the Cockburn Sound point-source discharges. More initiatives are indicated following the SMCWS including the management of diffuse-sourced contamination. Nonetheless, the loss of seagrass due to dredging on Success Bank needs to be seen in the wider context of cumulative losses of seagrass from the surrounding waters, and whether the sustainability of the regional marine ecosystem is being adversely affected.

The loss of an estimated 80% of the seagrass of Cockburn Sound represents a very significant and unacceptable loss of a primary benthic community. During the period of loss of seagrass in Cockburn Sound there has been a documented increase in the area of seagrass in Owen Anchorage (NGIS *et al.*, 1998), mainly on Success Bank. However, this expansion cannot be considered to compensate for the much greater loss in the adjoining area.

In part the answer to the question related to the direct loss of seagrass and its effect on the wider marine ecosystem will emerge from the biological studies still in progress under the EMP.

However, the EPA is able now to draw on a number of findings:

(a) seagrass distribution and density in Owen Anchorage including on Success and Parmelia Banks have changed significantly over the past 30 years mainly through natural causes and the changes are continuing, concurrent with anthropogenic changes through dredging;

(b) ocean swell conditions and intense storm events drive natural changes, and that smothering of seagrass occurs episodically during these high energy events at which time seagrasses retreat, while during quiescent times recolonisation and expansion of the seagrass domain occurs;

(c) bare sand on Success and Parmelia Banks has provided habitat for seagrass from time to time, and bare sand remains a substrate available for seagrass colonisation under natural conditions by the lateral extension of existing clumps, or through fruit settlement and seedling germination;

(d) the combined seagrass area on those portions of Success and Parmelia Banks that have been closely mapped has increased by 198ha between 1972 and 1995; and

(e) seagrasses are only a minor (10%) contributor of calcium carbonate to the overall sediment store.

The medium-term proposal will result in the removal of 99ha of seafloor with varying amounts of seagrass cover (Table 3) The short-term proposal involved 67ha of seafloor. However, the

studies to date suggest that all the seafloor is potential seagrass habitat. But also under naturally prevailing conditions the extent of seagrass expansion and retraction over time can be vast, affecting an area substantially greater than the combined area of these two developments.

By comparison, the extent of the documented loss in seagrass cover over the combined area of Cockburn Sound and Owen Anchorage is about 2600ha (5242ha-2635ha) (ie combining figures from NGIS *et al.*, 1998 and SMCWS).

The dredging of 99ha of Success Bank has the following consequences upon seagrass:

- loss of an estimated 81ha of existing seagrass with patchy to dense seagrass cover;
- a small portion of this seagrass (about 2ha over 5 years operation of ECOSUB 2) can be used in the transplanting research programme;
- loss of 18ha of currently unvegetated habitat which is known to be potential seagrass habitat; and
- using seagrass cover data from 1957 for Cockburn Sound and 1965 for Owen Anchorage, there has been a total loss of seagrass area of around 2600ha in spite of the overall increase in seagrass cover on Success Bank.

It is not considered appropriate to separate the seagrass-related values of Owen Anchorage from those of Cockburn Sound. Further the loss of seagrass within Cockburn Sound and Owen Anchorage and the consequential implications arising from the substantial reduction in a primary benthic community cannot be supported by the EPA. Indeed, the protection of what remains and the establishment and maintenance of conditions which promote the growth and expansion of seagrass cover are key environmental outcomes for the EPA.

Relevant to this outcome is the EMP research programme being undertaken by Cockburn.

It has already identified a number of significant findings with implications for seagrass. Further investigation is to be undertaken, particularly related to the ecological role of seagrasses. The EPA believes that this programme is an extremely valuable contribution to the understanding of seagrass-dominated biological systems.

One area of very relevant research relates to the avoidance of the loss of seagrass by its transplanting to a new site. This work may have significant implications to a range of situations. To the extent that the medium-term dredging proposal would cause the removal of seagrass the transplanting of material from the area to be dredged is to be encouraged. This is discussed in more detail in section 4.4.

From the foregoing discussion, in relation to the respective components of the environmental factor seagrass - distribution, abundance and diversity, the EPA advises that:

- the research so far has indicated that the ecological role of the seagrass beds of Owen Anchorage differs from seagrass ecosystems studied elsewhere and that completion of the research would improve our understanding of seagrass ecosystems on the Western Australian coastline;
- within a regional setting of Owen Anchorage, the scale of seagrass loss from the proposed medium term dredging together with past dredging of Success Bank is comparable to the scale of natural variation in seagrass cover over the past 20 years on Success Bank, thus the distribution of seagrass will not be severely restricted by the proposal;

- within the broader setting of the southern metropolitan coastal waters of Perth the proposal represents, on one hand, a further loss of primary benthic community but on the other hand an opportunity to develop the technology for seagrass rehabilitation;

- the diversity of seagrass species in the region will not be substantially altered, although there will be a shift from Posidonia/Amphibolus meadows on sandbanks to patches of Halophila and Heterozostera in the dredged area.

It is the EPA's opinion therefore that although there is seagrass loss the scale of loss is of the order of natural variation in Owen Anchorage so that the EPA's objectives in relation to abundance, diversity and distribution are unlikely to be compromised. However, on a broader scale further loss of seagrass is a concern. It is the EPA's view that there is value in having the research on the ecological role of seagrass and the development of seagrass rehabilitation techniques associated with the proposal to provide the framework for reversing past degradation. On balance, considering the scale of the cumulative loss in Owen Anchorage from dredging and the benefits flowing from the research programme, the proposal is considered acceptable. However, any further dredging is considered unreasonable and continuation of rehabilitation beyond the completion of dredging of lime sands is warranted.

4.4 Transplanting of seagrass - feasibility and success

Description

Investigations by Cockburn into the transplanting of seagrass as a rehabilitation measure has followed two pathways:

- literature review and desk studies into the feasibility of *in situ* propagation of seagrasses; and

- mechanical excavation of seagrass and transplanting in a prepared reception site.

The field area for these studies has largely been Success Bank inshore from the unfinished second shipping channel.

The literature search involved reviewing articles in international journals and conference proceedings, and through the transfer of information on pilot projects (LeProvost Dames and Moore, and Paling *in* Cockburn Cement, 1996b). That work indicated that the propagation of seagrass from seedlings, sprigs, cores or plugs of various seagrass species, and small-scale transplantation of individual plants, has been of only limited success (Cockburn Cement, 1997a). Furthermore it seemed likely that because Success Bank is a wave-dominated environment, individual plantings of seagrass would prove time consuming and difficult with no guarantee of success. Hence, the reported small-scale and low seagrass survival for these experiments prompted Cockburn to underwrite trials into the *in situ* excavation of seagrass and substrate, and the transplanting of the material to a prepared reception site away from likely development impacts.

Those trials on Success Bank are progressing using a prototype underwater mechanical harvester - ECOSUB 1. It is capable of excavating and transplanting "10 sods per day, or a total of 2.5 square metres per day", but that rate is regarded as "too low for large scale transplantation" purposes (Cockburn Cement, 1997a, p46). Each sod of a quarter of a square metre comprises seafloor substrate to a depth of 0.4m and seagrass canopy including associated epiphytic plants and fauna. The work has involved the harvesting of sods from areas shortly to be dredged. The intention in relation to the medium-term proposal is to continue the feasibility trials to relocate existing seagrass in the path of the dredge, and to enable plans to be made for seagrass rehabilitation as part of a programme for longer-term (beyond 2002) dredging. Cockburn has commenced the development of a larger underwater harvester capable of excavating and transplanting 40 square metres/day and be operational for a minimum of 100 days each year.

To the end of June 1997 using ECOSUB 1 approximately 220 sods of mainly *Posidonia coriacea* and some *Amphibolis* have been excavated and relocated. The condition of the plants has been regularly monitored, and a survival incidence for each sod of 95% is indicated (Cockburn Cement, 1997a). Some of the plants have shown evidence of lateral spread, and some winter smothering of a number of sods is reported (D Lord, *pers. comm.*). The transplanting trials are continuing with in excess of 300 sods relocated by March 1998. In addition, it is reported that in places seagrass is recolonising the seafloor hollows from which sods were excavated.

Cockburn Cement is required within its February 1998 approval to implement the short-term proposal to utilise the remaining seagrass area of that proposal for transplanting trials consistent with the EMP.

Assessment

The area considered for assessment of this environmental factor is Success Bank.

The EPA's objectives in regard to this relevant environmental factor are:

(i) to encourage innovation in the development of practical technical solutions for the rehabilitation of the environment; and

(ii) to maintain the ecological function, abundance, species diversity and geographical distribution of seagrasses.

Between February 1996 and June 1998 1000 sods (250 m^2) covering an area of 1000 m^2 of seafloor have been transplanted using ECOSUB 1.

The EPA takes particular note of the comments of the IPRG (Cockburn Cement, 1997b), that "this project is a unique blend of university scientists and industry R & D. The latter are interested in developing a tool for transplanting large amounts of seagrass in a wave-dominated system that is a deterrent to normal transplant methodologies, while the former are interested in solving basic questions of seagrass biology using transplanted seagrass. The IPRG believes this blend is a significant factor in the overall success of the project to date".

While the EPA supports this approach the EPA also believes that such a requirement needs auditing, and furthermore every endeavour must be made to utilise within the trials the seagrass affected by current activity. The EPA believes that Cockburn should provide within its EMP Annual Report a detailed audit of both the area of seagrass effected by current and ongoing operations, and the area transplanted. That audit should also show statistics relevant to the monitoring of the transplanted material.

The EPA notes that the construction of a practical subsea harvester for the large-scale excavation and relocation of seagrasses will have benefits worldwide where seagrasses have been or are likely to be impacted by development and where rehabilitation is a vital key to maintaining ecological processes.

Having particular regard to:

(a) the results of the subsea mechanical transplanting experiments; and

(b) the commitment by Cockburn to continue the research, including the further development of a practical machine for seagrass recovery and transplanting,

it is the EPA's opinion that the proposal can be managed to meet the first part of the objective in relation to the factor:- transplanting of seagrass - feasibility and success i.e. to encourage innovation in the development of practical technical solutions for the rehabilitation of the environment.

However, having regard to:

(c) the current rate of transplanting,

the second part of the objective (i.e. to maintain the ecological function, abundance, species diversity and geographical distribution of seagrasses) cannot be met without an increase in the rate of transplanting and the application of the findings of the research program beyond the completion of dredging for shellsand.

4.5 Alternative resources and measures

Description

Within the CER, Cockburn has reported studies into locating sources of raw material for its manufacturing plant other than relatively high grade Owen Anchorage shellsand. A number of land-based sources of limestone and limesand have been investigated.

Cockburn has also undertaken technical studies into the beneficiation of both lower grade (<92% $CaCO_3$) shellsand, and limestone and limesands.

The CER argues that alternative resources must meet the feedstock grades acceptable to Cockburn's current manufacturing plant until new technologies are developed, and that there needs to be sufficient material of an economic grade for the company to meet present commercial obligations for quicklime and cement products. In that regard Cockburn's specifications for any alternative resource are for 10 million tonnes at 92% calcium carbonate over 5 years.

In addition the company has considered the prospect of moving its operations closer to a confirmed long-term terrestrial supply of limestone elsewhere in the State.

Specific alternatives evaluated by Cockburn include (CER; EMP):

- beneficiation of lower quality shellsand, limesand and limestone;
- completion of a second shipping channel through Success and Parmelia Banks;
- use of spoil from maintenance dredging of the FPA Shipping Channel;
- widening the existing FPA Shipping Channel through Success and Parmelia Banks;
- dredging shellsand of lower grade in the Mewstone Rock area;
- land-based limestone resources from the Metropolitan Region;
- land-based resources from the Perth Basin - Geraldton to Augusta;
- relocation of Cockburn's Munster cement and lime plant; and
- dredging the area between the FPA Shipping Channel and the second shipping channel on Success Bank - essentially the short- and medium-term proposals.

The beneficiation studies have included technical and commercial feasibility tests of a number of technologies. Cockburn has reported that it has commissioned a 200 000 tonne per annum electrostatic beneficiation plant at premises in Dongara. This beneficiation plant is operating to specifications.

From the current evaluation of alternative resources, Cockburn has concluded that the required material is not available within economic distance of its Munster plant over the time of the

medium-term proposal, nor is the technology sufficiently advanced to enable lower grade material from any source to be upgraded to feedstock specification (CER; Cockburn Cement, 1997a).

The EPA has been advised by the Minister for the Environment that concurrent with the February 1998 approval for the short-term proposal the Western Australian government has commissioned a strategic review of lime resources.

In addition to the above, Cockburn is undertaking further shellsand exploration in the Mewstone Rock area westward of the FPA Shipping Channel. Also, Cockburn has reported that it will continue to review the technical performance of its current dredging operation with the intention to adopt, where practical, technologies to enhance shellsand recovery while lessening the impact on seagrass (CER; Cockburn Cement, 1997a). It is the EPA's expectation in these circumstances that a proponent will endeavour to achieve 'best practice' and continuous environmental improvement.

Within its commitments for the medium-term proposal, Cockburn has undertaken to audit its operations and to report through the EMP Annual Report. The EPA would also expect an audit of the technical performance of the dredging operations, as mentioned above. This aspect has been also mentioned in Section 4.4 in relation to the transplanting of seagrass.

Assessment

The area considered for assessment of this environmental factor is potential calcium carbonate resources within Owen Anchorage and elsewhere onshore.

The EPA's objective in regard to this relevant environmental factor is to ensure that all reasonable alternatives to a proposal are considered within sound social and environmental constraints before a decision is made to adopt the proposal.

The EPA notes that the medium-term proposal is a continuation of an already approved activity, and that the operation is accompanied by a five year research programme aimed at understanding the environmental impacts of the proposal as it proceeds, and for developing means of managing those impacts.

The EPA has considered the environmental implications of alternative resources to the medium-term proposal and is of the opinion that environmental factors will have a strong influence on any decision to develop other limesand or limestone resources, whether they be marine or terrestrial. The EPA is encouraged by the intended government strategic review of lime and limestone resources. The finalisation of that review however, is some time away.

The EPA believes nonetheless that it needs to flag this issue further. It is the EPA's experience that limestone deposits of relatively high calcium carbonate content within the Perth Basin, because of there relative paucity, provide unusual surface and subsurface habitats for plants and animals, a number of which could be rare or endangered. Additionally, limestone deposits may also exhibit karstic landforms containing cave formations and uncommon geological structures, and provide habitat for rare cave-dwelling organisms. Some caves are also important palaeontological sites for research and teaching, particularly where animals that are now extinct have been trapped. Many caves also are important for archaeological and anthropological reasons.

Furthermore with respect to terrestrial plants and animals, the EPA elsewhere has identified as an important environmental factor the need 'to maintain the abundance, species diversity and geographical distribution of terrestrial flora and fauna, and associated habitats'; and, 'to protect Declared Rare and Priority Flora, and Specially Protected (Threatened) Fauna, consistent with the *Wildlife Conservation Act , 1950*'.

The EPA therefore must caution against any assumption that terrestrial limestone deposits could be developed without significant environmental risk. In this context Cockburn would be advantaged by seeking strategic advice from the EPA on a number of limestone sources to gauge the relative environmental impacts of each.

Added to the above, the EPA notes the early finding from the biological studies that the sandy substratum serves as a holdfast for seagrasses, and wonders whether reject material from the Woodman Point washing plant, or clean waste from any beneficiation plant, could be replaced into parts of the dredged area to rebuild the substrate as a substitute for shellsand removed by dredging.

If the chemical composition and the constituents of the shellsand is not a limiting factor in seagrass seedling settlement and growth, then an alternative substrate might be developed. Such a scheme presumably would require the reshaping of the dredged area.

Having particular regard to:

(a) the alternative raw material resources investigated by Cockburn;

(b) the commitment by Cockburn to continue reviewing alternative resources that may become available before decisions are taken on "long-term" resource acquisition; and

(c) the review of dredging technologies to seek improvements and the indication that such technologies will frequently be reviewed,

it is the EPA's opinion that all reasonable alternatives have been considered in relation to the medium term availability of shellsand. However, it is appropriate for Cockburn to accelerate the development of potential alternatives to shellsand dredging. If an environmentally acceptable alternative can be developed and implemented before the term of the medium term proposal is complete then greater retention of dense seagrass beds could be achieved.

5. Conditions

Pursuant to section 44 of the Environmental Protection Act 1986 the EPA is required to report to the Minister for the Environment on the environmental factors relevant to the proposal and on the conditions and procedures to which the proposal should be subject, if implemented. The EPA may make other recommendations as it sees fit.

In regard to the establishment of conditions the EPA prefers the proponent to commit to a series of environmental protection measures for the proposal which can be written to make them enforceable under the *Environmental Protection Act, 1986* over the term of the proposal. It is not always possible to do this.

However, where enforceable provisions are not easily identified, there needs to be clear statements of the action to be taken by the proponent toward continuous environmental performance and improvement. Proponent statements as commitments of this kind are recommended by the EPA as part of the conditions to which the proposal should be subject. The EPA may recommend additional conditions.

As discussed in Section 3 the medium-term proposal is predicated on the undertaking of a research programme set out in the EMP to which Cockburn has committed, vis: "implementing all the programmes of scientific and technical investigation as outlined in the EMP (February 1995) and its Supplement (September 1995)".

This commitment is different from those which usually accompany a proposal before the EPA, as commitments are designed to ensure environmental protection through continuous and improving environmental management of the proposal during the proposal's life. In the medium-term proposal on the other hand, the EMP research is undertaken over the five year life

of the proposal, with the aim being both to minimise environmental consequences (which is similar to the usual form of commitments), and to resolve the issue of the long-term access (ie beyond the medium-term proposal) to shellsand.

The implication in these circumstances is that while the research results may be used for continuing and better environmental management of the proposal there is not a direct obligation to do so. Rather, to a degree the research has a longer-term objective. The management of the EMP process is facilitated through an 'Audit Compliance System' which checks the progress and stages of the research programme. However, the current commitments do not appear to account for the adoption of research findings during the term of the proposal. In addition, to achieve the EPA's objectives application of the findings of the research program beyond the completion of dredging for shellsand is warranted. This approach is consistent with the mine closure requirements of land-based mining proposals.

Accordingly the EPA is of the view that the commitment to the research should be accompanied by a condition toward utilising research findings for continuous environmental improvement both during the period of the Medium-term dredging proposal and post dredging, and that action in this regard should be audited and reported in each year of the EMP Annual Report.

In this way the research outcomes will also meet the expectation of the independent members of the EMAB who, while endorsing the international standing of the research, also commented that "This ensures the credibility of the work undertaken, and that it will provide the basis for the development of appropriate management plans".

In addition, the EPA's concern about further regional loss could be accommodated by accelerating the development of potential alternatives to shellsand dredging, thereby retaining a greater area of potential seagrass meadow habitat, in particular, areas which currently support dense seagrass cover.

Having considered the proponent's commitments and the information provided in this report, the EPA has developed a set of conditions which the EPA recommends be imposed if the proposal by Cockburn to dredge shellsand within the medium-term area of Success Bank over the period 1997 to approximately 2002, is approved for implementation. These conditions are presented in Appendix 3. Matters addressed in these conditions include the following:

(a) The proponent shall fulfil the commitments in the Consolidated Commitments statement set out as an attachment to the recommended conditions in Appendix 3, noting that the commitments include:

- implementing all of the programmes of scientific and technical investigation as outlined in the EMP (Cockburn Cement Limited, February 1995) and its Supplement (Cockburn Cement Limited, December 1995);
- development of a detailed audit programme for this project;
- referral of its plan for long-term resources for assessment by the EPA under Part IV of the *Environmental Protection Act* at least 15 months prior to the expected depletion of the medium-term resource; and
- implementation of a dredging programme that prioritises dredging areas, gaining access to areas of lower seagrass cover first.

(b) The proponent shall prepare a report to the EPA within two years of the approval to implement the proposal on the potential alternative sources of lime material (terrestrial and marine) for its manufacturing process such that the EPA can review, seek public comment and provide strategic environmental advice;

(c) The proponent shall prepare a post-dredging closure plan indicating how transplanting research will be applied to on-going seagrass re-establishment. This plan shall be prepared, within two years of the approval to implement the proposal, for EPA review and public comment prior to submission to the Minister for the Environment for acceptance;

(d) The proponent's Annual Report on the 'Shellsand Dredging - Environmental Management Programme' shall include a summary statement of the research results to the end of each year, and shall include the following:

- those results adopted for incorporation into the environmental management of the proposal; and
- any research results which are not adopted, or which indicate that aspects of the environment are being adversely affected, including measures or steps introduced to overcome those effects; and
- a detailed audit of both the area of seagrass affected by current and ongoing operations, and the area transplanted. That audit should also show statistics relevant to the monitoring of the performance of the transplanted material.

(e) In order to manage the relevant environmental factors and the EPA objectives contained in this bulletin, and subsequent conditions and procedures authorised by the Minister for the Environment, the proponent shall demonstrate that there is an environmental management system in place which includes the following elements:

- an environmental policy and a corporate commitment to it;
- mechanisms or processes to ensure planning of environmental requirements;
- mechanisms or processes to ensure implementation and operation of environmental requirements;
- mechanisms or processes to ensure measurement and evaluation of environmental performance; and
- a mechanism for continuous review and improvement of environmental outcomes.

6. Other advice

A fundamental aspect arising from the medium-term proposal is the issue of Success Bank seagrass distribution and significance in terms of ecological function vis-a-vis seagrass occurrence and function in the surrounding areas of Cockburn Sound, and the Garden Island and Rottnest Shelves. Within this relationship, the loss of Success Bank seagrass and its function through dredging, needs to be weighed against the broad environmental effects of the loss of seagrass in the wider surrounds.

Elsewhere cumulative impacts through piece-meal but progressive alteration of parts of the natural environment has led either to gross environmental deterioration or to a new, human-induced, regional environmental setting.

In regard to Owen Anchorage and Success Bank in particular, the value of seagrass as a functional biological component of the localised ecosystem is still being determined. Ecological function is one element of the suite of studies. However, and as discussed in Section 4.2, the abundance of seagrass on Success Bank and hence its ecosystem role, shifts from time to time in response to natural forces. Thus the localised ecosystem is not static and its organisms are adapted to change.

On a regional scale, there has been past degradation through seagrass loss. The ability to restore seagrass meadows would be of ecological benefit. As there is ongoing decline in Cockburn Sound, reliance on natural regeneration appears unlikely. Owen Anchorage, where natural regeneration is still occurring, could be a source for transplanting.

The judgement drawn from this complexity of issues is that the medium-term proposal as it relates to the continuing EMP process is environmentally acceptable as there will be compensating adjustments to the environment both human and natural, which will reduce the proposal's adverse effects. The assessment conducted in Section 4 above sets out the EPA's consideration of those matters.

However, within the region there has already been substantial losses of seagrass and probable significant ecosystem change. About 80% of the pre-industrial seagrass in Cockburn Sound has been lost, although there is still scientific uncertainty as to the overall consequences of that change. It is generally agreed, however, that seagrass loss will be accompanied by a significant change in an area's primary production resource. Gross biological production on the other hand, may shift, and overall biomass may not always be reduced as other sources of biological production come into play. In the case of Cockburn Sound the human-induced nutrient-enriched status of the water body has established a new set of functional ecological relationships. In the context of 'environmental quality objectives', which includes both human and biological values, the system is nonetheless severely stressed (SMCWS, 1996).

Accordingly, for Cockburn Sound, the EPA holds the opinion, that development proposals should not adversely add to the gross changes that have already occurred. As seagrasses are the main biological element significantly impacted by the water quality change in Cockburn Sound it is paramount that there should not be any further losses. The EPA draws attention in these matters to the dual objective of protecting the remaining seagrass meadows of Cockburn Sound and the need to conserve those areas where seagrasses are most likely to grow, for example sand banks and sandy seafloor.

The EPA has stated this a number of times. In a 1993 report on a marina proposal in Mangles Bay, Cockburn Sound, the EPA recommended that the proposal not proceed because the development would have directly removed 32ha of seagrass meadow with an indirect loss of a further 30ha of seagrass being indicated (EPA Bulletin 693, 1993). Furthermore, the EPA is aware of other development proposals within Cockburn Sound, and would caution against an argument that the further removal of seagrass could be environmentally justifiable.

In reviewing seagrasses in a wider regional context a different picture unfolds. Seagrasses are prolific in the temperate waters of the west and south coasts of Western Australia (Kirkman and Walker *in* Larkum *et al.*, 1989), including the waters off the metropolitan coast (SMCWS). The seagrasses offshore on the Garden Island and Rottnest Shelves are healthy.

The distribution, diversity and ecological function of seagrasses within this wider marine environment is unlikely to be affected by the proposal.

Cumulative impacts of development proposals on seagrass are important nonetheless within each separate setting. Furthermore, it is the EPA's opinion that there is no scientific information available to infer that the impacts of the medium-term proposal will add to the environmental deterioration of Cockburn Sound.

The completion of the medium-term proposal will provide two direct opportunities, firstly a reason to stop the further loss of seagrass by dredging and, secondly the focus to move to other resource acquisition options. Hence, a longer-term proposal which would see the further removal of seagrass from the confines of Owen Anchorage should be recognised as environmentally unreasonable.

7. Conclusions

The EPA has considered the proposal by Cockburn Cement to continue Shellsand dredging on Success Bank in the area described in its medium-term environmental review document.

The EPA has concluded that its advice on acceptability of the proposal needs to consider on one hand a reduction in seagrass and seagrass habitat and on the other hand the value of the research being undertaken on wave climate on Success Bank, distribution of seagrass within Owen Anchorage, ecological significance and function of seagrasses, rehabilitation techniques for the replacement of seagrass function and beneficiation of lower grade shellsand material.

Within the Owen Anchorage area there have been gains and losses of seagrass cover between 1972 and 1995 with a net gain of 198ha. Accordingly, the seagrass habitat needs to be considered in association with actual seagrass cover. Within this context, the proposal could be regarded as not bringing about a major change in the Owen Anchorage area. However, Owen Anchorage cannot be separated from the extensive reduction in seagrass in Cockburn Sound even though the reason for that reduction had nothing to do with the activities of Cockburn Cement.

In general terms, the further loss of seagrass and the consequential reduction in a primary benthic community cannot be supported by the EPA. However, in the particular case of the Cockburn Cement proposal, the EPA has taken into account the long term environmental aspects of acquiring information about the ecological functions of seagrass and the development of techniques for seagrass rehabilitation. The research being undertaken is of world-class status and is peer reviewed by an "International Peer Review Group".

The research effort has led to a number of significant findings and conclusions relevant to the medium-term proposal even though the studies are still ongoing. In addition, Cockburn Cement has developed a machine for small-scale excavation of seagrass and substrate, and the transplanting of the material in a prepared reception site away from likely development sites. The research is continuing, including the development of another more efficient machine.

The EPA holds the view that, on balance, there is an environmental benefit to be gained in having the research continue in both the biological and engineering fields vis-à-vis the environmental damage caused by the loss of seagrass in the area described in the mid-term proposal.

Accordingly, the EPA has concluded that the environmental harm resulting from the mid-term proposal by Cockburn Cement is outweighed by the environmental value of the information flowing from the research being undertaken provided the commitment to research is accompanied by a condition towards utilising the research findings for continuous improvement in the environmental performance, both during the period of the Medium-term dredging proposal and post dredging.

8. Recommendations

Section 44 of the Environmental Protection Act 1986 requires the EPA to report to the Minister for the Environment on the environmental factors relevant to the proposal and on the conditions and procedures to which the proposal should be subject, if implemented. In addition, the EPA may make recommendations as it sees fit.

The EPA submits the following recommendations to the Minister:

1. That the Minister considers the report on the relevant factors of Wave climate, sediment movement and shoreline stability, Seagrass, the Transplanting of seagrasses, and Alternative measures and resources;

2. That the Minister notes that the EPA has concluded that the environmental harm resulting from the mid-term proposal by Cockburn Cement is outweighed by the environmental value of the information flowing from the research being undertaken provided the commitment to research is accompanied by a condition towards utilising the research findings for continuous improvement in the environmental performance, both during the period of the Medium-term dredging proposal and post dredging;

3. That the Minister notes that the EPA has recommended that, within two years of the approval to implement the proposal, the proponent investigate and prepare a report on potential alternative sources of lime-making material (marine sources, terrestrial sources and environmental impacts of development and production), to the requirements of the Environmental Protection Authority on advice of the Department of Resources Development, the Department of Minerals and Energy and the Department of Environmental Protection. The EPA will seek public comment on the report and provide advice to the Minister for the Environment on that report.

4. That the Minister imposes the conditions and procedures consistent with Section 5 and set out in formal detail in Appendix 3 of this report; and

5. That the Minister notes that the EPA has formed the view that proposals involving the removal of seagrass and potential seagrass habitat in the long-term for shellsand should be recognised as environmentally unreasonable.

Appendix 1

List of Submitters

Public Submissions

- City of Cockburn
- WA Recreational and Sportfishing Council Inc (including Coastal Waters Alliance)
- Dr J Searle
- Dr P Woods
- Conservation Council of WA Inc
- Australian Marine Sciences Association of WA
- Australian Marine Conservation Society, West Coast Branch

State Government Submissions

- Fisheries Department of WA
- Department of Resources Development
- Fremantle Port Authority

Appendix 2

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Appendix 3

List of Recommended Ministerial Conditions and Proponent's Consolidated Commitments

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

MEDIUM-TERM SHELLSAND DREDGING
SUCCESS BANK, OWEN ANCHORAGE (1027)

Proposal: Dredging of approximately 9.1 million tonnes of shellsand from two zones on Success Bank, Owen Anchorage, as documented in schedule 1 of this statement.

Proponent: Cockburn Cement Limited

Proponent Address: Lot 242, Russell Road East, Munster WA 6166

Assessment Number: 1027

Report of the Environmental Protection Authority: Bulletin 901

The proposal to which the above report of the Environmental Protection Authority relates may be implemented subject to the following conditions and procedures:

1 Implementation

1-1 Subject to these conditions and procedures, the proponent shall implement the proposal as documented in schedule 1 of this statement.

1-2 Where, in the course of implementing the proposal, the proponent seeks to change any aspect of the proposal as documented in schedule 1 of this statement in any way that the Minister for the Environment determines, on advice of the Environmental Protection Authority, is not substantial, those changes may be effected.

2 Proponent Commitments

2-1 The proponent shall implement the consolidated environmental management commitments documented in schedule 2 of this statement.

2-2 The proponent shall implement subsequent environmental management commitments which the proponent makes as part of the fulfilment of conditions and procedures in this statement.

3 Environmental Management System

3-1 In order to manage the environmental impacts of the project, and to fulfil the requirements of the conditions and procedures in this statement, prior to commencement of operations, the proponent shall demonstrate to the requirements of the Environmental Protection Authority on advice of the Department of Environmental Protection that there is in place an environmental management system which includes the following elements:

1. environmental policy and commitment;
2. planning of environmental requirements;
3. implementation and operation of environmental requirements;
4. measurement and evaluation of environmental performance; and
5. review and improvement of environmental outcomes.

3-2 The proponent shall implement the environmental management system referred to in condition 3-1 within six months of the formal authority issued to the decision-making authorities under Section 45(7) of the Environmental Protection Act 1986.

4 Seagrass

4-1 The proponent shall use the seagrass in the project area where dredging for shellsand will occur for transplanting trials, consistent with the proponent's commitments and research programme outlined in the document entitled 'Cockburn Cement Shellsand Dredging Environmental Management Programme (1995)'.

5 Alternative sources of lime-making material

5-1 Within two years of the formal authority issued to the decision-making authorities under Section 45(7) of the Environmental Protection Act 1986, the proponent shall investigate and prepare a report on potential alternative sources of lime-making material, to the requirements of the Environmental Protection Authority on advice of the Department of Resources Development, the Department of Minerals and Energy and the Department of Environmental Protection.

This report shall address:
1. marine sources;
2. terrestrial sources; and
3. environmental impacts of development and production.

5-2 The Environmental Protection Authority will seek public comment on the report required by condition 5-1 for at least four weeks, and provide advice to the Minister for the Environment on that report.

6 Post-Dredging Closure Plan

6-1 Within two years of the formal authority issued to the decision-making authorities under Section 45(7) of the Environmental Protection Act 1986, the proponent shall prepare a post-dredging closure plan indicating how transplanting research will be applied to on-going seagrass re-establishment, to the requirements of the Minister for the Environment on advice of the Environmental Protection Authority, the Department of Resources Development and the Fremantle Port Authority

6-2 The Environmental Protection Authority will seek public comment on the plan required by condition 6-1 for at least four weeks, prior to providing advice to the Minister for the Environment.

7 Annual Report (Environmental Management Plan)

7-1 In the Annual Report on the 'Shellsand Dredging - Environmental Management Plan' (published by the proponent each year during the period of the operation), the proponent shall include a summary statement of the research results to the end of each year, showing:

1. those research results adopted for incorporation into the environmental management of the proposal;
2. any research results which are not adopted, or which indicate that aspects of the environment are being adversely affected, including measures or steps introduced to overcome those effects; and
3. a detailed audit of both the area of seagrass effected by current and ongoing operations, and the area transplanted. This audit shall also show statistics relevant to the monitoring of the performance of the transplanted material.

8 Proponent

8-1 The proponent for the time being nominated by the Minister for the Environment under section 38(6) or (7) of the Environmental Protection Act is responsible for the implementation of the proposal until such time as the Minister for the Environment has exercised the Minister's power under section 38(7) of the Act to revoke the nomination of that proponent and nominate another person in respect of the proposal.

8-2 Any request for the exercise of that power of the Minister referred to in condition 8-1 shall be accompanied by a copy of this statement endorsed with an undertaking by the proposed replacement proponent to carry out the proposal in accordance with the conditions and procedures set out in the statement.

8-3 The proponent shall notify the Minister for the Environment of any change of proponent contact name and address within 30 days of such change.

9 Commencement

9-1 The proponent shall provide evidence to the Minister for the Environment within five years of the date of this statement that the proposal has been substantially commenced.

9-2 Where the proposal has not been substantially commenced within five years of the date of this statement, the approval to implement the proposal as granted in this statement shall lapse and be void. The Minister for the Environment will determine any question as to whether the proposal has been substantially commenced.

9-3 The proponent shall make application to the Minister for the Environment for any extension of approval for the substantial commencement of the proposal beyond five years from the date of this statement.

9-4 Where the proponent demonstrates to the requirements of the Minister for the Environment on advice of the Environmental Protection Authority that the environmental parameters of the proposal have not changed significantly, then the Minister may grant an extension not exceeding five years for the substantial commencement of the proposal.

10 Compliance Auditing

10-1 The proponent shall submit periodic Performance and Compliance Reports, in accordance with an audit program prepared in consultation between the proponent and the Department of Environmental Protection.

10-2 Unless otherwise specified, the Department of Environmental Protection is responsible for assessing compliance with the conditions contained in this statement and for issuing formal clearance of conditions.

10-3 Where compliance with any condition or procedure is in dispute, the matter will be determined by the Minister for the Environment.

Note

The Minister for the Environment set conditions on short-term shellsand dredging (Assessment number 1022, Environmental Protection Authority Bulletin 833) in Statement 468 which was published on 24 February 1998.

Schedule 1

The Proposal

The medium-term dredging of shellsand involves suction dredging over an estimated six year period of about 9.1 million tonnes of shellsand sediment from two zones on Success Bank, Owen Anchorage. The two zones total 99 hectares of seafloor between the Kwinana Shipping Channel and a second partly constructed channel to the east, excluding a 100m buffer zone immediately east of the Fremantle Port Authority (FPA) Shipping Channel (Figure 1).

The key characteristics of the proposal are described in the table below.

Element	Description
Site location and area	• Dredging, in accordance with a 'dredging management programme' of 99 hectares in 2 zones on Success Bank containing approximately 9.1 million tonnes of shellsand sediment averaging 92% calcium carbonate; • The dredged depth generally will be 13-14 metres below the sea surface; • The dredging is a continuation of earlier shellsand operations on Success Bank.
Timing	• The operation is scheduled over a period 1997 to approx. end of 2002 or to the end of the resource;
Operation	• Water-jet suction dredge acquiring sediment at the rate of 800 tonnes per hour in depths of 5-16 metres operating 12 hours a day; • Dredged sediment as a slurry is transferred by barge to a spoil dump adjacent to Woodman Point; • Sediment is recovered, washed and pumped via pipeline to Cockburn's Munster manufacturing plant.
Management measures	• Cockburn commits to implementing all the programmes of scientific and technical investigations outlined in the Environmental Management Plan (Feb 1995) and 'Supplement' (Sept 1995); • Cockburn commits to a detailed environmental management audit (Appendix 1 of Consultative Environmental Review); • Cockburn commits to a dredging programme gaining access first to lower seagrass cover.
Long-term access	• Plans for longer-term access will be referred to the Environmental Protection Authority.

Plans, Specifications, Charts

Figure 1: Location of proposed medium-term dredging.

Schedule 2

Proponent's Consolidated Environmental Management Commitments

August 1996

MEDIUM-TERM SHELLSAND DREDGING SUCCESS BANK, OWEN ANCHORAGE (1027)

COCKBURN CEMENT LIMITED

The Proponent's consolidated environmental management commitments (August 1996) are as follows:

1. The proponent will implement all of the programmes of scientific and technical investigation as outlined in the EMP (Cockburn Cement Limited, February 1995) and its Supplement (Cockburn Cement Limited, December 1995).

   The major studies, which are summarised in Attachment 1, include:

   - determining the influence of dredging on wave climate and shoreline stability;
   - determining the ecological significance of seagrass;
   - developing techniques for seagrass rehabilitation;
   - developing techniques for beneficiation; and
   - examination of alternative resources.

2. The proponent will implement a detailed audit programme that will be developed for this project. A proposed audit programme is shown in Attachment 2.

3. The proponent will refer its plan for long-term resources for assessment by the EPA under Part IV of the Environmental Protection Act at least 15 months prior to the expected depletion of the medium-term resource.

4. The proponent will implement a dredging programme that prioritises dredging areas, gaining access to areas of lower seagrass cover first.

COCKBURN CEMENT LIMITED

SHELLSAND DREDGING

Responses to questions and issues raised during the public review of the

CONSULTATIVE ENVIRONMENTAL REVIEW

MEDIUM-TERM SHELLSAND DREDGING

OWEN ANCHORAGE

DECEMBER 1996

TABLE OF CONTENTS

LIST OF TABLES

LIST OF PLATES

1 INTRODUCTION

In August 1996, Cockburn Cement Limited (Cockburn) submitted a Consultative Environmental Review (CER) to the Environmental Protection Authority (EPA) for the dredging of shellsand from Success Bank, Owen Anchorage. The area proposed for dredging is located on Success Bank between the existing FPA shipping and the second shipping channel and is termed the proposed medium-term dredging area. Cockburn is currently dredging in the vicinity in the short-term dredging area.

This CER for medium-term dredging was released for public review during the period of 27 August to 23 September 1996. A total of 7 separate public submissions and 3 WA state governmental department submissions responding to the CER were received by the EPA. These are listed in Appendix 1.

An evaluation of the submissions indicated that four main issues were common, while a number of other questions concerning specific matters were presented.

The main issues that were identified are:

- The current status of the CER for short-term dredging, the current status of the proposed Environmental Management Programme (EMP), and the current standing of approvals for dredging;
- Access to resources, and development of alternative resources;
- Sedimentology of the Banks, their origin, patterns of sediment transport, and the production of carbonate by seagrass;
- The concept of ecological significance of seagrasses, changes in seagrass cover and relevance of seagrasses to fisheries.

This response to the submissions will be presented by first addressing in order each of the main issues identified above, followed by responses to further specific statements and questions contained in the submissions.

2 STATUS OF CER, EMP, AND CURRENT STANDING OF APPROVALS

In August 1994, the Minister approved the short-term dredging proposal submitted by Cockburn, and required Cockburn to undertake an Environmental Management Programme (EMP) to gather information to allow for decisions to be made regarding future (ie., post 2001) dredging proposals for shellsand extraction from Success Bank and its surrounds. Access to the medium-term dredge area on Success Bank was dependent on the development of an 'acceptable' EMP. In November 1995, the Minister approved the EMP which had been amended by a Supplement.

In March 1996, the Supreme Court ruled that the EPA has acted beyond its powers under the Environmental Protection Act (1986) in preparing its recommendations which the Minister used for approving the short-term dredging proposal. This ruling

made the Minister's decision on the short-term CER null and void, and consequently, the approval of the EMP also became null and void.

The EPA then recommenced its assessment of the short-term CER, with its recommendations issued on 9 November 1996 (Bulletin 833). This Bulletin also recommends that the EMP sets out an appropriate programme of research and development.

Since March 1996 Cockburn has continued to dredge in the short-term area in accordance with its Agreement Act. In addition, Cockburn advised the Minister in 1966 it would, during the process of assessment of the short-term dredging proposal, continue the programmes of research and technical investigation described in the EMP.

3 ACCESS TO RESOURCES, AND DEVELOPMENT OF ALTERNATIVE RESOURCES

3.1 ALTERNATIVE RESOURCES - MARINE

3.1.1 CCL advise they plan to relocate to Mewstone before 2002 (CER p4). Why is the alternative set out above not a viable option now?

Cockburn have never stated that they plan to relocate to Mewstone for its long-term resource requirements. The extraction of shellsand from Mewstone is contingent upon a number of factors, including:

- Granting of a mining lease for the area;
- Cockburn acquiring a suitable dredge to work in the Mewstone area where wave energies are higher and where limestone pinnacles occur;
- The development and implementation of a commercial beneficiation process; and
- Environmental approval to dredge in this area.

The CER indicates that if these matters can all be satisfactorily addressed, relocation to Mewstone before 2002 is an option that would be evaluated by Cockburn along with other options.

3.1.2 CCL rejects this (the Mewstone option) and other alternatives on the basis of cost. This raises a number of questions.

- *Why has CCL continued to expand its plant at Coogee when there was already a question over resource security on Success Bank (vii para 3)?*

Over many years Cockburn has established strong customer-supplier relationships across Western Australian industry. It is Cockburn's Mission to provide outstanding

service to customers through (*inter alia*) provision of a sufficient supply of quality limes. Continuous improvement towards world class manufacturing capabilities, environmental performance and excellence in supplier relationships is necessary to fulfil this Mission.

Cockburn meets all regulatory requirements and actively responds as environmental knowledge expands. Cockburn supports the WA system of environmental impact assessment and believes that through continued high performance and willingness to adapt, it can satisfy customer requirements and community standards and maintain its lime operations for many years to come.

Further, Cockburn believes that it has a legal right to continue extraction of resource from the State Agreement Act area subject to meeting all approvals.

- *Why has CCL continued to enter long term supply contracts without a secure resource supply?*

Cockburn continues to assess all options for future resource security.

For a resource whether marine or terrestrial to be a genuine alternative in the medium-term it must qualify in a number of ways. Qualification in only one or a few of these ways is not sufficient.

- ◊ Resource must be of proven quantity and as a minimum be sufficient for Cockburn's projected needs in the medium-term (>10 million tonnes).

- ◊ Resource must be of suitable quality in terms of grade (carbonate purity), particle size distribution and physical integrity. Cockburn's lime manufacturing processes and those processes of many of the customers that consume lime have been designed around the known quality attributes of the shellsand resource and its consequent lime.

- ◊ Resource must have assured access, with prior resolution of the issues of location, ownership, social, archaeological and ethnographic features preservation zoning and environmental protection.

- ◊ Resource must be able to be mined and transported within reasonable economic bounds to ultimately provide customers with materials that support their international competitiveness. Throughout the world, calcium carbonate minerals are low cost materials and uneconomic mining or long distances from mine to manufacturing site or markets brings ultimate extinction of the operation. The recent move by Cockburn to develop operations at Dongara, in balance with growth in regional lime consumption exemplifies this point.

- *Why should the EPA consider reference to costs in their consideration of the CER?*

The-EPA must evaluate the proposal submitted by Cockburn in light of the advice it receives from a variety of sources, and in terms of the Environmental Protection Act (1986). The CER prepared by Cockburn recognises that there are a number of issues to be addressed in any resource development, including satisfying environmental, social, and economic criteria. Information presented in the CER largely addresses the environmental issues associated with the proposal. The limited information on costs provided in the CER is to allow the public to be as well informed as possible on the issues facing Cockburn.

- *Why does CCL believe that there are no other resources capable of being developed within a two year time frame to supply all Western Australia's lime requirements by either CCL and/or its competitors?*

Cockburn believes that the only practical option to meet its requirements over the next 5 years is its proposed medium-term (shellsand) area. No other resource now available to Cockburn or likely to be available qualifies as a genuine alternative. See also 3.1.1 for additional detail.

See also previous section of reply to item 3.1.2

- *Why doesn't CCL relocate to Mewstone area within the next two years rather than wait to 2002?*

See reply to 3.1.1 above.

3.1.3 *4 million tonnes of suitable limesand exists on the floor of the second channel and the FPA channel. Why doesn't CCL use this sand while it sources barges and a dredge capable of operating at Mewstone?*

Cockburn estimates the floor of the second channel to contain about 0.5 to 1 million tonnes. This would require specialist dredging with a high risk of shellsand contamination by underlying sediments. Nevertheless, opportunities to access this resource are being investigated.

Widening of the FPA channel may yield up to a further 3 million tonnes. This is not an option available to Cockburn at this time because of restrictions imposed by the FPA but is the subject of evaluation with the FPA and is being actively pursued.

3.1.4 *CCL acknowledge they intend to relocate to Mewstone before 2002. Why can this not be made a recommendation to government?*

Cockburn have not acknowledged that they intend to relocate to Mewstone before 2002.

See also reply to 3.1.1 above.

3.2 ALTERNATIVE RESOURCES - TERRESTRIAL

3.2.1 Why has CCL consistently said the Dongara resource is not suitable until March 1996 within weeks of a competitor announcing its intentions to build a lime plant at Dongara?

Cockburn does not believe that Dongara provides a genuine alternative resource for Cockburn's medium-term requirements (see section 3.1.2 for further details). However, for more than 10 years, Cockburn has held limesand resources at Dongara with a plan to manufacture **in that region** in the event that lime consumption grew sufficiently. This has now occurred. The presence (or absence) or timing of a competitor's lime plant at Dongara has no bearing on the suitability of Dongara limesands as an alternative resource for Cockburn's total requirements in the medium-term.

3.2.2 CCL dismiss the Dongara resource on the basis of the cost and environmental impact of the trucking task, and the limited size of the CCL resource. CCL is looking at alternatives at Wedge Island, Lancelin and Guilderton. Whether the limesand is sourced from these three areas or Dongara, the impact on the metropolitan area will be the same. CCL fails to mention the larger resource at Dongara which was offered to CCL. What difference in environmental impact is there between sourcing limesands from Dongara, Wedge Island, Lancelin, etc.?

Upon investigation, the environmental impact of developing any available resource at Wedge Island, Lancelin or Guilderton may prove to be similar to that of Dongara. However such detailed investigations have not been undertaken.

3.2.3 Why until early 1996, has CCL rejected Dongara as an option?

Cockburn continues to regard Dongara limesands as an unsuitable option for its total medium-term resource requirements. The Dongara development recently announced by Cockburn is specifically to serve the smaller but growing market in that region.

3.2.4 Does CCL agree that the Dongara limesand deposits held by CCL and others are of sufficient size to supply the whole of the State's quicklime needs for the next 50 years or more? If not, why not? If yes, why was this not discussed in CER 2.7?

Cockburn's proven reserve of suitable limesand at Dongara is certainly not sufficient to supply the whole of the State's quicklime needs for the next 50 years. The proven extent of others' holdings is unknown. In any event, the **quantity** of limesand is only one of the essential factors to be used in selecting a resource.

3.3 BENEFICIATION

3.3.1 The objections to beneficiation and associated impacts were all raised in previous submissions as reasons why the plant at Coogee is not a long term option. The fact that CCL now recognises problems associated with beneficiation is a reason why it should look at other resources. Has the EPA provided this advice to government as part of its duty to inform on options?

In all previous submissions, the environmental impacts associated with beneficiation of marine shellsand have been raised. These may include: need for large volumes of freshwater; use of extra energy for drying; and, need to dispose of significant amounts of residue. These matters can all potentially be resolved at the existing site; therefore the implementation of beneficiation does not preclude the continuing use of Coogee site.

3.3.2 *Beneficiation will increase the grade of raw material entering CCL plant, but it will require large amounts of fresh water and require disposal of around 200,000 to 300,000 tonnes every year of waste. So apart from the current problems of operating at this site CCL will be faced with other problems in the long term. Should not the EPA be looking at alternatives for long-term supply of lime?*

See reply to 3.3.1 above.

3.3.3 *Substantially more emphasis should be placed on the investigation of and development of strategies relating to the reduction of lime quality standards as a major environmental management and mitigation measure by the Company.*

Industrial pressures in WA and elsewhere are to improve the quality of lime being provided. None of Cockburn's existing customers would accept lower quality lime by preference.

Most of Cockburn's lime customers export their products into competitive international markets. Any steps that reduce the quality or increase the costs of lime in their process simply reduce their competitiveness.

3.4 STATE AGREEMENT ACT COMMITMENTS

3.4.1 *Does CCL believe the State has not met its obligation in making alternative resources available (CER 2 1.3.1)? If not, why not?*

Under the State Agreement Act the obligations for the State arises 'if and when it should become impractical for the Company to obtain shellsand'. This circumstance has not arisen.

3.4.2 *It is our understanding that CCL pay no royalties on the use of this area, and also that there are economically viable, less environmentally sensitive alternatives to the supply of lime, most notably from the Dongara area.*

Under the current provisions of its Agreement Act, Cockburn is not required to pay royalties for shellsand. It is recognised that Cockburn's dredging activities so far have virtually generated a 'second channel' in the area at no cost to the State.

Cockburn do not agree that other options such as Dongara present genuine alternatives (refer to 3.1.2) for its medium-term requirements.

3.4.3 *How can Cockburn dredge without environmental approval? Why does Cockburn need environmental approval when it is operating without it?*

Cockburn meets all of the regulatory requirements for its operation as imposed by the various regulatory authorities. Cockburn is of the opinion that it has a legal right to continue extraction of resource from the State Agreement Act area subject to meeting these approvals.

4 SEDIMENTOLOGY OF THE BANKS, THEIR ORIGIN, PATTERNS OF SEDIMENT TRANSPORT AND THE PRODUCTION OF CARBONATE BY SEAGRASSES

4.1 INTRODUCTION

In May 1994, the Minister approved the proposed short-term dredging on Success Bank, Owen Anchorage (Bulletin 739). The Minister's conditions called for a number of scientific studies and technical investigations, to be presented as an Environmental Management Programme (EMP). The Technical Advisory Group (TAG) preparing the EMP identified that the existing knowledge of the structure and origin of the Banks was largely contained in the studies of France (1977) and Searle (1984). Since then, additional information on Bank structure and composition had become available from a suite of exploratory bores that Cockburn has had drilled in the area. Further pertinent information had also been collected by biologists working on seagrasses in the area.

Consequently, the TAG for the EMP then recommended to Cockburn that the EMP be expanded and that all existing information on bank sedimentology be reviewed. This work was presented in a draft report in November 1995. The principle conclusions contained in the draft report were:

- using available information on the age of the Banks and on *in situ* carbonate production rates, it appeared that less than 10% of the Banks volume was obtained from *in situ* carbonate production. This contrasted strongly with the previous estimate that 50% of the Success Bank is from *in situ* carbonate production. Consequently, it was recommended that further measurements be made of *in situ* carbonate production rates.

This work was commenced, some results are now available and were quoted in the CER, while further measurements are continuing.

- Analysis of sediment characteristics from the Surface of Success Bank indicated no statistically discernible differences between sites that had seagrass cover from nil to high. This information was interpreted as, ***over the long-term*** (i.e. years) the dominant factor controlling sediment distribution on the Banks is physical forces from waves. Seagrasses themselves will always influence local patterns of sediment distribution especially during periods of low wave energy.

The draft report was made available to all those who expressed interest in receiving it. The draft report also made a series of recommendations of further measurements and evaluations that needed to be conducted to test the conclusions presented in the report. These are further described in section 4.6 of this response.

The report that has been prepared will remain in draft form until the studies described in section 4.6 are complete. Interim progress reports will be prepared. The studies have been, and will continue to be exposed to peer review.

4.2 BANK ORIGIN

4.2.1 Sea levels reached around the present level around or shortly before 6000 year ago and have subsequently been within 1 to 2 m of the present level.

We fully concur. Wyrwoll et al. (1995) note that the most parsimonious interpretation of events is that at approximately 10,000 years Before Present (BP) sea level was still more than 25 m lower than today. It had reached a position of −20 m by about 8,000 BP and at approximately 6,400 BP the sea level was slightly elevated above the present level (Holocene high-stand). Since then there has been a decline of sea level, with its present height being reached by about 1,500 BP. Hence, it appears that the sea level of Southwestern Australia has remained within approximately 1 m of the present level in the past 4,000 yr BP and in the last 2,000 to 1,500 yr BP the sea level has remained at approximately the present level.

4.2.2 Why are Cockburn's dates for the age of the Banks so different to Searle's, what did CCL date and how?

Searle (1984) provides three radiocarbon dates for Parmelia Bank and one radiocarbon date from the centre of Success Bank. From these dates Searle (1984) estimated that Parmelia Bank started forming approximately 4,000 years ago, while Success Bank was initiated approximately 2,500 years ago.

As part of the EMP study, a total of 9 samples from Success Bank were submitted for radiocarbon dating. These included:

- Five (5) samples taken from various depths within Success Bank. Samples were sieved (1 mm sieve) and then hand-picked to select fresh coarse shell fragments which showed no signs of reworking or surface cement. These were selected to represent recent production.

- Three (3) bulk samples, unsorted. These would be a combination of Holocene and Pleistocene material and

- One (1) sample of a large mollusc shell, later identified as *Eucrasatella decipiens*. This large mollusc has been found in sandy areas between Perth and Rottnest Island. However, live samples of this mollusc have not been found on Success Bank.

The radiocarbon dates obtained from these samples respectively were:

- in the range 980 to 7410 BP
- in the range 6200 to 14000 BP
- 540 BP

From these results it has been interpreted that Success Bank started forming about 6,000 to 5,000 years ago, and has been progressively built, reaching a depth of 9m below the surface by the year 2900BP. This study has not undertaken any additional dating of Parmelia Bank as suitable samples do not presently exist for this area.

The presence of significant numbers of recently formed *Eucrasatella decipiens* shells in Success Bank and the lack of live samples of this mollusc would indicate that either the nature of the habitat of Success Bank has changed over the last 550 years, or else recent biogenic carbonate material is being transported on to the Banks.

4.2.3 *Sedimentology study of France (1977), Searle (1984) and Semeniuk and Searle (1985) were based on: samples from undisturbed vibro-cores, thin-section petrology, and chemical and grain-size results from wash bores put down by Cockburn Cement. The methodology of the Cockburn Cement study is not given, but unless the samples were firstly derived from unwashed and undisturbed samples and secondly analysed by detailed thin section petrography by a competent carbonate petrologist then the results must be considered to be secondary to the results procured by France, Semeniuk and Searle.*

The samples described in the EMP study were obtained by Dames & Moore using a rotary wash-boring technique. The boreholes were cased and advanced in 1.5 m lengths and downhole sampling was performed using a driven tube sampler at 1.5 m intervals. Care was taken during the advancement of the casing to ensure minimal disturbance of the underlying sediments. In addition, the topmost section of sample retained in the tube sampler was discarded. Following extrusion from the downhole sample, the collected samples were bagged. This technique prevented any winnowing of the finer fraction of the sediments; however, it is likely that the impact of driving of the downhole sampler would destroy any fine scale stratigraphic features.

These samples were subjected to grain size analysis (mechanical sieving), chemical composition analysis (XRF analysis) and grain characterisation using a binocular microscope. The binocular microscope examination was conducted as a preliminary examination of the sediments and one of the major recommendations of the draft sedimentology report was that further more detailed thin-section petrographic work be conducted, to be undertaken by a recognised carbonate petrologist.

4.2.4 *Instead of a "limited range of particle types" the sediment particles ... reflect the diverse flora and fauna of the carbonate producing organisms from on and within the seagrass meadows.*

The reference to a "limited range of particle types" was used in a general sense and reflects the use by Searle (1984) in which he notes that "the banks are composed of a relatively small range of particle types: lithoskels, lithoclasts, detrital quartz and skeletal fragments."

4.2.5 *Instead of a "uniform internal structure" the banks exhibit large scale composition variations and smaller scale, but not pronounced variations in concentrations of different shell components.*

The full quote was "*relatively* uniform internal structure" (CER, p 24) and this comment reflects previous work by Semeniuk and Searle (1985) in which they refer to the Becher Sand unit as "predominantly of homogenous to bioturbated sand and muddy sand" (p. 109) and a "structureless unit (related to seagrass systems)" (p 113).

4.2.6 *Submarine sediment bodies dominated by physical processes tend to extend laterally in the direction of the dominant sediment transport vector. It is difficult to construct a mechanism by which sediment transport into the growth locus of the bank would produce a body that grows principally by shoaling rather than lateral extension.*

We consider that the Success and Parmelia Banks represent incipient tombolo features which have developed in the lee of high points, such as islands in the offshore reef chain, such as Straggler Rock and Mewstone (Success Bank) and Carnac Island (Parmelia Bank). Wave interactions in the lee of these features result in reduced wave energy which promotes sedimentation and the development of tombolos (Carter, 1988). Both France (1977) and Searle (1984) recognise that Success and Parmelia Banks are controlled by the prevailing wave regime and their accretion is primarily controlled by wave refraction patterns in the lee of the reef chain.

4.3 WAVE CLIMATE, SEDIMENT TRANSPORT AND SEDIMENT BUDGET

4.3.1 *Their findings are inconclusive at this stage though they suggest that there may be "a causal relationship between the configuration of the access channel to the Cockburn Cement Jetty that was dredged in the 1970's and the localised erosion which occurred at the southwestern end of Quarantine Beach that occurred at the same time".*

Cockburn and its Consultants have developed an investigation programme to thoroughly examine this issue. The work is scheduled to commence later this year and includes comprehensive hydrographic surveys, detailed computer modelling of the nearshore swell patterns before and after dredging the access channel, and a coastal engineering assessment of the effects of the access channel on the adjacent beach.

4.3.2 *We believe that the whole exercise conducted by Cockburn on Owen Anchorage is a red herring and the findings are not of any value when the concern, as is clearly indicated by the advice from the EPA to the Premier, is the effects of changes in wave climate on Cockburn Sound from the dredging.*

The detailed investigation into the effects of the proposed dredging on the wave climate covered both Owen Anchorage and Cockburn Sound. The issue of the changes to the wave climate and its effect on shipping in the area was outlined in detail in Section 5.2.2.4 Navigation on page 42 of the CER. Table 5.1 provides the results of the predicted changes in swell wave conditions for a number of locations. The last two locations are in Cockburn Sound and indicate negligible change after the dredging. In addition, Cockburn and its Consultants have discussed the issue of the effects of the dredging on shipping with officers of the Fremantle Port Authority at the start of the investigations and during the course of the work. At the completion

of the wave study, a formal presentation of the work and the results was made to the CEO, the Harbour Master, the Shipping Services Manager and the Planning Manager of the FPA. Cockburn was led to believe that the FPA was satisfied with the detail of the work and was not concerned at the minor changes to the wave climate that would result from the proposed dredging. The FPA has had further opportunity to assess the predicted changes to the wave climate in Owen Anchorage and Cockburn Sound in its comments on the CER.

4.3.3 *Fig 4.1 clearly shows the shoreline south of the old power station as eroded. This contradicts the statement that " the shoreline is quite stable or accreting' with " no areas experiencing long-term erosion". Which is correct?*

Figure 4.1 of the CER shows the change in the position of the shoreline of Owen Anchorage between 1942 and 1994. During the period from 1942 to the 1970s, the area immediately to the south of the old South Fremantle Power Station did erode. This was mainly due to effects of the cooling water pond for the power station. The pond kept silting up (ie accreting) and to overcome this problem the pond was periodically extended seaward by means of a groyne. This interrupted the feed of sand from the Catherine Point area to the beaches to the south and caused the observed localised erosion. Cockburn's investigations also show that since the 1970s, beaches to the south of the power station have been accreting, hence the statement that there is no long-term erosion.

4.3.4 *Recolonisation of east Success bank probably reflects the effect of the dredged channel trapping onshore moving sand. Eventually this lack of feeding to the coast will be reflected in shoreline erosion. What does CCL think of this?*

Cockburn and its Consultants are not able to offer a good explanation for this recolonisation, but are doubtful that the recolonisation of the eastern section of Success Bank was caused solely by the dredging of the Fremantle Port Authority's shipping channel. This channel was originally dredged prior to 1944. Consequently, patterns of sediment transport in the early 1970's would have been similar to the recolonised seagrass meadows since the 1970's.

The eastern portion of Success Bank contains roughly 50 million m^3 of sand and there is clear evidence that sand is being moved through seagrass present in the area and onshore. At the present rates, it would take in the order of 1,000 years for sand of equivalent volume to that contained in the eastern portion of Success Bank to be moved to the shores of Owen Anchorage. This would cause significant accretion and the shoreline of Owen Anchorage would move to the west. Eventually, the shore would probably not continue to accrete at the present rates, but this does not mean that they would erode. They would more likely become dynamically stable at a position that is further west than present.

4.3.5 *The wave climate study (MP Rogers & Associates, 1996) is used to downplay the importance of seagrass meadows in altering bottom shear velocities in the Success Bank Region (7.2: Executive Summary). But, the resolution of the wave climate study is either 1000m or 250m depending on the geographical extent used in their model. These scales of resolution are greater than the influence, and the size, of many of the seagrass meadows across the study area. In a similar way, the results*

from the dredging slopes study and the sedimentology study are used to downplay the role of seagrasses on Success Bank and the impact of dredging on existing seagrass meadows.

The wave model uses a range of scales to cover a wide geographic area. The model also uses quite different bottom friction factors to represent the seagrass meadows compared to bare sand areas. The results have been verified by directional wave measurements taken on the eastern side of Success Bank and hence, Cockburn, its Consultants and peer reviewers are satisfied with the model performance and its suitability for the work. The wave model results and a number of wave measurement programmes have all shown that the Garden Island Ridge causes large attenuation of the offshore waves as they travel into Owen Anchorage. The seagrass meadows further attenuate the waves and this is explicitly included in the wave model. The role of the seagrass meadows in attenuating the incoming waves is not downplayed in any way, it is merely put into perspective.

4.4 *IN SITU* CARBONATE PRODUCTION

4.4.1 Background

Seagrass meadows are home to a variety of organisms that produce calcium carbonate. Carbonate producing organisms also occur in reef areas, seaweeds and bare sand. Determining the rates of calcium carbonate production from these environments enables a determination of their relative contribution to sediment accumulation to be made.

The measurement of carbonate production is normally undertaken either (1) directly, via biological surveys of the organisms producing the carbonate; or (2) indirectly, by measuring changes in alkalinity in the water column caused by the removal of carbonate from solution.

For this EMP study, the method of direct measurement was employed. Carbonate production rates have now been measured on Success Bank across a range of seagrass types as well as in bare sand.

Using these rates of carbonate production, and combining these with as knowledge of Bank growth rates and with areas of the Bank covered by seagrasses, it is possible to estimate the contribution of *in situ* production of carbonate to the total volume of the banks.

These estimates indicate *in situ* carbonate production accounts for only about 10% of this bank volume. Further preliminary petrographic evidence from sediment analysis indicates that approximately 50% of the banks material is Pleistocene (greater than 10,000 years old), with 50% of the Banks of Holocene (less than 10,000 years old). The question that we now face is: What is the source of this unaccounted Holocene production?

The potential sources for this 'unaccounted' Holocene material are:

- estimates of *in situ* carbonate production rates are too low, and
- external sources of Holocene carbonate material exist, such as from animal production from the reef system as well as offshore seagrass areas.

Evidence gained to date from direct measurements of carbonate production rates as well as comparison with national and international literature does not support the first of these options. *In situ* production rates will continue to be measured to cover full seasonal ranges, and in addition, detailed petrographic analysis of sediment samples will be undertaken to assess the sediment characteristics to further characterise the origin of recent carbonate material.

4.4.2 *Why is 9 m the cut off point for in situ seagrass contribution?*

Below a depth of approximately 9 m light attenuation through the water column limits the development of dense seagrass meadows in local waters.

4.4.3 *If the seagrass meadows contribute so little to the carbonate content as to be basically insignificant, why then must dredging on seagrass meadows be of the utmost importance to CCL?*

Presently, Cockburn's dredging programme is primarily dictated by the requirement for access to appropriate quality shellsand. This is found both outside of areas covered by seagrasses as well as within, as seen on Success Bank. Further, there are areas of Parmelia Bank, for example, that are covered by seagrass but where shellsand quality is too low.

The EMP studies have never indicated that '*in situ*' carbonate production is irrelevant. Rather, the objective of the EMP studies is to actually measure rates of '*in situ*' carbonate production and to relate these to the rates of Bank formation.

4.4.4 *Examination under a simple binocular microscope would not permit identification of sediment components to indicate the significant role of seagrasses on the bank evolution and sedimentology*

The binocular microscope analysis provided an appropriate means for the preliminary examination of the sediment characteristics. The limitations of this technique have always been recognised and hence a major recommendation of the draft sedimentology report was that further work be carried out to distinguish the carbonate grain types by a carbonate specialist using thin-section petrographic analysis. A recognised carbonate petrologist has been approached to complete this analysis.

4.4.5 *As discussed previously the type of data collected by Cockburn Cement to date does not provide the information necessary to interpret the sedimentology of the bank sequences. Grain size and chemical composition are gross indicators. The previous studies alluded to here presumably France (1977), Searle (1984) and Semeniuk and Searle (1985), are based on a much higher standard of petrographic analysis, and a broader appreciation of the processes involved than is exhibited in this CER.*

See response to 4.4.4

4.4.6 *The Cockburn Sound study referred to here has not at this stage satisfactorily completed petrographic analysis of a standard that would be able to identify the skeletal components of the bank sediments sufficiently to identify their origin. The conclusions from this study of the sedimentology of Parmelia and Success Banks reported in this CER are principally:*

- *seagrasses have not contributed significantly to the bank sediment budget;*
- *seagrasses do not physically influence the physical processes of sedimentation;*
- *seagrasses have played no significant role in bank evolution.*

These conclusions are inconsistent with a multi disciplinary range of local and international literature. The CER conclusions are based on inadequate petrographic studies, unsubstantiated radiocarbon dating, and misinterpretation of sedimentary processes in and around seagrass meadows. The carbonate sediment production figures quoted for the study are from unpublished data, and no methodology is given here. In Table 5.3 which reports estimates of inorganic carbon production from the literature is selective and does not quote other estimates closer to the figure of Searle (1984). Other references are misleading because they refer to situations that are not relevant to the situation in Cockburn Sound in terms of sedimentologic setting or biological equivalence.

The area of interest for this dredging proposal is Owen Anchorage, not Cockburn Sound.

The radiocarbon dating has been properly substantiated, while the measurements of *in situ* carbonate production are to our knowledge, among the most detailed undertaken internationally. In addition, carbonate production rates measured here are not dissimilar to those measured elsewhere in seagrasses. It is acknowledged that further petrographic studies are needed.

Interpretations in the CER were based on these measurements. It is still the view of the study team that physical forces are dominant in controlling the processes of bank evolution and sediment distribution.

Finally the literature review undertaken on carbonate production rates has been extremely detailed, and will be maintained. It has included on-line searches of several databases including GEOPAC, GeoRef, Biological Abstracts and the Aquatic Plant Information Retrieval System. In addition, information has also been received from the SEAGRASS_FORUM, an international Internet listserver group. Consultation with researchers in the field has also enabled several unpublished manuscripts of recent research findings to be examined. All new information will be used to expand this literature review.

4.4.7 *Pending presentation of acceptable petrographic data the only evidence presented in the CER for the contention that 95% of the bank sediments are derived from the Garden Island Ridge are estimates of carbonate production presented from unpublished and unreviewed data. The methodology used is not presented and cannot therefore be commented on. Table 5.3 includes data by the same researchers*

in Shark Bay Western Australia using supposedly the same direct measurement technique. The epiphyte production of 35 to 500 g/m^2/year quoted is much less that the conservative estimate of 1.7 kg/m^2/year that can be calculated from the stratigraphic data presented by Davies (1970) for banks developed under seagrass cover in the same area. The figures for coral reefs are in the lower part of the spectrum for coral reefs which range from 2 to 10 kg/m^2/year. Another critical factor may well be density of the meadow and the species. Available substrates in a dense Posidonia meadow are many times greater in area than for even a moderate density Amphibolis meadow.

The contention that 95% of the Bank sediments are derived from the Garden Island Ridge is not made in the CER. What is stated is: "conservative calculations (that take the highest value for calcium carbonate production by seagrass biota in the study area, and assume both Parmelia and Success Banks are entirely covered by dense seagrass) indicate that seagrass meadows would have contributed less than 5% of bank sediments during the formation of the banks" (CER, p 47–48). This estimate was based on the available direct measurements of macro-invertebrate and epiphyte calcium carbonate production. Further data is being collected and this estimate will be revised accordingly (see section 4.4.1 of this response). The remaining (not produced *in situ*) sediment forming the Banks may have been derived from several sources, including production of carbonate from seagrass meadows outside of the study area, erosion of the Tamala Limestone, production of carbonate on the offshore Islands and reefs and delivery of sediment from rivers.

The calcium carbonate production rates were determined using replicate direct measurements of both macro-invertebrates and epiphytes. The production rates were based on calcium carbonate standing stocks, production/biomass ratios, leaf area and leaf turnover rates. The complete details of the methods used are available on request and they will be presented in a peer reviewed report.

The $CaCO_3$ rates presented by Walker and Woelkerling (1988) were determined using three independent methods of measurement: standing stock estimates, leaf accumulation data and alkalinity calculations. The range quoted in the table (35–500 g/m^2/yr) was taken across all three techniques and these rates compared well with the rates obtained by Smith and Atkinson (1983) of 3.2 mmol m^{-2} d^{-1} (117 g/m^2/yr) using the alkalinity technique. Walker and Woelkerling (1988) combined their data with that of Smith and Atkinson (1983) to estimate that the epiphytic calcium carbonate production may account for approximately 70% of the total calcification in Shark Bay. Details on how the estimate of 1.7 kg/m^2/year was derived from Davies (1970) data, are not available

Rates of calcium carbonate productivity up to 10 kg/m^2/year have been determined for the fast growing edge of coral reefs however, these edges are estimated to occupy only 1–2% of the whole reef system (Barnes et al., 1986). Barnes et al., (1986) note that the reef flat has a calcium carbonate production ranging from 4 to 5 kg/m2/yr and these environments occupy 4–8% of the whole reef system and the majority of the whole reef environment (90 to 95%) has a calcium carbonate production ranging from 500 to 1000 g/m^2/yr (Barnes et al., 1986).

The crux of the matter appears to be that rates of calcium carbonate production in seagrasses will be dependent on seagrass plant density, seagrass species, and most importantly epiphyte load. For example, the leaf area of *Posidonia coriacea* is substantially greater than for *Amphibolis griffithii*, but epiphyte loads on *Amphibolis griffithii* are generally greater. Hence, the contribution of epiphytes to calcium carbonate production is dependent on the leaf area, the turnover times of the leaves, colonisation rates of the epiphytes and turnover rates of the epiphytes.

4.5 BINDING AND TRAPPING OF SEDIMENTS

4.5.1 The CER concludes in several places that seagrasses do not play a significant role in sedimentation processes on the banks and that sediments are transported through the meadows towards the shoreline. This is in contrast to EPA Bulletin 739 and a large body of international and Australian literature.

Examination of the sediment characteristics within areas of varying seagrass coverage in this area do not show any significant difference in sediment characteristics (grain size analysis or chemical composition). This has been interpreted to indicate that the seagrasses on Success Bank do not play the dominant role in controlling sediment distribution on the banks, and that physical forces prevail.

There is indeed a vast literature on the role of seagrasses in modifying the near-bottom current velocity structure (summarised most recently in Verduin and Backhaus, In press) and it is widely acknowledged that bottom vegetation has an effect on water flow. For example, many studies of the effects of seagrasses in modifying the near-bed current profile have been conducted under uni-directional currents to simulate tidal currents, using flume tests on seagrass species with elongated blade-like or cylindrical leaves such as *Zostera marina*, *Thalassia testudinum*, *Syringodium filiforme* and *Halodule wrightii* (Verduin and Backhaus, In press).

One further comment needs to be made at this stage. The public responses to the CER on the role of binding and trapping of sediment assume 'dense' meadows of seagrass occur on Success Bank. This is not the case. Individual plants and clumps of plants especially of *Posidonia coriacea* are well separated. This is shown in plates 1A and 1B, taken in an area classed as a dense *Posidonia coriacea* meadow. In the photograph, 2 important features are seen:

- very localised influence on sediment transport patterns of erosion and accretion around stems of plants;
- ripple marks showing influence of wave induced motion of sand through the seagrass.

Amphibolis griffithii on Success Bank can occur in dense meadows in terms of canopy cover (75-100% cover), but again, considerable area of sand patches occur between individual plants. Verduin and Backhaus (in press) have measured strong oscillatory currents in open meadows like this.

4.5.2 *There is no evidence in the CER that supports the contention that "seagrasses play a minor role in the accumulation and stabilisation of sediments". There is a diverse and voluminous body of scientific literature to the contrary. The question that the proponents investigations should be investigating is whether or not the trapping and binding effects of the seagrasses are relevant to the management of the proposed environmental impact.*

See response to 4.5.1.

4.5.3 *The lack of correlation between dredging on the Bank top and the stability of the adjacent shoreline is strong evidence for a lack of sediment supply from much of the Bank top to the adjacent shore. In Figure 4.2 the arrows representing sediment transport across the bank tops would appear to be inconsistent with this conclusion. It would be more realistic to have exchanges between the shallow sublittoral sand sheet and the beach rather than having to move sediment shorewards through the seagrass meadow.*

The total volume of the Bank is considerably greater than the volume removed by dredging and this minor reduction in Bank volume would not be expected to be reflected in the stability of the shoreline. It should also be noted that the shoreline is approximately 4 km from the dredged region and there is a substantial area of bank top between the dredge area and the shoreline from which sediment may be exchanged with the shore. Sediment movement (reflected in bed level changes and sand waves) throughout seagrass meadows (*Amphibolis griffithii*) has been documented by Walker et al. (1996) in Warnbro Sound. Walker et al (1996) conclude that "the paradigms for the role seagrasses play in coastal processes, and which have been derived from tidal-dominated systems are not applicable to southwestern Australian seagrasses, and further work is required to understand these processes more fully" (p. 121).

4.5.4 *The statement that "wave action is believed to have a strong influence on the movement of sand across the bank tops", has a major practical problem. Movement of sand across mobile unvegetated portions of the bank top is possible under the combined action of wave and current energy moving shorewards. However, the movement of sediment through areas of dense seagrass meadow is not likely, except for wrack borne epibionts and suspended particulates. There is ample laboratory (eg Scoffin, 1970) and field observational data (eg Ball et. al., 1967; Davies, 1970; Wayne, 1976) to demonstrate that under unidirectional and oscillatory currents that dense seagrass meadows are extremely resistant to disruption and sediment winnowing from the substrate.*

See response to 4.5.1 and 4.5.2 and Plate 1. The study by Walker et al. (1996) clearly indicates sediment movement occurs beneath meadows of 100% *Amphibolis griffithii* in Warnbro Sound.

4.5.5 *The statement that "historical surveys show that the dredging on Success Bank by Cockburn since 1987 has not affected the stability of the beaches" is consistent with a lack of transport across the bank top seagrass meadows as discussed above.*

See response to 4.3.5 and 4.3.7.

4.5.6 How can material be trapped and rapidly transported?

We recognise that during relatively calm conditions the influence of the seagrass meadow on the near bed currents may cause the preferential trapping of sediment in the immediate vicinity of the plant. Under more energetic conditions it appears that sediment is transported through the meadow areas.

The importance of *Posidonia australis* and *Posidonia sinuosa* seagrass meadows in trapping and stabilising sediments in local sheltered, coastal waters is not questioned. These seagrasses are large, vigorous species that form extremely dense canopies, and that have extensive underground rhizome systems. However on Success Bank the main meadow forming species of seagrass are *Amphibolis griffithii* and *Posidonia coriacea*, and it is their ability to stabilise sediments in the characteristic wave climate of the study area that is doubted. *Amphibolis griffithii* forms dense canopies, but its structure (clusters of leaves borne on the end of woody stems) is such that at the seabed surface the individual plants are widely spaced, unlike *Posidonia australis* and *Posidonia sinuosa,* where plant density can be in the thousands per square metre. The meadows of *Posidonia coriacea* exist as isolated clumps of seagrass separated by bare sand.

The majority of seagrass research demonstrating the ability of seagrasses to stabilise sediments talks about how seagrasses are readily bent over by currents to form a dense intermeshed layer. This research involved seagrasses of similar structure and leaf density to *Posidonia australis* and *Posidonia sinuosa* (although somewhat smaller leaves), and was carried out under conditions of unidirectional water movement, ie. currents (in estuaries or sheltered embayments). In Perth's local coastal waters there are swell waves and water movement is orbital not unidirectional: seagrass canopies do not bend over to form a dense, intermeshed layer, on the contrary they are constantly being tossed from side to side. The swell waves are also very effective at suspending sediment (p. 27 of CER), thus with the passage of each swell wave there is a sequence of sediment suspension and settling out, with the settling out occurring slightly downstream from where it was suspended.

The more limited role of seagrasses on Success Bank in stabilising sediments does not contradict previous research by scientific experts because of:

- the difference in species of seagrasses involved with differences in plant density, canopy structure, meadow structure and amount of below ground rhizome material; and

- the high energy hydrodynamic regime on Success Bank, dominated by wave energy.

4.5.7 If the eroding reefs were (and presumably still are) the major contributors to carbonate sediment and the Mewstone area is considered to be the most significant contributor to the carbonate content what possible argument, other than dredge modification costs and increased distance for the barges, prevents them from dredging on the bare (and available) ground around the Mewstones?

The calcium carbonate grade varies throughout the area due to the combined influence of hydrodynamic processes on sediment transport and production of calcium carbonate within the seagrass meadows. It was stated in the CER that although the average grade of material in the Mewstone area is less than 92%, there are pockets with calcium carbonate grades of 92% or greater. These high grade shellsands are overlain and interleaved by low grade sands and would require extremely close control of the dredging operation for their selective extraction. Thus, dredging in the Mewstone area would require (in addition to dredge modification) the development of suitable beneficiation process, and environmental approval.

4.5.8 *Macroscale numerical modelling may indicate a potential for sediment movement uniformly across the bank top, but metre to centimetre scale baffling effects beneath dense seagrass canopy will ensure little sediment passes shorewards through the dense meadow.*

See response to 4.5.1

4.5.9 *The conclusion that any sediment trapped within the meadow is rapidly transported shorewards is not sustainable. There is an error in logic to reach this conclusion solely from the consistency in sediment composition between seagrass meadows and bare sand. Within the meadow areas the contemporary supply of sediment to sand areas is the exposed bank, and if the bank has been generated largely from sediments derived from organisms living in and around the meadow then it is only to be expected that there should be little difference. A difference will occur when there is a different source feeding the system. A simple local illustration of this is the accumulation of fine alumina in meadow patches near the Alcoa loading facility in Cockburn Sound. Levels of alumina in the meadows are typically several times greater than levels in the surrounding bare sand.*

The following logic has been used to suggest that the seagrasses in the study area are not operating as effective trapping mechanisms. If seagrasses are more effective at trapping sediment over the long term than bare sand areas then it can be expected that the seagrass meadows will have (1) a greater proportion of finer sediments than the bare sand areas (due to the baffling effect of the leaves causing lower current velocities at the bed); and (2) a higher proportion of calcium carbonate (since the seagrass meadows have a higher calcium carbonate production rate than the bare sand areas and are assumed to be trapping this sediment). One does not require an extraneous feed source to support this logic. This logic underpins several other studies (eg Scoffin, 1970; Fonseca et al., 1983; Walker et al., 1996). However, in the present study area, the sedimentologic data did not indicate a significant (or consistent) difference between bare sand and seagrass meadows.

The evidence of increased fine alumina in the seagrass meadows that was obtained from Cockburn Sound is not unreasonable. It is an area which is considerably more sheltered than the present study area, and supports a different array of seagrass species.

4.5.10 *It is our understanding that the removal of seagrass brings with it issues of seabed stability which may threaten the surrounding shipping lanes, coastlines, etc.*

There are a number of matters to be addressed in responding this statement. First, in areas where dredging has occurred, monitoring has shown that dredge slopes stabilise rapidly, with minor modification at the top edge of the dredge slope. Evidence of this stability can be gained from the FPA shipping channel itself which has been in place for more than 50 years with no signs of instability.

Second, there is ample evidence that sediment is able to be transported through the meadows on Success Bank, including *Posidonia coriacea* meadows classed as dense (see Plate 1). In addition, the evidence is also become more convincing that substantial colonisation of the eastern portion of Success Bank has occurred since 1961, which is after the construction of the FPA shipping channel, and during the dredging programme of Cockburn Cement.

4.6 ADDITIONAL INVESTIGATIONS TO BE CONDUCTED

The draft report on the sedimentology of the Banks that was produced in 1995 recognised that several of the conclusions that were reached required testing with further investigations. These are presently being undertaken and are at various stages of completion. These include:

- Continued improvement of the estimates of the contribution of biogenic sediments to the Banks, by direct measurements of calcium carbonate production of organisms from a range of habitats in the Owen Anchorage area.
- Additional field sampling to determine the sediment characteristics across a range of seagrass species and coverages and bare sand environments to further examine any sedimentological differences between these environments.
- Further examination of the contribution of recently deposited carbonate grains to the development of the Bank to distinguish the carbonate grain origins and types. This work will be conducted by a carbonate specialist and may include thin-section analysis.
- Additional dating of sediments as samples become available to further understand the development history of the Banks. This dating will be conducted on carbonate particles which have been carefully selected to be contemporaneous with the development of the Banks.

Interim reports on each of these investigations will be prepared.

5 BIOLOGICAL SIGNIFICANCE OF SEAGRASSES, CHANGES IN SEAGRASS COVER, RELEVANCE OF SEAGRASSES TO FISHERIES, AND SEAGRASS REHABILITATION

A number of responses to the CER addressed the general topic of seagrass ecology. Specific issues that were raised are addressed below. A detailed and very valuable submission was provided by the Australian Marine Sciences Association (AMSA) that emphasised the importance of establishing the relationship between seagrasses and fisheries.

5.1 ECOLOGICAL SIGNIFICANCE AND RELEVANCE TO FISHERIES

5.1.1 The seagrass meadows across Success Bank are unique in being predominantly Posidonia coriacea and Amphibolis griffithii. Any downplaying of the importance of this seagrass resource so close to Perth should be met with scepticism from the regulatory authorities.

Large meadows of varying degrees of cover of *Amphibolis griffithii* are present along the Perth metropolitan coast in Warnbro Sound, Shoalwater Bay, Parmelia Bank, Success Bank, Marmion Lagoon and around Rottnest Island. In a more general geographic sense, *Amphibolis griffithii* meadows are found along the coast from Champion Bay in Western Australia (latitude 29°S) around to the South Australian coast. In local coastal waters *Posidonia coriacea* is found on Parmelia Bank and Success Bank, and the deeper waters off Swanbourne and in Marmion and Whitfords Lagoons. The geographic range of *Posidonia coriacea* is from Shark Bay (latitude 25°S) to the Victorian coast. The characteristically sparse, patchy meadows of *Posidonia coriacea* are less conspicuous than *Amphibolis griffithii* meadows, and along the coasts of W.A. and S.A. they tend to occur wherever reefs or islands give local protection from oceanic swell (such as on Success Bank) or at depths sufficient to reduce wave energy (such as in Marmion and Whitfords Lagoons). The meadows of these two species on Success Bank are therefore not a unique habitat.

There are six major sand banks in local metropolitan waters; Becher Bank, Rockingham Bank, Parmelia Bank, Success Bank, Fairway Bank (off Fremantle) and Lal Bank. These banks are of differing geological ages and have different types of seagrass meadows that presumably reflect changes in hydrodynamics (as the banks grow) and seagrass successional patterns. A feature that distinguishes Success Bank (although little is known about Becher Bank or Fairway Bank) is the south to north gradation of meadow types from patchy *Posidonia coriacea* meadows, to mixed *Posidonia coriacea* and *Amphibolis griffithii* meadows to continuous dense *Amphibolis griffithii* meadows. EMP studies currently underway indicate that there is a sequence of initial colonisation by *Posidonia coriacea*, followed by increased cover of *Posidonia coriacea,* recruitment of *Amphibolis griffithii* into the meadows of *Posidonia coriacea,* and finally development of continuous *Amphibolis griffithii* meadows. A large proportion of the seagrass meadows on eastern Success Bank is also a relatively recent feature (i.e. within the last 30 years). The inference is that the *Posidonia coriacea* meadows may be a transient feature that ultimately becomes *Amphibolis griffithii* meadows. In time, another seagrass species may well move into the *Amphibolis griffithii* meadows, producing a mosaic of meadows similar to that of parts of Parmelia Bank.

The dynamics that govern the meadows of Success Bank are also being studied as part of the EMP. However the loss of seagrass meadows from the medium term dredging area is unlikely to affect the ecological functioning of the study area, or the successional processes currently operating west of the FPA Channel or east of the Second Shipping Channel.

Since patches of *Posidonia coriacea*, patches of mixed *Posidonia coriacea* and *Amphibolis griffithii* and patches of *Amphibolis griffithii* also occur in the waters off

Swanbourne and in Whitfords Lagoon, it is extremely unlikely that Success Bank is the only place in Perth metropolitan waters where these successional processes are taking place.

5.1.2 *What impact does degrading wrack have on the enclosing water body and adjacent habitats? What is the impact of this wrack not travelling to where it did before the holes were dug?*

Wrack accumulates in deeper areas such as the basins of Owen Anchorage and Cockburn Sound and dredged areas, and, particularly in winter, it accumulates along the shore. Wrack can also accumulate in seagrass meadows. Large amounts of wrack have been observed in the Cockburn Sound and Owen Anchorage basins and the FPA shipping channel, and in shallow waters around Woodman's Point. The wrack in the deeper areas includes large amounts of reef kelp, whereas the nearshore material is dominated more by seagrass. The decomposing wrack supports detrital foodwebs and is also believed to provide temporary shelter to some organisms; the nearshore accumulations are believed to be important for juvenile fish. The wrack that remains in seagrass meadows is believed to be largely recycled to support the ongoing growth of the seagrass themselves.

Within the study area much of reef wrack material and the seagrass wrack generated by meadows west of the FPA shipping channel is probably trapped by the Owen Anchorage basin and the shipping channels. The sources of wrack for these areas will not be changed by the medium-term dredging. Seagrass wrack generated in meadows east of the shipping channels probably ends up as nearshore accumulations in winter. The loss of seagrass due to shellsand dredging may result in a slight decrease in the amount of seagrass material from eastern Success Bank that accumulates in the nearshore areas. The creation of more dredged areas may also result in less reef algae and less seagrass material from western Success Bank finding its way to shore (since a greater area of deep habitat is available for it to accumulate in). Overall these changes are unlikely to be measurable because of the proportionately small areas involved, particularly in view of a recent review by CSIRO (Kendrick et al, 1995) which indicates that in local coastal waters the source of wrack in any stretch of coast is likely to extend well beyond the immediate area. It should also be borne in mind that aerial photography extending back to the 1960's shows that the development of some large areas of dense seagrass meadows on eastern Success Bank is a relatively recent event, and therefore that even with losses due to shellsand dredging, the amount of seagrass wrack from this area in nearshore accumulations may have actually increased in the last 30 years.

5.1.3 *The nearshore wrack is recognised as an important habitat for juvenile fish. Elsewhere CCL say wrack will accumulate in dredged holes. What impact will this have on juvenile fish?*

See comments in 5.1.1

5.1.4 *Loss of seagrass will have a significant environmental impact.*

In terms of the overall ecological functioning of the study area, the changes in the area occupied by the main types of habitat due to shellsand dredging in the medium-

term area are: shallow unvegetated habitat from 38% of the study area to 37%; deep unvegetated habitat from 30% to 32%; known seagrass meadows from 22% to 21%; and unconfirmed seagrass/reef remains unchanged at 10%. Thus the relative changes in area of habitat type available for biota are minor, particularly compared to the radical changes in seagrass cover density that have taken place since 1961 (see section 5.2). The changes in the primary production of the area, due to shellsand dredging, are also minor, and the impact on detrital food webs may be even less if - as appears to be the case - they are also supported by reef algae (see also 5.1.1). Under these circumstances it will be difficult to measure any environmental impact due to dredging unless there are major changes in the hydrodynamics that either influence remaining seagrass meadows or result in more wrack being lost from the area. The results of the hydrodynamic studies indicate that this will not occur.

5.1.5 *The last sentence in paragraph 2 of page 51 needs a lot of substantiating. Does it mean that there are no species endemic to these seagrass habitats?*

The sentence of the paragraph on p. 51 of the CER that is referred to above could be changed to read "It should also be noted that many of species of algae, invertebrates and fish that occur within seagrass meadows are also found on and in unvegetated areas and/or reef habitats".

5.1.6 *The final paragraph on P 51 shows that the writer has an unusual concept of a detrital food web. The detritus is broken down physically and by microbes which are fed upon by amphipods etc whose faecal pellets are then consumed by other invertebrates and small particles are used by filter feeders. Respiration removes carbon but production through detrital food web cannot be dismissed as simply as it is here.*

In the CER, it was not intended to deny the importance of detrital food chains, or argue a total dependence on algal carbon in seagrass meadows. The point that was intended was that higher order consumers (fish and larger crustaceans) are almost certainly supported more by algal carbon grazed by invertebrates than by seagrass carbon which passes through detrital food chains, particularly (as in the study area) seagrass and epiphyte production rates are similar. Grazing food chains involve fewer trophic steps to reach higher order consumers than detrital food chains, and given the efficiency in carbon transfer from one organism to another, it follows that a unit of grazed algal carbon will support a greater biomass of higher order consumers than the same unit of seagrass carbon. It should be noted that the relative importance of detrital and grazing food chains was not used in the assessment of the influence of shellsand dredging in the CER precisely because the proportions of carbon that are channelled through detrital versus grazing food chains in seagrass meadows are not accurately known. It was therefore deemed appropriate to deal in terms of total primary production generated in seagrass meadows (ie. seagrass, seagrass epiphyte, sand microflora and phytoplankton) versus total primary production generated in unvegetated areas (sand microflora and phytoplankton).

5.1.7 *Phytoplankton production is negligible per square meter of bottom surface compared with seagrass. This whole paragraph needs references so that the reader can determine for himself whether digging a big hole in the seagrass meadow "may actually slightly increase overall production in dredged areas."*

We acknowledge the misleading nature of this statement and would like to provide the following clarification.

It was not intended to suggest that phytoplankton production in dredged areas would exceed the total primary production (seagrasses, epiphytes, phytoplankton and benthic microflora) in a seagrass meadow. The word 'productivity' should have been deleted from the last sentence in paragraph 3 on p. 51, which should now read "Calculations have indicated that the primary production in areas with dense seagrass (which includes seagrass, seagrass epiphytes, sand microflora and phytoplankton production) is about double that in patchy meadows or unvegetated meadows of the same depth, however the production of phytoplankton may actually slightly increase overall in dredged areas due to the greater depth of water column available for them to inhabit." If the area to be dredged is seagrass meadow, then the total primary production will obviously decrease. Where the area to be dredged is unvegetated sand (as the majority of the medium-term dredge area is), then total primary production may increase slightly. Conservatively speaking, phytoplankton can probably maintain positive growth down to about depths of 15–20 m (ie. where 5% of surface irradiance is present).

Few studies in the world have compared the relative importance of the various primary producers in seagrass bed ecosystems, and those that do indicate that phytoplankton contribute 25–75% of the total primary production (eg. Moncrieff et al., 1992). There is still insufficient data to determine whether these coastal waters are different. Phytoplankton production in marine and estuarine ecosystems is generally in the range 100–500 g carbon per square metre per year, and recent research at CSIRO as part of the Water Corporation's Perth Long-term Ocean Outfall Monitoring (PLOOM) programme has indicated that although phytoplankton levels in local coastal waters are low, their productivity rates are surprisingly high. The importance of seagrass as a primary producer is not doubted, but the contribution to productivity by phytoplankton in local waters is unlikely to be negligible.

5.1.8 *Preliminary assessment has indicated that there is little loss of ecological significance. This assessment was done from estimates that were not site specific. Although a lot of work has been done on monospecific seagrass meadows Kirkman (1985) and Kirkman and Co (1990) have reported on multispecific seagrass meadows. It would be useful to find a site similar to Success Bank to use as a control.*

We agree that if suitable 'control' sites were available, these would be a great asset to this study. The only potentially useful sites for selecting a control are Parmelia Bank, which has been degraded on its south-side due to past nutrient enrichment, or the *Amphibolis* meadows of Warnbro Sound, which have a different hydrodynamic regime. Furthermore, a control for Success Bank is further complicated by the very dynamic nature of seagrass distribution on Success Bank. The seagrass coverage and species distribution on the eastern side of the bank today bear little relationship to 30 years ago, and over the same time span there has been a loss of seagrasses on the western side due to natural sand migration.

5.1.9 *Larval fish need to be investigated as far as seagrass meadows are supposed to be nursery areas for them. There is no investigation into the likelihood of Success and*

Parmelia Banks being supply areas of larval or juvenile fish or crustacea for Cockburn Sound. Those banks stretch across the northern end of Cockburn and may supply spores, larvae, seedlings, eggs, and juveniles to the Sound.

Given the canopy characteristics of these seagrass meadows and the hydrodynamics of the area (see 5.1.10) it would be as difficult to characterise the larval fish communities as the phytoplankton communities associated with seagrass meadows. The presence of juvenile fish (which will be measured) should be a better indication of the nursery importance because the larvae have actually survived and grown in the seagrass meadows.

The fauna within seagrass meadows are either resident or transient. Transient fauna include most of the fish, which arrive there as planktonic larvae spawned outside the seagrass meadows. Resident fauna include most of the invertebrates and a few fish, and the meadows would be a source of planktonic larvae for these species. The main source of epiphytic algae propagules is believed to be reefs. The closest sources of propagules for seagrass meadows of Cockburn Sound - which are largely at its southern end - are the seagrass meadows and reefs south of the causeway, the dense seagrass meadows at the north-eastern end of Garden Island, and the seagrass meadows of Parmelia Bank. Success Bank would have a lesser role. The planktonic larvae of many animals are long-lived, and therefore the seagrass meadows of Cockburn Sound probably received these larvae from a far larger range than the stretch of coast from Fremantle to Rockingham. Algal propagules are much shorter-lived, and the reefs to the south of the causeway and north of Garden Island are probably the main outside sources. Success Bank does appear to generate large amounts of *Posidonia coriacea* and *Amphibolis griffithii* seedlings, but their ability to survive and establish in Cockburn Sound is doubtful, due to the higher nutrient levels of Cockburn Sound waters.

5.1.10 *The seagrass meadows most likely to be permanently affected by further dredging in Cockburn Sound are Posidonia -- the slowest growing and most fragile seagrass, well identified as of the utmost importance for marine nurseries.*

Posidonia species are neither slow growing nor fragile. *Posidonia australis* and *Posidonia sinuosa* are slow to spread laterally and establish in sheltered waters which makes them more susceptible to the impacts of eutrophication. Success Bank has only a very small area of *Posidonia sinuosa* in deep waters (that will not be affected by shellsand dredging). The meadows affected by shellsand dredging are of patchy *Posidonia coriacea* or dense meadows of predominantly *Amphibolis griffithii*, which can tolerate more vigorous hydrodynamic conditions than *Posidonia australis* and *Posidonia sinuosa*. Both *Posidonia coriacea* and *Amphibolis griffithii* appear to be actively colonising Success Bank, and the latter species has also be found to colonise areas around Rottnest Island. The importance of *Posidonia coriacea* and *Amphibolis griffithii* meadows as nursery areas under the hydrodynamic conditions such as on Success Bank has yet to be established.

5.1.11 *Section 5.3.4 of the CER contains a number of generalisations which are not supported. In particular paragraph 3 on page 53 requires some further consideration. Paragraph 3 states " on the basis of information available, it is difficult to predict whether dredging of the medium-term resource will be deleterious*

to the or even beneficial to fisheries. This statement may or may not be correct but given the public significance of the issue the study should seek to collect that data required to make an informed and responsible judgement. In the absence of such data the question cannot be properly addresses and public concern will remain.

The importance of the study area to fisheries has not been documented, and therefore no technically defensible statement can be made concerning deleterious or beneficial impacts. Scientific data from adjacent areas in Western Australia and other temperate waters in Australia suggest there are few commercial species dependent on seagrass meadows. EMP studies should resolve these matters.

The public significance of the issue is recognised. The informed opinion of the EMP study team personnel is that the impact on fisheries in the Owen Anchorage and surrounding area will be negligible given the proportionately small changes in available habitat type, particularly considered against the changes in seagrass cover/density since 1961 (see Section 5.1.4).

5.1.12 *Section 7.3.2.6 on page 72 contains a statement that "the lack of commercially or recreational important species within a seagrass meadows is generally confirmed by the scientific data available". It would be most appropriate to say that there is not enough data to confirm the presence or absence of valued fish species in the seagrass beds. This Department was of the understanding that one of the original objectives of the study was to gain a better understanding of the relative importance of different species of seagrasses to the key commercial and recreational fish and crustacea. Again, this is a vital issue because existing public perception is that seagrass communities are vitally important to fisheries and must be protected.*

See Section 5.1.11

5.1.13 *The statement "initial sampling design has been approved by the Fisheries Department" is not entirely consistent with this Department's understanding of the situation.*

Studies undertaken during 1996 as part of the EMP were designed to determine appropriate techniques for sampling and analysis. The results of this pilot study work are being used to design the detailed sampling programme for phase 3 of this programme. This will only be undertaken with prior endorsement of the Fisheries Department of WA.

5.1.14 *It is considered that the CER does not provide sufficient detail on the impacts of the dredging and hence loss of seagrass on recreational fisheries within the study area. Given that recreational fishing is considered a beneficial use within the study area, and opportunities will be considered to exist to gain further detailed information on this impact, it is suggested that considerably more information on impacts associated with recreational fisheries should be incorporated into the CER.*

One of the objectives of the EMP studies is to gather sufficient information to address the matter of the association between seagrasses and recreational fisheries. This will then allow an assessment to be made of the proposed dredging plan.

This information does not presently exist in the study area.

5.2 CHANGES IN SEAGRASS COVER - MAPPING

5.2.1 Introduction

One of the EMP projects undertaken has been the mapping of seagrass within the study area. This was completed for 1995, using aerial photography that was rectified, and supported by underwater validation of the aerial photography. A map showing seagrass assemblages in the study area is produced as Figure 4.4 in the CER.

A second requirement of this mapping project was to determine changes in seagrass cover in the study area from 1971 to 1995, as Cockburn initially commenced dredging in the area (on Parmelia Bank) in 1971. Aerial photography from 1971 and 1972 was used to produce a seagrass distribution map for 1971. Seagrass distribution in 1971 was compared with that for 1995. A map showing where seagrass cover had remained unchanged or had increased or decreased, was provided as Figure 4.6 in the CER. This showed that seagrass cover had remained unchanged over large parts of Parmelia Bank and some parts of Success bank. In addition, the comparison showed that:

- seagrass density/cover has increased on
  - north west of Success Bank
  - eastern side of Success Bank

- seagrass density/cover had decreased on
  - centre of east Parmelia Bank
  - centre of west Success Bank
  - south of Fremantle.

The overall changes in areas covered by seagrasses on Parmelia Bank and Success Bank including the effects of dredging are shown in Table 5.1.

TABLE 5.1 SEAGRASS AREAS, OWEN ANCHORAGE, 1971 AND 1995 (HA)

LOCATION	1971	1995	CHANGE
Success Bank	978	1503	+525
Parmelia Bank	1004	866	-138
TOTAL	1982	2369	+387

These results were surprising as these changes (both increase and decrease) were not anticipated. Consequently, the seagrass mapping programme has been extended to review historical aerial photography for 1961, 1965, 1971, 1972, 1985, 1993, and 1995 to examine in more detail the observed changes. This work is being undertaken with all precision possible, and will be completed early in 1997. Preliminary indications are that seagrass cover/density over both Success and Parmelia Bank has changed radically between 1961 and 1995, and is consistent with the findings of the 1971/1995 comparison; that is, seagrass cover/density is increasing on the eastern side of Success Bank.. The report on this crucial work will be subject to full peer

review, and results will be presented at an international conference on remote sensing in the USA in March 1997.

A summary of the areas dredged on Success and Parmelia Banks, and estimates of the cumulative impact on bank top seagrass habitat in this area, is shown in Table 5.2.

TABLE 5.2 **DREDGED AREAS AND ESTIMATED LOSS OF SEAGRASS AREA, OWEN ANCHORAGE, TO 2001 (HA)**

LOCATION	PERIOD	AREA	
		TOTAL	SEAGRASS (>25%)
1. Completed			
Parmelia Bank: 2nd Channel	1971 - 1984	39	estimate 39
Success Bank: 2nd Channel	1984 - 1994	142	estimate 50
Success Bank: Short-term dredging	1994 - 1996	67	4
FPA Shipping Channel: Success Bank	last 50 years	71	estimate 35
FPA Shipping Channel: Parmelia Bank	last 50 years	54	estimate 50
TOTAL		373	174
2. Proposed			
Medium-term dredging	1997-2001	97	77

Note: Estimate of areas of loss of seagrass due to dredging provided in the final column are conservative (i.e. over estimated). These will be modified as further analysis of aerial photography is completed.

5.2.2 *Has the short-term dredging had an impact on adjacent seagrass meadows as shown in these figures?* [Note: Figures referred to in this question are areas of seagrass cover.]

An analysis of the areas covered by seagrass on Success Bank and Parmelia bank (see item 5.2.1 above) shows that:

- In 1995, the total area of seagrass on Success Bank is estimated to be 1503 ha with 866 ha on Parmelia Bank
- Between 1971 to 1995, the area covered by seagrass on Success Bank increased by 525 ha. This included a loss of 54 ha due to shellsand dredging. Losses of approximately 35 ha of seagrass due to the construction of the FPA shipping channel were incurred before 1971.
- Between 1971 to 1995, the area covered by seagrass on Parmelia Bank decreased by 138 ha. This includes the losses of a maximum of 39 ha due to shellsand dredging. Losses of approximately 50 ha due to construction of the FPA shipping channel were incurred before 1971.
- The loss of seagrass due to the proposed medium-term dredging will be 77 ha.
- The total loss of banktop seagrass due to dredging on Success and Parmelia Bank to 2001 (completion of medium-term dredging) is estimated to be 251 ha.

Of this 170 ha would be due to shellsand dredging. Approximately 85 ha is due to construction of the FPA shipping channels.

5.2.3 *Page xii of the summary in the CER indicates that medium-term dredging will remove 3% of the remaining seagrass cover. What is the cumulative impact on bank top habitat over the past 25 years?*

See item 5.2.2 above

5.2.4 *What is and where are the data on cumulative impact as a % of habitat on Success Bank?*

See item 5.2.2 above

5.2.5 *The basis for the statement that seagrasses are dynamic with colonisation, recession and changes in seagrass cover, needs to be clearly shown particularly in areas of sediment movement.*

This statement is based on results from mapping using rectified aerial photography supported by underwater ground truth examinations, as well as by the detailed measurements being made on the dynamics of colonisation and recession. The significance of this statement is recognised. Measurements will continue to further document the rate and nature of this processes.

5.2.6 *Did the reviews on seagrass rehabilitation really establish that local seagrass meadows are dynamic, able to recover, recolonise, etc? A recent review for Cockburn Cement Ltd. by CSIRO that summarised previous experiments on revegetation in local seagrass species reported the opposite that seagrasses have a very low potential for recolonisation.*

There are two matters to be addressed in this question. The first, regarding the natural dynamic nature of the local seagrass meadows, is answered in section 5.2.1 and 5.2.5 above. The second concerns the recent review for Cockburn by CSIRO that summarised the results from a series of pilot experiments on the potential for restoration of seagrass meadows. Careful reading of the report indicates that the statement contained in the question above is not made anywhere in the report. In addition, this study looked at seagrass restoration using transplanted material, as distinct from monitoring natural recolonisation.

5.2.7 *The findings by CCL that an area was previously regarded as barren has regenerated, that conclusion being drawn from aerial survey photographs, as proof of the ability for short-term regeneration of seagrass is totally incorrect. Typical of their findings it is poorly researched as evidence from five of WA's leading professional fisherman will testify that seagrass has existed in that area for a period exceeding fifty years.*

These results of recolonisation of areas of Success Bank by seagrasses are based on detailed interpretation of rectified aerial photography collected from 1961 to 1995. These photographs show clearly that there was very limited seagrass cover on the eastern side of Success Bank in the 1960's. Consideration is now being given to

undertaking an historical assessment (prior to 1961) of seagrass cover in the area using information from a variety of sources including anecdotal information from fisherman.

5.2.8 *The fact that the loss of 90 hectares of seagrass during the proposed medium-term dredging is somewhat misleading and does not appear to take into account existing seagrass loss within the study area as a result of previous dredging operations and the construction of shipping channels. Further to this, it is considered that the loss of seagrass should be considered in broader regional context such that historical losses of seagrass within Cockburn Sound and other areas adjacent to the proposed dredging area can be considered.*

The study area is considered to cover Owen Anchorage, and its surrounds. The effects of dredging will be assessed in this context.

5.3 REHABILITATION OF SEAGRASSES

5.3.1 *Cockburn Cement's claims regarding re-establishment of seagrass meadows are unfounded and totally at odds with all of the recognised world's seagrass experts.*

The reviews that were undertaken as part of the development work indicate that seagrass rehabilitation is being actively investigated in many parts of the world, with varying degrees of success. The bulk of this work is being undertaken in the United States using the seagrass *Zostera*. International seagrass experts who are directly involved in seagrass rehabilitation programmes include Mark Fonseca (Gulf of Mexico); Professor Bob Orth (Chesapeake Bay) and Professor Alex Meinesz (Mediterranean). Only Professor Meinesz has examined the rehabilitation of *Posidonia*, which is planted manually. No rehabilitation work outside of WA has been undertaken on *Amphibolis*, although successful experimental transplantation at a small scale has been demonstrated in *Amphibolis* and *Posidonia* on Success Bank.

5.3.2 *This grass CANNOT be regrown. All attempts to cultivate it have failed. It is environmental insanity to deplete further the 10% or so of seagrass remaining in this area.*

See response to 5.3.1 above.

5.3.3 *It is an undeniable fact that nowhere in the world has meadows of Posidonia ever been regrown through any method used. If Cockburn Cement are convinced that they have the ability to do that which has never been achieved before, then they should be given the opportunity to do so but this proof of restoration must be achieved prior to permission being granted to destroy the seagrass meadows that do remain.*

The rehabilitation programme proposed in the EMP recognised that there is no proven methods for *Posidonia* (or *Amphibolis*) transplantation. Performance criteria for the rehabilitation of these species were set to allow for progressive demonstration of mechanical transplantation techniques, and the survival of transplanted sods. The overall programme is scheduled to take a minimum of 5 years, and to demonstrate

survival of 0.1 ha of transplanted seagrasses for 3 years and 1 ha of seagrasses for 1 year.

5.3.5 *The Council of the City of Cockburn requires demonstrable proof that the revegetation of previously dredged seagrass areas has been proceeded with.*

The seagrass rehabilitation programme proposed by Cockburn is largely directed at undertaking mechanical transportation into areas of similar depth to the existing bank top. Experimental work will also be undertaken on transplanting sods on to slopes as well as the floors of dredged areas. It will take at least 5 years for reliable results of the success of transplantation to be obtained. The City of Cockburn will be kept informed of all results of this work.

6 PEER REVIEW

6.1 *The document "Cockburn Cement Shell Sand Dredging EMP International Peer Review Group and technical Presentations" is not an international peer review document, it was merely an interim report on the preliminary findings of the EMP. It does not give Cockburn's activities any International scientific approval. The full report of the International peer review team has never been released for public scrutiny. In the absence of the original report it is not possible to draw any conclusions about their assessment.*

The document referred to was distributed to all those who attended these Presentations in January 1996, and simply provided information on the presentations. It did not contain the report of the International Peer Review Group (IPRG), who attended the presentations to obtain further detailed information on the progress of the EMP.

The IPRG subsequently prepared a report on its findings. The EMP Study Team then addressed the IPRG recommendations and responded to them, indicating how each of the IPRG recommendations would be addressed. The Environmental Management Advisory Board (EMAB) for this programme followed this entire process, and reviewed both the IPRG recommendations and the Study Team response. The EMAB then prepared their own evaluation of the process.

The 3 reports mentioned above were included into a further report which described the procedure outlined above. This combined report was produced in June 1996. It has been distributed to the EPA, the DEP, the IPRG members, and any other groups who have requested the report.

6.2 *The findings contained within that document were subjected to a peer review group in January of this year. The comments of the reviewing peers has never been released by Cockburn Cement leading one to draw the obvious assumption that the comments received by CCL from that group are not in its best interests to be made public.*

See item 6.1 above

7 DREDGING PLAN

7.1 *The dredging plan does not address in detail, effects and issues relating to shellsand dumping and storage in the vicinity of the Woodman Point jetty.*

The dredging plan that is presented in the CER relates to the management of the dredging on Success Bank for shellsand.

Issues relating to the shellsand dredging and retrieval in the vicinity of the Woodman Point jetty have been previously addressed by a number of separate studies on the effects of these activities. The activities in the vicinity of the Woodman Point jetty have been continuing since 1971 and have regularly received approval as part of the Dredging Management Plans that have been submitted to government.

8 ARTIFICIAL REEFS

8.1 *The fishing community has categorically rejected the transformation of the area into a place of reefs, artificial or otherwise, for the following reasons;*

- *Reefs do not restore the function of seagrass meadows.*
- *It may attract predatory fish to a nursery area and the fishing community believe that there is one predator too many in there already.*
- *Except in the areas scoured out by the dredging, the reefs would create a navigational hazard in the normally shallow waters of Owen Anchorage.*
- *It would be equivalent of placing a rain forest on a grassy meadow to try and restore ecological function that did not exist there in the first place.*

Artificial reefs are not viewed as a direct replacement habitat for seagrass meadows, nor could they be deployed to cover the areas that are proposed to be dredged. The artificial reefs are viewed as a small-scale means of enhancing primary production and habitat complexity in the area. The study area is a complex mosaic of reefs, bare sand, seagrass meadows and deep basins, and the variety of habitat types in the area is the reason for its species diversity. The addition of several very small artificial reefs, will slightly increase habitat complexity. They will not be able to attract species (predator or otherwise) that are not already in the area. This ability to act as a fish attracting device should also be of some benefit to recreational fishing. The Department of Transport has specified very strict guidelines for the placement and water clearance of the artificial reefs, so navigational hazards should not occur.

9 STATUS OF THE EMP

9.1 *Considering that this EMP is Null and void, its preliminary findings cannot be used in support of this proposal.*

The programme of scientific study and technical investigations that are outlined in the EMP have been extensively reviewed, modified, and agreed to. In November 1995, the Minister stated in Bulletin 803 that "the Environmental Management Programme as amended by the Supplement is environmentally acceptable". The Supreme Court decision that overturned the short-term CER, and therefore the recommendations on the EMP, should be interpreted as overturning the approval to Cockburn to gain access to the medium-term area even though the EMP programme has been considered acceptable. The scientific and technical information being gained by the implementation of the EMP is not changed by any legal ruling and it is valid to use information from these in the CER for the proposed medium-term dredging.

9.2 Whilst the legal position in relation to the EMP studies which are summarised within the CER is understood, it is considered important that within the context of the CER that the objectives and performance criteria of each of the EMP studies should be detailed within the 1996 CER. This would make clear the aims and expected outcomes of each of these studies within the context of the proposal as outlined in the CER.

Subsequent to the Supreme Court decision in March 1996, Cockburn advised the Minister that it would continue to carry out the EMP studies as modified by the Supplement. The full details of these modifications were published in Bulletin 803.

10 FOR RESPONSE BY DEP/EPA

The analysis of public submissions indicated that a number of the issues that had been raised were directed at the EPA and/or DEP, and not to Cockburn. These are listed below:

10.1 How can the public be asked for comment on this CER when assessment by the EPA of the 1994 CER for the short-term dredging has not yet been finalised or made public?

10.2 How can the EPA comply with its Act and obligations without first completing its own assessment of the 1994 CER and acting on that assessment as required by its own Act?

10.3 Could the EPA please explain: what has changed since 1991 which has altered the position of the EPA to now consider dredging environmentally acceptable, and how has the EPA carried out its duty to protect the environment in this instance?

10.4 Is there any reason why the EPA should not advise the Minister to direct CCL to entertain an alternative proposal to that promoted by this CER?

10.5 Are there any other companies operating in WA without environmental approval?

10.6 Why has CCL been allowed to continue, or at least why has the EPA not recommended to Government that dredging cease while the assessment is completed? Why has the EPA not released its findings after nearly 6 months?

10.7 *Currently Cockburn Cement Limited (CCL) is operating their shellsand dredging operations in Cockburn Sound/Owen Anchorage without environmental approval. It is unclear how the EPA can consider a proposal for medium-term dredging when it has failed to produce a Report and Recommendation on the short-term dredging activity.*

10.8 *To the best of our knowledge there has been no Report and Recommendations by the EPA for short-term dredging that is currently taking place, let alone any further dredging.*

10.9 *It is also of great concern that the EPA has not released its revised report to replace the one quashed by the Supreme Court in March of this year when it was promised within a time frame of 5-6 weeks.*

10.10 *If Cockburn Cement are allowed to continue and the ridiculous conclusions arrived at in their CER are accepted by this Government it leaves the door open to;*

- *All companies that have projects rejected in the past such as Marina developments, etc that have been disallowed to proceed because of the loss of seagrass, will have a good case under the law to;*
- *Demand approval to proceed citing CCL as their precedent who have been given permission to destroy seagrass meadows for the sole purpose of assisting industry.*
- *Engage in litigation with the government for loss of profits to date by not being allowed to proceed at the time they applied.*

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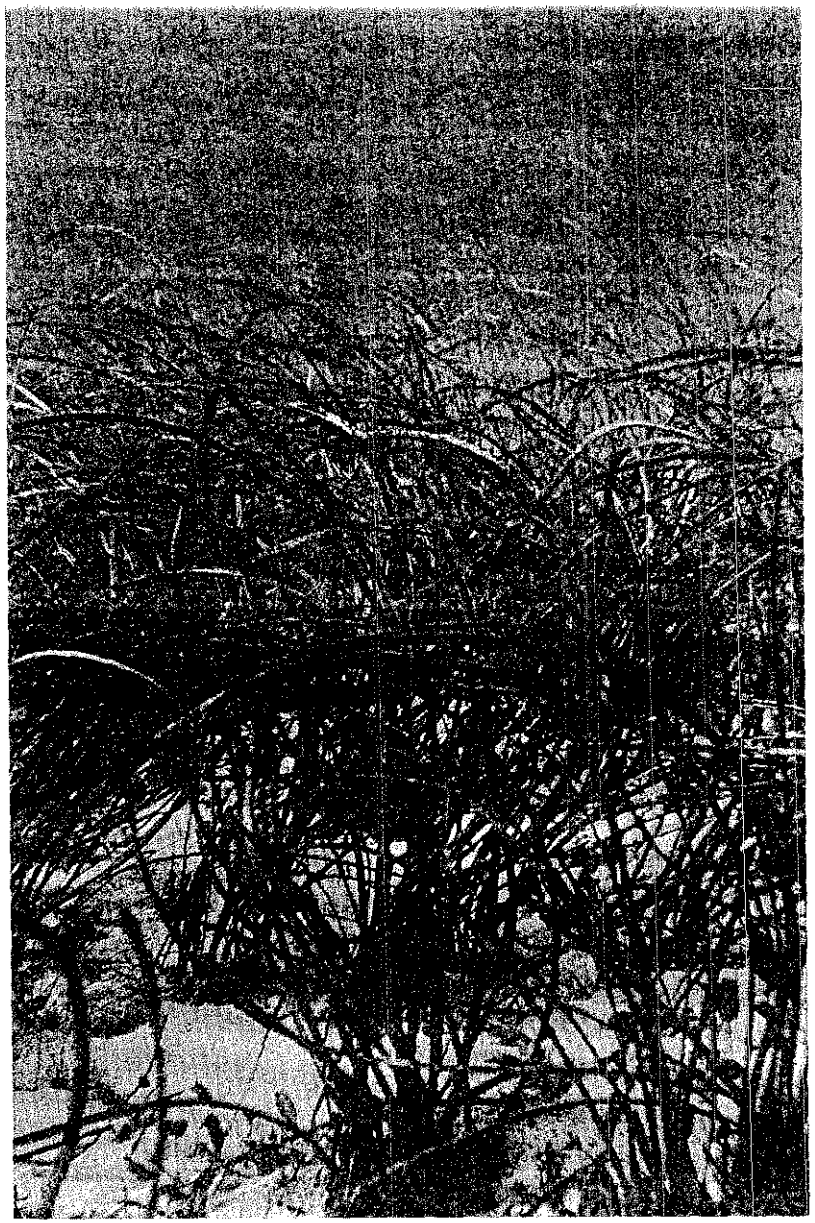
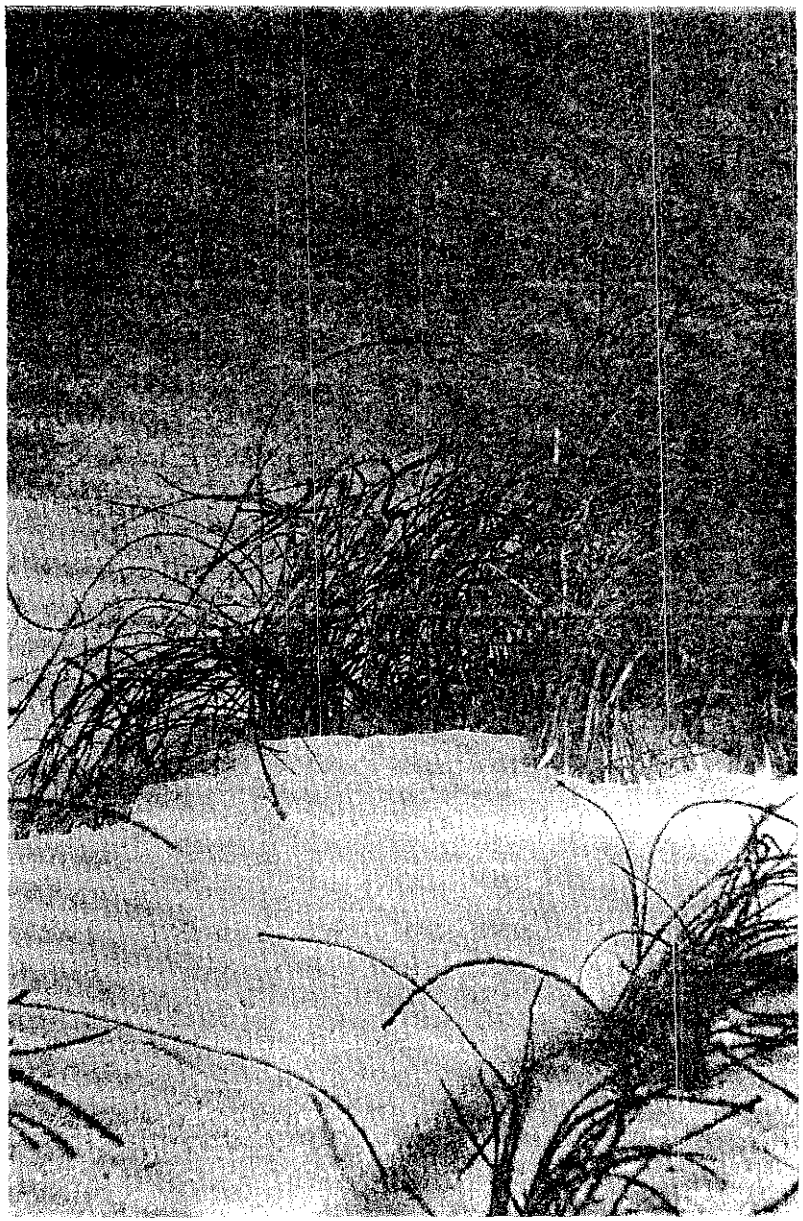


B



A *Posidonia coriacea* dense cover
Plants in small clumps. Understory of *Halophila*.
Extensive exposed sand areas between plants.

PLATE 1: Dense *Posidonia coriacea* on Success Bank

B *Posidonia coriacea* dense cover.
Plants in small meadows. (10m across).
Extensive sand sheets.

APPENDIX 1 SUBMISSIONS RECEIVED FOR CER: MEDIUM-TERM DREDGING, OWEN ANCHORAGE

PUBLIC SUBMISSIONS

- City of Cockburn
- WA Recreational and Sportfishing Council Inc., with and on behalf of the Coastal Waters Alliance
- Dr James Searle, Earth Sciences Pty Ltd
- Dr Peter Woods, Cottesloe
- Conservation Council of WA Inc
- Australian marine Sciences Association (AMSA) of WA
- Australian Marine Conservation Society, West Coast Branch

STATE GOVERNMENT DEPARTMENT SUBMISSIONS

- Fisheries Department of WA
- Department of Resources Development (DRD)
- Fremantle Port Authority (FPA)

APPENDIX 2 AGREED REVISIONS TO THE GOALS, OBJECTIVES AND PERFORMANCE CRITERIA FOR THE COCKBURN CEMENT LIMITED SHELLSAND DREDGING EMP

ORIGINAL		AGREED REVISION	
Title	**OVERALL OBJECTIVES OF THE EMP**	**Title**	**OVERALL OBJECTIVES OF THE EMP**
Objectives	The objectives of this EMP are to provide the principles, framework and procedures that will: (i) minimise the potential for adverse environmental effects arising out of the short and medium-term dredging operations; and (ii) resolve the issue of long-term resource access.	**Objectives**	The objectives of the EMP are: (i) to provide sufficient technical information to the EPA to evaluate the environmental acceptability of Cockburn's proposed long-term dredging operation on Success Bank between 2000 and 2021 (end of Agreement). (ii) Where possible, to use the information gained from the studies in the EMP to minimise the adverse environmental effects arising out of the short and medium-term dredging operations.
Performance Criteria	None.	**Performance Criteria**	None.
Title	**CRITERIA FOR ACCEPTABLE IMPACTS**	**Title**	**CRITERIA FOR ACCEPTABLE IMPACTS**
Objective	The DEP and EPA have indicated in the Guidance Notes that the intention of Ministerial Condition 6-2 is for the long-term shellsand dredging operations and rehabilitation programme to maintain ecological function and to result in a net environmental benefit in the Owen Anchorage/Cockburn Sound area. A net environmental benefit may be achieved by enhancing the present function and values of seagrass communities in the above area. This can be achieved in a number of ways including reducing the impact on existing areas of valuable seagrass communities, or restoring these communities from where they have disappeared. Cockburn Cement have accepted the above principle of no net loss of ecological function and preferably net benefit as the criteria by which the success of studies into ecological significance and seagrass rehabilitation will be judged.	**Objective**	The criteria for acceptable impacts from Cockburn's dredging operations will be "that due to Cockburn's shellsand dredging operations on Success Bank in Owen Anchorage, there be no net loss of present (August 1994) ecological and cultural function in the Owen Anchorage/ Cockburn Sound area". Ecological function refers to the biophysical attributes of the seagrass meadows on Success Bank and include attributes such as primary production (C and N cycling), habitat and nursery roles for flora and fauna and sediment binding and wave attenuation properties. Cultural function refers to their recreational, educational and economic benefits to humans.
Performance Criteria	None.	**Performance Criteria**	None.

ORIGINAL		AGREED REVISION	
Title	ECOLOGICAL SIGNIFICANCE OF SEAGRASSES (PROJECT S1) Relates to Ministerial Condition 5-3(2)	Title	ECOLOGICAL SIGNIFICANCE OF SEAGRASSES IN THE OWEN ANCHORAGE/COCKBURN SOUND AREA (PROJECT S1)
Objective	(i) Define ecological significance and describe the approaches to be used in its determination. (ii) Assess the ecological significance of seagrasses and other habitats in the Success and Owen Anchorage region. (iii) Formulate an estimate of the potential loss of ecological significance through dredging. (iv) Formulate estimates of the amount of ecological function that can be replaced by mitigation techniques.	Objective	(i) Define the functional (ecological and cultural) roles of seagrasses of the Cockburn Sound/Owen Anchorage area. (ii) Quantify the loss of functional (ecological and cultural) role resulting from historical seagrasses losses in the Cockburn Sound/Owen Anchorage area. (iii) Determine the loss of seagrass meadow in the Cockburn Sound/Owen Anchorage area that can be sustained without significantly impairing the functional (ecological and cultural) role of seagrasses. (iv) Quantify the loss of functional (ecological and cultural) role of seagrasses in the Cockburn Sound/Owen Anchorage area resulting from dredging (1972 to the year 2021). (v) Quantify the functional (ecological and cultural) role of seagrasses that can be potentially replaced by mitigation techniques.
Performance Criteria	None.	Performance Criteria	None.
Title	SEAGRASS REHABILITATION (PROJECT S2) Relates to Ministerial Conditions 5-3(1) and 6-2	Title	REPLACEMENT OF THE ECOLOGICAL AND CULTURAL FUNCTIONAL ROLES OF SEAGRASSES LOST BY DREDGING IN THE OWEN ANCHORAGE/ COCKBURN SOUND AREA SINCE AUGUST 1994 (PROJECT S2).
Objective	(i) Over the first five years develop technology and optimise procedures appropriate to local condition and seagrass species so that they can then be applied to seagrass rehabilitation at the large scale. (ii) Beyond the first five years, begin to rehabilitate with seagrass at the large scale. This involves rehabilitation of areas of tens of hectares or more, with expectation of achieving full results over time spans ranging from a few years up to three or four decades plus, depending on the choice of seagrass and its growth rate and growing conditions at the rehabilitation site.	Objective	To demonstrate that long-term replacement of the ecological and cultural functional roles (as identified in the S1 study) of seagrasses lost by dredging on Success Bank is technically, environmentally and economically feasible.

ORIGINAL	AGREED REVISION
	Explanatory Notes: **(i)** the prime objective of rehabilitation in the long-term is to maintain ecological function of the Owen Anchorage/Cockburn Sound area (Study area). The functional roles of seagrasses in the Study area and particularly in the proposed dredge area will be measured separately (by project S1 of this study). Key functional roles that are lost through dredging need to be replaced by rehabilitation to the extent required within the Owen Anchorage/ Cockburn Sound area; **(ii)** the "success" of rehabilitation should be measured based on the area and density of seagrass generated. This is a quantitative measure that can be equated with ecological function (Fonseca, 1994); **(iii)** the determination of the area of seagrass that requires rehabilitation will be based on measurements of functional roles of seagrass (to be determined by study S1) and the area occupied by each of the species. The following table provides a conceptual example of the way in which functional equivalence may be expressed. The table suggests *Posidonia* and *Amphibolis* are functionally equivalent, but *Heterozostera/Halophila* are not.

	Functional Equivalence (1 is maximum)		
Depth	***Posidonia***	***Amphibolis***	***Heterozostera/ Halophila***
5m	1	1	0.3
12m	0.1	0.1	0.3

(iv) techniques that will be considered for rehabilitation include:

- mechanical transplantation (salvage);
- mechanical sowing/planting;
- manual sowing/planting;
- innovative dredging;
- natural regrowth; and
- artificial habitats (eg reefs).

ORIGINAL		AGREED REVISION	
			(v) evidence from local studies suggests that most loss of transplanted seagrass occurs during the first 12 months. Therefore, if the seagrass survives for 12 months, the chances of longer term success are higher. (vi) the larger scale (10,000m²-30,000m²) rehabilitation will be carried out over several years in the period up to 15 months prior to the depletion of the medium-term resource. Thus, a proportion may have been in for up to three years, whilst some may have been in for only 12 months. Hence, short-term criterion 3.2(ii) has been expressed as 10,000m²-30,000m² of seagrass with evidence of ≥12 months' survival.
Performance Criteria	*Long-term objective:* (i) seagrass beds generated through rehabilitation spreads and persist without assistance; (ii) rehabilitated seagrass beds are generated within timeframes which accord with minimum times indicated from technical data. (iii) rehabilitated seagrass beds are eventually capable of contributing functional attributes of seagrass equivalent to those lost through dredging, or if this is not possible, of contributing attributes identified in Project S1 as ecologically important to the region. The functional attributes are present at levels that ensure regional functional roles of seagrass are not compromised. The functional characteristics developed replace, and possibly enhance, functional roles lost through dredging. *Short-term objective:* (i) for planted propagules: • planted propagules not only survive but spread; • unassisted spreading occurs for a minimum of three years from the time of planting;	**Performance Criteria**	*Long-term criteria:* [to be met during long-term dredging programme] (i) Rehabilitated seagrass beds replace functional attributes of seagrass equivalent to those lost through dredging and persist without assistance. *Short-term criteria:* [to be met by completion of EMP, ie during dredging of medium-term area] (i) demonstrate that the success of rehabilitation can be measured by area and density of seagrass generated, and that this is a quantitative measure that can be equated with ecological function;

ORIGINAL	AGREED REVISION
The following values, based on experience with local seagrass species, provide a guide as to minimum likely spreading rates: 2.5cm per year in species of *Posidonia*; 24cm per year in species of *Amphibolis*; and 72cm per year in *Heterozostera* and species of *Halophila*. The above spreading rates will be refined through review of available data early in the project and technical finding over the first two years of the project. • reliable survival and spreading rates for several techniques are determined; The techniques may include the following: using seedling and Growool pots, anchoring plants and seedlings with geomatting, planting sprigs, turfs, seeds and seedlings. • planting procedures are developed appropriate to local conditions to provide, along with data on spreading rates, an evaluation of times over which seagrass beds can be generated through large scale rehabilitation. (ii) For mechanical transplantation of seagrasses • techniques for undertaking mechanical transplantation are evaluated for their application to large scale transplantation; • survival rates of transplanted seagrasses are determined. (iii) For experimental studies: • a research programme is developed, yearly milestones are identified and the milestones are met.	(ii) demonstrate 15 months prior to depletion of the medium-term resource (currently estimated to occur in December 2001) that rehabilitation techniques are developed and implemented, that have rehabilitated 10,000m² to 30,000m² with an array of seagrasses with evidence of ≥12 months of survival, and have rehabilitated 1,000m² with evidence of ≥ three years survival; (iii) demonstrate, 15 months prior to the depletion of the medium-term resource, currently estimated to occur in December 2001, that long-term, broadacre rehabilitation at a rate required by the proposed long-term dredging programme is both technically and economically feasible.

ORIGINAL		AGREED REVISION	
Title	**SEAGRASS HABITAT MAPPING (Project S3)** Relates to Ministerial Conditions 5-3(1), 5-3(2) and 7	**Title**	**SEAGRASS HABITAT MAPPING (Project S3)** Relates to Ministerial Conditions 5-3(1), 5-3(2) and 7
Objective	To produce maps which: (i) show the distribution of the marine habitats and seagrass assemblages which occur within the study area; (ii) provide an information base for the ecological significance (S1) and seagrass rehabilitation (S2) study groups to assist in the location of study sites and for the determination of the number of sites required for their respective studies; and (iii) accurately delineate and define the area and nature of the seagrass lost as a result of short and medium-term dredging by CCL after 4 August 1994, for the purpose of determining seagrass rehabilitation requirements in accordance with Ministerial Condition 7.	**Objective**	(i) to determine the distribution and relative abundance of seagrass species within each habitat of the study area; (ii) to determine gains and losses in seagrass cover in Cockburn Sound/Owen Anchorage over the period of aerial photographic records (from 1971/72); and (iii) to determine the seagrass meadow edge advancement and/or regression between 1995 and 1999.
Performance Criteria	None.	**Performance Criteria**	None.
Title	**ARTIFICIAL HABITAT STUDIES (Project S4)** Relates to Ministerial Condition 5-3(1)	**Title**	**ARTIFICIAL HABITAT STUDIES (Project S4)** Relates to Ministerial Condition 5-3(1)
Objective	To construct an artificial reef and/or artificial seagrass mats in Owen Anchorage as trials, and monitor their performance with respect to increasing the biological productivity of the area.	**Objective**	To determine the performance of artificial habitats in Owen Anchorage with respect to replacing the functional role of seagrass meadows lost as a result of dredging.
Performance Criteria	To compare the species diversity and abundance of the artificial reef/seagrass beds with a seagrass meadow.	**Performance Criteria**	See revised performance criteria for Project S2.
Title	**SLOPE/SEAGRASS STABILITY MONITORING PROGRAMME (Project S5)** Relates to Ministerial Conditions 5-3 and 6-2.	**Title**	**SLOPE/SEAGRASS STABILITY MONITORING PROGRAMME (Project S5)** Relates to Ministerial Conditions 5-3 and 6-2.
Objective	To determine the long-term stability of dredged slopes and seagrass cover on banks immediately adjacent to dredged areas.	**Objective**	To determine the long-term stability of dredged slopes and seagrass cover on banks immediately adjacent to dredged areas.
Performance Criteria	None.	**Performance Criteria**	None.

ORIGINAL		AGREED REVISION	
Title	**WAVE CLIMATE STUDIES (Project C1)** Relates to Ministerial Conditions 5-3(3) and 6-2	Title	**WAVE CLIMATE STUDIES (Project C1)** Relates to Ministerial Conditions 5-3(3) and 6-2
Objective	To determine the implications of dredging both the short and medium-term resource areas on the wave climate of the surrounding waters and adjacent coastline (objective taken from Chapter 5, not Appendix 3).	Objective	To predict changes in wave climate that would occur as a result of proposed dredging in the short, medium and long-term and the effects on banks and shoreline stability, water column light attenuation and shipping facilities with and without existing seagrass cover.
Performance Criteria	None.	Performance Criteria	None.
Title	**SHORELINE MONITORING (Project C2)** Relates to Ministerial Conditions 5-3 and 6-2	Title	**SHORELINE MONITORING (Project C2)** Relates to Ministerial Conditions 5-3 and 6-2
Objective	To monitor the shoreline of Owen Anchorage in order to observe any changes in the position and profile of the beaches.	Objective	To determine the temporal variation of the position and profile of the beaches of Owen Anchorage (and some parts of Cockburn Sound as appropriate), and relate this variation to causal factors.
Performance Criteria	None.	Performance Criteria	None.
Title	**BENEFICIATION OF CALCIUM CARBONATE (Project R1)** Relates to Ministerial Condition 5-4	Title	**BENEFICIATION OF SELECTED NATURAL CALCAREOUS MATERIALS (Project R1)** Relates to Ministerial Condition 5-4
Objective	Carry out a detailed investigation into the technical and economic feasibility of beneficiating limestone for a one million tonnes per annum lime manufacturing process.	Objective	To determine the economic and technical feasibility of beneficiating limestone in the order of one million tonnes per annum.
Performance Criteria	None.	Performance Criteria	None.
Title	**ALTERNATIVE SOURCES OF LIMESTONE AND LIMESAND (Project R2)** Relates to Ministerial Condition 5-4	Title	**ALTERNATIVE SOURCES OF LIMESTONE AND LIMESAND (Project R2)** Relates to Ministerial Condition 5-4
Objective	To carry out a detailed study based on existing information for alternative shore and off-shore resources suitable for Cockburn's lime and cement manufacturing operation, having regard to technical and economic considerations.	Objective	To determine whether alternative shore and marine-based resources suitable for Cockburn's lime and cement manufacturing operation exist and are prioritised with regard to technical and economic considerations.
Performance Criteria	None.	Performance Criteria	None.

ORIGINAL		AGREED REVISION	
Title	DREDGING RESOURCE PLAN (Project R3) Relates to Ministerial Condition 5-5	Title	DREDGING RESOURCE PLAN (Project R3) Relates to Ministerial Condition 5-5
Objective	(i) To determine the total quantity and quality of resource between the FPA channel and the second channel on Success Bank. (ii) To develop a dredging plan from the information gathered in objective (i).	Objective	(i) To determine the total quantity and quality of resource between the FPA channel and the second channel on Success Bank. (ii) To develop a dredging plan from the information gathered in objective (i).
Performance Criteria	None.	Performance Criteria	None.
Title	INNOVATIVE DREDGING (Project R4) Relates to Ministerial Condition 5-3(1)	Title	INNOVATIVE DREDGING (Project R4) Relates to Ministerial Condition 5-3(1)
Objective	To carry out feasibility investigation into developing and testing innovative dredging techniques which will help to mitigate the effects of the current dredging operation on the seagrass habitat.	Objective	To develop innovative dredging techniques to mitigate the effects of the current dredging operation on the seagrass habitat.
Performance Criteria	None.	Performance Criteria	None.