Derby Tidal Power Project

Derby Hydro Power Pty Ltd

Report and Recommendations
of the Environmental Protection Authority

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Summary and Recommendations

Derby Hydro Power Pty Ltd proposes to construct and operate a tidal power station in Doctors Creek near Derby and construct 450 km of new transmission lines to supply the power requirements of Broome, Derby, Fitzroy Crossing and Blendevale.

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

The EPA's judgement is that the environmental impacts, uncertainties and risks associated with the proposal at the proposed location are significant and are of such nature that the proposal should not be implemented. As a consequence the EPA has not developed recommended conditions and procedures at this time. However, if Government is of the view that it is desirable for the proposal by Derby Hydro Power Pty Ltd to proceed, the EPA would provide further advice in relation to the proposal, including the environmental conditions and procedures to which the project should be subject.

Relevant environmental factors

Although a number of environmental factors were considered by the EPA in the assessment, it is the EPA's opinion that the following are the environmental factors relevant to the proposal, which require detailed evaluation:

a) Mangroves - impact on mangrove communities, abundance, structure and function

b) Geo-heritage - changes to the geomorphological and sedimentary processes, mangrove communities and aspects of significant geo-heritage value

c) Proposed nature reserve - potential impact on vegetation communities proposed to be set aside for conservation

d) Groundwater - potential impact on Derby groundwater resources

e) Water quality - changes to water quality, pH and suspended solids load

f) Acid Sulphate Soils - impact from oxidation of Acid Sulphate Soils

g) Sedimentation - impacts from and around the basins

h) Terrestrial fauna - impact on the potential habitat of Declared Rare Fauna and waterbirds

i) Marine fauna - impact on marine species and habitat

j) Dust - increase in dust levels in town

k) Greenhouse gas emissions - potential benefit from greenhouse gas emission savings

l) Decommissioning - assurance of rehabilitation at the completion of the project

m) Environmental management - implications of uncertainty for management of this proposal.

It should be noted that the EPA's advice on the factor of sedimentation has not been completed. Furthermore, the transmission lines have not been assessed.

Conclusions

The EPA has considered the proposal by Derby Hydro Power Pty Ltd to construct and operate a tidal power station at Doctors Creek, near Derby. The proposal also includes 450 km of new power transmission lines but this element has not yet been assessed.

The Derby Hydro Power proposal is for the purpose of providing power for the West Kimberley area. During the course of this assessment the Government has established a Regional Power Procurement Committee which has called tenders for the provision of power to the West Kimberley, and Derby Hydro Power Pty Ltd has submitted a tender. Accordingly there are a range of options available to Government for power generation, and each will have its own set of environmental benefits and disbenefits. As set out in the EPA's Administrative Procedures it is appropriate for an assessment report to include findings on the environmental benefits and disbenefits of a proposal as well as a recommendation on whether a proposal should proceed.

The proposal, if implemented, would produce power from a renewable source of energy and that has a greenhouse gas emission benefit. However, this benefit has to be reduced by consideration of the release of carbon from the progressive decomposition of approximately 1500 ha of mangroves. Also, the proposal would still require some use of conventional power generation from non-renewable energy sources. A paper presented to the EPA on the mangrove loss concluded that the tidal power station would have to operate for 4 to 8 months each year in order to compensate for the quantities of carbon released from the progressive mangrove decomposition (Gordon, 1999b). Accordingly, the potential for environmental benefit from savings in greenhouse gas emissions from this proposal would be reduced.

The concerns about the proposal flow from the uncertainties attaching to the impact of the proposal on the mangroves in Doctors Creek and associated ecosystems as well as the uncertainties relating to altered sedimentation and its management. In addition, the proposal, if implemented, would affect the geo-heritage values of the site as it would impact on the area as a site of scientific interest as a documented geo-morphological reference point.

There would be a loss of mangrove ecosystems in Doctors Creek (both in terms of area and linear extent of mangroves), at least for a significant length of time, and the sedimentary patterns would be altered as a result of the structures to be built and the proposed method of operation of the system. There would also be a loss of geo-heritage values through disruption to the processes that support them.

The proposal has all the hallmarks of a large field scale experiment because about 1500 ha of mangroves would be lost and a new potential mangrove habitat, estimated to be more than 2300 ha, could be available for rehabilitation if the changed circumstances are favourable to that outcome. However, the length of mangrove margin would remain substantially reduced. The proposal would require substantial sediment control in a macro-tidal area, and the proponent has yet to demonstrate how this would be managed.

The EPA provided advice to the Minister for the Environment in July 1998 to the effect that the combination of geo-heritage and other environmental uncertainties at the proposed location were of sufficient concern to the EPA that the Government should give consideration, at that time, as to whether or not the proposal should proceed. Following consideration of the issues, including advice from the MPRA, the Minister requested the EPA to conclude its environmental assessment and provide its report and recommendations pursuant to section 44 of the Environmental Protection Act.

The proponent has undertaken a range of investigations into potential environmental impacts and management responses. Even so, the EPA considers that there is still a significant degree of uncertainty over the environmental management aspects of and likely outcomes for several of the factors regarded by the EPA as being very important. These uncertainties are associated with the regeneration responses of the mangroves and associated ecosystems in the manner predicted by the proponent as well as the sedimentation problems which may become unmanageable. The combination of these uncertainties, if they were realised, together with the impact on the geo-morphological attributes of Doctors Creek would lead to the overall environmental consequences of the proposal being unacceptable.

The EPA's judgement is that the environmental impacts, uncertainties and risks associated with the proposal at the proposed location are significant and are of such nature that the proposal should not be implemented. As a consequence the EPA has not developed recommended conditions and procedures at this time. However, if Government is of the view that it is desirable for the proposal by Derby Hydro Power Pty Ltd to proceed, the EPA would provide further advice in relation to the proposal, including the environmental conditions and procedures to which the project should be subject.

The EPA is aware that the proposal by Derby Hydro Power Pty Ltd is one of a number of potential means of supplying power to the West Kimberley. While other potential power supply options have yet to be considered by the EPA, we know that other more conventional forms of power generation would have different and lower environmental impacts (with the exception of greenhouse gas) with a higher level of certainty about the ability to manage the impacts that would result. On this basis, the EPA considers that other potential power supply options for the West Kimberley would be likely to be more acceptable from an environmental impact perspective.

The EPA is supportive of innovative renewable energy projects that would make a substantial contribution to greenhouse gas savings, and may also have benefits in terms of technology transfer opportunities. The EPA would welcome the investigation of innovative tidal power generation at other sites as the Doctors Creek site poses some particular environmental problems.

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, 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 for the Environment:

1. That the Minister considers the report on the relevant environmental factors of mangroves, geo-heritage, proposed nature reserve, groundwater, water quality, Acid Sulphate Soils, sedimentation, visual amenity, terrestrial fauna, marine fauna, dust, greenhouse gas emissions, environmental management, and decommissioning, as set out in Section 4.
2. That the Minister notes that the EPA has not provided advice on the following matters at this time:
   (a) the EPA's final advice on the factor of sedimentation;
   (b) the EPA's advice on assessment of the power transmission lines;
   (c) the draft conditions and procedures.
3. That the Minister notes that the EPA has concluded that the proposal cannot meet the EPA's environmental objective for geo-heritage and that the proponent has not demonstrated that the proposal would be able to meet the EPA's objectives for mangroves and for sediment management.
4. That the Minister notes that it is the EPA's judgement that the environmental impact of the proposal submitted, if implemented at the proposed location, would be significant, resulting from:
   (a) a loss of the mangrove ecosystems in Doctors Creek (both in areal and linear extent) at least for a significant length of time; and
   (b) the loss of geo-heritage values through disruption to the processes that support them and consequent impact on scientific values of the site as a documented geo-morphological reference point; and
   (c) the uncertainties relating to the altered sedimentation and its management.

5. That the Minister notes that the EPA has concluded that the environmental impacts, uncertainties and risks associated with the proposal are significant and are of such a nature that the proposal should not be implemented.

6. That the Minister notes that if Government is of the view that it is desirable for the Derby Hydro Power Pty Ltd proposal to proceed, the EPA would need to finalise its advice on the matters in Recommendation 2, including:

   (a) the proponent undertaking additional modelling to enable the EPA to advise on sedimentation impacts and management;

   (b) an assessment of the transmission lines; and

   (c) the environmental conditions and procedures to which the project should be subject.

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1. Introduction and background

Derby Hydro Power Pty Ltd, the proponent, proposes to construct and operate a tidal power station in Doctors Creek near Derby (Figure 1). For the purpose of this report use of the term Doctors Creek refers to Doctors Creek East and Doctors Creek West unless specifically stated otherwise.

The diesel generators used to power the towns of Derby, Broome and Fitzroy Crossing are coming to the end of their design life. In line with the present State Government's policy on de-regulation of the power generation industry, Western Power has called for tenders to supply power to the West Kimberley region. The successful tender will sell the power to Western Power which will remain the 'retail outlet' for power supply in the region.

Derby Hydro Power Pty Ltd is one of a number of companies tendering to supply power but is the only company to have submitted a proposal for assessment by the EPA at this stage. The successful tender will be required to comply with the requirements of the *Environmental Protection Act 1986.*

Derby Hydro Power submitted a proposal to construct a 48 megawatt (MW) twin basin tidal power station at the entrance to East and West Doctors Creek. This also involves a new 450 km distribution network of 132 kilovolt (kV) transmission lines to Derby, Broome, Fitzroy Crossing and Pillara.

The project would result in changes in the average tidal heights and amplitude of tidal variations of both East and West Doctors Creek (the reason for this operational requirement is described below). This would lead to major changes to the hydrology of the Creeks, the mangrove communities that have adapted over time to the present tidal regime, and other associated aspects such as the fresh groundwater hydrology and geo-heritage aspects displayed in the Creeks. The EPA considered that the proposal required formal assessment and a Consultative Environmental Review level of assessment was set on 24 December 1996.

Further details of the proposal are presented in Section 2 of this Report. Section 3 outlines the EPA's view of environmental significance while Section 4 discusses the environmental factors relevant to the proposal. Section 5 provides additional EPA comment and advice. Section 6 presents the EPA's conclusion and Section 7 the EPA's recommendations.

A list of people and organisations that made submissions is included in Appendix 1. References are listed in Appendix 2. The EPA's earlier advice to the Minister in relation to aspects of the proposal, and the advice to the Minister from the Marine Parks and Reserves Authority (MPRA) on the issue of geo-heritage, are Appendix 3 and 4 respectively.

The DEP's summary of submissions and the proponent's response to those submissions has been published as Appendix 5 of this report. Appendix 6 lists the commitments given the proponent.

2. The proposal

The proposal involves the construction of two barrages of approximately 0.5 and 1.3 km long with sluice gates across the entrance to West and East Doctors Creek (see Figure 2) and) the construction of 26 km of levee banks to separate the high and low basins and to prevent over-topping during high tides within King Sound. The two basins would be joined by a channel in which four to six power turbines would be installed with a generation capacity of 48 MW. The proposal also involves the installation of 450 km of new 132 kV transmission lines to Derby, Broome, Fitzroy Crossing and Pillara (Halpern Glick Maunsell, 1997). It is estimated that there would be excess power generation that would be available to accommodate new resource projects that come on-line in the West Kimberley.

The system operates by opening the sluices gates to West Doctors Creek (high basin) on a rising tide and closing the gates at the highest tide, thereby enclosing the maximum body of water. East Doctors Creek (low basin) remains closed until the falling tide is below the water level in the low basin, when the sluice gates are opened, effectively draining the creek. The low

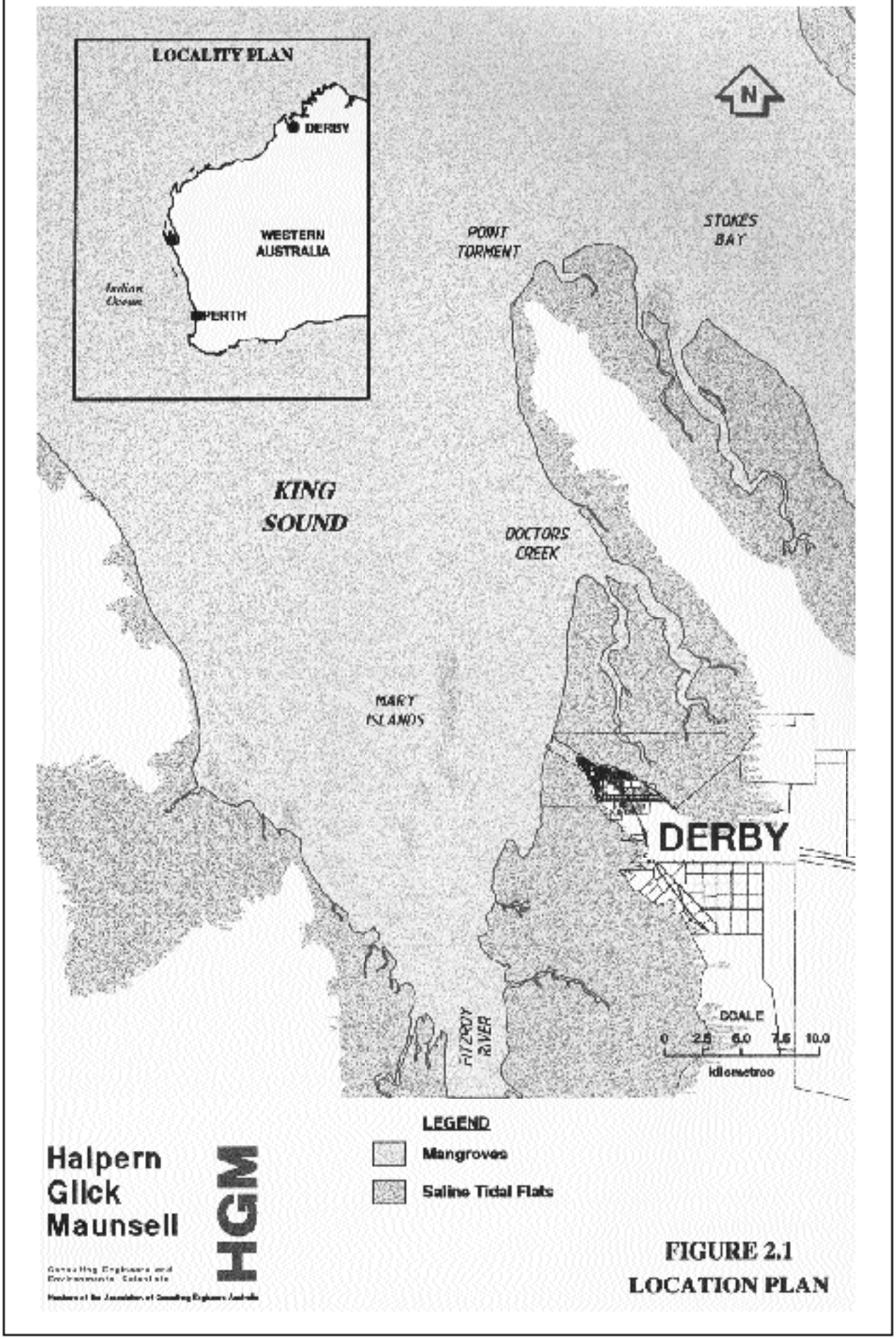


Figure 1. Locality map, East & West Doctors Creeks, Derby

Figure 2. Tidal power station design.

basin gates are then closed again on a rising tide. The difference in height of the two creeks allows the water to flow from the high basin to the low basin through the turbine channel hence generating the electricity. The larger the water difference, or 'head' of water, the greater the power generation capacity. Figure 3 shows a diagrammatic representation of how the system will work.

The twin basin design allows the project to operate continuously over the tidal cycle, except during the neap tide (two to three days every fortnight) when the tidal range is at its lowest. During this time power generation can be supplemented by pumping water from King Sound to the high basin during low electrical load times to increase the head of water. However supplementary generation would be required from either the existing diesel generators or from new gas-fired generators, which would be included in the development.

The project also involves the installation of approximately 450 km of high tension 132 kV transmission lines. The transmission lines would service the towns of Broome, Fitzroy Crossing and Derby and the mine site at Pillara. A 33 kV line would also service Fitzroy Crossing from Pillara for security and supplementary power supply purposes. The transmission lines would generally lie within the existing Great Northern Highway road reserve between Derby, Broome and Fitzroy Crossing.

Other associated components include an office and control room complex, switchyard, public ablutions block and visitor centre.

Project construction would require approximately 1.3 million cubic metres of earth fill, 130 000 cubic metres of rip-rap and rock armour and 220 000 cubic metres of gravel. The sourcing of these materials is not included as part of this assessment.

A summary of the key characteristics of the proposal is presented in Table 1. A detailed description of the proposal is provided in Section 5 of the CER (Halpern Glick Maunsell, 1997).

Since release of the CER a number of modifications to the proposal have been made by the proponent. Refer to Figure 4 for the re-designed structure. The changes include:

- barrages across East and West Doctors Creek cover the entire length of the mouths of both creeks; and
- channels dug on the peninsula between the two creeks in which the sluice gates will be placed.

The potential impacts of the proposal initially predicted by the proponent in the CER document (Halpern Glick Maunsell, 1997) and their proposed management are summarised in Table 2.

3. EPA's Judgement of Environmental Significance

Environmental significance is a judgement made by the EPA and is based upon the following:

(a) the character of the receiving environment and its values;

(b) the magnitude, spatial extent and duration of environmental risk and anticipated change;

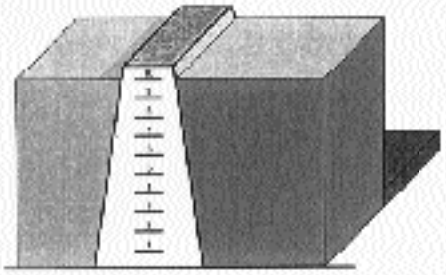
(c) the ability of the environment to accommodate or cope with change (including environmental (ecosystem) resilience);

(d) any uncertainty in ability to forecast changes to be induced by the proposal;

(e) the policies, programs, plans, procedures and approval processes that exist and that will be used to enable the EPA's environmental objectives to be achieved;

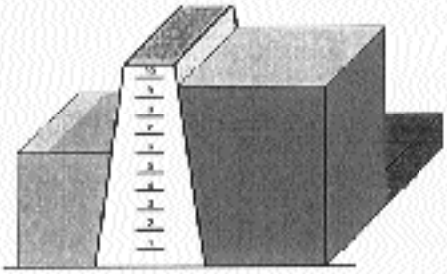
(f) applicable environmental policies, standards and procedures; and

(g) the degree and nature of public interest in the proposal and the environmental effects likely to be associated with that proposal.



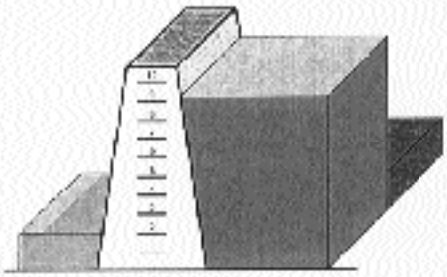
Phase One

1 In this part of the cycle, maximum high tide has been reached and the gates on the high basin are now closing, locking in maximum water in the high basin. Meanwhile, water is running continuously into the low basin (gates are closed in the low basin).



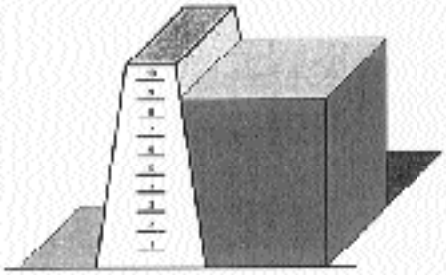
Phase Two

2 The tide is receding in King Sound. Water is transferring from the high basin to the low basin via the raceway and turbines. The level in the high basin therefore, is slowly receding and the low basin is slowly increasing.



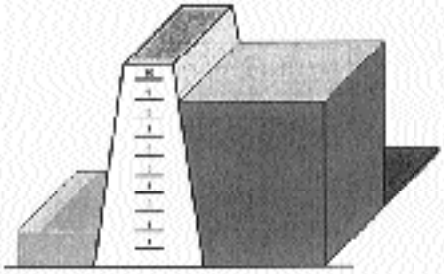
Phase Three

3 At this point of the receding tide, the water level is equal in both the low basin and King Sound. The gates in the low basin are now opened, draining accumulated water into the Sound.



Phase Four

4 The tide is at its lowest and the water in the low basin has fully drained. The gates in the low basin are now closed. Meanwhile, water is still passing from the high basin via the raceway and turbines.



Phase Five

5 This phase demarcates the increasing tide level, the slowly receding high basin level and the slowly increasing low basin level. When the tide reaches the same level as the high basin, the high basin gates are opened allowing water to enter and maximum tide is reached as in Phase One. At this point, they are closed again.

King Sound High Basin Low Basin

Figure 3. Tidal power — How it works.

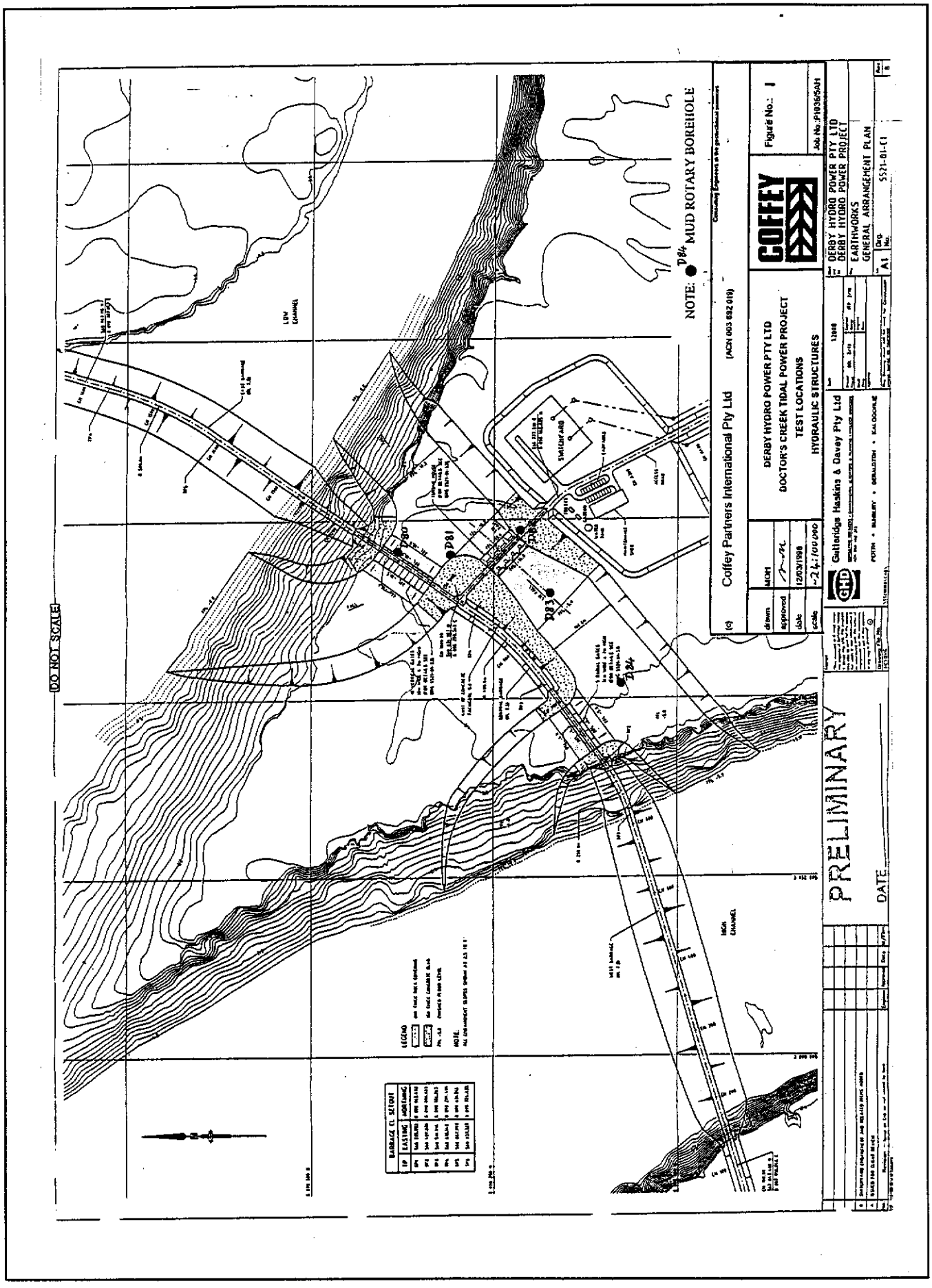


Figure 4. Tidal power station redesign.

Table 1. Summary of key proposal characteristics

Characteristic	Description
Barrages	Approximately 0.5 and 1.3 kilometres long, comprising 1.0 million cubic metres of earth fill
Rock armour	Approximately 60 000 cubic metres
Rip-rap (stone)	Approximately 70 000 cubic metres
Levees	Approximately 26 kilometres
Turbine channel	Excavation of approximately 1.0 million cubic metres from channel approximately 100 metres wide, 600 metres long and between 10 and 15 metres deep
Dredging	Initial low basin dredging approximately 10 million cubic metres, maintenance dredging is ongoing
Sluice gates x 2	High basin 60 to 70 metres wide Low basin 100 to 160 metres wide
Turbines x 4 to 6	Total capacity 48 megawatts
Standby Generators	Gas or diesel generators
Transmission lines	Approximately 450 kilometres of 132 kilovolt lines
Associated buildings	Office and control room Switchyard Public ablutions block Visitor centre
Access road	Approximately 20 km causeway
Anticipated life of project	Up to 120 years

The test of significance for the Derby Hydro Power Pty Ltd proposal resides in the judgements made about:

(i) the confidence of the prediction of change;

(ii) the environmental consequences of that change;

(iii) the consequences if the proposal does not fulfil the EPA's stated objectives; and

(iv) the environmental impact of the alternative sources of power likely to be available.

The EPA is about protecting the environment and advising on the risks and acceptability of environmental impacts of proposals.

4. Environmental considerations

4.1 Relevant environmental factors

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.

It is the EPA's opinion that the following are the environmental factors relevant to the proposal, which require detailed evaluation in this report:

a) Mangroves - impact on mangrove communities, abundance, structure and function

b) Geo-heritage - changes to the geomorphological and sedimentary processes, mangrove communities and aspects of significant geo-heritage value

c) Proposed nature reserve - potential impact on vegetation communities proposed to be set aside for conservation

d) Groundwater - potential impact on Derby groundwater resources

e) Water quality - changes to water quality, pH and suspended solids load

f) Acid Sulphate Soils - impact from oxidation of Acid Sulphate Soils

g) Sedimentation - impacts from and around the basins

h) Terrestrial fauna - impact on the potential habitat of Declared Rare Fauna and waterbirds

i) Marine fauna - impact on marine species and habitat

j) Dust - increase in dust levels in town

k) Greenhouse gas emissions - potential benefit from greenhouse gas emission savings

l) Decommissioning - assurance of rehabilitation at the completion of the project

m) Environmental management - implications of uncertainty for management of this proposal

The above relevant factors were identified from the EPA's consideration and review of all environmental factors (preliminary factors) generated from the CER document and the submissions received, in conjunction with the proposal characteristics (including significance of the potential impacts), the adequacy of the proponent's response and commitments, the effectiveness of current management, the ability to manage potential impacts and the potential environmental benefits and costs from the proposal. On this basis, the EPA determined that rare fauna, shoreline, sea level, noise, impact on Aboriginal communities and heritage factors (other than those associated with the transmission lines, which have yet to be assessed) and other issues raised in the submissions do not require further evaluation by the EPA. The identification process is summarised in Table 2.

The relevant environmental factors are discussed in Sections 4.2 to 4.14 of this report. The summary of this is presented in Table 3.

4.2 Mangroves

Description

The proponent has estimated that up to 1500 ha of mangroves would be lost initially by the changes in the hydrodynamics of the creeks, however the proponent has estimated that more than up to 2300 ha of land would be available for mangrove colonisation in the medium to longer term, 5 years or more (Halpern Glick Maunsell, 1997).

A total of six mangrove communities have been mapped by the proponent (Halpern Glick Maunsell, 1997).

Table 2. Identification of Relevant Environmental Factors

FACTOR	PROPOSAL COMPONENT WITH POSSIBLE IMPACT	GOVERNMENT AGENCY AND PUBLIC COMMENTS	IDENTIFICATION OF RELEVANT ENVIRONMENTAL FACTORS
BIOPHYSICAL			
Mangroves	Alteration of hydrological regime in East and West Doctors Creek would lead to the loss of up to 1500 ha of mangroves.	A report by Semeniuk identifies the mangrove communities as significant due to their existence in an erosional environment. CALM, Water and Rivers Commission, Environment Australia, Conservation Council, Giz Watson and members of the public expressed concern about the extent of impact on mangroves and lack of certainty of regrowth.	There exists a high degree of certainty about the loss of mangroves and a high degree of uncertainty as to the nature and extent of mangrove community re-establishment with this proposal. Considered to be a relevant environmental factor.
Geo-heritage	The proposal would result in alteration to the processes that have created the features of scientific interest.	CALM, Conservation Council and members of the public referred to a report by Semeniuk on the geo-heritage, scientific and International significance of the Doctors Creek system. The MPRA stated that the geo-heritage value of the site does not warrant its preservation as a Marine Reserve.	The erosional processes would change affecting the (claimed) internationally significant mangrove system (erosional setting), the tidal flat to hinterland groundwater relationship would be altered and the value of Doctors Creek as a "fractal laboratory" would be lost. These issues can be monitored but are not considered to be manageable if the project proceeds. Considered to be a relevant environmental factor.
Proposed nature reserve	The altered inundation patterns at the upper ends of the mud flats could potentially impact on the vegetation communities of the proposed nature reserve.	CALM expressed concern over the potential impact on vegetation communities of the proposed nature reserve from changes in saltwater/groundwater interaction and restriction of inundation during spring tides.	There is a high degree of certainty about changes in inundation patterns. The alteration of groundwater salinities and subsequent impact on vegetation communities near the nature reserve is less certain. Considered to be a relevant environmental factor.

FACTOR	PROPOSAL COMPONENT WITH POSSIBLE IMPACT	GOVERNMENT AGENCY AND PUBLIC COMMENTS	IDENTIFICATION OF RELEVANT ENVIRONMENTAL FACTORS
Sedimentation	The impoundment of the water bodies would alter the sedimentation and erosion processes occurring in the creeks and at the mouth of the creeks.	Giz Watson expressed concern with 'overtopping' of the high basin across the peninsula leading to erosion and the loss of further vegetation. Advice from the Centre for Water Research stated that the impact of changes in sedimentation far field from the creeks would be minimal.	Sedimentation could impact on the flushing of the creeks, the restoration of mangroves and the viability of the project. Considered to be a relevant environmental factor.
Terrestrial fauna	The alteration of habitat may impact on terrestrial fauna and particularly waterbirds protected under International treaties.	CALM advised that no Declared Rare or Priority Listed Flora or Fauna is likely to be affected by this proposal. Through a desktop study Environment Australia identified a number of species of mammal listed under the *Endangered Species Protection Act 1992* as potentially occurring in the area and recommended further survey work be carried out prior to commencement of construction. Environmental Australia has raised concerns over the immediate reduction in habitat and the long term implications for wader populations, particularly in relation to Australia's obligations under JAMBA and CAMBA. Proponent claims the increase in productivity of creeks would increase food supply and hence would benefit wader birds.	Further survey work required for terrestrial fauna and on-going monitoring of bird use of the area. Ability to manage would be very limited. Considered to be a relevant environmental factor.
Marine fauna	The disruption of ecological processes and destruction of extensive areas of mangroves could potential impact on fish and fish habitat in the creeks.	The Water and Rivers Commission, CALM, Fisheries WA, Giz Watson and members of the public cited a lack of information on marine fauna as a concern. Fisheries WA requested they be consulted during the preparation of management and monitoring plans for the creeks and would like to see monitoring of fish use of the area and recreational fishers use of the area if the proposal is implemented.	There is very little information available on the role of Doctors Creek for fish communities in the area. Considered to be a relevant environmental factor.
Declared rare and priority flora	Impact from construction of transmission lines and alteration of tidal regime.	CALM advised that no Declared Rare or Priority Listed Flora or Fauna are likely to be affected by this proposal but have requested to be consulted on final detailed route alignment of transmission lines. Environment Australia commented on the lack of detailed locality map showing transmission line alignment.	No DRF have been identified. Final detailed route alignment can avoid any significant or protected flora. Compliance with the Wildlife Conservation Act 1950 still required. Not considered to be a relevant environmental factor.

FACTOR	PROPOSAL COMPONENT WITH POSSIBLE IMPACT	GOVERNMENT AGENCY AND PUBLIC COMMENTS	IDENTIFICATION OF RELEVANT ENVIRONMENTAL FACTORS
Sea level	Barrage construction would alter hydrology of creeks.	Concern was expressed by CALM and in a number of public submissions on the impacts on the proposed nature reserve from changes in inundation patterns of the mudflats after barrage construction.	Impacts resulting from changes in tidal height are considered highly significant. However impacts on the proposed nature reserve, mangroves etc as a result of altered sea level are addressed in other factors above. Not considered to be a relevant environmental factor.
Rare fauna	The project could impact on the habitat of rare fauna.	CALM advised that no Declared Rare or Priority Listed Flora or Fauna is likely to be affected by this proposal. Through a desktop study Environment Australia identified a number of species of mammal listed under the *Endangered Species Protection Act 1992* as potentially occurring in the area and recommended further survey work be carried out prior to commencement of construction.	Given that no rare fauna had specifically been identified in this area the EPA considered this factor could be managed under 'Terrestrial fauna'. Not considered to be a relevant environmental factor.
Shoreline	The alteration of processes occurring in the creeks could alter the stability of the shoreline in the vicinity of the barrages or sluice gates.	Implications of long-term erosion patterns were highlighted in a report by Semeniuk and EnviroEng (1997) and in a submission by Giz Watson.	The EPA considered that sedimentation was likely to represent a greater risk to the shoreline than erosion, this is addressed above. Not considered to be a relevant environmental factor.
Decommissioning	Extensive on-going management after decommissioning will be required.	Environment Australia, Conservation Council and members of the public raised concerns about the decommissioning requirements.	Substantial management commitment would be required to return disturbed area to a system approaching pre-disturbance condition or suitable state. Considered to be a relevant environmental factor.

FACTOR	PROPOSAL COMPONENT WITH POSSIBLE IMPACT	GOVERNMENT AGENCY AND PUBLIC COMMENTS	IDENTIFICATION OF RELEVANT ENVIRONMENTAL FACTORS
POLLUTION			
Groundwater	Impact on Derby groundwater supplies and groundwater dependant vegetation from change in hydrology of creeks.	CALM, Conservation Council, Environment Australia, Giz Watson, Water and Rivers Commission and members of the public raised concerns about the potential impact on groundwater and recommended further work be undertaken. Further study was undertaken by Rockwater which concluded that any change in the salt water interface is likely to be very small and probably undetectable.	Due to relatively poor detailed knowledge of the aquifer and stratigraphy of the peninsula and tidal flats, there is not a high degree of certainty of impacts on groundwater supplies. Considered to be a relevant environmental factor.
Water quality	Impact on water quality through change in flushing, turbidity and increased nutrient input.	CALM and FWA express concern over the uncertainty of impacts from changes in water clarity.	There is a high degree of certainty of increase in water clarity, little certainty of impacts of this on water quality. Water can be 'flushed' by sluice gate management if unacceptable water quality results. Considered to be a relevant environmental factor.
Acid Sulphate Soils	Disturbance of soils high in iron sulphides may potentially generate acid run-off.	Members of the public raised the issue of acid sulphate soils.	The generation of ASS could affect water quality and inhibit mangrove regrowth. Considered to be a relevant environmental factor.
Dust	Permanently dry mud flats may increase dust levels in the town.	Public concern was raised over the possible increase in dust from areas of permanently dry mud flats.	It is unlikely that this project would significantly increase dust levels in the town. Dust creation is a 'manageable' issue but could be a high cost. Considered to be a relevant environmental factor.

FACTOR	PROPOSAL COMPONENT WITH POSSIBLE IMPACT	GOVERNMENT AGENCY AND PUBLIC COMMENTS	IDENTIFICATION OF RELEVANT ENVIRONMENTAL FACTORS
Greenhouse gas emissions	This proposal has the potential to reduce greenhouse gas emissions by reduction in use of gas and diesel generators for renewable energy.	Concern was raised that loss of mangroves may off-set gains made in reducing greenhouse gas production. Preliminary work by Dr Gordon suggested, as worst case, that the tidal power station would need to operate for 4 to 8 months every year before 'real' savings in carbon release were realised.	This project is likely to lead to a net benefit in reduction of greenhouse gases, however the benefit may only be minor. Considered to be a relevant environmental factor.
Noise	The generation of noise from construction activities and turbines could impact on the amenity of nearby residents.	One public submission raised the issue of noise during construction.	Truck traffic may increase noise during construction but this would be temporary and can be managed through the assessment of any quarries if required. Not considered to be a relevant environmental factor.
SOCIAL SURROUNDINGS			
Visual amenity	Installation of approximately 450 km of transmission lines would affect visual amenity from highway.	Visual impacts from the transmission lines were raised as an issue by Environment Australia and members of the public.	Sensitive route alignment can minimise visual impacts but would still be prominent in flat landscape. This factor will require further assessment by the EPA.
Impact on communities	The alteration of the ecology in the area could affect subsistence communities.	The proponent is negotiating with Aboriginal communities on employment and other opportunities that may become available. However this has not been identified as a issue of high concern.	This has not been raised as a concern by Aboriginal groups or Government agencies. Not considered to be a relevant environmental factor.
Heritage	The change in processes of the creek could impact on heritage sites, if identified in the area.	Aboriginal Affairs state heritage issues have been covered.	No sites identified. Not considered to be a relevant environmental factor.

FACTOR	PROPOSAL COMPONENT WITH POSSIBLE IMPACT	GOVERNMENT AGENCY AND PUBLIC COMMENTS	IDENTIFICATION OF RELEVANT ENVIRONMENTAL FACTORS
OTHER			
Environmental management	The ability to manage some factors and the uncertainty with aspects of the environment and extent of likely impact has implications for management of the project as a whole.		If the project is approved, the management conditions placed on it will need to be extensive and rigorous. Considered to be a relevant environmental factor.

Table 3. Summary of Assessment of Relevant Environmental Factors

RELEVANT FACTOR	RELEVANT AREA	EPA OBJECTIVES	EPA ASSESSMENT	EPA ADVICE
Mangroves	East and West Doctors Creek and the surrounding fringing mangrove vegetation within King Sound south from a line from Point Torment.	Maintain the ecological function, abundance, species diversity and geographic distribution of mangroves.	· The proposal is likely to lead to the loss of 1500 ha of mangroves. · Modelling by the proponent shows an area of approximately 2300 ha becoming available for colonisation be mangroves in the mid to long term. · A high degree of uncertainty exists about the extent, quality and diversity of mangrove communities that may develop. · The proposal may threaten the geographic distribution of a species of mangrove at the local scale. · The ability to manage impacts or to regrow mangrove communities on this scale is very uncertain. · Mangroves are important habitat for nutrient cycling and primary production. The EPA considers the biodiversity and ecological function of the State's coastal waters to be fundamental values requiring a high level of protection.	Having particular regard to: · the initial loss of 1500 ha of mangroves due to the changed tidal regime in Doctors Creek; · disruption to the ecological function and reduction in abundance of mangroves in Doctors Creek, at least in the short term (0 to 5 years); · the reduction which would occur in linear length of mangrove margin, which is important for recruitment; · the degree of uncertainty about regrowth of an area of mangroves at least equivalent in area to that lost; and · the degree of uncertainty with regard to the impact on species diversity and geographic distribution at a local scale in the longer term even if there is successful regrowth, it is the EPA's opinion that there is a significant degree of uncertainty in relation to the outcome for this factor and on the information available it is highly probable that the EPA's objective cannot be met.

RELEVANT FACTOR	RELEVANT AREA	EPA OBJECTIVES	EPA ASSESSMENT	EPA ADVICE
Geo-heritage	East and West Doctors Creek and the surrounding mudflats and groundwater.	Protect the environmental values including the geomorphological and sedimentalogical processes of areas of high scientific interest.	· The area is of significant scientific interest because of geo-heritage components. · The proposal would alter the erosional, geomorphological and sedimentalogical processes, tidal patterns, potentially the groundwater hydrology and the mangrove systems of Doctors Creek. · The MPRA do not believe the values of the site warrant preservation through the Marine Reserves process but recognise that the site does have significant value as a site of scientific interest. · The fractal patterns and historical and contemporary erosional forms are likely to be altered if this proposal is implemented. · The ability to manage the impacts on aspects of geo-heritage are limited to the documentation of change.	Having particular regard to the: · expert advice that the area has significant scientific interest; · recognition that this proposal would result in alteration to the processes that have created the features of scientific interest; and · management measures are unlikely to be able to prevent impacts from this proposal on the contemporary features and processes of significance, it is the EPA's opinion that the geo-heritage values and the processes that produce them are important and at least in some of these values and processes would be impacted significantly if the proposal were to be implemented. Accordingly, the proposal cannot be managed to meet the EPA's objective for this factor.

RELEVANT FACTOR	RELEVANT AREA	EPA OBJECTIVES	EPA ASSESSMENT	EPA ADVICE
Proposed nature reserve	Lots 263 and 87, the proposed nature reserve and adjoining mudflats.	Ensure the conservation values of the proposed nature reserve are not compromised.	· CALM have stated there is little of this type of community protected through reservation in the region. · This proposal may potentially impact on the vegetation communities of the proposed reserve. · These exists the ability to replace the environmental values lost.	Having particular regard to: · intention for a representative portion of this type of land to be incorporated in the conservation estate; · the potential changes that alteration to the surface water flow or groundwater interface could have on vegetation communities and other environmental values on Lots 263 and 87; and · the occurrence of similar environmental values on other parcels of land in the Derby area, providing an opportunity to protect these values if the proposal affects the proposed nature reserve, it is the EPA's opinion that the proposal can meet the EPA's objective for the proposed nature reserve provided the proponent acquires and makes available to CALM an alternate comparable area of land, in consultation with CALM, for reservation within the conservation estate if proposal has adverse impacts on the area of the proposed nature reserve.

RELEVANT FACTOR	RELEVANT AREA	EPA OBJECTIVES	EPA ASSESSMENT	EPA ADVICE
Groundwater	The groundwater beneath Doctors Creek and the Derby peninsula.	Maintain the quantity of groundwater so that existing and potential uses, including ecosystem maintenance, are protected.	· Saline intrusion has been a problem with private shallow bores on the Derby peninsula in the past due to excessive groundwater abstraction. · The lower confined aquifer that provides the majority of the town water supply is unlikely to be affected. · There is some risk of salinisation of the upper aquifer, however excessive abstraction presents a greater risk to shallow bore users. · The WRC has indicated that they believe the risk to aquifers is low.	Having particular regard to: · advice offered by Rockwater concluding that the potential impact on the fresh groundwater reserves of the peninsula would not be significantly affected; · indication by WRC that they believe the proposal represents a low risk to the public water supply; · proponent's commitment to monitor groundwater impacts; and · management options available to provide alternate freshwater resources to affected users, it is the EPA's opinion that the proposal can be managed to meet the EPA's objective for groundwater provided that suitable monitoring is in place and contingency plans for alternate water supplies to affected users are in place.

RELEVANT FACTOR	RELEVANT AREA	EPA OBJECTIVES	EPA ASSESSMENT	EPA ADVICE
Water quality	The waters of Doctors Creek.	Maintain water quality to ensure ecosystem maintenance in agreed areas.	· Water quality would change in Doctors Creek as a result of the proposal, ie there will be a decrease in turbidity. · There will be a significant load of organic matter delivered to the low basin over a period of several months as a result of mangrove die-off. · The background nutrient levels and increase in water clarity may lead to excessive algal growth in the high basin and water quality problems in the high basin. · The proponent has the ability to drain or flush the creeks (to a large degree) if water quality is unacceptable, however at a cost to power production and other users that rely on a consistently high water level.	Having particular regard to: · short-term increase in nutrient levels in Doctors Creek resulting from the loss of mangroves; · potential implications on water quality with an increase in the depth to which light can penetrate from a decrease in turbidity; and · ability to drain and/or flush the water in both the high and low basins, it is the EPA's opinion that the proposal can be managed to meet the EPA's environmental objective for water quality provided that adequate management of flushing and draining regimes are implemented.
Acid Sulphate Soils	Doctors Creek and surrounds.	Minimise the risk to the environment resulting from Acid Sulphate Soils.	· Acid Sulphate Soils have not been recorded in this area specifically but the Doctors Creek system is typical of where ASS can be found. · Depending on the scale of soils disturbed, ASS can lead to localised impacts on water quality and vegetation growth. · There are 'standard' methods for managing the impacts from ASS, including threats to integrity of infrastructure, in addition this proposal has the ability to manage the sluice gates to flush the creeks.	Having particular regard to: · risk associated with the generation of ASS in Doctors Creek; and · the strategies available to the proponent for the management of ASS if it occurs, it is the EPA's opinion that the proposal can be managed to meet the EPA's objective for Acid Sulphate Soils provided that necessary detection and management strategies are implemented.

RELEVANT FACTOR	RELEVANT AREA	EPA OBJECTIVES	EPA ASSESSMENT	EPA ADVICE
Sedimentation	Doctors Creek and King Sound.	Ensure existing coastal processes outside of Doctors Creek, including off-shore sediment movement, are not significantly impacted.	· Given the advice provided by leading experts in the State it would seem that the issue of sedimentation is not likely to significant far-field effects, however there is potential for sedimentation in the area in front of the barrages, and there is potential for silting of the high basin, especially near the proposed turbine site. · If the worst case scenario for sedimentation is realised, there would be a need to dispose of a huge volume of sediment dredged from West Doctors Creek and could possibly lead to the premature decommissioning of the project. · The proponent has committed to the permanent installation of dredger in Doctors Creek to manage the sedimentation problem. · Further modelling work is required, particularly for storm events.	Having particular regard to: · advice received from the reviewers with regard to hydrodynamics and sedimentation; · the uncertainty that sedimentation management poses to the local environment; · the options available to the proponent to manage impacts with regard to sedimentation inside the basins; and · the proponent's acknowledgment of the need for further detailed sediment related-modelling, it is the EPA's opinion that there is uncertainty with the sedimentary processes affected by this proposal and that further information would be required for the EPA to finalise its advice.

RELEVANT FACTOR	RELEVANT AREA	EPA OBJECTIVES	EPA ASSESSMENT	EPA ADVICE
Terrestrial fauna	Doctors Creek and its catchment.	Protect Threatened Fauna and Priority Fauna species and their habitats, consistent with the provisions of the Wildlife Conservation Act 1950 and the Endangered Species Protection Act 1992.	· This proposal may impact on the use of the area by some species of wader birds and potentially some species protected under International agreements, however the area is not considered extremely important for nesting, roosting or feeding. · Mangrove communities do provide habitat for local water bird species and this proposal will result in a loss of this habitat at least in the short to mid- term, however approximately 1200 ha of mangroves will be retained within 5 km of the barrages. It is also acknowledged that the modelling suggests a greater and more productive intertidal area will become available over time. · Some species declared rare may potentially occur in the area, further survey work is required.	Having particular regard to: · apparent value of King Sound as a feeding and roosting area for migratory wader birds; · area of similar mangrove systems in King Sound; · potential for roosting and intertidal feeding areas to increase in the short to medium term; · potential area available for establishment of mangals in the medium to long term; and · proponent commitment to undertake a monitoring programme to detect changes in bird use of the area, it is the EPA's opinion that the proposal can be managed to meet the EPA's objective for terrestrial fauna provided that the necessary survey work is undertaken on advice from CALM and Environment Australia and the relevant wildlife conservation legislation and relevant international agreements are adhered to.

RELEVANT FACTOR	RELEVANT AREA	EPA OBJECTIVES	EPA ASSESSMENT	EPA ADVICE
Marine fauna	The waters of Doctors Creek.	Maintain the abundance, species diversity and geographic distribution of marine fauna.	· Little work has been done on the marine species using Doctors Creek and the impact this proposal would have on that species. · Given that both creeks currently empty each tidal cycle it is unlikely that the creeks contain species that are unique to the area however the role as a nutrient source and habitat for invertebrates has not been quantified. The loss of linear extent of mangroves would be significant in the short term. · Restriction of passage through the turbine channel is important to prevent injury or death to fish that move through it. · The proponent has committed to quantifying changes in phytoplankton and zooplankton density and species diversity, infauna density and species diversity and fish use.	Having particular regard to: · the area of and linear extent of similar mangrove systems in King Sound; · commitment to monitoring provided by the proponent; and · commitment to the use of a suitable fish exclusion device on the entrance to the turbine channel, it is the EPA's opinion that the proposal can be managed to meet the EPA's objective for marine fauna.
Dust	The mudflats around Doctors Creek.	Ensure dust levels generated by this proposal do not adversely impact on the amenity or cause health problems by complying with statutory requirements and acceptable standards.	· The EPA recognises that dust levels in Derby, under certain wind conditions, already cause nuisance. · The distance to town and the practices available to suppress dust can be used to ensure that this proposal does not significantly increase dust levels.	Having particular regard to: · high levels of dust already experienced in Derby during certain times of the year; · distance between Derby and the eastern arm of Doctors Creek; · management techniques proposed by the proponent, it is the EPA's opinion that the proposal can be managed to meet the EPA's objective for dust provided that adequate monitoring methods and dust management contingency plans are implemented.

RELEVANT FACTOR	RELEVANT AREA	EPA OBJECTIVES	EPA ASSESSMENT	EPA ADVICE
Greenhouse gas emissions	The mangrove community around Doctors Creek.	Ensure that greenhouse gas emissions meet acceptable standards and requirements of Section 51 of the Environmental Protection Act 1986 (all reasonable and practicable measures are taken to minimise greenhouse gas discharge).	· This proposal would result in a net savings in greenhouse gas emissions over the life of the project, although there are uncertainties regarding how big that figure would be. · The need for supplementary power generation by the use of diesel or gas generators and the loss of mangroves will reduce the size of the carbon emission savings. · Initial studies show that the tidal power station would have to operate for between 4 to 8 months each year to match the quantity of carbon lost through mangrove decomposition.	Having particular regard to: · the expected greenhouse gas emission savings stated by the proponent; and · the reduced greenhouse gas emission savings when loss of mangroves is considered, the EPA has concluded that the proposal, if implemented, would have the environmental benefit of reducing greenhouse gas emissions to some extent compared with other potential energy sources but that the benefit would be less than that presented by the proponent in the CER, and would be regarded as being quite small.
Decommissioning	The Doctors Creek area and surrounds.	Ensure that infrastructure that is no longer required is removed and the area rehabilitated to an environmentally stable state consistent with surrounding land uses.	· There is very high uncertainty as to the reversibility of the impacts. · Decommissioning would involve significant and long-term management of the Doctors Creek system, long after the infrastructure has been removed. · There is a need to ensure that decommissioning and rehabilitation would be undertaken to an acceptable standard, independent of the viability of the company.	Mechanisms available to ensure decommissioning is undertaken to an acceptable level are discussed in Section 5 Other Advice.

RELEVANT FACTOR	RELEVANT AREA	EPA OBJECTIVES	EPA ASSESSMENT	EPA ADVICE
Environmental Management	Doctors Creek and surrounds.	Protect the environment.	· The elements of uncertainty of impacts, uncertainty of ability to manage and cost of management present the biggest risk to the success of environmental management and financial viability of this project. · Reducing the degree of uncertainty involves either disallowing the proposal, requiring further research that may take years, providing contingencies for all outcomes, some of which are unlikely to be manageably or selecting an alternative project that achieves the same objectives with lower environmental cost.	Having particular regard to: · the methods available to manage uncertainty, it is the EPA's opinion that the proposal carries with it a high degree of risk in terms of environmental management. Any environmental conditions placed on the proposal would need to be thorough, rigorous and extensive to manage the degree of uncertainty of impacts and uncertainty of the manageability of impacts from the proposal. As such, the EPA has provided only an indication of the likely requirements in terms of environmental conditions which would need to be rigorous to reduce the risks and uncertainties with the proposal. , The EPA recognises that the proposal would still carry with it a high environmental cost which would have intergenerational implications.

The mangrove species *Bruguiera parviflora* was noted in Doctors Creek and the western side of King Sound (Paling, 1997). Previously the species has only been noted in two other locations in the northern Kimberley. While this further identification would suggest that the species is more widely distributed than is currently recorded (Paling, 1997), the limited positive identification should warrant the classification of the species in Doctors Creek as, at least, locally significant. The likely loss of the recorded species in Doctors Creek may threaten the geographic distribution of the *B. parviflora* at the local (King Sound) scale.

Submissions

Concern was expressed by Department of Conservation and Land Management (CALM), Water and Rivers Commission (WRC), Environment Australia, the Conservation Council and members of the public about the extent of impacts on mangroves and the uncertainty of regeneration of mangroves.

Assessment

The area considered for assessment of this factor is Doctors Creek and the fringing mangrove vegetation within King Sound south of a line from Point Torment.

The EPA's objective in regard to this environmental factor is to maintain the ecological function, abundance, species diversity and geographic distribution of mangroves.

The EPA provided advice to the Minister for the Environment under Section 16(e) of the *Environmental Protection Act 1986* in July 1998 on the uncertainties in relation to mangrove regeneration. A copy of that advice is included in Appendix 3. In that advice, the EPA noted that while mangroves do have the capacity to quickly colonise and become established as dense thickets, the exact areas of colonisation, the extent to which biological productivity will change, the conditions required for mangrove propagule recruitment and hence diversity of community regeneration are not known (EPA, 1998a).

The DEP sought further information on the factors critical to mangrove regeneration to try to reduce the uncertainty surrounding the predicted areas of potential mangrove regeneration that were estimated in the report on mangrove assemblages prepared for the proponent (Paling, 1997). In addition to salinity and inundation, factors including site conditions, regional and local climatic conditions, soil properties, and local and regional hydrology are considered important in determining regrowth of mangroves (Gordon, 1999a). These additional factors were not considered by the proponent in the estimation of areas available for mangrove regrowth.

The EPA has recently received advice from the CSIRO that the linear extent of mangroves in these areas is very important in terms of recruitment (N Loneragan, pers com).

The proponent has committed to a programme of research, monitoring and management for the mangroves. However, a high degree of uncertainty exists as to the nature and likely extent of mangrove community re-establishment.

The EPA is presently developing a position paper on marine primary producer habitat protection, including mangroves. These habitats are important for nutrient cycling and primary production. The EPA considers the biodiversity and ecological function of the State's marine habitats to be fundamental values requiring a high level of protection.

While it is inevitable that some mangroves will be impacted by some developments, the nature and extent of the environmental impacts needs to be considered against the benefits flowing from proposed developments.

The EPA, in consultation with the Department of Resources Development, is currently preparing a guidance statement on mangroves in the Pilbara area to assist proponents understand their importance and to provide guidance as to the EPA's expectations in relation to their protection. The guidance statement being developed reflects the view that it is preferable for small areas of mangroves in a few designated areas to be impacted by industrial development, rather than have extensive impacts at greenfield locations. A similar guidance is

planned for the Kimberley coast with the aim of assisting proponents to identify environmentally appropriate locations for proposals.

However, it does not contemplate proposals which have the potential to impact large areas of the nature of the Doctors Creek proposal.

Should the area of mangrove regrowth predicted by the proponent not occur, the ability to rehabilitate or replant an area of this size of mangroves is highly uncertain as it has not been recorded before in Australia.

Summary

Having particular regard to the:

(a) the initial loss of 1500 ha of mangroves due to the changed tidal regime in Doctors Creek;

(b) disruption to the ecological function and reduction in abundance of mangroves in Doctors Creek, at least in the short term (0 to 5 years);

(c) the reduction which would occur in linear length of mangrove margin, which is important for recruitment;

(d) the degree of uncertainty about regrowth of an area of mangroves at least equivalent in area to that lost; and

(e) the degree of uncertainty with regard to the impact on species diversity and geographic distribution at a local scale in the longer term even if there is successful regrowth,

it is the EPA's opinion that there is a significant degree of uncertainty in relation to the outcome for this factor and on the information available it is highly probable that the EPA's objective cannot be met.

4.3 Geo-heritage

Description

Geo-heritage is a concept which encompasses the diversity of minerals, rocks and fossils, and the features that indicate their origin through time, and it includes landforms and other geomorphic features that illustrate the effects of present, and past exposure to climate and earth forces (Joyce, 1995; Eberhard, 1997).

A particular range of geo-heritage values of the Doctors Creek area have been identified by various authors who have published scientific literature over the period since 1961 (Fairbridge, 1961; Jennings and Coventry, 1973; Jennings, 1975, Semeniuk, 1980). Recently, Semeniuk and EnviroEng (1997) identified the values to be of international, national and State-wide significance. The array of attributes of significance are described further in Appendix 4.

The EPA sought the advice of an independent expert to assess the significance of the geomorphological and geo-heritage values of the site. Professor Bruce Thom listed the significant values of the Doctors Creek site as being the representation of six erosional stages in Doctors Creek, the macro-tidal forces, the fractal patterns embedded in the system, the relationship of the Quaternary red sand dunes to the Holocene tidal flat deposits, the relationship of the hinterland freshwater with the tidal flat hypersaline water, and the development of mangrove systems adapted to this environment (Thom, 1998a in EPA, 1998a).

The tidal power station would alter the natural tidal inundation patterns, reduce the tidal amplitude in both creeks, alter the erosional, geomorphological and sedimentological processes occurring, potentially impact on the groundwater hydrology and would impact on the mangrove systems of Doctors Creek(Thom, 1998a in EPA, 1998a).

Submissions

CALM, the Conservation Council and members of the public referred to the report prepared by Semeniuk and EnviroEng (1997) highlighting the significance of the area as described in the report.

The EPA held a workshop run by Prof. Thom to consider the issue of geo-heritage with a broad range of stakeholders, prior to the EPA reporting under Section 16(e) (EPA, 1998a).

Assessment

The area considered for assessment of this factor is Doctors Creek and the surrounding mudflats and groundwater.

The EPA's objective in regard to this environmental factor is to protect the environmental values including the geomorphological and sedimentological processes of areas of high scientific interest.

The EPA commissioned Professor Bruce Thom to review the literature, visit the site and liaise with the experts on geo-heritage to provide independent expert advice on this factor. His advice is included in Attachment 1 of Appendix 3. In summary he advised that the attributes described above are not individually unique. However, the occurrence of these components within one system provides a site of significant scientific interest. A similar conclusion was reached independently by Dr Semeniuk and Associate Professor Woodroffe (EPA, 1998a).

This advice was provided to the Minister for the Environment in a report prepared by the EPA under Section 16(e) of the *Environmental Protection Act 1986* (EPA, 1998a). A copy of the report is included in Appendix 3.

The EPA then sought advice from the Marine Parks and Reserves Authority (MPRA) as the primary body for the development of marine reserve policy and development of policies to preserve the natural marine and estuarine environments in the State. A copy of this advice is included in Appendix 4. The MPRA advised:

> "...the MPRA does not consider that the values of the site are of such importance at State, national and international levels to warrant its preservation at this time."

The letter went on to say that "In reaching this conclusion, the Authority recognised that the site does have significant value in terms of its geological features and as a site of significant scientific research."

The Doctors Creek site represents one end of a spectrum of erosional forms that occur in King Sound. It has been described as unique as it not only represents the sixth erosional stage (in a system that has at least six erosional stages) (Semeniuk and EnviroEng, 1997) but also displays evidence of all six erosional stages in the fractal patterns of the Doctors Creek system. These small scale erosional patterns reflect the large scale patterns that occur throughout Doctors Creek system (Semeniuk and EnviroEng, 1997). This fractal pattern displays a historical picture of the erosional processes that have occurred in the creek shaping the patterns currently seen, up to the current erosional stage where contemporary processes continue to occur within this eroding system.

The geo-heritage values listed in Thom (1998a in EPA, 1998a) represent a series of both historical and contemporary processes. The historical record in Doctors Creek is unlikely to be adversely affected if the proposal were to proceed, but the contemporary processes would undoubtedly be changed, thus altering future values.

The EPA considers that the nature of the proposal and impacts from the proposal cannot be managed in a way that will be able to protect the combination of historical and contemporary processes or features of significance.

Summary

Having particular regard to the:

(a) expert advice that the area has significant scientific interest;

(b) recognition that this proposal would result in alteration to the processes that have created the features of scientific interest; and

(c) management measures are unlikely to be able to prevent impacts from this proposal on the contemporary features and processes of significance,

it is the EPA's opinion that the geo-heritage values and the processes that produce them are important and at least some of these values and processes would be impacted significantly if the proposal were to be implemented. Accordingly, the proposal cannot be managed to meet the EPA's objective for this factor.

4.4 Proposed nature reserve

Description

A nature reserve is proposed for an area to the south east of the mudflats of Doctors Creek on Lots 263 and 87 (Figure 5). The proposed nature reserve has the objective of protecting within the conservation estate the vegetation communities of an area of land that is representative of the mudflats, remnant Pleistocene pindan (red sand) dunes and sub-coastal black-soil plain of the south-west Kimberley. The area supports mixed woodland of Melaleuca, Eucalyptus and Boab trees, scattered shrubs and some samphire (Burbidge, 1982).

The lower margins of the proposed nature reserve are subject to inundation 6 to 12 times per year on high spring tides. The construction of the tidal power station would alter the mean tidal height in both creeks and reduce the maximum tidal height reached on spring tides, affecting the inundation patterns at the most easterly part of the mudflats. The altered hydrology of the creeks may also change the groundwater salinity near the margins of the mudflats, potentially affecting the fringing vegetation.

Submissions

CALM expressed concern over the potential impact on the proposed nature reserve from changes in surface and groundwater flow patterns.

Assessment

The area considered for assessment of this factor is Lots 263 and 87, the proposed nature reserve and adjoining mudflats.

The EPA's objective in regard to this environmental factor is to ensure the conservation values of the proposed nature reserve are not compromised.

A proposal to establish a nature reserve on Lots 263 and 87 for the conservation of flora and fauna was initiated in 1982. Since this time CALM has been progressing this proposal through the conservation reserve process with the intention of ensuring a representative portion of this type of land is included in the conservation estate. The process has been delayed by issues associated with tenure of the site.

The vegetation communities on the proposed nature reserve may be affected by changes in the surface water flow across the mudflats. The alteration of the hydrology of Doctors Creek may also lead to a change in the salt water/ fresh water interface of the groundwater at the eastern end of the mudflats which may also potentially affect the groundwater reliant vegetation communities at the margin of the nature reserve. Changes in the salinity of the groundwater is discussed in more detail in Section 4.5.

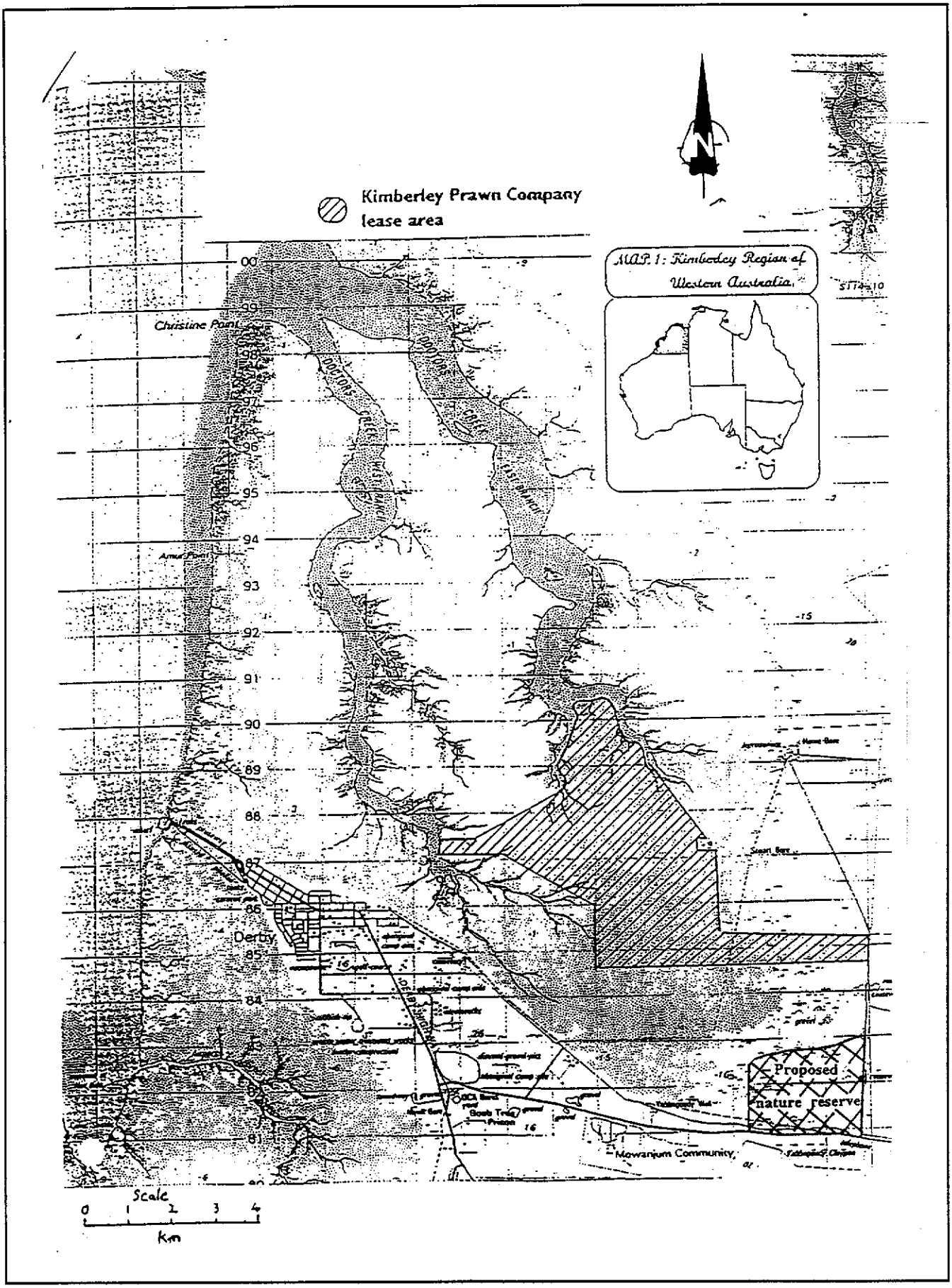


Figure 5. Location of proposed nature reserve.

To ensure the protection of a representative portion of this type of community the proponent would be required to establish a monitoring program that detects any changes in the vegetation structure or health. If such a change is detected then the proponent would be required to identify an alternate comparable area of land in consultation with CALM, acquire this land and make it available for CALM for reservation within the conservation estate. CALM has indicated that similar parcels of land exist in the area and that it would be willing to consider such an arrangement. This would ensure that the environmental values of the area are protected within the conservation estate.

Summary

Having particular regard to the:

(a) intention for a representative portion of this type of land to be incorporated in the conservation estate;

(b) the potential changes that alteration to the surface water flow or groundwater interface could have on vegetation communities and other environmental values on Lots 263 and 87; and

(c) the occurrence of similar environmental values on other parcels of land in the Derby area, providing an opportunity to protect these values if the proposal affects the proposed nature reserve,

it is the EPA's opinion that the proposal can meet the EPA's objective for the proposed nature reserve provided the proponent acquires and makes available to CALM an alternate comparable area of land, in consultation with CALM, for reservation within the conservation estate if proposal has adverse impacts on the area of the proposed nature reserve.

4.5 Groundwater

Description

The Derby town water supply is sourced primarily from the Lower Erskine aquifer (70 %) and is supplemented by the upper unconfined aquifer (30 %) (WAWA, 1992). The upper aquifer is gradually being phased out as a source for the town water supply. However the upper aquifer is used by private bores for gardens, parks, schools and hospital grounds and for drinking water and horticultural activities in the Hamlet Grove rural subdivision. Saline intrusion has already proved a problem in this area in the past (WRC, 1998).

This proposal could potentially affect the position of the saltwater/ freshwater interface near the peninsula due to a higher mean tidal height altering the hydraulic gradient and effectively moving the saltwater interface further onto the peninsula.

Submissions

The potential impact on groundwater resources for the town and for groundwater- dependent vegetation was raised as a concern by CALM, the Conservation Council, the Water and Rivers Commission, Environment Australia and members of the public.

Assessment

The area considered for assessment of this factor is the groundwater beneath Doctors Creek and the Derby peninsula.

The EPA's environmental objective for this factor is to maintain the quantity of groundwater so that existing and potential uses, including ecosystem maintenance, are protected.

Subsequent to the release of the CER (Halpern Glick Maunsell, 1997) the proponent sought further information from Rockwater Pty Ltd on the potential impact on groundwater beneath the Derby peninsula. This response is provided as an attachment to Appendix 6. This report

concluded that any change in the aquifers in the Wallal Sandstone and Erskine Sandstone that might arise from the change in seawater levels in the high basin would be very small and probably undetectable because:

a) the high basin is underlain by estuarine muds of low permeability;

b) there is likely to be a shale aquiclude (the Munkayarra Shale) present between the Wallal Sandstone and Erskine Sandstone beneath the high basin;

c) the presence of the low-permeability estuarine muds and Munkayarra Shale mean that there is probably little or no natural groundwater discharge to the high basin, and that any rise in heads induced in aquifers underlying the basin would be attenuated and not directly affect the fresh groundwater flow system;

d) the high basin is 0.5 to 2 km north of the northern margin of the peninsula, in areas subject to tidal inundation and beyond the groundwater discharge area. Much of the natural discharge from the Wallal/Erskine aquifers beneath the peninsula is interpreted from the position of springs to occur around the margins of the peninsula.

Rockwater also concluded that there is no possibility that the saltwater interface in the lower part of the Erskine Sandstone could be affected by the project because discharge from that part of the formation probably occurs off-shore in King Sound. Also the Munkayarra Shale within the Erskine Sandstone form effective confining layers (Rockwater, 1998).

The Water and Rivers Commission has a responsibility for the protection of public water supply. The WRC has indicated that the risk to aquifers from this proposal is low, however a groundwater monitoring program would be necessary to determine the extent of change.

The proponent has committed to the installation of monitoring bores adjacent to the peninsula to monitor movement of the saltwater wedge. If a project-induced effect is identified the proponent would investigate options to remedy the problem.

Saline intrusion into the unconfined aquifer has proved to be a problem due to over-abstraction in the past. There are a number of management options if saline intrusion as a result of this proposal is induced, for example provision of alternate fresh water supplies from a borefield off the peninsula or from a desalination plant.

Summary

Having particular regard to the:

(a) advice provided by Rockwater that the potential impact on the fresh groundwater reserves of the peninsula will not be significantly affected;

(b) indication by WRC that the proposal represents a low risk to the public water supply;

(c) the proponent's commitment to monitor groundwater impacts; and

(d) management options available to provide alternate freshwater resources to affected users,

it is the EPA's opinion that the proposal can be managed to meet the EPA's environmental objective for groundwater provided that suitable monitoring is in place and contingency plans for alternate water supplies to affected users are in place.

4.6 Water quality

Description

There are a number of implications to water quality in the creek that are likely to occur if the proposal is implemented.

The first is related to the large load of organic matter expected as a result of the death of 1500 ha of mangroves. While this is likely to occur over a period of months, it represents a significant load of organic matter and nutrients.

The second process is the reduction in tidal and current movement in the creeks (primarily the high basin) leading to a large sediment load dropping out of suspension. This is discussed further in Section 4.8. The current euphotic zone (depth of good light penetration) ranges from 0.1 to 0.3 m and, this may increase to 0.2 to 0.8 m with the reduction in suspended sediments (Halpern Glick Maunsell, 1998). This is likely to lead to an increase in primary production in the water column and in the benthic community.

The third process is by the reduction in flushing of Doctors Creek. The construction of the barrages and the turbine channel will reduce flushing of West Doctors Creek by about 70 % (Halpern Glick Maunsell, 1997). The longer residence time would potentially cause water quality problems, particularly in the upper reaches of the creek.

Water quality may also be affected by disturbance of Acid Sulphate Soils. This is discussed further in Section 4.7.

Submissions

Concern was raised by CALM and Fisheries WA over the uncertainty of impacts on the ecology of the creeks as a result of changes in water clarity.

Assessment

The area considered for assessment of this factor are the waters of Doctors Creek.

The EPA's environmental objective for this factor is to maintain water quality to ensure ecosystem maintenance in agreed areas.

The CER (Halpern Glick Maunsell, 1997) predicts an initial loss of 1500 ha of mangroves as a result of this project. Initial estimates by Gordon (1999a) suggest that this would equate to approximately 40 500 tonnes of carbon released to the environment in the first year. Most of the loss of mangroves would occur in the low basin. As the low basin is fully drained on each tide (Halpern Glick Maunsell, 1997) the dissolved and suspended nutrients and organic matter would be flushed into King Sound. The consequences of this discharge would largely depend on the capacity of the southern portion of King Sound to assimilate the nutrients.

Any anthropogenic nutrient sources into the low basin, such as the proposed prawn farm on the mudflats behind Doctors Creek, are unlikely to significantly impact water quality in East Doctors Creek due to the ability to drain the water from the creek each tidal cycle and to flush the creek with water from King Sound if water or sediment quality deteriorates to an unacceptable level.

Nutrient input to the high basin represents a more serious threat to water quality in the basin. Based on the limited information available, the current background nutrient levels in King Sound near Derby are 2.71 mg/L total nitrogen and 0.27 mg/L total phosphorus (EPA, 1998c). The Draft Western Australian Water Quality Guidelines (EPA, 1993) quote problem nuisance algal growth occurring in estuaries and embayments at concentrations of less than 0.010 - 0.100 mg/L for NO_3-N and 0.005 - 0.015 mg/L for PO_4-P. There have been no reports of problems with algal growth in the waters near Derby, probably due to the high suspended sediment loads restricting light penetration to 0.1 to 0.3 metres. As mentioned above, the lower water movement in the high basin will likely cause much of the suspended sediments to drop out of suspension and hence increase water clarity, increasing the depth to which light can penetrate and potentially increasing primary productivity. The current nutrient levels in West Doctors Creek may lead to potential water quality problems and increases in external sources may lead to further deterioration of water quality.

As mentioned above, the potential for reduced flushing of water in the upper reaches of West Doctors Creek also represents a risk to water quality.

The EPA notes, however, that the proponent would have the ability to drain and/or flush the high basin should water and sediment quality become unacceptable. It is also noted that this would have implications for power production and other activities that develop in or around the high basin which rely on a consistently high level of water in the creek. Due to the design of

the sluice gates and the position of the turbine channel, it is unlikely that the high basin would be able to be drained completely.

Summary

Having particular regard to the:

(a) short-term increase in nutrient levels in Doctors Creek resulting from the loss of mangroves;

(b) potential implications on water quality with an increase in the depth to which light can penetrate from a decrease in turbidity; and

(c) ability to drain and/or flush the water in both the high and low basins,

it is the EPA's opinion that the proposal can be managed to meet the EPA's environmental objective for water quality provided that adequate management of flushing and draining regimes are implemented.

4.7 Acid Sulphate Soils

Description

Acid Sulphate Soil is the common name given to sediment and soil containing iron sulphides. Exposure of these soils to oxygenation by drainage or excavation leads to the generation of sulphuric acid (ASSMAC, 1997). Special conditions are required for the natural generation of Acid Sulphate Soils (ASS), which often occur around mangrove systems (ASSMAC, 1997). The construction of bunding, infrastructure, dredging and disposal of dredge spoil and altered erosional processes occurring in the creeks could potential disturb ASS and result in acidic leachate draining into Doctors Creek.

Submissions

The issue of ASS was raised by members of the public.

Assessment

The area considered for assessment of this factor is Doctors Creek and surrounds.

The EPA's environmental objective for this factor is to minimise the risk to the environment resulting from Acid Sulphate Soils.

Although ASS have not been recorded in this area specifically, the type of environment associated with Doctors Creek is typical of where ASS can be found. The EPA expressed concern over the potential environmental impacts associated with ASS particularly with respect to the generation of acidic leachate and threat to the structural integrity of infrastructure. The latter was of concern due to the potential impacts that a catastrophic failure of the barrages or sluice gates may have on the environment.

Following a request from the EPA the proponent commissioned a review to address the concerns raised about ASS (Halpern Glick Maunsell, 1999). The report concluded that ASS do not present a problem in undisturbed sediments, acid release from clayey soils can occur over many decades and up to in excess of 100 years, and acid discharge can be managed in a way that minimises the likely impact on the environment. The report also concluded that ASS are unlikely to impact on the areas predicted for mangrove colonisation in the CER as these areas would not be subject to drying and hence sulphuric acid would not be generated from oxidation of iron pyrites if it were present.

The report states that if acid is generated the buffering capacity of seawater would prevent significant changes in pH of the waters in Doctors Creek (Halpern Glick Maunsell, 1999). If 'hot spots' of acid release are detected they could be managed through neutralisation by the

application of lime, increased flushing by dredging channels in the basins and increased flushing with waters from King Sound.

The presence of ASS may also affect the anticipated regrowth of mangroves and have implications for the management of spoil resulting from dredging of sediments.

Summary

Having particular regard to:

(a) the risk associated with the generation of ASS in Doctors Creek; and

(b) the strategies available to the proponent for the management of ASS if it occurs,

it is the EPA's opinion that the proposal can be managed to meet the EPA's environmental objective for Acid Sulphate Soils provided that the necessary detection and management strategies are implemented.

4.8 Sedimentation

Description

The characteristic 'brown water' of King Sound around Derby is the result of the suspension of fine particles in the water column. The high energy environment caused by the high tidal movement keeps much of the sediments in suspension in the water column. These suspended solid loads begin to drop out of the water column quite rapidly when current movement is slowed, as is evident on 'turning' of the tides in Doctors Creek. The impoundment of water and changes in tidal movement within the creeks will alter the current sediment dynamics within the creeks and at the mouth of the creeks and potentially lead to the creation of large banks within and near the mouth of the creeks, restrict water movement through the sluice gates and cause the progressive infilling of West Doctors Creek.

Assessment

The area considered for assessment of this factor is Doctors Creek and King Sound.

The EPA's environmental objective for this factor is to ensure existing coastal processes outside of Doctors Creek, including off-shore sediment movement, are not significantly impacted.

The proponent has stated that a dredge would be permanently stationed in the creeks, initially to increase the capacity of the low basin and subsequently as an on-going sediment management device to ensure the high basin does not silt up to a level that would reduce power generation ability.

Following discussions with the EPA, The proponent obtained further information on the issue of sedimentation from Dr Wolanski of the Australian Institute of Marine Science and Dr Pattiaratchi and Dr Imberger from the Centre for Water Research (Imberger, 1998). After a review of available data they concluded that:

1. there would be no significant far-field effects;
2. the proposed tidal barrage would not impact on the circulation, tidal regime, sediment suspension patterns or sand movement within the greater King Sound; and
3. detailed modelling would be necessary to provide the information that the EPA was seeking.

However at a local scale (near-field effects within approximately 10 km) Imberger (1988) advised that the proposal would be likely to have a potential impact in three ways:

1. the sand bed off-shore would most likely change its pattern of movement with the potential for sedimentation of the area immediately in front of the barrage, which would require maintenance of entry and exit water channels to ensure available 'head' to the generators would not be affected;

2. the suspended sediment concentrations would also be influenced locally in front of the proposed barrage, but the changes would be likely to be small compared to the natural fluctuations of suspended sediment concentrations in the area; and

3. the high concentration of suspended sediment in the intake water has the potential for silting up the high water level basin, especially near the proposed turbine site.

It was concluded that the potential impact would be local, with no major environmental consequences, and that the risk primarily relates to the financial viability of the project (Imberger, 1998).

The EPA requested that the further modelling studies of hydrodynamics and associated sedimentation in King Sound and Doctors Creek suggested by Imberger be undertaken, particularly to cover storm and cyclonic events. Although this work has yet to be done, additional information was presented in February 1999 (Halpern Glick Maunsell, 1999) which concluded, with respect to the near-field effects, that the 4.5 square kilometres (km^2) entrance zone outside of the barrages would act as a pre-settlement basin accommodating up to 150 000 cubic metres (m^3)/year of sand in the long-term (in excess of 100 years). An empirical model and a hydrodynamic model were used to predict the sedimentation rates for the high basin. The two different models predicted a sedimentation rate of 250 000 m^3 /year and 1.2 million m^3/year respectively. Using the worst case scenario, if sedimentation continued to build up at 1.2 million m^3 /year, an impact on the performance of the tidal plant would be felt in the medium term (approximately 25 years). If the low figure was used the impact would not be felt for approximately 100 years. The environmental effects of this sedimentation was concluded to be negligible (Halpern Glick Maunsell, 1998). Modelling of sedimentation rates in the low basin predicted very low rates primarily due to the short residence time and relatively higher exit velocities.

The far-field effects (beyond 10 km) were considered to be negligible and to have no environmental impacts (Halpern Glick Maunsell, 1999).

The EPA notes the conclusions of the proponent and comments by independent reviewers on the environmental implications arising from altered sediment processes and patterns within and near Doctors Creek and notes that the detailed modelling suggested by Imberger to provide a definitive scenario has not yet been undertaken. However, the EPA is concerned about the environmental implications if the worst case scenario modelled to date by the proponent is found to be close to the situation if the proposal is implemented. In particular, this scenario would lead to the need to dispose of a huge volume of sediment dredged from West Doctors Creek and could even result in the premature decommissioning of the project. Both of these possibilities could cause environmental impacts and they have not been closely evaluated by the EPA in this assessment.

The proponent has committed to undertaking the more detailed modelling studies suggested by Imberger as part of the Environmental Management Plan for the project. However, the EPA considers that this information should be available prior to a decision being made to implement the proposal. Should the Government be of the view that this proposal should proceed, the proponent should be required to undertake the additional modelling to enable the EPA to finalise its advice on sedimentation.

Summary

Having particular regard to:

(a) the advice received from the reviewers with regard to hydrodynamics and sedimentation;

(b) the uncertainty that sedimentation management poses to the local environment;

(c) the options available to the proponent to manage impacts with regard to sedimentation inside the basins; and

(d) the proponent's acknowledgment of the need for further detailed sediment-related modelling,

it is the EPA's opinion that there is uncertainty associated with the sedimentary processes affected by this proposal and that further information would be required for the EPA to finalise its advice.

4.9 Terrestrial fauna

Description

This proposal would result in the initial loss of 1500 ha of mangroves and associated habitat and would alter the intertidal area available for foraging by waders and water birds.

A total of 228 bird species potentially occur within the project area (Halpern Glick Maunsell, 1997). During a November survey 16 species of migratory shorebirds were recorded using the intertidal area for foraging (Halpern Glick Maunsell, 1997). A number of these species are protected under the Japan - Australia Migratory Birds Agreement (JAMBA) and the China - Australia Migratory Birds Agreement (CAMBA). Of these species, 15 were Asian breeding and only one species of migratory bird was identified as using Australia as a breeding ground. Therefore the predominant use of the area is as a feeding and resting area. However a recent comparative survey of the invertebrates of Roebuck Bay and King Sound found 181 different invertebrate species in Roebuck Bay and 20 species in King Sound (Edinger, 1998) which would seem to suggest King Sound is not a 'high value' feeding site for wader birds.

Submissions

CALM advised that no Declared Rare or Priority Listed Fauna are likely to be affected by this proposal. Environment Australia listed a number of endangered species as potentially occurring in the area and recommended further survey work be carried out in the area prior to commencement of construction. Environment Australia also raised concerns over the immediate reduction in habitat and the long-term implications for wader populations.

Assessment

The area considered for assessment of this factor is Doctors Creek and its catchment.

The EPA's environmental objective for this factor is to protect Threatened Fauna and Priority Fauna species and their habitats, consistent with the provisions of the Wildlife Conservation Act 1950 and the Endangered Species Protection Act 1992.

The greatest bird species richness was recorded from within the denser, tall mangrove woodland habitats which predominantly fringed the lower half of both East and West Doctors Creeks (Halpern Glick Maunsell, 1997). The majority of mangals of East Doctors Creek south of the barrage are expected to be lost in the short term, representing approximately 1060 ha. However, approximately 1200 ha of mangrove habitat will be retained within 5 km of the barrages. The upper reaches of East Doctors Creek will potentially provide an additional 500 ha of intertidal area available for feeding and the proponent states that potentially over 2300 ha of mangals will establish in the medium to long term

Environment Australia acknowledges the results of the model that suggests a greater and more productive intertidal area will become available over time and the potential for establishment of mangals, but they have raised concerns over the immediate reduction in habitat and the long term implications to wader populations. The concern is particularly in relation to Australia's obligations under the Japan - Australia Migratory Birds Agreement (JAMBA) and the China - Australia Migratory Birds Agreement (CAMBA).

Environment Australia also expressed concern over the lack of detail about other vertebrate fauna and has recommended that a full scientific survey of the fauna of all associated and potentially affected areas (excluding avifauna) be undertaken prior to the commencement of construction.

As outlined in section 4.2 of this report, the EPA believes that there is a significant degree of uncertainty in relation the regrowth of mangroves .

The proponent has committed to undertaking a monitoring programme to quantify changes in bird use of the area.

Summary

Having particular regard to:

(a) the apparent value of King Sound as a feeding and roosting area for migratory wader birds;

(b) the area of similar mangrove systems in King Sound;

(c) the potential for roosting and intertidal feeding areas to increase in the short to medium term;

(d) the potential area available for establishment of mangals in the medium to long term; and

(e) the proponent commitment to undertake a monitoring programme to detect changes in bird use of the area,

it is the EPA's opinion that the proposal can be managed to meet the EPA's environmental objective for terrestrial fauna provided that the necessary survey work is undertaken on advice from CALM and Environment Australia and the relevant wildlife conservation legislation and relevant international agreements are adhered to.

4.10 Marine fauna

Description

The tidal power station would result in the initial loss of 1500 ha of mangroves and associated habitat and would restrict movement to and from the creeks by the construction of barrages across the entrances to both creeks. Movement to and from the creeks would be restricted to times when the sluice gates are open. Movement through the turbine channel may also result in injury or death to small and juvenile fish.

Submissions

Concern was raised during the public submission period about the lack of information regarding marine fauna of the creeks. Fisheries WA acknowledged that the proposal would likely result in an increase in the numbers of fish in the creeks in the long term and noted potential aquaculture development in the creek. However, Fisheries WA also would like to see monitoring of the impacts from dredging on the development of benthic communities, ability of fish species to traverse the sluice gates and turbines, the provision of recreational fishing access on both sides of the sluice gates and the proponent to undertake monitoring of recreational fishers use of the area. Fisheries WA has also requested to be consulted with regarding the development of the 'fish use' monitoring programme.

Assessment

The area considered for assessment of this factor is the waters of Doctors Creek.

The EPA's environmental objective for this factor is to maintain the abundance, species diversity and geographic distribution of marine fauna.

The value of Doctors Creek to marine species is not known. The proponent considers that the impacts on fisheries in the short term would be minimal and the impact in the medium to long term would be beneficial due to the increased area available for mangrove colonisation (Halpern Glick Maunsell, 1997).

Due to the high tidal regime and the complete emptying of the creeks each tidal cycle, it is unlikely that the creeks contain any species that are unique to the area. For similar reasons their role as an important nursery area is also likely to be reduced as protection to juveniles would only be offered during times when mangroves are inundated. The role of the mangroves in

Doctors Creek for provision of nutrients and habitat for invertebrates, which may be a food source for fish, has not been quantified. However, the loss of linear extent of mangroves would be considerable in the short-term.

The proponent has committed to undertaking a monitoring programme to quantify changes in phytoplankton and zooplankton density and species diversity, infauna density and species diversity and fish use.

The potential for injury or death of fish passing through the turbine channel would be reduced with the installation of mesh across the entrance to the channel. Suitable design would need to be employed to prevent injury to fish against the screen while ensuring the screen does not become blocked by debris. The proponent has committed to the installation of mesh or other suitable exclusion devices.

Summary

Having particular regard to:

(a) the area of and linear length of similar mangrove systems in King Sound;

(b) the commitment to monitoring provided by the proponent; and

(c) the commitment to the use of a suitable fish exclusion device on the entrance to the turbine channel,

it is the EPA's opinion that the proposal can be managed to meet the EPA's environmental objective for marine fauna.

4.11 Dust

Description

Large areas of mudflats would be permanently dry, particularly in and around the low basin, due to the reduced mean tidal height and the reduced amplitude of tidal variation in the low basin.

Submissions

Public concern was raised over the potential increase in dust levels in the town of Derby from the proposal.

Assessment

The area considered for assessment of this factor is the mudflats around Doctors Creek.

The EPA's environmental objective for this factor is to ensure dust levels generated by this proposal do not adversely impact on the amenity or cause health problems by complying with statutory requirements and acceptable standards.

Dust levels in Derby during certain times of the year, when north east winds are blowing, are already at a nuisance level. Concern has been raised that causing large areas of mudflats to become permanently dry as they would no longer be subject to tidal inundation during spring tides, would further increase the dust levels during north east winds.

The proponent has stated that the 3 km separation distance between Derby and the eastern arm of Doctors Creek would reduce the likelihood of a dust problem in Derby and that the crust of salt that would be left on the mudflats would act to seal the ground and prevent dust generation. However, the long term effectiveness of this method has been questioned.

The proponent has committed to assist the Shire in developing a dust management plan for the tidal flats that would address public use of the area and minimise disturbance to the protective salt crust.

Summary

Having particular regard to the:

(a) high levels of dust already experienced in Derby during certain times of the year;

(b) distance between Derby and the eastern arm of Doctors Creek;

(c) management techniques proposed by the proponent,

it is the EPA's opinion that the proposal can be managed to meet the EPA's environmental objective for dust provided that adequate monitoring methods and dust management contingency plans are implemented.

4.12 Greenhouse gas emissions

Description

This proposal has the potential to reduce greenhouse gas emissions by reducing the amount of fossil fuels burnt for energy generation for the West Kimberley.

Submissions

Concerns were raised that the loss of mangroves may partially or fully off-set any potential gains in greenhouse gas emission savings by the release of the 'carbon sink' stored within the mangrove biomass and the removal of the continued ability to take up carbon dioxide through photosynthesis.

Assessment

The area considered for assessment of this factor is the mangrove community around Doctors Creek.

The EPA's general environmental objective for this factor is to ensure that greenhouse gas emissions meet acceptable standards and requirements of Section 51 of the Environmental Protection Act 1986 (all reasonable and practicable measures are taken to minimise greenhouse gas discharge).

The proponent states that the proposal would result in a reduction in greenhouse gas emissions of between 135 000 and 210 000 tonnes of carbon dioxide per year. The potential savings in greenhouse gas emissions are put forward by the proponent as a major environmental benefit associated with this proposal. However, the figure quoted by the proponent only takes into account savings from the use of renewable energy sources and does not include greenhouse gas emissions from the burning of gas or diesel through conventional power generators which would be required as part of the proposal (see Table 1).

The EPA raised concerns over the greenhouse gas issues in its Section 16(e) report (Appendix 3).

The Department of Environmental Protection commissioned D M Gordon and Associates to produce a paper on carbon stocks and fluxes in mangroves to better define the potential carbon budgets associated with this proposal (Gordon, 1999b).

The paper noted the lack of information about carbon sequestering and release rates of mangrove communities in the Kimberley region. The paper concluded that the power station would have to operate in the order of 4 to 8 months each year in order to match the quantity of carbon that would be released from the progressive decomposition of the original 1500 ha of mangroves that would no longer be assimilated through canopy photosynthesis.

While the precise reduction of greenhouse gas emissions that would be achieved by this proposal is debatable, it is clear that it is not as great as that outlined in the CER.

Summary

Having particular regard to the:

(a) the expected greenhouse gas emission savings stated by the proponent; and

(b) the reduced greenhouse gas emission savings when loss of mangroves is considered,

the EPA has concluded that the proposal, if implemented, would have the environmental benefit of reducing greenhouse gas emissions to some extent compared with other potential energy sources but that the benefit would be less than that presented by the proponent in the CER, and would be regarded as being quite small.

4.13 Decommissioning

Description

The proposal has an anticipated operating life of 120 years. By its very nature the proposal will alter the processes that have influenced the environment that has developed in Doctors Creek. At the end of the 120 years the local environment could be expected to have adjusted to the processes occurring in the creeks after the development. Changing the processes by removal of the tidal power station infrastructure would again subject the environment to severe stress and would alter the ecological structure in the Creek existing at the time. It may take years or decades to establish a new equilibrium. To ensure that the long-term implications to the natural environment are minimised, it is envisaged that significant management measures would be required throughout the life of the project.

Furthermore, should the project prove financially unviable or cease operations prematurely for any reason, significant management measures would be required to ensure disturbance to the natural environment is managed appropriately.

Submissions

Environment Australia, the Conservation Council and members of the public raised concerns about decommissioning and how this could be carried out to an acceptable level.

Assessment

The area considered for assessment of this factor is the Doctors Creek area and surrounds.

The EPA's environmental objective for this factor is to ensure that infrastructure that is no longer required is removed and the area rehabilitated to a environmentally stable state consistent with surrounding land uses.

There is a high degree of uncertainty as to how the ecology of Doctors Creek would be altered by implementation of the proposal and what the final structure of the ecological community would be like in response to the altered processes occurring in the creeks. Even more uncertain is how the community that establishes would be altered when the infrastructure is removed at decommissioning. The reversibility of the impacts cannot be assessed as the degree of change to the processes and landforms that result from the project cannot be clearly predicted at this stage.

However, it is the EPA's view that managing the environmental impacts from decommissioning is likely to be at least as difficult as managing the impacts during construction and operations and would require on-going management and monitoring for a significant period of time. The proponent has committed to the development of a decommissioning plan that will address the removal of plant and equipment and the rehabilitation of disturbed areas.

The issue of premature decommissioning or abandonment due to sedimentation problems is of concern to the EPA. In relation to sedimentation, Dr Imberger (1998) suggested that the;

"proponent be asked to set up a bank security to demolish the barrage works if so requested and return the site to its natural state in the event the venture is disbanded because of local sedimentation problems that prove unmanageable."

While assessment of the financial viability of the proposal is beyond the scope of the EPA, the financial arrangements in the event of early decommissioning or abandonment of the project are not issues that the EPA considers can be left to a future time and must be addressed prior to any decision to implement the proposal.

The EPA is aware of mechanisms available under other approval processes that would reduce the risk of decommissioning not being carried out to a suitable standard. This is discussed in more detail in Section 5 of this report.

4.14 Environmental management

This proposal carries with it a high degree of uncertainty about the scope and extent of environmental impacts, several of which are significant. Likewise, the ability to manage the impacts to an acceptable level also carries with it a high degree of uncertainty.

There are a number of ways this uncertainty can be considered. These include:

1. *The application of the precautionary principle:*

   The application of the precautionary principle, as described by Deville and Harding (1997), would require 'strict precaution' for the factor of mangroves alone. Given that the proposal cannot be staged and the impacts are highly unlikely to be able to be reversed, the precautionary principle would dictate that the proposal should not proceed based upon the information currently available.

2. *Reducing uncertainty to an 'acceptable level' by further studies, modelling, analysis and research, which in this case could take up to 5 years:*

   The resolution of uncertainty with respect to mangrove regrowth in the area, through further research, could take up to 5 years. Other issues such as quantifying the potential impacts on marine fauna could take longer if a full understanding of all of the ecological implications were required. The environmental impacts are likely to be significant, and if the proposal were to be implemented it would need to be accompanied by a detailed research programme.

3. *Undertaking assessment assuming 'worst case' level of impact and determine if the impacts can be managed to an acceptable level:*

   If the worst case scenario was assumed, which would include no regrowth of mangroves and significant sedimentation of the high basin which could not be managed the proposal would quite clearly be unacceptable.

4. *Putting in place contingency plans to manage all possible environmental outcomes:*

   Developing contingency plans for all possible environmental impacts may prove to be the best environmental management strategy if this proposal was to be implemented. The proponent's commitments partially identify the contingency plans that would be required. However a much greater commitment to monitoring, including extensive background monitoring and ongoing monitoring leading to adaptive management would be required. Ongoing monitoring and management would be an essential component of any environmental approval conditions. Contingency plans may still be unable to manage or mitigate many of the impacts and contingency plans would be of little use to address some of the impacts, for example the impacts on geo-heritage, which would have to be considered an 'environmental cost' of the proposal. Should worst case impacts eventuate and management methods to ameliorate the impacts be unsuccessful, a final contingency would be to remove the structure. This would involve further significant impacts and would not restore the natural physical processes that were there prior to the project. Rehabilitation plans could be implemented to assist in recolonisation and re-establishment of ecological processes in the new Doctors Creek system. This approach would place a

significant long-term economic cost on the proposal and funds would need to be secured during and beyond the project's operating life.

5. *Evaluating alternatives that achieve the desired outcome with lower environmental cost and which avoids the risk associated with uncertainty:*

   The final option for managing uncertainty would be by the assessment of alternative means of generating power. While it may not be the role of the EPA to consider this aspect, Government may wish to consider the environmental cost of alternative projects when selecting a tender for the supply of power to the West Kimberley. It may well be that an alternative competitive proposal can fulfil the primary purpose of power generation, at a much reduced environmental cost.

Summary

It is the EPA's opinion that the proposal carries with it a high degree of risk in terms of environmental management. Any environmental conditions placed on the proposal would need to be thorough, rigorous and extensive to manage the degree of uncertainty of impacts and uncertainty of the manageability of impacts from the proposal. As such, the EPA has provided only an indication of the likely requirements in terms of environmental conditions which would need to be rigorous to reduce the risks and uncertainties with the proposal. , The EPA recognises that the proposal would still carry with it a high environmental cost which would have intergenerational implications.

5. Other Advice

As discussed above, this proposal carries with it a high degree of environmental risk. It also carries with it a significant economic risk, particularly with regard to sedimentation and overall environmental management throughout and beyond the operating life of the project. While the commercial risk to the proponent is beyond the role of the EPA, it has implications for environmental management with which the EPA is concerned. In particular, if the proposal is found to be unviable or the company managing the project collapses or abandons it, the resources required to ensure decommissioning and rehabilitation is carried out needs to be secured. The *Environmental Protection Act 1986* currently has no process by which this provision of resources can be assured, however such a provision is available under the *Land Act 1933*. Therefore, should the Minister for the Environment be of the view that the proposal could be implemented, the Government should require the Department of Land Administration to secure a substantial bond as part of the lease agreement, for the purposes of ensuring that decommissioning and rehabilitation are properly undertaken and managed. It is recommended that the bond be periodically reviewed with respect to its ongoing adequacy to fund decommissioning and rehabilitation requirements.

The issue of cumulative impacts is also of concern to the EPA. The EPA has recommended that a proposal for a prawn farm on the mud-flats on the upper reaches of Doctors Creek could be managed to meet the EPA's environmental objectives. While the EPA believes that water quality, along with a range of other issues, can be adequately managed in the case of the prawn farm, the discharge of prawn farm effluent to the low basin may add further stress to a system already under stress from a change in hydrology. This may have implications for water quality in the low basin and affect the rehabilitation of mangroves. The EPA considers that, in the event that both projects are implemented, it would be appropriate for a joint management plan to be prepared by both proponents that address the issues of water quality, mangrove establishment and erosion/ sedimentation and outlines management measures and contingency plans to be undertaken by both proponents if management is not effective. These joint management plans should be reviewed by the EPA.

6. Conclusions

The EPA has considered the proposal by Derby Hydro Power Pty Ltd to construct and operate a tidal power station at Doctors Creek, near Derby. The proposal also includes 450 km of new power transmission lines but this element has not yet been assessed.

The Derby Hydro Power proposal is for the purpose of providing power for the West Kimberley area. During the course of this assessment the Government has established a Regional Power Procurement Committee which has called tenders for the provision of power to the West Kimberley, and Derby Hydro Power Pty Ltd has submitted a tender. Accordingly there are a range of options available to Government for power generation, and each will have its own set of environmental benefits and disbenefits. As set out in the EPA's Administrative Procedures it is appropriate for an assessment report to include findings on the environmental benefits and disbenefits of a proposal as well as a recommendation on whether a proposal should proceed.

The proposal, if implemented, would produce power from a renewable source of energy and that has a greenhouse gas emission benefit. However, this benefit has to be reduced by consideration of the release of carbon from the progressive decomposition of approximately 1500 ha of mangroves. Also, the proposal would still require some use of conventional power generation from non-renewable energy sources. A paper presented to the EPA on the mangrove loss concluded that the tidal power station would have to operate for 4 to 8 months each year in order to compensate for the quantities of carbon released from the progressive mangrove decomposition (Gordon, 1999b). Accordingly, the potential for environmental benefit from savings in greenhouse gas emissions from this proposal would be reduced.

The concerns about the proposal flow from the uncertainties attaching to the impact of the proposal on the mangroves in Doctors Creek and associated ecosystems as well as the uncertainties relating to altered sedimentation and its management. In addition, the proposal, if implemented, would affect the geo-heritage values of the site as it would impact on the area as a site of scientific interest as a documented geo-morphological reference point.

There would be a loss of mangrove ecosystems in Doctors Creek (both in terms of area and linear extent of mangroves), at least for a significant length of time, and the sedimentary patterns would be altered as a result of the structures to be built and the proposed method of operation of the system. There would also be a loss of geo-heritage values through disruption to the processes that support them.

The proposal has all the hallmarks of a large field scale experiment because about 1500 ha of mangroves would be lost and a new potential mangrove habitat, estimated to be more than 2300 ha, could be available for rehabilitation if the changed circumstances are favourable to that outcome. However, the length of mangrove margin would remain substantially reduced. The proposal would require substantial sediment control in a macro-tidal area, and the proponent has yet to demonstrate how this would be managed.

The EPA provided advice to the Minister for the Environment in July 1998 to the effect that the combination of geo-heritage and other environmental uncertainties at the proposed location were of sufficient concern to the EPA that the Government should give consideration, at that time, as to whether or not the proposal should proceed. Following consideration of the issues, including advice from the MPRA, the Minister requested the EPA to conclude its environmental assessment and provide its report and recommendations pursuant to section 44 of the Environmental Protection Act.

The proponent has undertaken a range of investigations into potential environmental impacts and management responses. Even so, the EPA considers that there is still a significant degree of uncertainty over the environmental management aspects of and likely outcomes for several of the factors regarded by the EPA as being very important. These uncertainties are associated with the regeneration responses of the mangroves and associated ecosystems in the manner predicted by the proponent as well as the sedimentation problems which may become unmanageable. The combination of these uncertainties, if they were realised, together with the impact on the geo-morphological attributes of Doctors Creek would lead to the overall environmental consequences of the proposal being unacceptable.

The EPA's judgement is that the environmental impacts, uncertainties and risks associated with the proposal at the proposed location are significant and are of such nature that the proposal should not be implemented. As a consequence the EPA has not developed recommended conditions and procedures at this time. However, if Government is of the view that it is desirable for the proposal by Derby Hydro Power Pty Ltd to proceed, the EPA would provide further advice in relation to the proposal, including the environmental conditions and procedures to which the project should be subject.

The EPA is aware that the proposal by Derby Hydro Power Pty Ltd is one of a number of potential means of supplying power to the West Kimberley. While other potential power supply options have yet to be considered by the EPA, we know that other more conventional forms of power generation would have different and lower environmental impacts (with the exception of greenhouse gas) with a higher level of certainty about the ability to manage the impacts that would result. On this basis, the EPA considers that other potential power supply options for the West Kimberley would be likely to be more acceptable from an environmental impact perspective.

The EPA is supportive of innovative renewable energy projects that would make a substantial contribution to greenhouse gas savings, and may also have benefits in terms of technology transfer opportunities. The EPA would welcome the investigation of innovative tidal power generation at other sites as the Doctors Creek site poses some particular environmental problems.

7. 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, 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 for the Environment:

1. That the Minister considers the report on the relevant environmental factors of mangroves, geo-heritage, proposed nature reserve, groundwater, water quality, Acid Sulphate Soils, sedimentation, visual amenity, terrestrial fauna, marine fauna, dust, greenhouse gas emissions, environmental management, and decommissioning, as set out in Section 4.
2. That the Minister notes that the EPA has not provided advice on the following matters at this time:
   (a) the EPA's final advice on the factor of sedimentation;
   (b) the EPA's advice on assessment of the power transmission lines;
   (c) the draft conditions and procedures.
3. That the Minister notes that the EPA has concluded that the proposal cannot meet the EPA's environmental objective for geo-heritage and that the proponent has not demonstrated that the proposal would be able to meet the EPA's objectives for mangroves and for sediment management.
4. That the Minister notes that it is the EPA's judgement that the environmental impact of the proposal submitted, if implemented at the proposed location, would be significant, resulting from:
   (a) a loss of the mangrove ecosystems in Doctors Creek (both in areal and linear extent) at least for a significant length of time;
   (b) the loss of geo-heritage values through disruption to the processes that support them and consequent impact on scientific values of the site as a documented geo-morphological reference point; and
   (c) the uncertainties relating to the altered sedimentation and its management.

5. That the Minister notes that the EPA has concluded that the environmental impacts, uncertainties and risks associated with the proposal are significant and are of such a nature that the proposal should not be implemented.

6. That the Minister notes that if Government is of the view that it is desirable for the Derby Hydro Power Pty Ltd proposal to proceed, the EPA would need to finalise its advice on the matters in Recommendation 2, including:

   (a) the proponent undertaking additional modelling to enable the EPA to advise on sedimentation impacts and management;

   (b) an assessment of the transmission lines; and

   (c) the environmental conditions and procedures to which the project should be subject.

Appendix 1

List of submitters

Organisations:

Aboriginal Affairs Department
Conservation Council of Western Australia
Department of Conservation and Land Management
Derby Chamber of Commerce
Derby Residents Action Group
Environment Australia
Fisheries Western Australia
Kimberley Development Commission
Kimberley Land Council
Shire of Derby/West Kimberley
Water and Rivers Commission

Individual:

D. Clay
P. Kulczckckyi
N. Lyons
N. Madden
J. Silver
G. Watson

Appendix 2

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Appendix 3

Derby Tidal Power, Advice to the Minister for the Environment under Section 16(e)

Derby Tidal Power
Derby Hydro Power Pty Ltd

[and the related issue of Derby Prawn Farm Kimberley Prawn Company]

Advice to the Minister for the Environment from the Environmental Protection Authority under Section 16(e) of the Environmental Protection Act, 1986

(This is not an assessment by the Environmental Protection Authority under Part IV of the Environmental Protection Act, 1986)

Environmental Protection Authority
Perth, Western Australia
Bulletin XXX
July 1998

Contents

Summary and Recommendations

This report forms interim advice to the Minister for the Environment under section 16(e) of the Environmental Protection Act and is provided to assist the Minister, the proponent and the government in their decision-making on the tidal power proposal.

The EPA is supportive of tidal power in principle and would welcome projects that provide substantial contributions to reducing greenhouse gas emissions. However, the particular site selected for this proposal does raise environmental concerns and uncertainties which are addressed more fully in this report.

The EPA has concluded that the geo-heritage value of the Doctors Creek area is a major issue requiring resolution by Government, following additional advice.

Furthermore, there are numerous significant uncertainties associated with the project. The EPA considers these are of sufficient magnitude to require further work by the proponent to enable the EPA to provide full and proper advice to the Minister. Some of these uncertainties may be impossible to resolve prior to the construction of the project, given that there is no comparable project from which to draw definitive conclusions. To this extent, and in the absence of resolution of these issues, implementation of the project could be described as a "bold" step at this time.

It is the EPA's view that the combination of the geo-heritage issue, and the uncertainties associated with the project which require more work by the proponent, suggest that it would be wise, in a precautionary sense, for the project not to proceed until Government has decided upon the geo-heritage issues and the proponent has addressed the uncertainties.

Finally, the indicative figures obtained by the EPA during the assessment provide sufficient doubt to suggest that it would be unwise for potential savings in Greenhouse gas emissions to be attributed significant weight in the decision-making process on the tidal power project at this time.

The Derby Prawn Farm is impacted by this advice to the extent of the geo-heritage value and acid sulphate soils.

Recommendations

The EPA submits the following recommendations:

Recommendation 1

That the Minister for the Environment notes that the EPA has written to the Chairman of the Marine Parks and Reserves Authority requesting the MPRA to consider, as a matter of urgency, whether Doctors Creek, near Derby, in the context of its geo-heritage value is of such importance at a State, National and International level to warrant its preservation.

Recommendation 2

That the Minister for the Environment notes that it is the EPA's opinion that the combination of the geo-heritage issue, and the uncertainties associated with the project which require more work by the proponent, suggest that it would be wise, in a precautionary sense, for the project not to proceed until Government has decided upon the geo-heritage issues and the proponent has addressed the uncertainties.

Recommendation 3

That the Minister for the Environment notes the environmental uncertainties associated with the project upon which further advice from the proponent is required.

Recommendation 4

That the Minister for the Environment notes the precautionary advice in regard to the predicted Greenhouse gas savings that might accrue from the tidal power project. Specifically that it would be unwise for potential savings in Greenhouse gas emissions to be attributed significant weight in the decision-making process on the tidal power project until such time as the reduction in carbon dioxide sequestering resulting from the loss of mangroves has been properly quantified.

1. Purpose

The purpose of this report is to provide interim advice to the Minister for the Environment, pursuant to s16(e) of the Environmental Protection Act, on the proposal entitled "Derby Tidal Power Project, Doctor's Creek, Kimberley", submitted to the Environmental Protection Authority (EPA) by Derby Hydro Power Pty Ltd.

2. Introduction

Derby Hydro Power proposes to construct a 48 MW double basin tidal power generation facility to the two arms of Doctor's Creek, near Derby (Figure 1). The power station is designed to supply the requirements of Derby, Broome, Fitzroy Crossing and the Pillara mine, east of Fitzroy Crossing. The tidal flat area at the end of Doctor's Creek is also the location of a prawn farm proposed by Kimberley Prawn Company Pty Ltd (Figure 2), and the advice contained in this report also has implications for the prawn farm proposal.

The tidal power proposal would also require a 30 MW back-up thermal generation facility to operate at times when power from the tidal power facility was not available (for example on neap tides). There would also need to be approximately 450 km of high tension power lines from the site to Derby, Broome, Fitzroy Crossing and the Pillara mine. The power distribution network has not yet been assessed and is not reported on herein.

The reasons for providing this interim advice on the tidal power facility are as follows:

i) a specific matter of the geo-heritage of the site has come to the EPA's attention during the assessment process; and

ii) it is appropriate at this stage of the assessment to draw to the Minister's attention to some of the significant uncertainties about which additional information is required from the proponent.

The matter of geo-heritage was not addressed by the proponent in its environmental documentation (the CER) and has assumed greater significance during the assessment process. Because of the specialised nature of geo-heritage as an environmental issue, the EPA undertook a number of actions which included:

i) contracting Professor Bruce Thom to undertake a consultancy to provide expert geo-heritage and geo-morphological advice to the EPA;

ii) conducting a one-day technical workshop, which was attended by members of the EPA, the proponents, proponent's consultants, Professor Thom, and specialists from Government Departments and Agencies, including Dr Barry Wilson and Dr Di Walker from the Marine Parks and Reserves Authority;

iii) holding discussions with the Derby Residents Action Group (DRAG), whose consultant, Dr Semeniuk, wrote some of the papers on the stratigraphy and geo-evolutionary history of the area (published in refereed journals) as well as covering the geo-heritage values in the submission sent to the EPA during the public review period;

iv) having access to a report by Professor Daborn, from the Acadia Centre for Estuarine Research in Canada, who had experience in tidal power impacts relevant to the Bay of Fundy, Canada and has published work in the area of tidal power (Daborn, 1987); and

vi) having access to other advice from the proponent who sought advice from a second expert in geomorphology, Associate Professor Colin Woodroffe from the University of Wollongong.

In addition, during the assessment, all members of the EPA visited the site of the tidal power station, accompanied by Professor Bruce Thom. The EPA also held a public meeting with the residents of Derby in April 1998.

3. Geo-heritage value of Doctors Creek and King Sound

The potential geo-heritage values of Doctors Creek were identified by the EPA early in the assessment process. Aspects of the Doctors Creek system and King Sound have been described in refereed literature by Fairbridge (1961), Jennings and Coventry (1973), Jennings (1975) and Semeniuk (1980a & b; 1981a & b; 1982; 1993; and undated).

The collection of attributes within the single area of Doctors Creek have been identified as being of international, national and State-wide significance by Semeniuk & EnviroEng (1997), because of a range of particular geo-heritage values of the area. The geo-heritage values have also been assessed by Professor Bruce Thom, an independent expert contracted by the EPA to review the literature, visit the site and liaise with experts in geo-heritage.

Professor Thom has advised that, as a flanking tidal-flat environment to the King Sound/Fitzroy deltaic complex, Doctors Creek offers scientists an accessible array of sub-environments and habitats which can be used to document biophysical conditions and processes (Thom, 1998a (see Attachment 1)). The individual components of the array, such as the six erosional stages represented in the creek, the macro-tidal forces, the fractal patterns embedded in the system, the relationship of the Quaternary red sand dunes to the Holocene tidal flat deposits, the relationship of the hinterland freshwater with the tidal flat hypersaline water, and the development of mangrove systems adapted to this environment, are not, individually, unique. However the occurrence of these components within one system provides a site of significant scientific interest.

This scientific interest is reflected in the work undertaken in the area. In particular the coastal stratigraphy is described by Fairbridge (1961), Jennings and Coventry (1973) and Jennings (1975) and the groundwater interrelationship is described by Semeniuk (1981a). The area is considered the “type site” for sedimentation/erosional processes in a macro-tidal deltaic setting.

Given the array of attributes described above, the areas of King Sound and Doctors Creek are regarded as being of special importance, a conclusion reached independently by Dr Semeniuk, Associate Professor Woodroffe and Professor Bruce Thom.

The geo-heritage attributes described above extend to the mud flats and adjacent Pleistocene / Holocene interfingering dunes and the proposed nature reserve. Thus, the proposed prawn farm may also impact on these geo-heritage values.

The Chairman of the Marine Parks and Reserves Authority (MPRA) has advised the EPA that although Doctors Creek was not formally identified in the Marine Parks and Reserves Selection Working Group Report in 1986, the section of the Report dealing with the Kimberley region was prepared prior to the methodology and selection criteria having been finalised, and to that extent may have overlooked some important areas. The MPRA is about to initiate a review of the recommendations of the Working Group Report and has indicated that the recommendations for the Kimberley region, including King Sound, will require a substantial update. It was further advised that the MPRA would have no hesitation in recommending the establishment of a marine reserve, primarily for the protection of geo-heritage, if the area in question had geo-heritage features judged by the MPRA to be of sufficient significance. The EPA has now written to the MPRA seeking advice as to whether the geo-heritage value is of such importance to warrant its preservation.

The EPA is of the opinion that the decision as to whether the geo-heritage value of this site should be protected from development requires a decision beyond the role of the Authority. Therefore, prior to the EPA finalising its report and recommendations on the proposals under s 44, guidance is sought, through the Minister for the Environment, from Government, as to whether the Doctors Creek/King Sound area is likely to be protected through reservation as a marine reserve under the Conservation and Land Management Act 1985.

It should be noted that such advice on the geo-heritage values would also affect the prawn farm project.

Professor Thom outlined his understanding of the geo-heritage values of the Doctor's Creek area at the Workshop and later provided a written summary, which is included as Attachment 5 to the Rapporteur's Report of the proceedings of the Workshop and is attached to this report as Attachment 1.

4. Project uncertainties

As part of the consultancy to the EPA, Professor Thom provided his assessment, both at the Workshop and later in writing, of the uncertainties associated with the Tidal Power project. He also provided, in writing, advice on uncertainties in relation to the prawn project. These form part of the Rapporteur's Report as Attachments 6 and 8, and are attached to this report as Attachments 2 and 3.

At the meeting of the Environmental Protection Authority, held on 25 June 1998, the matters upon which the EPA would like further information from the proponent were discussed and included:

i) Modelling studies of the hydrodynamics of King Sound and Doctors Creeks and associated sedimentation, to determine risk of nearfield and farfield erosion, and actual sedimentation, particularly outside the barrages, and the fate of settled sediment inside and outside the sluice gates;

ii) The sites for placement of, and long term effects of disposal of dredged material requiring removal from both inside and outside the barrages;

iii) Consideration of the effects of acid sulphate soils on structures, water quality and biota;

iv) The preparation of a detailed EMP covering the total area that may be affected by the project, including all source areas for raw materials. Some of the issues the EMP would need to cover include *(inter alia)*:

- mangrove regeneration;
- sediment dredging;
- provision of fish exclusion devices at the turbines;
- management of acid sulphate soils;

v) Results from evaluations of other sites conducted to date.

The EPA recognises that some of these uncertainties may be impossible to resolve prior to construction of the project, given that there is no comparable project throughout the world from which to draw definitive conclusions. To this extent, and in the absence of resolution of the uncertainties, implementation of the project could be described as a "bold" step at this time.

The following points may be helpful in understanding some of the uncertainties listed above.

4.1 Mangrove regeneration

The proponent has estimated that up to 1500 ha of mangroves will be lost by the changes in hydrodynamics in the creeks, however the proponent estimates up to 2400 ha of land will be available for mature mangrove colonisation in the medium to longer term, 5 years or more (HGM, 1997), with full mangrove productivity taking up to ten years. However the exact areas of colonisation and the extent to which productivity will change is difficult to predict because this development is the first of its type in this type of environment (Paling, 1997). In this respect the regeneration of mangroves could be looked upon as a long-term experiment in mangrove recolonisation.

Mangroves do have the capacity to quickly colonise and become established as dense thickets. However the combined effects of altered tidal regime and potential changes in water quality on mangrove colonisation are unknown. In addition there is little knowledge of conditions required for mangrove propagule recruitment as well as the land elevation and inundation patterns needed for successful long-term mangrove community regeneration. The issue of acid sulphate soils from dredge spoil disposal is also relevant to the ability of mangroves to re-colonise on dredged material (see section 4.6).

Therefore, while it is expected there will be some regeneration of mangroves in the Doctors Creek system, the scale, extent and timeframe for recolonisation is uncertain. The EPA would require further information on the methods to be used to encourage mangrove establishment, including strategies for propagule recruitment, bank stabilisation, modification of bank elevations and strategies for ensuring diversity of mangrove communities. The issue of acid sulphate soils would also need to be addressed.

Contingency strategies should also be prepared that outline the course of action in the event that expected mangrove establishment does not occur.

4.2 Sedimentation - impact from alteration of sedimentary processes

The impoundment of water and changes in tidal movement within the creeks would alter the current sediment dynamics within the creeks and at the mouth of the creeks. Thom has also identified possible farfield impacts (Attachment 2).

Previous experience in the Bay of Fundy, where another tidal power station is located, indicates that sediment behaviour near tidal barrages is so variable as to be nearly impossible to predict. This emphasises the uncertainty of what may happen in Doctors Creek/King Sound (Thom, 1998b (Attachment 2)).

Experience in Canada has also shown that there are broader implications than just the viability of the project itself. Farfield effects on bank stability and/or shoaling have been recorded kilometres from the project and this could impact on the navigation channels for the Derby Jetty and potentially use of the jetty itself (Thom, 1998b (Attachment 2)).

4.3 Tidal flat surface instability and Erosion

Thom in his report on geo-heritage (Thom, 1998a (Attachment 1)) says that Semeniuk and to some extent Jennings propose that King Sound over the past 5000-6000 years has passed from a state of general deposition or tidal flat growth to one of erosion or tidal flat destruction. Measurements by Semeniuk and by the proponents show rates of 2-3 metres per year for shoreline/bank erosion; 3-4 metres per year for headward tidal creek erosion and several centimetres per year for sheet erosion of flats. These rates of erosion are occurring over engineering timescales and need to be considered in project design and construction.

Thom says that the “erosional” model raises questions as to the stability of surfaces where structures are to be built at the proposed site, as well as questions about impacts of the barrages,

tidal flow changes, sediment re-distribution, creek position and bank stability on the area, both in the vicinity of the barrages (nearfield effects) as well as at a distance from structures elsewhere in King Sound (farfield effects). Thom concludes that "The necessity for engineering safeguards and modifications during the life of the project (120 years) should not be under-estimated given the inherent instability of the tidal flat surface (Thom 1998a, p2 (Attachment 1)).

4.4 Ecological uncertainties

Dr Daborn has expressed the view that the productivity of macro-tidal estuaries and their importance as fish nurseries has been traditionally underestimated. This is mainly due to the turbidity of the systems (lack of visibility and assumptions of low productivity) as well as the lack of commercial fishing in the area to provide indications of fish stocks. Daborn points out that the assumptions made by the Derby tidal power proponent are similar to those made for the Bay of Fundy project and others, where, once more detailed studies have been undertaken, it has been realised that the productivity has been grossly underestimated.

Daborn states that:

"in more than two decades of work on macro-tidal estuaries on three continents, I have come to the conclusion that they are all exceptionally biologically productive … (and that further) research.... would show that much of its richness has been overlooked" (Daborn, 1998).

A range of uncertainties exist in relation to the influence of the proposed project on the biological systems within the tidal flats, the two branches of Doctors Creek, the mangroves are (see 4.1) and the area of King Sound adjacent to the barrages.

The EPA would require further information on these current ecosystems and the potential effects of mangrove modifications and sedimentation on a range of key biological indicators and their productivity. These indicators would include the crabs (which are currently utilised by local people for food), the mangroves (which are dominant species), micro-organisms in the tidal flats and estuarine systems (which may reflect changes in tides and sedimentation). The proponent should also seek more advice from scientists who have studied similar ecosystems around the world for this selection of potential bioindicators.

4.5 Geo-technical uncertainties

The tidal power project would be constructed on unconsolidated sediments of the Doctors Creek system. The two (or so) tidal power generation systems which have been constructed elsewhere in the world (Bay of Fundy, Canada, and La Rance in France) are constructed on rock substrates and no project has yet been constructed on clays such as occur at Doctors Creek. Although consulting engineers have advised the proponent that they believe the difficulties of the site can be overcome through engineering design and construction methods, they also acknowledge that the site poses a substantial challenge in engineering terms. This has been further highlighted in advice provided by Professor Daborn (Daborn, 1998).

The EPA acknowledges that the final design for the project would undoubtedly be carried out in an expert and professional manner, with the difficulties of the site being fully taken into account. However, at the time of reporting, the EPA has concerns about the uncertainties relating to the barrages and long term stability of the structures.

4.6 Acid sulphate soils

Acid sulphate soils are soil types that contain sulphide compounds such as pyrite. They are widely distributed around the eastern, northern and northwestern coastlines of Australia and are particularly associated with mangrove habitats. When disturbed and exposed to air, these soils have the potential to cause adverse impacts to water quality, biota and coastal structures, because the sulphide oxidises and produces sulphuric acid.

Although acid sulphate soils are manageable, they have not been taken into consideration at all in either the tidal power project or the prawn farm project, to date. The proponents for the tidal power proposal and the prawn farm project would need to *(inter alia)*:

- clarify the potential for and extent of acid sulphate soils in the project area;
- review the project to ensure the engineering uses appropriate acid sulphate soil-resistant design, materials and construction techniques to minimise disturbance of acid sulphate soils; and
- develop monitoring and management strategies to prevent acidification of Doctors Creek and surrounding waters.

In addition, for the tidal power proposal the issue of acid sulphate soils is also relevant to dredge spoil disposal, and the ability of mangroves to re-colonise dredged material would need to be addressed in some detail.

5. Greenhouse issues

The tidal power station is designed to replace the current diesel-fired generators at Derby and Fitzroy Crossing and reduce the load on generators at Broome and Pillara. The proponents have advised that this will result in reduction of greenhouse gas emissions of between 135 000 and 210 000 tonnes of carbon dioxide per year (0.2 % and 0.4% of Western Australia's emissions) (HGM, 1997).

This would assist Western Australia, and Western Power in particular, in meeting its commitments on greenhouse gas reduction and its commitment to the production of 2% renewable energy by 2000.

It is useful to look at the greenhouse gas issue in a WA context. In December 1997 at Kyoto Japan, developed countries, including Australia, agreed to limit greenhouse gas emissions. Australia is committed to limit greenhouse gas emissions to an increase of not more than 8% (in the period 1990-2010) instead of the calculated "business as usual" increase of 43% if no greenhouse gas mitigation measures are adopted.

In WA proposed additional investment in major projects over the next 10 years would significantly increase WA's greenhouse gas emissions. This would result mainly from increased energy use by expanding new industries and the extraction and processing of energy in the form of natural gas for export.

Greenhouse gas emissions in WA have increased already by 19% since 1995. The next six planned major development projects for WA (HBI plant, briquette plant, two LPG plants, alumina expansion, petro-chemical plant) would add more than 8% to Australia's emissions by themselves. One of the LPG plants, on current proposed mitigation measures, would contribute in the order of 8-9 million tonnes of greenhouse gas per year. Although any saving in greenhouse gas is a step in the right direction, against this backdrop, a proposed saving of some 200 000 tonnes per year for the tidal power proposal is not very significant in terms of WA's savings or those of Australia as a whole.

In addition, the mangroves of Doctors Creek currently absorb greenhouse gas. Indicative figures obtained by the EPA suggest that this sequestering capacity could be reduced if the mangroves fail to regenerate, with consequent impacts on the overall greenhouse gas benefits of the tidal power proposal.

The actual and indicative figures obtained by the EPA during the assessment provide sufficient doubt to suggest that it would be unwise for potential savings in Greenhouse gas emissions to

be attributed significant weight in the decision-making process on the tidal power project at this time.

6. Conclusions

The EPA concludes that:

1. The geo-heritage value of the Doctors Creek area is a major issue requiring the resolution by Government, following advice from the EPA and MPRA.

2. There are numerous significant uncertainties associated with the project. The EPA considers these are of sufficient magnitude to require further work by the proponent to enable the EPA to provide full and proper advice to the Minister. Some of these uncertainties may be impossible to resolve prior to the construction of the project, given that there is no comparable project from which to draw definitive conclusions. To this extent, and in the absence of resolution of these issues, implementation of the project could be described as a "bold" step at this time.

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3. The combination of the geo-heritage issue, combined with the uncertainties associated with the project which require more work by the proponent, suggest that it would be wise, in a precautionary sense, for the project not to proceed until Government has decided upon the geo-heritage issues and the proponent has addressed the uncertainties.

   The proponent could have some comfort in carrying out the additional work required to resolve some of the uncertainties when a decision on the geo-heritage value and possible reservation of the Doctors Creek/King Sound area has been made by Government.

4. The indicative figures obtained by the EPA during the assessment provide sufficient doubt to suggest that it would be unwise for potential savings in Greenhouse gas emissions to be attributed significant weight in the decision-making process on the tidal power project at this time.

7. Recommendations

The EPA submits the following recommendations:

Recommendation 1

That the Minister for the Environment notes that the EPA has written to the Chairman of the Marine Parks and Reserves Authority requesting the MPRA to consider, as a matter of urgency, whether Doctors Creek, near Derby, in the context of its geo-heritage value is of such importance at a State, National and International level to warrant its preservation.

Recommendation 2

That the Minister for the Environment notes that it is the EPA's opinion that the combination of the geo-heritage issue, combined with the uncertainties associated with the project which require more work by the proponent, suggest that it would be wise, in a precautionary sense, for the project not to proceed until Government has decided upon the geo-heritage issues and the proponent has addressed the uncertainties.

Recommendation 3

That the Minister for the Environment notes the environmental uncertainties associated with the project upon which further advice from the proponent is required.

Recommendation 4

That the Minister for the Environment notes the precautionary advice in regard to the predicted Greenhouse gas savings that might accrue from the tidal power project. Specifically that it would be unwise for potential savings in Greenhouse gas emissions to be attributed significant weight in the decision-making process on the tidal power project until such time as the reduction in carbon dioxide sequestering resulting from the loss of mangroves has been properly quantified.

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Thom, B, 1998a, Geo-heritage Values of Doctors Creek/King Sound (Attachment 1)

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ATTACHMENT 1

GEOHERITAGE VALUES OF DOCTORS CREEK/KING SOUND

1. KING SOUND IN A GLOBAL CONTEXT

From a general biophysical perspective there are very few high tidal deltaic systems with tidal ranges in excess of 10m. They are not common in semi-arid environments. The most studied "super" high tidal areas surround the Bay of Fundy; this area lacks a major river and possesses a very different geologic history. Geologists and ecologists require areas where documentation of the system can test hypotheses and provide general contexts for examination of other areas and theories. For instance the Mississippi Delta has long been the "type" site for delta sedimentation as geologists use the present as a key to the past. Yet it has no tide! In recent decades geologists have explored other contemporary environments to expand their range of "types". Work in King Sound has provided useful knowledge of conditions near the end of the spectrum of deltaic types where tides are very high and river discharge is periodic and quite large.

2. KING SOUND IN A REGIONAL CONTEXT

Only two deltaic areas with high tides exist in Northwest Australia : the Ord-Victoria and Fitzroy-King Sound. Although King Sound is not the area of highest tide, it certainly exceeds that of the Ord region. Therefore it possesses a distinctive character based on two highly dynamic physical processes : the exchange of massive volumes of semi-diurnal tidal water and periodic high river discharge. Both processes involve enormous sediment movement, both in suspension and as bedload, producing distinctive geomorphological and sedimentologic imprints on sub-tidal, intertidal and supertidal environments. That these imprints are different from those seen elsewhere in Western Australia (except for an overlap with less extreme Ord conditions) has now been well established by scientific work.

The regional context is further enhanced by the linkage between geology, climate and plant ecology. Semeniuk and others have defined regional contrasts associated with the ecosystems

which characterise the different environments of the Northwest. King Sound's distinctiveness is quite pronounced.

3. SIGNIFICANCE OF DOCTORS CREEK

As a flanking tidal-flat environment to the King Sound/Fitzroy deltaic complex, Doctors Creek offers scientists an accessible array of sub-environments and habitats which can be used to document biophysical conditions and processes. This has occurred over the last three decades, especially as a result of Semeniuk's work. It is an array which is not in itself "unique" but can be used to examine past and present conditions typical of the region's tidal flats and creeks.

Various researchers have pointed to the special assemblage of vegetated dunes (Pleistocene linear-type) and tidal flats of eastern King Sound. This conjunction deserves consideration in any assessment of areas deserving protection. Although the dunes will not be directly impacted by the project, they form part of the basin into which sea level has risen and tidal flats have extended, "drowning" their western tips. This conjunction of dunes and tidal flat development is unique in the world to my knowledge.

(Note: Professor Thom later informed the EPA that a similar situation occurs at Exmouth Gulf and made the observation that as this is in an arid zone quite distinct from the Kimberley, the processes and resultant features are likely to be different).

Doctors Creek has become a type site for geologic/ecologic research into tidal flats in high-tidal, semi-arid deltaic areas. As such it has value in the future as an area of reference. This means it can serve as a laboratory to research natural processes within a "known" framework, and as a "benchmark" site for monitoring future change (e.g. those induced by Greenhouse Effect). The more such sites exist around the Australian coast the better can we assess impacts. By being close to Derby there are opportunities for future researchers to utilise the site for understanding processes and changes to sediments, landforms, water movements and biota. The inter-relationship of various phenomena can be best assessed in a site which has a background of research where new hypotheses can be tested.

There are uncertainties surrounding the interpretations reached by Jennings and Semeniuk on climate change, depositional histories and erosional trends. More work must be done to test their ideas which have regional and perhaps continental scale significance.

In summary, a case can be developed for the protection of not just a type site of a geologic record, but more broadly an area that has been studied extensively from a geologic, geomorphologic and ecologic perspective. Had such broader criteria been applied by the Wilson review of marine/parks, it is possible that Doctors Creek may have achieved protected status of an earlier time. It is perhaps fortunate that an assessment such as this by the EPA can highlight the importance of considering type processes and ecological relationships in a studied area, as a basis for environmental protection.

ATTACHMENT 2

PROJECT UNCERTAINTIES ASSOCIATED WITH THE TIDAL POWER PROJECT AT DOCTORS CREEK

1. TIDAL FLAT SURFACE INSTABILITY

1.1 There are three fundamental scales for evaluating landform dynamics: geologic, engineering, immediate. Interaction between scales occurs, leading to trends, switches in state (erosion-deposition), and pulses and cycles (flood vs ebb tide). Semeniuk (and to some extent Jennings) propose that King Sound over the past 5,000-6,000 years (geologic scale) passed from general deposition (or tidal flat growth) to erosion (or tidal flat destruction). Acceptance by Semeniuk that the "Christine Point Clay is Holocene not Pleistocene in age adds a further complication to this model by requiring two phases in geologic time of deposition (Christine Point Clay and Doctors Creek Formation) separated by a phase of erosion. The more recent depositional unit (Doctors Creek Formation) was followed by the contemporary geologic phase of erosion which blends into the engineering time scale (c.100 years). Measurements of shoreline/bank erosion by Semeniuk and the proponents (2-3m per year), plus headward tidal creek erosion (3-4m per year), plus sheet erosion of flats (several cm per year), highlight an eroding trend into the engineering scale at Doctors Creek. Superimposed on this trend are localised depositional sites along banks and on islands within channels and the Sound which are subject to mangrove colonisation.

1.2 If this "erosional" model is accepted then there are uncertainties as to the stability of surfaces where structures are to be built at the proposed project site. It could be argued that further field studies by geomorphologists are needed to test the "erosional" trend model.

The model invokes questions as to impacts of barrages and tidal flow changes, sediment redistribution, creek position and bank stability on the area, both in the

vicinity of the barrages (nearfield), and at a distance from it in King Sound (farfield). The necessity for engineering safeguards and modifications during the life of the project (120 years) should not be underestimated given the inherent instability of the tidal flat land surface.

2. GREENHOUSE IMPLICATIONS ON TIDAL FLAT CONDITIONS

2.1 Recommendations, which flowed from the coastal engineering panel which advised the National Research Council in the USA in 1987. highlighted the need for proponents of infrastructure proposals to consider the implication of Greenhouse-stimulated changes to environmental conditions. These changes operate at the engineering time scale and involve not only rise in sea level (20 to 50 cm over next 50+ years), but also changes in frequency, location and magnitude of cyclonic storms (with consequential impacts on runoff and river sediment discharge). The erosional trends noted above (1.1) may be modified in unknown ways by Greenhouse conditions.

2.2 Uncertainties of Greenhouse climatic and hydrologic conditions have not been incorporated into the CER. However the proponent is aware of the implications in requiring design to accommodate 1:500 extreme events and elevated surfaces for electrical equipment to withstand such impacts. What is less clear is how changing conditions stimulated by the Greenhouse Effect will impact on the hydrodynamics of the estuary and on tidal flat stability, requiring modifications to structures during the life of the project.

3. SEDIMENTATION — PATTERNS AND CIRCULATION

3.1 In his critical review of the CER, Dr Daborn of Canada stated:

> *The least convincing, and in some ways most crucial aspect of the CER is the account of the sedimentary nature of the system...From the CER I have identified <u>several critical uncertainties</u> about the sedimentary regime of the Doctors Creek ecosystem that seem to me to be potentially devastating for the project (p.3).*

At issue here is whether the proponents require more knowledge of sediment dynamics (including a better understanding of hydrodynamics) for the project to be viable. Daborn argues that in the absence of such information:

> *....it is impossible at this time to make any judgement beyond pure guesswork about the effect of the barrages, the channel and the filling/discharging operations that would be involved in building this project (p.6). .*

Experience in the Bay of Fundy suggests different modes of sediment behaviour for barrages depending on variation in conditions: this experience emphasises the uncertainty of what might happen in King Sound/Doctors Creek.

3.2 The extent to which field observations of processes responsible for sediment transport coupled with hydrodynamic models are both needed to provide a firmer base for project planning and management, is a vital question which needs more informed debate. In Australia there are experts who can offer advice on this matter. Clearly the proponents are taking a "minimalist" approach. Difficulties in doing such work (time, cost, etc,), plus a view that there is sufficient engineering experience and "flexible" management practices, have meant the proponents are prepared to live with uncertainties of outcome with barrage construction — is that acceptable? This question has broader implications than just viability of the project ("nearfield" impacts) because the Canadian experience suggests possible "farfield" effects on bank stability and/or shoaling many kilometres distant (e.g. the Derby area).

4. DREDGE SPOIL DISPOSAL

4.1 An uncertain element of the project is the amount of dredging required at the time of construction and during the life of the project. Peter Woods informed us that dredging is needed in the low basin to excavate it further so more water can be stored. In addition there will be headwall accumulation as experienced in Canada. He indicated to me three likely disposal sites : in "holes" in the basin,

over the barrage wall into the Sound, and up onto tidal flats (least preferred option).

4.2 It is not at all clear as to what will be the consequences of spoil disposal at any of the three sites. Growing vegetation on tidal flat spoil in this climate, given the uncertain chemistry of the material, must require experiments and development of management techniques before being acceptable. I do not think the proponents have developed their proposal to a sufficient extent to address uncertainties associated with dredge spoil disposal.

5. GEOTECHNICAL UNCERTAINTIES

5.1 We were well briefed by the proponent's geotechnical consultants (Coffeys) who are very experienced in evaluating the viability of engineering projects from a geotechnical perspective. Although the consultant (Michael Hillman) accepted that the project as "challenging" given the conditions, there are engineering solutions which can be designed to meet the difficulties. Risks posed by environmental factors such as tidal currents, sediment movement, bank instability, surges, earthquakes, etc, are not insurmountable according to Hillman. The fact that structures can be anchored on underlying clays and not bedrock was a surprise to me, but I accept their professional judgement. However, the fact that they had not considered at this point the impact of acid soils on concrete suggests to me that they have still a lot to learn about the environmental conditions of such a site.

5.2 The proponents are going to tender on construction using the "design and construct" approach. This means the successful tenderer will have the option of adjusting the design as construction proceeds. Already a new design has emerged on the location and lining of sluices. This new design has not been subject to external review. What is worrying is that any new designs may have environmental impacts different from those which have been canvassed in the CER and evaluation by the EPA.

6. WATER QUALITY

6.1 Creation of two "basins" with modified water levels and tidal ranges raises questions on water quality. The natural system involves semidiurnal flushing and exchange of water (including sediments in suspension). It is an extremely efficient system for dilution and mixing of contaminants. However, the new "basins" are expected to create quieter waters leading to reduced turbidity and consequential biological changes in the water column. The proponents have developed a view as to what might happen given this new aquatic ecosystem, but our capacity to predict at two stages (initial basin filling and long-term basin establishment) is very limited. The proponents state that they have the ability to "manage" water quality given their capacity to handle discharges in and out of basins with a degree of flexibility during the construction phase and during operations (e.g. less power needed at night giving the opportunity to allow more flushing).

6.2 The proponents have provided little data on possible nutrient changes associated with mangrove die-back (see 7.1) and less turbidity. Uncertainties associated with generation of acid (and toxic aluminium) from oxidation of potential acid soils (e.g. Christine Point Clay) are not considered in the CER. Work in Netherlands and Gambia are suggestive of problems with acid liberation following changes to the environment. However, as the proponents argue, such problems may be quite insignificant given a flexible flushing regime. Uncertainties raised by some, concerning groundwater intrusion from high water levels in one of the basins, do not rate very highly according to the advice received, but do require monitoring if the project was to proceed.

7. MANGROVES

7.1 Eric Paling, a consultant for the proponents, has stated that a "central question" for the proposal is whether mangroves will return to areas surrounding the newly created "basins." There is no precedent for saying that this will or will not occur although salt pans in the Pilbara provide some guidance. Undoubtedly

mangroves have the capacity to quickly colonise and become established as dense thickets on newly-emerged land. This has occurred in historic time in tidal deltaic areas of the Ord and King Sound. There will be created in the new basins new levels for colonisation with lower tidal ranges. What is not clear is whether these new surfaces will be sufficiently flushed to facilitate growth, and whether, following the initial loss of 1500ha of mangroves, seed sources are available for colonisation? Again management of water levels can assist recovery, but the proponents are aware that they are engaged in a long-term natural experiment in plant regeneration with consequences on water quality and estuarine productivity.

7.2 There will be severe visual impacts resulting from mangrove death near a township which will be long lasting and have the potential for adverse comment. Expected mangrove establishment and continued growth are thwart with uncertainties even though intuitively there are good reasons to expect recovery. However, the timing, extent and types of mangrove that appear on the new surfaces is most unclear and the failure of recovery, if it does not proceed as expected, would most probably result in severe public criticism.

8. FISH AND OTHER FAUNA

8.1 The question of the area to be affected by the power project and its role in the aquatic ecosystem of King Sound (and beyond) is very open. The proponents take a view on the relative size of impact area to the whole and conclude relatively little impact. This may or may not be correct. Again there is limited knowledge of the system (organisms present, food chain, productivity, migrations etc.) to make any clear statements of what might occur once the barrages and turbines are in place. Experience from Canada is helpful although may be misleading given the different environmental conditions.

Dr Daborn is adamant that the proponents have underestimated the importance of the system just as they did in the seventies in the Bay of Fundy. He concludes:

However, in more than two decades of work in macrotidal estuaries on three continents I have come to the conclusion that they are all exceptionally biologically productive. I am confident that some real and intelligent research on the Doctors Creek ecosystem would show that much of its richness has been overlooked (p.9).

There is the further issue of mortality in turbines which Dr Daborn claims the proponents have underestimated in the CER. Peter Woods has indicated that knowledge from France and UK offers solutions to this problem, but without assessment of details of design by those who are experienced with such matters it is impossible to define potential impacts.

8.2 Uncertainties related to impacts on aquatic fauna (including fish, crabs, crocodiles, etc.) and birds as they may be affected by vegetation changes, as well as impacts on benthic fauna are extremely difficult to assess given current knowledge. Whether power operational procedures would overcome adverse impacts cannot be judged at this stage and would be limited in future without baseline studies.

9. OTHER UNCERTAINTIES

9.1 The workshop canvassed possible increases in mosquitoes and midges resulting from the project, and the advice was that such an effect was unlikely, given an understanding of breeding conditions. Control measures could be put in place.

9.2 Another issue relates to responsibility for the management plan of area impacted by the project given leasehold status of the area. It was indicated that the proponents will seek to be responsible only for infrastructure. What are their responsibilities over the life of the lease (any beyond)?

ATTACHMENT 3

ISSUES ASSOCIATED WITH THE DERBY *PRAWN FARM PROJECT

1. GEOHERITAGE

Points raised on the geoheritage values of eastern parts of King Sound in the vicinity of Derby, including Doctors Creek and the proposed nature reserve site, as described in my report on the tidal power project, have equal relevance to the prawn farm project. The proposed site of the prawn farm, as far as I am aware, is contiguous both with tidal creeks extending east and south of the well-studied Doctors Creek system, and the nature reserve. The linear dunes of Pleistocene age extend east to west onto (and under) the broad high-tidal flat which merges into the creek system. The complex Pleistocene/ Holocene interfingering of dunes and tidal deposits, first identified here by Fairbridge in 1961, and studied in detail by Jennings in 1975, is the only known occurrence of such and geologic-geomorphic relationship in the world. The prawn project is situated on flats where this relationship is best expressed. It is a relationship which deserves further investigation and consideration as a protected site even in terms of not permitting the use of the sands for construction materials and as sources of water.

2. TIDAL FLAT SURFACE STABILITY

Tidal flats in the Derby-Doctors Creek area have been documented by Semeniuk as undergoing erosion through bank collapse, tidal creek headward incision and surface sheet erosion. The dynamic relationship between erosion and deposition on broad surfaces marginal to the creeks requires further investigation. The likelihood of further headward extension of creeks must also be considered in terms of stability of embankments and channels feeding the ponds. More particularly, the interference of very high tidal flows ("king tides") across these flats by the embankments may stimulate new patterns of creek and surface erosion. It is uncertain as to what may be the consequences of "diverted" flows during "king tides"; for instance, could there be acceleration of creek erosion in the vicinity of Derby by those feeding West Doctors Creek?

3. GREENHOUSE IMPLICATIONS ON TIDAL FLAT CONDITIONS

As noted in the report on the power station project, sea-level rise and change in cyclonic storm patterns are uncertainties which any coastal project must take into consideration in planning. How do the proponents seek to address such uncertainties and risks?

4. EXCAVATION AND WATER QUALITY

The proposal involves shallow excavation to form the pond embankments. It is indicated that sediments from the flats are suitable for this purpose and there will be no significant geotechnical or water quality implications. The Code of Practice used for Australian Prawn Farmers suggests an appreciation of problems caused by acid sulphate soil be considered in areas where a potential threat exists. I am not convinced that the proponent has followed the advice of the Code on such matters. Stratigraphic studies by Semeniuk suggest organic-rich, reduced clays underlie these flats. These are prime materials for generating acid when oxidised as well as toxic aluminium. I strongly recommend the proponent undertake an acid sulphate soil management plan following a more detailed study of stratigraphy and geochemistry. Advice should be obtained from those expert in this field. study of stratigraphy and geochemistry. Advice should be obtained from those expert in this field.

Appendix 4

Marine Parks and Reserves Authority advice on Doctors Creek

MPRA

MARINE PARKS &
RESERVES AUTHORITY

Mr Bernard Bowen
Chairman
Environmental Protection Authority
PO Box K822
Perth WA 6842

Dear Bernard

ADVICE ON DOCTORS CREEK

You wrote to me on 24 July seeking the advice of the Marine Parks and Reserves Authority (MPRA) on the "geoheritage" value of Doctors Creek. I have since had an opportunity, myself, to fly over the coastline of King Sound, including the Doctors Creek site. With the benefit of that experience I prepared a discussion paper which was circulated to the members of the MPRA along with the background papers provided by the Environmental Protection Authority (EPA). The matter was discussed at the meeting of the MPRA on 3 September.

In short, the outcome is that the MPRA does not consider that the values of the site are "of such importance at State, national and international levels to warrant its preservation" at this time.

In reaching this conclusion, the Authority recognised that the site does have significant value in terms of its geological features and as a site of significant scientific research. These are both criteria that may qualify an area for reservation (that is, applying the IUCN reserve selection criteria and the current national and State versions of them). However, in declining to recommend reservation of the area at the present time the MPRA took account of the following factors.

1. The original Marine Parks and Reserve Selection Working Group report (the Kimberley section of which was drafted in 1986) recognised King Sound as a "distinctive coastal type" but selected the Buccaneer Archipelago as the preferred candidate area for reservation. That preference was on the ground that the archipelago (encompassing waters in the mouth of the Sound) contains a wide range of values meeting the selection criteria including high habitat diversity, high biodiversity, high scenic qualities and recreational potential, very significant cultural and historic values, and habitat for a number of threatened marine species.

   In making that selection the Working Group recognised that it did not include the turbid water, mud flat and certain types of mangrove habitats characteristic of the inner parts of the Sound. Consideration was given to Stokes Bay which has a wide range of mangal, mudflat and estuarine habitats. However, those habitat types were well represented in Walcott Inlet and other areas further north where marine reserves were recommended.

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No case was made for reservation of Doctors Creek on the basis of geological and scientific reference values. At the time that section of the report was prepared there was no geomorphologist on the Committee. (Vic Semenuik joined the group later when the Pilbara section was initiated. His King Sound papers were used as references for their utility as habitat descriptors.)

2. While acknowledging that there are no detailed biological (or geomorphological) survey data for King Sound, after a review of what is known of habitat types and reconsidering the selection criteria, the MPRA confirmed that the Buccaneer Archipelago is the best selection for a marine reserve in the area as it embraces such a wide range of values of such a high calibre.

3. The MPRA has now adopted a revised set of criteria for the identification of marine areas of value and the selection of examples for reservation that is consistent with current national and international practice. A process has been initiated for review of the Working Group recommendations applying those criteria and determining priorities for implementation. The Authority is confident that this process is technically rigorous and will take into consideration all relevant aspects including economic as well as biological, geological, social and cultural factors.

   Priority will be given to areas that embrace a number of values. Given the enormity of the task of establishing a statewide representative marine reserve system it is important that the areas chosen in the near future are those which are of the highest possible standard and that maximise the range of the "beneficial uses" that are thus protected.

   The MPRA believes that it would not be appropriate for that process to be compromised by incidental proposals for reservation that have not been subjected to rigorous assessment in a regional context unless the grounds for reservation are truly outstanding. The Authority is not convinced that the geological and scientific values of Doctors Creek are in that league.

Yours sincerely

B.R. Wilson
Chair

4 September 1998

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Appendix 5

Summary of Public Submissions and Proponent's Response

Biophysical issues:

1. *No modeling or detailed assessment is provided in the CER that justifies the claim that 2300 ha of mangroves will regenerate in 5 years. The regeneration figures are based on alteration of tides required for growth but does not refer to the need for other requirements such as nutrients, soil types, elevation, and tidal flooding requirements. Will further investigation be carried out regarding the impact of revegetating 2500 ha of mangroves and will on-ground planting of mangroves be carried out if required?*

   The CER states that "there is potentially an area of over 2,300 ha available for colonisation in the medium to long term (5 years or more)".

   Sufficient justification is provided in the CER (page 43 onwards) and its Appendix (Paling, 1997) for this area of potential recolonisation. It is believed that the calculation of 2,300 ha was a conservative figure and that more than this could regenerate/revegetate.

   Nutrients and soil types would be expected to remain constant as there is little reason to expect them to change. The regeneration areas derived were based on the tides required for growth, and elevation and tidal flooding requirements are directly related to tidal height which is why these figures were used.

   Manual or mechanical 'on-ground' planting of mangroves is not envisaged as it is expected that natural seedling colonisation will be sufficient to provide propagules. Therefore there should be little "impact of revegetating...".

2. *Natural sedimentation processes will be severely impacted. The rate of sedimentation in the ponded areas and the ocean side of the barrages is likely to significantly increase. This may lead to water quality problems from aquaculture developments in the western basin due to reduced tidal exchange and increased water clarity. Has this impact been investigated?*

   Sedimentation processes will be impacted by the proposal. The CER predicts that there will be deposition of sediment both within the creek and external to the barrages. Settlement of suspended sediments will increase water clarity and this will be beneficial to aquaculture developments. Water quality within the western (high) basin will not be influenced by the proposed prawn farm since the western basin will supply water to this development with discharge to the eastern (low) basin. Should aquaculture developments be proposed for the western arm, these will need to demonstrate as a condition of environmental approval that water quality can be maintained at a high level both within the basin and to the prawn farm.

3. *Estimated sedimentation loads have been questioned. Tests carried out by Analytical Reference Laboratory (WA) Pty Ltd indicated a sediment load of 5500 mg/L in Doctors Creek (as opposed to 363 mg/L max. in CER). Will this large discrepancy be investigated and responded to?*

   The CER states that sediment concentrations in Doctors Creek ranged between 100 mg/L and 650 mg/L under a tidal range of 9.7 m. This was based on the collection of 48 samples at 16 locations from both the west and east arms of Doctors Creek and throughout the water column. Turbidity was found to be significantly correlated with suspended sediment concentration and consequently we are confident that the calculation of suspended sediment loads was accurate on this occasion. Further samples will be collected prior to construction and this information used to assess ongoing requirements for dredging.

4. *The CER acknowledges the salinity intrusion on groundwater as a major potential impact of the proposal however does not provide any modeling of the likely impacts or outline possible remedies for the problem. Given that salinity intrusion could potentially have a devastating affect on a potential drinking water resource and phreataphytic vegetation, what further investigations regarding the potential salinity intrusion into the Derby groundwater area is planned?*

   This issue has been further investigated and the results are provided in Attachment 1.

5. *Will the proponent commit to developing a contingency plan to be implemented if groundwater intrusion into the freshwater aquifer is detected which may include remuneration to affected groundwater users?*

   The proponent has committed to investigating options to remedy any problems should the project induce adverse impacts on Derby groundwater. This may include funding for development of further bores or headworks, or provision of alternative sources of water via, say, desalination.

6. *Given that this proposal will impact on significant areas of marine flora and fauna habitats, what studies have been undertaken or are planned to ensure the natural ecology of the area is uninterrupted?*

   The existing ecology of Doctors Creek will be modified as a result of the tidal power station. Studies to date have concentrated on mangroves and birds. A comprehensive programme of investigation has been committed to and, prior to construction occurring, this programme will be implemented with the objective of describing the existing ecological system in more detail to allow changes in the ecosystem following construction of the barrages to be quantified.

7. *The loss of 1500 ha of mangroves may result in a reduction of oxygen in the sediments leading to release of nutrients from sediments and possible algal blooms. What methods are proposed to manage algal blooms?*

The primary losses of mangroves will be associated with the lack of flushing i.e. mangroves toward the landward edge of the system. These areas will be rarely underwater (no overlying water column) and consequently there is unlikely to be a release of nutrients from the sediments to drive the formation of an algal bloom.

A relatively minor area of mangroves will be submerged at the seaward edge of the system and consequently these mangroves will not pass oxygen to their roots and to the surrounding rhizosphere. It should be noted that mangrove sediments are usually anoxic and the process of root aeration is to allow firstly the roots to survive and secondly to allow aerobic nutrient cycling processes to take place (e.g. conversion of ammonium to nitrate and the disruption of certain metal chelations). It is therefore envisaged that little nutrient release will occur from the permanently submerged mangroves. Even if nutrient release were to occur, as suggested in this question, the area of permanently submerged mangroves would be very small in relation to the total area permanently inundated.

8. *The CER predicts the loss of up to 1500 ha of mangroves in the short term, with the possibility of recolonisation. How long is the 'short term' and what is the available knowledge on the regeneration of mangroves? Why is this information not presented? What will be the impact of the huge amount of decomposing mangrove material on the environment?*

The term "recolonisation" is misleading because the process will be a colonising one. "Recolonisation" implies that mangroves will return to an area previously containing mangroves.

In the CER, "short term" refers to the death of mangroves over approximately five years with colonisation expected to start to take place almost immediately (in regard to seedling settlement). Seedling growth to maturity would take approximately ten years. This is based on evidence presented in Paling (1997) which included a review of historical aerial photographs of the area. This report also presents all of the available data on mangrove regeneration for this area. Only a summary of this information is presented in the CER.

Mangrove parts decompose at varying rates. Leaves are shed first and may persist in the environment for anywhere between 100 and 300 days depending on the availability of grazers, mechanical abrasion and the activity of microorganisms. Mangrove wood is very persistent and may take decades to decompose (e.g. Dampier Salt, Port Hedland and areas at the most landward areas of Doctors Creek and other creeks within King Sound). The primary concern for this issue is the potential initial influx of leaves into the system from the eastern arm of Doctors Creek. As can be observed on outgoing spring tides at present, particularly after storms (e.g. Paling, 1986), a large amount of leaf material is exported from the system. It is this source of carbon, nitrogen and phosphorus that is believed to support other offshore processes (e.g. fisheries). Given that the eastern arm will not be inundated to the level of a spring tide the leaves may remain in the system and not be covered by tidal water. i.e. they may decompose dry, which would be a slow process. In

this instance there would not be a massive influx of material. If all of the leaf material were to find its way to the eastern arm, it is expected that it would be exported into King Sound. Any leaves that remain in the system would decompose at a relatively slow rate.

9. *How will the potential change in water quality impact mangrove colonies (established and regrowth areas) and fish populations?*

   Potential changes in water quality would occur mostly in the western arm. It is expected that the water will become much clearer as well as persisting for longer periods around the base of the mangrove roots. This implies that fish will be more protected than they are at present, however, predators would also be able to see their prey more clearly.

   Examples from other areas of impounded water along this coast (e.g. Port Hedland) have shown little change in mangrove growth as long as salinity levels have remained nominally the same as the original conditions.

10. *Concern has been raised over the sediments at the mouth of Doctors Creek and although the following questions are not directly related to environmental impacts they may render the project uneconomic:*
    - *Can the sediments support the weight of the structure?*
    - *Are the sediments uniform enough and dense enough to ensure piping (flow of water through the patched or porous sediments) will not occur?*
    - *If this information has been gathered will it be made publicly available?*

    An extensive test drilling program is being undertaken to assess the geology of the infrastructure site. Once testing and analysis of this work is complete a suitable structural design for the infrastructure will be developed to meet the design life requirement of 120 years.

    Testing will determine whether sediments are uniform and dense enough in structure to ensure that piping does not occur. If it is found that piping may be a problem then design solutions are available to prevent piping.

    Soil structure results can be made publicly available.

11. *Given the information available on the impacts on fish from the Bay of Fundy research and monitoring, how will similar impacts (injury and mortality) on fish be managed in this proposal?*

    Fish injury and mortality from the Bay of Fundy tidal power station is due to the passage of large fish through the turbines. At Doctors Creek mesh or other suitable exclusion devices will be installed to prevent larger fish from entering the turbines.

12. *The CER has not assessed the regional significance of the mangroves, has failed to provide a model of the likely mangrove response, and has not even provided contour maps of the area. Will this information and assessment be carried out?*

The CER does assess the regional significance of the mangroves in terms of area. Paling (1997) assesses it also in terms of species distribution patterns and zonation. A model of the likely mangrove response is provided in the CER (page 43 onwards) and also in Paling (1997). Extensive contour maps were produced of the area in the process of determining this response (see Paling, 1997) but it was not felt necessary to produce contour maps in the CER document.

13. *The CER gives little information about the current turbidity of the water, and there is an expectation that this will decrease with the construction of the tidal power station. However, given that "predictions of sediment behaviour tend to be of low accuracy because of deposition and resuspension of sediment are not well understood" (Seymour, 1992), there is no certainty that levels will drop sufficiently to cause the improvements in biological productivity that are proposed. Nor is there any certainty as to the development of new mud flats that will provide sites for re-colonisation of mangroves. What research/studies were used to make these predictions and how accurate are they likely to be?*

Observations made during the field work demonstrate that water clarity increases at slack water due to the settling of suspended sediments. Once current velocities increase turbidity levels again rise as sediments are remixed through the water column.

In the high basin turbulent mixing will be confined to an area adjacent to the barrage. Outside of this zone current velocities will be substantially reduced resulting in the settling of sediments. Water clarity over a large proportion of the high basin will therefore increase resulting in an increase in the euphotic zone and consequently in pelagic primary production. The extent to which water clarity improves will be dependent on a number of factors including wind speed, wind direction, water depth and particle size.

Sedimentation will certainly occur at the mouth of Doctors Creek due to reduced current velocities in this region. The speed and extent of mud flat formation cannot be determined at this stage.

14. *Concern has been raised about the potential for large areas of mud flats (about 100 sq. km) around the eastern creek, that will no longer be inundated, to become a 'dust bowl'. How will this be managed?*

Derby is separated from the eastern arm of Doctors Creek by a minimum of 3 km. It is unlikely that dust will be a problem. Nonetheless, the proponent will assist the Shire in developing a management plan for the tidal flats. This will address issues including public use of the area to minimise disturbance to the protective crust overlying the mudflats

15. *What assurances can the proponent provide that, upon decommissioning, the area can be rehabilitated?*

Refer to CER document section 5.11 Decommissioning. The design life of the infrastructure is 120 years and as such a significant monetary investment will be made by the company in building the power station.

The environment and public use of the Creeks is expected to be enhanced once the Tidal Power Station is in operation. Decommissioning of the plant after a lifetime of operation will in itself cause environmental change. There may be a balance of advantage in retaining the civil structures and any decommissioning would be done in consultation with the relevant Government Departments and the people and organisations that will be affected.

16. *Will the barrages be removed on decommissioning of the project?*

Refer to Question 15.

17. *Given the fragile environment of Point Torment, have alternative sites for sourcing building materials been considered?*

The proponent does not consider that Point Torment is a fragile environment. Alternative sites have been investigated for sourcing building materials, including the use of existing quarries. Although further work is proposed, it would appear that at this stage the Point Torment peninsula offers the best opportunity to source this material.

18. *How will the rock armour proposed from the seaward side of the barrages be placed, and over what length of coastline will rock armour protection be required?*

Rock armour will be placed on the seaward side of the barrages by means of end tipping and placement by crane. No coastline will require rock armour.

19. *Given the tidal range at this location, what vertical height of shoreline will require protection with rock armouring?*

Refer to Figure 5.3 in the CER.

20. *What monitoring and mitigation methods are proposed for the shoreline in the vicinity of the barrages should "significant" erosion occur?*

Refer to page 70 of the CER. Monitoring and mitigation measures are necessary to protect the integrity of the civil structures to safeguard the continuation of power generation. An annual maintenance budget will be provided for this type of work. Monitoring will be conducted through visual inspections.

21. *What baseline data will be collected for water quality monitoring and what criteria (nutrients, salinity, suspended solids etc.) will be deemed "acceptable"?*

Baseline data including salinity, temperature, turbidity, suspended sediments, dissolved oxygen and chlorophyll *a* will be collected prior to construction and on a regular basis post-construction. The frequency of monitoring, monitoring locations and the criteria that will be applied will be determined in consultation with the DEP.

22. *Are acid sulphate soils present in the area and if so how does the proponent intend to manage them, especially during construction?*

Acid sulphate soils are not known to occur in the area. The proponent is aware of the issues relating to the integrity of concrete structures in acid sulphate soils and soil analysis will be conducted prior to construction.

23. *Two species were identified in the 'rare and declared flora' section of the CER. What is the schedule of these species and how will the habitat be avoided?*

Nymphoides beaglensis is a Priority 2 species. A single specimen was recorded from a swamp on the transmission line alignment. The transmission line can be designed to span this area.

Bruguiera parviflora is not "rare or declared". However it is only known from a few locations due probably to its cryptic nature. The single specimen known to occurr within Doctors Creek will be lost as a result of the project.

24. *Will the proponent commit to planting new mangroves and samphire areas suitable for recolonisation?*

The proponent does not propose to plant mangroves and samphires. The objective of rehabilitation will be to create habitat which is suitable for recolonisation. If this is done successfully the area will be colonised naturally.

25. *Concern has been raised that the fauna surveys undertaken were not sufficient to adequately identify fauna and avifauna (especially migratory birds) that will be impacted by the proposal. How does the proponent respond to this concern and will further fauna surveys be undertaken?*

Bird surveys were conducted on two occasions, once by the Broome Bird Observatory. Commitment 4 in the CER lists the monitoring that will be undertaken. Baseline (pre-construction) surveys will be undertaken and data will be collected against which changes can be quantified.

26. *Incoming tides over 8 metres or 4 metres AHD will have increased lateral flow across the western arm due to restriction of flow up Doctors Creek West caused by the sluice gates in the western barrage (+7m) and the height of the northern end of the western land arm (figures provided on request). Over time this flow could lead to the development of a new channel being formed in the mud of the southern end of the western land arm and significant erosion impacts on the mangrove and samphire understorey systems already there. This would also inhibit recolonisation. How would this be managed to ensure mangrove regeneration and bank stabilisation?*

    The supplied spot height data has limits of accuracy of +/- 0.35 m. Further investigation shows that in fact very few tides will cross the western land arm into the west creek. Somewhere in the order of 30% of total number of tides will overtop this land. The west creek will have a slightly reduced water level than the natural tidal height due to friction of the water passing the sluice gates. Any overtopping of the western land arm will result in water flowing in one direction into the creek rather than both ways as presently occurs. Therefore it is expected that erosion impacts will be decreased from the present situation. This location will be carefully monitored for possible erosion.

27. *How will the 225 ha of vegetation affected by the transmission line alignment be rehabilitated? What measures will be put in place to ensure that over clearing does not occur and habitat trees are retained? Will the proponent liaise with CALM prior to finalisation of detailed route maps to ensure environmental impacts are minimised?*

    Clearing will be restricted to those areas necessary to allow construction and the ongoing safe operation and maintenance of the transmission line. Disturbed areas which are not required to remain cleared following commissioning will be rehabilitated. This will involve the removal of any waste material followed by ripping and grading of compacted areas. Areas disturbed will be relatively small and consequently revegetation is expected to occur naturally. If required supplementary planting or seeding will be undertaken on advise from CALM. Wherever possible habitat trees will be retained and, in accordance with Shire policy, boab trees will be protected.

28. *Can the proponent provide a detailed locality map showing the preferred location of the proposed transmission line alignment in relation to the Derby Tidal Power site? This should be linked to reference points such as the townsites of Derby, Broome, Fitzroy Crossing, and the Great Northern Highway.*

    Refer to Figure 6.3 in the CER and accompanying map (Attachment 2). A detailed plan will be available as a result of consultation with MRD and DOLA.

29. *Dolphins, turtles and dugongs use the creeks during the wet. Will they be removed from the project area to be able to continue migration?*

    Dolphins, turtles and dugongs will still be able to move between Doctors Creek and King Sound. CALM's advice will be sought on the need to manage these species.

30. *How will the proposed borrow pits from Point Torment impact on the mining leases for mineral sands?*

Any impacts on Point torment will be limited to shallow borrow pits.

31. *If the residency time of the tidal water is increased how then is the 'extent and duration of inundation of the tidal flats close to the peninsula decreased?*

The residency time of water within the western arm of Doctors Creek will increase. However, due to the restriction of water inflow via the sluice gates the maximum tidal height reached and consequently the extent of tidal penetration across the tidal flats will be reduced.

32. *There needs to be a clear indication that the hydrology of the proposed nature reserve will not be adversely affected by the development. Will the reduction in the inland extent of spring tides alter significantly the vegetation of the nature reserve?*

The vegetation of the proposed nature reserve is not reliant on seawater for its survival. A reduction in the extent of tidal waters will not impact this vegetation.

33. *Will the environmental monitoring programme include the impact of dredging on the development of benthic communities and the ability of fish species to traverse the sluice gates and turbines?*

Yes.

34. *Can the proponent provide an outline of the mitigation measures to be included in the Environmental Management Programme that will address issues such as groundwater pollution, increased sedimentation, salinity/stratification, excessive mangrove losses, lack of fish migration and nutrient input? This will provide assurances that the EMP can provide an adequate mechanism for protection of the environment.*

Groundwater - refer Question 4.

Sedimentation - sedimentation within the basins will be controlled by ongoing dredging. Sedimentation external to the barrages will occur until a new equilibrium is reached. This will likely be monitored from aerial photography.

Salinity/stratification - the sluice gates can be manipulated to increase water exchange and hence control any potential increase in salinity or break down stratification by increasing mixing.

Excessive mangrove loss - it is believed that the CER provides an accurate estimate of the potential loss of mangroves.

Fish migration - the sluice gates can be manipulated to increase water exchange and hence fish ingress/egress.

Nutrient input - as per salinity/stratification. Also refer to Questions 7 and 8.

35. *Can the proponent provide details of which authorities / agencies will be responsible for ensuring mitigation measures are carried out?*

Mitigation will be to the satisfaction of the Minister for the Environment on advise from the DEP.

36. *Is the proponent intending to develop contingency plans for issues such as excessive groundwater pollution, erosion, corrosion to marine structures and equipment, little or no mangrove regeneration, power transmission line destruction by cyclones, barrage collapse or lack of fish and bird breeding within the creek system?*

Groundwater, mangroves, fish - refer Question 34.

Erosion - erosion will be monitored and corrective action taken should this prove to be excessive. This could include additional placement of rock armour or rip-rap, construction of berms etc.

Corrosion of marine structures and equipment - design criteria will be included in the specifications provided to the suppliers of equipment.

Power transmission line destruction by cyclones - cyclone protection will be provided in areas specified as cyclone prone. Should a section of the transmission line be destroyed, this section will be repaired.

Barrage collapse - civil specifications will nominate a minimum design life of 120 years.

Bird breeding - this is related to re-establishment of suitable vegetation which is one of the primary objectives of the Programme of Research, Monitoring and Management (Commitments 3 and 4). Refer also to Question 24.

37. *Where is the dredge spoil to be disposed of and what are the potential environmental impacts?*

Section 5.4 of the CER outlines the options available for dredge spoil disposal. The option of in-creek disposal will have an environmental benefit by providing additional area for mangrove colonisation. Spoil resuspension and discharge to King Sound will allow the sediment cycle to be completed and will assist in the development of banks at the entrance to Doctors Creek for mangrove colonisation. Disposal to land is the least preferred option.

38. *Doctor's Creek has been described as of International and heritage significance due to:*
    - *its setting as a macrotidal tropical semi-arid mangrove coast;*
    - *its erosional patterns;*
    - *its tide-dominated deltaic estuarine setting; and*
    - *the fractal laboratory therein.*

- *How have these issues been addressed in the management of the potential impacts from this proposal?*

Although Doctors Creek may have "been described as of International and Heritage significance..." the most recent (December 1997) listing of World Heritage areas describes those in Australia as the following 13:

1981 Great Barrier Reef
1981 Kakadu National Park
1981 Willandra Lakes Region
1982 Tasmanian Wilderness
1982 Lord Howe Island Group
1987 Uluru-Kata Tjuta National Park
1987 Central Eastern Rainforest Reserves (Australia)
1988 Wet Tropics of Queensland
1991 Shark Bay, Western Australia
1992 Fraser Island
1994 Australian Fossil Mammal Sites (Riversleigh/Naracoorte)
1997 Heard and McDonald Islands
1997 Macquarie Island

(source http://www.unesco.org/whc/heritage.htm, Update: 4 December 1997; access date 1 February, 1998)

No mention is made of Doctors Creek. However each component of this issue is discussed below

"its setting as a macrotidal tropical semi arid mangrove coast"
According to Semenuik et al., (1978) The boundary of the 'tropical semi-arid' and 'tropical sub-humid' biogeographic zones occurs at Derby. Other authors however differ on the location of biogeographic zones in general (e.g. Bridgewater, 1985). These zones cover a vast area (over 5 degrees of latitude). Mangroves are distributed along this coast. It seems curious to single out Doctors Creek as representative of this category when much better developed mangals occur within King Sound and along the coast in either direction.

"its erosional patterns"
The erosional patterns in Doctors Creek also occur in salt flat and mangrove creek systems to the east of Derby. There is adequate representation of this type of erosional pattern elsewhere and it is not unique.

"its tide-dominated deltaic estuarine setting"
Although Doctors Creek is a tide-dominated deltaic estuarine setting it is not unique in this area or along the coastline. Semenuik (1986) notes that "some geomorphic units can make an appearance at a number of different scales" but goes on further to describe delta lands as occurring in the regional scale (Table 2, Semenuik 1986). His example of this is the DeGrey River delta as opposed to Doctors Creek. It can be further noted that in his study of King Sound, work was concentrated in a system on the western side of King Sound rather than Doctors Creek. Further research either on Doctors Creek specifically,

or in general terms, has not commonly referred to it by the above terminology (Semenuik, 1980; 1981; 1985). Deltaic estuarine systems do however occur in other areas of the Kimberley (e.g. Thom et al., 1975).

"the fractal laboratory contained therein"
The term 'fractal' refers to a repeated geological pattern and in geomorphological terms it is likened to creek systems, submerged valleys etc. (i.e. anything with a repeating pattern). In that case all of the environments in this area (including most of the salt flats in King Sound) and particularly in creeks east of Doctors Creek also provide a "fractal laboratory".

39. *Has the proponent developed a map of the topographic contours of the area? If not how has the prediction of possible recolonisation been accurately carried out?*

Topographic contours of the area have been developed which assisted in determining the potential extent of mangrove recolonisation. The +3 m AHD and +4.1 m AHD contours are shown in Figure 6.8 for the high basin.

40. *If no study of the tidal zone groundwater system has been undertaken, how can valid predictions on the effects of the project on the groundwater bodies and the ecosystems sustained/maintained by this groundwater be made?*

All groundwater data available have been used. However, all studies usually only indicate the zone of mangrove occurrence on a large scale, as opposed to species distribution patterns at finer scales. This is discussed quite extensively in Paling (1997). Groundwater in mangrove systems does determine mangrove distribution and these properties vary over the neap to spring cycles (e.g. Ridd, 1997). The integration of these over time is what determines species patterns and health (e.g. temporary defoliation at higher elevations, Paling 1996). Tidal inundation, its frequency and time are paramount to determining the groundwater salinity and this can thus be modeled as a surrogate by tidal inundation which is what has been carried out for this CER.

41. *How will the tidal resonance in King Sound be impacted by the proposal?*

Section 6.4.2.2 identifies that King Sound tidal resonance will not be affected.

42. *How will the sedimentation/scouring patterns of the estuary or the planned basins be altered?*

This is described in Section 6.5 of the CER.

43. *How will the groundwater hydrology, which will affect both upwelling of fresh water within the estuary and the fresh/salt water interface upgradient of the proposed project area, be impacted by the implementation of this proposal?*

Offshore upwelling is not expected to be impacted. Impacts on the fresh/saltwater interface are discussed under Question 4.

44. *In the report by Paling (1997) "Mangrove Assemblages in Doctors Creek, Derby, Their Regional Significance and the Potential Impacts of a Tidal Power Station", it is noted that Doctors Creek mangroves account for 7 % of the King Sound mangroves. It is also noted that most of the King Sound mangroves are "Type 1" and "Type 2" communities, whereas the Doctors Creek mangroves are "Type 3". What percentage of King Sound's "Type 3" mangrove community occur in Doctors Creek?*

Approximately 7 to 10% of the "Type 3" (as defined by Paling 1997) communities occurring in King Sound occur in Doctors Creek. There are extensive Type 3 communities westward around Goodenough and Disaster Bays, Airport Creek below Derby, the south-west area of Stokes Bay and very extensive stands on the north east part of King Sound (adjacent to the Defence reserve land). These areas were categorised originally but not placed onto a map for the CER purposes due to a desire to maintain clarity.

45. *The species associations identified in Areas 2 and 6 (p. 36, Table 10, Paling 1997) are found not to occur outside Doctors Creek. Given that these areas are "expected to be lost" (CER, Figs. 6.4, 6.5 and 6.8) what measures will be taken to protect or replace these communities of international interest?*

Area 6 (less than 5 m high Avicennia trees with a samphire understorey is very common throughout the entire region. It would certainly not be considered of international interest or a rare association.

Area 2 (Ceriops-dominated) is much less common. There were 38.3 ha noted in Doctors Creek in approximately three major stands. This association was not observed elsewhere in King Sound. Although this association cannot be regarded as being of "international interest", it may be lost to this system. Detailed monitoring would take place in these areas to determine firstly that loss was occurring (the CER uses the term "probable loss") and secondly possible methods of regeneration.

46. *How will the proponent ensure that the colonising mangrove communities will represent the degree of diversity currently existing in Doctors Creek? Will the proponent undertake to ensure not only abundance but diversity of mangrove communities will be replaced (by direct planting if necessary)?*

Given that the seeds for colonisation will come from trees within and around the Doctors Creek system it is expected that the genetic diversity of the system will be preserved, very probably better than if mangroves were manually transplanted. Direct planting is not proposed.

47. *What will be the impacts of the altered tidal regime on the marsh shoreline? Where will the shoreline be in 10 years or 20 years and what will be the impact on the foreshore vegetation?*

Upstream of the barrages the shoreline is not expected to significantly change due to a reduction in current velocities. Operation of a river dredge in both basins will ensure that excess sediment is regularly removed. Sediment banks are expected to form at the entrance to Doctors Creek, however the rate at which they will develop has not been determined. The project is expected to have minimal impact outside of the immediate area of Doctors Creek.

48. *Will the predicted net increase of benthic invertebrates be accessible to shorebirds?*

Any increase in benthic invertebrates in the intertidal and shallow creek areas will be accessible to shorebirds.

49. *What is the expected impact on the nationally important populations of Terek and Common Sandpipers?*

Impacts on these two species are discussed in Section 6.9.2.2 of the CER.

Pollution management issues:

50. *Has the option of using underground power lines been seriously considered to reduce the visual impact of transmission lines?*

Research is continuing into the use of high voltage direct current as a transmission option. It is possible that the section of 33kV line that passes through the Derby townsite may be placed underground.

51. *What method of sewage treatment is proposed and what is the "acceptable standard" of treatment referred to in the CER?*

Sewage will be either removed by a licensed contractor or treated prior to disposal on-site. Options for treatment and on-site disposal will be discussed with the Health Department and DEP.

52. *Should the prawn farm proposed for the mud flats of Doctors Creek proceed, what are the potential implications for the impacts predicted for the tidal power station?*

The prawn farm is not predicted to contribute to the impacts predicted for the tidal power station.

Social surroundings issues:

53. *Will the proponent commit to developing a monitoring and management plan to cater for the "huge increase" in recreational fishers?*

For safety reasons, access by the public will be controlled in areas adjacent to the barrages and turbine channel. It is not proposed to formally manage recreational fishers.

It is envisioned that the State in conjunction with Derby Hydro Power and the local Shire will develop a monitoring and management plan for the use of the larger portion of the tidal flat. Derby Hydro Power will have a lease over a small fraction of the tidal flat area and as such will have a specific obligation over this area.

54. *How will construction noise be managed to minimise disruption to residents?*

All noise emissions will comply with the latest noise regulations recognising the proponents obligations under the *Environmental Protection* Act 1986.

55. *Will the proponent commit to retaining a 500 m buffer of remnant vegetation between the power lines and residential areas to help alleviate any potential health problems and reduce visual impact?*

No.

56. *CALM will not give an undertaking to guarantee the safety of the public with respect to the likely presence of crocodiles in this area. Will the proponent commit to ensuring the public is aware of the dangers from crocodiles and provide funds for the removal of 'problem' crocodiles from the area?*

Derby Hydro Power will have a responsibility to guarantee public safety in the area of land and water that it holds a lease over. The issues of public safety on the State reserve land would become a State issue.

57. *Has there been an assessment of the national estate values of the region (i.e. places that may be included in the Register of the National Estate) and how they are likely to be affected?*

No.

58. *Comment should be sought from the Australian Heritage Commission of Environment Australia on the archaeological and ethnographical reports being conducted.*

Why? Extensive consultation has occurred to date with local aboriginals. Formal ethnographic and archaeological studies have been conducted under the guidance of the Kimberley Land Council. Consultation with Environment Australia is not proposed or required.

59. *What consultation has been undertaken by the proponent with Aboriginal groups of the area and what has been the outcome of those discussions?*

Extensive consultation has been carried our with Aboriginal groups in the area. (refer to Section 7.5 Community Consultation in the CER). Groups consulted include the Kimberley Land Council, Commission of Elders, Aboriginal Affairs Department and the Kamali Land Council. Aboriginal groups have been fully supportive of the project.

60. *What studies have been undertaken of the recreational uses of the marsh and how will they be impacted by the proposal?*

Recreational use of Doctors Creek is described in Section 7.1.3, based on discussions with local residents. The tidal power station is expected to have a positive effect on recreation through an increase in accessibility and water based recreation.

61. *Advice from a research scientist from the Department of Biological Sciences at Northern Territory University states that Culicides ornatus usually occurs in its greatest numbers for approximately 1 to 1.5 km from mangroves, although it has been recorded at 3.5 km from mangroves. This clearly puts Derby within the midge flight path. Given that the reduced water flow in both creeks would increase the midge breeding habitat, how will the proponent manage the potential increase in midges in Derby?*

The information provided in Sections 6.9.1.4 and 6.9.2.5 of the CER on midges was reviewed by the Medical Entomology Section of the Health Department of WA. Their advice is that there is unlikely to be a significant increase in midge numbers in Derby.

Other issues:

62. *Has a cost-benefit analysis been undertaken to compare the construction of a tidal power station against a gas powered station?*

An examination has been made into the option of a gas fired power station at Broome. The conclusions drawn from this work confirm that the tidal power plant is likely to provide electricity at the lowest overall cost.

63. *Has the proponent investigated the possibility of using alternative energy / design systems such as free stream turbines mounted under moored pontoons to harness part of the tidal energy or solar power generation?*

Testing of moored tidal stream power generation has been conducted off the Northern Territory coast. The prototype has small outputs and would not produce continuous electricity supply in tidal locations such as Derby. Solar power on this scale is uneconomic.

64. *Concern has been expressed that there is no evidence of 'macroeconomic planning' having played a role in considering the economic viability of the project. Given the comments made by Wood et al. (1992) "the strongest doubt for such developments exists in the unknown future power demand in the region. For this macroeconomic planning will have a vital role to play", how has the assessment of long-term economic viability of the project been conducted?*

Remoteness from major centres of energy consumption has been the principle reason why the vast tidal energy resources of the Kimberley coastline have not yet been exploited.

In 1991 the WA Parliamentary Select Committee on "Energy and the Processing of Resources" examined at the macro-economic scale the potential for harvesting the Kimberley tidal energy. The Committee's report (Legislative Assembly of WA, 1991) reviewed earlier work by Lewis (1962) which indicated that the Kimberley tidal resource could readily meet the whole of Australia's electricity requirements.

The Select Committee inspected tidal power stations in Europe and North America and reviewed latest research effort. In examining macro-economic issues it reviewed alternative methods of transporting energy over large distances. These included high voltage direct current transmission (HVDC) and the conversion of tidal power to hydrogen gas through electrolysis. The hydrogen gas could then be blended with natural gas and transported by pipeline to centres of population, or liquefied for export. Some of these issues were taken up in a paper presented to the Institute of Engineers in the U.K (Wood et al., 1992).

Following the publication of the Select Committee's report in 1992, discussion with the Committee's Chairman and various technical experts suggested that development of tidal energy at the macro scale was premature. It was agreed however that a demonstration - scale plant of say 20 MW should be built to demonstrate the technology and to monitor environmental impacts. Subsequently a research study into potential sites for a demonstration project was published and this ultimately resulted in the selection of Doctors Creek Derby (Wood, 1993).

65. *The CER states that one benefit is 'the removal of the financial burden on Western Power to provide subsidised energy to remote areas'. Where is the information on costing, on financing the project, or on present subsidies, to support this statement?*

Western Power Corporation implements State Government policies with regard to uniform tariff levels for small customers statewide. This means that in remote areas the cost of generation from isolated diesel plant (as in the case in Broome, Derby and Fitzroy Crossing) is much higher than the tariff level for retail sales. Information on the actual generating costs in remote centres is not published by Western Power Corporation. However, the 1997 Annual Report indicates an operating loss of 44 million dollars for Regional Power (which includes Derby, Broome and Fitzroy Crossing) in the 1996 /97 financial year.

Confidential discussions between Western Power Corporation and Derby Hydro Power Pty Ltd on the power purchase agreement will provide contractually guaranteed tariff levels giving savings to Regional Power's operational costs.

66. *Will the proponent be willing to lodge a sufficient bond (or similar) to finance decommissioning and rehabilitation should the project become unviable?*

No.

67. *Concern was raised over the lack of detail on the construction techniques and methods. Can the proponent provide respond to the following questions on construction impacts:*

68. *How will the construction site be isolated from the waters of King Sound?*

It is unlikely that the construction site will be isolated from King Sound. The proponent is committed to ensuring that environmental impacts are minimised and this requires that Doctors Creek does not become excessively isolated. Subject to detailed engineering design, closure of the barrages will likely be effected once the sluice gates are operational. Levees constructed adjacent to the barrages will prevent the overland migration of water.

69. *How will the foundations for the barrages be prepared?*

This will be determined following further geotechnical investigation and detailed design.

70. *What indication is there that the levees can resist the lateral thrust from the stored water?*

Levees have been constructed elsewhere on tidal flats (e.g. Onslow, Dampier, Port Hedland). Similar techniques will be used in this instance.

71. *What is the proposed sequence of construction?*

This will be finalised during the detailed design phase of the project. It is likely that the access road will be constructed first followed by general activity associated with the barrages and levees.

72. *How will the construction materials be delivered to the site?*

By truck and possibly barge.

73. *Given the nature of the marine sediments, how long will it take to dewater the various construction sites, for example, the turbine channel?*

Further investigation is required before this question can be answered.

74. *Given the construction material for the levee banks will be sourced from the tidal flats or the peninsula, what will be the approximate size of the borrow pits and the depth of the pits?*

Borrow pit size is subject to further investigation.

75. *Where will they be located?*

An area of prospective source material has been identified on the peninsula. Further work is required to define the exact location of the pits in this area. The proponent has committed to referring any new borrow pits to the DEP.

76. *What are the material characteristics that indicate the tidal flat soils are suitable for levee construction?*

All of the major salt fields in WA have been built on tidal flat soils and geotechnical investigations have indicated that the soils at Derby will be capable of supporting the access road and levee embankments. As local examples, the Derby Jetty causeway and the airport are both built on tidal flats.

77. *What is the groundwater regime at this location?*

Groundwater in proximity to the leeves is hypersaline. Depth is unknown.

78. *Will extraction at such a site have an impact on the groundwater hydrology of the tidal flats and therefore a potential impact on the Derby water supply?*

No.

79. *If such an excavation is not 'rehabilitated', it can be assumed that the excavation will pond water either from seepage or rainfall runoff, or both. Accordingly, will such as excavation result in an increase in mosquito breeding areas with an associated increase in potential impact on the residents of Derby?*

Any excavation on the tidal flats will be left in a free draining state. There will be no increase in mosquito numbers.

80. *Will direct access be provided by an access track across the tidal flat, or will access be provided around the tidal flat via Derby? The former has the potential to impact on the hydrology of the flat and the latter has the potential to impact on the residents of Derby in terms of safety, noise, and potential damage to roads.*

Direct access will be provided by an access track originating from Derby. Culverts will be installed to maintain satisfactory inflow and outflow of water.

81. *Will the proponent commit to remove roads and other infrastructure not required after construction?*

Yes, in consultation with the Shire.

82. *What is the nature of the sediments in the low basin and are they amenable to dredging?*

Sediments are mud, silt and clay with some areas of coarse yellow sand. These are amenable to dredging.

83. *What type of dredging operation is anticipated?*

A small river dredge will be permanently deployed in the basins.

84. *How will selective placement of dredged material be achieved?*

The placement of dredged material will be effected by guiding the discharge pipe on the dredge to areas where fill material is required.

85. *As no details of the environmental impacts of powerline construction are provided, will the environmental management program be divided into a construction phase and an operational phase to detail the potential impacts and their management?*

Yes.

86. *Given that the King Sound area is a net erosional situation (Semeniuk, 1980), how can the structural integrity of the barrages, canal walls and levees be guaranteed for the projected life of the project.*

A comparison between aerial photographs taken in 1949 and 1997 shows the following:

- Christine Point is eroding at around 1 m per year;
- the point between the two arms of Doctors Creek shows erosion on the western side (~ 1 m/yr) with stability on the eastern side; and
- the area to the north-east of Doctors Creek is eroding at between 2 - 2.5 m per year.

None of these erosion rates will affect the integrity of the barrages over the design life of the project. In addition, with a projected build up of sediment seaward of the barrages, erosion is likely to substantially reduce and could possibly be reversed.

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Attachment 1

Rockwater
PROPRIETARY LIMITED

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P.O. BOX 237, SUBIACO, WESTERN AUSTRALIA 6008.
TELEPHONE: (09) 382 4922 A.C.N. 008 804 653
INTERNATIONAL: 619 382 4922
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011/15.12

11 February 1998

Mr I McCardle
Manager Environmental Sciences
Halpern Glick Maunsell
Level 1, Western End
John Tonkin Centre
LEEDERVILLE WA 6007

Dear Mr McCardle

Re: Derby Groundwater Issues

As requested, we have considered the potential impacts of retaining seawater in Doctors Creek West Branch for the tidal power station, on groundwater beneath the Derby peninsula that is utilised for the town water supply, and for a number of private water supplies.

Most bores are 30 to 40 m deep, and intersect fresh groundwater contained within the Wallal Sandstone and the upper part of the underlying Erskine Sandstone. There are also several bores that were drilled to between 243 and 356 m depth that draw water from the lower part of the Erskine Sandstone.

A groundwater mound occurs beneath the Derby peninsula. Around the edges of the mound the fresh groundwater rests on a saltwater interface which extends into the Wallal Sandstone and upper part of the Erskine Sandstone. A number of bores located above or near the interface have become saline after being pumped at high rates or for extended periods. These bores include Derby TWS Nos. 3, 8 and 9, Derby Shire oval bore, and Lytton Park bore: many of these are near the end, or are on the northern side of the peninsula.

A second, deep, saltwater interface occurs near the base of the Erskine Sandstone at about -300 m AHD and was intersected by a deep monitoring bore (2/88) located near the northern edge of the peninsula.

The possibility has been raised that retaining seawater in Doctors Creek West Branch ("High Basin") could cause the saltwater interfaces to move inland beneath the peninsula. This possibility is discussed below.

The tidal power project will result in seawater being retained permanently in the High Basin, with levels at high tide ranging from 3.2 m to 4.0 m AHD, and at low tide from 1.6 m to 3.2 m AHD. At present, the High Basin is dry at low tide, and water levels range from 2.84 m to 4.79 m at high tide. With the bed of the High Basin at an elevation of about -0.5 to 1.5 m AHD adjacent to the Derby peninsula, the rise in average water level in the High Basin will be about two metres.

The position of a saltwater interface in a homogeneous sand aquifer is controlled by the height of the water table above sea level in the area of groundwater discharge around the coast. Groundwater extraction causes a local reduction in the water table elevation and consequently the interface moves upwards and inland. Theoretically, raising seawater levels in the High Basin could also cause the saltwater interfaces to move up and inland because of the small increase in seawater levels.

Upper Saltwater Interface

In our opinion, any change to the position of the saltwater interface in the Wallal Sandstone/Erskine Sandstone that might arise from the change in seawater levels in the High Basin will be very small and probably undetectable, because:

1. The High Basin is underlain by estuarine muds of low permeability.

2. There is likely to be a shale aquiclude (the Munkayarra Shale) present between the Wallal Sandstone and Erskine Sandstone beneath the High Basin (the shale has been completely eroded away beneath the Derby peninsula, which is on an anticlinal crest).

3. The presence of the low-permeability estuarine muds and Munkayarra Shale mean that there is probably little or no natural groundwater discharge to the High Basin, and that any rise in heads induced in aquifers underlying the basin will be attenuated and not directly affect the fresh groundwater flow system.

4. The High Basin is 0.5 to 2 km north of the northern margin of the peninsula, in areas subject to tidal inundation, beyond the groundwater discharge area. Much of the natural discharge from the Wallal/Erskine aquifer beneath the peninsula is interpreted from the position of springs to occur around the margins of the peninsula.

Lower Saltwater Interface

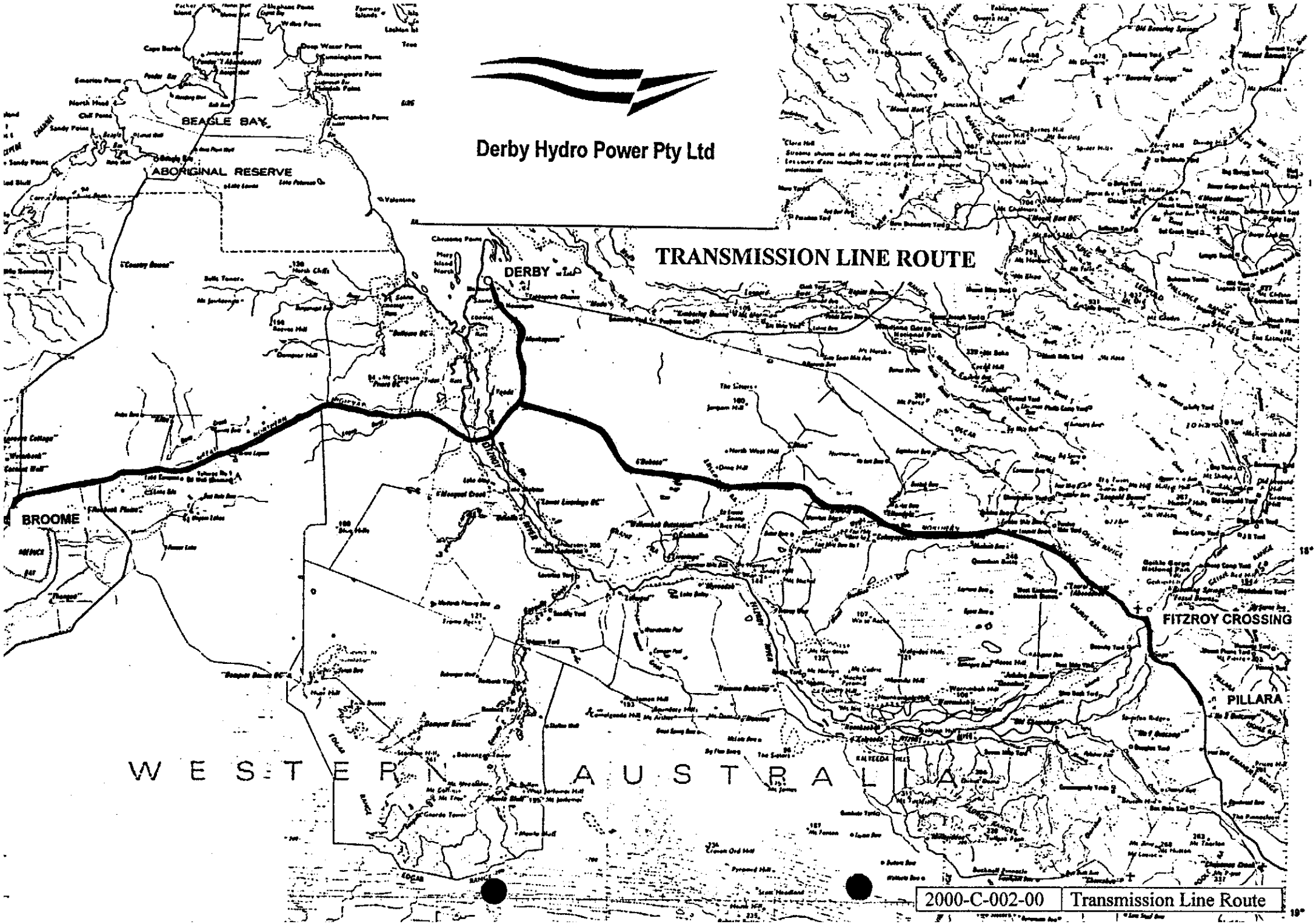
We consider that there is no possibility that the saltwater interface in the lower part of the Erskine Sandstone could be affected by the project, because discharge from that part of the formation probably occurs off-shore in King Sound. Also the Munkayarra Shale and shale beds within the Erskine Sandstone form effective confining layers.

It is recommended that a nest of two monitoring bores be installed on the northern side of the peninsula at about 571100 m E, 8085100 m N for monitoring salinity profiles before and after the project has been completed. Bore depths and screened intervals would depend on strata and salinities encountered during drilling, but one is likely to be about 40 m deep, and the other 20 m deep.

Regular monitoring of salinity profiles could also be undertaken in the existing deep monitoring bore 2/88 (subject to Water and Rivers Commission approval).

Yours sincerely
ROCKWATER PTY LTD

P H WHARTON
Principal Hydrogeologist


Derby Hydro Power Pty Ltd
TRANSMISSION LINE ROUTE
BEAGLE BAY
ABORIGINAL RESERVE
DERBY
BROOME
FITZROY CROSSING
PILLARA
WESTERN AUSTRALIA
2000-C-002-00
Transmission Line Route

Appendix 6

Proponent's consolidated commitments

8.0 Proponent Commitments

This section presents a summary of commitments made by the proponent in the preceding sections of the CER.

(1) Prior to construction, the proponent will prepare an Environmental Management Programme (EMP) to the satisfaction of the Department of Environmental Protection. The EMP will be implemented during the construction and operational phases of the project to manage potential environmental impacts arising from the project.

(2) The EMP referred to in Commitment (1) will contain measures to address the following:

Aboriginal Heritage

- Consultation with local Aboriginal groups will be ongoing.
- All contractors will be instructed in respect of their obligations under the *Aboriginal Heritage* Act 1972 and arising from any commitments made during Native Title negotiations.
- The proponent will recognise any commitments made during Native Title negotiations with respect to compensation, employment, training opportunities and business development.

Contaminants

- Any oil and lubricants stored on site will be located within areas designed to the requirements of the Department of Minerals and Energy.
- Sewage will be regularly removed from site by a licensed contractor or treated to an acceptable standard on site.

Road and Transmission Line Construction

- The proponent will liaise with the Shire of Derby/West Kimberley and Main Roads Western Australia during design and construction of the access road and to ensure appropriate signage is erected.
- The proponent will liaise with Main Roads Western Australia and Western Power during construction of the transmission line. Where water courses are crossed by the transmission line, the proponent will liaise with Water and Rivers Commission on the management of construction activities.
- The proponent will develop a protocol to maintain the maintenance track beneath the transmission line and to regularly survey the track for the occurrence of Declared Flora. Should Declared Flora be identified, a programme of control will be implemented.

Noise and Dust

- All operations will be managed in accordance with the Noise Abatement (Neighbourhood Annoyance) Act 1979. The proponent recognises its obligations under the noise provisions of the Environmental Protection Act 1986 to ensure that noise levels comply with these requirements.

- Dust levels will be controlled on a needs basis in accordance with the provisions of the Environmental Protection Act 1986.

Vesting

- The proponent will document the proposed vesting for multiple use of the project area and detail the proposed structure which will promote effective management and the development of management objectives. This will be conducted in consultation with local Aboriginal groups and local government.

Environmental

- Construction activities will minimise direct disturbance to mangroves. Vegetation will only be removed if it is essential for construction purposes or the safe operation of the tidal power facility and associated infrastructure.

- All construction vehicle movements outside of the construction areas will be restricted, where practicable, to designated roads and tracks.

- Borrow material will be obtained from either existing or approved borrow pits. Any new pits developed as a component of the project will be referred to the DEP and rehabilitated to the satisfaction of CALM.

- Disturbed areas that are not required for the safe operation of the project will be rehabilitated.

- Salinity measurements of impounded water will be undertaken on a regular basis. Should salinity levels significantly increase above ambient, water flow through the sluices will be manipulated to reduce salinity levels.

- Mesh or other suitable exclusion devices will be installed at the entrance to the turbine raceway to prevent the entry of fish. Final design will be undertaken in consultation with the Department of Fisheries.

- Dredge spoil will be preferentially deposited in the deeper upper reaches of the low basin where practicable to increase the availability of habitat for mangrove colonisation.

- The shoreline in the vicinity of the barrages will be monitored and mitigation measures (such as provision of armour protection) will be implemented should significant erosion occur.

- Ongoing monitoring will be conducted in accordance with the Programme of Research, Monitoring and Management (Commitment (3)).

- A decommissioning plan will be developed prior to decommissioning which will address the removal of plant and equipment and the rehabilitation of disturbed areas.

- Monitoring bores will be installed adjacent to the peninsula to monitor any movement in the saltwater wedge. This will be to the satisfaction of the Water and Rivers Commission. Should a project induced adverse effect be identified, the proponent will investigate options to remedy the problem.

(3) Prior to construction, the proponent will prepare a Programme of Research, Monitoring and Management to the satisfaction of the Department of Environmental Protection. This programme will be implemented prior to construction and has the objective of initiating a programme of research into mangrove biology and re-establishment, and quantifying and documenting ecosystem changes following construction of the barrages.

(4) The Programme of Research, Monitoring and Management referred to in Commitment (3) will contain measures to address the following:

- Research and implementation of a programme to re-establish mangroves including recontouring of creek banks and creek bed to increase the intertidal area available for recolonisation, and dredging of channels in the low basin to increase water penetration into the creek. This work will be directed towards an objective of no net loss of mangroves with a view to increasing primary production in the medium to long term.

- Research into mangrove biology including interactions between soil salinity, elevation, aspect, ground stability and soil type on mangrove distribution, productivity and ecological value.

- A monitoring programme, centred on Doctors Creek, to quantify changes in:

  - water quality including temperature, salinity, dissolved oxygen, turbidity and chlorophyll a;
  - sediment characteristics including oxygen demand, particle size and organic carbon;
  - phytoplankton and zooplankton density and species diversity;
  - infauna density and species diversity;
  - density and species diversity of benthic flora and fauna;
  - mangrove distribution, density and species diversity;
  - fish use; and
  - bird use.