PEEL INLET AND HARVEY ESTUARY MANAGEMENT STRATEGY ENVIRONMENTAL REVIEW AND MANAGEMENT PROGRAMME STAGE 2

DEPARTMENT OF MARINE AND HARBOURS
DEPARTMENT OF AGRICULTURE

Report and Recommendations of the Environmental Protection Authority

Part I

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PEEL INLET AND HARVEY ESTUARY MANAGEMENT STRATEGY

STAGE 2

Department of Marine and Harbours

Department of Agriculture

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by the
Environmental Protection Authority

Summary Report

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PART I

SUMMARY REPORT

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PRECIS

The Peel-Harvey Estuarine System is important to the South West Region for its recreation, tourism, conservation and amenity values. It is heavily polluted through an excess of phosphorus fertilisers which wash from farmlands, through drains, creeks and rivers, and into the estuary. The excess phosphorus stimulates the growth of algae so much that, in most years there is eutrophy (or nutrient enrichment). This causes algal growth in the estuaries. There is a real risk that rotting algae may lead to a total collapse of the biological systems in the estuary, with associated large kills of fish, crabs and bottom-dwelling creatures. The amenity values of the estuary could also be lost.

The estuarine system has been intensively studied for the past 12 years. These studies show that the estuary system is overloaded with nutrients (ie the system is eutrophic) and algae. During the past 12 years, on average, 140 tonnes of phosphorus have been washed into the estuary. The eutrophic conditions have occurred in 9 of the last 12 years. This period has been a relatively dry spell, and it is predicted that eutrophic conditions would occur in 11 out of 12 years if the local climate becomes wetter like the long-term average. The more rain, the wetter the catchment becomes and a greater volume of water is available to wash more phosphorus into the estuaries.

Observations over the past 12 years show that an input of 200 tonnes of phosphorus per year would stimulate algal growth, and subsequent rotting of algae, to the extent that the system could be poisoned, or collapse. Although this collapse has occurred only once during this 12 year period, it is predicted that if normal climatic conditions return, such a collapse would occur in 50% of years.

In considering the condition of the Peel-Harvey Estuary with a view to establishing ways of managing the problems that are occurring, it is necessary to take account of the Greenhouse Effect. There is much uncertainty about the Greenhouse Effect, although predictions suggest that a significant reduction in rainfall could occur. While the Greenhouse Effect will produce changes in rainfall patterns and sea level, it is not known how these changes will affect the problems occurring in the estuaries. Because action on the problems is needed urgently, it is not appropriate to adopt a 'wait and see' approach with respect to the Greenhouse Effect.

Given the magnitude of the problems, the EPA has recommended that urgent action is needed to improve conditions in the estuary system. Firstly, an additional opening from the Harvey Estuary to the ocean should be made, to allow more of the phosphorus to be flushed out, and to allow more of the clean, salty sea water in. This opening, through the proposed Dawesville Channel, is the only action which can quickly bring the problem to manageable proportions.

It is predicted that such a channel would make the estuary more resilient and clean, and the system could then take up to 165 tonnes per year of phosphorus before becoming eutrophic. Furthermore, with the channel, it is predicted that up to 400 tonnes of phosphorus per year would be needed to cause total collapse.

The extra salt water input through the channel would prevent growth of the alga Nodularia, the main alga of present concern. However, other algae, of more manageable proportions, may follow.

Even with the Dawesville Channel,it will be necessary to manage land uses in the catchment of Peel Inlet and Harvey Estuary carefully so as to reduce the amount of phosphorus entering the system through the drains, creeks and rivers. Some catchment soil types, in particular the deep grey sands, lose enormous amounts of phosphorus from applied fertilisers. The poor phosphorus retention capacity of these sands also means that large amounts of phosphorus need to be applied to sustain agricultural productivity. If the estuary water quality is to be improved, then land uses requiring or producing large amounts of phosphorus would not be compatible with protection of the estuarine environmental quality. A plan to guide land uses in the estuaries' catchments will be needed to ensure that the amount of phosphorus washing into the system will be reduced. In addition, to meet this objective, a number of particular measures will be required.

For example, the present programme to modify the kinds of agricultural fertilisers being used, and the way they are applied, will need to continue. The planting of tree crops on land presently used for conventional agricultural activities would be another important initiative, particularly in those parts of the catchment containing deep grey sands where the conversion of agricultural land to tree plantations would substantially reduce phosphorus loads entering the estuarine system. In addition, particular activities that are a major source of phosphorus pollution (eg piggeries, stock holding operations, intensive horticulture, abattoirs) will need to be located in suitable areas (eg where soils have a high capacity to retain phosphorus), and operated in such a way that the control of phosphorus (either applied as fertiliser or generated in wastes) is maximised. Continuation of the moratorium on land clearing and drainage within the coastal plain catchments will also be needed, at least on an interim basis.

The basic components of the catchment management required to reduce the amount of phosphorus entering the estuaries can be summarised as:

. preparation of a guiding plan (ie the catchment management plan);

. continuation of the present fertiliser management programme;

. control of point sources of phosphorus;

. changes in land use (such as establishment of tree plantations) so as to adapt land use to the overall suitability of the land for the purpose proposed; and

. continuation of the moratorium on land clearing and drainage.

The scale and complexity of the Peel-Harvey Estuary and the proposed management strategy mean that some things cannot be fully finalised now. Therefore, it will be important to keep the estuarine system and other affected areas under review as part of the process of putting the management measures into effect. Accordingly, monitoring and responding as necessary to the results obtained, is an integral part of the overall management strategy.

This report (ie Bulletin 363 Part I) provides an overview of the Environmental Protection Authority's assessment of the management proposals for the Peel-Harvey Estuary. Part II of Bulletin 363 explains in detail the outcome of the Authority's assessment, the underlying rationale and the technical justification for the conclusions drawn and the recommendations made.

The following guide will help readers to understand the format of this report.

The report is divided into the following broad sections:

1. **SCOPE** - identifies more specifically what the report addresses.

2. **WHAT THE PROBLEMS ARE AND WHY THEY OCCUR** - outlines the nature of the problems in the estuarine system, what causes them, and the background investigations that have occurred.

3. **OBJECTIVES FOR MANAGEMENT** - indicates what water quality objectives for the estuaries need to be achieved in order to address the problems, and also the management implications of these objectives.

4. **PROPOSALS FOR THE MANAGEMENT STRATEGY** - looks at the particular management measures needed and their environmental effects, and the associated implementation responsibilities and management and monitoring requirements.

5. **CONCLUSIONS** - outlines the overall context for the conclusions drawn and recommendations made, and presents the Authority's conclusions and recommendations.

SCOPE

1. SCOPE OF THE ENVIRONMENTAL PROTECTION AUTHORITY'S REPORT

This report summarises, in brief, the technical assessment of the Peel Inlet-Harvey Estuary Management Strategy Stage 2 Environmental Review and Management Programme (ERMP). It examines:

- the environmental problems in the Peel-Harvey System;
- the investigations into the problems, their causes and possible solutions;
- the capacity of the system to cope with additional stress, both with and without management;
- the water quality targets required to achieve a healthy estuary system that is environmentally acceptable and in which beneficial uses are protected;
- the management elements needed to achieve the above targets;
- the reasons why a combined management strategy is necessary;
- the ways in which the management strategy can be implemented and monitored; and
- the Environmental Protection Authority's (EPA) conclusions and recommendations.

The Authority has also prepared a technical report which contains the detailed scientific information and justification for the conclusions presented in this summary report. The technical report has been published as Bulletin 363 Part II.

The position taken by the Authority in this assessment is that the estuarine water quality is presently seriously degraded, and that this requires significant improvement to make it environmentally acceptable and to ensure that the beneficial uses of the system such as direct water contact recreation, fishing, fishery protection, and habitat protection can continue. To date, catchment land uses have taken place without due regard for the downstream consequences and impacts on the end receiving water body. The environmental quality of the estuaries has been traded off for the benefit of catchment land uses. This balance needs to be redressed to achieve conservation and sustainable development of the Peel-Harvey System. Adequate protection of the estuaries' beneficial uses will dictate changes to the amount and types of catchment activities that will be possible.

What follows is a chronological account of how the problems occurred and how the management solution has been derived.

Management of the problems of the Peel Inlet and Harvey Estuary waterways and their catchments will require the adoption of a long-term view and a holistic approach. Because some of the remedial measures proposed in this report will be on a scale and of a kind not previously undertaken, they will generate considerable world-wide interest. At a local level, the Dawesville Channel element of the management strategy will be the largest coastal engineering project undertaken since C.Y.O'Connor built Fremantle Harbour. The proposals to manage agricultural activities in the catchment would also

be innovative in that the emphasis is on a co-operative approach rather than on a strict regulatory approach of the kind being adopted by a number of European countries to control similar problems.

WHAT THE PROBLEMS ARE AND WHY THEY OCCUR

2. THE PROBLEMS

Problems in the Peel Inlet were identified as long ago as the mid 1960s when large amounts of green weed (algae) were beached close to houses where it decomposed and caused a foul smell. The algae also caught in the nets of fishermen and tangled boat propellers. The algae problem is generally thought to have reduced tourism and recreational enjoyment of the region and may have caused some reduction in property values (ERMP Summary,1988a). The large algae (macroalgae) problem has been reduced in part by a weed harvesting programme which has cost well in excess of $1 million over the last thirteen years, but the cause of the problems still remains.

In 1973, the problems became much worse when large blooms of a tiny, blue-green alga (cyanobacterium) called Nodularia occurred in the Harvey Estuary. Nodularia is an indicator that the estuary system is severely nutrient-enriched (eutrophic) and is in a serious condition. Further deterioration would make the recovery of the system more difficult or even impossible, therefore management is required urgently.

3. INVESTIGATING THE PROBLEMS

Studies into the biological and physical aspects of the Peel-Harvey System began in 1977 and fall into four phases:

Phase 1

Phase 1 was initiated by the Environmental Protection Authority through its Estuarine and Marine Advisory Committee (EMAC). This Committtee's task was "to determine the causes of the excessive growth and accumulation of green algae in Peel Inlet and if possible to propose methods for its control" (EMAC, 1981,p.6). The principal conclusions presented in the EMAC report were:

- the Peel-Harvey system is eutrophic (severely nutrient-enriched) in that there is an excess of the nutrients phosphorus and nitrogen available for plant growth. The eutrophication shows up in Peel Inlet as an abundance of bottom-living, large green algae (macroalgae);

- the excess nutrient supply enters the system from activities in the catchment, in particular from application of phosphorus-rich fertilisers; and

- that proper management of the system can only be achieved by reducing the present input of nutrients from agricultural drainage, by preventing the increase of nutrients from other sources, and by not further restricting the flushing of nutrients to the sea.

Phase 2

The second phase of the studies began in 1981 and confirmed the importance of drainage from the coastal plain catchments as the main source of phosphorus to the system. The occurrence of large blooms of Nodularia in

Harvey Estuary increased concerns about the deteriorating condition of the system.

Phase 3

In 1983 a study into the feasibility of all the possible management options for the Peel-Harvey System was carried out by the Centre for Water Research at the University of Western Australia. A summary report of the findings is given in Humphries and Croft (1983) and in Department of Conservation and Environment (DCE) 1984.

The study established management constraints and objectives and proposed management strategies that would keep eutrophication of the estuaries within "acceptable" limits. These proposals were adopted by the Peel-Harvey Study Group and were presented to the EPA and the community as the Stage 1 ERMP in August 1985 (PHSG, 1985). The EPA assessment report on the Stage 1 ERMP was published in December 1985. The EPA recommended that a combined management strategy consisting of a new channel to the ocean at Dawesville (the Dawesville Channel) and control of phosphorus inputs from the catchment (catchment management) was essential (see Appendix 1).

Phase 4

Phase 4 is the current stage of the process. Following the recommendations made by the EPA in its Stage 1 assessment, the following studies have been carried out in order to prepare the Stage 2 ERMP:

. detailed engineering for the Dawesville Channel;

. dredging of the Mandurah Channel, Fairbridge Bank and Sticks Channel (assessed by the EPA in Bulletin 231, (EPA,1985));

. continuation of catchment monitoring and fertiliser management;

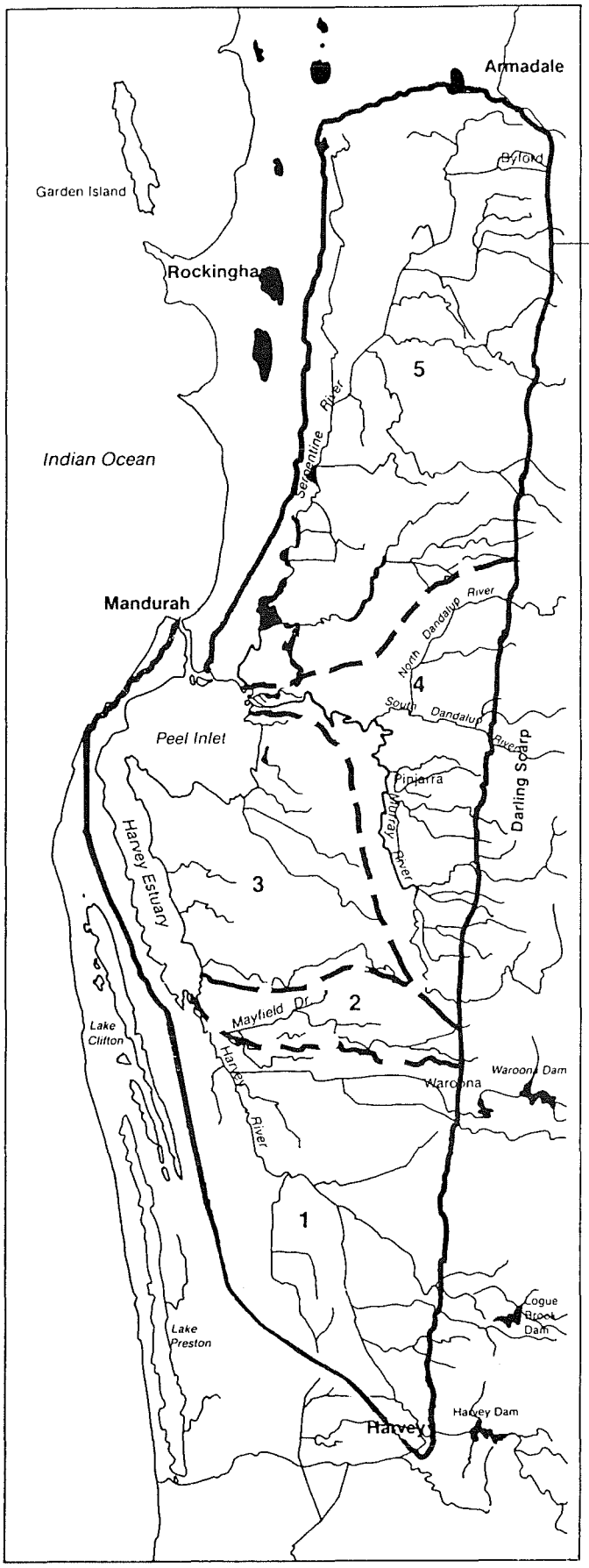
. investigation into point sources of phosphorus. (Point sources are intensive agricultural or other activities that have a high concentration of nutrients in their effluents); and

. investigations into practicable changes in land use for the coastal plain catchment (defined as the area on the coastal plain that feeds into the Peel-Harvey System as shown on Figure 1).

The Stage 2 ERMP (ERMP, 1988a) was released for public comment from 24 May 1988 to 1 August 1988. Eighty-four submissions were received. The issues raised in the submissions have been considered by the Authority in its assessment of the management proposals.

4. WHY DO THE PROBLEMS OCCUR?

The Peel-Harvey System is a broad, shallow waterbody and exchange of water with the ocean is restricted by the narrow opening at the Mandurah Channel (Figure 2). River inflow to the system takes place over only a few months of the year and there are substantial nutrient inputs as a result. The abovementioned characteristics combine to make the system ideal for growing large amounts of algae. The large amounts of algae that are growing in the estuaries are causing problems. While there has been some consideration given to using the macro algae for commercial purposes, investigations have shown that this is not presently feasible. Accordingly, the excess amounts of algae in the estuaries require management.



Catchment	Area (ha)	Cleared area (ha)	% cleared
1	53,995	41,454	76.8
2	11,044	10,139	91.8
3	26,365	21,296	80.8
4	32,366	29,149	90.0
5	78,645	48,962	62.3
Total	202,415	151,000	74.6

Figure 1

Location map of Peel-Harvey Estuary System and boundaries of the Coastal Plain Catchment and Sub-catchments

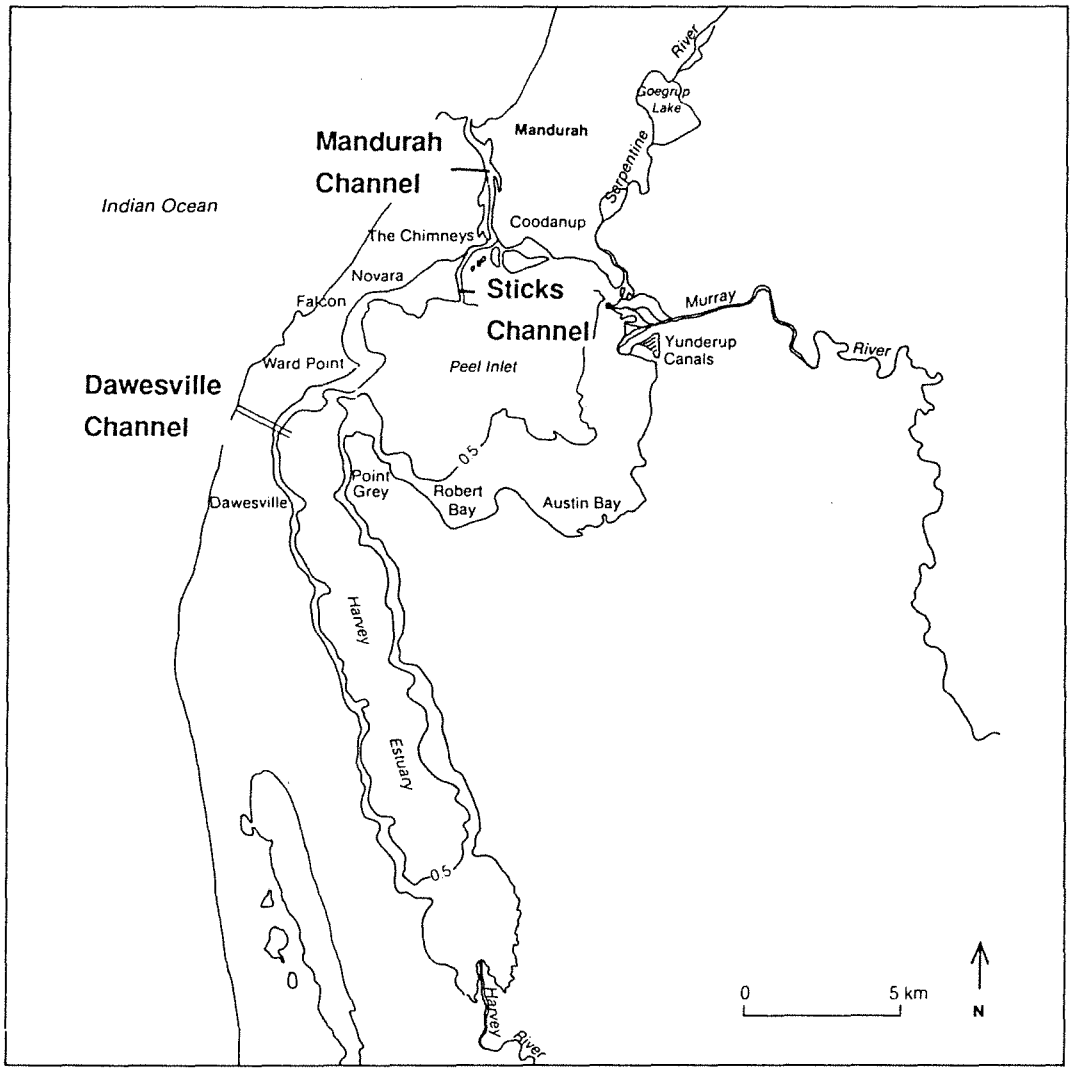


Figure 2
Location of the Mandurah Channel, Sticks Channel and proposed Dawesville Channel

In order to understand the environmental management required to restore the estuary system to a clean, healthy condition, it is necessary to explain a few of the features of the system that affect management. The key aspects of the estuary system are as follows:

. the sandy soils of the Peel-Harvey coastal plain catchment are deficient in phosphorus and other nutrients which have to be applied in the form of fertilisers;

. the soils are very poor at retaining nutrients and therefore nutrients not used by the plants wash out very easily and enter the system from rivers and agricultural drains;

. the greater the amount of excess fertiliser applied, the more nutrients end up in the estuaries;

. too much nutrient in the estuarine system is causing excessive algal growth;

. the main problem nutrient in this system is phosphorus;

. the total amount of water entering the estuary from rivers and drains is called the "flow";

. the total amount of phosphorus entering the system is best expressed as tonnes and is called the "load";

. the amount of phosphorus entering the system is related to the amount of phosphorus applied to agricultural properties in the catchment, to the runoff from the catchment, and inputs from intensive animal, plant and other industries;

. the amount of runoff from the catchment depends on both the total amount of rainfall that occurs in a given year and also on the "distribution" of that rainfall. (Distribution refers to whether the rain falls in a few large storms, or as finer more continuous rain, whether it occurs mainly in winter or throughout the year, and when it falls relative to phosphorus being applied to agricultural land); and

. a system such as the Peel-Harvey Estuarine System has a natural ability to absorb inputs up to a certain limit without environmental damage resulting. This natural level is called the "assimilative capacity" and can be expressed in this case as the maximum amount (load) of nutrients that the estuary can cope with under various specified flow conditions.

The best way of expressing a management target for this system, one that can be measured in numbers, is to state the assimilative capacity of the system in tonnes of phosphorus per year that it can absorb without the environmental quality suffering. This is discussed in later sections.

5. INTERACTIONS BETWEEN RAINFALL, PHOSPHORUS, WEED GROWTH AND OXYGEN STATUS

PHOSPHORUS, RAINFALL AND RUNOFF.

The performance of the Peel-Harvey System has been closely observed and measured over the last twelve years, from 1977-1988. In that time, rainfall and flow conditions have been much drier than average. During this period,

the system has received large loads of phosphorus, observed to be about 140 tonnes per year on average and Nodularia blooms have occurred in nine out of the twelve years. The fact that large blooms have occurred with a load of 140 tonnes is an indication that this amount of phosphorus is too much for the system, and that its natural assimilative capacity is being exceeded. It is of major concern to the Authority that the amount of phosphorus entering the system is already far too much, especially as this is occurring in relatively low rainfall and flow conditions. Even if these relatively dry conditions were to persist, unacceptably high loads of phosphorus would still continue to enter the estuaries in most years and the current form of algal problems would continue at a severe level.

Maximum phosphorus loss from the coastal plain soils occurs from rain falling on the catchment when it is already wet. This maximises runoff and encourages movement of phosphorus in the soil to the drainage system and then to the estuaries. As a result of this, phosphorus losses resulting from a few heavy storms on wetted soil can be much greater than from occasional lighter rain that only begins to wet the catchment. Most phosphorus loss occurs during the first flush at the winter season break.

If the climate returns to long-term average conditions, which are wetter than have occurred in the last twelve years, loads to the system in the order of 200 to 300 tonnes would become commonplace, with loads of up to 400 tonnes occurring in very wet years. These loads are estimates based on projections from the observations and measurements made between 1977 and 1988. The assumption is made that the flow/load relationship observed during this period would continue with the return to long-term average (ie wetter) conditions. Nevertheless, as a phosphorus load of 140 tonnes is known by observation to cause serious environmental problems, reduction of phosphorus inputs to the system and increased phosphorus losses from the system therefore become urgent. These are the primary objectives for management.

The Greenhouse Effect also complicates the consideration of climatic influences on the estuaries' problems. The Greenhouse Effect would have implications for the management strategy, because of likely changes to the amount, duration and frequency of rainfall. If the Greenhouse prediction that there could be a 20 percent reduction in rainfall in the catchment areas is correct, then this could result in a phosphorus reduction of about 30 percent. However, it is also anticipated that the Greenhouse Effect could result in the sporadic occurrence of intense storms. These storms would cause surface runoff that would wash phosphorus into the estuarine system. It is difficult to say what climatic and other changes will occur because of the Greenhouse Effect and, therefore, how these changes will effect the problems occurring in the estuarine system.

The Authority has had to adopt a particular position with respect to the Greenhouse Effect in order to complete its assessment of the management proposals. The position adopted by the Authority in this assessment is that possible reductions in total rainfall would be likely to be balanced out by increased phosphorus losses from first flush conditions resulting from intense storms.

Notwithstanding the present uncertainties about changes resulting from the Greenhouse Effect, a "wait and see" approach is not appropriate. This is because action on the estuaries' problems is needed urgently. An adaptive approach towards management of the estuaries will, therefore, be needed in order to respond appropriately to changing conditions.

To the extent that it can be done, it would be advisable for the final design work for the Dawesville Channel to take account of the most likely Greenhouse scenario with respect to sea level increase and to ensure that planning is based on a suitable long-term time frame.

OXYGEN STATUS AND RESILIENCE

All oxygen-breathing animals require enough oxygen to survive. When there are large algal blooms in the system there is a risk that when they collapse and decay, the level of oxygen in the water will become seriously reduced. This is because the bacteria involved in the decay process consume oxygen at the expense of other animals. This results in what is called an "oxygen crash". When this occurs, very large numbers of fish, crabs and bottom-living creatures such as worms and molluscs can be killed. These in turn decay, thus increasing the amount of oxygen being removed from the system. When Nodularia blooms occur, the amount of oxygen is also reduced by the thick scum which forms on the water surface and prevents oxygen from the atmosphere from diffusing into the water.

It is under these extreme conditions of oxygen depletion that the estuary system is at greatest risk. From observations of the system made in 1981, it is clear that when an extreme Nodularia bloom collapses about 2000 tonnes of oxygen is required for the process of decay. This is almost impossible to achieve in summer when the low level of tidal flushing is insufficient to remove the bloom quickly. A new channel would greatly increase flushing of the system, particularly in summer and the effect of this would be two-fold:

. the channel would remove decaying matter on the ebb tide; and

. the channel would introduce new, oxygenated marine water on flood tides.

The combination of these factors would dramatically reduce the duration and intensity of the adverse effects of decaying algal blooms on the estuarine system and would mean that severe oxygen crashes would not occur. This would provide the system with a resilience, or ability to bounce back after a major disturbance, that it does not presently have.

The only practicable way of managing oxygen crashes and providing resilience is by building a new channel to the ocean.

WEED GROWTH

Weed growth in the system consists of various species of large weed or macroalgae and also blooms of a microscopic cyanobacterium called Nodularia. These two types of plants require different conditions for germination and growth. These requirements are summarised below.

Macroalgae in the system include sea lettuce (Ulva) and rope weed (Chaetomorpha) species. Macroalgae can thrive in water of varying saltiness from almost fresh through to marine. Its growth rate is affected by water temperature and also by the availability of both phosphorus and nitrogen as well as other critical nutrients. It also requires reasonable light conditions for photosynthesis. In the Peel-Harvey System, growth of macroalgae is usually limited by poor light conditions rather than by lack of nutrients. The reduced light occurs when brown-stained water enters the system from rivers and drains in winter and also when Nodularia blooms occur and when other organisms eg. phytoplankton are suspended in the water column.

Nodularia is rather different. It also needs nutrients, in particular phosphorus and nitrogen. However, it is able to extract and utilise nitrogen from the atmosphere. This means that restricting the amount of nitrogen entering a waterbody containing Nodularia will not restrict its growth. Nodularia will simply extract what it needs from the air and continue to grow until phosphorus or some other critical nutrient becomes in short supply. Other critical requirements for Nodularia growth are particular levels of saltiness of the water and water temperature. If these two are not right, then Nodularia cannot germinate and therefore large blooms cannot occur.

In general, the amount of nutrients available in a system determines the total amount of plant and animal growth (biomass) that the system can sustain. The salinity of the system determines which species will live in the system. It is these factors and the specific requirements of Nodularia and macroalgae that enable the Peel-Harvey System to be managed. If the saltiness of the water is increased to a level more like that of the ocean, Nodularia cannot germinate. If the amount of phosphorus entering the system is restricted, the amount of macroalgae and/or Nodularia that can grow is much less. These points are both critical for management and are discussed in more detail later.

OBJECTIVES FOR MANAGEMENT

6. THE WATER QUALITY TARGET - CLEAN WATER AND A PRODUCTIVE ESTUARY

In its assessment of the Stage 1 ERMP, the Authority's management objective was stated simply as:

"to produce and maintain an estuary system that is visibly clean and healthy and is ecologically healthy and resilient" (EPA,1985).

This objective recognised that the Peel-Harvey System has important biological and social values. It contains an ecosystem that is important to maintain for the biological health of the system. The ecosystem itself contains elements that make the system attractive to humans, such as water and fish or crabs for recreation. Managing the system at the expense of either the components of the ecosystem, or at the expense of its human user groups would be undesirable. The target for management is, therefore, to strike a balance which meets the requirements of both groups and results in an estuarine system that is in an environmentally acceptable condition. The Stage 1 assessment report identified the ideal water quality as being moderately nutrient enriched so that a large biomass of fish and crabs could be supported without the system becoming unhealthy. This condition is called "mesotrophic" which means a state of medium nutrient enrichment. This can be measured numerically in the estuaries' waters by taking water samples and having them analysed. On world standards, the conditions are considered mesotrophic when the concentration of phosphorus in the water lies between 0.1 and 0.2 milligrams per litre of estuary water (Reckhow and Chapra, 1983).

The approach taken by the Authority in the Stage 2 assessment is broadly the same. However, because there are now sufficient data available from monitoring of both the catchment and the estuaries, the Authority is able to also express the management target in numerical as well as descriptive terms. This is an important step as it will enable people to judge the success of the management strategy over time by measuring the performance of

the system and comparing it with what is required to meet the management target. The numerical target is discussed in Section 7 which follows.

In descriptive terms, the Authority's management objectives are:

. at least an acceptable to good level of water quality, defined as moderately nutrient enriched (mesotrophic);

. a high level of resilience in the system to ensure that massive oxygen depletion does not occur;

. a large reduction in phosphorus input to the system from the catchment area;

. a solution, that will preferably show major improvement within five years, to ensure that irreversible damage to the system does not occur; and

. a very high probability that the strategy will succeed in both the short and long-term.

Although not environmental in nature, another important consideration is the overall cost-benefit that would result from the system being adequately managed and becoming healthy and resilient.

7. PHOSPHORUS LOAD TARGET AND FREQUENCY OF BLOOMS

The estuary system has been measured and observed over the last twelve years. The numbers that follow have been derived from these observations and mathematical predictive modelling. Section 7.2.1 of Bulletin 363 Part II addresses these issues in more detail.

In order to define the water quality target numerically, it is necessary first to answer some critical questions:

. how much phosphorus is entering the system now? The twelve year annual average (measured between 1977 and 1988) is over 140 tonnes;

. how much phosphorus entering the system causes blooms to occur? Information from observations and measurement over the period 1977-1988 indicates that this is observed to be over 85 tonnes for the whole estuary system;

. how frequently can we expect blooms to occur with over 85 tonnes of phosphorus? Refer to the following table;

. how much phosphorus would be likely to enter the system if climatic conditions return to long-term average (ie wetter than now)? This could be commonly 200 to 300 tonnes and up to 400 tonnes in very wet years. These loads are estimates based on the observations and measurements in the 1977-1988 period;

. how frequently would blooms occur with this level of phosphorus? Refer to the following table; and

. what level of phosphorus can the system tolerate (ie what is its assimilative capacity) with and without enhancing phosphorus losses from the system? Losses from the system could be increased by building a new channel to the ocean - the Dawesville Channel. At present the maximum

that can be assimilated is up to 85 tonnes of phosphorus (based on observations and measurements between 1977 and 1988). With the Dawesville Channel this would increase to up to about 165 tonnes of phosphorus. This defines the management target which is 85 tonnes phosphorus if there is no Dawesville Channel, or 165 tonnes with a Dawesville Channel.

From the Authority's investigations and assessment, it is clear that it is environmentally unacceptable for the system to suffer excessive algal blooms or such a large lack of oxygen that massive kills of fish, crabs, and bottom-living creatures result in most years. Consequently, the Authority's management target is to reduce the amount of phosphorus in the system to 85 tonnes in six years out of ten (on average). This equates to a load of 165 tonnes in very wet years (approximately one year in ten on average). In terms of the phosphorus concentration in the estuaries' water, a level of between 0.1 and 0.2 milligrams of phosphorus per litre of water would be healthy (Reckhow and Chapra, 1983). This is easy to sample and measure.

The following table indicates how frequently blooms would be expected to occur with the above loads of phosphorus and flow scenarios:

	FREQUENCY OF BLOOMS	
	If climate like the last 12 years	If climate like long-term average
With the present assimilative capacity of Peel-Harvey (85 tonnes) how often would blooms occur with over 85 tonnes phosphorus load?	9 in 12 years	9 in 10 years
If the assimilative capacity of the system is increased to 165 tonnes (with the Dawesville Channel and no additional new management) how often would blooms occur with a 165 tonne phosphorus load?	4 in 10 years	7 in 10 years
How often does the Peel-Harvey System go into severe oxygen deficiency now resulting from a phosphorus load of over 200 tonnes ?	1 in 12 years	1 in 2 years
How often would severe oxygen deficiency occur with the Dawesville Channel (critical phosphorus load that could be tolerated would then be 400 tonnes maximum)	would not occur	1 in 5 years

8. WHAT DOES THE TARGET MEAN IN TERMS OF MANAGEMENT?

Management can focus on the causes of an environmental problem , on the problem itself (the symptoms), or on a combination of both. The symptoms in the Peel-Harvey System are the macroalgal blooms and occurrences of Nodularia. Options for management of the large weed (ie. macroalgal) problem include:

. harvesting of beached weed - this has been employed for over thirteen years but it cannot cope with the amount of weed. It also causes degradation of the beaches;

- aquatic harvesting of weed before it reaches the beaches - this has also been occurring for some years. Weed harvesting is only moderately successful as the two methods presently employed cannot trap all the weed. Weed occurring in water too deep for front-end loaders or too shallow for the aquatic harvester cannot be collected until it is beached;

- treatment with herbicides or algicides; and

- reduction of phosphorus within the system so that growth becomes restricted by lack of phosphorus.

In the case of Nodularia there is no management that can be applied once an algal bloom is underway. To control Nodularia it is necessary to manipulate some of the physical requirements of the alga, in particular:

- reduction of phosphorus within the system so that growth of Nodularia becomes limited by lack of phosphorus; and

- changing the saltiness of the system so that the critical requirements for germination of right temperature and salinity cannot occur. This can be achieved by building a new channel to the ocean to make the system more marine.

If the focus is upon the causes of the problems, that is too much phosphorus entering the system and remaining within it, then the options for management are:

- reducing the amount of phosphorus entering the system from the catchment. This can be achieved by catchment management;

- increasing the amount of phosphorus lost from the system by increasing flushing to the ocean via the Dawesville Channel; and

- ensuring that the phosphorus already within the system, bound up in the sediments, either remains there or is lost so rapidly that it cannot be used by plants or animals (the Dawesville Channel would achieve this by preventing deoxygenation of the sediment surface over most of the estuary).

PROPOSALS FOR THE MANAGEMENT STRATEGY

9. THE NEED FOR THE DAWESVILLE CHANNEL

The Dawesville Channel is essential to the management strategy because it would increase flushing of the system. Improved flushing:

- would mean that the whole system could tolerate a much larger annual loading of phosphorus than at present (up to 165 tonnes instead of up to 85 tonnes) before the environmental condition of the estuaries would suffer;

- would remove a larger amount of phosphorus from the system than is presently lost through the Mandurah Channel;

- would make the system more marine or salty which would virtually eliminate Nodularia from the system;

- would mean that residence time (which is the length of time that water entering the system from drains, rivers and the ocean remains in the system) is reduced;

- would increase the resilience of the system by increasing its assimilative capacity and preventing massive loss of oxygen from the system with consequent large kills of fish, crabs and bottom-living creatures.

10. ENVIRONMENTAL EFFECTS OF THE DAWESVILLE CHANNEL

The environmental impacts of the Dawesville Channel have been described in detail in the Stage 2 ERMP and in the Part II report of the Stage 2 assessment (Bulletin 363, Part II). The following effects are considered to be beneficial for management of the system:

- increased tidal range;

- increased water exchange with the ocean;

- reduction in the length of time that water and nutrients remain within the system;

- reduction in stratification (layering) of the water bodies so that better overall mixing of river and ocean waters occurs over more months of the year;

- increased salinity which would virtually prevent germination of Nodularia;

- high levels of oxygen in the water;

- improved water clarity; and

- increased loss of phosphorus from the system from improved flushing.

The above effects would be beneficial in managing the target organisms. There will also be impacts on non-target organisms, including on plankton, invertebrates, crustaceans, fish, birds and fringing vegetation. There would also be impacts on humans, in particular possible flooding and increased mosquito nuisance.

The Authority has determined that the environmental impacts of the Dawesville Channel, as an element of the management strategy, are acceptable.

11. THE NEED FOR CATCHMENT MANAGEMENT

Management of catchment land uses and activities is essential to reduce the overall load of phosphorus entering the system. Even with a new channel to the ocean, phosphorus inputs to the system would have to be reduced to ensure that the total phosphorus load entering the estuaries does not exceed the assimilative capacity of the system.

Management of land uses and catchment activities will include continuation of the present fertiliser management programme which is designed to reduce the amount of phosphorus being used. It will also mean controlling phosphorus losses from intensive agricultural activities (point sources) such as piggeries and other industries. In addition, catchment

management will mean changes in land use. Some catchment soil types, in particular, the "deep grey sands", lose enormous amounts of phosphorus from fertilisers. Phosphorus concentrations in drainage rise steeply when the amount of the catchment cleared reaches half. Therefore progressive reafforestation of the coastal plain catchment would achieve a rapid improvement in phosphorus loss and is a management priority. If the reafforestation is concentrated on the "deep grey sands" the benefits will be greatest because these soils which are less suitable for agriculture would then be used more appropriately.

Elements of the catchment management strategy are:

. fertiliser management;

. changes in land use;

. control of point sources of phosphorus (and other) pollution;

. preparation of an integrated catchment management plan; and

. continuation of the moratorium on clearing and drainage.

12. ENVIRONMENTAL EFFECTS OF CATCHMENT MANAGEMENT

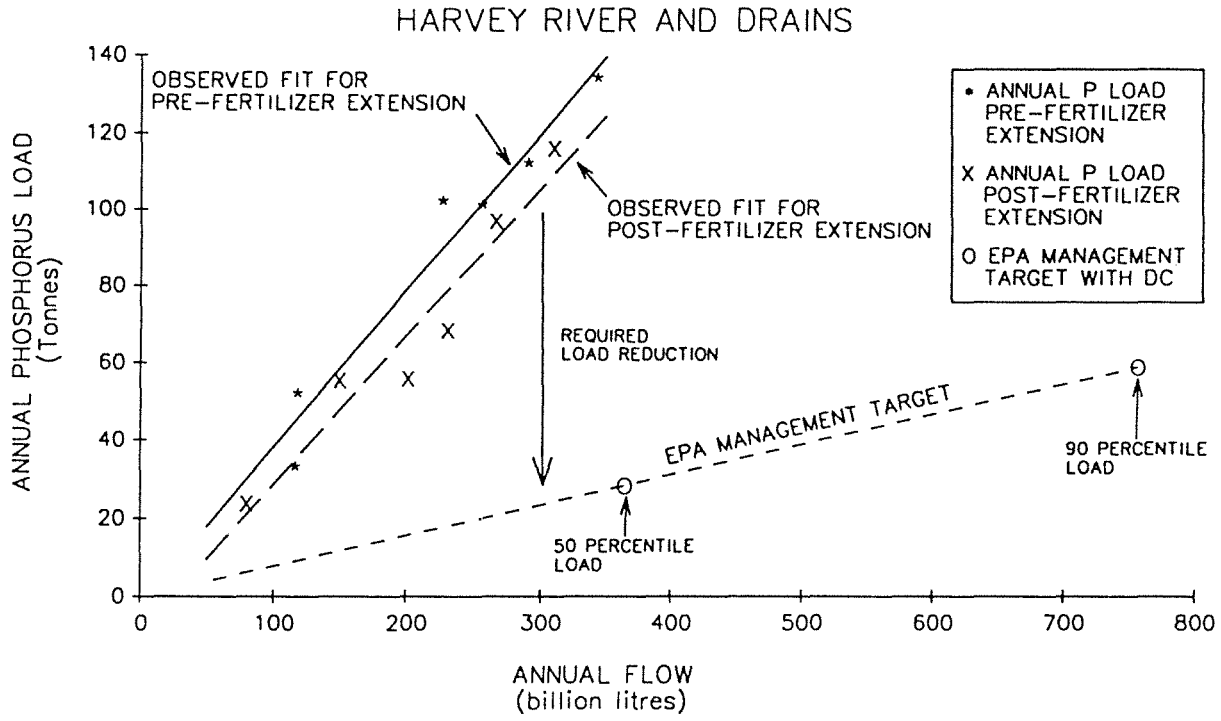
The environmental impacts of catchment management have been described in detail in the Stage 2 ERMP and in the Part II report on the Stage 2 assessment (Bulletin 363 Part II).

It should be remembered that proposals for catchment management in the ERMP were designed to reduce phosphorus inputs from the catchment from the observed 12 year average annual loading of 140 tonnes, to about 85 tonnes. This would represent a forty percent reduction. This would hold only if the pattern of rainfall and runoff observed between 1977 and 1988 continued. This period has been unseasonally dry (in terms of the long-term average) and a return to average rainfall and runoff conditions would greatly increase the annual phosphorus loading to the system to as much as 300 to 400 tonnes. If the load increased to these amounts, the estuary system could still only assimilate a maximum of up to 85 tonnes if there is no Dawesville Channel, or up to 165 tonnes if the Dawesville Channel is built. Therefore, catchment management needs to be designed to achieve enough phosphorus reduction to ensure that in most years the assimilative capacity of the system is not exceeded.

Clearly, under average rainfall and runoff conditions, a forty percent reduction is not sufficient to ensure that the management target will be met. From its assessment, the Authority has established that a reduction of around sixty percent will be needed to sufficiently reduce phosphorus inputs for the Dawesville Channel to perform as required, even in heavy rainfall and runoff years. This is explained in graph form for the Harvey River and Drains Catchment in Figure 3.

Figure 3

Graph for Harvey River and Drains showing the Phosphorus Load Reduction required to achieve the EPA management target, compared with loads observed before and after implementation of the fertiliser management programme



EXPLANATION OF FIGURE 3

The graph shows a plot of annual phosphorus load in tonnes against annual flow from rivers and drains in the Harvey River and Drains Catchment. The points on the graph indicated by stars and crosses are actual measured occurrences of a given load and flow. Each point represents a whole year of measurements to give total annual load and flow.

The solid line is the best fit for the star points which represent the total amount of phosphorus entering the estuary system from the catchment before any management of fertiliser commenced.

The line in long dashes is the best fit for the large crosses on the graph. This represents the situation measured after implementation of the fertiliser programme.

The bottom line in short dashes represents the load that is required to meet the EPA management target and to achieve a clean, healthy estuary system.

The steeper the gradient on the line, the greater the total load of phosphorus entering the system each year relative to total flow. The flatter the gradient, the better the nutrient status (and therefore health) of the system relative to its present condition. However, it would be undesirable for the gradient to become significantly less than that shown by the EPA management target line or the productivity of the system would start to be seriously affected and the system would become nutrient-poor.

13. THE NEED FOR A COMBINED STRATEGY

With a target of a clean, healthy and resilient system a combined management strategy is necessary. The parts to be played by the two major elements are shown in Table 2 .

Table 2. Contributions of Dawesville Channel and Catchment Management to Achieving the Management Target.

MANAGEMENT CRITERIA	DAWESVILLE CHANNEL	CATCHMENT MANAGEMENT
. at least an acceptable to good level of water quality	Essential	Essential
. marine or near-marine conditions, for control of Nodularia	Essential	-
. high resilience in the system to ensure it does not 'go over the edge'	Essential	Essential
. a large reduction in phosphorus input to the system (discussed further in Section 9.2 in Bulletin 363 Part II)	-	Essential
. increased removal of phosphorus from the system	Essential	-
. very high chance of success of the strategy and ongoing success	Essential	Essential

The full management strategy consists of:

. constructing the Dawesville Channel as soon as possible;

. implement catchment management, to include:

- fertiliser management;
- changes in land use;
- control of point sources;
- continuation of the moratorium on clearing and drainage;
- preparation and implementation of an integrated catchment management plan to meet the target for phosphorus load reduction specified in this report;

. continue weed control and harvesting; and

. implement appropriate monitoring to measure the success of the strategy.

14. ENVIRONMENTAL EFFECTS OF THE COMBINED STRATEGY

The environmental effects of the two main management elements have already been discussed. In summary, the combined strategy would have the desired effects on the target organisms and is environmentally acceptable. The effects on non-target organisms are also environmentally acceptable.

It is likely that the hydraulic improvements achieved by the Dawesville Channel would be better than predicted. The channel is analogous to the Mandurah Channel in some respects, and some of the assumptions made in the mathematical modelling for the Mandurah Channel and Sticks Channel dredging have also been applied to the predictive modelling for the Dawesville Channel. The dredging of the Mandurah Channel, Sticks Channel and Fairbridge Bank has now been completed. The effects of this dredging, in terms of hydraulic improvements, have already been observed to be much better than had been predicted. Based on this experience it is probable that the performance of the Dawesville Channel would also be better than has been predicted. However, it is impossible to say just how much better it will be.

The mathematical modelling that has been carried out assumes existing water depths, obstructions and flows in the Peel-Harvey System. Therefore, if work is carried out that would affect these factors, for example major dredging work, the performance of the Dawesville Channel may be reduced. Therefore, it would be essential to assess properly any future proposals that might reduce the effectiveness of the Dawesville Channel.

15. IMPLEMENTATION RESPONSIBILITIES, MANAGEMENT AND MONITORING

The proponents nominated by the Minister for Environment as responsible for the Peel Inlet-Harvey Estuary Management Strategy Stage 2 are the Minister for Transport, the Minister for Agriculture and the Minister for Waterways. These proponents are equally responsible for the implementation of the whole management strategy and for the monitoring and management of the proposals and their impacts. Under the Environmental Protection Act,1986, the proponents would be legally responsible for the implementation of the environmental conditions set on the proposal by the Minister for Environment.

CONCLUSIONS

16. SUMMARY OF RATIONALE FOR THE CONCLUSIONS AND RECOMMENDATIONS

. Sections 4 and 5 describe how levels of phosphorus in water, weed growth, oxygen depletion and kills of fish, crabs etc occur in response to interactions between rainfall, nutrient inputs and flushing (which removes weed and nutrients and increases the salinity of the water).

. The management of the system is designed to influence nutrient inputs and flushing and to provide for removal of weed by harvesting or chemical control.

. Monitoring over the last 12 years has shown the quantitative relationships between rainfall, runoff, phosphorus inputs, flushing and growth of weed. It indicates an average yearly phosphorus input over that period of 140 tonnes, and Nodularia blooms in nine out of the twelve years. Observations also indicate that the 12-year period was much drier than average.

. Predictions and calculations show that:

- the assimilative capacity of the system at present is a maximum of up to 85 tonnes of phosphorus per year;

- inputs of phosphorus would increase to 200 to 300 tonnes in average wet years and up to 400 tonnes in very wet years;

- the Dawesville Channel would increase the assimilative capacity of the system to 165 tonnes of phosphorus per year, and would increase water salinity, eliminate Nodularia blooms, decrease oxygen losses and hence increase the resilience of the system;

- catchment management as proposed in the ERMP would reduce phosphorus inputs by 40 percent in dry years, from 140 tonnes per year to 85 tonnes per year. Average rainfall would mean phosphorus inputs of 200 to 300 tonnes and in very wet years this would rise to 400 tonnes. Therefore, it is necessary to reduce phosphorus inputs to the system by 60 percent to ensure that water quality is good enough in nine years out of ten.

. The conclusion is that both the Dawesville Channel and catchment management are needed to reach an environmentally acceptable water quality in the estuaries. The detailed conclusions and recommendations in support of this follow.

17. CONCLUSIONS AND RECOMMENDATIONS

OVERALL CONCLUSION AND RECOMMENDATION

The problems in the Peel-Harvey System, their causes and possible solutions have been addressed elsewhere in this report. It is clear that successful management of this estuary system can only be achieved by both reducing phosphorus and other nutrient inputs to the system, increasing the rate at which phosphorus and other nutrients are lost from the system and by making the system more marine and therefore unfavourable for Nodularia. The former can be achieved by managing activities in the catchment and the latter two by construction of a new channel to the ocean at Dawesville. Only implementation of both management elements would achieve the recommended target water quality and ensure sufficient resilience in the system to withstand development pressures without further degradation of the environment. The Authority therefore makes the following overall recommendation:

RECOMMENDATION 1

The EPA concludes that the Dawesville Channel and other management strategies proposed in the Stage 2 Environmental Review and Management Programme, as modified by this assessment report, are environmentally acceptable and recommends that these proceed in accordance with the commitments in Appendix 2 and the EPA recommendations.

CATCHMENT MANAGEMENT

Fertiliser Management and Catchment Land Uses

To meet the overall management objectives, careful and detailed agricultural planning of the catchment needs to take place. This has already been commenced by the Department of Agriculture which is coordinating the preparation of an integrated catchment management plan (ICMP) at the request

of the Integrated Catchment Management Policy Group. However, to date, this has been proceeding in the absence of clearly stated environmental objectives, or an enabling framework which requires an adequate level of phosphorus reduction. In the Stage 1 assessment report, the Authority identified the need to develop a long-term land management plan for the coastal plain catchment in particular, and an appropriate enabling framework to attain and secure, for all time, reductions in nutrient loadings to the system. In the Stage 2 assessment, the Authority has defined more specific management targets. The Authority has also determined that the most effective mechanism to enable these targets to be met, and which would provide a sound legal basis, is an Environmental Protection Policy. Consequently, the Authority recommends:

RECOMMENDATION 2

The EPA recommends that proposals for control of phosphorus through catchment management should be developed and implemented as rapidly as possible so that, in conjunction with the Dawesville Channel, the following objective is met:

- **the Peel-Harvey System is clean, healthy and resilient.**

  On the basis of studies undertaken (see Bulletin 363 Part II) the Authority believes that the above would be achieved with target figures of:

  - **annual phosphorus input to the system not to exceed 165 tonnes in nine out of ten years;**

  - **average phosphorus concentration in estuary water is not to exceed 0.2 milligrams per litre in nine years out of ten (on average);**

These target figures should be reviewed in the light of measured performance of the system.

RECOMMENDATION 3

The EPA recommends that the proponents jointly prepare an Environmental Protection Policy for the Peel-Harvey catchment, in accordance with the objective and targets specified in Recommendation 2 of this report.

RECOMMENDATION 4

The EPA recommends that the proponents develop an integrated catchment management plan to meet the objective and targets specified in Recommendation 2 of this report and in accordance with the principles to be developed in the Environmental Protection Policy for the area pursuant to Recommendation 3.

It will be necessary to control land uses which presently lead to excessive inputs of phosphorus into the estuaries. It will likely require less area fertilised for agriculture and more area planted under trees.

The catchment management plan, to which Recommendation 4 applies, would need to address a number of issues, some of which were raised in the ERMP. The plan should include consideration of the following:

- the environmental water quality requirement for the estuary system will set constraints on land uses in the catchment;

. changes in land use should have environmental benefits as the prime objective;

. nutrient inputs from all rural sources should be managed so that the total nutrient load is within the assimilative capacity of the Peel-Harvey System (ie 165 tonnes in nine years out of ten);

  - export of phosphorus from all properties in the catchment must be reduced to meet the above water quality targets;

  - export of nitrogen from all properties must meet a water quality target for nitrogen, to be specified during the catchment planning exercise;

  - appropriate fertilisers should be developed for the area, in particular sulphur only or low phosphorus sulphur fertiliser;

  - soil testing and provision of fertiliser advice to farmers should continue;

  - alternative methods of applying fertiliser should be investigated with a view to late winter spreading;

. nutrient inputs from all urban sources should be managed (see also Recommendation 6);

. pollution from point sources should be controlled to meet the objectives;

. major tree planting programmes should be based on maximising the environmental benefits as the primary objective and should be carried out in accordance with the EPA's recommendations in its assessment of the WA Chip and Pulp Company proposals (EPA, 1988b);

. clearing practices in the catchment should be reviewed to ensure environmental protection of the estuary system in accordance with the EPA's recommendations on retention of remnant native vegetation in EPA Bulletin 319 (EPA, 1988a) and Bulletin 329 (EPA, 1988b) (see Recommendation 5); and

. drainage practices in the catchment should be reviewed to ensure environmental protection of the estuary system (see Recommendation 5).

Clearing and Drainage

Clearing of native vegetation and replacement with pasture requiring fertiliser has been a major contributor to the severity of the estuaries' problems. Artificial drainage also plays a part by speeding up the rate at which phosphorus enters the estuaries from the catchment. The ERMP proposed a moratorium on further clearing and drainage and the Authority believes that the moratorium should continue and be reviewed during the integrated catchment management planning process. The moratorium covers clearing of all shrubs and trees. The removal of non-native vegetation could be environmentally acceptable under some circumstances and this would need to be reviewed as part of the integrated catchment planning exercise. The Authority believes that further clearing of remnant native vegetation in the coastal plain catchment is environmentally unacceptable. This includes passive clearing which occurs when stock are allowed to ringbark trees and

shrubs, causing them to die. The moratorium on clearing and drainage could be removed when the Minister for Environment is satisfied that these activities would be environmentally acceptable.

RECOMMENDATION 5

The EPA recommends that the moratorium on clearing and drainage in the Peel-Harvey coastal catchment should continue until the Minister for Environment is satisfied that these activities would be environmentally acceptable.

Waste Disposal

Another potential contributor to phosphorus pollution is the use of septic tanks in sandy soils, such as those occurring in the Peel-Harvey coastal plain catchment. Recently, the Legislative Assembly Select Committee into Effluent Disposal reviewed the suitability of septic tanks for effluent disposal in the Perth Metropolitan Area which has similar soil conditions (Legislative Assembly, 1988). The Committee recommended, among other things, that:

"Septic tanks in their present mode are not to be used as a long-term solution to Perth's effluent disposal needs" (Legislative Assembly,1988, p.43).

The soils of the Perth Metropolitan Area and the Peel-Harvey coastal plain catchment are very similar, as both areas are on the Swan Coastal Plain. Therefore the Authority believes that environmentally acceptable waste disposal systems and management practices should be used wherever necessary to prevent pollution of the Peel-Harvey System.

RECOMMENDATION 6

The EPA recommends that all developments within 2 kilometres of the Peel-Harvey Estuary System (as defined in Estuarine and Marine Advisory Committee EMAC, 1981) include appropriate nutrient-attenuating waste disposal systems and management practices.

DREDGING AND DREDGE SPOIL DISPOSAL

Dredging and dredge spoil disposal are likely to be ongoing issues in the Peel-Harvey System as new developments are proposed and expectations are raised. In addition, there is likely to be some requirement for occasional maintenance dredging. Major dredging within the estuaries could affect the hydraulic and flushing characteristics of the Dawesville Channel and estuaries. The Authority believes that proposals for dredging and spoil disposal need to be addressed in a co-ordinated manner and that preparation of a dredging and spoil disposal management plan for the Dawesville Channel would be a practical way in which to achieve this and to maximise opportunities whilst protecting the environment. Dredging not already part of the ERMP proposals will require full separate assessment.

RECOMMENDATION 7

The EPA recommends that, prior to construction of the Dawesville Channel commencing, a dredging and spoil disposal management plan for the Dawesville Channel be prepared by the Department of Marine and Harbours, Peel Inlet Management Authority and the Waterways Commission, to the satisfaction of the EPA. Dredging not already part of the proposals in the ERMP would be the subject of separate assessment by the Environmental Protection Authority.

WEED HARVESTING

Weed harvesting and control will need to be continued and may need to be increased in the short-term, as the Dawesville Channel would improve water clarity (which will benefit macroalgae) ahead of a substantial reduction in phosphorus occurring. Over time, it could be expected that macroalgae would become limited in abundance by lack of nutrients where at present they are limited by a combination of lack of light and nutrients.

RECOMMENDATION 8

The EPA recommends that weed harvesting and control should be continued and increased as necessary to manage the expected initial increase in the occurrence of nuisance macroalgae.

DEVELOPMENT PROSPECTS

From the assessment of catchment management and probable performance of the Peel-Harvey System with a Dawesville Channel, it is evident that there are some uncertainties which would have an effect on likely future developments in the area. The problems in the system have tended to act as a constraint upon development in near-estuarine areas. Therefore, as conditions within the estuarine system improve, there may well be an upsurge in development pressure. On present knowledge, it is not possible to predict the extent to which additional major development would be environmentally acceptable.

Monitoring of the altered system will enable an estimation to be made of the new assimilative capacity of the estuary environment. This in turn will provide a guide as to the ability of the system to accommodate any additional development.

The Authority believes that these uncertainties will require development decisions to be conservative in the initial period following implementation of the full management strategy and recommends:

RECOMMENDATION 9

The EPA recommends that development decisions in the Peel-Harvey Estuary area and coastal catchment area should be conservative until the new assimilative capacity of the Peel-Harvey Estuary System can be determined and the effects of the management elements have been measured or are being managed, in particular:

. the ability of the system to assimilate more development;

. water quality;

. foreshore reserve requirements;

. impact of increased mosquito nuisance;

. potential flood impacts and review of 100-year flood level.

PEEL-HARVEY REGIONAL PARK

The Peel-Harvey System is a regional resource and an additional aspect of estuary development is the implementation of the System 6 Redbook recommendation for a Peel-Harvey regional park (EPA, 1983). These proposals

touch on the area of co-operative management as well as other aspects such as foreshore reserves and mosquito control.

Ideally, regional parks should evolve out of the planning process, and this is occurring in the Peel-Harvey area. Implementation of the regional park is progressing. However, as other management issues hinge on this occurring soon, action should be undertaken immediately.

RECOMMENDATION 10

The EPA recommends that the Peel-Harvey regional park concept, as originally proposed in the System 6 Redbook report (EPA, 1983) should be implemented.

MOSQUITO NUISANCE

The Dawesville Channel will increase diurnal tides in the estuarine system. This will have an effect on mosquito breeding habitats. Submissions received by the Authority have suggested that mosquito nuisance could increase. The Authority is uncertain about the extent of this effect. The proponents should therefore, have a responsibility for addressing the matter of mosquito control.

RECOMMENDATION 11

The EPA recommends that if the Dawesville Channel is constructed, the proponents should have a responsibility for ensuring that mosquito management is effective and is carried out in an environmentally acceptable manner.

ONGOING ADMINISTRATION AND IMPLEMENTATION

Ongoing administration and management of this project as a whole will require taking a long-term view and inputs of management agencies will need to be coordinated. The Minister for Environment has nominated the Minister for Transport, Minister for Agriculture and Minister for Waterways as co-proponents for the proposal because of their interests and responsibilities in the Dawesville Channel, catchment management, and estuary water quality.

RECOMMENDATION 12

The EPA recommends that the proponents be jointly responsible for:

- **the construction, operation, monitoring and maintenance of the Dawesville Channel and its impacts within the estuaries and within the immediate marine environment;**

- **the management and required monitoring of the catchment and collection of data necessary for the development of the integrated catchment management plan of the Peel-Harvey catchment; and**

- **all in-estuary monitoring and management, including weed harvesting.**

MANAGEMENT AND MONITORING

There will be a requirement for substantial ongoing management and monitoring of the Peel-Harvey System and a requirement for acquisition of some additional base-line water quality data against which to compare the performance of the management strategy, when implemented. This has been

addressed in Section 11 of this report. Proposals for monitoring and management should include:

. construction impacts;
. sand by-passing associated with the Dawesville Channel;
. estimation of and/or measurement of flushing rates;
. tidal level monitoring;
. water circulation;
. flooding;
. mosquito control;
. catchment groundwater and surface water hydrology;
. catchment nutrient balance;
. estuarine water quality;
. assimilative capacity of the estuaries;
. weed occurrence;
. weed harvesting;
. phytoplankton (including Nodularia) occurrence;
. birds, including a detailed assessment of the regional and international significance of the Peel-Harvey System as a habitat;
. fish; and
. foreshore protection.

The Authority therefore makes the following recommendation:

RECOMMENDATION 13

The EPA recommends that the proponents should prepare in stages a monitoring programme, to the satisfaction of the EPA, prior to the construction of the Dawesville Channel.

The programme should address:

. **essential additional baseline monitoring to be in place as soon as possible and prior to construction commencing;**

. **construction impacts and monitoring, prior to construction; and**

operational and long-term monitoring, in stages, to be determined by the EPA.

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APPENDIX 1

SUMMARY AND RECOMMENDATIONS OF STAGE 1 ASSESSMENT REPORT

SUMMARY AND RECOMMENDATIONS OF STAGE 1 ASSESSMENT REPORT

The Environmental Protection Authority has concluded its review of the Stage 1 ERMP on the Peel-Inlet Harvey Estuary Management Strategy. The Authority's assessment will assist in the development of the investigations leading to the preparation of the Stage 2 ERMP by the proponents.

The Authority has set its objective for management of the system, namely:

> "to produce and maintain an estuary system that is visibly clean and healthy and is ecologically healthy and resilient."

Within the context of the objective, the assessment report addresses:

- the staged assessment process;
- the description of the problem and its causes;
- possible management measures for reducing the nutrient level; and
- estuary and catchment use and management.

The Authority has reached a number of conclusions. The principal ones are as follows:

- the major source of nutrient input to the Peel-Harvey System is the Catchment Area, but there is also a large nutrient store in the sediments of the estuaries;
- there needs to be a reduction in the level of nutrients entering the estuaries from the Catchment Area, and a reduction in the amount of nutrient already held in the sediments of the estuaries;
- it will be necessary to develop a long-term land management plan for the Catchment Area and an appropriate enabling framework, to attain and secure for all time reductions in nutrient loading to the System;
- improvements to the water exchange between the Peel-Harvey System and the ocean will have to be made to reduce the impact of nutrients and to produce a System that is ecologically resilient;
- the nutrient oversupply cannot be cured either by management in the Catchment Area or by improving water exchange alone. A combination of both measures will be needed to restore the health and resilience of the System within the time that is envisaged; and
- commercial developments and use of suitable low phosphorus fertilisers (eg a sulphur only fertiliser) would be beneficial to the pollution management of the Catchment Area.

In conclusion, the Authority, after giving due consideration to the information presently to hand and subject to the implementation of the following recommendations, is of the opinion that neither management of the Catchment Area nor construction of the Dawesville Channel alone can reduce the level of nutrient enrichment in the System sufficiently to achieve a clean, healthy estuary system, at least in the short term.

SUMMARY AND RECOMMENDATIONS (Contd)

RECOMMENDATION 1

The EPA recommends that initiatives already in place, specifically, commitment to long term continuation of the fertiliser management programme, commercial development of a sulphur only (non-phosphorus) fertiliser, farmer extension programme, weed harvesting and monitoring of aspects of the catchment and estuary should be continued. The latter should be designed to meet the following management objectives:

. verify that the management programme will fulfil the EPA's objective;

. verify/improve predictions about the phosphorus rundown in soils and sediments;

. indicate what occurs if widespread use of sulphur-only (non-phosphorus) fertiliser commences in 1986;

. to allow for prediction of blooms (from measuring the chlorophyll$_a$ level and nutrients in the sediments in the estuaries);

. to provide data on whether and how an oxygen collapse develops; and

. to provide up-to-date information which will allow for an accurate description of the existing environment in the catchments and estuary at any time.

RECOMMENDATION 2

The EPA recommends that in order to protect the Peel-Harvey System from excessive loads of phosphorus (and other nutrients) a Catchment Management Plan and an appropriate mechanism to facilitate its implementation be developed. To secure continuation of gains already achieved in the Catchment Area, an interim mechanism should be instituted as a high priority.

RECOMMENDATION 3

The EPA recommends that the Peel Inlet Management Programme be reviewed and revised to be in accord with the EPA's management objective for the Peel-Harvey System and to be consistent with the Catchment Management Plan and enabling mechanism (see Recommendation 2).

RECOMMENDATION 4

The EPA recommends that if the dredging of both ends of the Mandurah Channel, to improve the flushing in Peel Inlet, is carried out early enough, then the work should be monitored in order to facilitate the following:

. the data obtained from the monitoring of the effects of the above dredging should be used to check the validity of the predictions from the mathematical modelling which has been used to predict the improved flushing of Peel Inlet; and

. the above findings should then be used to further enhance the predictive modelling of solute transport (phosphorus) resulting from the Dawesville

Channel and the interactions between the improved flushing characteristics of the dredged Mandurah Channel and the Dawesville Channel.

RECOMMENDATION 5

The EPA recommends that investigations continue into the size, design, location and implications of construction of a channel (or channels) connecting the sea to the Harvey Estuary, specifically in the context of the EPA's objectives and other recommendations in this report.

In addition, there may be an improvement in the pollution problem in the Harvey Estuary if circulation is improved between the Harvey Estuary and the Peel Inlet. Therefore there should be further investigations into the dredging of the channel between Ward Point and Point Grey (see Section 5.3.1 and Figure 2 of this report).

RECOMMENDATION 6

The EPA recommends that environmental review of the management strategy should continue in the State's environmental impact assessment process in the following manner: (see Figure 7)

. the studies aimed at providing specific information to assist in management decisions contained in Recommendations 1-3 and 5 be implemented**;

. the Stage 2 ERMP be prepared when the results and/or data from the above are available to incorporate into that document;

. the Stage 2 ERMP should inter alia:

  - report the results of the implementation of the recommendations made in this assessment report;

  - identify the probability of success associated with the management alternatives for meeting the EPA's objectives;

  - give the timetable for the preferred management strategy and the implications thereof;

  - consider the anticipated effects on the Estuaries resulting from the Catchment Management Plan and enabling mechanism;

  - outline a monitoring programme to verify that the management strategy is fulfilling the EPA's objectives;

  - outline a mechanism for a review and reporting of the monitoring results; and

  - examine the impacts of the construction of a channel (or channels) and its/their consequences.

** this would also apply to Recommendation 4 if the work is completed early enough.

. to ensure a meaningful public review phase the following condition would be necessary:

  - ongoing EPA involvement in determining the level, nature and timing of assessment required for possible associated developments.

APPENDIX 2

LIST OF COMMITMENTS MADE BY THE PROPONENTS

MANAGEMENT COMMITMENTS MADE BY THE PROPONENTS

The following list has been amended by the EPA and accepted by the proponents to reflect the 'whole of Government approach' which is essential for management of this proposal.

1. DAWESVILLE CHANNEL

- The proponents will conduct a detailed survey to locate, assess and offer protection to Aboriginal sites and heritage.

- During construction of the Dawesville Channel, the proponents will ensure the continuity of road access, power supply, communications, and water and sewerage services that require relocation, and will minimize dust and noise impacts upon nearby residential areas.

- Spoil from the excavated channel will be used in redeveloping the fill areas as a stable and varied landscape, reflecting naturally occurring topography elsewhere on the coastal strip.

- The proponents will manage spoil disposal to minimize disturbance to important land elements, including coastal dunes, tree belts along Old Coast Road and near the estuary foreshore. Spoil disposed of adjacent to the undisturbed coastal dunes will be contoured to co-ordinate with natural dune topography in order to minimize the potential for erosion.

- The land area used to dispose of excavated material will be contoured to facilitate possible future development into a prime residential and holiday area. Views from existing residences near the estuary will be retained, taking into consideration that these views may have been ultimately reduced by foreshore development and landscaping, irrespective of the proposed channel development.

- Littoral sand drift northwards along the ocean coast will be mechanically bypassed beyond the channel entrance, to minimise siltation within the channel and to avoid adverse effects on beaches to the north and south.

- The Dawesville Channel will be maintained as a navigable waterway, although, as with the existing Mandurah Channel, sea conditions at the ocean entrance may frequently preclude its use by small boats.

- The estuary will be closely monitored to evaluate the management strategy's success in reducing the algal nuisance and to enable the development of appropriate management strategies to mitigate any deleterious effects that may occur. Current and proposed future monitoring studies in the estuary are described in Section 13 of the ERMP and Section 11 of the EPA assessment report.

2. CONTROL OF WEED ACCUMULATIONS

- Weed harvesting will be continued most likely at an increased rate, until the weed nuisance in the estuary is successfully reduced.

- Possible methods of improving the efficiency of harvesting operations, and the possible use of algicides to control weed growth, will be evaluated by the proponents and implemented if shown to be practicable.

MANAGEMENT COMMITMENTS MADE BY THE PROPONENTS (Contd)

. The Peel Inlet Management Authority will continue the existing programme of shoreline management and will rehabilitate areas where weed accumulations or harvesting operations cause excessive retreat of the shoreline.

3. **CATCHMENT MANAGEMENT**

. The proponents will continue to provide advice to farmers on fertilizer requirements, based on accurate assessment by paddock-specific soil tests.

. The proponents will encourage further development and use of individual-nutrient fertilizers, and will undertake detailed investigations of ways to overcome existing economic constraints to their production and use.

. The proponents will ensure that large-scale field trials are carried out to ascertain the technical and economic feasibility of converting use of sandy soils from agriculture to forestry. Private enterprise involvement in these studies will be encouraged.

. The EPA and the Department of Agriculture will continue to provide advice to producers to define and implement practicable and cost-effective waste management strategies for control of point sources of phosphorus.

. The Department of Agriculture will coordinate the preparation and implementation of a detailed catchment management plan aimed at reducing phosphorus losses to the estuary to less than 85 t/a in a 60 percentile year with minimal economic or social disruption to the catchment community.

. The Department of Agriculture will implement a moratorium on further clearing and drainage in the catchment, pending determination of the success of the catchment management plan in reducing phosphorus losses from existing cleared land.

. The success of catchment management measures in reducing phosphorus losses to the estuary will be monitored by the proponents and audited by the EPA. The social and economic effects of catchment management measures upon the catchment community will be closely monitored by the proponents. Current and proposed future monitoring studies are described in Section 13 of the ERMP and in Section 11 of the EPA assessment report. The catchment management plan will be regularly reviewed by the EPA.